DRAFT

H-5 SPILLGATE REPLACEMENT

Preliminary Design Report

BLACK & VEATCH PROJECT NO. 400368

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PREPARED FOR

Guadalupe-Blanco River Authority

12 APRIL 2019

BLACK & VEATCH

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LIST OF ACRONYMS AND ABBREVIATIONS

ACT	Antiquities Code of Texas
Baer	Baer Engineering and Environmental Consulting, Inc.
cfs	cubic feet per second
CWA	Clean Water Act
EAL	Environmentally Acceptable Lubricant
EL	Elevation
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FM	Farm-to-Market
ft	feet
GBRA	Guadalupe Blanco River Authority
GVHS	Guadalupe Valley Hydroelectric System
HPU	hydraulic power unit
IFC	International Fire Code
in	inch
I/O	input/output

JQ	JQ Infrastructure, LLC
LOMC	Letter of Map Change
LOMR	Letter of Map Revision
NAD 83	North American Datum of 1983
NAVD 1988	North American Vertical Datum of 1988
NEPA	National Environmental Policy Act
NFPA	National Fire Protection Association
NHPA	National Historic Preservation Act
NRHP	National Register of Historic Places
NWI	National Wetland Inventory
NWP	Nationwide Permit
OSHA	Occupational Safety and Health Administration
PAG	polyalkylene glycol
PDR	Preliminary Design Report
P&ID	Piping and Instrumentation Diagram
PLC	Programmable Logic Controller
psi	Pounds per square inch
ROW	Right-of-way
SCADA	supervisory control and data acquisition
SPCC	Spill Prevention Control and Countermeasures
SWPPP	Stormwater Pollution Prevention Plan
TCEQ	Texas Commission on Environmental Quality
TES	Threatened and Endangered Species
THC	Texas Historical Commission
TPWD	Texas Parks and Wildlife Department
TxDOT	Texas Department of Transportation
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VGP	Vessel General Permit
WOTUS	Waters of the US

1.0 Introduction

The Guadalupe-Blanco River Authority (GBRA) owns and operates the Guadalupe Valley Hydroelectric System (GVHS) on the Guadalupe River near Seguin and Gonzales, Texas. The system was purchased by GBRA in 1963 and consists of six dams; Dunlap, TP-3 (Lake McQueeney), TP-4 (Lake Placid), Nolte (Meadow Lake), H-4 (Lake Gonzales), and H-5 (Lake Wood) and associated hydroelectric generation stations that were put into service between 1928 and 1932. Due to the age of the system, all fifteen spillgates in the system are believed to be at the end of their useful life.

GBRA has contracted Black & Veatch to develop a preliminary design for installation of hydraulically actuated steel crest gates at the six similarly configured hydroelectric dams in their system. The planned gates are intended to replace the existing bear-trap style crest gates which were originally constructed, along with the dams, between 1928 and 1932. The gates provide primary control of headwater levels in their corresponding reservoirs, and while they have been regularly maintained, the advanced age of the gates has resulted in increased maintenance requirements, unreliable operation, and unrepairable failure of one gate at H-5 dam.

The purpose of this Preliminary Design Report is to evaluate all six dam facilities in the system and develop a plan to implement gate replacement over a multi-year program. Black & Veatch has evaluated key considerations to implement hydraulic crest gates at all six of the GVHS facilities. Because GBRA has selected the H-5 dam as the first spillway to be modernized, focus has been placed on design and installation of hydraulically actuated spillgates to replace both existing gates at H-5 dam. The results of these tasks are summarized in this Preliminary Design Report.

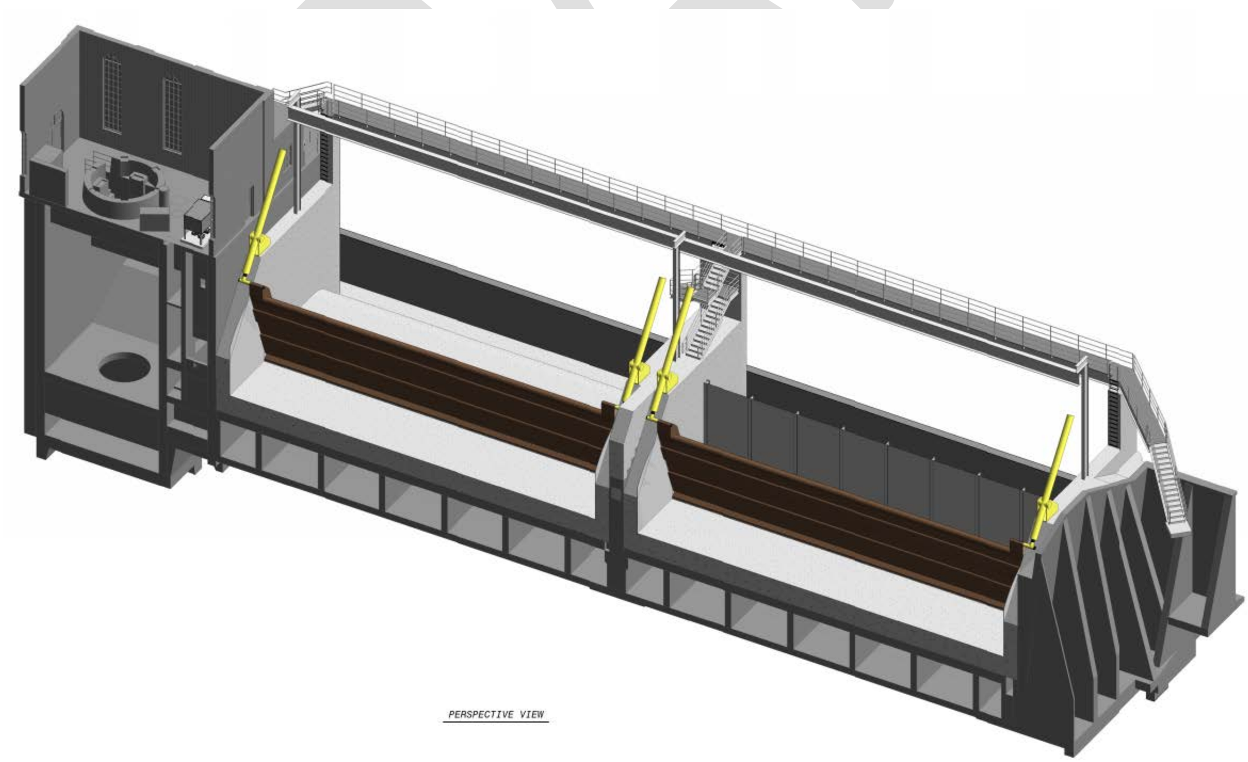


Figure 1-1 H-5 Proposed Spillway

2.0 Description of Existing Facilities

The six hydroelectric facilities are situated along approximately 85 miles of the Guadalupe River. From upstream to downstream the sites are; Dunlap, TP-3 (Lake McQueeney), TP-4 (Lake Placid), Nolte (Meadow Lake), H-4 (Lake Gonzales), and H-5 (Lake Wood). Dunlap, TP-3, TP-4, and Nolte are located near Seguin, Texas. H-4 and H-5 are located closer to Gonzales, Texas.

Figure 2-1 presents the locations of the six facilities.

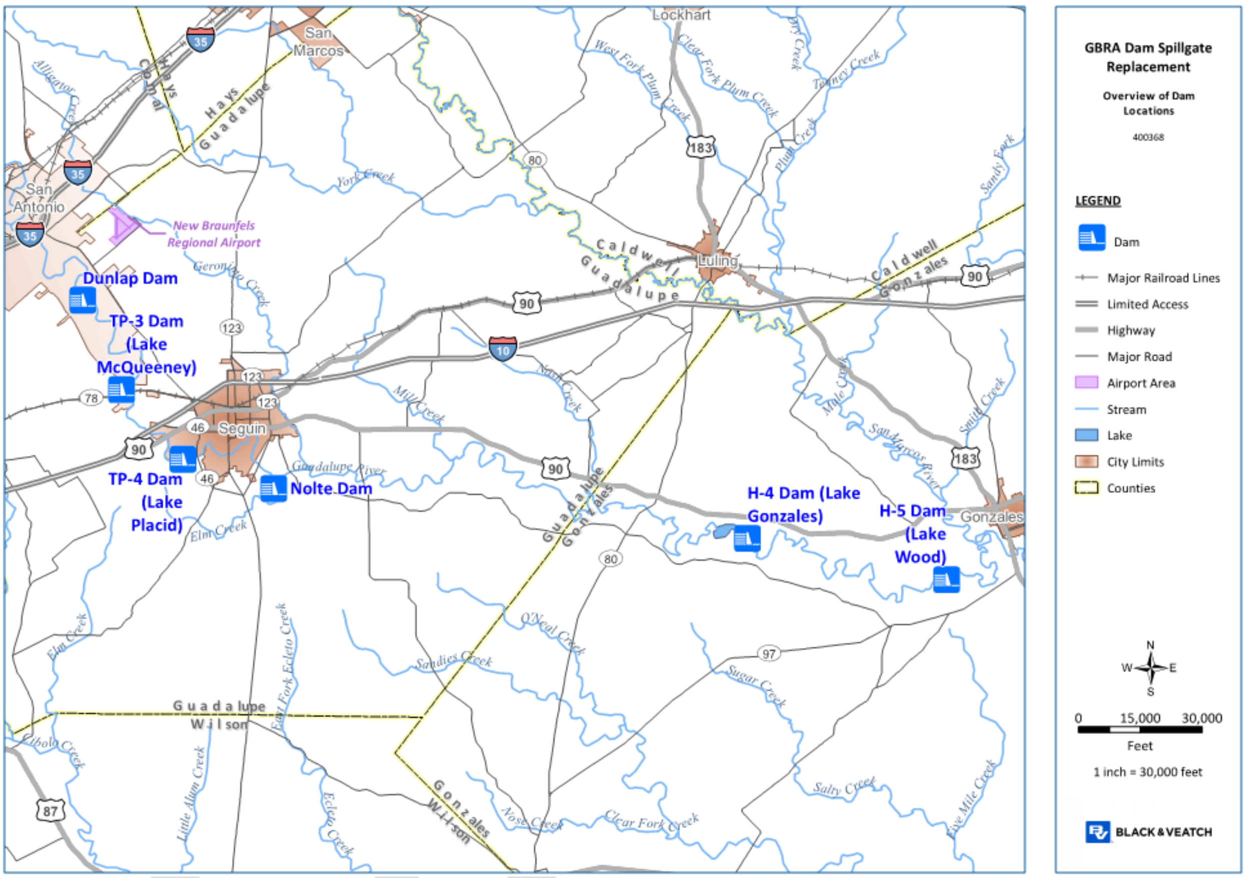


Figure 2-1 Overview of Site Locations

Flow in the Gonzales Guadalupe River is highly variable. Based on USGS stream gage data (Guadalupe River at FM 1117 near Seguin), during the last 13 years (April 2005 to October 2018), average monthly flow rates have been as low as 74 cfs (September, 2014) and as high as 7,000 cfs (August, 2007). According to the GBRA/USACE Interim Feasibility Study (Halff, 2014), the 2-year flood (2% annual exceedance probability) is in the order of 10,000 cfs; the 100-year flood (1% annual exceedance probability) exceeds 100,000 cfs.

Figure 2-2 presents the hydraulic profile of the river system between the six hydroelectric facilities. All elevations presented in this report are based on data from the GBRA SCADA system. These elevations do not match a standard vertical datum such as NAVD88.

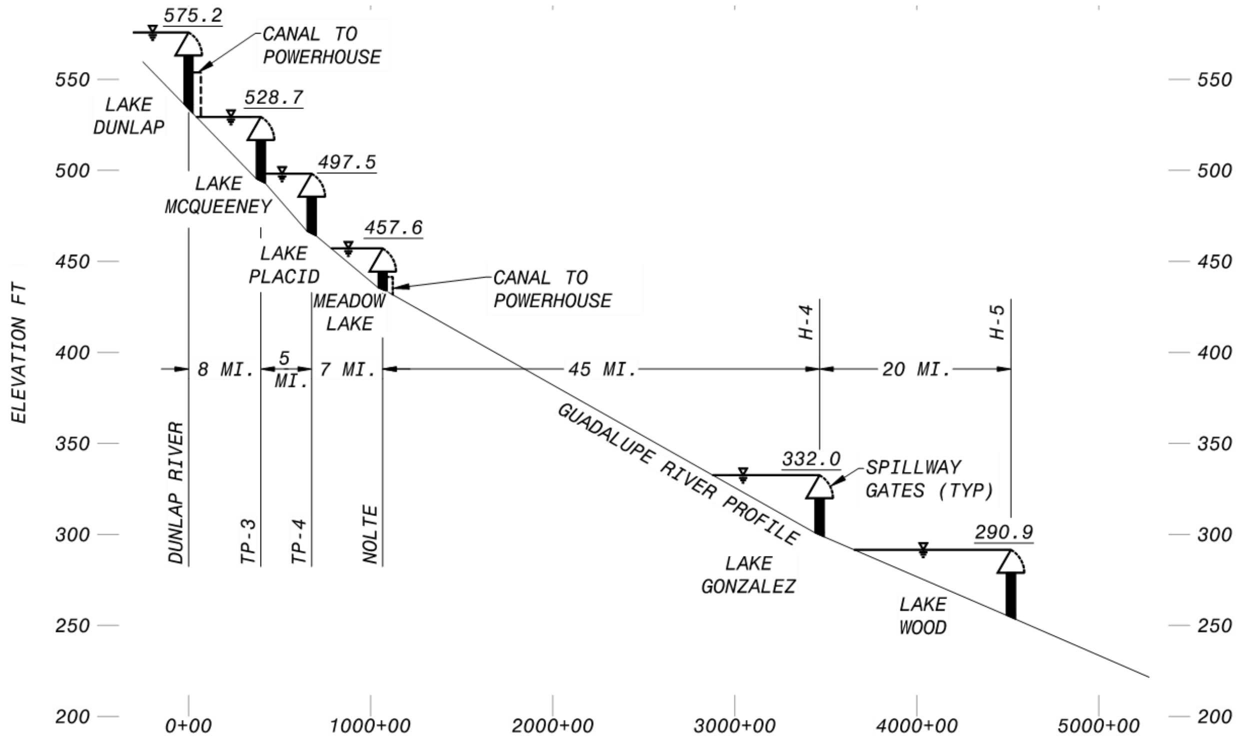


Figure 2-2 Hydraulic Profile of Guadalupe River from Dunlap to H-5

2.1 SYSTEM WIDE OBSERVATIONS

On November 27 and 28, 2018, GBRA personnel lead a team of Black & Veatch engineers on site visits to the six hydroelectric facilities along the Guadalupe River. The site visits were intended to familiarize the Black & Veatch team with the sites and allow them to collect data necessary in determining the feasibility of installing hydraulically actuated steel crest gates at each of the sites. The Black & Veatch team's observations are documented in the H-5 Spillgate Replacement - Site Visit Report dated January 2019.

Error! Reference source not found. and the following are a summary of system wide observations noted in the Site Visit Report:

- All six sites have sufficient space within the existing buildings to locate hydraulic power units (HPUs) for operating the new crest gates. The HPUs will be located where existing gate control equipment is removed.
- All six sites have sufficient space within the existing buildings to locate electrical and supervisory control and data acquisition (SCADA) equipment for the new crest gates.
- The top of the spillway piers at all sites are below the headwater level during flooding. GBRA staff described the heavy debris typically observed to pass over the gates during flood events, including large trees, boats, and mobile homes. At the piers, the new hydraulic cylinders, instrumentation, wiring, piping, etc. associated with the proposed steel crest gates will need to be protected from floating debris impact of this kind. The new steel crest gates will also need to be robust enough to pass such debris without sustaining damage.

- Existing station service power at all sites is insufficient to supply the additional power required for new HPUs associated with new crest gates. Electrical power distribution is 120/240 volt single phase at all sites. Three phase power is not currently available. Existing back-up propane generators are insufficient to support the additional power required for new HPU's.
- GBRA's current SCADA system services all six facilities and was last upgraded approximately 9 to 10 years ago. The future SCADA work master plan will include recommendations for upgrades to the SCADA system resulting from gate replacement.
- Headwater elevation is monitored at each of the six sites using float and cable systems. Tailwater level is monitored at some of the sites. GBRA would prefer new headwater and tailwater measurement devices as part of any gate upgrades.
- GBRA would prefer new video surveillance systems be installed as part of any gate upgrades to monitor gate position, facilitate remote operation of the gates, and for security.

Table 2-1 Summary of Existing Spillway Characteristics

DAM	SPILLGATE DIMENSIONS	SPILLGATE SILL ELEVATION (FT)	FULL POND[1] ELEVATION (FT)	SPILL TO HOLD[2] ELEVATION (FT)	SPILL POINT[3] ELEVATION (FT)
Dunlap	3 Gates 12 ft H x 85 ft W	563.2	575.80 (w/ Flashboards)	576.00	576.20
TP-3	3 Gates 12 ft H x 85 ft W	516.7	528.70	529.00	529.20
TP-4	2 Gates 12 ft H x 98 ft-8 in W	485.5	497.50	497.80	498.00
Nolte	3 Gates 12 ft H x 85 ft W	445.6	458.25 (w/ Flashboards)	459.00	459.60
H-4	2 Gates 12 ft H x 85 ft W	320.0	332.65 (w/ Flashboards)	333.20	333.50
H-5	2 Gates 12 ft H x 85 ft W	278.9	291.60 (w/ Flashboards)	291.70	291.90

1. Full Pond = Normal reservoir operating level (SCADA datum).
2. Spill to Hold = Target reservoir level to be maintained when using spillgates (SCADA datum).
3. Spill Point = Reservoir level when spillgate operation starts (SCADA datum).

***Spillway elevations are the values used in the GBRA SCADA system which do not match NAVD88.**

2.2 DUNLAP

The Dunlap Dam (Figure 2-3) is comprised of an approximately 1,500 ft long, partially armored embankment and concrete spillway which includes three gates, each 85 ft wide by 12 ft tall. A gate control house, located on the left (north) embankment, contains the actuators which control flow through the spillway gates.

Dunlap Dam spans the primary run of the river and diverts flow to a canal located on the left (north) side. The canal which begins approximately 400 feet upstream of the spillway, conveys water to the Dunlap powerhouse. The Dunlap powerhouse is located approximately 1.5 miles downstream of the dam. Flow through the canal is controlled by a concrete control structure with two radial gates.

North site access is provided by an approximately 1 mile long gravel service, entered from the south from Canal Lane. South site access is provided immediately off Lakeside Pass.

Dunlap Dam impounds water for two large regional water supply intakes. Thus, Lake Dunlap cannot be drained to facilitate construction.

Figure 2-3 Overview of Dunlap Spillway

2.3 TP-3 (LAKE McQUEENEY)

The TP-3 Dam (Figure 2-4) is comprised of an approximately 1,500 ft long, partially armored embankment and concrete spillway which includes three gates each 85 feet wide by 12 feet tall. The TP-3 powerhouse is located on the right (south) embankment adjacent to the spillway. The gate control house is accessed through the powerhouse and up a flight of concrete stairs. The gate control house contains the actuators which control flow through the spillway gates. Plan dimensions of the gate control house are approximately 13 ft by 37 ft.

North site access is provided immediately off Bamboo Bluff Drive, a residential road. South site access is provided immediately off of Farm-to-Market (FM) 725. A residential area is situated immediately upstream of the left (north) embankment, with docks less than 200 ft from the spillway.

Figure 2-4 Overview of TP-3 (Lake McQueeney) Spillway

2.4 TP-4 (LAKE PLACID)

The TP-4 Dam (Figure 2-5) is comprised of an approximately 1,500 ft long, partially armored embankment and concrete spillway which includes two gates each 98.7 ft wide by 12 ft tall. The TP-4 powerhouse is located on the right (south) embankment adjacent to the spillway and contains the actuators which control flow through the spillway gates.

Lake Placid provides water to Springs Hill Water – a private water supply company – and the intake for a steel mill.

North site access is provided immediately off Lakeview Drive. South site access is provided by an approximately 1.4 mile long gravel service, entered from the west from FM 725. A pedestrian suspension bridge spans the TP-4 spillway but is closed for use due to safety concerns.

Figure 2-5 Overview of TP-4 (Lake Placid) Spillway

2.5 NOLTE (MEADOW LAKE)

The Nolte Dam (Figure 2-6) is comprised of an approximately 2,000 ft long, partially armored embankment and concrete spillway which includes three gates, each 85 ft wide by 12 ft tall. A gate control house, located on the left embankment, contains the actuators which control flow through the spillway gates. The control house is comprised of two rooms, the largest of which is 12.5 ft wide by 28 ft long.

Nolte Dam spans the primary run of the river and diverts flow to an artificial canal on the left (north) side, creating Nolte Island in between. The canal, which begins approximately 600 ft upstream of the dam, conveys water to the Nolte powerhouse. The Nolte powerhouse is located approximately three-quarters of a mile downstream of Nolte Dam. Flow through the canal is controlled by a concrete structure with two radial gates.

North site access is provided by an approximately 1 mile long gravel service road, entered from the north from FM 466. South site access is limited by an adjacent ranch. A large staging area is present on both the upstream and downstream sides of the dam just north of the spillway.

Figure 2-6 Overview of Nolte (Meadow Lake) Spillway

2.6 H-4 (LAKE GONZALES)

The H-4 Dam (Figure 2-7) is comprised of an approximately 800 ft long, partially armored embankment and concrete spillway which includes two gates each 85 ft wide by 12 ft tall. H-4 is the only site with a concrete auxiliary spillway, which is over 200 ft wide and situated within the left embankment approximately 500 ft from the primary spillway.

The H-4 powerhouse is located on the right embankment adjacent to the spillway and contains the actuators which control flow through the spillway gates. The powerhouse is comprised of two rooms. The main room, approximately 40 ft by 30 ft, houses the generator, electrical gear, and some of the gate control actuators. Additional actuators for gate control are located in an adjacent room approximately 12 ft by 9.5 ft.

A 20-ton bridge crane is present in the main room of the powerhouse.

North site access is provided by the approximately 0.7 mile long Dam Road, entered from the north from County Road 481. South site access is provided by an approximately 1.4 mile long gravel easement on private land, entered from the south from FM 466. A pedestrian suspension bridge spans the H-4 spillway but is closed to use for safety.

Figure 2-7 Overview of H-4 (Lake Gonzales) Spillway

2.7 H-5 (LAKE WOOD)

The H-5 Dam spillway and powerhouse (Figure 2-8) has many features identical to those at the H-4 facility. The dam is comprised of an approximately 2,200 ft long, partially armored embankment and concrete spillway which includes two gates each 85 feet wide by 12 feet tall. The left gate suffered a catastrophic failure in 2016.

The H-5 powerhouse is located on the right (south) embankment adjacent to the spillway and contains the existing actuators which control flow through the spillway gates. The powerhouse is comprised of two rooms. The main room, approximately 40 ft by 30 ft, houses the generator, electrical gear, and some of the gate control actuators. Additional actuators for gate control are located in an adjacent room approximately 12 ft by 9.5 ft.

North site access is provided by the approximately 0.4 mile long County Road 254, entered from the north from FM 2091 and also providing access to the adjacent Lake Wood Recreation Area, a GBRA-owned campground. South site access is provided by an approximately 1.8 mile long gravel easement on private land, entered from Texas Route 97. A pedestrian suspension bridge spans the H-5 spillway but is closed to use for safety.

The H-5 Dam impounds water for one private water intake.

Figure 2-8 Overview of H-5 (Lake Wood) Spillway

2.8 CULTURAL AND ENVIRONMENTAL INVESTIGATIONS

Baer Engineering and Environmental Consulting, Inc. (Baer) performed a database search to identify cultural and environmental features that must be protected or mitigated during construction work at the six sites. The Preliminary Constraints Maps and Permitting Analysis Report includes;

- Results of the database research and mapping of cultural and environmental constraints
- A summary of regulatory requirements impacting the project including the Texas Historical Commission (THC), Texas Parks and Wildlife Department (TPWD), US Fish and Wildlife Service (USFWS), Texas Commission on Environmental Quality (TCEQ), and the U.S. Army Corps of Engineers (USACE).
- Recommendations for mitigation or protection for each concern

Findings and recommendations of the cultural and environmental investigations contained within the Baer report are summarized in the below sections.

2.8.1 Environmental Considerations

Wetlands provide a multitude of ecological, economic and social benefits. They provide habitat for fish, wildlife and plants - many of which have a commercial or recreational value - recharge groundwater, reduce flooding, provide clean drinking water, offer food and fiber, and support cultural and recreational activities. National Wetland Inventory (NWI) data is used by landowners, developers, real estate agents, and environmental consultants as a first step in assessing the potential restrictions of land for residential, commercial, and industrial development. An estimated 46% of endangered or threatened species are associated with wetlands. NWI data (including riparian habitat data for western states) were used to help determine the occurrence of species and design plans for species recovery. NWI wetland classification types are used to identify potential habitat for some species or could be used in combination with other data to locate such habitat. The USFWS will use wetlands data for its Strategic Habitat Conservation adaptive management and its surrogate species performance reporting approach for planning and monitoring fully-functioning landscapes together with needed upland mapping efforts. USFWS supported Landscape Conservation Cooperatives will use these data for planning and modeling for wildlife habitats.

Based on Baer's review, the USFWS Critical Habitat for Threatened and Endangered Species online viewer lists no critical habitat mapped within the six proposed assessment areas. However, three TPWD state-classified rare species were identified as occurring within the project impact areas of three sites. Rare species are uncommon or vulnerable to extirpation but are currently not protected by the Endangered Species Act of 1973. Two rare aquatic species were identified as occurring within the project boundaries of three sites. The Dunlap, TP-3, and TP-4 sites have no impacted rare species. The Nolte site has potential to impact the downstream habitat of the Guadalupe Bass, listed as rare. The Golden Orb Freshwater Mussel, also listed as rare, has been observed upstream and downstream of H-5 and downstream of H-4. The Golden Orb is a candidate species for future listing of threatened or endangered. Additionally, several rare vegetation species have been observed outside but near to the project boundaries of Dunlap and H-5 Dams. An environmental survey would determine if encroachment of these species is of concern to the project.

Since the proposed project has the potential to disturb protected natural resources, for example due to dewatering, a Threatened and Endangered Species (TES) Habitat Assessment and an aquatic resource's relocation plan are likely to be required. No indications of contamination were found from desktop review.

2.8.2 Cultural Considerations

Baer's desktop review included both historic and archeological considerations. The review included national and state databases and inventories, aerial maps, and surveys. Based on this review, there is a potential for the associated structures of all six sites to be considered eligible for the National Register of Historic Places (NRHP) since the facilities are of historic age and may retain historical significance. Historically, construction of dams and associated structures was essential for the development of early water-powered industries and communities, agricultural irrigation and flood control. The six project dams retain features that demonstrate significant engineering practices and design and played a role in forging the development of the surrounding communities. Additional historic features were observed near but not within the project impact areas and are not likely to be impacted by remediation of the gates.

Based on the geologic and geotechnical categorizations of each of the six sites, archeological surveys will likely be requested by the THC due to their likelihood of containing intact archeological deposits. The desktop review indicated that there have been no previous archaeological investigations or previously-recorded sites within the project impact area of all six sites. However, at TP-4 there is one nearby potentially significant archeological site – a prehistoric campsite located on an alluvial terrace on the south side of the dam – sited within the 150 ft buffer zone outside the project area the horizontal boundaries for which are not certain. In 2010, the THC determined that this site is not nationally registered. Coordination with the THC once preliminary design plans are in place will inform the extent to which addition investigations must be conducted.

2.9 FIELD SURVEY OF H-5

In December 2018, a field survey was completed at H-5 to establish elevations of existing surfaces and structures for use during final design. The survey was performed by JQ Infrastructure, LLC (JQ). A survey map has been produced with one foot contours locating property boundary lines and permanent improvements such as buildings, structures, and other facilities. A representation of the survey map is included in Figure 2-9 and Appendix A.

The field survey identified on-site survey benchmarks and permanent monuments on each side of the dam to serve as baseline for the survey and reference points for the General Contractor. Vertical survey data has been surveyed relative to the North American Vertical Datum of 1988 (NAVD88). Horizontal survey data has been surveyed relative to the North American Datum of 1983 (NAD 83), South Central Zone-5401. The datums used as well as benchmark coordinates will be documented on the final drawings. The vertical datum used for the site survey (NAVD88) is that which is typically used for modern surveying. NAVD88 does not match that of the original 1930 design drawings. An approximate adjustment of the vertical datum is NAVD88 = original 1930 drawing elevations + 0.3 ft., i.e. top of concrete EL 303.0 ft from 1930 drawings = EL 303.3 NAVD88.

From a review of the 2010 field survey data and this 2018 field survey, it has been determined that the elevations used in the GBRA SCADA system do not match the vertical datum of either the original H-5 drawings or NAVD88. An approximate adjustment of the vertical datum is NAVD88 = H-5 SCADA – 0.3 ft., i.e. H-5 full pond of 291.6 SCADA = 291.3 NAVD88.

The survey has identified property boundaries adjacent to and extending beyond the H-5 site. Permanent monuments locating property corners were located in the field and documented on the site survey. Property boundaries adjacent to the H-5 site are shown on Figure 2-10.

Easements on and extending beyond the H-5 site will be identified and included on the survey map. The identification of easements is not yet complete and this work is ongoing.

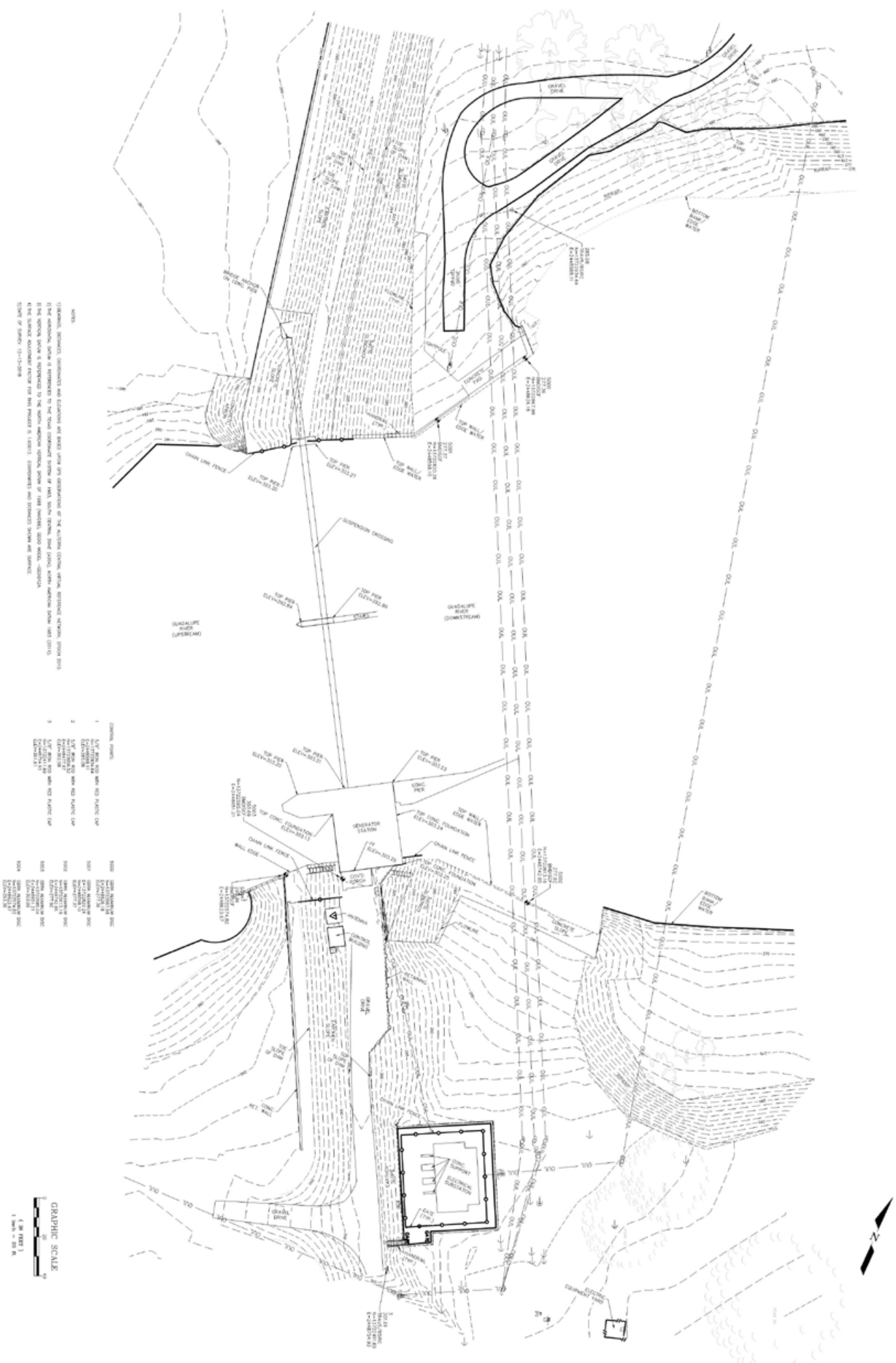


Figure 2-9 Topographic Survey of H-5

Figure 2-10 Property Boundaries Adjacent to H-5

A bathymetric survey of the river extending 100 feet upstream and downstream of the spillway was scheduled to be performed at the time of the field survey. The volume of flow passing over the H-5 spillway in December 2018 prevented the bathymetric survey from being performed at that time. The bathymetric survey has been tentatively rescheduled for the summer of 2019 pending favorable flow conditions.

3.0 Overall Program Definition

GBRA has previously evaluated alternative control gate options for the H-5 dam spillway and has selected hydraulically actuated crest gates as the preferred solution. This Preliminary Design Report provides a preliminary program to implement hydraulically actuated steel crest gates at the six similarly configured hydroelectric dams in the GBRA system.

3.1 SYSTEM WIDE IMPLEMENTATION OF IMPROVEMENTS

3.1.1 Hydraulics

As described in detail in the subsequent section of this report, replacement of the gates with hydraulically actuated crest gates will require structural modifications to the existing spillway structure. Required structural modifications include widening the intermediate pier and extending the abutment. These changes will result in a narrower gate opening.

The FEMA Flood Insurance Rate Maps indicate that a floodway has been defined for the Guadalupe River at the locations of the six dams. Federal regulations prohibit new construction or substantial improvements within the adopted regulatory floodway unless it is demonstrated that the proposed encroachment would not result in any increase in flood levels during the occurrence of the base flood discharge. The base flood is defined as the flood that has one percent annual exceedance probability (one percent chance of occurring any given year). The base flood is informally referred to as the 100-year flood.

Therefore, to comply with Federal regulations and to prevent increasing flood risks further modifications to the gate openings are required. To compensate for the anticipated narrower gate opening the gate sill will need to be lowered. A lowered sill would allow maintaining the gates' spill capacity and thus, not increase flood levels during the 100-year flood. Because the sill will be lowered, taller gates will be needed to maintain current operational water levels upstream of the gates. The existing gates are 12 feet tall. Gates at four of the six spillways have flashboards which add an additional 0.7 feet to the height of the gates. To maintain spill capacity equivalent to that of the existing gates, hydraulic analysis indicates that the new gate sills will need to be 1.5 feet lower than the sills of the exiting gates. Thus, the height of the new gates will be no less than 12 ft + 0.7 ft + 1.5 ft = 14.2 ft.

Bathymetric surveys show that a large scour hole has formed downstream of the H-5 spillway. Hydraulic conditions have been evaluated to determine if the proposed modifications could result in significant additional scour. Options for mitigation of scour have been developed.

3.1.2 Structural

Replacement of the existing bear trap style crest gates with modern hydraulically actuated crest gates will require structural modification of the existing spillway. Structural modifications are required to both strengthen the spillway and to provide stability of the spillway in accordance with modern standards. New concrete added to the spillway will be designed to optimize flow through the spillway and provide a long service life with minimal maintenance. A pedestrian bridge will be included in the design to allow for inspection and maintenance access to the hydraulic cylinders and to provide a protected location to route hydraulic lines and control wiring to each hydraulic cylinder. The bottom of the new bridge will be set at EL 310.0 ft. At this elevation the lowest point on the bridge will be approximately 9 feet above the elevation of the 100-year flood, high enough so as to not be hit by debris during river flooding. The high point of the bottom of the existing suspension bridge is at EL 309.5 ft.

The new crest gates will transfer load to the spillway structure much differently than the existing bear trap style gates. Load from the existing gates is distributed evenly across the width of the spillway. Load from the new gates and hydraulic cylinders will be concentrated into the intermediate piers and abutments. Additional concrete will be added to the intermediate piers and abutments to strengthen them to support the concentrated loads from the hydraulic cylinders. Concrete will also be added to raise the top of the intermediate piers above the flood level of the river. Raising the top of the intermediate piers will protect the hydraulic cylinder from debris impact during river flooding.

The concrete added to strengthen the intermediate piers also increases the stability of the piers. The hydraulic cylinders which support the gates impart on the piers very large forces. The mass of the additional concrete is required to resist sliding and overturning of the piers. Likewise, concrete will be added to the entire width of the spillway. This concrete will be used to both anchor the new gates and to provide the mass required to resist sliding of the spillway in accordance with modern design standards. Figure 3-1 shows the typical isometric view of the proposed spillway gate modification.

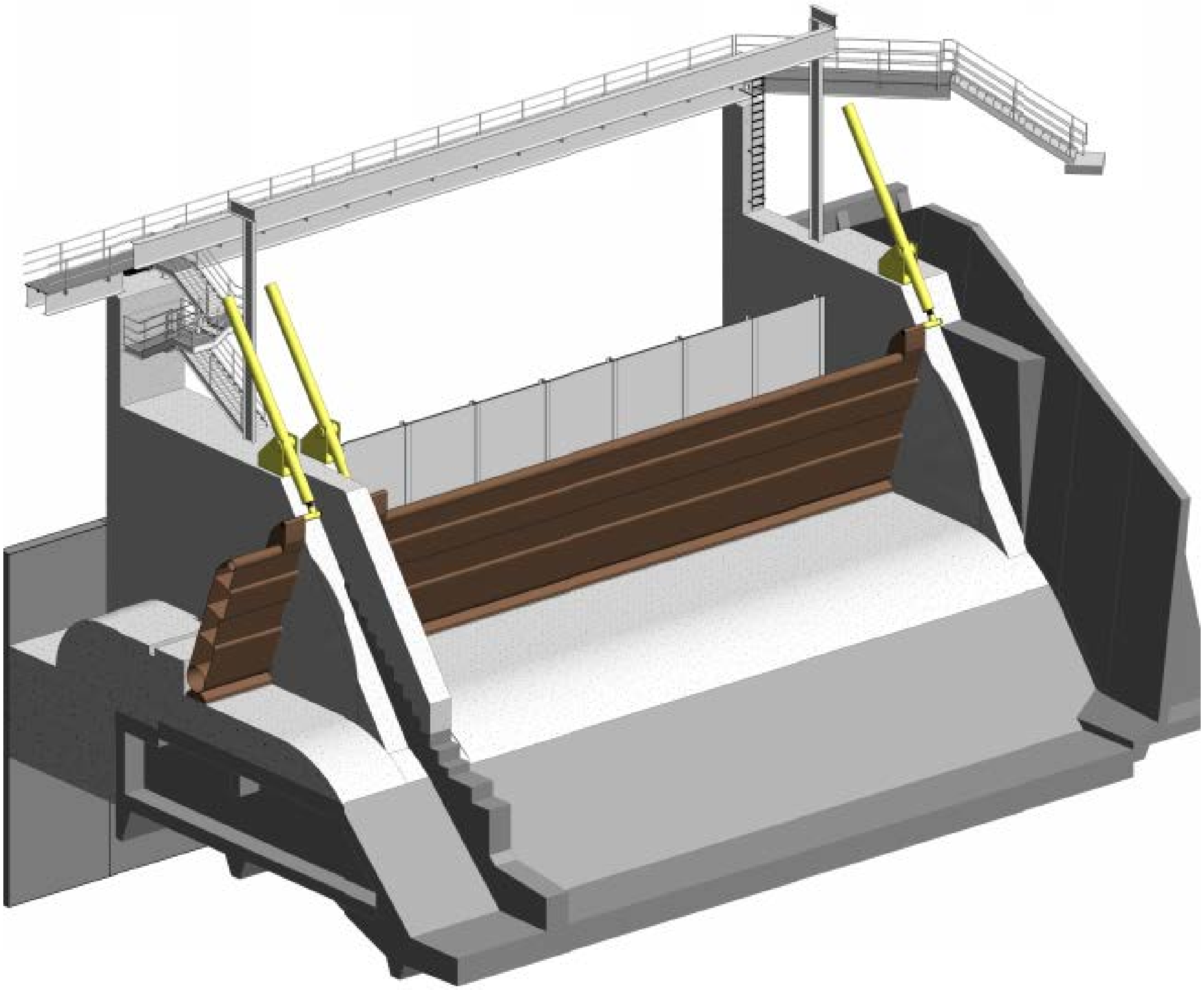


Figure 3-1 Spillway Isometric

3.1.3 Mechanical

The existing spillway gates will be removed and replaced with new crest gates. The new gates will be raised and lowered using hydraulic cylinders. Each gate will have two hydraulic cylinders, one at each end of each gate. The hydraulic cylinders will be powered by an HPU. All components of the system will be rated to operate at 3,000 pounds per square inch (psi). The reservoir for the hydraulic fluid, hydraulic pumps, manifolds, valves, piping, and local control panel will be assembled and factory tested before shipping. It is recommended that the HPU be transported fully intact and without oil. This would avoid introducing contamination and disassembling a system which has already been shop tested. The assembled HPU's will fit through a standard double door. The estimated maximum weight of the HPU is 3,000 pounds without oil.

The system will be configured with two 25 horsepower pumps and motors. The HPU will be piped and manifolded so that either pump can operate any of the gates but only one pump runs at any given time and the second pump remains in stand-by. The electric power required to operate either pump is 25 horsepower. This amount of power will raise and lower one gate at a time at approximately 2.5 ft per minute. If two gates are raised simultaneously the speed would be reduced to approximately 1 ft per minute. The HPU footprint is approximately 4 ft wide x 6 ft tall x

6 ft long. The reservoir will be approximately 4 ft wide x 3 ft tall x 6 ft long. The bottom of the reservoir will be approximately 3 ft off the floor and supported by members in 4 corners. The skid assembly to which the equipment is mounted will include an integral drip pan.

The 4 ft x 6 ft x 6 ft HPU is based on 3 gates and 6 cylinders. The volume of oil required for the 3 gate system is approximately 500 gallons. The 500 gallons includes approximately 25 percent reserve capacity. The spillways at TP-4, H-4, and H-5 each have 2 gates rather than the 3 gates present at Nolte, TP-3, and Dunlap. Fewer gates would allow the hydraulic oil reservoirs at TP-4, H-4 and H-5 to be 300 to 350 gallons rather than the 500 gallons required at Nolte, TP-3, and Dunlap. It would be possible to make the 2 gate HPU a little shorter but the 4 ft width would remain to provide enough space to fit two motors and pumps. This would provide for some amount of standardization between the HPU's at all six sites.

The estimated hydraulic cylinder bore size is 14 in to 16 in depending on the final cylinder arrangement. The existing spillway gates at TP-4 are 98 ft-9 in wide rather than the 85 ft width at the 5 other sites. The increased gate width increases the required actuator force by approximately 16 percent. This additional force can be accommodated by the same cylinder size while still staying within the 3,000 psi pressure rating of the system.

There are many potential choices for hydraulic fluid for the system. Consideration should be given to performance of the fluid, environmental considerations, and fire resistance. The recommended fluid is PAG (polyalkylene glycol) such as American Chemical Technologies Neptune fluid. PAG was originally used by the Navy in World War II as a fire resistant hydraulic fluid. It is an Environmentally Acceptable Lubricant (EAL), meets the Vessel General Permit (VGP) and has been become widely used in the marine industry to meet Environmental Protection Agency (EPA) regulations since it meets the EPA's definition of an EAL. This is one of the few EAL's that has outstanding oxidation resistance. The oxidation resistance gives the fluid a long life. It is non-sheening. It is a good fluid when used in a new system. This fluid is typically not the best choice when replacing fluid into an old system because of oil compatibility issues. This fluid can accommodate Buna-N seals though Viton seals would be a recommended for this application. Figure 3-2 shows the preliminary layout of hydraulic power unit.

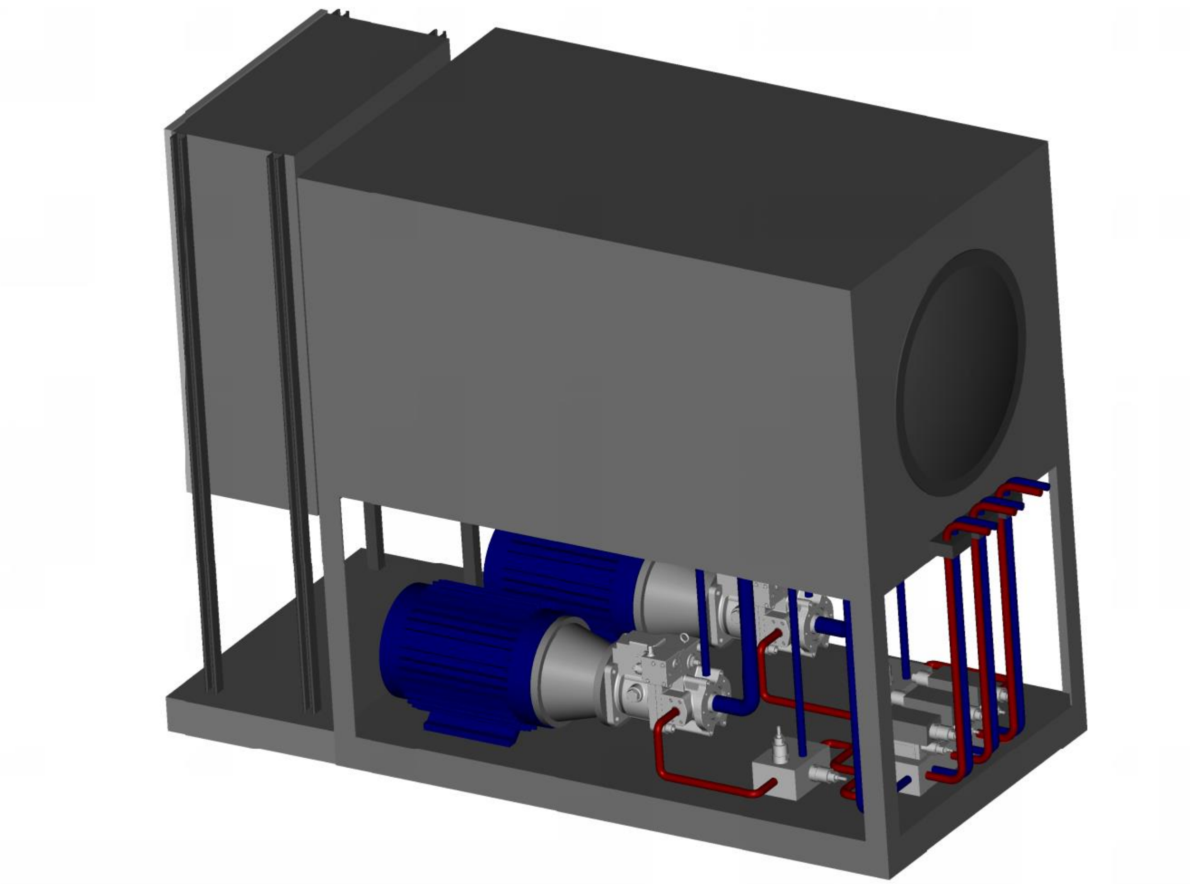


Figure 3-2 Preliminary Layout of Hydraulic Power Unit

Introducing 500 gallons of this oil into the existing buildings creates no building code related issues. Upon review of the recommended hydraulic fluid (American Chemical Technologies Neptune) Safety Data Sheets, we have found the following information:

- Flash point of this material is 491^{0}F per ASTM D92.
- Per National Fire Protection Association (NFPA) 30, this is considered a Class III B Combustible Liquid.
- Per International Fire Code (IFC) 2012, the exempt amount is 13,200 gallons if storage or in a closed system, and 3,200 gallons in an open system. The hydraulic systems would be considered a closed system.
- NFPA 30, Chapter 7 Electrical Systems, applies when the material is stored at or above its flashpoint. As the flashpoint is 491 degrees Fahrenheit, Chapter 7 does not apply.

With the addition of this amount of oil in the buildings it is suggested that the Spill Prevention Control and Countermeasures plan (SPCC) be updated or one developed for each site.

3.1.4 Electrical

Existing electrical distribution power at all sites is not configured and, in some cases, is insufficient to supply 480 volt three phase power to the new HPUs associated with the new gates. Existing distribution is 120/240 volt single phase at all sites.

The local electric utility furnishes power to Nolte and Dunlap at 120/240 volt single phase. These sites will require a new 480 volt three phase service from the utility. A new three phase power panel will feed the HPUs as well as a new step-down transformer. The step-down transformer will in turn feed the existing single-phase panel. See Power Distribution Functional Diagram Figure 3-3 and Appendix B.

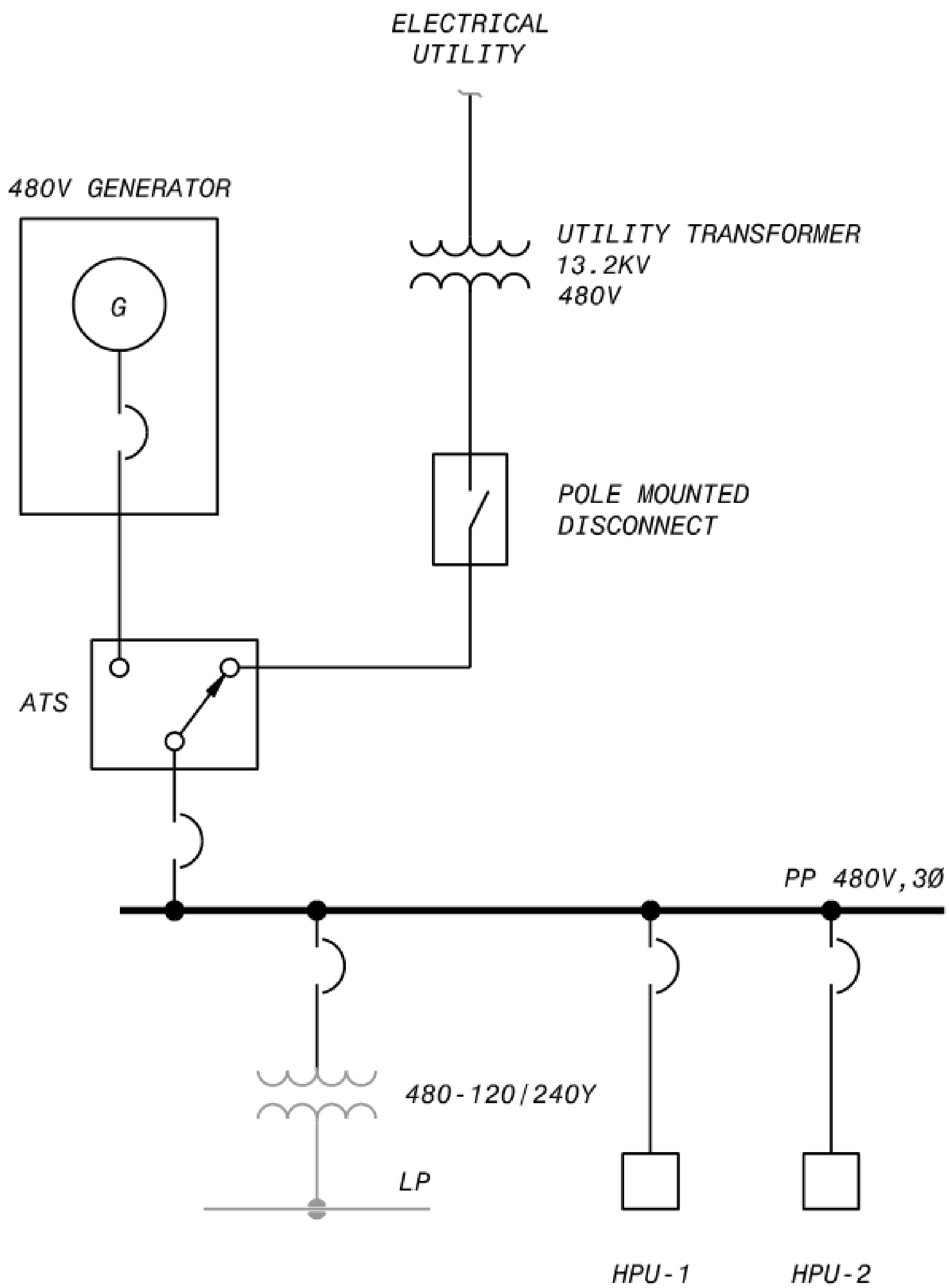


Figure 3-3 Power Distribution Functional Diagram for Dunlap and Nolte

The incoming power from the local electric utility at all other sites is 2,400 volt. Fused cutout switches at 2,400 volt are connected to existing transformers which step the voltage down to 120/240 volt single phase to feed an existing panelboard. Similar to the existing fused cutout switches, new switches will be added for connection to a new 2,400 volt-480 volt dry type transformer. The new transformer will feed a new 480 volt power panel sized to supply power to the HPUs. See Power Distribution Functional Diagram Figure 3-4 and Appendix B.

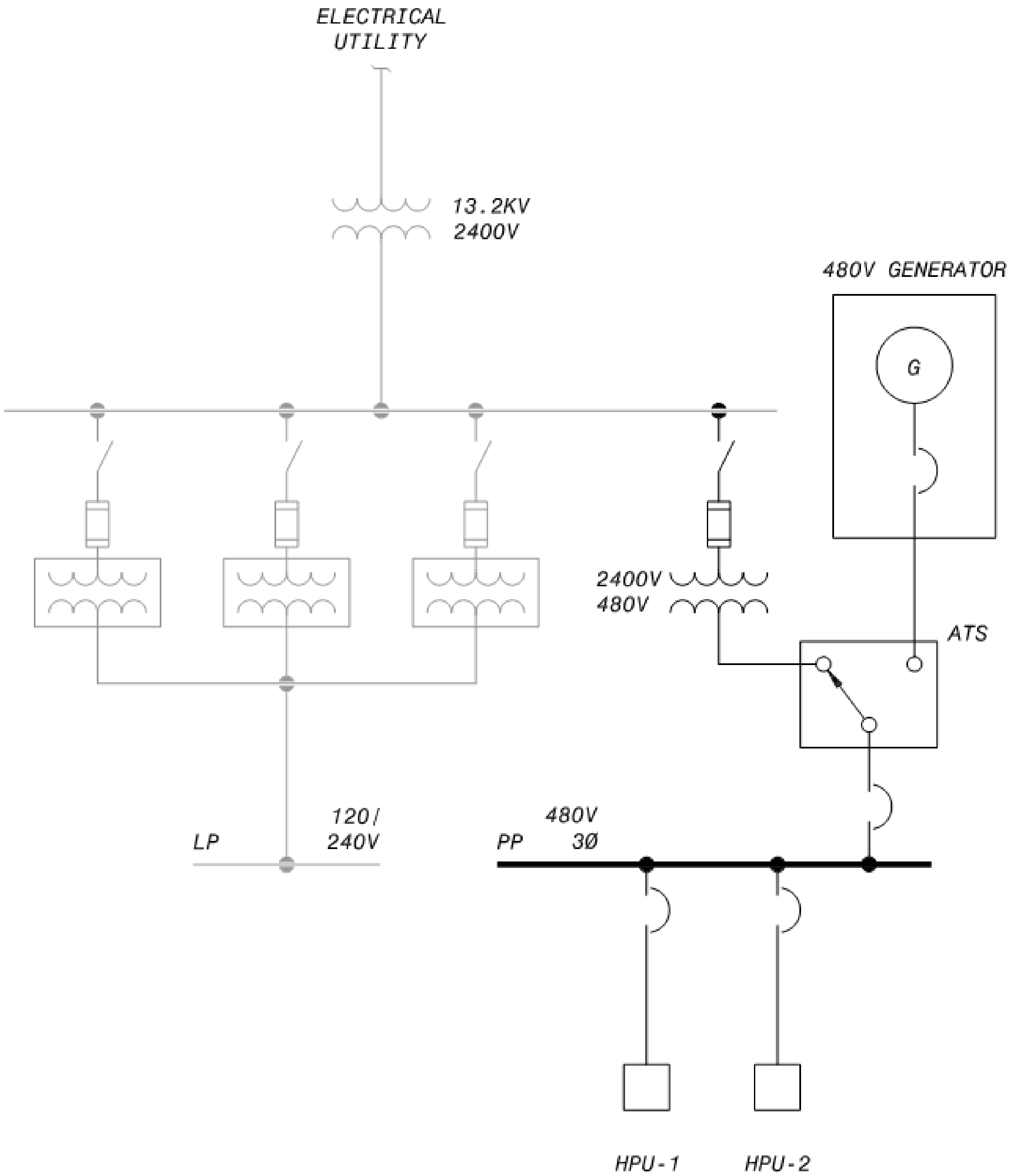


Figure 3-4 Power Distribution Functional Diagram for TP-3, TP-4, H-4, and H-5

3.1.5 Back-up Power

Backup power for single phase loads is currently provided by a propane generator and automatic transfer switch at most sites. This back-up system is insufficient to power the primary pumps of the HPU. In the event of loss of 480 volt power to the HPU's, the gates could begin to slowly lower as a result of hydraulic fluid leakage within the HPU system. The valve and manifold systems of the HPU will be designed to hold the gates in position without requiring the HPU to run. However, as the system ages leakage past the valves and seals may develop. To prevent the gates from creeping downward during a power outage a source of back-up power should be considered. There are several options for back-up power to be considered.

Do Nothing – There are factors which make this a viable alternative; initial leakage within the HPU might by negligible and a minor temporary lowering of the level of Lake Wood might be acceptable during a power outage. Unknown risks include frequency and duration of power loss. The estimated capital cost of this option is $0. However, there may be indirect costs associated with the potential temporary lowering of a lake.

Accumulator Tanks – A hydraulic accumulator system consists of a pressure tank and a flow control valve. The pressurized tank stores energy to maintain gate position in the event of a power loss. The control system would be programmed to maintain gate position based on gate position feedback. A battery system would be required to maintain power to the control system. The duration that an accumulator can maintain gate position is highly variable and depends on the actual leakage rate and the size of the accumulator(s). One day of maintaining gate position is realistic but this could vary greatly if hydraulic cylinder leakage is higher than expected. The estimated capital cost of an accumulator system varies based on the size and complexity of the system but could be expected to be in the range of $10,000 - $40,000.

New 480 Volt 3 Phase Propane Generator – A new propane generator set capable of starting the HPU's 25 horsepower pump motors is the most expensive option, but would retain full operational capability of the gates upon loss of primary power. This option would require a new generator set, larger propane tank, transfer switch, and possibly a new step-down transformer. The installed cost of this option is expected to be in the range of $50,000 - $80,000.

240 Volt Back-up Motor and Pump – The HPU can be provided with a low horsepower 240 volt motor and pump. The motor size would be selected based on the capacity of the existing propane generator. It is expected that the size of this motor would be on the order of 1 horsepower. A 1 horsepower pump would have enough capacity to keep up with normal anticipated leakage for the gate system. The pump would have capacity to very slowly raise or lower the gates if that were needed during loss of power. The estimated capital cost of this option is expected to be in the range of $5,000 - $20,000. The footprint size of the HPU would remain the same.

New 480 V 150 kW generators and appurtenances have been included in the construction cost estimates for back-up power.

3.1.6 Instrumentation and Control

Instrumentation and control for all dams will have similar equipment and functionality. Instruments will consist of level measurement devices and accessories associated with the HPU and gate actuators. Control will be through a Programmable Logic Controller (PLC). A typical piping and instrumentation diagram (P&ID) is shown in Figure 3-5. Site specific P&ID's are included in Appendix C.

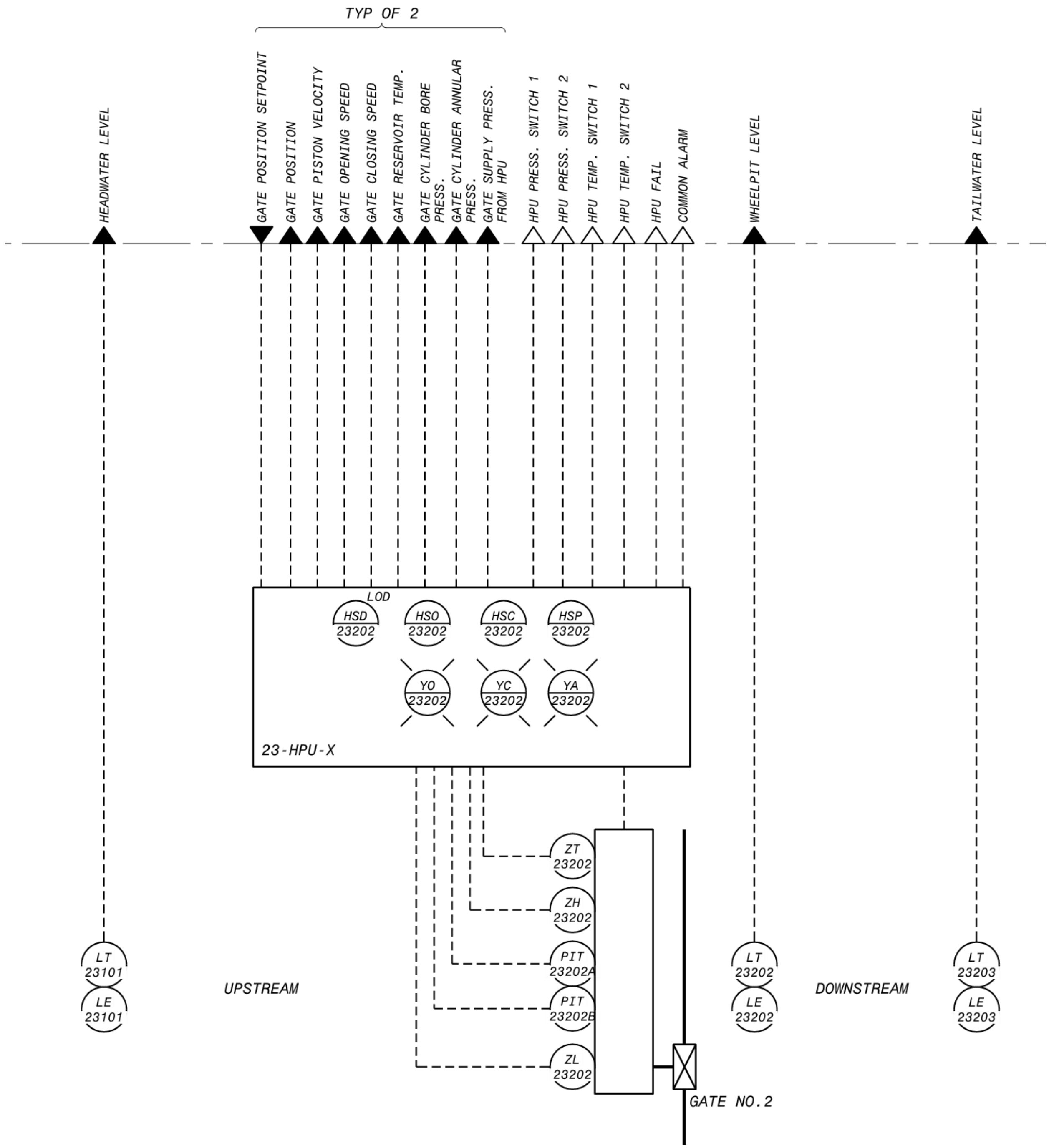


Figure 3-5 Typical Piping and Instrumentation Diagram

3.1.6.1 Level Instruments

All dams are currently equipped with level instruments measuring the dam headwater level. Some of the dams are equipped with a wheelpit level instrument. Existing headwater and wheelpit level instruments are float type devices. Tailwater levels, when measured, utilize either a bubbler level device or a float level device. Some of these devices are damaged and are not functioning correctly.

New headwater, tailwater, and wheelpit level monitoring devices will be included in the design. GBRA is currently using float type level instruments manufactured by Varec, model 2500 Automatic Tank Gauge installed in stilling wells. These devices occasionally need a manual adjustment to reset the float device and this is accomplished by twisting a nob on the face of the level transmitter. This manual adjustment makes these devices suitable for local operation of the gates but not for remote operation of the gates. A combination of level instruments is therefore recommended. New headwater and wheelpit level devices should utilize an ultrasonic type level transmitter in a stilling well. A redundant level measurement is recommended to measure the headwater and with the second level transmitter being either an ultrasonic type level transmitter in a stilling well or a radar type level transmitter in a stilling well. Utilizing a stilling well for the level transmitters protects against false level readings that may be introduced from floating debris.

Tailwater level measurement will depend on the dam configuration. When possible a single ultrasonic type level instrument will be utilized. If conditions at the dam prevent the use of float type level instrument a bubbler or pressure sensing level device will be used. Specific instrumentation will be determined during design as conditions may change before detailed design commences.

3.1.6.2 Gate Controllers

The gate controllers will consist of the gate actuator and HPU. Instrumentation associated with this equipment will be provided by the manufacturer of the equipment. All instrumentation devices should be installed and wired to and terminated to a single location on the equipment.

3.1.6.3 Control

All dams are equipped with an existing Allen Bradley CompactLogix L23. Existing equipment including generators, gate actuators, and level transmitters, that have input/output (I/O) signals are wired to the existing PLCs. Each of the existing PLCs have been evaluated to determine if the PLC has enough spare I/O available to accept the additional signals from the added HPU, gate controller, and in some instances, a new emergency generator and ATS. See individual piping and instrumentation diagrams, in Appendix C, showing additional I/O needed to monitor and control new gate equipment.

When possible existing spare I/O and I/O that have been deemed reusable on existing I/O modules will be used first. If there are not enough I/O or an I/O module does not exist, additional modules will be added to the PLC, if there is adequate space within the enclosure. If adequate space does not exist, then a remote I/O enclosure will be added to accommodate all I/O and type of I/O.

3.1.6.4 Video

GBRA desires to integrate video looking at key elements of the dam. Specific viewing angles will be determined during design with significant input from GBRA. Video cameras will be Internet Protocol (IP) based and use the current video technology available at the time and within the GBRA guidelines and standards that exist at the time of design. Video cameras may incorporate the use of pan-zoom-tilt depending on the communication capabilities, physical location of the camera, and necessity of the camera viewing area.

Video will use GBRA's existing communication system to transmit video from the dams to the central control center in Seguin. Most of the communication infrastructure is currently installed with a few exceptions. H-4 and H-5 dams currently do not have the communication towers or communication equipment to transmit video. Additional communication equipment will need to be installed to transmit video. Prior to design at the various dams, the communication system may be upgraded from a different project, communication design effort will be determined at the time of design for each dam.

3.2 CONCEPTUAL PLANS AND SECTIONS FOR EACH SITE

Existing bear trap style gates will be replaced with hydraulically actuated crest gates at all six sites. While the solution to be implemented is the same at all sites, the uniqueness of each location must be considered for successful implementation.

3.2.1 Dunlap

The gate control house for the Dunlap spillway is located on the left embankment of the river. Plan dimensions of the gate control house are approximately 12.5 ft by 28 ft. The inside dimensions of the gate control house are adequate to accommodate a new HPU. The existing exterior door is too small to get the new HPU into this space, but modifications can be made to the building to install the new equipment. Refer to Figure 3-6 and Figure 3-7 for an overview of the Dunlap site and gate control house floor plan.

The existing 3 bear trap style gates, 85 feet wide by 12 feet tall, will be replaced with 3 hydraulically actuated crest gates 79 feet wide by 14 feet tall. Structural modification of the spillway will be required to both provide the strength needed to support the new gates and to meet modern standards for spillway stability. Refer to Figure 3-8 for a cross section of the proposed modifications.

Construction staging areas are present upstream and downstream of the left embankment and to a lesser degree on the right embankment. Dunlap Dam impounds water for two large regional water supply intakes. Thus, Lake Dunlap cannot be drained to facilitate construction.

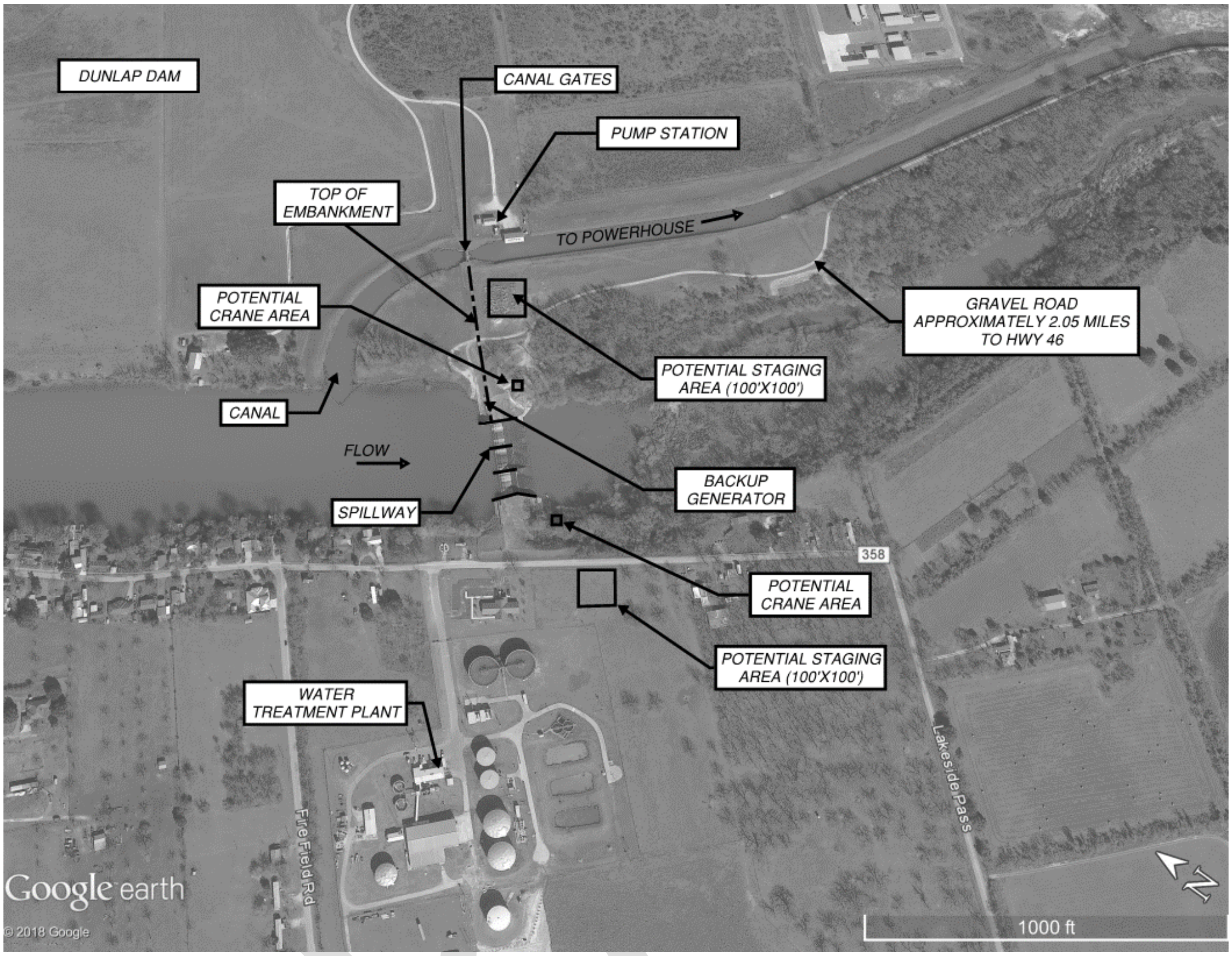


Figure 3-6 Dunlap Spillway Site Plan

The Dunlap gate control house will require a new 480 volt three phase service from the utility. A new three phase power panel will feed the HPU as well as a new step-down transformer. The step-down transformer will in turn feed the existing single-phase panel. The PLC will need to be expanded with additional modules to accommodate new I/O from the HPU and gate actuators.

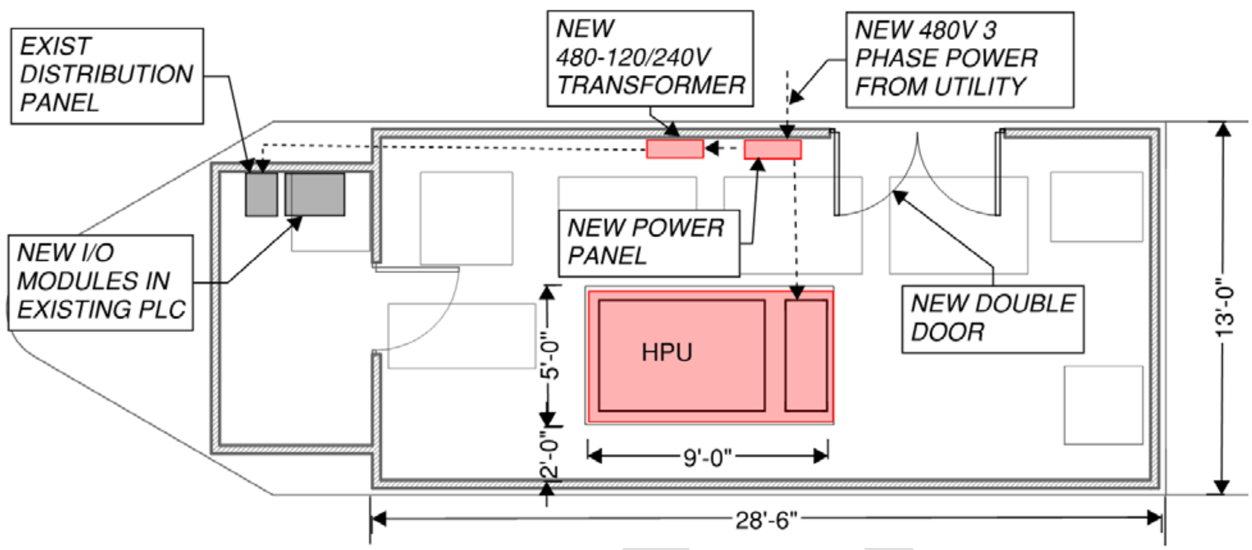


Figure 3-7 Dunlap Building Plan

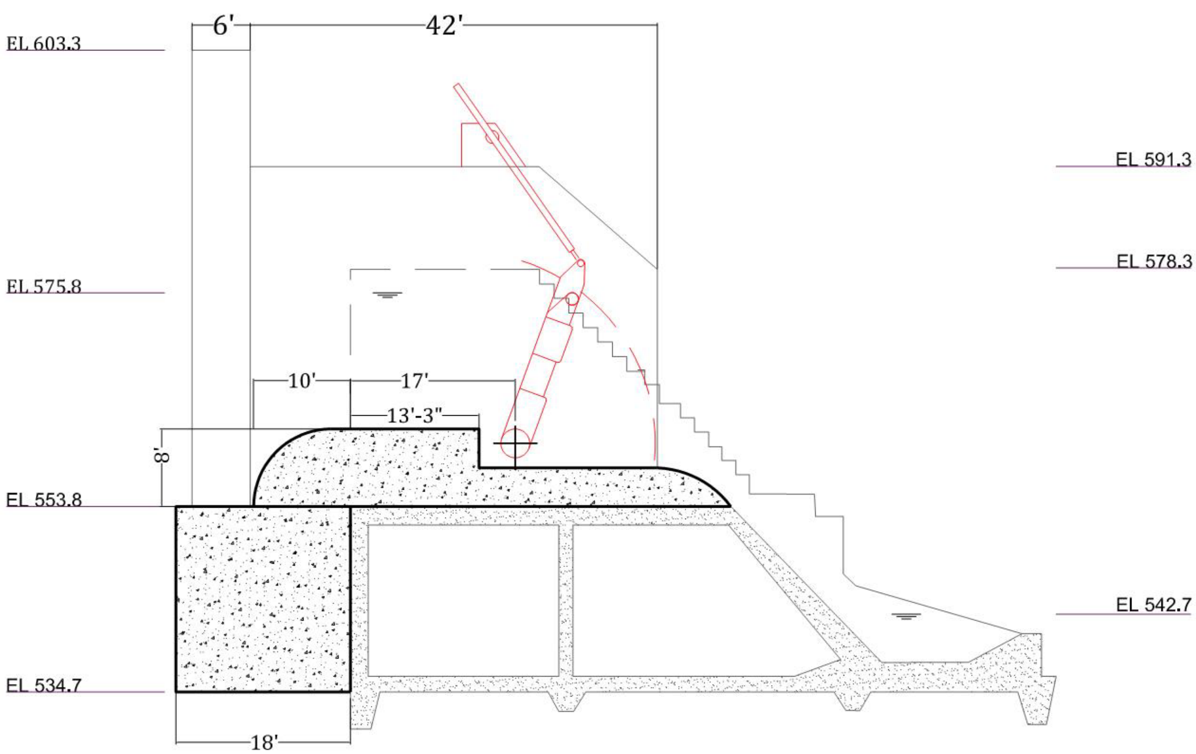


Figure 3-8 Dunlap Spillway Section

3.2.2 TP-3 (Lake McQueeney)

The gate control house for the TP-3 spillway is located on the right embankment of the river and adjacent to the TP-3 powerhouse. The gate control house is accessed through the powerhouse and up a flight of concrete stairs. Plan dimensions of the gate control house are approximately 13 ft by 37 ft. The inside dimensions of the control house are adequate to accommodate a new HPU. However, there is no direct access path to this room from land or through the powerhouse. The HPU could be moved into place using a crane or unloaded from a barge or boat with a new monorail hoist installed in the room. Refer to Figure 3-9 and Figure 3-10 for an overview of the TP-3 dam site and gate control house floor plan.

The existing 3 bear trap style gates, 85 feet wide by 12 feet tall, will be replaced with 3 hydraulically actuated crest gates 79 feet wide by 14 feet tall. Structural modification of the spillway will be required to both provide the strength needed to support the new gates and to meet modern standards for spillway stability. Refer to Figure 3-11 for a cross section of the proposed modifications

North site access is provided immediately off Bamboo Bluff Drive, a residential road. South site access is provided immediately off of FM 725. A residential area is situated immediately upstream of the left embankment, with docks less than 200 ft from the spillway. A small staging area for construction is present on the north side of the site, downstream of the left embankment. Limited space is available on the south side of the site.

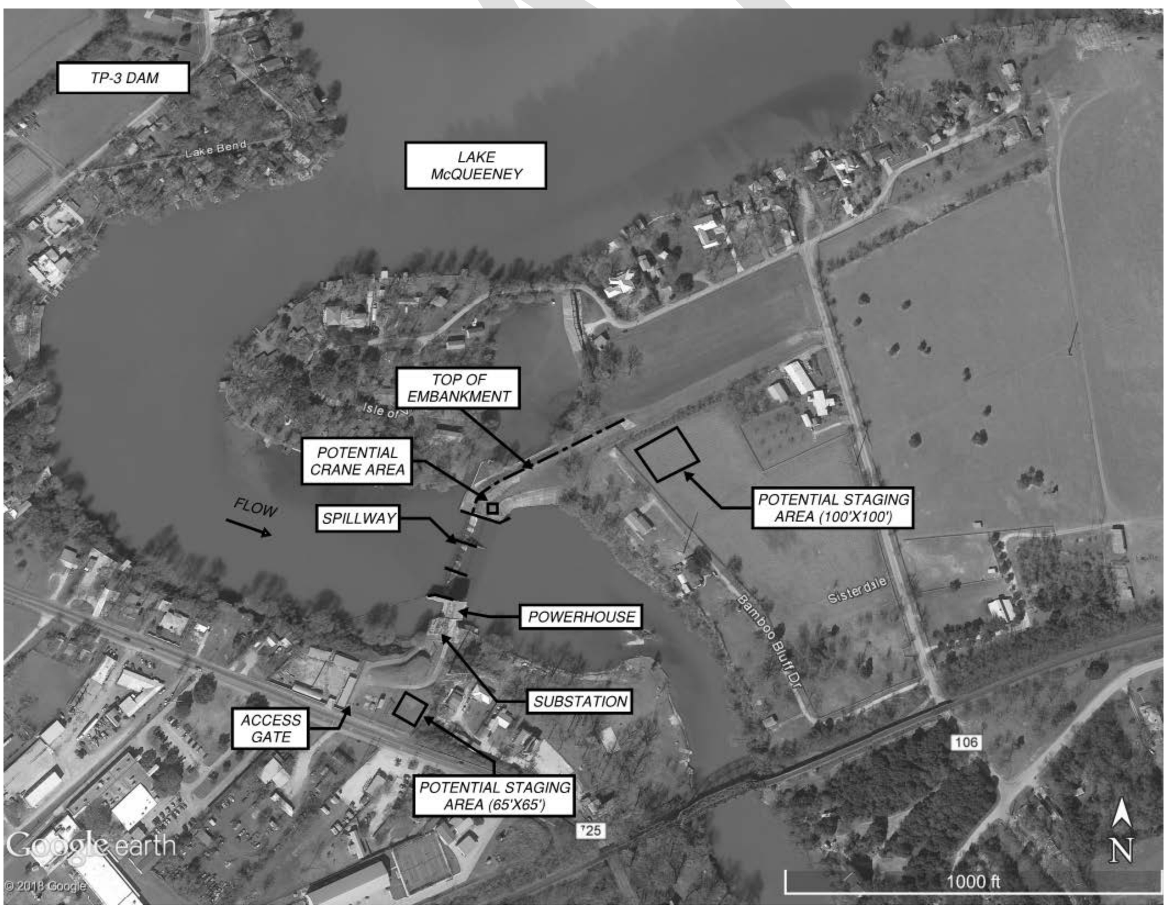


Figure 3-9 TP-3 (Lake McQueeney) Spillway Site Plan

The incoming power from the local electric utility at TP-3 is 2,400 volt. Fused cutout switches at 2,400 volt are connected to existing transformers which step the voltage down to 120/240 volt single phase to feed an existing panelboard. Similar to the existing fused cutout switches, new switches will be added for connection to a new 2,400 volt-480 volt dry type transformer. The new transformer will feed a new 480 volt power panel sized to supply power to the HPU.

The PLC will need to be expanded with additional modules to accommodate new I/O from the HPU and gate actuators. In order to support video at the dam, the communication system needs to be enhanced to support greater bandwidth. The communication system will be evaluated during design.

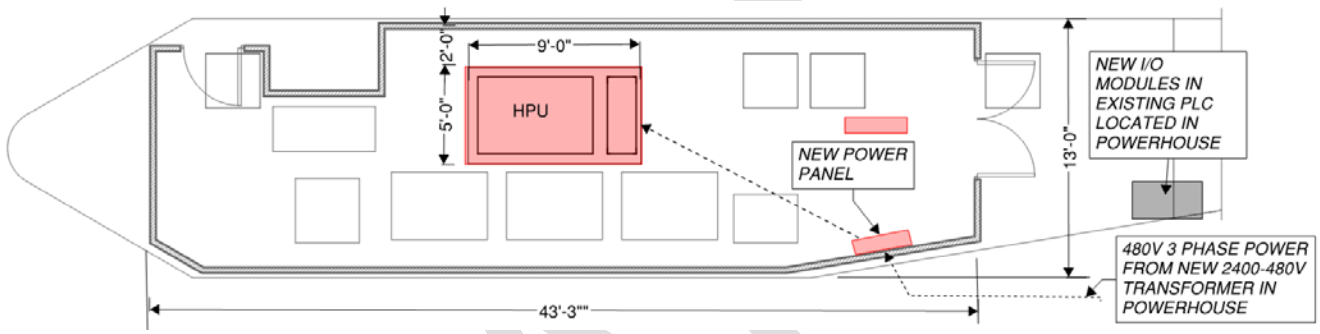


Figure 3-10 TP-3 (Lake McQueeney) Building Plan

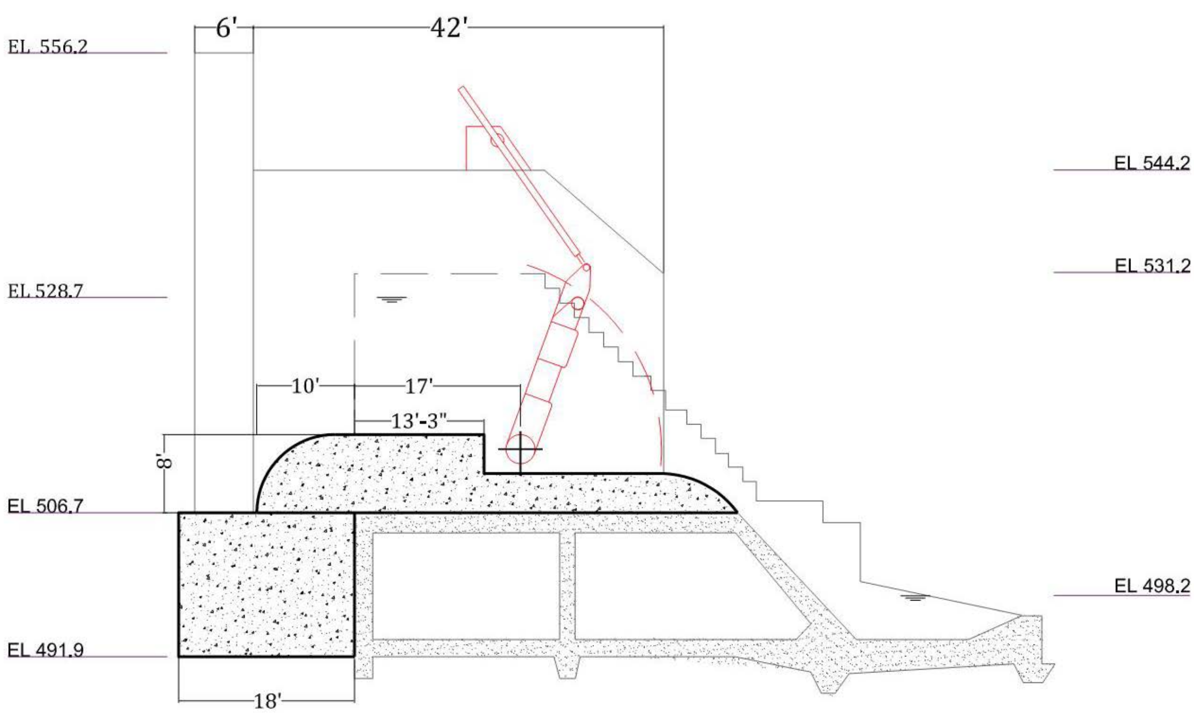


Figure 3-11 TP-3 (Lake McQueeney) Spillway Section

3.2.3 TP-4 (Lake Placid)

The TP-4 powerhouse is located on the right embankment adjacent to the spillway and contain the existing actuators which control flow through the spillway gates. The valve room, which is adjacent to the powerhouse floor, is 12 ft by 9 ft. The inside dimensions of the valve room are adequate to accommodate a new HPU. Alternatively, the HPU could be located on the end of the powerhouse floor in a space which is 25 ft long by over 6 ft wide. Refer to Figure 3-12 and Figure 3-13 for an overview of the TP-4 dam site and powerhouse floor plan.

The existing 2 bear trap style gates, 98 feet wide by 12 feet tall, will be replaced with 2 hydraulically actuated crest gates 92 feet wide by 14 feet tall. Structural modification of the spillway will be required to both provide the strength needed to support the new gates and to meet modern standards for spillway stability. Refer to Figure 3-14 for a cross section of the proposed modifications

North site access is provided immediately off Lakeview Drive. South site access is provided by an approximately 1.4 mile long gravel service, entered from the west from FM 725. Construction staging areas are present on the downstream of the left embankment and on both the upstream and downstream sides of the right embankment. More space is available to the south, but adjacent facilities may limit use.

Lake Placid provides water to Springs Hill Water – a private water supply company – and the intake for a steel mill. Thus, Lake Placid cannot be drained to facilitate construction.

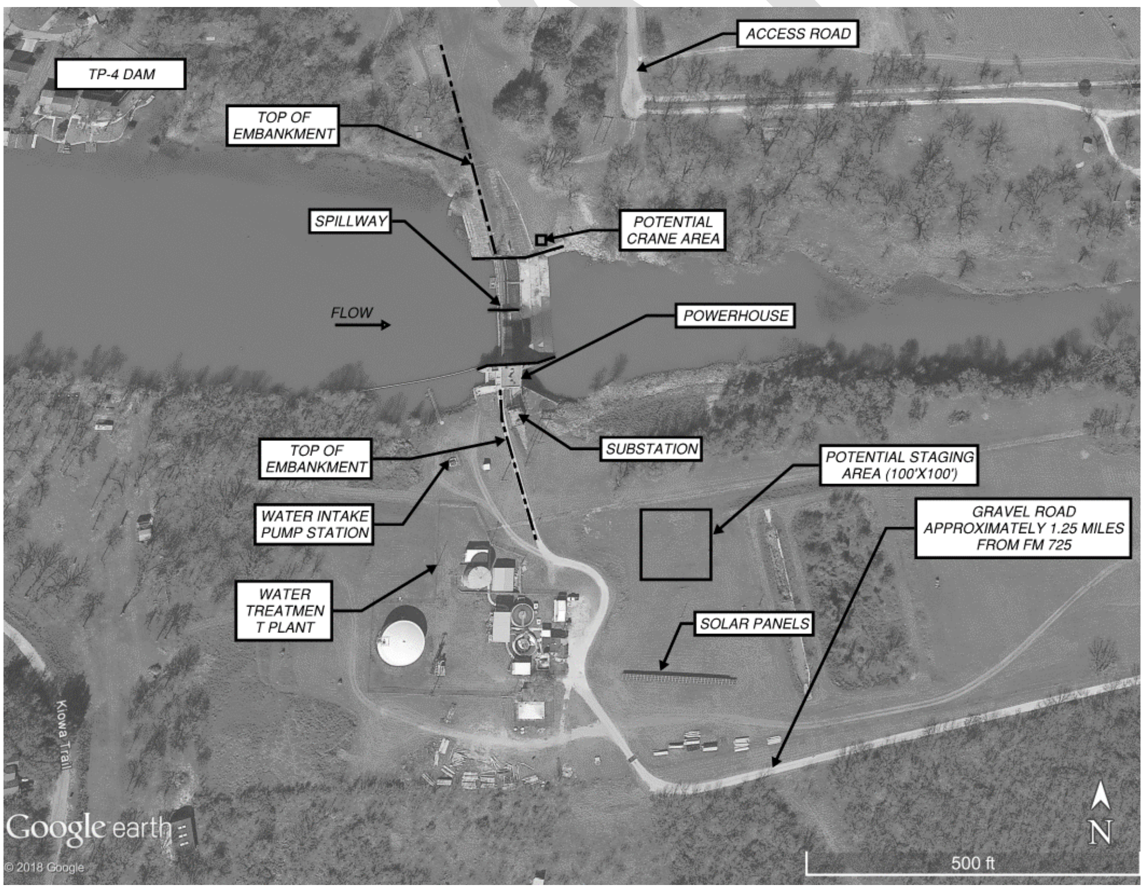


Figure 3-12 TP-4 (Lake Placid) Spillway Site Plan

The incoming power from the local electric utility at TP-4 is 2,400 volt. Fused cutout switches at 2,400 volt are connected to existing transformers which step the voltage down to 120/240 volt single phase to feed an existing panelboard. Similar to the existing fused cutout switches, new switches will be added for connection to a new 2,400 volt-480 volt dry type transformer. The new transformer will feed a new 480 volt power panel sized to supply power to the HPUs

The PLC will need to be expanded with additional modules to accommodate new I/O from the HPU and gate actuators. In order to support video at the dam, the communication system needs to be enhanced to support greater bandwidth. The communication system will be evaluated during design.

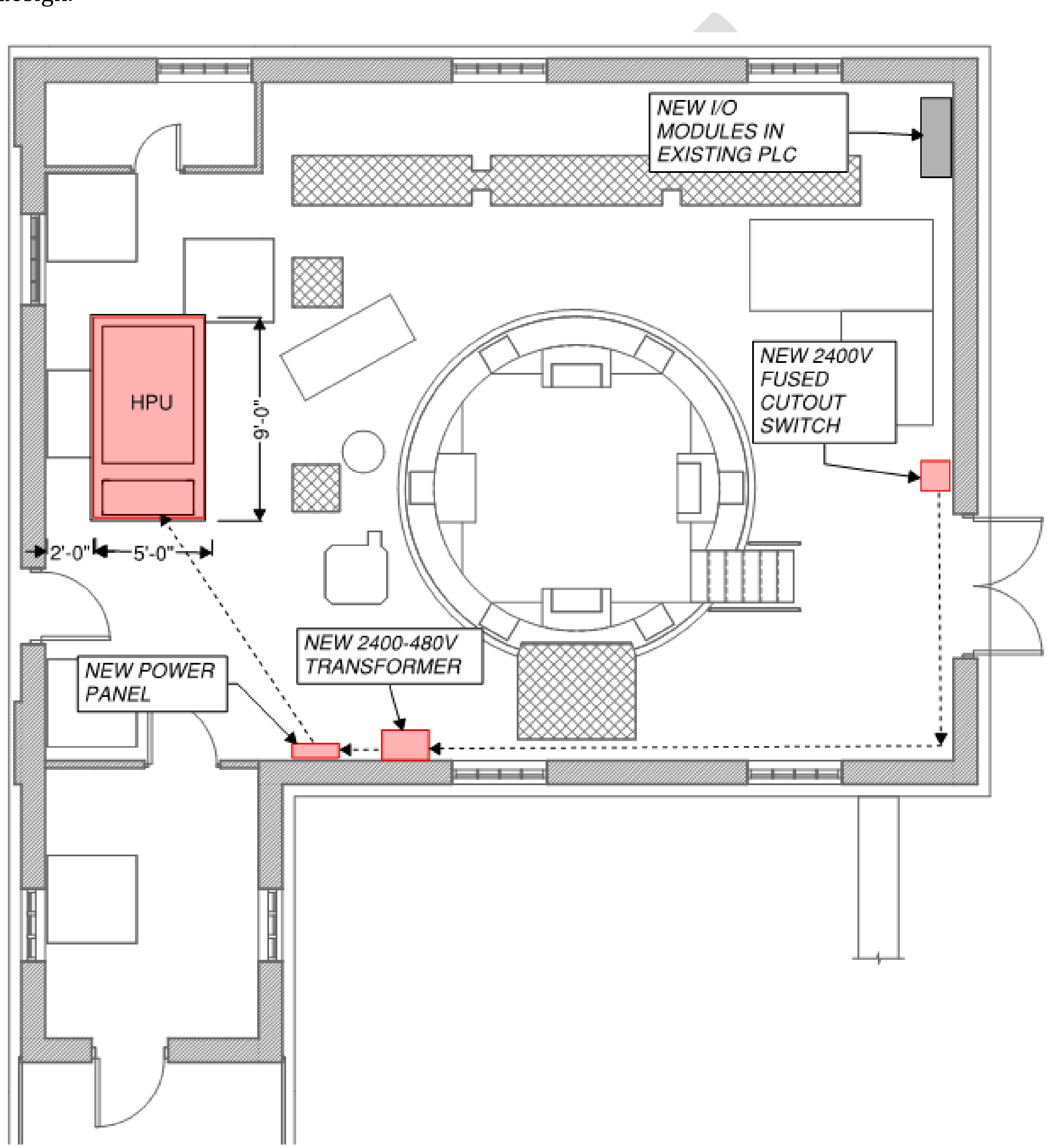


Figure 3-13 TP-4 (Lake Placid) Building Plan

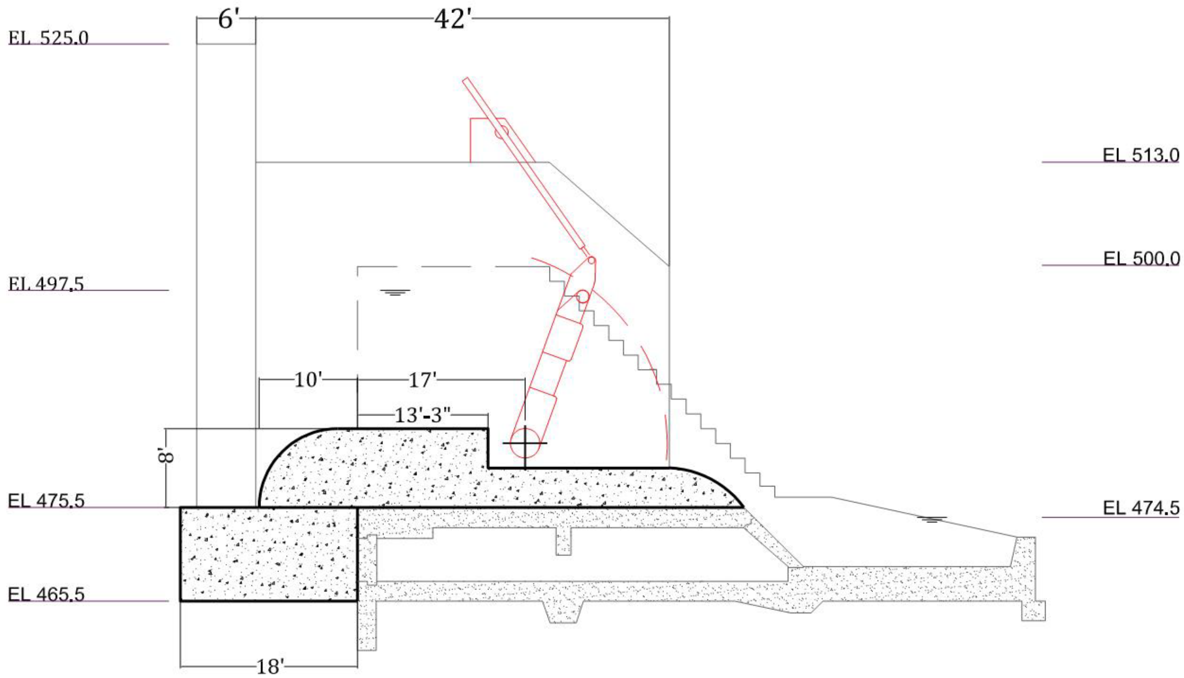


Figure 3-14 TP-4 (Lake Placid) Spillway Section

3.2.4 Nolte (Meadow Lake)

The gate control house for the Nolte spillway is located on the left embankment of the river. Plan dimensions of the gate control house are approximately 12.5 ft by 28 ft. The inside dimensions of the gate control house are adequate to accommodate a new HPU. The existing exterior door is too small to get the new HPU into this space, but modifications can be made to the building to install the new equipment. Refer to Figure 3-15 and Figure 3-16 for an overview of the Nolte dam site and gate control house floor plan.

The existing 3 bear trap style gates, 85 feet wide by 12 feet tall, will be replaced with 3 hydraulically actuated crest gates 79 feet wide by 14 feet tall. Structural modification of the spillway will be required to both provide the strength needed to support the new gates and to meet modern standards for spillway stability. Refer to Figure 3-17 for a cross section of the proposed modifications

Large staging areas are present both upstream and downstream of the dam.

The Nolte gate house will require a new 480 volt three phase service from the utility. A new three phase power panel will feed the HPU as well as a new step-down transformer. The step-down transformer will in turn feed the existing single-phase panel.

The PLC will need to be expanded with additional modules to accommodate new I/O from the HPU and gate actuators. In order to support video at the dam, the communication system needs to be enhanced to support greater bandwidth. Communication system will be evaluated during design.

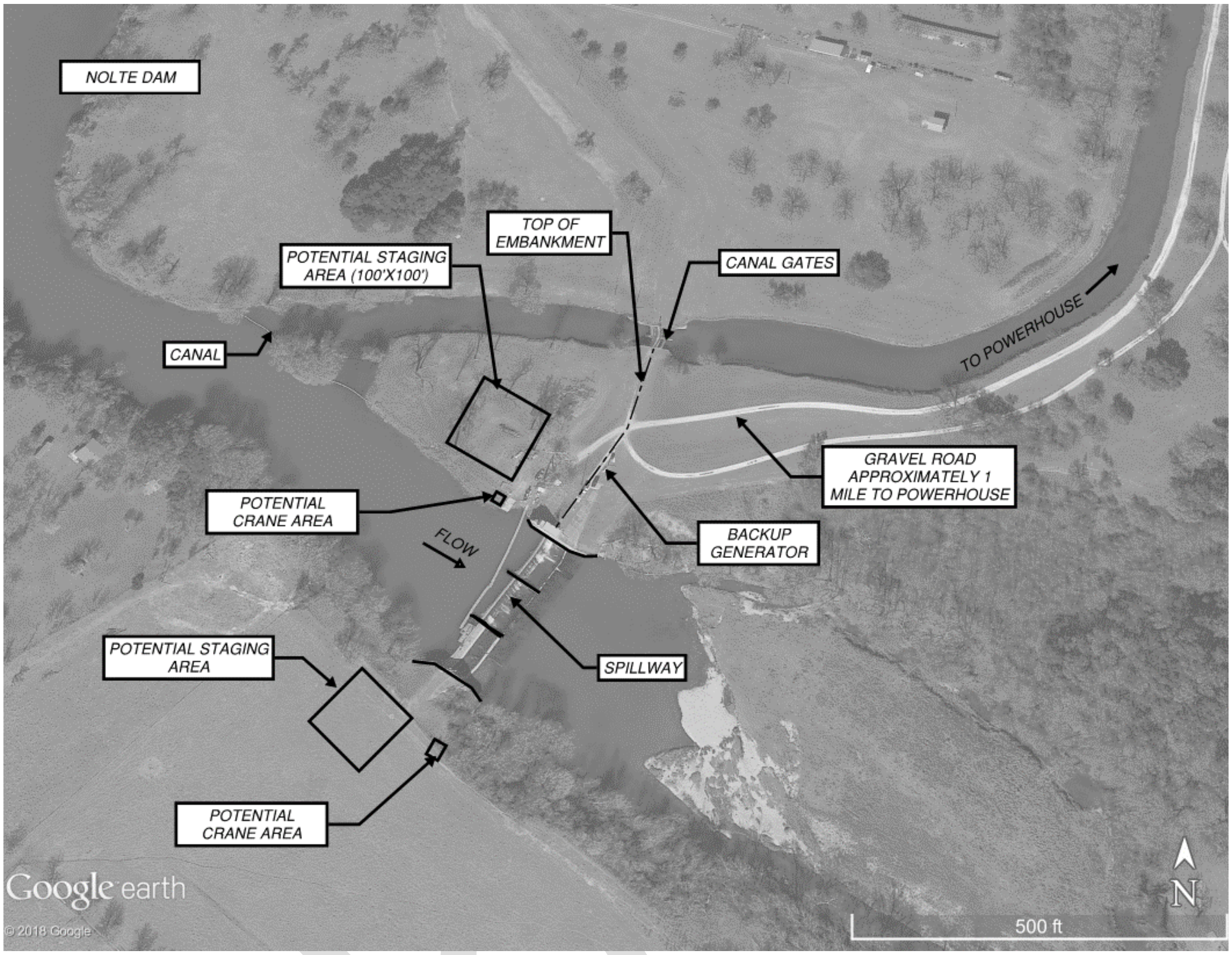


Figure 3-15 Nolte (Meadow Lake) Spillway Site Plan

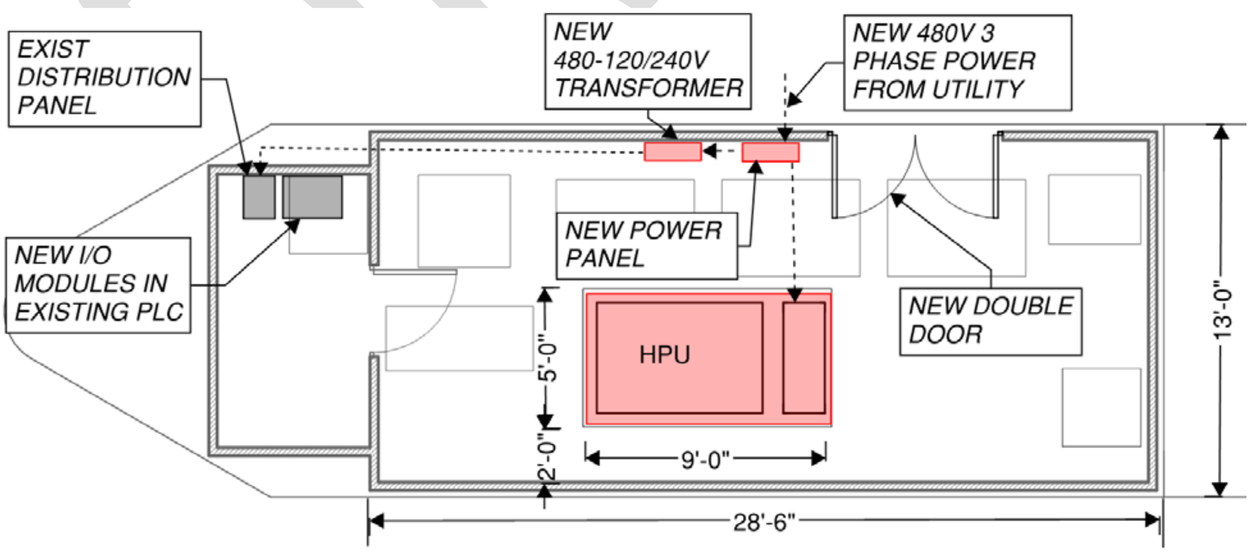


Figure 3-16 Nolte (Meadow Lake) Building Plan

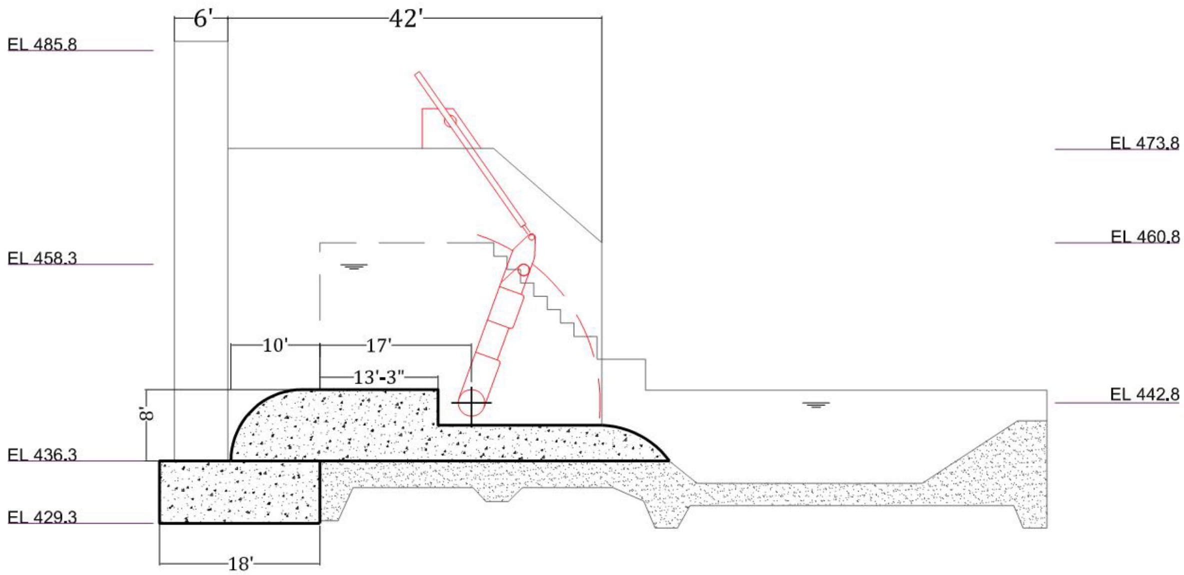


Figure 3-17 Nolte (Meadow Lake) Spillway Section

3.2.5 H-4 (Lake Gonzales)

The H-4 powerhouse is located on the right embankment adjacent to the spillway and contain the existing actuators which control flow through the spillway gates. The valve room, which is adjacent to the powerhouse floor, is 12 ft by 9 ft. The inside dimensions of the valve room are adequate to accommodate a new HPU. Alternatively, the HPU could be located on the end of the powerhouse floor in a space which is 25 ft long by over 6 ft wide. Refer to Figure 3-19 for the H-4 powerhouse floor plan.

The existing 2 bear trap style gates, 85 feet wide by 12 feet tall, will be replaced with 2 hydraulically actuated crest gates 79 feet wide by 14 feet tall. Structural modification of the spillway will be required to both provide the strength needed to support the new gates and to meet modern standards for spillway stability. Refer to Figure 3-20 for a cross section of the proposed modifications

North site access is provided by the approximately 0.7 mile long Dam Road, entered from the north from County Road 481. South site access is provided by an approximately 1.4 mile long gravel easement on private land, entered from the south from FM 466. Construction staging areas are present on the downstream of the left embankment and on both the upstream and downstream sides of the right embankment.. Refer to Figure 3-18 for an overview of the H-4 site.

The incoming power from the local electric utility at H-4 is 2,400 volt. Fused cutout switches at 2,400 volt are connected to existing transformers which step the voltage down to 120/240 volt single phase to feed an existing panelboard. Similar to the existing fused cutout switches, new switches will be added for connection to a new 2,400 volt-480 volt dry type transformer. The new transformer will feed a new 480 volt power panel sized to supply power to the HPU.

The PLC will need to be expanded with additional modules to accommodate new I/O from the HPU and gate actuators. In order to support video at the dam, the communication system needs to be enhanced to support greater bandwidth. The communication system will be evaluated during design.

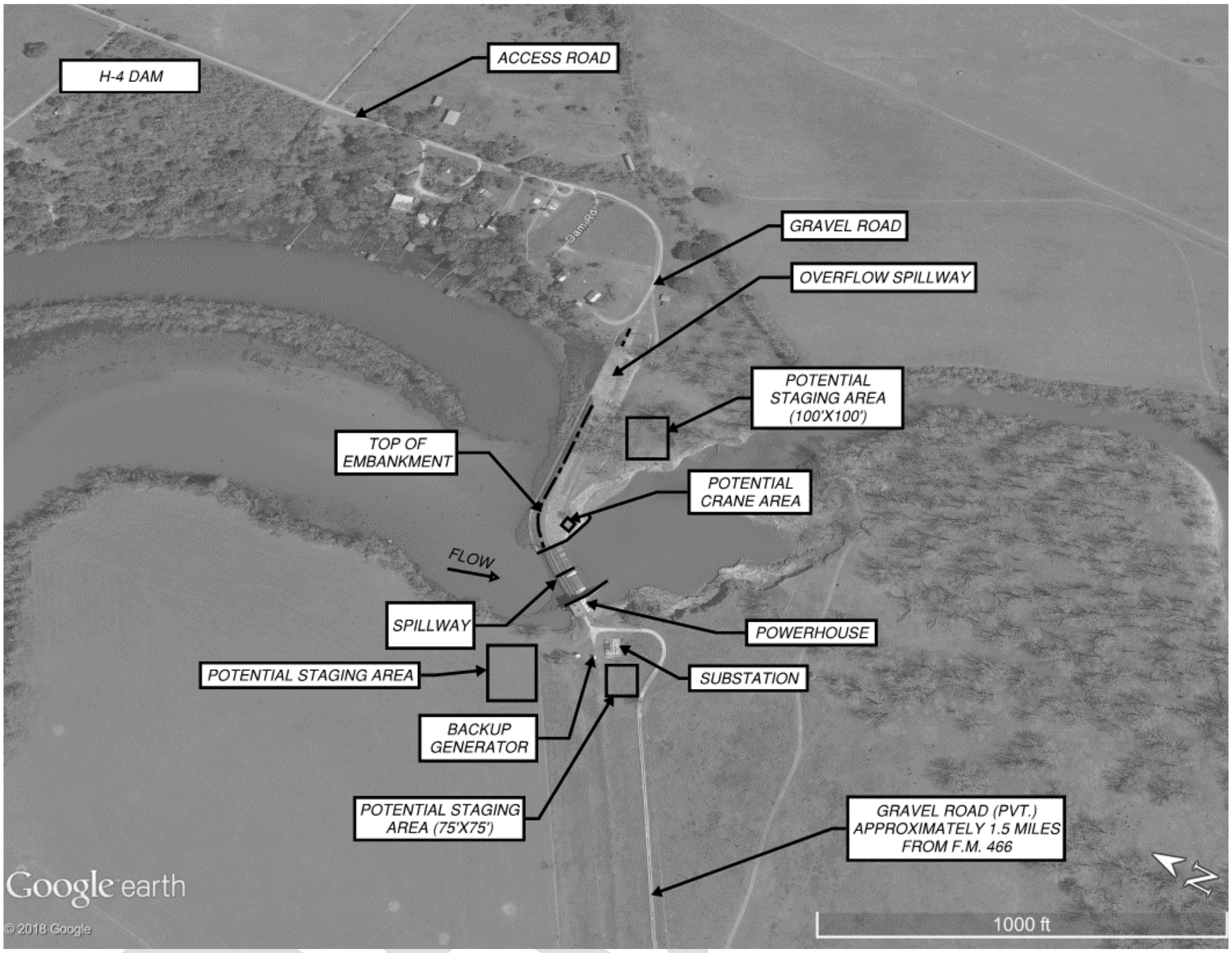


Figure 3-18 H-4 (Lake Gonzales) Spillway Site Plan

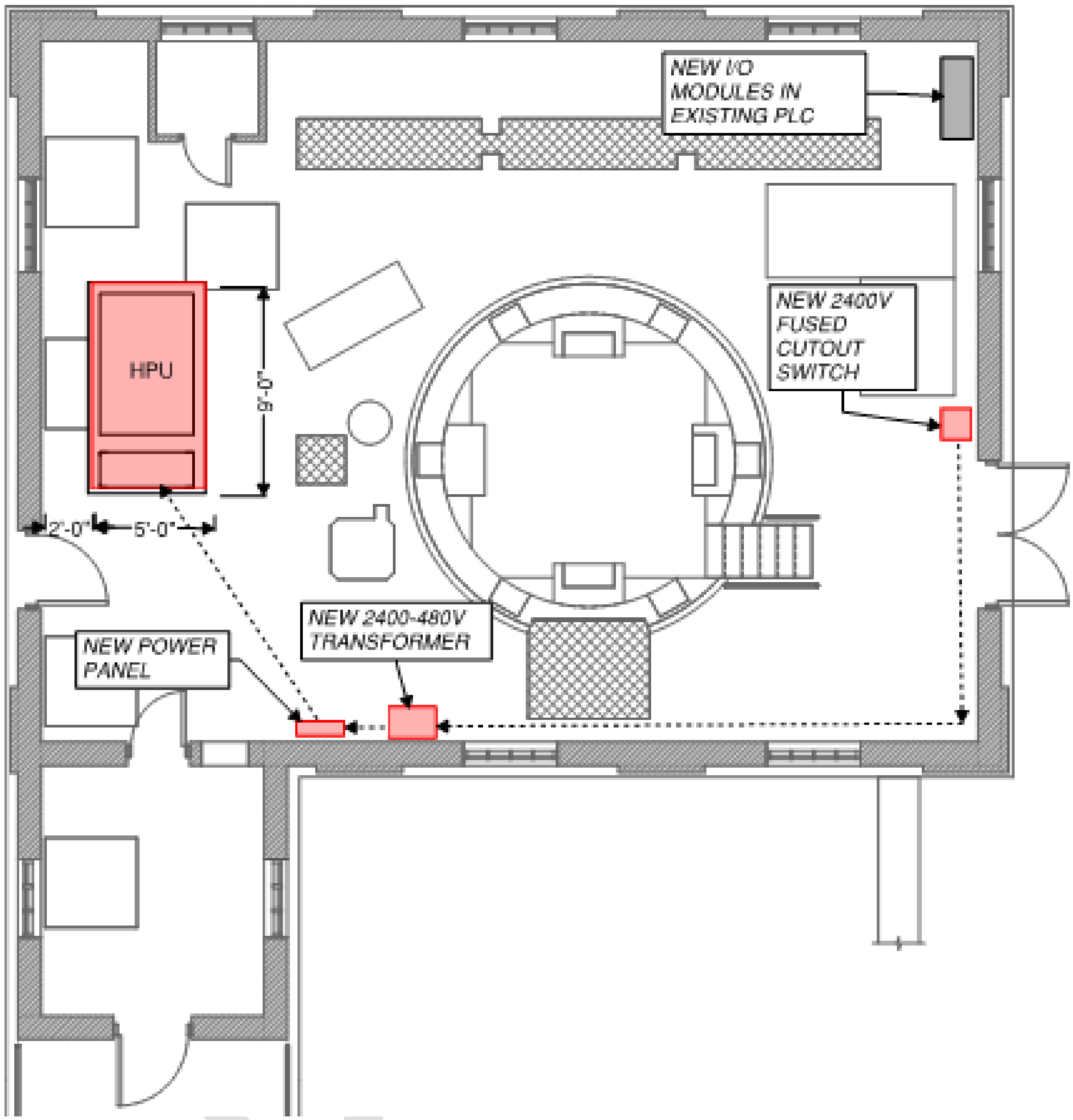


Figure 3-19 H-4 (Lake Gonzales) Building Plan

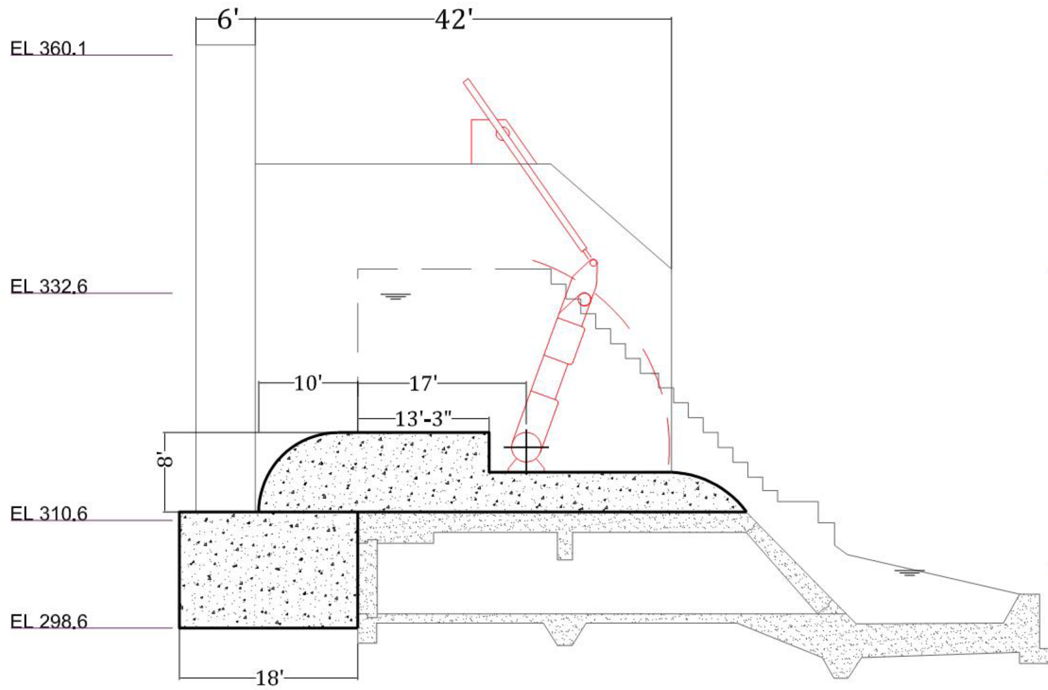


Figure 3-20 H-4 (Lake Gonzales) Spillway Section

3.2.6 H-5 (Lake Wood)

The H-5 powerhouse is located on the right embankment adjacent to the spillway and contain the existing actuators which control flow through the spillway gates. The valve room, which is adjacent to the powerhouse floor, is 12 ft by 9 ft. The inside dimensions of the valve room are adequate to accommodate a new HPU. Alternatively, the HPU could be located on the end of the powerhouse floor in a space which is 25 ft long by over 6 ft wide. Refer to Figure 3-22 for the H-5 powerhouse house floor plan.

The existing 2 bear trap style gates, 85 feet wide by 12 feet tall, will be replaced with 2 hydraulically actuated crest gates 79 feet wide by 14 feet tall. Structural modification of the spillway will be required to both provide the strength needed to support the new gates and to meet modern standards for spillway stability. Refer to Figure 3-23 for a cross section of the proposed modifications

North site access is provided by the approximately 0.4 mile long County Road 254, entered from the north from FM 2091 and also providing access to the adjacent Lake Wood Recreation Area, a GBRA-owned campground. South site access is provided by an approximately 1.8 mile long gravel easement on private land, entered from Texas Route 97. Construction staging areas are present on the downstream of the left embankment and on both the upstream and downstream sides of the right embankment. Refer to Figure 3-21 for an overview of the H-5 site.

The incoming power from the local electric utility at H-4 is 2,400 volt. Fused cutout switches at 2,400 volt are connected to existing transformers which step the voltage down to 120/240 volt single phase to feed an existing panelboard. Similar to the existing fused cutout switches, new switches will be added for connection to a new 2,400 volt-480 volt dry type transformer. The new transformer will feed a new 480 volt power panel sized to supply power to the HPU.

The PLC will need to be expanded with additional modules to accommodate new I/O from the HPU and gate actuators. In order to support video at the dam, the communication system needs to be enhanced to support greater bandwidth. GBRA is working with adjacent utilities to lease tower space on nearby towers, expanding the microwave communication system capable for video transmission.

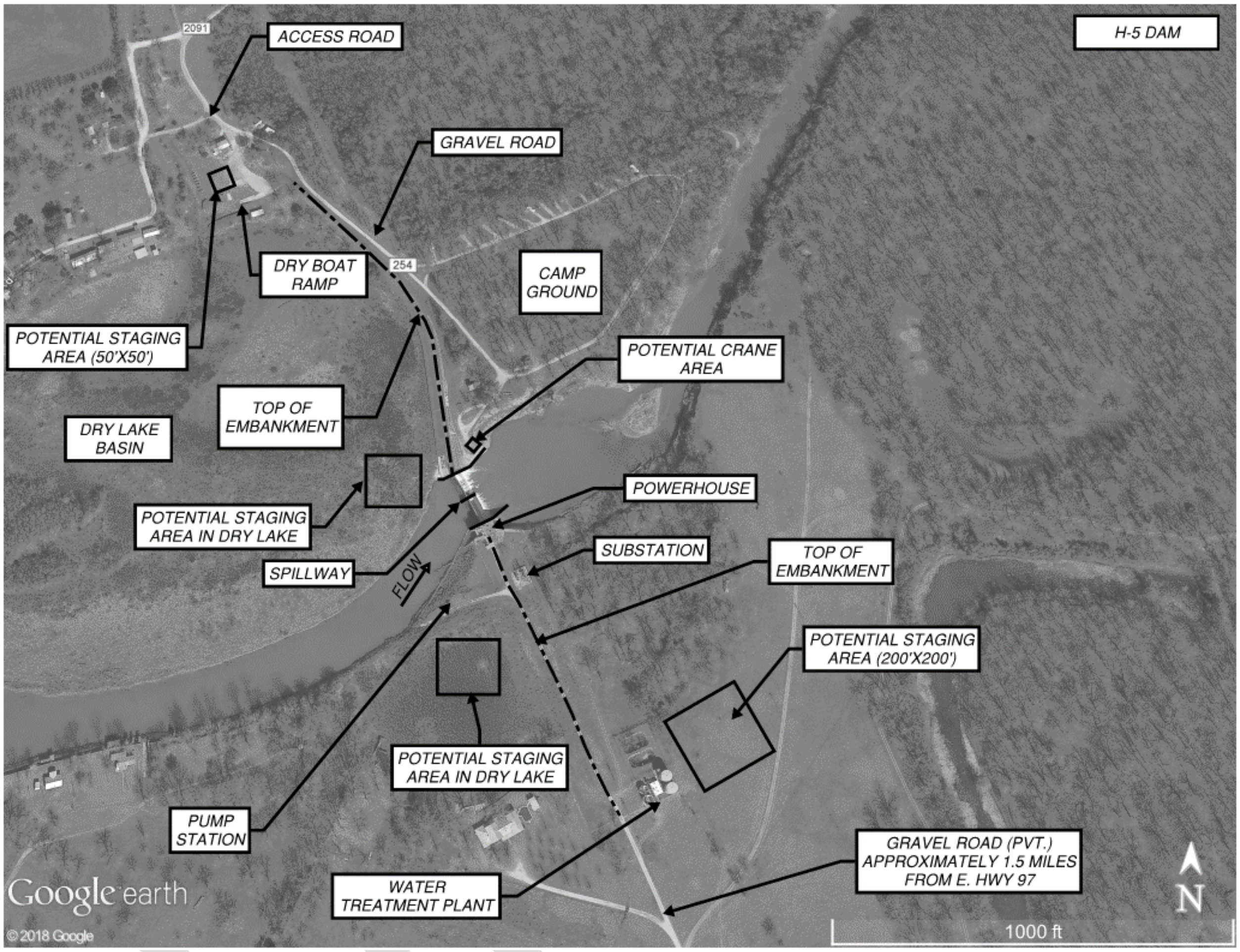


Figure 3-21 H-5 (Lake Wood) Spillway Site Plan

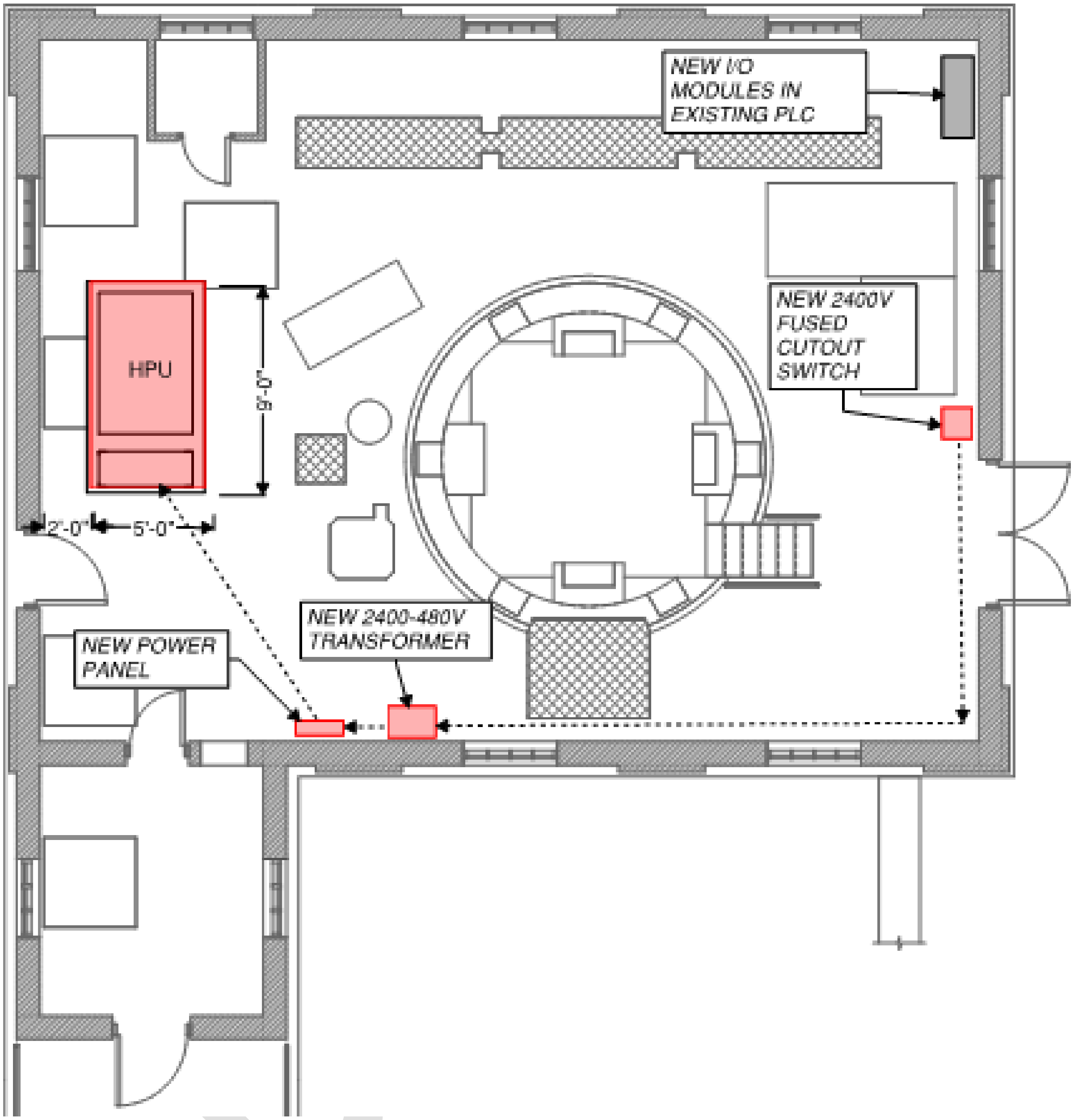


Figure 3-22 H-5 (Lake Wood) Building Plan

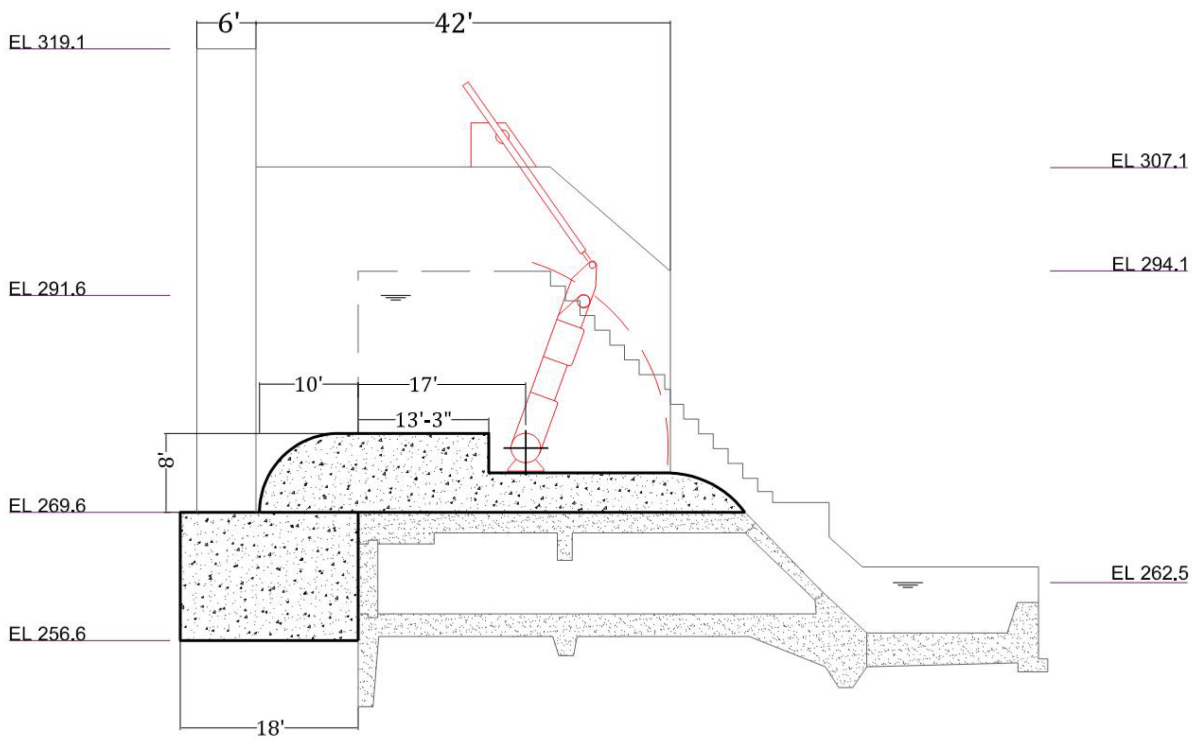


Figure 3-23 H-5 (Lake Wood) Spillway Section

3.3 CONSTRUCTION SCHEDULE AND BUDGET

Construction schedules and budgets have been developed for the proposed gate replacement at H-5 (Lake Wood) and the overall six dam program to implement hydraulically actuated crest gates at the six similarly configured hydroelectric dams in the GBRA system. Construction schedules are included in Appendix D and details of the opinion of construction costs are included in Appendix E.

3.3.1 H-5 (Lake Wood) Schedule and Budget

Gate procurement costs provided by 4 manufacturers have been used in development of the construction cost estimate for H-5. The estimates from the 4 manufactures ranged from $2.5M to $4.8M. The average of the 4 estimates is $3.3M and that is the value which has been used in the construction cost estimate.

Table 3-1 H-5 Construction Cost Estimate

SITE	ACTIVITY & DURATION	ESTIMATE	25% CONTINGENCY	TOTAL
H-5 (Lake Wood)	Construction (28 months)	$11.1 M	$2.8 M	$13.9 M

Large gates and HPU's are custom products with long lead times. The 4 manufactures provided lead times ranging between 14 and 18 months from the time they are awarded a contract to delivery to the site. A lead time of 14 months has been used in the H-5 project schedules. With such a long lead time, gate delivery has the potential to drive the overall schedule. Two schedules have been prepared for H-5. The two options determine the effect of differing sequences of construction involving a long lead item. The goal is to reduce the effect of the long lead item on the completion date of the project.

Option 1 Sequence of Construction	Option 2 Sequence of Construction
- Construct Bay 1 Concrete	- Construct Bay 1 Concrete
- Install Bay 1 Gate	- Construct Bay 2 Concrete
- Construct Bay 2 Concrete	- Install Bay 2 Gate
- Install Bay 2 Gate	- Install Bay 1 Gate
Construction duration 32 months	Construction duration 28 months

Option 1 is the traditional method of construction within a waterway; a cofferdam is constructed and dewatered and all work in that area is completed before the cofferdam is removed. As can be seen in the schedule of Figure 3-24, waiting for the first gate to be delivered delays the start of the concrete work in the second bay of the spillway.

Option 2, Figure 3-25, requires cofferdams around the same areas as Option 1 but removal of the first cofferdam to proceed with concrete work in the second bay is not dependent on delivery of the first gate. With Option 2 all concrete work in both bays is completed before the installation of the first gate. Installation of a gate requires that the spillway bay in which the gate is to be installed be dewatered. Option 1 relies on the construction cofferdam to provide this dry work area. Option 2 takes advantage of the maintenance cofferdam system which will be included with the work. The same cofferdam system which will allow for future maintenance of the gates can be used during the initial installation of the gates. By completing all concrete work before the installation of the first gate, delivery of the gate is removed from the critical path and the project schedule is shortened by 4 months.

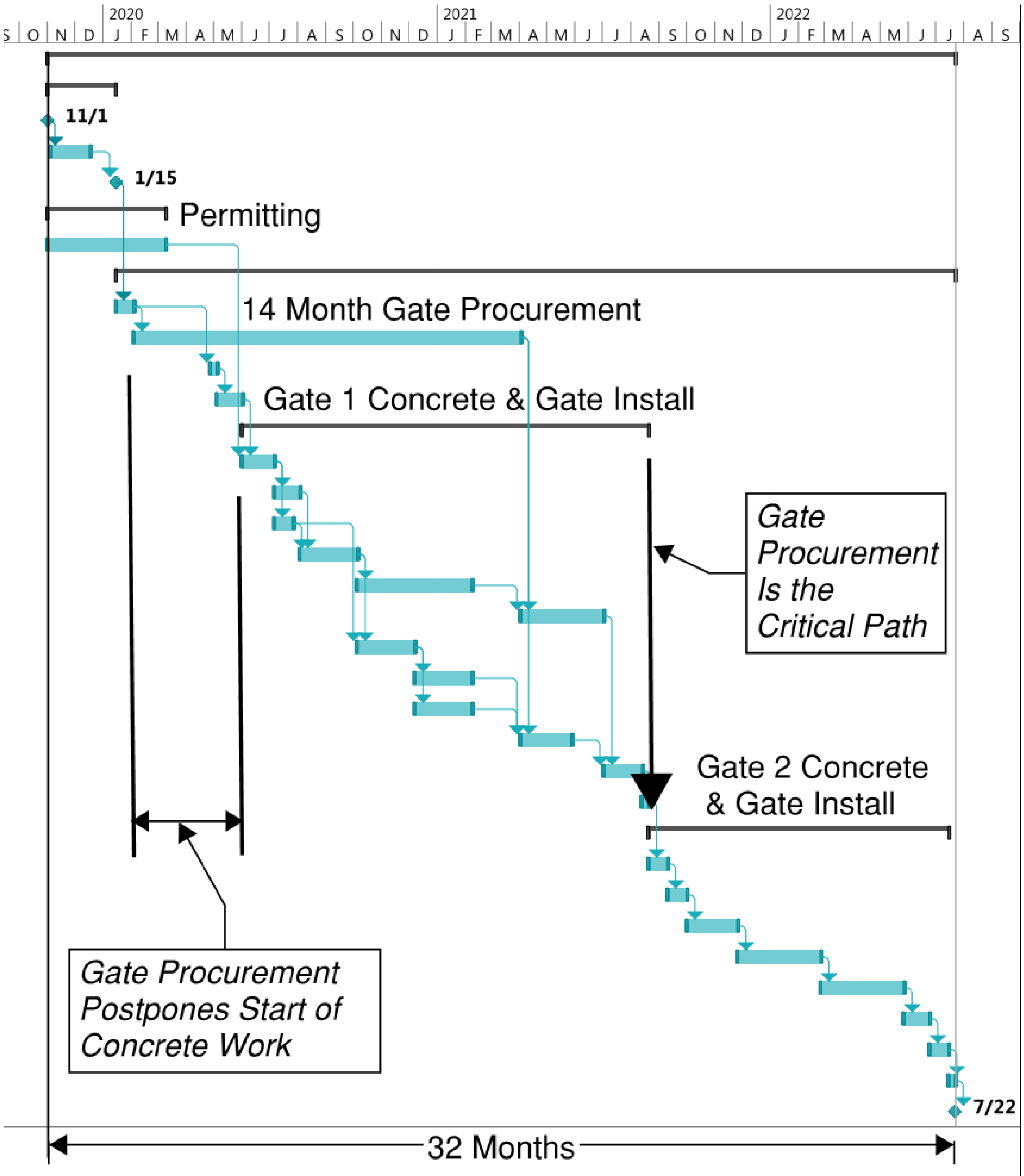


Figure 3-24 Construction Schedule Option 1 – Sequential Gate & Concrete Construction

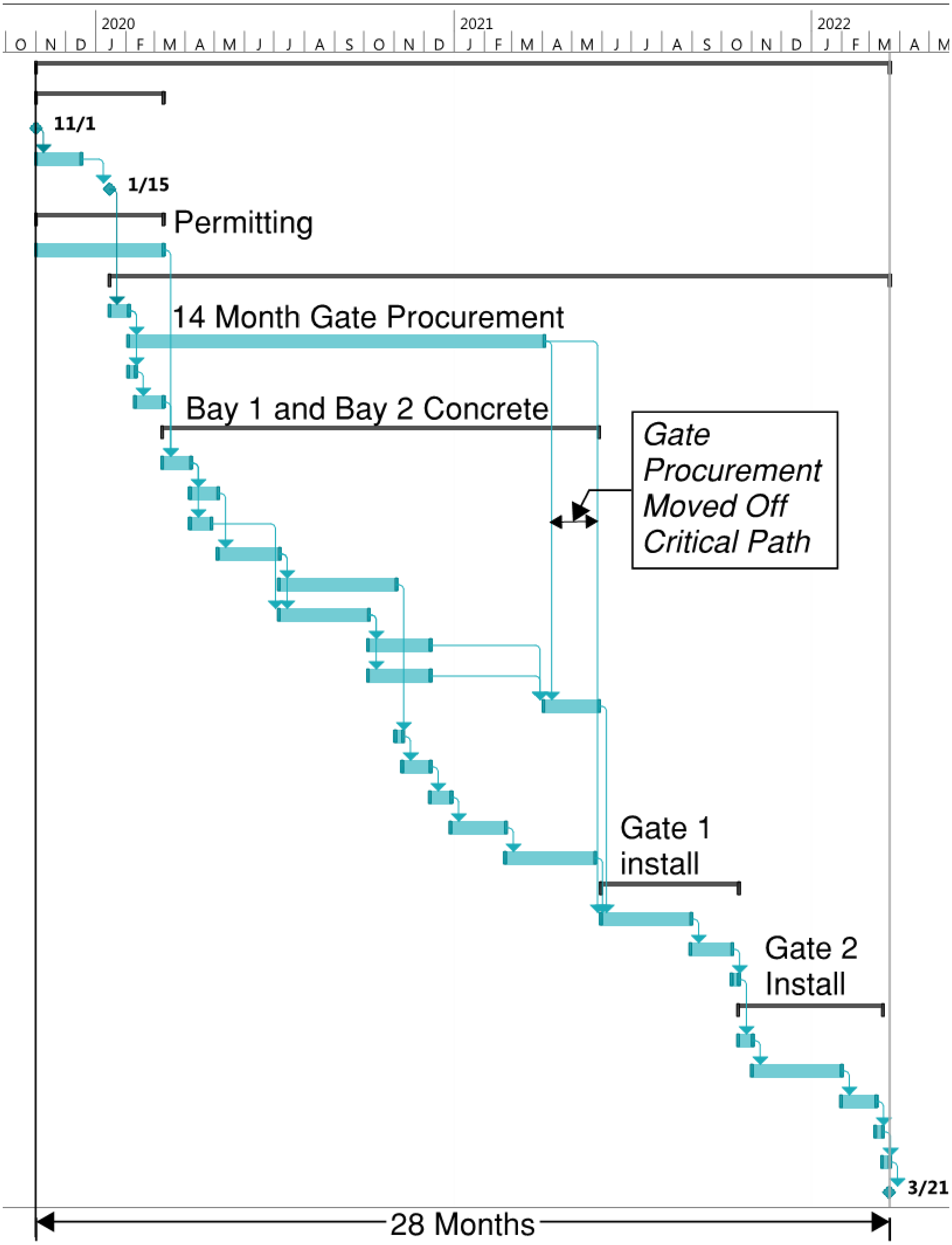


Figure 3-25 Construction Schedule Option 2 – Concrete Construction Followed by Gate Installation

3.3.2 Six Dam Program Schedule and Budget

For long-term planning purposes, milestone dates and budgets for major design and construction phases for all six dams have been developed and are presented in Table 3-2. The duration of construction for the 2 gate spillways at TP-4, H-4, and H-5 is assumed to be 28 months. The duration of construction for the 3 gate spillways at Dunlap, TP-3, and Nolte is assumed to be 34 months. The dates presented represent an approximate 20 year implementation schedule for replacement of gates at all six dams. Allowing for a 20 year implementation schedule provides for minimal schedule overlap of design and construction activities between work for each of the six dams. Refer to Figure 3-26. This schedule could be accelerated or slowed depending on availability of funding or other resources.

The program budget estimate for design and construction has been developed based on the assumed 20 year schedule for replacement of gates at all six dams. The budget estimate includes a 25 percent contingency and costs have been escalated 3 percent per year to account for inflation. Not included in the program budget are GBRA internal program management costs or costs required for ongoing maintenance of the existing gates. As the existing gates age, it is expected that cost to maintain the existing gates may increase.

Also excluded from the budgets are uncertainties unique to each site such as river channel conditions, integrity of the spillway at time of construction, changes in site access or adjacent development, gate vendor availability, commodity prices, and other conditions which could change over the duration of a 20 year program.

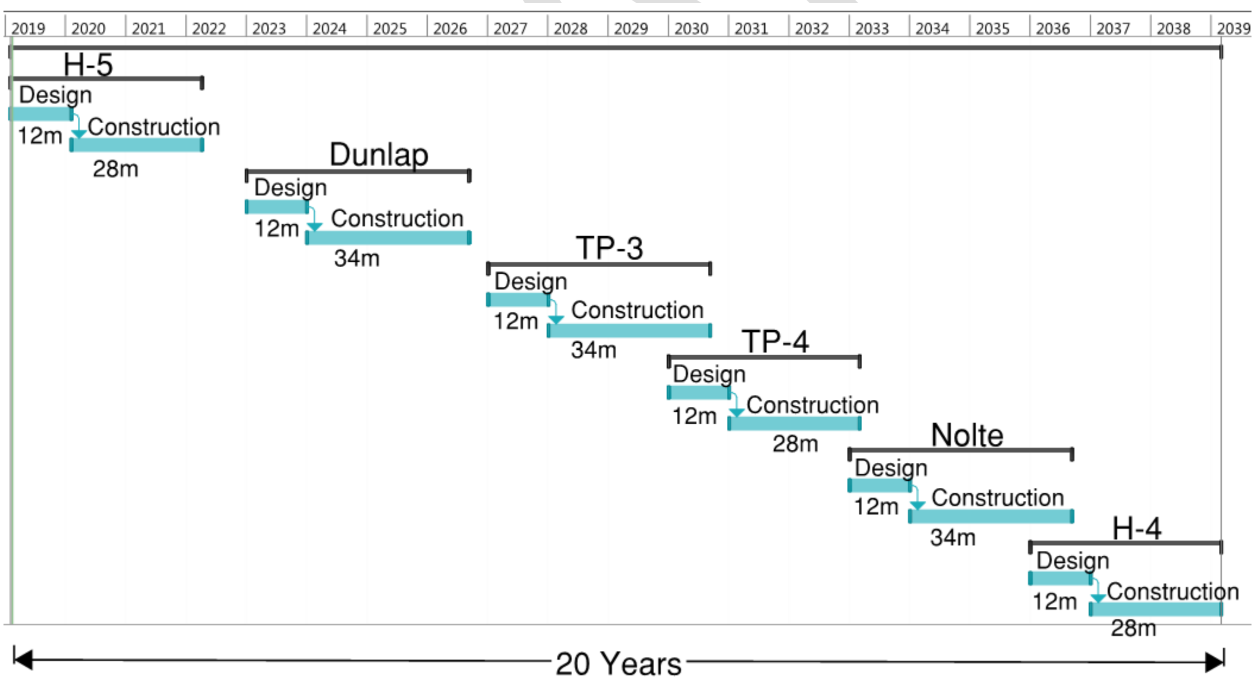


Figure 3-26 Six Dam Program Schedule

Table 3-2 Six Dam Program Schedule & Budget

SITE	ACTIVITY & DURATION	YEAR	2019 COST	FUTURE COST	FUTURE COST
H-5 (Lake Wood) Years 1 - 4	Design & Bidding (12 months)	2019	$0.6 M	$0.6 M	$14.5 M
	Construction (28 months)	2020 - 2022	$13.9 M	$13.9 M	
Dunlap Years 5 - 8	Design & Bidding (12 months)	2023	$0.6 M	$0.7 M	$24.7 M
	Construction (34 months)	2024- 2025	$20.9 M	$24.0 M	
TP-3 (Lake McQueeney) Years 8 - 12	Design & Bidding (12 months)	2027	$0.6 M	$0.8 M	$27.3 M
	Construction (34 months)	2028 - 2029	$20.9 M	$26.5 M	
TP-4 (Lake Placid) Years 12 - 15	Design & Bidding (12 months)	2030	$0.6 M	$0.9 M	$22.7 M
	Construction (28 months)	2031 - 2032	$16.0 M	$21.8 M	
Nolte (Meadow Lake) Years 15 - 18	Design & Bidding (12 months)	2033	$0.6 M	$1.0 M	$31.3 M
	Construction (34months)	2034 - 2035	$20.9 M	$30.3 M	
H-4 (Lake Gonzales) Years 18 - 21	Design & Bidding (12 months)	2036	$0.6 M	$1.1 M	$22.5 M
	Construction (28 months)	2037 - 2038	$13.9 M	$21.4 M	
			$110M		$143M

Notes:

1. These tabulated costs do not include the cost of additional construction required to maintain the lakes a full pool level during construction.

4.0 Hydraulic Analysis

A Hydraulic analysis was performed to evaluate hydraulic conditions through and near the six dams. The primary purpose of the spillways is to pass large flows during floods while having the ability to maintain a constant water level for operation of the hydroelectric generation stations. The hydraulic analysis consists of an evaluation of existing conditions to establish a baseline for the design of the proposed gates. The hydraulic analysis also includes evaluating scour potential downstream of the gate structures. The need to modify or add an energy dissipation component to the gate structures has also been evaluated.

The modification to the spillways will result in a narrower gate openings. To compensate for the anticipated narrower gate openings, the gate sill will need to be lowered to convey flood flows without increasing water levels upstream of the gate. Correspondingly, under normal operations, the new gate would have to be set at lower elevations to convey a given flow while maintaining a constant operation level upstream of the gate. That is, for a given gate crest elevation setting, discharges are expected to be lower for the proposed gates compared to the existing ones. The additional conveyance would only be available when the gates are fully lowered. Therefore, for design purposes, capacity will only be compared for fully lowered gates to define the new gate sill elevation.

Under both existing and proposed conditions, the gates can be assumed to be equivalent to a sharp crested weir when raised. When fully lowered, the spillway gates lay flat and the gate structure would resemble a broad crested weir. However, under normal operations and during flood events, water levels would be high enough that the weir would not function as a broad-crested weir but as a short-crested weir instead. A publication by the International Institute for Land Reclamation (Bos, 1976) describes an adjustment to the broad-crested weir equation coefficient that allows analyzing short-crested weir hydraulics. Using this adjustment, as discharges increase the weir coefficient increases. In some instances, the weir coefficient had to be extrapolated from the values presented in this publication. In cases where the extrapolated value was greater than the weir coefficient of a sharp crested weir, the sharp crested weir equation was used instead. Capacity calculations were performed to determine discharges for a range of upstream water elevations between the operating level and nominal top of dam.

Tailwater conditions were assessed as part of the analysis to determine if tailwater could affect discharges through the gate structures. Tailwater levels were preliminarily obtained from two HEC-RAS models provided by GBRA. These models were developed as part of the US Army Corps of Engineers Lower Guadalupe River Basin Guadalupe-Blanco River Authority Interim Feasibility Study. The preliminary analysis indicates that even though tailwater may raise above the gate crest, the submergence effect of the tailwater on the spillway gates is negligible.

A more detailed review of the USACE HEC-RAS model near and downstream of the H-5 dam showed that the dams and corresponding spillways, including the six GVHS dams, have not been correctly represented in the model. This issue results in systematically overestimating flow depths upstream of these structures, especially when simulating low flows. A more detailed analysis outside the scope of this preliminary design report would have to be conducted to assess the magnitude of the impact at the individual gates. Because the tailwater effect is negligible to determine the gates capacity and, considering that the tailwater is likely overestimated, this issue is not expected to impact the design of the new gates. Understanding tailwater conditions, however, is extremely important to evaluate scour and energy dissipation requirements immediately downstream of the spillways. The HEC-RAS model downstream of the H-5 was modified to obtain a better estimate of tailwater conditions. Scour and energy dissipation needs were thus only assessed for the H-5 dam; however, final design will likely require further investigating this issue.

Following FEMA regulatory requirements, the new gates will be sized to ensure that, when fully lowered, the gate improvements would not result in any increase in flood levels during the occurrence of the 100-year flood. Because the 100-year flood is expected to flank or overtop all six dams, the hydraulic design focuses on ensuring that the proposed spillway can discharge at least the same flow compared to the existing spillway for a range of water levels ranging from the normal operating level to the nominal top of the dam embankment. This approach tends to be conservative because once the dam is flanked or overtopped, the impact of gate modifications is reduced. Therefore, it is expected that the preliminary proposed gate configuration will meet FEMA regulatory requirements. However, permitting of the structure will require a complete analysis using FEMA effective model as a baseline to demonstrate that there are no increases in flood levels during the 100-year event. This analysis would be performed as part of permitting efforts during final design.

4.1 FLOOD FREQUENCY DATA

Table 4-1 shows the flows associated with floods with annual exceedance probabilities between 50% (2-year) and 1% (100-year); which were obtained from the two HEC-RAS models provided by GBRA. The flows shown in the table are provided for reference based on the assumption that these are the most current flood frequency discharge estimates. According to Appendix D.1 of the Technical Report Notebook of the USACE Feasibility Study, these frequency discharges were derived from an analysis of USACE gage data instead of existing hydrologic studies. It is important to note that these discharges are substantially larger than the peak discharges published in the effective FEMA Flood Insurance Study (FIS) (FEMA 2007, 2010).

Table 4-1 Flows vs. Annual Exceedance Probabilities (cfs)

FLOOD EVENT	ANNUAL EXCEEDANCE PROBABILITY	DUNLAP	TP-3 LAKE MCQUEENEY	TP-4 LAKE PLACID	NOLTE MEADOW LAKE	H-4 LAKE GONZALES	H-5 LAKE WOOD
2-year	50%	6,000	7,100	7,100	7,700	9,600	10,000
5-year	20%	16,300	19,700	19,700	21,200	26,000	26,900
10-year	10%	27,900	34,100	34,100	36,500	44,400	45,900
25-year	4%	50,400	61,000	61,000	65,000	78,300	80,800
50-year	2%	74,400	89,300	89,300	95,000	113,800	117,400
100-year	1%	106,000	126,800	126,800	134,700	160,600	165,600

Flow in the Guadalupe River is highly variable. Historical flow records from 2008 to 2018 for USGS streamflow gage No. 08169792 ("Guadalupe River at FM 1117 near Seguin, TX"), located approximately six miles downstream of Nolte, show that the flows ranged from 28 cubic cfs to 46,300 cfs with a median and average flow of 395 cfs and 613 cfs, respectively. Canyon Lake Dam, which is located about 30 miles upstream of Dunlap, has a discharge capacity of approximately

5,000 cfs. This indicates that during large flood events, rainfall on the intervening watershed areas downstream of Canyon Lake Dam can contribute a significant portion of the river flow.

A flow duration relationship was developed for the six GVHS dams as shown in Figure 4-1 using streamflow data from the USGS gage near Seguin and USGS streamflow gage No. 08167800 (“Guadalupe River at Sattler, TX”), located just downstream of Canyon Lake Dam. The curves show that the flow range is quite wide with extreme flood events occurring about 5% of the time.

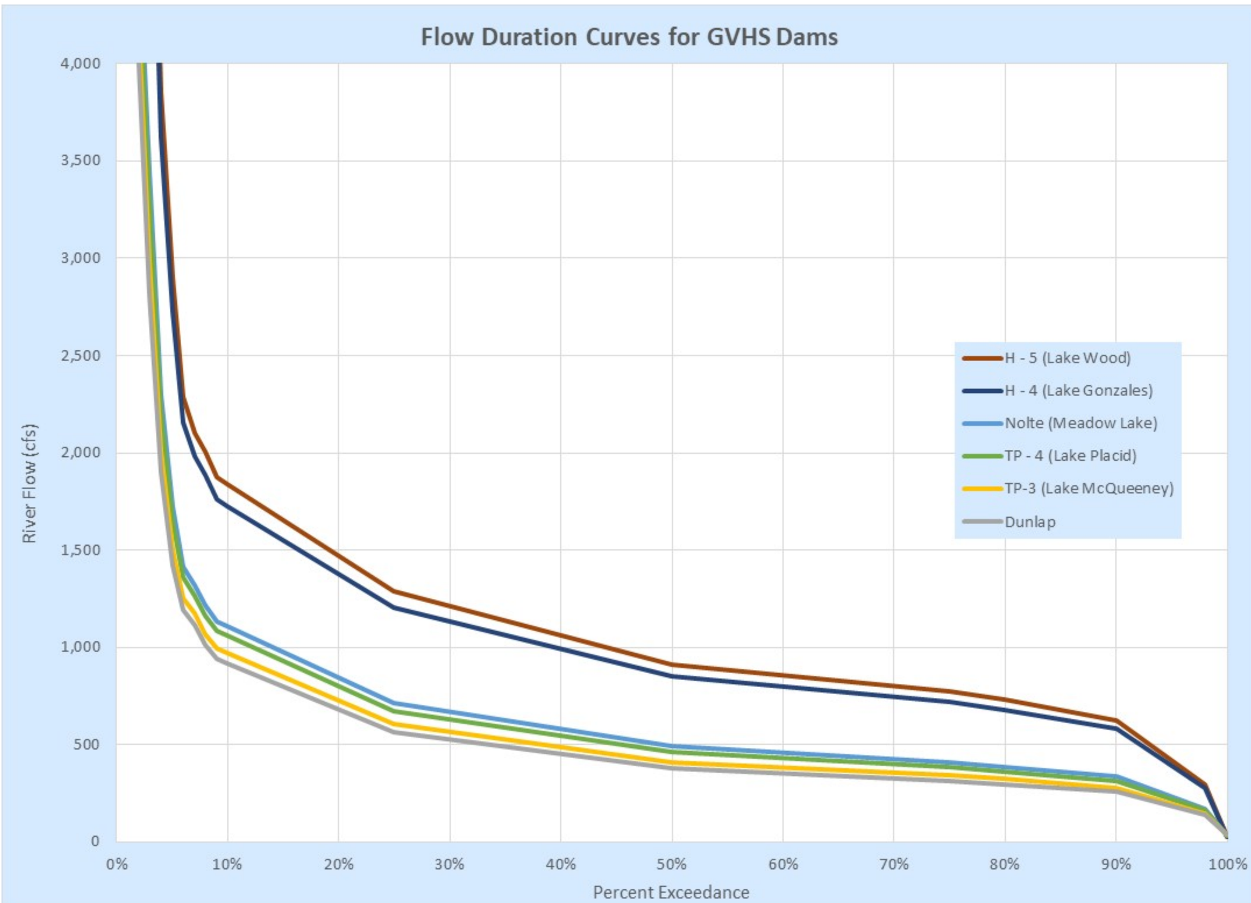


Figure 4-1 Flow Duration Curves for the GVHS Dams

4.2 DUNLAP

The Dunlap Dam existing spillway includes three 85 ft wide by 12 ft tall gates. When the gates are fully raised, the crest elevation is EL 575.20 ft. With the existing flashboards, the crest elevation increases to EL 575.80 ft. When fully lowered the spillway crest elevation is EL 563.20 ft. The dam crest elevation is approximately EL 587.50 ft.

Hydraulic calculations were performed to determine discharges for a range of upstream water surface elevations between the operating level (EL 575.80 ft) and nominal top of dam (EL 587.5 ft).

To accommodate the new gates, the spillway width will be reduced by 6 ft at each gate bay; each gate will thus be 79 ft wide. To compensate for the reduced width, it has been calculated that the gate sill would have to be lowered by 1.5 ft; therefore, when fully lowered, the spillway crest would be at EL 561.7 ft. Figure 4-2 shows the elevation-discharge curves for the gate structure under existing and proposed conditions. The proposed gates provide a spillway discharge capacity equivalent to that of the existing gates.

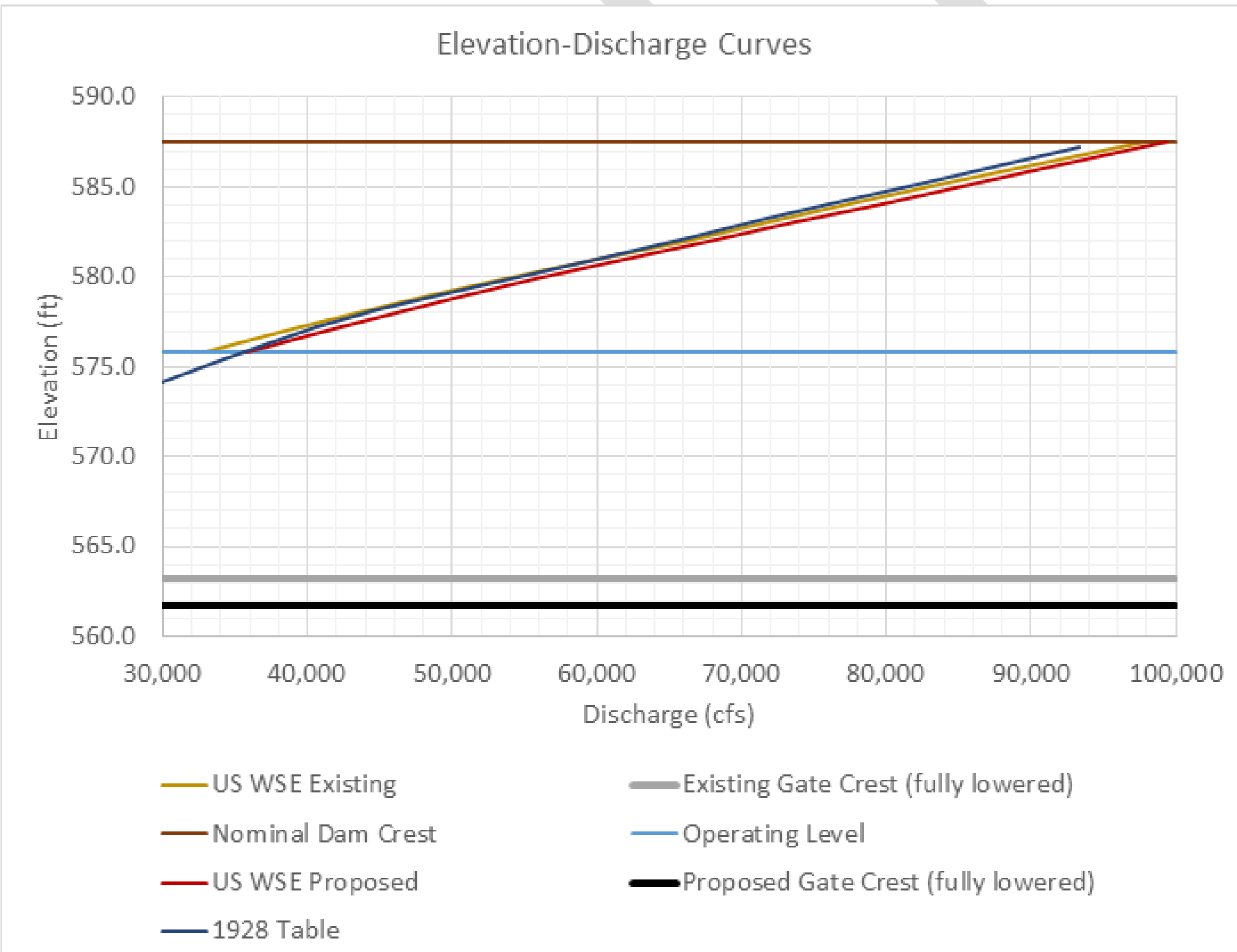


Figure 4-2 Dunlap Spillway - Existing and Proposed Elevation-Discharge Curves

4.3 TP-3 (LAKE MCQUEENEY)

The TP-3 Dam existing spillway includes three 85 ft wide by 12 ft tall gates. When the gates are fully raised, the crest elevation is EL 528.70 ft. When fully lowered the spillway crest elevation is EL 516.70 ft. The dam crest elevation is approximately EL 542.5 ft.

Hydraulic calculations were performed to determine discharges for a range of upstream water surface elevations between the operating level (EL 528.7 ft) and nominal top of dam (EL 542.5 ft).

To accommodate the new gates, the spillway width will be reduced by 6 ft at each gate bay; each gate will thus be 79 ft wide. To compensate for the reduced width, it has been calculated that the gate sill would have to be lowered by 1.5 ft; therefore, when fully lowered, the spillway crest would be at elevation EL 515.2 ft. Figure 4-3 shows the elevation-discharge curves under existing and proposed conditions. The proposed gates provide a spillway discharge capacity equivalent to that of the existing gates.

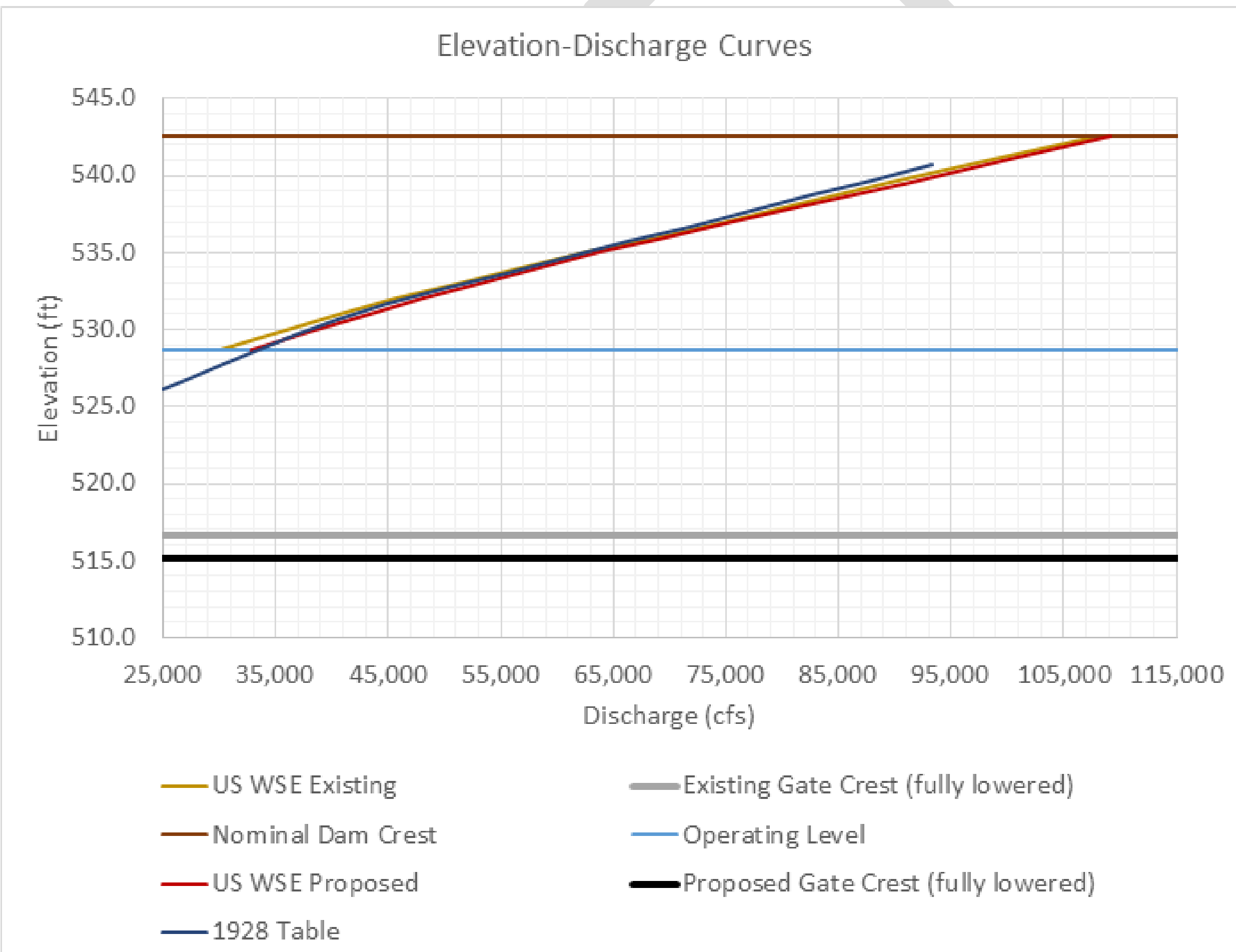


Figure 4-3 TP-3 Spillway - Existing and Proposed Elevation-Discharge Curves

4.4 TP-4 (LAKE PLACID)

The TP-4 Dam existing spillway includes two 98'-8" wide by 12 ft tall gates. When the gates are fully raised, the crest elevation is EL 497.5 ft. When fully lowered the spillway crest elevation is EL 485.5 ft. The dam crest elevation is approximately EL 512.5 ft.

Hydraulic calculations were performed to determine discharges for a range of upstream water surface elevations between the operating level (EL 497.5 ft) and nominal top of dam (EL 512.5 ft).

To accommodate the new gates, the spillway width will be reduced by 6 ft at each gate bay; each gate will thus be 79 ft wide. To compensate for the reduced width, it has been calculated that the gate sill would have to be lowered by 1.5 ft; therefore, when fully lowered, the spillway crest would be at EL 484.0 ft. Figure 4-4 shows the elevation-discharge curves under existing and proposed conditions. The proposed gates provide a spillway discharge capacity equivalent to that of the existing gates.

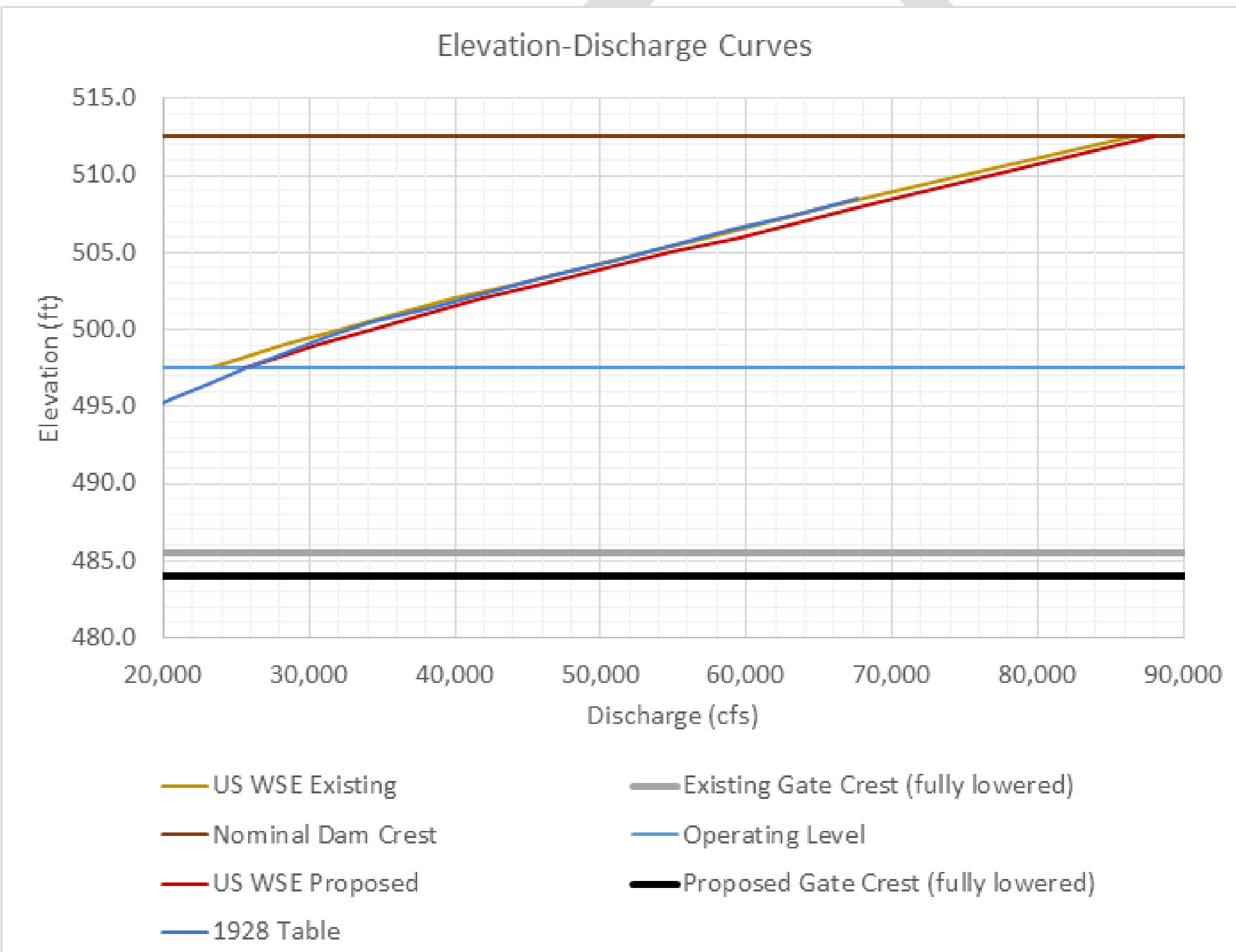


Figure 4-4 TP-4 Spillway - Existing and Proposed Elevation-Discharge Curves

4.5 NOLTE (MEADOW LAKE)

The Nolte Dam existing spillway includes three 85 ft wide by 12 ft tall gates. When the gates are fully raised, the crest elevation is EL 457.6 ft. With the existing flashboards, the crest elevation increases to EL 458.25 ft. When fully lowered the spillway crest elevation is EL 445.6 ft. The dam crest elevation is approximately EL 473.5 ft.

Hydraulic calculations were performed to determine discharges for a range of upstream water surface elevations between the operating level (EL 458.25 ft) and nominal top of dam (EL 473.5 ft).

To accommodate the new gates, the spillway width will be reduced by 6 ft at each gate bay; each gate will thus be 79 ft wide. To compensate for the reduced width, it has been calculated that the gate sill would have to be lowered by 1.5 ft; therefore, when fully lowered, the spillway crest would be at EL 444.1 ft. Figure 4-5 shows the elevation-discharge curves under existing and proposed conditions. The proposed gates provide a spillway discharge capacity equivalent to that of the existing gates.

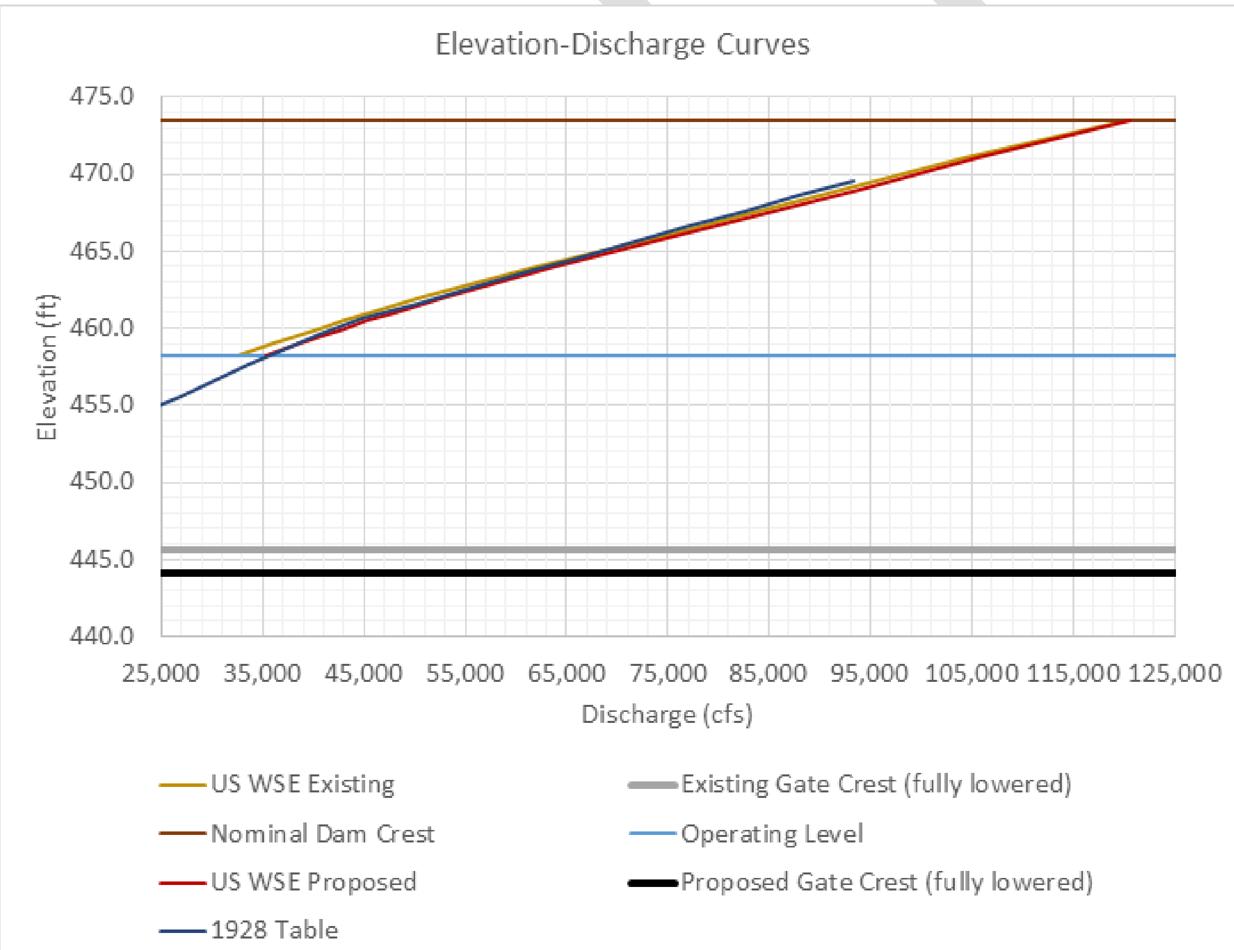


Figure 4-5 Nolte Spillway - Existing and Proposed Elevation-Discharge Curves

4.6 H-4 (LAKE GONZALES)

The H-4 Dam existing spillway includes two 85 ft wide by 12 ft tall gates. When the gates are fully raised, the crest elevation is EL 332.0 ft. With the existing flashboards, the crest elevation increases to EL 332.65 ft. When fully lowered the spillway crest elevation is EL 320 ft. The dam crest elevation is approximately EL 344.0 ft.

Hydraulic calculations were performed to determine discharges for a range of upstream water surface elevations between the operating level (EL 332.65 ft) and nominal top of dam (EL 344.0 ft).

To accommodate the new gates, the spillway width will be reduced by 6 ft at each gate bay; each gate will thus be 79 ft wide. To compensate for the reduced width, it has been calculated that the gate sill would have to be lowered by 1.5 ft; therefore, when fully lowered, the spillway crest would be at EL 318.5 ft. Figure 4-6 shows the elevation-discharge curves under existing and proposed conditions. The proposed gates provide a spillway discharge capacity equivalent to that of the existing gates.

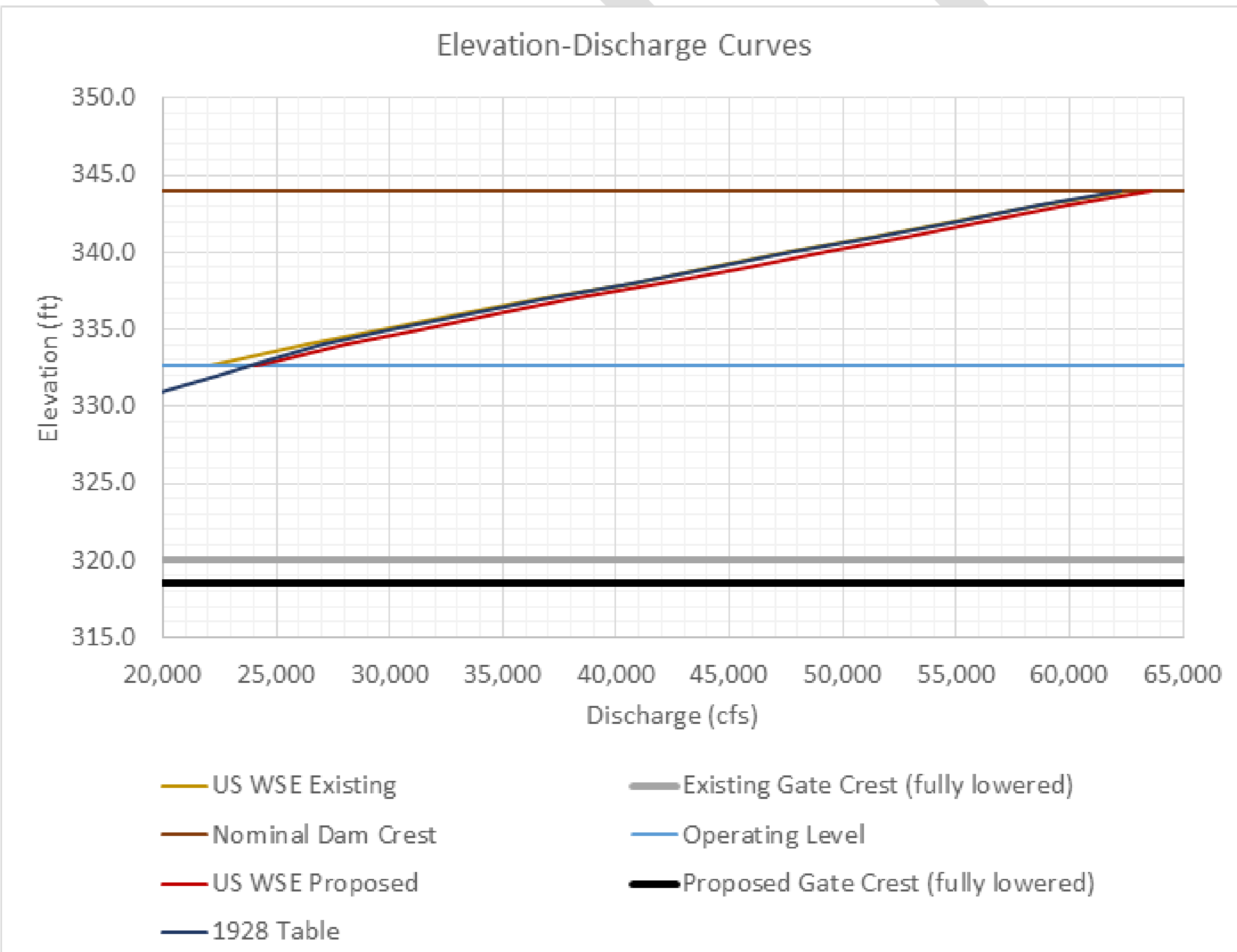


Figure 4-6 H-4 Spillway - Existing and Proposed Elevation-Discharge Curves

4.7 H-5 (LAKE WOOD)

The H-5 Dam existing spillway includes two 85 ft wide by 12 ft tall gates. When the gates are fully raised, the crest is at EL 290.90 ft. With the existing flashboards, the crest elevation increases to EL 291.60 ft. When fully lowered the spillway crest is at EL 278.9 ft. The dam crest elevation is approximately EL 303.0 ft.

Hydraulic calculations were performed to determine discharges for a range of upstream water surface elevations between the operating level (EL 291.6) and nominal top of dam (EL 303.0 ft).

To accommodate the new gates, the spillway width will be reduced by 6 ft at each gate bay; each gate will thus be 79 ft wide. To compensate for the reduced width, it has been calculated that the gate sill would have to be lowered by 1.5 ft; therefore, when fully lowered, the spillway crest would be at EL 277.4 ft. Figure 4-3 shows the elevation-discharge curves under existing and proposed conditions. The proposed gates provide a spillway discharge capacity equivalent to that of the existing gates.

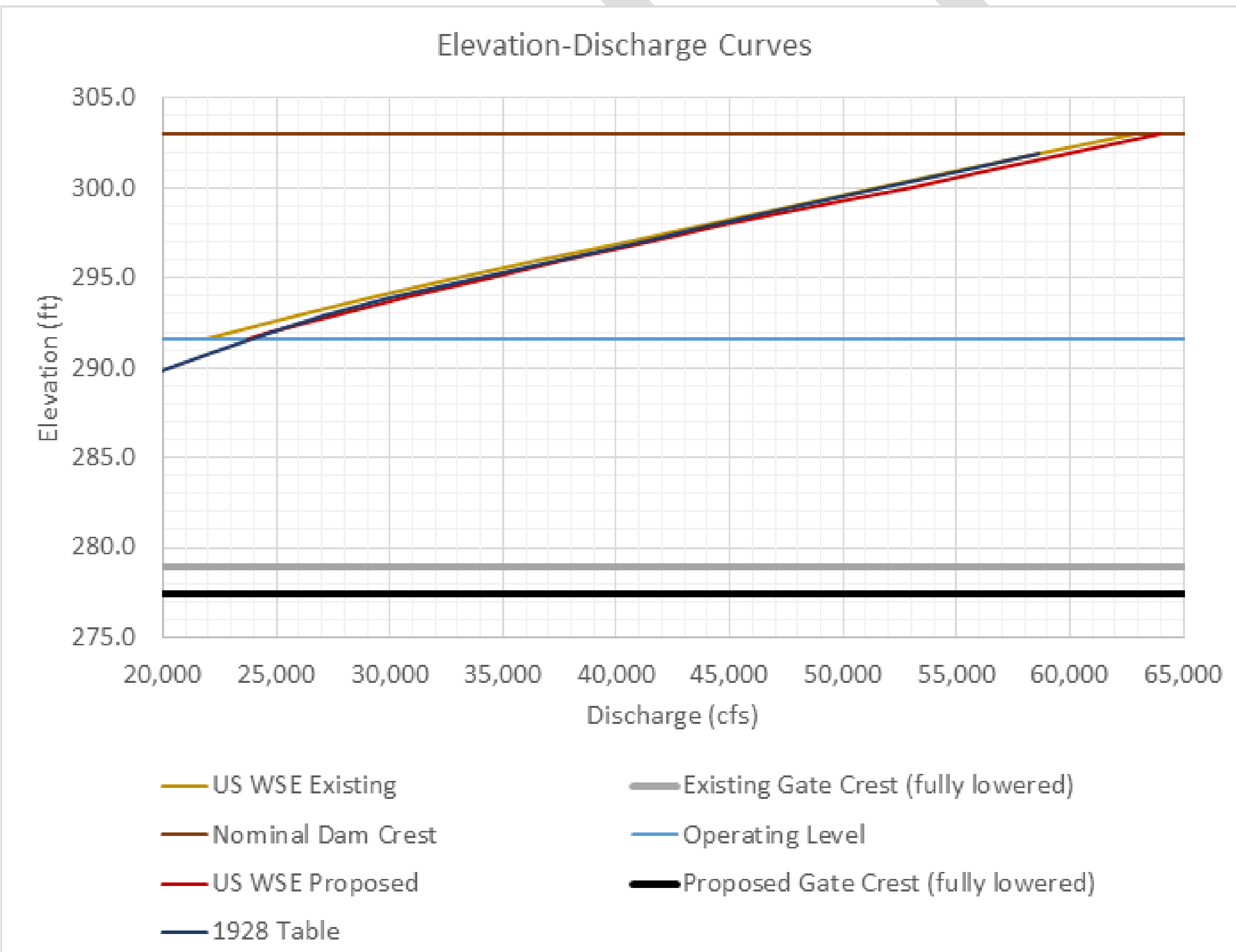


Figure 4-7 H-5 Spillway - Existing and Proposed Elevation-Discharge Curves

4.7.1 Scour and Energy Dissipation at H-5

Scour analysis and the need for energy dissipation was evaluated for the H-5 Dam. The analysis indicates that the current basin and concrete slabs located on the downstream end of the structure are insufficient to contain the anticipated hydraulic jump that can form downstream of the structure. The maximum hydraulic jump length that can be expected under the range of flows and gate settings analyzed has been estimated to be 166 feet. A United States Bureau of Reclamation (USBR) Type I hydraulic jump basin would have to extend for at least this length to provide adequate energy dissipation. This length can be substantially reduced if chute blocks and baffle blocks are added to the basin (USBR Type III basin).

Without proper energy dissipation a scour hole is anticipated to occur downstream of the structure. USBR Design of Small Dams (1987) provides a simple empirical approximation of ultimate scour depths that can be expected downstream of a spillway. Analysis based on this approximation indicates that the ultimate scour under existing conditions could reach elevation 236.3. Note that as shown on Figure 4-8, Figure 4-9 and Figure 4-10, the bathymetric survey shows that currently the scour hole reaches EL 240.3 ft. Because of concentration of flows due to narrowing of the proposed gates, it has been estimated that the ultimate scour hole could reach EL 234.4 ft under proposed conditions.

Several options exist for addressing the scour hole.

- Sheet pile could be placed downstream of the spillway apron to prevent undermining of the apron.
- Large riprap could be placed in the existing scour hole adjacent to the spillway apron. The riprap would protect the apron slab from undermining.
- Operation of the gates during spilling could favor the gate farthest from the powerhouse. On this side of the spillway the scour hole is not as extensive as the hole adjacent to the powerhouse.
- Energy dissipation blocks could be constructed downstream of the spillway to reduce the rate of growth of the scour holes. It is anticipated the concrete blocks would have to be of substantial size and require a new foundation slab to anchor them in place.
- More frequent monitoring of the scour hole by divers or bathymetry could be performed. It is possible that after almost 90 years of operation the scour hole has reached equilibrium and will not grow. The proposed slight narrowing of the gates might have no significant detrimental effect on growth of the scour hole. If the hole does continue to growth it could be detected by the monitoring and intervention taken at that time.

For the purpose of the cost estimate it is assumed that sheet pile will be placed downstream of the spillway apron.

A second scour hole is located in the tailrace of the powerhouse. This scour hole is deep enough that it should be filled during construction. The cost estimate includes 100 cubic yards of tremie placed underwater concrete to fill the tailrace scour hole.

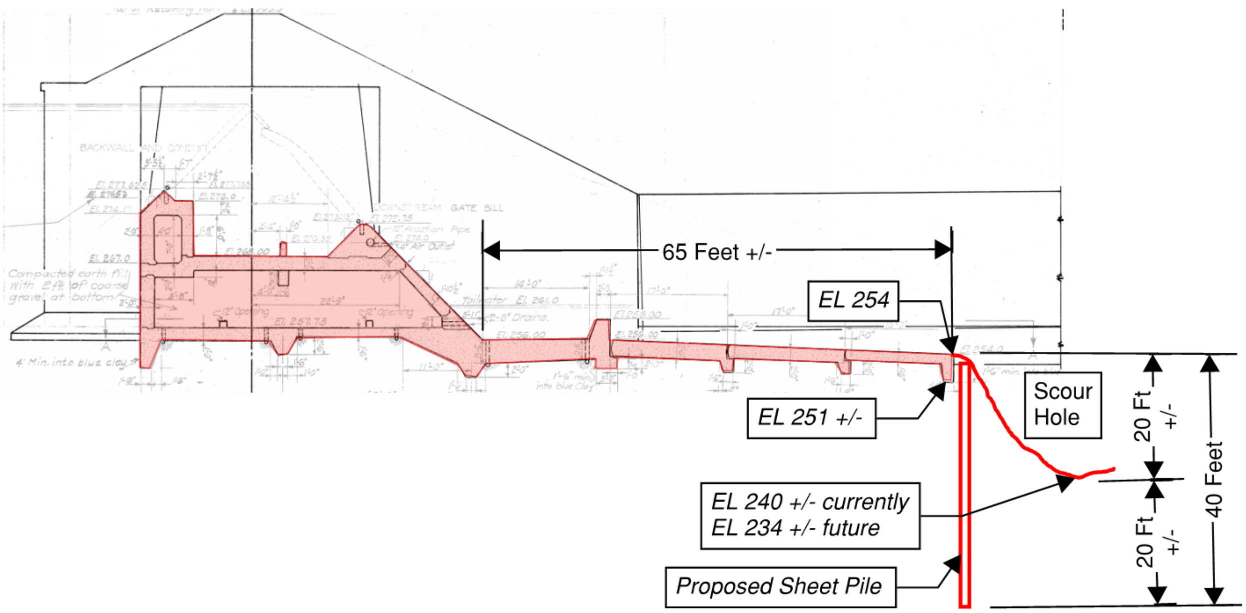


Figure 4-8 Proposed Sheet Pile at H-5 Scour Hole Downstream of Spillway Apron

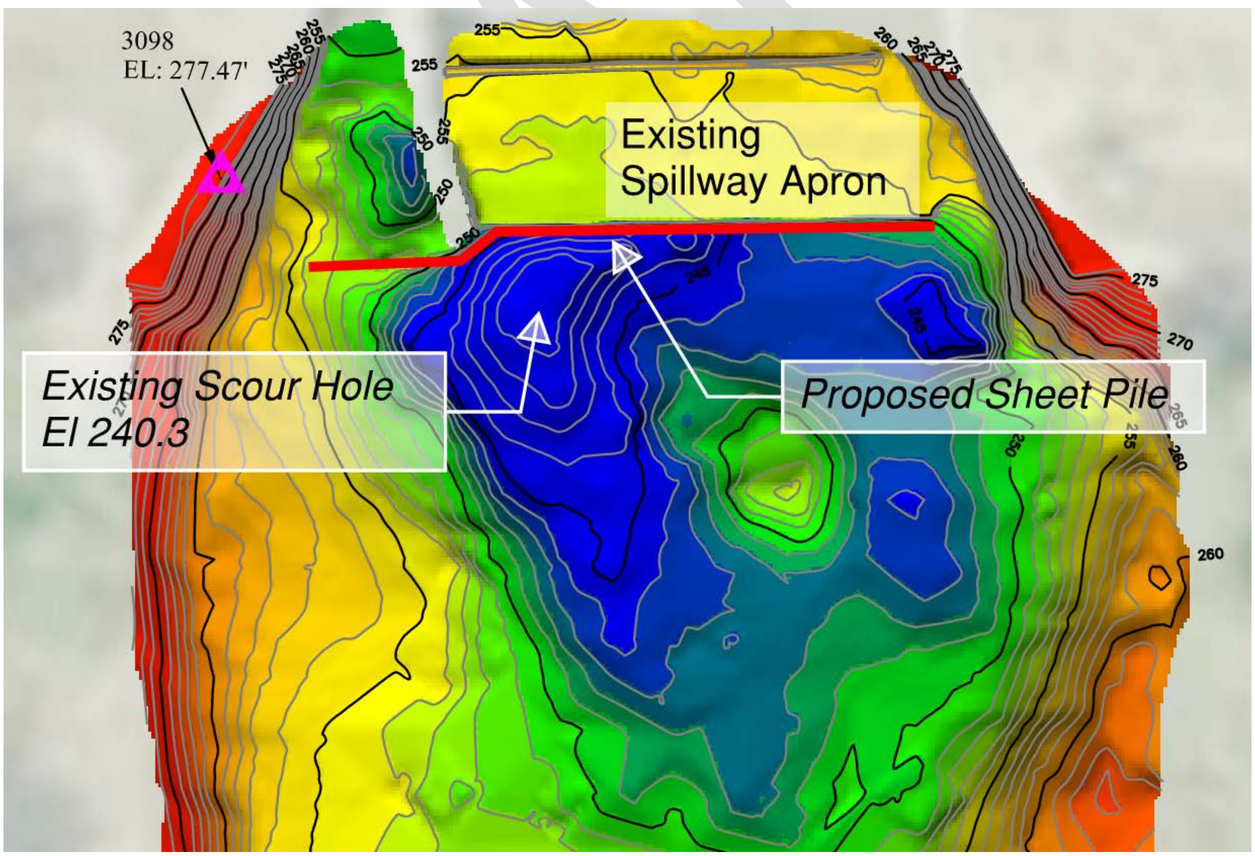


Figure 4-9 H-5 Downstream Scour Hole Plan View

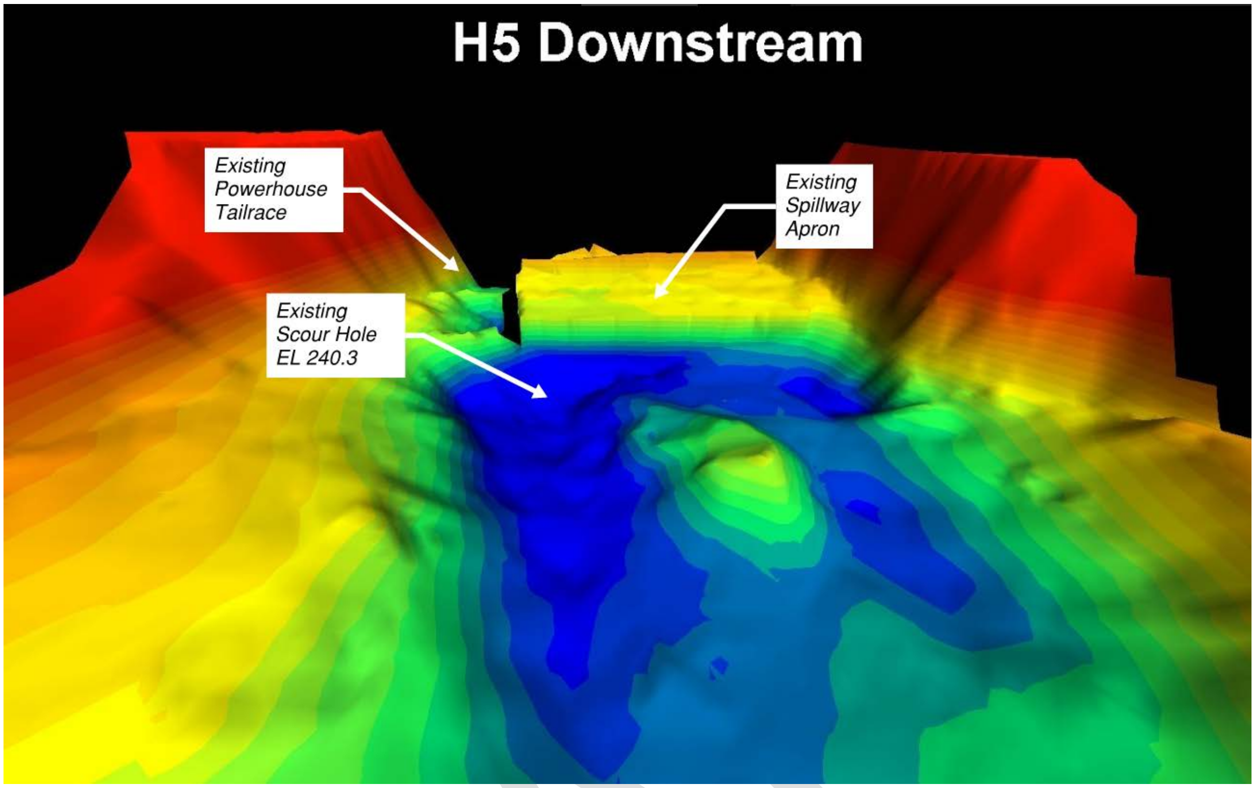


Figure 4-10 H-5 Downstream Scour Hole 3-D Image

5.0 Spillway and River Operations Plan

5.1 POWERHOUSE OPERATIONS

The six GVHS hydroelectric facilities all have similar configurations and generating capacities. Each powerhouse is equipped with either one or two turbine-generator units. As shown in Table 5-1, the total flow capacity through each of these facilities are very similar at the normal operating level, Full Pond, ranging from 1,230 cfs to 1,300 cfs.

During normal operation, the six facilities are operated to pass all river flow through the turbines while maintaining the reservoir level at its Full Pond level to maximize operating head without spilling over the spillgates. When the river flow exceeds the flow capacity through a powerhouse or when the powerhouse is not generating, GBRA will spill the flow over the spillgates. During low river conditions, when river flow is not adequate to operate the unit(s), GBRA shuts the units down and must pass the river flow over the spillgates.

Table 5-1 Flow Capacity at Each Powerhouse

DAM	GENERATOR NAMEPLATE CAPACITY	NUMBER OF UNITS	TOTAL GENERATOR CAPACITY	TOTAL FLOW CAPACITY AT FULL POND[1]	TOTAL FLOW CAPACITY AT SPILL POINT[2]
Dunlap	1.8 MW	2	3.6 MW	1,250 cfs[3]	2,300 cfs[4]
TP-3	1.4 MW	2	2.8 MW	1,250 cfs[3]	1,675 cfs[4]
TP-4	2.4 MW	1	2.4 MW	1,300 cfs[3]	1,500 cfs[4]
Nolte	1.24 MW	2	2.48 MW	1,250 cfs[3]	2,700 cfs[4]
H-4	2.4 MW	1	2.4 MW	1,230 cfs[3]	2,500 cfs[4]
H-5	2.4 MW	1	2.4 MW	1,280 cfs[3]	2,000 cfs[4]

1. Full Pond: Crest elevation of the spillgates in the raised position (up) with flashboards intact.
2. Spill Point: Reservoir elevation when GBRA will start to lower spillgates.
3. Flow capacity as reported by GBRA. Only includes flow through the powerhouse.
4. Flow capacity as reported by GBRA. Includes flow through the powerhouse and over spillgates with flashboards down (note: TP-3 and TP-4 do not have flashboards).

5.2 EXISTING SPILLGATE OPERATIONS

The six dams are all similarly configured with either two or three bear trap style crest spillgates that were part of the original construction of the dams. See Table 5-2 for a summary of the existing spillgate characteristics at each dam. As all gates have a similar vertical adjustment range, the difference in reported spill capacities is primarily due to the different overall width of the gates installed at each respective site.

During normal operations water level is held at the Full Pond level and all the flow is passed through the powerhouse facility. When a flood event occurs that exceeds the flow capacity through the powerhouse, the water level will start to rise and spill over the spillgates. When the water level reaches the specified Spill Point level, GBRA will manually start adjusting the spillgate positions in an attempt to keep the water at the specified Spill to Hold level. This level ranges anywhere from 0.2 to 0.6 ft below the Spill Point, depending on the dam. There is currently no set operational plan for relating change in water level to gate position. Without this, it is difficult to accurately determine the required gate position and existing gate operation is by trial and error and operator experience. GBRA personnel monitor upstream weather conditions and flow releases to help anticipate expected inflows. During spill events, the dams must be manned 24 hours a day to monitor water level and adjust gates.

Table 5-2 Summary of Existing Spillway Characteristics

DAM	SPILLGATE DIMENSIONS	SPILLGATE SILL ELEVATION (FT)	FULL POND[1] ELEVATION (FT)	SPILL TO HOLD[2] ELEVATION (FT)	SPILL POINT[3] ELEVATION (FT)
Dunlap	3 Gates 12 ft H x 85 ft W	563.2	575.80 (w/ Flashboards)	576.00	576.20
TP-3	3 Gates 12 ft H x 85 ft W	516.7	528.70	529.00	529.20
TP-4	2 Gates 12 ft H x 98 ft-8 in W	485.5	497.50	497.80	498.00
Nolte	3 Gates 12 ft H x 85 ft W	445.6	458.25 (w/ Flashboards)	459.00	459.60
H-4	2 Gates 12 ft H x 85 ft W	320.0	332.65 (w/ Flashboards)	333.20	333.50
H-5	2 Gates 12 ft H x 85 ft W	278.9	291.60 (w/ Flashboards)	291.70	291.90

1. Full Pond = Normal reservoir operating level (SCADA datum).
2. Spill to Hold = Target reservoir level to be maintained when using spillgates (SCADA datum).
3. Spill Point = Reservoir level when spillgate operation starts (SCADA datum).

5.3 PROPOSED SPILLGATE OPERATIONS

Installation of hydraulically operated crest gates at each of the GVHS dam sites will provide GBRA with gates that can be controlled with much more precision than the existing bear trap gates. The new gates will be operated using the same Spill Point and Spill to Hold reservoir level limits used for the existing gates. It is assumed that eventually all the crest gates will have the capability of being operated either automatically or manually.

A spillgate adjustment will be implemented by moving only one gate at a time. However, the gate opening procedure assumes that the position of each gate will be kept as close to the adjacent gate(s) as possible to assure uniform flow over the entire stilling basin area to help reduce downstream scour potential. Thus, when determining which gate to be moved, the operator should always select the gate that will maintain all the gates at a similar position.

Normally all flow will be routed through the powerhouse and the spillgates will remain in the up (closed) positions. The spillgate operation plan will be initiated when either the powerhouse is out of operation or the river flow is outside of the powerhouse operating range. During either of those conditions, the spillgate operation plan will be initiated at each dam as soon as the reservoir level rises to the **Spill Point** elevation identified in Table 5-2. At this level, the gates are all overtopped and the flashboards (where applicable) are assumed to have not failed. When the spillgate operation plan is initiated, the operators will lower one or more of the gates until reservoir level is equal to the **Spill to Hold** level. Spillgate operations will continue to to maintain the water level at the **Spill to Hold** levels until such time that the water level drops below the **Full Pond** level with all the gates in the raised position and powerhouse operational.

A hydraulic model was developed that checks the reservoir level every minute to see if it has departed more than 0.1 ft (up or down) from the **Spill to Hold** level. If the +/-0.1 ft threshold is exceeded, the gates are adjusted one at a time (down or up). Consistent with the operation plan, the gate position is adjusted by the same amount as the difference between the reservoir level and **Spill to Hold** level. The hydraulic modelling shows that the reservoir level responds well for major flood events (June 9, 2010 and October 30, 2015 flood events) and for normal daily fluctuations (April 2, 2019 flow)

5.3.1 Existing Bear Trap Gate Operations

While an automated spillgate operation plan will provide reasonable control of the water level, the schedule may be difficult to implement for manual operation. To simplify the operation plan, the gate position was correlated to the difference between the reservoir level and **Spill to Hold** level. The hydraulic model shows that adjustment of one gate equal to the difference between the reservoir level and **Spill to Hold** level provides adequate control of reservoir level.

The simplified spillgate operation plan discussed above can be used for the interim periods during construction where combinations of existing gates and proposed gates will have been installed. The hydraulic capacities of the existing bear trap gates are very similar to the proposed hydraulic crest gates. A significant opertional issue with the existing gates is the lack of precision with which the operators can control the gate position. It is assumed that the existing gates cannot be controlled with an accuracy better than 3 inches. For the existing gates, it is recommended that the gate operators wait until the difference between the reservoir level and **Spill to Hold** level exceed at least 3 inches before adjusting the gates.

5.3.2 Hydraulic Crest Gate Operations

Because of the inability to accurately forecast incoming flows, the proposed spillgate operation plan is based solely on how fast the reservoir levels are rising or dropping below the **Spill to Hold** level. The intent is to make the necessary adjustments in appropriate magnitude while at the same time limiting the frequency of adjustments to lessen wear on gate operating equipment. The distance the water level will be allowed to rise or drop before initiating a gate change, or the **Rise Limit**, will be established for each dam. The shorter the time required to raise or lower the reservoir to the specified **Rise Limit**, the larger the changes in gate position. To establish a correlation between the time to rise and gate position, a hydraulic model was developed to simulate gate operation during flood events. Hydrographs from the June 9, 2010 and October 30, 2015 flood events from USGS streamflow gage No. 08169792 ("Guadalupe River at FM 1117 near Seguin, TX") were used to create a hydraulic model that simulates actual flood events on this river. The hydraulic model accounts for reservoir storage and assumes the gates can be raised and dropped at a rate of 1 ft per minute. The hydraulic model yields a spillgate operation schedule as shown in Table 5-3, which can be used to control the gates solely based on how fast the reservoir level is changing relative to the target **Spill to Hold** level.

Table 5-3 Spillgate Operation Schedule

RESERVOIR RATE OF RISE TIME[1]	GATE ADJUSTMENT[2] FOR RISE[3] = 0.1 FT	GATE ADJUSTMENT[2] FOR RISE[3] = 0.2 FT	GATE ADJUSTMENT[2] FOR RISE[3] = 0.3 FT	GATE ADJUSTMENT[2] FOR RISE[3] = 0.4 FT
10 minutes+	0.2 inches	0.5 inches	1 inch	1.5 inches
5 minutes	0.5 inches	1 inch	2 inches	2.5 inches
2.5 minutes	1 inch	2 inches	4 inches	5 inches
1 minute	2 inches	4 inches	6 inches	12 inches
30 seconds	4 inches	7 inches	12 inches	18 inches

1. Time: Recorded time for water level to rise or fall from the Spill to Hold level to current reservoir level.
2. Gate Adjustment: Gate level adjustment for all gates from previous position (down if Rise is positive, up if Rise is negative).
3. Rise: Actual recorded difference between reservoir revel and Spill to Hold level when adjusting a gate.

5.3.3 Step-By-Step Operation Plan for H-5 Dam

The current spillgate operation scheme at the H-5 Dam is based on maintaining headwater level at EL 291.6 ft before spilling and EL 291.70 ft during spilling. Spilling is initiated at EL 291.9 ft. No changes to the existing spillgate operation are proposed for the new crest gates. The proposed spillgate operation plan for the gates at H-5 is provided below. The key parameters to be used with this spillgate operation plan are summarized in Table 5-4.

Table 5-4 Key Parameters for H-5 Dam (Lake Wood) Spillgate Operation Plan

PARAMETER	VALUE
Rise Limit	0.1 ft
Number of Gates	2
Spill Point Elevation	291.9 ft (SCADA datum)
Spill to Hold Elevation	291.7 ft (SCADA datum)
Full Pond Elevation	291.6 ft (SCADA datum)

This operation plan assumes the bear trap gates have been replaced with hydraulically operated crest gates that can beautomatically and precisely controlled. This operation plan utilizes the Spillgate Operation Schedule shown in Table 5-3; which is used to control the gates based on how fast the reservoir is changing (i.e. rise) relative to the target **Spill to Hold** level.

1. Activate spillgate operations plan when reservoir level reaches or exceeds the **Spill Point** elevation. This will normally occur when a flood event is occurring or if the powerhouse shuts down.

2. Adjust one of the spillgates. Vertical distance the gate must be adjusted to accomplish this is equal to the difference between reservoir level and **Spill to Hold** level. When changing a gate position, select the gate that will keep all gates in a similar position.

3. Monitor reservoir level for changes. When the difference between reservoir level and **Spill to Hold** level is equal to the specified **Rise Limit**, record the rise and time.

4. Using the Spillgate Operation Schedule (Table 5-3), adjust one of the spillgates using the recorded **Rise** and **Time**. For a positive rise, (i.e. reservoir level increasing), the gate adjustment is down (negative). For a negative rise, (i.e. reservoir level decreasing), the gate adjustment is up (positive). If possible, select the gate that will keep all gates in a similar position.

5. If the reservoir level is still outside of the **Rise Limit** after the gates have been adjusted in Step 4 or if the reservoir level does not return to the **Spill to Hold** level within 5 minutes after the gates have been adjusted in Step 4, adjust one of the spillgates by the difference between the reservoir level and **Spill to Hold** level.

6. If the gates are in a partially open position, return to Step 3.

7. If all gates are in the down (100% open) position and the reservoir level is above the **Spill to Hold** level, maintain the gates in this position and monitor reservoir level for changes. Once the reservoir level is at or below the **Spill to Hold** level, return to Steps 3.

8. If the gates are all in the up (100% closed) position:

    a. If the reservoir level is above the **Spill to Hold** level, return to Step 2.

    b. If the reservoir level is between the **Full Pond** and **Spill to Hold** levels, maintain the gates in the up (closed) position.

    c. If the reservoir level is at or below the **Full Pond** level, no imminent flooding is anticipated by the operators, and the powerhouse is operational, the operators will leave the gates in the up position and end operation of the spillgates.

6.0 Water Management Plan

The Contractor will be responsible for protecting the work area against both high headwater and tailwater during construction. This will be achieved using construction cofferdams and dewatering. Water will be pumped out of the dewatered area and routed back into the river in accordance with Texas Commission on Environmental Quality (TCEQ) requirements for both the initial pumping effort to drain the area and the pumping kept in place to maintain dry work areas during construction. Aquatic species captured during initial dewatering will be relocated in accordance with Texas Fish and Wildlife (TFW) requirements.

6.1 H-5 CONSTRUCTION COFFERDAM

Controlling the flow of water around the active construction areas to maximize the productivity of the work while maintaining the functionality of the spillway during construction is the purpose of the construction cofferdam. The construction cofferdam must do this in an economical manner while minimizing upstream impacts during high flow events.

This initial comparison of construction cofferdam alternatives will be based on a 2-year flood event of 10,000 cfs (50% annual chance of exceedance) as shown in Table 4-1. Headwater and tailwater levels at H-5 vary significantly depending on rain events. As shown in Figure 6-1, the maximum flow which can pass through one spillway gate without raising the headwater above normal pool EL 291.6 ft is 10,000 cfs. A flow of 10,000 cfs corresponds to a 2-year flood. At a flow of 10,000 cfs the tailwater rises to EL 286 ft. A tailwater elevation above EL 270 ft has the potential to flood the work area from the downstream side. The conclusion which can be reached from this is that while it might be possible to protect the worksite from the 2-year flood of 10,000 cfs, to do so would be prohibitively expensive. The most economical scenario will likely be to minimize the height and cost of the construction cofferdams and to accept some flooding of the work areas during high flow events.

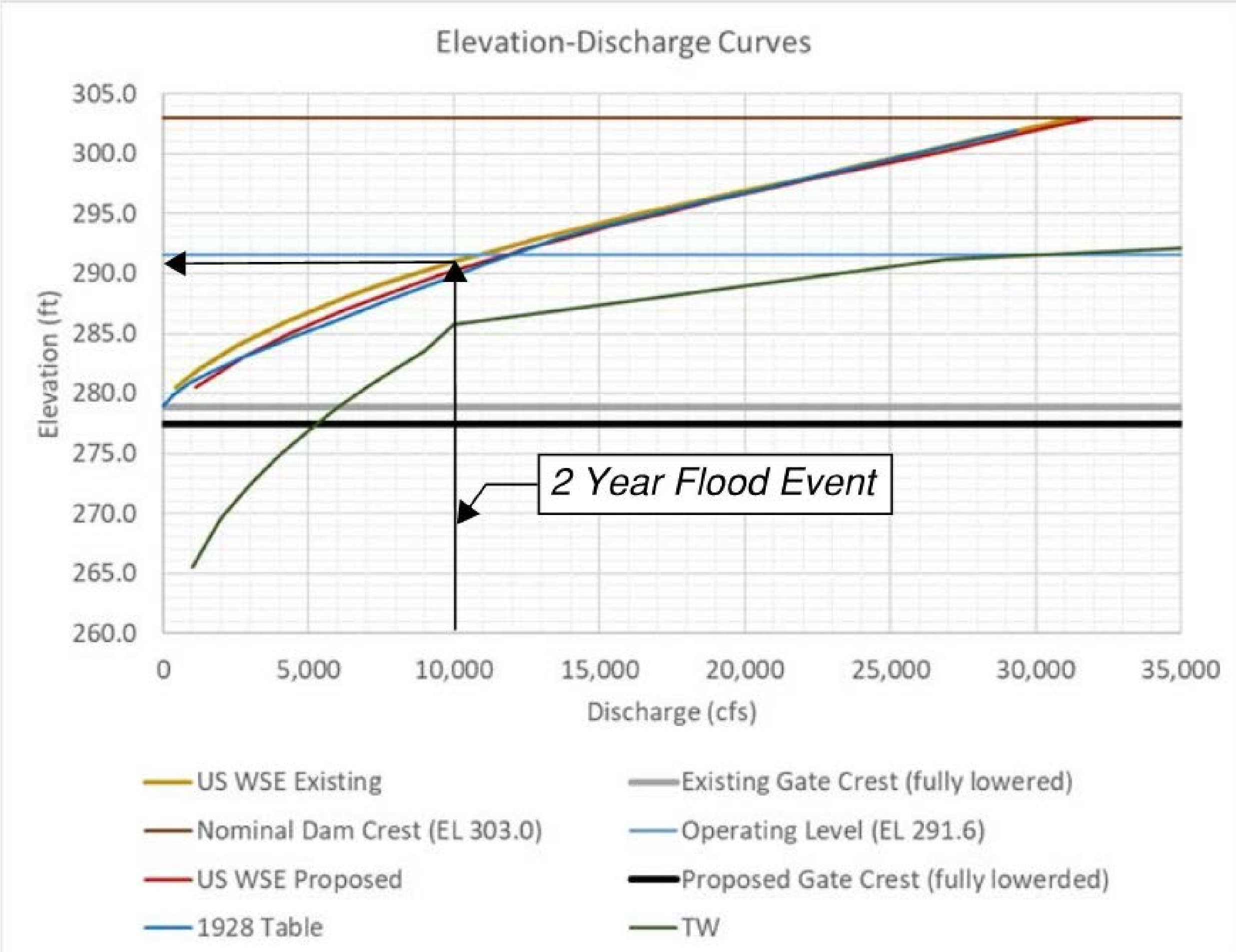


Figure 6-1 H-5 Spillway Single Gate Discharge Curve

6.1.1 Construction Cofferdam Option 1 - Bypass Channel

A bypass channel on the bank of the river, as shown on Figure 6-2, may provide a possible means of lowering the water level upstream of the dam. Preliminary sizing of the bypass channel indicates that a channel with the properties listed in Table 6-1 will be able to maintain the water level in the reservoir below elevation 270 for normal flows up to about 6,000 cfs, and maintain an elevation below EL 286 ft for 10,000 cfs (2 year flood flow). Both of these flows would require an earthen cofferdam across the river upstream of the dam. The estimated height of the cofferdam to divert the 10,000 cfs flow would be 24 feet. If only the normal flows are bypassed with low tailwater, a significantly shorter cofferdam of 7 feet would be required. It is important to note that there is less than 0.1 foot of elevation drop calculated for the bypass channel so upstream water surface elevation is very close to the tailwater elevation.

Because of the expected high cost of construction and permitting difficulties associated with a bypass channel around the spillway and through the dam this option will not be favorable.

Table 6-1 Bypass Channel Design Summary

UPSTREAM WATER EL	DOWNSTREAM WATER EL	FLOW	CHANNEL VELOCITY	CHANNEL INVERT	BOTTOM WIDTH	SIDE SLOPES H:V
270.1 ft	270	6,000	4 ft/s	250	40 ft	2:1
286.1 ft	286	10,000	2.5 ft/s	250	40 ft	2:1

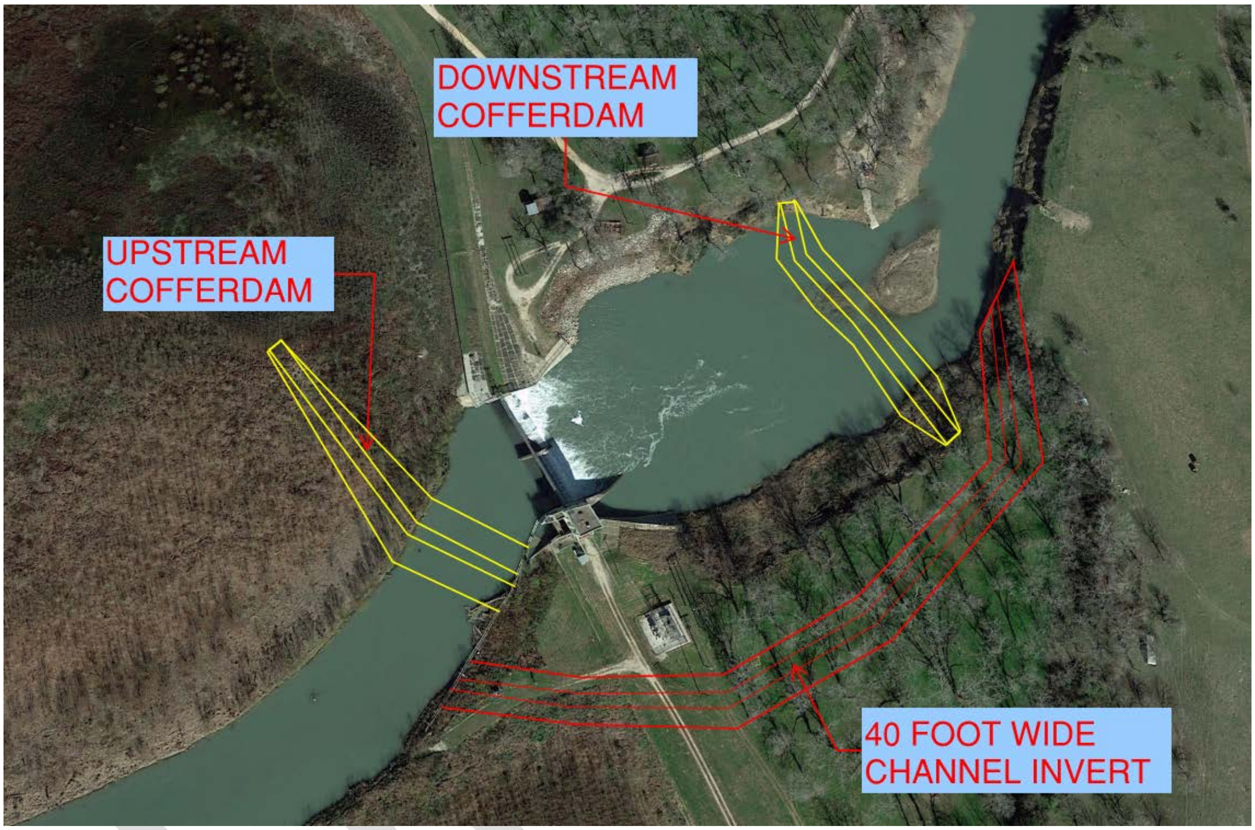


Figure 6-2 Construction Cofferdam Option 1 - Bypass Channel

6.1.2 Construction Cofferdam Option 2 - Earthen Cofferdam

An earthen cofferdam, as shown on Figure 6-3, can be constructed from each bank to the center pier for H-5. In order to provide clearance around the center pier, a section of sheet pile cofferdam would be required from the pier to approximately 100 feet upstream of the pier. This sheet pile cofferdam will allow the earthen embankment to butt up against it to seal a single gate bay for work. Based on providing protection from a two-year flood flow of 10,000 cfs passing through a single bay, the water surface elevation will need to be approximately EL 291 ft, and the top of the cofferdam will need to be EL 293.0 ft. The side slopes of the cofferdam would be approximately a 2H:1V. With a channel elevation of EL 265 ft, the total height of the cofferdam would be 28 feet, and the approximate width at the base of the cofferdam would be 128 feet. This makes the earthen cofferdam difficult to fit into the river channel without blocking areas required to complete the work on the gates. High velocity areas near the open bay would potentially erode part of the cofferdam if it is not armored with riprap which increases costs.

Because of the expected high cost of construction of an earthen cofferdam this option will not be favorable.

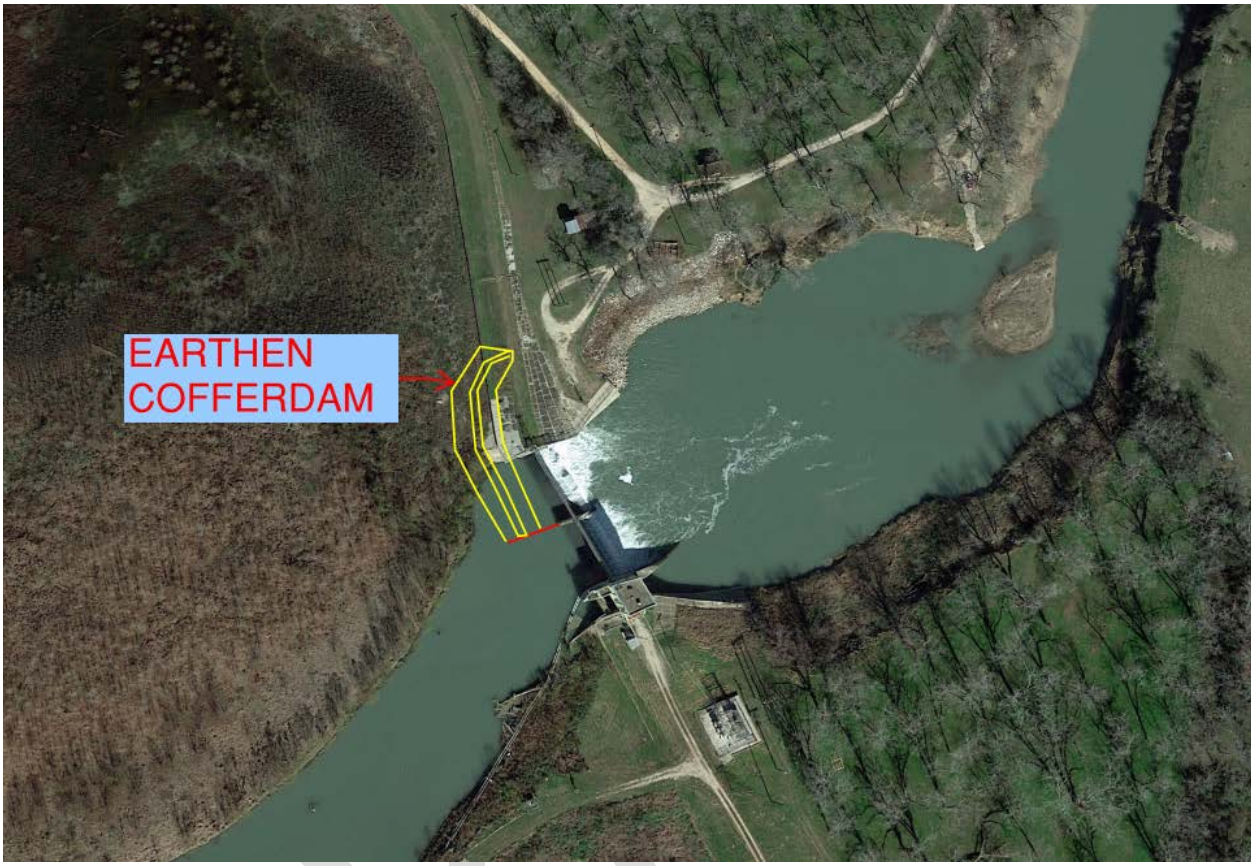


Figure 6-3 Earthen Cofferdam

6.1.3 Construction Cofferdam Option 3 – Sheet Pile

A sheet pile cofferdam, as shown on Figure 6-4, can be constructed in two stages to isolate each gate bay sequentially. The sheet pile cofferdam would be constructed approximately 18 feet upstream of the spillway. The first stage of cofferdam construction would extend from the north retaining wall to the center pier of the spillway. The second stage of cofferdam construction would extend from the center pier to the south pier of the spillway. During the first stage of construction, river flow would pass through the south gate bay. During the second stage of construction, river flow would pass through the north gate bay. During periods of high flow the cofferdam would overtop, flooding the construction area but limiting flooding of areas upstream of the dam.

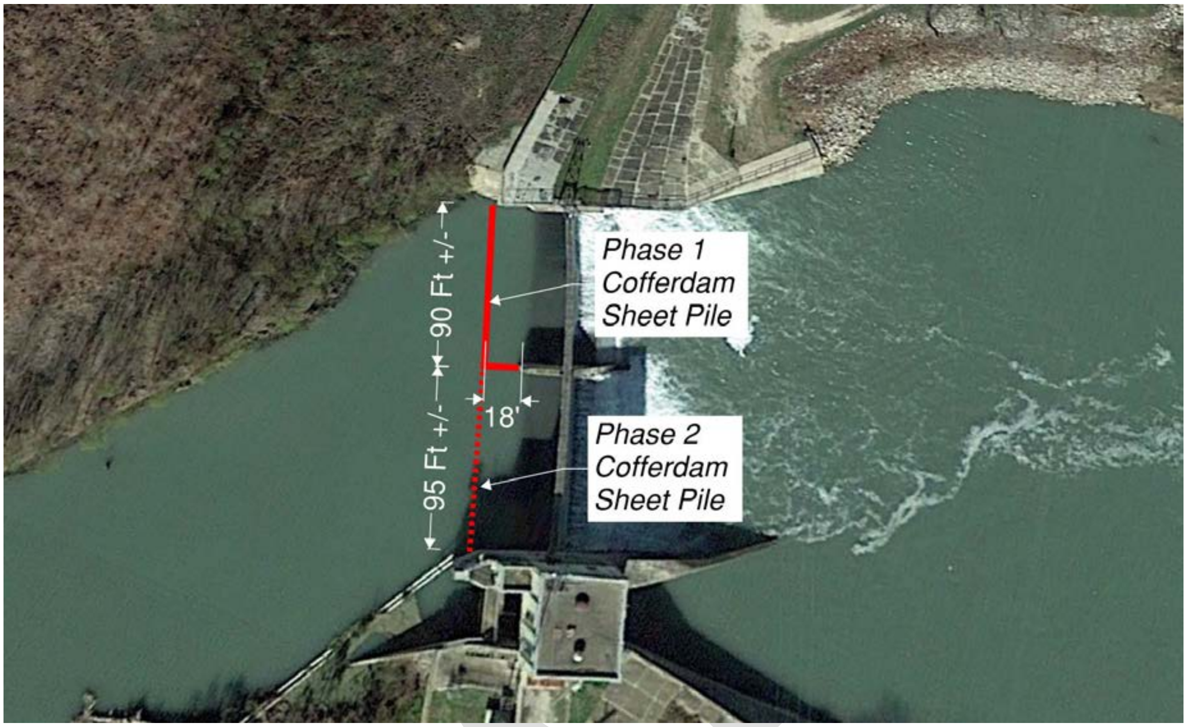


Figure 6-4 Construction Cofferdam Option 3 – Sheet Pile Plan

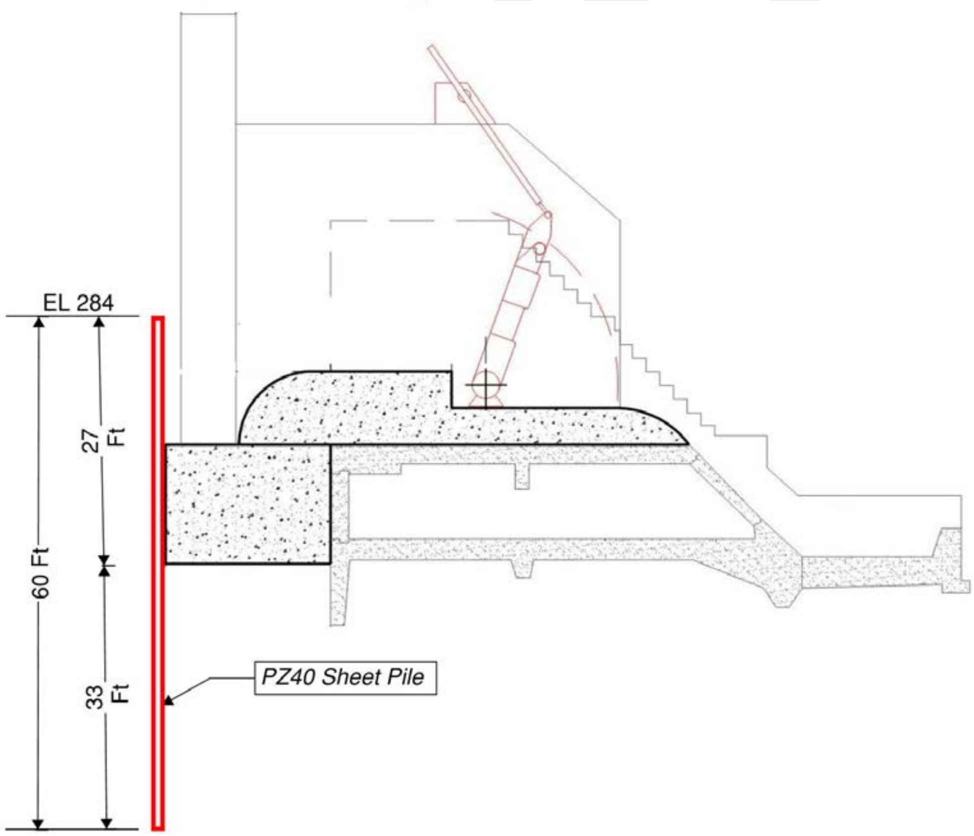


Figure 6-5 Construction Cofferdam Option 3 – Sheet Pile Section

6.1.4 Comparison of Alternatives

Each of the three temporary cofferdams has certain advantages and disadvantages when compared to the other cofferdams. Table 6-2 below summarizes the comparison between the three types of cofferdams by rating them on a scale of 1 to 3 with 3 being the most favorable and 1 being the least favorable alternative for that category. Even with this simplified comparison the sheet pile cofferdam is clearly the preferred alternative. A sheet pile cofferdam would be significantly less costly to construct and permit than either the bypass channel or the earthen cofferdam.

Table 6-2 Comparison of Temporary Cofferdams

CATEGORY	OPTION 1 - BYPASS CHANNEL	OPTION 2 - EARTHEN COFFERDAM	OPTION 3 - SHEETPILE COFFERDAM
Lowers Upstream WSEL	3	1	2
Tolerates high velocity	2	1	3
Speed of construction	2	1	3
Maintains space for construction	3	2	2
Flexible for configuration during construction	2	1	3
Ease of permitting	1	2	3
Cost	1	2	3
Average	2.0	1.4	2.7

6.1.5 Constraints to be Placed in Construction Contract

Cofferdam criteria will be incorporated into the construction plans and specifications. The plans and specifications will contractually define the responsibilities of the contractor as related to care of water during construction. Criteria included in the plans and specifications will be those developed to provide for robust systems to economically accommodate unexpected or changing conditions in the river while minimize detrimental effects on upstream properties during high flow events. Because of the limited spill capacity of the existing spillway and the need to prevent flooding upstream of the dam during construction, it is expected that the construction cofferdam will overtop and flood the spillway construction area multiple times during the duration of construction. Allowances need to be included in the project schedule to account for this expected flooding of the work area.

Figure 6-6, Figure 6-7 and Figure 6-8 were developed to assist in evaluating how cofferdam height impacts flooding as well as cofferdam overtopping. The lower the cofferdam height is set the more frequent it will be overtopped. The higher the cofferdam is set the greater the upstream impact during flooding. Using the flow durations developed to create Figure 4-1, a comparison of cofferdam height versus the number of times the cofferdam would be overtopped can be evaluated. Figure 6-6 shows that for even a cofferdam equal in height to that of the existing gates the cofferdam will be overtopped, on the average, at least three times a year and the number of times it is overtopped increases significantly with lower cofferdam crest levels. Based on Figure 6-6, it is recommended that the cofferdam height not be set below EL 282 ft; which results in the cofferdam being overtopped about 23 times a year. Also, from Figure 6-6, the difference appears to be insignificant in the number of times the cofferdam is overtopped for cofferdam heights at or above EL 287.5 ft, thus there is no flood protection benefit for having the cofferdam height set any higher than EL 287.5 ft.

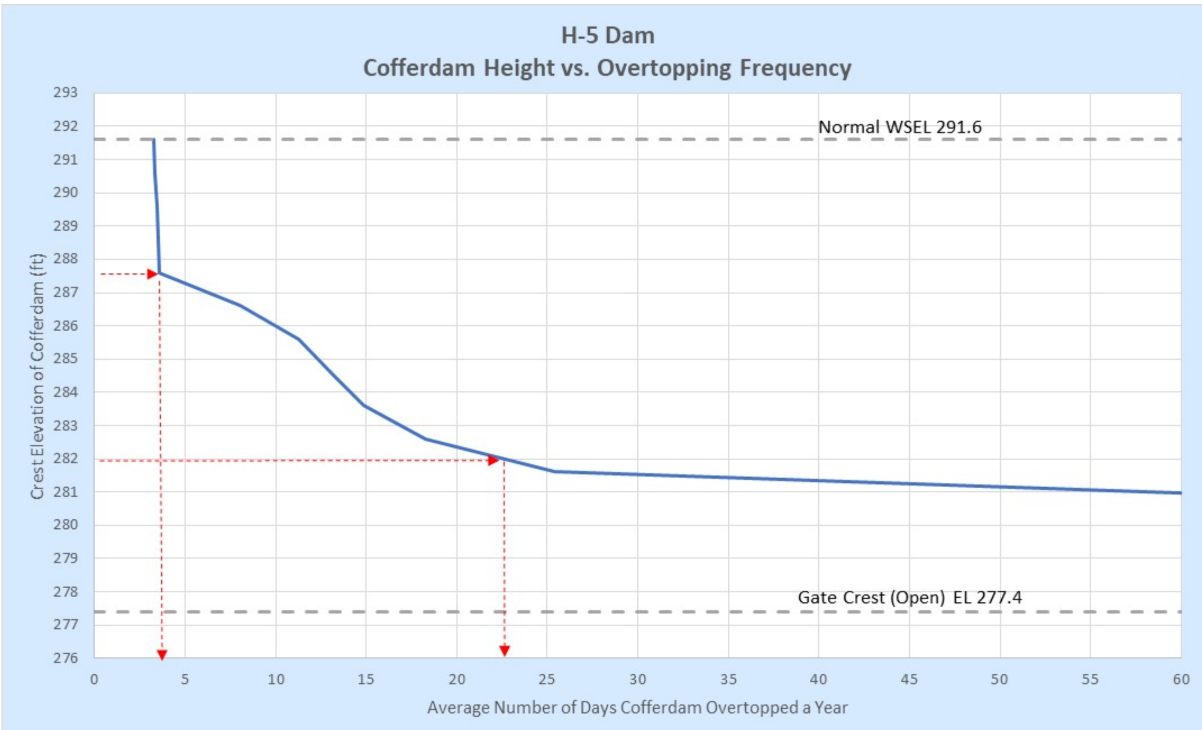


Figure 6-6 Cofferdam Height vs. Overtopping Frequency

Figure 6-7 provides a comparison of the cofferdam height versus the flood event that would cause the reservoir level to exceed the normal water level (EL 291.6 ft). The graph shows that the higher the cofferdam height, the more frequently upstream flooding will occur. If the cofferdam height is set at the normal water level, the adjacent gate fully opened can pass approximately the 2.6-year flood before there is upstream flooding. With the cofferdam height set at the gate sill elevation (EL 277.4 ft), no upstream flooding would occur until approximately the 4.8-year flood. For cofferdam heights between EL 282.0 ft and EL 287.5 ft, the frequency of upstream flooding would vary between the 3.9-year and 2.9-year flood event, respectively.

Figure 6-8 provides a comparison of how high the reservoir level is expected to rise during the 5-year and 100-year flood events for various cofferdam heights. While the 100-year event will result in a higher overall reservoir level, the 5-year flood will have a significantly larger incremental rise with higher cofferdam heights. For the 5-year event, a cofferdam height at the normal water level will increase the reservoir height by approximately 3.6 feet above what the same flood event would do if both gates were open. For cofferdam heights between EL 282.0 ft and EL 287.5 ft, the 5-year event increases the reservoir height between the 1.2 feet and 2.6 feet, respectively.

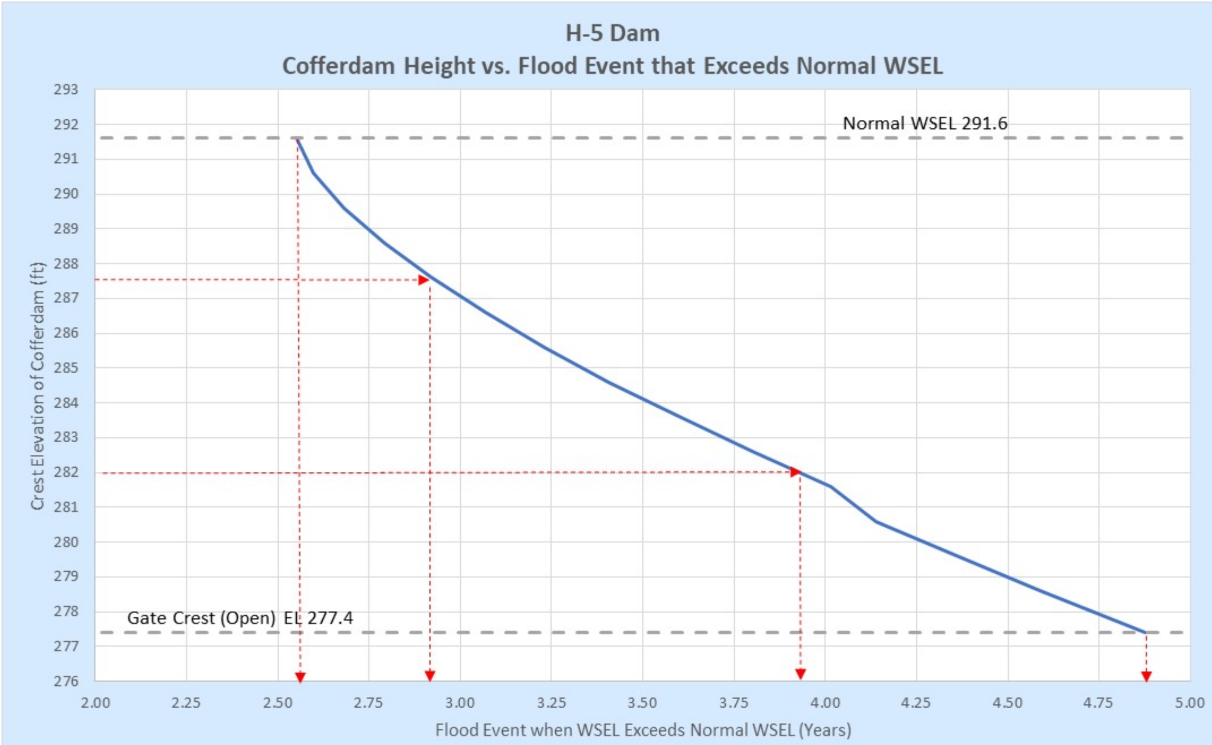


Figure 6-7 Cofferdam Height vs. Flood Event that Exceeds Normal WSEL

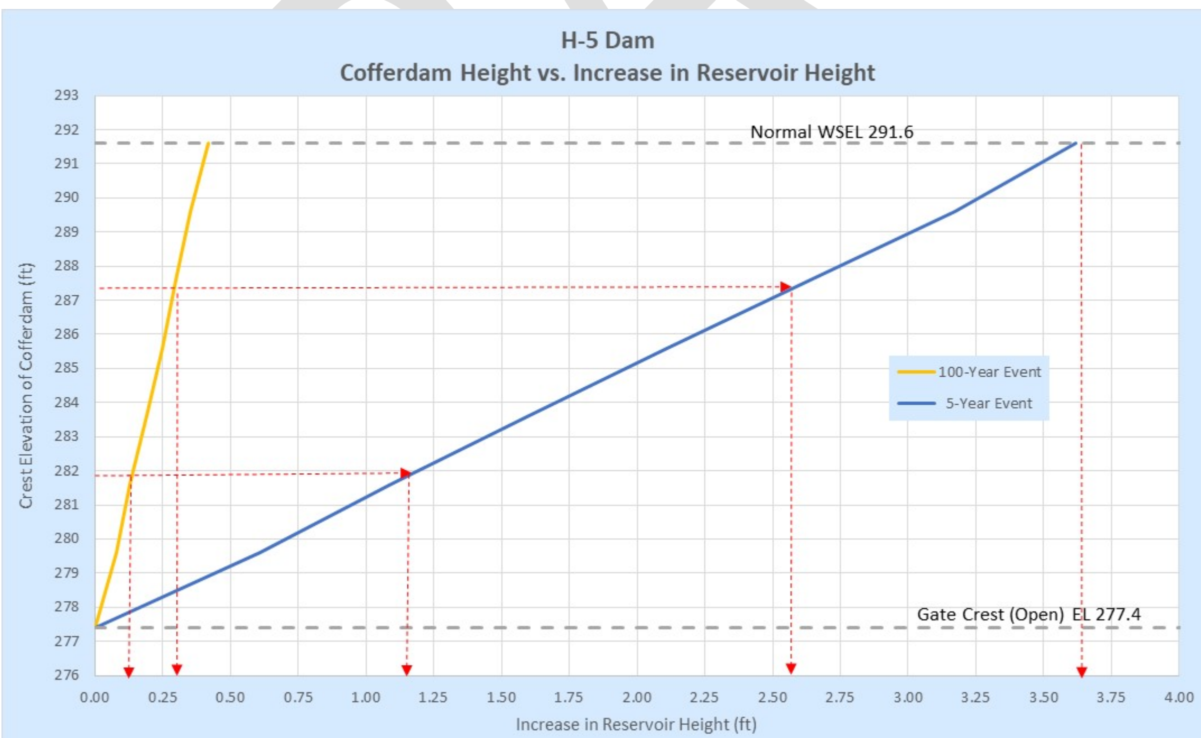


Figure 6-8 Cofferdam Height vs. Increase in Reservoir Height

In addition to the headwater cofferdam being overtopped and flooding the work area, the work area is also at risk of flooding from downstream tailwater. As shown in Figure 6-1, with headwater at EL 284 ft, approximately 2,000 cfs will pass through one gate. A flow of 2,000 cfs corresponds to tailwater at EL 274 ft, approximately 4 feet above the spillway working slab at EL 270 ft. An economical protection scheme would be to assume a short downstream cofferdam is constructed on the EL 270 ft work surface to provide tailwater flood protection to EL 274 ft. Allowing for one foot of freeboard, a headwater cofferdam to EL 285 and a downstream cofferdam to EL 275 would protect the work area from flooding up to EL 284 ft. A cofferdam at EL 285 would be expected to overtop on average once per month.

Based on the discussions above, the cofferdam height should not be set below EL 282.0 ft to control the frequency of overtopping. There does not appear to be any benefit to having the maximum cofferdam height set above EL 287.5 ft. In addition, if it is set above EL 285 ft, significant protection from tailwater flooding will need to be incorporated.

Table 6-3 Cofferdam Constraints

Constraints for Contractor Designed Cofferdams and Dewatering Systems	
Maximum Number of Gates Out of Service	One
Minimum Elevation of Top of Cofferdam	EL 282.0
Maximum Elevation of Top of Cofferdam	EL 287 (To Be Determined)
Minimum Elevation of Downstream Cofferdam	EL 274 (To Be Determined)
Dewatering Pumps	Multiple with Standbys

6.2 CONSTRUCTION COFFERDAMS AT SPILLWAYS UPSTREAM OF H-5

The construction cofferdam geometry proposed for use at H-5 is adequate at H-5 because the level of Lake Wood has already been lowered. Construction cofferdams at the five spillways upstream of H-5 could be almost identical to the cofferdam proposed for H-5 if the level of the lakes were lowered by 10 feet. For the five lakes upstream of H-5 it is possible to maintain the lake levels at nearly normal elevations during construction. To maintain the level of any of the lakes would require a greater length of sheet pile cofferdam than proposed for H-5.

To reduce the risk of flooding upstream of the spillway under construction, the sheet pile cofferdam must be allowed to overtop. When the design flow overtopping the sheet pile is equal to or greater than the flow through one existing gate the cofferdam will not increase the risk of flooding upstream. The lower the top of the cofferdam is relative to normal lake level, the more flow which can pass over the cofferdam without exceeding normal lake level. The greater the length of sheet pile provided the higher the level at which the lake can be maintained. The lesser the length of sheet pile provided the lower the level at which the lake can be maintained. Table 6-4 presents the additional costs associated with maintaining lake level during gate replacement. These costs would be in addition to the costs summarized in Table 3-2.

To maintain the functionality of the spillways, only one gate at a time can be taken out of service. Figure 6-9 shows the sequencing of sheet pile cofferdams at the Dunlap spillway. The sheet pile arrangement shown is that associated with maintaining the lake level 4 feet below the normal pool.

Table 6-4 Additional Construction Costs to Maintain Lake Levels During Gate Replacement

DISTANCE BELOW NORMAL LAKE LEVEL	LENGTH OF SHEET PILE REQUIRED (PER GATE)	ADDITIONAL LENGTH OF SHEET PILE REQUIRED (PER DAM)	COST PER LINEAR FOOT OF SHEET PILE	ADDITIONAL COST TO MAINTAIN LAKE LEVEL (PER DAM) (2019 DOLLARS)
1 Feet	1,500 Feet	2,580 Feet	$4,000	$10 M
2 Feet	700 Feet	1,080 Feet	$4,000	$4.3 M
3 Feet	430 Feet	540 Feet	$4,000	$2.2 M
4 Feet	300 Feet	360 Feet	$4,000	$1.4 M
5 Feet	220 Feet	180 Feet	$4,000	$0.7 M
10 Feet	88 Feet	0 Feet	$4,000	$0

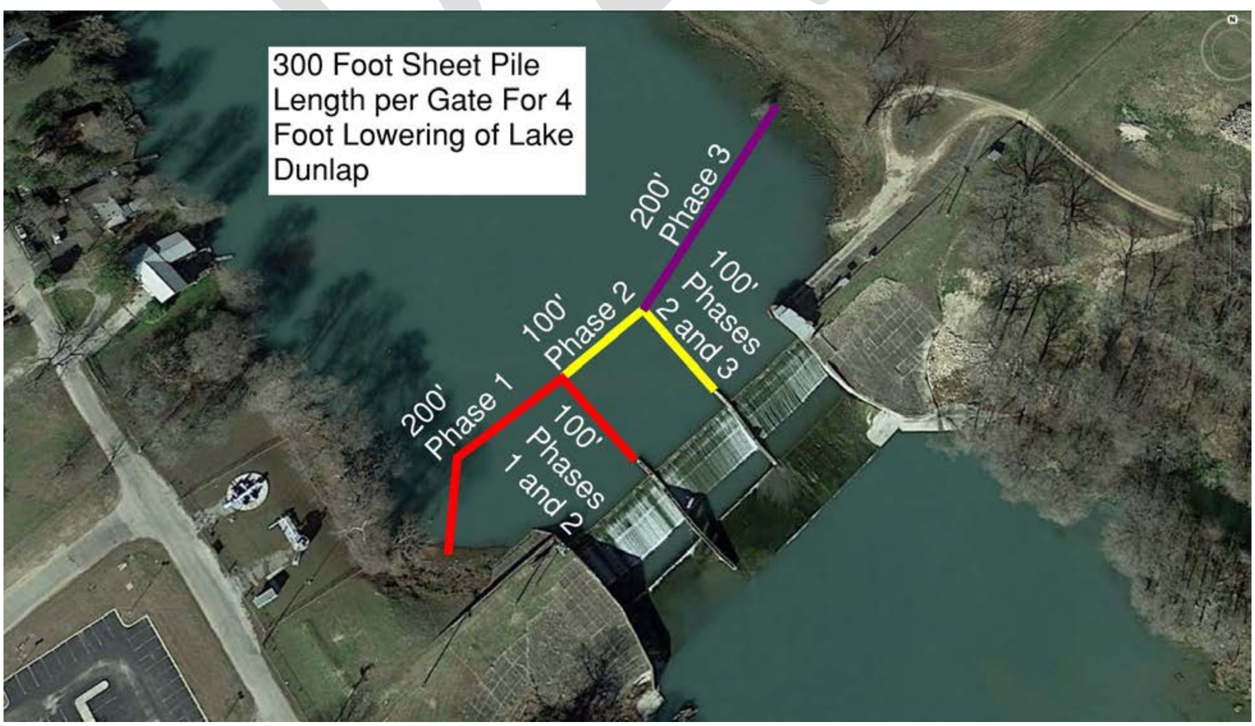


Figure 6-9 Sequential Phasing of Sheet Pile Cofferdam to Maintain Lake Level

6.3 GATE MAINTENANCE COFFERDAM

The H-5 spillgate replacement project will incorporate provision for the installation of a maintenance dewatering system. This dewatering system will be used to facilitate maintenance of the gates at the H-5 dam as well as future crest gates at the five other dams in the Guadalupe Valley Hydroelectric System.

6.3.1 Existing Hood

The existing maintenance hood is a short dewatering box which is positioned against the existing wood clad bear trap gates with its ends positioned near the existing ribs of the bear trap gate. Water in the dewatering box is then pumped out and the hydrostatic pressure forces the dewatering box against the gate creating a seal. As this system is of a relatively narrow width, sized only for removing and replacing boards or seals on the existing bear trap gates, it will not be effective for maintenance of the new gate which requires dewatering of the entire width of a bay.

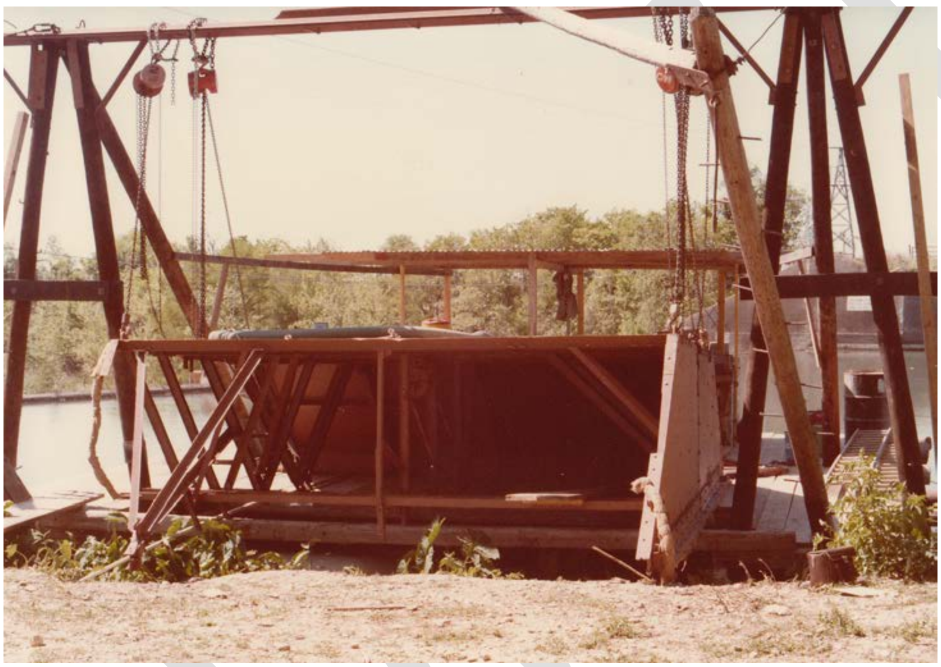


Figure 6-10 Existing Maintenance Hood

6.3.2 Floating Bulkhead

A floating bulkhead, similar to the existing maintenance hood, but much larger, could be used to dewater an entire bay. The floating bulkhead would include both upstream and downstream skinplates with buoyancy chambers between the skin plates. This system would be floated into place without the use of a barge mounted crane. Once in place the buoyancy chambers are filled with water to slowly sink the bulkhead into position against the spillway piers. Seals would be located around the two ends and bottom of the floating bulkhead to seal against the gate and concrete structure of the dam. Once in place, the isolated area downstream of the dewatering box would be pumped dry causing the hydrostatic head to push the dewatering box against the concrete structure and create a seal.

The floating bulkhead could be segmented to allow for dewatering of an entire bay or shorter sections of exiting gates for replacement of the upstream wood cladding or seals. Internal bracing members would be located at approximately 14 foot centers to align just off center of the existing ribs in the bear trap gates to allow replacing full sections of wood cladding. An extra internal brace would be utilized to allow re-positioning the internal braces to remove boards on adjacent segments of the bear trap gates. For maintenance on the new gates, the dewatering box will allow maintenance on seals as it braces back to the gate. If the entire gate needs to be removed, the braces would need to be set against an embedment in the concrete.

Because of the large size of the gates and the geometric differences between the existing and new gates, a floating cofferdam common to both will likely not be an economical alternative.

6.3.3 Steel Beam and Vertically Spanning Panels

A dewatering system consisting of vertical panels and a horizontal beam can be used to dewater the new gates. The horizontal beam would be supported in a slot in the spillway piers. This beam spans 79 feet between the center pier and the abutment wall. It is estimated that the weight of the horizontal beam would be approximately 12 tons. A crane would be required to assemble the horizontal beam and place it onto pontoons for transport across the lake. The vertical panels could be sheet pile transported and installed with a barge mounted crane. Alternatively, the vertical panels could be floating cofferdam sections. A small boat could push the buoyant sections across the lake. Once at the spillway, the buoyancy chambers in the floating sections would be filled with water to position the panels against the spillway and horizontal beam. If desired, the horizontal beam could also support a pedestrian walkway and allow for inspection access to the vertical panels when they are installed. Figure 6-11 below shows a conceptual arrangement of the steel beam and vertical panels.

Because of the large horizontal force the beam would place on the center pier, this option would not be feasible for use with the existing gates.

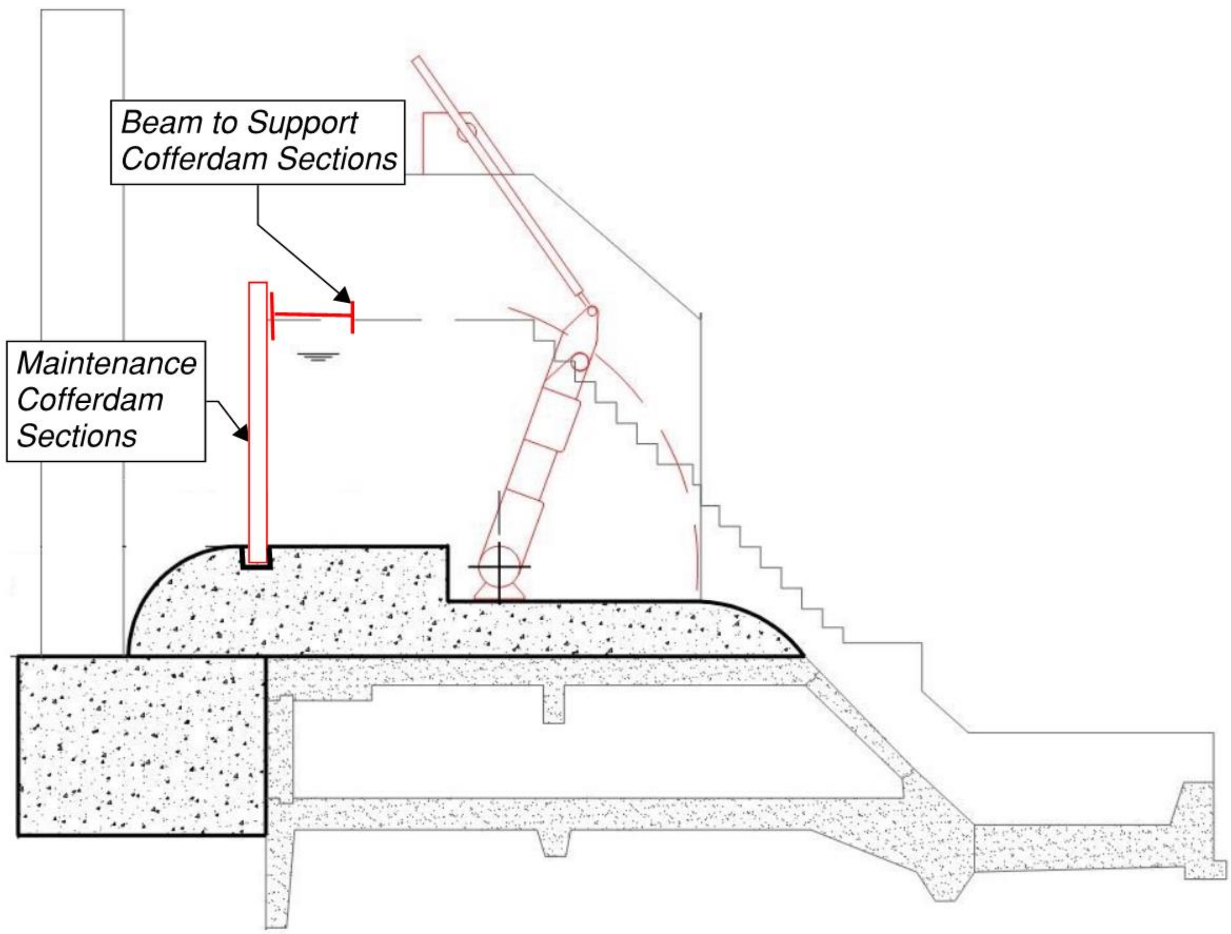


Figure 6-11 Conceptual Arrangement of Beam with Vertically Spanning Panels

6.3.4 Steel Columns and Horizontally Spanning Panels

A maintenance dewatering system for the new gates can be constructed by casting column pockets in the section of concrete to be placed at the front of the existing dam. The pockets will support steel columns. The steel columns will support and guide steel panels which span between the columns and form the cofferdam. A cofferdam height of 15.5 feet will provide 1 foot of freeboard above the normal full pool level. A plate will be necessary to cover the pockets when not in use to minimize the volume of debris which may enter the pocket.

The cofferdam steel panels are similar to a gate which has horizontal framing members for carrying the load and a skin plate to hold back the water. This system will allow for a rubber seal to be in contact with the wide flange columns. Wood lagging rather than steel panels is also an option. Wood members would not have the longevity of steel and could deteriorate between periods of usage. Steel panels would be kept to a size small enough to transport and store. The steel columns and panels could be installed using a monorail provided for that purpose. Figure 6-12 shows a conceptual arrangement of the steel columns and panels to create the maintenance dewatering system.

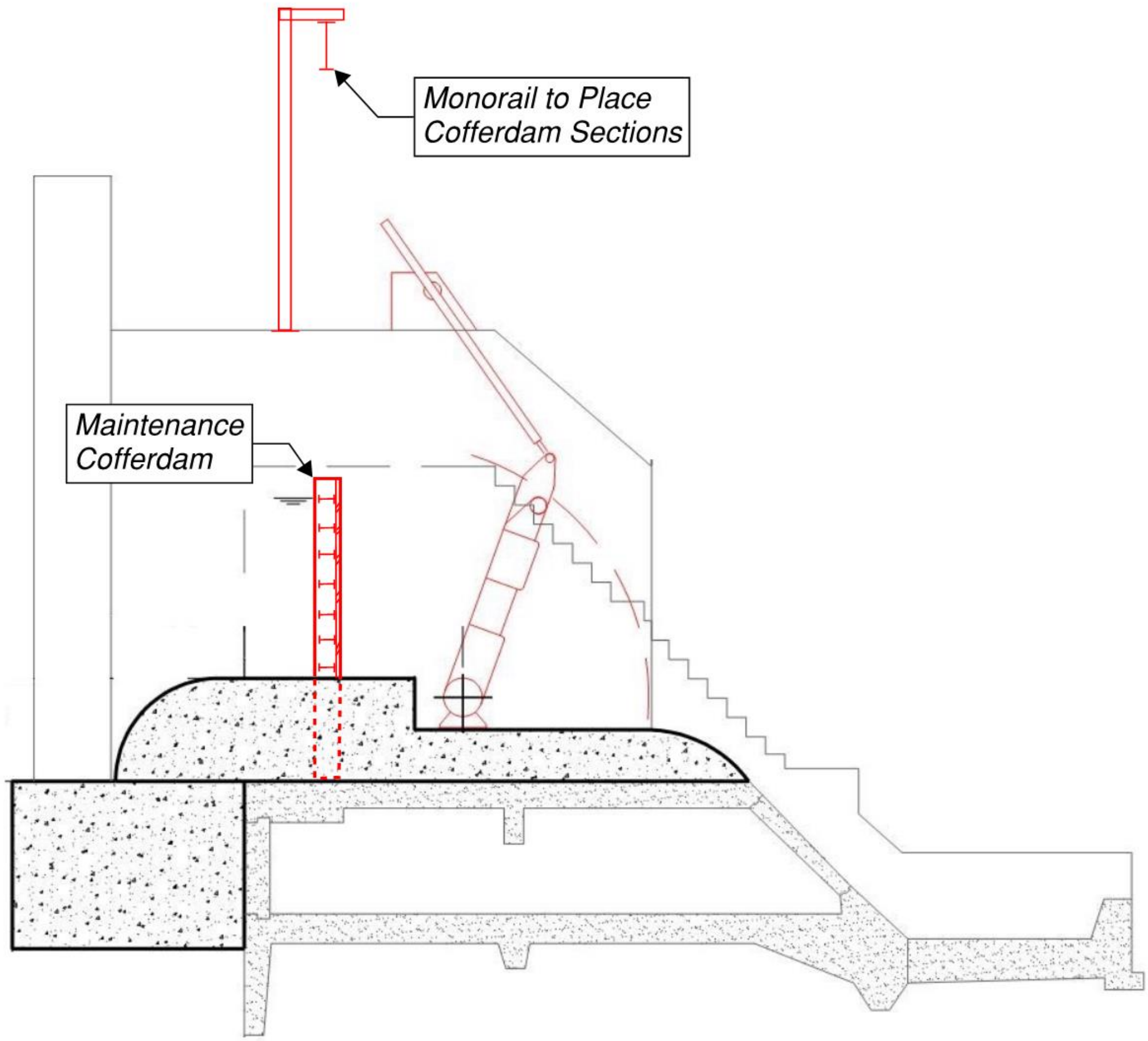


Figure 6-12 Conceptual Arrangement of Steel Columns and Horizontally Spanning Panels

6.3.5 Recommendations

Each of the three maintenance dewatering systems has certain advantages and disadvantages when compared to the other dewatering systems. Table 6-5 summarizes the comparison between the three types of maintenance dewatering systems by rating them on a scale of 1 to 3 with 3 being the best and 1 being the worst alternative for that category.

Table 6-5 Comparison of Permanent Dewatering Systems

CATEGORY	EXISTING/MODIFIED DEWATERING BOX	STEEL BEAM WITH VERTICALLY SPANNING PANELS	STEEL COLUMNS WITH HORIZONTALLY SPANNING PANELS
Easily reusable	3	3	3
Easily transportable	3	1	3
Requires use of a crane	3	1	2
Can be used for maintenance of existing gates	Yes	No	Yes (with modifications to existing spillways)
Can be used for maintenance of new gates	No	Yes	Yes
Cost	3	1	3
Average	3 for existing gates	1.5 for new gates	2.7 for new gates

There are significant differences in geometry and maintenance requirements between the new and existing gates. For these reasons it is recommended that different maintenance cofferdams be used for the new versus existing gates.

It is recommended that the steel column with horizontally spanning panel cofferdam system be designed for the new gates at H-5. The same system and components can also be used at the other five dams after gates at those spillways are replaced.

For maintenance at the five dams with bear trap style gates it is recommended that the existing cofferdam be strengthened as required and modified to include buoyance chambers to improve transportation and positioning in the water.

7.0 H-5 Spillway Stability Analysis

7.1 EXISTING SPILLWAY STABILITY ANALYSIS

A stability analysis was performed on the existing H-5 spillway. The purpose of analyzing the existing structure is to verify that our assumptions regarding soil properties, loadings, and other design assumptions result in realistic results when applied to the original structure. The existing spillway was evaluated for its resistance to sliding and floatation, limits on overturning, and limits on the bearing capacity of the foundation materials. All elevations referenced in the stability analysis are those from the 1930 design drawings.

The analysis determined geometric section properties of the spillway, the intermediate pier, and the left side retaining wall. The sections were drawn in CAD which assisted in determining the areas and centers of gravity of the concrete, compacted soil, and of the water on the spillway. A spreadsheet was used to determine the summation of total weight of each section along with the center of gravity.

The second step was to calculate the loading that is applied to the existing spillway. These loads where determined to be the reservoir water pressure, the soil below the reservoir, the uplift force, and the tailwater force. There were two load cases used in the analysis. The first load case was taken as the normal loading with the headwater at EL 290 ft (1930 datum as stated on the existing drawings) with no tailwater pressure. The second load case assumed headwater at EL 291ft and tailwater at EL 261 ft as stated on the 1930 drawings. Figure 7-1 presents the loading on existing spillway.

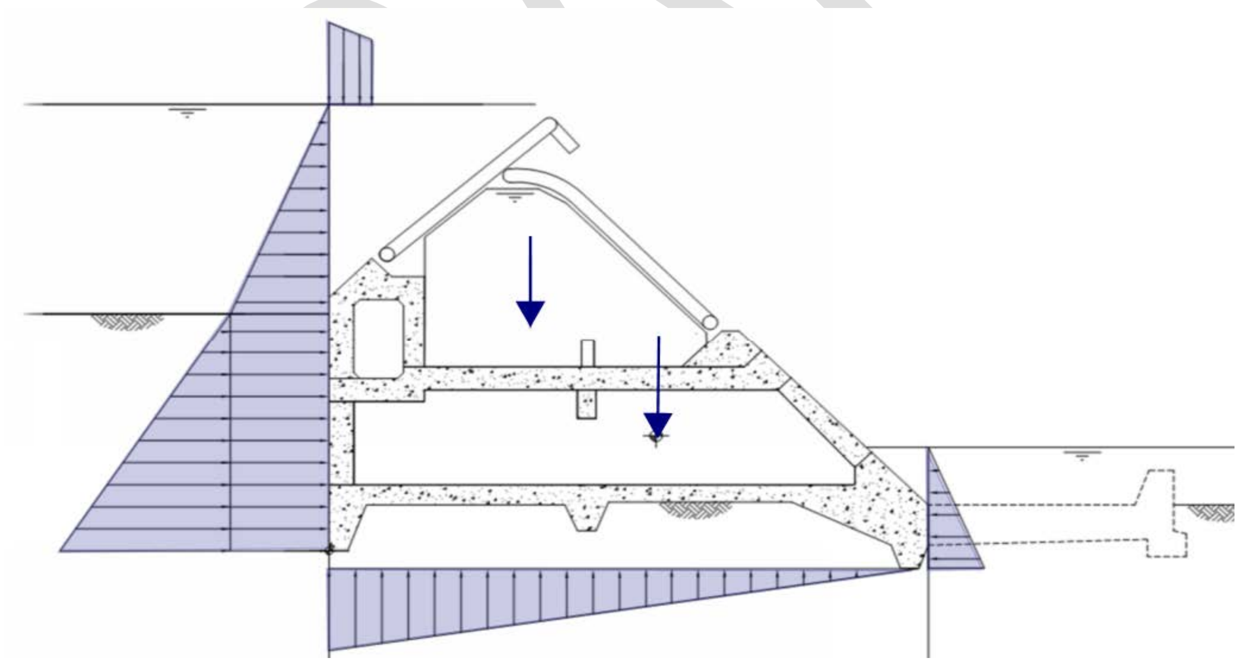


Figure 7-1 Loading on Existing Spillway

The existing spillway was analyzed for both a typical one-foot width and the northern half of the spillway. For the purpose of the analysis the northern half of the spillway was comprised of the intermediate pier, the 85 foot wide spillway, and the left retaining wall. The assumed sliding plane was taken to be a line from the bottom of the toes on the base slab. For the structure to slide the soil above this line would have to move along with it therefore this area of soil was added to the nominal force used to resist sliding. The original design of the spillway provided drains in the base slab to relieve uplift pressure. The area above the base slab was filled during construction with gravel and compacted earth. This drainage layer allows any ground water uplift pressure to flow vertically through the base slab up to the upper slab. Therefore the uplift pressure on the spillway was determined using the headwater elevation down to the bottom of the upper slab. Since the tailwater elevation was lower than the bottom of the upper slab the uplift pressure was taken to be distributed down to zero on the tailwater side. Given the type of existing gate and how it operated, there was assumed to be an area of water on top of the top slab that pushed the gates up to the fully raised position. This weight of water on the spillway increases the stability of the spillway. Bathymetry collected in 2011 by Hydrograph Consultants was used to determine the depth of the lake adjacent to the spillway. For the analysis the bottom of the lake was assumed to be at EL 265 ft. Below EL 265 ft the soil of the lake bed places a lateral load on the spillway.

The lateral force of the water acting on the spillway is the driving force trying to push the spillway downstream. The net vertical force on the spillway is weight of the spillway minus the uplift force on the bottom of the spillway. The net vertical force times the friction factor of the soil is the force which resists the lateral load of the water in the lake. The factor of safety for sliding is the resisting force divided by the driving force.

C = Unit Cohesion

A = Area of Section

ΣN = Summation of Vertical Forces

ΣU = Summation of Uplift Forces

ΣV = Summation of Shear Forces

μ = Coefficient of Friction (0.49 for the H-5 Site)

$$SF = \frac{CA + (\sum N - \sum U)\mu}{\sum V}$$

Table 7-1 Stability Forces for Existing Spillway

LOAD CASE	DOWNWARD FORCE	UPLIFT	NET DOWNWARD FORCE	RESISTING FORCE	SLIDING FORCE	FACTOR OF SAFETY AGAINST SLIDING
1	12,835 kips	(3,199) kips	9,636 kips	4,700 kips	3,723 kips	1.26
2	13,765 kips	(3,199) kips	10,566 kips	5,153 kips	3,656 kips	1.41

It is desirable by modern standards to have a factor of safety against sliding of at least 1.5. While the analysis of the existing structure did not achieve a safety factor of 1.5, as shown in Table 7-1, it did result in a safety factor over 1.0. Given that the spillway has been in place for 80 plus years and has not presented any issues we can conclude that the structure is stable and that the assumptions made in the stability analysis are acceptable. The stability analysis did conclude that the base slab drains are important to reduce the uplift force. Any work that modifies the structure will have to ensure that these drains are left untouched or improved on.

7.2 STABILITY ANALYSIS AFTER INSTALLATION OF NEW GATES

The new crest gates differ from the existing bear trap gates by using hydraulic cylinders to be raised versus the reservoir water which raises the existing bear trap gates. The new hydraulic cylinders will concentrate load on the outside and intermediate piers rather than distribute it uniformly across the spillway as occurs with the bear trap gates. The bottom of the crest gates will be supported by hinges placed approximately every ten feet along the width of the spillway. For the purpose of this preliminary stability analysis the hinges are assumed to be continuous support along the bottom of the gate. The bear trap gates are raised using water below the gate leaves. This water places a significant amount of weight on the existing spillway and this weight adds stability to the spillway. With the crest gates this stabilizing load will is not available. To provide enough spillway weight to resist sliding in accordance with modern design criteria, additional concrete will be added to the spillway. Figure 7-2 presents the proposed modification of the spillway.

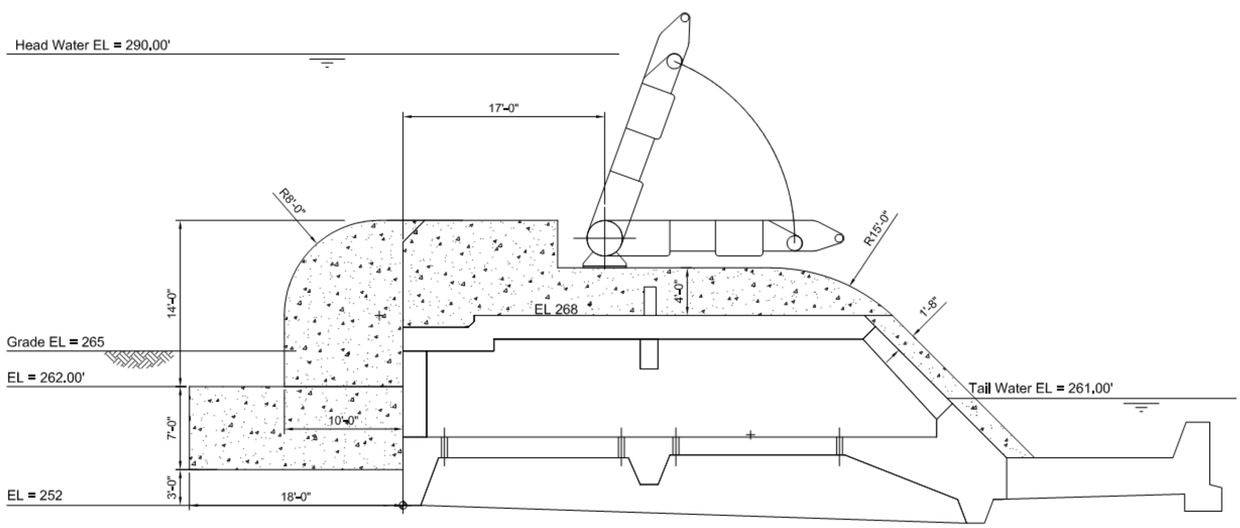


Figure 7-2 Proposed Modifications of Spillway

To analyze the spillway with the new gates the model was updated by locating the gate and modifying the concrete structure for better water flow over the new gate. Once the initial concrete sections where modified, calculations where performed to determine the amount of additional vertical load which was needed to achieve the required safety factor. The loading on the spillway has modified to only support the lower half of the gate on a per foot basis since it was supported by the hinges. The first major addition was the placement of the footer on the upstream side of the spillway which not only adds concrete weight but also included the water weight above it. The next addition was the upstream side wall that was sloped and has a curved top to achieve a better water flow. Another option was to move the gate further downstream which will allow the inclusion of the vertical water weight above the spillway. While this option helps on the spillway design it reduces the resisting moment on the intermediate pier making it require more concrete work. For the current approach the gate will remain further upstream.

The analysis on the intermediate pier was done only using a nine-foot section which relates to the pier wall thickness and its footing. The actual base of the intermediate pier is 12ft wide but it is part of the spillway and therefore would require additional loading be considered. A separate calculation was done to determine the maximum forces in the gate cylinders in different positions. The maximum cylinder forces were broken up into the vertical and horizontal components and applied to the pier. One option to help improve the stability was to increase the angle of the cylinders from 45 degrees up to 55 degrees. This increased the vertical reaction and decreased the horizontal reaction which helps the stability of the structure. While this is not a normal practice because it increases the loading in the cylinders it may be worth the offset cost on lowering the amount of concrete work required. Similar to the spillway design the new footer was continued in front of the intermediate pier but was topped with a new concrete column which would be used to support the new maintenance access bridge. The unused fish ladder will be filled with new concrete. The pier width will be increased to provide an area to mount the trunnions and to add additional weight. These new walls will wrap around the downstream side of the pier to square off the original step design. This new concrete work and cylinder placement will provide a stable structure.

The left retaining wall and the regulating pier will have new walls added to them comparable to the intermediate pier. With only supporting one new cylinder each and being large in mass, these structures will not require has much new concrete as the spillway or the intermediate pier.

8.0 Spillgate Manufacturers Evaluation

Black & Veatch has evaluated crest gate manufacturers and their ability to provide quality, competitively priced equipment for the H-5 Spillgate Replacement project. Based on Black & Veatch's experience, seven manufacturers of gates were selected to be evaluated for relevant experience and capability. The seven manufacturers were Hydro Gate, Linita, Mecan Hydro, Rodney Hunt, Steel-Fab, Vigor, and Waterman. Contact information for these companies is included in H-5 Spillgate Replacement – Spillgate Manufacturer Evaluation, March 2019.

Each manufacturer was contacted by phone and/or email. Based on this initial contact it was confirmed that Hydro Gate and Waterman did not have experience providing crest gates of the size required for the H-5 Spillgate Replacement project. A questionnaire was sent to the five remaining manufacturers; Linita, Mecan Hydro, Rodney Hunt, Steel-Fab, and Vigor. The questionnaire requested additional information regarding technical expertise and experience relevant to this project. Additional phone calls were initiated with each vendor to provide additional information and clarification when required. Copies of the questionnaire as well as manufacturer responses are included in the Spillgate Manufacturer Evaluation document.

Of the seven manufacturers contacted, only Linita, Mecan Hydro, Steel-Fab, and Vigor have both the technical expertise and production experience required for this project. Hydro Gate and Waterman do not produce gates of the size required and Rodney Hunt declined to pursue the project. Table 8-1 provides summary of the four gate manufacturers.

Table 8-1 Summary of Gate Manufacturer Data

MANUFACTURER	ANNUAL REVENUE	YEARS IN BUSINESS	SHOP SIZE	NUMBER OF SHOP PERSONNEL	NUMBER OF ENGINEEERS	SHOP LOCATION
Linita	$8M	35 years	90,000 sq ft	Not Provided	Not Provided	New York
Mecan Hydro	$10M	25 years	23,000 sq ft	31	13	Quebec, Canada
Steel-Fab	$12M	53 years	80,000 sq ft	48	5	Massachusetts
Vigor	$600M	40 +years	800,000 + sq ft	Not Provided	Not Provided	Oregon

Linita – www.linita.com Linita designs and fabricates water control custom products such as gates, hoists, and trash racks. They have significant large gate and hoist experience for roller gates, bulkheads, radial gates, and stop logs. They have a lesser amount of experience with crest gates. Linita has an annual revenue of approximately $8,000,000.

Mecan Hydro – www.mecanhydro.com – Mecan Hydro provides design, manufacturing and installation of all types of gates, hoists, trash racks, trash rakes, rubber dams, and other custom mechanical equipment. Approximately 100% of Mecan Hydro's 23,000 square foot fabrication facility and 13 engineers are dedicated to supplying custom equipment for the hydropower and spillway market. Mecan Hydro has supplied less than 10 crest gates in the last 10 years, most no more than approximately 100 sq-ft. The largest two crest gates Mecan Hydro has supplied are approximately 40 to 50 feet wide and 5 to 7 feet tall. They have provided numerous hydraulic cylinder and HPU systems of significant size however, none as large as those required for H-5. Mecan Hydro has an annual revenue of approximately $10,000,000.

Steel-Fab – www.steelfabinc.com Steel-Fab designs and fabricates a wide range of large fabricated gates, gate operating systems, fixed cone valves, and other custom water control equipment for the dams, hydropower, and municipal water and wastewater markets. In the last 20 years, Steel-Fab has designed and fabricated more large crest gates than all other North American suppliers combined. Steel- Fab has an annual revenue of approximately $12,000,000.

Vigor – www.oregoniron.com – Vigor (formerly Oregon Iron Works) has stated they would be interested in supplying gates and hydraulic actuators of the size required for the GBRA system. Gates are a small part of Vigor's business but one at which they effectively compete if the gates are exceptionally large or complex. With over 800,000 square feet of indoor fabrication facilities and one of the largest shipyards on the west coast, Vigor is a very large and capable fabricator of many sorts of large and complex mechanical and steel products in the marine, nuclear, aerospace, renewable energy, hydroelectric, bridge, and civil construction sectors. Vigor has supplied numerous large and complex gate and gate operating systems for the United States Corps of Engineers, United States Bureau of Reclamation, and other governmental and private clients. Vigor has an annual revenue of approximately $600,000,000.

Rodney Hunt - www.rodneyhunt.com - Rodney Hunt has stated at this time they would decline to bid a crest gate project of the size required for H-5. Rodney Hunt has been a supplier of custom gates and valves in the United States for over 100 years. Due to multiple restructuring and sales of the company during the last several years Rodney Hunt is now just a shell of its former self. All engineering design for Rodney Hunt is now performed in India by Rodney Hunt's new parent company Jash. Rodney Hunt's head of engineering in the United States is not yet confident that the Jash engineers have the experience or resources needed to guarantee success on a large crest gate project. Jash is in the process of dedicating more engineering and fabrication resources for the North American market so in several years Rodney Hunt might be willing to supply large crest gates.

Waterman – Waterman does not produce gates of the size required.

Hydro-Gate – Hydro-Gate does not produce gates of the size required.

Of the seven manufacturers contacted four have the capability to provide the required equipment; Linita, Mecan Hydro, Steel-Fab, and Vigor. While all four manufactures have designed and fabricated gates and hoists on the scale of that required at H-5, only one manufacturer, Steel-Fab, has produced crest gates similar in size to those required at H-5. Steel-Fab has produced more large crest gates than the other 3 manufacturers combined. While all four manufactures have the ability to provide crest gates of the size required at H-5 only Steel-Fab has recent experience in actually doing so.

8.1 BUDGET LEVEL COST ESTIMATES

Budget level cost estimates for the two-gates at H-5 were obtained from 4 of the 7 contacted manufactures. The estimates include design, fabrication, and shipping to Seguin, Texas of 2 gates, 4 cylinders, and 1 hydraulic power unit (HPU). Cost estimates obtained from the manufacturers are in the manufacture questionnaire responses included in the Spillgate Manufacturer Evaluation document. A summary of those estimates is presented in Table 8-2.

Table 8-2 Gate Manufacturer Cost Estimates for H-5

	2 GATES	1 HPU & 4 CYLINDERS	TOTAL	ADDER FOR "BUY AMERICA"	ADDER FOR 304 STAINLESS STEEL	LEAD TIME	BID TIME
Linita	$1,246,520	$1,240,000	$2,486,520	Info not provided	Info not provided	18 months	2 months
Mecan Hydro	$2,304,600	$849,600	$3,154,200	$0	$1,874,560	14 months	6-7 weeks
Steel-Fab	$2,000,000	$480,000	$2,480,000	$350,000	$2,000,000	14 months	1 month
Vigor	$4,200,000	$600,000	$4,800,000	$0	$2,240,000	18 months	1 month

The cost estimates obtained from the manufacturers include the base cost for the required equipment as well as identifying the additional costs if "Buy America" clauses for steel procurement are required. Only Steel-Fab indicated an increase in price for "Buy America". The increase for "Buy America" in Steel-Fab's estimate is approximately 14%. The manufacturers were requested to identify the price increase for providing stainless steel gates. The cost of stainless steel gates is approximately twice that of painted carbon steel gates.

The manufactures identified lead times of between 14 and 18 months for procurement of the gates. Steel-Fab's shorter lead time of 14 months could be attributed to their experience in having supplied numerous large crest gates. Large gates are custom products which require the manufactures to do some amount of detailed engineering to be able to provide quotes. All four manufacturers recommended a minimum bid duration of between 4 and 8 weeks.

From these cost estimates for the 2 gates at H-5, Black & Veatch developed budget level cost estimates for the remaining 13 gates at 5 sites. A base cost for the H-5 gates (carbon steel) was calculated by averaging the estimates from the 4 manufacturers. The base cost was then adjusted to account for the varying number and size of gates at the 5 other dams. A summary of the estimate is included in Table 8-3.

Table 8-3 Budgetary Cost Estimate for All 6 Dams

DAM	CURRENT SPILLWAY CONFIGURATION	GATE, HPU & CYLINDER COST
H-5 (Lake Wood)	2 gates @85’	$3.3M
Dunlap (Lake Dunlap)	3 gates @85’	$5.0M
TP-3 (Lake McQueeney)	3 gates @85’	$5.0M
TP-4 (Lake Placid)	2 gates @99’	$3.9M
Nolte (Meadow Lake)	3 gates @85’	$5.0M
H-4 (Lake Gonzales)	2 gates @85’	$3.3M
Total		**$25.5M (2019 dollars)**

8.2 EVALUATION OF PROCUREMENT APPROACHES

There is a broad range of procurement methods which could be used to procure the gates for the H-5 project. These procurement methods include sole source procurement by Owner (GBRA), competitively bid procurement by Owner, sole source procurement included in general construction package, and design-bid-build procurement as part of the general construction package. Key to all these procurement methods is a clearly stated division of responsibility between the design team, the gate manufacturer, and the General Contractor.

8.2.1 Sole Source Procurement by Owner

With sole source procurement by the Owner, the Owner selects and negotiates with one or more suppliers to arrive at technical specifications and commercial terms acceptable to the Owner. The Owner purchases the equipment and supplies it to the General Contractor in conformance with the terms of the general construction package.

Advantages:

- Greatest amount of control by the Owner. The Owner can purchase what they want from who that want.
- Ability to accelerate schedule. By pre-procuring the equipment before the award of the general construction package there is the opportunity to complete the project sooner.

Disadvantages:

- Greatest amount of responsibility of the Owner. The Owner is responsible for the delivery and performance of the equipment. Delays or failure to perform could lead to claims by the General Contractor.
- Without a competitive bid process there could be the perception by some parties that the Owner overpaid for the equipment or was not transparent in the procurement process.

8.2.2 Competitively Bid Procurement by Owner

With competitively bid procurement by the Owner, a set of technical specifications and commercial terms are prepared for the equipment and put out for bid. This procurement process may or may not include pre-qualification of equipment suppliers. A winning bidder is selected, and the Owner purchases the equipment and supplies it to the General Contractor in conformance with the terms of the general construction package.

Advantages:

- Large amount of control by the Owner subject to terms of the bid process.
- Ability to accelerate schedule. By pre-procuring the equipment before the award of the general construction package there is the opportunity to complete the project sooner.

Disadvantages:

- Greatest amount of responsibility of the Owner. The Owner is responsible for the delivery and performance of the equipment. Delays or failure to perform could lead to claims by the General Contractor.
- A bid package of technical specifications and commercial terms must be prepared.
- The Owner gives up some control of the procurement process subject to terms of the bidding process. This risk is somewhat mitigated with a thorough set of bid documents and pre-qualification of bidders.

8.2.3 Sole Source Procurement Included in General Construction Package

Sole source procurement of equipment in the general construction package can be accomplished in several ways. The most common method is to include in the general construction package technical specification for the equipment and limit the acceptable supply to a sole source. An alternate method of including sole source procurement in the general construction package is for the Owner to negotiate procurement of the equipment before bidding the general construction package and then assign the pre-negotiated contract to the General Contractor in conformance with commercial terms of the general construction contact. The goal of this hybrid method is to accelerate procurement of long-lead equipment, maintain Owner control over the selection of the equipment, and reduce the Owner's effort and risk in administering the procurement contract after construction begins.

Advantages:

- Large amount of control by the Owner in selection of the equipment.
- Reduced amount of responsibility for the Owner.
- Hybrid methods have the potential to accelerate the project schedule and identify conflicts by starting some aspects (such as shop drawings review) of the equipment procurement process before awarding the general construction package.

Disadvantages:

- Completion of the project could be delayed for procurement of long-lead items such as the H-5 gates and HPU.
- Commercial terms of both the equipment procurement and general construction contracts need to be well defined if using a hybrid method which assigns to the General Contractor an Owner negotiated contract for the equipment.

8.2.4 Design-Bid-Build Procurement Included in General Construction Package

With design-bid-build procurement of the equipment a set of technical specifications for the equipment would be included in the general construction package. Procurement of the equipment by the General Contractor would be in conformance with terms of the general construction contract. Once the general construction contract is awarded the Owner's control over procurement of the gate is limited to what has been included in the technical specifications and commercial terms of the general construction package. The technical specifications may or may not include pre-qualification of equipment suppliers. If prequalification of suppliers is not included, then the technical specifications would include a list of qualifications suppliers would have to meet to be approved to supply the equipment.

Advantages:

- Least amount of responsibility of the Owner. The Contractor is responsible for all issues related to the equipment.
- Least amount of effort on the part of the Owner.

Disadvantages:

- The Owner gives up most control after the general construction package is bid. This risk is somewhat mitigated with a thorough set of bid documents and pre-qualification or required experience of bidders.
- Completion of the project could be delayed for procurement of long-lead items such as the H-5 gates and HPU.

Each procurement method has advantages and disadvantages. Many of these advantages and disadvantages are related to the trade-off between the Owner's control over the procurement process and the risk assumed in doing so. The preferred procurement method is best selected in consultation with the Owner reviewing the unique aspects of the project.

8.3 DIVISION OF RESPONSIBILITY

Regardless of the procurement method used, a clear understanding by all parties of the division of responsibility between the project's engineer of record (Engineer) and the gate manufacturer is critical for the success of any project incorporating large custom gates. A well-defined division of responsibility helps to establishes which information is required by which party, who is responsible for supplying the information, and when various parties require the information.

The Engineer is responsible for design of the following gate elements:

- Definition of Project Criteria
- Spillway Stability
- Concrete Design
- HPU Controls Description
- HPU Preliminary P&ID
- Routing of Hydraulic Lines
- Routing of Control Wiring

- Supply of Power to the HPU

The gate manufacturer is responsible for design of the following gate elements:

- Gate Leaf
- Gate Hinges
- Gate Anchor Bolts
- Hydraulic Cylinder
- HPU
- HPU Final P&ID
- Detailing of Hydraulic Lines
- Detailing of Control Wiring

There will be several points during development of the H-5 spillgate project which will require the exchange of information between the Engineer and the gate manufacturer. The Engineer is responsible for coordinating this exchange of information.

8.3.1 Pre-bid

- The Engineer is responsible for developing a preliminary concept for a load path to transfer load from the gate to the concrete structure.
- The Engineer is responsible for communicating with gate manufactures to determine, based on the preliminary concept, the magnitude of the loads to be transferred from the gate to the concrete structure. These loads are calculated by the gate manufacturers during preliminary design before the gates are bid.
- The Engineer is responsible for communicating with gate manufactures to determine the expected number and locations of hinge points for the gate.
- The Engineer is responsible for designing the concrete of the spillway to accommodate the expected number and location of hinge points and the magnitude of the transferred loads. This design of the concrete needs to be reasonably conservative to accommodate the possibility of an increase in the magnitude of the loads during final design of the gates.
- The Engineer is responsible for communicating with gate manufacturers to determining the lead time required for design, fabrication, and delivery of the gates and HPU.
- The Engineer is responsible for incorporating gate supply lead time into the project schedule.
- The Engineer is responsible for defining the criteria governing the design and manufacture of the gate and HPU; governing design standards, design loadings, gate geometry, speed of gate operation, HPU power limitations, service conditions, minimum standards for materials of construction, and fabrication inspection criteria.
- The Engineer is responsible for communicating with gate manufacturers to solicit feedback on the governing criteria.
- The Engineer is responsible for developing the specifications and drawings which communicate the criteria to the gate manufacturer during the bid process.

8.3.2 During Bid

- The Engineer is responsible for responding to requests for clarification from the gate manufacturers.
- The Engineer is responsible for making a recommendation of award to the Owner.

8.3.3 Shop Drawing Phase

- The Engineer is responsible for reviewing and commenting on the gate submittals to confirm compliance by the gate manufacturer with the specified criteria.
- The Engineer is responsible for confirming the magnitude and location of the loads to be transferred from the gate to the structures and obtained from the gate shop drawings do not exceed those assumed during design of the structure.

8.3.4 Construction

- The Engineer is responsible for responding to requests for information from the gate supplier.
- The Engineer is responsible for reviewing change order requests from the gate supplier.
- The Engineer is responsible for confirming compliance with the specified criteria governing installation of the gates.
- The Engineer is responsible for confirming commissioning of the gates is in accordance with the specified criteria.

8.4 MANUFACTURER & PROCUREMENT METHOD RECOMMENDATIONS

Table 8-4 provides a subjective ranking of the four manufacturers' ability to provide quality, competitively priced equipment for the H-5 Spillgate Replacement project. The ranking considers pricing, schedule, and a heavy emphasis on large crest gate and HPU experience.

Table 8-4 Spillgate Manufacturer Ranking

MANUFACTURER	H-5 GATE COST (MILLION DOLLARS)	LEAD TIME	BID TIME	RANK
Steel-Fab	$2.8M	14 months	1 month	1
Mecan Hydro	$3.2M	14 months	1.75 months	2 (tie)
Linita	$2.5M	18 months	2 months	2 (tie)
Vigor	$4.8M	18 months	1 month	3

With four potential suppliers, and one of which having significantly more experience than the other three, any of the methods of gate procurement from sole source to competitive bid are realistic options. The preferred procurement method is best selected in consultation with the Owner reviewing the unique aspects of the project.

9.0 Permitting and Regulatory Requirements

The permits and approvals required for the construction of this project was determined through a desktop analysis and database search conducted by Baer Engineering and Environmental Consultants, Inc. (Baer) entitled "Guadalupe Blanco River Authority Gate Replacement at Six Dams on the Guadalupe River – Preliminary Constraints Maps and Permitting Analysis Report" (Baer, 2019). These permits are summarized in Table 9-1.

Table 9-1 Required Permits and Regulatory Approvals

REGULATORY AGENCY	PERMIT / APPROVAL ITEM	NECESSARY ACTIONS	TIMELINE
Necessary/Likely			
Guadalupe County – Environmental Health Department	Floodplain Permit	Obtain a Development (Floodplain) Permit for remodels / miscellaneous activity will be required for Lake Dunlap, Lake TP-3, TP-4, and Nolte Dams.	Permit secured prior to start of construction. Once more is known about the design, a permit application should be submitted. Request for ongoing coordination with GBRA during construction.
Gonzales County – Office of Emergency Management and County Permitting	Floodplain Permit	A Floodplain Development Permit Application will be required for H-4 and H-5 Dams.	Permit secured prior to start of construction. This application requires submission of a sealed plans set.
TPWD	TES Habitat Assessment	Coordination with the TPWD will be needed to protect the state's fish and wildlife resources. If the project has the potential to disturb protected natural resources, a TES Habitat Assessment may be required. Results of the assessment will determine if additional coordination with TPWD is required.	Coordinate with TPWD during preliminary design to inform dewatering and prevent/reduce impact to identified species. It is recommended that a biologist: review the TES list for Guadalupe County; conduct a habitat assessment to document the local vegetation and habitats within the project area; and field-check the NWI data for accuracy before commencing coordination efforts.
TPWD	Waters of the State – Marl, Sand, Gravel, Shell or Mudshell Permit	If the project design includes work in waterways, a Marl, Sand, Gravel, Shell or Mudshell Permit and coordination with the Kills and Spills Team may be required.	May require additional surveys. Need will be informed by TES Habitat Assessment activities.

REGULATORY AGENCY	PERMIT / APPROVAL ITEM	NECESSARY ACTIONS	TIMELINE
THC	Cultural Resource Protection and Antiquities Code of Texas (ACT)	Prepare an initial coordination letter with project description and results of records review. Request agency input on the need for additional surveys. If the project has the potential to disturb protected cultural resources, coordination with THC will be required. THC may request additional surveys for the proposed project.	Need will be informed by USACE coordination.
TCEQ	Dam Safety Program	The Engineer will submit and obtain approval of material required for a Major Repair Project and provide Notification of Completion. Owner will notify TCEQ of construction commencement.	Coordination with TCEQ during the preliminary design phase. TCEQ provides a response to packages within 30 days of submittal. If TCEQ does not respond to the submittal within 20 working days of acknowledgement of receipt, the submittal will be automatically approved. Approval is required prior to construction. The Owner is responsible for notifying TCEQ of construction start within 10 days of commencement. Engineer will provide Notification of Completion at the conclusion of each dam's remediation.
TCEQ	Water Quality	Texas Surface Water Quality Standards	Compliance with Texas Surface Water Quality Standards must be maintained throughout the project duration.
TCEQ	Texas Pollution Discharge Elimination System (TPDES)	Apply for a General Permit to Discharge. Develop a Stormwater Pollution Prevention Plan (SWPPP). If the project disturbs more than five acres, then a Notice of Intent and a Notice of Termination are also required.	Determine affected site area and required documentations during preliminary design and develop SWPPP during final design. Implement during construction

REGULATORY AGENCY	PERMIT / APPROVAL ITEM	NECESSARY ACTIONS	TIMELINE
USACE – Fort Worth District	Clean Water Act (CWA) Section 404 - Waters of the US (WOTUS)	Request a pre-application meeting by completing and submitting a Pre-App Meeting Request Form regarding dams in Guadalupe County. Project description best fits the USACE Nationwide Permit (NWP)	Conduct meeting as soon as possible to facilitate permit application and approval during design.
USACE – Galveston District	CWA Section 404 - WOTUS	Request a pre-application consultation via email regarding dams in Gonzales County.	Conduct meeting as soon as possible to facilitate permit application and approval during design.
Possible/Unknown Likelihood			
TCEQ	Water Rights	TCEQ has the rules that determine whether or not a water right is required and how much can be stored or diverted.	An evaluation to determine the need for a waters rights permit should be conducted prior to construction. This permitting process is deemed lengthy by TCEQ and is recommended to be started to determine need as soon as possible.
EPA	National Environmental Policy Act (NEPA) 1970	Pre-application meeting with USACE will include NEPA compliance. If federal funding is used or a federal permit is required for the proposed project, the appropriate level of NEPA coordination and analysis will be required.	See USACE actions associated with WOTU.
USACE – Fort Worth & Galveston Districts	National Historic Preservation Act (NHPA) Section 106	GBRA to initiate consultation with both USACE district to determine if a federal-level cultural resource review under NHPA Section 106 will be required.	Conduct meeting as soon as possible to determine if activities will be classified as a single project or as six separate projects, facilitate permit application and approval during design.
Not Applicable/Unlikely			
Federal Emergency Management Agency (FEMA)	100-year Floodplain Modification	If a change to the FEMA-defined 100-year floodplain elevation is proposed, a Letter of Map Change (LOMC) or a Letter of Map Revision (LOMR) may be required.	The during preliminary design, evaluate the changes in the floodplain and determine if coordination with FEMA will be required.

REGULATORY AGENCY	PERMIT / APPROVAL ITEM	NECESSARY ACTIONS	TIMELINE
USFWS	Threatened and Endangered Species	Prepare an initial coordination letter with project description and results of records review. Request agency input on the need for habitat assessments. Results of the TPWD habitat assessment will determine if additional coordination with USFWS is required.	Prepare initial coordination letter as soon as possible to facilitate USFWS coordination and approval during design.
Texas Department of Transportation (TxDOT)	Right-of-way (ROW) Coordination	The Lake McQueeney proposed project area and assessment area is located within FM 725. Coordination with TxDOT will be required as FM 725 is considered within TxDOT ROW. If work is proposed within the TxDOT ROW, coordination with TxDOT will be required	During preliminary design, confirm construction limits are outside TxDOT ROW.
Adapted from data presented in Preliminary Constraints Maps and Permitting Analysis Report (Baer, 2019).			

This section only covers site-specific permits and regulatory approval activities that would be necessary to initiate in advance of construction. It does not include non-site specific permits or regulatory actions required to be taken by the Contractor or Suppliers during construction. Additional permitting items, such as Occupational Safety and Health Administration (OSHA) or transportation permits for large pre-fabricated items should be considered once final design is complete.

All of the above permitting and approval actions can commence after completion of the preliminary design phase and are recommended to be initiated as soon as possible.

10.0 Findings and Recommendations

This Preliminary Design Report summarizes data and analysis instrumental in moving forward into detailed design. Significant findings and recommendations include;

Hydraulics:

- Spillway gates 14'-6" tall x 79'-0" wide will provide spill capacity equivalent to the existing gates.
- It is necessary to limit the height of the construction cofferdam at H-5 to minimize upstream impacts during high flow events. A sheet pile construction cofferdam at a crest elevation between EL 282.0 ft and EL 285.0 ft upstream of H-5 will have minimal upstream impacts during high flow events.
- Scour analysis indicates that the depth of the existing scour hole at H-5 is not unaccepted. The same analysis shows that there could be a slight increase in depth as a result of the new gate geometry.
- The primary difference between spillway operation of the new gates and the old gates will be the more precise control of gate position possible with the new gates.

Structural:

- Adding concrete to the existing spillway and piers will provide the strength required to support the new gates.
- Adding concrete to the existing spillway and piers will provide the stability required to satisfy modern criteria and standards.
- A pedestrian bridge across the spillway will provide access for inspection of the hydraulic cylinders and a protected and accessible location for routing of the hydraulic lines and control wiring to each hydraulic cylinder.
- Sheet pile placed downstream of the spillway apron would help to prevent scour from undermining the spillway structure. A second scour hole, located in the powerhouse tailrace, should be filled.
- A maintenance cofferdam constructed of steel columns and horizontally spanning panels installed using a permanent monorail is an economical solution for dewatering of the new gates.
- Refurbishment of the existing gate hood is a viable solution for maintenance of the existing gates.

Mechanical

- There is sufficient space within the power house or gate control building at each of the six sites to house the new hydraulic power unit (HPU).
- A 25 horsepower electric pump with raise or lower one gate at a time at approximately 2.5 ft per minute.
-

Electrical

- Existing electrical distribution power at all sites is not configured, and in some cases insufficient, to supply 480 volt three-phase power to the new HPU's. Nolte and Dunlap will require a new 480 volt three-phase service from the electric utility. The remaining four sites will require new fused cut-out switches and 2,400 volt – 480 volt transformers.

- New 480 volt three-phase propane generators, propane tanks, and transfer switches will be required to provide back-up power for the HPU's.

Instrumentation and Control

- Instrumentation and control for all six spillways will have similar equipment and functionality; level instruments, gate controllers, PLC's, and video.
- Additional communications equipment will be required at H-4 and H-5 to provide the bandwidth necessary to transmit video.
- Communication design standards will be determined at the time of design for each dam to be consistent with upgrades expected during the 20-year duration of the gate replacement program.

Construction Cost and Schedule

- The H-5 opinion of probable construction cost = $14 M in 2019 dollars.
- The expected duration of H-5 construction is 28 months.
- The six dam program opinion of probable construction cost = $110 M in 2019 dollars.
- A 20-year schedule for replacement of gates at all 6 dams provides for minimal schedule overlap of projects. The 20-year schedule could be accelerated if resources allow.
- The lead time to procure the crest gates and HPU is approximately 14 months.
- Four manufacturers have been identified with the capability to provide the required gates. While all four manufactures have designed and fabricated gates and hoists on the scale of that required at H-5, only one of the four has produced crest gates similar in size to those required at H-5.
- It is expected that the construction area at H-5 will flood multiple times during the duration of construction. The likelihood of flooding will need to be accounted for in the construction contracts.
- There are additional costs associated with maintaining full lake levels during gate replacement at the 5 dams upstream of H-5. Those costs have not been included in the cost estimates in this Preliminary Design Report.
- Contact with permitting agencies should coincide with completion of the 30% detailed design.

Detailed design is scheduled to begin immediately following completion of the Preliminary Design phase of the project, Table 10-1.

Table 10-1 H-5 Project Schedule

FLOOD EVENT	ANNUAL EXCEEDANCE PROBABILITY
Preliminary Design	October 24 – April 30, 2019
H-5 Spillgate 30% Design	May 1 – June 28, 2019
H-5 Spillgate 60% Design	July 1 - August 9, 2019
H-5 Spillgate 90% Design	August 12 - September 13, 2019
H-5 Spillgate 100% Design	September 16 - October 18, 2019
Bid Construction Contract for H-5 Spillway	November 15, 2019
Construction Phase for H-5 Spillway	January 2020 – March 2022

The following actions related to the Preliminary Design Report will be taken during the 30% design phase of the H-5 project;

- Coordination with gate manufacturers will continue.
- Spillway stability calculations will be updated for the final spillway and gate geometry.
- Construction cofferdam limitations will be incorporated into the project specifications.
- A back-up power scheme for the gates will be finalized.
- SCADA requirements based on expected bandwidth availability will be finalized.
- Initial contact with permitting agencies will be made.
- The opinion of probable construction cost will be updated.
- A plan for monitoring or mitigating scour will be finalized.

The following actions related to the Preliminary Design Report will be taken following completion of the 30% design phase of the H-5 project;

- A procurement method for the gates will be selected.
- Development of the gate drawings and specifications will be tailored to support the method of gate procurement selected.
- Permits will be applied for.

The spillway section of Figure 10-1 incorporates many of the findings and recommendations developed in this Preliminary Design Report. This will be the starting point for detailed design.

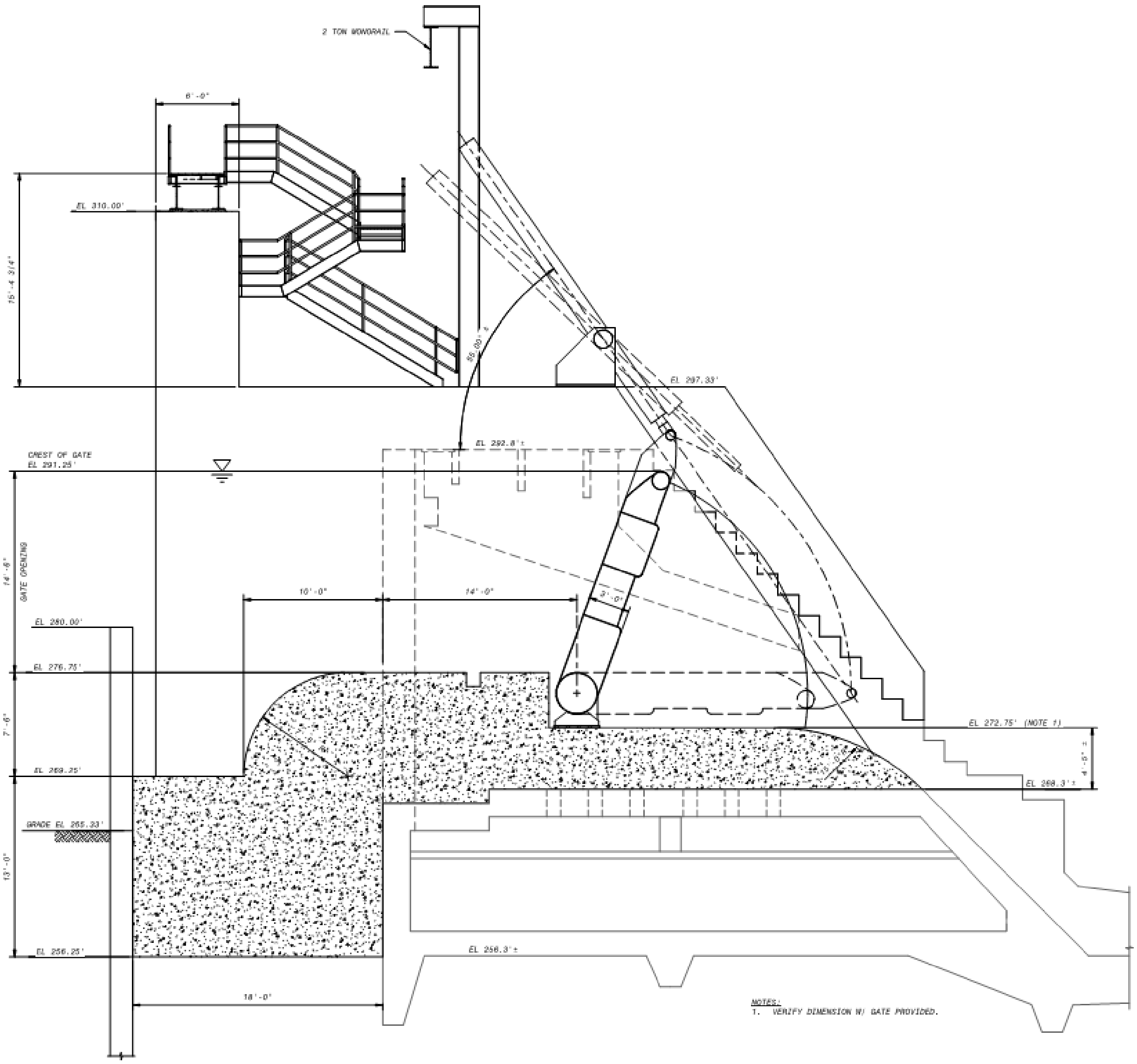


Figure 10-1 Preliminary Section of Proposed Spillway Modifications

11.0 References

Baer Engineering and Environmental Consultants, Inc. (Baer). (2019). Guadalupe Blanco River Authority Gate Replacement at Six Dams on the Guadalupe River – Preliminary Constraints Maps and Permitting Analysis Report. February 2019.

Black & Veatch. (2019a). H-5 Spillgate Replacement - Site Visit Report. January 2019.

Black & Veatch. (2019b). H-5 Spillgate Replacement – Spillgate Manufacturer Evaluation. March 2019.

Black & Veatch. (2019c). H-5 Spillgate Replacement – Spillway and River Operations Plan. April 2019.

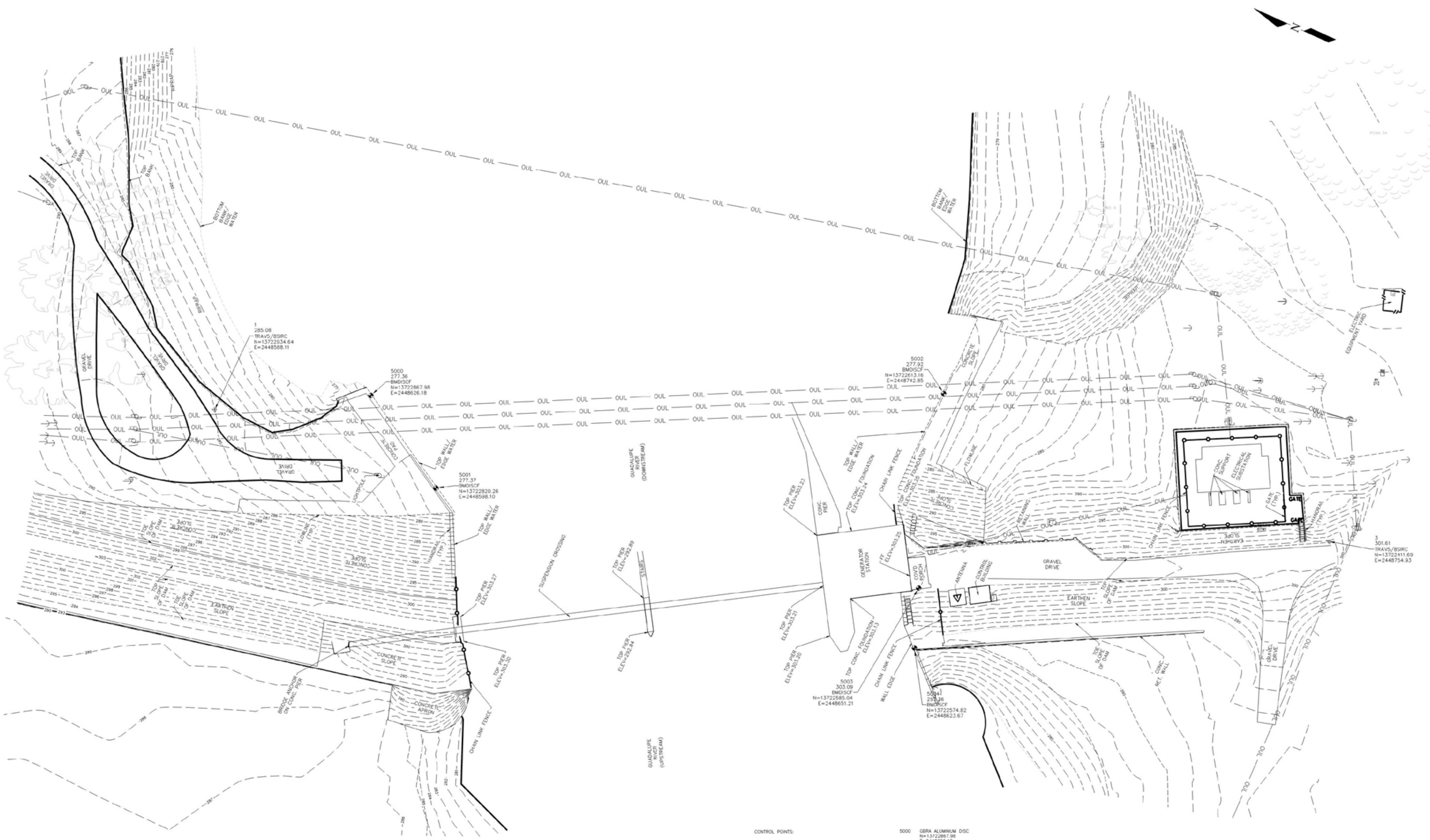
FEMA (2007). Flood Insurance Study, Guadalupe County, Texas and Incorporated Areas. November 2007.

FEMA (2010). Flood Insurance Study, Gonzales County, Texas and Incorporated Areas. December 2010.

Texas Department of Environmental Quality (TCEQ). (2009). Design and Construction Guidelines for Dams in. Texas. TCEQ Dam Safety Program, RG-473. August 2009.

TCEQ. (2018). General Permit to Discharge Under the Texas Pollutant Discharge Elimination System, Stormwater Discharges Associated with Construction Activities, TXR150000. 5 March 2018.

Appendix A. SITE SURVEY



CONTROL POINTS:

1 5/8" IRON ROD WITH RED PLASTIC CAP
N=13722934.64
E=2448588.11
ELEV=285.08

2 5/8" IRON ROD WITH RED PLASTIC CAP
N=13723056.52
E=2448477.67
ELEV=302.58

3 5/8" IRON ROD WITH RED PLASTIC CAP
N=13722411.69
E=2448754.93
ELEV=301.61

5000 GBRA ALUMINUM DISC
N=13722867.98
E=2448626.18
ELEV=277.36

5001 GBRA ALUMINUM DISC
E=13722820.26
N=2448598.10
ELEV=277.37

5002 GBRA ALUMINUM DISC
N=13722613.16
E=2448742.85
ELEV=277.92

5003 GBRA ALUMINUM DISC
N=13722585.04
E=2448651.21
ELEV=303.09

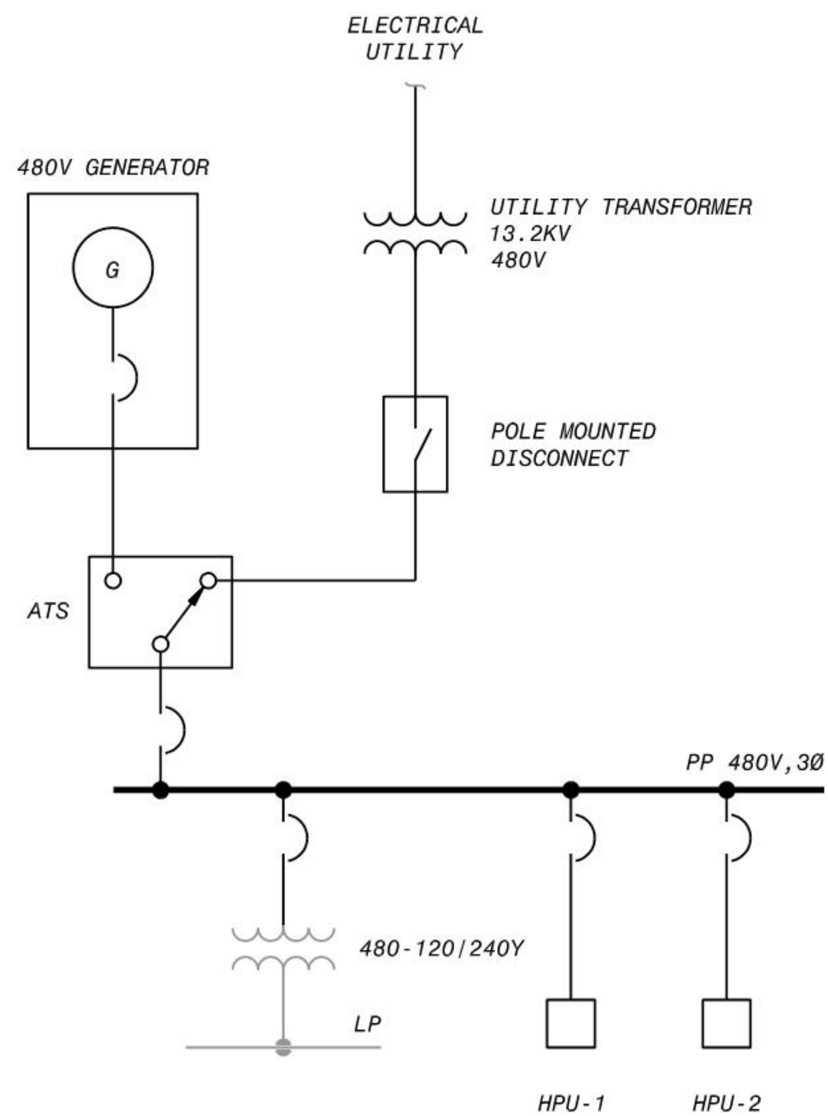
5004 GBRA ALUMINUM DISC
N=13722574.82
E=2448623.67
ELEV=293.36

NOTES:

1) BEARINGS, DISTANCES, COORDINATES AND ELEVATIONS ARE BASED UPON GPS OBSERVATIONS OF THE ALLTERRA CENTRAL VIRTUAL REFERENCE NETWORK, EPOCH 2010.
2) THE HORIZONTAL DATUM IS REFERENCED TO THE TEXAS COORDINATE SYSTEM OF 1983, SOUTH CENTRAL ZONE (4204), NORTH AMERICAN DATUM 1983 (2011).
3) THE VERTICAL DATUM IS REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88), GEOID MODEL -GEOID12A.
4) THE SURFACE ADJUSTMENT FACTOR FOR THIS PROJECT IS 1.00013. COORDINATES AND DISTANCES SHOWN ARE SURFACE.
5) DATE OF SURVEY: 12-13-2018

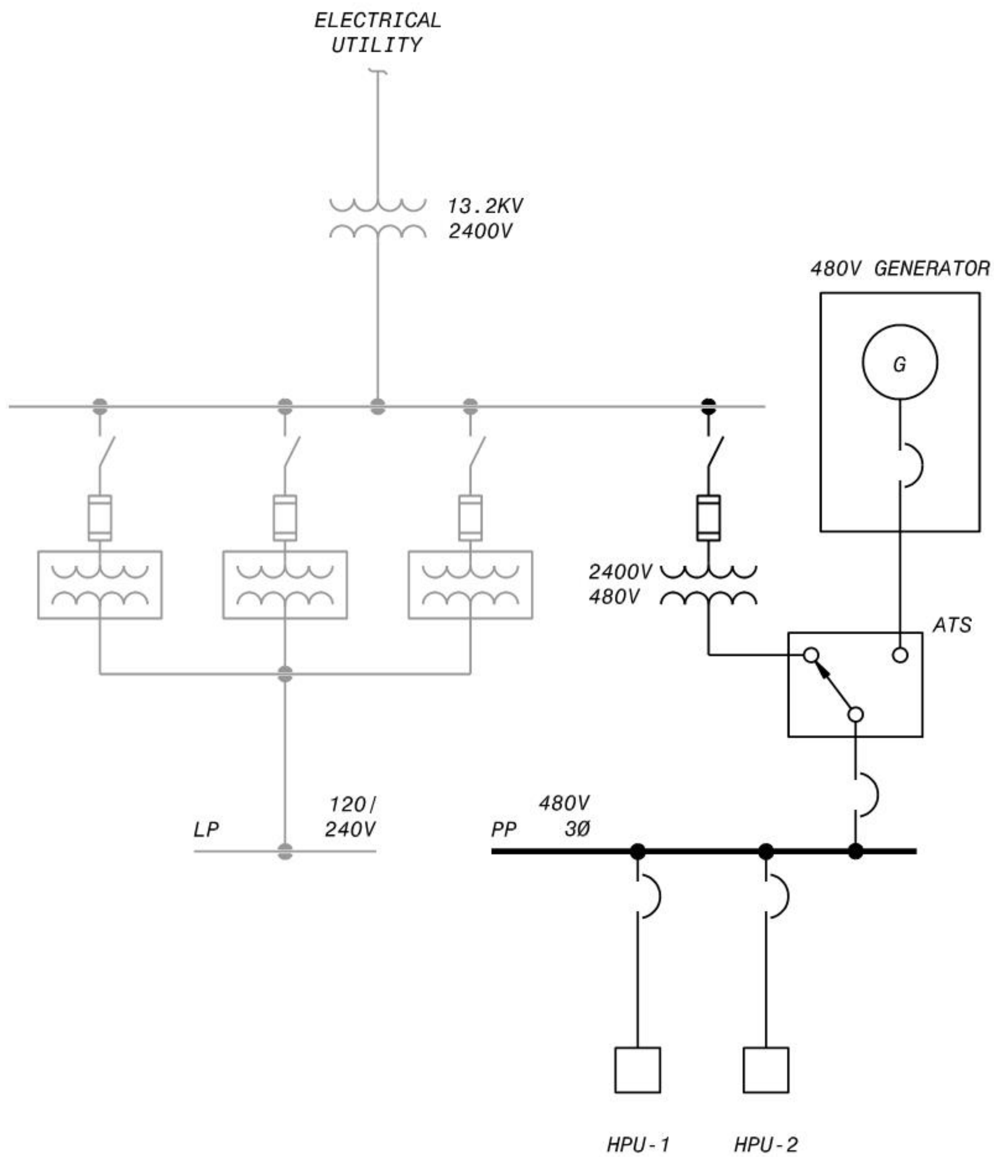
GRAPHIC SCALE
0 20 40
(IN FEET)
1 inch = 20 ft.

Appendix B. POWER DISTRIBUTION FUNCTIONAL DIAGRAMS



POWER DISTRIBUTION FUNCTIONAL DIAGRAM 1

GUADALUPE-BLANCO RIVER AUTHORITY H-5 SPILLGATE REPLACEMENT		
BLACK & VEATCH Black & Veatch Corporation San Antonio, Texas	H-5 SPILLWAY & POWERHOUSE ELECTRICAL PDFD	400368 E-H5-701



POWER DISTRIBUTION FUNCTIONAL DIAGRAM 2

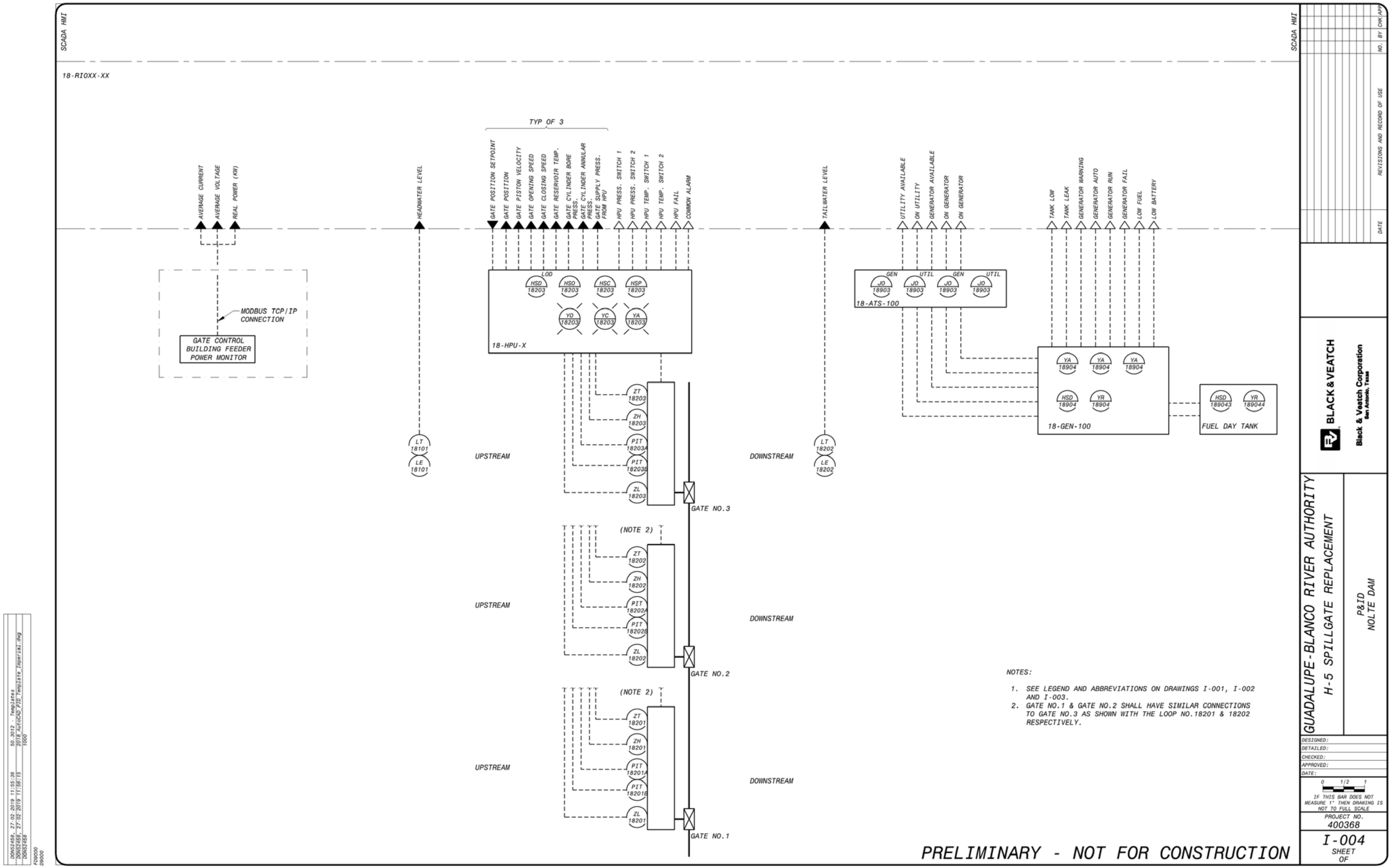
GUADALUPE-BLANCO RIVER AUTHORITY
H-5 SPILLGATE REPLACEMENT

BLACK & VEATCH
Black & Veatch Corporation

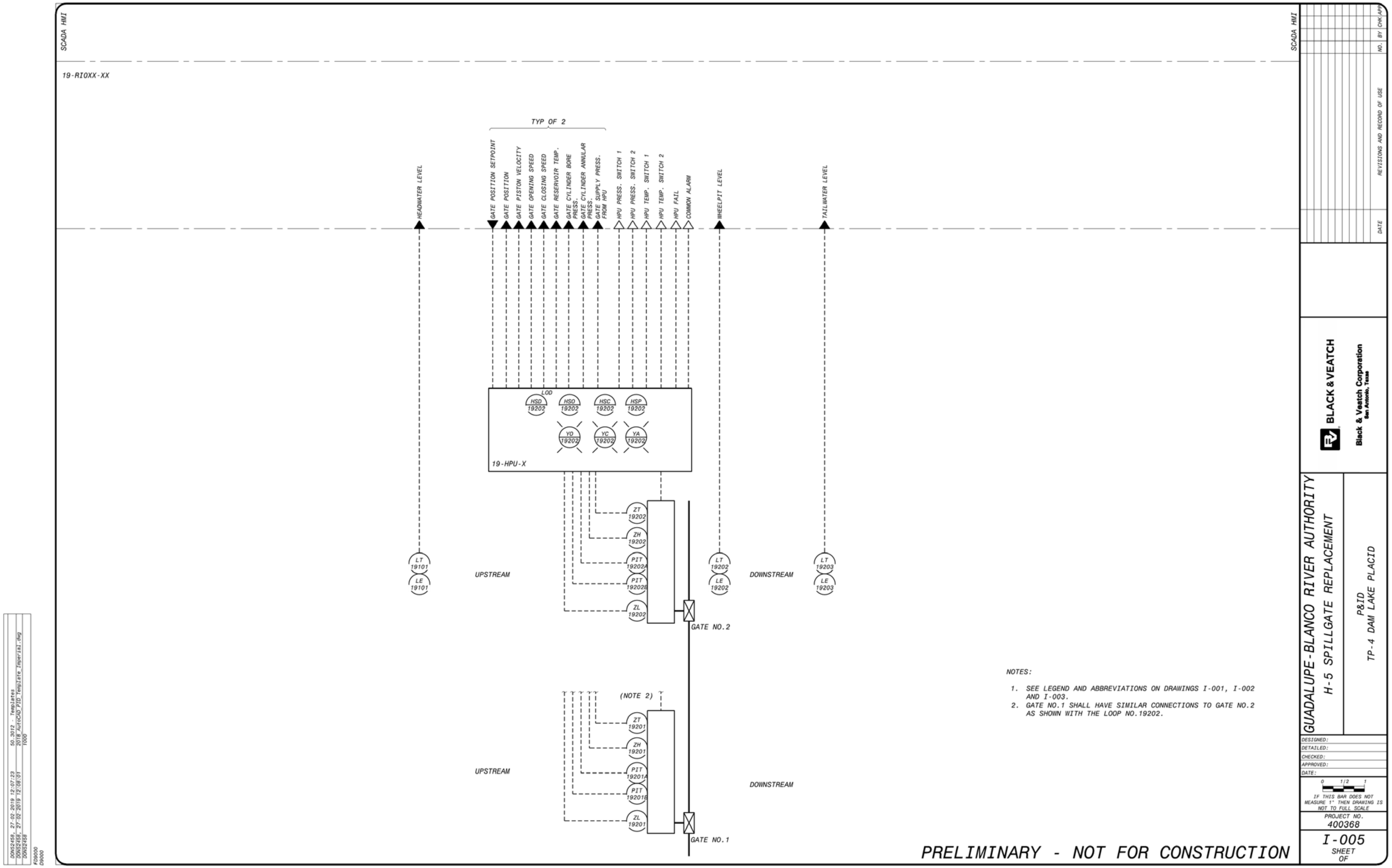
H-5 SPILLWAY & POWERHOUSE
ELECTRICAL
PDFD

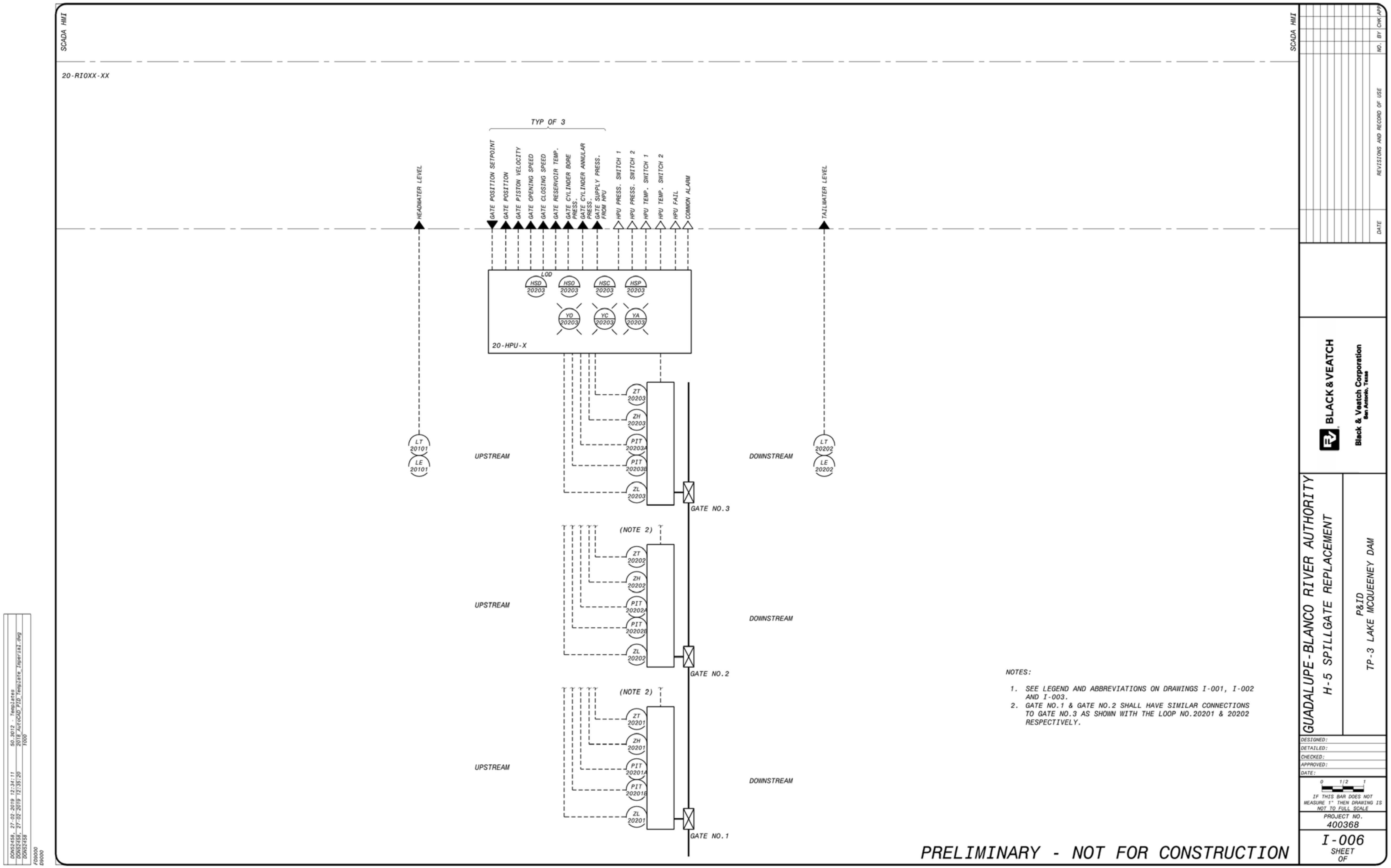
400368
E-H5-702

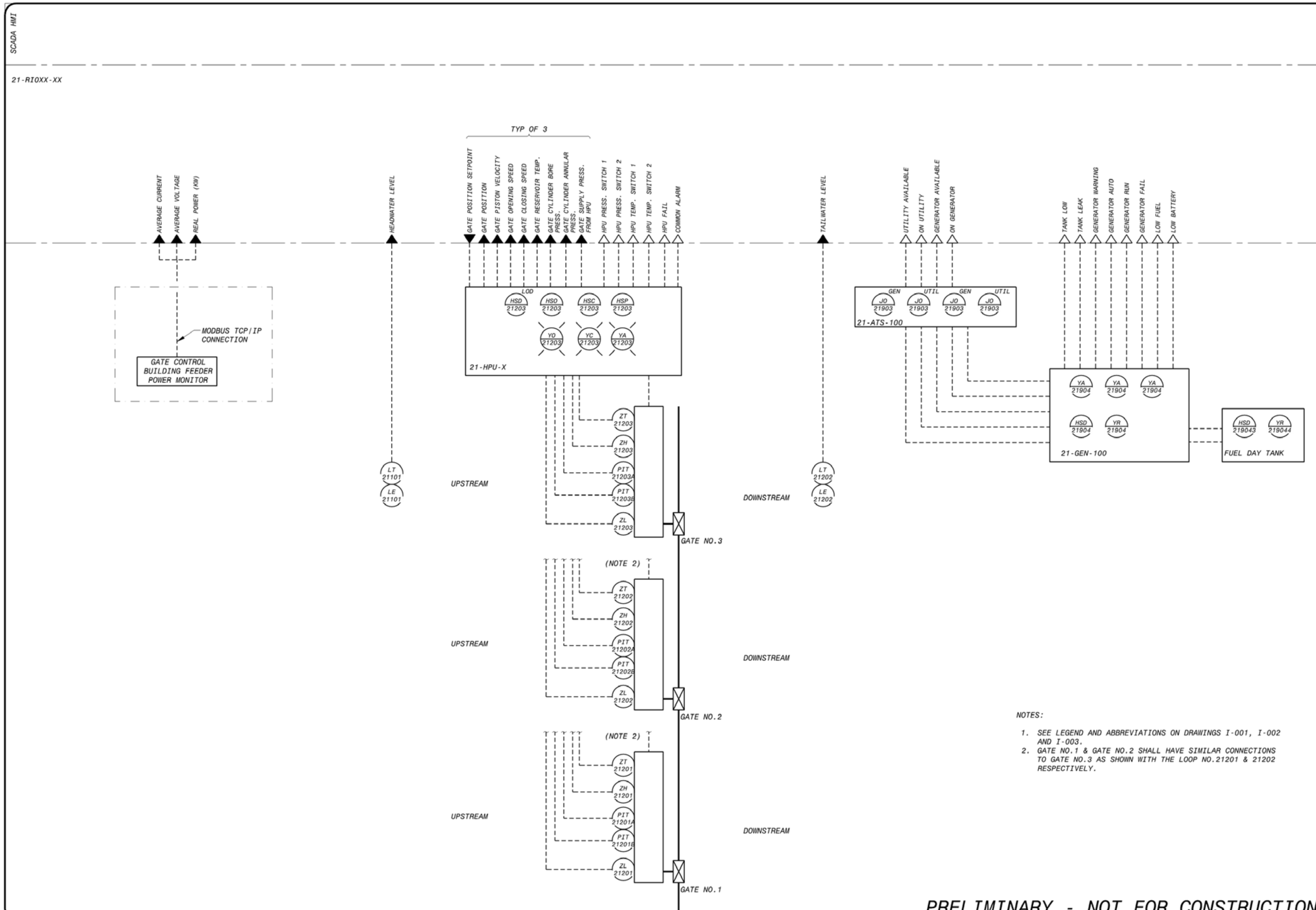
Appendix C. PIPING & INSTRUMENTATION DIAGRAMS (P&ID'S)



SCADA HMI
18-RIOXX-XX
AVERAGE CURRENT
AVERAGE VOLTAGE
REAL POWER (KW)
MODBUS TCP/IP CONNECTION
GATE CONTROL BUILDING FEEDER POWER MONITOR
HEADWATER LEVEL
TYP OF 3
GATE POSITION SETPOINT
GATE POSITION
GATE PISTON VELOCITY
GATE OPENING SPEED
GATE CLOSING SPEED
GATE RESERVOIR TEMP.
GATE CYLINDER BORE PRESS.
GATE CYLINDER ANNULAR PRESS.
GATE SUPPLY PRESS. FROM HPU
HPU PRESS. SWITCH 1
HPU PRESS. SWITCH 2
HPU TEMP. SWITCH 1
HPU TEMP. SWITCH 2
HPU FAIL
COMMON ALARM
18-HPU-X
TAILWATER LEVEL
UTILITY AVAILABLE
ON UTILITY
GENERATOR AVAILABLE
ON GENERATOR
ON GENERATOR
18-ATS-100
TANK LOW
TANK LEAK
GENERATOR WARNING
GENERATOR AUTO
GENERATOR RUN
GENERATOR FAIL
LOW FUEL
LOW BATTERY
18-GEN-100
FUEL DAY TANK
UPSTREAM
DOWNSTREAM
GATE NO.3
(NOTE 2)
GATE NO.2
GATE NO.1
NOTES:
1. SEE LEGEND AND ABBREVIATIONS ON DRAWINGS I-001, I-002 AND I-003.
2. GATE NO.1 & GATE NO.2 SHALL HAVE SIMILAR CONNECTIONS TO GATE NO.3 AS SHOWN WITH THE LOOP NO.18201 & 18202 RESPECTIVELY.
PRELIMINARY - NOT FOR CONSTRUCTION
BLACK & VEATCH
Black & Veatch Corporation
GUADALUPE-BLANCO RIVER AUTHORITY
H-5 SPILLGATE REPLACEMENT
P&ID
NOLTE DAM
PROJECT NO. 400368
I-004


SCADA HMI
19-RIOXX-XX
TYP OF 2
HEADWATER LEVEL
GATE POSITION SETPOINT
GATE POSITION
GATE PISTON VELOCITY
GATE OPENING SPEED
GATE CLOSING SPEED
GATE RESERVOIR TEMP.
GATE CYLINDER BORE PRESS.
GATE CYLINDER ANNULAR PRESS.
GATE SUPPLY PRESS. FROM HPU
HPU PRESS. SWITCH 1
HPU PRESS. SWITCH 2
HPU TEMP. SWITCH 1
HPU TEMP. SWITCH 2
HPU FAIL
COMMON ALARM
WHEELPIT LEVEL
TAILWATER LEVEL
LOD
HSD 19202
HSO 19202
HSC 19202
HSP 19202
YO 19202
YC 19202
YA 19202
19-HPU-X
ZT 19202
ZH 19202
PIT 19202A
PIT 19202B
ZL 19202
LT 19101
LE 19101
UPSTREAM
LT 19202
LE 19202
DOWNSTREAM
LT 19203
LE 19203
GATE NO.2
(NOTE 2)
ZT 19201
ZH 19201
PIT 19201A
PIT 19201B
ZL 19201
GATE NO.1
NOTES:
1. SEE LEGEND AND ABBREVIATIONS ON DRAWINGS I-001, I-002 AND I-003.
2. GATE NO.1 SHALL HAVE SIMILAR CONNECTIONS TO GATE NO.2 AS SHOWN WITH THE LOOP NO.19202.
PRELIMINARY - NOT FOR CONSTRUCTION
REVISIONS AND RECORD OF USE
DATE
NO. BY CHK APP
BLACK & VEATCH
Black & Veatch Corporation
San Antonio, Texas
GUADALUPE-BLANCO RIVER AUTHORITY
H-5 SPILLGATE REPLACEMENT
P&ID
TP-4 DAM LAKE PLACID
DESIGNED:
DETAILED:
CHECKED:
APPROVED:
DATE:
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO FULL SCALE
PROJECT NO.
400368
I-005
SHEET
OF


SCADA HMI
20-RIOXX-XX
TYP OF 3
HEADWATER LEVEL
GATE POSITION SETPOINT
GATE POSITION
GATE PISTON VELOCITY
GATE OPENING SPEED
GATE CLOSING SPEED
GATE RESERVOIR TEMP.
GATE CYLINDER BORE PRESS.
GATE CYLINDER ANNULAR PRESS.
GATE SUPPLY PRESS. FROM HPU
HPU PRESS. SWITCH 1
HPU PRESS. SWITCH 2
HPU TEMP. SWITCH 1
HPU TEMP. SWITCH 2
HPU FAIL
COMMON ALARM
TAILWATER LEVEL
LOD
HSD 20203
HSO 20203
HSC 20203
HSP 20203
YO 20203
YC 20203
YA 20203
20-HPU-X
ZT 20203
ZH 20203
PIT 20203A
PIT 20203B
ZL 20203
LT 20101
LE 20101
LT 20202
LE 20202
UPSTREAM
DOWNSTREAM
GATE NO.3
(NOTE 2)
ZT 20202
ZH 20202
PIT 20202A
PIT 20202B
ZL 20202
GATE NO.2
ZT 20201
ZH 20201
PIT 20201A
PIT 20201B
ZL 20201
GATE NO.1
NOTES:
1. SEE LEGEND AND ABBREVIATIONS ON DRAWINGS I-001, I-002 AND I-003.
2. GATE NO.1 & GATE NO.2 SHALL HAVE SIMILAR CONNECTIONS TO GATE NO.3 AS SHOWN WITH THE LOOP NO.20201 & 20202 RESPECTIVELY.
PRELIMINARY - NOT FOR CONSTRUCTION
NO. BY CHK APP
REVISIONS AND RECORD OF USE
DATE
BLACK & VEATCH
Black & Veatch Corporation
San Antonio, Texas
GUADALUPE-BLANCO RIVER AUTHORITY
H-5 SPILLGATE REPLACEMENT
P&ID
TP-3 LAKE MCQUEENEY DAM
DESIGNED:
DETAILED:
CHECKED:
APPROVED:
DATE:
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO FULL SCALE
PROJECT NO.
400368
I-006
SHEET
OF



NOTES:

1. SEE LEGEND AND ABBREVIATIONS ON DRAWINGS I-001, I-002 AND I-003.
2. GATE NO.1 & GATE NO.2 SHALL HAVE SIMILAR CONNECTIONS TO GATE NO.3 AS SHOWN WITH THE LOOP NO.21201 & 21202 RESPECTIVELY.

PRELIMINARY - NOT FOR CONSTRUCTION

BLACK & VEATCH
Black & Veatch Corporation
San Antonio, Texas

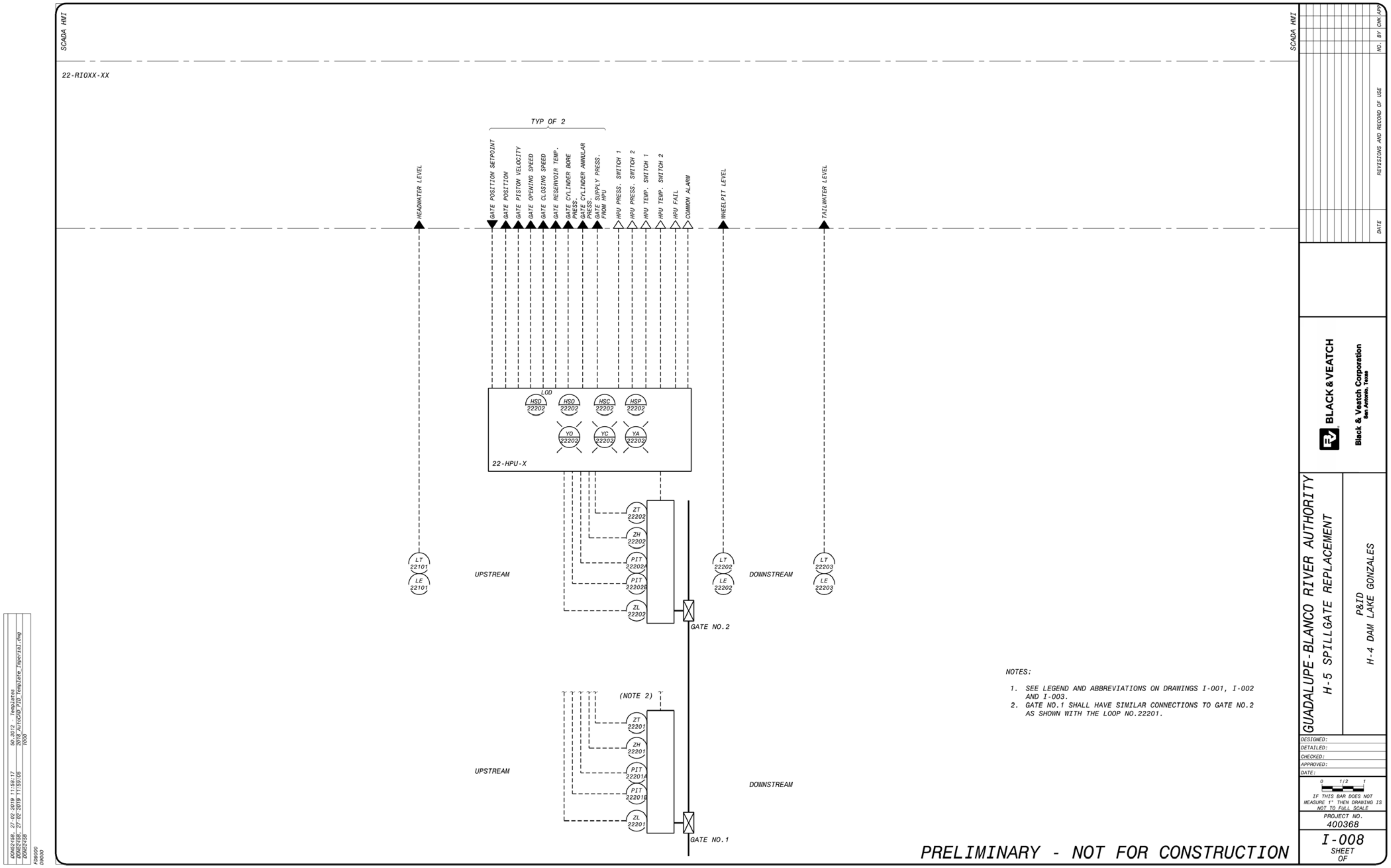
GUADALUPE-BLANCO RIVER AUTHORITY
H-5 SPILLGATE REPLACEMENT
P&ID
DUNLAP DAM

DESIGNED:
DETAILED:
CHECKED:
APPROVED:
DATE:

IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO FULL SCALE

PROJECT NO. 400368

I-007
SHEET
OF


SCADA HMI
22-RIOXX-XX
TYP OF 2
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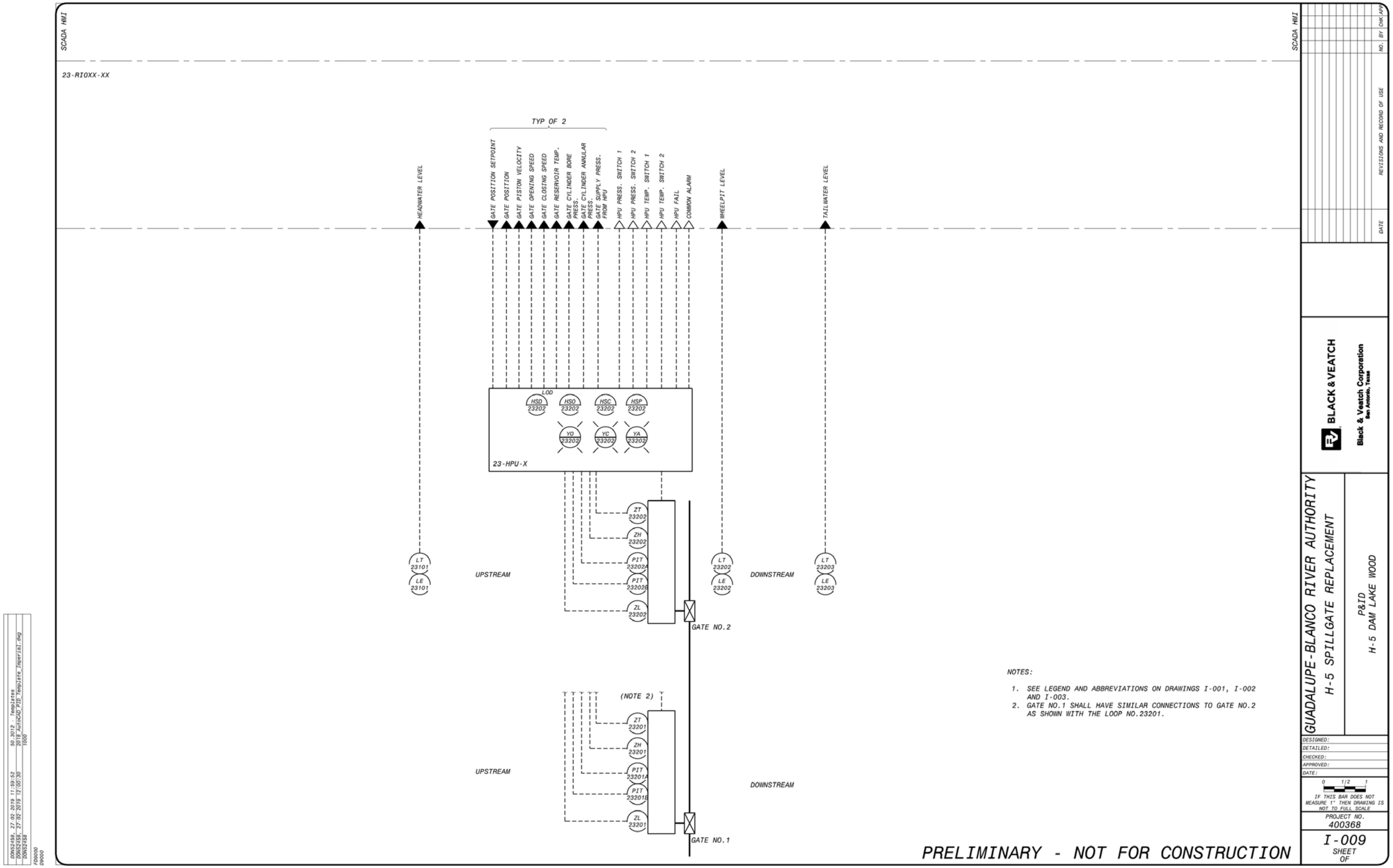
GATE POSITION SETPOINT
GATE POSITION
GATE PISTON VELOCITY
GATE OPENING SPEED
GATE CLOSING SPEED
GATE RESERVOIR TEMP.
GATE CYLINDER BORE PRESS.
GATE CYLINDER ANNULAR PRESS.
GATE SUPPLY PRESS. FROM HPU
HPU PRESS. SWITCH 1
HPU PRESS. SWITCH 2
HPU TEMP. SWITCH 1
HPU TEMP. SWITCH 2
HPU FAIL
COMMON ALARM
WHEELPIT LEVEL
TAILWATER LEVEL
22-HPU-X
UPSTREAM
DOWNSTREAM
GATE NO.2
(NOTE 2)
GATE NO.1
NOTES:
1. SEE LEGEND AND ABBREVIATIONS ON DRAWINGS I-001, I-002 AND I-003.
2. GATE NO.1 SHALL HAVE SIMILAR CONNECTIONS TO GATE NO.2 AS SHOWN WITH THE LOOP NO.22201.
PRELIMINARY - NOT FOR CONSTRUCTION
BLACK & VEATCH
Black & Veatch Corporation
GUADALUPE-BLANCO RIVER AUTHORITY
H-5 SPILLGATE REPLACEMENT
P&ID
H-4 DAM LAKE GONZALES
PROJECT NO. 400368
I-008


SCADA HMI
23-RIOXX-XX
TYP OF 2
HEADWATER LEVEL
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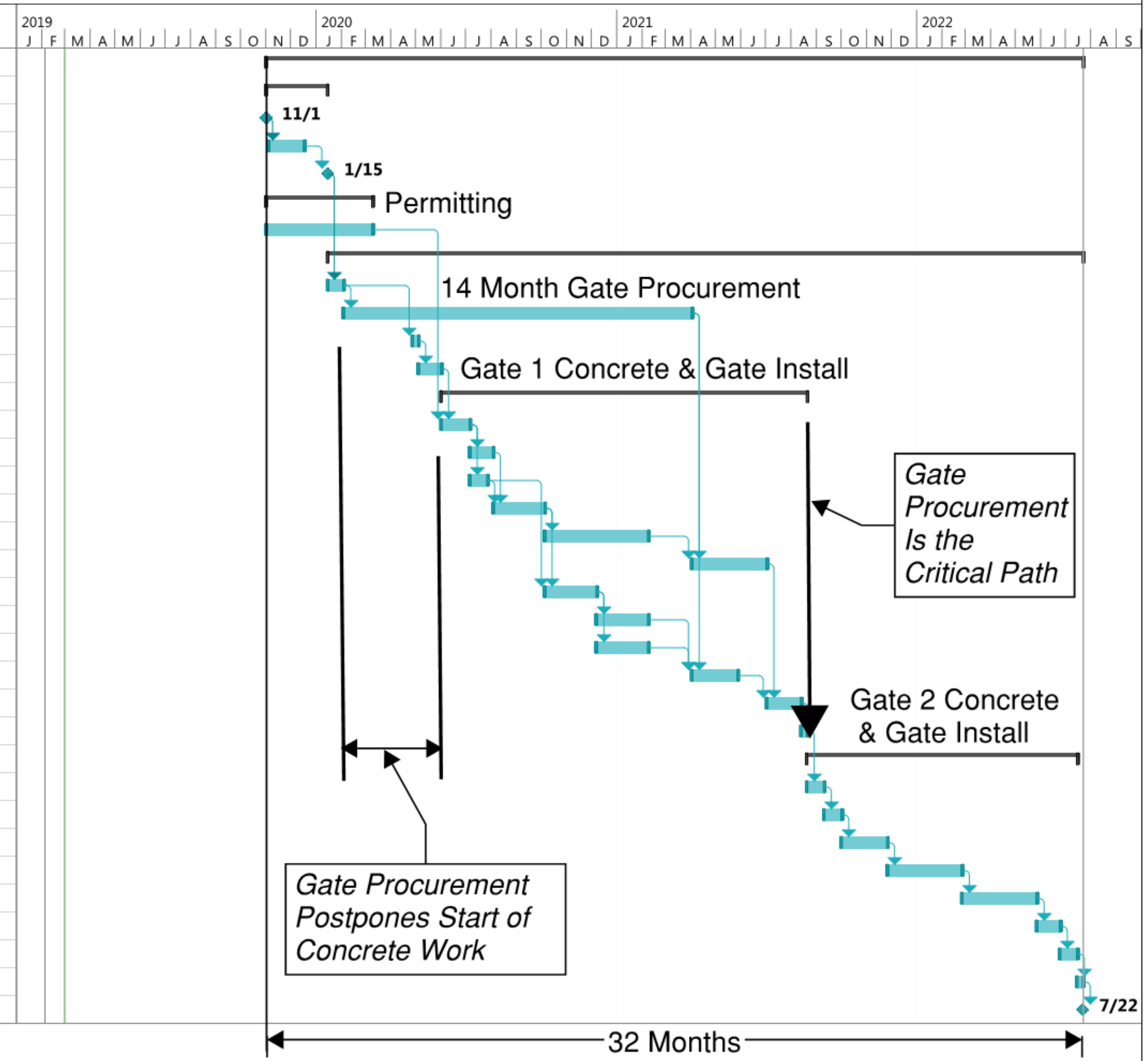
GATE POSITION
GATE PISTON VELOCITY
GATE OPENING SPEED
GATE CLOSING SPEED
GATE RESERVOIR TEMP.
GATE CYLINDER BORE PRESS.
GATE CYLINDER ANNULAR PRESS.
GATE SUPPLY PRESS. FROM HPU
HPU PRESS. SWITCH 1
HPU PRESS. SWITCH 2
HPU TEMP. SWITCH 1
HPU TEMP. SWITCH 2
HPU FAIL
COMMON ALARM
WHEELPIT LEVEL
TAILWATER LEVEL
23-HPU-X
UPSTREAM
DOWNSTREAM
GATE NO.2
GATE NO.1
(NOTE 2)
NOTES:
1. SEE LEGEND AND ABBREVIATIONS ON DRAWINGS I-001, I-002 AND I-003.
2. GATE NO.1 SHALL HAVE SIMILAR CONNECTIONS TO GATE NO.2 AS SHOWN WITH THE LOOP NO.23201.
PRELIMINARY - NOT FOR CONSTRUCTION
GUADALUPE-BLANCO RIVER AUTHORITY
H-5 SPILLGATE REPLACEMENT
P&ID
H-5 DAM LAKE WOOD
BLACK & VEATCH
Black & Veatch Corporation
San Antonio, Texas
PROJECT NO.
400368
I-009
SHEET
OF

Appendix D. CONSTRUCTION SCHEDULES

H-5 DAM SPILLGATE CONSTRUCTION SCHEDULE
OPTION 1

ID	Task Name	Duration	Start	Finish
1	**H-5 Dam Spillgate Replacement Option 1**	**711 days**	**Fri 11/1/19**	**Fri 7/22/22**
2	**Bid Phase**	**53 days**	**Fri 11/1/19**	**Wed 1/15/20**
3	Advertise for Bid	0 days	Fri 11/1/19	Fri 11/1/19
4	Bid	32 days	Mon 11/4/19	Tue 12/17/19
5	Award Bid	0 days	Wed 1/15/20	Wed 1/15/20
6	**Permitting**	**92 days**	**Fri 11/1/19**	**Mon 3/9/20**
7	Permit application and approval	92 days	Fri 11/1/19	Mon 3/9/20
8	**Construction Phase**	**658 days**	**Wed 1/15/20**	**Fri 7/22/22**
9	Administrative Mobilization	14 days	Wed 1/15/20	Mon 2/3/20
10	Gate Procurement	305 days	Mon 2/3/20	Fri 4/2/21
11	Site Mobilization	6 days	Mon 4/27/20	Mon 5/4/20
12	Site Preparation	21 days	Mon 5/4/20	Mon 6/1/20
13	**Gate 1 Construction**	**320 days**	**Mon 6/1/20**	**Fri 8/20/21**
14	Cofferdam & Dewater Gate 1	26 days	Mon 6/1/20	Mon 7/6/20
15	Remove Gate 1	21 days	Mon 7/6/20	Mon 8/3/20
16	Remove Existing Gate 1 and 2 Actuators	16 days	Mon 7/6/20	Mon 7/27/20
17	Demo Spillway Gate 1 Concrete	46 days	Mon 8/3/20	Mon 10/5/20
18	Construct New Concrete in Gate 1 Spillway	91 days	Mon 10/5/20	Mon 2/8/21
19	Gate 1 Installation	66 days	Fri 4/2/21	Fri 7/2/21
20	Construct New Concrete in Powerhouse	46 days	Mon 10/5/20	Mon 12/7/20
21	Install Electrical Power Supply Equipment	46 days	Mon 12/7/20	Mon 2/8/21
22	Install Instrumentation and Control Equipment	46 days	Mon 12/7/20	Mon 2/8/21
23	Install HPU	41 days	Fri 4/2/21	Fri 5/28/21
24	Commission Gate 1	31 days	Fri 7/2/21	Fri 8/13/21
25	Remove Gate 1 Cofferdam	6 days	Fri 8/13/21	Fri 8/20/21
26	**Gate 2 Construction**	**236 days**	**Fri 8/20/21**	**Fri 7/15/22**
27	Cofferdam and Dewater Gate 2	16 days	Fri 8/20/21	Fri 9/10/21
28	Remove Gate 2	16 days	Fri 9/10/21	Fri 10/1/21
29	Demo Spillway Gate 2 Concrete	41 days	Fri 10/1/21	Fri 11/26/21
30	Construct New Concrete in Gate 2 Spillway	66 days	Fri 11/26/21	Fri 2/25/22
31	Gate 2 Installation	66 days	Fri 2/25/22	Fri 5/27/22
32	Commission Gate 2	21 days	Fri 5/27/22	Fri 6/24/22
33	Remove Gate 2 Cofferdam	16 days	Fri 6/24/22	Fri 7/15/22
34	Demobilize	6 days	Fri 7/15/22	Fri 7/22/22
35	Project Completion	0 days	Fri 7/22/22	Fri 7/22/22



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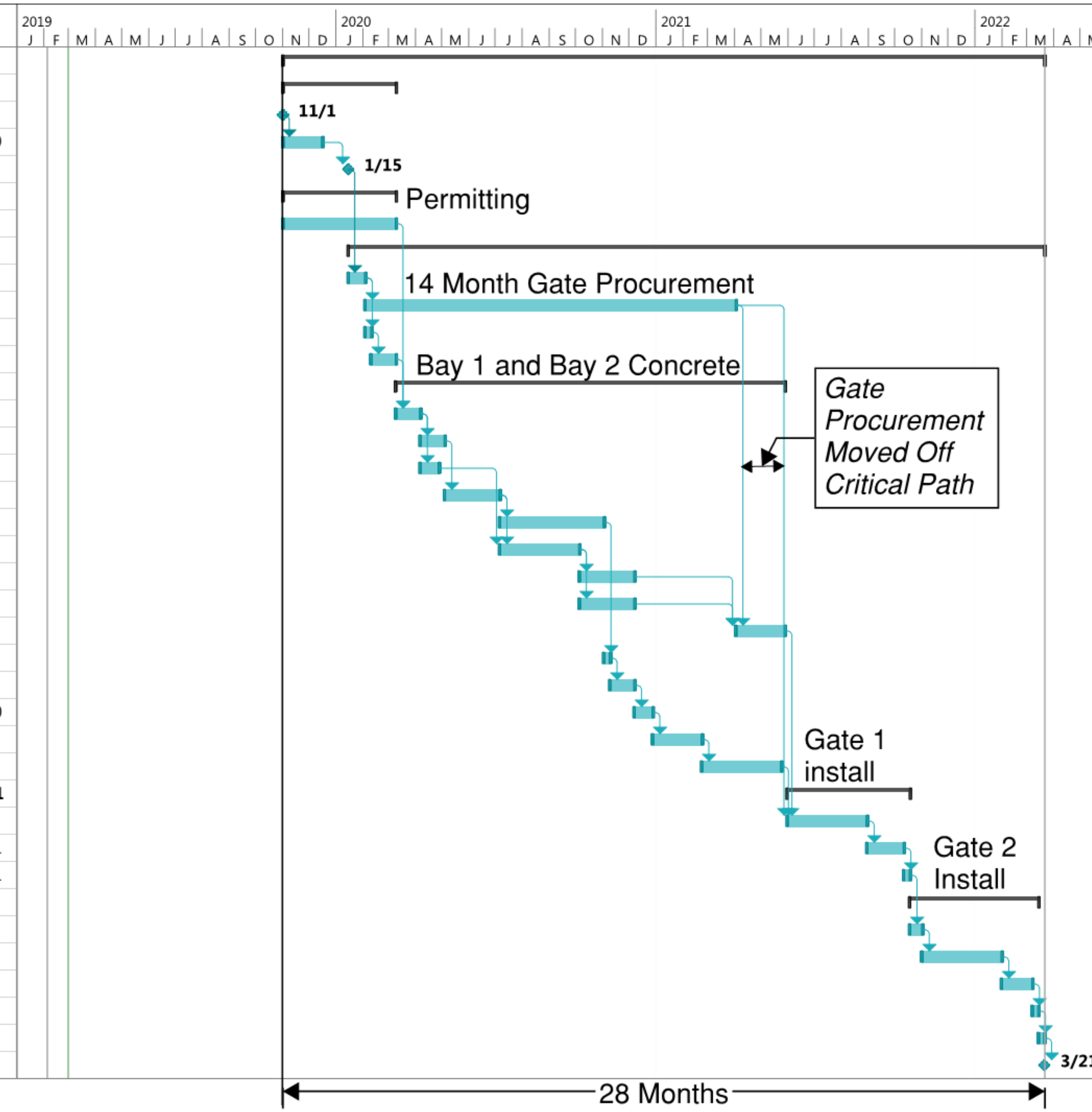
H-5 DAM SPILLGATE CONSTRUCTION SCHEDULE
OPTION 2

ID	Task Name	Duration	Start	Finish
1	**H-5 Dam Spillgate Replacement Option 2**	**622 days**	**Fri 11/1/19**	**Mon 3/21/22**
2	**Bid Phase**	**92 days**	**Fri 11/1/19**	**Mon 3/9/20**
3	Advertise for Bid	0 days	Fri 11/1/19	Fri 11/1/19
4	Bid	32 days	Fri 11/1/19	Mon 12/16/19
5	Award Bid	0 days	Wed 1/15/20	Wed 1/15/20
6	**Permitting**	**92 days**	**Fri 11/1/19**	**Mon 3/9/20**
7	Permit application and approval	92 days	Fri 11/1/19	Mon 3/9/20
8	**Construction Phase**	**569 days**	**Wed 1/15/20**	**Mon 3/21/22**
9	Administrative Mobilization	14 days	Wed 1/15/20	Mon 2/3/20
10	Gate Procurement	305 days	Mon 2/3/20	Fri 4/2/21
11	Site Mobilization	6 days	Mon 2/3/20	Mon 2/10/20
12	Site Preparation	21 days	Mon 2/10/20	Mon 3/9/20
13	**Concrete Construction**	**320 days**	**Mon 3/9/20**	**Fri 5/28/21**
14	Cofferdam & Dewater Gate 2	21 days	Mon 3/9/20	Mon 4/6/20
15	Remove Gate 2	21 days	Mon 4/6/20	Mon 5/4/20
16	Remove Existing Gate 1 and 2 Actuators	16 days	Mon 4/6/20	Mon 4/27/20
17	Demo Spillway Gate 2 Concrete	46 days	Mon 5/4/20	Mon 7/6/20
18	Construct New Concrete in Gate 2 Spillway	86 days	Mon 7/6/20	Mon 11/2/20
19	Construct New Concrete in Powerhouse	66 days	Mon 7/6/20	Mon 10/5/20
20	Install Electrical Power Supply Equipment	46 days	Mon 10/5/20	Mon 12/7/20
21	Install Instrumentation and Control Equipment	46 days	Mon 10/5/20	Mon 12/7/20
22	Install HPU	41 days	Fri 4/2/21	Fri 5/28/21
23	Remove Gate 2 Cofferdam	6 days	Mon 11/2/20	Mon 11/9/20
24	Cofferdam and Dewater Gate 1	21 days	Mon 11/9/20	Mon 12/7/20
25	Remove Gate 1	16 days	Mon 12/7/20	Mon 12/28/20
26	Demo Spillway Gate 1 Concrete	41 days	Mon 12/28/20	Mon 2/22/21
27	Construct New Concrete in Gate 1 Spillway	66 days	Mon 2/22/21	Mon 5/24/21
28	**Gate 1 Construction**	**101 days**	**Mon 5/31/21**	**Mon 10/18/21**
29	Gate 1 Installation	66 days	Mon 5/31/21	Mon 8/30/21
30	Commission Gate 1	31 days	Mon 8/30/21	Mon 10/11/21
31	Remove Gate 1 Cofferdam	6 days	Mon 10/11/21	Mon 10/18/21
32	**Gate 2 Construction**	**106 days**	**Mon 10/18/21**	**Mon 3/14/22**
33	Install Gate 2 Permanent Cofferdam	11 days	Mon 10/18/21	Mon 11/1/21
34	Gate 2 Installation	66 days	Mon 11/1/21	Mon 1/31/22
35	Commission Gate 2	26 days	Mon 1/31/22	Mon 3/7/22
36	Remove Gate 2 Permanent Cofferdam	6 days	Mon 3/7/22	Mon 3/14/22
37	Demobilize	6 days	Mon 3/14/22	Mon 3/21/22
38	Project Completion	0 days	Mon 3/21/22	Mon 3/21/22



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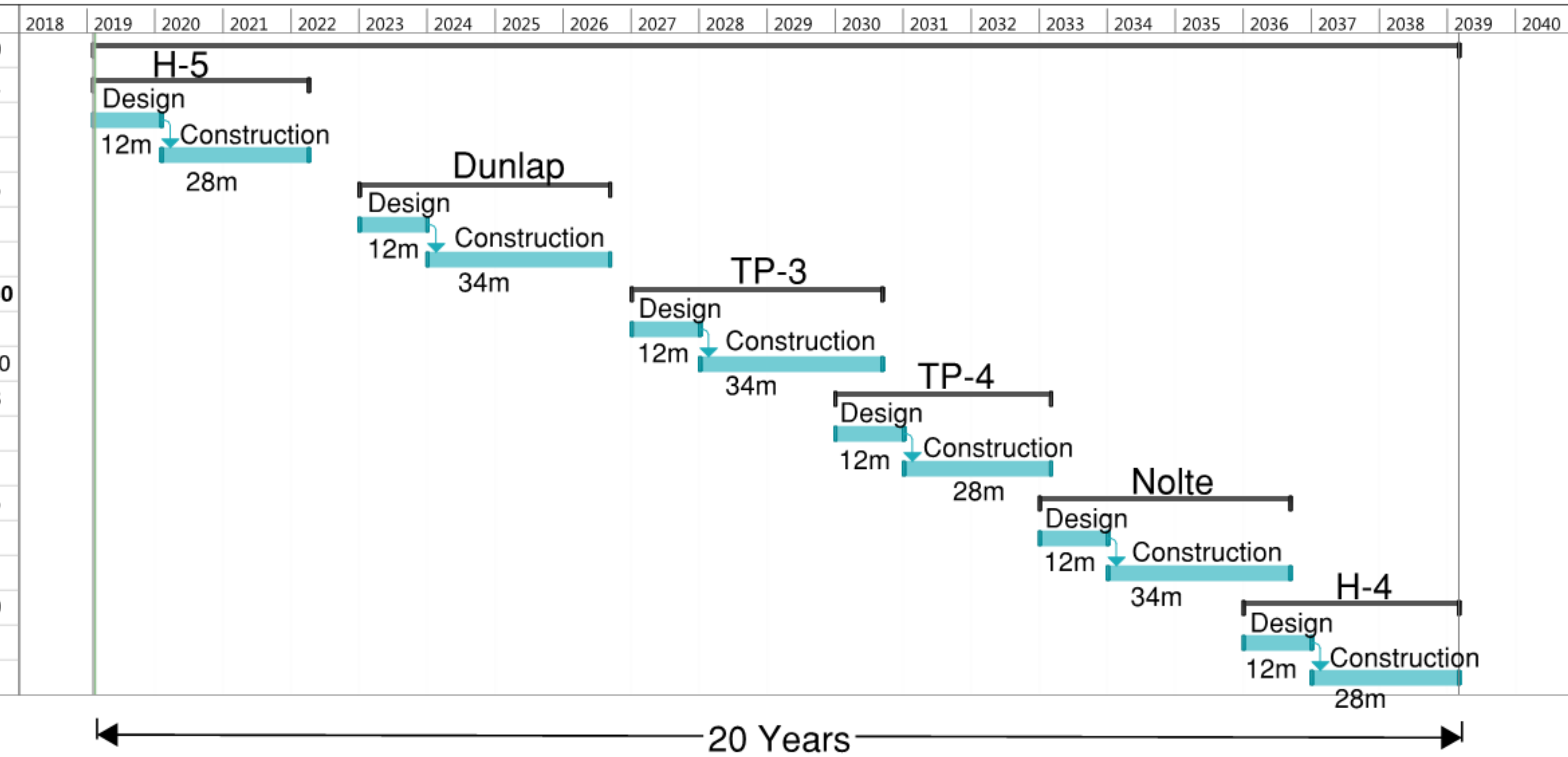
PROGRAM SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Program Schedule**	**5239 days**	**Mon 2/4/19**	**Thu 3/3/39**
2	**H-5 Dam (Lake Wood)**	**827 days**	**Mon 2/4/19**	**Tue 4/5/22**
3	Design & Bidding (12 months)	262 days	Mon 2/4/19	Tue 2/4/20
4	Construction (26 months)	565 days	Wed 2/5/20	Tue 4/5/22
5	**Dunlap Dam**	**962 days**	**Mon 1/2/23**	**Tue 9/8/26**
6	Design & Bidding (12 months)	262 days	Mon 1/2/23	Tue 1/2/24
7	Construction (32 months)	700 days	Wed 1/3/24	Tue 9/8/26
8	**TP-3 (Lake McQueeney)**	**962 days**	**Mon 1/4/27**	**Tue 9/10/30**
9	Design & Bidding (12 months)	262 days	Mon 1/4/27	Tue 1/4/28
10	Construction (32 months)	700 days	Wed 1/5/28	Tue 9/10/30
11	**TP-4 (Lake Placid)**	**827 days**	**Wed 1/2/30**	**Thu 3/3/33**
12	Design & Bidding (12 months)	262 days	Wed 1/2/30	Thu 1/2/31
13	Construction (26 months)	565 days	Fri 1/3/31	Thu 3/3/33
14	**Nolte Dam**	**962 days**	**Mon 1/3/33**	**Tue 9/9/36**
15	Design & Bidding (12 months)	262 days	Mon 1/3/33	Tue 1/3/34
16	Construction (32 months)	700 days	Wed 1/4/34	Tue 9/9/36
17	**H-4 Dam (Lake Gonzales)**	**827 days**	**Wed 1/2/36**	**Thu 3/3/39**
18	Design & Bidding (12 months)	262 days	Wed 1/2/36	Thu 1/1/37
19	Construction (26 months)	565 days	Fri 1/2/37	Thu 3/3/39



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Appendix E. OPINION OF PROBABLE CONSTRUCTION COST

ESTIMATE BASIS

Guadalupe-Blanco River Authority
H-5 SpillGate Replacement
Seguin, Texas

BLACK & VEATCH PROJECT NO. 400368

Guadalupe-Blanco River Authority

11 APRIL 2019

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1.0 INTRODUCTION

(CLASS 5 - Order of Magnitude)

LOW	OPCC RANGE	HIGH
-50%	BASE BID	+100%
$6,958,500	$13,917,030	$27,834,000

1.01 PROJECT DESCRIPTION

The H-5 Spillgate Replacement project is located near Sequin, Texas. Guadalupe-Blanco River Authority (GBRA) is needing to replace the existing spillway gates at 6 locations. The new gates will be hydraulically actuated steel crest gates. New concrete modifications to the existing dam will be needed to accommodate the crest gate design along with a hydraulic power unit and associated piping, electrical, and controls.

1.02 DISCLAIMER

The Opinion of Probable Construction Cost (hereinafter "OPCC" or "Estimate") estimates are based on a level of design detail and information that is directly related to the stage of design, and the level of effort budgeted to produce said estimate. As such, these estimates are preliminary with a range of uncertainty, and this should always be communicated to the OPCC recipient. Each OPCC estimate is prepared for guidance in project evaluation and implementation from the information available at the time the estimate was developed. The final costs of the project will depend on actual labor and material cost, competitive market conditions, final project scope, implementation schedule, and other variable conditions such as market events beyond the control of B&V and its client, and political events. As a result, the OPCC does not represent a certainty, and the final project costs may vary from the OPCC cost range presented to clients.

1.03 SUMMARY OF COSTS

The Engineer's Opinion of Probable Construction Cost (OPCC) Estimate includes anticipated construction costs including escalation to midpoint of construction, construction contingency, permitting fees, applicable taxes, and Engineering Design Fees or Engineering Services during construction when applicable to the project. Current design documents such as technical memos, design drawings, and specifications were utilized to produce the OPCC. Budget costs were developed from Black & Veatch data base with the basis of said data from historical cost from past projects, estimating team experience in the industry, NECA man hours for electrical labor, MCAA man hours for process mechanical labor, material cost from historical quotes as well as numerous other sources. Based on the aggregate of said data, the opinion of probable construction cost (OPCC) was developed. This level of definition allows for complete transparency throughout the lifecycle of design and helps the team deliver the project on schedule and budget. The estimate will have quotes for the stated process equipment, electrical gear, mechanical process piping and valves, and other aspects that are heavily weighting the overall cost of the project when available. Materials properties and assumptions will be verified as the design is further developed and the OPCC will be updated and provided with submittals per our contract with the client. The Final OPCC will be updated and submitted with the 100% Bidding Documents. Materials' properties used in this OPCC are as listed in preceding sections.

1.04 ESTIMATE ACCURACY

The estimate is based on the current design information dated January 2019 with scope development at the current PDR stage of design.

This cost estimate has been prepared for guidance in project evaluation and implementation from the information available at the time the estimate was developed. The final costs of the project will depend on actual labor and material cost, competitive market conditions, final project scope, implementation schedule, and other variable conditions. As a result, the final project costs will vary from the estimate presented herein.

1.05 UNIT PRICE RESOURCES

The following industry resources where used in developing this cost estimate:

- Black & Veatch Historical Data
- RSMeans Construction Cost Data
- Richardson Process Plant Estimating Standards
- Mechanical Contractors Association - Labor Manual
- National Electrical Contractors Association - Labor Unit Manual (NECA)
- Vendor Quotes on Equipment and Materials where available.
- Vendor/Distributor in-stock pricing for common construction items.

Labor unit prices reflect a burdened rate, including: workers compensation, unemployment taxes, Fringe Benefits, and medical insurance and other applicable markups based on project location adjusted from the RSMeans national average with adjustment based on area adjustments factors presented in the current annual labor index in RSMeans.
When available a wage rate prevailing determination will be utilized to adjust to local market conditions if provided.

1.06 ESTIMATE SCOPE OVERVIEW

The scope of the overall project includes the following:

- Removal of existing spillway gates & existing pedestrian suspension bridge
- New hydraulic actuated crest gates
- Concrete modifications
- Mechanical, electrical, and controls modifications
- Installation of a new pedestrian bridge across the dam for maintenance of gates

The following scoping documents are the basis for the estimate:

- Specifications – N/A
- Process Flow Diagrams, dated January 2019

1.07 ESTIMATE EXCLUSIONS

- Engineering or services during construction
- Land acquisition costs or fees
- Permitting costs or fees, other than specified
- Subsurface utility engineering or planning
- Removal, transportation, handling, classification, disposal or replacement of hazardous or deleterious soils or other materials, including groundwater.
- Removal, transportation, handling, classification, disposal or replacement of rock or rock-like materials.
- Existing material salvage values and the resulting impact on total project cost.

1.08 ESTIMATE ASSUMPTIONS

Due to the current level of design and available resources to complete this estimate, we have made a number of assumptions, they are summarized below:

- This estimate should be evaluated for market changes after 90 days of the issue date. It is assumed that much of the fabricated equipment will be shipped from the mainland USA.
- A 5 day per week, 8-hour shift was assumed during construction.

1.09 ESTIMATE ALLOWANCES

Due to the nature of the project location, the current level of design and the type of construction several allowances have been made in the OPCC, they are summarized below:

- Temperature Control for Mass Concrete $50,000

2.0 GENERAL PRICING NOTES

2.01 CONSTRUCTION LABOR

Wage rates were estimated based on 2018 national average wages. Productivities were evaluated based on actual jobsite conditions and adjusted accordingly to match the difficulties of items such as access to work, conditions of surrounding environment, quality and access to qualified craft, as well as weather conditions that can and will affect the overall performance of said craft. An all-in wage rate was used for the estimate. The stated wage rate includes base raw labor rate, fringes, insurance, overhead, and labor burden. Loaded wage rates are based on 5-8 hour days without adjustment for overtime. If overtime is required due to scheduling constraints, adjustments to the wage rate for overtime pay as well and productivity adjustments to loose of productivity will be taken into account.

2.02 CONSTRUCTION EQUIPMENT

Construction equipment is based on Permedia Rental Blue book rates based on the monthly rate published on a national average and is updated annually.

2.03 MATERIALS

Prices are based on a combination of Black & Veatch historical material estimating data base, recent vendor quote/pricing information and project specific quotes in **Table 1** below.

Table 1 - Project Specific Quotes

Vendor Name	Scope of Supply/Subcontract	Dated	Amount
Various	Spillway Gates, HPU, Side Seal Plates		$3.3m

2.04 CONSTRUCTION GENERAL CONDITIONS

Construction management is included as a percentage.

- Construction Management 5.5%
- Travel & Subsistence 2%
- Temporary Facilities 1%
- GC Equipment .5%
- Start-up 1.5%

2.05 SALES TAX

Local and state sales taxes are included in the estimate as applicable to the location of the project.

2.06 ESCALATION

Escalation has been estimated based on the current project schedule. Escalation is based on the IHS Global Insight Index and has been assumed at 6%.

2.07 CONSTRUCTION CONTINGENCY

An estimate construction contingency of 30% has been included in the estimate. Contingency is applied as a function of the level of design definition as well as level of effort applies to said estimate. The estimator that produces said estimate is responsible for said assessment.

2.08 ENGINEERING (IF APPLICABLE)

For projects that require a total capital investment cost for the project, the estimate will include the cost for engineering.

Noted assumptions and clarifications:

- Sheet pile cofferdams have been included upstream & downstream of the dam during gate replacement.

- Temporary roads are included to access each gate area during replacement and bridge installation.
- A cofferdam will be installed upstream during construction at each spillway gate. The cofferdam will be removed and installed upstream of the remaining spillway gate and then removed after construction is complete.
- Concrete strength is assumed at 4,500 psi with addons for required admixtures.
- Consideration has been made for the mass concrete placements and money allocated appropriately.
- All sheet pile work has been assumed to be installed with barges. The estimate includes costs for barge work.

Dam Project	Spillway Configuration	Prorated Lake Wood Dam H-5 Budget	Year of Construction	Escalation 3%	Prorated Budget
H-5	2 gates, 85' x 12'	$13,917,030	2019		
Dunlap	3 gates, 85' x 12'	$20,875,545	2024	1.15	$24,000,000
TP-3	3 gates, 85' x 12'	$20,875,545	2028	1.27	$26,500,000
TP-4	2 gates, 98' x 12'	$16,045,517	2031	1.36	$21,800,000
Nolte	3 gates, 85' x 12'	$20,875,545	2034	1.45	$30,300,000
H-4	2 gates, 85' x 12'	$13,917,030	2037	1.54	$21,400,000

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Guadalupe-Blanco River Authority
PDR Report

Spreadsheet Level	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Equip Amount	Sub Amount	Other Amount	Total Cost/Unit	Total Amount
01 H-5 Lake Wood									
02200 Site Preparation									
2000.3000.02.01001 Remove Existing Bear Trap Spillway Gates, 85' x 12'									
CRANE - Crawler - 140T (Kobelco CK1600) w/ Operator, Gate #1	8.00 day	64	4,039	-	10,475	-	-	1,814.30 /day	14,514
Crane Mats 12"X48"X20', Single Layer	16.00 ea		-	-	64,000	-	-	4,000.00 /ea	64,000
Cutting Torch, Welder	320.00 hr		-	-	1,062	-	-	3.32 /hr	1,062
Remove existing spillway gates, bear trap style, 85' x 12' tall	2.00 ea	320	20,093	-	-		-	10,046.72 /ea	20,093
Haul Demo/Off Site 20cy Rear Dump 2.00 Hour/Load	4.00 load	8	392	-	600	-	800	448.03 /load	1,792
2000.3000.02.01001 Remove Existing Bear Trap Spillway Gates, 85' x 12'	**2.00 ea**	**392**	**24,525**		**76,138**		**800**	**50,731.17 /ea**	**101,462**
2000.3000.02.01050 Remove Existing Valves in Powerhouse									
Remove existing Valves in Powerhouse	4.00 ea	16	1,072	-	-		-	268.05 /ea	1,072
2000.3000.02.01050 Remove Existing Valves in Powerhouse	**4.00 ea**	**16**	**1,072**					**268.05 /ea**	**1,072**
2000.3000.02.01100 Remove Existing Steel Suspension Bridge									
CRANE - RT - 89T (Max boom Length 105') w/ Operator	10.00 day	80	5,049	-	13,121	-	-	1,817.02 /day	18,170
Demo existing Steel suspension bridge, North side	117.00 lf	200	12,555	-	-	-	-	107.31 /lf	12,555
Demo existing Steel suspension bridge, South Side	118.00 lf	202	12,663	-	-	-	-	107.31 /lf	12,663
Demo bridge support structure, North End	1.00 ea	40	2,512	-		-	-	2,511.68 /ea	2,512
2000.3000.02.01100 Remove Existing Steel Suspension Bridge	**235.00 lf**	**522**	**32,779**		**13,121**			**195.32 /lf**	**45,900**
02200 Site Preparation		**930**	**58,376**		**89,258**		**800**		**148,435**
02240 Dewatering									
2000.0100.02.02240 Temporary Dewatering									
Dewatering 100' x 18', 6 mn - Cofferdam Gate 1	182.00 day	1,456	36,400	-	136,500	-	-	950.00 /day	172,900
Dewatering 100' x 18', 6 mn - Cofferdam Gate 2	182.00 day	1,456	36,400	-	136,500	-	-	950.00 /day	172,900
2000.0100.02.02240 Temporary Dewatering	**365.00 day**	**2,912**	**72,800**		**273,000**			**947.40 /day**	**345,800**
02240 Dewatering		**2,912**	**72,800**		**273,000**				**345,800**
02262 Cofferdams									
2000.0100.02.02262 Sheet Pile, Cofferdam Gate #1, Upstream, Barge Driven									
Barge, sheet piles	30.00 day		-	-	30,000	-	-	1,000.00 /day	30,000
Sheet piling, 50,000 psi steel, not inl wales, 50' deep excavation, 38 psf, left in place	103.00 ton		-	144,200	-	-	-	1,400.00 /ton	144,200
Drive sheet piles, steel, 50' deep excavation, 38 psf, left in place	103.00 ton	549	33,141	-	14,873	-	-	466.15 /ton	48,013
Mobilization	1.00 lot			-	20,000	-	-	20,000.00 /lot	20,000
Wales, connections & struts	103.00 ton		-	41,196	-	-	-	399.96 /ton	41,196
2000.0100.02.02262 Sheet Pile, Cofferdam Gate #1, Upstream, Barge Driven	**5,400.00 sf**	**549**	**33,141**	**185,396**	**64,873**			**52.48 /sf**	**283,409**
2000.0100.02.02266 Sheet Pile, Cofferdam Gate #2, Upstream, Barge Driven									
Barge, sheet piles	30.00 day		-	-	30,000	-	-	1,000.00 /day	30,000
Sheet piling, not inl wales, 50' deep excavation, 38 psf, left in place	91.00 ton		-	127,400	-	-	-	1,400.00 /ton	127,400
Drive sheet piles, steel, 50' deep excavation, 38 psf, left in place	91.00 ton	485	29,279	-	13,140	-	-	466.15 /ton	42,419
Mobilization	1.00 lot			-	20,000	-	-	20,000.00 /lot	20,000
Wales, connections & struts	91.00 ton		-	36,396	-	-	-	399.96 /ton	36,396
2000.0100.02.02266 Sheet Pile, Cofferdam Gate #2, Upstream, Barge Driven	**4,750.00 sf**	**485**	**29,279**	**163,796**	**63,140**			**53.94 /sf**	**256,216**
2000.0100.02.02269 Sheet Pile, Downstream of Spillway									
Barge, sheet piles	45.00 day		-	-	45,000	-	-	1,000.00 /day	45,000
Sheet piling, not inl wales, 40' deep excavation, 38 psf, left in place	190.00 ton		-	266,000	-	-	-	1,400.00 /ton	266,000
Drive sheet piles, steel, 40' deep excavation, 38 psf, left in place	190.00 ton	1,013	61,133	-	27,435	-	-	466.15 /ton	88,568
Mobilization	1.00 lot			-	20,000	-	-	20,000.00 /lot	20,000
Wales, connections & struts	190.00 ton		-	75,992	-	-	-	399.96 /ton	75,992
2000.0100.02.02269 Sheet Pile, Downstream of Spillway	**10,000.00 sf**	**1,013**	**61,133**	**341,992**	**92,435**			**49.56 /sf**	**495,560**
02262 Cofferdams		**2,048**	**123,553**	**691,185**	**220,447**				**1,035,185**
02300 Earthwork									
2000.0100.02.01050 Site Grading									
Grading for Staging areas, crane access	15,000.00 sy	75	4,558	-	5,906	-	-	0.70 /sy	10,463
2000.0100.02.01050 Site Grading	**15,000.00 sy**	**75**	**4,558**		**5,906**			**0.70 /sy**	**10,463**
2000.0100.02.01055 Cofferdam Extension, Earth Fill, North Side									
Dozer D6 (207 hp), spread common earth	370.00 cy	19	1,098	-	1,397	-	-	6.74 /cy	2,495
Import, common earth - extension of sheet pile cofferdam, North side	370.00 cy		-	2,590	-		-	7.00 /cy	2,590
Haul import fill, 12 cy dump truck, 50 mph average, cycle 40 miles	370.00 cy	9	453	-	606	-	-	2.86 /cy	1,058
Compact fill, single drum, padfoot, 8" lift	370.00 cy	8	488	-	289	-	-	2.10 /cy	777
2000.0100.02.01055 Cofferdam Extension, Earth Fill, North Side	**370.00 cy**	**36**	**2,039**	**2,590**	**2,291**			**18.70 /cy**	**6,920**
2000.0100.02.02340 Clear & Grub Access to Cofferdam #1 Excavation									
Grade access to cofferdam area, D6 dozer	5,632.00 sf	14	836	-	1,063	-	-	0.34 /sf	1,899
ASTM D448 # 3 Stone (2.00-1.00 in)	210.00 cy		-	1,764	-		-	8.40 /cy	1,764
Haul import fill, 12 cy dump truck, 35 mph average, cycle 40 miles	210.00 cy	21	1,028	-	1,375	-	-	11.44 /cy	2,403
Stone for access road to cofferdam excavation	5,632.00 sf	8	478		607	-	-	0.19 /sf	1,085

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Spreadsheet Level	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Equip Amount	Sub Amount	Other Amount	Total Cost/Unit	Total Amount
2000.0100.02.02340 Clear & Grub Access to Cofferdam #1 Excavation	**5,631.00 sf**	**43**	**2,342**	**1,764**	**3,045**			**1.27 /sf**	**7,151**
2000.0100.02.02345 Clear & Grub Access to Cofferdam #2 Excavation									
Grade access to cofferdam area, D6 dozer	3,205.00 sf	8	476	-	605	-	-	0.34 /sf	1,081
ASTM D448 # 3 Stone (2.00-1.00 in)	120.00 cy		-	1,008	-		-	8.40 /cy	1,008
Haul import fill, 12 cy dump truck, 35 mph average, cycle 40 miles	120.00 cy	12	588	-	786	-	-	11.44 /cy	1,373
Stone for access road to cofferdam excavation	3,205.00 sf	6	380		484	-	-	0.27 /sf	864
2000.0100.02.02345 Clear & Grub Access to Cofferdam #2 Excavation	**3,205.00 sf**	**26**	**1,444**	**1,008**	**1,874**			**1.35 /sf**	**4,326**
2000.0100.02.02360 Excavation for Spillway Gate #1 Concrete									
Excavate and load onto trucks, common earth, bulk bank measure, hydraulic excavator, crawler, 1.75 cy bucket	536.00 cy	13	814	-	1,525	-	-	4.36 /cy	2,339
Load excavated material onto dump truck, common earth, bulk bank measure, hydraulic excavator, crawler, 1.75 cy bucket	412.00 cy	3	193	-	361	-	-	1.34 /cy	553
Haul excavated material off-site, 12 cy dump truck, 35 mph average, cycle 40 miles	412.00 cy	34	1,681	-	2,247	-	-	9.54 /cy	3,929
Spread dumped material (from on-site stockpile), dozer (D6)	124.00 cy	2	147	-	187	-	-	2.70 /cy	334
Compact fill, single drum, padfoot, 8" lift	124.00 cy	2	113	-	67	-	-	1.45 /cy	180
2000.0100.02.02360 Excavation for Spillway Gate #1 Concrete	**536.00 cy**	**55**	**2,949**		**4,387**			**13.69 /cy**	**7,335**
2000.0100.02.02370 Excavation for Spillway Gate #2 Concrete									
Excavate and load onto trucks, common earth, bulk bank measure, hydraulic excavator, crawler, 1.75 cy bucket	536.00 cy	13	814	-	1,525	-	-	4.36 /cy	2,339
Load excavated material onto dump truck, common earth, bulk bank measure, hydraulic excavator, crawler, 1.75 cy bucket	412.00 cy	3	193	-	361	-	-	1.34 /cy	553
Haul excavated material off-site, 12 cy dump truck, 35 mph average, cycle 40 miles	412.00 cy	34	1,681	-	2,247	-	-	9.54 /cy	3,929
Spread dumped material (from on-site stockpile), dozer (D6)	124.00 cy	2	147	-	187	-	-	2.70 /cy	334
Compact fill, single drum, padfoot, 8" lift	124.00 cy	2	113	-	67	-	-	1.45 /cy	180
2000.0100.02.02370 Excavation for Spillway Gate #2 Concrete	**536.00 cy**	**55**	**2,949**		**4,387**			**13.69 /cy**	**7,335**
02300 Earthwork		**291**	**16,279**	**5,362**	**21,890**				**43,531**
02950 Site Restoration									
2000.0100.02.02950 Cofferdam #1 Access Road Restoration									
Restore cofferdam access road	625.00 sy				-	2,500	-	4.00 /sy	2,500
2000.0100.02.02950 Cofferdam #1 Access Road Restoration	**625.00 sy**					**2,500**		**4.00 /sy**	**2,500**
2000.0100.02.02955 Cofferdam #2 Access Road Restoration									
Restore cofferdam access road	360.00 sy				-	1,440	-	4.00 /sy	1,440
2000.0100.02.02955 Cofferdam #2 Access Road Restoration	**360.00 sy**					**1,440**		**4.00 /sy**	**1,440**
02950 Site Restoration						**3,940**			**3,940**
03000 Div. 03 General Conditions									
2000.0100.03.01001 Concrete Allowance, Mass Concrete Thermal Control (Allowance)									
Thermal / Temperature Monitoring for Mass Concrete	1.00 lot		-	-	-		***0***	0.01 /lot	0
2000.0100.03.01001 Concrete Allowance, Mass Concrete Thermal Control (Allowance)	**1.00 lot**						**0**	**0.01 /lot**	**0**
03000 Div. 03 General Conditions							**0**		**0**
03300 Cast-In-Place Concrete									
1170.0200.03.03311 HPU Concrete Equipment Pad									
Equipment Pad Form Mat'l 6" thick	14.00 sf		-	56	-	-	-	4.00 /sf	56
Chamfer 3/4"	28.00 lf		-	28	-	-	-	1.00 /lf	28
Equipment Pad Form Oil & Hardware	14.00 sf		-	7	-	-	-	0.50 /sf	7
-- Install Equipment Pad Forms 6" thick (SF)	14.00 sf	4	212	-	-	-	-	15.15 /sf	212
-- Install Chamfer 3/4"	28.00 lf	2	85	-	-	-	-	3.03 /lf	85
Equipment Pad Rebar and Accessories/Unload & Store	0.04 ton	2	83	0	31	-	-	2,727.60 /ton	115
Equipment Pad Rebar	0.04 ton		-	40	-	-	-	950.00 /ton	40
-- Install Equipment Pad Rebar	0.04 ton	1	42	-	-	-	-	1,001.20 /ton	42
3000 psi Concrete	0.83 cy		-	83	-	-	-	100.00 /cy	83
Place Equipment Pad, Pumped	0.83 cy	7	363	-	-	-	-	436.17 /cy	363
Trowel Finish Equipment Pad	45.00 sf	1	33	-	-	-	-	0.73 /sf	33
Equipment Pad Concrete Pump- 140' Boom (43m)	0.83 cy		-	-	-	267	83	420.00 /cy	350
Water Base Non-Residual Cure	45.00 sf	1	44	3	-	-	-	1.03 /sf	46
1170.0200.03.03311 HPU Concrete Equipment Pad	**0.83 cy**	**17**	**861**	**217**	**31**	**267**	**83**	**1,758.96 /cy**	**1,460**
2000.0100.03.01055 Spillway Crest Gate #1 Concrete Footing									
CRANE - RT - 45T (Max boom Length 105') w/ Operator	20.00 day	160	10,099	-	15,294	-	-	1,269.66 /day	25,393
Surface Blasting (Wet) existing dam surface	1,027.00 sf	21	1,011	-	135	-	-	1.12 /sf	1,146
Ice Chips, Concrete Cooling	684.67 cy		-	17,117	-	-	-	25.00 /cy	17,117
Mass Concrete Form Mat'l - Lumber 2-Use	1,027.00 sf		-	10,270	-	-	-	10.00 /sf	10,270
Mass Concrete Lumber Form Oil & Hardware	1,027.00 sf		-	514	-	-	-	0.50 /sf	514
-- Install Mass Concrete Forms - Lumber 2-Use	1,027.00 sf	257	12,721	-	-	-	-	12.39 /sf	12,721
Mass Concrete Rebar and Accessories/Unload & Store	51.35 ton	8	405	514	154	-	-	20.87 /ton	1,072
Mass Concrete Rebar	51.35 ton		-	48,783	-	-	-	950.00 /ton	48,783
-- Install Mass Concrete Rebar	51.35 ton	924	57,843	-	-	-	-	1,126.44 /ton	57,843
4500 psi Concrete	684.67 cy		-	71,890	-	-	-	105.00 /cy	71,890
4500 psi Concrete (Waste)	20.54 cy		-	2,157	-	-	-	105.00 /cy	2,157
Superplasticizers	684.67 cy		-	13,693	-	-	-	20.00 /cy	13,693
Place Mass Concrete, Pumped	684.67 cy	856	40,887	-	-	-	-	59.72 /cy	40,887

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Spreadsheet Level	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Equip Amount	Sub Amount	Other Amount	Total Cost/Unit	Total Amount
2000.0100.03.01055 Spillway Crest Gate #1 Concrete Footing									
Float Finish Mass Concrete	1,422.00 sf	43	2,066	-	-	-	-	1.45 /sf	2,066
Mass Concrete Concrete Pumping- 180' Boom (52m)	684.67 cy		-	-	-	3,150	6,847	14.60 /cy	9,997
Water Base Non-Residual Cure	1,422.00 sf	3	138	85	-	-	-	0.16 /sf	223
2000.0100.03.01055 Spillway Crest Gate #1 Concrete Footing	**684.67 cy**	**2,271**	**125,168**	**165,022**	**15,583**	**3,150**	**6,847**	**461.20 /cy**	**315,769**
2000.0100.03.01105 Spillway Crest Gate #2 Concrete Footing									
CRANE - RT - 45T (Max boom Length 105') w/ Operator	20.00 day	160	10,099	-	15,294	-	-	1,269.66 /day	25,393
Surface Blasting (Wet) existing dam surface	1,027.00 sf	21	1,011	-	135	-	-	1.12 /sf	1,146
Ice Chips, Concrete Cooling	684.67 cy		-	17,117	-	-	-	25.00 /cy	17,117
Mass Concrete Form Mat'l - Lumber 2-Use	1,027.00 sf		-	10,270	-	-	-	10.00 /sf	10,270
Mass Concrete Lumber Form Oil & Hardware	1,027.00 sf		-	514	-	-	-	0.50 /sf	514
-- Install Mass Concrete Forms - Lumber 2-Use	1,027.00 sf	257	12,721	-	-	-	-	12.39 /sf	12,721
Mass Concrete Rebar and Accessories/Unload & Store	51.35 ton	8	405	514	154	-	-	20.87 /ton	1,072
Mass Concrete Rebar	51.35 ton		-	48,783	-	-	-	950.00 /ton	48,783
-- Install Mass Concrete Rebar	51.35 ton	924	57,843	-	-	-	-	1,126.44 /ton	57,843
4500 psi Concrete	684.67 cy		-	71,890	-	-	-	105.00 /cy	71,890
4500 psi Concrete (Waste)	20.54 cy		-	2,157	-	-	-	105.00 /cy	2,157
Superplasticizers	684.67 cy		-	13,693	-	-	-	20.00 /cy	13,693
Place Mass Concrete, Pumped	684.67 cy	856	40,887	-	-	-	-	59.72 /cy	40,887
Float Finish Mass Concrete	1,422.00 sf	43	2,066	-	-	-	-	1.45 /sf	2,066
Mass Concrete Concrete Pumping- 180' Boom (52m)	684.67 cy		-	-	-	3,150	6,847	14.60 /cy	9,997
Water Base Non-Residual Cure	1,422.00 sf	3	138	85	-	-	-	0.16 /sf	223
2000.0100.03.01105 Spillway Crest Gate #2 Concrete Footing	**684.67 cy**	**2,271**	**125,168**	**165,022**	**15,583**	**3,150**	**6,847**	**461.20 /cy**	**315,769**
2000.0100.03.01205 Spillway Gate #1 Concrete Slab Infill									
CRANE - RT - 45T (Max boom Length 105') w/ Operator	20.00 day	160	10,099	-	15,294	-	-	1,269.66 /day	25,393
Surface Blasting (Wet) existing dam surface	2,550.00 sf	51	2,511	-	334	-	-	1.12 /sf	2,845
Concrete Admixtures	815.00 cy		-	16,300	-	-	-	20.00 /cy	16,300
Mass Concrete Form Mat'l - Lumber 2-Use	237.00 sf		-	2,370	-	-	-	10.00 /sf	2,370
Bulkheads/Construction Joints/Mass Concrete Ends	120.00 sf		-	381	-	-	-	3.18 /sf	381
Mass Concrete Lumber Form Oil & Hardware	237.00 sf		-	119	-	-	-	0.50 /sf	119
-- Install Mass Concrete Forms - Lumber 2-Use	237.00 sf	59	2,936	-	-	-	-	12.39 /sf	2,936
-- Install Bulkheads/Construction Joints/Mass Concrete Ends	120.00 sf	42	2,081	-	-	-	-	17.34 /sf	2,081
-- Blast Clean Construction Joints	120.00 sf	12	591	50	202	-	-	7.02 /sf	843
Mass Concrete Rebar and Accessories/Unload & Store	61.10 ton	20	963	611	366	-	-	31.74 /ton	1,939
Mass Concrete Rebar	61.10 ton		-	61,100	-	-	-	1,000.00 /ton	61,100
-- Install Mass Concrete Rebar	61.10 ton	1,100	68,825	-	-	-	-	1,126.44 /ton	68,825
4500 psi Concrete	815.00 cy		-	85,575	-	-	-	105.00 /cy	85,575
4500 psi Concrete (Waste)	24.50 cy		-	2,573	-	-	-	105.00 /cy	2,573
Ice Chips, concrete cooling	815.00 cy		-	20,375	-	-	-	25.00 /cy	20,375
Place Mass Concrete, Pumped	815.00 cy	1,630	77,872	-	-	-	-	95.55 /cy	77,872
Machine Trowel Finish Mass Concrete	2,550.00 sf	38	1,871	-	39	-	-	0.75 /sf	1,910
Mass Concrete Concrete Pumping- 170' Boom (52m)	815.00 cy		-	-	-	3,179	8,150	13.90 /cy	11,329
Water Base Non-Residual Cure	2,550.00 sf	5	247	153	-	-	-	0.16 /sf	400
2000.0100.03.01205 Spillway Gate #1 Concrete Slab Infill	**815.00 cy**	**3,117**	**167,995**	**189,606**	**16,235**	**3,179**	**8,150**	**472.59 /cy**	**385,164**
2000.0100.03.01227 Spillway Gate #2 Concrete Slab Infill									
CRANE - RT - 45T (Max boom Length 105') w/ Operator	20.00 day	160	10,099	-	15,294	-	-	1,269.66 /day	25,393
Surface Blasting (Wet) existing dam surface	2,550.00 sf	51	2,511	-	334	-	-	1.12 /sf	2,845
Concrete Admixtures	815.00 cy		-	16,300	-	-	-	20.00 /cy	16,300
Mass Concrete Form Mat'l - Lumber 2-Use	237.00 sf		-	2,370	-	-	-	10.00 /sf	2,370
Bulkheads/Construction Joints/Mass Concrete Ends	120.00 sf		-	381	-	-	-	3.18 /sf	381
Mass Concrete Lumber Form Oil & Hardware	237.00 sf		-	119	-	-	-	0.50 /sf	119
-- Install Mass Concrete Forms - Lumber 2-Use	237.00 sf	59	2,936	-	-	-	-	12.39 /sf	2,936
-- Install Bulkheads/Construction Joints/Mass Concrete Ends	120.00 sf	42	2,081	-	-	-	-	17.34 /sf	2,081
-- Blast Clean Construction Joints	120.00 sf	12	591	50	202	-	-	7.02 /sf	843
Mass Concrete Rebar and Accessories/Unload & Store	61.10 ton	20	963	611	366	-	-	31.74 /ton	1,939
Mass Concrete Rebar	61.10 ton		-	61,100	-	-	-	1,000.00 /ton	61,100
-- Install Mass Concrete Rebar	61.10 ton	1,100	68,825	-	-	-	-	1,126.44 /ton	68,825
4500 psi Concrete	815.00 cy		-	85,575	-	-	-	105.00 /cy	85,575
4500 psi Concrete (Waste)	24.50 cy		-	2,573	-	-	-	105.00 /cy	2,573
Ice Chips, concrete cooling	815.00 cy		-	20,375	-	-	-	25.00 /cy	20,375
Place Mass Concrete, Pumped	815.00 cy	1,630	77,872	-	-	-	-	95.55 /cy	77,872
Machine Trowel Finish Mass Concrete	2,550.00 sf	38	1,871	-	39	-	-	0.75 /sf	1,910
Mass Concrete Concrete Pumping- 170' Boom (52m)	815.00 cy		-	-	-	3,179	8,150	13.90 /cy	11,329
Water Base Non-Residual Cure	2,550.00 sf	5	247	153	-	-	-	0.16 /sf	400
2000.0100.03.01227 Spillway Gate #2 Concrete Slab Infill	**815.00 cy**	**3,117**	**167,995**	**189,606**	**16,235**	**3,179**	**8,150**	**472.59 /cy**	**385,164**
2000.0100.03.01300 Concrete Column, Center Pier									

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Spreadsheet Level	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Equip Amount	Sub Amount	Other Amount	Total Cost/Unit	Total Amount
2000.0100.03.01300 Concrete Column, Center Pier									
CRANE - RT - 45T (Max boom Length 105') w/ Operator	1.00 day	8	505	-	765	-	-	1,269.66 /day	1,270
Concrete Admixtures	20.05 cy		-	401	-	-	-	20.00 /cy	401
Custom column Form Mat'l <20' tall	403.65 sf		-	3,229	-	-	-	8.00 /sf	3,229
Column Form Oil & Hardware	403.65 sfca		-	133	-	-	-	0.33 /sfca	133
-- Install Rectangular Column Forms <20' tall	403.65 sf	121	6,000	-	-	-	-	14.86 /sf	6,000
Column Rebar and Accessories/Unload & Store	1.50 ton	0	24	15	9	-	-	31.74 /ton	48
Column Rebar,	1.50 ton		-	1,500	-	-	-	1,000.00 /ton	1,500
-- Install Column Rebar	1.50 ton	24	1,502	-	-	-	-	1,001.28 /ton	1,502
4500 psi Concrete	20.05 cy		-	2,105	-	-	-	105.00 /cy	2,105
4500 psi Concrete (Waste)	1.06 cy		-	111	-	-	-	105.00 /cy	111
Ice Chips, concrete cooling	20.05 cy		-	501	-	-	-	25.00 /cy	501
Place Column, Pumped	20.05 cy	25	1,214	-	4	-	-	60.72 /cy	1,218
Float Finish / Strike-off top of Column	42.50 sf	3	165	-	-	-	-	3.87 /sf	165
Column Concrete Pump- 170' Boom (52m)	20.05 cy		-	-	-	391	201	29.50 /cy	591
Point & Patch Column	403.65 sf	8	391	4	-	-	-	0.98 /sf	395
Setup & Remove Scaffolding	403.65 sf	81	3,974	-	-	-	-	9.85 /sf	3,974
2000.0100.03.01300 Concrete Column, Center Pier	**20.05 cy**	**271**	**13,774**	**8,000**	**777**	**391**	**201**	**1,154.25 /cy**	**23,143**
2000.0100.03.01320 Concrete Column, Spillway Gate #1, North									
CRANE - RT - 45T (Max boom Length 105') w/ Operator	1.00 day	8	505	-	765	-	-	1,269.66 /day	1,270
Concrete Admixtures	6.70 cy		-	134	-	-	-	20.00 /cy	134
Rectangle Column Form Mat'l <20' tall	206.26 sf		-	1,650	-	-	-	8.00 /sf	1,650
Column Form Oil & Hardware	206.26 sfca		-	68	-	-	-	0.33 /sfca	68
-- Install Rectangular Column Forms >20' tall	206.26 sf	37	1,839	-	-	-	-	8.92 /sf	1,839
Column Rebar and Accessories/Unload & Store	0.90 ton	1	71	9	27	-	-	118.71 /ton	107
Column Rebar	0.90 ton		-	900	-	-	-	1,000.00 /ton	900
-- Install Column Rebar	0.90 ton	14	901	-	-	-	-	1,001.28 /ton	901
4500 psi Concrete	6.70 cy		-	704	-	-	-	105.00 /cy	704
4500 psi Concrete (Waste)	0.36 cy		-	38	-	-	-	105.00 /cy	38
Ice Chips	6.70 cy		-	168	-	-	-	25.00 /cy	168
Place Column, Pumped	6.70 cy	13	649	-	13	-	-	98.88 /cy	662
Float Finish / Strike-off top of Column	14.30 sf	3	139	-	-	-	-	9.69 /sf	139
Column Concrete Pump- 170' Boom (52m)	6.70 cy		-	-	-	131	67	29.50 /cy	198
Point & Patch Column	206.26 sf	4	200	2	-	-	-	0.98 /sf	202
Setup & Remove Scaffolding	206.26 sf	41	2,031	-	-	-	-	9.85 /sf	2,031
2000.0100.03.01320 Concrete Column, Spillway Gate #1, North	**6.70 cy**	**123**	**6,334**	**3,672**	**805**	**131**	**67**	**1,643.15 /cy**	**11,009**
2000.0100.03.01340 Concrete Column, Spillway Gate #2, South									
CRANE - RT - 45T (Max boom Length 105') w/ Operator	1.00 day	8	505	-	765	-	-	1,269.66 /day	1,270
Concrete Admixtures	15.33 cy		-	307	-	-	-	20.00 /cy	307
Rectangle Column Form Mat'l >20' tall	328.00 sf		-	2,624	-	-	-	8.00 /sf	2,624
Column Form Oil & Hardware	328.03 sfca		-	108	-	-	-	0.33 /sfca	108
-- Install Rectangular Column Forms >20' tall	328.03 sf	59	2,925	-	-	-	-	8.92 /sf	2,925
Column Rebar and Accessories/Unload & Store	0.90 ton	1	71	9	27	-	-	118.71 /ton	107
Column Rebar	0.90 ton		-	900	-	-	-	1,000.00 /ton	900
-- Install Column Rebar	0.90 ton	14	901	-	-	-	-	1,001.28 /ton	901
4500 psi Concrete	15.33 cy		-	1,610	-	-	-	105.00 /cy	1,610
4500 psi Concrete (Waste)	0.36 cy		-	38	-	-	-	105.00 /cy	38
Ice Chips	15.33 cy		-	383	-	-	-	25.00 /cy	383
Place Column, Pumped	15.33 cy	31	1,485	-	31	-	-	98.88 /cy	1,516
Float Finish / Strike-off top of Column	14.30 sf	3	139	-	-	-	-	9.69 /sf	139
Column Concrete Pump- 170' Boom (52m)	15.33 cy		-	-	-	299	153	29.50 /cy	452
Point & Patch Column	328.03 sf	7	318	3	-	-	-	0.98 /sf	321
Setup & Remove Scaffolding	328.03 sf	66	3,230	-	-	-	-	9.85 /sf	3,230
2000.0100.03.01340 Concrete Column, Spillway Gate #2, South	**15.33 cy**	**189**	**9,573**	**5,982**	**822**	**299**	**153**	**1,097.82 /cy**	**16,830**
2000.0100.03.01360 Concrete Wall, Center Pier									
CRANE - RT - 45T (Max boom Length 105') w/ Operator	15.00 day	120	7,574	-	11,471	-	-	1,269.66 /day	19,045
Surface Blasting (Wet) existing dam surface at new Footing	1,000.00 sf	20	985	-	131	-	-	1.12 /sf	1,116
Concrete Admixtures	287.23 cy		-	5,745	-	-	-	20.00 /cy	5,745
Wall Form Mat'l - Lumber 20' tall 1-Use	2,818.20 sf		-	22,546	-	-	-	8.00 /sf	22,546
-- Build and Erect Wall Forms - Lumber 20' tall 1-Use	2,818.20 sf	507	25,133	-	-	-	-	8.92 /sf	25,133
Wall Form Oil & Hardware	2,818.20 sf		-	3,664	-	-	-	1.30 /sf	3,664
Wall Rebar and Accessories/Unload & Store	21.50 ton	7	339	215	129	-	-	31.74 /ton	682
Wall Rebar	21.50 ton		-	21,500	-	-	-	1,000.00 /ton	21,500
-- Install Wall Rebar	21.50 ton	387	24,218	-	-	-	-	1,126.44 /ton	24,218
4500 psi Concrete	287.23 cy		-	30,159	-	-	-	105.00 /cy	30,159
4500 psi Concrete (Waste)	8.60 cy		-	903	-	-	-	105.00 /cy	903
Ice Chips, concrete cooling	287.23 cy		-	7,181	-	-	-	25.00 /cy	7,181

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2000.0100.03.01360 Concrete Wall, Center Pier									
Place Straight Wall, Pumped	287.23 cy	402	19,478	-	56	-	-	68.01 /cy	19,535
Float Finish / Strike-off top of Wall	75.00 sf	6	291	-	-	-	-	3.87 /sf	291
Straight Wall Concrete Pump- 170' Boom (52m)	287.23 cy		-	-	-	9,335	2,872	42.50 /cy	12,207
2000.0100.03.01360 Concrete Wall, Center Pier	**287.23 cy**	**1,449**	**78,018**	**91,912**	**11,787**	**9,335**	**2,872**	**675.15 /cy**	**193,924**
2000.0100.03.01370 Concrete Side Wall, Spillway Gate #1, North									
CRANE - RT - 45T (Max boom Length 105') w/ Operator	5.00 day	40	2,525	-	3,824	-	-	1,269.66 /day	6,348
Surface Blasting (Wet) existing dam surface at new wall	1,174.38 sf	23	1,156	-	154	-	-	1.12 /sf	1,310
Concrete Admixtures	130.54 cy		-	2,611	-	-	-	20.00 /cy	2,611
Rent Conc.. Wall Gang Forms > 16' tall	1,174.38 sf		-	9,395	-	-	-	8.00 /sf	9,395
-- Assemble and Erect Rented Wall Gang Forms > 16' tall	1,174.38 sf	294	14,546	-	-	-	-	12.39 /sf	14,546
Wall Form Oil & Hardware	1,174.38 sf		-	1,527	-	-	-	1.30 /sf	1,527
Wall Rebar and Accessories/Unload & Store	7.90 ton	3	124	79	47	-	-	31.74 /ton	251
Wall Rebar, dowels	7.90 ton		-	7,900	-	-	-	1,000.00 /ton	7,900
-- Install Wall Rebar	7.90 ton	142	8,899	-	-	-	-	1,126.44 /ton	8,899
4500 psi Concrete	130.54 cy		-	13,707	-	-	-	105.00 /cy	13,707
4500 psi Concrete (Waste)	4.00 cy		-	420	-	-	-	105.00 /cy	420
Ice Chips, concrete cooling	130.54 cy		-	3,264	-	-	-	25.00 /cy	3,264
Place Straight Wall, Pumped	130.54 cy	163	7,904	-	23	-	-	60.72 /cy	7,927
Float Finish / Strike-off top of Wall	75.00 sf	8	363	-	-	-	-	4.84 /sf	363
Straight Wall Concrete Pump- 170' Boom (52m)	130.54 cy		-	-	-	4,243	1,305	42.50 /cy	5,548
Point & Patch Wall	1,174.38 sf	23	1,137	12	-	-	-	0.98 /sf	1,149
2000.0100.03.01370 Concrete Side Wall, Spillway Gate #1, North	**130.54 cy**	**696**	**36,655**	**38,913**	**4,048**	**4,243**	**1,305**	**652.40 /cy**	**85,164**
2000.0100.03.01380 Concrete Side Wall, Spillway Gate #2, South									
CRANE - RT - 45T (Max boom Length 105') w/ Operator	5.00 day	40	2,525	-	3,824	-	-	1,269.66 /day	6,348
Surface Blasting (Wet) existing dam surface at new wall	975.03 sf	20	960	-	128	-	-	1.12 /sf	1,088
Concrete Admixtures	108.34 cy		-	2,167	-	-	-	20.00 /cy	2,167
Rent Conc.. Wall Gang Forms > 16' tall	975.03 sf		-	7,800	-	-	-	8.00 /sf	7,800
-- Assemble and Erect Rented Wall Gang Forms > 16' tall	975.03 sf	244	12,077	-	-	-	-	12.39 /sf	12,077
Wall Form Oil & Hardware	975.03 sf		-	1,268	-	-	-	1.30 /sf	1,268
Wall Rebar and Accessories/Unload & Store	7.90 ton	3	124	79	47	-	-	31.74 /ton	251
Wall Rebar, dowels	7.90 ton		-	7,900	-	-	-	1,000.00 /ton	7,900
-- Install Wall Rebar	7.90 ton	142	8,899	-	-	-	-	1,126.44 /ton	8,899
4500 psi Concrete	108.34 cy		-	11,376	-	-	-	105.00 /cy	11,376
4500 psi Concrete (Waste)	3.25 cy		-	341	-	-	-	105.00 /cy	341
Ice Chips, concrete cooling	108.34 cy		-	2,709	-	-	-	25.00 /cy	2,709
Place Straight Wall, Pumped	108.34 cy	135	6,560	-	19	-	-	60.72 /cy	6,579
Float Finish / Strike-off top of Wall	75.00 sf	8	363	-	-	-	-	4.84 /sf	363
Straight Wall Concrete Pump- 170' Boom (52m)	108.34 cy		-	-	-	3,521	1,083	42.50 /cy	4,604
Point & Patch Wall	975.03 sf	20	944	10	-	-	-	0.98 /sf	954
2000.0100.03.01380 Concrete Side Wall, Spillway Gate #2, South	**108.34 cy**	**610**	**32,452**	**33,649**	**4,018**	**3,521**	**1,083**	**689.71 /cy**	**74,723**
2000.0100.03.01400 Concrete, Fill Scour Hole Downstream of Spillway Apron									
CRANE - Crawler - 140T (Kobelco CK1600) w/ Operator	4.00 day	32	2,020	-	5,237	-	-	1,814.30 /day	7,257
Barge, sheet piles	4.00 day		-	-	4,000	-	-	1,000.00 /day	4,000
Dive Crew	4.00 days			-	-	10,000	-	2,500.00 /days	10,000
Place Mass Concrete, Crane & Bucket	100.00 cy	314	15,000	-	-	-	-	150.00 /cy	15,000
Mass Concrete Concrete Pump trailer - Schwing 260 on barge	100.00 cy		-	-	-	1,800	1,000	28.00 /cy	2,800
Mass Concrete Concrete Pumping- 180' Boom (52m)	100.00 cy		-	-	-	3,600	1,000	46.00 /cy	4,600
4500 psi Concrete - Tremie placed	100.00 cy		-	25,000	-	-	-	250.00 /cy	25,000
Tremie Pipe	1.00 ea		-	20,000	-	-	-	20,000.00 /ea	20,000
4500 psi Concrete (Waste)	20.00 cy		-	5,000	-	-	-	250.00 /cy	5,000
2000.0100.03.01400 Concrete, Fill Scour Hole Downstream of Spillway Apron	**100.00 cy**	**346**	**17,020**	**50,000**	**9,237**	**15,400**	**2,000**	**936.57 /cy**	**93,657**
03300 Cast-In-Place Concrete		**14,477**	**781,014**	**941,602**	**95,160**	**46,243**	**37,759**		**1,901,777**
05100 Structural Metal Framing									
2000.0200.05.01001 Pedestrian Bridge, Steel, Galvanized									
CRANE - Crawler - 140T (Kobelco CK1600) w/ Operator	14.00 day	112	7,069	-	18,331	-	-	1,814.30 /day	25,400
Misc. Steel Angle - L 3-1/2 x 3-1/2 x 1/4 .45 tn	184.00 lf		-	2,134	-	-	-	11.60 /lf	2,134
Misc. Steel Angle - L 4 x 4 x 1/4 .02 tn	54.00 lf		-	713	-	-	-	13.20 /lf	713
-- Erect Misc. Steel Angle - L 3-1/2 x 3-1/2 x 1/4 .45 tn	184.00 lf	83	5,199	-	-	-	-	28.26 /lf	5,199
-- Erect Misc. Steel Angle - L 4 x 4 x 1/4 .02 tn	54.00 lf	24	1,526	-	-	-	-	28.26 /lf	1,526
W 8x24 Beam .32 tn	27.00 lf		-	1,944	-	-	-	72.00 /lf	1,944
W 10x26 Beam .13 tn	10.00 lf		-	780	-	-	-	78.00 /lf	780
W 21x44 Beam 1.06 tn	48.00 lf		-	6,336	-	-	-	132.00 /lf	6,336
W 30x99 Beam 16.63 tn	168.00 lf		-	49,896	-	-	-	297.00 /lf	49,896
-- Erect W 8x24 Beam .32 tn	27.00 lf	14	848	-	-	-	-	31.40 /lf	848
-- Erect W 10x26 Beam .13 tn	10.00 lf	8	471	-	-	-	-	47.09 /lf	471

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Spreadsheet Level	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Equip Amount	Sub Amount	Other Amount	Total Cost/Unit	Total Amount
2000.0200.05.01001 Pedestrian Bridge, Steel, Galvanized									
-- Erect W 21x44 Beam 1.06 tn	48.00 lf	36	2,261	-	-	-	-	47.09 /lf	2,261
-- Erect W 30x99 Beam 16.63 tn	168.00 lf	83	5,222	-	-	-	-	31.08 /lf	5,222
C 8x11.5 Channel Beam .02 tn	3.67 lf		-	127	-	-	-	34.50 /lf	127
C 12x20.7 Channel Beam .04 tn	3.67 lf		-	228	-	-	-	62.10 /lf	228
-- Erect C 8x11.5 Channel Beam .02 tn	3.67 lf	9	576	-	-	-	-	156.98 /lf	576
-- Erect C 12x20.7 Channel Beam .04	3.67 lf	9	576	-	-	-	-	156.98 /lf	576
Galv. Steel Stairs 4' wide x 8" C-Channel w/Grating Step, Light Duty	56.00 trd		-	12,264	-	-	-	219.00 /trd	12,264
-- Erect Galv. Stl Stairs 4' wide x 8" C-Channel w/Grating Step, Light Duty	56.00 trd	140	8,791	-	-	-	-	156.98 /trd	8,791
Straight Ladder - Steel, Galvanized, 2 ea	38.00 lf		-	2,166	-	-	-	57.00 /lf	2,166
-- Erect Straight Ladder w/o Cage	38.00 lf	30	1,909	-	-	-	-	50.23 /lf	1,909
3 Rail-Handrail Steel w/Toe	438.00 lf		-	21,900	-	-	-	50.00 /lf	21,900
3 Rail-Handrail Steel - Sloped	123.00 lf		-	6,765	-	-	-	55.00 /lf	6,765
-- Erect 3 Rail-Handrail Steel w/Toe	438.00 lf	175	11,001	-	-	-	-	25.12 /lf	11,001
-- Erect 3 Rail-Handrail Steel - Sloped	123.00 lf	55	3,476	-	-	-	-	28.26 /lf	3,476
Galvanized Steel Grate - Welded - 1-1/4 x 3/16	858.00 sf		-	23,423	-	-	-	27.30 /sf	23,423
-- Install Galvanized Steel Grating	858.00 sf	172	10,775	-	-	-	-	12.56 /sf	10,775
2000.0200.05.01001 Pedestrian Bridge, Steel, Galvanized	**200.00 lf**	**950**	**59,699**	**128,676**	**18,331**			**1,033.53 /lf**	**206,706**
2000.0200.05.01010 Monorail Beams & Columns, Galvanized									
CRANE - Crawler - 140T (Kobelco CK1600) w/ Operator	3.00 day	24	1,515	-	3,928	-	-	1,814.30 /day	5,443
W 36x135 Beam 11.48 tn	170.00 lf		-	68,850	-	-	-	405.00 /lf	68,850
-- Erect W 36x135 Beam 11.48 tn	170.00 lf	60	3,736	-	-	-	-	21.98 /lf	3,736
W 18x50 Columns, anchor bolts 1.95 tn	78.00 lf		-	11,700	-	-	-	150.00 /lf	11,700
-- Erect W 18x50 Columns, 3 ea 1.95 tn	78.00 lf	59	3,673	-	-	-	-	47.09 /lf	3,673
2000.0200.05.01010 Monorail Beams & Columns, Galvanized	**170.00 lf**	**142**	**8,924**	**80,550**	**3,928**			**549.43 /lf**	**93,402**
2000.0200.05.01020 Maintenance Cofferdam, Beams, Columns, Plate, Material Only, Galv.									
W 10x12 Beam 6.51 tn	1,085.00 lf		-	39,060	-	-	-	36.00 /lf	39,060
W 14x43 Column 9.68 tn	450.00 lf		-	58,050	-	-	-	129.00 /lf	58,050
1/2in - A36 - Steel Plate - 30.78 tn	2,868.00 sf		-	175,694	-	-	-	61.26 /sf	175,694
2000.0200.05.01020 Maintenance Cofferdam, Beams, Columns, Plate, Material Only, Galv.	**2,868.00 sf**			**272,804**				**95.12 /sf**	**272,804**
05100 Structural Metal Framing		**1,092**	**68,623**	**482,030**	**22,259**				**572,912**
11280 Hydraulic Gates and Valves									
2000.1200.11.01001 Spillway Crest Gate #1, Hydraulic actuated, 79' x 14'									
Freight & Shipping Insurance	1.00 ea		-	-	-	10,000	-	10,000.00 /ea	10,000
Adhesive Anchor Rod w/Epoxy 316 SS - 1/2" x 8"	176.00 ea		-	2,640	-	-	-	15.00 /ea	2,640
MIsc Consumables	1.00 ea		-	1,000	-	-	-	1,000.00 /ea	1,000
-- Drill and Set Epoxy Anchors	176.00 ea	176	10,229	-	-	-	-	58.12 /ea	10,229
-- Hoisting Equipment - Crawler Crane 200 tn	15.00 day	120	7,574	-	11,471	-	-	1,269.66 /day	19,045
Spillway Crest Gate #1, 2 hydraulic cylinders, 1 HPU	1.00 ea		-	1,650,000	-	-	-	1,650,000.00 /ea	1,650,000
-- Receiving & Storage of Equipment	1.00 ea	16	942	-	-	-	-	941.58 /ea	942
-- Align & Set Spillway Crest Gate, 4 sections, 20' x 14'	4.00 ea	320	18,599	-	-	-	-	4,649.76 /ea	18,599
-- Install hydraulic cylinders	2.00 ea	64	3,720	-	-	-	-	1,859.91 /ea	3,720
-- Install SS Side Seal Plates	2.00 ea	64	3,720	-	-	-	-	1,859.91 /ea	3,720
-- Install hydraulic cylinder brackets	2.00 ea	40	2,325	-	-	-	-	1,162.44 /ea	2,325
-- Install Spillway gate hinge brackets	20.00 ea	400	23,249	-	-	-	-	1,162.44 /ea	23,249
2000.1200.11.01001 Spillway Crest Gate #1, Hydraulic actuated, 79' x 14'	**1.00 ea**	**1,200**	**70,357**	**1,653,640**	**11,471**	**10,000**		**1,745,468.23 /ea**	**1,745,468**
2000.1200.11.01100 Spillway Crest Gate #2, Hydraulic actuated, 79' x 14'									
Freight & Shipping Insurance	1.00 ea		-	-	-	10,000	-	10,000.00 /ea	10,000
Adhesive Anchor Rod w/Epoxy 316 SS - 1/2" x 8"	176.00 ea		-	2,640	-	-	-	15.00 /ea	2,640
MIsc Consumables	1.00 ea		-	1,000	-	-	-	1,000.00 /ea	1,000
-- Drill and Set Epoxy Anchors	176.00 ea	176	10,229	-	-	-	-	58.12 /ea	10,229
-- Hoisting Equipment - Crawler Crane 200 tn	15.00 day	120	7,574	-	11,471	-	-	1,269.66 /day	19,045
Spillway Crest Gate #1, 2 hydraulic cylinders, 1 HPU	1.00 ea		-	1,650,000	-	-	-	1,650,000.00 /ea	1,650,000
-- Receiving & Storage of Equipment	1.00 ea	16	942	-	-	-	-	941.58 /ea	942
-- Align & Set Spillway Crest Gate, 4 sections, 20' x 14'	4.00 ea	320	18,599	-	-	-	-	4,649.76 /ea	18,599
-- Install hydraulic cylinders	2.00 ea	64	3,720	-	-	-	-	1,859.91 /ea	3,720
-- Install SS Side Seal Plates	2.00 ea	64	3,720	-	-	-	-	1,859.91 /ea	3,720
-- Install hydraulic cylinder brackets	2.00 ea	40	2,325	-	-	-	-	1,162.44 /ea	2,325
-- Install Spillway gate hinge brackets	20.00 ea	400	23,249	-	-	-	-	1,162.44 /ea	23,249
2000.1200.11.01100 Spillway Crest Gate #2, Hydraulic actuated, 79' x 14'	**1.00 ea**	**1,200**	**70,357**	**1,653,640**	**11,471**	**10,000**		**1,745,468.23 /ea**	**1,745,468**
2000.1200.11.01200 Install - Hydraulic Power Unit Skid, 3,000 lb									
-- Install Hydraulic Power Unit skid (HPU) 3,000 lbs	1.00 ea	30	1,744	-	-	-	-	1,743.66 /ea	1,744
2000.1200.11.01200 Install - Hydraulic Power Unit Skid, 3,000 lb	**1.00 ea**	**30**	**1,744**					**1,743.66 /ea**	**1,744**
11280 Hydraulic Gates and Valves		**2,430**	**142,459**	**3,307,280**	**22,942**	**20,000**			**3,492,680**
13700 Video Surveillance									

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Spreadsheet Level	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Equip Amount	Sub Amount	Other Amount	Total Cost/Unit	Total Amount
1120.1200.13.01001 Video Surveillance									
Video Surveillance	1.00 lot				-	25,000	-	25,000.00 /lot	25,000
1120.1200.13.01001 Video Surveillance	1.00 lot					25,000		25,000.00 /lot	25,000
13700 Video Surveillance						25,000			25,000
14600 Hoists and Cranes									
2000.0200.14.01001 Monorail, 2 ton									
--Install Monorail - 2 ton	1.00 ea	20	1,162		-	-	-	1,162.44 /ea	1,162
Monorail - 2 ton	1.00 ea			3,500	-	-	-	3,500.00 /ea	3,500
2000.0200.14.01001 Monorail, 2 ton	1.00 ea	20	1,162	3,500				4,662.44 /ea	4,662
14600 Hoists and Cranes		20	1,162	3,500					4,662
15200 Process Piping									
1120.1500.15.01001 Steel Pipe, Hydraulic, From HPU to Cylinders									
WELDER - Miller 500, 2164 lb, Diesel	180.00 hr		-	-	1,816	-	-	10.09 /hr	1,816
A53 steel pipe, continuous weld, std., BW, Unlined, 1" - Hydraulic pipe to cylinders	450.00 lf		-	2,267	-	-	-	5.04 /lf	2,267
-- Install A53 steel pipe, continuous weld, std., BW, 1"	450.00 lf	180	12,062	-	-	-	-	26.81 /lf	12,062
1120.1500.15.01001 Steel Pipe, Hydraulic, From HPU to Cylinders	450.00 lf	180	12,062	2,267	1,816			35.88 /lf	16,145
15200 Process Piping		180	12,062	2,267	1,816			/LF	16,145
16200 Electrical Power									
1120.1500.16.01001 Electrical Power									
Transformer, dry-type, 3 phase 2400 V primary 480 volt secondary, 300 kVA	1.00 ea		-	26,400	-	-	-	26,400.00 /ea	26,400
-- Install Transformer, dry-type, 3 phase 2400 V primary 480 volt secondary, 300 kVA	1.00 ea	44	2,281	-	-	-	-	2,280.87 /ea	2,281
Fused Cutout Switch 2400 V	1.00 ea			5,000	-	-	-	5,000.00 /ea	5,000
-- Install Fused Cutout Switch 2400 V	1.00 ea	10	513		-	-	-	513.20 /ea	513
Panelboards, 3 phase 3 wire, main circuit breaker, 480 V, 225 amp	1.00 ea		-	5,000	-	-	-	5,000.00 /ea	5,000
-- Install panelboard, 3 phase 3 wire, main circuit breaker, 480 V, 225 amp	1.00 ea	20	1,026	-	-	-	-	1,026.40 /ea	1,026
1120.1500.16.01001 Electrical Power	1.00 lot	74	3,820	36,400				40,220.47 /lot	40,220
1120.1500.16.01010 Propane Standby Generator, 150 kW									
Standby Generator Set, Low Voltage, Propane, 150KW, 3-Phase, 4-Wire, 480V, 60HZ	1.00 ea		-	0	-	80,000	-	80,000.00 /ea	80,000
1120.1500.16.01010 Propane Standby Generator, 150 kW	1.00 ea					80,000		80,000.00 /ea	80,000
16200 Electrical Power		74	3,820	36,400		80,000			120,220
17430 Controls									
1120.1500.17.01001 SCADA, PLC Controls									
SCADA - PLC Panel, instruments	1.00 lot				-	50,000	-	50,000.00 /lot	50,000
1120.1500.17.01001 SCADA, PLC Controls	1.00 lot					50,000		50,000.00 /lot	50,000
17430 Controls						50,000			50,000
01 H-5 Lake Wood		**24,454**	**1,280,149**	**5,469,625**	**746,772**	**225,183**	**38,559**		**7,760,287**

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Estimate Totals

Description	Amount	Totals	Hours	Rate
Labor	1,280,149		24,454	
Material	5,469,625			
Subcontract	225,183			
Equipment	746,772		7,206	
Other	38,559			
TOTAL DIRECT COST	7,760,288	7,760,288		
SUBCONTRACTOR MARK-UP'S				
Subcontractor-GCs	105,670			8.000 %
Subcontactor-OH	79,252			6.000 %
Subcontractor-Fee	79,252			6.000 %
Subcontractor-Bond/Insurance	33,022			2.500 %
GRAND TOTAL DIRECT COST	297,196	8,107,484		
RISK ASSESSMENT MARK-UP's				
Construction Contingency	2,026,871			25.000 %
Escalation to Mid Point	486,449			6.000 %
TOTAL INCLUDING RISK	2,513,320	10,620,804		
GENERAL REQUIREMENTS				
General Conditions Management	584,144			5.500 %
General Conditions Subsistance	212,416			2.000 %
General Conditions Temp Fac	106,208			1.000 %
General Conditions Equipment	53,104			0.500 %
General Conditions Start-up				
General Conditions Permits	53,104			0.500 %
Sales Tax	516,034			8.250 %
TOTAL INCLUDING GC'S	1,525,010	12,145,814		
CONTRACTOR FEE				
G&A	485,833			4.000 %
Profit	1,113,362			8.000 %
TOTAL INCLUDING FEE	1,599,195	13,745,009		
INSURANCES & BOND				
Builders All Risk Insurance	43,984			0.320 %
General Libility Insurance	27,834			0.200 %
P&P Bond	100,203			0.720 %
TOTAL CONSTRUCTION COST	172,021	13,917,030		
Total		***13,917,030***		