Energy Research and Development Division

**FINAL PROJECT REPORT**

# San Gabriel Valley Water Company "Plug-and-Play" In-Conduit Hydropower Development Project

**Gavin Newsom, Governor**

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# PREFACE

The California Energy Commission's (CEC) Energy Research and Development Division supports energy research and development programs to spur innovation in energy efficiency, renewable energy and advanced clean generation, energy-related environmental protection, energy transmission and distribution and transportation.

In 2012, the Electric Program Investment Charge (EPIC) was established by the California Public Utilities Commission to fund public investments in research to create and advance new energy solutions, foster regional innovation and bring ideas from the lab to the marketplace. The CEC and the state's three largest investor-owned utilities—Pacific Gas and Electric Company, San Diego Gas & Electric Company and Southern California Edison Company—were selected to administer the EPIC funds and advance novel technologies, tools, and strategies that provide benefits to their electric ratepayers.

The CEC is committed to ensuring public participation in its research and development programs that promote greater reliability, lower costs, and increase safety for the California electric ratepayer and include:

- Providing societal benefits.
- Reducing greenhouse gas emission in the electricity sector at the lowest possible cost.
- Supporting California's loading order to meet energy needs first with energy efficiency and demand response, next with renewable energy (distributed generation and utility scale), and finally with clean, conventional electricity supply.
- Supporting low-emission vehicles and transportation.
- Providing economic development.
- Using ratepayer funds efficiently.

*San Gabriel Valley Water Company "Plug-and-Play" In-Conduit Hydropower Development Project* is the final report for Contract Number EPC-16-024 conducted by San Gabriel Valley Water Company. The information from this project contributes to the Energy Research and Development Division's EPIC Program.

For more information about the Energy Research and Development Division, please visit the CEC's research website (www.energy.ca.gov/research/) or contact the CEC at ERDD@energy.ca.gov.

# ABSTRACT

California has many small, in-conduit hydroelectric stations with generation potential less than 100 kilowatts. Many of these stations have similar pressure and flow characteristics as well as design layouts, lending them to modularization and standardization. Recent technological advances in off-the-shelf, low-cost turbine technologies for these types of stations have reduced costs, but a significant barrier remains to broader development of existing conduits that would enable the extraction of power. This includes the high cost associated with the civil, mechanical, and electrical design, interconnection, and construction. Thus, further advancements in modularizing and standardizing in-conduit hydroelectric technology is needed to reduce costs and accelerate implementation.

The San Gabriel Valley Water Company "Plug-and-Play" In-Conduit Hydropower Development Project designed, developed, and demonstrated a modular in-conduit hydropower water-to-wire package that offers a standard design and equipment that can be installed in hundreds of in-conduit sites throughout California with generation potential of less than 100 kilowatts. This plug-and-play design template will advance the modularization of critical electrical and civil components common to small, in-conduit hydropower stations to take advantage of recent advances in modularization of the mechanical turbine technologies. The new design will maximize the cost-effective generation of the under-used sub-100 kilowatt hydroelectric sector throughout California — leading to increased generation of in-conduit hydropower in the statewide energy mix and contributing to the state's goal to provide 100 percent of its electricity from renewable and zero-carbon sources by 2045.

**Keywords:** in-conduit hydropower; small hydropower; energy recovery; energy efficiency; renewable energy

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# TABLE OF CONTENTS

Page

# LIST OF FIGURES



# LIST OF TABLES

# EXECUTIVE SUMMARY

## Introduction

California intends to provide 100 percent of its electricity with renewable and zero-carbon energy sources by 2045. A number of renewable energy sources contribute to this goal, with solar power providing the largest share. However, solar power poses several challenges given its intermittent nature. Therefore, California also must look to other clean alternatives, such as battery storage, and other baseload renewable energy sources, such as hydroelectric, to meet the goals of Senate Bill 100 (De León, Chapter 312, Statutes of 2018) goals, including for 50 percent and 60 percent of California's electricity to be powered by renewable resources by 2025 and 2030, respectively.

California has been a leader in developing large hydroelectric resources over the years, but the hundreds of small, in-conduit hydroelectric stations with generation potential of less than 100 kilowatts (kW) are often overlooked due to the installation and equipment costs relative to the volume of energy generated. Many of these small stations have similar pressure, flow characteristics, and design layouts — lending them to modularization and standardization.

There is a need to develop and demonstrate a "plug-and-play" package to expand use of small, in-conduit hydropower stations throughout California to meet the state's energy goals, expanding the statewide mix of generation resources and reducing costs.

## Project Purpose

The San Gabriel Valley Water Company "Plug-and-Play" In-Conduit Hydropower Development Project (San Gabriel Project) advanced the research and pre-commercial development of an innovative, plug-and-play packaged hydroelectric station and associated guidance documentation to improve the economic competitiveness of the sub-100-kW market by reducing the overall installation cost. The initial grant application outlined six goals:

1. Design a plug-and-play low-cost, in-conduit hydroelectric guidance package that addresses the sub-100-kW market.
2. Demonstrate improved efficiency and performance to maximize the capture of wasted energy in water supply networks.
3. Demonstrate the long-term operational capacity of an in-conduit turbine/generator system to provide renewable energy for the state energy mix.
4. Demonstrate benefits to California investor-owned utility electric ratepayers, including reduction of energy costs and greenhouse gas emissions and efficient use of ratepayer money.
5. Validate the method, tools, and technology implementation to expand the use of hydropower in California for the sub-100-kW market, help achieve the state's renewable energy initiatives, and improve the understanding of the grid benefits.
6. Develop a plan to share information gained and project results to the public and key decision-makers.

## Project Approach

The project applicant, San Gabriel Valley Water Company, is an investor-owned, public utility water company headquartered in El Monte in the San Gabriel Valley. The company provides water utility service to a population of more than 481,000 residents of the Los Angeles County and Fontana Water division service areas.

NLine Energy, the project subcontractor based in El Dorado Hills, California, is a full-service developer of in-conduit hydroelectric projects. NLine Energy is currently responsible for more than 91 percent of all hydroelectric development of less than 5 megawatts in California and 30 percent nationally.

Tesco Controls, headquartered in Sacramento, California, served as the system integrator, focused on supervisory control and data acquisition, communications, and control needs working from its state-of-the-art UL manufacturing facility.

The San Gabriel Valley Water Company, NLine Energy, Tesco Controls team worked together previously on the successful implementation of the San Gabriel Sandhill in-conduit hydroelectric project, one of the first in-conduit hydroelectric projects to be implemented in Southern California Edison territory in more than 20 years. This project was one of the first "net-neutral" energy sites, whereby the generation from the in-conduit hydroelectric unit completely offset the electricity requirements of the water treatment plant on an annual basis. The site is only the third in the state to receive a Self-Generation Incentive Program grant, classified as a Pressure-Reducing Turbine.

## Project Objectives

To achieve the project goals, the project team set the following objectives and targets:

1. Design a standardized civil, mechanical, and electric powerhouse, coupled with a plug-and-play, water-to-wire equipment package that can reduce implementation costs by at least 20 percent for future projects.
2. Implement a 73-kW water-to-wire, in-conduit hydroelectric station.
3. Generate 11,039,000 kilowatt-hours (kWh) of renewable energy while reducing greenhouse gas emissions by 8,040 metric tons carbon dioxide equivalent over a 30-year asset life.
4. Provide long-term monitoring, measurement, and verification of the mitigation measures and strategies, as well as in-conduit hydroelectric station performance.
5. Provide education and outreach to local and regional California water agencies, hydropower asset owners and state policymakers.

## Project Implementation

The team's first task was to analyze sub-100-kW project sites in an effort to identify commonalities amenable to a plug-and-play design, including the types of hydroelectric projects, their likely locations, and cost challenges associated with hydroelectric development for these projects. The team made a concerted effort to minimize project costs on both non-construction and construction elements by standardizing the designs, shortening construction time frames, streamlining interconnection processes, and working with vendors to use more prefabricated and off-the-shelf equipment. Toward that end, the team identified, researched, and implemented the following:

- Civil/mechanical engineering plans and specifications
- Multiple turbine technologies
- Potable water standards
- Seismic standards
- Building selection
- Electrical engineering plans and specifications.

A modular powerhouse design was implemented using a pre-engineered fiberglass building, within which was housed the turbine, generator, pressure relief assembly and controls. The project team selected and arranged components so as to maximize standardization while allowing a certain degree of customization to accommodate a range of site-specific requirements. The power assembly consisted of an off-the-shelf pump-as-turbine which was installed vertically to minimize its footprint. The load distribution characteristics of the fiberglass building allowed for use of a turned-down mat slab style foundation with continuous footing which could be achieved with only one concrete pour.

Modifications were made to San Gabriel Valley Water Company's B24 pumping station to accommodate the modular powerhouse assembly, which together with the balance-of-plant comprised the B24 hydroelectric station. Start-up, commissioning, and performance testing the B24 hydroelectric station was conducted on August 14, 2019. The team collected six weeks of flow, pressure, and power data to better assess the performance. In a comparison of theoretical to actual power generation, the generator produced power above anticipated levels at all flow rates tested through the turbine.

## Project Results

The San Gabriel Project successfully met its outlined goals and objectives.

- The team successfully developed a standardized low-cost civil, mechanical, and electrical hydroelectric design package that can be used in future sub-100-kW projects. It is estimated that the standardization of the engineering design will result in a 50 percent reduction in these specific design/engineering project costs on future projects. The design and specifications for this project are included in the appendix.
- The team implemented a 73-kW pilot project employing the modular powerhouse design that is fully operational at San Gabriel Valley Water Company B24 Pumping Station. Based on monitoring the limited operations of the project to date, it is estimated that the project will meet the annual generation of 403,000 kWhs annually and 11,662,000 kWhs over its 30-year useful asset life.
- The B24 hydroelectric pilot project cost approximately $1,462,000 to implement, and it is estimated that future projects of similar size can be developed at a cost ranging between $900,000 and $1,100,000. At this specific cost range, projects of similar size and generation profiles will be economically viable under current California electric rate tariffs.

- The project provided direct benefits to investor-owned utility ratepayers in San Gabriel's service territory, reducing energy costs, greenhouse gas emissions, and other harmful air emissions.
- Successful implementation of this sub-100-kilowatt project enabled the team to identify similar sub-100-kilowatt hydroelectric projects in California, Oregon, and Maryland and therefore use the research and development from this project to develop additional sub-100-kilowatt hydroelectric projects.
- The project team developed an information-sharing plan and has made numerous presentations to interested stakeholders and the public introducing the replicable nature, details, and results of the project.

## Technology/Knowledge Transfer/Market Adoption

The project team conducted a series of presentations to highlight the attributes of the project so that the research effort could be replicated by the United States target market for in-conduit hydroelectric technologies, namely municipal water systems such as water districts, irrigation districts, cities, counties, and other public and private water companies.

Results of this project were shared with more than 450 municipal water agencies, known as the Association of California Water Agencies, during several statewide, semi-annual conferences in 2017 and 2018. Additionally, a case study was shared at several presentations for the National Hydropower Association and the international hydropower conference, Hydrovision, from 2017 to 2019. Lastly, knowledge of this project was shared with other California Energy Commission Electric Program Investment Charge awardees through an informal information sharing workshop at the request of California Energy Commission staff.

## Benefits to California

Overall, the San Gabriel Project was a substantial success for residents in the San Gabriel Valley as measured by results of the 73-kW B24 Pumping Station pilot project, and for California ratepayers as measured by forecasted economic and environmental benefits.

The B24 Pumping Station pilot project was implemented at a total project cost of around $1,462,000 and is expected to generate 403,000 kWhs annually, resulting in energy cost savings of $56,000 per year. The project will provide direct benefits for investor-owned utility electricity ratepayers in the San Gabriel Valley Water Company service area, including greenhouse gas reductions, air emission reductions, and energy cost reductions. The project will produce 11,662,000 kWhs of renewable energy and reduce 8,550 metric tons of greenhouse gas emissions over its 30-year life. In addition, the project will demonstrate the ability to develop cost-effective projects in the sub-100-kW market, which will help expand the deployment of these small in-conduit hydropower systems throughout California.

For California, the San Gabriel Project provides a basis for expanding in-conduit hydropower throughout the state, particularly in under-used small-hydro sites. This project will open the sub-100-kW market, resulting in development of projects previously viewed as not financially viable. The researchers estimate success of this project will lead to additional deployments of at least 9,000 kW of annual renewable energy or 48,360,000 kWh of annual renewable generation, resulting in an annual reduction of 34,198 metric tons of carbon dioxide.

# CHAPTER 1: Introduction

In September 2018, former Governor Edmund G. Brown, Jr. signed Senate Bill 100 (de León, Chapter 312, Statutes of 2018) into law, establishing an ambitious goal to supply 100 percent of the state's electricity from renewable and zero-carbon energy sources by 2045. This law requires that 60 percent of power purchased by California utilities come from renewable sources by 2030. The additional 40 percent of power delivered by California utilities to residents and businesses must be from zero-carbon resources by 2045. Renewable energy as defined by California includes a multitude of energy sources such as biogas, wind, solar, hydro, and wave. Today a significant portion of California's renewable energy is generated from solar and wind assets. Solar and wind pose particular issues to the energy grid as they are intermittent. For example, solar energy production peaks mid-day and this causes net (of solar) electricity demand for other sources to drop off. Then later in the evening, as solar drops off and consumer demand increases, other generation sources are required by the grid. Researchers in California have labeled this relationship between solar generation and demand the "duck curve." The overarching issue is that one or two intermittent renewable energy sources such as solar or wind cannot sufficiently supply California's energy grid without other complementary resources. Therefore, California must identify alternative solutions such as energy storage or baseline renewables. At the moment, energy storage, whether it be small-scale lithium batteries or large-scale pump storage projects, is not yet financially viable. Baseline renewable energy sources such as hydro are a natural solution until energy storage becomes more cost effective.

Hydropower was one of the first forms of renewable energy developed and is still widely used throughout the United States. Hydroelectric power is electricity derived from turbines that convert the potential energy of falling or fast-flowing water into mechanical energy. Most people are familiar with large-scale hydropower dams like the Hoover Dam, but California defines renewable energy hydropower as small-scale hydroelectric sites of 30 megawatts (MW) or less. A number of rules established in the California's In-Conduit Hydropower Implementation Guidebook define what qualifies as a hydropower renewable energy source in the state, but the majority of the opportunities generating less than 30 MW reside with in-conduit hydro projects. In-conduit hydropower is defined as the hydroelectric generation potential in engineered conduits such as tunnels, canals, pipelines, aqueducts, flumes, ditches, or similar man-made water conveyances that are operated for the distribution of water for agricultural, municipal, and industrial consumption. California has done well to develop sub-30 MW in-conduit hydroelectric projects; however, as projects get smaller, they become less economically viable. Historically, hydroelectric projects sized at 100 kilowatts (kW) or less were not developed as it was extremely difficult, without significant grant funding, to get the projects to pencil out. The lack of development of these small-scale hydroelectric sites has created an interesting market opportunity that aligns with California's renewable energy needs, resources, and goals.

This under-developed market of sub-100-kW hydroelectric sites is due to many barriers that include high civil, mechanical, and electrical costs; the high-cost of turbine-generator and associated equipment; the high-cost of custom-designed control and switchgear equipment; the high cost and schedule delays associated with compliance with the California Public Utility Commission's Rule 21 interconnection process; and other engineering design and project development costs.

Given the economies of scale of these projects, the sub-100-kW, in-conduit hydroelectric market remains challenged largely based on economic benefit relative to project costs. In 2012, an Oak Ridge National Laboratory report had two main recommendations for cost-cutting for sub-100-kW micro-hydropower sites:(1)standardize the turbines for lower costs, as projects of this size are more sensitive to cost than efficiency, and(2)standardize pre-fabricated and pre-assembled civil configurations for the powerhouse. Since the report was published, little progress has been made to advance the sub-100-kW in-conduit hydropower market in California. Since 2013, more than 22 projects totaling 12 MW of Federal Energy Regulatory Commission (FERC) qualifying conduit facilities-designated hydropower sites have been approved through FERC. Only one of these sites, sized less than 100 kW, is located in California and has not yet been constructed.

Project sites with flows ranging from 3 to 20 cubic feet per second (cfs) and available head pressure ranging from 80 to 400 feet are common hydraulic characteristics witnessed throughout existing pressure-reducing valve (PRV) stations in California. While there are multiple hydroelectric turbine technologies that can address these hydraulic conditions, only a subset of technologies are efficient and small; provide downstream pressure (for example, reaction-style turbines); are simple to operate; and can meet potable water standards. Additionally, these turbines require coupling to a generator that is both efficient and cost-effective — and can also meet California's interconnection requirements.

Typically, the 100-kW or less sites are located in either below-grade vaults or open-air above-ground structures that are not suited for the addition of a complete in-conduit hydroelectric system that includes a turbine, generator, valves, hydraulic power unit, control panel, switchgear panel, batteries, and other equipment that comprise the entire water-to-wire package. To accommodate a water-to-wire system at these sites, considerable resources are spent designing a custom powerhouse to include civil, mechanical, and electrical equipment and systems. These projects may also be located at remote locations (for example, a PRV vault) and are required to interconnect to the local investor-owned utility (IOU) distribution electrical circuit. Since hydroelectric generators are reactive-power based (noninverter), they require additional scrutiny, cost, and time as part of the Rule 21 Interconnection process.

These common characteristics of sub-100-kW sites present an opportunity to integrate a standard civil, mechanical, electrical powerhouse design (above or below grade), with an integrated water-to-wire system constituting a plug-and-play in-conduit hydroelectric packaged system.

# CHAPTER 2: Project Approach

This chapter describes the approach and analysis conducted for the San Gabriel Valley Water Company "Plug-and-Play" Hydropower Development Project (San Gabriel Project) to advance the research and pre-commercial development of an innovative, plug-and-play packaged hydroelectric station. The intent was to improve the economic competitiveness by reducing the overall installation cost for sub-100-kW projects.

## Market Analysis / Data Gathering

Prior to developing the plug-and-play design project goals and objectives, the team needed to identify the market whereby by commonality among project sites could be standardized with a common plug-and-play design and components. NLine Energy is currently responsible for more than 91 percent of all hydroelectric development of less than 5 MW in the state and 30 percent nationally. NLine Energy has walked or received data on more than 200 potential hydroelectric project sites in California. NLine developed a database with all of this project site data, which was then the basis for the California's In-Conduit Hydropower Implementation Guidebook, recently developed for the California Energy Commission (CEC). During NLine Energy's evaluation of potential hydroelectric sites in California the company consistently encountered sub-100-kW sites similar to the B24 project site. Unfortunately, NLine typically did not qualify these sub-100-kW sites and did not gather data from the sites as it was believed the sites' development was not feasible. As energy prices increased, technology improved, and NLine gained experience, it was determined that many of the project sites in the sub-100-kW market had similar design characteristics and costs could be reduced enough to make these projects viable.

NLine Energy examined its database and found that the majority of potential sub-100 kilowatt sites had flows ranging from 0 to 13 cubic feet per second and pressure ranging from 100 to 450 feet of net head. Therefore, all aspects of the project, including turbine technology, standardize design, and facilities, would have to meet these pressure and flow requirements. One additional benefit realized from this project is that based on the pressure and flow ranges described, larger hydroelectric sites can use the standardized plug-and-play package to reduce project costs. Hydroelectric projects with name plate ratings as large as 500 kW could use plug-and-play standardized design as described in this paper to reduce costs as long as the proper pressure and flow characteristics are met. The project team identified, researched, and developed the following items in an effort to reduce project costs.

## Civil / Mechanical / Electrical Engineering Plans and Specifications

This section describes the operation of the hydroelectric project and standardized civil and mechanical design plans.

### Project Site Overview

Plant B24 is a water storage facility and pumping station located at 14632 Nelson Ave E, La Puente, California 91744 (34° 2'9.69" N; 117°58'15.61" W) owned and operated by San

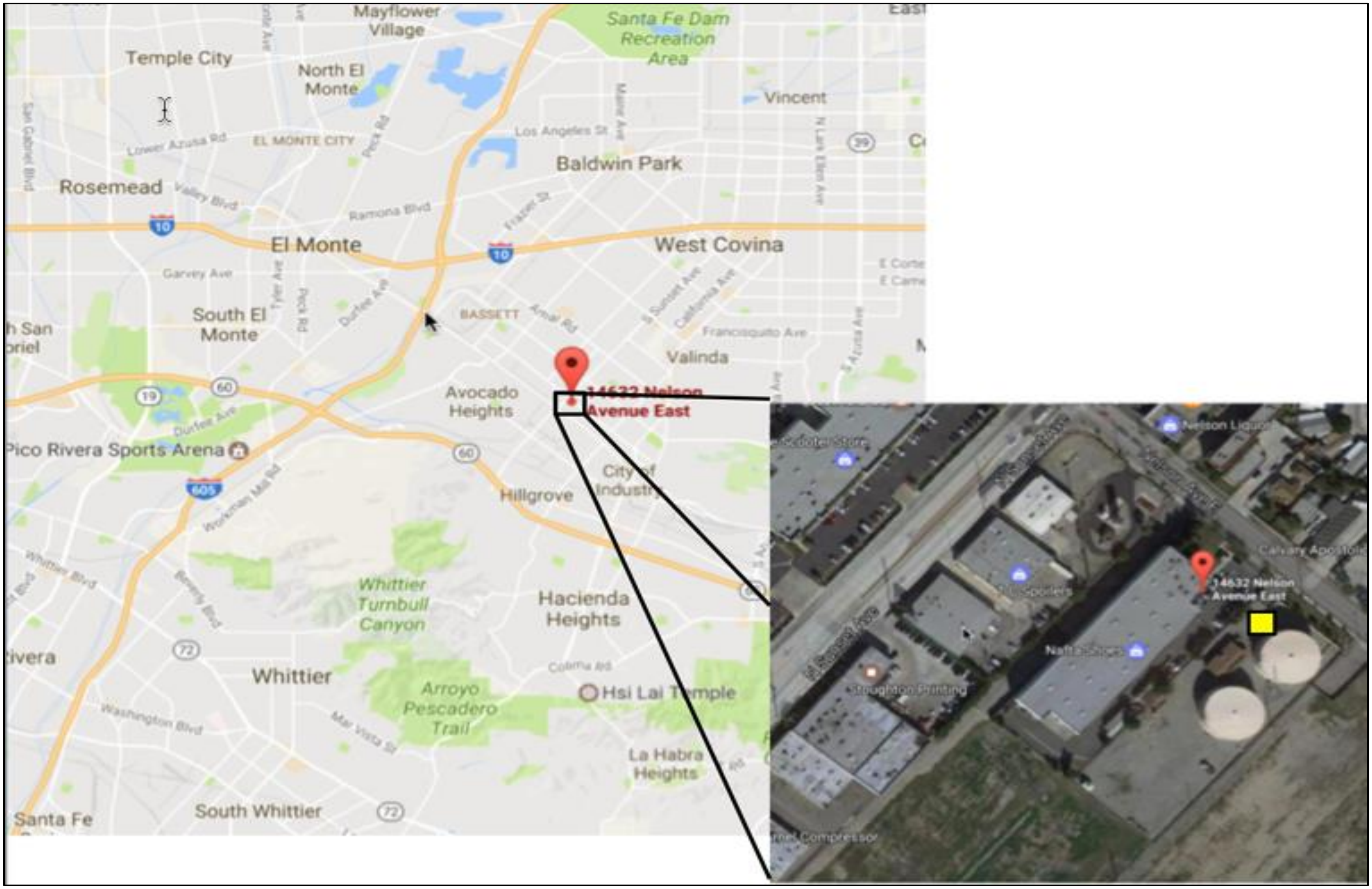
Gabriel Valley Water Company. The site receives potable water from the Reservoir 5 / 6 site, through a water distribution pipeline and breaks pressure using a CLA-Val pressure-reducing valve (PRV) before filling either the B24 or B24A storage tanks rated at 1.5 million gallons, 30-feet (ft) tall each. Potable water is pumped from the storage tanks, via six 150-horsepower (hp) booster pumps to LAD service areas based on demand.

Figure 1 provides an overview of the site; the yellow box represents the proposed location for the hydroelectric project. Figure 2 illustrates the location of the current pipe and PRV entering the B24 site that was used in the hydroelectric project.

The team determined the most feasible position for the hydroelectric facility would be northwest of the existing B24A tank, which consists of an open gravel area approximately 20 ft by 20 ft. An existing 17-inch supply pipeline and Southern California Edison (SCE) electrical conduit reside in this area and were re-routed. Figure 3 shows an aerial view of the project site.

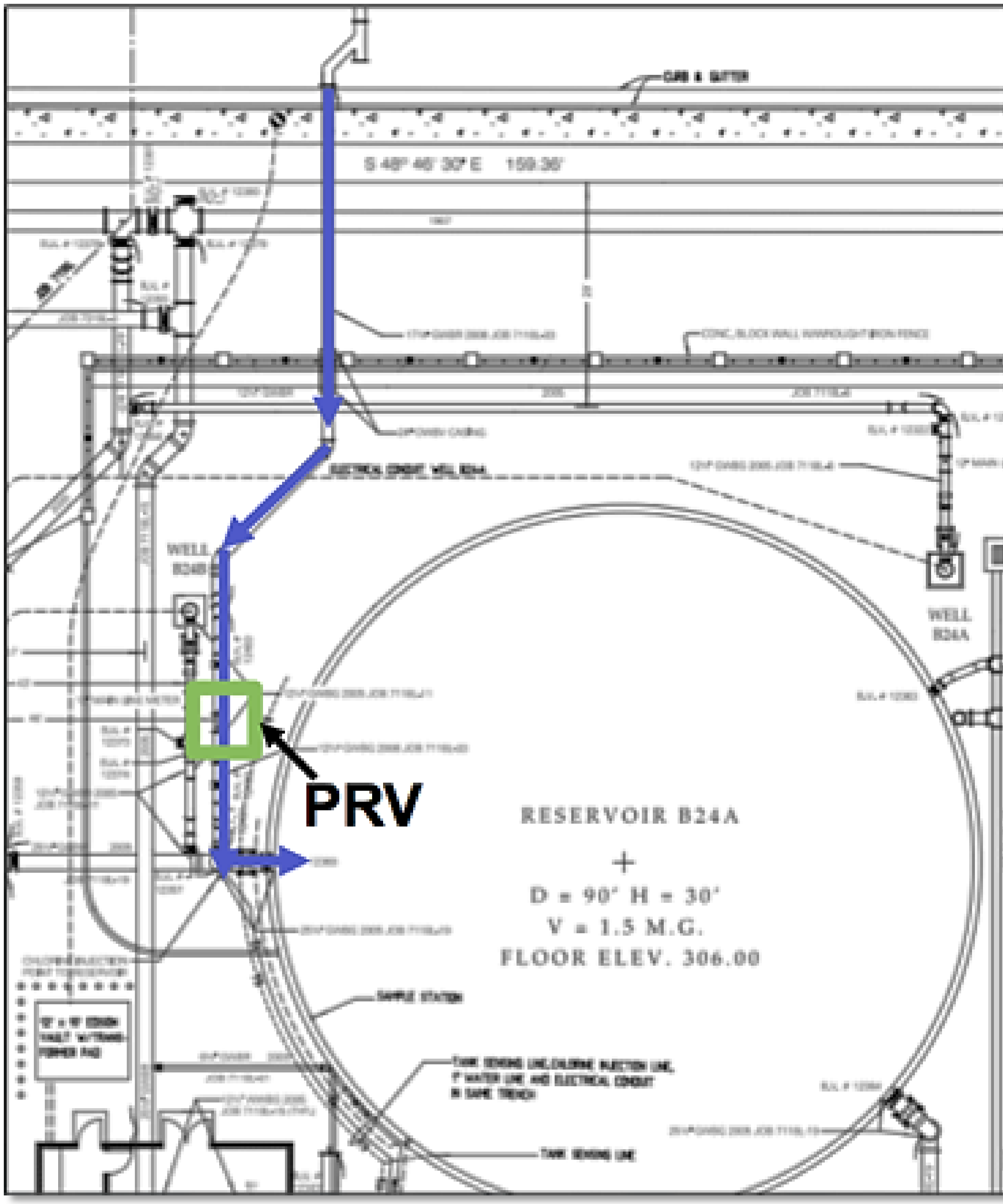
Design considerations were made to optimize the size of the powerhouse, pipe tie in locations, site access, and tie in to existing electrical infrastructure. Figure 4 is a plan view of the site.

**Figure 1: Project Vicinity Map**




Source: Google Maps

**Figure 2: Site Map**

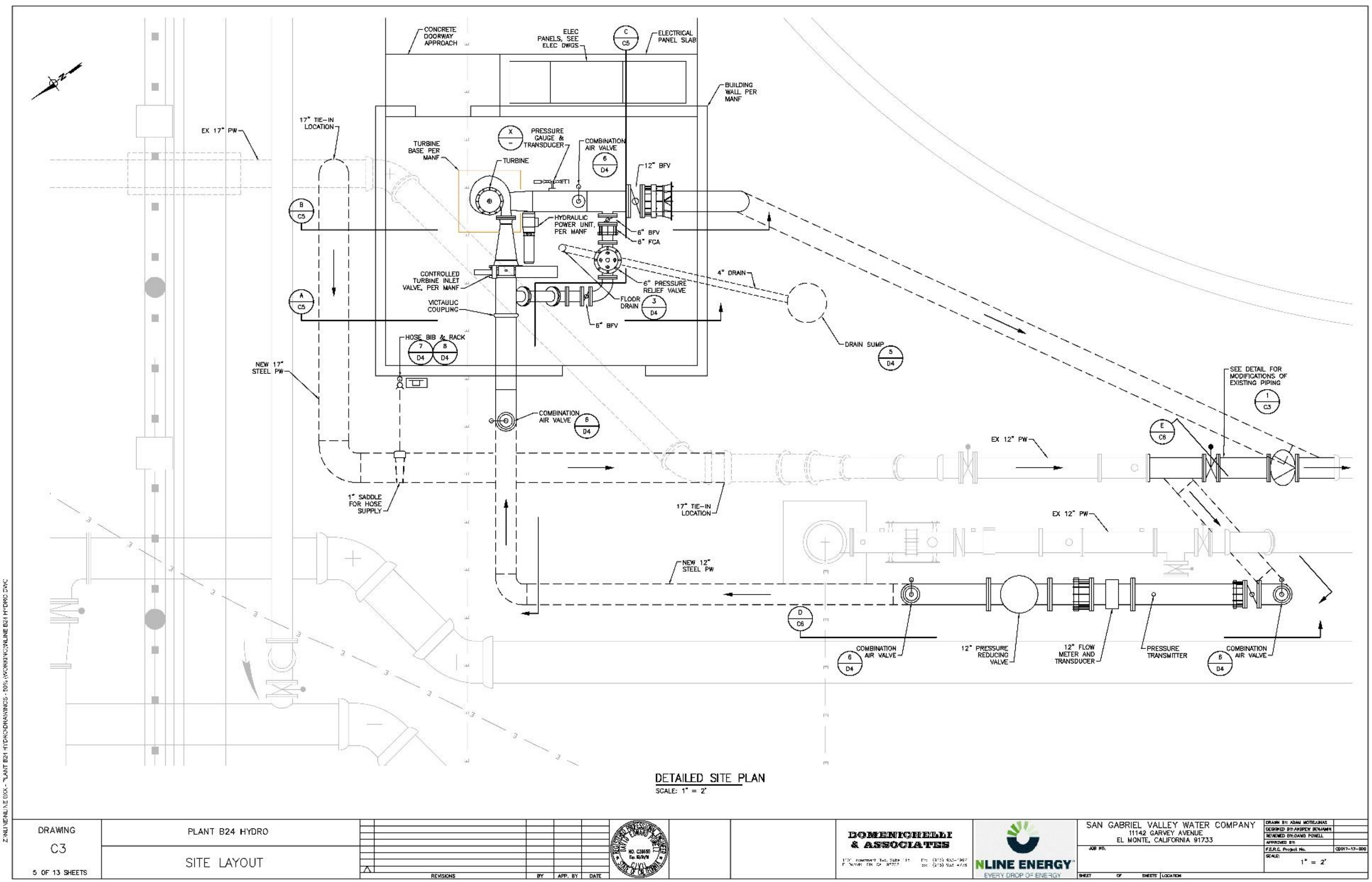



Source: San Gabriel Valley Water Company

**Figure 3: B24 Plant**


Source: Google Maps

**Figure 4: Detailed Site Plan**



Source: NLine Energy

The hydroelectric station design re-routes high-pressure flows from the B24 tank to the turbine and returns low-pressure water to the system downstream of the existing pressure reducing bypass valve (Cla-Val).

Originally, a horizontally oriented turbine layout was designed but limited site access near the tank. A horizontal spacing of 6 feet between the tank and powerhouse was desired to allow for small vehicle access. Positioning the turbine in a vertical orientation reduced the horizontal dimension of the powerhouse enough to provide 6 feet of clearance from the tank.

The pipeline layout and valving were designed with the goal of maintaining the existing visual and site access features of the site while minimizing effects to existing infrastructure. The existing underground 17-inch supply line would be re-routed to allow for ease of access for maintenance and avoid the powerhouse foundation zone of influence. A new 18-ft stretch of above-ground pipeline was situated adjacent to the existing above-ground pipe segment for positioning of the flow meter and turbine control valve. The flow meter was allotted 5 and 2 pipe diameters in length upstream and downstream, respectively, for laminar flow. Positioning the new segment of pipeline adjacent to the existing above-ground pipelines provides easier site access and workability.

Underground pipeline depths were selected to maintain minimum cover, avoid interference of zones of influence for nearby infrastructure, minimize sheeting and shoring, and allow for site workability.

## Pipes Valves

At the B24 site, San Gabriel Valley Water Company (SGVWC) uses cement-lined and coated steel pipe for underground applications. Above-ground applications consist of cement-lined and coated steel pipe. All new aboveground and underground pipeline was fitted to match this specification. At a maximum flow rate of 12 cubic feet per second (cfs), velocity in a 12-inch pipeline would be approximately 15 feet per second (ft/s).

The existing 12-inch Cla-Val pressure reducing valve is model number 90-01. These valves specialize in regulating downstream pressure. This valve is currently configured in an open position and not used for flow or pressure control. The existing Cla-Val was retrofitted to perform the function of a primary pressure-reducing bypass for the hydroelectric station. Cla-Val representatives were contacted in April 2018 to assure that a retrofit could be made to the existing valve to perform the desired function. The Cla-Val will require anti-cavitation trim and new pilot tubing. Cla-Val provided budgetary estimates and lead times. A new Cla-Val, model 131-01 was positioned upstream of the turbine to regulate pressure and flow.

The existing butterfly valve with an AUMA Actuators, Inc. operator was swapped positions with the existing Cla-Val. The valve will allow bypass flows to enter the existing Cla-Val. This will also reduce wear on the existing butterfly valve.

SGVWC staff uses and has familiarity with Pratt butterfly valves and Water Specialties flow meters. Valving and meters from the aforementioned manufacturers have been included in the specification.

Pipe supports were included for all above-ground piping segments. Weight of the fluid, valves, pipeline, and couplings was taken into consideration. Restrained flexible couplings and Victaulic couplings were used to adjoin piping segments that could not be welded.

Combination air release/vacuum valves from Dezurik/APCO have been included at high points and isolation points in the system to allow for laminar flow and to prevent pipe vacuum effects during a dewatering event. A 1-inch saddle for a potable water supply connected to a hose bib outside the building has been included. The hose bib is equipped with a Wilkins 975 XL2 backflow and pressure regulation assembly to comply with potable water standards.

## Foundation Design

The foundation design is dictated by several factors including seismic code requirements/geotechnical report recommendations, ease of installation for the general contractor, anchor depth of the steel vertical turbine support structure, and the building submittal.

## Powerhouse

The hydroelectric station is located northwest of the existing B24A tank. Flow from the existing 17-inch pipeline main inlet pipe will divert from an above-ground tee into a 12-inch pipeline, through the hydroelectric station and discharge into an underground pipeline that ties in upstream of the B24A tank. The powerhouse building is a pre-engineered metal building, approximately 13 ft by 16 ft. The siding thickness is six inches. The dimensions inside the powerhouse are approximately 12 ft by 15 ft. The powerhouse features a metal roof with a 4-ft by 4-ft roof hatch, meant to allow hoisting of the turbine/generator system for maintenance, if needed. The side wall height of the building is 10 feet and features a sloping 3 to 1 gable. The Cornell 6TR1 is vertically fit inside the building with an 8 ft side wall height. However, this design was meant to accommodate the array of turbines discussed earlier in the report. Therefore, a side wall height of 10 feet was selected.

The building features gutters and downspouts large enough to contain and channel expected water flows. The gutters are 6 inches deep and include 3-inch by 4-inch downspouts. The side wall and roof feature insulation thicknesses of R-13 and R-30 respectively for environmental control and noise mitigation.

The gable nearest the generator features a Greenheck exhaust fan, opposite the side of the louvers. This design allows for air crossflow through the powerhouse for proper ventilation. The powerhouse features a 32-inch man door, nearest the panels to allow for entry to the building. A manually operated, 4-ft by 8-ft rollup door was positioned on the opposite side of the building to allow for ease of access during construction, maintenance, and equipment hauling.

To create a smaller powerhouse as part of the modular design, the control valve, flow meter, air relief valve, and panels are positioned outside. The turbine, generator, and pressure relief assembly are positioned inside the powerhouse. A two-tier nickel cadmium battery rack was positioned inside the powerhouse to provide backup power for the programmable logic controller (PLC) in a load-shedding event. The battery system is rated at 24V, 140Ah and is sized to accommodate most sub-100-kW turbine arrangements, while maintaining a more compact size compared to lead acid. The main generator disconnect switch was encased in a

National Electric Manufacturers Association 3R enclosure attached to the outside of the powerhouse. The electrical conduits were positioned as such to allow for replicability on future designs. The orientation of equipment inside the powerhouse can be rotated on a site-to-site basis to accommodate different pipe inlet and outlet locations.

### Standardized Civil / Mechanical Plans

The final design specifications are included in the appendix of this report. Due to the commonality in projects of this size, these final design specifications will require minimal changes resulting in minimal engineering costs for future projects. Common design components of this project include the design and arrangement of equipment inside the powerhouse. Most existing pressure-reducing stations include existing metering, pressure transmitters, and a pressure-reducing valve, which are unique in location to each site. The team agreed that each site will require a certain level of customization based on the pipeline tie-in location and presence of existing piping, valving, and utilities. Therefore, the components included in the powerhouse were arranged and selected so that each site would comply with the package that is provided in the powerhouse. Items custom to each site include the pipeline tie-in location, routing of pipeline to the hydroelectric station, valving outside the powerhouse, and excavation.

## Turbine Technologies

NLine Energy analyzed several different off-the-shelf turbine technologies that would fit the expected pressure and flow ranges for these types of sites. Based on the pressure ranges of 100 to 450 feet of net head and flow ranges of 0 to 13 cfs, NLine identified two specific technologies that would best fit this project. The design enables all of these technologies to fit within the same powerhouse footprint and consist of an identical arrangement inside the powerhouse, with the exception of the exact turbine selected. The technologies selected and analyzed in further detail for this site were the Cornell's pump-as-turbine and Canyon Hydro's in-line turbine.

### Pump-as Turbines

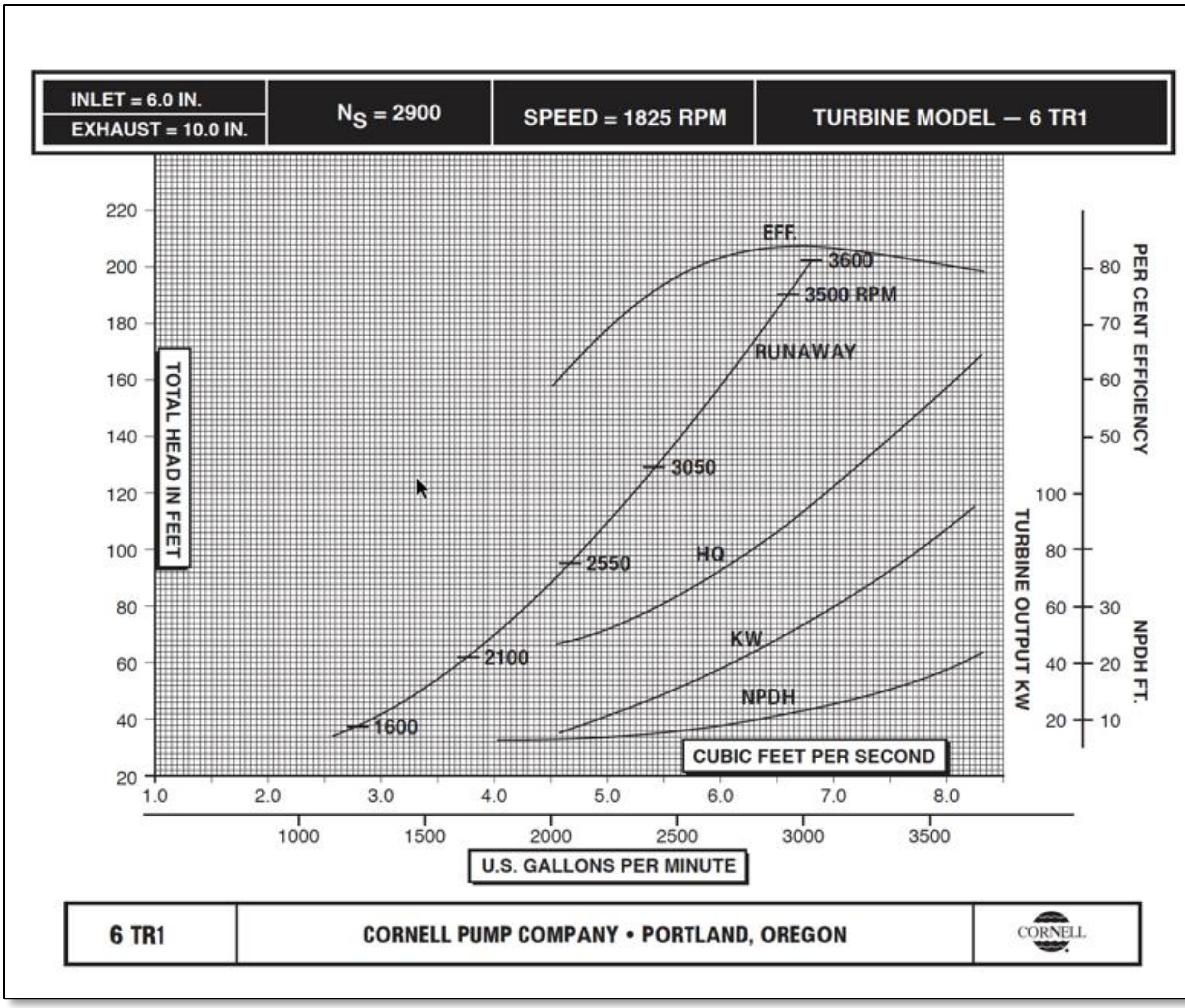
Pump-as-turbine, or PaT, is essentially what the name implies, a pump operating as a hydroelectric turbine. PaTs are considered reaction turbines, which discharge under positive head. Reaction turbines are driven by the flow of water through the runner blades. A PaT operates best at a single flow and head and generally does not operate well below approximately 50 percent of rated flow. Generally, pressure reducing valves are positioned upstream of a PaT to cut head based on the incoming flow rate. When there are variations in flow, these pressure reducing valves adjust the pressure to operate the PaT at its peak point of efficiency. PaTs have much higher efficiencies than other turbines when running within their optimum flow and pressure range. PaTs are low-cost options for sites that operate with flows from 1 to 30 cfs and with pressure head typically ranging between 100 to 400 feet. A number of different manufacturers provide PaTs, but our analysis focused on the Cornell PaT due to Cornell's wide range of products, manufacturing location, and low cost.Figure 5 shows a vertically mounted Cornell PaT configuration used at the B24 site. This PaT vertical configuration is the standard design that all models of the PaT would use.

For the B24 project a Cornell 6TR1 PaT was selected for implementation. The 6TR1 operates with flows ranging from approximately 4.5 to 8.5 cfs and net head ranging from 65 to 165 feet. Figure 6 displays the efficiency curve for the Cornell PaT model 6TR1.

**Figure 5: Cornell Pump-as Turbine-Generator in Vertical Configuration at B24**

Source: San Gabriel Valley Water Company

**Figure 6: Cornell Pump-as-Turbine Model 6TR1**

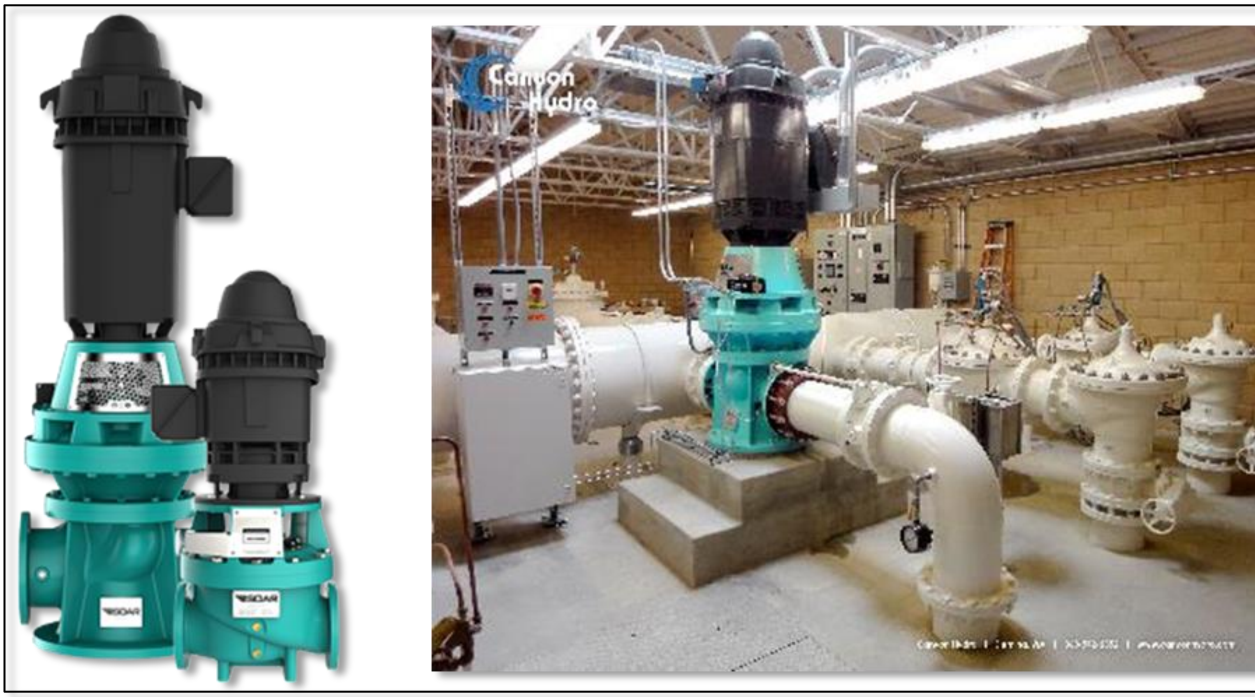



Source: Cornell Pump Company Turbine Catalog

## In-Line Turbine

The vertically mounted in-line turbine is manufactured by Canyon Hydro out of Deming, Washington. The design is similar to a PaT but uses internal wicket gates to control flow, which makes the in-line turbine a variable geometry unit similar to a traditional Francis turbine. The efficiency remains more constant across a wider range of flows and therefore can produce more power at sites with variable flows than the fixed geometry PaT. Figure 7 displays a typical in-line turbine installation.

**Figure 7: In-Line Turbine**




Source: Canyon Hydro

Once again, this vertical-mounted installation is standard for the plug-and-play design as it enables a small footprint for the powerhouse, thus reducing overall project costs. For the B24 project, a Canyon Hydro model ILT08 was considered for implementation. The in-line turbine would generate more electricity annually than the pump-as-turbine but was considerably more expensive than the pump-as-turbine. In addition, the in-line turbine was a relatively new technology with few installations at the time of design for this project. Therefore, it was determined that the least risky option was to select the pump-as-turbine, although future projects may elect the in-line turbine technology.

## Seismic Standards

According to the California Building Code (2016), the B24 project is situated in a Seismic Zone 4, a densely populated region in a seismically active area. Seismic Zone 4 regions are considered to have the highest possibility of earthquake danger. The hydroelectric station would classify as a Risk Category 3 structure due to its power production capability. Based on the soil type, seismic zone, risk category, and spectral response acceleration, the hydroelectric station was designed to seismic design Class D criteria. The seismic design classes range from A through F, with Class A requiring the least structural design strength, and Class F requiring the most structural design strength. All structural equipment associated with building, including the foundation, slabs, battery rack, and turbine vertical support structure, will need to be designed in accordance with seismic code. For future designs throughout the country, unless the building is to be situated near a fault line, the structural components selected may be replicated without additional consideration for seismic events.

## Building Selection

The team performed an extensive search to find a cost effective yet structurally sound building that met sound attenuation requirements. The team considered prefabricated metal, fiberglass, concrete masonry unit (CMU), and custom wood structure. With recent increases in steel tariff prices, the metal building cost about twice as much as previously anticipated and did not come with pre-built configurations such as lighting, receptacles, exhaust fan, louvers, doors, and roof hatch. Additionally, a metal building distributes most weight to the columns of the building, requiring a bulky and separate concrete column pour, followed by a foundation footing pour. The team wanted to use a turned-down mat slab style foundation with continuous footing, thus requiring only one concrete pour. Similarly, a CMU building added additional concrete and design costs. The prefabricated fiberglass building included pre-built configurations and distributes its weight evenly along the outer portions of the building, thus not requiring separate bulky column footings. When considering the cost of multiple concrete pours, additional concrete, custom design, steel costs, and pre-built configurations, the fiberglass building and construction cost about half the price of the other building types examined.

# CHAPTER 3: Project Results

Overall the San Gabriel Valley Water Company "Plug-and-Play" In-Conduit Hydroelectric Project was a success. The team successfully designed a standardized plug and play, low cost mechanical and electrical hydroelectric design package that can be used in future sub-100-kW projects. In addition, the team implemented a 73-kW hydroelectric project that will benefit the San Gabriel Valley Water Company and the surrounding community. This section describes in detail the project results as they relate to the following:

- Design standardization and project cost reduction
- Estimation of future project costs
- B24 project implementation and financials

## Design Standardization and Project Cost Reduction

The plug and play design described in Chapter 2 details the innovative low cost, standardized mechanical and electrical hydroelectric package that will be implemented in all future projects. It is estimated that the new design will result in cost savings related to engineering and design of approximately 20 percent. Table 1 compares the current non-construction project costs associated with the project as well as the forecasted costs assuming the same project would be developed now with the new standardized plug and play design package.

**Table 1: San Gabriel Valley Water Company B24 Project Cost Comparison**

| | Current Project Costs | Estimated Future Costs |
|---|---|---|
| Preliminary Design | $80,000 | $40,000 |
| 50% Design | $91,000 | $45,500 |
| Final Design & Specifications | $84,338 | $42,169 |
| Electrical Design | $67,994 | $33,997 |
| Interconnection & Tariff Analysis | $55,000 | $40,000 |
| Engineering During Construction - Submittal Review | $48,000 | $48,000 |
| Startup and Commissioning | $30,643 | $30,643 |
| FERC, Permits | $18,000 | $18,000 |
| Environmental | $4,700 | $4,700 |
| CEC EPIC Grant - Administrative Activities | $25,000 | $0 |
| CEC EPIC Grant - Knowledge Transfer | $25,000 | $0 |
| CEC EPIC Grant - Project Benefit Analysis | $25,000 | $0 |
| TESCO - R&D Electrical Package Design | $35,000 | $0 |
| **Total Non-Construction Costs** | **$589,675** | **$303,009** |
| **Total Construction and Equipment** | **$785,636** | **$748,636** |
| **Total Project Cost** | **$1,375,311** | **$1,051,645** |

Source: San Gabriel Valley Water Company

The table represents the project cost as it relates to actual cash payments by SGVWC. In addition to these project costs, SGVWC incurred significant in-kind labor costs. In-kind labor contribution is not considered in this analysis as each company has varying labor requirements, wages, overhead, and accounting methodology that make any comparison from agency to agency impossible. In addition, the preliminary design costs of $80,000 were not included in the CEC initial estimates as they were incurred prior to approval of the project by the CEC. Regardless, these preliminary design costs are necessary for design of the project and included in analysis for future projects.

Overall, it is estimated that non-construction costs would decrease by approximately $287,000 or 49 percent. This estimated cost reduction is driven by two elements, the elimination of certain tasks specific to the grant or research and development (R&D) associated with the project and the reduction of design costs related to the ability to reuse the standardized design. The team evaluated the project and estimated future costs, given the standardized plug-and-play package and the cost of any required customized design components. The estimation per line item is provided in the table above. A review of each of these line items follows.

- Preliminary Design – The preliminary design or feasibility assessment evaluates the project to ensure that it is viable from an environmental, technical, regulatory, and economic perspective. The analysis requires that the team model the pressure and flow of the site, perform a preliminary design, select potential turbine technology, and provide a high-level financial analysis. It is estimated that this cost would be significantly reduced based on the limiting of turbine technologies to evaluate as well as the standardized design. In other words, the team would not need to model or potentially design turbine technologies other than the three described earlier in this report. In addition, the standardized vertical turbine positioning, electrical design, and powerhouse size limits additional research, engineering, and design work.
- 50 Percent Design — The 50 percent design phase of the project takes the preliminary design to the next stage of the project. In this phase the specific turbine technology is selected and applied to the design of the project. Similar to the preliminary design, it is estimated that the standardized documentation will require limited customization for a new site. Therefore, estimated design costs have been significantly reduced for this line item.
- Final Design and Specification — The final design and specifications conclude the design of the project. The final design and specifications for the B24 hydroelectric project are included in the appendix. It is estimated that the specifications and drawings will require minimal customization based on the standardized plug-and-play design.
- Interconnection and Tariff Analysis — This line item represents the work required to model and select the specific tariff for the project site as well as work through the Rule 21 interconnection process. The cost associated with analyzing potential tariffs to use for a particular site is project specific and varies based on where the project is located and what tariffs are available. Therefore, no cost reduction is estimated for this task. The interconnection component of this line item consists of working through the Rule 21 interconnection process to get permission to connect the hydroelectric project. This process requires a single-line electrical design that will need only slight customization

for future sites. In addition, much of the electrical design as it relates to the interconnection process can be reused for future projects of this size. Therefore, a slight decrease in cost is related to this line item for future projects.

- Engineering Services During Construction — This task consists of all engineering-related tasks required during the construction of the projects. Items such as submittal reviews or change orders to the project are included in this line item. Unfortunately, each project is different, and much of this cost component is driven by the construction contractor. Therefore, it is impossible to estimate any cost reductions by the engineering/design for the project. The hope is that the simplified, standardized plug-and-play package will result in fewer change orders or submittal reviews, which would reduce the cost of this line item. But in an effort to be conservative, this line item was not reduced.
- Startup and Commissioning — This line item consists of the effort by the entire team to start up and commission the project. The bulk of the cost associated with this task is related to bringing all team members on site for the week or weeks required to test, start up, and commission the project. Ultimately the goal is to receive the permission-to-operate from the electric utility. Note that some minor cost reductions are expected by the standardization of documentation related to this task, such as the operations manual and final commission report, although the effort and cost reduction would be minor. Consequently, no reduction in the future costs for this line item is included in this estimation.
- FERC and Other Permits — This line item is related to all costs associated to securing the appropriate permits necessary for the projects. Certain permits such as FERC are required for all projects, while other permits such as Western Renewable Energy Generation Information System (WREGIS) are optional. Therefore, each potential project is different, and it is estimated that there will be no reduction in effort or costs for this line item.
- Environmental — This line item is related to the environmental analysis required of the project such as the National Environmental Policy Act (NEPA) or the California Environmental Quality Act (CEQA). This cost is specific to the project site, and no cost reduction is estimated for this line item.
- CEC Tasks (Administration, Knowledge Transfer, Benefits Analysis) — This line item is related to the specific tasks required by the CEC for the EPIC grant. The CEC required several administrative tasks such as monthly progress reports, meetings, and reimbursement documents. In addition, the CEC required the team to transfer knowledge of the project via webinars and conferences and evaluate the benefits of the project via items such as this final report. These tasks will not be required in future projects, so the cost is estimated at $0 for all three-line items.
- R&D Electrical Panel Design — Tesco researched and designed an electrical control panel to comply with the utility standard IEEE 1547 and UL 1741 requirements. Tesco created a 480V main switchgear and 120V human machine interface PLC control, housed inside a National Electrical Manufacturers Association 3R-rated metal enclosed structure. The panel is comprised of standardized and certified components meant to accommodate a wide range of generator types up to 500 kW. This research and

development is a one-time cost associated with the project. The cost reductions to the electrical components of the project are reflected in the construction costs and equipment. For future projects, this task is unnecessary, so the cost is estimated at $0.

The CEC tasks and R&D represent $110,000 of the cost reduction, while the standardization of the plug-and-play package represents approximately $177,000. The cost reduction in engineering tasks only is approximately 20 percent.

The overall construction would not have significant cost reductions in future projects as the cost reductions are already incorporated into this project. The research and development prior to the design of the project enabled the team to implement several innovative components, which resulted in lower project costs, as detailed in Chapter 2, Project Approach. This cost reduction is already included in the overall project cost for the current project and reflected in the future estimated project cost.

The B24 hydroelectric project had a total of three change orders during the project that accounted for approximately $111,000 in cost increase. The majority of the items associated with the change orders were normal requirements such as additional piping or tie-ins for the project, which were not considered initially. The project team would expect these additional costs to be reflected in similar projects or would be necessary if this project was built in the future. The first change order included an approximate $37,000 cost increase due to the hydro unit being part of a potable water system. Hydroelectric projects that are part of potable water systems need specific certifications verifying the system is safe for drinking water. San Gabriel Valley Water Company had the option to go through a lengthy process of having the selected pump-as-turbine certified for this project or purchasing equipment that was pre-certified. In the interest of time, because the EPIC grant had time limitations, SGVWC elected to pay the additional $37,000 and use the pre-certified equipment. Therefore, the team can eliminate this additional equipment cost in future projects.

## Future Project Costs

The standardized plug-and-play package used for the B24 project is already being used by NLine Energy to develop projects. During the development of the B24 project, two opportunities arose and were evaluated with the plug-and-play design, providing real time project cost estimates to use as benchmarks for similar-sized projects.

The following section provides the detailed project cost estimates for both of the projects based on the preliminary design performed by NLine Energy. These costs are estimates only and are subject to change based on further design, but provide a point of comparison for future similar-sized project costs that use the plug-and-play design. In addition, the Oregon projects have different permitting requirements, interconnection costs, and labor costs. Nevertheless, they are good reference points for comparison.

Both projects are located in Oregon. To keep the projects and site information confidential, the project team will refer to the sites as Project 1 and Project 2. The comparable sizes of each project are Project 1, 37 kW, and Project 2, 75 kW. Both projects are pressure reducing stations (vales), less than 100 kW, and will use single-mounted vertical turbines.

### Project 1 Pressure Reducing Station – 37 Kilowatts

In the preliminary design for the Project 1 hydroelectric station, NLine Energy selected a Canyon Hydro in-line turbine with a name plate rating of 32 kW for the technology. As shown in Figure 8, the cost estimate includes $310,000 in non-construction costs and $516,000 for construction/equipment cost for a total estimated project cost of $826,000. This project is expected to cost significantly less that the San Gabriel Valley Water Company B24 hydro project. The best apples-to-apples comparison to evaluate the expected benefits of the standardized plug-and-play design is to compare the estimated future cost of the B24 project to the estimated costs for Project 1. The overall project cost of Project 1 is approximately $225,000 less than the project cost of the B24 project. In addition, the non-construction cost of $310,000 is only slightly higher than the estimated non-construction project cost of the B24 project. The primary driver for the difference on overall project cost is the construction/ equipment costs. Project 1 uses a less costly and smaller turbine. In addition, Project 1 can be sited in an existing building so a new powerhouse is not necessary. Project 1 cost is below the target cost range of $900,000 to $1,100,000, which was a goal of the EPIC research project. More importantly, the non-construction costs have reduced significantly and are realizing the benefits of the plug-and-play design package.

## Figure 8: Cost Estimate for 37-Kilowatt Pressure Reducing Station

| Project 1<br>Engineer's Preliminary Estimate of Probable Costs<br>Option 2 - Canyon 32 kW In-Line-Turbine | | | | |
|---|---|---|---|---|
| **Description** | **Estimated Quantity** | **Units** | **Unit Price (installed)** | **Amount** |
| CONSTRUCTION | | | | |
| **Mobilization, Demobilization, Bonds, Insurance** | 1 | LS | $ 30,000 | $ 30,000 |
| | | | **Subtotal - Mobilization and Site Work:** | **$ 30,000** |
| **Pipe, Valves and Fittings** | | | | |
| Dewater & Tie into Exisitng facilities. | 1 | LS | $ 15,000 | $ 15,000 |
| Retrofit 4" PRV for Surge Relief Capability | 1 | LS | $ 1,000 | $ 1,000 |
| Automation and Control of Existing PR Valve | 1 | LS | $ 2,000 | $ 2,000 |
| 6" Fab Steel Pipe | 35 | LF | $ 125 | $ 4,400 |
| 6" Butterfly Valve | 2 | EA | $ 2,500 | $ 5,000 |
| 6" Flow Meter | 1 | EA | $ 2,000 | $ 2,000 |
| 2" ARV | 2 | EA | $ 3,800 | $ 7,600 |
| Fittings, couplings, Reducers, and pipe supports | 1 | LS | $ 15,000 | $ 15,000 |
| | | | **Subtotal :** | **$ 52,000** |
| **Powerhouse Building and Misc. Structural** | | | | |
| Relocate Existing Ladder | 1 | LS | $ 1,500 | $ 1,500 |
| Turbine Pad and Concrete | 3 | CY | $ 800 | $ 2,400 |
| Misc Building and Structural | 1 | LS | $ 5,000 | $ 5,000 |
| | | | **Subtotal - Powerhouse:** | **$ 8,900** |
| **Turbine / Generator System** | | | | |
| ILT 06 Turbine, Generator, HPU, TSV, Switchgear and PLC | 1 | EA | $ 147,200 | $ 147,200 |
| Shipping | 1 | LS | $ 2,000 | $ 2,000 |
| Startup and Commissioning | 1 | LS | $ 10,000 | $ 10,000 |
| Install Turbine/Generators | 1 | LS | $ 5,000 | $ 5,000 |
| | | | **Subtotal - Turbine / Generator System:** | **$ 164,200** |
| **Electrical and Controls** | | | | |
| Utility Disconnect Switch | 1 | LS | $ 6,000 | $ 6,000 |
| DC Power (Panel, Batteries and Charger) | 1 | LS | $ 8,000 | $ 8,000 |
| AC Panel and Step-down Transformer (480V to 120V) | 1 | LS | $ 7,000 | $ 7,000 |
| Site Electrical | 1 | LS | $ 25,000 | $ 25,000 |
| Pressure Transmitter | 2 | EA | $ 1,200 | $ 2,400 |
| PLC programming for existing system controls | 1 | LS | $ 25,000 | $ 25,000 |
| Communications; Cellular equipment and setup | 1 | LS | $ 8,000 | $ 8,000 |
| Power Coordination/Arc Flash and Certified Relay Testing. | 1 | LS | $ 8,500 | $ 8,500 |
| NEMA 4 Rated Panel | 1 | LS | $ 5,000 | $ 5,000 |
| Interconnection: New 3-phase power. Primary meter, CT/PT, Utility Disconnect, Step-up transformer, and ground fault detection equipment if required. | 1 | LS | $ 80,000 | $ 80,000 |
| | | | **Subtotal - Electrical & Utility:** | **$ 174,900** |
| | | | | |
| | | | **CONSTRUCTION SUBTOTAL:** | **$ 430,000** |
| Construction contingency Costs - 20% | | | | $ 86,000 |
| | | | **CONSTRUCTION TOTAL:** | **$ 516,000** |

| NON-CONSTRUCTION | | | | |
|---|---|---|---|---|
| Mechanical, Electrical, Civil Design | 1 | LS | $ 150,000 | $ 150,000 |
| Surge Analysis | 1 | LS | $ 10,000 | $ 10,000 |
| GC Bid Package / Bid | 1 | LS | $ 15,000 | $ 15,000 |
| Engineering Services during Construction | 1 | LS | $ 15,000 | $ 15,000 |
| Startup and Commissioning | 1 | LS | $ 20,000 | $ 20,000 |
| Project management | 1 | LS | $ 60,000 | $ 60,000 |
| Interconnection application and analysis | 1 | LS | $ 15,000 | $ 15,000 |
| FERC QCF NOI | 1 | LS | $ 5,000 | $ 5,000 |
| Environmental (NEPA) CatEx | 1 | LS | $ 15,000 | $ 15,000 |
| Regulatory Fees | 1 | LS | $ 5,000 | $ 5,000 |
| | | | **NON-CONSTRUCTION COSTS TOTAL:** | **$ 310,000** |
| | | | **TOTAL PROJECT COST:** | **$ 826,000** |

Source: San Gabriel Valley Water District

## Project 2 – Pressure Reducing Station – 75 Kilowatts

In the preliminary design for the Project 2 hydroelectric site, NLine Energy selected a Cornell Model 4TR3 pump-as-turbine with a name plate rating of 75 kW for the technology. As shown in Figure 9, the cost estimate includes $350,000 in non-construction costs and $584,000 for construction/equipment cost for a total estimated project cost of $934,000. This project is expected to cost significantly less that the San Gabriel Valley Water Company B24 hydro project. The best apples-to-apples comparison to evaluate the expected benefits of the standardized plug-and-play design is to compare the estimated future cost of the B24 project to the estimated costs for Project 2. The overall project cost of Project 2 is approximately $120,000 less than the project cost of the B24 project. In addition, the non-construction cost of $350,000 is higher than the estimated non-construction project cost of the B24 project because of some unique elements to consider. Project 2 will require more customized design, land acquisition, and a more complicated environmental process, all driving the cost of non-construction higher when compared to the estimated B24 non-construction cost estimate, although, Project 2 non-construction costs are still estimated to be significantly less than the original B24 project. The primary driver for the difference in overall project cost is the construction/equipment cost. Project 2 uses a slightly less costly turbine, and less foundation and piping is required for the project, resulting in lower costs. Project 2 cost is in the target cost range of $900,000 to $1,100,000, which was a goal of the EPIC research project. Due to the similar size and technology of the project, it is a good validation for the success of the plug-and-play package.

## Figure 9: Cost Estimate for 75-Kilowatt Pressure Reducing Station

| Project 2 | | | | |
|---|---|---|---|---|
| Engineer's Preliminary Estimate of Probable Costs | | | | |
| Canyon 75 kW Pump-As-Turbine | | | | |
| **Description** | **Estimated Quantity** | **Units** | **Unit Price (installed)** | **Amount** |
| **CONSTRUCTION** | | | | |
| **Mobilization, Demobilization, Bonds, Insurance** | 1 | LS | $18,845 | $18,800 |
| Site Prep.; Clearing, Grubbing, Survey Staking and Grading | 1 | LS | $10,000 | $10,000 |
| Excavation | 10 | CY | $50 | $500 |
| Foundation Prep and Forms | 1 | LS | $5,000 | $5,000 |
| Backfill and Compaction | 5 | CY | $25 | $100 |
| Roadbase for Drive and Parking area | 6 | CY | $35 | $200 |
| | | | **Subtotal - Mobilization and Site Work:** | **$34,600** |
| **Pipe, Valves and Fittings** | | | | |
| Dewater & Tie into Exisitng facilities | 2 | EA | $20,000 | $40,000 |
| 8" Tee DI MJxMJ | 2 | EA | $4,000 | $8,000 |
| Automation and Control of Existing PR Valve | 1 | LS | $2,000 | $2,000 |
| 8" Supply and Discharge Pipeline CMLC DI | 50 | LF | $140 | $7,000 |
| 8" Butterfly Valve | 3 | EA | $2,200 | $6,600 |
| 8" Flow Meter | 1 | EA | $6,000 | $6,000 |
| 8" 90 MJxMJ | 5 | EA | $1,800 | $9,000 |
| 2" ARV | 2 | EA | $3,800 | $7,600 |
| 4" Surge Relief Valve | 1 | EA | $1,500 | $1,500 |
| 4" Surge Relief Pipe DI | 40 | LF | $50 | $2,000 |
| 8" Flow Control Valve | 1 | EA | $3,000 | $3,000 |
| Thrust restraint (Concrete) | 2 | CY | $800 | $1,600 |
| Misc Fittings, couplings and supports | 1 | LS | $30,000 | $30,000 |
| | | | **Subtotal** | **$124,300** |
| **Powerhouse Building and Misc. Structural** | | | | |
| Prefabricated Building -Reinforced Fiberglass PaT 16'x16', ILT 12'x16' | 1 | LS | $25,000 | $25,000 |
| Foundation & Slab Concrete | 10 | CY | $800 | $8,000 |
| Misc Building and Structural | 1 | LS | $3,000 | $3,000 |
| | | | **Subtotal - Powerhouse:** | **$36,000** |
| **Turbine / Generator System** | | | | |
| Turbine, Generator, HPU, Switchgear and PLC | 1 | EA | $105,000 | $105,000 |
| Install Turbine/Generators | 1 | LS | $5,000 | $5,000 |
| | | | **Subtotal - Turbine / Generator System:** | **$110,000** |
| **Electrical and Controls** | | | | |
| Utility Disconnect Switch | 1 | LS | $6,000 | $6,000 |
| DC Power (Panel, Batteries and Charger) | 1 | LS | $8,000 | $8,000 |
| AC Panel and Step-down Transformer (480V to 120V) | 1 | LS | $7,000 | $7,000 |
| Site Electrical | 1 | LS | $30,000 | $30,000 |
| Pressure Transmitter | 2 | LS | $1,200 | $2,400 |
| PLC programming for existing system controls | 1 | LS | $30,000 | $30,000 |
| Communications; Cellular equipment and setup | 1 | LS | $10,000 | $10,000 |
| Power Coordination/Arc Flash and Certified Relay Testing. | 1 | LS | $8,500 | $8,500 |
| Interconnection: New 3-phase power approximately 4100 ft. Primary meter, CT/PT, Utility Disconnect, Step-up transformer, and ground fault detection equipment if required. | 1 | LS | $60,700 | $60,700 |
| | | | **Subtotal - Electrical & Utility:** | **$162,600** |
| | | | **CONSTRUCTION SUBTOTAL:** | **$467,500** |
| Construction contingency Costs - 25% | | | | $116,875 |
| | | | **CONSTRUCTION TOTAL:** | **$584,375** |

| | | | | |
|---|---|---|---|---|
| NON-CONSTRUCTION | | | | |
| Mechanical, Electrical, Civil Design | 1 | LS | $175,000 | $175,000 |
| Land Acquisition | 1 | LS | $5,000 | $5,000 |
| Survey | 1 | LS | $10,000 | $10,000 |
| Surge Analysis | 1 | LS | $10,000 | $10,000 |
| GC Bid Package / Bid | 1 | LS | $15,000 | $15,000 |
| Engineering Services during Construction | 1 | LS | $15,000 | $15,000 |
| Startup and Commissioning | 1 | LS | $20,000 | $20,000 |
| Project management | 1 | LS | $60,000 | $60,000 |
| Interconnection application and analysis | 1 | LS | $15,000 | $15,000 |
| FERC QCF NOI | 1 | LS | $5,000 | $5,000 |
| Environmental (NEPA) CatEx | 1 | LS | $15,000 | $15,000 |
| Regulatory Fees | 1 | LS | $5,000 | $5,000 |
| | NON-CONSTRUCTION COSTS TOTAL: | | | $350,000 |
| | | TOTAL PROJECT COST: | | $934,000 |

Source: San Gabriel Valley Water District

## B24 Hydro Project Results

The implementation and commissioning of the B24, 73-kW hydroelectric project was a successful milestone for the San Gabriel Project. This successful commissioning proved that a low cost, innovative, plug-and-play package could be implemented. Southern California Edison granted permission to operate on August 14, 2019, as shown in Figure 10.

**Figure 10: B24 Hydro Project Permission to Operate**

SOUTHERN CALIFORNIA
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**PERMISSION TO OPERATE**
Self-Generation Facility Interconnected to SCE's Electric Grid

**8/14/2019**

**San Gabriel Valley Water Company**
**14650 Nelson Ave East**
**City of Industry, CA 91744**

Dear Customer:

Southern California Edison Company ("SCE") completed its inspection of San Gabriel Valley Water Company's ("Customer") Electrical Components serving Customer's Generating Facility and reviewed the documentation showing compliance with the technical provisions of SCE's Rule 21 Tariff. Accordingly, as of the date of this letter, Customer is authorized to interconnect and operate its Generating Facility in parallel with SCE's Distribution System subject to the terms of the Generating Facility Interconnection Agreement ("GFIA") and/or Interconnection Facilities Financing and Ownership Agreement ("IFFOA") for NST-32071. If, at any time, SCE determines that this Generating Facility is not in compliance with the terms of the GFIA and/or IFFOA, this Permission to Operate may be revoked due to breach of contract.

**Generating Facility**

| | |
|---|---|
| **Address:** | **14650 Nelson Ave East**<br>**City of Industry, CA 91744** |
| **New Technology Type:** | **Small Hydroelectric Generation** |
| **Existing Technology Type (if applicable):** | |

**Capacity (kW):** **93.25**
**SA:** **3028641719**

SCE may inspect your electrical service panel to ensure it meets SCE's electrical service requirements for the Generation Facility you have selected. Electric service panels not meeting SCE's requirements will be required to be corrected in order for SCE to allow continued operation of your Generating Facility in parallel with SCE's electrical system. For further details regarding service panel requirements, please review SCE's Electrical Service Requirements (ESR).

For questions related to this interconnection and NEM billing rate, please refer to the Frequently Asked Questions (FAQ).

If you have any additional questions, please feel free to contact me by phone at (626) 302-9112 or by e-mail at Janae.Camacho@sce.com.

Sincerely,

Janae Camacho
Contract Manager - Grid Contract Management
Southern California Edison

**This is a system generated email.**

Start-up, commissioning, and performance testing of San Gabriel Valley Water Company's B24 hydroelectric station was conducted on August 14, 2019. Start-up and commissioning tests show that the hydroelectric station meets the design objectives for power systems, controls, outfall function, and power generation. These systems are all operational and within anticipated performance expectations. The emergency stop (e-stop) test results showed that the actual magnitude and duration of e-stop-generated transient pressure is below the allowable surge pressures.

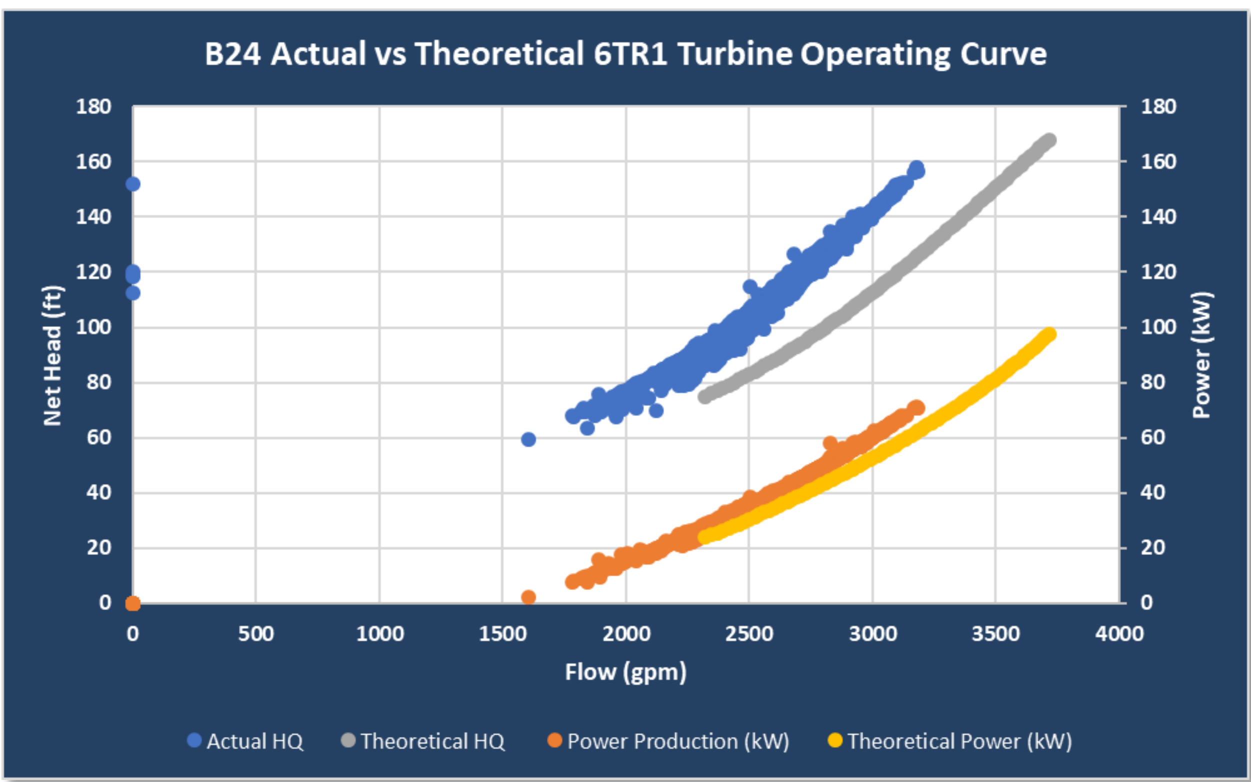
Performance testing was conducted by collecting flow, pressure, and electrical power production data while operating the turbine/generator unit through a variety of flow ranges. The team collected six weeks of flow, pressure, and power data to better assess the performance. In a comparison of theoretical to actual power generation, the generator produced power above anticipated levels at all flow rates tested through the turbine.

However, the turbine is producing, on average, less power than anticipated because the pressures and flows that the turbine is processing are less than previously modeled in 2015 and 2016 data. The data shows the turbine control valve (TCV) reduces the pressure by about 10 pounds per square inch (psi) on average. A reduction in 10 psi of available pressure also reduces the flow that the turbine will capture by about 315 gallons per minute (gpm), which equates to about 10 kW (14 percent) of lost power generation. The TCV can be adjusted to make up for the lost power. Making this adjustment will allow the hydroelectric station to exceed the expected annual power generation.

Tesco Controls provided six weeks of post commissioning data from August 26 through October 15, 2019. The data included 15-minute interval recordings of the bypass valve position, turbine control valve position, turbine power output (kW), turbine outlet pressure/tank levels (ft), turbine flow meter (gpm), plant flow meter (gpm) turbine inlet pressure (psi), and plant inlet pressure (psi).

Figure 11 shows the actual turbine data compared to theoretical performance. The grey and blue curves show the manufacturer operating curve and actual head and flow values respectively. The actual performance indicates that the turbine is able to capture flows and pressures less than the advertised operating curve. Additionally, the blue curve appears shifted left from the manufacturer curve by about 150 gpm. The project team believes this to be a discrepancy in the flow meter accuracy. The orange and yellow curves show the actual versus manufacturer operating curve for flow versus power production respectively. This curve indicates that the turbine is primarily operating between 2,000 and 3,000 gpm, and exceeding power production at the pressures and flows that the turbine is witnessing. Additionally, the turbine is able to process flows less than the manufacturer minimum of 2,300 gpm, effectively expanding its operating range. Table 2 shows three distinct flow and pressure scenarios and the corresponding actual performance data compared to the Canyon Hydro performance guarantee metrics for the generator.

**Figure 11: Turbine Performance Test Results**




Source: NLine Energy

**Table 2: Canyon Generator Performance**
**SGVWC- B24 Hydro Performance Test Results**

| Results | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|
| **Contract Requirements** | | | |
| Flow (gpm) | 3606.4 | 3561.6 | 3427.2 |
| Net Pressure (psi) | 69.3 | 67.5 | 62.8 |
| Net Pressure Head (ft) | 160 | 156 | 145 |
| Energy (kW) | 79 | 77 | 69 |
| Efficiency (%) | **0.72** | **0.73** | **0.73** |
| **Recorded Data** | | | |
| Flow (gpm) | 3330 | 3317 | 3191 |
| Pressure (psi) | 68.31 | 67.53 | 62.77 |
| Pressure Head (ft) | 157.8 | 156 | 145 |
| Energy (kW) | 71.4 | 70.6 | 62.7 |
| Efficiency (%) | **0.72** | **0.72** | **0.72** |
| **Results** | | | |
| Efficiency | **Pass** | **Pass** | **Pass** |
| Flow | **N/A** | **3561>3317** | **3427>3191** |

Source: NLine Energy

The results indicate that the turbine/generator efficiency meets the performance requirements of the contract. However, at given net head values, less flow is being delivered to the turbine than anticipated. This is likely a result of the bypass Cla-Val processing a minimal amount of flow to keep a pressure differential across the valve. It is anticipated that venting the turbine control valve to the atmosphere will aid by sending more pressure and flow to the turbine. The generator performance guarantee is met.

Overall, the commissioning and testing of the installed B24 hydro project has met or exceeded the expectations of the team, with the exception of the 10-psi loss due to the TCV. The team has implemented plans post project commissioning to mitigate the loss of pressure from the TCV. Therefore, the project is expected to meet or exceed the annual generation estimate based on historical pressure and flow. The specific financial and environmental benefits to California ratepayers are detailed in Chapter 6.

# CHAPTER 4: Technology/Knowledge/Market Transfer Activities

## Technology/Knowledge/Market Transfer Activities

The project team conducted a series of presentations at several key conferences starting in 2017 to highlight the attributes of the project so that the research effort could be replicated by the United States target market for in-conduit hydroelectric technologies, namely municipal water systems such as water districts, irrigation districts, cities, counties, and other public and private water companies.

Results of this project were shared with more than 450 municipal water agencies, known as the Association of California Water Agencies (ACWA) during several statewide, semi-annual conferences in 2017 and 2018. Additionally, a case study was shared at several presentations for the National Hydropower Association and the international hydropower conference, Hydrovision, from 2017 to 2019, and the Northwest Hydroelectric Association's National Conference in 2019. The project case study details the roadmap by which a municipal agency can take a step-wise approach to permitting and inform on policy changes at the water agency level to encourage in-conduit hydroelectric development.

Commissioning of the project was shared via social media targeting state and local officials, state regulatory agencies, existing hydropower owners, and California water infrastructure owners. Lastly, knowledge of this project was shared with other CEC EPIC awardees as part of Technical Advisory Committee or informal information sharing at the request of CEC staff.

# CHAPTER 5: Conclusions/Recommendations

The San Gabriel Valley Water Company "Plug-and-Play" In-Conduit Hydropower Development Project successfully developed a standardized modular package for in-conduit hydroelectric power stations generating less than 100 kW and demonstrated the package's potential to advance this untapped market, thus adding to the state's energy mix, helping to meet SB 100 goals, and saving significant costs in the process.

The team developed a standardized low-cost civil, mechanical, and electrical hydroelectric design package that can be used in future sub-100-kW projects. The modularized plug-and-play concept will reduce the levelof customization previously pursued at individual sites and require minimal changes to future projects similar in size, pressure, and flow. The design uses standard off-the-shelf turbine technology able to fit a number of pressure and flow ranges and considers the largest of 15 turbine technologies so any of the other 14 technologies could fit within the same powerhouse footprint. The package panels comply with IEEE and UL standards. The equipment designated for the project meets or exceeds ANSI-61 potable water drinking standards, and the civil design accommodates for locations of Seismic Design Category D, a standard that accommodates most locations in the country. Finally, the project team chose a pre-fabricated fiberglass building that requires minimal concrete pours; is pre-equipped with lighting, receptacles, exhaust fan, roof hatch, and louver; meets seismic standards; and is less than half the cost of a metal or pre-cast concrete building.

The team installed the package in a fully operational 73-kW pilot project at San Gabriel Water Valley Company's B24 Pumping Station to demonstrate improved efficiency and performance to maximize the capture of wasted energy in water supply networks. The pilot project will demonstrate the long-term operational capacity of an in-conduit turbine/generator system to provide renewable energy for the state energy mix and has already demonstrated qualitative and quantitative benefits to San Gabriel Valley's investor-owned utility electric ratepayers, including reduction of energy costs and greenhouse gas emissions and efficient use of ratepayer money.

Based on monitoring the limited operations of the project to date, it is estimated that the project will meet the annual generation of 403,000 kilowatt-hours (kWh) annually and 11,662,000 kWh over its 30-year useful asset life.

It is estimated that the standardization of the engineering design will result in a 50 percent reduction in these specific design/engineering project costs on future projects. The design and specifications for this project are included in the appendix.

The B24 hydroelectric pilot project cost approximately $1,462,000 to implement, and it is estimated that future projects of similar size can be developed at a cost ranging between $900,000 and $1,100,000. At this specific cost range, projects of similar size and generation profiles will be economically viable under current California electric rate tariffs.

The project provided direct benefits to investor-owned utility ratepayers in San Gabriel's service territory, reducing energy costs, greenhouse gas emissions, and other harmful air emissions.

The success of this project suggests that a sub-100-kW in-conduit hydroelectric project is achievable for less than $1 million. Water infrastructure owners can conduct evaluations of their system to identify areas of excess pressure differential where conduit hydroelectric power production may be possible, leveraging the data from this project to inform development opportunities and design options.

# CHAPTER 6: Benefits to Ratepayers

Ratepayers in the San Gabriel Valley will immediately benefit from the San Gabriel Valley Water Company (SGVWC) "Plug-and-Play" In-Conduit Hydroelectric project, and all of California as well as the rest of the United States will benefit from the project's replicable results. The B24 hydroelectric pilot project in San Gabriel Valley has been operational since August 2019 and is producing clean, reliable baseload power for the community. In addition, because electricity costs are one the largest expenses for SGVWC, the cost savings realized by SGVWC from the B24 project will help the water company keep water rates low for its consumers. The plug and play package developed for this project will enable other California water agencies to develop similar-sized hydroelectric projects, opening up the development of sub-100-kW projects in California.

## Local Benefits of the B24 Pilot Project

The cost of the B24 hydroelectric pilot project was approximately $1,462,000, which also included all research and development for the plug-and-play package. The project received multiple grants, including $500,000 from the CEC EPIC Program. The SGVWC B24 project will also qualify for the U.S. Department of Treasury investment tax credit. It is conservatively estimated that SGVWC will receive approximately $450,000 in tax credits for the hydroelectric project.

The B24 hydroelectric project is estimated to generate 403,000 kWh annually, resulting in energy cost savings of $56,000 per year. Energy rates are expected to increase over time, so annual cost savings are expected to increase by at least 2 percent per year. The asset life of the turbine ranges between 30 and 50 years. Therefore, the project is estimated to generate between 12,090,000 and 20,150,000 kWh, or $1,680,000 to 2,800,000 kWh, over the life of the asset. Overall, given the substantial grant funding and projected annual savings, this project should provide a positive return for local rate-payers and continue to benefit them over the next 30 to 50 years.

The B24 hydroelectric project will also provide substantial environmental benefits to the community. Based on an annual generation of 403,000 kWh, the project will offset 285 metric tons of carbon in the first year. Over its life, the project should offset between 8,549 and 14,249 metric tons of carbon. Assuming a 50-year asset life, the clean power generated from this project is the energy equivalent to the following:

- 3,025 passenger vehicles driven for one year
- 2,485 homes' electricity costs for one year
- 32,990 barrels of oil consumed
- 15,577,478 pounds of coal burned

## California Market Implications

The San Gabriel Project provides a basis for expanding in-conduit hydropower throughout California, particularly in under-used small hydro sites. Based on the assumptions that follow, the project will lead to at least 9,000 kW of annual renewable energy, or 48,360,000 kWh of annual renewable generation.

Since 2011, NLine Energy has evaluated more than 180 in-conduit hydroelectric sites across 100 different California water agencies. NLine Energy's initial data shows that 24 sites fit the sub-100-kW range that could be developed with a 20 percent total project cost reduction in engineering and design cost as previously seen in Table 1. More than 500 water agencies in California are of sufficient size to meet the minimum flow and available head requirements discussed in this report. Assuming that 13 percent (24 sub-100-kW sites / 180 sites evaluated) across 100 water agencies is a representative sample of the rest of California's water agencies, there are 120 potential sub-100-kW sites in California. Using the metrics of the San Gabriel B24 site to predict the total sub-100-kW market and using the quantitative metrics just presented regarding the B24 pilot project, the total addressable market is 9,000 kW (approximate calculation is 75 kW times 120 potential sites). These assumptions do not include the market potential of non-water utilities such as bottled water facilities, wineries, food and beverage processing, rock / sand / gravel, mining, refineries, oil and gas extraction / processing, chemical, pharmaceutical, ski resorts, or military bases in the total market. Given these additional inputs, the current 9,000 kW estimate for water utilities is attainable by 2030.

Expansion of the sub-100-kW market would have significant environmental benefits for California ratepayers. It is estimated that adding these small hydro units to the market would generate 48,360,000 kilowatt-hours per year or the equivalent of 34,198 metric tons of carbon dioxide annually. Assuming a 50-year asset life, the clean power generated from these projects could generate 2,418,000,000 kilowatt-hours over the life of the project, which is equivalent to the following:

- 1,709,891 metric tons of carbon dioxide
- 363,034 passenger vehicles driven for one year
- 298,182 homes' electricity costs for one year
- 3,958,759 barrels of oil consumed
- 1,869,297,310 pounds of coal burned

This project has demonstrated the significant opportunity for in-conduit hydropower to deliver financial and environmental benefits for California ratepayers.

# GLOSSARY AND ACRONYMS

| Term/Acronym | Definition |
|---|---|
| ACWA | Association of California Water Agencies |
| annual power generation | Power generated by a hydropower system in one year, usually expressed in kilowatt-hours |
| ANSI 61 | A set of national standards that relates to water treatment and establishes stringent requirements for the control of equipment that comes in contact with either potable water or products that support the production of potable water |
| CLA-Val | A type of valve designed to serve multiple purposes, the most common being in a water supply system. When pumping water, the valve will not open until the pressure behind it reaches a predetermined amount of pressure. |
| CEQA | California Environmental Quality Act |
| cfs | cubic feet per second |
| CSWD | Crystal Springs Water District |
| FERC | Federal Energy Regulatory Commission |
| ft | feet |
| generator | In electricity generation, a device that converts mechanical power into electrical power for use in an external circuit |
| GHG | greenhouse gas |
| gpm | gallons per minute |
| gross head | Overall head |
| head | The change in water levels between the hydropower system intake and discharge point |
| hydropower | Electricity generated from capturing potential energy of flowing water |
| IOU | investor-owned utility |
| in-conduit hydropower | Hydroelectric generation potential in man-made conduits such as tunnels, canals, pipelines, aqueducts, flumes, ditches, or similar man-made water conveyances that are operated for the distribution of water for agricultural, municipal, and industrial consumption |
| ILT | in-line turbine |
| kW | kilowatt |
| kWh | kilowatt-hour |
| MW | megawatt |

| Term/Acronym | Definition |
|---|---|
| NEPA | National Environmental Policy Act |
| net head | Gross head (overall head) minus the sum of all friction losses |
| O&M | operation and maintenance |
| PAT | pump-as-turbine |
| PLC | programmable logic controller |
| powerhouse | Hydropower system |
| psi | pounds per square inch |
| PTO | permission to operate |
| PRV | pressure-reducing valve: a pressure relief valve to control or limit the pressure in a system |
| SCADA | supervisory control and data acquisition |
| SCE | Southern California Edison |
| SGVWC | San Gabriel Valley Water Company |
| Turbine | A rotary machine that converts potential and kinetic energy of water into mechanical work |
| WREGIS | Western Renewable Energy Generation Information System |

# APPENDIX A:
# Design Specifications

# SAN GABRIEL VALLEY WATER COMPANY

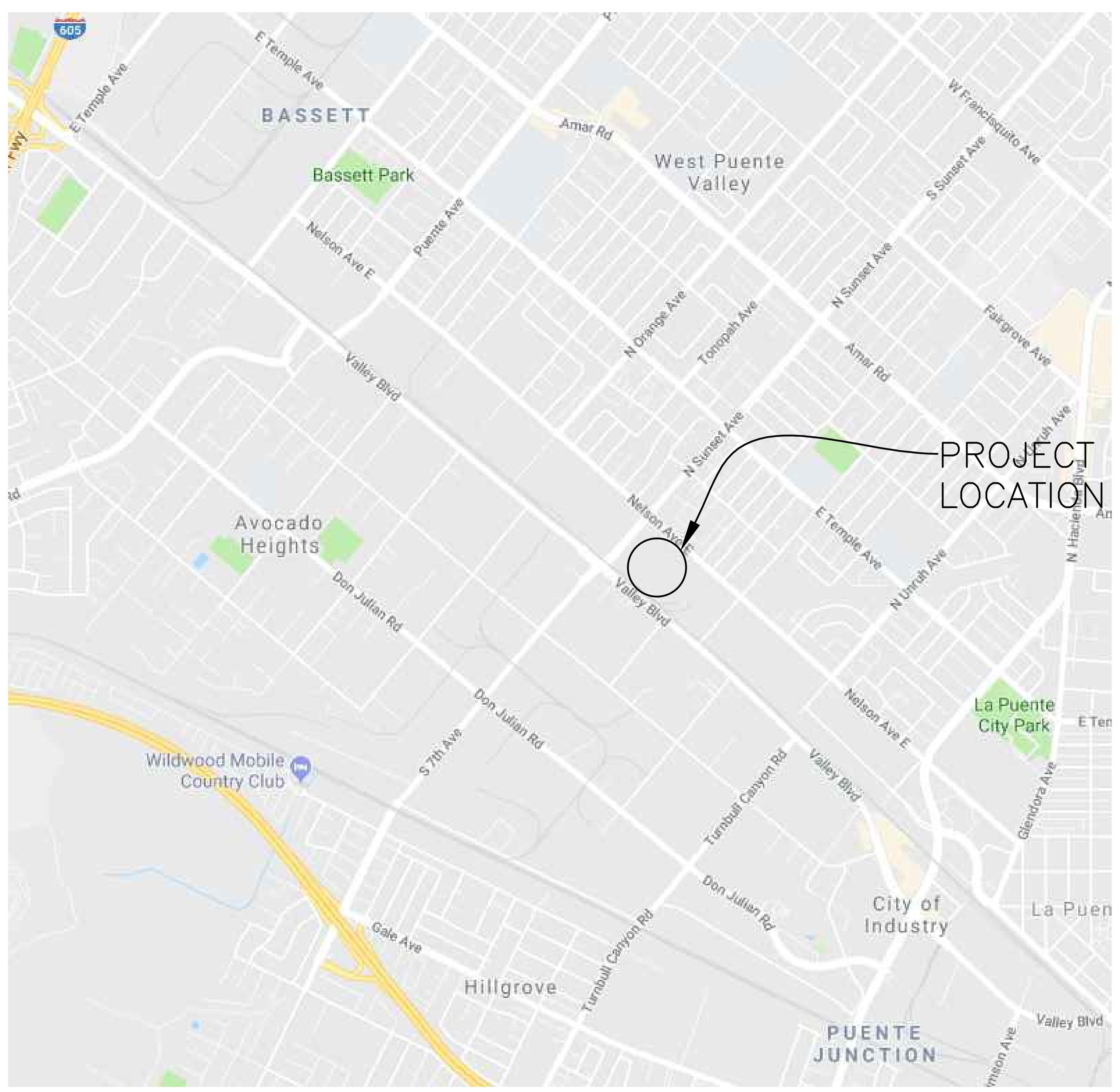
## LOS ANGELES COUNTY, CALIFORNIA

# PLANT B24
# HYDROELECTRIC PROJECT

## 100% PLANS SUBMITTAL



F.E.R. PROJECT NO. D017-17-000




LOCATION MAP
NOT TO SCALE


VICINITY MAP
NOT TO SCALE

Z:\NLINE\NLINE 020 - PLANT B24 HYDRO\DRAWINGS - 90% DRAFT 3 (WORKING)\D&NLINE B24 HYDRO.DWG

REVISIONS

CD017-17-000

EETSINC

NLINE ENERGY
EVERY DROP OF ENERGY

SAN GABRIEL VALLEY WATER COMPANY

SAN GABRIEL VALLEY WATER COMPANY
11142 GARVEY AVENUE
EL MONTE, CALIFORNIA

PLANT B24 HYDRO

TITLE SHEET, LOCATION MAP & INDEX OF DRAWINGS

DRAWING
G1

## GENERAL NOTES

1. ALL WORK SHALL CONFORM TO THE APPLICABLE LOCAL, STATE AND FEDERAL CODES AND SPECIFICATIONS INCLUDING OSHA.
2. EXCAVATIONS SHALL BE CARRIED OUT IN THE DRY AND PROVISIONS SHALL BE MADE TO PREVENT THE BOTTOM OF EXCAVATION FROM FLOODING AT ALL TIMES.
3. IT IS THE CONTRACTORS RESPONSIBILITY TO ASSURE JOB SAFETY. LOCAL, STATE AND FEDERAL, INCLUDING OSHA, LAWS AND RULES SHALL BE ENFORCED BY THE CONTRACTOR AT ALL TIMES.
4. ALL STRUCTURES AND FACILITIES DAMAGED BY CONTRACTOR SHALL BE REPAIRED OR REPLACED AT CONTRACTOR'S EXPENSE.
5. POTHOLE SURVEY WAS PREPARED BY THE CONTRACTOR.
6. PUBLIC SAFETY AND TRAFFIC CONTROL PLAN SHALL BE PROVIDED IN ACCORDANCE WITH THE SPECIAL PROVISIONS OF THESE SPECIFICATIONS. SAFE VEHICULAR AND OPERATION STAFF ACCESS SHALL BE PROVIDED AT ALL TIMES DURING CONSTRUCTION.
7. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE PROTECTION OF ALL EXISTING SURVEY MONUMENTS AND OTHER SURVEY MARKERS DURING CONSTRUCTION. ALL SUCH MONUMENTS OR MARKERS DESTROYED DURING CONSTRUCTION SHALL BE REPLACED AT THE CONTRACTOR'S EXPENSE.
8. THE TYPES LOCATIONS, SIZES, AND/OR DEPTHS OF EXISTING UNDERGROUND UTILITIES AS SHOWN ON THESE IMPROVEMENT PLANS WERE OBTAINED FROM SOURCES OF VARYING RELIABILITY. THE CONTRACTOR IS CAUTIONED THAT ONLY ACTUAL EXCAVATION WILL REVEAL THE TYPES, EXTENT, SIZES, LOCATIONS, AND DEPTHS OF SUCH UNDERGROUND UTILITIES. A REASONABLE EFFORT HAS BEEN MADE TO LOCATE AND DELINEATE ALL KNOWN UNDERGROUND UTILITIES. HOWEVER, THE SGVWC CAN ASSUME NO RESPONSIBILITY FOR THE COMPLETENESS OR ACCURACY OF THE DELINEATION OF SUCH UNDERGROUND UTILITIES NOR FOR THE EXISTENCE OF OTHER BURIED OBJECTS OR UTILITIES WHICH MAY BE ENCOUNTERED BUT WHICH ARE NOT SHOWN ON THESE DRAWINGS. IT IS THE CONTRACTOR'S RESPONSIBILITY TO VERIFY ACTUAL LOCATIONS.
9. ALL CONSTRUCTION SHALL CONFORM TO THESE PLANS AND THE LATEST EDITION OF SAN GABRIEL WATER COMPANY (SGVWC) STANDARD CONSTRUCTION SPECIFICATIONS.
10. THE CONTRACTOR SHALL NOTIFY SGVWC AT (626) 448-6183 48 HOURS PRIOR TO INTENDED START OF WORK TO ARRANGE A PRE-CONSTRUCTION FIELD MEETING AND SHALL VERIFY AT THIS TIME THAT THE INSPECTOR HAS RECEIVED COPIES OF THE APPROVED PLANS. NO CONSTRUCTION SHALL BE STARTED PRIOR TO THIS MEETING.
11. SGVWC IS A MEMBER OF THE UNDERGROUND SERVICES ALERT (USA) ONE CALL PROGRAM. THE CONTRACTOR OR ANY SUBCONTRACTOR FOR THIS CONTRACT SHALL NOTIFY MEMBERS OF USA 2 WORKING DAYS IN ADVANCE OF PERFORMING ANY EXCAVATION WORK BY CALLING THE TOLL FREE NUMBER 800-642-2444. THE CONTRACTOR SHALL ALSO NOTIFY ALL OTHER UTILITIES, NOT IN USA, 48 HOURS PRIOR TO ANY EXCAVATION.
12. COMPLIANCE WITH NOISE RESTRICTIONS IS REQUIRED. HOURS OF CONSTRUCTION OPERATION SHALL BE LIMITED FROM 7:00 A.M. TO 6:00 P.M. WEEKDAYS. NO SATURDAY WORK SHALL BE ALLOWED UNLESS APPROVED BY SGVWC. NO SUNDAY WORK IS APPROVED. CONSTRUCTION EQUIPMENT SHALL BE MUFFLED AND SHROUDED TO MINIMIZE NOISE LEVELS IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATIONS.
13. NO REFUELING, LUBRICATION, OR MAINTENANCE OF CONSTRUCTION VEHICLES SHALL BE DONE ANYWHERE ON THE SITE EXCEPT WITHIN APPROVED CONSTRUCTION STAGING AREAS.

## CONSTRUCTION UTIITIES

1. ALL CONSTRUCTION WATER TO BE METERED AND OBTAINED FROM A HYDRANT LOCATION APPROVED BY SGVWC
2. ALL CONSTRUCTION POWER TO BE OBTAINED FROM SGVWC APPROVED LOCATION.

DIGALERT 811

## LEGEND & SYMBOLS

FLANGED JOINT
MECHANICAL JOINT
WELDED JOINT
BELL & SPIGOT JOINT (LEADED)
BALL JOINT
GROOVED END JOINT
FLANGED COUPLING ADAPTER
FLEXIBLE COUPLING
FLEXIBLE COUPLING WITH THRUST TIES
STEEL BELLOWS EXP JOINT
ELASTOMER BELLOWS EXP JOINT
ELBOW UP
ELBOW DOWN
TEE UP
TEE DOWN
LATERAL UP
LATERAL DOWN
ELBOW 90°
CROSS
TEE
ELBOW 45°
LATERAL
CONCENTRIC REDUCER
ECCENTRIC REDUCER
UNION
CAP (WELDED)
TRAP
VENT
WYE
BURIED VALVE W/ BOX
BALL VALVE
BUTTERFLY VALVE
CHECK VALVE
DIAPHRAGM VALVE
GATE VALVE
PRESSURE REDUCING VALVE
PRESSURE RELIEF VALVE
PLUG VALVE
3 WAY VALVE
4 WAY VALVE
VACUUM RELIEF VALVE
BACKFLOW PREVENTER
BLIND FLANGE
DOUBLE MECHANICAL JOINT
PVC JOINT
EXPANSION COUPLING
PIPE CONTINUATION
PIPE CONTINUATION, END VIEW
CLEAN OUT (CO)
DRAIN OR BELL-UP
FILTER
FLEXIBLE HOSE OR TUBING
FLOWMETER (FM)
FLOWTUBE
FREE SURFACE
GAGE, PRESSURE (W/COCK)
HOSE BIBB 3/4" W/HOSE THREAD (HB)
YARD HYDRANT, FREEZE PROOF (HYD)
HOSE RACK

POWER/TELEPHONE
WATER SERVICE REGULATOR OR WATER METER (W or WM)
FIRE HYDRANT
LIGHT POLE
SIGN (S)
ORIFICE PLATE
PUMP, CENTRIFUGAL
PUMP, VARIABLE SPEED
PUMP, PROGRESSIVE CAVITY
SLEEVE
STRAINER (S)
WATER SERVICE
POINT ELEVATION (x 1789.6)
SLOPE
TREES OR SHRUBBERY
LANDSCAPED AREA
TEST BORING LOCATION AND NO. (TB-4)
EXISTING BUILDING
NEW BUILDING
CONCRETE PAVEMENT
ASPHALT PAVEMENT
DRAINAGE COURSE OR FLOW LINE
EXISTING GROUND CONTOUR (326)
FINISH GRADE CONTOUR (326)
STRUCTURAL CONTINUATION
CONCRETE
GROUT
ROAD BASE
DRAIN GRAVEL OR GRANULAR MATERIAL
COARSE BASE ROCK
FINISHED WOOD
ROUGH WOOD, CONTINUOUS
INSULATION
MASONRY BLOCK
EARTH OR GRADE
EARTH FILL
CHECKERED PLATE
GRATING
STEEL
PIPE SUPPORTS
CONDUIT
ELECTRICAL BOX
SEWER ACCESS
AIR RELEASE VALVE
METAL STRUT W/ CONC. FOOTING
IRON FENCING W/ CONC BASE & COLUMNS

LINETYPES

UNDERGROUND, NEW FACILITIES
ABOVE GROUND, NEW FACILITIES
UNDERGROUND, EXISTING FACILITIES
ABOVE GROUND, EXISTING FACILITIES
EXISTING FACILITIES TO BE REMOVED
EXISTING FACILITIES TO BE ABANDONED
EXISTING ELECTRICAL CONDUIT (E)
EXISTING OVERHEAD ELECTRICAL (OHE)
RIGHT OF WAY

## ABBREVIATIONS

| | |
|---|---|
| @ | AT |
| A.C. | ASPHALT CONCRETE |
| A.B. | AGGREGATE BASE |
| ARV | AIR RELEASE VALVE |
| BF | BLIND FLANGE |
| BFV | BUTTERFLY VALVE |
| BLDG | BUILDING |
| B.M. | BENCH MARK |
| BOF | BOTTOM OF FLANGE |
| BOF* | BOTTOM OF FLANGE, NOT INCLUDING BOLTS |
| BOP | BOTTOM OF PIPE |
| BOS | BOTTOM OF STAIRS |
| BW | BACKWASH WATER |
| CIP | CAST IN PLACE |
| CLG | CEILING |
| CLR | CLEAR |
| ℄ | CENTERLINE |
| CMP | CORRUGATED METAL PIPE |
| CO | CLEANOUT |
| CONC. | CONCRETE |
| CONT. | CONTINUOUS |
| CPLG | COUPLING |
| C TO C | CENTER TO CENTER |
| CV | CHECK VALVE |
| d | PENNY (NAIL SIZE) |
| DET | DETAIL |
| DIA | DIAMETER |
| DIP | DUCTILE IRON PIPE |
| DWG | DRAWING |
| EA | EACH |
| ECC | ECCENTRIC |
| EG | EXISTING GRADE |
| EL | ELEVATION |
| ELB | ELBOW |
| ELEC | ELECTRIC, ELECTRICAL |
| ESEW | EMERGENCY SHOWER & EYEWASH |
| EW | EACH WAY |
| EXH | EXHAUST |
| (E) | EXISTING |
| FC | FLEXIBLE COUPLING |
| FCA | FLANGED COUPLING ADAPTER |
| FCTRY | FACTORY |
| FD | FLOOR DRAIN |
| FDN | FOUNDATION |
| FF | FINISH FLOOR |
| FG | FINISH GRADE |
| FIG. | FIGURE |
| FL | FLOOR |
| FLG | FLANGE |
| FFL | FLOW LINE |
| FT. | FOOT OR FEET |
| FTG. | FOOTING |
| GA. | GAGE |
| GAL. | GALLON |
| GALV. | GALVANIZED |
| GV | GATE VALVE |
| GWBR | 10 GAUGE STEEL, CEMENT LINED & COATED |
| GWBG | 10 GAUGE STEEL, CEMENT LINED |
| HDW | HARDWARE |
| HORIZ | HORIZONTAL |
| HP | HORSEPOWER |
| HR | HOSE RACK |
| IE | INVERT ELEVATION |
| IN. | INCH |
| INSUL | INSULATION |
| INV. | INVERT |
| JT. | JOINT |
| KIP | THOUSAND POUNDS |
| KW | KILOWATT |

| | |
|---|---|
| L | ANGLE |
| LB | POUNDS |
| LF. | LINEAR FEET |
| LT. | LEFT |
| LR | LONG RADIUS |
| MAX. | MAXIMUM |
| MECH | MECHANICAL |
| MFR. | MANUFACTURER |
| MH | MANHOLE |
| MIN. | MINIMUM |
| MISC. | MISCELLANEOUS |
| MJ | MECHANICAL JOINT |
| MO | MASONRY OPENING |
| NO, OR # | NUMBER |
| NTS | NOT TO SCALE |
| (N) | NEW |
| O.C. | ON CENTER |
| OF | OVERFLOW |
| OZ | OUNCE |
| P.E. | PLAIN END |
| PL. | PLATE (STEEL) |
| PLYWD | PLYWOOD |
| PRESS. | PRESSURE |
| PL | PROPERTY LINE |
| P.S.I. | POUND PER SQUARE INCH |
| PW | POTABLE WATER |
| R. OR RAD. | RADIUS |
| RD. | ROAD |
| RDCR | REDUCER |
| RDW | REDWOOD |
| RM | ROOM |
| RO | ROUGH OPENING |
| RTN | RETURN |
| RV | ROOF FENT |
| R/W | RIGHT-OF-WAY |
| SCHED. | SCHEDULE |
| SEC. | SECTION |
| SH | SHEET |
| SHT'G | SHEATHING |
| SPEC. | SPECIFICATIONS |
| SQ | SQUARE |
| SST | STAINLESS STEEL |
| STA. | STATION |
| STD | STANDARD |
| STL | STEEL |
| STRL | STRUCTURAL |
| STRUCT | STRUCTURE |
| TAN | TANGENT |
| TARV | TOP OF AIR RELEASE VALVE |
| TBG | TUBING |
| TECH | TECHNICAL |
| TEMP | TEMPERATURE |
| THD | THREAD |
| TOC | TOP OF CURB |
| TOG | TOP OF GRATE |
| TOP | TOP OF PIPE |
| TOR | TOP OF ROCK |
| TOW | TOP OF WALL |
| TYP. | TYPICAL |
| TW | TREATED WATER |
| UBC | UNIFORM BUILDING CODE |
| UNO | UNLESS NOTED OTHERWISE |
| V | VENT, FOLT |
| VAC | VACUUM |
| VTR | VENT THRU ROOF |
| WM | WATER METER |
| WW | WASTE WATER |
| WTP | WATER TREATMENT PLANT |

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DESIGNED BY: ANDREW BENJAMIN
REVIEWED BY: DAVID POWELL
APPROVED BY:
F.E.R.C. Project No. C0017-17-000
SCALE: AS NOTED
JOB NO.

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SAN GABRIEL VALLEY WATER COMPANY

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EL MONTE, CALIFORNIA 91733

PLANT B24 HYDRO

ABBREVIATIONS & GENERAL NOTES

DRAWING G2

2 OF 19 SHEETS


SITE PLAN
SCALE: 1" = 10'

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REGISTERED PROFESSIONAL ENGINEER ANDREW M. BENJAMIN No. C88287 Exp. 03/2020 CIVIL STATE OF CALIFORNIA

REGISTERED PROFESSIONAL ENGINEER MICHAEL F BREGAR 10246 Exp. SEPT. 30, 2020 Electrical Engineer STATE OF CALIFORNIA

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PLANT B24 HYDRO

OVERALL PLAN

DRAWING C1

3 OF 19 SHEETS

NOTES:

1. REMOVE AND EXCHANGE POSITIONS OF THE EXISTING CLA–VAL AND BUTTERFLY. SEE DETAIL 1 ON DWG C6 FOR NEW VALVE POSITIONS AND TIE–INS FROM BELOW GRADE.
2. DEWATER AND ABANDON IN PLACE APPROXIMATELY 41' OF EXISTING 17" PIPEING BETWEEN THESE LOCATIONS. ABANDONMENT SHALL CONSIST OF FILLING WITH SAND, CONCRETE, OR GROUT AND, CAPPING THE ENDS.


## SITE PLAN & DEMOLITION

SCALE: 1" = 6'

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REGISTERED PROFESSIONAL ENGINEER — MICHAEL F BREGAR — 10246 — Exp. SEPT. 30, 2020 — Electrical Engineer — STATE OF CALIFORNIA

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| APPROVED BY: | |
| F.E.R.C. Project No. | CD017–17–000 |
| SCALE: | 1" = 6' |
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PLANT B24 HYDRO

SITE PLAN

DRAWING C2

4 OF 19 SHEETS


## DETAILED SITE PLAN

SCALE: 1" = 3'

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|---|---|---|---|

| | |
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| DESIGNED BY: | ANDREW BENJAMIN |
| REVIEWED BY: | DAVID POWELL |
| APPROVED BY: | |
| F.E.R.C. Project No. | CD017-17-000 |
| SCALE: | 1" = 3' |
| JOB NO. | |

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PLANT B24 HYDRO

SITE LAYOUT

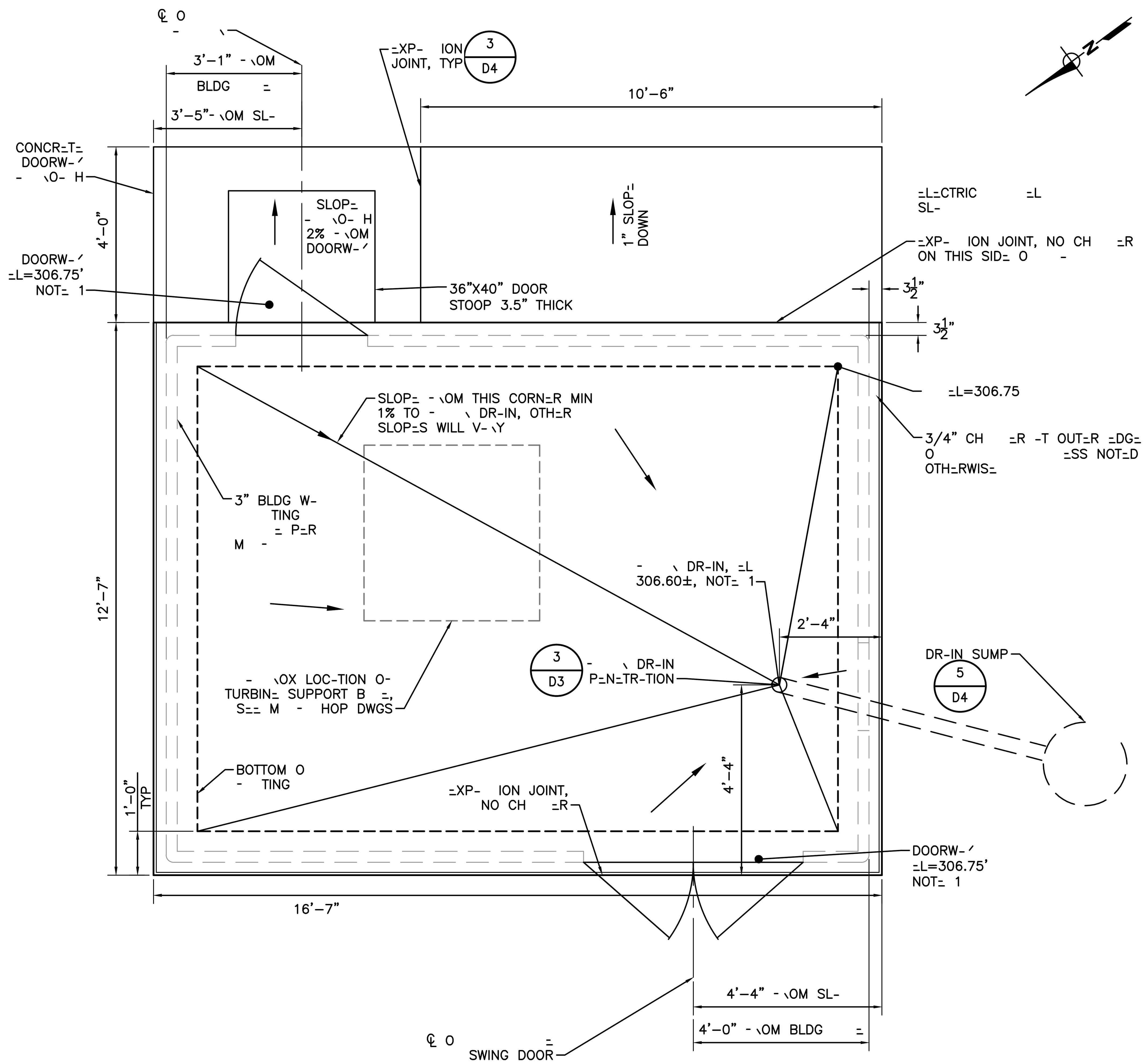
DRAWING C3

5 OF 19 SHEETS

Z:\NLINE\NLINE 020 - PLANT B24 HYDRO\DRAWINGS - 90% DRAFT 3 (WORKING)\D&A\NLINE B24 HYDRO.DWG

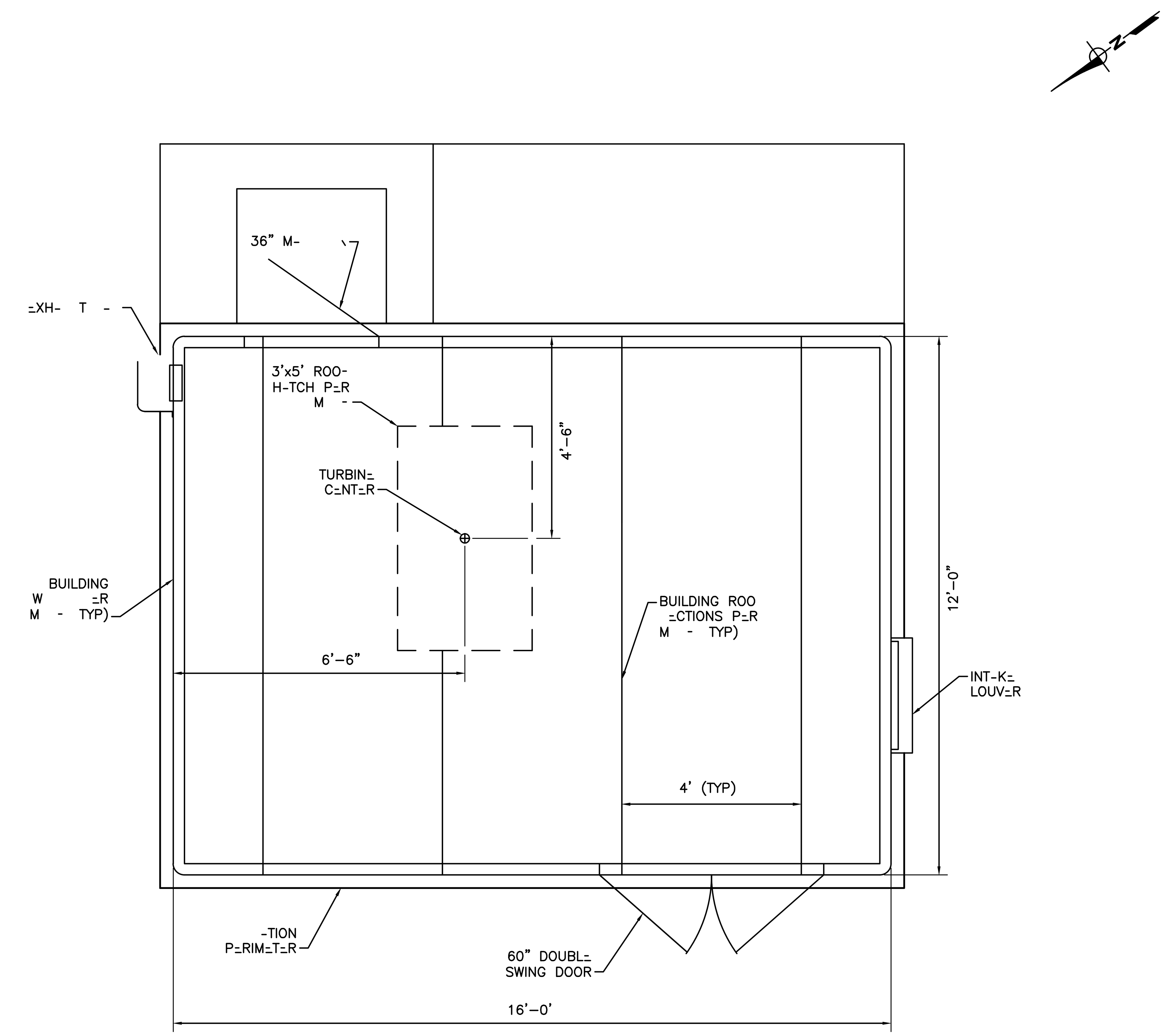
NOT=S:

1. -        \=T= STOOPS SH-    H  = WIR= M=SH R=IN- \C=M=NT (NOT SHOWN).




-TION PL

=: 1/2"=1'-0"




ROO =R M - TUR=R)

SC =: 1/2"=1'-0"

Z:\NLINE\NLINE 020 - PLANT B24 HYDRO\DRAWINGS - 90% DRAFT 3 (WORKING)\D&A\NLINE B24 HYDRO-ARCH.DWG

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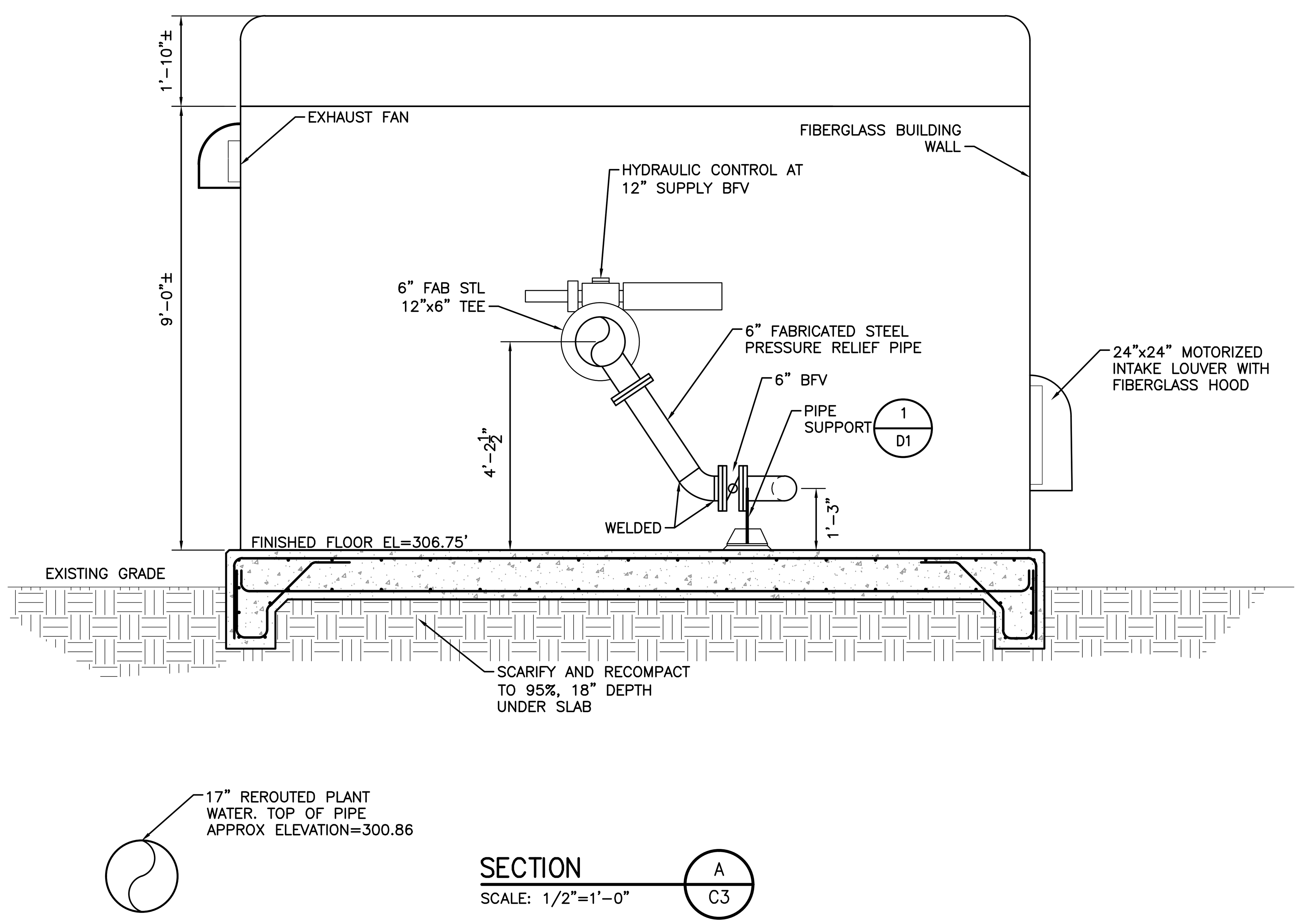
PLANT B24 HYDRO

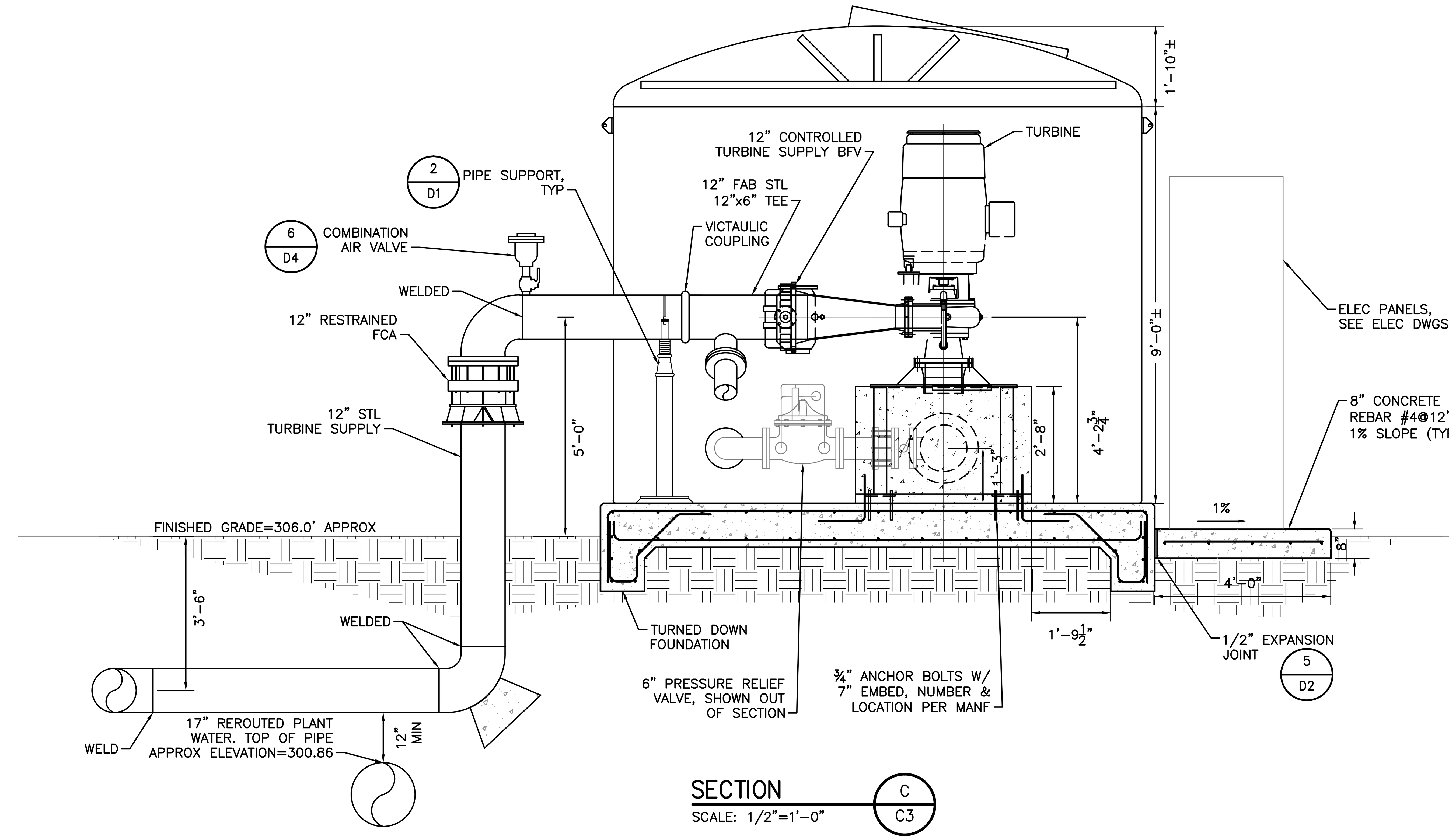
BUILDING PLANS

DRAWING C4

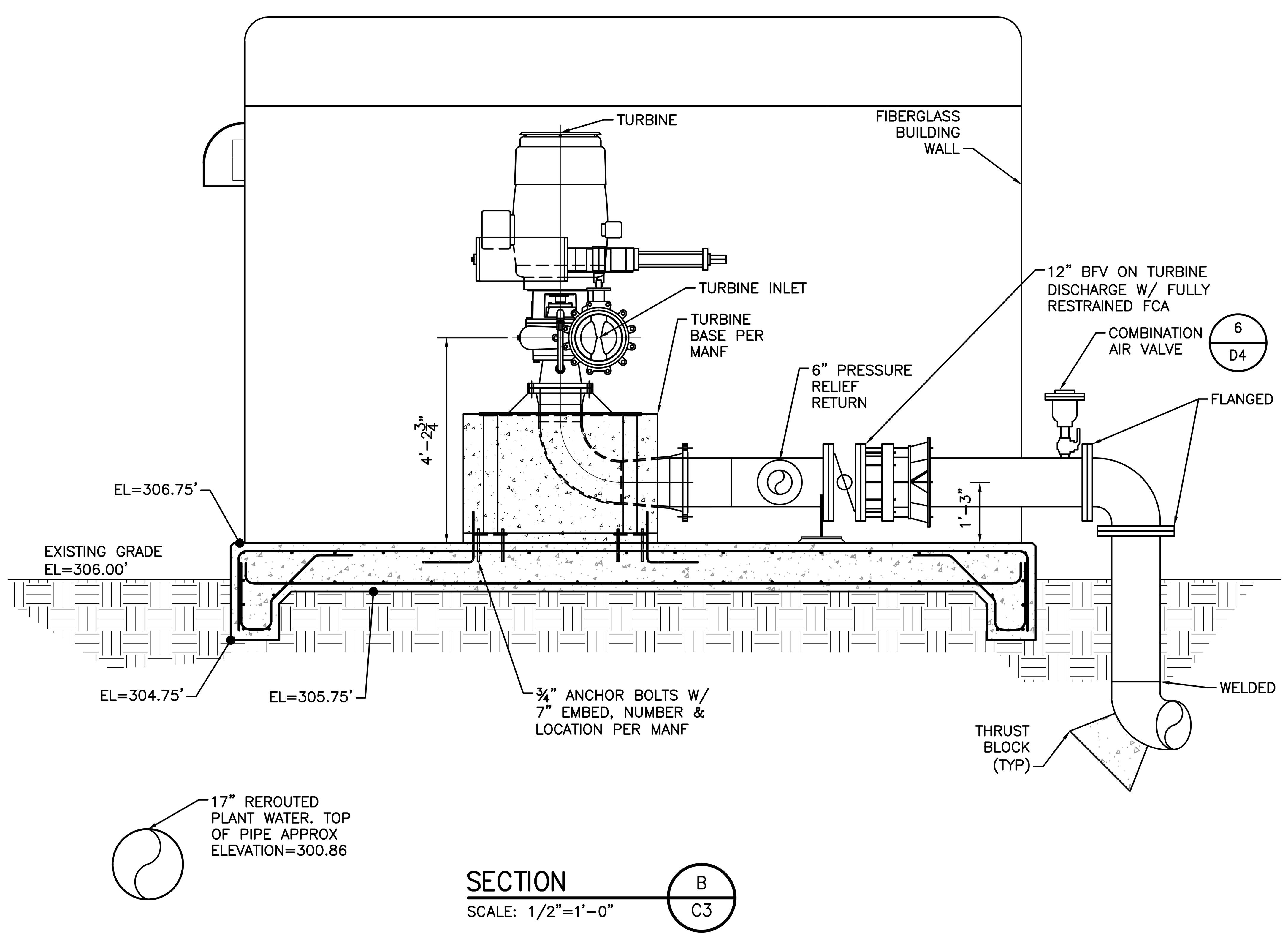
6 O- H==TS



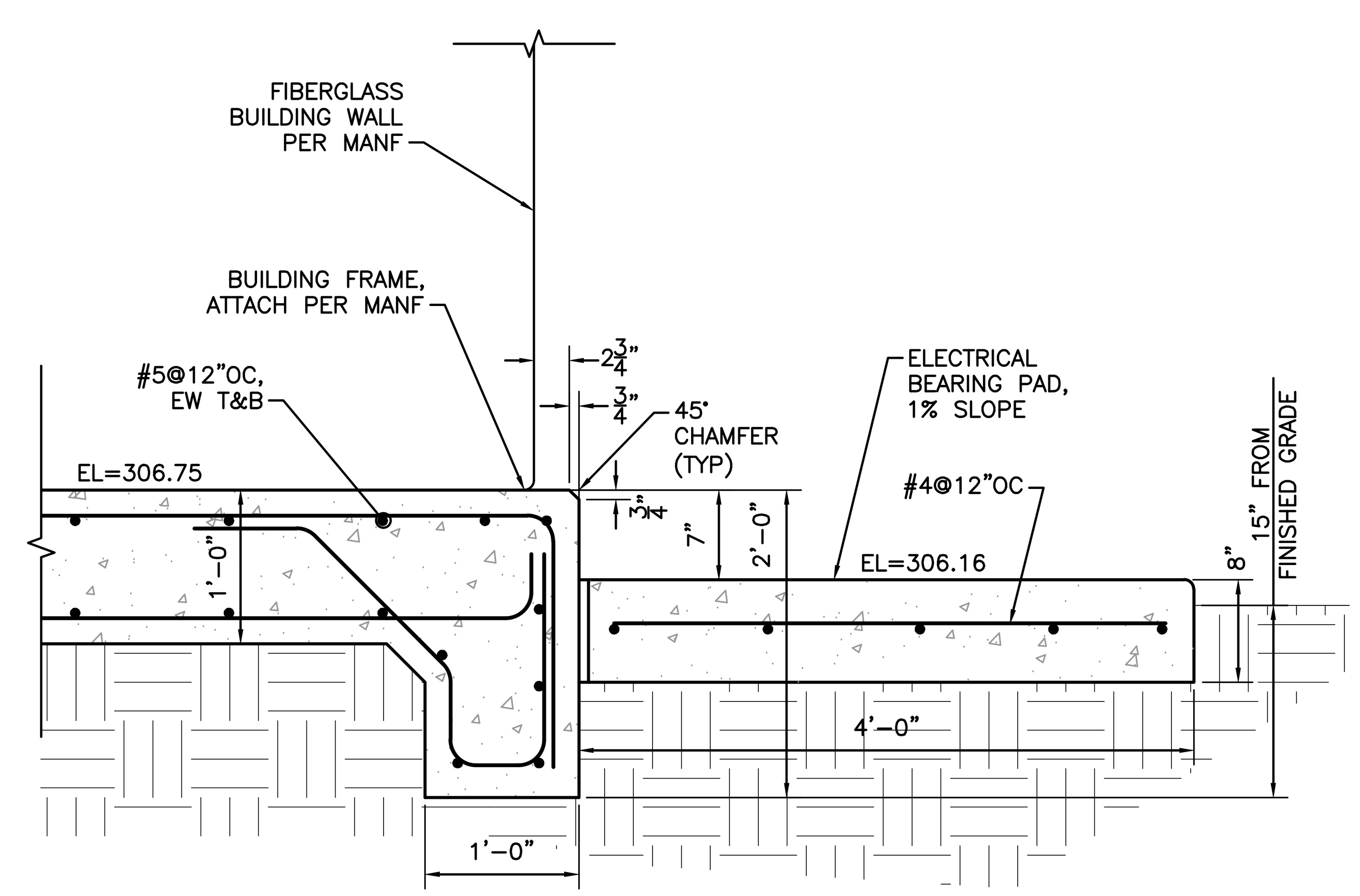

SECTION A / C3
SCALE: 1/2"=1'-0"




SECTION C / C3
SCALE: 1/2"=1'-0"




SECTION B / C3
SCALE: 1/2"=1'-0"




DETAIL 1 / –
SCALE: 1"=1'-0"



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| --- | --- | --- | --- |

REGISTERED PROFESSIONAL ENGINEER ANDREW M. BENJAMIN, CIVIL, STATE OF CALIFORNIA

REGISTERED PROFESSIONAL ENGINEER MICHAEL F. BREHM, 10246, Exp. SEPT. 30, 2020, Electrical Engineer, STATE OF CALIFORNIA

| | |
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| APPROVED BY: | |
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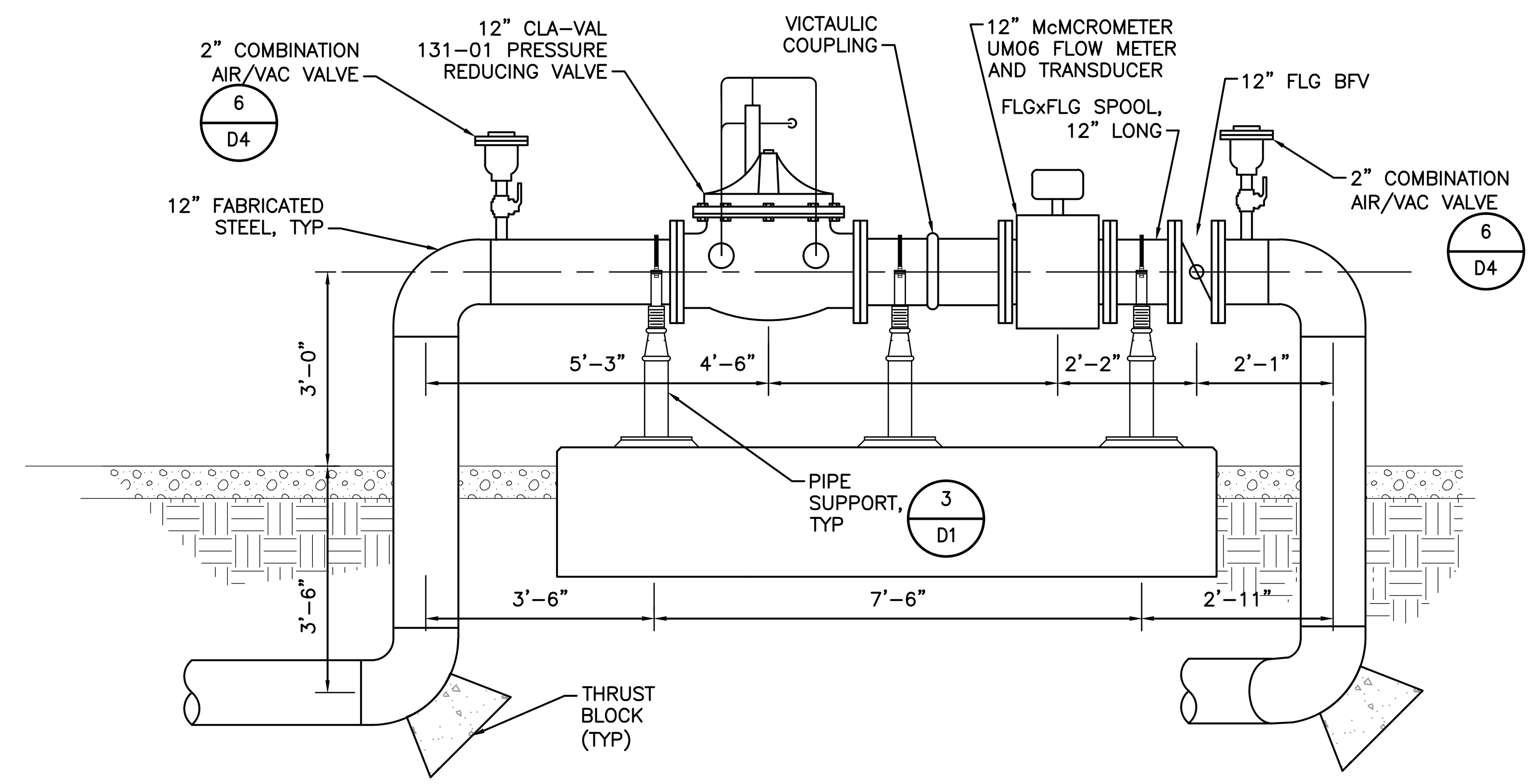
PLANT B24 HYDRO

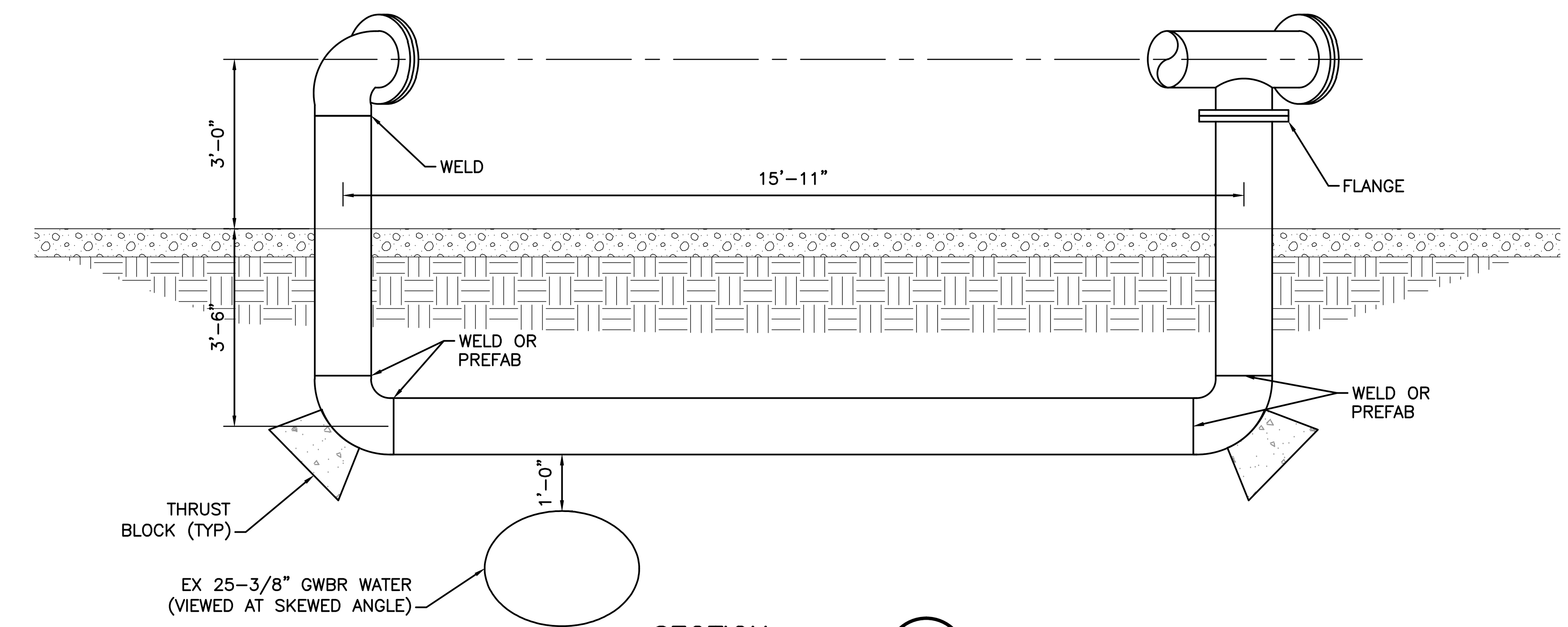
SECTIONS 1

DRAWING C5



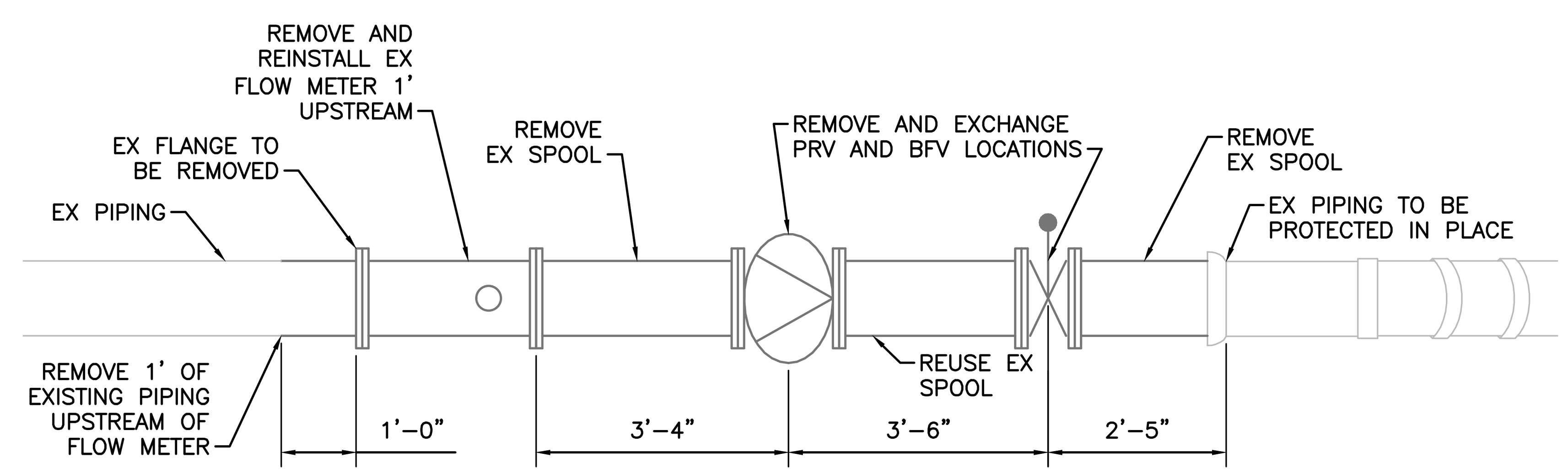

SECTION D / C3

SCALE: 1/2"=1'-0"



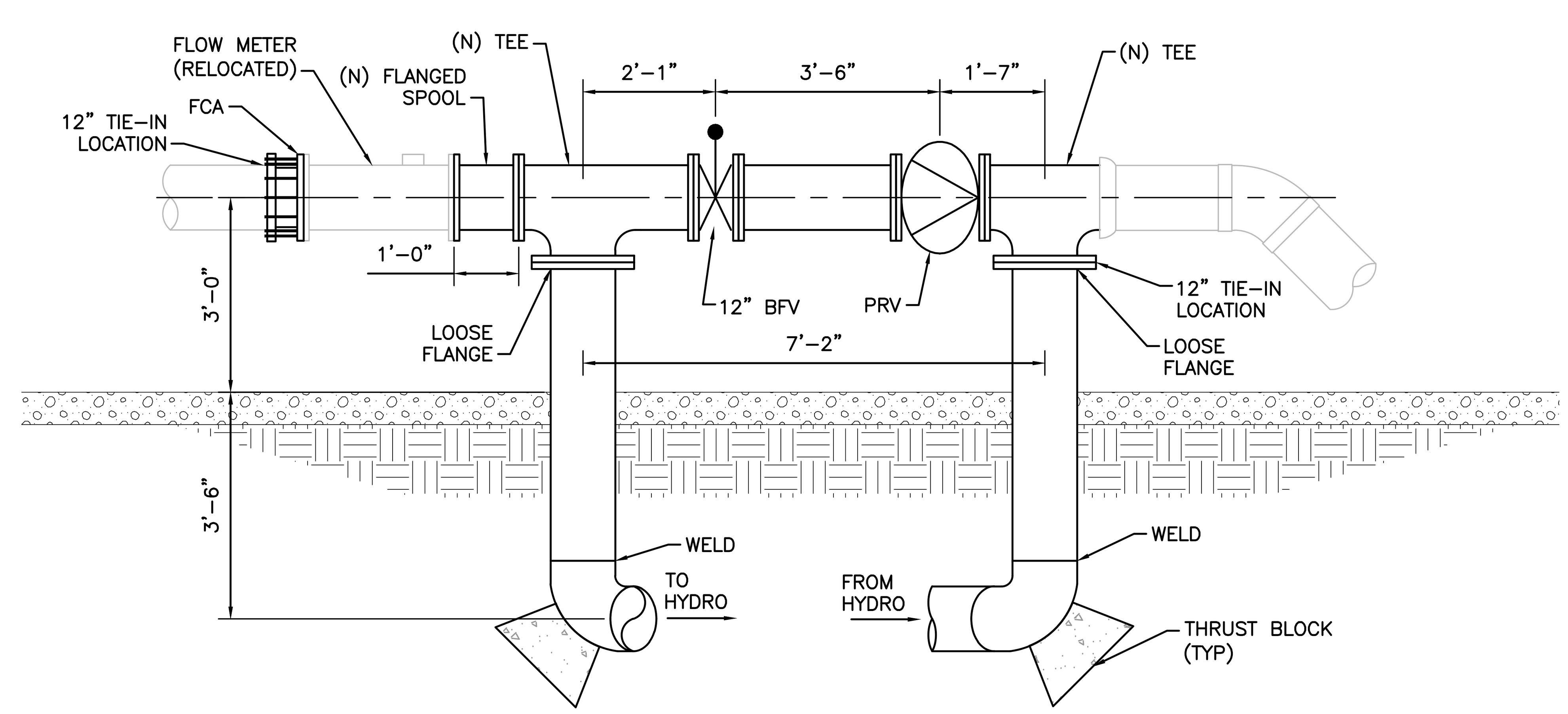

SECTION E / C3

SCALE: 1/2"=1'-0"



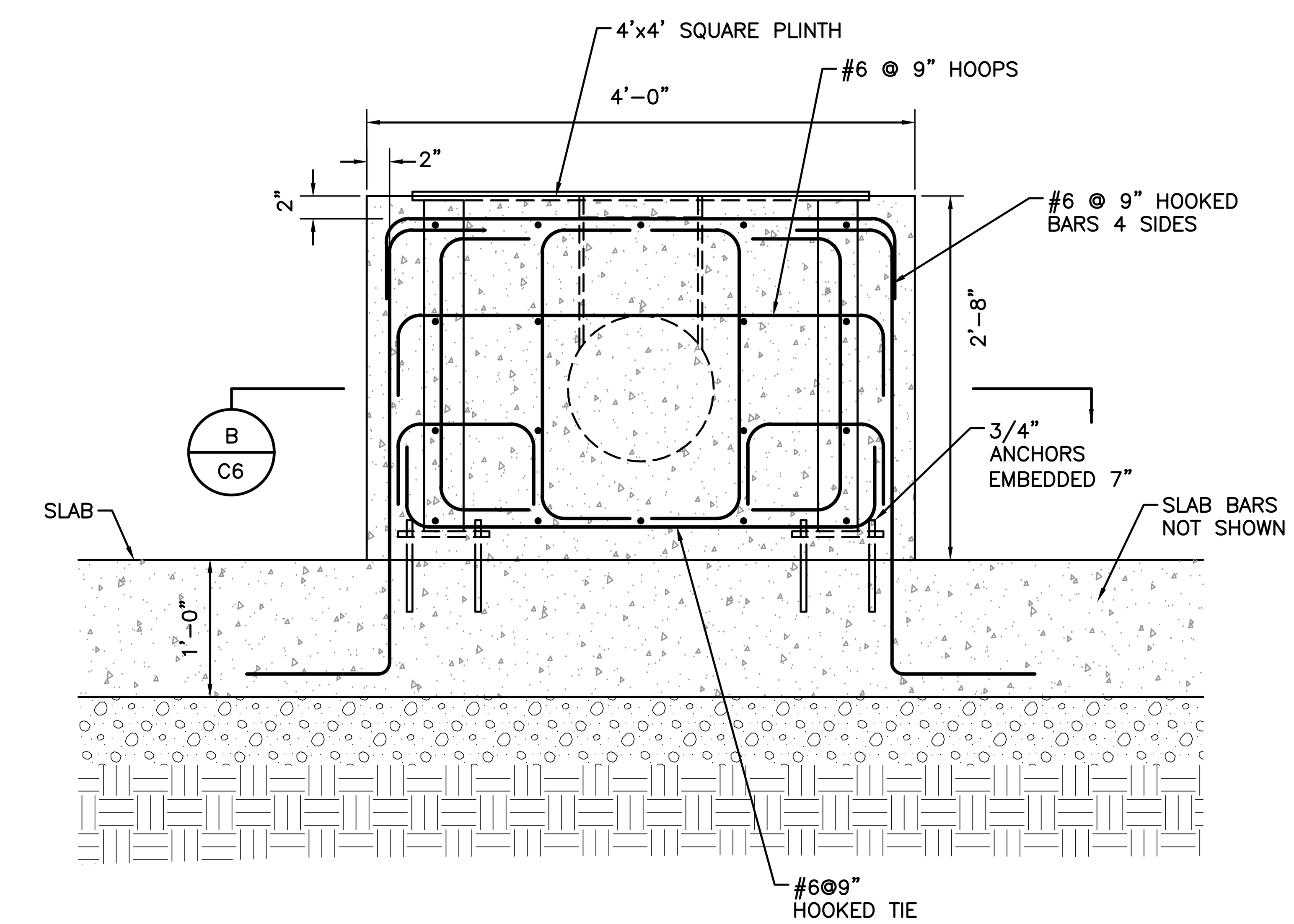

DETAIL 1 / C3

SCALE: 1/2"=1'-0"



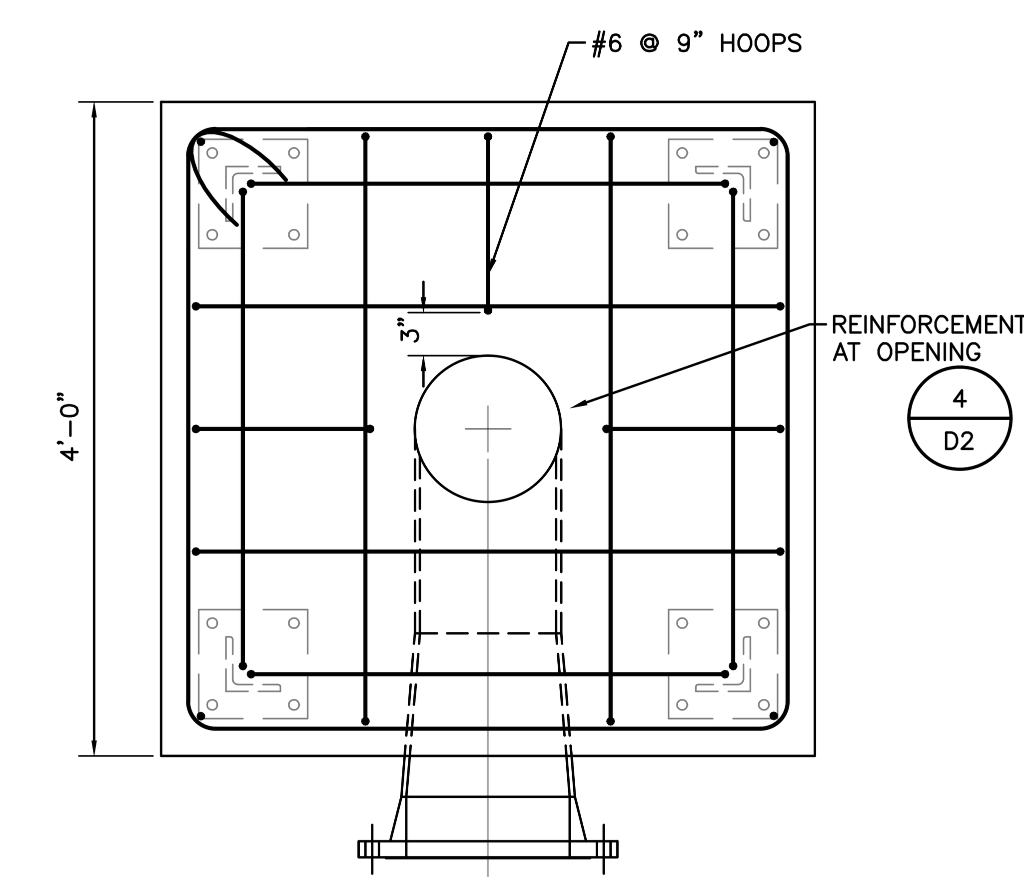

SECTION A / C3

SCALE: 1/2"=1'-0"




PLINTH SECTION 1 / TYP

SCALE: 1"=1'-0"




PLINTH PLAN VIEW B / –

SCALE: 1"=1'-0"

Z:\INLINE\INLINE 020 - PLANT B24 HYDRO\DRAWINGS - 90% DRAFT 3 (WORKING)\D&A\INLINE B24 HYDRO-ARCH.DWG

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PLANT B24 HYDRO

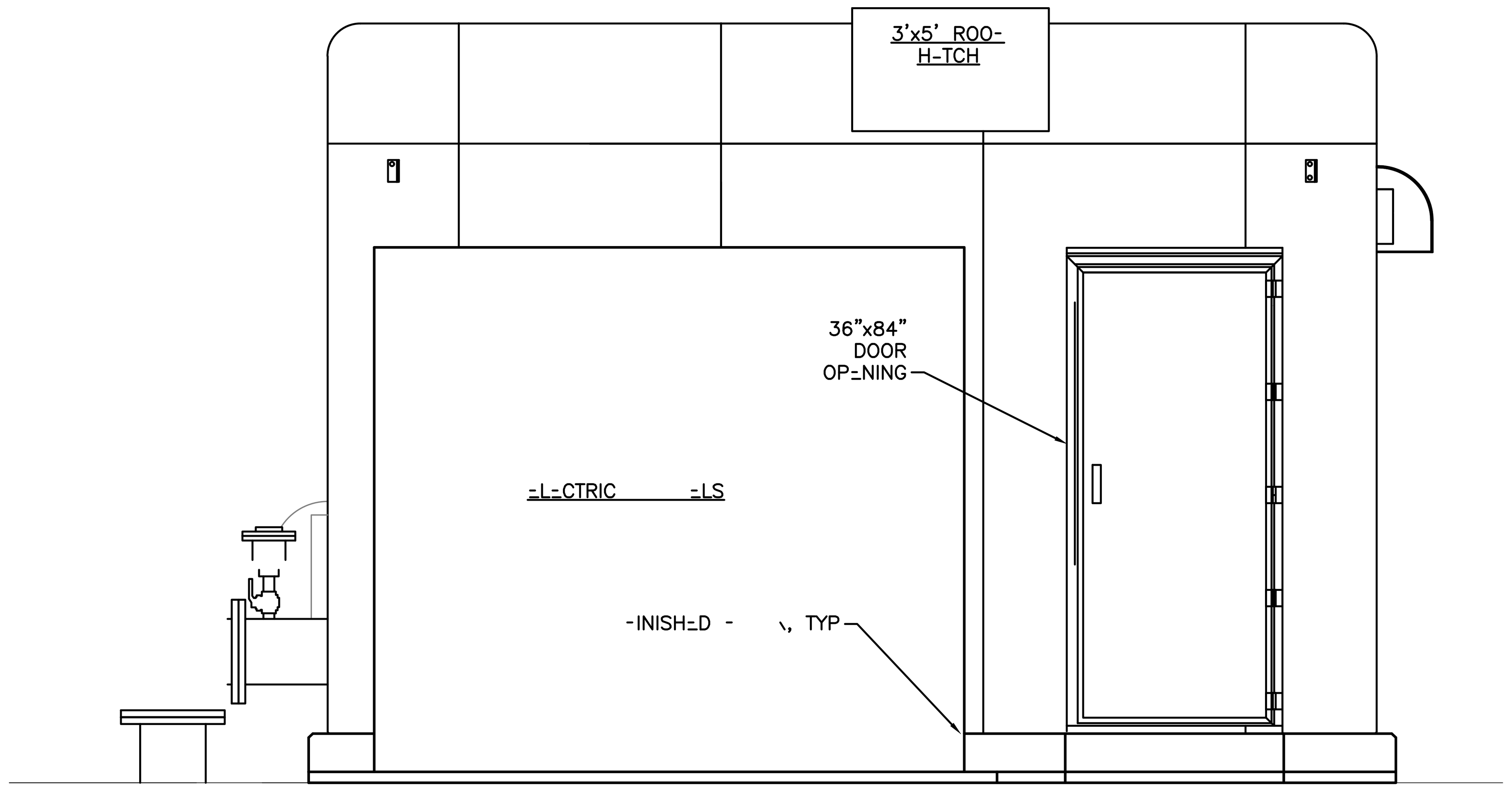
SECTIONS 2

DRAWING C6

8 OF 19 SHEETS

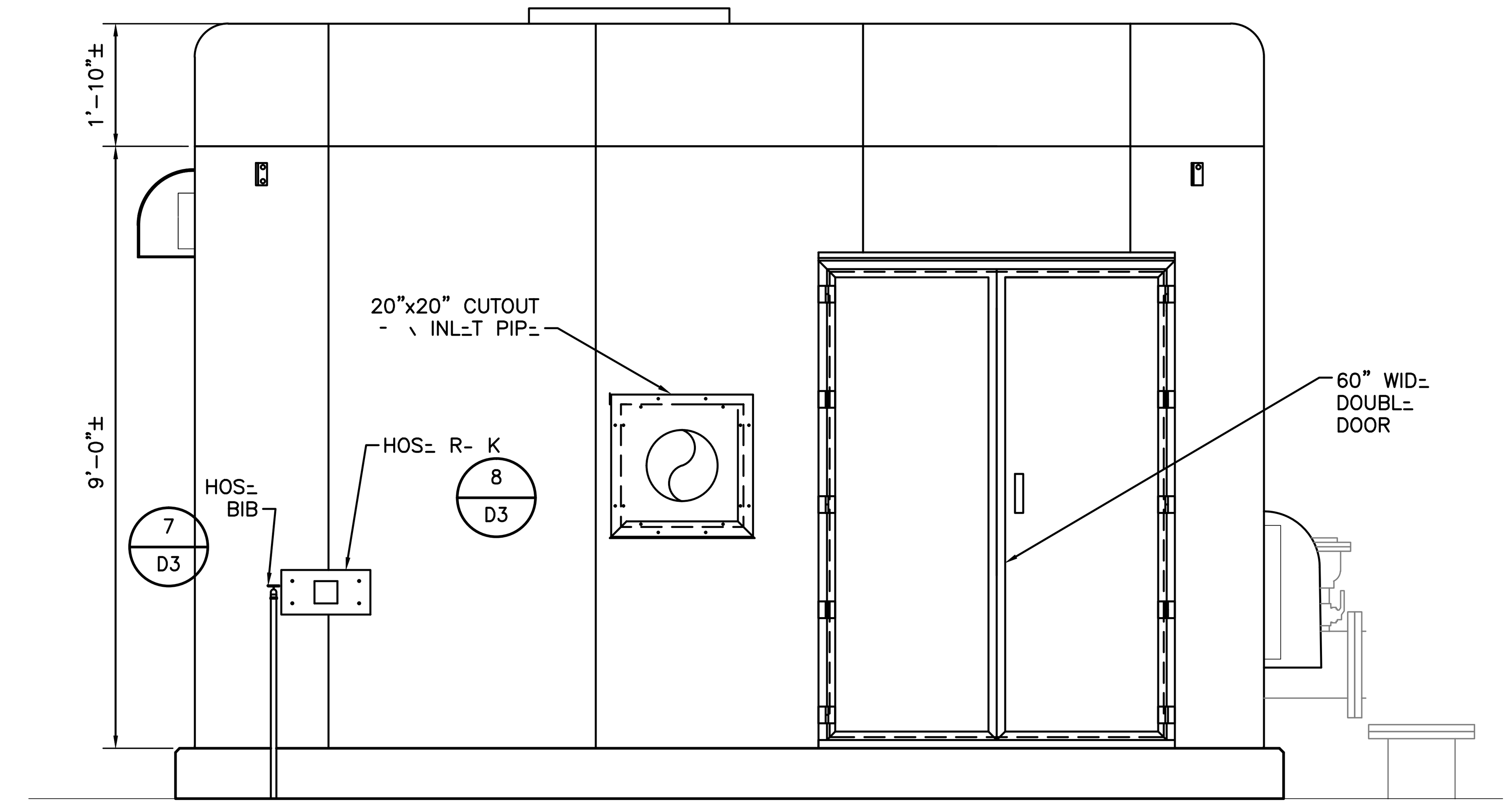
NOT=S:

1. PIP= P=N=TR-TION D=T-ILS P=R BUILDING M - TUR=R SUBMITT- .



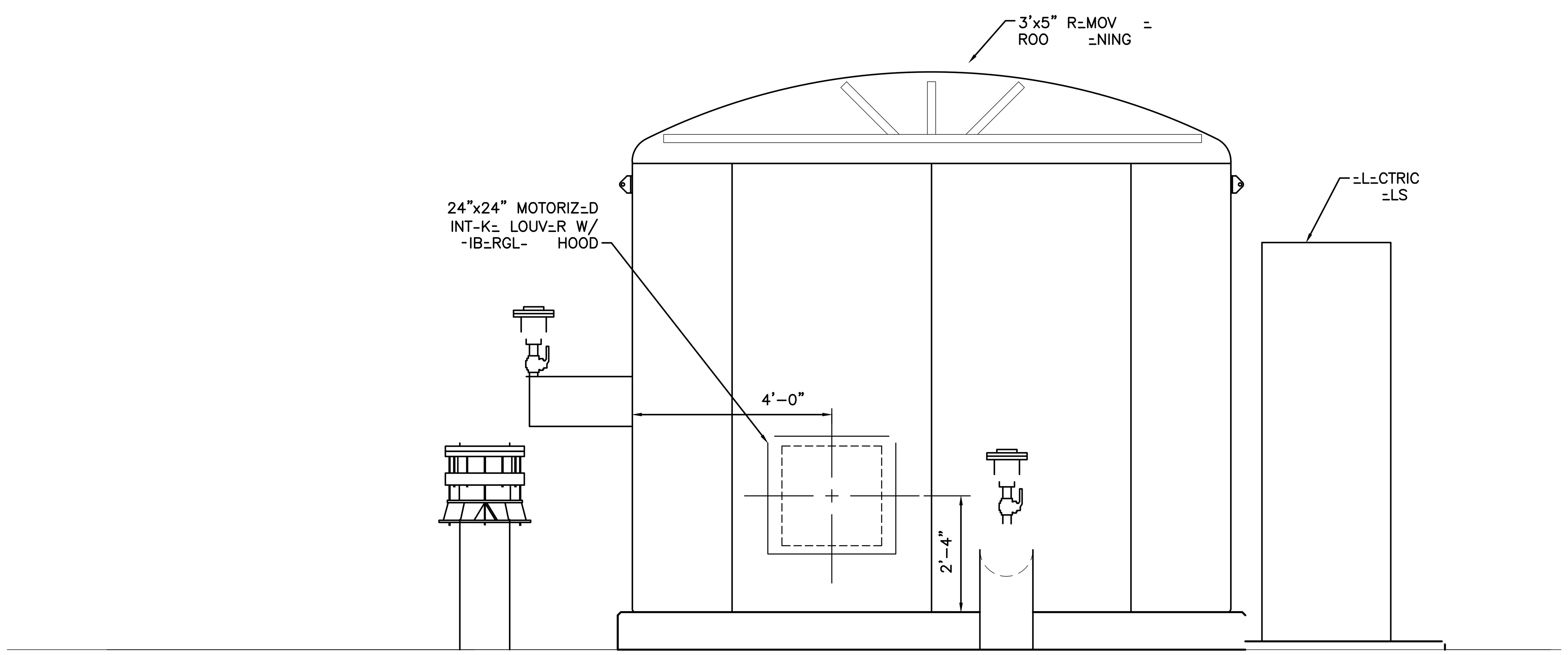

=- T =L=V-TION

SC =: 1/2"=1'-0"



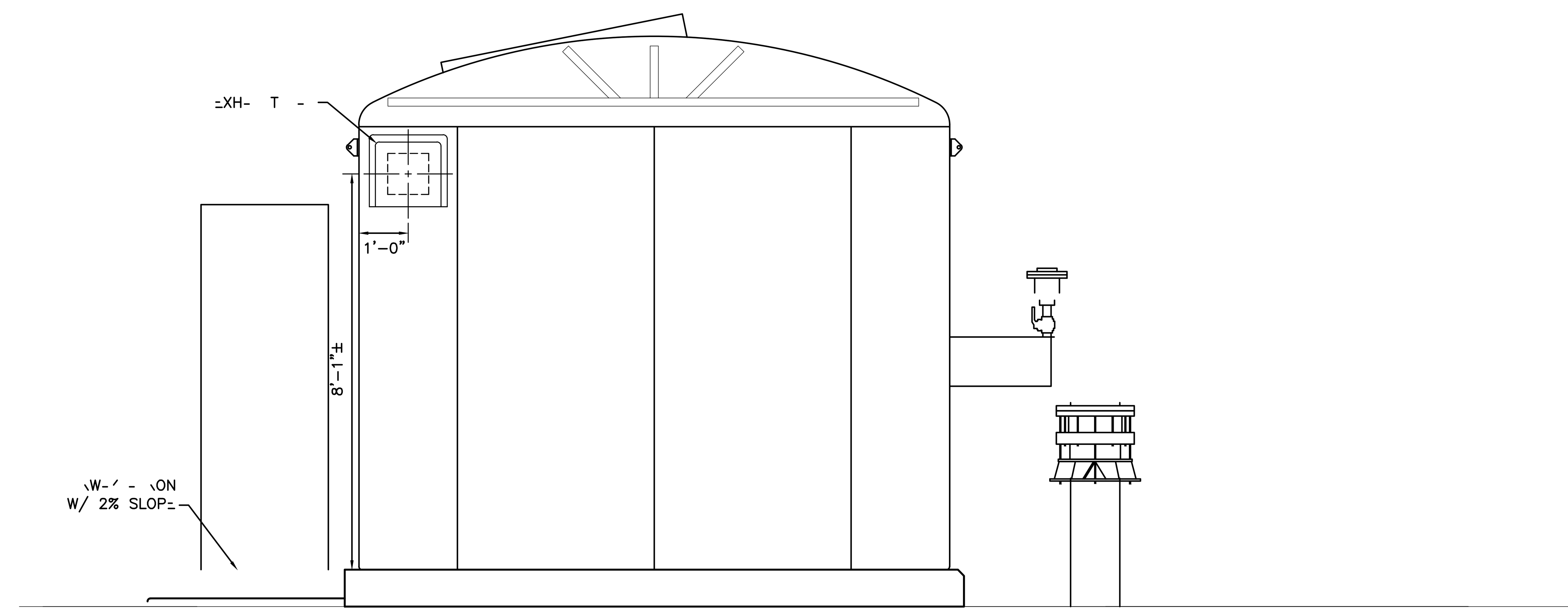

W=ST =L=V-TION

SC =: 1/2"=1'-0"




SOUTH =L=V-TION

SC =: 1/2"=1'-0"




NORTH =L=V-TION

SC =: 1/2"=1'-0"

| | | | |
|---|---|---|---|
| \= ISIONS | | - . B | D- I- |

DR : - T-
D= IGN- : - \- - - IN
R= I- - : D- ID POW-
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SC =:

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PLANT B24 HYDRO

ELEVATIONS

DRAWING
C7

9 O- H==TS

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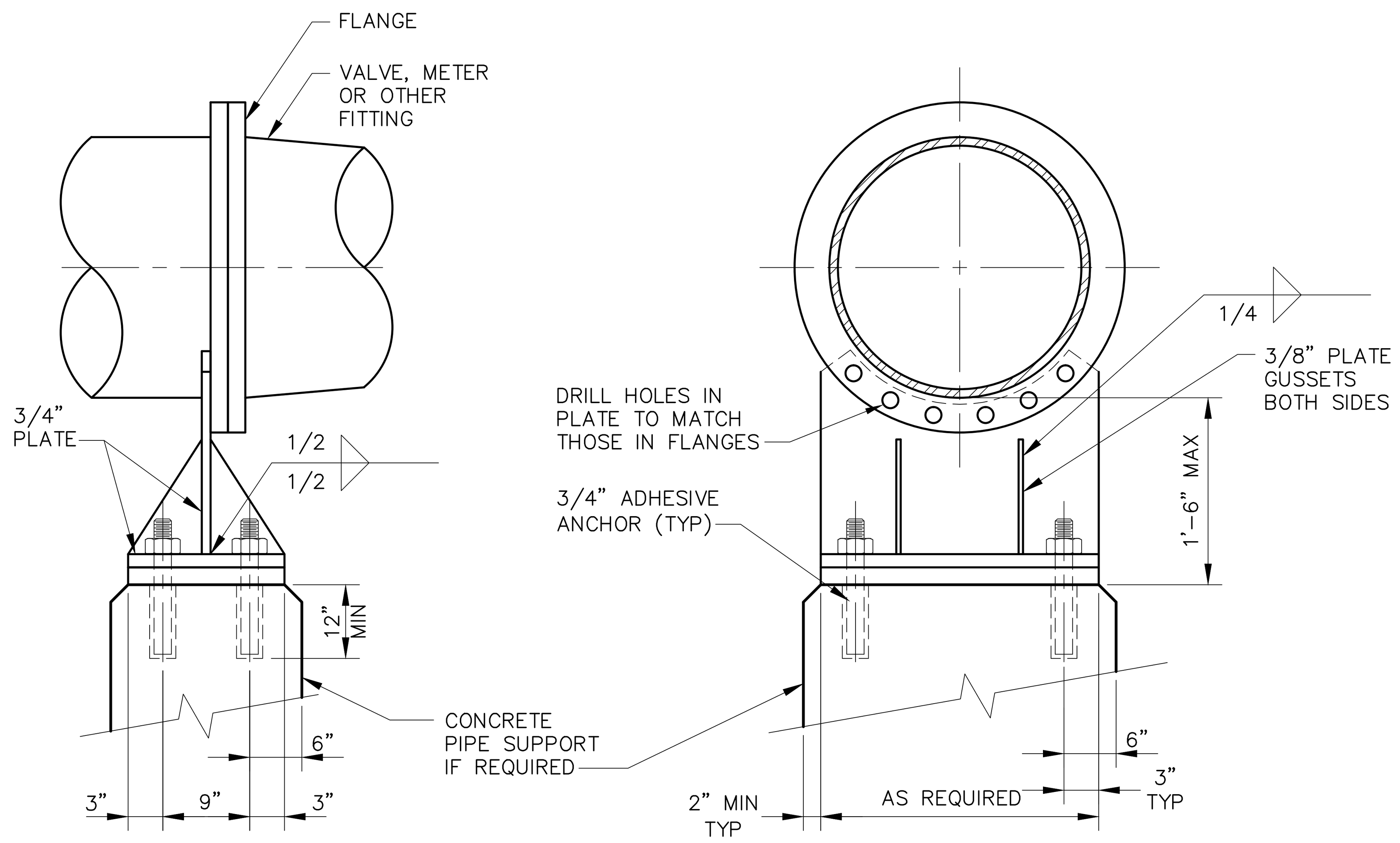
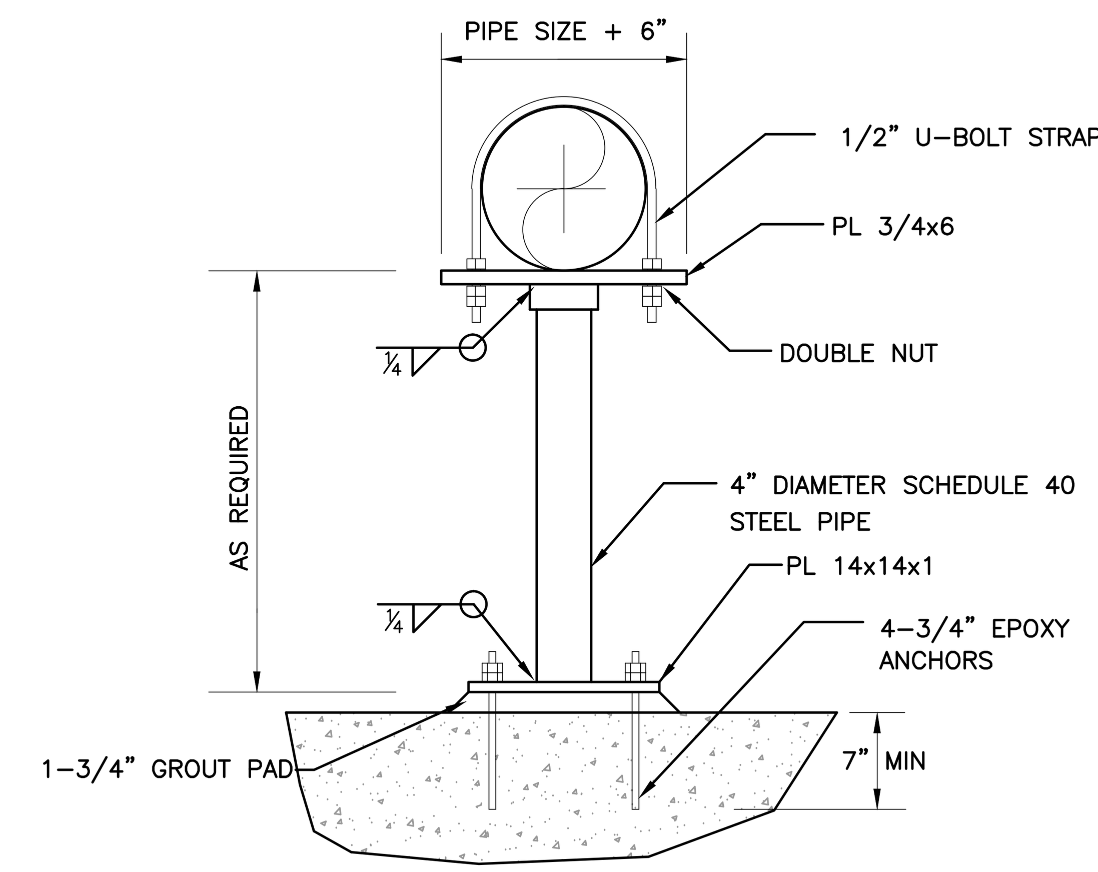


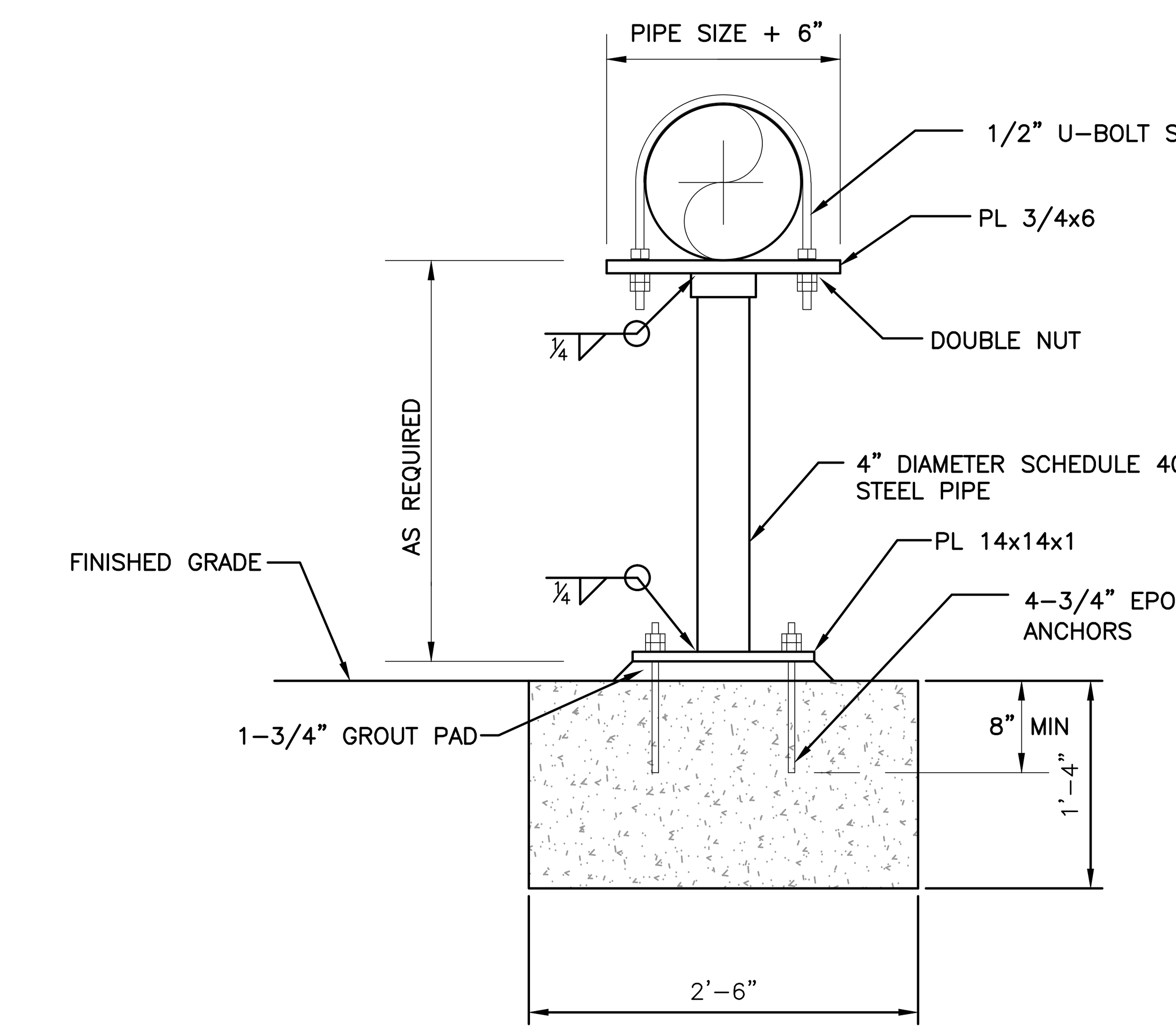

NOTES:

1. HOT DIP GALVANIZE, OR PAINT ALL STEEL PARTS AFTER FABRICATION

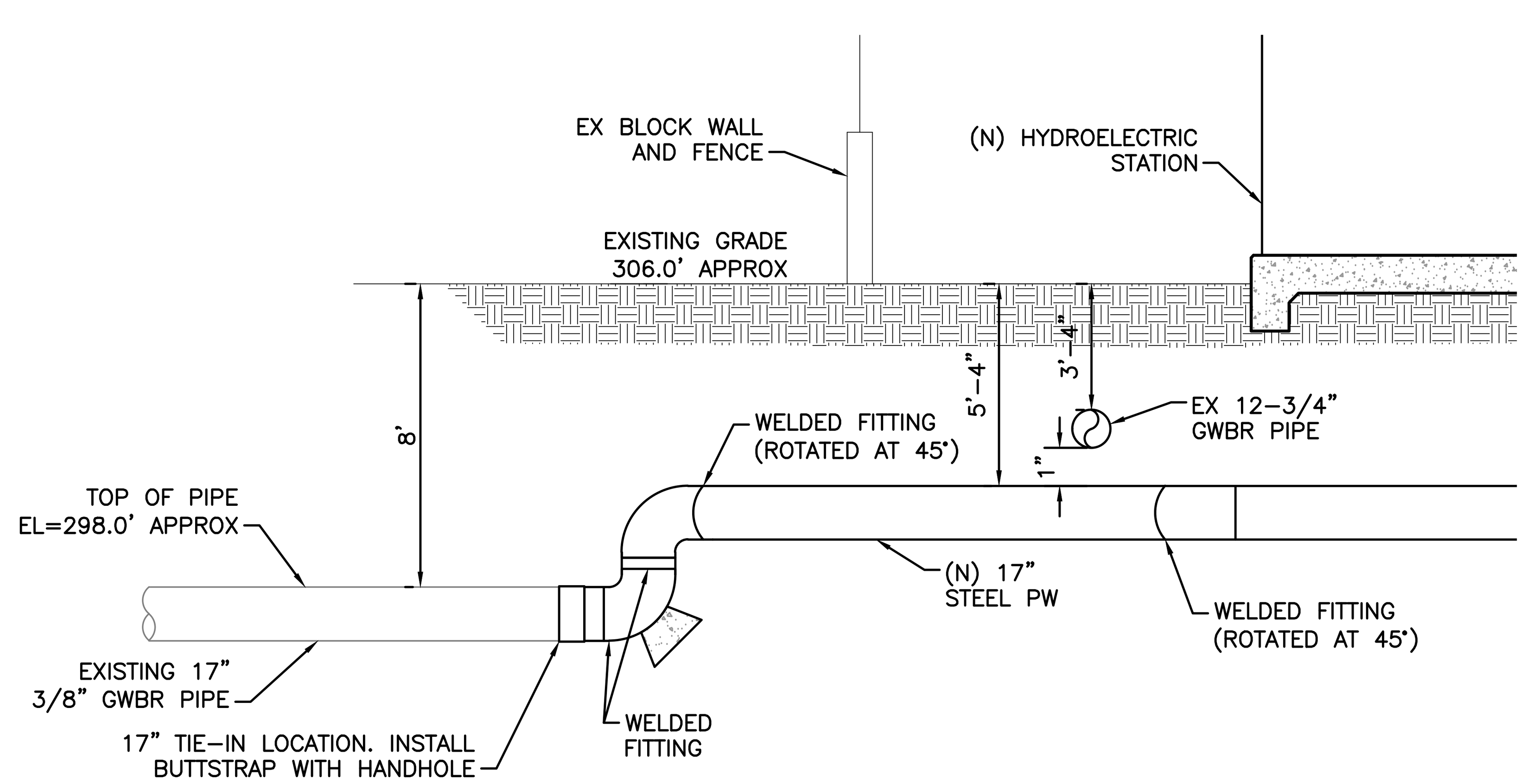
PIPE FLANGE SUPPORT (1 / TYP)
NTS



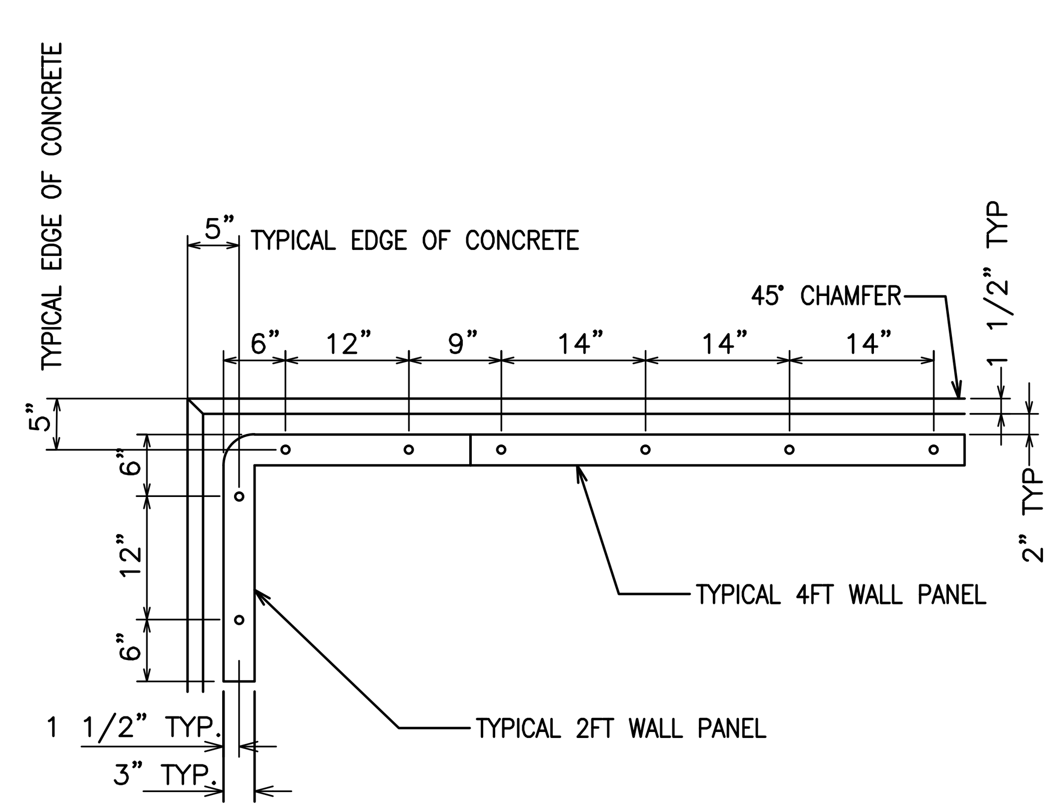

TYPICAL PIPE SUPPORT ON SLAB (2 / TYP)
NTS



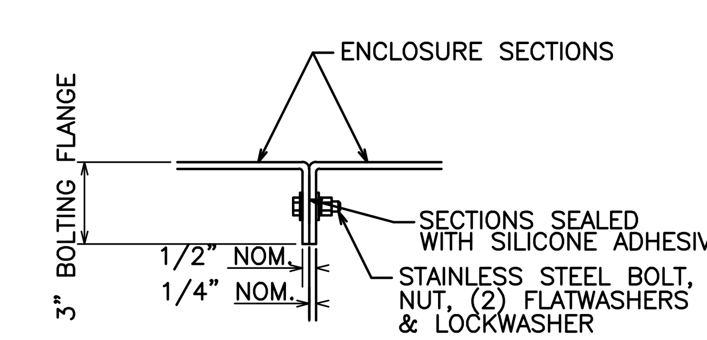

TYPICAL PIPE SUPPORT IN SOIL (3 / TYP)
NTS



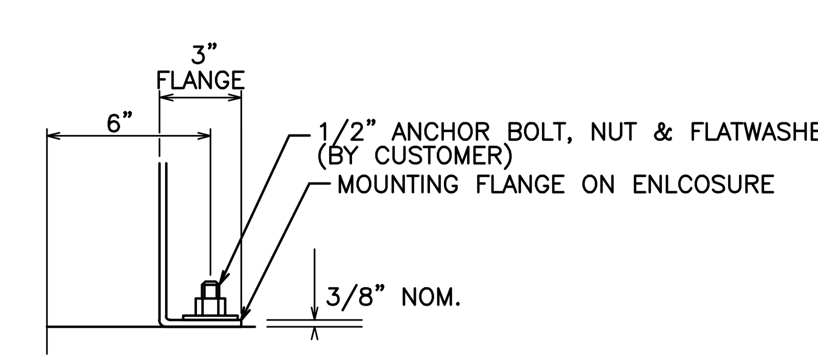

17" TIE-IN DETAIL (4 / C3)
NTS



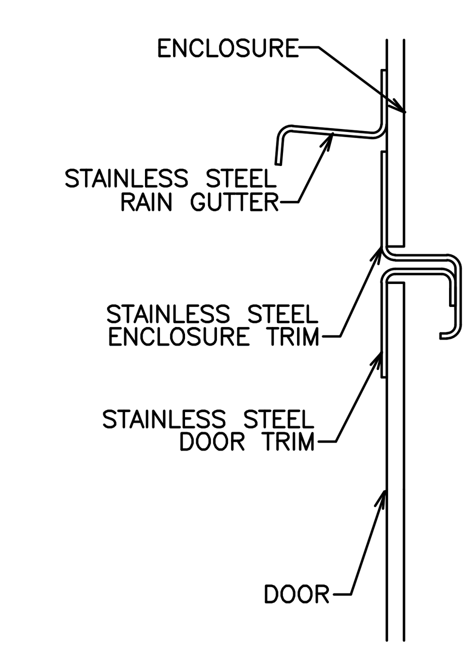

BUILDING FLANGE MOUNT DETAIL (5 / TYP)
NTS




BUILDING PANEL CONNECTION (6 / TYP)
NTS




BUILDING FOUNDATION ATTACHMENT (7 / TYP)
NTS




DOOR & ENCLOSURE SECTION (8 / TYP)
NTS

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PLANT B24 HYDRO

DETAILS 1

DRAWING D1

10 OF 19 SHEETS

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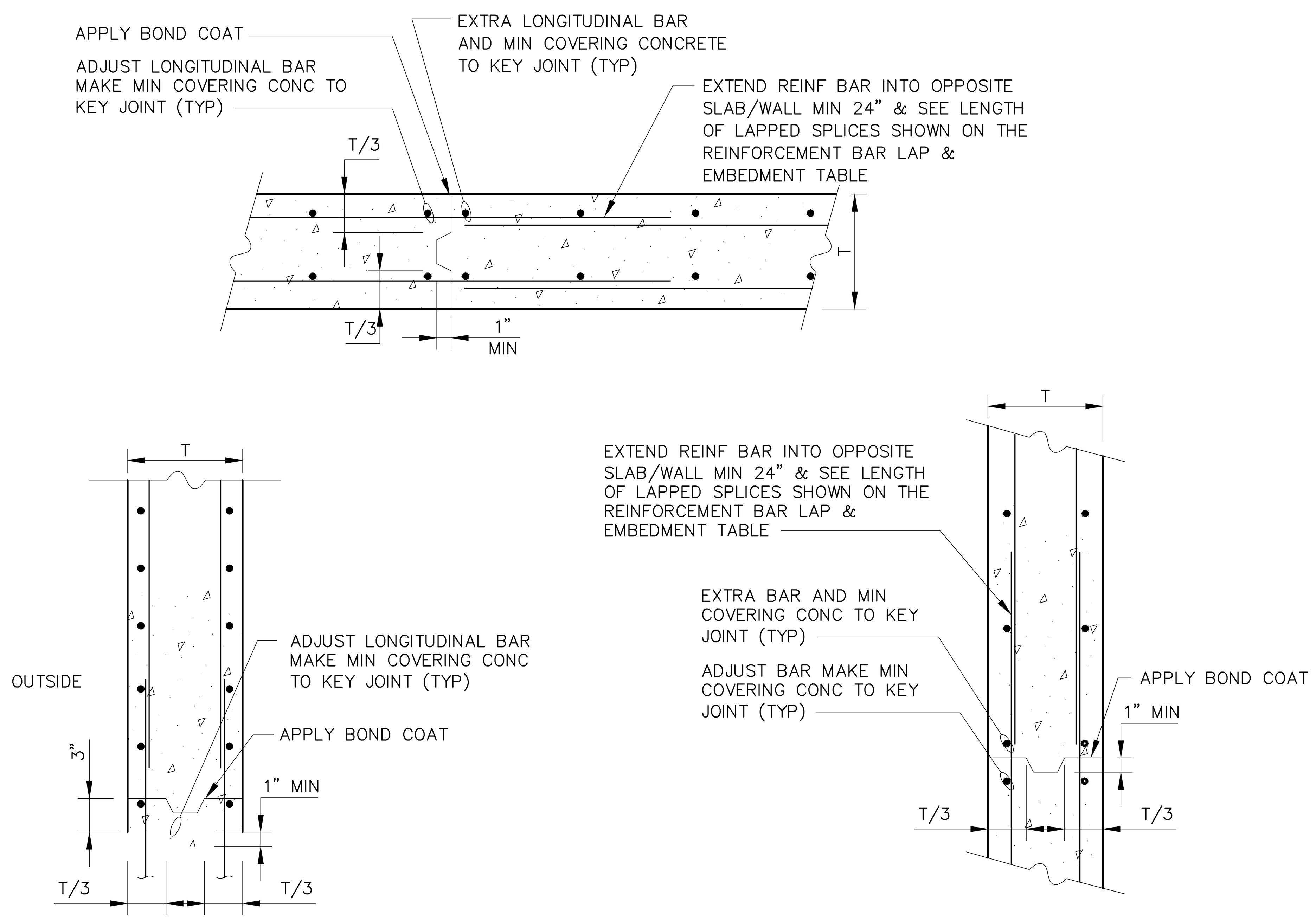



NOTES:

1. LOCATE PER PLANS.

## TYPICAL CONCRETE CONSTRUCTION JOINTS (1 / TYP)

NTS

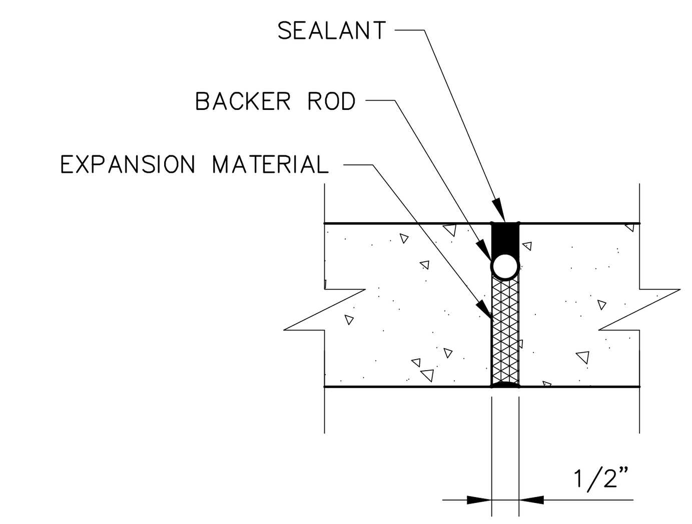
| BAR SIZE | LENGTH OF LAPPED SPLICES FOR REINFORCING IN INCHES | | LENGTH OF EMBEDMENT FOR END ANCHORAGE OF REINFORCING IN INCHES | |
|---|---|---|---|---|
| | *TOP BARS | OTHERS | *TOP BARS | OTHERS |
| 3 | 17 | 16 | 13 | 12 |
| 4 | 22 | 17 | 17 | 13 |
| 5 | 41 | 32 | 32 | 24 |
| 6 | 50 | 38 | 38 | 29 |
| 7 | 58 | 45 | 45 | 34 |
| 8 | 66 | 51 | 51 | 39 |
| 9 | 75 | 57 | 57 | 44 |
| 10 | 84 | 65 | 65 | 50 |
| 11 | 93 | 72 | 72 | 55 |
| 14 | NOT PERMITTED | | 97 | 74 |
| 18 | NOT PERMITTED | | 156 | 120 |

* TOP BARS ARE HORIZ BARS SO PLACED THAT MORE THAN 12" OF CONC IS CAST IN THE MEMBER BELOW THE BAR
HORIZ BARS IN WALLS ARE TO BE PROVIDED W/LAPS AS REQ'D FOR TOP BARS

EXCEPT AS OTHERWISE INDICATED ON THE PLANS, EMBEDMENT LENGTHS FOR END ANCHORAGE AND LAPPED SPLICES SHALL NOT BE LESS THAN (NO MINUS TOLERANCE) SHOWN ABOVE.

## REINFORCEMENT BAR LAP & EMBEDMENT (2 / TYP)

NTS




## EXPANSION JOINT DETAIL (5 / TYP)

NTS

| LOCATION | MINIMUM COVER |
|---|---|
| UNFORMED SURFACES ADJACENT TO EXCAVATION | 3" |
| FORMED OR TOP SURFACES EXPOSED TO WEATHER OR SATURATED AIR, SUBMERGED OR IN CONTACT W/EARTH | |
| #6 OR LARGER BARS | 2" |
| #5 OR SMALLER BARS | 1-1/2" |
| OTHER LOCATIONS: | |
| BARS IN BEAMS OR GIRDERS, INCL STIRRUPS | 1-1/2" |
| COLUMN SPIRALS OR TIES | 1-1/2" |
| OTHER BARS #7 OR LARGER | BAR DIA |
| OTHER BARS #6 OR SMALLER | 3/4" |

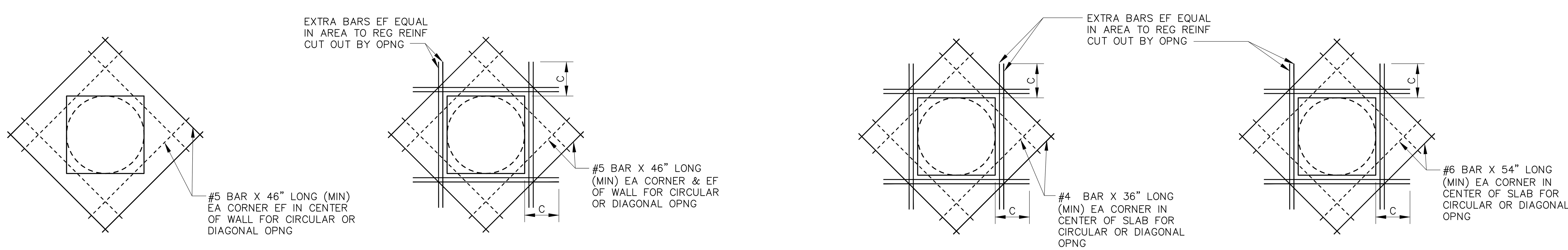
* COVER FOR REINF STEEL SHALL NOT BE LESS THAN THE MINIMUM GIVEN ABOVE (NO MINUS TOLERANCE) AND SHALL NOT EXCEED THE MINIMUM BY MORE THAN 1/4" WHERE THE CONC THICKNESS IS MORE THAN 24 INCHES.

LAPPED SPLICES SHALL NOT BE MADE AT POINTS OF MAX STRESS AS DETERMINED BY THE ENGINEER AND SHALL NOT BE SPACED CLOSER THAN 12 BAR DIAMETERS. NO MORE THAN 1/2 OF THE BARS SHALL BE SPLICED WITHIN A LENGTH OF 40 BAR DIAMETERS.

ALL REINFORCING TO BE MIN #5@12"EWEF UNLESS SHOWN OTHERWISE.

## CONCRETE COVER FOR REINFORCEMENT (3 / TYP)

NTS




NOTES:

1. THE SLAB OPNG DETAILS APPLY TO OPENING LARGER THAN 18" IN DIAM OR DIAGONAL
2. ——— DIAGONAL OPNG EXTRA REINF BAR
   - - - - - CIRCULAR OPNG EXTRA REINF BAR
3. C = THE REQ'D LENGTH FOR LAPPED SPLICE FOR TOP BARS AS SHOWN ON REINF BAR LAP & EMBEDMENT DETAIL TABLE

## TYPICAL EXTRA REINFORCING AT ALL OPENINGS (4 / TYP)

NTS

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REGISTERED PROFESSIONAL ENGINEER — MICHAEL F BREGAR — 10246 — Exp. SEPT. 30, 2020 — Electrical Engineer — STATE OF CALIFORNIA

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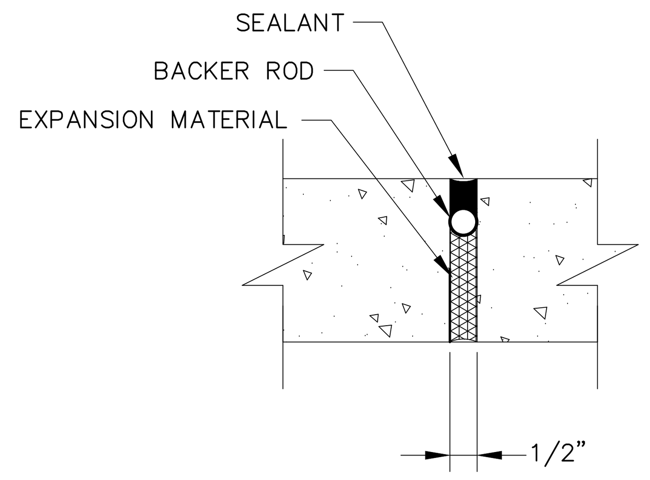
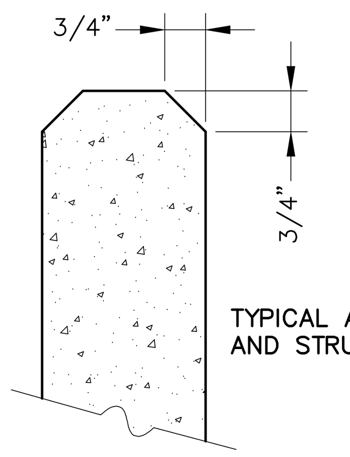
PLANT B24 HYDRO

DETAILS 2

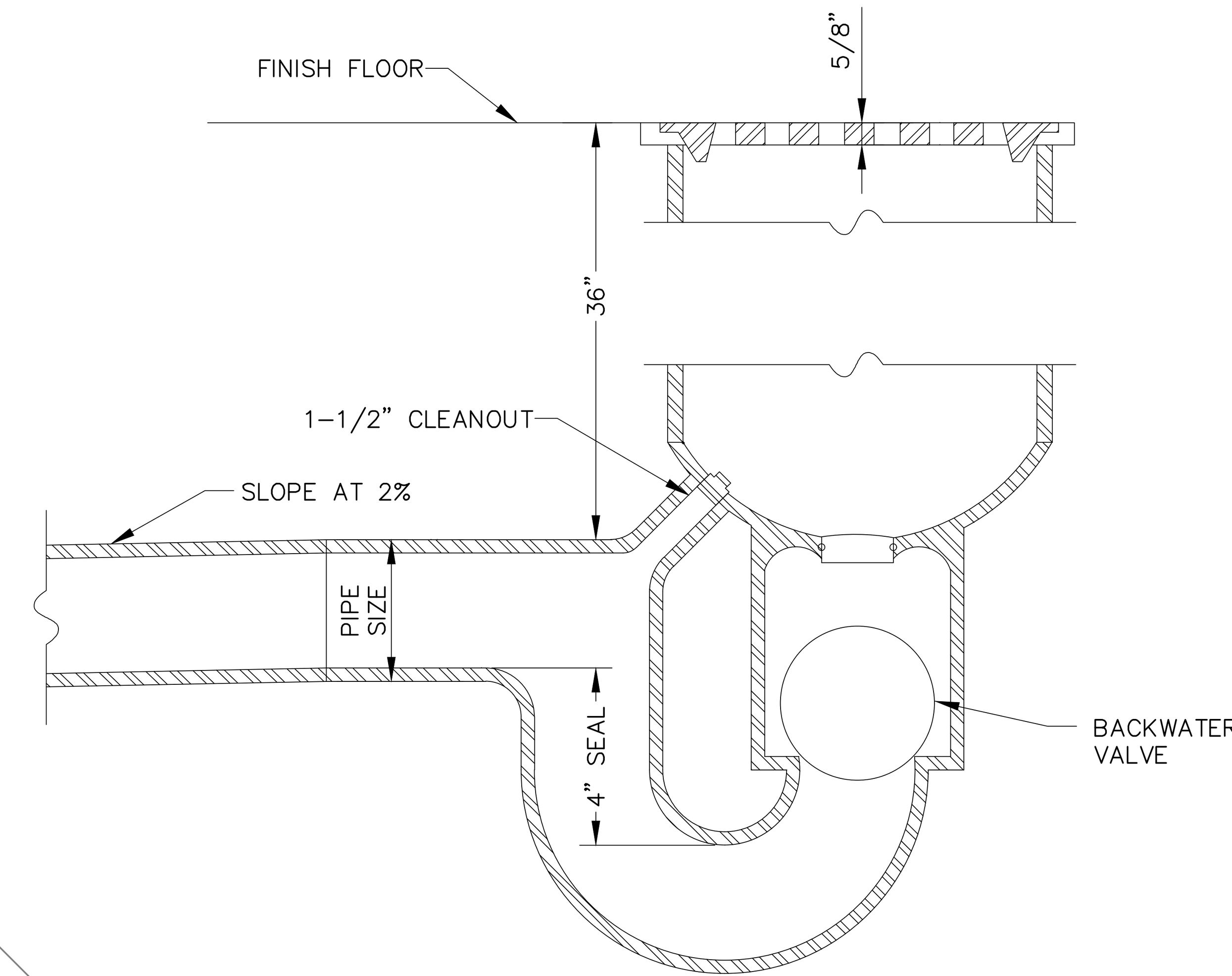
DRAWING D2



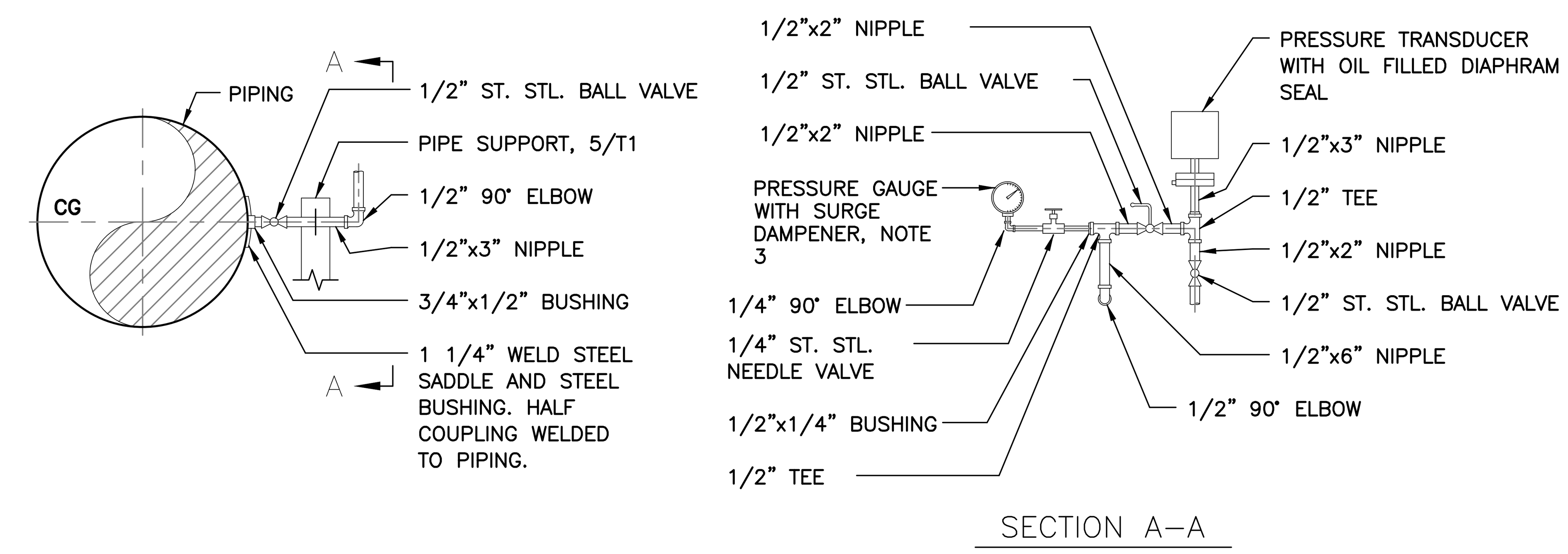

## EXPANSION JOINT DETAIL (1 TYP)
NTS




## CORNER CHAMFER DETAIL (2 TYP)
NTS

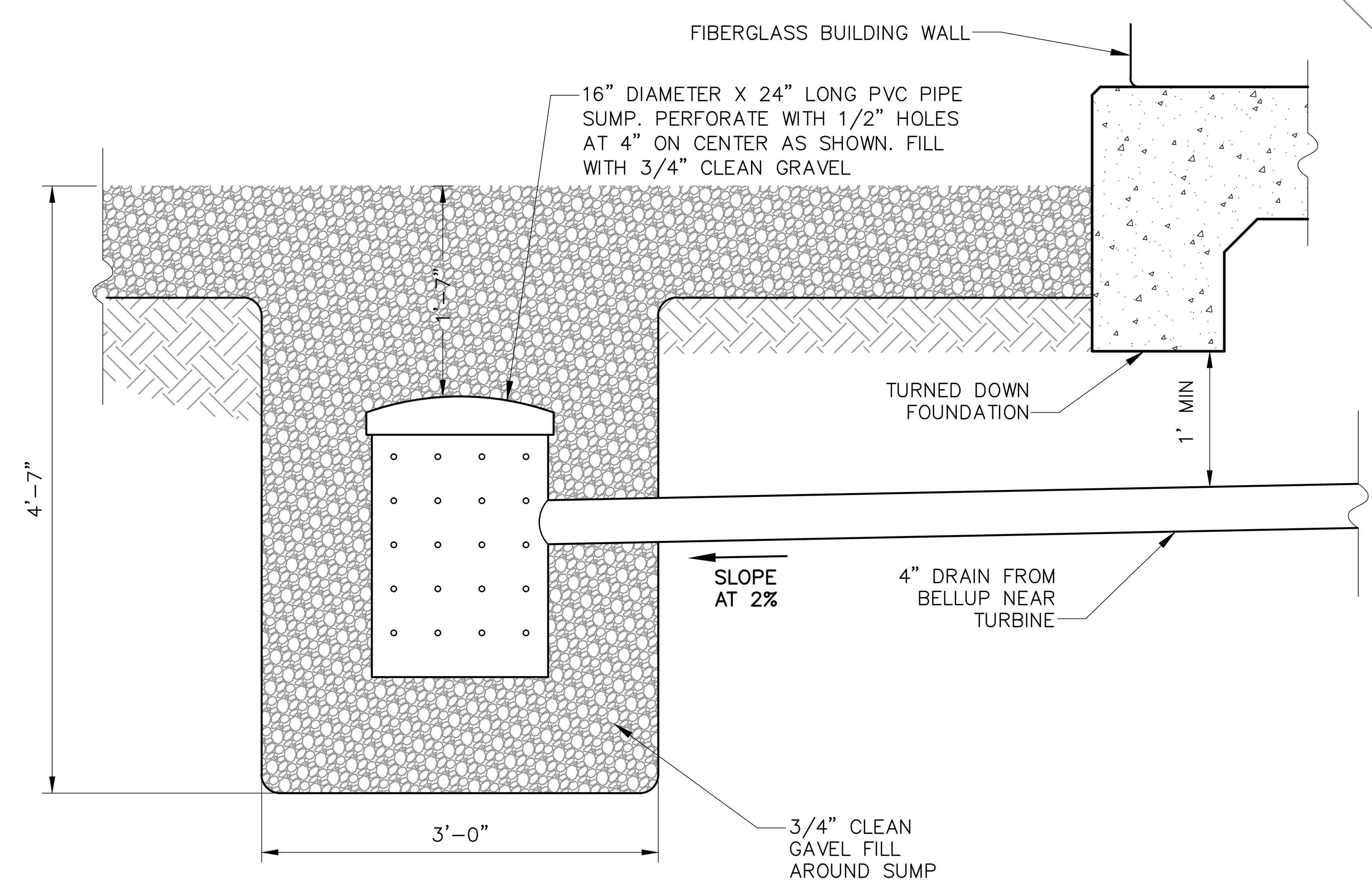



## FLOOR DRAIN DETAIL (3 TYP)
NTS

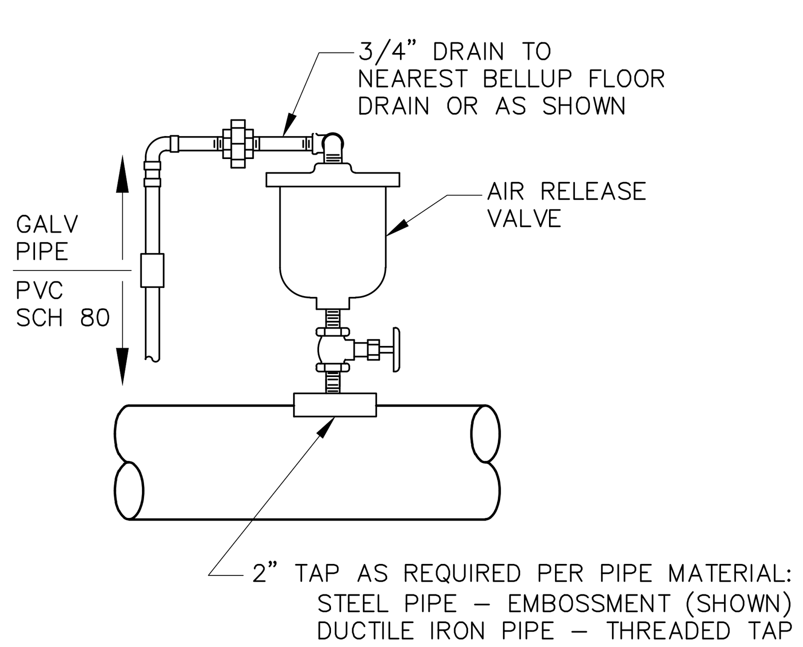



NOTES:
1. ALL MATERIALS EITHER BRASS OR STAINLESS STEEL UNLESS NOTED OTHERWISE
2. ALL VALVES AND FITTINGS SHALL BE SUITABLE FOR A WORKING PRESSURE OF 150 PSI (MIN)
3. CANYON HYDRO TO PROVIDE PRESSURE GAUGES.

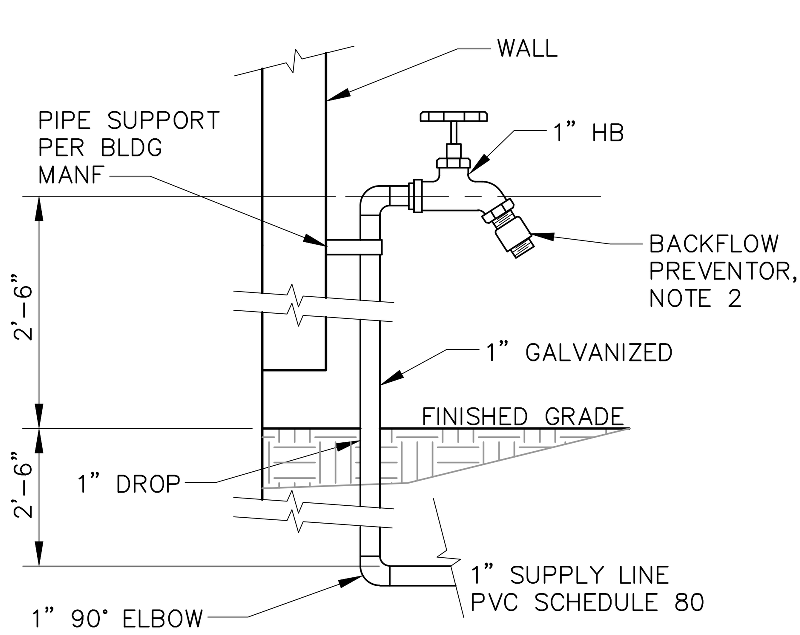
## PRESSURE GAUGE & PRESSURE TRANSDUCER DETAIL (4 TYP)
NTS




## SUMP DETAIL (5 TYP)
NTS

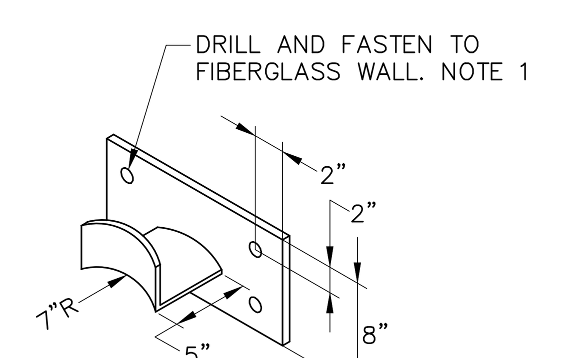



## ARV DETAIL (6 TYP)
NTS



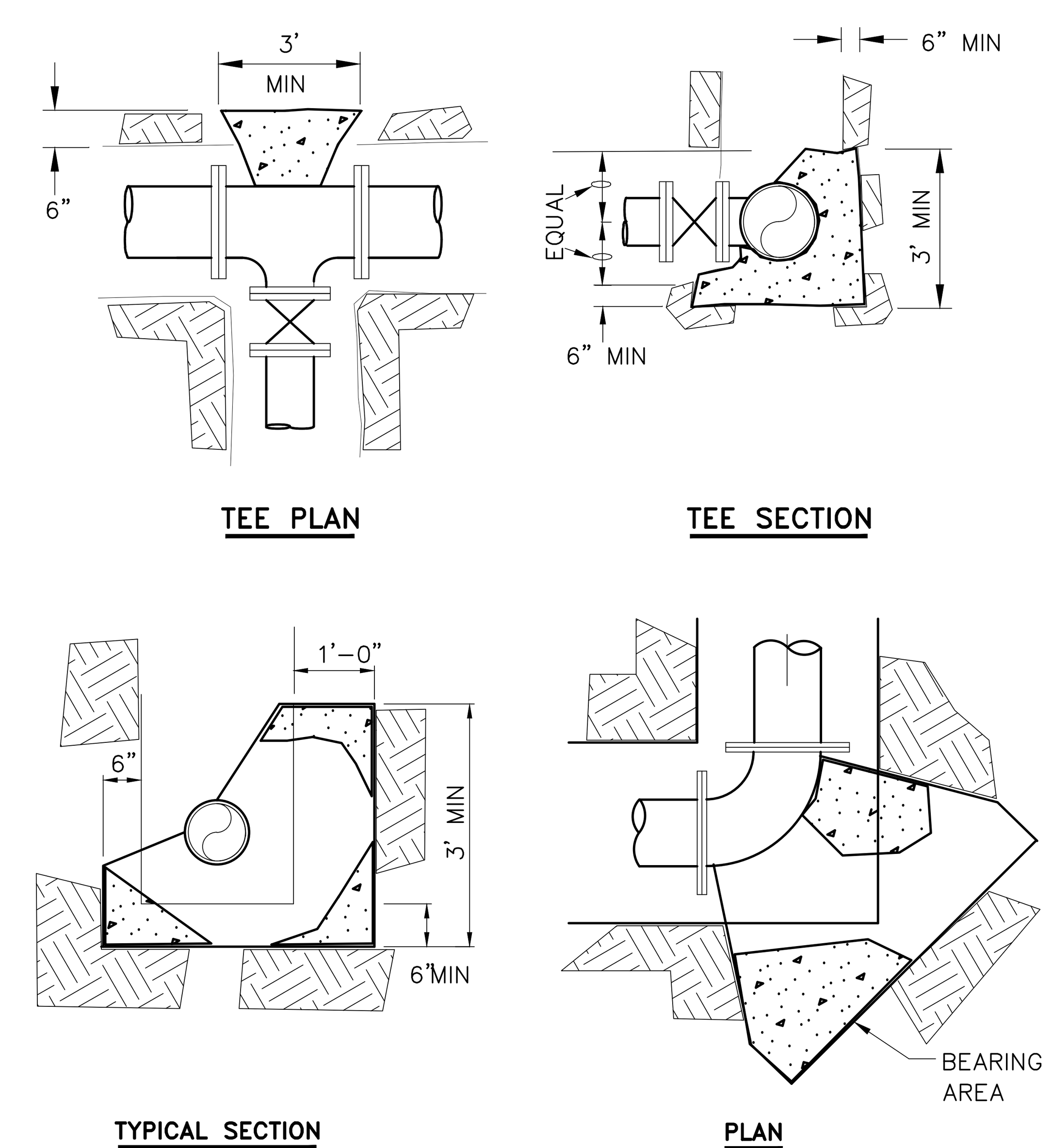

NOTES:
1. PROVIDE HOSE RACK AT EACH HOSE BIBB
2. ALL HOSE BIBBS TO BE EQUIPPED W/ BFP VALVE.

## HOSE BIB DETAILS (7 TYP)
NTS




NOTES:
1. HOSE RACK TO BE WALL MOUNTED USING 3/8" THICK, 3.5" LONG CARRIAGE BOLTS. USE SILCON CAULKING FOR WATERPROOFING.

## HOSE RACK DETAIL (8 TYP)
NTS




THRUST BLOCK BEARING AREA CALC

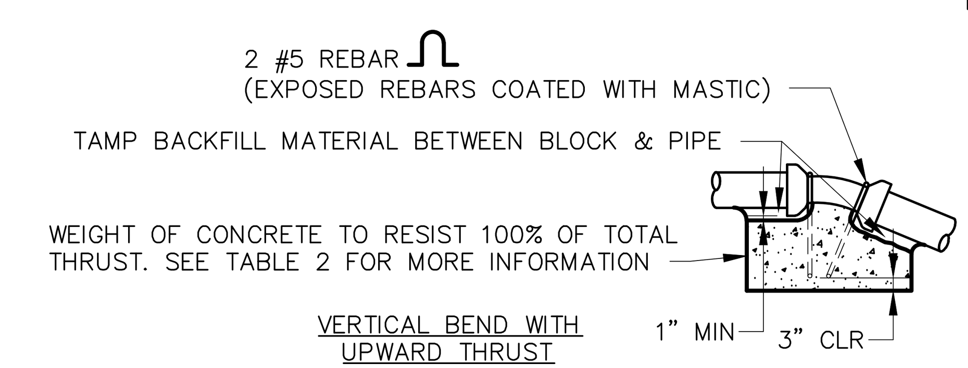
R = A*P*sin 1/2△

R = REACTION (lbs)
A = CROSS-SECTIONAL AREA OF PIPE (in)
P = PRESSURE IN PIPE (psi)
△ = DEFLECTION ANGLE OF BEND

ALLOWABLE SOIL BEARING = 2,000 psf
BEARING AREA (sq ft) = 2R/2,000
VARIOUS PRESSURES SPECIFIED ARE IN DIRECT PROPORTION TO THE CALCULATED TEST PRESSURES CALCULATED HERE WHICH ARE BASED ON 150 psi.

| SIZE OF PIPE | BEARING AREA (SQ FT) | | | | |
|---|---|---|---|---|---|
| | 11-1/4° BEND | 22-1/4° BEND | 45° BEND | 90° BEND | TEE OR DEAD ENDS |
| 24" | 7 | 13 | 26 | 48 | 39 |
| 18" | 4 | 7 | 15 | 27 | 22 |
| 16" | 3 | 6 | 12 | 21 | 17 |
| 14" | 2 | 4 | 9 | 16 | 13 |
| 12" | 2 | 3 | 6 | 12 | 10 |
| 10" | 1 | 2 | 5 | 8 | 7 |
| 8" | 1 | 1 | 3 | 5 | 4 |
| 6" | 0 | 1 | 2 | 3 | 2 |
| 4" | 0 | 0 | 1 | 1 | 1 |

* MINIMUM BEARING SURFACE AREA




NOTES:
1. THIS DETAIL SHALL BE USED ON ALL BENDS, DEAD ENDS AND TEES WHERE JOINTS ARE UNRESTRAINED AND WHERE SPECIFICALLY SHOWN. THIS DETAIL IS NOT REQUIRED FOR GRAVITY PIPE (TEST PRESSURE LESS THAN OR EQUAL TO 5 PSI).
2. ALL BURIED PRESSURE PIPE SHALL BE RESTRAINED TO RESIST THE ANTICIPATED PRESSURES.
3. CONCRETE FOR THRUST BLOCKS TO BE 6 SACK, 3/4" AGGREGATE MAX, 3000 PSI.
4. CAST CONCRETE THRUST BLOCK AGAINST UNDISTURBED EARTH.
5. FIGURE (100%) AT THRUST BLOCK INDICATES PERCENT OF TOTAL THRUST TO BE APPLIED FOR BEARING AREA.
6. MINIMUM GROUND COVER FOR PIPES IS 4'-0" OVER TOP OF PIPE, UNLESS SPECIFICALLY STATED OTHERWISE.
7. THRUST BLOCKS FOR VERTICAL BENDS HAVING DOWNWARD RESULTANT THRUST SHALL BE THE SAME AS FOR HORIZONTAL BENDS.
8. BEARING AREA OF THRUST BLOCK SHALL NOT BE LESS THAN 1.0 SQ FT.
9. IN USING THE TABLE, USE THE MAXIMUM INTERNAL PRESSURE ANTICIPATED (IE HYDROSTATIC TEST PRESSURE).
10. PROVIDE #4 REBAR AT 12" OC EW WITHIN ALL THRUST BLOCKS.
11. IF OTHER CIRCUMSTANCES ARISE NOT COVERED BY TABLE, CONTACT THE ENGINEER FOR BEARING AREA REQUIRED.

## THRUST BLOCK DETAIL (9 TYP)
NTS

Z:\NLINE\NLINE 020 - PLANT B24 HYDRO\DRAWINGS - 90% DRAFT 3 (WORKING)\D&NLINE B24 HYDRO.DWG

| REVISIONS | BY | APP. BY | DATE |
|---|---|---|---|

DRAWN BY: ADAM MOTIEJUNAS
DESIGNED BY: ANDREW BENJAMIN
REVIEWED BY: DAVID POWELL
APPROVED BY:
F.E.R.C. Project No. CD017-17-000
SCALE: AS NOTED
JOB NO.

REGISTERED PROFESSIONAL ENGINEER — MICHAEL F. BRESSER — 10246 — Exp. SEPT. 30, 2020 — Electrical Engineer — STATE OF CALIFORNIA

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11142 GARVEY AVENUE
EL MONTE, CALIFORNIA 91733

PLANT B24 HYDRO

DETAILS 3

DRAWING D3

12 OF 19 SHEETS


## OVERALL SITE PLAN
3/16"=1'-0"

| | | | |
|---|---|---|---|
| REVISIONS | BY | APP. BY | DATE |

REGISTERED PROFESSIONAL ENGINEER ANDREW M. BENJAMIN NO. C88287 Exp. 03/2020 CIVIL STATE OF CALIFORNIA

REGISTERED PROFESSIONAL ENGINEER MICHAEL F BREGAS Exp. SEPT. 30, 2020 Electrical Engineer STATE OF CALIFORNIA

| | |
|---|---|
| DRAWN BY: ADAM MOTIEJUNAS | |
| DESIGNED BY: ANDREW BENJAMIN | |
| REVIEWED BY: DAVID POWELL | |
| APPROVED BY: | |
| F.E.R.C. Project No. | CD017-17-000 |
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PLANT B24 HYDRO

OVERALL SITE PLAN

DRAWING
E1
13 OF 19 SHEETS

Z:\NLINE\NLINE 020 - PLANT B24 HYDRO\DRAWINGS - 90% DRAFT 3 (WORKING)\EETS\E1 - OVERALL SITE PLAN.DWG


## BUILDING PLAN EXTERIOR

1/2"=1'-0"

Z:\NLINE\NLINE 020 - PLANT B24 HYDRO\DRAWINGS - 90% DRAFT 3 (WORKING)\EETS\E2 - LOCAL SITE PLAN.DWG

| REVISIONS | BY | APP. BY | DATE |
|---|---|---|---|

REGISTERED PROFESSIONAL ENGINEER ANDREW M. BENJAMIN NO. C88287 Exp. 03/2020 CIVIL STATE OF CALIFORNIA

REGISTERED PROFESSIONAL ENGINEER MICHAEL F BREGAR Exp. SEPT. 30, 2020 Electrical Engineer STATE OF CALIFORNIA

| | |
|---|---|
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| APPROVED BY: | |
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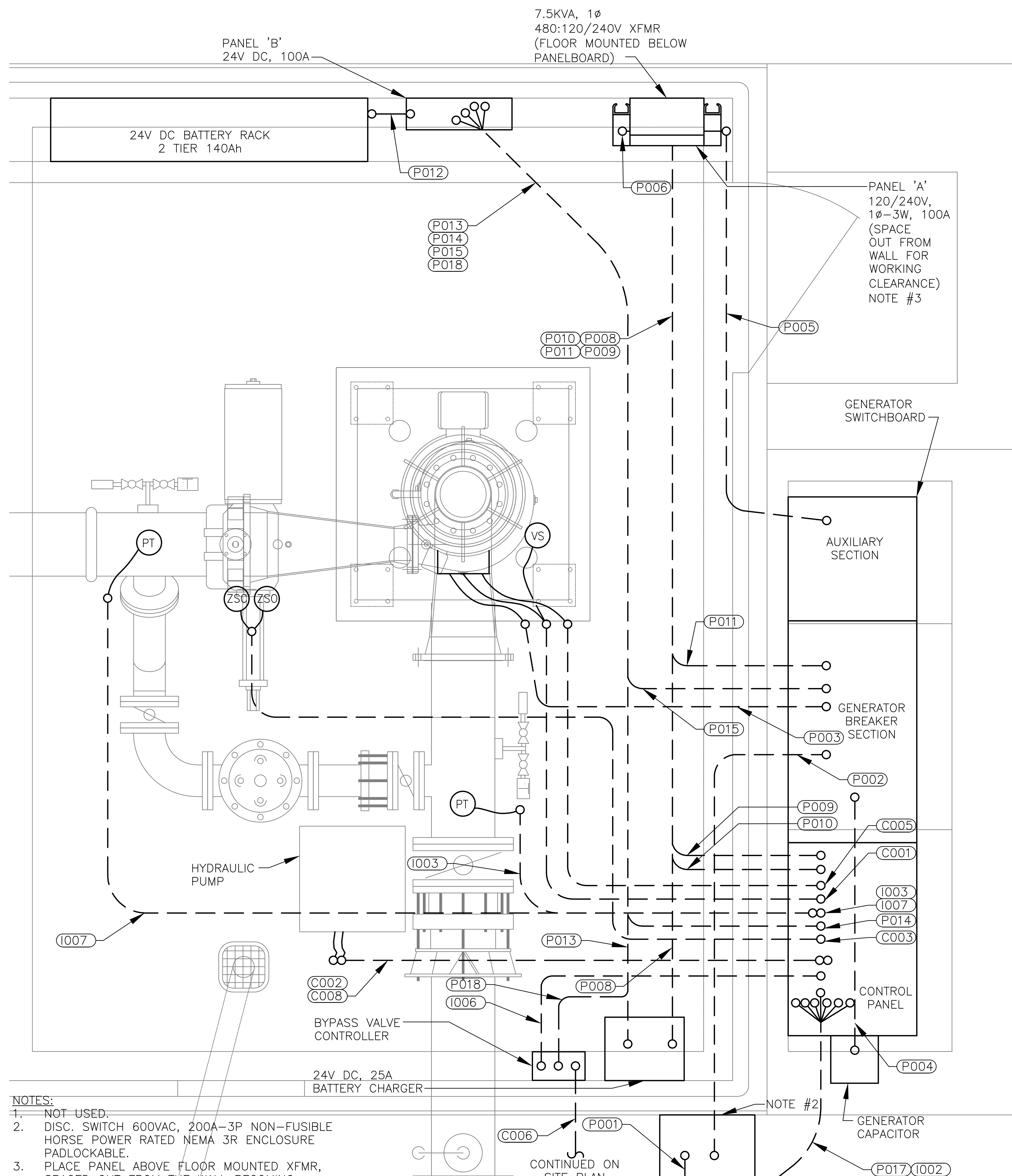
PLANT B24 HYDRO

SITE PLAN – 2

DRAWING E2

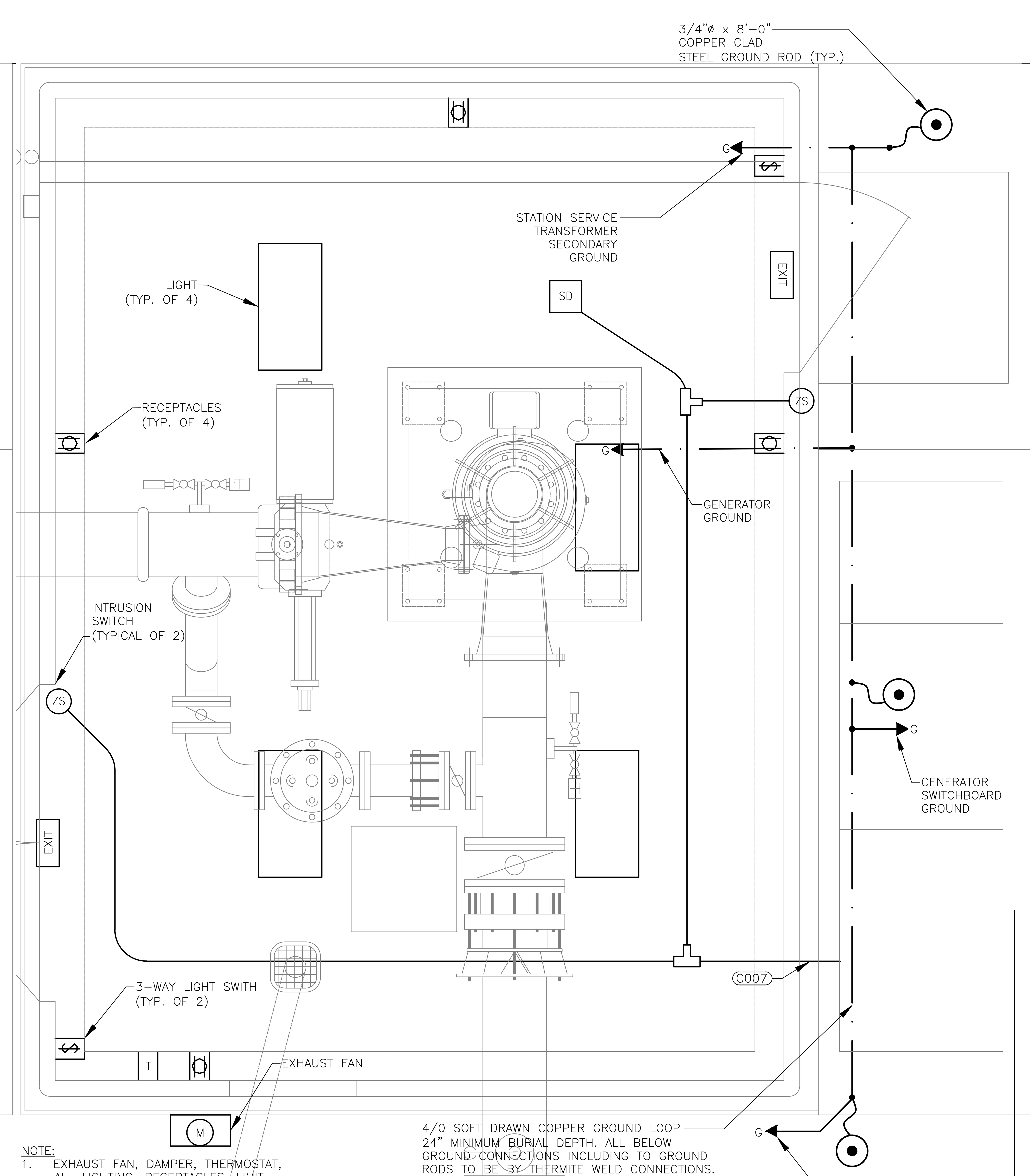
14 OF 19 SHEETS




NOTES:
1. NOT USED.
2. DISC. SWITCH 600VAC, 200A-3P NON-FUSIBLE HORSE POWER RATED NEMA 3R ENCLOSURE PADLOCKABLE.
3. PLACE PANEL ABOVE FLOOR MOUNTED XFMR, SPACED OUT FROM THE WALL BECOMING FLUSH WITH FACE OF XFMR.

## POWER, CONTROL, AND INSTRUMENTATION PLAN

1"=1'-0"




NOTE:
1. EXHAUST FAN, DAMPER, THERMOSTAT, ALL LIGHTING, RECEPTACLES, LIMIT SWITCHES, AND SMOKE DETECTOR TO BE PRE-WIRED BY THE BUILDING MANUFACTURER.

## LIGHTING, RECPETACLE, AND VENTILATION PLAN

1"=1'-0"

Z:\NLINE\NLINE 020 - PLANT B24 HYDRO\DRAWINGS - 90% DRAFT 3 (WORKING)\EETS\E3 - BUILDING PLAN.DWG

| REVISIONS | BY | APP. BY | DATE |
|---|---|---|---|

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SCALE:
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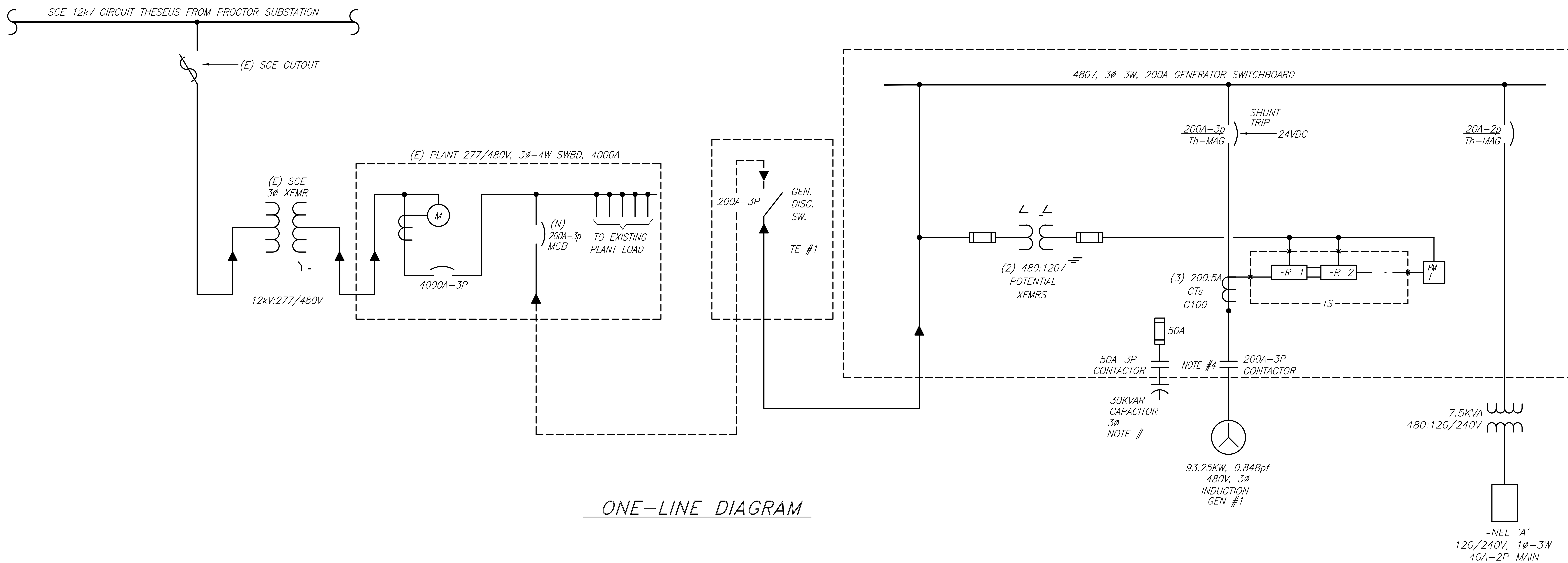
PLANT B24 HYDRO

BUILDING PLAN VIEWS

DRAWING E3

15 OF 19 SHEETS




ONE-LINE DIAGRAM

1. SIEMENS MODEL HNF364R 600V, 3-POLE, 200AMP, GROUP OPERATED, HEAVY DUTY, HORSEPOWER RATED, VISIBLE BLADE DISCONNECT SWITCH IN A NEMA 3R ENCLOSURE WITH PADLOCKABLE EXTERNAL OPERATING HANDLE, AND RED LAMACOID NAMEPLATE ENGRAVED 'GENERATOR DISCONNECT SWITCH' IN 1/2 INCH HIGH LETTERING.
2. (NOT USED)
3. (NOT USED)
4. GENERATING STATION CONTROL SYSTEM WILL RECEIVE GENERATOR POWER OUTPUT INFORMATION FROM PM-1.
5. TRIPPING POWER SHALL BE SUPPLIED AT 24VDC FROM A FLOODED CELL NICKEL CADMIUM BATTERY SYSTEM CHARGED BY A DUAL RATE (FLOAT & EQUALIZE) CHARGER, ALL BREAKERS SHALL BE EQUIPPED WITH 24VDC SHUNT TRIP ACCESSORY.
6. A 24VDC UNDERVOLTAGE RELAY (27DC) SHALL MONITOR THE BATTERY AND TRIP THE MAIN BREAKER ON LOW DC VOLTAGE.
7. GENERATOR CAPACITOR SIZED TO PROVIDE .90 OR GREATER POWER FACTOR ACROSS GENERATOR OPERATING RANGE.

| DEVICE | DESCRIPTION | MANUFACTURER | MODEL NO. | FUNCTION | |
|---|---|---|---|---|---|
| - | - | - | - | - | |
| MFR-1,-2 | MULTIFUNCTION RELAY 27, 59, 810, 81U, 32R, 46, 51V | BECKWITH | M3425A | M-1 & M-2: 27, 59, 810, 81U OPEN GEN CONTACTOR | MFR-1 & MFR-2: 51V, 32R, 46 TRIP GEN. BKR |
| 27DC-1 | DC UNDERVOLTAGE RELAY | TIME MARK | 2601-24VDC | TRIP MAIN BREAKER | |
| PM-1 | POWER METER / POWER METER DISPLAY | CUTLER HAMMER EATON | | POWER, CURRENT, VOLTAGE: DISPLAY & CONTROL SYSTEM INPUT | |
| TS | TEST SWITCH-CURRENT AND OR POTENTIAL (AS REQUIRED) | ABB | FT | PROVISIONS FOR TESTING AND ISOLATION OF DEVICES | |
| 32F-1 | FORWARD POWER DETECTION | BASLER | BE3-32-3-AINI | ALLOW CONTROL VALVE UNLOADING OF UNIT BEFORE SHUTDOWN | |
| CR | AUXILIARY CONTROL RELAY | ABB | MG-6 | CONTACT MULTIPLIER | |

Z:\NLINE\NLINE 020 - PLANT B24 HYDRO\DRAWINGS - 90% DRAFT 3 (WORKING)\EETS\E4 - ONE LINE DIAGRAM.DWG

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PLANT B24 HYDRO

GENERATING STATION OVERALL ONE-LINE DIAGRAM

DRAWING E4

16 OF SHEETS

| CONDUIT NUMBER | FROM | TO | CONDUIT SIZE | CONDUCTORS / NOTES |
|---|---|---|---|---|
| **POWER** | | | | |
| P001 | (E) PLANT MAIN SWBD | HYDRO DISCONNECT SWITCH | 2 1/2" | (3) 4/0 Cu. THHN/THWN & (1) #6 Cu. GRD. |
| P002 | GENERATOR SWBD | HYDRO DISCONNECT SWITCH | 2 1/2" | (3) 4/0 Cu. THHN/THWN & (1) #6 Cu. GRD. |
| P003 | GENERATOR SWBD | GENERATOR | 2 1/2" | (3) 4/0 Cu. THHN/THWN & (1) #6 Cu. GRD. |
| P004 | GENERATOR SWBD | P.F. CAPACITOR | 1" | (3) #6 Cu. THHN/THWN & (1) #6 Cu. GRD. |
| P005 | GENERATOR SWBD | STATION SERVICE XFMR | 3/4" | (2) #12 Cu. THHN/THWN & (1) #12 Cu. GRD. |
| P006 | PANEL 'A' | STATION SERVICE XFMR | 1" | (3) #8 Cu. THHN/THWN & (1) #10 Cu. GRD. |
| P007 | – | – | – | – |
| P008 | PANEL 'A' | BATTERY CHARGER | 3/4" | (2) #12 Cu. THHN/THWN & (1) #12 Cu. GRD. |
| P009 | PANEL 'A' | CONTROL PANEL (HYDRO. PUMP CONTROL) | 3/4" | (2) #12 Cu. THHN/THWN & (1) #12 Cu. GRD. |
| P010 | PANEL 'A' | CONTROL PANEL (GEN. SPACE HEATER) | 3/4" | (2) #12 Cu. THHN/THWN & (1) #12 Cu. GRD. |
| P011 | PANEL 'A' | GENERATOR SWBD (HEATERS/FANS) | 3/4" | (2) #12 Cu. THHN/THWN & (1) #12 Cu. GRD. |
| P012 | PANEL 'B' | 24V DC BATTERY BANK | 1" | (2) #6 Cu. THHN/THWN & (1) #10 Cu. GRD. |
| P013 | PANEL 'B' | BATTERY CHARGER | 3/4" | (2) #8 Cu. THHN/THWN & (1) #10 Cu. GRD. |
| P014 | PANEL 'B' | CONTROL PANEL | 3/4" | (2) #12 Cu. THHN/THWN & (1) #12 Cu. GRD. |
| P015 | PANEL 'B' | GENERATOR SWBD | 3/4" | (2) #8 Cu. THHN/THWN & (1) #10 Cu. GRD. |
| P016 | – | – | – | – |
| P017 | CONTROL PANEL | FLOW METER | 3/4" | (2) #12 Cu. THHN/THWN & (1) #12 Cu. GRD. |
| P018 | PANEL 'B' | BYPASS VALVE CONTROLLER | 3/4" | (2) #12 Cu. THHN/THWN & (1) #12 Cu. GRD. |

| CONDUIT NUMBER | FROM | TO | CONDUIT SIZE | CONDUCTORS / NOTES |
|---|---|---|---|---|
| **CONTROL** | | | | |
| C001 | CONTROL PANEL | GENERATOR (VS, TS) | 3/4" | (4) #12 Cu. THHN/THWN & (1) #12 Cu. GRD. |
| C002 | CONTROL PANEL | HYDRO. PUMP SOLENOID | 3/4" | (4) #12 Cu. THHN/THWN & (1) #12 Cu. GRD. |
| C003 | CONTROL PANEL | TSV (OPEN, CLOSE INDICATION) | 3/4" | (6) #12 Cu. THHN/THWN & (1) #12 Cu. GRD. |
| C004 | CONTROL PANEL | GENERATOR CONTROL VALVE | 3/4" | (4) #12 Cu. THHN/THWN & (1) #12 Cu. GRD. |
| C005 | CONTROL PANEL | GENERATOR (SPACE HEATER) | 3/4" | (2) #12 Cu. THHN/THWN & (1) #12 Cu. GRD. |
| C006 | BYPASS VALVE CONTROLLER | BYPASS VALVE | 3/4" | (4) #12 Cu. THHN/THWN & (1) #12 Cu. GRD. |
| C007 | CONTROL PANEL | ROUTE TO INTRUSION SW'S & SMOKE DETECTOR | 3/4" | (6) #12 Cu. THHN/THWN & (1) #12 Cu. GRD. |
| C008 | CONTROL PANEL | HYDRO. PUMP MOTOR | 3/4" | (2) #12 Cu. THHN/THWN & (1) #12 Cu. GRD. |
| **INSTRUMENTATION** | | | | |
| I001 | CONTROL PANEL | (E) PLANT CONTROL PANEL | 1" | (1) CAT 6 CABLE |
| I002 | CONTROL PANEL | FLOW METER/PRESSURE XMTR (INCOMING) | 1" | (1) 2/C #16 TWSP & (1) #12 Cu GRD (VIA NEMA 4 J. BOX) |
| I003 | CONTROL PANEL | PRESSURE TRANSMITTER (TURBINE) | 3/4" | (1) 2/C #16 TWSP & (1) #12 Cu GRD |
| I004 | CONTROL PANEL | GENERATOR CONTROL VALVE | 3/4" | (1) 2/C #16 TWSP & (1) #12 Cu GRD |
| I005 | CONTROL PANEL | BYPASS VALVE | 3/4" | (1) 2/C #16 TWSP & (1) #12 Cu GRD |
| I006 | CONTROL PANEL | BYPASS VALVE CONTROLLER | 3/4" | (1) 2/C #16 TWSP & (1) #12 Cu GRD |
| I007 | CONTROL PANEL | PRESSURE TRANSMITTER (TURBINE) | 3/4" | (1) 2/C #16 TWSP & (1) #12 Cu GRD |

## PANEL SCHEDULE

Panel: 'A' Type: AS SPECIFIED. Frame: 100A Main 100A–2P

Service: 120/240V, 1ø–3WIRE Mount: SURFACE

| LOAD | KW | CB | # | S/N | | # | CB | KW | LOAD |
|---|---|---|---|---|---|---|---|---|---|
| CONTROL PANEL | – | 20/1 | 1 | X | | 2 | 20/1 | – | INTERIOR LIGHTS/EXIT LIGHTS |
| HYDRAULIC PUMP | – | 20/1 | 3 | | X | 4 | 20/1 | – | INTAKE LOUVER/EXHAUST FAN |
| GENERATOR HEATER | – | 20/1 | 5 | X | | 6 | 20/1 | – | RECEPTACLES |
| SPARE | – | 20/1 | 7 | | X | 8 | 20/1 | – | RECEPTACLES |
| SPARE | – | 20/1 | 9 | X | | 10 | 20/1 | – | SMOKE DETECTOR |
| SPARE | – | 20/1 | 11 | | X | 12 | 20/1 | – | SPARE |
| SPARE | – | 20/1 | 13 | X | | 14 | 20/1 | – | SPARE |
| SPARE | – | 20/1 | 15 | | X | 16 | 20/2 | 0.4 | BATTERY CHARGER |
| SPARE | – | 20/1 | 17 | X | | 18 | ↓ | 0.4 | ↓ |
| SPACE | | | 19 | | X | 20 | | | SPACE |
| SPACE | | | 21 | X | | 22 | | | SPACE |
| SPACE | | | 23 | | X | 24 | | | SPACE |

## PANEL SCHEDULE

Panel: 'B' Type: AS SPECIFIED. Frame: 100A Main 60A–2P

Service: 24VDC Mount: SURFACE

| LOAD | KW | CB | # | S/N | | # | CB | KW | LOAD |
|---|---|---|---|---|---|---|---|---|---|
| *BATTERY CHARGER* | 1.0 | 30/2 | 1 | X | | 2 | 30/2 | – | GENERATOR SWBD |
| ↓ | | | 3 | | X | 4 | | | ↓ |
| *SPARE* | – | 30/2 | 5 | X | | 6 | 20/2 | – | GENERATOR CTRL PNL |
| ↓ | | | 7 | | X | 8 | | | ↓ |
| *SPARE* | – | 30/2 | 9 | X | | 10 | 20/2 | – | BYPASS VALVE CONTROL PANEL |
| ↓ | – | – | 11 | | X | 12 | | | ↓ |
| *SPARE* | – | 20/2 | 13 | X | | 14 | 20/2 | – | SPARE |
| ↓ | – | – | 15 | | X | 16 | | | ↓ |
| SPACE ONLY | | | 17 | X | | 18 | | | SPACE ONLY |
| | | | 19 | | X | 20 | | | |
| | | | 21 | X | | 22 | | | |
| ↓ | | | 23 | | X | 24 | | | ↓ |


THE FOLLOWING ARE VIRTUAL DEVICES IMPLEMENTED AT THE HYDRO STATION PLC/OID:

CS UNIT CONTROL SWITCH 'START-STOP'
43 MASTER SELECTOR SWITCH 'MANUAL-OFF-AUTO'
CS ISO. VALVE CONTROL SWITCH 'OPEN-CLOSE'
4 MASTER START RELAY
5 MASTER RUN PERMISSIVE RELAY
SPEED SWITCH UNDERSPEED, SYNC SPEED, OVERSPEED

REVISIONS | BY | APP. BY | DATE

DRAWN BY: ADAM MOTIEJUNAS
DESIGNED BY: ANDREW BENJAMIN
REVIEWED BY: DAVID POWELL
APPROVED BY:
F.E.R.C. Project No. CD017-17-000
SCALE:
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EL MONTE, CALIFORNIA 91733

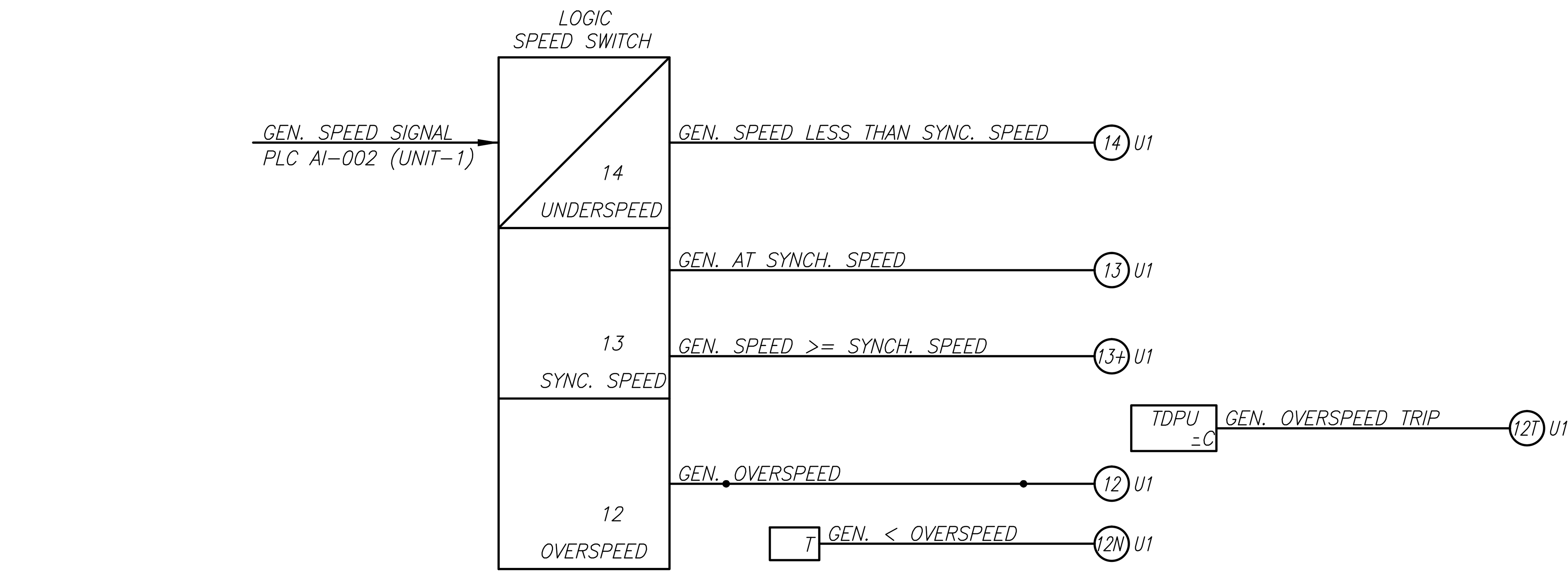
PLANT B24 HYDRO

LOGIC DIAGRAMS – 1

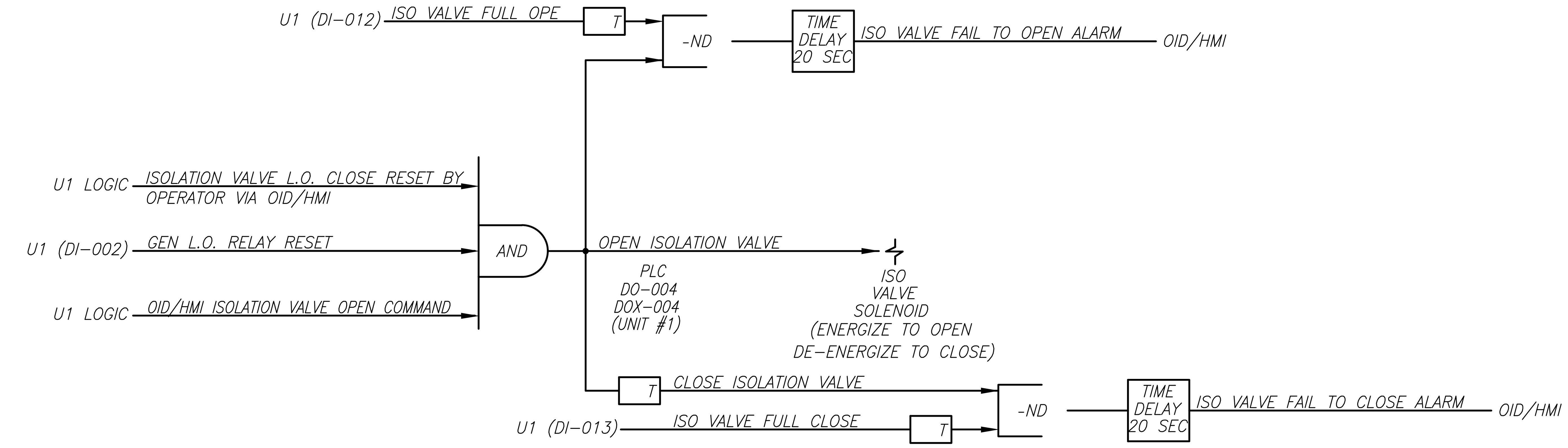
DRAWING E6

18 OF 19 SHEETS

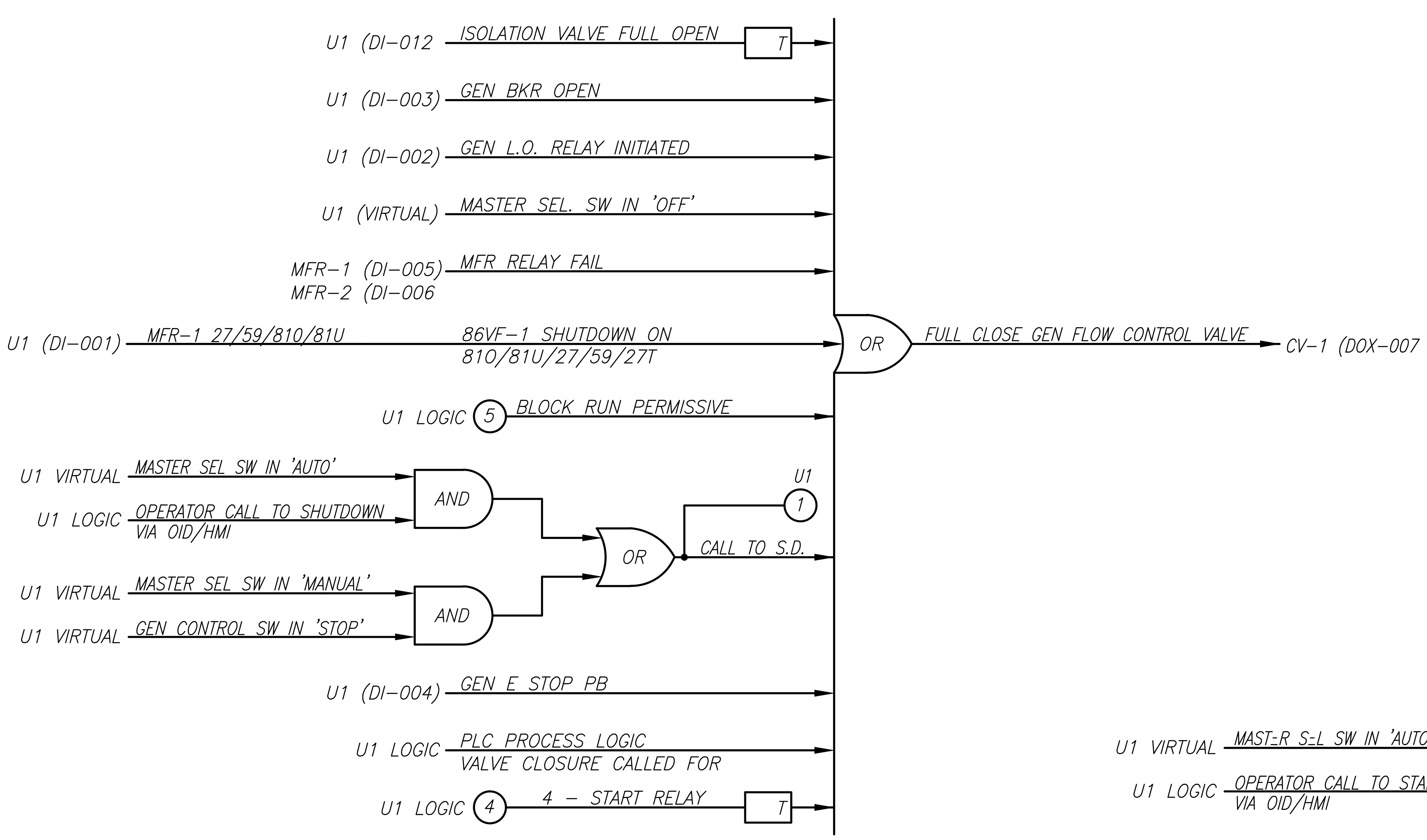
Z:\NLINE\NLINE 020 - PLANT B24 HYDRO\DRAWINGS - 90% DRAFT 3 (WORKING)\EETS\E6 - LOGIC DIAGRAM - 1.DWG



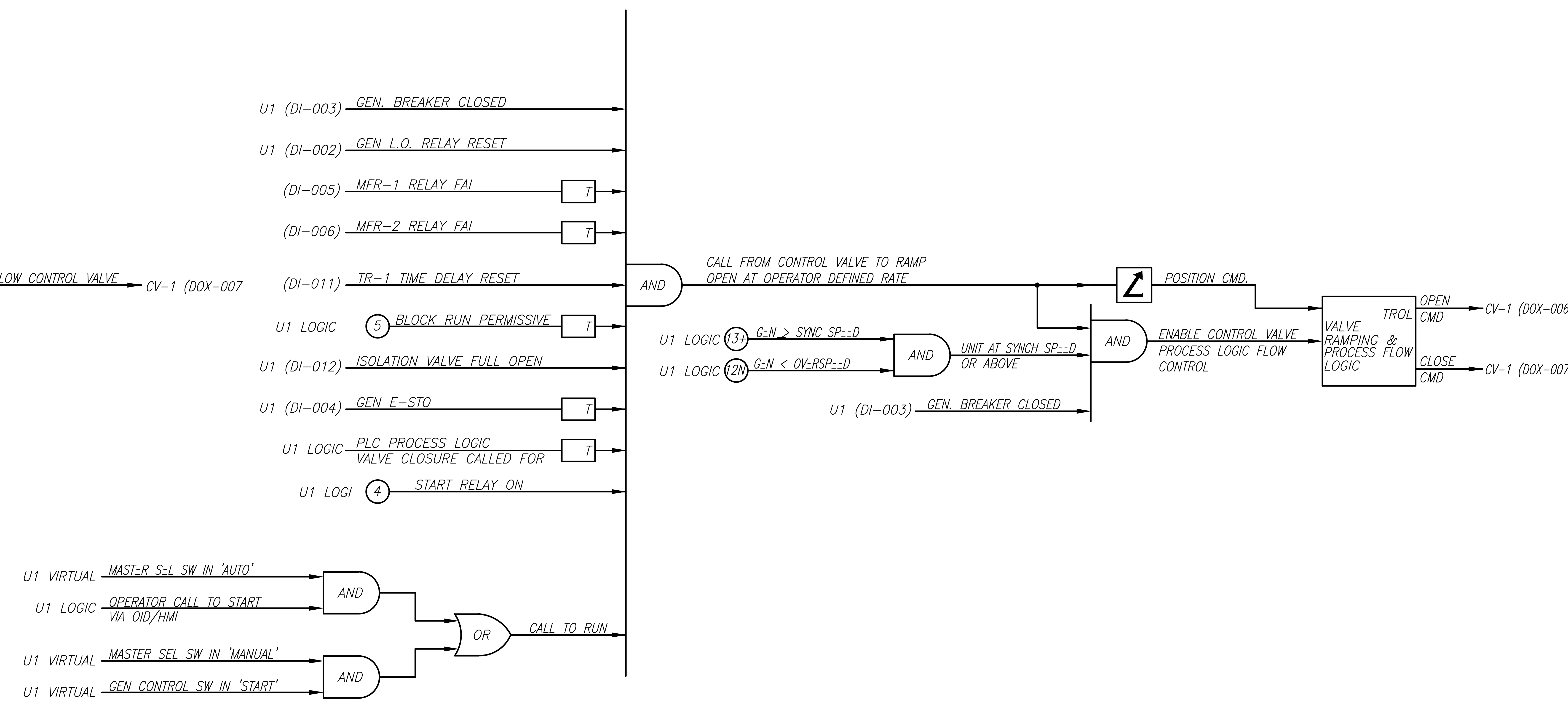

## GE ATOR SPEED SE ING AND SET-POINT LOGIC




## ISOLATION VALVE ATION LOGIC




## CLOSE IC




## MODULATING LOGIC

## CONTROL VALVE IC

Z:\NLINE\NLINE 020 - PLANT B24 HYDRO\DRAWINGS - 90% DRAFT 3 (WORKING)\EETS\E7 - LOGIC DIAGRAM - 2.DWG

| | |
|---|---|
| SAN GABRIEL VALLEY WATER COMPANY | PLANT B24 HYDRO |
| 11142 G VEY NU EL MONTE, C | LOGIC DIAGRAMS – 2 |
| DRAWING | E7 |

EETSINC

NLINE ENERGY — EVERY DROP OF ENERGY

SAN GABRIEL VALLEY WATER COMPANY

CD017-17-000