3.5 GEOLOGY AND SOILS

Geological and soil hazards are normally associated with issues such as seismicity (ground shaking), slope stability, liquefaction, subsidence, and expansive soils. This section identifies general geologic and soil conditions in the study area and potential impacts associated with the Proposed Project and alternatives. Mitigation measures that could be implemented to minimize potential impacts are also provided. Geologic and soil hazard information for the study area is available from publications and existing literature.

3.5.1 AFFECTED ENVIRONMENT

The project area, which for the purposes of this discussion is comprised of the general area traversed by the Proposed Project and Alternatives A and C transmission line alignments and Alternative B transmission line alignment, encompasses corridors through eastern to central Riverside County and northern to central Imperial County in southeastern California. The Proposed Project and Alternatives A and C alignments, lie primarily within alluvial filled structural basins between numerous mountain ranges. Westward from Blythe these basins include the Palo Verde Mesa, Chuckwalla, Orocopia Valley, and Coachella Valley basins. The eastern portion of the routes pass well south of the McCoy and Palen Mountains before skirting the Chuckwalla Mountains, the Orocopia Mountains, and the Mecca Hills to the south, and the Eagle, Cottonwood, and Little San Bernardino Mountains to the north. Near the western end, the alignments pass south; of the Indio Hills. Elevations along the alignments range from approximately 100 feet above msl in the Coachella Valley to almost 2,000 feet above msl in the Orocopia Valley near the Orocopia Mountains.

The Alternative B transmission line alignment passes through the Palo Verde Mesa, the Arroyo Seco Valley, Amos Valley, and the East Salton Sea Basin to the Midway Substation. The southwest segment of Alternative B , including segment alignment Option B-1, passes through or near portions of the Mule Mountains, the Palo Verde Mountains, the Midway Mountains, and the Chocolate Mountains before turning northwest through Amos Valley south of the Chocolate Mountains. Elevations along the Alternative B alignment range from 40 feet below msl, around the Midway Substations, to about 1,100 feet above msl in the southern portion of the Chocolate Mountains.

Gently sloping to undulating bajadas (broad, gently sloping alluvial aprons that extend from the base of mountain ranges out into basins or valleys) and valleys dominate the project area landscape. Desert pavement (a layer of coarse pebbles and gravel created after wind removal of the finer materials) is common in this climate and is often present in broad, well-developed patches along large portions of the project routes. Some steep terrain exists along the Proposed Project and Alternatives A and C alignments near the Chuckwalla Mountains, and along the Alternative B alignment in the Palo Verde Mountains.

3.5.1.1 Geology

Figure 3.5-1 is a geologic map of the project area. All of the alignment routes start in the southeastern Mojave Desert and pass into the Sonoran Desert. The 25,000 square mile Mojave Desert has numerous isolated mountain ranges with alluvial basins in between, as are characteristic of the Great Basin Desert to the north. Although primarily in California, the Mojave Desert also encompasses portions of Nevada, Arizona and Utah.

The Sonoran Desert in California is called the Lower Colorado Valley Region, the hottest, driest, and largest region of the Sonoran Desert. Much of the Lower Colorado Valley Region is sandy or gravely plains, but it also contains low mountains, sand dunes and alkali sinks. Drainage channels (washes or arroyos) store water to support trees and large shrubs along their banks. The dominant structural feature of the Colorado Desert is the Salton Trough, a rift valley formed by tectonic separation of the North American and Pacific tectonic plates, and the northern extension of the Gulf of California.

The valleys traversed by the alignments typically occupy structural basins between surrounding mountains. Geologically these are not true valleys because they were not formed by stream erosion (valleys near the Colorado River Valley may be the exception). Size, shape, orientation, and elevation of the valleys are highly variable, although most of the surrounding mountains (and therefore the valleys) trend northwest. The floors of the valleys in the Mojave regions have much higher elevations than those comprising the Salton Trough, where elevations can be well below sea level. The following discussion presents the general geographic and geologic features along the alignment alternatives.

3.5.1.1.1 Proposed Project and Alternatives A and C

From the starting point near Blythe, the Proposed Project and Alternatives A and C alignments pass westward through the Palo Verde Mesa, Chuckwalla Basin, Orocopia Valley, and Coachella Valley. These hydrogeologic basins are typically surrounded by mountains, but many are contiguous with each other and divided on the basis of groundwater barriers that may include faults, shallow bedrock, narrow gaps between bedrock, groundwater divides, low permeability zones, or adjudicated basin boundaries, as discussed in Section 3.4.

3.5.1.1.1.1 Palo Verde Mesa - The Palo Verde Mesa is the only basin common to all alignments. It is characterized by gently to moderately sloping alluvial fans and the nearly level floodplain of the mesa. Elevations along the mesa vary from approximately 335 feet above msl near the proposed Keim Substation/Switching Station location to over 400 feet above msl near the Mule Mountains. Fluvial (water-based) erosion and deposition are the main geomorphic processes in this area.

The Palo Verde Basin, encompassing the Palo Verde Mesa and Palo Verde Valley to the east, consists of an alluvial-filled structural basin that ranges in depth from a few feet at the margins (near the mountains) to more than 1,500 feet (DWR 1978 and Metzger et al. 1973). Alluvium within the basin is the result of degradation and aggradations from the Colorado River and outwash of the debris of adjacent bedrock. Alluvium is divided into the younger and older deposits. The younger alluvium is present in the Palo Verde Valley. The older alluvium

Figure 3.5-1 – Geology

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Figure 3.5-1 – Geology

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outcrops on the Palo Verde Mesa and consists of sand, gravel, silt, and clays. Washes or arroyos developed on alluvial slopes on the mesa because of rainwater drainage from western elevated areas to the Colorado River. During heavy rains, flash floods may occur in localized subbasins. McCoy Wash, located about 3.5 miles northeast of the proposed Keim Substation/Switching Station location, is the largest wash in this part of the mesa.

3.5.1.1.1.2 Chuckwalla and Orocopia Valleys – West of the Palo Verde Mesa, the northern alignments pass through the center of the Chuckwalla Valley and trend approximately west into the Orocopia Valley about 40 miles west of the Palo Verde Mesa boundary. The Chuckwalla Valley is a broad east-west valley lying at an elevation of approximately 500 feet above msl. The Proposed Project and Alternatives A and C begin to bear northwest about 20 miles west of the Palo Verde Mesa to circumvent the Chuckwalla Mountains that form the southern boundary of the valley.

East to west the Eagle, Cottonwood, and Little San Bernardino mountains, with elevations that exceed 4,000 to 5,000 feet above msl, form the northern boundary of the Chuckwalla and Orocopia Valleys. The Chuckwalla and Orocopia Mountains south of these basins have maximum elevations greater than 3,000 feet above msl. Fluvial erosion from surrounding mountains formed the alluvial deposits within the basins. Consequently, similar to lithologies in the local mountains. Lithologies in most ranges typically consist primarily of Mesozoic granitic, Tertiary volcanics, Eocene marine deposits, Oligocene and Miocene non-marine sediments, Pre-Cretaceous metasedimentary, and Precambrian igneous and metamorphic rocks.

The Orocopia Valley extends for about 25 miles along the Proposed Project and Alternatives A and C alignments. Most of the Orocopia Valley is relatively narrow between surrounding mountains, and contains the highest topography (almost 2,000 feet above msl) crossed by the northern alignments. The western end of the Orocopia Valley broadens considerably before it merges with the much larger Coachella Valley to the west.

3.5.1.1.1.3 Coachella Valley - The Proposed Project and Alternatives A and C alignments pass through the northern portion of the Coachella Valley, a broad, low, northwest trending valley that slopes southeast to elevations below sea level near the Salton Sea on its southeastern border. The valley is bordered by the Little San Bernardino Mountains to the north, and the Santa Rosa Mountains to the south. The Coachella Valley is composed of late Pleistocene and Holocene alluvial deposits from historical flooding of the Colorado River, and lacustrine (lake) deposits from the Salton Sea and its predecessors. The Ocotillo Conglomerate, a thick sequence of poorly bedded coarse sand and gravel, is greater than 1,000 feet thick in many places and is the primary water-bearing unit in the basin (DWR 1964). The Salton Sea is a major feature of the valley and area.

3.5.1.1.2 Alternative B Alignment

The Alternative B alignment trends southwest through the Palo Verde Mesa east of the Mule Mountains, and then passes through a rugged portion of the Palo Verde Mountains. The alignment enters the eastern Arroyo Seco Valley and then passes through the southern Chocolate Mountains into Amos Valley where the alignment turns northwest and terminates in the East Salton Sea Basin, east of the Salton Sea.

The Palo Verde Mesa is described above in the discussion of the Proposed Project and Alternatives A and C alignments. The Mule Mountains that form the western boundary of the mesa in this area are low (generally less than 550 feet above msl), but rugged, mountains. The route passes well east of the crest and avoids rugged terrain until it enters the Palo Verde Mountains to the south. The Alternative B segment alignment Option B-1 diverges from the main route as it crosses into Imperial County and runs east of the Alternative B alignment for about 15 miles before rejoining the main alignment.

3.5.1.1.2.1 Palo Verde Mountains, Arroyo Seco Valley, Chocolate Mountains – In Imperial County, Alternative B traverses some rugged parts of the Palo Verde Mountains, passing about a mile west of Palo Verde Peak, the high point in the range at 1,795 feet above msl. These mountains are composed of volcanic rocks (andesite, rhyolite, and volcaniclastic deposits) and the claystone, siltstone, and sandstone of the Bouse Formation. Segment alignment Option B-1 largely bypasses the Palo Verde Mountains by diverging east, through a sandy wash, and running along the east margin of the mountains near the Colorado River. This option rejoins the main alignment in the Arroyo Seco Valley south of the Palo Verde Mountains.

The southern alignment traverses the eastern edge of the Arroyo Seco Valley west of the Midway Mountains. The Arroyo Seco Valley is typical of other basins in this region, and has a floor elevation near the alignment of about 500 feet above msl. It is bordered by the Palo Verde, Midway, Chocolate, and Little Chuckwalla Mountains.

The southern alignment crosses the Chocolate Mountains through a broad pass that connects the Arroyo Seco and Amos Valleys. The Chocolate Mountains are a northwest trending range, approximately 50 miles long, with peak elevations of 2,000 to 3,000 feet above msl. This range parallels portions of the Salton Sea and the San Andreas Fault along the eastern margin of the Imperial Valley and is comprised of Precambrian igneous and metamorphic complexes, Mesozoic granitic rocks, Tertiary volcanic and intrusive rocks, and Plio-Pleistocene sedimentary deposits (DOD 1995).

3.5.1.1.2.2 Amos Valley and East Salton Sea Basin - The northwestern trending portion of Alternative B traverses Amos Valley and part of the East Salton Sea Basin along gently to moderately sloping alluvial fans formed by drainage from the western slopes of the Chocolate Mountains, and flatter deposits from historic flooding by the Colorado River. Much of the alluvial material traversed by this portion of the route is eolian (wind blown) sand.

Amos Valley and the East Salton Sea Basin are bordered by the Chocolate Mountains to the north and are contiguous with the Imperial Valley to the south. The basins are divided from the Imperial Basin by the Imperial fault zone and can be considered subbasins. Most of Imperial County is situated in the Salton Trough, a 3,100 square mile structural depression that extends for approximately 1,000 miles from San Gorgonio Pass southeast to the Mexican border, including the Gulf of California, and beyond the tip of the Baja California Peninsula. The surrounding mountains are largely faulted blocks of the Southern California batholith of Mesozoic age, overlain by fragments of an earlier metamorphic complex. The valley basin consists of a sedimentary fill of sands and gravels ranging up to 15,000 feet in thickness. The layers slope gently down-valley, and contain several important aquifers. The valley is laced with major members of the San Andreas Fault system. Minor to moderate earthquake events are common, but severe shocks have not been experienced in recorded history. The Salton Trough is an active spreading rift valley where sedimentation and natural tectonic subsidence are nearly in equilibrium (Imperial County 1993). The entire trough, including the Gulf, is an extension of the East Pacific Rise, a zone of separation in the Earth's crust. The axis of the Rise (along with the Salton Trough) is a great transform fault where a large portion of North America, consisting of the Baja Peninsula and coastal California, is rotating northwest (seaward) relative to the rest of the continent.

The formation of the Colorado River delta perpendicular to the Trough created a closed basin to the north that contains the Salton Sea. Internal drainage and high evaporation rates cause salts to be concentrated within the Salton Sea. The Alternative B alignment ends at the Midway Substation east of the Salton Sea.

3.5.1.1.2.3 Algodones Dunes – Much of the northwest trending portion of the Alternative B alignment runs along the northern edge of the Algodones Dunes south of the Chocolate Mountains. The dunes are eolian sand deposits from the former Lake Cahuilla that occupied this basin. The Gulf of California has been periodically inundated by flooding from the Colorado River forming an ancient body of water known as Lake Cahuilla, which covered a large portion of Imperial, Coachella, and Mexicali Valleys. As Lake Cahuilla dried, prevailing westerly and northwesterly winds deposited sand east of the old lakeshore, along the southwestern face of the Chocolate Mountains, forming the Algodones Dunes. Prevailing winds cause the dunes to migrate to the southeast at a rate of approximately one foot per year. The biggest dunes in the region are Competition Hill and Brawley Slide.

3.5.1.1.3 Mineral Resources

Figure 3.5-2 shows locations of mines and mineral producers in the project area. Mines near the Proposed Project and Alternatives A, B, and C alignments are listed in Table 3.5-1. The Proposed Project and Alternatives A and C alignments pass to the north around the Indio Gravel Pit, (Map No. 521), owned by the Granite Construction Company.

An area south of the Chocolate Mountains crossed by the Alternative B alignment has a high mineral potential for construction materials (BLM 1999, 2001, 2002). Because the Proposed Project and alternative alignments lie within existing transmission corridors, there are no expected impacts related to mines or mineral resources.

3.5.1.2 Seismic Hazards

The eastern portion of the project area lies within the Sonoran Zone, a relatively stable tectonic region in southern California, southwestern Arizona, southern Nevada, and northern Mexico. This zone is characterized by sparse seismicity and few Quaternary faults. The western portion of the project area is in the Salton Trough, a zone of tectonic separation between the North American and Pacific plates and one of the most seismically active regions in North America.

A Seismic Zone classification is used by the Uniform Building Code (UBC) to define the magnitude of protection required for design of buildings to withstand earthquake risk in the area or from adjacent areas. UBC Seismic Zones range from 1 to 4 and are based on a ten percent probability of specific peak ground acceleration (PGA) values being exceeded within 50 years. Figure 3.5-3 shows estimated zones of gravitational acceleration based on this ten percent probability of occurrence within 50 years. Peak acceleration values progressively increase from east to west across the project area until maximum values are reached along the San Andreas and Brawly Fault Zones. The western end of the Proposed Project and Alternatives A and C alignments enters a zone of high peak accelerations. The terminus of the Alternative B alignment at the Midway Substation resides in a lower zone of acceleration, but is near highly active areas within the Salton Trough. The UBC Seismic Zone 4 has a PGA of 0.4g (or 40 percent of gravitational acceleration shown in Figure 3.5-3). All of California is classified as Seismic Zones 3 or 4, so the area east of the 40 percent band is Seismic Zone 3, while more active areas to the west fall within Zone 4.

3.5.1.2.1 Earthquake Magnitude

Seismologists use magnitude scales to express the seismic energy released by an Earthquake. Since the original magnitude scale was developed by Charles Richter in the 1930's, there has been a proliferation of magnitude scales for measuring the size of earthquakes occurring in southern California using relatively high-frequency data from nearby seismograph stations. This scale (designated M_L for Local Magnitude) eventually became known as the Richter magnitude. As more seismograph stations were installed around the world, it became apparent that the method developed by Richter was strictly valid only for certain frequency and distance ranges. New magnitude scales, including body-wave magnitude (Mb) and surface-wave magnitude (Ms) were developed based on Richter's original scale, but each is valid only for a particular frequency range and type of seismic signal. Because of the limitations of the M_L, Mb, and Ms scales, a new, more uniformly applicable extension of the magnitude scale, known as moment magnitude or M_w, was developed. Moment magnitude generally gives the most reliable estimate of earthquake size, especially for large earthquakes, and seismologists generally favor the M_w scale.

3.5.1.2.2 Local Geologic Faults

Local faults are shown on Figure 3.5-3. There are no active or potentially active faults known in the Palo Verde Mesa area, where fault activity is believed to have ended more than one million years ago. Additionally, there are no Alquist-Priolo Earthquake Fault Zones (established by the State Geologist under the Alquist-Priolo Special Studies Zone Act of 1972) within the Palo Verde Mesa area.

The Proposed Project and Alternatives A and C, which parallel existing transmission line facilities in the utility corridor, cross the San Andreas Fault in two locations as shown on Figure 3.5-3.

The southernmost section of the San Andreas Fault is within the northwest portion of the project area (Jennings 1992), as indicated on Figure 3.5-3. The San Andreas Fault begins near the Salton Sea and extends northward to Point Delgado, located along the northern California coast. San Andreas is the longest fault in California, measuring 745 miles. The maximum credible earthquake (MCE) for the San Andreas Fault is believed to be 8.5 M_w along most of the fault line. However, the maximum probable earthquake (MPE) of the San Andreas Fault line is believed to range from 6.8 to 8.0 M_w. The largest recorded earthquake on the San Andreas Fault was the 1906 San Francisco earthquake that registered 7.9 M_w.

Figure 3.5-2 Mineral Resources

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Table 3.5-1
Mines and Mineral Producers [a]

Alternative	Map No.[b]	Mine	Operator	Commodity	Active?
A, B, and C	549	Thermal Canyon	Riverside Co. Transportation	Sand & Gravel	yes
A, B, and C	551	Valley Rock & Sand	Valley Rock & Sand, Inc.	Sand & Gravel	yes
A, B, and C	523	James E. Simon Company	James E. Simon Company	Sand & Gravel	yes
A, B, and C	542	R Bar C	Valley Rock & Sand, Inc.	Sand & Gravel	yes
A, B, and C	521	Indio Pit	Granite Construction Co.	Sand & Gravel	yes
A, B, and C	503	B.L.M.-Thousand Palms	E.L. Yeager Construction Co.	Sand & Gravel	yes
A, B, and C	536	Mountain View Road Pit	Riverside Co. Transportation	Decomposed Granite	yes
A, B, and C	516	Garnet Pit	Granite Construction Co.	Sand & Gravel	yes
B	178	Mesquite	Newmont Gold Company	Gold (Lode)	no
B	196	Vista Cherokee Rainbow (VDR)	Newmont Gold Company	Gold (Lode)	no
B	167	Elms Glamis Pit	Elms Equipment Rental, Inc.	Sand & Gravel	no
B	173	Glamis I and Glamis II	Imperial County Public Works	Sand & Gravel	no
B	168	Flowing Wells South Pit	Granite Construction Co.	Sand & Gravel	no

a. Source: Mines and Mineral Producers Active in California 1997-1998, California Department of Conservation 1999.
b. See Figure 2.5-2.

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Figure 3.5-3 Seismic Risk

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The Chocolate Mountains and adjacent areas in the Salton Trough are some of the most tectonically active areas in the U.S. The Salton Trough formed by crustal spreading between the North American and Pacific Tectonic Plates along the San Andreas Fault System. During Pliocene time (two to five million years ago), Baja California rifted from the mainland of Mexico along what is now the Gulf of California. Spreading progressed northward into the Salton Trough from the Gulf, resulting in the widening and elongation of Imperial Valley. Horizontal displacement (transverse faulting) along the San Andreas Fault forms the eastern boundary of the Salton Trough (Imperial County 2000).

Tectonically derived faults in the Salton Trough near the Alternative B alignment include the Sand Hill, Salton Creek, Hot Springs, and Hidden Springs Faults. These faults tend to run north of and parallel to the Salton Sea. Other faults in this area include the Brawley Fault, Elmore Ranch Fault, and Chiriaco Fault. Alternative B has a high potential of experiencing seismic events, because it runs through the northern portion of the Salton Trough where many of these faults are located, but estimated peak ground acceleration within the alignment is less than along the San Andreas Fault zone based on Figure 3.5-3.

The most seismically active fault system in southern California today is the 180-mile San Jacinto Fault and its branches or subordinate faults. The San Jacinto Fault separates from the San Andreas Fault near Cajon Pass (near Bakersfield, California). The San Jacinto Fault system is approximately 45 miles west of the Midway Substation. Southwest of the project area, there are at least six San Jacinto subordinate faults spaced approximately one-half to three miles apart. The most active fault branch of these subordinate faults is the Imperial Fault. This fault has been the source of many tremors and earthquakes in recent years, some of them very destructive. Another active branch is the Superstition Hills Fault along the west side of the Imperial Valley.

3.5.1.2.3 Recent Seismic Activity

There is no recent historic seismic activity in the northeastern portion of the project area in the Palo Verde Valley or Mesa area. The last seismic activity in this area is believed to have occurred more than one million years ago. Earth movement has been felt in the Palo Verde region from earthquake activities outside of the area, but significant earthquake damage in the region has not occurred. The most recent significant earthquake in the northern portion of the project area was the Hector Mine quake in 1999. The epicenter of this earthquake was approximately 200 miles north of the Blythe area (Greystone 1999).

The most recent seismic activity in the project vicinity was the magnitude 6.0 North Palm Springs Earthquake occurring along the Banning Fault and Garnet Hill Fault. The epicenter was about 6 miles northwest of Palm Springs. This earthquake resulted in significant damage to the existing Devers Substation. Subsequent upgrades were incorporated to the Devers Substation that met UBC seismic zone 4 design criteria. Project substation/switching stations will be designed to meet seismic zone 4 criteria.

In the southwestern portion of the project area, the San Jacinto Fault has been the most active. Between 1915 and 1954, five historic large quakes have occurred along this fault between the City of San Jacinto and the Salton Sea. These earthquakes ranged from 6.0 to 6.8 on the Richter scale. Although the San Andreas Fault has not been significantly active in the Salton Sea area over the past 50 years, earthquakes from the San Andreas Fault have occurred relatively recently in the Los Angeles area. The most recent of these earthquakes was the San Fernando earthquake of 1971, at a magnitude of 6.6 M_w.

Algermissen et al. (1982) determined Maximum Magnitude Earthquakes (MME) for seismic source zones based on historic seismic data including frequency, location, magnitude, and fault rupture length. The MME is defined as the largest earthquake that can occur, based on historical data for the region. Earthquake studies estimated a MME Richter magnitude of 7.3 for the southwestern portion of the project area in Imperial County (Algermissen et al. 1982).

The Modified Mercalli Intensity (MMI) scale, ranging from intensity I to XII, is used in the U.S. to rate the severity of an earthquake based upon its effects on people, structures, and objects. Historical earthquakes (1830 to 1980) in the area have ranged from MMI II to greater than VII. Intensity II (few people might notice movement if they are at rest) to VII (people have difficulty standing, loose bricks fall from buildings, drivers feel car shaking, and damage is slight to moderate in well-built buildings) indicates magnitudes of 4.0 to greater than 7.0 on the Richter scale (DuBois et al. 1982; Sumner 1976).

Historical records for the area indicate earthquakes have caused abrupt elevation changes in excess of one foot across fault lines (Imperial County 1993).

3.5.1.3 Subsidence

Land subsidence can be caused by various natural phenomena such as tectonic movement, consolidation, hydro compaction, or rapid sedimentation. Subsidence can also result from a variety of human activities, including withdrawal of water or petroleum from the subsurface.

Subsidence in the northeastern portion of the project area on the Palo Verde Mesa has not been recorded. However, existing transmission lines passing south of the Chocolate Mountains have experienced a continuous natural subsidence near the Salton Sea. Natural subsidence within the Salton Trough has averaged nearly 2 inches per year at the center of the Salton Sea, decreasing to 0 near the Mexican border.

3.5.1.4 Landslides

A landslide refers to rock or debris descending down a slope slowly to very rapidly due to gravity. Slopes along the Palo Verde Mesa in the eastern portion of the project area range from approximately 3 percent in the northeast to approximately 30 percent about 1 mile east of the proposed Keim Substation/Switching Station location. The mesa is relatively flat with an elevation ranging from approximately 335 feet above msl at the proposed Keim Substation/Switching Station location to about 400 feet above msl near the Mule Mountains. The nearest significant slope in this portion of the project area occurs within a linear distance of approximately 1,000 feet along which the mesa drops from about 345 to 260 feet above msl to the Palo Verde Valley. However, landslide potential in this area is considered to be small.

In general, areas with the steepest terrain have the greatest potential for landslides. The large majority of the Proposed Project and alternative alignments pass through valleys and mountain fringes where the risk of landslides is low. The steepest terrain crossed by the Proposed Project alignment is where it crosses the north end of the Chuckwalla Mountains near Desert Center.

The steepest portion of the Alternative B alignment is in the Palo Verde Mountains where the route passes just west of Palo Verde Peak. The Chocolate Mountains also contain steep inclines which could be subject to localized landslides. Areas along the Alternative B alignment near the Salton Sea subject to landslides include embankments along the East Highline and Westside Main Canals and bluffs adjacent to the Coachella Canal. The hazardous landslide areas adjacent to the canals are defined as a distance of one-half the canal bank height beyond the toe of the slope for all of the levee and canal banks.

3.5.1.5 Liquefaction

Liquefaction is a phenomenon in which saturated soils lose strength and cohesion when subjected to dynamic forces, such as shaking during an earthquake. Liquefaction can also occur in unsaturated soils with low cohesion, such as sand. Liquefaction and related phenomena have been responsible for tremendous amounts of damage during historical earthquakes when water pressure between soil particles can increase to the point where the soil cohesion is lost, along with the support that it normally supplies to building foundations.

Groundwater levels within the project area are relatively deep along the project transects, except in the Coachella Valley and near the Salton Sea. The only portion of the Proposed Project and Alternatives A and C with a moderate to very high liquefaction potential (Riverside County) is an approximate 10-mile section north of Indio (Figure 3.5-3). The last few miles of Alternative B to the Midway Substation also is an area of shallower groundwater and greater seismic risk; therefore, has a greater liquefaction potential. Groundwater levels in this area may also be enhanced by leakage from the Coachella and East Highline Canals, which are crossed by Alternative B in this area. The DWR has entered into a $74 million contract with the Metropolitan Water District for the Coachella Canal Lining Project, which will eliminate seepage from this source.

Some areas of unconsolidated soil, such as loose sand found in portions of the Chuckwalla and Coachella Valleys and the Algodones Dunes, may also pose a dry, liquefaction-like risk during a severe earthquake.

3.5.1.6 Soils

Soils in the project area have been mapped and described as “mapping units”. These mapping units provide a sufficient level of detail to determine the physical type and characteristics of soil in the project area. Soil series characteristics are described in Table 3.5-2, and shown on Figure 3.5-4. This information can be used by soil management agencies to make decisions regarding impacts associated with construction in the project area. The location and properties of the soil-mapping units were identified from maps of the area prepared by the U.S. Soil Conservation Service (now called the NRCS). These soil maps and properties were obtained from the *Soil Survey of Palo Verde Area, California* (U.S. Department of Agriculture [USDA] 1974); the *Soil Survey of Imperial Valley Area, California* (USDA 1981); the Yuma Training Range Complex Draft EIS (DOD 1995); and Ecological Sub regions of California.

3.5.2 REGULATORY SETTING

3.5.2.1 Federal

3.5.2.1.1 Uniform Building Code

The 1997 UBC is developed by the International Conference of Building Officials and used by most states, including California, as well as local jurisdictions to set basic standards for acceptable design of structures and facilities. The UBC provides information on criteria for seismic design, construction, and load-bearing capacity associated with various structures and facilities such as transmission lines and poles. Additionally, the UBC identifies design and construction requirements for dealing with geologic hazards.

3.5.2.1.2 Grading

On federal land construction and grading are regulated by the BLM under the use permits issued for development projects. As part of the right-of-way grant, the BLM requires that a COM Plan be developed, approved by the BLM, and implemented by the applicant. The COM Plan must be developed following the guidelines in the most recent edition of the BLM Rights-of-Way COM. This plan provides guidance on clearing, blasting, erosion control, protection of resources, revegetation, restoration and other elements. Construction on slopes is given particular attention because of potential soil erosion, health and safety hazards, and water quality concerns. In areas under local government jurisdiction, grading and construction are regulated through local use permits and grading permits in compliance with local ordinances. New construction generally must meet the requirements of the most recent version of the UBC, including sections dealing with natural hazards from unstable and corrosive soils and earthquakes.

3.5.2.2 State

3.5.2.2.1 Alquist-Priolo Earthquake Fault Zoning Act

The State Alquist-Priolo Earthquake Fault Zoning Act (A-P Act) was passed in 1972 to mitigate the hazard of surface faulting. Administered by the California State Department of Conservation, this act prevents construction of buildings used for human occupancy on the surface traces of active faults. Before a project can be permitted, cities and counties must require a geologic investigation to demonstrate that proposed buildings will not be constructed across active faults. Alquist-Priolo Earthquake Fault Zones have been designated by the California Division of Mines and Geology for the Elsinore, San Jacinto, and San Andreas Fault zones in Riverside County. The act does not address power lines, water lines, or roads unless there are associated structures for human occupancy that would exceed 2,000 person hours per year and is, therefore, not applicable to the Proposed Project or other alternatives.

3.5.2.2.2 Williamson Act

The California State Department of Conservation administers this act. This act enables local governments to enter into contracts with private landowners for the purpose of restricting specific parcels of land to agricultural or related open space use. In return, landowners receive property tax assessments, which are based on the agricultural value of the land rather than on its real estate market value, resulting in lower taxes.

Table 3.5-2
Soil Series and Characteristics Within the Project Area

Soil Series	Slope (% grade)	Characteristics
Aco	0 to 8	The Aco series consists of very deep, well drained to somewhat excessively drained soils that formed in mixed alluvium on terraces slightly above the flood plain. The representative profile of these soils is approximately 5 feet in depth. The permeability of Aco sandy loam soils is moderately rapid. Land containing this soil type is classified as prime agricultural land and has high revegetation potential. Where the soil is bare, runoff is slow and erosion hazards are slight.
Beeline	3 to 45	The Beeline series consists of shallow and very shallow, well drained soils that formed in mixed alluvium on fan terraces and hill slopes. This series has medium to rapid runoff and moderately rapid permeability. Land is used for range land and recreation. Native vegetation is mainly creosotebush, triangle bursage, ratany, big galleta, barrel cactus, saguaro, ocotillo, whitethorn, littleleaf paloverde, Mormon-tea and bush muhly.
Bitterwater	9 to 75	The Bitterwater series consists of deep, well-drained soils formed in material weathered from sandstone. Well drained; medium to very rapid runoff; moderately rapid permeability. Natural vegetation consists of red brome, fescues, filaree, allscale, and saltbush.
Cajon	0 to 15	The Cajon series consists of very deep, somewhat excessively drained soils that formed in sandy alluvium from dominantly granitic rocks. Cajon soils are on alluvial fans, fan aprons, fan skirts, inset fans and river terraces. Somewhat excessively drained; negligible to low runoff; rapid permeability. Cajon soils with sandy loam surface textures have moderately rapid over rapid permeability. Flooding is none to rare. Used mostly for range, watershed, and recreation. A few areas are irrigated and are used for growing alfalfa and other crops. Vegetation is mostly desert shrub, including creosote, saltbush, Mormon-tea, and Joshua trees; and some Indian ricegrass, annual grasses and forbs.
Carsitas	0 to 9	The Carrizo series consists of very deep, excessively drained soils formed in stratified alluvium from mixed sources. Carrizo soils are on flood plains and alluvial fans, fan aprons and fan terraces. Excessively drained; negligible through low runoff; rapid to very rapid permeability. Carrizo soils with loam or sandy loam surface textures have moderately rapid to rapid permeability. Used as a source of sand and gravel for construction material. Vegetation is a sparse growth of cacti, creosotebush, white bursage, mesquite, and paloverde.
Cherioni	0 to 70	The Cherioni series consists of very shallow and shallow, somewhat excessively drained soils that formed in slope alluvium on volcanic bedrock. Cherioni soils are on fan terraces or hills. Somewhat excessively drained; medium to rapid runoff; moderate permeability. Used for livestock grazing. Present vegetation is creosotebush, paloverde, saguaro, cholla, ocotillo, triangleleaf bursage and ratany.

Table 3.5-2
Soil Series and Characteristics Within the Project Area

Soil Series	Slope (% grade)	Characteristics
Chuckwalla	0 to 15	The Chuckwalla series consists of very deep, well-drained soils formed in stratified mixed alluvium. Chuckwalla soils are on fan terraces. Well drained; medium runoff; moderate permeability. Chuckwalla soils are usually barren except for some Turks Head (Plantaginaceae), six weeks grama (Boutelous barbata), and other annuals that occur for short periods in wetter years.
Cipriano	0 to 55	The Cipriano series consists of shallow and very shallow to hardpan, somewhat excessively drained soils that formed in fan alluvium from volcanic rock. Cipriano soils are on fan terraces. Somewhat excessively drained; slow to medium runoff; moderate permeability. Used mainly for livestock grazing and wildlife habitat. Present vegetation is creosotebush, paloverde, staghorn and chainfruit cholla, saguaro, ocotillo, and triangle bursage with some fluffgrass and sixweeks grama.
Gilman	0 to 3	The Gilman series consists of very deep, well drained soils that formed in stratified stream alluvium. Gilman soils are on flood plains and alluvial fans. Well drained; slow runoff; moderate permeability. Used for livestock grazing and irrigated cropland. Under cultivation, Gilman soils are used for growing alfalfa, cotton, grains, sugar beets and truck crops such as melons, lettuce, onion, carrots, broccoli and potatoes. Native vegetation is mesquite, catclaw, creosotebush, arrowweed and saltbush. Cottonwoods, willows and salt cedar grow in open areas.
Glenbar	0 to 3	The Glenbar series consists of very deep, well drained soils that formed in stratified stream alluvium. Glenbar soils are on flood plains and alluvial fans. Well drained; medium to slow runoff; moderately slow permeability. Used for livestock grazing, and where irrigated, for cultivated crops and pastures. Alfalfa, cotton, grain and vegetables are common irrigated crops. Vegetation is creosotebush, mesquite, paloverde, ironwood, salt cedar, cacti, annual weeds and grasses.
Gunsight	1 to 40	The Gunsight series consists of very deep, somewhat excessively drained, strongly calcareous soils that formed in alluvium from mixed sources. Gunsight soils are on fan terraces or stream terraces. Somewhat excessively drained; medium runoff; moderate or moderately rapid permeability. Used for livestock grazing and recreation. The vegetation is creosotebush, ocotillo, paloverde, saguaro, cholla and triangle bursage.
Hyder	1 to 65	The Hyder series consists of very shallow to shallow, somewhat excessively drained soils that formed in alluvium from rhyolite and related volcanic rocks. Hyder soils are on mountains and hills. Somewhat excessively drained; medium to rapid runoff; moderate or moderately rapid permeability. Hyder soils are used for livestock grazing, wildlife habitat and recreation. The present vegetation is creosotebush, white bursage, brittlebush, buckhorn cholla, and littleleaf paloverde.

Table 3.5-2
Soil Series and Characteristics Within the Project Area

Soil Series	Slope (% grade)	Characteristics
Imperial	Unspecified	The Imperial soils are nearly level to gently sloping and are on flood plains and in old lake beds at elevations of 235 feet below sea level to 300 feet above sea level. They formed in calcareous alluvium from mixed sources. Well and moderately well drained; slow or very slow runoff except on low scarps; very slow permeability. Under irrigation, tile drainage is needed to leach soluble salts and to maintain water tables below depths of 4 to 5 feet. Used for irrigated agriculture and unirrigated native desert plants. Irrigated common crops are cotton, sugar beets, barley, annual ryegrass, and where salinity is not too high, alfalfa, sorghums, flax, safflower, and winter vegetables. Unirrigated areas have a sparse growth of saltbush, creosotebush, Sueda, and Allenrolfea; mesquite and Tamarix grow where their roots can reach groundwater.
Laposa	10 to 75	The Laposa series consists of moderately deep, somewhat excessively drained soils formed in slope alluvium from schist, granite, gneiss, rhyolite and eolian deposits. Laposa soils are on hills and mountains. Somewhat excessively drained; rapid runoff; moderate permeability. These soils are used for wildlife habitat and limited livestock grazing. Native vegetation is creosotebush, white bursage, littleleaf paloverde, brittlebush, ocotillo, elephant tree, cholla, turkhead, and annual forbs.
Torriorthents and Orthids	5 to 30	This unit is made up of deep, well drained to excessively drained soils on terrace escarpments and old alluvial fans dissected by geologic erosion. Local relief is less than 25 feet. The soils formed in mixed, unconsolidated alluvial sediment. Permeability of the Torriorthents and Orthids ranges from slow to rapid, and available water capacity is low to very high. Surface runoff is rapid, and the hazard of erosion is high.
Lomitas	5 to 65	The Lomitas series consists of shallow, somewhat excessively drained soils formed in alluvium and colluvium. Lomitas soils are on hills and mountains and have slopes of 5 to 65 percent. Somewhat excessively drained; medium to rapid runoff; moderate permeability. Used for livestock grazing. The vegetation is creosotebush, brittlebush, triangle, bursage, paloverde, ocotillo, saguaro, organ pipe cactus and cholla.
Myoma	Unspecified	Myoma soils are nearly level to rolling, have hummocky micro relief where unprotected and are at elevations of 200 feet below sea level to 1,800 feet above sea level. The soil formed in sand blown from recent alluvium. Somewhat excessively drained; very slow runoff; rapid permeability. Myoma soils are used principally for growing citrus fruits, grapes, alfalfa, dates and truck crops under irrigation. Native vegetation is ephemeral grasses and forbs, and a sparse cover of creosotebush, bush sunflower and mesquite.
Omstott	Unspecified	Omstott soils are on gently rolling to steep uplands at elevations of 3,600 feet to 5,000 feet. They formed in material weathered from granodiorite, mica schist and gneiss. Well-drained; rapid to medium runoff; moderate and moderately rapid permeability. Omstott soils are used for watershed, wildlife, recreation and homesites. Vegetation is pine, pinyon pine, cedar, ribbonwood, ceanothus, scrub oak, manzanita, cholla, beavertail and barrel cactus, yucca, century plant, annual and perennial grasses.

Table 3.5-2
Soil Series and Characteristics Within the Project Area

Soil Series	Slope (% grade)	Characteristics
Orita	0 to 2	The Orita series consists of very deep, well drained soils that formed in alluvium from mixed sources. Orita soils are on fan remnants and terraces. The Orita soils are well drained. Runoff is very low to medium. Permeability is moderate. Orita soils have very little value as rangeland. They are well suited for cultivation where water is available for irrigation. Native vegetation is sparse cover mainly of creosote bush and white bursage.
Quilotosa	3 to 65	The Quilotosa series consists of very shallow and shallow, somewhat excessively drained soils that formed from granitic and metamorphic rocks. Quilotosa soils are on hills and mountains. Somewhat excessively drained; medium to rapid runoff; moderately rapid permeability. Used for livestock grazing, wildlife habitat and recreation. Vegetation is saguaro, littleleaf paloverde, brittlebush, creosotebush, ocotillo, ironwood, triangle bursage, white bursage, cholla, forbs and grasses.
Rillito	0 to 5 (Range to 40 percent)	The Rillito series consists of very deep, somewhat excessively drained soils that formed in mixed alluvium. Rillito soils are on fan terraces or stream terraces. Somewhat excessively drained; slow or medium runoff; moderate permeability. Irrigated areas are used to produce crops such as cotton, alfalfa, small grains and citrus. The desert areas are used to a limited extent for livestock grazing. The vegetation is mainly creosotebush, desert sage, cacti, mesquite, paloverde, ironwood, and annual grasses and weeds.
Rositas	0 to 30	The Rositas series consists of very deep, somewhat excessively drained soils formed in sandy eolian material blown from recent alluvium. Rositas soils are on dunes and sand sheets. Somewhat excessively drained; negligible to medium runoff; rapid permeability. Rositas soils are used for growing citrus fruits, grapes, alfalfa, and truck crops. Native vegetation creosotebush, white bursage, desert buckwheat and mesquite.
Sparkhule	5 to 50	The Sparkhule series consists of shallow to rock, well drained soils that formed in residuum from volcanic or granitic rocks. Sparkhule soils are on rock pediments and hills and have slopes of 5 to 50 percent. Well drained; high to very high runoff; moderately slow permeability. Used mainly for wildlife habitat, military operations and recreation. Native vegetation is sparse stands of creosotebush, yucca species, annual grasses and forbs.
Tecopa	15 to 75	The Tecopa series consists of very shallow soils formed in residuum and colluvium weathered from quartzite, schists, and gneiss. Tecopa soils are on low hills and low mountainside slopes. Well rained; medium to rapid runoff; permeability is moderate. These soils are used for rangeland and wildlife habitat. Vegetation is creosotebush, yucca, cacti, white bursage, Mormon tea and blackbrush.
Upspring	8 to 75	The Upspring series consists of very shallow and shallow, somewhat excessively drained soils formed in material weathered from extrusive basic igneous rocks and some pyroclastic material. Upspring soils are on hills, mountains, and plateaus and have slopes of 8 to 75 percent. Somewhat excessively drained; high or very high runoff; moderately rapid permeability over impermeable bedrock. Used mainly for watershed, wildlife habitat, and recreation land. The native vegetation is primarily shadscale and winterfat.

Figure 3.5-4
Soil Types

Back page of figure.

3.5.2.2.3 National Pollutant Discharge Elimination System Permit

In California, the State Water Resources Control Board administers the U.S. EPA-promulgated regulations (55 CFR 47990) requiring the permitting of stormwater-generated pollution under the NPDES. Pursuant to these federal regulations, an operator must obtain a General Permit under the NPDES Stormwater Program for all construction activities of one acre or greater. The General Permit requires the implementation of BMPs to reduce pollutant loads into the waters of the state.

3.5.2.2.4 California Building Code

The 1998 California Building Code (CBC) specifies the acceptable design and construction requirements associated with various facilities or structures. This code specifies criteria for open excavation, seismic design, and load-bearing capacity directly related to the layout of electrical transmission line and their poles. The CBC augments the UBC and provides information for specific changes to various sections in it.

3.5.2.3 Local

3.5.2.3.1 Imperial County

Objectives in the Imperial County General Plan concerning soil include preserving major areas of Class II and III soils, which are currently nonirrigated but offer significant potential when water is made available, and controlling and preventing soil erosion when possible (Imperial County 1993).

3.5.2.3.2 Riverside County

The Riverside County General Plan provides limits or use designations for development of land having lower suitability for development due to steep slopes, fire risk, flood hazards, seismic conditions, or other physical hazards. Additionally, the General Plan has provisions dealing with soil conservation, encouraging continued use of agricultural areas, and limiting incompatible urban development adjacent to productive agricultural land. Requirements of the County Special Use Permit will be incorporated into the project's design, thereby ensuring compliance with the seismic requirements of the County's General Plan.

3.5.3 ENVIRONMENTAL CONSEQUENCES

This section discusses potential impacts associated with geologic hazards and soil resources that may be affected or may affect the safety and operational reliability of facilities associated with the Proposed Project and alternatives. This section also includes mitigations to avoid or eliminate the impacts or reduce the effects to a less-than-significant level.

3.5.3.1 Methodology and Significance Criteria

Specific locations for transmission towers, materials yards and spur roads have not yet been determined. Therefore, this assessment addresses potential impacts, some of which are likely to be avoided by discretionary site selection decisions during final project design and construction contractors. Site-specific considerations will be addressed fully in the COM Plan.

Significant geology-related impacts would result if project facilities were to fail or create hazards to adjacent property due to:

- Effects of fault rupture or other effects from an earthquake; and/or
- Natural or induced soil movements and slope instability.

For the purpose of this analysis, project construction, operation, and maintenance activities would have a significant impact to soils if they would:

- Substantially increase erosion along the transmission line corridor, access and spur roads, or around associated facilities;
- Substantially affect downstream resources by erosion and sedimentation;
- Substantially increase soil compaction; and/or
- Substantially decrease the potential or increase the time period for reclamation success.

3.5.3.2 Proposed Project Impacts and Mitigation Measures

This section identifies the potentially significant adverse impacts and required mitigation measures for the Proposed Project. In addition, as described in Sections 1 and 2, in response to comments received on the Draft EIS/EIR, a minor variation to the Proposed Project was developed (referred to as Variation PP1). Variation PP1 would remain in the same general alignment as the Proposed Project but would be shifted south approximately 150 feet into SCE's existing and approved PVD2 right-of-way. Therefore, unless noted below, the geology and soils impacts of Variation PP1 would be similar to those identified for the Proposed Project.

Geology and Soils Impact 1: *Construction of Proposed Project facilities, including tower footings and access roads in areas with steep or unstable slopes, could create hazardous conditions that may pose a threat of disruption to Proposed Project facilities.*

The Proposed Project would require local grading that would alter the topography, particularly on steep slopes. Grading potentially could create unstable cut-and-fill slopes, especially on steep slopes and areas with weak rock materials. The total area of soil disturbance due to construction activities for the Proposed Project is estimated to be 1111-1242 acres (of which 148-179 acres would be permanent). Most grading would be required for construction of suitable footings for the transmission towers. Some grading would be needed for the temporary spur roads, widening of existing access roads, and construction pads for structure sites located on steep slopes in order to provide safe and level surfaces for excavation equipment, cranes, bucket trucks, and tower assembly. Hazards from unstable slopes and seismic hazards could affect roads; however, in general, the impacts are likely to be less than significant. Debris clearing and road repair would be required as a normal response to such an event.

Most transmission tower construction would involve minor excavations and fill, and the potential impact on the environment would be less than significant due to the small amount of land that is disturbed. However, some sites would encounter steep and difficult terrain or would be subject to geotechnical hazards that would need to be corrected before the towers are constructed. Such conditions potentially would include the following:

- Steep slopes (generally 15 percent or greater) may require fill or cuts to accommodate the footings for the towers or provide sufficient space for the necessary road surface width, grade, and turning radius. Selection of the 15 percent slope is based on the fact that large surface cutbacks for foundations are not needed and construction equipment can operate safely at slopes less than 15 percent.
- Soft, compressible soils may require deeper footings for the towers, or imported fill material or concrete to provide suitable restraint to meet code requirements. Similarly, weak soils may have to be regraded or reinforced with imported fill material to provide a suitable base for access by construction and maintenance equipment.
- Unstable slopes may need to be stabilized to ensure that the towers and roads would be protected from hazards that may result in tipping or failure of a road. This may include unstable slope hazards at the immediate construction site as well as adjacent areas that could affect the site. Such hazards may include landslides, rockfall and debris avalanches, mudflows, erosion on steep slopes, and areas subject to liquefaction in earthquakes.

The preceding geotechnical hazard conditions are site specific. As individual tower placement and road construction plans are not yet available, hazards and impacts are treated here generically. Hazards would be evaluated during final design specification for each tower location and road construction area. Options would include avoidance of a poor site by selection of a site with stable conditions, or correction of the unstable slope conditions, which usually entails grading and other methods. Correction of unstable soil conditions would have potential impacts, namely topographic alterations produced by cut-and-fill slopes. Improperly engineered and constructed cut-and-fill slopes could create unstable conditions in the long-term, which could compromise the operational reliability of the line. Construction spoil material improperly dumped at the site could create unstable soil conditions.

Due to the potential for site-specific geologic conditions to create a risk of disturbance to Proposed Project facilities, they are considered significant. Mitigation measures, presented below, would be required to reduce these impacts to less than significant.

Geology and Soils Impact 1 Mitigation:

(a) IID will retain a qualified engineering geologist to evaluate the potential for geotechnical hazards and unstable slopes on the centerline route and areas of new road construction or widening on slopes with over 15 percent gradient. The engineering geologist will evaluate the nature of the steep slope and/or unstable soil hazard at tower sites with these constraints and the immediate vicinity to allow options for avoiding the hazard. The evaluation should be based on an inspection of all sites where towers or roads will be constructed with slopes of 15 percent or greater, or have identified slope instability hazards. Soil testing will be conducted, if needed, to ascertain the depth, lateral extent of unstable materials, and potential hazards both upslope, and down slope of the site.

The engineering geologist will prepare a report that includes recommendations for moving the towers or roads, or identifies construction methods to stabilize the site or off-site areas that would threaten the hazard sites if the structures cannot be moved. IID will incorporate the recommendations of the engineering geologist into its COM Plan, including construction drawings and details for grading, drainage, and specialized slope treatment (e.g., installation of retaining walls, wire retention structures, gabions, berms to deflect debris avalanches, etc.). IID's construction contractor will implement the plans, and IID's quality assurance inspectors and the environmental monitors will inspect and certify that the slopes have been constructed and stabilized in accordance with details in the COM Plan.

(b) Under no circumstances will cut or fill slopes be allowed to pose a temporary or long-term hazard to the Proposed Project facilities or to off-site property in accordance with criteria set in the COM Plan. All cut slopes will be cut at an angle of repose and/or benched or otherwise protected to ensure long-term stability. IID will commit to appropriate re-contouring, erosion control, and reseeding of all cut-and-fill slopes. IID will also ensure the long-term stability of all slopes. Monitoring and stability requirements will be detailed in the Reclamation section of the COM Plan.

(c) To reduce the environmental impacts of slope alteration, all practicable measures will be taken to avoid locating transmission line footings and roads on sites that have severe geotechnical hazards requiring substantial grading and other engineering of cut and fill slopes.

Geology and Soils Impact 2: *Seismic activity in the project area could cause damage to Proposed Project facilities.*

The Proposed Project would be subject to earthquakes that could damage facilities and affect reliable use of the line. The entire region is located within Seismic Hazard Zones 3 or 4 of the UBC. The final 15 miles of alignment is within the San Andreas, Salton Creek, Hot Springs, and Chiriaco Fault areas, and parallels the active San Jacinto Fault. The Proposed Project, in fact, crosses the San Andreas Fault at two locations in the Coachella Valley. Existing transmission facilities adjacent to the Proposed Project also cross the San Andreas Fault. Subsidence risks exist due to passage of the line through sandy soil in the Coachella Valley. The Coachella Valley also has a relatively high water table in some areas, posing the risk of liquefaction.

Primary earthquake hazards include damage from ground displacement along a fault zone, severe ground shaking, and induced secondary hazards such as liquefaction, rapid differential settlement, lurching, landslides, and rockfalls. Most of the earthquake-related hazards can be accommodated by engineering design or avoidance of high hazard areas. In general, the most severe hazard is posed by ground displacement along a fault zone. Vertical or lateral ground displacement induced by movement along a fault zone could result in transmission tower tipping.

Often, known and mapped fault rupture zones can be avoided or spanned. Usually, there is sufficient leeway in conductor wires to accommodate some ground displacement without damage to the wires. In major earthquakes, wrapping of conductors potentially could occur as a result of the ground motions, resulting in operational failure. Severe ground shaking also can damage towers, although that is a rare occurrence in the U.S. The Landers Earthquake in 1992 in

California resulted in sufficient ground shaking to damage towers on soft soils in which amplified ground movements occurred during the earthquake. Most of the transmission corridor would be located on deep alluvial soils that may be generally expected to experience amplified ground shaking during earthquakes. The greatest hazards to the facilities from ground shaking would occur where they are located on alluvial soils or artificial fill, especially un-engineered fill (e.g., old road fills and mining spoils dumps). Violent ground shaking on bedrock may potentially result in some damage to transmission towers. In general, however, the nature of ground shaking on bedrock has had minor effects on transmission towers even for large earthquakes in the U.S.. Generally, the vibration and motion caused by earthquakes is no greater than that induced by severe windstorms. The evaluation of both earthquake-induced vibration and wind-induced vibration should be carried out in conjunction with one another.

Liquefaction is the rapid loss of physical soil structure caused by change in water pore pressure of saturated soil during an earthquake; in effect, the soil becomes fluid like quicksand. A loss of soil cohesion can also occur in dry, sandy soil. Liquefaction results in a loss of the ability of the soil to support structures. Tower footings could lose their support and sink or become laterally displaced, causing damage or tipping. Not all alluvial soils are subject to liquefaction. Alluvium must have at least one stratum of material that is comprised of fine sandy material, generally saturated by groundwater. If these conditions are not met in a substantial, relatively thick stratum in the alluvium, then the potential for liquefaction is very low. This hazard would typically be greatest in flat valley bottoms or near the base of alluvial fans. However, liquefaction can also occur in mountain valleys if the soil is sandy and saturated.

Other processes in alluvial soils that may be induced by ground shaking include, lurching (the lateral movement of the ground surface toward an unsupported face, such as a river bank), lateral spreading (the lateral displacement of the ground surface usually related to liquefaction of saturated soils), stream or wash banks collapsing, and rapid differential settlement resulting from sudden changes in the physical structure of the supporting soils.

The ground shaking accompanying an earthquake may be sufficient to dislodge unstable soil and rock material. The hazard to the facilities would depend on the location of the facilities in relation to the landslide or rock avalanche slope. Transmission towers and roads could be sited on unstable soils that move laterally or horizontally and result in damage to the facilities. Similarly, adjacent landslides may move onto the site of the towers or roads, burying them in debris. Earthquakes have often reactivated ancient landslides that have remained conditionally stable for centuries. The ground motions of the earthquake reactivate movements on the slide plane. In mountainous areas with steep slopes, rockfall avalanches may be created by earthquake ground shaking that could damage towers and access roads.

The potential risk to the Proposed Project from seismic activity is considered significant due to the portion of the alignment within the San Andreas Fault Zone. Implementation of mitigation would be required as presented in the following mitigation measures, and would reduce this impact to less than significant.

<u>Geology and Soils Impact 2 Mitigation:</u>

(a) To reduce the hazards of damage from ground rupture, all practicable measures will be taken to avoid sites for transmission towers that are located within known fault zones. Fault zones with a record of historic or Holocene (within the last 10,000 years) fault displacement will be considered capable fault zones. A geotechnical engineering investigation consistent with California geologic and engineering standards will be conducted for the Proposed Project by a licensed geotechnical engineer. The geotechnical engineer will prepare a report that summarizes the results of a field investigation, including site inspection and soil testing, potential geologic hazards including fault rupture and severe secondary effects of earthquakes (e.g., liquefaction), and design criteria and construction methods to effectively construct the Proposed Project with an acceptable level of risk. The report will address all geologic and geotechnical factors related to the design and construction of the Proposed Project. The geotechnical engineering investigation will delineate areas of active and potentially active faults. To the extent possible, it will identify fault traces and locate them in the field so faults can be avoided during tower siting. A more detailed geologic investigation may be necessary in some active and potentially active fault areas if the trace is not sufficiently defined by surface geologic features.

(b) All practicable precautions will be taken to design and construction of transmission towers and new substations, substation facility improvements, and equipment to withstand the projected ground shaking associated with the MPE in the area. This includes secondary hazards induced by earthquakes (liquefaction, lurching, lateral spreading, rapid differential settlement, induced landslides, and rock-fall avalanche). The MPE represents the strongest earthquake likely to occur over the design life of the Proposed Project. The geotechnical engineering investigation will provide regional seismic criteria for the design of the Proposed Project facilities including transmission components, new access roads, and substation additions. To minimize potential damage from ground shaking and secondary earthquake effects, transmission line structures will be designed using project-specific criteria in accordance with the latest revision of the NESC. New substation and substation facilities improvements will meet the appropriate design criteria contained in the most current applicable edition of the UBC.

Geology and Soils Impact 3: *Increased soil compaction and rutting in the transmission line corridor and substation could occur during construction, operation, and maintenance of the Proposed Project.*

Soils with a high water table and high clay content are susceptible to deep rutting and compaction by vehicles and heavy equipment when wet. Soils with high clay content are also susceptible to deep crack formations along created ruts when soils dry out. Compacted, rutted, or cracked soils can hinder or delay re-establishment of vegetation and success in reclamation objectives. The extent of this impact is expected to be very limited or localized in the project area and is, therefore, considered to be less than significant. However, if these conditions are encountered in isolated sections of the transmission line route they could pose an adverse impact. Implementation of the following mitigation measure would serve to reduce adverse impacts to these soil groups, if encountered.

Geology and Soils Impact 3 Mitigation:

(a) Construction, operation, and maintenance activities will be restricted when the soil is too wet to adequately support construction or maintenance equipment (i.e., when heavy equipment creates ruts in excess of 4 inches deep over a distance of 100 feet or more in wet or saturated soils). This standard will not apply in areas with silty soils, which easily form depressions even in dry weather. Where the soil is deemed too wet, one or more of the following measures will apply:

(1) When feasible, reroute all construction or maintenance activities around the wet areas while ensuring that the route does not cross sensitive resource areas.

(2) If wet areas cannot be avoided, implement BMPs for use in these areas during construction and improvement of access roads, and their subsequent reclamation. This includes use of wide-track or balloon-tire vehicles and equipment, or other weight dispersing systems approved by the appropriate resource agencies. It also may include use of geotextile cushions, pre-fabricated equipment pads, and other materials to minimize damage to the substrate where determined necessary by resource specialists. If BMPs cannot be successfully applied to wet or saturated soil areas, construction or routine maintenance activities would not be allowed in these areas until the Project environmental monitor(s) determine it is acceptable to proceed.

(3) Limit access of construction equipment to the minimum amount feasible, remove and separate topsoil in wet or saturated areas, and stabilize subsurface soils by grading dewater problem areas, utilizing weight dispersion mats, and/or maintaining erosion control measures such as surface drilling and back-dragging. After construction is complete, regrade and recontour the area, replace topsoil, and reseed to achieve the required plant densities.

Geology and Soils Impact 4: *Proposed Project activities on coarse to very coarse textured soils, alkaline/saline soils, or soils with shallow depth to bedrock could delay or reduce reclamation success.*

Coarse to very coarse textured soils, soils with shallow depth to bedrock, and alkaline/saline soils have characteristics that could delay or reduce reclamation success along the transmission line corridor or around new substation or substation upgrades. Coarse to very coarse textured soils have low water retention properties. Under these conditions, successful seed germination may be difficult due to the lack of water in the soil profile. Soils with a shallow depth to bedrock typically have insufficient water availability and a restricted root zone within the soil profile. It may be difficult for shrub species to develop under these conditions. Alkaline/saline soils can hinder seed germination and are often too toxic for all but alkaline/saline-adapted plants. Plant communities adapted to these conditions are regionally abundant and the relative extent of impacts to these communities would be small. Therefore, this impact would be adverse but less than significant. The following mitigation measure would serve to further reduce the effects to these soil constraint groups.

Geology and Soils Impact 4 Mitigation:

Vegetation removal and soil disturbances (including temporary road improvements) will be minimized in areas where soil constraints occur. Where vegetation removal is required, mowing or cutting will be the primary method utilized. Plants will generally be cut at a height that results in the least damage to the root crown during cutting or subsequent damage by vehicles and equipment. Blading will be restricted except when required for safe equipment operation (e.g., crane operation on a side hill). Previously located environmental constraint areas will be delineated in the field by a qualified resource specialist prior to construction and included in the COM Plan. These environmental constraint areas will then be avoided by construction activities, or mitigation would be applied consistent with measures described in this EIS/EIR.

Geology and Soils Impact 5: *Shrink and swell actions of expansive soils could damage equipment foundations.*

Structural foundations associated with the transmission lines would generally extend below the 4-foot zone which would not be affected by expansive soils (i.e., soils with high shrink/swell potential). However, new substation and substation improvements requiring foundations could be significantly affected by the presence of expansive soils. Geotechnical studies prepared for the Proposed Project would identify areas of expansive soils. Implementation of the following mitigation measure would ensure that construction on expansive soils would result in a less than significant impact.

Geology and Soils Impact 5 Mitigation:

Prior to construction, soils will be evaluated to determine if they are expansive and if they may have potential effects on the proposed facilities. Where they represent a potential hazard, solutions recommended by the Proposed Project's geotechnical engineer, such as excavation and replacement of the expansive soils with compacted backfill, will be required. If imported backfill material is used, it will be certified to be free of noxious weeds and propagates (i.e., seeds and root fragments).

Geology and Soils Impact 6: *Ground disturbance and vegetation removal during construction could result in increased soils erosion.*

Construction of the Proposed Project could result in surface disturbances and removal of vegetation along the transmission line corridor and around new substation and substation upgrades, leading to increased soil erosion. Sedimentation into streams and water bodies would likely increase if disturbed soils were left exposed during winter, early spring, and summer storm events (periods of high precipitation, runoff, and winds). Erosion potential is generally more severe on steep, sparsely vegetated slopes, fine sandy or silty soils, and in loose sandy soils where strong winds occur. Erosion potential is also elevated in recently burned areas (i.e., 1999 or subsequently) if such areas remain largely unvegetated, especially in areas with previously existing high erosion potential. Soil erosion is expected to be minimal following successful reclamation of disturbed areas. Because the areas where erosion may be increased are narrow and spread over a large area, this impact would be less-than-significant. However, the following mitigation measure would serve to further reduce erosion impacts.

Geology and Soils Impact 6 Mitigation: *Short-term erosion and sedimentation will be reduced and topography and vegetation will be restored, as quickly as practicable, to pre-construction conditions in all areas required and approved by BLM and private landowners.*

A qualified resource specialist will monitor implementation during construction and operations, until successful revegetation is achieved. Monitoring of the erosion control measures will continue until reclamation efforts were considered complete and successful. Measures to be implemented during the Proposed Project construction and reclamation are listed below.

Implementation of the following environmental protection practices will minimize the effects of grading, excavation, and other surface disturbances in all project areas. Schedules and specifications on the use of these features would be included in the COM Plan. In addition, specific mitigation measures for the construction of transmission lines within the CVPA and NECO planning areas, which are primarily associated with biological and recreational resources, are discussed in Sections 3.1 and 3.13 of this EIS/EIR.

- Confine all vehicular traffic associated with construction to designated right-of-ways, material yards, wire set-up sites, and access roads designated in the COM Plan.
- Limit disturbance/removal of soils and vegetation to the minimum area necessary for access and construction.
- Where vegetation removal is necessary, use cutting/mowing methods instead of blading, wherever possible.
- Adhere to a construction methodology that mitigates impacts to less than significant levels in sensitive areas during severe weather events.
- Inform all construction personnel before they are allowed to work on the Proposed Project of environmental concerns, pertinent laws and regulations, and elements of the erosion control plan. This could be presented in a multi-hour environmental training for project management and general foremen, and a short (one hour or less) environmental training class for construction personnel.
- Minimize grading to the extent possible. When required, grading will be conducted away from watercourses/washes to reduce the potential of material entering the watercourse.
- Slope and berm graded material, where possible, to reduce surface water flows across the graded area.
- Replace excavated materials in disturbed areas and minimize the time between excavation and backfilling.
- Direct the dewatering of excavations onto stable surfaces to avoid soil erosion.
- Use detention basins, certified weed-free straw bales, or silt fences, where appropriate.
- Use drainage control structures, where necessary, to direct surface drainage away from disturbance areas and to minimize runoff and sediment deposition downslope from all disturbed areas. These structures include culverts, ditches, water bars (berms and cross ditches), and sediment traps.
- Implement other applicable BMPs to minimize erosion-related impacts during construction and improvement of access roads, and their subsequent reclamation.
- Re-establish native and, if necessary, non-persistent, non-invasive, non-native vegetation cover in highly erodible areas as quickly as possible following construction.

In areas of highly erodible soils, non-standard construction equipment and techniques that minimize surface disturbance, soil compaction, and loss of topsoil will be used, such as vehicles with low ground pressure tires. Vegetation clearing will be minimized. Temporary erosion control measures, in accordance with the COM Plan, will be in place before construction is allowed to proceed in potential soil erosion areas (e.g., steep slope areas). Erodible slopes that do not require grading will be cleared using equipment that results in little to no soil disturbance.

3.5.3.3 Alternative A Impacts and Mitigation Measures

Geology and soil impacts of Alternative A would be similar to those identified for the Proposed Project. Potential differences in the impacts are discussed below.

Alternative A is approximately the same length as the Proposed Project and essentially crosses the same terrain, with only minor differences. The landslide risk for Alternative A should be slightly greater than that of the Proposed Project because it passes through the steep terrain on the north end of the Chuckwalla Mountains. Nevertheless, the potential for landslides would still exist, and design considerations and mitigation measures identified for the Proposed Project would be applied to Alternative A to ensure that this potential impact would remain at less than significant levels.

All mitigation measures identified for the Proposed Project would also be required for Alternative A, and would serve to reduce potential Alternative A impacts to less than significant.

3.5.3.4 Alternative B Impacts and Mitigation Measures

General geology and soils impacts of Alternative B would be similar to those identified for the Proposed Project. Potential differences in the impacts are discussed below.

Although the length of the new transmission line to be constructed under Alternative B is shorter than the Proposed Project transmission line, geologic hazards associated with potential landslides may be more significant. In addition to steep terrain in the Palo Verde Mountains traversed by Alternative B, part of this alignment runs along the seismically active region near the Salton Trough. Additionally, modifications and incorporation into this Alternative of upgrade segments 2 and 3 north of the Midway Substation would result in approximately the same total length of transmission line construction and upgrades under Alternative B.

Based on probability zones of ground acceleration (Figure 3.5-3), the southern portion of Alternative B will have a lower overall earthquake risk than the Proposed Project. However, the northwest trending portion of this alignment follows the Sand Hills Fault for approximately 25 miles, and is near the Brawley Fault Zone, so the risk may be significant. The seismic risk of the northwestern portion of Alternative B (improvement of existing alignment) would be identical to that of this portion of the Proposed Project and Alternatives A and C.

This alternative would have an increased liquefaction risk compared to the Proposed Project due to passage through the sandy Algodones Dunes region, and possibly around low lying areas near the western terminus. The portion of Alternative B near the Midway Substation has a land surface near or below sea level. The natural groundwater table here is shallow enough to pose a risk of liquefaction in some places; however, water levels in this area have generally dropped, due to pumping, and the risk is correspondingly less. Subsidence risk would be similar to the Proposed Project.

Alternative B would result in approximately 667 – 830 acres of soil disturbance during construction (71 – 79 acres of which would be permanent), compared with 1111-1242 acres (of which 148-179 acres would be permanent) for the Proposed Project. Potential soil impacts associated with this disturbance would be similar to those identified for the Proposed Project.

Segment alignment Option B-1 would traverse a sandy wash that would be avoided by the main Alternative B route. Crossing this wash would result in an increased potential for significant erosion during flash flood events along this segment. Although Option B-1 bypasses the steepest portions of Alternative B, it traverses a portion of the Colorado River floodplain where groundwater is likely to be shallow, thereby increasing the risk of liquefaction and subsidence.

All mitigation measures identified for the Proposed Project would also be required for Alternative B, and would serve to reduce potential Alternative B impacts to less than significant.

3.5.3.5 Alternative C Impacts and Mitigation Measures

Geology and soil impacts of Alternative C would be similar to those identified for the Proposed Project. Potential differences in the impacts are discussed below.

Alternative C is approximately the same length as the Proposed Project and essentially crosses the same terrain, with only minor differences. The landslide risk for Alternative C should be the same as that of the Proposed Project. The potential for landslides would still exist, and design considerations and mitigation measures identified for the Proposed Project would be applied to Alternative C to ensure that this potential impact would remain at less than significant levels.

All mitigation measures identified for the Proposed Project would also be required for Alternative C, and would serve to reduce potential Alternative C impacts to less than significant.

3.5.3.6 No Project Alternative

Under the No Project Alternative, no facilities would be constructed, and no geological- or soils-related impacts would occur.

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