5.5 GEOLOGIC RESOURCES AND HAZARDS

This section discusses the Project's potential effects on geologic resources and the potential geologic hazards that may be encountered by the Project. A Preliminary Geotechnical Investigation is being completed for the Project and will be made available to CEC. Information regarding a geomorphic and engineering geologic reconnaissance of the Project site will be included with the report. A Final Geotechnical Investigation will be completed as part of the detailed project design, and will include final seismic, earthwork, and foundation design criteria.

5.5.1 Affected Environment

This section discusses the existing geologic environment of the Project site, including underlying geologic structures, seismicity, and geologic hazards. A geologic map of the Project site vicinity is presented as Figure 5.5.1-1.

5.5.1.1 Regional Geology and Physiography

The Genesis Solar Energy Project is located between the communities of Blythe, CA (approximately 25 miles east) and Desert Center, CA (approximately 27 miles west). The Project site is situated within the northeastern portion of Chuckwalla Valley, an east-southeast trending valley in California's Mojave Desert Geomorphic Province. The Mojave Desert Geomorphic Province is a wedge-shaped interior region separated from the Sierra Nevada and Basin and Range Provinces to the northwest by the Garlock Fault and its eastward extensions, and is bounded to the southwest by the Transverse Range and Colorado Desert Provinces, the San Andreas Fault, and its southern extensions. The Mojave Desert Geomorphic Province is characterized by northwest-southeast as well as east-west trending structures and mountain ranges, separated by desert valleys and plains with many enclosed drainages and playas.

The Chuckwalla Valley is bounded by the Chuckwalla, Little Chuckwalla, and Mule mountains on the south, the Eagle Mountains on the west, the Mule and McCoy mountains on the east, and the Coxcomb, Granite, Palen, and Little Maria mountains on the north. The elevation of Chuckwalla Valley ranges from under 400 feet at Ford Dry Lake, just south of the Project site, to approximately 1,800 feet above mean sea level (amsl) west of Desert Center and along the upper portions of the alluvial fans that ring the valley flanks. The surrounding mountains rise to approximately 3,000 and 5,000 feet amsl.

The region has undergone a complex geologic history that includes sedimentation, volcanic activity, folding, faulting, uplift, and erosion. The project area is underlain by Holocene to Miocene basin fill deposits (Stone, 2006). These deposits include younger alluvium, older (Pleistocene) alluvium, the Pliocene Bouse Formation, and the Miocene fanglomerate. The uppermost alluvium in the basin consists of Holocene to Pleistocene alluvial fan, valley axial (fluvial), playa (dry lake), and aeolian (wind blown) deposits.

Quaternary Alluvium. Quaternary alluvial fill in the basin consists of Holocene to Pleistocene alluvial fan and valley axial (fluvial or stream) deposits, as well as lacustrine (lake) and playa (ephemeral lake) deposits (DWR, 2004). These deposits consist of gravel, sand, silt, and clay (DWR, 1963). In general, coarser alluvial fan deposits are expected near the valley edges and grade into finer distal fan deposits that interfinger with fine-grained lacustrine and playa deposits near the center of the basin. These deposits are typically heterogeneous. Valley axial drainages tend to be more uniform and continuous, and contain a greater proportion of sand and fine gravel. Portions of the basin are

also occupied by aeolian (wind blown) sand deposits, but the identified aeolian deposits occur at the ground surface and are of limited thickness. The Quaternary sediments include the Pleistocene-age Pinto Formation, which consists of coarse fanglomerate (cemented, consolidated, or semi-consolidated alluvial fan gravels) containing boulders and lacustrine clay with some interbedded basalt (DWR, 2004).

Pliocene Bouse Formation. The Pliocene Bouse Formation underlies the Quaternary sediments. The Bouse Formation includes a marine to brackish-water estuarine sequence deposited in an arm of the proto-Gulf of California (Stone, 2006; Wilson and Owen-Joyce, 1994). This formation has alternatively been interpreted as, or may include, lacustrine sediments deposited in a closed, brackish basin (Stone, 2006). The Bouse Formation is widely reported in the Colorado Valley and tributary basins in southeastern California and descriptions of this formation come from occurrences outside of Chuckwalla Valley. It is reported to be composed of a basal limestone (marl) overlain by interbedded clay, silt, sand, and tufa. The top of the Bouse Formation is relatively flat-lying with a reported dip of approximately 2 degrees south of Cibola (Metzger and others, 1973).

Miocene Fanglomerate. The Bouse Formation is unconformably underlain by a fanglomerate composed chiefly of angular to subrounded and poorly sorted partially to fully cemented pebbles with a sandy matrix (Metzger and others, 1973). The fanglomerate is likely Miocene-age; however, it may in part be Pliocene-age (Metzger and others, 1973). The Fanglomerate represents composite alluvial fans built from the mountains towards the valley and the debris of the fanglomerate likely represents a stage in the wearing-down of the mountains following the pronounced structural activity that produced the basin and range topography in the area (Metzger and others, 1973). Bedding surfaces generally dip from the mountains towards the basin. The fanglomerate reportedly dips between 2 and 17 degrees near the mountains due to structural warping (Metzger and others, 1973). The amount of tilting indicates a general decrease in structural movements since its deposition (Metzger and others, 1973).

Bedrock. Bedrock beneath the Project site consists of metamorphic and igneous intrusive rocks of pre-Tertiary age that form the basement complex (DWR, 1963), including Proterozoic schist and gneiss, Paleozoic sedimentary rocks, and Mesozoic sedimentary and metavolcanic rock sequences (Stone, 2006). In some areas of the Chuckwalla Valley, volcanic rocks of Tertiary age overlie the basement complex (DWR, 1963). The bedrock topography in the study area, as interpreted by modeling of Bouger gravity data obtained from USGS, is illustrated in Figures 5.4-1 and 5.4-2. The methods used to model the bedrock topography are discussed in more detail in Appendix E.

5.5.1.2 Regional Tectonic Setting

The Mojave Desert comprises an area bounded by the seismically active Salton Trough to the west and southwest, and the Garlock Fault to the north. To the east and southeast it is bounded by the Sonoran Desert subprovince, a relatively stable tectonic region located in southeastern California, southwestern Arizona, southern Nevada, and northern Mexico (Balderman, et al., 1978). Chuckwalla Valley is located in the eastern Mojave Desert province in an area that is relatively stable tectonically. Faults in the area occur primarily in Tertiary and pre-Tertiary strata and are related to compressional tectonism along a convergent Andean and island arc margin in the Mesozoic, and extensional detachment and block faulting during Tertiary time. No faults of Quaternary age are known to exist near the Project site (Figure 5.5-2).

5.5.1.3 Regional Seismicity

The Project site lies within the Sonoran Desert subprovince, which is a relatively stable tectonic region located in southeastern California, southwestern Arizona, southern Nevada, and northern Mexico. Review of the California Department of Conservation's *Map Sheet 49 – Epicenters and Areas Damaged by M>5 California Earthquakes 1800 – 1999* indicates eastern Riverside County did not experience any damaging earthquakes or ground shaking during this period (Toppozada and others, 2000). The locations of Quaternary and younger faults and historical earthquake epicenters within 100 kilometers of the Project site are shown on Figure 5.5-3, and indicate that more seismically active areas are located to the west, southwest, and northwest of the area. As shown on these figures and discussed further below under the section titled "Local Faulting and Seismicity," the nearest fault defined by the State of California as "Sufficiently Active" is located more than 46 miles (74 km) from the Project site.

5.5.1.4 Local Geology

The Project site lies on a broad, relatively flat, sloping surface underlain by alluvial deposits derived from the Palen Mountains to the north and the McCoy Mountains to the east. These alluvial deposits have created two distinct landform types and several discernable landform ages. The deposits immediately adjacent to the mountains have formed alluvial fans from multiple identifiable sources, and multiple fan surfaces have coalesced into a single bajada surface that wraps around each of these mountain fronts. Between the bajada surfaces from each mountain chain lies a broad valley-axial drainage that extends southward between the mountains and drains to the Ford Dry Lake playa, located about 1 mile south of the Project site. The Project site itself is relatively flat and generally slopes from north to south with elevations of approximately 400 to 370 feet amsl. It is occupied by a community of low creosote and bursage scrub vegetation.

Three lines of evidence have been used to describe the shallow geological conditions underlying the Project site. First, geophysical investigations conducted at the Project site (Appendix E) indicate the electrical conductivity of the underlying sediments (an indicator of the amount of fine-grained sediment and salinity of the groundwater) is consistent and similar across the Project site area. Second, seismic refraction profiling suggests the shallow alluvium has similar properties across the Project site. Third, site-specific subsurface investigations (Appendix E) demonstrated the Project site is underlain by alluvium consisting of interbedded and intermixed dense sand and gravel, and hard silt and clay to a depth of approximately 245 to 275 feet below ground surface (bgs), which is approximately 125 feet amsl. These sediments are heterogeneous both laterally and vertically, although the valley axial alluvium beneath the eastern portion of the Project site may contain cleaner sands than sediments underlying the bajada surfaces, and laterally may be more homogenous. Groundwater occurs within the shallow alluvium at a depth of approximately 70 to 90 feet bgs.

Beneath the alluvium, the Pliocene Bouse Formation is estimated to extend to approximately 2,000 feet bgs (approximately -1,500 feet amsl), and is generally richer in fine-grained sediments than the overlying alluvium. The Miocene fanglomerate is inferred to underlie the alluvium at this depth and is estimated to extend to approximately 2,900 feet bgs (-2,400 feet amsl).

A map presenting the surficial geology in the Project site area is presented as Figure 5.5-4. In developing this map, alluvial sediment units established by the USGS (Stone, 2006) have been adopted, with modifications, as summarized in Table 5.5-1, and described in greater detail below.

Table 5.5-1. Mapped Surficial Geologic Units

Map Unit	Inferred Age	Descriptive Name
Qyva	Post-late Holocene	Younger Valley Axial Alluvial Deposits
Qyma	Post-late Holocene	Younger Mixed Alluvial and Aeolian Deposits
Qyaf	Late Holocene	Younger Alluvial Fan Deposits
Qiaf	Mid-Holocene	Intermediate Alluvial Fan Deposits
Qoaf	Late Pleistocene	Older Alluvial Fan Deposits

Younger Valley Axial Alluvial Deposits (Q_{yva}). Deposits in the valley axial drainage that underlie the majority of the eastern part of the Project site are characterized by a north-south trending fabric in aerial photographs and possess a generally subdued bar and swale topography at ground level. These deposits represent the distal end of a northeast to southwest-trending valley axial drainage which lies between the Palen and McCoy Mountains and terminates at Ford Dry Lake. Very few small washes are continuous across the eastern part of the Project site.

The valley axial deposit surfaces display local incipient desert pavement development, and no carbonate accumulation in the soil. Surface morphology is a subdued bar and swale morphology generally lacking water erosional features and indicative of a depositional surface. Evidence of competing wind erosion, including lag deposits and small mounds next to bushes, was also noted; however, the dominant processes appear to be alluvial. The morphology and lack of soil development are consistent with depositional surfaces that are at most a few hundred years old, and suggest a prograding alluvial apron.

Subsurface stratification observed in the top 12 to 18 inches of these deposits consists of silty sand deposits in the downslope portions of the Project site, which is consistent with the formation of silt crusts after sheet floods. Also observed were cross-bedded silty sand beds about 8 to 10 cm thick and massive silty sand with gravel just upslope of the Project site. The recurrence interval of floods leaving these deposits is not known. Floods reaching Ford Dry Lake and filling the lakebed are reported to occur about once every 10 years. If each of these beds represents 10 years of accumulation, they would be indicative of deposition rates of 1 meter (m)/1,000 years in the downslope portions of the Project site and up to 10 times that in the upslope portions of the Project site. However, beneath the upslope portions of the Project site that are closer to the fan intersection points, the locus of deposition would be more likely to change from one flood event to the next, so the deposition rates are probably less.

Younger Mixed Alluvial and Aeolian Deposits (Q_{yma}). Between the Project site and Ford Dry Lake, the alluvial fan and valley axial alluvium deposits described above grade into a mixture of deposits consisting of distal alluvial deposits, sand and silt sheet flood deposits, and interspersed aeolian sand sheets and local small coppice dunes. These deposits are generally located south of the Project site boundaries, but underlie much of the alignment of the off-site linears associated with the Project.

Younger Alluvial Fan Deposits (Q_{yaf}). Similar to the Palen Mountains, the downslope extent of the Pleistocene-age, relict alluvial fan surfaces at the foot of the McCoy Mountains appear to mark the same type of intersection point on the fans in this area. However, the aerial photographs of this area suggest the bajada surface downslope of the McCoy Mountains has a more pronounced bar and swale topography, is generally lighter in color, and has more developed (or preserved) distributary channel development extending to the lower reaches of this surface. In addition, the presumed

ancient shoreline feature that trends across the Q_{iaf} surfaces downslope of the Palen Mountains (see description below) is not discernible across these fans, and appears to have been covered by deposition during the late Holocene. The Q_{yaf} deposits consist of silty sands and gravelly silty sands, with generally finer-grained gravel than the upslope deposits.

Intermediate Alluvial Fan Deposits (Q_{iaf}). The downslope extent of the Pleistocene terraces at the foot of the Palen Mountains marks the "intersection point" of the fans in this area. Downslope of these points, the incised (and confined) washes emerge from an erosional setting and transition into a depositional mode with fan lobes, subdued bar and swale topography, and shallow distributary washes, all of which are consistent with a distal fan environment. These lower fan deposits exhibit a darker color than the adjacent valley axial (Q_{yva}), aeolian (Q_{yma}), or playa (not mapped) deposits. Desert pavement is present, but its development is not as extensive, and the individual clasts that comprise the pavement do not exhibit the same degree of desert varnish development as the upslope, and older, alluvial fan surfaces. The intermediate fan deposits consist of silty sands and gravelly silty sands, with generally finer-grained gravel than the upslope deposits.

A photo lineament is discernible in Figure 5.5-4 based on a change from a rougher, lighter-colored and more dissected surface (on its north side) to a darker, smoother surface (on its south side). This lineament extends across the bajada surface in an east-west direction approximately along the 400 foot amsl elevation contour. The photo lineament disappears in the lighter-colored valley axial deposits that underlie the majority of the eastern portion of the Project site. To the west of the Project site, where the 400 foot contour trends southward across the valley floor, the lineament also disappears. However, similar features can be observed at approximately the same elevation on the south side of Chuckwalla Valley (*i.e.,* south of I-10), and on the south flank of the McCoy Mountains (north of I-10).

A plausible explanation for this feature consistent with the above observations is the preservation of an ancient shoreline developed during a pluvial lake highstand of Ford Dry Lake. The potential validity of this interpretation will be further investigated during future reconnaissance and reported to CEC. Shoreline features related to pluvial lake highstands are widely reported elsewhere in the southwestern United States, where they record the influence of wetter climates during the last glacial Maximum of the latest Pleistocene (approximately 17,000 to 10,000 years before present (BP)), as well as Holocene glacial oscillations approximately 8,300 years BP (early Holocene), 6,400 years BP (mid-Holocene), and 4,000 years BP (early Neoglacial) (Castiglia and Fawcett, 2006; Enzel et al., 1989; Briggs, 2003; and Wells, McFadden and Dohrenwend, 1986). More recent standing lakes were reported for short periods in some arid basins in the Mojave Desert during cooler, wetter intervals approximately 200 and 600 years BP, and during particularly wet periods in recorded history, such as 1916 to 1917, 1938 to 1939, and 1969. Based on the moderate degree of desert pavement development on these fan surfaces and slight to moderate desert varnish development on the pebble surfaces, it is estimated the lake highstand theorized to be responsible for this relict shoreline feature would have occurred during the mid-Holocene, at least 4,000 years ago (Elvidge and Iverson, 1983). If the presumed ancient shoreline can be verified, this would suggest the intermediate alluvial fan deposit surfaces at the Project site have been in a state of relative equilibrium (undergoing little erosion or sedimentation) for the last 4,000 years.

Older Alluvial Fan Deposits (Q_{oaf}). The upper and middle alluvial fan surfaces, located north of, and upslope from, the western portion of the Project site, consist of coarse to medium grained sandy gravels and gravelly sands and are extensively dissected by deep washes that are up to 1/4 mile

wide and over 50 feet deep in the proximal fan areas. Between these incised washes, the remnant alluvial fan surfaces are covered by well-developed desert pavement with nearly 100 percent stone cover, dark brown to nearly black desert varnish, and carbonate deposition on the lower sides of the clasts. The desert pavement development is consistent with a Pleistocene surface age and these remnant fan surfaces were mapped as late Pleistocene by Stone (2006). These remnant fan surfaces extend largely unbroken (between the incised washes) into the upslope portions of the western parcel of the Project site and northwestern-most corner of the eastern parcel.

5.5.1.5 Local Faulting and Seismicity

The Project site lies within the eastern part of Riverside County in a part of California considered not to be very seismically active. Although there are several bedrock faults off-site in the mountains surrounding Chuckwalla Valley, these do not exhibit recent activity and are presumed to be Tertiary or pre-Tertiary in age (Stone, 2006). In addition, gravity anomalies suggest the presence of several subsurface faults beneath Chuckwalla Valley in the vicinity of the project area (Stone, 2006; Rotstein, et al., 1976). The gravity anomalies reflect abrupt changes in basement elevation strongly suggestive of dip-slip movements. In addition, some of these faults may have undergone right-lateral strike slip movements. These faults are presumed Tertiary and likely inactive with very low chance of earthquakes.

The active faults considered most likely to produce large earthquakes potentially affecting the Project site are located at a considerable distance to the west and southwest and include the San Andreas, Imperial, and San Jacinto-Anza faults. Other smaller faults are located within approximately 100 kilometers (km) of the Project site as summarized below. These faults are believed to be capable of producing ground shaking with peak ground accelerations exceeding 0.10 times the force of gravity (0.10 g).

Table 5.5-2. Sufficiently Active Faults within 100 Kilometers of the Project site

Fault Name	Approximate Distance and Direction from Project site	Slip Rate (mm/year)	Maximum Earthquake Magnitude
San Andreas Fault	46 miles (74 km) southwest	>5	7.4
Brawley Seismic Zone	47 miles (76 km) miles southwest	1 to >5	7.2
Pinto Mountain Fault	54 miles (86 km) west-northwest	1 to 5	7.0
Pisgah- Bullion Fault	57 miles (91 km) northwest	0.2 to 1	7.1
Imperial Fault	61 miles (98 km) southwest	>5	7.0
San Jacinto-Anza Fault	61 (98 km) miles southwest	1 to >5	7.2

Fault locations and slip rates taken from USGS Earthquake Hazard Program Quaternary Fault and Fold Database (http://gldims.cr.usgs.gov/qfault/viewer.htm), using lat 33.67, long 115.00 as the Project site coordinates.
Maximum magnitude taken from California Department of Conservation, Division of Mines and Geology, 1998. Maps of Known Active Fault Near-Source Zones in California and Adjacent Portions of Nevada.

A preliminary estimate of ground motions expected at the Project site was prepared using source and attenuation models developed by the USGS National Seismic Hazard Mapping Project (NSHMP, 2009). For design of important facility structures, a Project site-specific Probabilistic Seismic Hazard Assessment is being completed as part of an ongoing Geotechnical Investigation and will be made available to the CEC. The preliminary results indicate peak ground acceleration (PGA) with a probability of exceedance of 10 percent in 50 years (475 Year Return Period) is 0.14 g. The deaggregation information indicates the mean moment magnitude is 6.8 at a mean distance of 68 km. The PGA with a probability of exceedance of 2 percent in 50 years (2475 Year Return Period) is 0.23

g. The mean moment magnitude is 6.7 at a mean distance of 48 km. The deaggregation data for the 475- and 2475-year return periods is included in Appendix E.

Table 5.5-3 presents seismic design parameters based on the 2007 California Building Code (CBC). These seismic design parameters may be used for design of structures where appropriate. On the basis of available data regarding on-site geologic conditions and information from subsurface exploration at the well site located east of the power plant sites, the Project site may be classified as Project site Class C, very dense soil and soft rock. The Project site class and parameters listed below will be updated as appropriate based on the results of the Preliminary and Final Geotechnical Investigations for the Project.

Table 5.5-3. 2007 CBC Seismic Design Parameters

Parameter	Value
Project site Class (see discussion above)	C
Ss- Mapped Spectral Acceleration, Short Period	0.478 g
Ss- Mapped Spectral Acceleration, Long Period	0.239 g
Fa-Site Coefficient, Short Period	1.2
Fv-Site Coefficient, Long Period	1.551
SDs-Design Spectral Response Acceleration, Short Period	0.383 second
SD1-Design Spectral Response Acceleration, Long Period	0.258 second
SMs-MCE* Spectral Response Acceleration, Short Period	0.574 second
SM1- MCE* Spectral Response Acceleration, Short Period	0.387 second

Calculated using USGS Program “Earthquake Ground Motion Parameters” Version 5.0.9 based on the coordinates latitude 33.67, longitude -115.00.

MCE = Maximum Considered Earthquake

5.5.1.6 Earthquake History

Based on a search of the USGS National Earthquake Information Center database for historical earthquakes, 26 earthquakes exceeding a magnitude of 5.0 have occurred within 100 km (62 miles) of the Project site since 1872 (NEIC, 2009). The maximum historical earthquake magnitude within a 100-km radius was 6.5 and occurred on November 24, 1987. No earthquakes measuring 3.0 or greater in magnitude have been reported within a 40 km (25 mile) radius of the Project site. A figure showing the epicenters of historical earthquakes within 100 km of the Project site is included as Figure 5.5-3.

5.5.1.7 Geologic Hazards

Geologic hazards are normally associated with issues such as seismicity (ground shaking), slope instability, subsidence, and expansive soils. Seismic hazards related to ground shaking include ground rupture, slope instability, liquefaction, seismic compaction, tsunamis, and seiches. With the exception of tsunamis and seiches, these hazards are discussed in greater detail below. Because there are no open water bodies located in the vicinity of the Project site or the off-site linears associated with the Project, tsunami and seiche hazards do not exist for the Project.

Seismic Ground Shaking. Although the Project site is not located in a very seismically active area, it may be subjected to ground shaking from movement along one or more of the sufficiently active or well-defined faults in the adjacent, more seismically active areas such as the Salton Trough, the

Transverse Ranges, or Central Mojave Block. The California Geological Survey defines a “sufficiently active fault” (previously referred to as an “active fault”) as a fault that has broken the surface in the past 11,000 years. A “well-defined fault” (previously referred to as “potentially active fault”) is defined as a fault whose trace is clearly detectable by a trained geologist as a physical feature at or just below the ground surface.

The Riverside County General Plan, Safety Element (Riverside County, 2008) indicates the Project site and the off-site linears associated with the Project are in an area of moderate ground shaking risk, which means peak ground accelerations may reach 0.1 to 0.2 g. A preliminary seismic hazard analysis indicates the peak ground acceleration with a probability of exceedance of 10 percent in 50 years (475 Year Return Period) is 0.14 g. The 0.1 g value is an industry standard for significance in terms of foundation design; however, higher potential accelerations can be routinely managed with proper foundational design and Project site geotechnical investigation.

Based on the available data, the Project site is subject to low to moderate seismic ground shaking hazard.

Ground Rupture. The Project site is not located within a State of California Earthquake Fault Zone designated by the Alquist-Priolo Special Studies Zone Act of 1972 (formerly known as a Special Studies Zone), an area where the potential for fault rupture is considered probable (Riverside County, 2008). In addition, no Quaternary, Sufficiently Active, or Well Defined Faults are located under or near the Project site. Based on this information and engineering judgment, earthquake-induced ground rupture is not considered to be a significant hazard at the Project site.

Slope Stability. The Project site and off-site linears associated with the Project are not considered to be an area with the potential for permanent ground displacement due to earthquake-induced landslides because surface topography at and near the Project site is relatively flat (Riverside County, 2008). A review of the Riverside County General Plan, Safety Element, did indicate areas considered susceptible to earthquake-induced landslides and rockfalls in the Palen and McCoy Mountains; however, these areas are several miles from the Project site and are not expected to impact the Project. Based on this information and engineering judgment, slope instability is not considered to be a significant hazard at the Project site.

Erosion. Erosion is the displacement of solids (soil, mud, rock, and other particles) by wind, water, or ice and by downward or down-slope movement in response to gravity. Due to generally flat terrain, the Project site is not prone to significant mass wasting (gravity-driven erosion and non-fluvial sediment transport) at present. The Riverside County General Plan, Safety Element (Riverside County, 2008), indicates the Project site is in an area with moderate potential for wind erosion, and the off-site linears are in areas with moderate to high potential for wind erosion. Soil characteristics at the Project site allow for the potential for wind and water erosion, and significant sediment transport currently occurs across the valley axial drainage that crosses the majority of the Project site. As indicated above, these valley axial deposits are characterized by subdued bar and swale topography and ongoing deposition from sheet floods. Limited sand and aeolian erosion also occurs between depositional episodes.

Soil erosion from wind and water during construction activities is further evaluated in Section 5.6, Agriculture and Soils. Under current conditions, the soil loss is estimated to be about one ton per year from the Project site and areas of off-site linears associated with the Project. Construction activities without implementation of Best Management Practices (BMPs) would result in a potential for soil loss

of about 1,400 tons. The implementation of BMPs is expected to reduce water and wind erosion of soils during construction to less than significant levels.

To address the management of sediment transport, erosion, and sedimentation during operation, the project design will incorporate diversion berms, channels, detention basins, and dispersion structures as discussed in Section 5.4. The final design for these features will be developed during detailed design, and will include industry-standard calculations and modeling to reduce the potential for erosion or sedimentation, and the need for ongoing maintenance. Dirt roads and exposed surfaces will be periodically treated with dust palliatives as needed to reduce wind erosion. Construction and maintenance of the proposed drainage and sediment management system at the Project site is expected to reduce water and wind erosion at, and downstream of, the Project site to less than significant levels.

Liquefaction. Liquefaction is a soil condition in which seismically-induced ground motion causes an increase in soil water pressure in saturated, loose, uniformly-graded sands, resulting in loss of soil shear strength. As a result, the effects of liquefaction can include loss of bearing strength, differential settlement, ground oscillations, lateral spreading, and flow failures or slumping. Liquefaction occurs primarily in areas where the groundwater table is within approximately 50 feet of the surface (Riverside County, 2008). The Riverside County General Plan Safety Element (Riverside County, 2008) indicates the majority of Chuckwalla Valley, including the soils beneath the Project site and associated Project off-site linears, is mapped as having deep groundwater but underlain by soils with an otherwise moderate susceptibility to liquefaction. The depth to water beneath the Project site is estimated to range from approximately 61 to 94 feet bgs (see Section 5.4 and Appendix D). In addition, the sandy soils encountered in the upper 100 feet beneath the Project site during geotechnical drilling are generally dense and well graded, and typically contain a significant percentage of fines. Dense, well-graded sands are not generally considered susceptible to liquefaction. Based on this information and engineering judgment, the potential for liquefaction hazard at the Project site is considered to be low. The potential for liquefaction will be further evaluated as part of the Final Geotechnical Investigation for the Project, and if necessary, design parameters to address identified conditions will be incorporated into the detailed project design.

Subsidence. Subsidence, or a lowering of surface elevation due to removal of subsurface support, can result from several causes, and ranges from small or local collapses to broad regional lowering of the earth's surface. Potential causes of subsidence include tectonic movement, seismic compaction, hydrocompaction, consolidation induced by groundwater withdrawal, and consolidation under applied loads. Of greatest concern to structures at the Project site is localized or differential settlement that can damage foundations, structures, and surface improvements at the Project site. More widespread subsidence has regional implications and can be damaging to regional drainage, water conveyance, flood susceptibility, and other factors.

Ground subsidence can occur as a result of water level decline in aquifer systems. When the fluid pressure in an aquifer is reduced as a result of changes in the groundwater level, a shift in the balance of support for the overlying materials causes the “skeleton” of the aquifer system to deform slightly. Reversible deformation occurs in all aquifer systems as a result of the cyclical rise and fall of groundwater levels associated with short and longer term climatic cycles. Permanent ground subsidence can occur when pore water pressures in the aquifer fall below their lowest historical point, and the particles in the aquifer skeleton are permanently rearranged and compressed. Soils particularly susceptible to such consolidation and subsidence include compressible clays in a

confined aquifer system. This type of deformation is most prevalent when confined alluvial aquifer systems are overdrafted, resulting in water level declines of tens or hundreds of feet.

Based on the general geology of the Chuckwalla Valley, the Riverside County General Plan, Safety Element designates basin fill sediments in the valley as being susceptible to subsidence (Riverside County, 2008). However, subsidence has not been reported in the valley. As discussed in Section 5.4, groundwater demand in the valley was at a maximum in the 1980s and 1990s, when agricultural pumping was estimated to exceed 48,000 acre-feet per year. Current agricultural groundwater demand is estimated to be less than 2,000 acre-feet per year, and with implementation of the Project (water demand of approximately 1,600 acre-feet per year), the cumulative water demand in the basin is anticipated to remain well below the historical maximum. As such, it is not likely water levels in the Bouse Formation aquifer will drop below their historical low levels. In addition, the clays encountered during drilling of borings for the test well program at the Project site were hard and consolidated. Based on this information and engineering judgment, the potential for significant subsidence associated with the pumping of groundwater for the Project is considered low.

Seismically induced settlement can occur during moderate and large earthquakes in soft or loose, natural or fill soils that are located above the groundwater table, resulting in differential settlement. The settlement can cause damage to surface and near-surface structures. The most susceptible soils are clean loose granular soils. Due to the expected dense to very dense nature of the near surface soils, the potential for damage due to seismically-induced settlement is considered to be low at the Project site. The potential for seismically-induced settlement will be further evaluated as part of the Final Geotechnical Investigation for the Project, and if necessary, design parameters to address identified conditions will be incorporated into the detailed project design.

Collapsible Soil Conditions. Alluvial soils in arid and semi-arid environments can have characteristics that make them prone to collapse with increase in moisture content and without increase in external loads. Soils that are especially susceptible to collapse or hydrocompaction in a desert environment are loose dry sands and silts, and soils that contain a significant fraction of water soluble salts. In the Project site vicinity, this would include aeolian sand, playa evaporite deposits, and potential loose flash flood deposits. Based on surface reconnaissance, review of geologic mapping, and review of aerial photographs, although there are aeolian deposits south of the Project site near Ford Dry Lake, no significant aeolian or playa deposits are located within the Project site. There do not appear to be near surface evaporite deposits associated with Ford Dry Lake (Stone, 2006). The near surface soils at the Project site are composed primarily of alluvial soils which appear to have been deposited in relatively thin sheet flood and fluvial deposits which have a low potential for hydrocompaction. Based on this data and engineering judgment, the Project site soils do not have a significant potential for hydrocompaction or collapse. The potential for hydrocompaction and soil collapse will be further evaluated as part of the Final Geotechnical Investigation for the Project, and if necessary, design parameters to address identified conditions will be incorporated into the detailed project design.

Expansive Soil. Expansive soil is predominantly fine-grained and contains clay minerals capable of absorbing water in their crystal structure. It is often found in areas that were historically a flood plain or lake area, but can also be associated with some types of shale, volcanic ash, or other deposits, and can also occur in hillside areas. Expansive soil is subject to swelling and shrinkage, varying in proportion to the amount of moisture present in the soil. As water is initially introduced into the soil (by rainfall or watering), expansion takes place. If dried out, the soil will contract, often leaving small

fissures or cracks. Excessive drying and wetting of the soil can progressively deteriorate structures that are not designed to resist this effect, and can lead to differential settlement under buildings and other improvements. The surficial soils at the Project site generally consist of predominantly granular soils that do not contain much clay and are not subject to significant expansion hazards. The potential for expansive soils will be further evaluated as part of the Final Geotechnical Investigation for the Project, and if necessary, design parameters to address identified conditions will be incorporated into the detailed project design.

5.5.1.8 Geological Resources

Recreational and unique geologic resources and features typically include rock or mineral collecting, surface hydrothermal features, or surface expression of geologic features unique enough to generate recreational interests of the general public (natural bridges, caves, waterfalls, etc.). Based on a search of State and BLM recreation-related websites, there are no known recreational or unique geologic resources associated with or in proximity to the Project site, the natural gas pipeline route, or the proposed transmission line alignment.

Based on a review of California Division of Oil, Gas, and Geothermal Resources online mapping system (http://maps.conservation.ca.gov/doms/index.html), there are no oil, gas, or geothermal resources beneath the Project site, the off-site linear alignments associated with the Project, or other nearby areas (CDOGGR, 2009).

According to the Riverside County General Plan, Multipurpose Use Element (Riverside County, 2008), the mineral land classification within 2 miles of the Project site and off-site linears is MRZ-4. This designation is defined as an “(a)rea where geologic information does not rule out either the presence or absence of mineral resources.”

5.5.2 Environmental Impacts

Environmental impacts associated with the construction and operations of the Project are discussed in the following sections.

5.5.2.1 Construction

Construction-related impacts to the geologic environment primarily are related to erosion and dust generation during excavation and grading for Project development. No major unique geologic or physical features have been identified at the Project site. Dust generation and the potential for erosion-related impacts associated with construction are further discussed in Section 5.6, Agriculture and Soils. The area of the Project site and Project-related off-site linears has a moderate to high potential for wind and water erosion. Under current conditions, these processes are in relative equilibrium with ongoing depositional processes and soil loss is estimated at approximately 1 ton per year. Construction without implementation of BMPs would result in a potential for soil loss of about 1,400 tons; however, the implementation of BMPs is expected to reduce water and wind erosion of soils during construction to less than significant levels. Based on the conceptual grading plan (WorleyParsons, 2009; see Appendix A) for the Project site, construction will require cut and fill activities on the Project site, but import/export of earthen materials to and from the Project site will not be required. Therefore, potential construction-related impacts to the geologic environment would be confined to the Project site and related off-site linears. With implementation of BMPs, erosion is expected to be mitigated to a less than significant level.

As discussed in Section 5.4, Water Resources, on-site groundwater will be used as a construction water supply during the construction period. Groundwater drawdown, impacts to the basin water budget, and impacts to water quality and subsidence are not expected to be significant.

The likelihood that significant collapsible soils will be encountered during construction is small. Further investigation for collapsible soils will be performed as part of the Final Geotechnical Investigation for detailed design of the project, and appropriate recommendations for earthwork and foundation design will be provided, if needed.

The Project site is in an area of relatively low seismic activity; thus, although the potential for earthquake-related impacts would begin during Project construction, the likelihood that a damaging earthquake would occur during construction is relatively small. Seismic hazards during construction are assumed to be adequately addressed by compliance with LORS related to construction safety as required by the California Department of Occupational Safety and Health (DOSH) and the United States Occupational Safety and Health Administration (OSHA) (see Section 4.0).

5.5.2.2 Operation

Regional and local geologic conditions will not be altered significantly by the long-term operation of the Project, including its linear facilities (access road, transmission lines, and gas pipeline). No major unique geologic or physical features have been identified at the Project site or along the alignment of the off-site linears.

The Project area is subject to ground shaking hazards primarily from distant earthquakes. Peak ground accelerations up to 0.14 g have a 10 percent probability of being exceeded within 50 years (475-year return period) after project construction. This represents a low to moderate ground shaking hazard. The potential for other seismic hazards, including ground rupture, slope instability, liquefaction, and seismic compaction, is considered low. Project structures will be designed to meet the appropriate seismic design standards from the 2007 CBC, as well as the California Department of Conservation, California Geological Survey (CGS, 2004 and 2008). The potential for seismic hazards will be further evaluated as part of the Final Geotechnical Investigation for the Project, and if necessary, design parameters to address identified conditions will be incorporated into the detailed project design.

The potential for slope instability, subsidence, collapsible soil, and expansive soil hazards associated with the Project site and Project-related off-site linears is considered low. The potential for these hazards will be further evaluated as part of the Final Geotechnical Investigation for the Project, and if necessary, design parameters to address identified conditions will be incorporated into the detailed project design in accordance with 2007 CBC and Riverside County standards.

To address the management of sediment transport, erosion, and sedimentation during operation, the project design will incorporate diversion berms, channels, and detention basins, as discussed in Section 5.4. Dirt roads and exposed surfaces will be periodically treated with dust palliatives as needed to reduce wind erosion. Construction and maintenance of the proposed drainage and sediment management system at the Project site is expected to reduce water and wind erosion at, and downstream of, the Project site to less than significant levels.

In summary, the only identified potential geologic hazards for the Project are ground shaking from earthquakes and the potential for erosion. Construction of facilities in accordance with the mitigation

measures identified below will ensure earthquake-related impacts and impacts from erosion are minimized such that impacts are considered less than significant.

5.5.3 Mitigation Measures

Geologic impacts associated with the construction and operation of the Project are expected to be less than significant. Project site-specific geotechnical and seismic conditions, as well as the potential for erosion, will be appropriately addressed during Project detailed design and during Project construction. The following mitigation measures are proposed to ensure impacts are less than significant.

GEOL–1: Power plant structures and equipment, as well as offsite linear facilities (natural gas, pipeline; transmission line), will be designed in accordance with CBC 2007 requirements and Riverside County construction standards, considering the seismic hazard evaluation criteria contained in applicable CGS publications (CGS, 2004 and 2008).

GEOL-2: Project foundations, underground utilities, and other improvements will be designed in accordance with recommendations provided in the Final Geotechnical Investigation.

GEOL-3: Project drainage structures, including diversion berms, channels, detention basins, and dispersion structures, will be constructed in accordance with detailed grading and drainage plans developed during detailed Project design. These plans will incorporate industry-standard calculations and modeling to minimize the potential for erosion and sedimentation, and reduce the need for ongoing maintenance.

GEOL-4: A Dust, Erosion and Sediment Control Plan (DESCP), including a construction Storm Water Pollution Prevention Plan (SWPPP) that includes BMPs for wind and water erosion control, will be prepared and implemented to control erosion, soil loss, and dust emissions during construction of the Project.

GEOL-5: An Operations SWPPP that includes BMPs for erosion control will be prepared and implemented to control erosion and soil loss during operation of the Project.

5.5.4 Significant Unavoidable Adverse Impacts

The Project will be designed and constructed to meet 2007 CBC requirements for industrial facilities and will adhere to sound professional practices and appropriate regulatory requirements related to geologic hazards (*e.g.,* grading, slope stability). For these reasons and with implementation of the mitigation measures, the Project is expected to have no significant impacts on geologic hazards or resources.

5.5.5 Cumulative Impacts

Cumulative effects refer to a proposed project's incremental effect combined with other closely related past, current, or reasonably foreseeable projects whose impacts could compound or increase the incremental effect of the proposed project. As described above, the Project will not affect geologic resources; therefore, it would not contribute to a cumulative impact to geologic resources when considered in combination with cumulative projects in the vicinity.

Cumulative groundwater demand with implementation of planned and cumulative projects in the basin will remain well below historical high levels in the 1980s and 1990s; therefore, pumping-induced subsidence is not considered a significant cumulative impact.

Mitigation measures have been identified that will reduce other geologic hazards to a level of insignificance. With implementation of these measures, the Project will not result in adverse geologic hazard impacts. Other cumulative projects will be subject to the same construction standards and requirements. As such, the Project will not result in a cumulative impact with other cumulative projects in the area.

5.5.6 Applicable Laws, Ordinances, Regulations, and Standards (LORS)

This section addresses the LORS applicable to geologic hazards and resources that are relevant to the Project. Table 5.5-4 summarizes the LORS that are expected to apply to the Project.

Table 5.5-4. LORS Applicable to Geological Resources and Hazards

LORS	Applicability	Where Discussed in AFC
Federal:		
Uniform Building Code	The Uniform Building Code specifies acceptable design criteria for structures and excavations with respect to seismic design and load-bearing capacity. It is superseded by 2007 CBC.	Section 5.5.6.1
State:		
California Building Code, 2007, as amended by Riverside County	Specifies acceptable design criteria for structures and excavations with respect to seismic design and load-bearing capacity.	Section 5.5.6.2
Alquist-Priolo Earthquake Fault Zoning Act	Identifies areas subject to surface rupture from active faults and required fault rupture hazard investigations and procedures.	Section 5.5.6.2
California Department of Conservation, California Geological Survey	Guidelines and standards for evaluation and mitigation of seismic hazards, and for delineating seismic hazard zones in California.	Sections 5.5.2 and 5.5.3
Local:		
Riverside County Building Codes and Fees (Ordinance 457)	Riverside County requires a grading permit for earth-moving activities exceeding 50 cubic yards. Grading plans shall address requirements of the Riverside County General Plan, Safety Element.	Section 5.5.6.2
Riverside County General Plan	Projects in Riverside County must comply with the requirements of the Riverside County General Plan, Safety Element.	Section 5.5.6.2
Riverside County Alquist-Prolo Earthquake Fault Zoning Act (Ordinance 547)	Riverside County requires all building permit applications for a project that lies within an earthquake fault zone shown on the maps prepared by the State Geologist pursuant to the Alquist-Priolo Earthquake Fault Zoning Act shall be accompanied by a geologic report.	Sections 5.5.6.2

5.5.6.1 Federal Authorities and Administering Agencies

The Uniform Building Code specifies acceptable design criteria for structures with respect to seismic design and load-bearing capacity. The State has adopted these provisions in the CBC, and the UBC is currently superseded by 2007 CBC in California.

5.5.6.2 State Authorities and Administering Agencies

California Building Code

The Project is subject to the applicable sections of the 2007 CBC. The Riverside County Department of Building and Safety is responsible for implementing the 2007 CBC for the Project.

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo (AP) Earthquake Fault Zoning Act was enacted by the State of California in 1972 to mitigate the hazard of surface faulting to structures planned for human occupancy and other critical structures. This law was a direct result of the 1971 San Fernando Earthquake, which was associated with extensive surface fault ruptures that damaged numerous homes, commercial buildings, and other structures. The State has established regulatory zones (known as Earthquake Fault Zones and often referred to as “AP zones”) around the surface traces of active faults and issued “Earthquake Fault Zone Maps” to be used by government agencies in planning/reviewing new construction. In addition to residential projects, structures planned for human occupancy that are associated with industrial and commercial projects are of concern.

Local Authorities and Administering Agencies

The Project is subject to the Riverside County Department of Building and Safety requirements for building and grading. Projects must comply with the Riverside County General Plan, Safety Element, including requirements to address hazards posed by seismic hazards, slope and soil instability hazards, flood and inundation hazards, fire hazards, hazardous waste and materials, and disaster preparedness, response and recovery.

5.5.7 Involved Agencies and Agency Contacts

There are no agencies directly responsible for compliance with geological LORS; however, the Riverside County Department of Building and Safety and the Riverside County Planning Department administer the Project’s compliance with the 2007 CBC and the Riverside County General Plan.

Table 5.5-5. Agencies and Agency Contacts

Agency Contact	Phone	Permit/Issue
David Jones County Geologist Riverside County Planning Department 4080 Lemon Street Riverside, CA 92502-1629	(951) 955-6863	Planning conformance.
Mike Lara Director of Building and Safety Riverside County Department of Building and Safety 4080 Lemon Street Riverside, CA 92502-1629	(951) 955-2025	Building permits, grading permit for earthmoving activities exceeding 50 cubic yards.

5.5.8 Permits Required and Permit Schedule

Compliance of construction with 2007 CBC standards is required under engineering and construction permits for the project. There are no other permit requirements that specifically address geologic resources and hazards. However, excavation/grading and inspection permits may be required prior to construction.

Building and grading permits are required by Riverside County Department of Building. Applications should be submitted at least six weeks prior to construction.

Table 5.5-6. Permits Required and Permit Schedule

Permit/Approval	Schedule
Building permit	Application must be submitted six weeks prior to the start of construction.
Grading permit	Application must be submitted six weeks prior to the start of construction.

5.5.9 References

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