Table of Contents

5.5 Geological Hazards and Resources 1
5.5.1 LORS Compliance 1
5.5.1.1 Federal LORS 2
5.5.1.2 State LORS 3
5.5.1.3 Local LORS 3
5.5.1.4 Involved Agencies 4
5.5.1.5 Required Permits and Permit Schedule 6
5.5.2 Affected Environment 7
5.5.2.1 Geological Setting 7
5.5.2.2 Faulting and Seismicity 8
5.5.2.3 Geologic Hazards 9
5.5.2.4 Geologic Resources 11
5.5.3 Environmental Impacts 11
5.5.3.1 Construction 11
5.5.3.2 Operation 12
5.5.3.3 Cumulative Impacts 12
5.5.4 Mitigation Measures 12
5.5.4.1 Construction 12
5.5.4.2 Operations 13
5.5.5 References 13

List of Tables

Table 5.5-1. LORS Applicable to Geological Resources and Hazards 1
Table 5.5-2. Agencies and Agency Contacts 4
Table 5.5-3. Permits Required and Permit Schedule 6
Table 5.5-2. Principal Active Faults 8
Table 5.5-4. Historical Earthquakes That Affected Site 9

List of Figures

Figure 5.5-1. Geologic Map 14

5.5 Geological Hazards and Resources

This section discusses the Mojave Solar Project's potential effects on geologic resources and the potential geologic hazards that may be encountered by the Project.

5.5.1 LORS Compliance

This section addresses the LORS applicable to Geologic Hazards and Resources that are relevant to the MSP. Table 5.5-1 summarizes the LORS that are expected to apply to the Project.

Table 5.5-1. LORS Applicable to Geological Resources and Hazards

LORS	Applicability	Where Discussed in AFC
Federal:		
2006 International Building Code (IBC)	The 2006 International Building Code specifies acceptable design criteria for structures and excavations with respect to seismic design and construction.	Section 5.5.2.2
State:		
2007 California Building Code (CBC), California Code of Regulations (CCR), Title 24	Specifies acceptable design criteria for structures and excavations with respect to seismic design and construction. (Based on 2006 IBC)	Section 5.5.2.2
Alquist-Priolo Earthquake Fault Zoning Act	Identifies areas subject to surface rupture from active faults.	Sections 5.5.2.2, 5.5.2.3, 5.5.3.2
California Porter Cologne Water Quality Act	A National Pollution Discharge Elimination System (NPDES) California General Activities Construction Permit is necessary if an area greater than one acre will be disturbed. Industrial facilities (including power plants) with potential to affect storm water discharges are required to obtain an NPDES permit during operation (Industrial Storm Water General Permit).	Section 5.5.1.2
Local:		

LORS	Applicability	Where Discussed in AFC
County of San Bernardino, Building and Safety Department Building Official Oversight	Building Official oversees independent review of design criteria for structures and excavations with respect to seismic design and construction. (Based on 2006 IBC/2007 CBC)	Section 5.5.1.3
County of San Bernardino 2007 Development Code, amended, January 15, 2009 Geological Hazards Overlay Chapter 82.15	County is to provide greater public safety by establishing investigation requirements for areas that are subject to potential geologic problems, including active faulting, land sliding, debris/mud flow, rock fall, liquefaction, seiche, and adverse soil conditions.	Section 5.5.1.3
County of San Bernardino 2007 Development Code, amended, January 15, 2009 Conditional Grading Compliance Chapter 83.04	To ensure the compliance with conditions of approval on projects involving earthwork and compliance with dust control regulations. Provisions for on-site continuous inspections required by the Building Official.	Section 5.5.1.3
County of San Bernardino 2007 Development Code, amended, January 15, 2009 Flood Hazard Development Review Chapter 85.07	A Flood Hazard Development Review shall be completed before the approval of a land use application or issuance of a development permit in specific area or where required by the director, the Division Chief of Environmental Health Services or the Flood Plan Management Administrator.	Section 5.5.1.3

5.5.1.1 Federal LORS

The Uniform Building Code (UBC) has been replaced with the 2006 International Building Code (IBC) which specifies acceptable design criteria for structures with respect to Seismic Design, Construction, Inspection and Independent Quality Control. The State has adopted these provisions of the 2006 IBC in the 2007 California Building Code (CBC).

5.5.1.2 State LORS

The Project is subject to the applicable sections of the CBC. The San Bernardino County Building Department is responsible for implementing the IBC/CBC for the Project.

Alquist-Priolo Earthquake Fault Zoning Act

The 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) 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.

Porter-Cologne Water Quality Control Act

The Porter-Cologne Water Quality Control Act of 1967, Water Code Section 13000 et seq., requires the State Water Resources Control Board (SWRCB) and the nine Regional Water Quality Control Boards (RWQCB) to adopt water quality criteria to protect State waters. Those criteria include the identification of beneficial uses, narrative and numerical water quality standards, and implementation procedures. Water quality criteria for the proposed project area are contained in the Water Quality Control Plan for the Lahontan Region (Basin Plan) which was adopted in 1994 and is in the process of being amended. This plan sets numerical and/or narrative water quality standards controlling the discharge of wastes to the State's waters and land. Stormwater and construction permitting is discussed in greater detail in Section 5.17, Water Resources.

5.5.1.3 Local LORS

The Project is subject to the San Bernardino County's Building and Safety Division requirements for Design, Construction, Inspection and Independent Quality Control. Building Official oversees independent review of acceptable design criteria for structures and excavations with respect to seismic design and construction based on 2006 IBC/2007 CBC.

Also, the requirements as outlined in the County's 2007 Development Code, Amended January 15, 2009, for Geological Hazards, Conditional Grading, and Flood Hazard Development Review.

Geological Hazards Overlay

County is to provide greater public safety by establishing investigation requirements for areas that are subject to potential geologic problems, including active faulting, land sliding, debris/mud flow, rock fall, liquefaction, seiche, and adverse soil conditions

Conditional Grading Compliance

On-site continuous inspections by the Building Official are required to ensure the compliance with conditions of approval on projects involving earthwork and compliance with dust control regulations.

Flood Hazard Development Review

A Flood Hazard Development Review shall be completed before the approval of a land use application or issuance of a development permit in specific area or where required by the Flood Plain Management Administrator. This project is not in a mapped Flood Plain. Drainage sheet flow coming from off-site tributaries will be channel around the proposed structures and back to historical sheet flows into the existing dry lake bed.

5.5.1.4 Involved Agencies

The agency and person(s) to contact for NPDES, grading, and building Permits, Geological and Flood Hazard Development Review are identified in Table 5.5-2.

Table 5.5-2. Agencies and Agency Contacts

Agency Contact	Phone/E-mail	Permit/Issue
Richard Booth Senior Engineering Geologist California Regional Water quality Control Board Lahontan Region 2501 Lake Tahoe Blvd. South lake Tahoe, CA 96150	(530)542-5574 RBooth@waterboards.ca.gov	NPDES Permit governing storm water discharges associated with construction activity for any disturbance of greater than one acre and for industrial activities.
Gia Kim Division Chief Land Development Division 825 East Third Street, Room,204 San Bernardino, CA 92415-0835	(909) 387-8145 gkim@dpw.sbcunty.gov	Grading, Drainage, Road Improvements
Sameh F. Basta, P.E. Chief, Desert Section Land Development Division 15456 West Sage Street, Suite 206 Victorville, CA 92392	(909) 842-4366 sbasta@dpw.sbcounty.gov	Grading, Drainage and Flood Hazard Development Review

Agency Contact	Phone/E-mail	Permit/Issue
Wesley Reeder County Geologist Land Use Services 385 N. Arrowhead Ave. San Bernardino, CA 92415	909-387-4237 wreeder@lusd.sbcounty.gov	Geological Hazards

5.5.1.5 Required Permits and Permit Schedule

Building and grading permits are required by the San Bernardino County Building and Safety Department. Applications are required at least six (6) to twelve (12) weeks prior to construction.

Table 5.5-3. Permits Required and Permit Schedule

Permit/Approval	Schedule
Notice of Intent (NOI) - Construction Phase Storm Water Permit	A Construction General Permit is required. A SWPPP that specifies BMPs to reduce or prevent construction pollutants from leaving the site. The NOI will be submitted prior to construction. It is anticipated that the NOI will be secured within one month of submittal.
Storm Water Pollution Prevention Plan Operations Phase Storm Water Permit	An Industrial General permit will be required for the Project operations phase. A separate SWPPP is required that outlines the monitoring and reporting plan, along with BMPs for the facility. The permit application package will be submitted to the County at the time of plan review for construction,
Building Permit	Application must be submitted six (6) to twelve (12) weeks prior to the start of construction.
Grading Permit	Application must be submitted six (6) to twelve (12) weeks prior to the start of construction.
Flood Hazard Development Review	Application must be submitted six (6) to twelve (12) weeks prior to the start of construction. Part of Development Review submittal for Grading and Drainage permit

5.5.2 Affected Environment

This section discusses the existing geologic environment of the MSP site. Underlying geologic structures, seismicity, and geologic hazards are discussed.

5.5.2.1 Geological Setting

The MSP site is located in the central Mojave Desert, which is part of the greater Mojave Desert Geomorphic Province. The Mojave Desert is one of 11 geomorphic provinces recognized in California. Each province displays unique, defining features based on geology, faults, topographic relief and climate (California Geological Survey, 2002). The Mojave Desert Province is characterized by broad alluvial basins of Cenozoic sedimentary and volcanic materials overlying older plutonic and metamorphic rocks (Dibblee, 1980). This province lies between the northeast-trending Garlock fault on the north and the northwest-trending San Andreas Fault on the south. Several smaller northwest trending faults are present within the province including the Lenwood-Lockhart-Old Woman Springs fault, located approximately 1/2-mile southwest of the Project site (Ninyo & Moore, 2009; See Appendix B.1).

The Project is located in the alluvial-filled basin of the Harper Valley. A southwest portion of the dry Harper Lake is located in the northeasterly portion of the Project site, which is underlain by Holocene-age lake bed deposits. Based on a geotechnical subsurface exploration (Ninyo & Moore, 2009), the lake bed deposits generally consist of damp to saturated, loose to medium dense, silt and sand, and soft to firm clay. Also based on the geotechnical exploration, remaining portions of the Project site are underlain by thin surficial deposits, such as alluvial soils which are, in turn, underlain by older alluvial deposits at shallow depths. The older alluvial deposits were reported as generally consisting of damp to saturated, loose to very dense, silty and clayey fine to coarse sand with occasional layers of gravel, silt and clay, and wet hard, fine sandy and silty clay. Some layers of caliche consisting of strongly cemented layers of sand and silt were also reported. A geologic map of the site vicinity is shown on Figure 5.5-1, Geologic Map.

The Project site includes Section 33 and portions of Sections 28, 29, 30, and 32 within Township 11N - Range 4W, San Bernardino Base Meridian. The site is relatively flat with a gentle downward slope toward Harper Lake to the northeast. Elevations on the main solar project site range from approximately 2,020 feet above mean sea level (MSL) near the northeastern end of the site on Harper Lake, to approximately 2,105 feet MSL at the southwest corners of Sections 30 and 33.

Surface water in Harper Valley drains to Harper Lake; however, Harper Lake is generally a dry lake bed. At the Project site, surface drainage is by sheetflow runoff toward Harper Lake to the northeast.

There are no permanent bodies of water located on the Project site. Based on a review of groundwater depth records for nearby wells (California Department of Water Resources, 2009) it is anticipated that the regional groundwater table at the Project site is at a depth of more than 100 feet. However, during a geotechnical subsurface exploration on the site (Ninyo & Moore, 2009) perched groundwater was encountered at depths as shallow as 4 feet in the vicinity of Harper Lake. Perched groundwater was also encountered in the vicinity of the proposed Alpha and Beta power blocks at a depth of approximately 27 feet.

A more detailed discussion of groundwater conditions at the Project site is provided in Section 5.17, Water Resources.

5.5.2.2 Faulting and Seismicity

The Project site is located in seismically active Southern California, a region that has experienced numerous earthquakes in the past. Also, a portion of the Project site is located within a State of California Alquist-Priolo Earthquake Fault Zone (AP Zone). The active Lenwood-Lockhart-Old Woman Springs fault is located approximately 2,300 feet southwest of the site. The following table lists selected principal known active faults within a radius of approximately 60 miles, the approximate fault-to-site distances, and the assigned maximum moment magnitude earthquake as published by Cao, et al. (2003) for the California Geological Survey (CGS). The fault-to-site distances were calculated using the computer program FRISKSP (Blake, 2001).

Table 5.5-2. Principal Active Faults

Fault Name	Approximate Distance from Site		Maximum Moment Magnitude
	Miles	Kilometers	
Lenwood-Lockhart-Old Woman Springs	0.4 (2,300 feet)	0.7	7.5
Helendale-S. Lockhardt	6.6	10.6	7.3
Gravel Hills-Harper Lake	9.0	14.5	7.1
Blackwater	15.4	24.7	7.1
Calico-Hidalgo	24.2	39.0	7.3
Landers	32.3	52.0	7.3
Garlock (East)	34.3	55.2	7.5
Garlock (West)	41.6	66.9	7.3
San Andreas (Mojave)	47.7	76.7	7.4
San Andreas (San Bernardion)	50.6	81.4	7.5

Since an AP Zone had been mapped on the Project site, a geologic evaluation was conducted to ascertain the actual presence and location of the fault trace so that appropriate setbacks could be established for human occupancy structures (any structures that are used or intended to be used for supporting or sheltering any use or occupancy, which is expected to have a human occupancy rate of more than 2,000 person-hours per year). The AP Zone mapping of the trace of the unnamed fault was based on aligned tonal lineaments, a subtle scarp in Holocene alluvium, and the linear western shoreline of Harper

Lake. These physiographic features are suggestive of faulting but not conclusive. To physically assess the mapped presence of the fault an exploratory trench was excavated across the AP Zone (Ninyo & Moore, 2009). After detailed geologic logging of the trench walls it was concluded that there was no evidence for the presence of active faulting in the AP Zone on the Project site (see Appendix B).

5.5.2.3 Geologic Hazards

Seismic hazards related to earthquakes and ground shaking include ground rupture, slope stability, liquefaction, subsidence, tsunamis, and seiches. Due to the inland location of the Project site and the absence of nearby large bodies of water, hazards from tsunamis and seiches are not present.

Ground Rupture

Since it has been shown that active faulting does not occur in the AP Zone on the Project site and that there are no other known or suspected active faults on the site, the potential for ground surface rupture due to on-site faulting is considered low. However, due to the relatively close proximity of the Lenwood-Lockhart-Old Woman Springs Fault, a moderate probability of damage from surface fault rupture on that fault is considered to exist. Also, a significant potential exists for lurching or cracking of the ground surface on the site as a result earthquake shaking.

Seismic Ground Shaking

The Project site is located in a seismically active area and therefore will likely be subjected to ground shaking from movement along one or more of the regions active faults in the future. According to a probabilistic seismic hazard model for California (California Geological Survey, 2003) peak horizontal ground accelerations having a 10 percent probability of exceedance in 50 years can be estimated to be approximately 0.3g (30 percent of gravity) which can be considered low to moderate when compared to some of the more seismically active areas of California. Historical earthquakes of magnitude 6.0 or greater with epicenters within approximately 100 km (62 miles) of the study area are shown in the following table.

Table 5.5-4. Historical Earthquakes That Affected Site

Date	Approximate Epicentral Distance from Site		Magnitude
	Miles	Kilometers	
July 22, 1899	50	80	8
September 20, 1907	57	92	7
April 10, 1947	44	71	7
June 28, 1992	62	100	6.5

Other notable earthquakes that occurred in the Mojave Desert, but with epicenters more than 100 km from the Project site, include the Landers Earthquake in 1992 with a magnitude of 7.3 and the Hector Mine Earthquake in 1999 with a magnitude of 7.1.

Mass Wasting and Slope Stability

The Project site is 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 site is relatively flat. Further, based on the topography, there are no indications of active or ancient landslides on the site.

Liquefaction

Liquefaction is the phenomenon in which loosely deposited granular soils with silt and clay contents of less than approximately 35 percent and non-plastic silts located below the water table undergo rapid loss of shear strength when subjected to strong earthquake-induced ground shaking. Ground shaking of sufficient duration results in the loss of grain-to-grain contact due to a rapid rise in pore water pressure, and causes the soil to behave as a fluid for a short period of time. Liquefaction is generally known to occur in saturated or near-saturated cohesionless soils at depths shallower than 50 feet below the ground surface.

As part of a geotechnical subsurface evaluation for the Project (Ninyo & Moore, 2009) an analysis was made of the liquefaction potential of the subsurface soils at the Alpha and Beta power blocks where perched groundwater was encountered with an assumed depth of 27 feet. The liquefaction analysis indicated that minor zones within the medium dense granular soil layers occurring below the assumed groundwater level and up to a depth of 37 feet below the ground surface are susceptible to liquefaction.

Subsidence

Subsidence due to groundwater withdrawal has been documented in various regions of the Mojave Desert. As part of the geotechnical subsurface evaluation for the Project (Ninyo & Moore, 2009) a review of well records for three wells on Lockhart Road, east of Harper Lake Road, was made to evaluate the subsidence potential. It was found that the groundwater level was at a depth of 18 feet in 1919, 95 feet in 1953, and 176 feet in 1996 shortly after much of the agricultural pumping ended in Lockhart. It was also found that the groundwater had since risen to a depth of approximately 140 feet. Based on the understanding that the groundwater withdrawal for the MSP will be less than the natural aquifer recharge, it was concluded that groundwater levels should continue to rise and as such there should be little potential for subsidence due to groundwater withdrawal (Ninyo & Moore, 2009).

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 at present. However, the soils on the site are classified as being highly susceptible to wind erosion (United States

Department of Agriculture, 2009). The implementation of Best Management Practices (BMPs) during construction is expected to reduce water and wind erosion of soils to less than significant levels.

Tsunami Runup

The Project site is not considered to be an area with the potential for Tsunami Runup because no surface water of any significant size is near the site.

Expansion or Collapsible of Soil Structures

Soil collapse, or hydro-consolidation, occurs when soils undergo a rearrangement of their grains and a loss of cementing agents, resulting in substantial and rapid settlement under relatively low loads. This phenomenon typically occurs in recently deposited Holocene soil in a dry or semiarid environment, including eolian (wind blown) sands and alluvial fan and mudflow sediment deposited during flash floods. The combination of weight from a building or other structures, and an increase in surface water infiltration (such as from irrigation or a rise in the groundwater table) can initiate settlement and cause structural foundations and walls to crack. Based on the geotechnical subsurface evaluation performed for the Project (Ninyo & Moore, 2009), the Project site, except for minor areas in the vicinity of Harper Lake, are underlain by "older alluvium." Older alluvium consists of alluvial deposits that are older than recently deposited Holocene alluvium and as such are more consolidated and less prone to soil collapse. Collapsible soils were not encountered in the geotechnical design evaluation performed for the project (Ninyo & Moore, 2009).

Expansive soils contain significant amounts of clay particles that have the ability to give up water (shrink) or take on water (swell). When these soils swell, the change in volume can exert significant pressures on loads that are placed on them, such as buildings, and can result in structural distress and/or damage. Due to the predominately granular nature of the older alluvial deposits that underlie the majority of the Project site, the potential for significant amounts of expansive soils is considered very low.

5.5.2.4 Geologic 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.). There are no such features on the Project site, nor are there any County, State, or National recreation areas on or adjacent to the site. Therefore, a map of geological resources which may be affected by the project is not included.

There is no known oil, gas or geothermal resource on or adjacent to the site.

5.5.3 Environmental Impacts

Environmental impacts associated with the construction and operations of the MSP Plant Site are discussed in the following sections.

5.5.3.1 Construction

Construction-related impacts to the geologic environment primarily are related to terrain modification (cuts, fills, and drainage diversion measures) and dust generation (excavation

and grading). No major unique geologic or physical features have been identified in the Project site.

The Project site is in the seismically active southern California region; thus, the Project site is subject to ground shaking, and potentially subject to ground accelerations from earthquakes along faults in the region. The potential for earthquake-related impacts would begin during Project construction. However, seismic impacts would be of greater concern during long-term Project operation than during the limited duration of the Project construction phase. These impacts are discussed immediately below.

5.5.3.2 Operation

Regional and local geologic conditions will not be altered significantly by the long-term operation of the MSP. No major unique geologic or physical features have been identified at the Project site. The Project areas may be underlain by deposits of sand and gravel, and these resources could not be recovered and used during the active life of the Project. No other impacts to the geologic environment were identified.

The MSP will be designed and constructed to meet IBC/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). Further, a geotechnical design report (Ninyo & Moore, 2009) has been prepared to address geotechnical issues and assist in the design and construction of the Project. For these reasons, the Project is expected to have no significant impacts on geologic hazards or resources.

5.5.3.3 Cumulative Impacts

No projects are located in the same vicinity that could be considered cumulative. However, any nearby projects would be expected to adhere to the appropriate professional standards and regulatory requirements. Because the MSP will be designed and constructed to meet all professional standards and regulatory requirements, the MSP would not be expected to contribute to cumulative effects on geologic resources and hazards during either construction or operation.

5.5.4 Mitigation Measures

5.5.4.1 Construction

Geologic impacts associated with the construction of the MSP are expected to be less than significant. Moreover, site-specific geotechnical and seismic conditions will be appropriately addressed in the detailed design and construction of project facilities and equipment. The following mitigation measures are proposed to ensure the impacts are less than significant.

- Power plant structures and equipment will be designed in accordance with seismic requirements of the Alquist-Priolo Earthquake Fault Zoning Act.
- Project foundation will be designed in accordance with recommendation provided in the final geotechnical design report for this Project.

5.5.4.2 Operations

Geologic impacts associated with the operation of the MSP are expected to be less than significant. Thus, no mitigation measures associated with geology are proposed for operations.

5.5.5 References

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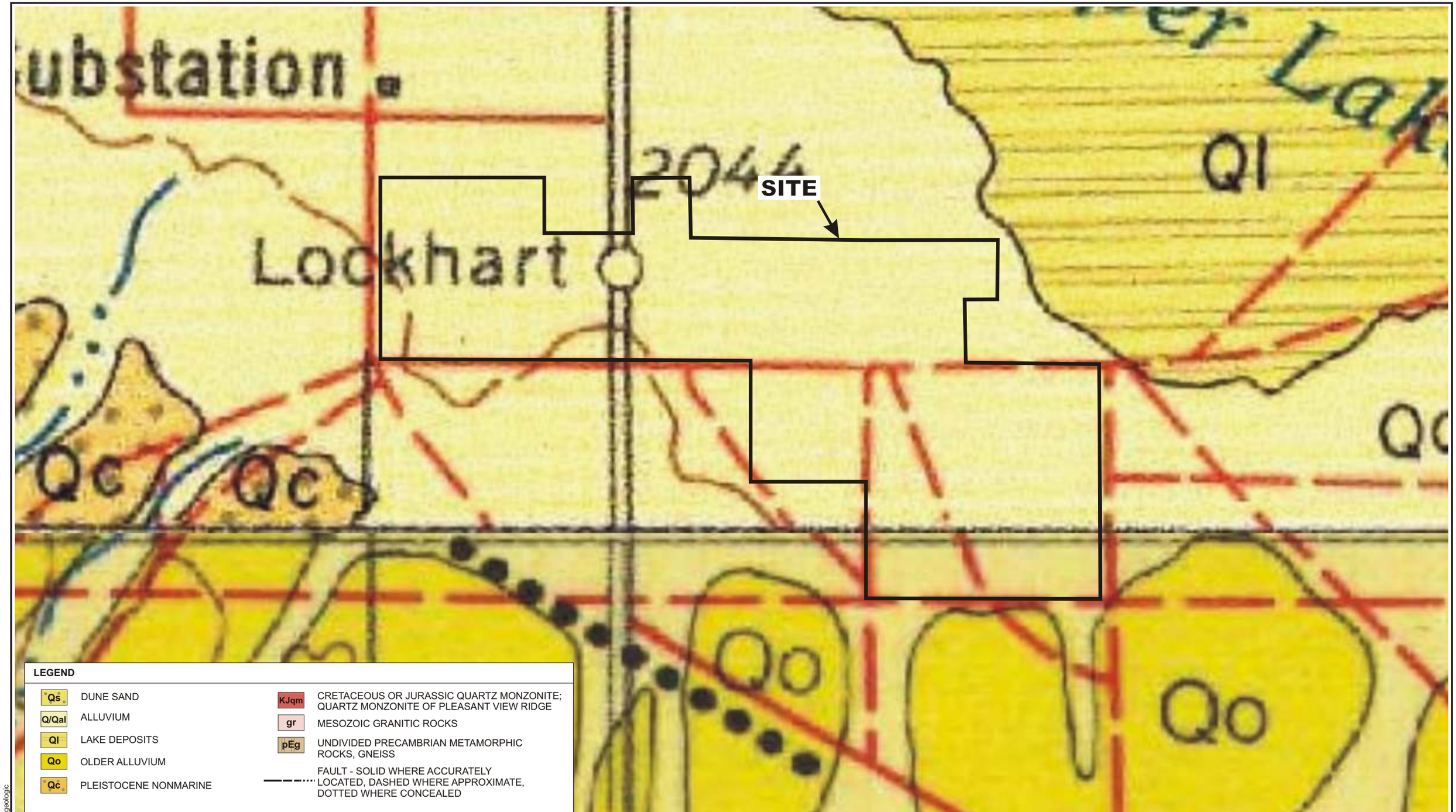

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APPROXIMATE SCALE

0 2000 4000 FEET

N

NOTE: ALL DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

fig 5.5-1 105879004 geologic

Ninyo & Moore		GEOLOGIC MAP	FIGURE
PROJECT NO.	DATE	MOJAVE SOLAR PROJECT LOCKHART, CALIFORNIA	5.5-1
105879004	7/09		