APPENDIX 10G

Geologic and Foundation Design Criteria

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10G.1 Introduction

This appendix contains a description of the site conditions and preliminary foundation-related subsurface conditions. Soil-related hazards addressed include soil liquefaction, hydrocompaction (or collapsible soils), and expansive soils. Preliminary foundation and earthwork considerations are addressed based on the results of general published information available for the project area and collected for the AFC, and established geotechnical engineering practices.

Information contained in this appendix reflects the codes, standards, criteria, and practices that will be used in the design and construction of site and foundation engineering systems for the facility. More specific project information will be developed during execution of the project to support detailed design, engineering, material procurement specification and construction specifications. This information will be included in a geotechnical engineering study, which, if requested, will be provided to the CEC upon completion.

10G.2 Scope of Work

The scope of services for the preparation of this appendix included an assessment of soils-related hazards, a summary of preliminary foundation and earthwork considerations, and preliminary guidelines for inspection and monitoring of geotechnical aspects of construction based on available published data as analyzed in Subsection 8.15, Geologic Hazards and Resources.

10G.3 Site Conditions

The proposed AES Highgrove Project site is a 9.8-acre parcel in the City of Grand Terrace, San Bernardino County, CA. The project site is located along the western side of Taylor Street, north of West Main Street (parcel No. 1167-151-1000). Elevation of the site is approximately 940 feet above mean sea level. An oil-fired power plant formerly operated at the location. The project also includes a natural gas pipeline that extends approximately 7 miles (11.5 km) south of the plant site to connection with a regional gas transmission pipeline. The project area lies in the Inland Empire area of southern California between the San Bernardino and San Jacinto mountains of the Transverse Ranges to the east, and the Chino Hills and Santa Ana Mountains to the west. The Box Springs Mountains lie immediately to the east of the pipeline route. The La Loma Hills lie immediately to the west and northwest of the plant site. Father to the east, the San Jacinto Fault Zone lies at the eastern base of the Box Springs Mountains and marks the eastern edge of the Perris Block. To the west, the Elsinore and Chino Fault Zones lie along the eastern margin of the Santa Ana Mountains and mark the western limit of the Perris Block.

10G.4 Site Subsurface Conditions

10G.4.1 Stratigraphy

Generalized stratigraphy is discussed in Subsection 8.15, Geologic Hazards and Resources. Borings will be performed at the project site to verify the soil consistency and characteristics.

10G.4.2 Seismicity/Ground-Shaking

The project site lies within a seismically active region. Large earthquakes have occurred in the past and will occur in the future. The region is influenced by the San Andreas Fault system that separates the North American and Pacific plate boundaries. This boundary has been the site of numerous large-scale earthquakes. Numerous active faults are in the vicinity of Grand Terrace although none are known to exist within the city (Burtugno, 1986). These include the Rialto-Colton fault (4 miles north of site), San Jacinto fault zone (3 miles east of site), the San Andreas fault zone (10 miles north of site), Cucamonga fault (13 miles northwest of site), Whittier-Elsinore fault (20 miles southwest of site). The site is not located within a special study zone, as delineated by the Alquist-Priolo Special Studies Zone Act of 1972; and no known fault, active or inactive, reaches the surface within the project area (Jennings, 1994). However, the San Jacinto Fault Zone that is less than 3 miles from the site is state-designated fault with a ground rupture hazard area. The project area is considered to be seismically active and is designated as a California UBC Seismic Zone 4.

The Inland Empire of southern California has experienced strong ground motion in the past and will do so in the future. Mualchin (1996) estimated that the ground-shaking of a Mw 7.50 earthquake along the San Jacinto Fault Zone system could produce peak bedrock acceleration of up to 0.55g (where g is gravity) in the vicinity of the Highgrove Project. A preliminary review of the probabilistic peak ground acceleration (PGA) with a return period of 475 years indicates that the PGA will be on the order of 0.7g at the site (CGS, 2003).

10G.4.3 Ground Rupture

Ruptures along the surface trace of a fault tend to occur along lines of previous faulting. The 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 to occur at the project site is low. However, a ground rupture study at the project site will be performed as part of the geotechnical investigation in order to verify this assumption.

10G.4.4 Liquefaction Potential

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. The depth to groundwater at the project site is relatively shallow, less than 50 feet, and the soil types generally consist of alluvial sediments. According to the City of Grand Terrace General Plan, the southwestern part of the city is susceptible to liquefaction due to high water table. Therefore, the likelihood that liquefaction will occur is considered high. Any significant damage due to liquefaction potential can be mitigated through ground improvement techniques or by the use of piles. The geotechnical investigation will determine the extent, if any, of mitigation required.

10G.4.5 Groundwater

The depth to groundwater at the project site is relatively shallow, less than 50 feet. The groundwater elevation will be confirmed during the geotechnical investigation.

10G.5 Assessment of Soil-Related Hazards

10G.5.1 Liquefaction

Soil liquefaction is a process by which loose, saturated, granular deposits lose a significant portion of their shear strength due to pore water pressure buildup resulting from cyclic loading, such as that caused by an earthquake. Soil liquefaction can lead to foundation bearing failures and excessive settlements when:

- The design ground acceleration is high (up to 0.4g)
- The water level is relatively shallow
- Low standard penetration tests (SPT) blow counts are measured in granular deposits (suggesting low soil density)

10G.5.2 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 have not been identified as a potential hazard in the Grand Terrace area. Based on this, the likelihood of expansive soils to be present at the site is low.

Laboratory test results for representative soil samples at the top 10 feet below grade will be tested to determine overall soil expansiveness. The soils near the project site are generally not clayey and indicate no soils with a potential for expansion. A soil investigation will be performed at the project site.

10G.5.3 Collapsible Soils

Soil collapse (hydrocompaction) is a phenomenon that results in relatively rapid settlement of soil deposits due to addition of water. This generally occurs in soils having a loose particle structure cemented together with soluble minerals or with small quantities of clay. Water infiltration into such soils can break down the interparticle cementation, resulting in collapse of the soil structure. Collapsible soils are usually identified with index tests, such as dry density and liquid limit, and consolidation tests where soil collapse potential is measured after inundation under load.

Based on the available data, the potential for soil collapse at the site is expected to be remote. However, this will be confirmed by testing soil samples retrieved from borings at the project site.

10G.6 Preliminary Foundation Considerations

10G.6.1 General Foundation Design Criteria

For satisfactory performance, the foundation of any structure must satisfy two independent design criteria. First, it must have an acceptable factor of safety against bearing failure in the foundation soils under maximum design load. Second, settlements during the life of the structure must not be of a magnitude that will cause structural damage, endanger piping connections or impair the operational efficiency of the facility. Selection of the foundation type to satisfy these criteria depends on the nature and magnitude of dead and live loads, the base area of the structure and the settlement tolerances. Where more than one foundation type satisfies these criteria, then cost, scheduling, material availability and local practice will probably influence or determine the final selection of the type of foundation.

An evaluation of the information collected for the AFC indicates that no adverse foundation-related subsurface and groundwater conditions would be encountered that would preclude the construction and operation of the proposed structures. The site can be considered suitable for development of the proposed structures, pursuant to completion of a geotechnical investigation, and the preliminary foundation and earthwork considerations discussed in this appendix.

10G.6.2 Shallow Foundations

Completion of the geotechnical investigation will determine if the proposed structures can be supported directly on the native soils. Shallow foundation construction will require the earthwork measures discussed in Subsection 10G.7, Preliminary Earthwork Considerations.

Allowable bearing pressures will include a safety factor of at least 3 against bearing failures. Settlements of footings are expected to be limited to 1 inch, and differential settlement between neighboring foundations to less than 0.5 inch. Tanks can usually undergo much larger settlements.

Frost depth is likely to be less than 5 inches at the site, but will be confirmed through a geotechnical investigation. Pursuant to a geotechnical investigation, exterior foundations and foundations in unheated areas should be placed at a depth of at least 1 foot below the ground surface for protection. Interior footings in permanently heated areas can be placed at nominal depths. The minimum recommended width is 3 feet for spread footings and 2 feet for wall footings.

10G.6.3 Deep Foundations

Compressible soils are not expected based on information analyzed for the AFC. However, if compressible soils are present at the project site, which would preclude use of shallow foundations mentioned above, piles will be needed. A typical pile could be a 12-inch or 14-inch square precast-prestressed concrete pile based on geotechnical investigation. These types of piles are expected to develop allowable loads of 60 to 80 tons in compression, 20 tons in uplift, and 4 tons laterally. The length, size, allowable bearing, uplift, and lateral capacity of the piles for the project site, if needed, will be determined using available software programs.

10G.6.4 Corrosion Potential and Ground Aggressiveness

Corrosivity tests will be conducted to determine whether the site soils to be noncorrosive or corrosive for buried steel based on the chloride content and pH values.

10G.7 Preliminary Earthwork Considerations

10G.7.1 Site Preparation and Grading

The subgrade preparation would include the complete removal of all vegetation and topsoil. The majority of the vegetation on the site consists of weeds and grasses with a maximum root depth of less than a foot. Topsoil can be stockpiled and may be reused in remote areas of the site where no future construction is expected.

As discussed in Subsections 8.9, 8.14, and 8.16 and shown on the Proposed Drainage Plan, any site fill work should be performed as detailed below. All soil surfaces to receive fill should be proof-rolled with a heavy vibratory roller or a fully loaded dump truck to detect soft areas.

10G.7.2 Temporary Excavations

All excavations should be sloped in accordance with Occupational Safety and Health Act (OSHA) requirements. Sheet piling could also be used to support any excavation. The need for internal supports in the excavation will be determined based on the final depth of the excavation. Any excavation below the water table should be dewatered using well points or other suitable system installed prior to the start of excavation. Since the water table is could be near the surface, the need for dewatering should be expected for deep excavations.

10G.7.3 Permanent Slopes

Cut and fill slopes shall be 2h:1v (horizontal to vertical) maximum. Embankments for creek diversions, if required, shall be 5h:1v maximum.

10G.7.4 Backfill Requirements

All fill material will be free of organic matter, debris, or clay balls, with a maximum size not exceeding 3 inches. Structural fill will also have a Plastic Index of less than 20, a Liquid Limit of less than 40, and a maximum fine content (passing the 200 sieve) of 40 percent. Granular, uniformly graded material with a maximum aggregate size of 0.5 inch may be used for pipe bedding. Based on the available site grading, it is anticipated that fill material will be available onsite.

Structural fill will be compacted to at least 95 percent of the maximum dry density as determined by American Society for Testing and Materials (ASTM) D 1557 when used for raising the grade throughout the site, below footings or mats, or for rough grading. Fill placed behind retaining structures may be compacted to 90 percent of the maximum dry density as determined by ASTM D 1557. Initially, structural fill will be placed in lifts not exceeding 8-inches loose thickness. Thicker lifts may be used pursuant to approval based on results of field compaction performance. The moisture content of all compacted fill will fall within 3 percentage points of the optimum moisture content measured by ASTM D 1557, except the top 12 inches of subgrade will be compacted to 95 percent of ASTM D 1557 maximum density.

Pipe bedding can be compacted in 12-inch lifts to 90 percent of the maximum dry density as determined by ASTM D 1557. Common fill to be placed in remote and/or unsurfaced areas may be compacted in 12-inch lifts to 85 percent of the maximum dry density as determined by ASTM D 1557.

10G.8 Inspection and Monitoring

A California-registered Geotechnical Engineer or Engineering Geologist will monitor geotechnical aspects of foundation construction and/or installation and fill placement. At a minimum the Geotechnical Engineer/Engineering Geologist will monitor the following activities:

- Surfaces to receive fill will be inspected prior to fill placement to verify that no pockets of loose/soft or otherwise unsuitable material were left in place and that the subgrade is suitable for structural fill placement.
- Fill placement operations will be monitored by an independent testing agency. Field compaction control testing will be performed regularly and in accordance with the applicable specification to be issued by the Geotechnical Engineer.
- The Geotechnical Engineer will witness pile load testing or pile driving analysis, and the initial stages of production pile installation if required.
- Settlement monitoring of significant foundations and equipment is recommended on at least a quarterly basis during construction and the first year of operation, and then semi-annually for the next 2 years.

10G.9 Site Design Criteria

10G.9.1 General

The project will be located in the City of Grand Terrace, California. The approximate 9.8-acre site is relatively flat, with no existing permanent type of structures on the project site. However, much of the site is lower than the street grade. The site would be accessible from Taylor Road.

10G.9.2 Datum

The site grade is approximately elevation 940 feet, mean sea level, based on the U.S. Geological Survey (USGS) Quad Map information and the 1929 National Geodetic Vertical Datum (NGVD). Final site grade elevation will be determined during detail design.

10G.92 Foundation Design Criteria

10G.9.1 General

Reinforced concrete structures (spread footings, mats, and deep foundations) will be designed consistent with Appendix 10B, Structural Engineering Design Criteria.

Allowable soil bearing pressures for foundation design will be in accordance with this appendix and the detailed geotechnical investigation for the site.

10G.9.2 Groundwater Pressures

Hydrostatic pressures due to groundwater or temporary water loads will be considered.

10G.9.3 Factors of Safety

The factor of safety for structures, tanks and equipment supports with respect to overturning, sliding, and uplift due to wind and buoyancy will be as defined in Appendix 10B, Structural Engineering Design Criteria.

10G.9.4 Load Factors and Load Combinations

For reinforced concrete structures and equipment supports, using the strength method, the load factors and load combinations will be in accordance with Appendix 10B, Structural Engineering Design Criteria.

10G.10 References

California Building Code. 2001.

Department of the Navy.1982. "Identification and Classification of Soil and Rock." Chapter 1 in *Soil Mechanics Design Manual 7.1*. Naval Facilities Engineering Command. Alexandria, VA.

Caltrans. 1996. "California Seismic Hazards Map."