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APPENDIX 10G

Geologic and Foundation Design Criteria

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10G1 Introduction

This appendix includes the results of the preliminary subsurface investigation, and geotechnical assessment for the Project to support the Application for Certification (AFC).

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 the site investigation at the Rancho Seco Plant site approximately half a mile north of the project site, and established geotechnical engineering practices.

Information contained in this appendix reflects the codes, standards, criteria and practices generally 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.

10G2 Scope of Work

The scope of geotechnical services for the preparation of this appendix included:

- Reviewing "Geotechnical Study for Proposed Independent Spent Fuel Storage Installation Rancho Seco Nuclear Generating Station, Sacramento County, California" prepared by Environmental Geotechnical Consultants, Inc. for the SMUD on June 1, 1993 (attached as Exhibit A).
- Preparing this appendix to include 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

10G3 Site Conditions

The site is located on the north side of Clay East Road between the road and the existing Rancho Seco Plant. The site is crossed by two ephemeral swales that meander toward Clay Creek. One swale enters the site through a culvert under Clay East Road and proceeds north through the eastern third of the site. At the northeast end of the site, this swale turns east to feed into a larger swale leading to Clay Creek. The second swale enters the site through a culvert under Clay East Road on the western side of the site.

The site topography is relatively flat, except for the slopes going down to the swales of Clay Creek. Elevations above sea level range from 140 to about 160. The site currently drains

towards the north and east into the existing stream channels. The general area is marked by gently rolling terrain, increasing in elevation by about 50 to 100 feet per mile to the east.

Currently the property is covered by sparse vegetation and a few scattered trees farther to the east, and away from the project site.

10G4 Site Subsurface Conditions

10.G4.1 Stratigraphy

Boreholes drilled at the nearby Rancho Seco Plant approximately 0.4 miles north of the project site typically encountered a layer of stiff silty to sandy clay to a depth of about 9 to 10.5 feet below grade, which is underlain by interbeds of dense to very dense sand, silt and sandy clay of stiff to very stiff consistency to explored depths of 62 to 75 feet below grade.

Despite the above data, it is necessary that borings will be performed at the project site to verify the soil consistency and characteristics as mentioned in this Appendix.

10G4.2 Seismicity/Ground Shaking

The project site is subject to the probability of seismic activities. No known active faults are reported to be crossing the area of the proposed development. The nearest fault system is the Foothill Fault System located approximately 10 miles east of the project site. The Foothill Fault System has been inactive since the Jurassic Period. The nearest known active faults are the Hayward and San Andreas Faults located approximately 70 and 90 miles west of the site, respectively. Per UBC diagrams, the site is located in a seismic Zone 3.

The project site is susceptible to ground shaking during major earthquakes from the Hayward and San Andreas Faults. The seismic risk to structures depends upon the distance to the epicenter; the characteristics of the earthquake, the geologic, and groundwater and soil conditions underlying the structures and their vicinity. Due to the site distance from the above faults and the subsurface conditions, maximum ground acceleration would be expected to be on the order of about 0.05g to 0.1g. Nevertheless, a site response characteristics study should be performed for the project site.

10G4.3 Ground Rupture

Ruptures along the surface trace of a fault tend to occur along lines of previous faulting. There is no evidence of potentially active fault trace at the nearby site; and thus the primary hazard of surface rupture at the project site is expected to be negligible. However, a ground rupture study at the project site should be carried out to verify this assumption.

10G4.4 Liquefaction Potential

Soil liquefaction is a phenomenon in which saturated cohesionless soils are subject to a temporary but essentially total loss of shear strength under the reversing cyclic shear stresses associated with earthquakes. Due to the dense sandy soils and stiff clay at the nearby site, coupled with low groundwater table in the region, it is expected that there is low potential for significant damage due to liquefaction unless otherwise there are loose saturated silty sand to sand present and high groundwater table at the project site.

10G4.5 Ground Water

Groundwater was not encountered in the borings drilled at the nearby site. According to Department of Water Resources Maps, available at Sacramento County Environmental Management Department (SCEMD) offices, groundwater in the area of the Rancho Seco Plant is on the order of 150 feet below grade. In spite of this finding, the groundwater table has to be determined and verified at the project site.

10G5 Assessment Of Soil-Related Hazards

10G5.1 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 SPT blow counts are measured in granular deposits (suggesting low soil density)

The results of the subsurface investigation at the nearby site indicate no soils with a potential for liquefaction. However, this must be verified by the subsurface investigation as mentioned above.

10G5.2 Expansive Soils

Soil expansion is a phenomenon by which clayey soils expand in volume as a result of an increase in moisture content, and shrink in volume upon drying. Expansive soils are usually identified with index tests, such as percentage of clay particles and liquid limit. It is generally accepted that soils with liquid limits larger than about 50 percent, i.e., soils that classify as high plasticity clays (CH) or high plasticity silts (MH), may be susceptible to volume change when subjected to moisture variations.

Laboratory test results for representative soil samples at the top 10 feet below grade should be tested to determine overall soil expansiveness. The soils at the Rancho Seco Plant site 0.4 miles to the north are considered non-swelling and the potential there for soil expansion are virtually nil; however, a soil investigation will be performed at the CPP site to ensure the soil is similar to the Rancho Seco Plant site.

10G5.3 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, it has to be verified by testing of the soil samples retrieved from borings.

10G6 Preliminary Foundation Considerations

10G6.1 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 from the SPT borings at the nearby site indicates that no adverse foundation-related subsurface and ground water conditions were encountered that would preclude the construction and operation of the proposed structures. Thus, the site can be considered suitable for development of the proposed structures, pursuant to the preliminary foundation and earthwork considerations discussed in this appendix.

10G6.2 Shallow Foundations

Proposed structures can be supported directly on the native dense sand or stiff clay. Preliminary calculations indicate that loading up to 4,000 PSF can be placed on these layers with acceptable levels of settlement. Shallow foundation construction will require the earthwork measures discussed in Section 10G7.

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 1/2 inch. Tanks can usually undergo much larger settlements.

Frost depth is estimated to be less than 5 inches at the site (Environmental Geotechnical Consultants, 1993). 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.

10.G6.3 Deep Foundations

Compressible soils are not expected due to results of the Rancho Seco Study (Exhibit A). However, if compressible soils are present at the project site, which would preclude use of shallow foundations mentioned above, piles are needed. Such piles will bear either into the dense sand and stiff clay. A typical pile could be a 12-inch or 14-inch square precast-prestressed concrete pile. 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 should be determined using available software programs.

10G6.4 Corrosion Potential and Ground Aggressiveness

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

10G7 Preliminary Earthwork Considerations

10G7.1 Site Preparation and Grading

There are no trees, structures, or debris to be removed at the project site. The subgrade preparation would include the complete removal of all vegetation and topsoil. The majority of the vegetation on the site consists of grasses and weeds with a maximum root depth of a few inches. Topsoil can be stockpiled and may be reused in remote areas of the site where no future construction is expected.

As shown on Proposed Drainage Facilities, site grading will include some minor fills to bring the site to a level grade. The 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.

10G7.2 Temporary Excavations

It is anticipated that confined temporary excavations at the site will be required during construction for the installation of the circulation water pipes and the cooling tower forebay. All excavations should be sloped in accordance with 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 installed prior to the start of excavation. Since the water table is more than 150 feet below the surface, the need for dewatering is not expected.

10G7.3 Permanent Slopes

Cut and fill slopes shall be 2h:1v maximum. Embankments for creek diversions shall be 5h:1v maximum.

10G7.4 Backfill Requirements

All fill material must be free of organic matter, debris or clay balls, with a maximum size not exceeding 2 inches. Structural fill must also be well graded and granular. Granular material with similar specifications can be used for pipe bedding, except that the maximum size should not exceed 1/2 inch. Based on the available site grading, it is not anticipated that any fill material would be available from on-site.

Structural fill should be compacted to at least 95 percent of the maximum dry density as determined by 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 should 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 should fall within 3 percentage points of the optimum moisture content measured by ASTM D 1557, except compact the top 12 inches of subgrade 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.

10G8 Inspection and Monitoring

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

- All surfaces to receive fill should 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.
- All fill placement operations should be monitored by an independent testing agency. Field compaction control testing should be performed regularly and in accordance with the applicable specification to be issued by the Geotechnical Engineer.
- All pile load testing and initial stages of production pile installation must be witnessed by the Geotechnical Engineer.
- 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.

10G9 Site Design Criteria

10G9.1 General

The Project will be located near the town of Herald, California. The approximate 30-acre site is relatively flat, with no existing permanent type of structures. The site is accessible from Clay East Road.

10G91.2 Datum

The site grade varies between El. 140 to 160 feet, mean sea level, based on the 1929 National Geodetic Vertical Datum (NGVD). Final site grade elevation will be determined.

10G92 Foundation Design Criteria

10G9.1 General

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

Allowable soil bearing pressures for foundation design will be in accordance with this Appendix.

10G9.2 Ground Water Pressures

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

10G9.3 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.

10G9.4 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.

10G10 References

California Building Code 1998.

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.

Environmental Geotechnical Consultants, Inc. (1993), Geotechnical Study for Proposed Independent Spent Fuel Storage Installation Rancho Seco Nuclear Generating Station, June 1.