OVERALL FEED PACKAGE

Large-Scale Commercial Carbon Capture Retrofit of the San Juan Generating Station

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EXECUTIVE SUMMARY

Enchant Energy, L.L.C. (Enchant) was selected to conduct a Front-End Engineering Design study (FEED) for the addition of a full-scale carbon capture system to remove carbon dioxide from the flue gas emissions of the two coal-fired generating units (total of 847 MW net) at San Juan Generating Station (SJGS), using Mitsubishi Heavy Industries Americas (MHIA) KM CDR Process™. Sargent & Lundy LLC (S&L) was selected as the primary technical lead, and along with various other organizations, were able to support Enchant's completion of the following FEED tasks: Task 1 – Project Management & Planning; Task 2 – FEED Study; Task 3 - Final FEED Study Package. The FEED study period was between October 15, 2019 to September 30, 2022.

SJGS Units 1 and 4 are already equipped with environment control equipment including wet flue gas desulfurization (WFGD) for sulfur dioxide (SO_2) control, fabric filter baghouses for particulate matter (PM) control, and selective noncatalytic reduction (SNCR) for nitrogen oxide (NOx) control. MHIA's amine based carbon capture technology will remove 95% of the CO2 from the flue gas, resulting in 20,026 metric ton per day (MTD) of CO_2 removed. At an 85% capacity factor, a total of 6,212,980 metric tons per year of CO_2 will be produced and transported from SJGS to either the Kinder Morgan Cortez CO_2 pipeline or Class VI sequestration wells. The site boundary pressure will be at an esimated 2,800 psig to account for the required injection pressures at the Cortez pipeline and sequestation wells, as well as the estimated pressure loss through the transport pipeline. Compression of the CO_2 extracted from the flue gas is accomplished by the combination of CO_2 compressors and CO_2 pumps.

Existing SJGS Unit 1 and 4 flue gas operating data, along with recent stack testing results and future coal seam projections, were used to establish the flue gas design basis for design of MHIA's carbon capture system. New Unit 1 and 4 flue gas ducts will tie-in between their respective WFGD outlets and exhaust stacks and will be directed to the north side of the site where the carbon capture system will be installed. Low energy steam is required as part of the amine process, and so it was determined to use steam from Unit 1 and 4, which will also be directed north to the carbon capture system. The condensed steam is returned back to the power plant.

A large cooling system is required to support the new carbon capture systems. It was determined that installation of a new dedicated cooling tower with all new piping would be the most cost effective solution as opposed to utilizing existing cooling equipment from SJGS. The new cooling tower will be located on the far north side of the site

Electric power to support the new carbon capture system will be sourced from the existing SJGS Unit 1 and 4 generators. Dedicated transformers will be installed for carbon capture and the power supply will be routed north to a new electrical building, which will also house a new and consolidated control system for the power plant and the carbon capture system.

Water supply and wastewater studies were conducted to determine the available capacity and impact to SJGS. Makeup water to SJGS is sourced from the San Juan river, and it was determined there is sufficient water to support the additional makeup water required for carbon capture. The additional waste produced from the carbon capture system will primarily be treated by the existing wastewater treatment system.

However, a new wastewater treatment system is required to treat the balance of waste that exceeds the current capacity. The small amount of untreatable wastewater will be directed to the existing south evaporation ponds.

Various balance of plant (BOP) systems are required to support the carbon capture system, including demineralized water, raw water, potable water, compressed air, fire protection, wastewater and drain systems. With exception of the compressed air system which will be a new dedicated system, the BOP systems will interface with the existing SJGS power plant.

Safety was a primary consideration in the design of the carbon capture system. A Hazard and Operability (HAZOP) review was conducted to identify potential risks and mitigating safety measures that should be implemented into the design. The results from the HAZOP will be incorporated in the detailed design phase of the Project.

An environmental, permitting, and regulatory review was conducted to determine what major environmental permits are required to execute the project and which regulatory agencies must be involved. A regional haze four-factor analysis was also conducted as part of this review to establish that additional NOx and SOx reduction is not required at this time. The review concluded that the CO2 capture addition is considered a modification to the existing air permit as agreed by the New Mexico Environmental Department (NMED). The Bureau of Land Management (BLM) & Bureau of Indian Affairs (BIA) govern the National Environmental Policy Act (NEPA) approval, which must also include the CO2 transport pipeline as part of the Project. Permit application work is an ongoing activity that will extend beyond the FEED.

A transportation study of major equipment and constructability review were conducted to ensure feasibility to construct the carbon capture facility. The concept is to utilize off-site modularization of the major utility racks. The large modules and large equipment is expected to be barged to the port of Corpus Christi, TX and shipped overland to the SJGS site. The carbon capture island is specifically designed to allow for improved constructability, allowing the use of large cranes to build the large vessels more efficiently. The review also identified how the SJGS site will be set up to support laydown space, field fabrication areas, construction parking, access points and trailer complexes.

The plan to execute the project is to utilize an Engineering, Procurement & Construction (EPC) contracting strategy as this presents the least financial and technical risk to the Owner. MHIA, S&L and Kiewit would be selected as the EPC team to execute the project. MHIA would be responsible for the carbon capture process design and equipment, while S&L would provide the balance of engineering to design the BOP systems as well as some of the civil and electrical work within the carbon capture boundary. Kiewit would be responsible for all construction work. The expected duration of the project from start of detailed engineering to final completion of construction, commissioning and startup is just under 5 years.

The projected capital cost for the project is $1.55 billion based on pricing through May 31, 2022. The projected O&M cost on an annual basis is $171 million. The resulting cost of capture for SJGS is projected to be $46.7 / tonne of CO_2 removed. The resulting net total electric power output from SJGS Units 1 and 4 after carbon capture addition is expected to be 482 MW.

1. PROJECT BACKGROUND

1.1. PROJECT OVERVIEW

Enchant Energy, L.L.C. (Enchant) was selected to support the work outlined in the National Energy Technology Laboratory (NETL) sponsored project, DE-FE0031843. The project involved conducting a Front-End Engineering Design study (FEED) for the retrofit two coal-fired generating units (~847 MWe net) at San Juan Generating Station (SJGS) with Mitsubishi Heavy Industries America (MHIA) KM CDR Process™ for Carbon Capture Utilization and Storage (CCUS) (together, the Project). It should be noted that utilization and sequestration aspects are not within the scope of this CO_2 capture FEED study and are part of separate studies performed by Enchant.

The FEED study scope of work was broken down into following tasks:

- Task 1 – Project Management and Planning
- Task 2 – FEED Study
  - Task 2.1 – Process Engineering and Design
  - Task 2.2 – Balance of Plant (BOP) Engineering
  - Task 2.3 – Studies and investigations
  - Task 2.4 – Cost Estimating
- Task 3 – Final FEED Study Package

The SJGS facility was identified as a prime candidate for retrofitting CO_2 capture technology due to four site-specific factors that have the potential to make the Project attractive from technical, economic, and financing perspective, including:

- **Environmental upgrades completed in 2017**
  The SJGS Units 1 & 4 are equipped with recently upgraded wet flue gas desulfurization (WFGD) for SO_2 control and selective non-catalytic reduction (SNCR) for nitrogen oxides (NOx) control, thus no additional controls upstream of the CO_2 capture plant are required

- **Shut-down of Units 2 and 3 in 2017**
  Retirement of Units 2 & 3 allows for the CO_2 capture plant system to utilize existing permitted water rights, cooling capacity, and repurposed in-place equipment, and provides available space in the plant footprint to construct the CO_2 capture system

- **Low electricity production cost**
  The SJGS plant utilizes high heat content coal supplied by the adjacent San Juan Mine, owned by Westmoreland Mining Holdings which allow for low electricity production cost and reduces impact of the dedicated CO_2 capture plant load on the levelized cost of capture.

- **Proximity to the carbon dioxide (CO_2) pipeline**
  The Kinder Morgan's Cortez CO_2 pipeline is located 21 miles from SJGS which has access to Permian basin oil fields where there is strong commercial market for Enhanced Oil Recovery (EOR) and also Environmental Protection Agency (EPA) certified sites for permanent storage of the captured CO_2.

- **Proximity to San Juan Basin with possible locations for direct geologic sequestration**
  The investigation of this geologic sequestration is partly funded by a separate Department of Energy (DOE) Cooperative Funding Agreement called CarbonSAFE III where Enchant Energy is a sub-recipient to New Mexico Tech. (Award Number: DE-FE0031890).

1.2. FEED STUDY DIVISION OF RESPONSIBILTIES

To support Enchant's efforts on the FEED study, they selected a group of highly-qualified vendors and participants to complete the proposed project; the overall project team members include:

- **Enchant – Project Co-Owner (Prime Awardee)**
  - Manage project coordination and project planning to the DOE/NETL

- **Farmington – Project Co-Owner and Co-Applicant (Sub-Awardee)**
  - Serve as the host-site
  - Manage project coordination and project planning to the DOE/NETL
  - Provide access to site and relevant plant documentation

- **Mitsubishi Heavy Industries America, Inc. (MHIA) – CO_2 Capture Technology Provider (Sub-Awardee)**
  - Sub-contract work to Mitsubishi Heavy Industries Engineering (MHIE) location in Yokohama, Japan; together MHIA and MHIE are collectively known as "MHI"
  - CO_2 capture technology vendor and provide engineering, design, and costing documents for their proprietary capture process

The vendors and subcontractors for the Project is as follows:

- **S&L – Vendor**
  - Commercial engineering services to provide BOP design and cost estimating, project execution planning and schedule
  - Permitting support

- **Baker Tilly – Vendor**
  - Manage project grant accounting services, audit preparation, and management services as defined by Task 1

- **Guidehouse (formerly known as Navigant) – Vendor**
  - Support Operational Benchmarking and Performance Analysis
  - Support Basic Contracting and Purchasing Strategy study included in Subtask 2.

- **EJM Associates – Vendor**
  - Environmental Consulting

1.3. HOST SITE OWNERSHIP AND RECONFIGURATION

The SJGS was owned by a group of public utilities and municipal power entities and was operated by Public Service of New Mexico (PNM) pursuant to the Amended San Juan Participation Agreement (ASJPA). The plant originally was a four-unit facility with eight (8) owners; however, as the original operating agreements expired, several owners decided to exit because of their changing energy resource needs leaving PNM with 66% share, Tucson Electric Power with 20% share, the City of Farmington with 5% share, Los Alamos County with 4% share, and Utah Associated Municipal power System with 4% share. Note that these values are rounded to nearest whole percent.

The City of Farmington through its municipal utility, the Farmington Electric Utility System (Farmington), has partnered with Enchant Energy, LLC (Enchant) on the Large-Scale Commercial Carbon Capture Retrofit of the SJGS project for the continued operation of SJGS. This public-private partnership intends to run the legacy coal plant until at least 2037 by adding carbon capture technology that will allow the plant to meet and exceed the stringent caron dioxide (CO_2) emission standards for the New Mexico Energy Transition Act (ETA). Under a signed agreement, Enchant Energy has targeted October 1, 2022, to assume ownership and operation of the SJGS with its partner the City of Farmington New Mexico. Farmington committed to transferring 95% of SJGS assets to Enchant Energy with Farmington retaining the balance, its original, and current 5% ownership of SJGS. The ASJPA provides Farmington and Enchant the right to access the site immediately for purposes of competing this FEED study.

1.4. PROJECT TIMELINE

The project was awarded in October 2019 and is based on a Project FEED definitization date of May 11, 2020. The overall Project duration is approximately 24 months from definitization, with the project end date on June 30, 2022. The final report was required to be issued within 90 days of the project end date, no later than September 30, 2022.

The FEED study was conducted to support an overall project development timeline proposed by Enchant to execute installation and operation of the post-combustion carbon capture technology. The overall project outlined by Enchant is divided into three phases as follows:

- Phase I: Pre-FEED Feasibility Study, **completed** April 2019 – July 2019
- Phase II: FEED Study, **completed** October 2019 – September 2022
- Phase III: Detailed Permitting, Engineering, Procurement, and Construction, **pending** October 2022 – September 2027

1.5. COMMUNITY ENGAGEMENT, BENEFITS, AND IMPACTS

It is Enchant's belief that these decarbonization efforts must include engagement from local & state officials, community organizations, academic institutions (research and job/skills training), labor representatives, Native American representatives, economic development organizations, local chamber of commerce members, other in-state industry representatives, Federal agencies (DOE, FPISC, EPC) and congressional members. We are trying to mitigate against a Global climate crisis and this imperative requires engagement by all stakeholders, local municipalities, the State, the Federal Government, Enchant's management, workers, partners, investors and the communities it affects working together towards a common goal of climate mitigation while preserving our economy and our standard of living.

The SJGS CO_2 capture project is in San Juan County, New Mexico. Censusreporter.org shows a population of 123,958 in 2019. Of that population, 38% are Native American and 21% Hispanic. The Median household income in 2019 for San Juan County was $44,321 and 21% of the population have incomes below the poverty line.

The Navajo Nation sprawls across New Mexico and other Four Corners states. The Navajo Nation is the largest Native American Reservation by way of land and is the largest Native American Tribe by population[1]. The Navajo has an astounding 35.8% of households under the federal poverty level (FPL) in 2020, an unemployment rate of 16.8% from 2015-2019, and 35% of households without access to running water [2]. The Jicarilla Apache Nation also lies within the San Juan Basin just to the east and south of Farmington. The Jicarilla have 17.6% of families living below the FPL and an unemployment rate of 23.5% from 2015-2019 [3].

The Four Corners is one of five priority areas across the USA identified by the Revitalizing Energy Communities Report for "focusing initial federal investments…and delivery of investment to Energy Communities."[4]

In September 2020, Management Information Services, Inc., under contract to the U.S. DOE published a report detailing the impact of the SJGS CO_2 capture project on local employment in San Juan County and state employment in New Mexico [5].

This study found that the SJGS CO_2 capture project would create 4,200 annual direct and indirect jobs during the construction phase and 3,200 permanent direct and indirect jobs after full commissioning. Because the permanent jobs represent 6% of the total labor force of San Juan County, the closure of the plant and mine would have the effect of doubling the unemployment rate in San Juan County New Mexico. A 100% increase in unemployment in a region that is already struggling with Transition from fossil-fuels would have a devastating impact to the local economy.

The 2018 economic impact study produced by Four Corners Economic Development, a Public-Private Partnership that promotes regional economic development, found that 40% of the 478 employees at SJGS and San Juan Mine ("SJM"), are Native Americans. This study found closure of the plant and mine would reduce funding to local schools by $3.5 million per year annually. As shown below, between 53% and 100% of the students at schools supported by tax revenues from SJGS and SJM come from economically disadvantaged groups. In particular, the Central Consolidated School District serves 91% of students who are Navajo.

Specifically, the DOE SJGS Study determined that the SJGS CO_2 capture would provide $1.33b in local tax revenues over an approximate 30-year period and provide over 3,200 jobs annually. The jobs at the SJGS and San Juan Mine are the most sought-after jobs in the region and their wage income is greater than 75% higher than the medium household income on the Navajo reservation and more than twice the average of the San Juan County family income.

[1] https://www.census.gov/history/pdf/c2010br-10.pdf
[2] https://www.census.gov/tribal/
[3] Ibid.
[4] Initial Report to the President on Empowering Workers Through Revitalizing Energy Communities (2021). Retrieved from: https://netl.doe.gov/sites/default/files/2021-04/Initial%20Report%20on%20Energy%20Communities_Apr2021.pdf
[5] https://www.energy.gov/sites/prod/files/2020/10/f79/SJ%20metric%20report%209-24-20.pdf

A high percentage of jobs at SJGS have been held by Native Americans. Enchant is committed to continuing to provide both high paying and skilled jobs to Native Americans and all underserved populations and to work with San Juan Community College and local labor unions to ensure there is a pipeline of skills training programs for many generations, including internships and apprenticeships. The average wage & benefits for these jobs, as highlighted in the DOE SJGS Study, is approximately $120,000 annually.

SJGS CO_2 capture provides an environmental and standard of living balance to San Juan County residents. Environmentally it will remove more than 6 million metric tons of CO_2 from the atmosphere as well as further reductions in SO_2 and particulate matter through the amine processing technology being implemented. Complimenting this environmental benefit, SJGS CO_2 capture preserves and creates high paying jobs, which are essential for maintaining the resident's standard of living. Working at SJGS and San Juan Mine has been generational for many families in the region and adding CO_2 capture to SJGS will ensure that future generations will have an opportunity for the same standard of living.

2. PROJECT SCOPE

2.1. PROJECT SUMMARY

The Project involve retrofit of SJGS with a post-combustion CO_2 capture technology. The SJGS is an 847 MW (net) coal-fired power plant originally built in the 1970s, expanded in the 1980s and is located in New Mexico approximately 15 miles Northwest of the City of Farmington. SJGS currently has two operating coal-fired utility boilers, Units 1 & 4, and two retired boilers, Units 2 & 3 which were retired in 2017 as part of settlement agreement reached between the State of New Mexico and the U.S. EPA. The units are mine-mouth facilities and fire western bituminous coal supplied from the adjacent San Juan Mine, owned by Westmoreland Holdings. Both operating units (Units 1 & 4) are equipped with state-of-the-art environmental controls including wet flue gas desulfurization (WFGD) for sulfur dioxide (SO_2) control, fabric filter baghouses for particulate matter (PM) control, and selective noncatalytic reduction (SNCR) for nitrogen oxide (NOx) control.

The CO_2 capture plant is designed to treat entire flue gas from the SJGS Units 1 & 4 and is estimated to capture 20,026 metric ton per day (MTD), approximately 95% of SJGS Units 1 & 4 current CO_2 emissions. The captured CO_2 is compressed to 2,800 psig for transportation to a pipeline off-site for integration into the Cortez pipeline for EOR use; a diverter station is also proposed which can route the product CO_2 to a secondary location for permanent geologic sequestration. The transportation and storage of the CO_2 is not included in the FEED project scope.

For details regarding the engineering studies and the BOP scope refer to BOP Summary Report attached in Appendix A. For details regarding the engineering and design scope provided by MHI for the process package refer to MHI FEED Study Final Report in Appendix B.

The overall goal of the project is to develop an Association of the Advancement of Cost Engineering (AACE) Class 2 Capital Cost Estimate with an accuracy of ± 15% to demonstrate the economic feasibility of constructing and operating CO_2 capture plant. The summary report outlines the background, design basis, the cost evaluation for the cost of capture, engineering approach, and the results of the FEED study as supplemented by the information presented in the various appendices.

2.2. PROJECT OBJECTIVES

The objectives for the CO_2 capture retrofit project at SJGS are as follows:

- Demonstrate successful operation through installation of MHI Kansai Mitsubishi Carbon Dioxide Recovery (KM CDR) Process™ to achieve 95% CO_2 capture efficiency on an 847 MW (net) coal-fired electric generation station
- Document initial engineering and cost estimates for the retrofit project, including the levelized cost of capture on an existing plant, which result in cost of capture less than other reported large-scale CO_2 capture projects and justifies Project financing based on total expected CO_2 sales and/or 45Q tax credits.
- Estimates of the technical and economic viability of extending the life of the existing SJGS coal-fired power plant through installation of post-combustion carbon capture

2.3. PROJECT BATTERY LIMITS

2.3.1. Flue Gas Ductwork Tie-in

The installation of the CO_2 capture plant requires new flue gas ductwork and modifications of existing Units 1 & 4 ductwork. New ductwork will tie-in to the existing ductwork downstream of each units' existing WFGD absorber vessel and upstream of the existing chimney. The CO_2 capture island will be designed to treat 100% of the typical full load flue gas generated from Units 1 & 4 and will be routed via new elevated, corrosion resistant ductwork. Penetrations with appropriate balancing dampers will be used on Units 1 & 4 separately prior to tie-in into a common duct. Prior to supplying to MHI's CO_2 capture island battery limit, the flue gas duct splits evenly to CO_2 capture Train 1 & 2.

2.3.2. CO_2-Depleted Vent Streams

The CO_2 capture plant is designed to capture 95% of the total CO_2 from SJGS Units 1 & 4 flue gas. The treated flue gas is emitted from top of the absorbers via new integrated stacks which serve as a new set of emission points. Any vent streams collected from the CO_2 capture island from dehydration and reclaimer sections for all depressurization and relief events are combined and routed via a common duct to the absorber stack location for a common emission point.

2.3.3. CO_2-Product Stream

The CO_2 capture island trains will capture CO_2 from the feedstock flue gas from SJGS Units 1 & 4 to generate a compressed CO_2 product as per the specification listed in table.

Table 2-1 — CO_2 Product Specifications

Parameter	Units	Data
Pressure at CO_2 Pipeline Battery Limit	psig	2,800
Pressure at MHI Compressor Outlet	psig	1,900
Temperature at Battery Limit	°F	< 120
CO_2 Capture Capacity	metric ton/day	20,026
Quality		
Carbon Dioxide	mol% dry	> 95
Water	lbs/MMSCF	< 30
Hydrogen Sulfide	ppmv (dry)	< 20
Nitrogen	mol% (dry)	< 4
Sulfur	ppmw (dry)	< 35
Oxygen	ppmw (dry)	< 10
Hydrocarbons	mol% (dry)	< 5
Glycol	gal/MMSCF (dry)	< 0.3
Carbon Monoxide	ppmw (dry)	< 4,250
Nitrogen Oxides	ppmw (dry)	< 1

Parameter	Units	Data
Sulfur Oxides	ppmw (dry)	< 1
Particulate	ppmw (dry)	< 1
Amines	ppmw (dry)	< 1
Hydrogen	mol% (dry)	< 1
Mercury	nanograms/liter	< 5
Ammonia	ppmw (dry)	< 50
Argon	mol% (dry)	< 1

2.3.4. Cooling Water

The circulating cooling water system consisting of cooling tower and supply pumps will be installed to supply cooling water to the various heat exchangers and process users throughout the CO_2 capture island to manage the heat rejection from the CO_2 capture process.

2.3.5. Service Water Tie-in

The service water will be used to primarily provide cooling water make-up water for the new cooling tower as part of CO_2 capture system, supply quench water to steam drain tanks, and supply water to the water wash down stations located throughout the new CO_2 capture island. Service water system will be fed from the existing plant raw water system. Two tie-in points will be used to supply the water: (1) north end of the CO_2 capture island for cooling tower makeup and (2) south end of the CO_2 capture island for supply to various water users.

2.3.6. Demineralized Water Tie-in

The demineralized water will be used to provide make-up water to the CO_2 capture plant for various uses including pump seal water, flue gas blower water spray system, wash water for pH meters, hydrogen generation, and makeup water for initial startup of various equipment. Demineralized water will be fed from the existing plant demineralized water treatment system. The tie-in location from the existing unit will be located at the Unit 4 Condensate Storage Tank, located on north side of Unit 4. Two (2) x 100% demineralized water supply pumps supply the required flow and pressure to the CO_2 capture island.

2.3.7. Potable Water Tie-in

The potable water will be used for safety shower and eye wash stations (SSEW) located with CO_2 capture plant and near chemical material areas at the cooling tower treatment chemical feed building and wastewater treatment building. Additionally, potable water will also be supplied to restroom facilities at the new control building. Potable water will be fed from the existing plant potable water system. The tie-in will be from the existing underground line located northeast of the existing units.

2.3.8. Steam and Condensate

The installation of the CO_2 capture plant requires a large amount of steam for use in regenerator to strip the CO_2 from the solvent. The steam will be extracted from the SJGS steam turbines and will be supplied to CO_2 capture plant. During normal operation, low pressure (LP) steam from Units 1 & 4 will be sourced from the intermediate pressure to low pressure (IP/LP) crossover piping upstream of the LP steam turbine. During start-up, main steam (MS) from Units 1 & 4 will be utilized using MS tie-in located on the superheater outlet piping, downstream of the existing MS isolation valve.

The condensate from the reboilers as part of the CO_2 capture plant is collected into a tank and pumped back to the power island. The tanks and pumps will be within MHI's scope whereas piping from condensate pump discharge header to existing Units 1 & 4 feedwater cycles deaerator will be within BOP scope.

2.3.9. Wastewater

The wastewater system collects and discharges wastewater from various systems as part of the CO_2 capture plant via Process Pond 3 for treatment in two operational brine concentrators (BC4 and BC5) or to the south evaporation ponds. Due to limited capacity of the existing treatment system, the cooling tower blowdown is treated using new reverse osmosis (RO) water treatment system to recover > 90% purified water for recycle. The reject from the RO treatment system along with tri-ethylene glycol (TEG) waste from the dehydration system as part of CO_2 capture plant will be discharged to the south evaporation ponds.

3. PROJECT DESIGN BASIS

The following section outlines the project inputs with regards to engineering design conditions, site characteristics, and flue gas design basis. This information is provided in detail in the Overall Design Basis & Criteria as part Appendix A, BOP Summary Report (see specifically Appendix B of the BOP Summary Report).

3.1. SITE CHARACTERISTICS

3.1.1. Site Location

SJGS is a mine-mouth power plant and is located at 6800 N Country Rd, Waterflow, NM 87421. The plant is located north of U.S. Highway 64 with CO_2 capture Trains 1 & 2 proposed to be located in the open space North of Unit 4 boiler area.

The site plot plan can be referenced in the BOP Summary Report as part of Appendix A.

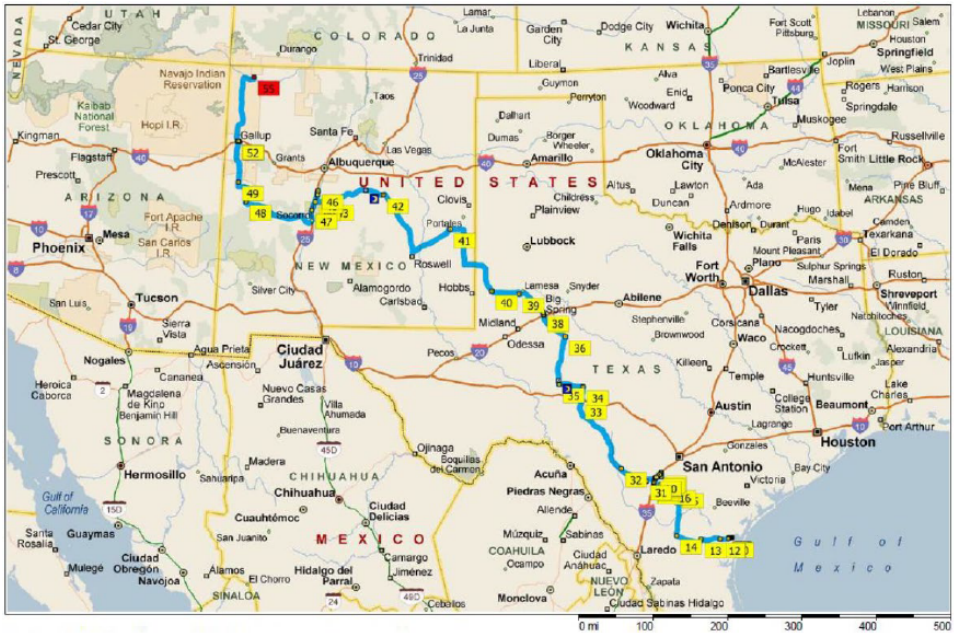
3.1.2. Site Topography

According to the review of elevation profile in Google Earth, the Project area where CO_2 capture island for Train 1 & 2 is proposed to be laid out is relatively flat terrain with topographic variation between 5,285 ft to 5,325 ft. above sea level.

3.1.3. Transportation Access & Logistics

As per transportation route surveyed in October 2021, the proposed roll-off location analyzed was the Port of Corpus Christi, TX as shown in Figure 3-1 below. Details of the transportation study are included in the MHI FEED Study Final Report in Appendix B.

Figure 3-1 — Route from Port of Corpus Christi to Proposed Site



Areas where there are high concentrations of low-hanging wires has been pinpointed. It will be assumed that all low lines can be raised and left live with the utility companies having the authority to decide whether they will want to shut down any lines in advance. It is assumed that any obstructions along the route (i.e. signs, poles, trees, etc.) can be moved or adjusted without any issues.

Present conditions limit the following three cargo dimension to be able to transport:

1. 40’ (L) x 24’ (W) x 17’ (H) at 184,000 lbs.
2. 26’ (L) x 18’ (W) x 14’ (H) at 185,000 lbs.
3. 48’ (L) x 11’ (W) x 12’ (H) at 249,000 lbs.

For transport throughout the United States of America, the maximum payload that can be transported along the route is determined by the Department of Transportation and the local governing officials based on evaluation of loadings to be exerted on the roads and bridges. If any of the roads or bridges are deemed not suitable, minor adjustments will be made to the route. Prior to shipment of equipment a review of the routes will be performed to evaluate any changes that could have occurred to the route such as construction of roads or bridges or new, low-hanging lines being strung. If such changes are identified, minor adjustments will be made to the route.

3.1.4. Site Available Utilities

The available site utilities and their conditions are summarized in sections below.

3.1.4.1. Service Water

The conditions for the service water supply to hose stations as part of CO_2 capture island Trains 1 & 2 are summarized in the following table:

Table 3-1 — Service Water Conditions

Parameter	Units	Data
Supply Pressure [Normal]	psig	135
Supply Temperature [Normal]	°F	80

3.1.4.2. Demineralized Water

The conditions for the demineralized water supply for use in pump seals, start-up, and hydrogen generation as part of CO_2 capture island Trains 1 & 2 are summarized in the following table:

Table 3-2 — Demineralized Water Conditions

Parameter	Units	Data
Supply Pressure [Minimum]	psig	110
Supply Temperature [Max / Norm / Min]	°F	90 / 70 / 50

3.1.4.3. Potable Water

The conditions for the potable water supply to eye wash, shower, and building as part of CO_2 capture island Trains 1 & 2 are summarized in the following table:

Table 3-3 — Potable Water Conditions

Parameter	Units	Data
Supply Pressure [Max / Min]	psig	100 / 66
Supply Temperature [Max / Min]	°F	100 / 60

3.1.4.4. Instrument Air

The conditions for the instrument air supplied to process equipment as part of CO_2 capture island Trains 1 & 2 are summarized in the following table:

Table 3-4 — Instrument Air Conditions

Parameter	Units	Data
Supply Pressure [Max / Norm / Min]	psig	125 / 115 / 60
Supply Temperature [Max]	°F	110
Contamination of Oil Mist	-	Oil free
Dew point Temperature	°F	-40

3.1.4.5. Electric Power

The conditions for the power supplied to the process equipment's as part of CO_2 capture island Trains 1 & 2 are summarized in the following table:

Table 3-5 — Power Supply Conditions

Parameter	Units	Data
Rated System Voltage	kV	22
Rate Frequency	Hz	60
Number of Supply Feeder	-	2

3.2. SITE CONDITIONS

The major site conditions based on American Society of Heating Refrigeration and Air Conditioning (ASHRAE) data are summarized in the following table. The Farmington Four Corners location is approximately 13 miles from SJGS and represents climate conditions over that distance.

Table 3-6 — Major Site Location Conditions

Parameter	Data
Nearest ASHRAE (2021 Fundamentals) Weather Data Location	Farmington Four Corners
World Meteorological Organization Number	723658
Latitude/Longitude (SJGS)	36.80°N / 108.44°W
Site Elevation (SJGS)	5,308 ft
Atmospheric Pressure	12.004 psia
Heating Dry Bulb Temperature, 99.6% occurrence	9.1°F
Cooling Dry Bulb Temperature, 0.4% occurrence Note 1	96.1°F
Cooling Wet Bulb Temperature, 0.4% occurrence	59.4°F
50-year occurrence Dry Bulb Temperature Note 2	

Parameter	Data
High	103.5°F
Low	-11.3°F
Frost Penetration	2.5 ft. below finish grade

Note 1 – Warranty design value
Note 2 – Design value

3.2.1. Air Temperature and Relative Humidity for Equipment Design

The air temperature requirements for the Project are summarized in table below.

Table 3-7 — Air Temperature and Relative Humidity Conditions

Parameter	Data
Outdoor Design Dry Bulb Temperature [Max / Min]	110°F / -20°F
Indoor Process Areas Design Dry Bulb Temperature [Max / Min]	104°F / 60°F
Indoor Process Areas Relatively Humidity [Max / Min]	NA / NA
Indoor Electric Rooms Design Dry Bulb Temperature [Max / Min]	85°F / 65°F
Indoor Electrical Rooms Relatively Humidity [Max / Min]	60 / 20
Indoor Battery Room Design Maintain Temperature	77°F
Indoor Battery Room Relatively Humidity [Max / Min]	60 / 20

3.2.2. Wind

The wind requirements for the Project are summarized in table below.

Table 3-8 — Wind Conditions

Parameter	Data
Risk Category	III
Exposure Category	C
Average Wind Speed	24.8 mph
Prevailing Wind Direction	N/A
Design Wind Speed, V_{ult} (3-sec gust speed at 33 ft above ground)	120 mph
Nominal Design Wind Speed, V_{asd}	93 mph

3.2.3. Rainfall/Precipitation

The rainfall/precipitation requirements for the Project are summarized in table below.

Table 3-9 — Rainfall/Precipitation Conditions

Parameter	Data
The 1 hour, 25-year Rainfall Note 1	1.87 inches
Annual Average Rainfall	N/A
Maximum Rainfall in 24-hr	N/A

Note 1 – 24-hour rainfall as given by the NOAA Atlas 14 Hydro meteorological Design Studies Center

3.2.4. Snow

The snow requirements for the Project are summarized in table below.

Table 3-10 — Snow Conditions

Parameter	Data
Risk Category	III
Ground Snow, p_g	10 lb/ft^2
Snow Importance Factor, I_s	1.1
Annual Average Snowfall	N/A
Maximum Snowfall in 24-hr	N/A

3.2.5. Seismic

The seismic requirements for the Project are summarized in table below.

Table 3-11 — Seismic Conditions

Parameter	Data
Risk Category	III
Seismic Importance Factor, I_e	1.25
Spectral Response Acceleration	
0.2-second period (short period), Ss	0.131
1-second period, S_1	0.049
Site Class Note 1	C
Design Spectral Response Acceleration Parameter	

Parameter	Data
0.2-second period (short period), S_{DS}	0.14
1-second period, S_{D1}	0.078
Seismic Design Category	B

Note 1 – From Terracon's 2014 Geotechnical Report for the San Juan Generating Station.

3.2.6. Noise Level Requirements

3.2.6.1. Near Field

Under normal operating conditions, the maximum A-weight sound level when measured at any point three (3) ft. away from any piece of equipment will not exceed 85 dB(A) in accordance with ANSI Standard S1.13. Equipment producing sound levels beyond 85 dB(A) will be placed in an enclosure and acoustically insulated as necessary.

3.2.6.2. Far Field

The requirements for the far field sound levels will be determined later during the detailed engineering phase. Currently, there is no local ordinance requirement for far field noise since there are no nearby residential or commercial areas.

3.3. SITE SPECIFIC DESIGN CONSIDERATIONS

3.3.1. Flood Plain

The proposed equipment site location is not within a regulatory flood plain as shown on FEMA FIRM 36045C0650F, effective August 5, 2010. Approximately 2,500 feet east of the proposed project location, as documented on FEMA FIRM 36045C0645, effective August 5, 2010, there is a regulatory floodplain within the Westwater Arroyo – this will not affect or impact this project scope or design.

3.3.2. Soil Conditions

Based on previous subsurface geotechnical reports for the plant site, the general soil profiles consist of an overburden of medium dense silty sand, clayey sand, and firm to stiff silty clay, clayey silt with occasional gravel, transitioning to interbedded highly weathered sandstone and shale with sandy clay seams, which is underlain by the massive sandstone bedrock. The top of competent sandstone bedrock elevations varies across the site, depending on the location. Groundwater varies and is approximately at elevation 5,287 feet.

All soil parameters will be verified during detailed design by a project-specific geotechnical investigation.

3.3.3. Building/Enclosure

Buildings and enclosure layouts are based on pre-engineered building systems. These systems are classified as Type II-B, non-combustible, steel framed per the IBC. The façade materials are insulated metal panel systems, color and profile will match the existing plant configuration. The metal panels with have a Kynar

coating system with a 20-year finish warranty. Insulation will be provided in thickness required to meet IECC requirements.

Interior partitions are gypsum board assemblies, fire rated partitions are provided where required by IBC or recommended by NFPA 850. Finishes for industrial areas are minimal, and in office areas acoustical tile ceilings, vinyl or ceramic tile floors and painted walls are provided. The Control Room and accessory areas have a raised access flooring system for ease of commodity distribution.

Personnel doors will be hollow metal door systems, exterior doors shall be insulated. Fire rated doors will be provided at fire rated partitions. Exterior doors, control room doors, electrical room and DCS room doors shall have card reader security installed.

Overhead access doors will be insulated, pre-finished rolling steel doors with a motor operator.

3.3.4. Local Community Requirements

In certain cases, CO_2 capture projects could have unexpected impacts on the local community. For the SJGS project, there are not expected to be any community constraints to the project based on its remote location with regards to plume visibility, height visibility constraints, and/or dark-sky determination limitations.

3.4. DESIGN COAL

SJGS provided coal analysis ran by SGS at one of their local labs on the eight (8) samples taken from San Juan Mine back in 2010. The analysis includes ultimate analysis as received, dry, and moist, mineral-matter-free basis (MAF) of major constituents such as carbon, hydrogen, nitrogen, and oxygen along with sulfur, ash, and volatile matter. The reports also provided detailed analysis for the coal fly ash composition. Additionally, SJGS also provided run of mine (ROM) qualities based on most current up to date geologic models and forecasted coal sulfur and heat content through 2034. The avg. value of the sulfur and gross calorific value along with range forecasted for period between 2020 through 2034 are summarized below.

Table 3-12 — San Juan Mine Future Coal Forecast

Coal Constituent	Units	Average Value	Range
Sulfur	wt.%	0.80	0.68 – 1.36
Gross Calorific Value	BTU/lb	9,930	9,778 – 10,228

The design coal out of the eight samples provided from 2010 for the Project was selected based on the lowest difference between the gross calorific value from coal sample and avg. gross calorific value of 9,930 BTU/lb forecasted. The table below outlines SGS coal sample (#6) analysis which was selected as the design coal for the Project.

Table 3-13 — Design Coal Characteristics

Parameter	Units	As Received
Carbon	wt.%	54.41
Hydrogen	wt.%	4.24
Nitrogen	wt.%	1.21
Sulfur Note 1	wt.%	0.80
Oxygen	wt.%	9.27
Chlorine	wt.%	0
Fluorine	wt.%	0
Moisture	wt.%	7.78
Ash Note 2	wt.%	22.29
Gross Calorific Value Note 1	BTU/lb	9,930
Volatile Matter	wt.%	33.35
Fixed carbon	wt.%	36.45

Note 1 – Adjusted to reflect average based on forecasted coal quality for San Juan Mine for period 2020 through 2034.

Note 2 – Adjusted based on sulfur content to meet 100 wt.% total coal composition.

3.5. FLUE GAS DESIGN BASIS

The material balances were developed to determine WFGD outlet conditions for SJGS Unit 1 & Unit 4. The spreadsheet used to determine mass flows was S&L's validated WFGD material balance. The inputs to the material balance were developed by analyzing the PI data provide by SJGS, input from Enchant/City of Farmington, and MHI design conditions at stack. The inputs to the material balance along with PI data plots can be referred in the Flue Gas Design Basis document attached as part of an attachment to the BOP Summary Report Appendix A.

3.5.1. Design Assumptions

The process tie-in conditions at full load were developed for the SJGS Units 1 & 4 WFGD Outlets individually. These flows were combined to provide any overall flow rate that enters the CO_2 capture island. Furthermore, pressure drop was estimated based on the overall ductwork run prior to MHI's equipment inlet. This information was provided to MHI for their design input.

Table 3-14 — CO_2 Capture Island Design Flow at Full Load

Parameter	Units	Unit 1 & 4 Combined Flow	
Temperature	°F	127	
Pressure [Note 1]	in.w.c.	-6	
	psia	11.788	
Volumetric Flow Rate	scfm at 68°F	2,846,302	
Flow Rate / Composition			
Nitrogen + Argon (N_2 + Ar)	lb/hr-vol.%	8,303,023	66.92
Oxygen (O_2)	lb/hr-vol.%	847,396	5,98
Water (H_2O)	lb/hr-vol.%	1,368,539	17.16
Carbon Dioxide (CO_2)	lb/hr-vol.%	1,936,347	9.93
Sulfur Dioxide (SO_2)	lb/hr-ppmv wet	523	18
Nitrogen Oxides (NOx)	lb/hr-ppmv wet	2,167	106

Note 1 – Atmospheric pressure = 12.004 psia

3.6. ENVIRONMENTAL PERMITTING

S&L reviewed the current design and applicable regulations to determine required permits for the construction of the CO_2 capture system at SJGS.

The following assumptions were made when determining permit applicability:

- The CO_2 capture system will be considered a modification to an existing major source of air pollutants
- There are sufficient existing water rights to supply the CO_2 capture system.
- Solid waste from the CO_2 capture system will be disposed at either on-site or off-site, as appropriate, at properly permitted disposal facilities.

The permit matrix for the project is included in Appendix C and lists the federal, state, and local permits required for the Project.

3.6.1. Air Emissions

SJGS is an existing major stationary source as defined in 20.2.74.7.AG(1) New Mexico Administrative Code (NMAC) and 20.2.74.501.G NMAC. SJGS has two operating coal-fired utility boilers, Units 1 & Unit 4, which fire western bituminous coal supplied by the adjacent San Juan Mine. Both units are equipped with recently upgraded WFGD for SO_2 control, fabric filter baghouses for PM control, and SNCR for NOx control.

Based on a review of project information, and discussions with New Mexico Environment Department (NMED), the carbon capture equipment will be considered a modification to an existing source. No new combustion equipment will be installed as part of the project.

The installation of the CO_2 capture system will result in the below estimated changes to SJGS average annual emission rates:

- 95% reduction in the annual average CO_2 emission rate;
- 50% reduction in the average annual SO_2 and SO_3 emission rates;
- No change from baseline average emission rate for NO_x, CO and PM;
- Projected increase in NH_3 and volatile organic compounds (VOCs) emission rates. This increase is due to a degradation reaction between the solvent as part of the amine-based CO_2 capture process and the oxygen present in the flue gas.

Flue gas will be permitted to still be emitted from the Units 1 & 4 stacks if the carbon capture equipment is not running at full capacity or is not in operation due to outage or maintenance. In these cases, the maximum amount of flue gas that can be treated will be sent to the carbon capture system, with any remaining flue gas above the available capacity will be exhausted through one or both of the existing stacks.

Based on the above information, it is anticipated that the carbon capture project will be subject to Part 74 Prevention of Serious Deterioration (PSD) permitting for VOCs, and Part 72 construction permitting for other regulated pollutants. Additionally, the project will require a modification of the existing SJGS Title V Operating Permit (Permit No. P062-R3M1).

3.6.2. Water Rights

Currently, SJGS has existing permits for the water rights that is shared with Four Corners Power Plant. Based on the S&L water balance, for annual average conditions at 85% capacity factor, the new river water usage is 11,075 gpm or 17,863 acre-ft/yr. and for summer design at 100% capacity factor the water usage is 15,236 gpm or 24,574 acre-ft/yr. As part of the SJGS ownership transfer, Enchant Energy will acquire all the existing water rights for the SJGS, as such, the quantity of water shall be sufficient to allow continued operations of existing Units 1 & 4 and meet demands for the new planned CO_2 capture system. The additional water consumption associated with the new CO_2 capture equipment is less than previously allocated to the facility when Units 2 & 3 were operation. However, in the event water usage projections change for Four Corners & Navajo Mine, then Enchant will look at exploring options for obtaining additional water rights.

3.6.3. Wastewater Discharge

No wastewater discharge is anticipated as a result of the Project, as SJGS is a zero-liquid discharge (ZLD) facility. The blowdown stream from the new cooling tower will be treated through existing wastewater treatment and a new reverse osmosis (RO) wastewater treatment system with RO reject stream routed to the South Evaporation Ponds along with waste stream from solvent reclaiming process from the carbon capture process.

3.6.4. Stormwater Run-off and Spill Containment

The Project will utilize the existing storm water system to drain storm water from proposed developed areas not subject to contamination from equipment oil and chemical spills; however it is expected that Enchant will have to develop a new stormwater pollution prevention plan (SWPPP) and spill prevention control and countermeasures (SPCC) plan for the new system incorporation once the ownership is transferred. Tank compounds, truck unloading areas, and process equipment including chemicals will be protected from leaks

and spills by a reinforced concentrate containment area sized for 25-year, 24-hour rainfall. For the tank compounds, the containment area will additionally be sized to contain the volume of the single largest tank along with volume of other equipment/tank/foundations within the containment area, plus a minimum volume of 25-year, 24-hour rainfall. The collected liquid in the containment area will be tested for contamination by the Owner prior to its discharge through a normally closed valved outlet pipe to nearest storm water drain facility. In the event any contaminated liquid is identified, the contaminated liquid will be transferred to a collection truck for treatment.

3.6.5. Solid Waste Disposal

Solid waste produced during construction will be disposed of either on-site or off-site, as appropriate, at properly permitted disposal facilities. During operations, the CO_2 capture process will generate certain solid wastes, including wastewater treatment solids, filter media, catalyst, and spent amine solvent. Solid wastes generated in the wastewater treatment system will be managed on-site and disposed of in a properly permitted solid waste disposal facility. Solid wastes generated in the CO_2 capture system, including sludge waste (composed of amine degradation components from the reclaimer) and precoat filter cake from the amine filtration system will be disposed of by a properly licensed third-party. At this time, not enough information is available to determine if these solid wastes would be considered hazardous in nature. Once the facility is operational, characterization of the waste product can be completed to confirm.

3.7. THERMAL OUTPUT IMPACTS

Carbon capture systems require a signficant auxiliary power demand to adequately operate the BOP and CO2 process mechanical equipment, including pums and compressors, and auxiliary support systems, including HVAC of buildings and heat tracing. The amine-based process which is intended to be used at SJGS also requires steam to release the CO2 from the solvent; for this application, the Project Team has decided to utilize low-pressure steam extracted from the existing steam paths on Unit 1 and Unit 4 steam turbines. Together, these demands reduce overall gross output of the facility as well as increase internal loads, reducing overall net power output to the grid. The following table summarizes the overall thermal impacts to the SJGS.

Table 3-15 — Output Changes to SJGS

Parameter	Units	Data[1]
Baseline Plant Gross Capacity	MW_{GROSS}	914
Baseline Plant Aux Power Consumption	MW	67
Baseline Plant Net Power Output	MW	847
Baseline Boiler Heat Input	MMBtu/hr	9,587
Baseline Plant Net Output	MW_{NET}	847
Baseline Plant Net Unit Heat Rate	Btu/kWh_{NET}	10,489
Future (w/ CO_2 Capture) Net Output	MW_{NET}	482
Future (w/ CO_2 Capture) Net Unit Heat Rate[4]	Btu/kWh_{NET}	19,873

Notes:

1. All data values are based on Units 1 and 4 and the carbon capture facility operating at full/design load.
2. Compression auxiliary power does not include the power consumption of the additional supercritical CO_2 pumps to get to 2800 psig at the facility terminal point; CO_2 pump auxiliary power is included in the BOP auxiliary power consumption.
3. Steam turbine derate needs to be confirmed by the turbine OEM, GE. At this time, GE has not been contracted to finalize the integration design. As such, it is expected that additional optimization of steam turbine extraction derate may be possible in the future.
4. Net unit heat rate provided in this table for the future is estimated directly based on total heat input to the boiler and total power output to the grid. It should be noted that there are alternative approaches to calculating heat rate equivalent for combined heat and power (CHP) facilities; this methodology credits the base facility for the power and steam supplied to other users. It is expected that the classification of SJGS in the future would be considered a CHP with supplying power and steam to the CO_2 capture facility.

3.8. MODULARIZATION DESIGN REQUIREMENTS

In order to minimize overall build schedule and the cost of the project, it is anticipated that most of the process structures along with pipe racks will be modularized to comply with the shipping limitation, hence modules will be fabricated at an off-site workshop and shipped for assembly at the site location.

4. PROJECT EXECUTION

4.1. BASIC CONTRACTING & PURCHASING STRATEGY

At the onset of the FEED, the project team determined the execution strategy for the project would be based on developing an Engineering, Procurement, and Construction (EPC) contract. This contracting strategy provides the least financial and technical risk to Enchant as the purchaser, by ensuring the entire project scope of the carbon capture facility and integration is covered under a single contract with associated performance-based guarantees.

4.1.1.1. Technical License and Teaming Agreement

Enchant has executed an Engineering Service Agreement (ESA) with MHIA as the technology supplier and licensor of the CO_2 capture process for the FEED study as well as for the EPC contract team.

4.1.1.2. EPC Contract

Enchant's intention is to move forward into fixed-priced EPC contract development, detailed design, procurement, and installation upon completion of the FEED study should the results of the study show the project to be technically feasible and economically viable.

Enchant has signed a memorandum of understanding (MOU) and designated Kiewit Power Constructors (Kiewit), S&L, and MHIA to act as an integrated EPC team. Kiewit will be brought into the team as the constructor for the BOP and carbon capture island equipment. The technical aspects of this contract will be based on the information developed during the FEED Study.

4.1.1.3. Long-Lead Contracts

Enchant is working with S&L and MHIA to identify any long-lead contracts for equipment procurement and when that equipment would need to be purchased in order to support the overall project schedule. Table below identifies preliminary long lead items that have been identified by MHIA and S&L.

Table 4-1 — Long Lead Items for Equipment Procurement

Procurement Item	Units	Delivery Lead Time
Flue Gas Blowers	weeks	72
Regenerators	weeks	109
Dehydration Units	weeks	79
CO_2 Compressors	weeks	113
Transformers	weeks	104

4.2. PROJECT EXECUTION SCHEDULE

A detailed project schedule was developed to aid in the overall construction timeline and costs associated with

the contractors. This has been included in Appendix D.

4.3. PROJECT EXECUTION DIVISION OF RESPONSIBILITY

A detailed division of responsibility was developed by the EPC team for the execution of the project to define where scope breaks are expected during construction and contracting.

5. COST ESTIMATE DEVELOPMENT

5.1. COST ESTIMATE INPUTS

The EPC estimate has been developed with an accuracy of ± 15% according to AACE Class 2 cost estimate by MHI, S&L and Kiewit ("Consortium") and is non-binding and indicative. The estimate shall be considered as an overnight cost with escalation based on the date of cost estimate, May 26, 2022.

5.1.1. Process Cost Development

The process procurement cost is developed based on information provided by MHI for the CO_2 capture and Compression systems including towers & internals, vessels & internals, pumps, blowers, etc. The procurement cost also includes cost for site management and construction of the module yard for assembling and installation of components on or in a specific module.

The indirect costs included as part of MHI process cost development include:

- Process Licensing Fee including solvent initial charge
- General & Administrative (G&A) Expense
- Profit
- Contingency

5.1.2. BOP Cost Development

5.1.2.1. Budgetary Quotes Utilized

Budgetary quotes were solicited from several vendors for each of the following components and/or process equipment identified below. Quotes were evaluated based on cost and performance. The vendor that offered the most effective option was selected, as identified in table below and used as input for cost estimate and engineering design. These budgetary quotes were also used to confirm there are no obvious scope gaps with the conceptual design.

Table 5-1 — Budgetary Quote Inputs

Equipment/System	Vendor	Scope Included	BOP by Others
Dampers	Fox Equipment	Units 1 & 4 Existing Chimney Isolation Damper Units 1 & 4 to Tie-In Isolation Damper Units 1 & 4 to Common Header Isolation Damper Units 1 & 4 Balancing Damper CO_2 capture trains 1 & 2 Inlet Damper	Motor and Seal air systems
Cooling Tower	SPX Marley	Field erected cooling tower with fans	Concrete cooling tower basin, anchor bolts, fire protection sprinkler system (if required),

Equipment/System	Vendor	Scope Included	BOP by Others
			pumps, piping, valves, water make-up, VFDs, disconnects, and controls
Compressed Air System	Atlas Copco	Three (3) x 50% oil free rotary screw air compressors, two (2) x 100% air cooled trim coolers, one (1) x 100% wet receiver, two (2) x 100% desiccant air dryer with pre-filter and after filter	
CO_2 Product Pumps	Baker Hughes	Four (4) x 25%, 5-stage centrifugal pumps	All piping, instrumentation, and wiring outside skid battery limit, 2-year spare parts, capital spare, anchor bolts, steam tracing/insulation, lubricants and hydraulic oil first fill
Miscellaneous Pumps	Goulds Pumps	Two (2) x 50% Circulating Water Pumps Two (2) x 100% Demineralized Water Pumps Two (2) x 100% Potable Water Pumps	
Pressure Relief Valves	Novaspect	Safety Relief Valves	
Steam Conditioning Valves	Novaspect	Units 1 & 4 Low Pressure Steam to valves with spray water control and spray water block valves Units 1 & 4 Main Steam to valves with spray water control and spray water block valves	
BOP Distributed Control System (DCS)	Schneider Electric / Foxboro	DCS additions, revisions, and upgrades.	
Three Winding Unit Auxiliary Transformers	ABB/Hitachi	Units 1 & 4 CO_2 capture plant Auxiliary Transformer supply.	Installation of equipment and cabling and wiring and IPBD connection for high side and cable bus connection for low side.
CO2 Compressor VFDs and Motors	Quad Plus/Siemens	Units 1 & 4 CO_2 compressor VFD, motor, and excitation systems including transformers	Installation of equipment and cabling and wiring between

Equipment/System	Vendor	Scope Included	BOP by Others
		for VFDs and PDCs to house equipment.	systems.
Electrical Distribution Equipment (Switchgear, MCCs, Cooling Tower PDCs, and aux substation transformers, etc.)	Siemens	Units 1 & 4 Switchgear, MCCs, Cooling Tower PDCs, and aux substation transformers, etc. supply.	Installation of equipment and cabling and wiring between systems.
Isolated Phase Bus (IPBD)	AZZ	Units 1 & 4 Isolated Phase Bus tap and bus work for new CCUS transformers.	Installation of equipment and connection to existing IPBD and new CCUS transformers.
Cable Bus	MP Husky	Units 1 & 4 cable bus supply.	Installation of equipment and connection from new CCUS transformers and new switchgear.
Security/Access Control	SCI	Supply and installation of new security and access control system.	

5.1.2.2. Equipment and Construction Costs Input

Equipment pricing developed by S&L and Kiewit for BOP items are based on previous project experience combined with engineering judgement. A constructability review was completed with Kiewit to ensure the logistics of implementing a multi-train system into an operating power plant would be as efficient and cost-effective as possible. This review also served as input to the overall site GA and costing exercise. Notes from the constructability review meeting are included in Appendix E.

Flue gas duct expansion joints are based on those identified in the design and dimensions of the ductwork. Pumps outside of equipment supplier's costing scope outlined in Table 5-1 above included the circulating water priming pump, miscellaneous sump pumps and chemical supply pumps. These pumps were preliminarily sized and types determined. Steam drains flash tanks, potable water tanks and chemical storage tanks were preliminarily designed with sizes and materials selected. The additional surge RO wastewater treatment system (pumps, filters, tanks, etc.) were sized based on the water balance results and used for estimation purposes. Other miscellaneous equipment such as cooling tower stop gates & trash screens, and emergency eyewash/shower stations were reviewed based on previous projects.

Foundation quantities were developed with MHIA input or available BOP vendor data according to the provided design/vendor drawings. The foundations are a combination of mat on grade or mat on pile type based on the available geotechnical data and loading provided from MHIA or BOP vendor data. S&L provided a foundation layout and Kiewit provided foundation quantities in cubic yards of yards of concrete for mat foundations and piles. Kiewit's quantities include formwork for concrete foundations and structures, tons of steel for embedment

and reinforcing, in addition to miscellaneous foundation items including, but not limited to, mudmats, pre-molded joint filler, and grout.

Structural steel quantities were developed with MHIA input for the CO_2 capture island area and S&L for the remaining BOP structures which include building steel, utility rack steel, Unit 4 structure reinforcing steel at duct tie-in, duct support steel, cooling tower steel and access gallery, platforms, and miscellaneous piping and cable tray supports. In addition, square footage of grating and linear feet of handrail were also estimated. Kiewit provided total quantities in tons of steel and where information was not provided such as connection allowance and reinforcing of Unit 4 structural steel, Kiewit included this along with costs for bolt ups and welded connections.

Ductwork sizing and material selection was determined by S&L with available Units 1 & 4 site data and MHIA input. The ductwork is a combination of fiberglass reinforced plastic (FRP) and carbon steel with a clad liner. Linear feet and tons of steel for the ductwork are included in addition to square footage of insulation and lagging, linear feet of expansion joints, ductwork accessories including support locations for slide bearing plates/spherical bearings, and access doors.

Civil quantities were developed for sitework including, but not limited to, temporary sediment and erosion control, earthwork (including onsite disposal of excess material), retaining walls, roadways, area surfacing, storm sewer system, oily sewer system, oil water separator, and chain link fences and gates. Also included are temporary use areas that include laydown and craft parking areas that will be used during the construction phase of the project. This included takeoffs of roadways, estimating excavation and backfill for foundations, deep foundation, and drainage to name a few. Kiewit included construction related scopes, such as silt fence construction and maintenance, in the estimate. Concrete quantities were provided by S&L to Kiewit for this estimate. Utilizing this information, Kiewit included typical rebar (lb/cy) for similar foundations as well as anchorage.

Demolition quantities are included in the civil estimate and were developed for known ductwork, structures, and foundations that currently interfere with installation of the CO_2 capture plant.

Architectural costs were based on the building dimensions indicated on the architectural plan and elevation drawings. Quantities developed include siding, roofing, downspouts and gutters, doors, interior partitions, and finishes.

Electrical quantities were developed for cables, raceway, lighting, grounding, lightning protection, and receptacles using the conceptual design drawings. Lengths for raceway and cables were estimated from take-offs using the conceptual design drawings.

All piping costs are based on material, diameter, thickness, and length as indicated in the design. This is inclusive of in-line piping items such as valves, strainers, expansion joints, etc. Insulation is included as needed and is based on process conditions. Mineral fiber insulation with a vapor barrier and jacketing shall be used on process piping and equipment where temperatures exceed 140°F to provide personnel protection and process heat conservation. Heat tracing shall be used in conjunction with mineral fiber insulation on piping and equipment that could be subject to freezing or process interruption upon exposure to freezing conditions.

S&L received vendor pricing for the BOP DCS expansion (CO_2 capture plant DCS is independent of the existing plant controls and is included in the MHI costs). The BOP DCS expansion includes preliminary control system hardware design and system integration services required for the expansion of BOP DCS. This cost includes all DCS hardware, network hardware, and all engineering or support services required to design, fabricate, deliver, and assist in commissioning the complete DCS expansion. This cost also includes upgrading the existing Unit 1, Unit 4, and Common DCS Operator Workstations to facilitate relocation of operations into a new integrated station main control room. Preliminary control system hardware design was developed based on the I/O quantities defined in the preliminary I/O list and the interfaces required per the network architecture diagram.

Instrumentation costs are based on BOP instrumentation quantities identified in the design and extracted from the various vendor quote information received. Manufacturer configuration tools and historic procurement costs were used to develop the estimated costs for each instrument type. Costs for installation materials, tubing, instrument stands and enclosures, and GWC installation labor are also included. Procurement and installation costs were included for each instrument type, listed as separate line items by instrument type. Together, these costs represent the total installed instrumentation cost not covered by a supplier package or major equipment cost represented in other sections of the cost estimate

Labor-hour estimates are included for most line items in the cost estimate, with the exception of some all-in costs provided for subcontracted efforts and allowances. The magnitude of labor-hours is indicative of the level of effort for the installation for each item. All construction labor manhour costs were drawn from a combination of ongoing projects in similar proximity to the San Juan facility or from a labor analysis. Costs include labor, fringes, and craft attraction necessary to draw enough craft to the San Juan site for the project. The project assumes a 5x10 construction schedule.

Labor productivity was drawing from Kiewit's past cost for work similar in the area (primarily civil and steel) where possible or from similar projects and scopes (electrical, mechanical, equipment, and Instrumentation). Per diems were drawn from ongoing nearby projects. Small Tools, supplies, and consumables were estimated for each of the disciplines and included in the estimate. Construction equipment costs were included based on the overall project schedule.

The indirect costs included in the cost development include:

- Permits & Taxes
- General & Administrative (G&A) Expense and Margin
- Bonds/LOC/Insurance
- Escalation
- Contingency
- Home Office Constructability Support
- Job Related Overhead
- Operation Support

5.2. TOTAL PROJECT COST ESTIMATE

The total project cost estimate is summarized below based on the process cost development by MHI and BOP cost development by the Consortium in Sections above.

Table 5-2 — Total Project Capital Cost

Parameter	Amount (USD)
Total Project Cost	**$1,554,275,657**

5.3. OPERATING & MAINTENACE COST ESTIMATE

The operating and maintenance (O&M) cost estimate was developed using commodity pricing confirmed by Enchant/Farmington, chemical pricing, various utility needs provided by MHI, process flows and water balance prepared by S&L, and engineering judgement. O&M estimates were broken down into variable O&M costs, that are contingent upon the unit capacity factor and fixed O&M costs which are expected annually, regardless of unit operations.

Variable O&M costs include items such as energy consumption for steam and power, water costs for high quality and raw water use, and chemical/solvent consumption for MHI's equipment and BOP water treatment.

The fixed O&M costs include operating personnel, labor cost, and maintenance cost (including material and labor). The anticipated staffing was provided by MHI to operate and maintain CO_2 capture plant.

The total first year O&M costs are summarized in table below, provided in 2022-dollar basis.

Table 5-3 — Total First Year Fixed O&M Costs

Parameter	Unit	Amount
Total O&M Costs ($2022)	$/yr.	**170,706,000**

5.4. COST OF CAPTURE

The cost of capture is based on assuming lifespan of 20 years for the operation of CO_2 capture plant at an interest rate of 4.5%, which is generally consistent with other recent NETL and DOE reports. The cost of capture is summarized in the table below.

Table 5-4 — Total Cost of Capture

Parameter	Unit	Amount
Total CO_2 Capture Rate – at 85% CF	metric ton/yr.	6,212,980
Lifespan of Facility	years	20
Interest Rate	%	4.5
Annualized Factor	--	0.0769
Total Capital Cost	$	1,554,276,000

Parameter	Unit	Amount
Annualized Capital Cost	$/yr.	119,487,000
Total First-Year O&M Cost	$/yr.	170,706,000
Total Annual Cost	**$/yr.**	**290,193,000**
Cost of Capture	**$/tonne**	**46.7**

6. Open Issues & Next Steps

Following the completion of the FEED study, some of the next steps for future considerations were discussed with the Project Team. Based on the development level of this project, it is expected that the overall risk and next steps are minimal in comparison with less advanced technologies and smaller scopes of projects. Some of the open items and next steps include: securing permits, finalization of EPC between Enchant and the selected EPC team of S&L/MHI/Kiewit, securing financing for the execution of the CO_2 capture plant discussed below.

- Permitting is a key hurdle for any major retrofit to an existing power or industrial facility. While carbon capture is planned to remove over 6M tonnes of CO_2 from the SJGS facility annually, there are still other impacts to the air permit that are required to be modified in the permit. S&L and Enchant are currently working on developing air permits, but submittal and approval of these permits is a key next step before on-site construction can be initiated.

- In parallel with the development of the FEED study, the team developed an EPC arrangement between Kiewit, S&L, and MHIA with the intent to eventually develop an EPC proposal for Enchant to execute.
    - A firm fixed priced cost estimate to include in the EPC proposal will be developed by the S&L/MHI/Kiewit Consortium and negotiated with Enchant to be able to execute the CO_2 capture project.
    - A Limited Notice to Proceed (LNTP) concept for the execution phase of the project must be defined. This will allow the EPC team to lock in long-lead pricing for major equipment and finalize key detailed engineering activities such as the steam turbine studies to be conducted by the OEM.

- The FEED study is intended to be a step toward development of a firm price of the project, which Enchant can align investors and financing for. There are expected to be multiple next steps with regards to securing that financing.
    - Developing a pro-forma or other economic model is typically a tool used to secure financing. Enchant initially developed an economic modeled based on the pre-feasibility study competed prior to the FEED study. A next step will be to confirm how the revised O&M and capital costs impact the viability of the project.
    - Furthermore, the results of the FEED study developed detailed energy derate impacts that will need to be included in overall power sales assessments.
    - Prior to signing a contract, it is anticipated that Enchant would intend to secure demonstration funding for large-scale CO_2 projects if made available by the DOE. As part of this process, the overall project team would utilize the information and conclusions developed in this study to prepare an application.

- Outside of the carbon capture project, there is a planned betterment project for the base power plant after Enchant takes majority ownership of the facility. This betterment project is intended to ensure the base facility can maintain high output and reliability over the operational course of the carbon capture facility. One of the next steps is to develop an execution plan for the SJGS plant betterment project, which are required maintenance and repair projects to the existing station and ensure the achieve the reliability and availability targets for future operation and are able to be completed on a similar timeline as the carbon capture facility development.

- While the scope of the FEED study does not include the transportation and storage of the product CO_2, Enchant has been working with the CarbonSAFE project to ensure there is an option for permanent geologic sequestration as well as development of potential CO_2 off-take agreements for injection into the Cortez pipeline for EOR use. Finalization of CO_2 sequestration/transport and off-take agreement
    - Depending on the plan for CO_2 transport, there may be a future option to eliminate the need for additional compression on site, to match the different needs for sequestration versus Cortez injection. Finalization of this arrangement will be a necessary next step to optimize overall cost and operational impacts of the proposed configuration. If the on-site compression is limited to just compressors and pumps are located off-site, the overall auxiliary power consumption is expected to be reduced.
    - Finalization of EOR off-take agreements will also impact the overall financial model.

Appendix A. S&L BOP Summary Report

ENCHANT ENERGY CORPORATION

ENCHANT ENERGY, L.L.C.
SAN JUAN GENERATING STATION UNITS 1 & 4

Enchant Carbon Capture FEED Study S&L BOP Summary Report

Revision 1

September 30, 2022

Project No.: 13891-010

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1. INTRODUCTION

1.1. PROJECT OVERVIEW

Sargent & Lundy (S&L) was retained by Enchant/Farmington to support the work outlined in the National Energy Technology Laboratory (NETL) sponsored project, DE-FE0031843. The project involved conducting a Front-End Engineering Design study (FEED) for the retrofit of the San Juan Generating Station (SJGS) with post-combustion carbon dixoide (CO_2) capture technology. SJGS currently has two operating coal-fired steam electric generating units (Units 1 & 4) and two recently retired units, Units 2 & 3. SJGS Unit 1 is a nominal 370 MW-gross (MWg) Foster Wheeler subcritical wall-fired boiler and SJGS Unit 4 is a nominal 544 MWg B&W subcritical opposed wall-fired boiler. The CO_2 capture plant is designed to treat entire flue gas from the SJGS Units 1 & 4 and will capture 20,026 metric ton per day (MTD), approximately 95% of SJGS Units 1 & 4 current CO_2 emissions. The captured CO_2 is compressed to 2,800 psig for transportation to a pipeline off-site for enchanced oil recovery (EOR) and/or sequestration. It should be noted that the utilization and sequestration aspects are not within the scope of this CO_2 capture FEED study and are part of separate studies performed by Enchant.

S&L was tasked with preliminary engineering and design of all balance of plant (BOP) components and providing input and oversight on other project deliverables. The S&L BOP design included utility tie-ins, interconnecting ductwork/piping, cooling tower, reagent/chemical supply and storage, wastewater collection and treatment, structural, civil, switchyard, substation, electrical, and instrumentation and controls. S&L prepared the overall project design criteria, execution phase technical specifications, plot plan and general arrangement (GA) drawings, overall process flow diagram (PFD), process and instrumentation diagrams (P&IDs), system descriptions, single line diagrams, network architecture diagrams, controls description, typical loop diagrams and I/O tables, and instrument and I/O lists. S&L also developed the detailed engineering and design project schedule and completed other critical engineering deliverables or tasks to support the design effort. In addition, S&L supported the development of budgetary request templates, soliciting equipment budgetary requests, and the development of detailed cost estimates.

The overall goal of the project is to develop an Association of the Advancement of Cost Engineering (AACE) Class 2 Capital Cost Estimate with an accuracy of ± 15% to demonstrate the economic feasibility of constructing and operating CO_2 capture plant. The summary report outlines the scope, engineering approach, and results of the FEED study, as supplemented by the information presented in the various appendices.

2. BALANCE OF PLANT DESIGN

S&L was tasked with performing preliminary engineering and design for the BOP scope to support implementation of a CO_2 capture system at SJGS. BOP design and engineering was supplemented by information provided by Enchant regarding the operating conditions of the boiler, existing electrical layouts, existing foundations, surrounding landscape and facilities, and available utilities.

The approach for the preliminary design and engineering for the BOP scope is summarized in the following sections.

2.1. DESIGN INPUTS

A flue gas design basis document was prepared that outlines the boiler conditions, operating parameters, and process assumptions that affect flue gas conditions along its flow path. An overall design criteria document was also prepared which outlines the efforts of the different S&L disciplines. The final flue gas design basis and design criteria documents are located in Appendix A and Appendix B, respectively.

2.2. BALANCE OF PLANT SCOPE / SYSTEM DESCRIPTIONS

S&L performed the FEED design for the major BOP scope to support the development of the detailed cost estimate and technical specification for the CO_2 capture plant. The major BOP scope includes the following:

- Flue gas ductwork
- Steam extraction from Units 1 & 4
- Condensate return to SJGS Units 1 & 4
- Circulating water and cooling system
- Demineralized water supply and tie-in
- Service water system
- Potable water system
- Fire protection system
- Wastewater management
- Chemical storage and forwarding
- Electrical system
- Control system
- Miscellaneous support systems (foundations, support steel, utility racks, etc.)
- Miscellaneous buildings (mechanical equipment building, wastewater treatment, chemical feed, and CO_2 pump building, electrical equipment and control building, etc.)

Details of the major BOP scope are described in the sections below.

2.2.1. Flue Gas Ductwork

The area north of SJGS Unit 4 and west of wastewater recovery area was selected as the location for the CO_2 capture equipment because this area is relatively clear and available for industrial development. New ductwork will tie-in to the existing ductwork downstream of each units' existing WFGD absorber vessel and upstream of the existing chimney or stack. The CO_2 capture island will be designed to treat 100% of the flue gas generated from Unit 1 & Unit 4 and will be routed via new elevated, corrosion resistant ductwork from Units 1 & 4

separately prior to tie-in into a common ductwork for supply to CO_2 capture island where-in the flue gas supply from common duct to Train 1 and Train 2 is split.

The ductwork to the exiting chimney with motor operated isolation damper will remain in place to bypass the CO_2 capture island if required for venting during excursion scenarios when flue gas volumetric flow rate sent to CO_2 capture island is greater than design, or during CO_2 capture system maintenance cycle with one/both trains are run at reduced capacity, or when CO_2 capture system trains are offline. For the new ductwork, motor operated isolation dampers will be provided at each tie-in to the existing ductwork and subsequently in the ductwork leading to the common header. Opposed blade motor operated modulating dampers will be provided at each units' tie-in to the common ductwork routed to the CO_2 capture island for balancing pressure from the unit to the common ductwork. Finally, parallel blade dampers will be provided in the flue gas ductwork path to each CO_2 capture system Train 1 and Train 2 to isolate the ductwork to each individual train.

Additionally, two (2) x 100% seal air blowers supply seal air to the flue gas ductwork dampers to provide complete sealing from the process. Blowers are provided in the area of the Units 1 & 4 tie-in to the existing ductwork and also at each unit's tie-in to the common ductwork to the CO_2 capture plant. The expansion joints in the flue gas path will be provided to allow duct expansion as a result of thermal, seismic, and environmental loading which occurs during normal and excursion conditions.

2.2.2. Steam Extraction

The CO_2 capture process relies on heat energy provided by steam to facilitate the release of CO_2 from the proprietary solvent. This regeneration process is carried out in the stripper vessel. Heat energy is provided by steam from the SJGS Units 1 & 4 steam cycle and routed to the CO_2 capture island. S&L prepared a steam and electric sourcing study to determine the best steam extraction and condensate return locations from the SJGS steam cycle. This study is discussed in detail in Section 3.1.

2.2.3. Circulating Water and Cooling System

Cooling is required throughout the CO_2 capture process for flue gas cooling, solvent performance, and compression. The original concept was to re-use the existing Unit 3 cooling tower and build a new supplemental cooling tower over the existing Unit 2 cooling tower basin. Based on the Cooling Study (Appendix E) completed by S&L, it was determined that modifications to the Unit 3 tower and work to build the supplemental cooling tower was not cost effective. A new cooling tower dedicated to the CO_2 capture island will be provided to supply the large volume of cooling water required. Large circulating water headers will be routed underground from the cooling tower to the CO_2 capture island, where they will split to the various CO_2 capture system users and come above ground. Two (2) x 50% pumps supply cooling water from the cooling tower basin to the circulating water headers and return water to the cooling tower. The return circulating water will also accept the pre-scrubber blowdown water from the CO_2 capture island. The water quality of the pre-scrubber blowdown will impact the cycles of concentration that the cooling system can safely operate without detrimental effects on the cooling system materials. Circulating water chemical treatment is required to combat against biological growth, fouling and corrosion within the system.

2.2.4. Demineralized Water System

Demineralized water is required by the CO_2 capture system for various uses including pump seal water, hydrogen generation, flue gas blower water spray system, wash water, and makeup water for initial startup of various equipment. The demineralized water will be supplied by the existing SJGS facility. The tie-in location

from the existing unit will be located at the Unit 4 Condensate Storage Tanks. New pumps located within a weather enclosure are provided to transfer water from the storage tank to the CO_2 capture system users.

2.2.5. Service Water System

Service quality makeup water is required to support the new CO_2 capture system. The main function of the service water system is to provide the primary source of the CO_2 capture system cooling tower makeup. Service water will also be used for quench water to the steam drains tanks and as water supply to wash down stations located throughout the new Facility. The supply of the service water system will come from tie-ins from of the existing underground raw water header.

2.2.6. Potable and Fire Water System

The new facility will tie into the existing potable water, raw water, and fire water systems at SJGS. New fire protection systems are included in the design and cost estimating for the new CO_2 capture island process buildings, BOP mechanical equipment buildings, administration and control areas, and general site protection (yard hydrants).

2.2.7. Wastewater Treatment

Several new sources of wastewater will be produced and managed due to the new CO_2 capture system, including cooling tower blowdown, oily waste drains, steam drains, tri-ethylene glycol (TEG) waste, and other miscellaneous drains. As noted previously, the pre-scrubber blowdown water from the CO_2 capture plant will discharge to the circulating water system. The majority of the CO_2 capture system cooling tower blowdown will be sent to the existing facility's wastewater treatment system (brine concentrators) via Process Pond 3. The balance of the cooling tower blowdown will be sent to a new wastewater treatment system. Effluent from this new wastewater system will be sent back to the new CO_2 capture system cooling tower as makeup, which will help reduce the total fresh makeup water. Treated oily waste drains and quenched steam drains will be sent to existing facility's wastewater treatment system. TEG waste and RO reject cannot be further treated and will be sent to the South Evaporation Pond located on site.

2.2.8. Electrical System

Primary power for the new CO_2 capture island will be sourced from the existing Units 1 & 4 generators. The main Isolated Phase Bus Duct connecting the Units 1 & 4 generators to their respective Generator Step-Up Transformers will be modified with additional tap connections to two (2) new 3-winding auxiliary transformers. The new 3-winding auxiliary transformers will be 2 x 100% redundant and capable of supplying power for both trains of the new CO_2 capture island. The main electrical distribution system will be 13.8kV and consist of two 15kV metal clad switchgear lineups each with a main and reserve breakers and connected to the secondary windings of the auxiliary transformers with cable bus as shown on the attached overall single line diagrams.

2.2.9. Control System

A new control system for the CO_2 Capture System will be a standalone distributed control system (DCS). This standalone DCS will be the same type of DCS (Foxboro) that controls the existing SJGS Units 1 & 4. The existing SJGS Plant DCS will not operate or monitor the new CO_2 Capture System, however, it will be expanded to control new Balance of Plant instrumentation, valves, and equipment. Any process signals/commands required to be exchanged between the existing SJGS DCS (Foxboro) and the new CO_2 DCS will be via hardwired signals. A new electrical and control building will be added and will house a new

station Main Control Room (MCR). Operations of the existing SJGS plant will be moved to this new MCR, along with the primary operation of the new CO_2 capture plant. DCS controller and/or input/output (I/O) cabinets will be distributed in electrical rooms and a Power Distribution Center (PDC) electrical building to support control of remote systems and structures.

2.2.10. Structural Supports & Building Steel

All structural steel work will conform to the American Institute of Steel Construction (AISC) Specification for Structural Steel Buildings the AISC Code of Standard Practice. All structural steel will be designed to resist vertical and horizontal loads, including dead, live, wind, seismic, pressure, temperature and equipment loads as applicable and as required by the International Building Code and industry standards.

2.2.11. Containment and Foundations

All concrete will be designed in accordance with the requirements of American Concrete Institute (ACI). All concrete will be designed to resist vertical and horizontal loads, including dead, live, wind, seismic, pressure, temperature and equipment loads as applicable and as required by the International Building Code. Foundations will be soil supported mat foundations or on piles based on information from existing geotechnical support. Containment areas will be concrete slab foundations with perimeter curbs/walls and coatings as required.

2.3. PRELIMINARY ENGINEERING

An outline of the general engineering scope and supporting deliverables produced by S&L for the FEED study includes the following major scopes. This section describes the approach taken for completing preliminary BOP engineering and design.

2.3.1. Process Engineering

Process engineering and design for the CO_2 capture island was completed by MHI. S&L scope and associated deliverables for the FEED study include the following:

- Overall PFD
- Overall Mass Balance
- Overall Water Balance
- Overall Design Basis & Criteria
- BOP Equipment List
- P&IDs for BOP Scope
- BOP System Descriptions
- Overall Heat Balance
- Preliminary BOP Mechanical Specifications

S&L prepared PFDs for the BOP system and integration using Visio. These deliverables were used to visualize all project components and major tie-in locations related to the carbon capture process island. Detailed CO_2 island PFDs are provided separately by MHI. S&L also prepared an overall mass balance for all major gas and liquid process flows. These balances aided in sizing pipelines, pumps, and storage tanks. Further, the balance served as a check on process flows and waste generation and commodity consumption rates.

For the water balance, prior to preparing and integrating the CO_2 capture process into the overall water

balance, S&L updated the water balance prepared by S&L back in 2011 by adding or removing components and updating water flows for an accurate starting point. The water balances were modified to reflect the following:

- Decommissioning of Units 2 & 3
- Operation of Units 1 & 4 cooling towers at 11.0 and 15.0 cycles of concentration, respectively
- Prorating Units 1 & 4 cooing tower evaporation rates in average water balance to reflect 85% capacity factor
- Closure of North Evaporation Ponds and routing of all residual wastewater to South Evaporation ponds

S&L then prepared overall water balance for annual average and summer design conditions. The annual average and summer water balances were developed based on 85% and 100% capacity factors.

S&L prepared the overall design basis & criteria to outline all design consideration, major system design basis, and governing engineering codes.

An overall heat balance for both Units 1 & 4 was prepared by S&L as part of the steam and electric sourcing study. Steam was sourced from the IP/LP crossover piping which provides an extraction location with steam conditions available close to the required carbon capture pressures and temperatures. S&L's heat balances depicts all heat content, enthalpy, mass flow rates, and power allocations associated with the major boiler and turbine sections and extractions streams.

S&L developed P&IDs for the CO_2 capture balance of plant (BOP) systems, upon completion of which equipment list was developed. Other deliverables prepared include the process area description and specifications for the new cooling tower, new pumps, and steam conditioning valves.

2.3.2. Mechanical Engineering

The mechanical engineering scope for the SJGS project included the BOP scope identified above and interconnections to the CO_2 capture island. The following deliverables were developed as part of the preliminary mechanical engineering and design:

- Terminal Point List
- Piping Line List
- Valve List
- 3D Model (not attached)
- Project Site Plan
- GA Drawings for Cooling Tower Area and Wastewater Treatment Building
- Piping Isometric Drawings
- Underground Composite Plans
- Demolition and Modification Drawings
- Fire Protection System Breakdown

Preliminary pipe sizes and equipment sizing for the BOP systems were developed using S&L standard engineering and design practices and sound engineering judgement. Upon completion of the P&IDs, engineering lists including, piping line list, specialties list, and valve list were developed. These lists are

representative of all components included in the BOP systems. Separate engineering lists for the CO_2 island were prepared by MHI. These comprehensive lists included the technical details necessary for the cost estimating department to provide an appropriate cost for each line item. The terminal point list was developed by identifying terminal points between the new CO_2 island and the existing plant. Review of existing plant drawings and required demands of the new process connections aided in populating the terminal list operating and design conditions.

As part of the preliminary engineering and design, a 3D model of the balance of plant equipment was developed. The balance of plant equipment, piping, and components were developed and modeled by S&L. The 3D model serves as the basis for generating other project deliverables, including the site plan, general arrangement, layout drawings, isometric drawings, underground composite drawings, and flue gas ductwork drawings. Additional drawings, such as the demolition and modification drawings, were prepared separately.

Phase 2 work also included developing the preliminary Fire Protection System scheme, including the expected fire protection, detection and suppression systems for the various systems, structures and equipment in the CO_2 Island. Additionally, the Heating, Ventilating and Air Conditioning (HVAC) systems for the CO_2 Island were established, including preliminary sizing of equipment and ductwork systems.

2.3.3. Electrical Engineering

The electrical engineering scope for the SJGS project included the balance of plant electrical distribution system for the new CO_2 capture island and interconnections to the existing SJGS Units 1 & 4 generators. The electrical distribution design for the CO_2 capture island was completed by MHI. The following deliverables were developed as part of the preliminary electrical engineering design:

- Overall Single Line Diagrams
- Electrical Load List
- Electrical Equipment List
- Auxiliary Power System Study (Load Flow, Short Circuit, Large Motor Starting)
- Cable Tray Layout Drawings
- Duct Run Drawings
- Lighting Drawings
- Grounding Drawings
- Lightning Protection Drawings
- Electrical Notes and Details
- Electrical Equipment Room Arrangement Drawings
- Welding Receptacle Drawing
- Communication Network Diagrams
- Cable Lists/Bills of Material
- Preliminary Letter Specs (Cable Bus, Isophase Bus Duct, Security and telephone, Switchgear, MCCs, PDC, Unit Auxiliary Transformers, Variable Frequency Drives, and Motors.
- Preliminary Specifications (Heat Trace and Cathodic Protection)

Primary power for the new CO_2 capture island will be sourced from the existing Units 1 & 4 generators. The main Isolated Phase Bus Duct connecting the Units 1 & 4 generators to their respective Generator Step-Up

Transformers will be modified with additional tap connections to two (2) new 3-winding auxiliary transformers. The new 3-winding auxiliary transformers will be 2 x 100% redundant and capable of supplying power for both trains of the new CO_2 capture island. The main electrical distribution system will be 13.8kV and consist of two 15kV metal clad switchgear lineups each with a main and reserve breakers and connected to the secondary windings of the auxiliary transformers with cable bus as shown on the attached overall single line diagrams.

The 13.8kV switchgears will provide medium voltage power to the large CO_2 compressor motors, flue gas blowers, and circulating water pumps. The 13.8kV medium voltage distribution will be further stepped down to 4.16kV and 480V for providing power to CO_2 capture island and the BOP electrical users.

The electrical distribution equipment will be located in an electrical equipment room inside the main electrical and control building. The auxiliary transformers will be oil filled type and be located just outside the electrical room.

A new pre-fabricated electrical distribution Center (PDC) will be provided at the cooling tower to distribute power to all of the BOP loads and fans in the cooling tower area.

Due to the large size of the CO_2 compressor motors new medium voltage VFDs will be required for starting. Two (2) VFDs will be provided, one for each train, but will include a cross tie for 100% redundancy. Each VFD will be sized for starting duty with the ability to start all four (4) CO_2 compressor motors sequentially. Once the motors are running at synchronous speed they will be automatically transferred from the drive to the main 13.8kV bus. New PDC units containing the VFDs will be provided and be located near the main electrical and control building.

A backup power feed for lighting, HVAC, and station battery charger will be taken from the existing Unit 3 6.9kV Switchgear. The 6.9kV feed will be stepped down to 480V at the new CO_2 capture island area to a 480V Essential Services MCC. This MCC will provide power for essential lighting, HVAC and battery charger for the CO2 island in the event that both Units 1 & 4 are offline. The 480V Essential MCC will be equipped with an automatic transfer switch (ATS) that will switch from normal power (the new CO_2 capture island distribution system) to the alternate source (existing Unit 3 6.9kV switchgear) on loss of voltage at the line side of the ATS.

Medium and low voltage power cable will be used to connect individual loads to their respective switchgear and motor control centers. Cables will be routed in a combination of cable tray, conduit, and duct bank.

2.3.4. Instrumentation & Controls Engineering

The following deliverables were developed as part of the preliminary I&C engineering and design:

- BOP Controls Description
- Control System Network Architecture Diagram
- Instrument List
- Control System Equipment List
- Preliminary Control System Letter Specification
- Control System Typical Loop Wiring Diagrams

The Instrumentation and Controls (I&C) team developed an overall control strategy description detailing the system layout assumptions as well as BOP system tie-in assumptions to set the basis of instrumentation location, control system equipment and control logic. S&L also completed a Control System Study to evaluate

the impact and advantages of relocating the SJGS plant operations to a new MCR, which will also include the primary operation of the CO_2 capture plant. This study was used as input to the control room layout drawings, along with network architecture diagram.

The controls architecture diagram details the interface plan for the existing DCS with the new CO_2 island DCS. The BOP P&IDs were used as input to generate the instrumentation list.

2.3.5. Structural & Civil Engineering

The following deliverables were developed as part of the preliminary structural engineering and design:

- Spill & Containment Plan
- Foundation Drawing
- Ductwork Drawings
- Utility Rack Drawing
- Architectural Design Drawings
- Building and Facility Security Plan
- Control & Electrical Building Layout Drawing
- Control Room Conceptual Layout

The structural engineering scope includes the preliminary design and estimates for the anticipated structural support steel, flue gas ductwork, utility rack, process and equipment buildings, and all associated foundations for these systems. In addition, site plans, grade elevation and stormwater runoff plan, containment plan, and a building security plan were prepared.

A site plan drawing was prepared to show the location of new equipment on the site overlaid on an aerial image taken from Google Earth. Cooling water, miscellaneous utilities, and electrical tie-ins are also depicted on the site plan.

Preliminary structural and foundation designs considered all loads including dead, live, snow, impact, wind, thermal expansion, dynamic, settlement, movement, seismic, friction, and other appropriate load conditions. These loads were determined in accordance with IBC 2015 and ASCE 7-10 standards.

3. ENGINEERING STUDIES & EVALUATIONS

S&L conducted several evaluations and studies throughout the Enchant SJGS Carbon Capture FEED Study to identify design considerations or requirements for modifications or additions to existing systems and equipment, evaluate the optimal design in areas with numerous considerations, and evaluate the safety of the design. The conclusions of these studies were used as a basis of the preliminary design; however, in many cases, the reference design drawings or deliverables used to generate the studies have been superseded by later revisions created during the course of the FEED Study. This section of the report outlines the purpose, scope, and conclusions of those evaluations and studies.

3.1. STEAM AND ELECTRIC SOURCING STUDY

S&L completed a steam and electric sourcing study to evaluate the impacts of steam extraction to the plant steam cycle and outline next steps for the steam turbine original equipment manufacturer (OEM) to evaluate what modification or limitation are required, if any, to support the extraction. MHI's CO_2 capture system requires large amount of steam to heat the solvent to strip the CO_2 from the solvent; as such, only steam extraction was considered for the study and other options such as new auxiliary boiler or cogeneration plant were not evaluated due to much higher expected cost of these systems. It was concluded from the study that in total, both units combined lose approximately 200 MWg generation by extracting steam at full load. When extracting steam, minimum load for Unit 1 was determined by the low-pressure turbine exhaust overheating and minimum load for Unit 4 was determined by the boiler minimum steal generation. The results and details of this study are included in Appendix D.

As next steps, evaluation of the heat balances and the performance impacts of steam extraction will need to be evaluated by steam turbine OEM.

3.2. COOLING STUDY

S&L completed a cooling study to evaluate the cooling system requirements to support the heat rejection required as part of the MHI's CO_2 capture system. The scope of the study includes looking at the impacts to the GA, cooling water piping, and high-level costs for two (2) options: (1) the feasibility of the existing Unit 2 and 3 facilities being able to support the required heat rejection; and (2) completely new cooling tower(s). It was concluded that, using existing Unit 2 and Unit 3 cooling tower would present many challenges including asbestos insulation abatement, significant repair work, and project impacts due to 345 kV transmission line and evaporation pond impact creating more cost and schedule delay due to CO_2 capture proposed location north of Unit 3 cooling tower. As a result, it was concluded that Option 2 for a brand-new cooling tower was chosen for the design to avoid project impacts and it being less expensive than Option 1 with cost savings on ductwork, piping, steel, electrical etc. due to shorter distance between the power station and CO_2 capture island. The results and details of this study are included in Appendix E.

3.3. WATER SUPPLY STUDY

S&L completed a water supply study to ensure SJGS has adequate water rights and infrastructure for continuous operation of the CO_2 capture system. S&L supported this effort by fist updating the water balance prepared by S&L back in 2011 by adding or removing components and updating water flows for an accurate starting point. Based on the preliminary water balance and the operating data shared for the existing water consumption and existing wastewater treatment system, evaluations were performed for the four water supplies: (1) river water, (2) demineralized water, (3) utility (service) water, and (4) potable water. Based on

the water balance, with CO_2 capture system the new river water usage is 11,075 gpm or 17,836 acre-ft/yr. for annual average conditions at 85% capacity factor with wastewater recycle and 15,236 gpm or 24,574 acre-ft/yr. for summer conditions at 100% capacity factor. For the demineralized water, utility, and potable water the requirements from MHI were determined to very small and concluded to be available from existing supply and treatment systems. The results and details of this study are included in Appendix F.

3.4. WASTEWATER STUDY

S&L evaluated various treatment options to treat various wastewater streams from the CO_2 capture process to allow SJGS top operated as zero-liquid discharge (ZLD) facility. S&L supported this effort by determining whether SJGS has the existing infrastructure to recycle, treat and/or dispose of these wastewater streams via existing ponds. It was concluded that existing ZLD does not have enough excess capacity to treat the additional wastewater associated with the CO_2 capture process, therefore, S&L recommended to install a high efficiency reverse osmosis (RO) to treat excess wastewater and recover > 90% in the form of high purity permeate for recycle back to CO_2 capture system. The blowdown from the new cooling tower will be directly routed to new equalization tank, which will then direct portions of the total flow to both new wastewater treatment system and existing brine concentrators. The reject from the RO system will be routed to the South Evaporation Pond along with waste stream from the solvent recovery process. For the DCC condensate/SO_2 polisher blowdown, the plan will be to recycle all to cooling tower as makeup and limit the new cooling to 8.0 cycles of concentration. The results and details of this study are included in Appendix G.

3.5. COMPUTATIONAL FLUID DYNAMICS (CFD) FLOW STUDY

S&L completed CFD study to confirm the ductwork design does not exceed the pressure drop expected at the MHI terminal point at their tie-in and to ensure the induced draft (ID) fan employed by MHI is adequately sized to overcome the entire flue gas ductwork pressure loss. Additionally, the study was also conducted to understand the flue gas flow uniformity at the terminal point tie-in location just upstream of the MHI flue gas quencher vessels. S&L supported this effort by utilizing CFD model using Star-CCM+ software using tie-in flue gas characteristics developed by S&L as part of establishing developing flue gas design basis. It was concluded that with 5% margin in MHI's flue gas blower design and the additional conservatism in S&L WFGD tie-in pressure, it is expected that even without further optimization the blower will be able to successfully operate at flue gas ductwork pressure drop of 5.6 inches of water column. The results and details of this study are included in Appendix H.

3.6. CONTROL SYSTEM STUDY

S&L completed a control system study to evaluate existing plant control systems and provide a recommendation for controlling the new CO_2 capture system. It was concluded from the study that to maintain control system functionality consistency and compatibility, all new additions to the control system be of the same DCS platform as the existing Foxboro I/A Series DCS to ensure hardware and software consistency between existing DCS and the new DCS additions and optimize operator training. Additionally, it was recommended to design a new control building to include a control room to serve as the central location for both existing SJGS units and CO_2 capture plant controls. Electronics room will also be constructed adjacent to the new control room to house new network, server, and DCS cabinets for the BOP DCS and possibility a limited number of CO_2 capture plant DCS cabinet(s). The results and details of this study are included in Appendix I.

4. Open Issues & Next Steps

Preliminary BOP engineering and design were completed during the FEED study in order to establish mass & water balances, plant layout, existing plant tie-ins, mechanical & electrical system design philosophies, control system configuration, high-level execution schedule and a Class 2 cost estimate. In order for the San Juan Generating Stations CO_2 capture project to move forward into the execution phase, an Engineering, Procurement & Construction (EPC) will need to be finalized between Enchant and the selected EPC team of S&L/MHI/Kiewit. This will allow detailed engineering and early procurement activities to begin. In order to progress with these initial activities, many of the open issues will need to be finalized.

A summary of the primary open issues and next steps is listed below:

1. Verify and finalize all process interface conditions with the carbon capture island
2. Verify and finalize all interfaces with the existing San Juan Units 1 and 4.
3. Conduct a detailed steam turbine impact study with the steam turbine generator OEM (General Electric)
4. Finalize the CO_2 offsite discharge conditions
5. Finalize the CO_2 capture cooling tower chemical treatment program and cycles of concentration in order to establish final sizing conditions for the waste-water treatment system.

Appendix A. Flue Gas Design Basis

Enchant Energy
CO_2 Capture Project

FLUE GAS DESIGN BASIS

San Juan Generating Station

Units 1 & 4

Project No. 13891-010
August 03, 2021
For: Use
Revision: 1

Prepared By:
Sargent & Lundy LLC
55 East Monroe Street
Chicago, Illinois 60603

ISSUE SUMMARY

REVISION & PURPOSE	DATE	PREPARED	REVIEWED	APPROVED
1 For Use	August 03, 2021	_____ V. Patel Environmental	_____ E. Kunkel Environmental	_____ S. Wylie Project Manager

REVISION HISTORY

REVISION	DATE	NOTES
A	May 5, 2020	For Comment
0	June 16th, 2020	For Use
1	August 03, 2021	Updated with Low Load Design information and additional trace constituent data

Table 1: Full Load Flue Gas Design Conditions

Parameter	Units	Unit 1 Full Load Design	Unit 4 Full Load Design
Temperature[1]	°F	127	127
Pressure[1]	in w.c.	-1	-1
Flue Gas Flowrate	scfm[2]	1,143,055	1,703,246
	lb/hr	5,000,147	7,457,942
N_2	vol-%	66.90	66.93
O_2	vol-%	6.14	5.87
H_2O[1]	vol-%	17.16	17.16
CO_2	vol-%	9.79	10.03
SO_2	ppmv	11	23
SO_3	ppmv	1.1	1.2
NOx	ppmv	102	109
NH_3	ppmvd	3.4	3.4 [3]
Hg	µg/dscf	0.117	0.051
PM	mg/dscf	0.192	0.104
Existing Stack Normal Flow - Expected Based on Design Conditions			
Parameter	**Units**	**Unit 1 Full Load Design**	**Unit 4 Full Load Design**
Flue Gas Flowrate	acfm	0	0
	lb/hr	0	0
CO_2 Island Inlet Conditions - Based on Design Conditions (Full Load Design - Combined Ductwork)			
Parameter	**Units**	**Conditions with Minimal Temp Loss [4]**	**Conditions with Moderate Temp Loss [5]**
Temperature	°F	127	110
Pressure[6]	in w.c.	-6	-6
Flue Gas Flowrate	scfm[2]	2,846,302	2,590,920
	lb/hr	12,458,089	11,662,124
N_2	vol-%	66.92	72.06
O_2	vol-%	5.98	6.18
H_2O	vol-%	17.16	10.83

Parameter	Units	Conditions with Minimal Temp Loss [4]	Conditions with Moderate Temp Loss [5]
CO_2	vol-%	9.93	10.91
SO_2	ppmv	18	20
SO_3	ppmv	1.2	1.3
NOx	ppmv	106	117
NH_3	ppmvd	3.4	3.4 [3]
Hg	µg/dscf	0.08	
PM	mg/dscf	0.139	

[1] Parameters per MHI request: Design temperature, pressure, & vol% moisture
[2] Standard conditions based on 68°F and 14.7psi
[3] Unit 1 test result used for Unit 4 for conservatism as Unit 4 results were very low
[4] Parameter per MHI request: Design temperature, pressure, & vol% moisture
[5] Parameter per MHI request: Minimum temperature, pressure, & vol% moisture
[6] Current design estimates 5 in. w.c. pressure drop from WFGD outlet; to be confirmed during CFD modeling.

Table 2: Low Load Flue Gas Design Conditions

Parameter	Units	Unit 1 Low Load Design	Unit 4 Low Load Design
Temperature	°F	115	111
Pressure[1]	in w.c.	-1	-1
Flue Gas Flowrate	scfm[2]	669,600	1,104,600
	lb/hr	2,963,900	4,900,900
N_2	vol-%	70.73	71.96
O_2	vol-%	9.48	11.02
H_2O [3]	vol-%	11.98	10.25
CO_2	vol-%	7.80	6.77
SO_2	ppmv	12	9
SO_3	ppmv	1	1
NOx	ppmv	81	67
NH_3	ppmvd	3.4	3.4 [4]
Hg	µg/dscf	0.117	0.051
PM	mg/dscf	0.192	0.104
Existing Stack Normal Flow - Expected Based on Design Conditions			
		Unit 1 Low Load Design	**Unit 4 Low Load Design**
Flue Gas Flowrate	acfm	0	0
	lb/hr	0	0
CO_2 Island Inlet Conditions - Based on Design Conditions (Low Load Design - Combined Ductwork)			
Parameter	**Units**	**Conditions with Minimal Temp Loss [5]**	**Conditions with Moderate Temp Loss [6]**
Temperature	°F	113	103
Pressure	in w.c.	-1	-6
Flue Gas Flowrate	scfm[2]	1,774,200	1,696,100
	lb/hr	7,864,800	7,645,900
N_2	vol-%	71.49	74.78
O_2	vol-%	10.44	10.92
H_2O [3]	vol-%	10.90	6.80

Parameter	Units	Conditions with Minimal Temp Loss [4]	Conditions with Moderate Temp Loss [5]
CO_2	vol-%	7.16	7.49
SO_2	ppmv	10	10.5
SO_3	ppmv	1	1
NOx	ppmv	73	76
NH_3	ppmvd	3.4	3.4 [4]
Hg	µg/dscf	0.08	
PM	mg/dscf	0.14	

[1] Design Pressure per MHI request
[2] Standard conditions based on 68°F and 14.7psi
[3] Moisture concentration determined using Standard moisture v. Temperature summary table provided by MHI on June 09, 2020. See Attachment H.
[4] Unit 1 test result used for Unit 4 for conservatism as Unit 4 results were very low; assumes same ammonia slip at low load as full load test data. [5] Design conditions represent Unit 1 and Unit 4 WFGD outlet flue gas combined, assuming minimal to no temperature loss.
[6] Assume 10°F temperature loss with moisture drop out and "typical" 5 inwc pressure drop (to be confirmed during CFD modeling).

Table 3: Flue Gas Trace Constituents (Provided by PNM)

Parameter	Units	Unit 1 Full Load Design	Unit 4 Full Load Design
HF	mg/dscf	2.66E-09	2.23E-09
HCl	mg/dscf	5.41E-09	2.14E-09
As	mg/dscf	1.12E-12	1.55E-12
Cd	mg/dscf	5.59E-12	5.41E-11
Cr	mg/dscf	8.79E-11	7.14E-11
Pb	mg/dscf	2.46E-10	1.11E-10
Se	mg/dscf	3.08E-12	3.24E-12
Sb	mg/dscf	2.55E-12	2.04E-12
Co	mg/dscf	1.61E-11	1.01E-11
Mn	mg/dscf	1.13E-10	3.75E-11
Ni	mg/dscf	7.00E-11	3.37E-11
CO_2 Island Inlet Conditions - Based on Design Conditions			
Parameter	**Units**	**Full Load Design**	
HF	mg/dscf	2.40E-09	
HCl	mg/dscf	3.45E-09	
Cr	mg/dscf	7.80E-11	
Parameter	**Units**	**Full Load Design**	
Sb	mg/dscf	2.25E-12	
Cd	mg/dscf	3.46E-11	
Co	mg/dscf	1.25E-11	
Pb	mg/dscf	1.65E-10	
Mn	mg/dscf	6.77E-11	
Ni	mg/dscf	4.82E-11	
Se	mg/dscf	3.18E-12	
As	mg/dscf	1.38E-12	

For additional trace constituents refer to Attachment J for the DRAFT Stack Testing Report.

Attachment A

Flue Gas Design Basis Inputs

Flue Gas Design Basis Inputs

Plant Conditions

Parameter	Units	Value	Source
Air Humidity	lb/lb dry air	0.0013	SNCR Design Basis
Ambient Pressure	psia	12.004	ASHRAE Abient Design Conditions
Ambient Temperature	°F	95.9	ASHRAE 0.4% Occurrence Wet Bulb
Design Coal			
Carbon	wt%	54.41	2010 Coal Analysis (072-43981-006)
Hydrogen	wt%	4.24	2010 Coal Analysis (072-43981-006)
Nitrogen	wt%	1.21	2010 Coal Analysis (072-43981-006)
Sulfur	wt%	0.80	Average of Future Projected Coal (2020-2034)
Oxygen	wt%	9.27	2010 Coal Analysis (072-43981-006)
Chlorine	wt%	0.00	2010 Coal Analysis (072-43981-006)
Fluorine	wt%	0.00	2010 Coal Analysis (072-43981-006)
Moisture	wt%	7.78	2010 Coal Analysis (072-43981-006)
Ash	wt%	22.29	Calculated based on future sulfur content
HHV	BTU/lb	9930	Average of Future Projected Coal (2020-2034)

Full Load Flue Gas Input				
Parameter	**Units**	**Unit 1**	**Unit 4**	**Notes**
Load (Gross)	MW	370	544	City of Farmining input to design
Aux Power	MW	30	37	City of Farmining input to design
Load (Net)	MWn	340	507	City of Farmining input to design
Heat Rate (net)	Btu/kWh-n	11,163	11,424	5% above annual average heat rate
Full Load Design Heat Input	MMBtu/hr	3795	5792	Calculated from 5% above annual average heat rate
Boiler SO_2 to SO_3 Oxidation	wt% SO_2	0.4	0.4	Engineering Judgement
Excess Air	%	12.6	19.8	Back calculated based on Economzier O_2 outlet PI Data
O_2 at Economizer Outlet	vol% (wet)	2.19	3.24	Avg of Full Load of PI Data
Economizer Outlet Pressure	in. w.c.	-2.9	-3.1	Based on the Boiler Balanced Draft Conversion Project (N-3606 A&B)
Economizer Outlet Temp	°F	658	606	Avg of Full Load of PI Data
Air In-Leakage	%	30.5	20.6	Calculated based on Stack O_2 outlet PI Data
O_2 at the Air Heater Outlet	%	6.64	6.31	Calculated based Stack O_2 outlet PI Data
Air Heater Outlet Pressure	in. w.c.	-8.90	-9.45	Unit 1 based on 6" dP from Balanced Draft report Based on PI Data for Unit 4
Air Heater Outlet Temperature	°F	301	240	Avg of Full Load of PI Data
Baghouse Outlet Pressure	in. w.c.	-19.90	-23.35	Calculated from the AH outlet based on the pressure drop from the AH & across the BH in the Boiler Balance Draft Project
Baghouse Outlet Temperature	°F	289	253	Avg of Full Load of PI Data
Baghouse Particulate Removal	%	99.9%	99.9%	Calculated based on permit limit.
ID Fan Outlet Pressure	in. w.c.	13.0	14.3	Calculated based on Absorber dP assuming +1.0 inwc at stack inlet
ID Fan Outlet Temperature	°F	351	337	Estimated based on the FGD outlet saturation temperature calculation. Note: ID fan temperature rise is expected to be lower in actuality.
Target SO_3 Removal	wt%	25	25	Engineering Judgement
Absorber dP	in. w.c.	12.0	13.3	Unit 1: Balanced Draft report delta between ID fan outlet and scrubber outlet Unit 4: 2014 TRAX reported ID fan outlet and WFGD delta
Full Load Stack Parameters				
Stack Temperature	°F	127	127	MHI Design Condition. Average 125 and 124°F for Unit 1 and Unit 4, respectively from PI data.
WFGD Outlet Pressure	in. w.c.	-1	-1	MHI Design Condition.
Stack SO_2	ppmv	11	23	Calculation based on PI Data of SO_2 outlet of 0.034 (Unit 1) and 0.068 (Unit 4) lb/MMBtu
Stack SO_3	ppmv	1.1	1.2	Calculation based an assumed 25% removal across WFGD
Stack NOx	ppmv	102	109	Calculation based on PI Data
Stack NH_3	ppmv	3.4	3.4	Based on test data information from PNM (Permit limit equilalent to 7 ppmv at the stack)
Stack Hg	µg/dscm	0.117	0.051	Based on test data from PNM (MATS limit 1.2 lb/TBtu)
Particulate Matter (PM)	mg/dscf	0.192	0.104	Based on test data from PNM (Permit limit 0.015 lb/MMBtu)
Stack O_2	%	6.14	5.87	Avg of Full Load of PI Data

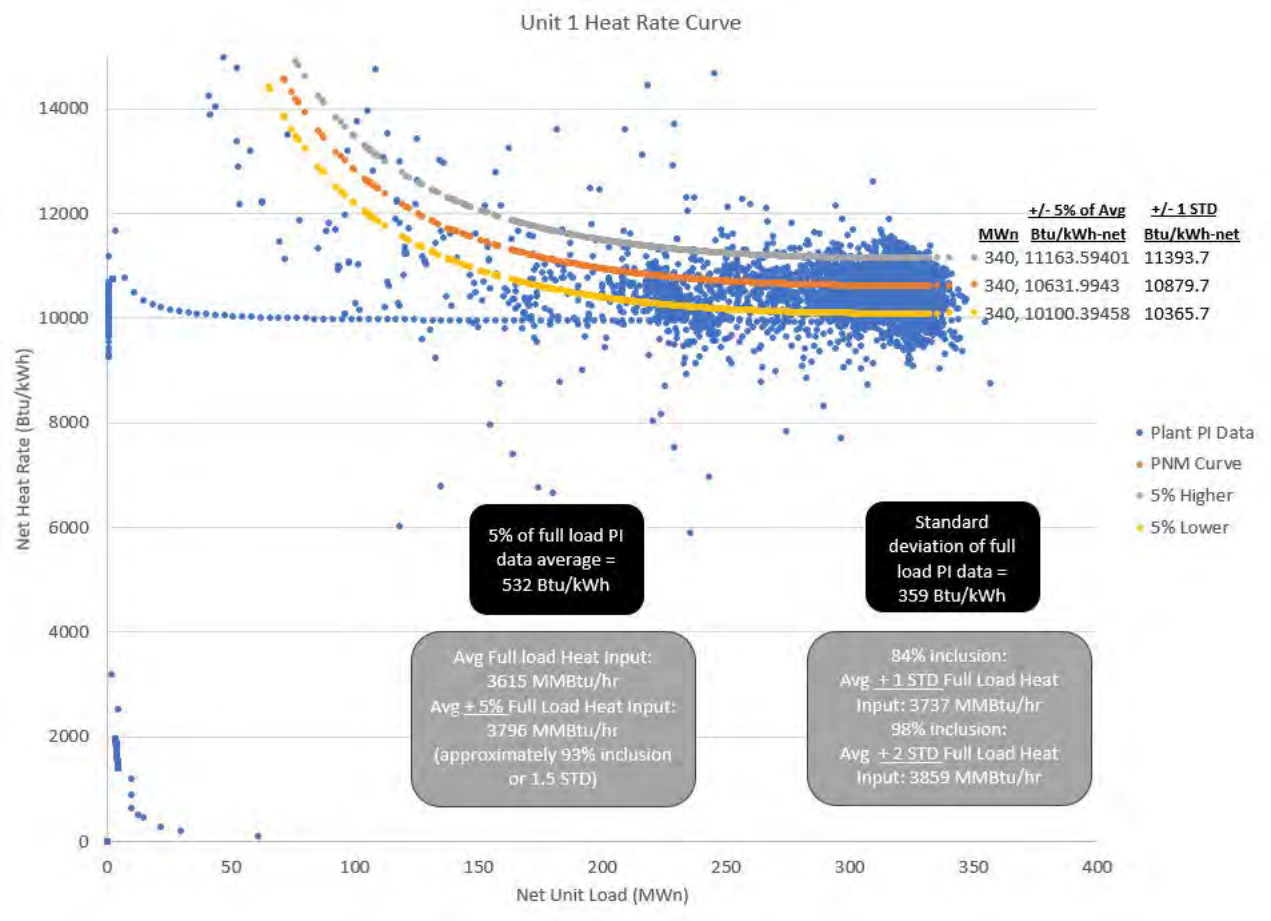
PI Data is from 1-1-2019 to 12-31-2019

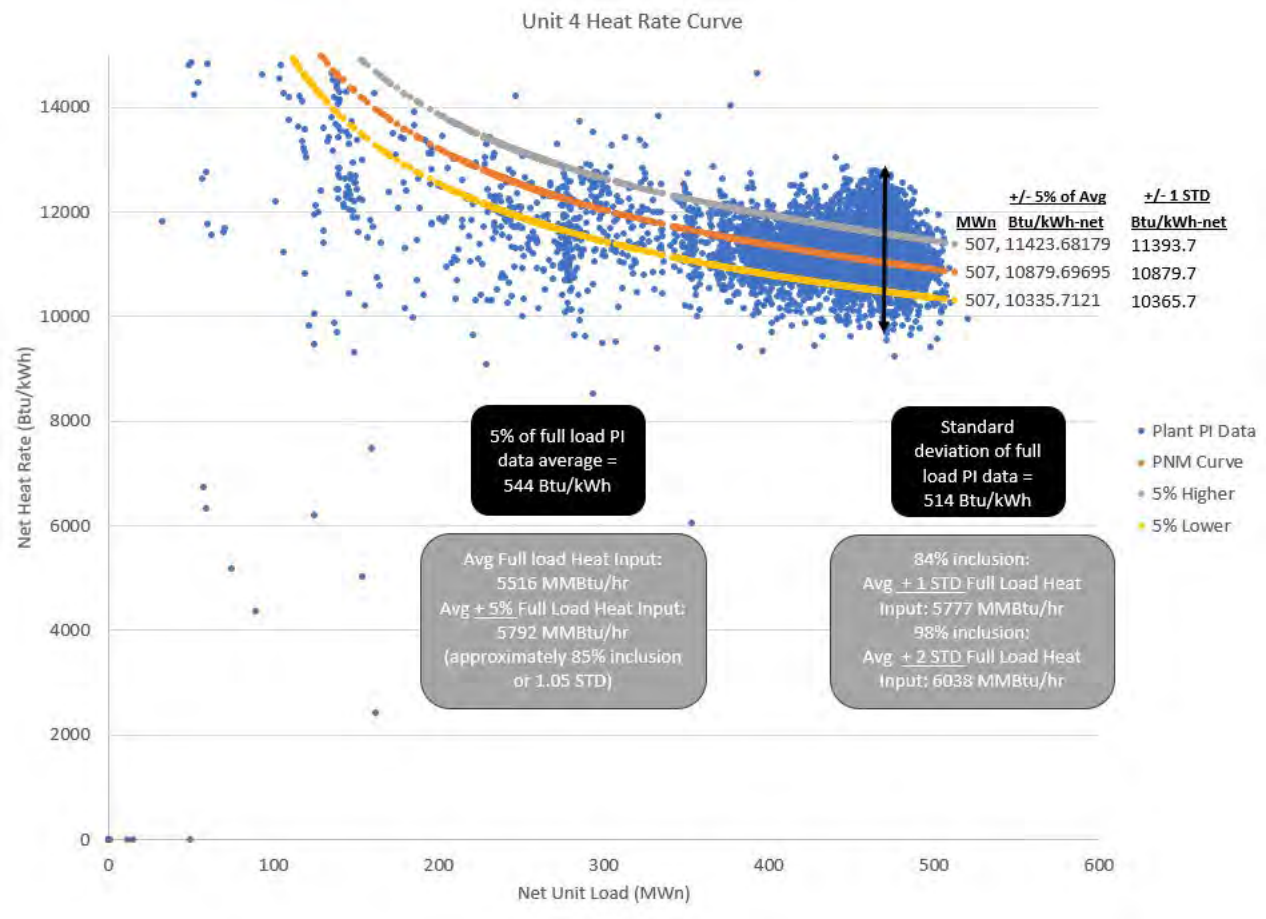
Low Load Flue Gas Input				
Parameter	**Units**	**Unit 1**	**Unit 4**	**Notes**
Load (Gross)	MW	177	220	Based on steam turbine limitation for Unit 1 and boiler turndown for Unit 4
Aux Power	MW	22	31	Calculated
Load (Net)	MWn	155	189	Calculated
Heat Rate (net)	Btu/kWh-n	11,423	13,393	Based on annual average heat rate
Full Load Design Heat Input	MMBtu/hr	1772	2535	Calculated from annual average heat rate
Boiler SO_2 to SO_3 Oxidation	wt% SO_2	0.4	0.4	Engineering Judgement
Excess Air	%	35.2	75.1	Back calculated based on Economzier O_2 outlet PI Data
O_2 at Economizer Outlet	vol% (wet)	5.15	8.58	Avg of Low Load of PI Data
Economizer Outlet Pressure	in. w.c.	-1.0	-1.0	Engineering Judgement
Economizer Outlet Temperature	°F	565	492	Avg of Low Load of PI Data
Air In-Leakage	%	46.8	34.3	Calculated based on Stack O_2 outlet PI Data
O_2 at the Air Heater Outlet	%	6.64	6.31	Calculated based Stack O_2 outlet PI Data
Air Heater Outlet Pressure	in. w.c.	-2.10	-2.30	Adjusted based on ratio of change from baghouse outlet from full load (-19.9 in. w.c.) to low load compared to full load AH outlet (-8.9 in. w.c.) for Unit 1 and from (-23.35 in. w.c.) to (-9.45 in. w.c.) for Unit 4
Air Heater Outlet Temperature	°F	243	181	Avg of Low Load of PI Data
Baghouse Outlet Pressure	in. w.c.	-4.80	-5.60	Ratio of Fan Inlet Static Pressure from TRAX to Unit 4 fan / motor design parameters for low load (-6.86 in. w.c.) vs full load (-28.47 in. w.c.) compared to original full load value (-19.9 in. w.c.) for Unit 1 and (-23.35 in. w.c.) for Unit 4
Baghouse Outlet Temperature	°F	226	199	Avg of Low Load of PI Data
Baghouse Particulate Removal	%	99.9%	99.9%	Calculated based on permit limit.
ID Fan Outlet Pressure	in. w.c.	5.4	6.0	Ratio of Fan Outlet Static Pressure from TRAX to Unit 4 fan / motor design parameters for low load (3.82 in. w.c.) vs full load (9.12 in. w.c.) compared to original full load value (13 in. w.c.) for Unit 1 and (14.3 in. w.c.) for Unit 4
ID Fan Outlet Temperature	°F	231	205	Calculated based on baghouse outlet temperature and expected ID fan pressure rise
Target SO_3 Removal	wt%	25	25	Engineering Judgement
Absorber dP	in. w.c.	12	13	Unit 1: Balanced Draft report delta between ID fan outlet and scrubber outlet Unit 4: 2014 TRAX reported ID fan outlet and WFGD delta
Low Load Stack Parameters				
Stack Temperature	°F	115.0	111.0	Avg of Low Load of PI Data
WFGD Outlet Pressure	in. w.c.	-1	-1	MHI Design Condition.
Stack SO_2	ppmv	12	9	Calculation based on PI Data of SO2 stack outlet of 0.046 (Unit 1) and 0.037 (Unit 4) lb/MMBtu
Stack SO_3	ppmv	0.9	0.8	Calculation based an assumed 25% removal across WFGD
Stack NOx	ppmv	81	67	Calculation based on PI Data of NOx stack outlet of 0.22 (Unit 1) and 0.21 (Unit 4) lb/MMBtu
Stack NH_3	ppmv	3.4	3.4	Based on test data information from PNM (Permit limit equivalent to 11 ppmv at the stack)
Stack Hg	µg/dscm	0.117	0.051	Based on test data from PNM (MATS limit 1.2 lb/TBtu)
Particulate Matter (PM)	mg/dscf	0.192	0.104	Based on test data from PNM (Permit limit 0.015 lb/MMBtu)
Stack O_2	%	9.48	11.02	Avg of Low Load of PI Data

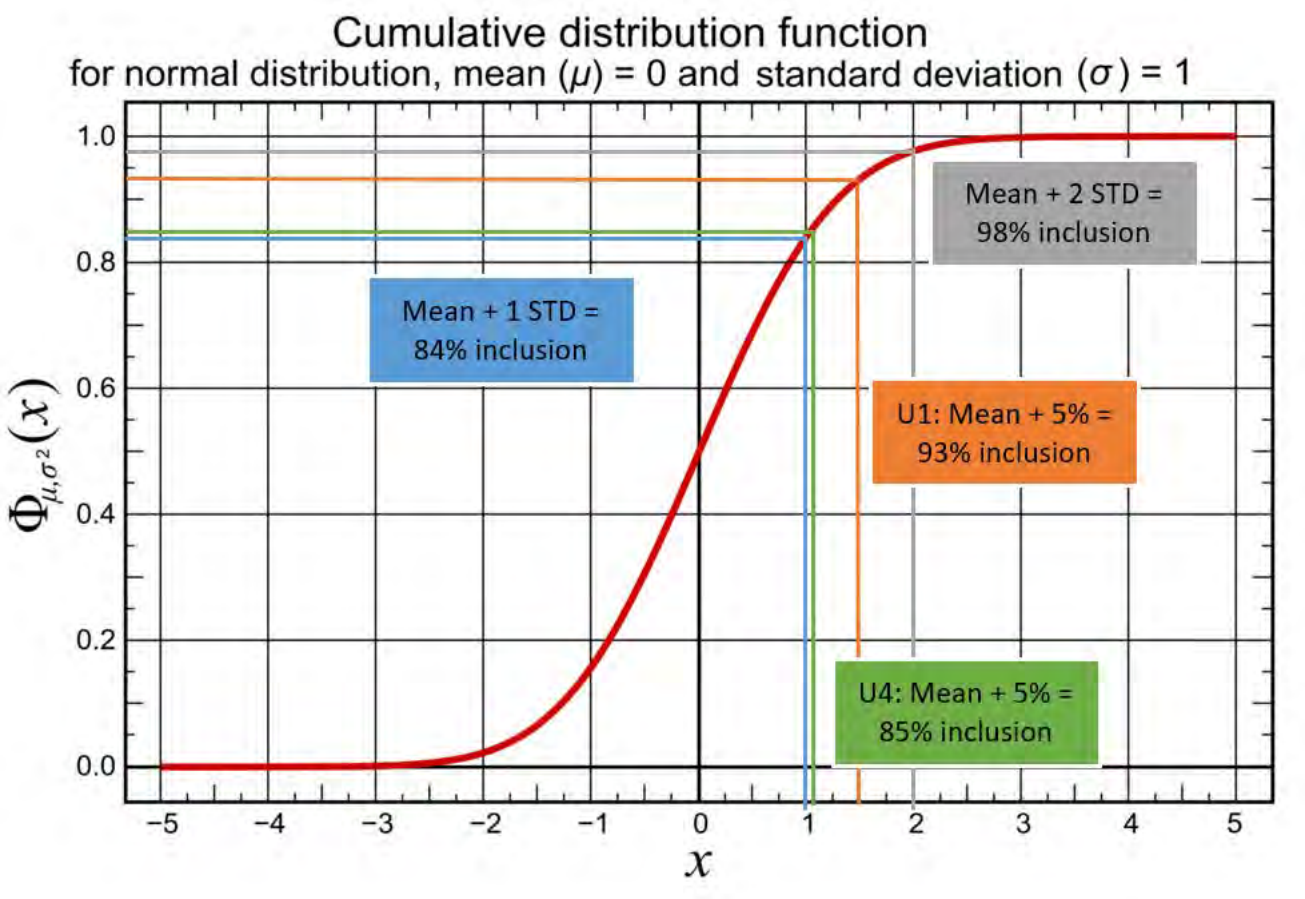
PI Data is from 1-1-2019 to 12-31-2019

Attachment B

Heat Rate & Heat Input Analysis


Unit 1 Heat Rate Curve
Net Heat Rate (Btu/kWh)
Net Unit Load (MWn)
14000
12000
10000
8000
6000
4000
2000
0
0
50
100
150
200
250
300
350
400
MWn
+/- 5% of Avg Btu/kWh-net
+/- 1 STD Btu/kWh-net
340, 11163.59401 11393.7
340, 10631.9943 10879.7
340, 10100.39458 10365.7
Plant PI Data
PNM Curve
5% Higher
5% Lower
5% of full load PI data average = 532 Btu/kWh
Standard deviation of full load PI data = 359 Btu/kWh
Avg Full load Heat Input: 3615 MMBtu/hr
Avg + 5% Full Load Heat Input: 3796 MMBtu/hr
(approximately 93% inclusion or 1.5 STD)
84% inclusion:
Avg + 1 STD Full Load Heat Input: 3737 MMBtu/hr
98% inclusion:
Avg + 2 STD Full Load Heat Input: 3859 MMBtu/hr


Unit 4 Heat Rate Curve
Net Heat Rate (Btu/kWh)
Net Unit Load (MWn)
14000
12000
10000
8000
6000
4000
2000
0
0
100
200
300
400
500
600
+/- 5% of Avg
+/- 1 STD
MWn
Btu/kWh-net
Btu/kWh-net
507, 11423.68179
11393.7
507, 10879.69695
10879.7
507, 10335.7121
10365.7
5% of full load PI data average = 544 Btu/kWh
Standard deviation of full load PI data = 514 Btu/kWh
Avg Full load Heat Input: 5516 MMBtu/hr
Avg + 5% Full Load Heat Input: 5792 MMBtu/hr
(approximately 85% inclusion or 1.05 STD)
84% inclusion:
Avg + 1 STD Full Load Heat Input: 5777 MMBtu/hr
98% inclusion:
Avg + 2 STD Full Load Heat Input: 6038 MMBtu/hr
Plant PI Data
PNM Curve
5% Higher
5% Lower


Cumulative distribution function
for normal distribution, mean (μ) = 0 and standard deviation (σ) = 1
Mean + 2 STD = 98% inclusion
Mean + 1 STD = 84% inclusion
U1: Mean + 5% = 93% inclusion
U4: Mean + 5% = 85% inclusion
$\Phi_{\mu,\sigma^2}(x)$
x
1.0
0.8
0.6
0.4
0.2
0.0
−5
−4
−3
−2
−1
0
1
2
3
4
5

Attachment C

Complete Material Balances

Limestone Forced Oxidation FGD System - Unit 1 Full Load

DESIGN PARAMETERS

COAL ANALYSIS		
Carbon	wt%	54.41
Hydrogen	wt%	4.24
Nitrogen	wt%	1.21
Sulfur	wt%	0.80
Oxygen	wt%	9.27
Chlorine	wt%	0.00
Fluorine	wt%	0.00
Moisture	wt%	7.78
Ash	wt%	22.29
Calc. HHV	Btu/lb	9,930

PLANT PRODUCTION		
MCR Output	MW	370.0
Heat Input	MMBtu/hr	3,795.0
Firing Rate	lb/hr	382,175
AIR DATA		
Excess Air	%	12.6
In Leakage	wt% total	32.9
Air H_2O	lb/lb dry air	0.001

REMOVAL EFFICIENCIES		
Ash-Boiler	wt%	20.0
Ash-Bgh	wt%	99.9
SO3-Bgh	wt%	5.0
Ash-FGD	wt%	25.0
HCl-FGD	wt%	100.0
HF-FGD	wt%	100.0
SO_2-FGD	wt%	97.9
SO_3-FGD	wt%	25.0

SULFUR TRIOXIDE PRODUCTION		
Boiler	wt% SO_2	0.4
SULFUR LEVELS THROUGH FGD		
SO_2 In	lb/hr	6,090
SO_2 Out	lb/hr	129
SO_2 In	ppmv	607
SO_2 Out	ppmv	11
SO_2 In	lb/MMBtu	1.605
SO_2 Out	lb/MMBtu	0.034
SO_3 In	ppmv	2
SO_3 Out	ppmv	1
SO_3 In	lb/MMBtu	0.006
SO_3 Out	lb/MMBtu	0.004

PROCESS FLOWSCHEME				
	PRESSURES		TEMPERATURES	
Atmospheric Pressure	psia	12.00	°F	96
Dry Oxidation Air	psia	22.31	°F	240
Economizer Outlet	in. w.c.	-2.9	°F	658
Air Heater Outlet	in. w.c.	-8.9	°F	301
Baghouse Outlet	in. w.c.	-19.9	°F	289
ID Fan Outlet	in. w.c.	13	°F	305.45
FGD Outlet	in. w.c.	-1	°F	127

GAS STREAMS

Stream Characteristics		Combustion Air		Economizer Outlet		Air Heater Outlet	
Temperature	°F	96		658		301	
Pressure	psia	12.004		11.899		11.683	
N_2	lb/hr-vol%	2,436,490	78.98	2,441,115	74.41	3,318,648	75.57
O_2	lb/hr-vol%	733,959	20.82	82,179	2.19	346,523	6.90
H_2O	lb/hr-vol%	4,122	0.21	179,693	8.52	181,177	6.42
CO_2	lb/hr-vol%	0	0.00	762,452	14.79	762,452	11.05
SO_2	lb/hr-ppmv	0	0	6,090	812	6,090	607
SO_3	lb/hr-ppmv	0	0	31	3	23	2
HCl	lb/hr-ppmv	0	0	0	0	0	0
HF	lb/hr-ppmv	0	0	0	0	0	0
Total Flow	lb/hr-acfm	3,174,571	912,178	3,471,559	1,967,793	4,614,914	1,826,315
MW & Moist.	g/mol-lb/lb	28.81	0.001	29.63	0.055	29.42	0.041
Ash	lb/hr-gr/acf	0	0.000	68,149	4.040	68,149	4.353

Baghouse Outlet		ID Fan Outlet		FGD Outlet		Dry Oxidation Air		Wet Oxidation Air	
289		305		127		240		127	
11.287		12.472		11.968		22.313		22.313	
3,318,648	75.57	3,318,648	75.57	3,333,490	66.91	14,842	78.98	14,842	69.54
346,523	6.90	346,523	6.90	349,504	6.14	4,471	20.82	4,471	18.33
181,177	6.42	181,177	6.42	549,599	17.16	25	0.21	1,665	12.14
762,452	11.05	762,452	11.05	766,554	9.79	0	0.00	0	0.00
6,090	607	6,090	607	129	11	0	0	0	0
22	2	22	2	16	1	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
4,614,913	1,860,646	4,614,913	1,720,760	4,999,292	1,560,157	19,338	3,762	20,978	3,585
29.42	0.041	29.42	0.041	28.10	0.086	28.81	0.001	27.52	0.086
76	0.005	76	0.005	57	0.004	0	0.000	0	0.000

Limestone Forced Oxidation FGD System - Unit 4 Full Load

DESIGN PARAMETERS

COAL ANALYSIS		
Carbon	wt%	54.41
Hydrogen	wt%	4.24
Nitrogen	wt%	1.21
Sulfur	wt%	0.80
Oxygen	wt%	9.27
Chlorine	wt%	0.00
Fluorine	wt%	0.00
Moisture	wt%	7.78
Ash	wt%	22.29
Calc. HHV	Btu/lb	9,930

PLANT PRODUCTION		
MCR Output	MW	544.0
Heat Input	MMBtu/hr	5,792.0
Firing Rate	lb/hr	583,283

AIR DATA		
Excess Air	%	19.8
In Leakage	wt% total	22.9
Air H_2O	lb/lb dry air	0.001

REMOVAL EFFICIENCIES		
Ash-Boiler	wt%	20.0
Ash-Bgh	wt%	99.9
SO3-Bgh	wt%	5.0
Ash-FGD	wt%	25.0
HCl-FGD	wt%	100.0
HF-FGD	wt%	100.0
SO_2-FGD	wt%	95.8
SO_3-FGD	wt%	25.0

SULFUR TRIOXIDE PRODUCTION		
Boiler	wt% SO_2	0.4

SULFUR LEVELS THROUGH FGD		
SO_2 In	lb/hr	9,295
SO_2 Out	lb/hr	394
SO_2 In	ppmv	621
SO_2 Out	ppmv	23
SO_2 In	lb/MMBtu	1.605
SO_2 Out	lb/MMBtu	0.068
SO_3 In	ppmv	2
SO_3 Out	ppmv	1
SO_3 In	lb/MMBtu	0.006
SO_3 Out	lb/MMBtu	0.004

PROCESS FLOWSCHEME				
	PRESSURES		TEMPERATURES	
Atmospheric Pressure	psia	12.00	°F	96
Dry Oxidation Air	psia	22.31	°F	240
Economizer Outlet	in. w.c.	-3.1	°F	750
Air Heater Outlet	in. w.c.	-9.45	°F	350
Baghouse Outlet	in. w.c.	-23.35	°F	300
ID Fan Outlet	in. w.c.	13.3	°F	318.325
FGD Outlet	in. w.c.	-1	°F	127

GAS STREAMS

Stream Characteristics		Combustion Air		Economizer Outlet		Air Heater Outlet	
Temperature	°F	96		750		350	
Pressure	psia	12.004		11.892		11.663	
N_2	lb/hr-vol%	3,955,038	78.98	3,962,096	74.67	4,947,371	75.49
O_2	lb/hr-vol%	1,191,401	20.82	196,641	3.24	493,441	6.59
H_2O	lb/hr-vol%	6,690	0.21	274,651	8.05	276,317	6.56
CO_2	lb/hr-vol%	0	0.00	1,163,669	13.96	1,163,669	11.30
SO_2	lb/hr-ppmv	0	0	9,295	766	9,295	621
SO_3	lb/hr-ppmv	0	0	47	3	35	2
HCl	lb/hr-ppmv	0	0	0	0	0	0
HF	lb/hr-ppmv	0	0	0	0	0	0
Total Flow	lb/hr-acfm	5,153,129	1,480,695	5,606,399	3,446,861	6,890,129	2,905,842
MW & Moist.	g/mol-lb/lb	28.81	0.001	29.59	0.052	29.44	0.042
Ash	lb/hr-gr/acf	0	0.000	104,011	3.520	104,011	4.176

Baghouse Outlet		ID Fan Outlet		FGD Outlet		Dry Oxidation Air		Wet Oxidation Air	
300		318		127		240		127	
11.163		12.483		11.968		22.313		22.313	
4,947,371	75.49	4,947,371	75.49	4,969,533	66.94	22,162	78.98	22,162	69.18
493,441	6.59	493,441	6.59	497,892	5.87	6,676	20.82	6,676	18.23
276,317	6.56	276,317	6.56	818,941	17.16	37	0.21	2,592	12.59
1,163,669	11.30	1,163,669	11.30	1,169,793	10.03	0	0.00	0	0.00
9,295	621	9,295	621	394	23.21	0	0	0	0
33	2	33	2	25	1.18	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
6,890,127	2,848,814	6,890,127	2,608,835	7,456,577	2,324,744	28,876	5,617	31,430	5,381
29.44	0.042	29.44	0.042	28.12	0.090	28.81	0.001	27.47	0.090
116	0.005	116	0.005	87	0.004	0	0.000	0	0.000

Limestone Forced Oxidation FGD System - Unit 1 Low Load

DESIGN PARAMETERS

COAL ANALYSIS		
Carbon	wt%	54.41
Hydrogen	wt%	4.24
Nitrogen	wt%	1.21
Sulfur	wt%	0.80
Oxygen	wt%	9.27
Chlorine	wt%	0.00
Fluorine	wt%	0.00
Moisture	wt%	7.78
Ash	wt%	22.29
Calc. HHV	Btu/lb	9,930

PLANT PRODUCTION		
MCR Output	MW	177.0
Heat Input	MMBtu/hr	1,772.0
Firing Rate	lb/hr	178,449
AIR DATA		
Excess Air	%	35.2
In Leakage	wt% total	46.8
Air H_2O	lb/lb dry air	0.001

REMOVAL EFFICIENCIES		
Ash-Boiler	wt%	20.0
Ash-Bgh	wt%	99.9
SO3-Bgh	wt%	5.0
Ash-FGD	wt%	25.0
HCl-FGD	wt%	100.0
HF-FGD	wt%	100.0
SO_2-FGD	wt%	97.1
SO_3-FGD	wt%	25.0

SULFUR TRIOXIDE PRODUCTION		
Boiler	wt% SO_2	0.4
SULFUR LEVELS THROUGH FGD		
SO_2 In	lb/hr	2,844
SO_2 Out	lb/hr	82
SO_2 In	ppmv	462
SO_2 Out	ppmv	12
SO_2 In	lb/MMBtu	1.605
SO_2 Out	lb/MMBtu	0.046
SO_3 In	ppmv	1
SO_3 Out	ppmv	1
SO_3 In	lb/MMBtu	0.006
SO_3 Out	lb/MMBtu	0.004

PROCESS FLOWSCHEME				
	PRESSURES		TEMPERATURES	
Atmospheric Pressure	psia	12.00	°F	96
Dry Oxidation Air	psia	22.31	°F	240
Economizer Outlet	in. w.c.	-1	°F	565
Air Heater Outlet	in. w.c.	-2.1	°F	243
Baghouse Outlet	in. w.c.	-4.8	°F	226
ID Fan Outlet	in. w.c.	5.4	°F	231
FGD Outlet	in. w.c.	-1	°F	115

GAS STREAMS

Stream Characteristics		Combustion Air		Economizer Outlet		Air Heater Outlet	
Temperature	°F	96		565		243	
Pressure	psia	12.004		11.968		11.927	
N_2	lb/hr-vol%	1,366,074	78.98	1,368,233	75.14	2,057,555	76.38
O_2	lb/hr-vol%	411,511	20.82	107,175	5.15	314,824	10.23
H_2O	lb/hr-vol%	2,311	0.21	84,290	7.20	85,456	4.93
CO_2	lb/hr-vol%	0	0.00	356,012	12.44	356,012	8.41
SO_2	lb/hr-ppmv	0	0	2,844	683	2,844	462
SO_3	lb/hr-ppmv	0	0	14	3	11	1
HCl	lb/hr-ppmv	0	0	0	0	0	0
HF	lb/hr-ppmv	0	0	0	0	0	0
Total Flow	lb/hr-acfm	1,779,896	511,433	1,918,568	995,714	2,816,702	1,013,749
MW & Moist.	g/mol-lb/lb	28.81	0.001	29.50	0.046	29.28	0.031
Ash	lb/hr-gr/acf	0	0.000	31,821	3.728	31,821	3.662

Baghouse Outlet		ID Fan Outlet		FGD Outlet		Dry Oxidation Air		Wet Oxidation Air	
226		231		115		240		115	
11.831		12.200		11.968		22.313		22.313	
2,057,555	76.38	2,057,555	76.38	2,064,432	70.73	6,877	78.98	6,877	69.94
314,824	10.23	314,824	10.23	316,205	9.48	2,072	20.82	2,072	18.44
85,456	4.93	85,456	4.93	224,770	11.98	12	0.21	734	11.62
356,012	8.41	356,012	8.41	357,912	7.80	0	0.00	0	0.00
2,844	462	2,844	462	82	12	0	0	0	0
10	1	10	1	8	1	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
2,816,701	997,220	2,816,701	974,276	2,963,409	895,268	8,961	1,743	9,683	1,618
29.28	0.031	29.28	0.031	28.43	0.082	28.81	0.001	27.58	0.082
35	0.004	35	0.004	27	0.003	0	0.000	0	0.000

Limestone Forced Oxidation FGD System - Unit 4 Low Load

DESIGN PARAMETERS

COAL ANALYSIS		
Carbon	wt%	54.41
Hydrogen	wt%	4.24
Nitrogen	wt%	1.21
Sulfur	wt%	0.80
Oxygen	wt%	9.27
Chlorine	wt%	0.00
Fluorine	wt%	0.00
Moisture	wt%	7.78
Ash	wt%	22.29
Calc. HHV	Btu/lb	9,930

PLANT PRODUCTION		
MCR Output	MW	220.0
Heat Input	MMBtu/hr	2,535.0
Firing Rate	lb/hr	255,287
AIR DATA		
Excess Air	%	75.1
In Leakage	wt% total	34.3
Air H_2O	lb/lb dry air	0.001

REMOVAL EFFICIENCIES		
Ash-Boiler	wt%	20.0
Ash-Bgh	wt%	99.9
SO3-Bgh	wt%	5.0
Ash-FGD	wt%	25.0
HCl-FGD	wt%	100.0
HF-FGD	wt%	100.0
SO_2-FGD	wt%	97.7
SO_3-FGD	wt%	25.0

SULFUR TRIOXIDE PRODUCTION		
Boiler	wt% SO_2	0.4
SULFUR LEVELS THROUGH FGD		
SO_2 In	lb/hr	4,068
SO_2 Out	lb/hr	94
SO_2 In	ppmv	395
SO_2 Out	ppmv	9
SO_2 In	lb/MMBtu	1.605
SO_2 Out	lb/MMBtu	0.037
SO_3 In	ppmv	1
SO_3 Out	ppmv	1
SO_3 In	lb/MMBtu	0.006
SO_3 Out	lb/MMBtu	0.004

PROCESS FLOWSCHEME				
	PRESSURES		TEMPERATURES	
Atmospheric Pressure	psia	12.00	°F	96
Dry Oxidation Air	psia	22.31	°F	240
Economizer Outlet	in. w.c.	-1	°F	492
Air Heater Outlet	in. w.c.	-2.3	°F	**181**
Baghouse Outlet	in. w.c.	-5.6	°F	199
ID Fan Outlet	in. w.c.	6.0	°F	205
FGD Outlet	in. w.c.	-1	°F	111

GAS STREAMS

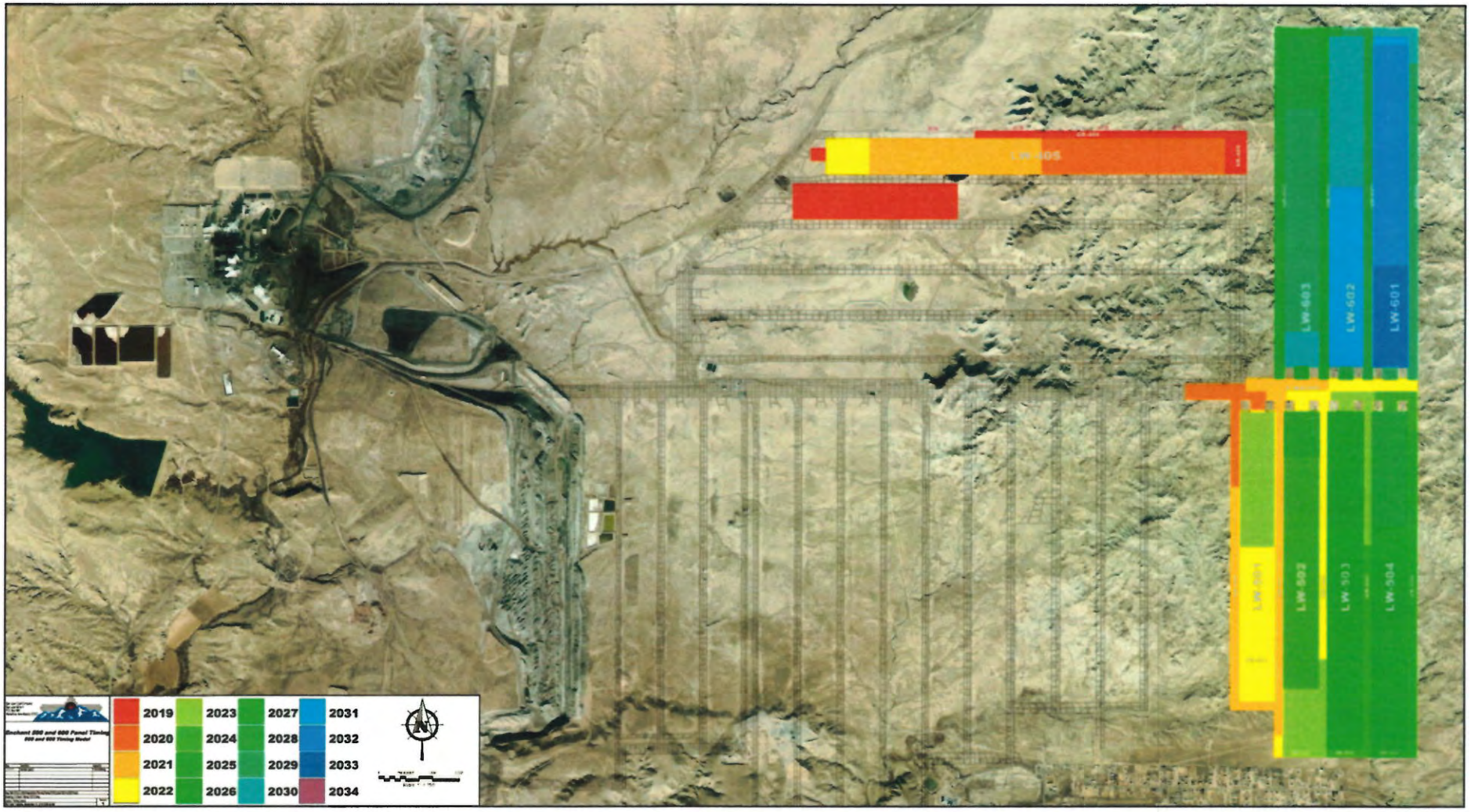
Stream Characteristics		Combustion Air		Economizer Outlet		Air Heater Outlet	
Temperature	°F	96		492		181	
Pressure	psia	12.004		11.968		11.922	
N_2	lb/hr-vol%	2,530,970	78.98	2,534,059	75.98	3,454,685	76.76
O_2	lb/hr-vol%	762,420	20.82	327,041	8.58	604,366	11.75
H_2O	lb/hr-vol%	4,281	0.21	121,560	5.67	123,118	4.26
CO_2	lb/hr-vol%	0	0.00	509,306	9.72	509,306	7.20
SO_2	lb/hr-ppmv	0	0	4,068	534	4,068	395
SO_3	lb/hr-ppmv	0	0	20	2	15	1
HCl	lb/hr-ppmv	0	0	0	0	0	0
HF	lb/hr-ppmv	0	0	0	0	0	0
Total Flow	lb/hr-acfm	3,297,671	947,549	3,496,054	1,693,856	4,695,559	1,545,072
MW & Moist.	g/mol-lb/lb	28.81	0.001	29.35	0.036	29.21	0.027
Ash	lb/hr-gr/acf	0	0.000	45,523	3.135	45,523	3.437

Baghouse Outlet		ID Fan Outlet		FGD Outlet		Dry Oxidation Air		Wet Oxidation Air	
199		205		111		240		111	
11.801		12.220		11.968		22.313		22.313	
3,454,685	76.76	3,454,685	76.76	3,464,580	71.96	9,895	78.98	9,895	71.24
604,366	11.75	604,366	11.75	606,354	11.02	2,981	20.82	2,981	18.78
123,118	4.26	123,118	4.26	317,242	10.25	17	0.21	891	9.98
509,306	7.20	509,306	7.20	512,041	6.77	0	0.00	0	0.00
4,068	395	4,068	395	94	9	0	0	0	0
15	1	15	1	11	1	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
4,695,558	1,604,705	4,695,558	1,563,394	4,900,321	1,466,581	12,893	2,508	13,768	2,269
29.21	0.027	29.21	0.027	28.50	0.069	28.81	0.001	27.75	0.069
51	0.004	51	0.004	38	0.003	0	0.000	0	0.000

Attachment D

Future Mine Projections

Layout & Timing



ROM Qualities



Weighted Average BTU and Sulfur content

- Based on most current up to date geologic models
- Coal get progressively higher quality the further to the East
- No significant geologic structures within the 500 and 600 panels

	BTU	Sulfur
2020	9,934	0.77
2021	10,228	1.36
2022	10,211	1.18
2023	9,848	0.88
2024	9,778	0.85
2025	9,845	0.72
2026	10,003	0.73
2027	9,929	0.70
2028	9,978	0.68
2029	9,937	0.68
2030	9,891	0.69
2031	9,851	0.69
2032	9,817	0.69
2033	9,841	0.70
2034	9,854	0.69

Attachment E

Representative Historic Coal Analyses

March 08, 2010

BHP Billiton
P.O. Box 561
Waterflow, NM 87421
USA

Client Sample ID:	Nov-09 SJUG Composite Mix	**P. O. # :**	6400012787
Date Received:	02/09/2010	**Sample Type :**	-60 Mesh
Matrix:	Coal		
Mine :	San Juan PNM Plant		

SGS Sample ID: 072-43981-006

		As Received	Dry	MAF
% Moisture, Total	[ASTM D 3302]	7.78		
% Ash	[ASTM D 3174/5142]	22.42	24.31	
% Volatile Matter	[ASTM D 5142]	33.35	36.16	47.77
% Fixed Carbon	[ASTM D 3172]	36.45	39.53	52.23
Gross Calorific Value (Btu/lb)	[ASTM D 5865]	9761	10584	13984
% Sulfur	[ASTM D 4239]	0.67	0.72	
% Carbon	[ASTM D 5373]	54.41	58.99	
% Hydrogen	[ASTM D 5373]	4.24	4.60	
% Nitrogen	[ASTM D 5373]	1.21	1.31	
% Oxygen (Calc)	[ASTM D 3176]	9.27	10.07	

Analyte	Result	Method
Pounds of Ash/mm Btu	22.97 lb	
Pounds of Sulfur/mm Btu	0.68 lb	
Pounds of SO2/mm Btu	1.37 lb	

Respectfully submitted,
SGS NORTH AMERICA INC.

Tony Stoyko

Denver Laboratory 2010

SGS North America Inc. | Minerals Services Division
4665 Paris Street, Suite B-200, Denver, CO 80239 t (303) 373-4772 f (303) 373-4791 www.us.sgs.com/minerals

Member of the SGS Group

F-465

GENERAL CONDITIONS OF SERVICE ON REVERSE

March 08, 2010

BHP Billiton
P.O. Box 561
Waterflow, NM 87421
USA

Client Sample ID:	Nov-09 SJUG Composite Mix	**P. O. # :**	6400012787
Date Received:	02/09/2010	**Sample Type :**	-60 Mesh
Matrix:	Coal		
Mine :	San Juan PNM Plant		

SGS Sample ID: 072-43981-006

Analyte	Result		Method
Ash Analysis Basis	Ignited		ASTM D 4326
Silicon Dioxide SiO2	57.26	%	ASTM D 4326
Aluminum Oxide Al2O3	27.36	%	ASTM D 4326
Titanium Dioxide TiO2	0.97	%	ASTM D 4326
Iron Oxide Fe2O3	3.51	%	ASTM D 4326
Calcium Oxide CaO	4.15	%	ASTM D 4326
Magnesium Oxide MgO	0.72	%	ASTM D 4326
Potassium Oxide K2O	1.02	%	ASTM D 4326
Sodium Oxide Na2O	1.59	%	ASTM D 4326
Sulfur Trioxide SO3	3.08	%	ASTM D 4326
Phosphorus Pentoxide P2O5	0.20	%	ASTM D 4326
Strontium Oxide SrO	0.05	%	ASTM D 4326
Barium Oxide BaO	0.07	%	ASTM D 4326
Manganese Oxide MnO2	0.02	%	ASTM D 4326
Undetermined	0.00	%	
Sum	100.00	%	
Alkalies	2.26	%	
Silica Value	87.23	%	
Base:Acid Ratio	0.13		
T250 Temperature	>2900	°F	
Type of Ash	Lignitic		

Respectfully submitted,
SGS NORTH AMERICA INC.

Tony Stoyko

Denver Laboratory 2010

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Member of the SGS Group

F-465

GENERAL CONDITIONS OF SERVICE ON REVERSE

March 08, 2010

BHP Billiton
P.O. Box 561
Waterflow, NM 87421
USA

Client Sample ID:	Nov-09 SJUG Composite Mix	**P. O. # :**	6400012787
Date Received:	02/09/2010	**Sample Type :**	-60 Mesh
Matrix:	Coal		
Mine :	San Juan PNM Plant		

SGS Sample ID: 072-43981-006

Analyte	Result	Method
Trace Analysis Basis	Dry Coal	
Antimony	<2 ug/g	ASTM D 3683 mod./ICP
Barium	166 ug/g	ASTM D 3683 mod./ICP
Beryllium	1.0 ug/g	ASTM D 3683 mod./ICP
Cadmium	<0.5 ug/g	ASTM D 3683 mod./ICP
Cobalt	3 ug/g	ASTM D 3683 mod./ICP
Chromium	6 ug/g	ASTM D 3683 mod./ICP
Copper	14 ug/g	ASTM D 3683 mod./ICP
Lithium	20 ug/g	ASTM D 3683 mod./ICP
Manganese	45 ug/g	ASTM D 3683 mod./ICP
Molybdenum	<5 ug/g	ASTM D 3683 mod./ICP
Nickel	4 ug/g	ASTM D 3683 mod./ICP
Lead	13 ug/g	ASTM D 3683 mod./ICP
Silver	<0.4 ug/g	ASTM D 3683 mod./ICP
Strontium	109 ug/g	ASTM D 3683 mod./ICP
Thallium	<2 ug/g	ASTM D 3683 mod./ICP
Tin	<2 ug/g	ASTM D 3683 mod./ICP
Vanadium	24 ug/g	ASTM D 3683 mod./ICP
Zinc	13 ug/g	ASTM D 3683 mod./ICP
Zirconium	91 ug/g	ASTM D 3683 mod./ICP
Phosphorus	210 ug/g	ASTM D 4326
Boron	100 ug/g	ASTM D 3684 mod./ICP
Bromine, Dry	<20 ug/g	ASTM D 4208-Br
Chlorine, Dry	66 ug/g	ASTM D 6721
Fluorine, Dry	140 ug/g	ASTM D 3761
Arsenic	2 ug/g	ASTM D 3684/6357
Selenium	2 ug/g	ASTM D 3684/6357
Mercury, Dry	0.06 ug/g	ASTM D 6722

Respectfully submitted,
SGS NORTH AMERICA INC.

Tony Stoyko

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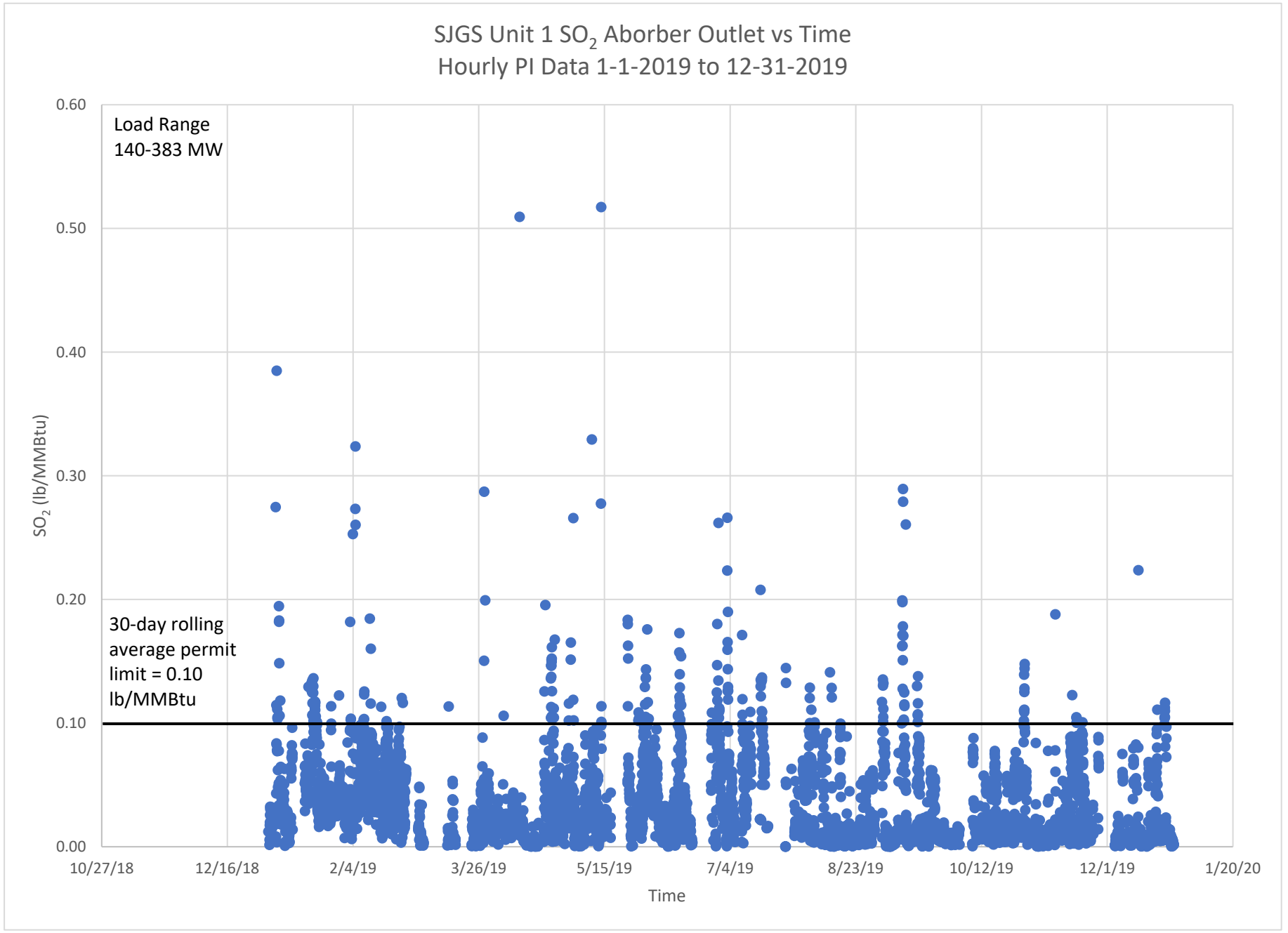
Member of the SGS Group

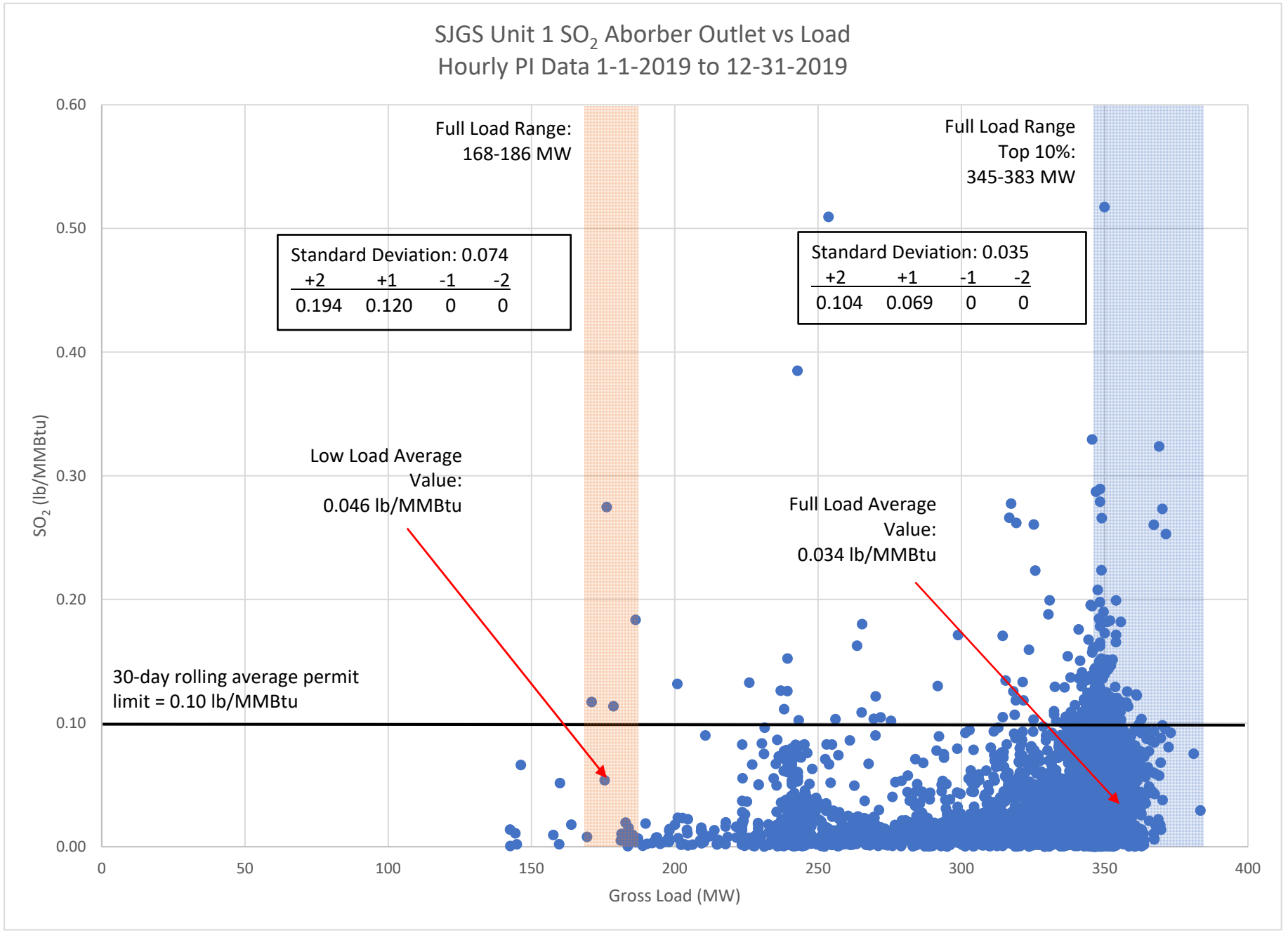
F-465

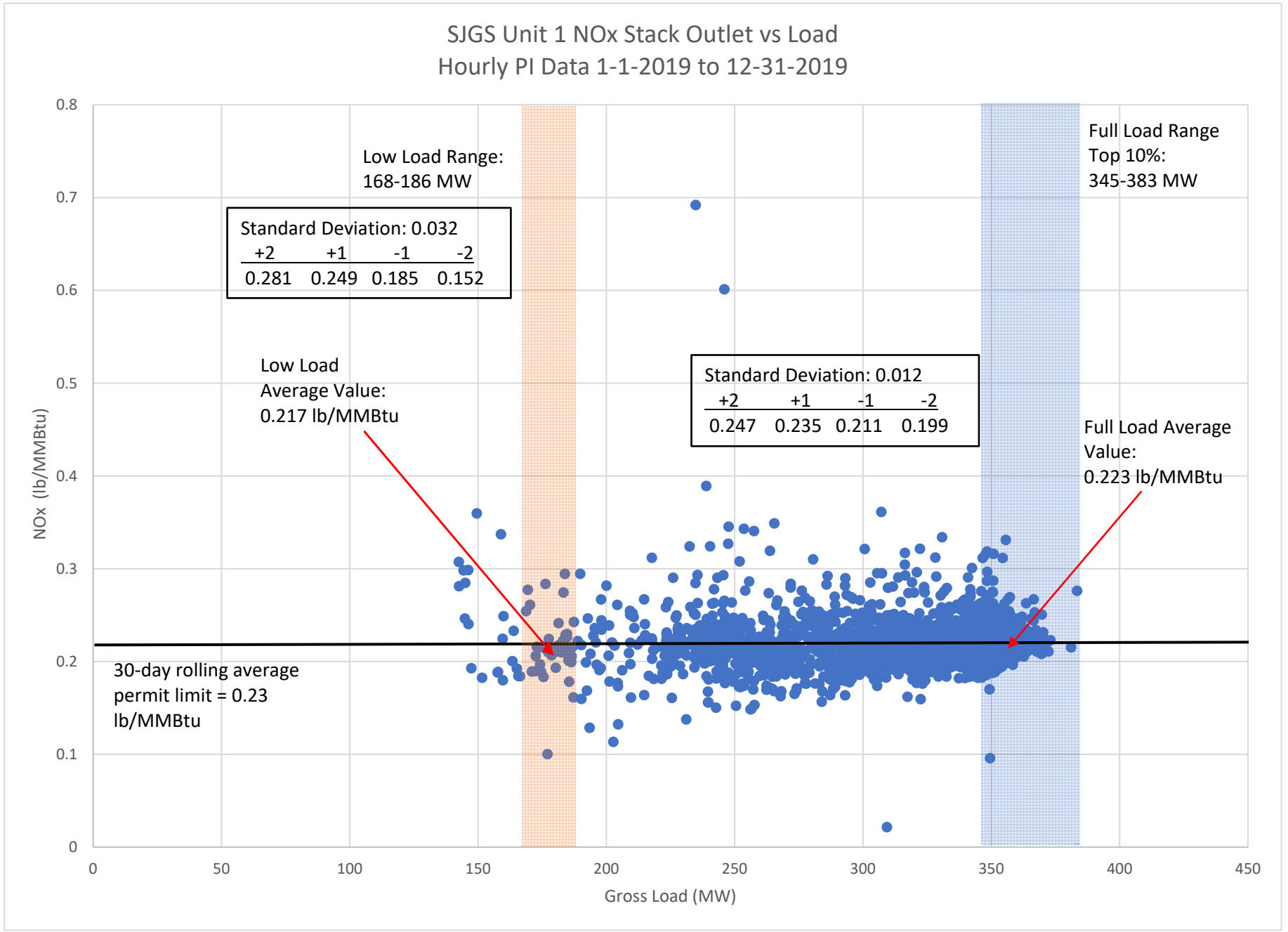
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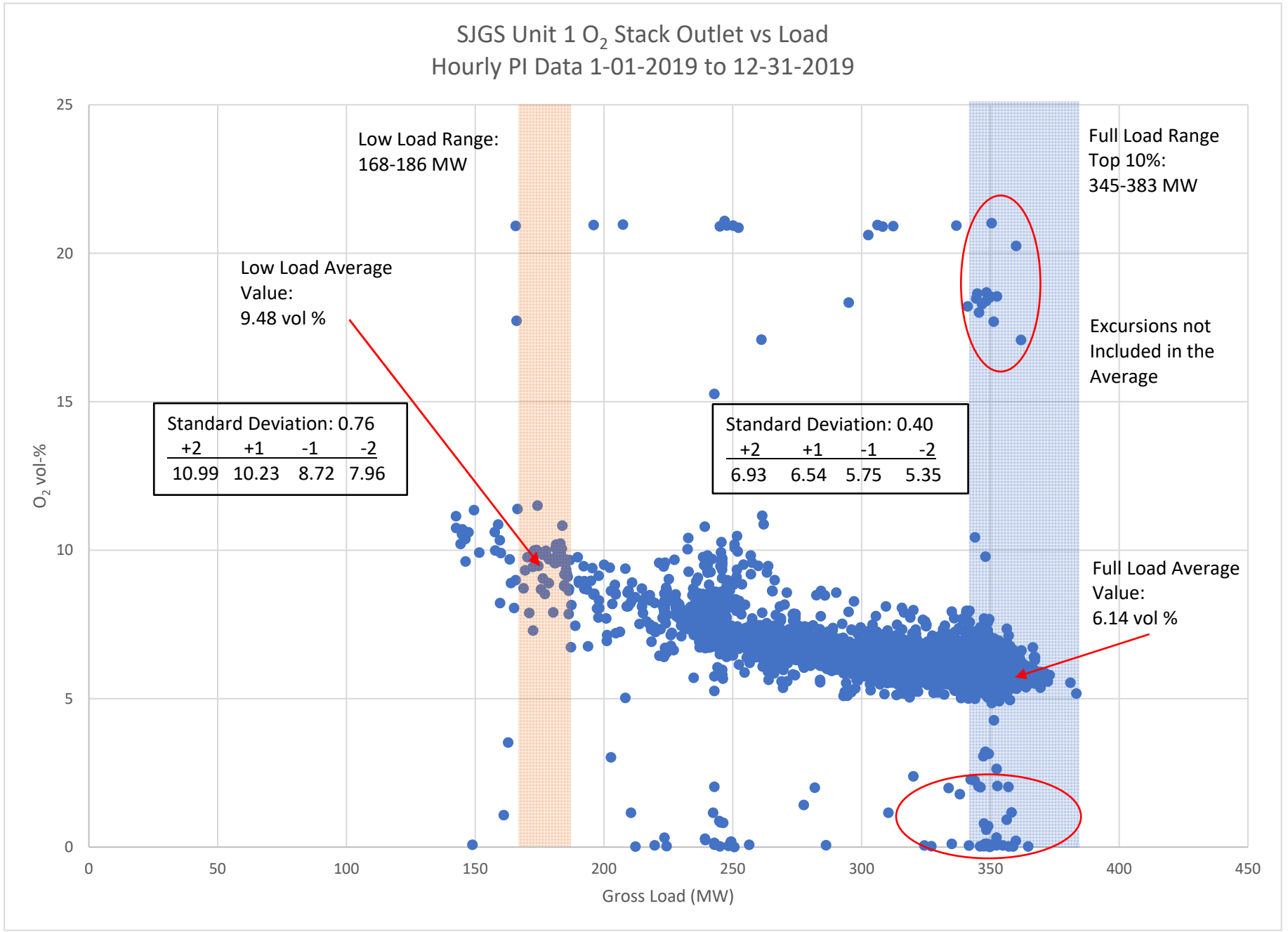
Attachment F

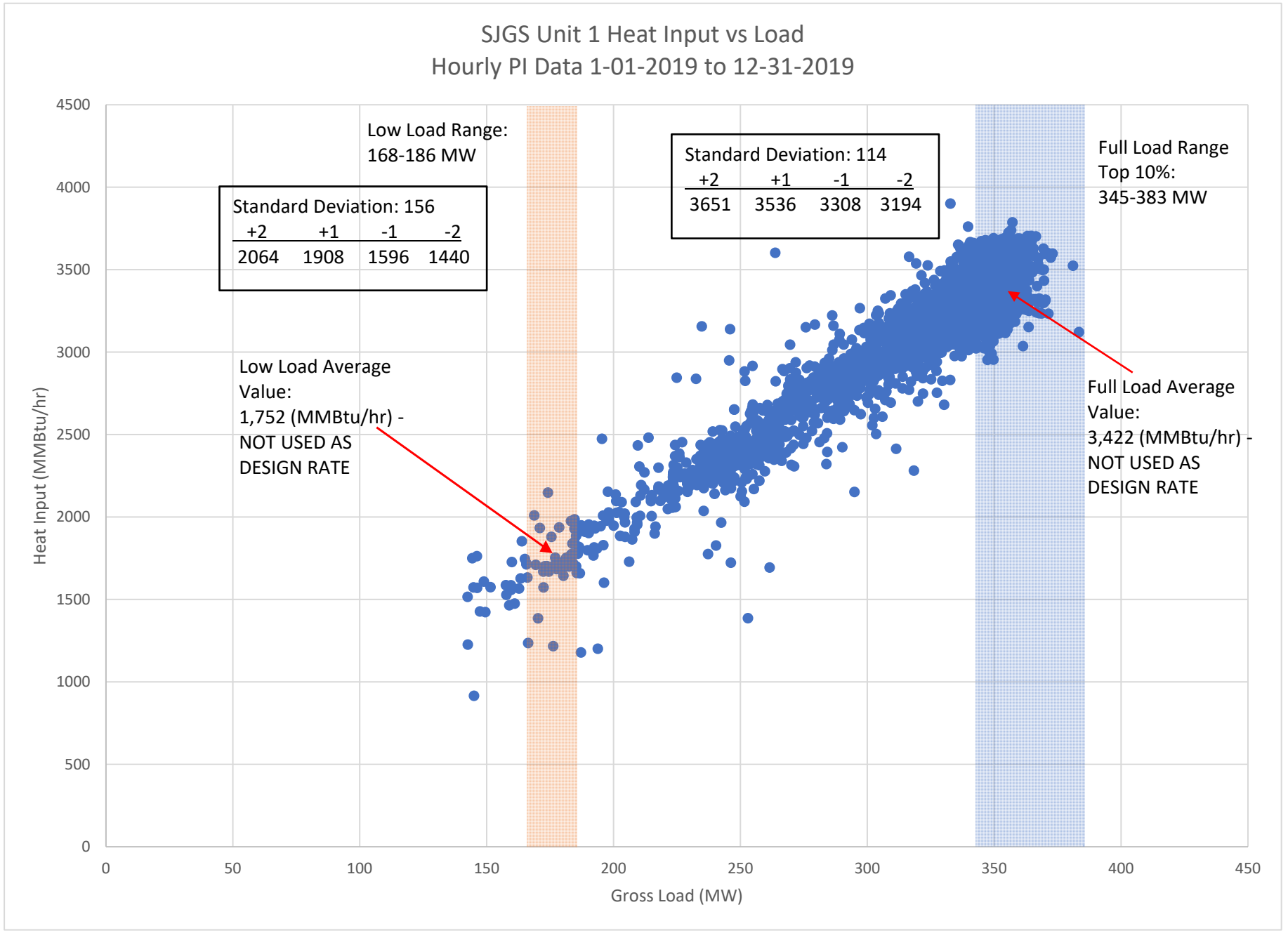
Historic Stack Operating (PI) Data

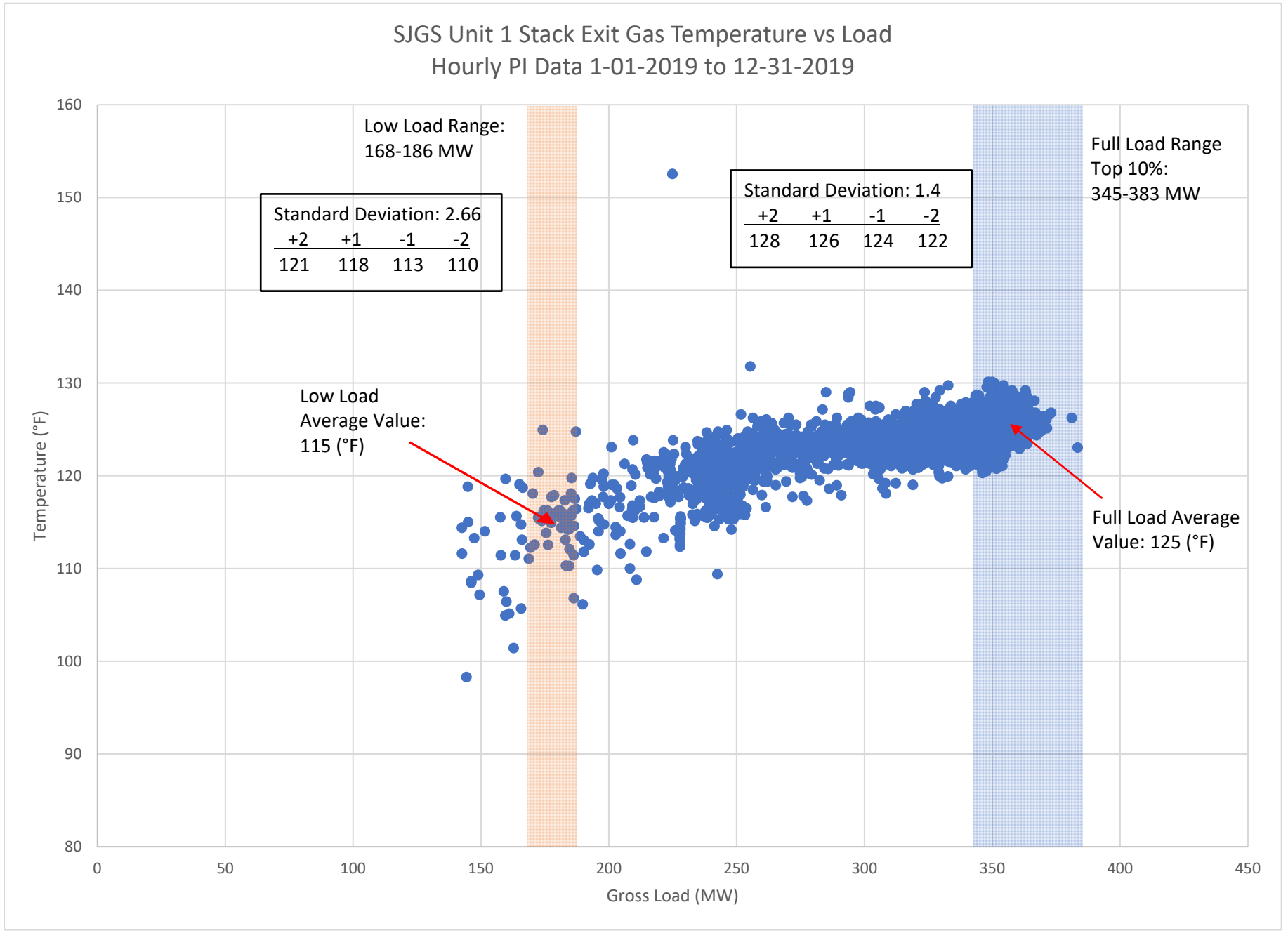

SJGS Unit 1 SO2 Aborber Outlet vs Time
Hourly PI Data 1-1-2019 to 12-31-2019
Load Range
140-383 MW
30-day rolling
average permit
limit = 0.10
lb/MMBtu
SO2 (lb/MMBtu)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
10/27/18
12/16/18
2/4/19
3/26/19
5/15/19
7/4/19
8/23/19
10/12/19
12/1/19
1/20/20
Time

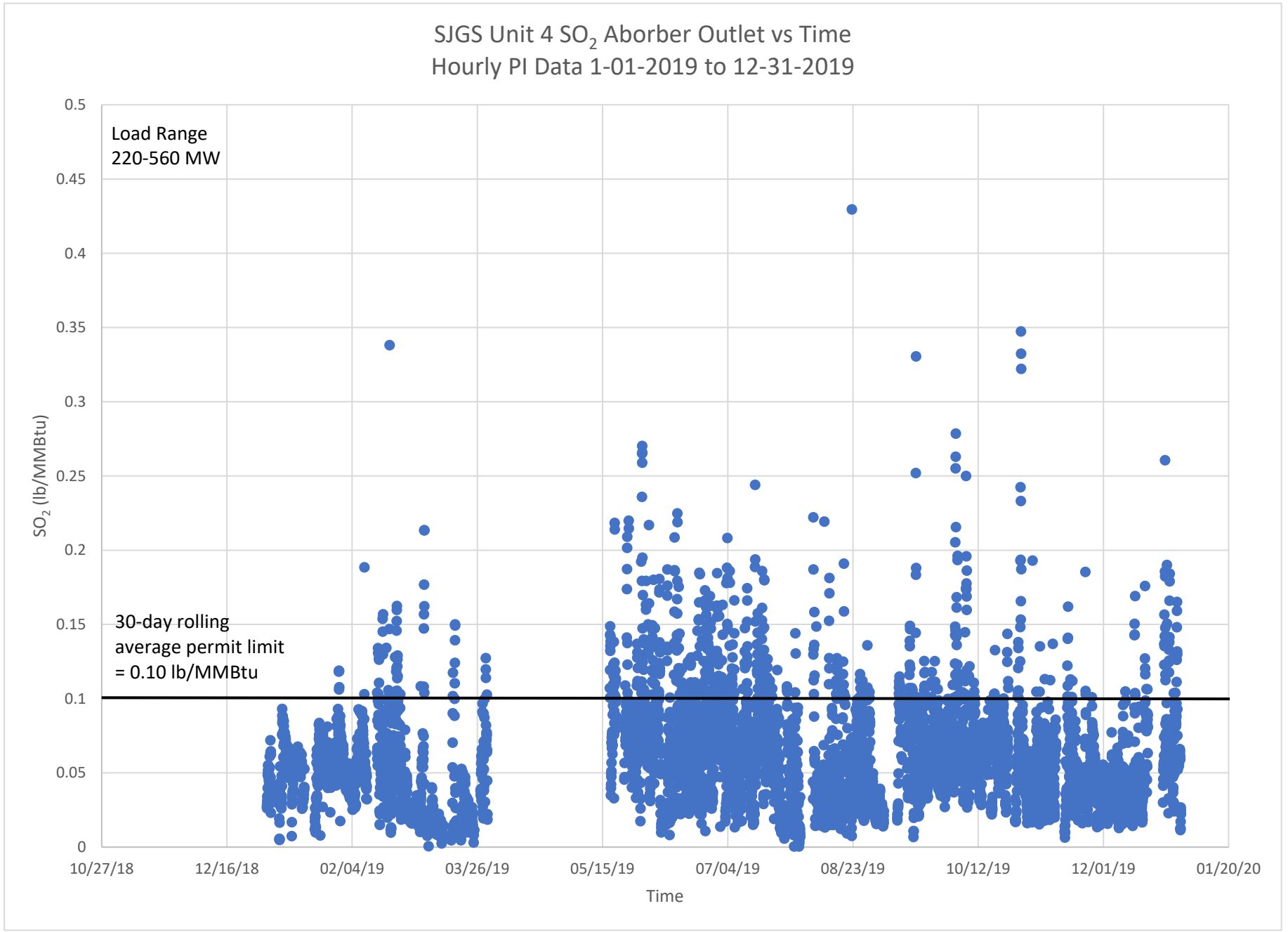

SJGS Unit 1 SO2 Aborber Outlet vs Load
Hourly PI Data 1-1-2019 to 12-31-2019
Full Load Range:
168-186 MW
Full Load Range
Top 10%:
345-383 MW
Standard Deviation: 0.074
+2 +1 -1 -2
0.194 0.120 0 0
Standard Deviation: 0.035
+2 +1 -1 -2
0.104 0.069 0 0
Low Load Average
Value:
0.046 lb/MMBtu
Full Load Average
Value:
0.034 lb/MMBtu
30-day rolling average permit
limit = 0.10 lb/MMBtu
SO2 (lb/MMBtu)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
50
100
150
200
250
300
350
400
Gross Load (MW)

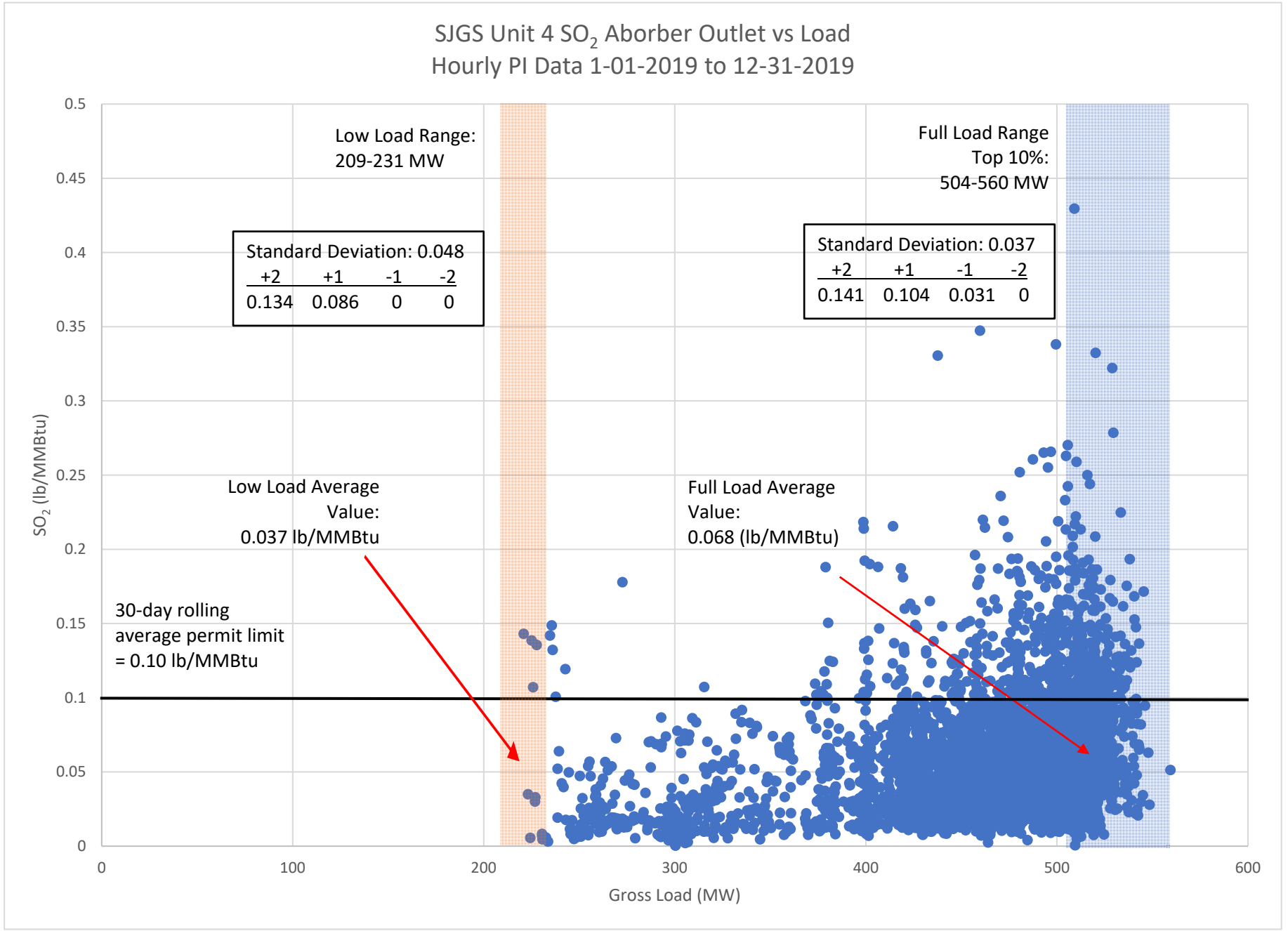

SJGS Unit 1 NOx Stack Outlet vs Load
Hourly PI Data 1-1-2019 to 12-31-2019
NOx (lb/MMBtu)
Gross Load (MW)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150
200
250
300
350
400
450
Low Load Range:
168-186 MW
Standard Deviation: 0.032
+2 +1 -1 -2
0.281 0.249 0.185 0.152
Low Load
Average Value:
0.217 lb/MMBtu
Full Load Range
Top 10%:
345-383 MW
Standard Deviation: 0.012
+2 +1 -1 -2
0.247 0.235 0.211 0.199
Full Load Average
Value:
0.223 lb/MMBtu
30-day rolling average
permit limit = 0.23
lb/MMBtu

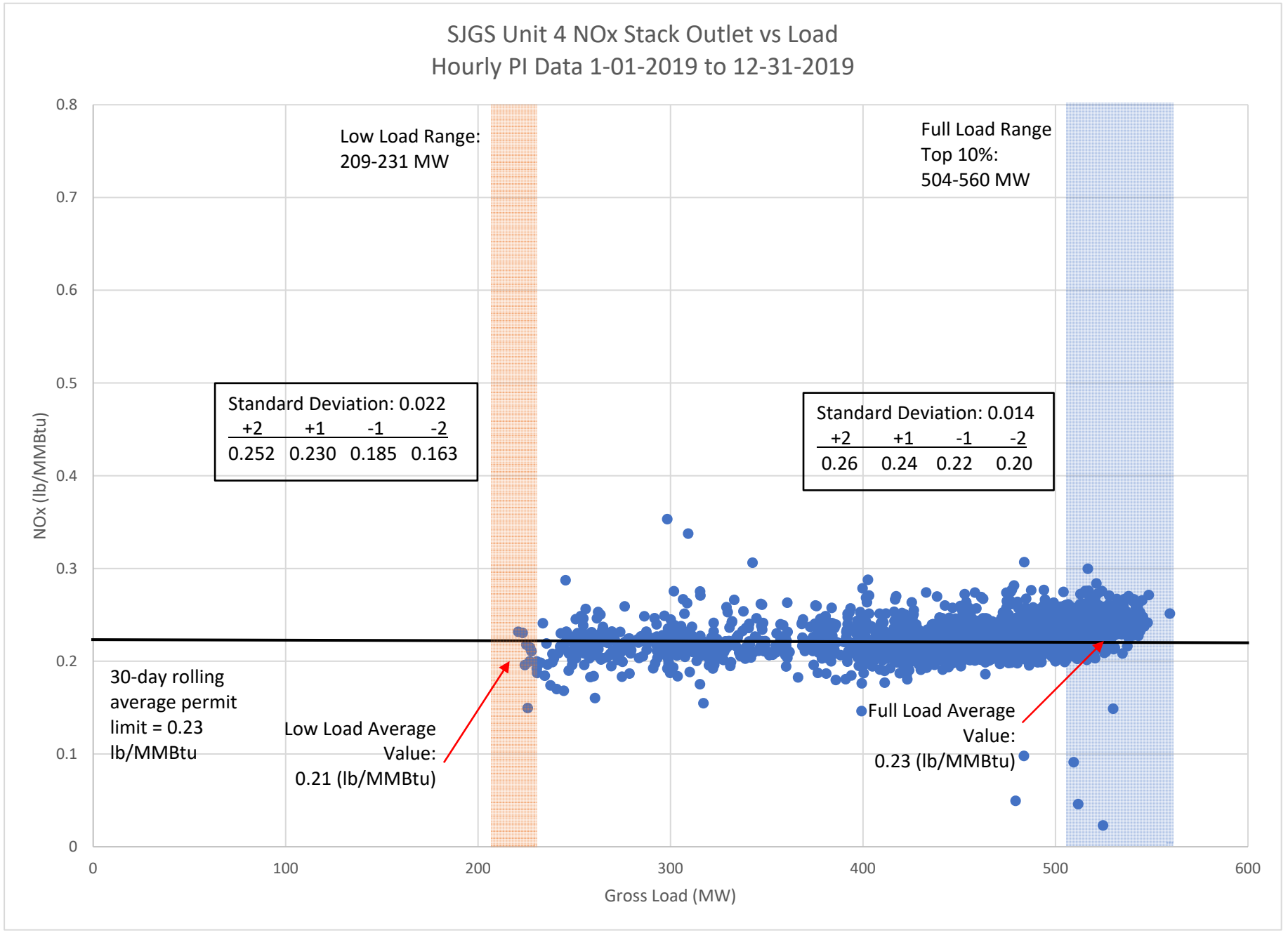

SJGS Unit 1 O_2 Stack Outlet vs Load
Hourly PI Data 1-01-2019 to 12-31-2019
Low Load Range:
168-186 MW
Full Load Range
Top 10%:
345-383 MW
Low Load Average
Value:
9.48 vol %
Excursions not
Included in the
Average
Standard Deviation: 0.76
+2 +1 -1 -2
10.99 10.23 8.72 7.96
Standard Deviation: 0.40
+2 +1 -1 -2
6.93 6.54 5.75 5.35
Full Load Average
Value:
6.14 vol %
O_2 vol-%
Gross Load (MW)
0
5
10
15
20
25
0
50
100
150
200
250
300
350
400
450

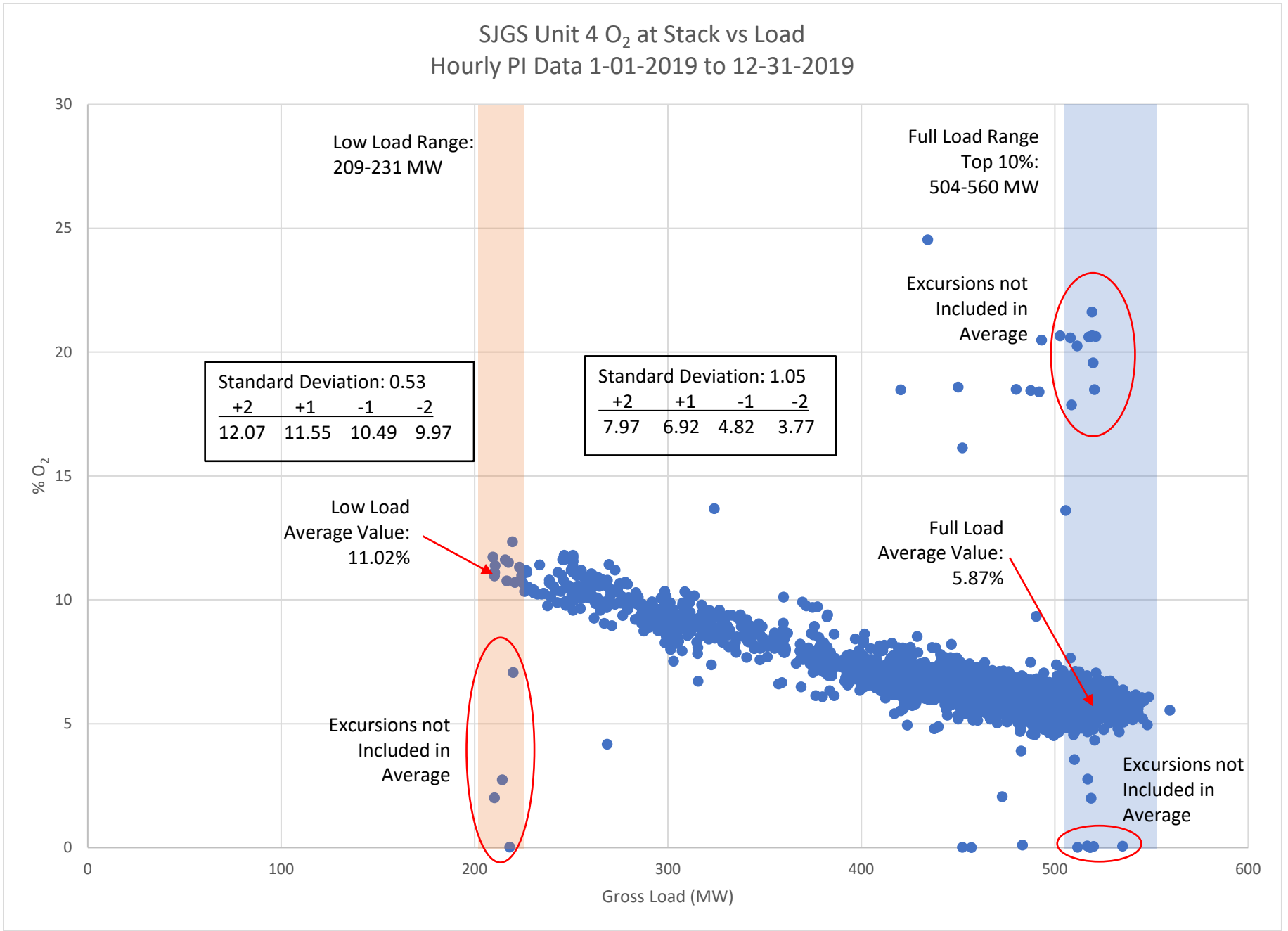

SJGS Unit 1 Heat Input vs Load
Hourly PI Data 1-01-2019 to 12-31-2019
Heat Input (MMBtu/hr)
Gross Load (MW)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
0
50
100
150
200
250
300
350
400
450
Low Load Range:
168-186 MW
Standard Deviation: 156
+2 +1 -1 -2
2064 1908 1596 1440
Standard Deviation: 114
+2 +1 -1 -2
3651 3536 3308 3194
Full Load Range
Top 10%:
345-383 MW
Low Load Average
Value:
1,752 (MMBtu/hr) -
NOT USED AS
DESIGN RATE
Full Load Average
Value:
3,422 (MMBtu/hr) -
NOT USED AS
DESIGN RATE

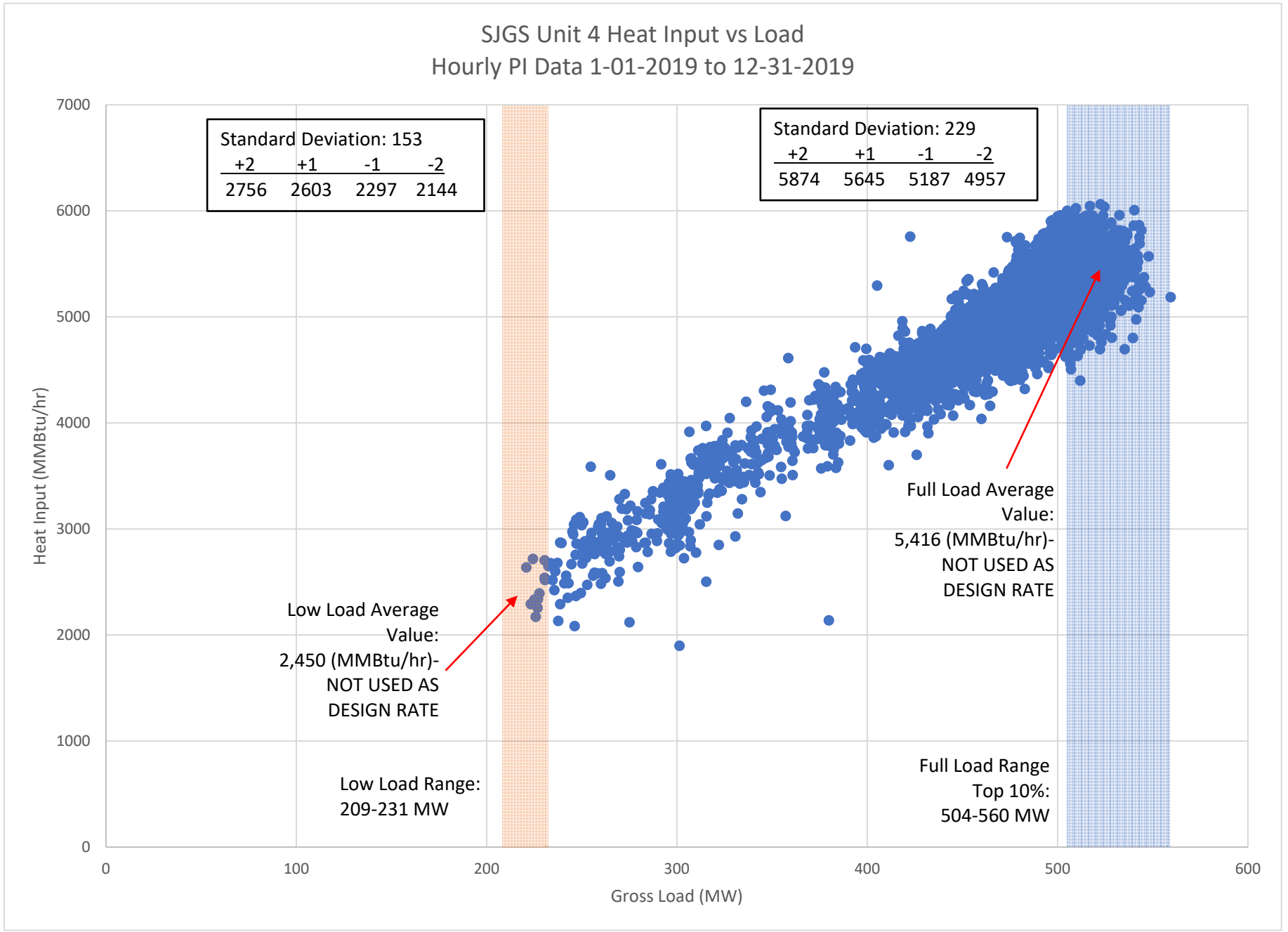

SJGS Unit 1 Stack Exit Gas Temperature vs Load
Hourly PI Data 1-01-2019 to 12-31-2019
Low Load Range:
168-186 MW
Standard Deviation: 2.66
+2 +1 -1 -2
121 118 113 110
Standard Deviation: 1.4
+2 +1 -1 -2
128 126 124 122
Full Load Range
Top 10%:
345-383 MW
Low Load
Average Value:
115 (°F)
Full Load Average
Value: 125 (°F)
Temperature (°F)
Gross Load (MW)
160
150
140
130
120
110
100
90
80
0
50
100
150
200
250
300
350
400
450

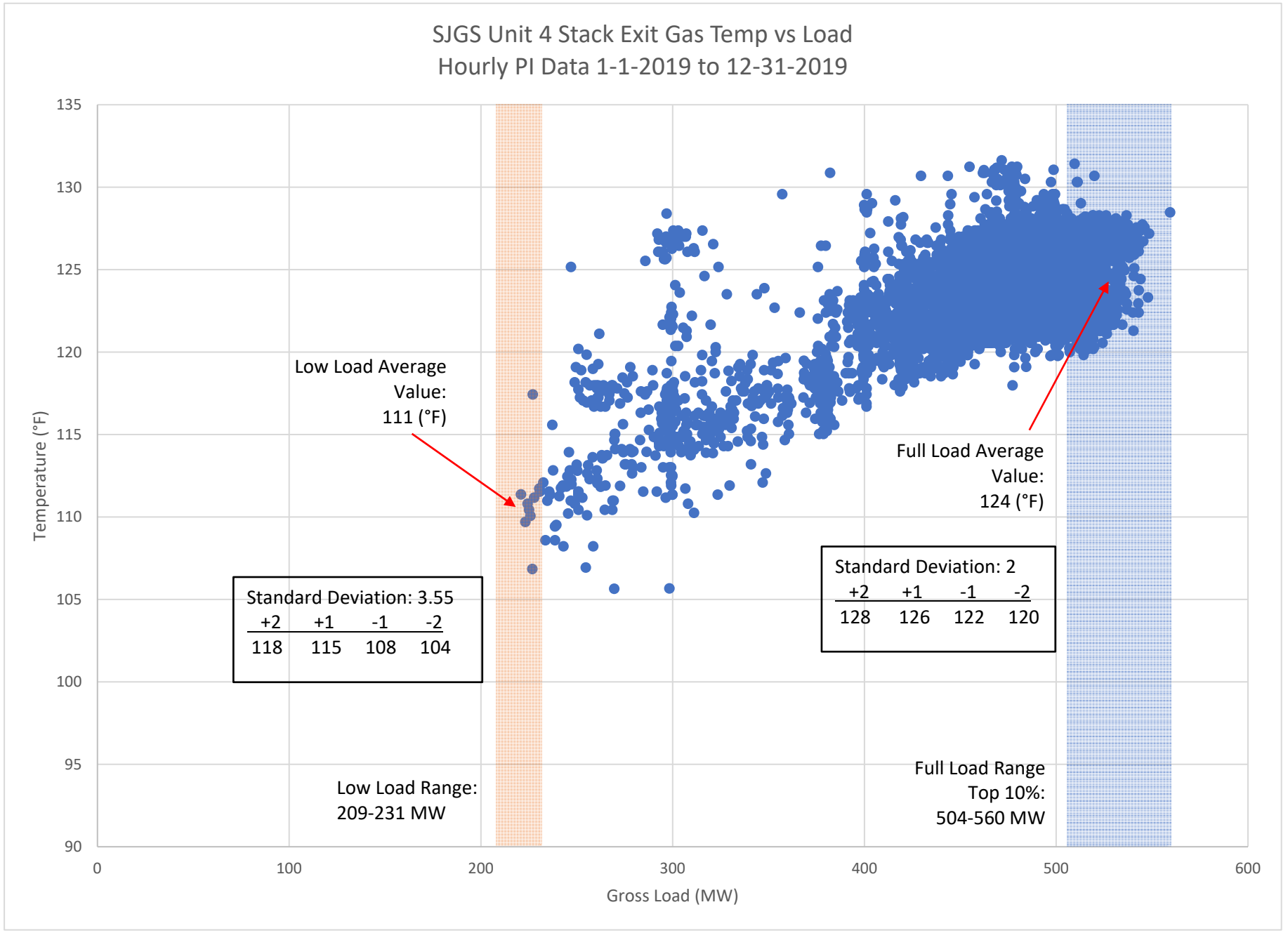

SJGS Unit 4 SO_2 Aborber Outlet vs Time
Hourly PI Data 1-01-2019 to 12-31-2019
Load Range
220-560 MW
30-day rolling
average permit limit
= 0.10 lb/MMBtu
SO_2 (lb/MMBtu)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
10/27/18
12/16/18
02/04/19
03/26/19
05/15/19
07/04/19
08/23/19
10/12/19
12/01/19
01/20/20
Time


SJGS Unit 4 SO_2 Aborber Outlet vs Load
Hourly PI Data 1-01-2019 to 12-31-2019
Low Load Range:
209-231 MW
Full Load Range
Top 10%:
504-560 MW
Standard Deviation: 0.048
+2 +1 -1 -2
0.134 0.086 0 0
Standard Deviation: 0.037
+2 +1 -1 -2
0.141 0.104 0.031 0
Low Load Average
Value:
0.037 lb/MMBtu
Full Load Average
Value:
0.068 (lb/MMBtu)
30-day rolling
average permit limit
= 0.10 lb/MMBtu
SO_2 (lb/MMBtu)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
100
200
300
400
500
600
Gross Load (MW)


SJGS Unit 4 NOx Stack Outlet vs Load
Hourly PI Data 1-01-2019 to 12-31-2019
Low Load Range:
209-231 MW
Full Load Range
Top 10%:
504-560 MW
Standard Deviation: 0.022
+2 +1 -1 -2
0.252 0.230 0.185 0.163
Standard Deviation: 0.014
+2 +1 -1 -2
0.26 0.24 0.22 0.20
30-day rolling
average permit
limit = 0.23
lb/MMBtu
Low Load Average
Value:
0.21 (lb/MMBtu)
Full Load Average
Value:
0.23 (lb/MMBtu)
NOx (lb/MMBtu)
Gross Load (MW)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
100
200
300
400
500
600


SJGS Unit 4 O_2 at Stack vs Load
Hourly PI Data 1-01-2019 to 12-31-2019
% O_2
Gross Load (MW)
0
5
10
15
20
25
30
0
100
200
300
400
500
600
Low Load Range:
209-231 MW
Full Load Range
Top 10%:
504-560 MW
Excursions not
Included in
Average
Standard Deviation: 0.53
+2 +1 -1 -2
12.07 11.55 10.49 9.97
Standard Deviation: 1.05
+2 +1 -1 -2
7.97 6.92 4.82 3.77
Low Load
Average Value:
11.02%
Full Load
Average Value:
5.87%
Excursions not
Included in
Average
Excursions not
Included in
Average


SJGS Unit 4 Heat Input vs Load
Hourly PI Data 1-01-2019 to 12-31-2019
Standard Deviation: 153
+2 +1 -1 -2
2756 2603 2297 2144
Standard Deviation: 229
+2 +1 -1 -2
5874 5645 5187 4957
Full Load Average Value: 5,416 (MMBtu/hr)- NOT USED AS DESIGN RATE
Low Load Average Value: 2,450 (MMBtu/hr)- NOT USED AS DESIGN RATE
Low Load Range: 209-231 MW
Full Load Range Top 10%: 504-560 MW
Heat Input (MMBtu/hr)
Gross Load (MW)
0
1000
2000
3000
4000
5000
6000
7000
0
100
200
300
400
500
600


SJGS Unit 4 Stack Exit Gas Temp vs Load
Hourly PI Data 1-1-2019 to 12-31-2019
Temperature (°F)
135
130
125
120
115
110
105
100
95
90
0
100
200
300
400
500
600
Gross Load (MW)
Low Load Average Value: 111 (°F)
Full Load Average Value: 124 (°F)
Standard Deviation: 3.55
+2 +1 -1 -2
118 115 108 104
Standard Deviation: 2
+2 +1 -1 -2
128 126 122 120
Low Load Range: 209-231 MW
Full Load Range Top 10%: 504-560 MW

Attachment G

Flue Gas Pressure Profile Information

Unit 1 Gas Path Pressures

	Forced Draft Operation inwc	Forced Draft Design inwc		Note	Forced Draft Transient per TRAX inwc		Forced Draft Recommended Design Excursion (+/-5 of transient) inwc		Current Excursion Design inwc		Balanced Draft Operation inwc	Balanced Draft Design inwc		Balanced Draft Transient Estimated inwc		Balanced Draft Design Excursion (+/-5 of transient) inwc	
		+	-		+	-	+	-	+	-		+	-	+	-	+	-
FD Fan Outlet	22.4	Later	Later		28.9	-0.3	33.9	-5.3	Later	Later	12.0	20.3	-9.4	28.9	-10.7	33.9	-15.7
Ductwork		Later	Later		---	---	---	---	Later	Later	12.0	20.3	-9.6	28.9	-11.0	33.9	-16.0
SAH Air Inlet	20.9	Later	Later		27.5	-0.6	32.5	-5.6	Later	Later	10.5	19.5	-9.6	27.5	-11.0	32.5	-16.0
SAH Air Outlet	16.6	Later	Later		23.4	-2.4	28.4	-7.4	Later	Later	6.2	17.0	-10.7	23.4	-12.8	28.4	-17.8
Ductwork		Later	Later		---	---	---	---	Later	Later	6.2	17.0	-11.4	23.4	-14.0	28.4	-19.0
Windbox	14.7	Later	Later		21.7	-3.6	26.7	-8.6	Later	Later	4.3	16.0	-11.4	21.7	-14.0	26.7	-19.0
Furnace	9.9	25.0	0.0	2	17.4	-6.9	22.4	-11.9	Later	Later	-0.5	13.4	-13.4	17.4	-17.3	22.4	-22.3
Economizer Outlet	7.5	Later	Later		15.4	-7.2	20.4	-12.2	Later	Later	-2.9	12.2	-13.6	15.4	-17.6	20.4	-22.6
Ductwork		Later	Later		---	---	---	---	Later	Later	-4.3	12.2	-13.7	15.4	-17.8	20.4	-22.8
ESP Outlet	6.1	15.0	-15.0		14.2	-7.4	19.2	-12.4	Later	Later	-4.3	11.5	-13.7	14.2	-17.8	19.2	-22.8
Ductwork		Later	Later		---	---	---	---	Later	Later	-8.9	11.5	-13.9	14.2	-18.1	19.2	-23.1
SAH Gas Outlet	1.5	Later	Later		10.3	-7.7	15.3	-12.7	Later	Later	-8.9	9.2	-13.9	10.3	-18.1	15.3	-23.1
Ductwork		Later	Later		---	---	---	---	Later	Later	-10.3	9.2	-14.0	10.3	-18.4	15.3	-23.4
Baghouse Inlet	0.1	10.0	-22.0	1	9.1	-8.0	14.1	-13.0	Later	Later	-10.3	8.5	-14.0	9.1	-18.4	14.1	-23.4
Baghouse Outlet	-9.5	10.0	-35.0	1	1.0	-9.5	6.0	-14.5	Later	Later	-19.9	3.6	**-20.0**	1.0	-19.9	6.0	-24.9
Ductwork		Later	Later		---	---	---	---	Later	Later	-21.4	3.6	**-22.0**	1.0	-21.4	6.0	-26.4
Booster Fan Inlet	-11.0	Later	Later		-0.6	-11.0	4.4	-16.0	Later	Later	-21.4				-21.4	4.4	-26.4
Booster Fan Outlet	14.9	Later	Later		28.0	0.4	33.0	-4.6	Later	Later	4.5	1			-10.0	33.0	-15.0
Ductwork		Later	Later		---	---	---	---	Later	Later	4.5	1			-11.4	33.0	-16.4
Scrubber Outlet	2.9	Later	Later		3.2	-1.0	8.2	-6.0	Later	Later	-7.5	4			-11.4	8.2	-16.4
Ductwork		Later	Later		---	---	---	---	Later	Later	-10.9	4			-11.9	8.2	-16.9
Stack Base	-0.5	Later	Later		-0.4	-1.5	4.6	-6.5	Later	Later	-10.9	2.8	**-11.0**	-0.4	-11.9	4.6	-16.9
Notes	TRAX Report Values	Per Design Drawings	Per Design Drawings		Mitigated One Booster Trip	FD Trip	Max mitigated transient +5	Max mitigated transient -5	Per Design Drawings	Per Design Drawings	10.4" less than FD Operation	60% of excursion	60% of excursion (3)	Same as FD (4)	FD - 10.4" (4)	Transient +5	Transient -5

12.0 inwc
WFGD dP

1. From BW BH Design Criteria

2. From S&L NFPA White Paper
3. Bold cells indicate design pressures are dictated by Operation, not Transient
4. To be verified by new Boiler Transient Model

Unit 4 Gas Path Pressures

	Forced Draft Operation inwc	Current Design inwc		Note	Forced Draft Transient per TRAX inwc		Forced Draft Recommended Design Excursion (+/-5 of transient) inwc		Current Excursion Design inwc		Balanced Draft Operation inwc	Estimated Balanced Draft Design inwc		Balanced Draft Transient Estimated inwc		Balanced Draft Design Excursion (+/-5 of transient) inwc	
		+	-		+	-	+	-	+	-		+	-	+	-	+	-
FD Fan Outlet	30.0	Later	Later		35.8	1.1	40.8	-3.9	Later	Later	19.9	24.5	-8.5	35.8	-9.0	40.8	-14.1
Ductwork		Later	Later		---	---	---	---	Later	Later	19.9	24.5	-8.5	35.8	-9.0	40.8	-14.1
SAH Air Inlet	29.0	Later	Later		33.2	1.1	38.2	-3.9	Later	Later	18.9	24.5	-8.5	33.2	-9.0	40.8	-14.1
SAH Air Outlet	25.0	Later	Later		29.4	1.0	34.4	-4.0	Later	Later	14.9	20.6	-8.5	29.4	-9.1	34.4	-14.1
Ductwork	23.0	Later	Later		27.6	1.0	32.6	-4.0	Later	Later	14.9	20.6	-8.5	29.4	-9.1	34.4	-14.1
Windbox	15.2	Later	Later		27.6	1.0	32.6	-4.0	Later	Later	5.1	20.6	-8.5	27.6	-9.1	34.4	-14.1
Furnace	9.6	Later	Later		15.3	-10.3	20.3	-15.3	Later	Later	-0.5	12.2	-15.7	15.3	-20.4	20.3	-26.1
Economizer Outlet	7.0	Later	Later		14.6	-11.0	19.6	-16.0	Later	Later	-3.1	12.2	-15.7	14.6	-21.1	20.3	-26.1
Ductwork		15.9	-15.2	1	---	---	---	---	Later	Later	-4.8	11.8	-16.0	14.6	-21.6	19.6	-26.6
ESP Outlet	5.3	10.0	0.0		13.9	-11.5	18.9	-16.5	25.0	-15.0	-4.8	11.3	-16.0	13.9	-21.6	18.9	-26.6
Ductwork		15.9	-15.2	1	---	---	---	---	Later	Later	-10.1	11.3	-16.9	13.9	-23.2	18.9	-28.2
SAH Gas Outlet	0.0	Later	Later		11.9	-13.1	16.9	-18.1	Later	Later	-10.1	10.1	-16.9	11.9	-23.2	16.9	-28.2
Ductwork		16.8	-16.8	1	---	---	---	---	Later	Later	-13.4	10.7	-17.5	11.9	-24.1	16.9	-29.1
Baghouse Inlet	-3.3	Later	Later		10.9	-14.0	15.9	-19.0	Later	Later	-13.4			10.9	-24.1	15.9	-29.1
Baghouse Outlet	-13.9	Later	Later		6.6	-18.2	11.6	-23.2	Later	Later	-24.0			6.6	-28.3	11.6	-33.3
Ductwork		Later	Later		---	---	---	---	Later	Later	-26.2			6.6	-30.0	11.6	-35.0
Booster Fan Inlet	-16.1	Later	Later		6.1	-19.9	11.1	-24.9	Later	Later	-26.2			6.1	-30.0	11.1	-35.0
Booster Fan Outlet	17.4	Later	Later		17.4	-2.0	22.4	-7.0	Later	Later	7.3	13.4	-10.3	17.4	-12.1	22.4	-17.1
Ductwork		22.4	-22.4	1	---	---	---	---	Later	Later	7.3	13.4	-10.4	17.4	-12.3	22.4	-17.3
Scrubber Outlet	1.2	Later	Later		1.8	-2.2	6.8	-7.2	Later	Later	-8.9	4.1	-10.4	1.8	-12.3	6.8	-17.3
Ductwork		Later	Later		---	---	---	---	Later	Later	-9.6	4.1	-10.4	1.8	-12.3	6.8	-17.3
Stack Base	0.5	Later	Later		0.5	-2.2	5.5	-7.2	Later	Later	-9.6	3.3	-10.4	0.5	-12.3	5.5	-17.3
Notes	TRAX Report Values	Per Design Drawings	Per Design Drawings				Max mitigated transient +5	Max mitigated transient -5	Per Design Drawings	Per Design Drawings	10.1" less than FD Operation	60% of excursion	60% of excursion (2)	Same as FD (3)	FD - 10.1" (3)	Transient +5	Transient -5

13.9 inwc dP

1. U34 FG System Review (J Charles)
2. Bold cells indicate design pressures are dictated by Operation, not Transient
3. To be verified by new Boiler Transient Model

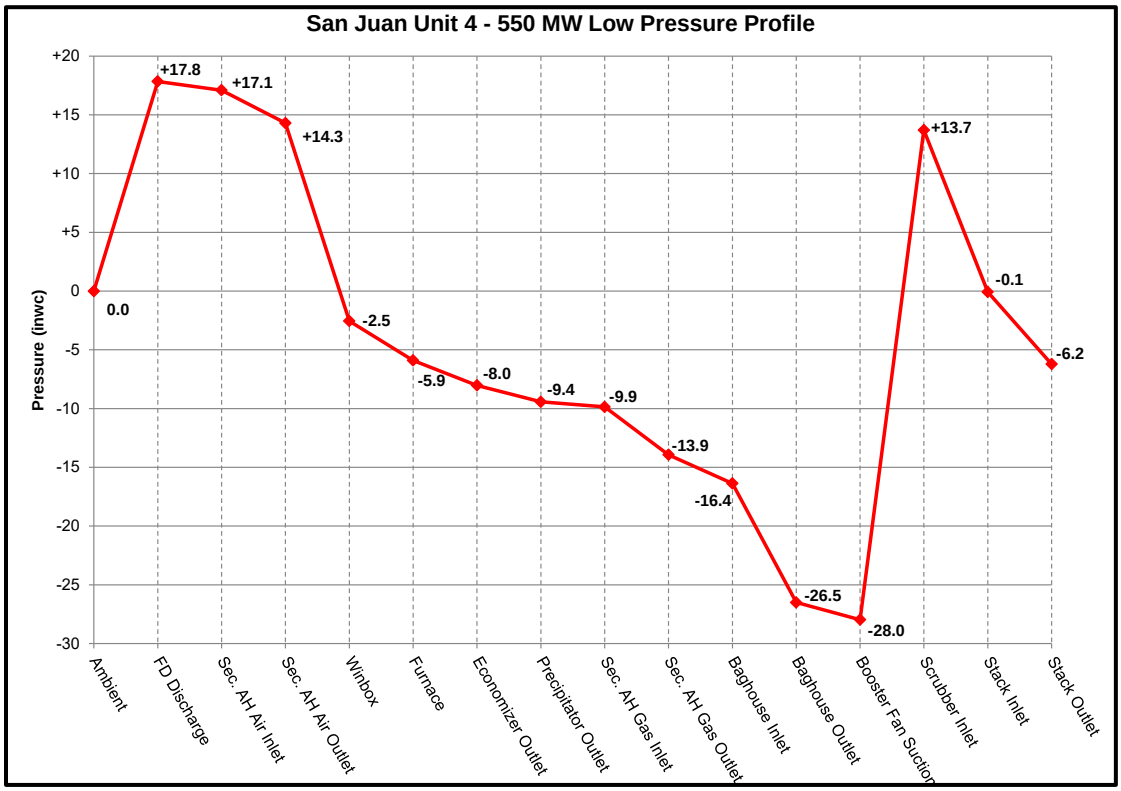


Figure 4. IC1: Low Pressure, 100% Load (550 MW gross)

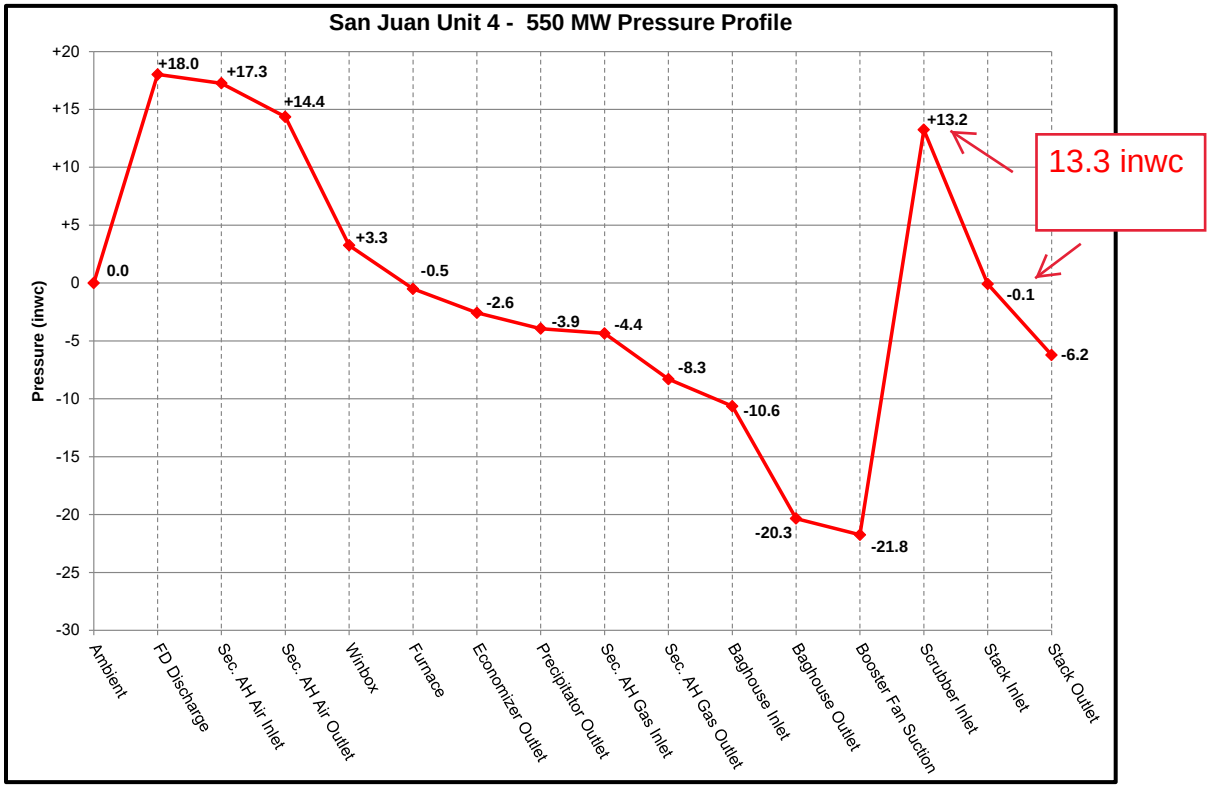


Figure 5. IC2: 100% Load (550 MW gross)

APPENDIX K

Unit 4 – Fan / Motor Design Parameters

		Unit 4		
		Balanced Draft w/ ESP	Balanced Draft w/ ESP Test Block	Balanced Draft w/ ESP Low Load
Volumetric Flow per Fan	ACFM	1,003,970	1,062,842	431,650
Design Temperature at Fan Inlet	F	285	285	285
Excursion Temperature at Fan Inlet	F	700	700	700
Density at Fan Inlet	lb/ft3	0.0395	0.0392	0.0424
Fan Inlet Static Pressure	in wg	-28.47	-31.01	-6.86
Fan Outlet Static Pressure	in wg	9.12	9.34	3.82
Fan Static Pressure Rise	in wg	37.59	40.35	10.68

Attachment H

Design Parameter Requests from MHI

(Email Correspondence)

From: Miyamoto, Osamu
To: KUNKEL, EMILY J
Cc: Maas, Cole; GOZDOWIAK, AMY M; Iwakura, Keisuke; WYLIE JR, STEPHEN R; HORNISH, CHRISTOPHER D
Subject: RE: SJGS CO2 - Flue Gas Design Basis Review
Date: Tuesday, June 9, 2020 4:09:38 AM
Attachments: image003.png

Emily,

Here is the summary table.
I hope we are on the same page!

Case	Pressure	Temperature	Saturated moisture *1)	Note
-	psia	°F	mol%	
Average	11.97	125	16.25	- 1 inH2O (Barometric = 12.004 psi) at Stack tie-in
Design	11.97	127	17.16	- 1 inH2O (Barometric = 12.004 psi) at Stack tie-in
Max	11.97	128	17.63	- 1 inH2O (Barometric = 12.004 psi) at Stack tie-in
Min	11.97	120	14.16	- 1 inH2O (Barometric = 12.004 psi) at Stack tie-in
Min	11.79	110	10.83	- 6 inH2O (Barometric = 12.004 psi) at CO2 Capture Island tie-in
*1) JSME Steam Table, based on IAPWS-IF97				

Osamu “Sam” Miyamoto
Tel: 713-351-6441 Cell: 713-398-4867
osamu.miyamoto@mhia.com

Attachment I

Trace Constituents from PNM

Trace Constituent Test Information

	Green denotes information recorded in CEMS. This information will be recorded in CEMS during future testing.
	Orange denotes items estimated with factors (AP-42)
	Yellow denotes items previously tested with available data.
	Gray denotes items that will be proposed to PNM to obtain test information. Approval to be confirmed by PNM.

Parameter	Unit	Value	MHI Request	Source
Flue gas flow rate	1	CEMS Data	kscfh	
	4	CEMS Data	kscfh	
O_2	1	CEMS Data	vol%-wet	
	4	CEMS Data	vol%-wet	
CO_2	1	CEMS Data	lb/hr	
	4	CEMS Data	lb/hr	
Moisture content	1 & 4	Various	vol%-wet	
SO_2	1	CEMS Data	Detection limit: 0.1 ppmv	
	4	CEMS Data	Detection limit: 0.1 ppmv	
SO_3 (as H_2SO_4)		TBD	Detection limit: 0.1 ppm ppmvd	
Hydrogen Halides (HF & HCl only)	1	HCl: 0.402 mg/180 min 0.00011 lb/MMBtuO2 HF: 0.818 mg/180 min 0.00023 lb/MMBtuO2	Detection limit: 0.04 ppmvd	US EPA EU MACT ICR 2010 Test Method 26A
	4	HCl: 0.442 mg/192 min 0.00013 lb/MMBtuO2 HF: 0.424 mg/192min 0.00011 lb/ MMBtuO2	Detection limit: 0.04 ppmvd	US EPA EU MACT ICR 2010 Test Method 26A
Hydrogen Halides (HBr & HI)		TBD	Detection limit: 0.04 ppmvd	
Halogens (Br_2, Cl_2, I_2)		TBD	Detection limit: 0.04 ppmvd	
Total NO_X	1	CEMS Data	Detection limit: 0.1 ppmv	
	4	CEMS Data	Detection limit: 0.1 ppmv	
NO_2		TBD	Detection limit: 0.1 ppmvd	
Ammonia	1	4.3 ppmv (dry) 8.9 lb/hr	Detection limit: 0.1 ppmvd	Unit 1 NH_3 Emissions Report (Full Load) Test Method CTM-027
	1 & 4	Unit 1: 3.4 ppmv (dry) 7.4 lb/hr Unit 4: 0.9 ppmv (dry) 2.4 lb/hr	Detection limit: 0.1 ppmvd	Unit 1 & Unit 4 NH_3 Emissions Report (Full Load) Test Method CTM-027
Ammonium Sulfate (as NH_3)		TBD	Detection limit: 0.01 ppmvd	
Total Particulate Matter (PM)	1	Filterable: 0.0044 lb/MMBtu Total PM: 42.6 lb/hr 0.012 lb/MMBtu	Detection limit: 0.1 mg/Nm^3	Source Test Report (3rd Quarter PM/CPM & CO Testing) Test Method 5I/202
	4	Filterable: 0.0044 lb/MMBtu Total PM: 44.5 lb/hr 0.0083 lb/MMBtu	Detection limit: 0.1 mg/Nm^3	Source Test Report (3rd Quarter PM/CPM & CO Testing) Test Method 5I/202
PM Size Distribution (hourly max)		TBD	Detection limit: 0.01 ppmvd	
Hg	1	CEMS Data	Detection limit: 0.1 µg/Nm^3	Sorbent Traps
	4	CEMS Data	Detection limit: 0.1 µg/Nm^3	

Trace Constituent Test Information

	Green denotes information recorded in CEMS. This information will be recorded in CEMS during future testing.
	Orange denotes items estimated with factors (AP-42)
	Yellow denotes items previously tested with available data.
	Gray denotes items that will be proposed to PNM to obtain test information. Approval to be confirmed by PNM.

Parameter	Unit	Value	MHI Request	Source
VOCs		TBD	Detection limit: 0.01 ppmvd	
Heavy Metals (As, Cd, Cr, Pb, Se, Sb, Ni, Mn, Co only)	1	All Method 29 - 240 min Chromium: 0.01807 mg & 0.004273 mg/dscf Antimony: 0.000524 mg & 0.000125 mg/dscf Cadmium: 0.00115 mg & 0.000274 mg/dscf Cobalt: 0.0033 mg & 0.00079 mg/dscf Lead: 0.0505 mg & 0.0012 mg/dscf Manganese: 0.02317 mg & 0.005463 mg/dscf Nickel: 0.01438 mg & 0.003413 mg/dscf Selenium: 0.000633 mg & 0.0001517 mg/dscf Arsenic: 0.00023 mg & 0.0000547 mg/dscf	Detection Limit: 1 µg/Nm^3	US EPA EU MACT ICR 2010 Test Method 29
	4	All Method 29 - 256 min Chromium: 0.0198 mg & 3.717E-7 lb/MMBtuO2 Antimony: 05.67E-4 mg & 1.08E-7 lb/MMBtuO2 Cadmium: 0.015 mg & 2.95E-7 lb/MMBtuO2 Cobalt: 0.0028 mg & 5.27E-7 lb/MMBtuO2 Lead: 0.0307 mg & 5.87E-7 lb/MMBtuO2 Manganese: 0.0104 mg & 1.98E-6 lb/MMBtuO2 Nickel: 0.00934 mg & 1.77E-6 lb/MMBtuO2 Selenium: 0.0009 mg & 1.71E-7 lb/MMBtuO2 Arsenic: 0.00043 mg & 8.25E-8 lb/MMBtuO2	Detection Limit: 1 µg/Nm^3	US EPA EU MACT ICR 2010 Test Method 29

Appendix B. Design Criteria

Enchant Energy
CO_2 Capture Project

OVERALL DESIGN BASIS & CRITERIA

San Juan Generating Station

Units 1 & 4

Project No. 13891-010
September 30, 2022
For: FEED
Revision: D

Prepared By:
Sargent & Lundy LLC
55 East Monroe Street
Chicago, Illinois 60603

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1. INTRODUCTION

1.1. Purpose

1.1.1. The New Mexico Energy Transition Act, (recently passed legislation) requires the environmental improvement board, or local board, to adopt regulations limiting carbon dioxide (CO_2) emissions from coal-fired electric generating facilities with an originally installed capacity exceeding 300 MW to no more than 1,100 pounds CO_2 per megawatt-hour (lb/MWh) by January 1, 2023. In order to comply with this regulation, the installation of carbon capture utilization and sequestration (CCUS) technology is required on existing coal-fired generating facility; San Juan Generating Station (SJGS) Units 1 and 4

1.1.2. This document outlines the design criteria for various disciplines for the CCUS project. It is based on previous experience at San Juan Generating Station, as well as industry experience with CCUS implementation.

1.2. Project Background and Participants

1.2.1. Enchant Energy LLC ("Enchant") has entered into an Agency Agreement with the City of Farmington ("Farmington") to develop and manage the CCUS retrofit process. Enchant intends to acquire ownership of SJGS with the exception of Farmington's current plant ownership interest on June 30, 2022 through the assignment by Farmington to Enchant of Farmington's acquisition rights under the Amended San Juan Participation Agreement (ASJPA).

1.2.2. Enchant has engaged with Mitsubishi Heavy Industries (MHI) for the design of the carbon capture system. MHIA is the entity responsible for carbon capture projects in the United States. MHIA will subcontract the majority of its work to Mitsubishi Heavy Industries Engineering (MHIE) located in Yokohama, Japan. MHIA and MHIE, collectively known as "MHI", will provide the engineering and design documents, and costs for the carbon capture island in support of the overall project FEED study.

1.2.3. Enchant has engaged with Kiewit for the construction of the carbon capture and balance of plant (BOP) systems.

1.2.4. Sargent & Lundy will provide detailed engineering for the BOP systems and overall integration to the existing site.

1.3. Plant Background

1.4. Units 2 & 3 were decommissioned in 2017, leaving previously used equipment for potential repurpose.

1.4.1. The existing air quality control systems (AQCS) for each operating unit at the plant are listed below:

a. Low NOx burners with Neural Networks

b. Under Fired Air (Unit 1 only)

c. Over Fired Air (OFA)

d. Selective Non-Catalytic Reduction (SNCR)

e. Brominated Activated Carbon Injection (ACI)

f. Baghouse

g. Wet Flue Gas Desulfurization (WFGD)

1.5. Revisions to Document

1.5.1. These criteria will be revised and updated periodically as additional information becomes available.

2. AMBIENT DESIGN CONDITIONS

2.1. ASHRAE Data

2.1.1. Major site conditions are listed below, which are based on American Society of Heating, Refrigeration and Air Conditioning (ASHRAE) data.

Table 2-1: Major Site Conditions

Parameter	Data
Nearest ASHRAE (2021 Fundamentals) weather data location	Farmington Four Corners
World Meteorological Organization Number	723658
Latitude / Longitude (SJGS)	N 36.80° / W 108.44°
Elevation (SJGS)	5,308 ft
Standard pressure	12.004 psia
Heating dry bulb temperature, 99.6% occurrence	9.1°F
Humidity ratio, 99.6% occurrence	5.1 gpp of dry air
Evaporation wet bulb temperature, 0.4% occurrence	64.6°F
Mean coincident dry bulb temperature	81.2°F
50-year occurrence dry bulb temperatures (1):	
High	103.8°F
Low	-11.3°F
Hottest month (July) dry bulb range	29.6°F
Cooling dry bulb temperature, 0.4% occurrence (2)	96.1°F
Cooling wet bulb temperature, 0.4% occurrence	59.4°F

(1) Design Value (For mechanical design and winterization design)
(2) Warranty Design Value (For heating and cooling load design of HVAC system)

2.2. Water Quality

Makeup water is required in various conditions for the CCUS and BOP processes. Depending on system requirements, treated high-quality and raw water sources are available.

2.3. Flue Gas Estimation

Flue gas design conditions are included in Section 4.

3. CARBON CAPTURE SYSTEM

3.1. The carbon capture system for SJGS – Units 1 & 4, reduces carbon emissions from the flue gas via amine-based solvent which absorbs the CO_2. This application will use a proprietary amine-based system developed by MHI.

3.2. Amine-based CCUS systems consist of a quencher (or pre-scrubber), an absorber, and a stripper (or regenerator). Compression and dehydration are also included to produce CO_2 at pipeline requirements.

3.3. The CCUS island will be designed based on two equivalent trains of capture based on maximum equipment sizing and minimum turndown requirements.

3.4. Trains will be designed and arranged in a mirror fashion.

3.5. Two trains will allow for system turndown capacity based on flue gas availability or equipment maintenance.

3.5.1. Each train will be designed for approximately 50% of design flue gas flow.

3.6. Redundancy: Due to the CCUS system not being required to operate at full two-train capacity at all times, dedicated in-line spares and fully redundant equipment is not expected to be required for all equipment. However, redundancy of the flue gas blowers was increased from MHI's original design of 1x100% per train to 2 x 50% per train due to the fact that failure of one blower would automatically reduce the CCUS system capacity to 50% of design. In addition, a Reliability, Availability and Maintainability (RAM) analysis was conducted by MHI to determine which components were critical to the CCUS system. Based on this analysis, minimum sparing and redundancy was finalized within the CCUS system to the Owner's satisfaction.

3.7. CCUS island consumables storage will be designed by MHI.

3.8. The following BOP equipment/systems are required to support operation the CCUS:

3.8.1. Flue gas blowers (provided by MHI within the CCUS island)

3.8.2. Circulating cooling water and cooling system

3.8.3. Auxiliary power (high voltage)

3.8.4. Low-quality steam

3.8.5. Demineralized water

3.8.6. Instrument and plant air

3.8.7. Service water, including fire water, potable water, and utility water for hose stations

3.9. Waste products produced from the CCUS will be collected and treated by the BOP system scope, or sent to existing evaporation ponds.

3.10. The CCUS island will be located north of the existing Units 1 & 4. Flue gas from the Units downstream of the WFGD systems will be combined in a common ductwork path and routed to the CCUS island.

3.11. Performance Requirements

3.11.1. The CCUS compression and dehydration system will be designed to provide pipeline quality CO_2 based on the following requirements, to be confirmed once off-taker agreement is finalized:

a. CO_2 Purity: > 95 mol%

b. N_2 content: < 4 mol%

c. O_2 content: < 10 ppm by weight

d. Moisture content: < 30 lb/mmscf

e. Pressure: 2220 psig at the CO2 product pipeline tie-in (to be confirmed)

f. Temperature: < 120°F

3.11.2. Emissions:

a. The CCUS will be designed to reduce CO_2 emissions by 95%.

b. SO_2 emissions will be reduced by at least 50% in the caustic pre-scrubber.

c. VOC concentrations in the CO_2 absorber exhaust are expected to marginally increase and will be reviewed with a VOC BACT analysis.

d. PM concentrations through the CO_2 absorber exhaust are not expected to increase. However PM concentrations for the overall facility are expected to increase due to the cooling tower addition.

4. FLUE GAS DESIGN BASIS

4.1. This section documents inputs and results of the mass flow and other flue gas characteristics as input to the CCUS island at SJGS for Units 1 & 4.

4.2. The carbon capture island will be designed to treat 100% of the flue gas generated from the two units based on the following design conditions. Partial venting through the existing stack will be used if flue gas volume is higher than CCUS island design conditions. Operating scenarios where venting is expected are the following:

4.2.1. Minimal venting if flue gas volumetric flow at full load is greater than design, due to off-design or excursion conditions.

4.2.2. Partial venting if one of the trains of the CCUS system are out of service due to maintenance.

4.2.3. Full venting through the stack in the event the carbon capture island is offline.

4.3. The CCUS island will be designed for operation at full load for Units 1 & 4 and will include a nominal amount of margin based on annual average operating conditions.

4.3.1. A flue gas combustion calculation and mass balance were generated for each unit to determine flue gas volume and conditions at the existing stack breaching. The results will be used for flue gas path design basis. The results will also be used as input to MHI's design of the CCUS island, including the flue gas blowers.

4.3.2. Flue Gas Design Basis

a. Coal quality is expected to change as Westmoreland continues to expand the San Juan Mine. The ultimate analysis used for the design basis is based on a historic coal analysis that most closely matches future average heating values.

b. Full load for each unit is defined based on the design net power output for the facility.

c. Full load heat input is determined based on full load net unit heat rate defined by existing calculations from PNM, with additional margin. PNM calculations were based on annual average conditions. As such, 5% margin was added to the annual average to account for higher heat rate and heat input that would be expected for half of the year.

d. The "key inputs" for the flue gas determination at the tie-in points were determined based on historic plant PI data from 2019.

e. Full load flue gas information is developed based on the average of operating data from the highest 10% of load profile.

f. Emissions Stack Testing will be completed for a more accurate representation of the trace constituents required by MHI for the system design. A representative sample of coal will be used during the testing to confirm the WFGD performance and WFGD outlet conditions.

4.3.3. Two x 50% flue gas blowers per train will be used as the motive force to convey the flue gas to the carbon capture island and through the ductwork, quencher, and absorber. The flue gas blowers will be located at the CCUS island downstream of the quencher, therefore, flue gas will be under negative pressure at MHI's terminal point based on tie-in ductwork pressure drop.

a. The pressure drop along the ductwork is initially estimated to be 5 in. w.c.

b. The potential for temperature loss in the ductwork is possible during certain operating loads or ambient conditions. A case with 10°F temperature drop and resulting moisture drop out was analyzed

4.3.4. Based on the results from the Flue Gas Design Basis, the following values will be used as input to the design basis for the SJGS carbon capture island.

a. Emission Stack Testing (S-9800) is in the process of being procured to obtain more accurate representation of trace constituents.

Table 4-1 End Conditions

Parameter	Units	Unit 1 Full Load Design	Unit 4 Full Load Design
Temperature[1]	°F	127	127
Pressure[1]	in w.c.	-1	-1
Flue Gas Flowrate	scfm[2]	1,143,055	1,703,246
	lb/hr	5,000,147	7,457,942
N_2	vol-%	66.90	66.93
O_2	vol-%	6.14	5.87
H_2O[1]	vol-%	17.16	17.16
CO_2	vol-%	9.79	10.03
SO_2	ppmv	11	23
SO_3	ppmv	1.1	1.2
NOx	ppmv	102	109
NH_3	ppmvd	3.4	3.4 [3]

Hg	µg/dscm	0.117	0.051
PM	mg/dscf	0.192	0.104
Existing Stack Normal Flow - Expected Based on Design Conditions			
Parameter	**Units**	**Unit 1 Full Load Design**	**Unit 4 Full Load Design**
Flue Gas Flowrate	acfm	0	0
	lb/hr	0	0
CO_2 Island Inlet Conditions - Based on Design Conditions (Full Load Design - Combined Ductwork)			
Parameter	**Units**	**Conditions with Minimal Temp Loss [4]**	**Conditions with Moderate Temp Loss [5]**
Temperature	°F	127	110
Pressure [6]	in w.c.	-6	-6
Flue Gas Flowrate	scfm[2]	2,846,302	2,590,920
	lb/hr	12,458,089	11,662,124
N_2	vol-%	66.92	72.06
O_2	vol-%	5.98	6.18
H_2O	vol-%	17.16	10.83
Parameter	**Units**	**Conditions with Minimal Temp Loss [4]**	**Conditions with Moderate Temp Loss [5]**
CO_2	vol-%	9.93	10.91
SO_2	ppmv	18	20
SO_3	ppmv	1.2	1.3
NOx	ppmv	106	117
NH_3	ppmvd	3.4	3.4 [3]
Hg	µg/dscm	0.08	
PM	mg/dscf	0.139	

[1] Parameters per MHI request: Design temperature, pressure, & vol% moisture
[2] Standard conditions based on 68°F and 14.7psi
[3] Unit 1 test result used for Unit 4 for conservatism as Unit 4 results were very low
[4] Parameter per MHI request: Design temperature, pressure, & vol% moisture
[5] Parameter per MHI request: Minimum temperature, pressure, & vol% moisture
[6] Current design estimates 5 in w.c. pressure drop from WFGD outlet

5. FLUE GAS PATH AND FLUE GAS DUCTWORK

5.1. General

5.1.1. Installation of the CCUS facility will require new flue gas system ductwork and modifications of existing ductwork for Units 1 & 4. New ductwork will tie-in to the existing ductwork downstream of each units' existing WFGD absorber vessel and upstream of the existing stack.

5.1.2. To overcome pressure losses of the CCUS facility and the new ductwork, flue gas blowers provided by MHI will be installed downstream of the quenchers. Detailed design of the blowers will be in MHI's scope.

5.2. Ductwork

5.2.1. Flue gas will be routed from the tie-in point downstream of the existing WFGD absorber to the CCUS facility via new elevated, corrosion resistant ductwork.

5.2.2. New ductwork will be designed to operate at a flue gas velocity of approximately 75 feet per second at normal full load operating conditions. S&L in-house Computational Fluid Dynamics (CFD) modeling will be used to determine the optimal duct arrangements and turning vane configurations as needed to minimize pressure drop, and provide good flow mixing and distribution.

5.2.3. Design operating temperatures and pressures of the new ductwork will be considered to occur simultaneously. Excursion temperatures and pressures will be combined as dictated by the associated transient event. Excursion pressure will not be combined with any other environmental transient event (e.g. wind or seismic).

5.2.4. The flue gas blower additions may alter existing flue gas system operating pressures, as well as the magnitude of pressure excursions in the existing furnace and balance of plant ductwork system due to master fuel trips, control malfunctions or other transients. The effects of these changes to the boiler draft system will be evaluated.

5.2.5. If the new design operating pressure for the existing ductwork exceeds the original design pressure, then the ductwork will be reinforced as required.

5.2.6. If the new design transient pressures exceed the original design transient pressures of the existing furnace or balance of plant ductwork, then the associated implosion and explosion protection issues will be addressed. The modifications to the existing system components, the supporting structures, and the control systems will comply with the latest requirements of NFPA 85 - Boiler and Combustion Systems Hazards Codes – and other design considerations.

5.2.7. The following scenarios will be analyzed, as a minimum, for determination of any new design transient pressures for the flue gas system based on NFPA 85 compliant controls being in-place:

- Master fuel trip at full load
- Fan and master fuel trip at full load under normal operating temperature conditions
- Runaway ID fan under the following conditions:
    - Cold unit start at 40°F fan inlet temperature
    - Normal operation at low load and normal operating temperature
- Black station trip at full load at normal full load operating temperature
- Runaway flue gas blower
- CC System trip
- Flue gas blower trip

5.2.8. The following scenarios will be analyzed, as a minimum, for determination of design transient temperature:

- Single locked air heater rotor with continued unit operation at maximum achievable load
- Black station trip a minimum of 2 hours after the trip

5.2.9. Since the new ductwork will be located downstream of the WFGD system, the ductwork will be subjected to acidic, high moisture loading. Accordingly, the ductwork system materials of construction will be suitable for the conditions. Primarily the ductwork will consist of round FRP duct and carbon steel rectangular duct with internal Hastelloy (C276) cladding. In addition, the high moisture loading will require provisions for ductwork drainage.

5.2.10. Ductwork may be sloped for collection of condensation depending on feasibility and physical constraints. Due to the potentially long lengths of duct involved, alternating slope pitch between expansion joints to create local low points may be utilized.

5.3. Ductwork insulation

Since new ductwork will be installed downstream of the existing WFGDs, the flue gas temperature is not expected to exceed 140°F. In addition, the CCUS facility benefits from lower flue gas temperatures. Therefore, new ductwork insulation for personnel protection and/or heat retention is not required. However, a thermal loss calculation needs to be performed to determine the worst case heat

loss through the ductwork to understand how much condensate could be expected to fall out of the wet flue gas. Insulation may be desired to limit condensate formation and freezing based on this calculation.

5.4. Turning vanes

Turning vanes will be included in the ductwork to improve flow characteristics, reduce individual fitting pressure loss coefficients, facilitate mixing of flow streams, and aid flow distribution. The default loss coefficient improvement is 40%. Improved reductions may be assumed depending on CFD analysis results.

5.5. Dampers

5.5.1. Dampers are used to control and isolate flue gas flow in the ductwork and will be provided as follows:

- Isolation dampers located at tie-in to the existing ductwork.
- Modulating, opposed blade louver dampers will be located where the Unit 1 and Unit 4 flows combine into a header that supplies the flue gas blowers. In this case, it would be used for flow modulation for each individual unit.
- Parallel blade isolating dampers will be located upstream of each CCUS train inlet terminal point, just upstream MHI's quencher. These dampers are not required to be zero leakage. Modulation of flow through each train is accomplished by dampers located just upstream of the flue gas blowers and are provided by MHI.

5.5.1. Isolation dampers are expected to be provided between the new tie-in to the existing ductwork and upstream of the existing stack. CFD analysis will be performed to understand the interaction and flow characteristics of flow through the existing chimneys. The goal is to limit the amount of air drawn into the flue gas system to the CCUS system, while at the same time allowing for an open pathway of excess flue gas through the chimneys during load conditions above the CCUS maximum design limit or during existing boiler excursions. The type of dampers will be selected appropriately based on the analysis. S&L will also perform an NFPA 85 study to ensure adequate boiler protection is provided.

5.5.2. Since the new dampers will be located downstream of the WFGD absorber, selection of the damper materials and design features will consider the severe operating conditions due to slurry carry over, water and acid condensation, solids deposition, and an alternating wet/dry environment.

5.5.3. Dampers will be motor actuated and will be equipped with position feedback signals (either from the drive unit's integral position feedback or via a discrete transmitter) for remote monitoring of damper position at the DCS. Dampers will also be provided with full travel limit switches for remote monitoring at the DCS.

5.5.4. Dampers will be easily accessible from gallery and will be serviceable from outside the normal flue gas stream.

5.5.5. Seal air will be provided for the dampers per vendor requirements.

5.6. Expansion joints

5.6.1. Fabric expansion joints will be provided in the flue gas ductwork to allow for thermal expansion and movement of the ductwork without transmitting forces or moments to the in-line equipment or adjacent ductwork segments in the flue gas system.

5.6.2. Expansion joints will be provided as follows:

- At the branch duct tie-in to the existing ductwork and upstream of the new branch duct isolation damper.
- Upstream or downstream of each isolation/modulating damper
- At regular intervals along the duct run between the units and the CCUS system
- At the interface to the CCUS system

5.6.3. The expansion joints will be designed and constructed to operate as specified at design full load, 24 hours per day, 7 days per week, 365 days per year. All expansion joints will be designed and constructed for the specified thermal and non-thermal, as well as operating and excursion movements, inclusive of wind or seismic excursions, with the unit online or offline. Movements will be determined by S&L.

5.6.4. All expansion joint belts will be non-metallic belt type designed to eliminate load transfer across the joint, and to remain functional and leak tight during and after exposure to the specified excursion conditions.

5.6.5. Expansion joints frames and belt materials will be designed to accommodate drains.

6. MECHANICAL DESIGN CRITERIA

6.1. General

The design of the mechanical equipment and piping systems will be in accordance with S&L, industry and the plant's design standards and codes.

For CCUS island mechanical scope, design of mechanical equipment and piping will follow MHI standards and industry codes.

6.2. Piping

6.2.1. All piping systems outside of the CCUS island will be designed to ASME B31.1 unless otherwise noted. CO_2 piping within the plant will be designed to ASME B31.3. Fire Protection systems will be designed per NFPA, the insurance carrier, and AHJ requirements. Plumbing and sanitary piping will be designed per local code requirements.

6.2.2. Design Pressure and Temperature

The design pressure for piping systems designed by S&L will be the maximum sustained pressure during normal or transient conditions plus an additional 10%. The design pressure will be rounded off to the next higher 5 psi and will be no less than 50 psig.

In general, the design temperature of piping systems will be the maximum sustained temperature during normal operating or transient conditions plus an additional 10%. For steam systems, the design temperature of the piping will be the maximum sustained operating temperature plus a 25°F margin. The design temperature will be rounded up to the next 5° F.

Refer to MHI BEDD for basis of design pressures and temperatures for MHI piping systems.

6.2.3. Pipe velocities

Recommended maximum pipe velocities are shown in Table 6-1 below and will be used as the initial sizing basis for piping.

Table 6-1: Recommended Maximum Pipe Velocities

Fluid/System	Velocity
Superheated steam - minimum of 25°F superheat	20,000 fpm
Saturated steam greater than 25 psia (and superheated steam with less than 25°F superheat)	9,000 fpm

Fluid/System	Velocity
Low pressure wet steam (including saturated steam up to 25 psia)	7,500 fpm
Condensate	12 fps
Circulating water pipe (Concrete)	7 to 10 fps
Circulating water pipe (Steel)	8 to 14 fps
General service water pipe	10 fps
Compressed air & gases (header)	20 fps
Compressed air & gases (branch line)	20 to 100 fps
Gravity drains	4 fps

6.2.4. Buried Piping

a. Buried process piping will be installed below the frost depth of 4 feet. Fire protection will be buried below the frost depth of 5 feet per NFPA 24.

b. Underground process piping will be high-density polyethylene (HDPE) except where service conditions, fluid characteristics or other considerations dictate use of metallic or alternative non-metallic pipe materials. Non-metallic buried piping systems will have a tracer tape system installed. HDPE piping entering into or emerging from a structure will extend through the building substructure or foundation and will transition to metallic pipe materials inside the structure above the floor elevation. The transition for fire protection piping will be provided with suitable protection. Fire protection HDPE piping will be FM approved.

c. Large diameter circulating water piping will be prestressed concrete embedded cylinder pipe or mortar lined steel pipe.

6.2.5. Piping Design and Analysis

a. During detailed design, the following piping will be designed as follows:

b. All hot piping with a design temperature of 300˚F and above will be routed in the 3D model, analyzed and issued on piping isometric drawings

c. All cold piping (less than 300˚F design temperature) 1" and above will be routed in the 3D model and issued on piping isometric drawings. Cold piping less than 1" will be field routed by the installation contractor.

6.2.6. Pipe Materials

Table 6-2: Pipe Materials

System	Material Spec	
	Above Ground	Underground

System	Material Spec	
	Above Ground	Underground
Low Pressure Steam	ASTM A106 Gr. B (up to 24" NPS) ASTM A672, Gr. B60, Class 22 EFW (greater than 24" NPS)	N/A
High Pressure Steam	ASTM A335 Gr. P22 or P91	N/A
Condensate Return	ASTM A106 Gr. B	N/A
Circulating Water	ASTM A53 Gr. B ASTM A106 Gr. B ASTM A139 Gr. C	Prestressed concrete embedded cylinder ASTM A139 Gr. C (mortar lined) HDPE
Demineralized Water	ASTM A312 TP 304/304L	HDPE
Cooling Tower Makeup	ASTM A53 Gr. B ASTM A106 Gr. B	HDPE
Waste Water	ASTM A53 Gr. B ASTM A106 Gr. B	HDPE ASTM A106 Gr. B (for design temperatures at 140˚F or above)
Potable Water	ASTM A53 Gr. B (galv.) ASTM A106 Gr. B (galv) ASTM A312 TP 304/304L Copper CPVC	HDPE (NSF certified)
Fire Protection	ASTM A53 Gr. A or B ASTM A795 Gr. A or B	HDPE (FM) Cement lined ductile iron
Instrument Air	ASTM A312 TP 304/304L	ASTM A312 TP 304/304L
Service Air	ASTM A53 Gr. B ASTM A106 Gr. B	ASTM A53 Gr. B ASTM A106 Gr. B
Plant Drains	ASTM A53 Gr. B ASTM A106 Gr. B PVC	HDPE PVC ASTM A106 Gr. B (for design temperatures at 140˚F or above)

6.2.7. Pipe Heat Tracing and Insulation Criteria

a. Insulation thicknesses will be determined by S&L. Detailed design of the heat tracing system will be by the selected heat trace contractors per S&L and OEM requirements. Insulation will be mineral wool with aluminum lagging 0.16" thick. Insulation for valves, flanges, instruments, etc., will be removable to provide operations and maintenance access.

b. Outdoor water piping 6" diameter and below will be freeze protected (heat traced and insulated). Piping 8" diameter and above will be reviewed for freeze protection on a case by case basis.

c. A wind speed of 20 miles per hour (mph) will be used for heat tracing and insulation design calculations.

d. Surface temperature of pipes, equipment, ductwork, etc., accessible to personnel will be insulated to a maximum design surface temperature of 140 °F at the cooling dry bulb temperature. 0.4% occurrence with a coincident wind speed of zero (0) mph.

6.2.8. Vents and Drains

a. All systems will have high point vents and low point drains as required by the process and for hydrostatic testing as applicable. High point vents installed for hydrostatic testing will generally terminate at the outlet of vent valve with threaded nipple and cap. Water system drains and other low point drains provided for hydrostatic testing will generally terminate at the outlet of the drain valve with threaded nipple and cap.

b. High point vents and low point drains will be a minimum size of 3/4" for all piping 3/4" diameter and larger. Exceptions may include strainer blowoff piping or other drains which may match standard equipment component connection sizes.

c. High and low pressure steam system low points will consist of a drain pot sized per S&L standards. The high pressure steam system will be drained automatically with the use of pneumatically operated ball valves. The low pressure steam system will be drained automatically with pneumatically operated ball valves or steam traps. All steam traps will be installed per the manufacturer's instructions.

d. The discharge of vents and drains will be reviewed by S&L on a case by case basis to determine a safe means of venting and draining the pipe.

6.2.9. End Connections

End connections of piping and valves will be welded, with the exception of tanks, general service large bore valves, equipment, and vents/drains. Insulating flanges and dielectric unions will be used where connecting to dissimilar materials that would cause galvanic corrosion on a case by case basis.

6.2.10. Fittings

Changes in direction will be made by fittings instead of bending the pipe. Long radius elbows will normally be used. Short radius elbows will be limited to

special cases. Branches may be made using either tees, laterals or reinforced (Weld-o-let) nozzles, or reinforcement pads (for special cases).

6.2.11. Power piping and non-boiler external piping will be tested in accordance with ASME B31.1. Where a full hydrostatic test is not practical, Owner may accept an initial service test in accordance with B31.1, Article 137.7.

6.2.12. Pipe Supports

a. Pipe supports and accessories will be designed to resist project specific loads, current building code specified loads and loads identified in applicable codes and standards. Auxiliary steel will be hot dipped galvanized per ASTM A 123, A 153, A 354 and A 385, or painted with the same system used for structural steel. Support accessories including but not limited to; u-bolts, rods, clamps, etc., will be hot dipped galvanized.

b. Cold small bore supports will be designed by the piping installation contractor, utilizing S&L's typical details. Large bore supports and all hot system pipe supports will be detail designed by the pipe support vendor. The pipe support vendor will utilize conceptual 3D models and load tables (for hot systems) provided by S&L and will complete the detailed design.

c. Auxiliary steel for pipe support attachments should be incorporated into the building and utility rack structural steel supply as much as feasibly possible.

6.3. Valves

Valve Design Tables (VDTs) for each system will be referenced in the Piping Design Table (PDT) - generally matching the pipe material. Intermediate pressure class valves are not acceptable unless approved by Owner.

6.3.1. Isolation and Check Valves

a. For cold water piping systems, ball valves will typically be used for isolation of piping 3" diameter and under. Butterfly valves will typically be used for isolation of piping larger than 3" diameter. Gate valves are an acceptable alternative for isolation. Globe valves may also be used in either isolation or throttling service.

b. Check valves are used to automatically prevent flow reversal. Check valves located on pump discharges will be placed between the pump and the system block valve so the check valve may be serviced. Non-slam type check valves should be selected for pump discharge service to minimize water hammer upon a pump start/shutdown condition if there is any concern about water hammer.

c. Isolation Valves on the High Pressure Steam System:

Instrument sensing lines, pressure taps, vents, drains and similar branch connections on the high pressure, steam system will be provided with two manually operated isolation valves (i.e.; double block valves).

d. Steam System Drain Pots:

d.1. Drain pots on the high pressure steam system will be provided with two full ported ball valves upstream of the level controlled on-off drain valve. These isolation valves will be indicated on the P&IDs as being locked open.

d.2. Additionally, drain pots on the high pressure steam system will be provided with two full-ported ball valves on the cleanout line located at the bottom of the drain pot. One of the valves in the drain pot cleanout line will be indicated on the P&IDs as being locked closed. Screwed or welded caps will not be provided on the drain pot cleanout lines.

d.3. Drain pots on the low pressure steam system will be provided with a single full-ported ball valve (locked open) upstream of the level controlled on-off drain valve and a single full-ported ball valve (locked closed) in the drain pot cleanout line.

e. Isolation of Equipment and Critical Components:

In general, single block and bleed isolation will be implemented throughout. Double block and bleed will be considered for high energy (greater than ASME class 600 and/or greater than 800°F) / hazardous equipment and components that must be isolated and maintained while the system is still energized or on-line. This will be reviewed with the Owner on a case by case basis.

6.3.2. Control Valves

a. Control valves are used to regulate the flow, pressure, or temperature of fluid in a piping system. Control valves will be pneumatically actuated, operated with a diaphragm or cylinder operator.

b. Control valves will be sized with a flow coefficient (Cv) at normal operating conditions that is less than 85% of the maximum valve Cv. The range of operating conditions will be within 10-90% of the valve stroke. Sizing of control valves will be in accordance with ANSI/ISA-S 75.01.

c. All control valves will be provided with manual isolation capabilities. Bypasses for the control valves will be provided on a case by case basis as approved by Owner. Double block and bleed will be provided where recommended by equipment OEMs or requested by the Owner. All control valve accessories will be provided in an enclosure per the requirements in Section 9.

6.3.3. Relief Valves

a. Pressure relief valves protect systems from excessive overpressure by automatically opening upon a rise in system pressure, typically due to an excursion from the design conditions, and close promptly when pressure returns to normal levels. Capacity may be based on specific code requirements of ASME Section VIII, B31.1, and API 520. In general, relief valves are sized to protect in the case of a failure of an upstream component. All relief valve discharges will be routed away from personnel access areas.

b. For steam system safety relief valves, the vent stacks will be sized to pass the required relieving capacities and prevent blowback at the vent stack slip joint. Two separate methodologies, 1) ANSI/ASME B31.1 Non-Mandatory Appendix II and 2) Liao Methodology (ASME Paper No. 74-WA/PWR-3 July 31, 1974), will be employed in the vent stack sizing calculation. The more conservative result of the two methods will be used.

6.3.4. Valve Operators

a. Handwheels or lever actuators may be used for smaller valves that do not require excessive force to open.

b. Gear operators will be furnished for manually actuated valves to obtain mechanical advantage when opening forces with handwheels or levers are excessive and for manually actuated valves 8-in. size and larger. Handwheel rim pull for manually operated valves will generally not exceed 50 lb at the maximum operating torque requirement. This limit can be exceeded where the valve supplier recommends a higher force limit for valves in which the seating / unseating torque exceeds the running torque. In such cases, the handweel rim pull will not exceed 100 lbs.

c. Portable air motors may be used to operate valves for infrequently repositioned valves where gear operators are not practical.

d. Electric motors may be used for automatic operation of valves. Electric motors should not be used in applications where failure in last position is not acceptable (for example turbine water induction protection drain lines).

e. Pneumatic actuators may be applied where fast closing times or modulating service is required (e.g., control valves). Pneumatic valves may be specified to fail in place, fail opened, or fail closed, as required by the system.

f. Remote indication of valve position may be required. Limit switches or geared position switches may be used for valves that are normally fully opened, fully closed or opened to a predetermined intermediate position. Valves requiring full range position indication will be provided with position transmitters.

6.4. Mechanical Equipment

6.4.1. Pumps

a. Vertical turbine, centrifugal, wet pit pumps will be used for the circulating water pumps.

b. Horizontal, centrifugal, direct motor drive pumps will be used most general pump services.

c. Positive displacement metering pumps will be used for chemical injection when precise flow control is needed. Either piston type, rotary type, or diaphragm type pumps may be used.

d. Vertical line shaft sump cover mounted or submersible type pumps will be used for sump pump applications. Submersible sump pump will be supplied with a guide rail removal system. Sump pumps will be installed in a duplex arrangement complete with motor drives, level instruments, control panel, sensors and all accessories and appurtenances.

e. Water pumps may be furnished with packed stuffing box shaft seals or mechanical seals.

f. Positive displacement pumps should be furnished with packed stuffing box shaft seals.

g. Mechanical seals will not be dead-ended but will be provided with a suitable flushing plan per API Standard 682 (Pumps Shaft Sealing Systems for Centrifugal and Rotary Pumps) or Hydraulic Institute Standards.

h. Net Positive Suction Head (NPSH) available to pumps should be at least 25% greater than the manufacturer's NPSH requirements, based on 3% head loss.

6.4.2. Atmospheric Tanks

a. Atmospheric storage tanks will be sized for the appropriate storage time and constructed to the appropriate materials.

b. In general, atmospheric steel tanks storing water will be designed per API 650. Insulation and heat tracing for the tanks will be reviewed on a case by case basis depending on the total volume.

c. Chemical storage tanks will be located outdoors and located within containment sized per Section 7.14. Chemicals will be reviewed for compatibility and separate containments for chemical segregation provided as required.

d. The sulfuric acid storage tank will be designed and fabricated per ASME Section VIII, but not required to be code stamped. The tank will be constructed of carbon steel with an internal flakeline novolac epoxy coating and provided with a dri-breather connected to the tank vent. The overflow connection will also be

provided with a loop seal filled with mineral oil.

e. Flat-bottom fiberglass tanks will be provided for the sodium hypochlorite and bio-dispersant storage tanks. The tanks will be designed and constructed per ASTM D3299 and ASME RTP-1. Each of these tanks will be fabricated with an integral heat trace system to prevent freezing.

f. The scale/corrosion inhibitor storage tank will be a flat-bottom HDPE or fiberglass tank and will require heat tracing and insulation for freeze protection.

6.4.3. Pressurized Tanks and Equipment

Pressurized Tanks and Equipment will be designed and constructed in accordance with the requirements of ASME B&PV Code Section VIII.

6.4.4. CO_2 Pumps

Multistage, horizontal centrifugal pumps will be provided for the CO2 delivery system. These pumps will increase the pressure of the CO2 to within its supercritical zone. Dry gas mechanical seals (double seals in one cartridge) will be provided. A forced lubrication system will be provided for the pump bearings.

6.5. Mechanical Systems

6.5.1. Low Pressure Steam System

a. Low pressure steam will be supplied to the CCUS island from the existing steam turbine IP-LP crossover pipe via a new tie-in connection. This will be the source of steam during normal operation.

b. Maximum pressure and temperature will equal the maximum conditions from the crossover pipe as determined from the heat balances.

c. Steam piping will generally be sloped downward in the direction of flow to low point drains under cold and hot position. Each low point drain will consist of a steam trap, upstream strainer (can be integral to the steam trap), isolation valves and check valve if required. The drains will be routed to a flash tank or existing sump or tank as appropriate.

d. Warming lines will be provided as required at any dead legs to prevent condensate buildup and potential water hammer upon header valve operation. Warming lines will consist of a drain line with locked open ball valve and automated warming valve, which will be a pneumatically operated open/close ball valve. The warming line will be open during startup and will remain open until the low pressure header isolation valve is open to supply steam to the CCUS island.

e. Low point drains or warming lines near the power block will be routed back to the condenser. Spare connections capable of handling the design conditions of these drains will be utilized if available. Otherwise, new connections may be necessary. Condenser manufacturer drawings will be reviewed for appropriate locations.

f. Low point drains, warming lines near the CCUS island, and steam line drains within the CCUS island will be routed to a new flash tank. The flash tanks will vent the steam to atmosphere, while the condensate will be quenched and directed to a drain sump.

g. A steam conditioning valve will need to be provided at each unit to ensure proper steam conditions are provided to the CCUS island under all operating modes and to ensure proper steam flow balancing between the units due to the varying pressure drops. Steam flow from each unit will be measured on each unit's low pressure header, downstream of the conditioning valves.

h. Automated isolation valves will be provided on the low pressure steam supply from each unit to allow for automatic switchover to the low pressure steam source. These valves will be motor operated.

6.5.2. High Pressure Steam System

a. High pressure steam will be supplied to the CCUS island from a new tie-in connection off the existing main steam system during startup. Low pressure steam will not meet the required conditions at the CCUS island during startup.

b. Maximum pressure and temperature will equal the maximum conditions from the crossover pipe as determined from the heat balances.

c. Steam piping will generally be sloped downward in the direction of flow to low point drains under cold and hot position. Low point drains will consist of a locked open ball valve and automated drain valve, which will be a pneumatically operated open/close ball valve. The automated drain valve will normally be energized and closed but will automatically open upon high-water level in the drain pot as sensed by dual thermocouples or on signal failure. The drains will be routed to a flash tank.

d. Warming lines will be provided as required at any dead legs to prevent condensate buildup and potential water hammer upon header valve operation. Warming lines will consist of a drain line with locked open ball valve and automated warming valve, which will be a pneumatically operated open/close ball valve. The warming line will be equipped with thermocouples to sense temperature, and when temperature drops to within 25 deg F of saturation, the automated drain valve will open. The warming drains will be routed to a flash tank.

e. Low point drains or warming lines near the power block will be routed back to the condenser. Spare connections at the condenser or drain header capable of handling the design conditions of these drains will be utilized if available. Otherwise, new connections may be necessary. Condenser manufacturer drawings will be reviewed for appropriate locations.

f. A steam conditioning valve will be required at each unit to knock down the pressure and temperature of the main steam down to the low pressure steam conditions. Attemperation water will be supplied from the condensate system.

g. Automated isolation valves will be provided on the main steam supply from each unit to allow for automatic switchover to the low pressure steam source. These valves will be motor operated.

6.5.3. Condensate Return System

a. The steam supply to the CCUS island will be condensed in each of the reboilers. The condensed steam at each CCUS train will be collected into a tank and pumped back to the power island. The tanks and pumps are within MHI's scope. S&L will tie into the pump discharge headers and route piping back to the power island. The condensate header will be split to Unit 1 and 4 and returned to each of their respective feedwater cycles.

b. Maximum pressure and temperature will equal the maximum conditions as determined from the heat balances.

c. The condensate flow back to each unit should be controlled to closely equal the steam supply flow extracted from the corresponding unit.

6.5.4. Cooling Water (Circulating Water) System

a. The CCUS island requires a large amount of cooling. The original concept was to re-use the existing Unit 3 cooling tower and build a new supplemental cooling tower over the existing Unit 2 cooling tower basin (original Unit 2 cooling tower was previously demolished and removed)An evaluation of the existing Unit 3 cooling tower was performed to determine its design capacity based on the new CCUS island conditions, in addition to the condition assessment of the tower. Based on the CCUS Cooling Study completed by S&L, it was determined that modifications to the Unit 3 tower and work to build the supplemental cooling tower was not cost effective due to the poor condition of the Unit 3 tower and the extensive piping work to tie into the existing circulating water headers. Therefore, a new cooling tower, dedicated to the CCUS island, will be provided.

b. Large circulating water headers will be routed underground from the cooling tower to the CCUS island, where they will split to the various users and come above ground.

c. The individual cooling lines will require some amount of throttling in order to obtain the proper flow. Those valves are provided by MHI.

d. The return circulating water will also accept the pre-scrubber blowdown water from the CCUS island. This blowdown will help reduce the total makeup required to the system. The water quality of the pre-scrubber blowdown will impact the cycles of concentration that the cooling system can safely operate without detrimental effects on the cooling system materials.

e. Chemical treatment for the cooling water will be provided. The chemical feed system is described below.

6.5.5. Chemical Feed System

a. Circulating water chemical treatment is required to combat against biological growth, fouling and corrosion within the system. In discussion with the organization (Suez) managing the chemical treatment programs at San Juan, the chemicals described below were deemed necessary.

a.1. Sulfuric acid will be injected continuously to maintain a pH level of 7.5 (to be verified during detailed design) to help prevent formation of calcium carbonate. The acid will be pre-mixed with service water in a mixing trough located at the cooling tower basin. The sulfuric acid will be stored in a tank located outdoors within a containment.

a.2. Sodium hypochlorite (bleach) will be injected continuously to prevent biological growth in the system and on the cooling tower fill. The option for intermittent shock treatment will also be incorporated into the design. The bleach will be injected directly into the cooling tower basin through a diffuser pipe. The sodium hypochlorite will be stored in a tank located outdoors within a containment.

a.3. Scale/corrosion inhibitor will be injected continuously to prevent the formation of solute deposits and prevents corrosion within the circulating water system. The scale/corrosion inhibitor is a proprietary chemical blend provided by Suez and will be injected directly into the cooling tower basin through a diffuser pipe. The scale/corrosion inhibitor will be stored in a tank located outdoors within a containment.

a.4. Bio-dispersant will be injected continuously to break up microbials and improve biofilm control within the circulating water system. The addition of the bio-dispersant is recommended based on the use of plate and frame heat exchangers within the CCUS island. The bio-dispersant is a proprietary chemical blend provided by Suez and will be injected directly into the cooling tower basin through a diffuser pipe. The bio-dispersant will be stored in a tank located outdoors within a containment.

b. Steam/Condensate chemical treatment should be considered to minimize corrosion within the large carbon steel pipes that run between the power plant

and CCUS island. An amine injection system would be used for both Unit 1 and 4 to inject amine directly into the low pressure steam headers. The amine will be able to passivate the internal surface of the carbon steel and further prevent corrosion of the carbon steel pipe. This will limit the corrosion particles from being introduced into the main plant's power cycles. Amine would be supplied from portable totes to be located within a containment area.

c. Each chemical feed skid will consist of two 100% metering pumps with VFDs, pump isolation valves, check valves, relief valves, calibration column, and additional components as required.

6.5.6. Demineralized Water System

a. Demineralized water will be fed from the existing plant demineralized water treatment system. The tie-in location from the existing unit will be located at the Unit 4 Condensate Storage Tanks, located on the north side of Unit 4.

b. 2x100% Pumps located within a weather enclosure are provided to transfer water from the storage tank to the CCUS users.

c. A piping distribution system feeding each CCUS train is provided to serve MHI's users including H2 generation, pump seals and flush water.

6.5.7. Service Water System

a. The primary functions of the service water system will be to: 1) Provide the primary source of the CCUS Cooling tower makeup; 2) Supply quench water to the steam drains tanks and 3) Supply water to the water wash down stations located throughout the new Facility.

b. The supply of the service water system will come from tie-ins to the existing Raw Water System. The tie-ins will be off of the existing underground raw water header, located appropriately based on their destination to the cooling tower and CCUS terminal points.

c. A self-cleaning filter is provided to remove particulates from the raw water makeup supply to the cooling tower before entering the cooling tower basin.

6.5.8. Waste Water System

a. Several new sources of waste water will be produced and managed due to the new CCUS facility.

b. The majority of the CCUS cooling tower blowdown will be sent to the existing waste water treatment system (brine concentrators) via Process Pond 3. The existing brine concentrators can recycle this blowdown which can be reused as makeup to Unit 1 and 4. The balance of the cooling tower blowdown will be sent to a new waste water treatment system. Effluent from this new waste water

system will be sent back to the new CCUS cooling tower as makeup, which will help reduce the total fresh makeup water.

c. Waste Water Treatment System

c.1. The balance of the CCUS cooling tower blowdown exceeding the capacity of the existing brine concentrators will be collected in a new equalization tank located upstream of the treatment system. This will dampen the flow transients and provide for a consistent flow into the treatment system. Waste water forwarding pumps will pump the waste water to the inlet of the treatment system.

c.2. The waste water treatment system will be a high efficiency reverse osmosis (RO) treatment system. The primary system equipment includes: Reaction tanks, microfilters (MF), RO feed tank, RO feed pumps, RO units, recycle pumps, waste pumps, clean-in-place (CIP) tank, CIP pumps, permeate tank, chemical feed equipment, thickener, sludge pumps, filter press and controls. The treatment system includes 3 x 33% trains of MF and RO.

c.3. The reject from the waste water treatment system can not be further treated. Therefore, it will be collected and sent to the existing south evaporation ponds.

d. The waste water treatment building sump will contain two (2) x 100% sump pumps which will discharge the collected waste to the equalization tank for subsequent treatment in the waste water treatment system.

e. Each flash tank sump will contain two (2) x 100% sump pumps which will discharge the quenched steam condensate to Process Pond 3.

f. The collected oily waste will be treated in the new oil water separator. The effluent from the OWS will be pumped to the new CCUS cooling tower as makeup.

g. The CCUS system produces a small amount of waste from their CO_2 dehydration system. This waste consists of tri-ethylene glycol (TEG), which can't be treated. This waste will be collected and sent to the existing south evaporation ponds.

h. Flue gas duct drains will be collected and sent to the nearest waste sumps as appropriate. Drains near the units will be sent to sumps near the existing WFGD units. Drains near the CCUS island will be sent to waste sumps/tanks provided by MHI.

6.5.9. Potable Water System

a. Restroom facilities are required in the new Control Building which we be added as part of this project. All plumbing will be designed and installed in accordance with state and local code requirements.

b. Safety shower & eye wash (SSEW) stations per ANSI Z358.1 will be provided as required for chemical and other hazardous material areas. Most of these

locations are expected to be within MHI's CCUS island. MHI will provide the SSEWs for their equipment.

c. Tepid water temperatures per ANSI Z358.1 will be provided. This can be accomplished using local heaters at each station or a common heater.

d. Outdoor SSEWs will be freeze protected and associated outdoor potable water piping will be freeze protected. Outdoor piping downstream of the tepid water heaters will be provided with process heat tracing to ensure tepid water temperatures are maintained at all times.

e. The potable water supply to the new equipment will be supplied from the existing plant potable water system. Potable water from the existing system will be sent to a new potable water storage tank. A new set of 2 x 100% pumps and a bladder tank will be provided to supply a pressurized source of potable water to the CCUS users.

6.5.10. Fire Protection System

a. The fire protection and detection systems will be in accordance with NFPA and the Authority Having Jurisdiction (AHJ), as applicable. New areas will be protected by extending the existing fire protection underground yard piping system. The new hydrants will be located based on approximately 250' diameter coverage zones.

b. The fire alarm system will be addressable. All new local fire alarm panels will communicate back to the existing plant's main fire alarm control panel (MFACP) via a fiber optic network system compatible with the existing system. New fire alarm components and alarm panels will be of the same manufacturer as used throughout the existing facility.

c. Manual pull stations, fire alarm horns/strobes and fire alarm bells will be provided as required for all new buildings

d. Fire protection systems will be provided for the new areas as detailed below:

Table 6-3: Fire Protection Systems

Equipment, Area, or Building Protected	**Control Building** Control Room, Electrical Room, Telecom Room	**Control Building** Occupied areas	**Equipment Buildings**	**Power Distribution Centers (PDCs)**
Fire Protection Suppression System	Clean Agent Novec™ 1230 or FM 200	Wet-Pipe Sprinkler System	Wet-Pipe Sprinkler System	N/A
Fixed Suppression Actuation System	Actuate based on activation of second stage Smoke	Activation of one or more sprinklers	Activation of one or more sprinklers	N/A

	Detectors			
Detection System	Cross-Zone Smoke Detectors (including subfloor)	Smoke Detectors	N/A	Smoke Detectors
Design Density (gpm/ft^2)	Design Concentration (TBD)	0.10 gpm/ft^2	0.20 gpm/ft^2	N/A
System Area Coverage	Entire room including subfloor	Occupied administration and office areas, bathrooms, etc.	Entire building	Entire Building
Auxiliary Functions to be Provided	Shutdown HVAC system on activation of second smoke detector	N/A		Activation of any smoke detector will initiate a shutdown of the shelter HVAC system

6.5.11. Compressed Air System

a. Compressed air for the new equipment areas will be supplied from a new set of air compressors, dryers, and receivers. Instrument air and service air will be suppled as a common piping system, with stainless steel material used for the main headers and instrument air piping and carbon steel material used for the service air hose stations. Back-pressure regulators will be provided on the service air taps to automatically cut off the service air users when system pressure falls below an acceptable pressure for instrument air.

b. Instrument air piping will not be heat traced or insulated. Service air piping will be provided with periodic drains and heat traced as required.

c. Minimum pressure at end user will be designed to be 60 psig.

d. Air receivers will be located in remote areas, if required, to ensure adequate pressure is readily available.

6.5.12. Carbon Dioxide System

a. The CO_2 produced from the CCUS system will be routed offsite to a new pipeline header which will send the CO_2 to two destinations: the Cortez pipeline used for enhanced oil recovery (EOR); sequestration wells used for storage. The offsite pipeline will be designed and constructed by others.

b. The CO_2 will be boosted in pressure to meet the offsite requirements. MHI is

providing the CO_2 compressors which will boost pressure to approximately 1900 psig. Further compression will be required to meet the offsite tie-in pressure with the use of CO_2 pumps, supplied by S&L. Interconnect piping between the MHI CO_2 compressor discharge terminal point to the terminal point at the San Juan property boundary will be provided by S&L. Overpressure protection will be provided as required.

c. The CO2 pumps will be 4 x 25% capacity and VFD operated to allow for flexible operation when the CCUS system is at reduced capacity or equipment is offline for maintenance.

d. CO_2 pipe within the SJGS site will be designed to ASME B31.3.

6.5.13. Drains and Sumps

a. The chemical process buildings within the CCUS island will be provided with containments to collect any leakage from equipment/piping that spills on the floor. Floor drains will not be provided in these chemical containing buildings. Cleanup will need to be performed with vacuum trucks in these areas.

b. For building areas with oil containing equipment, such as CO2 compressors and CO2 pumps, oily-waste floor drains will be provided and sent to the new CCUS area oil water separator.

c. A sump will be located within the waste water treatment building for collection of trench drains and process drains generated from the waste water treatment system.

d. Piping systems will be provided with low point drains. Water will be drained back to sumps, trenches, floor drains or other Owner approved destinations.

e. New flash tanks near the steam conditioning valve area and each CCUS train will collect low pressure steam line drains, which will be quenched with service water. The flash tank drain is then routed to a new sump located adjacent to the tank which discharges to the waste water system.

f. Equipment drains within MHI's CCUS island will be collected with funnel drains tied into an underground piping system, provided by S&L. The underground piping will be connected to the MHI provided sump tanks to allow for the drains to be reused in the process.

g. Chemical tank overflows and drains will be routed to the containment area sump.

6.6. Heating, Ventilation and Air Conditioning (HVAC):

a. HVAC systems will maintain the indoor environmental conditions in terms of space temperature and humidity, air filtration, air quality, and enclosure pressurization in order to provide efficient equipment operation and comfortable working conditions for personnel.

b. General process equipment enclosures, maintenance shops and warehouses will be heated and ventilated. Heating will be by electric unit heaters. Ventilation will be by dual combination louver-dampers and induction fans.

c. The new control building, which consists of BOP electrical / DCS equipment room, control room, laboratory, IT room, offices, kitchen, lunchroom, bathrooms and locker rooms will be air conditioned and heated to maintain suitable operating temperatures as defined in Table 6-4. This building will be LEED certified (level to be determined later) and the HVAC system will be designed to meet the minimum efficiency requirements.

d. All VFD heating and cooling requirements and equipment are by the VFD vendor.

e. All electrical equipment rooms and the control room will be maintained at a positive pressure of 0.10" wg.

f. Design configuration, room temperatures for the various buildings and enclosures may be found in Table 6-4 below. Ambient conditions used in the sizing of the HVAC systems will be based on the site conditions included in Section 2. Detail design will be by the HVAC subcontractor.

Table 6-4: Indoor Design Conditions for HVAC Systems

Building	Rooms	Type	Min Temp	Max temp	Min RH	Max RH
Control Building	Control room	HVAC	68°F	78°F	20%	60%
Control Building	Electrical equipment / IT rooms,	HVAC	65°F	85°F	20%	60%
Control Building	Battery room (Note 2)	HVAC	77°F	77°F	20%	60%
Control Building	Office space, kitchen, bathrooms, lunchroom, locker rooms (Note 1)	HVAC	68°F	78°F	20%	60%
VFD Enclosures		HVAC	65°F	85°F	20%	60%
Miscellaneous Unoccupied Process Equipment Areas		H&V	60°F	104°F	---	---

Notes:
1. Dedicated ventilation fans will be provided as required for bathroom and kitchen areas
2. Two (2) by 100% ventilation fans dedicated to the battery room will be installed and will be powered from the emergency power system.

g. The heating and cooling required for each space will be calculated in accordance with the methodology described in the ASHRAE Fundamentals Handbook chapter for Nonresidential Heating and Cooling Load Calculation Procedures and

ASHRAE Standard 183.

h. The minimum amount of outdoor air for spaces served by HVAC systems will meet the requirements of the International Mechanical Code and ASHRAE 62.1.

i. Exhaust ventilation will be provided for areas required by the International Mechanical Code and ASHRAE 62.1.

j. The design of the HVAC systems and equipment will meet the applicable requirements of ASHRAE 90.1.

k. The design of the HVAC systems will meet the applicable requirements of NFPA 90A "Installation of Air Conditioning and Ventilating Systems."

l. Duct penetrations and air transfer openings in fire barriers will be protected with approved fire dampers installed in accordance with their listing as required by the International Mechanical Code and International Building Code.

m. Air distribution systems will be provided with smoke detectors listed and labeled for installation in air distribution systems as required by the International Mechanical Code.

n. Smoke control systems will be provided in accordance with the International Building Code and the International Mechanical Code where required by Chapter 4 of the International Building Code.

o. Smoke and heat vents will be provided where required by the fire risk evaluation. The smoke and heat vents will be designed in accordance with NFPA 204.

p. The heating, ventilating, and air conditioning system controls will meet the applicable requirements of ASHRAE 90.1 ASHRAE/ANSI 135 (BACnet).

6.7. Noise

a. Near Field: The maximum A-weighted sound level will not exceed 85 dB(A) under any normal operating condition when measured at any point three feet away from any piece of equipment in accordance with ANSI Standard S1.13. Equipment not meeting the sound requirements will be placed in an enclosure and acoustically insulated as necessary.

b. In the case that any new equipment cannot meet the sound requirements (even through use of an enclosure and/or acoustic insulation), plant personnel, when near this equipment, shall wear ear protection to reduce sound level.

c. Far Field: There are no known far field stipulations for this site. However, good engineering practice will be used to minimize the overall noise from the new facility such as using silencers on flash tank vents and relief valves. Additional sound mitigating facilities, such as sound walls or low noise fans, are not expected for this site.

7. CIVIL AND STRUCTURAL DESIGN CRITERIA

7.1. Wind loads and criteria will be in accordance with the requirements of the 2015 New Mexico Commercial Building Code, International Building Code 2015 Edition with New Mexico Provisions, which also references ASCE 7-10. Wind design criteria are as follows:

Ultimate Design Wind Speed, V_{ult}	120 mph
Nominal Design Wind Speed, V_{asd}	93 mph
Wind Exposure Category	C
Wind Risk Category	III

7.2. Seismic loads will be determined in accordance with the requirements of the 2015 New Mexico Commercial Building Code, International Building Code 2015 Edition with New Mexico Provisions, which also references ASCE 7-10 for seismic load determination. The seismic design criteria are as follows:

Occupancy Category	III
Seismic Importance Factor	1.25
Spectral Acceleration, Mapped for 0.2 Sec, S_S	0.131g
Spectral Acceleration, Mapped for 1 Sec, S_1	0.049g
Site Class	D
Seismic Design Category	B

7.2.1. Snowfall: Snow loads will be determined in accordance with the 2015 New Mexico Commercial Building Code, International Building Code 2015 Edition with New Mexico Provisions, based on a ground snow load at San Juan Generating Station of 10 psf and an Importance Factor of 1.1 for snow loads and

an Occupancy Category III classification.

7.3. Rainfall: The rainfall design basis may vary for the different systems and system components. Precipitation amounts to be used for sizing the containment areas will be 2.0". This value represents a 24 hour, 25 year occurrence rainfall as given by the NOAA Atlas 14 Hydro meteorological Design Studies Center (Precipitation Frequency Data Server). Other precipitation design values for the systems described below have also be taken from this source document.

7.4. Temperature: Systems and system component design criteria which require ambient temperature extremes will use the temperatures located in Section 2.1.1.

7.5. Relative Humidity: The average annual relative humidity is 53 percent.

7.6. Barometric Pressure: The standard barometric pressure is 24.44 inches HgA based on a site elevation of 5,308 feet above mean sea level.

7.6.1. Groundwater Table: From existing soil borings, the estimated groundwater level approximately 21 feet below grade. Given the anticipated foundation depths large amounts of groundwater seepage into excavations are not anticipated.

7.7. Frost Depth: Foundations will be founded a minimum of four feet (4') below finish grade to protect against frost heave.

For minimum freeze protection requirements for piping systems, see Paragraph 6.2.4, Buried Piping.

7.8. Structural steel will be designed to resist vertical and horizontal loads, including dead, live, wind, seismic, pressure, temperature and equipment loads as applicable and as required by the Building Code.

7.9. Building Code Information

The following building codes will be followed in the design:

Governing Building Code (2015 New Mexico Commercial Building Code)	IBC 2015 w/ NM modifications
Ductwork and Ductwork Support Structure Classification (Per IBC 2015)	Non-Building or Other Structures
Occupancy (IBC 2015)	Factory Industrial F1-Moderate Hazard
Life Safety Code (Per IBC 2015)	NFPA 101

OSHA Safety Standards	OSHA 29 CFR 1910
NFPA 850, "Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations"	For power plant facilities

a. Buildings and structures will be considered not occupied for the purpose of determining egress and fire protection requirements and so forth, with the exception of the control room and other such areas of the site where plant personnel are typically present.

b. The general construction classification will be Type II, non-combustible unprotected steel construction.

7.10. Site Grading

The high point of finished surface (HPFS) elevation in the vicinity of new equipment will be at a nominal elevation of 5,350 feet [to be verified by topographic mapping]. Finished grade will be sloped away from the equipment and access roadways to adjacent storm drainage structures or trapezoidal ditches.

7.11. Bench Marks

a. The horizontal control is based on the New Mexico State Plane Coordinate System, West Zone (NAD 27).

b. The vertical control is based on local Plant Datum (Elevation 100.00 feet = Elevation 5,308.00 feet above sea level).

7.12. Storm Water Drainage System

The project will utilize the existing storm water system to drain storm water from proposed developed areas not subject to contamination from equipment oil and chemical spills. Examples of areas drained to the ditches are equipment areas, building roofs, roadways, and parking areas.

Surface drainage systems will be sized to discharge the 10-year runoff while maintaining water levels in a storm drain system without ponding or surcharging above the rim elevation of storm water drainage structures, and maintaining water levels in ditches while providing a minimum of 1 foot of freeboard to the top of the ditch. The storm drainage system will be checked for a 50-year event to ensure that there is no flooding of roads or plant facility equipment.

Temporary and permanent erosion and sediment control measures will be designed to preserve the existing and new site drainage patterns and promote the protection of groundwater and surface water. These protection measures will be in accordance with all applicable regulations.

7.13. Roadways and Surfacing

All roads will be asphalt paved unless otherwise specified. Minimum lane width will be 12 feet, and the width may be increased to accommodate truck turns and two way traffic.

Road pavements will be designed for AASHTO HS-20 truckloads and the thickness will be based on soil conditions and other local conditions as recommended in the geotechnical report. Design life of pavement structures will be 20 years.

The roadway system will be designed in accordance with "A Policy on Geometric Highway Design of Highways and Streets," latest edition, published by AASHTO.

Clearance requirements over roads will be 18 vertical feet from the high point of the road to the bottom of the lowest overhead obstruction.

7.14. Containment and Unloading for Chemicals and Hydrocarbons

a. Tank compounds for chemical and oil storage will be protected from leaks and spills by a reinforced concrete containment area. The containment area will be sized to contain the volume of the single largest tank, plus a minimum volume of a 25-year, 24-hour rainfall. The containment areas will have a normally closed valved outlet pipe that discharges to the nearest storm water drain facility. Collected water will be inspected by Owner for contamination prior to discharge to the storm water system. Any contaminated liquid will be transferred to a collection truck for offsite treatment.

b. Truck unloading areas for chemical and oil storage tanks will be protected from leaks and spills by a reinforced concrete containment area. The containment area will be sized to contain the volume of the single largest truck plus a minimum volume of a 25-year, 24-hour rainfall. The truck unloading containment areas will have a normally closed valved outlet pipe that discharges to the nearest storm water drain facility or to the Urea tank containment area. Collected water will be inspected by Owner for contamination prior to discharge to the storm water system. Any contaminated liquid will be transferred to a collection truck for offsite treatment.

7.15. Geotechnical Criteria

7.15.1. General Description of Subsurface Conditions

a. The general soil profiles in the proposed CCUS site may consist of an overburden of sand, silty sand, clayey sand, with silt and clay trace gravel, transitioning to interbedded highly weathered silt stone, sandstone and shale with soil seams, which are underlain by the massive sandstone bedrock. The top of competent sandstone bedrock elevations vary across the site and could be up to 25' in difference (depth) depending on the location.

b. The groundwater table varies generally from El. 5,273 feet to El. 5,287 feet (to be verified with a subsurface geotechnical investigation)

c. The detailed and site specific subsurface conditions are pending for future new geotechnical investigation.

7.15.2. Excavation Criteria

a. The final grade of the new project should be close to the existing plant grade. All temporary excavations will conform to "29 CFR, Part 1926 (OSHA) Subpart P – Excavations" and any existing local code requirements. After excavating to the foundation base level, the exposed subgrade will be inspected, proofrolled, and tested prior to construction of foundations. In some areas of the proposed new foundations, existing fill contains construction debris (metal wires, concrete, insulation, plastic, paper, chemicals, etc.) and other deleterious materials. All these foreign materials and soft unsuitable soils will be removed and replaced with approved engineered fill.

b. If pockets of loose material or soft cohesive soils are encountered in the bottom of these excavations, additional excavation to remove these unacceptable materials will be performed. The subgrade at the bottom of the excavation will be proofrolled or recompacted to ensure that it is compacted to a minimum dry density of 95% per ASTM D1557.

7.15.3. Backfill Criteria

a. On-site materials free of organic matter and debris, consisting of granular or low-plasticity cohesive soils, can be used as both general backfill and structural fill. Fill soils should contain less than 1 % organic deleterious materials. Low-plasticity cohesive soils should have a Liquid Limit less than or equal to 40 and Plasticity Index less than or equal to 25. Inclusions of high-plasticity soils should be removed from the fill material prior to placement and compaction. All proposed fill soils will be tested and approved prior to construction. Follow detailed requirements in the project "Earthwork" specification.

7.15.4. Compaction Criteria

a. Structural fill soil will be compacted to a minimum of 95 percent of maximum dry density as determined by ASTM D1557 (Modified Proctor Test). General fill will be compacted to a minimum of 90 percent of maximum dry density as determined by ASTM D1557 (Modified Proctor Test).

b. Suitable on-site lean clay, sandy clay, silty sand and clayey sand soils used as structural fill under foundations will be compacted within a moisture content range of 2 percent below to 2 percent above the optimum moisture content as determined by ASTM D1557. When clean granular materials are used as fill, the moisture content of the compacted material should not be used as a sole

criterion for acceptance/rejection of the fill.

c. Cohesive general fill will be compacted within a moisture content range of 3 percent below to 3 percent above the optimum moisture content as determined by ASTM D1557.

7.15.5. Foundation Types & Design Parameters

a. Lightly loaded structures and equipment can be supported by shallow foundations, including mat foundations, spread footings, strip footings or slabs-on-grade. Heavily loaded and settlement-sensitive structures and equipment should be founded on deep foundations, socketed into the competent sandstone bedrock, which can provide sufficient compression and uplift capacities and can limit the potential settlement. For existing structures, both drilled piers of varying sizes and lengths and micropiles were used. Micropiles were used in the recent plant retrofit projects where only limited headroom was available for pile installation.

b. Shallow foundation embedment will satisfy the frost protection requirements as described in Section 7.7.

c. Design Parameters - Shallow Foundations

Note: Shallow foundation recommendations with design parameters for the table below will be provided later, and based on the findings from future site-specific geotechnical investigation.

Area **(boring locations in Ref. 1)**	**Foundation Type & Size**	**Allowable Bearing Pressure (psf)**	**Subgrade Modulus (pci)**

Notes:
- Allowable bearing pressures for large foundations will be based on a permitted total average settlement of 1.0 inch.
- Minimum foundation embedment will satisfy frost protection requirement = 4'.
- When transient loads (wind, earthquake) are included, allowable bearing pressure may be increased by one-third.

d. Settlement Criteria

Unless other more stringent settlement and differential settlement criteria is provided by equipment vendors and/or S&L design engineers, foundations will be designed to limit the total average settlement to 1 inch. Differential settlement will be limited to approximately ½ of the total settlement.

7.15.6. Other Soil Design Parameters

a. Lateral Earth Pressures [to be verified per future site-specific soil data]

The static lateral earth pressures for all foundations (including retaining walls) will be calculated using the following soil parameters considering compacted backfill:

Average In-situ Soil Unit Weight = 120 pcf

Recompacted Soil Unit Weight = 125 pcf

Earth Pressure Coefficients:

Granular soils (sands), $\phi = 30^{\circ}$ Ka (Active) = 0.33

Kp (Passive) = 3.0

Ko (at rest) = 0.5

Cohesive soils (clays), $\phi = 22^{\circ}$ (long-term effect)

Ka (Active) = 0.45

Kp (Passive) = 2.2

Ko (at rest) = 0.63

b. Coefficient of Soil/Concrete Friction for shallow foundations

For fine sands = 0.40

For clay = 0.30

In calculating passive resistance, disregard the upper 2 feet of soil.

7.15.7. Dynamic Soil Properties

Based on the field seismic survey results and geotechnical investigation data for the Unit 4 ID Fan foundation area, the dynamic geotechnical parameters are [when the fan foundation and other vibrating equipment are located in the CCUS site, the following dynamic parameters may not be correct and will be verified]:

Depth* (ft)	**Soil/Rock Type**	**Vs** (ft/s)	**Total Unit Wt.** (pcf)	**Poisson's Ratio**
0 – 10	Silty Sand and Gravel	800 - 2500	115 – 125	0.33
10 – 35	Interbedded weathered Sandstone, shale, claystone,	1000 – 2500	125 – 135	0.3 – 0.45

	clay layers			
35 – 60	Weathered Sandstone with shale seams	1500 – 3500	130 – 140	0.3 – 0.4
60 – 85	Sandstone bedrock	2500 – 4000	140	0.3 – 0.4
85 – 100	Sandstone bedrock	3000 – 4500	140	0.3 – 0.4

* Depth below existing ground surface.

The groundwater level varies from approximately 15' to 22' below grade depending on the time of the year.

7.15.8. Slope Stability

All safety standards presented in OSHA 29 CFR Part 1926, Subpart P will be followed for all excavations. Also, the actual site conditions will be reviewed by the on-site engineer, and the appropriate slope configuration will be determined by the engineer as required.

All permanent slopes, both excavated and compacted fill, will be designed to meet the following minimum factors of safety:

End of Construction - 1.3

Long Term Stability - 1.5

Seismic Stability (pseudo static case) - 1.1

However, the permanent earth slopes will not be steeper than 2H:1V under any circumstances.

7.15.9. Geotechnical References

The following documents were used as the source of the geotechnical design criteria:

Ref. 1 – Terracon, "Geotechnical Engineering Report, Regional Haze Reduction, San Juan Generating Station, PNM Geotechnical Investigation Specification N-3610", dated March 15, 2014.

Ref. 2 – GEOMAT Soil Investigation, "PNM San Juan Generating Station, Baghouse Project – Units 1-4", March 16, 2006.

Ref. 3 – Acres International Ltd., for Babcock & Wilcox, "San Juan Generating Station FGD System Modifications, Site Investigations and Evaluation of Foundations", July 1996

Ref. 4 – Woodward-Clyde & Associates, "Soil Engineering and Geologic Investigations for San Juan Power Station Near Fruitland, New Mexico", dated March 31, 1970.

7.16. Structural Steel Framing and Flue Gas Ductwork:

a. All structural steel work will conform to the American Institute of Steel Construction (AISC) Specification for Structural Steel Buildings the AISC Code of Standard Practice.

b. All structural steel will be designed to resist vertical and horizontal loads, including dead, live, wind, seismic, pressure, temperature and equipment loads as applicable and as required by the International Building Code and industry standards.

c. Flue gas ductwork design will consider the effects of internal pressure loads on ductwork design, expansion and contraction of the flue gas ductwork due to temperature changes, and reduced material properties at elevated temperatures.

d. Framing for motor removal of the south Unit 4 ID Fan motor (Fan "N") will be designed to include impact, lateral and longitudinal loads associated with the trolley system as well as the vertical loads, as required by the AISC Specification and S&L guidelines.

e. Framing System: Structural steel, tubing, plate, bar stock, and bolt materials will be as listed in Table 7-16.

f. Welding will conform to AWS D1.1.

Table 7-16. Structural Steel Framing Materials

Parameter		
Structural Steel		
Yield strength, new steel unless noted (ASTM A572 Grade 50 or ASTM A992)	ksi	50
Yield strength, new steel, angles and channels (ASTM A36)	ksi	36
Yield strength, new steel, round HSS sections (ASTM A500 Gr. B)	ksi	42
Yield strength, new steel, rectangular HSS sections (ASTM A500 Gr. B)	ksi	46
Yield strength, new and existing steel, pipe sections (ASTM A53 Gr. B)	ksi	35
Yield strength, existing steel (ASTM A36)	ksi	36
High strength bolts (slip critical)	-	7/8" Dia -A325

Parameter		
Welding electrodes	-	E70
Welded steel bar grating, 3/16" bearing bars at 1-3/16" c.c.		
Finish	-	Galvanized
Surface	-	Interior - Plain; Exterior- Serrated
Nominal depth	in	1 1/4
Self weight - 1-1/4" grating	psf	9

7.17. Concrete:

a. All concrete will be designed in accordance with the requirements of ACI 318-14.

b. All concrete will be designed to resist vertical and horizontal loads, including dead, live, wind, seismic, pressure, temperature and equipment loads as applicable and as required by the International Building Code.

c. Concrete materials will be as listed in Table 7-17.

Table 7-17. Foundation Material

Parameter		
Foundations		
Concrete strength at 28 days	psi	5,000
Reinforcing steel yield strength (ASTM A615, Grade 60)	ksi	60
Welded wire reinforcement minimum yield strength (ASTM A496 deformed or A185 plain)	ksi	60

7.18. Live Loads:

a. Grade floors, 350 psf.

b.	Elevated concrete floors,	200 psf.
c.	Electrical Equipment Rooms,	200 psf.
d.	Access Gallery,	75 psf.
e.	Stairs,	100 psf.
f.	Minimum roof,	20 psf.
g.	Soil Surcharge – Normal Load Case,	500 psf.
h.	Soil Surcharge – Construction Load Case,	1000 psf.
i.	Dust load on floor of flue gas duct	270 psf
j.	upstream of fabric filters (3 ft of ash)	
k.	Dust load on floor of flue gas duct between fabric filter and FGD system (1 ft of ash)	90 psf
l.	Sludge load on floor of flue gas duct downstream of FGD system (1 ft of sludge)	125 psf
m.	Forklift loads,	By rated capacity.

7.19. Material Densities:

a.	Steel,	490 pcf.
b.	Structural concrete,	150 pcf.
c.	Plain concrete,	145 pcf.
d.	Fly ash,	90 pcf.
e.	Fly ash, volume calculations,	45 pcf.
f.	Urea 50% solution containment calculations	71 pcf

8. ELECTRICAL SYSTEM DESIGN CRITERIA

8.1. General

8.1.1. The CCUS system will incorporate various pumps and fans with motors as well as large CO_2 compressors. As such, the facility will consume a significant amount of power on a continuous basis, approximately 100 MW (preliminary TBD). The flue gas blowers and cooling tower systems require an additional 30 MW of auxiliary power (preliminary TBD). A new auxiliary power system will be designed to supply the required loads at various voltages, depending on the equipment requirements.

8.1.2. The new CCUS system will be powered from two (2) new Unit Auxiliary Transformers (UATs), one (1) from the Unit 1 generator bus and one (1) from the Unit 4 generator bus. This will require tapping into the existing Isolated Phase Bus Ducts (IPBDs) for the respective Units.

8.2. Auxiliary Power System

8.2.1. The auxiliary power distribution system will provide 13.8kV and 4.16kV for medium voltage and 480V for low voltage to provide the most efficient and economic design.

8.3. System Design

8.3.1. Reliability of the electrical system is extremely important. The electrical system will be designed with redundancy at the medium voltage level in order to ensure the CO2 capture plant can be powered under loss of power from one of the main transformers or units such that no single failure will cause a loss of complete power. Each main power transformer is sized to supply power to the entire system, they are 100% redundant. At the low voltage levels, the electrical redundancy will follow suite with the redundancy of the process loads (i.e. for one set of process equipment there will be one MCC but if there are an 'A' and 'B' train, there will be an 'A' and 'B' MCC, etc.).

8.3.2. During all operating conditions and with all normal electrical power distribution equipment in service (e.g., no tie breakers closed) other than during the starting of large motors, the voltage at motor terminals will be maintained between 95% and 105% of motor rated voltage. The voltage at the motor terminals of a large motor being started with the system operating at full load, will not be less than 80% of motor voltage.

8.4. Auxiliary Bus Capabilities

8.4.1. The load carrying capability of an auxiliary bus is primarily determined by the switchgear ratings. Other parameters that can influence bus capability are the impedance and voltage variation of the high voltage supply to the bus, the size of

the largest motor connected to the bus, and the type of bus load. The ETAP computer program will be used for the analysis of Electrical Auxiliary Systems to optimize auxiliary transformer impedances and bus capabilities, and the generally analyze bus capabilities under various conditions.

8.5. System Protection

8.5.1. Multi-function microprocessor relays will be provided with associated lockout relays and test switches. Lockout relays are provided to trip the appropriate circuit breakers and mechanical equipment under a fault condition. Each of the multi-function relays will have its own set of lockout relays in order to achieve redundancy in tripping functions. The number of lockout relays used in a set will depend on the final tripping logic adopted.

8.5.2. Protective relays for transformers and bus protection will be housed in protective relay panels. Protective relays for medium voltage and low voltage loads will be housed in the associated switchgear.

8.6. Electrical Enclosures

8.6.1. Electrical enclosures located indoors will be NEMA 12 rated.

8.6.2. Electrical enclosures located outdoors will be NEMA 4X, stainless steel rated.

8.7. Main Power Transformer (MPT)

8.7.1. The transformer will be used for step-down service to connect the plant turbine-generator bus to the CCUS system auxiliary power system.

8.7.2. The transformer will be three -phase, two winding, 60 Hz, outdoor, step down, oil-immersed type.

8.7.3. The transformer will have the following ratings: TBD later, pending auxiliary power study.

8.7.4. The high side of the transformer will use isolated phase bus duct to connect to the plant generator bus.

8.7.5. Cable bus will be used on the secondary side of the transformer to connect the transformer to the switchgear.

8.8. Isolated Phase Bus Duct (IPBD)

8.8.1. The isolated phase bus duct system will consist of rigid electrical conductors mounted on insulators. Each phase will be enclosed in a separate weather and dust-tight nonmagnetic metal enclosure, separated by an air space from the adjacent phases. The three-phase assembly will be securely braced, mounted on

and supported by a metal structure. Where taps are specified from the bus to cubicles housing auxiliary equipment, the tap connections and cubicles will be of the isolated phase construction.

8.8.2. The isolated phase bus duct will be used to connect the UAT to the plant turbine-generator bus.

8.8.3. All bus conductors and connections, insulators, supports, enclosures and supporting structures, when installed, will have sufficient mechanical strength to ensure continuous, satisfactory operation under normal operating conditions and will withstand, without incurring damage, the effect of any momentary current resulting from a three-phase, line-to-line or line-to-ground short circuit. The rated momentary withstand current will be the rms asymmetrical currents specified.

8.8.4. Technical Data Table: TBD later, pending auxiliary power study.

8.8.5. The isolated phase bus duct will be a self-cooled design.

8.8.6. All bus conductors will be of high conductivity aluminum and designed for welded construction.

8.8.7. All bus conductors, when installed in their housings, will have a cross-sectional area to carry rated current continuously with a temperature rise not to exceed the values specified. All bolted connections will be tinned, or silver plated and supplied with NO-OX-ID grease. Field welded joints will be properly prepared in the factory.

8.8.8. The bus enclosure will be electrically continuous over the entire length and will function as a ground bus. The three-phase assembly will be electrically short circuited at all equipment terminations. Shorting plates will have NEMA two-hole ground pads for connection to the ground grid.

8.8.9. Thermostatically controlled space heaters will be supplied to prevent condensation in the isolated phase bus when the unit is out of service.

8.8.10. Space heaters will be rated 240 VAC for operation on single phase 120 VAC circuit.

8.9. Cable Bus

8.9.1. The cable bus will be used to connect the secondary side of the transformer to the switchgear

8.9.2. The cable bus will have the following ratings: TBD later, pending auxiliary power study.

8.9.3. The cable bus will be suitable for indoor and outdoor installation.

8.9.4. Conductors will be rated 105 ºC, fully insulated and shielded power cables. Conductor ampacities will be based on full-load application, with consideration given to site conditions and the effects of solar radiation. The temperature rise of the conductor carrying continuous current will not exceed 50C rise over 40C ambient. Conductors will be suitable for indoor or outdoor use.

8.9.5. Individual conductors will be supported on cable support blocks. The blocks will be molded glass reinforced polyester (fiberglass) or approved equal. Block sections will be bolted together with stainless steel, non-magnetic bolts and held firmly in place to prevent movement during short circuit. Properties of the support blocks will be flame-retardant, track-resistant, and non-hygroscopic.

8.9.6. The bus enclosure will be made of extruded aluminum with top removable covers.

8.10. Medium Voltage Switchgear

8.10.1. The medium voltage switchgear will supply auxiliary power to loads greater than 250HP.

8.10.2. Switchgear will be designed as defined in ANSI C37.20.2, and derating factors for unusual service conditions (i.e., altitude) will apply in accordance with this standard.

8.10.3. Each medium voltage switchgear will be designed for operation under the following service conditions and ratings: TBD later, pending auxiliary power study.

8.10.4. Indoor, Type 2B, arc-resistant, NEMA 1 gasketed, metal-clad switchgear and assemblies will conform to the requirements of IEEE C37.20.2, IEEE C37.20.7, NEMA ICS 3, NEMA SG4 and SG5. Circuit breakers will have ratings per ANSI C37.06 and conform to ANSI C37.04 rating structure. Protective relays will conform to ANSI C37.90 and indicating instruments to ANSI 39.1.

8.10.5. Medium voltage switchgear will comprise of one or more arc-resistant vertical sections mounted side by side and connected mechanically and electrically together to form a rigid, self-supporting structure. Each vertical section will consist of separate compartments where all live parts are completely enclosed within grounded metal barriers. In addition, opening of the door of the control compartment will not defeat the arc resistant feature of the switchgear. The arc event will not enter the switchgear control compartment. The arc event will be exhausted through a plenum to a designated protected outdoor area.

8.10.6. The switchgear will consist of electrically operated, draw out vacuum type circuit

breakers installed two high, with necessary buses, and associated equipment as specified, installed and connected in the factory, in a self-supporting arc-resistant steel enclosure.

8.10.7. The switchgear lineups will be configured in "double-ended" main-tie-main configuration at the main busses where redundancy is required and in "single-ended" configuration where redundancy is not required.

8.10.8. An automatic transfer relay will be installed in the switchgear to transfer sources under a loss of power and/or trip conditions.

8.11. Low Voltage Transformers

8.11.1. The low voltage transformers will step down auxiliary power from medium voltage switchgear to the low voltage 480V switchgear.

8.11.2. The transformers will be three -phase, two winding, 60 Hz, outdoor, step down, dry type.

8.11.3. The transformers will have the following ratings: TBD later, pending auxiliary power study.

8.11.4. Cable will be used to connect the high side and secondary side of the transformers to the switchgears.

8.12. Low Voltage Switchgear

8.12.1. The low voltage switchgear will supply auxiliary power to loads greater than 100HP and up to and including 250HP.

8.12.2. The low voltage switchgear will be designed for operation under the following service conditions and ratings: TBD later, pending auxiliary power study.

8.12.3. Switchgear assemblies will be supplied in accordance with the requirements of ANSI/IEEE Standard C37.20.1 and C37.20.7 for arc-resistant type.

8.12.4. Each low voltage switchgear will consist of one or more vertical sections bolted together to form a rigid, free standing, ventilated, indoor, Type 2B, arc-resistant, NEMA 1 gasketed enclosure assembly. Enclosure will meet all the requirements of ANSI C37.20.1. The arc event will be exhausted through a plenum to a designated protected outdoor area.

8.12.5. The circuit breaker interrupting device will be of the air magnetic type. Circuit breakers will be draw-out, three-pole, 60 Hz, 600 V class and will be rated on a symmetrical basis in accordance with ANSI/IEEE Standard C37.13. They will be electrically operated.

8.12.6. The switchgear lineups will be configured in "double-ended" main-tie-main configuration at the main busses where redundancy is required and in "single-ended" configuration where redundancy is not required.

8.12.7. An automatic transfer relay will be installed in the switchgear to transfer sources under a loss of power and/or trip conditions.

8.13. Low Voltage Motor Control Center (MCC)

8.13.1. The low voltage MCC will supply auxiliary power to loads greater than 1/2HP and up to and including 100HP.

8.13.2. Each low voltage MCC will be designed for operation under the following service conditions and ratings: TBD later, pending auxiliary power study.

8.13.3. Motor Control Centers suitable for indoor service in power generating and distribution facilities will be provided. Each low voltage motor control center will consist of one or more vertical sections, nominally 20" wide, 15" deep, and 90" high bolted together to form a rigid, free standing assembly. Enclosure type will be NEMA 12 suitable for installation indoors. MCC will be front access only.

8.13.4. Circuit breakers will be 600 V, 60Hz, and 3 pole. Circuit breakers will be molded case, draw-out, thermal magnetic type. Exceptions are circuit breakers to Resistance Welding and heater circuits; they will be 600 V, 60Hz, three-pole with instantaneous magnetic-only trip units.

8.13.5. Motor starters for 480 V service will include 480 V circuit breakers, 480 V, 3-phase, 60Hz contactors with manual reset electronic overload relays, 120 V ac or 460 V ac operating coils and control power transformers. Motor starters will not be smaller than NEMA Size 1.

a. Circuit breakers will be 600V, 60Hz, three-pole with instantaneous magnetic only trip units.

b. Control transformers will be rated at a minimum of 100VA.

8.13.6. MCC's will be provided with a main circuit breaker for the incoming feeder from the 480V switchgear.

8.13.7. MCC feeders will be manually operated thermal magnetic circuit breakers.

8.13.8. Power for motor starters, contactors, feeders, etc. will be supplied from two separate MCCs or distribution panels, arranged so that all equipment in one train is fed from the same MCC or distribution panel and the second train is fed from another.

8.13.9. Contactors for heaters, etc. will not be smaller than NEMA Size 1.

8.13.10. Minimum bucket size will be minimum 12 inches.

8.13.11. All feeder circuit and motor starter buckets will be capable of being Locked Out/Tagged Out.

8.14. Motors

8.14.1. Motors ½ HP and less will be rated 120V, 1-phase, 60Hz. Motors more than ½ HP and up to and including 250 HP will be rated 460V, 3-phase, 60Hz.

8.14.2. Motors greater than 250 HP and up to and including 4500 HP will be rated 4000V, 3-phase, 60 Hz.

8.14.3. Motors greater than 4500 HP will be rated 13200V, 3-phase, 60 Hz.

8.14.4. 4000V and 13200V motors will have a 1.0 service factor.

8.14.5. 120V and 460V motors will have a 1.15 service factor.

8.14.6. Motors 25 HP and larger will be provided with 240V rated space heaters operated from a 120V power source.

8.14.7. 4000V and 13200V motors will be provided with single element 100Ω platinum resistance temperature detectors (RTDs), one (1) per bearing and six (6) winding RTDs.

8.14.8. Motor terminal enclosures and auxiliary enclosures will be rated NEMA 4X unless located in hazardous areas in which case the hazardous rating will govern.

8.15. Medium Voltage Power Cables

8.15.1. 5 kV medium voltage rated power cables for the 4.16kV system, will be copper and shielded with copper tape for all applications

8.15.2. 15 kV medium voltage rated power cables for the 13.8kV system, will be copper and shielded with copper tape for all applications

8.15.3. All three (3) conductor medium voltage power cables will include an integral ground conductor(s).

8.15.4. Single conductor medium voltage power cable circuits will include an insulated ground conductor. Single conductor cable can be triplexed or placed in triad configuration.

8.15.5. Insulation will be EPR, 133% rated for 105 ºC conductor temperature. Jackets

will be thermoset CPE.

8.15.6. Minimum conductor size will be #4/0 AW for all medium voltage cables.

8.15.7. Maximum conductor size will be 750KCMIL for all medium voltage cables.

8.16. Low Voltage Power Cables

8.16.1. 600V low voltage power cable will have thermosetting cross-linked polyethylene (XLPE) insulation rated for 90°C and the conductors will be copper.

8.16.2. Low smoke zero halogen (LSZH) jackets will be provided for single conductor and multi conductor cables.

8.16.3. All three (3) conductor low voltage power cables will include an integral ground conductor.

8.16.4. In low voltage variable frequency drive (VFD) applications, VFD rated cable will be used.

8.16.5. The minimum conductor size will be #12 AWG.

8.17. Control Cable

8.17.1. 600V control cable will have thermosetting XLPE insulation rated for 90°C and the conductors will be copper.

8.17.2. Jackets will be LSZH.

8.17.3. The minimum size of control cables will be #14 AWG. Control cable will utilize E-2 (formerly K-2) color coding.

8.18. Instrumentation and Thermocouple Cable

8.18.1. 600V instrumentation cable and 300V thermocouple cable jackets will be LSZH.

8.18.2. The insulation will be thermosetting XLPE with copper conductors for instrumentation cable, chromel-constantan (Type E), iron-constantan (Type J), or chromel-alumel (Type K) for thermocouple cables, with individual pair/triads shielded, and a tinned #18 AWG copper drain wire, with a minimum twist frequency of 1-1/2 to 2 inches.

8.18.3. The minimum conductor size will be #16 AWG.

8.19. Lighting

8.19.1. For normal operation, the lighting systems provide illumination in all interior

and exterior areas.

8.19.2. During emergency or abnormal conditions, minimum lighting will be provided for personnel safety and emergency egress.

8.19.3. The 208/120V AC lighting system will be served by lighting transformers fed from the 480V auxiliary system.

8.19.4. All outdoor lighting will be corrosion-resistant. Outdoor and indoor high-bay lighting will utilize 208V fixtures.

8.19.5. The emergency lighting will be from self-contained wall mounted lighting fixtures with battery backup units.

8.19.6. The normal AC lighting will be powered from dedicated lighting transformers and panels generally located in the vicinity of the lighting loads.

8.19.7. Process power distribution transformers and panels will supply power to the 120V convenience receptacle circuits.

8.19.8. Convenience receptacles rated 20A, 125 VAC will be limited to five per circuit. Duplex receptacles will be located such that 75 foot extension cords will reach.

8.19.9. All distribution panel breakers will be capable of being Locked Out/Tagged Out.

8.19.10. All new lighting fixtures will be of 4000K LED type.

8.20. Low Voltage Distribution Transformers and Panels

8.20.1. Low voltage distribution transformers are used to step down power from 480V to 120/240VAC single phase or 480V to 120/208V three phase.

a. Insulation system and average winding temperature rise will be Class 185 with 80 C rise.

b. Transformer insulation system will be UL rated.

c. All insulation materials will be flame-retardant and will not support combustion as defined in ASTM Standard Test Method D635.

d. Core and coil assembly will be low loss type with minimum efficiencies per NEMA TP1 when operated at 35% of full load capacity. Efficiency will be tested in accordance with NEMA TP2.

e. All transformers will have resin encapsulated, copper primary winding and secondary winding.

8.20.2. Low voltage distribution panels are used to distribute 120/240V single phase or 120/208V three phase power.

a. The distribution panel will be designed to allow it to be wall mounted. All components of the distribution panel will be mounted on a common frame, completely assembled and factory tested. The distribution panel components will be electrically isolated from the frame.

b. The power distribution panel includes the following:

b.1. Main circuit breaker

b.2. Feeder circuit breakers

b.3. Main bus

b.4. Neutral bus

b.5. Grounding bus

c. Panelboards will have vertically aligned continuous copper bus bars. Joints are not permitted in the vertical bus.

d. Bus bars will have sufficient cross sectional area to meet UL 67 temperature rise requirements through actual tests.

e. Bus bars will be phase-sequenced and rigidly supported by high impact resistant, insulated bus supporting assemblies to prevent vibration or short circuit mechanical damage.

f. Split solid neutral bus will be plated and located in main compartment for all incoming neutral cables to be same length. Neutral bus will be rated 100%.

g. An isolated ground bus will be included.

h. Lugs will be rated for 75°C terminations.

i. Circuit Breakers:

i.1. Main and branch circuit breakers will be bolt-on, fully rated, quick-make, quick break, and trip indicating.

i.2. All circuit breakers will have thermal and magnetic trip elements in each pole.

i.3. Circuit breakers with the following minimum interrupting capacities will be provided:

i.3.1. 120V applications: 10,000 amperes, RMS symmetrical

i.3.2. 240V applications: 10,000 amperes, RMS symmetrical

i.3.3. 480V applications: 65,000 amperes, RMS symmetrical

8.21. DC & UPS System

8.21.1. The DC and UPS system will provide uninterruptible power to critical components under emergency loss of AC power conditions.

8.21.2. The battery rating will be sized such that power will be maintained for a minimum of 8 hours, in the event of loss of AC power.

8.21.3. The battery chargers will be sized to provide the normal operating power for the 125VDC loads as well as recharge the battery system in 12 hours.

8.21.4. The UPS panel will normally be fed from the bypass transformer. During loss of AC power, the inverter will feed the UPS panel.

8.21.5. A manual bypass switch will be provided to bypass the inverter for maintenance.

8.22. Raceway

8.22.1. Medium voltage power cables, low voltage power cables, control cables, and low-level signal instrument cables will be installed in separate raceways.

8.22.2. Cables of like levels may be run together in conduits or trays and unlike levels will be run in separate conduits or trays. Power cable will be limited to one (1) cable per conduit.

8.22.3. Intermixing of circuit levels is not allowed in the same raceway, except in cable tray with appropriate barriers installed to provide separation.

8.22.4. Redundant circuits that are critical, such as DCS fiber communications, will be routed in separate raceways.

8.22.5. All cable trays will be heavy duty type with a minimum load rating of NEMA 20C. Minimum cable tray width will be 12".

8.22.6. Cable trays will generally be provided where ten or more circuits of the same separation class are routed in the same direction above ground.

8.22.7. Power, control, and instrumentation cable trays will be aluminum, ladder type, 6 inches deep unless otherwise noted with topmost tray provided with covers.

8.22.8. Tray supports will have a maximum spacing of 10 feet depending upon the

layout.

8.22.9. Conduits will be used for areas where a tray system is not feasible or economically justifiable.

8.22.10. Conduits will also be used for routing cables from the tray system or embedded conduit to the terminal equipment.

8.22.11. Conduits will be rigid galvanized steel and will generally be limited to 3/4, 1, 1-1/2, 2, 3 and 4-inch diameters.

8.22.12. Intermediate conduit (IMC) and electrical metallic tubing will not be used.

8.23. Grounding

8.23.1. The existing power plant grounding system will be extended to include an inter-connection of buried bare copper conductors and ground rods to from a new ground grid for the CCUS system.

8.23.2. All new structures and equipment will be connected to the ground grid.

8.23.3. The grounding ring around equipment foundations will be approximately 3 feet from the foundation edge.

8.23.4. The new areas of grounding will be connected to the existing grounding system at multiple points.

8.23.5. The conductors for the power block grounding loops and interconnections will be a minimum of #4/0 AWG bare stranded copper cables.

8.23.6. Ground rods will be copperweld ¾" x 10 feet long.

8.23.7. The horizontal ground conductors will be laid 30 inches below grade level.

8.23.8. Foundation rebar will be connected to the underground conductors (Ufer ground) to improve the overall grounding system.

8.23.9. Above ground connections will be mechanical (compression) type connections.

8.23.10. Below ground connections will be exothermic welds.

8.24. Lightning Protection

8.24.1. Lightning protection will be provided for structures that are not adequately shielded from direct lightning strikes by other structures.

8.24.2. Lightning protection generally will not be required for metallic structures that

are not likely to be damaged by a lightning stroke, provided the structure is electrically continuous and capable of conducting lightning currents without damage.

8.24.3. Lightning protection systems will be designed per NFPA-780.

8.24.4. Lightning protection systems will be UL 96A certified.

8.25. Freeze Protection and Heat Tracing

8.25.1. Freeze protection and heat trace temperature maintenance of pipes will be accomplished with straight runs of self-limiting heat tracing cable attached and covered with thermal insulation.

8.25.2. Freeze protection/heat trace circuits will be fed from dedicated 208/120V freeze protection/heat trace distribution panels that are thermostatically controlled.

8.25.3. The minimum design temperature for the freeze protection and temperature maintenance will be per section 2.1.1 with a 20 mph wind.

8.26. Low Voltage Variable Frequency Drives (LV VFDs)

8.26.1. The VFD continuous output rating will meet the motor and driver load combination requirements.

8.26.2. The VFD base rating will be capable of operating the motor at its service factor.

8.26.3. The VFD will be capable of producing a variable AC voltage/frequency output to provide continuous operation over the normal system 0-100% speed range. The VFD will be capable of sustaining operation at 0% speed to facilitate checkout and maintenance of the driven equipment. When V/Hz control is utilized, the V/Hz ratio will be constant over the operating speed range.

8.26.4. The overload rating of the drive will be 110% of its normal duty current rating for 1 minute every 10 minutes, 130% overload for 2 seconds. The minimum FLA rating will meet or exceed the values in the NEC/UL table 430-150 for 4-pole motors.

8.26.5. The VFD output will allow the motor to produce full rated torque at any speed in the operating range.

8.26.6. VFD's will comply with the latest edition of IEEE 519 for total harmonic voltage and current distortion calculation and measurement.

8.26.7. VFD will be capable of maintaining a 0.98 minimum true power factor, adjustable between 0.90 lagging to 0.90 leading, from 10% to 100% speed.

8.27. Medium Voltage Variable Frequency Drives (MV VFDs)

8.27.1. For the CO2 compressors, VFDs will be used to improve starting conditions.

8.27.2. The VFDs will be supplied power from the 13.8kV switchgear.

8.27.3. The VFDs will be located indoors.

8.27.4. VFD's will meet the following speed and torque requirements:

a. The VFD's will be capable of producing a variable AC voltage/frequency output to provide continuous operation over the normal system 30-100% speed range. The VFD's will be capable of sustained operation at 10% speed to facilitate checkout and maintenance of the driven equipment. As a commissioning and troubleshooting feature, the VFD power circuit will be capable of operating without a motor connected to the VFD output.

b. The speed accuracy within the specified speed range, expressed as a percent of top speed, will be within 0.5 % of base speed without encoder or pulse tachometer feedback and 0.01 % with encoder or pulse tachometer feedback.

c. The VFD's will be capable of momentary overload of 110% above run out speed and horsepower for one minute, based on the maximum current rating of the power cells.

d. The VFD will be able to produce 80% torque at 0.1Hz.

8.27.5. The VFD output will be suitable for a motor designed and insulated for operation on a sine wave without a VFD having a motor voltage rating of 13200V, 3 phase, 60 Hz.

8.27.6. VFD's will comply with the latest edition of IEEE 519 for total harmonic voltage and current distortion calculation and measurement.

8.27.7. Front end isolation transformers will be provided.

8.27.8. The VFDs will utilize a liquid cooled system.

9. INSTRUMENTATION & CONTROLS DESIGN CRITERIA

The following controls design requirements apply to the generating station modifications and to the Carbon Capture System. Each system will adhere to the requirements described below.

9.1. General Control Requirements

9.1.1. The Carbon Capture System including the BOP for the Carbon Capture System will also be controlled through a Foxboro I/A system DCS.

9.1.2. The BOP systems controls associated with the Carbon Capture Island will be designed by S&L and forwarded to the Carbon Capture Supplier for implementation in the DCS.

9.1.3. A new Control Room will be designed and built near the Carbon Capture Island. The existing generating station operations for Units 1 and 4 will be relocated to this Control Room. This new Control Room will also house the main controls of the new Carbon Capture System.

9.1.4. Programmable Logic Controllers (PLCs) will only be used for packaged equipment (such as an air compressor) with the prior approval from the Owner.

9.1.5. All control switch functions and indications on Local Control Panels will be monitored by the DCS.

9.1.6. The use of pneumatic and motor operated actuators will be evaluated on a per control loop basis. Considerations to be taken include cost, fail-safe requirements, and environment of the device.

9.1.7. S&L will be responsible to supply an I/O list, instrument list, functional description, instrument data sheets, logics, instrument location drawings, instrument installation drawings (for non-skid mounted instruments), and network architecture sketches, as required.

9.2. Distributed Control System (DCS)

9.2.1. The instrumentation and control system will be composed of a microprocessor based Foxboro I/A Distributed Control System (DCS) extended and remote I/O cabinets, analog instruments, digital discrete sensors, and data links to packaged control systems, such as PLCs, for indication and monitoring.

9.2.2. The DCS control system will perform the functions of modulating and discrete control, equipment protection and process interlocking, component diagnostic, unit/process upset analysis and maintenance guidance, and data archiving of the entire system to meet all operational conditions, assuring a safe, environmentally

compliant and economic operation of the unit. The DCS extended and remote I/O cabinets will be supplied with redundant power supplies, redundant communication, and redundant fiber optic communication to the existing redundant processors.

9.2.3. The fundamental functions such as control, alarm, monitoring, interlock, and protection will be fully integrated within the DCS. The DCS will have self-diagnosing abilities, so that internal faults can be detected within the system prior to the resulting disturbance to the process and so that measures can be taken to prevent spreading of the fault. Diagnostic aids will be developed within the DCS graphics to include dynamic device permissive screens, manual reject cause screens, process overview, and control system status screens. DCS graphic development will be in accordance to the existing plant's requirements.

9.2.4. The control system will be designed so that no single fault will cause the complete failure of any system or cause the process to result in mis-action or anti-action. Process variable point redundancy will be provided for all parameters that may directly cause a unit safeguards function to activate. Redundancy in the control system structure will be provided so that no single fault within a control system can cause failure of the controlled equipment or cause the standby equipment to be unavailable. In case of a failure of in-service equipment, the standby equipment will start automatically without any system interference.

9.2.5. The Carbon Capture DCS will be a Foxboro I/A DCS. Its design will be consistent with the existing generating station Units 1 & 4 DCS.

9.2.6. The Carbon Capture DCS will be on a new network mesh, independent of the existing Foxboro mesh networks. Signals will be hard wired between the new Carbon Capture DCS and the existing plant DCS.

9.2.7. Flue gas control additions and modifications will be controlled by Owner's DCS/BMS. Based on the logics supplied by S&L, the DCS will be integrated and configured (by Others) in the existing Owner's DCS.

9.2.8. Existing DCS hardware (I/O cards, controllers, cabinets, etc.) will be used to the greatest extent possible. New I/O cards and/or controllers will be added as necessary.

9.2.9. Revisions to the plant DCS and the addition of the Carbon Capture System to the DCS will be designed and implemented following all applicable station NERC CIP compliance requirements.

9.2.10. Control Wiring Philosophy

a. The control alarm wiring philosophy will be such that all field alarm devices

utilize normally open contacts during normal operating condition.

b. Power feeds to control devices will be monitored. Loss of power will result in an alarm condition.

c. Signals from redundant components will be partitioned to separate DCS Input/Output modules to improve reliability.

d. Normally Closed (N/C) contacts for fail safe operation will be used so that a broken wire, etc. will indicate a non-normal condition. Use of transmitters is preferred over switches for items where reliability is important.

9.3. Fiber Optic Cable and Patch Panels

9.3.1. Fiber optic cables will be 12 or 24 count 62.5/125 µm multimode or 9/125 µm single mode cables. Multimode fiber optic cable will be used unless cable length is a concern or the data network's standard design requires single mode.

9.3.2. The cable jacket will be chloronated polyethelyne (CPE). A ripcord will be placed under the overall jacket. The overall cable jacket will be UV resistant and moisture resistant.

9.3.3. Fiber cable constructed with tight buffer tube design. Construction will be suitable for Indoor/Outdoor use per ICEA S-104-696. Non-hygroscopic flame-retardant fillers will be used to provide a firm circular cross section. All assemblies will be bound with a non-hygroscopic, dielectric strength member.

9.3.4. The individual fibers and buffer tubes will be color coded for identification on accordance with ANSI/EIA Standard TIA-598.

9.3.5. Fiber field cables and patch cords will be installed in patch panels ensuring that the manufacturer's minimum bend radius will not be violated.

9.3.6. All fibers of the fiber optic field cables will have ST connectors and will be installed on the bulkhead connectors in the patch panel. There will be no unconnected spare fibers.

9.4. Instrumentation

9.4.1. General Requirements

a. All instrumentation and systems will be designed to provide safe and reliable operation of equipment in accordance with all applicable codes and standards.

b. All instrumentation will be of heavy-duty industrial quality design with all materials of construction suitable for the application. The manufacturers and

models of the instruments and instrument accessories to be used will be subject to approval by the Owner. All instrument and control devices will be suitable for service in outdoors area.

c. Local indications will be provided on all remotely operated valves/dampers, analog transmitters, and auxiliary system local control panels. Local audible alarms will be provided for remote independent systems when warranted for system and personnel safety or system troubleshooting.

d. Instrument tags will be permanently attached to the devices. If this is not possible, the instrument tag will be fastened to the instrument with stainless steel wire. The wired instrument tag will be supplied as 1/16" thick, ¾" by 3" stainless steel instrument tag. Tag number characters will be 3/8" in height.

e. Instrument enclosures will be provided where required for instruments mounted outdoors, instrument pedestals will be provided for instruments mounted indoors.

9.4.2. Transmitters

a. Transmitters will be electronic, 2-wire, with isolated 4-20 ma dc output signals and supplied with an appropriate two or five valve instrument manifold to allow on-line calibration.

b. Transmitters will not contribute more than 500 ohms to the overall loop impedance at 24 VDC and will be generally powered from the DCS.

c. Pressure, flow, differential pressure, level, and other miscellaneous transmitters' accuracy will be within 0.15% of calibrated span, where possible.

d. Excluding temperature transmitters, local output indicators will be provided as part of the transmitter.

e. Transmitters will generally be "smart" and will also communicate via "Hart" communications protocol.

f. Transmitters will be as manufactured by Foxboro, where possible.

9.4.3. Pressure Instruments

a. All pressure instrumentation will be capable of withstanding the greater of their body rating conditions or 1.5 times the process design pressure without permanent damage or loss of calibration.

b. In general, air or flue gas duct pressure connections will be 2-inch pipe. If required, connection reinforcement will be provided. Any connection to duct

work will be capable of serving as a test tap location and be provided with the ability for rod out without removal of any instrument lines.

c. Differential pressure instrumentation of the force balance low displacement type, regardless of the applied service, will be capable of withstanding a differential pressure equal to full process pressure on either side of the measurement element without damage or loss of calibration.

d. Local pressure gauges will have 4-1/2 inch round dials, solid front safety case type with blowout back, ½-inch NPT bottom connection, phenol or drawn stainless steel case, with black figures on white face. Bourdon tube types will be used for pressures of 10 psig and above and bellows for pressures below 10 psig and vacuum service. Movements are to be of nylon and stainless steel except for corrosive service where Monel will be used. Pigtail syphons are to be used for steam service, snubbers for pulsating flows, chemical seals for acid and caustic service. These pressure gauge requirements are for process measurements and do not apply for gauges supplied with control valve positioners.

e. Pressure test points will be supplied on all piping to permit pressure determination in the future without removing sensing lines for remote gauges. In general, test points will be supplied before and after each major piece of equipment which can affect pressure such as pumps, control valves, flow measurement devices, filters, and heat exchangers. All tanks will have pressure test points.

f. Pressure test points will not be supplied adjacent to pressure gauge or transmitter taps. Test instrumentation can be connected through the two valve manifold of a pressure transmitter or the pressure gauge connection, if necessary.

g. In general, pressure points will be valved so that local gauges can be isolated without affecting remote equipment.

9.4.4. Level Instruments

a. Differential pressure transmitters will be used to measure level in atmospheric tanks or in tanks at saturated pressure using a liquid filled reference leg. Guided wave radar level transmitters will be used in low pressure and vacuum applications where there is a potential for evaporation of the filled leg of a differential pressure level measurement system. Ultrasonic or capacitance level transmitters may be used for special applications and large tanks.

b. All level transmitters will provide 4-20 mA DC output signals and Hart communications interface. Ultrasonic level transmitters will be 120 VAC powered, with isolated 4-20 mA DC output signals powered from the transmitters.

c. Level instruments for local indication will be supplied as required. These will, in general, consist of local magnetic level indicators or gauge glasses with guards to protect glass from breakage.

d. For installations that do not require a gauge glass to satisfy a Code requirement, a transmitter with local indicator option may be used provided that the tank level can be easily read.

e. Tubular gauge glasses will be used for low-pressure applications. Transparent or reflex gauges will be used for high-pressure applications.

f. All gauge glasses will be fitted with ballchecks and have means for isolation and flushing (cleaning) glasses. Gauge glass will not be used where glass breakage cannot be tolerated (such as acid and caustic tanks).

g. Level switches will generally be cage float type, rated for ANSI B31.1 requirements. Sump level switches will utilize point type capacitance or ultrasonic. Use of float switches in sumps will be prohibited.

h. Radar level instrumentation will be utilized for silo and/or hopper measurements.

9.4.5. Flow Instrumentation

a. Flow venturis, nozzles, orifice plates, or compact orifice plates will be used, in general, for flow measurements. Consideration will be given to the use of low-loss flow tubes where unrecovered head loss must be kept at a minimum.

b. Annubars may be used for measurement of water and steam flow in 10” pipes and larger. Flow elements will conform to requirements of ASME 19.5, "Application, Part of Fluid Meters: Interim Supplement on Instruments and Apparatus."

c. Flow nozzles will be of the weld-in holding ring type ASME long radius, with dual wall taps. Depending on the piping line specification, the nozzle material will either match the piping material or will be made of stainless steel. Metered pipe run and nozzle will match the pipe material and size in which the metered section is to be installed.

d. Orifice plates will be 316 SS, sharp square edge thin plate, paddle type suitable for installation between raised face orifice flanges. Orifice flanges, gaskets, and jacketing screws will be furnished by the piping Contractor. Paddle will be stamped with the orifice ID bore diameter on the upstream side. Orifice flanges will be of the raised-face, weld-neck type with dual sets of taps.

e. Complete design data, sizing calculations, installation drawings, and installation

procedures will be provided by the supplier with each nozzle and orifice. Beta ratios will be between 0.4 and 0.75.

f. In general, square root extraction of the flow signal will be performed in the DCS.

g. Magnetic flow meters or ultrasonic meters may be used when the process conditions dictates this type of application.

h. Thermal mass flow instruments may be used where appropriate in particular for flue gas and process air measurements.

9.4.6. Temperature Instrumentation

a. Temperature measurements for control and monitoring inputs will be made with RTDs, Chromel – Constantan (Type E) (Unit 4), Chromel-Alumel (Type K) and Iron – Constantan (Type J) (Unit 1) thermocouples. Other types of thermocouples will be acceptable only if approved by Owner. All thermocouples and RTD's will be supplied with temperature transmitters mounted in the head, providing a 4-20 mA signal to the DCS.

b. RTDs furnished by equipment suppliers will be of the dual-element, three-wire type made with 100-ohm platinum resistance elements. They will be certified to meet the requirements of the International Temperature Scale, calibrated to the IEC standard (Alpha = 0.00385 Ohms/Ohm/°C), and guaranteed to an accuracy of within 1.1°C of this standard. The RTDs will be contained in an insulated material and a sheath or sleeve of stainless steel and will be mounted to withstand the greatest shocks and vibrations, without deterioration, that can be imposed upon them in the system piping.

c. Thermocouples will be dual element with ungrounded measuring junction, manufactured in accordance with the ISA Standard MC961.1, "Temperature Measurement Thermocouples." All thermocouples will be Chromel – Constantan (Type E) for process temperatures up to +1200° F. Ungrounded Chromel-Alumel (Type K) thermocouples will be used for process temperatures above 1200° F. Cold junctions will be located at the receiving end with automatic reference junction compensation provided (i.e., at the monitor input cabinets). All thermocouple and low level DC wiring will be shielded. Thermocouples will be of swaged construction. The sheath or sleeve will be spring-loaded to maintain thermal and electrical contact with the bottom of the protecting well. Ungrounded multiple-element thermocouples will have electrically isolated measuring junctions.

d. Bimetallic dial type thermometers with minimum 4½" dial, every angle form, hermetically sealed with external recalibration adjustment, 3/8" OD SS stem, ½" NPT connection, and SS case will be used wherever possible. Where the point of measurement is not easily available for viewing, the filled-bulb type with long

capillary tube may be used.

e. All RTDs, thermocouples, thermometers, and remote temperature sensing elements installed in pipelines or ducts will have thermowells or protection tubes, extensions and heads.

f. An extension nipple or union nipple will be furnished for each thermocouple or RTD assembly. Terminal blocks will be marked with polarity, and connectors will be resistant to heat, vibration, and galling. The cap will provide a weather-tight enclosure and a chain will be provided to prevent loss of cap. The cap will be made of cast aluminum.

g. Thermowells will be made of proper material type based on the process fluid and piping design conditions.

h. Thermowell length will consider insulation thickness, and the appropriate lagging will be provided to extend the length above the insulation by no less than one inch.

i. Thermowell immersion length will be between 1/3 and 2/3 the distance to the center of the pipe. Where thermowells are installed in lines smaller than 3", the piping will be expanded to a minimum 3" size to accommodate the thermowell.

j. Thermowells in high velocity steam and water pipes will have an ASME PTC 19.3 calculation for determination of their resonant frequency. Thermowells that do not meet the acceptance criteria will be resized or relocated as necessary.

9.4.7. Process Switches

a. Process switches will be avoided in favor of transmitters wherever possible with control logic to replace functionality of the process switch.

b. Each switch will provide safe and reliable electrical contacts for alarm, interlock and/or indication.

c. Pressure and temperature switches will be of the snap action type and will have a minimum of two SPDT contacts or one DPDT contact unless the application requires types furnished only as SPDT due to deadband requirements. When additional contacts are required, they will be multiplied by relays.

d. All switches, unless otherwise specified, will be furnished with two (2) form C contacts rated 10 amperes, 120 VAC or 0.5 amperes conductives, 125 VDC, continuously.

e. Mercury switches are not permitted.

9.4.8. Instrument Enclosures/Pedestals

a. Heated enclosures will be furnished for all instruments located outdoors where freeze protection is required.

b. The instrument enclosures rating will be NEMA 4X.

c. The size of the enclosure will be based on the number of instruments to be mounted in the enclosure. Doors and body stiffeners will be provided as required for rigid construction based on the size of the enclosure. Access to the instruments mounted inside the heated enclosure will be possible by opening the enclosure door.

d. Each enclosure will be furnished with a space heater and thermostat. The power supply to the heater will be 120VAC. Terminal blocks will be protected from piping leaks, etc.

e. All instrument piping, tubing, valves, and fittings will be installed and securely fastened to the enclosure mounting in an orderly manner. Each sensing line will be identified at penetrations through the enclosure by a stainless steel tag bearing the number of the instrument associated with the sensing line. Clamps, pads, and supports in direct contact with stainless steel pipe or tubing will be of the appropriate material.

f. Instrument pedestals will be provided for indoor mounted instruments.

g. Piping or tubing will not be routed across the face or rear of an instrument or other device in a manner that prevents the opening or removal of covers or obstructs access to leads, terminals, or instruments for servicing.

h. Test connections will be provided so that each device can be calibrated and checked without its removal from the panel or pedestal.

9.4.9. Tubing and Fitting

a. Primary process and pneumatic tubing will be in accordance with ANSI B31.1. Tubing will be ½" O.D., minimum, 316 stainless steel with 0.049" wall thickness. Compression fittings will be stainless steel. High pressure applications will use ½" O.D., minimum, 316 stainless steel with 0.065" wall thickness.

b. Tube fittings will be Swagelok compression fittings.

9.5. Control Devices

9.5.1. General Requirements

a. Process related devices containing contacts will have a minimum of two (2) normally open and two (2) normally closed electrically independent contacts. Contacts will have a minimum continuous rating of 10 amperes at 120 VAC and 0.5 ampere inductive at 125 VDC.

b. Solenoids will have a 120 VAC, 125 VDC, or 24 VDC encapsulated coil with Class H insulation and rated for continuous duty.

c. Integral valve positioners complete with feedback linkage will be provided with all modulating control valves. A cam or similar means of adjustment will be incorporated so that the relationship between the input signal and the valve position can be characterized. Positioners will be easily reversible in the field and be complete with a bypass feature and input/output gauges.

d. Valve will be capable of accepting a locking device for Lockout/Tagout.

9.5.2. Pneumatic Control Valves

a. Instrument air shutoff valve and air set, consisting of a combination regulator, filter, pressure gauge, and relief valve, will be provided on each pneumatic control valve assembly.

b. All integrally mounted instrumentation (controllers, positioners, regulators, etc.) will be designed for a maximum instrument air supply pressure of 125 psig.

c. Electro-pneumatic positioners will be integrally mounted to the modulating control valves. All positioners will support HART communication for setup, calibration, and diagnostic functions.

d. The failure position of each valve will be selected based on the service to fail either open (FO), closed (FC), or locked in current position (FL) in the event of loss of signal or loss of motive power. Valve failure position will be specified on the valve list.

e. Limit switches will be provided for on/off service control valves. Each switch will have a minimum of two (2) normally open and two (2) normally closed electrically independent contacts. Contacts will have a minimum continuous rating of 10 amperes at 120 VAC and 0.5 ampere inductive at 125 VDC.

f. All valve position indicators will read 0% with valve fully closed, 100% with valves fully open, and be provided with intermediate marking. Stem mounted valve limit switches will be magnetic proximity type switches. Enclosures for control valve accessories will be NEMA 4X. Valves provided with limit switches and/or solenoids will have the limit switches and solenoid valve terminated to a terminal box (or junction box) mounted to the valve assembly.

9.5.3. Motor Operated Valves

a. Motor operated valves will be equipped with an integral reversing motor starter and integral motor and limit switch compartment heaters. Motor starters will be housed in NEMA 4X enclosures. Where possible, actuators will be mounted directly to the valve. Actuators not accessible by mounting directly on the valve will be floor mounted.

b. The actuator will be provided with a manual hand-wheel that does not rotate during motor operation and with a safety de-clutching feature should the motor drive become energized while the valve is under manual control. The actuators will be capable of operating the valve with full differential pressure across the valve. Operation of the hand-wheel will not change the set points of the limit switches. Valves will be designed so that burned out bearings and/or motors will not prevent hand operation of valves.

c. Motor operated valves will be capable of being operated locally. When in local control, all DCS interlocks will be disabled.

9.5.4. Modulating Type Electrical Control Drives

a. Each control drive unit enclosure will be dust tight and weatherproof, NEMA 4X, and will be capable of operating in the ambient temperature range specified, and relative humidity of 0-100%, noncondensing.

b. Electrical control devices will be either 480, 60 Hz, 3Ø or 120 VAC, 60 Hz, 1 Ø power source as required for each control drive unit. No voltage regulating equipment will be allowed.

c. The control drive unit will have ample power to successfully operate the equipment to be controlled. The control drive unit will be sized to develop a minimum of 150% of maximum operating torque at the lowest ambient air conditions to overcome operating resistance due to dirt, corrosion, and wear that may develop during the life of the equipment. The travel time from closed to open and vice versa will not be more than 30 seconds.

d. The control drive units will be furnished with an integral manual hand wheel or hand crank capable of being operated by one person.

e. The control drive units will be provided with travel stops to limit the maximum opening and closing of the vanes and with calibrated, field-adjustable torque switches.

f. The control drive units will fail in place on loss of the control signal, or loss of power. The control drive units will include provisions for initiating an alarm signal on loss of control signal and on loss of power. In addition, the control

drive units will be provided with a stall alarm contact.

g. The DCS signal to the electric drive units will be two-wire, 4-20 mAdc. The input impedance of the control drive unit will not exceed 250 ohms. Smart or HART capabilities will be provided for diagnosis with interface into the DCS. The control drive units will be provided with a two-wire, 24 VDC, 4-20 mA position feedback, contact-less position sensor.

h. The control drive unit electronics, if not an integral part of the drive unit assembly, will be mounted remotely from the drives in NEMA 4 enclosures. The enclosures will be furnished complete with the electronics installed.

i. All required drive unit linkage components will be supplied, including necessary clevises, ball and socket assemblies, drive unit control arms, etc., required for a workable system. The linkage will be capable of operating at the rated torque of the control drive units.

10. GOVERNING CODES

Codes listed below are the primary codes used on the project but not intended to be all inclusive. Latest editions as of project initiation will be used.

10.1. AASHTO – American Association of State Highway and Transportation Officials

10.2. ACI – American Concrete Institute

a. ACI 543R – 12 – Guide to Design, Manufacture and Installation of Concrete Piles

b. ACI 318-14 – Building Code Requirements for Structural Concrete and Commentary

10.3. AGMA - American Gear Manufacturer Association

10.4. AISC – American Institute of Steel Construction

a. AISC – Manual of Steel Construction

b. AISC 341 – Seismic Provisions for Structural Steel Buildings

c. AISC 360 – Specification for Structural Steel Buildings

10.5. AMCA - Air Movement and Controls Association

10.6. API – American Petroleum Institute

a. API STD 520 - Sizing, Selection, and Installation of Pressure-relieving Devices

b. API STD 610 - Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries

c. API STD 614 - Lubrication, Shaft-sealing and Oil-control Systems and Auxiliaries

d. API STD 617 - Axial and Centrifugal Compressors and Expander-compressors

e. API STD 620 – Design and Construction of Large Welded, Low Pressure Storage Tanks

f. API STD 650 – Welded Steel Tanks for Oil Storage

g. API STD 673 - Centrifugal Fans for Petroleum, Chemical and Gas Industry Services

h. API STD 682 - Pumps-Shaft Sealing Systems for Centrifugal and Rotary Pumps

10.7. ASCE – American Society of Civil Engineers

a. ASCE 7-10 – Minimum Design Loads for Buildings and Other Structures

b. ASCE 20-96 – Standard Guidelines for the Design and Installation of Pile Foundations

10.8. ASHRAE – American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc.

10.9. ANSI – American National Standards Institute

10.10. ASME – American Society of Mechanical Engineers

a. ASME B31.1 - Power Piping Code

b. ASME Section VIII – Boiler and Pressure Vessel Code

10.11. ASTM – ASTM International: By Standard Specification, Test Method, Practice or Guide specified

10.12. AWWA – American Water Works Association

10.13. AWS – American Welding Society

a. AWS A2.4 – Standard Symbols for Welding, Brazing and Nondestructive Examination

b. AWS A3.0 – Welding Terms and Definitions

c. AWS A5.1 to A5.31 – Specification for Welding Electrodes

d. AWS A6.1 – Recommended Safe Practice for Gas-Shielded Arc-Welding

e. AWS D1.1 – Structural Welding Code – Steel

f. AWS D1.2 – Structural Welding Code – Aluminum

g. AWS D1.3 – Structural Welding Code – Sheet Steel

h. AWS D14 – Rotating Equipment

10.14. AWWA – American Water Works Association

10.15. CFR - Code of Federal Regulations

10.16. CRSI – Concrete Reinforcing Steel Institute, Manual of Standard Practice

10.17. CTI – Cooling Technology Institute

10.18. Factory Mutual Loss Prevention Data Sheets

10.19. HEI – Heat Exchanger Institute

10.20. IBC 2015- International Building Code

10.21. IFC – International Fire Code

10.22. IMC – International Mechanical Code

10.23. ISA – International Society of Automation

10.24. MBMA – Metal Building Manufacturer's Association, Metal Building Systems Manual

10.25. NEC – National Electrical Code

10.26. NEMA – North American Electric Reliability Council

10.27. NERC – North American Electric Reliability Corporation

a. CIP – Critical Infrastructure Protection Standards

10.28. NFPA – National Fire Protection Association

a. NFPA 101 – Life Safety Code

b. NFPA 850 – Recommended Practice of Fire Protection for Electric Generating Plants

c. NFPA 85 – Boiler and Combustion Systems Hazards Code

10.29. OSHA – Occupational Safety & Health Administration 29 CFR Part 1910 Occupational Safety & Health Standards

10.30. RCSC – Research Council on Structural Connections – Specification for Structural Joints Using ASTM A 325 or A 490 Bolts, Endorsed by the American Institute of Steel Construction, Inc.

10.31. SSPC – Steel Structures Painting Council: By Practice or Guide Specified

10.32. UL – Underwriter's Laboratories, Inc.

Appendix C. BOP Engineering Design Package

PROCESS STREAMS

Flue Gas Stream Characteristics		Unit 1 WFGD Outlet		Unit 4 WFGD Outlet		Total Flue Gas to Carbon Capture Island		Flue Gas Quencher Inlet for Train 1	
PFD Stream Label		**A**		**B**		**C**		**D**	
Temperature	°F	127		127		127		127	
Pressure	psia	11.968		11.968		11.788		11.788	
N_2	lb/hr-vol%	3,333,490	66.90	4,969,533	66.93	8,303,023	66.92	4,151,511	66.9
O_2	lb/hr-vol%	349,504	6.14	497,892	5.87	847,396	5.98	423,698	6.0
H_2O	lb/hr-vol%	549,599	17.16	818,941	17.16	1,368,539	17.16	684,270	17.2
CO_2	lb/hr-vol%	766,554	9.79	1,169,793	10.03	1,936,347	9.93	968,173	9.9
SO_2	lb/hr-ppmv	129	11	394	23	523	18.44	261	18.44
SO_3	lb/hr-ppmv	*16.34*	*1.1*	*25*	*1.2*	*41*	*1.16*	*21*	*1.16*
NOx	lb/hr-ppmv	835	102	1,332	109	2,167	106	1,084	106
NH_3	lb/hr-ppmv	19.92	7	32.74	7	52.66	7	26.33	7
Hg	ppbv	0.2		0.2		0.2		--	
Total Flow	lb/hr-acfm	5,000,147	1,560,326	7,457,942	2,325,015	12,458,089	3,944,730	6,229,045	1,972,365
MW & Moist.	g/mol-lb/lb	28.1	0.087	28.1	0.091	28.1	0.123	28.1	0.123
Ash	lb/hr-gr/acf	57	0.004	87	0.004				

Notes:

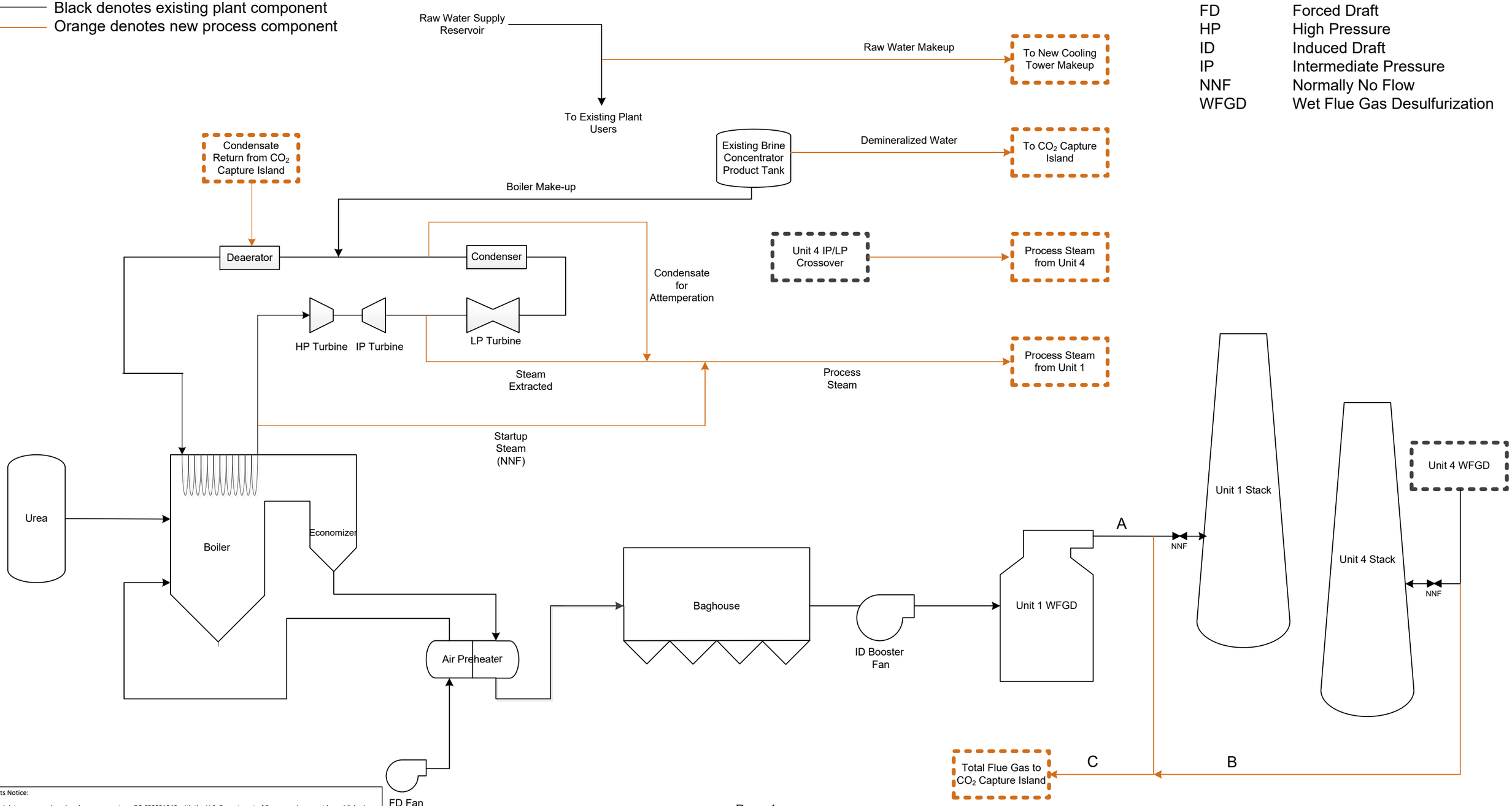
(1) Based on S&L Design Basis Rev. 0 with Pressure and Moisture input from MHI

(2) Items in red text (italicized) denote values to be finalized later

Base Plant Integration PFD

Black denotes existing plant component
Orange denotes new process component

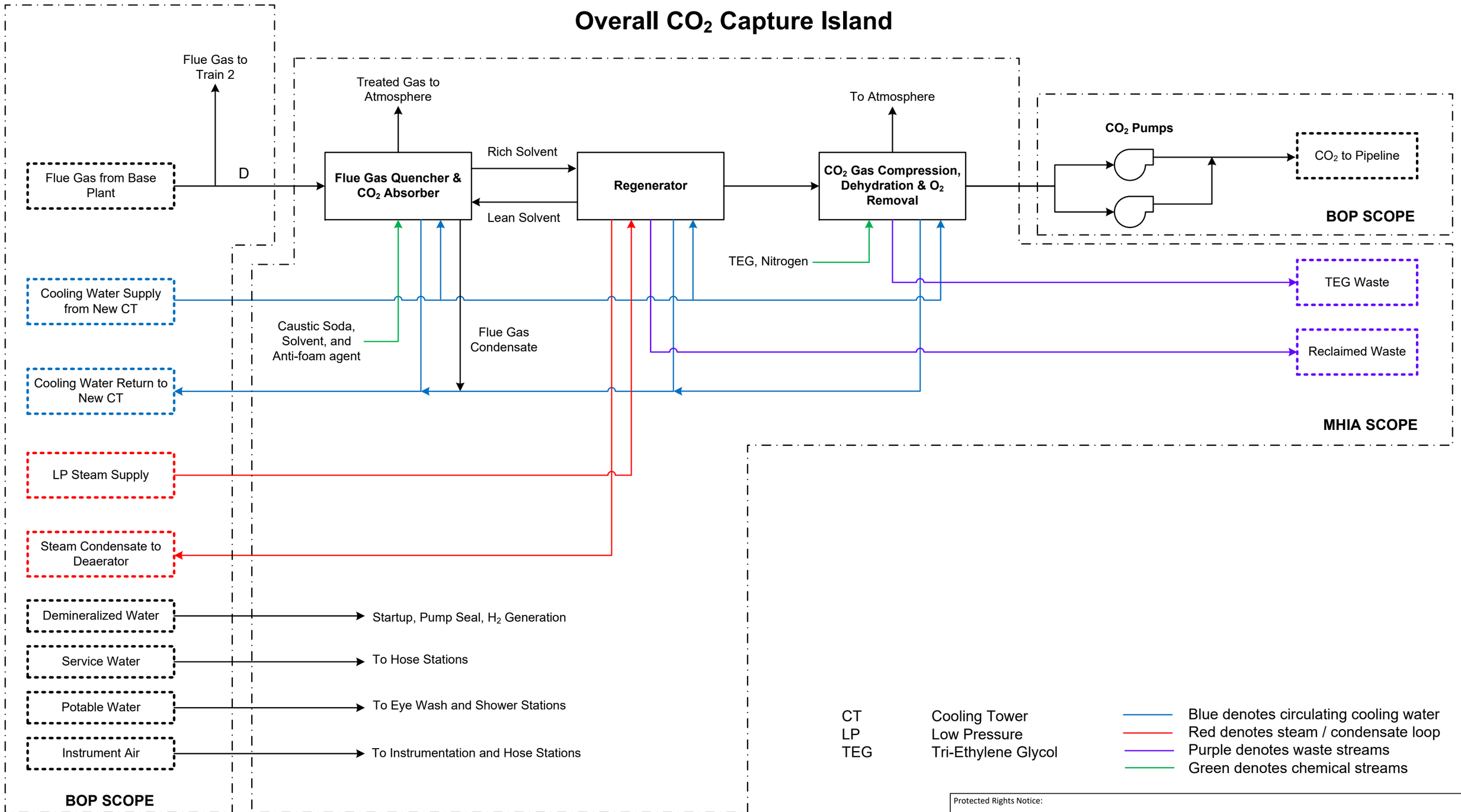
FD	Forced Draft
HP	High Pressure
ID	Induced Draft
IP	Intermediate Pressure
NNF	Normally No Flow
WFGD	Wet Flue Gas Desulfurization



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Overall CO_2 Capture Island



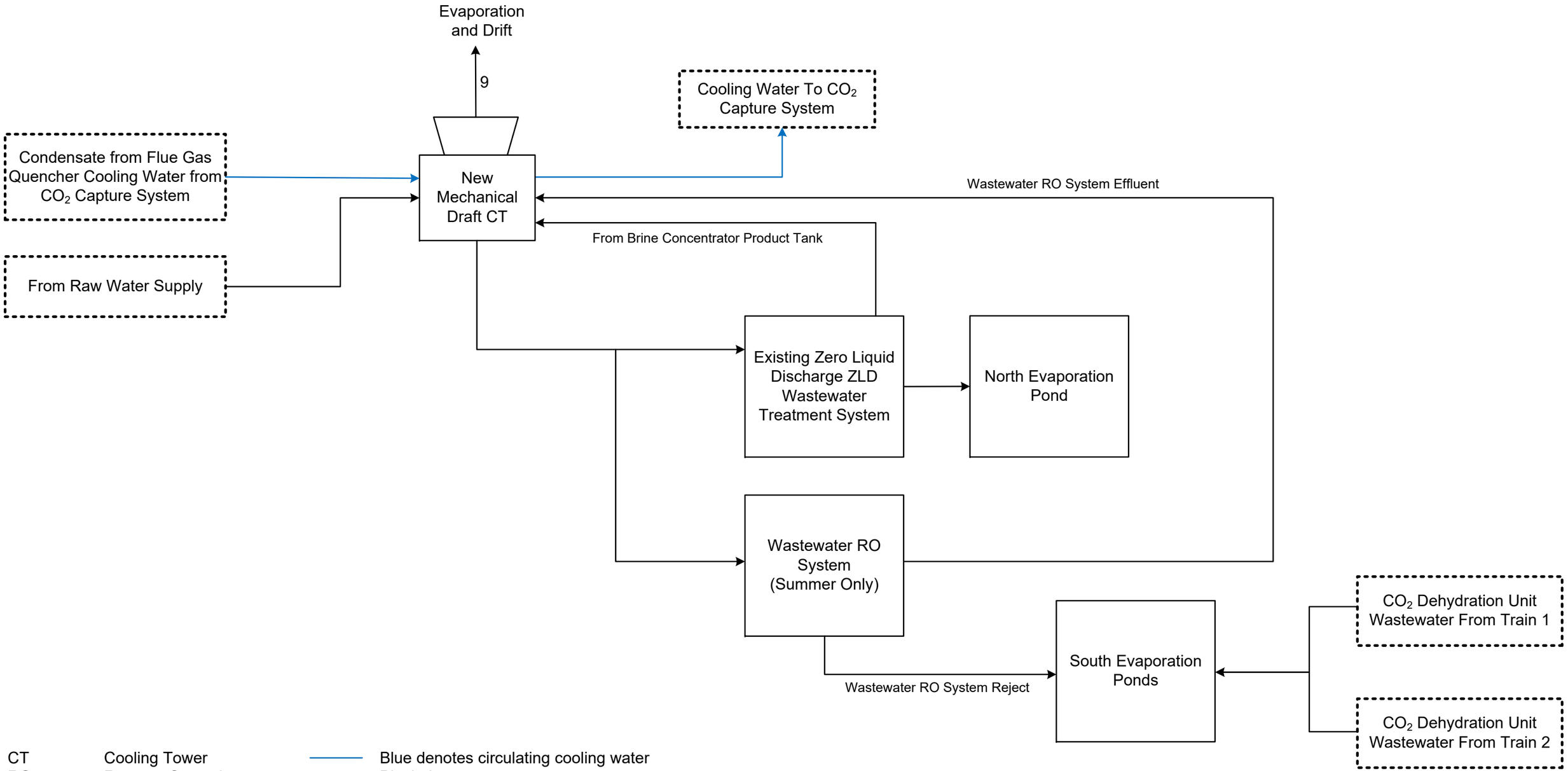
CT	Cooling Tower
LP	Low Pressure
TEG	Tri-Ethylene Glycol

- Blue denotes circulating cooling water
- Red denotes steam / condensate loop
- Purple denotes waste streams
- Green denotes chemical streams

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Balance of Plant PFD



CT Cooling Tower
RO Reverse Osmosis
ZLD Zero Liquid Discharge

Blue denotes circulating cooling water
Black denotes process streams

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01	TRAIN 1 COMPRESSION AREA
02	TRAIN 1 CARBON CAPTURE PROCESS AREA
03	TRAIN 2 CARBON CAPTURE PROCESS AREA
04	TRAIN 2 COMPRESSION AREA
05	CARBON CAPTURE CHEMICAL STORAGE AND PRECOAT FILTER UNIT
06	NEW CONTROL/ELECTRICAL BUILDING
07	BOP MECHANICAL BUILDING (REPORPOSED SWITCHGEAR BUILDING)
08	COMPRESSED AIR EQUIPMENT
09	POTABLE WATER EQUIPMENT
10	UNIT 1 FLUE GAS DUCT
11	UNIT 4 FLUE GAS DUCT
12	COMBINED FLUE GAS DUCT
13	COOLING TOWER
14	EXISTING TRANSMISSION LINES
15	NEW DEMIN PUMPS
16	COOLING TOWER PDC
17	COOLING TOWER CHEMICAL STORAGE
18	CO2 PUMP BUILDING
19	VFD PDCs AND TRANSFORMERS
20	AUXILIARY TRANSFORMERS
21	NEW UNIT 4 AUXILIARY TRANSFORMER
22	NEW UNIT 1 AUXILIARY TRANSFORMER
23	CIRCULATING WATER PUMPS
24	WASTE WATER TREATMENT BUILDING

N 2114000
N 2113500
N 2113000
N 2112500
N 2112000
N 2111500

230 KV SWITCH YARD
MATERIAL LAYDOWN AREA
CONTROL HOUSE
SWITCHGEAR
TRANSFORMER
PIPING WHSE
CONST WHSE
INSULATION WHSE
CONSTRUCTION PARKING LOT
CONST OFFICE
OFFICE
S & R OFFICE
REPRO S & R
START-UP BLDG.
D/H CRANE LAYDOWN AREA
REGEN. WATER LINES
TAKE OFF STRUCT
OIL STOP TANKS
345 KV SWITCHING STATION
VEHICLE MAINT.
CUBE OIL RACK
MAIN TRANS
UNIT #4
UNIT #3
UNIT #2
UNIT #1
BOILER AREA
PRECIP AREA
AIR HEATER AREA
#4 STACK
#3 STACK
#2 STACK
#1 STACK
SO2 ABSORBER AREA
CONDENSATE TANK
ABSORBER MOD
CONTROL ROOM
ELEC EQUIP BLDG
ELECTRICAL EQUIP BLDG
S-R BUILDING
COND TANK
DEWATERING BINS
SETTLING TANK
ASH WATER PUMP HOUSE
REGEN. WATER SURGE TANK
PUMP HOUSE
ABSORBER TANKS
PLANT COAL CONVEYOR
RECLAIM CONVEYOR
ELEC SWGR BLDG
COMPRESSOR BLDG
(MISC TANKS)
TANKS
COOLING TOWER UNIT 4
COOLING TOWER UNIT
SO2 MAKE UP
RO REACTIVATOR CLAR
RO PRE
SAND FILTER
NEUTRAL THICKENER
CENTRATE STO
RCC STO
WASTE WATER RECOV AREA
SODA ASH SILO
LIME SILO
NEUTRAL PREMIX TANKS
FUEL OIL PUMP HOUSE #3 &
FUEL OIL TANK
DRAINAGE STRUCTURE
W/L 5275.3
EFFLUENT POND 3
PRE-POND 3
34A SEWAGE TREATMENT
AUX COOLING TOWER
MOTOR CONTROL CENTER BLDG
CHEMICAL PLANT SHOPS & WHSE
WAREHOUSE
OFFICE
STO TANK
SODA ASH DRIED PURGE BIN
AIR COMPRESSOR BLDG
ASHWATER STORAGE BIN
PUMP HSE
SETTLING TANK
SURGE TANK
ASH HANDLING UNIT #4
WR
VETOR

100' 0 100' 200' 300'
GRAPHIC SCALE

DRAWING SCALE
1" = 100'-0"

NOTE:
1. CARBON CAPTURE SYSTEM DETAIL NOT SHOW FOR CONFIDENTIALITY PURPOSES.

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TEXT	ALL TEXT

REVISIONS

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SITE LAYOUT DRAWING
GENERAL ARRANGEMENT

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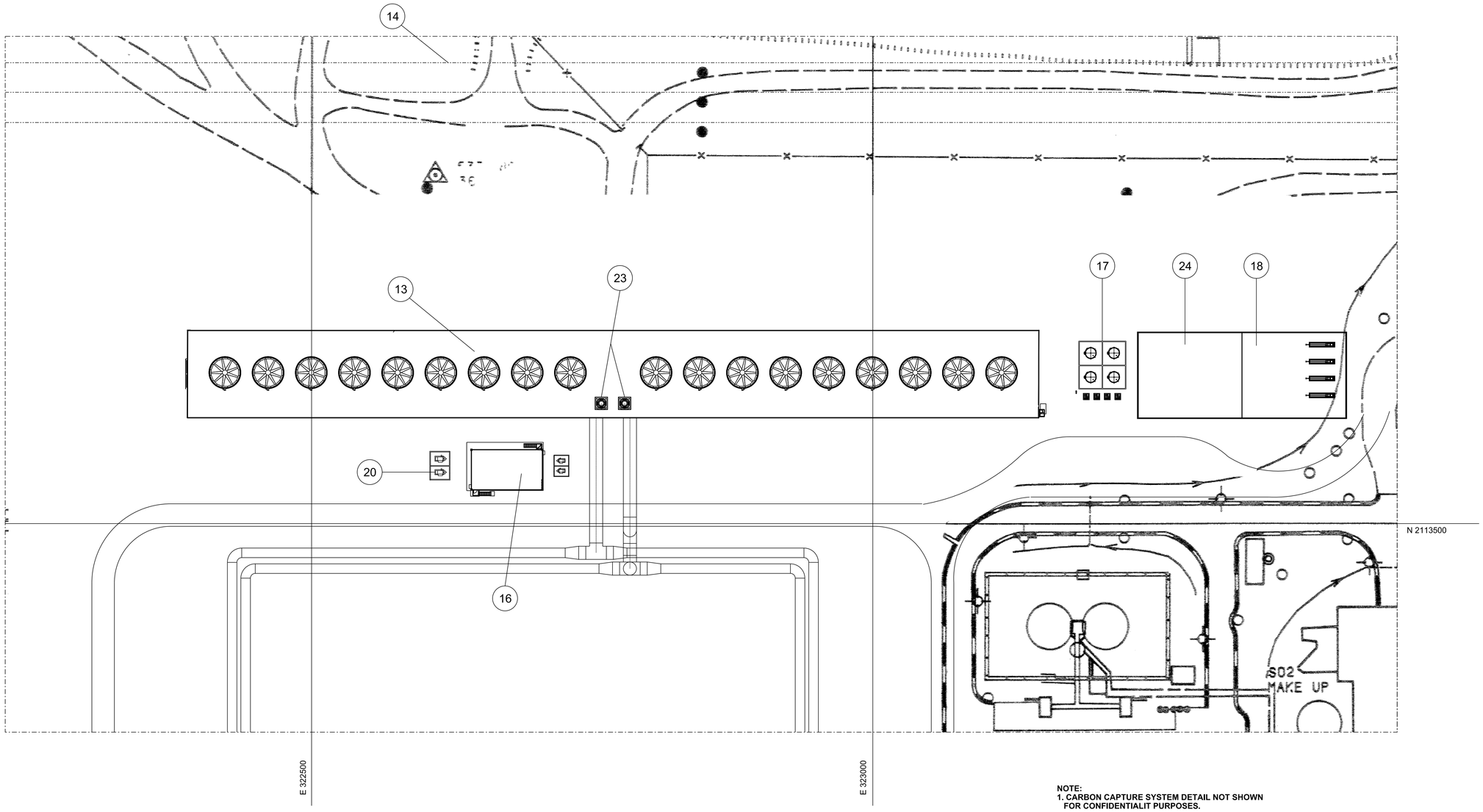
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ACAD FILE: M0-5001

ENCHANT ENERGY CORPORATION

DRAWING NO. M0-5001
SHEET NO. 1
REVISION NO. A

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

13	COOLING TOWER
14	EXISTING TRANSMISSION LINES
16	COOLING TOWER PDC
17	COOLING TOWER CHEMICAL STORAGE
18	CO2 PUMP BUILDING
20	AUXLIARY TRANSFORMERS
23	CIRCULATING WATER PUMPS
24	WASTE WATER TREATMENT BUILDING



NOTE:
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NORTH

40' 0 40' 80' 120'
GRAPHIC SCALE

DRAWING SCALE
1" = 40'-0"

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TEXT	ALL TEXT

REVISIONS						
NO.	DATE	DESCRIPTION	BY	CHK'D	OKD	APP'D
1	11-23-21	FOR CLIENT COMMENTS	MB	RAM	---	---

COOLING TOWER
GENERAL ARRANGEMENT

DRAWN BY:	DATE:	CHECKED:	OK'D:	APPROVED:
MB	11-23-21	RAM	---	---

SCALE
1" = 40'-0"
ACAD FILE:
M0-5002

ENCHANT ENERGY CORPORATION

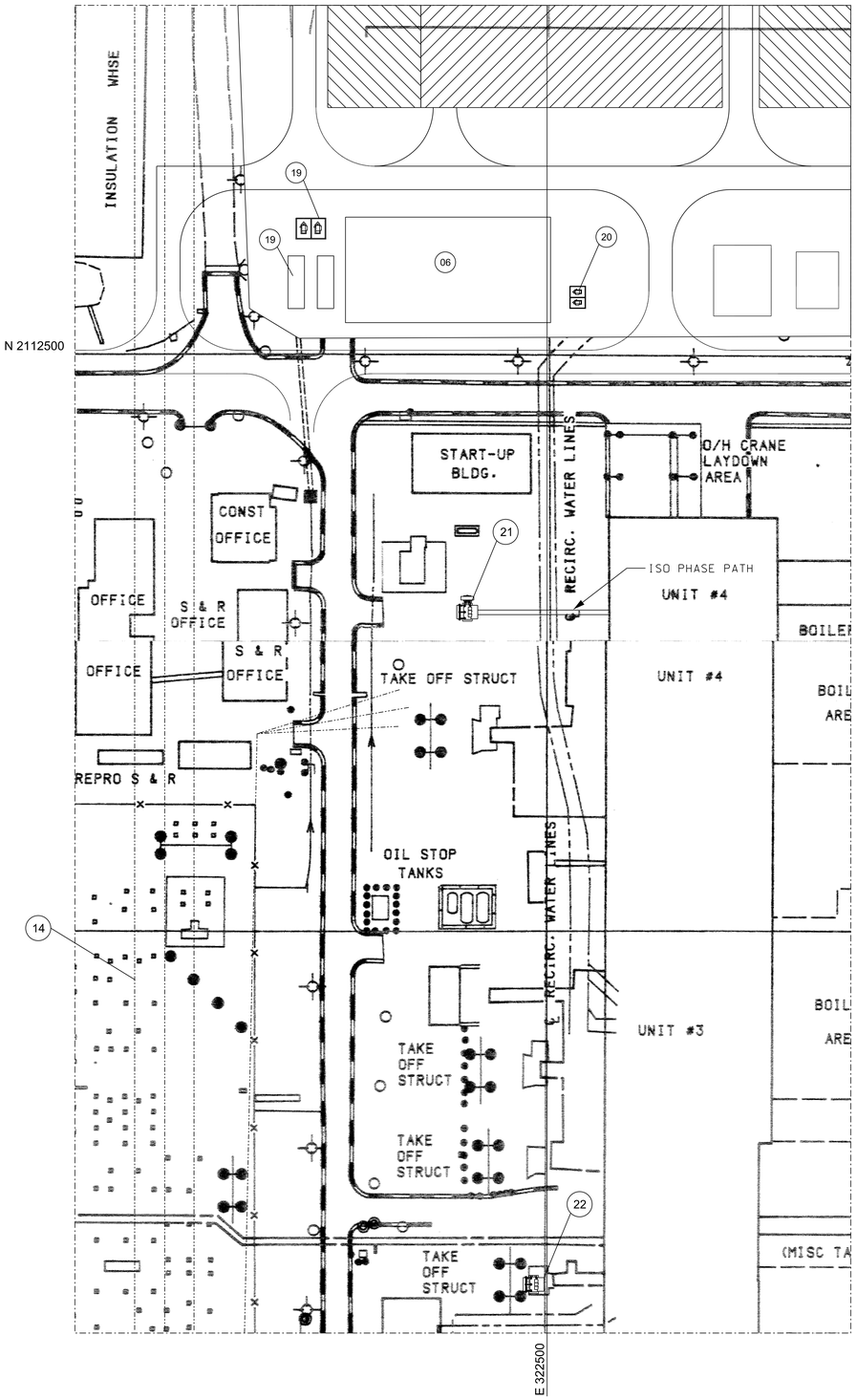
DRAWING NO.
M0-5002

SHEET NO.
1

REVISION NO.
A

A B C D E F G H

06	NEW CONTROL/ELECTRICAL BUILDNG
14	EXISTING TRANSMISSION LINES
19	VFD PDCS AND TRANSFORMERS
20	AUXLIARY TRANSFORMERS
21	NEW UNIT 4 AUXILIARY TRANSFORMER
22	NEW UNIT 1 AUXILIARY TRANSFORMER



NOTE:
1. CARBON CAPTURE SYSTEM DETAIL NOT SHOWN FOR CONFIDENTIALIT PURPOSES.

NORTH

50' 0 50' 100' 150'
GRAPHIC SCALE

DRAWING SCALE
1" = 50'-0"

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TEXT	ALL TEXT

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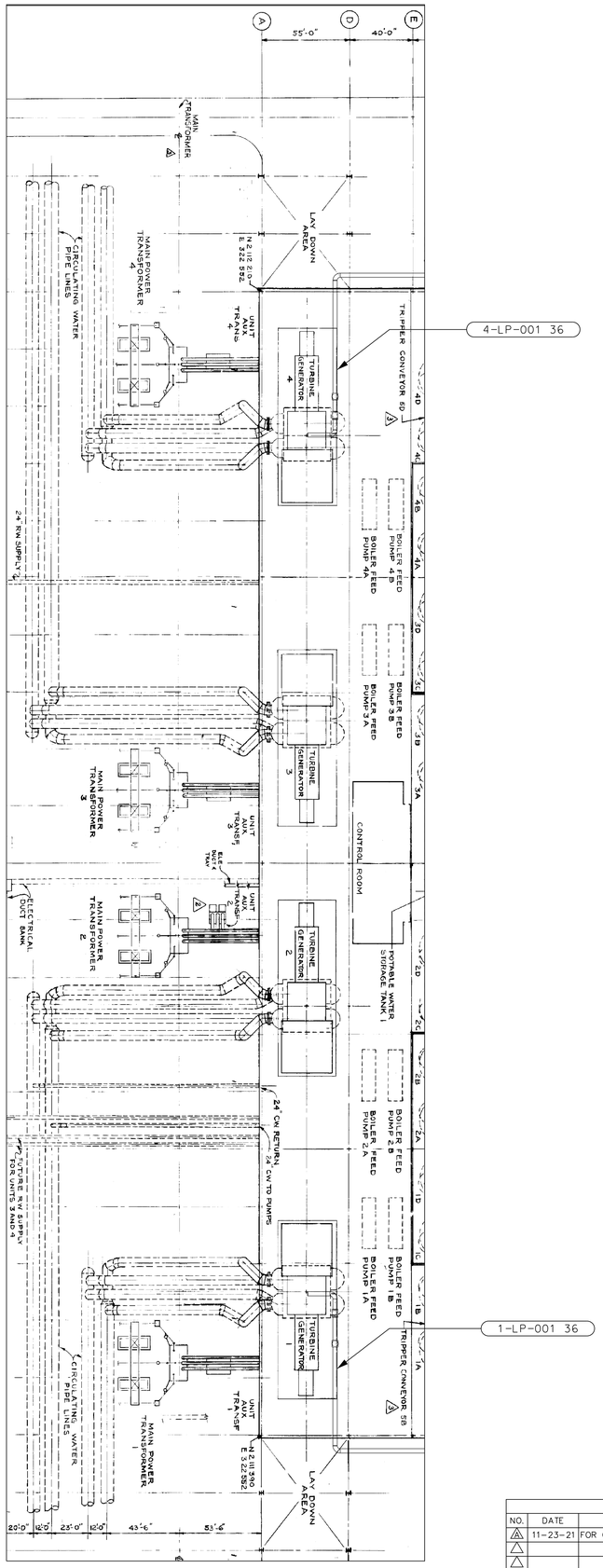
ELECTRICAL GENERAL ARRANGEMENT

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MB	11-23-21	RAM	---	---

SCALE: 1" = 50'-0"
ACAD FILE: M0-5003

ENCHANT ENERGY CORPORATION

DRAWING NO. M0-5003
SHEET NO. 01
REVISION NO. A



NORTH

50' 0 50' 100' 150'

GRAPHIC SCALE

DRAWING SCALE
1" = 50'-0"

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TURBINE PIPING
GENERAL ARRANGEMENT

DRAWN BY:	DATE:	CHECKED:	OK'D:	APPROVED:
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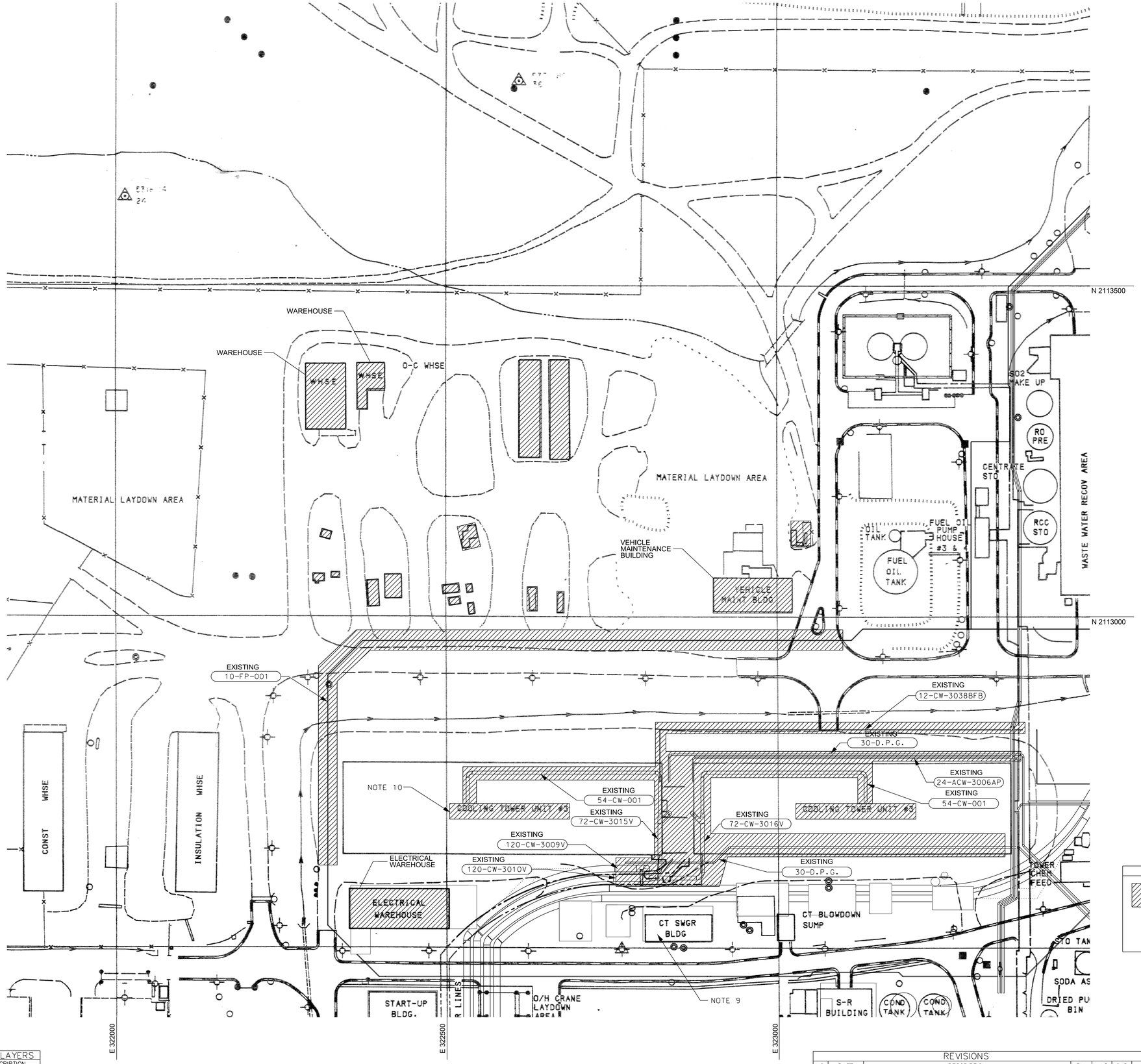
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ACAD FILE:
M0-5004

ENCHANT ENERGY CORPORATION

DRAWING NO.
M0-5004

SHEET NO.
01

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(B) BE PERFORMED EXCLUSIVELY BY ITS TRAINED, COMPETENT PERSONNEL, OR, WHERE PERMITTED, THAT OF ITS SUBCONTRACTOR(S); AND
(C) COMPLY WITH ALL APPLICABLE SAFETY LAWS, REGULATIONS, PROGRAMS AND PRACTICES TO ENSURE THE SAFETY OF ALL PEOPLE LOCATED ON THE WORK SITE, INCLUDING THE CONTRACTOR'S/INSTALLER'S PERSONNEL (OR THAT OF ITS SUBCONTRACTOR(S)) PERFORMING THE WORK.

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3. REFERENCES USED HAVE BEEN IDENTIFIED ON EXCAVATION/FOUNDATION/DEMOLITION DRAWINGS AND HAVE BEEN PROVIDED TO ASSIST THE CONTRACTOR/INSTALLER IN THE FIELD LOCATING EXISTING UTILITIES AND OTHER POTENTIAL UNDERGROUND OR EMBEDDED INTERFERENCES. THESE REFERENCES ONLY SHOW THE APPROXIMATE LOCATION OF POTENTIAL UNDERGROUND OR EMBEDDED UTILITIES AND MAY NOT INDICATE OR REFLECT ALL EXISTING UNDERGROUND OR EMBEDDED UTILITIES OR THEIR ACTUAL LOCATIONS.

4. REFERENCES IDENTIFIED SHALL NOT SUBSTITUTE FOR THE CONTRACTOR'S/INSTALLER'S OBLIGATION TO FIELD LOCATE ANY UNDERGROUND OR EMBEDDED UTILITIES OR INTERFERENCES THAT MAY AFFECT THE WORK.

5. DUE CAUTION SHALL BE TAKEN DURING ANY EXCAVATION/FOUNDATION/DEMOLITION WORK WITHIN THE AREA OF AND ADJACENT TO THE LIMITS OF THE WORK DUE TO POSSIBLE INTERFERENCES THAT MAY NOT BE REFLECTED ON THE REFERENCES IDENTIFIED.

6. UNDERGROUND OR EMBEDDED UTILITIES ARE (OR MAY BE) LOCATED WITHIN OR ADJACENT TO THE AREA IN WHICH EXCAVATION, DEMOLITION, FOUNDATION, OR MODIFICATION WORK IS TO BE PERFORMED.

REFERENCES RELATING TO THE UNDERGROUND OR EMBEDDED UTILITIES ARE PROVIDED TO ASSIST THE CONTRACTOR/INSTALLER IN THE FIELD LOCATING THOSE UTILITIES AND OTHER POSSIBLE UNDERGROUND OR EMBEDDED INTERFERENCES WITH THE WORK.

THE CONTRACTOR/INSTALLER SHALL EXERCISE DUE CAUTION DURING ALL EXCAVATION/FOUNDATION/DEMOLITION WORK.

7. ALL EXISTING CONCRETE MAY CONTAIN EMBEDDED CONDUIT WITH ENERGIZED CIRCUITS OR OPERABLE UTILITIES THAT ARE NOT IDENTIFIED ON, OR ARE IN LOCATIONS OTHER THAN AS INDICATED ON, S&L DESIGN DRAWINGS OR OTHER DRAWINGS. IT IS THE CONTRACTOR'S RESPONSIBILITY TO FIELD LOCATE AND IDENTIFY ALL EMBEDDED ITEMS PRIOR TO STARTING THE WORK.

8. THIS DRAWING HAS BEEN DRAWN BY OR REPRODUCED FROM A DRAWING PREPARED BY AN ORGANIZATION OTHER THAN SARGENT & LUNDY. SARGENT & LUNDY IS NOT RESPONSIBLE FOR WORK COMPLETED BY OTHER ORGANIZATIONS.

9. PORTIONS OF EXISTING EQUIPMENT AND UTILITIES WITHIN THIS BUILDING MAY REQUIRE DEMOLITION TO FACILITATE INSTALLATION OF NEW EQUIPMENT AND FACILITIES.

10. ALL PORTIONS OF COOLING TOWER AND BASIN TO BE DEMOLISHED.

11. EXISTING UNIT 3 CW PIPING CAN BE REMOVED OR FILLED WITH CONCRETE/GROUT.

12. OTHER EXISTING BURIED PIPE TO BE ABANDONNED IN PLACE. REMOVE SECTIONS OF EXISITNG PIPE WHERE NECESSARY TO FACILITATE INSTALLION OF NEW PIPING, ELECTRICAL DUCT BANK, FOUNDATIONS, ETC.

LEGEND

TO BE DEMOLISHED

NORTH

60' 0 60' 120' 180'
GRAPHIC SCALE

DRAWING SCALE
1" = 60"

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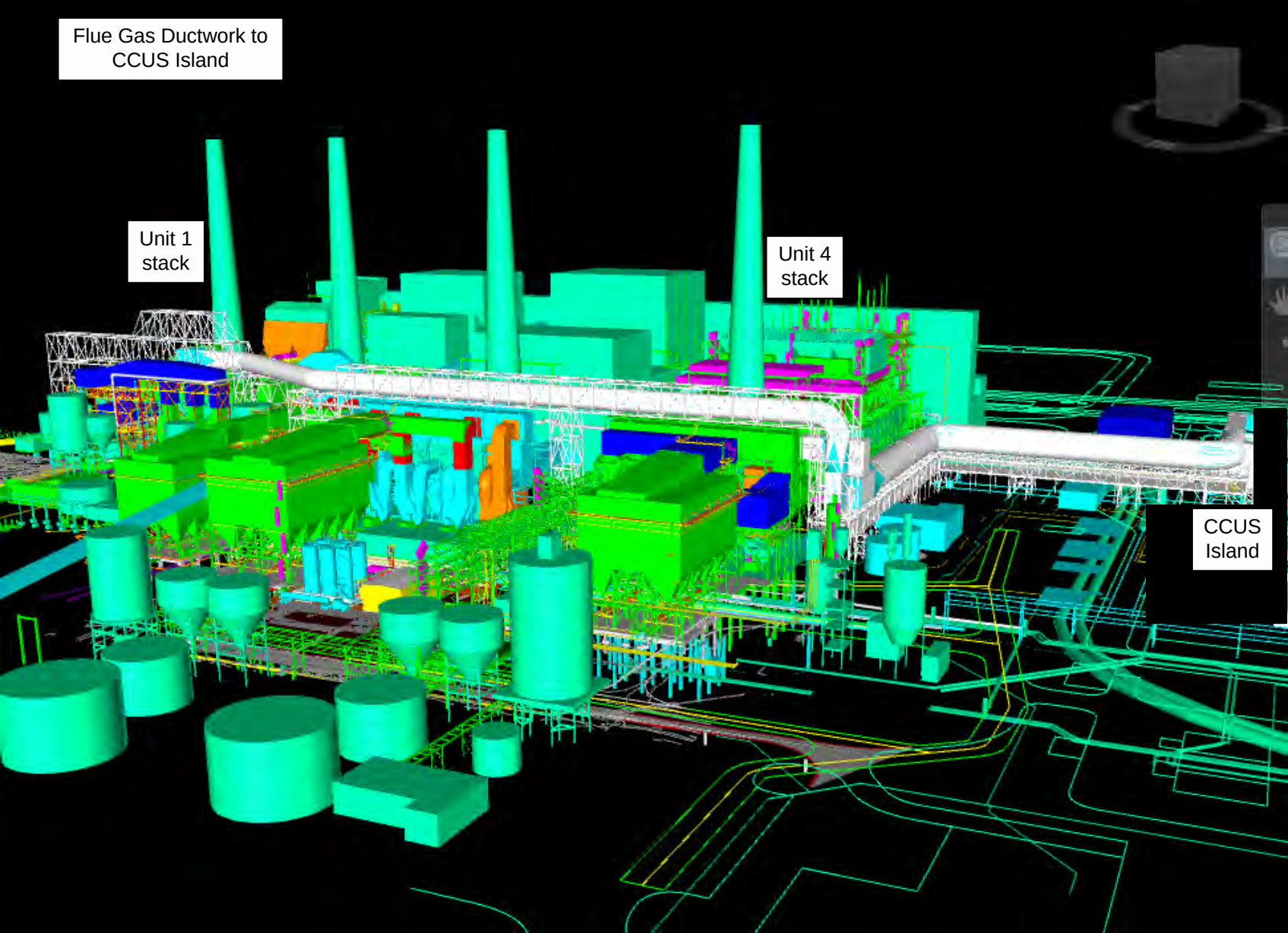
COOLING TOWER AREA
DEMO DRAWING

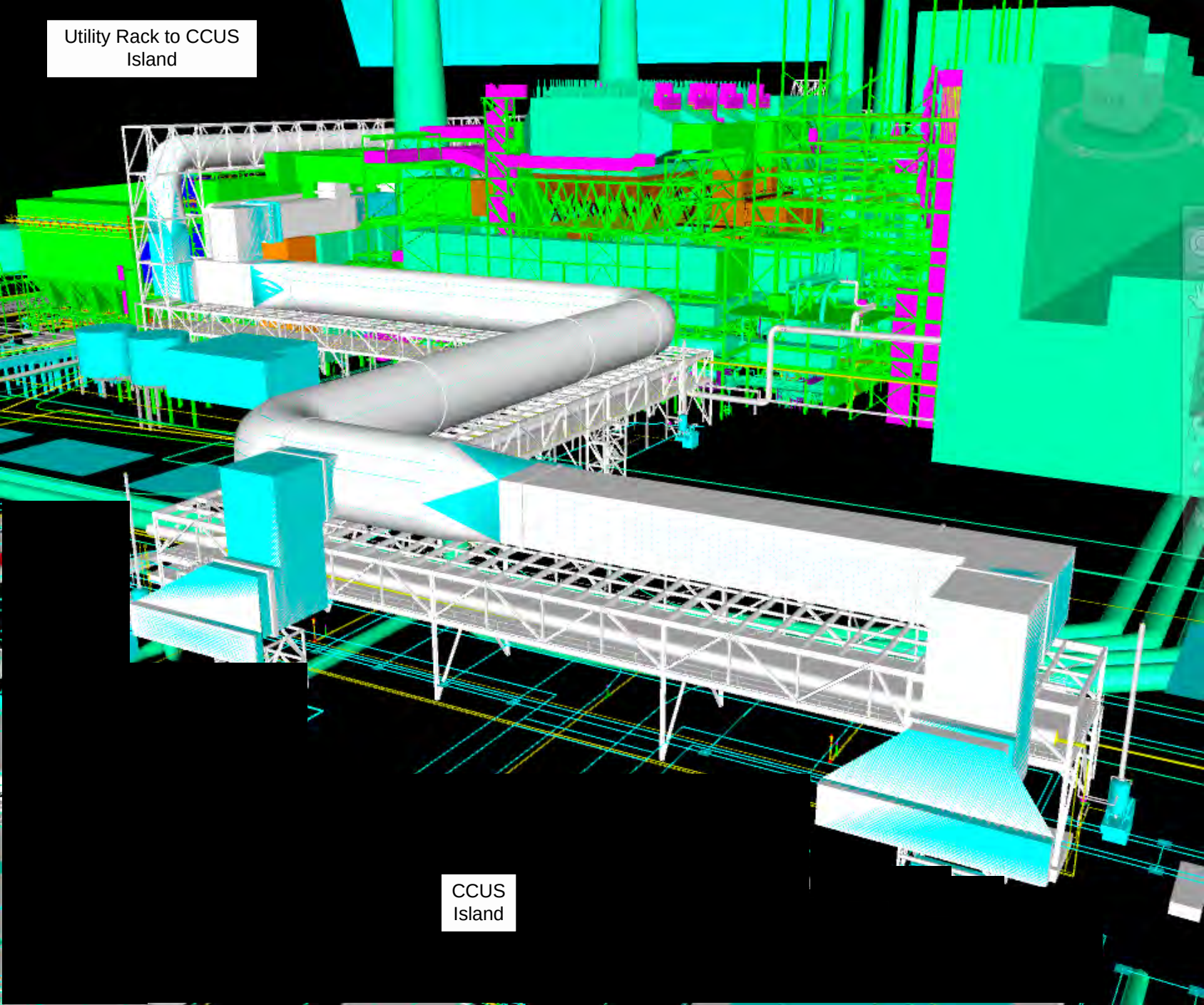
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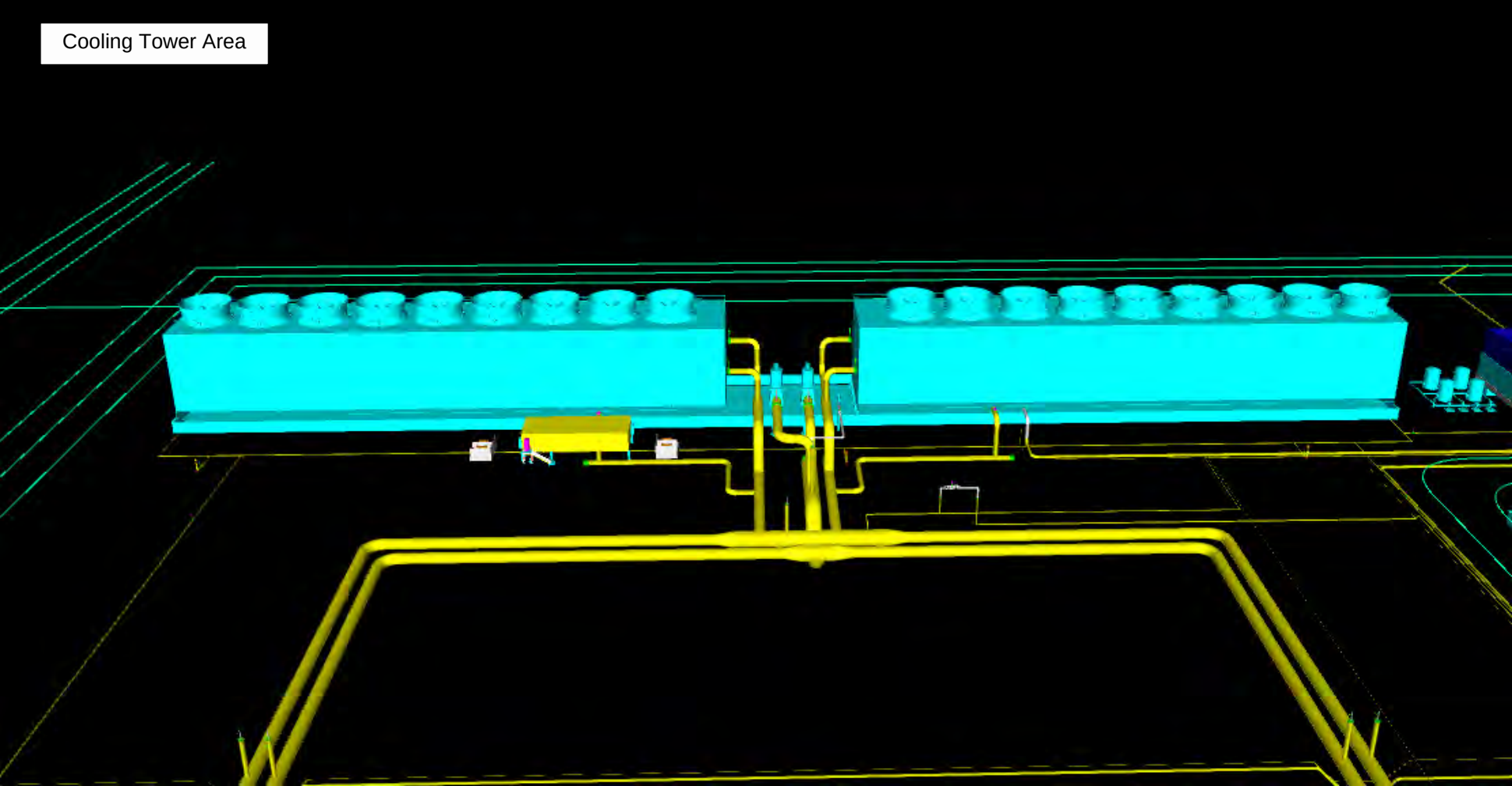
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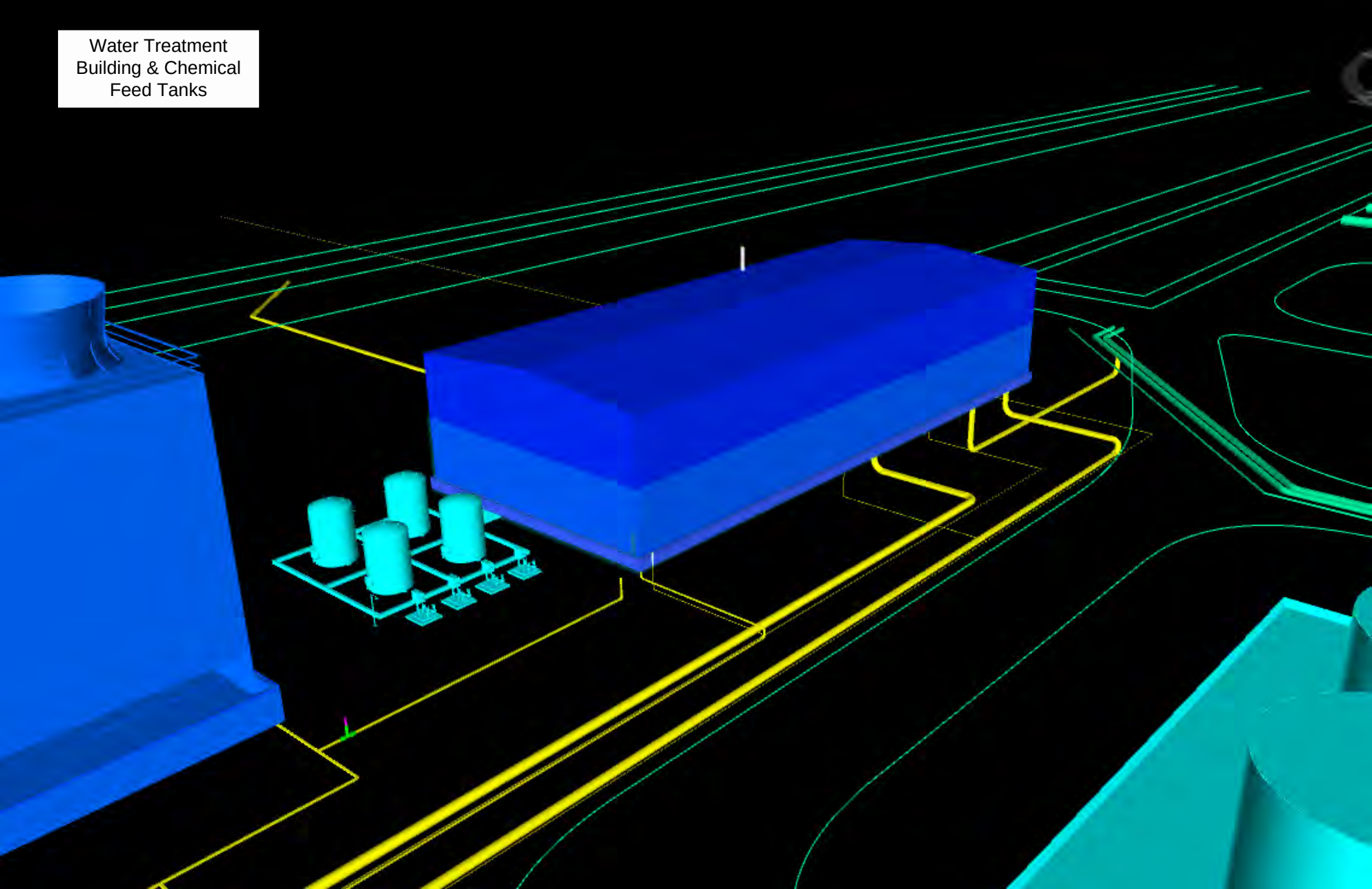
ENCHANT ENERGY CORPORATION

DRAWING NO. M0-5005
SHEET NO. 01
REVISION NO. A


Flue Gas Ductwork to CCUS Island
Unit 1 stack
Unit 4 stack
CCUS Island


Utility Rack to CCUS Island
CCUS Island


Cooling Tower Area


Water Treatment
Building & Chemical
Feed Tanks

Appendix D. Steam & Electric Sourcing Study

Enchant Energy
San Juan Generating Station – Units 1 & 4

Carbon Capture (CO_2) Steam and Electric Sourcing Study

Issued For FEED

Revision B

January 19, 2022
Project No. A13981.010

Prepared by

Sargent & Lundy
55 East Monroe Street • Chicago, IL 60603 USA • 312-269-2000
www.sargentlundy.com

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ISSUE SUMMARY

Revision & Purpose	Date	Prepared	Reviewed	Approved
A Client Comments	September 23, 2021	M. Zitkus	C. Hornish	--
B Issued for FEED	January 19, 2022	M. Zitkus	C. Hornish	C. Hornish

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2. CCUS Steam Sourcing 5
3. Steam Turbine impacts 6
4. CCUS Electric Sourcing 7
5. Summary and Conclusions 7

1. Introduction

The San Juan Generating Station (SJGS) facility is a nominal 847 MW-net coal-fired power plant located in northwest New Mexico approximately 15 miles northwest of the City of Farmington ("Farmington"). SJGS currently has two operating coal-fired utility boilers, Unit 1 and Unit 4, and two recently retired units, Units 2 and 3. The retired units have been left in place with much of the auxiliary equipment decommissioned. The operating Units 1 and 4 will be retrofitted with carbon capture utilization and sequestration (CCUS) technology. The CCUS system will be a centralized arrangement to treat the combined flue gas flows from Units 1 and 4.

Mitsubishi Heavy Industries (MHI) KM CDR Process™ is the selected technology for the SJGS CCUS system. This process requires a large amount of steam and electricity for operation. Steam extraction from SJGS steam turbines to supply the carbon capture system is one potential source of this steam.

The purpose of this study will be to evaluate the impacts of steam extraction to the plant steam cycle and outline next steps for the Steam Turbine OEM to evaluate what modifications or limitations are required, if any, to support such extraction.

2. CCUS Steam Sourcing

MHI's CCUS system requires a large amount of steam to heat the CO_2 solvent and capture the CO_2 absorbed from the flue gas stream.

Table 2-1: Steam Requirements

Parameter	Data
Steam flow	2,502,800 lb/hr

Note this requirement is for treating the flue gas at both Units 1 and 4. The extraction steam portions from both units was ratioed based on the unit's maximum main steam flow. MHI has confirmed the flexibility of the pressure and temperature for a few operating conditions. Slight superheat of the steam supplied is acceptable, up to 5 °F. MHI's system will accept lower pressures at lower plant operating loads, however, this will impact the efficiency of the system. The heat balances include a slight margin on temperature and pressure to account for piping losses to the carbon capture facility.

Due to the large amount of steam required, only extraction from the existing steam cycle was considered. A new auxiliary boiler or cogeneration plant are other options for generating the required steam and electricity, but these were not evaluated due to the much higher expected cost of these systems and additional carbon capture treatment required.

Based on previous experience, steam was sourced from the IP/LP crossover piping. This provides an extraction location with steam conditions available close to the carbon capture required pressures

and temperatures. Extracting steam from farther upstream in the cycle causes a larger performance reduction and requires additional steam conditioning compared to the IP/LP crossover.

Less steam flow is required during startup of the carbon capture island, only around 20% to 30% of the full load flow. In the event that either Unit 1 or 4 are offline and the other Unit is in startup mode, the source of steam for the carbon capture system will need to come from the main steam system of the Unit that is in startup operation. Main steam will be the first available steam source. Steam from the IP/LP crossover will not be available for much of the startup sequence since steam is not admitted to the steam turbine until late in the sequence and the steam turbine will require several hours for warmup and heat soak. Using main steam also avoids potential HP-IP turbine imbalance issues with extracting from the reheat system.

The carbon capture island condenses the steam and returns the condensate to the cycle at significant temperature. Two locations where this hot water could be integrated back into the cycle were considered, the deaerator and the condenser. Returning to the deaerator more closely matches the water temperatures. Returning to the condenser potentially simplifies operation by cooling the water further and returning it to the normal feedwater heating cycle. Based on further heat balance analysis, the deaerator was selected as the return location because returning to the condenser reduces total output from both units by about 27MW.

3. Steam Turbine Impacts

3.1 Current Heat Balances

Extracting large portions of the flow from the steam turbine forces operation to a mode not originally designed for by the OEM. Further evaluation of extraction operation by the OEM is required to fully validate this operating mode is acceptable or to explore modifications necessary to allow for extraction.

One common modification used in these heat balances is the installation of a crossover backpressure valve. This valve would be downstream of the extraction piping connecting to the IP/LP crossover and upstream of the LP turbine inlet. By adjusting this valve to maintain backpressure on the IP turbine, the impact of extraction on the STG can be potentially limited to the LP turbine. The IP turbine would experience pressures identical to normal operation. Only the LP turbine would experience pressures not consistent with normal operation when extraction is in service. This valve also allows for operating at lower loads – without it, the IP/LP crossover pressure would drop to below the extraction required pressure at a much higher load.

Low load scenarios were also evaluated to determine if the boiler or the steam turbine are expected to be the limiting factor. For Unit 1 with extraction in service, the LP turbine reaches the typical exhaust temperature limit of 175°F before the boiler minimum load. There may be other windage heating issues with the Unit 1 steam turbine at low loads. For Unit 4 with extraction in service, there

were no thermodynamic limits on the steam cycle encountered before the boiler minimum load.

3.2 OEM Next Steps

As noted above, the STG OEM needs to evaluate the STG for extraction operation. The first steps would be to perform high-level reviews of the S&L heat balances and STG design to identify any critical flaws and initial confirmation that extraction is possible for the steam turbines at SJGS.

Next, the OEM would need to develop conceptual modifications and initial performance impacts and cost estimates. Support of S&L design work to incorporate these modifications would also be performed at this stage.

Final costs and detailed assessments of all modes of operation (low load, startup, shutdown, etc.) is the last stage. This would also include any new equipment and controls updates, with support for installation.

4. CCUS Electric Sourcing

The carbon capture facility is expected to require approximately 170MVA total for both trains (160MW). This additional auxiliary power is not included in the steam derates or heat balances and would be an additional parasitic consumer on the net power output and net heat rates.

Sourcing this power from the plant or the grid is the only option available, as a cogeneration alternative that would provide additional power was previously ruled out. Power will be sourced from each unit's generator bus, sized so either unit can support the full facility load for redundancy.

5. Summary and Conclusions

This study establishes the performance impacts of steam extraction from the SJGS for carbon capture and outlines the next steps for the STG OEM.

In total, both units combined lose approximately 200MW in gross generation by extracting steam at full load. When extracting steam, minimum load for Unit 1 is determined by the LP turbine exhaust overheating and minimum load for Unit 4 is determined by the boiler minimum steam generation. It is possible that OEM review can identify modifications to both units to enhance the minimum load, if desired.

The use of a crossover backpressure valve can minimize the modifications to the STG required to operate with steam extraction and allow for lower load extraction operation.

Further evaluation of these heat balances and the impacts of steam extraction by the STG OEM are recommended as next steps.

Appendix E. Cooling Study

Enchant Energy
San Juan Generating Station – Units 1 & 4

CO_2 Capture Cooling Study

Issued For FEED

Revision B

February 3, 2022
Project No. A13891.010

Prepared by

Sargent & Lundy
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ISSUE SUMMARY

Revision & Purpose	Date	Prepared	Reviewed	Approved
A Client Comments	August 27, 2020	C. Hornish	E. Kunkle	--
B Issued for FEED	January 19, 2022	C. Goodenough	C. Hornish	C. Hornish

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APPENDICES:

A – UNIT 3 COOLING SYSTEM DATA
B – UNIT 3 COOLING TOWER RETROFIT QUOTATION
C – SUPPLEMENTAL COOLING TOWER QUOTATION
D – NEW COOLING TOWER QUOTATION
E – EXISTING CIRCULATING WATER PIPING DRAWINGS

1. Introduction

The San Juan Generating Station (SJGS) facility is a nominal 847 MW-net coal-fired power plant located in northwest New Mexico approximately 15 miles northwest of the City of Farmington ("Farmington"). SJGS currently has two operating coal-fired utility boilers, Unit 1 and Unit 4, and two recently retired units, Units 2 and 3. The retired units have been left in place with much of the auxiliary equipment mothballed. The operating Units 1 and 4 will be retrofitted with carbon capture utilization and sequestration (CCUS) technology. The CCUS system will be a centralized to treat the combined flue gas flows from Units 1 and 4.

Mitsubishi Heavy Industries (MHI) KM CDR Process™ is the selected technology for the SJGS CCUS system. Their process requires a tremendous amount of heat rejection. The only feasible source of cooling from SJGS to support this large of a load is from large evaporative cooling towers. The Unit 3 cooling tower, which has not been operated since the end of 2017, is still intact and is large enough to potentially provide a large portion of the heat rejection. The Unit 2 cooling tower was demolished a few years ago, but the basin and foundation are still intact and could potentially be used for a new supplemental tower that would be sized to provide the balance of the required heat rejection.

The purpose of this study will be to evaluate the cooling system requirements and implementation required for the SJGS CCUS project. This evaluation will look at the impacts to the general arrangement, cooling water piping, and high-level costs for two options: 1) The feasibility of the existing Unit 2 and 3 facilities being able to support the required heat rejection; and 2) Completely new cooling tower(s).

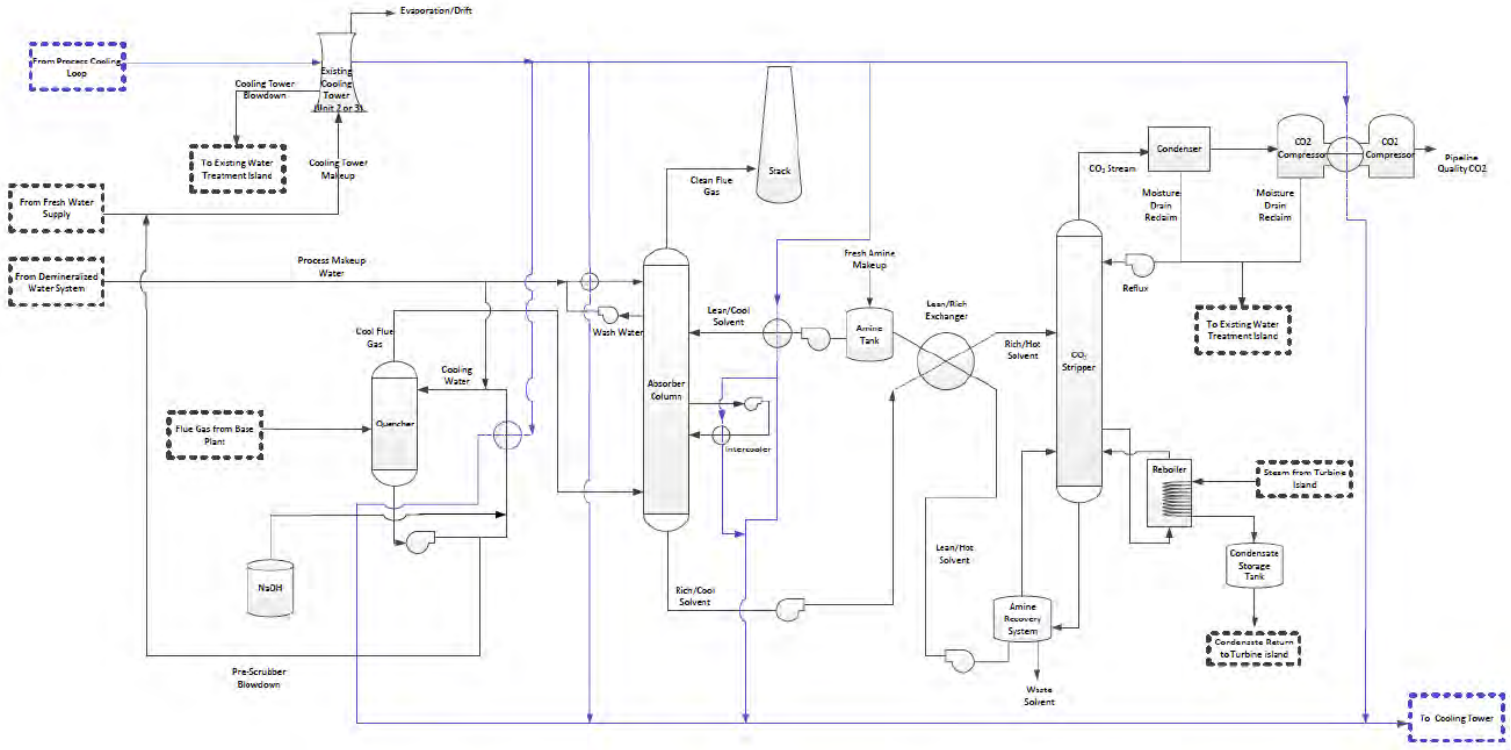
2. CCUS Cooling Requirements

MHI's CCUS system absorbs a large amount of heat energy throughout the process, which must be rejected through various heat exchangers (as shown in Figure 2-1). During the preliminary investigation of this project back in 2019, MHI provided estimated performance data based on the anticipated CCUS system design capacity. The cooling water demand was estimated to be 106,000 ston/hr (approximately 425,000 gpm). Later in the FEED study, MHI revised this number. In addition, MHI provided input on the cooling design in February 2020 indicating that colder cooling water would provide a cost benefit to their CCUS system design.

At this time, MHI has not provided any further information. It is expected that once MHI develops their design basis for this project, the cooling data will not significantly change. Therefore, the data from 2019 will serve as the basis for this study (*See Note 1 in Section 10 for updated information*).

Due to the large cooling water volume, the heat rejection can only be accomplished at SJGS using large evaporative cooling towers. At a cooling water flow of 425,000 gpm, this is similar to cooling the steam exhaust of a 850-900 MW steam turbine. This would be in the range of the combined capacity of the decommissioned San Juan Units 2 and 3. Therefore, the existing Unit 3 cooling tower and a re-built Unit 2 tower present a good opportunity to accomplish the required cooling.

Figure 2-1: CO_2 Capture Block Diagram

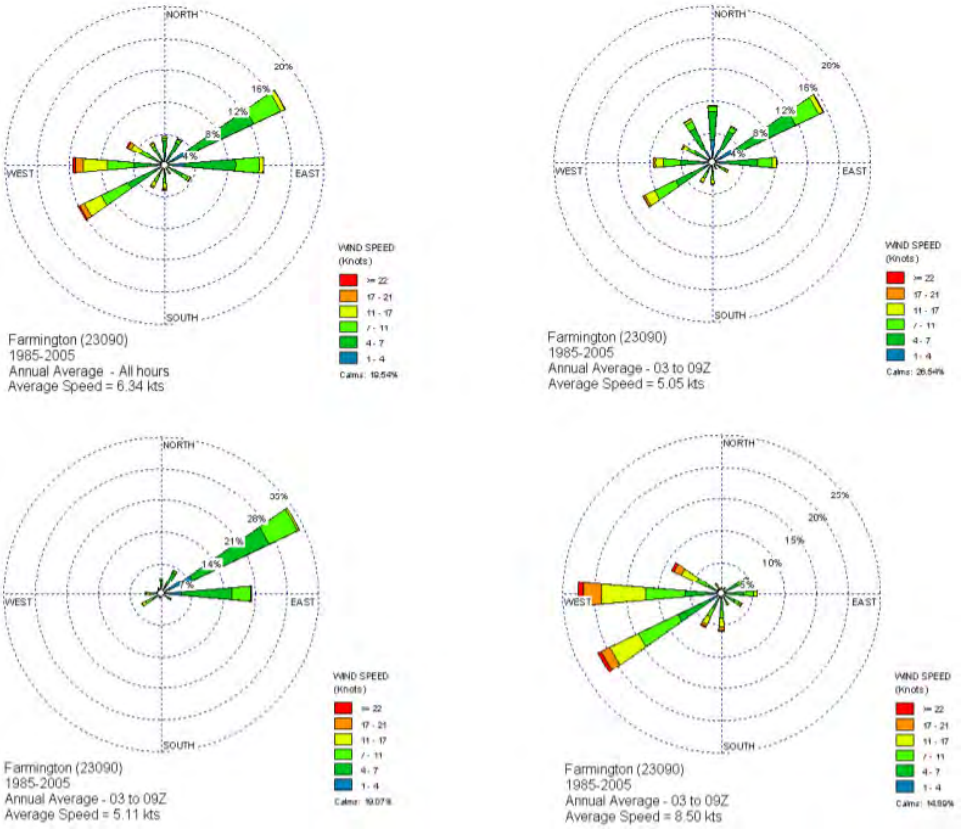


The conditions at the San Juan site are to be considered in this evaluation. Table 2-1 shows the applicable conditions to be utilized in the cooling system design, while Figure 2-2 shows the annual average wind roses.

Table 2-1: Site Conditions

Parameter	Data
Nearest ASHRAE (2017 Fundamentals) weather data location	Farmington Four Corners, NM
Evaporation wet bulb temperature, 0.4% occurrence	64.6°F
Mean coincident dry bulb temperature	81.4°F
50-year occurrence dry bulb temperatures (1):	
High	105.6°F
Low	-14.1°F

Figure 2-2: Annual Average Wind Roses for Farmington, NM



The evaporative wet bulb temperature is important to determine how cold of cooling water can be achieved. Typically, with cooling tower applications, we apply a 2°F recirculating allowance, meaning the design wet bulb would be 66.6°F. Large evaporative cooling towers can be designed for close approach temperatures (approach is the difference between cold water temperature and maximum wet bulb temperature), but usually it's not cost effective to design them for anything less than a 10°F approach. With MHI asking for an 80°F cooling water supply temperature (approach of 13.6°F), it appears this could be reasonably achieved, depending on the evaluation of the Unit 3 cooling tower.

The winds roses are useful in identifying the ideal orientation of the cooling towers. Orienting the tower with its longitudinal dimension parallel to the prevailing wind direction will minimize wind effects on its performance. This is because as wind first encounters the relatively high, narrow end of the tower, and the small negative pressure zone at the far end is easily filled by wind flowing around the vertical sides. Additionally, wind moving parallel to the line of fans causes the separate effluents from each fan cylinder to stack up one on another forming a concentrated plume of greater buoyancy. The Unit 3 cooling tower is installed in an east-west direction, ideal for the prevailing wind direction. The Unit 2 cooling tower basin is oriented in a northwest-southeast direction, so a

new tower installed in this location would need to consider the wind affects in its design. Lastly, a new cooling tower located on the site should be oriented in an east-west direction.

3. Unit 3 Cooling Tower

3.1 Original Design Conditions

The Unit 3 cooling tower was originally designed as a parallel air path wet-dry water conservation tower and was provided by Marley (now part of SPX). It consisted of two (2) 5 cell towers, with each cell consisting of four (4) 200 hp dry section fans and one (1) 100 hp wet section fan. The tower was originally designed to reject heat from the Unit 3 steam turbine with gross rating of 565 MW plus the heat load from the SO2 system primary condenser. Below is a summary of the design conditions:

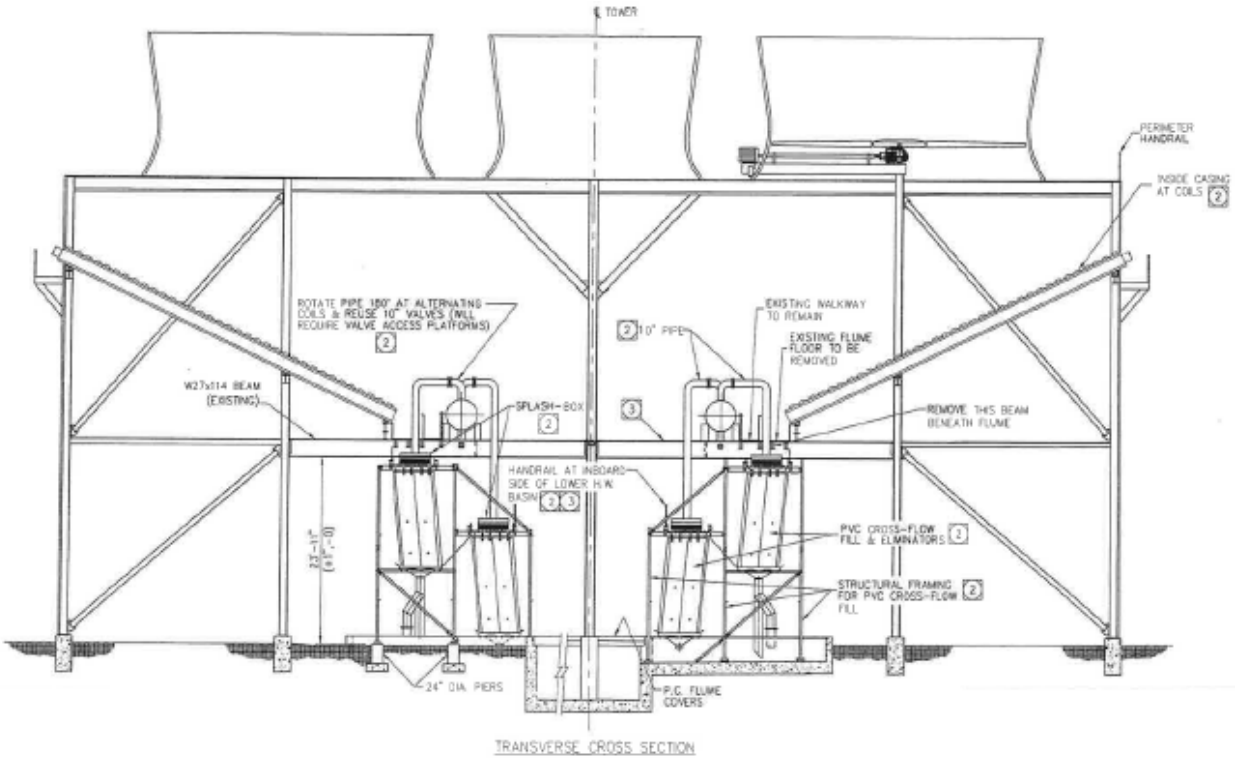
Table 3-1: Unit 3 Cooling Tower Original Performance

Design Case		Condenser Heat Load (MMBtu/hr)	SO2 Heat Load (MMBtu/hr)	Total Heat Load (MMBtu/hr)	Flow (gpm)	Range (ºF)
1	105% – VWO	2,458	137	2,595	220,000	23.59
2	100% - Summer	2,325	137	2,462	220,000	22.38
3	100% - Winter 1	2,277	137	2,414	220,000	21.95
4	100% - Winter 2	2,277	238	2,515	220,000	22.86
5	100% - Summer (condenser only)	2,325	---	2,325	205,000	22.69

Note 1: See Appendix A for complete design information

At some point after the initial installation of this cooling tower, the 2 outer cells were converted to a "Matrix" design. The Matrix cell in the case of the modified Unit 3 tower consists of multiple vertical sections of PVC cross-flow film fill, with the middle fan and two of the larger fans taken out of service and blanked off, leaving 2 of the larger fans in service. A cross section of the Matrix cell is shown in Figure 3-1. It is unclear what drove the decision to convert these cells, but it is assumed that performance improvements were necessary.

Figure 3-1: Unit 3 Cooling Tower Matrix Cell Design



Even after this initial retrofit, the Unit 3 cooling tower continued to exhibit degraded performance as well as increased maintenance. The primary issues consisted of freezing, pluggage, severe corrosion and excessive leakage of the dry sections, causing larger makeup to the tower essentially eliminating the water savings benefit of the design. Additionally, the cooling capacity of the tower degraded which impacted net power output. Due to the loss in revenue and high maintenance costs, Public Service Company of New Mexico (PNM) decided to evaluate various upgrade options. It was determined to proceed with converting 4 additional cells to the Matrix design, making the tower a 6 matrix cell + 4 wet cell design. The conversion was completed around 2010.

3.2 New Design

Ultimately, the Unit 3 cooling tower's performance (post conversion) was evaluated for its use to provide cooling to the CCUS system. Due to historical issues with performance of the cooling tower and its expected degradation since the conversion in 2010, we decided to proceed with Design Case 5 (heat load of 2,325 MMBtu/hr) as the benchmark. In addition, it was identified in our review of the Unit 3 circulating water pumps, that they were sized for a total cooling water flow of 205,000 gpm (2 pumps @ 102,500 gpm each).

The heat load imposed on a cooling tower is determined by the pounds of water per minute being circulated through the process multiplied by the number of degrees Fahrenheit that the process elevates the circulating water temperature. To simplify, the relationship of heat load, temperature and flow can be defined by the following equation:

$$Q = V \times R \times 8.33 \times 60$$

Where:
Q = heat load in Btu/hr
V = volumetric flow of circulating water in gpm
R = Range (hot water inlet temp – cold water outlet temp)
8.33 = pounds per gallon of water at typical temperature
60 = conversion factor from hours to minutes

Based on this, the new Unit 3 cooling tower performance for the CCUS is estimated to be:

Circulating water flow	268,900 gpm

3.3 Current Condition and Challenges

Due to SPX's historical information of the existing tower, including the original design and modified designs, they were engaged to help evaluate the Unit 3 cooling tower and the possibility of it being used under the new design conditions. Two primary assessments were necessary: 1) a theoretical performance assessment to ensure the tower has the capacity to achieve the new performance conditions, and 2) a high level condition assessment to determine the structural integrity, mechanical system integrity, and remaining life of the primary components such as the fill.

SPX was able to determine that the Unit 3 cooling tower could meet the new design conditions but requiring the remaining 4 cells to be converted to the Matrix cell design. Complete performance conditions of the retrofitted tower can be found in Appendix B.

In late July of 2020, an SPX crew was already at the San Juan facility inspecting the Unit 1 and 4 cooling towers. They took advantage of this assignment to perform a high-level inspection of the Unit 3 cooling tower. From their inspection, several major issues were identified:

1. The cooling tower has asbestos insulation on each of the cell partition walls. This would need to be abated prior to the modification work.
2. The dry coils that remain in this tower leak badly, and some of the sections are not usable.
3. The piping system is in poor condition and requires extensive repair or replacement.
4. The fill used for this tower is a PVC film fill and only lasts for a couple of years due to the excessive fouling. Film fill is the only choice for this style of cooling tower, but fouls easily due to the water quality. This subject is explained in more detail later in this section.

In addition to the retrofit required for the new performance conditions, SPX would need to perform significant repair work throughout the tower. They provided a quotation for all this work, which is summarized in Section 8 and detailed in Appendix B.

3.3.1 Requirement for Raw Water Treatment

The raw water makeup to the San Juan facility is sourced from the San Juan River. The portion of water used for cooling tower makeup is untreated as there is no raw water treatment system at the site, such as a clarifier system. This led to a crossflow type cooling tower with splash fill for Units 1,2 and 4. Splash fill is specifically designed for dirty water applications and can handle cooling water with high total

suspended solids (TSS) content such as river water. However, due to the design of the Unit 3 Matrix cells, a film fill is the only option to achieve performance. Splash fill unfortunately is not an option for the Unit 3 cooling tower because the performance will be so poor that SPX will not quote it or guarantee the performance.

Film fill is typically recommended to operate with water that has a total suspended solids (TSS) content of 150 ppm or less. Considering that the circulating water in the Unit 3 cooling tower loop has historically been cycled up close to 5 times, the TSS content would be well above the recommended limit for film fill. This is the reason that the film fill has only lasted 2 years before failing due to the fouling and accumulation of solids. Operating in this manner will significantly degrade the performance over a short period of time and will cause maintenance headaches.

Therefore, in order to re-use the Unit 3 cooling tower, a raw water treatment system must be installed to clean up the makeup water prior to it being sent to the cooling tower. A clarifier system would be recommended in this case to drop the TSS level of the river water down to about 15 ppm. This would allow the cooling tower to be cycled up close to 10 times and still allow the use of film fill. Since the cooling water from the Unit 3 tower would be combined with the cooling water from the new supplemental tower, the entire makeup to both towers are recommended to be treated.

There are two primary types of raw water treatment systems available as noted below:

1. Traditional solids contact clarifier system which includes a large diameter vessel to allow for settling of the heavy solid particles. At the expected makeup flow rate for these towers, we would anticipate the vessel to be close to 85 ft. diameter or larger.
2. High flow rate clarifier system. This type of a system allows for a smaller footprint since it does not require a large diameter vessel for settling of the solids. Suez and Veolia are two manufacturers that offer these types of systems.

In addition to the clarifier itself, the raw water treatment system would include a clearwell, auxiliary equipment, electrical equipment, and a building would be recommended to house this equipment. Other considerations for the raw water treatment system are the additional handling requirements for chemicals and sludge removal, and additional O&M costs for this new equipment.

Indicative capital costs for the raw water treatment system are summarized in Section 8.

4. Supplemental Cooling Tower

Based on the new design conditions for the Unit 3 cooling tower, the balance of the cooling will need to be provided with a new supplemental cooling tower, designed to the following performance conditions:

Circulating water flow 156,100 gpm

These conditions were used by SPX to quote the new cooling tower. Refer to Appendix C for details. This tower is proposed to be a crossflow type with splash fill, a similar design as the Unit 1 and 4 cooling towers as well as the old Unit 2 cooling tower. In fact, each of the cells would have the same design and footprint as the cells for Unit 1,2 and 4, with the only exception being that the height will be larger to accommodate additional fill to achieve the desired performance. The new tower would require a total of 9 cells. The original Unit 2 cooling tower consisted of 11 cells, so therefore, the existing Unit 2 basin would be able to accommodate the new supplemental tower.

5. New Cooling Tower

Realizing the challenges of re-using the Unit 3 cooling tower, we determined that it was prudent to look at a completely new cooling tower for the CCUS system. This cooling tower would be designed for the full system, with performance as follows:

Circulating water flow 425,000 gpm

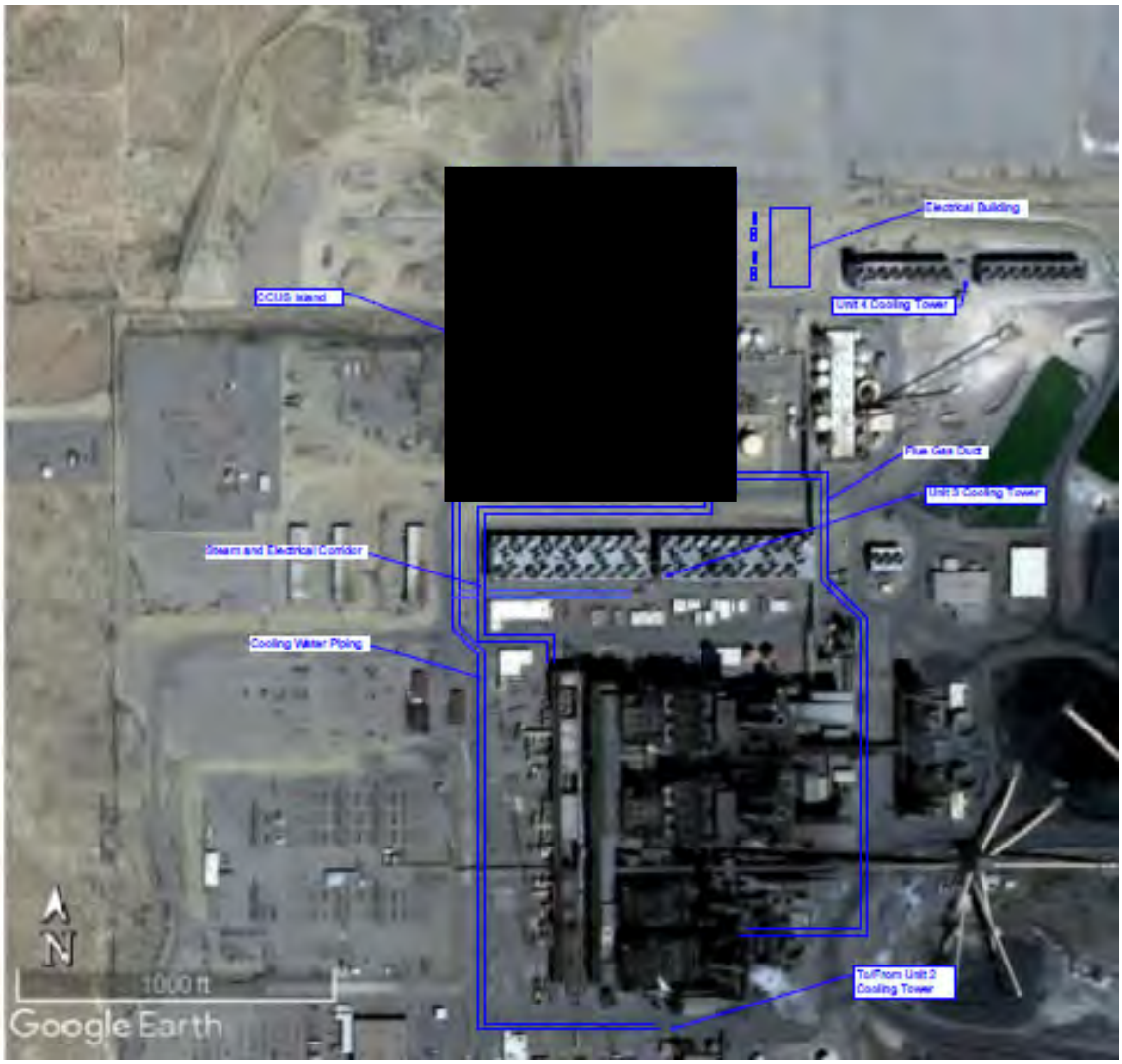
This tower would be designed as a crossflow type with splash fill, eliminating the need for raw water treatment and designed similar to the Unit 1 and 4 towers. Based on the quotation from SPX (See Appendix D), this tower will consist of 24 cells. The height of the tower would need to be the same as the height for the supplemental tower option, with a pumping head of 46.52 ft. Due to the crossflow design, the cells would need to be oriented in a single row. A back-to-back arrangement, which is commonly used for large counterflow cooling towers, is not an option since each cell needs to draw in the ambient air from both sides. If the length of this tower (total length of 961 ft, not including the basin), is too difficult to orient on the site, we can look at splitting this tower into two (2) 12 cell towers.

6. General Arrangement Options

6.1 Re-use Unit 3 Cooling Tower with Supplemental Cooling Tower – OPTION 1

Under this scenario, the general arrangement would be similar to the original concept developed during the pre-feasibility phase. Here the Unit 3 cooling tower remains intact, and the CCUS island would be located north between the existing switchyard and water treatment area. Since the supplemental tower was confirmed to be small enough to fit within the existing Unit 2 cooling tower basin, it would be located there, south of the powerhouse. Existing underground piping from Unit 2 and 3 can be utilized for a portion of the piping (further described in Section 7). The CCUS island footprint is based on the latest MHI information.

Figure 6-1: General Arrangement Option 1



As shown from the layout, the CCUS island extends far enough north that the east-west run of the 345 kV transmission lines would need to be rerouted. This work can be done but would be costly and requires careful coordination on timing of the work, which would likely delay the start of construction for this project. Additionally, the CCUS island extends into the evaporation pond cell #1, which has been closed off for some time. Work in this area would require permits, which can be costly and create delays in the schedule similar to the transmission line rework.

The raw water treatment plant is required for this scenario and would take up a significant footprint. Specific locations have not been studied but the only likely locations would either be north of the CCUS island or south of the powerhouse. Ideally, the basis of the location should consider the location of the river water source into the facility to minimize piping to the water treatment system as well as the effluent piping to the cooling towers. Good road access would be required in this area for maintenance, transport of chemical deliveries and hauling of solid waste.

6.2 New Cooling Tower – OPTION 2

The new 24-cell cooling tower would take up a substantial amount of land. Based on the available land, the cooling tower can be located north or northwest of the CCUS island. The cooling tower would have to be located carefully enough to avoid the 345 kV transmission lines. It should also be located to avoid the evaporation ponds. The natural grade and elevation will need to be studied to determine the amount of earthwork required to excavate the area for the cooling tower basin and pump bay.

Since the Unit 3 cooling tower would not be used in this scenario, there exists the possibility to demolish the tower and its foundation, along with some of the structures just south of this tower. It is understood these structures are minimally used storage containers / buildings that can be moved or demolished. This would allow the CCUS island to shift south nearly 400 ft, which would get it out of the evaporation pond and avoid the 345 kV transmission line re-route. Also, locating the CCUS island closer to the Units means that there would be savings across the board for piping, ductwork, utility rack steel, electrical cable/cable tray, etc. Even though there will be time and cost associated with the demolition work, the amount of cost savings should far exceed the added cost, making this an attractive option.

Figure 6-2: General Arrangement Option 2



7. Cooling Water Pumps and Piping

7.1 OPTION 1

The new flow conditions, as well as new pressure drop conditions for the CCUS, will lead to new sets of pumps for the Unit 2 and 3 cooling towers since they are too far from the original pumps' design conditions. Additionally, these pumps are not likely in a condition to be re-used since they have been mothballed for several years. The pumps are vertical turbine wet-pit pumps. The original pumps were in a 2x50% configuration, and it would be recommended to follow the same concept. The new

pump design conditions (includes 5% flow margin) would be as follows:

Unit 2 (new supplemental tower):

Flow - 82,000 gpm
Total developed head (TDH) – TBD (require pressure drop information from MHI)

Unit 3:

Flow - 140,700 gpm
TDH – TBD (require pressure drop information from MHI)

The original circulating (cooling) water underground piping for Unit 2 and 3 is still intact and a portion of this piping could be re-used close to the cooling towers. The following is a summary of the existing circulating water piping (refer to Appendix E for drawings):

Table 7-1: Existing Circulating Water Piping

	NPS (in.)	Velocity at New Design Flow (ft/sec)*
Unit 2 Circulating water pump discharge	72	6.5
Unit 2 Circulating water supply header	96	7.3
Unit 3 Circulating water pump discharge	72	11.1
Unit 3 Circulating water supply header	120	8.0

*Velocity is calculated assuming the piping internal diameter is equal to the NPS size.

The piping material for each system is unknown at this time, but we assume it is either concrete, mortar lined steel, or bare steel pipe. Based on Table 7-1, the existing piping is capable and falls within the Sargent & Lundy recommended flow velocities for these (Note that we normally limit concrete pipe to 10 ft/s, however we can accept higher, realizing it will increase pressure drop).

A condition assessment of this piping would need to be performed in order determine the future long-term use. Figure 6-1 indicates the new circulating water piping that would need to be installed, and an approximate location for the tie-in with the existing piping. Additional exploration of the underground areas would need to be performed to determine the optimal tie-in locations. The biggest challenge for the new Unit 2 piping and tie-in is the location on the west side of the powerhouse. There are a lot of mechanical and electrical utilities in this area that will need to be avoided. Also, the disruption of this critical area during excavation and installation of the circulating water piping will be major. The open trench size for this diameter piping will be large. More research would be required to fully understand the construction costs and schedule for this work.

7.2 OPTION 2

With the new cooling tower, all new pumps will be required. With a total circulating water flow requirement of 425,000 gpm, it is recommended to have a minimum of 4 operating pumps to match

the number of CCUS trains supplied by MHI. It is ideal to match the number of evenly sized circulating water pumps to the number of CCUS islands, so in the case of an out of service CCUS train, one pump can be shut down and the other 3 pumps will remain in service while still operating at their design point (most efficient). Alternatively, if one pump fails, then only one CCUS island would need to be shutdown, with the other 3 trains operating at their normal design conditions. The new circulating water pump conditions (includes 5% flow margin) would be as follows:

New cooling tower:
Flow – 112,000 gpm
TDH – TBD (require pressure drop information from MHI)

All new piping will be required from the new cooling tower to the CCUS island. The pipe sizes would be determined based on the Sargent & Lundy velocity recommendations. For the purposes of this study, we are assuming that the circulating water piping would either be concrete (with embedded steel cylinder) or steel pipe with mortar lining. Recommended velocity for this type of piping is 7 to 10 ft/s. The following is a summary of the new circulating water piping:

Table 7-2: New Circulating Water Piping

	NPS (in.)	Velocity at New Design Flow (ft/sec)*
Circulating water pump discharge	72	8.8
Circulating water supply & return header	144	8.8

*Velocity is calculated assuming the piping internal diameter is equal to the NPS size.

The installation of this piping should be easier to manage than Option 1 as it will all be located in remote areas of the site and interferences with existing utilities is not expected, nor will it interfere with normal plant operations.

8. Cost Analysis

The costs obtained for this study are limited to the cooling tower supply and erection for each of the options. SPX was contacted to provide the pricing for each option as they (Marley) are the original OEM for the existing towers at San Juan.

Table 8-1: Cooling Tower Supply & Erection Costs

	OPTION 1	OPTION 2
Unit 3 Retrofitted Cooling Tower	$16,100,000*	--
New Supplemental Cooling Tower	$7,600,000	--
New 24 Cell Cooling Tower	--	$20,400,000
Total	**$23,700,000**	**$20,400,000**

*Does not include rework or replacement cost of fans, gearboxes, motors or other drive components which may need to be upgraded.

Additional costs or savings to consider as part of each option, but not quantified in detail, include:

Table 8-2: Additional Costs or Savings

	OPTION 1 Cost/Savings	OPTION 2 Cost/Savings
Raw Water Treatment System & Infrastructure	Large Cost (added O&M costs)	--
Relocation of 345 kV transmission lines	Medium Cost (schedule impact)	--
Re-work & permitting of evaporation pond	Small Cost (schedule impact)	--
Demolition of Unit 3 Cooling Tower, foundation & utilities	--	Small/Medium Cost
Reduced ductwork, piping, utility rack steel, electrical, etc.	--	Large Savings
New cooling tower basin		Medium Cost

Large Cost/Savings: x > $10M
Medium Cost/Savings: $1M < x > $10M
Small Cost/Savings: x < $1M

There are potentially more cost/savings that could be reviewed including: circulating water pipe costs, makeup piping, blowdown piping and electrical utilities. Whether they are an additional cost or savings to the project, and how much, would depend on the final location of the new cooling tower in Option 2. However, this level of detail can't be determined at this time.

9. Operation

The operation of the circulating water system needs to be considered. For Option 1, there are operational challenges associated with providing cooling water from 2 separate sources:

1. The circulating water pumps from the Unit 2 and 3 cooling towers will be sized differently, both in flow and TDH. The pump discharge piping from each unit will be combined into a common supply header. Even with properly sized pumps, it's likely that the valves at the discharge of each pump will need to be throttled in order to keep the pump at or near its design point, particularly during cases where a CCUS train or trains are offline and cooling flow needs to be reduced. Although large butterfly valves like this can be designed for throttling, they are not best suited for long term throttling operation. The motor actuators for these valves will need to be designed for inching operation.
2. The circulating water returned from the CCUS trains will be combined into a common return header, then split to the Unit 2 and 3 cooling towers. These split flows will need to be throttled to ensure the correct amount of flow is sent to each tower. This will involve a large butterfly valve with inching type motor operator permanently set to a throttled position, which again, is not ideal for this type of valve.
3. The control scheme for this system will be more complex than a typical circulating water system.

The operation of a new single cooling tower configuration under Option 2 will be much simpler and designed much like a standard circulating water system. The design using 4 evenly sized pumps, to match the 4 CCUS trains, will simplify operation during reduced load scenarios. Throttling of pump discharge valves or return header valves would not be required.

10.Summary and Conclusions

This study establishes the options to be considered to cool the CCUS system provided by MHI. Preliminary information from MHI indicates a cooling water flow of 425,000 gpm with temperature rise of 18ºF. The data was used to evaluate the potential use of existing San Juan equipment - Unit 3 cooling tower and the Unit 2 cooling tower basin (designated as Option 1). An alternative option for a completely new cooling tower (designated as Option 2) was also studied for comparative purposes.

The re-use of the Unit 3 cooling tower presents many challenges. It was determined that the current design of the tower is inadequate and requires significant repair work. Additionally, there is asbestos insulation which will need to be abated. The cost to retrofit this cooling tower is significant. Adding the cost of the new supplemental tower to this retrofit cost, the total cost of Option 1 ends up being more expensive than Option 2 for a brand-new cooling tower, from a cooling tower cost perspective.

There are also various other undesirable project impacts with Option 1. The raw water treatment system will add significant project cost as well as future O&M cost. Since the CCUS island is located north of the Unit 3 tower for Option 1, the 345 kV transmission line and evaporation pond are also impacted, creating more cost and schedule delay. Lastly for Option 1, tying the new circulating water pipe to the existing Unit 2 and 3 piping, and operation of the system present more difficulties compared to Option 2.

Option 2 allows the CCUS island to be shifted south to avoid the interference with the 345 kV transmission lines and evaporation pond. The shift south will also provide significant cost savings on ductwork, piping, steel, electrical, etc. due to shorter distances between the power station and the CCUS island. Additionally, a raw water treatment system is not required, and the new cooling tower can accept untreated river water just like the operating Unit 1 & 4 cooling towers. There are additional costs associated with the demolition of the Unit 3 cooling tower (including asbestos removal), and the new cooling tower basin that will need to be constructed. However, the cost savings are expected to outweigh the additional costs.

Therefore, it is recommended to proceed with Option 2 for the new cooling tower located north of the CCUS island, which will be located further south as shown in the arrangement presented in Figure 6-2.

Note 1: After completion of this study in 2020, MHI reduced the cooling flow requirement to approximately 290,000 gpm. At this flow rate, it was determined that the original concept of using the existing cooling tower infrastructure (Option 1) would still require refurbishment of the Unit 3 tower and a new supplemental tower. The new cooling tower (Option 2) was reduced in size and a final quotation was received in early 2022. It is reasonable to assume that the refurbished cost of the Unit 3 cooling tower would remain the same and the cost of the cooling system new components would be scaled down linearly for both options. Therefore, the conclusions of the study remain the same.

APPENDIX A:

UNIT 3 COOLING SYSTEM DATA

11.4 SYSTEM INTERFACES

The following systems or equipment interface with the circulating system:

Main Surface Condenser

Ash Water Storage Tank & Ash Handling Control System

Silt Dispersant (Chemical Feed System)

Acid Feed (Chemical Feed System)

Scale Inhibitor (Chemical Feed System)

Chlorine (Chemical Feed System)

Units 1 & 2 SO_2 System (Primary Condenser-Future)

Discharge From Blowdown Tank Drain Pumps

Auxiliary Cooling Tower Units 1 & 2 Blowdown

Effluent Pond or Waste Water Recovery Area

Auxiliary Cooling Tower Unit 3

Main Cooling Tower Unit 4 (Future)

Raw Water System

Chemical Building

11.5 EQUIPMENT DATA

The following pages are equipment data sheets for the major equipment in this system. Information on the cooling towers can be found in the Marley Cooling Tower Operating Manual.

11.5.1 Circulating Water Pumps

Manufacturer	Johnston Pump Co.
Type/Model No.	Mixed Flow/80 THS
Number of Stages	One
Capacity	102,500 gpm

Total Developed Head	84 feet
Shut-off Head	126 feet
Operating Speed	355 rpm
Efficiency	88.5
Brake Horsepower	
Design	2399
Maximum	2426
Inertia Wk^2	15,700 $lb\text{-}ft^2$
Minimum Flow	70,000 gpm
Materials	
Impeller	B-145, Gr. 4A
Inlet Bell	A-48, Class 30
Impeller Bowl	A-48, Class 30
Coupling	
Manufacturer	Johnston Pump
Type	Flanged - Adjustable
Size	9F
Motors	
Manufacturer	Westinghouse
Type	Induction
Enclosure	WP-II
Horsepower	3000

	Speed	354 rpm
	Inertia Wk^2	15,700 lb-ft^2
	Voltage	6600
	Amperes	248
	Bearings	Kingsbury Thrust

11.5.2 Cooling Tower Blowdown Pumps

Manufacturer	Barrett, Haentjens & Co.
Type	VNB
Capacity	300 gpm
Total Dynamic Head	100 feet
Speed	1770 rpm
Efficiency	61%
Horsepower	12.4
Materials	
Casing	Cast Iron
Impeller	28% Chrome Alloy
Shaft Sleeve	450 Stainless Steel
Shaft	Alloy Steel

11.5.3 Condenser

Manufacturer	Foster Wheeler Energy Co.
Type	Surface, single pressure, twin shell
Steam Flow	2515.15 X 10^3 #/Hr.

Water Flow	205,000 GPM
Total Duty	2.458×10^9 Btu/Hr.
Overall Heat Transfer Rate	662 Btu/Hr.-Ft^2- F
Maximum Pressure	5 in. Hg. Abs.
Water Inlet Temperature	104 F
Water Outlet Temperature	128.24 F
Total Head Loss	16.7 feet
Tube Velocity	7 feet/sec.
Cleanliness Factor	.85
Waterbox Design Pressure	60 psig
Shell Design Pressure	0 psig and 15 psig
Materials (type/thickness)	
Shell	A-515 Gr. 70/5/8"
Tube Sheet	Muntz B-171/1-1/4"
Tube Support Plates	A-285/3/4"
Water Boxes	A-515 Gr.70/3/4"
Air Cooler Buffles	A-285/1/4"
Impingment Buffles	304 SS
Hotwell	A-515 Gr.70/5/8"
Tubes	
Total Surface	261,100 $Ft.^2$

Main Section

Material	Inhibited Admiralty
Number	25,650
OD	1-inch
Gauge	19 BWG
Effective Length	35'-0"

Air Removal Section

Material	Stainless Steel
Number	1,708
OD	1-inch
Gauge	20 BWG
Effective Length	35'-0"

Impingment Section

Material	Stainless Steel
Number	1,138
OD	1-inch
Gauge	20 BWG
Effective Length	35'-0"

11.5.4 Cooling Tower

Tower Model Number: Marley 2 @ 644-4-05(5) BFY
16-A12W48H4R2P218

Type: Partitioned, ventilated parallel air path wet-dry water conservation cooling tower.

Heat Loads

Main Condensers (per unit)

Summer - 2.325×10^9 BTUH @ 205,000 gpm (100% VWO)

Winter - 2.277×10^9 BTUH @ 205,000 gpm (100% VWO)

Summer - 2.458×10^9 BTUH @ 205,000 gpm (105% VWO)

Auxiliary #1 - SO_2 Load (per two units)

H.L. = 0.101×10^9 BTUH @ 10,000 gpm (82°F C.W. - Max.)

Auxiliary #2 - SO_2 Load (per two units)

H.L. = 0.045×10^9 BTUH @ 13,000 gpm (75°F C.W. - Max.)

Auxiliary #3 - SO_2 Load (per unit)

H.L. = 0.137×10^9 BTUH @ 15,000 gpm

Main Tower Operating Heat Loads

(1) 105% Design Back Pressure (VWO) and Auxiliary #3

   a. H.L. = $(2.458 + 0.137) \times 10^9 = 2.595 \times 10^9$ BTUH

   b. Range & Flow = 23.59 F @ 220,000 gpm

(2) 100% Design Back Pressure (summer) and Aux. #3

   a. H.L. = $(2.325 + 0.137) \times 10^9 = 2.462 \times 10^9$ BTUH

   b. Range & Flow = 22.38 F @ 220,000 gpm

(3) 100% Design Back Pressure (winter) and Aux. #3

   a. H.L. = $(2.277 + 0.137)\ 10^9 = 2.414 \times 10^9$ BTUH

   b. Range & Flow = 21.95 F @ 220,000 gpm

(4) 100% Design Back Pressure (winter) with Aux #3 and Aux. #1

a. H.L. = (2.277 + 0.137 + 0.101) X 10^9 = 2.515 X 10^9 BTUH

b. Range & Flow = 22.86 F @ 220,000 pgm

Water Consumption Summary

Available Water Supply	=	619.200 X 10^6 gal./yr.
Main Tower Consumption	=	566.612 X 10^6 gal./yr.
Aux. #1 Tower Consumption	=	18.182 x 10^6 gal./yr.
Aux. #2 Tower Consumption	=	33.392 X 10^6 gal./yr.
TOTAL	=	618.186 X 10^6 gal./yr.

Dynamic Head Loss - Tower pumping head data expressed as the head of water above the basin curb as a datum line, measured at the center of the flange connecting the external piping system with the main tower piping. The expected pumping head under design flow rate (220,000 GPM) to be as follows: (Note: Operating water level is 2.5' below top of curb and 1.0' below grade.)

Static pressure above atmosphere measured at the connecting inlet flange, ft. H_2O.	28.4'
Dry section friction (at coil inlet nozzle) ft. H_2O.	23.3'
Total Dynamic pumping head, ft. H_2O.	51.7'

Wet Section Water Distribution Basins

Side Board Height, inches	7.9"
Normal Operating Water Depth, inches	3.9"

Wet Section Fans - Fan Performance
Each fan at design conditions

Brake Horsepower	75
Calculated air flow at site elevation for design conditions and optimum fan blade pitch setting, actual cfm	690,200

Air-vapor mixture density at the fan when operating at design condition, lb/ft.^{3}	0.05465
Fan static efficiency, percent	59.9
Fan total efficiency, percent	72.3
Fan static pressure, inches H_2O	.386
Total dynamic fan pressure, including recovery, inches H_2O	.465
Airflow, lb. dry air/hr.	2.098×10^6
Air-vapor wet bulb, dry bulb temperatures at fan, ^oF	112.1/112.1
Maximum brake horsepower expected with blades pitched for design conditions	100 @ 0 F

Dry Section Fans - Fan Performance

Each fan at design conditions	
Brake Horsepower	185
Calculated air flow at site elevation for design conditions and optimum fan blade pitching setting, actual cfm	1,582,000
Air-vapor mixture density at fan when operating at design condition, lb/ft.^{3}	0.05623
Fan Static efficiency, percent	62.9
Fan Total Efficiency, percent	82.0
Fan stack discharge velocity (F.P.M.)	1557.5
Fan Static pressure, inches H_2O	0.446
Total dynamic fan pressure, including recovery, inches H_2O	0.581

Air flow, lb. mixture/hr	5.337×10^6
Air vapor wet bulb, dry bulb temperatures at fan, ^{o}F	70.4/111.3
Maximum brake horsepower expected with blades pitched for design conditions	200 @ 0 F
Wet Sections Performance At design conditions per cell	
Water Loading, GPM/ft.^{2}	21.48
KAV/L	1.09
L/G	5.24
Air mixture velocities (F.P.M. Avg.)/ component static pressure (inches H_2O)	
Inlet Louvers	449.4/0.020
Fill	449.4/0.031
Drift eliminators	449.4/0.031
Air rate, lb. dry air/hr.	2.098×10^6
Ambient air-vapor mixture density, lb/ft^3	.05845
Air-vapor mixture density at wet section fans, lb/ft^3	.05465
Dry Sections Performance At design conditions per cell	
Total extended surface, ft.^{2}	890,350
Air rate, lb. mixture/hr.	21.348×10^6
Ambient air-vapor mixture density, lb/ft.^{3}	0.05845
Air-vapor mixture density at dry section, lb/ft.^{3}	0.05623

Air-side pressure drop, inches H_2O	0.446
Inside fouling factor	0.001
Free flow area, $ft.^2$	4294
Average dry section face velocity, F.P.M.	760.6
Overall heat transfer coefficient, BTU/Hr. - ^oF - $Ft.^2$ ext. surf.	6.5

DRY SECTION DESIGN

Number of dry sections per cell	16
Tube Material	Admiralty Brass
Fin Material	1100 Series Aluminum
Method of Fin Attachment	Tension wound Footed Fins
Number of Tubes Per Section	218
Number of Heat Transfer/Hydraulic Passes	2/2
Section Face Height/Width - ft.	48'/11.6'
Tube Dimensions:	
Length, ft.	48' First pass 49' Second pass
Outside Diameter, inches	1.0"
Inside Diameter, inches	0.916"
Fin Height/Stock Width (inches)	5/8"/.018"
Tube Spacing:	
Pattern	Equilateral Triangular
Pitch	2-7/16"

Number of Rows	4
Vent Manifold Design:	
Coil Inlet Nozzle Pipe Size (inches)	3-1/2"
Manifold Pipe Size (inches)	8"
Atmospheric Vent Valve Size (inches)	12"
Number of Vent Valves Per Tower	6
Structural Details - Main Towers	
Number of Cells, each tower/each unit	5/10
Number of Dry Section Fans, each cell	4
Number of Wet Section Fans, each cell	1
Nominal Cell Frame Dimensions, (LxW), feet	96' X 137'
Overall Tower Dimensions (LxW), feet	482' X 140'
Height, Grade to Fan Deck, feet (Grade at 0'-0" datum elev.)	59' 8-3/16"
Height, Basin Curb to Wet Section Water Distribution Basin Floor, feet	22' 11-1/16"
Height, Grade to Centerline of Water Distribution Header, feet	29' 5"
Fan Stack Height, feet	18'
Overall Tower Height, feet (from grade)	77' 8-3/16"
Inside Basin Dimensions, each wet section (LxW), feet	33' 4" X 60' 6"
Basin Connecting Flume Dimensions (LxW), feet (nom.)	64' X 13.5'
Wet Section Vertical Column size, inches	Angle 3 x 2-1/2 x 1/4
Wet Section Horizontal Column Bracing, Spacing, longit./transv., feet	6'/6'

Wet Section Vertical Column spacing, longitudinal/transverse, feet	4'/8' & 16'
Superstructure Vertical Column Size, inches	W14 X 78#
Superstructure Vertical Column Spacing, Longitudinal/Transverse, feet	24'/28.5', 40',40', 28.5'
Load Per Column, Tower Operating Dead Load, Max. lbs.	89,500
Compressive Stress Per Column, Tower Operating Dead Load, Maximum PSI	3,908
Fill Support Members, Size, inches	16GA x 3-3/16" x 3'-9-1/2" Formed Half R'nds
Horizontal Spacing of Fill support Members, feet	3.5'
Vertical "lift" Height of Fill Support Grids, feet	6'
Fan Deck:	
Thickness of Deck, inches	3/16'
Minimum clearance between fan cylinders, feet	9'
Safe Loading, lb/ft.^{2}	60 PSF Live
Dimensions (LxW), feet	481 X 138
Thickness of Dry Section Partitions, inches	.0785
Wet Section Louvers:	
Louvered Area, Total Per Wet Section, feet^2	1536
Net Inlet Area Per Wet Section, Ft.^{2}	1456
Louver Thickness, inches	3/8

Wet Section Fill Description:	
Splash Bar Dimensions, inches	9/32" x 2.1" x 3'-11-1/2" (1/2 cycle of 4.2" Corr.)
Actual Fill Projected Surface Area Excluding Openings, feet^2	1024
Effective splash Surface Area, Fill only, feet^2	9680
Effective Cooling Volume, feet^3	24,577
Total Fill Volume, feet^3	23,936
Maximum Length of Unsupported Fill Bar, feet-inches	3'-6"
Fill Height, Feet	24
Water Free Fall Height, feet	24.5'
Fill Splash Bar Spacing, Horizontal/ Vertical, inches	16/4
Horizontal Airflow Space Between Vertical Levels of fill, inches	4
Total Wetted Surface Area, including fill, feet^2	31,306
Fill Splash Bar Shape	1/2 of 4.2" cycle corr. ACB
Total Number of Splash Bars Per Cell	12,288
Drift Eliminators:	
Total Face Area Per Cell, feet	1575
Number of Passes	2
Eliminator Cell Angle from Vertical, First Pass/Second Pass, degrees	47.5/47.5

Materials of Construction

Structural Framework Members:

Superstructure	HDG Steel
Dry Sections	HDG Steel
Wet Sections	HDG Steel
Casing	3/8" Corr. ACB
Fill	9/32" Corr. ACB
Fill Support Grids	Fire Retardant Glass Reinforced Polyester
Drift Eliminators	Neoprene/Asbestos
Fan Stacks	Glass Reinforced Polyester
Inlet Louvers	3/8" Corr. ACB
Dry Section Partitions	HMG Steel
Fan Deck	HDG Steel

Main Distribution Headers, Horizontal:

Size, inches	48
Connections, Type	Bolted Flange
Pipe Hardware	HDG Steel
Dry Section Inlet Size, inches	10
Number of Inlets Per Cell	16

Wet Section Bypass Valves:

Number Per Cell	4

Size	12" Dia
Riser Valves:	
Number Per Tower	2
Size	48" Dia
Tower Bypass Valves:	
Number Per Tower	One
Size	48" Dia
Vent Manifold Valves:	
Number Per Tower	6
Size	12" Dia
Stairways and Handrails	HDG Steel, MG Pipe & Alum Pipe Fittings
Bolts, Nuts, Washers	HDG A-307 & 325
Anchor Bolts	HDG A36
Mechanical Equipment Support	HDG Steel Tube
Fan Assembly Materials:	
Fan blades	Glass Reinforced Polyester
Hub	HDG Steel
Blade Clamps/Hardware	HDG Steel/300 S.S.
Driveshaft/Hardware	HDG Steel/300 S.S.
Fan Cylinder Spider	300 S.S.

Mechanical Equipment

Dry Section Fans:

Type or Model	HP6
Manufacturer	The Marley Cooling Tower Company
Diameter, feet	32.808
Number of Blades Per Fan	12
Fan Blade Speed, rpm	120
Blade Tip Speed, fpm	12,370
Blade Tip Clearance, inches	1.0" $\pm$ 0.25"
Blade Pitch:	
Maximum Degrees	19.5°(stall)
Minimum Degrees	7.5°
Optimum Setting at Design, degrees	12°

Gear Reducers:

Total Number per Tower	25
Type	Right Angle
Model/Manufacturer - Wet Sections	34.3T/Marley
Model/Manufacturer - Dry Sections	36/Marley
No Load Friction Horsepower Wet/Dry	3.6/5.0
Gear Efficiency - percent	98
Reduction Ratio - Wet Sections	11.18
Reduction Ratio - Dry Sections	14.79

Service Factor at Rated HPR of Driver Wet/Dry	4.20/2.59
Gear Type - Mat'l	Spiral Beval: Helical 4620 Steel
Number of Reductions	Two
Number of Bearings	Six
Type of Bearings	2-Single Row, Pinion Shaft 2-Double Row, Inter-stage Shaft 2-Single Row, Fan Shaft All Tapered Rollers

Drive Shafts:

Number Required per tower	25
Type	Floating
Model/Manufacturer - Wet Section	225/Marley
Model/Manufacturer - Dry Section	350/Marley
Rated Horsepower Wet-Dry	150/276
Drive Shaft Material	300 S.S.

Electric Motor Drive Data

Full Load Speed (rpm)	1775
Voltage/No. of Phases/Frequency, Hertz	460/3/60
Enclosure Type	TEFC
Class of Insulation	F
Temperature Rise, ^{o}C. at service factor load (ambient temperature specified for motor location and 5300 feet above sea level).	115^{o}C.

Service Factor 1.15

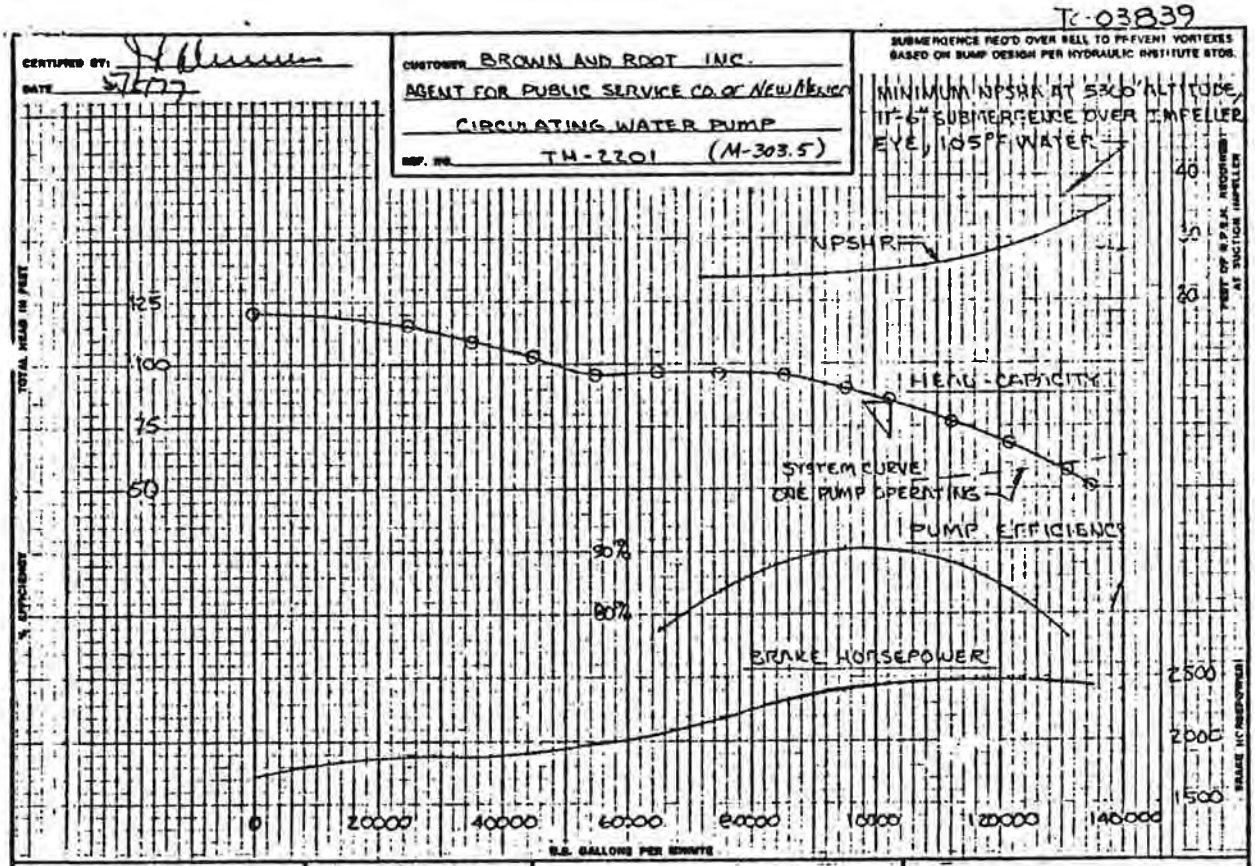
11.6 PERFORMANCE CURVES

A. Circulating Water Pumps

B. Cooling Tower Blowdown Sump Pumps

C. Main Cooling Tower unit.

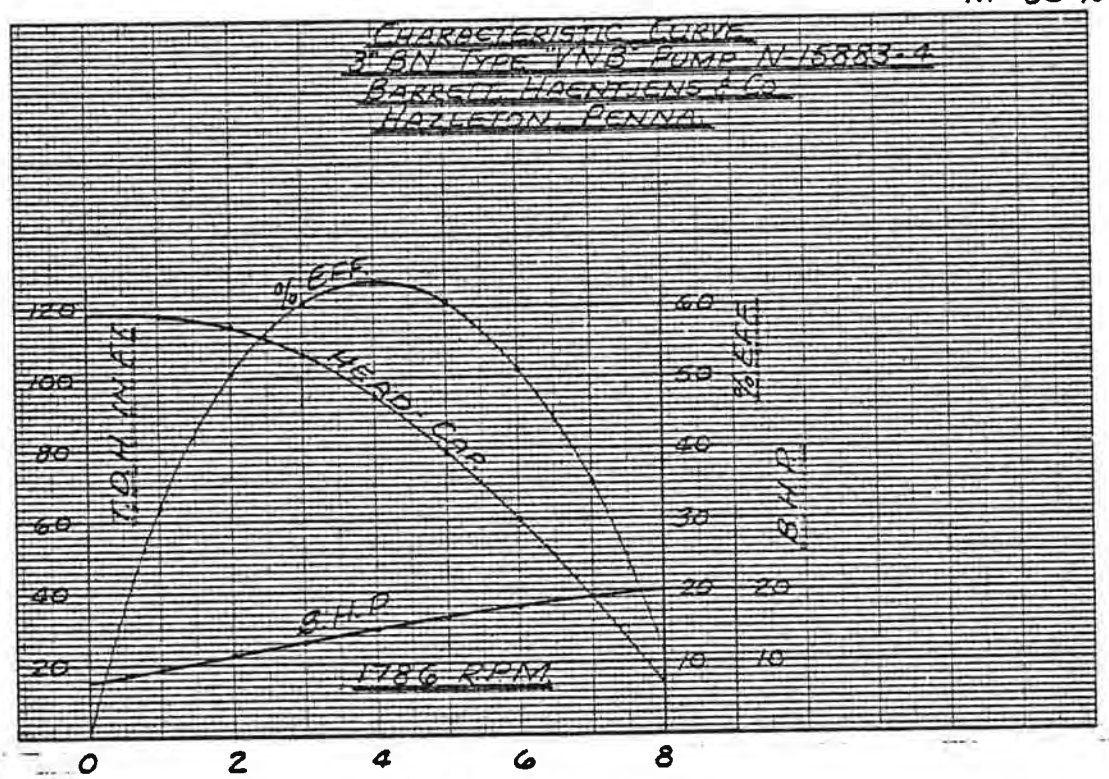
T-03839



PUMP CURVE SHEET

Brown & Root, Inc. POWER DIVISION	CIRCULATING WATER PUMP	DWG. NO.
MECHANICAL ENGINEERING STANDARD	SAN JUAN STATION UNIT 3 FRUITLAND, NEW MEXICO CP-0008	TAG NO. M-303.5
PUBLIC SERVICE CO. OF NEW MEXICO & TUCSON GAS & ELECTRIC CO.		SHT 1 OF 1

CAS D9641 P9641 V9641 - 11.250B. - IMP D10998 P9647 V6792 - 5 - 10.250 T.
M = 85 %

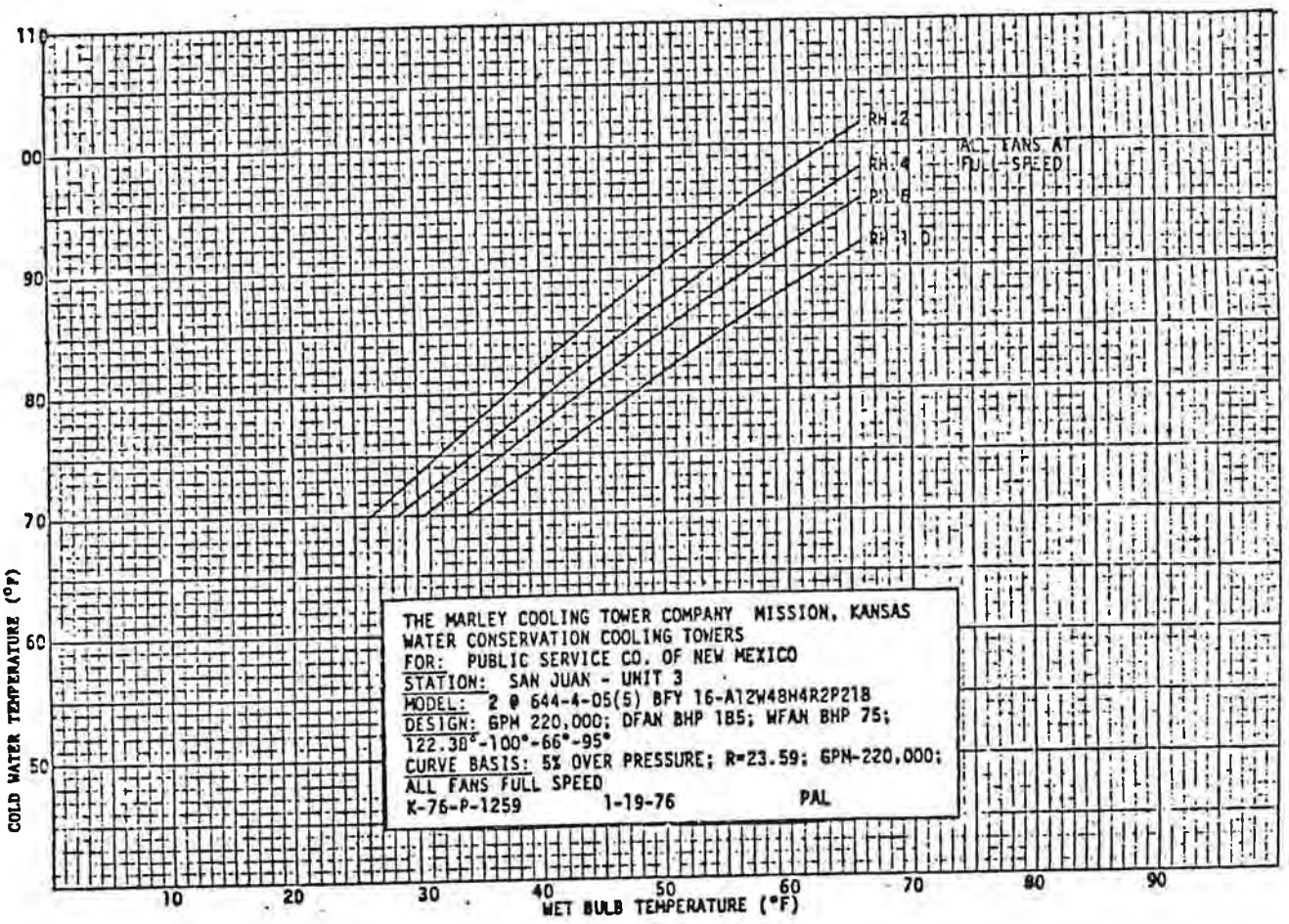


100 G.P.M.

19 AH IMP
45 5/8" BMP - BP - 2 1/2" PIPES
MAX. CAP. 822 G.P.M. - 7.5' T.D.H. - 1780 R.P.M. TESTED 10-11-78

PUMP CURVE SHEET

Brown & Root, Inc. POWER DIVISION MECHANICAL ENGINEERING STANDARD	COOLING TOWER BLOWDOWN SUMP PUMP SAN JUAN STATION UNIT 3 FRUITLAND, NEW MEXICO CP-0008	DWG. NO. TAG NO. B/M M-328
PUBLIC SERVICE CO. OF NEW MEXICO & TUCSON GAS & ELECTRIC CO.		SHT 1 OF 1



MAIN COOLING TOWER PERFORMANCE CURVE

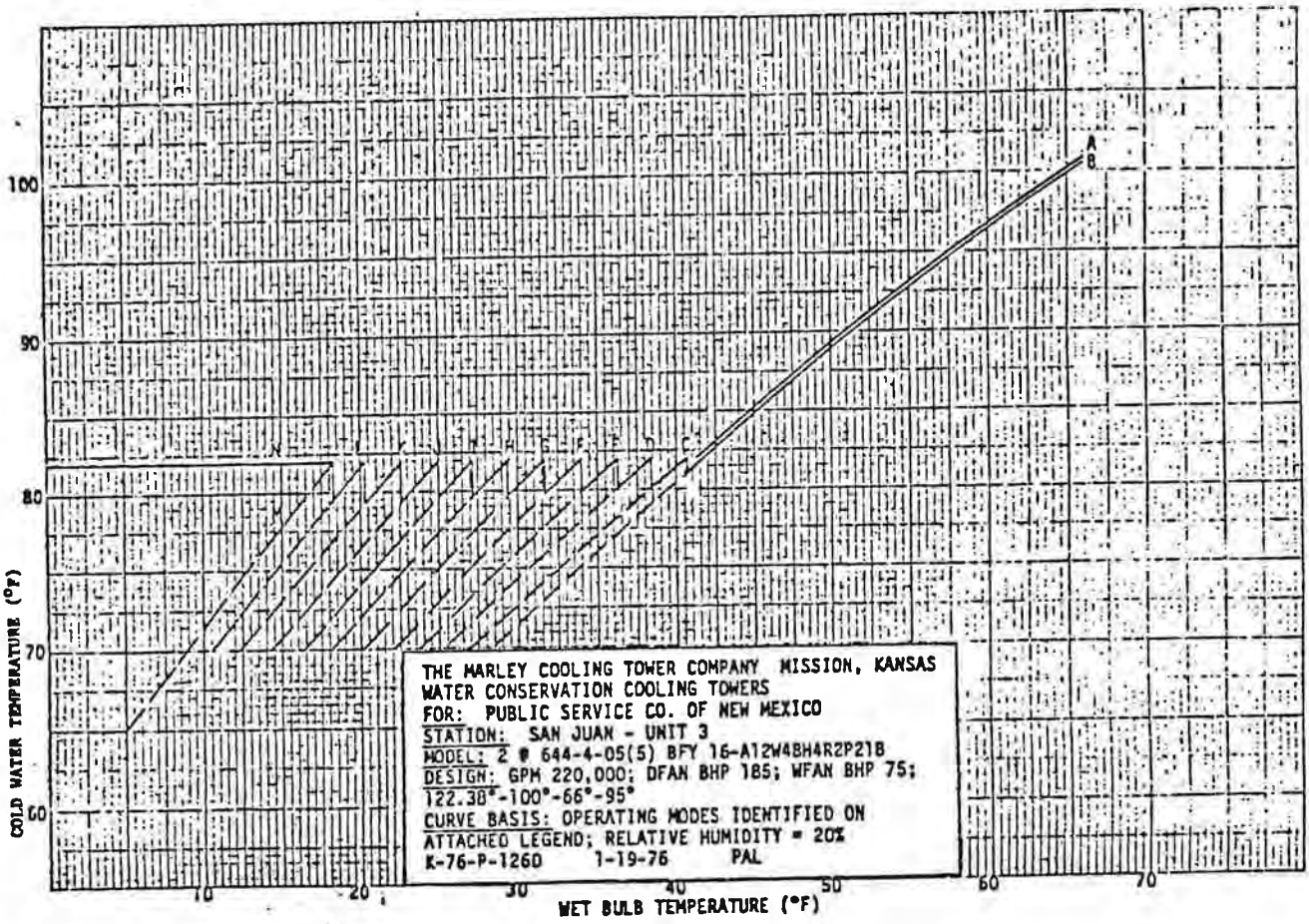
Brown & Root, Inc.
POWER DIVISION
MECHANICAL ENGINEERING STANDARD

MAIN COOLING TOWER
SAN JUAN STATION UNIT 3
FRUITLAND, NEW MEXICO CP-0008

DWG. NO.
TAG NO. M-329

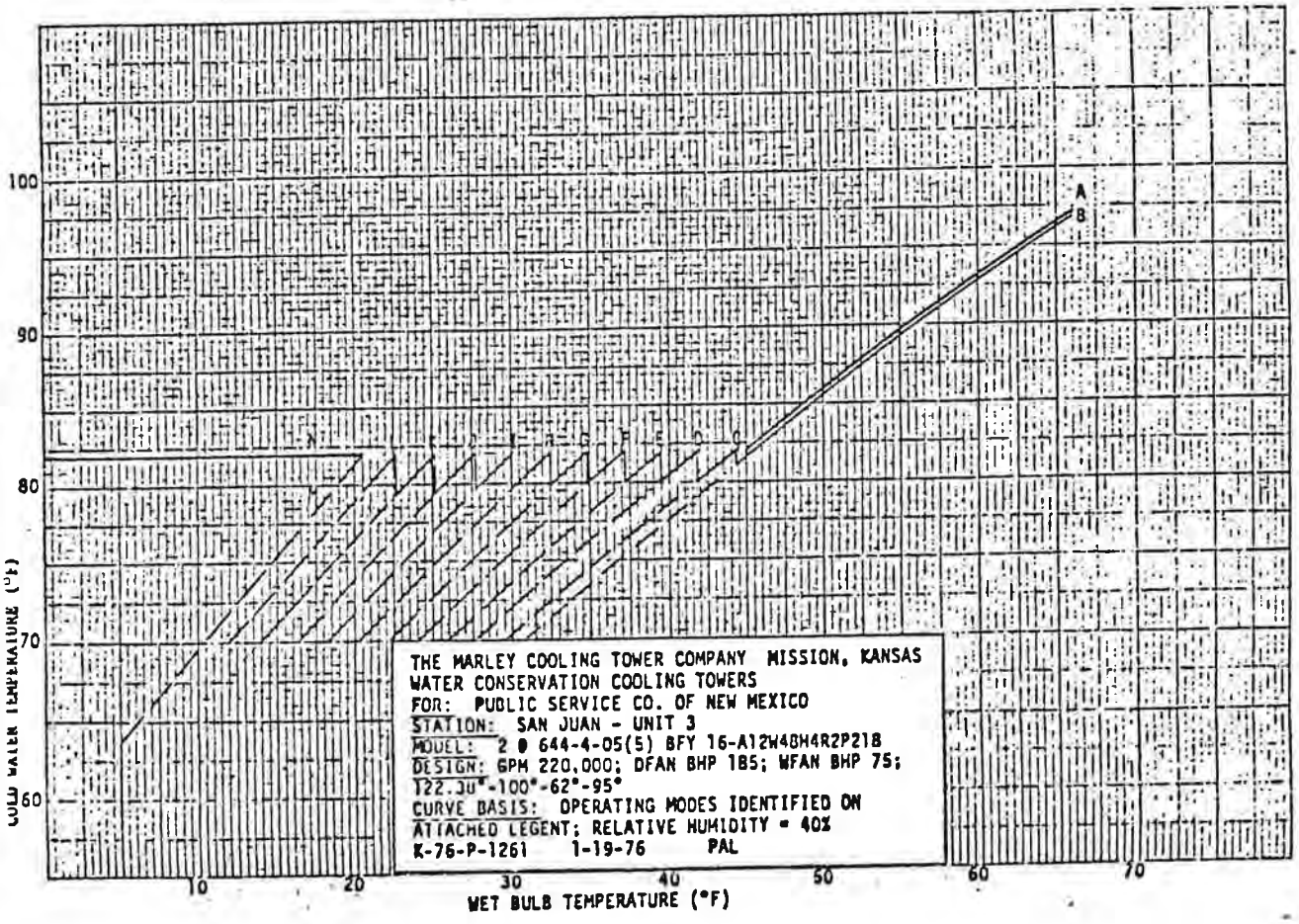
PUBLIC SERVICE CO. OF NEW MEXICO & TUCSON GAS & ELECTRIC CO.

SHT 1 OF 6



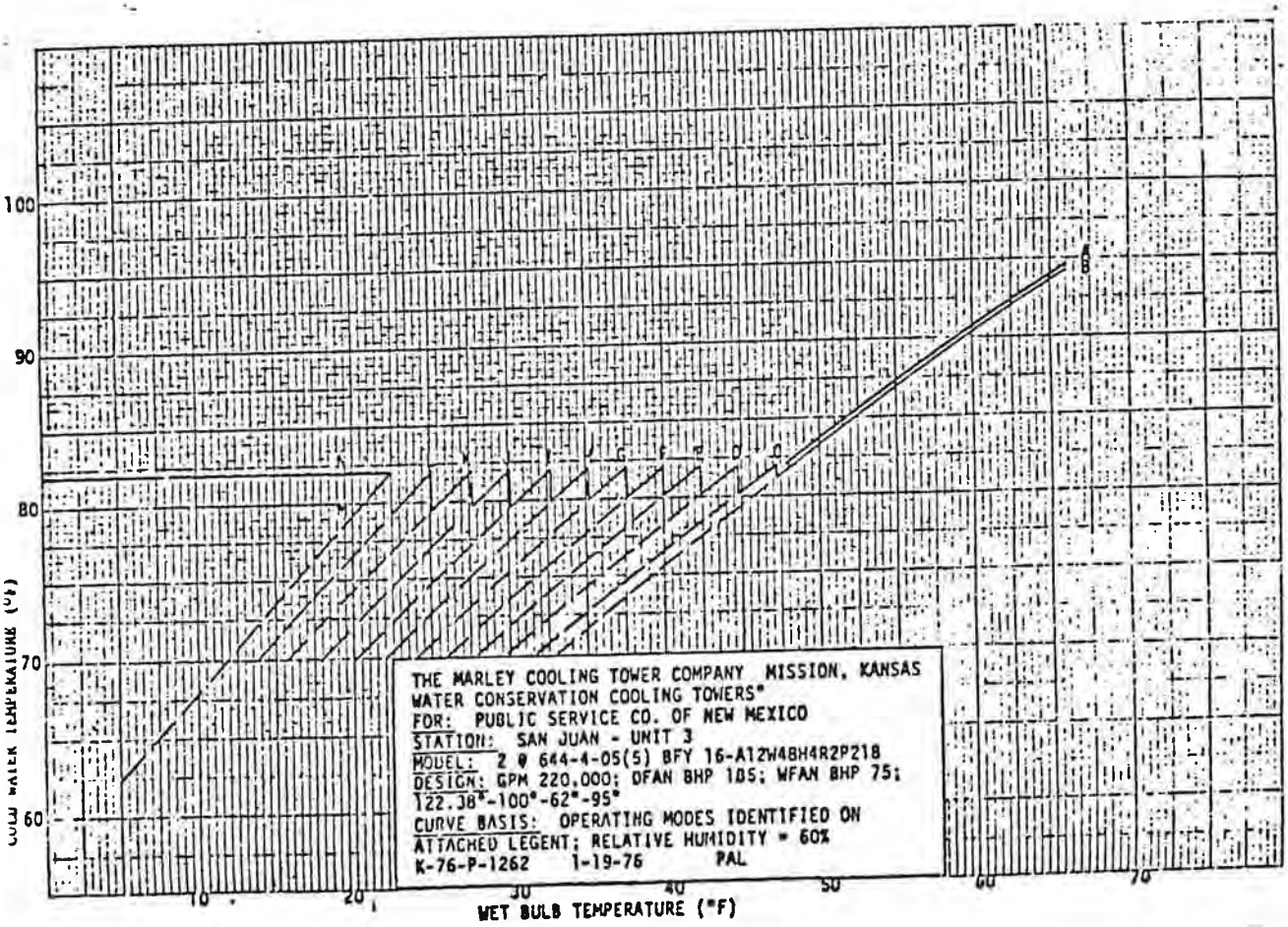
MAIN COOLING TOWER PERFORMANCE CURVE

Brown & Root, Inc. POWER DIVISION MECHANICAL ENGINEERING STANDARD	MAIN COOLING TOWER SAN JUAN STATION UNIT 3 FRUITLAND, NEW MEXICO CP-0008	DWG. NO. TAG NO. M-329
PUBLIC SERVICE CO. OF NEW MEXICO & TUCSON GAS & ELECTRIC CO.		SHT 2 OF 6



MAIN COOLING TOWER PERFORMANCE CURVE

Brown & Root, Inc. POWER DIVISION	MAIN COOLING TOWER	DWG. NO.
MECHANICAL ENGINEERING STANDARD	SAN JUAN STATION UNIT 3 FRUITLAND, NEW MEXICO CP-0008	TAG NO. M-329
PUBLIC SERVICE CO. OF NEW MEXICO & TUCSON GAS & ELECTRIC CO.		SHT 3 OF 6



MAIN COOLING TOWER PERFORMANCE CURVE

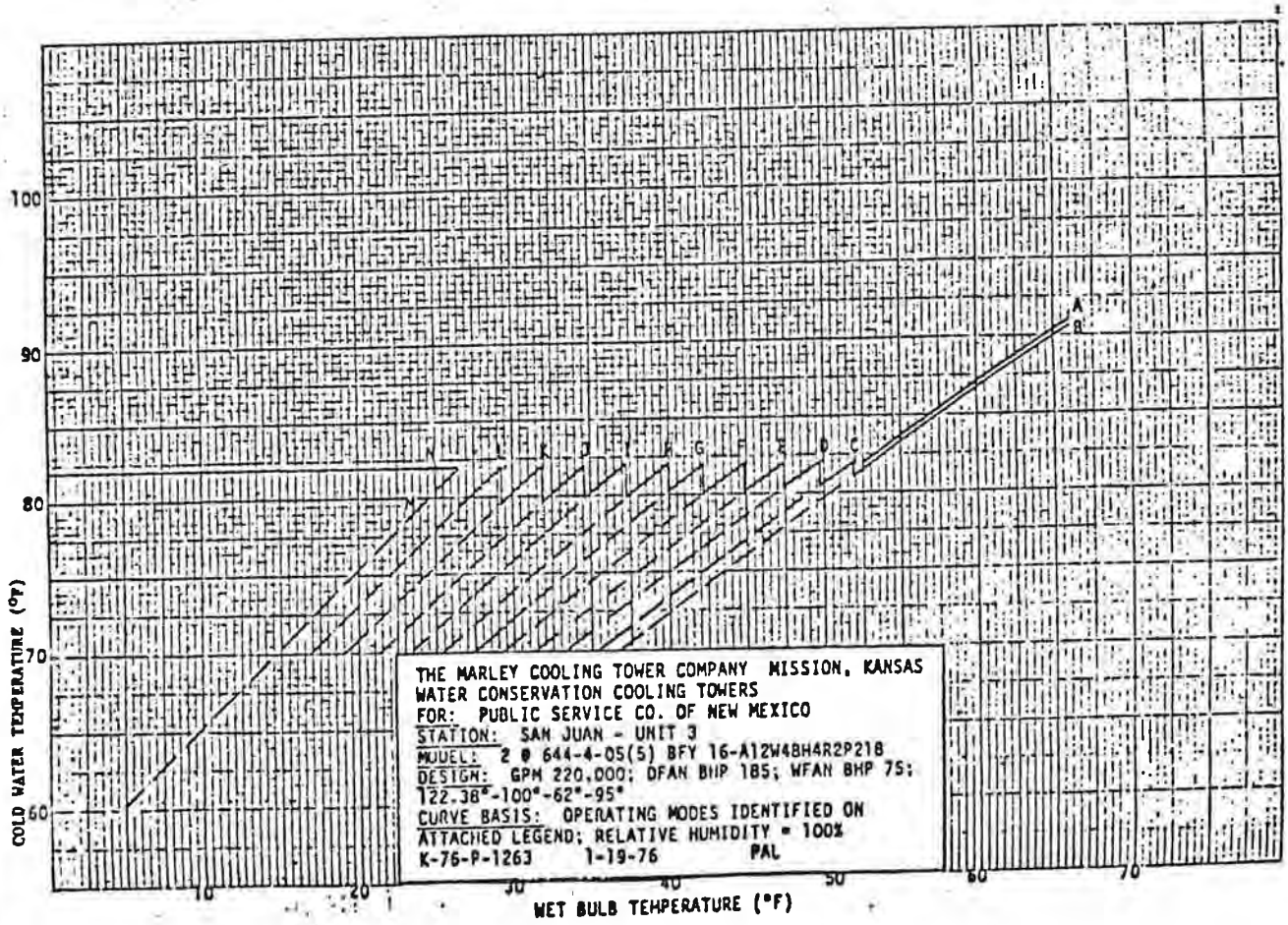
Brown & Root, Inc.
POWER DIVISION
MECHANICAL ENGINEERING STANDARD

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SAN JUAN STATION UNIT 3
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SHT 4 OF 6



MAIN COOLING TOWER PERFORMANCE CURVE

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MAIN COOLING TOWER
SAN JUAN STATION UNIT 3
FRUITLAND, NEW MEXICO CP-0008

DWG. NO.
TAG NO. M-329

PUBLIC SERVICE CO. OF NEW MEXICO & TUCSON GAS & ELECTRIC CO.

SHT 5 OF 6

THE MARLEY COOLING TOWER COMPANY
WATER CONSERVATION COOLING TOWERS
FOR PUBLIC SERVICE CO. OF NEW MEXICO
SAN JUAN STATION - UNIT 3
PERFORMANCE CURVES
PERFORMANCE CURVE OPERATING MODE LEGEND

MODE IDENT. LETTER	COOLING RANGE (°F)	WATER RATE (GPM)	NUMBER OF WET SECTION FANS ON	NUMBER OF WET SECTION FANS OFF	NUMBER OF DRY SECTION FANS ON	NUMBER OF DRY SECTION FANS OFF	COMMENTS
A	22.38	220,000	10	0	40	0	
B	21.95	220,000	10	0	40	0	
C	22.86	220,000	10	0	40	0	
D	22.86	220,000	9	1	40	0	
E	22.86	220,000	8	2	40	0	SOLID CURVES REPRESENT
F	22.86	220,000	7	3	40	0	AUTOMATIC CONTROL STEPS.
G	22.86	220,000	6	4	40	0	DASHED CURVES EXTEND
H	22.86	220,000	5	5	40	0	PERFORMANCE FOR EACH
I	22.86	220,000	4	6	40	0	MODE TO 70° C.W.T.
J	22.86	220,000	3	7	40	0	
K	22.86	220,000	2	8	40	0	
L	22.86	220,000	1	9	40	0	
M	22.86	220,000	0	10	40	0	
N	22.86	220,000	0	10	VARIES	VARIES	DRY SECT. FANS CYCLED FOR 82° CW

MAIN COOLING TOWER PERFORMANCE CURVE OPERATING MODE LEGEND

Brown & Root, Inc.
POWER DIVISION
MECHANICAL ENGINEERING STANDARD

MAIN COOLING TOWER
SAN JUAN STATION UNIT 3
FRUITLAND, NEW MEXICO CP-0008

DWG. NO.
TAG NO. M-329

PUBLIC SERVICE CO. OF NEW MEXICO & TUCSON GAS & ELECTRIC CO.

SHT 6 OF 6

APPENDIX B:

UNIT 3 COOLING TOWER RETROFIT QUOTATION

SPX COOLING TECHNOLOGIES

7401 West 129th Street, Overland Park, Kansas 66213 / Tel: 913-664-7617 / Fax: 913-664-7876 /
robert.fleming@spx.com

MARLEY FIELD ERECTED COOLING TOWER

TO: Sargent & Lundy
ATTN: Chris Hornish

DATE: July 31, 2020
FROM: Robert Fleming

PROJECT: PNM San Juan –Unit 3 Retrofit to Matrix Tower

BUDGETARY SELECTION

DESIGN CONDITIONS:	Flow	268900 gpm(predicted)
	Wet Bulb	66.6 °F
TOWER DESCRIPTION:	Model	X12-E2-20
	Number of Cells	20
	Pump Head	27 ft
	Fan Diameter	10 M (existing)
	Motor Size	18 @ 200 Hp,2@175 bhp
	Brake Horsepower	18 @ 200 Hp, 2@175 bhp
	Evaporation	4880 gpm
	Drift Rate	0.0010 %
TOWER DIMENSION:	Tower Length	960 ft
	Retrofit Fill Width	4.5 ft air travel x 2
	Retrofit Fill Length	960 ft
	Retrofit Fill Height	24 .3 ft
BUDGET PRICE:	$16,100,000	

Please note you will need to add the nine cell tower to this budget price to get the total cost for this option. The new nine cell tower was $7.6 million so the total cost to provide the cooling duty required for this option is $23,700,000.

The budget pricing above includes the cost of converting the remaining 4 cells of Unit 3 to Matrix cells. The fill being used is identical to what is currently in the existing tower.

The existing tower has already has six cells retrofitted with the Matrix design. The existing fill in the Matrix cells is a medium low clog film fill that will need to be replaced due to clogging. The

fill used in this retrofit is a medium low clog fill that will clog rapidly with the existing water quality. The cost for the fill replacement is included in the budget price.

A clarifier should probably needs to be installed if this retrofit is to be seriously considered.

Extensive pipe modifications, blanking off of coils, installing air seals is part of the scope of work required to successfully install the Matrix fill.

This budget price is based upon a scope that includes engineering, prefabrication of materials, freight to jobsite and supervision and labor to field assemble the above retrofit to the field erected cooling tower. The following are not included, and should be provided by the purchaser: Sales and/or use taxes, concrete cold water basin, anchor bolts, fire protection sprinkler system (if required by Owner's insurance underwriter), pumps, piping, valves, water make-up, motor starter, disconnects, and controls.

APPENDIX C:

SUPPLEMENTAL COOLING TOWER QUOTATION

Dimensions

Tower Width	79.13 ft	Basin Width	55.50 ft
Tower Length	360.67 ft	Basin Length	361.00 ft
Tower Height (TOC)	61.08 ft	Static Lift (TOC)	42.68 ft
Fan Deck Height (TOC)	47.33 ft	Pump Head (TOC)	46.37 ft

Conditions

Tower Water Flow	156100 gpm	Altitude	0 ft
Tower Water Mass Flow	21570 lb/s	Barometric Pressure	29.92 in Hg
Wet-Bulb Temperature	66.60 °F	Air Density In	0.07302 lb/ft³
Dry-Bulb Temperature	79.89 °F	Air Density Out	0.07092 lb/ft³
Relative Humidity	50 %	Humidity Ratio In	0.0109
Total Dissolved Solids	0 ppm	Humidity Ratio Out	0.0308
Water Density In Water	62.02 lb/ft³	Evaporation	2380 gpm
Specific Heat In Site	0.998 Btu/lb·F	Drift	<0.0010 %
Factor	1.000		

Thermal Analysis

Fill Air Travel	19.36 ft	Water Rate	11.2 gpm/ft²
Fill Height	42.00 ft	Dry Air Rate	33.06 lb/min/ft²
Fill LNF per cell	40.00 ft	L/G	1.295
Flows per cell	2	KaV/L (CTI)	1.492

Air Flow

Flow/Fan Tower Air Inlet	1538000 cfm	External P.D. In	0.000 in H2O
Flow/Fan Discharge	1615000 cfm	Louver P.D.	0.027 in H2O
Louver Velocity	458 fpm	Fill P.D.	0.234 in H2O
Fill Velocity	469 fpm	Eliminator P.D.	0.039 in H2O
Eliminator Velocity	481 fpm	Plenum P.D.	0.065 in H2O
Discharge Velocity	2055 fpm	Buoyancy P.D.	0.000 in H2O
Inlet P.D. Vel. Heads	0	External P.D. Out	0.000 in H2O
Outlet P.D. Vel. Heads	0	Static P.D.	0.366 in H2O
		Velocity P.D.	0.249 in H2O

Fan Information

Fan Speed (100 %)	134 rpm	Fan Tip Speed	11790 fpm
Fan Power	209.1 Hp	Static Fan Efficiency	44.4 %
Motor Output	217.2 BHp	Total Fan Efficiency	74.7 %
Motor Capacity	250.0 BHp	Fan Pitch	18.0 °

7401 West 129th Street, Overland Park, Kansas 66213 / Tel: 913-664-7617 / Fax: 913-664-7876 /
robert.fleming@spx.com

MARLEY FIELD ERECTED COOLING TOWER

TO:	Sargent & Lundy	DATE:	July 27, 2020
ATTN:	Chris Hornish	FROM:	Robert Fleming

PROJECT: PNM San Juan – Supplemental Tower to Unit 3

BUDGETARY SELECTION

DESIGN CONDITIONS:	Flow	156100 gpm
	Wet Bulb	66.6 °F
TOWER DESCRIPTION:	Model	6716-5-9
	Number of Cells	9
	Pump Head	46.37 ft
	Fan Diameter	28 ft
	Motor Size	9 @ 250 Hp
	Brake Horsepower	9 @ 217.2 Hp
	Evaporation	2380 gpm
	Drift Rate	0.0010 %
TOWER DIMENSION:	Tower Width	79.13 ft
	Tower Length	360.7 ft
	Tower Height	61.08 ft
	Fan Deck Height	47.33 ft
BASIN DIMENSION:	Basin Width	55.5 ft
	Basin Length	361 ft
BUDGET PRICE:	$7,650,000 USD	

This budget price is based upon a scope that includes engineering, prefabrication of materials, freight to jobsite and supervision and labor to field assemble the above field erected cooling tower. The following are not included, and should be provided by the purchaser: Sales and/or use taxes, concrete cold water basin, anchor bolts, fire protection sprinkler system (if required by Owner's insurance underwriter), pumps, piping, valves, water make-up, motor starter, disconnects, and controls.

APPENDIX D:

NEW COOLING TOWER QUOTATIONS

ORIGINAL

7401 West 129th Street, Overland Park, Kansas 66213 / Tel: 913-664-7617 / Fax: 913-664-7876 /
robert.fleming@spx.com

MARLEY FIELD ERECTED COOLING TOWER

TO: Sargent & Lundy
ATTN: Chris Hornish
DATE: July 27, 2020
FROM: Robert Fleming

PROJECT: PNM San Juan Station- New Tower Option

BUDGETARY SELECTION

DESIGN CONDITIONS:	Flow	425000 gpm
	Wet Bulb	66.6 °F
TOWER DESCRIPTION:	Model	6716-5-24
	Number of Cells	24
	Pump Head	46.52 ft
	Fan Diameter	28 ft
	Motor Size	24 @ 250 Hp
	Brake Horsepower	24 @ 230.2 Hp
	Evaporation	6490 gpm
	Drift Rate	0.0010 %
TOWER DIMENSION:	Tower Width	79.13 ft
	Tower Length	960.7 ft
	Tower Height	61.08 ft
	Fan Deck Height	47.33 ft
BASIN DIMENSION:	Basin Width	55.5 ft
	Basin Length	961 ft
BUDGET PRICE:	$20,400,000 USD	

This budget price is based upon a scope that includes engineering, prefabrication of materials, freight to jobsite and supervision and labor to field assemble the above field erected cooling tower. The following are not included, and should be provided by the purchaser: Sales and/or use taxes, concrete cold water basin, anchor bolts, fire protection sprinkler system (if required by Owner's insurance underwriter), pumps, piping, valves, water make-up, motor starter, disconnects, and controls.

Dimensions

Tower Width	79.13 ft	Basin Width	55.50 ft
Tower Length	960.67 ft	Basin Length	961.00 ft
Tower Height (TOC)	61.08 ft	Static Lift (TOC)	42.68 ft
Fan Deck Height (TOC)	47.33 ft	Pump Head (TOC)	46.52 ft

Conditions

Tower Water Flow	425000 gpm	Altitude	0 ft
Tower Water Mass Flow	58730 lb/s	Barometric Pressure	29.92 in Hg
Wet-Bulb Temperature	66.60 °F	Air Density In	0.07302 lb/ft³
Dry-Bulb Temperature	79.89 °F	Air Density Out	0.07093 lb/ft³
Relative Humidity	50 %	Humidity Ratio In	0.0109
Total Dissolved Solids	0 ppm	Humidity Ratio Out	0.0307
Water Density In Water	62.02 lb/ft³	Evaporation	6490 gpm
Specific Heat In Site	0.998 Btu/lb·F	Drift	<0.0010 %
Factor	1.000		

Thermal Analysis

Fill Air Travel	19.36 ft	Water Rate	11.43 gpm/ft²
Fill Height	42.00 ft	Dry Air Rate	33.81 lb/min/ft²
Fill LNF per cell	40.00 ft	L/G	1.293
Flows per cell	2	KaV/L (CTI)	1.490

Air Flow

Flow/Fan Tower Air Inlet	1573000 cfm	External P.D. In	0.000 in H2O
Flow/Fan Discharge	1651000 cfm	Louver P.D.	0.028 in H2O
Louver Velocity	468 fpm	Fill P.D.	0.246 in H2O
Fill Velocity	480 fpm	Eliminator P.D.	0.041 in H2O
Eliminator Velocity	491 fpm	Plenum P.D.	0.068 in H2O
Discharge Velocity	2102 fpm	Buoyancy P.D.	0.000 in H2O
Inlet P.D. Vel. Heads	0	External P.D. Out	0.000 in H2O
Outlet P.D. Vel. Heads	0	Static P.D.	0.384 in H2O
		Velocity P.D.	0.260 in H2O

Fan Information

Fan Speed (100 %)	134 rpm	Fan Tip Speed	11790 fpm
Fan Power	221.8 Hp	Static Fan Efficiency	44.9 %
Motor Output	230.2 BHp	Total Fan Efficiency	75.4 %
Motor Capacity	250.0 BHp	Fan Pitch	18.5 °

SPX COOLING TECHNOLOGIES

UPDATED

7401 West 129th Street, Overland Park, Ks 66213 / Tel: 913 515 5376 / Fax: / robert.fleming@spx.com

MARLEY FIELD ERECTED COOLING TOWER

TO: Sargent & Lundy
ATTN: Chris Hornish

DATE: February 2, 2022
FROM: Robert Fleming

PROJECT: PNM San Juan Carbon Capture

BUDGETARY SELECTION

DESIGN CONDITIONS:	Flow	288190 gpm
	Wet Bulb	66.6 °F
TOWER DESCRIPTION:	Model	F677C-18-18
	Number of Cells	18
	Pump Head	45.89 ft
	Fan Diameter	28 ft
	Motor Size	18 @ 250 Hp
	Brake Horsepower	18 @ 248.5 Hp
	Evaporation	6490 gpm
	Drift Rate	0.0010 %
TOWER DIMENSION:	Tower Width	74.17 ft
	Tower Length	756.7 ft
	Tower Height	61.58 ft
	Fan Deck Height	47.83 ft
BASIN DIMENSION:	Basin Width	51.5 ft
	Basin Length	757 ft
BUDGET PRICE:	$17,100,000 USD	

This budget price is based upon a scope that includes engineering, prefabrication of materials, freight to jobsite and supervision and labor to field assemble the above field erected cooling tower. The following are not included, and should be provided by the purchaser: Sales and/or use taxes, concrete cold water basin, anchor bolts, fire protection sprinkler system (if required by Owner's insurance underwriter), pumps, piping, valves, water make-up, motor starter, disconnects, and controls.

APPENDIX E:

EXISTING CIRCULATING WATER PIPING DRAWINGS

G-1030-11

Unit 3 Circulating Water Pipe

Unit 4 Circulating Water Pipe

FOR TOWER RELATED PIPING IN THIS AREA SEE G-1034

COOLING TOWER NO. 4

N 2113,610.00
E 323,851.20

N 2113,455.08
E 324,000.00

N 2113,452.38
E 324,150.00

P.I. N-2,113,322.88
E-322,803.00
R=225.00'
T=60.43'
L=117.81'
Δ=30°

P.I. N-2,113,316.46
E-323,810.00
R=240.00'
Δ=3°

PVI N2113434.47
EL 5284.01

PVI N2113426.62
EL 5284.01

BY SCWPF

BY CCWPF

PMH #5

PMH #6

MATCH LINE N-2113450.00
SEE DWG. G-1034

ELECTRICAL DUCT

16" POND WATER TRANSFER LINE

SEE DETAIL A

IN PLACE PHASE III

IN PLACE PHASE II

EFFLUENT POND

END OF PHASE I-LINE "C"
℄-ELEVATION 5288.08

P.I. N-2,112,612.50
E-322,617.45
R=390.00'
T=132.55'
L=251.33'
Δ=45°

P.I. N-2,112,597.50
E-322,623.66
R=305.00'
T=126.34'
L=239.55'
Δ=45°

P.I. N-2,112,582.50
E-322,629.88
R=290.00'
T=120.12'
L=227.77'
Δ=45°

P.I. N-2,112,567.50
E-322,636.09
R=275.00'
T=113.91'
L=215.98'
Δ=45°

N-2,112,712.50
E-322,850.00

P.I. N-2,112,567.50
E-323,384.20
R=290.00'
T=167.43'
L=302.09'
Δ=60°

P.I. N-2,112,562.50
E-323,375.54
R=275.00'
T=158.77'
L=287.98'
Δ=60°

COOLING TOWER #3

CONC. PIPE IN PLACE

BY S.C.W.P.F.

FOR TOWER RELATED PIPING, SEE G-1033.

P.T. E-322,750.00

P.C. E-323,216.77

24" BRANCH CONN. TO BE CAPPED

BEGIN 0.010 SLOPE

100.00'

366.77'

N-2,112,466.41
E-322,537.00

N-2,112,472.62
E-322,520.00

N-2,112,478.83
E-322,505.00

N-2,112,485.04
E-322,490.00

LINE A
LINE B
LINE C
LINE D

120" DIA. CIRCULATING WATER PIPE ℄-ELEVATION 5295.0

FOR UNDERGROUND PIPING SEE DWG G-1045

N-2,112,283.00
SEE DWG. G-1032

P.T. N-2,112,238.81

UNIT No. 4 N-2,112,218

P.I. N-2,112,200.64
E-322,490.00
R=290.00'
T=38.18'
L=75.92'
Δ=15°

P.I. N-2,112,202.61
E-322,505.00
R=275.00'
T=36.20'
L=71.99'
Δ=15°

P.I. N-2,112,088.68
E-322,520.00
R=275.00'
T=36.20'
L=71.99'
Δ=15°

P.I. N-2,112,083.18
E-322,537.00
R=290.00'
T=38.18'
L=75.92'
Δ=15°

P.C. N-2,112,052.48
E-322,520.00

P.C. N-2,112,045.00
E-322,537.00

N-2,111,994.96
SEE DWG. G-1032

120" DIA. CIRCULATING WATER PIPE ℄-ELEVATION 5295.0

UNIT No. 3, N-2,111,930

17.0'

15.0'

ACTIVE COAL PILES

N-2,113,000

N-2,112,500

N-2,112,000

N-2,111,995

E-323,000

E-323,500

E-324,000

E-324,500

5320
5310
5300
5290
5280
5270
5260

SECTION LINE

N 2113500.7
E 325098.00

N 2113500.7
E 325,098.00

N 2113000

N 2112500

PLAN

DETAIL A
SCALE 1" = 10'-0"

TOP/MANHOLE EL. 5289.01

36" DIA. MANHOLE

BY OTHERS

6"x4" REDUCER

2'-6"

14'-5"

7'-0"

℄ 120" I.D. CIRCULATING WATER PIPE EL. 52"4.5"

SECTION 1
SCALE 1"=4'-0"

NOTES

1. FOR GENERAL NOTES SEE DRAWING G-1001.

REFERENCE DWGS.

G-1002	GENERAL ARRANGEMENT PLOT PLAN
G-1031	UNDERGROUND PIPING AUXILIARY COOLING TOWER AREA PLAN
G-1033	CIRCULATING WATER SYSTEM UNIT 3 TOWER DETAILS
G-1034	CIRCULATING WATER SYSTEM UNIT 4 TOWER DETAILS
G-1035	CIRCULATING WATER SYSTEM MISCELLANEOUS SECTIONS AND DETAILS
G-1036	UNDERGROUND PIPING ALXILIARY COOLING TOWER AREA DETAILS
G-1037	CIRCULATING WATER SYSTEM PIECE MARK REFERENCE PLAN SHEET 1
G-1038	
G-1039	UNDERGROUND PIPING DETAILS
G-1045	UNDERGROUND PIPING PLAN
G-1046	UNDERGROUND PIPING DETAILS
G-1047	UNDERGROUND PIPING DETAILS

NO.	DATE	REVISION	BY	CHK.	APP.
11	11-20-81	REVISED DETAIL A & SECTION 1 - AS BUILT	MLC	MLC	MLC
10	4-17-80	REVISED DIMENSIONS FOR END OF PHASE II; DET. A	KWT		
9	1-21-80	REVISED CO-ORDINATES AS NOTED	JRG		MLC
8	1-10-80	ISSUED FOR FABRICATION PHASE III	JRG		MLC
7	4-6-78	REVISED AS NOTED			
6	12-7-77	ADDED DIMENSIONS FOR END OF PHASE II	L.F.		
5	11-1-77	ISSUED FOR FABRICATION PHASE II	L.F.		
4	6-8-77	ISSUED FOR P.O. SPEC. 357.5, & REVISED AS NOTED	R.D.		
3	3-1-77	ISSUED FOR BIDS NO. 357.5			
2	1-14-77	ADDED TOWER 3 RELATED PIPING; RELOCATED COOLING TOWER #4; ADDED PHASE II CIRCULATING WATER			
1	9-26-75	REDRAWN AND ISSUED FOR CONSTRUCTION	RA		

DRAWN
CHECKED
APPROVED
CUSTOMER APP.

REGISTERED PROFESSIONAL ENGINEER No. 5729 STATE OF NEW MEXICO

BROWN & ROOT, INC.
ENGINEERS AND CONSTRUCTORS
OAK BROOK, ILLINOIS

SAN JUAN STATION
UNIT 3&4
FRUITLAND N.M.
PUBLIC SERVICE CO. OF NEW MEXICO
AND
TUCSON GAS & ELECTRIC COMPANY

DRAWING TITLE
CIVIL
CIRCULATING WATER SYSTEM
PLAN

CONTRACT NO. CP-0008
DATE: SEPT. 5, 1975
SCALE: 1"=80'(U.N.)
B & R DRAWING NO. G-1030-11

14464
9754
9-1-77
9766

MATCH LINE STA. N 2,112,000 NO MATCH DWG.

Unit 2 Circulating Water Pipe

SWITCHYARD

UNIT # 2

UNIT # 1

DRAWING UNDER REVISION

DATE: 3/16/24

PROJECT NO. GE-83-53

PROJECT NAME:

JOB ENGR. Jerry Trujillo

PLANT CONTACT:

NOV 9 1987

MATCH LINE STA. N. 2,111,500 FOR CONT. SEE DWG. PG-16

MATCH LINE STA. E 322,700 FOR CONT. SEE DWG. PG-14

MATCH LINE STA. E 322,000 NO MATCH DWG.

NO.	REVISIONS	DATE	BY	CK'D	APP'D	REF.
1	"AS BUILT" TO 8-12-76	8-12-76	TC			
2	ROUTED PIPING TO HYDROGEN STATIONS UNITS 1 AND 2	9-12-77	AT	ABT		
3	ADDED TELEPHONE CABLE AND RAW WATER LINE	6-8-78	GDN		TPO	
4	REVISED R.W. LINE SIZE	7-1-80	GDN		TJC	
5	ADDED RW VALVES @ 22123 AND UK#1 & UK#2	12-2-81	HA	TJC	TJC	---
6	ABANDONED OLD UNIT-2 HYDROGEN LINE FROM TANK TO BLDG.	8/29/84	P.F.J.	AB	AB	
7	REVISED RAW WATER LINE TO REFLECT ACTUAL FIELD LOCATION (PWM REV.)	3/14/89	PWM	JMM	JMM	
8	STORM DRAIN MODIFICATION AT ENTRANCE TO U2&U3 BREEZEWAY, AS PER RFD 3857	4/21/14	BT	RC	HA	

PRINT RECORD			
DATE ISSUED	9-12-76	7-1-80	12-2-81
REVISION NO.		1	5
FOR	AFC	2AFC	
CUSTOMER	8	8	
FIELD	2	1,3	
INTRA CO.	10-7-76	16 7-7-76	

ENG. RECORD		
DRAWN	T.C.	3-12-76
CHECKED	–	
MECH. CK.	–	
STRUCT. CK.	–	
ELECT. CK.	–	
INST. CK.	–	
APPROVED		
APPROVED		

DRAWING STATUS	
ISSUED	DATE
PRELIMINARY FOR COMMENTS AND/OR APPROVAL	
APPROVED FOR CONSTRUCTION	4/14/87
1 REVISED & APPROVED FOR CONSTRUCTION	3/24/89

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED & DATED. RECEIPT ALL PRINTS DESIGNED EARLIER DATE & AS REVISING NO.

YARD PIPING

UNDERGROUND FACILITIES

SAN JUAN STATION UNIT NO. 1 & 2 FRUITLAND, N. M.

PUBLIC SERVICE COMPANY OF NEW MEXICO AND TUCSON GAS & ELECTRIC COMPANY

SCALE 1" = 20'-0" Stearns-Roger INCORPORATED ORDER NO. C-11500

DWG. NO. L-22325

SHEET NO. P 6-13

REV. 8

MICROFILMED SEP 3 '84

Form 173-1

Unit 1 Circulating Water Pipe

Unit 2 Circulating Water Pipe

MATCH LINE STA. N. 2,111,500 FOR CONT. SEE DWG. PG-13

MATCH LINE STA. E. 322,000 NO MATCH DWG.

MATCH LINE STA. E. 322,700 FOR CONT. SEE DWG. PG-17

MATCH LINE STA. N. 2,111,000 FOR CONT. SEE DWG. PG-19

SWITCHYARD

UNIT #1

S-R OFFICE BLDG.

CONSTRUCTION CHANGE HOUSE

CHEMICAL LAB.

ENGINEERING TRAILER

DRAFTING TRAILER

WASH RACK

PARKING AREA

ADMINISTRATION BUILDING

WAREHOUSE

CHAIN LINK FENCE – N. 2,111,450.2'

CHAIN LINK FENCE – N. 2,111,250.0'

CHAIN LINK FENCE – E. 322,190'

CHAIN LINK FENCE – E. 322,160

STAIRS DOWN

AREA INLET

VALVE BOX

LINE ABANDONED IN PLACE

ABANDON UNDERGROUND LINE IN PLACE

GUARD HOUSE

WASH ROOM

ELECTRIC MH #10

TELEPHONE LINE

TELEPHONE LINES

ELECT. MH #2

ELECT. MH #3

ELECT. MH #4

ELECT. MH #5

ELECT. DUCT BANK

STORM DRAIN "A"

STORM DRAIN "B"

STORM DRAIN "C"

ROAD "C"

ROAD "D"

ROAD "B"

2" CITY WATER (ABANDONED)

3" WASH WATER SUPPLY

12" RAW WATER

12" DRUM WATER

12 KV CABLES (APPROX 30" COVER)

GROUND BED No. 6

INSTALLED PI. N 2111,230.00 E 322,303.00 STA. BK PI 151 33.04

INSTALLED PI. N 2111,140.21 E 322,224.50 INSTALLED STA 60+31.15

N. 2,111,480.0' ℄ CONDENSER #1

TORSIONAL DYNAMIC STABILIZER REF: BHM DWG 3B0-110,051

NOTES:
REFERENCE PLAN AND PROFILE BOHANNAN AND HOUSTON DRAWINGS 20120113-01-G-01 SHEETS 1-12

NO.	REVISIONS	DATE	BY	CHK'D	APP'D
12	AS-BUILT PNM PROJECT GE-88026 211.D-E-17-18	7/29/02	D.M.	KVB	LEA
11	AS BUILT PER DCS #8045, ZN. G-10	8/9/01	GB	DM	DM
10	AS BUILT PER DCS #8058, ZN. F11,12,13	9/29/01	GB	DM	DM
9	UNIT 1 AS-BUILT NEW 4" POTABLE WATER LINE, AS PER RFD #3548	12-12-12	BT	–	AB
8	ADDED TELEPHONE CABLE AND RAW WATER LINE	6-4-90	GPN	GPN	TFC
7	REVISED R.W. LINE SIZE	7-1-88	GPN	GPN	TFC
6	ADDED TORSIONAL DYNAMIC STABILIZER (PNM REVISION)	2-24-88	GPN	KVR	KVR
5	ADDED GROUND BED No. 6 GROUNDING AND POWER.	6-18-81	HG	KVR	KVR

NO.	REFERENCE DRAWINGS

PRINT RECORD			
DATE ISSUED	8-9-76	7-19-77	
REVISION NO.	1	4	
FOR	AFC	RAFC	
CUSTOMER	8	8	
FIELD	2	1-5 1P	
INTRA CO.	1-5 2-VL	1P P/C	

ENG. RECORD		
DRAWN	T.C.	5-1976
CHECKED	–	
MECH. CK.	–	
STRUCT. CK.	–	
ELECT. CK.	–	
INST. CK.	–	
APPROVED		
APPROVED		

DRAWING STATUS	
ISSUED	DATE
PRELIMINARY	
FOR COMMENTS AND/OR APPROVAL	
APPROVED FOR CONSTRUCTION	8/11/76
1 REVISED & APPROVED FOR CONSTRUCTION	2/6/77
NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED & DATED BELOW!! ALL PRINTS BEARING EARLIER DATE X/M REVISION NO.	

YARD PIPING
UNDERGROUND FACILITIES

SAN JUAN STATION UNIT NO. 1 & 2 FRUITLAND, N. M.

PUBLIC SERVICE COMPANY OF NEW MEXICO AND TUCSON GAS & ELECTRIC COMPANY

SCALE 1" : 20'-0"

Stearns-Roger INCORPORATED

ORDER NO. C-11500

DWG. NO. L-22325

SHEET NO. P 6-16

REV. 15

Form 773-1

MICROFILMED SEP 3 '84

MATCH LINE STA. N 2,111,500 FOR CONT SEE DWG. PG-14

UNIT #1

AIR HEATER BLDG.

CHIMNEY NO. 1

ELECTRICAL EQUIPMENT BUILDING

Unit 1 Circulating Water Pipe

Unit 2 Circulating Water Pipe

ASH PUMP SUMP

TO M.H. #16

F.H #15 N 2,111,329.05 E 323,136.00

M.H.#4 N 2,111,307 E 322,898.5

M.H.#3 N 2,111,433.75 E 322,898.5

M.H.#14 N 2,111,448.0 E 323,189.0

MH#24 N 2,111,375 E 323,116

F.H #3 N 2,111,737 E 322,750

N 2,111,400

N 2,111,300

N 2,111,200

N 2,111,100

N 2,111,000

E 322,800

E 322,900

E 323,000

E 323,100

E 323,200

E 323,300

E 323,400

MATCH LINE STA. E 322,700 FOR CONT SEE DWG. PG-16

MATCH LINE STA. E 323,400 FOR CONT. SEE DWG. PG-18

MATCH LINE STA. N 2,111,000 FOR CONT. SEE DWG. PG-20

BOILER BLOWDOWN TANK

CONCRETE SUMP

SCRUBBER MAKE-UP WATER TANK NO.1

PREMIX TANK NO.1

ELECTRICAL DUCT BANK

WASTE WATER RECOVERY SYSTEM CHEM. BLDG.

INSTALL OIC SEWAGE TREATMENT SYSTEM

SPARE PARTS WAREHOUSE

"AREA" (EXTENSIVELY MODIFIED SEE RCC 174 SERIES DWGS)

FUEL OIL STORAGE TANK 1

D.R.G. INTERFACE PT.

GROUND BED No. 5

SAMPLER ENCLOSURE

UNDERGROUND PIPING (6&8-P-9201)

ELECT. COND. LINE SLOPE APPX. 3.5%

ELECT. DUCTS, & OTHER PIPING.

APPROX. INV. EL. 9269.0' FIELD TO ESTABLISH INV. EL TO CLEAR 96-CW-627-7 E2, ELECT. DUCTS, & OTHER PIPING.

SEWAGE TREATMENT PLANTS & PORTION OF EXISTING SEWERS ABANDONED IN PLACE.

NOTES:
1. REFERENCE PLAN AND PROFILE BOHANNAN AND HOUSTON DRAWINGS 20120113-01-G-01 SHEETS 1-12

NOTES:
2. 12" FIRE PROTECTION RE-ROUTE (285') 12" PVC 200# RATED-RESTRAINED COUPLINGS. HYDRO-EXCAUTE BY AIMS - 5' DEEP, 4' SAND BEDDING BELOW PIPE - 6" ABOVE PIPE

TITLE SHEET

P6-18	
P6-20	P6-21 P6-22
P6-23	P6-24
P6-25	P6-26

NO.	REVISIONS	DATE	BY	CHK	APP'D
17	12" FIRE PROTECTION PIPE RE-ROUTE AT SSWW BLDG. AREA, PER RFD 4846	/19/17	BT	AB	JJ
16	UNIT 1 AS-BUILT NEW 4" POTABLE WATER LINE, AS PER RFD #3548	12-12-12	BT	—	AB
15	LINES ARE ABANDON IN PLACE AND RE-ROUTED OVERHEAD	6/8/09	BT	SB	TK
14	OVERLAY OF PARTIAL DRAWINGS AND ADDED REFERENCE NOTATION AS PER RFD #2496	1/16/07	BT	BB	CM
13	AS PER SJ DCS #5603, 2HK18	4/30/04	LD		
12	AS-BUILT P&M PROJECT GE-88-026 EN. D2	9/1996	P.M.		
11	BOWIE I-HTS # 8 H-17	6/1987	D.M.		
10	4" PVC 3' UNDER GROUND @ APPROX. 3% GRADE	8.24.84	P.E.J.	DE K	DE K

REFERENCE DRAWINGS

PRINT RECORD

| | | |

MATCH LINE STA N 2111,000 - FOR CONT. SEE DWG. P6-17

MATCH LINE STA. N 2,110,900 - NO MATCH DWG.

MATCH LINE STA. E 322,700 - FOR CONT. SEE DWG. P6-19

MATCH LINE STA. E 323,400 - FOR CONT. SEE DWG. P6-21

(EXTENSIVELY MODIFIED SEE RCC 174 SERIES DWGS.)

AREA 2

SPARE PARTS WAREHOUSE

TO ADMIN. BLDG.

ELECTRICAL

SAS MH3 N.2110880.40 E.322861.63

SAS MH4 N.2110724.64 E.323059.61

SAS MH5 N.2110576.24 E.323248.23

NEW 4" SANITARY SEWER AND WWTP LINE

ABANDONED

CHLORINE BLDG

R.O. BLDG.

R.C.C. BLDG.

PRECIP. (DRAINAGE)

CITY WATER STORAGE TANKS SEE DWG. L-22325 P4-43

4" POTABLE WATER SEE NOTE 7.

CITY WATER IN

DECANT PITS

MATCH LINE B - THIS DWG.

MATCH LINE A SEE DWG. P6-23

PARTIAL PLAN DETAIL - CONTINUED

TO SEE THIS SECTION OF DRAWING SEE BOHANNAN AND HOUSTON DWG 20120113-01-G-03 20120113-01-G-06

Unit 2 Circulating Water Pipe

WASTE SETTLING POND S.P.#1 (L-22603)

TO POND #1

SEE SHEET P6-23 FOR PARTIAL PLAN THIS DWG.

TITLE SHEET

P6-17	P6-18		
P6-21	P6-22		
P6-23	P6-24		
P6-25	P6-26		

NOTES (GE-83-53)

1. Pipe to be installed in accordance with rcc spec.
2. Buried pipe to have a min.cover of 3'-0" (unless otherwise noted).
3. Buried pipe under roadways is to be sleeved (C.S.) or encased in concrete.
4. Drisco pipe to be installed in accordance with manuf's. recommendations.
5. the 8"-316L-S.S. fittings, branch conn., flange, etc. are to be installed with 5'-0" of sch.40 pipe on each side.(runs are sch.10).
6. The 8" PE line is to be sloped from the Centrifuge Surge Tank to Ponds 1&2 (completely self-draining - no vertical loops allowed).
7. REFERENCE PLAN AND PROFILE BOHANNAN AND HOUSTON DWGS. 20120113-01-G-01 SHEETS 1-12
8. 12" FIRE PROTECTION RE-ROUTE (285'). 12" PVC 200# RATED-RESTRAINED COUPLINGS. HYDRO-EXCAUTE BY AIMS - 5' DEEP. 4" SAND BEDDING BELOW PIPE - 6" ABOVE PIPE

Form 173-1

NO.	REVISIONS	DATE	BY	CHK'D	APP'D	ISS.
1	"AS BUILT" TO 8-12-76	8-12-76	TC			
2	ADDED ACID TRENCH ⊕ 1-CU-828-11E	3-23-77	AT	A.B.T		
3	ADDED 4"PW-175# ABANDONED TY. 2"CITY WATER LINE (4"PW(PVC)) CHANGED 3"PW(PVC) AS SHOWN	5-10-79	GTA			
4	REROUTED 6" 308-SG DRAIN LINE	11-21-83	SDJT	JTEC	AL	
5	AS-BUILT NEW PIPE PROJECT GE-83-53 ZONE-ALL	8-1-87	RM			
6	UNIT 1 AS-BUILT NEW 4" POTABLE WATER LINE, AS PER RFD #3548	12-12-12	BT	–	AB	
7	12" FIRE PROTECTION PIPE RE-ROUTE AT SSWW BLDG. AREA, PER RFD 4846	1/19/17	BT	AB	JJ	
8	ADDED NEW 4" SEWER LINE PER B&H DWGS, PER RFD 4952	5/2/17	BT	AB	JJ	

REFERENCE DRAWINGS

PRINT RECORD												
DATE ISSUED	8-9-76	4/7/77										
REVISION NO.		1	1									
FOR	AFC	RJFC										
CUSTOMER	B	B										
FIELD	2	2										
INTRA CO.	1-5 2-14	1-5 2-14										

ENG. RECORD		
DRAWN	W.V.	3-12-76
CHECKED	—	
MECH. CK.	—	
STRUCT. CK.	—	
ELECT. CK.	—	
INST. CK.	—	
APPROVED		
APPROVED		

DRAWING STATUS

ISSUED	DATE
PRELIMINARY FOR COMMENTS AND/OR APPROVAL	
APPROVED FOR CONSTRUCTION	8/14/76
REVISED & APPROVED FOR CONSTRUCTION 1	4/11/77
REV. 2	

NOT APPROVED FOR CONSTRUCTION UNTIL ALL REVISIONS ARE APPROVED BY PUBLIC SERVICE CO. OF NEW MEXICO & EL PASO NATURAL GAS CO.

YARD PIPING

UNDERGROUND FACILITIES

SAN JUAN STATION UNIT NO. 1&2 FRUITLAND, N. M.

PUBLIC SERVICE COMPANY OF NEW MEXICO AND TUCSON GAS & ELECTRIC COMPANY

SCALE 1" : 20'-0"

Stearns-Roger INCORPORATED

ORDER NO. C-11500

DWG. NO. L-22325

SHEET NO. P 6-20

REV. 2

Appendix F. Water Sourcing Study

Enchant Energy
Carbon Capture FEED Study
San Juan Generating Station
Units 1 & 4

Water Supply Study

Issued For FEED

Revision B

June 9, 2022
Project No. A13891.010

Prepared by

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LEGAL NOTICE

This Report (“Deliverable”) was prepared by Sargent & Lundy, L.L.C. ("S&L"), expressly for the sole use of Enchant Energy LLC ("Client") in accordance with the agreement between S&L and Client. This Deliverable was prepared using the degree of skill and care ordinarily exercised by engineers practicing under similar circumstances. Client acknowledges: (1) S&L prepared this Deliverable subject to the particular scope limitations, budgetary and time constraints, and business objectives of the Client; (2) information and data provided by others may not have been independently verified by S&L; and (3) the information and data contained in this Deliverable are time sensitive and changes in the data, applicable codes, standards, and acceptable engineering practices may invalidate the findings of this Deliverable. Any use or reliance upon this Deliverable by third parties shall be at their sole risk.

ISSUE SUMMARY

Revision & Purpose	Date	Prepared	Reviewed	Approved
A Client Comments	October 29, 2021	M. Rosen	C. Hornish	--
B Issued for FEED	June 9, 2022	M. Rosen	C. Hornish	C. Hornish

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1 Introduction

Enchant Energy's San Juan Generating Station (SJGS) will be installing Mitsubishi Heavy Industry's (MHI) KM CDR^{TM} carbon capture process to treat the entire flue gas from Units 1 and 4. MHI's technology is an amine-based CO_2 capture process which uses a proprietary solvent that will be designed to recover 95% of the CO_2 from the flue gas and compress the treated CO_2 to acceptable pipeline conditions. The process essentially consists of four stages including flue gas pretreatment, CO_2 recovery, solvent regeneration and CO_2 compression. Two identical trains are planned to treat the entire flue gas from the two generating units.

The carbon capture process has very high heat rejection requirements from all four stages. A new cooling tower will be built north of the carbon capture island to reject the new heat loads. Although it is currently planned to recycle flue gas condensate for use as cooling tower makeup this will constitute only a small portion of the total required makeup. In addition to cooling tower makeup, lesser amounts of demineralized, potable and utility (service) water will also be required by the carbon capture process.

The purpose of this report is to identify the various water requirements for the carbon capture process and confirm whether SJGS has enough water rights and existing infrastructure to meet these requirements. Preliminary pipe routings and material takeoffs for providing the necessary water resources to the new carbon capture facility are outside the scope of the current report and will be addressed separately.

2 Evaluation of Water Supply Resources

2.1 Water Balances

The station water balances for annual average and summer design conditions with all four units in operation were previously updated by S&L in 2011. These water balances were modified in the current study to reflect the following:

- Decommissioning of Units 2&3, (flows associated with Units 2 or 3 were set to zero and common flows associated with Units 1&2 and Units 3&4 were reduced by 50% study.
- Operation of Unit 1 and Unit 4 cooling towers at 11.0 and 15.0 cycles of concentration, respectively (stated by water treatment chemical supplier in recent discussions and verified based on recent water quality data; it is noted that COC has limited impact on water consumption since most blowdown is recovered as high purity distillate in the brine concentrators)
- Annual average and summer water balances based on 85% and 100% capacity factors, respectively

- Prorating Unit 1 and Unit 4 cooling tower evaporation rates in average water balance to reflect 85% rather than 79% to 80% capacity factors, respectively (it is noted that cooling tower evaporation appeared to be the only parameter that was prorated based on capacity factor in the previous water balances)
- Inclusion of carbon capture process in both average and summer water balances
- Prorating carbon capture flows in average water balance to reflect 85% rather than 100% capacity factor
- Closure of North Evaporation Ponds and routing of all residual wastewater to South Evaporation Ponds

Figure 2-1 – Average Water Balance with Carbon Capture

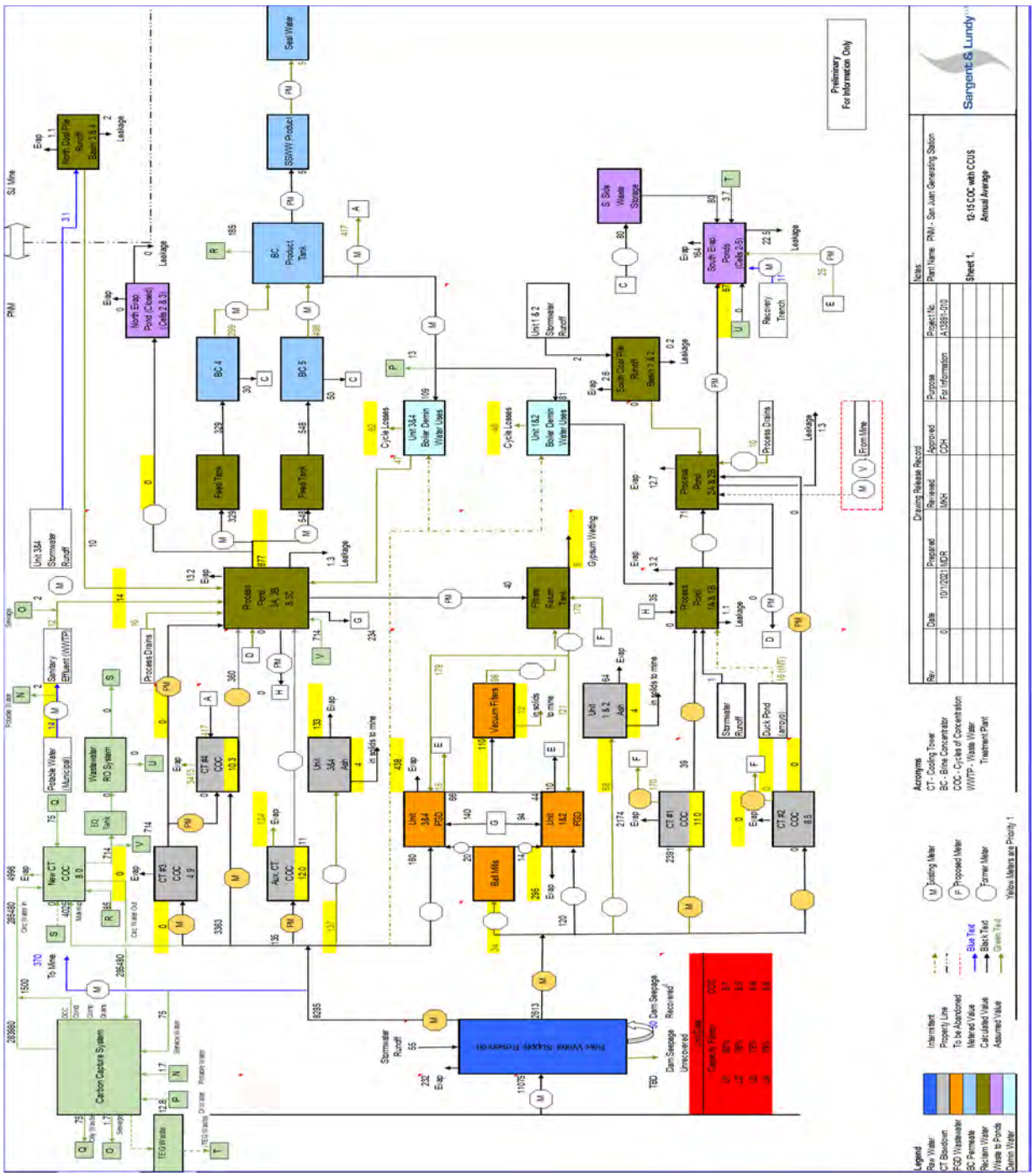
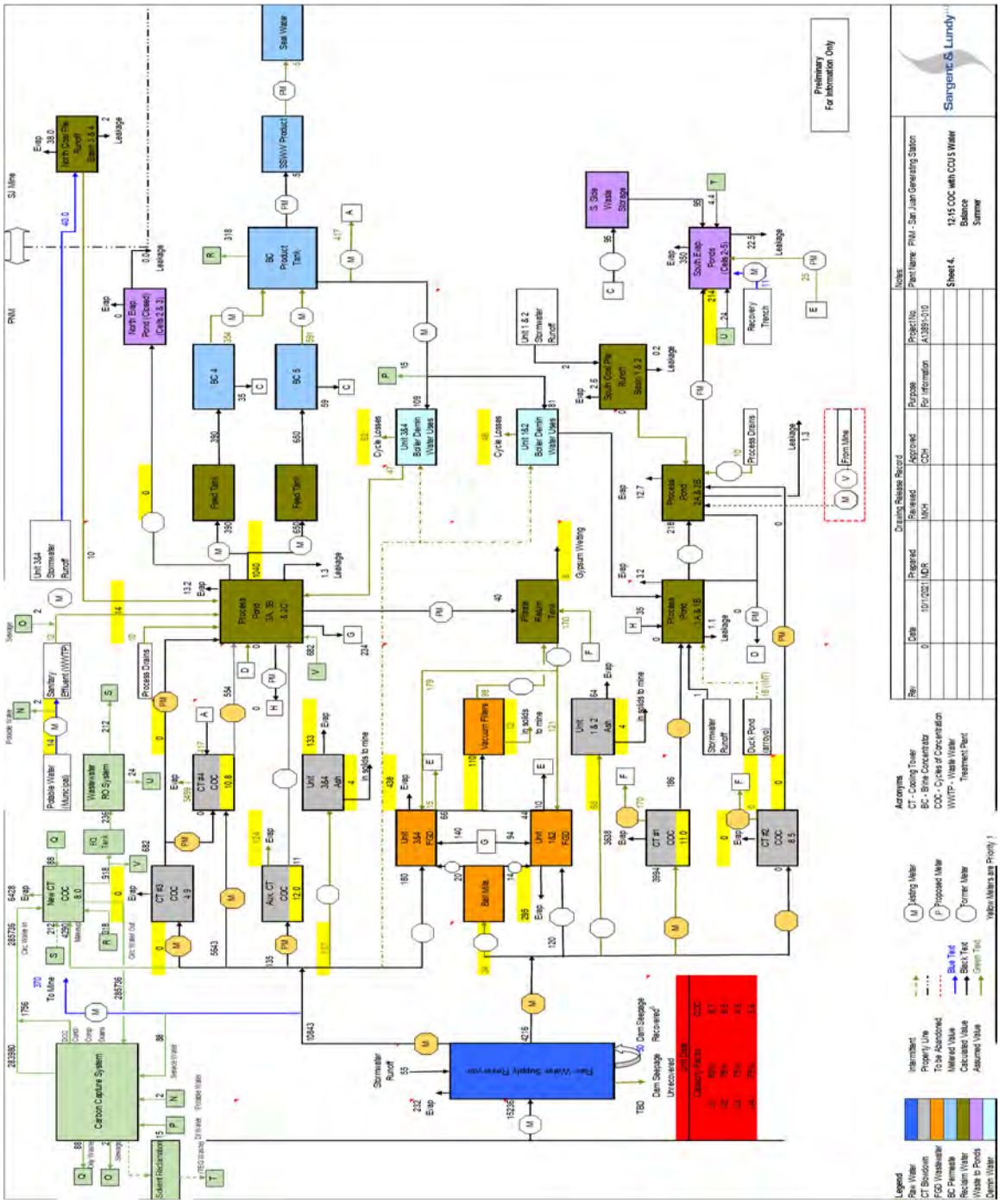


Figure 2-2 – Summer Design Water Balance with Carbon Capture



These water balances were also used to develop the following high-level water balances illustrating the interfaces between the carbon capture facility and the existing plant.

Figure 2-3– Overall Water Balance for Carbon Capture Process (Annual Average)

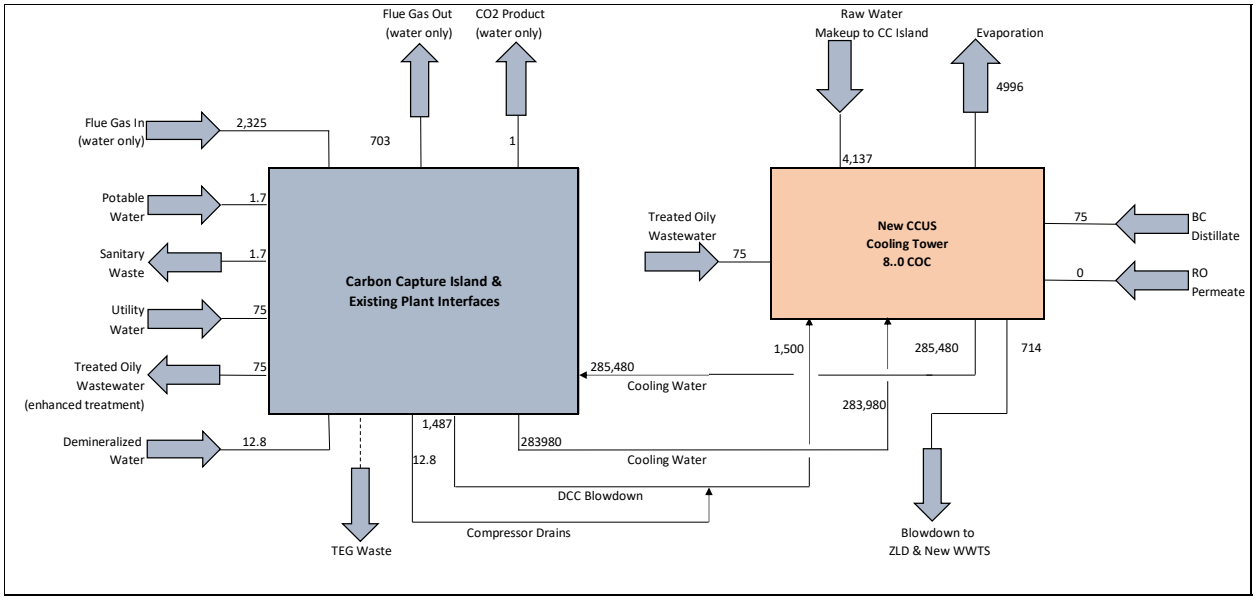
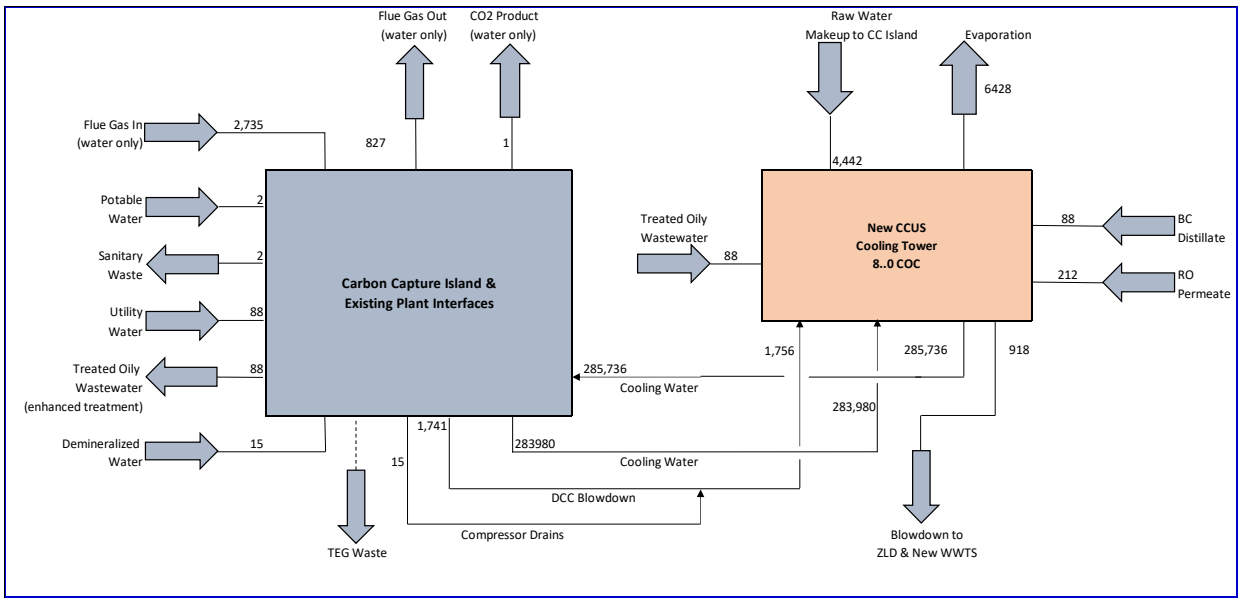


Figure 2-4 – Overall Water Balance for Carbon Capture Process (Summer Design)



As illustrated the carbon capture facility will require river water for cooling tower makeup and lesser quantities of demineralized water, utility (service) water and potable water. A substantial amount of water is currently planned to be recovered from the flue gas in the direct contact cooler (DCC)/SO_2 polishing scrubber, whose blowdown reduces the net river water makeup by 25%. According to MHI the SO_3/SO_4 concentration in the flue gas condensate may be as high as 950 ppm, which limits the new cooling tower to 8.0 cycles of concentration. The blowdown from the new cooling tower will be sent to two brine concentrators that are part of the existing zero liquid discharge (ZLD) treatment system as well as any new wastewater treatment equipment that may be required. The capabilities of the existing ZLD system and the need for supplemental wastewater treatment are evaluated separately in the wastewater study.

From a logistical perspective, the substantial cooling water flows will require new, large diameter piping between the carbon capture facility and the new cooling tower. Smaller diameter piping will be required to supply service water, demineralized water and potable water to the carbon capture facility and return process wastewater and sewage to the appropriate locations within SJGS.

2.2 Pi Data

Pi data for 2019 has been provided for water usage within SJGS in the following three files.

- 2019 River-Lake Readings.xlsx

- COF.waterbalanceDR.xlsx
- EOM Lake and River 2019.xlsx

Data for external sources of water (i.e. river water and potable water) provided to SJGS is presented in the form of monthly and daily meter readings. Data for internal uses and treatment of water within SJGS (e.g. distillate produced by brine concentrators) is presented in the form of instantaneous flows on an hourly basis. A summary of the Pi data with all flows converted to gpm is provided below.

Table 2-1 - Pi Water Data Summary for 2019

Description	Average (gpm)	Std Dev (gpm)	Maximum (gpm)
RAW WATER INTEGRATOR	6860	1963	10000
POTABLE WATER INTEGRATOR	12.5	1.9	16
MINE IRRIGATION SUPPLY	147	148	381
U1 RAW WATER FROM LAKE STATION	2243	1126	7241
U4 RAW WATER FROM LAKE STATION	4328	1721	10317
U1 COOLING TOWER MAKEUP	2827	1799	6694
U4 COOLING TOWER MAKEUP	170	120	381
U6 BC4 FEED FLOW	351	115	714
U6 POND 3 EFF. TO BC5 FEED TANK	189	121	507
U6 BC4 PRODUCT FLOW	360	119	501
U6 BC5 PRODUCT FLOW	288	123	808
U6 PRODUCT STORAGE DISCHARGE FLOW	1899	1062	7119
Unit 1 GROSS MW	255	139	384
Unit 4 GROSS MW	346	213	560

In addition to water usage the Pi data shows that Unit 1 and Unit 4 operated at 66% and 62% annual average capacity factors during 2019, respectively.

2.3 Supply of Water Services to New Carbon Capture Facility

Based on the preliminary water balance for the carbon capture facility and Pi data for existing water consumption and treatment the following evaluation was performed for the four needed water supplies.

2.3.1 River Water

Based on the water balance shown in Figure 1 representing annual average conditions at 85% capacity factor, the new river water usage is 11,075 gpm or 17,863 acre-ft/yr. It is noted that the new annual consumption is very close to the previously provided range of 17,665 acre-ft/yr. to 19,362 acre-ft/yr. with and without wastewater recycle, respectively. The summer design river water usage is 15,236 gpm or 2,048 acre-ft/month.

It is also noted that the baseline water usage under average conditions at 85% capacity factor is approximately 7,000 gpm based on prorating the previously developed water balances. This estimate is based on adjustments to the previous set of water balances prepared by S&L in 2011. By comparison, the 2019 Pi data for the Unit 1&4 Lake Station meters and Raw Water Integrator indicates water usage in the range of 6,571 gpm to 6,860 gpm, respectively. The Pi data further indicates that Unit 1 and Unit 4 capacity factors during 2019 were 66% and 62%, respectively, meaning that prorating to 85% capacity factor would increase the estimated water consumption to 8,500 to 9,000 gpm. Therefore, the more recent Pi data appears to show 25% higher baseline water consumption compared to the 2011 water balances. SJGS has indicated they believe the 2019 Pi data is more accurate and that they have been using 21,000 acre-ft/yr including mine reclamation in recent discussions with the Bureau of Water Reclamation (BOR).

2.3.2 Demineralized Water

According to MHI's terminal point list, a total of 15 gpm of demineralized water is required for the entire carbon capture facility for preparation of fresh solvent as well as a few pump seals

The station has a zero-liquid discharge (ZLD) system with two brine concentrators (BC 4 and BC 5) followed by two demineralizer systems for Units 1&2 and Units 3&4, respectively. It is noted that the demineralizers are not depicted on the existing water balance and that the type of system (e.g. mixed beds, full demineralizer, RO-mixed bed, etc.) has not been identified based the documents currently available. However, in a recent Email, SJGS indicated that Unit 1 has two trains and Unit 4 has one primary bed train plus two mixed beds.

According to the Pi data, BC 4 and BC 5 on average produced between 189 gpm and 360 gpm of distillate, respectively during 2019. Approximately half (288 gpm) of this distillate was processed by the demineralizers for cycle makeup with the remainder recycled to the Unit 4 cooling tower. Prorating for the future capacity factor of 85% would increase the BC 4 and BC 5 distillate to 247 gpm and 470 gpm, respectively. Approximately half (358 gpm) would still be processed by the demineralizers for cycle makeup. Both the original water balances (Figure 1&2) as well as the notes included with the Pi data

appear to indicate that the capacities of the Unit 1&2 and Unit 3&4 demineralizer systems are 217 gpm and 161 gpm, respectively (378 gpm total). However, in the recent SJGS Email it was indicated that the maximum capacity of the Unit 1 demineralizer system is 300 gpm with both trains running and the maximum capacity of the Unit 4 demineralizer system is also 300 gpm. It is further stated that the Unit 4 demineralizer system is already running close to its' maximum rated capacity but also implied that there is currently some slack in operation of the Unit 1 demineralizer system. Therefore, in the future it appears that the demineralizers should have enough excess capacity to produce an additional 15 gpm of demineralized water for the carbon capture process. It is noted that carbon capture would reduce the amount of distillate recycled to the Unit 4 cooling tower by 15 gpm, requiring an additional 20 gpm (32 acre-ft/yr.) of river water.

2.3.3 Utility (Service) Water

The amount of utility (service) water required for the carbon capture facility has been established at 44 gpm per train (total of 88 gpm) based on MHI's terminal point list. Although the rated capacities of the Unit 1&4 service water systems have not been provided it is expected that enough water can be obtained between the two units to support the carbon capture process. It is noted that approximately 90% of the wastewater associated with service water usage will be recovered within the ZLD system meaning that the net river water usage would only be increased by 8 gpm (13 acre-ft/yr.). The service water will be sourced from the existing raw water system as SJGS does not have a separate service water system.

2.3.4 Potable Water

Based on experience at other facilities MHI has recommended that the carbon capture facility be manned by approximately 20 people per day. It would be reasonable to expect an equal number of contractors and visitors to the site each day. Based on 40 people per day and per capita consumption of 50 gal/day the amount of potable water that will need to be provided is 2,000 gal/day or 1.4 gpm (rounded to 2 gpm in water balances). Based on Pi data the power plant and mine on average use 18,000 gallons per day of potable water. Therefore, even though the maximum allotment of potable water based on the size and pressure of the forced main was not provided it is expected that enough potable water will be available for the carbon capture facility. It is noted that the potable water supply system is not intended to supply all the needed water during construction or startup and commissioning as much larger quantities will need to be trucked to the site by the Contractor during this period.

3 Piping Modifications for Supply of Water Resources

S&L has modeled the pipe runs based on the latest general arrangement of the plant and MHI's CCUS island. We have also identified most of the primary tie-in locations with the existing plant. Although the design is still high level, it should be sufficient for cost estimating purposes. Preliminary pipe routings for CCUS water supplies including cooling tower, demineralized and utility water makeup are depicted within S&L Dwg M0-5006 (Piping Composite – CCUS and Cooling Tower Areas), which is currently under development.

4 Summary and Conclusions

- Annual average river water usage at 85% capacity factor with carbon capture is 11,075 gpm or 17,863 acre-ft/yr. The current estimate is close to the range of 17,665 acre-ft/yr. to 19,362 acre-ft/yr. with and without wastewater recycle, respectively that was previously provided to SJGS. It is noted that the current estimate includes baseline water consumption of approximately 7,000 gpm at 85% load without carbon capture. This estimate is based on adjustments to the previous set of water balances prepared by S&L in 2011. According to the 2019 Pi data the average river water consumption at 62% to 66% capacity factor was in the range of 6,500 to 6,800 gpm meaning that baseline consumption prorated for 85% capacity factor could be in the range of 8,500 gpm to 9,000 gpm. Therefore, the more recent Pi data appears to show 25% higher baseline water consumption compared to the 2011 water balances. SJGS has indicated they believe the 2019 Pi data is more accurate and that they have been using 21,000 acre-ft/yr including mine reclamation in recent discussions with the Bureau of Water Reclamation (BOR).

- Current plans are to recycle all the flue gas condensate for use as cooling tower makeup. Since the SO_3/SO_4 concentration in the flue gas condensate may be as high as 950 ppm, the new cooling tower will be limited to approximately 8.0 cycles of concentration. Blowdown from the new cooling tower will be treated in the existing ZLD system along with any new wastewater treatment equipment that may be required. The capabilities of the existing ZLD system are evaluated separately in the wastewater study.

- The MHI requirements for demineralized, utility and potable water are relatively small and should be available to the new carbon capture facility from existing supply and treatment systems.

Appendix G. WASTEWATER STUDY

Enchant Energy
Carbon Capture FEED Study
San Juan Generating Station
Units 1 & 4

Wastewater Study

Issued For FEED

Revision B

June 9, 2022
Project No. A13891.010

Prepared by

55 East Monroe Street • Chicago, IL 60603 USA • 312-269-2000
www.sargentlundy.com

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A Client Comments	October 29, 2021	M. Rosen	C. Hornish	--
B Issued for FEED	June 9, 2022	M. Rosen	C. Hornish	C. Hornish

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APPENDICES:

A – VENDOR LITERATURE FOR WASTEWATER TREATMENT PROCESS
B – GENERAL ARRANGEMENT FOR WASTEWATER TREATMENT SYSTEM BUILDING

1 Introduction

San Juan Generating Station (SJGS) will be installing Mitsubishi Heavy Industries' (MHI) KM CDR™ carbon capture process to treat the entire flue gas from Units 1 and 4. MHI's technology is an amine-based CO_2 capture process which uses a proprietary solvent that will be designed to recover 95% of the CO_2 from the flue gas and compress the treated CO_2 to acceptable pipeline conditions. The process essentially consists of four stages including flue gas pretreatment, CO_2 recovery, solvent regeneration and CO_2 compression. Two identical trains are planned to treat the entire flue gas from the two generating units.

The carbon capture process has very high heat rejection requirements from all four stages. A new cooling tower will be built north of the carbon capture island to reject the new heat loads. There will be a substantial amount of cooling tower blowdown that will need to be treated, recycled and/or disposed in existing evaporation ponds as SJGS is a zero-liquid discharge (ZLD) facility. Lesser amounts of low volume and sanitary wastewater will also require treatment. At this time, it is planned to recycle blowdown from the direct contact cooler/SO_2 trim scrubber to the cooling tower for water conservation purposes and to avoid having to directly treat this waste stream.

The purpose of this report is to identify the various wastewater streams from the carbon capture process and determine whether SJGS has the existing infrastructure to recycle, treat and/or dispose of these streams via existing ponds. Conceptual routings and material takeoffs for new piping to handle these wastewater streams are developed at a high level and briefly discussed within the current report.

2 Evaluation of Wastewater Treatment Resources

2.1 Water Balances

The station water balances with all four units in operation were previously updated by S&L in 2011. S&L updated these water balances again in the current study to reflect decommissioning of Units 2&3, installation of the carbon capture process and closure of the North Evaporation Ponds. The annual average water balance was further updated to reflect operation at an 85% capacity factor.

Figure 2-1 - CCUS Water Balance (Annual Average)

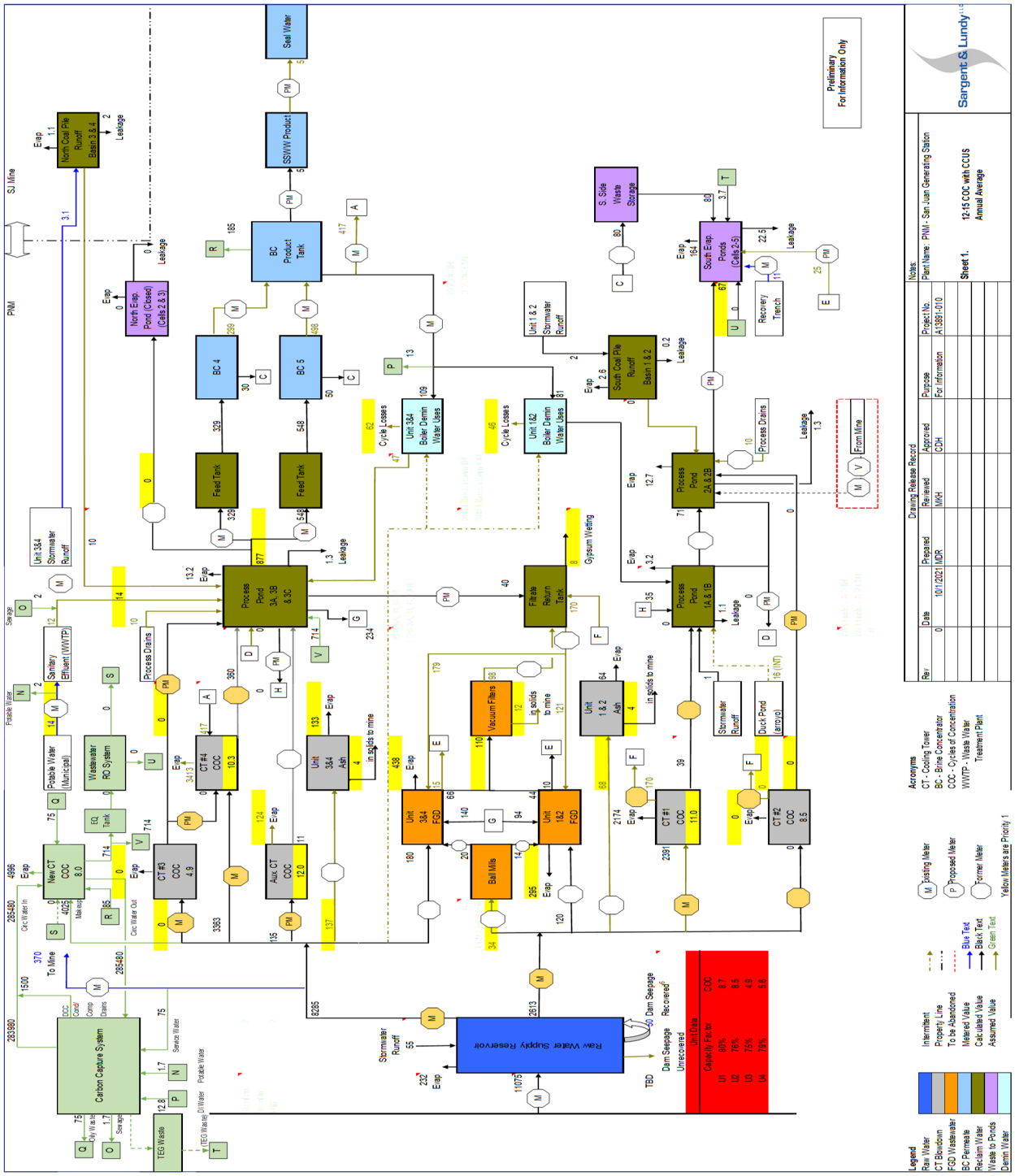
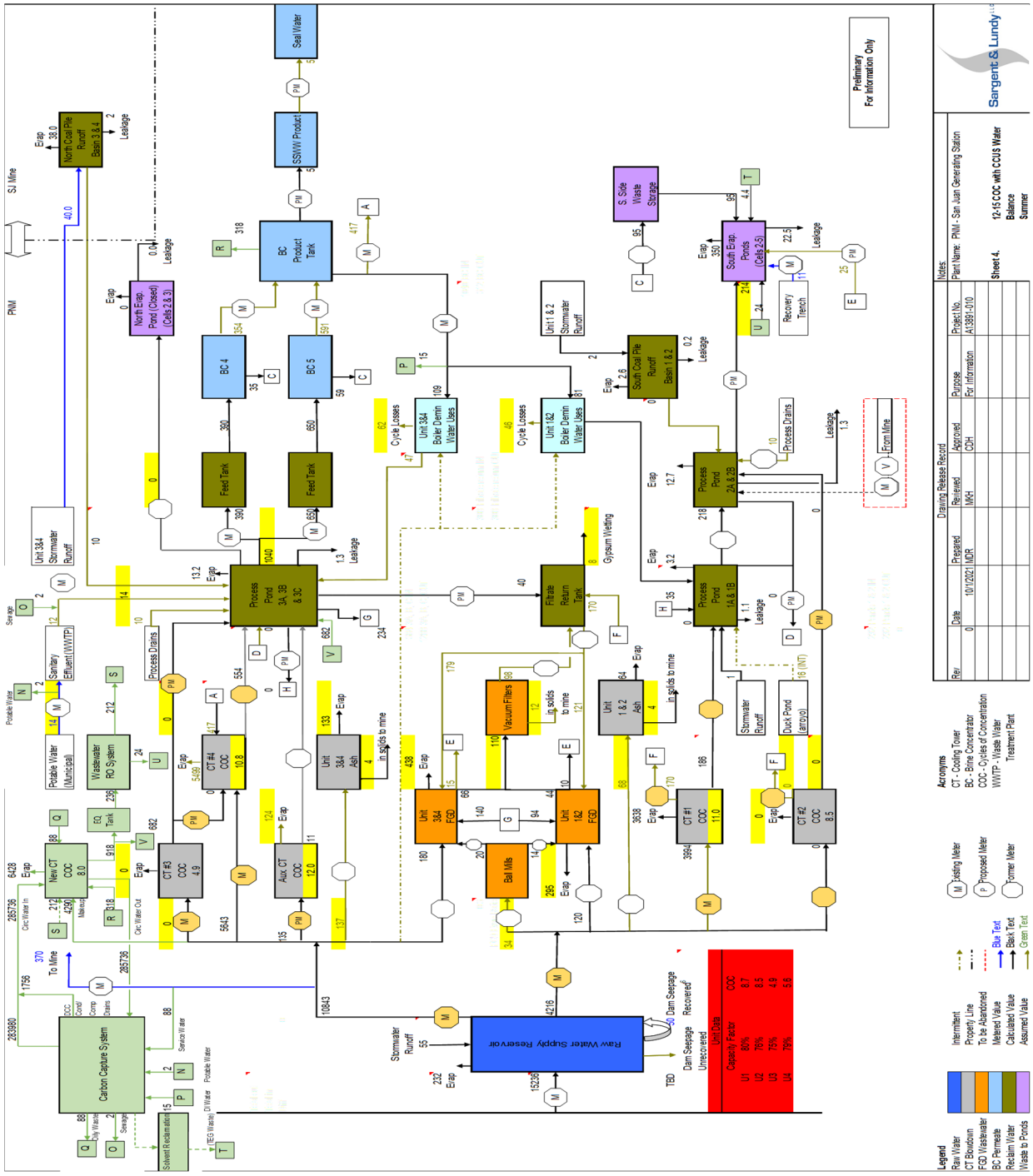


Figure 2-2 - CCUS Water Balance (Summer Maximum)



The original water balances together with information from MHI were used to develop the following high-level water balances illustrating the interfaces between the carbon capture facility and the existing plant.

Figure 2-3 – Overall Water Balance for Carbon Capture Process (Annual Average)

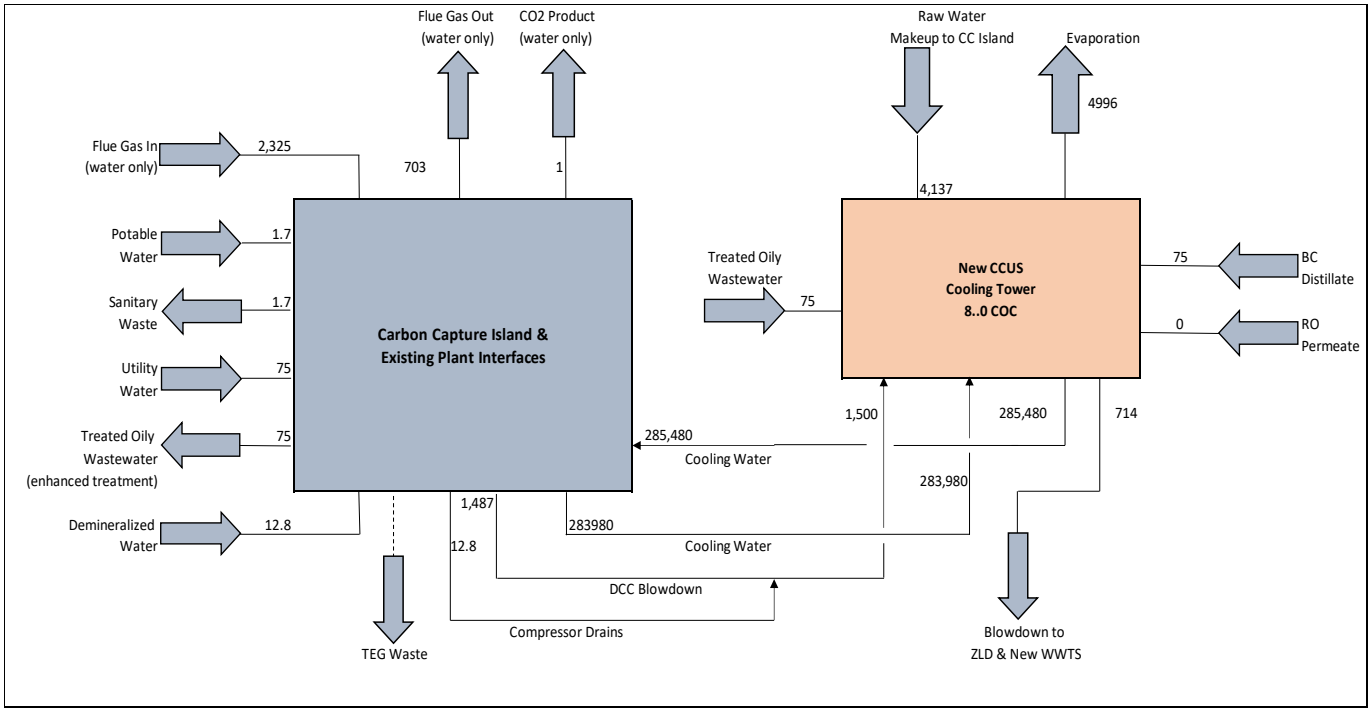
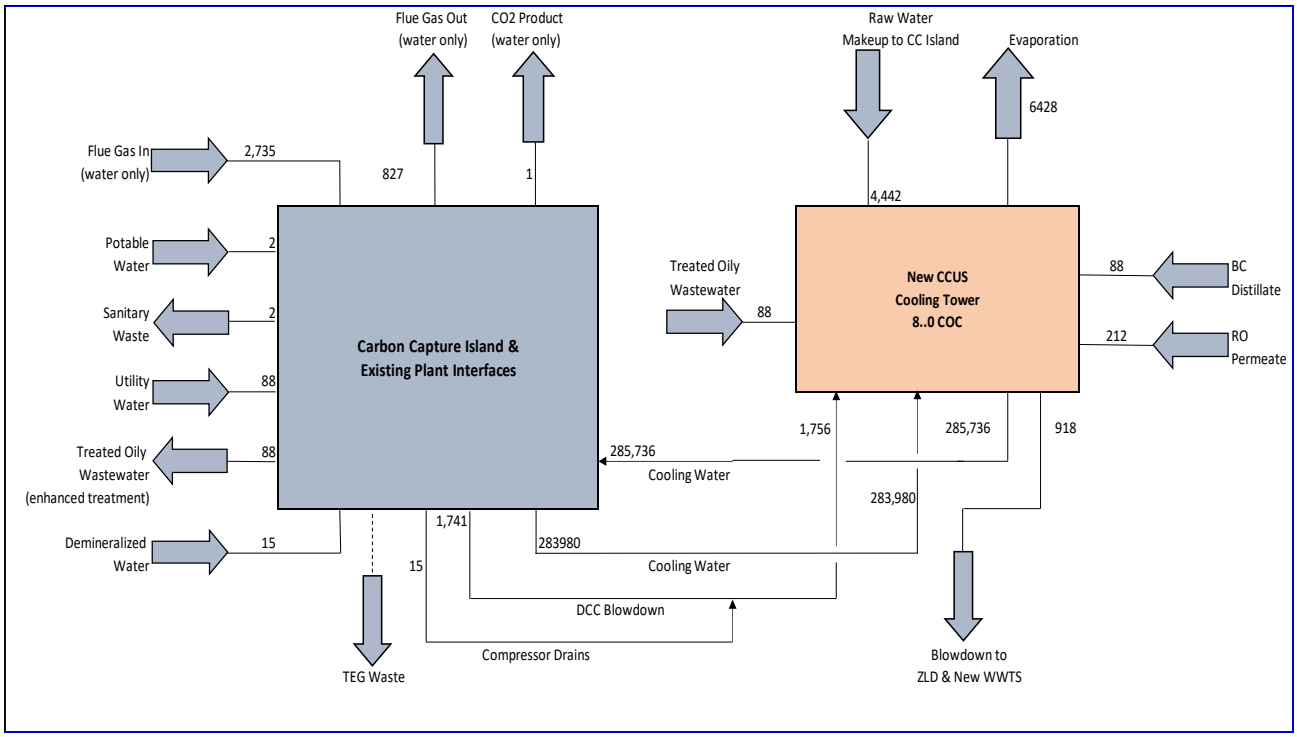


Figure 2-4 – Overall Water Balance for Carbon Capture Process (Summer Maximum)



As illustrated the four streams that will need to be processed on a continuous basis are cooling tower blowdown, low volume (oily) wastewater, sanitary waste and tri-ethylene glycol (TEG) waste from solvent recovery. There will be occasional drains from the carbon capture ductwork that will need to be routed to local sumps. There will also be local sumps that will collect rainwater that can be discharged into the stormwater system after inspection to verify that no chemicals or oil are present.

Based on composition information from MHI the DCC condensate/SO_2 polisher blowdown can be used as cooling tower makeup. However, because the SO_3/SO_4 content of this stream may be as high as 950 ppm, the new cooling tower will be limited to 8.0 cycles of concentration.

Low volume wastewater, after enhanced treatment for oil removal, will be recycled for use as makeup to the new CCUS cooling tower (see discussion below). Cooling tower blowdown will be routed via a new equalization tank for treatment in the two operational brine concentrators (BC 4 and BC 5) plus any new wastewater treatment equipment that may be required to handle the additional wastewater (see discussion below). In this regard it is noted that the assumed cycles of concentration for the Unit 1&4 cooling towers that formed the basis for the new water balances are inconsistent with actual Pi data for BC feedwater obtained during the water supply study. Therefore, the amount of excess wastewater requiring treatment in a new system may be somewhat higher than the flows estimated in the current studies.

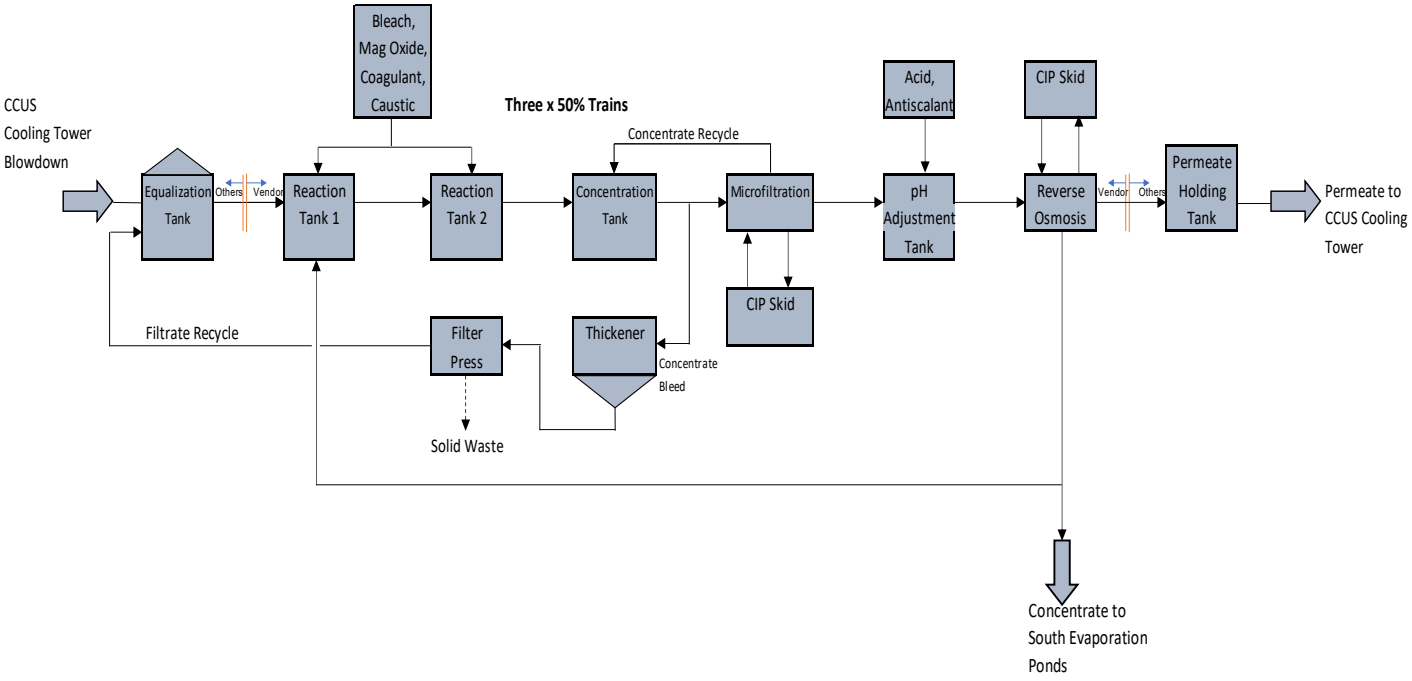
2.2 Treatment and Disposal of Wastewater Streams from Carbon Capture Facility

2.2.1 Cooling Tower Blowdown

As discussed above, it is proposed to send the blowdown from the new CCUS cooling tower to a new wastewater treatment system as well as BC 4 and BC 5 after interim storage in a new equalization tank. Due to their locations at the south end of the plant, Process Ponds 3A,B&C would not receive blowdown from the new CCUS cooling tower. Bypassing these ponds also ensures that a portion of the blowdown, which has high sulfate concentrations (from flue gas condensate) would not be sent to the Unit 1 and 4 FGD systems.

Based on limited information shown within plant wastewater drawings, the average and maximum total capacities of BC4 and BC5 are 765 gpm and 880 gpm, respectively. Under average ambient conditions the net wastewater from Process Ponds 3A, B & C falls within the average capabilities of BC 4 and BC 5. However, under summer design ambient conditions the amount of excess wastewater exceeds the maximum capabilities of the two brine concentrators by 236 gpm. Although the South Evaporation Ponds may be capable of evaporating relatively small quantities of additional TEG wastewater or concentrate from a new treatment system, they are not large enough to handle this excess. Based on recent discussions with one of the leading suppliers, the summer surplus could be handled by 6-9 enhanced evaporation machines that could be installed for approximately $0.5 million. However, as water is considered a scarce commodity in the southwest, there are public policy issues that may preclude use of this relatively simple and inexpensive technology for water management. Additionally, despite being a mature and proven technology, the utility industry appears reluctant to implement enhanced evaporation, citing issues with first generation machines that resulted in freezing, scaling, and high drift emissions. The CCUS stakeholders have also indicated a strong preference for treatment technologies that recover in lieu of those that strictly evaporate water. For these reasons we have proposed a high efficiency reverse osmosis process that can recover as much as 97% of the wastewater as high quality permeate that can recycled to the carbon capture system. A simplified process flow diagram and system description for this process are provided below.

Figure 2-5 – Process Flow Diagram for High Efficiency RO Treatment System



As indicated, equalization is typically followed by two reaction tanks in series in which chemicals are added to raise pH and precipitate silica as a magnesium silicate compound. Some hardness and alkalinity may also be precipitated depending on the raw wastewater quality and the process objectives. These constituents are then removed in a microfiltration (MF) process, allowing the downstream RO units to operate at much higher recovery without mineral scaling concerns. A concentration loop is provided between the MF units and a dedicated upstream tank with periodic purges to maintain a consistent level of solids. The purges are directed to a thickener and downstream filter press for sludge dewatering. The filtrate is returned to the inlet of the process and a solid waste product is produced that is disposed in an onsite or offsite landfill. Vendor literature describing the treatment process is provided in Appendix A.

The wastewater treatment system would include three x 50% trains of MF and RO and would be located inside a dedicated two-level building. The system is currently sized for 300 gpm based on an excess wastewater flow of 236 gpm in the summer design water balance and 25% margin so that the brine concentrators are not operating continuously. As noted previously, the required treatment system capacity could be higher as the reported cooling tower cycles of concentration (11-15 COC) are inconsistent with Pi data for BC feedwater that are indicative of lower cycles. General arrangement drawings that have been developed for the proposed building based on the current treatment system capacity are provided in Appendix B.

Based on another recent carbon capture study it is expected that the equipment and total installed costs for this treatment process are in the range of $4.0 million and $10.0 to $12.0 million, respectively.

2.2.2 Low-Volume Wastewater

The carbon capture process will generate approximately 80 gpm of low volume wastewater originating from equipment washdowns and miscellaneous drains. Current plans are to treat this waste in a new, packaged oil/water separator(s) as the capacity and condition of the existing plant separators is unknown and trying to repurpose them doesn't appear economical. It was initially planned to send the treated oily wastewater to Process Ponds 3A,B&C; however as these ponds are located a considerable distance from the carbon capture process, closer alternatives were desired. The wastewater could be sent to the new treatment process and existing brine concentrators after interim storage in a new equalization. Since the RO based treatment process has little or no tolerance for residual oil, it would be necessary to provide secondary oil removal in coalescing cartridge filters or other suitable devices. However, with inclusion of secondary oil removal, it is now planned to use treated oily wastewater for cooling tower makeup, thereby reducing plant makeup as well as the load on new and existing wastewater treatment equipment by approximately 80 gpm. It is noted that MHI's process does not have any miscellaneous water needs that can be supplied from treated oily wastewater.

2.2.3 Sanitary Waste

Based on experience at other facilities MHI has recommended that the two train carbon capture facility be manned by approximately 20 people per day. It would be reasonable to expect an equal number of contractors and visitors to the site each day. Based on 40 people per day and per capita consumption of 50 gal/day the amount of sanitary wastewater that will need to be treated is 2000 gal/day or 1.4 gpm.

Although no details have been provided, the station has an existing treatment facility for sanitary waste before it is discharged internally to Process Ponds 3A, B and C. According to 2019 Pi data for the potable water integrator an average of 18,000 gal/day (12.5 gpm) and a maximum of 23,000 gal/day (16 gpm) of sanitary waste are currently being treated. Therefore, it appears that the existing treatment system should have enough capacity to treat an additional 2000 gallons per day that will originate from bathrooms, kitchen, etc. in the new control building in the carbon capture facility.

It is noted that the sanitary treatment facility is not intended to treat waste during construction or startup and commissioning as much larger facilities provided by the Contractor will be needed during this period.

2.2.4 TEG Wastewater

The carbon capture process includes a solvent regeneration system that produces a small amount of wastewater containing 5% tri-ethylene glycol (TEG). Since the amount of wastewater is relatively small and there is already some dibasic acid (dba) from FGD operation being discharged to the ponds, it is proposed to route this new waste stream to the South Evaporation Ponds. It is noted that although this

waste stream is relatively small that the cost for collection and trucking offsite for treatment and disposal by a third party would probably be prohibitive.

2.2.5 Flue Gas Ductwork Drains

Conceptually, drains will be located at low points of the ductwork route. Based on the current flue gas duct configuration, the low point occurs near Unit 4. It is also anticipated that there will be an initial drain near Unit 1 tie-in location as well. The drains will need to be routed to nearby waste sumps that are still active. During detailed design, these areas will be investigated (with additional walkdowns) to determine feasible drain pipe routes.

2.2.6 Storm Drains

S&L will be designing an underground stormwater piping system with catch basins, swales, etc. to collect stormwater within the carbon capture island.

3 Piping Modifications for Internal Wastewater Discharges

S&L has modeled the pipe runs based on the latest general arrangement of the plant and MHI's CCUS island. We have also identified most of the primary tie-in locations with the existing plant. The design is still high level, but sufficient for cost estimating purposes. Preliminary pipe routings for CCUS wastewater including cooling tower blowdown, treated oily, sanitary and TEG waste as well as ductwork drains are depicted within S&L Dwg M0-5006 (Piping Composite – CCUS and Cooling Tower Areas), which is currently under development.

4 Summary and Conclusions

- Existing plant water balances for annual average and summer design conditions that were last updated by S&L in 2011 were updated again as part of the water supply study. Specifically, the flows in each water balance were adjusted to reflect decommissioning of Units 2&3, installation of a carbon capture system for Units 1&4 and closure of North Evaporation Ponds. The annual average water balance was also adjusted to reflect operation at an 85% capacity factor. Additionally, simplified block diagram water balances were prepared to illustrate the relationship between the new carbon capture process and the existing units. From a wastewater perspective, the four waste streams generated by the carbon capture process include cooling tower blowdown, low volume waste, sanitary waste and a byproduct stream associated with solvent reclamation.

- Largest wastewater flow will be blowdown from the new carbon capture cooling tower, which will be built on a new foundation north of the CCUS island. It is proposed to route the blowdown from the new cooling tower directly to a new equalization tank, which will then direct portions of the total flow to both the new wastewater treatment system and existing brine concentrators. The

RO reject stream from the new wastewater treatment system will be routed to the South Evaporation Ponds as the North Evaporation Ponds have been closed and capped.

- Current plans are to recycle all the DCC condensate/SO_2 polisher blowdown for use as cooling tower makeup. The high SO_3/SO_4 concentration in this stream will limit the new cooling tower to 8.0 cycles of concentration.

- ZLD system does not appear to have enough excess capacity to treat the additional wastewater associated with the carbon capture process. Under annual average conditions there is a relatively small (i.e. 64 gpm) imbalance but during the summer the imbalance is more pronounced (i.e. 316 gpm). S&L estimated that 8-12 enhanced evaporation machines could be installed in the South Evaporation Ponds at a cost of ~$0.5 million to dispose of the excess wastewater. However, based on public policy issues associated with water conservation as well as the CCUS stakeholders' strong preference for technologies that recover water, enhanced evaporation was not further pursued in the current study. At present our recommendation is to install a high efficiency reverse osmosis process to treat the excess wastewater and recover > 90% in the form of a high purity permeate that would be recycled to the carbon capture process. The new treatment system would include three x 50% trains and would be sized to treat 300 gpm of excess wastewater. The amount of excess wastewater was based on Unit 1&4 cooling towers operating at 11 and 15 cycles of concentration, respectively, which is inconsistent with Pi data for BC feedwater that is indicative of lower cycles. Therefore, it is possible that the required treatment system capacity could be somewhat higher.

- Low volume wastewater from the carbon capture process is treated in primary and secondary oil removal equipment and routed to the CCUS cooling tower. This eliminates the need to route this wastewater to Process Ponds 3A,B&C and would reduce plant makeup as well as loading on the existing brine concentrators and new wastewater treatment equipment by 80 gpm.

- Existing sanitary waste treatment facility, which currently handles high daily volumes from the power plant and mine should be able to treat the small amount of additional waste from the carbon capture facility.

- No provisions have been included for treatment or off-site disposal of the waste stream from the solvent recovery process, which is presumed to be sent to the South Evaporation Ponds for ultimate disposal

APPENDIX A:

VENDOR LITERATURE FOR WASTEWATER TREATMENT PROCESS

evoqua
WATER TECHNOLOGIES





ADVANCED MEMBRANE FILTRATION



Memtek®
EFC-Series
Microfiltration
System

A MAJOR ADVANTAGE FOR RELIABLE WASTEWATER TREATMENT OR PROCESS FILTRATION

SYSTEMS THAT GIVE YOU GREATER FLEXIBILITY AND BETTER PERFORMANCE

E-Series Membrane Filtration Systems

Evoqua Water Technologies offers the Memtek® E-Series systems incorporating proprietary crossflow tubular membranes which remove precipitated contaminants and produce a high quality filtrate suitable for discharge or further treatment. The modular components can stand alone, work together or work with existing equipment. The stand alone units are ideally suited for integrating with existing reaction tanks or settlers for effluent polishing. Membrane filtrate from an E-Series system can be discharged from the plant or reused directly in non-critical rinses. The filtrate is also suitable as a feed to reverse osmosis where from 75-90% of the water can be recycled and reused within the plant. Standard E-Series systems accommodate flow rates up to 400 gpm while custom designed systems are available to handle larger flow capacities. These Memtek systems are easy to operate and provide for continuous solid/liquid separation with minimal operator attention.

EF Advanced Membrane Filtration Systems

The basic EF system is a skid-mounted package consisting of membrane modules, recirculation pump, in-place cleaning loop, backpulse mechanism, instrumentation and controls. The skid-mounted design is compact and requires minimal floor space.

EFC Advanced Membrane Filtration Systems

The EFC system includes the EF system equipment plus a recirculation tank with level controls, anti-swirl baffles and slurry transfer pump.

RX and RXP Reaction Systems

These systems are rugged, corrosion resistant tanks equipped with heavy duty mixers; metering pumps; chemical reaction monitors and controllers; level controls and alarms; inlet, overflow and drain ports; control panel; access platform and covers.

Materials of Construction

The rugged fluorocarbon membranes are non-plugging, abrasion and chlorine resistant. The process tanks are fabricated from heavy duty fiberglass reinforced epoxy resins or high density polyethylene. All components in contact with wastewater are PVC, polypropylene, nylon, stainless steel or other corrosion resistant material.



EFC Model 424

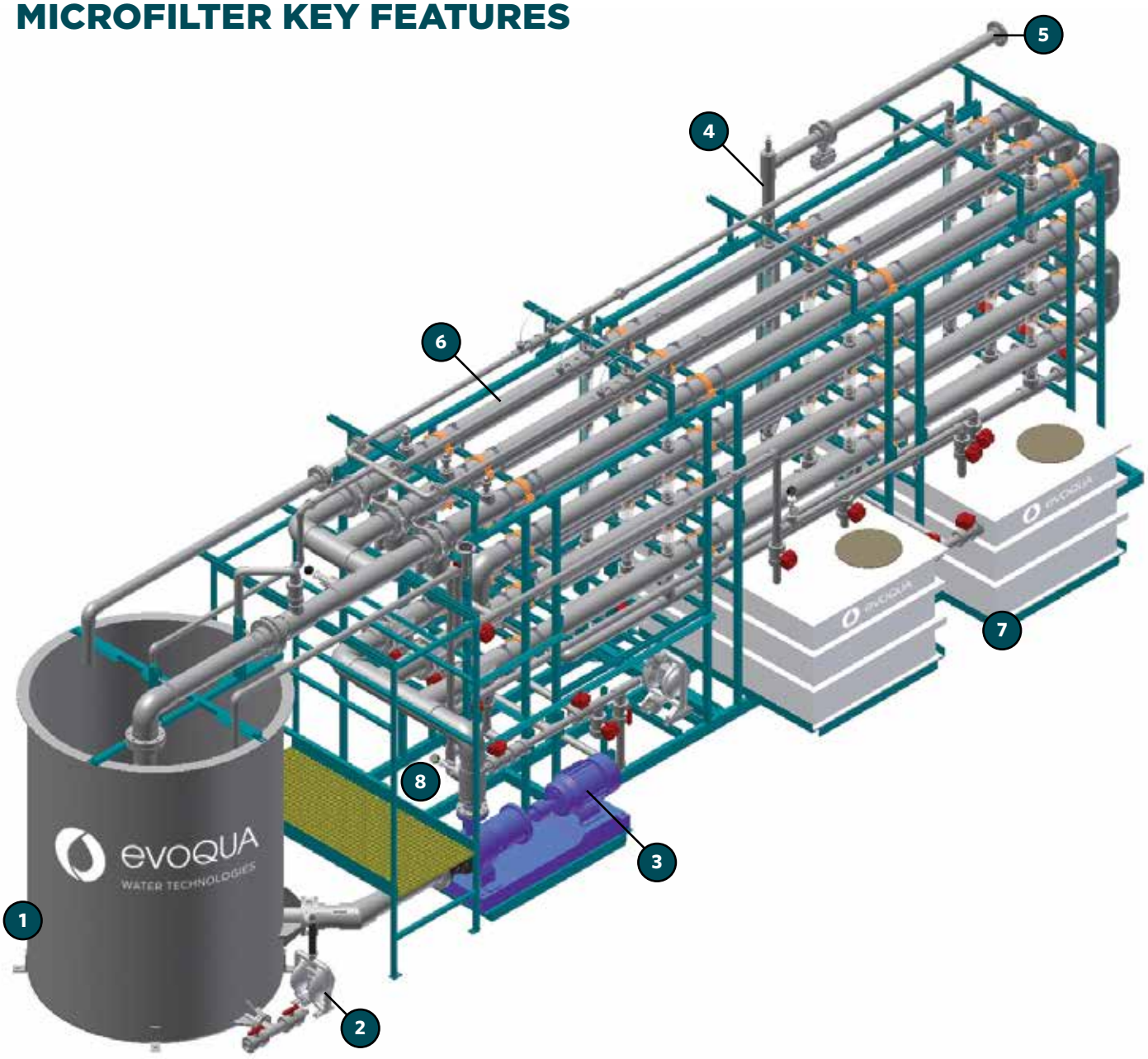
MARKET	APPLICATION
Metal Finishing	Removal of heavy metals to less than 0.1 ppm
Printed Circuit Board	Removal of heavy metals to less than 0.1 ppm
Semiconductor	Arsenic removal to less than 0.1 ppm Fluoride removal to below 5 ppm Cutting fluid recycle from silica grinding and slicing operations Deionized water recycle from wet blast and back grinding processes Heavy metals removal from tin/lead plating onto lead frames
Groundwater Remediation	Removal of heavy metals to less than 0.1 ppm
Battery Manufacturing	Removal of lead and cadmium from wastewater
Automotive	Removal of zinc and phosphate from phosphatizing operations
General Industry	Removal of heavy metals from incinerator scrubber water Pretreatment for reverse osmosis water recycling Lime softening of cooling tower blowdown for water recycling General heavy metals removal to less than 0.1 ppm Replacement of clarifier or a clarifier followed by a sand filter

E-SERIES SYSTEM CAPABILITY*

CONTAINMENT	WASTEWATER CONC. (mg/l)	MEMTEK® EFFLUENT (mg/l)
Aluminum	10 - 1000	0.5
Arsenic	1 - 50	0.005
Cadmium	25 - 115	0.05
Chromium	3 - 275	0.1
Copper	1 - 1500	0.1
Cyanide	5 - 300	0.1
Gallium	4 - 20	0.5
Germanium	20 - 110	0.5
Gold	1 - 12	0.15
Iron	2 - 1500	0.02
Lead	2 - 100	0.05
Manganese	1 - 10	0.02
Mercury	3 - 30	0.005
Nickel	4 - 300	0.1
Rhodium	20 - 500	0.1
Silver	10 - 200	0.1
Tin	20 - 75	0.1
Uranium	1 - 15	0.01
Zinc	2 - 400	0.1

*Typical values achieved in practice may vary depending on equipment configuration and pretreatment chemistry

MICROFILTER KEY FEATURES



1. CONCENTRATION TANK

The concentration tank is used to ensure that a constant concentration of solids is being pumped to and from the microfiltration membranes. The tank is equipped with level probes to allow the microfilter feed pump to cycle on and off.

2. SLUDGE WITHDRAWAL PUMP

In order to maintain the right solids concentration (typically 3-5% solids) in the microfiltration recirculation loop for proper system operation, an automatic sludge withdrawal pump is supplied with timers. The sludge or solids removed from the concentration are either pumped to a sludge storage tank or directly to a filter press.

3. FEED PUMP

A reliable pump is used to provide the adequate crossflow through the membrane tube.

4. BACKPULSE

The microfilter is equipped with an automatic backpulse mechanism. The permeate flow rate is periodically reversed through the membrane. This results in maintaining higher flow rate and extends the time between cleaning cycles.

5. PERMEATE

The microfilter permeate (membrane filtrate) usually contains heavy metal that is less than 0.1 ppm. After final neutralization, the permeate can be discharged to drain, reused for non-critical rinses or further processed by reverse osmosis (RO) for water recycle.

6. MEMBRANE/MODULES

The membrane is a rugged polyvinylidene difluoride (PVDF)material attached to a porous one inch substrate. The membrane tubes are bundled together either in a 4 or 10 tube arrangement and placed inside a PVC or CPVC housing.

7. CLEAN-IN-PLACE

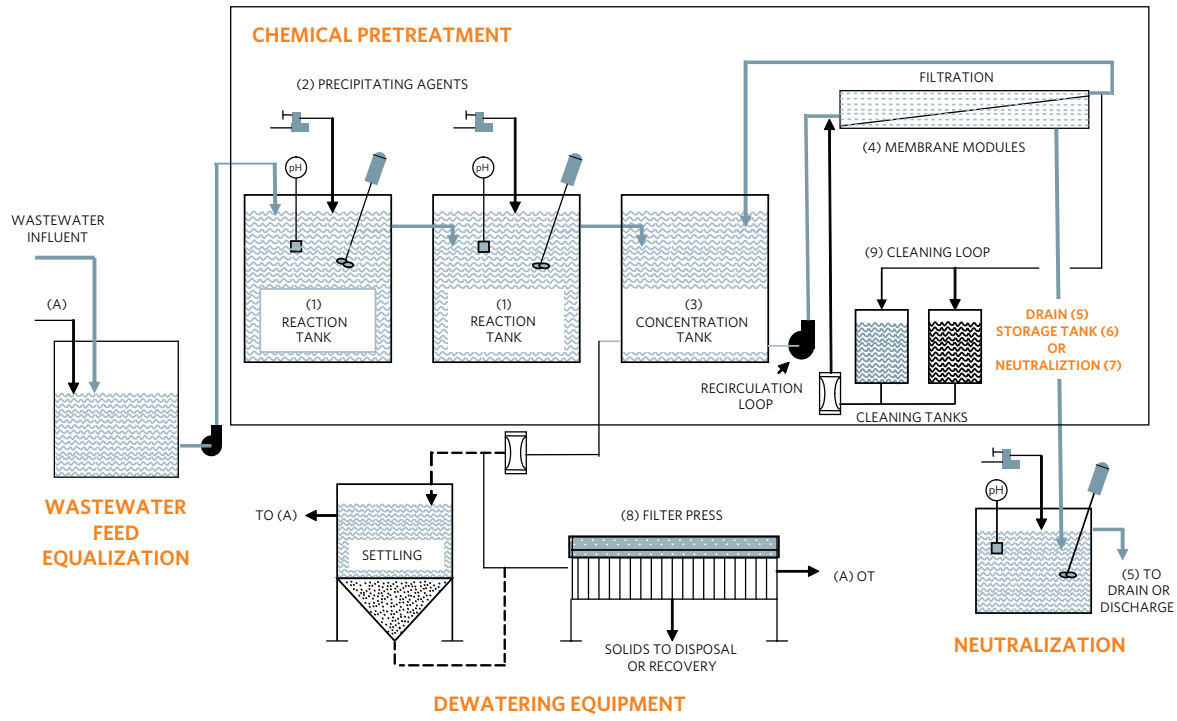
The on-board clean-in-place system consists of two cleaning tanks. One tank is used to make up the cleaning solution; while the other tank contains fresh water to flush the membranes after cleaning. The membranes can be cleaned with acids, caustic, bleach and other various cleaning agents. Automatic cleaning is also available as an option.

8. MODULAR DESIGN

The system is fully skid-mounted and includes the membrane modules, backpulse mechanism, recirculation pump, clean-in-place system, air diaphragm pump, concentrate recirculation tank, electrical power controls, instrumentation and PLC controller. The system is fully piped, wired and equipped for operation.

TECHNICAL INFORMATION

Model Number	EF/EFC 400	EF/EFC 424	EF/EFC 1200	EF/EFC 2400	EF/EFC 3600	EF/EFC 4800	EF/EFC 7200	EF/EFC 10800
Capacity (nominal)	4 - 16 gpm 1 - 4 m^3/hr	4 - 32 gpm 1 - 7 m^3/hr	12 - 36 gpm 3 - 8 m^3/hr	24 - 72 gpm 5 - 16 m^3/hr	36 - 108 gpm 8 - 24 m^3/hr	48 - 144 gpm 911 - 33 m^3/hr	72 - 216 gpm 16 - 49 m^3/hr	108 - 324 gpm 25 - 74 m^3/hr
Tubes per Module	4	4	10	10	10	10	10	10
Module Quantity (min-max)	4 - 12	12 - 24	6 - 12	12 - 24	18 - 36	24 - 48	36 - 72	54 - 108
Concentration Tank Volume	275 gal 1.0 m^3 (HDPE)	550 gal 2.1 m^3 (HDPE)	660 gal 2.5 m^3 (FRP)	1,375 gal 5.2 m^3 (FRP)	1,700 gal 6.4 m^3 (FRP)	2,600 gal 9.8 m^3 (FRP)	4,280 gal 16.2 m^3 (FRP)	5,000 gal 18.9 m^3 (FRP)
	(Note: Concentration Tank Included with EFC Series only.)							
Process Pump(s)	Qty. 1 7.5 HP	Qty. 1 15.0 HP	Qty. 1 20.0 HP	Qty. 1 30.0 HP	Qty. 1 50.0 HP	Qty. 2 30.0 HP	Qty. 2 50.0 HP	Qty. 3 50.0 HP
Dimensions (L x W x H)	11′-10″ x 4′-10″ x 8′-11″ 3,607 x 1,473 x 2,718 mm	18′-3″ x 5′-4″ x 11′-7″ 5,563 x 1,626 x 3,531 mm	24′-7″ x 5′-10″ x 9′-10″ 7,493 x 1,778 x 2,997 mm	25′-5″ x 7′-1″ x 10′-0″ 7,747 x 2,159 x 3,048 mm	33′-0″ x 8′-1″ x 11′-10″ 10,058 x 2,464 x 3,607 mm	37′-5″ x 10′ x 11′-11″ 11,404 x 3,048 x 3,632 mm	37′-10″ x 17′-1″ x 11′-11″ 11,532 x 5,207 x 3,632 mm	39′-4 x 25′-3″ x 11′-11″ 11,989 x 7,696 x 3,632 mm
Shipping Weight	1,000 lbs 450 kg	2,000 lbs 900 kg	7,500 lbs 3,400 kg	10,000 lbs 4,550 kg	15,000 lbs 6,800 kg	18,000 lbs 8,160 kg	29,000 lbs 13,150 kg	43,000 lbs 19,500 kg
Operating Weight	4,000 lbs 1,810 kg	8,000 lbs 3,630 kg	18,000 lbs 8,160 kg	26,000 lbs 11,800 kg	34,000 lbs 15,420 kg	52,000 lbs 23,590 kg	73,000 lbs 33,110 kg	98,000 lbs 44,450 kg



Microfiltration Wastewater Treatment System

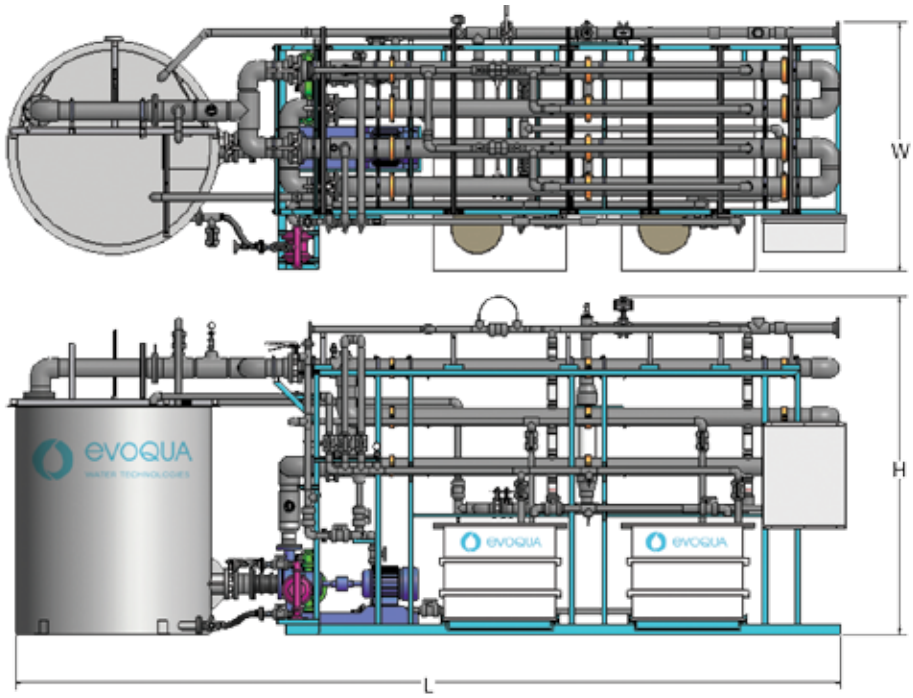
E-SERIES SYSTEM OPERATION

Pretreatment in RX and RXP Systems

The process begins with the transfer of wastewater to one or more reaction tanks (1). Pretreatment chemistry (2) is selected considering the nature of the wastewater and is controlled automatically and continuously.

Filtration in EF and EFC Systems

The chemically pretreated wastewater then flows to the concentration tank (3). From there, the water is pumped continuously through the tubular membrane filtration modules (4) at a high fluid velocity. At the



normal operating pressure (20 - 40 psi), clean water is forced through the pores of the membrane while the particulate contaminants remain suspended in the recirculated stream. The filtration piping also includes a backpulse mechanism which reverses the flow of filtrate to maintain higher flow rates and extend the time between cleaning cycles. The clean water (membrane filtrate) flows by gravity from the membrane modules to drain (5), storage tank (6) or the final neutralization tank (7). The concentration of the wastewater slurry recirculated in the membrane modules is typically maintained between 2-5% solids. Under normal operating conditions, a portion of the slurry is periodically removed from the system, usually to a filter press (8). Every E-Series filtration system includes a convenient integral cleaning loop (9) consisting of a pump, two tanks and the necessary piping and valving to permit in-place cleaning of the membrane modules.

E-SERIES SYSTEMS ARE KEY ELEMENTS OF TREATMENT UPGRADES

Wire and Cable Manufacturer, Jacksonville, FL

A manufacturer of high carbon steel wire products is using the E-Series system to treat rinsewaters from the acid cleaning and descaling of wire rod and processed wire. The E-Series system consistently produces effluent at less than half the discharge limits for all metals. The management staff wanted assurance that the waste treatment system would operate in compliance. Memtek® products demonstrated detailed knowledge of the company's wastewater and confirmed their design concept with treatability testing on actual samples of the wastewater. Memtek products provided turnkey installation, startup and operator training. The system provides the customer with the confidence that the effluent is consistently well below discharge limits.

Parts Manufacturer, New Haven, IN

A leading manufacturer of industrial, automotive, aerospace defense fluid connectors, as well as automotive and commercial custom engineered molded extruded plastic products is using the Memtek E-Series microfiltration system to treat metal bearing wastewaters. Since startup, the treatment system has consistently met the required effluent limitations at operating costs that are lower than conventional technologies.

Printed Circuit Board Manufacturer, Raleigh, NC

A major manufacturer of printed circuit boards, recently upgraded their wet processing operations with new, state-of-the-art equipment. The customer also replaced their wastewater treatment system, which was based on ion exchange, with a Memtek E-Series microfiltration system. The customer needed a reliable waste treatment system to meet very low compliance limits. The E-Series microfiltration system has reduced operating costs and generated sludge with high copper content. As a result, sludge disposal costs are significantly lower than expected.



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A Unique Integrated Membrane Makeup and Zero Liquid Discharge System for a Combined Cycle Power Plant

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KEYWORDS: Zero liquid discharge, tubular microfiltration, reverse osmosis, evaporation ponds, cross flow microfiltration, softening/clarification, silica reduction, reverse osmosis concentrate

ABSTRACT: The growing trend to limit the use of fresh water while minimizing, if not totally eliminating, the discharge of wastewater in the Power Industry has made the need to provide an integrated approach a critical factor. This case study describes how the combination of off-site service with a wastewater plant design that incorporates precipitation with micro-filtration was the solution for the Harry Allen Gas Turbine Combined Cycle power plant. The virtually all membrane design operates at an overall recovery of greater than 95% while discharging a stream of wastewater to evaporation ponds and trucking solids off-site. The feedwater to the plant is variable originating from three different wells while the wastewater is a combination of reverse osmosis concentrate, steam generator blowdown, evaporative cooler blowdown, wet surface air cooler blowdown, multimedia backwash water, oil/water separator wastes, and other service water wastes. This design overcomes many of the shortcomings of a conventional approach or a thermal design which would have much higher capital and operating costs.

Background

The Harry Allen Generating Station is a natural gas fueled power plant located in Southern Nevada approximately 25 miles northeast of Las Vegas. The Plant was originally built in 1995 as a simple cycle plant with a 72-megawatt combustion turbine. A second similar sized combustion turbine was installed in 2006 doubling the plant capacity to 144-megawatts. The final build-out of the Plant was completed in 2011 with the addition of two heat recovery steam generators that capture waste heat from the combustion turbines which then drive a single steam turbine generator to produce an additional capacity of 484 mega-watts raising the total Plant capacity to 628 mega-watts. This modification resulted in the transformation of the Plant from a peaker to a base loaded combined cycle Plant.

One of the design objectives of the Plant was to minimize the quantity of water required while eliminating any water discharge off-site. The Plant consumes a mere 32 gallons of water for each mega-watt of power produced whereas a conventional plant would use more than 600 gallons per megawatt of energy produced. The reduction in water demand was principally addressed by the use of air-cooled condenser cells and evaporative coolers.

The combined wastewater from the Plant is discharged to a pair of refurbished 2.5 acre geo-textile, riprap-lined evaporation ponds. The solids produced from the wastewater are recovered by a filter press and sent off-site for disposal to a sanitary landfill. In essence the objective of the Plant's water and wastewater treatment systems was to achieve zero liquid discharge (ZLD). The selection of a wastewater treatment system that was capable of meeting this objective is the heart of this paper.

Design Requirements

The water and wastewater requirements of the Plant can be summarized as follows:

- Potable Water Treatment System (PWTS)
- Make-up Water Treatment System (MWTS)
- Wastewater Treatment System (WWTS)

The source of raw water for the Plant is from the Harvey well with alternate supplies from the Chuck Lenzie Station Wells #1 and #2. The system design is based upon the worst possible blend of any of the three wells. The synthetic design well water analysis use for the Plant design is given in Attachment A. This water quality was used for the design of both the potable water and the makeup water treatment systems.

PWTS

The potable water system treats the well water and has a design capacity of 3 gpm continuous net to storage. Due to the insignificant capacity of this system in relation to the makeup and wastewater, its design will not be a topic discussion in this paper. For information purposes, the system consisted of two (2) 100% trains, each consisting of multimedia filters, granular activated carbon, brine regenerated strong acid cation units (softeners), reverse osmosis and sodium hypochlorite addition.

MWTS

The makeup water treatment system consists of three (3) 50% trains. The system is divided into a roughing treatment system followed by a polishing system. The roughing system is capable of treating 300 GPM of well water with the flexibility to also treat a portion of the recovered wastewater. The treated water from this roughing system is channeled to a blend storage tank that also has the ability to store recovered water from the wastewater treatment system. This partially treated and blended water is used for various plant demands including fire protection. The balance of this stored water is fed to a polishing makeup demineralizer system. The multimedia filter backwash/rinse and reverse osmosis concentrate is sent to the wastewater treatment plant. The polishing system consists of three (3) 50% 40 GPM feed second pass reverse osmosis trains and off-site regenerated mixed bed ion exchange polishers. The polished water is stored demineralized water storage tank. The second pass RO concentrate is returned to the filtered/blend water storage tank so the polishing system does not produce any wastewater during normal operation.

WWTS

The wastewater treatment system is designed to treat the Heat Recovery Steam Generator (HRSG) blowdown, the MWTS multi-media filter backwash water, the MWTS first pass RO concentrate, the Combustion Turbine Generator (CTG) evaporative cooler blowdown, the Wet Surface Air Cooler (WSAC) blowdown, the existing service water wastes, the discharge from the oil/water separator, and recycle water from the WWTS after these streams are collected in a wastewater equalization tank. The design capacity of the WWTS is 300 GPM. The water processed by this system is either sent to the evaporation ponds or returned to the makeup treatment system for further processing and recovery. The solids produced are dewatered and hauled off-site.

Makeup Water Treatment System

The raw water source being well water makes the design of the pretreatment system very straight forward. The well water analysis reports suspended solids in the range of 3 mg/l dictating the need for filtration to reduce the silt density index (SDI) to an acceptable value for RO feed. The alternatives for filtration were either multi-media filtration (MMF) or ultra-filtration (UF). While the UF would provide a more positive barrier and produce a superior filtrate water quality, it does have some drawbacks given the fact its wastewaters would require recovery to minimize the volume of waste that would have to be sent to the wastewater treatment system. The backwash water for the MMF is less than one percent (1%) whereas the UF would require a backwash water volume of approximately five percent (5%). In addition, the MMF does not require periodic chemical cleanings that would further complicate the wastewater recovery system.

The well water is dosed with sodium hypochlorite to ensure the complete oxidation of any soluble iron. The filtrate from the multimedia filters is stored in a filtered water/blend water storage tank. In addition to the filtered water, this tank will receive concentrate from the downstream makeup second pass RO, permeate from the wastewater recovery RO, and potentially some of the wastewater recovery RO concentrate.

The filtered water is dosed with an anti-scalant, sodium bisulfite and then processed through five (5) micron (nominal) safety cartridge filters before being sent to the first pass roughing reverse osmosis trains. The selection of

a two pass RO was chosen to minimize the loading on the downstream polishing demineralizer. While the pH of the well water would indicate the minimal presence of carbon dioxide, provisions are included to eliminate the presence of any carbon dioxide by the addition of inter-stage sodium hydroxide.

An inter-pass permeate storage tank is included to collect and blend the first pass RO permeate and the reclaimed wastewater RO permeate. A portion of the permeate stored in this tank is used for various plant uses including first pass RO flushing and firewater. The balance of the permeate is treated by the second pass RO and then the off-site regenerated mixed bed polishers to produce demineralized makeup water.

The concentrate from the first pass RO is sent to the wastewater treatment plant for treatment. This pass operates at a comfortable recovery of approximately 75%. The relatively low recovery ensures simple, reliable, and trouble free operation without producing excessive wastewater while its concentrate stream will be recovered by the wastewater treatment system. The second pass operates at a recovery of approximately 85% with its concentrate being sent to the filtered water/blend tank. This second pass concentrate will be blended with the filtrate from the multi-media filters and permeate from the wastewater RO.

The second pass RO permeate could have been polished by either electro-deionization (EDI) or conventional mixed bed ion exchange (MBIX). The EDI would have the advantage of eliminating any waste stream, other than the possibility of periodic cleaning. Its concentrate stream could be returned to one of the upstream RO permeate storage tank or the filtrate/blend storage tank. The ion exchange approach would require off-site regeneration to avoid the production of spent regenerant wastewater. The off-site regeneration also shifts the capital investment and the operation and maintenance costs to the service provider. Finally, the mixed bed ion exchange simplifies the recycling of the stored demineralized water to ensure the highest possible water quality is always available. The final decision was to use a mixed bed ion exchange solution with off-site regeneration in lieu of the EDI.

Refer to Attachment B for a block Process Flow Diagram of the system.

Wastewater Treatment System

The wastewater that must be treated comes from a multitude of sources which increases the complexity of any wastewater treatment process that would be used to reduce the volume of wastes and its discharge to the evaporation ponds. The first option for treatment would have been a thermal process, or evaporator. This process has been used in many plants throughout the western United States but it is a given fact they are very expensive to not only purchase but operate as well. The second option was a design based upon the use of reverse osmosis membrane technology to concentrate the wastewater into an acceptable stream that could be sent to the evaporation ponds. The key to the membrane approach is to manage the water chemistry and avoid exceeding the solubility of any inorganic contaminants that could be possible. In addition, it is necessary to reduce particulates, remove undesirable organic constituents, and manage the bio-fouling that can result in excessive membrane fouling. Finally it is important to minimize the cleaning frequency of the RO that would place an unacceptable burden on the Plant's operators. It should be noted although a full clean-in-place (CIP) membrane

cleaning system was provided, the current plant operation utilizes off-site membrane cleaning. The reverse osmosis membrane approach was selected for this Plant as the most cost effective design and one that could be operated and maintained without placing a burden on the operating personnel.

As with all reverse osmosis membrane plants, their performance is a function of the pretreatment system's ability to minimize membrane fouling. The variety and the variability of the wastewaters for this application would have been a challenge for any pretreatment system. Two options were evaluated for the reverse osmosis pretreatment system. The first option consisted of a conventional solids contact clarifier for the reduction in sparingly soluble salts followed by media filtration. The use of a solids contact clarifier is commonly employed in power plants as a standalone cooling tower blowdown minimization system or in combination with media filters. It can also be used as pretreatment in a thermal zero liquid discharge (ZLD) system to reduce the size of the evaporator. The second option involved chemical precipitation in combination with a cross-flow tubular micro-filtration system. As with a solids contact clarifier, this design uses chemical precipitation to reduce the salts and concentration of chemical species that can limit the recovery of the wastewater RO. The unique feature of this approach is the use of a cross-flow tubular MF to enhance the reduction in the unwanted salts while providing a physical barrier to reduce the level of suspended solids that cannot be achieved with a media filter. In essence, the slurry cross flow tubular microfiltration system replaces the function of a typical precipitator/clarifier/filter system into a single unit operation. The chemically pretreated wastewater flows through the tubular modules at a high cross flow velocity sufficient to maintain turbulent flow. This design is a pressure driven process with typical operating pressures in the range of 40 – 60 psi. The fluid is forced through the membrane with a pore size in the range of 0.1 – 0.3 microns that is cast onto the inside of a tubular porous material. The turbulent flow prevents the buildup of particles on the inner surface of the modules while the filtrate is forced through the pores of the membrane. The design incorporates a periodic back-pulse with air to prevent solids accumulation on the surface of the membrane and extend the service cycle before a chemical clean in place is required. This turbulent cross-flow and tubular design also eliminates the need for pre-filtration with the ability to handle solids levels up to five percent (5%) by weight.

Experience indicates this type of design is particularly beneficial when treating a mixture of waters. Chemical dispersants/soaps routinely found in cooling water interfere with critical coagulation, flocculation and settling processes in a conventional precipitator/clarifier. Consistency of both the precipitation and solids removal processes is more effective when both processes occur within the micro-filtration process.

Perhaps the key issue in the decision to select the cross-flow tubular MF over a clarifier was its ability to deal with the variability of the wastewater that was to be treated. While some of the streams to the WWTP are relatively constant in flow and contaminants and an equalization tank is used to moderate the variability, it would be impossible to maintain a constant flow and feedwater analysis. One of the traits of a solids contact clarifier is the fact it is a constant rate process. Variations in temperature, flow rate, and salinity can result in an upset in the sludge blanket and the

settling velocity of the solids unless the changes are gradual and controlled which in this instance was not possible. In addition, there can be carry over of polymers that are normally used to enhance the performance of the clarifier. Most polymers will result in severe membrane fouling of either low pressure filtration or high pressure reverse osmosis membranes. Operation of the cross-flow MF however does not require the use of a polymer. The use of an equalization tank attempts to level out such variations in operating parameters but it is not possible to provide a tank sized large enough to minimize the impact upon the performance of a clarifier. Such variations will result in excessive solids carryover from the solids contact clarifier as the suspended matter will not be able to settle. This carryover can produce excessive loading on the downstream filtration system and the resultant short service runs. Variations in the raw water analysis require corresponding modifications in chemical addition to ensure the required precipitation of the undesirable salts. This includes salts that are not only precipitated but those that are adsorbed on precipitated material, such as silica. With the elimination of sparingly insoluble salts from the process, the limiting factor of the downstream reverse osmosis system becomes the level of TDS in the concentrate stream. The use of seawater membranes in the RO system will permit a reduction in the wastewater volume corresponding to the limitation of the osmotic pressure, which would be a concentrate steam that contains a TDS in the range of approximately 80,000 mg/l. This would equate to an overall recovery of about 98-99% assuming a feedwater TDS of approximately 1,000 mg/l.

The wastewater treatment system begins with an equalization tank that blends the multi-media filter backwash water, the first pass RO reject from the makeup water treatment system, the raw water, and the various plant waste streams. The effluent from the equalization tank is pumped to the two (2) stage reaction tanks where the chemical addition is performed. The chemical addition is specific to the precipitation/adsorption that must be accomplished. This process relies upon hardness reduction by precipitation and silica reduction by the adsorption of silica on magnesium hydroxide precipitate. While the design feedwater contained ample magnesium for this purpose, the decision was made to incorporate the ability to add a magnesium salt to ensure the required silica reduction could be produced.

Sodium hypochlorite and hydrochloric acid are added to the first reaction tank for pH control and to oxidize any incoming organic matter to prevent potential membrane fouling. Provisions are also included to feed ferric chloride to act as a coagulant which can often be helpful in minimizing the frequency of membrane cleaning. The adjusted water flows to the second stage reaction tank where soda ash and caustic soda are added to precipitate calcium carbonate and magnesium as magnesium hydroxide.

The effluent from the two stage reaction tanks flows by gravity to a MF feed/concentration tank. This tank acts as a pump suction tank, a level control device, a slurry recirculation tank for the downstream MF. By increasing the slurry of the precipitated materials, it enhances the reduction of the silica by increasing the concentrations of the solids that are used to remove certain species such as silica. The concentration of this slurry is in the range of 2 – 5 percent solids. Excess sludge is intermittently bled from the system by pumping some of the sludge from the concentrate tank to a thickener.

Each cross-flow tubular MF train consists of a feed/recirculation pump, membrane modules, a cleaning pump, and a chemical cleaning tank and water rinse tanks. The flow is controlled to each module by the level in the concentrate tank. If this level drops below a given set-point, the flow to the first stage reaction tank is increased. When the flow to an MF train drops below the design rate that was established to process all the wastewater, the train is removed from service and cleaned. There are a total of four (4) – 33% MF trains. The trains utilize ten (10) tubular PVDF membranes with a pore size in the range of 0.1 micron (nominal). Each module is approximately one (1) inch dia. and 72 inches long and there are a total of four (4) modules per housing. There are a total of thirty six (36) eight (6) inch dia. by ten (10) foot long PVC housings housing per train. The MF membranes are typically rated to operate at a flux of approximately 300 GFD for this application. The actual operating flux will be dependent upon the nature of the precipitated materials, the particulates, and other impurities combined with the effectiveness of the cleaning regime.

A redundant MF train is provided to ensure the design flow rate is maintained when a train is taken off-line for module cleaning. The automated design cleaning frequency for each MF train is approximately three (3) days. When the MF is cleaned, the feed/recirculation pump is shut down and the MF is flushed to displace the slurry back to the feed tank. For this application, cleaning is conducted with hydrochloric acid and occasionally sodium hypochlorite. This is accomplished by recirculating the cleaning solution back to the cleaning tank for about 30-60 minutes. After the cleaning cycle is completed, the cleaning chemicals will be reclaimed by feeding them back to the concentrate feed tank. The solids that are sent to the sludge thickener are processed by a filter press that produce a cake of approximately 50% solids. The filtrate from the press along with the overflow from the thickener is returned to the first reaction tank for reprocessing.

The filtrate from the MF is be pH adjusted with hydrochloric acid in a pH adjustment tank for optimum pH for the downstream RO and then flow by gravity to a MF filtrate tank. The filtrate from this tank is pumped to the reverse osmosis units. Chemical addition ahead of the RO consists of sodium bisulfite for the removal of any residual free chlorine that could be present in the filtrate as a result of the feed to the reaction tanks or the MF cleaning process. A non-oxidizing biocide can also be added to retard biological activity. It should be noted an anti-scalant is not required or included as the sparingly insoluble salts are all kept well below their saturation levels by the upstream process.

The reverse osmosis concentrate system consists of five (5) - 25% three (3) stage trains designed to treat a feedwater capacity of 300 gpm. The system is design to operate at an overall recovery of 90% with 270 gpm of permeate being reclaimed by returning this stream to the makeup treatment system to either the filtrate tank for further reprocessing or to the first pass permeate storage tank for plant use including the Wet Surface Air Cooler. As noted, the design recovery of the RO is 90%. However, due to the fact a portion of the concentrate stream can be returned upstream to either the reaction tanks or the pH correction tanks for reprocessing, it is possible to operate the RO at a very comfortable recovery of 75% producing a total concentrate flow rate of 75 GPM while still maintaining the overall system recovery

at a minimum of 90%. The 75 GPM of concentrate is routed to a RO reject holding tank where it can be split into three streams. The RO concentrate is either directed to the evaporation ponds, the first stage reaction tank, and/or the pH adjustment tank. The exact ratios depend upon the actual concentrate water quality. There are conditions under which the RO reject's water quality is such that a majority of the reject can be recycled to the makeup plant increasing the recovery above the 90% value. To date a recovery of up to 98% has been achieved under certain operating conditions.

Operation and Performance

A well trained and competent operator is critical to the reliable and efficient performance of any water or wastewater treatment system. This is especially true when a wastewater stream varies in composition, temperature, and flow rate as in the case for this system. While the various unit operations are primarily pressure driven membrane processes, the correct chemistry must be maintained to ensure the necessary operating parameters are maintained and that the required membrane cleanings are performed when required. Based upon the design data presented, the key constituents that must be monitored and controlled to permit the required RO recovery at a minimum of 90% are total hardness and silica. The MF systems primary function is to reduce these impurities and any others constituents that could limit recovery if they are concentrated in the RO and permitted to result in scaling. Naturally, the MF must also ensure the silt density index (SDI) of the RO feed water is below 3.0. To ensure the system is in chemical balance, the operators monitor the following key parameters of the MF filtrate to determine if any adjustments to the chemical addition are required:

- Silica
- Total Hardness
- Alkalinity
- pH

Since the raw water can contain a wide variety of contaminants due to the various wastewater streams that are fed to the equalization tank, provisions were incorporated into the design to utilize a wide variety of chemicals to precipitate the hardness, silica and any other constituents prior to the MF. It has not been necessary however, to feed each of the available chemicals at all times. The filtrate is then pH adjusted and dosed with a biocide to further condition the filtrate for feed to the RO. The chemicals required for the MF system include:

- Sodium hypochlorite
- Hydrochloric acid
- Sodium hydroxide
- Magnesium sulfate
- Sodium carbonate
- Ferric chloride
- Calcium chloride

In addition to the above, the following additional chemicals are used for operation of the MF and RO. It should be noted the RO elements are cleaned off-site in a service center while a portion of the MF cleaning chemicals are sent to the evaporation ponds for final disposal:

- Sodium hypochlorite
- sodium biusulfite
- Anti-scalant
- Biocide

Based upon the composition of the wastewater that has been treated to date, the chemical utilization has been primarily sodium hydroxide for hardness reduction and hydrochloric acid for pH adjustment. Given this operating condition, the actual operating flux of the

membrane is substantially higher than the design flux permitting fewer on-line units during normal operation and extending the period of time between MF membrane cleanings. A summary of the chemical consumption for one month of operation is given in Attachment D.

The operator has a great deal of flexibility in determining the timing for the MF cleaning. Unlike other membrane processes that rely upon trans-membrane pressure loss or flux decline to initiate a cleaning, the cleaning of the MF is based upon the ability of the MF to process a specific wastewater flow rate. If the level in the equalization tank begins to rise to an unacceptable level due to a limit in the downstream MF processing capacity, an MF is taken off-line and replaced with a standby MF thereby increasing the wastewater treatment processing rate. Since the maximum operating flux for easy to treat wastewaters can be in the range of 600 gallons per square foot per day (GFD), the operator has a greater flexibility in deciding when to perform a cleaning of an MF. For example although each of the MF trains were designed to operate at a capacity of 100 GPM, the trains have been operated at flow rates up to approximately 250 GPM. The operator may also find it convenient to schedule MF cleanings based upon the total production capacity or use the calendar for initiation. Attachment D illustrates some performance data for the MF over a period of time. To date, an acid cleaning using hydrochloric acid has be very effective in returning the membrane to its required flux which accounts for the higher than anticipated flow rates.

As is the case for all RO systems, the performance of the wastewater RO concentrator is a function of the quality of the feedwater produced by the pretreatment system, which in this case is the MF. Since being placed into operation on about February 2011, the wastewater RO has been cleaned only one time. The RO is the unit process that determines if the required overall recovery of 90 percent can be achieved. The system has consistently exceeded this objective by returning a portion of its concentrate/reject stream to the first stage reaction tank. As indicated in Attachment D, after the initial commissioning of the system the average recovery of the system has been approximately 98%. The high system recovery has been possible by the use of seawater RO membranes in the wastewater RO which operate at pressures up to approximately 500 psig. The wastewater RO produces a permeate water quality with a total dissolved solids content in the range of 50 micro-siemens per centimeter, or 25 mg/l of total dissolved solids. Since this relatively low TDS water quality is returned to the makeup demineralizer system and further polished by the makeup RO as illustrated in Attachment C, the loading on the service ion exchange demineralizers has extended their service cycle. Currently the replacement frequency for the ion exchange units is in the range of six (6) to eight (8) weeks. This also reduces the raw water demand on the well water that supports the overall Plant.

Conclusions

The integrated water and wastewater system has been operating for over one year. After a normal commissioning and start-up period, the required objective of producing the required makeup water and treating a variety of wastewaters, the plant is continuously exceeding the primary goal of minimizing the wastewater discharge to the evaporation ponds by a maximum of 90% for design. In fact, the discharge over the past approximately six months has been consistently in the range of 5% of design. While it can be said the

wastewater that the system has had to treat is less demanding than the original design analysis, it should also be recognized the demands on the system from a start-stop operation perspective and the variations in feedwater create a difficult operating environment. This would be especially true if the system had included conventional softener/clarifier and filtration process in lieu of the existing slurry cross-flow tubular micro-filtration system. The guaranteed performance has been validated not only by the minimal discharge to the evaporation ponds but the trouble free performance of the reverse osmosis wastewater concentrator.

The successful performance of this integrated membrane makeup and zero liquid discharge system is based upon the following considerations:

- A complete profile of the various raw water and wastewater streams that must be treated. This information must not only include the design basis for the system but also the actual water quality variations that can occur during the Plant's operation.
- An understanding of the water and wastewater treatment chemistries required to produce the desired results. The overall recovery of the system is ultimately based upon the control of the solubility of the potential compounds that can be produced within the system.
- An understanding of the basic unit processes required to achieve the specified objectives. The system should be flexible enough to deal with reasonable changes in the design criteria which will occur in all water and wastewater treatment plants.
- A trained operating staff committed to operate and maintain the system. Their success will ultimately be a function of the data collection, analysis, and ability to implement periodic changes in the operation of the system. This also includes their ability to address periodic performance shortcomings as a result in unanticipated changes.

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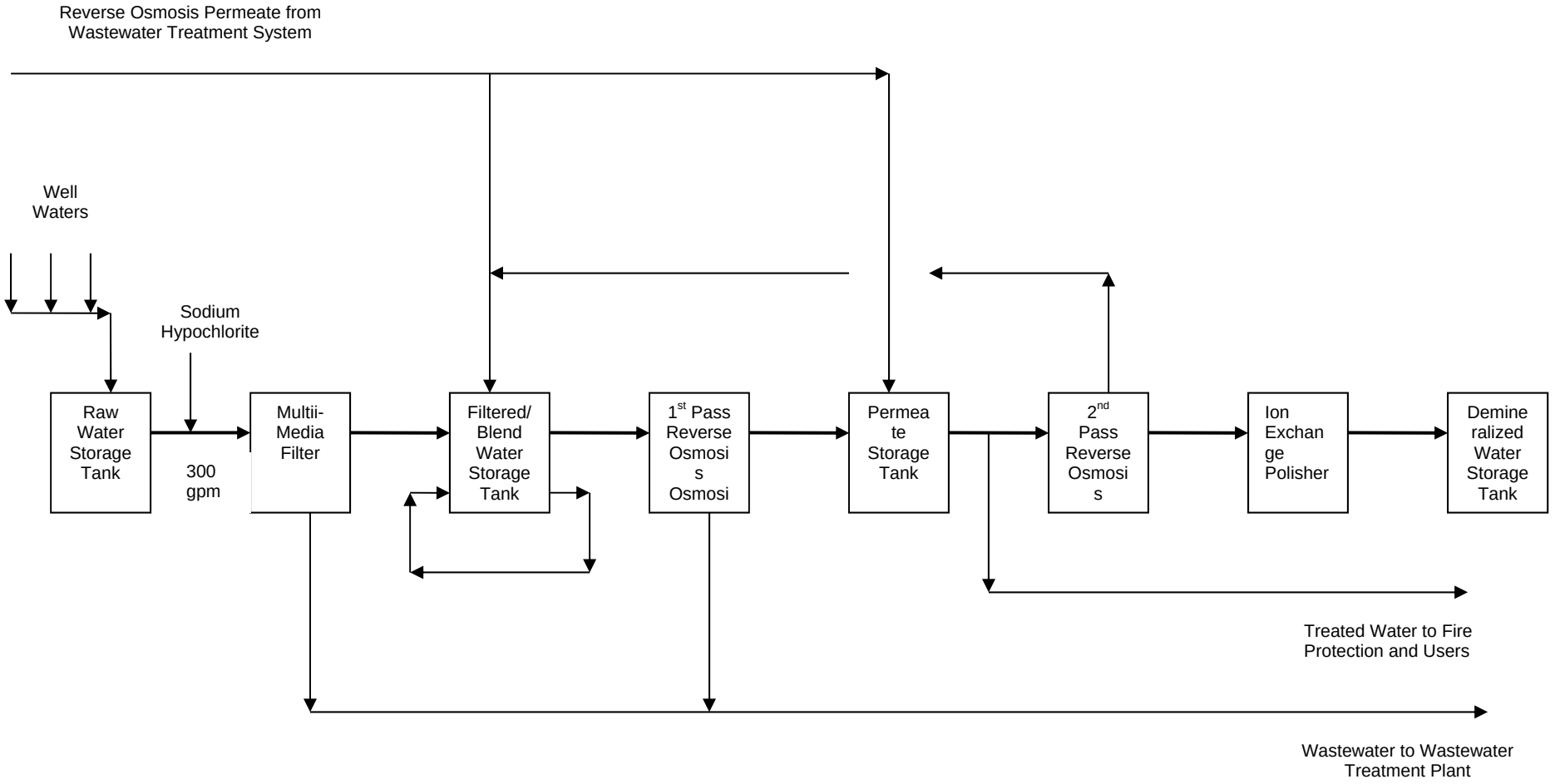
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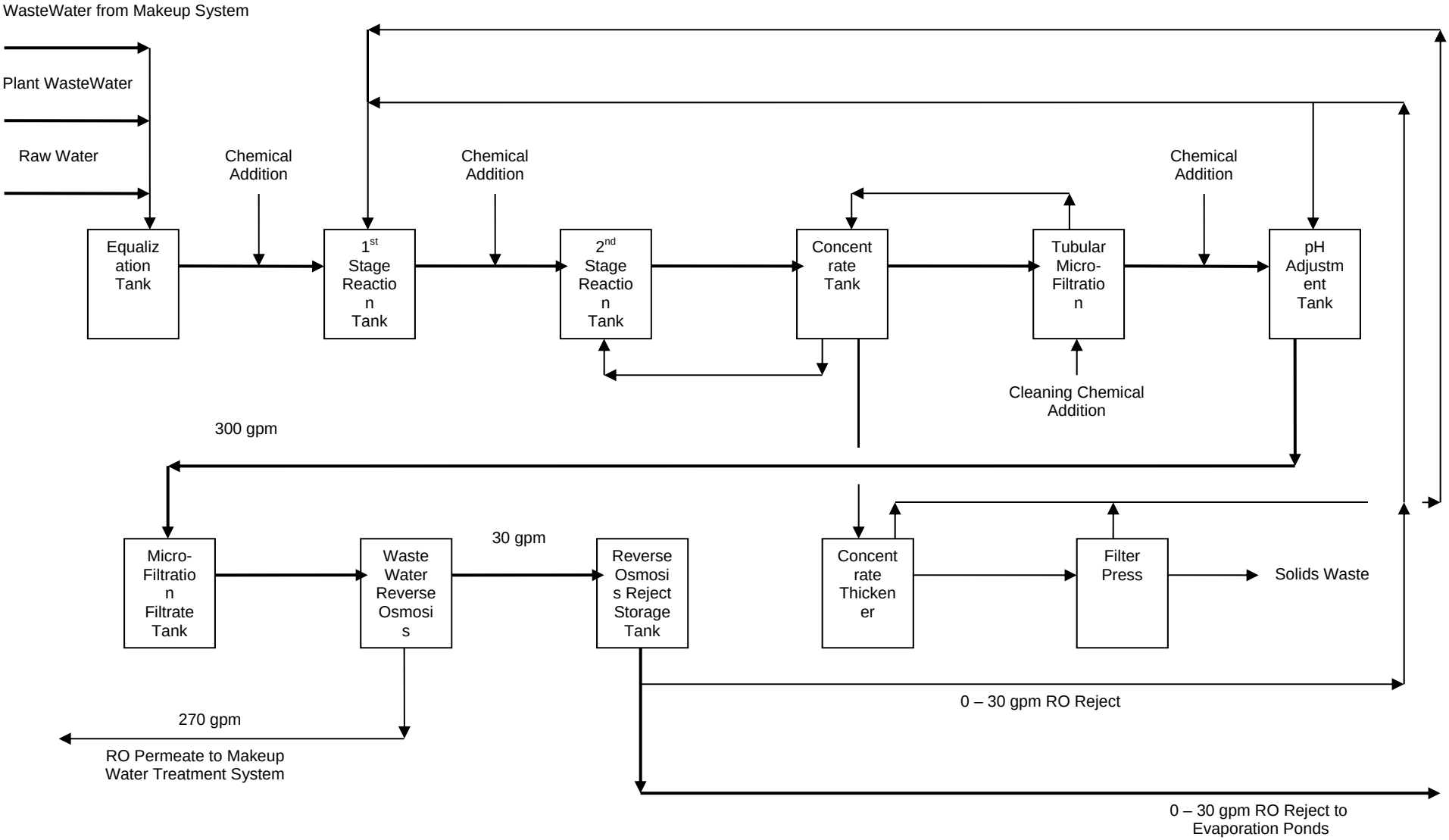
NVEnergy
Siemens Customer Service
Siemens Industries, Inc.

ATTACHMENT A

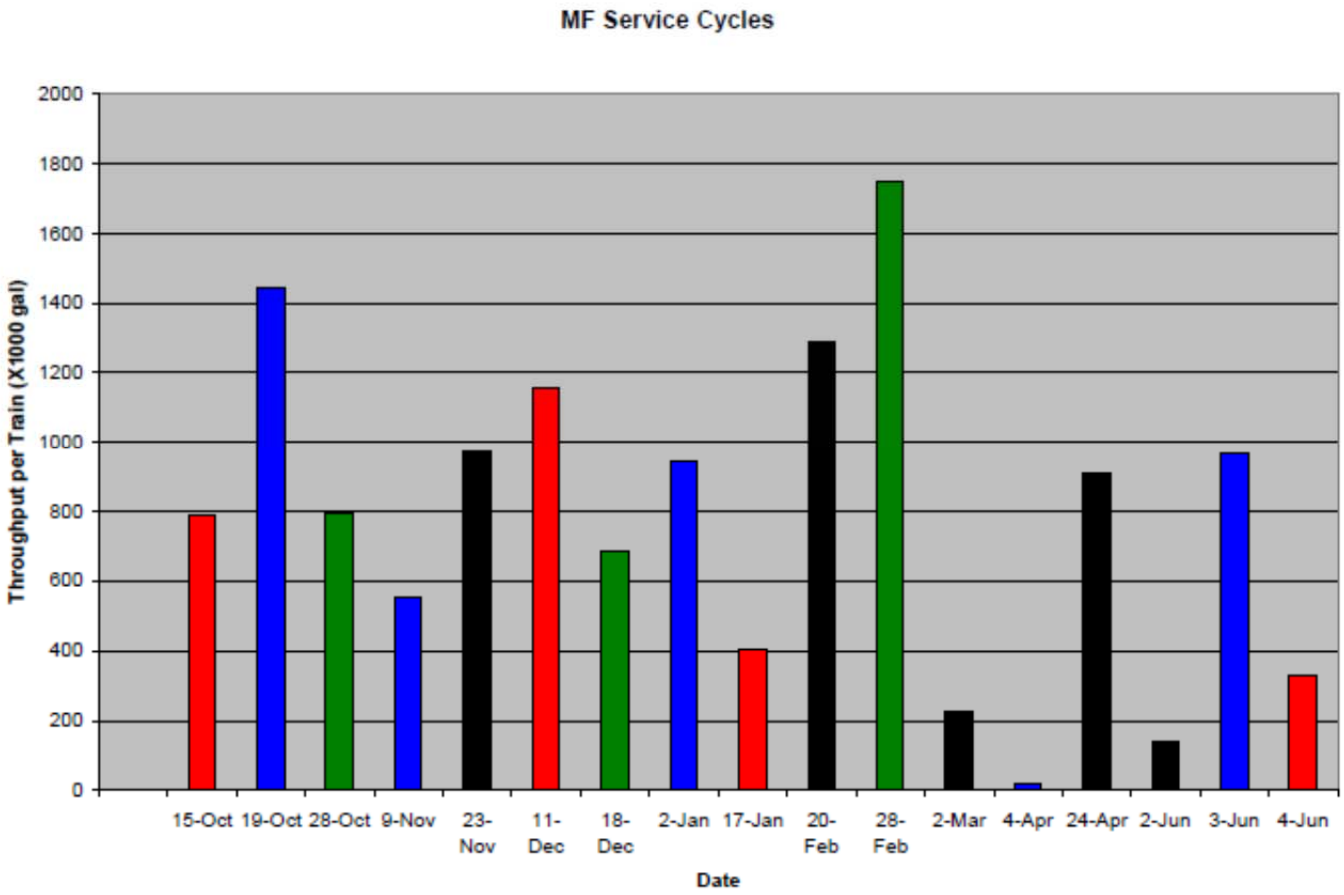
Parameter	Design Well Water Composite	Design Wastewater Influent	Guaranteed Wastewater Effluent	Actual WasteWater Effluent
Cations/Metals	<0.1			
Aluminum (Al), mg/l	<0.05			
Barium (Ba), mg/l	0.3	<0.05		
Boron (B), mg/l	<0.05	0.18		
Cadnium (Cd), mg/l	100 - 120			
Calcium (Ca), mg/l	<0.05	178		
Chromium (Cr), mg/l	<0.05			
Copper (Cu), mg/l	<0.05			
Iron (Fe) – Soluble, mg/l	0.12 – 0.75			
Iron (Fe) – Total, mg/l				
Lead (Pb), mg/l	<0.1			
Lithium (Li), mg/l	0.14 – 0.23	0.27		
Magnesium (Mg), mg/l	49 – 57	62.6		
Manganese (Mn), mg/l	<0.05			
Molybdenum (Mo), mg/l	<0.1			
Nickel (Ni), mg/l	<0.05			
Phosphorus (P), mg/l	<0.1			
Phosphorus (PO_4), mg/l	<0.3			
Potassium (K), mg/l	15	33		
Silica (SiO_2), mg/l	21.0	36.4		
Sodium (Na), mg/l	130	266	<130	
Strontium (Sr), mg/l	3.60	5.69		
Vanadium (V), mg/l	<0.05			
Zinc (Zn), mg/l	<0.05			
Anions				
Bromide (Br), mg/l	<2.0			
Chloride (Cl), mg/l	160 – 180	582.4	<160	
Nitrate (NO_3), mg/l	<2.0 – 6.7	<2.0		
Nitrite (NO_2), mg/l				
Phosphate (PO_4), - Total	<0.2			
Phosphate (PO_4), - Ortho	<0.10		<300	
Sulfate (SO_4), mg/l	300 – 350	307		
Alkalinity				
Bicarbonate ($CaCO_3$), mg/l	170 – 180	222		
Methyl Orange ($CaCO_{3)}$, mg/l	170 – 180			
Phenolphthalein, ($CaCO_{3)}$, mg/l	<10			
Others				
pH, standard units	8.2	6.0 – 8.3		
Sum of Ions	998 – 1,097	1,656		
Carbon Dioxide (CO_2), mg/l	2.0	67		
Conductivity, *u*S/cm	1,400 – 1,600	2,939	<1,400	
Organic Carbon (C) - Total, mg/l	<2.0			
Ammonia (NH_3), mg/l	<0.04			
Ammonia ($CaCO_3$), mg/l	<0.12			
Suspended Solids(Total at 105^O C)	<3.1			
Benzoltriazole Background, %	TBD			
Temperature, deg. F	55-65	60 - 100		



MAKEUP WATER TREATMENT SYSTEM



WASTEWATER TREATMENT SYSTEM


MF Service Cycles
Throughput per Train (X1000 gal)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
15-Oct
19-Oct
28-Oct
9-Nov
23-Nov
11-Dec
18-Dec
2-Jan
17-Jan
20-Feb
28-Feb
2-Mar
4-Apr
24-Apr
2-Jun
3-Jun
4-Jun
Date

SIEMENS

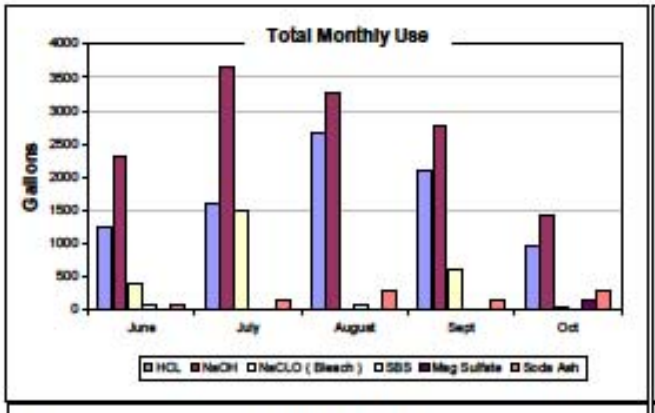
HARRY ALLEN Chemical Inventory - Monthly Usage Report

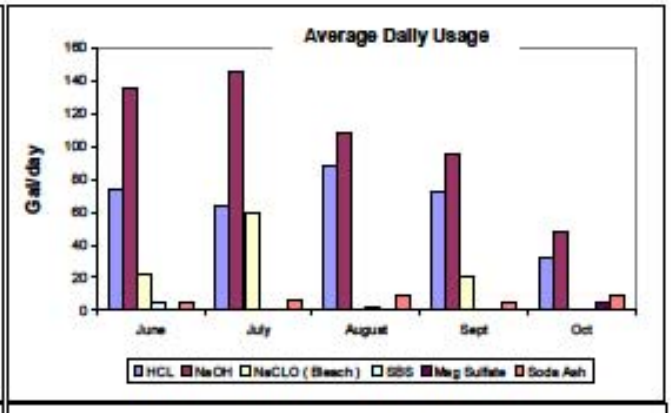
NVEnergy

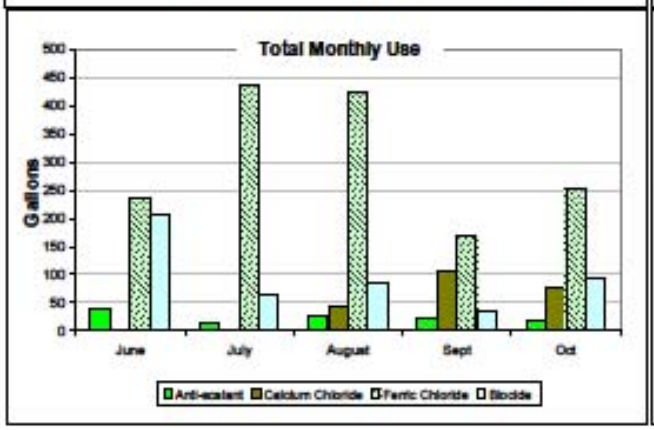
Month: October, 2011

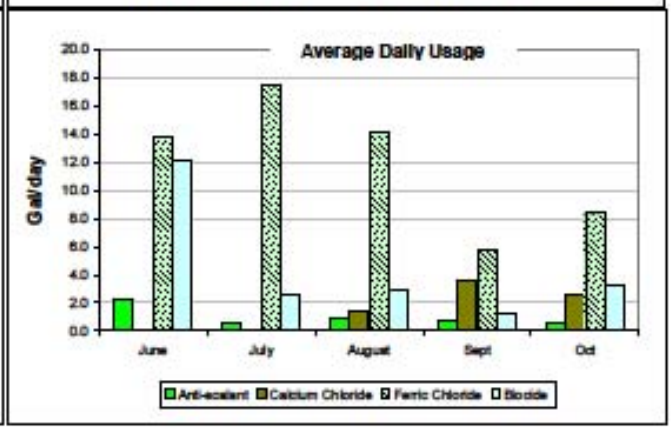
Chemical Tank/Tote Levels	Beginning Inventory	Gallons	End Inventory	Gallons	Total Gallons Delivered	Total Gallons Used	Average Daily Usage
Date	10/1/2011		10/31/2011				30
HCL	63%	5962	53%	5012	0	950	31.7
NaOH	35%	4839	53%	7355	3940	1425	47.5
NaCLO (Bleach)	24%	1127	88%	4110	3004	21	0.7
SBS	0%	0	78%	566	566	0	0.0
Mag Sulfate	89%	4690	86%	4555	0	135	4.5
Soda Ash	45%	6222	43%	5955	0	267	8.9

	Beginning Inventory	End Inventory	Gallons Delivered	Gallons Used	Average Daily Usage
Chemical Tote Levels	Gallons	Gallons			Gallons
Anti-scalant	236	217	0	19	0.6
Calcium Chloride	69	229	236	77	2.6
Ferric Chloride	272	85	67	253	8.4
Biocide	213	213	95	96	3.2









Comments:

- Chemical usage is stable.

A New Approach to Zero Liquid Discharge (ZLD) at Constellation Energy Group's High Desert Power Project

by
Stephen J Shulder (Constellation Power Source Generation) and Marek K Mierzejewski (USFilter)

Abstract

A new preconcentration technology, using softening microfiltration/reverse osmosis (MF/RO), has been selected for the High Desert Power Project in Victorville, California. This technology represents an alternative to the conventional lime softening/media filtration approach to Zero Liquid Discharge (ZLD). The plant is currently in detailed design: it is hoped that operating data will be provided at this forum at a later date.

Introduction

The High Desert Power Project's parent company, Constellation Energy Group, is a holding company with energy-related businesses. It includes the nation's oldest utility, Baltimore Gas & Electric Company, which provides service to more than 1.1 million electric customers and nearly 600,000 natural gas customers in central Maryland.

The High Desert Power Project, to be located in Victorville, California will be the first new major power plant to serve the Southern California area in more than a decade. This 750-megawatt combined cycle plant is due to begin commercial operation in July 2003.

From a water management viewpoint, this plant is of interest because in addition to the normal power plant water treatment requirements for cooling tower and steam cycle makeup, Constellation Energy is obliged to treat surface water for aquifer recharge, and produce no process liquid discharge from the plant.

Shortage of available water, and the need to get the power plant into commercial operation rapidly were the reasons why the plant was permitted as a ZLD installation. In such systems, the waste water is recovered and reused, instead of being discharged to the environment, which usually requires a time-consuming, albeit essential, environmental permitting process.

Water will be available from the Mojave Water Agency (MWA), which will deliver State Water Project (SWP) water from the California Aqueduct. Banked ground water will be used as a backup water supply if water from the MWA is not available.

Based upon meeting the power facility's water requirements, the aquifer banking objectives and the zero liquid discharge mandate, a water management system consisting of five subsystems, is specified as follows:

- Water Pretreatment System (WPS): Clarification and filtration to remove suspended solids and potential pathogens, pretreating the water for cooling tower makeup (CTMU), the combustion turbine evaporative cooler, steam cycle makeup and for the Aquifer Banking System (ABS). Both the latter uses require further treatment, for process and public health reasons respectively.

- Aquifer Banking System (ABS): Constellation has selected an ultrafiltration system to treat all the water from the WPS that will be used for aquifer recharge. This system has been proposed to the regional water quality control board.

- Cooling Tower Blowdown System (CTBDS): Lime softening and filtration, followed by Reverse Osmosis (RO). The RO permeate will be returned to the tower, with the reject stream feeding the zero liquid discharge system.

- Zero Liquid Discharge System (ZLDS): A two stage thermal system comprising evaporation and crystallization to produce a dry crystalline solid from the RO reject. The solids will be landfilled, and the distillate used as make up water for the Heat Recovery Steam Generators (HRSGs), with the balance returned to the cooling tower.

- Demineralized Water System (DWS): A demineralization system to provide make-up water for the HRSGs.

While it was not an explicit requirement that a single water treatment equipment supplier provide all six subsystems, there were evident benefits in so doing, among which were the following:

- Any changes arising during detailed design, start-up and commissioning could be addressed efficiently, by having a single point of project responsibility
- Integration of all systems in a water management plan, facilitating identification and characterization of all streams likely to affect the CTBDS and ZLDS.
- Uniformity of balance of plant equipment (pumps, valves, instruments, etc.) facilitating O&M and minimizing the spares inventory
- Improved inspection and controls testing

USFilter worked with Bibb & Associates in developing the design that was subsequently presented to Constellation Energy Group, identifying the suggested modifications to the specified system configuration and highlighting the resulting capital and operational benefits. This paper focuses on the design of the CTBDS and ZLDS, and references other subsystems only insofar as they affected the zero liquid discharge design. The projected water balance for the plant, showing the integration of the various subsystems, is shown in Figure 1.

System Design Basis

The source water analyses were developed by Bibb & Associates using historical water quality data from 1983-1999. The use of historical data is highly recommended in ZLD projects, as inaccuracies in water composition can have substantial effects on the tower chemistry and blowdown treatment systems. The design water analysis is provided in the Attachment 1.

In the course of design of the water systems, USFilter developed overall water and wastewater mass and energy balance projections, using the following requirements at different design conditions for the High Desert Power Project (Table 1):

Table 1: Water needs for the High Desert Power Project at different design conditions *(all flows in USGPM)*

Design Criteria	***Supply water Pretreatment system feed***	***Aquifer Banking System feed***	***HRSG cycle makeup***	***Evaporative Cooler makeup***	***Water Demand Cooling Tower Evaporation***
Design Temperature, 98ºF	5784	2090	42	164	3584
Design Temperature, 112ºF (duct fired)	5842	2090	42	39	3626
Design Temperature, 59ºF	4732	2090	42	0	2655
Design Temperature, 32ºF	2476	2090	42	0	401

The limiting criteria on the water management system were the operating and permitting limits of the cooling tower chemistry. The predicted composition of the cooling tower circulating water is shown in Table 2.

Table 2: Predicted Cooling Tower Circulating Water Composition.

Parameter	***Units***	***Projected Circulating Water Quality***	***Circulating Water limits***	***Reason***
pH	SU	7.2		
Cations				
Ca	mg/l as ion	196.0	400.0	Scaling
Mg	mg/l as ion	136.0	200.0	Scaling
Na	mg/l as ion	883.5		
K	mg/l as ion	32.1		
Metals	mg/l as ion	3.7		
Anions				
SO4	mg/l as ion	1538.8	2000.0	
Cl	mg/l as ion	884.8	1000.0	Metallurgy
PO4	mg/l as ion	0.0		
NO3	mg/l as ion	28.8	300.0	Bacterial nutrient
F	mg/l as ion	0.9		
SiO2	mg/l as ion	145.4	150.0	Scaling
HCO3	mg/l as ion	150.0	180.0	Alkaline regime
Total	mg/l as ion	4000.0	4000.0	

Several operational configurations were investigated: raw water softening, sidestream softening and blowdown treatment. Given the low Total Dissolved Solids (TDS) permit

for the cooling tower, and the low hardness of the water (averages of Ca: 55 mg/l as $CaCO_3$, Mg: 54 mg/l as $CaCO_3$), there was no possibility to increase cycles through makeup or sidestream softening. Accordingly, the blowdown (as a purge of TDS) from the tower (at a calculated flow of 557 gpm at the design condition 1A: full load, 98ºF ambient, ABS in operation) has to be treated, with return of the RO permeate to the tower. This reduces the raw water make up requirements by over 450 gpm under these conditions.

Design Differences

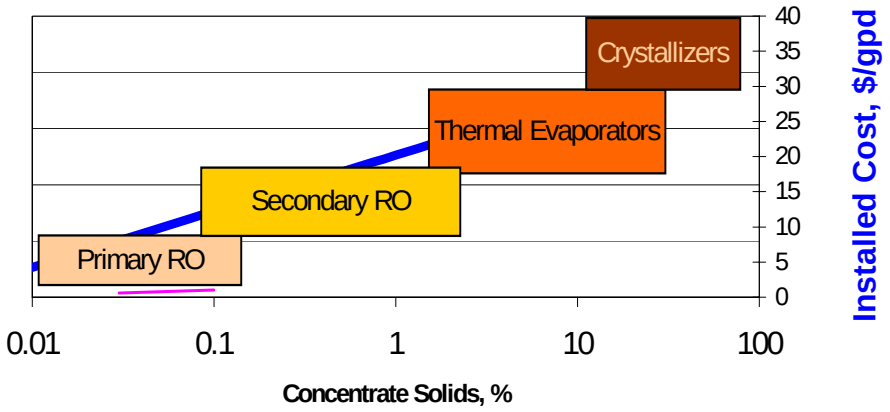
WPS:
The clarifier specified in the original Request for Quotation was superseded by Actiflo® high rate clarification. The Actiflo® process is a compact, conventional-type water clarification system that uses microsand as a seed for floc formation. The microsand provides surface area that enhances flocculation and acts as a ballast or weight. The resulting sand ballasted floc displays rapid settling characteristics, which allow clarifier designs with high overflow rates and short retention times. These designs result in system footprints that can be half the size of conventional clarification systems of similar capacity, yielding substantial savings in construction costs. Furthermore, Actiflo® technology has been piloted and approved by the State of California for drinking water pretreatment and wastewater effluent treatment for reuse, and is operating for this purpose in several locations in the State. Since the power plant and consumers would share water from the aquifer, such State approval for the WPS was a requirement. This reduces the amount of chemical addition to separate suspended solids and impact on the ZLD. In addition, less sludge will be produced so the cost for sludge disposal will be lower then with conventional clarification.

CTBDS and ZLDS:
The difference between the wastewater system specified and that ultimately selected is in the means of processing the circulating water blowdown, and the elimination of one stage of thermal treatment (evaporation). The costs of evaporation, both capital and operational, are well known, and significant operating and capital cost benefits are realized when the flow rate of any stream to be treated thermally can be minimized. Furthermore, since the subject plant is located in a high seismic zone area, the elimination of a tall, high center of gravity evaporator has clear advantages.

The modified CTBD recovery system configuration replaces the specified softener/clarifier/filter system functions and design redundancy into a single unit operation (microfiltration, MF). Experience with numerous cooling tower systems has demonstrated that the chemical dispersants and scale inhibitors used routinely in the conditioning of circulating water, together with the high TDS load typical of cooling tower blowdown can interfere with critical softening, coagulation, flocculation and settling processes in a conventional softener/clarifier, such that reliable control of downstream filtration processes is very difficult.

Such blowdown minimization invariably calls for a membrane process such as RO, which in turn requires removal of hardness, silica and other potential scaling compounds in order to enhance recovery and protect the downstream membranes . Figure 3 is a graphical representation of installed cost (relative, not actual values), for unit processes used in ZLD.

Figure 3: Increasing relative installed costs of unit processes used in ZLD relative to resulting concentration of solids



In the specified design, 600gpm of blowdown would be first treated in a cold lime softener through the addition of hydrated lime ($Ca(OH)_2$), soda ash (Na_2CO_3), magnesium chloride ($MgCl_2$) and any coagulants and flocculants as might be required. The softened water would be filtered through (3) 50% multimedia pressure filters after pH adjustment with sulfuric acid. After passing through 5µm cartridge filters, the water would enter the RO (550 gpm, 2x50% trains), to be designed at a recovery rate of 67%.

The concentrate from the RO would then be sent to the ZLDS, to be sized for at least 220 gpm. This system would be designed to produce a truck-transportable solid filter cake and a low TDS distillate.

Cooling Tower Blowdown System

The actual CTBD recovery system will include the following unit operations:

- (6) 20% capacity cooling tower blowdown microfilters
- (2) 50% capacity, Primary (Recovery) RO systems
- (1) 100% capacity, Secondary (Concentrator) RO system
- Solids dewatering equipment
- Chemical feed equipment.

The softening and solids separation processes have been found to be more consistent when both processes occur within the MF process. This is due to the fact that concentration of solids in contact with the water in a MF unit (3-5%v/v) is significantly higher than in a conventional unit, to a point where they are more likely “overwhelm” the effect of dispersants. Furthermore, because the MF has a nominal pore size of 0.1µm, well below the 0.45µm filter used in the standard Silt Density Index (SDI) test for RO, the

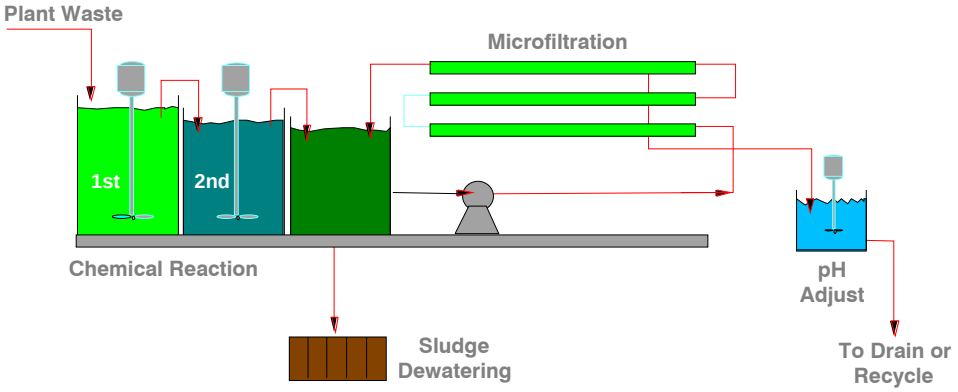
MF effectively ensures virtually particle free water going to the RO, with a SDI always <3.

Not only did the use of MF represent process advantages, but also benefits in reduced on-site construction work, since the MF units are delivered as prepiped and prewired skids, leading to accelerated installation and commissioning.

As with any new technology, or application of established technology in a new application (as is the case here), there were concerns about replacing the clarifier/media filter combination with a membrane process (1). However, the use of MF softening of waste streams containing scale inhibition chemicals was widespread, with a number of these installations being followed by RO. One of these (the General Motors Ramos Arizpe Complex in Mexico) has since won the prestigious Stockholm Industry Water Award. This facility uses softening MF/RO for recovery of brine from the main water supply RO, bringing the combined system's recovery of well water to 97% (2). On the basis of this and other installations, and the process and performance guarantees offered by the technology provider, and driven by the life cycle cost benefits, the decision was made to select MF/RO as the preconcentration technology for this project.

The lime softening filtration system consists of lime softening MF that perform the function of both the softener/clarifiers and the filtration system typically used for softening. A typical MF arrangement is shown in Fig. 2.

Figure 2: Typical Tubular Microfiltration Arrangement.



Hot side cooling water from the tower return line is delivered to a dual compartment reaction tank, where magnesium chloride is added to the feed water to the desired level necessary to co-precipitate silica. Soda ash and lime are added to precipitate calcium hardness as calcium carbonate and magnesium as magnesium hydroxide. A provision exists for optional feeding of ferric chloride to the reaction tank. The treated water slurry then flows by gravity to the MF feed tank.

Since the MF systems operate in a "crossflow" mode, slurry is constantly being pumped to the MF and returned to this feed tank. The slurry concentration in the tank increases as the filtrate leaves the process.

Normal frequency of microfilter cleaning is one to three times per month. During normal cleaning, which is automated, 2-5% w/v hydrochloric acid is recirculated from the cleaning tank through the membrane modules and back to the cleaning tank for 30 to 60 minutes. Since the MF membrane is made of chlorine-resistant PVDF,

cleaning with sodium hypochlorite (up to 10% v/v) is possible. After recirculation, the cleaning chemicals are neutralized and discharged to the final thermal step downstream.

Solids removed during softening are directed to a sludge storage tank, from where they are pumped to a single recessed chamber filter press, to produce a dewatered cake suitable for landfill disposal.

Permeate from the MF system is pH adjusted with hydrochloric acid to prevent post precipitation, and sent to the reverse osmosis system. A small amount (ca. 8gpm) of the permeate, prior to acidification, is used in lime and soda ash dilution.

The primary RO consists of (2) 50% trains, using Filmtec BW30-365 spiral wound TFC membranes arranged in 8:4 arrays. The reject from these units passes to the secondary RO, consisting of (1) 100% train using Filmtec SW30-380 membranes in a 4 vessel, single stage array. Given the low chlorine tolerance of TFC membranes, dechlorination is assured by the dosing of sodium bisulfite.

The overall recovery from the combined (primary and secondary) RO system is projected to be nearly 86%, compared to the 67% specified. This improved recovery more than halves the flow to the thermal process downstream.

Table 3 shows the fate of various constituents as they pass through the CTBDS. High quality distillate (approx 75 gpm), in excess of that used for HRSG make up demands (approx 42 gpm), is returned to the tower.

Table 3: The fate of various CTBD constituents through the MF/RO preconcentration process *(all concentrations expressed in mg/l as ion)*

Stream Species	***CT Blowdown***	***MF Permeate***	***Secondary RO Reject***
Flow (gpm)	557	555	78
Ca	196	40	282
Mg	136	4	26
SiO2	145	10	67
TDS	4,000	3,957	28,166

Zero Liquid Discharge System

The result of the revised preconcentration configuration was the elimination of he need for an evaporator, by producing a high enough concentration of reject that it becomes economically advantageous to go directly to a crystallizer.

The design flow of secondary RO reject to the crystallizer is 80 gpm, of which all but 2 gpm returns as distillate. This distillate is used as the source water for make up to the HRSGs using CDI-LX electrodeionization, which does not require any chemicals and produces no unrecoverable waste, important factors in a ZLD facility. The treated distillate will meet quality requirements given in the Table 4.

Table 4: HRSG make up water requirements

Parameter	***Units***	***Value***
Conductivity	µmhos/cm	0.1
Total Dissolved Solids	mg/l	0.05
Silica as SiO2	mg/l	0.005
Iron as Fe	mg/l	0.010
Sodium as Na	mg/l	0.0075
Sulfates as SO4	mg/l	0.0075
TOC	mg/l	0.2

The brine crystallizer is designed to concentrate the secondary RO reject to the point that a "dry" solid cake can be separated and collected for disposal. The process for crystallizing the brine consists of a forced circulation crystallizer, positive displacement blower and a centrifuge to separate the crystallized solids. The RO reject is blended with centrate and transferred to vapor body of the brine crystallizer. A recirculation pump circulates the concentrated slurry through the heater where it picks up heat from condensing steam on the shell side of the heater. The liquor entering the vapor body flash boils to release heat in the form of water vapors. As the water is driven from the system in the vapor phase the liquor concentration increases. When the concentration reaches the design value, a portion is removed by pumping to the centrifuge.

The vapor developed in the vapor body passes through a mesh type entrainment separator, and is then compressed by a lobe type positive displacement type blower. The compressed steam from the discharge of the blower is desuperheated and directed to the shell of the brine crystallizer heat exchanger to drive the evaporation in the crystallizer.

The distillate that condenses on the shellside of the heat exchanger is pumped by the brine crystallizer condensate pump to the brine concentrator feed preheater in order to further recover heat from the evaporation system. The heat exchanger shell is vented to the brine concentrator deaerator to prevent build-up of non-condensibles in the heater shell and to help drive the deaeration of the brine concentrator feed.

Summary

The ZLD system for the 750MW High Desert Power plant will comprise microfiltration softening and two stages of RO to concentrate the cooling tower blowdown from 557 gpm to 80 gpm. This high strength concentrate (with a TDS of ~2.8% w/v) will be sent directly to a mechanical vapor recompression Forced Circulation Crystallizer, to produce a truckable waste.

Permeate from the RO systems will be returned to the cooling tower, while high quality distillate will be used for HRSG make up needs. The overall recovery of the combined CTBD and ZLD systems is expected to be in excess of 98%.

Zero Liquid Discharge systems present significant engineering challenges. There are numerous process configurations that can be applied. The options must be evaluated carefully on the basis of initial capital and more importantly on operating costs.

On innovative projects such as High Desert Power, it is important that the Owner, Engineer and Technology Provider develop a relationship in which design alternatives

can be reviewed critically and openly. Constellation Energy Group, Bibb & Associates, and USFilter have formed such a partnership, and are working together on this project. It is hoped to present operating data at this forum following commercial operation.

Acknowledgements

The authors wish to thank Ms. Mai Hattar of Bibb & Associates and Mr. Tim Rittof of USFilter-HPD Products for their valuable input in the preparation of this paper.

References

(1) Toohil, J., Karrs, S. and Severing, K. “The Road to Zero Discharge”, Pollution Engineering, August 1999

(2) Krzesowski, Lawrence: “Recovery of Reverse Osmosis Brine at GM de Mexico Ramos Arizpe Complex”, IWC-97-23, International Water **1**, 2 (1997)

Attachment 1: Make-up water analyses for the High Desert Power Project

Constituents	***Units***	***Groundwater Quality***		***SWP Water Quality***		
		Range	*Average*	*Range*	*Average*	*Typical Max*
Total Dissolved Solids (TDS)	mg/l	116 – 314	165.0	73 – 593	297	
Specific Conductance	µmhos/cm	193 – 475	257.0	106 – 998	509	756
Calcium(Ca)	mg/l	1.6 – 32	10.0	10 – 35	22	23
Magnesium(Mg)	mg/l	0.1 – 7.7	2.0	2 – 22	13	16
Sodium(Na)	mg/l	29.8 – 81.9	46.0	8 – 159	59	100
Potassium(K)	mg/l	0.4 – 20.28	2.0	0.0 – 5.2	2.2	3.6
Carbonate(CO_3)	mg/l	0.0 – 48	8.0			
Bicarbonate(HCO_3)	mg/l	36 – 110	78.0			
Sulfate(SO_4)	mg/l	0.5 – 161	28.0	1 – 157	52	120
Chloride(Cl)	mg/l	2.7 – 54.4	15.0	2 – 151	75	98
Hardness(as $CaCO_3$)	mg/l	4 – 96	32.0	33 – 178	107	123
Alkalinity (as $CaCO_3$)	mg/l	40 – 140	78.0	38 – 109	74	78
Fluoride(F)	mg/l	0.1 – 1.50	0.5	0.1 – 1.1	0.1	0.1
Nitrate(as NO_3)	mg/l	0.3 – 23.9	5.9	0.0 – 6.8	2.9	2.9
Iron (Fe)	mg/l	0.01 – 0.11	0.1	0 – 0.01	0	0.32
Manganese(Mn)	mg/l	0.01 – 0.03	0.03	0 – 0.01	0	0.18
Aluminum(Al)	mg/l	0 – 0.100	0.046	0 – 0.101	0.022	0.1
Antimony(Sb)	mg/l	0.006 – 0.006	0.006			
Arsenic(As)	mg/l	0.002 – 0.014	0.005	0 – 0.010	0.003	0.01
Barium(Ba)	mg/l	0.013 – 0.500	0.112	0 – 0.086	0.042	0.086
Boron(B)	mg/l			0.1 – 0.650	0.214	0.65
pH (lab)	std units	7.62 - 9.4	8.5	6.9 – 8.8	8	8.50
Turbidity	NTU[d]	0.05 – 1.9	0.17	0 – 140	9	
Total Suspended Solids	Mg/L				25	200
Silica	Mg/L				15	17
TOC	mg/l			0-8.1	2.5	8.1

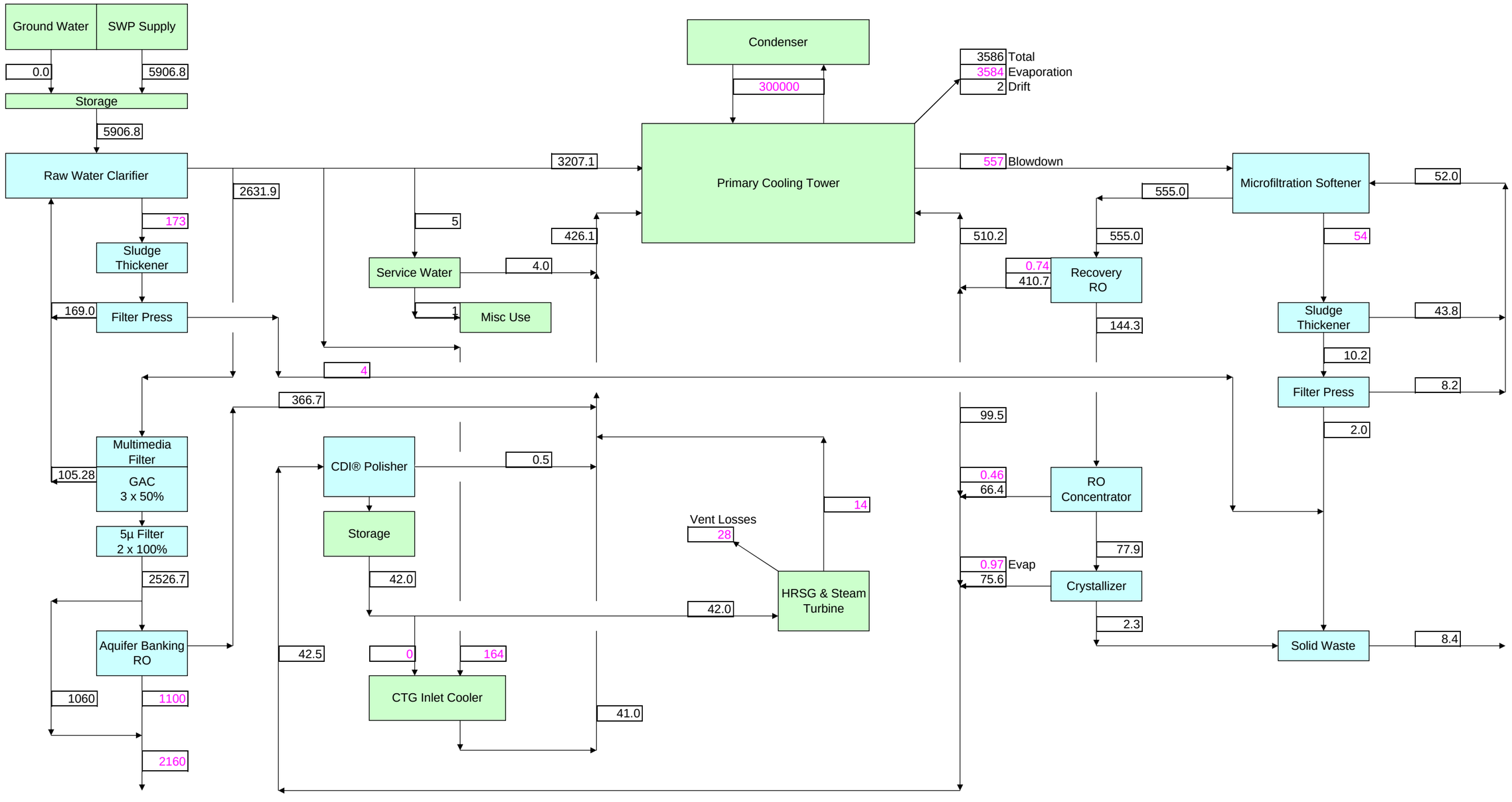
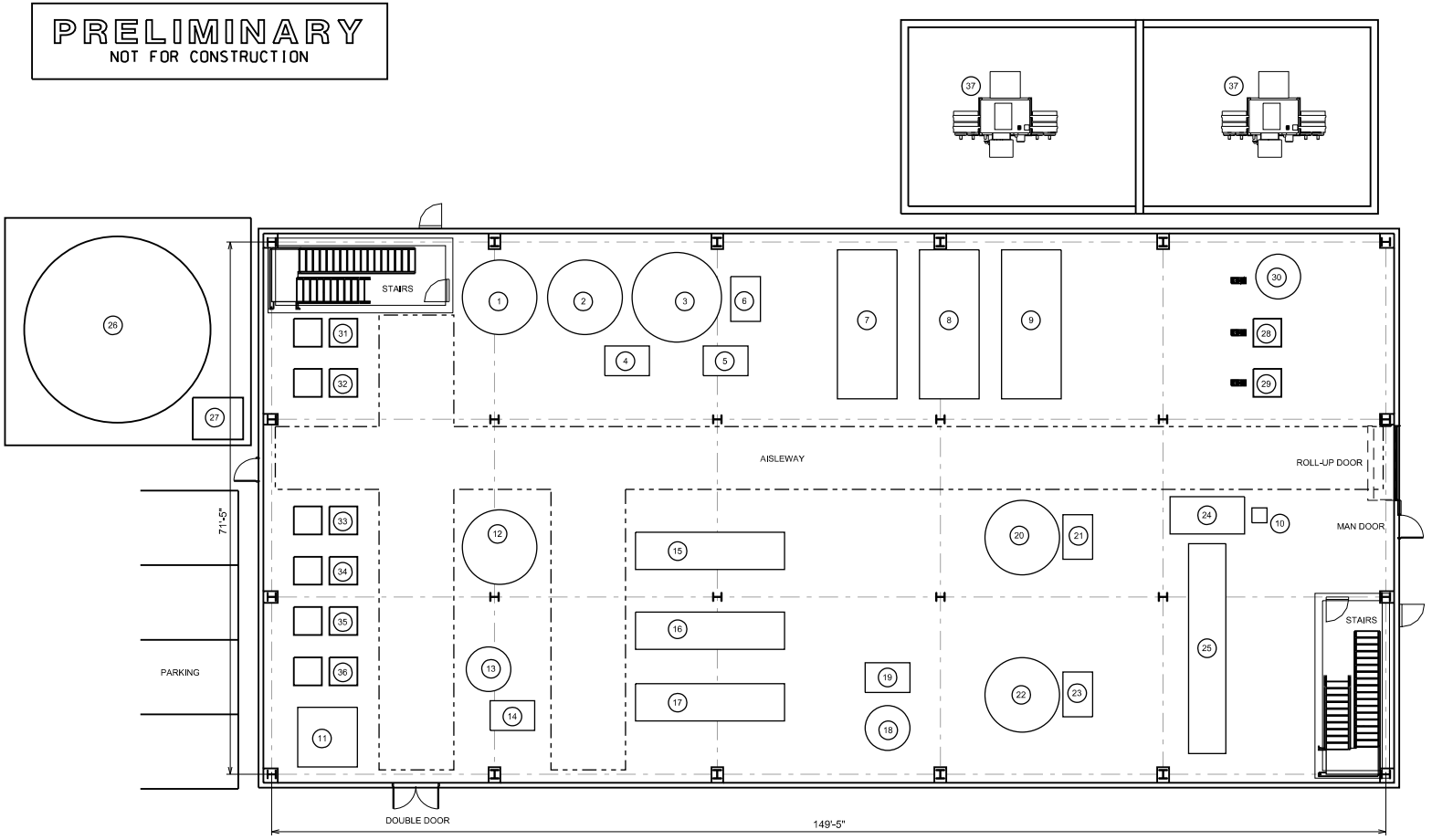


Figure 1: Projected Water Balance under Design Conditions with ABS in operation

APPENDIX B:

GENERAL ARRANGEMENT FOR WASTEWATER TREATMENT SYSTEM BUILDING

PRELIMINARY
NOT FOR CONSTRUCTION



GRADE FLOOR

ITEM	DESCRIPTION						
1	RXN TANK 1	11	BUILDING SUMP & PUMPS	21	PERMEATE TANK PUMP SKID	31	MF CAUSTIC TOTE & METERING SKID
2	RXN TANK 2	12	PH ADJUST TANK	22	THICKENER	32	MF HYPOCHLORITE TOTE & METERING SKID
3	CONC TANK	13	FEED TANK	23	SLUDGE PUMPS	33	MF FERRIC CHLORIDE TOTE & METERING SKID
4	RECYCLE PUMPS	14	FEED TANK PUMP SKID	24	CONTROL PANEL	34	MF MAGNESIUM OXIDE TOTE & METERING SKID
5	FEED PUMPS	15	RO SKID 1	25	FILTER PRESS	35	RO ACID TOTE & METERING SKID
6	WASTE PUMPS	16	RO SKID 2	26	WASTEWATER EQUALIZATION TANK	36	RO ANTISCALANT TOTE & METERING SKID
7	MF SKID 1	17	RO SKID 3	27	WASTEWATER PUMP SKID	37	13800-4160V TRANSFORMER
8	MF SKID 2	18	CIP TANK	28	BROMIDE TOTE & PUMP		
9	MF SKID 3	19	CIP PUMP SKID	29	ANTISCALANT TOTE & PUMP		
10	HMI STATION	20	PERMEATE TANK	30	BLEACH BULK TANK & PUMP		

0' 5' 10' 15'
GRAPHIC SCALE
DRAWING SCALE

REVISIONS						
NO.	DATE	DESCRIPTION	BY	CHK'D	OKD	APP'D
A	11/02/2021	WASTEWATER STUDY				

GENERAL ARRANGEMENT
WASTEWATER TREATMENT BUILDING

DRAWN BY: | DATE: 10/25/2021 | CHECKED: | OK'D: | APPROVED:

SCALE: 12" = 1'-0"
ACAD FILE:

ENCHANT ENERGY CORPORATION

DRAWING NO. MSK-WWT GA
SHEET NO. 1
REVISION NO. A

Appendix H. CFD Study

ENCHANT ENERGY LLC
CARBON CAPTURE FEED STUDY
SAN JUAN GENERATING STATION
UNITS 1 & 4

CFD FLOW STUDY

DRAFT

FOR COMMENT, REV A

January 14, 2022

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Sargent & Lundy

ATTACHMENTS

A. Enchant SJGS – Overall Mass Balances Rev. B

1. INTRODUCTION

1.1 BACKGROUND

Enchant Energy LLC (Enchant) and the City of Farmington, New Mexico (Farmington) are proposing to install and manage a carbon capture control system to remove carbon dioxide (CO_2) from San Juan Generating Station (SJGS) Unit 1 and Unit 4 flue gas (the "CO_2 Capture Project").

Enchant SJGS will be installing Mitsubishi Heavy Industry's (MHI) KM CDR™ carbon capture process to treat the entire flue gas from Units 1 and 4. MHI's technology is an amine-based CO_2 capture process which uses a proprietary solvent that will be designed to recover 95% of the CO_2 from the flue gas and compress the treated CO_2 to acceptable pipeline conditions.

SJGS currently has two operating coal-fired steam electric generating units (Units 1 & 4) and two recently retired units, Units 2 & 3. SJGS Unit 1 is a nominal 370 MW-gross (MWg) Foster Wheeler subcritical wall-fired boiler. SJGS Unit 4 is a nominal 544 MWg B&W subcritical opposed wall-fired boiler. Both units fire western bituminous coal supplied by the adjacent mine, San Juan Coal Company owned by Westmoreland Holdings, as their primary fuel and are currently equipped with state-of-the-art air pollution control systems including: selective non-catalytic reduction (SNCR) for nitrogen oxide (NOx) emissions control; pulse-jet fabric filter (PJFF) baghouses for particulate matter (PM) control; wet limestone flue gas desulfurization (WFGD) systems for sulfur dioxide (SO_2) emissions control; and activated carbon injection (ACI) for reducing mercury (Hg) emissions.

Sargent and Lundy (S&L) propose to tie into the Unit 1 & 4 existing WFGD exhaust ductwork prior to the stack to ensure the flue gas being routed to the CO_2 capture system is scrubbed of as many impurities as possible. Dampers are intended to be installed into the existing exhaust stack breaching duct to prevent flow to the stack while the Carbon Capture System (CCS) is in operation; however, additional review of this configuration will be completed during detailed design. Additionally, dampers will also be designed as part of the carbon capture trains to ensure equal flow split between the trains. Refer to the geometry indicated in Section 2 indicating Unit 1 & Unit 4 tie-in points.

1.2 PURPOSE

The purpose of this study is to confirm the preliminary ductwork design does not exceed the pressure drop expected at the MHI terminal point at their tie-in; this will ensure the induced draft fan employed by MHI is adequately sized to overcome the entire draft pressure loss. This study utilizes computational fluid dynamics (CFD) to estimated the pressure drop due to friction and flow separation to be used in preliminary sizing of the CCS induced draft fan and provides additional guidance for additional optimization that should be considered while performing the detailed design of the ductwork. Another purpose of this study is to understand the flue gas flow uniformity at the terminal point tie-in location just upstream of the MHI quencher vessels.

Note that these results are preliminary and flow correction devices have been added to mitigate turbulence and flow separation in certain areas which impacted the convergence of the model. While the vanes are expected to mitigate the majority of the flow separation issues, additional optimization is expected to be required during during detailed design. Furthermore, these model results will be shared with MHI to ensure the pressure drop and flue gas distribution expected is within the margin of their FEED system design.

2. DESIGN INPUTS

2.1 GEOMETRY

The flow model geometry imported into the Star-CCM+ software is based on the two Parasolid model files namely “CO2ductwork” and “CO2ductwork_12-7” dated October 7 and December 7, 2021, respectively.

The flue gas from the single Unit 1 tie-in is conveyed through a round duct where it merges with the flue gas from Unit 4; due to the larger size of the unit and use of multiple stack breachings, two tie-ins to Unit 4 ductwork are required. The combined flue gas then is routed through round duct to carbon capture island connection where it splits equally into each carbon capture train inlet; the model concludes at the quencher inlets terminal points with MHI.

The tie-in points for Unit 1 and Unit 4 along with outlets to the carbon capture trains 1 and 2 (CCS Inlet #1 and CCS Inlet #2) are shown in Figure 2-1. Note that additional duct length was modeled at the CCS inlet locations (discussed further in Section 5.1.3). The CFD model extends the duct an additional 500 ft, which is shown in the follow figure. The dimensions of the inlet and outlet connections may be found in Table 1.

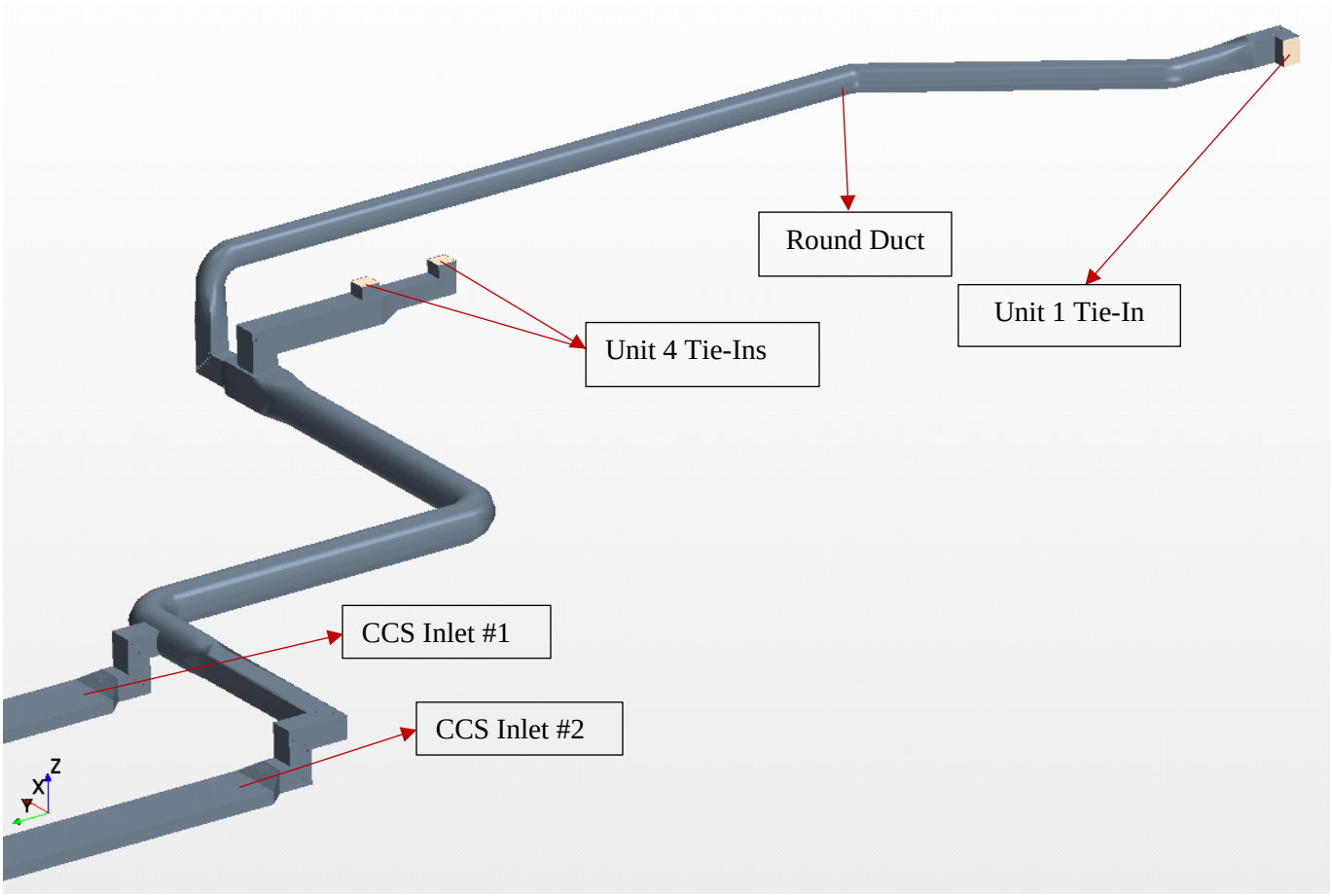


Figure 2-1: CFD Model Geometry

Table 1: Tie-In Inlets and Outlets to Carbon Capture Trains Description and Dimensions

Computational Fluid Dynamics (CFD) Model Boundary	Description	Number and Dimensions	Boundary Type
Inlet	Unit 1 Tie-In	One (1) 15 ft. (W) x 22 ft. (H)	Mass Flow Inlet
Inlet	Unit 4 Tie-Ins	Two (2) 16 ft. (W) x 16 ft. (H)	Mass Flow Inlet
Outlet	CCS Inlet #1	One (1) 51 ft. (W) x 10 ft, – 6 in. (H)	Pressure Outlet with Mass Flow Target (half of total Inlet flow)
Outlet	CCS Inlet #2	One (1) 51 ft. (W) x 10 ft, – 6 in. (H)	Pressure Outlet

2.2 SJGS FLUE GAS CHARACTERISTICS

The following SJGS Unit 1 & 4 flue gas characteristics were taken from the file "Enchant SJGS – Overall Mass Balances Rev. B.pdf" prepared by S&L on December 3, 2021, included in Attachment A. The values reported are the flow rates and conditions from each unit at the ductwork tie in location downstream of the WFGDs.

Table 2: SJGS Unit 1 & 4 Flue Gas Characteristics

Parameter	Unit of Measure	Unit 1	Unit 4
Pressure	psia	11.968	11.968
Temperature	°F	127	127
Molecular Weight	lb/lbmol	28.1	28.1
Density:	lbs/ft^3	0.053	0.053
Mass Flow	lb/s	1,388.930	2,071.651*
* Note that Unit 4 contain two inlets, therefore mass flow was equally split between two inlets i.e. each inlet mass flow equal 1,035.825 lb/s			

The boundary conditions resulting from the flue gas conditions and ductwork geometry may be found in Section 0.

2.3 COMPUTATIONAL FLUID DYNAMICS ANALYSIS PARAMETERS

The simulation software used in this study is Siemens' Star-CCM+.

The software version used is 12.02.010 for Windows 64.

The simulation is run on the STARCCM-EAS07 server.

The Star-CCM+ software discretizes the fluid volume, the interior volume of the ductwork, into over 1 million hexahedral cells. For each cell in the flow model, the fluid dynamics model solves the K-Epsilon Turbulence Model partial differential equations simultaneously with the Reynolds-Averaged Navier-Stokes equations in order to complete the mass and energy balance for the cell. This system of equations is solved simultaneously and iteratively for each cell in the flow model until the energy and mass balance for the whole system is converged.

3. DESIGN TARGETS

Prior to the development of the flue gas ductwork design, a rough calculation was performed to estimate the approximate flue gas pressure drop between the WFGD outlet tie-in location and the MHI inlet location. Based on this estimate, the flue gas design basis prepared by S&L assumed a 5 inW.C. pressure drop, resulting in a gage pressure of approximately -6 inW.C. at the MHI system inlet. MHI utilized this information to develop the fan sizing. As such, the design target of this CFD flow study was to ensure the total pressure drop of the modeled ductwork is ≤ 5 inW.C, but ultimately -6 inW.C. at the terminal point is the true target.

Another design target for this study is to understand the flow profile of the flue gas at the inlet to MHI's quenchers. S&L requested a design target, for example in a root mean square (%RMS) value, that MHI would require at the quencher inlet; however, no design target was provided. As such, this report only provides information of what the distribution may be if there is no additional back pressure from the CO_2 system.

4. ASSUMPTIONS

The flue gas through the ductwork is modelled as constant density fluids.

The density of the flue gas from SJGS Unit 1 and SJGS Unit 4 (0.053 lbs/ft^3) was estimated based on the mass flow rate (lb/hr) and volumetric flow rate (acfm), hence the density of mix flue gas transported to carbon capture trains 1 and 2 was also estimated to be same.

The velocity profile at each model inlet is assumed to be uniform.

The effects of gravity and buoyancy are considered negligible and are not modelled.

5. CALCULATIONS

5.1 MODEL BOUNDARY CONDITIONS

CFD modeling requires a definition at each boundary set. While information is known on both the velocity and mass flow rate at the inlet, only one criterion can be used as the boundary inlet conditions. For this study, mass flow was used as the definition, which is an independent variable of boundary condition dimensions.

Similarly, for the exit of the model, ideally we would like to converge the model based on seeking a specific flow split (i.e. 50/50) at the outlets and based on a constant pressure (i.e. equal between both ducts). To obtain the best results, a pressure outlet was used with a mass flow target.

5.1.1 Mass Flow Inlet Calculation

Unit 1 Inlet: 1

Mass flow rate: 5,000,147 lb/hr
Mass flow rate: 5,000,147 [lb/hr] / 3600 [sec/hr] = 1,388.930 lb/s

Unit 4 Inlet: 2

Mass flow rate: 7,457,942 lb/hr
Mass flow rate: 7,457,942 [lb/hr] / 3600 [sec/hr] / 2 = 1,035.825 lb/s

5.1.2 Pressure Outlet w/ Mass Flow Target

A pressure outlet was used as the boundary condition for the model outlet. For CCS Inlet #1, a flow split target was also defined for half of the entire model flow. By defining the flow split, this allows the pressure of one of the CCS inlets to fluctuate to allow for balanced flow. The expected mass flow in each outlet is anticipated to be 1730.29 lb/s, per the following basis:

Mass flow split to CCS Inlet #1: (5,000,147 [lb/hr] + 7,457,942 [lb/hr]) / 3600 [sec/hr] / 2 = 1730.290

5.1.3 Pressure Drop Calculation

To determine pressure drop, given the mass flow inlet and pressure outlet specified for model outlets, the CFD model calculates the pressure required to drive the flow through the model geometry and to overcome any less than ideal flow conditions, such as flow separation and recirculation. The inlet to the carbon capture trains (model outlet) is also extruded to mitigate boundary effects on pressure measurement and

to ensure recirculation of flow at the boundary plane is eliminated as part of the calculation. This extrusion is straight in nature and not expected to influence the results by adding any meaningful pressure drop. Overall, this additional length is estimated to add 0.1 inW.C. pressure drop. This additional pressure drop is removed from the overall pressure drops referenced in Section 6.2.

To manage the flow split between the two CCS inlets, the pressure at the model outlet at the CCS Inlet #1 is allowed to change to ensure that half of the mass flow goes to CCS #1. The CFD model boundary condition downstream of the CCS Inlet #2 is set to 0.0 inW.C. The estimated pressure at the actual quencher inlet location is approximately 0.1 inW.C.

The results of this calculation may be seen in Section 6.

5.1.4 Other Physics Inputs

Unit 1 Inlet

Mass flow rate: 5,000,147 lb/hr
Volumetric flow rate: 1,560,326 acfm
Density: (5,000,147 [lb/hr] / 60 [hr/min]) / 1,560,326 [acfm] = 0.053 lb/ft^3

Unit 4 Inlet

Mass flow rate: 7,457,942 lb/hr
Volumetric flow rate: 2,325,015 acfm
Denisty: (7,457,942 [lb/hr] / 60 [hr/min]) / 2,325,015 acfm = 0.053 lb/ft^3

5.2 COMPUTATIONAL FLUID DYNAMICS MODEL

The actual CFD model was prepared in accordance with S&L standards using the flows calculated above, the design inputs, and the assumptions listed in Sections 2 and 3, respectively.

6. RESULTS

6.1 CCS TIE-IN DUCT

Sargent and Lundy prepared one model simulating normal CCS operation at full load. Figure 5-1 shows the entire tie-in duct with a pressure profile of the duct centerline.

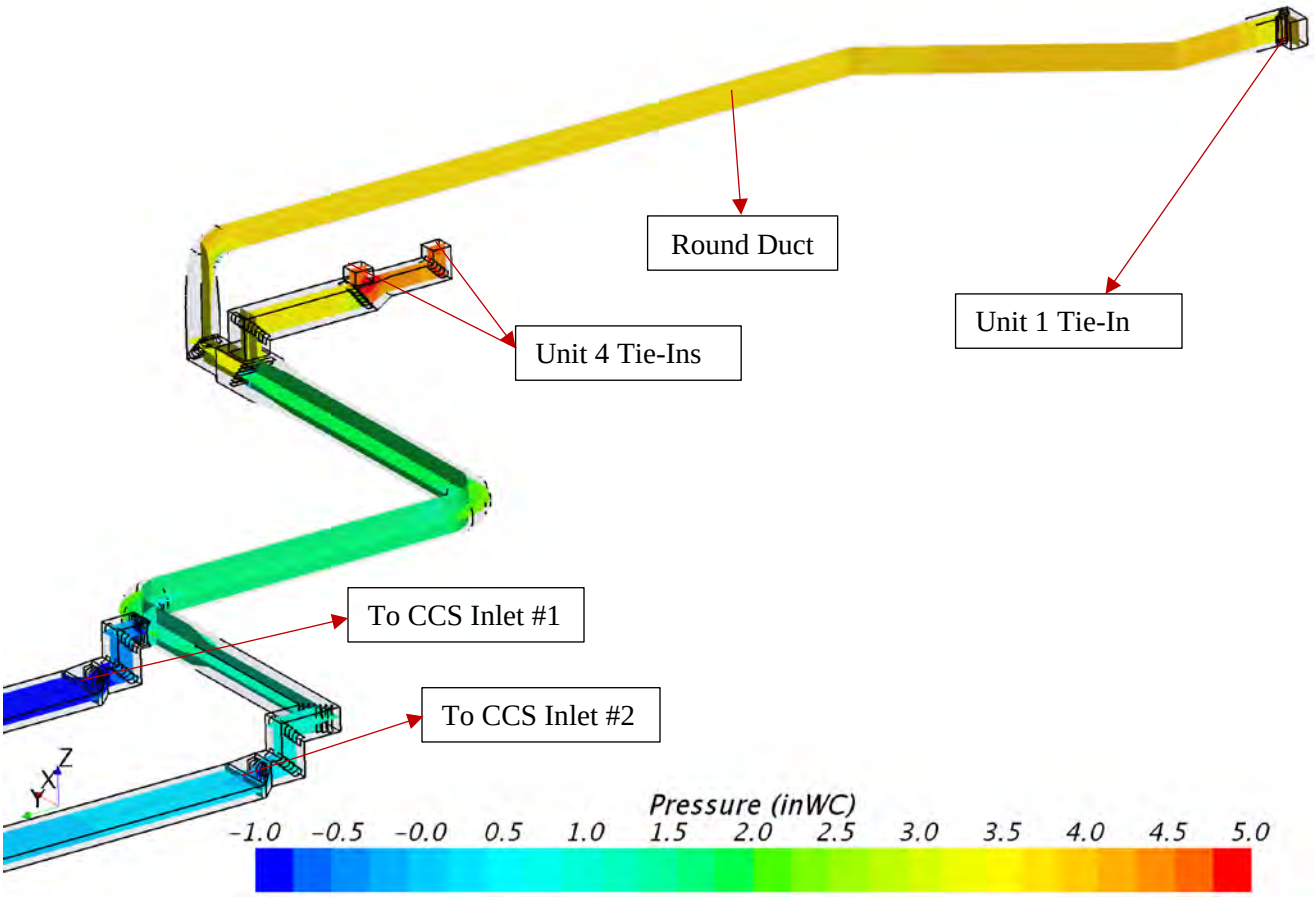


Figure 5-1 Overall Duct Configuration with Pressure Profile

The total pressure drop across the duct from CCS inlets to the Unit 1 and Unit 4 tie-in connections ranges from 4.5 to 5.6 inWC, with the more tortuous path (i.e. higher pressure drop) being to the nearer CCS Inlet #1. Note that while the Unit 1 ductwork is further away, the Unit 4 tie-in ductwork header has a more tortuous path, making that the defining criteria for the total overall pressure drop of the system. Due to the differences in pressure drop to each CCS inlet, the model indicates additional pressure drop or suction pressure is needed to balance the flow to each CCS inlet, based on the additional pressure drop in the

duct path for the first train. In practice, this means the CCS Inlet #2 damper will have to be partially closed compared to CCS Inlet #1 to both meet the same overall pressure drop and balance the flow. Similarly, additional pressure drop may be required on the Unit 1 ductwork leg in the form of a tie-in damper to not allow the CCS fans to pull too much suction from that location.

6.1.1 CCS Quencher Inlet Velocity Profiles

The velocity profiles for the CCS inlets are shown below. These profiles are based on guillotine dampers, not double louver dampers, in each branch upstream of the CCS absorbers. Note that turning vanes have been added to improve flow distribution. These may be further optimized during detailed design.

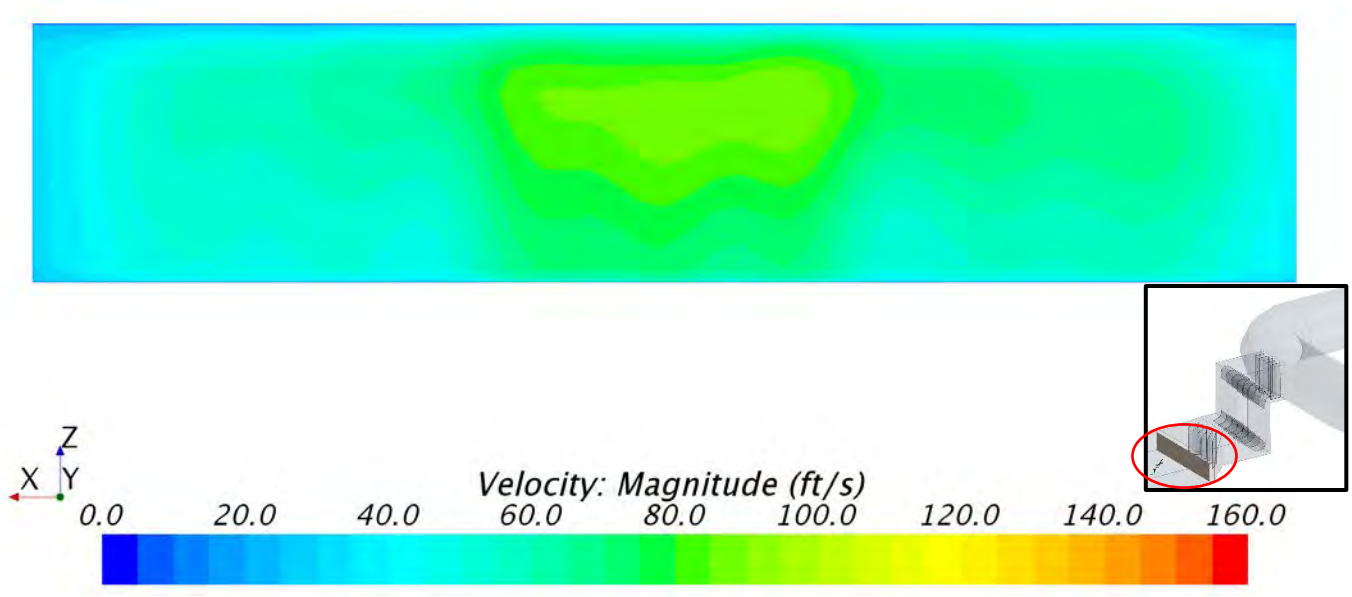


Figure 5-2: CCS Inlet #1 Velocity Profile

The mean of the magnitude of the velocity across the CCS Inlet #1 is 55.3 ft/s with a root mean squared (RMS) of the deviation of 32.8% of the mean.

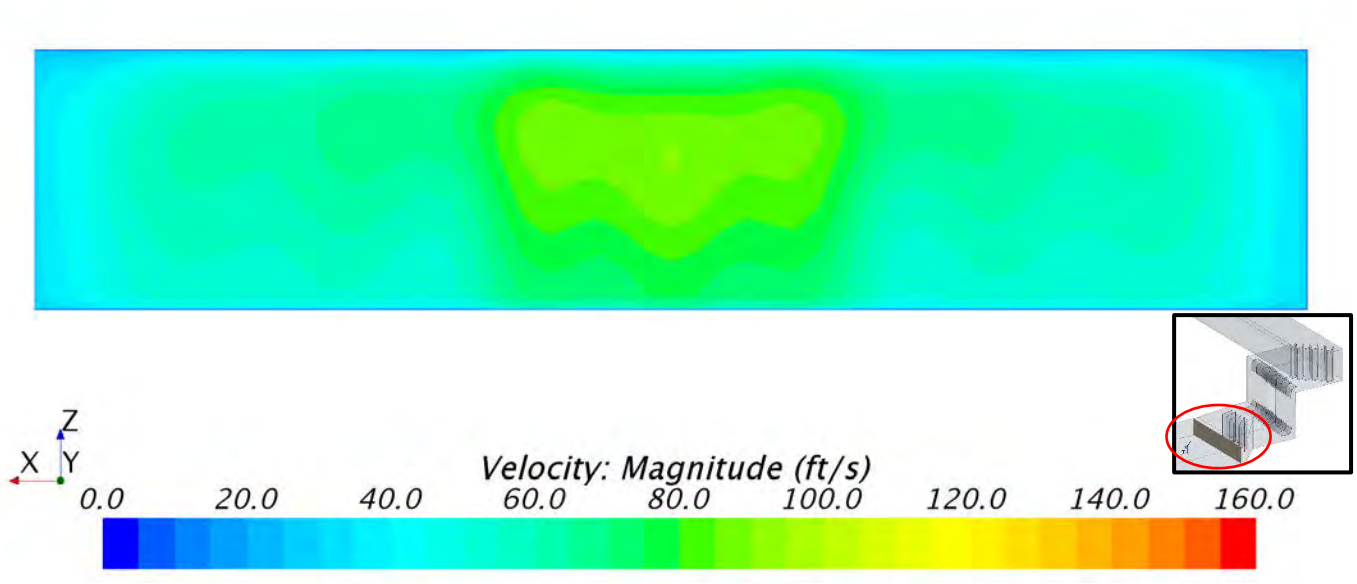


Figure 5-3: CCS Inlet #2 Velocity Profile

The velocity profile is very similar to CCS Inlet #1. The mean of the magnitude of the velocity across the CCS Inlet #2 is 55.2 ft/s with a root mean squared (RMS) of the deviation of 33.2% of the mean.

6.2 SUMMARY OF RESULTS

Table 3: Summary of Results

Section	CCS Inlet #1	CCS Inlet #2
	inW.C	inW.C
Pressure Drop (From Unit 4 Tie-Ins to Train Inlet)	5.6	4.5
Velocity, Min – Max, ft/s	13 – 90	13 – 90
Flow Uniformity, %RMS	32.8	33.2
Mass Flow Outlet – lb/s	1729.65	1729.65

As shown in Table 3, the total pressure drop from the unit tie-in locations to the CCS quencher inlets is expected to be up to 5.6 inW.C. This pressure drop is higher than expected based on initial design basis inputs; however, a tie-in pressure of > -6 inW.C. is still expected at the MHI terminal point due to a conservative estimate of -1 inW.C. at the WFGD outlet. In addition, optimization of the flow control devices during detailed design will reduce pressure drop to the CCS island under normal operating conditions further.

7. RECOMMENDATIONS

This preliminary CFD study indicates that there is significant pressure drop from the WFGD outlets to the CCS quencher inlets. The most significant contributors to this pressure drop are the non-ideal flow in the Unit 4 tie-in ductwork and CCS Inlet #1 plenum. This pressure drop may be mitigated by optimization or additional flow control devices in the ductwork. Other options that may benefit the flow separation and overall pressure drop is by adding an internal flow divider plate at the Unit 1 and Unit 4 header merge point as well as at the turn before the CCS Inlet #1 plenum to separate the flow while it is uniform.

Overall, with the 5% margin in MHI's blower design and the additional conservatism in S&L's WFGD tie-in pressure, it is expected that even without further optimization, that the system would be able to successfully operate at a pressure drop of 5.6 inW.C.

Attachment A:

Enchant SJGS – Overall Mass Balances

(Refer to Mass Balances in Appendix C of BOP Summary Report)

Appendix I. Control System Study

Enchant Energy
CO_2 Capture Project

CONTROL SYSTEM STUDY

San Juan Generating Station

Units 1 & 4

Prepared By:
Sargent & Lundy LLC
55 East Monroe Street
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Project No. 13891-010
November 04, 2021
Revision 0-For Information

ISSUE SUMMARY

REVISION & PURPOSE	DATE	PREPARED	REVIEWED	APPROVED
A Client Comments	August 25, 2021	Signature On File R. Ventura Instrumentation and Controls	Signature On File S. McCarthy Instrumentation and Controls	Signature On File S. Wylie Project Manager
0 For Information	November 04, 2021	 R. Ventura Instrumentation and Controls	 S. McCarthy Instrumentation and Controls	 S. McCarthy Instrumentation and Controls

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1. INTRODUCTION

1.1. Purpose

1.1.1. The New Mexico Energy Transition Act (recently passed legislation) requires the environmental improvement board, or local board, to adopt regulations limiting carbon dioxide (CO_2) emissions from coal-fired electric generating facilities with an originally installed capacity exceeding 300 MW to no more than 1,100 pounds CO_2 per megawatt-hour (lbs/MWh) by January 1, 2023. To comply with this regulation, the installation of Carbon Capture Utilization and Sequestration (CCUS) technology is required on existing coal-fired generating facility, San Juan Generating Station (SJGS) Units 1 and 4.

1.1.2. The CCUS system is planned to commence construction in mid-2022.

1.1.3. The purpose of this study is to provide a summary of the existing Distributed Control System (DCS) configuration, and to present a summary of recommendations for the implementation of a Control Room that will include the new CCUS system. The study is based on previous experience at SJGS, interviews with SJGS individuals, as well as industry experience with DCS Control Room design, layout, and implementation.

1.1.4. This document will be revised and updated periodically as additional information becomes available.

1.2. Project Background

1.2.1. Enchant Energy LLC has entered into an Agency Agreement with Farmington to develop and manage the CCUS system retrofit process. Enchant intends to acquire ownership of SJGS with the exception of Farmington's current plant ownership interest on June 30, 2022 through the assignment by Farmington to Enchant of Farmington's acquisition rights under the Amended San Juan Participation Agreement (ASJPA).

1.2.2. Enchant has engaged with Mitsubishi Heavy Industries (MHI) for the design of the CCUS system.

1.2.3. Enchant has engaged with Kiewit for the construction of the CCUS system and balance of plant (BOP) system.

1.2.4. Sargent & Lundy will provide detailed engineering for the BOP systems and overall integration to the existing site.

1.3. Carbon Capture System

1.3.1. The CCUS system for SJGS Units 1 and 4 will reduce carbon emissions from the flue gas by absorbing CO_2 via amine-based solvent. The amine-based CCUS system consists of a quencher (or pre-scrubber), an absorber, and a stripper (or regenerator). Compression and dehydration are also included to produce CO_2 at pipeline requirements.

1.3.2. The following BOP equipment/systems are required to support the operation of the CCUS system:

a. Main Steam

b. Low Pressure Steam

c. Condensate System

d. Circulating Cooling Water System

e. Demineralized Water System

f. Potable Water System

g. Equipment Drains System

h. Wastewater System

i. Fire Protection System

j. Instrument Air System

k. Carbon Dioxide System

l. Condensate Attemperation Water System

m. Service Water System

n. Chemical Feed System

o. Flue Gas System

p. Auxiliary Power System (high voltage)

1.3.3. The CCUS system island will be located north of the existing Units 1 and 4. Flue gas from the Units downstream of the WFGD systems will be combined in a common ductwork path and routed to the CCUS system island.

1.4. Plant Background

1.4.1. SJGS originally consisted of 2 pairs of similar units (4 units total). All 4 units utilize/utilized a Foxboro I/A DCS for the majority of their controls. Some individual systems and equipment utilize/utilized Allen Bradley (Rockwell Automation) Programmable Logic Controllers (PLCs), which are networked together separately from the DCS.

1.4.2. Units 2 and 3 were decommissioned in 2017, leaving previously used equipment and components available for possible repurposing.

2. EXISTING CONTROL SYSTEM

This section may be revised and updated periodically as additional information regarding the existing control system becomes available.

2.1. Existing Control Systems

2.1.1. Each unit's existing DCS is composed of microprocessor-based Foxboro I/A DCS, distributed control and remote I/O (RIO) cabinets, analog instruments, digital discrete sensors, redundant network links, and control devices. The existing DCS performs the functions of modulating and discrete control, equipment protection and process interlocking, component diagnostic, unit/process upset analysis and maintenance guidance, and data archiving of the entire system, meeting all operational conditions, assuring a safe, environmentally compliant, and economic operation of the plant.

2.1.2. Although the Foxboro DCS controls most of the plant systems, there are a few systems that are controlled via an Allen Bradley PLC network, such as: Continuous Emissions Monitoring Systems (CEMS), lake station, FGD baghouses (baghouses only), bottom ash systems, water treatment systems, etc.

2.1.3. After decommissioning Units 2 and 3, the Unit 1 main control room Operations was relocated to the existing Unit 4 Control Room. The relocated equipment includes the Unit 1 DCS operator workstations, the Allen Bradley PLC network workstations, and the emergency stop/trip pushbuttons panel. Each Unit operates on a separate mesh network for operations controls.

2.1.4. The existing DCS was last updated early in 2017. The current version is IA Series 8.9/9.0.

2.1.5. Plant personnel indicated that a few years ago they received a quotation from Emerson to upgrade the existing DCS from Foxboro to Emerson Ovation. Although the Plant felt that other DCS vendors (such as Emerson or ABB) may have better systems and support, ultimately the differences in operator interface between the two systems were not significant enough to justify the cost of the upgrade.

2.1.6. There are approximately 18 Foxboro DCS HP ThinClients that support quad screen layout: 6-8 at the Unit 1 side, 6-8 at the Unit 4 Side, and 2 common system thin clients.

a. Each ThinClient remotes into a Foxboro Application Workstation (AW) that provides the controls.

b. Most of the common coal controls were moved to Allen-Bradley PLC controls and only send equipment status indication to the DCS.

c. The thin clients support remote desktop to the AWs, and use a custom program developed to ensure that if one connection goes down, another starts up automatically on an adjacent AW.

d. All AWs are virtualized and run Windows 2008 R2 or higher.

e. All thin clients run Windows 10 IOT Enterprise.

2.1.7. There is a large screen HMI for the PLC network for each Unit 1 and Unit 4. This allows the Operator to monitor the systems that are being controlled via PLCs.

2.1.8. There is an existing DCS Simulator located behind the Units 3 and 4 Control Room. The simulator is a representation of Unit 1 and Unit 4 and the older ash/coal handling. It is a relatively open concept with 3 wings in a U-shape configuration, and it is disconnected from the rest of the system. The simulator has not been maintained or used for several years.

2.2. Existing Control Network

2.2.1. For the DCS, there are currently 3 mesh networks at SJGS:

a. One mesh network for Unit 1

b. One mesh network for Unit 4

c. One mesh network for the common systems

2.2.2. There are multiple switches and redundant fiber optic networks to support the DCSs. Controllers and I/O cabinets are distributed throughout the existing plant.

2.2.3. For the PLC systems, there are multiple switches, routers, and fiber optic cable connections to network the PLCs together and allow Operations to interface with multiple independent systems together. The PLCs are distributed throughout the existing plant.

2.3. Existing Network Security

2.3.1. For increased security, the Unit 1 DCS control network is isolated from the Unit 4 DCS control network. This was previously done to follow NERC CIP guidelines for segmentation of generation for NERC CIP v5 and allowed the plant to transition from a critical v3 facility to a v5 low impact facility when there were four base-load units.

a. There is a common firewall at the root where all networks bridge.

b. Both Unit 1 and Unit 4 have a network router on the DCS side.

c. Although the current segmentation of the DCS network is conservative from a cyber security perspective, it is no longer a requirement due to the current total generation of the site because of the previous retirement of Unit 2 and Unit 3.

2.3.2. There is a common control network, known as the 50-network, that connects many Allen-Bradley, Emission Controls, and other common non-critical networks. This network has several additional servers.

a. The 50-network also has switches, routers, and other PLCs, as well as Blackbox, Enterasys, and other switch vendors.

2.3.3. The existing security camera network consists of a single camera server with a network all over the facility bridged together to ensure isolation from corporate systems.

3. CONCEPTUAL DESIGN

3.1. Control System Design

3.1.1. The addition of the CCUS system and its auxiliaries at SJGS will require modification and expansion of the existing station control systems.

a. Plant personnel expressed interest in utilizing Rockwell Automation's Allen Bradley ControlLogix PLC platform to control the new CCUS system, during a meeting on site June 29, 2021.

b. S&L inquired whether the new CCUS system could be supplied with Allen Bradley PLC control system, however, MHI indicated that they have not implemented their system utilizing PLCs for control and therefore do not feel comfortable doing so.

c. MHI's controls are implemented using DCS systems. MHI's DCS experience includes Emerson, Honeywell, Yokogawa, ABB, as well as other brands. During early phases of this project, MHI indicated that they can provide Foxboro I/A series DCS for the SJGS CCUS system controls.

3.1.2. The CCUS system will be controlled through a Foxboro I/A system DCS compatible with the existing station DCS. Procurement of the CCUS DCS will be by MHI.

a. Signal interface between the new CCUS DCS and the existing plant DCS and new CCUS BOP DCS drop will be via hardwired connections only. The new CCUS DCS (by MHI) will not have network connections to either the existing plant DCS nor the new CCUS BOP DCS drop.

3.1.3. The new CCUS BOP DCS will be an extension of the existing plant's Foxboro DCS. A new redundant controller drop will be added to the common mesh network for the CCUS BOP control interface. New signals and logic revisions will also be required to the existing Unit 1 and Unit 4 DCSs.

a. Utilizing a Foxboro DCS for both the new CCUS DCS and new CCUS BOP DCS drop will optimize operator training and will maintain hardware and software consistency between the existing DCS and the new DCS additions.

3.1.4. New control cabinets and control processors for the CCUS will be installed where required, primarily in MHI-supplied buildings and electrical rooms.

3.1.5. New control cabinets and control processors for the CCUS BOP will be installed where required and integrated into the existing DCS network.

a. Existing DCS and PLC control cabinets, RIO cabinets, and I/O cabinets will not be replaced.

b. Depending on existing DCS spare I/O availability and equipment location, a limited number of new I/O may be added to existing cards.

3.1.6. Tentatively, the following control system components will be included to support the addition of the CCUS:

a. CCUS DCS system controller, networking, and I/O cabinets located in the MHI CCUS system Electrical PDC Buildings (one PDC per train of CCUS equipment for a total of 2 PDCs).

b. CCUS system DCS RIO cabinet drop(s) for hardwiring CCUS system field equipment and instrumentation. CCUS DCS RIO cabinet(s) will be networked to the CCUS DCS via fiber optic.

c. Precoat PLC control cabinet located in the new CCUS Train 2 PDC Building.

d. Precoat Local Control Station (LCS) for hardwiring Precoat field equipment and instrumentation. This LCS will be hardwired to the Precoat PLC control cabinet located in the new CCUS Train 2 PDC Building.

e. CO_2 Compressors PLC control cabinets located in the new CCUS PDC Buildings (one per CCUS train).

f. CO_2 Compressors PLC RIO cabinets for hardwiring CO_2 Compressors field equipment and instrumentation. These RIO cabinets will be networked via fiber optic cables to the CO_2 Compressors PLC control cabinets located in each of the new CCUS PDC Buildings (signal interface media to be finalized during detailed design depending on final location of cabinets).

g. Generating Station BOP controller, networking, and I/O cabinets located in the new Control Building and/or existing station.

h. CCUS BOP DCS RIO cabinet(s) (if necessary, to be determined during detailed design) for hardwiring CCUS BOP field equipment and instrumentation. This cabinet(s) will be networked to the CCUS BOP DCS via fiber optic.

3.1.7. It is recommended that new packaged equipment procured with vendor's standard microprocessor-based control systems be, at a minimum, hardwire interfaced with either the CCUS DCS for supervisory control and monitoring. A datalink for status information only is recommended.

3.1.8. The new additions (CCUS BOP DCS) and the modified existing control systems will be designed to be in compliance with the requirements of NERC/CIP low impact facility.

3.2. Control Room

3.2.1. A new Control Building will be designed and built near the Carbon Capture Island. This new Control Building will include a new Control Room that will provide a single location for primary plant controls and monitoring.

a. The existing generating station operations for Unit 1 and Unit 4 will be relocated to the new Control Room.

b. The new controls for the CCUS and the CCUS BOP will also be housed in the new Control Room.

c. Having Unit 1, Unit 4, CCUS, and CCUS BOP operations in one focused location will better facilitate communication between Control Room operators and systems.

d. Any issues with either unit or system will be easier to communicate between controls and can be addressed more efficiently by operators within the same location. For example, start-up, shutdown, and load changes can be more easily communicated and planned.

3.2.2. The new Control Building will also include an Electronics Room adjacent to the new Control Room. The new Electronics Room will house new network, server, and DCS cabinets for the CCUS BOP DCS and possibly a limited number of CCUS DCS cabinet(s).

3.2.3. The following control system components will be included in the new Control Room:

a. Existing Unit 1 and Unit 4 Auxiliary Consoles will be relocated from the existing Control Room (for emergency stop pushbuttons, dedicated displays, etc.)

b. Existing Unit 1 and Unit 4 Operator Workstations (OWSs), relocated from the existing Control Room (new screens and thin clients will replace all the existing ones).

c. Existing FGD, Limestone, and water treatment OWSs, relocated from the existing Control Room

d. Existing PLC network OWS, relocated from the existing Control Room

e. Existing LAN computers for Unit 1 and Unit 4, relocated from the existing Control Room

f. New CCUS system Auxiliary Console

g. New CCUS DCS Quad-Screen OWSs (one OWS per CCUS train)

h. New CCUS CEMS DAHS workstation

i. New Unit 1 and Unit 4 Engineering Workstations (EWSs, to be located in the new Electronics Room)

j. New CO_2 Compressor Quad-Screen PLC OWSs (one OWS per CCUS train)

k. New CCUS BOP DCS Quad-Screen OWS

l. New Station DCS network root switches (to be located in the new Electronics Room)

m. Existing Unit 1 and Unit 4 CEMS DAHS workstations

n. New office printers

3.2.4. The following existing control system components will remain in the existing Generating Station Control Room and Electrical Room:

a. Units 1 and 4 existing EWSs (new EWSs will be added at the new Control Building)

b. Unit 1 DCS control cabinets

c. Unit 4 DCS control cabinets

d. DCS network servers and switches

e. FGD/Limestone PLC control cabinet

f. WWT PLC control cabinet

g. DCS and PLC network fiber optic patch panels and media converters

h. Office printers for Unit 1 and Unit 4

3.2.5. The following new control system components will be included at each of the new CCUS PDC Buildings unless noted otherwise:

a. CCUS EWS

b. CO_2 Compressor EWS

c. Office printer

d. CCUS Network Cabinet

e. CCUS DCS control and I/O cabinets

f. Vibration Monitoring System (VMS) cabinet and maintenance laptop computer

g. CO_2 Compressor PLC and Electrical cabinets

h. Precoat PLC control cabinet (one cabinet located at CCUS Train 2 PDC Building only)

i. Electrical Cabinet

3.2.6. The existing DCS simulator located behind Units 3 and 4 control room will not be moved to the new Control Building.

a. Plant personnel indicated that the simulator has not been actively used and that it has not been recently updated.

3.3. Control System Interface

3.3.1. The existing control network distribution throughout the plant, utilizing network cabinets, distributed controllers, remote I/O (RIO) cabinets, and fiber optic cabling, will simplify the expansion of the existing DCS to support the controls of the new CCUS system.

3.3.2. The following equipment will provide the necessary network connections between the existing Generating Station control room, the New Control Building, and the New CCUS PDC Buildings:

a. Generating Station network cabinets, servers, and switches (existing). Located in the existing Generating Station Control Room, these cabinets will be connected via redundant fiber optic cables to a new SJGS network cabinet to be located in the Electronics Room of the new Control Building.

b. New SJGS network/server cabinet, to be located in the Electronics Room of the new Control Building.

c. New CCUS BOP network cabinet, to be located in the Electronics Room of the new Control Building.

d. New CCUS network cabinet, to be located in the Electronics Room of the new Control Building. This cabinet will be networked via fiber optic cables to the new CCUS network cabinets located in the new CCUS PDC Buildings.

e. New CCUS network cabinets, to be located in the new CCUS PDC Buildings.

3.4. Existing DCS Upgrades

3.4.1. SJGS has not contacted Foxboro in the recent past to inquire about possible DCS hardware upgrades. The following items need to be considered for upgrades

during the addition of the CCUS system:

a. The descriptions in this study regarding moving the existing DCS OWSs from the existing control room to the new control room are intended to be functional descriptions. The recommended implementation is to replace the existing DCS workstations with new workstations and thin clients and relocate them into the new control room.

b. Generally, network servers and switches are expected to remain in place and not be moved or replaced.

c. Similar to typical control system upgrades, existing station I/O card and termination assemblies are not expected to be upgraded; much of the station I/O utilizes current versions of Foxboro's I/O cards, and controllers are compatible with older versions.

d. Most of the DCS controllers are CP270s. The latest version is the CP280. Based on discussion with the station personnel, the existing controllers are adequate for the near future. There are several spare controllers as a result of the retirement of the previous units; and replacement of processor pairs (processors are implemented in redundant pairs) can be done in the future on a case-by-case basis. The DCS network is designed to function with both new and older model processors concurrently.

3.4.2. Foxboro will be contacted for budgetary pricing, including inquiries regarding possible recommended system upgrades.

3.5. Ductwork/Boiler Protection

3.5.1. Installation of the CCUS system requires new flue gas system ductwork as well as modifications to the existing ductwork for Unit 1 and Unit 4.

a. The new flue gas ductwork will tie into the existing ductwork downstream of each unit's existing WFGD absorber vessel and upstream of the existing stack.

b. Flue gas will be routed from the tie-in point downstream of the existing WFGD absorber to the CCUS system facility via the new ductwork.

3.5.2. New Flue Gas Blowers, two (2) per train (four total), will be used to mitigate pressure losses of the CCUS system facility and the new ductwork.

a. The new Flue Gas Blowers will be controlled and monitored by the new CCUS DCS, and will interface (interlock) with the existing plant DCS via hardwired connections.

3.5.3. New dampers will be used for controlling and isolating the flue gas flow in the ductwork and will be provided between the tie-in to the existing ductwork and

upstream and downstream of each Flue Gas Blower.

3.5.4. The addition of the Flue Gas Blowers and dampers will alter the existing flue gas system operating pressures, the magnitude of pressure excursions in the existing furnace, and the balance of plant ductwork system due to master fuel trips, control malfunctions, or other transients.

a. The new flue gas ductwork configuration will require triple redundant pressure instrumentation, per NFPA 85 requirements, to continuously monitor the pressure throughout the new and existing flue gas ductwork.

a.1. Specific locations for triple redundant pressure instrumentation will be evaluated during detailed design, but will typically be located upstream and downstream of major equipment such as the Flue Gas Blowers and the dampers.

b. The pressure instrumentation will be used to measure and monitor the pressure in each respective section of ductwork.

b.1. Each section of ductwork will have pressure set points for alarming and control of the flue gas path and furnace system pressure.

b.2. Less severe low pressure setpoints will initiate alarms and runback of the Flue Gas Blowers, while more severe low pressure setpoints will initiate a Unit trip.

c. The pressure instrumentation's calibrated range will envelope the highest and lowest pressure the ductwork is rated for. This will ensure that any pressure excursions are monitored by the DCS.

3.5.5. The Ductwork Pressure Protection system will be accomplished by the existing DCS. The pressure instrumentation signals will be connected to the existing DCS and used for graphic indication to the operator via the DCS HMI.

a. It is assumed that the existing DCS cabinets have adequate spare I/O available and adequate processing capacity to handle any added or revised logic. In S&L's discussions with the station engineers, it was stated that there is a reasonable amount of spare I/O on the Unit 1 and Unit 4 DCSs. Additionally, there were no issues brought up of controllers being overloaded.

b. The existing ductwork pressure protection controls logic in the DCS will require modification to include the new ductwork sections as well as the new Flue Gas Blowers and dampers.

c. The existing sequence of operations controls logic in the DCS, such as start-up and shutdown, will also require modification to include the new ductwork sections as well as the new Flue Gas Blowers and dampers.

d. Modifications to the ductwork pressure protection controls and sequence of

operation controls will be accomplished in compliance with the latest requirements of NFPA 85 - Boiler and Combustion Systems Hazards Codes, and other design considerations.

4. EVALUATION AND RECOMMENDATIONS

4.1. Summary

4.1.1. Control System

a. To maintain control system functionality consistency and compatibility, it is recommended that all new additions to the control system be of the same DCS platform as the existing Foxboro I/A Series DCS. This approach will also optimize operator training and will maintain hardware and software consistency between the existing DCS and the new DCS additions.

b. The new CCUS BOP DCS will be an extension of the existing plant's DCS and will be a redundant controller drop added to the common mesh network.

c. The new CCUS DCS (by MHI) will be an independent Foxboro I/A Series DCS and will interface with the existing plant's DCS and new CCUS BOP DCS drop via hardwired connections only.

4.1.2. Control Room

a. As part of the CCUS Project, a new Control Building will be designed. This Control building will be built near the Carbon Capture Island and will include a new Control Room and Electronics Room. This new Control Room will serve as the central location for both the SJGS plants and the CCUS System controls, monitoring, and operation.

b. A new CCUS PDC Building will also be designed and installed for each train of equipment (total of two CCUS PDC Buildings) and will house key components of the CCUS control system(s).

c. The existing SJGS operations for Unit 1 and Unit 4, and the new controls for the CCUS and associated BOP system(s) will be housed in the new Control Room. New workstations/thin clients will replace the existing DCS OWSs when the operations are relocated to the new Control Room. This will facilitate better and more efficient communication between operators in the Control Room across all units.

d. The DCS simulator and associated equipment has previously been abandoned and will not be moved to the new Control Building.

4.1.3. Control System Interface

a. New and existing control network cabinets will provide the necessary network connections between the existing SJGS Control Room, the new Control Room, and the two (2) new CCUS PDC Buildings. These cabinets will be networked via fiber optic cables. Existing DCS servers and switches will remain in their current

locations in their respective unit electrical rooms.

4.1.4. Ductwork Protection

a. The new Flue Gas Blowers will be controlled and monitored by the new CCUS DCS.

b. The addition of the Flue Gas Blowers and dampers will alter the existing flue gas system operation. The new ductwork configuration will require redundant pressure instrumentation to monitor pressure throughout the flue gas ductwork.

c. Ductwork Pressure Protection will be accomplished by the existing DCS.

c.1. The existing pressure protection controls logic will be modified accordingly to account for the addition of the new ductwork sections as well as the new Flue Gas Blowers and dampers.

c.2. The existing sequence of operations controls logic will also be modified accordingly.

d. All modifications to the ductwork pressure protection controls and sequence of operation controls will be accomplished per requirements of NFPA 85 and other engineering design considerations.

Appendix B. MHI FEED Study Final Report

Sargent & Lundy

FEED STUDY FINAL REPORT
(CARBON CAPTURE PLANT)

45 SHEETS WITH COVER

STATUS				
☐ FOR INFORMATION	☑ FOR REVIEW	☐ FOR APPROVAL	☐ FOR CONSTRUCTION
☐ FOR BID	☐ FOR PROCUREMENT	☐ PRELIMINARY	☐ FOR INTERNAL USE

REVISIONS NO.	DATE	DESCRIPTION	REFERENCE	PREP'D (DISCIPLINE)	CHK'D (DISCIPLINE)	APP'D (DISCIPLINE)	APP'D (PROJECT)
1	03/28/22	Revised as marked		-	-	-	T.Y.

ORDER NO.	**583160**
PROJECT	**SJGS-FEED**
APPROVED	*S. Kiuchi*
	T. Yoshimura
	T. Yamamoto
DISCIPLINE	
APPROVED	-
CHECKED	-
	-
PREPARED	-
JAPAN EXPORT CONTROL	☐ On the control list ■ Not on the control list
DATE	03/28/2022

CUSTOMER

ENCHANT ENERGY CORPORATION

PROJECT

SAN JUAN GENERATING STATION
CARBON CAPTURE PROJECT FEED STUDY

MHI DRAWING NUMBER

8262 - J 1BW - 000 - 0010

REV. **1**

DISTRIBUTION	
DOE	E
Enchant	E
S&L	E
KIEWIT	E
MHIA	E
PM	E
EM	E
PE	E
QA/QC	
PROCURE.	
SUBCONT.	
LOGISTICS	E
COST	
SCHEDULE	
BUSINESS	
PROCESS	E
MACHINE	E
EQUIP.	E
FURNACE	
PIPING	E
I&C	E
ELECT.	E
CIVIL	E
CONST.	E
VENDOR	
SITE	
TOTAL	

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PROJECT BACKGROUND

The overall goal of the project is to conduct a full front-end engineering design (FEED) study for a carbon capture system for Unit #1 (370 MWg) and Unit #4 (544 MWg) at the San Juan Generating Station (SJGS) in Farmington, NM based on the KM CDR Process CO_2 capture technology from Mitsubishi Heavy Industries (MHI) using the proprietary solvent KS-1™. This capture technology is the same used at Thompsons Texas. The capture technology will be scaled up to 914 MWg to be the largest post-combustion capture plant in the world. In addition, it will incorporate advancements in the proprietary solvent that translate into reduced capital costs.

SJGS is a mine-mouth power plant, burning New Mexico Sub Bituminous coal mined nearby and has a typical gross capacity of approximately 914 MWg. The plant normally operates at full load but can run at 25% load of the design capacity. The new CO_2 capture facility will pre-treat the flue gas from the Unit #1 and #4 2 coal-fired boiler to remove CO_2 from the flue gas and generate a high purity CO_2 stream that is conditioned and compressed to pipeline quality for transportation via a dedicated pipeline off-site for sequestration and/or enhanced oil recovery.

The CO_2 capture facility will have the capacity to treat 100% of the flue gas generated by Unit #1 and #4. The facility will also have turndown capability to treat only a part of the SJGS's 2 coal-fired boilers' flue gas exhaust. The flue gas tie-in will be incorporated downstream to the Unit #1 and #4, upstream of the existing stack. To promote balanced flow, the new ductwork will tie-in to the Unit #1 and #4 and will transition to a fiberglass reinforced plastic (FRP) duct to the CO_2 capture facility.

The CO_2 capture team acknowledges the economic benefit of the 45Q tax credit of $50/ton for stored CO_2 and $35/ton for used CO_2 and is targeting an overall cost of capture that would make the commercial project economical. This cost of capture was minimized as a result of the benefits of using the KS-1™ solvent and lessons learned from other capture projects.

PROJECT SCOPE

This project is for a full front-end engineering design (FEED) for a carbon capture system that will capture CO_2 from Unit #1 and #4 (914 MWg) at the San Juan Generating Station (SJGS), NM. The capture

facility is based on the KM CDR Process CO_2 capture technology from Mitsubishi Heavy Industries (MHI) and will use the KS-1™ solvent.

Mitsubishi Heavy Industries (MHI) provided the detailed design and engineering of the ISBL components for the carbon capture island, as well as providing the solvent used in the system. The carbon capture system being designed as part of this study is based on MHI's KM CDR Process™ CO_2 capture technology using KS-1™.

PROJECT DESIGN BASIS

Site Characteristics

Location

*See **Figure 1**.*

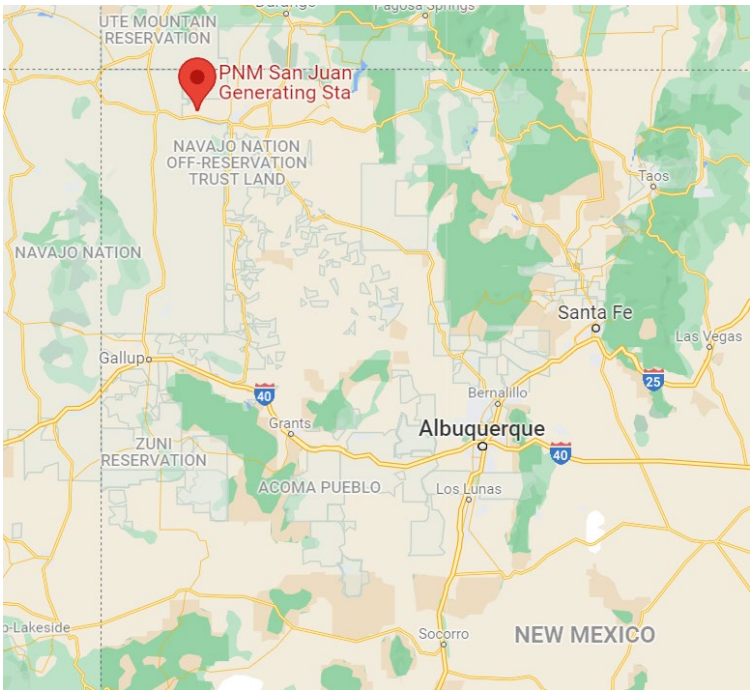


***Figure 1**. SJGS is located in Farmington in New Mexico.*

The following aerial view (***Figure 2***) shows the layout of SJGS outside of Farmington, NM at address 6800 N Country Rd, Waterflow, NM 87421.



***Figure 2**. Aerial view of the San Juan Generating Station.*

Topography

The site topographic information for the build location of the CO_2 capture facility indicates the site is generally flat. The build location is shown in the map below in the blue square (***Figure 3***). Prospective laydown areas are marked with red boxes on the map.



***Figure 3**. The build location is outlined in blue.*

Transportation Access

A potential transportation route was surveyed in Oct 2021. The roll-off locations that were analyzed were the port of Corpus Christi, TX.

Present conditions limit the following three cargo dimensions (L x W x H) to be able to transport.

Equipment-A

40’L x 24’W x 17’H @184,000lb

Equipment-B

26’L x 18’W x 14’H @185,000lb

Equipment-C

48’L x 11’W x 12’H @249,000lb

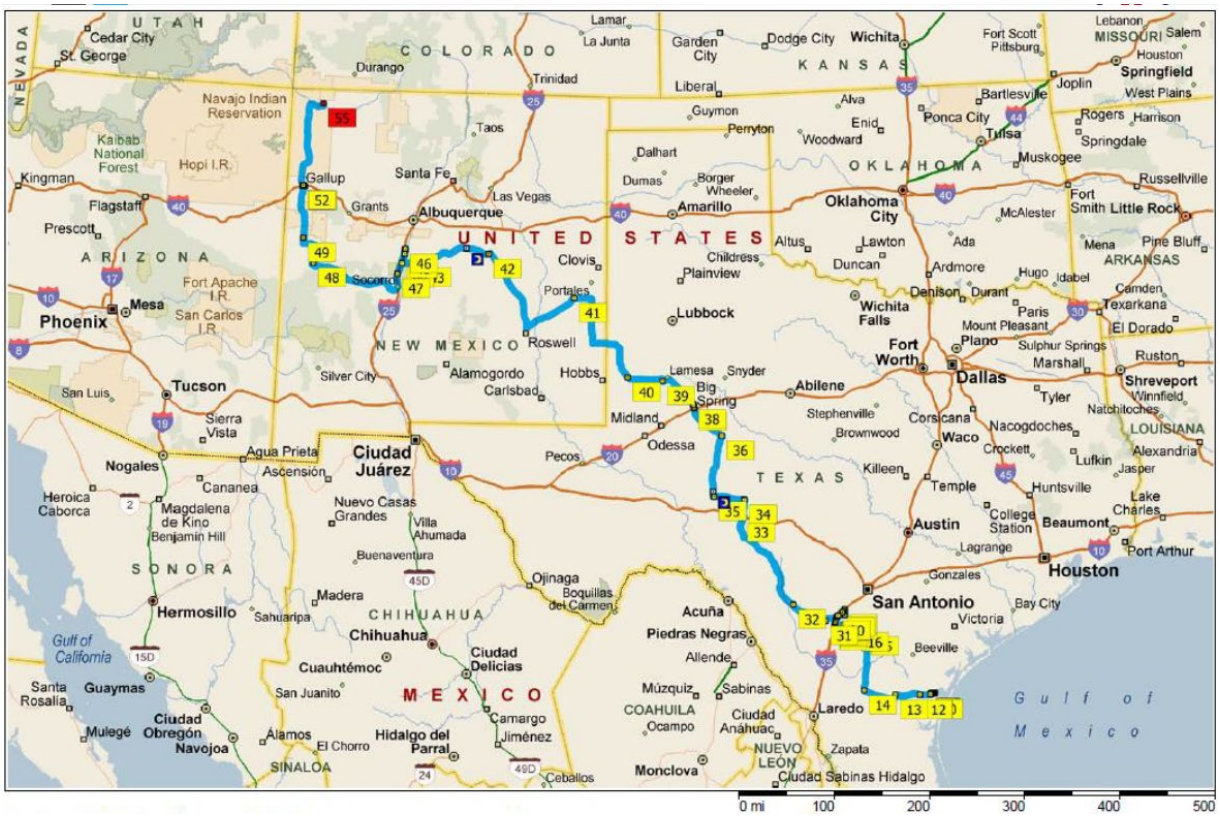


Figure 4. *Route from port of Corpus Christi to Proposed Site*

For transport throughout the United States of America, the maximum payload that can be transported along the route is determined by the Department of Transportation and the local governing officials based on evaluation of loadings to be exerted on the roads and bridges. If any of the roads or bridges are deemed

not suitable, minor adjustments will be made to the route. Prior to shipment of equipment a review of the routes will be performed to evaluate any changes that could have occurred to the route such as construction of roads or bridges or new, low-hanging lines being strung. If such changes are identified, minor adjustments will be made to the route.

Areas where there are high concentrations of low-hanging wires has been pinpointed. It will be assumed that all low lines can be raised and left live with the utility companies having the authority to decide whether they will want to shut down any lines in advance. It is assumed that any obstructions along the route (i.e. signs, poles, trees, etc.) can be moved or adjusted without any issues.

Available Utilities

Utilities that are available for use: electricity (existing generation unit), potable water (existing plant potable water system), demineralized water (existing plant distribution system) and makeup water (existing fresh water source).

Site Ambient Conditions

Major site conditions are based on American Society of Heating, Refrigeration and Air Conditioning (ASHRAE) and the data location Farmington Four Corners that is approximately 13 miles from SJGS and represents climate conditions over that distance. ***Table 1*** shows Farmington Four Corners details and major site conditions.

Table 1*. The nearest long-term weather observations are collected at the Farmington Four Corners.*

Nearest ASHRAE (2021) weather data location	**World Meteorological Organization Number**	**Latitude**	**Longitude**
Farmington Four Corners	723658	36.744°N	108.229°W

Table 2. Major site conditions.

Parameter	**Data**
Elevation	5,308 ft
Standard Pressure	12.004 psia
Heating dry bulb temperature, 99.6% occurrence	9.1°F
50 - year occurrence dry bulb temperatures	
High	103.8°F
Low	-11.3°F
Cooling dry bulb temperature, 0.4% occurrence	96.1°F
Cooling wet bulb temperature, 0.4% occurrence	59.4°F

Site Specific Design Considerations

The site ambient design conditions that will be used for this project are as follows:

Temperature

Basis for design of outdoor equipment

- Design maximum dry bulb: 110°F
- Design minimum dry bulb: -20°F

Rainfall/Snowfall

Rainfall for 24-hour shall be from NOAA Atlas 14 Hydro meteorological Design Studies Center (Precipitation Frequency Data Server)

Precipitation

- Annual average: N/A
- 25 year, 24-hour max: 2.0 in.

Snowfall

- Annual average: N/A
- Maximum snowfall in 24-hr: N/A

Frost Penetration

1 2 1/2 feet below finish grade

Wind

Table 3. Wind Design Parameters

Average Wind Speed [mph]	24.8
Prevailing Wind Direction	N/A
Ultimate Design Wind Speed, V_{ult} (3-second Gust)	120
Nominal Design Wind Speed, V_{asd}	93
Risk Category	III
Exposure Category	C

Seismic Data

Table 4. *Seismic Design Parameters*

Risk Category	Building Category III
Seismic Importance Factor, Ie	1.25
Spectral Response Acceleration	
Short Period, 0.2 Second, Ss	0.131
1-Second Period, S1	0.049
Site Class	D (TBD by S&L Geotechnical Investigation for CCS Area)
Design Spectral Response Acceleration Parameter	
Short Period, 0.2 Second, S_{DS}	0.14
1-Second Period, S_{D1}	0.078
Seismic Design Category	B

Codes and Standards

Codes listed below are the primary codes used on the project but not intended to be all inclusive. Latest editions as of project initiation will be used, except where local Code adoption states otherwise.

Governing Building Code (2015 New Mexico Commercial Building Code)

International Building Code – IBC 2018

AASHTO – American Association of State Highway and Transportation Officials

ACI – American Concrete Institute

a. ACI 543R – 12 – Guide to Design, Manufacture and Installation of Concrete Piles

b. ACI 318 – Building Code Requirements for Structural Concrete and Commentary as stipulated by 2015 New Mexico Commercial Building Code and International Building Code – IBC 2018

AGMA - American Gear Manufacturer Association

AISC – American Institute of Steel Construction\

a. AISC – Manual of Steel Construction

b. AISC 341 – Seismic Provisions for Structural Steel Buildings

c. AISC 360 – Specification for Structural Steel Buildings

AMCA - Air Movement and Controls Association

ANSI – American National Standards Institute

API – American Petroleum Institute

a. API STD 650 – Welded Steel Tanks for Oil Storage

b. API STD 620 – Design and Construction of Large Welded, Low Pressure Storage Tanks

ASCE – American Society of Civil Engineers

a. ASCE 7-10 – Minimum Design Loads for Buildings and Other Structures

b. ASCE 20 – 96 – Standard Guidelines for the Design and Installation of Pile Foundations

ASHRAE – American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc.

AWWA – American Water Works Association

ASME – American Society of Mechanical Engineers

a. ASME B31.1 - Power Piping Code

b. ASME B31.3 - Process Piping Code (B31.3 will be used for CO_2 Capture island)

c. ASME Section VIII – Boiler and Pressure Vessel Code

ASTM – ASTM International: By Standard Specification, Test Method, Practice or Guide specified

AWS – American Welding Society

a. AWS A2.4 – Standard Symbols for Welding, Brazing and Nondestructive Examination

b. AWS A3.0 – Welding Terms and Definitions

c. AWS A5.1 to A5.31 – Specification for Welding Electrodes

d. AWS A6.1 – Recommended Safe Practice for Gas - Shielded Arc - Welding

e. AWS D1.1 – Structural Welding Code – Steel

f. AWS D1.2 – Structural Welding Code – Aluminum

g. AWS D1.3 – Structural Welding Code – Sheet Steel

h. AWS D14 – Rotating Equipment

CFR - Code of Federal Regulations

CRSI – Concrete Reinforcing Steel Institute, Manual of Standard Practice

CTI – Cooling Technology Institute

Factory Mutual Loss Prevention Data Sheets

HEI – Heat Exchanger Institute

IBC – International Building Code

IECC – International Energy Conservation Code - 2018

IFC – International Fire Code - 2018

IMC – International Mechanical Code - 2018

IPC – International Plumbing Code - 2018

ISA – International Society of Automation

MBMA – Metal Building Manufacturer's Association, Metal Building Systems Manual

NEC – National Electrical Code - 2020

NEMA – North American Electric Reliability Council

NERC – North American Electric Reliability Corporation

a. CIP – Critical Infrastructure Protection Standards

NFPA – National Fire Protection Association

a. NFPA 101 – Life Safety Code

b. NFPA 850 – Recommended Practice of Fire Protection for Electric Generating Plants

c. NFPA 85 – Boiler and Combustion Systems Hazards Code

OSHA – Occupational Safety & Health Administration 29 CFR Part 1910 Occupational Safety & Health Standards

RCSC – Research Council on Structural Connections – Specification for Structural Joints Using

ASTM A 325 or A 490 Bolts, Endorsed by the American Institute of Steel Construction, Inc.

SSPC – Steel Structures Painting Council: By Practice or Guide Specified

UL – Underwriter's Laboratories, Inc.

Fuel Feedstock and Flue Gas Characteristics

Power Plant Fuel Data

SJGS is a mine-mouth plant, burning New Mexico Sub-Bituminous coal mined nearby. ***Table 5*** below summarizes the fuel properties for the coal.

Table 5*. Coal Analysis Summary*

Parameter	Units	Value	Source
Moisture	wt%	7.78	2010 Coal Analysis (072-43981-006)
Carbon	wt%	54.41	2010 Coal Analysis (072-43981-006)
Hydrogen	wt%	4.24	2010 Coal Analysis (072-43981-006)
Nitrogen	wt%	1.21	2010 Coal Analysis (072-43981-006)
Oxygen	wt%	9.27	2010 Coal Analysis (072-43981-006)
Chlorine	wt%	0.00	2010 Coal Analysis (072-43981-006)
Fluorine	wt%	0.00	2010 Coal Analysis (072-43981-006)
Sulfur	wt%	0.80	Average of Future Projected Coal (2020-2034)
Ash	wt%	22.29	Calculated based on future sulfur content
HHV	Btu/lb	9,930	Average of Future Projected Coal (2020-2034)

Flue Gas Conditions

Table 6 below summarizes the flue gas design conditions (normal operating point) for the existing SJGS Unit #1 and #4 coal-fired boiler.

Table 6*. SJGS Flue Gas Analysis Summary*

	Units	Value
Temperature	°F	127
Pressure	inWC	-6
Volume	scfm@68°F	2,846,302
CO_2	vol %	9.93
O_2	vol %	5.98
N_2, Ar	vol %	66.92
SO_2	ppmv	18
NOx	ppmv	106
H_2O	vol %	17.16

BASIC CONTRACTING AND PURCHASING STRATEGY

Procurement Strategy

The project team will use competitive bidding to compare multiple suppliers' pricing offers, availability and commercial terms, identifying the supplier whose offering presents the lowest cost. Project aspects considered during evaluation include technical specifications, delivery date requirements and project specific or companywide standards. Purchase contracts are reviewed to verify that safety, quality and delivery requirements are met before contracts are signed.

Engineering Interface

The procurement team looks to the project engineers to understand the technical factors that need to be considered when purchasing equipment. As part of their review, engineering provides technical review of bids received, providing a recommendation based on the requirements suppliers meet. The project team has identified the following areas where alignment between engineering and procurement personnel is essential to project success:

- Identifying critical scope that needs to be procured early in order to work with the supplier or subcontractor in their design that will have downstream affects
- Finding solutions to sourcing more domestic materials and scope instead of looking internationally, in order to cut down on logistics and supply issues, while also being aware of the overall cost impact to the project.

Modularization Requirements

The purpose for modularization is to reduce the costs of the project and shorten the overall build schedule. Modularization splits components of a process into parts "modules" that will be fabricated at an offsite workshop and assembled later at the build location. A preliminary modularization study has been carried out. Process structures and pipe racks will be modularized to fit within the shipping limitations determined by the transportation study. Two key process structures of the CO_2 capture process will be modularized into pieces that will accommodate the shipping limitations. The process area pipe racks will

also be modularized and shipped. Equipment will also be modularized and shipped to the build site for assembly.

Long-Lead Procurement

Long-lead items are procured during detailed design. ***Table 7*** lists the long lead items that have been identified at this time; however, this list is preliminary.

Table 7. *Identified ISBL Long Lead Items*

Critical Procurement Item	**Delivery Lead Time**
Regenerators	96 Weeks
CO2 Compressors	92 Weeks
Dehydration Units	76 Weeks
Flue Gas Blowers	64 Weeks

ENGINEERING DESIGN PACKAGES

Process Engineering

The CO_2 capture system will have capacity to treat 100% of the flue gas generated by Unit #1 and #4 but will also have the capability to operate at 25% of full design capacity. The flue gas tie-in will be incorporated downstream to the upstream of the existing stack.

Process Flow Diagrams

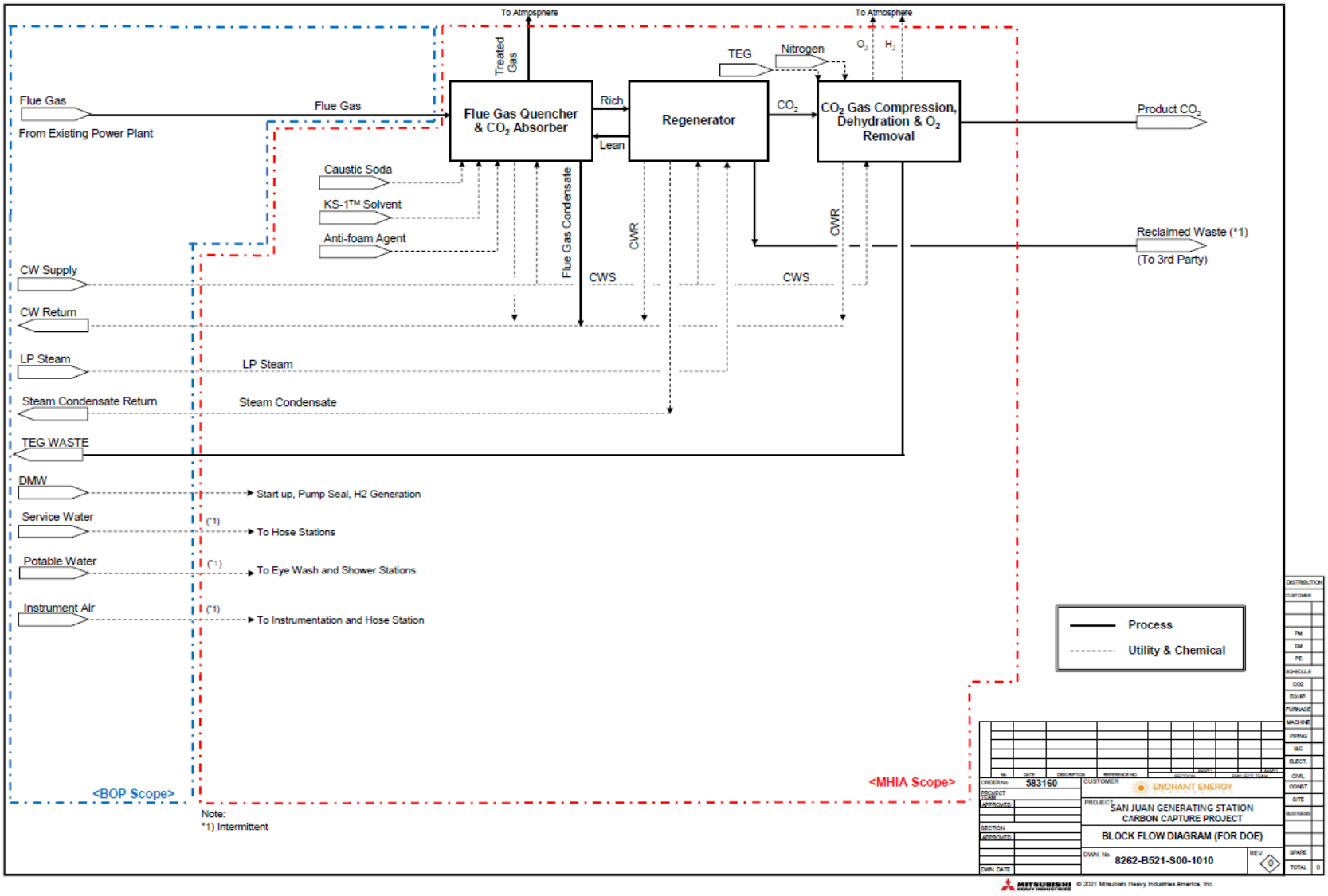


Figure 5. *Block Flow Diagram (BFD)*

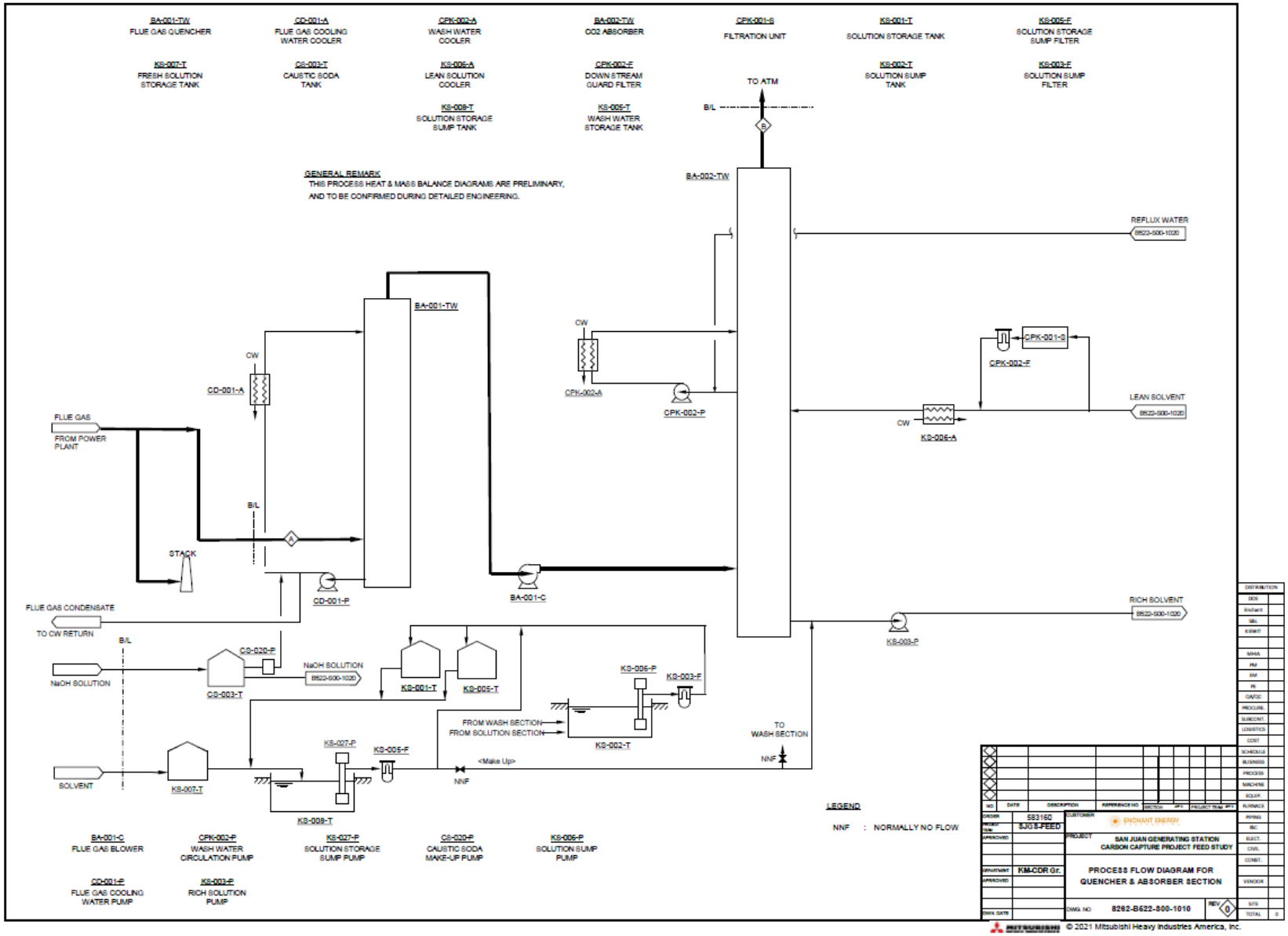


Figure 6. *Process Flow Diagram for Quencher and Absorber Section*

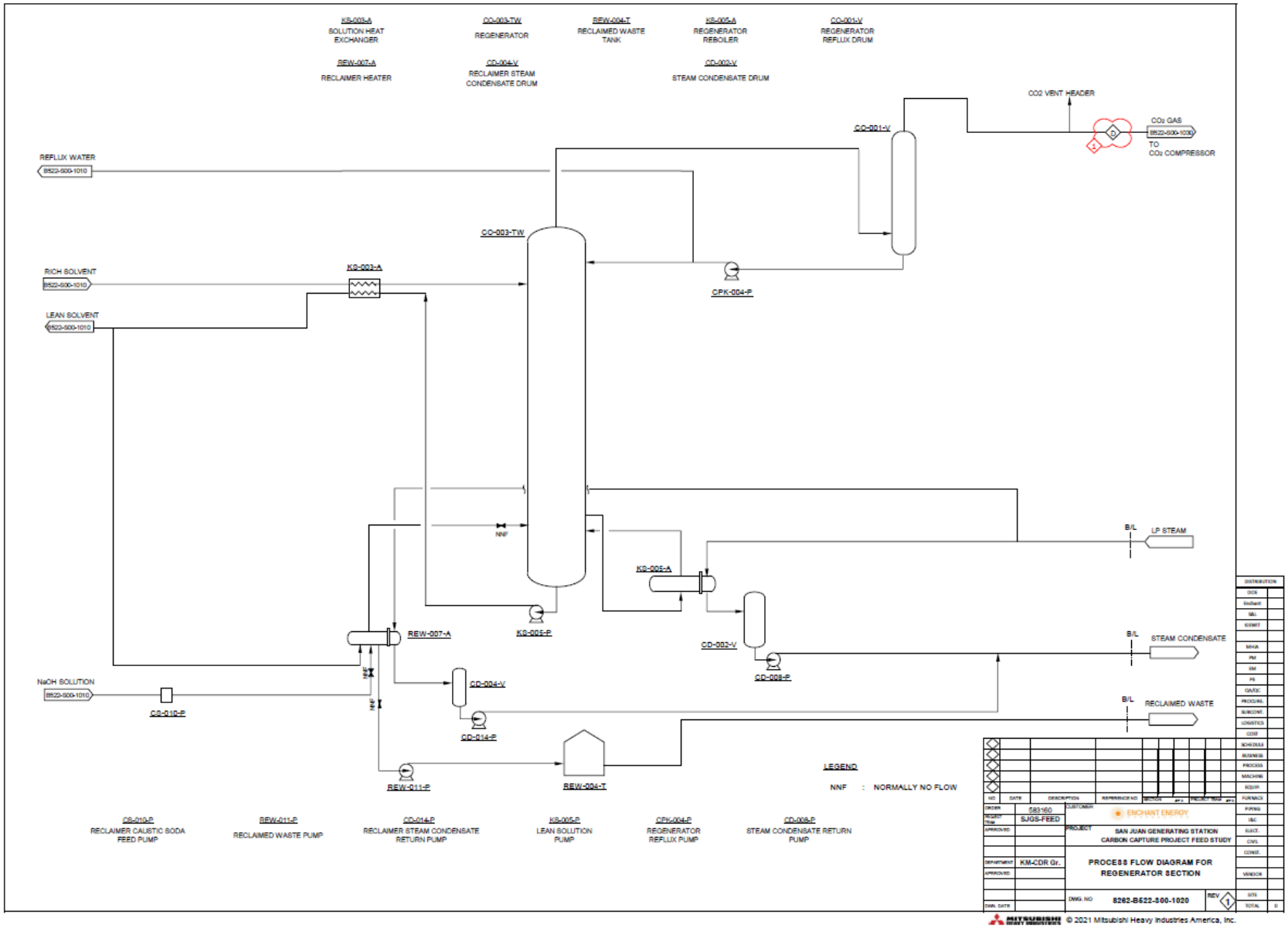


Figure 7. *Process Flow Diagram for Regenerator Section*

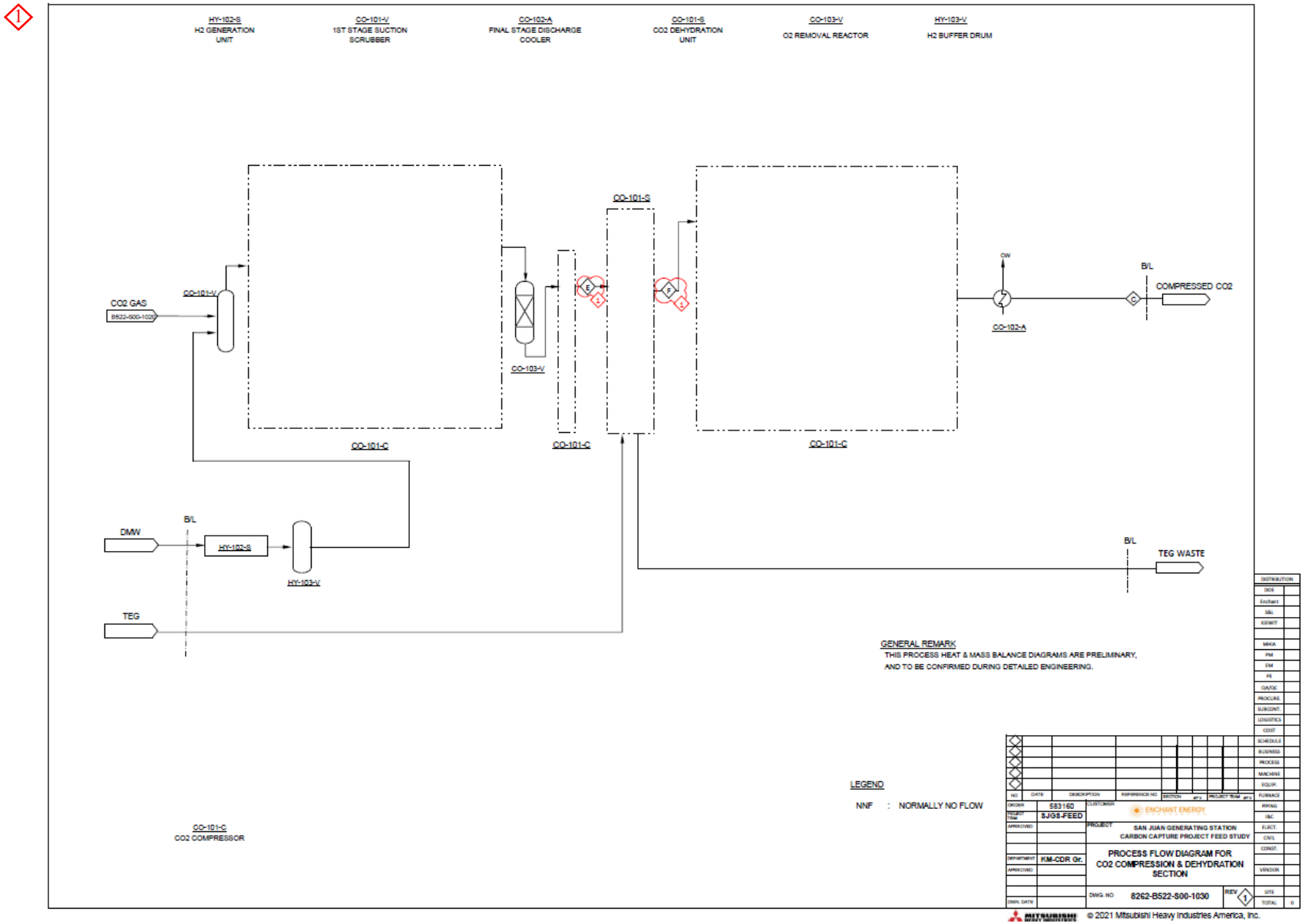


Figure 8. *Process Flow Diagram for CO_2 Compression and Dehydration Section*

HAZOP/PHA

PHA Process

A FEED Process Hazard Analysis (PHA) was conducted at the MHIA office in Houston TX on November 8th through 12th to identify hazards associated with the process. Trimeric Corporation facilitated the PHA and provided a summary report upon which this deliverable is based. The method selected for the PHA was a Hazard and Operability Study (HAZOP). The scope of the PHA included a hazard analysis of the process equipment, piping, and components associated with the Carbon capture portion of the project. The scope did not include the host site equipment beyond duct and piping connections; however, safeguards located in the existing facility were documented where appropriate. The objectives of the PHA were as follows:

- Systematically identify process hazards associated with the operation of the unit
- Evaluate the possible safety, environmental, production, and community consequences in the absence of engineering and administrative controls
- Summarize the design's existing engineering and administrative controls
- Make recommendations for additional controls when needed to reduce the risk in the process

P&IDs provided to Trimeric were used to develop nodes for the PHA. Nodes were identified by the MHIA engineer and facilitator and were clearly marked on the P&IDs by the facilitator prior to the session. Prior to the PHA, a copy of the node drawings, risk—ranking matrix, definitions and assumptions, and preliminary agenda were sent to the MHIA engineer for review. A current Cause & Effect Diagram along with alarm rationalization and operator response information were available during the HAZOP sessions. Process hazards were identified by the team for each node and any

A PHA team was selected by MHIA to include personnel knowledgeable of the MHI Carbon capture process, the host power plant operations, project design engineering, and the method employed for this PHA (HAZOP). Core team members included personnel highly experienced in operations, engineering, I&E, process controls, safety, and PHA facilitation. The team members are listed in ***Table 8***.

Table 8. PHA Team

Name	Title	Company
Cole Maas	Lead Process Engineer	Mitsubishi Heavy Industries America
Daisuke "Dash" Shimada	Process Engineering Manager	Mitsubishi Heavy Industries America
Cindy Crane	CEO	Enchant Energy
Peter Mandelstam	COO	Enchant Energy
Hank Adair	Electric Utility Director	City of Farmington
Emily Kunkel	Project Associate	Sargent & Lundy
Chris Hornish	Engineering Manager	Sargent & Lundy
Stephen Wylie	Senior Project Manager	Sargent & Lundy
Vrushant Patel		Sargent & Lundy
Vivi Melendez	Environmental Manager	NTEC Navajo Mine
Tim Thomas	Senior VP	Mitsubishi Heavy Industries America
Tiffany Wu	Business Development Manager	Mitsubishi Heavy Industries America
Masao Matsumoto	Senior Project Director	Mitsubishi Heavy Industries America
Rosalind Jones	Senior Process Engineer/Facilitator/Scribe	Trimeric Corporation

The PHA study was performed to identify potential process hazards in the process design. The scope of the PHA included all process equipment and piping associated with the Carbon Capture process. Evaluation of utilities and service systems such as instrument air and steam were not part of this PHA; however, the impact of loss of services such as power and instrument air were discussed as global topics for each node. The potential for utility contamination such as in the case of a heat exchanger leak was discussed where applicable. A list of the nodes and related equipment is shown in ***Table 9.***

Table 9. Project Node List

Section Number	Unit / Process
1	Flue Gas
2	Flue Gas Quench
3	Flue Gas Washing
4	CO_2 Absorption
5	Regeneration
6	Rich Solvent
7	Lean Solvent
8	Solvent Filtration
9	Reflux System
10	CO_2

11	Steam and Condensate
12	Solvent & Water Storage and Sumps
13	Chemical Storage and Supply
14	Reclaiming

Methodology

For this hazard analysis, the HAZOP methodologies was used. The methodology uses a systematic approach to identify process hazards, capture the engineering and administrative controls in place, and determine the consequences associated with the failure of those controls. Recommendations are made for implementing additional engineering controls when necessary to reduce the risk in the process.

Prior to the PHA, the facilitator and MHIA process engineer identified nodes and deviations for the HAZOP. For each node, the HAZOP team identified potential hazards by considering process deviations based on combinations of guide words (high, low, no, reverse, etc.) and process parameters (flow, temperature, pressure, etc.). Examples of deviations that were considered are high pressure, reverse flow, and low temperature.

For each deviation, the team identified possible causes, consequences, and the engineering or administrative controls in place to prevent or mitigate the hazardous scenario. The consequence was ranked by the team assuming a worst-case scenario without any engineering controls and the likelihood was ranked by the team assuming that existing controls in the design were in place.

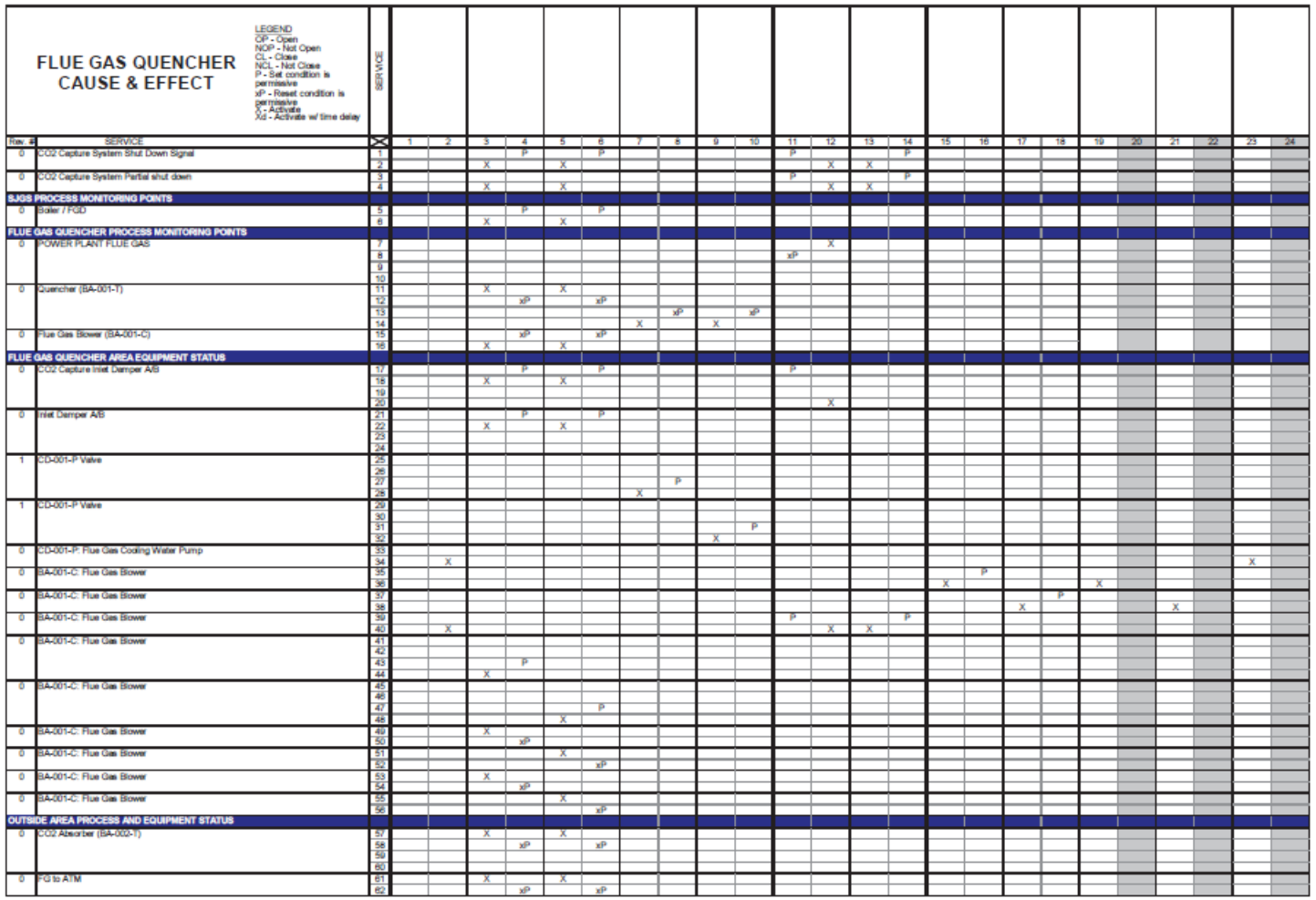
The consequence and likelihood rankings were then combined to achieve an overall risk ranking, ranging from "A – Critical" to "E – Negligible" – with a risk ranking of "A" representing the highest risk and a risk ranking of "E" representing the lowest risk. Recommendations were made by the team in accordance with the risk ranking guidelines. Recommendations were required for a risk ranking of Critical or Serious.

PHA Recommendations

The PHA team developed 74 HAZOP recommendations related to the design and operation of the unit. Note that some recommendations were repeated as potential solutions to multiple scenarios. A summary of the 74 unique recommendations is as follows:

- 0 recommendations address “A” – Critical risk items
- 2 recommendations address “B” – Serious risk items
- 38 recommendations address “C” – Moderate risk items
- 5 recommendations address “D” – Minor risk items
- 1 recommendations address “E” – Negligible risk items
- 28 recommendations address “O” – Operating issue items

Cause and Effect Diagrams



FLUE GAS QUENCHER CAUSE & EFFECT

LEGEND
OP - Open
NOP - Not Open
CL - Close
NCL - Not Close
P - Set condition is permissive
xP - Reset condition is permissive
X - Activate
Xd - Activate w/ time delay

Rev. #	SERVICE	SERVICE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
0	CO2 Capture System Shut Down Signal	1				P		P					P			P										
		2			X		X							X	X											
0	CO2 Capture System Partial shut down	3											P			P										
		4			X		X							X	X											
BJGS PROCESS MONITORING POINTS																										
0	Boiler / FGD	5				P		P																		
		6			X		X																			
FLUE GAS QUENCHER PROCESS MONITORING POINTS																										
0	POWER PLANT FLUE GAS	7												X												
		8											xP													
		9																								
		10																								
0	Quencher (BA-001-T)	11			X		X																			
		12				xP		xP																		
		13								xP		xP														
		14							X		X															
0	Flue Gas Blower (BA-001-C)	15				xP		xP																		
		16			X		X																			
FLUE GAS QUENCHER AREA EQUIPMENT STATUS																										
0	CO2 Capture Inlet Damper A/B	17				P		P					P													
		18			X		X																			
		19																								
		20												X												
0	Inlet Damper A/B	21				P		P																		
		22			X		X																			
		23																								
		24																								
1	CD-001-P Valve	25																								
		26																								
		27								P																
		28							X																	
1	CD-001-P Valve	29																								
		30																								
		31										P														
		32									X															
0	CD-001-P: Flue Gas Cooling Water Pump	33																								
		34		X																					X	
0	BA-001-C: Flue Gas Blower	35																P								
		36															X				X					
0	BA-001-C: Flue Gas Blower	37																		P						
		38																	X				X			
0	BA-001-C: Flue Gas Blower	39											P			P										
		40		X										X	X											
0	BA-001-C: Flue Gas Blower	41																								
		42																								
		43				P																				
		44			X																					
0	BA-001-C: Flue Gas Blower	45																								
		46																								
		47						P																		
		48					X																			
0	BA-001-C: Flue Gas Blower	49			X																					
		50				xP																				
0	BA-001-C: Flue Gas Blower	51					X																			
		52						xP																		
0	BA-001-C: Flue Gas Blower	53			X																					
		54				xP																				
0	BA-001-C: Flue Gas Blower	55					X																			
		56						xP																		
OUTSIDE AREA PROCESS AND EQUIPMENT STATUS																										
0	CO2 Absorber (BA-002-T)	57			X		X																			
		58				xP		xP																		
		59																								
		60																								
0	FG to ATM	61			X		X																			
		62				xP		xP																		

Figure 9. *Cause and Effect Diagrams (1/7)*

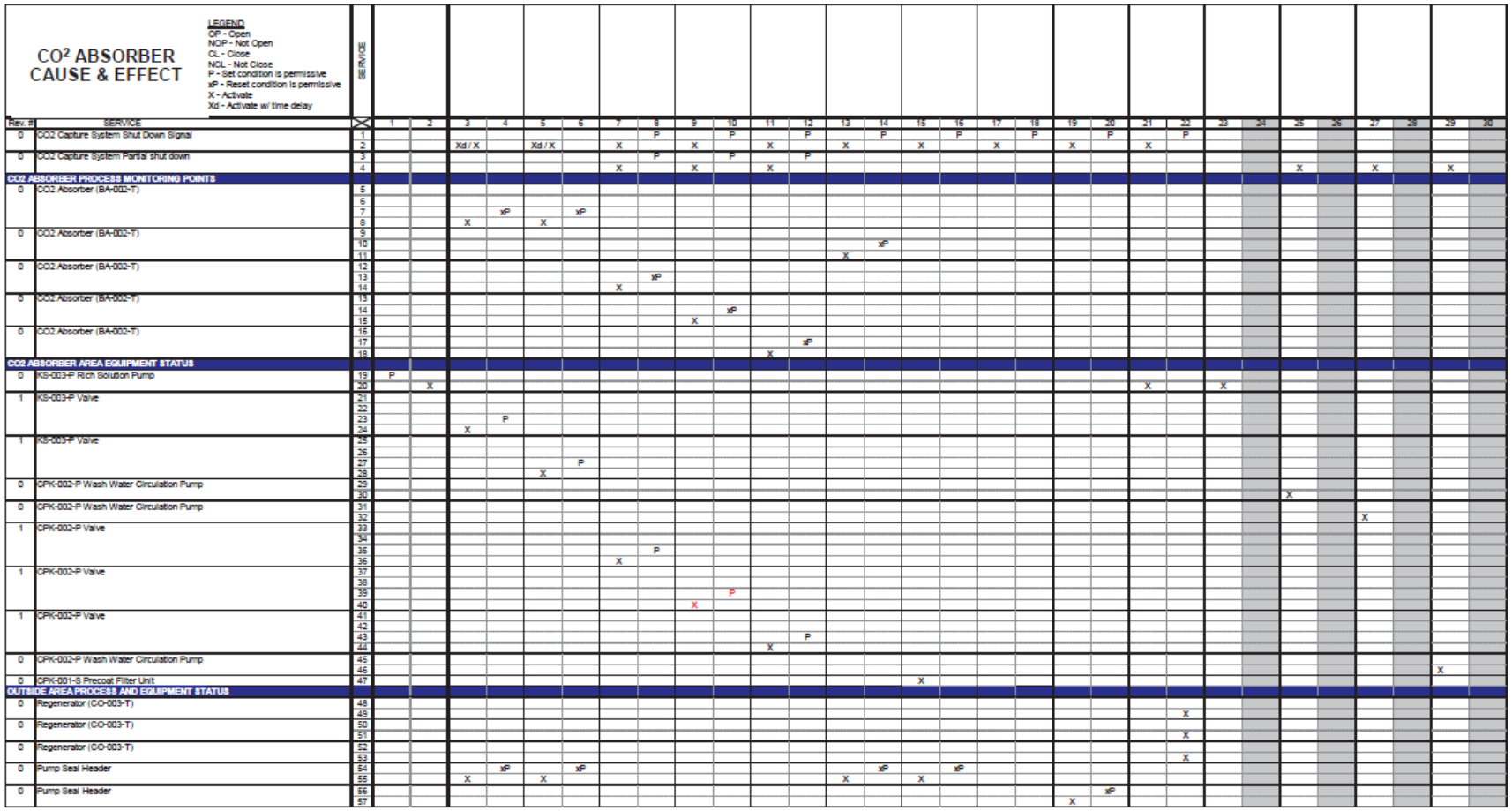


Figure 10. *Cause and Effect Diagrams (2/7)*

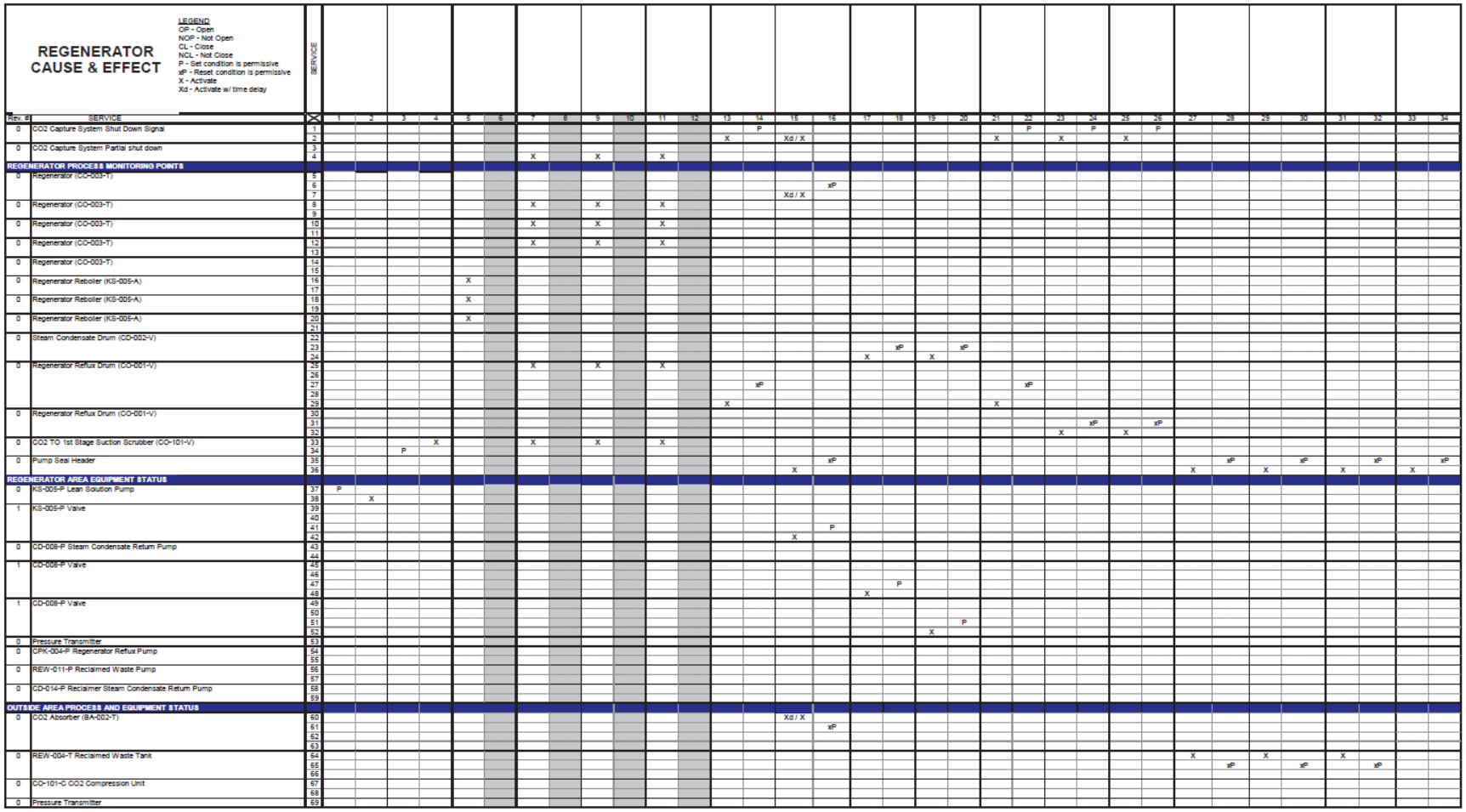
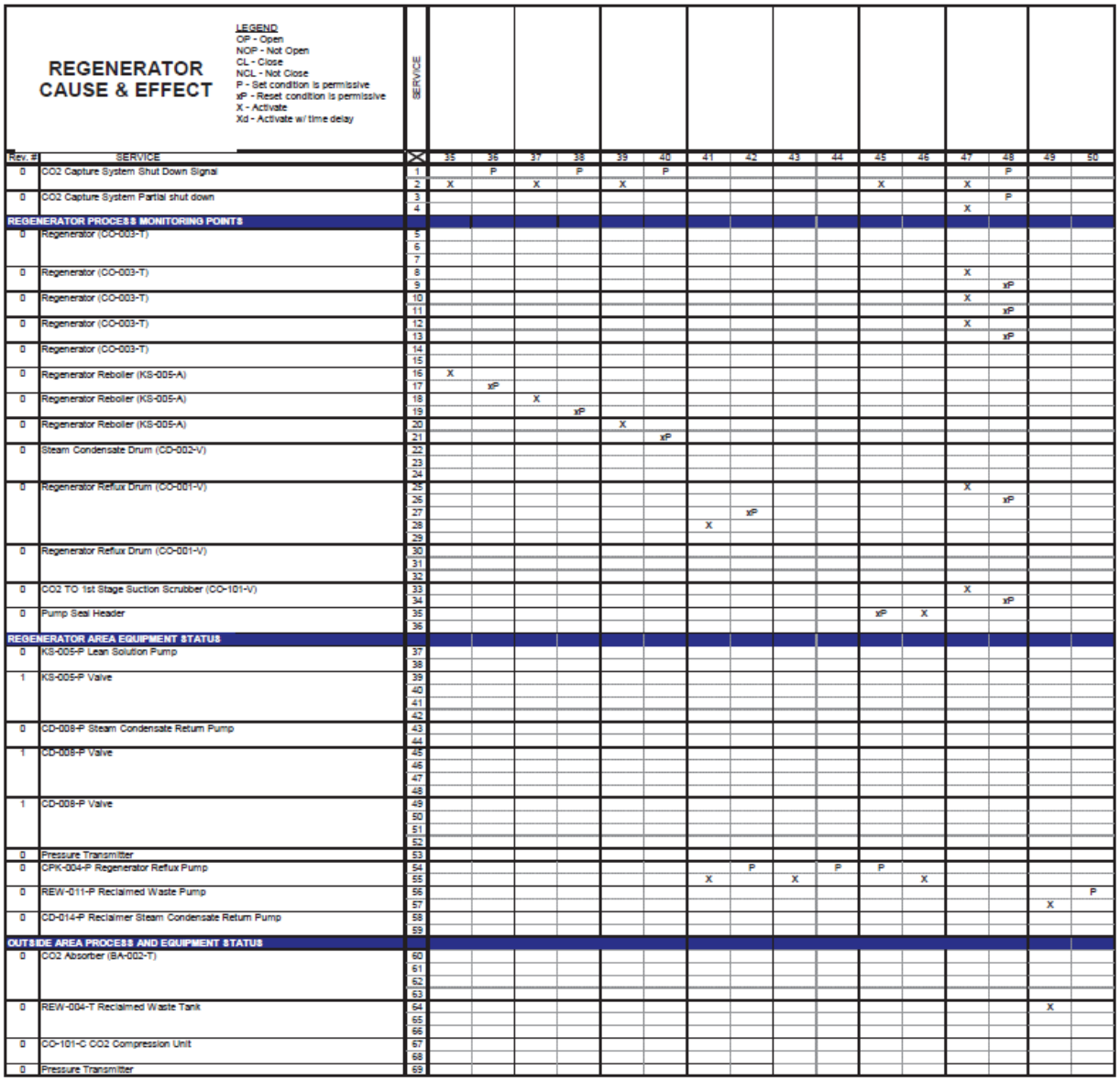


Figure 11. *Cause and Effect Diagrams (3/7)*

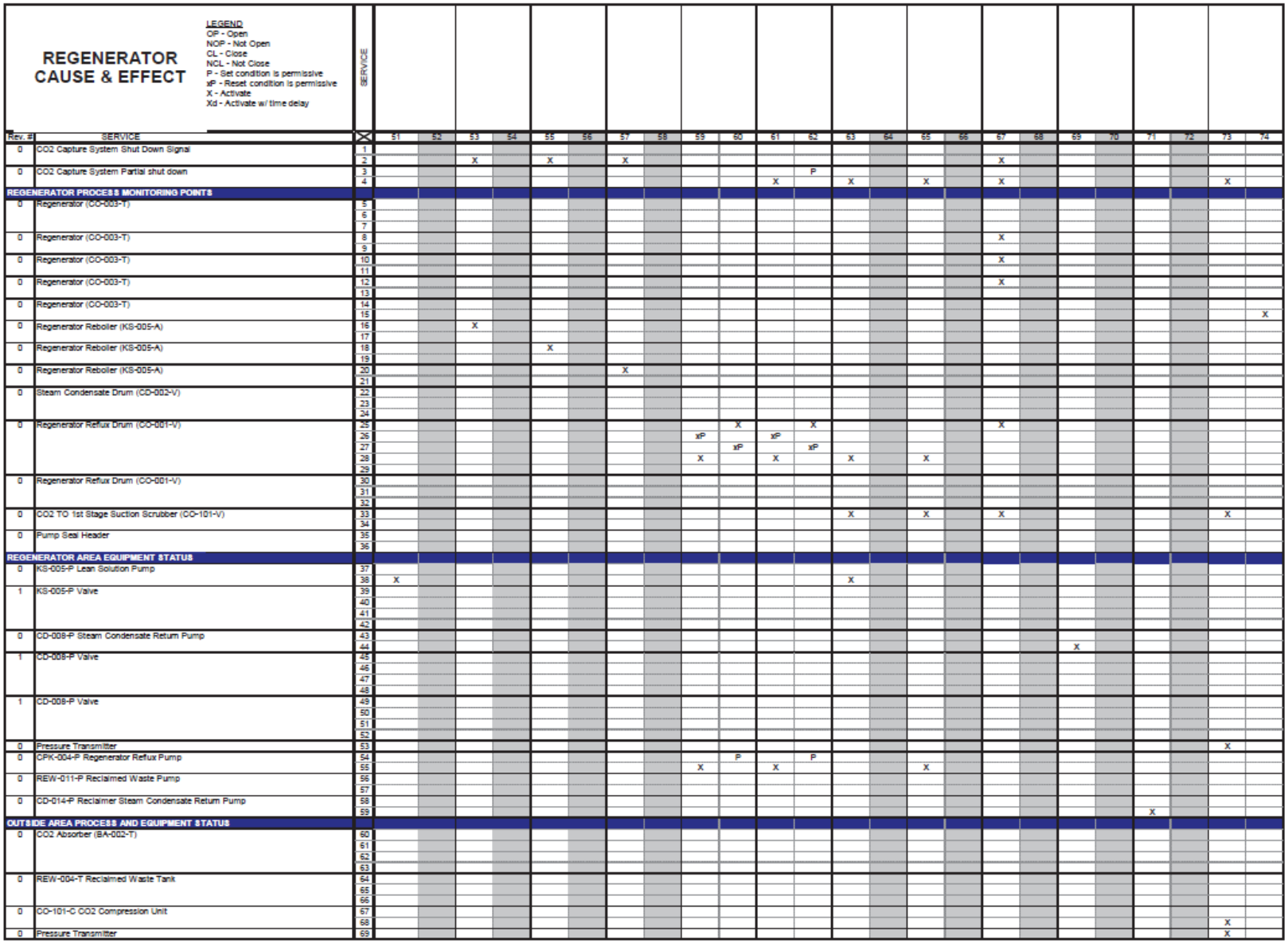


REGENERATOR CAUSE & EFFECT

LEGEND
OP - Open
NOP - Not Open
CL - Close
NCL - Not Close
P - Set condition is permissive
xP - Reset condition is permissive
X - Activate
Xd - Activate w/ time delay

Rev. #	SERVICE	SERVICE	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
0	CO2 Capture System Shut Down Signal	1		P		P		P								P		
		2	X		X		X						X		X			
0	CO2 Capture System Partial shut down	3														P		
		4													X			
REGENERATOR PROCESS MONITORING POINTS																		
0	Regenerator (CO-003-T)	5																
		6																
		7																
0	Regenerator (CO-003-T)	8													X			
		9														xP		
0	Regenerator (CO-003-T)	10													X			
		11														xP		
0	Regenerator (CO-003-T)	12													X			
		13														xP		
0	Regenerator (CO-003-T)	14																
		15																
0	Regenerator Reboiler (KS-005-A)	16	X															
		17		xP														
0	Regenerator Reboiler (KS-005-A)	18			X													
		19				xP												
0	Regenerator Reboiler (KS-005-A)	20					X											
		21						xP										
0	Steam Condensate Drum (CD-002-V)	22																
		23																
		24																
0	Regenerator Reflux Drum (CO-001-V)	25													X			
		26														xP		
		27								xP								
		28							X									
		29																
0	Regenerator Reflux Drum (CO-001-V)	30																
		31																
		32																
0	CO2 TO 1st Stage Suction Scrubber (CO-101-V)	33													X			
		34														xP		
0	Pump Seal Header	35											xP	X				
		36																
REGENERATOR AREA EQUIPMENT STATUS																		
0	KS-005-P Lean Solution Pump	37																
		38																
1	KS-005-P Valve	39																
		40																
		41																
		42																
0	CD-008-P Steam Condensate Return Pump	43																
		44																
1	CD-008-P Valve	45																
		46																
		47																
		48																
1	CD-008-P Valve	49																
		50																
		51																
		52																
0	Pressure Transmitter	53																
0	CPK-004-P Regenerator Reflux Pump	54								P		P	P					
		55							X		X			X				
0	REW-011-P Reclaimed Waste Pump	56																P
		57															X	
0	CD-014-P Reclaimer Steam Condensate Return Pump	58																
		59																
OUTSIDE AREA PROCESS AND EQUIPMENT STATUS																		
0	CO2 Absorber (BA-002-T)	60																
		61																
		62																
		63																
0	REW-004-T Reclaimed Waste Tank	64															X	
		65																
		66																
0	CO-101-C CO2 Compression Unit	67																
		68																
0	Pressure Transmitter	69																

Figure 12. *Cause and Effect Diagrams (4/7)*



REGENERATOR CAUSE & EFFECT

LEGEND
OP - Open
NOP - Not Open
CL - Close
NCL - Not Close
P - Set condition is permissive
xP - Reset condition is permissive
X - Activate
Xd - Activate w/ time delay

Rev. #	SERVICE		51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74
0	CO2 Capture System Shut Down Signal	1																								
		2			X		X		X										X							
0	CO2 Capture System Partial shut down	3												P												
		4											X		X		X		X						X	
REGENERATOR PROCESS MONITORING POINTS		5																								
0	Regenerator (CO-003-T)	6																								
		7																								
0	Regenerator (CO-003-T)	8																	X							
		9																								
0	Regenerator (CO-003-T)	10																	X							
		11																								
0	Regenerator (CO-003-T)	12																	X							
		13																								
0	Regenerator (CO-003-T)	14																								
		15																								X
0	Regenerator Reboiler (KS-005-A)	16			X																					
		17																								
0	Regenerator Reboiler (KS-005-A)	18					X																			
		19																								
0	Regenerator Reboiler (KS-005-A)	20							X																	
		21																								
0	Steam Condensate Drum (CD-002-V)	22																								
		23																								
		24																								
0	Regenerator Reflux Drum (CO-001-V)	25										X		X					X							
		26									xP		xP													
		27										xP		xP												
		28									X		X		X		X									
		29																								
0	Regenerator Reflux Drum (CO-001-V)	30																								
		31																								
		32																								
0	CO2 TO 1st Stage Suction Scrubber (CO-101-V)	33													X		X		X						X	
		34																								
0	Pump Seal Header	35																								
		36																								
REGENERATOR AREA EQUIPMENT STATUS		37																								
0	KS-005-P Lean Solution Pump	38	X												X											
1	KS-005-P Valve	39																								
		40																								
		41																								
		42																								
0	CD-008-P Steam Condensate Return Pump	43																								
		44																			X					
1	CD-008-P Valve	45																								
		46																								
		47																								
		48																								
1	CD-008-P Valve	49																								
		50																								
		51																								
		52																								
0	Pressure Transmitter	53																							X	
0	CPK-004-P Regenerator Reflux Pump	54										P		P												
		55									X		X				X									
0	REW-011-P Reclaimed Waste Pump	56																								
		57																								
0	CD-014-P Reclaimer Steam Condensate Return Pump	58																								
		59																					X			
OUTSIDE AREA PROCESS AND EQUIPMENT STATUS		60																								
0	CO2 Absorber (BA-002-T)	61																								
		62																								
		63																								
0	REW-004-T Reclaimed Waste Tank	64																								
		65																								
		66																								
0	CO-101-C CO2 Compression Unit	67																								
		68																							X	
0	Pressure Transmitter	69																							X	

Figure 13. *Cause and Effect Diagrams (5/7)*

TANK AREA CAUSE & EFFECT

LEGEND
OP - Open
NOP - Not Open
CL - Close
NCL - Not Close
P - Set condition is permissive
xP - Reset condition is permissive
X - Activate

Rev. #	SERVICE	SERVICE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	CO2 Capture System Shut Down Signal	1						P		P								
		2					X		X									
0	CO2 Capture System Partial shut down	3								P								
		4							X									
TANK PROCESS MONITORING POINTS																		
0	Solution Sump Tank (KS-002-V)	5									X				X	xP		
		6		xP														
		7	X															
0	Solution Sump Tank (KS-002-V)	8									X							
0	Solution Storage Sump Tank (KS-008-V)	9											X		X			
		10				xP										xP		
		11			X													
0	Solution Storage Sump Tank (KS-008-V)	12											X					
0	Caustic Storage Tank (CS-003-V)	13													X		X	
		14														xP		xP
		15																
TANK AREA EQUIPMENT STATUS																		
0	CS-020-P Caustic Soda Make-up Pump	16																
		17																
0	CS-020-P Caustic Soda Make-up Pump	18																
		19																
0	CS-010-P Reclaimer Caustic Soda Feed Pump	20																
		21																
OUTSIDE TANK AREA PROCESS POINTS AND EQUIPMENT																		
0	CD-001-P Flue Gas Cooling Water Pump	22						xP										
		23					X											
0	CD-001-P Flue Gas Cooling Water Pump	24						xP										
		25					X											

Figure 14. *Cause and Effect Diagrams (6/7)*

CO_2 COMPRESSION CAUSE & EFFECT

LEGEND
OP - Open
NOP - Not Open
CL - Close
NCL - Not Close
P - Set condition is permissive
xP - Reset condition is permissive
X - Activate

Rev. #	SERVICE	SERVICE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	CO2 Capture System Shut Down Signal	1											P				
		2										X					
0	CO2 Capture System Partial shut down	3											P				
		4										X					
0	CO2 Compression System Shut Down Signal	5				P							P				
		6			X							X				X	
COMPRESSOR PROCESS MONITORING POINTS																	
0	1st Stage Suction Scrubber (CO-101-V)	7			X												
		8				xP											
0	Dehydration Unit (CO-101-S)	9								X						X	
		10															
0	Final Stage Cooler (CO-102-A)	11								X						X	
		12															
0	PIC-CO-501 Final Stage Cooler (CO-102-A) CO2 Outlet	13			X												
		14															
0	PIC-CO-501 Final Stage Cooler (CO-102-A) CO2 Outlet	15		X													
		16	xP														
0	CO2 Tie-in	17								X						X	
		18															
		19															
		20								X						X	
0	CO2 Tie-in	21															
		22								X						X	
COMPRESSOR AREA EQUIPMENT STATUS																	
0	CO-101-C CO2 Compression Unit	23															
		24												X			
0	CO-101-C CO2 Compression Unit	25															
		26	xP	X				X									
0	CO2 TO 1st Stage Suction Scrubber (CO-101-V)	27															
		28					X										
		29					X										
		30					X										
0	HY-102-S H2 Generation Unit	31	P														
		32		X													
0	CO-101-S Dehydration Unit	33	P														
		34		X													
0	Pressure Transmitter	35										X	xP				
OUTSIDE COMPRESSOR AREA PROCESS POINTS AND EQUIPMENT																	
0	Pressure Transmitter	36										X	xP				
0	CO2 TO 1st Stage Suction Scrubber (CO-101-V)	37										X					
		38											xP				

Figure 15. *Cause and Effect Diagrams (7/7)*

Overpressure Relief Study

Introduction

The following overpressure relief study summary is based on the carbon capture plant designed by Mitsubishi Heavy Industries (MHI) for installation at the San Juan Generating Station. Contained herein is a description of the relief philosophy, an explanation of the method for determining pressure relief requirements within the carbon capture island. This summary is provided for information only – detailed calculations are not included.

Relief Philosophy

Generally, pressure relief is design possible. For example, Pressure Safety Valves (PSVs) for liquid solvent would normally be relieved by routing the liquid to another location in the process that can safely relieve the pressure without resulting in losses.

MHI utilizes many common industrial pressure relief methods such as relief around a potential block or relief to atmosphere from a pressure vessel. Typical relief locations such as these are considered common practice and are included in the design but not described in detail here.

Systems containing CO_2 are designed with consideration for oxygen displacement and suffocation when CO_2 is released in sufficient quantities. MHI applies a common vent header for CO_2 that must be relieved to the atmosphere. All process equipment containing CO_2 PSVs and Pressure Control Valves (PV) discharge to this header. The header is routed to the CO_2 Absorber (BA-002-TW) stack where the CO_2 will mix with treated flue gas and be carried into the atmosphere with enough elevation and velocity to eliminate the potential for accumulation at ground level.

Evaluation Method

Pressure relief evaluations are based on API 520 and API 521. In accordance with these standards, MHI considered the following potential causes: thermal expansion, tube rupture, cooling water failure, fire (vapor or liquid), block out, and control valve (CV) failure. Special causes that do not fit any of these are grouped together as “Others”.

First, each of the seven causes above are considered for all equipment in the capture acidity, including rare or abnormal occurrences. This process produces a list of equipment that is considered to have potential for overpressure along with the cause(s) for that equipment. Next, the relief needs for each cause for an equipment are evaluated to determine the case with the highest flow rate required to relieve pressure. Then a PSV will be sized and incorporated into the system to prevent a hazardous situation where it will be necessary. Finally, the original list is reviewed to make sure the PSVs added to the system can safely relieve all of the potential causes identified in the first step.

Structural Engineering

Design Condition

Wind/Seismic/Snow loads and criteria are in accordance with the requirements of the International Building Code 2018, which also references ASCE 7-10 for wind/seismic load determination. The structural design will be in accordance with the LRFD (Load and Resistance Factor Design) for steel structure as specified in AISC 360-10.

Table 10. *ISBL Structural Design Conditions*

	Structural Analysis Method		Design Method	Load Calculations and Load Combinations (*1)		Design Verification Items for Structural as a whole and each Structural Elements	
	Structural Analysis	Stability Analysis					
Steel Structure	Linear Elastic Analysis with Moment Redistribution (AISC360-10 B3.3)	Direct Analysis Method (AISC360-10 C1.1)	Load and Resistance Factor Design (LRFD)	Strength Limit State	LRFD Load Combinations thereof (AISC360-10 B.2)	Strength	Design Strength ≥ Required Strength (Ru) φRn ≥ Ru
						Story Drift (Earthquake Load) (*2)	Story Drift (Δ)≤ Allowable Limit (Δa)
				Serviceability Limit State	Serviceability Limit State Load Combinations thereof (ASCE7-10 Appendix CC)	Beam Deflection	Beam Deflection ≤ Allowable Limit
						Story Drift (Wind Load)	Story Drift (Δ)≤ Allowable Limit (Δa) (PIP STC01015 Structural Design Criteria)

Notes)

(*1) For details of each load and their combinations shall be referred to ***Table 3*** and ***4***.

(*2) Drift limitations need not to apply to non-building structure in accordance with ASCE 7-10.

Stairs, Ladders and Platforms

Stairs or ladders and platforms will be used to provide access within and to all buildings and structures for inspection and maintenance of the functioning equipment parts. These stairs or ladders and platforms will be in compliance with OSHA 1910. Ladders with safety systems will be provided to ladder with length of climb greater than 24’-0” or fall greater than 24’-0” and self-closing safety gate at ladder opening on all walking platform with length of climb more than 2’-6” and all safety gate shall be

model XL-71 by FABENCO INC. or approved equal.

Access and maintenance design requirements

Equipment Access

Equipment is expected to require regular maintenance as required by the manufacturer's O&M manuals. Sufficient space shall be provided for maintenance of all equipment, including equipment removal without excessive rigging or removal of surrounding equipment, piping, and valves.

Valves

Valves shall be installed so that they can be operated from the main operating floors or platforms without the use of ladders or special operating devices except the valves located at the height not exceeding 15 ft to be operated during shut-down only. The piping arrangement shall be designed to minimize the use of extensions to valve operators. Gate/Globe valve shall not be installed with the stem downward, in principle. And large size butterfly valve shall not be installed with the stem horizontally.

Maintenance and Accessibility

Adequate space will allow for removal and replacement of components and equipment. All utility service connections off primary headers have isolation valves for maintenance of individual systems.

Mechanical Engineering and Environment

General Design Criteria

Design Pressure and Temperature

Design pressure shall be a minimum of 5% above the maximum possible pressure during operation. For vessels and heat exchangers, 110% of the maximum operating pressure in the system considering normal operation, start up, shut down and upset conditions or 30 psig, whichever is greater, or set point of pressure relief valve. Equipment at downstream of a centrifugal pump which can be blocked has a design pressure not lower than the pump shutoff pressure or set point of pressure relief

valve. For equipment which has a steam out connection shall be designed under full vacuum unless a vacuum relief system is installed. Design temperature shall be 10 °F above a minimum of maximum operating temperature considering normal operation, start up, shut down and upset conditions.

Piping

All piping system will be designed to ASME 31.1. Piping for each system will be per Contractor's piping specifications, and piping and instrumentation diagrams (P&IDs) are provided for all systems. Pipe sizes shall be selected primarily on the basis of velocity, allowable pressure drop for the service, and good engineering practice. For general service piping, 2" and smaller diameter pipes will not be less than schedule 80 thickness. The minimum wall thickness shall be as follows.

Table 11. *Minimum Wall Thickness Table*

Material	Nominal Pipe Size (in)	Minimum Thickness
Carbon steel	<2	Sch 80
	2 1/2 through 6	Sch 40
	8 through 14	Sch 20
	>16	1/4"
Stainless Steel	<2	Sch 40S
	2 1/2 through 8	Sch 10S
	10 through 18	Sch 5S
	>20	0.18"

Valves

Valve material selection will match or be comparable to the piping system on which they are installed. Material will conform to appropriate ASTM standards.

(1) Gate valve shall be used as a shut off valve in general, with exception of following provisions.

(a) Use of butterfly valve: for NPS 4" & larger of water service.

(b) Use of ball valve: as per process requirement.

(2) Globe valve shall be used as a throttle valve, however, butterfly valve (throttle type) or gate valve may be used for piping of NPS 8" & larger of water service according to the application standard of shut off valve.

(3) The joint type of valve shall be as follows.

(a) NPS 2 & smaller: same as pipe and fitting

(b) NPS 2-1/2 & larger: flanged or butt welded ends

(4) Bypass valve (for equalizing during start up and etc.)

Basically, bypass valve shall be installed as per process requirement, however if necessary, bypass valve may be installed based on following criteria.

(a) Globe valve shall be installed as a bypass for gate valve at the piping which require warming up. The size of the globe valve shall be in accordance with the table below.

(b) If the pressure difference between up-stream side and down-stream side of a gate valve becomes more than 80% of maximum working pressure of the valve at the operation temperature, and it is required to balance such pressure difference in normal operation procedure, the bypass valve for balancing shall be provided in accordance with the basis as shown in the table below.

Table 12. *Bypass Valve Requirement Criteria*

Valve Size (NPS: in)	Bypass Valve Size (NPS: in)	Necessity of Bypass Valve			
		Class 300	Class 600	Class 900	Class 1500
6	3/4	Not Required	Not Required	Not Required	Not Required
8	3/4	Not Required	Not Required	Not Required	Required
10	1	Not Required	Not Required	Required	Required
12	1	Not Required	Required	Required	Required
14	1	Not Required	Required	Required	Required
16	1 1/2	Required	Required	Required	Required
18	1 1/2	Required	Required	Required	Required
20	1 1/2	Required	Required	Required	Required
>24	>2	Required	Required	Required	Required

Freeze Protection / Heat Tracing System

All outdoor piping and equipment subject to freezing will be provided with freeze protection including insulation and heat tracing as specified and sufficient drains to drain the entire length of the pipe located outdoors. All outdoor instruments sensing tubing will be heat traced and insulated. Pumps shall generally be located within heated enclosures. Pumps shall be equipped with drains to fully drain the casing when not in use. Pumps in intermittent service shall be winterized with insulation and heating trace if the liquid handled will freeze. Generally, piping 6” in diameter or less that may be subjected to freezing will be protected from freezing via electrical heat tracing wire and insulation and lagging.

Noise

The maximum A-weight sound level will not exceed 85 dB (A) under any normal operating condition when measured at any point three feet away from any piece of equipment in accordance with ANSI Standard S1.13.

Tank Containment

Tank compounds will be protected from leaks and spills by a reinforced concrete containment area. The containment area will be sized to contain the volume of the single largest tank, plus a minimum volume of a 25-year, 24-hour rainfall. Precipitation amounts representing a 24 hour, 25 year occurrence rainfall to be used for sizing the containment areas will be 2.0".

Electrical Engineering

Power System

The new Carbon Capture systems will be powered from two (2) new Unit Auxiliary Transformers (UATs), one (1) from the Unit #1 generator bus and one (1) from the Unit #4 generator bus. The auxiliary power distribution system will provide 13.8 kV and 4.16 kV for medium voltage and 480 V for low voltage.

Prefabricated Power Distribution Center

Prefabricated power distribution center (PDC) will be installed for the Carbon Capture System. This PDC will house the medium voltage switchgear, motor control centers, remote I/O cabinets, lighting panels, process power panels, UPS and other electrical equipment. HVAC units will be installed with N+1 redundancy to ensure a proper environment for the electrical equipment. The PDC will also be provided with a fire alarm system that will be connected to the main plant system.
The configuration of electrical power distribution network of Carbon Capture system is shown in ***Figure 16***.

One-line diagram(s)

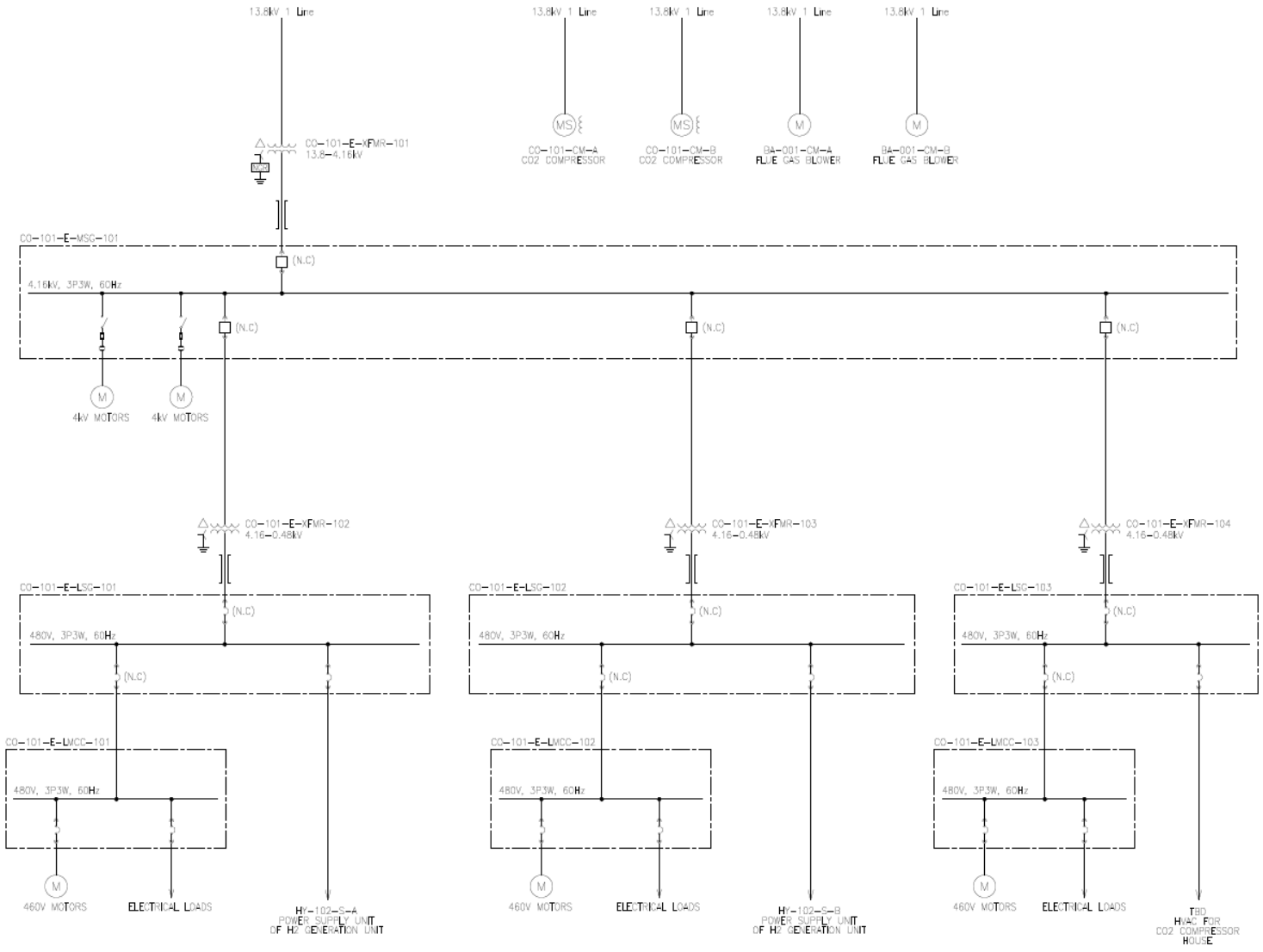


Figure 16. *ISBL Key Line Diagram*

Instrumentation & Controls Engineering (System Integration)

The addition of the Carbon Capture and Compression System will require a new Distributed Control System (DCS) and the new DCS will be located in New Control Room. The Carbon Capture DCS will be on a new network mesh, independent of existing mesh network. Signals will be hard wired between the new Carbon Capture DCS and the existing plant DCS. The BOP systems controls associated with the Carbon Capture Island will be designed by S&L and forwarded to the Carbon Capture Supplier for implementation in the DCS.

New Operator Workstations (OWS) will be provided for control and monitoring, to be located in the new Control Room with new Human Machine Interface (HMI) graphics. Engineering Workstations (EWS) will be located in the new PDC Building Rack room.

New packaged equipment that is procured with the vendor's standard microprocessor-based control systems or Programmable Logic Controllers (PLC) will interface with the new DCS.

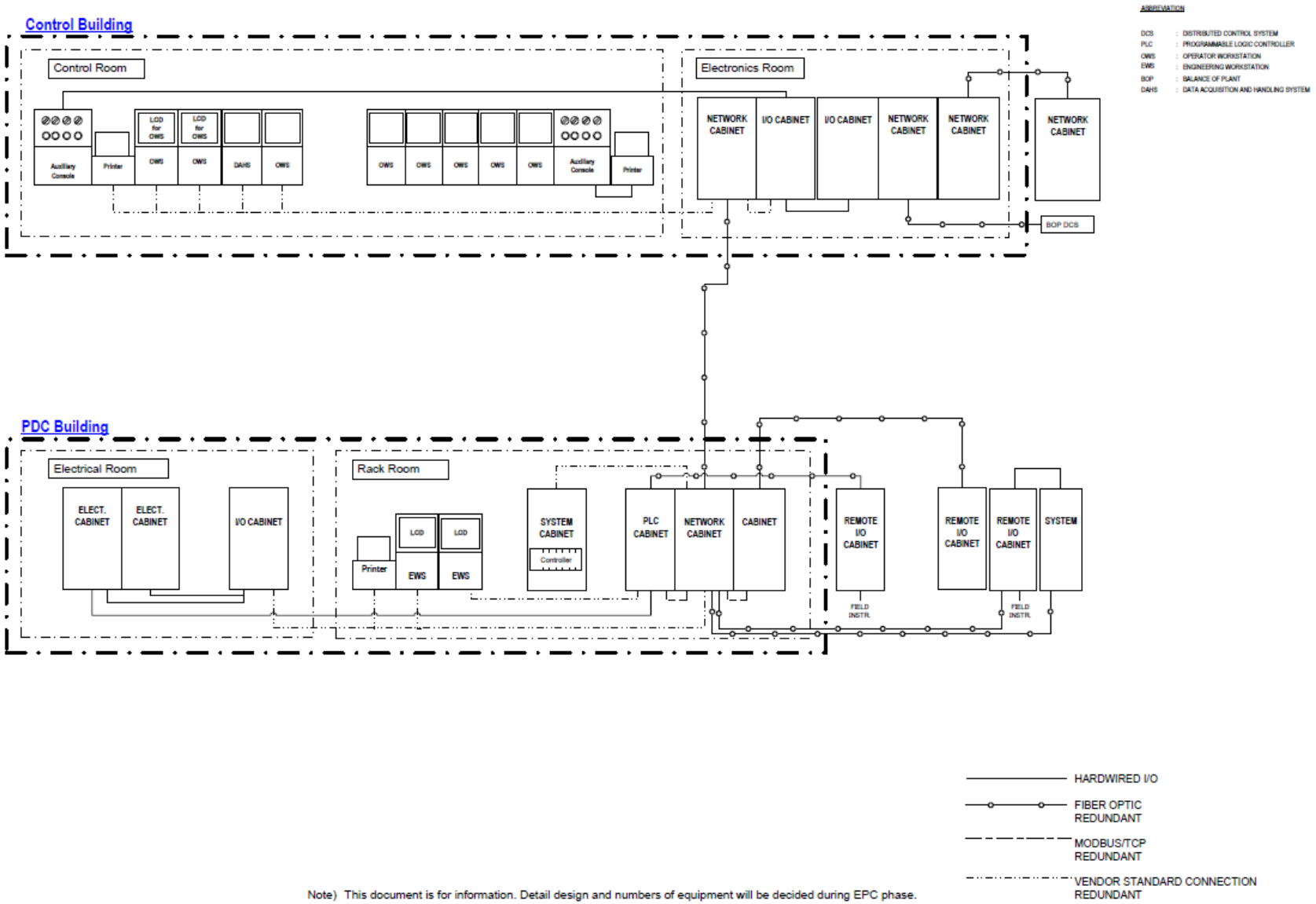


Figure 17. *Conceptual Control System Architecture*

Facilities Engineering

HVAC

General HVAC Design Criteria

Design Temperatures:

- ASHRAE Fundamentals Handbook: Four Corners Regional, NM (WMO: 723658)
- Cooling design dry bulb temperature: 96.1°F
- Cooling design wet bulb temperature:59.4°F
- Heating design dry bulb temperature: 9.1°F

Design Criteria:

a) HVAC systems will maintain the indoor environmental conditions in terms of space temperature and humidity, air filtration, air quality, and enclosure pressurization in order to provide efficient equipment operation and comfortable working conditions for personnel.

b) General process equipment enclosures will be heated and ventilated. Heating will be by electric unit heaters. Ventilation will be by louvers at high level of the external wall for natural exhaust.

c) The PDC building and H2 Generation Unit enclosure will be air conditioned, heated and ventilated to maintain suitable operating temperatures as defined in ***Table 13***. Ambient conditions used in the sizing of the HVAC systems will be based on the site conditions included in Section 2. Detail design will be by the HVAC subcontractor.

Table 13*. Indoor Design Conditions for HVAC Systems*

Building	**Rooms**	**Type**	**Min Temp**	**Max Temp**	**Min RH**	**Max RH**
PDC Building	Electrical equipment	HVAC	65^{o}F	85^{o}F	20%	60%
H_2 Generation Unit		HVAC	60^{o}F	95^{o}F	---	---
Miscellaneous Unoccupied Process Equipment Areas		H&V	60^{o}F	104^{o}F	---	---

d) The heating and cooling required for each space will be calculated in accordance with the methodology described in the ASHRAE Fundamentals Handbook chapter for Nonresidential Heating and Cooling Load Calculation Procedures and ASHRAE Standard 183.

e) The minimum amount of outdoor air for spaces served by HVAC systems will meet the requirements of the International Mechanical Code and ASHRAE 62.1.

f) Exhaust ventilation will be provided for areas required by the International Mechanical Code and ASHRAE 62.1.

g) The design of the HVAC systems and equipment will meet the applicable requirements of ASHRAE 90.1.

h) The design of the HVAC systems will meet the applicable requirements of NFPA 90A "Installation of Air Conditioning and Ventilating Systems."

i) Duct penetrations and air transfer openings in fire barriers will be protected with approved fire dampers installed in accordance with their listing as required by the International Mechanical Code and International Building Code.

j) Air distribution systems will be provided with smoke detectors listed and labeled for installation in air distribution systems as required by the International Mechanical Code.

k) Smoke control systems will be provided in accordance with the International Building Code and the International Mechanical Code where required by Chapter 4 of the International Building Code.

l) Smoke and heat vents will be provided where required by the fire risk evaluation. The smoke and heat vents will be designed in accordance with NFPA 204.

m) The heating, ventilating, and air conditioning system controls will meet the applicable requirements of ASHRAE 90.1 ASHRAE/ANSI 135 (BACnet).

Plant Layout and Construction Access

The new carbon capture facility will consist of the equipment shown in the Plot Plan. A “mirrored” arrangement was selected to allow the construction site to be grouped into smaller unitized areas. Each unit area contains identical process equipment and components to its “mirrored” counterpart area. This “mirrored” arrangement enhances design efficiency, minimizes quantities, and improves construction work area activity planning.

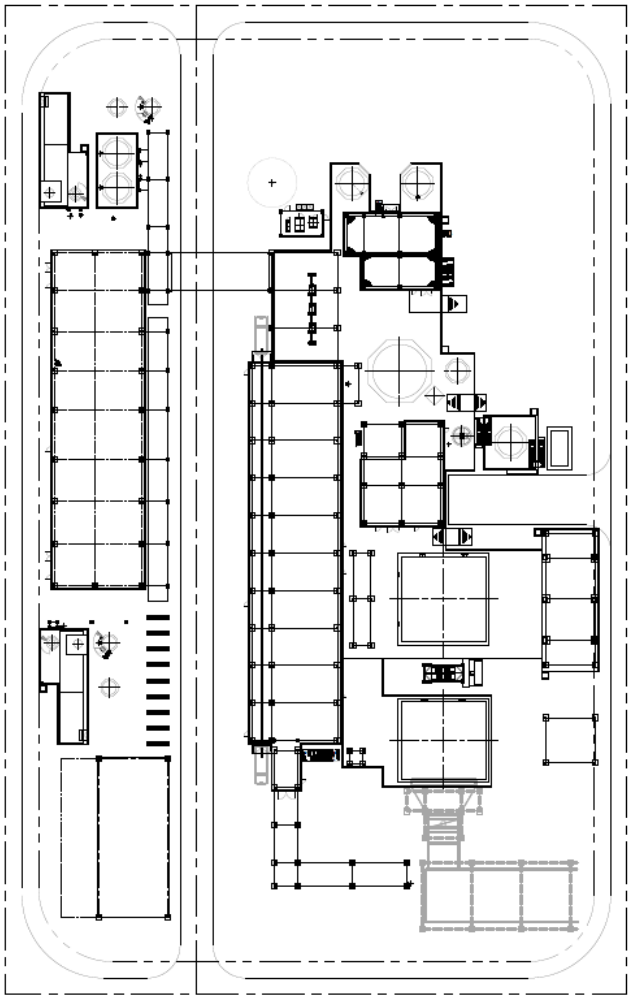


Figure 18. *General Plot Plan*

Pipe Rack and Process Structure Modularization (ISBL)

Pipe rack and process structure modularization allows for parallel construction of modules offsite at specialized fabrication facilities while the main site is under construction. The benefits of doing this include improved project efficiency, schedule, safety, quality, cost, and convenience. Each module is a pre-designed and pre-fabricated steel structure mounted with process mechanical and electrical equipment, pipes, insulation, instrumentation, valves, and wiring. These pre-fabricated modules will be transported from the off-site fabricator's shop in separate pieces.

Appendix C. Permit Matrix

No.	Agency	Permit or Approval	Applicability	When Required	Expected Agency Review Time	Comments
Enchant Energy Carbon Capture Retrofit Project						
1.0	**Federal Permits**					
1.1	Federal Aviation Administration (FAA)	Determination of No Hazard	Required for the construction of structures over 200' above ground level, and any other activities requiring aeronautical review under 14 CFR § 77.9.	Prior to start of construction	45 days	Application is submitted electronically.
1.2	U.S.EPA Federal Land Manager Indian Governing Body	Federal Review of Air Permit specified by 20.2.74.403 NMAC	Required for Part 74 (PSD) construction permit applications that may affect Federal Class I areas.	Prior to start of construction	60 days - parallel review with Part 74 construction permit	Federal review of air permit if the project is classified as a major modification located within 100 km of any Class I area. SJGS is less than 100 km from Mesa Verde National Park, which is a Class I area. NMED coordinates this review as part of Part 74 permit review - separate application/coordination not required.
1.3	BLM BIA	NEPA Environmental Review	Required for projects with a significant federal nexus.	Prior to commencing construction activities (including placing binding equipment orders)	Varies depending on the level of NEPA review required (CatEx, EA, EIS)	Federal actions associated with the carbon capture project consist of right-of-way grants across BLM/BIA land (for the project's associated CO2 pipeline).
1.4	U.S. Fish & Wildlife Service	Section 7 Endangered Species Act Consultation	Required as part of NEPA process	Prior to NEPA decision	TBD	Level of consultation depends on potential project-related impacts. NEPA lead agency coordinates this consultation.
1.5	U.S.EPA	NPDES Construction General Stormwater Permit	Required if construction activities disturb >1 acre of ground	Prior to start of construction	14 days after receiving completed NOI.	

No.	Agency	Permit or Approval	Applicability	When Required	Expected Agency Review Time	Comments
2.0	**State Permits**					
2.1	NMED	State Pre-Construction/New Source Review Air Permit (under 20.2.72 NMAC)	Required if proposed facility modifications meet the criteria of 20.2.72.200.A(2) NMAC (physical or operational change that results in an increase in the potential emission rate of any regulated air contaminant). Note that the regulation includes an exception for the installation of air pollution control equipment "undertaken for the purpose of complying with regulations adopted by the board or pursuant to the federal act"	Prior to start of construction	Completeness review period is 30 days. Permit review period is 90 days from completeness determination for non-PSD construction permits. NMED can request a review period extension of 90 days (one reason would be if public hearings are required). Approx. 120-210 days depending on public comment/hearings	"Modification" means any physical change in, or change in the method of operation of, a stationary source which results in an increase in the potential emission rate of any regulated air contaminant emitted by the source or which results in the emission of any regulated air contaminant not previously emitted, but does not include: (1) a change in ownership of the source; (2) routine maintenance, repair or replacement; (3) installation of air pollution control equipment, and all related process equipment and materials necessary for its operation, undertaken for the purpose of complying with regulations adopted by the board or pursuant to the federal act; or (4) unless previously limited by enforceable permit conditions: (a) an increase in the production rate, if such increase does not exceed the operating design capacity of the source; (b) an increase in the hours of operation
2.2	NMED	Notice of Intent to modify air contaminants source (20.2.73 NMAC)	Must submit if intending to modify facility with potential emissions of more than 10 tpy of any regulated air contaminant or 1 tpy of lead.	Written confirmation from NMED that no permit is required must be obtained prior to construction. If a permit IS required, the permit must be obtained prior to construction.	30 day review period.	Notice of intent is included in the Part 72/74 construction permit application forms. Separate submittal is not required.
2.3	NMED	State Pre-Construction/New Source Review Major Source Prevention of Significant Deterioration (PSD) Permit (under 20.2.74 NMAC)	Required if the project meets the definition of a "major modification" in 20.2.74.	Prior to commencing construction activities (including entering into binding agreements or contractual obligations)	30 day completeness review 180 day review period (which can be extended up to 90 more days if requested) Approx. 10 months	Required if the project is classified as a "major modification," to the San Juan Generating Station (see 20.2.74). At this time, the Project is expected to be subject to PSD permitting for VOCs. Only one permit application needs to be submitted for both PSD and construction permit.

No.	Agency	Permit or Approval	Applicability	When Required	Expected Agency Review Time	Comments
2.0	**State Permits (Continued)**					
2.4	NMED	Title V Permit Administrative Revision	Required for change in ownership.	Prior to the ownership transfer.	60 days	20.2.70.404 PERMIT MODIFICATIONS: A. Administrative Permit Amendments: (2) Changes in ownership or operational control of a source may be made as administrative amendments provided that: (a) A written agreement, containing a specific date for transfer of permit responsibility, coverage, and liability between the current and new permittee, has been submitted to the Department, and either the Department has determined that no other change in the permit is necessary, or changes deemed necessary by the Department have been made; (b) The new owners have submitted the application information required in paragraph (2) of subsection D of 20.2.70.300 NMAC; (c) No grounds exist for permit termination, as set out in subparagraphs (b) and (c) of paragraph (3) of subsection A of 20.2.70.405 NMAC; and (d) The permittee has published a public notice of the change in ownership of the source in a newspaper of general circulation in the area where the source is located.
2.5	NMED	Title V Permit Significant Modification	Required to incorporate construction permit requirements.	Within 12 months after commencing operation, and written notification to NMED required prior to construction.	Completeness review period is 60 days. Full review takes 9 months on average; however, legally NMED has up to 18 months to review. Longest = 20 months	The carbon capture project will be a major modification subject to the Part 72 Construction Permit requirements; therefore, the Title V will require modification within 12-months of commencing construction. Title V also requires modification for change in ownership. Note: PNM submitted renewal for existing permit 11/10/20. Contact: Melinda Owens (Title V Program Manager) 505-476-4341
2.6	NMED	Acid Rain Permit	Permit transfer required	Prior to the ownership transfer.	To be determined	Operation of affected unit under the federal Acid Rain Program. Existing San Juan Generating Station permit will be transferred.

No.	Agency	Permit or Approval	Applicability	When Required	Expected Agency Review Time	Comments
2.0	**State Permits (Continued)**					
2.7	NMED	Statewide Air Quality Permit	Required if a major modification will be located within an area designated as attainment or unclassifiable for any national ambient air quality standard pursuant to Section 107 of the federal Clean Air Act, when it would cause or contribute to a violation of any national ambient air quality standard	N/A	30 day completeness review 90 day review period (which can be extended up to 90 more days if requested) Longest = 7 months	Further evaluation pursuant to Subsection D of 20.2.79.109 NMAC is required to confirm applicability.
2.8	New Mexico - Game and Fish Department	State Threatened/ Endangered Species Consultation	Required as part of NEPA process.	Prior to NEPA decision	TBD - if applicable	
2.9	State Historic Preservation Officer (SHPO) or Tribal Historic Preservation Officer (THPO)	National Historic Preservation Act Consultation	Required as part of NEPA process.	Prior to NEPA decision	TBD - if applicable	
2.10	NM OSE	Water Rights	SJGS has existing OSE Permit 2838 and SJ-2197. No additional rights will be required if total facility water use remains below the existing amount of water available for use.	N/A	N/A	"The amount of water rights available for use at SJGS is 15,877 afa diversion and 12,000 afa consumptive use, of which 10,585 diversion/8,000 afa consumptive use is not subject to prior call by Four Corners Power and 5,292 afa diversion/4,000 afa consumptive use is subject to prior call by FCPP" (Cuddy & McCarthy, December 30, 2019)
2.11	NMED	Solid waste	Modification to existing permits/compliance plan if changes to types of solid waste being generated. No changes are anticipated, therefore no changes will be required aside from the transfer of any existing permits.	N/A	N/A	No changes to solid waste generation are anticipated.

No.	Agency	Permit or Approval	Applicability	When Required	Expected Agency Review Time	Comments
2.0	**State Permits (Continued)**					
2.12	NMED	Groundwater discharge permit (under 20.6.2.2.3104 NMAC)	Transfer of existing permits required. Permit modifications may be required if there are changes in the amount or makeup of discharge water.	Prior to ownership transfer	N/A	Zero liquid discharge facility. Transfer requirements discussed in 20.6.2.3111 NMAC: A. Prior to any transfer of ownership, control, or possession (whether by lease, conveyance or otherwise) of a facility with a discharge permit, the transferor shall notify the transferee in writing of the existence of the discharge permit, and shall deliver or send by certified mail to the department a copy of such written notification, together with a certification or other proof that such notification has in fact been received by the transferee. B. Upon receipt of such notification, the transferee shall have the duty to inquire into all of the provisions and requirements contained in such discharge permit, and the transferee shall be charged with notice of all such provisions and requirements as they appear of record in the department's file or files concerning such discharge permit. C. Until both ownership and possession of the facility have been transferred to the transferee, the transferor shall continue to be responsible for any discharge from the facility. D. Upon assuming either ownership or possession of the facility, the transferee shall have the same rights and responsibilities under the discharge permit as were applicable to the transferor.

No.	Agency	Permit or Approval	Applicability	When Required	Expected Agency Review Time	Comments
2.13	NMED	Petroleum Tanks	Existing tanks require ownership transfer. Notification will be required for the construction of any new tanks subject to 20.5.101 NMAC	Prior to ownership transfer.	N/A	20.5.102.201 TRANSFER OF OWNERSHIP: A. No purported transfer of any storage tank system shall be effective to create, alter or extinguish any right or responsibility of any person subject to this part, unless the following transfer requirements are met. (1) Prior to any transfer of ownership, control or possession, whether by lease, conveyance or otherwise, of a property with a regulated storage tank system, the transferor shall notify the department and shall provide the name, address and phone number of the transferee, as well as the date and type of transfer (sale or lease, for example). The transferor shall also notify the transferee, prior to the transfer, of the existence of the storage tank system, of the transferee's registration obligations under this part, and of these rules. (2) Upon receipt of such notification, the transferee shall re-register the tank with the department within 30 days of transfer of ownership, and shall provide all information required for registration in 20.5.102.206 NMAC. The transferee also shall have the duty to inquire into all of the provisions and requirements of this part. 20.5.102.202 NEW STORAGE TANK SYSTEMS: The owner shall notify the department in writing at least 30 days before any new above ground or underground storage tank system is installed, and shall register any new tank or storage tank system with the department within 60 days of placing a regulated substance in the tank, unless an extension is granted.
2.14	NMDOT	Hauling Permit	For oversize/overweight loads. Will be responsibility of owner/operator of transporting vehicle.	Prior to transporting oversize/overweight loads.	N/A	Only the owner/operator of the transporting vehicle or someone operating the transporting vehicle under a lease agreement may apply for a special permit.

No.	Agency	Permit or Approval	Applicability	When Required	Expected Agency Review Time	Comments
3.0	**Local Permits**					
3.1	San Juan County Building Division	Construction Permit	Required for erection, construction, alterations, enlargements, repairs, moving, improving, converting, or demolishing projects.	Start of construction	TBD	San Juan County has jurisdiction at SJGS Contact: Larry Hathaway 505-334-4550 Expires 1 year from date of issuance. Can be extended an additional year by paying an extra fee. Fee is based on total project value * .005
3.2	San Juan County Building Division	Plan Review	Any building or structure requiring an architect or engineer's seal.	Start of construction	TBD	Fee is based on total project value * .0012

* This is a preliminary list of the environmental permits and approvals that may be required for the SJGS carbon capture project. The list includes only those permits/approvals that may require significant engineering, environmental review, or agency review time. Permits included in this list are limited to those required for upgrades to the existing SJGS boilers and installation of the carbon capture island, and does not include permits/approvals required for construction of the proposed CO2 pipeline.

Appendix D. Project Execution Schedule

ENCHANT ENERGY LLC

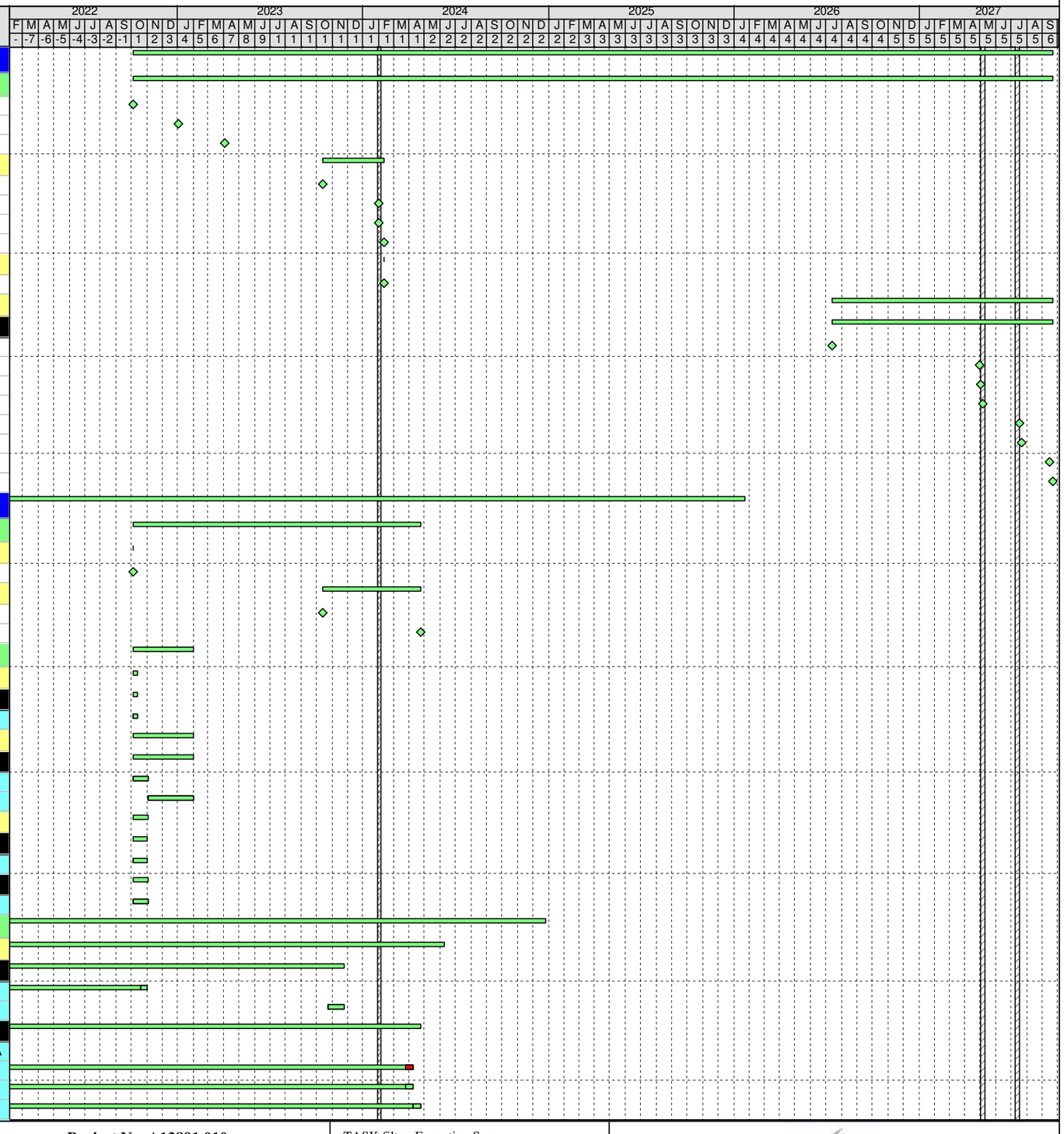
OWNER

Enchant Estimated Summary Schedule

Data Date: 20-Jul-21

07-Jun-22

Activity ID	Activity Name	Ori Dur	Start	Finish
SJGS EXECUTION MS		813	04-Oct-22	20-Sep-27
Execution Milestones		813	04-Oct-22	20-Sep-27
MSX-EPC	EPC Contract Award / LNTP	0		04-Oct-22
MSX-ETA	ETA Deadline	0		01-Jan-23
MSX-EPCF	EPC Financial Close / FNTP	0		03-Apr-23
Permitting MS		121	13-Oct-23	12-Feb-24
MS-PRM	Receive PSD Air Permit	0		13-Oct-23
MS-PRM02	Receive LOCAL Bldg Permits	0		01-Feb-24
MS-PRM03	Receive Stormwater General Permit	0		01-Feb-24
MS-PRM01	Receive NEPA Permit	0		12-Feb-24
Construction MS		0	12-Feb-24	12-Feb-24
MSX-CN	Start Construction/Site Mobilization	0	12-Feb-24*	
Commissioning & Start-Up MS		434	14-Jul-26	20-Sep-27
CC Island Com/SU Train MS		434	14-Jul-26	20-Sep-27
MSCC-BF	CC - Backfeed	0	14-Jul-26	
MSX-CO1	1st Train - Ready for Flue Gas	0		29-Apr-27
MSX-FF1	First Fire U1	0		01-May-27
MSX-FF2	First Fire U4	0		06-May-27
MSX-COD1	Substantial Completion - U1	0		16-Jul-27
MSX-COD2	Substantial Completion - U4	0		21-Jul-27
MSX-FC1	Final Completion - U1	0		15-Sep-27
MSX-FC2	Final Completion - U4	0		20-Sep-27
SJGS - EPC Schedule_Working		977	24-Aug-20 A	21-Jan-26
MILESTONE		568	04-Oct-22	23-Apr-24
Contract Milistone		0	04-Oct-22	04-Oct-22
MC005	Full Notice to Proceed(FNTP) - CCS Portion	0	04-Oct-22*	
Project Milestone		193	13-Oct-23	23-Apr-24
MG260	3D Model Review 2nd Complete	0		13-Oct-23
MG270	3D Model Review 3rd Complete	0		23-Apr-24
PROJECT MANAGEMENT		120	04-Oct-22	31-Jan-23
Project Management		10	04-Oct-22	13-Oct-22
Project Management General		10	04-Oct-22	13-Oct-22
Planning & Procedure		10	04-Oct-22	13-Oct-22
Schedule Control		120	04-Oct-22	31-Jan-23
Baseline Schedule Planning		120	04-Oct-22	31-Jan-23
Master Schedule Planning (Lv.2)		31	04-Oct-22	03-Nov-22
Detailed Schedule Planning (Lv.3)		89	04-Nov-22	31-Jan-23
QA/QC		31	04-Oct-22	03-Nov-22
Inspection Planning		30	04-Oct-22	02-Nov-22
Inspection Planning - Overall		30	04-Oct-22	02-Nov-22
Quality Assurance		31	04-Oct-22	03-Nov-22
Quality Assurance - QA Plan Preparation, etc.		31	04-Oct-22	03-Nov-22
ENGINEERING		586	24-Aug-20 A	26-Dec-24
Process		1119	17-May-21 A	08-Jun-24
Process Design Basis		922	17-May-21 A	24-Nov-23
Design Basis		535	17-May-21 A	02-Nov-22
Conceptual Operation Plan		31	25-Oct-23	24-Nov-23
Process Basic Design		055	04-Jun-21 A	23-Apr-24
Equipment List		23	16-Jun-21 A	09-Jul-21 A
Process Flow Diagram		040	04-Jun-21 A	09-Apr-24
Utility Flow Diagram		028	16-Jun-21 A	09-Apr-24
Stream Data		968	30-Aug-21 A	23-Apr-24



Remaining Level of Effort
Actual Level of Effort
Actual Work
Remaining Work
Critical Remaining Work
Current Milestone
Actual Milestone
WBS Summary Act

TASK filter: Execution Sum.
P6 Project Id: 583160 Rev.P-1...
Database Location: FPT04

Sargent & Lundy

ENCHANT ENERGY LLC

OWNER

Enchant Estimated Summary Schedule

Data Date: 20-Jul-21

07-Jun-22

Activity ID	Activity Name	Ori Dur	Start	Finish
	Process Description	29	13-Sep-21 A	12-Oct-21 A
	Utility Summary List	25	16-Sep-21 A	11-Oct-21 A
	Design Flow Plan	1023	21-Jun-21 A	08-Apr-24
	Piping & Instrument Diagram	831	05-Jul-21 A	13-Oct-23
	P&I Diagram - Process	831	05-Jul-21 A	13-Oct-23
	Process Data Sheet	592	10-Jun-21 A	22-Jan-23
	Process Data Sheet - Process	592	10-Jun-21 A	22-Jan-23
	Study & Calculation	724	01-Oct-21 A	24-Sep-23
	HAZOP Study	56	31-Jul-23	24-Sep-23
	HAZOP Study No.2	56	31-Jul-23	24-Sep-23
	Pump Head Calculation	15	18-Nov-22	02-Dec-22
	Pressure Drop Calculation	45	18-Nov-22	01-Jan-23
	Safety Valve Calculation	35	01-Oct-21 A	05-Nov-21
	Information for Other Groups	30	18-Nov-22	17-Dec-22
	Information for Instrumentation	30	18-Nov-22	17-Dec-22
	Catalyst & Chemical List	1012	02-Aug-21 A	09-May-24
	Chemical List	1012	02-Aug-21 A	09-May-24
	Laboratory Design	873	04-Oct-21 A	23-Feb-24
	Laboratory Design	873	04-Oct-21 A	23-Feb-24
	Commissioning	214	25-Sep-23	25-Apr-24
	Operation Manual	91	25-Sep-23	24-Dec-23
	Commissioning Procedure	92	25-Oct-23	24-Jan-24
	Performance Test Procedure	92	25-Jan-24	25-Apr-24
	Analytical Manual	92	25-Jan-24	25-Apr-24
	Purchase Spec. / Subcontract Spec.	951	01-Nov-21 A	08-Jun-24
	Purchase Spec.	951	01-Nov-21 A	08-Jun-24
	Equipment	1194	24-Aug-20 A	30-Nov-23
	Equipment Basic Design	101	07-Jun-21 A	16-Sep-21
	Equipment Eng'g Standard	7	07-Jun-21 A	14-Jun-21 A
	Equipment Reference Drawing	7	09-Sep-21 A	16-Sep-21
	Engineering Dwg & Loading Data	996	24-Aug-20 A	16-May-23
	Engineering Dwg	674	12-Jul-21 A	16-May-23
	Engineering Dwg for Piping Layout	674	12-Jul-21 A	16-May-23
	Engineering Dwg with Nozzle Orientation	120	17-Jan-23	16-May-23
	Loading Data	459	24-Aug-20 A	26-Nov-21
	Equipment Detail Design (Vendor Dwg)	273	03-Mar-23	30-Nov-23
	General Arrangement Drawing	226	03-Mar-23	14-Oct-23
	Loading Data	225	19-Mar-23	29-Oct-23
	Other Dwg	273	03-Mar-23	30-Nov-23
	Coordination for Other Groups	1009	23-Jan-21 A	29-Oct-23
	Coordination for Piping	904	23-Jan-21 A	16-Jul-23
	Coordination for Civil & Architecture	1003	29-Jan-21 A	29-Oct-23
	Equipment BOQ / MPPL	361	18-Nov-22	13-Nov-23
	Bill of Quantity	361	18-Nov-22	13-Nov-23
	3D Model Review	61	14-Aug-23	13-Oct-23
	Equipment 3D Model Check with Vendor Dwg	61	14-Aug-23	13-Oct-23
	Purchase Spec. / Subcontract Spec.	1023	28-Aug-20 A	16-Jun-23
	Purchase Spec.	1023	28-Aug-20 A	16-Jun-23
	Machinery	1172	02-Oct-20 A	18-Dec-23
	Machinery Basic Design	36	10-Jun-21 A	16-Jul-21 A
	Machinery Eng'g Standard	7	10-Jun-21 A	17-Jun-21 A
	Machinery Reference Drawing	14	02-Jul-21 A	16-Jul-21 A
	Machinery Detail Design (Vendor Dwg)	260	03-Apr-23	18-Dec-23

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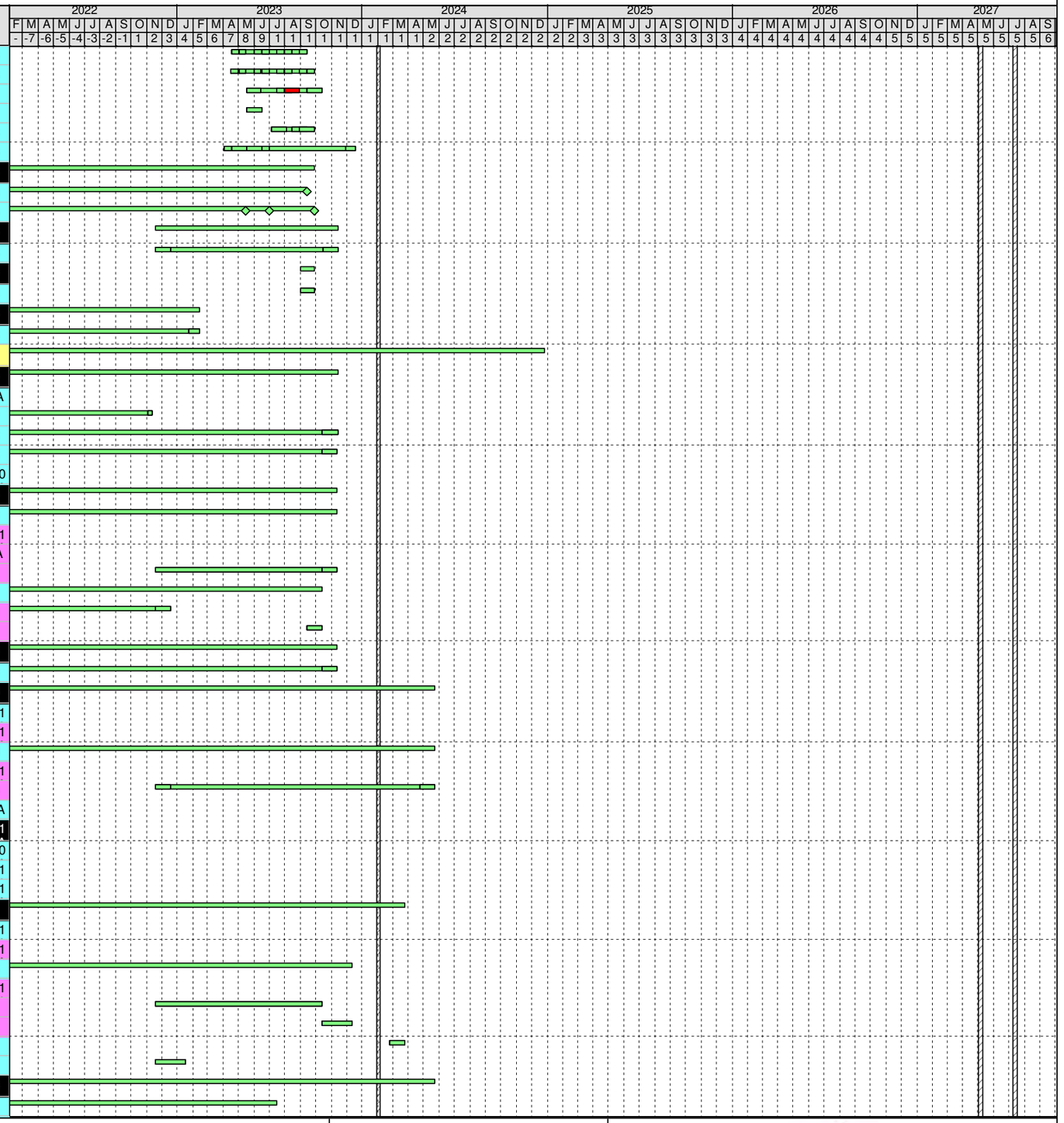
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Enchant Estimated Summary Schedule

Data Date: 20-Jul-21

07-Jun-22

Activity ID	Activity Name	Ori Dur	Start	Finish
	GA Dwg / Outline Dwg	149	18-Apr-23	13-Sep-23
	Loading Data	165	17-Apr-23	28-Sep-23
	Vendor P&ID	150	17-May-23	13-Oct-23
	Allowable Nozzle Forces and Moment	31	17-May-23	16-Jun-23
	Logic Diagram	85	06-Jul-23	28-Sep-23
	Other Vendor Dwg	260	03-Apr-23	18-Dec-23
	Coordination for Other Groups	091	02-Oct-20 A	28-Sep-23
	Coordination for Piping	076	02-Oct-20 A	13-Sep-23
	Coordination for Civil & Architecture	091	02-Oct-20 A	28-Sep-23
	Machinery BOQ / MPPL	361	18-Nov-22	13-Nov-23
	Bill of Quantity	361	18-Nov-22	13-Nov-23
	3D Model Review	30	31-Aug-23	29-Sep-23
	Machinery 3D Model Check with Vendor Dwg	30	31-Aug-23	29-Sep-23
	Purchase Specification	584	09-Jul-21 A	12-Feb-23
	Purchase Spec.	584	09-Jul-21 A	12-Feb-23
	Piping	544	05-Oct-20 A	26-Dec-24
	Piping Design Basis	057	23-Dec-20 A	14-Nov-23
	Piping Design Basis	8	07-Jun-21 A	15-Jun-21 A
	Piping Material Spec.	493	08-Jul-21 A	12-Nov-22
	Piping Standard Dwg	882	16-Jun-21 A	14-Nov-23
	Piping Support Standard Dwg	880	16-Jun-21 A	12-Nov-23
	Fire Protection System Design Basis	6	23-Dec-20 A	28-Dec-20
	Piping & Instrument Diagram	861	05-Jul-21 A	12-Nov-23
	P&I Diagram - Process (inc. Legend)	861	05-Jul-21 A	12-Nov-23
	Process P&ID (IFA)	63	05-Jul-21 A	06-Sep-21
	Process P&ID of Follow-Up Comment & HAZOP Study	38	07-Sep-21 A	15-Oct-21 A
	Process P&ID of Follow-Up Vendor Dwg	360	18-Nov-22	12-Nov-23
	Line List	773	01-Sep-21 A	13-Oct-23
	Line List (IFA)	474	01-Sep-21 A	18-Dec-22
	Line List for Construction	31	13-Sep-23	13-Oct-23
	Piping Material Data Sheet	091	17-Nov-20 A	12-Nov-23
	Piping Material Data Sheet	091	17-Nov-20 A	12-Nov-23
	Plot Plan / Equipment Layout	228	12-Jan-21 A	23-May-24
	Plot Plan	64	28-Jun-21 A	31-Aug-21
	Plot Plan (IFA)	64	28-Jun-21 A	31-Aug-21
	Equipment Layout	914	22-Nov-21 A	23-May-24
	Equipment Layout (IFA)	23	22-Nov-21 A	15-Dec-21
	Equipment Layout Follow-Up Vendor Dwg	553	18-Nov-22	23-May-24
	Fire Protection System Layout	29	12-Jan-21 A	10-Feb-21 A
	Piping Route Plan	431	05-Oct-20 A	10-Dec-21
	U/G Piping Plan	28	05-Oct-20 A	02-Nov-20
	Piping Route Plan for Piperack	39	01-Nov-21 A	10-Dec-21
	Piping Route Plan around Equipment	39	01-Nov-21 A	10-Dec-21
	Calculation & Analysis	906	01-Oct-21 A	24-Mar-24
	Piping Pressure Loss Calculation	60	01-Oct-21 A	30-Nov-21
	Piping Pressure Loss Calculation for Piping Layout Dwg	60	01-Oct-21 A	30-Nov-21
	Piping Thermal Stress Calculation	758	15-Nov-21 A	12-Dec-23
	Piping Thermal Stress Calculation for Piperack/Structure Plan & L/D	44	15-Nov-21 A	28-Dec-21
	Piping Thermal Stress Calculation for Piping Layout	330	18-Nov-22	13-Oct-23
	Piping Thermal Stress Calculation for Final	60	14-Oct-23	12-Dec-23
	Safety Valve Sizing Calculation	30	24-Feb-24	24-Mar-24
	Restriction Orifice Calculation	61	18-Nov-22	17-Jan-23
	Information for Other Groups	264	07-Dec-20 A	23-May-24
	Pipe Rack Plan & L/D	951	07-Dec-20 A	15-Jul-23



Remaining Level of Effort
Actual Level of Effort
Actual Work
Remaining Work
Critical Remaining Work
Current Milestone
Actual Milestone
WBS Summary Act

TASK filter: Execution Sum.
P6 Project Id: 583160 Rev.P-1...
Database Location: FPT04

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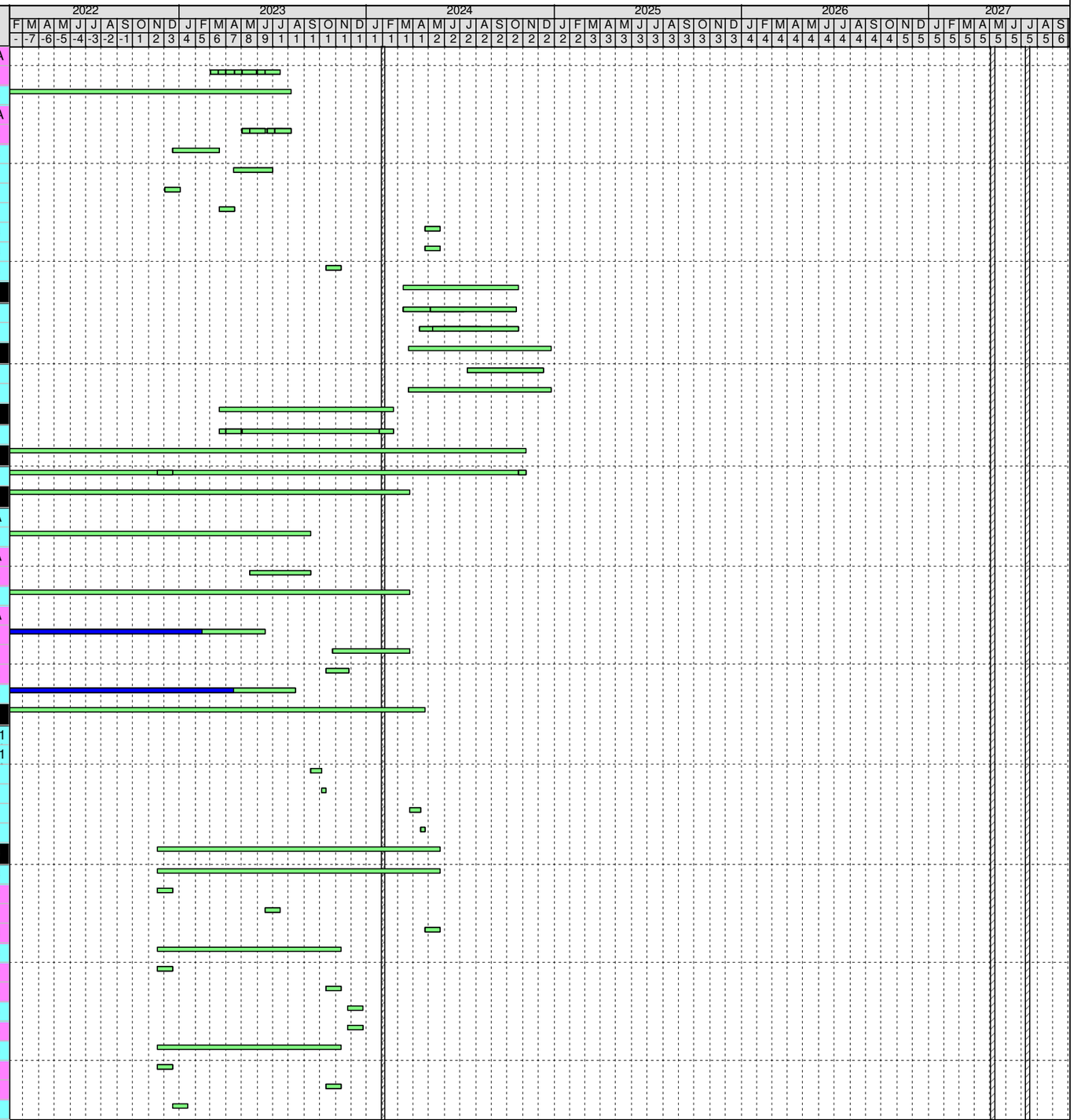
OWNER

Enchant Estimated Summary Schedule

Data Date: 20-Jul-21

07-Jun-22

Activity ID	Activity Name	Ori Dur	Start	Finish
	Piperack L/D for Civil Structural Calc.	122	07-Dec-20 A	08-Apr-21 A
	Piperack L/D for Civil Detail Design	135	03-Mar-23	15-Jul-23
	Structure Plan & L/D	971	08-Dec-20 A	05-Aug-23
	Structure L/D for Civil Structural Calc.	118	08-Dec-20 A	05-Apr-21 A
	Structure L/D for Civil Detail Design	96	02-May-23	05-Aug-23
	Nozzle Orientation Plan	92	18-Dec-22	19-Mar-23
	Piping Support Pad Plan	77	17-Apr-23	02-Jul-23
	Platform and Stage Plan & L/D	30	03-Dec-22	01-Jan-23
	Piping Sewer & Pit Plan	30	20-Mar-23	18-Apr-23
	Piping Penetration Hole Plan	30	24-Apr-24	23-May-24
	Piping Support Embedded Plate Plan	30	24-Apr-24	23-May-24
	Miscellaneous Piping Information	30	14-Oct-23	12-Nov-23
	Piping Isometric Dwg	225	12-Mar-24	22-Oct-24
	Piping Isometric Dwg for Pipe Rack	222	12-Mar-24	19-Oct-24
	Piping Isometric Dwg around Equipment	194	12-Apr-24	22-Oct-24
	Piping Support Dwg	280	22-Mar-24	26-Dec-24
	Piping Support Foundation Layout Dwg	150	15-Jul-24	11-Dec-24
	Support Style List around Equipment	280	22-Mar-24	26-Dec-24
	Piping Vendor Dwg Review	340	19-Mar-23	21-Feb-24
	Piping Vendor Dwg	340	19-Mar-23	21-Feb-24
	Piping BOQ / MPPL	1156	08-Sep-21 A	06-Nov-24
	Bill of Quantity	1156	08-Sep-21 A	06-Nov-24
	3D Modeling Work	1244	28-Oct-20 A	24-Mar-24
	3D Set Up	180	18-Jan-21 A	16-Jul-21 A
	3D Modeling Work for Equipment & Machinery	1051	28-Oct-20 A	13-Sep-23
	3D Modeling for Equipment & Machinery for 1st Review	276	28-Oct-20 A	31-Jul-21 A
	3D Modeling for Equipment & Machinery for 2nd Review	120	17-May-23	13-Sep-23
	3D Modeling Work for A/G Piping	1244	28-Oct-20 A	24-Mar-24
	3D Modeling for A/G Piping for 1st Review	276	28-Oct-20 A	31-Jul-21 A
	3D Modeling for A/G Piping for 2nd Review	962	28-Oct-20 A	16-Jun-23
	3D Modeling for A/G Piping for 3rd Review	150	27-Oct-23	24-Mar-24
	A/G Piping Follow-Up 3rd Review	45	14-Oct-23	27-Nov-23
	3D Modeling Work for Others	942	15-Jan-21 A	14-Aug-23
	3D Model Review	884	22-Nov-21 A	23-Apr-24
	Internal Review & Follow 1st	4	22-Nov-21 A	26-Nov-21
	3D Model Review 1st (30%)	1	30-Nov-21 A	01-Dec-21
	Internal Review & Follow 2nd	21	14-Sep-23	04-Oct-23
	3D Model Review 2nd (60%)	9	05-Oct-23	13-Oct-23
	Internal Review & Follow 3rd	21	25-Mar-24	14-Apr-24
	3D Model Review 3rd (90%)	9	15-Apr-24	23-Apr-24
	Piping MTO	553	18-Nov-22	23-May-24
	Piping Material MTO (Piping / Fitting / Flange)	553	18-Nov-22	23-May-24
	AGP 1st MTO	30	18-Nov-22	17-Dec-22
	AGP 2nd MTO	30	17-Jun-23	16-Jul-23
	AGP 3rd MTO	30	24-Apr-24	23-May-24
	Valve MTO	360	18-Nov-22	12-Nov-23
	Valve 1st MTO	31	18-Nov-22	18-Dec-22
	Valve 2nd MTO	30	14-Oct-23	12-Nov-23
	Safety Device MTO	31	25-Nov-23	25-Dec-23
	Safety Valve / Rupture Disk MTO	31	25-Nov-23	25-Dec-23
	Complete Parts MTO	360	18-Nov-22	12-Nov-23
	Expansion Joint MTO	30	18-Nov-22	17-Dec-22
	Other Complete Parts MTO	30	14-Oct-23	12-Nov-23
	Piping Support MTO	31	18-Dec-22	17-Jan-23



Remaining Level of Effort | Actual Work | Critical Remaining Work | Actual Milestone

Actual Level of Effort | Remaining Work | Current Milestone | WBS Summary Act

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P6 Project Id: 583160 Rev.P-1...
Database Location: FPT04

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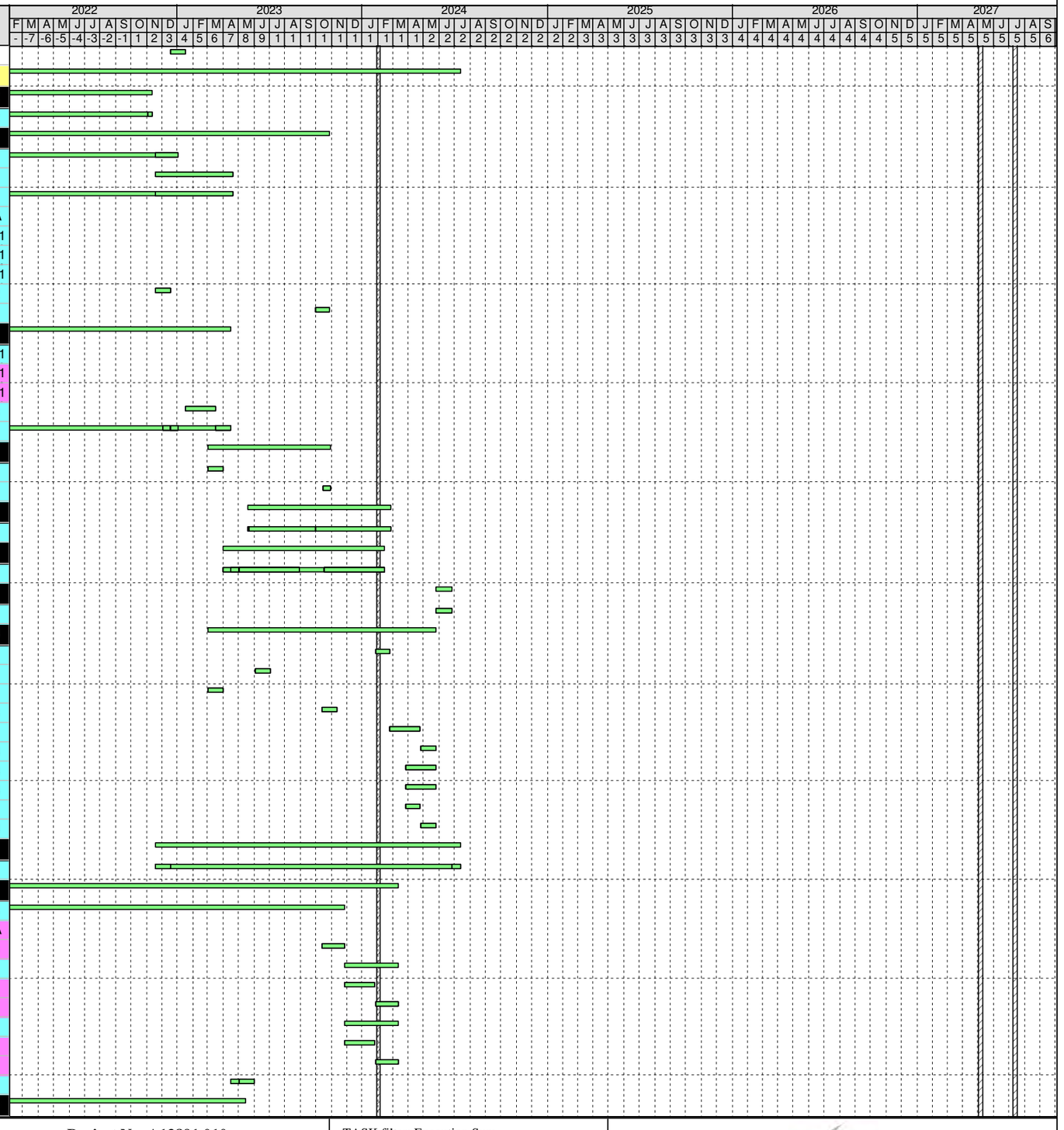
OWNER

Enchant Estimated Summary Schedule

Data Date: 20-Jul-21

07-Jun-22

Activity ID	Activity Name	Ori Dur	Start	Finish
EPN80010A	Piping Support MTO	31	18-Dec-22	17-Jan-23
Instrumentation		326	25-Nov-20 A	12-Jul-24
Instrumentation Design Basis		524	07-Jun-21 A	12-Nov-22
Instrumentation Eng'g Standard		524	07-Jun-21 A	12-Nov-22
Control System Basic Design		1068	25-Nov-20 A	28-Oct-23
Control System Configuration Diagram		481	08-Sep-21 A	01-Jan-23
Instrument Loop Scheme		153	18-Nov-22	19-Apr-23
Interlock / Sequence Logic Diagram		542	25-Oct-21 A	19-Apr-23
Layout Plan of Control System in Control Room and Loading Data		225	25-Nov-20 A	08-Jul-21 A
Power Supply and Grounding Diagram for Instrument System		32	22-Nov-21 A	24-Dec-21
I/O List		78	08-Sep-21 A	25-Nov-21
Control System Specification		74	17-Sep-21 A	30-Nov-21
Control System Detail Specification		31	18-Nov-22	18-Dec-22
Set Point List		28	01-Oct-23	28-Oct-23
Field Instrument Basic Design		586	08-Sep-21 A	16-Apr-23
Instrument Schedule List		71	08-Sep-21 A	18-Nov-21
Instrument Schedule List Preliminary		71	08-Sep-21 A	18-Nov-21
Instrument Schedule List (IFA)		71	08-Sep-21 A	18-Nov-21
Nozzle Elevation Plan for Level Instrument		60	17-Jan-23	17-Mar-23
Field Instrument Specification		514	19-Nov-21 A	16-Apr-23
Instrumentation Work Planning and Basic Design		242	02-Mar-23	29-Oct-23
Layout Plan of Instrument Main Cable way and Loading Data		31	02-Mar-23	01-Apr-23
Foundation Plan for Instrumentation		15	15-Oct-23	29-Oct-23
Control System Vendor Dwg Review		283	20-May-23	26-Feb-24
Control System Vendor Dwg Review		283	20-May-23	26-Feb-24
Field Instrument Vendor Dwg Review		319	02-Apr-23	14-Feb-24
Field Instrument Vendor Dwg Review		319	02-Apr-23	14-Feb-24
Construction Specification / Procedure		31	26-May-24	25-Jun-24
Instrumentation Work Test Procedure		31	26-May-24	25-Jun-24
Instrumentation Work Design		451	02-Mar-23	25-May-24
Instrument Plot Plan		28	27-Jan-24	23-Feb-24
Control Equipment Layout in Control Room		31	04-Jun-23	04-Jul-23
Layout of Instrument U/G Conduit		31	02-Mar-23	01-Apr-23
Instrument Main Cable Way Layout		30	14-Oct-23	12-Nov-23
Layout of Instrument Wiring		61	24-Feb-24	24-Apr-24
Instrument Wiring/Tubing Connection List		31	25-Apr-24	25-May-24
Instrument Wiring Hook-Up		61	26-Mar-24	25-May-24
Instrument Piping Hook-Up		61	26-Mar-24	25-May-24
Instrument Cable/Tube Schedule/Wiring Diagram		30	26-Mar-24	24-Apr-24
Instrument Cable/Tube Drum Schedule		31	25-Apr-24	25-May-24
Instrument BOQ / MPPL		603	18-Nov-22	12-Jul-24
Bill of Quantity		603	18-Nov-22	12-Jul-24
3D Modeling Work		1015	01-Jun-21 A	11-Mar-24
3D Modeling Work for Instr. Cable Tray		910	01-Jun-21 A	27-Nov-23
3D Modeling for Instr. Cable Tray for 2nd Review		30	01-Jun-21 A	01-Jul-21 A
3D Model Review Follow-up for Instr. Cable Tray		45	14-Oct-23	27-Nov-23
3D Modeling Work for Field Panel and JB		107	26-Nov-23	11-Mar-24
3D Modeling for Field Panel and JB for 2nd Review		62	26-Nov-23	26-Jan-24
3D Model Review Follow-up for Field Panel and JB		45	27-Jan-24	11-Mar-24
3D Modeling Work for Stanchion Instrument		107	26-Nov-23	11-Mar-24
3D Modeling for Stanchion Instrument for 2nd Review		62	26-Nov-23	26-Jan-24
3D Model Review Follow-up for Stanchion Instrument		45	27-Jan-24	11-Mar-24
In-line Instrument Outline Data (RDB)		46	17-Apr-23	01-Jun-23
Purchase Spec. / Subcontract Spec.		824	12-Feb-21 A	16-May-23



Remaining Level of Effort | Actual Work | Critical Remaining Work | Actual Milestone

Actual Level of Effort | Remaining Work | Current Milestone | WBS Summary Act

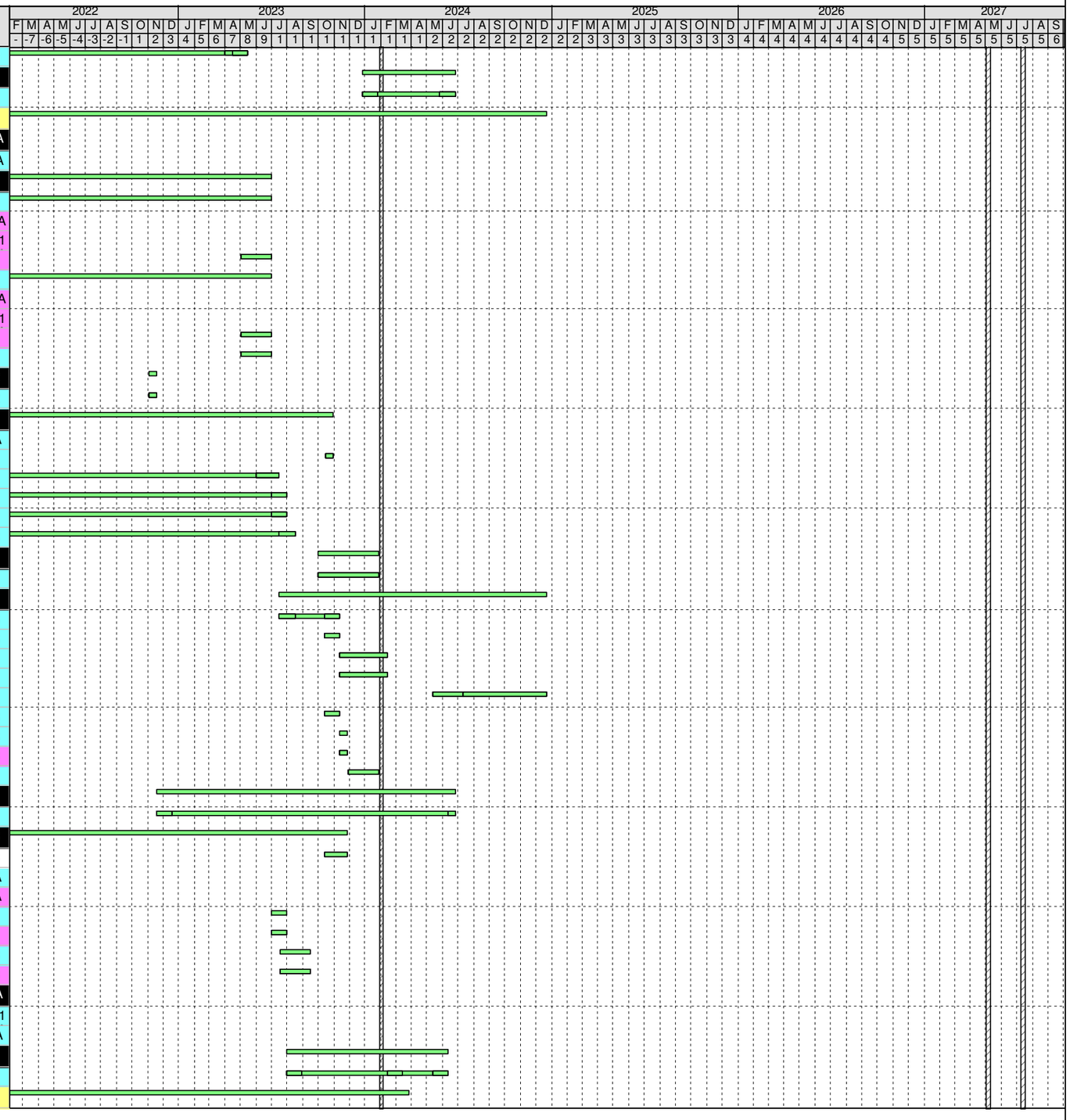
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P6 Project Id: 583160 Rev.P-1...

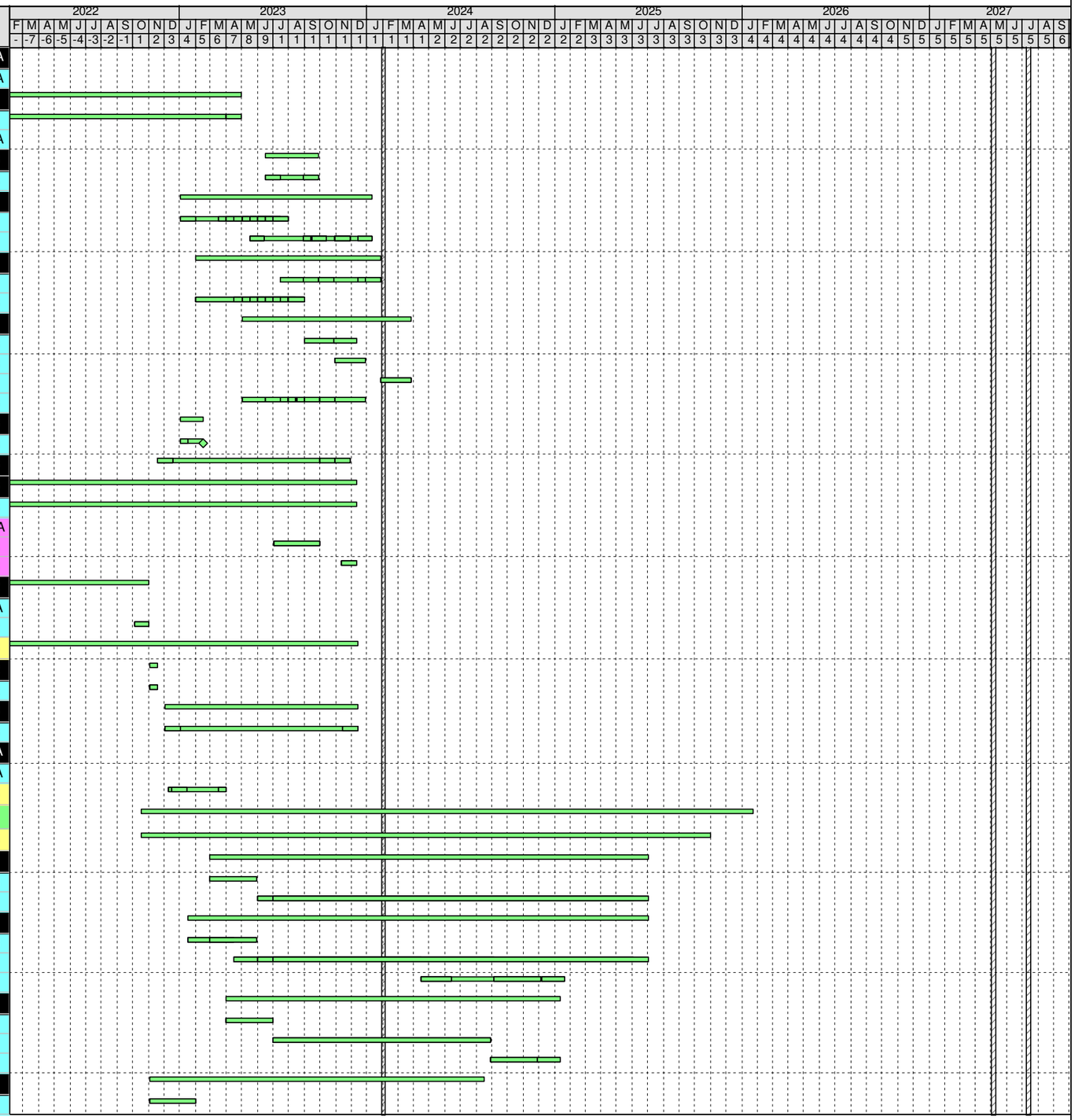
Database Location: FPT04

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Activity ID	Activity Name	Ori Dur	Start	Finish
	Purchase Spec.	824	12-Feb-21 A	16-May-23
	Instrumentation Construction Material MTO	182	27-Dec-23	25-Jun-24
	Instrument Installation Material MTO	182	27-Dec-23	25-Jun-24
	Electrical	1300	01-Jun-21 A	21-Dec-24
	Electrical Design Basis	8	07-Jun-21 A	15-Jun-21 A
	Electrical Eng'g Standard	8	07-Jun-21 A	15-Jun-21 A
	Electrical Basic Design	718	14-Jul-21 A	02-Jul-23
	Electrical Load Summary	718	14-Jul-21 A	02-Jul-23
	Electrical Load Summary for Electrical Equip. Inquiry	28	14-Jul-21 A	11-Aug-21 A
	Electrical Load Summary for Electrical Equip. PO (IFA)	63	14-Jul-21 A	15-Sep-21
	Electrical Load Summary for Electrical Equip. Fabrication	60	03-May-23	02-Jul-23
	One Line Diagram	718	14-Jul-21 A	01-Jul-23
	One Line Diagram for Electrical Equip. Inquiry	28	14-Jul-21 A	11-Aug-21 A
	One Line Diagram for Electrical Equip. PO (IFA)	63	14-Jul-21 A	15-Sep-21
	One Line Diagram for Electrical Equip. Fabrication	60	03-May-23	01-Jul-23
	Calculation of Electrical Basic Design	60	03-May-23	02-Jul-23
	Electrical Equipment Basic Design	15	03-Nov-22	17-Nov-22
	Electrical Equipment Specification	15	03-Nov-22	17-Nov-22
	Electrical Work Planning	866	16-Jun-21 A	29-Oct-23
	Electrical Standard for Construction Design	21	16-Jun-21 A	07-Jul-21 A
	Substation Layout and L/D	15	15-Oct-23	29-Oct-23
	Electrical Main Cable Route Plan	642	13-Oct-21 A	16-Jul-23
	Electrical Main Cable Route L/D	684	16-Sep-21 A	31-Jul-23
	Electrical Cable Trench Plan	657	13-Oct-21 A	31-Jul-23
	Lighting Plan	661	25-Oct-21 A	16-Aug-23
	Electrical Equip. Vendor Dwg Review	120	30-Sep-23	27-Jan-24
	Electrical Equip. Vendor Dwg Review	120	30-Sep-23	27-Jan-24
	Electrical Work Design	524	17-Jul-23	21-Dec-24
	U/G Conduit / Duct Bank / Trench Layout	119	17-Jul-23	12-Nov-23
	Electrical Cable Tray Layout	30	14-Oct-23	12-Nov-23
	Power & Control Wiring Layout	92	13-Nov-23	12-Feb-24
	Lighting Wiring Layout	92	13-Nov-23	12-Feb-24
	Heat Trace Layout	224	12-May-24	21-Dec-24
	Electrical Cable Schedule	30	14-Oct-23	12-Nov-23
	Electrical Cable Drum Schedule	15	13-Nov-23	27-Nov-23
	Cable Drum Schedule for Fabrication	15	13-Nov-23	27-Nov-23
	Electrical Terminal Connection Diagram	61	28-Nov-23	27-Jan-24
	Electrical BOQ / MPPL	587	18-Nov-22	26-Jun-24
	Bill of Quantity	587	18-Nov-22	26-Jun-24
	3D Modeling Work	910	01-Jun-21 A	27-Nov-23
EEK00010A	3D Model Update	45	14-Oct-23	27-Nov-23
	3D Modeling Work for Electrical Cable Tray	30	01-Jun-21 A	01-Jul-21 A
	3D Modeling for Electrical Cable Tray	30	01-Jun-21 A	01-Jul-21 A
	3D Modeling Work for Local Control Switch / Local Panel	30	01-Jul-23	30-Jul-23
	3D Modeling for Local Control Switch / Local Panel	30	01-Jul-23	30-Jul-23
	3D Modeling Work for Lighting	60	18-Jul-23	15-Sep-23
	3D Modeling for Lighting	60	18-Jul-23	15-Sep-23
	Electrical Purchase Specification	90	07-Jul-21 A	05-Oct-21 A
	Purchase Spec.	77	07-Jul-21 A	22-Sep-21
	Subcontract Specification	1	04-Oct-21 A	05-Oct-21 A
	Electrical Construction Material MTO	317	31-Jul-23	11-Jun-24
	Electrical Construction Material MTO	317	31-Jul-23	11-Jun-24
	Civil & Architecture	1247	28-Oct-20 A	27-Mar-24



Activity ID	Activity Name	Ori Dur	Start	Finish
	General Design Basis	15	03-Jun-21 A	18-Jun-21 A
	Engineering Standard	15	03-Jun-21 A	18-Jun-21 A
	Standard Drawing	693	07-Jun-21 A	30-Apr-23
	Steel Structure Standard Dwg	693	07-Jun-21 A	30-Apr-23
	Civil Standard Dwg	17	07-Jun-21 A	24-Jun-21 A
	Basic Plan Drawing (For Owner's Approval)	104	17-Jun-23	28-Sep-23
	Building Basic Plan Dwg	104	17-Jun-23	28-Sep-23
	Design Guide & Preliminary Design Guide Dwg.	375	02-Jan-23	11-Jan-24
	Design Guide for Structure	210	02-Jan-23	30-Jul-23
	Loading Data	240	17-May-23	11-Jan-24
	Detail Design Calculation	361	01-Feb-23	27-Jan-24
	Calculation Sheet for Building	196	16-Jul-23	27-Jan-24
	Calculation Sheet for Structure	212	01-Feb-23	31-Aug-23
	Detail Design Drawing	331	02-May-23	27-Mar-24
	Building Structural Dwg	104	31-Aug-23	12-Dec-23
	Building Architectural Dwg	60	30-Oct-23	28-Dec-23
	Building HVAC Dwg	60	28-Jan-24	27-Mar-24
	Structure Detail Dwg	242	02-May-23	29-Dec-23
	Coordination for Other Groups	45	02-Jan-23	15-Feb-23
	Common & Coordination for Others	45	02-Jan-23	15-Feb-23
	Civil BOQ / MPPL	377	18-Nov-22	29-Nov-23
	3D Modeling Work	I141	28-Oct-20 A	12-Dec-23
	3D Modeling Work for Structure	I141	28-Oct-20 A	12-Dec-23
	3D Modeling for Structure (Step-1)	132	28-Oct-20 A	09-Mar-21 A
	3D Update for Structure (Step-2)	90	03-Jul-23	30-Sep-23
	3D Update for Structure (Step-4)	31	12-Nov-23	12-Dec-23
	Purchase Spec. / Subcontract Spec.	462	29-Jul-21 A	02-Nov-22
	Subcontract Specification	78	29-Jul-21 A	15-Oct-21 A
	Engineering Work Specification	30	04-Oct-22	02-Nov-22
	Construction	826	10-Sep-21 A	14-Dec-23
	Construction Specification	15	03-Nov-22	17-Nov-22
	Spec. for Painting	15	03-Nov-22	17-Nov-22
	Construction BOQ / MPPL	377	03-Dec-22	14-Dec-23
	Bill of Quantity	377	03-Dec-22	14-Dec-23
	Purchase Spec. / Subcontract Spec.	31	10-Sep-21 A	11-Oct-21 A
	Subcontract Specification	31	10-Sep-21 A	11-Oct-21 A
	Transportation	112	10-Dec-22	31-Mar-23
	PROCUREMENT	I193	17-Oct-22	21-Jan-26
	Stationary Equipment Procurement	1112	17-Oct-22	01-Nov-25
	Tower / Column	856	01-Mar-23	03-Jul-25
	Tower / Column Inquiry/PO	92	01-Mar-23	31-May-23
	Tower / Column Fabrication	764	01-Jun-23	03-Jul-25
	Vessel / Drum	900	16-Jan-23	03-Jul-25
	Vessel / Drum Inquiry/PO	136	16-Jan-23	31-May-23
	Vessel / Drum Fabrication	809	17-Apr-23	03-Jul-25
	Vessel / Drum Transportation	279	16-Apr-24	19-Jan-25
	S&T Heat Exchanger	652	02-Apr-23	12-Jan-25
	S&T Heat Exchanger Inquiry/PO	90	02-Apr-23	30-Jun-23
	S&T Heat Exchanger Fabrication	425	01-Jul-23	28-Aug-24
	S&T Heat Exchanger Transportation	137	29-Aug-24	12-Jan-25
	Plate Heat Exchanger	652	03-Nov-22	15-Aug-24
	Plate Heat Exchanger Inquiry/PO	90	03-Nov-22	31-Jan-23



ENCHANT ENERGY LLC

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Enchant Estimated Summary Schedule

Data Date: 20-Jul-21

07-Jun-22

Activity ID	Activity Name	Ori Dur	Start	Finish
	Plate Heat Exchanger Fabrication	425	01-Feb-23	31-Mar-24
	Plate Heat Exchanger Transportation	137	01-Apr-24	15-Aug-24
	Shop Tank	639	15-Apr-23	12-Jan-25
	Shop Tank Inquiry/PO	92	15-Apr-23	15-Jul-23
	Shop Tank Fabrication	410	16-Jul-23	28-Aug-24
	Shop Tank Transportation	137	29-Aug-24	12-Jan-25
	Mixer / Silencer / Ejector	624	30-Apr-23	12-Jan-25
	Mixer / Silencer / Ejector Inquiry/PO	92	30-Apr-23	30-Jul-23
	Mixer / Silencer / Ejector Fabrication	395	31-Jul-23	28-Aug-24
	Mixer / Silencer / Ejector Transportation	137	29-Aug-24	12-Jan-25
	Tower Internal & Other Internal	1112	17-Oct-22	01-Nov-25
	Tower Internal & Other Internal Inquiry/PO	137	17-Oct-22	02-Mar-23
	Tower Internal & Other Internal Fabrication	1020	17-Jan-23	01-Nov-25
	Tower Internal & Other Internal Transportation	436	01-Apr-24	10-Jun-25
	Other Equipment	712	01-Feb-23	12-Jan-25
	Other Equipment Inquiry/PO	180	01-Feb-23	30-Jul-23
	Other Equipment Fabrication	485	02-May-23	28-Aug-24
	Other Equipment Transportation	137	29-Aug-24	12-Jan-25
	Machinery Procurement	1031	03-Nov-22	29-Aug-25
	Centrifugal Pump (Middle & Light Duty)	712	03-Nov-22	14-Oct-24
	Centrifugal Pump (Middle & Light Duty) Inquiry/PO	120	03-Nov-22	02-Mar-23
	Centrifugal Pump (Middle & Light Duty) Fabrication	455	03-Mar-23	30-May-24
	Centrifugal Pump (Middle & Light Duty) Transportation	197	01-Apr-24	14-Oct-24
	Centrifugal Compressor	1017	17-Nov-22	29-Aug-25
	Centrifugal Compressor Inquiry/PO	91	17-Nov-22	15-Feb-23
	Centrifugal Compressor Fabrication	790	16-Feb-23	15-Apr-25
	Centrifugal Compressor Transportation	226	16-Jan-25	29-Aug-25
	Fan / Blower	764	16-Dec-22	17-Jan-25
	Fan / Blower Inquiry/PO	122	16-Dec-22	16-Apr-23
	Fan / Blower Fabrication	505	17-Apr-23	02-Sep-24
	Fan / Blower Transportation	137	03-Sep-24	17-Jan-25
	Hydrogen Recoery Unit	702	16-Feb-23	17-Jan-25
	Hydrogen Recoery Unit Inquiry/PO	90	16-Feb-23	16-May-23
	Hydrogen Recoery Unit Fabrication	475	17-May-23	02-Sep-24
	Hydrogen Recoery Unit Transportation	137	03-Sep-24	17-Jan-25
	Other Unit	794	13-Feb-23	16-Apr-25
	Other Unit Inquiry/PO	108	13-Feb-23	31-May-23
	Other Unit Fabrication	567	15-May-23	01-Dec-24
	Other Unit Transportation	272	19-Jul-24	16-Apr-25
	Piping Materail Procurement	765	18-Dec-22	20-Jan-25
	A/G Piping Material (1st)	301	16-Jan-23	12-Nov-23
	A/G Piping Material (1st) Inquiry/PO	61	16-Jan-23	17-Mar-23
	A/G Piping Material (1st) Fabrication	180	18-Mar-23	13-Sep-23
	A/G Piping Material (1st) Transportation	60	14-Sep-23	12-Nov-23
	A/G Piping Material (2nd)	241	17-Jul-23	13-Mar-24
	A/G Piping Material (2nd) Inquiry/PO	61	17-Jul-23	15-Sep-23
	A/G Piping Material (2nd) Fabrication	120	16-Sep-23	13-Jan-24
	A/G Piping Material (2nd) Transportation	60	14-Jan-24	13-Mar-24
	A/G Piping Material (3rd)	226	23-Apr-24	04-Dec-24
	A/G Piping Material (3rd) Inquiry/PO	61	23-Apr-24	22-Jun-24
	A/G Piping Material (3rd) Fabrication	105	23-Jun-24	05-Oct-24
	A/G Piping Material (3rd) Transportation	60	06-Oct-24	04-Dec-24
	Valve (1st)	406	17-Jan-23	26-Feb-24



Remaining Level of Effort
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TASK filter: Execution Sum.
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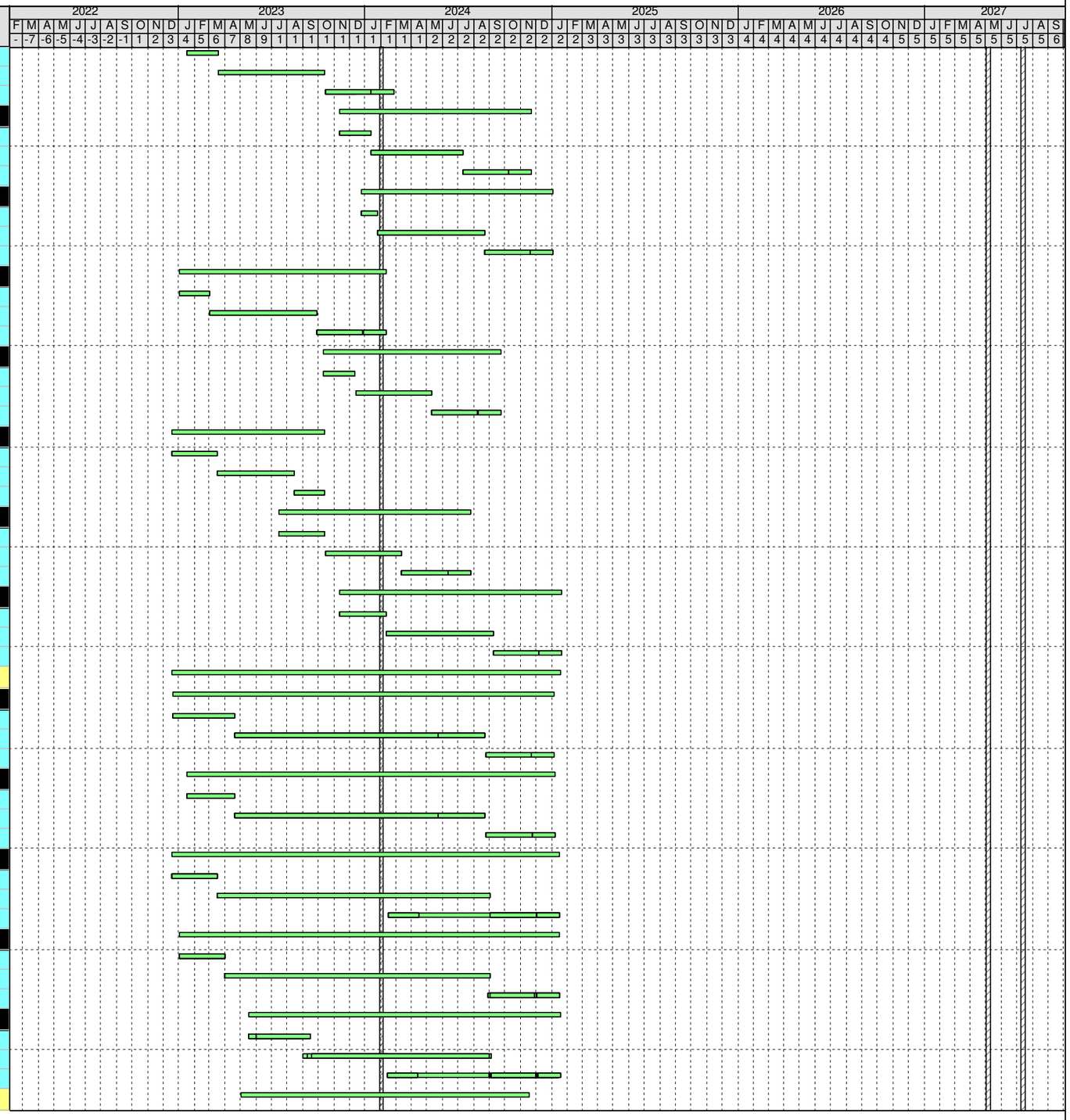
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Enchant Estimated Summary Schedule

Data Date: 20-Jul-21

07-Jun-22

Activity ID	Activity Name	Ori Dur	Start	Finish
	Valve (1st) Inquiry/PO	61	17-Jan-23	18-Mar-23
	Valve (1st) Fabrication	210	19-Mar-23	14-Oct-23
	Valve (1st) Transportation	135	15-Oct-23	26-Feb-24
	Valve (2nd)	376	13-Nov-23	22-Nov-24
	Valve (2nd) Inquiry/PO	61	13-Nov-23	12-Jan-24
	Valve (2nd) Fabrication	180	13-Jan-24	10-Jul-24
	Valve (2nd) Transportation	135	11-Jul-24	22-Nov-24
	Safety Device (1st)	376	25-Dec-23	03-Jan-25
	Safety Device (1st) Inqury/PO	31	25-Dec-23	24-Jan-24
	Safety Device (1st) Fabrication	210	25-Jan-24	21-Aug-24
	Safety Device (1st) Transportation	135	22-Aug-24	03-Jan-25
	Complete Parts (1st)	406	01-Jan-23	10-Feb-24
	Complete Parts (1st) Inqury/PO	61	01-Jan-23	02-Mar-23
	Complete Parts (1st) Fabrication	210	03-Mar-23	28-Sep-23
	Complete Parts (1st) Transportation	135	29-Sep-23	10-Feb-24
	Complete Parts (2nd)	347	12-Oct-23	22-Sep-24
	Complete Parts (2nd) Inqury/PO	62	12-Oct-23	12-Dec-23
	Complete Parts (2nd) Fabrication	150	13-Dec-23	10-May-24
	Complete Parts (2nd) Transportation	135	11-May-24	22-Sep-24
	Bolt, Nut & Gasket (1st)	300	18-Dec-22	13-Oct-23
	Bolt, Nut & Gasket (1st) Inquiry/PO	90	18-Dec-22	17-Mar-23
	Bolt, Nut & Gasket (1st) Fabrication	150	18-Mar-23	14-Aug-23
	Bolt, Nut & Gasket (1st) Transportation	60	15-Aug-23	13-Oct-23
	Bolt, Nut & Gasket (2nd)	375	17-Jul-23	25-Jul-24
	Bolt, Nut & Gasket (2nd) Inquiry/PO	90	17-Jul-23	14-Oct-23
	Bolt, Nut & Gasket (2nd) Fabrication	150	15-Oct-23	12-Mar-24
	Bolt, Nut & Gasket (2nd) Transportation	135	13-Mar-24	25-Jul-24
	Piping Support Material (1st)	435	13-Nov-23	20-Jan-25
	Piping Support Material (1st) Inqury/PO	90	13-Nov-23	10-Feb-24
	Piping Support Material (1st) Fabrication	210	11-Feb-24	07-Sep-24
	Piping Support Material (1st) Transportation	135	08-Sep-24	20-Jan-25
	Instrumentation Procurement	763	18-Dec-22	18-Jan-25
	DCS	747	21-Dec-22	05-Jan-25
	DCS Inquiry/PO	120	21-Dec-22	19-Apr-23
	DCS Fabrication	492	20-Apr-23	23-Aug-24
	DCS Transportation	135	24-Aug-24	05-Jan-25
	Other Control System	722	17-Jan-23	07-Jan-25
	Other Control System Inquiry/PO	93	17-Jan-23	19-Apr-23
	Other Control System Fabrication	492	20-Apr-23	23-Aug-24
	Other Control System Transportation	137	24-Aug-24	07-Jan-25
	Control Valve	760	18-Dec-22	15-Jan-25
	Control Valve Inquiry/PO	90	18-Dec-22	17-Mar-23
	Control Valve Fabrication	535	18-Mar-23	02-Sep-24
	Control Valve Transportation	335	16-Feb-24	15-Jan-25
	Flow Instrument	745	02-Jan-23	15-Jan-25
	Flow Instrument Inquiry/PO	90	02-Jan-23	01-Apr-23
	Flow Instrument Fabrication	520	02-Apr-23	02-Sep-24
	Flow Instrument Transportation	140	29-Aug-24	15-Jan-25
	Other Instrument	613	17-May-23	18-Jan-25
	Other Insrument Inquiry/PO	123	17-May-23	16-Sep-23
	Other Insrument Fabrication	370	31-Aug-23	03-Sep-24
	Other Insrument Transportation	340	14-Feb-24	18-Jan-25
	Electrical Equipment & Material Procurement	565	03-May-23	17-Nov-24



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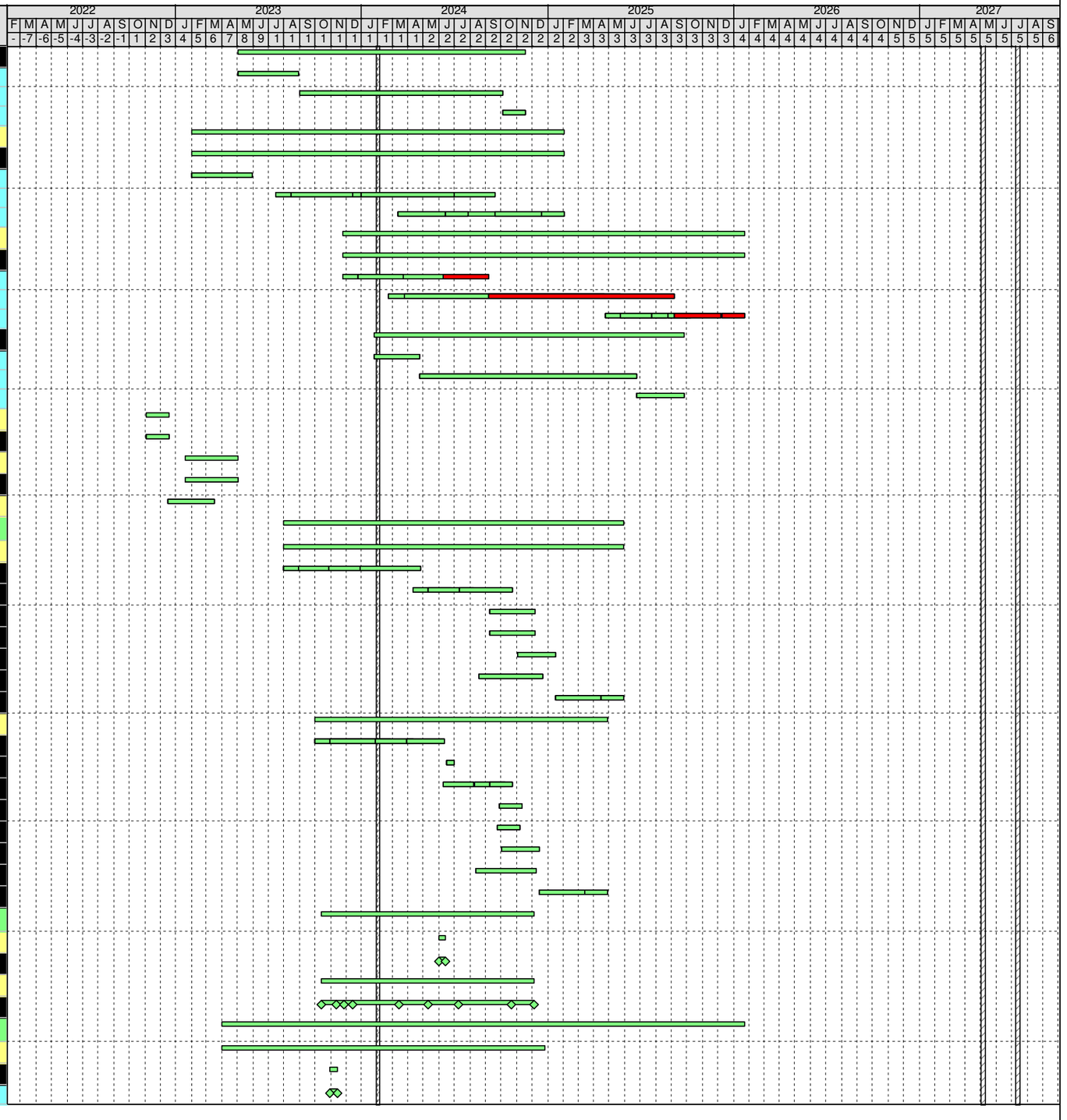
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Enchant Estimated Summary Schedule

Data Date: 20-Jul-21

07-Jun-22

Activity ID	Activity Name	Ori Dur	Start	Finish
	Package Substation	565	03-May-23	17-Nov-24
	Package Substation Inq	120	03-May-23	30-Aug-23
	Package Substation Fabrication	400	31-Aug-23	03-Oct-24
	Package Substation Transportation	45	04-Oct-24	17-Nov-24
	Civil & Building Procurement	733	01-Feb-23	02-Feb-25
	Quencher / Absorber	733	01-Feb-23	02-Feb-25
	Quencher / Absorber Inquiry/PO	120	01-Feb-23	31-May-23
	Quencher / Absorber Fabrication	431	16-Jul-23	18-Sep-24
	Quencher / Absorber Transportation	328	12-Mar-24	02-Feb-25
	Catalyst, Chemical & Laboratory Procurement	790	24-Nov-23	21-Jan-26
	Catalist & Chemical	790	24-Nov-23	21-Jan-26
	Catalist & Chemical Inquiry/PO	288	24-Nov-23	06-Sep-24
	Catalist & Chemical Fabrication	563	22-Feb-24	06-Sep-25
	Catalist & Chemical Transportation	274	23-Apr-25	21-Jan-26
	Laboratory Equipment	609	25-Jan-24	24-Sep-25
	Laboratory Equipment Inquiry/PO	90	25-Jan-24	23-Apr-24
	Laboratory Equipment Fabrication	427	24-Apr-24	24-Jun-25
	Laboratory Equipment Transportation	92	25-Jun-25	24-Sep-25
	Civil & Architecture Subcontract	45	03-Nov-22	17-Dec-22
	Civil Detail Design	45	03-Nov-22	17-Dec-22
	Construction Work Subcontracting	105	18-Jan-23	02-May-23
	Module Work Subcontract	105	18-Jan-23	02-May-23
	Transportation Work Subcontract	90	17-Dec-22	16-Mar-23
	MODULE CONSTRUCTION	670	31-Jul-23	30-May-25
	Main Pipe Rack & Sub Rack	670	31-Jul-23	30-May-25
	Structure	270	31-Jul-23	25-Apr-24
	Piping	195	11-Apr-24	22-Oct-24
	Electrical	90	08-Sep-24	06-Dec-24
	Instrument	90	08-Sep-24	06-Dec-24
	Insulation	75	02-Nov-24	15-Jan-25
	Blasting & Painting	125	19-Aug-24	21-Dec-24
	Transportation	135	16-Jan-25	30-May-25
	Reboiler Module & Sub Rack	577	30-Sep-23	28-Apr-25
	Structure	255	30-Sep-23	10-Jun-24
	Mechanical Installation	15	15-Jun-24	29-Jun-24
	Piping	135	10-Jun-24	22-Oct-24
	Electrical	45	28-Sep-24	11-Nov-24
	Instrument	45	23-Sep-24	06-Nov-24
	Insulation	75	01-Oct-24	14-Dec-24
	Blasting & Painting	120	11-Aug-24	08-Dec-24
	Transportation	135	15-Dec-24	28-Apr-25
	DELIVERY MILESTONE(Module)	418	13-Oct-23	04-Dec-24
	Equipment & Machinery	13	01-Jun-24	14-Jun-24
	Equipment & Machinery Delivery at Site	13	01-Jun-24	14-Jun-24
	Piping Material	418	13-Oct-23	04-Dec-24
	Piping Material Delivery at Site	418	13-Oct-23	04-Dec-24
	INTERFACE MILESTONE(Site)	1026	01-Apr-23	21-Jan-26
	Engineering Interface	635	01-Apr-23	26-Dec-24
	Static Equipment	15	29-Oct-23	13-Nov-23
	Delivery to Partner	15	29-Oct-23	13-Nov-23



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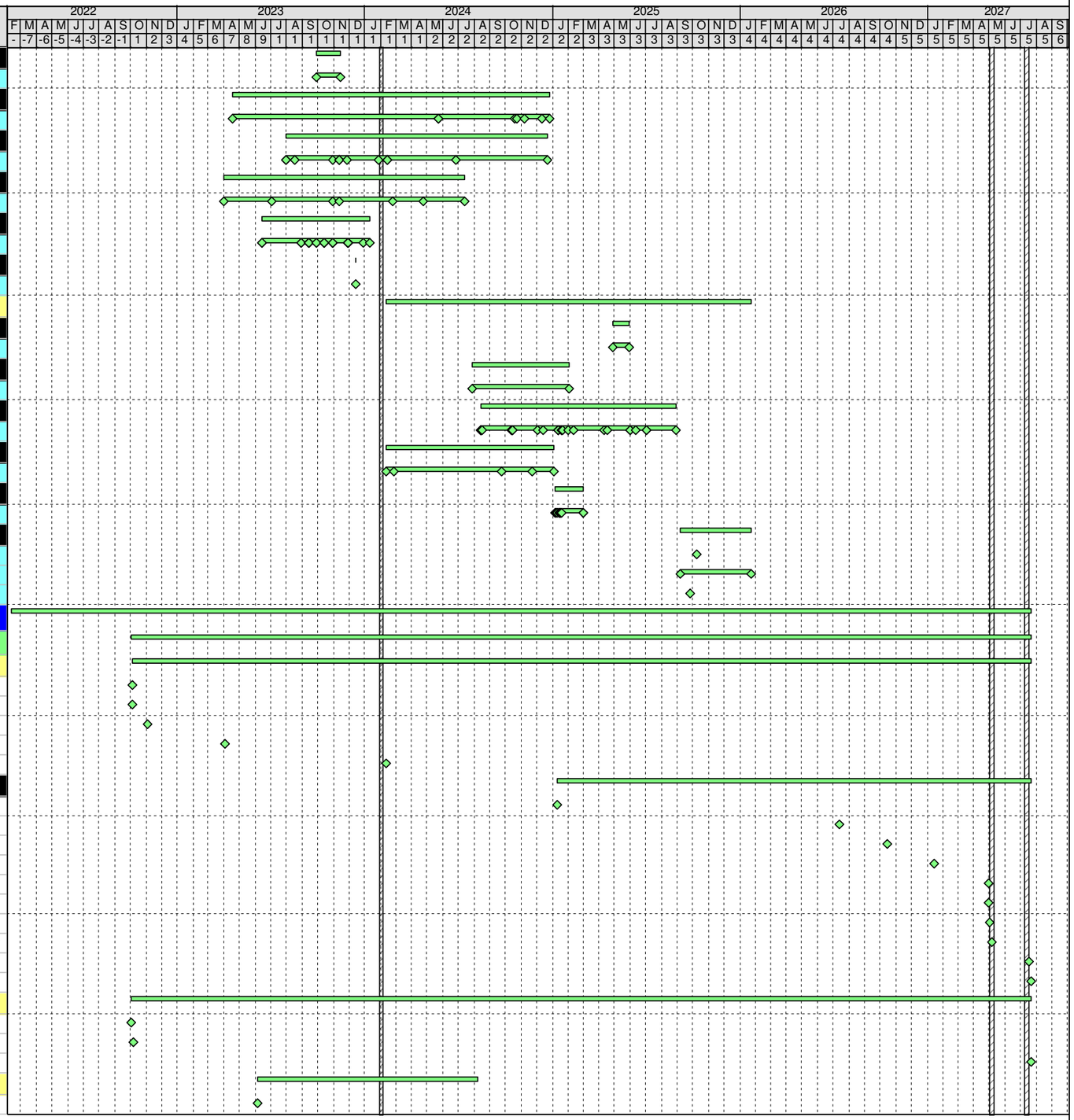
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Enchant Estimated Summary Schedule

Data Date: 20-Jul-21

07-Jun-22

Activity ID	Activity Name	Ori Dur	Start	Finish
	Machinery Equipment	46	28-Sep-23	13-Nov-23
	Delivery to Partner	46	28-Sep-23	13-Nov-23
	Piping	618	18-Apr-23	26-Dec-24
	Delivery to Partner	618	18-Apr-23	26-Dec-24
	Electrical	509	31-Jul-23	21-Dec-24
	Delivery to Partner	509	31-Jul-23	21-Dec-24
	Instrument & Control	468	01-Apr-23	12-Jul-24
	Delivery to Partner	468	01-Apr-23	12-Jul-24
	Civil & Architecture	210	15-Jun-23	11-Jan-24
	Delivery to Partner	210	15-Jun-23	11-Jan-24
	Construction	0	14-Dec-23	14-Dec-23
	Delivery to Partner	0	14-Dec-23	14-Dec-23
	Procurement Interface	711	10-Feb-24	21-Jan-26
	Module	32	28-Apr-25	30-May-25
	Module Delevery at Site	32	28-Apr-25	30-May-25
	Aborber & Quencher	189	28-Jul-24	02-Feb-25
	Absorber & Quencher Delevery at Site	189	28-Jul-24	02-Feb-25
	Equipment & Machinery	380	14-Aug-24	29-Aug-25
	Equipment & Machinery Delivery at Site	380	14-Aug-24	29-Aug-25
	Piping Material	328	10-Feb-24	03-Jan-25
	Piping Material Delivery at Site	328	10-Feb-24	03-Jan-25
	Instrument Equipment & Material	56	05-Jan-25	02-Mar-25
	Instrument Equipment & Material Delivery at Site	56	05-Jan-25	02-Mar-25
	Other Material	137	06-Sep-25	21-Jan-26
	Catalyst Delivery at Site	0	07-Oct-25	07-Oct-25
	Chemical Delivery at Site	137	06-Sep-25	21-Jan-26
	Laboratory Equip. Delivery at Site	0	24-Sep-25	24-Sep-25
	SJGS BOP ENG/PROC	398	11-Feb-22	21-Jul-27
	Milestones	235	03-Oct-22	21-Jul-27
	Level 1 Milestones	234	04-Oct-22	21-Jul-27
MS-LNTP	Receive LNTP	0	04-Oct-22*	
MS-SRVY	Release Exploratory Surveys	0	04-Oct-22	
MS-PLNT	Release PLANT Scope	0	04-Nov-22*	
MS-NTP	Receive FNTP	0		03-Apr-23
MS-CN01	Site Mobilization/Begin Construction	0	12-Feb-24	
	CO2 Island	658	10-Jan-25	21-Jul-27
MSCC-FDN1	CC Major Fdns Complete	0		10-Jan-25
MSCC-BF	Backfeed	0		14-Jul-26
MSCC-EQP1	CC Major Install Complete	0		15-Oct-26
MSCC-PPG1	CC Piping Complete	0		14-Jan-27
MS-FF1	1st Train Ready for COD (Flue Gas to CC Unit)	0	30-Apr-27	
MS-FF2	2nd Train Ready for COD (Flue Gas to CC Unit)	0	30-Apr-27	
MSCC-FF1	First Fire U1	0		03-May-27
MSCC-FF4	First Fire U4	0		06-May-27*
MSCC-COD1	Commercial Operation - U1	0		16-Jul-27*
MSCC-COD4	Commercial Operation - U4	0		21-Jul-27*
	Engineering Milestones	235	03-Oct-22	21-Jul-27
Start	Start	0	03-Oct-22*	
SLMTG001	Kickoff Mtg	0		06-Oct-22
Finish	Finish	0		21-Jul-27
	Procurement Milestones	300	05-Jun-23	08-Aug-24
SLS9804--60M	Cooling Tower - Award (PO)	0		05-Jun-23



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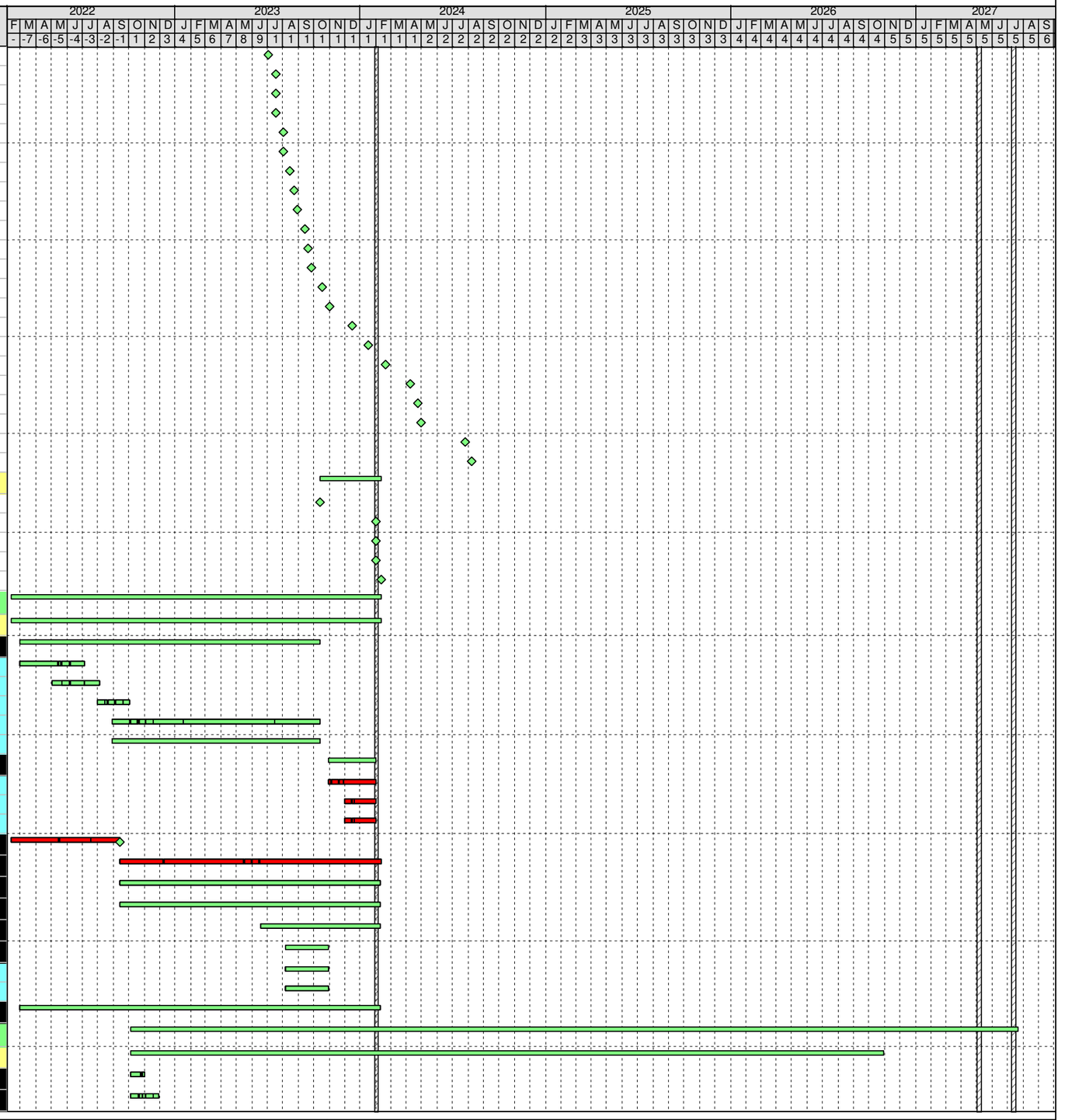
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Data Date: 20-Jul-21

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Activity ID	Activity Name	Ori Dur	Start	Finish
SLS9852-60M	Steam Turbine Mods - Award (PO)	0		03-Jul-23
SLS9807-60M	Air Compressors/Dryers - Award (PO)	0		18-Jul-23
SLS9805-60M	Circ Water Pumps - Award (PO)	0		18-Jul-23
SLS9805B-60M	Misc Water Pumps - Award (PO)	0		18-Jul-23
SLS9839-60M	Fire Protection - Award (PO)	0		01-Aug-23
SLS9831-60M	Batteries UPS & Chargers - Award (PO)	0		01-Aug-23
SLS9835-60M	Chemical Feed - Award (PO)	0		15-Aug-23
SLS9808A-60M	Field Fab Tanks - Award (PO)	0		22-Aug-23
SLS9842-60M	Protective Relay Panels - Award (PO)	0		29-Aug-23
SLS9836-60M	Waste Water Treatment - Award (PO)	0		13-Sep-23
SLS9844-60M	Pre-Eng Bldgs - Award (PO)	0		20-Sep-23
SLS9805A-60M	CO2 Pumps - Award (PO)	0		27-Sep-23
SLS9806-60M	Control Valves - Award (PO)	0		18-Oct-23
SLS9809-60M	Circ Water Piping - Award (PO)	0		01-Nov-23
SLS9822-60M	Auxiliary Xfmrs - Award (PO)	0		15-Dec-23
SLS9843-60M	Structural Steel Fab - Award (PO)	0		16-Jan-24
SLS9823-60M	PDC Bldg - Award (PO)	0		20-Feb-24
SLS9826-60M	Unit Substation Xfmrs - Award (PO)	0		09-Apr-24
SLS9840-60M	CO2 Compressor VFDs - Award (PO)	0		23-Apr-24
SLS9833-60M	Plant Communication - Award (PO)	0		30-Apr-24
SLS9824-60M	Isophase Bus Duct - Award (PO)	0		25-Jul-24
SLS9834-60M	DCS - Award (PO)	0		08-Aug-24
Permitting Milestones		81	13-Oct-23	12-Feb-24
MS-PSD	Receive PSD Air Permit	0		13-Oct-23
MS-PRSTRM	Receive Construction Stormwater Permit	0		01-Feb-24
MS-PRBLDG	Receive Local Building Permit	0		01-Feb-24
MS-PRPLAN	Receive Local Plan Review Permit	0		01-Feb-24
MS-NEPA	Receive NEPA Permit	0		12-Feb-24
Permitting / Support		507	11-Feb-22	11-Feb-24
Permitting		507	11-Feb-22	11-Feb-24
Construction PSD Air Permit		415	28-Feb-22	13-Oct-23
Construction PSD Air Permit - Project Description / Emissions		90	28-Feb-22	05-Jul-22
PSD Applicability (Section 12)		67	02-May-22	04-Aug-22
Construction PSD Air Permit - Air Quality Impact Modeling		45	01-Aug-22	03-Oct-22
Construction PSD Air Permit - Application Forms		287	29-Aug-22	13-Oct-23
Air Permit - Agencies Correspondence & Mtgs		287	29-Aug-22	13-Oct-23
Construction Permits		65	30-Oct-23	01-Feb-24
Construction Stormwater General Permit		65	30-Oct-23	01-Feb-24
Local Building Permit		43	01-Dec-23	01-Feb-24
Local Plan Review		43	01-Dec-23	01-Feb-24
NEPA Work Plan and Preliminary Impacts Assessment		150	11-Feb-22	13-Sep-22
NEPA Detailed Assessment Preparation (EA Assumed)		357	14-Sep-22	11-Feb-24
NEPA - Federal Agencies Correspondence & Mtgs		357	14-Sep-22	09-Feb-24
Field study coordination		357	14-Sep-22	09-Feb-24
Tech Support during EQ / EIV / EA		164	19-Jun-23	09-Feb-24
Transfers / Permit Administration		60	07-Aug-23	30-Oct-23
Title V Permit Transfer from PNM		60	07-Aug-23	30-Oct-23
Transfer Applicable Federal Permits		60	07-Aug-23	30-Oct-23
Permitting & Regulatory Support		496	28-Feb-22	09-Feb-24
Carbon Capture Project - Engineering		1234	04-Oct-22	21-Jul-27
General		1046	04-Oct-22	30-Oct-26
Project Work Plan		22	04-Oct-22	02-Nov-22
Draft Project Instrucitons Manual		38	04-Oct-22	28-Nov-22

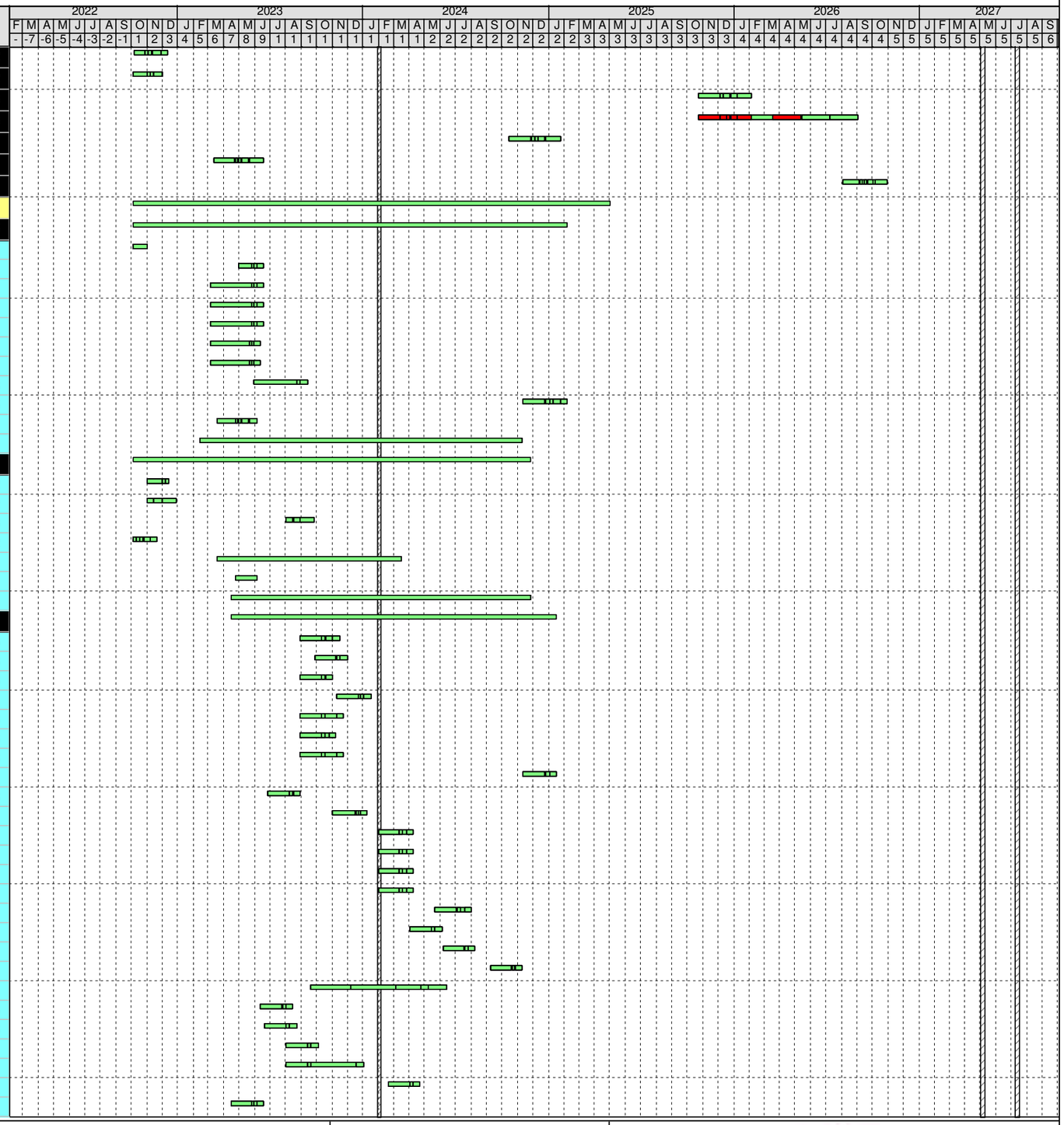


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Activity ID	Activity Name	Ori Dur	Start	Finish
	Baseline Schedule	45	07-Oct-22	12-Dec-22
	Project Procurement Plan	41	04-Oct-22	01-Dec-22
	Equipment Startup & Operating Procedures	75	23-Oct-25	04-Feb-26
	Training Program	225	23-Oct-25	02-Sep-26
	Plant Commissioning Procedure & Manual	70	14-Oct-24	23-Jan-25
	Construction Management Plan	70	13-Mar-23	19-Jun-23
	Performance Testing Procedure	65	03-Aug-26	30-Oct-26
	Civil /Structural / Architecural Engineering & Design	655	04-Oct-22	01-May-25
	Civil	595	04-Oct-22	06-Feb-25
	Civil/Structural Design Criteria	20	04-Oct-22	31-Oct-22
	Civil General Notes & Details	35	01-May-23	19-Jun-23
	Initial Sitework Carbon Capture Train 1 Area	75	06-Mar-23	19-Jun-23
	Initial Sitework Carbon Capture Train 2 Area	75	06-Mar-23	19-Jun-23
	Initial Sitework Cooling Tower & Water Treatment Area	75	06-Mar-23	19-Jun-23
	Initial Sitework Control Bldg & Chem Storage Areas	70	06-Mar-23	12-Jun-23
	Initial Sitework Laydown Area	70	06-Mar-23	12-Jun-23
	U/G Gravity Sewers	75	30-May-23	13-Sep-23
	Final Sitework	60	11-Nov-24	06-Feb-25
	Civil Demolition	55	20-Mar-23	05-Jun-23
	Geotechnical Support	445	13-Feb-23	08-Nov-24
	Structural General & Modeling	545	04-Oct-22	26-Nov-24
	Concrete General Notes & Standard Details	30	01-Nov-22	14-Dec-22
	Structural Steel General Notes & Standard Details	40	01-Nov-22	29-Dec-22
	Circ Water Pipe (Dwgs by Mech)	40	02-Aug-23	27-Sep-23
	Structural Design Criteria	35	04-Oct-22	21-Nov-22
	PLADES Model - Fdn	253	20-Mar-23	15-Mar-24
	PLADES Model - Arch	30	24-Apr-23	05-Jun-23
	PLADES Model - BOP Steel	410	17-Apr-23	26-Nov-24
	Foundations BOP	445	17-Apr-23	16-Jan-25
	Cooling Tower Basin & Pump Structure Foundations	55	30-Aug-23	15-Nov-23
	Cooling Tower Chemical Storage (17) Foundations	45	28-Sep-23	01-Dec-23
	Circ Water Pipe Riser Foundations	45	30-Aug-23	01-Nov-23
	Waste Wtr Treat & CO2 Pump Building (18 & 24) Foundations	45	09-Nov-23	16-Jan-24
	Demin Pumps Foundations	60	30-Aug-23	22-Nov-23
	Air Compressor Pads in BOP Mech Bldg Foundations	50	30-Aug-23	08-Nov-23
	Potable Water Pads in BOP Mech Bldg Foundations	60	30-Aug-23	22-Nov-23
	Misc BOP Foundations	45	11-Nov-24	16-Jan-25
	Oil/Water Separator Foundations	45	27-Jun-23	29-Aug-23
	Control/Elect Bldg Foundations	45	02-Nov-23	09-Jan-24
	Aux Transformer @ Cooling Tower Foundations	50	31-Jan-24	09-Apr-24
	Aux Transformer @ New Control/Elect Bldg Foundations	50	31-Jan-24	09-Apr-24
	New U1 Aux Transformer Foundations	50	31-Jan-24	09-Apr-24
	New U4 Aux Transformer Foundations	50	31-Jan-24	09-Apr-24
	Misc Transformers outside VFD PDC Foundations	50	22-May-24	01-Aug-24
	Cooling Tower PDC Foundations	45	03-Apr-24	05-Jun-24
	VFD PDC Foundations	45	06-Jun-24	08-Aug-24
	Isophase Bus Duct Foundations	45	09-Sep-24	08-Nov-24
	Ductbanks & Manholes Foundations	185	21-Sep-23	12-Jun-24
	Utility/Pipe Rack Foundations	45	13-Jun-23	15-Aug-23
	U1 Ductwork Support Area Foundations	45	20-Jun-23	22-Aug-23
	U4 Ductwork Support Area Foundations	45	02-Aug-23	04-Oct-23
	U1/U4 Ductwork Support Combined Foundations	105	02-Aug-23	02-Jan-24
	Misc. CC Foundations	45	20-Feb-24	22-Apr-24
	Demo Dwgs for Existing Fdn & Piles Foundations	45	17-Apr-23	19-Jun-23



ENCHANT ENERGY LLC

OWNER

Enchant Estimated Summary Schedule

Data Date: 20-Jul-21

07-Jun-22

Activity ID	Activity Name	Ori Dur	Start	Finish
	MHI Chemical Storage & Precoat Filter Unit Area Foundations	203	20-Mar-23	05-Jan-24
	Wash Water and Solution Storage Tank Foundations	183	20-Mar-23	06-Dec-23
	TEG Storage Tank Foundations	183	20-Mar-23	06-Dec-23
	Precoat Filter Unit Area Foundations	183	20-Mar-23	06-Dec-23
	Precoat Filter Air Receiver Foundations	183	20-Mar-23	06-Dec-23
	Caustic Soda Tank Foundations	183	20-Mar-23	06-Dec-23
	Caustic Soda Feed Pump Foundations	183	20-Mar-23	06-Dec-23
	OPR-11 Area Foundations	45	31-Oct-23	05-Jan-24
	OPR-12 Area Foundations	45	31-Oct-23	05-Jan-24
	1PR-02 Area Foundations	45	31-Oct-23	05-Jan-24
	2PR-02 Area Foundations	45	31-Oct-23	05-Jan-24
	MHI Carbon Capture Train 1 & 2 Area Foundations	253	20-Mar-23	15-Mar-24
	Quencher 01 & 02 Foundations	70	19-Jun-23	26-Sep-23
	Absorber 01 & 02 Foundations	60	19-Jun-23	12-Sep-23
	1ST-01 & 2ST-01 Foundations	45	30-Nov-23	02-Feb-24
	Absorber 01 & 02 Stair Tower Foundations	45	14-Dec-23	16-Feb-24
	Flue Gas Blower 01 & 02 Foundations	55	01-Dec-23	19-Feb-24
	1ST-01 & 2ST-02 Ductwork Foundations	45	01-Dec-23	05-Feb-24
	1ST-03 & 2ST-03 Foundations	45	30-Nov-23	02-Feb-24
	1PR-01 & 2PR-01 Foundations	45	02-Oct-23	05-Dec-23
	1PR-04 & 2PR-04 Foundations	45	17-Oct-23	20-Dec-23
	1ST-21, 22, & 23 and 2ST-21 , 22, & 23 Area Foundations	45	30-Nov-23	02-Feb-24
	Reclaim Waste Tank 01 & 02 Foundations	178	20-Mar-23	29-Nov-23
	Analyzer House 01 & 02 Foundations	45	31-Oct-23	05-Jan-24
	H2 Generation Unit 01 & 02 Foundations	45	15-Jan-24	15-Mar-24
	1SL-01 and 2SL-01 Foundations	45	17-Oct-23	20-Dec-23
	Vendor Unit Intercooler 01 & 02 Foundations	183	20-Mar-23	06-Dec-23
	Final Stage Discharge Cooler 01 & 02 Foundations	183	20-Mar-23	06-Dec-23
	Dehydation Unit Knock-Out Drum 01 & 02 Foundations	45	02-Oct-23	05-Dec-23
	CO2 Removal Reactor 01 & 02 Foundations	183	20-Mar-23	06-Dec-23
	C02 Dehydration Unit 01 & 02 Foundations	45	02-Oct-23	05-Dec-23
	Suction Scrubber 01 & 02 Foundations	183	20-Mar-23	06-Dec-23
	1LR-01 & 2LR-01 & Compressor House Foundations	45	30-Nov-23	02-Feb-24
	1PR-09 & 2PR-09 Foundations	45	31-Oct-23	05-Jan-24
	MHI PDC 01 & 02 Foundations	45	31-Oct-23	05-Jan-24
	Structural Steel	410	17-Apr-23	26-Nov-24
	Structural Steel - Utility/Pipe Rack	170	17-Apr-23	15-Dec-23
	Structural Steel - U1 Duct Support Steel	140	30-May-23	15-Dec-23
	Structural Steel - U1 Duct Support Steel Tie-In	140	30-May-23	15-Dec-23
	Structural Steel - U4 Duct Support Steel	140	30-May-23	15-Dec-23
	Structural Steel - U4 Duct Support Steel Tie-In	140	30-May-23	15-Dec-23
	Structural Steel - U1/U4 Duct Support Steel Combined	140	30-May-23	15-Dec-23
	Structural Steel - Misc. Steel Platform Access, Stairs, and Ladders	85	26-Jul-24	26-Nov-24
	Ductwork	95	17-Apr-23	29-Aug-23
	U1 Ductwork	95	17-Apr-23	29-Aug-23
	U1 Ductwork Tie-In	95	17-Apr-23	29-Aug-23
	U4 Ductwork	95	17-Apr-23	29-Aug-23
	U4 Ductwork Tie-In	95	17-Apr-23	29-Aug-23
	U1/U4 Ductwork Combined	95	17-Apr-23	29-Aug-23
	Structural Pipe Support Reviews	280	06-Jun-23	11-Jul-24
	Hot LB Pipe Supports Reviews	235	06-Jun-23	07-May-24
	Hot SB Pipe Supports Reviews	160	21-Sep-23	07-May-24
	Cold LB Pipe Supports Reviews	265	27-Jun-23	11-Jul-24
	Architectural	155	08-Nov-22	19-Jun-23

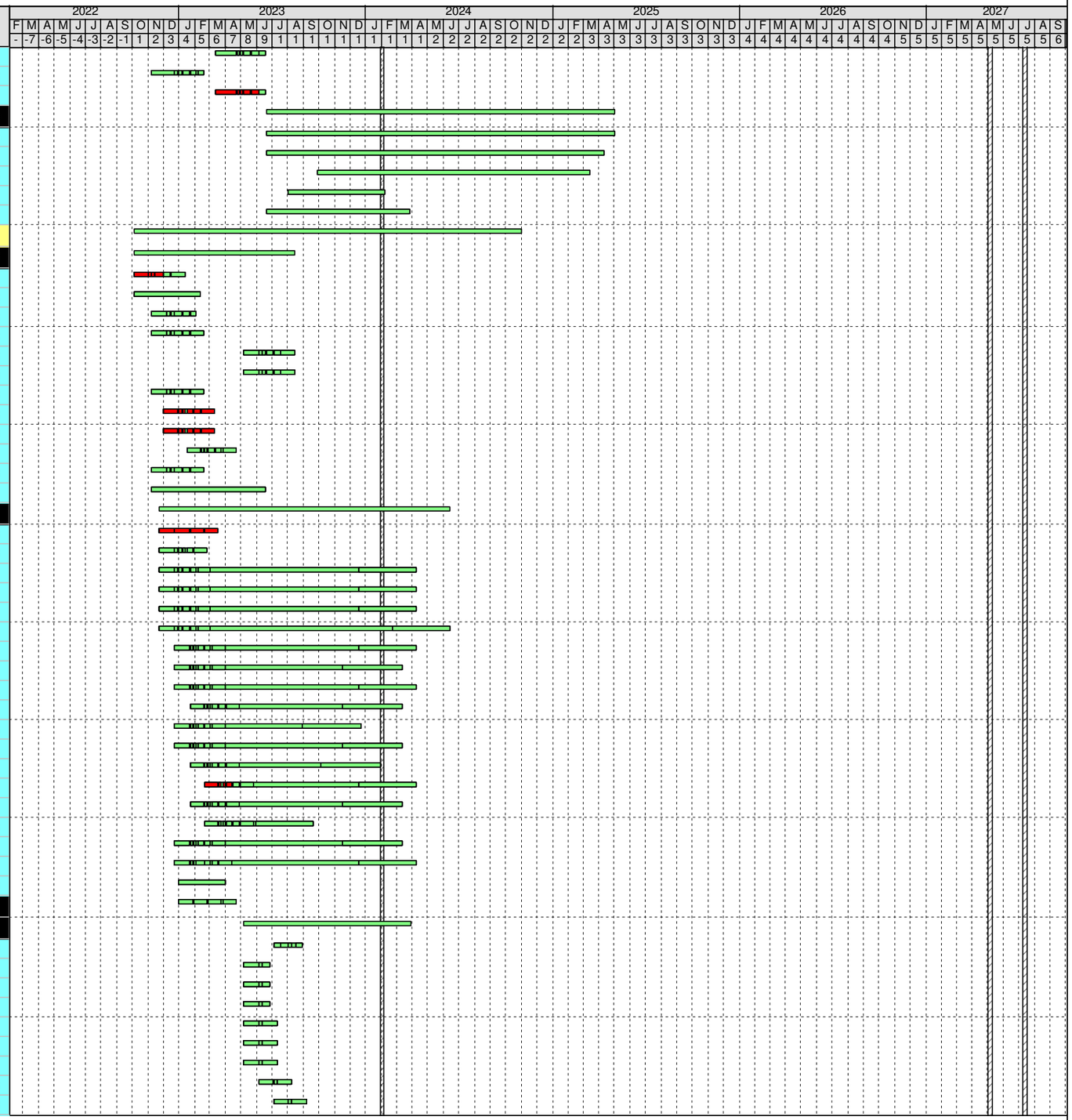


Remaining Level of Effort
Actual Level of Effort
Actual Work
Remaining Work
Critical Remaining Work
Current Milestone
Actual Milestone
WBS Summary Act

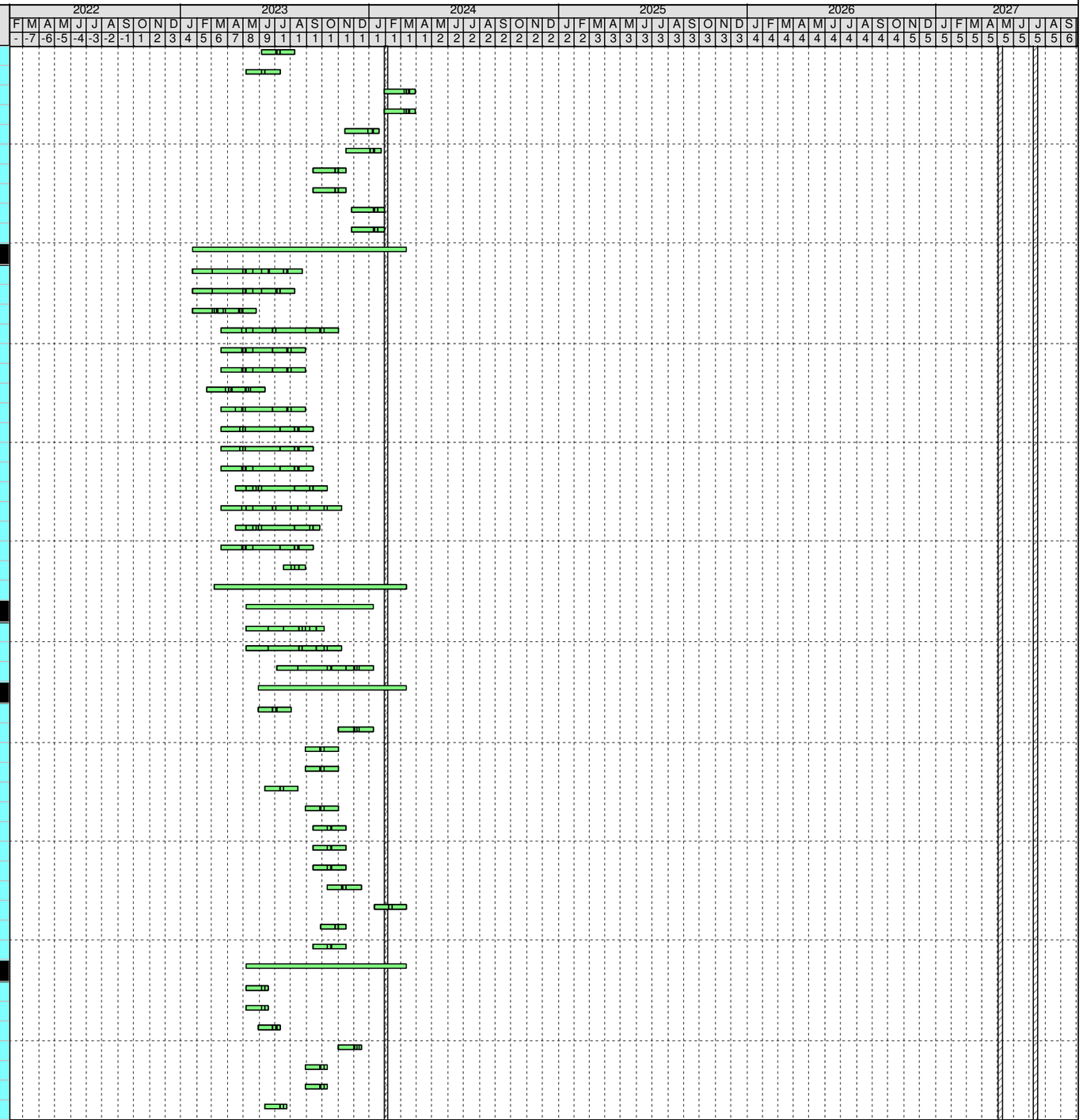
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Sargent & Lundy

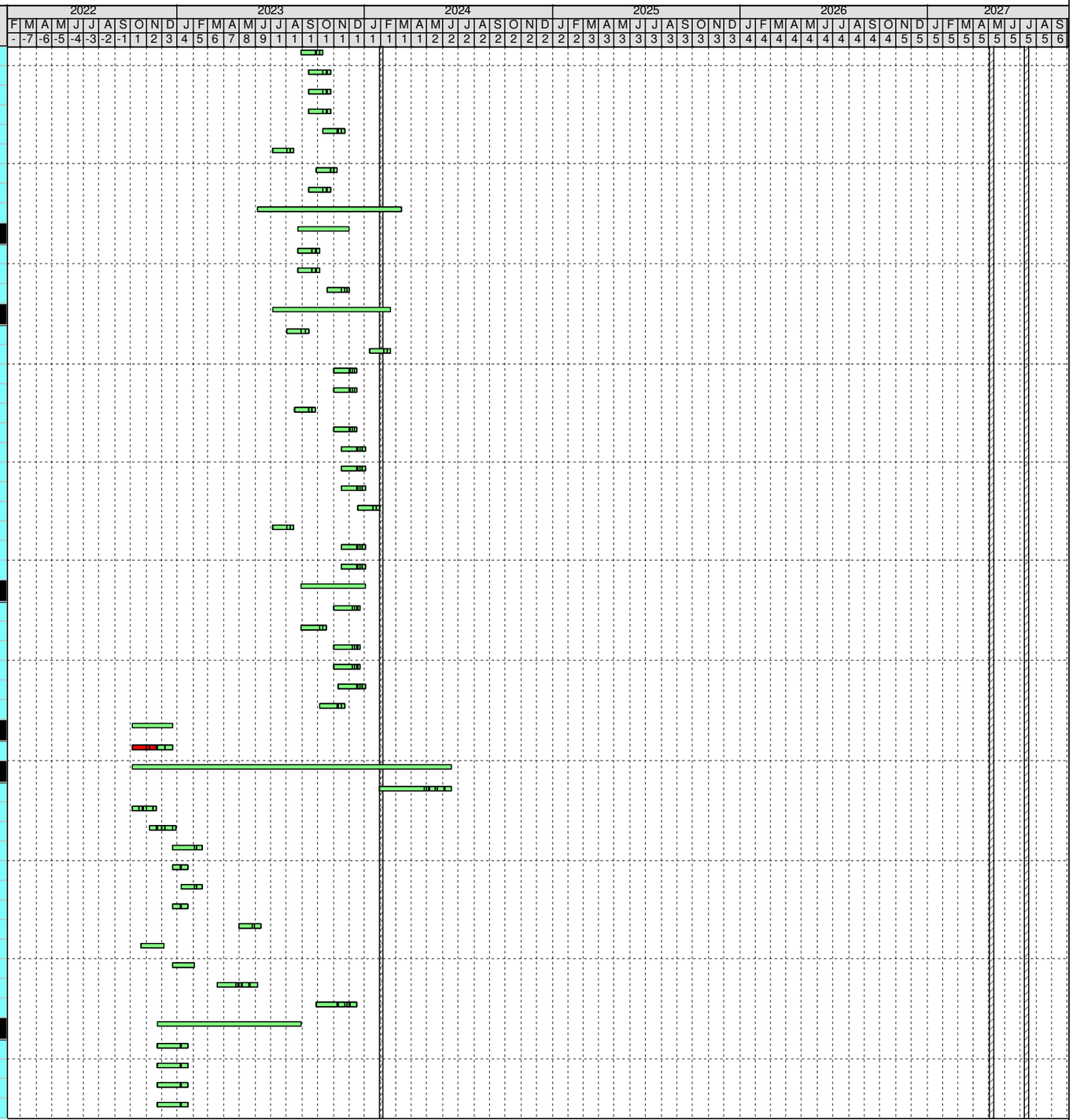
Activity ID	Activity Name	Ori Dur	Start	Finish
	Architectural General Notes & Details	70	13-Mar-23	19-Jun-23
	Architectural Design Criteria	70	08-Nov-22	17-Feb-23
	Arch Plans & Elevations - Pre-Eng Bldgs	70	13-Mar-23	19-Jun-23
	Revs after Construction	475	20-Jun-23	01-May-25
	Civil Revs after Construction	475	20-Jun-23	01-May-25
	Struct Fdn Revs after Construction	460	20-Jun-23	10-Apr-25
	Struct Steel Revs after Construction	370	28-Sep-23	13-Mar-25
	Ductwork Revs after Construction	130	02-Aug-23	06-Feb-24
	Arch Revs after Construction	195	20-Jun-23	26-Mar-24
	Mechanical Engineering & Design	529	04-Oct-22	31-Oct-24
	General Arrangements	220	04-Oct-22	15-Aug-23
	Site GA	70	04-Oct-22	13-Jan-23
	MHI CO2 Island GA	90	04-Oct-22	10-Feb-23
	New Control Elect Building GA	60	08-Nov-22	03-Feb-23
	BOP Mechanical Building GA	70	08-Nov-22	17-Feb-23
	U1 Steam Pipe GA	70	08-May-23	15-Aug-23
	U4 Steam Pipe GA	70	08-May-23	15-Aug-23
	New Cooling Tower GA	70	08-Nov-22	17-Feb-23
	CO2 Pump Building GA	70	01-Dec-22	10-Mar-23
	Waste Water Treatment Building GA	70	01-Dec-22	10-Mar-23
	Equipment Laydown & Removal GA	70	16-Jan-23	21-Apr-23
	Demolition GA	70	08-Nov-22	17-Feb-23
	GA Peer Reviews	155	08-Nov-22	19-Jun-23
	P&IDs	395	22-Nov-22	12-Jun-24
	P&IDs - Groups	80	22-Nov-22	17-Mar-23
	P&IDs - Index & Symbols	65	22-Nov-22	24-Feb-23
	P&IDs - Main Steam	350	22-Nov-22	09-Apr-24
	P&IDs - LP Steam	350	22-Nov-22	09-Apr-24
	P&IDs - Condensate	350	22-Nov-22	09-Apr-24
	P&IDs - Circ Water	395	22-Nov-22	12-Jun-24
	P&IDs - Service Water	330	22-Dec-22	09-Apr-24
	P&IDs - Demin Water	310	22-Dec-22	12-Mar-24
	P&IDs - Condensate Attermperating	330	22-Dec-22	09-Apr-24
	P&IDs - Potable Water	290	23-Jan-23	12-Mar-24
	P&IDs - Fire Protection	255	22-Dec-22	22-Dec-23
	P&IDs - Instrument Air	310	22-Dec-22	12-Mar-24
	P&IDs - Chemical Feed	260	23-Jan-23	30-Jan-24
	P&IDs - CO2	290	20-Feb-23	09-Apr-24
	P&IDs - Equipment Drains	290	23-Jan-23	12-Mar-24
	P&IDs - Plant Drains	150	20-Feb-23	20-Sep-23
	P&IDs - Waste Water	310	22-Dec-22	12-Mar-24
	P&IDs - Flue Gas	330	22-Dec-22	09-Apr-24
	P&IDs - Peer Reviews	65	30-Dec-22	31-Mar-23
	LB Ppg Iso - Priority Groups	80	30-Dec-22	21-Apr-23
	U/G & Embedded Piping	228	08-May-23	29-Mar-24
	U/G Iso - Circulating Water	40	05-Jul-23	29-Aug-23
	U/G Iso - Service Water	35	08-May-23	26-Jun-23
	U/G Iso - Demin Water	35	08-May-23	26-Jun-23
	U/G Iso - Potable Water	35	08-May-23	26-Jun-23
	U/G Iso - Fire Protection	45	08-May-23	11-Jul-23
	U/G Iso - Instrument Air	45	08-May-23	11-Jul-23
	U/G Iso - Chem Feed	45	08-May-23	11-Jul-23
	U/G Iso - CO2	45	06-Jun-23	08-Aug-23
	U/G Iso - Equipment Vents & Drains	45	05-Jul-23	06-Sep-23



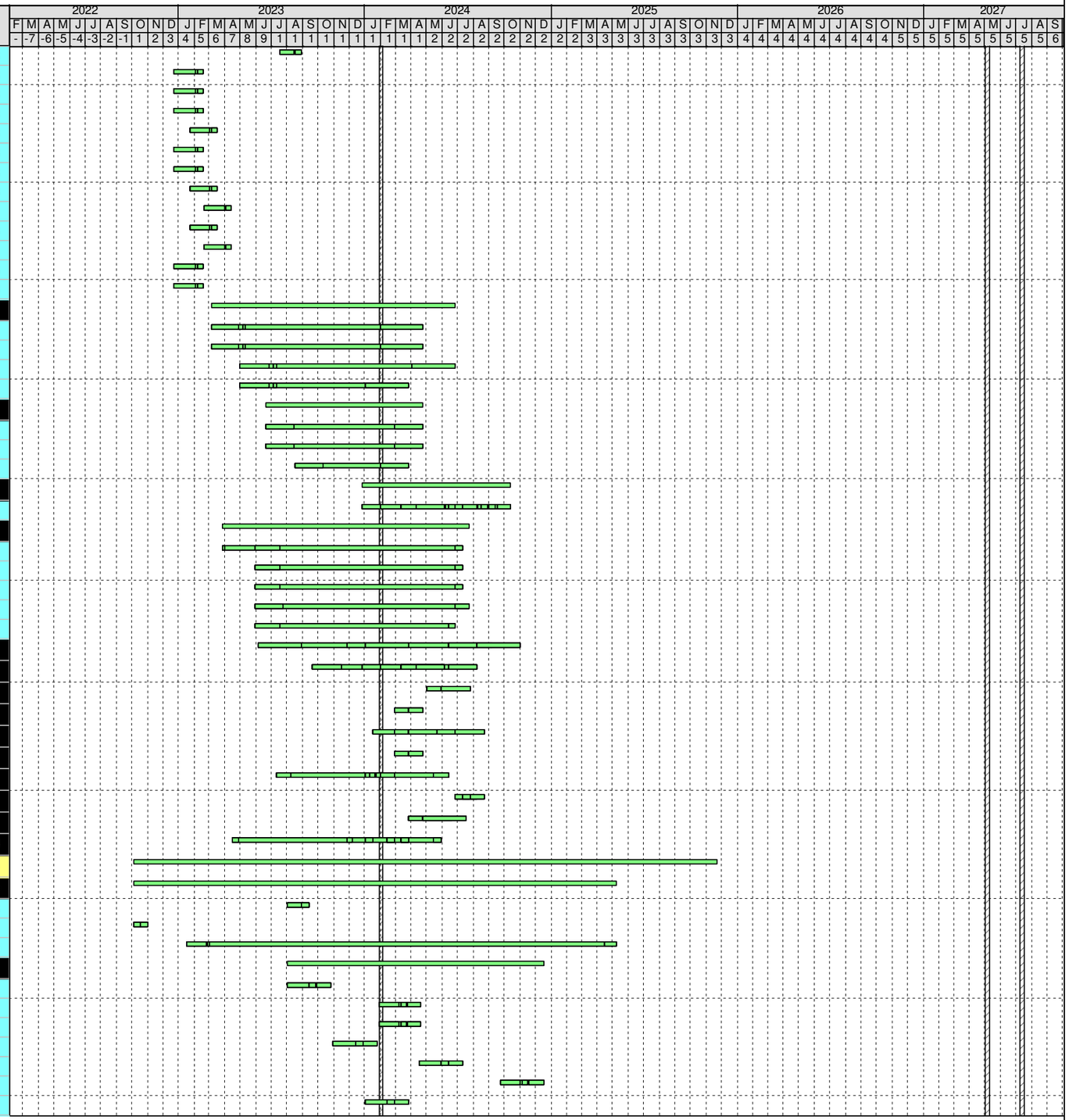
Activity ID	Activity Name	Ori Dur	Start	Finish
	U/G Iso - Plant Drains	45	06-Jun-23	08-Aug-23
	U/G Iso - Waste Water	45	08-May-23	11-Jul-23
	U/G Embedded Piping - CC Train 1 Area	45	29-Jan-24	29-Mar-24
	U/G Embedded Piping - CC Train 2 Area	45	29-Jan-24	29-Mar-24
	U/G Embedded Piping - CC Chemical Storage & Precoat Filter Unit (05)	45	14-Nov-23	19-Jan-24
	U/G Embedded Piping - New Control Electrical Bldg (06)	45	16-Nov-23	23-Jan-24
	U/G Embedded Piping - BOP Mechanical Bldg (07)	45	14-Sep-23	15-Nov-23
	U/G Embedded Piping - New Cooling Tower Area (13)	45	14-Sep-23	15-Nov-23
	U/G Embedded Piping - CO2 Pump Bldg (18)	45	27-Nov-23	30-Jan-24
	U/G Embedded Piping - Waste Water Treatment Bldg (24)	45	27-Nov-23	30-Jan-24
	LB Piping Isos	290	23-Jan-23	12-Mar-24
	LB Piping Isos - Main Steam	150	23-Jan-23	22-Aug-23
	LB Piping Isos - LP Steam	140	23-Jan-23	08-Aug-23
	LB Piping Isos - Condensate	90	23-Jan-23	26-May-23
	LB Piping Isos - Circ Water	160	20-Mar-23	01-Nov-23
	LB Piping Isos - Service Water	115	20-Mar-23	29-Aug-23
	LB Piping Isos - Demin Water	115	20-Mar-23	29-Aug-23
	LB Piping Isos - Condensate Attermperating	80	20-Feb-23	12-Jun-23
	LB Piping Isos - Potable Water	115	20-Mar-23	29-Aug-23
	LB Piping Isos - Fire Protection	125	20-Mar-23	13-Sep-23
	LB Piping Isos - Instrument/Service Air	125	20-Mar-23	13-Sep-23
	LB Piping Isos - Chemical Feed	125	20-Mar-23	13-Sep-23
	LB Piping Isos - CO2	125	17-Apr-23	11-Oct-23
	LB Piping Isos - Equipment Drains	165	20-Mar-23	08-Nov-23
	LB Piping Isos - Plant Drains	115	17-Apr-23	27-Sep-23
	LB Piping Isos - Waste Water	125	20-Mar-23	13-Sep-23
	Mechanical General Notes & Details	30	19-Jul-23	29-Aug-23
	Iso Eng Reviews	260	06-Mar-23	12-Mar-24
	Hot SB Piping Isos	170	08-May-23	09-Jan-24
	Hot SB Piping Iso - Main Steam	105	08-May-23	04-Oct-23
	Hot SB Piping Iso - LP Steam	130	08-May-23	08-Nov-23
	Hot SB Piping Iso -Equipment Drains	130	05-Jul-23	09-Jan-24
	Cold SB Piping Isos	200	30-May-23	12-Mar-24
	Cold SB Piping Isos - Condensate	45	30-May-23	01-Aug-23
	Cold SB Piping Isos - Circ Water	45	02-Nov-23	09-Jan-24
	Cold SB Piping Isos - Service Water	45	30-Aug-23	01-Nov-23
	Cold SB Piping Isos - Demin Water	45	30-Aug-23	01-Nov-23
	Cold SB Piping Isos - Condensate Attermperating	45	13-Jun-23	15-Aug-23
	Cold SB Piping Isos - Potable Water	45	30-Aug-23	01-Nov-23
	Cold SB Piping Isos - Fire Protection	45	14-Sep-23	15-Nov-23
	Cold SB Piping Isos - Instrument/Service Air	45	14-Sep-23	15-Nov-23
	Cold SB Piping Isos - Chemical Feed	45	14-Sep-23	15-Nov-23
	Cold SB Piping Isos - CO2	45	12-Oct-23	15-Dec-23
	Cold SB Piping Isos - Equipment Drains	45	10-Jan-24	12-Mar-24
	Cold SB Piping Isos - Plant Drains	35	28-Sep-23	15-Nov-23
	Cold SB Piping Isos - Waste Water	45	14-Sep-23	15-Nov-23
	LB Pipe Supports Schedules	215	08-May-23	12-Mar-24
	LB Piping Support - Main Steam	30	08-May-23	19-Jun-23
	LB Piping Support - LP Steam	30	08-May-23	19-Jun-23
	LB Piping Support - Condensate	30	30-May-23	11-Jul-23
	LB Piping Support - Circ Water	30	02-Nov-23	15-Dec-23
	LB Piping Support - Service Water	30	30-Aug-23	11-Oct-23
	LB Piping Support - Demin Water	30	30-Aug-23	11-Oct-23
	LB Piping Support - Condensate Attermperating	30	13-Jun-23	25-Jul-23



Activity ID	Activity Name	Ori Dur	Start	Finish
	LB Piping Support - Potable Water	30	30-Aug-23	11-Oct-23
	LB Piping Support - Fire Protection	30	14-Sep-23	25-Oct-23
	LB Piping Support - Instrument Air	30	14-Sep-23	25-Oct-23
	LB Piping Support - Chemical Feed	30	14-Sep-23	25-Oct-23
	LB Piping Support - CO2	30	12-Oct-23	22-Nov-23
	LB Piping Support - Equipment Drains	30	05-Jul-23	15-Aug-23
	LB Piping Support - Plant Drains	30	28-Sep-23	08-Nov-23
	LB Piping Support - Waste Water	30	14-Sep-23	25-Oct-23
	Support Eng Reviews	195	06-Jun-23	12-Mar-24
	Hot SB Piping Supports Schedules	70	23-Aug-23	01-Dec-23
	Hot SB Piping Support - Main Steam	30	23-Aug-23	04-Oct-23
	Hot SB Piping Support - LP Steam	30	23-Aug-23	04-Oct-23
	Hot SB Piping Support - Equipment Drains	30	19-Oct-23	01-Dec-23
	Cold SB Piping Supports	160	05-Jul-23	20-Feb-24
	Cold SB Piping Support - Condensate	30	02-Aug-23	13-Sep-23
	Cold SB Piping Support - Circ Water	30	10-Jan-24	20-Feb-24
	Cold SB Piping Support - Service Water	30	02-Nov-23	15-Dec-23
	Cold SB Piping Support - Demin Water	30	02-Nov-23	15-Dec-23
	Cold SB Piping Support - Condensate Attermperating	30	16-Aug-23	27-Sep-23
	Cold SB Piping Support - Potable Water	30	02-Nov-23	15-Dec-23
	Cold SB Piping Support - Fire Protection	30	16-Nov-23	02-Jan-24
	Cold SB Piping Support - Instrument Air	30	16-Nov-23	02-Jan-24
	Cold SB Piping Support - Chemical Feed	30	16-Nov-23	02-Jan-24
	Cold SB Piping Support - CO2	30	18-Dec-23	30-Jan-24
	Cold SB Piping Support - Equipment Drains	30	05-Jul-23	15-Aug-23
	Cold SB Piping Support - Plant Drains	30	16-Nov-23	02-Jan-24
	Cold SB Piping Support - Waste Water	30	16-Nov-23	02-Jan-24
	Mechanical Equipment Locations	85	30-Aug-23	02-Jan-24
	Equip Locs - New Control Electrical Bldg (06)	35	02-Nov-23	22-Dec-23
	Equip Locs - BOP Mechanical Bldg (07)	35	30-Aug-23	18-Oct-23
	Equip Locs - New Cooling Tower Area (13)	35	02-Nov-23	22-Dec-23
	Equip Locations - U4 Cooling Tower	35	02-Nov-23	22-Dec-23
	Equip Locs - CO2 Pump Bldg (18)	35	09-Nov-23	02-Jan-24
	Equip Locs - Waste Water Treatment Bldg (24)	35	05-Oct-23	22-Nov-23
	Design Criteria	55	04-Oct-22	21-Dec-22
	Mech Design Criteria	55	04-Oct-22	21-Dec-22
	Mechanical Misc	433	04-Oct-22	17-Jun-24
	Hazard Area Locations	100	29-Jan-24	17-Jun-24
	Heat Balance	35	04-Oct-22	21-Nov-22
	Water Balance	35	08-Nov-22	29-Dec-22
	TRAX Analysis Calc	40	22-Dec-22	17-Feb-23
	Insulation Calc	20	22-Dec-22	20-Jan-23
	Piping Analysis Design Criteria	30	09-Jan-23	17-Feb-23
	Piping Analysis Cold Pipe Guideline	20	22-Dec-22	20-Jan-23
	Piping Analysis Welded Attachments	30	01-May-23	12-Jun-23
	Existing Plant Tie-In Reviews	30	21-Oct-22	05-Dec-22
	PLADES Discrepancies	30	22-Dec-22	03-Feb-23
	Mechanical Demolition	55	20-Mar-23	05-Jun-23
	HAZOP Review	55	28-Sep-23	15-Dec-23
	Mechanical System Calcs	195	22-Nov-22	29-Aug-23
	Main Steam Calcs	40	22-Nov-22	20-Jan-23
	Low Pressure Steam Calcs	40	22-Nov-22	20-Jan-23
	Condensate Calcs	40	22-Nov-22	20-Jan-23
	Circ Water System Calc	40	22-Nov-22	20-Jan-23



Activity ID	Activity Name	Ori Dur	Start	Finish
	Circ Water Water Hammer Calc	30	19-Jul-23	29-Aug-23
	Service Water Calcs-	40	22-Dec-22	17-Feb-23
	Demin Water Calcs	40	22-Dec-22	17-Feb-23
	Condensate Attermperating Calcs	40	22-Dec-22	17-Feb-23
	Potable Water Calcs	40	23-Jan-23	17-Mar-23
	Fire Prot Calcs	40	22-Dec-22	17-Feb-23
	Instrument Air Calcs	40	22-Dec-22	17-Feb-23
	Chemical Feed Calcs	40	23-Jan-23	17-Mar-23
	CO2 Calcs	40	20-Feb-23	14-Apr-23
	Equipment Drains Calcs	40	23-Jan-23	17-Mar-23
	Plant Drains Calcs	40	20-Feb-23	14-Apr-23
	Waste Water Calcs	40	22-Dec-22	17-Feb-23
	Boiler Air Calcs	40	22-Dec-22	17-Feb-23
	LB Piping Analysis	335	06-Mar-23	26-Jun-24
	LB Piping Analysis - Main Steam	290	06-Mar-23	23-Apr-24
	LB Piping Analysis - LP Steam	290	06-Mar-23	23-Apr-24
	LB Piping Analysis - Circ Water	295	01-May-23	26-Jun-24
	LB Piping Analysis - Equipment Vents & Drains	230	01-May-23	26-Mar-24
	Hot SB Piping Analysis	215	20-Jun-23	23-Apr-24
	Hot SB Piping Analysis - Main Steam	215	20-Jun-23	23-Apr-24
	Hot SB Piping Analysis - LP Steam	215	20-Jun-23	23-Apr-24
	Hot SB Piping Analysis - Equipment Vents & Drains	155	16-Aug-23	26-Mar-24
	System Descriptions	205	26-Dec-23	11-Oct-24
	Sys Descriptions	205	26-Dec-23	11-Oct-24
	Mechanical Lists	339	27-Mar-23	24-Jul-24
	Mech Equipment list	329	27-Mar-23	10-Jul-24
	Mech Pipeline list	284	30-May-23	10-Jul-24
	Mech Valve list	284	30-May-23	10-Jul-24
	Mech Specialty list	294	30-May-23	24-Jul-24
	Mech PDT/VDT	275	30-May-23	26-Jun-24
	General Arrangements Revisions after Construction	359	06-Jun-23	31-Oct-24
	P&IDs Revisions after Construction	225	21-Sep-23	08-Aug-24
	LB Piping Isometrics Revisions after Construction	60	01-May-24	25-Jul-24
	SB Piping Isometrics Revisions after Construction	40	28-Feb-24	23-Apr-24
	LB Piping Supports Revisions after Construction	155	17-Jan-24	22-Aug-24
	SB Piping Supports Revisions after Construction	40	28-Feb-24	23-Apr-24
	U/G Piping Revisions after Construction	235	12-Jul-23	12-Jun-24
	Mech Lists Revisions after Use	40	26-Jun-24	21-Aug-24
	Piping Analysis Revisions after Construction	80	27-Mar-24	18-Jul-24
	Calcs Resolve Unverified Assumptions	285	17-Apr-23	29-May-24
	Electrical Engineering & Design	801	04-Oct-22	21-Nov-25
	Electrical General	661	04-Oct-22	09-May-25
	Aux Power Study	30	02-Aug-23	13-Sep-23
	Elect Design Criteria	20	04-Oct-22	31-Oct-22
	Elec Notes & Details	591	16-Jan-23	09-May-25
	Grounding	350	02-Aug-23	17-Dec-24
	Grounding Site Area	60	02-Aug-23	25-Oct-23
	Grounding CC Train 1 Area	60	29-Jan-24	19-Apr-24
	Grounding CC Train 2 Area	60	29-Jan-24	19-Apr-24
	Grounding CC Chemical Storage & Precoat Filter Area	60	31-Oct-23	26-Jan-24
	Grounding North Area	60	17-Apr-24	11-Jul-24
	Grounding South Area	60	23-Sep-24	17-Dec-24
	Grounding Lightning Protection	60	03-Jan-24	26-Mar-24



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Activity ID	Activity Name	Ori Dur	Start	Finish
	Underground Raceway	220	30-Aug-23	11-Jul-24
	Elect U/G Ductbanks - CC Train 1 Area	60	30-Aug-23	22-Nov-23
	Elect U/G Ductbanks - CC Train 2 Area	60	30-Aug-23	22-Nov-23
	Elect U/G Ductbanks - CC Chemical Storage & Precoat Filter Area	60	12-Oct-23	09-Jan-24
	Elect U/G Ductbanks - North Area	60	17-Apr-24	11-Jul-24
	Elect U/G Ductbanks - South Area	70	14-Feb-24	21-May-24
	Embeded Conduit	142	14-Nov-23	05-Jun-24
	Embed Conduit - CC Train 1 Area	80	29-Jan-24	17-May-24
	Embed Conduit - CC Train 2 Area	80	29-Jan-24	17-May-24
	Embed Conduit - CC Chemical Storage & Precoat Filter Area (05)	80	14-Nov-23	08-Mar-24
	Embed Conduit - New Electrical Control Bldg (06)	80	14-Feb-24	05-Jun-24
	Embed Conduit - U4 Cooling Tower Area	80	27-Nov-23	19-Mar-24
	Cable Tray	212	14-Nov-23	13-Sep-24
	Cable Tray - CC Train 1 Area	75	14-Nov-23	01-Mar-24
	Cable Tray - CC Train 2 Area	75	14-Nov-23	01-Mar-24
	Cable Tray - CC Chemical Storage & Precoat Filter Area (05)	75	27-Nov-23	12-Mar-24
	Cable Tray - North End BOP Area	75	30-May-24	13-Sep-24
	Cable Tray - South End BOP Area	70	27-Mar-24	03-Jul-24
	Electrical Installation Diagrams	398	15-Jan-24	01-Aug-25
	Elec Installation - CC Train 1 Area	100	15-Jan-24	03-Jun-24
	Elec Installation - CC Train 2 Area	100	15-Jan-24	03-Jun-24
	Elec Installation - CC Chemical Storage & Precoat Filter Area (05)	100	16-Sep-24	06-Feb-25
	Elec Installation - North End BOP Area	100	16-Sep-24	06-Feb-25
	Elec Installation - South End BOP Area	100	17-Mar-25	01-Aug-25
	Lighting	320	24-Jan-24	24-Apr-25
	Lighting - CC Train 1 Area	80	26-Feb-24	17-Jun-24
	Lighting - CC Train 2 Area	80	26-Feb-24	17-Jun-24
	Lighting - CC Chemical Storage & Precoat Filter Area	80	24-Jan-24	14-May-24
	Lighting - North End BOP Area	80	26-Jul-24	15-Nov-24
	Lighting - South End BOP Area	80	22-May-24	13-Sep-24
	Lighting - Roadway	80	03-Jan-25	24-Apr-25
	Cable Tabulations	326	16-Aug-24	21-Nov-25
	Cable Tabs	326	16-Aug-24	21-Nov-25
	Single Line Diagrams	515	18-Oct-22	25-Oct-24
	Single Line Diagrams	505	18-Oct-22	11-Oct-24
	Three Line Diagrams	450	23-Jan-23	25-Oct-24
	Phasing Diagram	80	05-Jul-24	25-Oct-24
	Network Diagram	70	14-Sep-23	22-Dec-23
	Key Diagrams	95	02-Aug-24	17-Dec-24
	Key Diagrams - MV & LV Switchgear One Line	95	02-Aug-24	17-Dec-24
	Key Diagrams - 480V MCC's	95	02-Aug-24	17-Dec-24
	MSD Seed Files	380	06-Feb-23	01-Aug-24
	PLADES Cable Blocks	276	02-Aug-24	29-Aug-25
	PLADES Block Diagrams	156	02-Aug-24	14-Mar-25
	MSD - Low Voltage Power Sys	120	17-Mar-25	29-Aug-25
	MSD - Med Voltage Power Sys	120	18-Dec-24	05-Jun-25
	MSD - DC Sys	120	17-Mar-25	29-Aug-25
	MSD - Main Steam Sys	120	16-Sep-24	06-Mar-25
	MSD - Low Pressure Sys	120	16-Sep-24	06-Mar-25
	MSD - Condensate Sys	120	16-Sep-24	06-Mar-25
	MSD - Circ Water Sys	120	16-Sep-24	06-Mar-25
	MSD - Service Water Sys	120	19-Nov-24	09-May-25
	MSD - Demin Water Sys	120	19-Nov-24	09-May-25
	MSD - Condensate Attemperating Sys	120	19-Nov-24	09-May-25



Remaining Level of Effort
Actual Level of Effort
Actual Work
Remaining Work
Critical Remaining Work
Current Milestone
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WBS Summary Act

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Activity ID	Activity Name	Ori Dur	Start	Finish
	MSD - Potable Water Sys	120	19-Nov-24	09-May-25
	MSD - Fire Protection Sys	120	19-Nov-24	09-May-25
	MSD - Instrument Air Sys	120	16-Sep-24	06-Mar-25
	MSD - Chemical Feed Sys	120	16-Sep-24	06-Mar-25
	MSD - CO2 Sys	120	16-Sep-24	06-Mar-25
	MSD - Equipment Drains & Vents Sys	120	16-Sep-24	06-Mar-25
	MSD - Plant Drains Sys	120	16-Sep-24	06-Mar-25
	MSD - Waste water Sys	120	16-Sep-24	06-Mar-25
	MSD - Flue Gas Sys	120	19-Nov-24	09-May-25
	MSD - Cooling Tower	120	16-Sep-24	06-Mar-25
	Electrical System Descriptions	75	09-Sep-24	24-Dec-24
	Elec Aux Pwr System Description	75	09-Sep-24	24-Dec-24
	Electrical Calcs	625	23-Jan-23	03-Jul-25
	Battery Calc, Cable Pulling & UG Cable Ampacity Calc	245	30-Aug-23	15-Aug-24
	Equipment & Cable Sizing Calc	245	30-Aug-23	15-Aug-24
	Grounding Calc	125	23-Jan-23	18-Jul-23
	Lighting Calc	45	16-Aug-23	18-Oct-23
	Relay Setting Calc MV	90	04-Nov-24	13-Mar-25
	Relay Setting Calc LV	90	04-Nov-24	13-Mar-25
	Arc Flash Study Final Calc	90	28-Feb-25	03-Jul-25
	Electrical Misc	330	19-Jul-23	01-Nov-24
	Electrical Load List	330	19-Jul-23	01-Nov-24
	Electrical Revisions after Construction	520	19-Jul-23	31-Jul-25
	Calcs Revs After Construction	520	19-Jul-23	31-Jul-25
	I&C Engineering & Design	721	04-Oct-22	01-Aug-25
	Design Criteria, Diagrams & Misc	665	04-Oct-22	15-May-25
	I&C Design Criteria	20	04-Oct-22	31-Oct-22
	Instrument Installation Detail	90	26-Jul-23	01-Dec-23
	Instrument Location Dwgs	90	31-Jan-24	05-Jun-24
	Instrument List	315	01-May-23	25-Jul-24
	Instrument Data Sheets	60	13-Jun-24	06-Sep-24
	Control Sys Arch Diagrams	446	13-Jun-23	14-Mar-25
	DCS I/O List	280	04-Dec-23	09-Jan-25
	DCS Data Link Development & Coordination	110	12-Jul-24	17-Dec-24
	Alarm List	80	16-Sep-24	09-Jan-25
	Control System Master Logics	100	08-May-23	27-Sep-23
	Control System Logics / Control Narrative	100	26-Dec-24	15-May-25
	Graphic Sketches	100	12-Jul-24	03-Dec-24
	I&C Misc Support	666	22-Dec-22	01-Aug-25
	I&C Support for MSDs	166	11-Dec-24	01-Aug-25
	I&C Review of Ppg ISO's	245	23-Jan-23	09-Jan-24
	I&C Support for P&IDs	375	22-Dec-22	12-Jun-24
	I&C Support for System Descriptions	215	21-Feb-24	24-Dec-24
	I&C Revisions After Construction	280	04-Dec-23	09-Jan-25
	LOE, Project Admin & Management	1234	04-Oct-22	21-Jul-27
	Project Administration & Management	1234	04-Oct-22	21-Jul-27
	Procurement	1216	04-Oct-22	25-Jun-27
	Major Equipment Procurment	782	03-Apr-23	20-Apr-26
	MHI Submittals	442	03-Apr-23	27-Dec-24
	Civil & Architecture	145	16-Jun-23	12-Jan-24
	Static Equipment	12	30-Oct-23	14-Nov-23
	Machinery Equipment	33	29-Sep-23	14-Nov-23
	Piping	430	19-Apr-23	27-Dec-24



Remaining Level of Effort
Actual Level of Effort
Actual Work
Remaining Work
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WBS Summary Act

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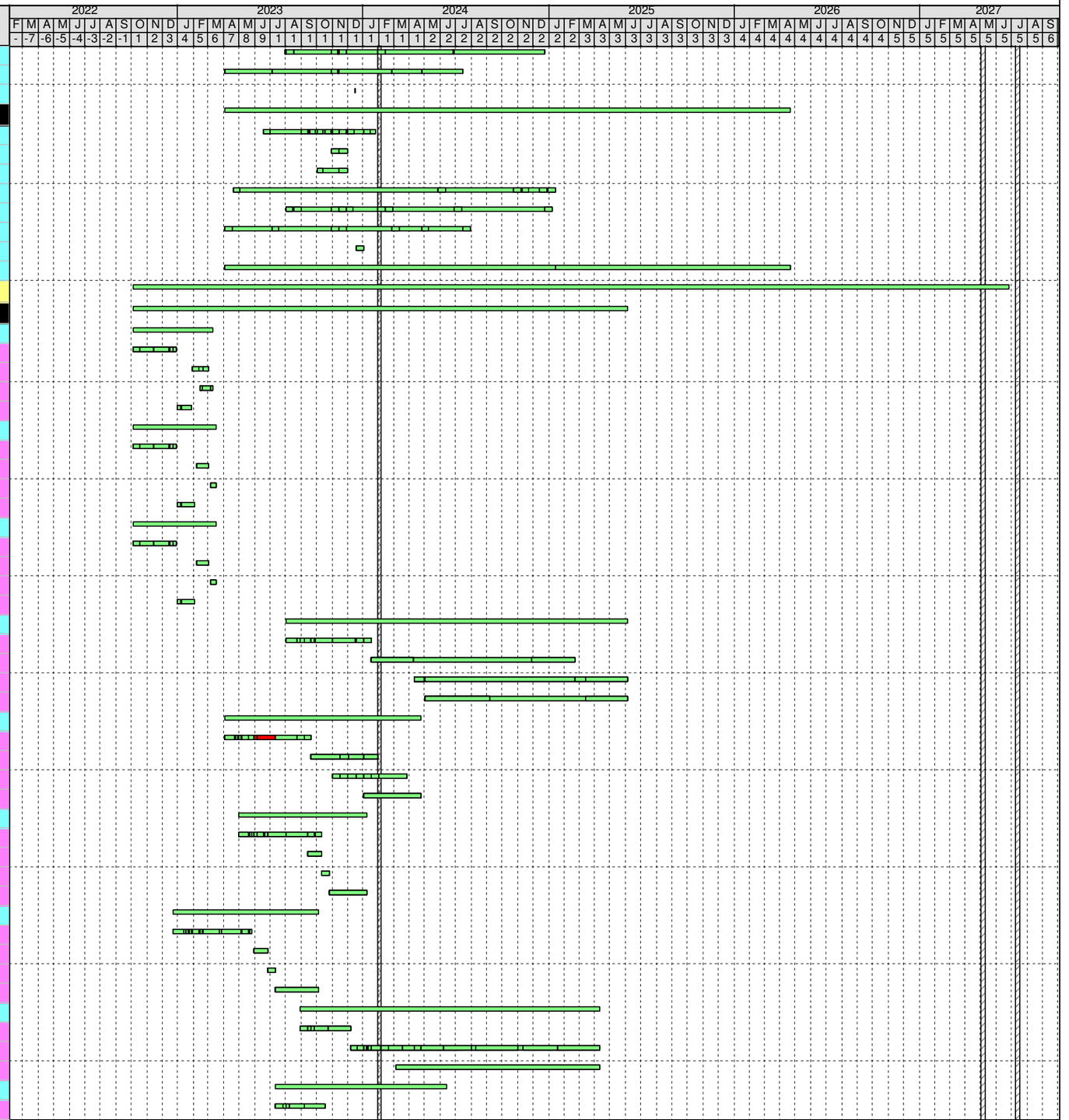
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Enchant Estimated Summary Schedule

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Activity ID	Activity Name	Ori Dur	Start	Finish
	Electrical	355	01-Aug-23	23-Dec-24
	Instrument & Control	327	03-Apr-23	15-Jul-24
	Construction	1	15-Dec-23	15-Dec-23
	MHI Reviews	781	04-Apr-23	20-Apr-26
	Civil & Architecture	154	19-Jun-23	26-Jan-24
	Static Equipment	21	31-Oct-23	30-Nov-23
	Machinery Equipment	42	02-Oct-23	30-Nov-23
	Piping	439	20-Apr-23	13-Jan-25
	Electrical	364	02-Aug-23	08-Jan-25
	Instrument & Control	336	04-Apr-23	29-Jul-24
	Construction	10	18-Dec-23	02-Jan-24
	Vendor Interface	781	04-Apr-23	20-Apr-26
	BOP Procurement	216	04-Oct-22	25-Jun-27
	Civil /Structural / Architecural Procurement	680	04-Oct-22	05-Jun-25
	Geotechnical Investigation Procurement	110	04-Oct-22	10-Mar-23
	Geotechnical Investigation Spec	60	04-Oct-22	29-Dec-22
	Geotechnical Investigation Vendor Drawings	25	30-Jan-23	03-Mar-23
	Geotechnical Investigation Vendor Dwg Reviews	20	13-Feb-23	10-Mar-23
	Geotechnical Investigation Site Mobilization	20	30-Dec-22	27-Jan-23
	Site U/G Utility Investigation Procurement	115	04-Oct-22	17-Mar-23
	Site U/G Utility Investigation Spec	60	04-Oct-22	29-Dec-22
	Site U/G Utility Investigation Vendor Drawings	20	06-Feb-23	03-Mar-23
	Site U/G Utility Investigation Vendor Dwg Reviews	10	06-Mar-23	17-Mar-23
	Site U/G Utility Investigation Site Mobilization	25	30-Dec-22	03-Feb-23
	Site Survey Procurement	115	04-Oct-22	17-Mar-23
	Site Survey Spec	60	04-Oct-22	29-Dec-22
	Site Survey Vendor Drawings	20	06-Feb-23	03-Mar-23
	Site Survey Vendor Dwg Reviews	10	06-Mar-23	17-Mar-23
	Site Survey Site Mobilization	25	30-Dec-22	03-Feb-23
	Structural Steel Fabrication Procurement	470	02-Aug-23	05-Jun-25
	Structural Steel Fabrication Spec	115	02-Aug-23	16-Jan-24
	Structural Steel Fabrication Vendor Submittals	280	17-Jan-24	20-Feb-25
	Structural Steel Fabrication Vendor Dwg Reviews	295	10-Apr-24	05-Jun-25
	Structural Steel Fabrication Fab & Deliver	280	01-May-24	05-Jun-25
	Pre-Engineered Bldgs Procurement	270	03-Apr-23	23-Apr-24
	Pre-Engineered Bldgs Spec	120	03-Apr-23	20-Sep-23
	Pre-Engineered Bldgs Vendor Submittals	90	21-Sep-23	30-Jan-24
	Pre-Engineered Bldgs Vendor Dwg Reviews	100	02-Nov-23	26-Mar-24
	Pre-Engineered Bldgs Fab & Deliver	80	03-Jan-24	23-Apr-24
	Elevator Procurement	175	01-May-23	09-Jan-24
	Elevator Spec	115	01-May-23	11-Oct-23
	Elevator Vendor Drawings	20	14-Sep-23	11-Oct-23
	Elevator Vendor Dwg Reviews	10	12-Oct-23	25-Oct-23
	Elevator Fab & Deliver	50	26-Oct-23	09-Jan-24
	Oily Water Separator Procurement	200	22-Dec-22	04-Oct-23
	Oily Water Separator Spec	110	22-Dec-22	26-May-23
	Oily Water Separator Vendor Drawings	20	30-May-23	26-Jun-23
	Oily Water Separator Vendor Dwg Reviews	10	27-Jun-23	11-Jul-23
	Oily Water Separator Fab & Deliver	60	12-Jul-23	04-Oct-23
	Kiewit Fdn Procurement (Placeholder)	411	29-Aug-23	10-Apr-25
	KIE Fdn Spec	70	29-Aug-23	07-Dec-23
	KIE Fdn Rebar Submittals/Review/Fab & Delivery	341	08-Dec-23	10-Apr-25
	S&L Rebar Shop Dwg Rvw	281	05-Mar-24	10-Apr-25
	Kiewit Ductwork Procurement (Placeholder)	235	12-Jul-23	12-Jun-24
	KIE Ductwork Spec	70	12-Jul-23	18-Oct-23



Remaining Level of Effort | Actual Work | Critical Remaining Work | Actual Milestone

Actual Level of Effort | Remaining Work | Current Milestone | WBS Summary Act

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Activity ID	Activity Name	Ori Dur	Start	Finish
	Ductwork Fabrication Vendor Submittals	60	19-Oct-23	16-Jan-24
	Ductwork Fabrication Vendor Dwg Reviews	45	04-Dec-23	06-Feb-24
	Ductwork Fabrication Fabr & Deliver	90	07-Feb-24	12-Jun-24
	Mechanical Procurement	1161	22-Dec-22	25-Jun-27
	Cooling Tower Procurement	275	22-Dec-22	23-Jan-24
	Cooling Tower Spec	115	22-Dec-22	05-Jun-23
	Cooling Tower Vendor Drawings Submittals	90	06-Jun-23	11-Oct-23
	Cooling Tower Vendor Dwg Reviews	130	19-Jul-23	23-Jan-24
	Cooling Tower Fabrication & Delivery	80	14-Sep-23	09-Jan-24
	Water Pumps Procurement	295	27-Feb-23	23-Apr-24
	Water Pumps Spec	100	27-Feb-23	18-Jul-23
	Water Pumps Vendor Drawings Submittals	90	19-Jul-23	22-Nov-23
	Water Pumps Vendor Dwg Reviews	130	30-Aug-23	05-Mar-24
	Water Pumps Fabrication & Delivery	125	26-Oct-23	23-Apr-24
	CO2 Pumps Procurement	310	17-Apr-23	03-Jul-24
	CO2 Pumps Spec	115	17-Apr-23	27-Sep-23
	CO2 Pumps Vendor Drawings Submittals	90	28-Sep-23	06-Feb-24
	CO2 Pumps Vendor Dwg Reviews	130	09-Nov-23	14-May-24
	CO2 Pumps Fabrication & Delivery	125	10-Jan-24	03-Jul-24
	Sump Pumps Procurement	280	27-Feb-23	02-Apr-24
	Sump Pumps Spec	100	27-Feb-23	18-Jul-23
	Sump Pumps Vendor Drawings Submittals	90	19-Jul-23	22-Nov-23
	Sump Pumps Vendor Dwg Reviews	130	30-Aug-23	05-Mar-24
	Sump Pumps Fabrication & Delivery	100	09-Nov-23	02-Apr-24
	Control Valves Procurement	340	30-May-23	27-Sep-24
	Control Valves Spec	100	30-May-23	18-Oct-23
	Control Valves Vendor Drawings Submittals	90	19-Oct-23	27-Feb-24
	Control Valves Vendor Dwg Reviews	100	17-Jan-24	05-Jun-24
	Control Valves Fabrication & Delivery	140	13-Mar-24	27-Sep-24
	Air Compressors & Dryers Procurement	300	20-Feb-23	23-Apr-24
	Air Compressors & Dryers Spec	105	20-Feb-23	18-Jul-23
	Air Compressors & Dryers Vendor Drawings Submittals	90	19-Jul-23	22-Nov-23
	Air Compressors & Dryers Vendor Drawings Rvw	130	30-Aug-23	05-Mar-24
	Air Compressors & Dryers Fabrication & Delivery	125	26-Oct-23	23-Apr-24
	Shop Fabricated Tanks (Steel) Procurement	250	01-May-23	23-Apr-24
	Shop Fabricated Tanks (Steel) Spec	100	01-May-23	20-Sep-23
	Shop Fabricated Tanks (Steel) Vendor Drawings Submittals	60	21-Sep-23	15-Dec-23
	Shop Fabricated Tanks (Steel) Vendor Dwg Reviews	100	02-Nov-23	26-Mar-24
	Shop Fabricated Tanks (Steel) Fabrication & Delivery	80	03-Jan-24	23-Apr-24
	Field Fabricated Tanks Procurement	285	03-Apr-23	14-May-24
	Field Fabricated Tanks Spec	100	03-Apr-23	22-Aug-23
	Field Fabricated Tanks Vendor Drawings Submittals	70	23-Aug-23	01-Dec-23
	Field Fabricated Tanks Vendor Dwg Reviews	110	05-Oct-23	12-Mar-24
	Field Fabricated Tanks Fabrication & Delivery	105	18-Dec-23	14-May-24
	Shop Fabricated Tanks (Fiberglass / HDPE) Procurement	275	01-May-23	29-May-24
	Shop Fabricated Tanks (Fiberglass / HDPE) Spec	100	01-May-23	20-Sep-23
	Shop Fabricated Tanks (Fiberglass / HDPE) Vendor Drawings Submittals	60	21-Sep-23	15-Dec-23
	Shop Fabricated Tanks (Fiberglass / HDPE) Vendor Dwg Reviews	100	02-Nov-23	26-Mar-24
	Shop Fabricated Tanks (Fiberglass / HDPE) Fabrication & Delivery	105	03-Jan-24	29-May-24
	Circ Water Piping Procurement	415	09-Jan-23	22-Aug-24
	Circ Water Piping Spec	210	09-Jan-23	01-Nov-23
	Circ Water Piping Vendor Drawings	65	24-Jan-24	23-Apr-24
	Circ Water Piping Vendor Drawing Review	85	13-Mar-24	11-Jul-24
	Circ Water Piping Fab & Deliver	70	15-May-24	22-Aug-24
	Shop Fabricated Piping (Steel) Procurement	325	06-Mar-23	12-Jun-24



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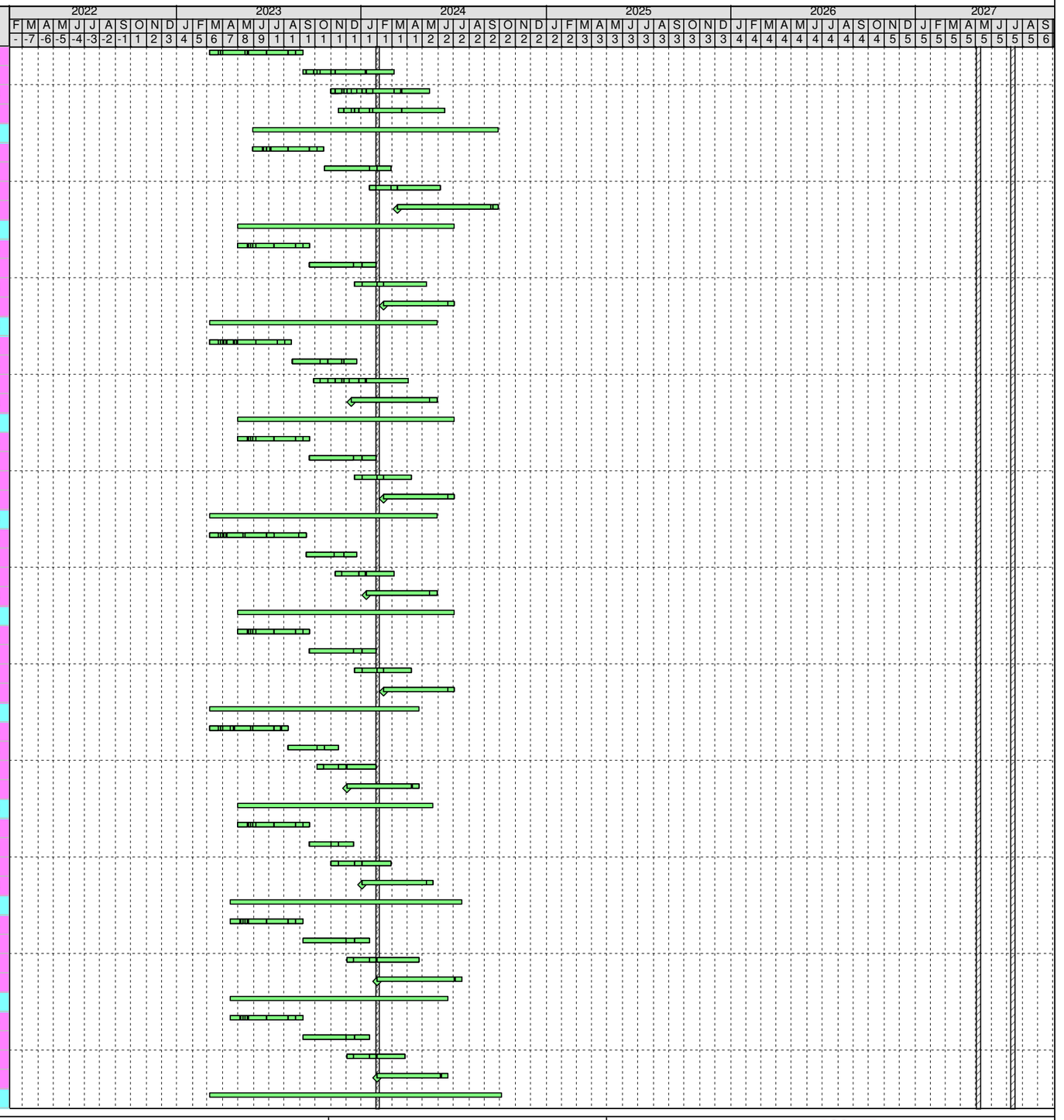
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Enchant Estimated Summary Schedule

Data Date: 20-Jul-21

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Activity ID	Activity Name	Ori Dur	Start	Finish
	Shop Fabricated Piping (Steel) Spec	130	06-Mar-23	06-Sep-23
	Shop Fabricated Piping (Steel) Vendor Drawings	125	07-Sep-23	05-Mar-24
	Shop Fabricated Piping (Steel) Vendor Drawing Review	135	02-Nov-23	14-May-24
	Shop Fabricated Piping (Steel) Fab & Deliver	145	16-Nov-23	12-Jun-24
	High Pressure Valves (Globes, Gates, Checks) Procurement	340	30-May-23	27-Sep-24
	High Pressure Valves (Globes, Gates, Checks) Spec	100	30-May-23	18-Oct-23
	High Pressure Valves (Globes, Gates, Checks) Vendor Drawings Submittals	90	19-Oct-23	27-Feb-24
	High Pressure Valves (Globes, Gates, Checks) Vendor Dwg Reviews	100	17-Jan-24	05-Jun-24
	High Pressure Valves (Globes, Gates, Checks) Fabrication & Delivery	140	13-Mar-24	27-Sep-24
	Low Pressure Valves (Globes, Gates, Checks) Procurement	300	01-May-23	03-Jul-24
	Low Pressure Valves (Globes, Gates, Checks) Spec	100	01-May-23	20-Sep-23
	Low Pressure Valves (Globes, Gates, Checks) Vendor Drawings Submittals	90	21-Sep-23	30-Jan-24
	Low Pressure Valves (Globes, Gates, Checks) Vendor Dwg Reviews	100	18-Dec-23	07-May-24
	Low Pressure Valves (Globes, Gates, Checks) Fab & Deliver	100	14-Feb-24	03-Jul-24
	Extraction Steam Check Valves Procurement	315	06-Mar-23	29-May-24
	Extraction Steam Check Valves Spec	115	06-Mar-23	15-Aug-23
	Extraction Steam Check Valves Vendor Drawings Submittals	90	16-Aug-23	22-Dec-23
	Extraction Steam Check Valves Vendor Dwg Reviews	130	28-Sep-23	02-Apr-24
	Extraction Steam Check Valves Fab & Deliver	120	11-Dec-23	29-May-24
	High Performance Butterfly Valves Procurement	300	01-May-23	03-Jul-24
	High Performance Butterfly Valves Spec	100	01-May-23	20-Sep-23
	High Performance Butterfly Valves Vendor Drawings Submittals	90	21-Sep-23	30-Jan-24
	High Performance Butterfly Valves Vendor Dwg Reviews	80	18-Dec-23	09-Apr-24
	High Performance Butterfly Valves Fabrication & Delivery	100	14-Feb-24	03-Jul-24
	AWWA Butterfly Valves Procurement	315	06-Mar-23	29-May-24
	AWWA Butterfly Valves Spec	135	06-Mar-23	13-Sep-23
	AWWA Butterfly Valves Vendor Drawings Submittals	70	14-Sep-23	22-Dec-23
	AWWA Butterfly Valves Vendor Dwg Reviews	80	09-Nov-23	05-Mar-24
	AWWA Butterfly Valves Fab & Deliver	100	10-Jan-24	29-May-24
	Ball Valves Procurement	300	01-May-23	03-Jul-24
	Ball Valves Spec	100	01-May-23	20-Sep-23
	Ball Valves Vendor Drawings Submittals	90	21-Sep-23	30-Jan-24
	Ball Valves Vendor Dwg Reviews	80	18-Dec-23	09-Apr-24
	Ball Valves Fabrication & Delivery	100	14-Feb-24	03-Jul-24
	Safety and Relief Valves Procurement	290	06-Mar-23	23-Apr-24
	Safety and Relief Valves Spec	110	06-Mar-23	08-Aug-23
	Safety and Relief Valves Vendor Drawings Submittals	70	09-Aug-23	15-Nov-23
	Safety and Relief Valves Vendor Dwg Reviews	80	05-Oct-23	30-Jan-24
	Safety and Relief Valves Fab & Deliver	100	04-Dec-23	23-Apr-24
	Mechanical Specialties Procurement	270	01-May-23	21-May-24
	Mechanical Specialties Spec	100	01-May-23	20-Sep-23
	Mechanical Specialties Vendor Drawings	60	21-Sep-23	15-Dec-23
	Mechanical Specialties Vendor Drawing Review	80	02-Nov-23	27-Feb-24
	Mechanical Specialties Valves Fab & Deliver	100	03-Jan-24	21-May-24
	Flue Gas Dampers Procurement	320	17-Apr-23	18-Jul-24
	Flue Gas Dampers Spec	100	17-Apr-23	06-Sep-23
	Flue Gas Dampers Vendor Drawings Submittals	90	07-Sep-23	16-Jan-24
	Flue Gas Dampers Vendor Dwg Reviews	100	04-Dec-23	23-Apr-24
	Flue Gas Dampers Fab & Deliver	120	31-Jan-24	18-Jul-24
	Flue Gas Expansion Joints Procurement	300	17-Apr-23	19-Jun-24
	Natural Gas Valves Spec	100	17-Apr-23	06-Sep-23
	Natural Gas Valves Vendor Drawings Submittals	90	07-Sep-23	16-Jan-24
	Natural Gas Valves Vendor Dwg Reviews	80	04-Dec-23	26-Mar-24
	Natural Gas Valves Fab & Deliver	100	31-Jan-24	19-Jun-24
	Engineered Pipe Supports Procurement	405	06-Mar-23	04-Oct-24



Remaining Level of Effort
Actual Level of Effort
Actual Work
Remaining Work
Critical Remaining Work
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Actual Milestone
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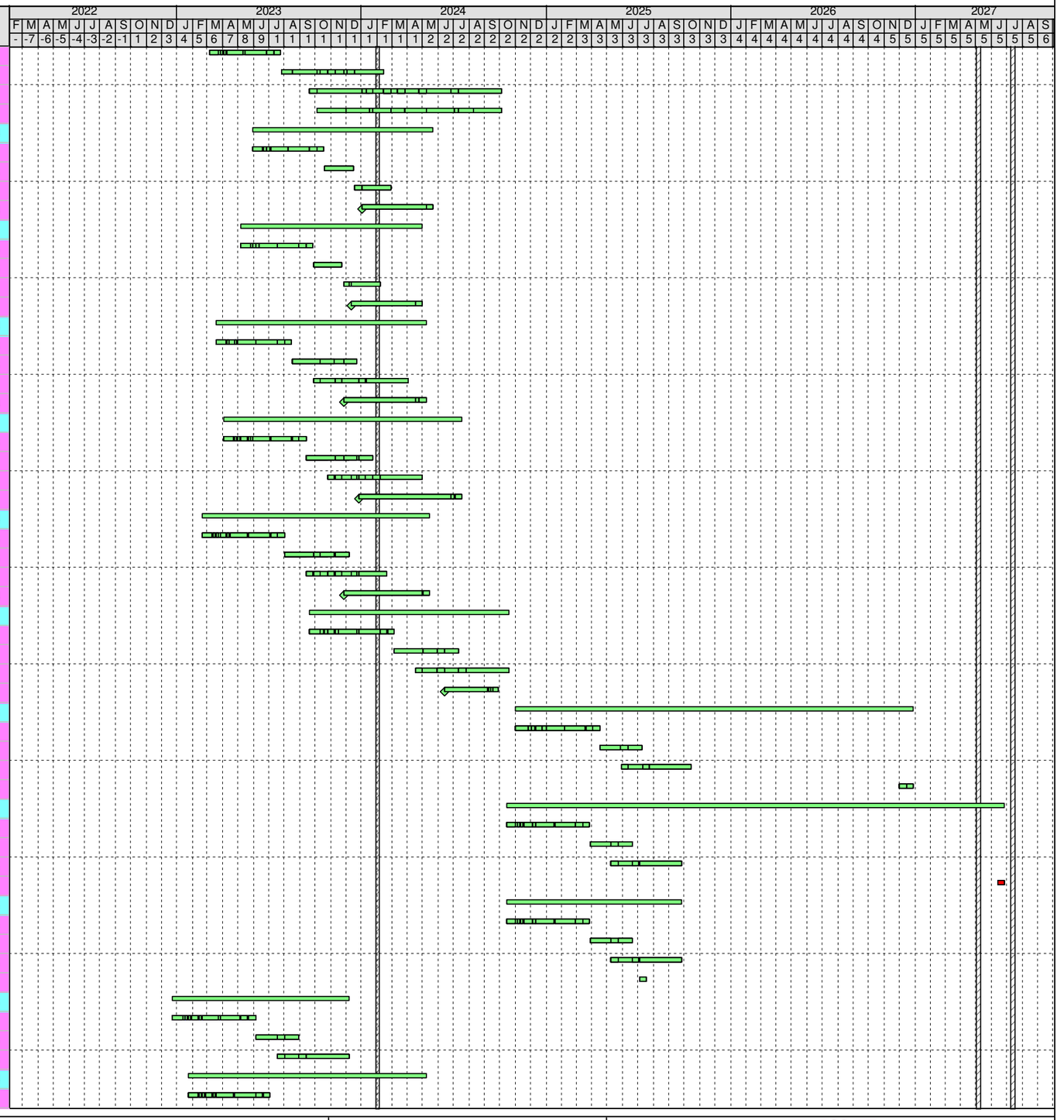
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Activity ID	Activity Name	Ori Dur	Start	Finish
	Engineered Pipe Supports Spec	100	06-Mar-23	25-Jul-23
	Engineered Pipe Supports Vendor Drawings Submittals	140	26-Jul-23	13-Feb-24
	Engineered Pipe Supports Vendor Drawing Reviews	265	21-Sep-23	04-Oct-24
	Engineered Pipe Supports Fab & Deliver	255	05-Oct-23	04-Oct-24
	Insulation & Lagging Procurement	250	30-May-23	21-May-24
	Insulation & Lagging Spec	100	30-May-23	18-Oct-23
	Insulation & Lagging Vendor Drawings Submittals	40	19-Oct-23	15-Dec-23
	Insulation & Lagging Vendor Dwg Reviews	50	18-Dec-23	27-Feb-24
	Insulation & Lagging Fab & Deliver	100	03-Jan-24	21-May-24
	Coatings Procurement	250	08-May-23	30-Apr-24
	Coatings Spec	100	08-May-23	27-Sep-23
	Coatings Vendor Drawings Submittals	40	28-Sep-23	22-Nov-23
	Coatings Vendor Dwg Reviews	50	27-Nov-23	06-Feb-24
	Coatings Fab & Deliver	100	11-Dec-23	30-Apr-24
	Chemical Feed Procurement	290	20-Mar-23	07-May-24
	Chemical Feed Spec	105	20-Mar-23	15-Aug-23
	Chemical Feed Vendor Drawings Submittals	90	16-Aug-23	22-Dec-23
	Chemical Feed Vendor Dwg Reviews	130	28-Sep-23	02-Apr-24
	Chemical Feed Fabrication & Delivery	115	27-Nov-23	07-May-24
	Waste Water Treatment Procurement	330	03-Apr-23	18-Jul-24
	Waste Water Treatment Spec	115	03-Apr-23	13-Sep-23
	Waste Water Treatment Vendor Drawings Submittals	90	14-Sep-23	23-Jan-24
	Waste Water Treatment Vendor Dwg Reviews	130	26-Oct-23	30-Apr-24
	Waste Water Treatment Fabrication & Delivery	145	26-Dec-23	18-Jul-24
	Fire Protection Sys Procurement	315	20-Feb-23	14-May-24
	Fire Protection Sys Spec	115	20-Feb-23	01-Aug-23
	Fire Protection Sys Vendor Drawings Submittals	90	02-Aug-23	08-Dec-23
	Fire Protection Sys Vendor Dwg Reviews	110	14-Sep-23	20-Feb-24
	Fire Protection Sys Fab & Deliver	120	27-Nov-23	14-May-24
	Hoists & Cranes Procurement	275	21-Sep-23	18-Oct-24
	Hoists & Cranes Spec	115	21-Sep-23	05-Mar-24
	Hoists & Cranes Vendor Drawings Submittals	90	06-Mar-24	11-Jul-24
	Hoists & Cranes Vendor Dwg Reviews	130	17-Apr-24	18-Oct-24
	Hoists & Cranes Fabrication & Delivery	75	13-Jun-24	27-Sep-24
	Noise Testing Procurement	558	01-Nov-24	28-Dec-26
	Noise Testing Spec	115	01-Nov-24	16-Apr-25
	Noise Testing Vendor Drawings Submittals	60	17-Apr-25	09-Jul-25
	Noise Testing Vendor Dwg Reviews	100	29-May-25	15-Oct-25
	Noise Testing Fabrication & Delivery	20	01-Dec-26	28-Dec-26
	Performance Testing Procurement	701	14-Oct-24	25-Jun-27
	Performance Testing Spec	115	14-Oct-24	27-Mar-25
	Performance Testing Vendor Submittals	60	28-Mar-25	19-Jun-25
	Performance Testing Vendor Reviews	100	09-May-25	25-Sep-25
	Performance Testing Mobilize	10	14-Jun-27	25-Jun-27
	Emissions Testing Procurement	245	14-Oct-24	25-Sep-25
	Emissions Testing Spec	115	14-Oct-24	27-Mar-25
	Emissions Testing Vendor Drawings Submittals	60	28-Mar-25	19-Jun-25
	Emissions Testing Vendor Dwg Reviews	100	09-May-25	25-Sep-25
	Emissions Testing Fabrication & Delivery	10	04-Jul-25	17-Jul-25
	Steam Turbine Study Procurement	245	22-Dec-22	08-Dec-23
	Steam Turbine Study Spec	115	22-Dec-22	05-Jun-23
	Steam Turbine Study Vendor Drawings Submittals	60	06-Jun-23	29-Aug-23
	Steam Turbine Study Vendor Dwg Reviews	100	19-Jul-23	08-Dec-23
	Steam Turbine Modifications Procurement	330	23-Jan-23	07-May-24
	Steam Turbine Modifications Spec	115	23-Jan-23	03-Jul-23



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Enchant Estimated Summary Schedule

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Activity ID	Activity Name	Ori Dur	Start	Finish
	Steam Turbine Modifications Vendor Drawings Submittals	60	05-Jul-23	27-Sep-23
	Steam Turbine Modifications Vendor Dwg Reviews	100	16-Aug-23	09-Jan-24
	Steam Turbine Modifications Fabrication & Delivery	145	12-Oct-23	07-May-24
	HVAC Procurement	290	15-Nov-23	08-Jan-25
	HVAC Spec	115	15-Nov-23	29-Apr-24
	HVAC Vendor Drawings Submittals	90	30-Apr-24	05-Sep-24
	HVAC Vendor Dwg Reviews	130	12-Jun-24	16-Dec-24
	HVAC Fabrication & Delivery	105	08-Aug-24	08-Jan-25
	Cooling Tower Intake Screens & Stop Logs Procurement	260	05-Oct-23	11-Oct-24
	Cooling Tower Intake Screens & Stop Logs Spec	115	05-Oct-23	19-Mar-24
	Cooling Tower Intake Screens & Stop Logs Vendor Drawings Submittals	60	20-Mar-24	12-Jun-24
	Cooling Tower Intake Screens & Stop Logs Vendor Dwg Reviews	100	01-May-24	20-Sep-24
	Cooling Tower Intake Screens & Stop Logs Fabrication & Delivery	75	27-Jun-24	11-Oct-24
	Electrical Procurement	765	08-Dec-22	04-Dec-25
	Auxiliary Transformers Procurement	765	08-Dec-22	04-Dec-25
	Auxiliary Transformer Spec	260	08-Dec-22	15-Dec-23
	Auxiliary Transformer Vendor Drawings Submittals	90	18-Dec-23	23-Apr-24
	Auxiliary Transformer Vendor Dwg Reviews	130	31-Jan-24	01-Aug-24
	Auxiliary Transformer Fabrication & Delivery	435	27-Mar-24	04-Dec-25
	PDC (incl 5kV Swgr/MCCs) Procurement	435	09-Aug-23	24-Apr-25
	PDC (incl 5kV Swgr/MCCs) Spec	135	09-Aug-23	20-Feb-24
	PDC (incl 5kV Swgr/MCCs) COOL TWR Vendor Drawings	60	21-Feb-24	14-May-24
	PDC (incl 5kV Swgr/MCCs) COOL TWR Vendor Dwg Reviews	105	03-Apr-24	29-Aug-24
	PDC (incl 5kV Swgr/MCCs) MHI CC Vendor Drawings	60	21-Feb-24	14-May-24
	PDC (incl 5kV Swgr/MCCs) MHI CC Vendor Dwg Reviews	105	03-Apr-24	29-Aug-24
	PDC COOL TOWER Assembly Fab & Deliver	230	30-May-24	24-Apr-25
	PDC MHI CC Assembly Fab & Deliver	230	30-May-24	24-Apr-25
	Iso Phase Bus Duct Procurement	330	31-Jan-24	15-May-25
	Iso Phase Bus Duct Spec	125	31-Jan-24	25-Jul-24
	Iso Phase Bus Duct Vendor Drawings	90	26-Jul-24	03-Dec-24
	Iso Phase Bus Duct Vendor Dwg Reviews	135	09-Sep-24	20-Mar-25
	Iso Phase Bus Duct Fab & Deliver	105	18-Dec-24	15-May-25
	Cable Bus Phase Bus Duct Procurement	310	17-Apr-24	03-Jul-25
	Cable Bus Phase Bus Duct Spec	160	17-Apr-24	03-Dec-24
	Cable Bus Phase Bus Duct Vendor Drawings	60	04-Dec-24	27-Feb-25
	Cable Bus Phase Bus Duct Vendor Dwg Reviews	105	17-Jan-25	12-Jun-25
	Cable Bus Phase Bus Duct Fab & Deliver	80	14-Mar-25	03-Jul-25
	480V Unit Substation Transformers Procurement	325	19-Oct-23	30-Jan-25
	480V Unit Substation Transformer Spec	120	19-Oct-23	09-Apr-24
	480V Unit Substation Transformer Vendor Drawings Submittals	90	10-Apr-24	15-Aug-24
	480V Unit Substation Transformer Vendor Dwg Reviews	150	22-May-24	24-Dec-24
	480V Unit Substation Transformer Fabrication & Delivery	105	30-Aug-24	30-Jan-25
	Power Cable Procurement	230	05-Jul-24	29-May-25
	Power Cable Spec	130	05-Jul-24	09-Jan-25
	Power Cable Vendor Drawings Submittals	20	10-Jan-25	06-Feb-25
	Power Cable Vendor Dwg Reviews	80	07-Feb-25	29-May-25
	Power Cable Fab & Deliver	90	10-Jan-25	15-May-25
	Grounding & Lightning Protection Procurement	235	18-Dec-23	15-Nov-24
	Grounding & Lightning Protection Spec	120	18-Dec-23	05-Jun-24
	Grounding & Lightning Protection Vendor Drawings	20	06-Jun-24	03-Jul-24
	Grounding & Lightning Protection Vendor Dwg Reviews	65	24-Apr-24	25-Jul-24
	Grounding & Lightning Protection Fabrication & Delivery	80	26-Jul-24	15-Nov-24
	Lighting & Receptacles Procurement	200	09-Sep-24	19-Jun-25
	Lighting & Receptacles Spec	120	09-Sep-24	27-Feb-25
	Lighting & Receptacles Vendor Drawings	20	28-Feb-25	27-Mar-25



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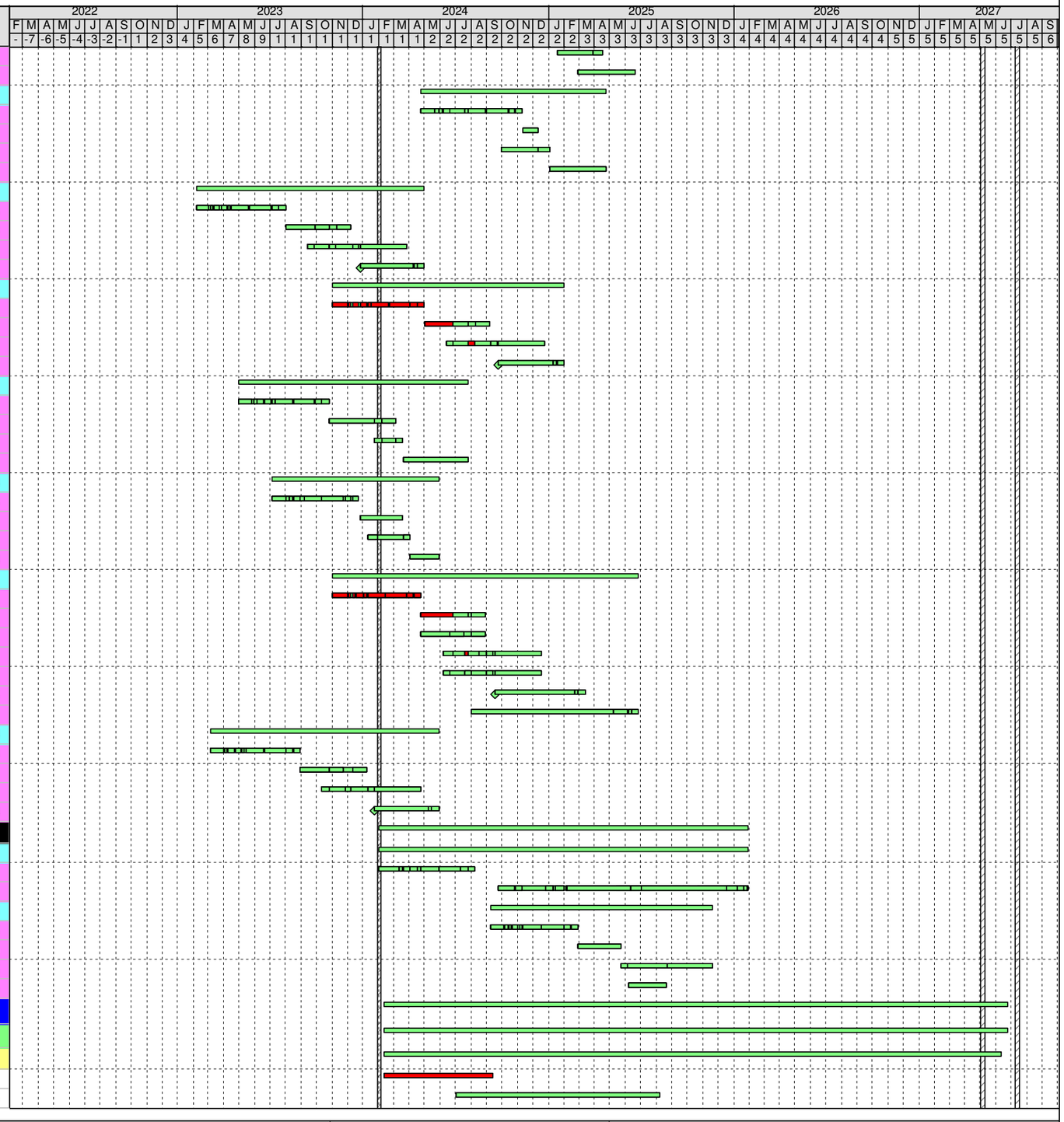
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Activity ID	Activity Name	Ori Dur	Start	Finish
	Lighting & Receptacles Vendor Dwg Reviews	65	17-Jan-25	17-Apr-25
	Lighting & Receptacles Fabrication & Delivery	80	28-Feb-25	19-Jun-25
	Raceway (Cable Tray, Conduit, Junction Boxes, etc) Procurement	255	24-Apr-24	24-Apr-25
	Raceway (Cable Tray, Conduit, Junction Boxes, etc) Spec	140	24-Apr-24	08-Nov-24
	Raceway (Cable Tray, Conduit, Junction Boxes, etc) Vendor Dwg Reviews	20	11-Nov-24	10-Dec-24
	Raceway (Cable Tray, Conduit, Junction Boxes, etc) Vendor Drawings	65	30-Sep-24	02-Jan-25
	Raceway (Cable Tray, Conduit, Junction Boxes, etc) Fabrication & Delivery	80	03-Jan-25	24-Apr-25
	Batteries Procurement	315	06-Feb-23	30-Apr-24
	Batteries Spec	125	06-Feb-23	01-Aug-23
	Batteries Vendor Drawings Submittals	90	02-Aug-23	08-Dec-23
	Batteries Vendor Dwg Reviews	135	14-Sep-23	26-Mar-24
	Batteries Fab & Deliver	90	26-Dec-23	30-Apr-24
	Plant Communication Procurement	315	02-Nov-23	30-Jan-25
	Plant Communication Spec	125	02-Nov-23	30-Apr-24
	Plant Communication Vendor Drawings Submittals	90	01-May-24	06-Sep-24
	Plant Communication Vendor Dwg Reviews	135	13-Jun-24	24-Dec-24
	Plant Communication Fab & Deliver	90	23-Sep-24	30-Jan-25
	Freeze Protection Heat Tracing Procurement	315	01-May-23	25-Jul-24
	Freeze Protection Heat Tracing Spec	125	01-May-23	25-Oct-23
	Freeze Protection Heat Tracing Vendor Drawings Submittals	90	26-Oct-23	05-Mar-24
	Freeze Protection Heat Tracing Vendor Dwg Reviews	40	24-Jan-24	19-Mar-24
	Freeze Protection Heat Tracing Fabrication & Delivery	90	20-Mar-24	25-Jul-24
	Cathodic Protection Procurement	230	05-Jul-23	29-May-24
	Cathodic Protection Spec	120	05-Jul-23	22-Dec-23
	Cathodic Protection Vendor Drawings	60	26-Dec-23	19-Mar-24
	Cathodic Protection Vendor Dwg Reviews	60	10-Jan-24	02-Apr-24
	Cathodic Protection Fabrication & Delivery	40	03-Apr-24	29-May-24
	CO2 Compressor VFDs Procurement	420	02-Nov-23	26-Jun-25
	CO2 Compressor VFDs Spec	120	02-Nov-23	23-Apr-24
	CO2 Compressor VFDs Vendor Drawings Submittals	90	24-Apr-24	29-Aug-24
	CO2 Compressor VFDs PDC (incl 5kV Swgr/MCCs) VFD Vendor Drawings	90	24-Apr-24	29-Aug-24
	CO2 Compressor VFDs Vendor Dwg Reviews	135	06-Jun-24	17-Dec-24
	CO2 Compressor VFDs PDC (incl 5kV Swgr/MCCs) VFD Vendor Dwg Reviews	135	06-Jun-24	17-Dec-24
	CO2 Compressor VFDs Fab & Deliver	125	16-Sep-24	13-Mar-25
	CO2 Compressor VFD PDC Assembly Fab & Deliver	230	02-Aug-24	26-Jun-25
	Protective Relay Panel Procurement	315	06-Mar-23	29-May-24
	Protective Relay Panel Spec	125	06-Mar-23	29-Aug-23
	Protective Relay Panel Vendor Drawings Submittals	90	30-Aug-23	09-Jan-24
	Protective Relay Panel Vendor Dwg Reviews	135	12-Oct-23	23-Apr-24
	Protective Relay Panel Fab & Deliver	90	24-Jan-24	29-May-24
	I&C Procurement	514	31-Jan-24	28-Jan-26
	DCS Procurement	514	31-Jan-24	28-Jan-26
	DCS Spec	135	31-Jan-24	08-Aug-24
	DCS Vendor Eng	349	23-Sep-24	28-Jan-26
	Instruments Procurement	310	09-Sep-24	20-Nov-25
	Instruments Spec	120	09-Sep-24	27-Feb-25
	Instruments Vendor Drawings	60	28-Feb-25	22-May-25
	Instruments Vendor Dwg Reviews	130	23-May-25	20-Nov-25
	Instruments Fab & Deliver	55	06-Jun-25	21-Aug-25
	San Juan Generating Station Carbon Capture L1	860	12-Feb-24	24-Jun-27
	4. Site Construction	860	12-Feb-24	24-Jun-27
	Civil & Structure Work	850	12-Feb-24	10-Jun-27
A1000	Site Development	150	12-Feb-24*	13-Sep-24
A1010	Foundation and Paving Work	275	03-Jul-24	07-Aug-25



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Activity ID	Activity Name	Ori Dur	Start	Finish
A1020	Steel Structure Fabrication Work	115	23-Sep-24	07-Mar-25
A1030	Common Pipe Rack Erection	100	27-Jan-25	17-Jun-25
A1390	Misc Foundations	120	08-Aug-25	29-Jan-26
A1040	Duct Support Installation (Train 1 & 2)	35	20-Mar-26	07-May-26
A1050	Duct Installation Work (Train 1 & 2)	55	08-May-26	23-Jul-26
A1400	Final Sitework	160	30-Oct-26	10-Jun-27
Mechanical Installation Work		465	20-May-25	11-Mar-27
A1210	Pump + PHE Installation (Pipe Rack)	40	20-May-25	17-Jul-25
A1090	Main Pipe Rack & Pipe Chase Installation (Train 1 & 2)	35	18-Jun-25	07-Aug-25
A1060	Quencher Ground Assembly	125	15-Aug-25	12-Feb-26
A1200	Reboiler Module Ground Assemble and Installation (Train 1 & 2)	50	29-Aug-25	07-Nov-25
A1110	Absorber Ground Assembly	250	15-Sep-25	03-Sep-26
A1070	Quencher Box Erection	110	06-Oct-25	12-Mar-26
A1130	Absorber Box Erection	250	27-Oct-25	15-Oct-26
A1180	Regenerator Ground Dress-Up and Installation (Train 1 & 2)	40	10-Nov-25	08-Jan-26
A1240	Other Equipment Installation	85	24-Nov-25	26-Mar-26
A1190	Regenerator Internal Work	55	09-Jan-26	26-Mar-26
A1220	Compressor & Dehydration Unit Installation (Train 1 & 2)	110	09-Jan-26	11-Jun-26
A1230	Blower Installation (Train 1 & 2)	45	06-Mar-26	07-May-26
A1080	Erect Quencher Equipment/Ductwork/Externals/Piping/Internals	130	06-Mar-26	03-Sep-26
A1160	Erect Absorber Equipment/Ductwork/Externals/Piping/Internals	115	02-Oct-26	11-Mar-27
Piping		675	21-May-24	14-Jan-27
A1250	UG Piping Work & Duct Bank	110	21-May-24	25-Oct-24
A1270	Piping Installation Work (Train 1 & 2)	345	15-Aug-25	17-Dec-26
A1280	Piping Test & Reinstatement (Train 1 & 2)	305	10-Nov-25	14-Jan-27
Instrumentation		360	15-Sep-25	04-Feb-27
A1300	Cable Tray / Cabling Work (Train 1 & 2 & Common)	345	15-Sep-25	14-Jan-27
A1290	Cabinet Installation	20	29-Sep-25	24-Oct-25
A1310	Instrument Work (Train 1 & 2)	240	23-Jan-26	24-Dec-26
A1320	Loop / Sequence Test (Train 1 & 2)	230	20-Mar-26	04-Feb-27
Electrical		345	15-Sep-25	14-Jan-27
A1340	Cable Tray / Cabling Work (Train 1 & 2 & Common)	345	15-Sep-25	14-Jan-27
A1330	PDC Building Installation	20	29-Sep-25	24-Oct-25
A1350	Motor Solo Running (Train 1 & 2)	60	29-May-26	20-Aug-26
Painting / Insulation		270	06-Mar-26	18-Mar-27
A1360	Painting / Insulation Work	270	06-Mar-26	18-Mar-27
Pre - Commissioning		290	15-May-26	24-Jun-27
A1380	Pre-Commissioning	250	15-May-26	29-Apr-27
A1370	Commissioning	250	10-Jul-26	24-Jun-27
SJGS EXECUTION BOP CONSTRUCTION		604	12-Feb-24	04-Jun-26
Construction		604	12-Feb-24	04-Jun-26
BOP		604	12-Feb-24	04-Jun-26
CNBOP001	BOP - Site Mobilization	20	12-Feb-24	08-Mar-24
CNBOP101	BOP - Sitework	105	11-Mar-24	02-Aug-24
CNBOP121	BOP - U/G Piping & Ductbanks	190	20-May-24	07-Feb-25
CNBOP130	BOP - Foundations	260	08-Jul-24	04-Jul-25
CNBOP140	BOP - Control, CO2, WW Treat Bldgs Erection	190	07-Oct-24	27-Jun-25
CNBOP180	BOP - Flue Gas Ductwork Erection	260	07-Oct-24	03-Oct-25
CNBOP170	BOP - BOP Mechanical/Piping Installation	260	15-Nov-24	13-Nov-25
CNBOP193	BOP - Cooling Tower Installation	260	06-Jan-25	02-Jan-26
CNBOP190	BOP - Electrical Installation	310	28-Mar-25	04-Jun-26
SJGS EXECUTION COMMISSIONING		352	15-May-26	20-Sep-27
Commissioning & Start-Up		350	15-May-26	29-Apr-27



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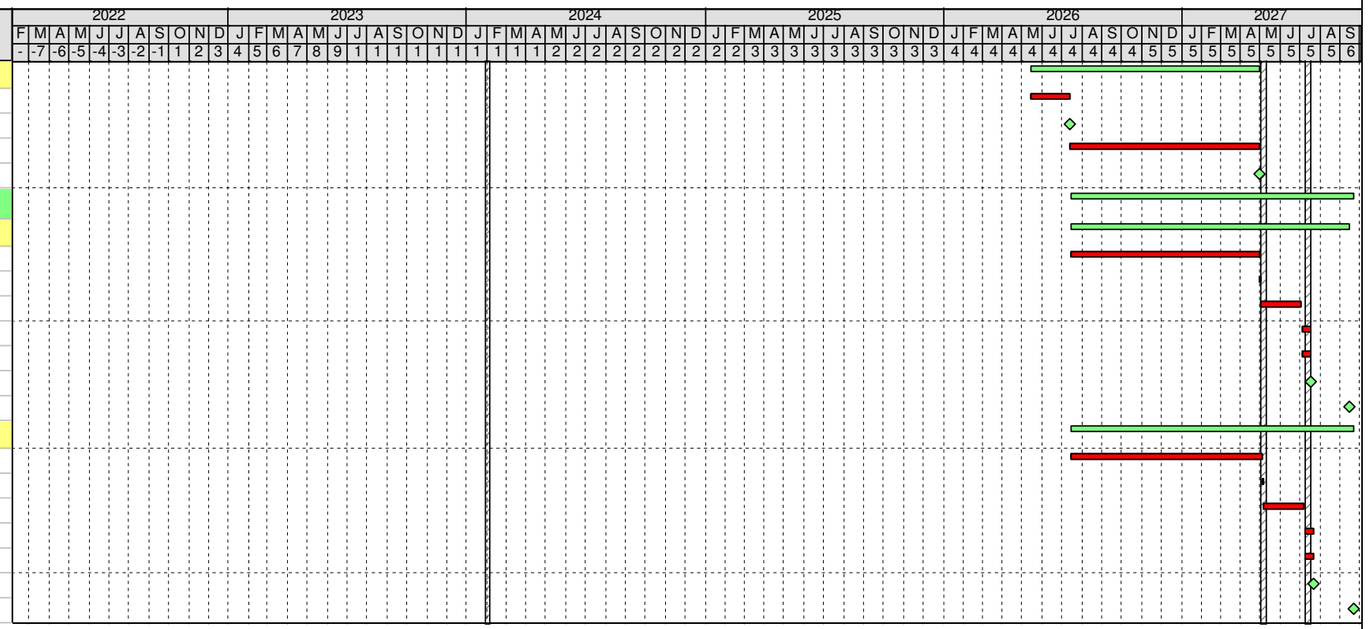
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Enchant Estimated Summary Schedule

Data Date: 20-Jul-21

07-Jun-22

Activity ID	Activity Name	Ori Dur	Start	Finish
Carbon Capture Island		350	15-May-26	29-Apr-27
SU150	1st Train - Start Pre-Commissioning	60	15-May-26*	13-Jul-26
SU160	1st Train - Backfeed/Energize Xfmr/Swgr	0	14-Jul-26	
SU162	1st Train - Equip Checkout / Flushing	290	14-Jul-26	29-Apr-27
SU190	1st Train - Ready for COD (Flue Gas to CC Unit)	0		29-Apr-27
Commissioning		309	15-Jul-26	20-Sep-27
U1 Commissioning & Startup		306	15-Jul-26	15-Sep-27
SU-01C	U1 Cold Commissioning	289	15-Jul-26	29-Apr-27
SU-140	U1 1st Fire	2	30-Apr-27	01-May-27
SU-180	U1 Hot Commissioning / Tuning	62	02-May-27	02-Jul-27
SU-181	U1 Performance Testing	10	05-Jul-27	16-Jul-27
SU-182	U1 Emissions Testing	10	05-Jul-27	16-Jul-27
SU-190	U1 Substantial Completion	0		16-Jul-27
SU-200	U1 Final Completion	0		15-Sep-27
U4 Commissioning & Startup		309	15-Jul-26	20-Sep-27
SU-04C	U4 Cold Commissioning	294	15-Jul-26	04-May-27
SU-440	U4 1st Fire	2	05-May-27	06-May-27
SU-480	U4 Hot Commissioning / Tuning	62	07-May-27	07-Jul-27
SU-481	U4 Emissions Testing	10	08-Jul-27	21-Jul-27
SU-482	U4 Performance Testing	10	08-Jul-27	21-Jul-27
SU-490	U4 Substantial Completion	0		21-Jul-27
SU-500	U4 Final Completion	0		20-Sep-27



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APPENDIX E. CONSTRUCTABILITY REVIEW MEETING NOTES

SAN JUAN GENERATING STATION CO2 CAPTURE PROJECT FEED STUDY

CONSTRUCTABILITY MEETING NOTES

AUGUST 31, 2021

LEGAL NOTICE

This report ("Deliverable") was prepared by Sargent & Lundy, L.L.C. ("S&L"), expressly for the sole use of Enchant Energy & City of Farmington (Client) in accordance with the agreement between S&L and Client. This Deliverable was prepared using the degree of skill and care ordinarily exercised by engineers practicing under similar circumstances. Client acknowledges: (1) S&L prepared this Deliverable subject to the particular scope limitations, budgetary and time constraints, and business objectives of the Client; (2) information and data provided by others may not have been independently verified by S&L; and (3) the information and data contained in this Deliverable are time sensitive and changes in the data, applicable codes, standards, and acceptable engineering practices may invalidate the findings of this Deliverable. Any use or reliance upon this Deliverable by third parties shall be at their sole risk.

Table of Contents

1. Development of Construction Laydown Drawing
2. Meeting Notes
3. Attachment 1 - Laydown Area Drawing

1. Development of Construction Laydown Drawing

1.1. The construction laydown drawing was developed with input from multiple companies as well as input from City of Farmington. A discussion was held with Hank Adair (City of Farmington) about the available space and how construction for major projects has been historically performed at San Juan Station. A separate meeting was held with Kiewit to review how major equipment would be fabricated and erected on site. Input was received from MHI on the fabrication and layout of the site.

The construction laydown area required for the project is based on a 3:1 ratio of the permanent equipment. There is approximately 35 acres of layout area for the project, along with other additional areas dedicated fabrication.

Craft parking will be in the area that the San Juan Station have historically used for craft parking. The area is approximately 4.9 acres allocated for parking.

2. Constructability Meeting Notes (August 24th, 2021)

2.1. Attendees

S&L
Steve Wylie
Emily Kunkel
Kirk Israelsen
Chris Hornish
Sean McHone
Rich Miller

Enchant
Peter Mandelstam
Cindy Crane

City of Farmington
Hank Adair

MHI
Daisuke Shimada
Toshiya Yoshimura
Tetsuya Okuyama
Kohei Higaki
Shintaro Kiuchi
Nobuyuki Kawahara
Shouichirou Kannari
Tim Thomas
Miki Amano

Mayu Toyobe
Keisuke Iwakura
Cole Mass

Kiewit
Mike Burton
John Carr

2.2. Craft Entrance and Parking

2.2.1. Discussed plant entrance and west route for craft to get parking lot North of the switchyard.

- It was noted that if additional parking was needed the 2 acres of laydown north of the craft parking could also be used as craft parking.
- Plant to consider relocating the guard house closer to the plant so craft doesn't have to go thru existing plant guard house.

2.2.2. Enchant suggested providing a shuttle from town for craft personnel. This will be discussed further with Enchant/COF once the EPC contract is close to finalization and more logistics are planned.

2.2.3. It was stated that truck deliveries would follow the same western route and not thru the main plant road. Gate would be north of craft parking.

2.3. Construction Trainer Area

2.3.1. Owner trailer to be added to the trailer city

2.3.2. The "insulation warehouse" is currently scaffolding storage. This is an insulated building and could be good candidate for craft lunch area. The scaffolding could be relocated as necessary.

2.3.3. It was mentioned there is an office near the parking area that could be re-purposed as a large meeting room for construction.

2.4. Laydown areas

2.4.1. Different available areas were reviewed as laydown areas on the site.

- It was stated that the 'force majeure' coal pile should be completely depleted within the next month, therefore that area is available for laydown.
- It was mentioned that the southernmost laydown area has the potential for a separate truck delivery.

2.5. Fabrication areas

2.5.1. Various areas for fabrication were discussed:

- The pipe fab area (0.3 acres) near limestone area is on steep slope, so may need to be moved.

- Duct fabrication area will require some site preparation. Also, the drive path to the area is at a slope.
- It was suggested that there could be some areas inside existing units 2 & 3 that could be used for indoor pipe fabrication.

2.6. Review of fabrication and erection of large components.

2.6.1. Kiewit discuss the plan for the Quencher and Absorber fabrication and erection. They noted the layout of the fabrication tables and matting allow multiple option for moving and erecting modules.

2.6.2. The laydown area to the northwest of the CCS island could be used for Regenerator fabrication.

2.6.3. It was noted that the new equipment layout and crane plan there should not be an issue in installing the i.d. fans.

2.6.4. For the flue gas duct fabrication areas noted on the east side of the units, existing undergrounds will need to be investigated so proper protection can be provided as the heavy duct pieces and cranes move in the area.

2.7. Open discussion

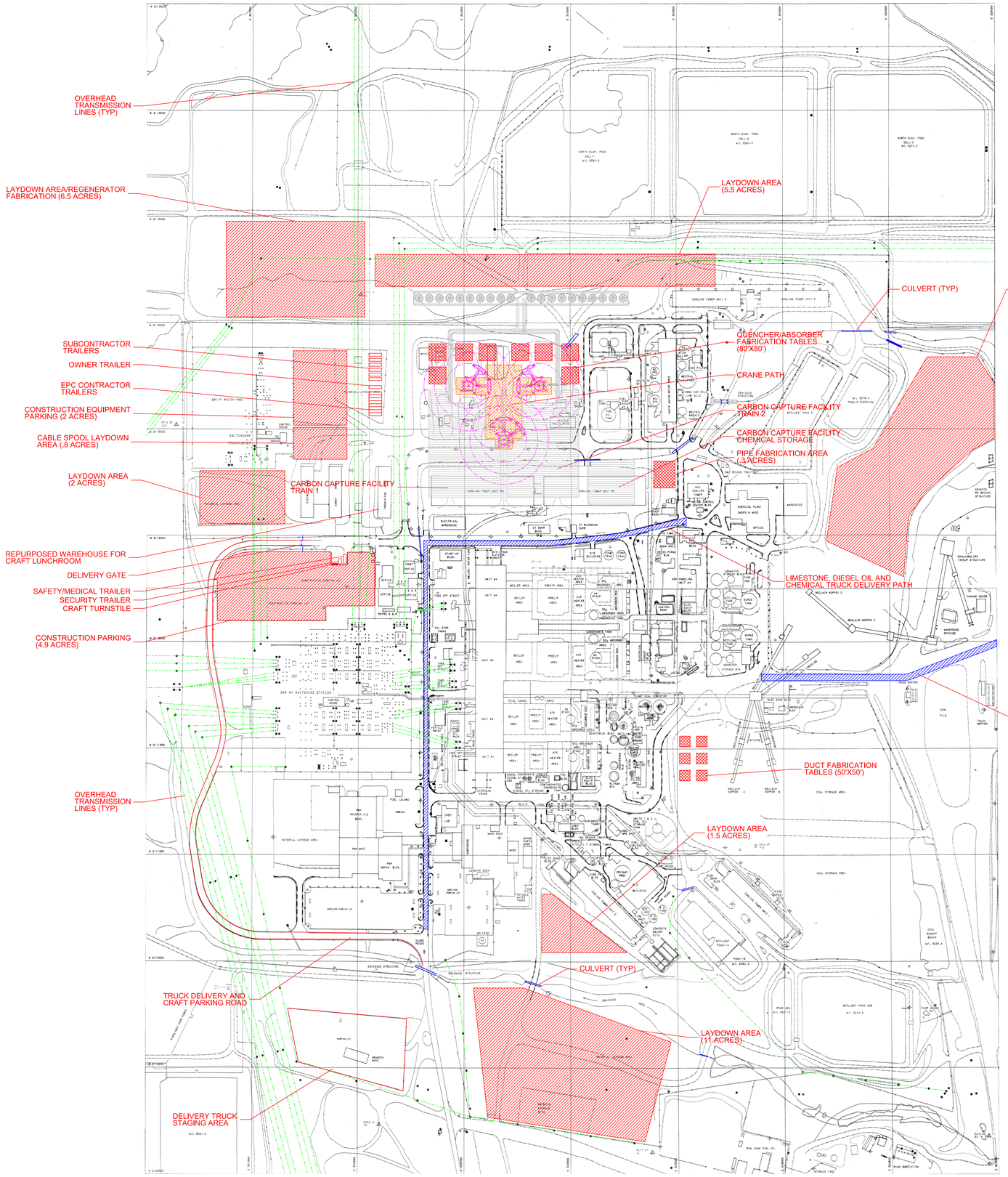
2.7.1. It was suggested the limestone, chemical, fuel oil and coal truck delivery paths be added to the drawing for information.

2.7.2. S&L will add notes to the laydown drawing to address some general comments/constructability items like protecting existing undergrounds.

2.7.3. S&L will incorporate other comments received separately from KIE (adding overhead lines, culverts, etc.) to the laydown drawing.

3. Attachment 1

Laydown Area Drawing



NOTE:
1. UNDERGROUND PIPING TO BE REVIEWED AND PROTECTED AS REQUIRED.

NORTH

200' 0 200' 300' 400'

GRAPHIC SCALE

DRAWING SCALE
1" = 200'-0"

HOLD INFORMATION

NO.	DESCRIPTION

CONTRACTOR/INSTALLER SHALL TAKE ALL APPROPRIATE PRECAUTIONS TO ENSURE THE SAFETY OF ALL PEOPLE LOCATED ON THE WORK SITE, INCLUDING CONTRACTORS/INSTALLER'S PERSONNEL (OR THAT OF ITS SUB-CONTRACTOR(S)) PERFORMING THE WORK.

RELEASE INFORMATION

REV.	DATE	DESCRIPTION
A	08-24-2021	FOR INFORMATION
B	8-31-2021	FOR INFORMATION

ISSUE PURPOSE: FOR INFORMATION

SPECIFICATION:

PROJECT NO.:

I HEREBY CERTIFY THAT THIS ENGINEERING DOCUMENT WAS PREPARED BY ME OR UNDER MY DIRECT PERSONAL SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF ENTER NAME.

_____
ENTER NAME
ENTER DATE

MY LICENSE RENEWAL DATE IS: ENTER DATE
PAGES OR SHEETS COVERED BY THIS SEAL:
THIS DOCUMENT ONLY.

CAD FILE NAME:

PREPARED BY: RAM

REVIEWED BY:

APPROVED BY:

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55 EAST MONROE STREET
CHICAGO, ILLINOIS 60603-5780

PROJECT

SAN JUAN GENERATING STATION

DRAWING TITLE

CONSTRUCTION LAYDOWN DRAWING

DRAWING NUMBER	REVISION
CONST-MSK-0001	B
SHEET 1 OF 1	

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Revision 11A, Revision Date: 04-30-2010