US Army Corps of Engineers®
Portland District

DESIGN DOCUMENTATION REPORT NO.

DETROIT DAM
LINN COUNTY, OREGON
CONTRACT NO. W9127N-17-C-0032

DETROIT FLOATING SCREEN STRUCTURE

Prepared by:

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To be Included in the 60% DDR.

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PERTINENT PROJECT DATA

PERTINENT PROJECT DATA Detroit Dam Floating Screen Structure	
GENERAL POWERHOUSE	
Location	North Santiam River, Detroit Oregon
County and State	Linn County, Oregon
Number of Units	Two
Generation Capacity	50 MW Francis turbines, (4,300-5,300 cfs combined hydraulic capacity). Cavitation limit is between 1,100-1,000 cfs per unit within normal pool operations range.
Spillway Gates	Six radial Tainter gates (176,000 cfs combined hydraulic capacity)
River Mile	60.9 (from Santiam mouth)
Drainage Area (square miles)	438
Dam Height (feet)	450
Construction Completed	1953
DETROIT DAM AND RESERVOIR KEY ELEVATIONS	
Dam Crest [elevation feet mean sea level (MSL)]	1,579.0
Maximum Pool	1,574.0 feet (472,600 acre-feet)
Full Pool	1,569.0 feet (455,100 acre-feet)
Maximum Conservation Pool	1,563.5 feet (436,000 acre-feet)
Spillway Crest	1,541.0 feet (363,200 acre-feet)
Minimum Conservation Pool	1,450.0 feet (154,400 acre-feet)
Minimum Power Pool	1,425.0 feet (115,000 acre-feet)
Penstock Intake Elevation	1,403.0 feet
Upper Regulating Outlets	Two at elevation 1340 feet (13,050 cfs combined capacity)
Test Flume Conduit	One at elevation 1340 feet (same dimensions as Upper Regulating Outlet, not currently used)
Lower Regulating Outlets	Two at elevation 1265 feet that are not used

ABBREVIATIONS AND ACRONYMS

ASD	Allowed Strength Design
ABS	American Bureau of Shipping
AISC	American Institute of Steel Construction
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Material
AWS	American Welding Society
cf	Cubic Feet
CFD	Computational Fluid Dynamics
CFS	cubic feet per second
DDR	Design Documentation Report
DISPL	Displacement
EDR	Engineering Design Report
F	Fahrenheit
FFC	Floating Fish Collector
FHF	Fish Handling Facilities
fps	Feet per Second
FSC	Floating Surface Collector
FSS	Floating Screen Structure
ft	Feet
GHS	General Hydrostatics
GM	Metacentric Height
GMr	Required Metacentric Height
gpm	Gallons per Minute
h	hydraulic head
IBC	International Building Code
ICC	International Code Council
in	Inches

kips	thousands of pounds
L	Length Overall
lb(s)	Pound(s)
LCG	Longitudinal Center of Gravity
mm	Millimeters
mph	Miles per hour
MW	Megawatts
NMFS	National Marine Fisheries Service
OSSC	Oregon Structural Specialty Code
PLC	Programmable Logic Controller
psf	pounds per square foot
sec	Second
SNAME	Society of Naval Architects and Marine Engineers
SWBS	Ship Work Breakdown Structure
SWS	Selective Withdrawal Structure
TBD	To Be Determined
TCG	Transverse Center of Gravity
TDH	Total Dynamic Head
temp	Temperature
TLI	Tank Level Indicator
UFC	Unified Facilities Criteria
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
VCG	Vertical Center of Gravity
VFD	Variable Frequency Drive
WSEL	Water Surface Elevation

1 PURPOSE AND INTRODUCTION

1.1 Scope and Purpose

This Design Documentation Report (DDR) presents the technical details of the main features of the proposed Floating Screen Structure (FSS) at Detroit Dam. The purpose of the proposed project is to provide a downstream juvenile fish passage facility that meets National Marine Fisheries Service (NMFS) criteria for Endangered Species Act (ESA) listed fish and provides a safe working environment for the operators. The parameters used to establish the design criteria for the FSS and system to transport collected fish pertain specifically to juvenile Spring Chinook salmon and downstream migratory winter steelhead. However, the facility will be designed to capture and sort other fish species.

1.2 General Description

1.2.1 Location

The North Santiam subbasin drains about 760 square miles. Detroit and Big Cliff dams on the North Santiam River are two of the 13 multi-purpose projects operated by the U.S. Army Corps of Engineers (USACE) in the Willamette Valley in Oregon. Located in Marion County in the rugged mountain forests below Mt. Jefferson, the two dams store the waters of the North Santiam River. Detroit and Big Cliff dams were both constructed without adult fish ladders, or facilities for safely passing downstream migrants. The Minto Fish Collection Facility is located downstream of Big Cliff Dam and is used to trap upstream migrating adults and transport them to the hatchery located upstream of Detroit Dam, and to release locations in the reservoirs and tributaries upstream. The facility was recently rebuilt and construction was completed in March 2013.

Detroit Dam is located at river mile 60.9 on the North Santiam River, approximately 50 miles southeast of Salem, Oregon. Big Cliff is a re-regulating dam located at river mile 58.1 about 3 miles downstream from Detroit Dam. Big Cliff Lake is a small reservoir that is used to even out peak discharges of water used for power generation at Detroit Dam and thus control downstream river level fluctuations. The Minto adult fish collection facility is located on the north bank of the North Santiam River at RM 55, about 4 miles downstream of Big Cliff Reregulating Dam and 7 miles downstream of Detroit Dam.

Detroit Dam is a 450-foot-high, 1,457-foot-long concrete gravity structure. The dam has a gated spillway which is 294.5 feet long, with 6 spill bays, each 42 feet wide and 28.0 feet high. The spillway crest is at elevation 1,541.0 feet, full pool is elevation 1,569.0 feet, and minimum conservation pool is elevation 1,450.0 feet. Detroit Dam also has four regulating outlets (ROs), two with an invert elevation of 1265.3 feet, two at elevation 1340.0 feet, and two turbines with penstock intake elevation at 1403 feet.

1.2.2 Project Authorization

The construction of the Detroit Dam and Reservoir, North Santiam River, Oregon, was authorized by the Flood Control Act approved June 28, 1938 (Public Law 761, House Resolution No. 10,618). The law approved the general comprehensive plan for flood control, navigation, and other purposes in the Willamette River Basin as set forth in House Document Numbered 544, Seventh-fifth Congress, Third session. The Flood Control Act approved June 30, 1948 (Public Law No. 858, Eightieth Congress, Second Session) modified the Flood Control Act of June 28, 1938, to provide for the installation of hydroelectric power-generating facilities at Detroit Dam, and included the construction of Big Cliff Reregulating Dam and Reservoir as a part of the Detroit project, in accordance with plans on file in the Office, Chief of Engineers.

As authorized by law, the USACE is responsible for the construction and operation of the project for its primary purposes, which included flood control, navigation, consumptive water use, and power production; and in carrying out these functions has basic jurisdiction over all project areas including withdrawn National Forest lands. The use or utilization of withdrawn National Forest lands for purposes extraneous to project operation remains under the jurisdiction of the U.S. Forest Service. In order to facilitate the management and control of project resources and to eliminate the overlapping of administrative responsibilities, the operational area at Detroit Dam and the Big Cliff project lands lying outside the National Forest boundary will remain under the exclusive control of the USACE. The responsibility for administering all other project lands within the National Forest boundary for recreation, fire protection, and land management is vested with the U.S. Forest Service in accordance with a Memorandum of Understanding between the U.S. Department of Agriculture and the U.S. Department of Army, effective November 10, 1954.

The Detroit project is a major unit of the comprehensive plan for the coordinated development and utilization of the water resources in the Willamette River Basin. The principal functions of the project are to provide flood control, navigation, irrigation, power, domestic water supply, pollution abatement, and related benefits.

1.3 Project Specific References

Reports and Studies used in the Design Documentation Report:

- Detroit and Big Cliff Long Term Temperature Control and Downstream Fish Passage Final Engineering and Documentation Report, USACE, July 2017.
- Detroit Temperature Control 30% DDR, USACE, March 2017.

1.4 Proposed Floating Screen Structure

The FSS is a floating structure that will operate in conjunction with the selective withdrawal structure (SWS) that is currently being designed to control the water temperatures downstream of Detroit Dam. The FSS will provide for screening of the surface inflow to the SWS with the goal of collecting downstream migrating fish for safe passage to the river downstream of the Minto facility. The fish will be captured and directed to a fish sorting and collection facility within the FSS. Once the fish are sorted they will be lifted via a tank or hopper to a fish transfer truck and transported downstream.

1.5 Agency Coordination

The design is being fully coordinated with NMFS, the Oregon Department of Fish and Wildlife (ODFW), Native American tribal representatives, and the Oregon Department of Environmental Quality. Coordination with other agencies will be conducted as necessary.

1.6 Environmental Compliance

Compliance with various federal, state and local environmental regulations, such as the Clean Water Act and Endangered Species Act, are addressed in Section 8 of this DDR.

2 BIOLOGICAL DESIGN CONSIDERATIONS AND CRITERIA

2.1 General

The Biological Design Considerations and Criteria for the Detroit FSS were based on relevant USACE and National Marine Fisheries Service (NMFS) documents. References to sources of information in the following tables and text include:

- NMFS 2011: Anadromous Salmonid Passage Facility Design, National Marine Fisheries Service Northwest Region, July 2011.
- Bell 1991: Fisheries Handbook of Engineering Requirements and Biological Criteria, USACE North Pacific Division, 1991.
- EDR: Willamette Biological Opinion Engineering Documentation Report – Detroit and Big Cliff Long-Term Temperature Control and Downstream Fish Passage – North Santiam River, 90% Engineering Document Report, USACE, February 2017.
- Piper 1982: Fish Hatchery Management. U.S. Department of the Interior Fish and Wildlife Service. Piper et al. 1982.
- Senn 1984: Compendium of Low-Cost Pacific Salmon and Steelhead Trout Production Facilities and Practices in the Pacific Northwest, Senn, 1984.
- USACE: USACE Water Temperature Data for Detroit Dan and Reservoir (2011 to 2017), on line at: http://www.nwd-wc.usace.army.mil/ftppub/water_quality/tempstrings/#DET_S1.

2.2 Biological Criteria

The following tables are a compilation of the fisheries design criteria to which the FSS facilities have been designed.

Table 2-1 - Screen Facility Criteria

Criteria	Design Value	Source	Notes
Maximum Screen Approach Velocity	0.4 fps	NMFS 2011 11.6.1.1	Average velocity for active screens (with automated cleaners)
Uniform Approach Velocity	0.4 fps +10%	NMFS 2011 11.6.1.4 & 15.2	Baffles to ensure even distribution with max point velocity below criterion
Minimum Sweeping Velocity	Greater than screen approach velocity	NMFS 2011 11.6.1.5	
Maximum Rate of Velocity Increase	0.2 fps/ft	NMFS 2011 11.9.1.8	Also, do not decelerate velocity upstream of capture

Criteria	Design Value	Source	Notes
Maximum Screen Exposure Time	60 seconds	NMFS 2011 11.9.1.2	Assume fish are moving at the sweeping flow velocity
Maximum Slotted Screen Opening Size	1.75 mm	NMFS 2011 11.7.1.2	
Minimum Perforated Plate Hole Size	3/32-inch Diameter	NMFS 2011 11.7.1.1	Square openings 3/32-inch on each side also allowed
Screen Material	Corrosion Resistant	NMFS 2011 11.7.1.4	Sufficiently durable to maintain smooth surface
Minimum Open Area	27%	NMFS 2011 11.7.1.6	
Screen Cleaning	Automatic Screen Cleaning	NMFS 2011 11.10.1.2	Required for active screen design criteria
Trashrack Bar Spacing	8 inches clear	NMFS 2011 4.8.2.5	Fish ladder exit rack for adult fish
Maximum Trashrack Velocity	4 fps	USACE	Based on experience at Bonneville intakes
Capture Velocity	8 – 12 fps	EDR 9.1.3	Velocity required to commit target fish to facility

Table 2-2 - Fish Sorting, Holding, and Transfer Facility

Criteria	Design Value	Source	Notes
Maximum Fish Holding Timing	24 hours	NMFS 2011 6.3.1.4	Fish must be removed from trap at least daily
Minimum Flume Width	15 inches	NMFS 2011 6.4.1.4	For flumes where adults may be present
Minimum Flume Curvature Radius	5 times width	NMFS 2011 6.4.1.4	
Flume Conditions	Smooth joints and sides	NMFS 2011 6.4.1.4	No sharp edges or abrupt rises or turns
Holding Tank Volume (density) Adult size fish	0.25 cf/lb (4 lb/cf)	NMFS 2011 6.5.1.2	For holding less than 24 hours in 50-degree F water, increase 5% for each degree above 50 degrees
Holding Tank Volume (density) Smolt size fish	0.25 cf/lb (4 lb/cf)	Senn 1984	Half Senn's volume for rearing (intended for long term holding) assuming FSS holding limited to 24 hours

Criteria	Design Value	Source	Notes
Holding Tank Volume (density) Fry size fish	0.3125 cf/lb (3.2 lb/cf)	Senn 1984	Half Senn's volume for rearing (intended for long term holding) assuming FSS holding limited to 24 hours
Maximum Operating Water Temperature	70 degrees F	USACE	Maximum surface (35 ft depth) temperature in August (not peak run time)
Maximum Design Water Temperature	58 degrees F	USACE	Maximum surface (35 ft depth) temperature during peak outmigration time. See Section 2.1.2.2 below
Tank Circulation Flow Adult size fish	0.67 gpm/adult fish	NMFS 2011 6.5.1.3	For holding less than 24 hours in 50-degree F water, and DO between 6 to 7%
Tank Circulation Flow Smolt size fish	0.14 gpm/lb (7.2 lbs/gpm)	Senn 1984 Bell, Page 19.9	Senn's rearing criteria for long term rearing (based on assumed 58°F water temp). Increase gpm/lb 3.5% per degree above 58 degrees (Bell)
Tank Circulation Flow Fry size fish	0.133 gpm/lb (7.5 lbs/gpm)	Senn 1984 Bell, Page 19.9	Senn's rearing criteria for long term rearing (based on assumed 58°F water temp). Increase gpm/lb 3.5% per degree above 58 degrees (Bell)
Max. Transport Truck Density	0.15 cf/lb (6.7 lb/cf)	NMFS 2011 6.7.2.1	Will also be used for short-term transfer tank (hopper) if operating plan is to hold in hopper less than one hour
Tank Freeboard - Adults	5 feet	NMFS 2011 6.5.1.4	To minimize jumping; alternatively use sprinklers, cover, or nets
Max. Crowder Panel Bar Spacing - Adult	7/8-inch clear between bars	NMFS 2011 6.5.1.7	
Max. Crowder Panel Bar Spacing - Juveniles	1.75 mm	NMFS 2011 11.7.1.2	Screen criteria

Table 2-3 - Fish Species Criteria

Criteria	Design Value	Source	Notes
Spring Chinook Salmon – ESA Listed Species			
Peak Annual Run	TBD	USACE	

Criteria	Design Value	Source	Notes
Peak Daily Run	TBD	USACE	Bio. Criteria, 07-16-2014
Average Adult Weight	15 lb	Bell 1991 Page 5.2	
Average Smolt Weight	10 fish/lb	Bell 1991 Page 30.2	Assumes average smolt length of 6 inches
Timing	TBD		
Winter Steelhead Trout – ESA Listed Species			
Peak Annual Run	TBD	USACE	Bio. Criteria, 07-16-2014
Peak Daily Run	TBD	USACE	Bio. Criteria, 07-16-2014
Average Adult (Kelt) Weight	8 lbs	Bell 1991 Page 5.8	
Average Smolt Weight	5 fish/lb	Bell 1991 Page 30.2	Assumes average smolt length of 8 inches
Timing	TBD		

2.3 Biological Considerations

The following are biological and operational considerations used in the design of the fisheries related components of the FSS, in coordination with the design criteria listed above.

2.3.1 FSS Design Operations

The Detroit powerhouse includes two turbine units each rated at 50 MW. The project is operated as a peaking project, with either one unit operating at 50 MW or both units operating with a total generation of 100 MW. During off-peak hours, when demand is low, the Detroit powerhouse is generally not operating, with no flow passing Detroit Dam. During these periods, The Big Cliff Dam downstream provides reregulation for the river flow downstream.

The Detroit Reservoir is also operated as a flood control project, with the water level varying significantly throughout the year. The minimum conservation pool level is 1450 feet, with an emergency extreme low level of 1425 feet. The maximum conservation pool level is 1563.5 feet, with an emergency extreme high level of 1574 feet. The FSS will be designed to operate over a range of reservoir levels from 1445.0 (5 feet below the minimum conservation pool level) to 1569.0 (5.5 feet above the maximum conservation pool level). The FSS will also be designed to allow for full reservoir level fluctuation from 1425.0 to 1574.0 without damage to the FSS; however, this may require de-ballasting the FSS and raising it mostly out of the water during the extreme low reservoir level events.

The powerhouse flow to achieve 100 MW is a function of the reservoir level and the total head on the turbines. When the reservoir is at the minimum pool level, and the resulting turbine head is minimized, the required flow can be as high as approximately 5,600 cfs. This condition would typically be limited to the winter months of December and January. After that, refilling of the pool would begin. At maximum pool level conditions, when the resulting turbine head is highest, the required turbine flow can be as low as approximately 3,900 cfs.

The FSS will operate in conjunction with the Selective Withdrawal Structure (SWS), designed to combine warmer surface-flow withdrawals with colder deep low-level withdrawals to meet downstream temperature requirements. Surface withdrawals would pass through the FSS screens. This operation will require most or all flow from the surface during the spring months from March to May. At other times of the year some smaller percentage of the total flow would pass through the FSS. In the fall months from September through December the majority of the flow would be through the low-level withdrawals.

The USACE produced a memorandum Detroit FSS: Recommended Design Flow Rates (dated 8/4/2107, revised 9/18/2017), summarizing historic monthly project operations and concluding that the FSS flow will be below 4,500 cfs over 95% of the time. A copy of the memorandum is included in Appendix A. Based on this USACE analysis the design maximum flow rate for design of the FSS screen system is 4,500 cfs. Rare operation above this flow rate may result in average screen approach velocities slightly above the design criterion.

2.3.2 Water Temperature

Water temperature impacts the design density of fish being held in holding tanks on the FSS. The inflow to the FSS is the warmer surface water over the upper 35 feet of the reservoir depth. For temperatures above 50 degrees F the allowable density in the holding tanks needs to be reduced to meet the NMFS design criteria. The tanks need to be sized to handle the maximum estimated number of fish expected to arrive at the facility between off-loading transfer events. Therefore, the temperature that is significant from the standpoint of design is the maximum estimated temperature during the peak outmigration period, which is anticipated to be the spring Chinook outmigration during the months of March to May. Therefore, the peak design temperature is the maximum temperature anticipated during those months (not necessarily the peak temperature during the entire year, which typically occurs in August). The maximum daily average surface water temperature during the month of May (based on 4 years of data from 2014 through 2017) is approximately 58 degrees F. There will also be a fall run of Steelhead smolt from October to December; however, it is not anticipated that this run would be as large as the Chinook run in the spring. The maximum daily average surface water temperature in early October is approximately 64 degrees.

2.3.3 Transport Truck Operations

At a minimum, fish held in the Fish Handling Facilities (FHF) will be off-loaded to the transport trucks at least once every 24 hours. This is to ensure that fish are held for less than one day. However, the design assumes that during peak migration days off-loading to transport trucks will occur more often, so the holding tanks in the FHF do not necessarily need to be able to hold an entire peak day run at one time.

3 NAVAL ARCHITECTURE

3.1 General

The Detroit Reservoir Floating Screen Structure (FSS) is a barge-like floating structure 304 feet long overall by 101.5 feet wide by 48 feet deep. It is composed of four functional sections.

1) Belly tanks: Belly tanks, 264 feet long by 101.5 feet wide by 8 feet deep, are located at the lowest level. This section is divided longitudinally and transversely into approximately 15 ballast tanks. A void extending the full width of the belly tanks is retained near midships to house a pump room along with access tunnels from the port and starboard which lead to stairwells housed in the flotation cells.

2) Flotation cells: Spanning from the top of the belly tanks to the main deck are four flotation cells. One on the forward centerline of the structure, one bordering the length of the fish attraction channel to port, one bordering the length of the fish attraction channel to starboard, and one along the aft end of the fish attraction channels. The flotation cells are divided into ballast tanks, trim tanks, and house access trunks for the pump room. The port flotation cell has a section removed in way of the discharge openings adjacent to the SWS intakes. Here, the flotation cell extends from the main deck down 21.00 feet to the top of the opening.

3) Main structure: The main structure is made up of port and starboard fish attraction channels and their supporting equipment, decks, and deck equipment. Each attraction channel includes an ogee inlet weir at the bow, an entrance channel with ramp section and expansion channel, Trashrack, primary screen channel, and secondary screen channel. Screened flow from the primary and secondary screen channels discharges into the screened flow plenum. Flow to either attraction channel can be closed off utilizing the inlet weir at the entrance.

4) Sorting area: A sorting area, 40 feet long by 101.5 feet wide by 21 feet deep, is located at the aft end of the structure. The sorting area houses the facilities at the termination of the attraction channels which facilitate the fish being processed and loaded into tanks for transporting off of the FSS.

3.2 Arrangement and Compartmentation

To be included in the 60% DDR.

3.3 Weight Estimate

The weight, location, and longitudinal extent of all structure, screens, mechanical and electrical equipment, furnishings, and outfit items of the FSS are estimated to determine FSS lightweight characteristics. Each weight item is categorized in accordance with the U.S. Navy's Ship Work Breakdown Structure (SWBS). For this project SWBS Group 200, "Propulsion Plant," is not needed. SWBS Group 700, renamed "Special Purpose Systems," is used for items associated with fish capture, sorting, and handling. This includes weirs, screens, trash racks, and the like. The weight estimate coordinate system is the same used to develop the hydrostatics geometry file.

A margin policy is used to account for uncertainties in the magnitude of weight items. Design margin is applied to each weight item as a percent increase in estimated weight depending on the estimate's source. Design margin percentages are shown in Table 3.1. Weight item location and longitudinal extent are used as estimated with no margin applied.

Table 3-1 - Weight Item Design Margin Percentage

Description	Symbol	Margin Value
Scaled weight	S	0%
Vendor weight	V	2%
Calculated weight	C	5%
Estimated weight	E	12%

A 2% builders margin is applied to the estimated lightweight with design margin to account for uncertainties in actual as-built weights. No service life allowance is applied.

Weight, location, and longitudinal extent of load items, such as ballast water, water in trim tanks, and lost weight from water levels in fish channels and plenums being below reservoir level are calculated from known tank arrangement and hydraulic design features. A 5% "calculated" margin is applied.

A weight estimate summary at the 1-digit SWBS level is shown in Table 3.2. The complete weight estimate is Appendix B.

Table 3-2 - Weight Estimate Summary

Group	Description	w/o Margin	w/ Margin			
		Weight [lbs]	Weight [lbs]	VCG [feet]	LCG [feet]	TCG [feet]
100	Hull Structure	4,026,904	5,634,151	12.97	133.42	0.92
200	Propulsion Plant	0	0			
300	Electrical Plant	81,250	91,000	35.00	173.33	0.00
400	Command and Control	500	560	35.00	173.33	0.00
500	Auxiliary Systems	652,844	731,184	11.28	104.38	-2.91
600	Outfit and Furnishings	158,800	177,856	47.06	224.71	11.21
700	Special Purpose Sys	1,799,994	2,015,994	24.19	172.51	-1.05
	Subtotal	8,059237	8,650745	16.38	142.37	0.34
	Builder's Margin (2%)	161,185	173,015	16.38	142.37	0.34
	Service Life Margin	0	0			
	Estimated Lightweight	8,220,422	8,823,760	16.38	142.37	0.34

3.4 Hydrostatics

A computer model of FSS geometry suitable for use with the General HydroStatics (GHS) program published by Creative Systems, Port Townsend WA has been developed. The geometry file includes all buoyant volumes (e.g. belly tanks, flotation cells, and sorting area) and internal tanks, voids, pump room, stair towers, and the like. The geometry file is developed with the following right-handed coordinate system.

- Origin at the forward end of fish channel structure, on centerline, and top of belly tanks,
- Longitudinal, X-axis positive aft,
- Transverse, Y-axis positive to starboard, and
- Vertical, Z-axis positive upward.

All hydrostatic calculations for hydrostatic properties, tank capacities, stability calculations, and ballasting and deballasting calculations are performed using GHS with this geometry file.

Zero trim, zero heel, and zero vertical center of gravity hydrostatic properties are shown in Appendix C.

GHS calculates the static draft (at origin and/or longitudinal center of flotation), trim, and heel for any loading condition defined by lightweight, tank loading, and other fixed weights. The liquid surface in slack tanks is adjusted to match equilibrium trim and heel so that liquid surface properties, such as free surface moment, and center of gravity are properly calculated. Height above equilibrium waterline (or immersion below equilibrium waterline) can be calculated for predefined points of interest, such as forward and aft corners.

3.5 Stability

Intact stability refers to the ability of a floating body to right itself when acted upon by an external, overturning force. Such forces can arise from wind, wave action, lifting weights over the side, moving on board weights from one side to the other, and the like. Metacentric height (GM), which is the distance between the vertical center of gravity and the metacenter, is one measure used to quantify intact stability. The metacenter is the point on the craft’s centerline about which the center of buoyancy rotates as the craft heels. Vertical center of gravity is determined from the weight estimate. The metacenter is determined by the craft’s geometry, and is one of the calculated hydrostatic properties.

Damage stability refers to the ability of a floating body to sustain damage to the it’s watertight boundary that allows water to flood interior spaces and remain afloat with sufficient metacentric height to be stable. In large measure damage stability depends on arrangement, size, and type (i.e. tank, void, living space) of internal spaces.

Normally, federal (U.S. Coast Guard) and international (International Maritime Organization) regulatory bodies set criteria for adequate stability. Design calculations must demonstrate that stability criteria are satisfied in all operating conditions. Since Detroit Reservoir is neither navigable waters of the United States nor international waters these criteria do not apply. Instead the following criteria have been developed to demonstrate adequate stability for the FSS in all operating conditions, including intermediate stages of ballasting and deballasting.

3.5.1 Intact Stability

The FSS belly tanks and port and starboard floatation cells somewhat resemble a floating dry dock. The intact stability criteria adopted is similar to that included in “American Bureau of Shipping Rules for Building and Classing Steel Floating Dry Docks 2009.” This criterion prescribes a minimum, or required, metacentric height (GMr) based on the rated lifting capacity of the dry dock. For the FSS intact stability criteria displacement (DISPL) is substituted for lifting capacity. Thus, GMr is different for the maintenance (pumped out) and operating conditions and varies for intermediate stages of ballasting and deballasting. GMr is calculated as follows where DISPL is in kips.

GMr = 5.00 feet for DISPL <= 22,400 kips

GMr = 5.43 – 1.920*DISPL / 100,000 kips feet for DISPL > 22,400 kips and <= 112,000 kips

GMr = 3.28 feet for DISPL > 112,000 kips

Intact stability calculations are performed assuming the FSS is free-floating. No consideration is given to restraining forces from the mooring piles or the limits of trim and heel due to pile yoke geometry.

Intact stability calculations to be included in the 60% DDR.

3.5.2 Damage Stability

Both the character and extent of damage and damage survival criteria must be considered in assessing damage stability.

The FSS will operate on a fresh water reservoir that only allows recreational boating traffic. In addition, winter icing is not severe enough to cause structural damage resulting in flooding. Further, the FSS is moored in place to avoid contact with the bottom, or any other obstacle, that might be encountered at normal reservoir levels at all operating conditions. Thus, any damage that results in flooding would occur at the waterline. The worst such damage would be at a transverse watertight bulkhead. The character and extent of damage for FSS damage stability calculations is a breach at the waterline causing any two adjacent compartments, and any non-watertight connecting spaces, to flood.

The FSS is considered to survive the character and extent of damage if all of the following survival criteria are satisfied in the final damaged equilibrium condition.

- The FSS remains afloat and upright,
- Damage equilibrium trim is no more than 5 degrees,
- Damage equilibrium heel is no more than 15 degrees, and

- The FSS has at least 18 inches of GM.

The main deck is allowed to be immersed in the damaged equilibrium condition so long as this does not result in flooding of undamaged compartments.

Damage stability calculations are performed assuming the FSS is free-floating. No consideration is given to restraining forces from the mooring piles or the limits of trim and heel due to pile yoke geometry.

Damage stability calculations to be included in the 60% DDR.

3.6 Operating Considerations

At all flow rates from a minimum 1000 cfs to the design maximum 4500 cfs the fish attraction channel hydraulics are designed to capture fish with the FSS level with zero trim and zero heel. For 1000 cfs flow one attraction channel (either port or starboard) will be closed by operation of the inlet weir so that all flow is directed through one attraction channel. During operation flow through the FSS results in water levels in the expansion sections, primary screen sections, primary screen plenums, secondary screen sections, and plenum to be drawn down below the reservoir level. The amount of drawdown depends on the flow rate. This drawdown effectively acts as removing weight from the FSS that changes its trim and heel. Dedicated on board “trim tanks” are provided so that adjusting the volume (hence weight) of water in each tank compensates for changing trim and heel and keeps the FSS level.

The number, location, and size of trim tanks to be included in the 60% DDR.

The complete FSS with all ballast and trim tanks empty, and without operating liquids in fish handling equipment, fish sorting equipment, holding tanks, and transfer tanks, is termed the lightweight (empty) condition. In the lightweight condition, the FSS will float with the top of the belly tanks above water. When in this condition, maintenance can be performed in the dry on those portions of the FSS that are submerged during normal operations.

FSS lightweight draft, trim, and heel to be included in the 60% DDR.

All FSS operating conditions with flow through the fish attraction channels occur at a draft of 35.00 feet above the top of the belly tanks (5.00-foot freeboard) with zero trim and zero heel. Ballasting (filling ballast and trim tanks to prescribed levels and adding operating liquids to fish handling equipment, fish sorting equipment, holding tanks, and transfer tanks) brings the FSS to the operating condition from the lightweight condition. Tanks must be filled and operating liquids added in a precise, calculated sequence to avoid excessive trim and heel while transitioning from the lightweight condition to the operating condition. Metacentric height (GM) must be greater than required metacentric height (GMr) throughout the ballasting sequence in order to satisfy the intact stability criteria.

Transitioning from the operating condition to the lightweight condition empties tanks and removes operating liquids in the reverse order from the ballasting sequence.

Preliminary ballasting/deballasting sequence to be included in the 60% DDR.

4 HYDRAULIC DESIGN

4.1 General

The Floating Screen Structure (FSS) is being designed to function in coordination with the USACE-designed Selective Withdrawal Structure (SWS). The SWS will be attached to the turbine intakes, and will be designed to combine warmer surface water with colder deep water to achieve desired temperatures throughout the year for discharge downstream. The FSS will screen the surface water portion of the withdrawals to keep fish out of the turbine flow and deliver them to the Fish Handling Facilities (FHF) at the downstream end of the FSS. Fish will ultimately be lifted from the FSS and trucked to designated release locations either downstream of Big Cliff and Minto Diversion Dams, or in some cases upstream of Detroit Dam.

4.2 Hydraulic Criteria and Considerations

There are two general areas that have hydraulic criteria and considerations for the design of the FSS: those related to effective fish collection, handling and transport; and those related to the structural integrity of the facility. In general, these considerations have been described in previous sections of the report. The hydraulic criteria and considerations related to biological performance are summarized in Section 2.2. In addition to the criteria listed in Section 2.2, hydraulic considerations that affect the biological performance of the FSS include:

- At a minimum, the hydraulic conditions in the reservoir during FSS operation should not inhibit fish access to the FSS. The general layout of the FSS and SWS is assumed to be fixed at this stage of design; therefore, the focus of this consideration is the pumped flow alternative. The CFD model results will be reviewed to identify positive and negative hydraulic characteristics.
- The FSS entrance weirs should operate as submerged weirs over the full range of FSS design operating flows (1,000 cfs to 4,500 cfs), and capture velocity should be achieved at the entrance weirs.
- The FSS dewatering screens should have provisions to facilitate in-field balancing and debris control.

The FSS structure and mooring shall be designed to withstand the exterior loads applied during the peak spillway discharge. The spillway design flood is:

- Spillway discharge = 176,000 cfs distributed through all six bays in the spillway.
- Reservoir level = 1574.0 feet with gated discharge via 25 foot openings; or
- Reservoir level = 1572.4 feet with free flow over the spillway.

The FSS is assumed to be shut down during the spillway design flood.

4.3 Selective Withdrawal Structure

The Selective Withdrawal Structure (SWS) is being designed by the USACE, and details of the design can be found in the Selective Withdrawal Structure DDR. For the purposes of this Floating Screen Structure DDR the description of the SWS components will be limited to those that impact the design and operations of the FSS.

The SWS tower will be square, with outside wall dimensions of 80 feet on each side. It will be located in the forebay far enough upstream (east) of the dam to allow for installation of the FSS between the dam and the SWS, with the FSS positioned 40 feet away from the upstream face of the dam. The SWS will also be located far enough north (with north/south for the purposes of this description being defined as the axis of the Detroit Dam) to allow the entire FSS to be positioned to the north of the spillways, keeping the FSS out of the flow path of the spill flow.

Surface flows into the FSS will occur through two deep slots in the west wall of the SWS, each 20 feet wide. Prior to installation of the FSS, flow through the SWS slots will be controlled multi-leaf overflow weir gates designed to accommodate reservoir level variations from the minimum to maximum reservoir elevations (1425.0 to 1574.0). After installation of the FSS, the SWS weir gates will be attached to the underside of the FSS to prevent flow from entering the SWS through the slots from the area below the FSS. Surface flow into the SWS will then pass through the FSS screens and ultimately through the upper portion of the SWS slots.

The SWS will also include features that will protect the screens within the FSS from being overloaded in the event of rapid debris buildup on the screens. The SWS will include automated operation of the lower intake gate in the event of extreme head differential between the reservoir and the water inside the SWS. In addition, blow out panels will be included in the walls of the SWS as a backup to the automated gate operation. These features will prevent overloading of the screens in the FSS, and the FSS design team will work closely with the USACE to ensure that adequate strength is designed into the screen channel to match the safety features incorporated into the SWS.

4.4 Operations

The Detroit Powerhouse is operated as a peaking project, with the project entirely turned off at times each day during periods of low load demand. When the project is operating the overall flow to the units is controlled by the turbine wicket gates, to maintain a generation of 50 MW from each of the two units. The magnitude of the total flow is a function of the reservoir level, and resulting head on the turbines as described in Section 2.3.1. The percentage distribution of the total flow coming from the upper and lower intakes to the SWS tower will be controlled by the opening of the SWS lower gates, based on temperature gage readings of the overall powerhouse discharge. If the temperature is above the target, the SWS lower gates will be opened slightly to allow in more of the colder deep water from the reservoir, with a resulting decrease in the warmer flow from the FSS at the surface. The opposite would be the case if the temperature reading is below the target. If the SWS lower gates becomes fully open, and the discharge is still too warm, the upper flow can be throttled back by partially closing the upper SWS discharge control weir gates, creating greater head drop between the FSS and the SWS, further reducing the surface flow from the FSS and increasing the colder flow through the lower gates. Ultimately, if only flow through the SWS lower gates is desired, the FSS discharge control gates can be fully closed, redirecting all of the SWS inflow to the SWS lower gates.

With the surface flow rate to the FSS controlled as described above during operation of the powerhouse, it is only necessary to control the FSS Entrance Weir gates to maintain the desired head drop across the weirs (as described in Section 4.6.1 below).

The FSS is designed to integrate provisions for the future installation of attraction pumps, should it be determined by USACE that fish collection be needed during periods when the turbines are not operated and when no flow is passing from the FSS to the SWS. Future provisions for pumped attraction flow will accommodate 1,000 cfs to drive flow through the FSS, and continue attracting and collecting fish from the forebay. The integration of the attraction flow pumps may be part of a phased approach to implementation based upon biological performance of the system under power peaking operations. Implementation strategies are being developed by the USACE in collaboration with the regional fish managers. It is recommended that if this operational scenario occurred in the future, the FSS discharge control gates would need to be fully closed to hydraulically isolate the SWS from the FSS, allowing the SWS lower gates to remain open without short-circuiting colder deep water into the FSS behind the screens.

4.5 Hydraulic Modeling

Computational fluid dynamic (CFD) modeling is being performed to assist in the design of the FSS. Two distinct model domains are being used in the modeling for this project; a far field model spanning a large portion of the reservoir, and a near field model focusing on the dam and immediate forebay around the FSS. The model outputs include three-dimensional velocity magnitudes, local pressures, and streamlines, as appropriate, to help predict the hydraulic and biological performance.

The far field model will be used to investigate the maximum hydraulic loads on the FSS during the spillway design flood. These loads will be used in the mooring design. The near field model will focus on the flow patterns in the forebay resulting from the FSS intake as well as discharge from the FSS pumps during pumped operations. Of particular interest is if flow patterns develop that are considered adverse for capturing fish in the FSS.

Several simplifications are being made to reduce the computational overhead of the modeling:

- All modeling is being performed assuming a rigid lid is used to simulate the free water surface, i.e. the water surface elevation is fixed at the lid elevation. As such, no drawdown of the water surface associated with flow over the spillway or into the FSS will be captured.
- Temperature and any temperature variability (density variability) in the forebay are not being modeled.
- All runs will be performed in a steady state configuration. No transient phenomena will be captured or investigated.

- Only the hydraulic conditions external to the FSS are being modeled. Flow through the FSS and into the temperature control tower is not being simulated.

The hydraulic modeling is described in detail in a standalone CFD modeling report (Appendix D). Where CFD model outputs are used in the design of the FSS, they are described in the sections of this DDR pertaining to the specific components to which the results have been applied.

4.6 Floating Screen Structure

Given the wide range of operating flows, with a high design flow of 4,500 cfs (see Section 2.3.1) and a potential minimum flow during pumped flow operations of 1,000 cfs (see Section 4.4), the FSS has been designed with two screen channels so that one channel can be closed during the future low-flow pumping operation. Therefore, at the high design flow each channel is operating at a flow of 2,250 cfs, and during the future low-flow pumping operation the open channel is operating at a flow of 1,000 cfs, slightly less than half the design flow rate rather than less than a quarter of the design flow rate if a single channel had been used which would become hard to control and might not have encouraged fish to continue downstream through the FSS. The use of two channels also greatly reduces the overall length of the FSS, allowing it to fit between the spillways and the SWS location, and allowing fish to pass the length of the screen channel in a timely manner. A plan view of the FSS and SWS is provided in Figure 4-1.

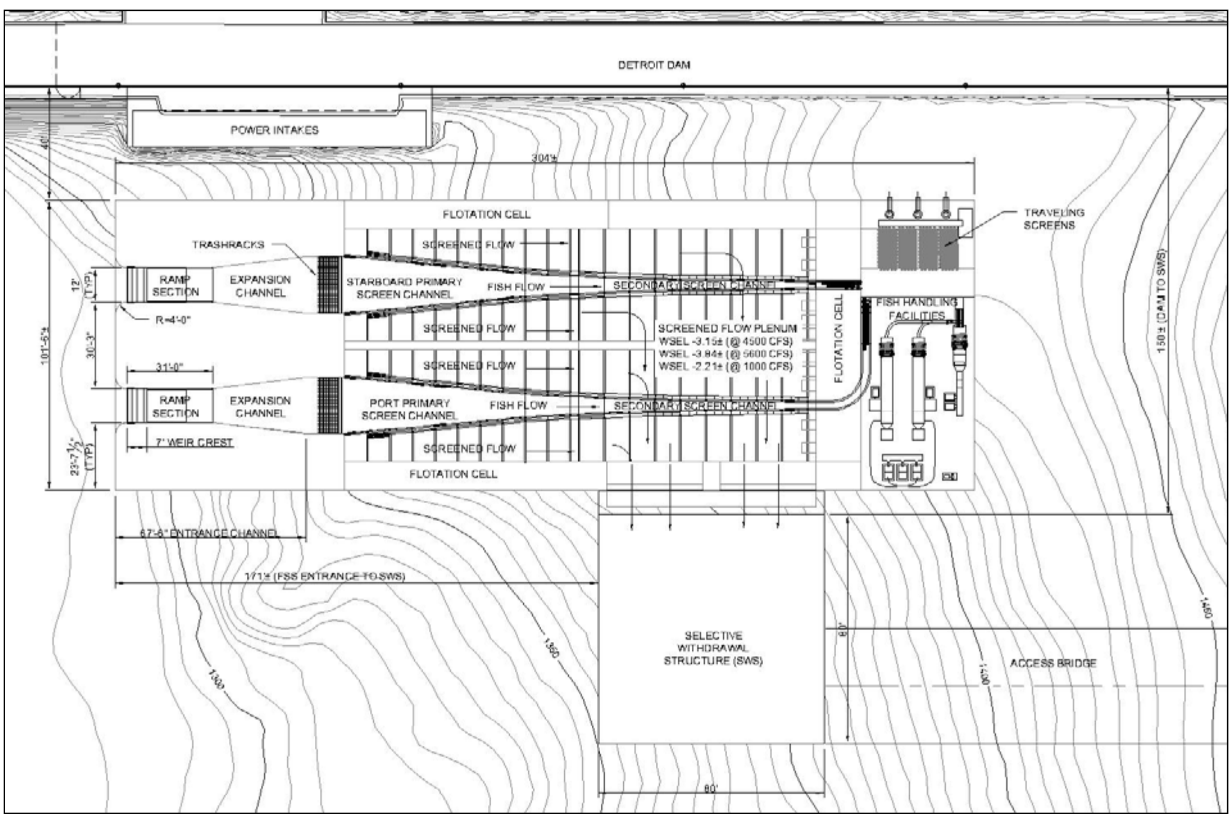

Figure 4-1 - Plan View of the FSS and SWS (upper deck not shown for support clarity)

The following sections describe the FSS components involved in the collection and handling of fish. The components are described starting at the upstream end of the FSS, in the order of fish travel through the system. Each of the two screen channels are identical, and include the following components described below; Entrance Weirs, Expansion Channels, Trashracks, Screen Channels, Flow Control Baffles, Screen Cleaners, Coarse Debris Racks, Fish Handling Facilities (FHF), and SWS Control Gates.

4.6.1 Entrance Weirs

Each of the two collection screen channels begins with a 12-foot-long adjustable Entrance Weir at the upstream end. The weirs operate as submerged weirs, with water above the weir crest on the downstream side. The Entrance Weirs will be automatically raised and lowered to maintain a 2.0-foot head drop across the weirs. This will result in average velocities over the weirs in excess of 8 feet per second, which will effectively trap the fish and commit them to the FSS after entry.

The Entrance Weirs consist of a triple-leaf vertical slide gate with an elliptical crest extending 7.0 feet downstream from the upstream face of the upper slide gate leaf, and rising 3.91 feet above the top of the gate leaf. Figure 4-2 shows the triple-leaf slide gate with the elliptical crest shape. The shape is a quarter-ellipse with a major axis (horizontal) of 5.86 feet and a minor axis (vertical) of 3.91 feet. A flat plate 1.14 feet long completes the total distance of 7.0 feet downstream. The shape closely matches the upstream portion of an ogee crest shape designed for a head of 22.1 feet; except that the elliptical shape extends further down to meet the face of the leaf gate tangentially instead of the kinked junction of an ogee. This shape should result in a weir flow coefficient in excess of 3.9 over much of its operating range.

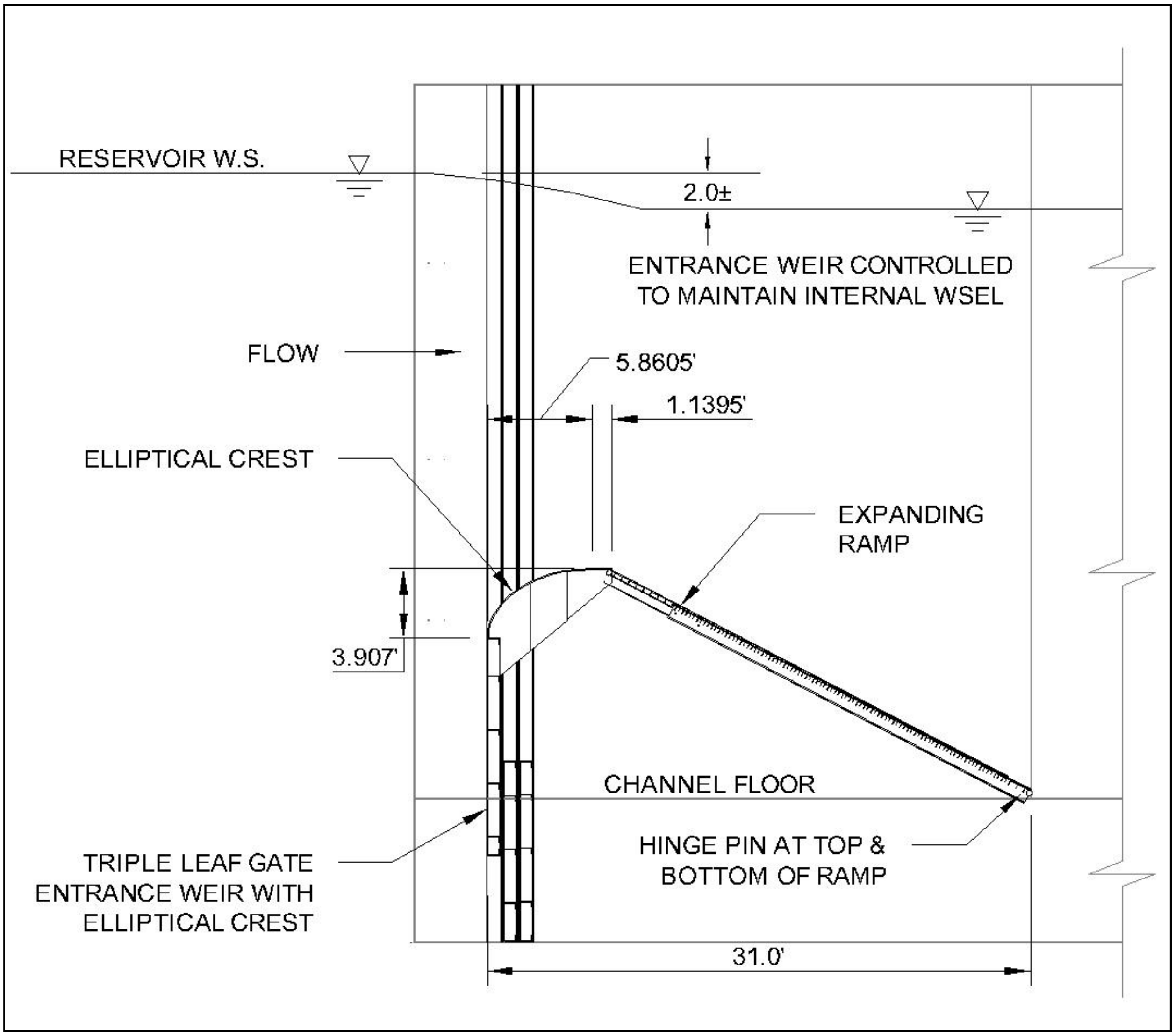

Figure 4-2 - Entrance Weir with Elliptical Shaped Crest

Downstream of the weir crest an expanding ramp is pinned to the underside of the weir crest. The ramp extends down to the channel floor approximately 30 feet downstream of the upstream face of the leaf gate. The ramp is also pinned at the floor, so that both ends of the ramp can rotate as the ramp extends or contracts. The face of the ramp is mostly solid, but enough porosity would be included to allow ‘leakage’ through the surface to prevent pressure from being applied to the ramp. The purpose of the ramp is to prevent fish from getting into the area below the weir crest, where there would be little flow and fish could hold for extended periods of time. However, some hydraulic benefit may also be realized in that the ramp should tend to break up the eddy that would otherwise form downstream of the weir below the flow jet. The ramp would extend and contract much like an extension ladder.

The Entrance Weir will be designed to automatically adjust vertically to maintain the 2-foot head drop throughout a range of potential flow rates. The weir operator will consist of a double-drum wire-rope hoist mounted on the upper deck of the FSS, with cables down to the upper gate leaf recessed into the weir guide pockets. Additional detail regarding the operator will be provided in the Mechanical Design section of the DDR. Figure 4-3 shows the approximate settings of the weirs at four significant settings. Settings A and B are the settings of the two weirs during the low-flow (pumped flow during the no power generation periods) with one channel weir closed and the other channel weir open to approximately 10.8 feet below the reservoir level. The water in the closed channel will equalize with the plenum level outside the screen channel (approximately 2.3 feet below the reservoir level during low-flow operation). Setting C represents the weir setting for both of the two weirs during the design flow rate of 4,500 cfs, with each channel operating at 2,250 cfs. Both weirs would be open approximately 22.1 feet below the reservoir level. Setting D represents the weir setting for both of the two weirs during the potential maximum flow rate of 5,600 cfs, with each channel operating at 2,800 cfs. Both weirs would be open approximately 26.8 feet below the reservoir level. The actual weir setting may vary slightly from those shown here, but since the flow rate is controlled by the turbines, and the setting of the lower SWS gates) the weir setting only needs to be set to maintain the 2-foot head drop ensuring that the fish collected are committed to the FSS.

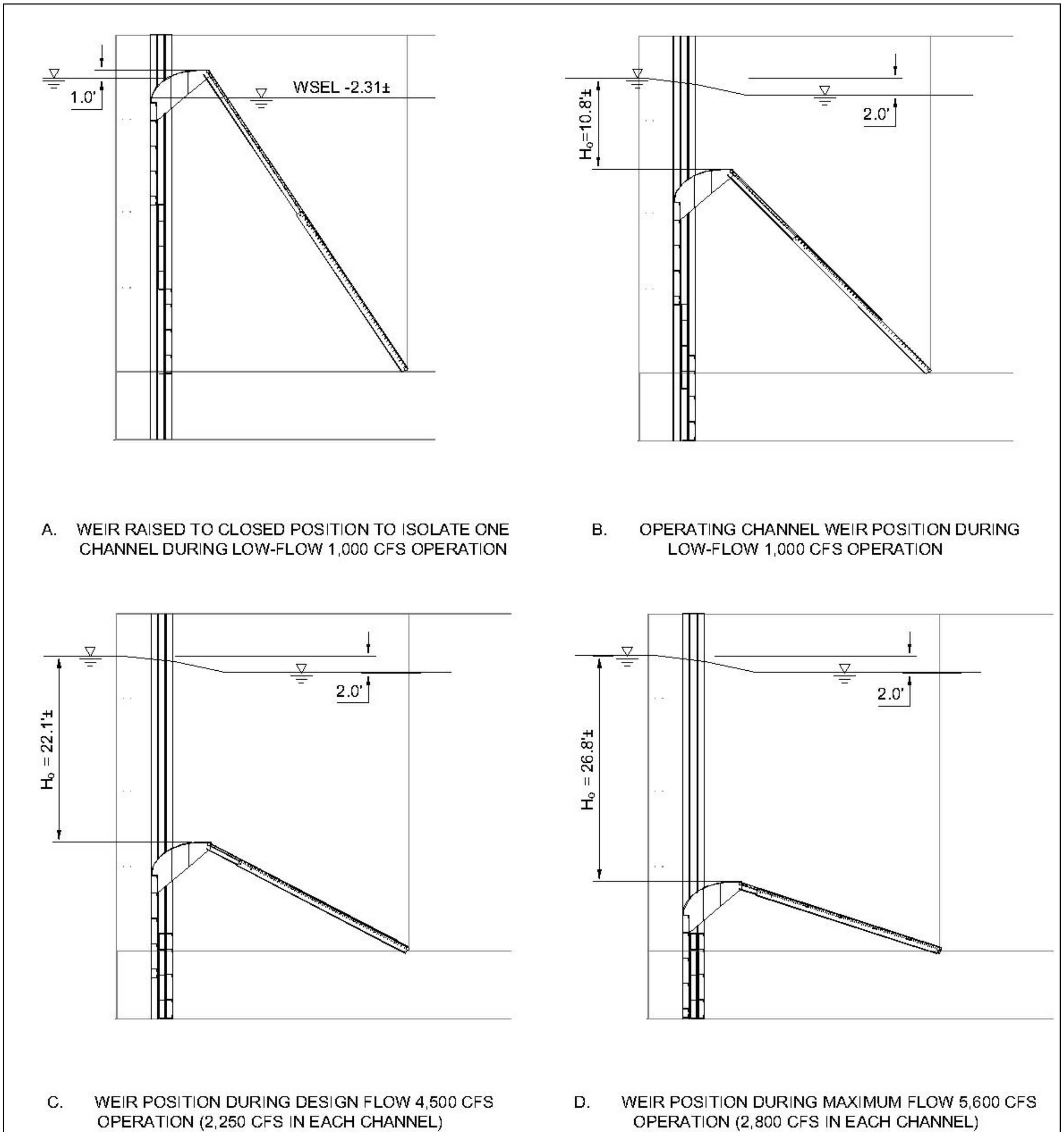

Figure 4-3 - Entrance Weir with Elliptical Shaped Crest - Four Entrance Weir Settings

4.6.2 Expansion Channels

The Entrance Weirs, and the channels housing them, are 12.0 feet wide. The walls of the channels remain 12.0 feet wide to just downstream of the lower expanding ramp pin. Continuing downstream, the channels gently expand to a width of 20.0 feet, to reduce the velocity prior to passage through the Trashracks, as described in Section 4.6.3. The expansion occurs over a length of 32.5 feet, resulting in an expansion angle of approximately 7 degrees, which is gentle enough to likely result in some energy recovery as the velocity of the flow decreases. The resulting water level may increase slightly at the downstream end of the expansion channel, which could result in a water level that is less than 2 feet below the reservoir level. This should be investigated in the USACE hydraulic model of the entrance area. For the 30% DDR it has been assumed that the water level remains at 2 feet below the reservoir level throughout the length of the expansion channel, which is the conservative design approach.

4.6.3 Trashracks

Trashracks are positioned in the 20-foot-wide channels downstream of the expansion channels to prevent large debris from entering and potentially plugging or damaging the screen channel. The average velocity approaching the racks will be 3.4 feet per second at the design flow of 4,500 cfs. At a maximum flow rate of 5,600 cfs and flows as low as potentially 1,000 cfs the velocities at the Trashracks would be 4.2 and 1.5 feet per second, respectively. Trashracks have been designed with similar velocities with successful results at entrances of other large surface collectors. The Trashrack will consist of vertical bars spaced to create an 8-inch-wide clear space between the bars. This meets the NMFS criteria for a trashrack at the exit of a fish ladder. In the upper few feet of depth there will be two additional bars between the main bars resulting in a clear spacing of slightly over 2 inches, depending upon the bar thickness. These additional bars are included at the surface to increase the quantity of floating debris removed from the channel flow. There will be at least one clear space within each Trashrack where these two additional bars will be omitted, to allow free passage of steelhead kelts which tend to be surface-oriented swimmers. The rack is tilted back at approximately 13 degrees to aid in screen cleaning and to better hold surface debris within the upper area where the bars are spaced closer together.

The Trashrack will be cleaned with a mechanical Trash Rake. Trash will be removed and placed in a portable container for removal from the FSS. Other than the sizing of the rack, the trashrack has not yet been designed for the 30% DDR. Material and strength requirements will mostly be dictated by the requirements and loads placed on the rack by the Trash Rake. The 20-foot-wide channel is considered to be an adequate length to house the Trashrack and to allow for full operation of the Trash Rake within the confines of the fixed-width channel section. Details concerning the Trash Rake will be included in the Mechanical Design section of this DDR.

4.6.4 Screen Channels

Each of the two screen channels consists of two sections, the Primary Screens and the Secondary Screens. In both cases the screens are vertically oriented and located along both sides of the channel, with a solid floor between the screens. The walls of the screen channel taper in horizontally, reducing the width of the channel in the downstream direction. Initially, the depth remains constant while the velocity is maintained approximately constant as flow is removed. Ultimately, both the width and the depth are reduced while mildly accelerating the flow, further committing the fish to continuing downstream through the channel.

The screen panels will be stainless steel, vertically oriented profile bar screening with 1.75 mm clear spaces between the bars. Each panel will be framed with stainless steel 3x3x1/4 angles, and bolted to the flanges of vertical wide-flange support columns, as shown in Figure 4-4. With a constant clear space between bars for all screens, the porosity of a particular screen panel becomes a function of the thickness of the bars. Two different porosities are used in the design, as described below in the descriptions of the Primary (4.6.4.1) and Secondary (4.6.4.2) Screen Channels.

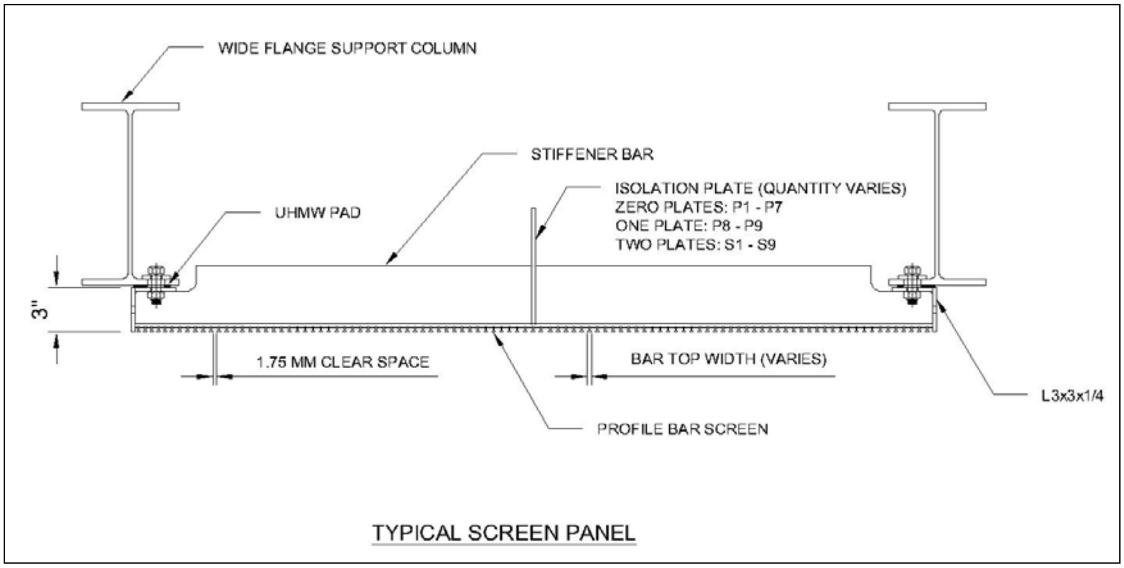

Figure 4-4 - Typical Screen Panel Section View

Flow through the screens will be controlled and evenly distributed by adjustable Flow Control Baffles located behind the screens. The Flow Control Baffles are described in Section 4.6.5. Screen cleaning will be performed using high-pressure backwash spray from behind the screens, as described in Section 4.6.6.

4.6.4.1 Primary Screens

After passage through the Trashracks, the flow and fish enter the Primary Screen Channel. The purpose of the primary screen section is to remove the majority of the incoming flow from the screen channel while the velocities are still relatively low. Plan and profile views of the Primary Screen Channel are shown in Figure 4-5. At the upstream end of the Primary Screen Channel the floor is 35.0 feet below the reservoir level with a depth of approximately 33 feet, and the channel width is 20.0 feet. The average velocity at this location is 3.4 feet per second at the design flow rate of 2,250 cfs in each channel (4,500 cfs total). At the maximum potential flow of 2,800 cfs per channel (5,600 cfs total) the velocity would be about 4.2 feet per second, and at a potential minimum flow of 1,000 cfs in a single channel the velocity would be about 1.5 feet per second.

Over the initial 64 feet of the Primary Screen Channel length the width reduces from 20 feet to 8 feet wide, a reduction of 2.25 inches per foot. Throughout this length the floor of the channel is level at 35 feet below the reservoir water surface. The initial 8 feet of channel length has solid blank panels on the walls instead of screens. The purpose of this 8-foot section is to reestablish well-distributed flow in the channel prior to the start of the screen panels. Flow through trashracks under these conditions has been shown to cause localized areas of turbulence and flow disruptions that can impact screen flow effectiveness. The reduced width, associated with constant flow, results in a mild increase in velocity to about 3.7 feet per second at the end of the initial 8-foot channel sections. Over the remaining 56 feet of this initial section there are seven hydraulically isolated screens on each side of the channel (labeled as Screens P1 through P7). Approximately 1,260 cfs, of the design 2,250 cfs inflow, is removed from the channel through these 14 screens (7 on each side). The remaining 990 cfs results in a final channel velocity of about 3.8 feet per second. The screens are mounted 6 inches above the floor of the channel and extend up 33.5 feet. Given the height of these screens we have assumed that for fabrication, transport, and installation reasons these screens would consist of two 16.75-foot-high panels. The screen panels in this section (P1 through P7) will be fabricated using profile bars with a top width of 2.36 mm (Hendrick Screen Co. Style B-6 profile bar), resulting in a porosity of 43%.

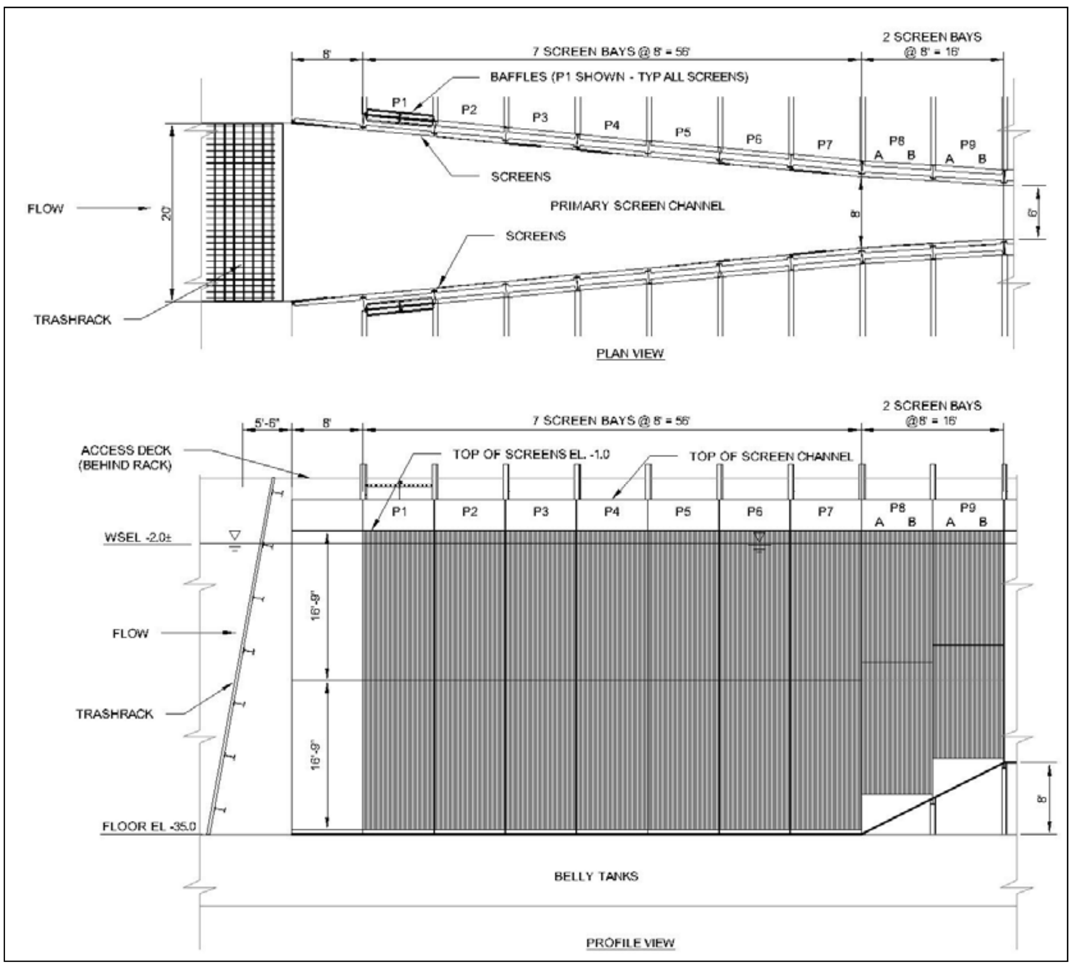

Figure 4-5 - Primary Screen Channel, Plan & Profile (elevations relative to reservoir)

Over the final 16 feet of the Primary Screen Channel the width further reduces from 8 feet to 6 feet, a reduction of 1.5 inches per foot. The floor through this section rises 8 feet (6 inches per foot) to begin the necessary reduction in channel depth as the flow is further reduced. There are two screens on each side of the channel over this 16 feet (labeled P8 and P9), with four hydraulically isolated sections. Each of the two screens is functionally divided in half with a plate mounted behind the screen that extends perpendicularly back to the baffle frame. This creates two hydraulically isolated sections within each screen (labeled A and B). An additional 280 cfs is removed through the screens in this section, resulting in a remaining channel flow of approximately 710 cfs at a velocity of 4.8 feet per second. The screen panels in this section (P8 and P9) will be fabricated using profile bars with a top width of 3.56 mm (Hendrick Screen Co. Style B-9 profile bar), resulting in a porosity of 33%. The screen porosity is reduced in this section because the flow velocity in the channel is increasing in the downstream direction, resulting in a lowering of the water level in the channel over the length of the screen, while the water level behind the screen (between the screen and the baffle) is relatively flat. Therefore, it is necessary that the head drop across the screen be increased so that the water level in the channel at the downstream end of the screen section does not become lower than the water behind the screen, which would result in reverse flow through a portion of the screen. This is also the reason that the screens are divided into shorter hydraulically isolated sections, to reduce the difference in the channel water levels between the upstream and downstream end of the isolated screen section. The criteria used for determining the length of the individual screen sections is that the approach velocity calculated at the upstream edge of the screen (where the water level difference from the channel side to the back side of the screen is greatest) does not exceed 0.44 feet per second, which is the NMFS criterion for maximum ‘hot spots’ on the screen.

At the end of the primary screen channel there is a 3-foot-long section of unscreened channel with a level floor prior to the start of the secondary screens.

4.6.4.2 Secondary Screens

The Secondary Screen Channel is designed to remove the remainder of the attraction flow that is not intended to pass downstream with the fish to the handling facilities. Plan and profile views of the Secondary Screen Channel are shown in Figure 4-6. At the upstream end of the Secondary Screen Channel the floor is 27.0 feet below the reservoir level with a depth of approximately 25 feet, and the channel width is 8.0 feet. The remaining channel flow at this location is approximately 710 cfs with an average velocity of 4.8 feet per second, at the design flow rate of 2,250 cfs in each channel (4,500 cfs total). At the maximum potential flow of 2,800 cfs per channel (5,600 cfs total) the flow at this location would be approximately 860 cfs at a velocity of about 5.8 feet per second, and at the minimum flow of 1,000 cfs in a single channel the flow would be approximately 325 cfs at a velocity of about 2.2 feet per second.

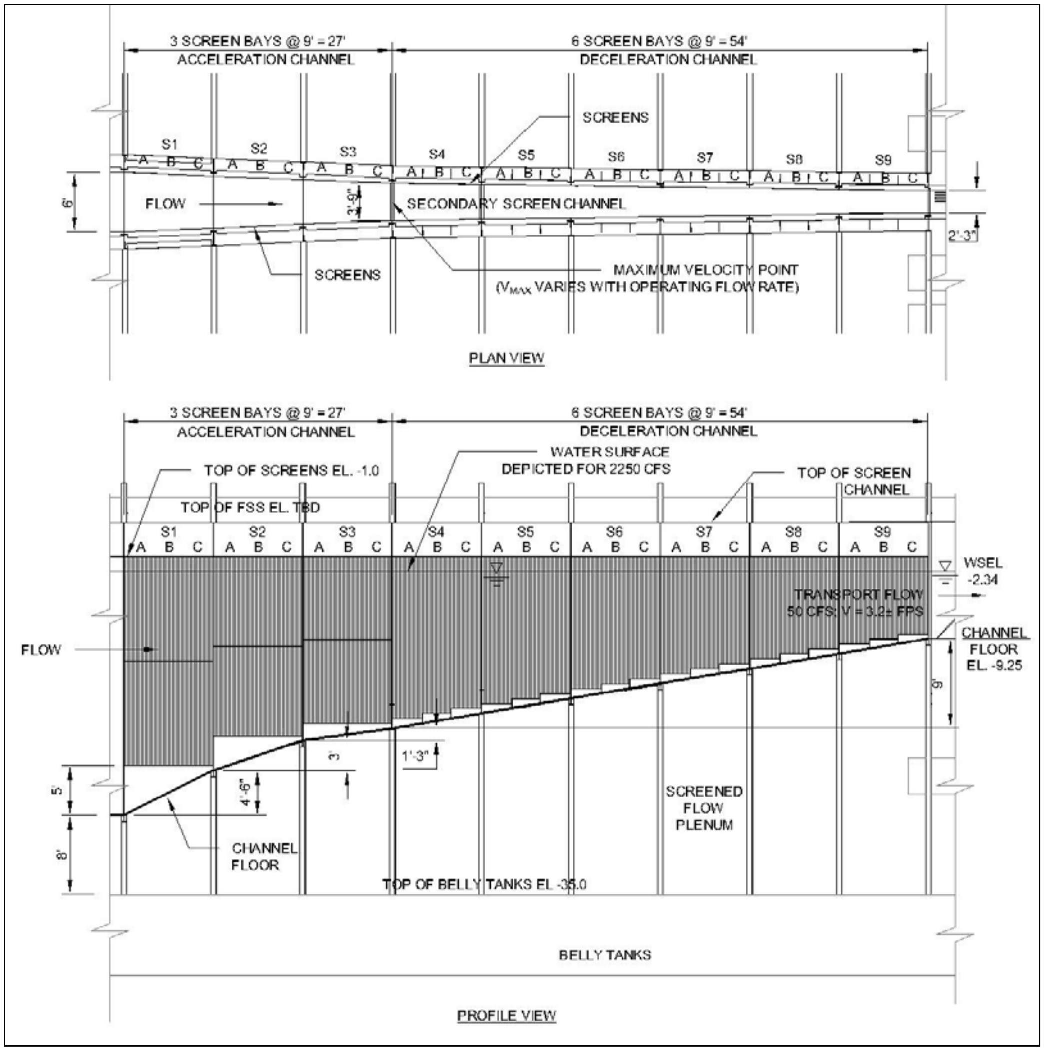

Figure 4-6 - Secondary Screen Channel, Plan & Profile (elevations relative to reservoir)

The initial 27 feet of the Secondary Screen Channel is referred to as the acceleration channel. The purpose of this section is to accelerate the flow velocity up to a point that the fish will be unlikely to be able to turn around and swim back upstream in the channel. Over this length the channel reduces in width from 8.0 feet to 3.75 feet. The channel floor rises in three 9-foot-long slopes, rising 4.5 feet, then 3.0 feet, and finally 1.25 feet. There are three approximately 9-foot-long screen panels on each side of the acceleration channel (Panels S1 through S3), and each panel is divided into three hydraulically independent sections (labelled A, B, and C). The panels each have a horizontal bottom located 6 inches above the high point of the floor. A trapezoidal solid blank panel is located between the channel floor and the bottom of the screen panel to complete the wall. The remaining flow at the end of the acceleration channel is approximately 410 cfs with a velocity of about 7.1 feet per second, at the design flow rate of 2,250 cfs in each channel (4,500 cfs total). At the maximum potential flow of 2,800 cfs per channel (5,600 cfs total) the flow at this maximum velocity point would be approximately 490 cfs at a velocity of about 8.7 feet per second. At the potential minimum flow of 1,000 cfs if pumped attraction flow were to be integrated, there is not enough flow in a single channel to achieve a trapping velocity at any location in the screen channel; however, fish that enter the FSS are still trapped and committed to the FSS when they pass over the Entrance Weir. Under these minimum flow conditions, the flow at the maximum velocity point would be approximately 200 cfs at a velocity of about 3.3 feet per second.

The final 54 feet of Secondary Screen Channel is referred to as the deceleration channel and serves to remove the last of the attraction flow from the channel, while slowing the flow down to a point that it is safe for fish to pass downstream through the Transport Channels and Coarse Debris Racks and ultimately to the Fish Handling Facilities (FHF). Over this final section of Secondary Screen Channel the channel width further reduces from 3.75 feet to 2.25 feet. The channel floor rises 9.0 feet over this 54-foot-long channel section. There are six approximately 9-foot-long screen panels on each side of the deceleration channel (Panels S4 through S9), and like the other secondary screen panels each panel is divided into three hydraulically independent sections (labelled A, B, and C). To maximize the dewatering capacity of this final section of channel, which in turn maximizes the flow and velocity at the end of the acceleration channel, the bottoms of these final six screen panels are stepped, with the bottom of each hydraulically controlled section being located 6 inched above the high point of the rising floor over that particular section. Regardless of the inflow rate to the FSS, the final fish flow in the channel downstream of the secondary screens is always the same, and is controlled by components within the FHF downstream. The current 30% design calls for this flow to be 50 cfs, at a channel velocity of about 3.2 feet per second. Note that at the minimum FSS flow rate of 1,000 cfs there is no significant deceleration in this final section of channel, and the maximum channel velocity is essentially maintained through the entire final section of the screen channel.

All of the secondary screen panels (S1 through S9) will be fabricated using profile bars with a top width of 3.56 mm (Hendrick Screen Co. Style B-9 profile bar), resulting in a porosity of 33%. This is necessary because of the varying channel velocity within the secondary screen channel, and the resulting variation in the channel water surface.

4.6.5 Flow Control Baffles

On the back side of the screen panels are adjustable Flow Control Baffle panels that can be individually adjusted to accommodate final in-field balancing of the screen flow. They would typically be attached to the back flanges of the support columns. These baffles will consist of two UHMW plastic perforated plates (one fixed and one movable) mounted in a steel frame. The perforated plates are in contact with each other with an orifice pattern such that when they are aligned the full porosity is available and when the movable plate is adjusted by one perforation hole diameter the panel becomes fully occluded. The perforation pattern consists of a staggered pattern of 3.0- inch-diameter holes spaced at 7.5 inches on center horizontally and vertically. This results in a porosity of approximately 25%. The holes on the two plates, one fixed in the baffle frame and one vertically adjustable, are cut through both UHMW plates at the same time so that the patterns are identical. Figure 4-7 provides photos of individual baffle panels at a fabrication shop and a bank of baffle panels installed on a floating surface collector. The individual panel shown in the photo is one designed to operate with a screen panel that is divided down the middle into two hydraulically isolated sections and the two sides of the baffle panel are individually controllable (as described above for FSS screen panels P8 and P9). Initial settings of the baffles will be based on the screen channel design model, and will then be checked in the field after startup and readjusted if necessary. The baffles should not need to be adjusted again after the startup adjustments.

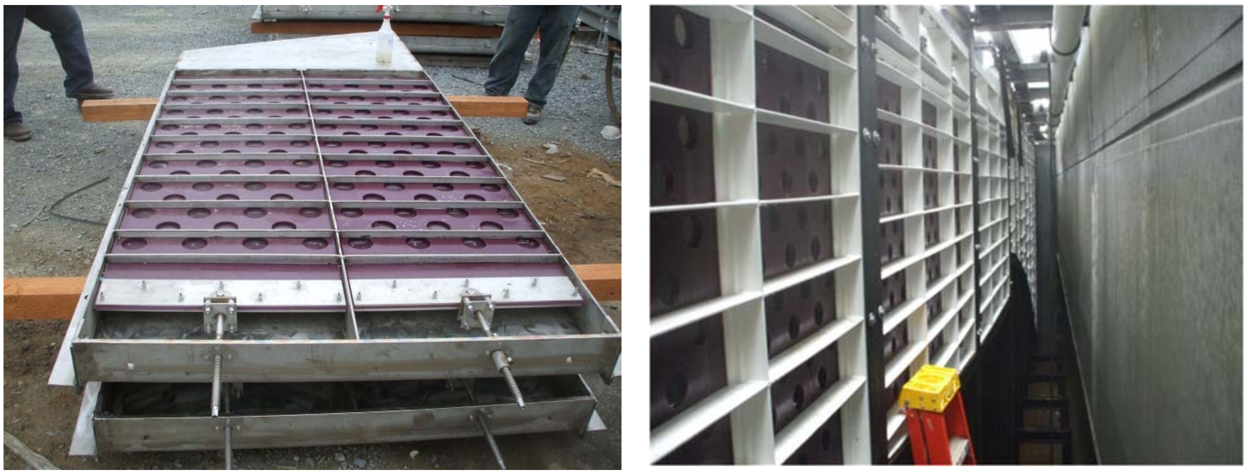

Figure 4-7 - Individual Baffle Panels and Baffles Installed on Floating Surface Collector

4.6.6 Screen Cleaners

Screen cleaning will be accomplished with horizontally-sweeping pressure backwash cleaners located between the screen and baffle panels on each side of the channel. The system will spray high pressure water at the back of the screens using vertical spray bars. There are four separate spray bar carriages on either side of the channel. Each carriage is split into a number of zones which will be activated sequentially upstream to downstream while the carriage is moved back and forth the over the length of the hydraulically isolated sections within the screen panels. The upstream carriage will have seven vertical spray bars to clean panels P1 - P7, and will have a travel distance of approximately 8 feet. The second carriage will include four vertical spray bars to clean panels P8A – P9B, and will travel approximately 4 feet. The third carriage will have nine vertical spray bars to clean panels S1A – S3C, and will travel approximately 3 feet. The last carriage will have eighteen vertical spray bars to clean panels S4A – S9C, and will travel approximately 3 feet. Operation of the valves isolating each of the vertical spray bars, and the drive motors that move the carriages back and forth, are controlled by the facility PLC based on a pre-programmed logic designed to clean the screens systematically from the upstream end to the downstream end. The cleaner system may be activated by a timer in the PLC, or in response to an increase in the head drop across the screens. Flow to the backwash cleaners will be supplied by submersible turbine pumps located in the plenum behind the baffles. Each carriage is served by a dedicated pump. The pumps are sized to provide water at approximately 40 psi to the orifices on the backwash spray bars. The orifices are 0.25-inch-diameter holes spaced at 1.5 inches on center along the spray bar pipes. Opposing zones on either side of the channel will be identical and can be activated simultaneously to prevent simply transferring debris from one side of the channel screens to the other. Figure 4-8 provides a general arrangement for the screen cleaners, and Figure 4-9 provides a section view of cleaner carriage 1.

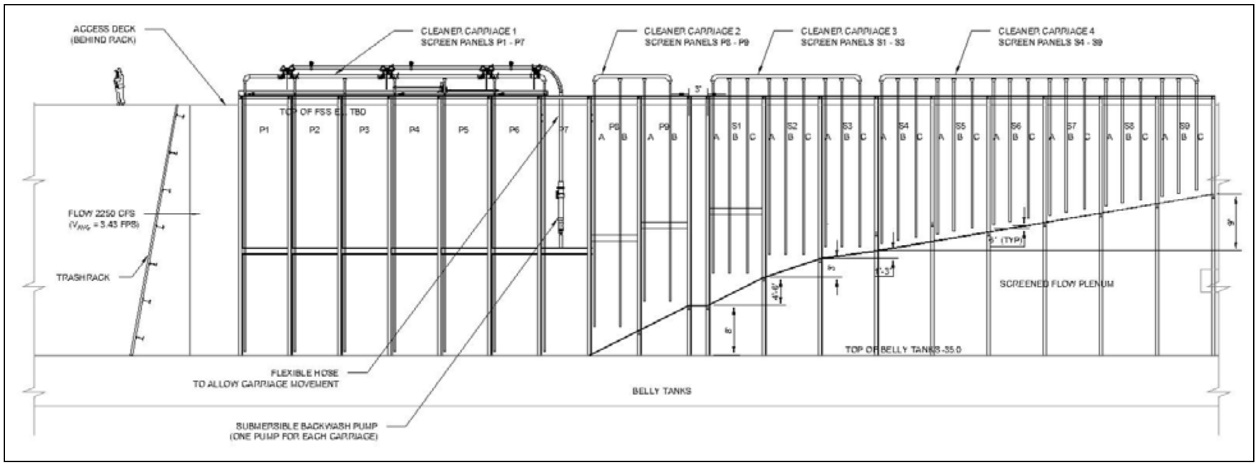

Figure 4-8 General Arrangement of the Screen Cleaners

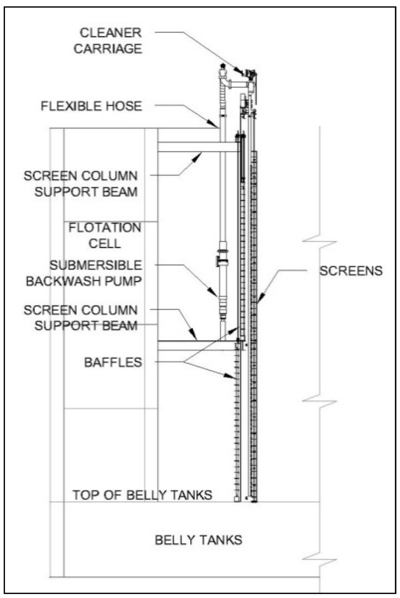

Figure 4-9 - Section View through Cleaner Carriage 1

4.6.7 Coarse Debris Racks

Downstream of each Secondary Screen Channel the fish pass to the FHF in a Transport Channel that is 2.25 feet wide and approximately 7 feet deep. Flow from the two channels is combined downstream in the in the FHF Debris Removal Tank. The initial design calls for a flow of 50 cfs in each of the two transport channels, with a velocity of about 3.2 feet per second. However, the final flow rate will be adjustable with variable speed pumps located behind the traveling screens in the Debris Removal Tank (see Section 4.6.8.1). Coarse Debris Racks are positioned within the transport channels to remove larger woody debris that is small enough to have passed through the trashracks upstream, but is too large to be effectively removed by the traveling screens downstream.

The Coarse Debris Racks are based on a design developed for the North Fork FSC on the Clackamas River in northwestern Oregon. Each rack consists of 1-inch schedule 40 stainless steel pipes sloped back at 45 degrees from vertical. The number and spacing of the pipes is adjustable; however, it is proposed to start with four pipes in each rack with a clear spacing of approximately 2 inches between the pipes. This will result in the furthest pipe from the wall being approximately halfway across the channel. The spacing between the racks along the length of the channel is also adjustable, with each subsequent rack occupying the opposite side of the channel from the previous rack. Supports for the racks will be mounted on Unistrut guides to allow for adjustable spacing between the racks. Three racks are shown in this preliminary 30% design. The optimal number of racks, spacing between racks, number of pipes within each rack, and the spacing of the pipes can be experimented with to determine the optimal arrangement to keep large debris out of the transport channel while allowing for safe fish passage. The Coarse Debris Racks in the transition channel should be checked on a daily basis and any debris caught in the channel should be removed. Debris removal would be performed manually with a long-handled debris rake, and debris placed in a bin for removal from the FSS. Figure 4-10 provides photos of the debris racks at the North Fork FSC, and Figure 4-10 - Photos of the Debris Rack in the North Fork FSC Transport Channel

shows the debris bin at the North Fork FSC with the type of debris that is removed at the coarse debris rack. It should be noted that the transport channel at the North Fork FSC (shown in the photos) is only 16 inches wide so fewer rack pipes were required than described above for the Detroit FSS.

Figure 4-10 - Photos of the Debris Rack in the North Fork FSC Transport Channel

Figure 4-11 - Type of Debris Removed at the North Fork FSC Coarse Debris Rack

4.6.8 Fish Handling Facilities

Downstream of the screen channels the fish are transported to the Fish Handling Facilities (FHF). These facilities provide for combining the two fish flows from the screen channels, final removal of debris, in-line separation of juvenile-sized fish from adult fish, sampling stations including anesthetic tanks and sample tables, and transfer pods for transferring fish to the transport truck loading station above. The estimated peak daily and seasonal fish migration numbers have not been determined for the FSS project at the 30% DDR phase. The design approach for the FHF is to conservatively size the facility based on facilities implemented in other river basins, and report the capacity of the Detroit Dam FHF components based on the design criteria. Figure 4-12 provides a plan view of the FHF components which include the Debris Removal Tank, the Juvenile Fish Separator, the Juvenile Holding Tanks, the Juvenile Sampling and Transfer Area, and the Adult Holding, Sampling, and Transfer Area. The following sections provide descriptions of the components of the FHF.

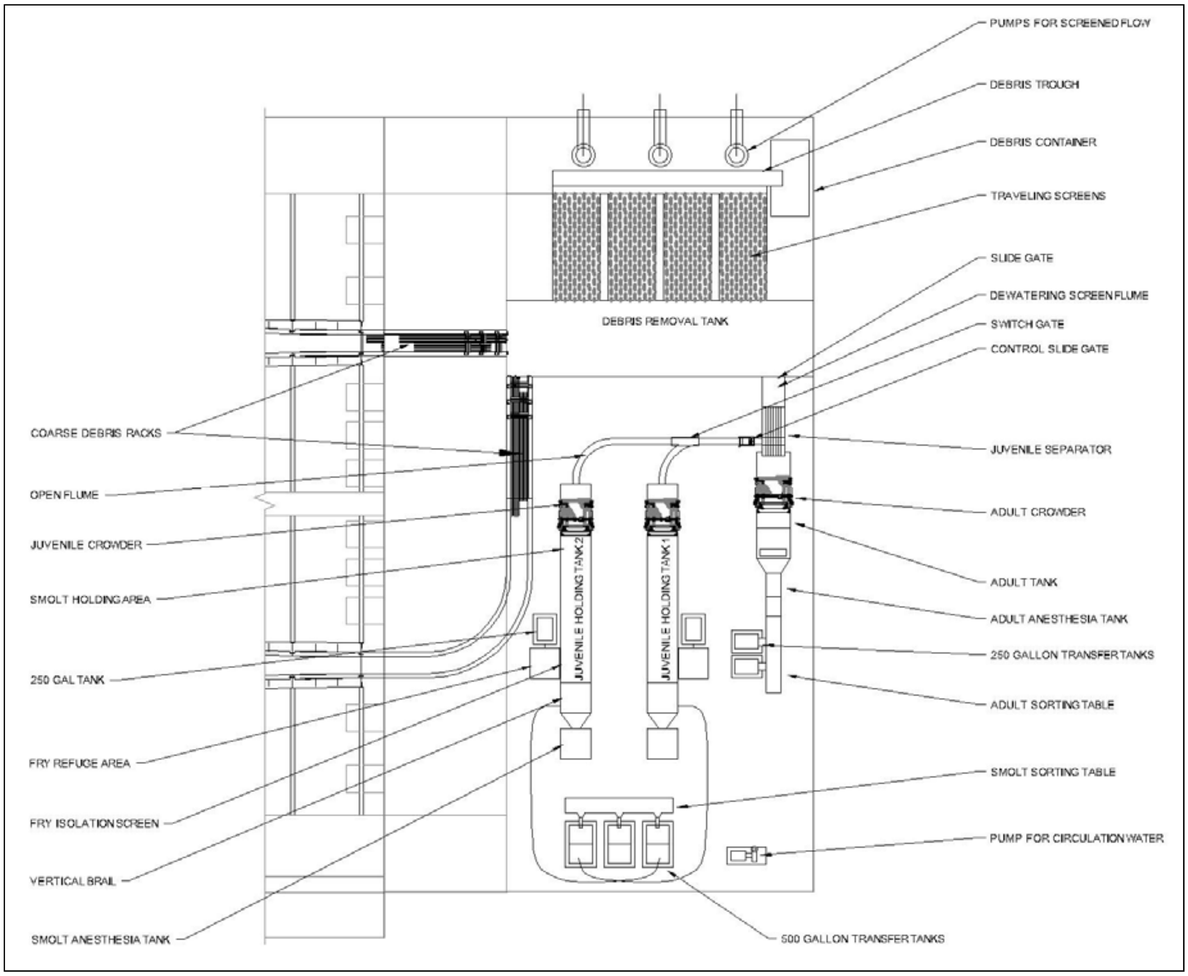

Figure 4-12 - Plan View of the Fish Handling Facilities

4.6.8.1 Debris Removal Tank

The flow from the two transport channels is combined in the Debris Removal Tank located along the starboard side of the fish handling facilities. The tank is 40 feet long and includes a bank of traveling screens along one side to dewater the majority of the combined flow from the two screen channels. The screens are sized to dewater up to 100 cfs, while meeting all NMFS criteria for juvenile fish screening. The screens are sloped back from vertical by 37.5 degrees so that the debris remains on the screens as the screen belt rises up out of the water. This results in a varying width of the tank, with a greater width at the top than at the bottom. It is recommended that debris pegs (one-inch-long hooked plastic pegs) be attached to the screen belt material to further increase the ability of the screen to hold onto the debris. This design is successfully used at the North Fork tertiary screen structure (TSS) to dewater and remove debris from the combined flow from two downstream migrant collectors before the fish enter the downstream bypass pipe. Figure 4-13 provides a photo of the North Fork TSS traveling screen installation showing the sloped screen with debris pegs.

Figure 4-13 - Photos of the North Fork TSS Traveling Screens with Debris Pegs

Three pumps are located on the back side of the screens to provide for the screen flow. Pumped flow will be returned to the reservoir through the side wall of the FSS. The pumps will be operated with variable frequency drives (VFDs) to allow for flow control, which in turn controls the fish flow in the transport channels. Only two pumps are required to provide up to 100 cfs, but a third pump is included as a redundant back up, given the crucial nature of this flow to attract fish through the transport channels. Pump rating curves will be programmed into the PLC allowing it to control the speed of the pumps via the VFDs based on the desired flow setpoint (manually entered into the PLC) and measurements of the water level difference between the pump sump and the reservoir level.

Debris that is carried up over the top of the traveling screen will fall off and/or be sprayed off of the screen belt into a debris trough on the back side. During operation of the screens, water would also be sprayed into the trough to move the debris to the end of the trough. At the end of the trough the debris will flow into a debris container. The bottom of the container will be screened or perforated to allow water to drain out while the debris remains confined. When required, the debris container can be lifted with the FSS bridge crane and moved over to the port side of the fish handling facility area to be lifted off the FSS by the truck loading crane on the access bridge above.

At the far end of the Debris Removal Tank (opposite end from the inflow) is an adjustable surface outlet weir for passing fish to the juvenile fish separator. The amount of flow passing over the weir can be adjusted to optimize the fish attraction to the outlet.

4.6.8.2 Juvenile Fish Separator

On the downstream side of the outlet weir the fish flow passes onto a dewatering screen flume, and then onto a Juvenile Fish Separator. The dewatering screen flume is used to remove any excess flow from the outlet weir that is in excess of the capacity of the juvenile separator. The flume will have a drain box incorporated under it with a valve to control the amount of water being removed. The remaining flow will pass with the fish onto the juvenile separator.

The juvenile separator consists of a downwardly sloping flume with a porous bottom. The porous bottom is an aluminum rack made from 1-inch-diameter tubes spaced adequately to allow juvenile fish to pass through between them. The tubes run lengthwise along the slope of the flume. Various racks can be provided and easily changed out with different clear spacing for different species and/or seasons depending upon the size of fish to be separated. The entire flow passing from the dewatering screen flume will drop down through the separator rack so that all fish small enough to fit will be forced to pass down through the rack. Larger, adult-sized, fish will slide down the rack and drop into the adult holding tank. Below the separator rack is a tank with a fish-friendly outlet control gate leading to a flume. The flume includes a bifurcation and switch gate directing the juvenile fish to one of two juvenile holding tanks.

4.6.8.3 Juvenile Holding Tanks

There are two identical Juvenile Holding Tanks. Each tank contains two areas. The main area of each tank is the smolt holding area, which is 30 feet long, 4 feet wide, and 4 feet deep. Each tank can hold up to 9,500 smolts with an average length of 8 inches (steelhead), or 19,000 smolts with an average length of 6 inches (Chinook). Near the far end of each juvenile tank (opposite from where the fish enter) is a fry refuge area. The refuge area is 4 feet by 4 feet and is located adjacent to the side of the smolt holding area. The refuge area is hydraulically connected to the smolt holding area, but separated by a fry isolation screen. The fry isolation screen allows fry-sized fish to pass into the refuge area but prevents smolt-sized fish from entering. Circulation water in the juvenile tanks will flow from the upstream end of the tank, where the fish enter, downstream toward the fry refuge areas, to help encourage the fry to move downstream toward the refuge areas.

Each juvenile holding tank includes a horizontally travelling crowder for moving fish toward the downstream end of the tank. At the far downstream end of the tank, just beyond the fry refuge area, there is a floor brail. The tank crowder travel range ends at the upstream edge of the brail forming a walled box surrounding the perimeter of the brail. The brail can then be raised vertically to move the fish toward the surface where they can be transferred to an anesthetic tank located just beyond the holding tank. The smolt anesthesia tank will also have a floor brail that will be used to crowd anesthetized fish toward the surface of the tank for transfer to the smolt sorting table. The juvenile tank brail area will also have the ability to transition fish to a hose assembly attachment to allow for direct passage of the fish to the transfer tanks for transport of the fish downstream without anesthesia or sampling. Hoses or Spiralite pipe is recommended over fixed rigid supports for moving smolts and fry to allow for flexibility of destination pods and the ability to remove the hoses when not in use. The hose can be easily moved about in the FHF depending on the use and destination of the fish.

The flume passing fish from the juvenile separator to the juvenile holding tanks includes a switch gate to direct the fish to one of the two juvenile holding tanks. The switch gate could be operated for a variety of purposes. First, the switch gate would always be switched to the opposite tank when a crowding operation is about to begin, to prevent fish from being discharged into the back side of the crowder panel. Second, the switch gate could be operated manually by choice, to switch to the second tank when the first tank appears to adequately full of fish. A third operation could be timed to automatically operate the gate by the PLC to direct a subsample of fish (based on a timed percentage) to one of the tanks and the remainder of the fish to the other tank. This type of operation would allow for subsampling a portion of the population while passing the majority of the fish directly to the transfer tanks.

4.6.8.4 Juvenile Sampling and Transfer

The smolt sorting table is located adjacent to the smolt anesthetic tank, and it is used during sampling for identifying and sorting the fish into one of three 500-gallon transfer tanks. The sorting table also serves as a work table for any other activities such as sampling, tagging, or miscellaneous fish handling. The table will have a splash board along the back side with three opening ports, each leading to a hose attachment to be used for placing fish into one of the three transfer tanks. In this way the fish can be separated by species and/or final transport destination before the fish are lifted off the FSS. Ultimately, the transfer tanks will be sealed and lifted off the FSS by the bridge crane located above at the transport truck loading station on the SWS access bridge. The bridge crane on the access bridge is being designed by the USACE, and details can be found in the DDR document for the SWS. The transport trucks will be specially-designed flatbed trucks designed to accommodate the transfer tanks and to provide oxygenation to the tanks during transport.

Fry-sized fish that have taken refuge in the refuge areas would be transferred directly into 250-gallon transfer tanks located directly adjacent to the refuge areas. These fry transfer tanks, when filled with fish, would be sealed and lifted with the FSS bridge crane for transfer to the far port side of the handling facilities, adjacent to the 500-gallon tanks, so that they can be reached and lifted by the bridge crane above on the access bridge. It is assumed that the fry will not require any anesthesia or sampling and can be loaded and transferred directly off the FSS.

4.6.8.5 Adult Holding, Sampling, and Transfer

Fish too large to fit between the tubes of the juvenile separator will slide off the ends of the tubes into an adult holding tank. It is not anticipated that there will be a large number of adult fish captured by the FSS. The majority will likely be steelhead kelts returning downstream. Adult Chinook fallbacks are anticipated to be unlikely occurrences because the adult fish will be transported upstream for release in the tributaries or upstream reaches of the reservoir. Fallbacks are more common at facilities where there is a fish ladder and adult fish are released at the dam and are expected to swim up through the reservoir on their own. Other fish that may find their way to the adult holding tank would include adult resident species that although significantly smaller than kelts or anadromous adult fallbacks still may be too large to pass down through the juvenile separator.

The adult holding tank is 14 feet long by 4.4 feet wide, with a water depth of 5 feet. It has a capacity to hold about 150 adults at an average weight of 8 pounds per fish, in 50º F water. The capacity should be halved to 75 fish of the same weight if the temperature is 70º F. As with the juvenile holding tank, the adult tank has a brail at the downstream end (opposite end from where the fish enter the tank). A horizontally travelling crowder (similar to juvenile tanks) is used to crowd fish over the brail, and the brail is used to raise fish vertically so they can be sluiced into the anesthetic tank. In this case, the anesthetic tank is integral with the adult sorting table, so that anesthetized fish can simply be slid up onto the table. From the table, the fish are placed into one of two 250-gallon adult transfer tanks. As with the 250-gallon fry tanks, the adult transfer tanks will need to be lifted with the FSS bridge crane and moved to a position on the port side so that they can be reached by the upper bridge crane on the access bridge.

4.6.8.6 250/500 Gallon Transfer Tanks

Fish will be transported from the FHF to a release point by either 250-gallon or 500-gallon transfer tanks. The transfer tanks are rectangular box shaped containers constructed of either aluminum or stainless steel. The tanks are equipped with removable/refillable oxygen tanks and internal water circulation systems that provide life support for the fish while in transit to the desired release point. The 250/500-gallon capacities work as a modular system, that can be used independently or in combination with the larger 1500-gallon transport truck. The 250/500-gallon transfer tanks could be used to move fish from the FHF for transfer into the existing 1500-gallon trucks on the access road if needed. However, the design intent is that the tanks could be loaded on a specially-designed flatbed truck for transport directly to the release sites.

4.6.9 SWS Control Gates

The screened flow from the two large screen channels is all combined in a large plenum. The water level in the plenum will be a function of the FSS operating flow at the time. With the current preliminary design settings, at the design flow rate of 4,500 cfs the water level in the plenum would be 3.15 feet below the reservoir level. At the minimum flow rate of 1,000 cfs (off-line operation with pumps) the level would be about 2.21 feet below the reservoir, and at the maximum flow of 5,600 cfs the plenum level would be 3.84 feet below the reservoir.

Toward the aft end of the port side of the FSS, the FSS will meet with the west wall of the SWS. At this location there are two large outlet gates along the wall of the FSS for passing the flow from the FSS plenum into the SWS. Over a 74-foot-long area, adjoining the 80-foot-long SWS west wall, the flotation cell on the port side of the FSS will be shortened leaving a 20-foot-high opening in the wall between the bottom of the shortened flotation cell and the top of the belly tanks. A gate support column will be in the center of this opening, creating two openings each approximately 34 feet wide by 20 feet tall. The openings will have control gates to open up or shut off the flow. The gates will be controlled with operators located above them along the side of the FSS.

Typically, these gates would be either full open (raised up and stored in a slot adjacent to the shortened flotation cell) or fully closed (lowered down to the top of the belly tanks), and flow control would be accomplished by adjustment of the turbine wicket gates and the setting of the lower SWS gates to match the target temperature, as described in Section 4.4. On rare occasions where there is a call for a very small flow percentage from the surface to meet the temperature goal, and the lower SWS gates are already fully open, there may be a need to perform some level of flow control with these gates.

Flow will pass through the two gate openings into a pocket of water between the FSS and the SWS, and then pass into the SWS through the 20-foot-wide slots in the SWS wall. At the design FSS flow of 4,500 cfs the head drop across the gates, from the plenum to the pocket area would be about 0.4 feet. An additional approximately 0.4 feet would be dropped with the flow passing through the SWS slots. This would result in an estimated water level in the SWS at about 4.0 feet below the reservoir level. At the maximum flow of 5,600 cfs, the loss through FSS openings would increase to over 0.6 feet, with a corresponding loss through the SWS slots. This would result in an estimated water level in the SWS at 5.1 feet below the reservoir level.

5 STRUCTURAL DESIGN

5.1 FSS Structural Design

5.1.1 General

The FSS is an all-welded, rectangular-shaped, floating steel structure 304 feet long by 101.5 feet wide by 48 feet high. Structural arrangement is designed to allow breakdown into a series of modules that are intended to be fabricated off site and trucked to a site on the Detroit reservoir for assembly into the complete structure. Field welding is required to join modules together at the assembly site. It is intended that modules be pre-outfitted prior to delivery to the assembly site as much as practicable. However, various outfitting activities such as pulling electrical cable, installation of screen cleaners, and the like must be accomplished after the FSS structure is fully assembled.

To reduce the number of stiffener connections at module boundaries the belly tanks, including the tank top, will be transversely framed and all structure above the belly tanks will be longitudinally framed.

Preliminary plate thickness calculations for use in developing the weight estimate are in Appendix E. Further Structural Calculations in accordance with design standards and loads will be provided in the 60% DDR.

5.1.2 Design Standards and Reference

The structural design will conform to the following.

- American Bureau of Shipping (ABS), Rules for Building and Classing Steel Barges 2018
- American Institute of Steel Construction (AISC), Steel Construction Manual, 14th Edition (AISC 360-10)
- American Welding Society (AWS), AWS D1.1, 2010 Structural Steel Welding Code
- Structural Engineers Association of Oregon, 2007, Snow Load Analysis for Oregon

ABS *Rules for Building and Classing Steel Barges 2018* applies to the design and construction of steel barges in unlimited ocean service. Using this design standard represents a conservative approach to FSS structural design since the FSS is moored and operates in a fresh water reservoir.

Structural members are sized in accordance with ABS barge rules, which provides parametric rules for required minimum thickness and/or section modulus for plates and shapes (stiffeners). Rules are given that are specific to location of the structure (e.g. deck, bottom, shell, and the like) and the type of stiffener (e.g. stringer, girder, deck beam, and the like). Rule parameters for stiffeners include factors to account for moment connections (fixity) at the ends.

ABS barge rules reflect an Allowed Strength Design (ASD) approach with 50% factor of safety.

Additional design standards and references to be included in the 60% DDR.

5.1.3 Performance and Serviceability Criteria

The FSS design service life is 50 years. A key element of this criteria is the ability to service the structure on site and in the water when the FSS is dewatered with fish attraction channel elements above water. This also allows internal inspection of belly tanks. It is intended that all surfaces that remain submerged when dewatered are provided with a 50-year protective coating system. Thus, no “corrosion allowance”, other than included in ABS rules, will be applied to structural member scantlings.

5.1.4 Design Loads and Load Combinations

Design loads and load combinations for ASD identified in the AISC Steel Construction Manual are not explicitly applied in the structural design. FSS structure is not subject to live roof load, wind load, or earthquake load. Dead load, live load, and snow and ice load are not identified separately, but combined into a single pressure load in the ABS rules.

ABS rules apply a pressure load based on the hydrostatic head to the member under consideration. The hydrostatic head is expressed as the distance from the member under consideration to a higher point (water surface, tank overflow, distance above the main deck, and the like). For horizontal members, the pressure load is uniform over the entire area supported. For vertical members, the pressure load is triangular increasing over the area supported as the member’s distance below the water surface increases.

The hydrostatic head used in ABS rule equations for the design of all members below the main deck is the distance from the member under consideration to the main deck at edge. The hydraulic head (h) for the design of main deck structure is in accordance with the following ABS rule equation.

$h = 0.02\ L + 2.5$ feet = 8.58 feet; where L is FSS overall length.

For fresh water, h = 8.58 feet is equivalent to 535 psf. This is much greater than the sum of anticipated dead load (less than 40 psf) and snow and ice load (about 30 psf). The implied live load, then, is 450 psf or greater.

Loads for the design of structure supporting localized loads, such as from bridge columns, are combined with the pressure load used in ABS rules.

5.2 Mooring Pile Structural Design

5.2.1 General

This section describes design performance and serviceability criteria, load criteria, and load combinations for design of the FSS mooring structural system and any ancillary structures or facilities. Criteria are developed from applicable industry codes and standards, as referenced herein. The objective of the FSS mooring system is to meet all strength and serviceability requirements, and interface appropriately with the temperature control tower, also referred to as the selective withdrawal structure (SWS), and surrounding environment. Calculations applicable to criteria listed in this section can be found in the appendix.

5.2.2 Design Standards and References

- American Institute of Steel Construction (AISC), Steel Construction Manual, 14th Edition (AISC 360-10).
- American Society of Civil Engineers (ASCE), Minimum Design Loads for Buildings and Other Structures (ASCE 7-10).
- Department of the Army, Waterways Experiment Station, Corps of Engineers (1984) Shore Protection Manual Volume I, Second Printing
- EM 1110-2-6503, Earthquake Design and Evaluation of Concrete Hydraulic Structures
- ETL 1110-2-584, Design of Hydraulic Steel Structures
- International Building Code (IBC), 2012, International Building Code
- International Code Council (ICC), Oregon Structural Specialty Code, 2014
- Unified Facilities Criteria, UFC 4-150-06, Military Harbors and Coastal Facilities
- Unified Facilities Criteria. UFC 4-152-01 Design: Piers and Wharves.
- Unified Facilities Criteria. UFC 4-159-03 Design: Moorings.
- U.S. Geological Survey (USGS). 2017. National Seismic Hazard Maps

5.2.3 Performance and Serviceability Criteria

5.2.3.1 Operational, Geometric, and Constructability Constraints

- Translation in the horizontal (x,z) plane will need to be carefully managed because the FSS will be located in close proximity to the SWS. This will likely require that the mooring dolphins be placed on both planes of the FSS hull. Four dolphins located around the FSS may be required to handle motion in all six degrees of freedom. Increasing the number of FSS mooring positions to four could allow for substantial reduction in the diameter of the required piling. With this tight tolerance, binding problems could occur in the pile hoop and tracks. This could create damage, and will need to be evaluated.
- It is likely that the FSS and SWS would collide in a seismic event, as both structures would have different modes and frequencies of vibration. If the two structures are less than one foot apart, a fender system would likely be essential to mitigate damage from collision in an earthquake. Also, strong consideration should be given to a connection between the FSS and SWS. This connection would require coordination between the designs of the FSS and the SWS, including seismic analysis results, which would likely benefit both structures by providing damping and support for asymmetric load scenarios.
- Assuming the use of guide piles for FSS moorings, it will be necessary to consider potential interference with crane operation to handle fish hoppers.

- If the Piles are driven plumb, then the pile frames (two) could serve as templates for driving. The Piles would serve as portals for drilling equipment.
- Frames will need to be floating (not connected to the piles), thus underwater work will be required to fix the collars for the intermediate frame either by fixing the frame brackets via welding or threaded rods.
- Batter piles are probably not feasible except perhaps on the highway side, depending on pile lengths required. The use of batter piles eliminates the ability to use intermediate frames, and potentially buckling will be an issue.
- To avoid uplift concerns, piles will need to be filled with concrete. To decrease pile deflection, rebar cages will need to be inserted before or during placement of concrete.
- Corrosion will not be a serious concern as this is fresh water – anodes not required.
- The current concept design for the FSS mooring employs large diameter steel pipe pile that could weigh over 100 tons each. The feasibility of both transport and installation of such heavy and large piles should be considered.

5.2.3.2 FSS Dimensions

- FSS Length = 304 feet
- FSS Width = 101.5 feet
- FSS Overall Height = 48 feet
- De-ballasted Condition:
    - Freeboard = 41.5 feet
    - Draft = 6.5 feet
    - Longitudinal Projected Wind Area (SWS shielding) = 8,725 ft^2
    - Longitudinal Projected Current Area (SWS shielding) = 1,235 ft^2
    - Longitudinal Projected Wind Area (Dam shielding full pool) = 10,476 ft^2
    - Longitudinal Projected Wind Area (No shielding) = 11,796 ft^2
    - Longitudinal Projected Current Area (No shielding) = 1,716 ft^2
    - Front Transverse Projected Wind Area = 4,212 ft^2
    - Front Transverse Projected Current Area = 660 ft^2
- Maximum Depth Condition:
    - Freeboard = 5 feet
    - Draft = 43 feet

- Longitudinal Projected Wind Area (Including SWS shielding) = 1,150 ft2
- Longitudinal Projected Current Area (Including SWS shielding) = 8,810 ft2
- Longitudinal Projected Wind Area (Excluding SWS shielding) = 1,520 ft2
- Longitudinal Projected Current Area (Excluding SWS shielding) = 11,992 ft2
- Front Transverse Projected Wind Area = 508 ft2
- Front Transverse Projected Current Area = 4,265 ft2

5.2.3.3 Facility Configuration

- Reservoir Levels
  - 1445 feet = Minimum operating reservoir elevation
  - 1569 feet = Maximum operating reservoir elevation
  - 1425 feet = Minimum extreme reservoir elevation
  - 1574 feet = Maximum extreme reservoir elevation

5.2.4 Material Properties

Steel Pipe Piles:

- ASTM A53 Grade B
- Yield Strength Fy = 35 ksi
- Elastic Modulus E = 29,000 ksi
- Size to be determined, but diameter to thickness ratio D/t will be kept less than 0.09E/Fy for concrete filled piles in order to keep the shape compact for flexure.

Composite Pile Concrete Fill:

- The pipe piles will be filled with reinforced concrete to form a composite member
- The effective stiffness of the composite pile can be determined by equation I2-12 in AISC 360-10. $(EI)_{eff} = E_sI_s+E_sI_{sr}+C_3E_cI_c$. Subscript “s” indicates a steel pipe property, subscript “sr” indicates a reinforcing steel property, and subscript “c” indicates a concrete property. C_3, as defined in AISC Specification chapter I, is between 0.6 and 0.9, depending on the ratio of steel area to concrete area.

5.2.5 Design Loads

Loads will be considered in three categories as defined in ETL 1110-2-584 and other USACE design publications.

1) Usual. Loads in the Usual load category occur daily or frequently during operation, with a return period between 1 and 10 years. The structure requires highly reliable performance under usual loads. Structural members should remain elastic, and serviceability limit states apply.

2) Unusual. Loads in the unusual load category occur less frequently, but can be reasonably expected to occur during the design life of the structure, with a return period between 10 and 300 years. The structure must have a defined level of performance under unusual loads. Localized yielding is acceptable, as is defined in industry design procedures such as the AISC Steel Construction Manual.

3) Extreme. Loads in the extreme category are not likely to occur within the design life of the structure, with a return period above 300 years. Significant damage may occur, but the objective is to prevent catastrophic collapse.

5.2.5.1 Wind

The Oregon Structural Specialty Code, 2014, along with ASCE 7-10, contain basic wind design criteria and procedures for calculating wind forces on buildings, components, and building-like structures. These criteria can be used for design of the FSS structural elements, components, and cladding. Wind forces impact floating structures and mooring systems differently than fixed buildings. UFC 4-152-01 Design: Piers and Wharves, UFC 4-159-03 Design: Moorings, and the Shore Protection Manual contain information for developing mooring wind loads.

Table 5.1 - Wind load criteria for use in mooring system design

Description of Criteria		Criteria	Reference and Notes
Wind - Mooring			
	Exposure Category	D	Defined in 1609.4, OSSC. Also recommended in UFC 4-159-03 Table 3-5 Note 1.
	Wind Gust Duration	30 seconds	UFC 4-152-01 3-4.2
	Wind Return Period	100 years	UFC 4-159-03 Table 3-5
	Ultimate Design Wind Speed	115 mph	Figure 1609C, OSSC, Marion County. This is for a 3 second gust at 33 feet, with a 300 year return period
	Mooring Design Wind Speed	91 mph	Converted from ultimate design wind speed for mooring application. See UFC 4-152-01 3-4.2. This speed serves for calculating “Unusual” wind and wave forces.
	Operational Wind Speed	40 mph	This speed serves for calculating “Usual” wind and wave forces.

5.2.5.2 Seismic

Seismic ground motions will impact structures attached to the ground, meaning the dam, the temperature control tower, and any FSS mooring ground connections. Forces will be transferred to the floating FSS through the guide mooring system. The relative stiffness of connecting elements, and damping effects of the water will need to be considered. There will also be inertial hydrodynamic seismic forces from the water acting on underwater elements of the FSS.

Since there is no direct connection between the ground and the FSS, and because the seismic motions are cyclic and the composite period of the floating FSS structure is quite large, it is unlikely that the seismic displacement of the guidepiles (in the x and z directions) will be able to impose any movement in the FSS. The cyclic motion of the piles inside the pile hoops, assuming it is greater than the tolerance between the pile and the UHMW bearings, could potentially cause damage to the UHMW bearings. Whether damage occurs, and the degree of any damage, is dependent on the frequency and amount of translation invoked into the guidepiles by the movement of the earth at the base of the guidepiles. Since the piles themselves are flexible (springs), it is doubtful that much, if any, movement of the top of the pile will occur at the elevation of the mooring bearing points during the design earthquake.

The same is not true of the SWS, since it is founded directly into the rock. Depending on the clearance between the SWS and the FSS, during a seismic event, the SWS could collide with the FSS. Therefore, a fender system should be designed to allow for proper dissipation of the energy of these collisions into the FSS – in this way the FSS combined with its guidepile mooring system could act as a damping system for the SWS in the z direction.

Design seismic values are obtained from the USGS web-based seismic design tool, which provides values in accordance with ASCE 7-10 and the IBC, based on the 2009 NEHRP recommendations. Values are based on the risk-targeted maximum considered earthquake (MCE_R), derived from a 1% probability of collapse in 50 years, adjusted from a uniform hazard of 2% probability of exceedance in 50 years. The design values are therefore classified as “Extreme” loads.

Table 5.2 - Seismic design parameters

Description of Criteria		Criteria	Reference and Notes
Seismic			
	Seismic Importance Factor I_E	1.0	
	S_S S_1	0.652 0.310	Generated using USGS Seismic Design Map Tool. Input: Latitude: 44.72 Longitude: -122.25 Code Ref: 2009 NEHRP Recommended Site Class: B – “Rock” Risk Category: I
	S_{DS}	0.435	See above.

	S_{D1}	0.207	
	PGA	0.290	See above
	Site Class	B	ASCE 7-10 20.3

5.2.5.3 Hydrodynamic Forces

Hydrodynamic forces on the FSS will be from waves, current in the reservoir, and suction and momentum changes from operational flows through the FSS. It is assumed that there will be no net hydrostatic forces acting on the FSS as a whole.

5.2.5.3.1 *Waves*

Significant Wave Height H_s:

- 2.94 ft (Based on wind speed V = 91 mph)
- 1.23 ft (Based on wind speed V = 40 mph)

Wave Period:

- 2.96 sec (Based on wind speed V = 91 mph)
- 2.21 sec (Based on wind speed V = 40 mph)

The fetch is approximately 2.3 miles to the southeast of the Detroit Dam.

5.2.5.3.2 *Current*

Hydrodynamic modeling will be used in the next stages to determine more accurate current forces and distribution. At this point, a current load estimate was determined using basic hydrodynamic drag, with an assumed coefficient of drag of 0.95. A 5 ft/sec current generates approximately a 23 psf force on underwater surfaces, and a 1 ft/sec current generates approximately a 0.92 psf force on underwater surfaces.

5.2.5.3.3 *Suction and Momentum Change*

An analysis is herein conducted of the forces caused due to momentum changes, both caused by suction and via change in direction of the flow inside the FSS. This was conducted to ensure that these loads are or are not significant as they could influence the mooring geometry and design:

Maximum flow through FSS = 5,400 CFS

dm/dt = density*velocity*area = mass flow/time

= Mass flow rate= (62.4 lbs/cu ft)*(5,400 cfs)/(32.2 ft/sec^2) = 10,646 slug/sec

Thrust Force (F) = change in Momentum with time

$F = d(mv)/dt + A_e*dp =\sim (m_1v_1 – m_0v_0)/(t_1 – t_0) + (p_1 – p_0)* A_e$

If $v_0 = 0$ and $p_1 = p_0$, then $F = v_1*dm/dt$

i. Analyzing flow in the x – direction (towards the stern of the FSS)

v_1 = 7 fps (capture velocity)

Idealized maximum Thrust Force = F = 7*(10,646) = 74.5 kips in negative x direction – i.e. suction force.

There is a counter-thrust force in the x direction due to the 90 degree change in direction (i.e. where the flow rate is reduced to 3 fps and the x component of that momentum goes to zero). Thus, v_1 is approximately reduced to the value at the point where the 90 degree turn occurs, i.e. v_1 = 3 fps

Approximate maximum Thrust Force in negative x direction = F_x = -74.5 kips + 3* 10,646 = -42.5 kips

ii. Analyzing flow in the z – direction (towards the port side of the FSS, into the SWS):

v_0 =3 fps, and v_1 =0

Approximate maximum Thrust Force in negative z direction = F_z = -3* 10,646 = -32 kips

Thus, the Thrust Forces on the FSS due to momentum changes are significant relative to the environmental loads.

5.2.6 Environmental Load Combinations

Wind and wave loads are combined in the following load cases:

- Case 1: Wind and wave forces on the east side of the FSS. The SWS is assumed to shield the FSS from wind and waves over the adjacent area.
  - Case 1a.1: FSS deballasted (draft = 6.5 feet), unusual wind (V=91 mph)
  - Case 1a.2: FSS deballasted (draft = 6.5 feet), usual wind (V=40 mph)
  - Case 1b.1: FSS fully ballasted (draft = 43 feet), unusual wind (V=91 mph)
  - Case 1b.2: FSS fully ballasted (draft = 43 feet), usual wind (V=40 mph)
- Case 2: Wind forces on the west side of the FSS. No waves, due to no fetch in this direction. The dam is not assumed to shield the FSS from wind force.
  - Case 2a.1: FSS deballasted (draft = 6.5 feet), unusual wind (V=91 mph)
  - Case 2a.2: FSS deballasted (draft = 6.5 feet), usual wind (V=40 mph)
  - Case 2b.1: FSS fully ballasted (draft = 43 feet), unusual wind (V=91 mph)
  - Case 2b.2: FSS fully ballasted (draft = 43 feet), usual wind (V=40 mph)
- Case 3: Wind and wave forces on the south side of the FSS
  - Case 3a.1: FSS deballasted (draft = 6.5 feet), unusual wind (V=91 mph)
  - Case 3a.2: FSS deballasted (draft = 6.5 feet), usual wind (V=40 mph)
  - Case 3b.1: FSS fully ballasted (draft = 43 feet), unusual wind (V=91 mph)
  - Case 3b.2: FSS fully ballasted (draft = 43 feet), usual wind (V=40 mph)

Using the above load cases and conditions the following logical load combinations are developed to determine the worst-case design scenario for FSS mooring system:

Wind from the East (z direction) load combinations:

1) Worst case operating load combination:
   a. Assumptions:
      i. Barge will be deballasted (freeboard = 41.5 ft, draft = 6.5 ft)
      ii. Since the operational loads are greater than the "usual" environmental loads, the worst-case load occurs when the wind is assumed to be directly on the port side of the FSS (from the East).

iii. FSS superstructure is shielded from the wind by the SWS.

iv. Usual wind and wave conditions (wind – 40 mph from the East).

v. Maximum operational flow will be used (5,400 cfs)

vi. Current flow will be low = 1 fps towards the dam

b. Unprotected length of FSS = 220 ft (RISA model)

c. Wind force = 24 kips/220 ft (unprotected area) = 0.11 kip/ft (-z direction)

d. Wave force = 3.3 kips/170 ft (area nearest the FSS bow) = 0.019 kips/ft (-z direction)

e. Current force = 1.1 kips/170 ft (area nearest the FSS bow) = 0.007 kips/ft (-z direction)

f. Operational Forces:

i. -x direction = 42.5 kips/102 ft (acting on the bow of the FSS) = 0.42 kips/ft

ii. -z direction = 32 kips/80 ft (into the SWS) = 0.4 kips/ft

2) Survival Load Case No. 1

a. Assumptions:

i. FSS is not in operational mode

ii. FSS is de-ballasted

iii. Dam is spilling

iv. Maximum winds/waves from the East (wind - 91 mph)

b. Wind force = 124 kips/220 ft (unprotected area) = 0.56 kip/ft (-z direction)

c. Wave force = 10.5 kips/220 ft = 0.05 kips/ft (-z direction)

d. Current force = 28.4 kips/170 ft (closest to bow of FSS) = 0.167 kips/ft (-z direction)

3) Survival Load Case No. 2

a. Assumptions:

i. FSS is not in operational mode

ii. FSS is ballasted

iii. Dam is spilling

iv. Maximum winds/waves from the East

b. Wind force = 16.3 kips/220 ft (unprotected area) = 0.075 kip/ft (-z direction)

c. Wave force = 3.3 kips/220 ft = 0.015 kips/ft (-z direction)

d. Current force = 172.4 kips/170 ft (closest to bow of FSS) = 1.0 kips/ft from 0 to 170' and 14.7 kips/50 = 0.3 k/ft from 250 to 300 (-z direction)

4) Survival Load Case No. 3

a. Assumptions:

i. FSS is not in operational mode

ii. FSS is de-ballasted

iii. Dam is spilling

iv. Maximum winds/waves from the South

b. Wind force = 35.6 kips/102 ft (unprotected area) = 0.35 kip/ft (x direction)

c. Wave force = 5.8 kips/102 ft = 0.57 kips/ft (x direction)

d. Current force = 15.2 kips/170 ft (closest to bow of FSS) = 0.089 kips/ft (-z direction)

5) Survival Load Case No. 4

a. Assumptions:

i. FSS is not in operational mode

ii. FSS is de-ballasted

iii. Dam is not spilling (no current)

iv. Maximum winds (no waves) from the West

b. Wind force = 182 kips/300 ft (unprotected area) = 0.61 kip/ft (z direction)

5.2.7 Load Combination – RISA Model results

RISA-3D (Rapid Interactive Structural Analysis – 3-Dimensional, by RISA Technologies Inc.), is a three-dimensional structural analysis and design software program used for analysis of the FSS mooring pile system. The software provides graphical modeling capability, along with analysis results and design calculations for a variety of structural materials. Hot rolled steel and concrete analysis are supported in the software; however, design of composite reinforced concrete filled steel pipes is a bit more nuanced, and is not directly performed in the software.

Since RISA will not model composite pipe/concrete members, it was necessary to construct a model with pure pipe piles that had a value of EI (the product of the modulus of elasticity of the material times the moment of inertia of the section) that would limit deflection of the system to no greater than 30” for any portion of the FSS under a survival scenario. This number was based on iterative analysis of the model. The required EI was determined to be about 1.4 X 10^{13}. This required a 72” diameter steel pile with 4” thick walls. This is roughly equivalent in EI to a composite pile 72” in diameter with 2” walls filled with reinforced concrete.

Since concrete has little strength in tension, the overall strength of a composite steel-concrete pile will not match the strength performance of an EI-equivalent pure steel pile. The rebar in the composite will need to be designed to provide enough resistance in tension to achieve the required bending strength under the worst load combination, which is the controlling factor in the design of this type of cantilever pile.

Since the loads are much greater on the bow of the FSS, a fourth pile (forming a diamond shaped dolphin) was added to the forward-most dolphin. The longer pile dolphins along the portside of the FSS are built with A36 72” diameter steel piles with 4” walls. The shorter pile dolphins are built with A36 60” steel piles with 2” walls. The width of the walls will be refined during the design process, but for the concept design, it can be assumed that when filled with properly reinforced concrete the longer piles can be reduced to 2.0” walls and the 60” piles can be reduced to 1.0” walls.

A 6” limit in deflection of the FSS with respect to the SWS is considered the limit in operational mode.

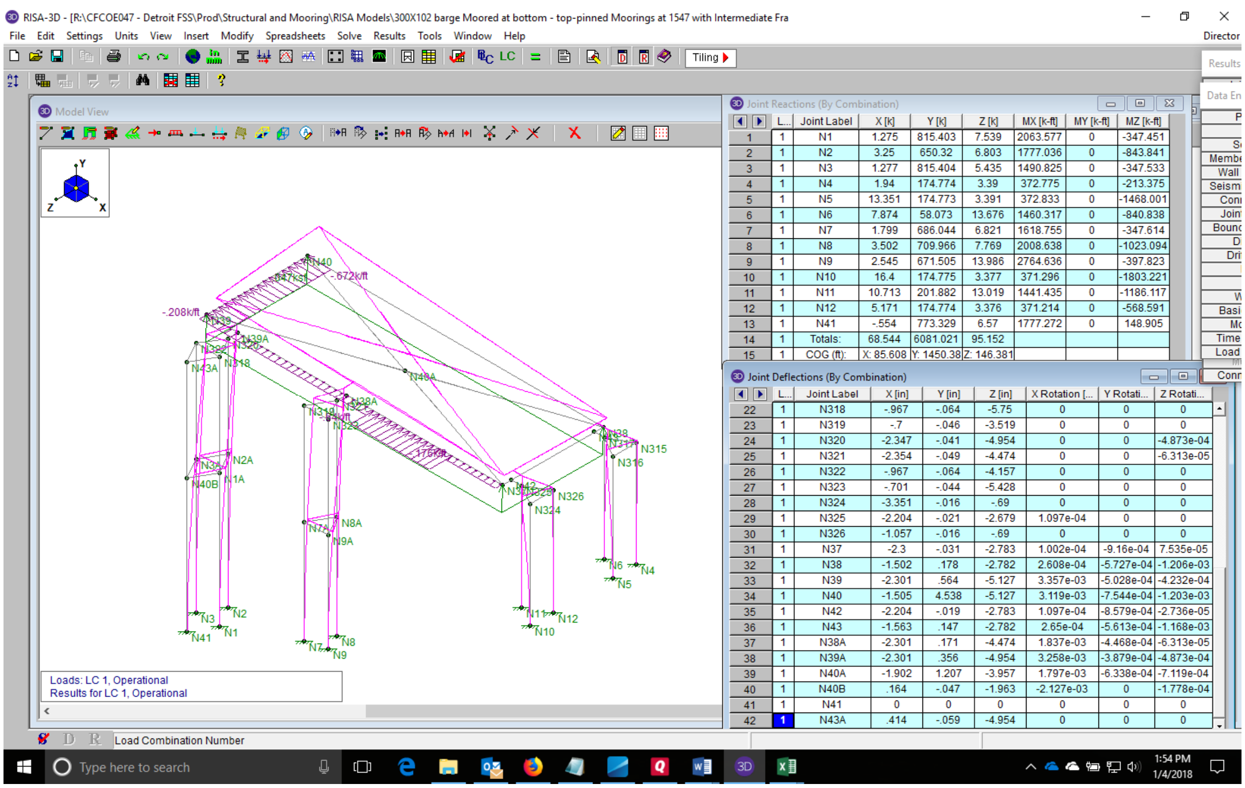

Figure 5-1 - Worst Case Operational Load

Under this normal operational scenario under the most extreme operating conditions expected, movement of the barge varies from near zero at the stern of the FSS to about 5.5 inches at the bow. Therefore, this placement geometry of the dolphins will meet the 6” movement criteria for the FSS during worst case operating conditions.

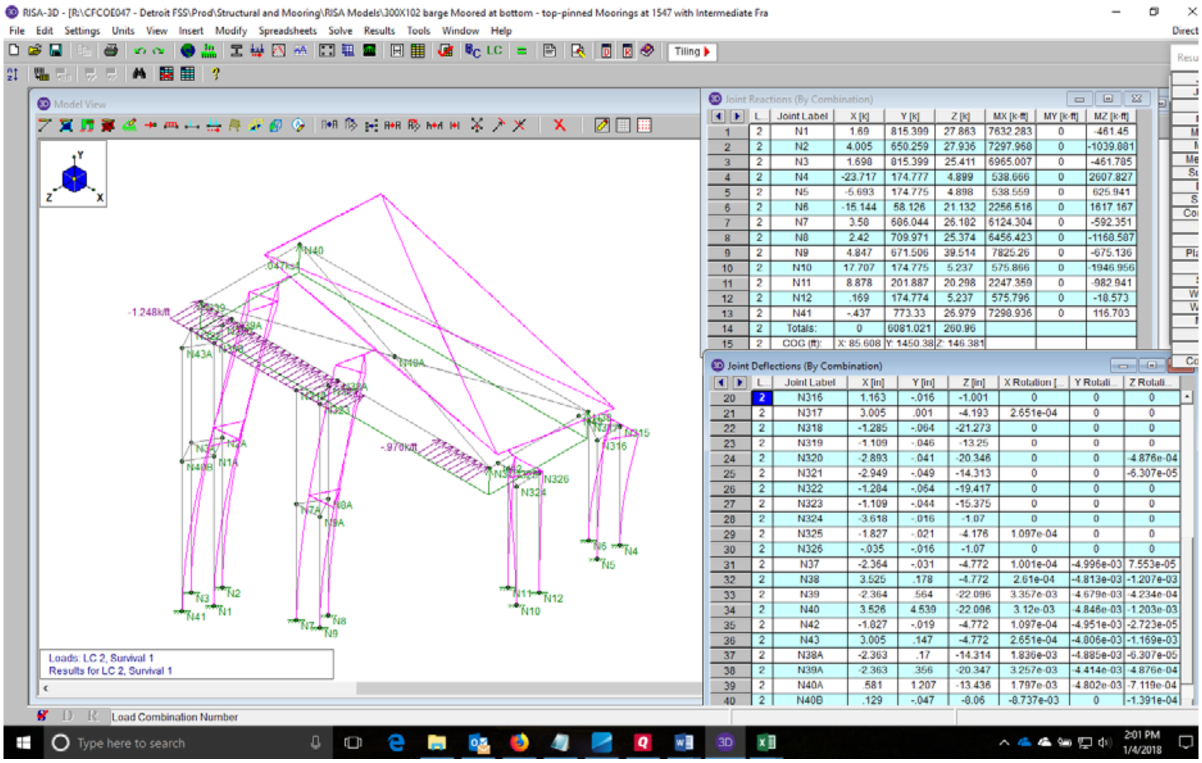

Figure 5-2 - Survival Load Combination Scenario no. 1

Under this load combination the FSS will move approximately 23” near the bow and about 6” near the stern. Loads on the piles are large enough to be significant for this load combination.

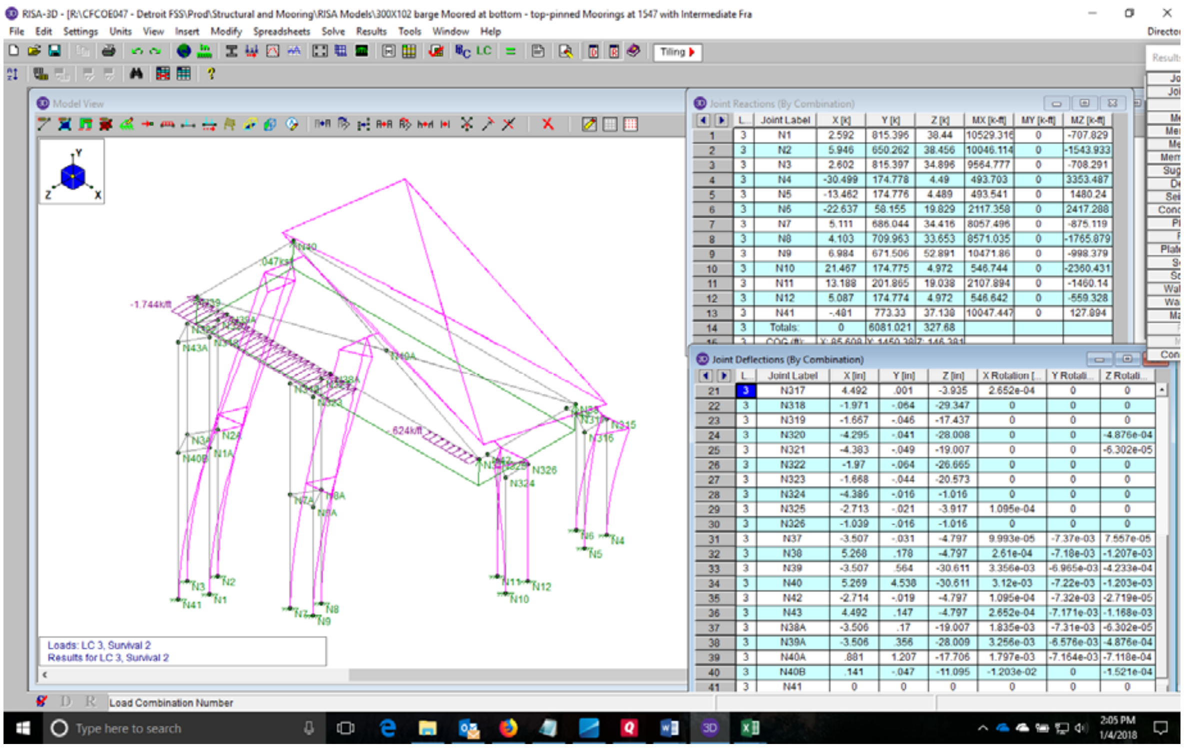

Figure 5-3 - Survival Load Combination Scenario No.2

This is the load combination that produces the greatest deflections and the highest stresses in the piles. The highest deflections of approximately 31" will occur near the bow of the FSS and about 6" at the stern. The highest bending moment will occur at the bottom of all four piles in the dolphin supporting the bow at about 10,500 k-ft or 126,000 k-in. A 72" steel pile with a 2" thick wall that is filled with concrete has a factored moment resisting capacity of 371,000 k-in. Based on the model output for this apparent worst-case scenario, the six shorter piles are receiving loads in the 2,000 k-ft or 72,000 k-in range. A 60" pile with a 1" wall augmented by reinforcing steel has a factored moment resisting capacity of 139,000 k-in. Even under this worst-case load combination the piles will be performing well below their allowable stress limit, and the piles will not fail.

Comparison of survival load combinations 1 and 2 predicts that when a storm is imminent from the Easterly direction and the dam is spilling, it would likely be better to leave the FSS in a de-ballasted condition, as the loads from the maximum wind are less than those from the current generated by the spilling event. If the dam is not spilling then it would be better to ballast the FSS during a storm as it will reduce the forces due to wind. If this could be considered to be an operating constraint, and removal of survival mode no. 2 is feasible, the size of the piles could be reduced. These potential operating parameters can be refined as the design progresses and more accurate loads and design refinements can be derived based on hydrodynamic modeling of the various scenarios.

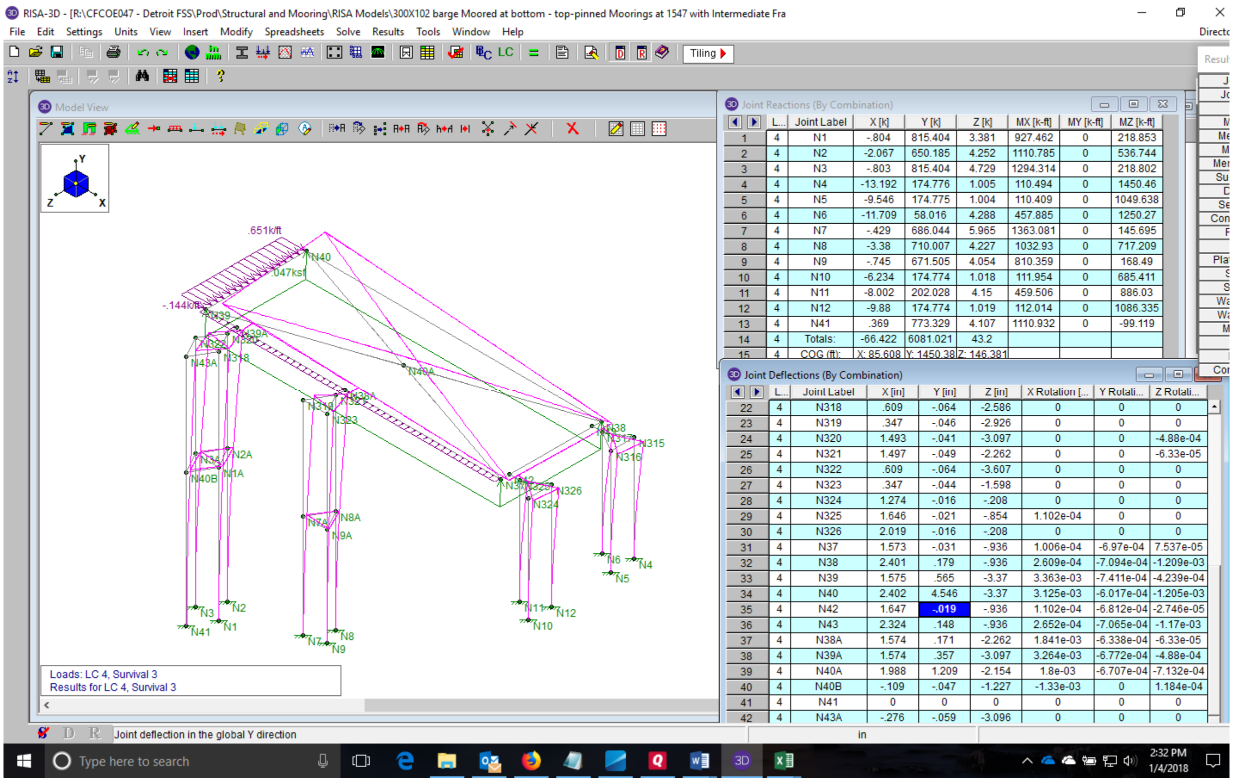

Figure 5-4 - Survival Load Combination Scenario No.3

Both the loads and deflections are insignificant for this load combination

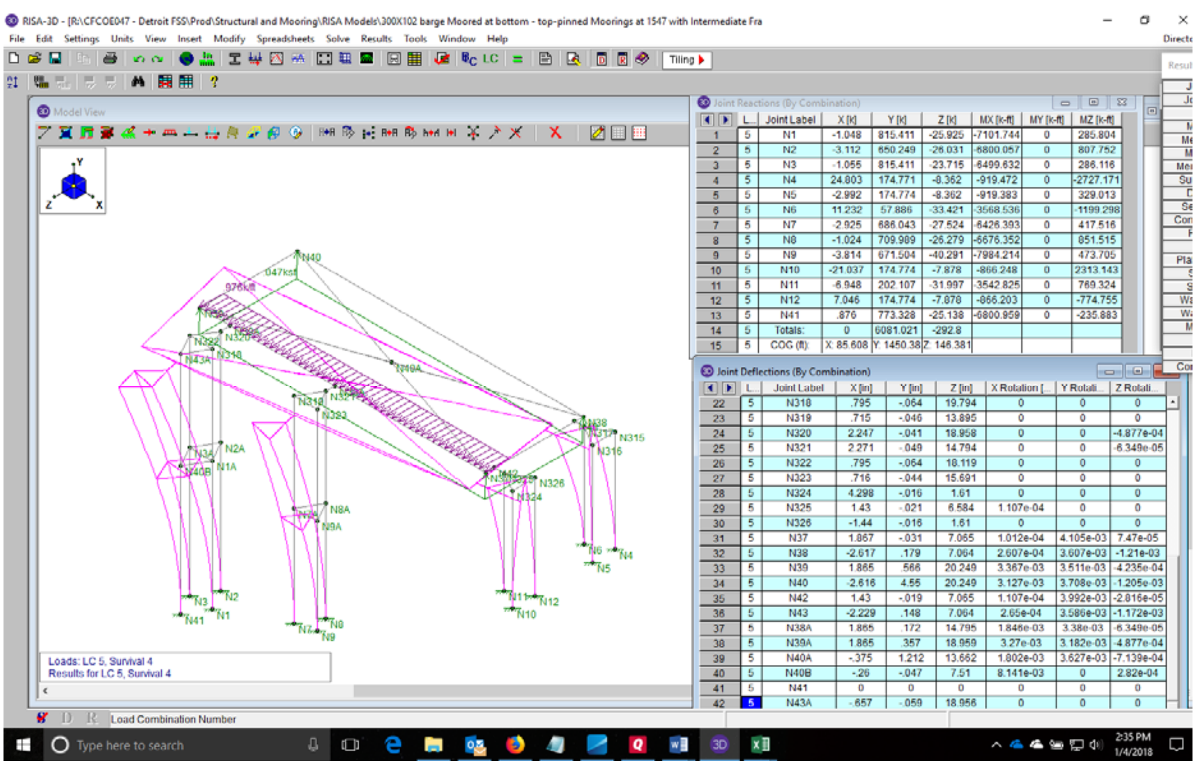

Figure 5-5 - Survival Load Combination Scenario No.4

For this rare load combination, deflections of the FSS will be significant enough towards the SWS (approximately 8”) that it could cause interaction between the FSS and SWS. The loads on the piles are not significant. In this scenario, when a storm is approaching from the West (Westerly winds) and the reservoir level is high enough that the de-ballasted FSS profile extends over the top of the dam (i.e. exposed to the wind), it would likely be best to ballast the FSS to get its profile behind the dam to protect it from the wind and reduce overwater exposed wind area.

6 MECHANICAL DESIGN

6.1 GENERAL

The major mechanical components on the Detroit Floating Screen Structure include the attraction water pumps, dewatering, and auxiliary water pumps, weir gate actuators, cranes and hoists for handling equipment onboard the collector, and trashrack cleaner. This section will discuss primary features and functions of this equipment as well as the design criteria, and assumptions used in development of the design of this equipment. Other mechanical equipment includes ballast pumps and other devices associated with the floatation of the vessel as discussed in Section 3, and attraction channel screen cleaners as discussed in Section 4.

6.2 Seismic Considerations for Mechanical Equipment

Seismic considerations for on-board mechanical equipment are neglected given that the structure is floating in a reservoir.

6.3 Attraction Flow Pumps

6.3.1 General

Provisions shall be integrated into the FSS to accommodate the potential future installation of attraction flow pumps that are to be operated during periods when the powerhouse and turbines are not in operation. These pumps are to be added at the discretion of USACE, should additional fish collection efforts be necessary. Based on the hydraulic design criteria presented above in Section 4, the attraction flow pumping plant shall be capable of drawing 1,000 cfs through the FSS entrance, dewatering screens, and secondary plenum. Preliminary modeling of the collector hydraulics estimates that the static pumping head will be approximately 2 to 4 feet.

In this design scenario, pumping is required to develop sufficient driving head to pull flow through the FSS. Specifically, water is moved from the reservoir into the FSS, then from the FSS channel, through the fish screens, into the screen plenum, and finally discharged back into the reservoir. Head loss in the FSS channel and the plenum are minimal. The largest anticipated need for pump head is due to losses across the entrance weirs, through the fish screens and baffles, and in the discharge from the pumps back into the reservoir.

Based on the hydraulic calculations and consideration for minor and major pumping losses, the total dynamic pumping head (TDH) envisioned is approximately 4 feet, depending on the pumping rate and conveyance design.

When considering the flow rate required for each pump, consideration must be given to providing the best compromise between lifecycle cost (capital cost and energy and maintenance costs over the life of the pumps), plant spatial requirements, maintenance, and reliability. In selection of pump size and type, off-the-shelf pumps are evaluated more favorably than custom pumps as off-the-shelf pumps allow for quick procurement of replacement parts and have better maintenance support. However, with a pumping plant of this size, off-the-shelf pumps may not be practical.

The remainder of this section discusses the different types of attraction pumps considered in the pumping plant design. Following the introduction of the pump architectures considered, Section 6.3.6 documents the preferred pump architecture, sizing, and plant layout.

6.3.2 References for Attraction Flow Pumping Plant Design

The primary reference for the pumping plant design ANSI/HI 9.8-2012, American National Standard for Rotodynamic Pumps for Pump Intake Design. This reference was used to determine the pump bay dimensions and minimum submergence. Other references which may be consulted during the design process include:

- Pump manufacturer design recommendations and installation instructions
- USACE Engineering Manuals:
    - EM 1110-2-3102 General Principles of Pumping Station Design and Layout
    - EM 1110-2-3105 Mechanical and Electrical Design of Pumping Stations

6.3.3 Horizontal Mixer Pump

The horizontal mixer pump (or propeller pump) is an axial flow pump consisting of a propeller on a horizontal shaft connected to a horizontal submersible motor. Mixer pumps were developed to aid in mixing in wastewater treatment tanks by circulating large quantities of flow at very low driving head and typically were not used to lift water. However, these pumps are suitable for this low head application due to their ability to move large volumes of water at very low pumping heads. Horizontal mixer pumps have been installed at multiple other fish collection facilities, including floating collectors in this configuration. In this design, a bell-shaped shroud surrounds the impeller for vortex suppression and to increase hydraulic efficiency. The whole package is factory assembled, tested, and shipped to site. The pump is typically lowered into place via guide rails and a wire rope winch or the facility hoist equipment. The guide rail and wire rope lifting allow for simple installation and removal for maintenance. Hooks on the pump shroud and gravity keep it in place. An example photo of a mixer pump is shown below in Figure 6-1.

Figure 6-1 - Typical installation of Flygt mixer pumps, guard rails, & submersible power cable

Horizontal mixer pumps were considered for use in the facility. Based on experience with the design of the USACE's FFC at Cougar Dam on the McKenzie River, near McKenzie Bridge, Oregon, and with other floating screen structures, the horizontal orientation was chosen as the preferred alternative. With the horizontal orientation, the piping requirements are minimized, and the orientation allows for easy removal of the pump by vertical rails when maintenance is needed.

6.3.4 Vertical Turbine Pump

Vertical turbine pumps are centrifugal or mixed flow type pumps comprised of one or more stages which accommodate rotating impellers and stationary bowls possessing guide vanes. As opposed to the axial style mixer pump discussed above, this pump has a semi-open or enclosed impeller discharging through a bowl and column assembly, through which the pump shaft passes. These pumps are typically used when the pumping head is within the range of 20 to 80 feet with maximum values above 100 feet. While the arrangement of these pumps can take many forms, typically the motor is located above water level where it can be easily maintained, and is connected through a line shaft to the impeller as shown in Figure 6-2.

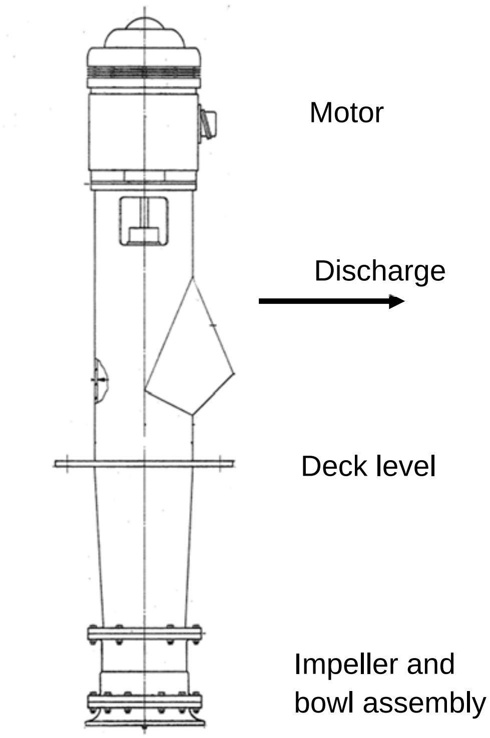

Figure 6-2 - An example of a vertical turbine pump considered for use in the Detroit FSS

Several manufacturers of vertical turbine pumps were contacted for standard products available for use at the Detroit FSS facility. Based on feedback from those manufacturers, the lowest pumping head possible with this type of design is approximately 6 to 14 feet, which is above the targeted range of 2 to 4 feet. As such, a control valve would be required for each pump to introduce an artificial head loss. The additional head loss is required to keep the pump operating in a safe range while not drawing more flow than necessary, but would result is additional power costs to pump against the increased head. For this reason, vertical turbine pumps were eliminated from consideration.

6.3.5 Axial Flow Pumps

Enclosed-style axial flow style pumps were also considered in this application. Enclosed-style axial flow style pumps are horizontal propeller pumps with shafts penetrating the discharge pipe. Due to the cost and complexity of the pumping arrangement in relation to the mixer-style axial flow pumps, this alternative was eliminated from consideration. Examples of enclosed-style axial flow pumps are shown below in Figure 6-3 for illustration.

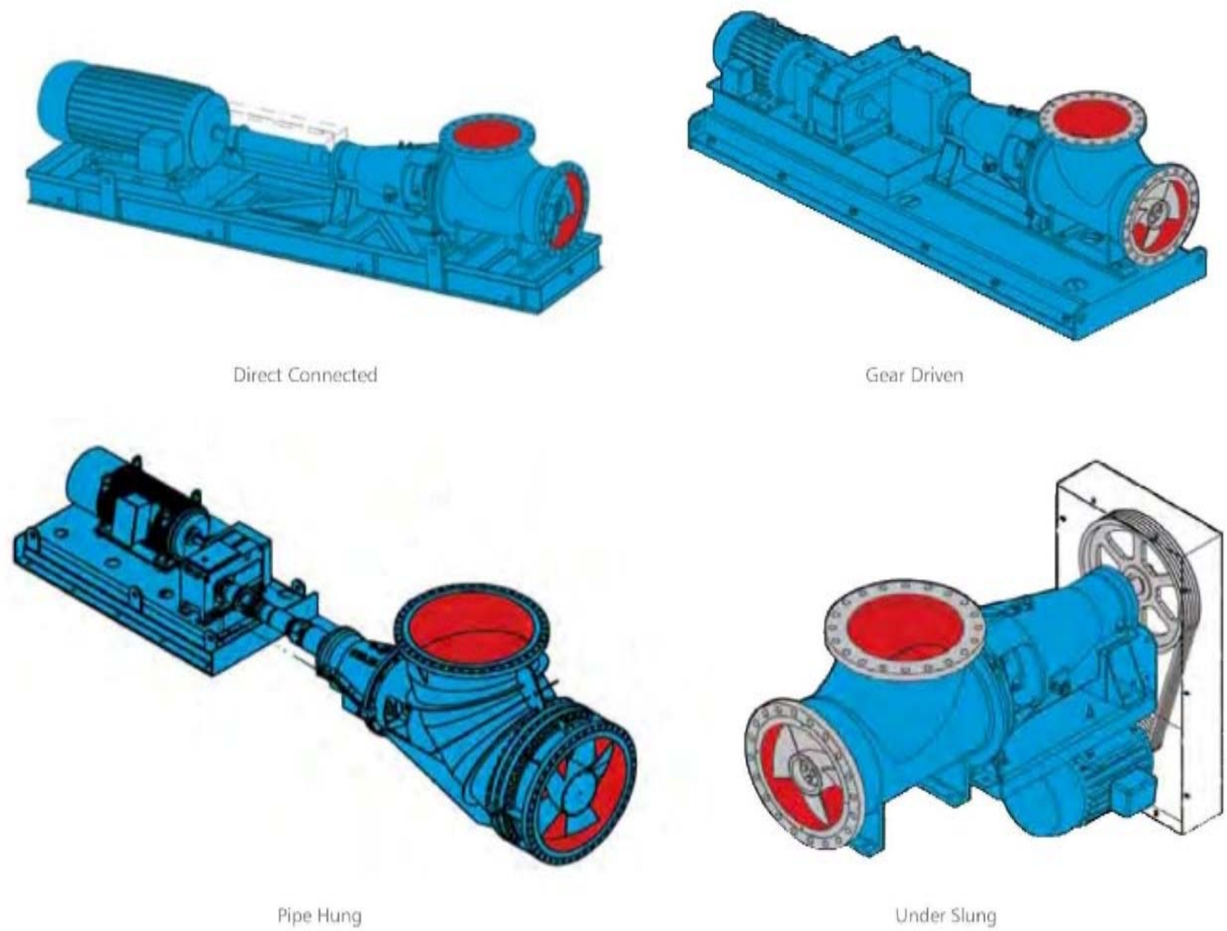

Figure 6-3 - Examples of enclosed-style axial flow pumps

6.3.6 Pumping Plant Design

Based on discussions with pump manufacturers and a preliminary analysis of the three pump types considering pump sizing, pumping cost, off-the-shelf availability, and design team experience at other floating screen structures, it was determined that the horizontal shaft mixer-style pumps were the preferred alternative. Preliminary pump selection data and calculations to support this conclusion are provided in Appendix F. Discussions with Flygt, the manufacturer of mixer pumps used at the USACE's Cougar FFC, Puget Sound Energy's (PSE) two Baker River Project floating surface collectors (FSCs), PacifiCorp's Swift FSC, Portland General Electric's (PGE) North Fork FSC, and other fish facilities, indicated that the largest standard pump they offered of this type, the PP-4680 series, would pass approximately 50 cfs at 4 ft of TDH. However, Flygt has also provided custom mixer pumps of similar heads that pass 250 cfs each at PSE's two Baker River FSCs.

As such, the potential to reduce the number of pumps needed and pursue a larger, custom version of the Flygt PP series pumps which could pass approximately 125 cfs each at 2 to 5 feet of pumping head was evaluated. With a plant size of 8 to 10 pumps, the required pumping rate could be achieved with one pump offline. The size and scale of these pumps would be such that the pump could be removed from the water using guide rails and serviced on-site, or in the event of a need for major maintenance, the entire unit could be removed and transported to shore using the FSS bridge crane and SWS access bridge crane.

In design discussions with Flygt, they expressed interest in developing a pump specific to the Detroit FSS application using standard parts to the extent possible. Pertinent physical characteristics envisioned for each 125 cfs mixer pump are shown below in Table 6-1. These characteristics are representative of Flygt's estimated design of 125 cfs pumps.

Table 6-1 Estimated mixer pump physical characteristics

Pump Characteristic	Value
Impeller Diameter	37 inches
Bell Diameter	38 inches
Unit Length	5.5 ft
Motor Size	80 HP
Unit Weight, Including Guide Rails	3,500 lbs

Based on the sizing shown above, and a flow rate of 125 cfs, a preliminary pumping plant layout was completed using guidance from ANSI/HI 9.8-2012, American National Standard for Rotodynamic Pumps for Pump Intake Design. Pump bay dimensions and operational constraints are summarized in Table 6-2, as derived from the Hydraulic Institute calculations.

Table 6-2 Pump bay sizing and operational parameters per HI 9.8-2012

Pump Characteristic	Value
Velocity at Pump Inlet at 125 cfs	16.7 ft/s
Bay Width	6 ft 3 in
Bay Training Wall Length	15 ft
Bay Water Velocity at 125 cfs	0.6 ft/s
Minimum Required Submergence	15 ft
Assumed Submergence	35 ft

Based on a bay width of 6'-3" and allowance for training wall thickness, for a pumping plant size of 10 units, the required width is approximately 68 ft, which is less than the total plenum interior width presently envisioned (87'-6"). The pumps are to be placed at the aft wall of the plenum, lowered into place near the floor of the plenum by guide rails. The pumps would discharge water from the plenum to the reservoir. A discharge cone will be designed and installed on the plenum wall in the reservoir. The discharge cone is expected to reduce the discharge head loss, allowing the pump to produce a greater flow rate resulting from the reduced total dynamic head (TDH). Flap gates are located on the discharge side of the discharge cones. When the pumps are not in use, water will be drawn down the FSS channel, through the fish screens and baffles, into the SWS intake gates. Flap gates are necessary to prevent reservoir water from being drawn unscreened, backwards through the mixer pumps, potentially harming fish (unless nets are included to preclude fish from the area) and adversely affecting FSS hydraulics. The general layout of the pump bays is shown below in Figure 6-4.

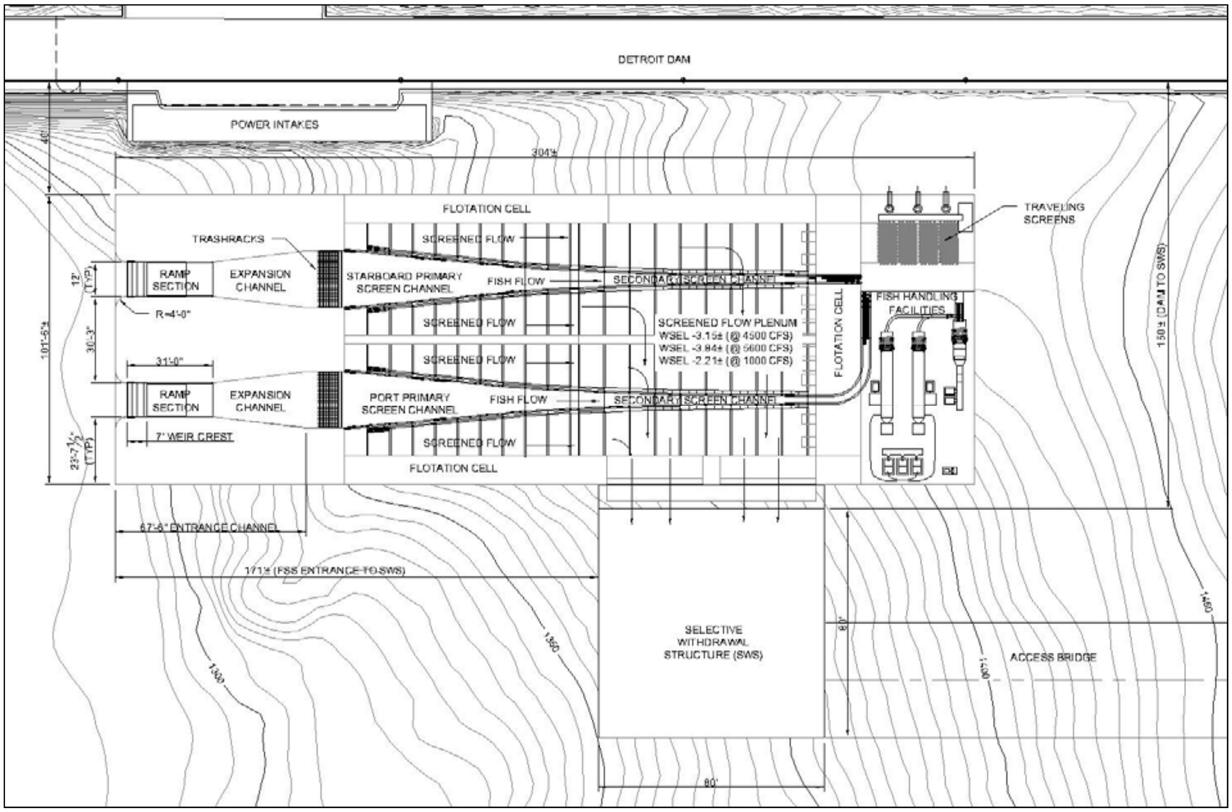

Figure 6-4 Preliminary pumping plant layout

6.4 Motor Operated Gate Actuators

The current design calls for 3-leaf vertical slide gates located at the weir entrances. It is presumed that these gates will be designed to self-open under their own weight. Consequently a double-drum wire rope hoist can be used to raise and lower the gate leaves. Sizing of the wire rope hoist will be confirmed as the design progresses. Wire rope gate operators are typically custom-designed machines. Current best practices in motor operated gate actuators will be applied, including those provided in USACE Engineering Manuals.

The actuators will be designed with PLC controls with controlled ramp rates for smooth start/stop operation, and safety features appropriate to avoid overloading of the gates, operating machinery, or physical structures. The design will incorporate current best design practices, including torque limiters, slip clutches, and motor current limiters.

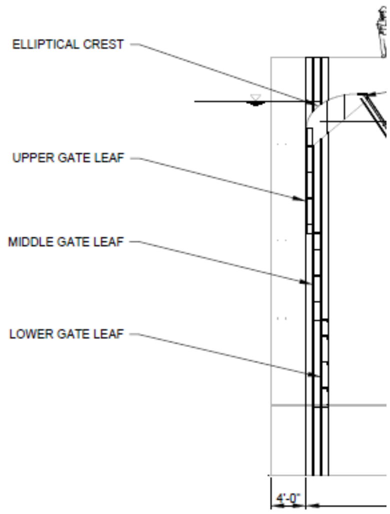

Figure 6-5 Entrance Weir Gate Section

6.5 Lifting Devices - Bridge Crane and Other Lifting Devices

6.5.1 General

The FSS bridge crane will be designed to lift and transport fish hoppers, pumps, and other major equipment to the designated staging location where they will be lifted by the access crane mounted to the selective withdrawal structure or access bridge. From the SWS or access bridge equipment can be collected and transported offsite. The FSS bridge crane capacity, span, travel limits, and high/low hook elevations will be established as the FSS layout is finalized. If required, job-specific hoists will be included to remove pumps, motors, or other equipment for service and designed to move these items to a location where the FSS bridge crane and/or the SWS/access bridge crane can lift them for offsite servicing. However, if the FSS bridge crane can be adequately designed to serve all of these activities, additional hoists will not be needed. Due to the relative size of the FSS bridge crane, it is not anticipated a custom-designed crane will be required. Multiple crane manufacturers can provide a standard crane in the size anticipated for this project.

If required for servicing the crane, suitable access ladders and platforms will be provided to facilitate serving the bridge crane trolley and hoist equipment. However, USACE may choose to utilize temporary ladders or man-lifts for these activities at its discretion. If required by USACE, the crane will be equipped with safety features, as applicable, such as walkways, platforms, handrails and ladders for the proper functioning, access and maintenance of important components of the crane.

6.5.2 References for Cranes and Lifting Devices

All cranes and hoists for this project will comply with the applicable portions of the American Society of Mechanical Engineers (ASME) B30 Series standards and the standards of the Crane Manufacturer’s Association of America (CMAA), in addition to applicable standards established by USACE. Support structures for lifting devices will comply with applicable structural codes and standards. Electrical power supplies will comply with applicable electrical codes and standards. The following codes and standards will apply along with additional codes and standards referenced by these publications:

- American Institute of Steel Construction Manual, 9th Edition
- American Association of State Highway and Transportation Officials (AASHTO) LRFD Moveable Highway Bridge Design Specifications
- The Guide to Hydropower Mechanical Design, by the ASME Hydro Power Technical Committee
- EM 1110-2-2610 - Mechanical and Electrical Design for Lock and Dam Operating Equipment
- EM 1110-2-2702: Design of Spillway Tainter Gates
- EM 1110-2-3006 – Hydroelectric Power Plants – Electrical Design
- EM 1110-2-4205 – Hydroelectric Power Plants – Mechanical Design
- EM 1110-2-3200 – Wire Rope Selection Criteria for Gate Operating Devices
- EM 385-1-1 – Safety and Health Requirements Manual
- Crane Manufacturer’s Association of America (CMAA) No. 70, 2015 – Specifications for Top Running Bridge & Gantry Type Multiple Girder Electric Overhead Traveling Cranes, No. 74, 2015 – Specifications for Top Running & Under Running Single Girder Electric Traveling Cranes Utilizing Under Running Trolley Hoist
- ANSI MH27.1 Specifications for Patented Track Underhung Cranes and Monorail Systems, MH27.2 Specifications for Enclosed Track Underhung Cranes and Monorail Systems
- National Electrical Manufacturer’s Association (NEMA): 250 Enclosures for Electrical Equipment (1000 Volts Maximum), Industrial Control Systems 2 Controllers, Contactors and Overload Relays Rated 600 V, Industrial Control Systems 5 Industrial Control and Systems Control-Circuit and Pilot Devices, Industrial Control Systems 6 Industrial Control and Systems: Enclosures, ICS8 Application Guide for Industrial Control and Systems Crane and Hoist Controllers, MG1 Motors and Generators
- National Fire Protection Association (NFPA) 70, National Electrical Code, 2014 edition
- UL: 1004-1 Standard for Rotating Electrical Machines - General Requirements, 1449 Standard for Surge Protective Devices, 489 Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures, 50 Enclosures for Electrical Equipment, Non-Environmental Considerations, 943 Ground-Fault Circuit-Interrupters
- Institute of Electrical and Electronics Engineers (IEEE): C2 2017 National Electrical Safety Code (R), 519 Institute of Electrical and Electronics Engineers Recommended Practice and Requirements for Harmonic Control in Electric Power Systems

- American Society of Mechanical Engineers (ASME): B30.2 Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist), B30.7 Winches, B30.20 Below-the-Hook Lifting Devices, B30.10 Hooks, B30.16 Overhead Hoists (Underhung), B30.17 Cranes and Monorails with Underhung Trolley or Bridge), B30.20 Below the Hook Lifting Devices, and HST-4 Performance Standard for Overhead Electric Wire Rope Hoists
- Federal Wire Rope Specification RR-W-410
- OSHA 1926 Safety and Health Regulations for Construction

6.5.3 Bridge Crane Design Criteria

The bridge crane will be designed to meet applicable current industry standards, such as CMAA No. 70 or 74 (as applicable) and American Institute of Steel Construction Manual, 9th Edition.

Components will be designed to meet the requirements of ASME B30.2, EM 4205 and EM 2610, as well as other industry standards where applicable. Where practical, the design will include features for ease of maintenance, such as self-lubricating bushings and permanently lubricated bearings.

6.5.3.1 Hoist

The crane will have one hoist, rated for [TBD] tons, with a total lift of [TBD] feet. High hook will be at elevation [TBD] feet and low hook at elevation [TBD] feet. Rated hook speed will be [TBD] feet per minute and will include a variable frequency drive (VFD) controller providing approximately a 100:1 ratio between low and high speed. Values for these elements have not yet been developed and will be completed in the 60% submittal.

6.5.3.2 Trolley

The crane will have a single trolley with a rated speed of approximately [TBD] feet per minute and will include a VFD controller providing a variable speed range of approximately 100:1. The trolley will travel on crane rails mounted on the bridge structure and provided by the crane manufacturer. Values for these elements have not yet been developed and will be completed in the 60% submittal.

6.5.3.3 Bridge

The bridge will have a span of [TBD] feet and will travel at a rated speed of approximately [TBD] feet per minute and include a VFD controller providing approximately a 100:1 ratio between low and high speed. The bridge will travel on permanently mounted crane rails supported by the FSS structure and will be part of the FSS contractor's responsibility. Final size and layout of the crane rails will be determined as the crane capacity and travel limits are finalized. If feasible, the bridge rails will be designed such that the bridge crane hoist can reach, lift, and transport all items requiring service or removal from the FSS to suitable locations in accordance with CMAA and ASME requirements. Values for these elements have not yet been developed and will be completed in the 60% submittal.

6.5.3.4 Controls

The crane will have a pendant controller along with radio remote control for operation of all motions. Two remotes will be provided with spare batteries and stored in a designated location at the site to be determined by USACE. Standard industrial radio systems that operate in the 2.4 GHz band and use frequency-hopping spread spectrum technology are preferred for security reasons. It is anticipated that the majority of the crane operations would be from the radio remotes, with the pendant controller serving primarily as a backup. Controls will be switchable so only one control station can be used at a time. Controls will be arranged such that multiple motions (hoist, trolley, and gantry movement) can occur simultaneously. VFD controls will be designed with ramping profiles such that all motions start and stop smoothly such that there is minimal load sway during normal operations. All motions (hoist, bridge, and trolley) will be variable with an approximate 100:1 ratio between the lowest and highest (rated speed).

If required by USACE, a load cell with readouts on the bridge and remote control stations can be provided that indicates the load being lifted by the crane.

6.5.3.5 Crane Lighting

It is anticipated that flood lighting will be provided mounted to the bridge to illuminate the working area below the crane and to eliminate shadows cast by the crane structure. Floodlights will be designed in accordance with Illuminating Engineering Society standards to produce accurate color rendition and provide an average illumination level of approximately 15- to 25-foot candles at the deck level underneath the crane, with a target minimum design level of 15-foot candles at any given point. Accurate color rendition is critical if crane lights are being used to illuminate activities involving electrical wiring.

6.5.3.5.1 *Crane Power*

The bridge crane will be powered by a conductor rail permanently mounted to the FSS structure. An enclosed four-conductor power rail, where the fourth conductor is connected to ground will be specified. Location and mounting of the power rail will be finalized as the FSS structure layout is developed. The trolley will be powered by a festoon system interconnected to the bridge. The power supply will incorporate required emergency stop (E-stop) pushbuttons and a travel warning bell and flashing red lights to indicate bridge/trolley motion. The E-stop pushbuttons will be hard-wired into the control circuits so as to directly remove power and not rely on any programming or ancillary device, and will be located on the wall beside the crane, and on the wireless control station. Locations and number of E-stops will be determined as the project layout is finalized. Voltage and amp rating of the crane power supply will be determined when the crane ratings and speeds are finalized, but nominally is expected to be 480 volts AC and integrated with the FSS power supply. If necessary the crane can be powered by an onboard diesel or gas-powered generator.

6.5.3.6 Safety/Environmental

All enclosures will be environmentally rated for their installation location and provided with interior climate-control equipment as needed. Panels and enclosures installed inside will be

NEMA 250 Type 12. Panels and enclosures installed outside will be NEMA 250 Type 4 or 4X. No asbestos or lead paint will be permitted in the new crane equipment. All oil reservoirs and lubricant filling locations will include appropriate drip pans or catch basins to collect oil and lubricant overflows and minimize environmental contamination. Where possible, environmentally-safe, biodegradable oil and lubricants will be used. Where exposed to the outdoor environment, components shall be weather sealed to preclude the entry of rainwater or snow melt into oil reservoirs.

The following general safety items apply to the crane if required by USACE (may not apply if crane will be serviced using temporary ladders, man-lifts, etc.):

- All permanently installed platforms, walkways, ladders and handrails must meet OSHA requirements, EM standard 385-1-1, and American National Standards Institute (ANSI) standard A14.3. If there are conflicts between the design criteria listed within the USACE standard specification or reference industry standards, the more stringent requirements will govern.
- Safe access will be provided to the top of the crane service platform, trolley, and other machinery spaces where maintenance activities will be required. Contract drawings will show general configuration of ladders, stairs, and the cage, as required, to gain access to the trolley at the top of the crane.
- Access will be provided to the trolley walkway by a conveniently placed fixed ladder, stair and/or platform. Fixed ladders must be in conformance with the American National Standard Safety Code for Fixed Ladders, ANSI A14.3 and EM 385-1-1.
- Any outdoor platform and walkways must be fabricated with anti-slip grating and have a width of no less than 48 inches. In general and where possible, all outdoor platforms, walkways, handrails and ladders will be galvanized.
- The fixed ladder from the deck to the top of the crane support rails (access to the trolley) will have an intermediate platform to minimize run length and avoid the requirement for a ladder climbing safety device if required to meet EM 385-1-1 requirements. A self-closing swing gate will be specified at the landing surface at the top of the ladder.
- Fall protection and fall arrest, if required, must be designed to meet applicable industry and safety standards including OSHA, EM 385-1-1, and ANSI Z359.
- Fall protection anchor points will be added to the top of the structure to allow inspection of the structural frame, trolley rails and other machinery only accessible from outside the trolley housings. It is anticipated that there will be an occasional need to walk the length of the bridge rails on each side of the crane to inspect anchor bolts and rail condition, which will require fall protection along the length of the rail.
- Anchor points will be designed for a 5,000-pound force and installed in accordance with EM 385 Fall Protection System and ANSI Z359. Anchor points will include a D-ring.
- A rescue hoist will be required for personnel working on the machinery deck unless USACE will be providing an alternative rescue device, such as a man-lift.

6.6 Collector Entrance Trashrack Cleaner

The trashracks located in the collector entrance (refer to Section 4.6.3) are anticipated to collect significant amounts of buoyant and semi buoyant debris composed primarily of small to medium sized wood. On occasion, large debris in the form of trees with diameters up to 6 to 12 inches could pass through primary debris management measures in the reservoir (such as a floating debris boom with hanging barrier panels) and enter the collector entrance. An automated trash rake system must be in place to actively retrieve any accumulated debris from the trashracks, remove it from the collector entrance, and then place it in a manner that can be disposed of by facility technicians. Accumulations of debris that are not removed in a timely manner will result in direct impacts to facility hydraulics, fish survival, and the performance of other mechanical equipment located downstream of the trash racks.

An active trash rake system will be required to achieve the following performance characteristics:

- Operate in automatic, remote manual, and local manual modes to provide timely removal of debris from the trashracks. Operating modes shall be provided for single or continuous cycles;
- Capable of cycling across both trashracks and both collector entrances so that the full width each trashrack can be adequately cleaned;
- Capable of extending to the lowest point of the trashrack which is currently estimated to be 40 feet below the working deck;
- Have a minimum lifting capacity of 2,000 pounds from the furthest point away from the cleaning chassis;
- Able to travel to a location where debris can be placed in a debris receptacle and/or to a separate debris conveyor system that transfers the debris to a debris receptacle;

In general, the trash rake may be comprised of a hydraulically or electro-mechanically operated device complete with a steel superstructure, travel rail, telescoping boom, actuated rake head attachment (with or without a mechanical thumb), service platform, safety equipment, and fully integrated control system. At this point in the design process, the steel superstructure may be on deck or overhead dependent upon the final configuration of the debris transfer strategy. A travel rail will be mounted on top of the steel superstructure which allows full travel of the cleaning chassis across both trash racks and allows for delivery of debris to a debris receptacle or separate debris transfer system. The cleaner chassis shall be a self propelled unit which travels along the rail system, supports the telescoping boom, and is a slave to the local and onboard control panels. A service platform shall be incorporated so that access to the cleaning chassis can be safely provided for the purpose of performing all required maintenance and repair operations. The rake head attachment will need to be designed to be compatible with the trash rack configuration selected for the project and considerations to the trash rack will need to be made to accommodate full travel of the rake head without hanging on any structural members or breaks.

Under automatic control mode, the trash rake system will initiate a single cleaning cycle on an elapsed timer or hydraulic differential across the trash rake (whichever comes first). A single cleaning cycle can be set for one trashrack (port or starboard) or both trashracks as required. Each cleaning cycle is initiated with an initial move of the cleaning chassis from home position to a point along the trashrack where the telescoping boom is extended to the bottom at some distance away from the trashrack face. At this point, the rake head is pulled towards the trashrack until contact is made with the trashrack surface. The boom is then retracted and the rake begins to retrieve debris that is accumulated on the face of the rack. At the top of the trashrack, the rake head and/or mechanical thumb (if present) contracts to retain debris on the rake head. The cleaning chassis then travels to the designated debris release location where the debris is placed in a dedicated receptacle or a separate debris transfer system such as a conveyor. After releasing the debris, the cleaning chassis returns to the next position on the trash rack and performs another sweep. The cycles continue until the face of each trash rack has been cleaned. When all cycles are complete, the cleaning chassis returns back to home position and remains in a state of readiness for the next cycle initiation. A full cleaning cycle is anticipated to occur within a timeframe of 5 to 10 minutes but will vary upon manufacturer and final design configuration.

Under manual control, the local control panel is set to manual. After doing so, a single cycle can be initiated or the cleaning chassis can be operated solely by a technician using a remote control device. Such control is useful when large debris enters the collection channel, and careful maneuvering of the debris rack is required for removal.

There are several North American manufacturers that make vertically lifting, raker systems for trashracks. They include: Atlas Polar; Duperon; Hydro Component Systems: Lakside Equipment; and Transco. Other manufactures exist worldwide including: Cross Machine, Inc.; and Ovivo (formerly Bracket Green-Bosker). Some examples of debris rakes are provided in Figure 6-6, Figure 6-7, and Figure6- 8. Further development of this system will occur throughout the 60% DDR development phase of work.

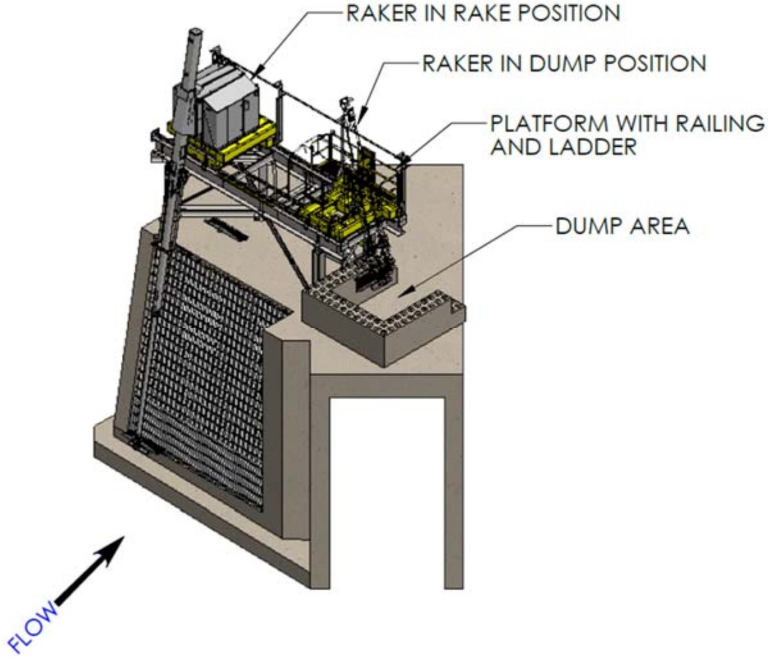

Figure 6-6. Example debris rake system with overhead rail system (courtesy of Hydro Components Systems).

Figure 6-7. Oregon Vertical Lifting Rake (courtesy Transco Industries)

Figure6- 8. City of Stockton Intake, Automated Debris Conveyor Debris Removal System

6.7 FSS Ballast and Trim System

The Detroit Reservoir FSS is a large floating structure designed to collect and sort fish for downstream passage. The FSS has two fish channels which are designed to operate at various flow rates. The ballast and trim system serves several purposes: aides with construction and transportation, helps with major maintenance of the fish channel, and provides trim and heel compensation for varying operational conditions.

6.7.1 Ballast System Description

The ballast system's primary purpose is to ballast the FSS near the required operational draft. The system consists of tanks, pumps, piping, valves, and other components interconnected to transfer water from the reservoir to the various tanks and vice versa. Additionally, the ballast system is designed to pump out the water trapped in the fish channel during the maintenance periods. A diagram of the ballast system is provided below.

Ballast Diagram to be developed in the 60% DDR.

6.7.1.1 References for Ballast and Trim System

The ballast and trim system design will conform to the following design standards and references:

1. American Bureau of Shipping (ABS), *Rules for Building and Classing Steel Barges 2017*
2. American Institute of Steel Construction (AISC), *Steel Construction Manual, 14th Edition* (AISC 360-10)
3. American Welding Society (AWS), AWS D1.1, *2010 Structural Steel Welding Code*
4. Society of Naval Architects and Marine Engineers (SNAME), *Marine Engineering, 1992*
5. American Society for Testing and Material (ASTM), *Vol 01.07, Ships and Marine Technology*

6.7.1.2 Tanks

The ballast system has two types of tanks, belly and ballast tanks. Both tanks are integral to the structure and not separate tanks. The difference between the belly and ballast tanks is the location of the tanks. The belly tanks are located below the fish channel and extend the full length and width of the FSS. The ballast tanks are located above the belly tanks and surround the fish channel. The operational volume of the belly and ballast tanks will not change based on the fish channel flow rates, once the FSS is ballasted to the operational draft these tanks will remain unchanged until maintenance is needed. Below is a table of the tanks volumes.

Table: Ballast Tank Volume (to be developed in the 60% DDR)

Each tank is vented to the atmosphere as required by ABS. The vent piping aggregate area shall be no less than 125% of effective area of the filling line (ABS Rules for building and classing steel barges 2017, Part 3, CH 1, Section 2, Subsection 5.3). The pipe will be similar to that used for filling and emptying the tanks.

6.7.1.2.1 *Tanks Level Indication*

All tanks are to be provided with separate sounding tubes and with approved tank-level indicating (TLI) apparatus. It is possible to affix a TLI to the top of each sounding tube provided that the sounding tube is straight. This gives the flexibility to use both even with limited tank top space.

There are many different TLI technologies used in the marine industry. Past projects have utilized radar TLIs and bubbler tube technology. Radar TLI’s are individual units which are typically mounted to the top of the tanks or piping attached to the tanks. They require a cable from a central instrumentation station, require little to no additional systems, and are minimally invasive. The bubbler tube technology requires two small tubes running from the central instrumentation station to each tank and compressed air from a central air compressor.

6.7.1.3 Pumps

The ballast system will utilize a minimum of two ballast pumps, this offers redundancy and allows multiple tanks to be filled or emptied in a shorter amount of time. Typically, centrifugal pumps offer ease of use, maintenance, and offer suitable operating range for ballast system. For these reasons, the ballast pumps will be centrifugal type pumps. The required flow rate, pressure loss, net positive suction head available, and available space will determine which pumps are suitable for the ballast system. Past projects have used single stage vertical inline pumps similar to the Aurora 380 series pump pictured below Figure 6-9.

Figure 6.9 - Single Stage Vertical Inline Pump (Aurora 380 series)

6.7.1.3.1 *Strainers*

The pumps will take suction from the reservoir to fill the belly and ballast tanks. They are the single most expensive components in the ballast system and the reservoir may have debris which could cause damage to the pump. Protecting the pumps from debris is crucial for a reliable, well operating ballast system. The pumps will be protected by the seachest and a marine grade strainer. The seachest is located on the bottom of the FSS where little debris is found and will have a plate with large perforations to prevent larger debris from entering the suction side of the ballast system. The marine grade strainer will have 1/8 inch perforated basket to prevent smaller foreign material such as plants and woody debris from damaging the pumps. There are two types of basket strainers, simplex and duplex. To clean a simplex strainer the operator must isolate the flow through the strainer before removing the basket. Duplex strainers have two baskets and a diverter valve, this allows the strainer to remain in service while one of the baskets is cleaned. The ballast system is only planned to operate twice a year during the maintenance period. This is infrequent enough that the additional cost on a duplex strainer is not warranted.

6.7.1.3.2 *Pump Priming system*

The level of the pumps has yet to be determined and as such it is possible that the pumps may be above water level when the FSS is de-ballasted. To pump ballasting water back in, priming of pumps may be necessary. Additionally, in some cases ballast my not be shifted for upwards of one year. During this time, piping may lose prime for a variety of reasons which would require the vacuum priming system. It is recommended to have a pump startup interlock which will prevent a pump from starting if the chamber is dry. This can be accomplished via a water presence sensor in the vacuum priming system and will lead to prolonged pump life.

6.7.1.4 Pipe

Typically, ballast systems utilize carbon steel pipe (ASTM A106 or A53), but the ASTM F1155 also allows the use of fiberglass pipe (ASTM D2996 or D2997). The cost of carbon steel pipe is typically less than the fiberglass pipe. However, the labor cost of installation is typically greater for welded fittings. Past projects have utilized carbon steel pipe and grooved fittings to decrease the installation cost, see Figure 6-10.

Figure 6-10 - Standard Grooved Coupling

The number of tanks and overall size of the FSS will dictate the amount of ballast piping installed. Based on the overall size, it is anticipated the labor cost of the installation of the piping will out weight the cost of the piping. Other considerations include bulkhead penetrations, overboard discharge, and modular construction. These items will be discussed further in the 60% DDR.

6.7.1.5 Valves

While the pump provides the power to move the water through the system, the valves control where the flow goes. There will be several types of valves in the ballast system including, check valves, globe valves, and gate valves.

6.7.1.5.1 *Check Valves*

Check valves are used in applications where reverse flow is unwanted. The discharge of each pump will have a check valve to prevent excessive back pressure or reverse flow, which could damage the pumps. The overboard discharge will have a check valves to ensure the reservoir water does not flow back into the discharge piping. Additional check valves may be required depending on the ballast system arrangement, to be developed in the 60% DDR.

6.7.1.5.2 *Gate Valves*

Gate valves are used for positive closure and for minimal pressure loss applications. The seachest should have a full port gate valve to provide positive closure and decrease the pressure loss on the suction side of the pumps. Each pump will also have full port gate valves on the suction and discharge side of the pumps. to isolate the pumps. This allows maintenance personnel to work on the pumps with minimal interruption to the system. Additional gate valves will be installed within the system, these will be identified in the 60% DDR.

6.7.1.5.3 *Globe Valves*

Globe valves are used in applications when flow rate control is required. Based on past projects and the size of the FSS, it is anticipated the ballast pumps will be required to have a large operating range. Globe valves can help provide additional flow control and increase the number of suitable pumps which can be used for the ballast system. The use of globe valves will be determined in the 60% DDR.

6.7.1.5.4 *Butterfly valves*

Butterfly valves are thin, inexpensive, and suitable for low head applications. Additionally, butterfly valves only take ¼ turn to go from full open to full closure, this makes them ideal in many applications. Higher performance butterfly valves are needed to provide a leak-tight seal. The use of butterfly valves will be identified in the 60% DDR.

6.7.1.5.5 *Manifolds*

Manifolds are a series of valves connected to a common header, this provides a compact centralized location to control several valves serving similar purposes. The belly and ballast tank must have an independent valve to control the flow to and from each tank. A manufactured or custom-built manifold is ideally suited for this application. Manufactured manifolds are typically constructed using angle globe check valves and are much more compact than custom-built manifolds. Custom-built manifolds can be constructed using any type of valve, but are typically constructed using butterfly valves. A simplex manifold connects the tanks to either the suction or discharge pump header. A duplex manifold connects the tanks to both the suction and discharge side of the pump. Manufactured duplex manifolds allow for the transfer of fluid between multiple tanks connected to the same manifold. Manufactured manifolds are much more expensive than custom-built butterfly manifolds.

The type of manifold used for the FSS will depend heavily on the desired operation of the ballast system and will be developed during the 60% DDR.

6.7.1.5.6 *Electric Valve Actuators*

Electric valve actuators allow personnel to operate the valves remotely. This is typically done from a central control station located near the pump controls. The need for remote valve actuation should be considered, but could add significant cost. The additional cost can increase significantly if an unmanned pump room is desired.

The need for electric valve actuation will depend heavily on the desired operation of the ballast system and will be developed during the 60% DDR.

6.7.1.6 Operation

It is recommended that the ballast system be manually operated. The operating station will have the pump controls and tank level readouts for each tank. The motorized or manual valve operation will be determined in the 60% DDR.

The timeframe for the FSS to transition from the maintenance draft to the operational draft, and vice versa, is 8 hours. Impacts of this design criteria will be identified in the 60% DDR.

6.7.2 Trim System Description

The trim system's primary purpose is to position the FSS in the optimal operational condition to collect fish. The system consists of tanks, pumps, piping, valves, and other components interconnected to transfer water from the between the trim tanks, and to and from the reservoir. A diagram of the trim system is provided below.

Trim System Diagram to be included in the 60% DDR.

6.7.2.1 Tanks

The system has four trim tanks near the corners of the FSS. The tanks are integral to the structure of the FSS and are not separate tanks. The operational volume and distribution of these tanks may change based on the fish channel flow rates. Below is a table of the tank volumes.

(Table Trim Tank Volume to be included in the 60% DDR).

Each tank is vented to the atmosphere as required by ABS. The vent piping aggregate area shall be no less than 125% of effective area of the filling line (ABS Rules for building and classing steel barges 2017, Part 3, CH 1, Section 2, Subsection 5.3). The pipe will be similar to that used for filling and emptying the tanks.

6.7.2.1.1 *Tanks Level Indication*

All tanks are to be provided with separate sounding tubes and with approved tank-level indicating (TLI) apparatus. It is possible to affix a TLI to the top of each sounding tube provided that the sounding tube is straight. This gives the flexibility to use both even with limited tank top space.

There are many different TLI technology used in the marine industry. Past projects have utilized radar TLIs and bubbler tube technology. Radar TLI's are individual units which are typically mounted to the top of the tanks or piping attached to the tanks. They require a cable from a central instrumentation station, require little to no additional systems, and are minimally invasive. The bubbler tube technology requires two small tubes running from the central instrumentation station to each tank and compressed air from a central air compressor.

In addition to the tank TLIs, the freeboard external to the FSS is needed to ensure the operational conditions of the FSS are maintained. Past projects have utilized both radar TLIs and bubbler tubes. Both required stilling wells, but the installation of the radar TLI system was simpler and required smaller stilling wells. For this reason, radar TLIs are recommended for the freeboard measurements.

6.7.2.2 Pumps

The number and type of trim pumps is highly dependent on the amount of water required to maintain operations and will be developed in the 60% DDR.

6.7.2.3 Piping

The amount and type of piping is highly dependent on the arrangement of the trim system and will be developed in the 60% DDR.

6.7.2.4 Valves

The number and type of trim valves is highly dependent on the amount of water and flow rates required to maintain operations and will be developed in the 60% DDR.

6.7.2.5 Operation

Due to the variations in fish channel flow, it is recommended that the trim system be automated. The level of automation and operator control should be discussed. A manual operating station will have the pump controls and tank level readouts for each tank. The operation will be developed further in the 60% DDR.

The timeframe for the FSS to transition between the various operational fish channel flow rates is approximately 15 minutes. Impacts of this design criteria will be identified in the 60% DDR.

6.8 HVAC

Ventilation systems for the occupied spaces such as the pump room, stairwells, and above deck structures will be required. These systems will incorporate heating elements but not cooling coils as air conditioning is unnecessary. Systems will incorporate supply and exhaust ducting to facilitate the minimum number of required air changes per hour.

The HVAC system will be developed in the 60% DDR.

7 ELECTRICAL DESIGN

This section presents the basic electrical components of the Floating Screen Structure (FSS). The primary electrical features are the electrical service to the structure, electrical distribution at the structure and control & indication of the mechanical equipment, including attraction flow pumps, dewatering and auxiliary flow pumps, motor operated gate actuators, bridge crane, debris rack cleaner, screen cleaners, PLC, and other mechanical equipment.

7.1 References

The electrical design will follow USACE Engineering Manuals (EMs), Engineering Regulations (ERs), Engineering Technical Letters (ETLs), and Technical Manuals (TMs), and Industry Codes listed below where applicable.

- EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations, 1999.
- EM 1110-2-2610, Mechanical and Electrical Design for Lock and Dam Operating Equipment, 30 June 2013.
- National Fire Protection Association NFPA 70, National Electrical Code, 2017.
- National Fire Protection Association NFPA 70E, Standard for Electrical Safety in the Workplace, 2015.
- The IESNA Lighting Handbook – 10th Edition.
- National Electrical Manufacturers Association (NEMA).
- International Society of Automation (ISA).
- Occupational Safety and Health Association (OSHA) Regulations

7.2 Seismic Considerations for Electrical Equipment

Typical seismic restraints for floor-mounted equipment will be required. Distribution transformers shall be seismically tested, seismically qualified, and meet or exceed requirements of Uniform Building Code (UBC) and International Building Code (IBC).

7.3 Electrical Service

The shore side electrical supply is to be medium voltage through a transformer on the barge to the 480 volt power distribution system. How power will be transferred to from shore to the barge will be determined for the 60% submittal.

A load study will need to be conducted of the existing electrical system at the Detroit Dam and powerhouse to determine if the existing station service electrical system is capable of providing the power required for the proposed FSS.

7.4 Electrical Distribution and Equipment

7.4.1 Distribution

Power for the FSS will be distributed in a simple radial configuration at 480 VAC to various loads including a lighting transformer, combination starters, variable frequency drives, and 480 V welding receptacles. A 120/208 V panelboard will be provided for lighting, receptacles and other small branch circuits.

7.4.2 Standby Generator

Due to environmental and space restrictions; installation of a standby generator on the FSS may not be practical. An evaluation of an alternate source of emergency power located at the dam is required to be conducted. This includes an electrical load to determine if the existing generator and switchboard have sufficient capacity to supply emergency power to the FSS.

7.4.3 Grounding and Bonding:

The electrical system will be solidly grounded and the installation shall comply with article 250 of the NEC.

Raceways: Rigid galvanized steel conduit (RGS) will be required for all exposed work.

7.5 Electrical Features

7.5.1 Control System:

A Programmable Logic Controller (PLC) system will be utilized to provide automatic and/or remote control of the FSS. The PLC will also provide status/indication and alarming to the powerhouse control rooms. Touch screens located at the FSS and powerhouse control room will display local alarms & system status. An industrial fieldbus will be utilized to connect all sensors, drives, actuators, remote I/O, power meters, and other devices supporting the standard. Process devices such as level sensors will require a 4-20mA transmitter, as fieldbus units are not commonly available. The processor power supply shall be backed-up by a small UPS so PLC operation will not experience disruptions during generator testing or short power failures. How the barge PLC will communicate with the powerhouse control room on-shore will be determined for the 60% submittal.

7.5.2 Supervisory Control and Data Acquisition (SCADA)

This system will be incorporated into the existing SCADA system at the Detroit Dam facility for remote control and/or monitoring of system parameters and alarms.

7.5.3 Communications

Telephone service will be furnished for communications to the control room at the Detroit Dam facility. How the telephone service will connect to the control room on-shore will be determined for the 60% submittal.

7.6 General Lighting

General lighting for security and local lighting for operation and maintenance will be provided on the FSS using LED light fixtures.

7.6.1 Bridge Crane Lighting

General lighting for security and local lighting for operation and maintenance will be provided on the FSS using LED light fixtures.

- Bridge Crane Lighting
- Floodlights for illumination during bridge crane operation and for activities involving electrical wiring. Bridge crane lighting will follow Illuminating Engineering Society standards. See Section 6.5.3 for additional information.

7.7 Feature Specific Electrical Loads

7.7.1 Attraction Flow Pumps

Loads to be estimated for the 60% submittal.

7.7.2 Dewatering and Auxiliary Flow Pumps

Loads to be estimated for the 60% submittal.

7.7.3 Motor Operated Gate Actuators

Loads to be estimated for the 60% submittal.

7.7.4 Bridge Crane

Loads to be estimated for the 60% submittal.

7.7.5 Trashrack Cleaner

Loads to be estimated for the 60% submittal.

7.7.6 Screen Cleaning Systems

Loads to be estimated for the 60% submittal.

7.7.7 Heating and Ventilation Equipment

Loads to be estimated for the 60% submittal.

7.7.8 Lighting and Receptacles

Security lighting, maintenance and operation lighting and general maintenance receptacles will be provided.

8 ENVIRONMENTAL AND CULTURAL RESOURCES

8.1 General

This section addresses environmental and cultural resources and permitting requirements as they apply to the Detroit Dam Floating Screen Structure to provide control of the water temperatures of the project's outflows. This system will utilize a multilevel intake structure to modify the outflow water temperature to more closely match the natural cycle of water temperatures in the river. The natural cycle of water temperatures was altered when the Detroit Dam project began operation. The change from the natural cycle disturbs the life cycles of the anadromous and native fish species downstream of the dam on the North Santiam River near Detroit, Oregon.

8.2 References

- DEQ (Oregon Department of Environmental Quality). 2000. NPDES permit. Application No. 977457. WQ File No. 64495. Salem, Oregon.
- DEQ (Oregon Department of Environmental Quality). 2005. General 1200-CA Permit. WQ File No. 114926. DEQ Northwest Region, Portland, Oregon.
- DEQ (Oregon Department of Environmental Quality). 2005. Erosion and Sediment Control Manual. GeoSyntec Consultants Project Number SW0106-01. April 2005. http://www.deq.state.or.us/wq/stormwater/escmanual.htm
- DEQ (Oregon Department of Environmental Quality). 2008. Stormwater Management Plan Submission Guidelines for Removal/Fill Permit Applications Which Involve Impervious Surfaces. DEQ Northwest Region, Portland, Oregon. http://www.deq.state.or.us/wq/sec401cert/docs/stormwaterGuidlines.pdf
- NMFS (National Marine Fisheries Service). 2000. Guidelines for electrofishing waters containing salmonids listed under the Endangered Species Act. NMFS, Portland, Oregon.
- NMFS (National Marine Fisheries Service). 2008a. Endangered Species Act Section 7(a)(2) Consultation Biological Opinion & Magnuson-Stevens Fishery Conservation & Management Act Essential Fish Habitat Consultation on the "Willamette River Basin Flood Control Project". NMFS, Northwest Region, Portland, Oregon.
- NMFS (National Marine Fisheries Service). 2011. Anadromous Salmonid Passage Facility Design. NMFS, Northwest Region, Portland, Oregon.
- ODFW (Oregon Department of Fish and Wildlife). 2008. Oregon Guidelines for Timing of In-Water Work to Protect Fish and Wildlife Resources. ODFW, Northwest Region North Coast Watershed District
- USACE (U.S. Army Corps of Engineers). 2002. Excerpted from the Civil Works Environmental Desk Reference. http://www.usace.army.mil/CECW/Documents/cecwp/envdref/2002ProfilesofLaws.pdf
- USFWS (U.S. Fish and Wildlife Service). 2008. Final Biological Opinion on the Willamette River Basin Flood Control Project Endangered Species Act Section 7

Consultation on the Continued Operation and Maintenance of the Willamette River Basin Project and Effects to Oregon Chub, Bull Trout, and Bull Trout Critical Habitat Designated Under the Endangered Species Act. USFWS, Portland, Oregon.

8.3 Environmental Planning

8.3.1 National Environmental Policy Act (NEPA)

All actions that are federally funded, permitted, or constructed must satisfy the requirements of the National Environmental Policy Act (NEPA) of 1969, as amended (42 U.S.C. 4321 et seq.). The project team should seek to avoid and minimize environmental impacts in the design and construction of the Cougar downstream juvenile fish passage project. In order to comply with NEPA, a draft Environmental Impact Statement (EIS) will be distributed for a 30-day public review and comment period for the proposed Cougar Downstream Fish Passage Facility. The draft EIS will address alternatives analyses and temporary and permanent environmental and impacts associated with project elements. Major project elements include: After the public notice period has closed, any comments will be addressed in the final EIS, and it is likely a Finding of No Significant Impact (FONSI) will be completed based on the assessment. If significant environmental concerns arise during the comment period, then an Environmental Impact Statement will be required.

8.3.2 Endangered Species Act (ESA)

In accordance with Section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended, federally funded, constructed, permitted, or licensed projects must take into consideration impacts to federally listed or proposed species. Listed species under the jurisdiction of the U.S. Fish and Wildlife Service (USFWS) which may occur in Lane County include: Northern spotted owl (Strix occidentalis caurina) and Bull trout (Salvalinus confluentus). Listed species under the jurisdiction of National Marine Fisheries Service (NMFS) include: Upper Willamette River Chinook salmon (Oncorhynchus tshawytscha) and Upper Willamette River steelhead (Oncorhynchus mykiss). The Detroit Dam Selective Withdrawal Structure is incorporated in the concurrently issued July 11, 2008, NMFS and USFWS ESA Section 7(a)(2) Consultation Biological Opinions (BiOps) on the "Willamette River Basin Flood Control Project". The Detroit Dam Selective Withdrawal Structure designs should also adhere to the NMFS 2008 Anadromous Salmonid Passage Facility Design Standards. Additionally, a summary describing anticipated effects and the significance assessment will be submitted to NMFS for their take determination. The consultation pathway will depend on whether any of the effects could qualify as "take" under the ESA regardless of whether the net effect of the project will be beneficial. Based on conversations with NMFS General Counsel, even if NMFS finds the effects rise to the level of "take," NMFS currently believe they will be able to provide take coverage through the existing BiOp rather than an individual consultation.

8.3.3 Magnuson-Stevens Fishery Conservation and Management Act

In compliance with the Magnuson-Stevens Fishery Conservation and Management Act, an Essential Fish Habitat (EFH) assessment will be prepared and included as part of the summary described under 9.2.b and sent to and reviewed by NMFS. Formal Consultation was completed and incorporated in the above referenced 2008 NMFS Biological Opinion.

8.3.4 Fish and Wildlife Conservation Act (FWCA)

To meet compliance with the Fish and Wildlife Conservation Act, input from the USFWS and state fish and wildlife agencies concerning this proposal will be requested during the public notice comment period for the EIS. Further, the Detroit Dam Selective Withdrawal Structure and FSS is being developed in close collaboration with NMFS and USFWS, and their staff has had and will continue to have input throughout the design of the facility. All elements of the project design should pass review by the resource agencies. Comments from resource agencies were also received on the original Environmental Impact Statement for the Willamette River Project. Additionally, some requirements of this Act have been simultaneously addressed in conjunction with the ESA consultations referenced above.

8.3.5 Coastal Zone Management Act (CZMA)

This Act is not applicable to the Detroit Dam Selective Withdrawal Structure and FSS due to its location outside the geographic boundaries of the Act.

8.3.6 Marine Protection, Research, & Sanctuaries Act Title I (MPRSA) (Section 103)

This project will not involve ocean dumping or any other action impacting the marine environment. Therefore, coordination under this Act is not required for this proposed action.

8.3.7 Clean Water Act (CWA) (Sections 401, 404r, 404b (1))

A 404(b) analysis will be completed for this project. Additionally, in order to comply with Section 404 of the Clean Water Act, dredge and fill activities proposed for the Detroit Dam FSS will require an individual State 401 Water Quality Certification (WQC) from the Oregon Department of Environmental Quality (DEQ) for temporary and permanent impacts to wetlands and waters of the State. This requires submission of fees and a Joint Permit Application (JPA) for Removal and Fill, which is accepted by both DEQ and the Department of State Lands (DSL). Because impervious surfaces are involved, the DEQ 401 program also requires submission of a post-construction Stormwater Management Plan (SWMP) for permanent treatment of nonpoint discharge from the facility. DEQ has accepted specific design criteria from five manuals. These approved design manuals and the checklist of information that will be required in the SWMP are referenced in the DEQ Stormwater Management Plan Submission Guidelines.

Temporary impacts to water quality should be avoided and minimized during the project's construction and staging. An Erosion and Sediment Control Plan must be developed and implemented in compliance with the Corps' existing general NPDES 1200-CA permit issued by DEQ for during-construction stormwater management. A guide for proper installation and maintenance of appropriate Best Management Practices (BMPs) for both uplands and in-water work can be found in the DEQ Erosion and Sediment Control Manual. Low Impact Development (LID) techniques including infiltration and protection of existing soils and vegetation should be implemented wherever appropriate. Site grubbing and clearing as much as possible should be kept to the minimum required for the permanent project footprint.

8.3.8 Clean Air Act (CAA)

Section 118 (42 U.S.C. 7418) of the Clean Air Act (CAA) specifies that each department, agency, and instrumentality of the executive, legislative, and judicial branches of the Federal Government (1) having jurisdiction over any property or facility or (2) engaged in any activity resulting, or which may result, in the discharge of air pollutants, shall be subject to, and comply with, all Federal, State, interstate, and local requirements respecting the control and abatement of air pollution in the same manner, and to the same extent as any non-governmental entity. Corps activities resulting in the discharge of air pollutants must conform to National Ambient Air Quality Standards (NAAQS) and State Implementation Plans (SIP), unless the activity is explicitly exempted by EPA regulations. Construction of the Detroit Dam Selective Withdrawal Structure is anticipated to remain in compliance with the CAA and the SIP. This is not a transportation project, it will not qualify as a major stationary source of emissions of criteria pollutants, and the project does not appear to be located in a non-attainment area for limited air quality. Any emissions that do occur during and after construction from motor vehicles or facility functions are expected to be de minimis and will be from activities of a similar scope and operation to those of the original facility.

8.3.9 Applicable Local and State Statutes.

DSL requires submission of fees and the same JPA as DEQ for impacts to wetlands and waters of the State (per Oregon Revised Statutes 196.795-990). DSL will require functional restoration for impacts to waters and wetland mitigation based on ratios set forth by statute and rules (OAR 141.085.680-715).

The ODFW recommends specific in-water work windows (IWWW) for the protection of endangered species. The IWWW for the South Fork McKenzie River is from July 1 - August 15. In-water work must be conducted within this window unless an exemption or extension is obtained through the approval of ODFW and NMFS, and the Corps must coordinate with these agencies in order to demonstrate approval as required in the DEQ WQC and by DSL. An exemption will likely be required for in-water work at as the construction of the will occur over several seasons.

ODFW has further requirements regarding blasting, and a permit for these activities must be obtained for work in and adjacent to waters. Blasting should be scheduled to occur during the in-water work window. ODFW also recommends coordination with the District Habitat Biologist who may serve as a valuable resource for implementing blasting BMPs to protect species and for developing an effective revegetation and mitigation plan to address restoration of ecosystem function. Finally, ODFW has its own mitigation policy that should be referenced when considering how to implement this plan. (OAR 635.415.0000-0025).

A complete application for DEQ 401 WQC review requires land use compatibility findings. Lane County may sign a City/County Planning Department Affidavit section on the JPA, or the Corps must show how the actions meet provisions of the local land use plan. Per OAR 340-048-0020, DEQ cannot issue a 401 Certification without this information.

The facility may also be required to operate under a general NPDES permit for wastewater discharge. The permit may include site-specific provisions for the disposal of anesthetics used for handling/sorting fish.

8.3.10 National Historic Preservation Act (NHPA)

Section 106 of the National Historic Preservation Act (NHPA) requires that federally assisted or federally permitted undertakings account for the potential effects on sites, districts, buildings, structures, or objects that are included in or eligible for inclusion in the National Register of Historic Places. Detroit Dam was built in 1953 and is recommended eligible to the National Register of Historic Places. It will be necessary to ensure that project construction is consistent with “in-kind” maintenance of the structure and will not impact eligibility. Any proposed drawdown to elevation below the minimum conservation pool elevation of 1450 feet has the potential to expose documented archeological sites and to expose new sites. Areas exposed will need to be inventoried prior to construction and known archeological sites will need to be monitored to update site condition to current State Historic Preservation Office standards. During any drawdown, law enforcement or rangers will need to increase patrols along the shoreline to watch for potential looting as sites are exposed. Consultation with the State Historic Preservation Office and the tribes will be conducted, which will include consultation on the Area of Potential Effect, which is assumed to include the dam, any staging areas, and the area exposed by the deep drawdown

9 Construction

To be included in 60% DDR.

10 Operations and Maintenance

To be included in 60% DDR

11 Cost Estimates

To be included on 60% DDR.

12 Recommendation

To be included on 60% DDR.

Appendix A – USACE Provided Technical Information

Detroit FSS: Recommended Design Flow Rates

Memorandum to the files. 8/4/2017

Revised 9/18/17

Subject: Detroit Floating Screen Structure - Recommended Minimum and Maximum Design Flow Rates (DRAFT)

From: CENWP-EC-HD

1. Purpose:

Provide the minimum (non-zero) and maximum design inflow rates for the Detroit Floating Screen Structure (FSS). This is needed to both refine the scope of the AE Task order for the FSS design document report (DDR) and finalize the engineering document report (EDR).

2. Assumptions:

   2.1. Spring (Mar – May) is the most important time for juvenile fish collection
   2.2. Autumn (Oct – Dec) is the second most important time for juvenile fish collection
   2.3. Temperature control targets essentially call for all surface flow in spring
   2.4. Temperature control targets essentially call for most or all flow from low level depths in autumn; the precise proportion or flow quantities are pending based on current temperature control modelling
   2.5. Power peaking power operations at Detroit will be continued after the installation of the FSS.
      2.5.1. The minimum FSS inflow represents the minimum 'non-zero' discharge into the FSS as project discharges are often terminated during the 24 hour day. During zero-discharge project periods, the minimum FSS inflow would be 100 cfs pumped discharge as needed to maintain the fish collection barge and provide a means of fish outlet from the FSS.
      2.5.2.
   2.6. NMFS criteria call for design flow rates to be between 95% and 5% exceedance within a 30 year record.
   2.7. Daily minimum discharge rate from Big Cliff is between 1000 – 1500 cfs depending on the month. This represents the minimum daily average flow from Detroit.
   2.8. Hourly discharge flow statistics are used to size the FSS as it must be sized to handle the range of flows caused by power peaking and other operations.
   2.9. Maximum FSS design discharge will not attempt encompass the 5% project discharge, but will instead will encompass the powerhouse discharges during the spring months during which most or all water will be pulled from the surface during a critical fish collection time. The goal is to ensure that the powerhouse discharges and the ability to meet temperature control goals are not constricted during these months.
   2.10. Minimum FSS design discharge will focus on spring 95% exceedance (again assuming all surface flow) and the surface proportion of the 95% exceedance flow during the autumn months. If the autumn flow case shows surface demand to be too low for effective fish collection, then the spring case will govern and forebay pumps will be required to augment the fish collection during autumn months.

Detroit FSS: Recommended Design Flow Rates

2.10.1. Assuming a design 2-foot head drop across a single 10-foot wide intake weir, the weir submergence below forebay is the following as a function of surface discharge:

Surface flow (cfs)	Weir Subm (ft)	Surface flow (cfs)	Weir Subm (ft)
1000	12.7	500	6.9
800	10.4	400	5.7
630	8.4	250	3.8

2.11. A factor to reduce the design limit and range of flows would be more consistent velocities in the FSS.

3. A factor to increase the design limit is to better combat competing flows at low reservoir levels (winter , early spring and late autumn) during higher flow conditions. Hourly Discharge exceedance data for Powerhouse and Total Project Discharge:

Hourly discharge exceedance represents the discharge rate which is exceeded at a specific percent of the time. The record only include hours in which the project discharge flow. For example for all the times that Detroit discharged flow during March, 980 cfs was exceeded 95% of the time. Thus the 95% exceedance project flow in March is 980 cfs. There are two periods of records presented for both powerhouse and project flow:

1985 -2016
Apr 2009 – mar 2017 (2015 excluded)

The larger records provides a general historical record for the project operations over 31 years. There are no omissions from the record and there are changes or disruption in the operation that occurred during this tenure.

The smaller data set represents a change in the project operations after a fire occurred in the powerhouse in 2006 and the Biological Opinion was released in 2008. The turbines are operated differently and the spillway is operated more frequently (non-flood) when the reservoir is above elevation 1541 feet in order to augment temperature control downstream of Big Cliff reservoir. Data from 2015 is omitted as it was a severe drought year that would skew the short record.

Detroit FSS: Recommended Design Flow Rates

Table 1~~Table 1~~ shows the hourly exceedance table for the total project flow from 1985 – 2016. This represents the combined discharge from powerhouse, regulating outlets and spillway. The minimum, maximum and percent exceedance flows (ranging from 99% to 1%) are included in the table for each month over the 31 year record. The right column includes the annual data. The bottom of the table shows the percent of time discharge was released from Detroit for each month. The percent of time discharge is released averages 62% of the time for the year and varies from 48% in August to 75% in November.

Table 2~~Table 2~~ shows the hourly exceedance table for the total powerhouse flow from 1985 – 2016. Note that the percentage of powerhouse operation time tracks about 7% less than total project operations, but varies most during summer months. Also note that the powerhouse flows are nearly always below 5500 cfs, whereas the total project discharge exceeds 10,000 cfs on several occasions.

Table 1 - Detroit Dam Hourly Project Discharge Exceedance Data (cfs) for 1985 - 2016

Detroit Dam Hourly Project Discharge Exceedance Data (cfs) *Period of Record: 1985 - 2016*													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max	14,120	14,140	11,860	11,060	11,370	9,750	7,430	6,810	7,210	8,100	10,240	13,070	14,140
1%	13,690	13,369	9,240	9,350	9,080	5,980	5,525	4,820	4,960	5,970	9,400	11,180	9,970
5%	9,760	9,530	6,720	5,510	4,990	4,230	3,930	3,962	4,140	4,580	7,510	9,310	6,710
10%	7,747	6,912	4,690	4,360	4,440	3,920	3,900	2,720	4,100	4,510	6,300	7,760	5,290
25%	5,320	4,710	4,210	4,040	3,920	3,900	2,250	1,990	4,000	4,350	4,950	5,410	4,390
Average	4,728	3,705	3,231	3,159	3,288	2,768	2,199	1,993	2,511	3,307	4,391	4,773	3,425
75%	2,650	2,290	2,150	2,020	1,980	1,940	1,890	1,830	1,970	2,170	3,220	2,690	1,990
90%	2,270	1,120	1,700	1,970	1,950	1,490	1,090	970	1,320	2,010	2,330	2,450	1,810
95%	1,750	940	980	1,790	1,880	1,190	830	860	840	1,455	2,230	2,120	1,150
99%	1,080	800	720	950	1,300	630	450	620	508	720	1,650	1,530	650
Min	30	50	70	50	50	50	50	50	50	50	40	50	30
Total Percent of Time Project Discharged Flow during 1985 - 2016													
	67%	51%	50%	56%	71%	64%	49%	48%	64%	74%	75%	70%	62%

Table 2 - Detroit Dam Hourly Powerhouse Discharge Exceedance Data (cfs) for 1985 - 2016

Detroit Dam Hourly Powerhouse Discharge Exceedance Data (cfs) *Period of Record: 1985 - 2016*													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max	5,760	5,780	5,110	4,600	4,730	4,630	4,740	4,910	5,110	5,390	5,740	5,750	5,780
1%	5,500	5,400	4,780	4,580	4,460	4,400	4,613	4,770	4,210	4,630	5,480	5,520	5,410
5%	5,360	5,110	4,510	4,230	3,950	3,920	3,930	3,970	4,140	4,540	5,170	5,410	5,160
10%	5,290	4,890	4,320	4,090	3,930	3,910	3,910	2,360	4,100	4,490	5,010	5,350	4,910
25%	5,060	4,530	4,150	4,010	3,910	3,900	2,050	1,990	4,020	4,350	4,820	5,150	4,250
Average	3,868	3,254	3,041	2,892	2,929	2,653	2,360	2,059	2,598	3,394	3,790	4,055	3,155
75%	2,550	2,340	2,150	2,000	1,960	1,950	1,950	1,950	1,990	2,180	2,440	2,660	2,000
90%	2,250	2,190	2,080	1,970	1,950	1,940	1,890	1,350	1,770	2,090	2,280	2,420	1,950
95%	2,020	1,160	1,150	1,920	1,900	1,770	1,567	970	1,270	1,970	2,170	2,025	1,780
99%	1,310	1,110	970	1,160	1,410	1,212	591	580	970	1,190	1,800	1,460	970
Min	30	50	70	50	50	20	50	10	30	50	35	50	10
Total Percent of Time Units were Operated during 1985 - 2016													
	64%	47%	47%	53%	68%	55%	37%	40%	55%	65%	69%	66%	55%

Detroit FSS: Recommended Design Flow Rates

Table 3~~Table 3~~ shows the hourly exceedance table for the total project flow from April 2009 – March 2017 (omitting year 2015). The percent of time discharge is released averages 80% of the time for the year and varies from 69% in August to 96% in November.

Table 4~~Table 4~~ shows the hourly exceedance table for the total powerhouse flow from rom April 2009 – March 2017 (omitting year 2015). Note that the percentage of powerhouse operation time tracks within 0% 11% less from November – May, and deviates most during summer months when spill is often discharged for temperature control purposes. Also note that the powerhouse flows are mostly below 5000 cfs, whereas the total project discharge approaches or exceeds 10,000 cfs on several occasions.

Table 3 - Detroit Dam Hourly Project Discharge Exceedance Data (cfs) for April 2009 – March 2017

Detroit Dam Hourly Project Discharge Exceedance Data (cfs) *Period of Record: April 2009 - March 2017 (2015 excluded)*													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max	10,060	9,830	9,220	11,060	11,370	9,750	3,410	3,460	5,190	8,100	7,180	10,230	11,370
1%	9,960	9,060	8,683	6,260	9,800	9,610	3,160	3,110	4,300	6,090	7,090	9,630	7,229
5%	9,680	7,360	7,020	5,426	4,990	4,920	2,720	2,430	3,210	5,910	6,450	8,780	5,741
10%	7,830	6,850	6,500	4,360	4,000	3,610	2,368	2,060	2,780	4,430	6,010	6,890	4,807
25%	4,840	4,360	4,210	3,770	3,760	3,070	1,960	1,940	2,090	3,900	4,440	5,010	3,613
Average	3,829	3,205	3,263	2,778	2,943	2,314	1,484	1,448	1,799	2,842	3,715	3,913	2,795
75%	2,120	1,190	2,030	1,960	1,960	1,400	980	970	1,320	2,020	2,580	2,400	1,744
90%	1,360	1,130	1,000	1,780	1,840	990	540	790	756	1,350	2,030	1,840	1,284
95%	1,160	1,110	980	1,380	1,710	817	460	710	600	1,056	1,900	1,660	1,129
99%	150	150	250	549	860	488	440	570	300	600	554	860	481
Min	50	50	50	50	50	50	50	50	50	150	40	50	40
Total Percent of Time Project Released Discharge from April 2009 - March 2017 (2015 excluded)													
	76%	65%	74%	71%	90%	84%	74%	69%	85%	96%	94%	82%	80%

Table 4 - Detroit Dam Hourly Powerhouse Discharge Exceedance Data (cfs) for April 2009 – March 2017

Detroit Dam Hourly Powerhouse Discharge Exceedance Data (cfs) *Period of Record: April 2009 - March 2017 (2015 excluded)*													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max	5,500	5,110	5,010	4,350	4,230	4,440	2,220	2,280	4,330	4,750	5,360	5,540	5,540
1%	5,370	4,890	4,390	4,240	4,000	4,030	2,090	2,080	4,030	4,416	5,120	5,280	5,150
5%	5,170	4,680	4,220	4,070	3,930	3,920	2,030	2,040	3,248	4,310	4,820	5,060	4,610
10%	5,000	4,440	4,110	3,990	3,920	2,840	2,020	2,010	2,120	4,260	4,640	4,790	4,280
25%	4,420	4,140	3,980	3,300	3,670	1,990	1,970	1,940	2,050	3,950	3,750	4,400	3,710
Average	3,169	2,835	2,722	2,467	2,482	1,999	1,717	1,484	1,825	2,780	2,978	3,253	2,570
50%	2,690	2,520	2,480	2,040	1,970	1,950	1,910	1,630	1,880	2,190	2,490	3,340	2,110
75%	2,220	1,203	2,030	1,960	1,940	1,790	1,550	970	1,420	2,070	2,240	2,380	1,900
90%	1,370	1,130	1,000	1,790	1,840	1,420	1,150	970	980	1,890	1,966	1,740	1,280
95%	1,280	1,110	980	1,540	1,710	1,280	840	840	980	1,350	1,860	1,620	990
99%	150	133	100	500	1,030	150	150	162	400	1,040	1,290	700	200
Min	50	50	50	50	50	20	50	10	30	50	35	50	10
Total Percent of Time Units were Operated from April 2009 - March 2017													
	74%	65%	68%	62%	79%	44%	30%	45%	66%	77%	87%	78%	64%

Detroit FSS: Recommended Design Flow Rates

4. Maximum Design Discharge:

   4.1. The 5% exceedance discharges for the powerhouse units vary from 3950 - 4510 for March – May for the 31 year record (average 4153 cfs)

   4.2. The 1% exceedance discharges for the powerhouse units vary from 4460 - 4780 for March – May for the 31 year record (average 4555 cfs)

   4.3. The 5% exceedance discharges for the powerhouse units vary from 3920 - 4220 for March – May for the 7 year record (average 4035 cfs)

   4.4. The 1% exceedance discharges for the powerhouse units vary from 4000 - 4390 for March – May for the 7 year record (average 4165 cfs)

   4.5. The max discharges for the powerhouse units vary from 4220 - 5010 for March – May for the 7 year record (average 4508 cfs)

   4.6. The 5% exceedance discharges for the for the total project flow vary from 4920 - 7020 for March – May for the 7 year record (average 5589 cfs)

   The recommendation is to meet the approximate March – May average of 1% exceedance of the powerhouse flow in the 31 year record and the average maximum PH flow of the 7 year record.
   Rounding down, the recommended maximum design discharge is 4500 cfs.

   During the important fish collection of March, 4500 cfs represents the 5% exceedance of the powerhouse flow in the 31 year record, and lands between the 1% (nearer) and maximum in the 7-year record.

   During May, 4500 cfs represents about the 9% exceedance of the total project flow and 7% in the 7-year record.

5. Minimum Design Discharge (based on spring and annual flows):

   5.1. The 95% exceedance discharges for the project discharge vary from 940 - 1880 for February – June for the 31 year record (average 1356 cfs)

   5.2. The 95% exceedance discharges for the annual project discharge is 1150 cfs for the 31 year record.

   5.3. The 95% exceedance discharges for the project discharge vary from 817 - 1170 for February – June for the 7 year record (average 1200 cfs)

   5.4. The 95% exceedance discharges for the annual project discharge is 1129 cfs for the 7 year record.

   5.5. The minimum daily discharge from Big Cliff is between 1000 – 1500 cfs depending on month.

   5.6. The 95% exceedence for important fish collection of month of March is 980 cfs in both 31 and 7-year records.

   Weighing the month of March and the minimum daily flow criteria of 1000 cfs, the recommended minimum design hourly discharge is 1000 cfs.

As noted, this minimum discharge represents the minimum 'non-zero' flow into the FSS during project discharge operations. During periods of no project discharge, the FSS inflow will only be 100 cfs discharge for the fish collection barge that would be pumped back to the surface of the forebay. This could change if additional larger surface water pumps (up to 1000 cfs) are deemed required either during the design phase, or sometime after initial construction of the FSS if performance results fall short of the design goals.

Recent temperature control modelling analyses indicate this minimum design flow would have minimal impact on the temperature control the targets of during the autumn months when most cold water is required.

Stephen Schlenker, CENWP-EC-HD

Review:

Sean Askelson, CENWP-EC-HD, Chief
Jeff Ament, CENWP-PM
Kristy Fortuny, TL, CENWP-EC-DS
Jon Rerecich, CENWP-PM-E
Mary-Karen Scullion, CENWP-EC-HR
Norm Bucolla, CENWP-EC-HR
Aaron Litzenberg, CENWP-EC-HD

Appendix B - Detroit FSS Weight Estimate

REVISIONS				
REV	ITEM	DESCRIPTION	DATE	APPROVED
		Initial issue.		
P0		30% DDR Submittal	Jan 12 2017	

NOTES:

1. vcg measured from top of belly tanks, + upward
2. lcg measred from headlog (fish entrance), + aft
3. tcg measured from centerline, + to starboard
4. Xfwd = Fwd boundary of item
5. Xaft = Aft boundary of item

SAP#		DETROIT RESERVOIR 30% DDR FSS BARGE WEIGHT ESTIMATE
PL#		
DATE	20170112	
ENG - CMS	DES -	
DR -	CHK - EDS	
APPROVAL		
SCALE: NONE	SHEET: 1	REVISION: P0

Filename: FSS Wt Est 8'BT 10'FLTS.xlsx
Printout Date: 1/4/2018

DETROIT FSS WEIGHT ESTIMATE, REV P0
SHEET: 1

SWBS 1-DIGIT LIGHTWEIGHT SUMMARY

REV	SWBS	DESCRIPTION	WITHOUT Design Margin				WITH Design Margin			
			WEIGHT [pounds]	VCG [feet]	LCG [feet]	TCG [feet]	WEIGHT [pounds]	VCG [feet]	LCG [feet]	TCG [feet]
P0	100	HULL STRUCTURE	4026904	12.97	133.42	0.92	4228256	12.97	133.42	0.92
		30% for Structure Support	1208071	12.97	133.42	0.92	1268477	12.97	133.42	0.92
		2.5% for welding and mil scale	130874	12.97	133.42	0.92	137418	12.97	133.42	0.92
P0	200	PROPULSION PLANT	0				0			
P0	300	ELECTRIC PLANT	81250	35.00	173.33	0.00	91000	35.00	173.33	0.00
P0	400	COMMAND AND SURVEILLANCE	500	35.00	173.33	0.00	560	35.00	173.33	0.00
P0	500	AUXILIARY SYSTEMS	652844	11.28	104.38	2.91	731184	11.28	104.38	2.91
P0	600	OUTFIT AND FURNISHINGS	158800	47.06	224.71	11.21	177856	47.06	224.71	11.21
P0	700	SPECIAL PURPOSE SYSTEMS	2933994	26.44	215.60	10.37	3286074	26.44	215.60	10.37
		less 798 Operating Fluids	-1134000	30.00	284.00	28.50	-1270080	30.00	284.00	28.50
		TOTALS	8059237	16.24	142.00	0.36	8850745	16.38	142.37	0.34
		Builders Margin (2.0%)	161185	16.24	142.00	0.36	173015	16.38	142.37	0.34
		Service Life Margin	0	0.00	0.00	0.00	0	0.00	0.00	0.00
		Estimated Lightweight	8220422	16.24	142.00	0.36	8823760	16.38	142.37	0.34
		(Long ton units)	3669.83	16.24	142.00	0.36	3939.18	16.38	142.37	0.34
		Margins Summary:								
		Design Margin (7.3%)	0	0.00	0.00	0.00	591508	19.31	147.45	0.01
		Builders Margin (2.0%)	161185	16.24	142.00	0.36	173015	16.38	142.37	0.34
		Service Life Margin	0	0.00	0.00	0.00	0	0.00	0.00	0.00
		TOTAL Margins	161185	16.24	142.00	0.36	764523	17.87	146.30	0.08
		(Long ton units)	71.96	16.24	142.00	0.36	341.30	17.87	146.30	0.08

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DETAILS + stbd

SWBS IDENT	REV	ITEM / DESCRIPTION	QTY	UNITS	UNIT WT [pounds]	MARG	WEIGHT [pounds]	XFwd [feet]	XAft [feet]	VCG [feet]	LCG [feet]	TCG [feet]
100	P0	HULL STRUCTURE										
111	P0	Float Cell Port	15,656	SF	20.4	1.05	335352	0.00	248.00	21.39	130.10	-46.60
111	P0	Float Cell Stbd	6,680	SF	20.4	1.05	143086	0.00	248.00	20.00	164.50	40.75
111	P0	Float Cell Stbd	10,320	SF	20.4	1.05	221054	0.00	248.00	20.00	119.19	50.56
111	P0	Float Cell Center-Aft	6,753	SF	20.4	1.05	144649	81.00	164.00	19.98	123.24	0.00
111	P0	Fish Coll Shell Stbd	840	SF	20.4	1.05	17993	264.00	304.00	29.50	284.00	50.75
111	P0	Fish Coll Shell-Port	840	SF	20.4	1.05	17993	264.00	304.00	29.50	284.00	-50.75
111	P0	Fish Coll Shell-Aft	2,132	SF	20.4	1.05	45667	304.00	304.00	29.50	304.00	0.00
111	P0	Fish Coll Shell Bottom	4,060	SF	20.4	1.05	86965	264.00	304.00	19.00	284.00	0.00
111	P0	Float Cell Aft-Port Shell	640	SF	20.4	1.05	13709	248.00	264.00	20.00	256.00	-50.75
111	P0	Float Cell Aft-Aft Bhd	3,664	SF	20.4	1.05	78483	264.00	264.00	20.81	264.00	0.00
111	P0	Float Cell Aft Stbd Shell	640	SF	20.4	1.05	13709	248.00	264.00	20.00	256.00	50.75
111	P0	Float Cell Aft-Fwd Bhd	3,900	SF	20.4	1.05	83538	248.00	248.00	20.22	248.00	0.00
111	P0	Belly Tank Shell, Bottom	26,796	SF	20.4	1.05	573970	0.00	264.00	-8.00	132.00	0.00
111	P0	Belly Tank Shell, Stbd	2,112	SF	20.4	1.05	45239	0.00	264.00	4.00	132.00	50.75
111	P0	Belly Tank Shell, Port	2,112	SF	20.4	1.05	45239	0.00	264.00	4.00	132.00	50.75
111	P0	Belly Tank Shell, Stern	812	SF	20.4	1.05	17393	264.00	264.00	-4.00	264.00	0.00
111	P0	Belly Tank Shell, Headlog	812	SF	20.4	1.05	17393	0.00	0.00	4.00	0.00	0.00
111	P0	Exp Chan Stbd	4,191	SF	20.4	1.05	89771	0.00	81.00	20.00	38.97	30.00
111	P0	Exp Chan Port	4,191	SF	20.4	1.05	89771	0.00	81.00	20.00	38.97	-30.00
111	P0	Exp Chan Center	8,622	SF	20.4	1.05	184683	0.00	81.00	20.00	39.01	0.00
113	P0	Belly Tank Shell, Top	26,796	SF	20.4	1.05	573970	0.00	264.00	0.00	132.00	0.00
114	P0	Float Cell Port -Tower Extension	924	SF	20.4	1.05	19792	174.00	248.00	10.39	211.00	-53.75
121	P0	Float Cell Port-Lower Diaphram	1,740	SF	20.4	1.05	37271	0.00	240.00	10.00	87.00	-45.75
121	P0	Float Cell Port-Mid Diaphram	1,742	SF	20.4	1.05	37314	0.00	240.00	19.00	87.00	-45.75
121	P0	BT-Long	2,112	SF	20.4	1.05	45239	0.00	240.00	-4.00	132.00	-40.75
121	P0	BT-Long	2,112	SF	20.4	1.05	45239	0.00	240.00	-4.00	132.00	-21.12
121	P0	BT-Long	2,112	SF	20.4	1.05	45239	0.00	240.00	-4.00	132.00	0.00
121	P0	BT-Long	2,112	SF	20.4	1.05	45239	0.00	240.00	-4.00	132.00	21.12
121	P0	BT-Long	2,112	SF	20.4	1.05	45239	0.00	240.00	-4.00	132.00	40.75
121	P0	Float Cell Center-Center Bhd	3,240	SF	20.4	1.05	69401	0.00	81.00	20.00	40.50	0.00
122	P0	Float Cell Stbd Transv. Diaphram	945	SF	20.4	1.05	20242	34.50	34.50	20.00	34.50	38.94
122	P0	Float Cell Port-Transv. Diaphram	945	SF	20.4	1.05	20242	34.50	34.50	20.00	34.50	-38.93
122	P0	Float Cell Stbd-Transv. Diaphram	400	SF	20.4	1.05	8568	76.40	76.40	20.00	76.40	45.76
122	P0	Float Cell Port Transv. Diaphram	400	SF	20.4	1.05	8568	76.40	76.40	20.00	76.50	45.75
122	P0	Float Cell Stbd-Lower Diaphram	2,480	SF	20.4	1.05	53122	0.00	240.00	10.00	124.00	45.75
122	P0	Float Cell Stbd-Mid Diaphram	2,480	SF	20.4	1.05	53122	0.00	240.00	19.00	124.00	45.75
122	P0	BT Transv	812	SF	20.4	1.05	17393	71.50	71.50	4.00	71.50	0.00

DETAILS + stbd

SWBS IDENT	REV	ITEM / DESCRIPTION	QTY	UNITS	UNIT WT [pounds]	MARG	WEIGHT [pounds]	Xfwd [feet]	Xaft [feet]	VCG [feet]	LCG [feet]	TCG [feet]
122	P0	BT-Transv	812	SF	20.4	1.05	17393	213.00	213.00	-4.00	213.00	0.00
122	P0	BT-Transv	812	SF	20.4	1.05	17393	33.75	33.75	-4.00	33.75	0.00
122	P0	Float Cell Center-Transv. Bhd	1,210	SF	20.4	1.05	25918	34.50	34.50	20.00	34.50	0.00
122	P0	Float Cell Stbd-Transv. Diaphram	400	SF	20.4	1.05	8568	67.40	67.40	20.00	67.40	45.76
122	P0	Float Cell Port-Transv. Diaphram	400	SF	20.4	1.05	8568	67.40	67.40	20.00	67.40	-45.75
122	P0	Float Cell Port-Transv. Diaphram	168	SF	20.4	1.05	3599	175.40	175.40	29.50	175.40	-44.75
122	P0	Float Cell Port-Transv. Diaphram	168	SF	20.4	1.05	3599	185.40	185.40	29.50	185.40	-44.75
122	P0	Float Cell Port-Transv. Diaphram	168	SF	20.4	1.05	3599	195.40	195.40	29.50	195.40	-44.75
122	P0	Float Cell Port-Transv. Diaphram	168	SF	20.4	1.05	3599	205.40	205.40	29.50	205.40	-44.75
122	P0	Float Cell Port-Transv. Diaphram	168	SF	20.4	1.05	3599	215.40	215.40	29.50	215.40	-44.75
122	P0	Float Cell Port-Transv. Diaphram	168	SF	20.4	1.05	3599	225.40	225.40	29.50	225.40	-44.75
122	P0	Float Cell Port-Transv. Diaphram	168	SF	20.4	1.05	3599	235.40	235.40	29.50	235.40	-44.75
122	P0	Float Cell Port-Transv. Diaphram	168	SF	20.4	1.05	3599	245.40	245.40	29.50	245.40	-44.75
122	P0	Float Cell Port-Transv. Diaphram	400	SF	20.4	1.05	8568	165.40	165.40	20.00	165.40	-45.74
122	P0	Float Cell Port-Transv. Diaphram	400	SF	20.4	1.05	8568	155.40	155.40	20.00	155.40	-45.74
122	P0	Float Cell Port-Transv. Diaphram	400	SF	20.4	1.05	8568	145.40	145.40	20.00	145.40	-45.74
122	P0	Float Cell Port-Transv. Diaphram	400	SF	20.4	1.05	8568	135.40	135.40	20.00	135.40	-45.74
122	P0	Float Cell Port-Transv. Diaphram	400	SF	20.4	1.05	8568	125.40	125.40	20.00	125.40	-45.74
122	P0	Float Cell Port-Transv. Diaphram	400	SF	20.4	1.05	8568	115.40	115.40	20.00	115.40	-45.74
122	P0	Float Cell Port-Transv. Diaphram	400	SF	20.4	1.05	8568	105.40	105.40	20.00	105.40	-45.74
122	P0	Float Cell Port-Transv. Diaphram	400	SF	20.4	1.05	8568	95.40	95.40	20.00	95.40	-45.74
122	P0	Float Cell Port-Transv. Diaphram	400	SF	20.4	1.05	8568	85.40	85.40	20.00	85.40	-45.74
122	P0	Float Cell Stbd-Transv. Diaphram	400	SF	20.4	1.05	8568	245.40	245.40	20.00	245.40	45.76
122	P0	Float Cell Stbd-Transv. Diaphram	400	SF	20.4	1.05	8568	235.40	235.40	20.00	235.40	45.76
122	P0	Float Cell Stbd-Transv. Diaphram	400	SF	20.4	1.05	8568	225.40	225.40	20.00	225.40	45.76
122	P0	Float Cell Stbd-Transv. Diaphram	400	SF	20.4	1.05	8568	215.40	215.40	20.00	215.40	45.76
122	P0	Float Cell Stbd-Transv. Diaphram	400	SF	20.4	1.05	8568	205.40	205.40	20.00	205.40	45.76
122	P0	Float Cell Stbd-Transv. Diaphram	400	SF	20.4	1.05	8568	195.40	195.40	20.00	195.40	45.76
122	P0	Float Cell Stbd-Transv. Diaphram	400	SF	20.4	1.05	8568	185.40	185.40	20.00	185.40	45.76
122	P0	Float Cell Stbd-Transv. Diaphram	400	SF	20.4	1.05	8568	175.40	175.40	20.00	175.40	45.76
122	P0	Float Cell Stbd-Transv. Diaphram	400	SF	20.4	1.05	8568	165.40	165.40	20.00	165.40	45.76
122	P0	Float Cell Stbd-Transv. Diaphram	400	SF	20.4	1.05	8568	155.40	155.40	20.00	155.40	45.76
122	P0	Float Cell Stbd-Transv. Diaphram	400	SF	20.4	1.05	8568	145.40	145.40	20.00	145.40	45.76
122	P0	Float Cell Stbd-Transv. Diaphram	400	SF	20.4	1.05	8568	135.40	135.40	20.00	135.40	45.76
122	P0	Float Cell Stbd-Transv. Diaphram	400	SF	20.4	1.05	8568	125.40	125.40	20.00	125.40	45.76
122	P0	Float Cell Stbd-Transv. Diaphram	400	SF	20.4	1.05	8568	115.40	115.40	20.00	115.40	45.76
122	P0	Float Cell Stbd-Transv. Diaphram	400	SF	20.4	1.05	8568	105.40	105.40	20.00	105.40	45.76
122	P0	Float Cell Stbd-Transv. Diaphram	400	SF	20.4	1.05	8568	95.40	95.40	20.00	95.40	45.76

DETAILS + stbd

SWBS IDENT	REV	ITEM / DESCRIPTION	QTY	UNITS	UNIT WT [pounds]	MARG	WEIGHT [pounds]	Xfwd [feet]	Xaft [feet]	VCG [feet]	LCG [feet]	TCG [feet]
122	P0	Float Cell Stbd-Transv. Diaphram	400	SF	20.4	1.05	8568	85.40	85.40	20.00	85.40	45.76
122	P0	BT Transv	812	SF	20.4	1.05	17393	162.00	162.00	4.00	162.00	0.00
122	P0	BT-Transv	812	SF	20.4	1.05	17393	118.75	118.75	-4.00	118.75	0.00
131	P0	Main Deck Grating	628	SF	15.3	1.05	10089	81.00	238.00	40.00	159.50	-27.28
131	P0	Main Deck Grating	628	SF	15.3	1.05	10089	81.00	238.00	40.00	159.50	-14.97
131	P0	Main Deck Grating	628	SF	15.3	1.05	10089	81.00	238.00	40.00	159.50	14.97
131	P0	Main Deck Grating	628	SF	15.3	1.05	10089	81.00	238.00	40.00	159.50	27.28
131	P0	Main Deck	746	SF	15.3	1.05	11984	81.00	161.00	40.00	126.17	35.85
131	P0	Main Deck	3,998	SF	15.3	1.05	64228	81.00	238.00	40.00	168.57	0.00
131	P0	Main Deck	746	SF	15.3	1.05	11984	81.00	161.00	40.00	126.17	35.85
131	P0	Float Cell Stbd Deck	2,480	SF	15.3	1.05	39841	0.00	248.00	40.00	124.00	45.75
131	P0	Float Cell Port Deck	2,344	SF	15.3	1.05	37656	0.00	248.00	40.00	118.95	45.52
131	P0	Float Cell Aft-Deck	1,624	SF	15.3	1.05	26090	248.00	264.00	40.00	256.00	0.00
131	P0	Exp Chan Port Deck	979	SF	15.3	1.05	15728	0.00	81.00	40.00	37.74	-34.59
131	P0	Exp Chan Stbd Deck	979	SF	15.3	1.05	15728	0.00	81.00	40.00	37.74	34.59
131	P0	Exp Chan Center Deck	2,201	SF	15.3	1.05	35359	0.00	81.00	40.00	38.04	0.00
131	P0	Main Deck Grating	98	SF	15.3	1.05	1569	81.00	86.00	40.00	83.48	21.12
131	P0	Main Deck Grating	38	SF	15.3	1.05	610	161.00	164.00	40.00	162.50	34.44
131	P0	Main Deck Grating	18	SF	15.3	1.05	289	161.00	164.00	40.00	162.00	-21.12
131	P0	Main Deck Grating	18	SF	15.3	1.05	289	161.00	164.00	40.00	162.00	21.12
131	P0	Main Deck Grating	38	SF	15.3	1.05	610	161.00	164.00	40.00	162.50	7.81
131	P0	Main Deck	1,018	SF	15.3	1.05	16354	164.00	238.00	40.00	201.74	-33.85
131	P0	Main Deck	1,018	SF	15.3	1.05	16354	164.00	238.00	40.00	201.74	33.85
131	P0	Main Deck Grating	98	SF	15.3	1.05	1569	81.00	86.00	40.00	83.48	21.12
131	P0	Main Deck Grating	38	SF	15.3	1.05	610	161.00	164.00	40.00	162.50	7.81
131	P0	Main Deck Grating	399	SF	15.3	1.05	6410	238.00	248.00	40.00	243.00	0.00
131	P0	Main Deck Grating	184	SF	15.3	1.05	2956	238.00	248.00	40.00	243.00	31.53
131	P0	Main Deck Grating	184	SF	15.3	1.05	2956	238.00	248.00	40.00	243.00	31.53
131	P0	Main Deck Grating	38	SF	15.3	1.05	610	161.00	164.00	40.00	162.50	-34.44
132	P0	Float Cell Stbd Lower Deck	2,480	SF	20.4	1.05	53122	0.00	240.00	30.00	124.00	45.75
132	P0	Float Cell Port-Lower Deck	2,332	SF	20.4	1.05	49951	0.00	240.00	30.00	118.48	-45.50
300	P0	Initial Estimate	1	LOT	81250	1.12	91000			35.00	173.33	0.00
400	P0	Initial Estimate	1	LOT	500.0	1.12	560			35.00	173.33	0.00
500	P0	Intake Weirs, Port	1	LOT	52335.0	1.12	58615	0.00	12.00	22.03	6.07	-21.13
500	P0	Intake Weir Sliding Ramps, Port	1	LOT	22310.0	1.12	24987	18.00	30.00	18.00	24.00	21.13
500	P0	Intake Weir Machinery, Port	1	LOT	74645.0	1.12	83602	2.00	10.00	10.00	6.00	-21.13
500	P0	Intake Weirs, Stbd	1	LOT	52335.0	1.12	58615	0.00	12.00	22.03	6.07	21.13
500	P0	Intake Weir Sliding Ramps, Stbd	1	LOT	22310.0	1.12	24987	18.00	30.00	18.00	24.00	21.13

Filename: FSS Wt Est 8'BT 10'FLTS.xlsx
Printout Date: 1/4/2018

DETROIT FLOATING FISH SCREEN 30% DDR

DETAILS + stbd

SWBS	IDENT	REV	ITEM / DESCRIPTION	QTY	UNITS	UNIT WT [pounds]	MARG	WEIGHT [pounds]	Xfwd [feet]	Xaft [feet]	VCG [feet]	LCG [feet]	TCG [feet]
500		P0	Intake Weir Machinery, Stbd	1	LOT	74645.0	1.12	83602	2.00	10.00	10.00	6.00	21.13
500		P0	Crane	1	EA	43764.0	1.12	49016			50.00	132.00	0.00
506		P0	Overflows, Air Escapes, & Sndg Tubes	1	EA	42000	1.12	47040			5.00	152.00	0.00
512		P0	Forced Ventilation	1	EA	24000	1.12	26880			0.00	165.00	0.00
524		P0	Aux Sea Water	1	EA	39000	1.12	43680			10.00	165.00	0.00
529		P0	Drainage and Ballast	1	EA	67500	1.12	75600			0.00	165.00	0.00
551		P0	Compressed Air	1	EA	12000	1.12	13440			40.00	230.00	0.00
582		P0	Pile Yoke 1	1	EA	18000	1.12	20160			-4.00	32.00	-52.75
582		P0	Pile Yoke 2	1	EA	18000	1.12	20160			-4.00	120.00	-52.75
582		P0	Pile Yoke 3	1	EA	18000	1.12	20160			4.00	306.00	42.00
582		P0	Pile Yoke 4	1	EA	18000	1.12	20160			-4.00	306.00	42.00
582		P0	Pile Yoke 3 & 4 Support Structure	1	EA	54000	1.12	60480	264.00	304.00	-4.00	284.00	0.00
612		P0	Guard Rails, Stantions, Lifelines	1	LOT	8800	1.12	9856			43.00	180.00	0.00
612		P0	Brush Cleaner Rails	1	LOT	12000	1.12	13440			50.00	71.00	0.00
621		P0	Buildings	1	LOT	89000	1.12	99680			55.00	260.00	20.00
622		P0	Floor Plates and Grating	1	LOT	25000	1.12	28000			30.00	165.00	0.00
630		P0	Insulation	1	LOT	7000	1.12	7840			0.00	165.00	0.00
661		P0	Office / Locker Rm Struct and Furn	1	LOT	17000	1.12	19040	100.00	112.00	50.00	284.00	0.00
700		P0	Screens, Baffles, Support Structure	1	LOT	1400000	1.12	1568000	81.00	248.00	23.36	157.95	0.00
700		P0	Area 1: Fish Flumes	1	LOT	112000	1.12	125440	248.00	264.00	30.00	256.00	0.00
700		P0	Area 2: Debris Removal Tank	1	LOT	20000	1.12	22400	264.00	304.00	30.00	284.00	35.00
700		P0	Area 3: Fish Handling Facilities	1	LOT	41000	1.12	45920	264.00	304.00	30.00	284.00	20.00
722		P0	Primary Screen Cleaners	2	EA	22000.0	1.12	49280	81.00	162.50	35.00	110.00	0.00
722		P0	Secondary Screen Cleaners	2	EA	31000.0	1.12	69440	162.50	248.00	35.00	200.00	0.00
724		P0	Fish Pumps:										
724		P0	Fish Pump PP1	1	EA	1700	1.12	1904	238.00	242.00	10.00	240.00	6.00
724		P0	Fish Pump PP2	1	EA	1700	1.12	1904	238.00	242.00	10.00	240.00	12.00
724		P0	Fish Pump PP3	1	EA	1700	1.12	1904	238.00	242.00	10.00	240.00	18.00
724		P0	Fish Pump PP4	1	EA	1700	1.12	1904	238.00	242.00	10.00	240.00	24.00
724		P0	Fish Pump PP5	1	EA	1700	1.12	1904	238.00	242.00	10.00	240.00	30.00
724		P0	Fish Pump PP6	1	EA	1700	1.12	1904	238.00	242.00	10.00	240.00	-6.00
724		P0	Fish Pump PP7	1	EA	1700	1.12	1904	238.00	242.00	10.00	240.00	-12.00
724		P0	Fish Pump PP8	1	EA	1700	1.12	1904	238.00	242.00	10.00	240.00	-18.00
724		P0	Fish Pump PP9	1	EA	1700	1.12	1904	238.00	242.00	10.00	240.00	24.00
724		P0	Fish Pump PP10	1	EA	1700	1.12	1904	238.00	242.00	10.00	240.00	30.00
724		P0	Discharge Cones	10	EA	5140.8	1.12	57577	248.00	264.00	10.80	256.80	0.00
725		P0	Discharge Gate FWD	595	SF	30.6	1.12	20392	174.00	208.00	24.75	191.00	-48.75
725		P0	Discharge Gate AFT	595	SF	30.6	1.12	20392	214.00	248.00	24.75	231.00	-48.75

FOR OFFICIAL USE ONLY

DETAILS

+ stbd

SWBS IDENT	REV	ITEM / DESCRIPTION	QTY	UNITS	UNIT WT [pounds]	MARG	WEIGHT [pounds]	Xfwd [feet]	Xaft [feet]	VCG [feet]	LCG [feet]	TCG [feet]
726	P0	Trash Racks	1,555	SF	10.4	1.12	18113	68.00	79.50	19.50	73.75	0.00
798	P0	Operating Fluids										
798	P0	Area 2	16025.64	CF	62.4	1.12	1120000	264.00	304.00	30.00	284.00	35.00
798	P0	Area 3	2147.44	CF	62.4	1.12	150080	264.00	304.00	30.00	284.00	-20.00
		SUMMARY IN POUNDS					8514930			18.97	164.98	4.44
		SUMMARY IN LONG TONS					3801.308			18.97	164.98	4.44

Appendix C – Hydrostatic Properties

01/04/18 15:14:37 Art Anderson Associates Page 1
GHS 15.78B DETROIT FSS ALTERNATE CONCEPT HYDROSTATICS: 8' BT 10' FLT

HYDROSTATIC PROPERTIES
No Trim, No Heel

Origin Depth	Displacement Weight(KP)	Center of Buoyancy LCB	TCB	VCB	WPA	LCF	BML	BMT
-7.000	1,672.82	132.00a	0.00	-7.50	26796	132.00a	5808.0	858.52
-6.000	3,345.64	132.00a	0.00	-7.00	26796	132.00a	2904.0	429.26
-5.000	5,018.46	132.00a	0.00	-6.50	26796	132.00a	1936.0	286.17
-4.000	6,691.28	132.00a	0.00	-6.00	26796	132.00a	1452.0	214.63
-3.000	8,364.10	132.00a	0.00	-5.50	26796	132.00a	1161.6	171.70
-2.000	10,036.92	132.00a	0.00	-5.00	26796	132.00a	968.0	143.09
-1.000	11,709.74	132.00a	0.00	-4.50	26796	132.00a	829.7	122.65
0.010	13,389.27	131.99a	0.00	-4.00	10756	108.70a	384.4	66.11
1.000	14,027.74	130.74a	0.13s	-3.79	10316	104.35a	344.7	57.05
2.000	14,671.76	129.58a	0.26s	-3.56	10316	104.35a	329.5	54.54
3.000	15,315.79	128.52a	0.37s	-3.31	10316	104.35a	315.7	52.25
4.000	15,959.26	127.54a	0.48s	-3.03	10281	103.81a	299.6	50.13
5.000	16,597.88	126.60a	0.58s	-2.74	10202	102.64a	281.2	48.18
6.000	17,233.96	125.70a	0.67s	-2.44	10176	102.24a	268.6	46.39
7.000	17,870.04	124.88a	0.75s	-2.12	10202	102.64a	261.2	44.75
8.000	18,508.67	124.12a	0.83s	-1.79	10281	103.81a	258.3	43.23
9.000	19,152.14	123.45a	0.90s	-1.44	10316	104.35a	252.4	41.78
10.000	19,793.95	122.82a	0.97s	-1.09	10174	102.17a	233.2	40.20
11.000	20,416.39	122.09a	1.04s	-0.73	9860	97.30a	202.9	38.39
12.000	21,028.64	121.35a	1.10s	-0.38	9754	95.58a	189.0	37.08
13.000	21,640.88	120.64a	1.15s	-0.01	9860	97.30a	191.4	36.22
14.000	22,263.33	120.04a	1.21s	0.36	10174	102.17a	207.4	35.74
15.000	22,905.14	119.58a	1.26s	0.76	10316	104.35a	211.1	34.94
16.000	23,549.17	119.17a	1.31s	1.16	10316	104.35a	205.3	33.98
17.000	24,193.19	118.77a	1.35s	1.57	10316	104.35a	199.8	33.08
18.000	24,837.21	118.40a	1.39s	1.98	10316	104.35a	194.7	32.22
19.000	25,481.24	118.04a	1.43s	2.40	10312	104.30a	189.6	31.38
20.000	26,412.41	119.42a	1.40s	3.01	14916	157.11a	411.1	41.31
21.000	27,343.59	120.70a	1.37s	3.60	14916	157.11a	397.1	39.90
22.000	28,274.76	121.90a	1.34s	4.19	14916	157.11a	384.0	38.59
23.000	29,205.94	123.02a	1.31s	4.77	14916	157.11a	371.7	37.36
24.000	30,137.11	124.08a	1.28s	5.35	14916	157.11a	360.3	36.20
25.000	31,068.29	125.07a	1.26s	5.93	14916	157.11a	349.5	35.12
26.000	31,998.34	125.99a	1.23s	6.50	14844	156.63a	337.9	34.03
27.000	32,925.02	126.86a	1.21s	7.06	14844	156.63a	328.4	33.07
28.000	33,851.70	127.67a	1.19s	7.62	14844	156.63a	319.4	32.17
29.000	34,778.38	128.44a	1.17s	8.17	14844	156.63a	310.9	31.31
30.000	35,705.05	129.17a	1.15s	8.73	14844	156.63a	302.8	30.50
31.000	36,631.73	129.87a	1.14s	9.28	14844	156.63a	295.2	29.73
32.000	37,558.41	130.53a	1.12s	9.83	14844	156.63a	287.9	28.99
33.000	38,485.09	131.16a	1.10s	10.37	14844	156.63a	281.0	28.30
34.000	39,411.77	131.76a	1.09s	10.92	14844	156.63a	274.4	27.63
35.000	40,338.45	132.33a	1.07s	11.46	14844	156.63a	268.1	27.00
36.000	41,265.13	132.87a	1.06s	12.00	14844	156.63a	262.0	26.39
37.000	42,191.81	133.39a	1.05s	12.54	14844	156.63a	256.3	25.81
38.000	43,118.49	133.89a	1.03s	13.07	14844	156.63a	250.8	25.26
39.000	44,045.17	134.37a	1.02s	13.61	14844	156.63a	245.5	24.72
40.000	44,971.85	134.83a	1.01s	14.14	0			

Distances in FEET.-------Specific Gravity = 1.000.--------------------------

Appendix D – CFD Modeling Report

US Army Corps of Engineers
Portland District

CONTRACT NO. W9127N-17-C-0032

DETROIT DAM
LINN COUNTY, OREGON

DETROIT FLOATING SCREEN STRUCTURE

Computational Fluid Dynamics Modeling

Report Outline

Prepared by:

ALDEN
Solving Flow Problems Since 1894

January XX, 2017

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The following Engineers of Record are declaring responsibility for preparing or supervising preparation of this report.

Shari Dunlop, P.E.

EXECUTIVE SUMMARY

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SECTION 4 FAR FIELD MODEL

4.1 Model Runs

4.2 Results and Discussion

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Appendix E – Preliminary Plate Thickness Calculations

	Task	CFCOE047	Date	28-Nov-17
	Title	Detroit FSS Concept ABS Plating and Bulkhead Structural Calculations	Prep	CMS
			SHT	see footer

Introduction

This worksheet is to determine preliminary plate thickness requirements per the Rules for Building and Classing Steel Barges 2017. These preliminary values will be input into the concept srtuctural steel weight estimate.

Using an estimate for 2 foot transverse belly tank frame spacing and 2 foot longitudinal spacing above the belly tanks, we see that 1/2 inch side shells, bottom plating, tanks decks, watertight bulkheads and tank bulkheads are appropirate. The decks may be 3/8 inch.

Calculations

Part 3 Hull Construction and Equipment
Chapter 1 General
Section 1 Definitions

Length

The length, *L*, shall be taken as 96 percent of the total length, in meters (feet), on a waterline at 85 percent of the least molded depth, *D*. In barges designed with a rake of keel, the waterline on which this length is measured shall be parallel to the designed waterline.

Belly Tank D =	8	ft	
Main Structure D =	40	ft	
D =	48	ft	
0.85xD =	40.8	ft	
Lwl at 0.85xD =	304	ft	(includes 40' sorting area)
L =	291.84	ft	
Freeboard =	5	ft	
Draft =	43	ft	
Long. Fr. Spacing, s =	24	in	(structure above belly tanks)
Transv. Fr. Spacing, s =	24	in	(belly tank structure)

	Task	CFCOE047	Date	28-Nov-17
	Title	Detroit FSS Concept ABS Plating and Bulkhead Structural Calculations	Prep	CMS
			SHT	see footer

Part 3 Hull Construction and Equipment
Chapter 2 Hull Structures and Arrangements
Section 2 Shell Plating

Side Shell Plating Amidships *Equation 3.1*

$t = 0.00084L + 0.007s$ in. for $L \leq 492$ feet

t = 0.413 in

Bottom Shell Plating Amidships *Equation 3.5.1*

$t = 0.00054L + 0.007s + 0.07$ in. for $L \leq 405$ feet

t =	0.396 in	
Transv. Fr. Add	0.03 in	In General, the thickness is to be 0.75 mm (0.03 in.)
	0.426 in	greater than obtained from the above equation 3.1

Side Shell Plating at Ends *Equation 5.1*

$t = 0.00018L + 0.01s + 0.087$ in. for $L > 250$ feet

t = 0.38 in

Bottom Plating Forward *Equation 5.3*

$t = 0.00066L + 0.01s + 0.04$ in. for $L \leq 360$ feet

t = 0.473 in

	Task	CFCOE047	Date	28-Nov-17
	Title	Detroit FSS Concept ABS Plating and Bulkhead Structural Calculations	Prep	CMS
			SHT	see footer

Part 3 Hull Construction and Equipment
Chapter 2 Hull Structures and Arrangements
Section 3 Decks

Deck Plating Thickness *Equation 1.1.1 (a)*

0.8L Amidships

$t = 0.009s + 0.095$ in. for $s \leq 30$ in.

t = 0.311 in

Equation 1.1.1 (b)

0.4L Amidships

$t = \frac{s(L+160)}{26L+28482}$ in. for $L \leq 600$ ft

t = 0.301 in

Exposed Strength Decks within Line of Openings 1.1.3

$t = 0.01s + 0.035$ in. for $s \leq 30$ in.

t = 0.275 in

	Task	CFCOE047	Date	28-Nov-17
	Title	Detroit FSS Concept ABS Plating and Bulkhead Structural Calculations	Prep	CMS
			SHT	see footer

Part 3 Hull Construction and Equipment
Chapter 2 Hull Structures and Arrangements
Section 6 Watertight Bulkheads

Recommended Watertight Bulkhead Spacing *Equation 3.3*

$S = 0.153L + 12.5$ ft for $L < 400$ ft

S 57.15 ft

Watertight Bulkhead Plating *Equation 5.1*

$t = sk\sqrt{qh}\ /c + 0.06$ in.

s =	24	in
k =	1	
Y =	36000	PSI
q =	0.944	
h =	48	ft
c =	525	
t =	0.368	in

t = thickness, in mm (in.)

s = spacing of stiffeners, in mm (in.)

k = $(3.075\sqrt{a} - 2.077)/(a + 0.272)$ where $(1 \le a \le 2)$

= 1.0 where $a > 2$

a = aspect ratio of the panel (longer edge/shorter edge)

q = $235/Y$ $(24/Y, 34000/Y)$

Y = yield point or yield strength as defined in 3-1-1/35 or 3-1-1/37 or 72% of the specified minimum tensile strength, whichever is less, in N/mm^2 (kgf/mm^2, lbf/in^2)

h = distance from the lower edge of the plate to the freeboard deck at center, in m (ft)

c = 254 (460) for collision bulkhead

= 290 (525) for other watertight bulkheads

	Task	CFCOE047	Date	28-Nov-17
	Title	Detroit FSS Concept ABS Plating and Bulkhead Structural Calculations	Prep	CMS
			SHT	see footer

Part 3 Hull Construction and Equipment
Chapter 2 Hull Structures and Arrangements
Section 7 Tank Bulkheads

Tank Bulkhead Plating

$$t = [sk\sqrt{qh}/460] + 0.10 \quad \text{in.}$$ *Equation 3.1*

s	24	in	
k	1		
q	0.944		
Plating Lower Edge	48	ft	(to main deck)
0.02L	5.8368	ft	
h	53.8368	ft	
t	0.472	in	

t = thickness, in mm (in.)

s = stiffener spacing, in mm (in.)

k = $(3.075\sqrt{a} - 2.077)/(a + 0.272)$ where $(1 \le a \le 2)$

= 1.0 where $a > 2$

a = aspect ratio of the panel (longer edge/shorter edge)

q = $235/Y$ $(24/Y, 34000/Y)$

Y = as defined in 3-2-6/5.1

h = as defined in 5-2-1/3

3 Tank Head for Scantlings *(1993)*

Except for stanchions (see 5-2-1/Figures 1 through 3), the scantling head of structural members in tanks is to be obtained as follows:

The scantling head h, in m (ft), is to be not less than h_1, nor less than h_0 where spill valves or rupture discs are fitted in lieu of high level alarms.

$$h_1 = \rho h_s + h_a \quad \text{m (ft)}$$

h_1 is to be not less than the distance to the top of the hatch.

h_0 = $(2/3)(\rho h_s + 9.95P_s)$ m (P_s in bar)

= $(2/3)(\rho h_s + 9.75P_s)$ m (P_s in kgf/cm^2)

= $(2/3)(\rho h_s + 2.25P_s)$ ft (P_s in lbf/in^2)

where

ρ = 1.0 where the specific gravity of liquid is 1.05 or less

= specific gravity of liquid where it is in excess of 1.05

h_s = head from the center of the supported area or lower edge of the plating to the deck at side or, where such is fitted, to the top of the trunk deck at side for tanks within trunk

h_a = the greater of h_{a1} or h_{a2}

	Task	CFCOE047	Date	28-Nov-17
	Title	Detroit FSS Concept ABS Plating and Bulkhead	Prep	CMS
		Structural Calculations	SHT	see footer

Part 5 Specific Barge Types
Chapter 2 Tank Barges
Section 1 Single Skin Tank Barges **5-2-1**

h_{a1} = 1.22 m (4 ft) for $L \leq 61$ m (200 ft)

= $0.02L$ for 61 m (200 ft) $< L \leq 122$ m (400 ft)

= 2.44 m (8 ft) for $L > 122$ m (400 ft)

L = barge length, as defined in 3-1-1/3

h_{a2} = $9.95p_v$ ($9.75p_v$, $2.25p_v$)

p_v = pressure/vacuum valve pressure setting, in bar (kgf/cm^2, lbf/in^2)

h_s = head to the spill valve or rupture disc, where fitted, in m (ft)

P_s = relieving pressure of spill valve or rupture disc, where fitted, in bar (kgf/cm^2, lbf/in^2)

Appendix F – Preliminary Pump Selection Data and Calculations

HDR

Project: Detroit FSS DDR
Subject: 30% DDR
Task: Initial Pump Station Sizing
Job #: 10079535

Computed by: Steve Meicke
Date:10/26/2017
Printed: 10/31/2017
Checked by: E. Zapel
Checked by Date: 10/30/2017

Detroit Floating Screen Structure - Pumping Plant Concepts
Pumping Plant Summary Sheet

Assumptions

Design Pumping Plant Flow	1,000 cfs
Assumed Power Cost	$0.04 /kW

Summary of Pumping Alternatives

Design Alternative		Alternative 1	Alternative 2	Alternative 3	Alternative 4
Pump Manuf. / Model		Flygt Mixer 4680	Peerless Vert. Turb. 54PL	Goulds Axial Flow 54x54-54	
Design Head (ft)		2	6	4	6
Capital Cost	-	$1,560,000	$2,800,000	$4,800,000	$4,800,000
Price per Pump / Valve Ass'y*	-	$60,000	$350,000	$600,000	$600,000
Power Cost per Hour Pumping	($/hr)	$18.60	36.68	$30.80	$30.80
Number of Pumps	-	25	7	7	7
Spare Pumps	-	1	1	1	1
Flow per Pump	(cfs)	40	150	150	150
Pump TDH	(ft)	2	8	6	6
Eff. at Design Head**	-	37%	65%	68%	68%
Pump Nameplate Power	(hp)	40	200	200	200
Pump Weight	(lbs/ea)	1,200	26,000	30,000	30,000
Pump Size (L x W x H)***	(ft)	4.5 ft x 3.5 ft x 6 ft	20 ft x 8 ft x 6 ft	26 ft x 5 ft x 9 ft	26 ft x 5 ft x 9 ft
Discharge Diameter	(in)	30	54	54	54

*Includes pump, motor, rails (mixer only), throttling valve, and baseplates. Does not include VFDs, starters, controls, or electrical equip.
**Pump & motor efficiency.
***General size. See pump detail sheets for detailed dimensions.

c:\pwworking\west01\d0555715\Detroit Initial Pump Alts.xlsx

Page: 1 of 14

Workbook: Detroit Initial Pump Alts.xlsx, Summary Tab

Project: Detroit FSS DDR Subject: 30% DDR Task: Initial Pump Station Sizing Job #: 10079535	Computed by: Steve Meicke Date:10/26/2017 Printed: 10/31/2017 Checked by: E. Zapel Checked by Date: 10/30/2017

Detroit Floating Screen Structure - Pumping Plant Concepts

Alternative 1 - 2 ft Design Head - Flygt 4600 Series

Parameter	Parameter	Unit	Notes
Design Information			
Design Flow	1,000	cfs	From Summary Tab
Target Gross Pumping Head	2	ft	From Summary Tab
Power Cost	$0.04	/kWh	From Summary Tab
Pump Information			
Pump Manufacturer	Flygt	-	
Pump Model	4680, 9º Pitch	-	9º pitch selected for operating range considerations, see below.
Pump Flow at Design Head	40	cfs	
Pump Nameplate HP	40	HP	Shaft power, not power at flow
Pump Power at Design Head	18.6	kW	25 HP per below
Efficiency at Design Head	37%	-	Pump and motor efficiency
Inlet Diameter	N/A	in	
Outlet Diameter	30	in	
Pump Weight	1,200	lb/pump	
Overall Approximate Dims. (LxWxH)	4.5 ft x 3.5 ft x 6 ft	-	
Plant Information			
Number of Pumps Needed	25	count	
Number of Spares	1	count	Designer discretion
Plant Power at 1,000 cfs	465	kW	Pumping power x number of pumps
Plant Pumping Cost per Hour	$18.60	/hr	$/kWh x rated power @1,000 cfs
Conceptual Equipment Cost			
Equipment Cost Each Unit	$60,000	/unit	See items included below
Total Equipment Cost Incl. Spares	$1,560,000	-	

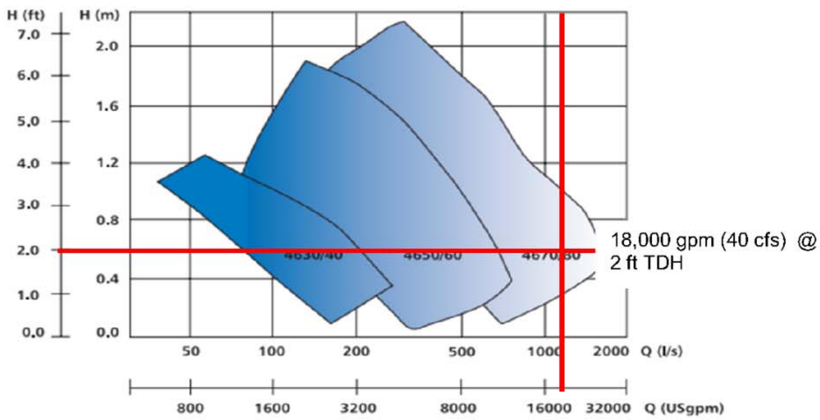
Equipment cost includes the following items: guide rails, meltric plugs, other standard items.
Does not include: VFDs, controls, starter, or other electronic equipment.

Project: Detroit FSS DDR	Computed by: Steve Meicke
Subject: 30% DDR	Date:10/26/2017
Task: Initial Pump Station Sizing	Printed: 10/31/2017
Job #: 10079535	Checked by: E. Zapel
	Checked by Date: 10/30/2017

Detroit Floating Screen Structure - Pumping Plant Concepts

Alternative 1 - 2 ft Design Head - Flygt 4600 Series

Family Coverage Chart for Flygt Mixer Pumps



Model	4630/4640	4650/4660	4670/4680
Shaft power	50 Hz 1.5/2.5kW 60 Hz 1.9/3kW 2.5/4.0 hp	50 Hz 5/10kW 60 Hz 5.6/11.2kW 7.5/15.0 hp	50 Hz 13/25kW 60 Hz 14.9/30kW 20.0/40.0 hp
Discharge	DN 400 U.S. 16"	DN 600 U.S. 24"	DN 800 U.S. 30"

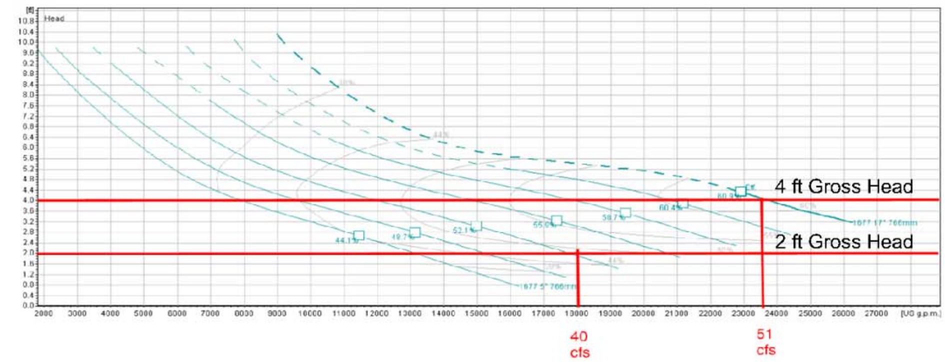
Project: Detroit FSS DDR
Subject: 30% DDR
Task: Initial Pump Station Sizing
Job #: 10079535

Computed by: Steve Meicke
Date:10/26/2017
Printed: 10/31/2017
Checked by: E. Zapel
Checked by Date: 10/30/2017

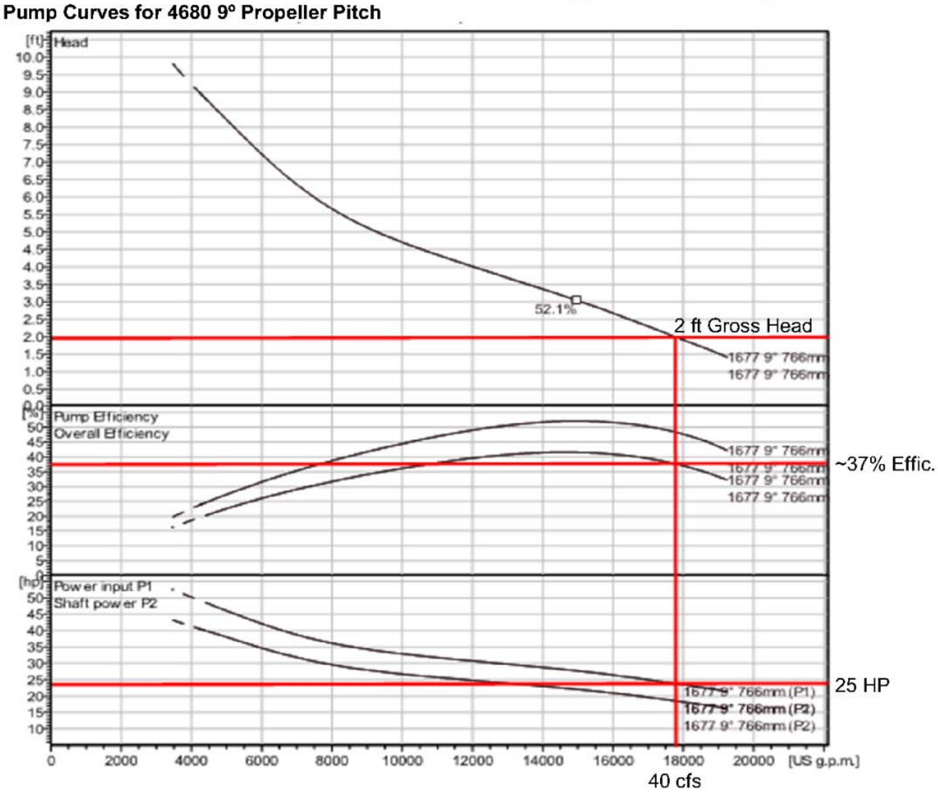
Detroit Floating Screen Structure - Pumping Plant Concepts

Alternative 1 - 2 ft Design Head - Flygt 4600 Series

Family Curves for the 4680 Series



Pump Curves for 4680 9º Propeller Pitch



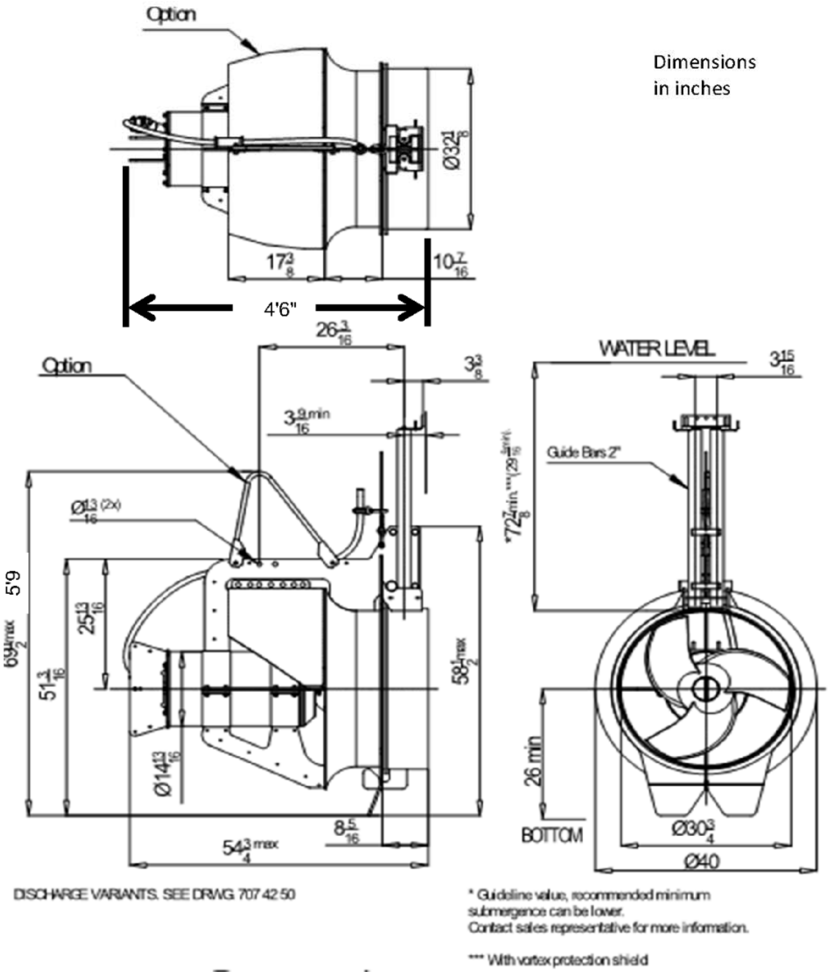
Project: Detroit FSS DDR
Subject: 30% DDR
Task: Initial Pump Station Sizing
Job #: 10079535

Computed by: Steve Meicke
Date:10/26/2017
Printed: 10/31/2017
Checked by: E. Zapel
Checked by Date: 10/30/2017

Detroit Floating Screen Structure - Pumping Plant Concepts

Alternative 1 - 2 ft Design Head - Flygt 4600 Series

Dimensional Information



FOR OFFICIAL USE ONLY

Project: Detroit FSS DDR
Subject: 30% DDR
Task: Initial Pump Station Sizing
Job #: 10079535

Computed by: Steve Meicke
Date:10/26/2017
Printed: 10/31/2017
Checked by: E. Zapel
Checked by Date: 10/30/2017

Detroit Floating Screen Structure - Pumping Plant Concepts
Alternative 2 - 6 ft Design Head - Vertical Turbine

Parameter	Parameter	Unit	Notes
Design Information			
Design Flow	1,000	cfs	From Summary Tab
Target Gross Pumping Head	6	ft	From Summary Tab
Power Cost	$0.04	/kWh	From Summary Tab
Pump Information			
Pump Manufacturer	Peerless	-	Owned by Grundfos
Pump Model	54 PL	-	Hydrofoil pump line, propeller pump
Pump TDH	8	ft	From chart below, includes minor losses
Pump Flow at Design Head	150	cfs	
Pump Nameplate HP	200	HP	
Pump Power at Design Head	131	kW	175 HP
Efficiency at Design Head	65%	-	Pump @ 70% eff. X NEMA premium motor @ 93% eff.
Inlet Diameter	54	in	
Outlet Diameter	54	in	
Pump Weight	26,000	lb/pump	CONFIRM
Overall Approximate Dims. (LxWxH)	20 ft x 8 ft x 6 ft	-	
Plant Information			
Number of Pumps Needed	7	count	
Number of Spares	1	count	Designer discretion
Plant Power at 1,000 cfs	917	kW	Pumping power x number of pumps
Plant Pumping Cost per Hour	$36.68	/hr	$/kWh x rated power @1,000 cfs
Conceptual Equipment Cost			
Pump Cost Each Unit	$250,000	/unit	Pump plus motor only
Knife Gate Cost Each Unit	$100,000	/unit	50 psi rated knife gate with electric actuator
Pump+Valve Cost Incl. Spares	$2,800,000	-	
Note: 50 psi bonnetted knife gate was chosen as a conservative price point.			

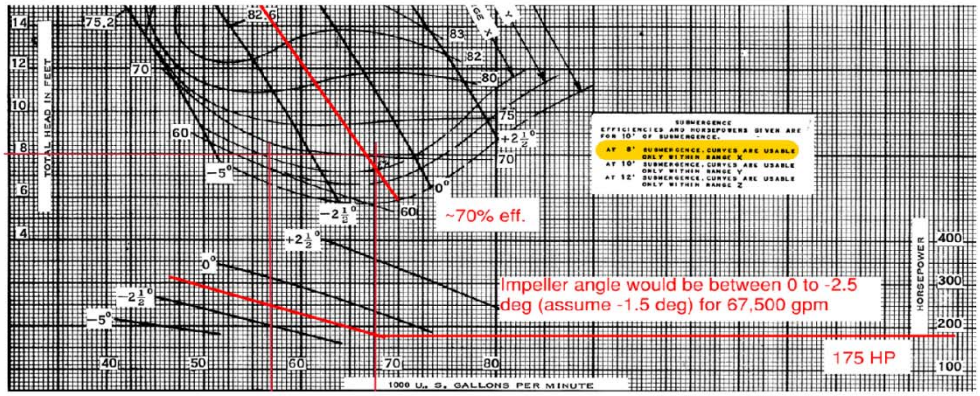
Project: Detroit FSS DDR
Subject: 30% DDR
Task: Initial Pump Station Sizing
Job #: 10079535

Computed by: Steve Meicke
Date:10/26/2017
Printed: 10/31/2017
Checked by: E. Zapel
Checked by Date: 10/30/2017

Detroit Floating Screen Structure - Pumping Plant Concepts

Alternative 2 - 6 ft Design Head - Vertical Turbine

Pump Curve / Manufacturer Information



Note: the head shown at left of plot is net pumping head; it includes minor losses associated with the pump column and discharge elbow.

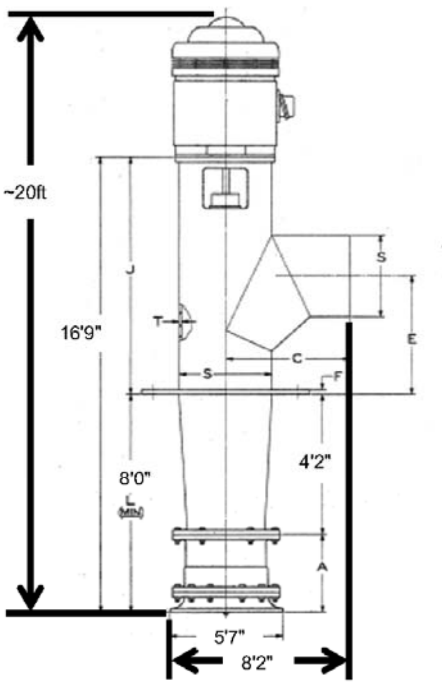
Project: Detroit FSS DDR
Subject: 30% DDR
Task: Initial Pump Station Sizing
Job #: 10079535

Computed by: Steve Meicke
Date:10/26/2017
Printed: 10/31/2017
Checked by: E. Zapel
Checked by Date: 10/30/2017

Detroit Floating Screen Structure - Pumping Plant Concepts

Alternative 2 - 6 ft Design Head - Vertical Turbine

Equipment Arrangement Options



Note: discharge above baseplate is shown to the left.
Discharge below baseplate is also available.

HDR	Project: Detroit FSS DDR Subject: 30% DDR Task: Initial Pump Station Sizing Job #: 10079535	Computed by: Steve Meicke Date:10/26/2017 Printed: 10/31/2017 Checked by: E. Zapel Checked by Date: 10/30/2017

Detroit Floating Screen Structure - Pumping Plant Concepts

Alternative 3 - 4 ft Design Head - Axial Flow Turbine

Parameter	Parameter	Unit	Notes
Design Information			
Design Flow	1,000	cfs	From Summary Tab
Target Gross Pumping Head	4	ft	From Summary Tab
Power Cost	$0.04	/kWh	From Summary Tab
Pump Information			
Pump Manufacturer	Goulds	-	
Pump Model	54x54-54	-	Axial Flow pump line
Pump TDH	6	ft	Note: pumping at 4 ft gross, induce headloss to run at peak efficiency
Pump Flow at Design Head	150	cfs	
Pump Nameplate HP	200	HP	
Pump Power at Design Head	110	kW	
Efficiency at Design Head	68%	-	Pump efficiency @ 73% x NEMA premium Motor @93%. Motor effic. assumed.
Inlet Diameter	54	in	
Outlet Diameter	54	in	
Pump Weight	30,000	lb/pump	Approximate: pump, motor, base frame
Plant Information			
Number of Pumps Needed	7	count	
Number of Spares	1	count	Designer discretion
Plant Power at 1,000 cfs	770	kW	Pumping power x number of pumps
Plant Pumping Cost per Hour	$30.80	/hr	$/kWh x rated power @1,000 cfs
Conceptual Equipment Cost			
Pump Cost Each Unit	$500,000	/unit	Includes: AF pump, motor, slide base, belts/sheaves and baseplate.
Knife Gate Cost Each Unit	$100,000	/unit	50 psi rated knife gate with electric actuator
Pump+Valve Cost Incl. Spares	$4,800,000	-	

Note 1: 50 psi bonnetted knife gate was chosen as a conservative price point.

Note 2: The manufacturer does not recommend running at 4 ft of head so this alternative runs the pump at a higher TDH and assumes the excess head is removed by a gate, valve, or other means introducing extra headloss.

HDR

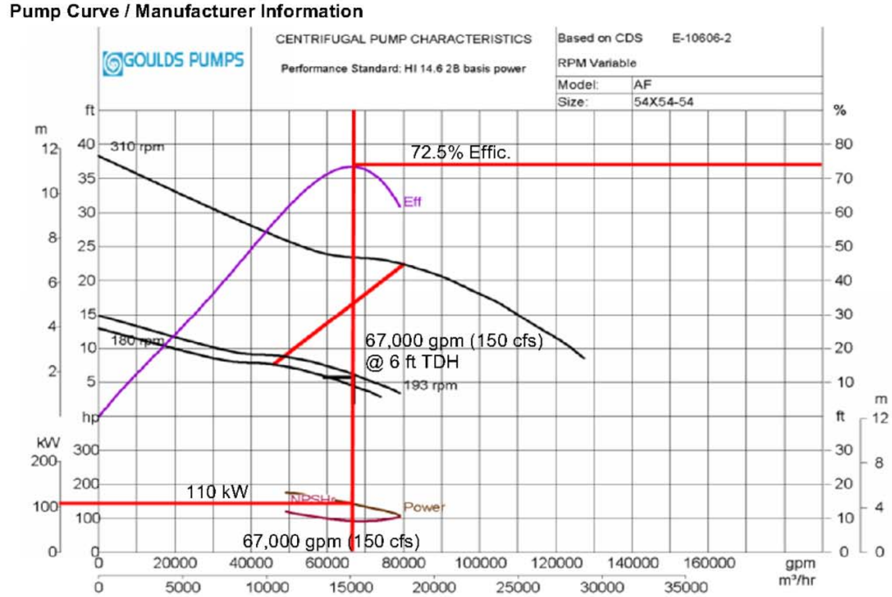
Project: Detroit FSS DDR
Subject: 30% DDR
Task: Initial Pump Station Sizing
Job #: 10079535

Computed by: Steve Meicke
Date:10/26/2017
Printed: 10/31/2017
Checked by: E. Zapel
Checked by Date: 10/30/2017

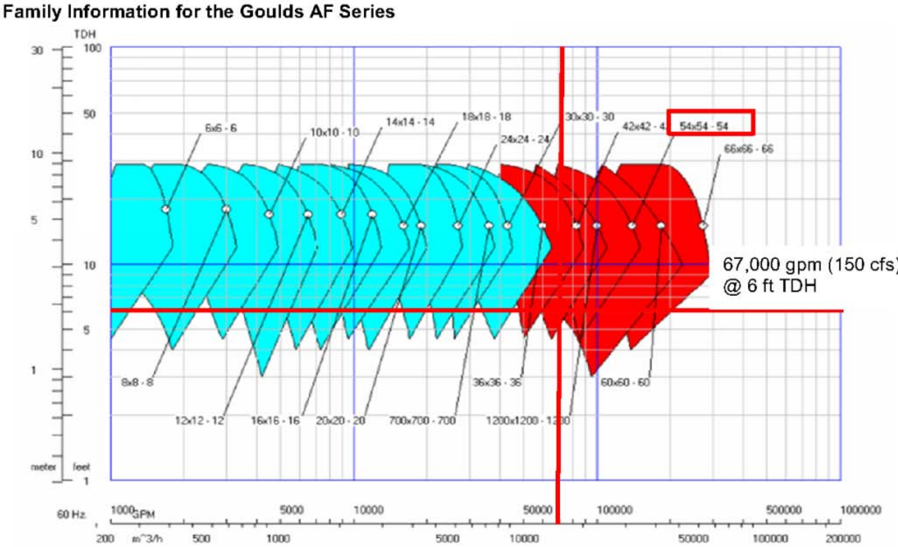
Detroit Floating Screen Structure - Pumping Plant Concepts

Alternative 3 - 4 ft Design Head - Axial Flow Turbine

Pump Curve / Manufacturer Information



Family Information for the Goulds AF Series



c:\pwworking\west01\d0565716\Detroit Initial Pump Alts.xlsx

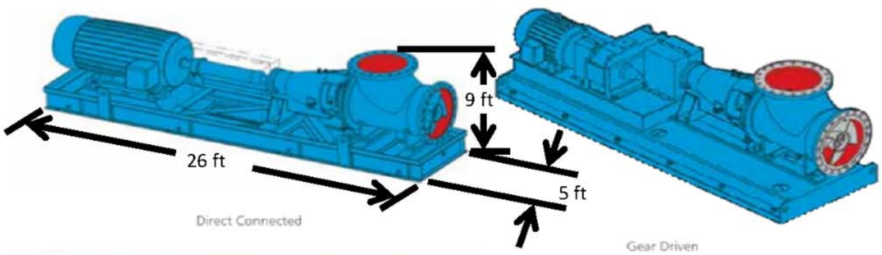
Project: Detroit FSS DDR
Subject: 30% DDR
Task: Initial Pump Station Sizing
Job #: 10079535

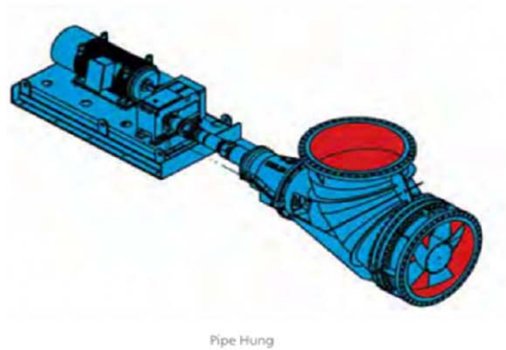
Computed by: Steve Meicke
Date:10/26/2017
Printed: 10/31/2017
Checked by: E. Zapel
Checked by Date: 10/30/2017

Detroit Floating Screen Structure - Pumping Plant Concepts

Alternative 3 - 4 ft Design Head - Axial Flow Turbine

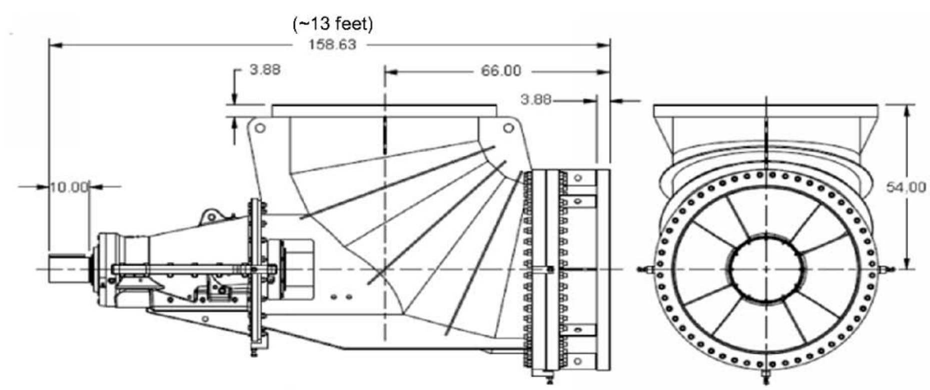
Equipment Arrangement Options





length from propeller to end of motor

Dimensional Information



Pump only weight	19,000 lbs	
Overall Length Including Motor and Baseplate	26 ft	for pipe hung configuration, approximate, from scaling
Overall Approximate Dims. (LxWxH)	26 ft x 5 ft x 9 ft	

HDR

Project: Detroit FSS DDR
Subject: 30% DDR
Task: Initial Pump Station Sizing
Job #: 10079535

Computed by: Steve Meicke
Date:10/26/2017
Printed: 10/31/2017
Checked by: E. Zapel
Checked by Date: 10/30/2017

Detroit Floating Screen Structure - Pumping Plant Concepts

Alternative 4 - 6 ft Design Head - Axial Flow Turbine

Parameter	Parameter	Unit	Notes
Design Information			
Design Flow	1,000	cfs	From Summary Tab
Target Gross Pumping Head	6	ft	From Summary Tab
Power Cost	$0.04	/kWh	From Summary Tab
Pump Information			
Pump Manufacturer	Goulds	-	
Pump Model	54x54-54	-	Axial Flow pump line
Pump Flow at Design Head	150	cfs	
Pump Nameplate HP	200	HP	
Pump Power at Design Head	110	kW	
Efficiency at Design Head	68%	-	Pump efficiency @ 73% x NEMA premium Motor @93%. Motor effic. assumed.
Inlet Diameter	54	in	
Outlet Diameter	54	in	
Pump Weight	30,000	lb/pump	Approximate: pump, motor, base frame
Plant Information			
Number of Pumps Needed	7	count	
Number of Spares	1	count	Designer discretion
Plant Power at 1,000 cfs	770	kW	Pumping power x number of pumps
Plant Pumping Cost per Hour	$30.80	/hr	$/kWh x rated power @1,000 cfs
Conceptual Equipment Cost			
Pump Cost Each Unit	$500,000	/unit	Includes: AF pump, motor, slide base, belts/sheaves and baseplate.
Knife Gate Cost Each Unit	$100,000	/unit	50 psi rated knife gate with electric actuator
Pump+Valve Cost Incl. Spares	$4,800,000	-	
Note 1: 50 psi bonnetted knife gate was chosen as a conservative price point.			

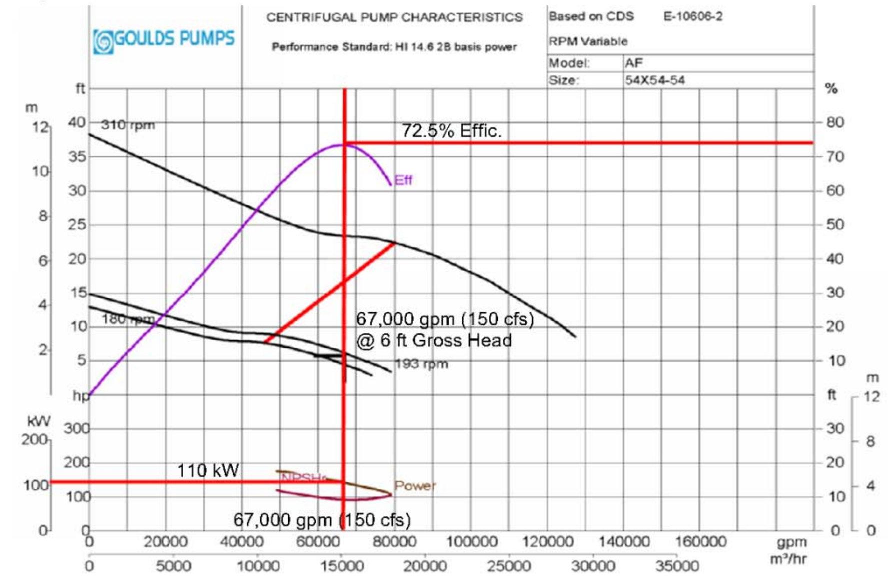
Project: Detroit FSS DDR
Subject: 30% DDR
Task: Initial Pump Station Sizing
Job #: 10079535

Computed by: Steve Meicke
Date:10/26/2017
Printed: 10/31/2017
Checked by: E. Zapel
Checked by Date: 10/30/2017

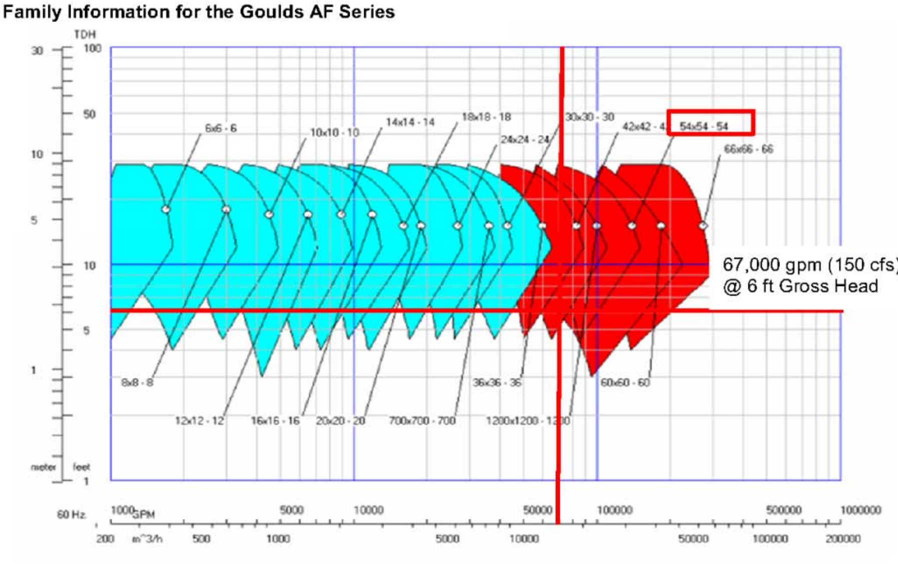
Detroit Floating Screen Structure - Pumping Plant Concepts

Alternative 4 - 6 ft Design Head - Axial Flow Turbine

Pump Curve / Manufacturer Information



Family Information for the Goulds AF Series



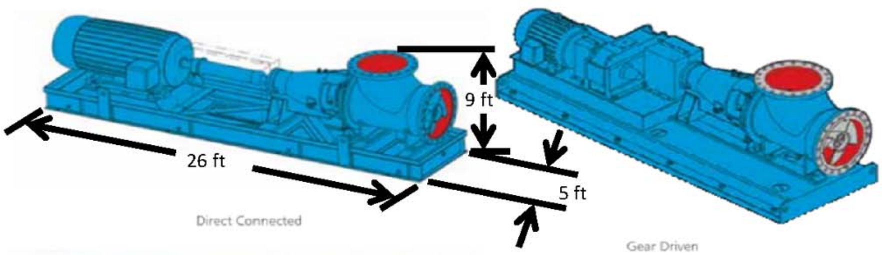
Project: Detroit FSS DDR
Subject: 30% DDR
Task: Initial Pump Station Sizing
Job #: 10079535

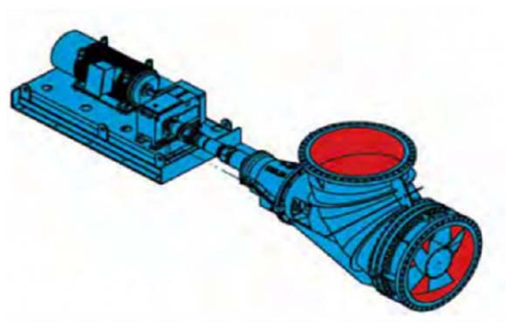
Computed by: Steve Meicke
Date:10/26/2017
Printed: 10/31/2017
Checked by: E. Zapel
Checked by Date: 10/30/2017

Detroit Floating Screen Structure - Pumping Plant Concepts

Alternative 4 - 6 ft Design Head - Axial Flow Turbine

Equipment Arrangement Options

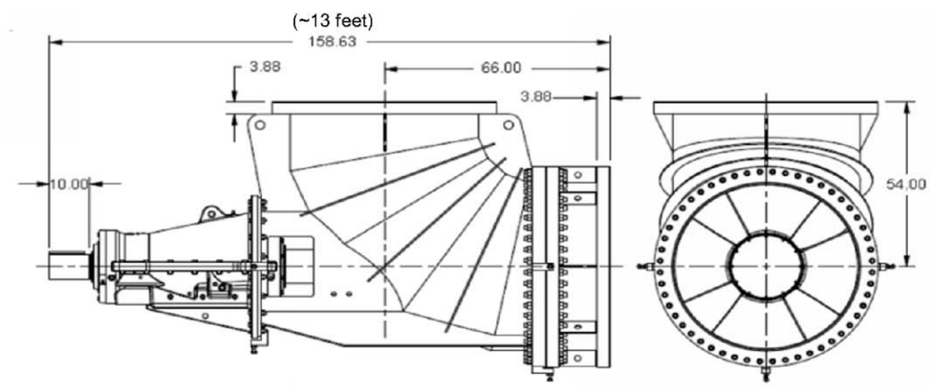




length from propeller to end of motor

Pipe Hung

Dimensional Information

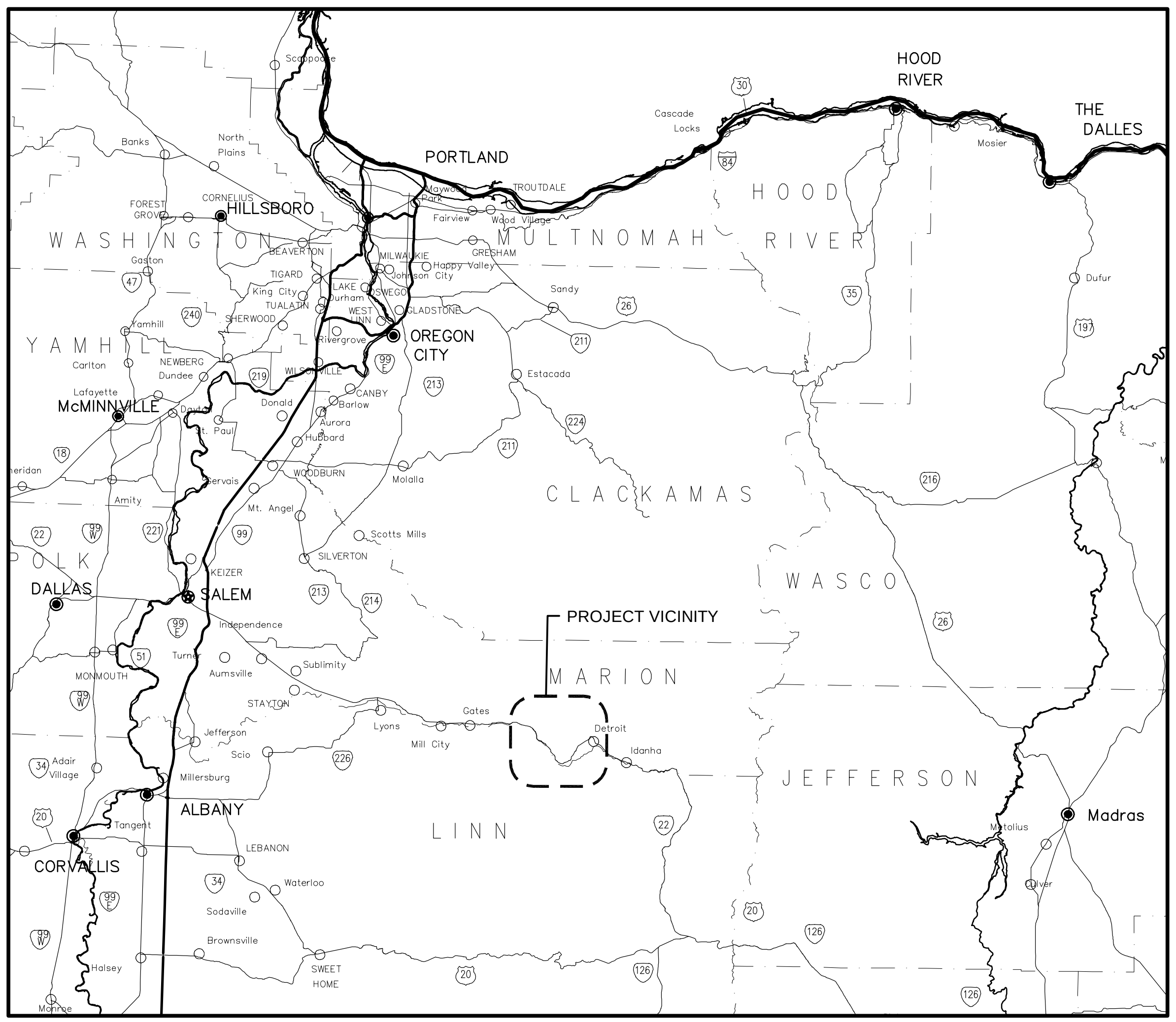


Pump only weight	19,000 lbs	
Overall Length Including Motor and Baseplate	26 ft	for pipe hung configuration, approximate, from scaling
Overall Approximate Dims. (LxWxH)	26 ft x 5 ft x 9 ft	

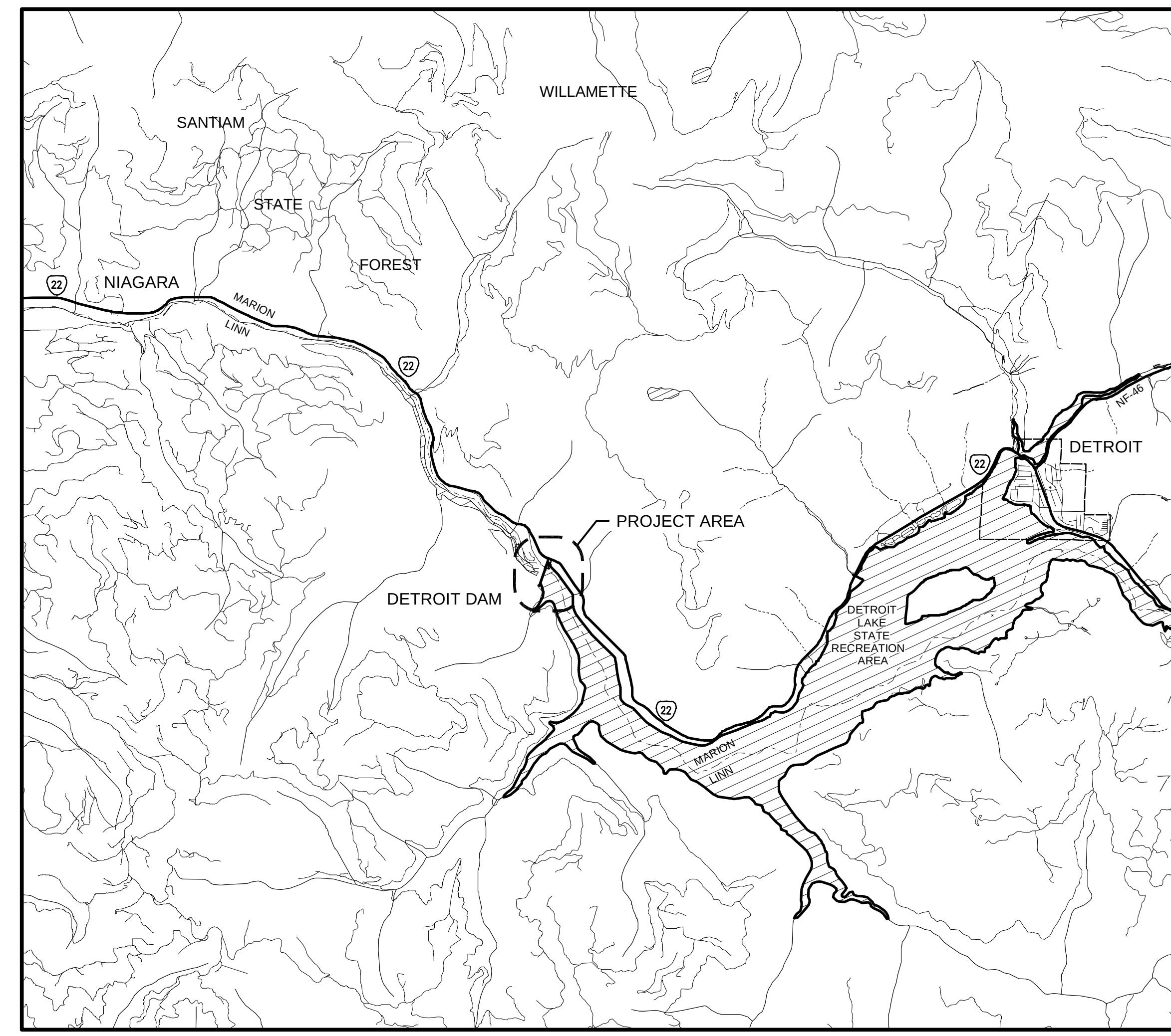
Appendix G - Plates

DETROIT FLOATING SCREEN STRUCTURE DESIGN DOCUMENTATION REPORT
DETROIT DAM, LINN COUNTY, OR

CLIN0002 - 30% SUBMITTAL - JANUARY 12, 2018



A LOCATION MAP
SCALE: 1" = 10 MILES



B VICINITY MAP
SCALE: 1" = 5000'

N

2" 0 1/4 1/2 1" 0 1/4 1/2 0 0 1" 2"

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PORTLAND, OREGON

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202 PACIFIC AVE, BREMERTON, WA 98337
(360) 479-5600

DESIGNED BY: J. WALKER AAA	DATE: JANUARY 12, 2018
DRAWN BY: J. WALKER AAA	PROJECT MANAGER: M. McKAY AAA
CHECKED BY: B. ANDERSON / AAA	PROGRAM MANAGER: J. CARLSON / AAA
PLOT SCALE: 1:2 / PLOT DATE: 1/10/2018	CONTRACT NO.: W9127N-17-C-0032
SIZE: D / FILE NAME: DEF-1.104_G-001xxx.dwg	

DETROIT DAM, LINN COUNTY, OREGON 97413
DETROIT FLOATING SCREEN STRUCTURE
DESIGN DOCUMENTATION REPORT

GENERAL
COVER SHEET,
LOCATION, AND VICINITY MAPS

PLATE IDENTIFICATION
G-001

STATUS (30%)

GENERAL NOTES:

1. ALL ELEVATIONS PROVIDED IN THIS REPORT ARE IN THE ORIGINAL PROJECT DATUM (DETROIT DAM DATUM).
2. PLAN AND PROFILE VIEWS OF THE FSS INCLUDE A REFERENCE FRAME LINE PROVIDING FRAME NUMBERS ALONG THE LENGTH OF THE FSS TO PROVIDE REFERENCE LOCATION. THE SPACING BETWEEN THE FRAME LINES IS 24 INCHES CENTER-TO-CENTER SPACING OF THE FSS STRUCTURAL FRAMING MEMBERS.

INDEX:

PLATE	1st LINE	2nd LINE - 3rd LINE
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G-002	GENERAL	INDEX, LEGEND, AND GENERAL NOTES
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G-004		
G-005	GENERAL	SITE ACCESS AND VICINITY PLAN
G-006		
G-007		
G-008	GENERAL	SURVEY CONTROL PLAN AND CRITICAL DIMENSIONS
G-009	GENERAL	PROJECT GENERAL ARRANGEMENT PLAN
G-010	GENERAL ARRANGEMENT	MAIN DECK PLAN
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S-024		
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M-020	ENTRANCE WEIRS	PLAN, SECTION, & ELEVATION CLOSED (RAISED) POSITION
M-021	ENTRANCE WEIRS	PLAN, SECTION, & ELEVATION OPEN (LOWERED) POSITION
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M-023		
M-024		
M-030	EXPANSION CHANNELS	PLAN & ELEVATION
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M-032		
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M-042		
M-043		

INDEX (CONTINUED):

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M-101		
M-102		
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E-002		
E-005		
E-006		

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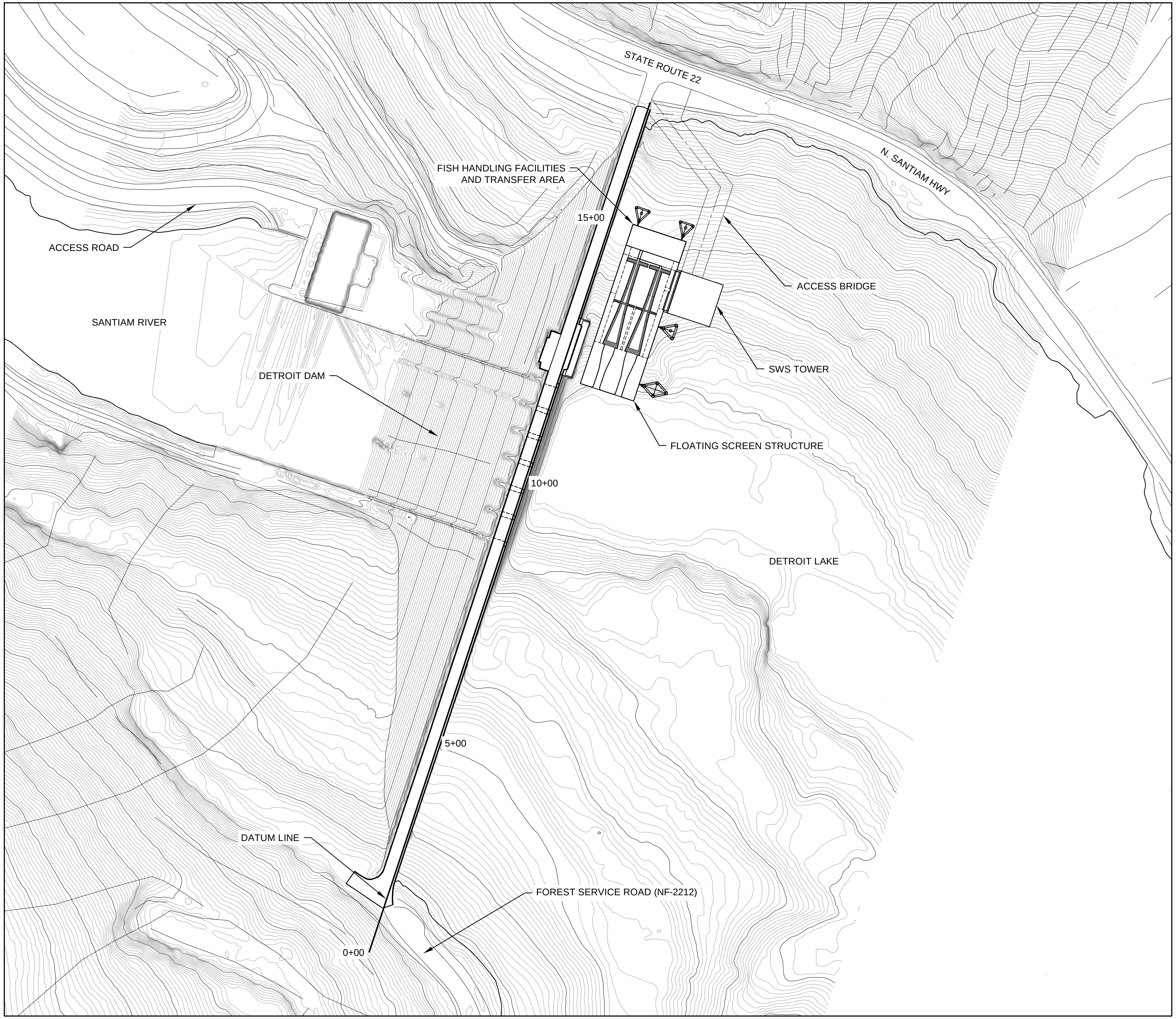
PLOT SCALE: 1:2 / PLOT DATE: 1/10/2018	CONTRACT NO.: W9127N-17-C-0032
SIZE: D / FILE NAME: DEF-1.104_G-002xxx.dwg	

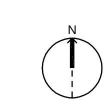
DETROIT DAM, LINN COUNTY, OREGON 97413
DETROIT FLOATING SCREEN STRUCTURE
DESIGN DOCUMENTATION REPORT

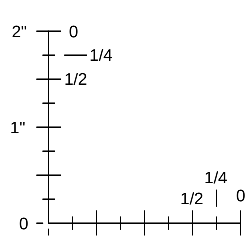
GENERAL
INDEX, LEGEND,
AND GENERAL NOTES

PLATE IDENTIFICATION
G-002

STATUS (30%)







A
S-010
(A)

DETROIT DAM ACCESS PLAN

SCALE: 1" = 100'-0"

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202 PACIFIC AVE, BREMERTON, WA 98337
(360) 479-5600

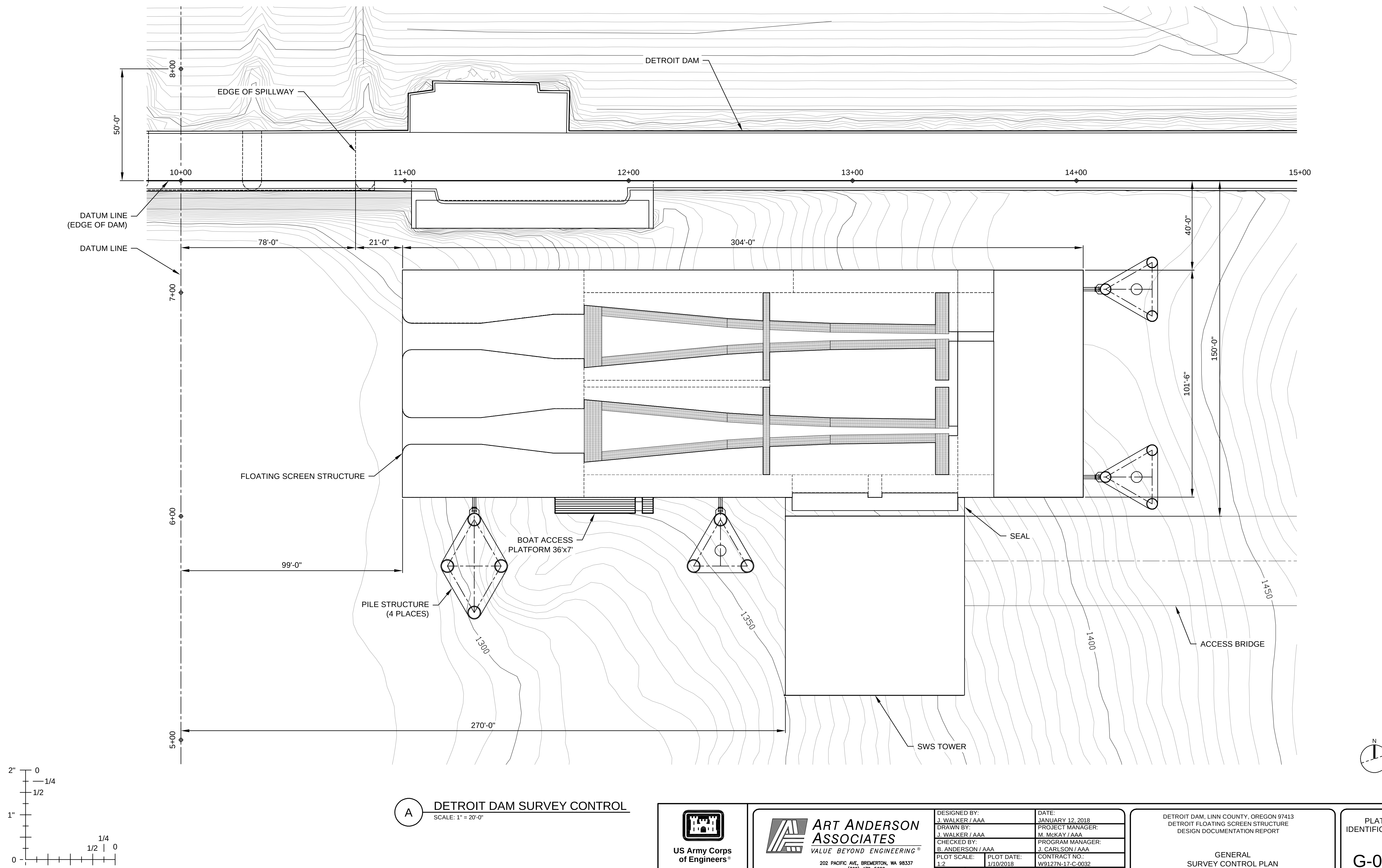
DESIGNED BY: J. WALKER / AAA	DATE: JANUARY 12, 2018
DRAWN BY: J. WALKER / AAA	PROJECT MANAGER: M. McKAY/ AAA
CHECKED BY: B. ANDERSON / AAA	PROGRAM MANAGER: J. CARLSON / AAA
PLOT SCALE: 1:2 / PLOT DATE: 1/10/2018	CONTRACT NO.: W9127N-17-C-0032
SIZE: D	FILE NAME: DEF-1.104_G-005xxx.dwg

DETROIT DAM, LINN COUNTY, OREGON 97413
DETROIT FLOATING SCREEN STRUCTURE
DESIGN DOCUMENTATION REPORT

GENERAL
SITE ACCESS AND VICINITY PLAN

PLATE IDENTIFICATION
G-005

STATUS (30%)



A DETROIT DAM SURVEY CONTROL

SCALE: 1" = 20'-0"

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202 PACIFIC AVE, BREMERTON, WA 98337
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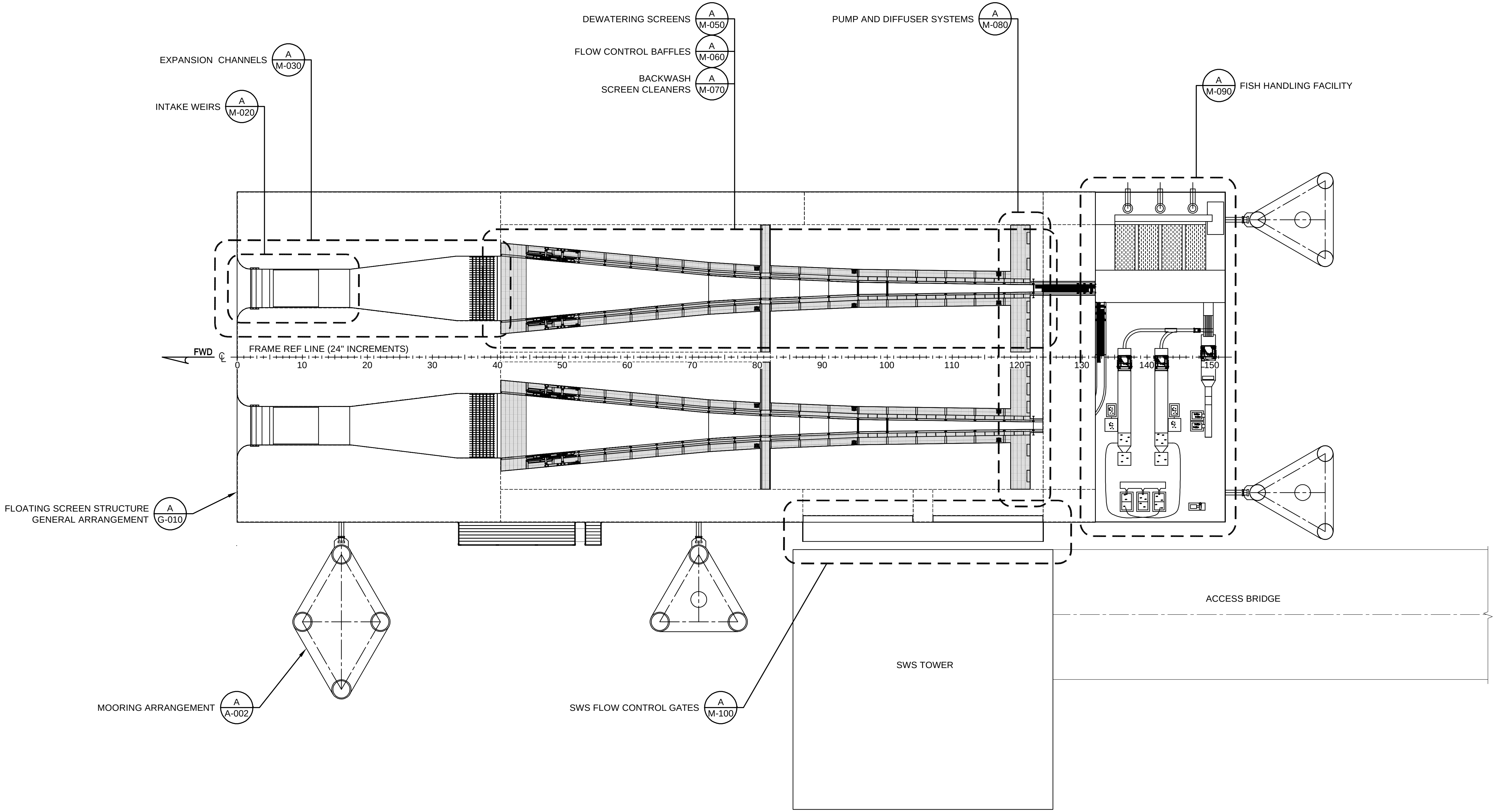
DESIGNED BY: J. WALKER / AAA	DATE: JANUARY 12, 2018
DRAWN BY: J. WALKER / AAA	PROJECT MANAGER: M. McKAY / AAA
CHECKED BY: B. ANDERSON / AAA	PROGRAM MANAGER: J. CARLSON / AAA
PLOT SCALE: 1:2 / PLOT DATE: 1/10/2018	CONTRACT NO.: W9127N-17-C-0032
SIZE: D	FILE NAME: DEF-1.104_G-008xxx.dwg

DETROIT DAM, LINN COUNTY, OREGON 97413
DETROIT FLOATING SCREEN STRUCTURE
DESIGN DOCUMENTATION REPORT

GENERAL
SURVEY CONTROL PLAN
AND CRITICAL DIMENSIONS

PLATE IDENTIFICATION
G-008

STATUS (30%)



A PROJECT GENERAL ARRANGEMENT PLAN

SCALE: 1/16" = 1'-0"

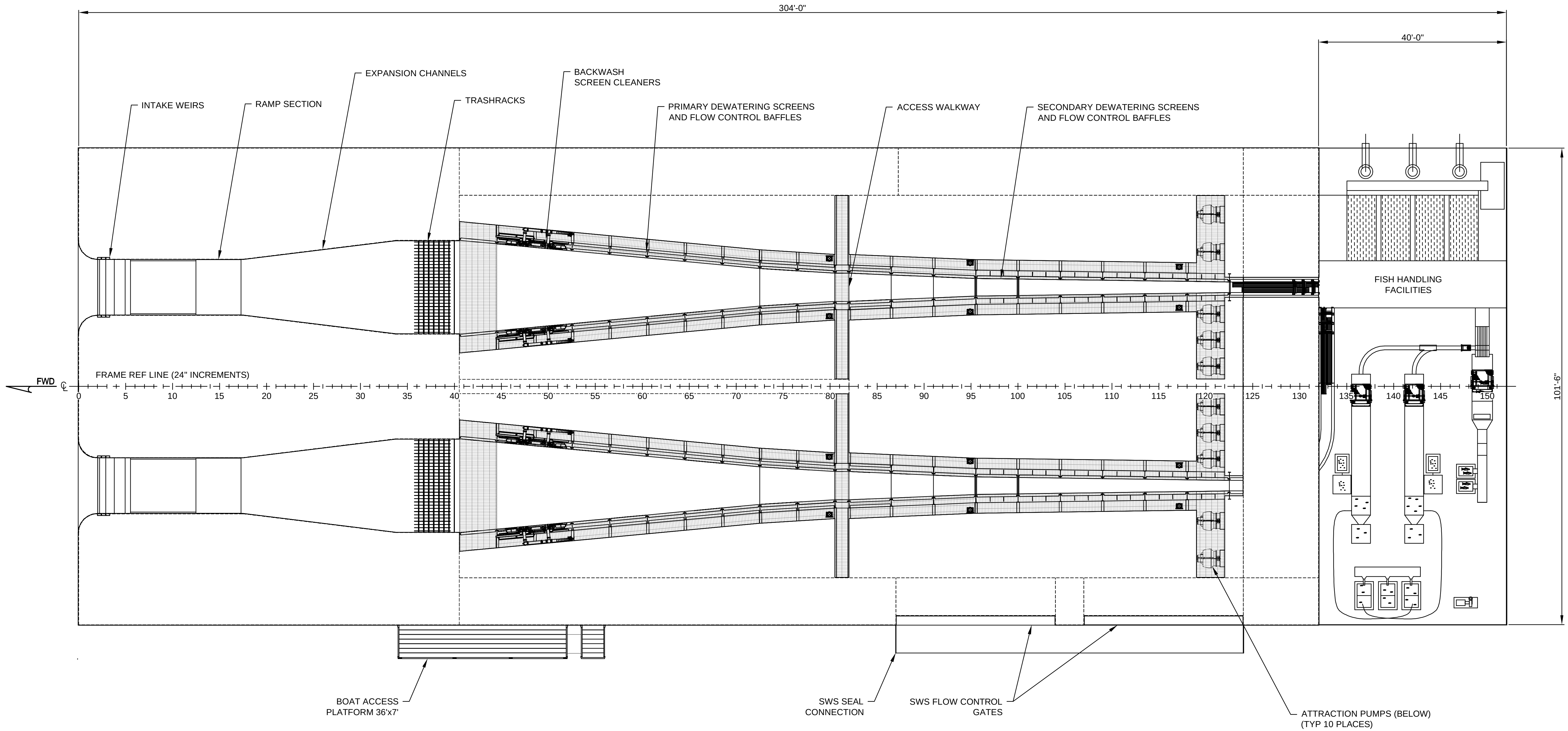
US Army Corps of Engineers® PORTLAND DISTRICT PORTLAND, OREGON	ART ANDERSON ASSOCIATES VALUE BEYOND ENGINEERING® 202 PACIFIC AVE, BREMERTON, WA 98337 (360) 479-5600	DESIGNED BY: J. WALKER / AAA	DATE: JANUARY 12, 2018
		DRAWN BY: J. WALKER / AAA	PROJECT MANAGER: M. McKAY / AAA
		CHECKED BY: B. ANDERSON / AAA	PROGRAM MANAGER: J. CARLSON / AAA
		PLOT SCALE: 1:2 / PLOT DATE: 1/10/2018	CONTRACT NO.: W9127N-17-C-0032
		SIZE: D	FILE NAME: DEF-1.104_G-009xxx.dwg

DETROIT DAM, LINN COUNTY, OREGON 97413
DETROIT FLOATING SCREEN STRUCTURE
DESIGN DOCUMENTATION REPORT

GENERAL
PROJECT GENERAL ARRANGEMENT PLAN

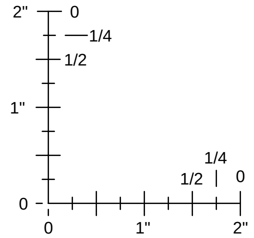
PLATE IDENTIFICATION
G-009

STATUS (30%)



A G-009 (A) GENERAL ARRANGEMENT- MAIN DECK

SCALE: 3/32" = 1'-0"



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DESIGNED BY: J. WALKER / AAA	DATE: JANUARY 12, 2018
DRAWN BY: J. WALKER / AAA	PROJECT MANAGER: M. McKAY / AAA
CHECKED BY: B. ANDERSON / AAA	PROGRAM MANAGER: J. CARLSON / AAA
PLOT SCALE: 1:2 / PLOT DATE: 1/11/2018	CONTRACT NO.: W9127N-17-C-0032
SIZE: D	FILE NAME: DEF-1.104_G-010xxx.dwg

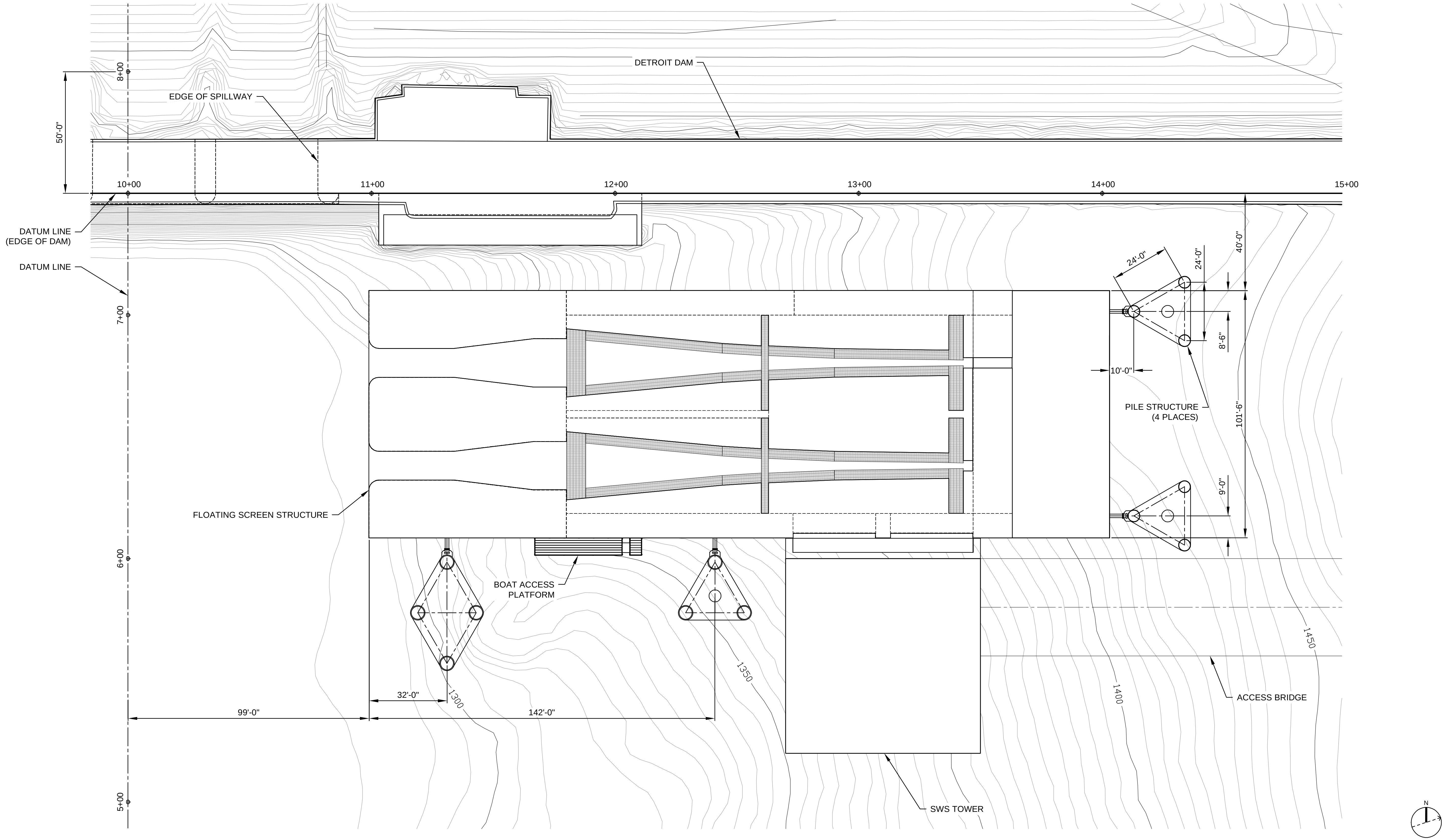
DETROIT DAM, LINN COUNTY, OREGON 97413
DETROIT FLOATING SCREEN STRUCTURE
DESIGN DOCUMENTATION REPORT

GENERAL ARRANGEMENT
MAIN DECK PLAN

PLATE IDENTIFICATION

G-010

STATUS (30%)



DETROIT DAM MOORING PLAN

A / G-009 — A

SCALE: 1" = 20'-0"

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DESIGNED BY: J. WALKER / AAA	DATE: JANUARY 12, 2018
DRAWN BY: J. WALKER / AAA	PROJECT MANAGER: M. McKAY / AAA
CHECKED BY: B. ANDERSON / AAA	PROGRAM MANAGER: J. CARLSON / AAA
PLOT SCALE: 1:2 / PLOT DATE: 1/10/2018	CONTRACT NO.: W9127N-17-C-0032
SIZE: D	FILE NAME: DEF-1.104_A-002xxx.dwg

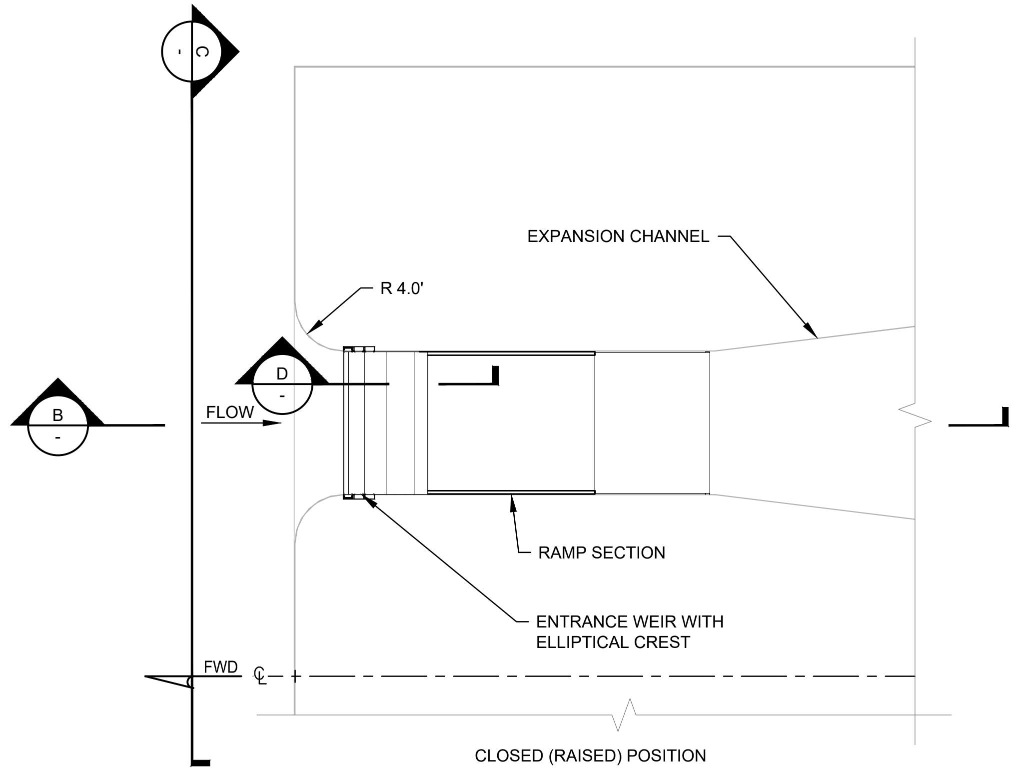
DETROIT DAM, LINN COUNTY, OREGON 97413
DETROIT FLOATING SCREEN STRUCTURE
DESIGN DOCUMENTATION REPORT

MOORING ARRANGEMENT
MOORING PLAN

PLATE IDENTIFICATION

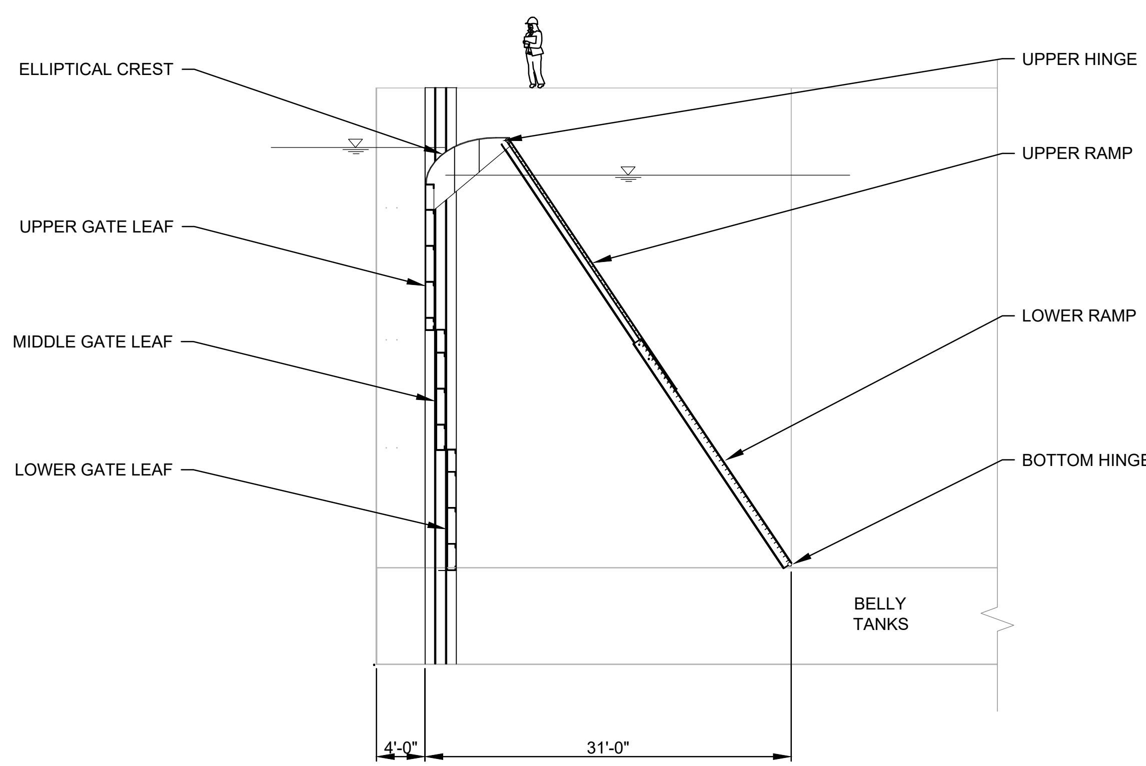
A-002

STATUS (30%)

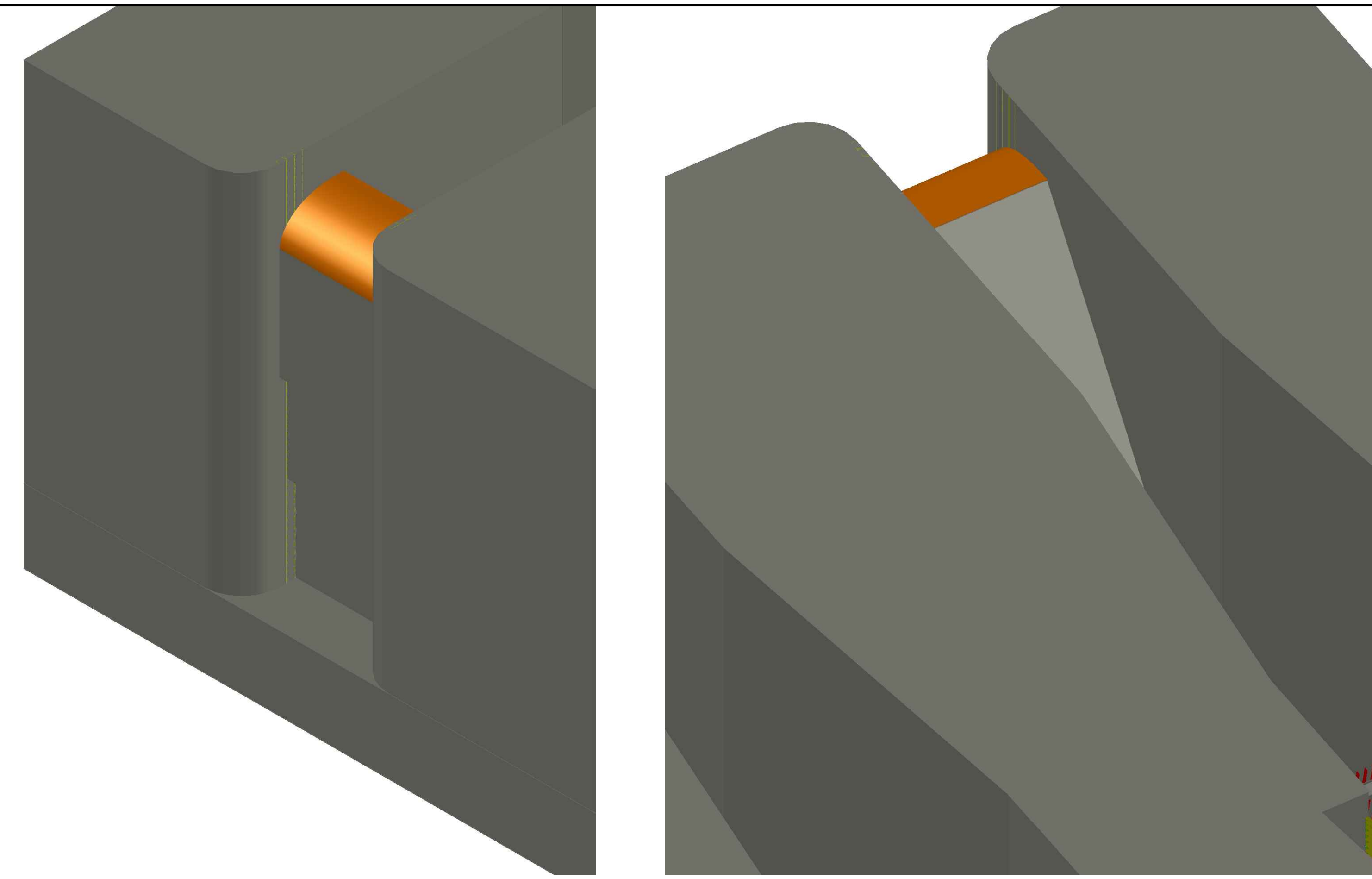


CLOSED (RAISED) POSITION

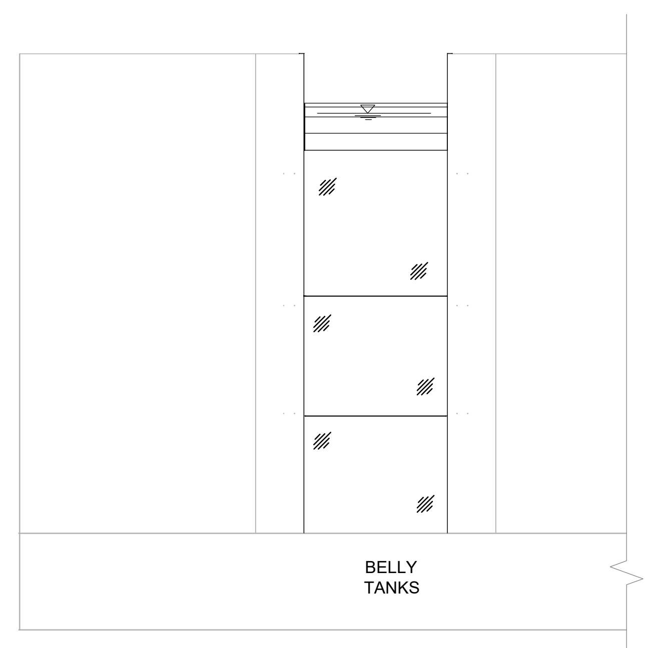
A
G-009
A
ENTRANCE WEIR PLAN
SCALE: 1/8" = 1'-0"



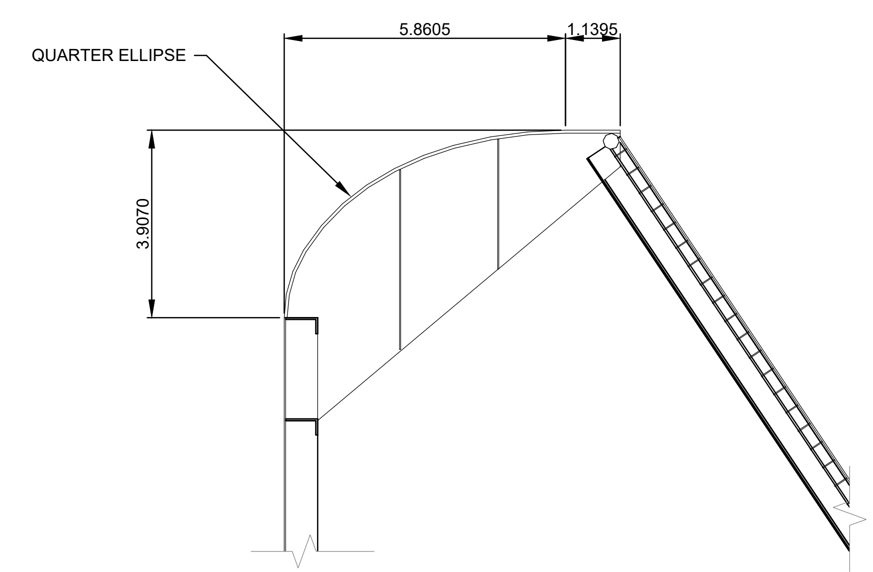
A
M-020
B
ELEVATION
SCALE: 1/8" = 1'-0"



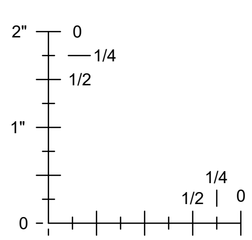
ISOMETRICS



A
M-020
C
SECTION
SCALE: 1/8" = 1'-0"



A
M-020
D
SECTION
SCALE: 1/2" = 1'-0"



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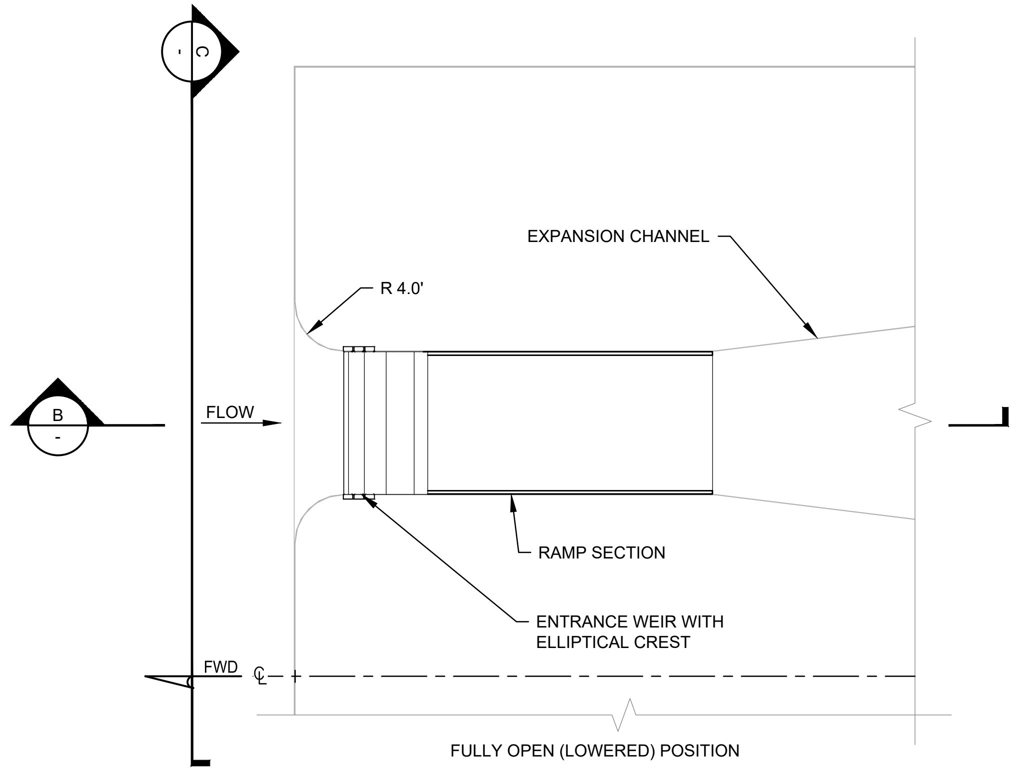
SIZE: D / FILE NAME: DEF-1.104_M-020.dwg	

DETROIT DAM, LINN COUNTY, OREGON 97413
DETROIT FLOATING SCREEN STRUCTURE
DESIGN DOCUMENTATION REPORT

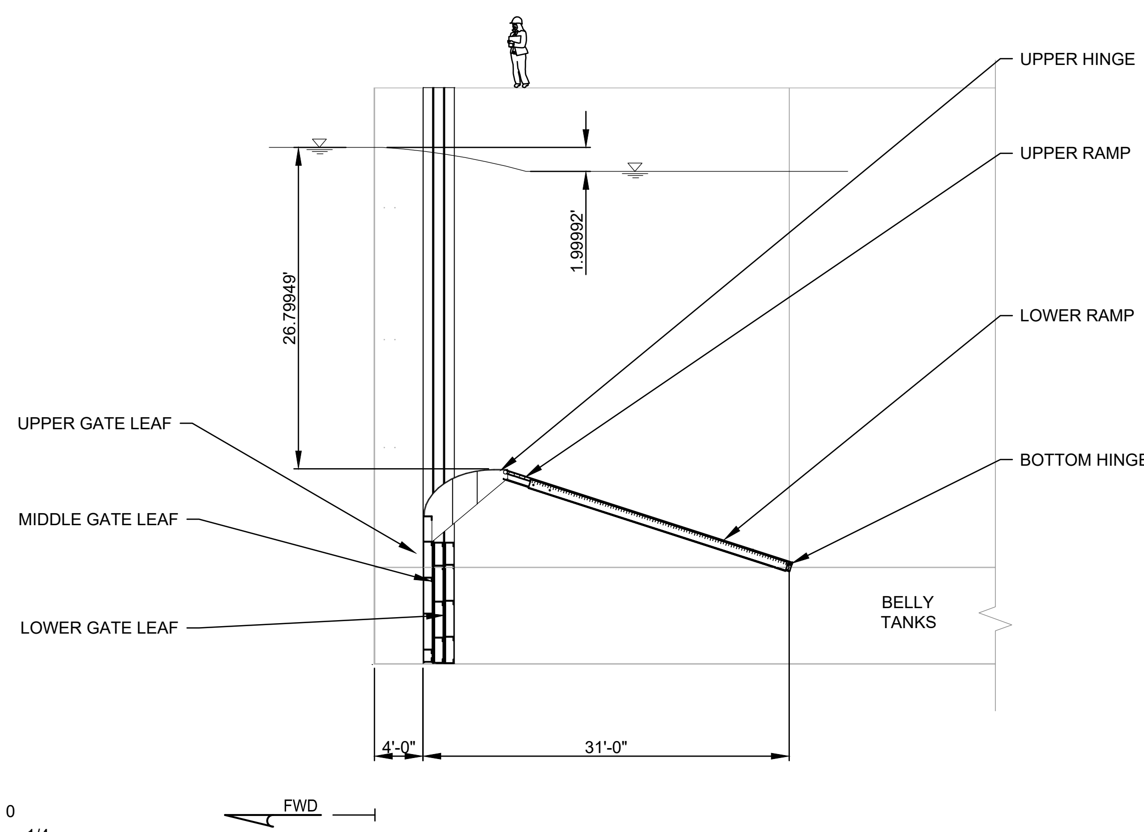
ENTRANCE WEIRS
PLAN, SECTION, & ELEVATION
CLOSED (RAISED) POSITION

PLATE IDENTIFICATION
M-020

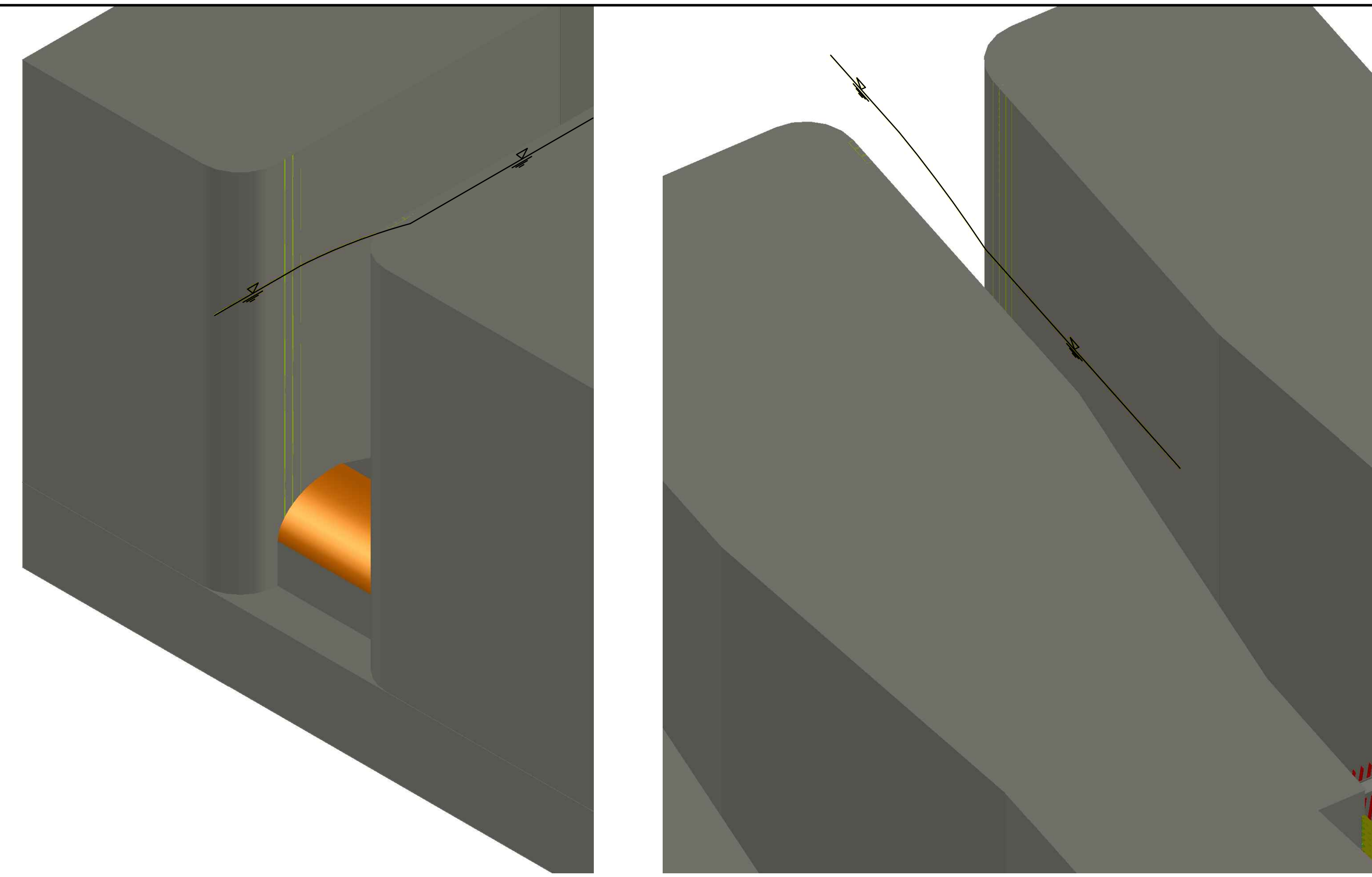
STATUS (30%)



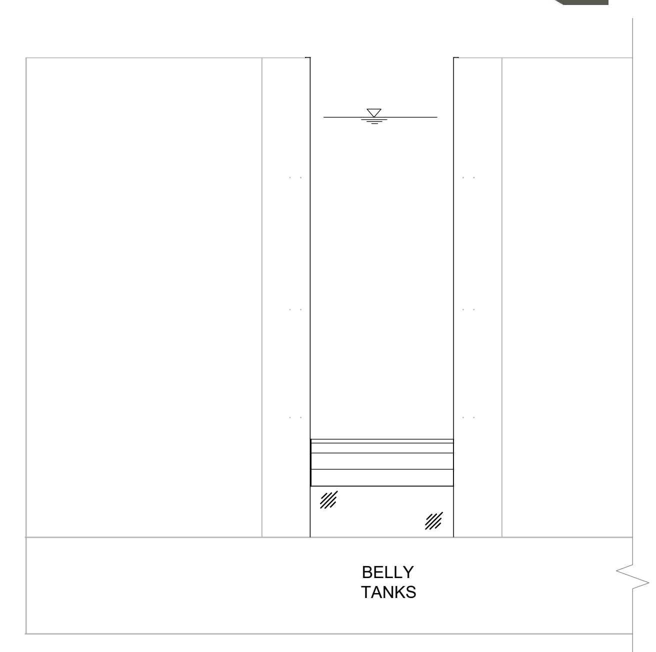
A / G-009 (A) ENTRANCE WEIRS PLAN
SCALE: 1/8" = 1'-0"



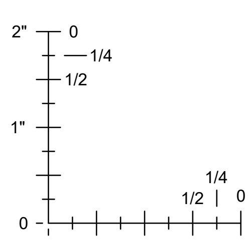
B / M-021 (B) ELEVATION
SCALE: 1/8" = 1'-0"



ISOMETRICS



C / M-021 (C) SECTION
SCALE: 1/8" = 1'-0"



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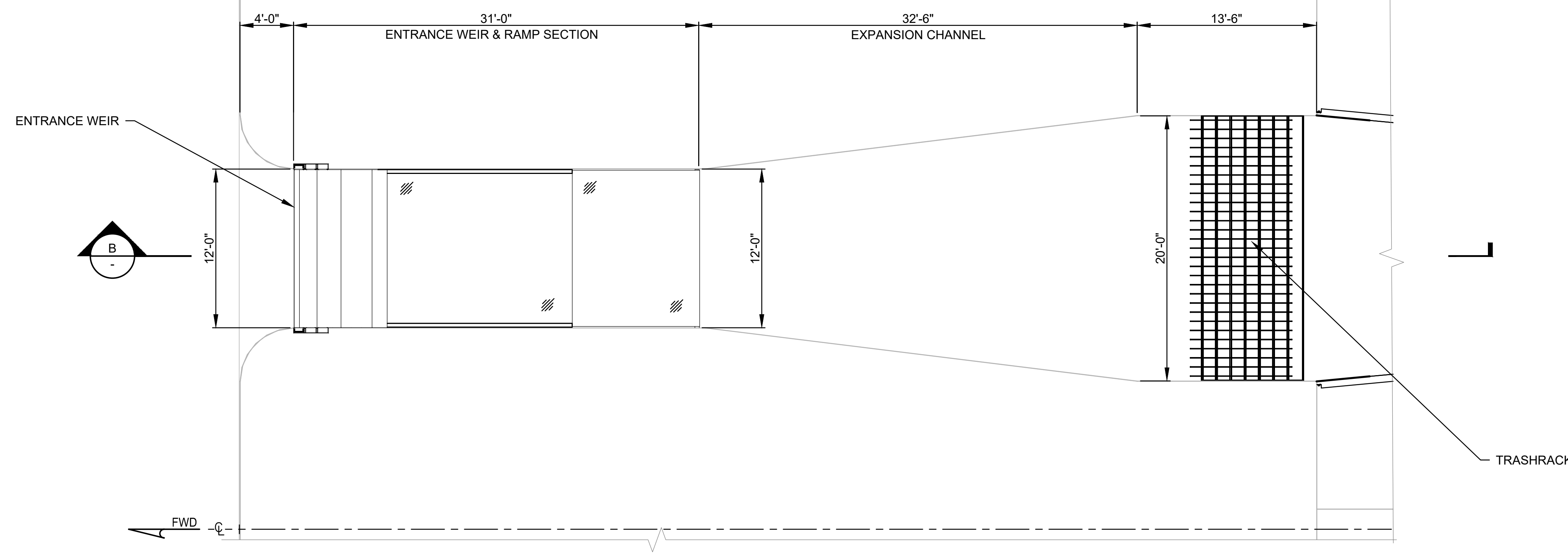
SIZE: D — FILE NAME: DEF-1.104_M-021.dwg	

DETROIT DAM, LINN COUNTY, OREGON 97413
DETROIT FLOATING SCREEN STRUCTURE
DESIGN DOCUMENTATION REPORT

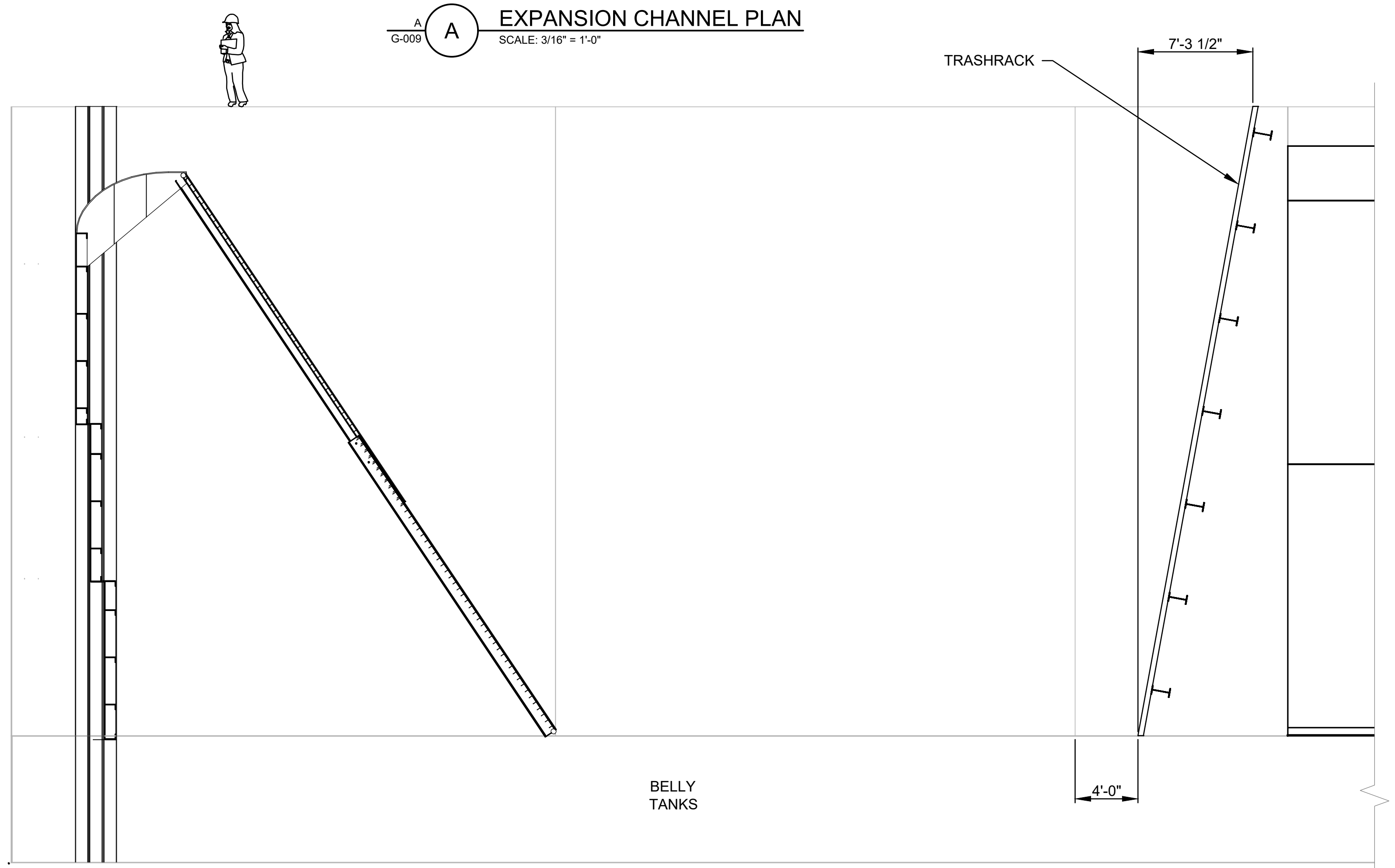
ENTRANCE WEIRS
PLAN, SECTION, & ELEVATION
FULLY OPEN (LOWERED) POSITION

PLATE IDENTIFICATION
M-021

STATUS (30%)



A
G-009
A
EXPANSION CHANNEL PLAN
SCALE: 3/16" = 1'-0"



A
M-030
B
ELEVATION
SCALE: 3/16" = 1'-0"

FWD

2" 0 1/4 1/2 1" 0 1/4 1/2 0 0 1" 2"

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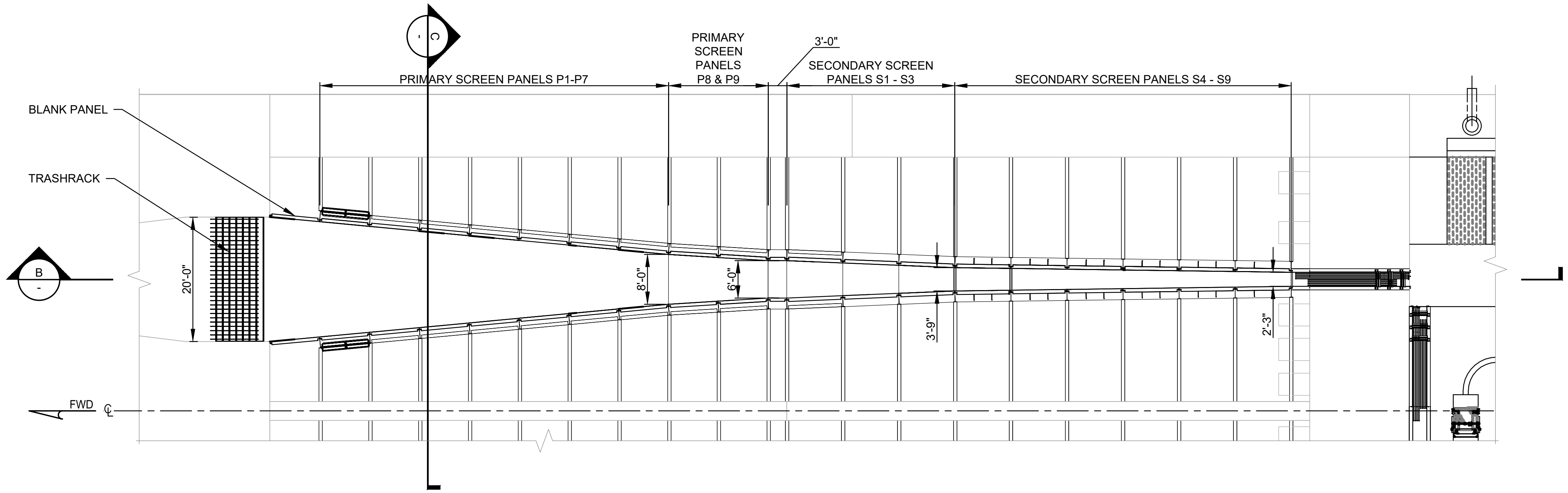
CHECKED BY: P. CHRISTENSEN / R2	PROGRAM MANAGER: J. CARLSON / AAA
PLOT SCALE: 1:2 / PLOT DATE: 1/10/2018	CONTRACT NO.: W9127N-17-C-0032
SIZE: D / FILE NAME: DEF-1.104_M-030.dwg	

DETROIT DAM, LINN COUNTY, OREGON 97413
DETROIT FLOATING SCREEN STRUCTURE
DESIGN DOCUMENTATION REPORT

EXPANSION CHANNEL
PLAN & ELEVATION

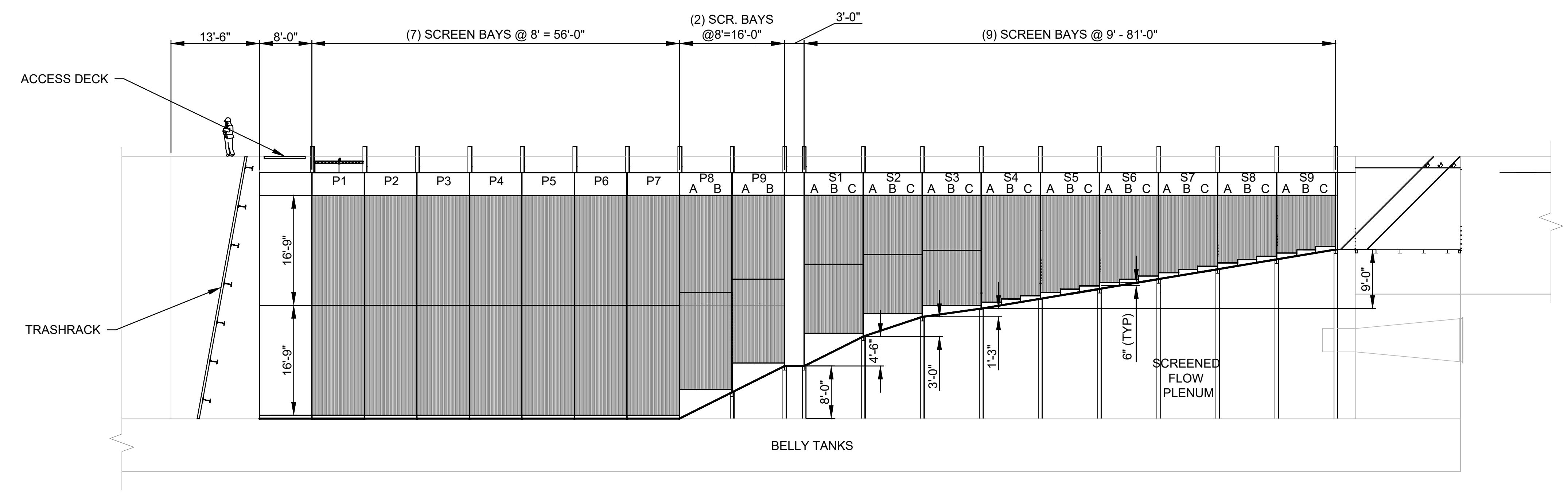
PLATE IDENTIFICATION
M-030

STATUS (30%)

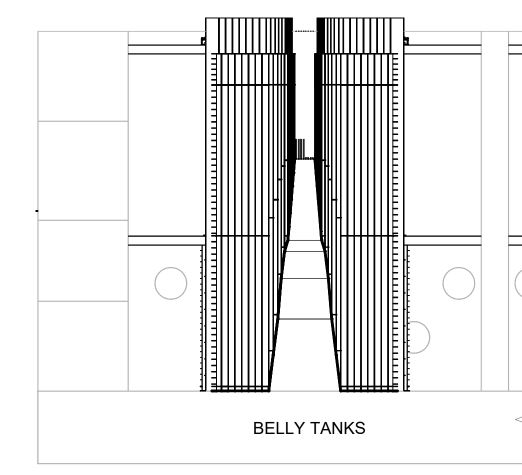


NOTE: UPPER DECK NOT SHOWN FOR CLARITY.

A G-009 (A) DEWATERING SCREEN PLAN
SCALE: 3/32" = 1'-0"



A M-050 (B) ELEVATION
SCALE: 3/32" = 1'-0"



A M-050 (C) SECTION
SCALE: 3/32" = 1'-0"

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DRAWN BY: J. SCHULZ / R2	PROJECT MANAGER: P. CHRISTENSEN / R2
CHECKED BY: P. CHRISTENSEN / R2	PROGRAM MANAGER: J. CARLSON / AAA
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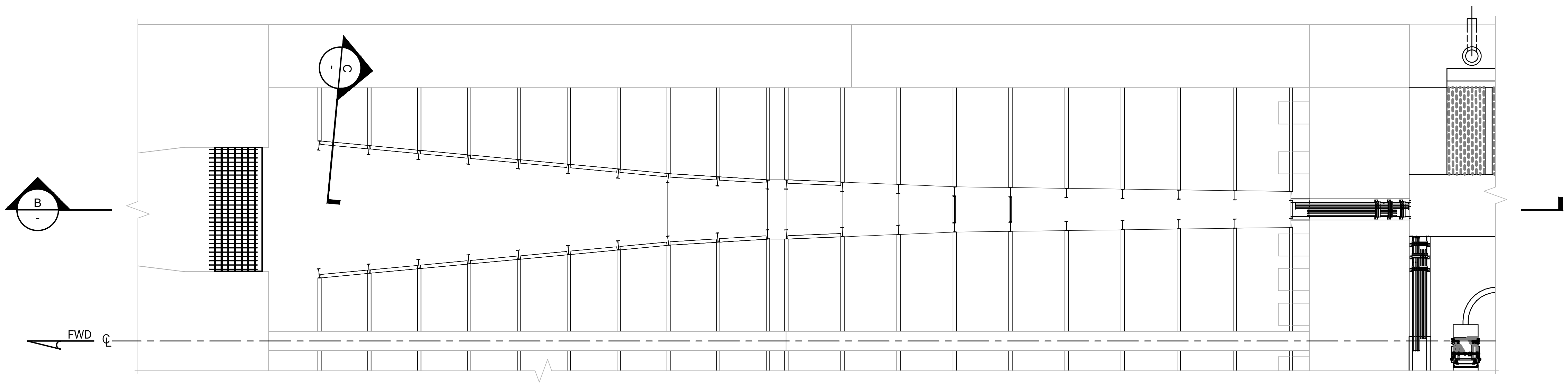
SIZE: D	FILE NAME: DEF-1.104_M-050.dwg

DETROIT DAM, LINN COUNTY, OREGON 97413
DETROIT FLOATING SCREEN STRUCTURE
DESIGN DOCUMENTATION REPORT

DEWATERING SCREEN
PLAN, SECTION, & ELEVATION

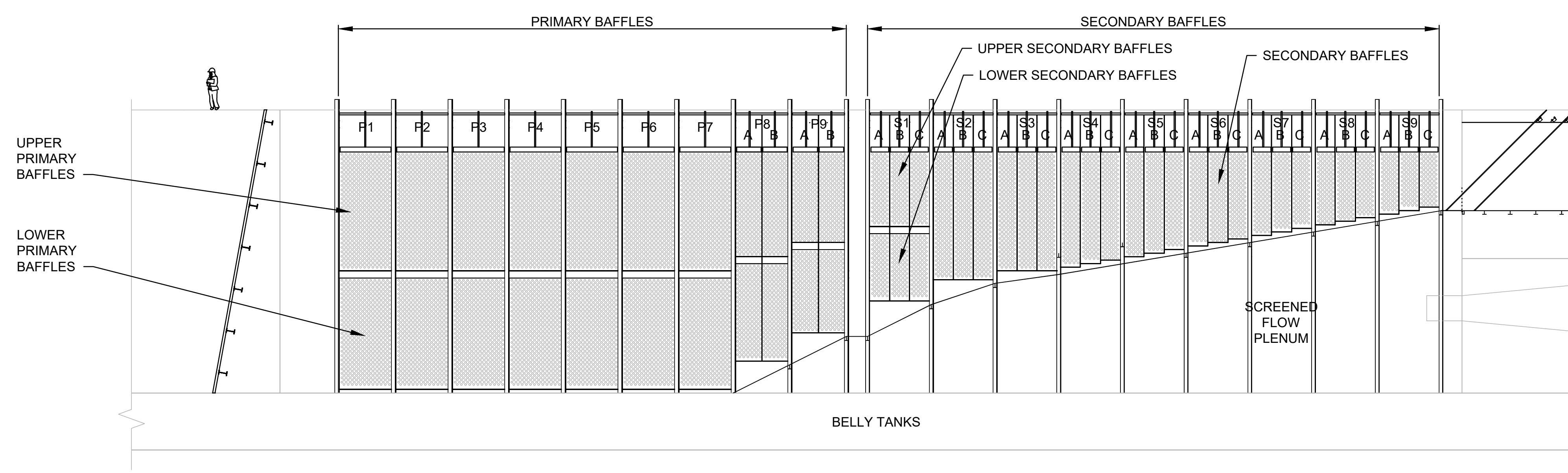
PLATE IDENTIFICATION
M-050

STATUS (30%)

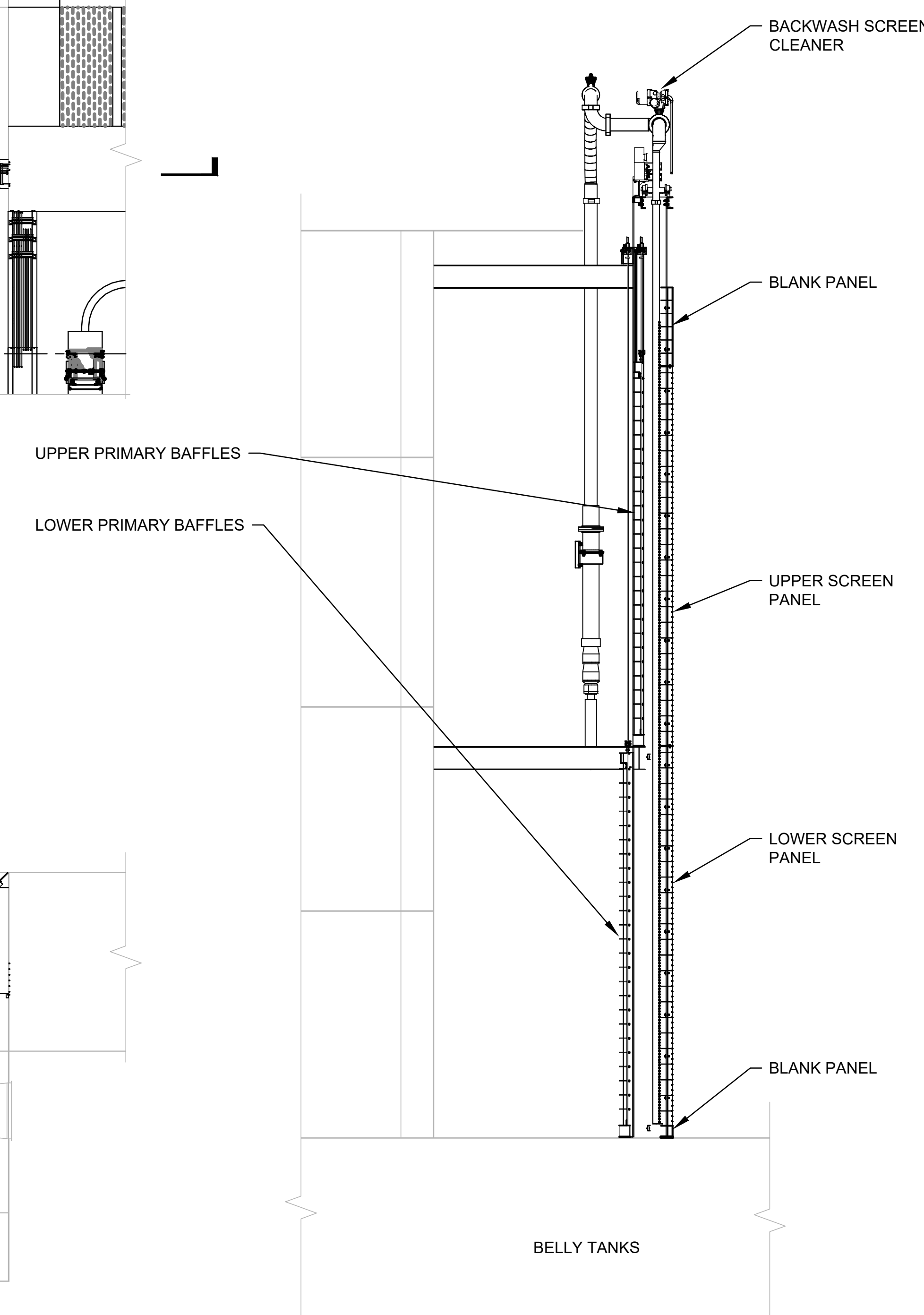


NOTE: UPPER DECK NOT SHOWN FOR CLARITY.

A / G-009 (A) FLOW CONTROL BAFFLES PLAN
SCALE: 3/32" = 1'-0"



A / M-060 (B) ELEVATION
SCALE: 3/32" = 1'-0"



A / M-060 (C) SECTION
SCALE: 1/4" = 1'-0"

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CHECKED BY: P. CHRISTENSEN / R2	PROGRAM MANAGER: J. CARLSON / AAA
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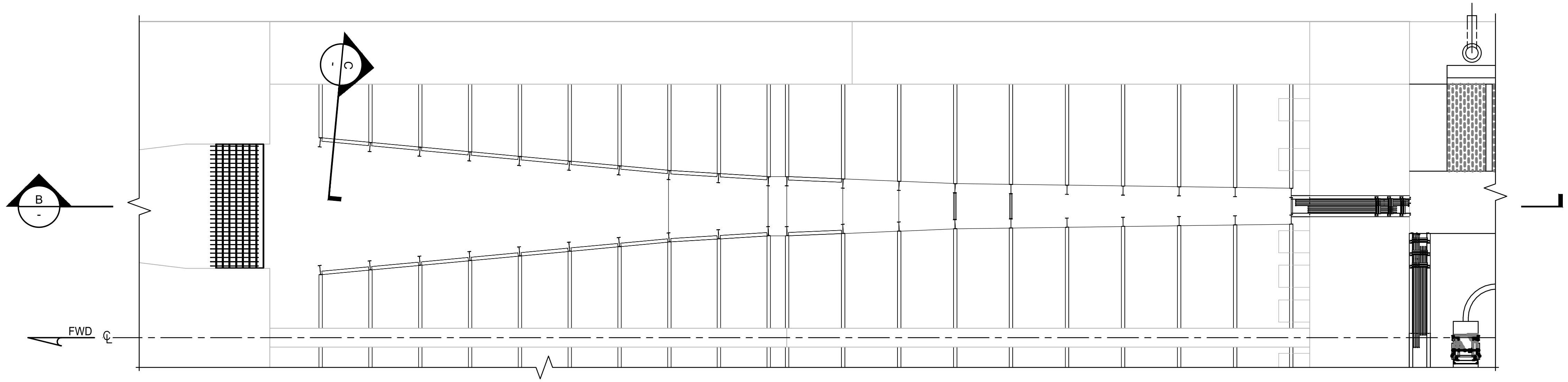
SIZE: D / FILE NAME: DEF-1.104_M-060.dwg	

DETROIT DAM, LINN COUNTY, OREGON 97413
DETROIT FLOATING SCREEN STRUCTURE
DESIGN DOCUMENTATION REPORT

FLOW CONTROL BAFFLES
PLAN, SECTION, & ELEVATION

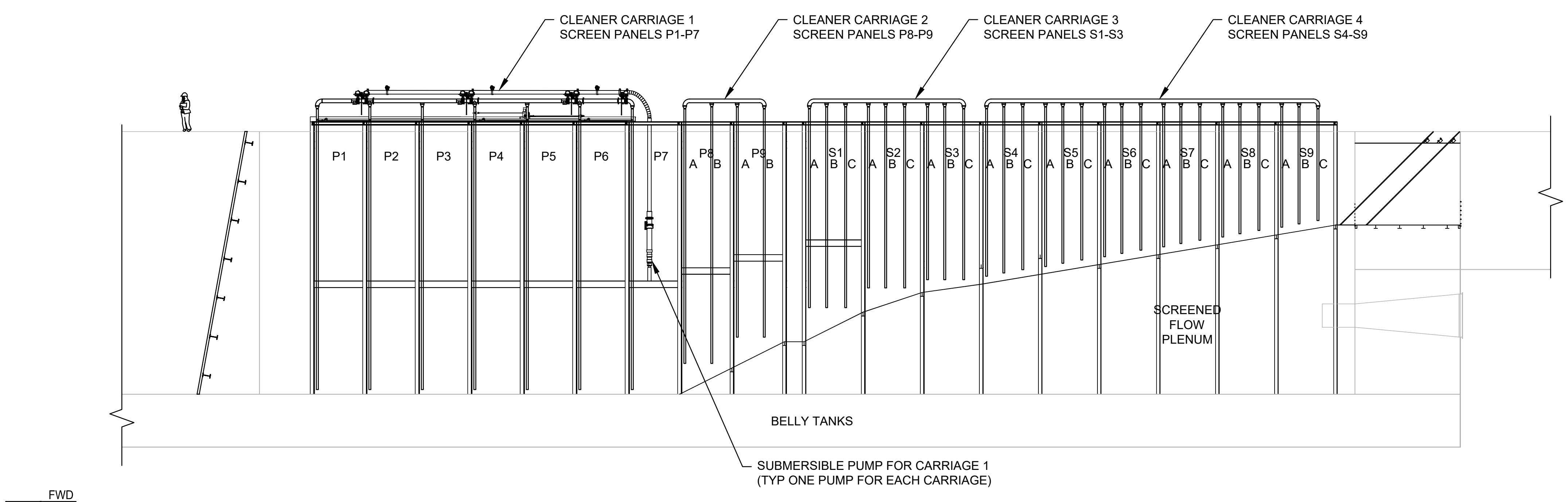
PLATE IDENTIFICATION
M-060

STATUS (30%)

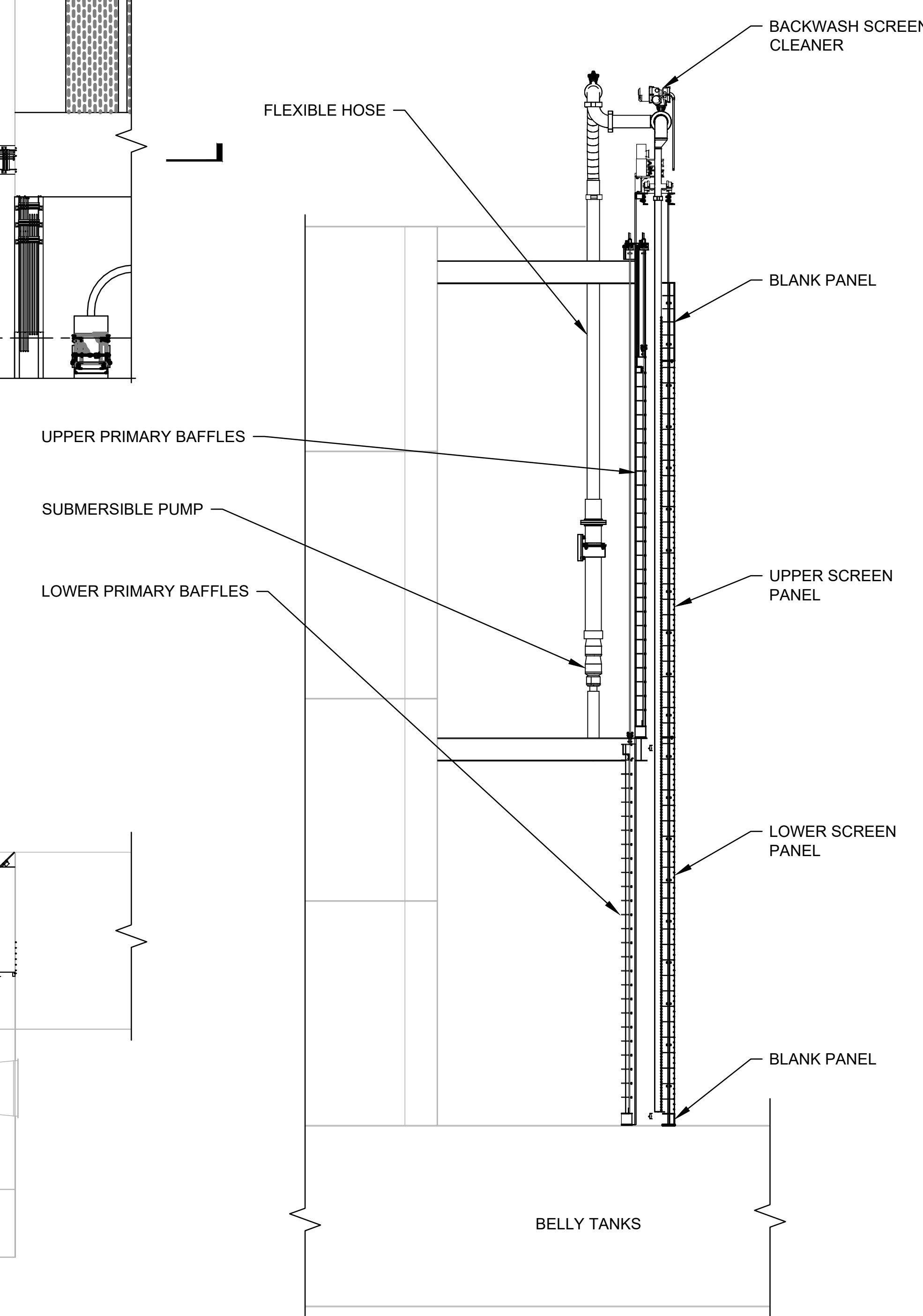


NOTE: UPPER DECK NOT SHOWN FOR CLARITY.

A / G-009 (A) SCREEN CLEANER PLAN
SCALE: 3/32" = 1'-0"



A / M-070 (B) ELEVATION
SCALE: 3/32" = 1'-0"



A / M-070 (C) SECTION
SCALE: 1/4" = 1'-0"

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CHECKED BY: P. CHRISTENSEN / R2	PROGRAM MANAGER: J. CARLSON / AAA
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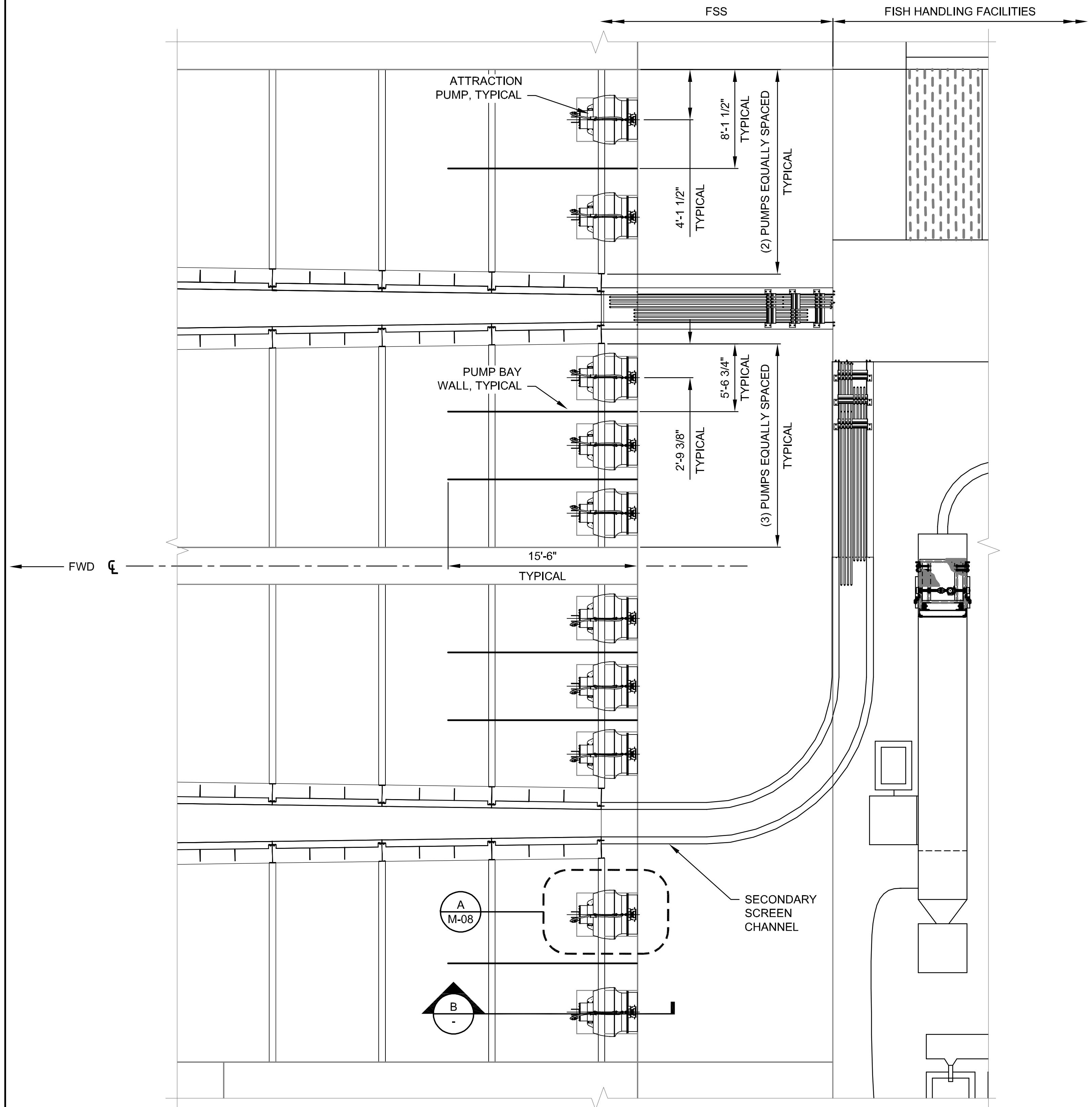
SIZE: D / FILE NAME: DEF-1.104_M-070.dwg	

DETROIT DAM, LINN COUNTY, OREGON 97413
DETROIT FLOATING SCREEN STRUCTURE
DESIGN DOCUMENTATION REPORT

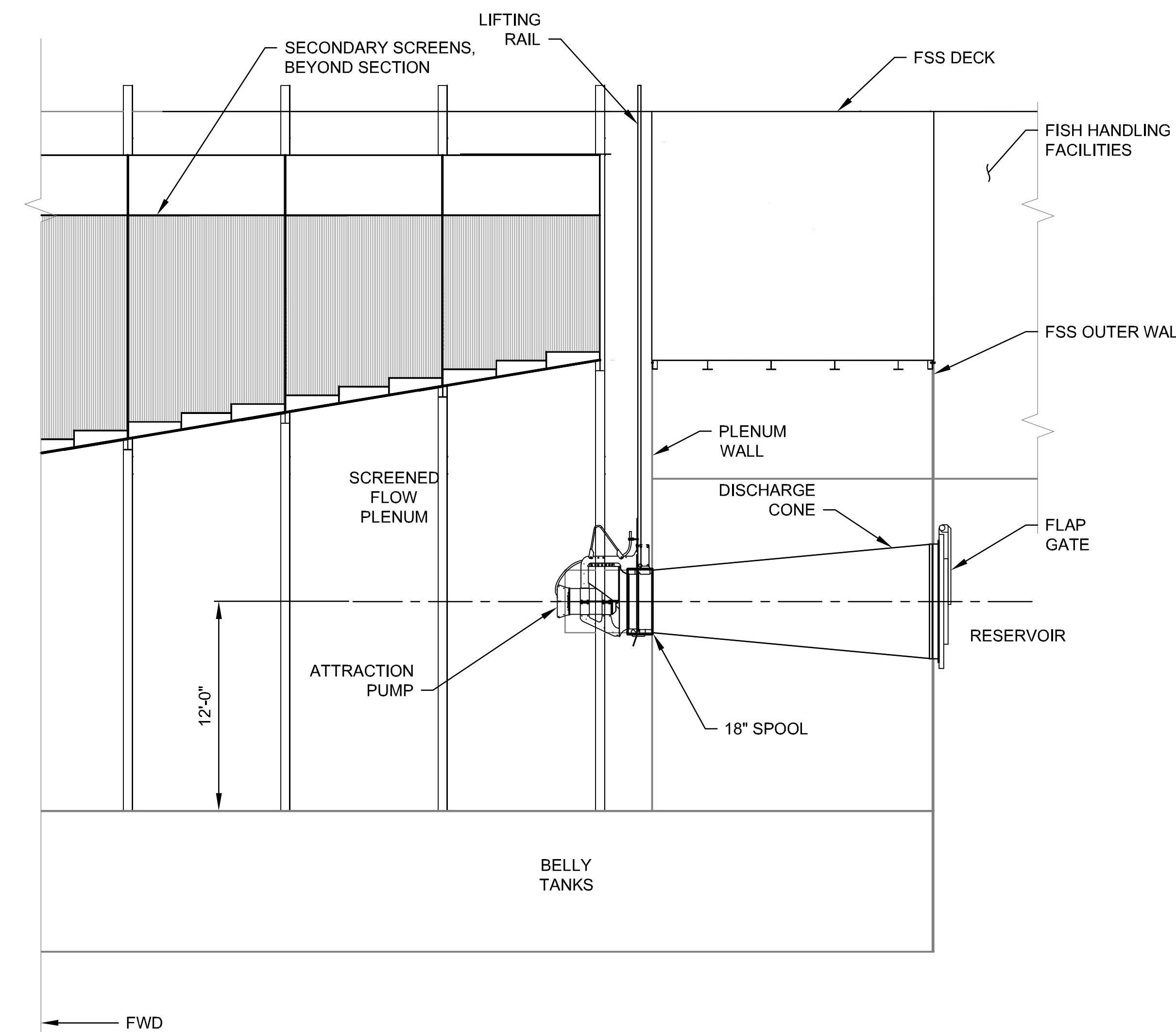
SCREEN CLEANER
PLAN, SECTION, & ELEVATION

PLATE IDENTIFICATION
M-070

STATUS (30%)



A G-004 (A) ATTRACTION PUMP PLAN
SCALE: 3/16" = 1'-0"



A M-080 (B) TYPICAL ATTRACTION PUMP PROFILE
SCALE: 3/16" = 1'-0"

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ART ANDERSON ASSOCIATES
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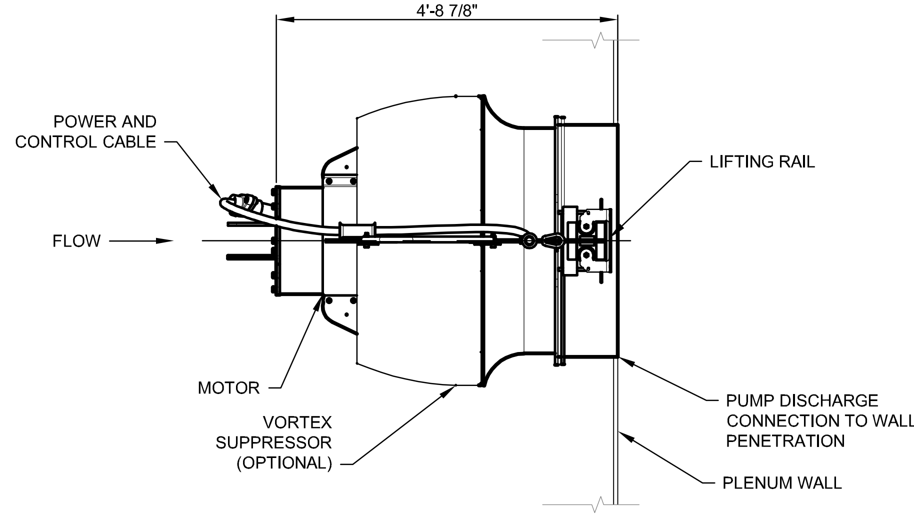
DESIGNED BY: S. MEICKE / HDR	DATE: JANUARY 12, 2018
DRAWN BY: J. CAMPBELL / HDR	PROJECT MANAGER: M. GARELLO / HDR
CHECKED BY: M. PROCIV /M. GARELLO / HDR	PROGRAM MANAGER: J. CARLSON / AAA
PLOT SCALE: 1:2 / PLOT DATE: 1/11/2018	CONTRACT NO.: W9127N-17-C-0032
SIZE: D	FILE NAME: DEF-1.104_M-080.dwg

DETROIT DAM, LINN COUNTY, OREGON 97413
DETROIT FLOATING SCREEN STRUCTURE
DESIGN DOCUMENTATION REPORT

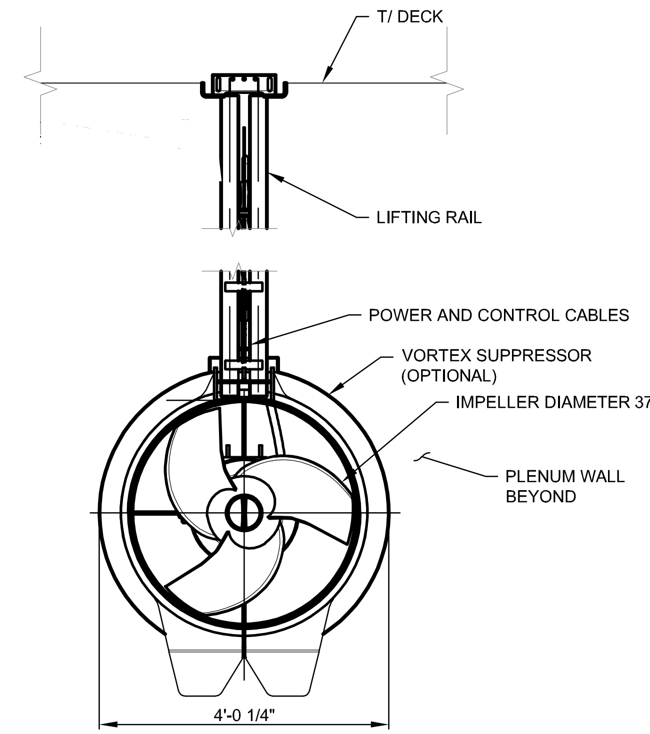
PUMP AND DIFFUSER SYSTEMS
PLAN & SECTION

PLATE IDENTIFICATION
M-080

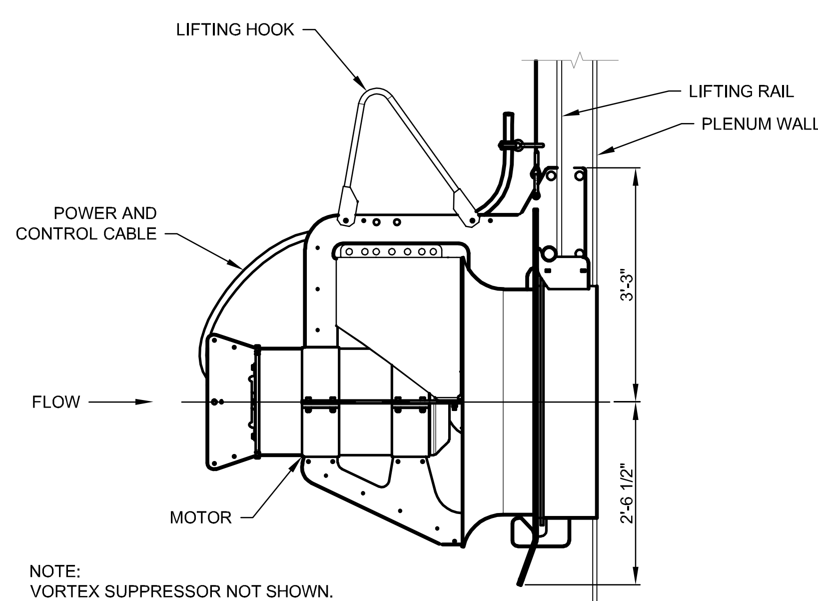
STATUS (30%)



A PLAN
SCALE: 3/4" = 1'-0"



B ELEVATION
SCALE: 3/4" = 1'-0"



NOTE:
VORTEX SUPPRESSOR NOT SHOWN.

C PROFILE
SCALE: 3/4" = 1'-0"

2" 0 1/4 1/2 1" 0
0 1" 2" 1/4 1/2 0

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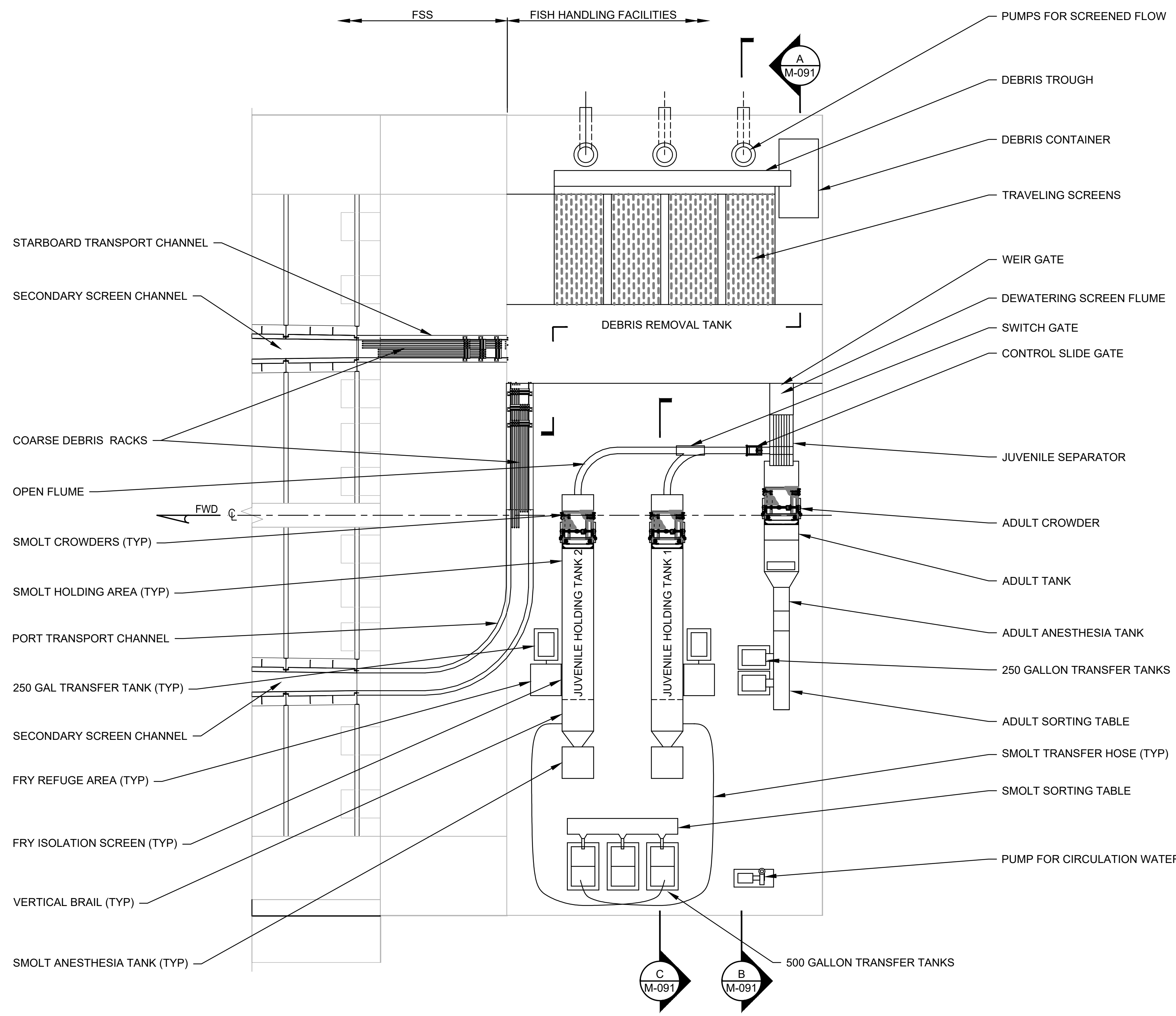
DETROIT DAM, LINN COUNTY, OREGON 97413
DETROIT FLOATING SCREEN STRUCTURE
DESIGN DOCUMENTATION REPORT

PUMP AND DIFFUSER SYSTEMS
TYPICAL ATTRACTION PUMP DETAILS

PLATE IDENTIFICATION
M-081

STATUS (30%)



A G-009 (A) **FISH HANDLING FACILITIES**
SCALE: 1/8" = 1'-0"

2" 0 1/4 1/2 1" 0 1" 2" 1/4 1/2 0

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CHECKED BY: P. CHRISTENSEN / R2	PROGRAM MANAGER: J. CARLSON / AAA
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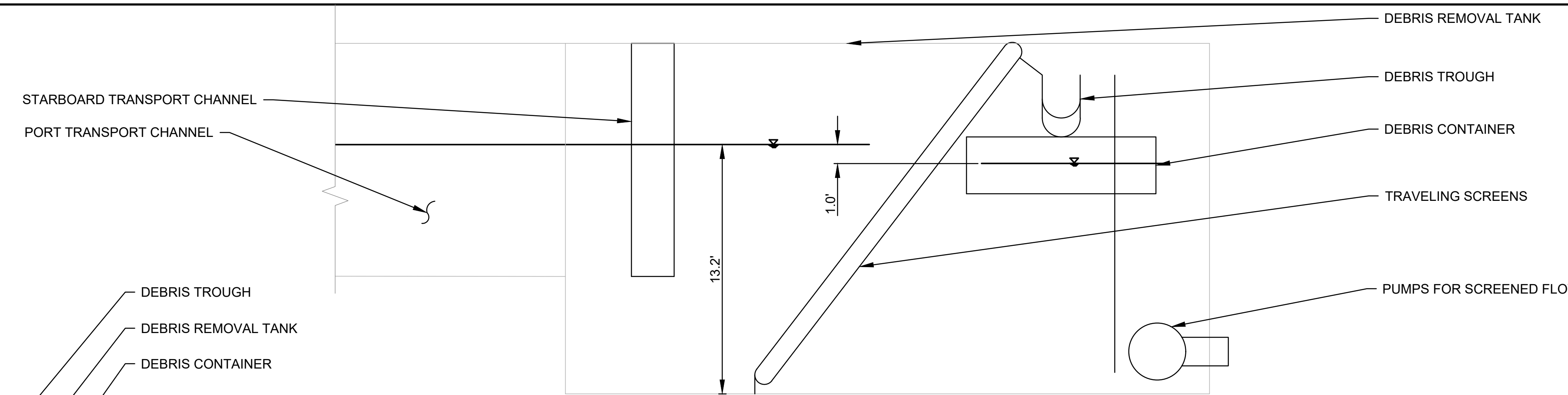
SIZE: D / FILE NAME: DEF-1.104_M-090.dwg	

DETROIT DAM, LINN COUNTY, OREGON 97413
DETROIT FLOATING SCREEN STRUCTURE
DESIGN DOCUMENTATION REPORT

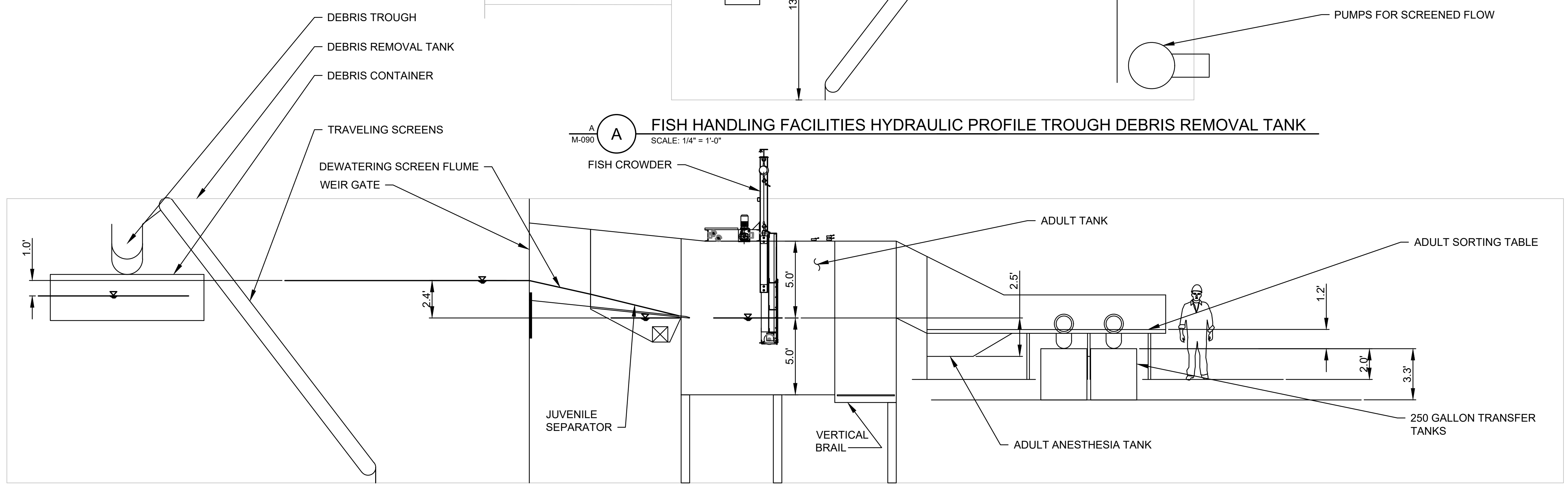
FISH HANDLING FACILITIES
PLAN

PLATE IDENTIFICATION
M-090

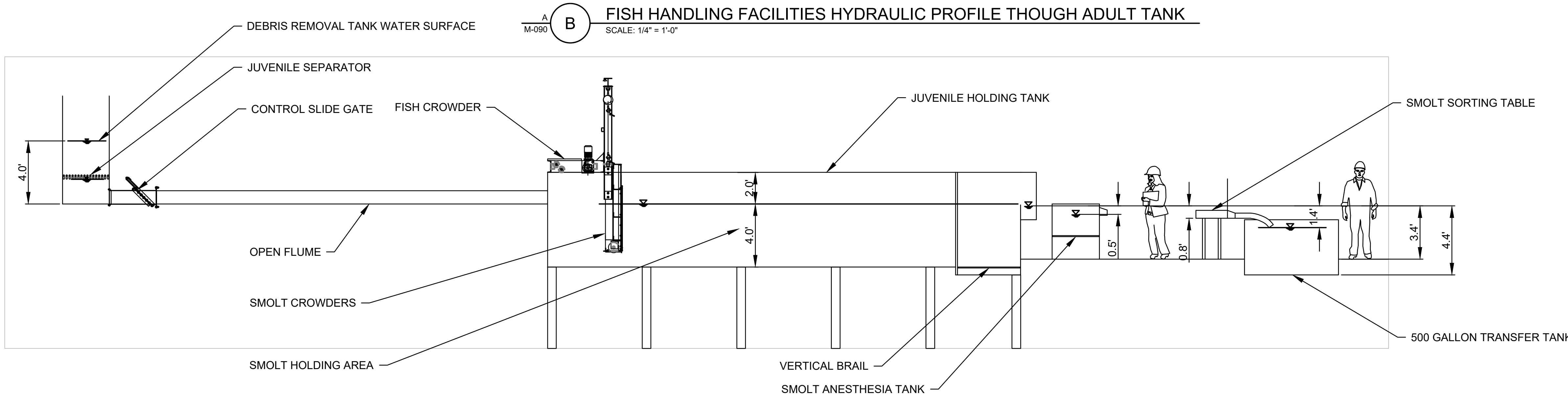
STATUS (30%)



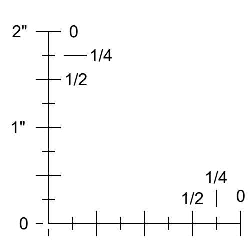
A
M-090
(A) FISH HANDLING FACILITIES HYDRAULIC PROFILE TROUGH DEBRIS REMOVAL TANK
SCALE: 1/4" = 1'-0"



A
M-090
(B) FISH HANDLING FACILITIES HYDRAULIC PROFILE THOUGH ADULT TANK
SCALE: 1/4" = 1'-0"



A
M-090
(C) FISH HANDLING FACILITIES HYDRAULIC PROFILE TRHOUGH JUVENILE HOLDING TANK
SCALE: 1/4" = 1'-0"



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R2 Resource Consultants, Inc.
REDMOND, WA.

ART ANDERSON ASSOCIATES
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(360) 479-5600

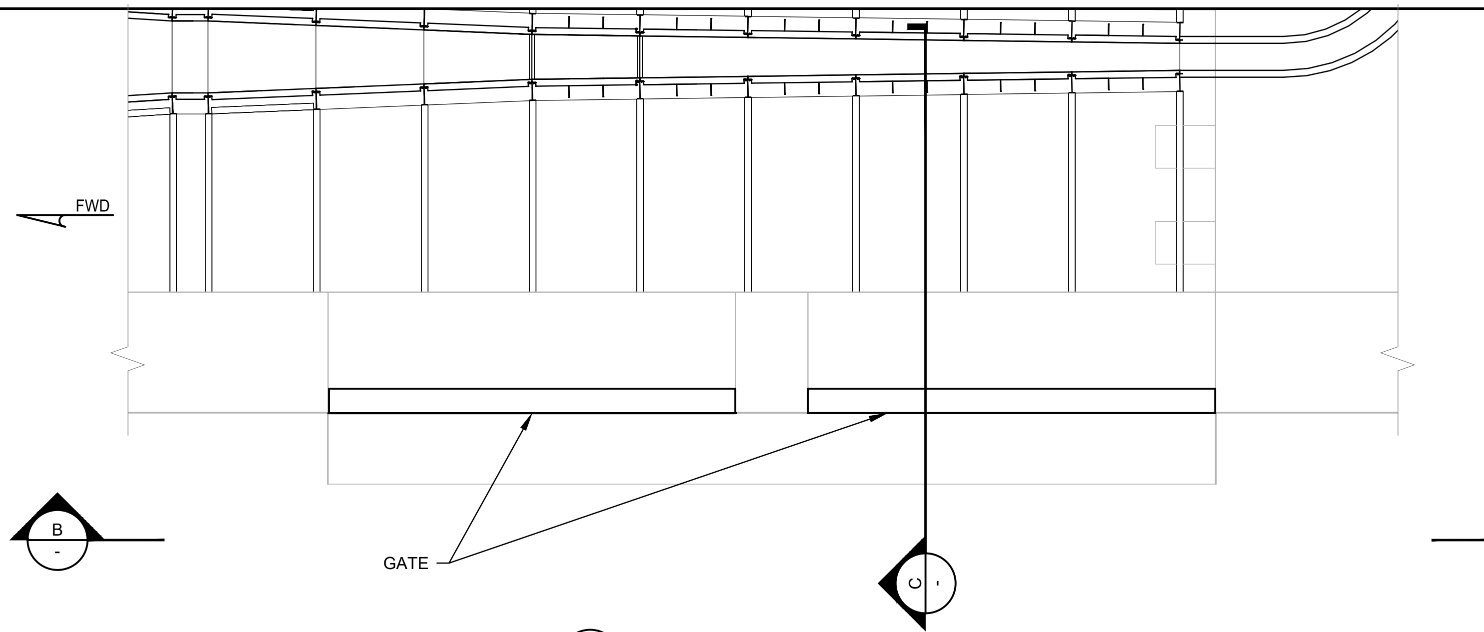
DESIGNED BY: D. TURNER / R2	DATE: JANUARY 12, 2018
DRAWN BY: J. SCHULZ / R2	PROJECT MANAGER: P. CHRISTENSEN / R2
CHECKED BY: P. CHRISTENSEN / R2	PROGRAM MANAGER: J. CARLSON / AAA
PLOT SCALE: 1:2 — PLOT DATE: 1/10/2018	CONTRACT NO.: W9127N-17-C-0032
SIZE: D — FILE NAME: DEF-1.104_M-091.dwg	

DETROIT DAM, LINN COUNTY, OREGON 97413
DETROIT FLOATING SCREEN STRUCTURE
DESIGN DOCUMENTATION REPORT

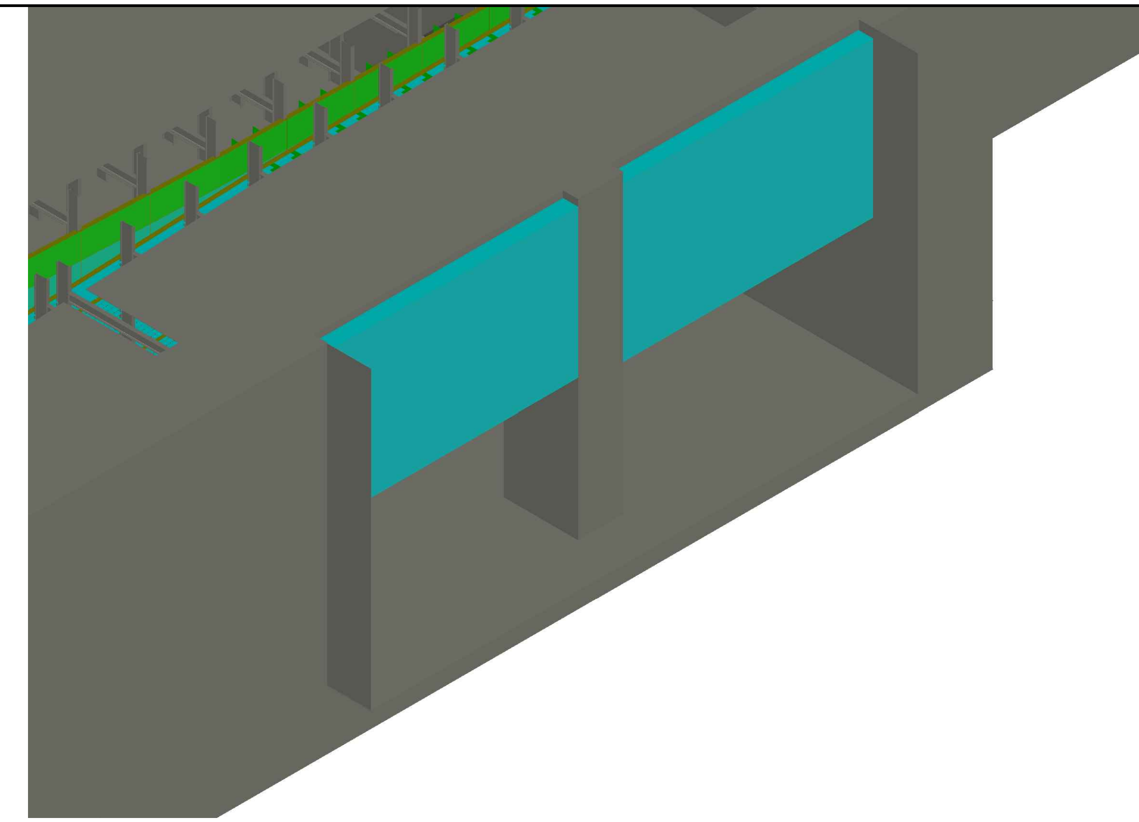
FISH HANDLING FACILITIES
HYDRAULIC PROFILES

PLATE IDENTIFICATION
M-091

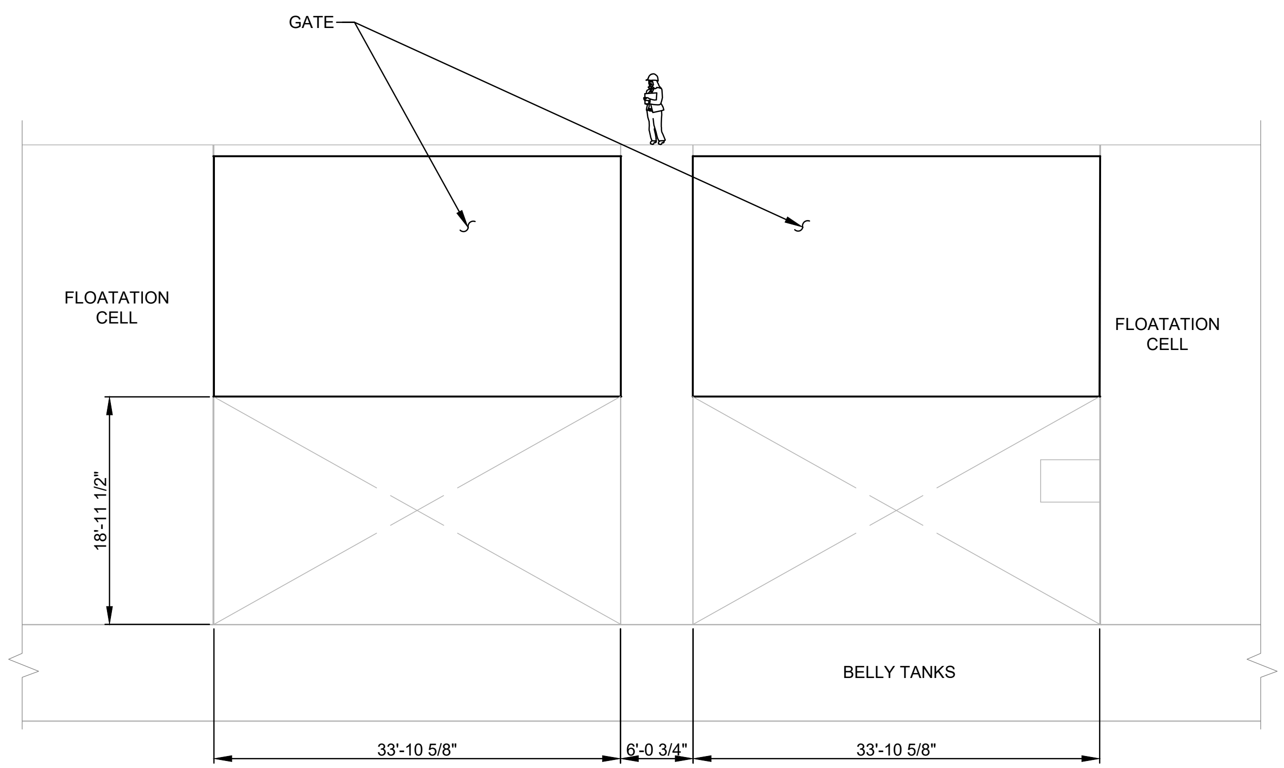
STATUS (30%)



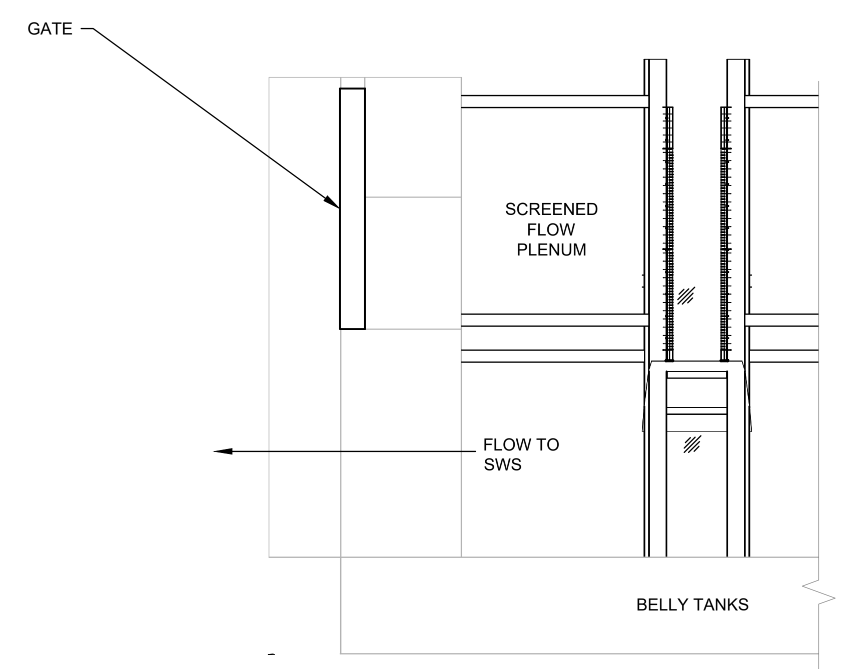
A — SWS FLOW CONTROL GATES PLAN
A / G-009
SCALE: 1/8" = 1'-0"



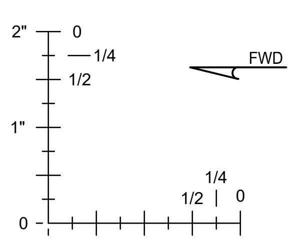
ISOMETRIC



B — ELEVATION
A / M-100
SCALE: 1/8" = 1'-0"



C — SECTION
A / M-100
SCALE: 1/8" = 1'-0"



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DETROIT DAM, LINN COUNTY, OREGON 97413
DETROIT FLOATING SCREEN STRUCTURE
DESIGN DOCUMENTATION REPORT

SWS FLOW CONTROL GATES
PLAN, SECTION, & ELEVATION

PLATE IDENTIFICATION
M-100

STATUS (30%)