5.4 Geologic Hazards and Resources

This section evaluates the geologic hazards and resources at the Lodi Energy Center (LEC) project site. Section 5.4.1 describes the existing environment that could be affected, including regional and local geology and geologic hazards. Section 5.4.2 identifies potential environmental effects from project development. Section 5.4.3 discusses potential cumulative effects. Section 5.4.4 discusses possible mitigation measures. Section 5.4.5 presents the laws, ordinances, regulations, and standards (LORS) applicable to geologic hazards and resources. Section 5.4.6 provides agency contacts. Section 5.4.7 describes the required permits. Section 5.4.8 provides the references used to develop this section.

5.4.1 Affected Environment

The LEC site is a 4.4-acre parcel off of North Thornton Road on land owned and incorporated by the City of Lodi southwest of the intersection of Highway 12 and Interstate 5, at the end of North Cord Road. The site is relatively flat and gently slopes to the west.

5.4.1.1 Regional Geology

The project area is situated in the Great Valley Geomorphic Province. The Great Valley and the adjacent Sierra Nevada to the east form a relatively stable crustal block (Sierran block) composed of Mesozoic crystalline basement that dips gently to the west. The western edge of the Sierra Nevada block, beneath the sediments of the Great Valley, may be coincident with the western margin of the Great Valley (Anderson, 1943).

The Great Valley physiographic province separates the Coast Ranges to the west from the Sierra Nevada to the east. This province is composed of two elongated northwest- to southeast-trending basins: the Sacramento basin to the northwest and the San Joaquin basin to the southeast. The present-day basin evolved from a late Jurassic to middle Tertiary (40-150 million years ago) marine fore-arc basin. In the late Tertiary (25–30 million years ago), a change in the relative motion between the Pacific and North American plates resulted in the gradual uplift of the Coast Ranges and the eventual isolation of the basin from the ocean. More recent Miocene and lower Pliocene sediments were derived from the neighboring Coast Ranges and the Sierra Nevada. By the late Pliocene (2–3 million years ago), subaerial depositional conditions prevailed and Sierra Nevada–derived sediments were deposited in the basins (Olmsted & Davis, 1961).

5.4.1.2 Local Geology

The project site is in an area of relatively flat topography typical of the Central Valley. The surficial geology within a 2-mile radius of the site is shown on Figure 5.4-1. The geologic units that are present within this 2-mile area are described below with details provided by *Preliminary Geologic Map Showing Quaternary Deposits of the Lodi, California Quadrangle, Open File Report 79-933* (USGS, 1979). Near-surface sediments in the area of the site have been deposited primarily from the Sacramento, Mokelumne, and San Joaquin river systems. The LEC project site is on the eastern edge of the Sacramento-San Joaquin River Delta (Delta). Groundwater at the site has been detected at a depth of approximately 10 feet below ground surface (Carlton, 2008).

Quaternary Modesto (Qm) Formation deposits —These deposits consist of undifferentiated alluvial deposits, mainly arkosic, forming a toe of Mokelumne alluvial fan, generally covered by Holocene intertidal deposits.

Quaternary Modesto upper member (Qm2) Formation deposits —These deposits consist of arkosic alluvium deposits, forming Mokelumne River alluvial fan; chiefly sand. Becomes finer-grained toward fan toe.

Quaternary Modesto lower member (Qm1) Formation deposits —These deposits consist of arkosic alluvium deposits, forming Mokelumne River alluvial fan; chiefly sand.

5.4.1.3 Project Site Stratigraphy

The LEC site is underlain by a fairly complete stratigraphic section of Createaceous, Tertiary and Quaternary deposits. The sediments deposited prior to mid-Tertiary time were in a marine environment. Changes in sea level, valley filling, and uplift resulted in the deposition of continental sediments after Mid-Tertiary time (Kleinfelder, 1993).

5.4.1.4 Seismic Setting

The project site is in central California and within the Coast Ranges-Sierran Block Basement Zone. The modern tectonic setting of central California is dominated largely by the transform plate boundary contact between the Pacific and North American plates south of the Mendocino triple junction. The Pacific plate is slipping in a north-northwest direction (N35°W to N38°W) at a rate of about 1.81 to 1.95 inches per year (46 to 47 millimeters per year) with respect to the North American plate. Right-lateral strike-slip displacement along the major branches of the San Andreas fault system accommodates most of this plate motion, with the remainder generating Holocene tectonism and seismicity at the western continental margin and to the east in the Sierra Nevada and Basin and Range Provinces.

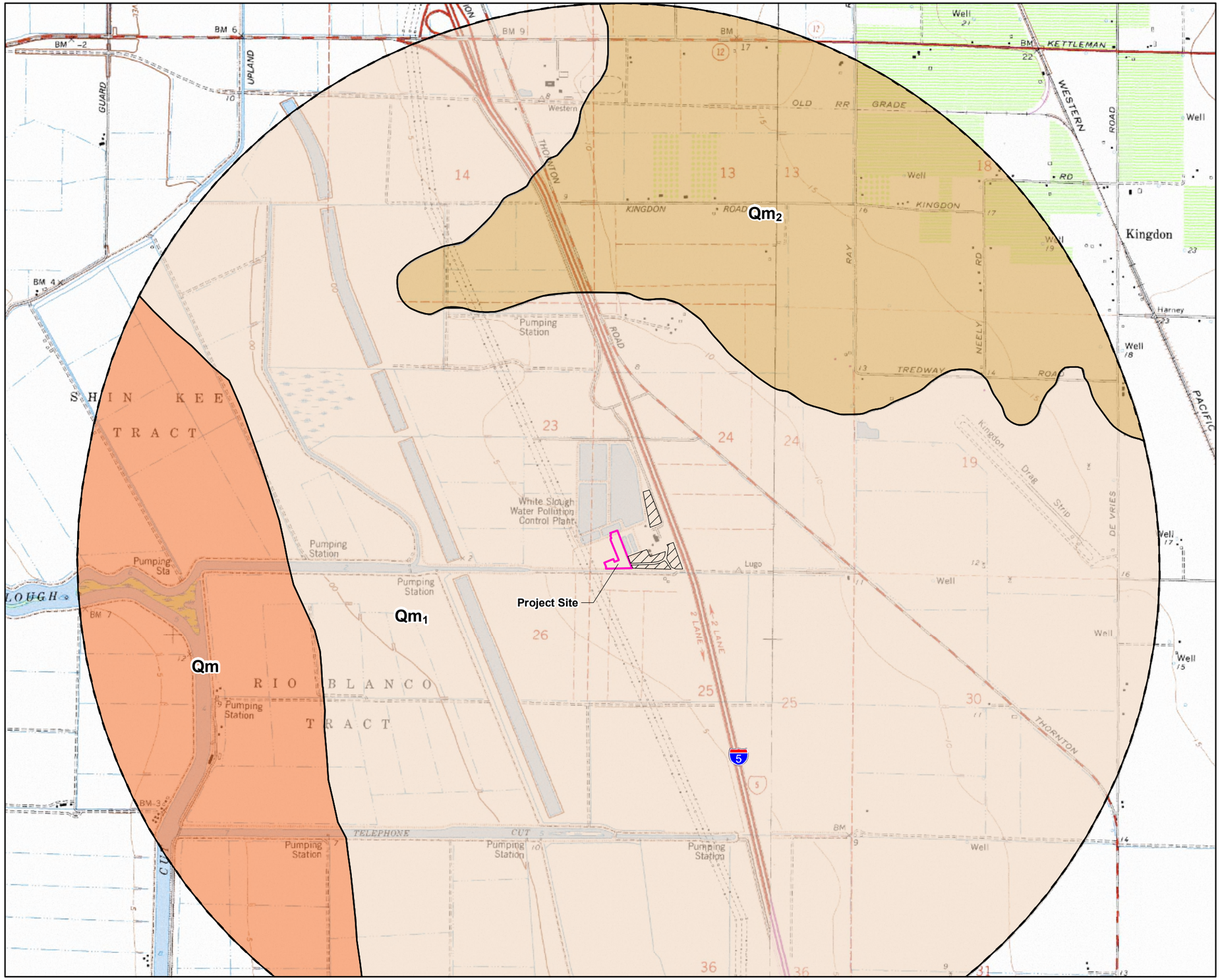
The seismicity of the project site area can be characterized as an area of potentially large-magnitude earthquakes. Active faults within 30 miles of the LEC site include the Segments 5 and 7 of the Great Valley, and Greenville. These faults are capable of generating maximum credible earthquake (MCE) moment magnitudes up to 7.3 (Blake, 2004). These fault zones represent a significant seismic hazard to the project site. No faults have been mapped crossing the project site and the site is not within an Alquist-Priolo Special Studies Zone (CGS, 2007). The locations of principal faults relative to the project site are shown on Figure 5.4-2.

5.4.1.5 Potential Geologic Hazards

The following subsections discuss the potential geologic hazards that might occur in the project area.

5.4.1.5.1 Ground Rupture

Ground rupture is caused when an earthquake event along a fault creates rupture at the surface. Since no known active faults cross the project site, the likelihood of ground rupture to occur is considered low.



LEGEND

- Proposed Lay Down and/or Parking
- Proposed Plant Site
- Two Mile Buffer
- Geologic contact (approximate)

Geology Type

- Qm1- Quaternary Modesto Formation
- Qm2 - Lower member
- Qm - Upper member

Notes:
1. Source: Perliminary Geologic Map Showing Quaternary Deposit fo Lodi Quadrangle, California. USGS OFR 79-932. D.E. Marchard and B.F. Atwater, 1979.

This map was compiled from various scale source data and maps and is intended for use as only an approximate representation of actual locations.

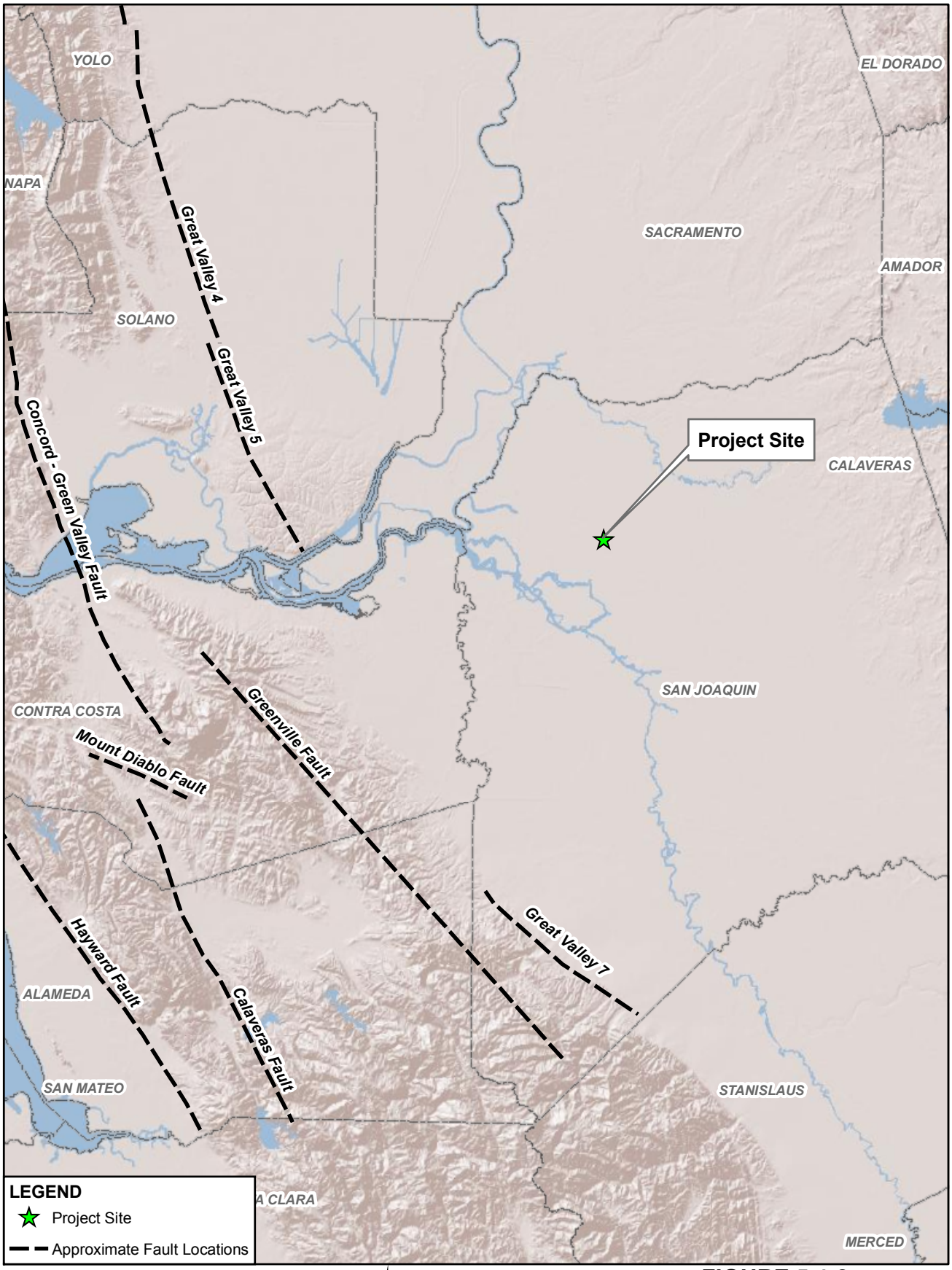
N

0 1,200 2,400
Feet

FIGURE 5.4-1
GEOLOGY WITHIN TWO MILES OF SITE
LODI ENERGY CENTER
LODI, CALIFORNIA

CH2MHILL

SAC\\ZION\SACGIS\PROJ\LODIENERGYCENTER_371322\MAPFILES\GEOLOGYTYPE.MXD MHASKELL 6/25/2008 17:10:27



Notes:
1. Source: Blake, 2004.

This map was compiled from various scale source data and maps and is intended for use as only an approximate representation of actual locations.

N

0 5 10
Miles

FIGURE 5.4-2
LEC IN RELATION TO PRINCIPAL FAULTS
LODI ENERGY CENTER
LODI, CALIFORNIA

CH2MHILL

SAC\\ZION\SACGIS\PROJ\LODIENERGYCENTER_371322\MAPFILES\FAULTS.MXD MHASKELL 6/25/2008 16:36:05

5.4.1.5.2 Seismic Shaking

The project area has experienced seismic activity with strong ground motion during past earthquakes, and it is likely that strong earthquakes causing seismic shaking will occur in the future. The significant geologic hazard at the LEC site is strong ground shaking due to an earthquake. Ground shaking from a magnitude 7.3 earthquake could occur within approximately 50 mile radius of the site (Blake, 2004).

The controlling fault for the LEC site is Segment 5 of the Great Valley Fault, located approximately 20 miles west of the site. This is a reverse-type fault dipping approximately 15 degrees west with a slip rate of approximately 1.5 millimeters per year (CGS, 2002) and is capable of generating a peak bedrock acceleration (PBA) at the site of 0.11g (Blake, 2004) based on the MCE event. Other faults within a 50-mile radius of the LEC site are capable of generating a PBA range of 0.04g to 0.10g (Blake, 2004). These PBA estimates are based on assuming an attenuation relationship by Boore et al (1997) for a rock outcrop.

5.4.1.5.3 Liquefaction

During strong ground earthquake, loose, saturated, cohesionless soils can experience a temporary loss of shear strength and act as a fluid. This phenomenon is known as liquefaction. Liquefaction is dependent on the depth to groundwater, 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. The static groundwater depth at the time of a recent geotechnical feasibility study conducted by Carlton Engineering, Inc. (Carlton, 2008) was approximately 10 feet below ground surface at the project site. A copy of the geotechnical report is provided in Appendix 2C. The soil units below groundwater consist of isolated pockets of loose, near-surface, sandy soils. Therefore, the likelihood that liquefaction will occur is considered moderate.

5.4.1.5.4 Mass Wasting

Mass wasting depends on steepness of the slope, underlying geology, surface soil strength, and moisture in the soil. Significant excavating, grading, or fill work during construction might introduce mass wasting hazards at the project site. Because the site is relatively flat and no significant excavation is planned during site construction, the potential for direct impact from mass wasting at the site is considered low to negligible.

5.4.1.5.5 Subsidence

Subsidence can be a natural or man-made phenomenon resulting from tectonic movement, consolidation, fluid removal (oil, gas, or water), or rapid sedimentation or oxidation of organic-rich soil. The Delta has had a history of subsidence, but the majority of the Delta's subsidence has been on the west end where subsidence greater than 15 feet has been noted (USGS, 2000). On the eastern end of the Delta, subsidence is typically less (0 to 10 feet range) (USGS, 2000).

At the LEC site, organic soils with significant collapse potential were not encountered during the geotechnical feasibility study of the site (Carlton, 2008). Also, subsidence has not been identified as a geologic hazard at the site according to the seismic and geological hazards section of the San Joaquin County General Plan. (San Joaquin, 1992). The potential for subsidence as a hazard that could affect the project site is considered low.

5.4.1.5.6 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. According to the San Joaquin County General Plan, the project site lies in an area mapped where the potential for expansive soils to be present is high (San Joaquin County, 1992). The recent geotechnical feasibility study also indicated that expansive soils may be present at the site (Carlton, 2008).

5.4.1.5.7 Flooding

The Federal Emergency Management Agency (FEMA) maintains a collection of flood insurance rate maps, which cover the entire United States. These maps identify those areas that may be subjected to 100-year floods. Based on review of the map for the LEC site (map ID 0602990260C), the project site lies with the mapped 100-year flood plain (FEMA, 2008). The potential for a 100-year flood event to impact the site is medium to high. Although the LEC project area is protected by levees, many of the Delta levees were crudely constructed, are potentially unstable, and may fail during severe storms or during a significant seismic event. Delta levees as a whole are currently being evaluated by the State of California and the U.S. Army Corps of Engineers.

5.4.1.6 Geologic Resources of Recreational, Commercial, or Scientific Value

There are no known geologic resources that provide a significant scientific or recreational value near the site. According to online maps of the State of California Division of Oil, Gas and Geothermal Resources (CDOGGR, 2008), the LEC is in an area where oil and gas exploration has occurred. Gas fields of potential value are present within 5 miles of the project site. Although several wells have been drilled within 2 miles of the LEC, most were labeled as "plugged and abandoned – dry hole" according to the CDOGGR maps. The nearest known active gas field is the King Island Gas field, approximately 2 miles to the west-southwest. One active well, "Piacentine" was identified. The Lodi Airport Gas field, approximately 2.5 miles to the southeast, is present, but this field contains no completed wells. The abandoned Harte Gas field is approximately 3 miles to the south-southwest.

5.4.2 Environmental Analysis

The potential environmental effects from construction and operation of the LEC on geologic resources and risks to life and property from geologic hazards are presented in the following sections.

5.4.2.1 Significance Criteria

According to Appendix G of the California Environmental Quality Act statues, the project would have a significant environmental impact in terms of geologic hazards and resources if it would do the following:

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:
  - Rupture of a known earthquake fault (Alquist-Priolo Fault Zone)
  - Strong seismic ground shaking
  - Seismic-related ground failure, including liquefaction

- Be located on a geologic unit or soil that is unstable or that would become unstable as a result of the project, and potentially result in on- or offsite landslide, lateral spreading, subsidence, liquefaction, or collapse
- Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state
- 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

5.4.2.2 Geologic Hazards

There is significant potential for seismic ground shaking to affect the project site in the event of a large-magnitude earthquake occurring on fault segments near the project. The project, however, is not located within an Alquist-Priolo Earthquake Fault Zone or within the trace of any known active fault. The project would thus not be likely to cause direct human exposure to ground rupture. Seismic and expansive soils risks will be minimized by conformance with the recommended seismic design and building criteria of the 2007 California Building Code (CBC). In addition, as stated previously, the probability of mass wasting or subsidence occurring at the project site is low.

The project structures, equipment, and natural gas compressor station will be designed in accordance with CBC, County of San Joaquin, and City of Lodi requirements. Compliance with the CBC seismic requirements will minimize the exposure of people to the risks associated with large seismic events. In addition, major structures will be designed to withstand the strong ground motion of an MCE event that is used for evaluating the earthquake resistance of a particular structure.

5.4.2.3 Geologic Resources

There are no known geologic resources of recreational or scientific value at the project site or in the project vicinity. There are known gas extraction facilities near the LEC site. However, the project would not have an effect on gas production or on other geologic resources of commercial value or on the availability of such resources.

5.4.3 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 (Public Resources Code § 21083; California Code of Regulations, title 14, § 15064(h), 15065(c), 15130, and 15355).

In July 2008, 21 projects were in various stages of progress with the City of Lodi. Most of these projects are zoned residential, with a few office, mixed use, institutional, commercial, and industrial projects proposed. All of these projects are more than 4 miles from the proposed project, except for the improvements at the White Slough WPCF (Draft EIR issued March 28, 2008), which is adjacent to the project site (Bereket, 2008; City of Lodi, 2008).

In July 2008, 72 projects[1] were being processed with the San Joaquin County Building Department. These projects were located in Acampo, Escalon, Farmington, French Camp, Linden, Lodi, Lockeford, Manteca, Ripon, Stockton, and Tracy. The types of projects included residential projects such as new residences, additions and remodels to existing residences, mobile home renovations, and pool construction; commercial projects such as administration buildings, barns, and a riding arena; light industrial projects such as storage buildings, spray booths, and warehouses; office projects such as building conversions and tenant improvements; and institutional projects such as classroom relocation and facilities to house animals (Raborn, 2008).

Because the LEC is a permitted use at the proposed site and would not result in significant adverse impacts that cannot be mitigated, and because the LEC's location is removed from the city limits (the site is 6 miles from Lodi's city center), impacts from the LEC would not likely combine with those from the projects being processed in the city limits to result in cumulative significant impacts.

As described above, the LEC will not cause any adverse impacts to geological resources and will not cause an exposure of people or property to geological hazards. There are no minor impacts, in addition, that could combine cumulatively with those of other projects.

5.4.4 Mitigation Measures

The following mitigation measures are proposed for the project:

- Structures will be designed to meet seismic requirements of the 2007 CBC. Moreover, the design of plant structures and equipment will be in accordance with CBC Seismic requirements to withstand the ground motion of an MCE event. In addition, special design considerations will be made for proposed facilities, if warranted, by the findings from any geotechnical investigation that will be conducted prior to construction.
- A geotechnical engineer will be assigned to the project to carry out the duties required by the California Energy Commission (CEC) to assess geologic conditions during construction and approve actual mitigation measures used to protect the facility from geologic hazards.
- If expansive soils are identified at the site, they can be mitigated by either removal or replacement with non-expansive soil or by blending with non-expansive soil under the supervision and direction of a geotechnical engineer.

With the implementation of these mitigation measures, the LEC will not result in significant direct, indirect, or cumulative geology-related impacts.

5.4.5 Laws, Ordinances, Regulations, and Standards

The LORS that may apply to geologic resources and hazards are summarized in Table 5.4-1. The local LORS discussed in this section are certain ordinances, plans, or policies of the San Joaquin County and the City of Lodi.

[1] For the purposes of this discussion, San Joaquin County sorted its projects by project cost, and provided a list of the projects costing $25,000 or more.

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

LORS	Requirements/ Applicability	Administering Agency	AFC Section Explaining Conformance
State/Local			
CBC, 2007 as amended by San Joaquin County and the City of Lodi	Acceptable design criteria for structures with respect to seismic design and load-bearing capacity	California Building Standards Commission, State of California, County of San Joaquin, and the City of Lodi	Section 5.4.2.2
Alquist-Priolo Earthquake Fault Zoning Act (Title 14, Division 2, Chapter 8, Subchapter 1, Article 3, California Code of Regulations)	Identifies areas subject to surface rupture from active faults	California Building Standards Commission, State of California, County of San Joaquin, and the City of Lodi	Section 5.4.2.2
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, County of San Joaquin, and the City of Lodi	Section 5.4.2.2
County of San Joaquin (1992)	Compliance of the Safety Element of the General Plan, County of San Joaquin General Plan	County of San Joaquin	Section 5.4.2.2
City of Lodi (1991)	Compliance of the Safety Element of the General Plan, City of Lodi General Plan	City of Lodi	Section 5.4.2.2

5.4.6 Agencies and Agency Contacts

Compliance of building construction with CBC standards is covered 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 and will be included in the overall project construction permit (see Section 5.6, Land Use).

5.4.7 Permits and Permit Schedule

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

5.4.8 References

Anderson, F.M. 1943. *Synopsis of Later Mesozoic in California*, California Division of Mines Bulletin 118, p. 183-186.

Bereket, Immanual/City of Lodi Community Development Department, Junior Planner. 2008. Personal communication with Wendy Haydon/CH2M HILL. July 8.

Blake, T.F. 2004. EQSEARCH, A Computer Program for the Estimation of Peak Acceleration from California Earthquake Catalogs.

Boore, D.M., W.B. Joyner, and T.E. Fumal. 1997. Equations for Estimating Horizontal Response Spectra and Peak Acceleration from Western North American Earthquakes: A Summary of Recent Work, Seismological Research Letters. Vol. 68, No 1.

California Building Standards Commission. 2007 California Building Code, California Code of Regulations, Based on 2007 Uniform Building Code.

California Department of Transportation (Caltrans). 1996, errata 2004, 2006. California Seismic Hazard Map, Office of Earthquake Engineering.

California Division of Oil, Gas, and Geothermal Resources (CDOGGR). 2008. Oil and Gas Field Maps. http://www.consrv.ca.gov/dog/. Online search for oil and gas fields.

California Geological Survey (CGS). 2002. *California Fault Model. Modified for use with FRISKSP and EQFAULT).* California Department of Conservation.

California Geological Survey (CGS). 2007. *Special Publication 42 (Interim Revision 2007). Fault-Rupture Hazard Zones in California. Alquist-Priolo Earthquake Fault Zoning Act*. California Department of Conservation.

Carlton Engineering, Inc. (Carlton). 2008. Geotechnical Feasibility Study for the Proposed Lodi Energy Center Property. Lodi, San Joaquin County, CA. July.

City of Lodi. 1991. *Health and Safety Element of the General Plan*.

City of Lodi. 2008. Lodi Environmental Impact Reports – Current Projects and Recent Projects. http:www.lodi.gov/com_dev/EIRs.html. Accessed on July 16, 2008.

Federal Emergency Response Agency (FEMA). 2008. Flood insurance maps. http://www.fema.gov/hazard/map/index.shtm#flood. Online search and review of Lodi CA area, flood map ID 0602990260C.

Kleinfelder. 1993. *Geotechnical Investigation, Proposed Combustion Turbine Project No. 1*. Lodi, California. February.

Olmsted, F.H. and G.H. Davis. 1961. *Geologic Features and Ground-Water Storage Capacity of Sacramento Valley California.* Geologic Survey Water-Supply Paper 1497.

Raborn, Carla/San Joaquin County. 2008. Personal communication with Wendy Haydon/CH2M HILL regarding an 18-month list of development projects located within the County on July 16 and 29, and August 1 and 11.

San Joaquin County. 1992. *San Joaquin County General Plan 2010. Chapter III.A - Seismic and Geologic Hazards*. December 13.

United States Geological Survey (USGS). 1979. *Preliminary Geologic Map Showing Quaternary Deposits of the Lodi Quadrangle, California.* Open File Report 79-933. Prepared by D. E. Marchand and B. F. Atwater.

United States Geological Survey (USGS). 2000. *Delta Subsidence in California*. Online report FS-05000. http://ca.water.usgs.gov/archive/reports/fs00500/fs00500.pdf