

## DOCKETED

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**Appendix 2D**  
**Engineering Design Criteria**

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# Engineering Design Criteria

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This appendix summarizes the codes, standards, criteria, and practices that generally will be used in the design and construction of the engineering systems for the Alamos Energy Center (AEC).

## 2D.1 Civil Engineering Design Criteria

### 2D.1.1 Introduction

This section summarizes the codes, standards, criteria, and practices that generally will be used in the design and construction of civil engineering systems for the AEC. Consistent with the usual California Energy Commission (CEC) processes post-certification for all projects, additional project information will be developed during detailed design, engineering, material procurement specification and construction specifications.

### 2D.1.2 Codes and Standards

The design of civil engineering systems for the project will be in accordance with the applicable laws and regulations of the federal government, the State of California, applicable codes and ordinances, and industry standards. The current issue or edition of the documents at the time of filing this Application for Certification (AFC) will apply, unless otherwise noted. In cases where conflicts between the cited documents exist, requirements of the more conservative document will be used.

#### 2D.1.2.1 Civil Engineering Codes and Standards

The following codes and standards have been identified as applicable, in whole or in part, to civil engineering design and construction of power plants.

- American Association of State Highway and Transportation Officials (AASHTO)—Standards and Specifications
- American Concrete Institute (ACI) – Standards and Recommended Practices
- American Institute of Steel Construction (AISC) – Standards and Specifications
- American National Standards Institute (ANSI) – Standards
- American Society of Testing and Materials (ASTM) – Standards, Specifications, and Recommended Practices
- American Water Works Association (AWWA) – Standards and Specifications
- American Welding Society – Codes and Standards
- Asphalt Institute – Asphalt Handbook
- State of California Department of Transportation (Caltrans) Standard Specification
- California Energy Commission (CEC) – Recommended Seismic Design Criteria for Non-Nuclear Generating Facilities in California, 1989
- Concrete Reinforcing Steel Institute (CRSI) – Standards
- Factory Mutual (FM) – Standards
- National Fire Protection Association (NFPA) – Standards
- California Building Code (CBC) 2010 (Effective July 1, 2012)

- Steel Structures Painting Council (SSPC) – Standards and Specifications
- American Society of Civil Engineers (ASCE) – Standards and Recommended Practices
- International Building Code (IBC) 2009 Effective July 1, 2012 with 2011 Los Angeles County Amendments
- United States Geological Survey

### 2D.1.2.2 Engineering Geology Codes, Standards, and Certifications

Engineering geology activities will conform to the applicable federal, state and local laws, regulations, ordinances, and industry codes and standards.

**Federal.** None are applicable.

**State.** The Warren-Alquist Act, Public Resources Code (PRC), Section 25000 et seq. and the CEC Code of Regulations (CCR), Siting Regulations, Title 20 CCR, Chapter 2, require that an AFC address the geologic and seismic aspects of the site.

The California Environmental Quality Act (CEQA), PRC 21000 et seq. and the CEQA Guidelines require that potential significant effects, including geologic hazards, be identified and a determination made as to whether they can be substantially reduced.

**Local.** California State Planning Law, Government Code Section 65302, requires each city and county to adopt a general plan, consisting of nine mandatory elements, to guide its physical development. Section 65302(g) requires that a safety element be included in the general plan addressing seismic issues, among other issues.

The site development activities will require certification by a Professional Geotechnical Engineer and a Professional Engineering Geologist during and following construction, in accordance with the CBC, Chapter 70. The Professional Geotechnical Engineer and the Professional Engineering Geologist will certify the placement of earthen fills and the adequacy of the site for structural improvements, as follows:

- Both the Professional Geotechnical Engineer and the Professional Engineering Geologist will address CBC Chapter 70, Sections 7006 (Grading Plans), 7011 (Cuts), 7012 (Terraces), 7013 (Erosion Control), and 7015 (Final Report).
- The Professional Geotechnical Engineer will also address CBC Chapter 70, Sections 7011 (Cuts) and 7012 (Terraces).

Additionally, the Professional Engineering Geologist will present findings and conclusions pursuant to PRC, Section 25523 (a) and (c); and 20 CCR, Section 1752 (b) and (c).

## 2D.2 Structural Engineering Design Criteria

### 2D.2.1 Introduction

This section summarizes the codes, standards, criteria, and practices that will be generally used in the design and construction of structural engineering systems for the AEC. Consistent with the usual CEC processes post-certification for all projects, additional project information will be developed during detail design, engineering, material procurement specification and construction specifications.

### 2D.2.2 Codes and Standards

The design of structural engineering systems for the project will be in accordance with the laws and regulations of the federal government, the State of California, applicable codes and ordinances, and the industry standards. The current issue or edition of the documents at the time of filing of this AFC will apply, unless otherwise noted. In cases where conflicts between the cited documents exist, requirements of the more conservative document will be used.

The following codes and standards have been identified as applicable, in whole or in part, to structural engineering design and construction of power plants.

- California Building Code, 2010 Edition (IBC, 2009) with 2011 Los Angeles County Amendments
- American Institute of Steel Construction (AISC)
  - Manual of Steel Construction—13th Edition 325-05
    - Specification for Structural Steel Buildings, March 9, 2005
    - Specification for Structural Joints Using ASTM A325 or A490 Bolts, June 30, 2004
    - Code of Standard Practice for Steel Buildings and Bridges, March 18, 2005
  - Seismic Design Manual 327-05
- American Concrete Institute (ACI)
  - ACI 318-08, Building Code Requirements for Structural Concrete
  - ACI 301-05, Specifications for Structural Concrete for Buildings
  - ACI 530-08, Building Code Requirements for Masonry Structures
- American Society of Civil Engineers (ASCE)
  - ASCE 7-05, Minimum Design Loads for Buildings and Other Structures
- American Society of Mechanical Engineers (ASME)
  - STS-1-2000, Steel Stacks
- American Welding Society (AWS)
  - D1.1—Structural Welding Code—Steel
  - D1.3—Structural Welding Code—Sheet Steel
- Code of Federal Regulations, Title 29—Labor, Chapter XVII, Occupational Safety and Health Administration (OSHA)
  - Part 1910—Occupational Safety and Health Standards
  - Part 1926—Construction Safety and Health Regulations
- National Association of Architectural Metal Manufacturers (NAAMM)—Metal Bar Grating Manual
- Hoist Manufacturers Institute (HMI), Standard Specifications for Electric Wire Rope Hoists (HMI 100)
- IEEE 980 – Guide for Containment and Control of Oil Spills in Substations
- National Electric Safety Code (NESC), C2-2007
- National Fire Protection Association (NFPA Standards)
  - NFPA 850 Fire Protection for Electric Generating Plants
- OSHA Williams-Steiger Occupational Safety and Health Act of 1970
- Steel Deck Institute (SDI)—Design Manual for Floor Decks and Roof Decks

#### 2D.2.2.1 CEC Special Requirements

Prior to the start of any increment of construction, the proposed seismic-force procedures for project structures and the applicable designs, plans and drawings for project structures will be submitted to the CEC's Compliance Project Manager or the Chief Building Official as the CEC's delegatee, for review.

Proposed seismic-force procedures, designs, plans, and drawings shall be those for:

- Major project structures
- Major foundations, equipment supports, and anchorage
- Large, field-fabricated tanks
- Switchyard structures

## 2D.2.3 Structural Design Criteria

### 2D.2.3.1 Datum

Site topographic elevations will be based on an elevation survey conducted using known elevation benchmarks.

### 2D.2.3.2 Frost Penetration

The site is located in an area free of frost penetration. Bottom elevation of all foundations for structures and equipment, however, will be maintained at a minimum of 12 inches below the finished grade.

### 2D.2.3.3 Temperatures

The historic maximum and minimum temperatures are as follows:

Maximum	111°F
Minimum	25°F

### 2D.2.3.4 Design Loads

**General.** Design loads for structures and foundations will comply with all applicable building code requirements.

**Dead Loads.** Dead loads will consist of the weights of structure and all equipment of a permanent or semi-permanent nature including tanks, bins, wall panels, partitions, roofing, drains, piping, cable trays, bus ducts, and the contents of tanks and bins measured at full operating capacity. The contents of the tanks and bins, however, will not be considered as effective in resisting structure uplift due to wind forces; but will be considered as effective for seismic forces.

**Live Loads.** Live load will consist of uniform floor live loads and equipment live loads. Uniform live loads are assumed equivalent unit loads that are considered sufficient to provide for movable and transitory loads, such as the weights of people, portable equipment and tools, small equipment or parts, which may be moved over or placed on the floors during maintenance operations, and planking. The uniform live loads will not be applied to floor areas that will be permanently occupied by equipment.

Lateral earth pressures, hydrostatic pressures, and wheel loads from trucks will be considered as live loads.

Uniform live loads will be in accordance with ASCE Standard 7, but will not be less than the following:

- Roofs 20 pounds per square foot (psf)
- Floors and Platforms 100 psf  
(steel grating and checkered plates)

In addition, a uniform load of 50 psf will be used to account for piping and cable trays, except that where the piping and cable loads exceed 50 psf, the actual loads will be used.

Furthermore, a concentrated load of 5 kips will be applied concurrently to the supporting beams of the floors to maximize stresses in the members, but the reactions from the concentrated loads will not be carried to the columns.

- Floors (elevated concrete floors) 100 psf

In addition, elevated concrete slabs will be designed to support an alternate concentrated load of 2 kips in lieu of the uniform loads, whichever governs. The concentrated load will be treated as a uniform distributed load acting over an area of 2.5 square feet, and will be located in a manner to produce the maximum stress conditions in the slabs.

- Operating Floors As applicable
- Control Room Floor 150 psf
- Electrical Rooms 250 psf
- Stairs, Landings, and Walkways 100 psf

In addition, a concentrated load of 2 kips will be applied concurrently to the supporting beams for the walkways to maximize the stresses in the members, but the reactions from the concentrated loads will not be carried to the columns.

- Pipe Racks 50 psf

Where the piping and cable tray loads exceed the design uniform load, the actual loads will be used. In addition, a concentrated load of 8 kips will be applied concurrently to the supporting beams for the walkways to maximize the stresses in the members, but the reactions from the concentrated loads will not be carried to the columns.

- Hand Railings

Hand railings will be designed for a 200-pound concentrated load applied at any point and in any direction.

- Slabs on Grade 250 psf
- Truck Loading Surcharge Adjacent to Structures 250 psf
- Truck Support Structures AASHTO-HS-20-44
- Special Loading Conditions Actual loadings

Lay down loads from equipment components during maintenance and floor areas where trucks, forklifts or other transports have access will be considered in the design of live loads.

Live loads may be reduced in accordance with the provisions of CBC Section 1607.

Posting of the floor load capacity signs for all roofs, elevated floors, platforms and walkways will be in compliance with the OSHA Occupational Safety and Health Standard, Walking and Working Surfaces, Subpart D. Floor load capacity for slabs on grade will not be posted.

**Earth Pressures.** Earth pressures will be in accordance with the recommendations contained in the project specific geotechnical report.

**Groundwater Pressures.** Hydrostatic pressures due to groundwater or temporary water loads will be considered in detailed design.

**Wind Loads.** The wind forces will be calculated in accordance with CBC 2010 with a basic wind speed of 85 miles per hour (mph) and an exposure category of 'C.'

**Seismic Loads.** Structures will be designed and constructed to resist the effects of earthquake loads as determined in CBC 2010, Section 1613. The Seismic Design Category is D. The occupancy category of the structure is III (per CBC Table 1604.5) and corresponding importance factor (I) is 1.25. Other seismic parameters will be obtained from the geotechnical report.

**Snow Loads.** Snow loads will not be considered.

**Turbine Generator Loads.** The combustion turbine generator loads for pedestal and foundation design will be furnished by the equipment manufacturers, and will be applied in accordance with the equipment manufacturers' specifications, criteria, and recommendations.

**Special Considerations for Steel Stacks.** Steel stacks will be designed to withstand the normal and abnormal operating conditions in combination with wind loads and seismic loads, and will include the along-wind and across-wind effects on the stacks. The design will meet the requirements of ASME/ANSI STS-1-2000, “Steel Stacks,” using allowable stress design method, except that increased allowable stress for wind loads as permitted by AISC will not be used.

**Special Considerations for Structures and Loads during Construction.** For temporary structures, or permanent structures left temporarily incomplete to facilitate equipment installations, or temporary loads imposed on permanent structures during construction, the allowable stresses may be increased by 33 percent.

Structural backfill may be placed against walls, retaining walls, and similar structures when the concrete strength attains 80 percent of the design compressive strength ( $f'_c$ ), as determined by sample cylinder tests. Restrictions on structural backfill, if any, will be shown on the engineering design drawings.

Design restrictions imposed on construction shoring removal that are different from normal practices recommended by the ACI codes will be shown on engineering design drawings.

Metal decking used as forms for elevated concrete slabs will be evaluated to adequately support the weight of concrete plus a uniform construction load of 50 psf, without increase in allowable stresses.

## 2D.2.4 Design Basis

### 2D.2.4.1 General

Reinforced concrete structures will be designed by the strength design method, in accordance with the CBC and the ACI 318, “Building Code Requirements for Structural Concrete.”

Steel structures will be designed by the working stress method, in accordance with the CBC and the AISC Specification for Structural Steel Buildings.

Foundation design will be in accordance with the “Final Subsurface Investigation and Foundation Report” for the facility.

### 2D.2.4.2 Factors of Safety

The factor of safety for all structures, tanks, and equipment supports will be as follows:

Against Overturning	1.50
Against Sliding	1.50 for Wind Loads 1.10 for Seismic Loads
Against Uplift Due to Wind	1.50
Against Buoyancy	1.25

### 2D.2.4.3 Allowable Stresses

Calculated stresses from the governing loading combinations for structures and equipment supports will not exceed the allowable limits permitted by the applicable codes, standards, and specifications.

### 2D.2.4.4 Load Factors and Load Combinations

For reinforced concrete structures and equipment supports, using the strength method, the strength design equations will be determined based on CBC 2010, Sections 1605.2.1, 1605.4, 1912, and ACI-318-08 Section 9.2. The Allowable Stress Design load combinations of CBC 2007 Section 1605.3 will be used to assess soil bearing pressure and stability of structures per CBC 2010 Sections 1805 and 1613, respectively.



Steel-framed structures will be designed in accordance with CBC 2010, Chapter 22 and the ANSI/AISC 360-05 Specification for Structural Steel Buildings, March 9, 2005. Connections will conform to Research Council on Structural Connections of the Engineering Foundation Specification for Structural Joints.

## 2D.2.5 Construction Materials

### 2D.2.5.1 Concrete and Grout

The design compressive strength ( $f'_c$ ) of concrete and grout, as measured at 28 days, will be as follows:

Underground electrical duct bank encasement and lean concrete backfill (Class D)	2,000 psi
Structural concrete (Classes CSA & CLA)	3,000 psi
Structural concrete (Class BSA & BLA)	4,000 psi
Structural grout	5,000 psi

The classes of concrete and grout to be used will be shown on engineering design drawings or indicated in design specifications.

### 2D.2.5.2 Reinforcing Steel

Reinforcing steel bars for concrete will be deformed bars of billet steel, conforming to ASTM A615, Grade 60 or A706, Grade 60.

Welded wire fabric for concrete will conform to ASTM A185.

### 2D.2.5.3 Structural and Miscellaneous Steel

Structural and miscellaneous steel will generally conform to ASTM A36, ASTM A572, or ASTM A992 except in special situations where higher strength steel is required.

High-strength structural bolts, including nuts and washers, will conform to ASTM A325 or ASTM A490.

Bolts other than high-strength structural bolts will conform to ASTM A307, Grade A.

Foundation anchor bolts to be F1554-Grade 36 unless noted otherwise.

### 2D.2.5.4 Concrete Masonry

Concrete masonry units will be hollow, normal weight, non-load-bearing Type I, conforming to ASTM C90, lightweight.

Mortar will conform to ASTM C270, Type S.

Grout will conform to ASTM C476.

### 2D.2.5.5 Other Materials

Other materials for construction, such as anchor bolts, shear connectors, concrete expansion anchors, embedded metal, etc., will conform to industry standards and will be identified on engineering design drawings or specifications.

## 2D.3 Mechanical Engineering Design Criteria

### 2D.3.1 Introduction

This section summarizes the codes, standards, criteria, and practices that will be generally used in the design and construction of mechanical engineering systems for the AEC. Consistent with the usual CEC processes post-certification for all projects, additional project information will be developed during detailed design, engineering, material procurement specification, and construction specifications.

## 2D.3.2 Codes and Standards

The design of the mechanical systems and components will be in accordance with the laws and regulations of the federal government, State of California applicable codes and ordinances, and industry standards. The current issue or revision of the documents at the time of the filing of this AFC will apply, unless otherwise noted. If there are conflicts between the cited documents, the more conservative requirements shall apply.

The following codes and standards are applicable to the mechanical aspects of the power facility.

- California Building Standards Code, 2010 (Effective July 2012) with 2011 Los Angeles County Amendments
- American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code
- ASME/ANSI B31.1 Power Piping Code
- ASME Performance Test Codes
- ASME Standard TDP-1
- American National Standards Institute (ANSI) B16.5, B16.34, and B133.8
- American Boiler Manufacturers Association (ABMA)
- American Gear Manufacturers Association (AGMA)
- Air Moving and Conditioning Association (AMCA)
- American Society for Testing and Materials (ASTM)
- American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE)
- American Welding Society (AWS)
- Cooling Tower Institute (CTI)
- Heat Exchange Institute (HEI)
- Manufacturing Standardization Society (MSS) of the Valve and Fitting Industry
- National Fire Protection Association (NFPA)
- Hydraulic Institute Standards (HIS)
- Tubular Exchanger Manufacturer's Association (TEMA)

## 2D.3.3 Mechanical Engineering General Design Criteria

### 2D.3.3.1 General

The systems, equipment, materials, and their installation will be designed in accordance with the applicable codes; industry standards; and local, state, and federal regulations, as well as the design criteria; manufacturing processes and procedures; and material selection, testing, welding, and finishing procedures specified in this section.

Detailed equipment design will be performed by the equipment vendors in accordance with the performance and general design requirements to be specified later by the project architect/engineering firm. Equipment vendors will be responsible for using construction materials suited for the intended use.

### 2D.3.3.2 Materials—General

Asbestos will not be used in the materials and equipment supplied. Where feasible, materials will be selected to withstand the design operating conditions, including expected ambient conditions, for the design life of the plant. It is anticipated that some materials will require replacement during the life of the plant due to corrosion, erosion, etc.

**Pumps.** Pumps will be sized in accordance with industry standards. Where feasible, pumps will be selected for maximum efficiency at the normal operating point. Pumps will be designed to be free from excessive vibration throughout the operating range.

**Tanks.** Large outdoor storage tanks will not be insulated except where required to maintain appropriate process temperatures or for personnel protection.

Overflow connections and lines will be provided. Maintenance drain connections will be provided for complete tank drainage.

Manholes, where provided, will be at least 24 inches in diameter and hinged to facilitate removal. Storage tanks will have ladders and cleanout doors as required to facilitate access/maintenance. Provisions will be included for proper tank ventilation during internal maintenance.

**Heat Exchangers.** The heat exchangers will be provided as components of mechanical equipment packages and may be air-cooled or water-cooled shell-and-tube or plate type. Heat exchangers will be designed in accordance with TEMA or manufacturer's standards. Fouling factors will be specified in accordance with TEMA.

**Pressure Vessels.** Pressure vessels will be designed, constructed, and installed in accordance with the ASME Boiler and Pressure Vessel Code

**Piping and Piping Supports.** Stainless steel pipe may be Schedule 10S where design pressure permits. Underground piping may be high-density polyethylene (HDPE) or polyvinyl chloride (PVC) where permitted by code, operating conditions, and fluid properties. In general, water system piping will be HDPE or PVC where embedded or underground and carbon steel where aboveground. Appropriately lined and coated carbon steel pipe may alternately be used for buried water piping.

Threaded joints will not normally be used in piping used for lubricating oil, and natural gas service. Natural gas piping components will not use synthetic lubricants. Victaulic, or equal, couplings may be used for low energy aboveground piping, where feasible.

Piping systems will have high point vents and low point drains. Drains with restricting orifices or automated valves will be installed in low points of lines where condensate can collect during normal operation.

Hose and process tubing connections to portable components and systems will be compatible with the respective equipment suppliers' standard connections for each service.

Stainless steel piping will be used for portions of the lubricating oil system downstream of the filters. Carbon steel piping may be used elsewhere.

## Valves

**General Requirements.** Valves will be arranged for convenient operation from floor level where possible and, if required, will have extension spindles, chain operators, or gearing. Hand-actuated valves will be operable by one person. Gear operators will be provided to make sure that the force required at the hand wheel of the operator does not exceed 20 lbs.

Valves will be arranged to close when the hand wheel is rotated in a clockwise direction when looking at the hand wheel from the operating position. The direction of rotation to close the valve will be clearly marked on the face of each hand wheel.

Valve materials will be suitable for operation at the maximum working pressure and temperature of the piping to which they are connected. Steel valves will have cast or forged steel spindles. Seats and faces will be of low friction, wear resistant materials. Valves in throttling service will be selected with design characteristics and of materials that will resist erosion of the valve seats when the valves are operated partly closed.

**Drain and Vent Valves and Traps.** Drains and vents in 600 pound class or higher piping and 900°F or higher service will be double-valved.

Trap bodies and covers will be cast or forged steel and will be suitable for operating at the maximum working pressure and temperature of the piping to which they are connected. Traps will be piped to drain collection tank or sumps and returned to the cycle if convenient.

**Low-pressure Water Valves.** Low-pressure water valves will be gate or butterfly type of cast iron construction. Ductile iron valves will have ductile iron bodies, covers, gates (discs), and bridges; the spindles, seats, and faces will be bronze. Fire protection valves will be Underwriters Laboratories-approved butterfly valves meeting NFPA requirements.

**Instrument Air Valves.** Instrument air valves will be the ball type of stainless construction, with valve face and seat of approved wear-resistant alloy.

**Nonreturn Valves.** Nonreturn valves for steam service will be in accordance with ANSI standards and properly drained. Nonreturn valves in vertical positions will have bypass and drain valves. Bodies will have removable access covers to enable the internal parts to be examined or renewed without removing the valve from the pipeline.

**Motor Actuated Valves.** Electric motor actuators will be designed specifically for the operating speeds, differential and static pressures, process line flow rates, operating environment, and frequency of operations for the application. Electric actuators will have self-locking features. A hand wheel and declutching mechanism will be provided to allow hand wheel engagement at any time except when the motor is energized. Actuators will automatically revert to motor operation, disengaging the hand wheel, upon energizing the motor. The motor actuator will be placed in a position relative to the valve that prevents leakage of liquid, steam, or corrosive gas from valve joints onto the motor or control equipment.

**Safety and Relief Valves.** Safety valves and/or relief valves will be provided as required by code for pressure vessels, heaters, and boilers. Safety and relief valves will be installed vertically. Piping systems that can be over-pressurized by a higher-pressure source will also be protected by pressure-relief valves. Equipment or parts of equipment that can be over pressurized by thermal expansion of the contained liquid will have thermal-relief valves.

**Instrument Root Valves.** Instrument root valves will be specified for operation at the working pressure and temperature of the piping to which they are connected. Test points and sample lines in systems that are 600 pound class or higher service will be double valved.

**Heating, Ventilating, and Air Conditioning (HVAC).** HVAC system design will be based on site ambient conditions specified in the, Project Description.

Except for the HVAC systems serving the control room, maintenance shop, lab areas, and administration areas, the systems will not be designed to provide comfort levels for extended human occupancy.

Air conditioning will include both heating and cooling of the inlet filtered air. Air velocities in ducts and from louvers and grills will be low enough not to cause unacceptable noise levels in areas where personnel are normally located.

Fans and motors will be mounted on anti-vibration bases to isolate the units from the building structure. Exposed fan outlets and inlets will be fitted with guards. Wire guards will be specified for belt driven fans and arranged to enclose the pulleys and belts.

Air filters will be housed in a manner that facilitates removal. The filter frames will be specified to pass the air being handled through the filter without leakage.

Ductwork, filter frames, and fan casings will be constructed of mild steel sheets stiffened with mild steel flanges and galvanized. Ductwork will be the sectional bolted type and will be adequately supported. Duct joints will be leak tight.

Grills and louvers will be of adjustable metal construction.

**Thermal Insulation and Cladding.** Parts of the facility requiring insulation to reduce heat loss or afford personnel safety will be thermally insulated. Minimum insulation thickness for hot surfaces near personnel will be designed to limit the outside lagging surface temperature to a maximum of 140°F.

The thermal insulation will have as its main constituent calcium silicate, foam glass, fiber glass, or mineral wool, and will consist of pre-formed slabs or blankets, where feasible. Asbestos-containing materials are prohibited. An aluminum jacket or suitable coating will be provided on the outside surface of the insulation. Insulation system materials, including jacketing, will have a flame spread rating of 25 or less when tested in accordance with ASTM E 84.

Insulation at valves, pipe joints, steam traps, or other points to which access may be required for maintenance will be specified to be removable with a minimum of disturbance to the pipe insulation. At each flanged joint, the molded material will terminate on the pipe at a distance from the flange equal to the overall length of the flange bolts to permit their removal without damaging the molded insulation. Outdoor aboveground insulated piping will be clad with textured aluminum of not less than 30 mil thickness and frame reinforced. At the joints, the sheets will be sufficiently overlapped and caulked to prevent moisture from penetrating the insulation. Steam trap stations will be “boxed” for ease of trap maintenance.

Design temperature limits for thermal insulation will be based on system operating temperature during normal operation.

Outdoor and underground insulation will be moisture resistant.

**Testing.** Hydrostatic testing, including pressure testing at 1.5 times the design pressure, or as required by the applicable code, will be specified and performed for pressure boundary components where an in-service test is not feasible or permitted by code.

**Welding.** Welders and welding procedures will be certified in accordance with the requirements of the applicable codes and standards before performing any welding. Records of welder qualifications and weld procedures will be maintained.

**Painting.** Except as otherwise specified, equipment will receive the respective manufacturer’s standard shop finish. Finish colors will be selected from among the paint manufacturer’s standard colors.

Finish painting of un-insulated piping will be limited to that required by OSHA for safety or for protection from the elements.

Piping to be insulated will not be finish painted.

**Lubrication.** The types of lubrication specified for facility equipment will be suited to the operating conditions and will comply with the recommendations of the equipment manufacturers.

The initial startup charge of flushing oil will be the equipment manufacturer’s standard lubricant for the intended service. Subsequently, such flushing oil will be sampled and analyzed to determine whether it can also be used for normal operation or must be replaced in accordance with the equipment supplier’s recommendations.

Rotating equipment will be lubricated as designed by the individual equipment manufacturers. Where automatic lubricators are fitted to equipment, provision for emergency hand lubrication will also be specified. Where applicable, equipment will be designed to be manually lubricated while in operation without the removal of protective guards. Lubrication filling and drain points will be readily accessible.

## 2D.4 Electrical Engineering Design Criteria

### 2D.4.1 Introduction

This section summarizes the codes, standards, criteria, and practices that will be generally used in the design and construction of electrical engineering systems for the AEC. Consistent with the usual CEC processes post-certification for all projects, additional project information will be developed during detailed design, engineering, material procurement specification, and construction specifications.

## 2D.4.2 Codes and Standards

The design of the electrical systems and components will be in accordance with the laws and regulations of the federal government, the State of California, applicable codes and ordinances, and industry standards. The current issue or revision of the documents at the time of filing this AFC will apply, unless otherwise noted. If there are conflicts between the cited documents, the more conservative requirement will apply.

The following codes and standards are applicable to the electrical aspects of the power facility:

- American National Standards Institute (ANSI)
- American Society for Testing and Materials (ASTM)
- Anti-Friction Bearing Manufacturers Association (AFBMA)
- California Building Standards Code
- California Electrical Code
- Insulated Cable Engineers Association (ICEA)
- Institute of Electrical and Electronics Engineers (IEEE)
- Illuminating Engineering Society (IES)
- National Association of Corrosion Engineers (NACE)
- National Electrical Code (NEC)
- National Electrical Manufacturers Association (NEMA)
- National Electrical Safety Code (NESC)
- National Fire Protection Association (NFPA)
- Underwriters Laboratories, Inc. (UL)

## 2D.4.3 Switchyard and Transformers

### 2D.4.3.1 Switchyard

Each power block at the AEC site will consist of three independent combustion turbine generators and one steam turbine generator. All sixteen generators from all four blocks will tie into an existing 230 kV switchyard.

The switchyard will consist of circuit breakers and lines to the grid. Each line will be equipped with the appropriate instrument transformers for protection and metering. Surge arresters will be provided for the outgoing lines in the area of the takeoff towers.

The switchyard will be located near the main step-up transformers and will require an overhead span for the connection.

The breakers will be of the dead tank design with current transformers on each bushing. Disconnect switches will be located on each side of the breakers to isolate the breaker, and one switch will be located at each line termination or transformer connection for isolation of the lines or transformer for maintenance.

Tubular bus used in the switchyard will be aluminum alloy. Cable connections between the tube bus and equipment will be ACSR, AAAC, or AAC cable. Tube and cables will meet all electrical and mechanical design requirements. Instrument transformers (current and capacitive voltage transformers) will be included for protection and synchronization where required.

A grounding grid will be provided to control step and touch potentials in accordance with IEEE Standard 80, Safety in Substation Grounding. Metallic equipment, structures, and fencing will be connected to the grounding grid of buried conductors and ground rods, as required for personnel safety. The substation ground grid will be tied to the plant ground grid.

Lightning protection will be provided by shield wires or lightning masts. The lightning protection system will be designed in accordance with IEEE 998 guidelines.

All faults will be detected, isolated, and cleared in a safe and coordinated manner as soon as practical to ensure the safety of equipment, personnel, and the public. Protective relaying will meet IEEE requirements and will be coordinated with the utility.

Revenue metering will be provided on the 230kV bus to record net power to or from the switchyard. Meters and a metering panel will be provided.

### 2D.4.3.2 Generator Circuit Breakers

Each generator will have a dedicated generator circuit breaker (GCB). The GCBs will be capable of handling the generator nameplate output. They will also be rated for the available through fault currents associated with the circuit.

The GCBs will serve two purposes. They will allow each generator to be isolated from the grid and they will be used to synchronize the generators with the grid.

During plant startup the GCBs will be open. When the generator is at full speed and synchronized with the grid, the GCBs will be closed to allow power flow from the generators to the grid.

### 2D.4.3.3 Transformers

The generators will be connected to the 230 kV switchyards through main step-up transformers. The step-up transformers will be designed in accordance with ANSI standards C57.12.00, C57.12.90, and C57.91. Each main step-up transformer will have metal oxide surge arrestors connected to the high-voltage terminals and will have manual de-energized (“no-load”) tap changers located in high-voltage windings.

Two of the four generators on each power block will be provided with 13.8-kV to 4.16-kV auxiliary power transformer. The auxiliary transformers will be used to feed all of the electrical loads associated with the plant.

During plant startup, power will be backed through the generator step-up transformers to the auxiliary transformers. Once each generator has been started and synchronized with the utility bus, the generator circuit breakers will be closed. When this occurs, the generators will begin feeding power to the auxiliary transformers (only applies to the units connected to auxiliary transformers) and exporting power to the grid.

## 2D.5 Control Engineering Design Criteria

### 2D.5.1 Introduction

This section summarizes the codes, standards, criteria, and practices that will be generally used in the design and installation of instrumentation and controls for the AEC. Consistent with the usual CEC processes post-certification for all projects, additional project information will be developed during detailed design, engineering, material procurement specification and construction specifications.

### 2D.5.2 Codes and Standards

The design specification of all work will be in accordance with the laws and regulations of the federal government, the State of California, and applicable codes and ordinances. A summary of general codes and industry standards applicable to design and control aspects of the power facility follows.

- American National Standards Institute (ANSI)
- American Society of Mechanical Engineers (ASME)
- The Institute of Electrical and Electronics Engineers (IEEE)
- International Society of Automation (ISA)
- National Electrical Manufacturers Association (NEMA)
- National Electrical Safety Code (NESC)
- National Fire Protection Association (NFPA)
- American Society for Testing and Materials (ASTM)

## 2D.5.3 Control Systems Design Criteria

### 2D.5.3.1 General Requirements

Electronic signal levels, where used, will be 4 to 20 milliamps (mA) for analog transmitter outputs, controller outputs, electric-to-pneumatic converter inputs, and valve positioner inputs.

The switched sensor full-scale signal level will be between 0 and 125 volt (V).

### 2D.5.3.2 Pressure Instruments

In general, pressure instruments will have linear scales with units of measurement in pounds per square inch, gauge (psig).

Pressure gauges will have either a blowout disk or a blowout back and an acrylic or shatterproof glass face.

Pressure gauges on process piping will be resistant to plant atmospheres.

Pressure test points will have isolation valves and caps or plugs. Pressure devices on pulsating services will have pulsation dampers.

### 2D.5.3.3 Temperature Instruments

In general, temperature instruments will have scales with temperature units in degrees Fahrenheit (°F). Exceptions to this are electrical machinery resistance temperature detectors (RTDs) and transformer winding temperatures, which are in degrees Celsius (°C).

Bimetal-actuated dial thermometers will have 4.5- or 5-inch-diameter (minimum) dials and white faces with black scale markings and will consist of every angle-type. Dial thermometers will be resistant to plant atmospheres.

Temperature elements and dial thermometers will be protected by thermowells except when measuring gas or air temperatures at atmospheric pressure. Temperature test points will have thermowells and caps or plugs.

RTDs will be 100-ohm platinum, 3-wire type. The element will be spring-loaded, mounted in a thermowell, and connected to a cast iron head assembly.

Thermocouples will be Type J or K dual-element, grounded, spring-loaded, for general service. Materials of construction will be dictated by service temperatures. Thermocouple heads will be the cast type with an internal grounding screw.

### 2D.5.3.4 Level Instruments

Reflex-glass or magnetic level gauges will be used. Level gauges for high-pressure service will have suitable personnel protection.

Gauge glasses used in conjunction with level instruments will cover a range that includes the highest and lowest trip/alarm set points.

### 2D.5.3.5 Flow Instruments

Flow transmitters will typically be the differential pressure-type with the range similar to that of the primary element. In general, linear scales will be used for flow indication and recording.

Magnetic flow transmitters may be used for liquid flow measurement below 200°F.

### 2D.5.3.6 Control Valves

Control valves in throttling service will generally be the globe-body cage type with body materials, pressure rating, and valve trims suitable for the service involved. Other style valve bodies (e.g., butterfly, eccentric disk) may also be used when suitable for the intended service.



Valves will be designed to fail in a safe position.

Control valve body size will not be more than two sizes smaller than line size, unless the smaller size is specifically reviewed for stresses in the piping.

Control valves in 600-Class service and below will be flanged where economical. Where flanged valves are used, minimum flange rating will be ANSI 300 Class.

Critical service valves will be defined as ANSI 900 Class and higher in valves of sizes larger than 2 inches.

Severe service valves will be defined as valves requiring anti-cavitation trim, low noise trim, or flashing service, with differential pressures greater than 100 pounds per square inch (psi).

In general, control valves will be specified for a noise level no greater than 90 decibel A-rated (dBA) when measured 3 feet downstream and 3 feet away from the pipe surface.

Valve actuators will use positioners and the highest pressure, smallest size actuator, and will be the pneumatic-spring diaphragm or piston type. Actuators will be sized to shut off against at least 110 percent of the maximum shutoff pressure and designed to function with instrument air pressure ranging from 80 to 125 psig.

Hand wheels will be furnished only on those valves that can be manually set and controlled during system operation (to maintain plant operation) and do not have manual bypasses.

Control valve accessories, excluding controllers, will be mounted on the valve actuator unless severe vibration is expected.

Solenoid valves supplied with the control valves will have Class H coils. The coil enclosure will normally be a minimum of NEMA 4 but will be suitable for the area of installation. Terminations will typically be by pigtail wires.

Valve position feedback (with input to the DCS for display) will be provided for all control valves.

### **2D.5.3.7 Instrument Tubing and Installation**

Tubing used to connect instruments to the process line will be stainless steel for primary instruments and sampling systems.

Instrument tubing fittings will be the compression type. One manufacturer will be selected for use and will be standardized as much as practical throughout the plant.

Differential pressure (flow) instruments will be fitted with three-valve manifolds; two-valve manifolds will be specified for other instruments as appropriate.

Instrument installation will be designed to correctly sense the process variable. Taps on process lines will be located so that sensing lines do not trap air in liquid service or liquid in gas service. Taps on process lines will be fitted with a shutoff (root or gauge valve) close to the process line. Root and gauge valves will be main-line class valves.

Instrument tubing will be supported in both horizontal and vertical runs as necessary. Expansion loops will be provided in tubing runs subject to high temperatures. The instrument tubing support design will allow for movement of the main process line.

### **2D.5.3.8 Pressure and Temperature Switches**

Field-mounted pressure and temperature switches will have either NEMA Type 4 housings or housings suitable for the environment.

In general, switches will be applied such that the actuation point is within the center one-third of the instrument range.

### 2D.5.3.9 Field-mounted Instruments

Field-mounted instruments will be of a design suitable for the area in which they are located. They will be mounted in areas accessible for maintenance and relatively free of vibration and will not block walkways or prevent maintenance of other equipment.

Field-mounted instruments will be grouped on racks. Supports for individual instruments will be prefabricated, off-the-shelf, 2-inch pipe stand. Instrument racks and individual supports will be mounted to concrete floors, to platforms, or on support steel in locations not subject to excessive vibration.

Individual field instrument sensing lines will be sloped or pitched in such a manner and be of such length, routing, and configuration that signal response is not adversely affected.

Liquid level controllers will generally be the non-indicating, displacement-type with external cages.

### 2D.5.3.10 Instrument Air System

Branch headers will have a shutoff valve at the takeoff from the main header. The branch headers will be sized for the air usage of the instruments served, but will be no smaller than 3/8 inch. Each instrument air user will have a shutoff valve, filter, outlet gauge, and regulator at the instrument.

## 2D.6 Chemical Engineering Design Criteria

### 2D.6.1 Introduction

This section summarizes the general chemical engineering design criteria for the AEC project. These criteria form the basis of the design for the chemical components and systems of the project. Consistent with the usual CEC processes post-certification for all projects, additional specific design information is developed during detailed design to support equipment and erection specifications. This appendix summarizes the codes, standards, and general criteria that will be used during detailed design.

### 2D.6.2 Design Codes and Standards

The design and specification of all work will be in accordance with the laws and regulations of the federal government, the State of California, and applicable codes and ordinances. Industry codes and standards relevant to chemical engineering design to be used in design and construction are summarized below.

- ANSI B31.1 Power Piping Code
- ASME Performance Test Code 31, Ion Exchange Equipment
- American Society for Testing and Materials (ASTM)
- California Building Code (CBC)
- Occupational Safety and Health Administration (OSHA)
- Steel Structures Painting Council Standards (SSPC)
- Underwriters Laboratories
- American Waterworks Association (AWWA)

Other recognized standards will be used as required to serve as design, fabrication, and construction guidelines when not in conflict with the above-listed standards.

The codes and industry standards used for design, fabrication, and construction will be the codes and industry standards, including all addenda, in effect as stated in equipment and construction purchase or contract documents.

## 2D.6.3 General Criteria

### 2D.6.3.1 Design Water Quality

**Service Water.** Service water (such as fire water, eye wash station water, etc.) will be provided by the Long Beach Water Department to the AEC.

**Reverse Osmosis Membrane System.** Raw water will be filtered and purified via a reverse osmosis (RO) system to remove suspended solids and the majority of the dissolved solids. The RO permeate will be forwarded to an RO storage tank that will supply the evaporative cooler makeup demand and the demineralized water system. The RO reject stream will be discharged to the existing circulating water outfall.

**Demineralized Water System.** Demineralized water will be produced by a Mixed Bed DI system. The high-quality demineralized water will be used for the on-line water wash, and steam cycle make up. The demineralized water will be the highest practical quality. Minimum quality requirements shall be in compliance with EPRI recommendations as stated in EPRI document 1010438 "Cycle Chemistry Guidelines for CC/HRSGs".

**Construction Water.** Water for use during construction will be supplied from the existing city water feed.

**Fire Protection Water.** The source of water for fire protection will be from the existing Redondo Beach Generating Station fire water tank. The tank will have a minimum capacity of 2 hours of firewater reserved in the tank.

### 2D.6.3.2 Chemical Conditioning

**Reverse Osmosis Membrane System Chemical Conditioning.** Chemical feed systems will supply the following water-conditioning chemicals to the RO system to minimize corrosion and control, the formation of mineral scale, and biofouling:

- Dechlorination: Sodium bisulfite to remove chlorine residual
- Mineral scale dispersant: Polyacrylate based solution
- Corrosion inhibitor: Phosphate based
- pH control: Sulfuric acid for alkalinity consumption and scaling tendencies
- Clean-in-place (CIP): Chemical cleaning solution contains sodium hydroxide, sodium hypochlorite, and citric acid

#### **Mixed Bed Demineralizer System Chemical Conditioning**

- Because the bottles will be regenerated offsite, no chemicals will be stored or handled onsite to service these units.

**Process Water Chemical Conditioning.** The plant process water will be chlorinated using sodium hypochlorite (bleach).

### 2D.6.3.3 Chemical Storage

**Storage Capacity.** Dechlorination feed equipment will consist of a returnable tote with two full capacity sodium bisulfite metering pumps.

The scale inhibitor feed equipment will consist of a returnable tote with two full-capacity scale inhibitor metering pumps.

Corrosion control feed equipment will consist of a returnable tote with two full-capacity corrosion control metering pumps.

The sulfuric acid feed equipment will consist of a storage tank. The tank will be accompanied by two, full-capacity sulfuric acid metering pumps.

The chemical cleaning solution tanks will consist of a drum and solution mixing tank for each of the three CIP chemicals. The cleaning solution is prepared by mixing sodium hydroxide (caustic), sodium hypochlorite (bleach), and citric acid.

The sodium hypochlorite feed equipment will consist of a bulk storage tank and two full-capacity hypochlorite metering pumps.

Facilities for feeding a non-oxidizing biocide will include returnable totes and two full-capacity chemical metering pumps.

**Containment.** Chemical storage tanks containing corrosive fluids will be surrounded by berms. Berms and drain piping design will allow a full tank capacity spill without overflowing the curbing. For multiple tanks located within the same curbed area, the largest single tank will be used to size the curbing and drain piping. For outdoor chemical containment areas, additional containment volume will be included for stormwater.

**Closed Drains.** Waste piping for volatile liquids and wastes with offensive odors will use closed drains to control noxious fumes and vapors.

**Coatings.** Tanks, piping, and curbing for chemical storage applications will be provided with a protective coating system. The specific requirements for selection of an appropriate coating will be identified prior to equipment and construction contract procurements.

#### 2D.6.3.4 Wastewater Treatment

The primary wastewater collection system will collect process wastewater from all of the plant equipment, including the evaporative coolers and water treatment equipment.

Wastewater from the water treatment system will consist of the reject stream from the RO units that will initially reduce the concentration of dissolved solids in the plant makeup water before it is treated in the EDI system.

General plant drains will collect area wash down, sample drains, and drainage from facility equipment areas. Water from these areas will be collected in a system of floor drains, hub drains, sumps, and piping and routed to the wastewater collection system. Drains that potentially could contain oil or grease will first be routed through an oil/water separator.

Wastewater from combustion turbine water washes will be collected in a water wash drains tank. The wastewater will be discharged to the existing oil/water separator and then sent to the wastewater tank to await truck collection and disposal.

## 2D.7 Geologic and Foundation Design Criteria

### 2D.7.1 Introduction

This section provides a summary description of the site conditions and preliminary foundation-related subsurface conditions. The project has been evaluated with respect to its potential impacts on the geologic environment and the potential impacts that geologic and seismic hazards may have on the proposed site. The principle seismic hazards evaluated at the site are surface ground rupture, ground shaking, seismically induced liquefaction, and various manifestations of liquefaction-related hazards, i.e. dynamic settlement and lateral spreading. Soil-related hazards addressed include soil liquefaction, hydrocompaction (or collapsible soils), and expansive soils. Preliminary foundation and earthwork considerations are based on Ninyo & Moore's preliminary geotechnical evaluation completed for the AEC site. For complete geotechnical information please see the attached Preliminary Geotechnical Evaluation report by Ninyo & Moore, dated October 19, 2011, project no. 208356001.

## 2D.7.2 Scope of Work

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. Consistent with the usual CEC processes post-certification for all projects, additional project information will be developed during detailed design, engineering, material procurement specification, and construction specifications. This information will be included in a final geotechnical engineering study to be completed prior to detailed design.

## 2D.7.3 Site Conditions

The proposed AEC site covers approximately 63 acres and is located in Los Angeles County, California, within the city limits of Long Beach, California. Elevation of the site is approximately 13 feet above mean sea level.

## 2D.7.4 Assessment of Seismic-Related Hazards

### 2D.7.4.1 Stratigraphy

Four (4) soil borings and four (4) cone penetrometer tests were performed by Ninyo & Moore at the project site to verify the soil consistency and characteristics.

### 2D.7.4.2 Regional Seismicity

The site is located in a seismically active area, as is the majority of southern California, and the potential for strong ground motion in the project area is considered significant during the design life of the proposed structures. Figure 5 shows the approximate site location relative to the principal faults in the region. Based on Ninyo & Moore's background review and site reconnaissance, the project site is not transected by known active or potentially active faults. The site is located within a State of California Seismic Hazard Zone as an area considered susceptible to liquefaction (CDMG, 1998), as shown on Figure 6 of the preliminary geotechnical report. The site is not located within a State of California Earthquake Fault Zone (EFZ).

### 2D.7.4.3 Surface Fault Rupture

Surface fault rupture is the offset or rupturing of the ground surface by relative displacement across a fault during an earthquake. Based on Ninyo & Moore's review of referenced geologic and fault hazard data, the site is not transected by known active or potentially active faults. The southwest corner of the power plant property is located approximately 200 feet from the State of California EFZ for the active Newport-Inglewood Fault Zone (NIFZ). The mapped projection of the fault zone near the site is approximately ½ mile from the proposed re-powering project area. Therefore, the potential for surface rupture is relatively low.

### 2D.7.4.4 Liquefaction, Dynamic Settling and Lateral Spreading

Liquefaction is the phenomenon in which loosely deposited granular soils located below the water table undergo rapid loss of shear strength due to excess pore pressure generation when subjected to strong earthquake-induced ground shaking. Ground shaking of sufficient duration results in the loss of grain-to-grain contact due to the rapid rise of in pore water pressure; causing the soil to behave as a fluid for a short period of time. Liquefaction is known generally to occur in saturated or near-saturated cohesionless soils at depths shallower than 50 feet below the ground surface. Factors known to influence liquefaction potential include composition and thickness of soil layers, grain size, relative density, groundwater level, degree of saturation, and both intensity and duration of ground shaking.

The project site is mapped in a State of California Seismic Hazard Zone as potentially liquefiable. The preliminary liquefaction analysis indicated that scattered saturated sandy alluvial layers between approximately 7 and 56 feet are potentially liquefiable during the design earthquake event. A groundwater depth of 2 feet was used in the analysis. The results of the liquefaction analysis are presented in Appendix C of the Ninyo & Moore Preliminary Geotechnical Report.

To evaluate the potential impact from liquefaction, an analysis was performed to estimate the magnitude of dynamic settlement due to liquefaction. The analysis indicated that liquefaction-induced settlement at the project site would be generally less than 1 inch (Appendix C of the Ninyo & Moore Preliminary Geotechnical Report).

Lateral spreading of the ground surface during an earthquake usually takes place along weak shear zones that have formed within a liquefiable soil layer. Based on the Ninyo & Moore analysis of the sampler blow counts and generally discontinuous nature of the underlying soil layers encountered in the exploration, the project site is not considered susceptible to significant seismically induced lateral spread.

#### **2D.7.4.5 Ground Shaking**

Earthquake events from one of the regional active or potentially active faults near the project could result in strong ground shaking which could affect the project site. The level of ground shaking at a given location depends on many factors, including the size and type of earthquake, distance from the earthquake, and subsurface geologic conditions. The type of construction also affects how particular structures and improvements perform during ground shaking.

The potential levels of ground shaking could impact the proposed re-powering project without appropriate design mitigation, and therefore, guidelines of the governing jurisdictions and the 2010 CBC should be followed in the detail design phase of the project.

### **2D.7.5 Assessment of Soil-related Hazards**

#### **2D.7.5.1 Expansive Soils**

Expansive soils include clay minerals that are characterized by their ability to undergo significant volume change (shrink or swell) due to variations in moisture content. Sandy soils are generally not expansive. Changes in soil moisture content can result from rainfall, irrigation, pipeline leakage, surface drainage, perched groundwater, drought, or other factors.

Volumetric change of expansive soil may cause excessive cracking and heaving of structures with shallow foundations, concrete slabs-on-grade, or pavements supported on these materials. Constructing project improvements on soils known to be potentially expansive could have a significant impact to the project. Based on the Ninyo & Moore subsurface exploration, the near-surface soils at the project site are predominantly composed of sandy silt and fine-grained sand with silt and clay. These soils are typically low to moderately expansive. The site-specific potential for expansive soils at the location of the proposed improvements should be evaluated during the detailed design stage of the project in order to provide recommendations to mitigate the potential impacts of expansive soils.

#### **2D.7.5.2 Compressible/Collapsible Soils**

Compressible soils are generally composed of soils that undergo consolidation when exposed to new loading, such as fill or foundation loads. Soil collapse is a phenomenon where the soils undergo a significant decrease in volume upon increase in moisture content, with or without an increase in external loads. Buildings, structures and other improvements may be subject to excessive settlement-related distress when compressible soils or collapsible soils are present.

Based on the Ninyo & Moore subsurface exploration and background review, the project site is underlain by existing fill soils and interbedded alluvial sediments. Older, undocumented fill soils are considered potentially compressible. In addition, some very soft to soft clayey silt and silty clay alluvial layers were encountered, which are considered potentially compressible. Due to the high groundwater levels encountered at the site and the reported historically high groundwater, the site soils are not susceptible to hydro-collapse. Due to the presence of potentially compressible soils at the site, the potential impacts of settlement are significant without appropriate mitigation during detailed project design and construction.

### **2D.7.5.3 Subsidence**

Subsidence is characterized as a sinking of the ground surface relative to surrounding areas, and can generally occur where deep soil deposits are present. Subsidence in areas of deep soil deposits is typically associated with regional groundwater withdrawal or other fluid withdrawal from the ground such as oil and natural gas. Subsidence can result in the development of ground cracks and damage to foundations, buildings and other improvements. Historic oil and gas withdrawal has resulted in significant ground subsidence in some areas of Long Beach. The City of Long Beach Seismic Safety Element includes information and maps regarding regional subsidence associated with oil and gas withdrawal including the locations and magnitude of known subsidence. The project site is not located in an area of mapped subsidence. Therefore, the potential for subsidence is relatively low.

### **2D.7.5.4 Groundwater**

During the subsurface exploration groundwater was encountered at depths ranging from 8 to 14 feet below the ground surface. Based on Ninyo & Moore's background review, historic high groundwater levels near the site have been measured at approximately 10 feet below the ground surface. Groundwater levels will vary and may be influenced by tidal fluctuations, precipitation, irrigation, groundwater pumping, projected sea level rise and other factors.

### **2D.7.5.5 Corrosive Soils**

The project site is located in a geologic environment that could potentially contain soils that are corrosive to concrete and metals. Corrosive soil conditions may exacerbate the corrosion hazard to buried conduits, foundations, and other buried concrete or metal improvements. Corrosive soil could cause premature deterioration of these underground structures or foundations. Constructing project improvements on corrosive soils could have a significant impact to the project. Recommendations should be provided by a corrosion engineer during the detailed design phase of the project to mitigate the potential impacts of corrosive soils.

## **2D.7.6 Preliminary Foundation Considerations**

### **2D.7.6.1 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.

Based on results of the preliminary geotechnical evaluation, the project site is suitable for the proposed improvements from a geotechnical perspective. The potential geologic and seismic hazards described above may be mitigated by employing sound engineering practice in the design and construction of the new power generating facilities and associated improvements. This practice includes the implementation of appropriate geotechnical recommendations during design and construction of the improvements at the site. Typical methods to mitigate potential significant hazards that may be encountered during construction are summarized in the following sections with further information and details provided in the Preliminary Geotechnical Report by Ninyo & Moore.

### **2D.7.6.2 Shallow Foundations**

Preliminary geotechnical evaluation indicates the proposed structures can be supported on mat foundations when combined with in-situ ground improvements. Relatively light minor structures, new pavements and

hardscape areas may be supported on suitable compacted fill, placed in accordance with detailed geotechnical recommendations.

Ground improvement techniques such as vibro-replacement stone columns, rammed aggregate piers or compaction grouting would mitigate the compressible soils and liquefaction hazard, and the new structures could then be supported on shallow mat foundation systems within the ground improvement zones. Further geotechnical investigation will be required to determine allowable bearing pressures if ground improvement techniques prove to be a cost effective solution for the project.

### **2D.7.6.3 Deep Foundations**

The site is susceptible to compressible soils and the potential for dynamic settlement related to liquefaction. Therefore, the preliminary geotechnical evaluation recommends supporting the major re-powering improvement structures on deep pile foundations.

Driven pre-cast concrete pile foundations can be considered for preliminary design of the proposed re-powering improvements. A typical 14 inch diameter pre-cast pile driven to approximately 50 feet deep can be considered based on preliminary geotechnical investigation. An axial capacity of 90 kips can be used.

## **2D.7.7 Preliminary Earthwork Considerations**

### **2D.7.7.1 Site Preparation and Grading**

The subgrade preparation would include the complete removal of all vegetation and any topsoil. Any vegetation 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.

As 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.

### **2D.7.7.2 Temporary Excavations**

All excavations should be sloped in accordance with Occupational Safety and Health Act (OSHA) requirements. Based on preliminary evaluation, subsurface excavation are anticipated to be composed of predominantly sandy silt and fine-grained sand with silt and clay. These sandy soils generally have relatively little cohesion and have a high potential for caving. Therefore, temporary slopes above the water table should be stable at an inclination of 1 ½:1 (horizontal to vertical) for excavations deeper than 4 feet but not more than 10 feet below existing grade. Some surficial sloughing may occur, and temporary slopes will be evaluated in the field by a geotechnical engineer. 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 would be dewatered prior to the start of excavation.

### **2D.7.7.3 Permanent Slopes**

Cut and fill slopes shall be 2h:1v (horizontal to vertical) maximum.

### **2D.7.7.4 Backfill Requirements**

Based on the preliminary geotechnical evaluation, it is anticipated that the materials encountered in near-surface excavations would be appropriate material for re-use as structural fill. Recommended backfill materials shall be in conformance with the "Green book" (Standard Specifications for Public Works Construction) specifications for structural backfill and approved by Geotechnical Engineer. All fill material will be free of organic matter, debris, or clay balls, with a maximum size not exceeding 3 inches.

Fill compaction requirements shall be verified with the final geotechnical investigation prior to detailed design. For preliminary design and estimating purposes the following guidelines shall be followed: Structural fill will 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 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.

### **2D.7.8 Inspection and Monitoring**

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

- Excavation operations will be monitored to confirm extent of excavation and removal of unsuitable material.
- 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, free of standing water 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 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.

### **2D.7.9 Site Design Criteria**

#### **2D.7.9.1 General**

The project will be located in Long Beach, CA. The approximate 63-acre site contains existing power generation structures.

#### **2D.7.9.2 Datum**

Currently, the site grade ranges from approximately 7 to 14 feet above mean sea level, as evidenced by a recent topographical survey, based on the North American Vertical Datum of 1988 (NAVD '88).

### **2D.7.10 Foundation Design Criteria**

#### **2D.7.10.1 General**

Reinforced concrete structures (spread footings, mats, and deep foundations) will be designed consistent with Section 1.1 and 1.2, Civil and Structural Engineering Design Criteria.

Foundation design will be in accordance with this appendix and the detailed design geotechnical investigation for the site.

#### **2D.7.10.2 Groundwater Pressures**

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

### **2D.7.10.3 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 Section 1.2, Structural Engineering Design Criteria.

### **2D.7.10.4 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 Section 1.2, Structural Engineering Design Criteria.

### **2D.7.11 References**

California Building Code. 2010.

Preliminary Geotechnical Evaluation Report by Ninyo & Moore, dated October 19, 2011, project no. 208356001.