4.7 GEOLOGY AND SOILS

4.7.1 Overview

This section of the Proponent's Environmental Assessment (PEA) describes the existing conditions related to geology, geologic hazards, and soils for the proposed TRTP. The construction and operation of electrical transmission facilities is subject to numerous laws and regulations. Summaries of state laws and regulations related to geology, geologic hazards, and soils are presented in this section. This section also assesses the potential for implementation of the proposed Project to create a significant hazard through construction and/or operations and maintenance activities. Applicant Proposed Measures (APMs) are described, as appropriate, to reduce potentially significant impacts related to geology and soils.

4.7.2 Technical Methodology

Existing conditions were determined from review of available published and unpublished literature, online sources, and an aerial reconnaissance of the Project segments by an engineering geologist. Descriptions of geologic units in the Project area are based on published geologic quadrangle maps by Thomas Dibblee (1989, 1996, 1997, 1998, 1999, 2001a, 2001b, 2001c, 2002a, 2002b, 2002c) and geologic maps for the Los Angeles, San Bernardino, Santa Ana, Long Beach, and Bakersfield sheets. Other sources of geologic information include the Southern California Earthquake Center (SCEC), U.S. Geological Survey (USGS), and available geotechnical information from SCE (SCE, 1952, 1957, 1971, 1996, 1997) summarized in Section 4.7.2.1.

Hazard evaluations for landslides and liquefaction derive primarily from published mapping from the California Geological Survey (CGS) Seismic Hazards Mapping Program geologic quadrangle maps and the Dibblee quadrangle maps.

Assessment for fault rupture hazard and ground shaking hazard derive from fault mapping, catalogs, and interactive maps. The primary sources derive from the CGS or USGS and include:

- Probabilistic Seismic Hazard Assessment (PSHA) for the State of California
- Earthquake Fault Zones Maps
- Fault Evaluation Reports
- Probabilistic Seismic Hazards Mapping Ground Motion
- Quaternary Fault and Fold Database of the United States

Soils information presented here derives from the United States Department of Agriculture (USDA) Soil Survey Geographic Database (SSURGO) data and soil mapping prepared by the Los Angeles Department of Water and Power (LADWP). Other sources of soil information reviewed include the following soil surveys by the USDA Natural Resources Conservation Service (NRCS):

- Soil Survey of Antelope Valley, California
- Soil Survey of the Los Angeles Area, California
- Soil Survey of the Pasadena Area, California

4.7.2.1 Previous Geotechnical Studies

Previous geotechnical studies have been performed for the existing Midway–Vincent No. 3 500 kV Transmission Line and the existing Antelope and Vincent substations. Although the Midway–Vincent No. 3 T/L extends further north, it parallels Segments 4 and 5 for the majority of their alignments between Cottonwind and Vincent Substations. Expansions to the Antelope and Vincent substations are part of the proposed Project. Accordingly, the information contained in the geotechnical investigations is applicable to the geologic and soils conditions for the Project. Summaries of these geotechnical reports are presented below.

4.7.2.1.1 Midway – Vincent No. 3 500 kV Transmission Line. The 1971 design report prepared by SCE summarizes the findings of a geotechnical investigation conducted for the construction of the No. 3 Midway – Vincent 500 kV T/L. It includes data for approximately 46 soil borings, approximately 30 of which are along the Segment 4 and 5 alignments. Borings were typically 20 to 35 feet deep. The report discusses crossings of the San Andreas and Garlock faults, noting that even with careful placement of the towers, those immediately adjacent to the faults could be damaged or lost during a major seismic event. No other geologic hazard information is included.

4.7.2.1.2 Antelope Substation. Several geotechnical-related letter reports have been prepared previously for various expansions at the Antelope Substation. Boring logs, limited laboratory testing results, and design recommendations are included in these reports. The information indicates that the site is underlain by Recent Alluvium, composed primarily of loose to medium dense silty sand with gravel, with local gravelly, cobbly, and clayey layers. Groundwater was not encountered within 40 feet of the ground surface. Geologic hazard information is not included.

4.7.2.1.3 Vincent Substation. A foundation investigation report (LeRoy Crandall & Associates, 1963) is available for the existing Vincent Substation. This report indicates that materials underlying the Vincent Substation site consist of alluvial deposits composed primarily of medium dense to dense interbedded silty sand and sand. Groundwater was not encountered in the borings, which extended to a maximum depth of 35 feet below ground surface. Laboratory test results indicate the presence of potentially collapsible soil.

4.7.3 Regulations, Plans, and Standards

Regulations, plans, and standards for management of geologic and seismic hazards have been promulgated by state, county and local government. Federal and state government allows local counties and cities to manage and/or implement many of the federal and state regulations relating to the construction and operation of facilities. Administrative provisions have been enacted to allow for the planning, coordination, and reporting of hazardous materials and hazardous waste programs among federal, state, and local governments. The highlighted details of potentially applicable federal and state programs are presented below.

4.7.3.1 Regulatory Definitions

The following provides summary definitions of the key terms used in evaluation and regulation of geologic hazards:

- Active Fault. An active fault has evidence of movement in the Holocene period, or approximately the last 11,000 years. The definitions of active, potentially active, and inactive faults provided herein are based on criteria developed by the CGS (previously the California Department of Conservation, Division of Mines and Geology [CDMG]) for the Alquist-Priolo Earthquake Fault Zoning Program.
- Potentially Active Fault. A potentially active fault is a fault that has demonstrated surface displacement of Quaternary age deposits (last 1.6 million years).
- Inactive Fault. Inactive faults have not moved in the last 1.6 million years.
- Seismic Parameters. Earthquakes, their causative fault sources, and the resultant ground motions are measured by parameters, including magnitude, intensity, fault length, rupture area, slip rate, recurrence maximum considered earthquake, and peak ground acceleration (PGA). These seismic parameters are used to evaluate and compare earthquake events, seismic hazard potential, and ground shaking.
- Magnitude. Magnitude refers to the size of an earthquake. A number of methods are used to measure magnitude, including Richter (M_L), surface wave (Ms), and body wave (M_b). These are instrumental methods, based on the measurement of amplitude of seismic waves recorded on a seismograph, and can yield inconsistent results when considered over wide ranges of magnitudes. A more consistent method of magnitude measurement is

provided by moment magnitude, or Mw. Moment magnitude is based on the energy released across the area of the fault.

- Maximum Considered Earthquake (MCE). Fault parameters are generally used to estimate the maximum considered earthquake (MCE) that could be generated by a given fault or fault segment. In some cases, historic earthquakes are used to characterize the MCE. In general, the MCE is a rational and believable projected event that can be supported by the seismic and paleoseismic geology of the area.
- Earthquake Fault Zones. The Alquist-Priolo Special Studies Zones Act passed in 1972 requires the establishment of "earthquake fault zones (EFZ)," formerly known as "special studies zones," along known active faults in California. Strict regulations on development within these zones are enforced to reduce the potential for damage due to fault displacement. However, these restrictions apply only to occupied structures and none of the proposed TRTP facilities would normally be staffed. In order to be designated as an "earthquake fault zone," a fault must be "sufficiently active and well defined" according to State guidelines. As a result, only faults or portion of faults with relatively high potential for ground rupture are zoned, while other faults which may partially meet the criteria are not zoned. The potential for fault rupture, therefore, is not limited solely to faults or portions of faults delineated as "earthquake fault zones."
- Liquefaction. Seismically-induced soil liquefaction is a phenomenon in which loose to medium dense, saturated, granular materials undergo matrix rearrangement, develop high pore water pressure, and lose shear strengths due to cyclic ground vibrations induced by earthquakes. This rearrangement and strength loss is followed by a reduction in bulk volume. Manifestations of soil liquefaction can include loss of bearing and lateral capacities for foundations, and surface settlements and tilting in level ground. Soil liquefaction can also result in instabilities and lateral deformation in areas of sloping ground.
- Lateral Spreading. Liquefaction-induced failure and lateral movements of slopes or free faces are referred to as lateral spreading.
- Landslides. Landslides, or downslope movement of soil or rock, can occur due to inherently weak underlying materials, or to oversteepening or loading (static or seismic) of existing stable slopes. Specific factors that affect the slope stability of an area include the steepness of the slope, the relative strength of the underlying rock material, and the thickness and cohesion of the overlying colluvium. The steeper the slope and/or the less strong the rock, the more likely the area is susceptible to landslides.
- Debris Flows. Debris flows are similar to landslides, except that they typically occur in saturated material and behave more as a liquid than a solid upon movement.

- Tsunami. A tsunami is an ocean wave produced by a sub-marine earthquake, landslide, or volcanic eruption. These waves may reach enormous dimensions and have sufficient energy to travel across entire oceans.
- Seiche. A seiche is a standing wave oscillation of an enclosed water body that continues, pendulum fashion, after the cessation of the originating force, which may have been either seismic or atmospheric.
- Expansive Soils. Expansive soils are those that contain significant amounts of clays that expand when wetted and can cause damage to foundations if moisture collects beneath structures.
- Collapsible Soils. Soils that collapse during wetting may be encountered in alluvial deposits when re-wetting causes chemical or physical bonds between soil particles to weaken. This allows the structure of the soil to collapse and the ground surface to subside. In order to collapse, soils must have a weak cementation or cohesive structure that can be modified by the addition of water.
- Subsidence. Land subsidence is a result of fluid withdrawal from compressible sediments. As fluid is withdrawn, the effective pressure in the drained sediments increases. Compressible sediments are then compacted because the over-burden pressure is no longer compensated by hydrostatic pressure. This effect is most pronounced in younger, uncompacted sediments. Subsidence can be triggered by seismic events. Land subsidence is generally characterized by a broad zone of deformation where differential settlements are small.
- Corrosivity. Corrosivity of soils is generally related to several key parameters: soil resistivity, presence of chlorides and sulfates, oxygen content, and acidity or alkalinity based on hydrogen ion concentration (pH). Typically, the most corrosive soils are those with the lowest pH and highest concentration of chlorides and sulfates. High sulfate soils are corrosive to concrete and may prevent complete curing, thereby reducing its strength considerably. Low pH and/or low resistivity soils could corrode buried or partially buried metal structures.
- Erosion. The properties of soil which influence erosion by rainfall and runoff, are ones which affect the infiltration capacity of a soil and those which affect the resistance of a soil to detachment and being carried away by falling or flowing water. Soils containing high percentages of fine sands and silt and that may have low in density are generally the most erodible. These soil types generally coincide with soils such as young alluvium and other surficial deposits, which occur in areas throughout the Project area. As the clay and organic matter content of these soils increases, the potential for erosion decreases. Clays act as a binder to soil particles, thus reducing the potential for erosion. However, while

clays have a tendency to resist erosion, once eroded they are easily transported by water. Clean, well-drained, and well-graded gravels and gravel-sand mixtures are usually the least erodible soils. Soils with high infiltration rates and permeabilities reduce the amount of runoff.

4.7.3.2 Federal Authorities and Administering Agencies

There are no federal regulations, plans, or standards for geological hazards and resources, or for grading and erosion control.

4.7.3.3 State Authorities and Administering Agencies

4.7.3.3.1 Earthquake Fault Zoning Act, California Public Resources Code 25523(a): 20 CCR § 1252 (b) and (c). The Alquist-Priolo (A.P.) Earthquake Fault Zoning Act of 1972 (formerly the Special Studies Zoning Act) regulates development and construction of buildings intended for human occupancy to avoid the hazard of surface fault rupture. The Act provides for the adoption and administration of zoning laws, ordinances, rules, and regulations by cities and counties in implementation of the general plan that is in effect in any city or county. It is intended to provide policies and criteria to assist cities, counties, and state agencies in the exercise of their responsibility to prohibit the location of developments and structures for human occupancy across the trace of active faults. Further, it is the intent of the Act to provide the citizens of the state with increased safety and to minimize the loss of life during and immediately following earthquakes by facilitating seismic retrofitting to strengthen buildings, including historical buildings, against ground shaking.

While this Act does not specifically regulate overhead transmission lines (T/Ls), it does help define areas where fault rupture is most likely to occur. This Act groups faults into categories of active, potentially active, and inactive. Historic and Holocene age faults are considered active, Late Quaternary and Quaternary age faults are considered potentially active, and pre-Quaternary age faults are considered inactive. These classifications are qualified by the conditions that a fault must be shown to be "sufficiently active" and "well defined" by detailed site-specific geologic explorations in order to determine whether building setbacks should be established.

4.7.3.3.2 Seismic Hazards Mapping Act, California Public Resources Code 2695(a): (1) and (3)-(5). The Seismic Hazards Mapping Act of 1990 (Public Resources Code, Chapter 7.8, Division 2) directs the CGS to delineate Seismic Hazard Zones. The purpose of the Act is to reduce the threat to public health and safety and to minimize the loss of life and property by identifying and mitigating seismic hazards. Cities, counties, and state agencies are directed to use seismic hazard zone maps developed by CGS in their land-use planning and permitting processes. The Act requires that site-specific geotechnical investigations be performed prior to permitting most urban development projects within seismic hazard zones. It addresses the effects of strong ground shaking, liquefaction, landslides, or other ground failure and other seismic hazards caused by earthquakes.

The Act also addresses tsunamis and seiches. It states that maps may include potential effects of tsunami and seiche when information becomes available from other sources and the State Geologist determines the information is appropriate for use by local government.

4.7.3.3.3 California Environmental Quality Act of 1970 (CEQA), California Public Resources Code Sections 21000-21177.1. The CPUC will be the lead agency for rules and regulations to implement the California Environmental Quality Act. Appendix G, Section VI of the CEQA guidelines provides for an evaluation of the impact of the proposed Project on geology and soil. CEQA was adopted in 1970 and applies to most public agency decisions to carry out, authorize or approve projects that may have adverse environmental impacts. CEQA requires that agencies inform themselves about the environmental effects of their proposed actions, consider all relevant information, provides the public an opportunity to comment on the environmental issues, and avoid or reduce potential environmental harm whenever feasible.

4.7.3.4 County/Regional Authorities and Administering Agencies[1]

4.7.3.4.1 General Plans. Elements of the General Plans for the counties and other areas through which the Project passes contain policies for the avoidance of geologic hazards.

Kern County**.** The Safety Element (Chapter 4) of the Kern County General Plan (2004) provides policies and measures to minimize injuries and loss of life and reduce property damage from seismic and geologic hazards. Kern County has developed a map of Seismic, Landslides, and Steep Slope Hazards Constraints. Seismic Hazards were developed based on the Alquist-Priolo Special Study Zone. Landslide Hazards are defined as areas of downslope ground movement, and Steep Slopes as having an average slope of 30 percent or steeper. No new development is allowed in the hazard zones areas unless technical studies demonstrate no “unmitigated significant impact.” The main policy relevant to the Project is “The County

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[1] The CPUC has primary jurisdiction over the TRTP because it authorizes the construction, operation, and maintenance of public utility facilities in the State of California. Although such projects are exempt from local land use and zoning regulations and permitting, General Order (GO) No. 131-D, Section III C requires “the utility to communicate with, and obtain the input of, local authorities regarding land use matters and obtain any non-discretionary local permits.”

shall encourage extra precautions be taken for the design of significant lifeline installations, such as highways, utilities, and petrochemical pipelines."

***Los Angeles County*.** The Safety Element of the Los Angeles County General Plan (1990) provides goals and policies to reduce impacts from seismic and geologic hazards and provide a safer environment. The two main policies that are potentially relevant to the Project are: minimize injury and loss of life, damage, and social, cultural, and economic impacts caused by earthquake hazards; and protect public safety and minimize the social and economic impacts from geologic hazards. Proper design of the Project facilities, including all APMs outlined in this document, would meet these goals and would be consistent with the Los Angeles County Safety Element.

***Antelope Valley Areawide General Plan*.** The Antelope Valley Areawide General Plan (1986) is a component of the Los Angeles County General Plan and provides policies related to public planning in the Antelope Valley area, including policies related to seismic and geologic hazards. These policies generally include enforcing standards and criteria to reduce impacts from seismic and geologic hazards, advocating detailed site evaluations and improved seismic design and construction standards for critical linear system facilities, and programs and practices for dealing with erosion, settlement, and other soil-related hazards. The Project would be consistent with these policies through implementation of the Project APMs outlined in this document.

***San Bernardino County*.** The Natural Hazards section of the San Bernardino County General Plan (2002) provides for mitigation of geologic hazards through a combination of engineering, construction, land use and development standards. The Plan addresses the geologic hazards present within the county, including fault rupture, ground shaking, liquefaction, seismically-generated subsidence, seiche and dam inundation, landslides/mudslides, non-seismic subsidence, erosion and volcanic activity. The county has prepared Hazard Overlay Maps to address fault rupture, liquefaction hazards and landslide hazards. Special consideration, including possible engineering/geologic evaluation, is required for development of sites designated on the maps.

4.7.3.5 Local Authorities and Administering Agencies

Individual cities and communities have prepared Specific Plans to address State and county regulations.[2] The local plans vary, although they are required to address the elements

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[2] See footnote 1 regarding GO 131-D.

contained within the county plans. Where Specific Plans contain major deviations from the General Plans, details are provided in the individual segment discussions.

4.7.4 Significance Criteria

The potential for a project to impact geologic or soil conditions or be impacted by geologic, seismic, or soil conditions is determined primarily by CEQA criteria. Based on the Environmental Checklist Form in Appendix G of the CEQA Guidelines, the following criteria are utilized to evaluate potential impacts:

- Would the Project expose people or structures to adverse effects as a result of rupture of an Alquist-Priolo Earthquake Fault or other substantial known fault?
- Would the Project expose people or structures to adverse effects as a result of seismic ground shaking?
- Would the Project expose people or structures to adverse effects as a result of seismic related ground failure including liquefaction?
- Would the Project expose people or structures to adverse effects as a result of landslides?
- Would the Project result in substantial soil erosion or the loss of topsoil?
- Would the Project be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the Project and potentially result in onsite or offsite landslide, lateral spreading, subsidence, liquefaction or collapse?
- Would the Project be located on expansive soil, creating substantial risks to life or property?
- Would the Project have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?

A wide range of potential impacts such as slope instability and seismic hazards was considered in this analysis. Each of the potential geologic, seismic, and soil impacts is discussed in the following sections for each TRTP segment.

4.7.5 Applicant Proposed Measures

The following are APMs to limit geological resource-related impacts to less-than-significant levels.

APM GEO-1: Seismic Design. For new substation construction, specific requirements for seismic design would be followed based on the Institute of Electrical and Electronic Engineers' 693 "Recommended Practices for Seismic Design of Substation." Other project elements would be designed and constructed in accordance with the appropriate industry standards, and good engineering and construction practices and methods, as applicable.

APM GEO-2: Perform Geotechnical Studies. Prior to final design of substation facilities and T/L tower foundations, a geotechnical study would be performed to identify site-specific geologic conditions and potential geologic hazards in enough detail to support good engineering practice. The geotechnical study would be performed by professional civil or geotechnical engineers and engineering geologists licensed in the State of California and would provide design and construction recommendations, as appropriate, to reduce potential impacts from geologic hazards or soil conditions.

APM GEO-3: Construction SWPPP. T/L and substation construction activities would be performed in accordance with the soil erosion/water quality protection measures to be specified in the Construction Storm Water Pollution Prevention Plan (SWPPP) for the TRTP.

4.7.6 Proposed Project and Alternatives

The proposed TRTP consists of seven T/L segments and one substation-related segment, enumerated as Segment 4 through Segment 11. Segments 4, 5, and 10 involve upgrading and expanding SCE's transmission system north of SCE's Vincent Substation in order to integrate Tehachapi area wind generation to SCE's electric system. Segments 6, 7, 8, and 11 involve upgrading and expanding SCE's transmission system south of SCE's Vincent Substation in order to deliver Tehachapi area wind-generated electricity to SCE's load centers. Segment 9 involves construction, expansion, or upgrading substations along the various T/L routes. The major components of these facilities are summarized in the following sections. More complete descriptions are provided in Section 3.0, Project Description. In addition, the following sections assess potential Project-related impacts on a segment-by-segment basis for geology and soils. The Project segments are shown on a Regional Geologic Map, Figures 4.7-1a, b, c.

4.7.6.1 Segment 4

4.7.6.1.1 Environmental Setting. This section describes the existing geologic conditions, geologic hazards and soil conditions in the proposed Project area for Segment 4 of the proposed TRTP.

Physiographic Setting**.** Segment 4 traverses the western portion of the Mojave Desert physiographic province extending from the eastern margins of the Tehachapi Mountains to the Antelope Valley. The segment begins at the proposed Cottonwind Substation located on an ancient alluvial fan complex and adjacent to Cottonwood Creek at an elevation of approximately 3,400 feet mean sea level (msl). The proposed Segment 4 extends southeasterly across the moderately sloping fan surface and into the Antelope Valley. The proposed and alternate Whirlwind substation sites are located on low relief terrain at the margins of agricultural land with elevations ranging from 2,660 to 2,720 feet msl. The terrain along the route continues to slope gently to the southeast and is locally interrupted by northeast- to southwest-trending low hills or buttes including Fairmont Buttes and Antelope Buttes. The alignment crosses the northern end of the Antelope Buttes at approximately S4 MP 12. The route continues along low relief valley terrain until it reaches Antelope Substation at an elevation of approximately 2,480 feet msl. The topography of the Project area is shown on the Detailed Project Location Map (Figure P.1-2). No perennial drainages are crossed by the proposed Segment 4 T/L route.

Geologic Setting**.** The route traverses varied geologic conditions associated with the Mojave Desert physiographic province discussed above. Table 4.7-1 includes a summary of geologic conditions, by milepost, for the Segment 4 T/L route.

The route starts within Pleistocene age alluvial fan deposits and transitions into valley fill deposits that underlie the Antelope Valley. The Antelope Valley is a large, undrained topographic basin characterized by relatively flat lying topography and extensive valley fill deposits. Scattered buttes resulting from Miocene-age extrusive volcanic rocks form the only topographic break across the central portion of the valley. The Fairmont Butte is underlain by volcanic rock and the adjacent Antelope Butte is underlain by granitic rock. The route ends at the existing SCE Antelope Substation near the southern margins of the Antelope Valley. The San Andreas Fault defines the southern margins of the Antelope Valley and the boundary with the Transverse Ranges.

Geologic Structure**.** Segment 4 initiates at the proposed Cottonwind Substation located on ancient alluvial fans shed off of the predominantly granitic terrain of the Tehachapi Mountains. The Tehachapi Mountains represent the southern margin of the Sierra Nevada structural block. This margin is largely defined by the Garlock fault. Segment 4 traverses the Antelope Valley and lies entirely within the Mojave structural block. The San Andreas Fault zone lies approximately 3 miles beyond the southern end of the Segment 4. The San Andreas Fault zone represents a major tectonic boundary and the boundary between the Mojave Desert structural block and the Transverse Ranges.

TABLE 4.7-1
GEOLOGIC CONDITIONS – SEGMENT 4[1]

Approximate Milepost	Geologic Unit/Structure	Formation Name	Description/Comments
0.0 – 2.7	Qc	Pleistocene nonmarine	Unconsolidated alluvial gravels, sand and silt, representing an ancient alluvial fan surface
2.7 – 10.9	Qa	Alluvium	Alluvial gravels, sand and silt
10.9 – 11.3	Qc	Pleistocene nonmarine	Unconsolidated alluvial gravels, sand and silt
11.3 – 11.7	Qa	Alluvium	Alluvial gravels, sand and silt
11.7 – 12.6	Gr	Granitic Rocks	Granitic rocks; fractured, variably weathered crystalline rock
12.6 – 19.6	Qa	Alluvium	Alluvial gravels, sand and silt

[1] Source: State Geologic Maps series (Bakersfield Sheet, 1:250,000 scale).

***Geologic Units*.** Geologic units encountered in the Project area are presented in Table 4.7-1 and are based on the State Geologic Maps series (Bakersfield Sheet, 1:250,000 scale). The geologic units are described briefly below.

***Surficial Deposits*.** Quaternary alluvium includes the valley fill deposits of the Antelope Valley and the distal fan deposits associated with the adjacent Tehachapi Mountains.

***Ancient Alluvial Fan*.** Pleistocene-age deposits of older alluvial fans are present at the northern end of Segment 4 at the toe of the Tehachapi Mountains. Slightly cemented silty gravelly sands are typical materials encountered within the older fan deposits.

***Tertiary Volcanic Rock*.** Miocene-age volcanic rocks are present in the Fairmont Butte area and consist of indurated pyroclastic rock A minor stretch of Segment 4 may encounter these deposits at the surface or in the shallow subsurface.

***Granitic Rocks*.** Crystalline rocks of granitic origin are present along the Segment 4 T/L route where the route crosses Antelope Butte.

***Geologic Hazards*.**

***Faults and Seismicity*.** Active and potentially active faults have been mapped in the region and documented by a number of government agencies and scientific entities. Numerous published maps and reports have been prepared by the United States Geological Survey (USGS), the CGS, and other State or public agencies (i.e., California Department of Transportation [Caltrans], Southern California Earthquake Center [SCEC]) that present information on fault location and activity. Table 4.7-2 presents a list of active and potentially active faults within approximately 60 miles of Segment 4. Fault characteristics listed in Table 4.7-2 are based on published data.

The Project area is seismically very active given the proximity and number of potential seismic sources. Figure 4.7-2 presents a regional fault and epicenter map showing the approximate location of the TRTP relative to seismic sources and past earthquakes. Notable historic seismic events affecting the Project area are presented in Table 4.7-3.

It is likely that the Project area will experience minor to moderate earthquakes and potentially a major earthquake (moment magnitude M7, or greater) during the Project's service life. A 1995 estimate by the Working Group on California Earthquake Probabilities gave an 80 to 90 percent probability of an M7 or greater earthquake in southern California before 2024. It should be noted that SCE's structural design basis for T/Ls is conservative and based on wind load, which is more restrictive than seismic hazard.

***Fault Rupture/Fault Displacement*.** Segment 4 does not cross any known active faults or significant potentially active faults. Further, it does not cross any Earthquake Fault Zones or any fault with significant potential for fault rupture. Therefore, there are no known hazards associated with fault rupture along an active fault within Segment 4.

***Landslides*.** The Segment 4 Project area has not been mapped at the quadrangle level by the State hazard mapping program. However, landslides are not a significant hazard within the Segment 4 route because of the moderate to gentle terrain traversed.

***Liquefaction and Lateral Spreading*.** Liquefaction is not considered a significant potential hazard along Segment 4 based on the available information. Liquefaction susceptible materials are present within the recent alluvial deposits, but the depth to groundwater in the Antelope Valley is deep and, therefore, the liquefaction potential is considered low.

***Ground Motions*.** Probabilistic Seismic Hazards Assessment (PSHA) models developed by USGS/CGS (CGS, 2002, revised April 2003) depict ground motions associated with a 10 percent probability of exceedance in a 50-year period. For Segment 4 the ground motion estimate for the start of the segment at the Cottonwind Substation is about 0.45 of the gravitational acceleration (g) and at the Antelope Substation is approximately 0.64g for the peak ground acceleration (PGA).

***Expansive and Collapsible Soils*.** Some potential for expansive or collapsible materials may be present in the Antelope Valley. Collapsible soils, if present within the Project area,

TABLE 4.7-2
SEISMIC SOURCE CHARACTERISTICS – SEGMENT 4

Fault Name	Nearest Distance to Segment 4 (Miles)[1]	Type of Faulting[2]	Fault Length (miles)[2]	Slip Rate[2] (mm/year)	Maximum Magnitude Earthquake[2] (M_{max})
Anacapa-Dume	53	Left lateral oblique	75	3	7.5
Big Pine	11	Left lateral strike-slip	41	0.8	6.9
Clamshell-Sawpit Canyon	40	Reverse	11	0.5	6.5
Cucamonga	54	Thrust	18	5	7
Elsinore, Chino segment	61	Right-lateral strike-slip	13	1	6.5
Garlock	8	Left-lateral strike-slip	155	2-11	7.1
Hollywood	41	Left reverse	9	1	6.5
Holser	27	Reverse	12	0.4	6.5
Malibu Coast	51	Reverse	21	0.3	6.7
Newport-Inglewood	45	Right-lateral strike-slip	46	0.6	6.9
Northridge Blind thrust	28	Blind thrust	31	1.5	7
Oak Ridge	43	Thrust	55	4	6.9
Palos Verdes	55	Right reverse	49	3	7.1
Pleito Thrust	26	Thrust	28	2	6.8
Puente Hills Blind Thrust	36	Blind thrust	25	0.7	7.1
Raymond	40	Left-lateral reverse	16	1.5	6.5
San Andreas – Mojave Segment	3	Right-lateral strike-slip	64	30	7.9
San Andreas – Carrizo Segment	37	Right-lateral strike-slip	90	34	7.9
San Cayetano	30	Thrust	28	6	6.8
San Fernando	28	Thrust	10	2	6.8
San Gabriel	23	Right-lateral strike-slip	87	1	7.2
San Jacinto, Glen Helen segment	52	Right-lateral strike-slip	46	12	6.9
Santa Monica	43	Left reverse	14	1	6.6
Santa Susana	32	Thrust	23	5	6.6
Sierra Madre	37	Reverse	46	2	7.2
Simi (Santa Rosa)	40	Reverse	24	1	6.7
Upper Elysian Park Thrust	36	Blind thrust	18	0.8	6.8
Whittier	55	Right-lateral strike-slip	24	2.5	6.8
White Wolf	27	Left-lateral reverse	37	2	7.2

[1] Fault distances based on Jennings, 1994.

[2] Data based on CGS, 2003a, 2003b, 2003c, and 2003d; Southern California Earthquake Center (SCEC)(www.scec.org).

TABLE 4.7-3
SIGNIFICANT HISTORIC EARTHQUAKES – SEGMENT 4

Date	Approximate Distance to Project Segment 4[1] (Miles)	Earthquake Magnitude[2]	Name, Location or Region Affected	Comments[2]
December 8, 1812	75	7.5?	Wrightwood Earthquake	Caused collapse of Mission at San Juan Capistrano resulting in the death of 40 people.
July 11, 1855	17	6.0	Los Angeles Region	The bells at San Gabriel Mission Church were thrown down and 26 buildings in Los Angeles were damaged.
January 9, 1857	103	Estimated from 7.9 to 8.25	Fort Tejon Earthquake	One of the largest earthquakes ever reported in the U.S. This earthquake caused damage from Monterey to San Bernardino and caused a surface rupture of greater than 220 miles in length. Due to sparse population at the time it only resulted in 2 deaths. Average displacement along the fault was 15 feet, with a maximum displacement of 30 feet in the Carrizo Plain Area.
January 16, 1857	Unknown	6.3	Generally felt in the Los Angeles Region	Aftershock of the January 9, 1857 M7.9 Fort Tejon Earthquake.
July 29, 1894	63	6.2	Lytle Creek region	Felt from Bakersfield to San Diego. Minor damage in the Mojave and Los Angeles areas.
July 21, 1952	31	7.3	Kern County Earthquake	Resulted in the death of 12 people and $60 million in property damage.
February 9, 1971	30	6.6	San Fernando (Sylmar) Earthquake	This earthquake caused over $500 million in damage and resulted in 65 deaths. As a result of the damage from this earthquake, building codes were strengthened and the Alquist-Priolo Special Studies Zone Act of 1972 was passed.
October 1, 1987	47	5.9	Whittier Narrows Earthquake	Resulted in eight deaths and $358 million in property damage. This earthquake occurred on a previously unknown blind thrust fault, the Puente Hills Fault.
January 17, 1994	32	6.7	Northridge Earthquake	Resulted in 60 deaths and approximately $15 billion in property damage. Damage was significant and widespread, including collapsed freeway overpasses and more than 40,000 damaged buildings in Los Angeles, Ventura, Orange, and San Bernardino counties.

[1] Earthquake magnitudes and locations before 1932 are estimated by Toppozada and others (1978, 1981, and 1982) based on reports of damage and felt effects.

[2] Earthquake damage information compiled from the Southern California Earthquake Data Center (SCEDC, 2006a and 2006b) and National Earthquake Information Center (NEIC, 2005) websites.

are most likely in the fine-grained desert soils. Extensive areas of expansive soils are not anticipated in the generally granular soil conditions encountered along the Segment 4 portion of the Project area.

***Subsidence*.** Subsidence has been documented within portions of the Antelope Valley where extensive groundwater withdrawal has been occurring for many years (USGS, 1995, 2000), specifically in the area around Edwards Air Force Base and the Lancaster areas. The subsidence around Lancaster has been estimated at up to 6 feet between 1930 and 1992 with up to 2 inches of additional subsidence between 1993 and 1995 (Galloway et al., 1998). The margins of this zone of subsidence have the potential to impact the Project area. The magnitude and the distribution of the deformation, however, suggest that this zone of subsidence does not constitute a significant hazard to Segment 4. This type of regional deformation is not generally a significant hazard to overhead transmission lines or substation facilities because the individual foundation elements of these types of structures would not be expected to experience significant differential settlement as a result of subsidence.

***Soils*.** The soils along the proposed Segment 4 T/L route reflect the underlying rock type, the extent of weathering of the rock, the degree of slope, and the degree of modification by humans. Soil data for the Project area were obtained from the Soil Survey Geographic (SSURGO) database for the Antelope Valley Area, California (Publication Date: January 4, 2007).

A summary of the significant characteristics, including the description, hazard of erosion, and risk of corrosion of the major soil units traversed by Segment 4 is presented in Table 4.7-4; soil units are listed in order of first occurrence along the segment and may occur in multiple locations.

4.7.6.1.2 Impact Analysis. The potential impacts to or from geologic, seismic, and soil conditions along the proposed Segment 4 T/L route are discussed below. The discussion follows the significance criteria presented in Section 4.7.4.

***Impact Summary*.** Construction, operation, and maintenance of the proposed TRTP Project Segment 4 would not create a significant hazard to the public or the environment relative to geology, soils, or geologic hazards. Segment 4 is not located within any designated geologic hazard zones based on a review of State and Local regulations. The proposed Project could be subject to moderate or high levels of ground shaking in the event of an earthquake on faults in the region. Impacts to soils would occur during construction with increased traffic and grading associated with pads and roads for T/L construction and substation construction.

TABLE 4.7-4[1]
SUMMARY OF SOIL UNIT CHARACTERISTICS – SEGMENT 4

Soil Series or Association	Description	Hazard of Erosion on Roads and Trails[1,2]	Risk of Corrosion	
			Uncoated Steel	Concrete
Terrace Escarpments	Variable gravel, cobble and boulder content	Not Applicable (NA)	NA	NA
Ramona	Coarse sandy loam, 0 to 30% slopes	Slight to Severe	Moderate	Moderate
Dune Land	Fine sand	Severe	NA	NA
Cajon	Loamy sand, 2 to 9% slopes	Slight to moderate	Moderate	Low
Hesperia	Fine Sandy loam, 0 to 5% slopes	Slight to Moderate	High	Low
Rosamond	Loamy fine sand, Fine sandy loam, Silty clay loam, loam	Slight	Moderate	Moderate
Vista	Coarse sandy loam, 9 to 30% slopes	Severe	Low	Low
Hanford	Coarse sandy loam, Fine sandy loam, Sandy loam; 0 to 9% slopes	Moderate to severe	Low	Low
Greenfield	Sandy loam, 0 to 9% slopes	Slight to moderate	Low	Low

[1] Source for soils mapping and characteristics: SSURGO, Antelope Valley Area, California, GIS.

[2] Qualitative descriptors of erosion hazard: Slight = little or no erosion is anticipated, Moderate = some erosion anticipated, Severe = significant erosion potential exists.

***Construction*.** The impact analysis for construction of Segment 4 is based on the significance criteria detailed above in Section 4.7.4. Once constructed, Segment 4 would be susceptible to geologic hazards; those impacts and applicable APMs are described under the Operations section.

Would the Project expose people or structures to adverse effects as a result of rupture of an Alquist-Priolo Earthquake Fault or other substantial known fault?

Because this segment does not cross an Alquist-Priolo Earthquake Fault or other substantial known fault, no impact is expected.

Would the Project expose people or structures to adverse effects as a result of seismic ground shaking?

Because of the temporary nature of the construction activity, no significant impacts to people or structures from ground shaking are expected during construction.

Would the Project expose people or structures to adverse effects as a result of seismic related ground failure including liquefaction?

Because of the temporary nature of the construction activity, no significant impacts to people or structures from ground failure are expected during construction.

Would the Project expose people or structures to adverse effects as a result of landslides?

Landslides have not been identified as a significant hazard in Segment 4 and no impact is expected during construction.

Would the Project result in substantial soil erosion or the loss of topsoil?

Grading and construction activities for the proposed Segment 4 T/L structures and associated road construction would affect soil and vegetation. Some soil types along the route are subject to moderate or severe erosion on roads and trails. Such areas, if not stabilized, could be subject to increased rates of erosion by wind and/or water. Without preventative measures, soil erosion is a potentially significant impact. Implementation of APM GEO-3 (Construction SWPPP) would limit Segment 4 T/L-related construction impacts to soils to a less-than-significant level.

Would the Project be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the Project and potentially result in onsite or offsite landslide, lateral spreading, subsidence, liquefaction or collapse?

Grading and construction activities for the T/L facilities would involve road building and pad construction. Such activities could impact slopes and reactivate or initiate landslides or shallower soil failures. For Segment 4, these activities would not impact soil or slope conditions given the low relief and slope gradients of the Project area. Potential impacts to unstable soils or geologic units would be reduced by implementation of APM GEO-2. Access road building and grading in areas of sloping terrain would be evaluated during design level geotechnical and geologic hazard investigations as outlined in APM GEO-2. With application of this APM, potential impacts would be reduced to a less-than-significant level.

Would the Project be located on expansive soil, creating substantial risks to life or property?

Expansive soils are not considered a significant hazard during construction because of the temporary nature of the construction process and no impact is expected.

Would the Project have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?

No impacts are expected. The TRTP would not construct septic tanks, and use of existing septic tanks during construction is not anticipated, as workers would use portable toilets. Waste would be pumped out by qualified contractors and disposed of in accordance with all applicable regulations and codes.

***Operations*.**

Would the Project expose people or structures to adverse effects as a result of rupture of an Alquist-Priolo Earthquake Fault or other substantial known fault?

Segment 4 does not cross any Alquist-Priolo Earthquake Fault Zones or any other substantial faults that represent a fault rupture hazard. These findings would be verified by the design-level studies performed under APM GEO-2. No impacts to Segment 4 related to fault rupture are expected.

Would the Project expose people or structures to adverse effects as a result of seismic ground shaking?

Project structures could be impacted by strong ground motions as a result of a significant earthquake in the area. Standard design and construction practices following appropriate code and industry standards as implemented by APM GEO-1 and GEO-2 would reduce the impacts from ground shaking to a less-than-significant level.

Would the Project expose people or structures to adverse effects as a result of seismic related ground failure including liquefaction.

Seismic-related ground failure could include landslides, liquefaction, lateral spreading, and ground-cracking. The geologic setting of Segment 4 includes very low relief and deep ground water and there is little potential for seismic ground failure. Design-level geotechnical and geologic hazards investigations (APM GEO-2) would be performed to verify this preliminary evaluation. No impacts resulting from seismic related ground failures are expected.

Would the Project expose people or structures to adverse effects as a result of landslides?

No landslides have been mapped along Segment 4 and the geologic setting indicates that landslides are unlikely to occur along the route. Landslides do not represent a significant hazard to the Project for Segment 4. These findings would be verified during design level geotechnical and geologic hazards studies (APM GEO-2). No impacts from landslides are expected.

Would the Project result in substantial soil erosion or the loss of topsoil?

Some soil types along the route are subject to potential moderate or severe erosion. Such areas, if not stabilized, could be subject to increased rates of erosion by wind and/or water. Proper initial design and appropriate construction and maintenance methods would reduce any significant erosion impacts during operation of the Project to less than significant. APM GEO-3 specifies appropriate soil erosion/water quality protection measures to be included in the Construction SWPPP and, thus, impacts related to soil erosion and/or the loss of topsoil would be less than significant.

Would the Project be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the Project and potentially result in onsite or offsite landslide, lateral spreading, subsidence, liquefaction or collapse?

Segment 4 is located entirely with the western portion of the Antelope Valley, characterized by deep groundwater, alluvial soils, and gently sloping to flat-lying terrain. Landslides, liquefaction, and lateral spreading are not significant hazards in this setting and no impacts to Segment 4 are expected from these hazards.

Subsidence is documented within the Antelope Valley and specifically the Lancaster area, east of the Project area. However, the style and magnitude of the surface deformation associated with this zone of subsidence does not pose a significant hazard to Segment 4 and no impact is expected.

Collapsible soils are a potential hazard in the Antelope Valley and, if present within the limits of a Project structure, could pose a significant impact if collapse were to occur. Implementation of APMs GEO-1 and GEO-2 would reduce any potential impacts to a less-than-significant level.

Would the Project be located on expansive soil, creating substantial risks to life or property?

Significant impacts resulting from expansive clays are conceivable in the Project area, but are not considered likely based on the geologic setting. If identified during design level studies, the geotechnical investigation report (APM GEO-2) would provide design recommendations that would be implemented to reduce the impacts of expansive soils to a less-than-significant level.

Would the Project have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?

No impacts are expected. The TRTP would not construct septic tanks, and use of existing septic tanks during construction is not anticipated, as workers would use portable toilets. Waste would be pumped out by qualified contractors and disposed of in accordance with all applicable regulations and codes.

4.7.6.1.3 Mitigation Measures. The aforementioned APMs have been incorporated into the Project design and apply to this segment; therefore, any potentially significant impacts have been avoided or reduced to a less-than-significant level, and no mitigation is required.

4.7.6.1.4 Impact Significance After Mitigation Measures. The potential impacts from geologic hazards and potential impacts to geology and soils associated with construction and operation of Segment 4 are considered to be less than significant.

4.7.6.2 Segment 5

4.7.6.2.1 Environmental Setting. This section describes the existing geologic conditions, geologic hazards and soil conditions in the proposed Project area for Segment 5 of the proposed TRTP.

***Physiographic Setting*.** Segment 5 traverses the southwestern portion of the Mojave Desert physiographic province extending from the central portion of the Antelope Valley into the Transverse Ranges physiographic province. The segment extends from the existing Antelope Substation to the existing Vincent Substation over a distance of approximately 17.8 miles.

From the Antelope Substation the route extends southeasterly across the Antelope Valley, Portal Ridge, the San Andreas Rift Zone (Leona Valley) and into the Sierra Pelona. The route ends at the existing Vincent Substation after crossing Soledad Canyon near Soledad Pass. The terrain varies from the low relief of the Antelope Valley and the gentle sloping fan surfaces adjacent to moderate and high relief along the northeasterly flanks of the Sierra Pelona. Significant drainages crossed by Segment 5 include Amargosa Creek, Anaverde Creek, and Soledad Canyon.

***Geologic Setting*.** The route traverses highly varied geologic conditions associated with the transition from the Mojave Desert to the Transverse Ranges. Table 4.7-5 presents a summary of geologic conditions by milepost for Segment 5 of the Project.

TABLE 4.7-5
GEOLOGIC CONDITIONS – SEGMENT 5[1]

Approximate Milepost	Geologic Unit/Structure	Formation Name	Description/Comments
0.0 – 4.2	Qa	Alluvium	Antelope Substation: Alluvial gravels, sand and silt
4.2 – 4.4	Qoa	Older Alluvium	Sand and gravel fan deposits
4.4 – 4.5	Qa	Alluvium	Railroad Canyon; Unconsolidated alluvial gravels, sand and silt
4.5 – 4.9	gr	Granitic Rocks	Granitic rocks; fractured, variably weathered crystalline rock
4.9	Fault	San Andreas Fault	Branch fault off San Andreas rift zone; fault rupture hazard
4.9 – 6.4	psp, psq	Pelona Schist	Mica schist, out-of-slope dipping foliation; landslide hazard potential
6.4 – 7.6	psp	Pelona Schist	Mica schist, into-slope dipping foliation
7.7	Fault	Un-named	Fault crossing
7.8	Fault	San Andreas Fault zone, Mojave Section	Fault crossing
7.6 – 7.9	Fault Zone, Tas, Qos, Qa	San Andreas Fault, Anaverde Formation, Older and younger Alluvium	Rift zone with slivers of Anaverde Formation (sandstone), and older and younger alluvial deposits; identified liquefaction potential in alluvial deposits; active right-slip fault, significant fault rupture hazard
8	Fault	Nadeau	Concealed fault, existence is uncertain; potential fault rupture hazard as coseismic with movement on San Andreas fault/Fault crossing
7.9 – 8.5	Qls	Landslide	(Qls) Landslide (CGS, SHZR 083 Ritter Ridge)
8.5 – 9.0	Qos, ps	Older Alluvium, Pelona Schist	Mica schist, out-of-slope dipping foliation; landslide hazard potential
9.0 – 12.5	Qa, ps	Alluvium, Pelona Schist	Mica schist, out-of-slope dipping foliation; landslide hazard potential
12.5 – 12.6	gr	Granitic Rocks	Granitic rocks; fractured, variably weathered crystalline rock
12.6 – 12.7	gnb	Gneiss	Banded gneiss
12.7 – 13.3	gr, Qa	Granitic Rocks, Alluvium	Granitic rocks, variable weathering profile
13.3 – 13.5	di	Dioritic Rocks	Mafic granitic rocks; fractured, variably weathered crystalline rock
13.5 – 14.5	sy	Syenite	Granitic rocks, variable weathering profile
13.65	Fault	Unnamed fault	Likely inactive, indefinite location, no significant fault rupture hazard
14.5 – 15.4	Qoa	Older Alluvium	Sand and gravel fan deposits

TABLE 4.7-5 (CONTINUED)
GEOLOGIC CONDITIONS – SEGMENT 5[1]

Approximate Milepost	Geologic Unit/Structure	Formation Name	Description/Comments
15.4 – 15.5	di	Dioritic Rocks	Mafic granitic rocks; fractured, variably weathered crystalline rock
15.5 – 15.6	Qoa	Older Alluvium	Sand and gravel fan deposits
15.6 – 15.7	lgbd	Lowe Granodiorite	Granitic rocks; fractured, variably weathered crystalline rock
15.7 – 16.3	Qoa	Older Alluvium	Sand and gravel fan deposits
16.3 – 17.2	Qa	Alluvium	Soledad Pass: Alluvial sand and clay
17.2 – 17.3	Qoa	Older Alluvium	Sand and gravel fan deposits
17.4 – 17.8	Qoa	Older Alluvium	Vincent Substation: Sand and gravel fan deposits

[1] Sources: State Geologic Maps series (Los Angeles Sheet, 1:250,000 scale) and Dibblee quadrangle maps (Lake Hughes and Del Sur; Sleepy Valley and Ritter Ridge; and Pacifico Mountain and Palmdale [southern half]).

Segment 5 starts near the transition between the recent valley fill deposits that underlie much of the Antelope Valley and the distal alluvial fan deposits that are shed off of the highland area of Portal Ridge. To the south of Portal Ridge the route traverses the Leona Valley and the San Andreas Rift Zone and then traverses obliquely across the northeasterly facing slopes of the Sierra Pelona. The Sierra Pelona is underlain by metamorphic and granitic rock including the Pelona schist, diorite, syenite, mylonite and undifferentiated granitic rocks. The route transitions into moderate terrain underlain by older alluvium and the younger alluvium that underlies the more active drainage portion of Soledad Canyon. Segment 5 ends at the Vincent Substation in an area underlain by older alluvium.

***Geologic Structure*.** Segment 5 traverses the San Andreas fault zone which represents the primary boundary between the Mojave and the Transverse Ranges structural blocks. The bedrock units in the vicinity of the fault are highly deformed metamorphic rocks, primarily Pelona schist. Foliations and flow banding within the metamorphic and granitic rocks are moderate to steeply dipping. The route crosses roughly perpendicular to a series of folds in the foothills of the Sierra Pelona south of the San Andreas fault. Segment 5 crosses secondary faults associated with the San Andreas fault including the Hitchbrook fault and the Nadeau fault, located north and south of the rift zone, respectively.

***Geologic Units*.** Geologic units encountered in the Project area are presented in Table 4.7-5 and are based on the Dibblee quadrangle maps (Lake Hughes and Del Sur, Sleepy Valley and Ritter Ridge, and Pacifico Mountain and Palmdale [southern half]). The geologic units are described briefly below.

***Surficial Deposits*.** A variety of surficial deposits are present along the alignment including recent alluvium, older alluvium, alluvial fan deposits and localized landslide deposits. A landslide is mapped along the route immediately south of the San Andreas fault crossing at approximate S5 MP 7.9 to 8.1 (CGS, 2003d).

***Tertiary Sediments*.** Tertiary-age sedimentary rocks of the Anaverde Formation are found within the San Andreas Rift Zone. Rock types in the Anaverde Formation include shale, sandstone and conglomerate.

***Granitic Rocks*.** Crystalline rocks of granitic origin are crossed by Segment 5 and include granite, diorite and gabbro, and syenite. These rocks crop out in bands that strike northeasterly, parallel to the folds and foliation of the metamorphic rocks.

***Metamorphic Rocks*.** Extensively folded and sheared metamorphic rocks are found in the Sierra Pelona adjacent to the San Andreas fault. Rock types include; schists, gneiss, marble, quartzite and mylonite.

***Geologic Hazards*.**

***Faults and Seismicity*.** Active and potentially active faults have been mapped in the region and documented by a number of government agencies and scientific entities. Numerous published maps and reports have been prepared by the USGS, the CGS, and other State or public agencies (i.e., Caltrans, Southern California Earthquake Center) that present information on fault location and activity. Table 4.7-6 presents a list of active and potentially active faults within approximately 60 miles of Segment 5. Fault characteristics listed in Table 4.7-6 are based on published data.

The Project area is seismically very active given the proximity and number of potential seismic sources. Figure 4.7-2 presents a regional fault and epicenter map showing the approximate location of the TRTP relative to seismic sources and past earthquakes. Notable historic seismic events affecting the Project area are presented in Table 4.7-7.

It is likely that the Project area will experience minor to moderate earthquakes and potentially a major earthquake (moment magnitude M7, or greater) during its service life. A 1995 estimate by the Working Group on California Earthquake Probabilities gave an 80 to 90 percent probability of an M7 or greater earthquake in southern California before 2024.

***Ground Motions*.** Probabilistic seismic hazard estimates based on the USGS/CGS PSHA Model, (CGS, 2002; revised April 2003) depict ground motions associated with a 10 percent probability of exceedance in a 50-year period. For Segment 5 the ground motion

TABLE 4.7-6
SEISMIC SOURCE CHARACTERISTICS – SEGMENT 5

Fault Name	Nearest Distance to Segment 5 (Miles)[1]	Type of Faulting[2]	Fault Length (miles)[2]	Slip Rate[2] (mm/year)	Maximum Magnitude Earthquake[2] (M_{max})
Anacapa-Dume	48	Left lateral oblique	47	3	7.5
Big Pine	62	Left lateral strike-slip	41	0.8	6.9
Clamshell-Sawpit Canyon	22	Reverse	11	0.5	6.5
Cucamonga	39	Thrust	18	5	7
Elsinore, Chino segment	44	Right-lateral strike-slip	112	4	6.8 – 7.1
Garlock	24	Left-lateral strike-slip	155	2 – 11	7.1
Hollywood	25	Left reverse	9	1	6.5
Holser	23	Reverse	12	0.4	6.5
Malibu Coast	43	Reverse	21	0.3	6.7
Newport-Inglewood	37	Right-lateral strike-slip	46	0.6	6.9
North Ridge Blind thrust	18	Blind thrust	31	1.5	7
Oak Ridge	45	Thrust	55	4	6.9
Palos Verdes	45	Right reverse	49	3	7.1
Pleito Thrust	38	Thrust	28	2	6.8
Puente Hills Blind Thrust	18	Blind thrust	25	0.7	7.1
Raymond	24	Left-lateral reverse	16	1.5	6.5
San Andreas – Mojave Segment	0	Right-lateral strike-slip	64	30	7.9
San Andreas – Carrizo Segment	28	Right-lateral strike-slip	90	34	7.9
San Cayetano	30	Thrust	28	6	6.8
San Fernando	20	Thrust	10	2	6.8
San Gabriel	14	Right-lateral strike-slip	87	1	7.2
San Jacinto, Glen Helen segment	40	Right-lateral strike-slip	46	12	6.9
Santa Monica	28	Left reverse	14	1	6.6
Santa Susana	27	Thrust	23	5	6.6
Sierra Madre	19	Reverse	46	2	7.2
Simi (Santa Rosa)	35	Reverse	24	1	6.7

TABLE 4.7-6 (CONTINUED)
SEISMIC SOURCE CHARACTERISTICS – SEGMENT 5

Fault Name	Nearest Distance to Segment 5 (Miles)[1]	Type of Faulting[2]	Fault Length (miles)[2]	Slip Rate[2] (mm/year)	Maximum Magnitude Earthquake[2] (M_{max})
Upper Elysian Park Thrust	19	Blind thrust	18	0.8	6.8
Whittier	33	Right-lateral strike-slip	24	2.5	6.8
White Wolf	43	Left-lateral reverse	37	2	7.2

[1] Fault distances based on Jennings, 1994.

[2] Data based on CGS, 2003; (SCEC)(www.scec.org).

TABLE 4.7-7
SIGNIFICANT HISTORIC EARTHQUAKES – SEGMENT 5

Date	Approximate Distance to Project Segment 5[1] (Miles)	Earthquake Magnitude[2]	Name, Location or Region Affected
December 8, 1812	60	7.5?	Wrightwood Earthquake
July 11, 1855	18	6.0	Los Angeles Region
January 9, 1857	118	Estimated from 7.9 to 8.25	Fort Tejon Earthquake
January 16, 1857	Unknown	6.3	Generally felt in the Los Angeles Region
July 29, 1894	48	6.2	Lytle Creek region
July 21, 1952	46	7.3	Kern County Earthquake
February 9, 1971	18	6.6	San Fernando (Sylmar) Earthquake
October 1, 1987	31	5.9	Whittier Narrows Earthquake
January 17, 1994	27	6.7	Northridge Earthquake

[1] Earthquake magnitudes and locations before 1932 are estimated by Toppozada and others (1978, 1981, and 1982) based on reports of damage and felt effects.

[2] Earthquake information compiled from the Southern California Data Center (SCDC, 2006a and 2006b) and the National Earthquake Information Center (NEIC, 2005) websites. Additional comments on the listed earthquake events were provided previously in the Segment 4 discussion.

estimate for the start of the segment at the Antelope Substation is approximately 0.64g for the PGA and approximately 0.59g at the end point at the Vincent Substation. The highest levels of ground shaking are estimated for the area in proximity to the San Andreas fault, estimated at approximately 0.8g for the 10 percent in 50-year hazard level.

***Fault Rupture*.** There is a significant potential for surface rupture within the Project area given the potential for moderate or large earthquakes on the Mojave segment of the 0.59g at the end point at the Vincent Substation. The highest levels of ground shaking are estimated for the area in proximity to the San Andreas Fault, estimated at approximately 0.8g for the 10 percent in 50-year hazard level. San Andreas fault. The route extends through the State-designated Earthquake Fault Zone between S5 MP 7.4 and MP 8.6. The primary fault rupture hazard appears to be in the central portion of Leona Valley with two active strands of the fault at approximate S5 MP 7.7 and MP 7.8. Mean and maximum values of displacement along the fault as a result of the 1857 event are reported at 15 and 30 feet, respectively (SCEC web site). Other regional surface faulting events that exceed 15 feet of displacement include the 1992 Landers Mw 7.3 earthquake and the 1999 Hector Mine Mw 7.1 event. Based on the orientation of the proposed Segment 5 T/L to the fault, lateral movement of the fault would shift the T/L towers somewhat closer to each other after lateral displacement of the ground surface along the fault.

***Landslides*.** The Segment 5 Project area has been mapped at the quadrangle level by the State hazard mapping program and zones of slope hazard are present along the route and one landslide has been mapped along the southern margin of Leona Valley in proximity to the fault crossing. In general, the hazard zones delineated along the route are of modest extent and represent the upper portions of ridges where slopes are steepest. The route avoids the more significant slope hazard zones located to the west where the slopes underlain by Pelona schist are steeper.

***Liquefaction and Lateral Spreading*.** Liquefaction is not considered a significant potential hazard along the majority of Segment 5 based on the available information. Liquefaction potential does exist in Leona Valley, Anaverde Valley and in the larger drainage crossings along Ritter Ridge and the Sierra Pelona.

***Expansive and Collapsible Soils*.** Some potential for expansive or collapsible materials may be present in the Antelope Valley portion of Segment 5 as discussed in Section 4.7.6.1.1 for Segment 4. In addition, localized zones of expansive soils may be present in the colluvial or residual soils from the bedrock units in the Sierra Pelona. However, the predominate soil types in the route area are sandy loams and loamy sands as described below.

***Subsidence*.** Subsidence has been documented within portions of the Antelope Valley as described in Section 4.7.6.1.1. Segment 5 traverses the southern-most margin of the zone of subsidence and would not likely experience any significant deformation related to subsidence.

A summary of the significant characteristics, including the description, hazard of erosion on roads, and risk of corrosion of the major soil units traversed by Segment 5 is presented in Table 4.7-8; soil units are listed in order of first occurrence along the segment and may occur in multiple locations.

TABLE 4.7-8
SUMMARY OF SOIL UNIT CHARACTERISTICS – SEGMENT 5[1]

Soil Series or Association	Description	Hazard of Erosion on Roads and Trails[2]	Risk of Corrosion	
			Uncoated Steel	Concrete
Terrace escarpments	Rocky talus	Severe	NA	NA
Greenfield	Sandy loam, 2 to 9% slopes	Slight to moderate	Low	Low
Hanford	Coarse sandy loam, Sandy loam; 2 to 15% slopes	Moderate to severe	Low	Low
Vista	Coarse sandy loam, 30 to 50% slopes, some have eroded	Severe	Low	Low
Amargosa	Rocky coarse sandy loam, 9 to 55% slopes, eroded	Severe	Moderate	Low
Godde	Rocky loam, Loam 30 to 50% slopes	Severe	Moderate	Moderate
Wyman	Gravelly loam, Loam, Coarse sandy loam, 2 to 15% slopes	Moderate	Low	Low
Anaverde	Rocky loam, 30 to 50% slopes	Severe	Moderate	Low
Las Posas-Toomes	Rocky loams, 30 to 50% slopes	Severe	High	Low
Ramona	Coarse sandy loam, Sandy loam, 5 to 30% slopes	Moderate to Severe	Moderate	Moderate
Las Posas	Loam, 9 to 30% slopes	Severe	High	Low

[1] Source for soils mapping and characteristics: SSURGO, Antelope Valley Area, California, GIS.

[2] Qualitative descriptors of erosion hazard: Slight = little or no erosion is anticipated, Moderate = some erosion anticipated, Severe = significant erosion potential exists.

<u>Soils</u>. The soils along the proposed Segment 5 T/L route reflect the underlying rock type, the extent of weathering of the rock, the degree of slope, and the degree of modification by humans. Soil data for the Project was obtained from the SSURGO database for Antelope Valley Area, California (Publication Date: January 4, 2007).

4.7.6.2.2 Impact Analysis. The potential impacts to or from geologic, seismic, and soil conditions along the proposed Segment 5 are discussed below. The discussion follows the CEQA Appendix G significance criteria presented in Section 4.7.4.

***Impact Summary*.** Construction, operation, and maintenance of the proposed TRTP Project Segment 5 would not create a significant hazard to the public or the environment relative to geology, soils, or geologic hazard. Segment 5 is located within a designated geologic hazard zone, but implementation of the APMs would limit the potential hazards and impacts to acceptable levels. Segment 5 would be constructed and operated within an existing T/L R-O-W corridor that has successfully operated for many years. Construction of proposed TRTP Segment 5 would not be expected to result in significant geological or soils-related impacts.

***Construction*.** The impact analysis for construction of Segment 5 is based on the significance criteria detailed above in Section 4.7.4. The analysis for Segment 5 is essentially the same as for Segment 4, except Segment 5 is located in an area more prone to earthquakes, soil erosion, loss of topsoil, and unstable conditions. All impacts would be reduced to less-than-significant levels by APMs GEO-1, GEO-2, and GEO-3.

***Operations*.**

Would the Project expose people or structures to adverse effects as a result of rupture of an Alquist-Priolo Earthquake Fault or other substantial known fault?

Segment 5 crosses the Alquist-Priolo Earthquake Fault Zone for the San Andreas fault as described above. There are potentially significant impacts to Segment 5 as a result of fault rupture. For the portion of the T/L across the active fault zone, special alignment and design measures (APMs GEO-1 and GEO-2) would be used to reduce potential impacts from significant fault rupture to less-than-significant levels.

Would the Project expose people or structures to adverse effects as a result of seismic ground shaking?

Project structures could be impacted by strong ground motions as a result of a significant earthquake in the area. Standard design and construction practices following appropriate code and industry standards as implemented by APMs GEO-1 and GEO-2 would mitigate the potential impacts from ground shaking to a less-than-significant level.

Would the Project expose people or structures to adverse effects as a result of seismic related ground failure including liquefaction?

Seismic-related ground failure could include landslides, liquefaction, lateral spreading, and ground-cracking. The geologic setting of Segment 5 includes limited areas of liquefaction potential and areas of moderate and steep terrain that are susceptible to seismically induced landsliding. Impacts resulting from seismic-related ground failures are possible at various locations along the route. With implementation of APMs GEO-1 and GEO-2, potentially significant impacts would be reduced to less-than-significant levels.

Would the Project expose people or structures to adverse effects as a result of landslides?

Landslides have been mapped along Segment 5 and the geologic setting indicates that landslides could occur in the steeper terrain along the route. Design-level geotechnical and geologic hazards investigations would be performed (APM GEO-2). With implementation of APMs GEO-1 and GEO-2, potentially significant impacts would be reduced to less-than-significant levels.

Would the Project result in substantial soil erosion or the loss of topsoil?

Some soil types along Segment 5 are potentially subject to moderate or severe erosion on roads and/or other disturbance areas. Such areas, if not stabilized, could be subject to increased rates of erosion by wind and/or water. Without preventative measures, soil erosion could constitute a significant impact. Proper initial design and appropriate construction and maintenance methods would reduce any potentially significant erosion impacts during operation of the Project to less than significant. APM GEO-3 calls for the appropriate soil erosion/water quality protection measures to be specified in the Construction SWPPP. With implementation of APM GEO-3 potentially significant impacts would be reduced to less-than-significant levels.

Would the Project be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the Project and potentially result in onsite or offsite landslide, lateral spreading, subsidence, liquefaction or collapse?

Segment 5 traverses varied geologic conditions between the Antelope Valley and the Transverse Ranges. Landslides, liquefaction, and lateral spreading are potentially significant hazards and require avoidance and minimization measures.

Subsidence and collapsible soils are potential hazards in the Antelope Valley as described above for Segment 4. However, as discusses in Section 4.7.6.1.2, these hazards would not result in significant impacts for Segment 5 following characterization and appropriate measures to avoid and reduce the potential hazards, (APM GEO-2).

With implementation of APMs GEO-1 and GEO-2, potentially significant impacts resulting from unstable geologic or soil conditions would be reduced to less-than-significant levels.

Would the Project be located on expansive soil, creating substantial risks to life or property?

Extensive areas of expansive soils are not anticipated in the generally granular soil conditions encountered in the Segment 5 portion of the Project area. However, localized areas of expansive clays could be encountered. Significant impacts resulting from expansive clays are conceivable in the Project area, but are not considered likely based on the geologic setting. With implementation of APM GEO-2), potential impacts associated with expansive soils would be reduced to less-than-significant levels.

Would the Project have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?

No impacts are expected. The TRTP would not construct septic tanks, and use of existing septic tanks during construction is not anticipated, as workers would use portable toilets. Waste would be pumped out by qualified contractors and disposed of in accordance with all applicable regulations and codes.

4.7.6.2.3 Mitigation Measures. The aforementioned APMs have been incorporated into the Project design and apply to this segment; therefore, any potentially significant impacts have been avoided or reduced to a less-than-significant level, and no mitigation is required.

4.7.6.2.4 Impact Significance After Mitigation Measures. The potential impacts from geologic hazards and potential impacts to geology and soils associated with construction and operation of Segment 5 are considered to be less than significant.

4.7.6.3 Segment 6

4.7.6.3.1 Environmental Setting. This section describes the existing geologic conditions, geologic hazards and soil conditions in the proposed Project area for Segment 6 of the proposed TRTP.

***Physiographic Setting*.** Segment 6 extends across the Transverse Ranges from the northern side near Soledad Pass to an end point near the southern range front. This area is characterized by mountainous terrain of the San Gabriel Mountains and lies with the Angeles National Forest (ANF). Elevations range from approximately 3,200 feet msl at the Vincent Substation to nearly 5,000 feet near Rabbit Peak and approximately 4,800 feet msl along the Flanks of Monrovia Peak. Segment 6 ends approximately 1 mile from the southern base of the mountains at an elevation of approximately 2,200 feet msl.

The route crosses numerous drainages and canyons including Kentucky Springs Canyon, Aliso Canyon, Mill Creek, Monte Cristo Creek, Lynx Gulch, Upper Big Tujunga Canyon, Shortcut Canyon, and the West Fork of the San Gabriel River. The route crosses the West Fork of the San Gabriel River approximately 3.5 miles upstream from Cogswell Dam.

***Geologic Setting*.** The route traverses mountainous terrain underlain by crystalline bedrock units with alluvial cover in the intervening valleys and drainages. Bedrock units include various plutonic and metamorphic rocks exposed in the core of the uplifted San Gabriel Mountains. These rocks are generally of Mesozoic age and older. A summary of geologic conditions along the route is presented in Table 4.7-9.

The active tectonic forces of the region have resulted in continued uplift of the San Gabriel Mountains. This geologically rapid uplift rate results in high rates of erosion within the range and along the steep range front. Deeply incised gorges and canyons mark the southern range front.

***Geologic Structure*.** The structural geology of the region is dominated by the compressional tectonic setting (north-south shortening) of the Transverse Ranges that results from the large bend in the San Andreas fault zone to the east. The active compressional environment of the Transverse Ranges has resulted in significant uplift, tilting, folding and faulting. As a result, the Transverse Ranges are cut by numerous active east-west trending faults that help accommodate the compression or shortening that is taking place. These faults are mainly thrust or thrust-oblique type and result in older geologic units being thrust up and over younger units. The Sierra Madre fault is a dramatic example of thrust faulting located approximately 1 mile south of the southern end of Segment 6. A lesser branch of the Sierra Madre fault zone, the Clamshell-Sawpit fault, is crossed at approximately S6 MP 26.5.

***Geologic Units*.** Geologic units encountered in the Project area for Segment 6 are presented in Table 4.7-9 and are based on the Dibblee map sheets listed in the notes for the table. The geologic units are described briefly below.

***Surficial Deposits*.** Quaternary alluvial deposits consisting primarily of sandy to gravelly channel deposits are present locally throughout the Project area. In addition, landslide deposits are common in the steeper terrain of the San Gabriel Mountains and have been mapped in and adjacent to the route based on a review of the Dibblee quadrangle maps and the CGS seismic hazard mapping program.

***Ancient Alluvial Fan*.** Pleistocene-age deposits of older alluvial fans are present throughout the length of Segment 6. Slightly cemented silty gravelly sands are typical materials encountered within these older fan deposits.

TABLE 4.7-9
GEOLOGIC CONDITIONS – SEGMENT 6[1]

Approximate Milepost	Geologic Unit/Structure	Formation Name	Description/Comments
0.0 – 0.1	Qoa	Older Alluvium	Sand and gravel fan deposits
0.1 – 0.2	Qg, Qa	Alluvium	Stream channel deposits of gravel, sand and silt
0.2 – 0.3	Qoa	Older Alluvium	Sand and gravel fan deposits
0.3 – 0.4	Hdg, Qoa	Hornblende Diorite Gabbro (Hdg), Older Alluvium (Qoa)	(Hdg) Mafic plutonic and gneissic rock, dark gray to nearly black, hard, but fractured, massive to slightly gneissoid/(Qoa) sand and gravel fan deposits
0.4 – 0.7	Qoa	Older Alluvium (Qoa)	Sand and gravel fan deposits.
0.7 – 0.9	Hdg	Hornblende Diorite Gabbro (Hdg)	Mafic plutonic and gneissic rock, dark gray to nearly black; hard, but fractured, massive to slightly gneissoid
0.9 – 1.5	Qoa	Older Alluvium	Sand and gravel fan deposits
1.5 – 2.1	Hdg, Qoa	Hornblende Diorite Gabbro (Hdg), Older Alluvium (Qoa)	(Hdg) Mafic plutonic and gneissic rock, dark gray to nearly black; hard, but fractured, massive to slightly gneissoid/(Qoa) sand and gravel fan deposits
2.1 – 2.5	Qg	Alluvium Fan	Stream channel deposits of gravel, sand and silt
2.5 – 3.2	Qoa	Older Alluvium	Sand and gravel fan deposits
3.3 – 4.2	Igd	Lowe Granodiorite	Plutonic igneous rock; undivided, leucocratic (nearly white), hard but much fractured
4.2 – 4.6	Idg, Qoa	Older Alluvium (Qoa), Lowe Granodiorite (Igd)	(Qoa) Sand and gravel fan deposits/(Igd) plutonic igneous rock; undivided, hard but much fractured
4.6 – 5.2	Igd	Lowe Granodiorite	Plutonic igneous rock; undivided, hard but much fractured
5.2 – 5.3	Qoa	Older Alluvium	Sand and gravel fan deposits
5.3 – 5.8	Idg	Lowe Granodiorite	Plutonic igneous rock; undivided, leucocratic (nearly white), hard but much fractured
5.8 – 5.9	Qoa	Older Alluvium	Sand and gravel fan deposits
5.9 – 6.4	Igd, Qoa, Qg	Older Alluvium (Qoa), Alluvium Fan (Qg), Lowe Granodiorite (Igd)	(Qoa) Sand and gravel fan deposits/(Qg) stream channel deposits of gravel, sand and silt/(Igd) plutonic igneous rock; hard but much fractured
6.4 – 6.5	Qoa	Older Alluvium	Sand and gravel fan deposits
6.5 – 6.7	Qg	Alluvium Fan	Stream channel deposits of gravel, sand and silt.
6.7 – 7.0	Igd	Lowe Granodiorite	Plutonic igneous rock; undivided, hard but much fractured
7.0 – 7.4	Igdp	Lowe Granodiorite	Plutonic igneous rock, grey
7.4 – 8.0	Qls	Landslide	(Qls) Landslide (Dibblee)
8.0 – 8.6	Igdp	Lowe Granodiorite	Plutonic igneous rock, grey

TABLE 4.7-9 (CONTINUED)
GEOLOGIC CONDITIONS – SEGMENT 6

Approximate Milepost	Geologic Unit/Structure	Formation Name	Description/Comments
8.6 – 8.7	Qoa	Older Alluvium	Sand and gravel fan deposits
8.7- 8.8	lgdh	Lowe Granodiorite	Plutonic Igneous rock, light gray
8.8 – 9.0	gn	Gneissic Rock	Gneissic rock metamorphosed from sedimentary or igneous protoliths
9.1 – 9.5	an, agb	Anorthosite Gabbro complex	Plutonic complex of plagioclase feldspar enriched rock; Light steel gray, but weathered white
9.5 – 9.8	hgb, Qls	(Qls), (hgb) Anorthosite Gabbro complex	(Qls) Landslide (Dibblee)/(hgb) plutonic complex; Light steel gray, but weathered white
9.8 – 12.2	hgb, an, agn, gba	Anorthosite Gabbro complex	Plutonic complex; light steel gray, but weathered white
12.2 – 13.0	gn	Gneissic Rock	Gneissic rock metamorphosed from sedimentary or igneous protoliths
13.0 – 13.4	lgdh	Lowe Granodiorite	Plutonic igneous rock, light gray
13.4 – 13.5	Qoa, Qg	Older Alluvium (Qoa), Alluvium Fan (Qg)	Sand and gravel fan deposits
13.5 – 15.6	lgdp	Lowe Granodiorite	Plutonic igneous rock, grey
15.6 – 15.7	Qoa, Qg	Older Alluvium (Qoa), Alluvium Fan (Qg)	Sand and gravel fan deposits
15.7 – 16.0	Qoa	Older Alluvium	Sand and gravel fan deposits
16.0 – 16.5	gr	Granitic Rocks	Plutonic rock, white to tan, hard, coherent but severely fractured
16.5 – 18.7	gn	Gneissic Rock	Gneissic rock metamorphosed from sedimentary or igneous protoliths
18.7 – 18.8	Qoa, Qg	Older Alluvium (Qoa), Alluvium Fan (Qg)	Sand and gravel fan deposits; stream channel deposits of gravel, sand and silt
18.8	Fault	North Branch of the San Gabriel Fault	Fault crossing
18.8 – 19.0	qd	Quartz Diorite	Plutonic Rock, light to medium gray
19.0 – 19.1	gn, qd	Gneissic Rock (gn), Quartz Diorite (qd)	Gneissic rock metamorphosed from sedimentary or igneous protoliths (gn)/plutonic rock, light to medium gray(qd)
19.1 – 19.3	gr	Granitic Rocks	Plutonic Rock, white to tan, hard, coherent but severely fractured
19.3 – 19.5	Qls	Landslide Complex	(Qls) Landslide (CGS, OFR 98-28)

TABLE 4.7-9 (CONTINUED)
GEOLOGIC CONDITIONS – SEGMENT 6

Approximate Milepost	Geologic Unit/Structure	Formation Name	Description/Comments
19.5 -19.6	gr	Granitic Rocks	Plutonic rock, white to tan, hard, coherent but severely fractured
19.6 – 19.8	Qls	Landslide Complex	(Qls) Landslide (CGS, OFR 98-28)
19.8 – 20.0	gr	Granitic Rocks	Plutonic rock, white to tan, hard, coherent but severely fractured
20.0 – 20.1	Qls	Landslide	(Qls) Landslide (Dibblee)
20.1 – 20.3	gr	Granitic Rocks	Plutonic rock, white to tan, hard, coherent but severely fractured
20.3 – 20.5	Qls	Landslide, Complex	(Qls) Landslide (Dibblee and CGS, OFR 98-12)
20.5 – 21.3	gr	Granitic Rocks	Plutonic rock, white to tan, hard, coherent but severely fractured
21.3 – 21.5	Qls	Landslide	(Qls) Landslide (CGS, OFR 98-12)
21.5 – 22.2	gr	Granitic Rocks	Plutonic rock, white to tan, hard, coherent but severely fractured
22.2 – 22.5	qd	Quartz Diorite	Plutonic rock, light to medium gray
22.5 – 23.5	Qls	Landslide, Complex	(Qls) Landslide (CGS, OFR 98-12)
23.5 – 23.3	gr	Granitic Rocks	Plutonic rock, white to tan, hard, coherent but severely fractured
23.3 – 24.2	qd	Quartz Diorite	Plutonic rock; gray, incoherent where weathered
24.2 – 24.5	gn	Gneissic Rock	Gneissic rock metamorphosed from sedimentary or igneous protoliths
24.5	Fault	Saw Pit Fault	Fault crossing
24.5 – 24.9	qd	Quartz Diorite	Plutonic rock; gray, incoherent where weathered
24.9 – 25.0	Qls	Landslide	(Qls) Landslide (CGS, OFR 98-12)
25.0 – 25.2	qd	Quartz Diorite	Plutonic rock; gray, incoherent where weathered
25.2 – 25.4	gn	Gneissic Rock	Gneissic rock metamorphosed from sedimentary or igneous protoliths
25.4 – 25.6	Qls	Landslide	(Qls) Landslide (CGS, OFR 98-12)
25.6 – 25.8	gn, gr	Gneissic Rock (gn), Granitic Rocks (gr)	Gneissic rock metamorphosed from sedimentary or igneous protoliths (gn)/plutonic rock, white to tan, hard (gr)
25.8 – 25.9	Qls	Landslide Complex	(Qls) Landslide (CGS, OFR 98-12)
25.9 – 26.7	gn	Gneissic Rock	Gneissic rock metamorphosed from sedimentary or igneous protoliths

TABLE 4.7-9 (CONTINUED)
GEOLOGIC CONDITIONS – SEGMENT 6

Approximate Milepost	Geologic Unit/Structure	Formation Name	Description/Comments
26.7 – 26.9	Qls	Landslide	(Qls) Landslide (Dibblee)

[1] Source: Dibblee map series (Pacifico Mountain and Palmdale Quads [southern half]; Chilao Flats Quad, Mt. Wilson and Azusa Quads, and CGS hazard mapping series (Ritter Ridge, SHZR 083; Pacifico Mtn. SHZR 104; Azusa, OFR 98-12; Mt. Wilson, OFR 98-21).

***Granitic Rocks*.** Crystalline rocks of varying granitic composition are encountered in Segment 6 and represent the dominate rock types. Rock types include quartz diorite, granodiorite, diorite, gabbro and anorthosite. Rocks are commonly foliated.

***Geologic Hazards*.**

***Faults and Seismicity*.** Active and potentially active faults have been mapped in the region and documented by a number of government agencies and scientific entities. Numerous published maps and reports have been prepared by the USGS, CGS, and other State or public agencies (i.e., Caltrans, SCEC) that present information on fault location and activity. Table 4.7-10 presents a list of active and potentially active faults within approximately 60 miles of Segment 6. Fault characteristics listed in Table 4.7-10 are based on published data.

The Project area is seismically very active given the proximity and number of potential seismic sources. Figure 4.7-2 presents a regional fault and epicenter map showing the approximate location of the TRTP relative to seismic sources and past earthquakes. Notable historic seismic events affecting the Project area are presented in Table 4.7-11.

It is likely that the Project area would experience minor and moderate earthquakes and potentially a major earthquake (moment magnitude M7, or greater) during its service life. A 1995 estimate by the Working Group on California Earthquake Probabilities gave an 80 to 90 percent probability of an M7 or greater earthquake in southern California before 2024.

***Fault Rupture/Fault Displacement*.** Segment 6 crosses the San Gabriel fault and the Clamshell-Sawpit fault, both with Quaternary activity. The Clamshell-Sawpit fault is thought to be the causative fault for the 1991 M 5.9 Sierra Madre earthquake. There was no report of surface rupture during this earthquake because of the moderate size and deep focus of the event. The Clamshell-Sawpit fault is not zoned by the State as an Earthquake Fault Zone.

TABLE 4.7-10
SEISMIC SOURCE CHARACTERISTICS – SEGMENT 6

Fault Name	Nearest Distance to Segment 6 (Miles)[1]	Type of Faulting[2]	Fault Length (Miles)[2]	Slip Rate[2] (mm/year)	Maximum Magnitude Earthquake[2] (M_{max})
Anacapa-Dume	48	Left lateral oblique	75	3	7.5
Big Pine	41	Left lateral strike-slip	41	0.8	6.9
Clamshell-Sawpit Canyon	0	Reverse	11	0.5	6.5
Cucamonga	15	Thrust	18	5	7
Elsinore, Chino segment	16	Right-lateral strike-slip	13	4	6.5
Garlock	44	Left-lateral strike-slip	155	2 – 11	7.1
Hollywood	17	Left reverse	9	1	6.5
Holser	32	Reverse	12	0.4	6.5
Malibu Coast	40	Reverse	21	0.3	6.7
Newport-Inglewood	22	Right-lateral strike-slip	46	0.6	6.9
North Ridge Blind Thrust	18	Blind thrust	31	1.5	7
Oak Ridge	49	Thrust	55	4	6.9
Palos Verdes	18	Right reverse	49	3	7.1
Pleito Thrust	56	Thrust	28	2	6.8
Puente Hills Blind Thrust	5	Blind thrust	25	0.7	7.1
Raymond	3	Left-lateral reverse	16	1.5	6.5
San Andreas – Mojave Segment	4	Right-lateral strike-slip	64	30	7.9
San Andreas – Carrizo Segment	41	Right-lateral strike-slip	90	34	7.9
San Cayetano	38	Thrust	28	6	6.8
San Fernando	13	Thrust	10	2	6.8
San Gabriel	0	Right-lateral strike-slip	87	1	7.2
San Jacinto, Glen Helen segment	0	Right-lateral strike-slip	46	12	6.9
Santa Monica	22	Left reverse	14	1	6.6
Santa Susana	28	Thrust	23	5	6.6
Sierra Madre	0	Reverse	46	2	7.2
Simi (Santa Rosa)	43	Reverse	24	1	6.7
Upper Elysian Park Thrust	10	Blind thrust	18	0.8	6.8
Whittier	17	Right-lateral strike-slip	24	2.5	6.8
White Wolf	65	Left-lateral reverse	37	2	7.2

[1] Fault distances based on Jennings, 1994.

[2] Source: CGS, 2003; SCEC (www.scec.org).

TABLE 4.7-11
SIGNIFICANT HISTORIC EARTHQUAKES – SEGMENT 6

Date	Approximate Distance to Project Segment 6[1] (Miles)	Earthquake Magnitude[2]	Name, Location or Region Affected
December 8, 1812	44	7.5?	Wrightwood Earthquake
July 11, 1855	28	6.0	Los Angeles Region
January 9, 1857	133	Estimated from 7.9 to 8.25	Fort Tejon Earthquake
January 16, 1857	Unknown	6.3	Generally felt in the Los Angeles Region
July 29, 1894	34	6.2	Lytle Creek region
July 21, 1952	62	7.3	Kern County Earthquake
February 9, 1971	10	6.6	San Fernando (Sylmar) Earthquake
October 1, 1987	11	5.9	Whittier Narrows Earthquake
January 17, 1994	19	6.7	Northridge Earthquake

[1] Earthquake magnitudes and locations before 1932 are estimated by Toppozada and others (1978, 1981, and 1982) based on reports of damage and felt effects.

[2] Earthquake damage information compiled from the Southern California Earthquake Data Center (SCEDC, 2006a and 2006b) and National Earthquake Information Center (NEIC, 2005) websites. Additional comments on the earthquakes are provided in the Segment 4 discussion.

The San Gabriel Fault is a complex structure that extends east-west across the Transverse Ranges. Slip rate and recurrence interval are thought to vary significantly along the length of the fault (SCEC, 2007). It is considered active along its western extent in the Santa Clarita area but activity is reduced to the east. The fault is zoned by the State as an Earthquake Fault Zone, but only at the western end in the Saugus to Santa Clarita area. Some evidence suggests that the fault may not be active in the San Gabriel Mountains (SCEC, 2007).

Other faults crossed by the route include the inactive Lonetree fault and the Mill Creek fault as mapped and named by Dibblee (Pacifico Mountain and Palmdale Quads, Chilao Flat Quad, respectively). Both of these fault names are potentially confusing since active faults with the same names are present in other areas of southern California.

The Segment 6 route does not cross any Earthquake Fault Zones, however, the Clamshell-Sawpit fault and the San Gabriel fault may represent some level of fault rupture hazard. Design level studies should address the potential for fault rupture on these faults.

***Landslides*.** A significant portion of the Segment 6 Project area has been mapped at the quadrangle level by the State seismic hazard mapping program. A number of ancient landslides are present along and immediately adjacent to the route based on this mapping. Much of the terrain that the route crosses is included in hazard zones for earthquake-induced slope failure. This is because of the frequency of existing landslides, the steep terrain, the fractured and weathered geologic units, and the proximity of significant seismic sources, including the San Andreas, Puente Hills blind thrust and Sierra Madre fault zones.

***Liquefaction and Lateral Spreading*.** Minor occurrences of liquefaction susceptible materials are present within the recent alluvial deposits along Segment 6. The presence of these materials leads to a potential liquefaction hazard in primarily two locations along the route. The most potentially significant liquefaction hazard exists along Segment 6 in Kentucky Springs Canyon (S6 MP 0.1 to 0.2 and S6 MP 2.2 to 2.4), Aliso Canyon (S6 MP 6.5 to 6.6), and the San Gabriel River (S6 MP 18.8).

***Ground Motions*.** USGS/CGS PSHA models, (CGS, 2002, revised April 2003) depict ground motions associated with a 10 percent probability of exceedance in a 50 year period. For Segment 6 the ground motion estimate for the start of the segment at SCE’s Vincent Substation is about 0.59g and at the end it is about 0.6g.

***Expansive and Collapsible Soils*.** Some potential for expansive materials may be present in the soils formed on the crystalline rock in the Transverse Ranges. However, based on the soil survey data, fine-grained soils are not a major constituent in the surface layers of the primary soil units mapped in the region. Expansive soils are not anticipated to be a significant hazard relative to T/L foundation design.

Collapsible soils are not anticipated in the mountainous setting of the Transverse Ranges.

***Subsidence*.** Subsidence is a phenomenon associated with deep alluvial basins and is not a potential hazard in the Transverse Ranges.

***Soils*.** The soils along the proposed T/L route reflect the underlying rock type, the extent of weathering of the rock, the degree of slope, and the degree of modification by man. Soil data for the Project was obtained from the SSURGO database for the ANF Area, California (Publication Date: December 14, 2006).

A summary of the significant characteristics, including the description, hazard of erosion on roads and trails, and risk of corrosion of the major soil units traversed by Segment 6, is presented in Table 4.7-12; soil units are listed in order of first occurrence along the segment and may occur in multiple locations.

TABLE 4.7-12
SUMMARY OF SOIL UNIT CHARACTERISTICS – SEGMENT 6[1]

Soil Series or Association	Description	Hazard of Erosion on Roads and Trails[2]	Risk of Corrosion	
			Uncoated Steel	Concrete
Hanford	Sandy loam, Coarse sandy loam, 2 to 15% slopes	Moderate to severe	Low	Low
Terrace Escarpments	Rocky talus	Severe	NA	NA
Vista	Course sandy loam, 30 to 50% slopes	Severe	Low	Low
Greenfield	Sandy loam, 2 to 9% slopes	Slight to moderate	Low	Low
Hanford Family	3 to 25% slopes	Severe	NA	NA
Pismo-Trigo-Excheqer families complex	30 to 70% slopes	Severe	NA	NA
Tujunga Capistrano Families association	2 to 20% slopes	Moderate	NA	NA
Pacifico family Xerothents complex	50 to 90% slopes	Severe	NA	NA
Pacifico Preston families complex	15 to 50% slopes	Severe	NA	NA
Olete Kilburn-Etsel families complex	50 to 80% slopes	Severe	NA	NA
Chilao families	20 to 60% slopes	Severe	NA	NA
Vista Family	5 to 30% slopes	Severe	NA	NA
Pismo Chilao-Shortcut families complex	45 to 80% slopes	Severe	NA	NA
Trigo Modjeska families association	Granitic substratum, 5 to 60% slopes	Severe	NA	NA
Trigo Exchequer families-Rock outcrop complex	Granitic substratum, 60 to 100% slopes	Severe	NA	NA
Green Bluff Hohmann families-Xerothents complex	15 to 60% slopes	Severe	NA	NA
Caperton-Trigo-Lodo families complex	Granitic substratum, 50 to 85% slopes	Severe	NA	NA
Stukel Sur-Winthrop families complex	60 to 100% slopes	Severe	NA	NA
Typic Xerorthents warm	55 to 90% slopes	Severe	NA	NA
Stukel Olete families association,	50 to 100% slopes	Severe	NA	NA

TABLE 4.7-12 (CONTINUED)
SUMMARY OF SOIL UNIT CHARACTERISTICS – SEGMENT 6[1]

Soil Series or Association	Description	Hazard of Erosion on Roads and Trails[2]	Risk of Corrosion	
			Uncoated Steel	Concrete
Vista-Trigo -Modesto families complex	Granitic Substratum, 40 to 70% slopes	Severe	NA	NA

[1] Source for soils mapping and characteristics: SSURGO, ANF Area, California, GIS.

[2] Qualitative descriptors of erosion hazard: Slight = little or no erosion is anticipated, Moderate = some erosion anticipated, Severe = significant erosion hazard.

4.7.6.3.2 Impact Analysis. The potential impacts to or from geologic, seismic, and soil conditions along the proposed Segment 6 are discussed below. The discussion follows the significance criteria presented in Section 4.7.4.

Impact Summary**.** Construction and operation of the proposed TRTP Project Segment 6 would be subject to a significant hazard relative to geology, soils, or geologic hazard. Extensive portions of the proposed Project element are located within designated geologic hazard zones based on a review of State hazard mapping program and published geologic mapping. The proposed Project could be subject to moderate or high levels of ground shaking in the event of an earthquake on faults in the region. Impacts to soils would occur during construction with increased traffic and grading associated with pads and roads for T/L construction and substation construction and/or expansion. APMs would reduce impacts to less than significant levels.

Construction**.** The impact analysis for construction of Segment 6 is based on the significance criteria detailed above in Section 4.7.4 and the results of the analysis for Segment 6 are essentially the same as Segment 4. See Section 4.7.6.3.1 for the discussion of construction impacts.

Operations**.**

Would the Project expose people or structures to adverse effects as a result of rupture of an Alquist-Priolo Earthquake Fault or other substantial known fault?

Segment 6 does not cross any Alquist-Priolo Earthquake Fault Zones but it does cross two faults that may represent a fault rupture hazard. The San Gabriel fault and the Clamshell-Sawpit fault are both faults with some level of recent seismic activity or evidence for active faulting somewhere along their trace. These types of faults should be evaluated during design level studies. Without proper design there could be significant impacts to Segment 6 as a result of fault rupture. APMs GEO-1 and GEO-2 would reduce this potential impact to a less-than-significant level.

Would the Project expose people or structures to adverse effects as a result of seismic ground shaking?

Project structures could be impacted by strong ground motions as a result of a significant earthquake in the area as described above. Such moderate to strong levels of ground shaking could damage Project structures if they were not properly designed. Without proper design, ground shaking would present a significant hazard to Segment 6. Standard design and construction practices following appropriate code and industry standards (APM GEO-1) would reduce impacts from ground shaking to a less-than-significant level.

Would the Project expose people or structures to adverse effects as a result of seismic related ground failure including liquefaction?

Seismic-related ground failure could include, liquefaction, lateral spreading, and ground-cracking. The geologic setting of Segment 6 includes very mountainous relief with intervening valleys. This setting contains some minor zones of possible liquefaction. Impacts resulting from seismic related ground failures could be significant for Segment 6. Design level geotechnical and geologic hazards investigations would be performed to fully characterize the hazards and provide recommendations (APM GEO-2). Implementation of APMs GEO-1 and GEO-2 would reduce any potential impacts to a less-than-significant level.

Would the Project expose people or structures to adverse effects as a result of landslides?

Numerous landslides have been mapped along the Segment 6 T/L route (some landslides based on the Dibblee quad maps and more mapped landslides based on the State SHZR map series). Significant zones of seismic induced slope failure hazard have been delineated by the State hazard mapping program, as follows.

Seismically induced slope failures include landslides, earth flows, soil slips and debris-flows. In the event of a large magnitude earthquake (moment magnitude 7.0 or greater) on the San Andreas fault, Sierra Madre thrust fault or Puente Hills blind thrust, seismically induced slope failures within the steep mountainous terrain of the San Gabriel Mountains cannot be precluded. These fault zones are thought capable of producing earthquakes approaching magnitude Mw 7.5 and ground motions could exceed 1 g during such an event (Field, et al, 2005). Seismically induced slope instability has the potential to undermine foundations, cause distortion and distress to overlying structures, and displace or destroy Project components. Damage to, or failure of, the proposed T/L segment could result in temporary electrical transmission outages.

The recurrence interval for large earthquakes on these faults is estimated to range from 2,000 to 3,000 years for the Puente Hills blind thrust (Dolan, J.F. et al, 2003) to perhaps greater than 6,000 to 8,000 years for the Sierra Madre fault (Rubin, C.M. et al., 1998; Tucker, A.Z. et al., 2001). The earthquake recurrence intervals for these faults exceed the design life of the proposed TRTP and are therefore considered unlikely to result in catastrophic failure of Project components.

Smaller seismically induced slope instability could damage Project components and could thus potentially result in temporary outages along the affected T/L. As required by the North American Electric Reliability Corporation, the Western Electricity Coordinating Council, and the California Independent System Operators, the regional transmission system is designed to provide transmission reliability. Should a T/L not be operational as a result of an accident, seismic event, or fire, or is taken out of service to permit safe maintenance, redundancy in the transmission system allows electrical transmission with no or only brief service interruptions to load areas. Temporary outages along the proposed T/L segment as a result of seismically induced slope instability would be avoided or minimized because of the redundancy incorporated into the transmission system and, therefore, the potential impacts are less than significant.

A design-level geotechnical survey (APM GEO-2) would be performed to evaluate the potential for unstable slopes, landslides, earth flows, soil slips and debris flows along the proposed segment. Overhead T/L structures may be placed to avoid and span slide areas. To the extent feasible, facilities would be located away from very steep hillsides, debris-flow source areas, the mouths of steep side-hill drainages, and the mouths of canyons that drain steep terrain. In cases of shallow sliding, slope creep, or raveling, specially designed deep foundations may be used to anchor the overlying structure to underlying, competent material. As appropriate, stabilization of unstable slopes would be performed by excavating and removing unstable material, regrading unstable slopes to improve surface drainage and limit infiltration, installing subsurface drainage systems, and/or constructing retaining structures to mechanically restrain slope movement.

With implementation of APM GEO-1 and APM GEO-2, potential impacts to the proposed T/L and subsequent outages resulting from seismically induced slope instability would be less than significant.

Would the Project result in substantial soil erosion or the loss of topsoil?

Some soil types along the route are subject to moderate or severe erosion on roads and trails. Such areas, if not stabilized, could be subject to increased rates of erosion by wind and/or water that could result in a significant impact. Proper initial design (APM GEO-2) and appropriate construction and maintenance methods would reduce significant erosion impacts during operation of the Project to less than significant. APM GEO-3 calls for appropriate soil erosion/water quality protection measures as specified in the Construction SWPPP.

Is the Project located on a geologic unit or soil that is unstable, or that would become unstable as a result of the Project and potentially result in onsite or offsite landslide, lateral spreading, subsidence, liquefaction or collapse?

Segment 6 could be impacted by unstable geologic units and soil conditions that include landslide prone areas, existing landslides, and relatively minor areas of liquefaction potential. These unstable geologic units and soils could impact the Project to varying degrees.

Collapsible soils are not a potential hazard in the Transverse Ranges and pose no potential impact to the Project. Hazards that may exist would be recognized and evaluated during site specific geotechnical investigations (APM GEO-2). Implementation of APMs GEO-1 and GEO-2 would reduce any potential impacts to less than significant.

Is the Project located on expansive soil, creating substantial risks to life or property?

Extensive areas of expansive soils are not anticipated in the generally granular soil conditions encountered in the Segment 6 portion of the Project area. However, localized areas of expansive clays could be encountered. Significant impacts resulting from expansive clays are conceivable in the Project area, but are not considered likely based on the geologic setting. If identified during design level studies, the geotechnical study (APM GEO-2) recommendations would be implemented to reduce the impacts of expansive soils to a less-than-significant level.

Would the Project have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?

No impacts are expected. The TRTP would not construct septic tanks, and use of existing septic tanks during construction is not anticipated, as workers would use portable toilets. Waste would be pumped out by qualified contractors and disposed of in accordance with all applicable regulations and codes.

4.7.6.3.3 Mitigation Measures. The aforementioned APMs have been incorporated into the Project design and apply to this segment; therefore, any potentially significant impacts have been avoided or reduced to a less-than-significant level, and no mitigation is required.

4.7.6.3.4 Impact Significance After Mitigation Measures. The potential impacts from geologic hazards and potential impacts to geology and soils associated with construction and operation of Segment 6 are considered to be less than significant.

4.7.6.4 Segment 7

4.7.6.4.1 Environmental Setting. This section describes the existing geologic conditions, geologic hazards and soil conditions in the proposed Project area for Segment 7 of the proposed TRTP.

***Physiographic Setting*.** Segment 7 extends from the Transverse Ranges physiographic province and into the Los Angeles Basin, a subprovince of the Peninsular Ranges physiographic province. The boundary between these distinct regions is the base of the San Gabriel Mountains. The Transverse Ranges are characterized by mountainous terrain of the San Gabriel Mountains and lie largely within the ANF. Segment 7 begins at the southern boundary of the ANF along the southerly sloping range front approximately 1 mile from the toe of the mountains and the valley floor. The valley floor marks the start of the L.A. Basin geomorphic subprovince. Segment 7 starts at an elevation approximately 1,600 feet above the base of the valley and extends south to southwesterly into the basin along the margins and across the channelized San Gabriel River. The T/L route turns westward across the Whittier Narrows Flood Control Basin and into the Montebello Hills and ends at SCE's Mesa Substation. The Montebello Hills are one of a series of low, east-west trending hills in the Basin that include the Whittier Hills and the Puente Hills to the east. The Santa Fe Flood Control Basin is also crossed.

***Geologic Setting*.** Segment 7 begins near the southern margin of the Transverse Ranges and traverses about 1 mile of steep, mountainous terrain before reaching the valley floor. This bedrock terrain is underlain by highly weathered and fractured crystalline bedrock units comprised of plutonic and metamorphic rocks. Localized landslides are present along the range front and within the Project route. The route abruptly transitions into the L.A. Basin along the margins of the San Gabriel River. Conditions in the northern margins of the L.A. Basin are marked by broad ancient alluvial fans and outwash channels that drain the Transverse Ranges. Much of Segment 7 is underlain by outwash gravels associated with the San Gabriel River. A summary of geologic conditions along the route is presented in Table 4.7-13.

The active tectonic forces of the region result in continued uplift of the San Gabriel Mountains. This geologically rapid uplift results in high rates of erosion within the range and along the steep range front. Deeply incised gorges and canyons mark the southern range front.

***Geologic Structure*.** The structural geology of the Transverse Ranges is dominated by the compressional tectonic setting (north-south shortening) that results from the large bend in the San Andreas fault zone to the east. The active compressional environment of the Transverse Ranges has resulted in significant uplift, tilting, folding and faulting. As a result, the range front is underlain by moderate to steep terrain and moderate to steeply dipping bedding or foliation in the granitic and metamorphic rock.

The Transverse Ranges are cut by numerous active east-west trending faults that help accommodate the compression or shortening that is taking place. These faults are mainly thrust or thrust-oblique type and result in older geologic units being thrust up and over younger units. The Sierra Madre fault is a dramatic example of thrust faulting located at the base of the range front in the Project area. This range front thrust fault has a complex surface expression. This type of thrust faulting occurs along north-dipping fault planes inclined at roughly 45 degrees. An earthquake of sufficient size to produce ground rupture would be expected to thrust the northern or older, upper plate out and over the southern, younger, lower plate.

As the route extends away from the range front it enters the L.A. Basin. The L.A. Basin represents a very complex structural zone. In the Miocene epoch the basin was formed by a largely extensional tectonic regime. In the early Pliocene epoch, the tectonic regime became compressional. Currently, a series of major strike slip faults enter the basin from the Peninsular Ranges to the south. The strike slip tectonic regime gives way to predominantly compressional features in the central and northern portions. Thrust faults, left-lateral strike slip faults, thrust-oblique faults, and low angle buried faults or “blind” thrust faults are all present in the central and northern portions of the basin. These compressional forces and in particular the blind thrusts are responsible for the uplifted and folded sedimentary rocks exposed along a series of anticlinal structures in the Project area. These anticlinal hills include the Montebello Hills, the Whittier Hills and the Puente Hills. The Puente Hills blind thrust underlies the Project area at depths ranging from an estimated 2 to 8 miles and extends approximately 25 miles from Glendale to Covina. This shallow dipping thrust fault represents a significant seismic source for the Project area (Dolan, et al. 2003).

***Geologic Units*.** Geologic units encountered in the Project area are presented in Table 4.7-13 and are based on the Dibblee map sheets listed in the notes for the table. The geologic units are described briefly below.

TABLE 4.7-13
GEOLOGIC CONDITIONS – SEGMENT 7[1]

Approximate Milepost	Geologic Unit/Structure	Formation Name	Description/Comments
0.0 – 0.1	Qls	Landslide	(Qls) Landslide in weathered rock (Dibblee)
0.1 – 0.3	gn	Gneissic Rock	Gneissic rock metamorphosed from sedimentary or igneous sources
0.3 – 0.5	qd	Quartz Diorite	Plutonic rock; gray, medium-grained, incoherent where weathered
0.5 – 0.7	Qls	Landslide	(Qls) Landslide in weathered rock (Dibblee)
0.7 – 1.0	Qog, qd	Quartz Diorite (qd), Old alluvium (Qog)	Plutonic Rock, light to medium gray, medium grained with older alluvial gravel, sand and silt
1	Fault	Sierra Madre Fault, D section	Fault crossing, one of multiple strands in active fault zone
1.1	Fault	Sierra Madre Fault, D section	Fault crossing, one of multiple strands in active fault zone
1.3	Fault	Sierra Madre Fault, D section	Fault crossing, one of multiple strands in active fault zone
1.0 – 1.5	Qa	Alluvium	Gravels, sands, and silts
1.5 – 12	Qg	Channel alluvium	Stream channel deposits of gravel, sand and silt. With localized artificial fill (af)
1.7	Fault	Sierra Madre Fault, D section	Fault crossing, one of multiple strands in active fault zone
12.0 – 13.5	Qa	Alluvium	Gravels, sands, and silts
13.5 – 13.6	Qg	Channel alluvium	Stream channel deposits of gravel, sand and silt.
13.6 – 13.7	Qoa	Older Alluvium	Sand and gravel fan deposits
13.7 – 13.9	Qg	Channel alluvium	Stream channel deposits of gravel, sand and silt.
13.9 – 14.1	Qls	Landslide	(Qls) Landslide (CGS, OFR 98-15)
14.1 – 15.8	Tfsc	Fernando Formation	Nonmarine sandstone and conglomerate; light gray to tan, crudely bedded

[1] Source: Dibblee map series (Mt Wilson and Azusa Quads; El Monte and Baldwin Park Quads; and CGS hazard mapping series Azusa, OFR 98-12; Baldwin Hills, OFR 98-13; El Monte, 98-15).

***Surficial Deposits*.** Quaternary alluvial deposits consisting primarily of gravelly and sandy channel deposits associated with the San Gabriel River underlie most of the Segment 7 T/L route within the Basin. In addition, landslide deposits are present in the steep terrain of the San Gabriel Mountain range front based on a review of the Dibblee quadrangle and CGS seismic hazard mapping program maps.

***Ancient Alluvial Fan*.** Pleistocene-age deposits of older alluvial fans are present as remnants along the range front and along the flanks of the Montebello Hills, near the end of the route. Slightly cemented silty gravelly sands and sandy gravels are typical materials encountered within this kind of older fan deposit.

Tertiary Sedimentary Rocks. Tertiary sedimentary rocks of the Fernando Formation underlie the Montebello Hills. The Fernando Formation is comprised of Pliocene-age marine sediments, primarily sandstones and lesser conglomerates.

***Granitic Rocks*.** Crystalline rocks of varying granitic composition are encountered in the northern portion of Segment 7. Rock types include quartz diorite, quartz monzonite, and granodiorite. The granitic rocks are commonly highly weathered, fractured, and foliated.

***Metamorphic Rocks*.** These are the oldest rocks in the study area and include primarily gneissic rocks that have been complexly intruded by the younger granitic rocks. The gneissic rocks are generally banded and foliated.

***Geologic Hazards*.**

***Faults and Seismicity*.** Active and potentially active faults associated with the Sierra Madre fault have been mapped in the region and documented by a number of government agencies and scientific entities. Numerous published maps and reports have been prepared by the USGS, CGS, and other State or public agencies (i.e., Caltrans, Southern California Earthquake Center) that present information on fault location and activity. Table 4.7-14 presents a list of active and potentially active faults within approximately 60 miles of Segment 7. Fault characteristics listed in Table 4.7-14 are based on published data.

The Project area is seismically very active given the proximity and number of potential seismic sources. Figure 4.7-2 presents a regional fault and epicenter map showing the approximate location of the TRTP relative to seismic sources and past earthquakes. Notable historic seismic events affecting the Project area are presented in Table 4.7-15.

It is likely that the Project area will experience minor and moderate earthquakes and potentially a major earthquake (moment magnitude M7, or greater) during its service life. A 1995 estimate by the Working Group on California Earthquake Probabilities gave an 80 to 90 percent probability of an M7 or greater earthquake in southern California before 2024.

TABLE 4.7-14
SEISMIC SOURCE CHARACTERISTICS – SEGMENT 7

Fault Name	Nearest Distance to Segment 7 (Miles)[1]	Type of Faulting[2]	Fault Length (Miles)[2]	Slip Rate[2] (mm/year)	Maximum Magnitude Earthquake[2] (M_{max})
Anacapa-Dume	46	Left lateral oblique	47	3	7.5
Big Pine	54	Left lateral strike-slip	44	0.8	6.9
Clamshell-Sawpit Canyon	6	Reverse	11	0.5	6.5
Cucamonga	15	Thrust	18	5	7
Elsinore, Chino segment	17	Right-lateral strike-slip	13	4	6.5
Hollywood	17	Left reverse	9	1	6.5
Holser	41	Reverse	12	0.4	6.5
Malibu Coast	30	Reverse	21	0.3	6.7
Newport-Inglewood	12	Right-lateral strike-slip	46	0.6	6.9
North Ridge Blind Thrust	24	Blind thrust	31	1.5	7
Oak Ridge	47	Thrust	55	4	6.9
Palos Verdes	21	Right reverse	49	3	7.1
Puente Hills Blind Thrust	4	Blind thrust	25	0.7	7.1
Raymond	0	Left-lateral reverse	16	1.5	6.5
San Andreas – Mojave Segment	25	Right-lateral strike-slip	64	30	7.9
San Andreas – Carrizo Segment	54	Right-lateral strike-slip	90	34	7.9
San Cayetano	48	Thrust	28	6	6.8
San Fernando	22	Thrust	10	2	6.8
San Gabriel	11	Right-lateral strike-slip	87	1	7.2
San Jacinto, Glen Helen segment	31	Right-lateral strike-slip	46	12	6.9
Santa Monica	12	Left reverse	14	1	6.6
Santa Susana	30	Thrust	23	5	6.6
Sierra Madre	0	Reverse	46	2	7.2
Simi (Santa Rosa)	40	Reverse	24	1	6.7
Upper Elysian Park Thrust	3	Blind thrust	18	0.8	6.8
Whittier-Workman Hills	0	Right-lateral strike-slip	24	2.5	6.8

[1] Fault distances based on Jennings, 1994.

[2] Source: CGS, 2003; Southern California Earthquake Center (SCEC)(www.scec.org).

TABLE 4.7-15
SIGNIFICANT HISTORIC EARTHQUAKES – SEGMENT 7

Date	Approximate Distance to Project Segment 7[1] (Miles)	Earthquake Magnitude[2]	Name, Location or Region Affected
December 8, 1812	44	7.5?	Wrightwood Earthquake
July 11, 1855	48	6.0	Los Angeles Region
January 9, 1857	150	Est. 7.9 to 8.25	Fort Tejon Earthquake
January 16, 1857	150	6.3	Generally felt in the Los Angeles Region
July 29, 1894	33	6.2	Lytle Creek region
July 21, 1952	84	7.3	Kern County Earthquake
February 9, 1971	18	6.6	San Fernando (Sylmar) Earthquake
October 1, 1987	0.3	5.9	Whittier Narrows Earthquake
January 17, 1994	14	6.7	Northridge Earthquake

[1] Earthquake magnitudes and locations before 1932 are estimated by Toppozada and others (1978, 1981, and 1982) based on reports of damage and felt effects.

[2] Earthquake damage information compiled from the Southern California Data Center (SCEDC, 2006a and 2006b) and National Earthquake Information Center (NEIC, 2005) websites. Additional comments on the earthquakes are provided in the Segment 4 discussion.

***Fault Rupture/Fault Displacement*.** Segment 7 crosses multiple fault strands associated with the active Sierra Madre fault zone. The reach of the Sierra Madre fault zone in the vicinity of Segment 7 is sometimes referred to as the ‘D section’ of the fault. The T/L route also crosses the projection of the Workman Hill fault along the eastern margin of the Montebello Hills.

The Sierra Madre fault is a complex structure that extends east-west across the Transverse Ranges defining the range front of the San Gabriel Mountain in the Project area. Four fault strands are mapped by the USGS that intersect the T/L route at S7 MP 1, 1.1, 3, and 6. The Sierra Madre fault zone is active through this region and capable of large magnitude earthquakes with displacements on the order of 15 to 20 feet or greater and magnitude Mw 7.2 to 7.6 earthquakes (Rubin, et al, 1998). Trenching performed in the Arroyo Seco area revealed evidence for two large earthquake events in the last 15,000 years. It is likely that some of the fault strands mapped are older structures and that they are not currently active.

The Segment 7 route passes within approximately 500 feet of the southern limits of the Earthquake Fault Zone for the Workman Hill fault. Based on the Dibblee mapping, the buried projection of the fault would cross the T/L route at approximately S7 MP 13.6.

As discussed above, Segment 7 is underlain at depth by the Puente Hills blind thrust. The thrust fault dips northward from the Montebello Hills and Puente Hills beneath the San Gabriel Basin. The fault does not represent a ground rupture hazard but displacement along the fault during an earthquake will result in uplift, folding, and significant ground shaking. Paleoseismic studies of the Puente Hills blind thrust have indicated the occurrence of at least four large (Mw 7.2 to 7.5) earthquakes of this fault during the past 11,000 years (Dolan, et al., 2003).

***Landslides*.** The Segment 7 Project area has been mapped at the quadrangle level by the State seismic hazard mapping program. Most of Segment 7 is located in the San Gabriel Valley on a broad relatively flat sediment filled basin. Hillside terrain is limited to the north and south ends of Segment 7.

Mapped landslides are present along and immediately adjacent to the route. Based on the earthquake induced landslide hazard zonation mapping, essentially all of the sloping terrain between S7 MP 0 and MP 1 is subject to possible landsliding in the event of a significant earthquake affecting the Project area. The risk of seismically-induced landsliding is moderate to high in this area because of the frequency of existing landslides, the steep terrain, the fractured and weathered geologic units, and the proximity of significant seismic sources, including the San Andreas and Sierra Madre fault zones and the Puente Hills blind thrust. In contrast, only localized portions of the slopes along the T/L route in the Montebello Hills are identified as prone to seismically-induced landsliding. Landslides and the potential for seismic-induced landsliding are a potential hazard in the steeply sloping areas of Segment 7.

***Liquefaction and Lateral Spreading*.** Liquefaction susceptible materials underlie a significant portion of the Segment 7 route. The CGS seismic hazard maps delineate liquefaction hazard zones between S7 MP 1.1 to MP 1.9 and MP 5.7 to MP 13.6. Without proper design, liquefaction would be a significant hazard to Segment 7.

***Ground Motions*.** For Segment 7 the estimates from the regional seismic hazard model (CGS, 2003) suggest ground motions of about 0.5g to 0.6gs for the hazard level associated with 10 percent probability of exceedance in a 50 year period. Estimates at the 2 percent in 50 year hazard level are on the order of 1g.

***Expansive and Collapsible Soils*.** Some potential for expansive materials may be present in the soils formed on the crystalline rock in the Transverse Ranges or the sedimentary rocks of the Montebello Hills. However, based on the soil survey data, fine-grained soils are not a major constituent in the surface layers of the primary soil units mapped in the region. Expansive soils are not anticipated to be a significant hazard relative to T/L foundation design in Segment 7.

Collapsible soils are not anticipated in the mountainous setting of the Transverse Ranges. Collapsible soils may be encountered in the alluvial plain or alluvial channel deposits encountered in the L.A. Basin. However, most of the Segment 7 route is underlain by gravelly deposits or very young deposits that have been inundated repeatedly since deposition. Therefore, collapsible soils are not likely to be a significant hazard to the Segment 7 route.

Subsidence**.** Subsidence is a phenomenon associated with deep alluvial basins and is not a potential hazard in the Transverse Ranges portion of the Project area. Subsidence has occurred within the L.A. basin and in the vicinity of the Project area as a result of fluid withdrawals associated with oil field extractions. Some continued subsidence is likely; however, the magnitudes of possible surface deformation are very small and are not considered a significant hazard to the T/L Project.

Soils**.** The soils along the proposed T/L route reflect the underlying rock type, the extent of weathering of the rock, the degree of slope, and the degree of modification by man. Soil data for the Project was obtained from the SSURGO database for the ANF Area, California (Publication Date: December 14, 2006) and the soil survey of the Los Angeles area (Walden, 2004).

A summary of the significant characteristics, including the description, hazard of erosion on roads and trails, and risk of corrosion of the major soil units traversed by Segment 7 is presented in Table 4.7-16; soil units are listed in order of first occurrence along the segment and may occur in multiple locations.

4.7.6.4.2 Impact Analysis. The potential impacts to or from geologic, seismic, and soil conditions along the proposed Segment 7 are discussed below. The discussion follows the significance criteria presented in Section 4.7.4.

Impact Summary**.** Construction, operation, and maintenance of the proposed TRTP Project Segment 7 would pose a significant hazard to the public or the environment relative to geology, soils, or geologic hazards. Portions of the proposed Project element are located within designated geologic hazard zones based on a review of the State hazard mapping program and published geologic mapping. The proposed Project could be subject to moderate or high levels of ground shaking in the event of an earthquake on faults in the region. Impacts to soils would occur during construction with increased traffic and grading associated with pads and roads for T/L construction and substation construction and/or expansion. APMs would reduce impacts to less than significant levels.

TABLE 4.7-16
SUMMARY OF SOIL UNIT CHARACTERISTICS – SEGMENT 7[1]

Soil Series or Association	Description	Hazard of Erosion on Roads and Trails[2]	Risk of Corrosion	
			Uncoated Steel	Concrete
Handford	Gravelly sandy loam, Silt loam, Fine sandy loam	Moderate	Low	Low
Tujunga	Fine sandy loam	Slight to Moderate	Low to Moderate	Low
Chino	Silt loam	Slight	High	Low
Ramona	Loam	Moderate	Moderate	Moderate
Yolo	Loam	Slight to Moderate	Low	Low
Altamont	Clay loam	NA	NA	NA
Upper San Gabriel River	Granitic substratum, steep slopes	Severe	NA	NA

[1] Source for soils mapping and characteristics: SSURGO, Angeles National Forest Area, California, GIS and LADWP, GIS.

[2] Qualitative descriptors of erosion hazard: Slight = little or no erosion is anticipated, Moderate = some erosion anticipated, Severe = significant erosion hazard.

***<u>Construction</u>*.** The impact analysis for construction of Segment 7 is based on the significance criteria detailed above in Section 4.7.4 and the results of the analysis for Segment 7 are essentially the same as Segment 4. See Section 4.7.6.1.2 for the discussion of construction impacts.

***<u>Operations</u>*.**

Would the Project expose people or structures to adverse effects as a result of rupture of an Alquist-Priolo Earthquake Fault or other substantial known fault?

Segment 7 crosses within 500 feet of the Alquist-Priolo Earthquake Fault Zone for the Workman Hill fault. The T/L route also crosses the Sierra Madre fault zone, a substantial known active fault. The Sierra Madre fault is capable of fault surface rupture and this constitutes a significant hazard to the Project.

The Workman Hill fault is crossed outside the EFZ where the fault is mapped as concealed. This fault is unlikely to rupture with a large displacement event and the potential fault rupture impact can be mitigated to a less than significant level following characterization of the fault.

The Sierra Madre represents a greater fault rupture hazard than the Workman Hills fault, but it is anticipated that risks from both fault crossings could be reduced to less than significant levels if structure locations can be optimized in the fault crossing area. Seismic design standards (GEO-1) would be followed and design level geotechnical and geologic hazards investigations (APM GEO-2) would be performed to reduce potential impacts to less than significant levels.

Would the Project expose people or structures to adverse effects as a result of seismic ground shaking?

As with all Project elements, impact from strong ground motions as a result of a significant earthquake in the area is possible. Standard design and construction practices following appropriate code and industry standards (APM GEO-1) would reduce the impacts from ground shaking to a less-than-significant level.

Would the Project expose people or structures to adverse effects as a result of seismic related ground failure including liquefaction?

Seismic related ground failure could include liquefaction, lateral spreading, and ground-cracking. The geologic setting of Segment 7 includes some mountainous and hilly relief but predominantly flat lying terrain associated with the L.A. Basin. This setting includes extensive zones of possible liquefaction. Design level geotechnical and geologic hazards investigations would be performed to fully characterize the hazards and provide recommendations for design (APM GEO-2). Implementation of APMs GEO-1 and GEO-2 would reduce any potential impacts to a less-than-significant level.

Would the Project expose people or structures to adverse effects as a result of landslides?

Mapped landslides are present along the range front portion of the Segment 7 T/L route and the State hazard mapping program has delineated the area as a hazard zone for seismically induced slope failure. Seismically induced slope failures include landslides, earth flows, soil slips and debris-flows. In the event of a large magnitude earthquake (moment magnitude 7.0 or greater) on the San Andreas fault, Sierra Madre thrust fault or Puente Hills blind thrust, seismically induced slope failures within the steep mountainous terrain of the San Gabriel Mountains cannot be precluded.

These fault zones are thought capable of producing earthquakes approaching magnitude Mw 7.5 and ground motions could exceed 1 g during such an event (USGS, 2002). Seismically induced slope instability has the potential to undermine foundations, cause distortion and distress to overlying structures, and displace or destroy Project components. Damage to, or failure of, the proposed T/L segment could result in temporary electrical transmission outages.

The recurrence interval for large earthquakes on these faults is estimated to range from 2,000 to 3,000 years for the Puente Hills blind thrust (Dolan et al, 2003) to perhaps greater than 6,000 to 8,000 years for the Sierra Madre fault (Rubin et al., 1998; Tucker et al., 2001). The earthquake recurrence intervals for these faults exceed the design life of the proposed TRTP and are therefore considered unlikely to result in catastrophic failure of Project components.

Smaller seismically induced slope instability could damage Project components and could thus potentially result in temporary outages along the affected T/L. As required by the North American Electric Reliability Corporation, the Western Electricity Coordinating Council, and the California Independent System Operators, the regional transmission system is designed to provide transmission reliability. Should a T/L not be operational as a result of an accident, seismic event, or fire, or is taken out of service to permit safe maintenance, redundancy in the transmission system allows electrical transmission with no or only brief service interruptions to load areas. Temporary outages along the proposed T/L segment as a result of seismically induced slope instability would be avoided or minimized because of the redundancy incorporated into the transmission system and, therefore, the potential impacts are less than significant.

A design-level geotechnical survey (APM GEO-2) would be performed to evaluate the potential for unstable slopes, landslides, earth flows, soil slips and debris flows along the proposed segment. Overhead T/L structures may be placed to avoid and span slide areas. To the extent feasible, facilities would be located away from very steep hillsides, debris-flow source areas, the mouths of steep side-hill drainages, and the mouths of canyons that drain steep terrain. In cases of shallow sliding, slope creep, or raveling, specially designed deep foundations may be used to anchor the overlying structure to underlying, competent material. As appropriate, stabilization of unstable slopes would be performed by excavating and removing unstable material, regrading unstable slopes to improve surface drainage and limit infiltration, installing subsurface drainage systems, and/or constructing retaining structures to mechanically restrain slope movement.

With implementation of APM GEO-1 and APM GEO-2, potential impacts to the proposed T/L and subsequent outages resulting from seismically induced slope instability would be less than significant.

Would the Project result in substantial soil erosion or the loss of topsoil?

Some soil types along the route are subject to moderate or severe erosion on roads and trails. Such areas, if not stabilized, could be subject to increased rates of erosion by wind and/or water. Soil erosion is a potentially significant impact. APM GEO-2 requires geotechnical studies and good engineering practices, and APM GEO-3 calls for appropriate soil erosion/water quality protection measures as specified in the Construction SWPPP. Implementation of APM GEO-2 and APM GEO-3 would reduce significant erosion impacts during operation of the Project to a less-than-significant level.

Would the Project be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the Project and potentially result in onsite or offsite landslide, lateral spreading, subsidence, liquefaction or collapse?

Segment 7 is potentially subject to hazards associated with unstable geologic units and soil conditions that include landslide prone areas, existing landslides and zones of liquefaction potential. These unstable geologic units and soils could impact the Project to varying degrees.

The landslide hazards, particularly the seismic induced landslides are a significant hazard and are discussed above. Liquefaction would be mitigated with foundation design or ground improvement approaches based on performance of APM GEO-2.

Some potential for collapsible soils may exist in the young alluvial deposits in the L.A. Basin. Recognition and evaluation of such conditions, if present, would be evaluated during site specific geotechnical investigations (APM GEO-2).

Implementation of APMs GEO-1 and GEO-2 would reduce potential impacts from unstable geologic units or soils to a less-than-significant level.

Would the Project be located on expansive soil, creating substantial risks to life or property?

Extensive areas of expansive soils are not anticipated in the generally granular soil conditions encountered in the Segment 7 portion of the Project area. However, localized areas of expansive clays could be encountered. Significant impacts resulting from expansive clays are conceivable in the Project area, but are not considered likely based on the geologic setting. If identified during design level studies, the geotechnical report (APM GEO-2) would provide recommendations to reduce the impacts of expansive soils. Implementation of appropriate measures would reduce impacts to a less-than-significant level.

Would the Project have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?

No impacts are expected. The TRTP would not construct septic tanks, and use of existing septic tanks during construction is not anticipated, as workers would use portable toilets. Waste would be pumped out by qualified contractors and disposed of in accordance with all applicable regulations and codes.

4.7.6.4.3 Mitigation Measures. The aforementioned APMs have been incorporated into the Project design and apply to this segment; therefore, any potentially significant impacts have been avoided or reduced to a less-than-significant level, and no mitigation is required.

4.7.6.4.4 Impact Significance After Mitigation Measures. The potential impacts from geologic hazards and potential impacts to geology and soils associated with construction and operation of Segment 7 are considered to be less than significant.

4.7.6.5 Segment 8

4.7.6.5.1 Environmental Setting. This section describes the existing geologic conditions, geologic hazards and soil conditions in the proposed Project area for Segment 8 of the proposed TRTP. Segment 8 is divided into three routes; Segment 8A comprises the majority of the alignment, while Segments 8B and 8C are at the eastern end of the alignment.

Physiographic Setting**.** Segment 8 is within the northern/northwestern portion of the Peninsular Ranges physiographic province, which is generally characterized by northwest-southwest trending faults, folds, and mountain ranges. However, Segment 8 is also within the Los Angeles Basin, a geologic sub-province of the Peninsular Ranges that includes the San Gabriel and San Fernando valleys. The Los Angeles Basin has a complex physiographic setting due to local tectonic forces. These forces, as discussed below, have created localized hills and mountains, separated by broad valleys or canyons, and continue to cause seismic activity in the area.

The western terminus of the alignment is in the low-lying Montebello Hills (300 to 400 feet msl), separated by an alluvial valley from the Puente Hills to the east. The cities of Rosemead, South El Monte, Pico Rivera and the City of Industry occupy the valley. The San Gabriel River, a major drainage of the Los Angeles Basin, passes through the valley and crosses the alignment near S8A MP 3.8.

The alignment continues east across the Puente Hills through the communities of Whittier, Hacienda Heights, La Habra Heights, Rowland Heights, Diamond Bar and Chino Hills. The

Puente Hills are a west to northwest trending mass of uplifted sedimentary rock. The alignment typically runs at an elevation of between 900 and 1,200 feet msl, although peaks of around 1,400 feet msl are present near the T/L. One of the highest points along the route is Workman Hill at 1,368 feet msl, near S8A MP 7.9. The Puente Hills are characterized by steep slopes and numerous alluvium-filled canyons and drainages. The major canyons crossing the Puente Hills (and the alignment) include Turnbull Canyon (S8A MP 7.6), Brea Canyon (S8A MP 17.1), Tonner Canyon (S8A MP 18.5) and Carbon Canyon (S8A MP 22.2). East of Chino Heights, the alignment descends the Puente Hills into the relatively flat alluvial valley areas of Chino and Ontario.

<u>Geologic Setting</u>. The route traverses the central portion of the Los Angeles Basin. The basin is underlain by a veneer of Holocene and late Pleistocene age alluvial deposits. The recent alluvial material that infilled the basin originates from the nearby San Gabriel and San Bernardino mountains. The local hills are comprised of older sedimentary deposits that have been uplifted. A summary of geologic conditions along the route is presented in Table 4.7-17.

The western portion of the alignment overlies several blind thrust faults, which do not intercept the ground surface, including the Puente Hills thrust, the Elysian Park thrust and the East Lost Angeles thrust. The M5.9 Whittier Narrows earthquake occurred on the Puente Hills fault. Further east, the alignment encounters and parallels the Whittier fault, which is an active fault that is thought to be capable of producing a M6.8 earthquake, and the associated Workman Hill fault. Whittier fault is the portion of northward extension of the Elsinore fault Zone that lies south of the Puente Hills. The Chino Hills, fault, which is the extension of the Elsinore fault Zone north of the Puente Hills, lies 4,000 feet south of the alignment, but within the study zone. The alignment crosses the Central Avenue fault, which is associated with the Chino fault.

<u>Geologic Structure</u>. The structural geology of the region is dominated by the compressional tectonic setting (north-south shortening) of the Los Angeles Basin that results from the large bend in the San Andreas fault zone to the east. The active compressional environment has resulted in significant uplift, tilting, folding and faulting, most notably in the Puente Hills. The deformation has also been a major factor in the presence of petroleum deposits in the hills/mountains.

The uplift of the Puente Hills is generated primarily by fault rupture along the Puente Hills blind thrust fault. Deformation in the Puente Hills is also influenced by the Whittier fault, which runs in a more westerly direction than the predominantly north-northwest-striking faults in the area, such as the Chino and Central Avenue faults. The Chino fault is typically considered a right lateral strike-slip fault associated with the Elsinore fault zone, although

TABLE 4.7-17
GEOLOGIC CONDITIONS – SEGMENT 8[1]

Approximate Milepost	Geologic Unit/Structure	Formation Name	Description/Comments
Segment 8A			
0.0 – 1.6	Tfsc	Fernando Formation	Nonmarine sandstone and conglomerate; light gray to tan, crudely bedded; conglomerate composed of pebbles and cobbles
1.6 – 1.8	Qls	Landslide	(Qls) Landslide (CGS, OFR 98-15)
1.8 – 2.1	Qg	Surficial Sediment	Stream channel deposits of gravel, sand and silt.
2.1 – 2.2	Qoa	Older Alluvium	Sand and gravel fan deposits
2.2 – 2.5	Qg	Alluvium Fan	Stream channel deposits of gravel, sand and silt.
2.5 – 3.6	Qa	Alluvium	Gravels, sands, and silts
3.6 – 3.9	Qg	Alluvium Fan	Stream channel deposits of gravel, sand and silt.
3.9 – 4.8	Qa	Alluvium	Gravels, sands, and silts (Oil Field at 4.0)
4.8 – 5.0	Qls	Landslide	(Qls) Landslide (CGS, OFR 98-15)
5.0 – 6.6	Tfp, Tfs, Tfr	Fernando Formation	Fine grained sedimentary rock from fine-medium grained sand to claystone or siltstone; gray, weathers brown.
5.6 – 6.4	Qls	Landslide Complex	(Qls) Landslide (Dibblee and CGS, OFR 98-15)
6.4 – 6.7	Tfp, Tfs, Tfr	Fernando Formation	Fine grained sedimentary rock from fine-medium grained sand to claystone or siltstone; gray, weathers brown.
6.7 – 7.1	Qls	Landslide Complex	(Qls) Landslide (CGS, OFR 98-15)
7.1 – 7.6	Tfr, Tscg, Tsc	Fernando Formation (Tfr), Sycamore Canyon Formation (Tscg) and (Tsc)	Claystone; gray micaceous silty claystone or siltstone (Tfr);/conglomerate sandstone unit (Tscg);/gray silty clay shale (Tsc)
7.6 – 8.0	Qls	Landslide Complex.	(Qls) Landslide (CGS, OFR 97-17)
8	Fault	Workman Hill Fault	Fault crossing
8.0 – 8.1	Tmlv	Monterey Formation	La Vida Shale Member; white, weathered; thin bedded, siliceous shale, clay shale, and siltstone
8.1 – 8.4	Qls	Landslide Complex.	(Qls) Landslide (CGS, OFR 97-17)
8.4 – 8.5	Tms	Monterey Formation	Soquel Sandstone member; weather to tan, medium grained could be coarse to pebbly
8.5 – 8.7	Qls	Landslide Complex.	(Qls) Landslide (CGS, OFR 97-17)
8.7 – 9.0	Tmlv	Monterey Formation	La Vida Shale Member; white, weathered; thin bedded, siliceous shale, clay shale, and siltstone

TABLE 4.7-17 (CONTINUED)
GEOLOGIC CONDITIONS – SEGMENT 8[1]

Approximate Milepost	Geologic Unit/Structure	Formation Name	Description/Comments
9.0 – 9.1	Tms	Monterey Formation	Soquel Sandstone Member; Bedded sandstone, light gray, weather tan, medium grained could have coarser grains to pebbles
9.1 – 10.3	Fault Zone	Whittier Fault, Monterey Formation	T/L route traverses fault zone obliquely. Yorba shale member; light gray, thin bedded, diatomaceous, semi-siliceous to clay shale, siltstone, minor sandstone; fish scales
9.3 – 9.6	Qls	Landslide Complex	(Qls) Landslide (CGS, OFR 97-17)
9.7 – 10.5	Qls	Landslide Complex	(Qls) Landslide (CGS, OFR 97-17)
10.5 – 10.7	Tsc	Sycamore Canyon Formation	Silty clay stone; gray, micaceous, weakly bedded to locally thinly bedded
10.7 – 11.0	Qls	Landslide Complex	(Qls) Landslide (Dibblee and CGS, OFR 97-17)
11.0 – 11.1	Tscs	Sycamore Canyon Formation	Conglomerate sandstone unit, gray to rusty-brown conglomerate, crudely bedded, composed of cobbles and pebbles
11.1 – 11.3	Tmy	Monterey Formation	Yorba shale member; light gray, thin bedded, semi-siliceous to clay shale, siltstone, minor sandstone; fish scales
11.3 – 11.5	Tms	Monterey Formation	Soquel Sandstone Member; Bedded sandstone, light gray, weather tan, medium grained could have coarser grains to pebbles
11.5 – 12.2	Qls	Landslide Complex	(Qls) Landslide (Dibblee and CGS, OFR 97-17)
12.2 – 12.4	Tmss, Tms, Tmy Tm	Monterey Formation	Soquel Sandstone Member (Tmss & Tms), Yorba shale Member (Tmy), Unassigned Member (Tm); fine-medium sedimentary unit from sand, clay to siltstone shale
12.4 – 12.6	Qls	Landslide	(Qls) Landslide (CGS, OFR 97-17)
12.6 – 13.5	Tmss, Tms, Tmy Tm	Monterey Formation	Soquel Sandstone Member (Tmss & Tms), Yorba shale Member (Tmy), Unassigned Member (Tm); fine-medium sedimentary unit from sand, clay to siltstone shale
13.5 – 13.6	Qa	Alluvium	Gravels, sands, and silts
13.6 – 14.0	Qae, Tmss, Tmlv	Monterey Formation (Tmss & Tmlv), Alluvium	Soquel Sandstone Member (Tmss) & La Vida Shale Member (Tmlv); fine-medium sedimentary unit from sand, clay to siltstone shale./Alluvium; Slightly elevated and locally desiccated alluvium gravels and sands (Qae)
14.0 – 14.3	Qls	Landslide Complex	(Qls) Landslide (CGS, OFR 97-17)

TABLE 4.7-17 (CONTINUED)
GEOLOGIC CONDITIONS – SEGMENT 8[1]

Approximate Milepost	Geologic Unit/Structure	Formation Name	Description/Comments
14.3 – 15.8	Tmlv	Monterey Formation	La Vida Shale Member; white, weathered; thin bedded, siliceous shale, clay shale, and siltstone
15.8 – 16.5	Tmss	Monterey Formation	Soquel Sandstone Member; Bedded sandstone, light gray, weather tan, medium grained could have coarser grains to pebbles
16.5 – 16.7	Tmlv	Monterey Formation	La Vida Shale Member; white, weathered; thin bedded, siliceous shale, clay shale, and siltstone
16.7 – 16.8	Qls	Landslide	(Qls) Landslide (CGS, SHZR 010, Yorba Linda)[2]
16.8 – 17.0	Qa	Alluvium	Gravels, sands, and silts
17.0 – 17.3	Qls	Landslide Complex	(Qls) Landslide (CGS, SHZR 010, Yorba Linda)
17.3 – 17.4	Tmlv	Monterey Formation	La Vida Shale Member; white, weathered; thin bedded, siliceous shale, clay shale, and siltstone
17.4 – 17.5	Qls	Landslide	(Qls) Landslide (CGS, SHZR 010, Yorba Linda)
17.5 – 17.8	Tmss	Monterey Formation	Soquel Sandstone Member; Bedded sandstone, light gray, weather tan, medium grained could have coarser grains to pebbles
17.8 – 18.4	Tmlv	Monterey Formation	La Vida Shale Member; white, weathered; thin bedded, siliceous shale, clay shale, and siltstone
18.4 – 18.5	Qa	Alluvium	Gravels, sands, and silts
18.5 – 18.6	Tmlv	Monterey Formation	La Vida Shale Member; white, weathered; thin bedded, platy, siliceous shale, clay shale, and siltstone
18.6 – 18.8	Qls	Landslide	(Qls) Landslide (CGS, SHZR 010, Yorba Linda)
18.8 – 19.1	Tmss	Monterey Formation	Soquel Sandstone Member; Bedded sandstone, light gray, weather tan, medium grained could have coarser grains to pebbles
19.1 – 19.4	Qls	Landslide	(Qls) Landslide (CGS, SHZR 010, Yorba Linda)
19.4 – 19.6	Tmss	Monterey Formation	Soquel Sandstone Member; Bedded sandstone, light gray, weather tan, medium grained could have coarser grains to pebbles
19.6 – 19.8	Qls	Landslide	(Qls) Landslide (CGS, SHZR 010, Yorba Linda)
19.8 – 21.4	Tmss	Monterey Formation	Soquel Sandstone Member; Bedded sandstone, light gray, weather tan, medium grained could have coarser grains to pebbles
21.4 – 21.8	Qls	Landslide	(Qls) Landslide (CGS, SHZR 010, Yorba Linda)

TABLE 4.7-17 (CONTINUED)
GEOLOGIC CONDITIONS – SEGMENT 8[1]

Approximate Milepost	Geologic Unit/Structure	Formation Name	Description/Comments
21.8 – 22.0	Tmss	Monterey Formation	Soquel Sandstone Member; bedded sandstone, light gray, weather tan, medium grained could have coarser grains to pebbles
22.0 – 22.1	Qls	Landslide	(Qls) Landslide (CGS, SHZR 010, Yorba Linda)
22.1 – 22.2	Tm	Monterey Formation	Unassigned shale; white, weathered; thin bedded, siliceous shale, clay shale, and siltstone
22.2 – 22.4	Qa	Alluvium	Gravels, sands, and silts
22.4 – 22.9	Tm	Monterey Formation	Unassigned shale; white, weathered; thin bedded, siliceous shale, clay shale, and siltstone
22.9 – 23.1	Tm, Qoa	Monterey Formation, Old alluvium	Unassigned shale; white, weathered; thin bedded, siliceous shale, clay shale, and siltstone (Tm)/gravel, sands, and silts (Qoa)
23.1 – 23.2	Qls	Landslide	(Qls) Landslide (CGS, SHZR 010, Yorba Linda)
22.9 – 23.3	Tm, Qoa	Monterey Formation, Old alluvium	Unassigned shale; white, weathered; thin bedded, platy, siliceous shale, clay shale, and siltstone (Tm)/gravel, sands, and silts (Qoa)
23.3 – 23.5	Qls	Landslide	(Qls) Landslide (CGS, SHZR 010, Yorba Linda)
23.5 – 23.6	Tm	Monterey Formation	Unassigned shale; white, weathered; thin bedded, siliceous shale, clay shale, and siltstone
23.6	Fault	Arnold Ranch Fault	Fault crossing, likely inactive fault
23.6 – 23.9	Tmy	Monterey Formation	Yorba shale member; light gray, thin bedded, semi-siliceous to clay shale, siltstone, minor sandstone; fish scales
23.9 – 24.0	Qa	Alluvium	Gravels, sands, and silts
24.0 – 24.5	Tmy	Monterey Formation	Yorba shale member; light gray, thin bedded, semi-siliceous to clay shale, siltstone, minor sandstone; fish scales
24.5 – 24.8	Qa	Alluvium	Gravels, sands, and silts
24.8 – 25.1	Tmy	Monterey Formation	Yorba shale member; light gray, thin bedded, semi-siliceous to clay shale, siltstone, minor sandstone; fish scales
25.1 – 25.9	Qa	Alluvium	Gravels, sands, and silts
25.9 – 26.1	Qg	Alluvium Fan	Stream channel deposits of gravel, sand and silt.
26.1 – 35.2	Qa	Alluvium	Gravels, sands, and silts
26.9	Fault	Central Avenue Fault	Fault crossing

TABLE 4.7-17 (CONTINUED)
GEOLOGIC CONDITIONS – SEGMENT 8[1]

Approximate Milepost	Geologic Unit/Structure	Formation Name	Description/Comments
Segment 8B			
0.0 – 4.1	Qa	Young Alluvium	Gravels, sands, and silts
4.1 – 4.8	Qf	Very Young Alluvium	Gravels, sands, and silts
4.8 – 6.8	Qye	Alluvium	Gravels, sands, and silts
Segment 8C			
0.0 – 4.5	Qa	Young Alluvium	Gravels, sands, and silts
4.5 – 4.7	Qf	Very Young Alluvium	Gravels, sands, and silts
4.7 – 6.4	Qye	Alluvium	Gravels, sands, and silts

[1] Data from: Dibblee map series (El Monte and Baldwin Park Quad; Whittier and La Habra Quad); and USGS 30’ by 60’ quadrangles (Santa Ana and San Bernardino).
SHZ = seismic hazard zone from CGS seismic hazard mapping program.

some reverse fault-type movement is also in evidence. The Central Avenue fault is generally considered a right step-over from the Chino fault.

***Geologic Units*.** Geologic units encountered in the Project area are presented in Table 4.7- 17 and are based on the map sheets listed in the notes for the table. The geologic units are described briefly below.

***Surficial Deposits*.** Quaternary alluvial deposits consisting primarily of sand, gravel and silt are present in the valleys and canyons throughout Segment 8 of the Project. In addition, landslide deposits are common in the steeper terrain of the Puente Hills and localized zones of the Montebello Hills. The landslide deposits have been mapped along and adjacent to the route based on a review of the Dibblee quadrangle maps, the 1:100,000 scale CGS maps (USGS, 1999; 2003b) and the CGS seismic hazard mapping program.

***Ancient Alluvial Fan*.** Pleistocene-age deposits of older alluvial fans are present in limited locations throughout the segment. Sand and gravel are typical materials encountered within these older fan deposits.

***Tertiary Sedimentary Rocks*.** Nonmarine and marine sedimentary rocks including sandstone, conglomerate, siltstone and claystone, predominate the hills that are present along much of the Segment 8 alignment. Formations include the Fernando Formation (sandstone, conglomerate, claystone and siltstone), Monterey Formation (sandstone and shale) and the Sycamore Canyon Formation (conglomerate sandstone). The conglomerate is typically composed of pebbles and cobbles of mostly granitic detritus in a friable sandstone matrix. The claystone and siltstone is typically micaceous. The Yorba shale member is thinly bedded, diatomaceous, and semi-siliceous.

***Geologic Hazards*.**

***Faults and Seismicity*.** Active and potentially active faults have been mapped in the region and documented by a number of government agencies and scientific entities. Numerous published maps and reports have been prepared by the USGS, CGS, and other State or public agencies (i.e., Caltrans, Southern California Earthquake Center) that present information on fault location and activity. Table 4.7-18 presents a list of active and potentially active faults within approximately 60 miles of Segment 8. Fault characteristics listed in Table 4.7-18 are based on published data.

The Project area is seismically very active given the proximity and number of potential seismic sources. Figure 4.7-2 presents a regional fault and epicenter map showing the approximate location of the TRTP relative to seismic sources and past earthquakes. Notable historic seismic events affecting the Project area are presented in Table 4.7-19.

It is likely that the Project area will experience minor and moderate earthquakes and potentially a major earthquake (moment magnitude M7, or greater) during its service life. A 1995 estimate by the Working Group on California Earthquake Probabilities gave an 80 to 90 percent probability of an M7 or greater earthquake in southern California before 2024.

***Fault Rupture/Fault Displacement*.** Near its western terminus at the base of the Montebello Hills, the Segment 8A alignment comes within about 500 feet of the Earthquake Zone associated with the Workman Hill fault, part of the Whittier fault zone. The fault is buried through the alluvial valley to the east, where there is a low potential for surface fault rupture. The alignment crosses obliquely into the Earthquake Fault Zone for the Whittier fault zone farther east between S8A MP 8.8 and 10.4. As discussed previously, the Whittier fault is an active part of the Elsinore Fault Zone and is thought to be capable of a M6.8 event. Design level studies should address the potential for fault rupture on the Workman Hill/Whittier faults. At S8A MP 23.6, the alignment crosses the Arnold Ranch fault, which is not a Quaternary fault and is not considered a fault rupture hazard. At S8A MP 26.9, the alignment crosses the Central Avenue fault, which has been active in the Quaternary (i.e., potentially active) but is not zoned by the State as an Earthquake Fault Zone. The northernmost trace of Chino fault, which is similarly dated and zoned, is present within the

TABLE 4.7-18
SEISMIC SOURCE CHARACTERISTICS – SEGMENT 8

Fault Name	Nearest Distance to Segment 8 (Miles)[1]	Type of Faulting[2]	Fault Length (Miles)[2]	Slip Rate[2] (mm/year)	Maximum Magnitude Earthquake[2] (M_{max})
Clamshell-Sawpit Canyon	13	Reverse	11	0.5	6.5
Cucamonga	10	Thrust	18	5	7
Elsinore, Chino segment	1	Right-lateral strike-slip	13	4	6.5
Garlock	72	Left-lateral strike-slip	155	7	7.1
Hollywood	17	Left reverse	9	1	6.5
Holser	41	Reverse	12	0.4	6.5
Malibu Coast	30	Reverse	21	0.3	6.7
Newport-Inglewood	12	Right-lateral strike-slip	46	0.6	6.9
North Ridge	24	Blind thrust	31	1.5	7
Oak Ridge	47	Thrust	55	4	6.9
Palos Verdes	21	Right reverse	49	3	7.1
Pleito Thrust	79	Thrust	28	2	6.8
Puente Hills Blind Thrust	3	Blind thrust	25	0.7	7.1
Raymond	8	Left-lateral reverse	16	1.5	6.5
San Andreas – Mojave Segment	3	Right-lateral strike-slip	64	30	7.9
San Andreas – Carrizo Segment	37	Right-lateral strike-slip	90	34	7.9
San Cayetano	48	Thrust	28	6	6.8
San Fernando	22	Thrust	10	5	6.8
San Gabriel	27	Right-lateral strike-slip	87	1	7.2
San Jacinto, Glen Helen segment	15	Right-lateral strike-slip	46	12	6.9
Santa Monica	12	Left reverse	14	1	6.6
Santa Susana	30	Thrust	23	5	6.6
Sierra Madre	12	Reverse	46	2	7
Simi (Santa Rosa)	40	Reverse	24	1	6.7
Upper Elysian Park Thrust	4	Blind thrust	18	0.8	6.8
Whittier	0	Right-lateral strike-slip	24	2.5	6.8
White Wolf	90	Left-lateral reverse	37	2	7.2

[1] Fault distances based on Jennings, 1994.

[2] Source: CGS, 2003; Southern California Earthquake Center (SCEC)(www.scec.org).

TABLE 4.7-19
SIGNIFICANT HISTORIC EARTHQUAKES – SEGMENT 8

Date	Approximate Distance to Project Segment 8[1] (Miles)	Earthquake Magnitude[2]	Name, Location or Region Affected
December 8, 1812	24	7.5?	Wrightwood Earthquake
July 11, 1855	48	6.0	Los Angeles Region
January 9, 1857	150	Est. from 7.9 to 8.25	Fort Tejon Earthquake
January 16, 1857	Unknown	6.3	Generally felt in the Los Angeles Region
July 29, 1894	17	6.2	Lytle Creek region
July 21, 1952	84	7.3	Kern County Earthquake
February 9, 1971	16	6.6	San Fernando (Sylmar) Earthquake
October 1, 1987	1	5.9	Whittier Narrows Earthquake
January 17, 1994	14	6.7	Northridge Earthquake

[1] Earthquake magnitudes and locations before 1932 are estimated by Toppozada and others (1978, 1981, and 1982) based on reports of damage and felt effects.

[2] Earthquake damage information compiled from the Southern California Data Center (SCEDC, 2006a and 2006b) and National Earthquake Information Center (NEIC, 2005) websites. Additional comments on the earthquakes are provided in the Segment 4 discussion.

study zone to the southwest. Design level studies should address the potential for fault rupture on the Chino or Central Avenue fault.

The western portion of Segment 8A is underlain at depth by the Puente Hills blind thrust interpreted to have a depth range of 2 miles to 8 miles below the ground surface (Dolan, et al., 2003). The thrust fault dips northward from the Montebello Hills and Puente Hills beneath the San Gabriel Basin. Paleoseismic studies of the Puente Hills blind thrust have indicated the occurrence of at least four large (moment-magnitude 7.2 to 7.5) earthquakes of this fault during the past 11,000 years (Dolan, et al., 2003). Fault rupture at depth along the Puente Hills thrust results in folding of the overlying strata and uplift of the Puente Hills.

***Landslides*.** A significant portion of the Segment 8A Project area has been mapped at the quadrangle level by the State seismic hazard mapping program. Based on this mapping, minor areas in the Montebello Hills area and major portions of the Puente Hills area are mapped as having landslide and earthquake induced landslide potential. This is because of the frequency of existing landslides, the steep terrain, the fractured and weathered geologic units, and the proximity of significant seismic sources, including the blind thrust faults and the branches of the Elsinore fault in the area. Previous landslides have also been mapped on the Dibblee quad maps and the Santa Ana Sheet (Morton, 2004). Monterey Park, La Habra

Heights, Hacienda Heights and Rowland Heights have a history of slope failures during rain and as a result of earthquakes (including the Whittier Narrows), as well as concerns with erosion and debris flows.

Landslides and the potential for seismic-induced landsliding are a significant hazard in the moderate and steeply sloping areas of Segment 8. Both Los Angeles and San Bernardino counties require special engineering/geologic evaluations in areas with landslide potential.

***Liquefaction and Lateral Spreading*.** Numerous occurrences of liquefaction susceptible materials are present within the recent alluvial deposits along Segment 8. The most potentially significant liquefaction hazard exists along Segment 8A in the San Gabriel River Valley (S8A MP 2.3 to 4.7). The City of South El Monte, which is present in this area and is completely within the liquefaction potential zone, reports groundwater levels on the order of 15 to 35 feet below the ground surface. The alignment also encounters potentially liquefiable material at several canyon crossings, including Powder Canyon (S8A MP 13.5 to 13.6, although the T/L pole locations are on the sides of the canyon), Brea Canyon (S8A, MP 17.1), Tonner Canyon (S8A, MP 18.5), and Carbon Canyon (S8A, MP 22.2).

The City of Chino Hills "Seismic Hazards, Fault Rupture and Liquefaction Susceptibility Map" maps the alluvial areas of Little Chino Creek and Chino Creek (S8A MP 24.6 to 26.0) on the eastern slope of the Puente Hills and the west side of Chino Creek as having moderate to high liquefaction potential. No data is available on the east side of Chino Creek in Chino and Ontario, although it is expected that a moderate liquefaction potential exists adjacent to the creek.

***Ground Motions*.** USGS/CGS PSHA models, (CGS, 2002, revised April 2003) depict ground motions associated with a 10 percent probability of exceedance in a 50 year period. For Segment 8A, the ground motion estimate for the Mesa Substation at the start of the segment is about 0.48g. The PGA estimate at Chino Substation is 0.49g, and at Mira Loma Substation at the end of the segment it is about 0.46g.

***Expansive and Collapsible Soils*.** Moderately expansive soil is likely to be present in the hills along the Segment 8 route due to the presence of weathered sandstone, claystone and siltstone and clay-rich older alluvium. Site specific evaluation would be required in these areas. The Chino Hills General Plan maps most of the study corridor within the hills as having near-surface soils with a moderate shrink swell potential. Expansion potential of the soil in the alluvial valleys and canyons is likely to be low, as the majority of this material is granular in nature and is derived from the primarily igneous rock of the San Gabriel and San Bernardino mountains.

Collapsible soils are not anticipated in the hills along the Segment 8 route. A low potential exists for collapsible soil in the valleys and canyons.

***Subsidence*.** Subsidence can occur within deep alluvial basins such as the Los Angeles Basin. However, groundwater withdrawal has not had a major impact on groundwater levels due to the presence of numerous drainages in the area. Therefore, the potential for subsidence along the Segment 8 route is very low.

***Soils*.** The soils along the proposed T/L route reflect the underlying rock type, the extent of weathering of the rock, the degree of slope, and the degree of modification by man. Soil data for the Project was obtained from the LADWP soil database and from the SSURGO database for the San Bernardino Area, California (Publication Date: December 14, 2006).

A summary of the significant characteristics, including the description, hazard of erosion on roads and trails, and risk of corrosion of the major soil units traversed by Segment 8, is presented in Table 4.7-20; soil units are listed in order of first occurrence along the segment and may occur in multiple locations.

4.7.6.5.2 Impact Analysis. The potential impacts to or from geologic, seismic, and soil conditions along the proposed Segment 8 are discussed below. The discussion follows the significance criteria presented in Section 4.7.4.

***Impact Summary*.** Construction, operation, and maintenance of the proposed TRTP Project Segment 8 would pose a significant hazard to the public or the environment relative to geology, soils, or geologic hazard. Extensive portions of the proposed Project element are located within designated geologic hazard zones based on a review of the State hazard mapping program and published geologic maps. The proposed Project could be subject to moderate or high levels of ground shaking in the event of an earthquake on faults in the region. Impacts to soils would occur during construction with increased traffic and grading associated with pads and roads for T/L construction, including the proposed undergrounding of 66 kV subtransmission lines near SCE’s Chino Substation. APMs would reduce impacts to less than significant levels.

***Construction*.** The impact analysis for construction of Segment 8 is based on the significance criteria detailed above in Section 4.7.4, and the results of the analysis for Segment 8 are essentially the same as Segment 4. See Section 4.7.6.1.2 for the discussion of construction impacts.

***Operations*.**

Would the Project expose people or structures to adverse effects as a result of rupture of an Alquist-Priolo Earthquake Fault or other substantial known fault?

Segment 8A crosses into the Alquist-Priolo Earthquake Fault Zone associated with the Whittier fault. It also crosses the Central Avenue fault, which does not have an Earthquake Fault Zone but is a Quaternary fault. Both faults may represent a fault rupture hazard and would be evaluated during design level studies (APM GEO-2) and engineering considerations (APM GEO-1). Implementation of APMs GEO-1 and GEO-2 would reduce any potential impacts to a less-than-significant level.

Would the Project expose people or structures to adverse effects as a result of seismic ground shaking?

Project structures could be impacted by strong ground motions as a result of a significant earthquake in the area as described above. Such moderate to strong levels of ground shaking could damage Project structures if they were not properly designed. Ground shaking could present a significant hazard to Segment 8. Implementation of APMs GEO-1 and GEO-2 would reduce any potential impacts to a less-than-significant level.

Would the Project expose people or structures to adverse effects as a result of seismic related ground failure including liquefaction?

Seismic related ground failure could include liquefaction, lateral spreading, and ground-cracking. The geologic setting of Segment 8 includes hilly terrain with intervening valleys and canyons. The valleys and canyons contain zones of possible liquefaction, while the hills and ridges contain extensive zones of seismically induced landslide hazard and possible ground cracking. Hazards associated with seismic-related ground failures are potentially significant for Segment 8. Implementation of APMs GEO-1 and GEO-2 would reduce any potential impacts to a less-than-significant level.

Would the Project expose people or structures to adverse effects as a result of landslides?

Numerous landslides have been mapped along the Segment 8A T/L route. Significant zones of seismic induced slope failure hazard have been delineated by the State hazard mapping program. Seismically induced slope failures include landslides, earth flows, soil slips and debris-flows. In the event of a major earthquake (Mw 7.0 or greater) on the Whittier-Elsinore fault, Sierra Madre thrust fault or Puente Hills blind thrust, seismically induced slope failures within the sloping terrain of the Montebello Hills or the Puente Hills cannot be precluded.

TABLE 4.7-20
SUMMARY OF SOIL UNIT CHARACTERISTICS – SEGMENT 8[1]

			Risk of Corrosion	
Soil Series or Association	Description	Hazard of Erosion on Roads and Trails[2]	Uncoated Steel	Concrete
Segment 8A				
Fontana	Clay loam, 15 to 50% slopes	Severe	High	Low
Gaviota	Rock outcrop complex	Moderate	High	Low
Chualar	Clay Loam, 2 to 15% slopes	Moderate to severe	High	Low
Sorrento	Clay loam, 0 to 2% slopes	Slight	High	Low
Chino	Silt loam	Slight	High	Low
Grangeville	Fine sandy loam	Slight	High	Low
Merrill	Silt loam	Not Rated	Not Rated	Not Rated
Hilmar	Loamy fine sand	Slight	High	Low
Tujunga	Loamy sand, 0 to 5% slopes, fine sandy loam	Slight	Moderate	Low
Delhi	Fine sand	Slight	Moderate	Low
Hanford	Coarse sandy loam, 2 to 9% slopes, fine sandy loam, silt loam	Moderate	Moderate	Low
Ramona	Loam	Moderate	Moderate	Moderate
Altamont	Clay loam	NA	NA	Na
Yolo	Loam	Slight to Moderate	Low	Low
Upper San Gabriel river	Granitic substratum, steep slopes	Severe	NA	NA
Segments 8B and 8C				
Chino	Silt loam	Slight	High	Low
Grangeville	Fine sandy loam	Slight	High	Low
Hilmar	Loamy fine sand	Slight	High	Low
Tujunga	Loamy sand, 0 to 5% slopes	Slight	Moderate	Low
Delhi	Fine sand	Slight	Moderate	Low

[1] Source for soils mapping and characteristics: SSURGO, San Bernardino Area, California, GIS, and LADWP, GIS.

[2] Qualitative descriptors of erosion hazard: Slight = little or no erosion is anticipated, Moderate = some erosion anticipated, Severe = significant erosion hazard.

These fault zones are thought capable of producing earthquakes approaching magnitude Mw 7.5 and ground motions could exceed 1 g during such an event (USGS, 2002). Seismically induced slope instability has the potential to undermine foundations, cause distortion and distress to overlying structures, and displace or destroy Project components. Damage to, or failure of, the proposed T/L segment could result in temporary electrical transmission outages.

The recurrence interval for major earthquakes on these faults is estimated to range from 250 years for the Whittier-Elsinore fault to 2,000 to 3,000 years for the Puente Hills blind thrust (Dolan et al, 2003) to perhaps greater than 6,000 to 8,000 years for the Sierra Madre fault (Rubin et al., 1998; Tucker et al., 2001). The earthquake recurrence intervals for these faults exceed the design life of the proposed TRTP and are therefore considered unlikely to result in catastrophic failure of Project components.

Smaller seismically induced slope instability could damage Project components and could thus potentially result in temporary outages along the affected T/L. As required by the North American Electric Reliability Corporation, the Western Electricity Coordinating Council, and the California Independent System Operators, the regional transmission system is designed to provide transmission reliability. Should a T/L not be operational as a result of an accident, seismic event, or fire, or is taken out of service to permit safe maintenance, redundancy in the transmission system allows electrical transmission with no or only brief service interruptions to load areas. Temporary outages along the proposed T/L segment as a result of seismically induced slope instability would be avoided or minimized because of the redundancy incorporated into the transmission system and, therefore, the potential impacts are less than significant.

Seismic design standards would be followed (APM GEO-1) and a design-level geotechnical survey (APM GEO-2) would be performed to evaluate the potential for unstable slopes, landslides, earth flows, soil slips and debris flows along the proposed segment. Overhead T/L structures may be placed to avoid and span slide areas. To the extent feasible, facilities would be located away from very steep hillsides, debris-flow source areas, the mouths of steep side-hill drainages, and the mouths of canyons that drain steep terrain. In cases of shallow sliding, slope creep, or raveling, specially designed deep foundations may be used to anchor the overlying structure to underlying, competent material. As appropriate, stabilization of unstable slopes would be performed by excavating and removing unstable material, regrading unstable slopes to improve surface drainage and limit infiltration, installing subsurface drainage systems, and/or constructing retaining structures to mechanically restrain slope movement.

With implementation of APM GEO-1 and APM GEO-2, potential impacts to the proposed T/L and subsequent outages resulting from seismically induced slope instability are less than significant.

Would the Project result in substantial soil erosion or the loss of topsoil?

Some soil types along the route are subject to moderate or severe erosion on roads and trails. Such areas, if not stabilized, could be subject to increased rates of erosion by wind and/or water. Soil erosion is a potentially significant impact. APM GEO-2 calls for geotechnical studies and good engineering practices, and APM GEO-3 calls for appropriate soil erosion/water quality protection measures as specified in the Construction SWPPP. Implementation of APM GEO-2 and APM GEO-3 would reduce significant erosion impacts during operation of the Project to a less-than-significant level.

Would the Project be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the Project and potentially result in onsite or offsite landslide, lateral spreading, subsidence, liquefaction or collapse?

Subsidence and collapsible soils are not expected to be a potential hazard along the Segment 8 route and pose no impact to the Project. Segment 8 could be impacted by unstable geologic units and soil conditions that include landslides and areas of liquefaction potential as discussed above. These unstable geologic units and soils could impact the Project to varying degrees. Implementation of APMs GEO-1 and GEO-2 would reduce any potential impacts to a less-than-significant level.

Would the Project be located on expansive soil, creating substantial risks to life or property?

Expansive soils could occur within portions of Segment 8. Significant impacts resulting from expansive clays are conceivable in the Project area, but are not considered likely based on the geologic setting. If expansive soils are identified during design level studies, geotechnical study (APM GEO-2) recommendations would be implemented to reduce the impacts of expansive soils to a less-than-significant level.

Would the Project have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?

No impacts are expected. The TRTP would not construct septic tanks, and use of existing septic tanks during construction is not anticipated, as workers would use portable toilets.

Waste would be pumped out by qualified contractors and disposed of in accordance with all applicable regulations and codes.

4.7.6.5.3 Mitigation Measures. The aforementioned APMs have been incorporated into the Project design and apply to this segment; therefore, any potentially significant impacts have been avoided or reduced to a less-than-significant level, and no mitigation is required.

4.7.6.5.4 Impact Significance After Mitigation Measures. The potential impacts from geologic hazards and potential impacts to geology and soils associated with construction and operation of Segment 8 are considered to be less than significant.

4.7.6.6 Segment 9

4.7.6.6.1 Environmental Setting. This section describes the existing geologic conditions, geologic hazards and soil conditions in the proposed Project area for Segment 9 of the proposed TRTP.

Segment 9 of the proposed Project consists of the following:

- Construction of a new substation (Whirlwind; three sites under consideration) in Kern County. Geologic information at the proposed substation is summarized below; additional information is provided in the Segment 4 discussion.
- Expansion of two existing substations (Antelope and Vincent) in Los Angeles County. Supplemental information to that provided below is included in the Segment 4 and 5 discussions, respectively.
- The balance of the substation work for the TRTP (i.e., Mesa, Gould, and Mira Loma substations) would be relatively minor and within the existing substation fence lines. Due to the limited scope of the proposed modifications, detailed geologic information for these substations is not presented in this section. General geologic information in the vicinity of the Mesa and Gould substations is presented as part of Segment 11, and the Mira Loma Substation is discussed as part of Segment 8.

***Physiographic Setting*.** The three alternative Whirlwind Substation sites and the proposed expansion to the existing Antelope Substation are located in the western portion of the Mojave Desert physiographic province in the Antelope Valley. The alternative Whirlwind Substation sites are located on low relief terrain between the eastern margins of the Tehachapi Mountains and agricultural land. The terrain slopes gently to the southeast with elevations ranging from approximately 2,660 to 2,730 feet msl.

The Antelope Substation and proposed expansion area are located west of Lancaster in the Antelope Valley. This is an area of low relief with an elevation of approximately 2,480 feet msl.

The proposed expansion to the Vincent Substation is located in the Transverse Ranges physiographic province on the southern edge of Soledad Canyon near Soledad Pass. Soledad Pass marks the boundary between the Sierra Pelona and the San Gabriel Mountains. The expansion is situated on a low relief alluvial surface between Soledad Canyon and Kentucky Springs Canyon at an elevation of approximately 3,200 feet msl.

***Geologic Setting*.** Table 4.7-21 presents a summary of geologic conditions at the proposed and expanded substations.

TABLE 4.7-21
GEOLOGIC CONDITIONS – SEGMENT 9[1]

Location	Geologic Unit/Structure	Formation Name	Description/Comments
Whirlwind Substation	Qa	Alluvium	Alluvial gravels, sand and silt
Antelope Substation	Qa	Alluvium	Alluvial gravels, sand and silt
Vincent Substation	Qa	Alluvium	Alluvium of upper Soledad Canyon
Vincent Substation	Qoa	Older Alluvium	Older sand and gravel fan deposits
Mesa Substation (northeast side)	Tfsc, Tfp	Fernando Formation (Tfsc) and (Tfp)	Nonmarine sandstone and conglomerate (Tfsc)/claystone; gray micaceous silty claystone or siltstone.
Mesa Substation (southwest side)	Qog	Older Alluvium	Uplifted remnants of alluvial gravel
Gould Substation (northern portion)	qd	Quartz Diorite	Plutonic rock; gray, incoherent where weathered
Gould Substation (southern portion)	af	Artificial Fill	Artificial Fill
Mira Loma Substation	Qa	Alluvium	Gravels, sands, and silts

[1] Source: State Geologic Maps series (Los Angeles Sheet, 1:250,000 scale).

The Whirlwind and Antelope substations are located in valley fill deposits that underlie the Antelope Valley. The Antelope Valley is a large, undrained topographic basin characterized by relatively flat lying topography and extensive valley fill deposits. Groundwater is relatively deep in the Antelope Valley. The San Andreas fault defines the southern margins of the Antelope Valley and the boundary with the Transverse Ranges.

The Vincent Substation is located south of the San Andreas Rift Zone at the southern edge of the Soledad Canyon drainage. The existing site and the proposed expansion area are underlain by older alluvium.

***Geologic Structure*.** The alternative Whirlwind and the existing Antelope substations are within the Antelope Valley and lie entirely within the Mojave structural block. The San Andreas fault zone to the south represents a major tectonic boundary and the boundary between the Mojave Desert structural block and the Transverse Ranges. The Vincent Substation lies adjacent to Soledad Pass which represents the boundary between the Pelona schist and the San Gabriel Mountains. The San Gabriel Mountains are cut by east-west trending faults and bounded by a steep mountain front on the south.

***Geologic Units*.** Geologic units encountered in the Project area are presented in Table 4.7-21 and are based on the State Geologic Maps series (Los Angeles Sheet, 1:250,000 scale) and the Dibblee quadrangle maps (Pacifico Mountain and Palmdale [southern half]). The geologic units are described briefly below.

***Surficial Deposits*.** Quaternary alluvium at the Whirlwind and Antelope substation locations consist of valley fill deposits of the Antelope Valley.

Older Alluvium. The older alluvial deposits underlying the Vincent substation expansion site are alluvial fan and ancient channel deposits comprised of sand and gravel shed off the adjacent hillsides or deposited by ancient stream courses emanating from Soledad Canyon.

***Geologic Hazards*.**

***Faults and Seismicity*.** Active and potentially active faults are common in southern California as shown on Figure 4.7.2. Potential seismic sources are presented in the Seismic Source Characteristics tables for each T/L segment. The relative distances of these seismic sources from the substation elements can be obtained from Tables 4.7-2 and 4.7-6 for Segments 4 and 5, respectively. The Project area is seismically very active given the proximity and number of potential seismic sources. Figure 4.7-2 presents a regional fault and epicenter map showing the approximate location of the TRTP relative to seismic sources and past earthquakes. Notable historic seismic events affecting the Project areas were presented previously in Table 4.7-3 and 4.7.7 for Segments 4 and 5 respectively.

It is likely that the Project area will experience minor to moderate earthquakes and potentially a major earthquake (moment magnitude M7, or greater) during the Project's service life.

***Fault Rupture/Fault Displacement*.** No known active faults or significant potentially active faults cross the Segment 9 elements. Further, the elements are not within any Earthquake Fault Zones nor are they adjacent to any fault with significant potential for fault rupture. Therefore, there are no known hazards associated with fault rupture along an active fault for Segment 9 substations.

***Landslides*.** Landslides are not a hazard for the Whirlwind sites or the Antelope Substation expansion site given the low relief of the Antelope Valley. Similarly, the Vincent Substation expansion site is located in an area of moderate relief and landslide hazards are not present.

***Liquefaction and Lateral Spreading*.** Liquefaction susceptible materials are present within the recent alluvial deposits, but the depth to groundwater in the Antelope Valley is very deep and therefore the liquefaction potential at the Whirlwind and Antelope substations is considered very low. A higher groundwater level could be present at the Vincent Substation and, therefore, a moderate liquefaction potential exists.

***Ground Motions*.** USGS/CGS PSHA models (CGS, 2002, revised April 2003) depict ground motions associated with a 10 percent probability of exceedance in a 50 year period. For Segment 9, the PGA estimates for the Whirlwind, Antelope and Vincent substations are 0.47g, 0.64g and 0.59g, respectively.

***Expansive and Collapsible Soils*.** Some potential for collapsible materials may be present in the fine-grained alluvial soils at Whirlwind and Antelope substations. The predominate soil types at the substations are sandy and are not expected to be expansive.

***Subsidence*.** Subsidence has been documented within portions of the Antelope Valley, as discussed for Segment 4, where extensive groundwater withdrawal has been occurring for many years. The margins of this zone of subsidence may impact the Whirlwind and Antelope substation sites. This type of regional deformation is not generally a significant hazard to substation facilities because the individual foundation elements of these types of structures would not experience significant differential settlement as a result of subsidence. Subsidence is not expected in the vicinity of the Vincent Substation.

***Soils*.** The soils at the substation sites reflect the underlying rock type, the extent of weathering of the rock, the degree of slope, and the degree of modification by man. Soil data for the Project was obtained from the SSURGO database for Antelope Valley Area, California (Publication Date: January 4, 2007).

A summary of the significant characteristics, including the description, hazard of erosion on roads and trails, and risk of corrosion of the major soil units at the substations, is presented in Table 4.7-22.

4.7.6.6.2 Impact Analysis. The potential impacts to or from geologic, seismic, and soil conditions at the proposed Segment 9 elements are discussed below. The discussion follows the significance criteria presented in Section 4.7.4.

***Impact Summary*.** Construction, operation, and maintenance of the proposed TRTP Project Segment 9 elements would not create a significant hazard to the public or the environment relative to geology, soils, or geologic hazards. The proposed Project Segment 9 elements are not located within any designated geologic hazard zones based on a review of State and local regulations. The proposed Project could be subject to moderate or high levels of ground shaking in the event of an earthquake on faults in the region. Impacts to soils would occur during construction with increased traffic and grading associated with substation construction and/or expansion. APMs would reduce impacts to less than significant levels.

***Construction*.** The impact analysis for construction of Segment 9 is based on the significance criteria detailed above in Section 4.7.4. The construction related impacts for Segment 9 are essentially the same as described for Segment 4 in Section 4.7.6.1.2.

***Operations*.**

Would the Project expose people or structures to adverse effects as a result of rupture of an Alquist-Priolo Earthquake Fault or other substantial known fault?

The Segment 9 elements are not within any Alquist-Priolo Earthquake Fault Zones or in the immediate vicinity of any substantial faults that represent a fault rupture hazard. There are no significant impacts to Segment 9 as a result of fault rupture.

Would the Project expose people or structures to adverse effects as a result of seismic ground shaking?

Project structures could be impacted by strong ground motions as a result of a significant earthquake in the area. Regional planning level evaluations of probabilistic seismic hazards suggest that Segment 9 could experience mean PGAs ranging from 0.41g to 0.47g for the hazard level associated with a 10 percent probability of exceedance in 50 years. Such moderate to strong levels of ground shaking could damage Project structures if they were not properly designed. Ground shaking represents a potentially significant hazard to Segment 9. Standard design and construction practices following appropriate code and industry standards

TABLE 4.7-22
SUMMARY OF SOIL UNIT CHARACTERISTICS – SEGMENT 9[1]

Substation	Soil Series or Association	Description	Hazard of Erosion[2]	Risk of Corrosion	
				Uncoated Steel	Concrete
Windhub	Cajon	Gravelly loamy sand, 0 to 9% slopes	Moderate to slight	Moderate	Low
	Garlock	Loamy Sand, 2 to 9% slopes	NA	NA	NA
Whirlwind, Alt. A	Hesperia	Fine sandy loam, 0 to 5% slopes	Slightly to moderate	High	Low
Whirlwind, Alt. B	Hesperia	Fine sandy loam, 0 to 5% slopes	Slightly to moderate	High	Low
	Rosamond	Loam	Slight	High	Low
Whirlwind, Alt. C	Hesperia	Fine sandy loam, 0 to 5% slopes	Slightly to moderate	High	Low
	Rosamond	Loam	Slight	High	Low
Antelope	Greenfield	Sandy loam, 2 to 9% slopes	Moderate	Low	Low
Vincent	Hanford	Sandy loam, 2 to 9% slopes	Moderate to slight	Low	Low
	Terrace	Escarpments	Severe	NA	NA
Gould	Mollic Haploxeralfs	2 to 50 percent slopes	Severe	NA	NA
Mesa	Altamont	Clay loam	No data (LADWP)	NA	NA
	Ramona	Loam	Moderate	Moderate	Moderate
Mira Loma	Delhi	Fine sand	Slight	Moderate	Low

[1] Source for soils mapping and characteristics: SSURGO, Antelope Valley Area, California, GIS; Angeles National Forest Area, California, GIS.

[2] Qualitative descriptors of erosion hazard: Slight = little or no erosion is anticipated, Moderate = some erosion anticipated, Severe = significant erosion hazard.

as implemented by APMs GEO-1 and GEO-2 would reduce the impacts from ground shaking to less-than-significant levels.

Would the Project expose people or structures to adverse effects as a result of seismic related ground failure including liquefaction.

Seismic related ground failure could include landslides, liquefaction, lateral spreading, and ground-cracking. The geologic setting of Segment 9 includes very low relief and primarily deep ground water. Design level geotechnical and geologic hazards investigations would be performed to verify this preliminary evaluation (APM GEO-2). Impacts resulting from seismic related ground failures appear unlikely. Any impacts would be expected to be less than significant.

Would the Project expose people or structures to adverse effects as a result of landslides?

No landslides have been mapped at the Segment 9 element locations and the geologic setting indicates that landslides are unlikely to occur at these locations. Landslides do not represent a significant hazard to the Project for Segment 9. No impacts are expected.

Would the Project result in substantial soil erosion or the loss of topsoil?

Some soil types within the Segment are subject to moderate or severe erosion. Such areas, if not stabilized, could be subject to increased rates of erosion by wind and/or water. Soil erosion is a potentially significant impact. APM GEO-2 calls for geotechnical studies and good engineering practices, and APM GEO-3 calls for appropriate soil erosion/water quality protection measures as specified in the Construction SWPPP. Implementation of APM GEO-2 and APM GEO-3 would reduce significant erosion impacts during operation of the Project to a less-than-significant level.

Would the Project be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the Project and potentially result in onsite or offsite landslide, lateral spreading, subsidence, liquefaction or collapse?

The Segment 9 elements are generally located in areas characterized by deep groundwater, alluvial soils and gently sloping to flat-lying terrain. Landslides, liquefaction, and lateral spreading are not significant hazards in this setting and are not expected to pose an impact to the Project. Design level geotechnical and geologic hazards investigations would be performed to verify this preliminary evaluation (APM GEO-2).

Subsidence is documented within the general vicinity of Whirlwind and Antelope substations, however, the style and magnitude of the surface deformation associated with this zone of subsidence does not pose a significant impact to these substations.

Collapsible soils are a potential hazard in the Mojave Desert (Whirlwind and Antelope substations), and if present within the limits of a Project structure, could pose a significant impact if collapse were to occur. Collapsible soils would be recognized and evaluated during site specific geotechnical investigation (APM GEO-2).

Implementation of APMs GEO-1 and GEO-2 at the various substation sites would reduce any potential impacts to a less-than-significant level.

Would the Project be located on expansive soil, creating substantial risks to life or property?

Extensive areas of expansive soils are not anticipated in the generally granular soil conditions anticipated in the Segment 9 portions of the Project area. However, localized areas of expansive clays could be encountered. Significant impacts resulting from expansive clays are conceivable in the Project area, but are not considered likely based on the geologic setting. Implementation of APMs GEO-1 and GEO-2 at the various substation sites would reduce any potential impacts to a less-than-significant level.

Would the Project have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?

No impacts are expected. The TRTP would not construct septic tanks, and use of existing septic tanks during construction is not anticipated, as workers would use portable toilets. Waste would be pumped out by qualified contractors and disposed of in accordance with all applicable regulations and codes.

4.7.6.6.3 Mitigation Measures. The aforementioned APMs have been incorporated into the Project design and apply to this segment; therefore, any potentially significant impacts have been avoided or reduced to a less-than-significant level, and no mitigation is required.

4.7.6.6.4 Impact Significance After Mitigation Measures. The potential impacts from geologic hazards and potential impacts to geology and soils associated with construction and operation of Segment 9 are considered to be less than significant.

4.7.6.7 Segment 10

4.7.6.7.1 Environmental Setting. This section describes the existing geologic conditions, geologic hazards and soil conditions in the proposed Project area for Segment 10 of the proposed TRTP.

Physiographic Setting. Segment 10 traverses the western portion of the Mojave Desert physiographic province along the eastern flanks of the Tehachapi Mountains. The Sierra Nevada Batholith lies to the northwest. The segment begins at the previously permitted Windhub Substation, located at the westerly edge of the Mohave Desert. As shown on the Detailed Project Location Maps (Figure P.1-2) in Appendix P, the terrain slopes gradually down to the southeast, away from the Tehachapi Mountains. The proposed Segment 10 and Alternates 10A and 10B continue to the southeast, roughly paralleling the base of the Tehachapi Mountains, and in some locations extending onto the base of the mountains. The terrain continues to slope generally to the southeast along the proposed alignment, with numerous creeks and drainages from the Tehachapi Mountains crossing the alignment. The segment terminates near the proposed and alternative Whirlwind Substation sites in an area of low relief terrain within the Antelope Valley at the margins of agricultural land.

***Geologic Setting*.** The routes traverse the varied geologic conditions associated with the Mojave Desert physiographic province discussed above. The segment lies primarily within alluvium typical of the Mojave Desert and the Antelope Valley, and in some locations extends westward into Pleistocene non-marine colluvial deposits, an alluvial fan complex associated with the Tehachapi Mountains. Table 4.7-23 presents a summary of geologic conditions by milepost for the Segment 10 Project routes.

The Windhub Substation is located with in the alluvial deposits of the Mohave Desert near the mouth of Oak Creek along the toe of the Tehachapi Mountains. Further south along the Segment 10 route, the alignment flanks the Tehachapi Mountains, crossing sloping dissected terrain underlain by alluvial fan deposits and eroded by active drainages. The Antelope Valley, encountered in the southern portion of the route, is a large, undrained topographic basin characterized by relatively flat lying topography and extensive valley fill deposits. Other than immediately adjacent to the drainages, groundwater is relatively deep in the Mojave Desert and the Antelope Valley.

***Geologic Structure*.** Segment 10 traverses the Mojave structural block and the flat lying alluvial deposits laid down in the Mojave Desert. The routes skirt the toe of the Tehachapi Mountains, in some locations extending eastward onto southeastern-dipping alluvial fan deposits shed off of the predominantly granitic terrain of the Tehachapi Mountains. The Tehachapi Mountains represent the southern margin of the Sierra Nevada structural block. This margin is largely defined by the Garlock fault.

The Mojave Desert and its southern extension, the Antelope Valley, are defined on their southern boundary by the San Andreas fault, well south of Segment 10. Ancient faults are mapped east and west of the Project and project towards Segment 10 near S10 MP 12. No fault is mapped crossing Segment 10, however the Cottonwood fault is named west of the route, and the Willow Springs fault, becoming the Rosamond fault further east, is mapped to the east of the route. This fault zone in part forms the northern boundary of the Antelope Valley, a downfaulted structural depression between the Cottonwood-Rosamond faults and the San Andreas fault zone.

TABLE 4.7-23
GEOLOGIC CONDITIONS – SEGMENT 10[1]

Approximate Milepost	Geologic Unit/Structure	Formation Name	Description/Comments
Segment 10			
0.0 – 3.5	Qa	Alluvium	Alluvial gravels, sand and silt
3.5 – 4.2	Qc	Pleistocene nonmarine	Unconsolidated alluvial gravels, sand and silt
4.2 – 4.6	Qa	Alluvium	Alluvial gravels, sand and silt
4.6 – 5.1	Qc	Pleistocene nonmarine	Unconsolidated alluvial gravels, sand and silt
5.1 – 16.8	Qa	Alluvium	Alluvial gravels, sand and silt
Alternative Segment 10A			
0.0 – 2.1	Qoa, Qa	Older Alluvium (Qoa), Alluvium (Qa)	Sand and gravel fan deposits
2.1 – 2.4	Qg, Qoa, Qa	Older Alluvium (Qoa), Alluvium (Qa), Alluvium Fan (Qg)	Sand and gravel fan deposits
2.4 – 7.3	Qoa, Qa	Older Alluvium (Qoa), Alluvium (Qa)	Sand and gravel fan deposits
4.7	Fault	Cotton Wood Fault	Projection of fault, buried beneath alluvium if present. Not a significant seismic source
4.7 – 6.7	Qg, Qoa, Qa	Older Alluvium (Qoa), Alluvium (Qa), Alluvium Fan (Qg)	Sand and gravel fan deposits
6.7 – 8.6	Qoa, Qa	Older Alluvium (Qoa), Alluvium (Qa)	Sand and gravel fan deposits
Alternative Segment 10B			
0.0 – 5.5	Qoa, Qa	Older Alluvium (Qoa), Alluvium (Qa)	Sand and gravel fan deposits
5.5	Fault	Cotton Wood Fault	Projection of fault, buried beneath alluvium if present. Not a significant seismic source
5.5 – 7.3	Qoa	Older Alluvium	Sand and gravel fan deposits
7.3 – 7.7	Qg, Qoa, Qa	Older Alluvium (Qoa), Alluvium (Qa), Alluvium Fan (Qg)	Sand and gravel fan deposits
7.7 – 9.6	Qoa, Qa	Older Alluvium (Qoa), Alluvium (Qa)	Sand and gravel fan deposits

[1] Source: State Geologic Maps series (Bakersfield Sheet, 1:250,000 scale).

<u>Geologic Units</u>**.** Geologic units encountered in the Project area for Segment 10 are presented in Table 4.7-23 and are based on the State Geologic Maps series (Bakersfield and Los Angeles Sheets, 1:250,000 scale). The geologic units are described briefly below.

***Surficial Deposits*.** Quaternary alluvium includes the valley fill deposits of the Mojave Desert and the distal fan deposits associated with the adjacent Tehachapi Mountains.

***Ancient Alluvial Fan*.** Pleistocene-age deposits of older alluvial fans are present throughout the Segment 10 route. Slightly-cemented silty-gravelly sands are typical materials encountered within the older fan deposits.

***Geologic Hazards*.**

***Faults and Seismicity*.** Active and potentially active faults have been mapped in the region. Table 4.7-24 presents a list of active and potentially active faults within approximately 60 miles of Segment 10.

The Project area is seismically active given the proximity and number of potential seismic sources. Figure 4.7-2 presents a regional fault and epicenter map showing the approximate location of the TRTP relative to seismic sources and past earthquakes. Notable historic seismic events affecting the Project area are presented in Table 4.7-25.

It is likely that the Project area will experience minor to moderate earthquakes and potentially a major earthquake (moment magnitude M7, or greater) during the Project's service life. A 1995 estimate by the Working Group on California Earthquake Probabilities gave an 80 to 90 percent probability of an M7 or greater earthquake in southern California before 2024.

***Fault Rupture/Fault Displacement*.** Segment 10 does not cross any known active faults or significant potentially active faults. Further, it does not cross any Earthquake Fault Zones or any fault with significant potential for fault rupture. Therefore, there are no known hazards associated with fault rupture along an active fault for Segment 10.

***Landslides*.** The Segment 10 Project area has not been mapped at the quadrangle level by the State hazard mapping program. However, landslides are not a significant hazard within the Segment 10 routes because of the moderate to gentle terrain traversed.

***Liquefaction and Lateral Spreading*.** Liquefaction is not considered a significant potential hazard along Segment 10 based on the available information. Liquefaction susceptible materials are present within the recent alluvial deposits, but with the exception of the drainages from the Tehachapi Mountains, the depth to groundwater in the Mojave Desert is deep and, therefore, the liquefaction potential is considered low.

***Ground Motions*.** USGS/CGS PSHA models, (CGS, 2002, revised April 2003) depict ground motions associated with a 10 percent probability of exceedance in a 50 year period.

TABLE 4.7-24
SEISMIC SOURCE CHARACTERISTICS – SEGMENT 10

Fault Name	Nearest Distance to Segment 10 (Miles)[1]	Type of Faulting[2]	Fault Length (Miles)[2]	Slip Rate[2] (mm/year)	Maximum Magnitude Earthquake[2] (Mmax)
Clamshell-Sawpit Canyon	52	Reverse	11	0.5	6.5
Garlock	4	Left-lateral strike-slip	155	7	7.1
Elsinore, Chino segment	75	Right-lateral strike-slip	13	4	6.8 – 7.1
Hollywood	51	Left reverse	9	1	6.5
Holser	29	Reverse	12	0.4	6.5
Lenwood-Lockhart	31	Right-lateral strike-slip	45	0.8	7.4
Little Lake	52	Right-lateral strike-slip	28	1	7
Newport-Inglewood	53	Right-lateral strike-slip	47	0.6	6.9
North Ridge Blind Thrust	33	Blind Thrust	31	1.5	7
Oak Ridge	36	Thrust	56	3.5 – 6	6.9
Pleito Thrust	27	Thrust	28	1.4	6.8
Puente Hills Blind Thrust	48	Blind Thrust	40	0.7	7.1
Raymond	53	Left-lateral reverse	16	1.5	6.5
San Andreas – Mojave Segment	3	Right-lateral strike-slip	64	30	7.9
San Andreas – Carrizo Segment	37	Right-lateral strike-slip	90	34	7.9
San Cayetano	34	Thrust	28	6	6.8
San Fernando	35	Thrust	10	5	6.8
San Gabriel	37	Right-lateral strike-slip	87	1	7
San Jacinto, Glen Helen segment	52	Right-lateral strike-slip	46	12	6.9
Santa Susana	36	Thrust	23	5	6.6
Santa Ynez	32	Left reverse	81	.7	7.5
Sierra Madre	41	Reverse	46	2	7
Simi (Santa Rosa)	39	Reverse	24	1	6.7
Southern Sierra Nevada	23	Normal	40	.5	7
Upper Elysian Park Blind thrust	48	Blind thrust	18	0.8	6.8
White Wolf	26	Left-lateral reverse	37	2	7.2

[1] Fault distances based on Jennings, 1994.

[2] Source: CGS, 2003; SCEC, www.scec.org.

TABLE 4.7-25
SIGNIFICANT HISTORIC EARTHQUAKES – SEGMENT 10

Date	Approximate Distance to Project Segment 10[1] (Miles)	Earthquake Magnitude[2]	Name, Location or Region Affected
December 8, 1812	86	7.5?	Wrightwood Earthquake
July 11, 1855	19	6.0	Los Angeles Region
January 9, 1857	106	Estimated from 7.9 to 8.25	Fort Tejon Earthquake
January 16, 1857	Unknown	6.3	Generally felt in the Los Angeles Region
July 29, 1894	76	6.2	Lytle Creek region
July 21, 1952	35	7.3	Kern County Earthquake
February 9, 1971	43	6.6	San Fernando (Sylmar) Earthquake
October 1, 1987	60	5.9	Whittier Narrows Earthquake
January 17, 1994	50	6.7	Northridge Earthquake

[1] Earthquake magnitudes and locations before 1932 are estimated by Toppozada and others (1978, 1981, and 1982) based on reports of damage and felt effects.

[2] Earthquake damage information compiled from the Southern California Data Center (SCEDC, 2006a and 2006b) and National Earthquake Information Center (NEIC, 2005) websites. Additional comments on the earthquakes are provided in the Segment 4 discussion.

For Segment 10, the ground motion estimate for the start of the segment at the Windhub Substation is about 0.41g and at the Whirlwind Substation near the southern terminus of the segment is approximately 0.47g for the PGA.

***Expansive and Collapsible Soils*.** Some potential for expansive or collapsible materials may be present in the Antelope Valley. Collapsible soils, if present within the Project area, are most likely in the fine-grained desert soils. Extensive areas of expansive soils are not anticipated in the generally granular soil conditions encountered in the Segment 10 portion of the Project area.

***Subsidence*.** Subsidence has been documented in the area around Edwards Air Force Base and the Lancaster area where extensive groundwater withdrawal has been occurring for many years (USGS, 1995, 2000). However, significant subsidence is not known to have affected the area in the immediate vicinity of Segment 10 (Kern County, 2004). Regardless, this type of regional deformation is not generally a significant hazard to overhead transmission lines or substation facilities because the individual foundation elements of these types of structures would not experience significant differential settlement as a result of subsidence.

***Soils*.** The soils along the proposed and alternative Segment 10 T/L routes reflect the underlying rock type, the extent of weathering of the rock, the degree of slope, and the degree of modification by man. Soil data for the Project was obtained from the SSURGO database for Antelope Valley Area, California (Publication Date: January 4, 2007).

A summary of the significant characteristics, including the description, hazard of erosion on roads and trails, and risk of corrosion of the major soil units traversed by Segment 10, is presented in Table 4.7-26; soil units are listed in order of first occurrence along the segment and may occur in multiple locations.

TABLE 4.7-26
SUMMARY OF SOIL UNIT CHARACTERISTICS – SEGMENT 10[1]

Soil Series or Association	Description	Hazard of Erosion on Roads and Trails[2]	Risk of Corrosion	
			Uncoated Steel	Concrete
Segment 10				
Garlock	Loamy sand, 2 to 9% slopes	Moderate	High	Low
Cajon	Loamy sand, Gravelly loamy sand, 0 to 9% slopes	Slight to Moderate	Moderate	Low
Adelanto	Loamy sand, 2 to 5% slopes	Moderate	High	Low
Hesperia	Loamy sand, 0 to 5% slopes	Slight to Moderate	High	Low
Hanford	Sandy loam, Coarse sandy loam, 2 to 9% slopes	Moderate	Low	Low
Arizo	Gravelly loamy sand, 0 to 5% slopes	Slight	Moderate	Low
Alternative Segment 10A				
Cajon	Loamy sand, Gravelly loamy sand, 0 to 9% slopes	Slight to Moderate	Moderate	Low
Adelanto	Loamy sand, 2 to 5% slopes	Moderate	High	Low
Hesperia	Fine sandy loam, 2 to 5% slopes	Moderate	High	Low
Hanford	Coarse sandy loam, 2 to 9% slopes	Moderate	Low	Low
Arizo	Gravelly loamy sand, 0 to 5% slopes	Slight	Moderate	Low
Alternative Segment 10B				
Greenfield	Sandy loam, 2 to 9% slopes	Moderate	Low	Low
Cajon	Loamy sand, 0 to 9 % slopes	Moderate	Moderate	Low
Hesperia	Fine sandy loam, 2 to 5% slopes	Moderate	High	Low
Hanford	Sandy loam, Coarse sandy loam, Gravelly sandy loam, 2 to 9% slopes	Moderate	Low	Low

[1] Source for soils mapping and characteristics: SSURGO, Antelope Valley Area, California, GIS

[2] Qualitative descriptors of erosion hazard: Slight = little or no erosion is anticipated, Moderate = some erosion anticipated, Severe = significant erosion hazard.

4.7.6.7.2 Impact Analysis. The potential impacts to or from geologic, seismic, and soil conditions along the proposed and alternative Segment 10 routes are discussed below. The discussion follows the significance criteria presented in Section 4.7.4.

Impact Summary**.** Construction, operation, and maintenance of the proposed TRTP Project Segment 10 would not create a significant hazard to the public or the environment relative to geology, soils, or geologic hazard. The proposed Project element is not located within any designated geologic hazard zones based on a review of State and Local regulations. The proposed Project could be subject to moderate or high levels of ground shaking in the event of an earthquake on faults in the region. Impacts to soils would occur during construction with increased traffic and grading associated with pads and roads for T/L construction. APMs would reduce impacts to less than significant levels.

Construction**.** The impact analysis for construction of Segment 10 is based on the significance criteria detailed above in Section 4.7.4. The construction related impacts for Segment 10 are essentially the same as described for Segment 4 in Section 4.7.6.1.2.

Operations**.**

Would the Project expose people or structures to adverse effects as a result of rupture of an Alquist-Priolo Earthquake Fault or other substantial known fault?

Segment 10 does not cross any Alquist-Priolo Earthquake Fault Zones or any other substantial faults that represent a fault rupture hazard. There are no impacts to Segment 10 as a result of fault rupture.

Would the Project expose people or structures to adverse effects as a result of seismic ground shaking?

Project structures could be impacted by strong ground motions as a result of a significant earthquake in the area. Ground shaking would present a significant hazard to Segment 10. Implementation of APMs GEO-1 and GEO-2 would reduce any potential impacts to a less-than-significant level.

Would the Project expose people or structures to adverse effects as a result of seismic related ground failure including liquefaction.

Seismic-related ground failure could include liquefaction, lateral spreading, and ground-cracking. The geologic setting of Segment 10 includes very low relief and primarily deep ground water. Therefore, impacts resulting from seismic related ground failures appear unlikely. Design level geotechnical and geologic hazards investigations would be performed to verify this preliminary evaluation (APM GEO-2). Implementation of APMs GEO-1 and GEO-2 would reduce any potential impacts to a less-than-significant level.

Would the Project expose people or structures to adverse effects as a result of landslides?

No landslides have been mapped along Segment 10 and the geologic setting indicates that landslides are unlikely to occur along the route. Landslides do not represent a significant hazard to the Project for Segment 10. No impacts to Segment 10 from landslides are expected.

Would the Project result in substantial soil erosion or the loss of topsoil?

Some soil types along the route are subject to moderate erosion on roads and trails. Such areas, if not stabilized, could be subject to increased rates of erosion by wind and/or water. Soil erosion is a potentially significant impact. APM GEO-2 calls for geotechnical studies and good engineering practices, and APM GEO-3 calls for appropriate soil erosion/water quality protection measures as specified in the Construction SWPPP. Implementation of APM GEO-2 and APM GEO-3 would reduce significant erosion impacts during operation of the Project to a less-than-significant level.

Would the Project be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the Project and potentially result in onsite or offsite landslide, lateral spreading, subsidence, liquefaction or collapse?

Segment 10 is located entirely with the western portion of the Mojave Desert, characterized by deep groundwater, alluvial soils and gently sloping to flat-lying terrain. Landslides, liquefaction, and lateral spreading are not significant hazards in this setting and pose no potentially significant impacts to the Project.

Subsidence is documented within the general vicinity of the Segment 10 routes; however, the style and magnitude of the surface deformation associated with this zone of subsidence does not pose potentially significant impacts to Segment 10.

Collapsible soils are a potential hazard in the Mojave Desert and, if present within the limits of a Project structure, could pose a significant impact if collapse were to occur. Collapsible soils would be recognized and evaluated during site specific geotechnical investigation.

Implementation of APMs GEO-1 and GEO-2 would reduce any potential impacts related to unstable geologic units or soils to a less-than-significant level.

Would the Project be located on expansive soil, creating substantial risks to life or property?

Extensive areas of expansive soils are not anticipated in the generally granular soil conditions encountered in the Segment 10 portion of the Project area. However, localized areas of expansive clays could be encountered. Significant impacts resulting from expansive clays are considered very unlikely. Implementation of APM GEO-2 would reduce any potential impacts to a less-than-significant level.

Would the Project have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?

No impacts are expected. The TRTP would not construct septic tanks, and use of existing septic tanks during construction is not anticipated, as workers would use portable toilets. Waste would be pumped out by qualified contractors and disposed of in accordance with all applicable regulations and codes.

4.7.6.7.3 Mitigation Measures. The aforementioned APMs have been incorporated into the Project design and apply to this segment; therefore, any potentially significant impacts have been avoided or reduced to a less-than-significant level, and no mitigation is required.

4.7.6.7.4 Impact Significance After Mitigation Measures. The potential impacts from geologic hazards and potential impacts to geology and soils associated with construction and operation of Segment 10 are considered to be less than significant.

4.7.6.8 Segment 11

4.7.6.8.1 Environmental Setting. This section describes the existing geologic conditions, geologic hazards and soil conditions in the proposed Project area for Segment 11 of the proposed TRTP.

Physiographic Setting**.** Segment 11 extends across the Transverse Ranges physiographic province and into the Los Angeles Basin, a subprovince of the Peninsular Ranges physiographic province. The boundary between these distinct regions is the base of the San Gabriel Mountains. The Transverse Ranges is characterized by mountainous terrain of the San Gabriel Mountains and lies with the Angeles National Forest. Elevations range from approximately 3,200 feet msl at the Vincent Substation to over 5,600 feet near the Little Gleason Forestry Plantation. Segment 11 ends approximately 11 miles into the Los Angeles Basin south of the range front and within Montebello Hills. The Montebello Hills are one of a series of low, east-west trending hills in the Basin that include the Whittier Hills and the Puente Hills to the east.

The route crosses numerous drainages and canyons including; Kentucky Springs Canyon, North Fork Mill Creek, Big Tujunga Canyon, Clear Creek, Arroyo Seco, Fern Canyon, El Prieto Canyon, Millard Canyon, Las Flores Canyon, and Eaton Wash. The route crosses Big Tujunga Canyon about 1 mile upstream of Tujunga Dam.

***Geologic Setting*.** In the Transverse Ranges the Segment 11 route traverses mountainous terrain underlain by crystalline bedrock units with alluvial cover in the intervening valleys and drainages. Bedrock units include various plutonic and metamorphic rocks exposed in the core of the uplifted San Gabriel Mountains. These rocks are generally of Mesozoic-age and older. The transition into the L.A. Basin is marked by broad ancient alluvial fans and outwash channels that drain the basin. A summary of geologic conditions along the route is presented in Table 4.7-27.

The active tectonic forces of the region result in continued uplift of the San Gabriel Mountains. This geologically rapid uplift rate results in high rates of erosion within the range and along the steep range front. Deeply incised gorges and canyons mark the southern range front.

***Geologic Structure*.** The structural geology of the Transverse Ranges is dominated by the compressional tectonic setting (north-south shortening) that results from the large bend in the San Andreas fault zone to the east. The active compressional environment of the Transverse Ranges has resulted in significant uplift, tilting, folding and faulting. As a result, much of the route is underlain by moderate to steep terrain and moderate to steeply dipping bedding or foliation in the granitic and metamorphic rock.

The Transverse Ranges are cut by numerous active east-west trending faults that help accommodate the compression or shortening that is taking place. These faults are mainly thrust or thrust-oblique type and result in older geologic units being thrust up and over younger units. The Sierra Madre fault is a dramatic example of thrust faulting located at the base of the range front in the Project area. This range front thrust fault has a complex surface expression.

As the route extends away from the range front it enters the L.A. Basin. The L.A. Basin represents a very complex structural zone. In the Miocene epoch the basin was formed by a largely extensional tectonic regime. In the early Pliocene epoch, the tectonic regime became compressional. Currently, a series of major strike slip faults enter the basin from the Peninsular Ranges to the south. The strike slip tectonic regime gives way to predominantly compressional features in the central and northern portions. Thrust faults, left-lateral strike slip faults, thrust-oblique faults, and low angle buried faults or “blind” thrust faults are all present in the central and northern portions of the basin. These compressional forces and in particular the blind thrusts are responsible for the uplifted and folded sedimentary rocks exposed along a series of anticlinal structures in the Project area. These anticlinal hills include the Montebello Hills, the Whittier Hills and the Puente Hills. The Puente Hills blind thrust underlies the Project area at depths ranging from an estimated 2 to 8 miles and extends approximately 25 miles from Glendale to Covina. This shallow dipping thrust fault represents a significant seismic source for the Project area (Dolan, et al. 2003).

***Geologic Units*.** Geologic units encountered in the Segment 11 Project area are presented in Table 4.7-27 and are based on the Dibblee map sheets listed in the table notes. The geologic units are described briefly below.

***Surficial Deposits*.** Quaternary alluvial deposits consisting primarily of sandy to gravelly channel deposits are present locally throughout the Transverse Ranges portion of the Project. In addition, landslide deposits are common in the steeper terrain of the San Gabriel Mountains and have been mapped in and adjacent to the route based on a review of the Dibblee quadrangle maps and the CGS seismic hazard mapping program. In the L.A. Basin, the alluvial deposits include floodplain deposits and channel deposits ranging from sands to gravels.

***Ancient Alluvial Fan*.** Pleistocene-age deposits of older alluvial fans are present throughout the segment. Slightly cemented silty gravelly sands and sandy gravels are typical materials encountered within these older fan deposits.

Tertiary Sedimentary Rocks. Tertiary sedimentary rocks underlie the Montebello Hills including the Fernando Formation mapped by Dibblee (Pasadena Quad). The Fernando Formation is comprised of Pliocene-age marine sediments, primarily sandstones.

***Granitic Rocks*.** Crystalline rocks of varying granitic composition are encountered in Segment 11 and represent the dominate rock types. Rock types include quartz diorite, granodiorite, diorite, gabbro and anorthosite. The granitic rocks are commonly foliated.

***Metamorphic Rocks*.** These are the oldest rocks in the study area and include primarily gneissic rocks that have been complexly intruded by the younger granitic rocks. The gneissic rocks are generally banded and foliated.

TABLE 4.7-27
GEOLOGIC CONDITIONS – SEGMENT 11[1]

Approximate Milepost	Geologic Unit/Structure	Formation Name	Description/Comments
0.0 – 0.4	Qg, Qoa	Older Alluvium (Qoa), Alluvium Fan (Qg)	Sand and gravel fan deposits
0.4 – 2.4	hdg	Hornblende Diorite Gabbro	Mafic Plutonic and Gneissic rock, Dark gray to nearly black
2.4 – 2.7	Qoa	Older Alluvium	Sand and gravel fan deposits
2.7 – 2.8	gr	Granitic Rocks	Granitic rock, white to tan, hard, coherent but severely fractured
2.8 – 3.5	lgdp, lgdh	Lowe Granodiorite	Plutonic igneous rock, grey
3.5 – 3.6	Qg	Alluvium Fan	Stream channel deposits of gravel, sand and silt
3.6 – 3.8	Qoa	Older Alluvium	Sand and gravel fan deposits
3.8 – 4.3	dgn	Dioritic Gneiss	Gneissic rock metamorphosed from igneous sources
4.3 – 4.4	Qoa	Older Alluvium	Sand and gravel fan deposits
4.4	Fault	Lonetree Fault	Minor fault crossing
4.4 – 4.6	lgdp, lgdh, lgdd	Lowe Granodiorite	Plutonic igneous rock, grey
4.6 – 5.0	Qls	Landslide	(Qls) Landslide (CGS, SHZR 100)
5.0 – 7.9	lgdp, lgdh, lgdd	Lowe Granodiorite	Plutonic igneous rock, grey
7.9 – 8.0	dgn	Dioritic Gneiss	Gneissic rock metamorphosed from igneous sources
8.0 – 8.1	lgd	Lowe Granodiorite	Plutonic igneous rock; hard but much fractured
8.1 – 8.6	an, agb	Anorthosite Gabbro complex	Plutonic complex, light steel gray, but weathered white
8.6	Fault	Fox Creek Fault	Minor fault crossing
8.6 – 8.85	agb, an	Anorthosite Gabbro complex	Plutonic complex, light steel gray, but weathered white
8.8 – 9	lgd	Lowe Granodiorite	Plutonic igneous rock; hard but much fractured
9.0 – 11.4	an, agb	Anorthosite Gabbro complex	Plutonic complex; light steel gray, but weathered white
11.4 – 11.5	grd	Granitic Rock	Leucocratic plutonic rock; nearly white; massive
11.5	Fault	Mill Creek Fault	Fault crossing
11.5 – 14.6	grd	Granitic Rock	Leucocratic plutonic rock; nearly white; massive.
14.6	Fault	Maple Canyon Fault	Fault crossing
14.6 – 14.8	grd	Granitic Rock	Leucocratic plutonic rock; nearly white; massive.

TABLE 4.7-27 (CONTINUED)
GEOLOGIC CONDITIONS – SEGMENT 11[1]

Approximate Milepost	Geologic Unit/Structure	Formation Name	Description/Comments
14.8	Fault	North Branch of San Gabriel Fault	Fault crossing
14.8 – 15.2	qd	Quartz Diorite	Plutonic rock; gray, medium-grained, incoherent where weathered
15.2 – 15.5	gn	Gneissic Rock	Gneissic rock metamorphosed from sedimentary or igneous sources
15.5 – 15.6	qd	Quartz Diorite	Plutonic rock; gray, medium-grained, incoherent where weathered
15.6 – 15.9	gn	Gneissic Rock	Gneissic rock metamorphosed from sedimentary or igneous sources
15.9 – 16.0	gr	Granitic Rocks	Plutonic rock, white to tan, hard, coherent but severely fractured
16.0 – 16.1	qd	Quartz Diorite	Plutonic rock; gray, incoherent where weathered.
16.1 – 16.2	gr	Granitic Rocks	Plutonic rock, white to tan, hard, coherent but severely fractured
16.2 – 16.3	gn	Gneissic Rock	Gneissic rock metamorphosed from sedimentary or igneous sources
16.3 – 16.4	qd	Quartz Diorite	Plutonic rock; gray, incoherent where weathered
16.4 – 16.6	gn	Gneissic Rock	Gneissic rock metamorphosed from sedimentary or igneous sources
16.6 – 16.9	gr	Granitic Rocks	Plutonic rock, white to tan, hard, coherent but severely fractured
16.9	Fault	Vasquez Creek fault	Fault crossing
16.9 – 17.3	gr	Granitic Rocks	Plutonic rock, white to tan, hard, coherent but severely fractured
17.3 – 17.5	hd	Hornblende Diorite	Mafic plutonic rock; dark gray to black
17.5 – 17.9	gr	Granitic Rocks	Plutonic rock, white to tan, hard, coherent but severely fractured
17.9	Fault	Sierra Madre fault zone	Fault crossing, one of many mapped strands
17.9 – 18.0	Qls	Landslide	(Qls) Landslide (CGS, OFR 98-05)
18.0 – 18.2	qd	Quartz Diorite	Plutonic rock; gray, incoherent where weathered
18.2 – 18.4	gr	Granitic Rocks	Plutonic rock, white to tan, hard, coherent but severely fractured
18.4	Fault	Sierra Madre fault zone	Fault crossing, one of many mapped strands

TABLE 4.7-27 (CONTINUED)
GEOLOGIC CONDITIONS – SEGMENT 11[1]

Approximate Milepost	Geologic Unit/Structure	Formation Name	Description/Comments
18.5	Fault	Sierra Madre fault zone	Fault crossing, one of many mapped strands
18.6	Fault	Sierra Madre fault zone	Fault crossing, one of many mapped strands
18.4 – 18.7	qd	Quartz Diorite	Plutonic rock; gray, incoherent where weathered.
18.7 – 18.9	af	Artificial Fill	Artificial fill
18.9 – 19.7	qd, Qg	Quartz Diorite(qd), Alluvium Fan(Qg)	Plutonic rock; gray, incoherent where weathered (qd)./Sand and gravel fan and channel deposits(Qg).
19.7 – 20.0	Qd, Qoa	Quartz Diorite(qd), Older Alluvium(Qoa),	Plutonic rock; gray incoherent where weathered (qd) with minor sand and gravel fan deposits(Qoa)
20.0 – 20.5	qd	Quartz Diorite	Plutonic rock; gray, incoherent where weathered
20.5 – 21.0	Qls	Landslide	(Qls) Landslide (CGS, OFR 98-05)
21.0 – 21.3	gr	Granitic Rocks	Plutonic rock, white to tan, hard, coherent but severely fractured
21.3 – 21.6	Qls	Landslide	(Qls) Landslide (CGS, OFR 98-05)
21.6 – 21.8	qd	Quartz Diorite	Plutonic rock; gray, incoherent where weathered
21.8 – 22.0	gr	Granitic Rocks	Plutonic rock, white to tan, hard, coherent but severely fractured
22.0 – 22.2	Qls	Landslide	(Qls) Landslide (CGS, OFR 98-05)
22.2 – 24.9	gr, hd	Hornblende Diorite(hd), Granitic Rocks(gr)	Mafic plutonic rock; dark gray to black, medium- grained diorite(hd)/plutonic rock, white to tan, hard, coherent but severely fractured (gr).
22.8 – 24.4	Fault	Sierra Madre fault zone	Multiple oblique fault crossing of closely spaced fault strands
24.2 – 24.3	Qls	Landslide	(Qls) Landslide (Dibblee)
24.6- 25.4	Fault Zone Qa	Sierra Madre fault zone	Fault crossing of multiple fault strands; gravels, sands, and silts
24.9 -25.4	Qog	Older Gravels	Older fan, channel and colluvial gravels with sand and silt.
25.4 – 25.8	Qof	Older Alluvium	Uplifted remnants of alluvial gravel
25.8 – 26.0	Qg	Alluvium Fan	Stream channel deposits of gravel, sand and silt.
26.0 – 26.1	af	Artificial Fill	Artificial fill
26.1 – 28.3	Qg	Alluvium Fan	Stream channel deposits of gravel, sand and silt.
28.3 – 28.9	Qoa	Older Alluvium	Sand and gravel fan deposits
28.9 & 31.1	Fault	Raymond Fault	Two fault strands crossed

TABLE 4.7-27 (CONTINUED) GEOLOGIC CONDITIONS – SEGMENT 11[1]

Approximate Milepost	Geologic Unit/Structure	Formation Name	Description/Comments
28.9 – 29.1	Qa	Alluvium	Gravels, sands, and silts
29.1 – 31.8	Qg	Alluvium Fan	Stream channel deposits of gravel, sand and silt.
31.8 – 34.1	Qa	Alluvium	Gravels, sands, and silts
34.1	Fault	Workman Hill Fault	Fault crossing
34.1 – 34.4	Qae	Alluvium	Slightly elevated and locally dissected alluvium gravels and sands
34.4 – 34.7	Qoa	Older Alluvium	Sand and gravel fan deposits
34.7 – 34.8	Qae	Alluvium	Slightly elevated and locally dissacted alluvium gravels and sands
34.8 – 34.9	Qoa	Older Alluvium	Sand and gravel fan deposits
34.9 – 36.0	Tfsc, Tfp	Fernando Formation (Tfsc) and (Tfp)	Nonmarine sandstone and conglomerate (Tfsc)/claystone; gray micaceous silty claystone or siltstone.
36.0 – 36.2	Qog	Older Alluvium	Uplifted remnants of alluvial gravel

[1] Source: Dibblee map series (Pacifico Mountain and Palmdale [southern half] Quads; Acton Quad; Condor Peak; Pasadena Quad, Mt. Wilson and Azusa Quads; El Monte and Baldwin Park Quads, and CGS hazard mapping series Palmdale SHZR 105, Pacifico Mtn. SHZR 104; Acton SHZR 100; Condor Peak SHZR 068; Pasadena SHZR 014; Azusa, OFR 98-12; Mt. Wilson, OFR 98-21, El Monte SHZR 024).

***Geologic Hazards*.**

***Faults and Seismicity*.** Active and potentially active faults have been mapped in the region and documented by a number of government agencies and scientific entities. Numerous published maps and reports have been prepared by the United States Geological Survey (USGS), the CGS, and other State or public agencies (i.e., California Department of Transportation [Caltrans], Southern California Earthquake Center) that present information on fault location and activity. Table 4.7-28 presents a list of active and potentially active faults within approximately 60 miles of Segment 11. Fault characteristics listed in Table 4.7-28 are based on published data.

The Project area is seismically very active given the proximity and number of potential seismic sources. Figure 4.7-2 presents a regional fault and epicenter map showing the approximate location of the TRTP relative to seismic sources and past earthquakes. Notable historic seismic events affecting the Project area are presented in Table 4.7-29.

TABLE 4.7-28
SEISMIC SOURCE CHARACTERISTICS – SEGMENT 11

Fault Name	Nearest Distance to Segment 11 (Miles)[1]	Type of Faulting[2]	Fault Length (Miles)[2]	Slip Rate[2] (mm/year)	Maximum Magnitude Earthquake[2] (M_{max})
Anacapa-Dume	34	Left lateral oblique	75	3	7.5
Big Pine	56	Left lateral strike-slip	41	0.8	6.9
Clamshell-Sawpit Canyon	7	Reverse	11	0.5	6.5
Cucamonga	23	Thrust	18	5	7
Elsinore, Chino segment	22	Right-lateral strike-slip	13	4	6.5
Garlock	41	Left-lateral strike-slip	155	7	7.1
Hollywood	9	Left reverse	9	1	6.5
Holser	29	Reverse	12	0.4	6.5
Malibu Coast	30	Reverse	21	0.3	6.7
Newport-Inglewood	15	Right-lateral strike-slip	46	0.6	6.9
North Ridge Blind Thrust	12	Blind Thrust	31	1.5	7
Oak Ridge	37	Thrust	55	4	6.9
Palos Verdes	23	Right reverse	49	3	7.1
Pleito Thrust	56	Thrust	28	2	6.8
Puente Hills Blind Thrust	3	Blind thrust	25	0.7	7.1
Raymond	0	Left-lateral reverse	16	1.5	6.5
San Andreas – Mojave Segment	4	Right-lateral strike-slip	64	30	7.9
San Andreas – Carrizo Segment	56	Right-lateral strike-slip	90	34	7.9
San Cayetano	37	Thrust	28	6	6.8
San Fernando	7	Thrust	10	2	6.8
San Gabriel	0	Right-lateral strike-slip	87	1	7.2
San Jacinto, Glen Helen segment	36	Right-lateral strike-slip	46	12	6.9
Santa Monica	12	Left reverse	14	1	6.6
Santa Susana	20	Thrust	23	5	6.6
Sierra Madre	0	Reverse	46	2	7.2
Simi (Santa Rosa)	37	Reverse	24	1	6.7
Upper Elysian Park Thrust	3	Blind thrust	18	0.8	6.8
Whittier-Workman Hills	3	Right-lateral strike-slip	24	2.5	6.8
White Wolf	65	Left-lateral reverse	37	2	7.2

[1] Fault distances based on Jennings, 1994.

[2] Data based on CGS, 2003; Southern California Earthquake Center (SCEC) (www.scec.org).

TABLE 4.7-29
SIGNIFICANT HISTORIC EARTHQUAKES – SEGMENT 11

Date	Approximate Distance to Project Segment 11[1] (Miles)	Earthquake Magnitude[2]	Name, Location or Region Affected
December 8, 1812	52	7.5?	Wrightwood Earthquake
July 11, 1855	28	6.0	Los Angeles Region
January 9, 1857	133	Est. 7.9 to 8.25	Fort Tejon Earthquake
January 16, 1857	Unknown	6.3	Generally felt in the Los Angeles Region
July 29, 1894	41	6.2	Lytle Creek region
July 21, 1952	62	7.3	Kern County Earthquake
February 9, 1971	3	6.6	San Fernando (Sylmar) Earthquake
October 1, 1987	3	5.9	Whittier Narrows Earthquake
January 17, 1994	10	6.7	Northridge Earthquake

[1] Earthquake magnitudes and locations before 1932 are estimated by Toppozada and others (1978, 1981, and 1982) based on reports of damage and felt effects.

[2] Earthquake damage information compiled from the Southern California Data Center (SCEDC, 2006a and 2006b) and National Earthquake Information Center (NEIC, 2005) websites.

It is likely that the Project area would experience minor and moderate earthquakes and potentially a major earthquake (moment magnitude M7, or greater) during its service life. A 1995 estimate by the Working Group on California Earthquake Probabilities gave an 80 to 90 percent probability of an M7 or greater earthquake in southern California before 2024.

***Fault Rupture/Fault Displacement*.** Segment 11 crosses multiple faults including: branches of the San Gabriel fault, the Vasquez fault, multiple branches of the Sierra Madre fault zone, the Raymond fault and the Workman Hill fault. These fault crossings are described briefly here.

The San Gabriel fault is a complex structure that extends east-west across the Transverse Ranges. Slip rate and recurrence interval are thought to vary significantly along the length of the fault. It is considered active along its western extent in the Santa Clarita area but activity is reduced to the east. The fault is zoned by the State as an Earthquake Fault Zone only at the western end in the Saugus to Santa Clarita area. Some evidence suggests that the fault may not be active in the San Gabriel Mountains.

Other faults in the Transverse Ranges crossed by the route include the inactive Lonetree fault and the Mill Creek fault as mapped and named by Dibblee (Palmdale and Pacifico Mountain Quad, Chilao Quad). Both of these fault names are potentially confusing since faults with the same names are present in other areas of southern California, and both these other faults are active.

The Segment 11 route crosses Earthquake Fault Zones (EFZs) for the Raymond fault and the Workman Hill fault. The EFZs for these two active faults are located between approximately S11 MP 28.8 and S11 MP 29.2 and S11 MP 34 and S11 MP 34.2, respectively.

There are also a series of other significant faults crossed near the range front, including the Vasquez Creek fault and a number of fault strands associated with the Sierra Madre fault. These two faults represent a wide, complex zone with numerous fault strands that bend and splay creating a complex pattern of faults. The proposed Segment 11 T/L route enters the fault zone along a southerly trend crossing a series of fault strands and then turns eastward (S11 MP 18.7) into and along the fault zone. From S11 MP 22.8 to 24.4 the T/L runs parallel along a series of branching fault strands. South of S11 MP 24.4 the T/L continues in a southeasterly direction before turning southward and exiting the fault zone at approximately S11 MP 25.4. Five mapped fault strands are crossed between S11 MP 24.4 and 25.4.

The Sierra Madre fault has been shown to be active in the general Project area, with evidence for at least two large ground rupturing events in the last 15,000 years (Rubin et al., 1998). Trenching in the Arroyo Seco area revealed evidence for displacements on the order of 12 to 20 feet and estimates of magnitude of Mw 7.2 to 7.6.

As discussed above, Segment 11 is underlain at depth by the Puente Hills blind thrust. The thrust fault dips northward from the Montebello Hills and Puente Hills beneath the San Gabriel Basin. The fault does not represent a ground rupture hazard but displacement along the fault during an earthquake will result in uplift, folding, and significant ground shaking. Paleoseismic studies of the Puente Hills blind thrust have indicated the occurrence of at least four large (Mw 7.2 to 7.5) earthquakes of this fault during the past 11,000 years (Dolan, et al., 2003).

Landslides**.** A portion of the Segment 11 Project area has been mapped at the quadrangle level by the State seismic hazard mapping program. A number of landslides are present along and immediately adjacent to the route based on this mapping. Based on the State SHZ mapping performed within the Project area and considering the adjacent areas that have been mapped, it appears that much of the sloping terrain that the route crosses is or would be included in hazard zones for earthquake induced landsliding. This is because of the frequency of existing landslides, the steep terrain, the fractured and weathered geologic units, and the proximity of significant seismic sources, including the San Andreas and Sierra Madre fault zones. Landslides and the potential for seismic-induced landsliding are a significant hazard in the moderate and steeply sloping areas of Segment 11.

***Liquefaction and Lateral Spreading*.** Minor occurrences of liquefaction susceptible materials are present within the recent alluvial deposits along Segment 11 in the Transverse Ranges. The presence of these materials leads to a potential liquefaction hazard in the major drainages crossed including, Kentucky Springs Canyon, Alisio Canyon, Tujunga Canyon, Arroyo Seco, Prieto Canyon, Millard Canyon and Rubio Canyon. Most of these canyon occurrences would not constitute a significant impact to the Project because the T/L structures routinely span canyons; i.e., they are not place in the bottom of small or moderate sized drainages.

Beyond the Traverse Ranges the T /L route traverses two large zones of liquefaction potential within the L.A. Basin starting with Eaton Wash, a major drainage flowing out of the range front (S11 MP 25.5 to S11 MP 27). The T/L route crosses the San Gabriel River basin and a broad zone of liquefaction potential extending from S11 MP 32.4 to S11 MP 34.1.

***Ground Motions*.** For Segment 11 the estimates from the regional seismic hazard model (CGS, 2003) suggest ground motions of about 0.6gs for the hazard level associated with 10 percent probability of exceedance in a 50 year period. Estimates at the 2 percent in 50 year hazard level are on the order of 1g.

***Expansive and Collapsible Soils*.** Some potential for expansive materials may be present in the soils formed on the crystalline rock in the Transverse Ranges. However, based on the soil survey data, fine-grained soils are not a major constituent in the surface layers of the primary soil units mapped in the region. Expansive soils are not anticipated to be a significant hazard relative to T/L foundation design.

Collapsible soils are not anticipated in the mountainous setting of the Transverse Ranges but may be encountered in the alluvial plain or alluvial channel deposits in the L.A. Basin.

***Subsidence*.** Subsidence is a phenomenon associated with deep alluvial basins and is not a potential hazard in the Transverse Ranges portion of the Project. Subsidence has occurred within the L.A. Basin and in the vicinity of the Project area as a result of fluid withdrawals associated with oil field extractions. Some continued subsidence is likely; however the magnitudes of possible surface deformation are very small and would not significantly impact the Segment 11 T/L.

***Soils*.** The soils along the proposed T/L route reflect the underlying rock type, the extent of weathering of the rock, the degree of slope, and the degree of modification by man. Soil data for the Project was obtained from the Soil Survey Geographic (SSURGO) database for the Angeles National Forest Area, California (Publication Date: December 14, 2006).

A summary of the significant characteristics, including the description, hazard of erosion on roads and trails, and risk of corrosion of the major soil units traversed by Segment 11 is presented in Table 4.7-30; soil units are listed in order of first occurrence along the segment and may occur in multiple locations.

4.7.6.8.2 **Impact Analysis.** The potential impacts to or from geologic, seismic, and soil conditions along the proposed Segment 11 are discussed below. The discussion follows the significance criteria presented in Section 4.7.4.

***Impact Summary*.** Construction, operation, and maintenance of the proposed TRTP Project Segment 11 would potentially pose a significant hazard to the public or the environment relative to geology, soils, or geologic hazard. Significant portions of the proposed Project element are located within designated geologic hazard zones based on a review of State hazard mapping program and published geologic mapping. Segment 11 of the proposed Project could be subject to moderate or high levels of ground shaking in the event of an earthquake on faults in the region. Impacts to soils would occur during construction with increased traffic and grading associated with pads and roads for T/L construction. APMs would reduce impacts to less than significant levels.

***Construction*.** The impact analysis for construction of Segment 11 is based on the significance criteria detailed above in Section 4.7.4. The construction related impacts for Segment 11 are essentially the same as described for Segment 4 in Section 4.7.6.1.2.

***Operations*.**

Would the Project expose people or structures to adverse effects as a result of rupture of an Alquist-Priolo Earthquake Fault or other substantial known fault?

Segment 11 crosses two Alquist-Priolo Earthquake Fault Zones and at least two other faults that likely represent some level of fault rupture hazard. The EFZs associated with the Raymond fault and the Workman Hill fault are crossed with favorable orientations and given the character of the faults, potential impacts could be reduced to a less-than-significant levels. Similarly, the San Gabriel fault is not likely to pose a significant threat given its likely low level of activity in the Project area. The most significant potential impacts to the Project as a result of possible fault rupture occur at the range front where the Vasquez Creek fault and the Sierra Madre fault are crossed.

The Sierra Madre fault crossing represents the greatest challenge to design given the potentially large displacements. It is anticipated that all fault crossings could be mitigated to less than significant levels if structure locations can be optimized in the fault crossing areas.

TABLE 4.7-30
SUMMARY OF SOIL UNIT CHARACTERISTICS – SEGMENT 11[1]

			Risk of Corrosion	
Soil Series or Association	Description	Hazard of Erosion on Roads and Trails[2]	Uncoated Steel	Concrete
Terrace escarpments	Rocky talus	Severe	NA	NA
Hanford	Coarse sandy loam, 0 to 2 percent slopes	Slight	Low	Low
Vista	Coarse sandy loam, 30 to 50 percent slopes	Slight	Low	Low
Pismo-Trigo -Exchequer, families complex	30 to 70 percent slopes	Severe	NA	NA
Hanford family	3 to 25 percent slopes	Severe	NA	NA
Tollhouse-Stukel-Wrentham families complex	30 to 90 percent slopes	Severe	NA	NA
Pismo-Chilao-Shortcut families complex	45 to 80 percent slopes	Severe	NA	NA
Rock outcrop-Chilao family-Haploxerolls association	15 to 120 percent slopes	Severe	NA	NA
Typic Xerorthents	55 to 90 percent slopes	Severe	NA	NA
Olete-Kilburn-Etsel families complex	50 to 80 percent slopes	Severe	NA	NA
Trigo -Modjeska families association	Granitic substratum 5 to 60 percent slopes	Severe	NA	NA
Stukel-Sur-Winthrop families complex	60 to 100 percent slopes	Severe	NA	NA
Chilao-Trigo -Lodo families complex	Granitic substratum, 55 to 85 percent slopes	Severe	NA	NA
Mollic Haploxeralfs	2 to 50 percent slopes	Severe	NA	NA
Trigo family	Granitic substratum, 60 to 90 percent slopes	Severe	NA	NA
Caperton-Trigo	Granitic substratum-Lodo families complex, 50 to 85 percent slopes	Severe	NA	NA

[1] Source for soils mapping and characteristics: SSURGO, Angeles National Forest Area, California, GIS.

[2] Qualitative descriptors of erosion hazard: Slight = little or no erosion is anticipated, Moderate = some erosion anticipated, Severe = significant erosion hazard.

Seismic design standards (APM GEO-1) would be followed and recommendations of design level geotechnical and geologic hazards investigations (APM GEO-2) would be implemented to properly design fault crossings. Implementation of APMs GEO-1 and GEO-2 would minimize the potential impact to less than significant.

Would the Project expose people or structures to adverse effects as a result of seismic ground shaking?

Seismic related ground failure could include liquefaction, lateral spreading, and ground-cracking. The geologic setting of Segment 11 includes mountainous relief to the north and flat lying terrain associated with the L.A. Basin. The basin setting includes extensive zones of possible liquefaction. Design level geotechnical and geologic hazards investigations would be performed to fully characterize the hazards and provide recommendations for engineering design measures to reduce impacts resulting from seismic ground shaking. Implementation of APMs GEO-1 and GEO-2 would reduce any potential impacts to a less-than-significant level.

Would the Project expose people or structures to adverse effects as a result of landslides?

Mapped landslides are present along the range front portion of the Segment 11 T/L route and the State hazard mapping program has delineated the area as a hazard zone for seismically induced slope failure. Seismically induced slope failures include landslides, earth flows, soil slips and debris-flows. In the event of a large magnitude earthquake (moment magnitude 7.0 or greater) on the San Andreas fault, Sierra Madre thrust fault or Puente Hills blind thrust, seismically induced slope failures within the steep mountainous terrain of the San Gabriel Mountains cannot be precluded.

These fault zones are thought capable of producing earthquakes approaching magnitude Mw 7.5 and ground motions could exceed 1 g during such an event (USGS, 2002). Seismically induced slope instability has the potential to undermine foundations, cause distortion and distress to overlying structures, and displace or destroy Project components. Damage to, or failure of, the proposed T/L segment could result in temporary electrical transmission outages.

The recurrence interval for large earthquakes on these faults is estimated to range from 2,000 to 3,000 years for the Puente Hills blind thrust (Dolan et al, 2003) to perhaps greater than 6,000 to 8,000 years for the Sierra Madre fault (Rubin et al., 1998; Tucker et al., 2001). The earthquake recurrence intervals for these faults exceed the design life of the proposed TRTP and are therefore considered unlikely to result in catastrophic failure of Project components.

Smaller seismically induced slope instability could damage Project components and could thus potentially result in temporary outages along the affected T/L. As required by the North American Electric Reliability Corporation, the Western Electricity Coordinating Council, and the California Independent System Operators, the regional transmission system is designed to provide transmission reliability. Should a T/L not be operational as a result of an accident, seismic event, or fire, or is taken out of service to permit safe maintenance, redundancy in the transmission system allows electrical transmission with no or only brief service interruptions to load areas. Temporary outages along the proposed T/L segment as a result of seismically induced slope instability would be avoided or minimized because of the redundancy incorporated into the transmission system and, therefore, the potential impacts are less than significant.

Seismic design standards (APM GEO-1) would be followed and a design-level geotechnical survey (APM GEO-2) would be performed to evaluate the potential for unstable slopes, landslides, earth flows, soil slips and debris flows along the proposed segment. Overhead T/L structures may be placed to avoid and span slide areas. To the extent feasible, facilities would be located away from very steep hillsides, debris-flow source areas, the mouths of steep side-hill drainages, and the mouths of canyons that drain steep terrain. In cases of shallow sliding, slope creep, or raveling, specially designed deep foundations may be used to anchor the overlying structure to underlying, competent material. As appropriate, stabilization of unstable slopes would be performed by excavating and removing unstable material, regrading unstable slopes to improve surface drainage and limit infiltration, installing subsurface drainage systems, and/or constructing retaining structures to mechanically restrain slope movement.

With implementation of APM GEO-1 and APM GEO-2, potential impacts to the proposed T/L and subsequent outages resulting from seismically induced slope instability would be less than significant.

Would the Project expose people or structures to adverse effects as a result of seismic related ground failure including liquefaction.

Seismic related ground failure could include liquefaction, lateral spreading, and ground-cracking. The geologic setting of Segment 11 includes very mountainous relief with intervening valleys in the San Gabriel Mountains to the north and very flat-lying terrain associated with the L.A. basin to the south. Segment 11 contains extensive zones of possible seismically-induced ground failure and impacts are potentially significant. Seismic design standards (APM GEO-1) would be followed, and design level geotechnical and geologic hazards investigations (APM GEO-2) would be performed to characterize the hazards and provide recommendations for engineering measures to reduce impacts. Implementation of

APMs GEO-1 and GEO-2 would reduce any potential impacts to a less-than-significant level.

Would the Project result in substantial soil erosion or the loss of topsoil?

Some soil types along the route are subject to moderate or severe erosion on roads and trails. Such areas, if not stabilized, could be subject to increased rates of erosion by wind and/or water. Soil erosion is a potentially significant impact. APM GEO-2 calls for geotechnical studies and good engineering practices, and APM GEO-3 calls for appropriate soil erosion/water quality protection measures as specified in the Construction SWPPP. Implementation of APM GEO-2 and APM GEO-3 would reduce significant erosion impacts during operation of the Project to a less-than-significant level.

Would the Project be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the Project and potentially result in onsite or offsite landslide, lateral spreading, subsidence, liquefaction or collapse?

Segment 11 could be impacted by unstable geologic units and soil conditions that include landslides and areas of liquefaction potential as discussed above. These unstable geologic units and soils could impact the Project to varying degrees.

Some potential for collapsible soils or subsidence may exist in the young alluvial deposits in the L.A. Basin. Recognition and evaluation of such conditions, if present, would be evaluated during site specific geotechnical investigations (APM GEO-2).

Implementation of APMs GEO-1 and GEO-2 would reduce potential impacts from unstable geologic units or soils to a less-than-significant level.

Would the Project be located on expansive soil, creating substantial risks to life or property?

Extensive areas of expansive soils are not anticipated in the generally granular soil conditions encountered along Segment 11. Significant impacts resulting from expansive clays but are not considered likely based on the geologic setting. Implementation of APM GEO-2 would reduce potential impacts from expansive soils to a less-than-significant level.

4.7.6.8.3 **Mitigation Measures.** The aforementioned APMs have been incorporated into the Project design and apply to this segment; therefore, any potentially significant impacts have been avoided or reduced to a less-than-significant level, and no mitigation is required.

4.7.6.8.4 Impact Significance After Mitigation Measures. The potential impacts from geologic hazards and potential impacts to geology and soils associated with construction and operation of Segment 11 are considered to be less than significant.

4.7.7 References

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