5.4 Geologic Hazards and Resources

5.4.1 Introduction

The Hidden Hills Solar Electric Generating System (HHSEGS) will be located on privately owned land in Inyo County, California, adjacent to the Nevada border. It will comprise two solar fields and associated facilities: the northern solar plant (Solar Plant 1) and the southern solar plant (Solar Plant 2). Each solar plant will generate 270 megawatts (MW) gross (250 MW net), for a total net output of 500 MW. Solar Plant 1 will occupy approximately 1,483 acres (or 2.3 square miles), and Solar Plant 2 will occupy approximately 1,510 acres (or 2.4 square miles). A 103-acre common area will be established on the southeastern corner of the site to accommodate an administration, warehouse, and maintenance complex, and an onsite switchyard. A temporary construction laydown and parking area on the west side of the site will occupy approximately 180 acres.

Each solar plant will use heliostats—elevated mirrors guided by a tracking system mounted on a pylon—to focus the sun's rays on a solar receiver steam generator (SRSG) atop a tower near the center of each solar field. The solar power tower technology for the HHSEGS project design incorporates an important technology advancement, the 750-foot-tall solar power tower. One principle advantage of the HHSEGS solar power tower design is that it results in more efficient land use and greater power generation. The new, higher, 750-foot solar power tower allows the heliostat rows to be placed closer together, with the mirrors at a steeper angle. This substantially reduces mirror shading and allows more heliostats to be placed per acre. More megawatts can be generated per acre and the design is more efficient overall.

In each solar plant, one Rankine-cycle steam turbine will receive steam from the SRSG (or solar boiler) to generate electricity. The solar field and power generation equipment will start each morning after sunrise and, unless augmented, will shut down when insolation drops below the level required to keep the turbine online. Each solar plant will include a natural-gas-fired auxiliary boiler, used to augment the solar operation when solar energy diminishes or during transient cloudy conditions, as well as a startup boiler, used during the morning startup cycle, and a nighttime preservation boiler, used to maintain system temperatures overnight. On an annual basis heat input from natural gas will be limited by fuel use and other conditions to less than 10 percent of the heat input from the sun.

To save water in the site's desert environment, each solar plant will use a dry-cooling condenser. Cooling will be provided by air-cooled condensers, supplemented by a partial dry-cooling system for auxiliary equipment cooling. Raw water will be drawn daily from onsite wells located in each power block and at the administration complex. Groundwater will be treated in an onsite treatment system for use as boiler make-up water and to wash the heliostats.

Two distinct transmission options are being considered because of a unique situation concerning Valley Electric Association (VEA). Under the first option, the project would interconnect via a 230-kilovolt (kV) transmission line to a new VEA-owned substation (Tap Substation) at the intersection of Tecopa Road[1] and Nevada State Route (SR) 160 (the Tecopa/SR 160 Option). The other option is a 500-kV transmission line that interconnects to the electric grid at the Eldorado Substation (the Eldorado Option), in Boulder City, Nevada.

A 12- to 16-inch-diameter natural gas pipeline will be required for the project. It will exit the HHSEGS site at the California-Nevada border and travel on the Nevada side southeast along the state line, then northeast along Tecopa Road until it crosses under SR 160. From this location a 36-inch line will turn southeast and continue approximately 26 miles, following the proposed Eldorado Option transmission line corridor, to intersect with the Kern River Gas Transmission (KRGT) pipeline. A tap station will be constructed at that point to connect it to the KRGT line. The total length of the natural gas pipeline will be approximately 35.3 miles.

The transmission and natural gas pipeline alignments will be located in Nevada, primarily on federal land managed by the U.S. Bureau of Land Management (BLM), except for small segments of the transmission line (both options) in the vicinity of the Eldorado Substation, which is located within the city limits of Boulder City, Nevada. A detailed environmental impact analysis of the transmission and natural gas pipeline alignments will be prepared by BLM.

This section is organized as follows: Section 5.4.2 describes the relevant laws, ordinances, regulations, and standards (LORS) for geologic hazards and resources. Section 5.4.3 describes the affected environment including the regional and local geology, seismicity, and hazards. The environmental analysis to determine potential impacts and potential cumulative impacts as a result of construction and operation of the project are provided in Sections 5.4.4 and 5.4.5, respectively. Section 5.4.6 provides mitigation measures to reduce significant impacts from geologic hazards and to geologic resources. Section 5.4.7 addresses relevant agencies, and Section 5.4.8 lists required permits. Subsection 5.4.9 lists references used in preparing this section.

5.4.2 Laws, Ordinances, Regulations, and Standards

The LORS that may apply to geologic resources and hazards are summarized in Table 5.4-1.

TABLE 5.4-1
Laws, Ordinances, Regulations, and Standards Applicable to Geologic Hazards and Resources

LORS	Requirements/ Applicability	Administering Agency	AFC Section Explaining Conformance
State			
California Building Code (CBC), 2010	Acceptable design criteria for structures with respect to seismic design and load-bearing capacity.	California Building Standards Commission, State of California, and County of Inyo	Section 5.4.2.1.1

[1] The road is also called Tecopa Highway and Old Spanish Trail Highway. The names are generally used interchangeably.

TABLE 5.4-1
Laws, Ordinances, Regulations, and Standards Applicable to Geologic Hazards and Resources

LORS	Requirements/ Applicability	Administering Agency	AFC Section Explaining Conformance
Alquist-Priolo Earthquake Fault Zoning Act Title 14, Division 2, Chapter 8, Subchapter 1, Article 3, California Code of Regulations as amended by the County of Inyo	Identifies areas subject to surface rupture from active faults.	California Building Standards Commission, State of California, and County of Inyo	Section 5.4.2.1.2
The Seismic Hazards Mapping Act Title 14, Division 2, Chapter 8, Subchapter 1, Article 10, California Code of Regulations.	Identifies non-surface fault rupture earthquake hazards, including liquefaction and seismically induced landslides.	California Building Standards Commission, State of California, and County of Inyo	Section 5.4.2.1.3
Local			
County of Inyo General Plan	Compliance with the Public Safety Element of the General Plan.	County of Inyo	Section 5.4.2.2.1

5.4.2.1 State LORS

5.4.2.1.1 California Building Code

The California Building Standards Code (CBC) provides specific and acceptable design criteria for excavations and structures for static and dynamic loading conditions. The project will comply with the CBC by ensuring seismic design and construction criteria of the 2010 CBC (California Building Standards Commission, 2010) are satisfied.

5.4.2.1.2 Alquist-Priolo Earthquake Fault Zoning Act

The main purpose of the Alquist-Priolo Earthquake Fault Zoning Act is to prevent the construction of structures for human occupancy across the trace of active faults. The project's structures are not located within a known Earthquake Fault Zone (EFZ) (CGS, 2010) or within an area identified as subject to surface rupture from active faults.

5.4.2.1.3 Seismic Hazards Mapping Act

The purpose of the Seismic Hazards Mapping Act is to protect public safety from the effects of strong ground shaking, liquefaction, landslides, or other ground failure, and other hazards caused by earthquakes. The program and actions mandated by the Seismic Hazards Mapping Act closely resemble those of the Alquist-Priolo Earthquake Fault Zoning Act (which addresses only surface fault-rupture hazards). The project will conform to this act by conducting an analysis for potential seismic hazards at the project site.

5.4.2.2 Local LORS

5.4.2.2.1 County of Inyo General Plan

The Public Safety Element of the Inyo County General Plan is intended to protect the public from the effects of natural geologic hazards. The Inyo County General Plan requires that the County ensure that the new developments meet the current seismic safety standards in accordance with UBC. According to the Inyo County Planning and Building Departments, there are no specific local LORS regarding geologic hazards that would be applicable to the proposed activities at the project site, other than a grading and building permit review process.

5.4.3 Affected Environment

The HHSEGS site is located in Inyo County, California. The site lies in the eastern part of the Mojave Desert physiographic province in the Pahrump Valley near the California–Nevada border. The Mojave Desert physiographic province exhibits characteristics similar to the Great Basin to the north, as well as the Colorado Desert province to the south. As subdivisions of the Basin and Range Physiographic Province (Fenneman, 1931) all three areas are dominated by broad alluviated basins that are mostly aggrading surfaces receiving non-marine continental deposits from adjacent uplands (Norris and Webb, 1990). The site is located on a gently sloping surface in the central portion of Pahrump Valley. Elevation across the site ranges from about 2,590 feet above mean sea level (amsl) on the northwest to about 2,680 feet amsl on the southeast. The Pahrump Valley is a northwest-trending valley and is bound by the Resting Spring and Nopah Ranges on the west and northwest, by the Kingston Range on the southwest and the Spring Mountains on the east (DWR, 2004 and 2011). Pahrump Dry Lake or Playa lies about 3 miles northwest of the HHSEGS. To the southeast, a low divide separates Pahrump Valley from Sandy Valley (also frequently called Mesquite Valley) while, to the northeast, another low divide separates it from Stewart Valley. To the north, the Last Chance Range separates the Pahrump Valley from the Amargosa Desert. The HHSEGS site is within the basin that comprises the lowest portion of Pahrump Valley, and is underlain by carbonate-rich fine-grained basin fill (chiefly sands, silts, and clays) (Lundstrom et al., 2002).

5.4.3.1 Regional Geology and Structure

The site is located within the Mojave Desert floristic region, and the southern Great Basin hydrographic region. The Mojave Desert area has undergone numerous transformations over geologic time. For much of the Paleozoic, 550 to 250 million years ago, the region lay off the western margin of the North American plate, frequently in relatively shallow marine environments. These sediments, primarily limestone but also quartzite, dolomite and limited shale deposits, now comprise the marine sedimentary rocks exposed by uplift in the surrounding mountains. Paleozoic marine rocks are separated by a hiatus from Mesozoic (Triassic to Jurassic; 250 to 145 million years ago) estuarine and continental sediments, which are exposed primarily to the east in the Spring Mountains of Nevada. A period of crustal compression followed in the Late Mesozoic, the most remarkable result of which is the Keystone Thrust in the Spring Mountains. Here a large crustal slab of Paleozoic rock is thrust over a layer of much younger Jurassic sandstone, each crustal slab being many thousands of feet thick. Compression was followed by crustal extension beginning during the Middle Tertiary, about 23 million years ago. Normal and strike-slip faulting, as well as

associated volcanic activity, transformed the landscape to the basin-and-range type topography typical of the Mojave region today. Beginning with this Basin and Range Orogeny and continuing into the Quaternary (the last 2 million years), uplift of the Sierra Nevada, as well as Transverse and Peninsular Ranges, led to a strengthened rain shadow and desertification as precipitation declined. Active faults in the vicinity of the HHSEGS site include the Garlock and West Spring Mountain faults. The Pahrump Fault is a segment of the Stateline Fault System, which extends from Amargosa Valley southeast to Primm, Nevada (Scheirer et al., 2010). Numerous inactive faults are present in the general area as well (Lundstrom et al., 2002). The faults that transect the project area are shown on Figure 5.4-1.

5.4.3.2 Local Geology

Locally, the HHSEGS area is underlain by Quaternary-aged sediments deposited via accumulation of fine-grained basin fill. Figure 5.4-1 shows the geology of the project area within a 2-mile buffer of the HHSEGS site. Generalized descriptions of the surficial geologic deposits that are mapped within the buffer zone are presented on the Geologic Map (Figure 5.4-1). The preliminary geotechnical investigation completed by Ninyo and Moore (2011) confirms the presence of local alluvial and lacustrine deposits to a depth at least 16 feet below ground surface at the project site. Additionally, the geotechnical investigation revealed the presence of layers of moderately to strongly cemented soil (caliche). A subsequent design-level geotechnical investigation will be conducted to further provide engineering properties for the geologic units present in the project area.

5.4.3.3 Seismic Setting

The project site lies within Inyo County in the eastern part of California. These areas are considered to exhibit low seismic activity.

The nearest active (Holocene-aged) faults are listed in Table 5.4-2, and are also shown on Figure 5.4-1.

TABLE 5.4-2
Active Faults near the HHSEGS Site

Fault name	Distance (miles) from HHSEGS	Direction from HHSEGS
Pahrump (Stateline) Fault Zone	0.1	NE
West Spring Mountain Fault Zone	3.2	NE
Garlock Fault Zone	37	SW
Southern Death Valley Fault Zone	38	SW
Black Mountain Fault Zone	45	W

Source: U.S. Geological Survey (USGS), 2006.

5.4.3.4 Potential Geologic Hazards

The following subsections discuss the potential geologic hazards that might occur in HHSEGS area based on a literature search and preliminary analysis for the site, including: seismic ground shaking; ground rupture; liquefaction; subsidence; expansive soils; eolian processes; and seiches/tsunamis, and the likelihood of occurrence of each.

5.4.3.4.1 Seismic Ground Shaking

During an earthquake, seismic waves are produced that emanate in all directions from the fault rupture. Seismic waves can produce strong ground shaking that is typically strongest near the fault and attenuates as the waves move away from the source. The severity of ground shaking is controlled by the interaction of magnitude, distance, and the type, thickness, and condition of underlying geologic materials. Areas underlain by unconsolidated, recent alluvium, or fill may amplify the strength and duration of strong ground motion. The nearest active faults are listed in Table 5.4-2, and are shown on Figure 5.4-1. Based on the latest California Department of Transportation data (Caltrans, 2009), the Pahrump (Stateline) and West Springs Mountain faults have estimated potential magnitudes of 6.9 and 7.0, respectively. The Garlock Fault has an estimated potential magnitude of 7.8.

Based on the subsurface profile types and average shear wave velocities estimated for typical alluvial soil, a probabilistic seismic hazard analysis was conducted to determine generalized peak ground acceleration (PGA) at the solar field area. The 2008 USGS deaggregation tool was used for this analysis, which indicated a level of ground shaking estimated at 0.11g for the solar field (USGS, 2008). This estimated acceleration is based on a seismic event with a 475 year return period, which is commonly referred to as the DBE.

Based on the references reviewed, and the DBE estimate (475 year return period) for the site discussed above, the potential for strong seismic ground shaking to occur at the project area is considered low to moderate.

5.4.3.4.2 Ground Rupture

Ground rupture is caused when an earthquake event along a fault creates rupture at the surface. The solar field site is not located within an EFZ, as delineated by the Alquist-Priolo Earthquake Fault Zone Act of 1972. Based on the referenced sources reviewed, no faults have been mapped transecting the proposed solar field site. The potential for ground rupture to occur at the solar field site is considered low.

5.4.3.4.3 Liquefaction

During strong ground shaking, loose, saturated, cohesionless soils can experience a temporary loss of shear strength. This phenomenon is known as liquefaction. Liquefaction is dependent on grain size distribution, relative density of the soils, degree of saturation, and intensity and duration of the earthquake. The potential hazard associated with liquefaction is seismically induced settlement and lateral spreading. As shown on Figure 5.4-2, the depth to groundwater at the HHSEGS site is relatively deep, greater than 100 feet below ground surface (DWR, 2011; Ninyo and Moore, 2011; Rush, 1974). Due to the lack of potential seismic activity and deep groundwater conditions, the HHSEGS site is considered to have a low potential for liquefaction.

5.4.3.4.4 Slope Stability

Slope instability depends on slope inclination, underlying geology, surface soil strength, and pore pressures in the soil. Excavating, grading, or fill work during construction might introduce temporary slope stability hazards. Slope stability hazards are not expected to be a concern in areas where topographic relief is minimal; this includes the HHSEGS site. The potential for direct impact of slope instability and/or landslides is considered low at the low-lying portions of the project area.

5.4.3.4.5 Subsidence

Subsidence can be caused by natural phenomena during tectonic movement, consolidation, hydrocompaction, liquefaction settlement as described above, or rapid sedimentation. Subsidence can also result from human activities, such as withdrawal of water and/or hydrocarbons in the subsurface soils and construction of new facilities such as mass fills and new structures or buildings. The preliminary geotechnical evaluation (Ninyo and Moore, 2011) identified soils with high porosity and high collapse potential. Further design-level geotechnical evaluation is being conducted to assess the effect of subsidence potential on the project and identify mitigation recommendations.

5.4.3.4.6 Expansive Soils

Expansive soils are clay-rich soils that have the ability to shrink and swell with wetting and drying. The shrink-swell capacity of expansive soils can result in differential movement beneath foundations. The HHSEGS site is underlain by a variety of geologic units. Clay rich soils were encountered primarily in the central part of the site during the preliminary geotechnical investigation, and could be subject to expansive properties. In particular, those areas that are underlain by lacustrine deposits have clay-rich soils. The potential for expansive soils to be present at the project site is moderate.

5.4.3.4.7 Eolian Processes

Sandstorms are common in the Mojave Desert, and windblown sands can be an erosional and depositional force that may damage structures. Due to the frequency and intensity of sandstorms that can occur in the Mojave Desert, the potential for eolian processes to affect the project site is low to moderate.

5.4.3.4.8 Tsunami/Seiche

Tsunamis are waves typically generated offshore or within large, open bodies of water during a subaqueous fault rupture or a subaqueous landslide event. Seiches are waves generated within a large, closed body of water, also caused by subaqueous fault rupture or a subaqueous landslide event. Because the project site is not near large bodies of water, there is no potential for the project site to be affected by a tsunami or seiche.

5.4.3.5 Geologic Resources of Recreational, Commercial, or Scientific Value

Geologic resources of recreational, commercial, or scientific value in the project vicinity that could be affected include mineral resources. No known scientific or recreational geologic resources were identified in the vicinity of the project site. No known oil or gas reserves were identified to be present in the project vicinity (CDOGGR, 2011). Commercial resources of value are discussed in the next paragraph.

5.4.3.5.1 Mineral Resources

The State of California Department of Mines and Geology (now known as the California Geological Survey) uses Mineral Resource Zone (MRZ) classifications to indicate the presence (or lack thereof) of measured or inferred mineral resources on lands across the state. The classifications identified by the CDMG for this project area include MRZ-3b and MRZ-4 (CDMG, 1993). These classifications are defined as follows:

MRZ-3b – Areas underlain by inferred mineral occurrence.

MRZ-4 – No known mineral occurrences.

In the vicinity of the project site, MRZ-3b was mapped across the entire Pahrump Valley for "sodium compounds". As stated in SR-167 (CDMG, 1993), these specific resources "have low mineralization density, no production has occurred, and there is a low potential for undiscovered resources".

The entire Pahrump Valley area was also mapped as MRZ-4, no known mineral occurrence, for hydrothermal mineral deposits (gold, silver, copper, lead, and zinc).

5.4.4 Environmental Analysis

5.4.4.1 Generating Facility

5.4.4.1.1 Potential Geologic Hazards

Ground shaking presents the most significant geologic hazard to the proposed solar site and transmission lines. Based on the analysis in Section 5.4.3, Table 5.4-3 summarizes the geologic hazards associated with the project that have at least a moderate potential to occur. With appropriate design and adherence to LORS, none of the listed hazards are expected to pose significant risk.

TABLE 5.4-3
Summary of Potential Geologic Hazards at the HHSEGS Site

Project Component	Area of Potential Concern	Geologic Hazards of Potential Concern
Proposed generating facility site	Entire site	Seismic ground shaking, subsidence, Expansive soil*, Eolian processes

*Expansive soil occurs mostly in the central portion of the site.

5.4.4.1.2 Geologic Conditions and Topography

Construction of HHSEGS is expected to require minor grading and excavation, thereby altering the terrain of the site. Impacts on the geologic conditions involve minor changes in drainage, cuts, and fills. Because the site has a fairly gentle slope from east to west, minor site grading is not expected to adversely affect the geologic environment.

5.4.4.2 Geologic Resources of Recreational, Commercial, and Scientific Value

HHSEGS will not result in a loss of availability of a known mineral resource that would be of value to the region and the residents of the state. In addition, the project would not result in the loss of availability of a locally important mineral resource recovery site delineated on a local plan, specific plan, or other land use plan. No impacts on geological resources are anticipated.

5.4.5 Cumulative Effects

A cumulative effect refers to a proposed project's incremental effect together with other closely related past, present, and reasonably foreseeable future projects whose impacts may compound or increase the incremental effect of the proposed project (Public Resources Code Section 21083; 14 CCR Sections 15064(h), 15065(c), 15130, and 15355). Cumulative projects are described in Section 5.6.7 and include the Pahrump Valley General Aviation Airport, St. Therese Mission (a commercial enterprise), and the Element Power Solar Project. Standard engineering practices are expected to reduce the potential for impacts due to geological hazards that could result from implementation of these projects in conjunction with HHSEGS.

As described above, the project would not affect geologic resources, and thus would not contribute to a cumulative impact when considered in combination with the cumulative projects. As described below, mitigation measures have been identified to reduce impacts from geologic hazards. With implementation of these measures, HHSEGS would not result in adverse geologic hazards impacts. Therefore, the project would not combine cumulatively with other closely related past, present, and reasonably foreseeable future projects and result in cumulative considerable geologic hazards impacts.

5.4.6 Mitigation Measures

The following subsections describe mitigation measures that could be used to reduce impacts from geologic hazards.

5.4.6.1 Ground Rupture

No mapped active faults cross the solar field area. Therefore, no mitigation measures are required to reduce the hazard from surface fault rupture.

5.4.6.2 Ground Shaking

The solar field area could be subject to seismic shaking. The project facilities will need to be designed and constructed to withstand earthquake shaking in accordance with current LORS. Structures will be designed to meet seismic requirements of the 2010 CBC. Moreover, the design of structures and equipment will be in accordance with 2010 CBC earthquake design requirements to withstand the ground motion of a DBE. A design-level geotechnical investigation will be performed to provide more detailed seismic design analysis criteria.

5.4.6.3 Liquefaction

Based on an expected low potential for seismic activity and deep groundwater conditions in the solar field area, liquefaction/lateral spreading hazard mitigation is not expected to be necessary.

5.4.6.4 Subsidence

A design-level geotechnical investigation will be conducted for the project to determine the level of subsidence potential for the site and provide recommendations to mitigate any potential significant impacts.

5.4.6.5 Expansive Soils

Expansive soils can be mitigated by removing the soil and backfilling with non-expansive soil, instituting chemical stabilization of the soil, or constructing a foundation treatment that resists uplift of the expansive soil. Soil types present in the central part of the solar field site may exhibit expansive properties potential; specifically in the areas of the site underlain by lacustrine deposits (this includes the proposed solar site area). A design-level geotechnical investigation will be performed to further determine the expansive soils potential for the site and present appropriate mitigation recommendations.

5.4.6.6 Eolian Processes

A design-level geotechnical investigation will evaluate potential windblown sand-related hazards as they relate to the HHSEGS site. Appropriate recommendations to mitigate the potential impacts will be provided, if significant.

5.4.7 Involved Agencies and Agency Contacts

No permits are required for compliance with geological LORS.

5.4.8 Permits Required and Permit Schedule

Building construction compliance with CBC standards is covered under engineering and construction permits for the project that is within the exclusive jurisdiction of the CEC. There are no other permit requirements that specifically address geologic resources and hazards.

5.4.9 References

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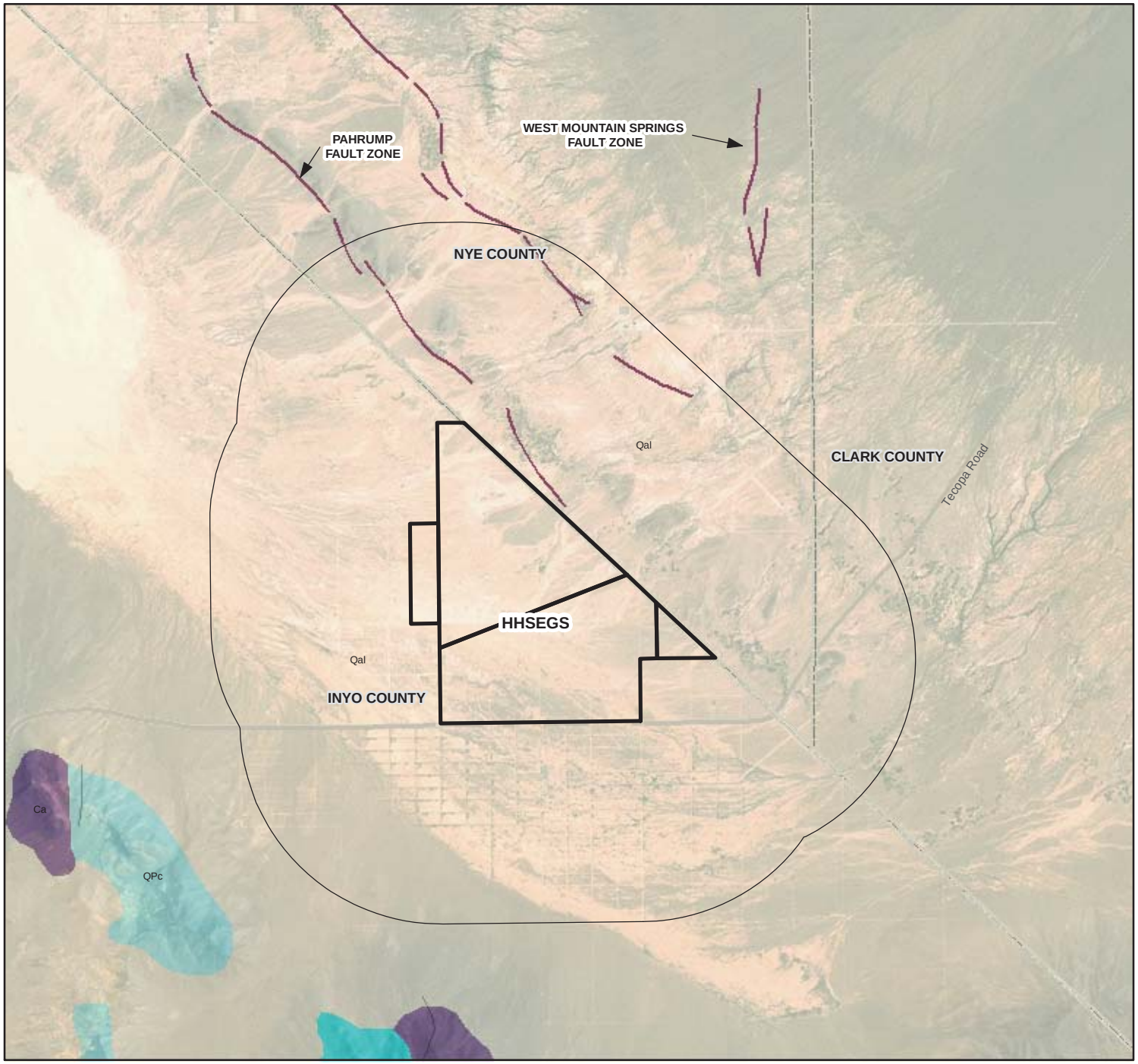


LEGEND

Roads and Trails

- Interstate
- Highway
- Major Road

Fault Types

- Concealed fault (Inactive)
- Fault (Inactive)
- Thrust fault (Inactive)
- Holocene (Active) Faults

Project Site Data

- HHSEGS Boundary
- HHSEGS Buffer (2 miles)

Geologic Units

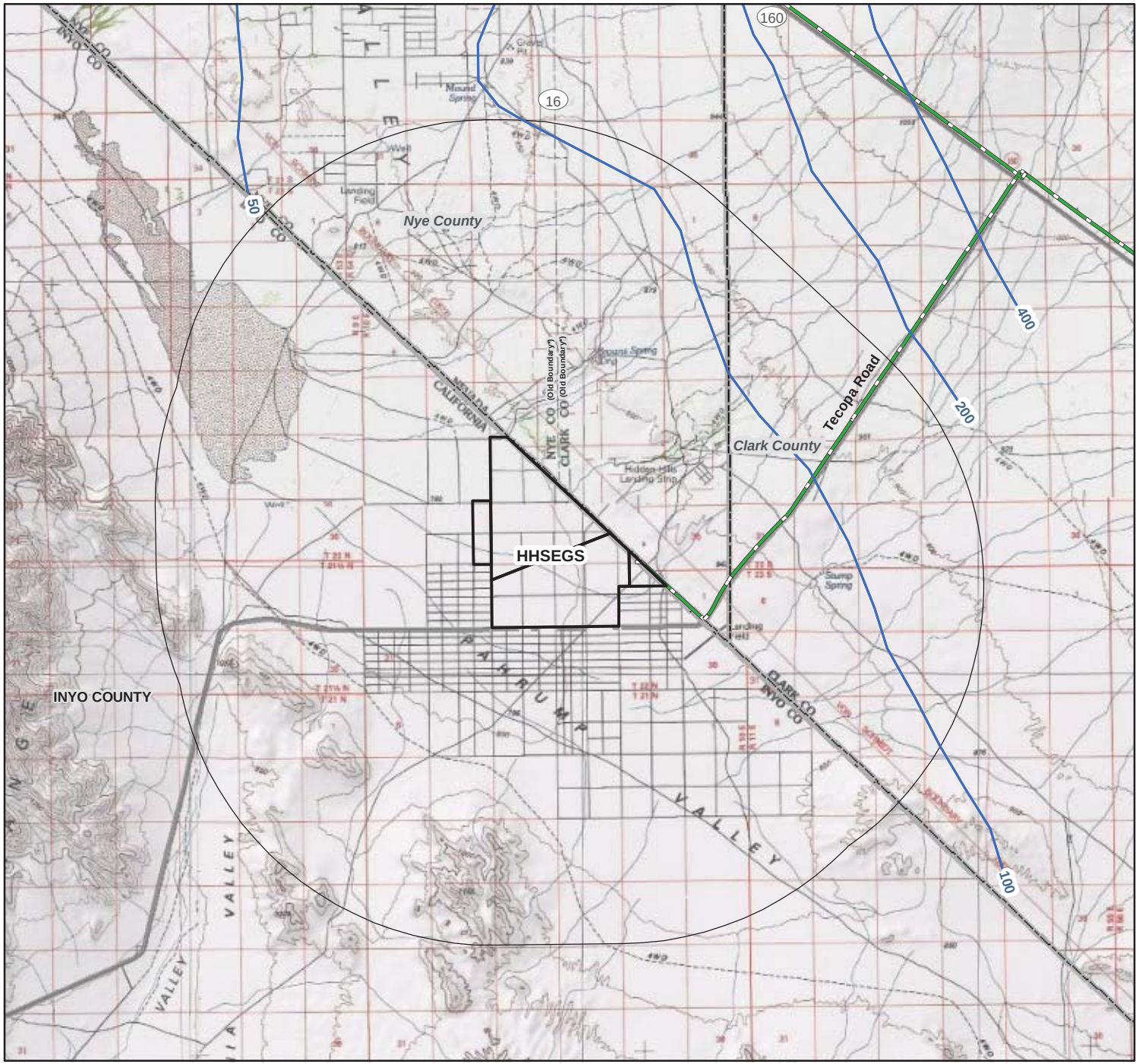
- Ca - Sandstone, dolostone (dolomite)
- Qal - Alluvium, undifferentiated
- QPc - sandstone, conglomerate

Notes:
1. Active Fault Data from: U.S. Geological Survey, 2006
   Geology from: USGS, 2007
2. Geologic Units data from: Nevada Bureau of Mines and Geology, 1997 and US Geologic Survey, California Geological Survey, 2000.

N

0 4,000 8,000
Feet

FIGURE 5.4-1
Geology Within 2 miles of HHSEGS
Hidden Hills Solar Electric Generating System



LEGEND

Name

- Survey Corridor (300ft)

Roads and Trails

- Interstate
- Highway
- Major Road

Groundwater Data

- Groundwater Contours (depth to water, feet bgs)

Project Site Data

- HHSEGS Boundary
- HHSEGS Buffer (5 miles)

*County boundary moved due to annexation, 2001

Notes:
1. Groundwater data courtacy of U.S. Geological Survey, 2006

N

0 6,000 12,000
Feet

FIGURE 5.4-2
Depth to Groundwater
Hidden Hills Solar Electric Generating System