4.7 GEOLOGICAL RESOURCES

4.7.1 Introduction

This section discusses existing geological and soil conditions, possible geologic hazards, and geotechnical considerations. Potential impacts and applicant-proposed mitigation measures for the project are discussed in Section 5.7.

4.7.2 Methodology

Existing conditions were determined from review of available published and unpublished literature and online sources. Descriptions of geologic units in the project area are based on published geologic quadrangle maps by Thomas Dibblee (1970, 1997) and State Geologic Maps for the Los Angeles and Bakersfield sheets. Other sources of geologic information include the Ritter Ranch Specific Plan (Robert Bein, William Frost & Associates, 1992) and the City Ranch (Anaverde) Specific Plan (Azeka De Almeida Planning, 1992c). Available geotechnical information was reviewed for the Antelope Substation (SCE, 1957; 1997).

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

Assessment for fault rupture hazard and ground shaking hazard derive from fault mapping and catalogs and interactive maps primarily from CGS (formerly known as California Division of Mines and Geology, CDMG) and U.S. Geological Survey (USGS) sources. The primary sources derive from CGS 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

Soils information presented here derives from the United States Department of Agriculture (USDA) STATSGO data set. Other sources of soil information reviewed include the following soil surveys by the USDA Natural Resources Conservation Service (NRCS) (formerly known as Soil Conservation Service):

- Soil Survey of Antelope Valley, California
- Soil Survey of Kern County, Southeastern Part, California
- Report and General Soil Map, Los Angeles County, California

Site-specific geotechnical investigations are necessary to evaluate subsurface conditions and support appropriate engineering design. Such studies would support the construction, operation, and maintenance of the proposed facilities.

4.7.3 Existing Conditions

4.7.3.1 Physiographic Setting

The project elements traverse three major physiographic provinces: the Transverse Ranges, the Mojave Desert, and the southern margin of the Sierra Nevada Batholith. The existing or proposed substations are located in each province. The existing Antelope Substation is located in the Antelope Valley, part of the Mojave Desert province. The Vincent Substation is located in the Transverse Ranges and proposed Substations One and Two are located in the Tehachapi Valley in the southwesterly portion of the Sierra Nevada Batholith. A regional geology map is presented on Figure 4.7-1, including the locations of Segments 2 and 3.

The T/Ls, Segment 2 (Antelope to Vincent) and Segment 3 (Antelope to Substations One and Two) originate at the Antelope Substation (refer to Figures 3-1, 3-2, and 3-3) within the western portion of the Mojave Desert and extend southward into the Transverse Ranges and the Vincent Substation and northward into the Sierra Nevada, respectively.

The Segment 2 route extends southeastward across the Antelope Valley and through the northwest-trending rift valley associated with the San Andreas fault zone. Alternative AV1 is a 2.1-mile-long alternative route offset to the east of the proposed Segment 2 just north of the San Andreas fault zone. Southeast of the fault zone the route enters the eastern margin of the San Gabriel Mountains, part of the Transverse Ranges. The proposed route jogs westward away from the western end of the Anaverde Valley and then extends southward across rugged ridge, canyon, and valley terrain before ending at the Vincent Substation. Alternative AV2 is a straighter route that passes through the western end of the Anaverde Valley. The existing Vincent Substation is situated at the southern end of Soledad Pass at the divergence of Kentucky Springs and Soledad Canyons.

The Segment 3 route and the associated two alternative routes (A, B) extend north from the Antelope Substation across Antelope Valley and the Mojave Desert. The three parallel routes extend just west of the Rosamond Hills before reaching Substation One along the eastern flanks of the Tehachapi Mountains. Between proposed Substations One and Two, the proposed 220 kV T/L route (and Alternative C) turn to the west into the Tehachapi Mountains along the Oak Creek drainage before turning north across the Garlock fault and entering the southern Sierra Nevada Province. The general route for these two alignments continues across the ridge and canyon terrain before dropping down the northern flanks of the Tehachapi Mountains into the Tehachapi Valley and Substation One.

4.7.3.2 Geologic Setting

The routes traverse diverse geologic conditions associated with the major physiographic provinces discussed above. Table 4.7-1 presents a summary of geologic conditions by milepost for the project routes.

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. Near the southern margins of the Antelope Valley at the flanks of Portal Ridge the proposed route crosses sloping terrain underlain by older alluvial fan deposits shed off of the adjacent topographic highland. Portal Ridge is primarily comprised of a variety of metamorphic crystalline rocks associated with the Pelona Schist. On the southern side of the ridgeline the proposed route drops down and across the San Andreas rift zone in Leona Valley. The rift valley is underlain by Quaternary age surficial deposits and Pliocene and Pleistocene age sedimentary deposits. After crossing the rift zone the proposed route enters the Transverse Ranges and metamorphic terrain characterized by ridge and valley topography. The Alternative AV2 route starts just south of the rift zone and skirts the edge of the Anaverde Valley, which is underlain by recent alluvial deposits. As the proposed route extends southeasterly, it crosses into granitic terrain before dropping onto an older alluvial fan surface and into the recent alluvial deposits at the head of Soledad and Kentucky Springs Canyons.

The northerly-trending Segment 3 routes (proposed and alternative) traverse flat lying topography and valley fill deposits as they extend northward. The routes pass just to the west of the Rosamond Hills and reach Substation One, located on ancient alluvial fans near the mouth of Oak Creek along the toe of the Tehachapi Mountains. The proposed 220 kV Substation One to Substation Two route and the Alternative C route extend northwesterly up the flanks of the mountains. The northern end of the T/L route is situated within the Tehachapi Valley characterized by relatively flat lying topography and valley fill deposits. Within the southern margin of the valley along the flanks of the Tehachapi Mountains the route crosses sloping dissected terrain underlain by older alluvial fan deposits and eroded by active drainages. The Tehachapi Mountains are primarily composed of Cretaceous-age, crystalline granitic rock of similar composition to the Sierra Nevada range to the north. Within the central portion of the mountains the routes cross the Garlock fault and granitic terrain with scattered intrusive volcanics before dropping onto an older fan surface. From this point the routes extend over the granitic terrain of the Tehachapi Mountains and into Tehachapi Valley. Older alluvial fan deposits underlie the margins of the valley and Substation One lies within the central portion of the valley underlain by alluvium.

TABLE 4.7-1
GEOLOGIC CONDITIONS ALONG SEGMENTS 2 AND 3

Segment and Approximate Milepost[1]	Geologic Unit/Structure	Formation Name	Description/Comments
Segment 2 (500 kV)			
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 - 6.5	psp, psq	Pelona Schist	Mica schist, out-of-slope dipping foliation; landslide hazard potential
6.5 - 6.6	Qa	Alluvium	Identified liquefaction potential
6.6 - 7.6	psp	Pelona Schist	Mica schist, into-slope dipping foliation
7.6 - 8.2	Fault Zone, Tas, Qos, Qa	San Andreas Fault, Anaverde Formation, Older and younger Alluvium	Rift zone of San Andreas fault 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
8.2	Fault	San Nadeau	Concealed fault, existence is uncertain; potential fault rupture hazard as coseismic with movement on San Andreas fault
8.2 - 13.3	Qa, Qos, ps	Alluvium, Older Alluvium, Pelona Schist	Mica schist, out-of-slope dipping foliation; landslide hazard potential; identified liquefaction potential in alluvial drainages
13.3 - 13.4	Qls	Landslide Deposits	Mapped landslide deposits
13.4 - 16.2	Qa, Qos, ps	Alluvium, Older Alluvium, Pelona Schist	Mica schist, out-of-slope dipping foliation; landslide hazard potential; identified liquefaction potential in alluvial drainages
16.2 - 16.3	my	Mylonitic Rocks	Mylonite
16.3 - 16.4	gr	Granitic Rocks	Granitic rocks; fractured, variably weathered crystalline rock
16.4 - 16.5	gnb	Gneiss	Banded gneiss
16.5 - 17.1	gr, Qa	Granitic Rocks, Alluvium	Granitic rocks, variable weathering profile, possible landslide hazard; identified liquefaction potential in alluvial drainages
17.1 - 17.3	di	Dioritic Rocks	Mafic granitic rocks; fractured, variably weathered crystalline rock
17.3 - 18.3	sy	Syenite	Granitic rocks, variable weathering profile, possible landslide hazard

TABLE 4.7-1 (CONTINUED)
GEOLOGIC CONDITIONS ALONG SEGMENTS 2 AND 3

Segment and Approximate Milepost[1]	Geologic Unit/Structure	Formation Name	Description/Comments
17.4	Fault	Unnamed fault	Likely inactive, indefinite location, no significant fault rupture hazard
18.3 - 19.2	Qoa	Older Alluvium	Sand and gravel fan deposits
19.2 - 19.3	di	Dioritic Rocks	Mafic granitic rocks; fractured, variably weathered crystalline rock
19.3 - 19.4	Qoa	Older Alluvium	Sand and gravel fan deposits
19.4 - 19.5	lgbd	Lowe Granodiorite	Granitic rocks; fractured, variably weathered crystalline rock
19.5 - 20.0	Qoa	Older Alluvium	Sand and gravel fan deposits
20.0 - 20.9	Qa	Alluvium	Soledad Pass: Alluvial sand and clay
20.9 - 21.0	Qoa	Older Alluvium	Sand and gravel fan deposits
21.0 - 21.2	Qa	Alluvium	Identified liquefaction potential
21.2 – 21.5	Qoa	Older Alluvium	Vincent Substation: Sand and gravel fan deposits
Segment 2, Alt. AV1			
0.0 - 0.7	psp, psq	Pelona Schist	Mica schist, out-of-slope dipping foliation; landslide hazard potential
0.7 - 0.8	Qa	Alluvium	Identified liquefaction potential
0.8 –2.1	psp	Pelona Schist	Mica schist, into-slope dipping foliation
Segment 2, Alt. AV2			
0.0 - 0.1	Tas, Qos, Qa	Anaverde Formation, Older and younger Alluvium	Anaverde Formation (sandstone), and older and younger alluvial deposits; identified liquefaction potential in alluvial deposits; active right-slip fault, significant fault rupture hazard
0.1	Fault	San Nadeau	Concealed fault, existence is uncertain; potential fault rupture hazard as coseismic with movement on San Andreas fault
0.1 - 1.6	Qa, Qos, ps	Alluvium, Older Alluvium, Pelona Schist	Mica schist, out-of-slope dipping foliation; landslide hazard potential; identified liquefaction potential in alluvial drainages
1.6 - 2.4	Qa	Alluvium	Anaverde Valley - Identified liquefaction potential
2.4 - 3.1	ps	Pelona Schist	Mica schist, out-of-slope dipping foliation; landslide hazard potential
Segment 3 (500 kV)			
0.0 - 3.0	Qa	Alluvium	Antelope Valley alluvial deposits: gravels, sands, and silts
3.0 - 3.3	Qs	Dune deposits	Non-cohesive, running sands
3.3 - 25.6	Qa	Alluvium	Antelope Valley alluvial deposits: gravels, sands, and silts

TABLE 4.7-1 (CONTINUED) GEOLOGIC CONDITIONS ALONG SEGMENTS 2 AND 3

Segment and Approximate Milepost[1]	Geologic Unit/Structure	Formation Name	Description/Comments
14.2	Fault	Rosamond - Willow Springs Flt	Likely inactive, indefinite location, no significant fault rupture hazard
Segment 3 Proposed 220 kV			
25.6 - 29.1	Qoa	Older Alluvium	Sand and gravel fan deposits
29.1 - 29.2	ml	Metasedimentary Rocks	Limestone country rock inclusions within crystalline granitics
29.2 - 29.9	Qa	Alluvium	Unconsolidated alluvial deposits, possible liquefaction potential
29.9 - 30.8	Qoa	Older Alluvium	Sand and gravel fan deposits
30.8 - 31.1	Qa	Alluvium	Unconsolidated alluvial deposits, possible liquefaction potential
31.1 - 31.4	Qoa	Older Alluvium	Sand and gravel fan deposits
31.4 - 31.7	qm w/ Tf	Quartz monzonite with intrusive felsite volcanics	Granitic and volcanic rocks; fractured, variably weathered crystalline rock
31.7	Fault Zone, Qoa	Garlock Fault, Older Alluvium	Garlock Fault and older alluvial deposits; active left-slip fault, significant fault rupture hazard
31.7 - 33.8	qm	Quartz monzonite	Granitic rocks; fractured, variably weathered crystalline rock
33.8 - 34.45	Qa	Alluvium	Tehachapi Valley alluvial deposits: gravels, sands, and silts
34.45 - 34.7	Qoa	Older Alluvium	Sand and gravel fan deposits
34.7 – 35.2	Qa	Alluvium	Tehachapi Valley alluvial deposits: gravels, sands, and silts
Segment 3 Alternative A			
0.0 - 8.6	Qa	Alluvium	Antelope Valley alluvial deposits: gravels, sands, and silts
8.6 - 8.8	Mvp	Pyroclastic volcanics	Indurated volcanic rock
8.8 - 25.9	Qa	Alluvium	Antelope Valley alluvial deposits: gravels, sands, and silts
14.3	Fault	Rosamond - Willow Springs Flt	Likely inactive, indefinite location, no significant fault rupture hazard
Segment 3 Alternative B			
0.0 - 20.0	Qa	Alluvium	Antelope Valley alluvial deposits: gravels, sands, and silts
14.4	Fault	Rosamond - Willow Springs Flt	Likely inactive, indefinite location, no significant fault rupture hazard
20.0 - 21.2	Qoa	Older Alluvium	Sand and gravel fan deposits
21.2 - 26.0	Qa	Alluvium	Antelope Valley alluvial deposits: gravels, sands, and silts

TABLE 4.7-1 (CONTINUED)
GEOLOGIC CONDITIONS ALONG SEGMENTS 2 AND 3

Segment and Approximate Milepost[1]	Geologic Unit/Structure	Formation Name	Description/Comments
Segment 3 Alternative C			
0.0 - 3.5	Qoa	Older Alluvium	Sand and gravel fan deposits
3.5 - 3.6	ml	Metasedimentary Rocks	Limestone country rock inclusions within crystalline granitics
3.6 - 4.25	Qa	Alluvium	Unconsolidated alluvial deposits, possible liquefaction potential
4.25 - 4.9	Qoa	Older Alluvium	Sand and gravel fan deposits
4.9 - 5.8	qm w/ Tf	Quartz monzonite with intrusive felsite volcanics	Granitic and volcanic rocks; fractured, variably weathered crystalline rock
5.8 - 6.0	Fault Zone, Qa	Garlock Fault, Alluvium	Garlock Fault and younger alluvial deposits; identified liquefaction potential in alluvial deposits; active left-slip fault, significant fault rupture hazard
6.0 - 7.9	qm	Quartz monzonite	Granitic rocks; fractured, variably weathered crystalline rock
7.9 –9.5	Qa	Alluvium	Tehachapi Valley alluvial deposits: gravels, sands, and silts

[1] Refer to Figures 3-2 (Segment 2) and 3-3 (Segment 3) for milepost locations.

4.7.3.3 Geologic Structure

Segment 2 initiates at the Antelope Substation within the Mojave structural block and crosses the San Andreas fault zone; a major tectonic plate boundary characterized by right lateral movement. Across the San Andreas fault the routes enter the Sierra Pelona characterized by the compressional tectonics (north-south shortening) of the Transverse Ranges that results from the large bend in the San Andreas fault zone. 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 sedimentary and metamorphic units, respectively.

The ancestral tectonic setting of the area included extensional tectonics and the formation of deep sedimentary basins during Tertiary time. The southern end of the route enters the Soledad basin. The Tertiary sediments deposited in this basin were subsequently folded and uplifted by the current compressive tectonic regime that formed the Transverse Ranges.

Segment 3 extends northward across the Mojave structural block and the flat lying alluvial deposits laid down in the Antelope Valley. The routes reach Substation One located at the toe of the Tehachapi Mountains on southeastern-dipping alluvial fan deposits. The Substation

One to Substation Two route crosses the southwesterly-to-northeasterly-trending Garlock fault and the subparallel Tehachapi Mountains. This marks the transition into the Sierra Nevada structural block. The Tehachapi Mountains are primarily comprised of granitic rock with subparallel bodies of metamorphic rock and intruded dikes of Tertiary-age volcanic rock. The Tehachapi Valley is an east-west-trending alluvial basin.

4.7.3.4 Geologic Units

Geologic units encountered in the project area are presented in Table 4.7-1 and are based on the quadrangle-level geologic maps of Dibblee. The geologic units are described briefly below.

4.7.3.4.1 Surficial Deposits. Quaternary alluvium includes the valley fill deposits of the Antelope Valley and the older alluvial and alluvial fan deposits associated with adjacent mountain fronts. Alluvial deposits are present in the Soledad Valley on Segment 2. Landslides are present locally on the steeper slopes along the southern portion of Segment 2. Alluvial deposits are also present along the northern end of the Segment 3 proposed route and Alternative C in the Tehachapi Valley.

4.7.3.4.2 Tertiary Sediments. Tertiary-age rocks are found only as a minor occurrence along the Segment 2 route and Segment 3. Weakly to moderately lithified deposits of the Anaverde Formation are present solely within the San Andreas rift zone within Segment 2. A minor stretch of the Segment 3 Alternative A extends across Miocene age, indurated pyroclastic volcanic rock within the central portion of the Antelope Valley.

4.7.3.4.3 Granitic Rocks. Crystalline rocks of granitic origin are encountered in Segment 2 after crossing the San Andreas fault and in Segment 3 in the Tehachapi Mountains. Mapped rock units in or adjacent to the routes include quartz diorite and quartz monzonite, syenite, granodiorite, and dioritic rocks.

4.7.3.4.4 Metamorphic Rocks. The Pelona Schist is mapped along Segment 2 near the San Andreas rift. These crystalline rocks are extensively folded and faulted with moderately-to-steeply-dipping foliations. Mylonitic and gneissic rocks are found along Segment 2 in the Sierra Pelona.

4.7.4 Geologic Hazards

4.7.4.1 Seismicity

The project area is seismically active given the presence of the San Andreas fault system, the Garlock fault and the active faults of the Transverse Ranges. Notable historic seismic events affecting the project area are presented on Figure 4.7-2. It is likely that the project area would 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.

4.7.4.1.1 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. These seismic parameters are used to evaluate and compare earthquake events, seismic hazard potential, and ground shaking.

4.7.4.1.2 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.

4.7.4.1.3 Maximum Considered Earthquake (MCE). Fault parameters are generally used to estimate the maximum considered earthquake (MCE) that can 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 event that can be supported by the seismic and paleoseismic geology of the area.

4.7.4.1.4 Ground Motions. Probabilistic seismic hazard estimates based on the USGS/CGS Probabilistic Seismic Hazards Assessment (PSHA) Model, (2002, revised April 2003) and presented on regional maps depict ground motions associated with a 10 percent probability of exceedance in a 50 year period.

For Segment 2 the ground motion estimate (given as the gravitational acceleration [g] for the peak ground acceleration) for the Antelope Substation is 0.66g and for the Vincent Substation it is approximately 0.59g. The ground motion estimates from this model peak at approximately 0.79g, along Segment 2 at the San Andreas fault zone.

Segment 3 begins at the Antelope Substation with the 0.66g probabilistic ground motion estimate described above and extends northward to Substation One with an estimated peak acceleration of 0.40g. Substation Two has an estimate peak ground acceleration of approximately 0.42g in the Tehachapi Valley.

4.7.4.2 Fault Rupture

Active and potentially active faults have been mapped in the project vicinity 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 4.7-2 presents a list of active and potentially active faults within the project vicinity and active faults within approximately 60 miles. Fault characteristics listed in Table 4.7-2 are based on published data.

Figure 4.7-2 presents a regional fault and epicenter map showing the approximate location of the project in the regional context of seismic sources. The San Andreas fault zone represents the primary component of the transform boundary between the North America and Pacific plates and the dominant seismic source in the project area. As discussed above there is a significant likelihood that there would be a large earthquake in the area within the near future. Specifically, the Mojave segment of the San Andreas has a significant potential to rupture with a large magnitude event within the project service life. The Garlock fault is an active left lateral slip fault with surface rupture potential. Segment 2 crosses the San Andreas fault zone at approximately MP 7.6 to 8.2. The Segment 3 Proposed 220 kV T/L crosses the Garlock fault at approximately MP 31.7 as noted in Table 4.7-1.

4.7.4.2.1 Earthquake Fault Zones. The Alquist-Priolo Special Studies Zones Act, passed in 1972, requires the establishment of “earthquake fault zones” (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 project facilities would be manned.

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.” Earthquake fault zones within the project area include the San Andreas and Garlock faults. Segment 2 and 3 fault crossings are listed in Table 4.7-1.

4.7.4.2.2 Fault Displacement. There is a significant potential for surface rupture within the project area given the potential for moderate or large earthquakes on the active Garlock and San Andreas faults. Estimates of likely surface displacement can be made based on empirical correlations from a catalog of worldwide earthquakes that includes measurements of ground rupture. Mean values of average and maximum displacement can be estimated for the San

TABLE 4.7-2
SEISMIC SOURCE CHARACTERISTICS
SEGMENTS 2 AND 3

Fault Name	Nearest Distance to Project Segment 2[1] Miles (km)	Nearest Distance to Project Segment 3[1] Miles (km)	Type of Faulting[2]	Fault Length[2] Miles (km)	Slip Rate Range[2] Inches/Year (mm/year)	Maximum Magnitude Earthquake[3] (M_{max})
Clamshell-Sawpit Canyon	23 (37)	42 (68)	reverse	11.2 (18)	0.02 - 0.04 (0.5 - 1)	6.5
Cucamonga	35 (56)	54 (87)	thrust	18.6 (30)	0.2 - 0.55 (5 - 14)	7.0
Elsinore	54 (87)	73 (118)	right-lateral strike-slip	112.0 (180)	0.16 (4)	6.8 - 7.1
Garlock	21 (34)	0 (0)	left-lateral strike-slip	155.0 (250)	0.08 - 0.43 (2-11)	7.1
Hollywood	28 (45)	45 (72)	left reverse	9.3 (15)	0.01 - 0.03 (0.33 - 0.75)	6.5
Holser	27 (43)	29 (47)	reverse	12.4 (20)	0.015 (0.4)	6.5
Malibu Coast	45 (72)	50 (81)	reverse	21.1 (34)	0.01 (0.3)	6.7
Newport-Inglewood	36 (58)	50 (81)	right-lateral strike-slip	46.6 (75)	0.024 (0.6)	6.9
Oak Ridge	39 (63)	37 (60)	thrust	55.9 (90)	0.14 - 0.24 (3.5 - 6)	6.9
Palos Verdes	47 (76)	60 (97)	right reverse	49.7 (80)	0.004 - 0.12 (0.1 - 3)	7.1
Pelona	17 (27)	17 (27)	left reverse	4.3 (7)	NA	NA
Pleito Thrust	37 (60)	24 (39)	thrust	28 (45)	0.06 (1.4)	6.8
Raymond	24 (39)	44 (71)	left-lateral reverse	16.2 (26)	0.004 - 0.009 (0.1 - 0.22)	6.5
San Andreas	0 (0)	7 (11)	right-lateral strike-slip	745 (1,200)	0.79 - 1.38 (20-35)	7.9
San Cayetano	35 (56)	35 (56)	thrust	28 (45)	0.05 - 0.35 (1.3 - 9)	6.8
San Fernando	20 (32)	33 (53)	thrust	10.56 (17)	0.2 (5)	6.8
San Gabriel	15 (24)	17 (27)	right-lateral strike-slip	87 (140)	0.04 - 0.2 (1 - 5)	7.0
San Jacinto	40 (64)	53 (85)	right-lateral strike-slip	130.5 (210)	0.28 - 0.67 (7 - 17)	6.9
Santa Monica	31 (50)	46 (74)	left reverse	14.9 (24)	0.01 - 0.015 (0.27 - 0.39)	6.6
Santa Susana	26 (42)	33 (53)	thrust	23.6 (38)	0.2 - 0.28 (5 - 7)	6.6
Sierra Madre	19 (31)	35 (56)	reverse	46.6 (75)	0.014 - 0.16 (0.36 - 4)	7.0
Simi (Santa Rosa)	31 (50)	35 (56)	reverse	24.9 (40)	0.04 (1)	6.7
Whittier	35 (56)	54 (87)	right-lateral strike-slip	24.9 (40)	0.098 - 0.12 (2.5 - 3)	6.8
White Wolf	42 (68)	15 (24)	left-lateral reverse	37.3 (60)	0.12 - 0.335 (3 - 8.5)	7.2

Sources:

[1] Jennings, 1994.

[2] SCEC.

[3] ICBO, 1998.

Andreas and the Garlock faults based on correlations to fault magnitude (Wells and Coppersmith, 1994). The mean value of the maximum displacement for an Mw 7.8 on the central portion of the San Andreas (repeat of 1857 rupture length) is approximately 10m and the mean value of the average displacement is approximately 5m. Values for the mean maximum and mean average displacements for the Garlock fault are approximately 1.9m and 1.2m respectively.

These estimates are based on statistical regressions and the computed displacements are mean values. The mean plus one standard deviation displacement is approximately twice the mean value, which indicates the wide range of possible displacements for a given magnitude event. Some comparable worldwide events on strike-slip faults provide additional insight into possible slip scenarios for hazard evaluation. For example, greater than 5m of slip was measured for the 1992 Landers Mw 7.3 earthquake, the 1999 Hector Mine Mw 7.1 event and the 1999 Turkey Mw 7.3 event.

4.7.4.3 Landslides

Landslides, earth flows, and debris flows are relatively common features in the steep ridge, valley, and canyon terrain of the Transverse Ranges. A portion of the Segment 2 T/L route has been mapped by the recent State Seismic Hazards Mapping Program. This program was instituted because "the effects of strong ground shaking, liquefaction, landslides, or other ground failure account for approximately 95 percent of economic losses caused by an earthquake." Segment 2 extends across one mapped landslide between MP 13.3 and MP 13.4. A review of the quadrangle-level hazard mapping for the areas that are mapped shows minor zones of potential landslide hazard in the areas of sloping terrain. These areas are listed in Table 4.7-1.

Quadrangle hazard mapping is not available for Segment 3. Segment 3 does traverse steeper terrain of the Tehachapi Mountains along the Substation 1 to Substation 2 routes. This type of granitic terrain is not typically as susceptible to landslide hazards as bedded sedimentary or foliated metamorphic rock. Some landslide hazard remains because of the sloping terrain, but overall the landslide hazard along this reach so Segment 3 is anticipated to be minor.

4.7.4.4 Liquefaction and Lateral Spreading

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. Liquefaction-induced failure and lateral movements of slopes or free faces are referred to as lateral spreading.

Liquefaction is a potential hazard at various locations along the Segment 2 T/L route based on the State seismic hazard mapping. These hazards are most significant in the Leona Valley, Anaverde Valley and the Soledad Canyon area near the Vincent Substation. The substation site is underlain by older alluvium and is not included within the liquefaction hazard zone. Lateral spreading is a potential hazard only if structures are placed near slopes or free faces underlain by liquefiable deposits.

Segment 3 is not underlain by significant liquefiable deposits based on our review of available information.

4.7.4.5 Expansive and Collapsible 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. Some potential for fine-grained expansive materials may be present in the Antelope Valley.

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. Collapsible soils, if present within the project area, are most likely in the fine-grained desert soils of Antelope Valley.

4.7.4.6 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.

Land subsidence is generally characterized by a broad zone of deformation where differential settlements are small. This type of deformation is not generally a significant hazard to overhead T/Ls or substation facilities because the individual foundation elements of these types of structures would not experience significant differential settlement as a result of regional subsidence. Subsidence is not considered a significant hazard for Segments 2 or 3 based on the geologic setting.

4.7.5 Soils

Soils result from both the physical and chemical weathering of the geologic deposits at and near the earth's surface. Soil formation is a complex phenomenon and is affected by the dynamic interaction of physical, chemical, and biological processes. Soil surveys classify soil characteristics based on soil associations, specifically, distinct combinations of soil types (soil series). Soil associations have been mapped by the USDA Natural Resources Conservation Service (NRCS) in the project area.

Soil Associations mapped within the project area are tabulated in Table 4.7-3. The map units present in the project area represent soil associations from four distinct groups; Mojave Desert soils, upland soils, soils on the eastern slopes of the Tehachapi Mountains, and alluvial soils. The Mojave Desert soil group is represented by the Hanford-Ramona-Greenfield, Cajon-Wasco-Rosamond, and Neuralia-Garlock-Cajon soil associations. Upland soils are present along the southern end of Segment 2 and include Cieneba-Caperton-Gaviota, Lodo-Sobrante-Gaviota, and Cieneba-Pismo-Caperton soil associations. Soils in the Tehachapi Mountains include the Rock Outcrop-Trigger-Torriorthents and Pajuela-Whitewolf-Rock Outcrop soil associations. The alluvial soils in the Tehachapi Valley are in the Havala-Steuber-Tehachapi soil association.

Some generalized characteristics for these associations are presented in Table 4.7-3.

TABLE 4.7-3
GENERAL CHARACTERISTICS OF SOIL ASSOCIATIONS PRESENT IN THE PROJECT AREA

Segment 2
Antelope to Vincent

Soil Association	Segment 2 Location (Milepost)[1]	Alternative AV1 (Milepost)[1]	Alternative AV2 (Milepost)[1]	Shrink-Swell Potential	Erosion Hazard	Corrosion Concrete	Corrosion Steel
Hanford-Ramona-Greenfield	Antelope Sub. 0.0 to 4.3			Low	Slight and Moderate	Low and Moderate	Moderate and High
Cieneba-Caperton-Gaviota	4.3 to 7.9	0.0 - 2.07		Low	Moderate and High	Moderate	Low and Moderate
Lodo-Sobrante-Gaviota	7.9 to 16.5		0.0 - 3.1	Low and Moderate	Moderate and High	Low and Moderate	Moderate
Cieneba-Pismo-Caperton	16.5 - 21.5 Vincent Sub			Low	Moderate and High	Moderate	Moderate

Segment 3
Antelope to Substation One

Soil Association	Segment 3 Location (Milepost)[1]	Alternative A (Milepost)[1]	Alternative B (Milepost)[1]	Shrink-Swell Potential	Erosion Hazard	Corrosion Concrete	Corrosion Steel
Hanford-Ramona-Greenfield	Antelope Sub 0.0 to 8.6	Antelope Sub 0.0 to 9.2	Antelope Sub 0.0 to 8.6	Low	Slight and Moderate	Low and Moderate	Moderate and High
Cajon-Wasco-Rosamond	8.6 - 21.8	9.2 - 22.3	8.6 - 20.4	Low	Slight and Moderate	Low	Moderate and High
Hanford-Ramona-Greenfield			20.4 - 21.2	Low	Slight and Moderate	Low and Moderate	Moderate and High
Cajon-Wasco-Rosamond			21.2 - 22.2	Low	Slight and Moderate	Low	Moderate and High
Neuralia-Garlock-Cajon	21.8 - 23.4	22.3 - 22.7	22.2 - 22.6	Low	Slight and Moderate	Low	Moderate and High
Cajon-Wasco-Rosamond	23.4 - 25.4	22.7 - 25.7	22.6 - 25.7	Low	Slight and Moderate	Low	Moderate and High
Neuralia-Garlock-Cajon	25.4 - 25.6 Substation One	25.7 - 25.9 Substation 1A	25.7 - 26.04 Substation 1B	Low	Slight and Moderate	Low	Moderate and High

TABLE 4.7-3 (CONTINUED)
GENERAL CHARACTERISTICS OF SOIL ASSOCIATIONS PRESENT IN THE PROJECT AREA

Segment 3

Soil Association	Proposed 220 kV (Milepost)[1]	Alternative C (Milepost)[1]	Shrink-Swell Potential	Erosion Hazard	Corrosion Concrete	Corrosion Steel
Neuralia-Garlock-Cajon	Substation One 25.6 - 26.2	Substation One 0.0 to 0.6	Low	Slight and Moderate	Low	Moderate and High
Pajuela-Whitewolf-Rock Outcrop	26.2 - 29.6	0.6 to 4.0	Low	Slight and Moderate	Low	Moderate and High
Rock Outcrop-Trigger-Torriorthents	29.6 - 34.6	4.0 to 8.0	Low	Slight and Moderate	Low	Moderate and High
Havala-Steuber-Tehachapi	34.6 - 35.2 Substation Two	8.0 to 9.5 Substation Two: 9.5 to 9.9 Substation 2A: 8.0 to 10.7 Substation 2B	Low	Moderate	Low	High

[1] Refer to Figures 3-2 (Segment 2) and 3-3 (Segment 3) for milepost locations.