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APPENDIX 2A

Engineering Design Criteria

APPENDIX 2A

Civil & Structural Engineering Design Criteria

EMPOWERING EPCM

Hydrostor A-CAES Project

Pecho Energy Storage Center

Civil & Structural Engineering Design Criteria

Document Number: 21-5375-00-3332-004

Date	Revision	Description of Revision	Prepared	Checked	Approved
08-05-2021	A	ISSUED FOR SQUAD CHECK (IFS)	KVS	YJH	NSM
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08-27-2021	C	ISSUED FOR PERMIT	KVS	GMT	NSM

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Design Criteria

1 CIVIL ENGINEERING DESIGN CRITERIA

This document summarizes the design criteria, standards codes and practices which will be used for civil engineering for the Pecho Energy Storage Center. During the detail engineering phase, further specific project information will be developed to support the detailed design, engineering, material procurements, specifications, and construction specifications.

1.1 Codes and Standards

Civil design will be in accordance with the laws, ordinances, and regulations of the federal government, State of California, San Luis Obispo County and City of Morro Bay as well as applicable industry standards. The required part of the current issue or edition of the codes and standards at the time of filing this Application for Certification (AFC) will apply unless noted otherwise. In case of any conflict between codes and standards, the most stringent standard will govern.

1.1.1 Civil Engineering Codes and Standards

The following codes and standards will be applied in whole or in part:

- Occupational Safety and Health Administration (OSHA)
- International Building Code (IBC)
- California Building Code (CBC)
- American National Standards Institute (ANSI) – Standards
- American Concrete Institute (ACI) – Standards and Recommended Practices
- Concrete Reinforcing Steel Institute (CRSI) – Standards
- Precast Prestressed Concrete Institute (PCI)
- American Institute of Steel Construction (AISC) – Standards and Specifications
- American Association of State Highway and Transportation Officials (AASHTO) – Standards and Specifications
- American National Standards Institute (ANSI) – Standards
- American Society of Testing and Materials (ASTM) – Standards, Specifications, and Recommended Practices
- Process Industry Practices (PIP)
  PIP CVC01015 Civil Design Criteria
- Asphalt Institute (AI) – 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
- National Fire Protection Association (NFPA) and International Fire Code
- International Plumbing Code (IPC)

- Association of Dam Safety Officials (ASDSO)
- California Department of Water Resources, Division of Safety of Dams (DSOD)
- American Society for Civil Engineering (ASCE)
- U.S Department of Interior Bureau of Reclamation, Embankment Dams
- United States Society on Dams (USSD).
- U.S. Army Corps of Engineers. "Engineer Manuals."
- American Water Works Association (AWWA)

2 STRUCTURAL ENGINEERING DESIGN CRITERIA

This document summarizes the design criteria, standards codes and practices which will be used for structural engineering for the Pecho Energy Storage Center. During the detail engineering phase, further specific project information will be developed to support the detailed design, engineering, material procurements, specifications, and construction specifications.

2.1 Codes and Standards

Structural design will be in accordance with the laws, ordinances, and regulations of the federal government, State of California, San Luis Obispo County and City of Morro Bay as well as applicable industry standards. The required part of the current issue or edition of the codes and standards at the time of filing this Application for Certification (AFC) will apply unless noted otherwise. In case of any conflict between codes and standards, the most stringent standard will govern.

2.1.1 Structural Engineering Codes and Standards

The following codes and standards will be applied in whole or in part:

- Occupational Safety and Health Administration (OSHA)
- International building Code (IBC)
- California Building Code (CBC)
- American Institute of Steel Construction (AISC):
  Manual of Steel Construction
  Specification for Structural Steel Buildings
  Specification for Structural Joints Using High-Strength Bolts
  Code of Standard Practice for Steel Buildings and Bridges
- American Concrete Institute (ACI)
  ACI 351-18, Foundations for Dynamic Equipment
  ACI 318-19, Building Code Requirements for Structural Concrete and Commentary
  ACI 301-20, Specifications for Concrete Construction
  ACI 530, Building Code Requirements and Specification for Masonry Structures and

Related
224, Control of Cracking in Concrete Structures
- Commentaries
- American Society of Civil Engineers (ASCE)
  ASCE 7-16, Minimum Design Loads for Buildings and Other Structures
  ASCE 37-14, Design Loads on Structures During Construction
  Design of Blast Resistant Buildings in Petrochemical Facilities
  Guidelines for Seismic Evaluation and Design of Petrochemical Facilities
  Wind Loads on Petrochemical Facilities
  ASCE 59-11, Blast Protection of Buildings
- American Petroleum Institute (API)
  API 650/620 Welded Steel Tanks
  API 686 Recommended Practice for Machinery Installation and Installation Design
- American Society of Mechanical Engineers (ASME)
  STS-1-2016 Steel Stacks
  A17 Safety Code for Elevators and Escalators
- American Welding Society (AWS)
  D1.1-20—Structural Welding Code—Steel
  D1.3-18—Structural Welding Code—Sheet Steel
  D1.4-18—Structural Welding Code—Reinforcing Steel
- National Association of Architectural Metal Manufacturers (NAAMM)—Metal Bar Grating Manual
- Steel Deck Institute (SDI)—Design Manual for Floor Decks and Roof Decks
- American Association of State Highway and Transportation Officials (AASHTO)
  AASHTO LRFD Design Bridge Design Specifications, 9th Edition, 2020
- Precast Prestressed Concrete Institute (PCI), PCI Design Handbook, 8th Edition
- American Society for Testing and Materials (ASTM)
  All applicable standards including but not limited to A36/A36M, A193/193M, A307, A500/A500M, A615/A615M, A992/A992M, F1554 and F3125/3125M
  D7380 Standard Test Method for Soil Compaction
- Portland Cement Association (PCA)
  EB075 Concrete Floors on Ground
- Crane Manufacturers Association of America, Inc. (CMAA)
  CMAA No.70 Specifications for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes
  CMAA No. 74 Specifications for Top Running and Under Running Single Girder Electric Traveling Cranes Utilizing Under Running Trolley Hoist
- Process Industry Practices
  PIP STC 01015 Structural Design Criteria
- Steel joist Institute (SJI)
  SJI-CJ - Standard Specification for Composite Steel Joists CJ-Series

SJI-K - Standard Specification for Open Web Steel Joists, K-Series
SJI-LH/DLH - Standard Specification for Long Span Joists, LH-Series and Deep Long Span Joists, DLH-Series
SJI-JG - Standard Specification for Joist Girders

2.2 Datum

A topographical survey will be provided for entire site. The existing ground elevations will be based on an elevation survey conducted using known elevation benchmarks.

2.3 Frost Penetration

Bottom of all foundations for the structures and equipment will be extended below the frost line of the locality. The frost depth will be determined by Geotechnical Engineer.

3 DESIGN LOADS

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

3.1 Dead Load

3.1.1 The dead load for structures shall consist of the self-weight of the structure, the weight of all materials of construction permanently incorporated into the structure, including insulation, fireproofing, fixed partitions, and permanent fixtures.

3.1.2 The dead load for equipment shall consist of the weight of all machinery, equipment, and/or vessels permanently supported by the structure, including insulation, fireproofing, partitions, permanent fixtures, and attachments.

3.1.3 Unless more determinate load information is available and requires otherwise, dead loads for the following items shall be estimated as follows:
a. Uniformly distributed loads for grating, checkered plate, and concrete decking:
Grating: 9.1 psf for 1-1/4 inches x 3/16 inch plain grating
Checkered Plate: 10.23 psf for 1/4-inch checkered plate
Concrete Deck: based upon deck manufacturer's tables
b. Guard systems and ladders and cages
Angle Guard Systems with Toe Plate: 15 lbs/ft of guard length (L 2 ½ x 2 ½ x ¼)
Pipe Guard Systems with Toe Plate: 11 lbs/ft of guard length for pipe guard (NPS 1 ½ STD or HSS 1.900 x 0.145)
Ladders with Cages: 30 lbs/ft of ladder length

Ladders without Cages: 11 lbs/ft of ladder length

3.2 Live Load

Live loads are loads produced by the use and occupancy of the building or structure. These include the weight of all movable loads (e.g., personnel, tools, miscellaneous equipment, movable partitions, wheel loads, parts of dismantled equipment, stored material).

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

The minimum uniform live loads will be in accordance with ASCE SEI 7-16, Chapter 4; CBC 2019 Section 1607; IBC 2021 Section 1607; as applicable or other applicable codes and standards but will not be less than the following:

Table 1- Minimum Live Loads

	Uniform (psf)	Concentrated (lbs) (1)
Stairs and Exitways	100	1000
Operating, Access Platforms and Walkways (3)	100 (framing design) 100 (grating Design)	1000 (Framing and Grating Design)
Platforms Used for Bundle/Equipment Repairs	150	1000
Control, I/O, HVAC Room Floor	100	1000
Manufacturing Floors and Storage Areas: Light Heavy	 125 250	 2000 3000
Elevator Machine room and control room grating	100	300
Control or Electrical Enclosure or Module Floor	150	-
Pipe Racks (4)	50 (Average)	As Identified by Engineer
Hand Railing	- (2)	200 applied at any point in any direction
Slab on Grade	250	-

Truck Loading Surcharge Adjacent to Structure	250	-
Truck Support Structure	AASHTO-HS-20-44	-
Laboratories	100	-
Roof	20	-
Fire Escapes	200	-
Office Buildings:		
Corridor above first floor	80	2000
Lobbies and First Floor Corridors	100	2000
Office – Ground and 1st floor	100	2000
Offices above first floor	50	2000

(1) Uniform and concentrated live load listed in Table 1 shall not be applied simultaneously. Use of either uniform or concentrated live loads shall be based on whichever produces the greater load effect. Unless otherwise specified, the indicated concentration shall be assumed to be uniformly distributed over an area 2.5 ft by 2.5 ft and shall be located to produce the maximum load effects in the members.

(2) Handrail and guardrail system shall also be designed to resist a load of 50 lb/ft (pound-force per linear foot) applied in any direction along the handrail or top rail and to transfer this load through the supports to the structure. This load need not be assumed to act concurrently with the concentrated load.

(3) 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.

(4) 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.

(5) Laydown 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.

3.3 Wind Loads

Wind loads shall be computed and applied in accordance with ASCE/SEI 7-16, Chapters 26 through 30; IBC 2021, Section 1609; or CBC 2019, Section 1609 as applicable, and the recommended guidelines in ASCE Wind Loads for Petrochemical and Other Industrial Facilities.

3.4 Snow Load/Rain Load

Snow Load will be calculated according to CBC Section 1603.1.3, Section 1608 and Chapter 7 of ASCE 7.

Rain Load will be applied if concentration on the roof is expected.

The design roof load shall not be less than that determined by CBC Section 1607.

3.5 Seismic Loads

Structures and the reservoir will be designed and constructed to resist the effects of earthquake loads and possible liquefaction as determined in CBC 2019. Site class and liquefaction measures for susceptible soil will be determined by geotechnical investigation report. The occupancy category of the structure is III (per CBC Table 1604.5) and the corresponding important factor is 1.25.

3.6 Earth Pressure

Earth passive and active pressures will be calculated based on geotechnical investigation report recommendations.

3.7 Groundwater Pressure

Based on the depth of groundwater, the hydrostatic pressure attributable to groundwater will be considered. Geotechnical investigation report will provide average depth of the groundwater within the site at the present and historical data.

3.8 Turbine-Generator/Compressor Loads

The heavy equipment loads (for generators/compressors) for platform/foundation design will be furnished by their manufacturers and will be applied according to the equipment manufacturer’s specifications, criteria, and recommendations.

3.9 Steel Stacks

Steel stacks will be designed by manufacturer’s Engineer to withstand normal and abnormal operating condition in combination with design 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. Supporting foundation will be designed according to stack manufacturer's footprint and loads, specifications, criteria, and recommendations.

3.10 Impact Loads

For structures carrying live loads which induce impact, the static live loads shall be increased sufficiently to cover the impact load.

Crane runways shall be designed for the crane stop forces provided by manufacturer's recommendations or specification.

Table 4- Impact Loads

Category	Vertical Impact (%)	Lateral Impact (%) *
For Support of Elevators	100	-
For Support of Light Machinery, Shaft or Motor Driven	20	-
For Support of Reciprocating Machinery or Power-Driven Units	50	-

*Lateral impact based on the manufacturer recommendation (e.g., lateral impact for cranes =20%)

4 DESIGN BASIS

Reinforced concrete structures shall be designed (ultimate strength design method) in accordance with the CBC 2019 and the ACI 318.

Allowable soil bearing pressure for foundation design will be in accordance with the geotechnical investigation report.

Steel structures will be designed by using strength design or allowable strength design methods according to CBC 2019 and AISC Specification for Structural Steel Buildings.

Earthen and rockfill structures will be designed in accordance with the recommendations provided in the geotechnical investigation report; where required, impermeable membranes will be installed on the wetted surface side of water retention structures. Reservoir structures that meet jurisdiction requirements under the Division of Safety of Dams (DSOD) will meet the applicable DSOD requirements

4.1 Following items shall be considered during the design in accordance with CBC 2019

4.1.1 Serviceability and Stability
4.1.2 Deflection and Drift Criteria
4.1.3 Load Factors and Load Combinations
4.1.4 Important Factors
4.1.5 Clearances

4.2 Factor of Safety

4.2.1 Against overturning: 1.50
4.2.2 Against sliding: 2.0 for wind loads, 1.10 for seismic loads
4.2.3 Against uplift due to wind: 1.50
4.2.4 Against buoyancy: 1.25

4.3 Construction Materials

4.3.1 Concrete (f’c as measured at 28 days):
Structural concrete (f’c) = 4,000 psi (min.), electrical duct bank encasement (f’c) = 2,500 psi and structural grout (f’c) = 5,000 psi

The concrete or grout classes to be determined by design drawings or design specifications

4.3.2 Concrete Reinforcement
Reinforcing steel shall be deformed bars of billet steel conforming to ASTM A615, Grade 60 or A706, Grade 60

4.3.3 Structural Steel

Structural steel shall conform to the standards listed in Table 3.

Table 3 (Structural Steel Standards)

Category	Applicable Standard
Structural and Miscellaneous steel	ASTM A36, ASTM A572 or ASTM A992
High Strength Structural Bolts, Nuts and Washers	ASTM A325, ASTM A490 or ASTM F1554 As Applicable
Bolts other than high-strength structural bolts	ASTM A307, Grade A or As Indicated in Design Drawings

4.3.4 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.

APPENDIX 2A

Control Engineering

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EMPOWERING EPCM

Hydrostor Pecho/ Gem Energy Storage Center - AFC Inputs

Appendix 2.5 – Control Engineering

Project Number: 21-5375

TWD Document Number: 21-5375-00-3536-001

Date (y/m/d)	Revision	Description of Revision	Prepared	Checked	Approved
25/08/21	0	Issued for Use	TME	AJS	SEP

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1 OBJECTIVE

1.1 Hydrostor is investigating two potential sites in California for their Advanced Compressed Air Energy Storage (A-CAES) technology. The two sites are Pecho (near Morro Bay), and Gem (near Rosamond).

1.2 TWD is working with Hydrostor and Golder to prepare an Application For Certification (AFC) to the California Energy Commission (CEC) for the two sites. Golder is preparing and will submit the overall AFC, with technical input from TWD.

1.3 This document provides technical input for Golder to develop the following AFC sections for both Pecho and Gem sites:

- Appendix 2.5 - Control Engineering

2 INTRODUCTION

2.1 This appendix summarizes the codes, standards, criteria, and practices that will be generally used in the design and installation of instrumentation and controls. More specific project information will be developed during execution of the project to support detailed design, engineering, material procurement specifications, and construction specifications.

3 CODES AND STANDARDS

3.1 The design specification of all work will be in accordance with the laws and regulations of the federal government, the State of California, local County, and City, as well as applicable industry standards. 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)

4 CONTROL SYSTSM DESIGN CRITERIA

4.1 General Requirements

All signals to and from the Central Control Room shall be electric / electronic. The standard signal shall be analogue 4-20 mA using 2-wire system, standard thermocouple, RTD output, and / or suitable pulse signal.

Instruments located on control panels and central control room (CCR) shall be microprocessor based.

On platforms with processing facilities, a Distributed Control System (DCS) shall be provided for monitoring and controlling the process, and for generating alarms in case of process upsets.

4.2 Process Control System

The process control system will provide all monitoring and control of the facility. The process control system configuration will be justified with the plant engineering contractor based on the facility complexity.

The facility will function automatically with minimum operator intervention. Emphasis will be given to automating routine actions so that the operator has more time to analyse and identify short and medium-term plant performance, efficiency and imminent failures.

Adequate instrumentation shall be installed to enable operations personnel to monitor plant performance from the central control room with minimum field intervention. Field operators will only assist in visual surveillance and intervene only when critical equipment and systems warrant immediate attention. All field functions will require a permissive signal from the control system.

For standalone control packages within the facility where operator action is entirely local, a package common alarm will be connected to the process control system to direct an operator to examine local indicators or panels in order to determine equipment status.

4.3 Monitoring and Controls

The Process Control System shall use solid-state equipment and Programmable Logic Controllers (PLC) or Distributed Control Systems (DCS) to increase reliability and flexibility.

The use of electromechanical control relays shall be avoided, except when required for safety interlocks.

Communications between the PLC and HMI, and PLC to PCS shall be Ethernet TCP/IP or ProfiNet.

Communications to MCC's and VFD's to be Ethernet based. Communications to discrete field contacts to be AS-I complete with limit switch indications.

Wireless communication devices shall be used for communication between control room and operators in the plant.

4.4 Field Instruments

Electronic instruments rather than pneumatic are preferred for operation of the equipment. Electronic instruments shall use 4-20 mA, 24 V DC signals for transmission and control. Smart Transmitters with 'Hart protocol' shall be used as much as possible. The remainder of the transmitters will preferably be of the two-wire type, and each transmitter shall be separately fused.

All instruments shall be rated for the hazardous environment in which they are located. When appropriately rated equipment is not available, intrinsically safe barriers mush be provided and installed in the control panel.

Auxiliary power supplies for instruments shall in the first instant be 24 V DC, however where increased power consumption is required, 120 V AC shall be used. Each instrument shall have its own power disconnect device, and each motorized and solenoid actuated valve shall be separately fused.

4.5 Pressure Instruments

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

4.6 Temperature Instruments

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

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.

Resistance temperature detectors will be 100-ohm platinum, three-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.

4.7 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.

4.8 Flow Instruments

Flow transmitters will typically be of the differential pressure-type. Alternate type flow transmitters may be used where required to ensure high accuracy measurements. In general, linear scales will be used for flow indication and recording. Magnetic type flow transmitters may be used for liquid flow measurement below 200°F.

4.9 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 were economical.

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 85 decibels, 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 pounds per square inch gauge.

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.

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

4.10 Instrument Tubing and Installation

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

Instrument tubing fittings will be the compression type.

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.

4.11 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.

4.12 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 type. 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.

4.13 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.

APPENDIX 2A

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EMPOWERING EPCM

Hydrostor Pecho/ Gem Energy Storage Center - AFC Inputs

Appendix 2.4 – Electrical Engineering

Project Number: 21-5375

TWD Document Number: 21-5375-00-3636-002

Date (y/m/d)	Revision	Description of Revision	Prepared	Checked	Approved
25/08/21	0	Issued for Use	CAB	TME	SEP

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1 OBJECTIVE

1.1 Hydrostor is investigating two potential sites in California for their Advanced Compressed Air Energy Storage (A-CAES) technology. The two sites are Pecho (near Morro Bay), and Gem (near Rosamond).

1.2 TWD is working with Hydrostor and Golder to prepare an Application For Certification (AFC) to the California Energy Commission (CEC) for the two sites. Golder is preparing and will submit the overall AFC, with technical input from TWD.

1.3 This document provides technical input for Golder to develop the following AFC sections for both Pecho and Gem sites:

- Appendix 2.4 – Electrical Engineering

2 INTRODUCTION

2.1 This appendix summarizes the codes, standards, criteria, and practices that will be generally used in the design and construction of electrical engineering systems. More specific project information will be developed prior to construction of the project to support detailed design, engineering, material procurement, and construction specifications as required by CEC.

3 CODES AND STANDARDS

3.1 The design specification of all work will be in accordance with the laws and regulations of the federal government, the State of California, local County, and City, as well as applicable 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 requirement shall 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)

- Insulated Cable Engineers Association (ICEA)
- Institute of Electrical and Electronics Engineers (IEEE)
- Illuminating Engineering Society (IES)
- California Electrical Code
- National Electrical Manufacturers Association (NEMA)
- National Electrical Safety Code (NESC)

4 SUBSTATION AND TRANSFORMERS

4.1 Substation

The substation will be located on the western end of both sites and will interconnect via a 230kV Overhead line to Whirlwind Substation and Morro Bay Substations for Gem and Pecho Sites respectively. The substation will be of the tubular IPS bus type with interconnecting conductors and will consist of high-voltage SF6-insulated dead-tank circuit breakers and no-load switches.

Connections to the aerial conductor cable will be provided from the two dual-winding transformers for the inter-tie to the utility grid. The high-voltage circuit breaker will be equipped with a no-load break, air-insulated, disconnect switch. A transformer circuit breaker and isolating disconnect switch will also be installed in each transformer connection to allow for transformer protection and isolation when the corresponding transformer is out of service. Tubular IPS bus type with interconnecting conductors will be used as the primary interconnection material within the switchyard. The IPS and conductors will be attached to post-insulator columns on structural steel supports. The main substation transforms power from/to 230kV to/from 69kV.

Current and voltage transformers will be located at points within the substation to provide for metering and relaying. Control, protection, and monitoring for the substation will be located in the substation protection and control building. Monitoring and alarms will be available to the supervisory control system operator workstations in the control module. All protection and circuit breaker control will be powered from the station battery-backed 125VDC system.

Each motor/generator substation will have two dual-winding transformers with wye-delta for the generator and delta-wye for the motors. The HV (69kV) side will be fed with underground cables and the 13.8kV side will be ISO Phase Bus Duct connections with SF6 circuit breakers.

The substation designs will meet the requirements of the National Electrical Safety Code—ANSI C2.

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

Lightning protection will be provided by shield wires and/or lightning masts for any overhead lines. 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 practicable for the safety of equipment, personnel, and the public. Protective relaying will meet IEEE requirements and will be coordinated with PG&E's requirements.

There will be a 10.5-mile-long (approximately) tie-line to the utility substation 230-kilovolt (kV) bus for Gem and a 3.5-mile-long (approximately) tie-line to the utility substation 230kV bus for Pecho. The high-voltage circuit breaker will be provided with a breaker failure relay protection scheme. Breaker failure protection will be accomplished by protective and timing relays. The high-voltage breaker will have two redundant trip coils.

Interface with PG&E's supervisory control and data acquisition system will be provided. Interface will be at the interface terminal box and remote terminal unit. Communication between the facility switchyard and the control building to which it is connected will be included.

Revenue metering will be provided on the 230kV outgoing lines recording net power to or from the PG&E switchyard (bi-directional). The revenue meters and a metering panel will be located in the main switchyard protection and control building.

4.2 Transformers

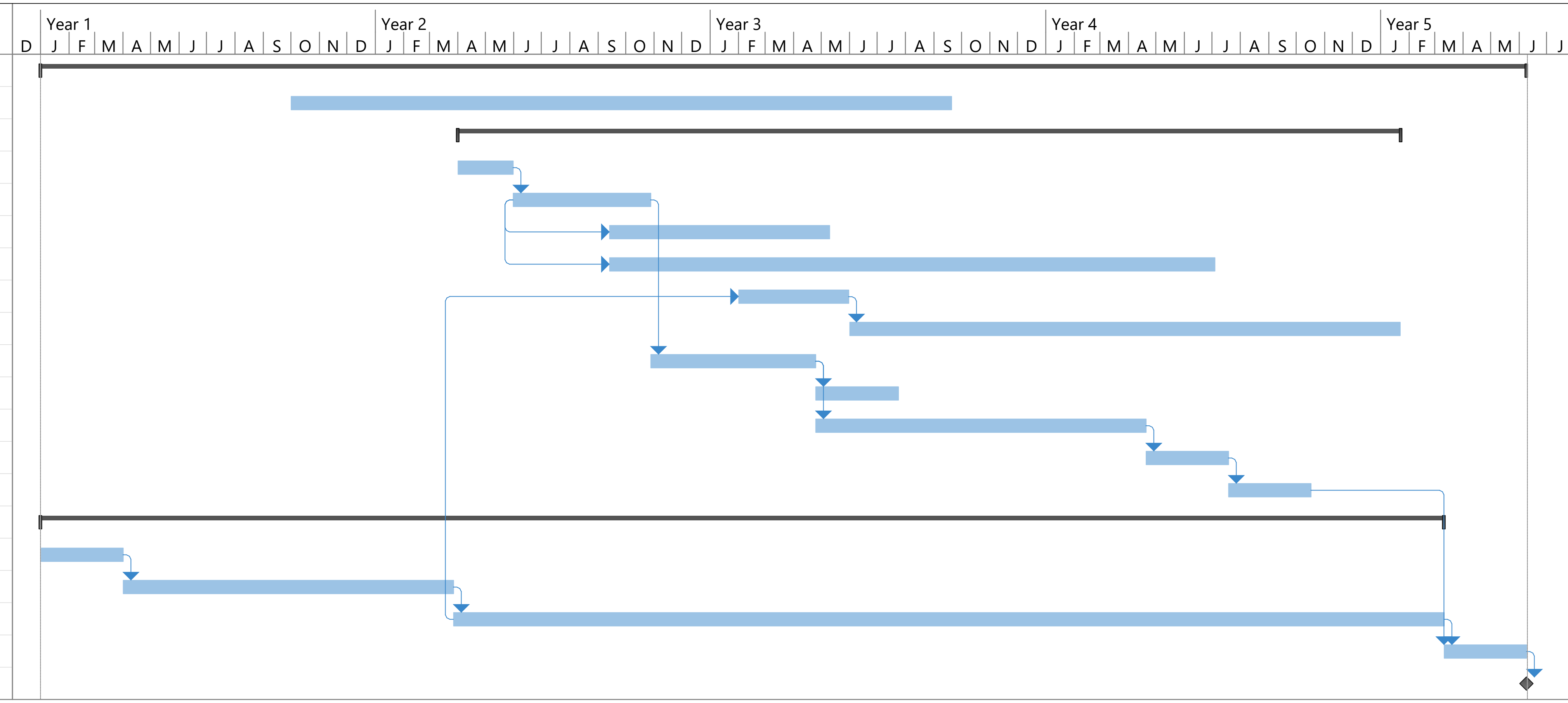
All generators and motors will be rated for 13.8kV and connect to a 69kV distribution system which in turn feeds the 230kV switchyard through step-up transformers. The step-up transformers will be designed in accordance with ANSI/IEEE standards C57.12.00, C57.12.90, and C57.116. The transformers will be dual-winding, delta-wye, ONAN/ONAF, 65°C rise. Grounding of the transformers will be suitable for both generation and motor function. The main substation will be equipped with lightning arrestors and will have manual de-energized ("no-load") tap changers located in the HV windings.

Facility power will be supplied through unit auxiliary transformers connected to the 69kV distribution system. Four two-winding, delta-wye 69kV to 4.16kV transformers with low impedance grounding resistors will be provided.

APPENDIX 2B

Construction Schedule

ID	Task Name	Duration
1	**Pecho Energy Storage Center Construction Schedule**	**54 emons**
2	**Transmission Infrastructure Construction**	24 emons
3	**Above Ground A-CAES Plant**	**34.25 emons**
4	Mobilization	2 emons
5	Site Civil & Foundations	5 emons
6	Turbine Hall	8 emons
7	Spherical Pressure Vessels	22 emons
8	Surface Reservoir	4 emons
9	Reservoir Fill Time	20 emons
10	Install Primary Equipment Modules	6 emons
11	Structural & Architectual	3 emons
12	Piping, Mechanical & Electrical	12 emons
13	Controls	3 emons
14	Pre-Comissioing	3 emons
15	**Subsurface Storage Cavern**	**51 emons**
16	Site Prep & Clearing	3 emons
17	Cavern Shaft Drilling	12 emons
18	Cavern Mining & Conversion	36 emons
19	**Final Comissioing Stage**	3 emons
20	**Commercial Operation Dates**	0 days



APPENDIX 2C

Heat and Mass Balance Average Temperature Case

Pro ect	Calculation o				
Hydrostor California Morro Bay/Rosamond	21-5375-00-3438-007				
Client					
Hydrostor	Re	Date	B	Chk	
Pro ect o				Y	Y
21-5375				AKN	

Heat and Material Balance - Pecho Unit - Case Average Temperature

Table 1. Heat and Material Balance Table - Air Streams

	Stream Number PFD *																			
	Description	Unit	tm ntake ir to P Com ressors	ir to P eat E chan ers	ir to P Com ressors	ir from P Com ressors	ir to P Com ressors	ir from P Com ressors	ir from P eat E chan er to ir Trim Cooler	ir from ir Trim Cooler	ll Trains ir to Stora e Ca ern	Ca ern ir to ll Trains	Ca ern ir to Train	ir to P Tur ine	ir from P Tur ine	ir to P Tur ine	ir from P Tur ine	ir to P Tur ine	P Tur ine utlet ent to tmos here
Overall	a our raction																		
	Tem erature																		
	Pressure	sia																	
	ass lo	l h																	
	olar lo	l mole h																	
	olecular Wei ht	l l mole																	
	ass Densit T P	l ft																	
	Enthal	BT hr																	

Table 2. Heat and Material Balance Table - Thermal Fluid Streams

	Stream Number PFD *				C	C	C	C	C	C	C	C	C	D	D	D	D	D	D	D	D	D		
	Description	Unit	Col Thermal lui from Col Tank	Col Thermal lui to ll Trains	Col Thermal lui to Train E chan ers	Col Thermal lui to P eat E chan ers	Col Thermal lui to P eat E chan ers	Col Thermal lui to P eat E chan ers	Thermal lui from P eat E chan ers	Warme Thermal lui from P eat E chan ers	Warme Thermal lui from P eat E chan ers	Train Warme Thermal lui to ot Stora e Tanks	ll Trains Thermal lui to ot Stora e Tanks	Thermal lui to Thermal Cooler in ans	Coole Thermal lui from P eat E chan ers	Coole Thermal lui from P eat E chan ers	Coole Thermal lui from P eat E chan ers	ot Thermal lui to P eat E chan ers	ot Thermal lui to P eat E chan ers	ot Thermal lui to P eat E chan ers	Train ot Thermal lui from ot Stora e Tanks	ot Thermal lui to ll Trains	Col Thermal lui to Thermal lui Trim Cooler	Col Thermal lui from Thermal lui Trim Cooler
Overall	a our raction																							
	Tem erature																							
	Pressure	sia																						
	ass lo	l h																						
	olar lo	l mole h																						
	olecular Wei ht	l l mole																						
	ass Densit T P	l ft																						
	Enthal	BT hr																						

Table 3. Heat and Material Balance Table - Cooling Medium Streams

	Stream Number PFD *		C	C	C		C	C		C	C	D	D	D	D	D	D	D
	Description	Unit	Coolin e ium to Coolin e ium Circulation Pum s	Coolin e ium from Coolin e ia Circulation Pum s	Coolin e ium from Coolin e ium in an Cooler	Coolin e ium to Train ir Trim Cooler	Coolin e ium to Coolin e ium Chiller	Coolin e ium to Tur omachiner Coolin	Coolin e ium Return from Train ir Trim Cooler	Coolin e ium Return from Tur omachiner Coolin	Coolin e ium Return to Coolin e ium Buffer Tank	Coolin e ium to Coolin e ium Circulation Pum s	Coolin e ium from Coolin e ia Circulation Pum s	Coolin e ium from Coolin e ium in an Cooler	Coolin e ium to Coolin e ium Chiller	Coolin e ium to Tur omachiner Coolin	Coolin e ium Return from Tur omachiner Coolin	Coolin e ium Return from Tur omachiner Coolin
Overall	a our raction																	
	Tem erature																	
	Pressure	sia																
	ass lo	l h																
	olar lo	l mole h																
	olecular Wei ht	l l mole																
	ass Densit T P	l ft																
	Enthal	BT hr																

NOTES:
(*) Letters C and D denote Charge and Discharge Cycle, respectively.

APPENDIX 2C

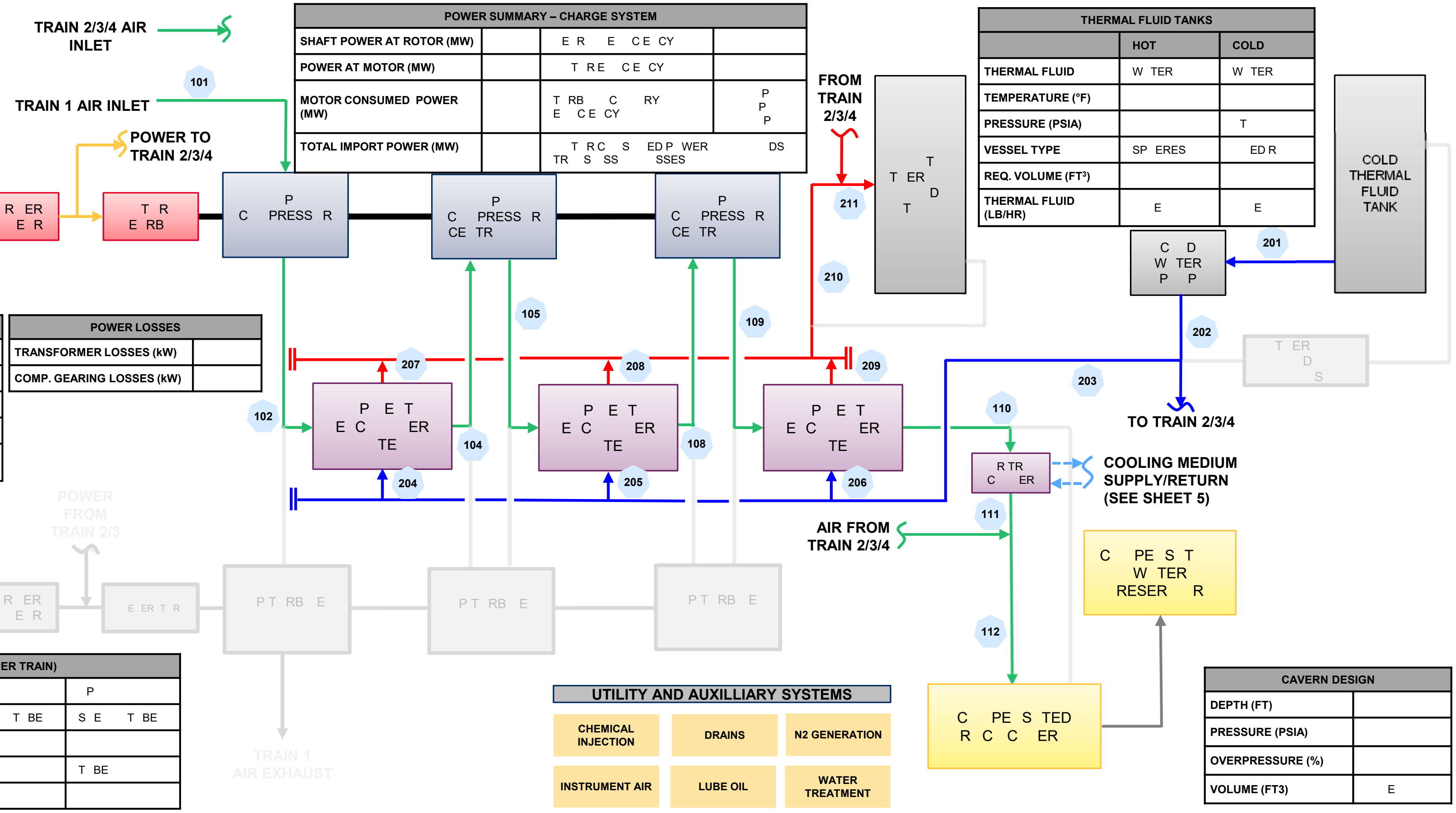
Heat and Mass Balance Diagrams

CHARGE CYCLE

SYSTEM PARAMETERS (NOTE 1)	
AIR FLOW (LB/HR) PER TRAIN	E
SYSTEM DISCHARGE ENERGY (MWh)	
ROUND TRIP EFFICIENCY (%)	
CHARGE DURATION (HRS)	

POWER SUMMARY – CHARGE SYSTEM			
SHAFT POWER AT ROTOR (MW)		E R E CE CY	
POWER AT MOTOR (MW)		T RE CE CY	
MOTOR CONSUMED POWER (MW)		T RB C RY E CE CY	P P P
TOTAL IMPORT POWER (MW)		T R C S ED P WER TR S SS SSES	DS

THERMAL FLUID TANKS		
	HOT	COLD
THERMAL FLUID	W TER	W TER
TEMPERATURE (°F)		
PRESSURE (PSIA)		T
VESSEL TYPE	SP ERES	ED R
REQ. VOLUME (FT³)		
THERMAL FLUID (LB/HR)	E	E



LOAD TABLE – CHARGE (CONSUMED POWER)	
COMPRESSOR AUXILIARIES (kW)	
PUMPS (kW)	
COOLING LOADS (kW)	
OTHER AUXILIARIES PER TRAIN (kW)	
TOTAL CHARGE LOAD PER TRAIN - INCL.30% CONTINGENCY (kW)	

POWER LOSSES	
TRANSFORMER LOSSES (kW)	
COMP. GEARING LOSSES (kW)	

MAIN HEAT EXCHANGERS (PER TRAIN)			
STAGE	P	P	P
TYPE	S E T BE	S E T BE	S E T BE
NO. SHELLS			
AIR FLOW SIDE	T BE	T BE	T BE
DUTY (MMBtu/hr)			

UTILITY AND AUXILLIARY SYSTEMS

CHEMICAL INJECTION
DRAINS
N2 GENERATION
INSTRUMENT AIR
LUBE OIL
WATER TREATMENT

CAVERN DESIGN	
DEPTH (FT)	
PRESSURE (PSIA)	
OVERPRESSURE (%)	
VOLUME (FT3)	E

LEGEND			
	MECHANICAL DRIVE		ELECTRICAL FLOW
	HOT THERMAL FLUID		COOLING MEDIUM
	COLD THERMAL FLUID		RESERVOIR WATER
	AIR		BATTERY LIMIT
	COOLING MEDIUM		

B BER

W TER SYSTE S
E T E C ER
T RB C ERY
E ECTR C SYSTE S
C ER SYSTE

T S C DE T D C E T C T S TE ECT PR PERTY D S S B ECT T D SC S RE REE E T RE D STR B T S STR CT Y PR B TED W T T WR TTE C SE T YDR ST R C

HYDROSTOR A-CAES PECHO
ER B C W D R
MAN LP AXIAL (100MW) – 400MW / 3200MWh
AVERAGE CASE

D C E T
RE
S T

DISCHARGE CYCLE

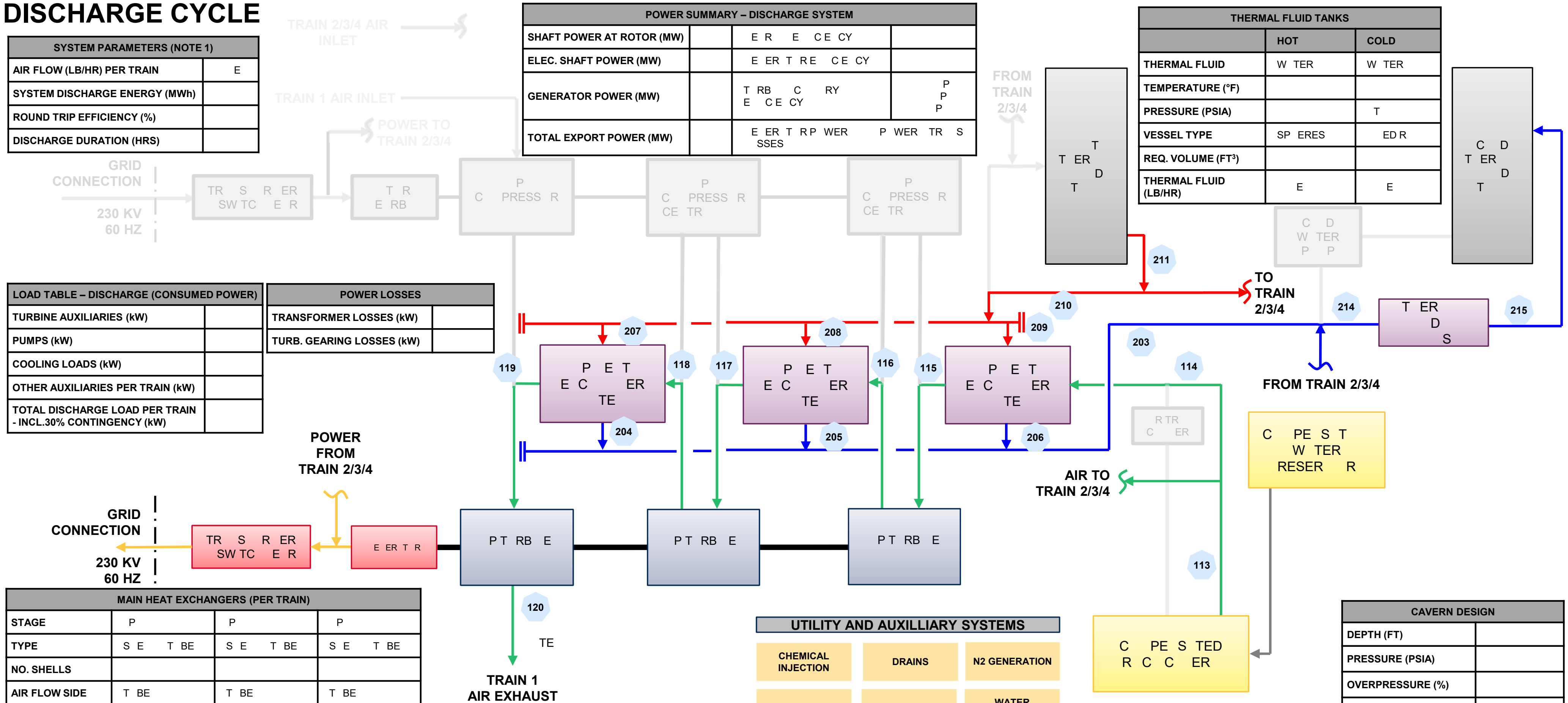
SYSTEM PARAMETERS (NOTE 1)	
AIR FLOW (LB/HR) PER TRAIN	E
SYSTEM DISCHARGE ENERGY (MWh)	
ROUND TRIP EFFICIENCY (%)	
DISCHARGE DURATION (HRS)	

POWER SUMMARY – DISCHARGE SYSTEM			
SHAFT POWER AT ROTOR (MW)		E R E CE CY	
ELEC. SHAFT POWER (MW)		E ER T RE CE CY	
GENERATOR POWER (MW)		T RB C RY E CE CY	P P P
TOTAL EXPORT POWER (MW)		E ER T RP WER P WER TR S SSES	

THERMAL FLUID TANKS	HOT	COLD
THERMAL FLUID	W TER	W TER
TEMPERATURE (°F)		
PRESSURE (PSIA)		T
VESSEL TYPE	SP ERES	ED R
REQ. VOLUME (FT³)		
THERMAL FLUID (LB/HR)	E	E

LOAD TABLE – DISCHARGE (CONSUMED POWER)	
TURBINE AUXILIARIES (kW)	
PUMPS (kW)	
COOLING LOADS (kW)	
OTHER AUXILIARIES PER TRAIN (kW)	
TOTAL DISCHARGE LOAD PER TRAIN - INCL.30% CONTINGENCY (kW)	

POWER LOSSES	
TRANSFORMER LOSSES (kW)	
TURB. GEARING LOSSES (kW)	



MAIN HEAT EXCHANGERS (PER TRAIN)			
STAGE	P	P	P
TYPE	S E T BE	S E T BE	S E T BE
NO. SHELLS			
AIR FLOW SIDE	T BE	T BE	T BE
DUTY (MMBTU/HR)			

UTILITY AND AUXILLIARY SYSTEMS

CHEMICAL INJECTION	DRAINS	N2 GENERATION
INSTRUMENT AIR	LUBE OIL	WATER TREATMENT

CAVERN DESIGN	
DEPTH (FT)	
PRESSURE (PSIA)	
OVERPRESSURE (%)	
VOLUME (FT3)	E

LEGEND		
MECHANICAL DRIVE		ELECTRICAL FLOW
HOT THERMAL FLUID		COOLING MEDIUM
COLD THERMAL FLUID		RESERVOIR WATER
AIR		BATTERY LIMIT
COOLING MEDIUM		

B BER

W TER SYSTE S
E T E C ER
T RB C ERY
E ECTR C SYSTE S
C ER SYSTE

T SC DE T D C E T C T S TE ECT PR PERTY D S S B ECT T D SC S RE REE E T RE D STR B T S STR CT Y PR B TED W T T WR TTE C SE T YDR ST R C

HYDROSTOR A-CAES PECHO

ER B C W D R

MAN LP AXIAL (100MW) – 400MW / 3200MWh AVERAGE CASE

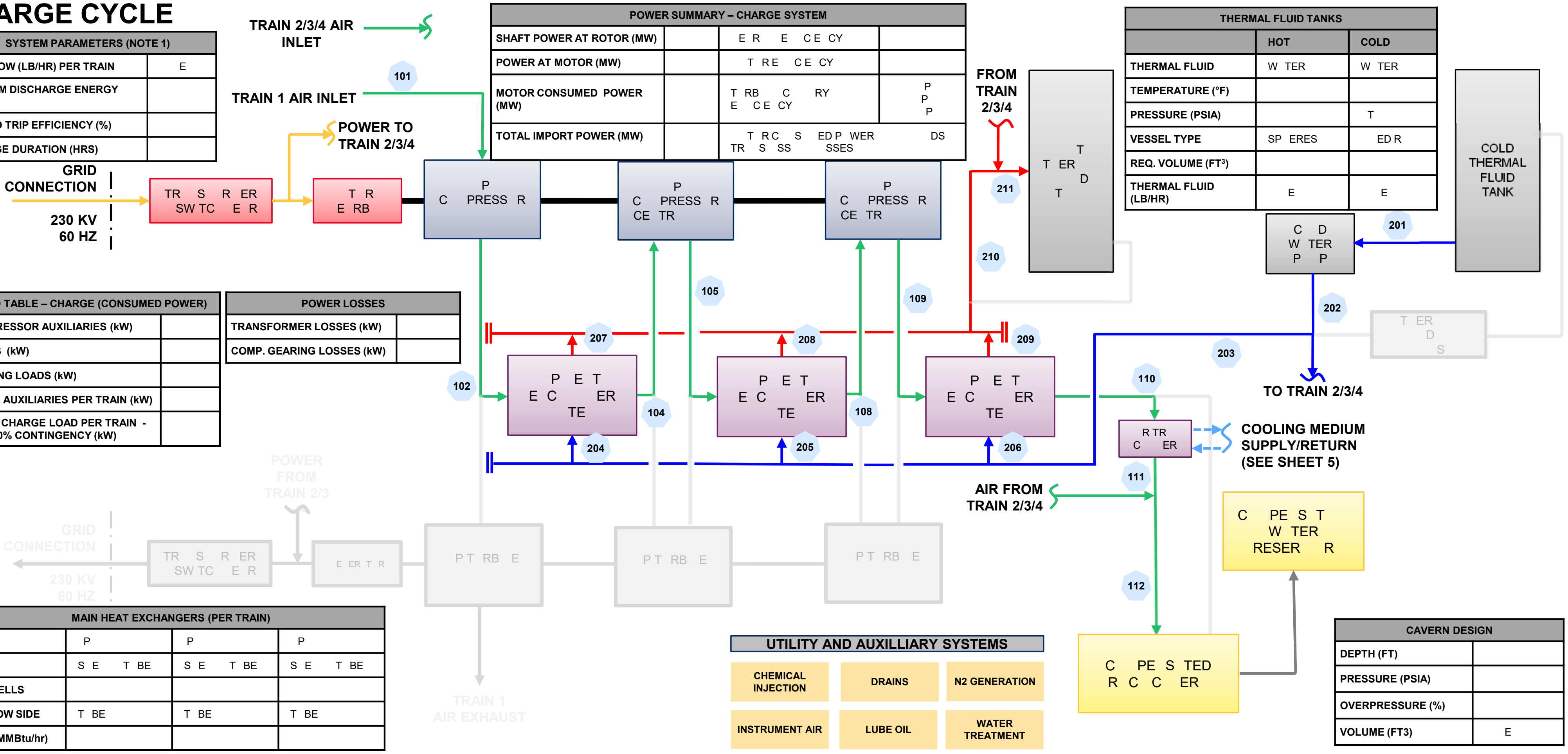
TWD EMPOWERING EPCM

HYDROSTOR

D C E T | RE

S T

CHARGE CYCLE



SYSTEM PARAMETERS (NOTE 1)	
AIR FLOW (LB/HR) PER TRAIN	E
SYSTEM DISCHARGE ENERGY (MWh)	
ROUND TRIP EFFICIENCY (%)	
CHARGE DURATION (HRS)	

POWER SUMMARY – CHARGE SYSTEM			
SHAFT POWER AT ROTOR (MW)		E R E CE CY	
POWER AT MOTOR (MW)		T RE CE CY	
MOTOR CONSUMED POWER (MW)		T RB C RY E CE CY	P P P
TOTAL IMPORT POWER (MW)		T R C S ED P WER TR S SS SSES	DS

THERMAL FLUID TANKS	HOT	COLD
THERMAL FLUID	W TER	W TER
TEMPERATURE (°F)		
PRESSURE (PSIA)		T
VESSEL TYPE	SP ERES	ED R
REQ. VOLUME (FT³)		
THERMAL FLUID (LB/HR)	E	E

LOAD TABLE – CHARGE (CONSUMED POWER)	
COMPRESSOR AUXILIARIES (kW)	
PUMPS (kW)	
COOLING LOADS (kW)	
OTHER AUXILIARIES PER TRAIN (kW)	
TOTAL CHARGE LOAD PER TRAIN - INCL.30% CONTINGENCY (kW)	

POWER LOSSES	
TRANSFORMER LOSSES (kW)	
COMP. GEARING LOSSES (kW)	

MAIN HEAT EXCHANGERS (PER TRAIN)			
STAGE	P	P	P
TYPE	S E T BE	S E T BE	S E T BE
NO. SHELLS			
AIR FLOW SIDE	T BE	T BE	T BE
DUTY (MMBtu/hr)			

UTILITY AND AUXILLIARY SYSTEMS

CHEMICAL INJECTION	DRAINS	N2 GENERATION
INSTRUMENT AIR	LUBE OIL	WATER TREATMENT

CAVERN DESIGN	
DEPTH (FT)	
PRESSURE (PSIA)	
OVERPRESSURE (%)	
VOLUME (FT3)	E

LEGEND

(black line)	MECHANICAL DRIVE	(yellow arrow)	ELECTRICAL FLOW
(red arrow)	HOT THERMAL FLUID	(dashed blue arrow)	COOLING MEDIUM
(blue arrow)	COLD THERMAL FLUID	(grey arrow)	RESERVOIR WATER
(green arrow)	AIR	(dash-dot line)	BATTERY LIMIT
(purple arrow)	COOLING MEDIUM		

B BER

W TER SYSTE S
E T E C ER
T RB C ERY
E ECTR C SYSTE S
C ER SYSTE

T S C DE T D C E TC T S TE ECT PR PERTY D S S B ECT T D SC S RE REE E T RE D STR B T S STR CT Y PR B TED W T T WR TTE C SE T YDR ST R C

HYDROSTOR A-CAES PECHO
ER B C W D R
MAN LP AXIAL (100MW) – 400MW / 3200MWh PEAK CASE

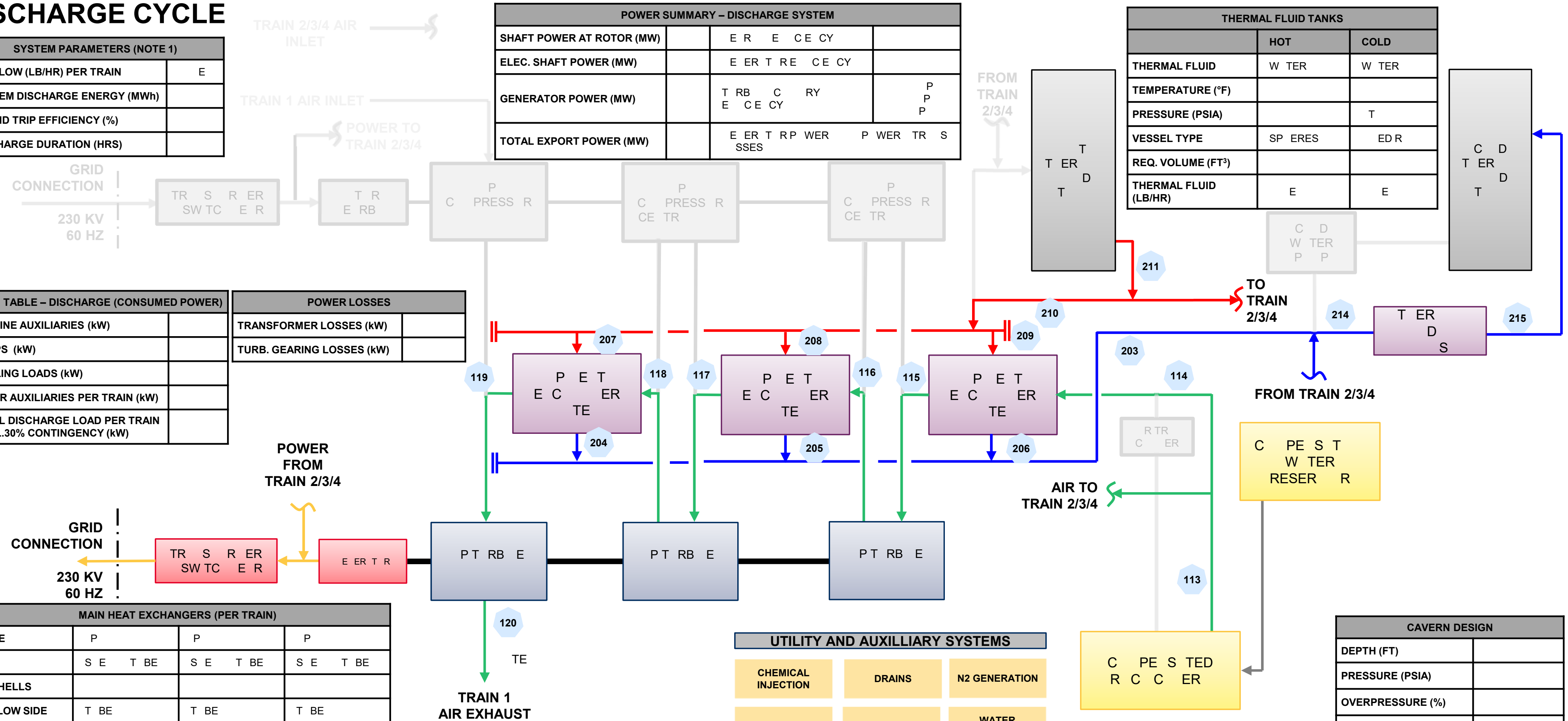
D C E T | RE
S T

DISCHARGE CYCLE

SYSTEM PARAMETERS (NOTE 1)	
AIR FLOW (LB/HR) PER TRAIN	E
SYSTEM DISCHARGE ENERGY (MWh)	
ROUND TRIP EFFICIENCY (%)	
DISCHARGE DURATION (HRS)	

POWER SUMMARY – DISCHARGE SYSTEM			
SHAFT POWER AT ROTOR (MW)		E R E CE CY	
ELEC. SHAFT POWER (MW)		E ER T RE CE CY	
GENERATOR POWER (MW)		T RB C RY E CE CY	P P P
TOTAL EXPORT POWER (MW)		E ER T RP WER P WER TR S SSES	

THERMAL FLUID TANKS		
	HOT	COLD
THERMAL FLUID	W TER	W TER
TEMPERATURE (°F)		
PRESSURE (PSIA)		T
VESSEL TYPE	SP ERES	ED R
REQ. VOLUME (FT³)		
THERMAL FLUID (LB/HR)	E	E



LOAD TABLE – DISCHARGE (CONSUMED POWER)	
TURBINE AUXILIARIES (kW)	
PUMPS (kW)	
COOLING LOADS (kW)	
OTHER AUXILIARIES PER TRAIN (kW)	
TOTAL DISCHARGE LOAD PER TRAIN - INCL.30% CONTINGENCY (kW)	

POWER LOSSES	
TRANSFORMER LOSSES (kW)	
TURB. GEARING LOSSES (kW)	

MAIN HEAT EXCHANGERS (PER TRAIN)			
STAGE	P	P	P
TYPE	S E T BE	S E T BE	S E T BE
NO. SHELLS			
AIR FLOW SIDE	T BE	T BE	T BE
DUTY (MMBTU/HR)			

UTILITY AND AUXILLIARY SYSTEMS

CHEMICAL INJECTION	DRAINS	N2 GENERATION
INSTRUMENT AIR	LUBE OIL	WATER TREATMENT

CAVERN DESIGN	
DEPTH (FT)	
PRESSURE (PSIA)	
OVERPRESSURE (%)	
VOLUME (FT3)	E

LEGEND		
MECHANICAL DRIVE		ELECTRICAL FLOW
HOT THERMAL FLUID		COOLING MEDIUM
COLD THERMAL FLUID		RESERVOIR WATER
AIR		BATTERY LIMIT
COOLING MEDIUM		

B BER

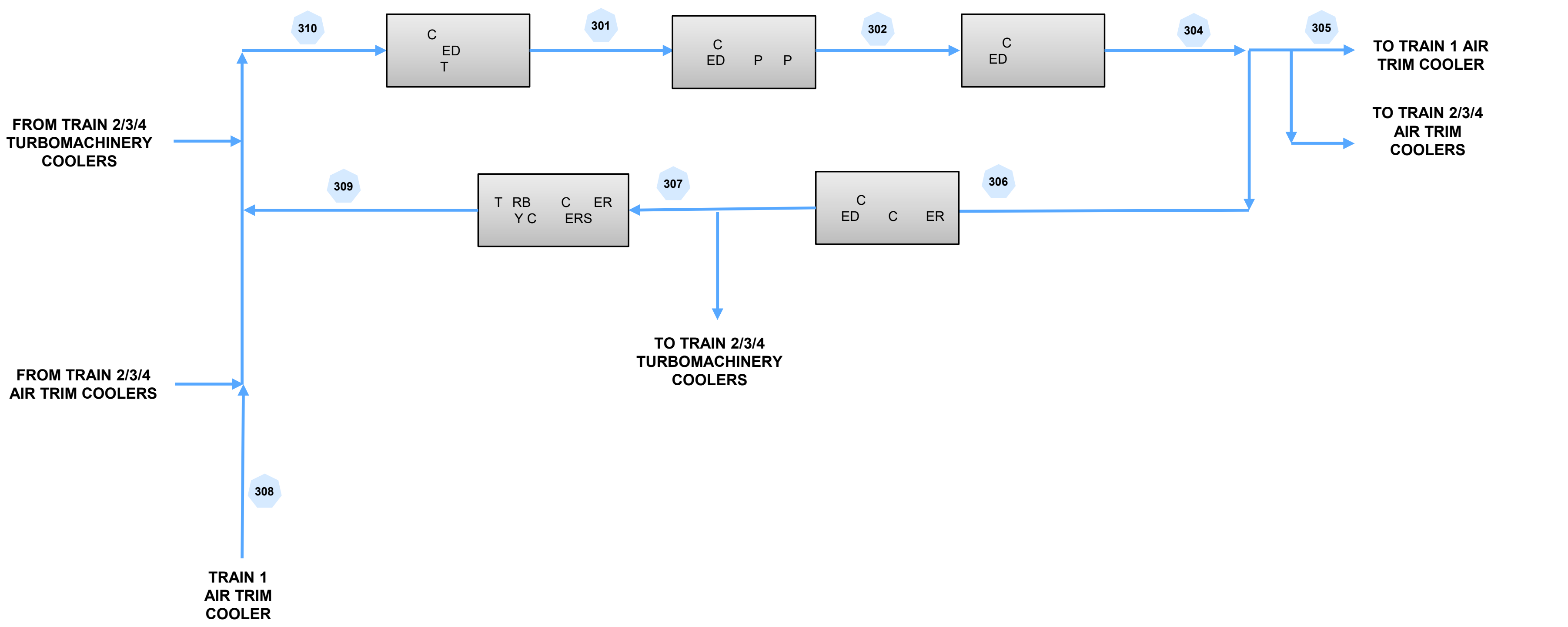
W TER SYSTE S
E T E C ER
T RB C ERY
E ECTR C SYSTE S
C ER SYSTE

T SC DE T D C E TC T S TE ECT PR PERTY D S S B ECT T D SC S RE REE E T RE D STR B T S STR CT Y PR B TED W T T WR TTE C SE T YDR ST R C

HYDROSTOR A-CAES PECHO
ER B C W D R
MAN LP AXIAL (100MW) – 400MW / 3200MWh PEAK CASE

D C E T	RE
S T	

COOLING MEDIUM SYSTEM



LEGEND

MECHANICAL DRIVE	ELECTRICAL FLOW
HOT THERMAL FLUID	COOLING MEDIUM
COLD THERMAL FLUID	RESERVOIR WATER
AIR	BATTERY LIMIT
COOLING MEDIUM	

HYDROSTOR A-CAES PECHO

MAN LP AXIAL (100MW) – 400MW / 3200MWh

NOTES

S E WC PRESS E P S TR SS W WTR S E PT E SYSTE S W E T ER D C ER D T TY SYSTE S B SED W C TY
P P D P E TE C ER PER T S RE ERS B E T E S EE C ERS RE SED B T T E C R E D D SC R E CYC ES T E E C ER B C S W REPRESE TS T P E E C ERS RE ER T E TE C ER T B E R BER E C ERS
ES S W T S DR W RE T E R T E YSYS S T DE
a ER E C SE B C SE RE C SE B R W PEC
PE C SE B C SE RE C SE B R W PEC
T S B C W D R S B SED T E W P R ETERS
a D SC R E D R T RS
P C PRESS R TYPE
c T RB C ERY E D R
D SC R E E ST RE E CY E PECTED T BE RS PER D Y

T S C DE T D C E T C T S TE ECT PR PERTY D S S B ECT T D SC S RE REE E T RE D STR B T S STR CT Y PR B TED W T T WR TTE C SE T YDR ST R C

HYDROSTOR A-CAES PECHO

ER B C W D R

MAN LP AXIAL (100MW) – 400MW / 3200MWh

D C E T

S T

RE

APPENDIX 2C

Heat and Mass Balance Maximum Temperature Case

Pro ect	Calculation o			
Hydrostor California Morro Bay/Rosamond	21-5375-00-3438-006			
Client				
Hydrostor	Re	Date	B	Chk
Pro ect o			Y	Y
21-5375				

Heat and Material Balance - Pecho Unit - Case Peak Temperature

Table 1. Heat and Material Balance Table - Air Streams

	Stream Number PFD *																		
	Description	Unit	tm ntake ir to P Com ressors	ir to P eat E chan ers	ir to P Com ressors	ir from P Com ressors	ir to P Com ressors	ir from P Com ressors	ir from P eat E chan er to ir Trim Cooler	ir from ir Trim Cooler	ll Trains ir to Stora e Ca ern	Ca ern ir to ll Trains	Ca ern ir to Train	ir to P Tur ine	ir from P Tur ine	ir to P Tur ine	ir from P Tur ine	ir to P Tur ine	P Tur ine utlet ent to tmos here
Overall	a our raction																		
	Tem erature																		
	Pressure	sia																	
	ass lo	l h																	
	olar lo	l mole h																	
	olecular Wei ht	l l mole																	
	ass Densit T P	l ft																	
	Enthal	BT hr																	

Table 2. Heat and Material Balance Table - Thermal Fluid Streams

	Stream Number PFD *				C	C	C	C	C	C	C	C	C	D	D	D	D	D	D	D	D	D		
	Description	Unit	Col Thermal lui from Col Tank	Col Thermal lui to ll Trains	Col Thermal lui to Train E chan ers	Col Thermal lui to P eat E chan ers	Col Thermal lui to P eat E chan ers	Col Thermal lui to P eat E chan ers	Thermal lui from P eat E chan ers	Warme Thermal lui from P eat E chan ers	Warme Thermal lui from P eat E chan ers	Train Warme Thermal lui to ot Stora e Tanks	ll Trains Thermal lui to ot Stora e Tanks	Thermal lui to Thermal Cooler in ans	Coole Thermal lui from P eat E chan ers	Coole Thermal lui from P eat E chan ers	Coole Thermal lui from P eat E chan ers	ot Thermal lui to P eat E chan ers	ot Thermal lui to P eat E chan ers	ot Thermal lui to P eat E chan ers	Train ot Thermal lui from ot Stora e Tanks	ot Thermal lui to ll Trains	Col Thermal lui to Thermal lui Trim Cooler	Col Thermal lui from Thermal lui Trim Cooler
Overall	a our raction																							
	Tem erature																							
	Pressure	sia																						
	ass lo	l h																						
	olar lo	l mole h																						
	olecular Wei ht	l l mole																						
	ass Densit T P	l ft																						
	Enthal	BT hr																						

Table 3. Heat and Material Balance Table - Cooling Medium Streams

	Stream Number PFD *		C	C	C		C	C		C	C	D	D	D	D	D	D	D
	Description	Unit	Coolin e ium to Coolin e ium Circulation Pum s	Coolin e ium from Coolin e ia Circulation Pum s	Coolin e ium from Coolin e ium in an Cooler	Coolin e ium to Train ir Trim Cooler	Coolin e ium to Coolin e ium Chiller	Coolin e ium to Tur omachiner Coolin	Coolin e ium Return from Train ir Trim Cooler	Coolin e ium Return from Tur omachiner Coolin	Coolin e ium Return to Coolin e ium Buffer Tank	Coolin e ium to Coolin e ium Circulation Pum s	Coolin e ium from Coolin e ia Circulation Pum s	Coolin e ium from Coolin e ium in an Cooler	Coolin e ium to Coolin e ium Chiller	Coolin e ium to Tur omachiner Coolin	Coolin e ium Return from Tur omachiner Coolin	Coolin e ium Return from Tur omachiner Coolin
Overall	a our raction																	
	Tem erature																	
	Pressure	sia																
	ass lo	l h																
	olar lo	l mole h																
	olecular Wei ht	l l mole																
	ass Densit T P	l ft																
	Enthal	BT hr																

NOTES:
(*) Letters C and D denote Charge and Discharge Cycle, respectively.

APPENDIX 2D

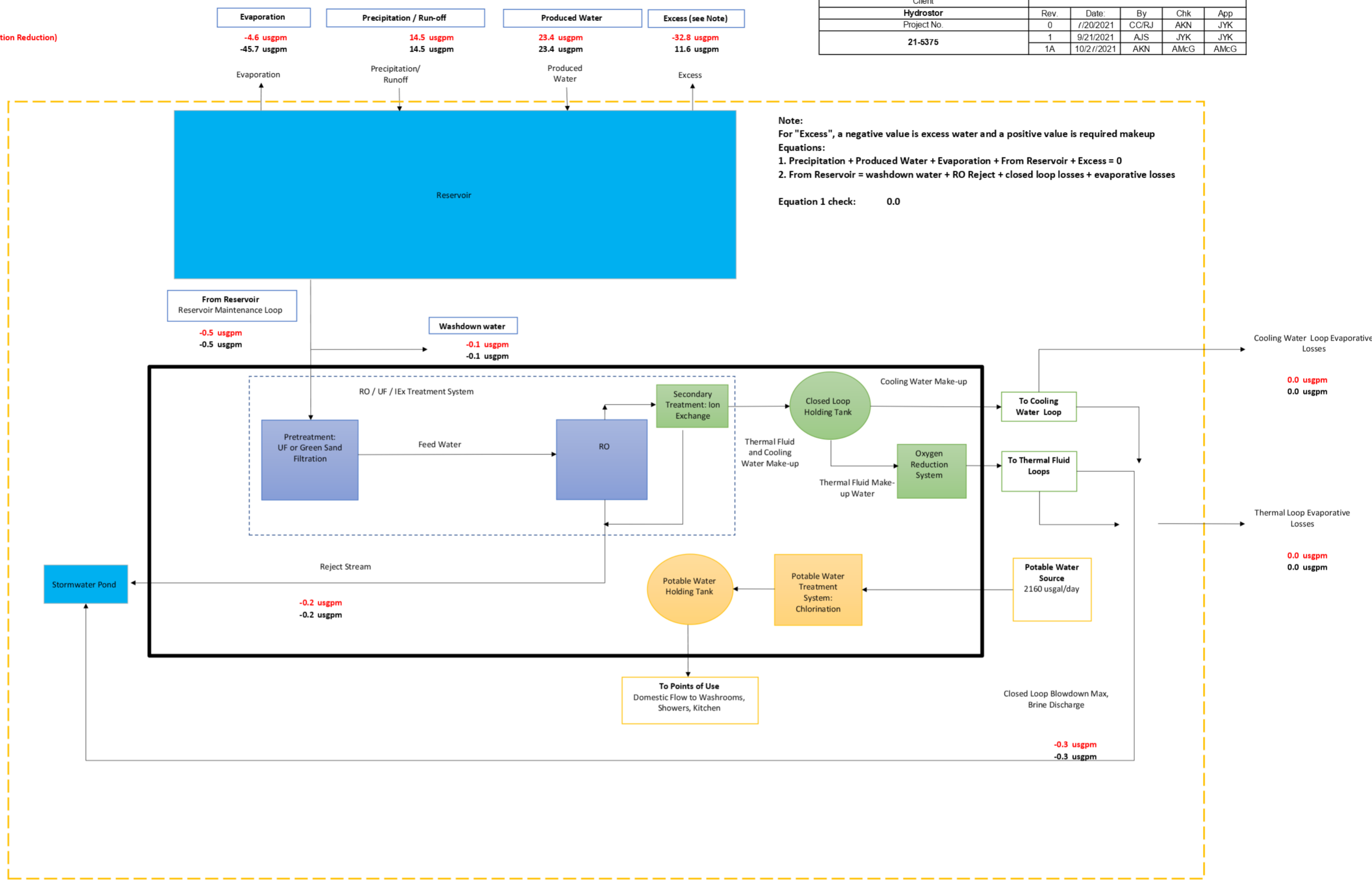
Pecho Water Balance BDF - Average

Overall BFD for Water Balance

PECHO Average Case
50% Plant Utilization
90% Evaporation Reduction from Cover

Values in Red are with a Reservoir Cover (90% Evaporation Reduction)
Values in Black are without a Reservoir Cover
Negative Values are losses

Project	Calculation No.				
Hydrostor California Gem and Pecho	**21-5375-00-3443-001**				
Client					
Hydrostor	Rev.	Date:	By	Chk	App
Project No.	0	/20/2021	CC/RJ	AKN	JYK
21-5375	1	9/21/2021	AJS	JYK	JYK
	1A	10/2/2021	AKN	AMcG	AMcG



Main Reservoir Treatment
Closed Loop Treatment
Potable Water

Notes: Numbers and cells in red refer to streams and cells in BFD Rev K

PECHO Site
Process Flow Diagram

APPENDIX 2D

Pecho Water Balance DRY Scenario

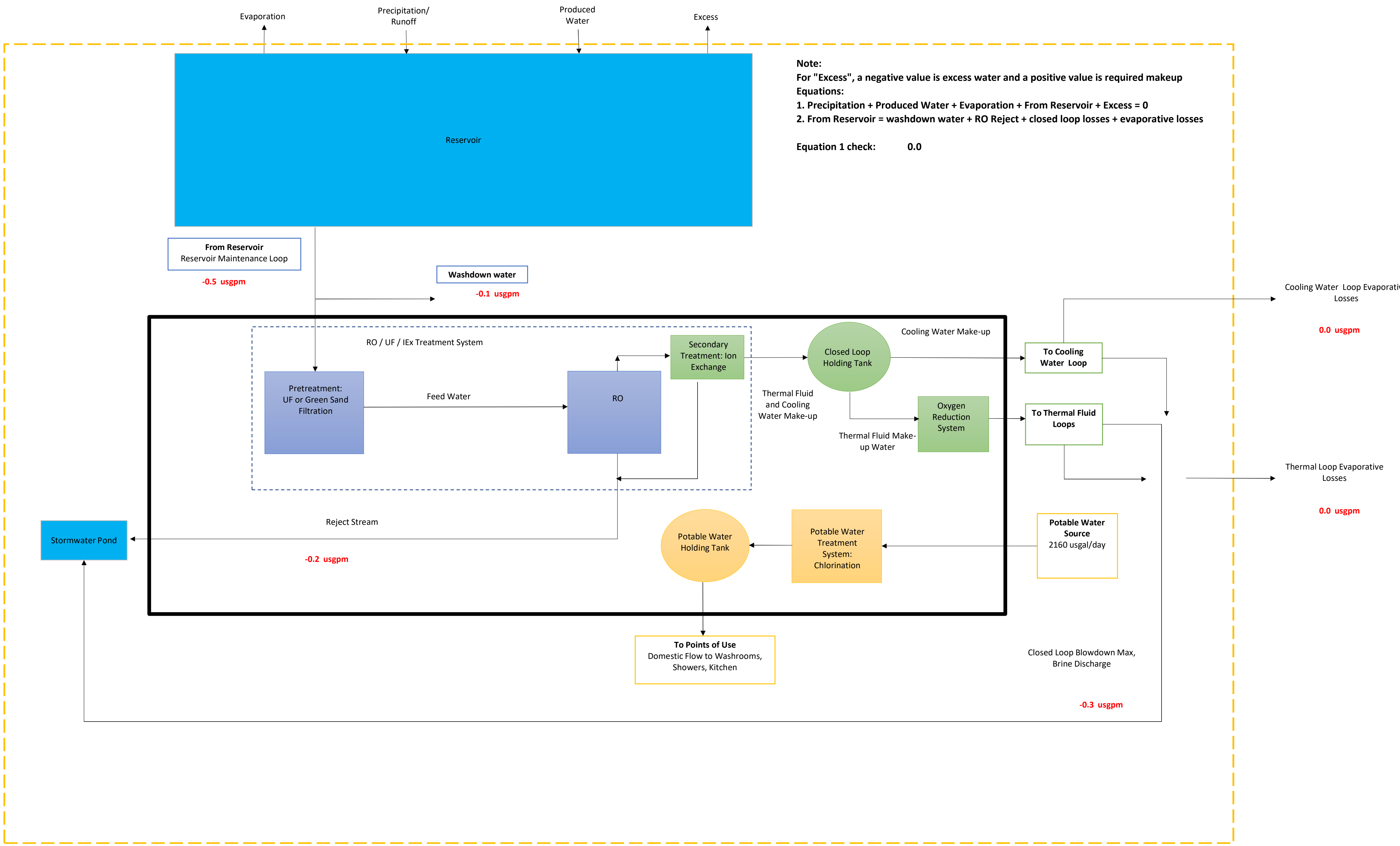
Overall BFD for Water Balance

PECHO Peak Dry Case (very low excess water production case)
30% Plant Utilization
90% Evaporation Reduction from Cover
5th Percentile Precipitation (i.e. DRY conditions)
Values in Red are with a Reservoir Cover (90% Evaporation Reduction)

Negative Values are losses

Project	Calculation No.				
Hydrostor California Gem and Pecho	**21-5375-00-3443-001**				
Client					
Hydrostor	Rev.	Date:	By	Chk	App
Project No.	0	2021-07-20	CC/RJ	AKN	JYK
21-5375	1	2021-09-21	AJS	JYK	JYK
	1A	2021-10-27	AKN	AMcG	AMcG

Evaporation	Precipitation / Run-off	Produced Water	Excess (see Note)
-4.6 usgpm	5.7 usgpm	14.0 usgpm	-14.7 usgpm



Main Reservoir Treatment
Closed Loop Treatment
Potable Water

Notes: Numbers and cells in red refer to streams and cells in BFD Rev K

PECHO Site
Process Flow Diagram

APPENDIX 2E

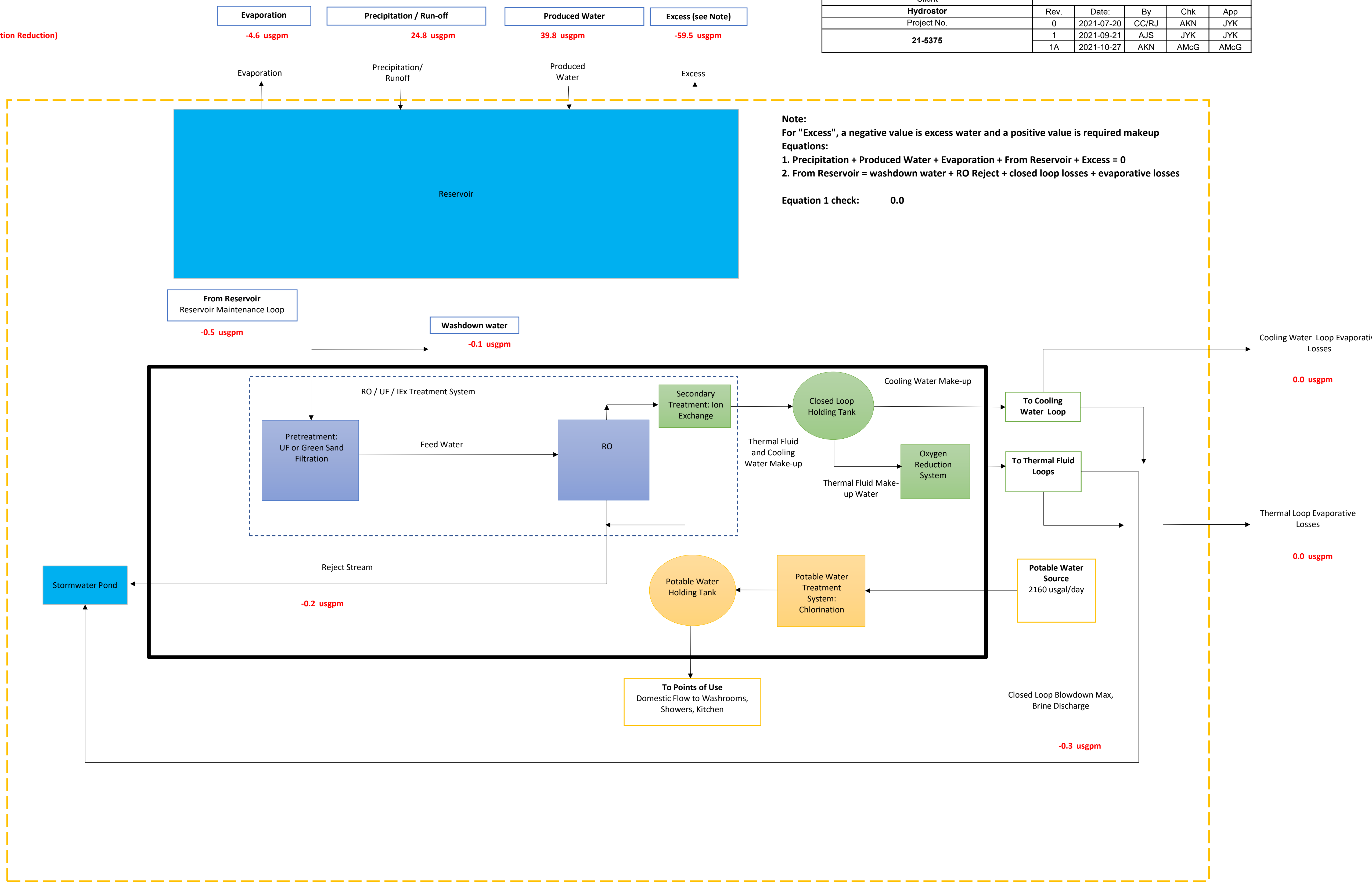
Pecho Water Balance WET Scenario

Overall BFD for Water Balance

PECHO Peak Wet Case (very high excess water production case)
85% Plant Utilization
90% Evaporation Reduction from Cover
95th Percentile Precipitation (i.e. WET conditions)
Values in Red are with a Reservoir Cover (90% Evaporation Reduction)

Negative Values are losses

Project	Calculation No.				
Hydrostor California Gem and Pecho	**21-5375-00-3443-001**				
Client					
Hydrostor	Rev.	Date:	By	Chk	App
Project No.	0	2021-07-20	CC/RJ	AKN	JYK
21-5375	1	2021-09-21	AJS	JYK	JYK
	1A	2021-10-27	AKN	AMcG	AMcG



Main Reservoir Treatment
Closed Loop Treatment
Potable Water

Notes: Numbers and cells in red refer to streams and cells in BFD Rev K

PECHO Site
Process Flow Diagram

APPENDIX 2D

Pecho Construction Water Use

Table 1 - Construction Water by Month
Site: Pecho

Hydrostor Pecho & Gem Energy Storage Center Projects – AFC Permitting Inputs
Item 2.21 – Construction Water
Rev: 19 July 2021

		Estimated Water Consumption by Month																											
		Cavern	Cavern	Surface & Cavern																								Cavern	Total Water
		Cavern Months 1-4	Cavern Months 5-12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	Cavern Months 37 - 51	
1. Potable Water																													
Worker use, wash/drinking																													
Surface Works and Cavern																													
Assumed 20 gal/day/worker	20 US gal/worker																												
	20																												
	Estimated # of workers	14	20	94	273	295	295	295	295	340	350	417	417	365	382	429	455	455	444	408	408	315	373	431	431	326	196	55	
	Water Per month	5,600	8,000	37,633	109,125	118,061	118,061	118,061	118,061	136,025	140,175	166,695	166,695	145,843	152,678	171,428	181,844	181,844	177,694	163,128	163,128	126,131	149,047	172,233	172,233	130,567	78,483	22,000	
	# months/period	4	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15	
	Total period (US gal)	22,400	64,000	37,633	109,125	118,061	118,061	118,061	118,061	136,025	140,175	166,695	166,695	145,843	152,678	171,428	181,844	181,844	177,694	163,128	163,128	126,131	149,047	172,233	172,233	130,567	78,483	330,000	3,811,273
Transmission Infrastructure	Estimated # of workers		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10								
	Water Per month		4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000								
	# months/period		8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1								
	Total period (US gal)		32,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000								104,000
Total Estimated Potable Water Demand by month		22,400	96,000	41,633	113,125	122,061	122,061	122,061	122,061	140,025	144,175	170,695	170,695	149,843	156,678	175,428	185,844	185,844	181,694	167,128	167,128	126,131	149,047	172,233	172,233	130,567	78,483	330,000	
																												Total Potable Water for Construction, USGAL	**3,915,273**
Average flow (if piped from source(s))																													
Gal/month		5,600	12,000	41,633	113,125	122,061	122,061	122,061	122,061	140,025	144,175	170,695	170,695	149,843	156,678	175,428	185,844	185,844	181,694	167,128	167,128	126,131	149,047	172,233	172,233	130,567	78,483	22,000	
Average flow, gpm																													
Flow, gpm, based on 40 hours/week		0.58	0.83	3.92	11.37	12.30	12.30	12.30	12.30	14.17	14.60	17.36	17.36	15.19	15.90	17.86	18.94	18.94	18.51	16.99	16.99	13.14	15.53	17.94	17.94	13.60	8.18	2.29	
Flow, gpm, based on 24/7		0.14	0.30	1.03	2.81	3.03	3.03	3.03	3.03	3.47	3.58	4.23	4.23	3.72	3.89	4.35	4.61	4.61	4.51	4.15	4.15	3.13	3.70	4.27	4.27	3.24	1.95	0.55	
Estimated Quantity of Truck Loads																													
Water truck volume (US gal)	9000																												
Total # of truck loads		2.5	10.7	4.6	12.6	13.6	13.6	13.6	13.6	15.6	16.0	19.0	19.0	16.6	17.4	19.5	20.6	20.6	20.2	18.6	18.6	14.0	16.6	19.1	19.1	14.5	8.7	36.7	
per month		0.6	1.3	4.6	12.6	13.6	13.6	13.6	13.6	15.6	16.0	19.0	19.0	16.6	17.4	19.5	20.6	20.6	20.2	18.6	18.6	14.0	16.6	19.1	19.1	14.5	8.7	2.4	
2. Non-potable Water																													
Surface Works																													
General Use	2x2000 gal trucks/day			80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000		
Road de-dusting, washdown, etc	# months/period			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
	Total period			80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000		1,920,000
Hydrotest	Cold Tank, 6.6M US gal																									6,600,000			6,600,000
	Piping Systems																									Re-use cold Tank Hydrotest			0
	Spheres																									Re-use cold Tank Hydrotest			0
Fire/sprinkler test	Test building fire system																									Re-use cold Tank Hydrotest			0
Excluded	Cement water (assumed at cement plant)																												
Transmission Infrastructure																													
General use	1x1000 gal trucks/day		20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000								
			8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1								
			160,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000								520,000
Cavern Works																													
Site Prep																													
General use	2x2000 gal trucks/day																												
	per month	80,000																											
	Total period	320,000																											320,000
Shaft Drilling																													
Shaft drilling water	To be all delivered in month 5		8,776,919																										8,776,919
	See detailed estimate attached																												
Mining	Avg 35 gpm, 24/7, per month									1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	
	# months/period									1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15	
	total per period									1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	22,914,360	50,411,592
Reservoir Fill																													
Average gpm, 24x7										330	330	330	330	330	330	330	330	330	330	330	330								
Volume/day																													
m3										1799	1799	1799	1799	1799	1799	1799	1799	1799	1799	1799	1799								
gal										475,296	475,296	475,296	475,296	475,296	475,296	475,296	475,296	475,296	475,296	475,296	475,296								
gpm										330.1	330.1	330.1	330.1	330.1	330.1	330.1	330.1	330.1	330.1	330.1	330.1								
Volume/month (24X7)	US gal									14,258,874	14,258,874	14,258,874	14,258,874	14,258,874	14,258,874	14,258,874	14,258,874	14,258,874	14,258,874	14,258,874	14,258,874								171,106,488

Table 1 - Construction Water by Month
Site: Pecho

Hydrostor Pecho & Gem Energy Storage Center Projects – AFC Permitting Inputs
Item 2.21 – Construction Water
Rev: 19 July 2021

		Estimated Water Consumption by Month																											
		Cavern	Cavern	Surface & Cavern																								Cavern	Total Water
		Cavern Months 1-4	Cavern Months 5-12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	Cavern Months 37 - 51	
Total Estimated Potable Water Demand by month		320,000	8,936,919	100,000	100,000	100,000	100,000	100,000	100,000	15,886,498	15,886,498	15,886,498	15,886,498	15,886,498	15,886,498	15,886,498	15,886,498	15,886,498	15,886,498	15,886,498	15,886,498	1,607,624	1,607,624	1,607,624	1,607,624	8,207,624	1,607,624	22,914,360	239,654,999
																									Total Non-potable Water for Construction, USGAL				239,654,999
Average flow (if piped from source(s))																													
Gal/month		80,000	8,936,919	100,000	100,000	100,000	100,000	100,000	100,000	15,886,498	15,886,498	15,886,498	15,886,498	15,886,498	15,886,498	15,886,498	15,886,498	15,886,498	15,886,498	15,886,498	15,886,498	1,607,624	1,607,624	1,607,624	1,607,624	8,207,624	1,607,624	1,527,624	
Average flow, gpm																													
40 hours/week		8.3	930.9	10.4	10.4	10.4	10.4	10.4	10.4	1,654.8	1,654.8	1,654.8	1,654.8	1,654.8	1,654.8	1,654.8	1,654.8	1,654.8	1,654.8	1,654.8	1,654.8	167.5	167.5	167.5	167.5	855.0	167.5	159.1	
Total Hours		160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	
Total Minutes		9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	
Flow, gpm, based on 40 hours/week		8.3	930.9	10.4	10.4	10.4	10.4	10.4	10.4	1,654.8	1,654.8	1,654.8	1,654.8	1,654.8	1,654.8	1,654.8	1,654.8	1,654.8	1,654.8	1,654.8	1,654.8	167.5	167.5	167.5	167.5	855.0	167.5	159.1	
Flow, gpm, based on 24/7		2.0	221.6	2.5	2.5	2.5	2.5	2.5	2.5	394.0	394.0	394.0	394.0	394.0	394.0	394.0	394.0	394.0	394.0	394.0	394.0	39.9	39.9	39.9	39.9	203.6	39.9	37.9	
Estimated Quantity of Truck Loads																													
Water truck volume (US gal) assumed	9000																												
Total # of truck loads		35.6	993.0	11.1	11.1	11.1	11.1	11.1	11.1	1765.2	1765.2	1765.2	1765.2	1765.2	1765.2	1765.2	1765.2	1765.2	1765.2	1765.2	1765.2	178.6	178.6	178.6	178.6	912.0	178.6	2546.0	
per month		8.9	993.0	11.1	11.1	11.1	11.1	11.1	11.1	1765.2	1765.2	1765.2	1765.2	1765.2	1765.2	1765.2	1765.2	1765.2	1765.2	1765.2	1765.2	178.6	178.6	178.6	178.6	912.0	178.6	169.7	
per day (24x7)		1.2	33.1	0.4	0.4	0.4	0.4	0.4	0.4	58.8	58.8	58.8	58.8	58.8	58.8	58.8	58.8	58.8	58.8	58.8	58.8	6.0	6.0	6.0	6.0	30.4	6.0	84.9	
per hour (24x7)			1.4							2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	0.2	0.2	0.2	0.2	1.3	0.2	3.5	
Assumed % volume trucked vs GW wells		50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	
# trucks per month (for AFC input)		4.4	496.5	5.6	5.6	5.6	5.6	5.6	5.6	882.6	882.6	882.6	882.6	882.6	882.6	882.6	882.6	882.6	882.6	882.6	882.6	89.3	89.3	89.3	89.3	456.0	89.3	84.9	

Notes:

2. Transmission infrastructure -
   Assume:
   Total duration Month 6 thru Month 30:
   Months 6 thru 18 - earthworks and pole installation - (1) 2000 gal water truck
   Months 19 thru 30 - install cabling,

3. Quantity of trucks required:
   Calculates equivalent # of trucks based on volume capacity. Fill times, unload times, traffic, travel distance from source to site would need to still be accounted for to estimate total # of trucks required for operation.

APPENDIX 2E

Pecho Construction Truck Traffic Estimates

Table 1 - Haul and Material Truck Quantities

Site: Pecho

Hydrostor Pecho & Gem A-CAES Projects – AFC Permitting Inputs
Item 5.6 – Haul and Material Truck Quantities
Rev: 19 Jul 2021

Task	Duration/Timing	Peak hours/throughout the day	Vehicle Type	Assumptions/Notes	Rev
1. CAVERN WORKS, Months 1 - 51					
Site Clearing - Months 1-4					
Workforce – 12 people = 12 vehicles @ 2 trips per day each = 12 x 5 days x 16 weeks x 2 = 1920 trips	Full duration	Daily peak hours	Passenger Car	No carpooling assumed	
Equipment mobilization – 10 tractor trailer loads, 1st week of site prep	Week 1	Throughout the day	Tractor Trailer		
Equipment demobilization – 10 tractor trailer loads, last week of site prep	Week 16	Throughout the day	Tractor Trailer		
Fuel delivery – 1 per day – 80 fuel truck trips, tandem fuel truck	Daily, full duration	Daily peak hours	Fuel truck (tandem)		
Fencing delivery – 2 trucks, tractor trailer	Week 1	Throughout the day	Tractor Trailer		
Concrete trucks – 30 loads, std 10 yd cement mix truck (3 periods x 10 trucks)	Week 1, Week 6, Week 12	Throughout the day	Cement mix truck (10 yd)		
Gravel delivery for 7 acres = 305,000 sq ft x 1 ft thick/27 = 11,300 cubic yards/12 yds/truck = 942 tandem truck loads (1st 3 we	Week 1, 2, 3	Throughout the day	Tandem truck load (12 yd)		
Trailer delivery – 12 trailers x 2 = 24 trips (1st week)	Week 1	Throughout the day	Tractor Trailer		
Shaft - Months 5-18					
Workforce – 3 rigs x 6 workers per per rig = 18 people x 5 days x 52 weeks x 2 ways = 9360 trips	Full duration	Daily peak hours	Passenger car	No carpooling assumed	
Shaft cuttings for disposal – 19,000 cy / 12cy per truck = NA = assumed used on site					
Shaft liner delivery – 2000 ft deep shafts / 40' shaft steel = 50 loads per shaft x 4 shafts = 200 loads (30 weeks in, tractor traile	Week 46	Throughout the day	Tractor trailer		
Rig delivery – 3 rigs x 8 loads per rig = 24 loads x 2 (mobe in and out) = 48 loads (24 mobe, 24 demob)	Week 16	Throughout the day	Tractor trailer		
Mining - Months 19-51					
Workforce					
Pecho – 55 people/day x 2 trips/day x 1010 days = 111,100 trips	Full duration	Daily peak hours	Passenger Car	No carpooling assumed	
Mobe of mining infrastructure – similar for both site					
Surface equipment – mob x 50 loads = 50 loads (tractor trailers)	Month 19	Throughout the day	Tractor Trailer		
Surface equipment – demob x 50 loads = 50 loads (tractor trailers)	Month 51	Throughout the day	Tractor Trailer		
Subsurface equipment – mob x 35 loads = 35 loads	Month 19	Throughout the day	Tractor Trailer		
Subsurface equipment – demob x 35 loads = 35 loads	Month 51	Throughout the day	Tractor Trailer		
Ground support – 1 load every 14 days = Morro Bay - 72 loads	Biweekly	Throughout the day	Flatbed tractor trailer		
Explosives – 1 load every 14 days = Morro Bay - 72 loads;	Biweekly	Throughout the day	Flatbed tractor trailer		
All waste rock handled on site, not "on-road"					
2. Surface Works, Months 13-36					
Workforce, average 307 workers per month @ 2 trips per day x 24 months x 20 days = 294,720 trips	Full duration	Daily peak hours	Passenger Car	No carpooling assumed	
Civil foundation excavation, 37186 cu yd @ 12 cy dump trucks + 30% allowance = 3,999 loads	Month 14, 15, 16	Throughout the day	12 cy dump truck	Preliminary estimates	
Cement Trucks, 27526 cu yd @ 12 yd cement trucks = 2,294 loads	Months 17, 18	Throughout the day	12 cy cement truck	Preliminary estimates	
Equipment and material delivery, 1050 loads (equipment, pipe, building, misc)	Months 19-31	Throughout the day	Flatbed	Preliminary estimates	
3. Water Import, full duration					**Rev 19 Jul 2021**
Potable water	Full duration	Throughout the day	9,000 gal water truck	Average rate over full construction duration	
Average truck loads per month = 15					
Peak truck loads per month = 21					
Non-potable water	Full duration	Throughout the day	9,000 gal water truck		
Assumed 50% of demand is provided by groundwater wells on site, assumed 50% of demand is trucked from Morro Bay Reclamation Project (2 mile distance, 1 way)					
Average truck loads per month = 450				Average rate over full construction duration	
Peak truck loads per month = 885				Peak during reservoir fill - assumed 12 month duration for fill, values estimated without cover	