APPENDIX A

FOUNDATIONS AND CIVIL ENGINEERING DESIGN CRITERIA

A.1 INTRODUCTION

The design, engineering, procurement, and construction activities on the project will be in accordance with various predetermined standards and project-specific practices. This appendix summarizes the civil engineering codes and standards, design criteria, and practices that will be used during design and construction. These criteria form the basis of the design for the foundations and civil systems of the project. More specific design information will be developed during the detailed design phase to support equipment procurement and construction specifications. It is not the intent of this appendix to present the detailed design information for each component and system, but rather to summarize the codes, standards, and general criteria that will be used.

Section A.2 summarizes the applicable codes and standards, and Section A.3 includes the general criteria for foundations, design loads, and site work.

A.2 DESIGN CODES AND STANDARDS

A.2.1 General Requirements

The design and specification of work will be in accordance with all applicable laws and regulations of the federal government, the State of California, and the applicable local codes and ordinances. Except where noted otherwise, the latest issue of all codes and standards, including addenda, in effect at the start of the project will be used. The codes and standards, including all addenda, in effect at the time of purchase will be utilized for material and equipment procurement.

A summary of the codes and the standards to be used in the design and construction follows:

- Seismic standards and criteria will follow the California Building Code (CBC).
- Specifications for materials will follow the standard specifications of the American Society for Testing and Materials (ASTM) and the American National Standards Institute (ANSI), unless noted otherwise.
- Field and laboratory testing procedures for materials will follow ASTM standards.

- Design and placement of structural concrete and reinforcing steel will be in accordance with the codes, guides, and standards of the American Concrete Institute (ACI) and the Concrete Reinforcing Steel Institute (CRSI).

- Specifications for materials for roads will follow the State of California Department of Transportation Standard Specifications.

- Design and construction of roads will follow the American Association of State Highway and Transportation Officials (AASHTO) and the State of California Department of Transportation standards.

- Design and construction of the sanitary sewer system will conform to the California Plumbing Code (CPC).

- Design and construction will conform to the federal and California Occupational Safety and Health Administration (OSHA and CAL-OSHA) requirements.

Other recognized standards will be used where required to serve as guidelines for the design, fabrication, and construction.

A.2.2 Government Rules and Regulations

The following laws, ordinances, codes, and standards are applicable to the civil engineering design and construction. In cases where conflicts between cited codes (or standards) exist, the requirements of the more stringent code will govern.

A.2.2.1 Federal

- Title 29, Code of Federal Regulations (CFR), Part 1910, Occupational Safety and Health Standards

- Title 29, CFR, Part 1926, National Safety and Health regulations for construction

- Walsh-Healy Public Contracts Act (Public Law [PL] 50-204.10)

- National Pollutant Discharge Elimination System (NPDES) (U.S. Environmental Protection Agency [EPA])

A.2.2.2 State

- Business and Professions Code Section 6704, et seq.; Sections 6730 and 6736. Requires state registration to practice as a Civil Engineer or Structural Engineer in California.

- Labor Code Section 6500, et seq. Requires a permit for construction of trenches or excavations 5 feet or deeper into which personnel have to descend. This also applies to construction or demolition of any building, structure, false work, or scaffolding that is more than three stories high or equivalent.

- Title 24, California Code of Regulations (CCR) Section 2-111, et seq.; Section 3-100, et seq.; Section 4-106, et seq.; Section 5-102, et seq.; Section 6-T8-769, et seq.; Section 6-T8-3233, et seq.; Section 6-T8-3270, et seq.; Section 6-T8-5138, et seq.; Section 6-T8-5465, et seq.; Section 6-T8-5531, et seq.; and Section 6-T8-5545, et seq. Adopts current edition of CBC as minimum legal building standards.

- State of California Department of Transportation, Standard Specifications

- Title 8, CCR Section 1500, et seq.; Section 2300, et seq.; and Section 3200, et seq. Describes general construction safety orders, industrial safety orders, and work safety requirements and procedures.

- Regulations of the following state agencies as applicable:

  - Department of Labor and Industry Regulations
  - Bureau of Fire Protection
  - Department of Public Health
  - Water and Power Resources

- Vehicle Code, Section 35780 et seq. Requires a permit from Caltrans to transport heavy loads on state roads.

A.2.2.3 Local

- County of Imperial – Planning & Building Department

A.2.3 Industry Codes and Standards

A.2.3.1 American Association of State Highway and Transportation Officials (AASHTO)

- A Policy on Geometric Design of Highways and Streets

A.2.3.2 American Concrete Institute (ACI)

ACI 117	Standard Specification for Tolerances for Concrete Construction and Materials
ACI 211.1	Standard Practice for Selecting Proportions of Normal, Heavyweight, and Mass Concrete
ACI 301	Specifications for Structural Concrete for Buildings
ACI 302.1R	Guide for Concrete Floor and Slab Construction
ACI 304R	Guide for Measuring, Mixing, Transporting, and Placing Concrete
ACI 305R	Hot Weather Concreting
ACI 306R	Cold Weather Concreting
ACI 308	Standard Practice for Curing Concrete
ACI 309R	Guide for Consolidation of Concrete
ACI 311.4R	Guide for Concrete Inspection
ACI 318	Building Code Requirements for Reinforced Concrete
ACI 318.1	Building Code Requirements for Structural Plain Concrete
ACI 347R	Guide to Formwork for Concrete

A.2.3.3 American Society for Testing and Materials (ASTM)

ASTM A82	Standard Specification for Steel Wire, Plain, for Concrete Reinforcement
ASTM A116	Standard Specification for Zinc-Coated (Galvanized) Steel Woven Wire Fence Fabric
ASTM A121	Standard Specification for Zinc-Coated (Galvanized) Steel Barbed Wire
ASTM A185	Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
ASTM A392	Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric
ASTM A615	Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM C31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33	Standard Specification for Concrete Aggregates
ASTM C39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C76	Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C94	Standard Specification for Ready-Mixed Concrete
ASTM C109	Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2 in. or 50 mm Cube Specimens)

ASTM C136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C138	Standard Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete
ASTM C143	Standard Test Method for Slump of Hydraulic Cement Concrete
ASTM C150	Standard Specification for Portland Cement
ASTM C172	Standard Practice for Sampling Freshly Mixed Concrete
ASTM C231	Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260	Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C289	Standard Test Method for Potential Reactivity of Aggregates (Chemical Method)
ASTM C443	Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets
ASTM C478	Standard Specification for Precast Reinforced Concrete Manhole Sections
ASTM C494	Standard Specification for Chemical Admixtures for Concrete
ASTM C586	Standard Test Method for Potential Alkali Reactivity of Carbonate Rocks for Concrete Aggregates (Rock Cylinder Method)

ASTM C618	Standard Specification for Coal Fly Ash and Raw or Calcinated Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
ASTM C1064	Standard Test Method for Temperature of Freshly Mixed Portland Cement Concrete
ASTM C1107	Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM D422	Standard Test Method for Particle-Size Analysis of Soils
ASTM D698	Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft (600 kN-m/m))
ASTM D1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1752	Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D2216	Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock
ASTM D2922	Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D3017	Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)
ASTM D3034	Standard Specification for Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings

ASTM D3740	Standard Practice for Evaluation of Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
ASTM D4318	Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM E329	Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction

A.2.3.4 Concrete Reinforcing Steel Institute (CRSI)

Manual of Standard Practice

A.2.3.5 International Association of Plumbing and Mechanical Officials

CPC	California Plumbing Code

A.2.3.6 International Conference of Building Officials

CBC	California Building Code

A.3 CIVIL DESIGN CRITERIA

A.3.1 Foundations

A.3.1.1 General

Geotechnical exploration, testing, and analysis determine the most suitable bearing methods for foundations. Criteria will be established to permit design of the most economical foundation that is compatible with the life expectancy and service of the structure.

The results of the subsurface investigation, laboratory testing program, and geotechnical assessment for the proposed site are presented in Appendix J, Geotechnical Engineering Investigation. These results indicate that the facility can be constructed at the proposed location.

A.3.1.2 Foundation Design Criteria

Allowable settlements for all foundations (based on predicted elastic or short-term, and consolidation or long-term settlements) will be limited as follows:

- Total settlement: 3 inches
- Differential settlement: 1 ½ inches between adjacent foundations

Foundations for all critical structures and equipment will be supported on reinforced concrete foundations bearing directly precast driven piles. Noncritical or lightly loaded structures and equipment will be founded on individual spread footings. The design of reinforced concrete foundations will satisfy the requirements of ACI 318.

Spread footings will have a minimum width of 3 feet, and a minimum width of 2 feet will be provided for wall footings. The bottom of footings will be located at a minimum of 12 inches below finished grade.

Detailed foundation design criteria, including allowable bearing pressures, will be developed based on the results of subsurface investigations, see Appendix J. Allowable bearing pressures will include a safety factor of at least 2 against bearing failures.

A.3.1.3 Equipment Foundations

Each piece of equipment will be supplied with a reinforced concrete foundation suitable to its operation. Where the equipment could induce excessive vibration, the foundation will be provided with adequate mass to dampen vibratory motions. Special consideration will be given to vibration and stiffness criteria where specified by an equipment manufacturer. Equipment located within an enclosed building with a grade slab will generally be placed on a concrete pad that is raised above the grade slab to keep the equipment off the floor surface.

Minimum temperature and shrinkage reinforcing steel will be provided for equipment foundations unless additional reinforcement is required for the equipment loads. Anchor bolts designed to develop their yield strength will be provided for critical equipment. For noncritical or lightly loaded equipment, concrete expansion anchors may be utilized to secure equipment to foundations.

A.3.1.4 Rotating Equipment Foundations

Dynamic behavior will be considered in the design of foundations subjected to significant rotating equipment loads such as foundations for the combustion turbines, steam turbines, and the boiler feedwater pumps. A dynamic analysis will be performed to determine the natural frequencies and dynamic responses of the foundation. To account for soil and structure interaction, geotechnical data will be used to determine the soil stiffnesses and damping coefficients used in the dynamic analysis.

Dynamic responses will satisfy the equipment manufacturer's criteria and/or industry standards in terms of maximum velocity/displacement amplitudes that are considered acceptable for machine and human tolerances. To avoid resonance during machine operation, the resonant frequency of the foundation will typically be less than 80 percent or greater than 120 percent of the machine operating speed.

A.3.2 Design Loads

A.3.2.1 General

Design loads for structures and equipment foundations are discussed in Appendix B. Design loads for pavements and buried items will be determined according to the criteria described below, unless the applicable building code requires more severe design conditions.

A.3.2.2 Wheel Loads

Loads exerted on roadway pavements, buried piping, electrical duct banks, and culverts will be reviewed and selected prior to design of the underlying items. As a minimum, these items will be designed for H20 loadings in accordance with AASHTO Standard Specifications. Loadings exceeding the H20 loadings will be considered where found applicable during the detailed design phase.

A surcharge load of 250 psf will be applied to plant structures accessible to truck traffic.

A.3.3 Site

A.3.3.1 Site Arrangement

The site arrangement will conform to all applicable laws, regulations, and environmental standards. The principal elements to be considered in selection of the site arrangement are the physical space requirements and relationships dictated by each of the major plant systems, and the constraints imposed by the physical size and existing topography of the site. Distances from the main plant to various systems will be minimized for economy. However, adequate clearance between various plant systems will be provided as needed for construction, operations, maintenance, and fire protection. The plant will be configured to minimize construction costs and visual impacts while remaining operationally effective. Utility interconnections will be optimized.

A.3.3.2 Site Preparation

Site preparation will consist of clearing and grubbing, the excavation of soils to design grade, and the preparation of fill slopes and embankments designed in such a fashion as to be stable and capable of carrying anticipated loads from either equipment or structures.

Root mats or stumps, tiles if any, will be removed to a depth of not less than 2 feet below existing grade, and holes will be refilled with material suitable for embankment and compacted. Materials from clearing and grubbing operations will either be removed from the site or, if suitable, reused on site.

A.3.3.3 Earthwork

Earthwork requirements are based on the results of the subsurface investigation in Appendix J, *Report of Geotechnical Investigation, Geothermal Power Plant, Salton Sea Unit No. 6, Calipatria, California*, by Geotechnics Incorporated (February 5, 2002), and the *Addendum to Geotechnical Investigation* (March 27, 2002).

Shallow foundations built on controlled compacted fill and natural dense granular soils are expected to provide adequate bearing pressures and undergo total settlements of less than 1.5 inch and differential settlement between neighboring foundations of less than ¾".

Excavation. Excavation work will consist of the removal, storage, and/or disposal of earth, sand, gravel, vegetation, organic matter, loose rock, boulders, and debris to the lines and grades necessary for construction.

Materials suitable for backfill will be stored in stockpiles at designated locations using proper erosion protection methods. Other excess noncontaminated material will be removed from the site and disposed of at an acceptable location. Disposal of contaminated material if encountered during excavation will comply with all applicable federal, state, and local regulations.

Confined temporary excavations will be sloped or braced to prevent cave-ins during construction. All excavation and trenching operations will comply with local, state, and federal OSHA regulations.

Based on soil borings performed for the subsurface investigation, the groundwater averages between four feet and six feet below grade.

Grading and Embankments. Graded areas will be smooth, compacted, free from irregular surface changes, and sloped to drain.

Final earth grade adjacent to buildings will be at least 6 inches below finished floor slab and will be sloped away from the building to maintain proper drainage.

Cut and fill slopes for permanent embankments will be designed to withstand horizontal ground accelerations for Seismic Zone 4. This will likely result in flat slopes. Geogrid reinforcement for fill slopes and soil nailing for cut slopes may be used for steep slopes requiring soil reinforcement to resist seismic loading. Slopes for embankments will be no steeper than 2:1 (horizontal:vertical). The grading plan may require the use of retaining walls. These will also be designed for Seismic Zone 4.

Backfilling and Compaction. Areas to be backfilled will be prepared by removing unsuitable material and rocks. The bottom of an excavation will be examined for loose or soft areas. Such areas will be excavated fully and backfilled with compacted fill.

Backfilling will be done in layers of uniform, specified thickness. Soil in each layer will be properly moistened to facilitate compaction to achieve the specified density. In order to verify

compaction, representative field density and moisture-content tests will be taken during compaction.

Structural fill supporting foundations, roads, parking areas, etc., will be compacted to at least 95 percent of the maximum dry density as determined by ASTM D698. Embankments, dikes, bedding for buried piping, and backfill surrounding structures will be compacted to a minimum of 90 percent of the maximum dry density. General backfill placed in remote and/or unsurfaced areas will be compacted to at least 85 percent of the maximum dry density.

Where fills are to be placed on subgrades sloped at 6:1 (horizontal:vertical) or greater, keys into the existing subgrade may be provided to help withstand horizontal seismic ground accelerations.

The subgrade (original ground), subbases, and base courses of roads will be prepared and compacted in accordance with California Department of Transportation (Caltrans) requirements. Testing will be in accordance with ASTM and Caltrans standards.

A.3.3.4 Site Drainage

The site drainage system will be designed to comply with all applicable federal, state, and local regulations. Onsite drainage will be accomplished by gravity flow, whenever possible. The surface drainage system will consist of mild slopes and open channels. The ground floor elevation of buildings and structures will be maintained at a minimum of 6 inches above the finished grade. The graded areas away from structures will be at a minimum slope of 1 percent.

Design of the site drainage facilities will be performed in accordance with state and local governmental requirements. Drainage facilities will be designed for the flow resulting from a 10 year, 24 hour rainfall. They will also be designed to prevent flooding of permanent plant facilities and overflow of plant roads during a 50 year, 24-hour storm. The flow of storm water from the site will be designed to generally follow the existing flow.

Runoff from possible oil and chemical contamination areas, such as the lube oil storage area, transformer areas, and chemical storage areas, will be contained and routed through an oil/water separator and then discharged to the Water District.

Ditches. Open channels and ditches generally will be trapezoidal in cross section, of sufficient width to facilitate cleaning, and mildly sloping so that erosion of the ditch bottom due to high flow velocities is minimized. Side slopes on ditches will be approximately 2:1 (horizontal:vertical) unless soil conditions dictate otherwise. The slope of the ditch bottom will generally be 1 percent, with a minimum slope of 0.5 percent. In areas where space is limited and design flow rates are small, ditches having a V-shaped cross section may be provided.

Ditches will be designed to carry the 10 year, 24-hour rainfall runoff with nonerosive velocities.

Culverts. Drainage culverts will be provided for passage of surface drainage under roads or embankments. Culverts will be constructed of reinforced concrete or corrugated metal pipe.

Culverts will be designed to convey the 10 year, 24-hour rainfall peak runoff flow without producing a headwater elevation above the pipe soffit. Cover provided under roads will be as required for wheel loads in accordance with Section A.3.2.2. Minimum cover will be 12 inches.

Erosion and Sedimentation Control. The proposed site development will alter the land areas of the site. Existing vegetation will be removed during site preparation operations. This will be followed by the earthwork activities required for construction of specific facilities. Final finish grading will begin when all other earthwork operations are complete.

Erosion and sedimentation control will be provided to retain sediment on site and prevent violations of water quality standards.

Permanent erosion and sedimentation control measures within the plant site will include the runoff collection system (ditches, inlets, culverts, drainage piping) and surfaced traffic and work areas. Final grading will include aggregate surfacing of the entire site except for paved roadways and landscaped areas. These measures will minimize the possibility of any appreciable erosion, and the resulting sedimentation, from occurring on the site.

Temporary erosion and sediment control measures which comply with the state and local requirements will be utilized during the construction phase.

A.3.3.5 Roads

Access to the plant site will be from Severe Road. Access within the plant site will be provided by the asphalt paved loop road that encircles the power block and major equipment in the resource production facility. The road will be 20 feet wide with a 2 foot shoulder on each side.

All other plant roads will generally be a minimum of 20 feet in width with gravel surface, except that if site space limitations require narrower roads, gravel roads may be a minimum of 12 feet wide. The permanent parking area adjacent to the administration/control building will be paved with asphalt.

The longitudinal slope of roads will not exceed 7 percent. The crown or transverse slope will be 2 percent. The minimum radius to the inside edge of roads (pavement or gravel) will be 20 feet.

A.3.3.6 Fencing and Security

Chain-link security fencing will be provided around the facility site, substation, and other areas requiring controlled access. Fencing heights will be in accordance with applicable codes and regulatory requirements. Controlled access gates will be located at the entrances to secured areas.

A.3.3.7 Sanitary Waste System

The sanitary waste system design will conform to the Imperial County regulations and California Plumbing Code. Sanitary wastes will be discharged via a septic tank and leech field system.

The total quantity of flow used in sizing the sanitary waste system will be calculated based on the total equivalent fixture units provided. Pipe will be sloped to provide a 2.5fps minimum velocity, half full. Minimum slope for main sewer pipe will be 1.0 percent.

The minimum diameter of sewer pipe will be 4 inches. Manholes will be provided at a maximum spacing of 300 ft. and at each change in direction greater than 45.

A.3.3.8 Spill Protection

Spill containment measures will be provided for chemical storage tanks and chemical additive/lube oil skid areas. All other chemical storage tanks will be provided with a containment structure with a volume equal to at least 100 percent of the largest tank capacity. In addition, all outdoor containment structures will have a volume equal to at least the capacity of the tank plus the volume of rainfall from a 100 year, 24 hour storm. Concrete curbs will be provided for chemical additive/lube oil skid areas. Where required for protection of the containment structure, appropriate surface coatings will be provided.

A.3.4 Geotechnical Investigation

The Geotechnical Engineering Investigation for the project is included as Appendix J.