5.4 Geologic Hazards and Resources

5.4.1 Introduction

This section evaluates the effect of geologic hazards and resources that might be encountered during the construction and operation of the Carlsbad Energy Center Project (CECP). The objective of this evaluation is to identify site conditions and the potential impacts from construction and operation and maintenance of the project. This section presents a summary of the relevant laws, ordinances, regulations, and standards (LORS); the existing site conditions; the expected direct, indirect, and cumulative impacts due to construction, operation and maintenance of the project, and proposed mitigation measures. The effectiveness of these mitigation measures and monitoring plans proposed to verify the effectiveness of mitigation are also discussed. In addition, the Applicant's proposed Conditions of Certification are also included.

Section 5.4.2 describes the relevant LORS for geologic hazards and resources. Section 5.4.3 describes the affected environment, including the regional and local geology, seismicity, and hazards. Section 5.4.4 assesses the project's effects, and Section 5.4.5 assesses the project's cumulative effects. Section 5.4.6 provides mitigation measures to reduce significant impacts from geologic hazards and to geologic resources. Section 5.4.7 provides proposed Conditions of Certification, Section 5.4.8 lists relevant agencies, and Section 5.4.9 addresses additional permit requirements. Section 5.4.10 lists the references used in preparing this section.

5.4.2 Laws, Ordinances, Regulations, and Standards

LORS that are applicable 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
Federal			
Uniform Building Code (UBC)	Design criteria for excavations and structures under static and dynamic loading conditions	San Diego County and City of Carlsbad	5.4.2.1
State			
California Building Code (CBC), 2007 as amended by the County of San Diego	Acceptable design criteria for structures with respect to seismic design and load-bearing capacity	California Building Standards Commission, State of California, and County of San Diego	5.4.5.2
Alquist-Priolo Earthquake Fault Zoning Act (Pub. Res. Code §§ 2621 et seq.)	Identifies areas subject to surface rupture from active faults	California Building Standards Commission, State of California, and County of San Diego	5.4.5.1

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

LORS	Requirements/ Applicability	Administering Agency	AFC Section Explaining Conformance
The Seismic Hazards Mapping Act (Pub. Res. Code §§ 2690 et seq.)	Identifies non-surface fault rupture earthquake hazards, including liquefaction and seismically induced landslides	California Building Standards Commission, State of California, and County of San Diego	5.4.5.3.
Local			
City of Carlsbad General Plan	Compliance with the Public Safety Element of the General Plan	City of Carlsbad	5.4.6

5.4.2.1 Federal LORS

Acceptable design criteria for excavations and structures for static and dynamic loading conditions are specified by the Uniform Building Code (1997). The project will comply with the UBC by ensuring that CECP design and construction criteria for Seismic Zone 4.

5.4.2.2 State LORS

5.4.2.2.1 California Building Code

The 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 that CECP design and construction meet the criteria for Seismic Zone 4.

5.4.2.2.2 Alquist-Priolo Earthquake Fault Zoning Act

The main purpose of the Alquist-Priolo Earthquake Fault Zoning Act is to prevent the construction of buildings used for human occupancy on the surface trace of active faults. Although the project is subject to the Alquist-Priolo Earthquake Fault Zoning Act, the project features are not located within areas identified as subject to surface rupture from active faults.

5.4.2.2.3 Seismic Hazards Mapping Act

The purpose of the Seismic Hazards Mapping Act is to ensure public safety from the effects of strong ground shaking, liquefaction, landslides, or other ground failure, and other hazards caused by earthquakes. The project will conform to this Act by conducting an analysis for potential seismic hazards at the CECP site.

5.4.2.3 Local LORS

5.4.2.3.1 City of Carlsbad

The Safety Element of the City's General Plan is intended to protect the public from the effects of natural geologic hazards. According to the City Planning and Building Department, there are no specific local LORS regarding geologic hazards that would be applicable to the proposed activities at the CECP site, other than grading and building permits issued by the Planning and Building Department. The project will conform to the

safety element of the City's General Plan by ensuring that construction complies with CBC seismic zone 4.

5.4.3 Affected Environment

The CECP will be located on an approximately 23-acre site located on the existing Encina Power Station property, in the City of Carlsbad, County of San Diego. The project site and linear facilities are located approximately one-half mile inland from the Pacific Ocean, within the Peninsular Ranges physiographic province of California. The project site is approximately 30 feet above mean sea level, and is relatively flat. The site is underlain by artificial fill, alluvium, and terrace deposits. Southern California has experienced moderate to large earthquakes during the past 50 years or so, but in the Coastal Greater San Diego area, small magnitude earthquakes are more common. The area is designated as a Seismic Zone 4.

5.4.3.1 Regional Geology

The CECP site is located inland of the Pacific Ocean within the Peninsular Ranges physiographic province of southern California. The Peninsular Ranges are characterized as one of the largest geologic units in western North America. They extend from the Transverse Ranges in the Los Angeles area to the tip of Baja, California. The province contains minor Jurassic and extensive Cretaceous igneous rocks primarily as a result of Nevadan plutonism and contains roof rocks that establish continuity of the pre-Nevadan history of the Sierra Nevada (Norris and Webb, 1990).

The geologic structure of southern California is dominated by right-lateral strike-slip faulting with the movement of two tectonic plates. The San Andreas fault system marks the principal boundary between the Pacific plate and the North American plate. Additional faults that affect the geologic structure of the project vicinity include the Newport-Inglewood Fault and the Rose Canyon Fault.

5.4.3.2 Local Geology

The project site and linear facilities are located in an area of fairly flat topography approximately 30 feet above mean sea level (amsl). The project site is on a coastal plain on the edge of the Peninsular Ranges physiographic province of Southern California. The coastal plain area has undergone several episodes of marine inundation and subsequent marine regression during the last 54 million years resulting in the deposition of a thick sequence of marine and non-marine sedimentary rocks on the uplifted and eroded high-relief basement terrain. Accelerated fluvial erosion during periods of heavy rainfall, coupled with the lowering of the base sea level during the quaternary, has resulted in the rolling hills, mesas, and deeply incised valleys that are present in the area (Geo-Logic, 2004).

Artificial fill is present at the project site, along with sandy sediments of the Santiago Formation (Geo-Logic, 2004). The predominant fill soil has been characterized is getorechnical investigations performed at the site as predominantly fine- to medium-grained sand with some silt and clay (Geo-Logic Associates, 2004). Thickness of fill is anticipated to be shallow (less that 10 feet) within the CECP site and along the linear facilities. The lateral limits of this soil unit are not known, as limited boring information is available at this time for the CECP site area (Geo-Logic Associates, 2004).

Figure 5.4-1 is a map of geologic, stratigraphic, and geomorphic units within a 2-mile radius of the CECP site.

5.4.3.3 Stratigraphy

In the vicinity of the project site, recent artificial fill overlies older quaternary marine and non-marine (Paralic) terrace deposits, which overlies the Eocene-aged Santiago Formation basal unit. The geologic units present within the project site area (2-mile radius) are described below with details provided by *Geologic Map of the Oceanside 30'x60' Quadrangle, California***.** (California Geological Survey, 2005).

Quaternary Artificially Compacted Fill – Consists of artificially compacted earth materials derived usually from local sources.

Quaternary Older Paralic deposits, Units 6-7 (late to middle Pleistocene) – Consists of mostly poorly sorted, moderately permeable, reddish-brown, interfingered strandline, beach, estuarine and colluvial deposits composed of siltstone, sandstone, and conglomerate.

Tsa – Santiago Formation (middle Eocene) – Named by Woodring and Popenoe (1945) for Eocene deposits of the northwestern Santa Ana Mountains, there are three distinctive parts to this formation, which includes a basal member consisting of a buff and brownish-gray, massive, coarse-grained, poorly sorted arkosic sandstone, and conglomerate (sandstone generally predominating). In some areas the basal member is overlain by a gray and brownish-gray (salt and pepper) central member that consists of soft, medium-grained, moderately well-sorted arkosic sandstone. An upper member consists of gray, coarse-grained arkosic sandstone and grit. Throughout the formation, both vertically and laterally, there exists greenish-brown, massive claystone interbeds, tongues and lenses of often fossiliferous, lagoonal claystone and siltstone. The lower part of the Santiago Formation interfingers with the Delmar Formation and Torrey Sandstone in the Encinitas quadrangle.

5.4.3.4 Seismicity

The seismicity of the greater San Diego County area has been characterized as a broad scattering of small magnitude earthquakes. Surrounding areas (Imperial Valley, northern Baja, and offshore regions) are typically characterized as having a high rate of moderate to large magnitude earthquakes.

The locations of principal faults relative to the project site are shown on Figure 5.4-2. Two major zones of seismic activity are located within 10 miles of the CECP site and include the offshore portions of the Newport-Inglewood and Rose Canyon fault zones. Both of these fault zones represents a potentially significant seismic hazard to the coastal region. The Rose Canyon fault zone is complex and is comprised of many structurally-related fault segments that have been the location of repeated small magnitude earthquakes. Some sections within this fault zone (approximately 5 miles along the offshore portion west/southwest of the CECP site) exhibit evidence of Holocene displacement (Jennings, 1994). The major fault associated with this zone is the Rose Canyon Fault, which has an estimated maximum magnitude earthquake event of 7.2 (Blake, 2004a). This fault is located approximately 4.5 miles west of the site. Similarly, the Newport Inglewood fault is located approximately 5.6 miles west of the CECP site and has an estimated maximum magnitude earthquake event of 7.1 (Blake, 2004a).

Located approximately 20.6 miles west of the CECP site lies the Coronado Bank Fault Zone. The major fault associated with this zone is the Coronado Bank Fault, which, like the Rose Canyon fault noted above, has exhibited Holocene displacement (Jennings, 1994). This fault has an estimated MCE magnitude of 7.6 (Blake, 2004a).

The CECP site is within Seismic Zone 4 as defined by the 2004 California Building Code. The site is not located within an area designated by the Alquist-Priolo Special Studies Zone Act of 1972 (Jennings 1994, and California Geological Survey, 1999).

5.4.3.5 Geologic Hazards

A geotechnical investigation was previously conducted at the project site by Geo-Logic Associates (2004). In addition, an EIR-level assessment of the geological and geotechnical aspects of the site was prepared and is included as Appendix 5.4A. The scope of these investigations was to assess geotechnical and environmental conditions for a proposed, but not yet constructed, desalination plant on the Encina Power Station property. Data from these investigations have been used to analyze potential geologic hazards in the project area, including linears (Geo-Logic, 2004 and RBF Consulting, 2006).

5.4.3.5.1 Ground Rupture

Ground rupture is caused when an earthquake event along a fault creates rupture at the surface. Since no known faults exist at the project site, the likelihood of ground rupture occurring at the project site and along the linears is low. (Jennings, 1994; Geo-Logic, 2004).

5.4.3.5.2 Seismic Shaking

The most significant geologic hazard at the CECP site is strong ground-shaking due to an earthquake. Ground-shaking of a magnitude 7 earthquake or greater could occur from earthquakes within a 100-mile radius of the site (Blake, 2004a).

The earthquake hazard for a particular site is traditionally quantified using two levels of seismic ground motion:

- **Design Basis Earthquake** (DBE): ground motions associated with a 500-year mean return period or 10 percent probability of exceedance in 50 years.
- **Maximum Credible Earthquake** (MCE): ground motions associated with a 2,500-year mean return period or 2 percent probability of exceedance in 50 years.

Because it is less frequent, the MCE normally represents a larger magnitude of ground shaking than the DBE. The California Building Code is inherently based on a DBE level event, with special provisions to provide for collapse prevention under the MCE.

The controlling fault impacting the CECP site area is the Rose Canyon fault. This fault is capable of generating a peak bedrock acceleration (PBA) along its trace of 0.47g (Blake, 2004a) based on the MCE event. According to the Caltrans Seismic Hazard Map, a PBA of approximately 0.42g at the CECP site and along the linears is estimated based on the MCE event. The DBE PBA ground motion at the site is estimated at 0.27g (Blake, 2004b).

5.4.3.5.3 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. In addition, liquefaction can cause sand boils, ground rupture, and lateral spreading. Based on an assessment during the geotechnical investigation, the overall subsurface profile and the overlying thickness of non-saturated (non-liquefiable soils) indicate that the likelihood for liquefaction to occur at the project site and along the linears is considered low (Geo-Logic, 2004).

5.4.3.5.4 Mass Wasting

Mass wasting is the down-slope movement of rock, regolith, and soil, under the influence of gravity and depends on the steepness of the slope, underlying geology, surface soil strength, and moisture in the soil. Because the CECP site lies in a gently sloping regional area with slight topographic relief and no significant excavation is planned during site construction, the potential for direct impact from mass wasting at the site is considered low.

The City of Carlsbad General Plan Update identifies the site area as not within a slope instability area (City of Carlsbad, 2006). It is anticipated that any minor grading that may occur during CECP construction will not have a significant effect on the mass wasting potential of the site.

5.4.3.5.5 Subsidence

Subsidence can be a natural or man-made phenomenon resulting from tectonic movement, consolidation, hydrocompaction, or rapid sedimentation. Subsidence has not been identified as a geologic hazard at the CECP site (Geo-Logic, 2004). The potential for subsidence as a hazard that could affect the project site is low.

5.4.3.5.6 Expansive Soils

Expansive soils shrink and swell with wetting and drying. The shrink-swell capacity of expansive soils can result in differential movement beneath foundations. Expansive soils has not been identified as a geologic hazard at the project site (Geo-Logic, 2004). The potential for expansive soils as a hazard that could affect the project site is low.

5.4.3.5.7 Tsunami/Seiche

Tsunamis are seismically-induced ocean waves with very long periods. Tsunamis may be manifested in the form of wave bores or a gradual upwelling of sea level and can be caused by landslides or earthquakes. The offshore area of San Diego County contains many faults and fault scarps capable of producing tsunamis, however, seismically induced sea waves are uncommon or rare. In the last 170 years, tsunami wave heights and runup elevations experienced along the San Diego area coastline have fallen within the normal range of tidal fluctuations (approximately 9 feet) (Geo-Logic, 2004). Because the project site is at an elevation of approximately 30 feet amsl and a predicted wave run-up from a 10 percent probability of being exceeded in 50 years event is approximately 11.5 feet amsl (Geo-Logic, 2004), the potential for a significant tsunami event that would affect the CECP site is low.

Seiches are defined as oscillations in confined or semi-confined bodies of water due to earthquake shaking. Since the site lies at an elevation of approximately 30 feet amsl, and a maximum wave run-up from a seismic event is only expected to be 11.5 feet amsl, the

likelihood for a seiche occurring on the adjacent Agua Hedionda Lagoon to impact the CECP site is low.

5.4.3.5.8 Geologic Resources of Recreational, Commercial, or Scientific Value

The City's General Plan and an internet search of the California Geologic Survey website did not identify any known areas of geologic resources of recreational, commercial or scientific value. Therefore, there are no known geologic resources value in the Project vicinity that could be affected.

5.4.3.5.9 Aggregate Resources

The project area is within Mineral Resource Zone 3, which is classified as having unknown aggregate deposits (California Geological Survey, 1996).

5.4.3.5.10 Natural Gas

No oil or gas fields are present in the immediate project vicinity, according to on-line maps from the State of California Division of Oil, Gas and Geothermal Resources (CDOGGR, 2007).

5.4.4 Environmental Analysis

5.4.4.1 Project Site

5.4.4.1.1 Geologic Hazards

As discussed in Section 5.4.3, ground-shaking presents the most significant geologic hazard to the CECP site and the project's linear facilities. Figure 5.4-3 shows the CECP plot plan and the project's linear facilities. All other potential geologic hazards are considered to be low, based on the technical studies and analysis presented in section 5.4.3. Table 5.4-2 summarizes the potentially significant geologic hazards that have a moderate to high potential to occur at the CECP site and along the project's linear facilities.

TABLE 5.4-2
Summary of Potential Geologic Hazards

Project Component	Area of Potential Concern	Geologic Hazards of Potential Concern
Project Site (23-acres)	Entire site	Seismic ground-shaking
Linear Facilities	On and offsite locations of linear facilities	Seismic ground-shaking

5.4.4.1.2 Geologic Conditions and Topography

CECP construction will require minor grading and excavation, thereby altering the terrain of the CECP site, areas of the Encina Power Station property used for construction laydown, and along the route of the project's offsite linear facilities. Impacts on geologic conditions involve changes in drainage, cuts, and fills. Since the CECP site is generally level, site grading during construction and operations and maintenance are not expected to adversely impact the geologic environment.

5.4.4.2 Linear Facilities

Linear facilities associated with the CECP site include a natural gas line, potable water line, sewer line, reclaimed water line, and electrical transmission lines as shown on Figure 5.4-3.

The geologic hazards associated with the project's linear facilities are summarized in Table 5.4-2.

Seismically induced ground-shaking presents a possible hazard to the project's linear facilities. This hazard could cause pipeline rupture and transmission line impacts. With implementation of the mitigation measures proposed in Section 5.4.6, the hazards will be reduced to less than significant.

5.4.4.3 Geologic Resources of Recreational, Commercial, and Scientific Value

There are no known geologic resources of recreational, commercial, or scientific value in the vicinity of the site. Therefore, the CECP will not affect any geologic resources.

5.4.5 Cumulative Effects

A cumulative impact 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 (Pub. Res. Code § 21083; 14 Cal. Code Regs., §§ 15064(h), 15065(c), 15130, and 15355).

As described above, the CECP will not affect geologic resources, and thus would not contribute to a cumulative impact when considered in combination with other projects. As described below, mitigation measures have been identified to reduce impacts from geologic hazards. With implementation of these measures, the CECP will not result in adverse impacts related to geologic hazards. Therefore, the project will 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 describes project design features that will be used to reduce impacts from geologic hazards.

5.4.6.1 Ground Rupture

No active faults cross the CECP site, nor are active faults located in the vicinity of the site, with the closest fault located approximately 4.5 miles west of the site (Blake, 2004a). Therefore, no design measures are required to reduce the hazard from surface faulting rupture.

5.4.6.2 Ground-Shaking

The CECP generating facility and associated linear facilities will be designed and constructed to withstand strong earthquake-shaking as specified in the 2007 CBC for Seismic Zone 4. Construction to this standard will minimize impacts to the project from design-basis earthquakes, and will be protective of life and property.

5.4.6.3 Liquefaction

The soil types present at the CECP site are not conducive to liquefaction. As a result, no design measures are required.

5.4.6.4 Mass Wasting

The project site area has not been identified to be in an area with potential for mass wasting to occur. Therefore, no design measures are required.

5.4.6.5 Subsidence

Subsidence have not been identified to have occurred in the project vicinity, and as a result, no design measures are required.

5.4.6.6 Expansive Soils

Expansive soils has not been identified as a project hazard, and as a result, no design measures are required.

5.4.6.7 Tsunami/Seiche

Since the project site lies at an elevation above the highest anticipated tsunami wave run-up height, no design measures are required.

5.4.7 Proposed Conditions of Certification

While the potential impact of geologic hazards and to geologic resources impact, resulting from the CECP, is less than significant, the following conditions of certification are proposed for the CECP by the Applicant to ensure that such impacts remain below the level of significance:

GEO-1: Prior to the start of construction, the Applicant shall assign to the project an engineering geologist(s) and a geotechnical engineer(s) certified by the State of California, to carry out the duties required by the 2001 edition of the CBC Appendix Chapter 33, Section 3309.4. The certified engineering geologist(s) and geotechnical engineer(s) assigned must be approved by the Chief Building Official (CBO) and their resumes submitted to the Compliance Project Manager (CPM) for concurrence.

Verification: At least 30 days (or a lesser number of days mutually agreed to by the Applicant and the CPM) prior to the start of construction, the Applicant shall submit to the CBO for approval the resume and license number(s) of the certified engineering geologist(s) and geotechnical engineer(s) assigned to the project. The submittal should include a statement that CPM concurrence is needed. The CBO and CPM will approve or disapprove of the engineering geologist(s) and geotechnical engineer(s) and will notify the Applicant of its findings within 15 days of receipt of the submittal. If the engineering geologist(s) and geotechnical engineer(s) are subsequently replaced, the Applicant shall submit for approval the resume(s) and license number(s) of the newly assigned individual(s) to the CBO and CPM. The CBO and CPM will approve or disapprove of the engineering geologist(s) and geotechnical engineer(s) and will notify the Applicant of the findings within 15 days of receipt of the notice of personnel change.

GEO-2: The assigned engineering geologist(s) shall carry out the duties required by the 1998 CBC, Appendix Chapter 33, Section 3309.4 Engineered Grading Requirements, and Section 3318.1 Final Reports. Those duties are:

- Prepare an Engineering Geology Report. This report shall accompany the Plans and Specifications when applying to the CBO for the grading permit.
- Monitor geologic conditions during construction.
- Prepare a Final Engineering Geology Report.

  The Engineering Geology Report required by the 1998 CBC Appendix Chapter 33, Section 3309.3 Grading Designation, shall include an adequate description of the geology of the site, conclusions, and recommendations regarding the effect of geologic conditions on the proposed development, and an opinion on the adequacy of the site for the intended use as affected by geologic factors.

  The Final Engineering Geology Report to be completed after completion of grading, as required by the 1998 CBC Appendix Chapter 33, Section 3318.1, shall contain the following: A final description of the geology of the site and any new information disclosed during grading and the effect of same on recommendations incorporated in the approved grading plan. The engineering geologist shall submit a statement that, to the best of his or her knowledge, the work within their area of responsibility is in accordance with the approved Engineering Geology Report and applicable provisions of this chapter.

Verification:

1. Within 15 days after submittal of the application(s) for grading permit(s) to the CBO, the Applicant shall submit a signed statement to the CPM stating that the Engineering Geology Report has been submitted to the CBO as a supplement to the plans and specifications and that the recommendations contained in the report are incorporated into the plans and specifications.
2. Within 90 days following completion of the final grading, the Applicant shall submit copies of the Final Engineering Geology Report required by the 1998 CBC Appendix Chapter 33, Section 3318 Completion of Work, to the CBO and to the CPM.

5.4.8 Involved Agencies and Agency Contacts

Compliance of building construction to CBC standards for compliance with the geological LORS are covered under engineering and construction permits for the project that are within the exclusive jurisdiction of the CEC. There are no local permit requirements that specifically address geologic resources and hazards. The City of Carlsbad will ensure that construction of the project meets building engineering standards defined in the CBC. Table 5.4-3 lists the agency contact for geologic hazards and resources.

TABLE 5.4-3
Agency Contact for Geologic Hazards and Resources

Permit or Approval	Agency Contact	Applicability
Approval of Engineering and Grading Plan	John O'Donnell, Senior Civil Engineer Carlsbad Engineering Department 1635 Faraday Avenue Carlsbad, CA 92008 (760) 602-2720 jodon@ci.carlsbad.ca.us	Grading of site Report approval required as part of grading permit

5.4.9 Permits Required and Permit Schedule

Ensuring the project's compliance with CBC standards is within the exclusive jurisdiction of the CEC. There are no additional engineering or construction permits, which the Applicant needs to obtain to comply with LORS applicable to geologic resources and hazards.

5.4.10 References

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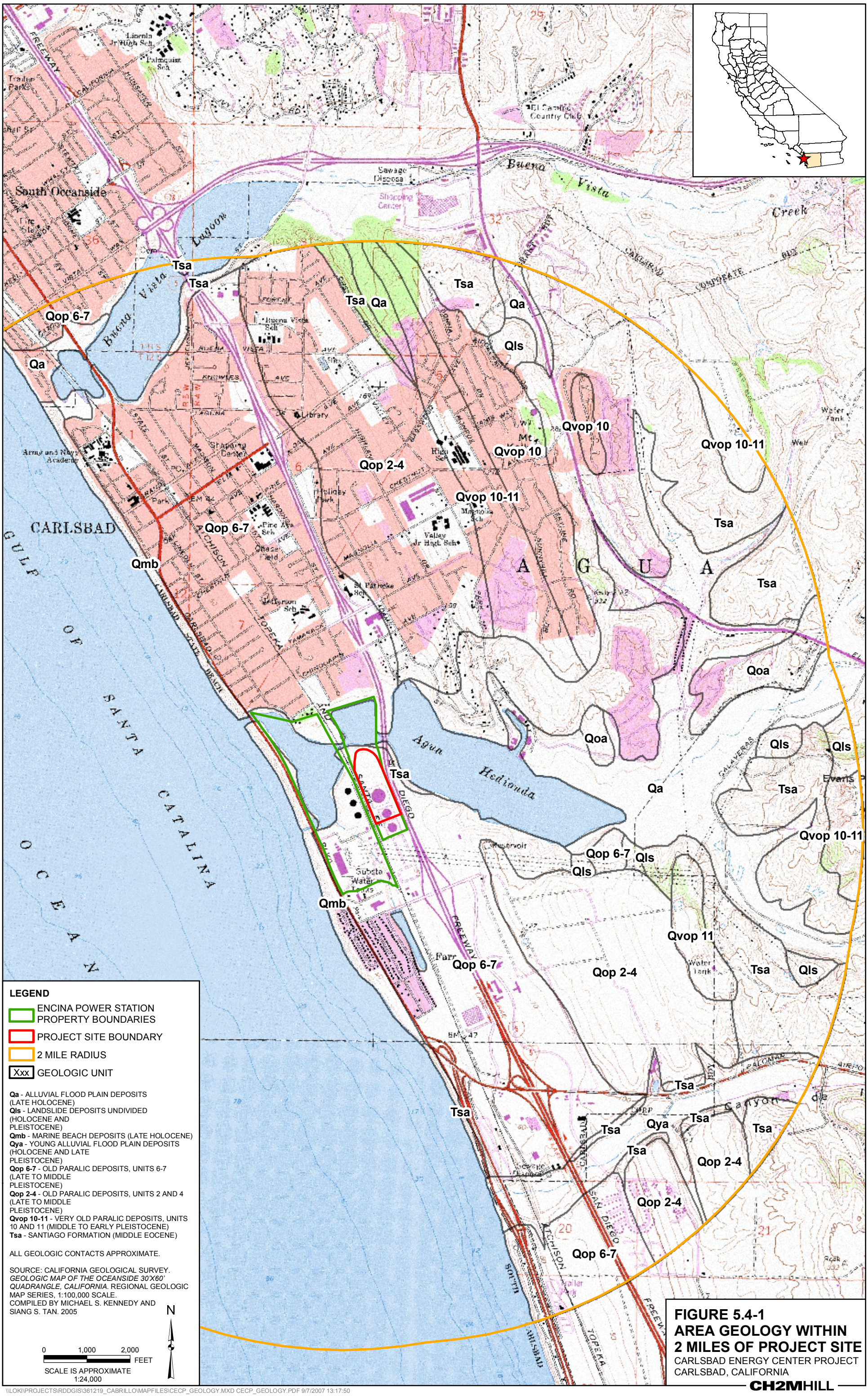

FIGURE 5.4-1
AREA GEOLOGY WITHIN 2 MILES OF PROJECT SITE
CARLSBAD ENERGY CENTER PROJECT
CARLSBAD, CALIFORNIA

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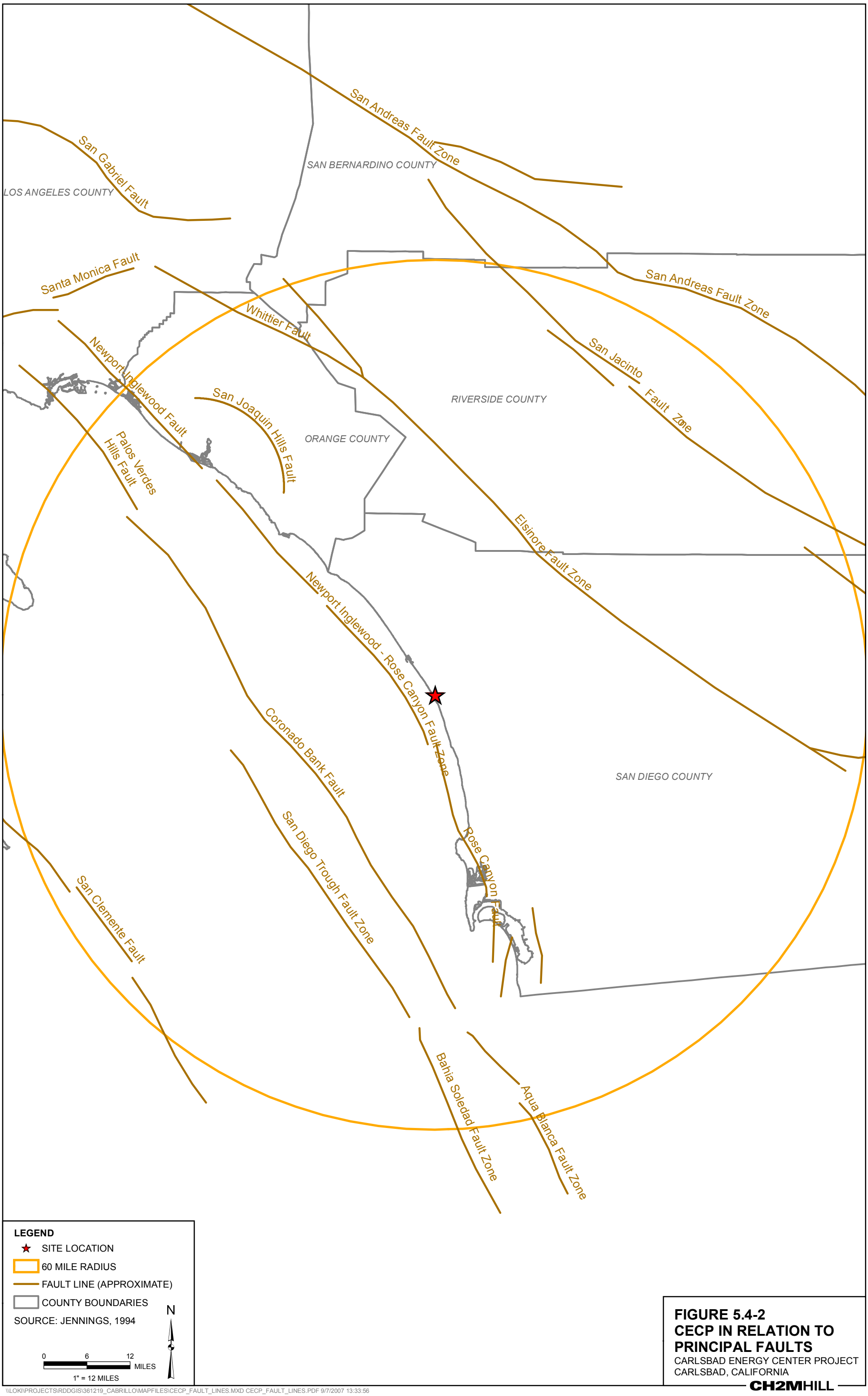

FIGURE 5.4-2
CECP IN RELATION TO PRINCIPAL FAULTS
CARLSBAD ENERGY CENTER PROJECT
CARLSBAD, CALIFORNIA

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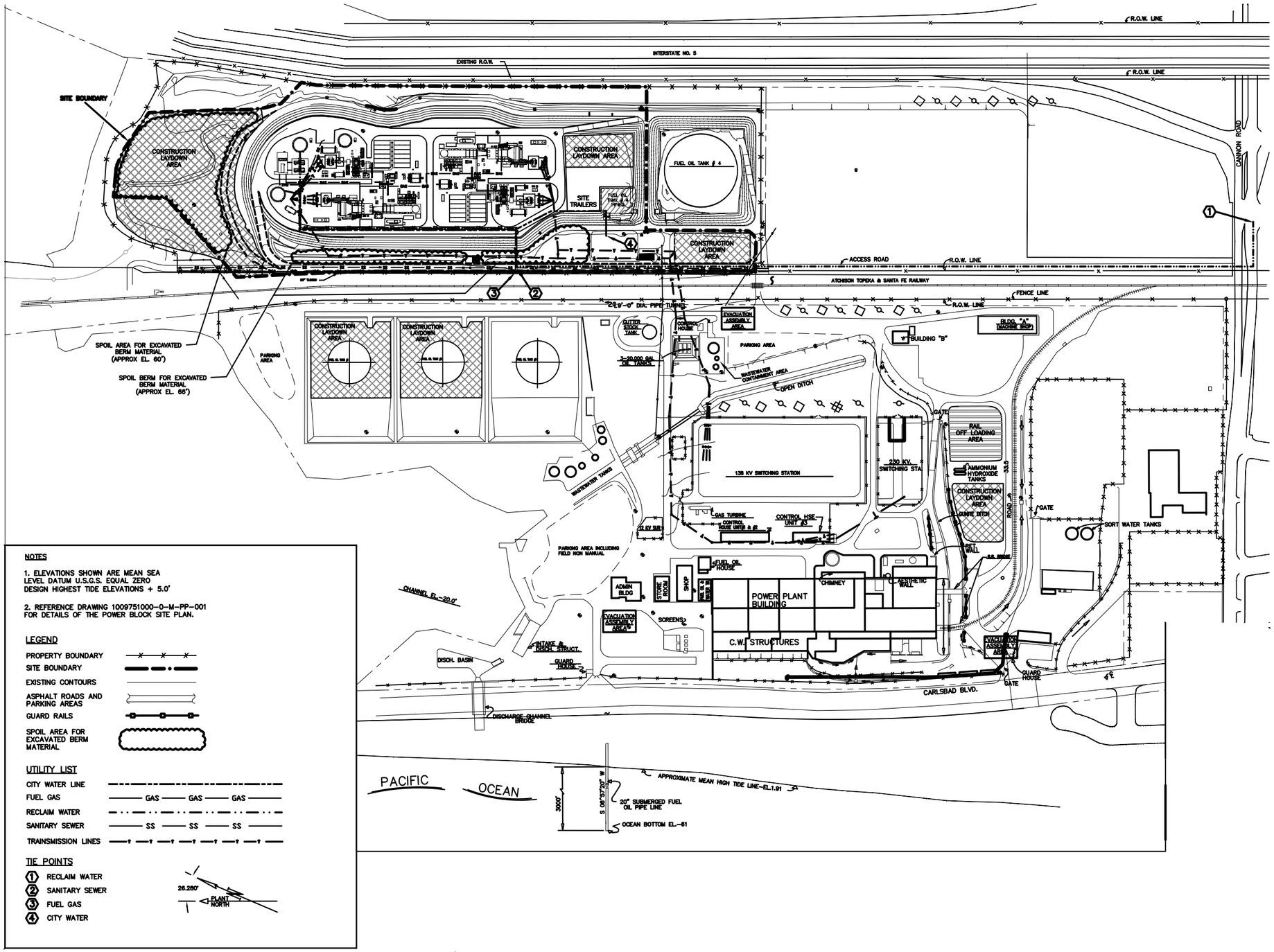

Source: Shaw Stone & Webster, Inc.

FIGURE 5.4-3
CECP PLOT PLAN
CARLSBAD ENERGY CENTER PROJECT
CARLSBAD, CALIFORNIA

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