DESIGN DOCUMENTATION REPORT NO.

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

US Army Corps of Engineers ®
Portland District

Phase 2 of Downstream Fish Passage – Floating Screen Structure

Prepared by:

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r2 HDR

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EXECUTIVE SUMMARY

Introduction

The NMFS 2008 Biological Opinion (BiOp) identified Reasonable and Prudent Alternatives (RPA) to avoid jeopardy of Endangered Species Act (ESA) listed fish in the Willamette basin. RPA 4.12.3 requires investigation and implementation of facilities for safely passing migratory fish species downstream of Detroit Dam. RPA 5.2 requires investigation and implementation of improvements to downstream temperatures and Total Dissolved Gas (TDG) exceedances in the North Santiam River for ESA-listed fish species.

This process started with the development of the Detroit and Big Cliff Long-Term Temperature Control and Downstream Fish Passage Engineering Documentation Report (EDR). The EDR started in 2010 and identified an array of structural and operational alternatives to provide temperature control and downstream passage at Detroit Dam. In addition to developing and evaluating alternatives for the two RPA's, this effort also provided data to the Willamette Valley Projects Configuration/Operation Plan (COP) team to enable the data to be evaluated throughout the entire Willamette basin, not just Detroit Dam. The EDR was finalized in 2017 and the recommendation was to move forward with a Selective Withdrawal Structure (SWS) for temperature control and two alternatives for fish collection; a Weir Box and a Floating Screen Structure (FSS).

Up to this point, there have been 3 Design Documentation Reports in progress for the purpose of developing design criteria and details for the SWS, the Weir Box, and the FSS. This Design Documentation Report (DDR) develops and documents the design of the Floating Screen Structure (FSS) alternative that was chosen in the 2017 Detroit and Big Cliff Long-Term Temperature Control and Downstream Fish Passage Engineering Documentation Report (EDR). The FSS will provide for safe collection and passage of downstream migratory fish, and will operate in conjunction with the Selective Withdrawal Structure, designed to improve downstream temperature control and TDG conditions. The design of the FSS in this DDR will take into account the design features of the SWS to accommodate the connection of the two facilities.

A separate DDR is being prepared for the design of the Selective Withdrawal Structure. The SWS will be a tower type structure, with warm water gates that allow for surface flow, or cold water gates that allow for at-depth water to be taken from the reservoir into a wet well where the water is mixed and passed through a turbine unit, or one upper regulating outlet (RO), to provide the optimal water temperatures downstream. See the Phase 1 Downstream Fish Passage – Selective Withdrawal Structure 60% DDR for further information on the SWS criteria and design.

The third concurrent DDR was for the Weir Box. The weir box utilized flow into the SWS wet well to attract and trap fish in the wet well, then entice fish to exit the wet well near the surface into the weir box. As the weir box design progressed to a 60% DDR level, the Product Development Team (PDT) found it very difficult to achieve biologically effective hydraulic conditions, even with increased size and cost of the SWS. Therefore, a decision was made to stop work on the weir box at the 60% DDR. See the Detroit Weir Box 60% DDR for further information on the weir box and the decision to stop work on the DDR.

The recommended design and construction schedule for Phase 1 and Phase 2 of downstream passage is shown below.

Phase 1 of Downstream Fish Passage – Selective Withdrawal Structure:

DDR: Oct 2016 – May 2019
Plans and Specifications: Feb 2018 – Jun 2020
Construction: Nov 2020 – Jun 2023

Phase 2 of Downstream Fish Passage – Floating Screen Structure:

DDR in support of Phase 1: Apr 2017 – July 2019
DDR in support of Phase 2: Jun 2021 – Dec 2022
Plans and Specifications: Jan 2023 – Jun 2024
Construction: Nov 2024 – Aug 2027

High head fish passage conveyance principally falls into two categories; trap and transport, and volitional bypass. For the Phase 1 Detroit FSS DDR, the AE firm was tasked with developing a trap and transport method for downstream fish conveyance. In order to evaluate the feasibility and applicability of a volitional bypass the Portland District formed the High Head Bypass PDT, which is currently developing a design parameters document. This document will guide the development of bypass alternatives by the PDT, which will be done in a separate EDR evaluation. The bypass feasibility and design will be evaluated by the High Head Bypass PDT in close collaboration with the Detroit downstream passage PDT

This FSS DDR in support of Phase 1 is being prepared concurrently with the SWS DDR to ensure that the SWS is configured correctly and can accommodate the FSS. The SWS and FSS will be hydraulically connected and will work together as a system. Since the completion of the EDR, the SWS location has moved further away from the dam to minimize the amount of excavation required and to avoid potential dam safety concerns. Due to the SWS location change, the FSS configuration has changed to a more linear layout than the curved layout shown in the EDR.

Purpose

The purpose of this DDR is to provide a record of design decisions, assumptions, and methods related to the Detroit Dam FSS. The purpose of the proposed project is to meet the Action Agency obligation under RPA 4.12.3 of the NMFS 2008 BiOp, and to reestablish populations of anadromous Upper Willamette River (UWR) Chinook and steelhead above Detroit and Big Cliff dams. The parameters used to establish the design criteria for the FSS and systems to capture, sort, and transport collected fish pertain to juvenile spring Chinook Salmon and downstream migratory winter steelhead, including juveniles and returning adult kelts. However, the facility will also be designed to capture and sort other fish species.

Project Location

Detroit Dam is one of 11 flood control dams in the Willamette River Basin and its construction was completed in 1953. The project was constructed primarily for flood control and hydroelectric power generation, but other major benefits include recreation and conservation uses involving releases of stored water. There are small communities located downstream on the North Santiam River, with the largest being Stayton (population 7,644, approximately 44 miles). The city of Salem (population 167,419, approximately 60 miles) is along the Willamette River, just after the North Santiam joins the Willamette River. Major features include a concrete dam, which includes a spillway, regulating outlets, penstocks, and a detached powerhouse.

The dam is a concrete gravity dam that is approximately 1,457 feet long with a maximum height of 450 feet above the lowest portion of its foundation. The spillway is a concrete ogee-type spillway with six tainter gates located in the middle of the dam. There are 4 regulating outlets, 2 at elevation 1340 and 2 at elevation 1265 located directly below the spillway. There is a fifth regulating outlet located at elevation 1340 at the south end of the spillway that was meant for hydraulic model testing, but that was never or hardly used.

There are 2 penstocks on the north side of the spillway with entrances at elevation 1403, that are steel pipes that daylight on the downstream side of the dam and provide water to the two 50 MW Francis turbines in the powerhouse. The North Santiam subbasin drains about 760 square miles. Detroit and Big Cliff dams are 2 of the 13 multipurpose projects operated by the U.S. Army Corps of Engineers 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 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.

Detroit and Big Cliff dams were both constructed without adult fish ladders. The Minto Fish Collection Facility was rebuilt in 2013 to provide trap and haul facilities to allow for reintroduction of spring Chinook salmon and winter steelhead above Detroit Dam. The Minto Fish Collection Facility is located on the north bank of the North Santiam River at river mile 55, about 4 miles downstream of Big Cliff Dam and 7 miles downstream of Detroit Dam.

Description of Facility

The FSS will include the following major features (Appendix A includes Plates showing the FSS features and layout):

- The FSS will be constructed of steel with an overall length of 308 feet , width of 101.5 feet, and depth (height) of 48 feet. The operating draft is 35 feet above the top of the belly tanks with a displacement of 42,882 kips. The maintenance draft is roughly 5.75 feet with a displacement of 11,187 kips.
- The FSS will sort fish by size and have sampling capabilities within the FSS.

- The FSS will be sealed to the SWS, but independently moored from the SWS via mooring dolphins.
- The FSS will be capable of handling flow ranges from 1,000 cfs to 5,600 cfs. The design flow rate for fish collection operations is 4,500 cfs. The 5,600 cfs flow rate is an extreme condition which is estimated to occur less than 5% of the time.
- The surface flow rate to the FSS is controlled by the powerhouse and setting of the SWS deep cold-water intake gates. FSS Entrance Weir Gates are included at the FSS intake to maintain a desired head drop across the weirs designed to capture the fish by creating velocities over the weirs in excess of 8 fps.
- The FSS is designed to integrate provisions for the future installation of attraction pumps, should it be determined by USACE that fish collection is 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.

Construction Access

Construction access is from Highway 22. Construction staging and access to the staging areas is discussed in detail in Sections 9 and 11 of this DDR.

Construction Schedule

Construction will take place over approximately 46 months. Notice to proceed is anticipated in Summer of 2024. Commissioning will occur immediately after construction is complete. Section 11 and Appendix J discuss the schedule in detail.

Operations During Construction

Construction of the FSS barge will be completed up reservoir from Detroit dam and should not impact the operation significantly. However, the installation of the mooring towers requires boats, barges, and other construction equipment near the dam and future SWS. The Contractor will be required to coordination with USACE operations personnel to ensure the construction of the mooring towers can be completed while maintaining maximum operating days.

Cost

The estimated total project cost is $397 million. See Appendix J Cost Estimate and Schedule for more details.

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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	Marion County, Oregon
Number of Units	Two
Generation Capacity	50 MW Francis turbines, (4,300-5,600 cfs combined hydraulic capacity of both turbine units). 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 Centerline Elevation	1,403.0 feet
Upper Regulating Outlets	Two at centerline elevation 1340 feet (13,050 cfs combined capacity)
Test Flume Conduit	One at centerline elevation 1340 feet (same dimensions as Upper Regulating Outlet, not currently used)
Lower Regulating Outlets	Two at centerline elevation 1265 feet that are not used

ABBREVIATIONS AND ACRONYMS

A	Amperes
AASHTO	American Association of State Highway and Transportation Officials
ABS	American Bureau of Shipping
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASD	Allowed Strength Design
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Material
AV	Amphibious Vehicle
AWS	American Welding Society
BiOp	2008 Willamette River Biological Opinion
BMPs	Best Management Practices
BPA	Bonneville Power Administration
CAA	Clean Air Act
cf	Cubic Feet
CFD	Computational Fluid Dynamics
cfs	cubic feet per second
CMAA	Crane Manufacturer's Association of America
DDR	Design Documentation Report
DEQ	Oregon Department of Environmental Quality
DISPL	Displacement
DSL	Oregon Department of State Lands
E	Elastic Modulus
EDR	Engineering Documentation Report
EEFH	Essential Fish Habitat
F	Fahrenheit
EIS	Environmental Impact Statement
EM	Engineering Manual
EPA	Environmental Protection Agency
ER	Engineering Regulation
ESA	Endangered Species Act

ETL	Engineering Technical Letter
FFC	Floating Fish Collector
FHF	Fish Handling Facilities
FONSI	Finding of No Significant Impact
fps	Feet per Second
FSC	Floating Surface Collector
FSS	Floating Screen Structure
ft	Feet
Fy	Yield Strength
GHS	General Hydrostatics
GM	Metacentric Height
GMr	Required Metacentric Height
gpm	Gallons per Minute
h	hydraulic head
HIW	High Intake Weirs (in SWS)
HP	Horsepower
HS	Significant Wave Height
IBC	International Building Code
ICC	International Code Council
IEEE	Institute of Electrical and Electronics Engineers
IESNA	Illuminating Engineering Society of North America
in	Inches
I/O	Input/Output
ISA	International Society of Automation
IWWW	In Water Work Window
JPA	Joint Permit Application
kips	thousands of pounds
Ksi	Kips per square inch
kW	Kilowatts
L	Length Overall
lb(s)	Pound(s)
LCG	Longitudinal Center of Gravity
LED	Light Emitting Diode
LIG	Low Intake Gates (in SWS)

LRFD	Load and Resistance Factor Design
mA	Milliamps
max	Maximum
MCE	Maximum Considered Earthquake
mg	Milligrams
min	Minimum
mm	Millimeters
mph	Miles per hour
MW	Megawatts
NAAQS	National Ambient Air Quality Standards
NEC	National Electrical Code
NEMA	National Electrical Manufacturer's Association
NFPA	National Fire Protection Association
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
OAR	Oregon Administrative Rules
ODFW	Oregon Department of Fish and Wildlife
OSHA	Occupational Safety and Health Administration
OSSC	Oregon Structural Specialty Code
PDT	Product Development Team
PLC	Programmable Logic Controller
PGA	Peak Ground Acceleration
PGE	Portland General Electric
ppm	Parts per Million
PSE	Puget Sound Energy
RGS	Rigid Galvanized Steel Conduit
RPA	Reasonable and Prudent Alternative
S_S	Mapped Spectral Response Acceleration Parameter at Short Periods
S_1	Mapped Spectral Response Acceleration Parameter at a Period of 1 Second
S_{DS}	Design Spectral Response Acceleration Parameter at Short Periods
S_{D1}	Design Spectral Response Acceleration Parameter at a Period of 1 Second
SCADA	Supervisory Control and Data Acquisition
sec	Second

SIP	State Implementation Plan
SNAME	Society of Naval Architects and Marine Engineers
SWBS	Ship Work Breakdown Structure
SWMP	Storm Water Management Plan
SWS	Selective Withdrawal Structure
TBD	To Be Determined
TCG	Transverse Center of Gravity
TDG	Total Dissolved Gas
TDH	Total Dynamic Head
temp	Temperature
TLI	Tank Level Indicator
TM	Technical Manual
TYP	Typical
UFC	Unified Facilities Criteria
UHMW	Ultra-High Molecular Weight Polyethylene
UL	Underwriters Laboratories
UPS	Uninterrupted Power Supply
USACE	United States Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
UWR	Upper Willamette River
V	Velocity, Volts
VAC	Volts Alternating Current
VCG	Vertical Center of Gravity
VFD	Variable Frequency Drive
WQC	Water Quality Certification
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 meet the Action Agency obligation under RPA 4.12.3 of the NMFS 2008 BiOp, and to reestablish populations of anadromous Upper Willamette River (UWR) Chinook and steelhead above Detroit and Big Cliff dams. The parameters used to establish the design criteria for the FSS and systems to capture, sort, and transport collected fish pertain to juvenile Spring Chinook Salmon and downstream migratory winter steelhead including juveniles and returning kelts. However, the facility will also be designed to capture and sort other fish species.

The NMFS 2008 Biological Opinion (BiOp) identified Reasonable and Prudent Alternatives (RPA) to avoid jeopardy of Endangered Species Act (ESA) listed fish in the Willamette basin. RPA 4.12.3 requires investigation and implementation of facilities for safely passing migratory fish species downstream of Detroit Dam. RPA 5.2 requires investigation and implementation of improvements to downstream temperatures and Total Dissolved Gas (TDG) exceedances in the North Santiam River for ESA-listed fish species.

This Design Documentation Report (DDR) develops and documents the design of the FSS alternative that was chosen in the 2017 Detroit and Big Cliff Long-Term Temperature Control and Downstream Fish Passage Engineering Documentation Report (EDR). The FSS will provide for safe collection and passage of downstream migratory fish and will operate in conjunction with the Selective Withdrawal Structure (SWS), designed to improve downstream temperature control and TDG conditions. The design of the FSS in this DDR will take into account the design features of the SWS to accommodate the connection of the two facilities. A separate DDR is being prepared for the design of the Selective Withdrawal Structure.

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 Minto 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 a centerline elevation of 1265.3 feet, two at elevation 1340.0 feet, and two turbines with penstock intake centerline elevation at 1403 feet.

1.2.2 Project Authorization

The construction of the Detroit Dam, North Santiam River, Oregon, was authorized by the Flood Control Act of 1938, Pub. L. No. 75-761 (52 Stat. 1215). 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, Seventy-fifth Congress, third session". The Flood Control Act of 1948, Pub. L. No. 80-858 (62 Stat. 1175), modified the Flood Control Act of 1938 to provide for the installation of hydroelectric power-generating facilities at Detroit Dam, and included the construction of Big Cliff Dam as a part of the Detroit project, in accordance with plans on file in the Headquarters Office, Chief of Engineers. These and subsequent laws have authorized the following project purposes at Detroit Dam: flood control, navigation, hydropower, water supply (irrigation, and municipal and industrial), water quality, fish and wildlife, and recreation."

The Corps is responsible for the construction and operation of the project for its authorized purposes and has exclusive control over all waters and all project lands adjacent to and beneath the water surfaces in carrying out these purposes, including withdrawn U.S. Forest Service (USFS) lands. The use or utilization of withdrawn USFS lands for purposes extraneous to project operation remains under the jurisdiction of the USFS. In order to facilitate the management and control of project resources and to eliminate the overlapping of administrative responsibilities, the operational area at Detroit and Big Cliff project lands lying outside the USFS boundary will remain under the exclusive control of the Corps. The responsibility for administering all other project lands within the boundary for recreation, fire protection, and land management is vested with the USFS, in accordance with a Memorandum of Understanding between the Secretary of Agriculture and the Secretary of the Army, effective November 10, 1954."

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 Documentation Report, USACE, July 2017.
- Detroit Temperature Control 60% DDR, USACE, January 2018.

- NMFS (National Marine Fisheries Service). 2008. Endangered Species Act Section 7(a)(2) Consultation, Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation, Consultation on the Willamette River Basin Flood Control Project. Log F/NWR/2000/02117, Northwest Region, Seattle, WA.
- USGS (U.S. Geological Survey), Behavior and Dam Passage of Juvenile Chinook Salmon and Juvenile Steelhead at Detroit Reservoir and Dam, Oregon, March 2012–February 2013, USGS, Open-File 2014-1144.
- USACE, Detroit Floating Screen Structure - Recommended Minimum and Maximum Design Flow Rates (DRAFT), CENWP-EC-HD Memorandum to the files, August 4, 2017 revised September 18, 2017.
- USGS (U.S. Geological Survey), In-Reservoir Behavior, Dam Passage, and Downstream Migration of Juvenile Chinook Salmon and Juvenile Steelhead from Detroit Reservoir and Dam to Portland, Oregon, February 2013–February 2014, USGS, Open-File 2015-1090.
- USGS (U.S. Geological Survey), Behavior, Passage, and Downstream Migration of Juvenile Chinook Salmon from Detroit Reservoir to Portland, Oregon, 2014–15, USGS, Open-File Report 2015-1220.
- USGS (U.S. Geological Survey), Synthesis of Downstream Fish Passage Information at Projects Owned by the U.S. Army Corps of Engineers in the Willamette River Basin, Oregon, USGS, Open-File 2017-1101.

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 fish transport tank pod to a fish transfer amphibious vehicle and transported downstream.

The FSS will include the following major features (See Appendix A for Plates showing the FSS features and layout).

- The FSS will be constructed of steel with an overall length of 308 feet long, width of 101.5 feet, and depth (height) of 48 feet. The operating draft is 35 feet with a displacement of 42,882 kips. The maintenance draft is roughly 5.75 feet with a displacement of 11,187 kips.
- The FSS will sort fish by size and have sampling capabilities within the FSS.
- The FSS will be sealed to the SWS, but independently moored from the SWS via mooring dolphins.
- The FSS will be capable of handling flow ranges from 1,000 cfs to 5,600 cfs. The design flow rate for fish collection operations is 4,500 cfs. The 5,600 cfs flow rate is an extreme condition which is estimated to occur less than 5% of the time.

- The surface flow rate to the FSS is controlled by the powerhouse and setting of the SWS deep cold-water intake gates. FSS Entrance Weir Gates are included at the FSS intake to maintain a desired head drop across the weirs designed to capture the fish by creating velocities over the weirs in excess of 8 fps.
- The FSS is designed to integrate provisions for the future installation of attraction pumps, should it be determined by USACE that fish collection is 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.

1.5 Agency Coordination

The design is being 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. All participating member agencies/entities of the Willamette Fish Facility Design Work Group (WFFDWG) will be included; USACE, BPA, NOAA, USFWS, ODFW, and the Confederated Tribes of Grande Ronde.

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, NMFS, and BPA 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, Engineering Document Report, USACE, July 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, Bonneville Power Administration, DOE/BP-365, September 1984.
- USACE(a): Summary of Route-Specific Passage Proportions and Survival Rates for Fish Passing through John Day Dam, The Dalles Dam, and Bonneville Dam in 2010 and 2011, Interim Report, June 2012.
- USACE (b): Bonneville Second Powerhouse Fish Guidance Efficiency (FGE) Computational Fluid Dynamics (CFD) Modeling Report for the DDR, Draft Report, November 2014.
- USACE(c): Water Temperature Data for Detroit Dam and Reservoir (2011 to 2017), 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

Criteria	Design Value	Source	Notes
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
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 11.7.1.3
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 criterion for adult fish; also used successfully on the North Fork Dam floating surface collector (FSC)
Maximum Trashrack Velocity	4 fps	USACE(a)/(b)	Based on safe fish passage through the 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

Criteria	Design Value	Source	Notes
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
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 Surface Water Temperature	70 degrees F	USACE(c)	Maximum surface (35 ft depth) temperature in August (not peak run time)
Peak Run Design Water Temperature	53 degrees F	USACE(c)	Impacts the adult holding allowable density. See Section 2.3.2 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 ppm
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 Density	0.15 cf/lb (6.7 lb/cf)	NMFS 2011 6.7.2.1	Will also be used for short-term transfer tank (pods) if operating plan is to hold in pods 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

Designing fish passage facilities associated with the reintroduction of an anadromous fish run provides challenges associated with predicting the ecology and behavior of the future run. When fish populations are present, metrics used to inform and provide scale for facility design and operation, such as run timing, run size, and migratory life stages can be documented under site-specific conditions. When existing runs of anadromous fish are not available, assumptions regarding biological design criteria introduce uncertainty into design parameters. Will the reintroduced population of fish exhibit life histories and behaviors consistent with donor stock, or will these metrics be affected by environmental conditions specific to the target watershed? The collection and passage performance of a proposed downstream fish passage facility will be affected by dominant life-stage outmigration timing and strategies. Understanding the biological assumptions supporting the design of fish passage facilities is important when evaluating potential facility performance. Uncertainty associated with the biological assumptions should translate to structural flexibility and adaptively managing fish passage facilities in response to observed performance. Facility designs developed in response to pre-project uncertainty and the opportunity for post-construction refinement will increase the probability of successful fish passage performance.

The USACE has developed design values for species timing, maximum daily run numbers by month, and fish weights based on life stages and seasons. This information is provided in Table 2-3.

Table 2-3 - Fish Species Criteria

	Jan	Feb	Mar	Apr	May	Jun
Steelhead per day high	1,110	924	4,311	22,798	40,051	10,919
Steelhead per day low	370	308	1,437	7,599	13,350	3,640
Average weight (lbs)	0.200	0.200	0.200	0.200	0.200	0.200
Chinook per day high	3,112	3,112	12,449	21,785	62,244	31,122
Chinook per day low	1,037	1,037	4,150	7,262	20,748	10,374
Average weight (lbs)	0.120	0.100	0.080	0.070	0.080	0.090
High fish catch weight (lbs)	595.56	495.93	1858.01	6084.54	12989.74	4984.85
Low fish catch weight (lbs)	198.52	165.31	619.34	2028.18	4329.91	1661.62
	Jul	Aug	Sep	Oct	Nov	Dec
Steelhead per day high	865	0	0	68	257	1,979
Steelhead per day low	216	0	0	23	86	660
Average weight (lbs)	0.100	0.100	0.100	0.100	0.100	0.100
Chinook per day high	4,150	4,150	21,785	46,683	77,805	24,898
Chinook per day low	1,037	1,037	7,262	15,561	25,935	8,299
Average weight (lbs)	0.110	0.110	0.132	0.132	0.132	0.132
High fish catch weight (lbs)	543.99	457.49	2882.21	6182.99	10319.27	3491.86
Low fish catch weight (lbs)	136.00	114.37	960.74	2061.00	3439.76	1163.95

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 powerhouse is operated to provide power during peaking demand, 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. 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. When de-ballasted, the FSS will not be operational for passing flow or collecting fish.

The powerhouse flow to achieve 100 MW (two turbines units operating at 50 MW each) 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 typically warmer surface-flow withdrawals with typically 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 there may be significant flow through the SWS low-level withdrawals for temperature management. The Corps continues to evaluate the balance of maximizing attraction flow to the FSS at the surface with temperature management downstream for adult migration, spawning, incubation and emergence, as well as juvenile rearing conditions. This effort is being captured in the SWS DDR.

The USACE produced a memorandum Detroit FSS: Recommended Design Flow Rates (dated 8/4/2017, 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 B. 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 and/or minimum required circulation water for fish being held on the FSS. The inflow to the FSS is the typically warmer surface water over the upper portion of the reservoir depth. For temperatures above 50 degrees F, the allowable density for holding adult fish needs to be reduced to meet the NMFS design criteria. For temperatures above 58 degrees F, the minimum required circulation water flow for holding juvenile fish needs to be increased to meet recommendation in Senn 1984 (see Table 2-2). During some winter periods the surface water can temporarily be slightly colder than the deep reservoir water, but this only occurs when the water is below 50 degrees F so these rare conditions do not impact the design criteria. The holding facilities 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; 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 when few fish are migrating)

The maximum daily run estimates are anticipated to occur in May and November (see Table 2-3). Based on the last 5 years of temperature data [USACE(c)] the average daily water temperature of the surface water (upper 35 feet) in May was 52.4 degrees F, with a maximum daily temperature of 58.6 degrees F on May 31, 2015. Since the estimated run in June is significantly less than in May, it is reasonable to assume that the peak day in May would not occur near the end of the month, so a reasonable design temperature for the month of May would appear to be 53 degrees F (the average rounded up to the nearest degree). In November the surface water temperatures were similar, with an average daily surface water temperature of 50.7 degrees F and a maximum daily temperature of 57.9 degrees F on November 1, 2014. As described for May, it does not seem likely that the peak run days in November would occur during the first days of the month, since October has a significantly lower estimated run, so a reasonable design temperature for the month of November would appear to be 51 degrees F.

2.3.3 Transport Operations

At a minimum, fish held in the Fish Handling Facilities (FHF) will be off-loaded for transport 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 will occur more often, so the holding facilities on the FHF do not necessarily need to be able to hold an entire peak day run at one time.

Fish will be off-loaded from the FSS in transport pods and placed onto an amphibious vehicle (AV) designed for water and land transportation. The AV will travel with the pods to the Minto fish facility downstream, where the fish will be discharged into stress relief ponds for temporary holding prior to release into the river below Minto. The transport pods are described in Section

4. The USACE is in the process of developing the details for the A.V., and information was not yet available at the time of this 90% DDR.

3 NAVAL ARCHITECTURE

3.1 General

The Detroit Reservoir Floating Screen Structure (FSS) is a barge-like floating structure 308 feet long overall by 101.5 feet wide by 48 feet deep. It is composed of four functional sections.

1) Belly tanks: Belly tanks, 308 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 20 ballast tanks. A 35-foot long by 22.25-foot wide portion extending the full 8-foot depth forms the Lower Pump Room.
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 extending from the extreme forward end to the aft end of the primary screen channels, one extending from the extreme forward end to the sorting and sampling area to port, one extending from the extreme forward end to the sorting and sampling area 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. Variable ballast tanks are located in the port and starboard flotation cells. The port flotation cell contains two openings adjacent to the SWS intakes. Here, the flotation cell extends from the main deck down 10 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 elliptical-crest intake weir at the bow. The intake weirs are 20 feet behind trash racks at the extreme forward end of the intake weirs is a 31-foot long straight ramp area, a 34-foot long expansion channel, an 81-foot long primary screen channel, and an 86-foot long secondary screen channel. Inboard screened flow from port and starboard primary screen channels is prevented interacting by a centerline structure extending the entire length of the primary screen channels. All screened flow from port and starboard primary and secondary screen channels discharges into a common plenum. The plenum in turn discharges into the SWS through two openings in the port flotation cell. Flow through either port or starboard fish attraction channel is capable of being closed off utilizing the intake weir at the entrance.
4) Fish Handling Facilities (FHF): A FHF area that is 56 feet long by 101.5 feet wide by approximately 14 feet deep, is located at the aft end of the structure and is comprised of a sorting area and a sampling area. The sorting area, located below the main deck level, houses the facilities at the termination of the attraction channels which facilitate the fish being processed and loaded into fish pods for transporting off of the FSS. The sampling area, located above the main deck level, houses facilities for scientifically processing sampled fish collected in the attraction channels.

3.2 Arrangement and Compartmentation

Interior volume below the Main Deck is divided by watertight boundaries into tanks, voids, and man-accessible compartments, as shown in Appendix A (Plates G-010, G-011, G-012, G-013, and M-090).

Compartment boundaries are located in accordance with the following considerations:

1) Alignment with transverse or longitudinal structure,
2) Where appropriate align tank top or tank bottom with decks and/or flats.
3) Reasonably reducing the number of ballast tanks consistent with avoiding extremes of trim and/or heel during ballasting and deballasting. This also reduces the length of ballast piping needed and manifold size.
4) Avoiding large tank surface area, especially with large transverse extent, to reduce free surface moment.
5) Reasonably reducing the total volume of adjacent compartments to limit the amount of flooding water when the common bulkhead is damaged to satisfy damage stability criteria.

To maintain level attitude during fish collection operations water is transferred fore and aft and/or port and starboard among four dedicated Trim Tanks. This weight transfer compensates for trim and/or heel due to external forces arising from wind, wave, or other such action. To maximize compensating trimming and heeling moments these tanks are located, as much as practicable, at the four corners of the FSS.

During fish collection operations the water level in the fish attraction channels and the plenum is drawn down below the reservoir level. The amount of draw down varies with the flow rate in the fish attraction channels. Dedicated variable ballast tanks are provided to adjust for this weight change and maintain a 5-foot freeboard. The variable ballast tanks are located near the longitudinal center of flotation (LCF) to minimize trim.

The Pump Room, Stair Tower access to the Pump Room, and Fish Handling Facility are the only man-accessible compartments on the FSS. The Pump Room and Stair Tower are located in the center flotation cell forward to provide sufficient space and height to accommodate ballast pumps. trim pumps, and associated piping. By necessity the Fish Handling Facility is located aft at the end of the fish attraction channels.

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 “Fish Collection Systems,” is used for items associated with fish capture, sorting, sampling, 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% builder's 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, water in variable ballast 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 weight estimate summary at the 1-digit SWBS level is shown in Table 3-2. The complete weight estimate is Appendix C.

2.5% of hull structure weight is included in Group 100 for the weight of welding and mil scale.

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	6,789,010	7,143,869	11.72	130.39	2.55
200	Propulsion Plant	0	0			
300	Electrical Plant	221,451	251,398	40.91	147.97	19.75
400	Command and Control	500	560	40.00	118.00	0.00
500	Auxiliary Systems	607,054	649,981	13.93	147.10	1.28
600	Outfit and Furnishings	8,800	9,856	43.00	168.00	0.00
700	Fish Collection System	2,628,505	2,909,932	28.23	142.85	-1.76
	Subtotal	10,255,320	10,965,596	16.93	135.12	1.72
	Builder's Margin (2%)	205,106	219,312	16.93	135.12	1.72
	Service Life Margin	0	0			
	Estimated Lightweight	10,460,426	11,184,908	16.93	135.12	1.72

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 as shown on Figure 3-1.

- 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.

Note:

1) FSS belly tank and port, centerline, and starboard flotation cell structure extends 16 feet forward of the coordinate system's origin. Structure, outfit, and furnishings in the forward extension have negative longitudinal coordinates.
2) Structure, outfit, and furnishings in the belly tanks have negative vertical coordinates.

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

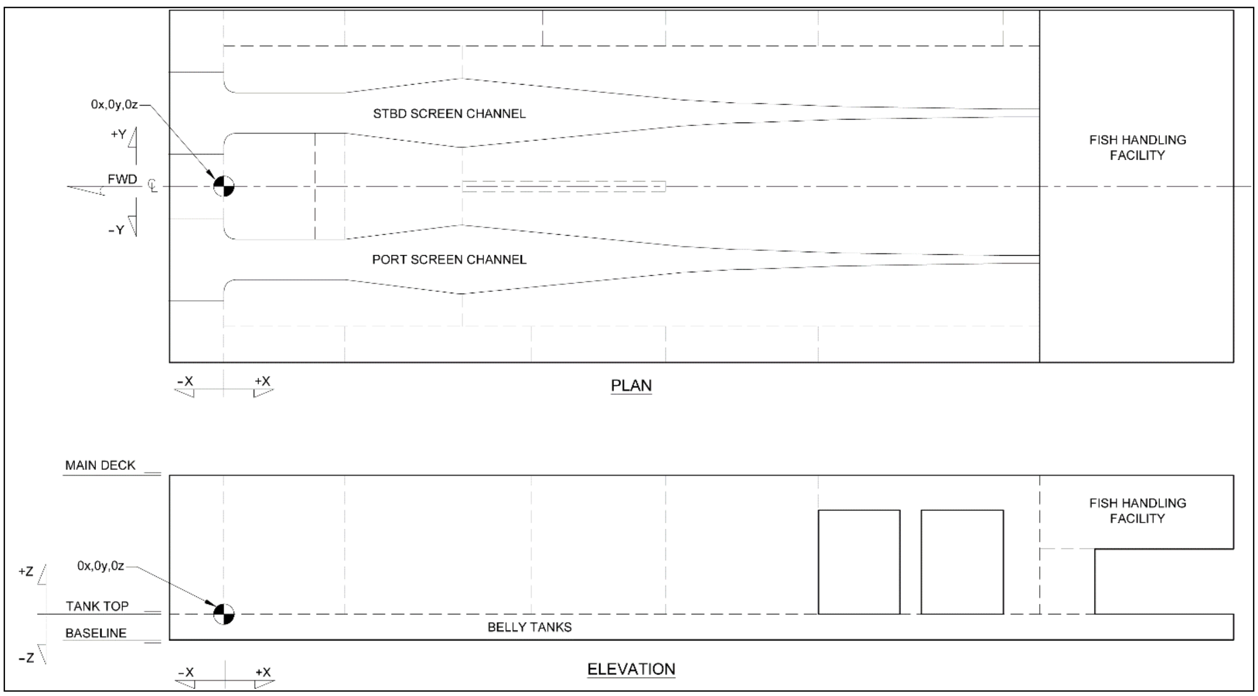

Figure 3-1 FSS-Coordinate System

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

GHS calculates the static equilibrium 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 of the main deck.

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 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 feet for DISPL > 22,400 kips and <= 112,000 kips

GMr = 3.28 feet for DISPL > 112,000 kips

In addition, since load handling equipment (LHE) are installed on board the FSS, stability during lifting operations will be evaluated. A recognized authority, such as EM-385-1-1, Section L, is used as the criteria against which lifting stability is assessed.

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.

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 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.

3.6 Loading Conditions

3.6.1 Maintenance (Lightweight) Condition

All structure, outfit, and furnishings of the FSS is complete. Belly, ballast, trim, and variable ballast tanks are empty. Operating liquids are in pumps and piping systems, but all fish collection and sampling equipment in the Fish Handling Facility are empty. This can be considered as the FSS's empty weight.

Since the top of the belly tanks is above water in this condition, maintenance can be performed in the dry on those portions of the FSS that are submerged during normal operations

Design calculations result in maintenance (lightweight) condition trim of 0.122 degrees forward and heel of 0.771 degrees starboard. Permanent, fixed ballast, such as concrete blocks or pea gravel, can be installed to achieve zero trim and zero heel. Such fixed ballast installation will have to be done after construction when the as-built maintenance condition trim and heel is known.

3.6.2 Operating Condition

Maintenance (Lightweight) condition plus belly, ballast, trim, and variable ballast tanks filled so that the FSS is level with zero trim, zero heel, and a freeboard of 5 feet (35-foot draft above the top of the belly tanks). The total weight of variable ballast tank water will change depending on the peaking demand attraction flow rate. The total weight of trim tank water is constant, but its distribution among the tanks will change depending on the peaking demand attraction flow rate. The effect of the weight of water surface drawdown below the reservoir level, which depends on the peaking demand attraction flow rate, is included.

3.6.3 Off-Peak Condition

As described in Section 2.3.1, during periods when demand is low the Detroit Dam powerhouse is generally not operating. During this “off-peak” period there is no attraction flow through the FSS and “lost” drawdown weight is regained increasing displacement (decreasing freeboard). Trim tank and variable ballast tank loading will be returned to levels associated with 3500 cfs attraction flow rate.

In the future a 1,000 cfs attraction flow rate (through either the port or starboard fish channel), provided by installing attraction pumps at the aft end of the plenum, may be necessary to capture fish during off-peak periods. In this case the off-peak condition will feature a 1,000 cfs attraction flow rate with trim and variable ballast tanks remaining loaded for a 3,500 cfs attraction flow rate. Loading condition characteristics are shown in Table 3-3. Operating condition characteristics are the same for all attraction flow rates from 1,000 cfs to 5,600 cfs.

Table 3-3 - Loading Condition Characteristics

Condition	Displ	Freeboard to Top of Belly Tanks (feet)				Trim	Heel
	[kips]	Fwd Port	Fwd Stbd	Aft Port	Aft Stbd	[deg]	[deg]
Maintenance	11,186.75	2.62	1.26	3.28	1.91	-0.122	0.771
		Freeboard to Main Deck (feet)					
Operating	42,882.35	5.00	5.00	5.00	5.00	0.000	0.005
Off-Peak (0 cfs)	44,257.28	3.48	3.51	3.59	3.61	-0.020	-0.014
Off-Peak (1000S cfs)	42,882.25	5.01	5.01	4.99	4.99	0.003	0.000
Off-Peak (1000P cfs)	42,882.09	5.01	5.01	5.00	5.00	0.002	0.000

3.7 Operating Considerations

3.7.1 Ballasting/Deballasting

Transitioning from the maintenance condition to the off-peak condition is achieved by filling belly, ballast, trim and variable ballast tanks with ballast water as needed. Individual belly and ballast tanks are filled to 100% or slack by design calculation to result in a prescribed aggregate weight and center of gravity. Trim tanks are filled so the aggregate weight is 50% of their total weight and distributed as needed for a 3,500 cfs attraction flow rate. Variable ballast tanks are filled as needed for a 3,500 cfs attraction flow rate.

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 off-peak condition. Metacentric height (GM) must be greater than the required metacentric height (GMr) throughout the ballasting sequence to satisfy the intact stability criteria.

To keep the vertical center of gravity (VCG) as low as possible, thus keeping metacentric height (GM) as large as possible, transitioning from the maintenance condition to the off-peak condition proceeds generally as follows.

- Belly tanks are filled first. Several belly tanks at a time will be cross connected together and opened to the reservoir so that they can be filled by gravity. Once filled, fill valves are closed isolating these tanks. When filled to their prescribed level cross connections will be closed.
- Ballast tanks in the flotation cells are filled after all belly tanks are filled to their prescribed level. Gravity fill of ballast tanks in the flotation cells will proceed until the difference between reservoir level and tank level is reduced sufficiently to make pumping appropriate.
- Trim tanks and variable ballast tanks are filled after all belly tanks and ballast tanks are filled to their prescribed levels.
- Operating liquids are added to fish handling equipment, fish sorting equipment, holding tanks, and transfer tanks.

Transitioning from the off-peak condition to the maintenance condition empties tanks generally in the reverse order from the ballasting sequence. When emptying tanks, the ballast pump takes suction only from a designated belly tank that acts as a “drain well.” This tank will be the first tank emptied in the deballasting sequence.

The deballasting sequence assumes operating liquids in the Fish Handling Facility are removed prior to emptying tanks.

The maintenance (lightweight) condition exhibits both trim and heel. Trim and/or heel can be eliminated by installing compensating permanent, fixed ballast such as concrete blocks or contained pea gravel. Permanent, fixed ballast will increase lightweight displacement and decrease maintenance condition freeboard. For example, heel compensation requires approximately 490 kips (approximately 4,900 cf pea gravel) of permanent, fixed ballast located 45.75 feet off centerline to port, which reduces freeboard by 3 inches.

3.7.2 Effect of Attraction Flow Rate

At all flow rates from a minimum 1,000 cfs to the design maximum 4,500 cfs the fish attraction channel hydraulics are designed to capture fish with the FSS level with zero trim, zero heel, and a freeboard of 5 feet (35-foot draft above the top of the belly tanks). For 1,000 cfs flow one attraction channel (either port or starboard) will be closed by operation of the intake weir so that all flow is directed through one attraction channel.

In the operating condition water surface level in the fish channel(s) and plenum will be below the level of the surrounding reservoir due to attraction flow. The amount of this drawdown is different in each section of a fish channel and in the plenum and depends in the flow rate. Higher flow rate results in larger drawdown. Drawdown height at selected flow rates in each section of the fish channels and the plenum is determined as part of hydraulic design. Volume and center of gravity "lost" from the surrounding reservoir level at selected flow rates is calculated from drawdown heights and fish channel and plenum geometry. These calculations are Appendix C and summarized in Table 3-4.

Table 3-4 – Lost Volume and Fresh Water Weight Due to Drawdown

Flow Rate [cfs]	Volume [feet^3]	Weight [kips]	VCG [feet]	LCG [feet]	TCG [feet]
1000S	17765.81	1108.59	34.41	139.48	-0.22
1000P	17765.81	1108.59	34.41	139.48	0.22
2750	19719.23	1230.48	34.34	140.16	-0.28
4500	26468.06	1651.61	34.09	145.17	-0.25
5600	33009.79	2059.81	33.83	147.91	-0.20

3,500 cfs flow rate values calculated by cubic interpolation

This drawdown effectively acts as removing weight from the FSS that changes its draft, trim, and heel. Consequently, compensating weight must be added to offset the weight of drawdown water. Additionally, the center of gravity of the compensating weight must be located to counter drawdown weight induced trim and heel. Tank loading to compensate for drawdown lost weight are determined in accordance with the following.

- Compensating weight is added by filling variable ballast tanks VB-59-1 and VB-59-2.
- Variable ballast tanks VB-59-1 and VB-59-2 are loaded asymmetrically to counter drawdown weight heel.
- Liquid is transferred between forward trim tanks (TT-H-1 and TT-H-2) and aft trim tanks (TT-118-1 and TT-118-2) to counter drawdown weight trim. The total amount of liquid in trim tanks is unchanged.
- Trim tank liquid is transferred symmetrically port and starboard so that no change in heel is induced.

During peaking demand periods, the FSS must be in the operating condition for the known required attraction flow rate. Transitioning from the off-peak condition to the operating condition must occur in no more than 15 minutes. 3,500 cfs compensating weight is selected for the off-peak condition to reduce the amount of weight (hence volume of water) to be added or removed for other flow rates. Thus, variable ballast water must be removed for flow rates less than 3,500 cfs. Variable ballast water must be added for flow rates greater than 3,500 cfs. Calculated change in trim and variable ballast tank loading for various attraction flow rates is shown in Table 3-5.

Table 3-5 – Flow Rate Tank Loading Change

Flow Rate	Trim Tanks [gal]				Var Blst Tk [gal]	
[kips]	Fwd Port	Fwd Stbd	Aft Port	Aft Stbd	[deg]	[deg]
1000S	407	407	-407	-407	-15,949	-16,026
1000P	407	407	-407	-407	-15,290	-16,685
2750	407	407	-406	-406	-8,778	-8,610
3500	0	0	0	0	0	0
4500	-854	-854	856	856	16,366	16,712
5600	-2,198	-2,198	2,199	2,199	40,826	41,170

3.7.3 Fish Handling Facility Flooding

The Fish Handling Facility is the largest potentially floodable space on board. Initial flooding calculation using the standard permeability of 0.98 showed the FSS cannot survive FHF flooding. In order to survive FHF, flooding the amount of flooding water must be reduced by, effectively, decreasing the volume of the space without affecting fish collection and handling. The arrangement of this equipment must remain unchanged.

Flooding calculations with varying permeabilities determined that if the permeability were 0.53 the FSS would survive FHF flooding with the main deck 3.0 inches above the flooded static equilibrium. The permeability of the space, however, cannot be this low without providing an enclosed volume (i.e. a void or “air tank”) that does not interfere with fish collection and handling equipment and needed manned access. Total required air tank volume is 21,030 cubic feet. FHF flooding analysis calculations are Appendix C.

Air tank volume does not have to be just one piece. Areas that might be used for air tank volume are below the flumes at the stern, enclosing the space under the stairs, and raising the floor locally to the grating level (instead of installing the grating on columns).

Required air tank volume can be reduced if a detailed permeability calculation that includes all non-flooding volume in the space such as flume structure, tank structure, fish pod structure, operating liquid flumes, tanks, debris collectors, and the like results in values less than 0.98.

Increasing the freeboard, either locally in way of the FHF or for the entire FSS, will provided increase reserve buoyancy, which reduces the effect of FHF flooding water.

3.8 Auxiliary Floating Structures

Three auxiliary floating structures will be constructed, as identified below, to allow the FSS to perform its full range of operational duties. Each is an all-welded steel structure of sufficient strength to withstand hydrostatic loads, uniform deck loads, and loads imposed by deck fittings, attachment to the FSS, and local loads from their function.

3.8.1 Debris Staging Float

Located on the forward port side of the FSS this float provides a proper receptacle for transferring trash and debris collected by the installed trash rack cleaner. Into on board dumpsters. The location of the float allows the cantilever extension on the trash rake to orientate itself directly above the dumpsters for debris transfer. Upon the filling of the dumpsters, trash and debris will be transferred and disposed of at the proper shoreside facilities.

3.8.2 Access Float

Located near midship on the port side of the FSS this float is designed for the loading and unloading of the amphibious vehicles, as well as a mooring location for any additional small boats used for FSS operations. This float will act as a docking station for the transfer of personnel to and from the FSS as well as the transfer of the fish pods from the FSS to their respected amphibious vehicles when transporting fish downstream. The loading float will also be the location for the portable toilet staging, along with the transfer of sewage to shore facilities. This float will be sufficiently sized to ease in the safe transfer of personnel and equipment.

3.8.3 Auxiliary Access Float

Located between the Access Float and the SWS stairwell this float is to aid in the ease of accessing the stairwell between the loading float and the SWS. It is intended for personnel transfer between shore-based facilities and the FSS using the previously defined Access Float, however during an emergency or equipment failure the need for a path of manual egress is required. This float will act as a transition platform to safely reach the emergency vertical ladder and/or the stairwell in the case of required evacuation.

Currently at this stage of the FSS development, detailed design and orientation of these floats have not been conducted or decided on. Further development of the FSS design will produce the design requirements needed to construct for these floats

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 to one of the upper regulating outlets 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 transported 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, once available, to identify positive and negative hydraulic characteristics.
- The FSS entrance weirs should operate as submerged weirs over the full range of FSS operating flows (1,000 cfs to 5,600 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.

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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 FSS 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 be controlled by operation of the SWS (as described below in Section 4.4). Passage of flow from the FSS to the SWS will occur through the High Intake Weirs (HIW) in the west wall of the SWS, each 20 feet wide. Flow through the SWS slots will pass over the multi-leaf HIW gates designed to accommodate reservoir level variations from the minimum to maximum reservoir elevations (1425.0 to 1574.0). The FSS is being designed to seal against the SWS and the upper leaf of the HIW gates, providing an essentially leak-free passage of flow between the two structures.

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 SWS Low Intake Gates (LIG) 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 is working closely with the USACE to ensure that adequate strength is designed into the FSS screen channels to match the safety features incorporated into the SWS.

4.4 Operations

The Detroit Powerhouse is operated as a peaking project, with the project turbines 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 HIW and lower LIG intakes to the SWS tower will be essentially controlled by the openings of the LIG intakes, with greater or lesser amounts of deep cold-water flow required based on temperature gage readings of the overall powerhouse discharge. The remainder of the SWS flow passes through the FSS and over the upper HIW gates in the upper slots. Ultimately, if only colder flow through the LIG intakes is desired, the upper HIW gates can be fully raised to above the reservoir level closing off the surface flow component, redirecting all of the SWS inflow to the lower LIG intakes, and shutting off flow to the FSS.

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/or 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. If this operational scenario occurred in the future, it may be necessary to close off the HIW intakes in the SWS to prevent the possibility of flow passing from the SWS back into the FSS and getting pumped back into the forebay. If the turbines are off, this could be accomplished by simply closing the LIG intakes in the SWS. However, if the turbines are operating, but only deep cold water is required, the upper HIW gates would need to be fully closed (raised to above the reservoir level) to hydraulically isolate the SWS from the FSS before starting the pumps.

4.5 Hydraulic Modeling

Computational fluid dynamic (CFD) modeling was performed to assist in the design of the FSS. The CFD modeling software used for this study was Star-CCM+ by Siemens. Two versions of the CFD model were created to separately investigate far-field and near-field flow phenomena. The models use a single domain, but the computational cell size and locations of grid refinement are different, based on the hydraulic phenomena being investigated. The far-field model focuses on large scale flow patterns in the reservoir and the near-field model focuses on flow patterns near the dam and immediate forebay around the FSS. The model outputs include three-dimensional velocity magnitudes, local pressures, and streamlines (as appropriate) to estimate the anticipated hydraulic conditions and support predictions of relative biological performance.

The model domain, shown in Figure 4-1 includes the full length of the dam and approximately 4,200 ft of the reservoir (spanning shoreline to shoreline) upstream of the dam face.

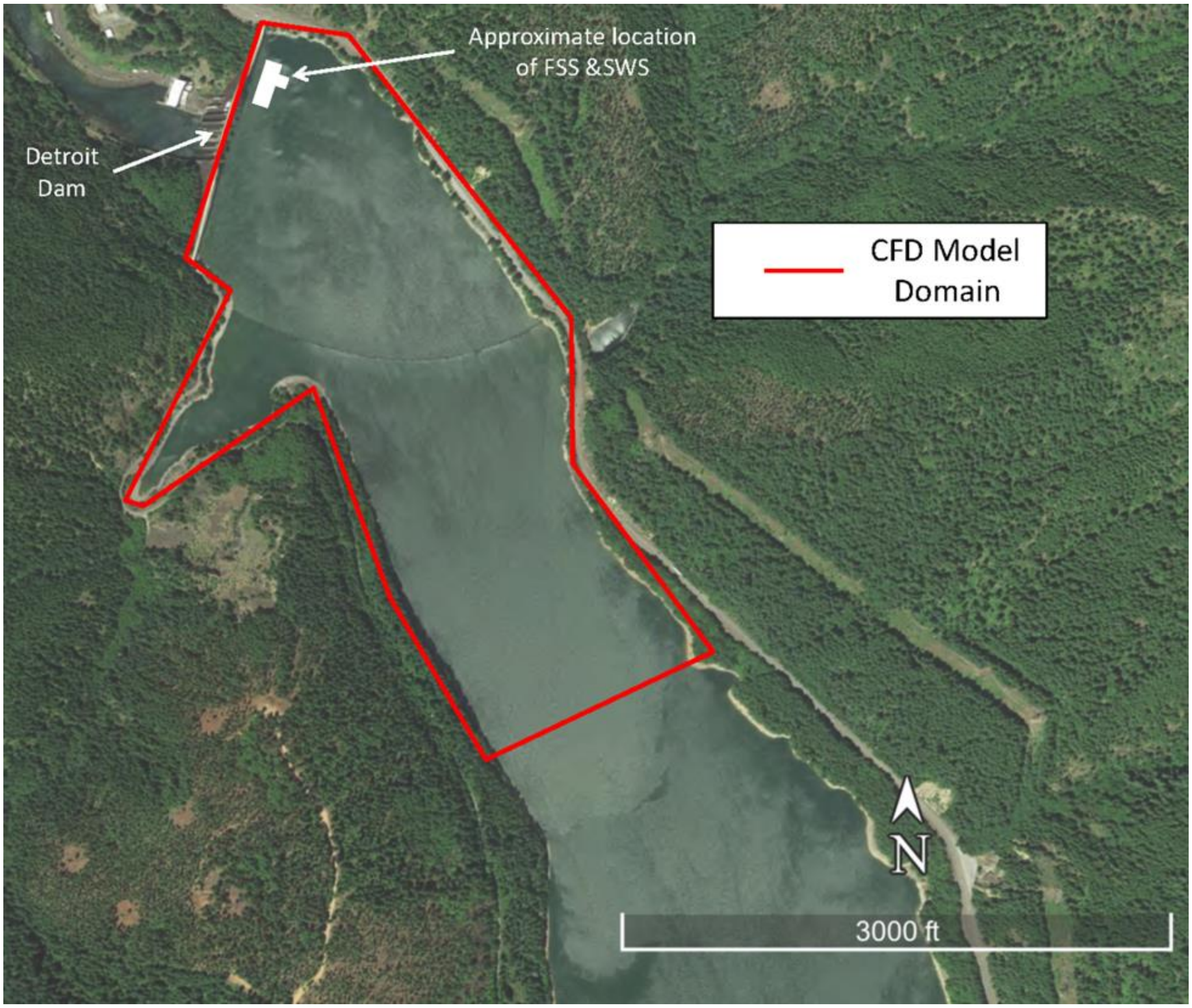

Figure 4-1 – Approximate Outline of CFD Model Domain

Several simplifications were made to reduce the computational demand of the modeling:

- All modeling was performed assuming a rigid lid. As such, no drawdown associated with flow over the spillway or into the FSS was captured, aside from a simple modification to account for the local drawdown and associated velocity increase as flow passes over the spillway crest (far-field model run only).
- Temperature and any temperature variability (density variability) in the forebay was not modeled.
- All runs were performed in a steady state configuration. No transient phenomena were captured or investigated.
- Only the hydraulic conditions exterior to the FSS and SWS were modeled. Flow through the FSS and into the SWS was not simulated.

It needs to be emphasized that the modeling does not include the effects of density stratification due to temperature, and the presence of a thermocline may significantly change the results because it will separate and constrain the flow field features both above and below the thermocline. A future phase of modeling will include the thermocline.

The hydraulic modeling is described in detail in a standalone CFD modeling report (Appendix D). The following sub-sections provide an overview of the model set-up and primary findings. 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.

In addition to the modeling described in this section of the report, USACE has performed CFD modeling during prior phases of design (USACE, 2013) and to support the optimization and selection of the FSS Trashrack layout (USACE, 2018).

4.5.1 Far-Field Model

The far-field model was used to investigate the maximum hydraulic loads on the FSS during the spillway design flood. The spillway design flood condition is the critical case for hydrodynamic forces on the FSS and SWS as it employs the highest outflow rates and will result in the highest flow velocities in the vicinity of the structures. The spillway design flood was modeled with the total discharge of 176,000 cfs evenly split across all six bays. For this scenario all flow passing the dam is routed through the spillway; there is no flow into the FSS or SWS.

The far-field model includes the full length of the dam and approximately 4,200 ft of the reservoir (spanning shoreline to shoreline) upstream of the dam face. The far-field model geometry includes the following features: the dam face, all six spillway bays, the penstock intake, the SWS, the FSS, the regulating outlet (RO) and penstock conduits, and the reservoir bathymetry. An overview of the model domain and depiction of the modeled features is shown in Figure 4-2.

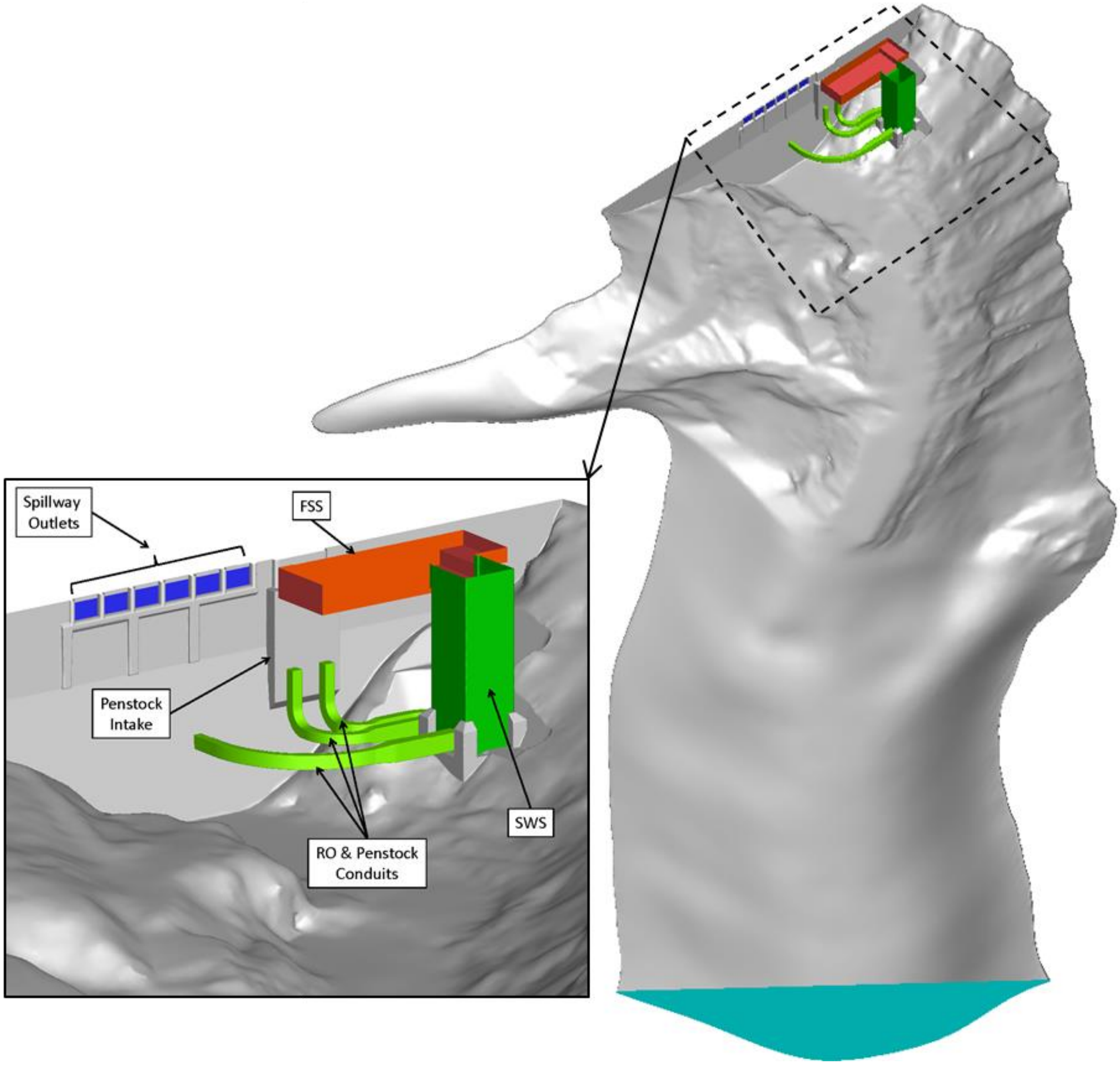

Figure 4-2 - Far-Field Model Domain and Geometric Features

The far-field model was run to evaluate the hydraulic loading on the FSS during the spillway design flood. The FSS would not be operating under these conditions and operating procedures would likely dictate that the FSS be in the maintenance position (6.5 ft draft); however, to capture a worst-case scenario for hydraulic loading the FSS was assumed to be in the operating position (43 ft draft), which would expose the maximum surface area to hydraulic forces.

The maximum modeled velocity adjacent to the FSS is approximately 4 fps and this is limited to a small area near the corner of the FSS that is closest to the spillway. The model results show that the majority of the FSS will be exposed to velocities that are less than 0.5 fps during the spillway design flood. All the dynamic pressures on the FSS are negative due to flow moving past the FSS surfaces, which reduces the dynamic pressure below the reference pressure of 0 psi.

The maximum recorded dynamic pressure recorded was approximately 0 psf and the minimum recorded dynamic pressure recorded was nearly -27 psf. The minimum dynamic pressure occurs near the corner closest to the spillway where the velocities along the FSS surface are the highest. The dynamic pressures were converted to forces and simplified to a series of normal force vectors for use in the mooring design. Details can be found in Appendix D and Section 5.2.4.3. Figure 4-3 and Figure 4-4 show the velocity and dynamic pressure contours acting on and around the FSS.

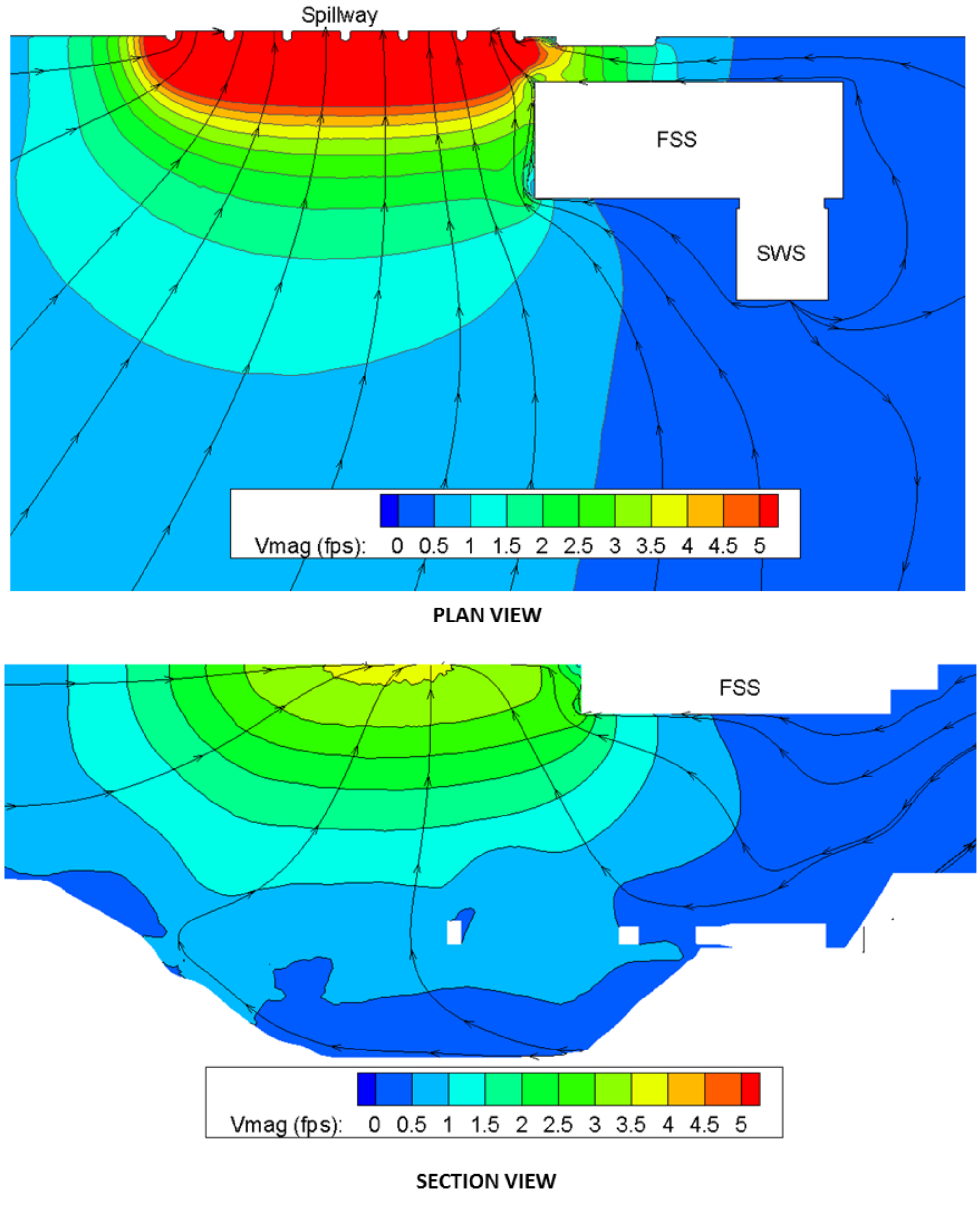

Figure 4-3 - Far-Field Model Velocity Contours at Mid-Depth of FSS (Plan View) and Centerline of FSS (Section View) for the Spillway Design Flood

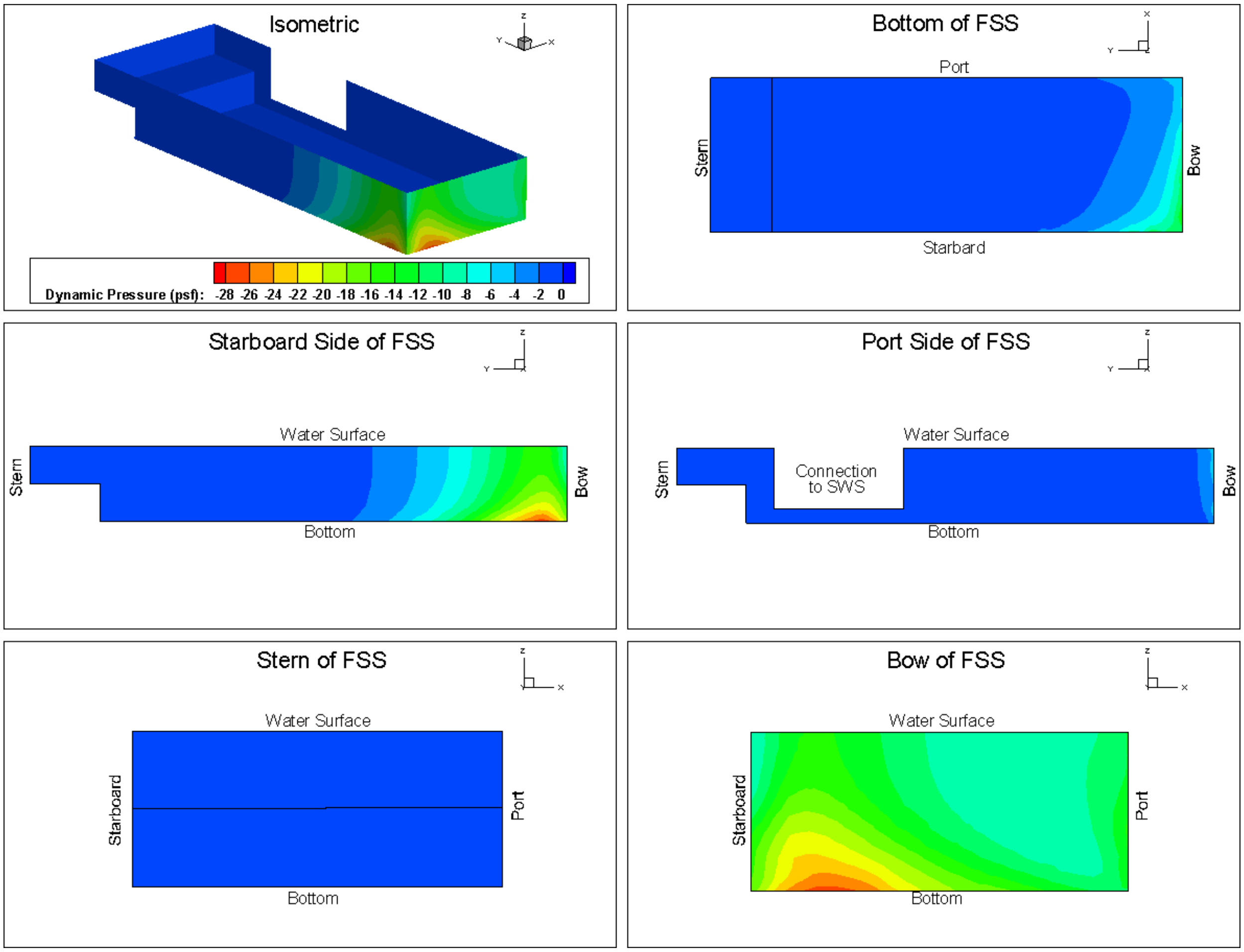

Figure 4-4 - Far-Field Model Dynamic Pressure Contours on the FSS for the Spillway Design Flood

4.5.2 Near Field Model

The near field model was used to investigate flow patterns in the forebay resulting from the FSS intake flow as well as discharge from the FSS pumps during pumped operations. Of particular interest is whether flow patterns that are considered adverse for attracting fish to the FSS would develop.

The near-field model uses the same domain as the far-field model, shown in Figure 4-5**Error! Reference source not found.**; however the model geometry includes several additional features such as:

- the FSS entrances, including the span from the Trashrack to the crest of the weir
- the FSS pump discharge cones
- the FSS mooring piles at the stern, which would be in the direct flow path of the pump discharge
- the low intake hood on the SWS

A depiction of the modeled features is shown in Figure 4-5, with specific emphasis on items that were included only in the near-field model.

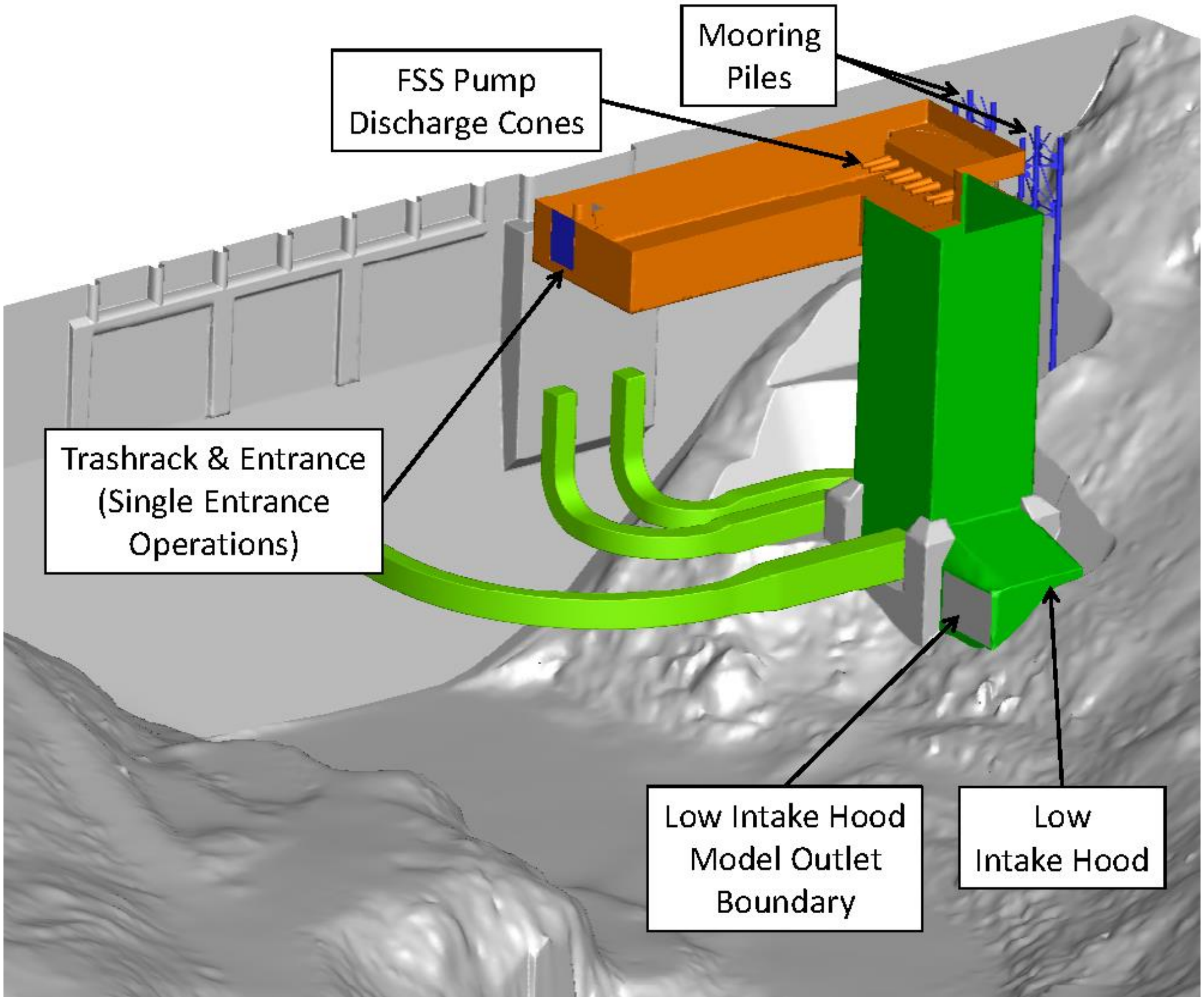

Figure 4-5 - Near-Field Model Geometric Features

Three scenarios (i.e., combinations of flows and reservoir elevations) were simulated to cover a range of anticipated FSS operating conditions in which the FSS operates under gravity flow, and two scenarios were simulated to document the potential hydraulic effect of releasing 1,000 cfs of pumped flow discharge into the reservoir. In addition, several design development runs were completed to support the selection of an initial diffusion strategy to be used in the model. Table 4-1 shows the modeled scenarios.

Table 4-1 - Near-Field Model Runs

Run	Forebay WSE (ft)	Flow (cfs)					Weir Submergence (ft)	
		Spillway	FSS	Pump Outlet	Fish Handling Facility*	Low Intake	Single FSS Weir	Dual FSS Weirs
2	1540	0	4,500	0	0	0	NA	22.1
3	1450.0	0	1,000	0	0	3,500	10.8	NA
4	1510.0	0	2,000	0	0	2,500	19.9	NA
5	1563.5	0	1,000	1,000	0	0	10.8	NA
6	1450.0	0	1,000	1,000	0	4,500	10.8	NA

*All fish handling facility flow assumed to be returned to FSS plenum and not returned to the forebay.

4.5.2.1 Gravity Flow (Non-Pumped) Runs

The results for the non-pumped flow scenarios indicate that the FSS would have a zone of influence that extends 75 ft to 170 ft in front of the FSS entrance, 50 ft to 135 ft to either side of the FSS entrance, and to a depth of 80 ft to 140 ft below the water surface for the modeled combinations of flow and reservoir level. The zone of influence was defined by the area in which the velocity exceeds 0.05 ft/s. The largest zone of influence occurred for Run 2, which represents a two-unit power peaking operation in mid-spring with all flow taken from the surface (FSS) to meet temperature control targets. The smallest zone of influence occurred for Run 3, which is intended to represent a condition in which the temperature control targets require approximately 78% cold water from the low intake and the rest as surface flow drawn through the FSS. In addition, for this scenario flow withdrawal from the SWW low intake produced velocities greater than 0.05 ft/s at mid-depth of the FSS, i.e., there is the potential for false attraction to the zone of influence from the low intake flow field. Figure 4-6 shows thumbnail views of the velocity vectors for these three cases. Additional detail is available in Appendix D.

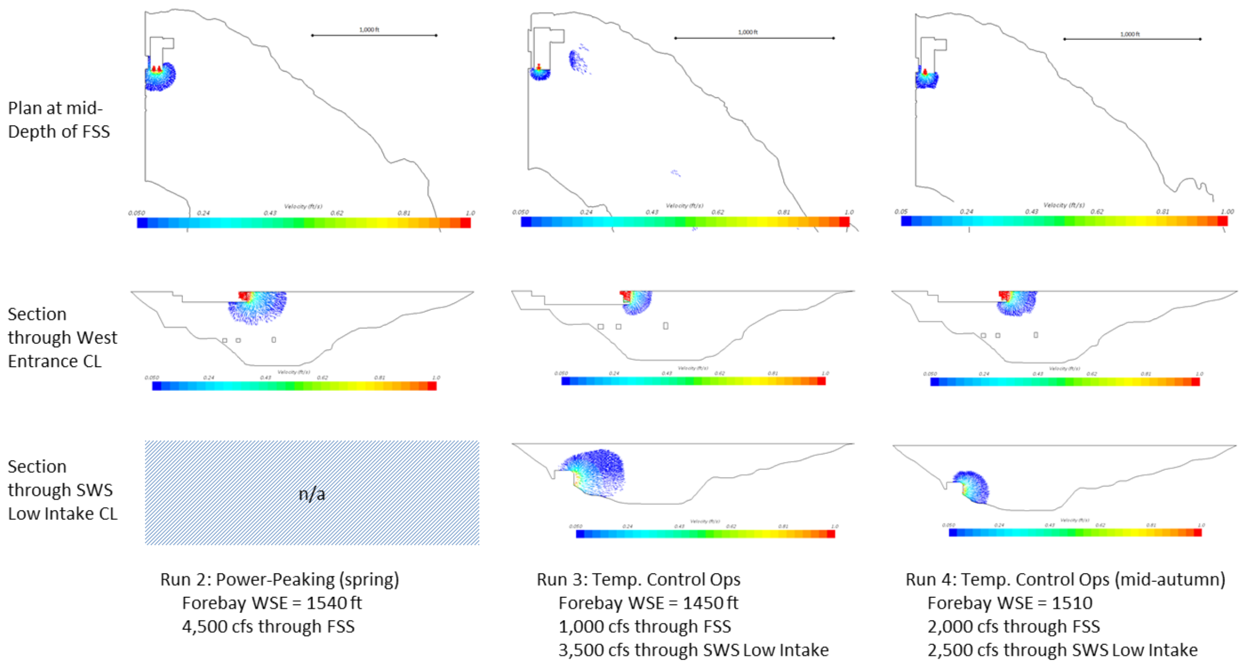

Figure 4-6 - Gravity Flow (Non-Pumped) Near-Field Model Results Overview

4.5.2.2 Pumped Flow Runs

The FSS is designed to integrate provisions for the future installation of attraction pumps, should USACE determine that they are needed. An initial run with undiffused pump discharge released into the forebay from the stern of the FSS showed that a jet, traveling upstream and away from the dam and FSS, would form along the north shoreline. This flow pattern would likely be detrimental to fish collection; therefore, diffusion concepts were pursued.

The modeling for the pumped flow scenarios was conducted in two phases: an initial design development phase was used to screen potential diffusion concepts using idealized, uniform velocity boundary conditions at the outlet of the pump diffuser. Based on the results of the design development runs, a concept that aimed to achieve 180 degree uniform dispersion was developed and modeled in detail for the conditions described as Runs 5 and 6. The pump diffusion runs (Runs 5 and 6) show that the resulting flow fields still produce adverse conditions for fish passage; therefore additional refinement and modeling of the diffuser system in future design phases is recommended. The diffuser design and selected results from the CFD model are presented in Section 6.3.5, with additional details provided in Appendix D.

4.6 Floating Screen Structure

Given the wide range of operating flows, with a targeted design flow of 4,500 cfs, a maximum potential flow of 5,600, (see Section 2.3.1) and a potential flow of 1,000 cfs during pumped flow operations (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 design flow each channel is operating at a flow of 2,250 cfs. If implemented in the future, the low-flow pumping operation of 1,000 cfs would result in slightly less than half the design flow rate rather than less than a quarter of the design flow rate if the FSS had been designed with a single channel. Use of one larger channel under this condition might not encourage 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 4-7.

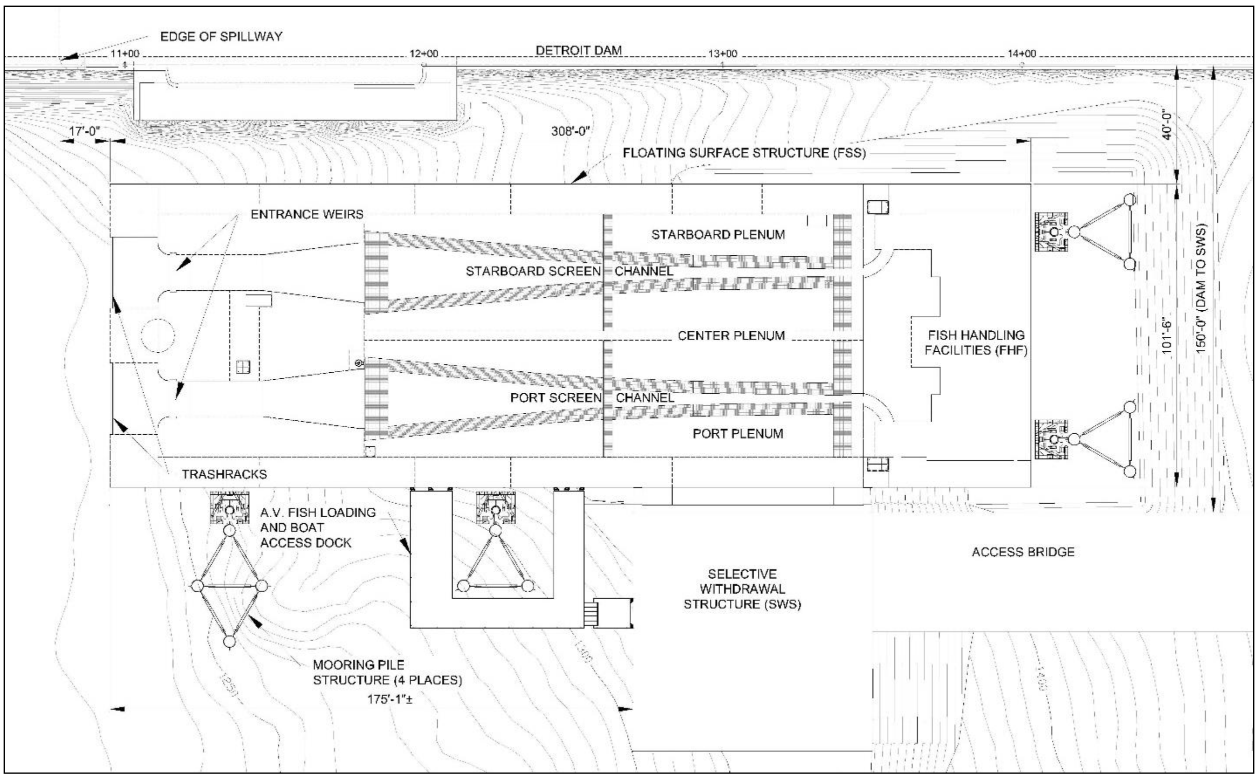

Figure 4-7 – Plan View of the FSS and SWS

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; Trashracks, entrance weirs, expansion channels, screen channels, flow control baffles, screen cleaners, coarse debris racks, and Fish Handling Facilities (FHF).

4.6.1 Trashracks

Trashracks are included in the design to prevent large debris from entering and potentially plugging or damaging the screen channel. The Trashracks are located at the upstream end of the FSS. Each of the two Trashracks is 24 feet wide and 35 feet deep, resulting in an area of 840 square feet, and a combined area of 1,680 square feet for the two racks. This is a large Trashrack requiring a robust cleaning system. A brief description of the proposed raking system is provided below, and mechanical details of the raking system are provided in Section 6. The average velocity approaching the Trashracks will be 2.7 feet per second (fps) at the design flow of 4,500 cfs. At a potential maximum flow rate of 5,600 cfs the average approach velocity to the racks would be 3.3 fps, and with a single channel operating at 1,000 cfs the average approach velocity would be 1.2 fps. Trashracks have been designed with similar velocities with successful results at entrances of other large surface collectors, including the North Fork FSC and the River Mill Surface Collector on the Clackamas River. Downstream of the Trashracks are entrance weirs designed to capture the fish by creating flows over the weirs in excess of 8 fps. This will have some influence on the distribution of flow through the Trashracks; however, the racks have been located 20 feet upstream of the weirs, and CFD model runs performed by the USACE show that the distribution of flow at that distance is fairly well distributed. Therefore, approach velocities to the Trashracks are not expected to exceed 4 fps at any location (see Table 2-1). Figure 4-8 provides results of the USACE CFD model analysis of the Trashrack at a flow of approximately 4,500 cfs with the adjustable weir crest setting 22.1 ft below the reservoir level.

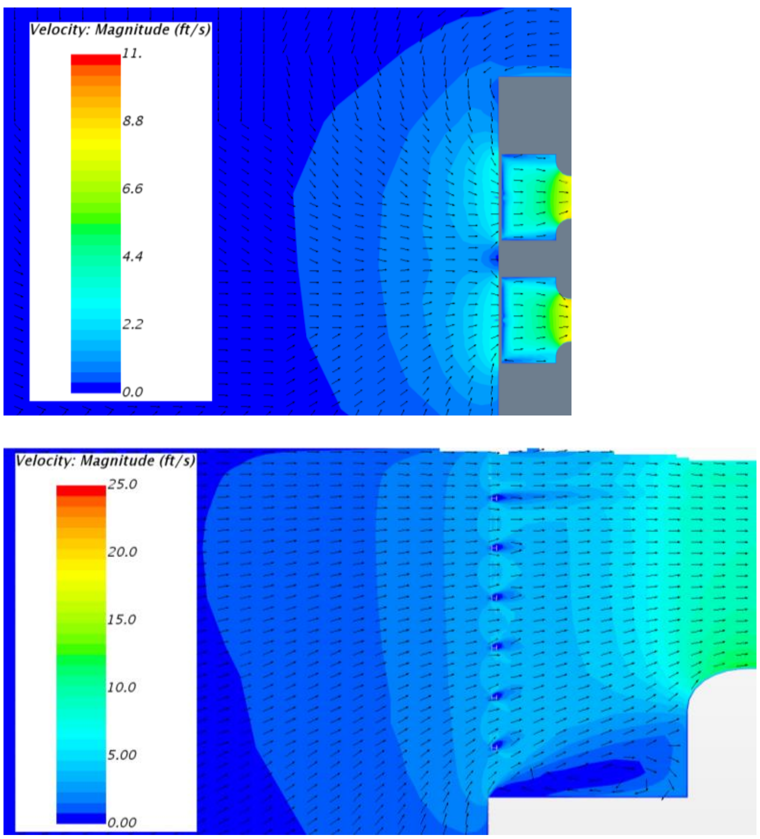

Figure 4-8 - Plan (Top) and Section (Bottom) Results of Trashrack Hydraulics from USACE CFD Model During Design Flow of 4,500 cfs.

The Trashracks will consist of vertical bars spaced to create a clear space between the bars of 8 inches. In the upper three feet of depth there will be two additional bars between the main bars to increase the quantity of floating debris excluded from the channel flow. Assuming ½-inch-thick bars, the two additional bars would create clear spaces of 2.33 inches. This Trashrack design approach was used on the Trashracks at the North Fork FSC and the River Mill Collector with no apparent detrimental impact on fish attraction into the collectors or reported fish injury. In two locations on each rack the additional surface bars will be omitted creating 8-inch-clear openings all the way to the surface to allow free passage of steelhead kelts, which tend to be very surface-oriented swimmers.

The Trashrack will be cleaned with a mechanical trash rake. Trash will be removed and placed in portable containers for removal from the FSS. Trashrack material and strength requirements will mostly be dictated by the requirements and loads placed on the rack by the trash rake as well as a maximum water surface differential of 8 feet. Therefore, it is recommended that, consistent with the description above, the final design of the Trashrack be performed by the fabricator of the trash rake to ensure compatibility of the racks with the requirements of the trash rake. The trash rake considered for this installation is a bracket bosker rake (as manufactured by Ovivo), designed to be lowered to the bottom of the rack, where the rake head is rotated so teeth rotate into the spaces between the bars and the rake is lifted pulling debris impinged on the rack up to the surface. Additional fingers are then rotated from the other side encapsulating the debris so it can be lifted out of the water and placed into a debris container or dumpster. A photo of a Bracket Bosker trash rake system, taken from the Ovivo website, is provided in Figure 4-9. Details concerning the trash rake are included in the Section 6 of this DDR.

Figure 4-9 - Bracket Bosker Automatic Raking Machine (From the ovivowater.com Website)

4.6.2 Entrance Weirs

Downstream of the Trashracks, the channels continue for 16 feet at the full width of 24 feet. The channel then reduces in width to 12 feet, with 4-foot-radius curves on each side. At the downstream ends of these curves there is a 12-foot-wide adjustable entrance weir. 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 (see Table 2-1). The flow remains subcritical over the weir, and although there will be some turbulence associated with this flow condition there will not be any hydraulic jump on the downstream side as the flow velocity reduces.

The entrance weirs consist of a triple-leaf vertical wheeled gate. As the upper leaf is lifted, the bottom of the upper leaf latches onto the top of the second leaf and lifts it. Similarly, the bottom of the second leaf latches onto the top of the third leaf and lifts it. In this way, only the upper leaf needs to be lifted by the operator to lift all leafs. When lowering the weir, the lower leafs are released as they seat in the bottom of their guide. An elliptical crest is included 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 4-10 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-foot-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 (the estimated head required for the design flow of 4,500 cfs); 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 more than 3.9 over much of its operating range. The gate panels are designed for a potential head differential of 8 feet, based on the head-differential safety features incorporated into the SWS tower. Typical operating head differential on the entrance weirs should be limited to approximately 2 feet, and although it is very unlikely that any operating scenario could result in a head differential of 8 feet on the weirs it is considered prudent to design them to support and operate under the same conditions being applied to other FSS features.

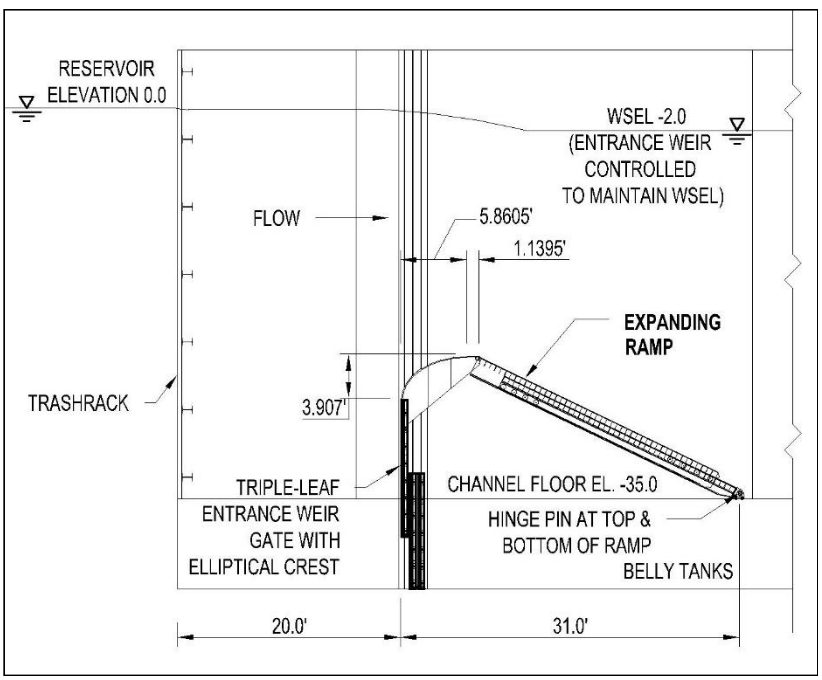

Figure 4-10 – Section View of Entrance Weir with Elliptical Shaped Crest

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 perforated enough to allow ‘leakage’ through the surface to prevent pressure from being applied to the ramp. The perforation holes will be small enough to meet the NMFS criteria for fish screens (see Table 2-1). 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. Although the perforated skin plate should minimize any pressure differences across the ramp structure, the ramp was designed conservatively for a two-foot head differential. This resulted in a heavy stiff structure with a high natural frequency. This was checked against the driving frequency of the high-velocity flow passing over the weir, and the natural frequency of the ramp structure was found to be 1,000 times greater than the driving frequency. Therefore, the ramp should be stable under all flow conditions. However, this should be reanalyzed during final design if any changes are made to reduce the stiffness of the ramp structural framing.

The entrance weir will be designed to automatically adjust vertically to maintain the desired head drop throughout a range of potential flow rates. The optimum head drop across the weir will be determined through experience, but current design estimates and CFD modeling reveals that the differential will likely be approximately 2 feet. Details regarding the weir operator are provided in Section 6. Figure 4-11 shows the approximate settings of the weirs at four significant settings. Settings A and B in Figure 4-11 are the settings of the two weirs during the potential low-flow 1,000-cfs operation 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 1.35 feet below the reservoir level during low-flow operation). Setting C in Figure 4-11 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 in Figure 4-5 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.

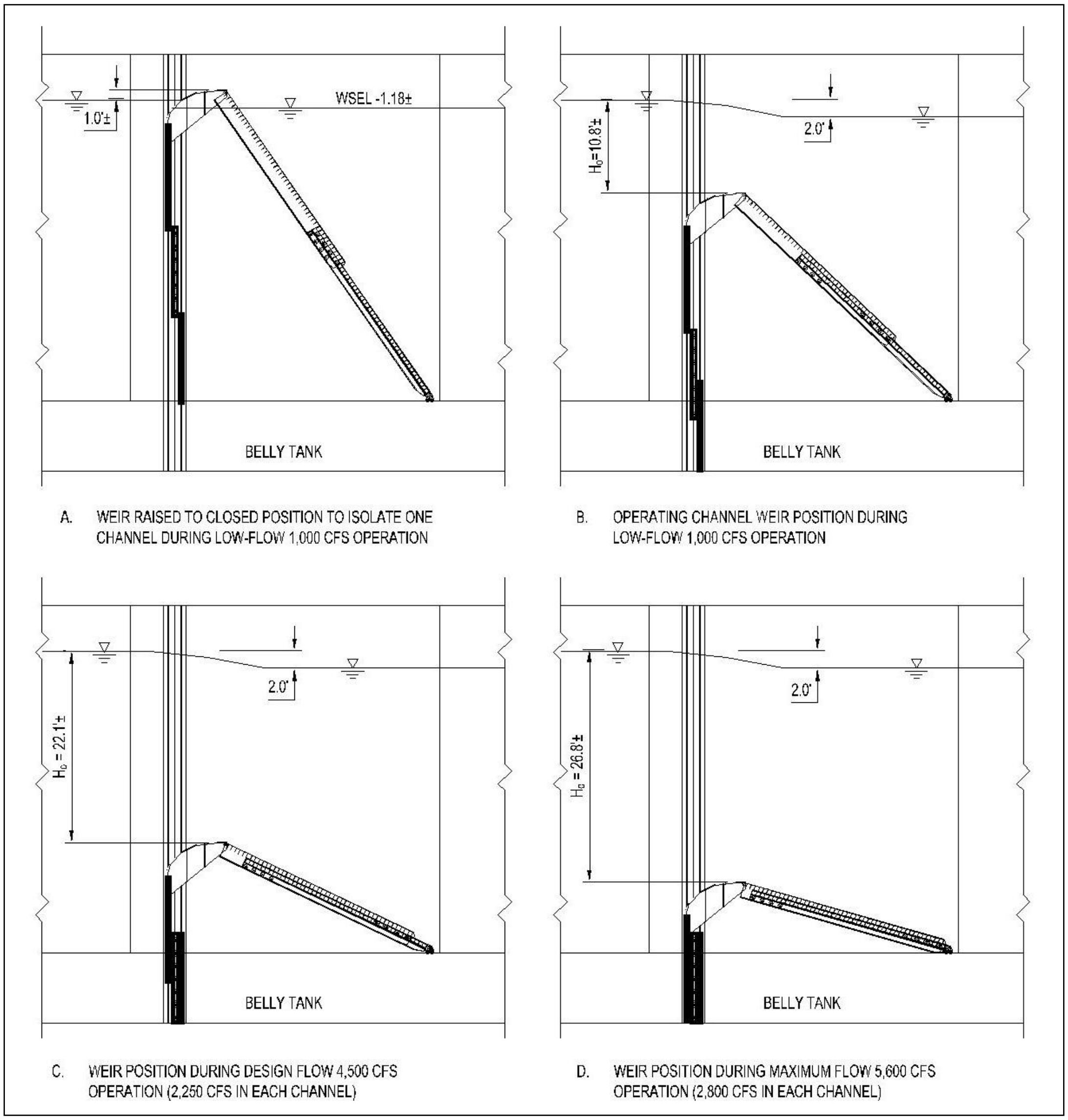

Figure 4-11 – Section Views of Entrance Weirs at Four Entrance Weir Settings

The actual entrance weir setting will be adjusted automatically in real time to meet the target head differential based on water surface measurements and may vary slightly from those estimated here. However, since the flow rate is controlled by the turbines and the setting of the lower LIG intakes in the SWS the entrance weirs do not control the flow rate and the setting only needs to maintain the desired head drop ensuring that the fish collected are captured and committed to the FSS. Table 4-2 provides the estimated entrance weirs settings, in feet below the reservoir level, for a target head drop of 2.0 feet across the weir over a range of potential flow rates.

Table 4-2 - Entrance Weir Settings for a Range of FSS Flow Rates

FSS Flow	Number of Operating Channels	Weir Crest Submergence (ft below reservoir)
5600	2	26.8
5000	2	24.3
4500	2	22.1
4000	2	19.9
3500	2	17.7
3000	2	15.4
2500	2	13.1
2000	1	19.9
1500	1	15.4
1000	1	10.8

To minimize the impact of the panel guides on the flow and fish passing over the weir, the wheel mounting tube located in the guide is a separate structural component from the weir gate panel. The two components are attached to each other with a continuous 5/8-inch-thick plate. This plate is the only portion of the combined weir panel assembly that passes through the wall. Therefore, the slot in the wall is limited to a width of one inch. This arrangement is depicted in Figure 4-12.

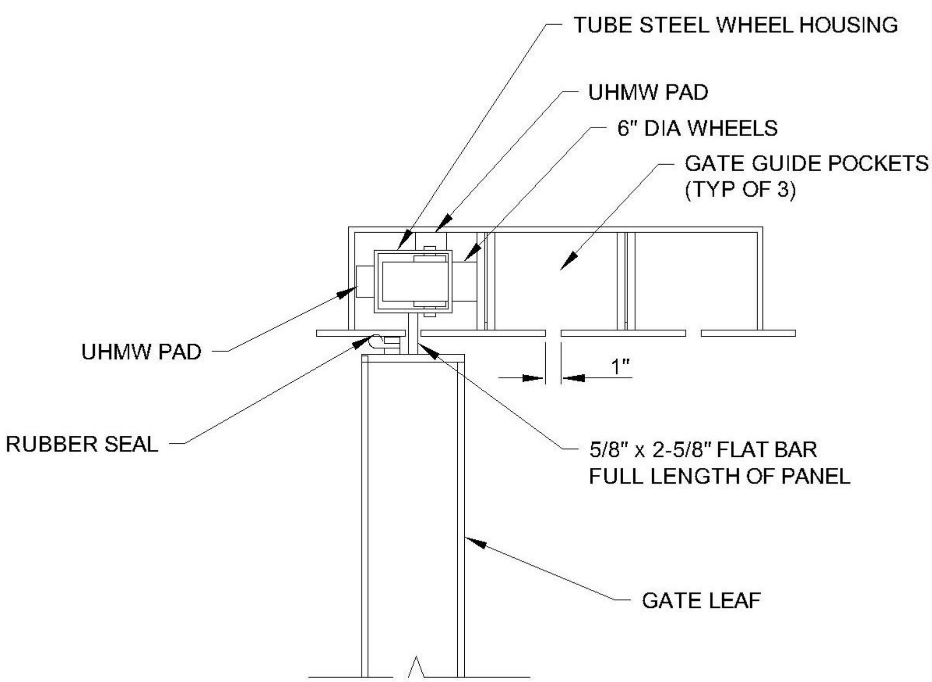

Figure 4-12 – Plan View Detail of Weir Gate Panel Wheel and Guide Configuration

4.6.3 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 into the screen channels. The expansion occurs over a length of 32 feet, resulting in an expansion angle of approximately 7 degrees, which is gentle enough to result in energy recovery as the velocity of the flow decreases. Based on investigations in the USACE hydraulic CFD model of the entrance area the water surface should rise about one foot through the length of the expansion channel. Therefore, the water surface in the channel at the upstream end of the screen channels will be about one foot below the reservoir level.

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. Subsequently, 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 channels were designed using a proprietary R2 screen channel spreadsheet model. This design model was previously used to design the Swift FSC and North Fork FSC screen channels, and in both cases, there were no adjustments required to the control baffles during the in-field screen balancing to meet the NMFS design criteria. The model results provide the following information at each individually-controlled screen panel throughout the channel. Printouts of the model results, along with a description of the calculations performed, are provided in Appendix E.

- Channel Flow at Upstream and Downstream Ends of the Screen Panel
- Channel Velocity at Upstream and Downstream Ends of the Screen Panel
- Water Surfaces in the Channel (incorporating velocity head and energy losses to that point)
- Rate of Channel Velocity Increase (fps/ft analyzed over 6-inch lengths of channel)
- Screen Panel Flow (flow removed from the channel through the screen panel)
- Average Screen Approach Velocity (based on 90% of the total screen area being effective)
- Head Loss Across the Screen (with varying coefficient based on the channel velocity)
- Probable Maximum Point Screen Approach Velocity
- Baffle Porosity Setting
- Headloss Across the Baffle
- Plenum Water Level Behind the Baffle

The screen panels will be stainless steel, vertically oriented profile bar screen material with 1.75 mm clear spaces between the bars. The vertical orientation of the profile bars has been shown to result in less debris getting caught between the bars, and due to the small localized turbulence caused by the bars results in fish tending to avoid getting too close to the screen. 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 4-13. 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. The pocket between the screen panels (shown in Figure 4-13) is provided to facilitate lowering a row of velocity meters into the channel flow during the screen balancing activities. A solid filler plate will be installed to cover the slots between the screen panels for any locations not used during the balancing, and for all slots after conclusion of the balancing activities.

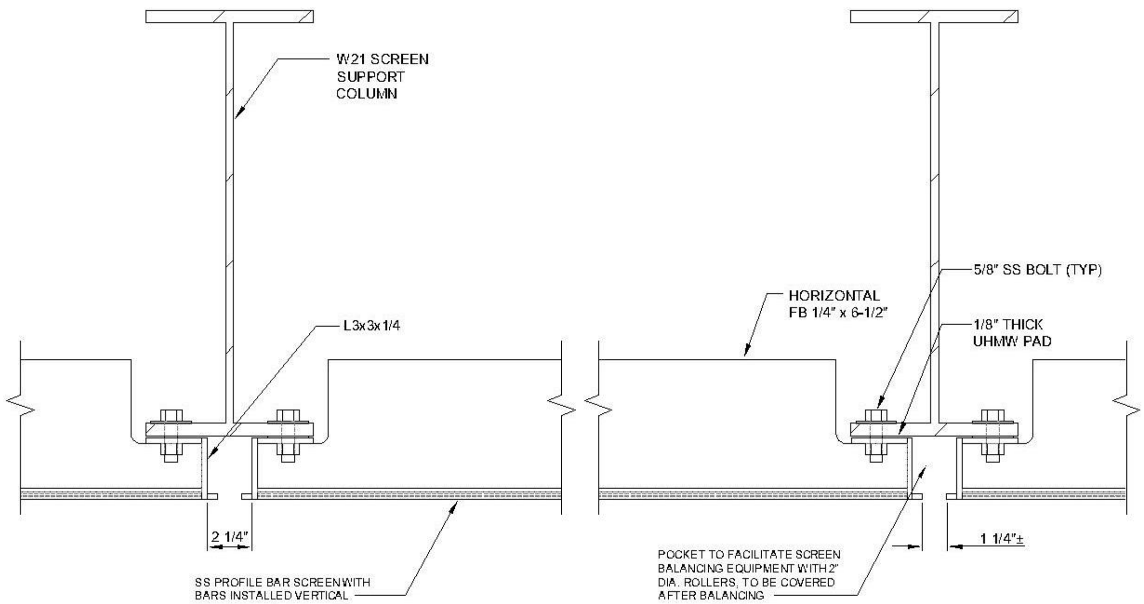

Figure 4-13 - Typical Screen Panel Section View

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 FSS entrance features described above, the flow and fish enter the primary screen channel. The purpose of the primary screen channel is to remove the majority of the incoming flow from the screen channel prior to accelerating the velocity. Plan and profile views of the primary screen channel are shown in Figure 4-14. At the upstream end of the primary screen channel the floor is 35.0 feet below the reservoir level with a depth of approximately 34 feet, and the channel width is 20.0 feet. The average velocity at this location is 3.3 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 4.1 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.

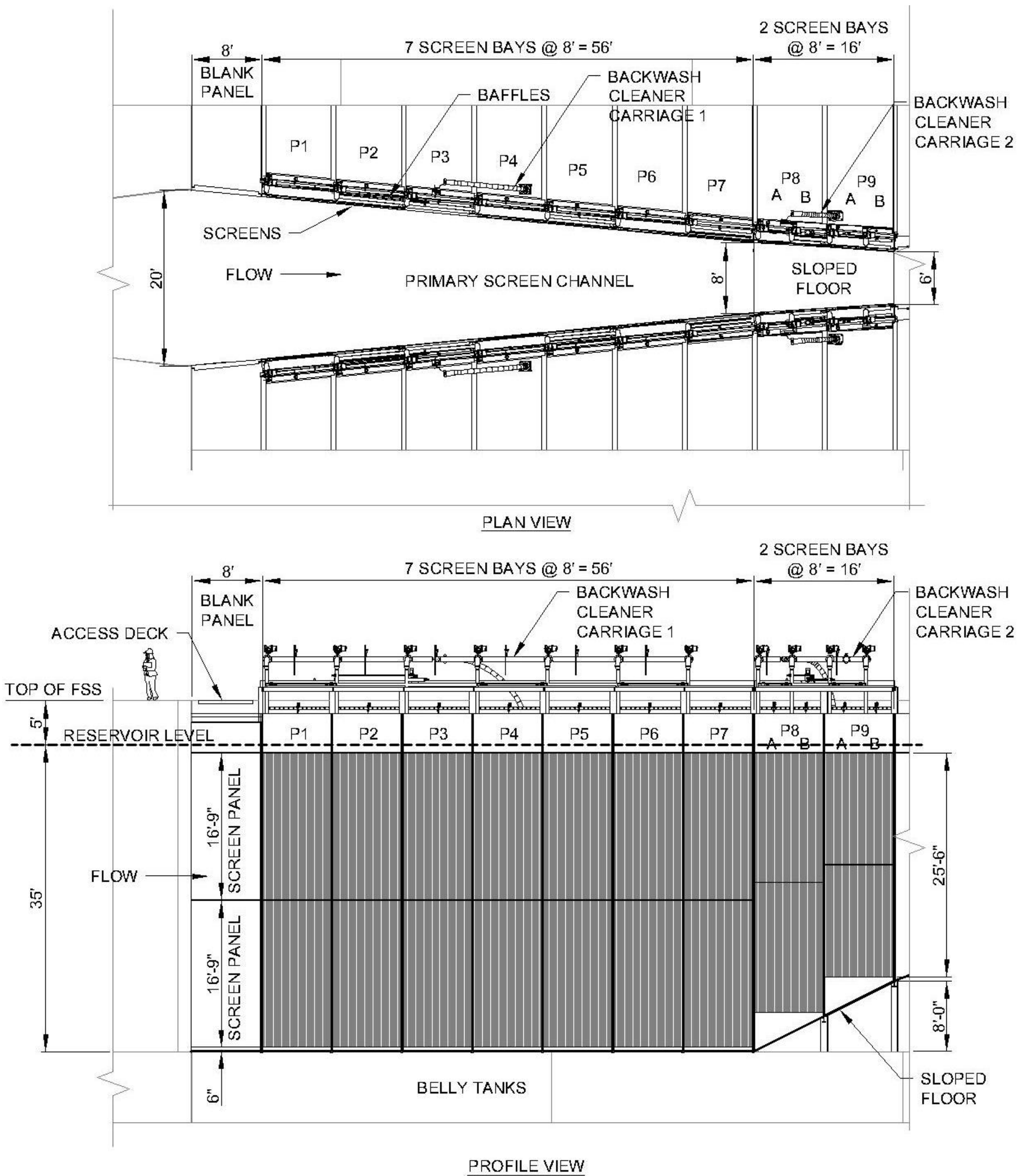

Figure 4-14 - Primary Screen Channel, Plan and Profile (Elevations Relative to Reservoir)

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. The reduced width, associated with constant flow, results in a mild increase in velocity from 3.3 to about 3.6 feet per second through the initial 8-foot channel sections. Over the next 56 feet of screen channel there are seven hydraulically isolated screens on each side of the channel (labeled as Screens P1 through P7). Approximately 1,277 cfs, of the design 2,250 cfs inflow, is removed from the channel through these 14 screens (7 on each side). Through this entire section the velocity remains at approximately 3.6 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%.

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 309 cfs is removed through the screens in this section, resulting in a remaining channel flow of approximately 664 cfs at a velocity of 4.3 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 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. The walls of this channel section are parallel, and there is no contraction of the channel width. However, the floor slopes up 1.25 feet through this section, or 5 inches per foot, resulting in a final average velocity of 4.5 feet per second entering the secondary screen channel.

Table 4-3 provides hydraulic conditions in the primary screen channel for four different operating flow rates. During rare high flow operations (less than 5% of the time) when the design operating flow is exceeded the screen approach velocities remain below 0.5 ft/s).

Table 4-3 – Primary Screen Channel Hydraulics Providing Flows (cfs) and Velocities (ft/s)

Primary Screen Channel Location	Design Flow 4,500 cfs			Maximum Flow 5,600 cfs			Moderate Flow 2,750 cfs			Minimum Flow 1,000 cfs**		
	Channel Flow	Channel Velocity	Screen Approach Velocity*	Channel Flow	Channel Velocity	Screen Approach Velocity*	Channel Flow	Channel Velocity	Screen Approach Velocity*	Channel Flow	Channel Velocity	Screen Approach Velocity*
Channel Start	2250	3.31		2800	4.12		1375	2.02		1000	1.47	
Start of Panel P1	2250	3.58		2800	4.46		1375	2.19		1000	1.59	
End of Panel P1	2068	3.58	0.38	2572	4.46	0.47	1265	2.19	0.23	919	1.59	0.17
End of Panel P2	1885	3.58	0.38	2343	4.45	0.47	1154	2.19	0.23	838	1.59	0.17
End of Panel P3	1703	3.58	0.38	2115	4.45	0.47	1044	2.19	0.23	757	1.59	0.17
End of Panel P4	1520	3.58	0.38	1886	4.44	0.47	933	2.20	0.23	676	1.59	0.17
End of Panel P5	1338	3.58	0.38	1658	4.44	0.47	823	2.20	0.23	595	1.59	0.17
End of Panel P6	1156	3.58	0.38	1430	4.43	0.47	713	2.21	0.23	514	1.59	0.17
End of Panel P7	973	3.58	0.38	1202	4.42	0.47	602	2.21	0.23	433	1.59	0.17
End of Panel P8-A	890	3.71	0.39	1097	4.58	0.49	551	2.30	0.24	397	1.65	0.17
End of Panel P8-B	807	3.85	0.39	993	4.74	0.49	501	2.39	0.24	361	1.72	0.17
End of Panel P9-A	736	4.05	0.39	904	4.99	0.49	457	2.52	0.24	330	1.81	0.17
End of Panel P9-B	664	4.28	0.39	814	5.25	0.49	414	2.66	0.24	299	1.92	0.17
End Blank Channel	664	4.50		814	5.53		414	2.79		299	2.01	

* Screen approach velocities conservatively calculated assuming only 90% of the gross screen area is available.

** Minimum flow of 1,000 cfs uses only one screen channel.

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 4-15. At the upstream end of the secondary screen channel the floor is 25.75 feet below the reservoir level with a depth of approximately 24.6 feet, and the channel width is 6.0 feet. The remaining channel flow at this location is approximately 664 cfs with an average velocity of 4.5 feet per second, at the design flow rate of 2,250 cfs in each channel (4,500 cfs total). At the maximum potential flow rate of 2,800 cfs per channel (5,600 cfs total) the flow at this location would be approximately 814 cfs at a velocity of about 5.5 feet per second, and at the minimum flow of 1,000 cfs in a single channel the flow would be approximately 299 cfs at a velocity of about 2.0 feet per second.

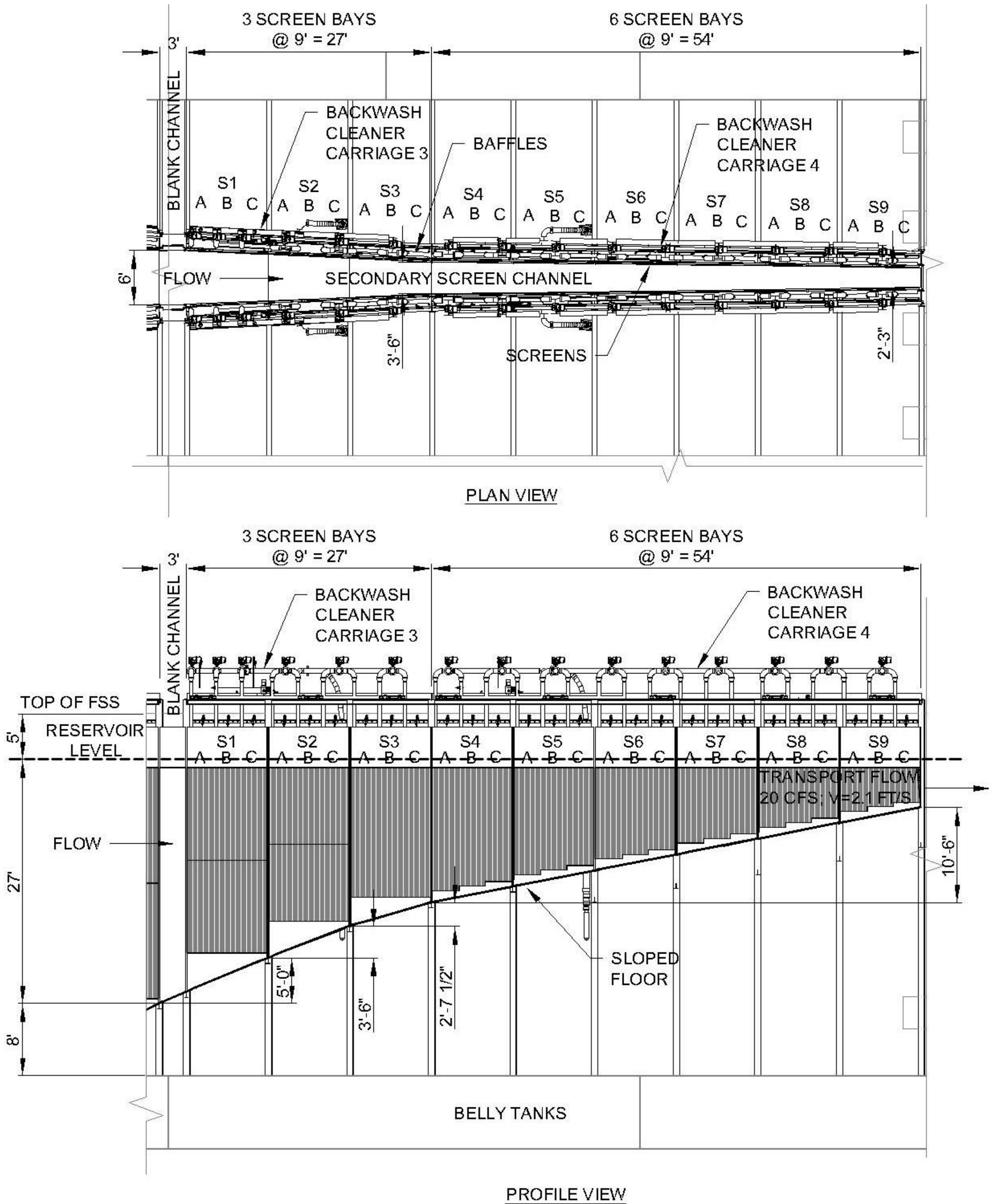

Figure 4-15 - Secondary Screen Channel, Plan and Profile (Elevations Relative to Reservoir)

The initial 27 feet of the secondary screen channel is referred to as the acceleration channel. The purpose of this section is to gradually accelerate the flow velocity to encourage the fish to continue downstream in the channel. Over this length the channel reduces in width from 8.0 feet to 3.50 feet. The channel floor rises in three 9-foot-long slopes, rising 3.75 feet, then 3.50 feet, and finally 2.625 feet over the final 9 feet of acceleration channel length. 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 rising floor. A trapezoidal solid blank panel is located between the channel floor and the bottom of the screen panel to complete the wall. The channel velocity is highest at the end of this acceleration channel, and at the design flow of 4,500 cfs it is approximately 6.9 feet per second, which should prevent fish that pass this point from turning and swimming back upstream. The remaining flow at the end of the acceleration channel is approximately 346 cfs 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 419 cfs at a velocity of about 8.6 feet per second. At the potential minimum flow of 1,000 cfs 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 159 cfs at a velocity of about 3.1 feet per second. Table 4-4 provides hydraulic conditions in the secondary screen channel for four different operating flow rates. During rare high flow operations (less than 5% of the time) when the design operating flow is exceeded the screen approach velocities remain at or below 0.5 ft/s).

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 3.50 feet to 2.25 feet. The channel floor rises 10.50 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 inches 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 design calls for a fish transport flow to the FHF of 20 cfs in each of the two channels, at a channel velocity of about 2.1 feet per second. The floor of the transport channels from the end of the secondary screens to the FHF is 5.375 feet below the reservoir level with a depth of flow of about 4.3 feet.

Table 4-4 - Secondary Screen Channel Hydraulics Providing Flows (cfs) and Velocities (ft/s)

	Secondary Screen Channel Location	Design Flow 4,500 cfs			Maximum Flow 5,600 cfs			Moderate Flow 2,750 cfs			Minimum Flow 1,000 cfs**		
		Channel Flow	Channel Velocity	Screen Approach Velocity*	Channel Flow	Channel Velocity	Screen Approach Velocity*	Channel Flow	Channel Velocity	Screen Approach Velocity*	Channel Flow	Channel Velocity	Screen Approach Velocity*
Acceleration Channel	Start of Panel S1-A	664	4.50		814	5.53		414	2.79		299	2.01	
	End of Panel S1-A	620	4.65	0.40	759	5.71	0.50	387	2.88	0.24	279	2.08	0.18
	End of Panel S1-B	577	4.80	0.40	705	5.89	0.50	360	2.98	0.24	261	2.15	0.17
	End of Panel S1-C	533	4.96	0.40	650	6.09	0.50	333	3.08	0.24	242	2.23	0.17
	End of Panel S2-A	497	5.19	0.39	606	6.37	0.49	312	3.23	0.24	227	2.34	0.17
	End of Panel S2-B	462	5.46	0.38	563	6.70	0.48	290	3.39	0.23	211	2.46	0.17
	End of Panel S2-C	428	5.76	0.38	520	7.07	0.48	269	3.58	0.23	196	2.60	0.17
	End of Panel S3-A	400	6.09	0.37	485	7.48	0.46	252	3.78	0.22	183	2.74	0.16
	End of Panel S3-B	373	6.46	0.37	451	7.95	0.46	236	4.01	0.22	171	2.89	0.17
	End of Panel S3-C	346	6.92	0.35	419	8.55	0.44	220	4.29	0.21	159	3.07	0.15
Deceleration Channel	End of Panel S4-A	318	6.75	0.40	384	8.33	0.49	202	4.19	0.24	146	3.00	0.17
	End of Panel S4-B	291	6.56	0.40	351	8.09	0.50	185	4.09	0.24	135	2.94	0.16
	End of Panel S4-C	265	6.37	0.40	319	7.84	0.50	170	3.99	0.24	124	2.88	0.16
	End of Panel S5-A	240	6.17	0.40	289	7.58	0.49	154	3.88	0.24	113	2.82	0.16
	End of Panel S5-B	216	5.96	0.40	260	7.31	0.49	140	3.77	0.24	103	2.75	0.16
	End of Panel S5-C	194	5.75	0.39	233	7.02	0.50	126	3.66	0.24	94	2.69	0.16
	End of Panel S6-A	173	5.52	0.39	207	6.72	0.49	114	3.54	0.23	85	2.63	0.16
	End of Panel S6-B	153	5.28	0.39	183	6.40	0.49	101	3.43	0.23	76	2.56	0.16
	End of Panel S6-C	135	5.03	0.39	160	6.06	0.50	90	3.30	0.24	68	2.49	0.16
	End of Panel S7-A	117	4.77	0.39	138	5.70	0.49	79	3.18	0.24	61	2.42	0.16
	End of Panel S7-B	101	4.50	0.39	118	5.33	0.49	69	3.04	0.24	54	2.35	0.16
	End of Panel S7-C	86	4.21	0.39	99	4.94	0.48	60	2.91	0.23	48	2.28	0.16
	End of Panel S8-A	72	3.90	0.39	82	4.52	0.49	52	2.77	0.24	42	2.22	0.16
	End of Panel S8-B	59	3.58	0.39	67	4.08	0.49	44	2.62	0.24	36	2.17	0.16
	End of Panel S8-C	47	3.24	0.39	53	3.62	0.48	37	2.48	0.23	32	2.11	0.16
	End of Panel S8-A	37	2.87	0.39	40	3.13	0.48	31	2.34	0.24	27	2.07	0.16
	End of Panel S8-B	28	2.48	0.39	29	2.62	0.47	25	2.19	0.24	23	2.05	0.16
	End of Panel S8-C	20	2.07	0.39	20	2.07	0.46	20	2.06	0.24	20	2.06	0.16

* Screen approach velocities conservatively calculated assuming only 90% of the gross screen area is available.

** Minimum flow of 1,000 cfs uses only one 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 over the length of individual screen panels. Table 4-5 provides estimated water surfaces (hydraulic profile) at locations throughout the length of the screen channel. Water surfaces are expressed in the table as feet below the reservoir level. This was done because the FSS is a floating structure and therefore the reservoir surface represents the only available fixed horizontal reference line. These hydraulic profiles are provided in a table format because the scale of the FSS is so large that variations in plotted lines would be nearly imperceptible.

Table 4-5 - Water Surfaces Throughout the Screen Channel in Feet Below the Reservoir Level

	Channel Location	Channel Water Surface in Feet Below Reservoir Level			
		Design Flow 4,500 cfs	Maximum Flow 5,600 cfs	Moderate Flow 2,750 cfs	Minimum Flow 1,000 cfs**
Primary Channel	Channel Start*	1.00	1.00	1.00	1.00
	Start of Panel P1	1.03	1.05	1.01	1.01
	End of Panel P1	1.03	1.05	1.01	1.01

	Channel Location	Channel Water Surface in Feet Below Reservoir Level			
		Design Flow 4,500 cfs	Maximum Flow 5,600 cfs	Moderate Flow 2,750 cfs	Minimum Flow 1,000 cfs**
	End of Panel P2	1.03	1.05	1.01	1.01
	End of Panel P3	1.03	1.05	1.01	1.01
	End of Panel P4	1.03	1.05	1.02	1.01
	End of Panel P5	1.03	1.05	1.02	1.01
	End of Panel P6	1.03	1.05	1.02	1.01
	End of Panel P7	1.03	1.05	1.02	1.01
	End of Panel P8-A	1.05	1.07	1.02	1.01
	End of Panel P8-B	1.06	1.09	1.03	1.02
	End of Panel P9-A	1.09	1.13	1.04	1.02
	End of Panel P9-B	1.12	1.17	1.05	1.03
Acceleration Channel	Start of Panel S1-A	1.15	1.22	1.06	1.03
	End of Panel S1-A	1.17	1.25	1.07	1.04
	End of Panel S1-B	1.19	1.29	1.08	1.04
	End of Panel S1-C	1.22	1.32	1.09	1.05
	End of Panel S2-A	1.25	1.38	1.10	1.06
	End of Panel S2-B	1.30	1.45	1.12	1.07
	End of Panel S2-C	1.35	1.52	1.14	1.08
	End of Panel S3-A	1.42	1.61	1.17	1.09
	End of Panel S3-B	1.48	1.73	1.19	1.10
	End of Panel S3-C	1.57	1.88	1.23	1.12
Deceleration Channel	End of Panel S4-A	1.55	1.84	1.22	1.11
	End of Panel S4-B	1.53	1.80	1.20	1.11
	End of Panel S4-C	1.49	1.76	1.20	1.11
	End of Panel S5-A	1.47	1.71	1.19	1.10
	End of Panel S5-B	1.44	1.66	1.18	1.09
	End of Panel S5-C	1.41	1.61	1.17	1.09
	End of Panel S6-A	1.38	1.57	1.16	1.09
	End of Panel S6-B	1.35	1.52	1.15	1.09
	End of Panel S6-C	1.32	1.47	1.14	1.08
	End of Panel S7-A	1.29	1.42	1.14	1.08
	End of Panel S7-B	1.27	1.37	1.12	1.08
	End of Panel S7-C	1.23	1.32	1.11	1.07
	End of Panel S8-A	1.21	1.29	1.11	1.07
	End of Panel S8-B	1.18	1.23	1.09	1.07
	End of Panel S8-C	1.15	1.20	1.08	1.06
	End of Panel S8-A	1.13	1.16	1.08	1.06
	End of Panel S8-B	1.10	1.13	1.07	1.06
	End of Panel S8-C	1.08	1.10	1.07	1.06

* Water surfaces upstream of the screen channel are controlled by modulating the entrance weirs to maintain trapping velocity. Some energy recovery is realized in the expansion channel, and although the resulting water surface at the start of the channel will vary slightly for different operating flow rates, it should remain close to one foot below the reservoir level in all operating cases.

** Minimum flow of 1,000 cfs uses only one screen channel.

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 will be attached to the screen support columns an adequate distance behind the screen panels to allow the backwash cleaner piping to fit between the screens and baffles. These baffles will consist of two UHMW plastic perforated plates (one fixed and one movable) mounted in a stainless 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 vertically and 7 inches on center horizontally. This results in a fully-open porosity of approximately 27%. The holes on the two plates, one fixed in the baffle frame and one vertically adjustable, should be cut through both UHMW plates at the same time so that the patterns are identical. Figure 4-16 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). Baffle for the secondary screen panels would include three individually controllable sections.

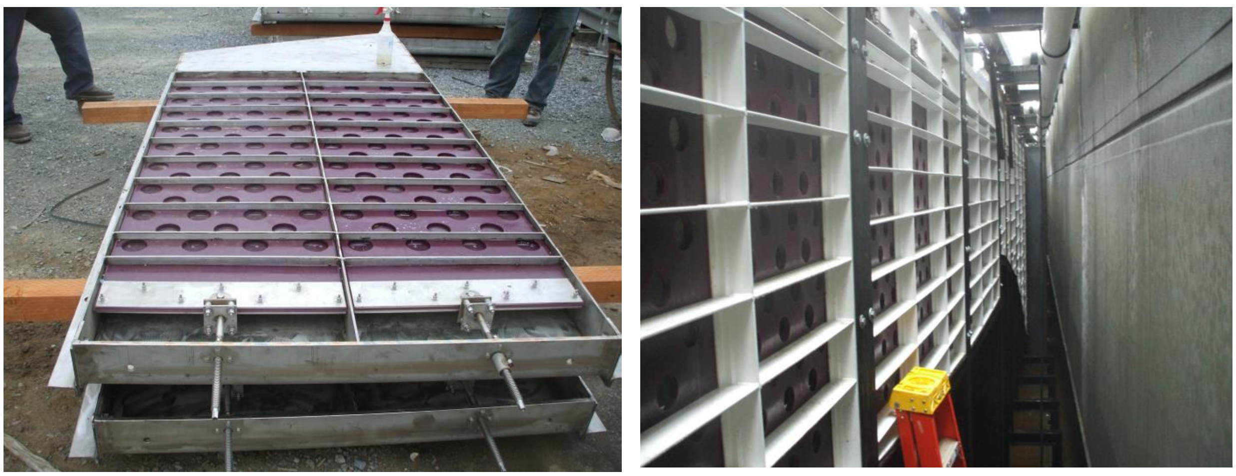

Figure 4-16 - Individual Baffle Panels and Baffles Installed on Floating Surface Collector

Prior to startup of the FSS, the baffles should be preset to porosities estimated to provide the design flow conditions at 4,500 cfs operating flow. As a result of the port-side discharge of flow from the FSS into the SWS the water level in the plenum varies from Starboard to port. This is due to portions of the flow having to pass under the secondary screen channels. One quarter of the overall screened flow needs to pass from the starboard plenum under the starboard secondary channel into the center plenum. Then, three quarters of the overall screened flow needs to pass from center plenum under the port secondary channel into the port plenum. We have assumed that a full velocity head will be lost in this passage of flow under the channels, resulting in subsequently lower water levels in the three plenums from starboard to port. Figure 4-6 provides the estimated water levels in the three plenums expressed as feet below the reservoir level for four different FSS flow rates. With increased screen flows the plenum levels drop due to greater headloss across the baffles, and conversely with decreased screen flow the plenum levels rise. There is never a need to readjust the baffle settings, rather they simply continue to distribute the flow evenly between the screen panels regardless of the overall screen flow rate. The R2 design model was used to adjust the baffle settings based on these plenum levels to balance the side-to-side screen flows in the channel at 4,500 cfs, given the plenum level associated with the baffles on that side of the channel. The estimated baffles settings in percent open area are provided in Table 4-7. After startup, the hydraulic conditions will be checked in the field to ensure that the screen flows are balanced and meet NMFS criteria, and individual baffles may need to be readjusted at that time if necessary. The baffles should not need to be adjusted again after the startup balancing.

Table 4-6 - Estimated Water Levels in the Plenums in Feet Below Reservoir Level

FSS Operating Flow	Water Surface in Feet Below Reservoir Level		
	Starboard Plenum	Center Plenum	Port Plenum
Design Flow 4,500 cfs	1.94	1.95	2.00
Maximum Potential Flow 5,600 cfs	2.52	2.53	2.61
Moderate Flow 2750 cfs	1.34	1.35	1.37
Minimum Channel Flow 1,000 cfs*	1.18	1.18	1.18

* Minimum operating flow assumes future pumped flow conditions, so all plenums are equal

Table 4-7 - Estimated Baffle Settings for Initial Startup of the FSS

	Baffle Panel	Baffle Setting Percent Open Area			
		Starboard Channel		Port Channel	
		Starboard Side	Port Side	Starboard Side	Port Side
Primary Channel	Panel P1	8.00%	7.96%	7.96%	7.76%
	Panel P2	8.00%	7.96%	7.96%	7.76%
	Panel P3	8.00%	7.96%	7.96%	7.76%
	Panel P4	8.00%	7.96%	7.96%	7.76%
	Panel P5	8.00%	7.96%	7.96%	7.76%
	Panel P6	8.00%	7.96%	7.96%	7.76%
	Panel P7	8.00%	7.96%	7.96%	7.76%
	Panel P8-A	8.24%	8.20%	8.20%	7.98%
	Panel P8-B	8.29%	8.24%	8.24%	8.03%
	Panel P9-A	8.34%	8.29%	8.29%	8.07%
	Panel P9-B	8.49%	8.44%	8.44%	8.21%
Acceleration Channel	Panel S1-A	9.12%	9.07%	9.07%	8.80%
	Panel S1-B	9.25%	9.19%	9.19%	8.91%
	Panel S1-C	9.38%	9.32%	9.32%	9.03%
	Panel S2-A	9.50%	9.44%	9.44%	9.13%
	Panel S2-B	9.55%	9.48%	9.48%	9.15%
	Panel S2-C	9.85%	9.77%	9.77%	9.40%
	Panel S3-A	10.12%	10.03%	10.03%	9.61%
	Panel S3-B	10.86%	10.75%	10.75%	10.22%
	Panel S3-C	11.44%	11.29%	11.29%	10.64%
Deceleration Channel	Panel S4-A	14.02%	13.82%	13.82%	12.89%
	Panel S4-B	13.61%	13.42%	13.42%	12.58%
	Panel S4-C	12.87%	12.71%	12.71%	11.99%
	Panel S5-A	12.40%	12.25%	12.25%	11.61%
	Panel S5-B	11.93%	11.81%	11.81%	11.22%
	Panel S5-C	11.50%	11.38%	11.38%	10.86%

Baffle Panel	Baffle Setting Percent Open Area			
	Starboard Channel		Port Channel	
	Starboard Side	Port Side	Starboard Side	Port Side
Panel S6-A	11.16%	11.04%	11.04%	10.58%
Panel S6-B	10.79%	10.68%	10.68%	10.27%
Panel S6-C	10.51%	10.42%	10.42%	10.03%
Panel S7-A	10.25%	10.17%	10.17%	9.81%
Panel S7-B	10.02%	9.94%	9.94%	9.61%
Panel S7-C	9.66%	9.60%	9.60%	9.30%
Panel S8-A	9.59%	9.53%	9.53%	9.25%
Panel S8-B	9.38%	9.33%	9.33%	9.07%
Panel S8-C	9.18%	9.12%	9.12%	8.88%
Panel S8-A	9.08%	9.03%	9.03%	8.80%
Panel S8-B	8.97%	8.93%	8.93%	8.72%
Panel S8-C	8.82%	8.78%	8.78%	8.59%

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. An elevation view of the screen Cleaners is shown in Figure 4-17. 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. Each of the seven spray bars is a zone, isolated by an associated butterfly valve. The second carriage will include four vertical spray bars to clean panels P8A – P9B and will travel approximately 4 feet. Each of the four spray bars is a zone, isolated by an associated butterfly valve. The third carriage will have nine vertical spray bars to clean panels S1A – S3C and will travel approximately 3 feet. This carriage includes six zones with the upstream three longer spray bars each being an individual zone, and the remaining six spray bars operating in three pairs with each pair isolated by an associated butterfly valve. The last carriage will have eighteen vertical spray bars to clean panels S4A – S9C and will travel approximately 3 feet. This carriage includes nine zones with two spray bars in each zone, with a butterfly valve isolating each zone. Figure 4-18 provides an isometric view of the backwash cleaning carriages. Operation of the valves isolating each of the vertical spray bars (zones), 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 to 50 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 screens on one side of the channel to screens on the other side. Figure 4-19 provides a section view of cleaner carriage installed into the primary screens.

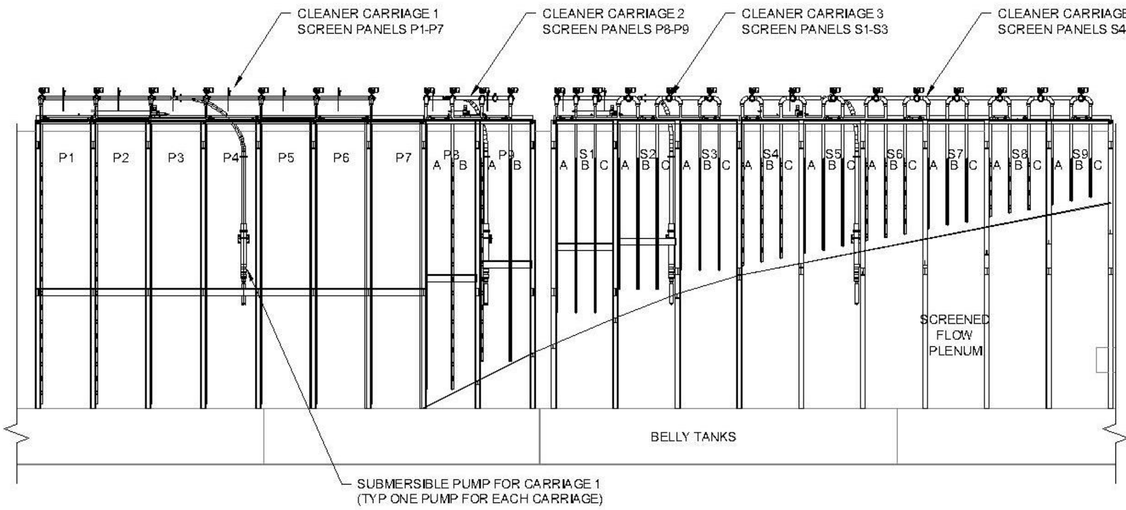

Figure 4-17 - General Arrangement of the Screen Cleaners

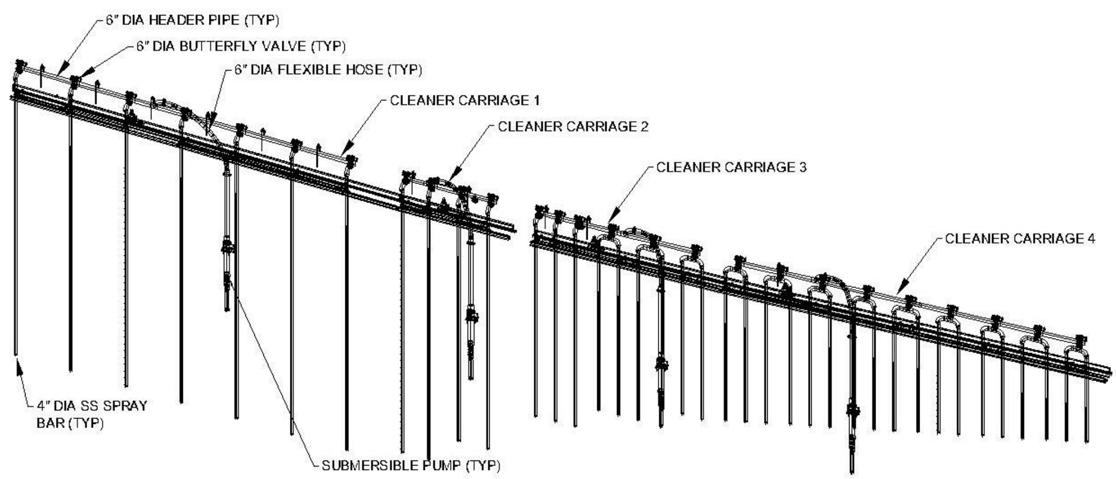

Figure 4-18 - Isometric View of Screen Cleaners

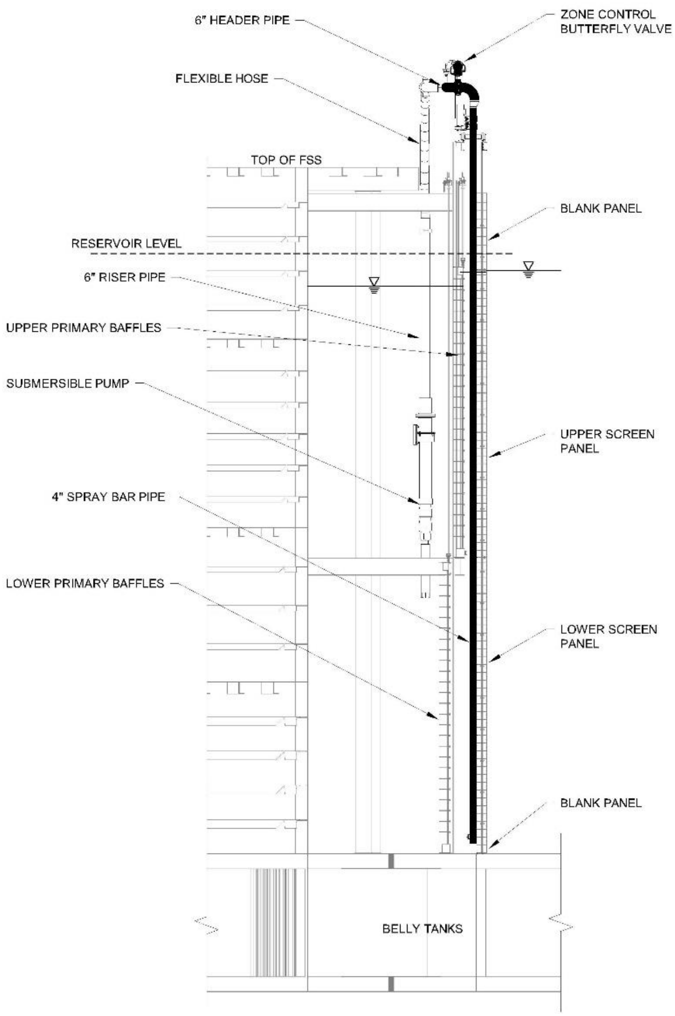

Figure 4-19 - Section View Through Cleaner Carriage 1

Operation of the screen cleaners would involve opening the upstream-most butterfly valve on each of the four number 1 carriages and starting the four associated pumps. The carriage would then travel downstream over the length of its travel, stop, and then travel back in the upstream direction to its parked position. The second valve would then open and the first valve closed, and the carriage travel would occur again. This process would be repeated seven times, for each of the seven zones on Carriage 1. This process would then be repeated successively for Carriages 2, 3 and 4, functionally cleaning the screens in the downstream direction, and moving the debris downstream. Individual dedicated pumps are provided for each carriage to minimize piping requirements and complication, and to facilitate operating all of the cleaner carriages simultaneously in a rare extreme debris event that might otherwise overload the screen structural support and/or the SWS tower. A UHMW rub pad will be mounted on the floor, and/or the bottom of the baffle frame, to support the bottom of the spray bar pipes (and mid-height on the longer pipes) to resists the back-pressure force of the spray jets.

4.6.7 Fish Handling Facilities

Downstream of each secondary screen channel the fish pass to the FHF in transport flumes that are 2.25 feet wide and approximately 4.3 feet deep. The design flow in each flume is 20 cfs; however, the final flow rate will be adjustable (within limits) using adjustable overflow weirs and variable speed pumps downstream in the FHF. These FHF facilities provide for dewatering the majority of the transport flow, final removal of debris, in-line separation of juvenile-sized fish from adult fish, fish holding and sampling, and transfer of fish for transport downstream (or in some cases upstream for release in the reservoir). The estimated peak daily and seasonal fish migration numbers are provided in Table 2-3. Figure 4-20 provides a plan view of the FHF components which include Emergency Shutoff Gates, Coarse Debris Racks, Dewatering Tanks for removing the majority of flow and remaining debris, Ramp Weirs with screens for controlling the final fish flow rate, a Juvenile Fish Separator, Adult Holding Tank, numerous Fish Transport Pods for temporary holding and transport of fish, subsampling capabilities, and a Fish Sampling Station. All fish holding and sampling facilities are provided with continuous circulation water based on the circulation water requirements shown in Table 2-2 for the full density fish holding capacities. However, the water supply and drain systems are overdesigned to provide for greater flow rates if desired. The following sections provide descriptions of the components of the FHF.

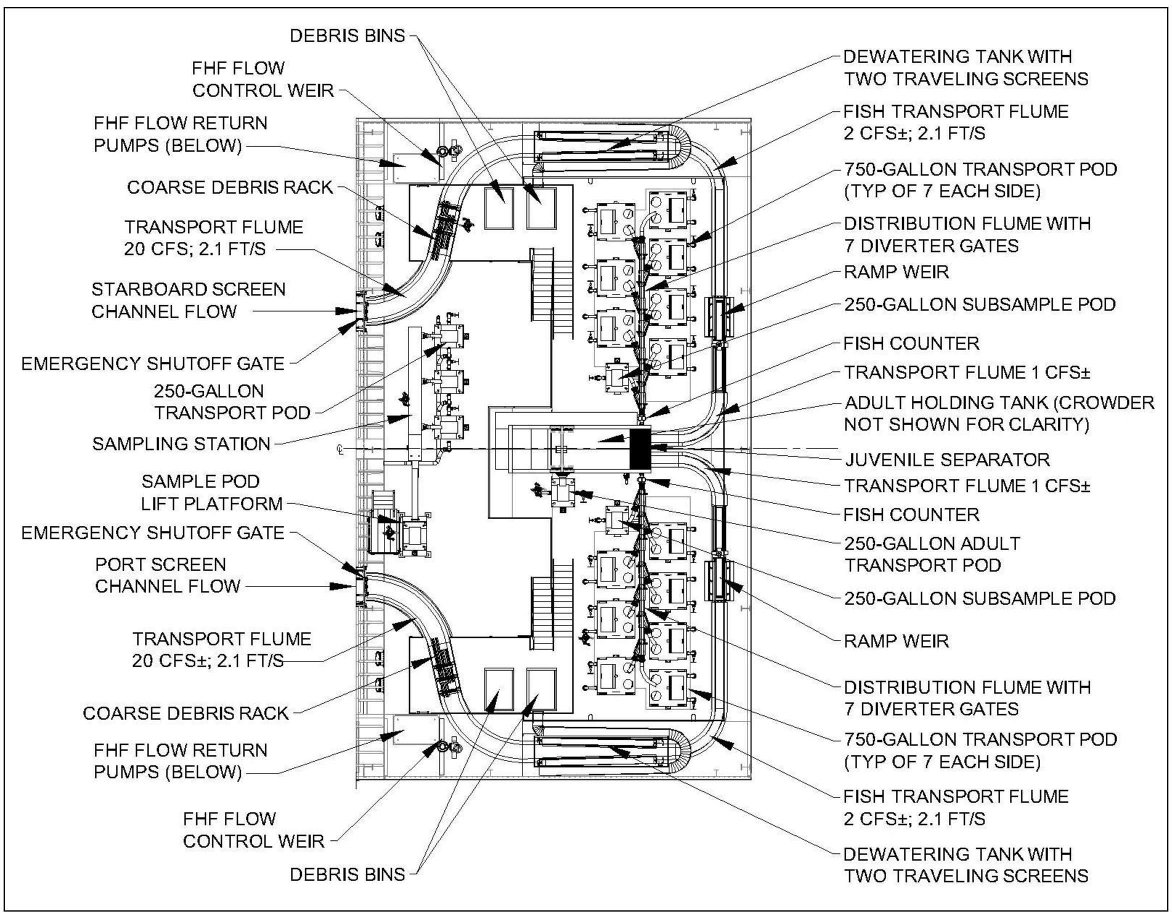

Figure 4-20 - Plan View of the Fish Handling Facilities

4.6.7.1 Emergency Shutoff Gates

At the downstream end of the secondary screen channels there are emergency shutoff gates in the fish transport flumes. These gates are designed to remain raised and entirely above the water in the flumes under all normal operating conditions. The gates will automatically drop in the event of a complete power failure, when power to the FHF recirculation pumps is lost. These gates are necessary to prevent flooding of the FHF area. Figure 4-21 provides isometric views of the shutoff gate design both open and closed. The gate consists of a heavy 1-inch-thick steel plate leaf that is held up with a pneumatic cylinder. When power is lost to the facility (including backup power), or the water level in the FHF recirculation pump sump starts to rise uncontrollably, a solenoid will open the cylinder and the gate leaf will drop under its own weight, shutting off flow from the screen channel to the FHF. The guides for the gate leaf only occupy the upper portion of the gate area, and do not extend down below the channel water level. Therefore, within the flow area there are no guides and the walls of the channel are continuous and smooth. Bulb seals on the upstream face of the gate seal the gate along the walls and floor when the gate is closed.

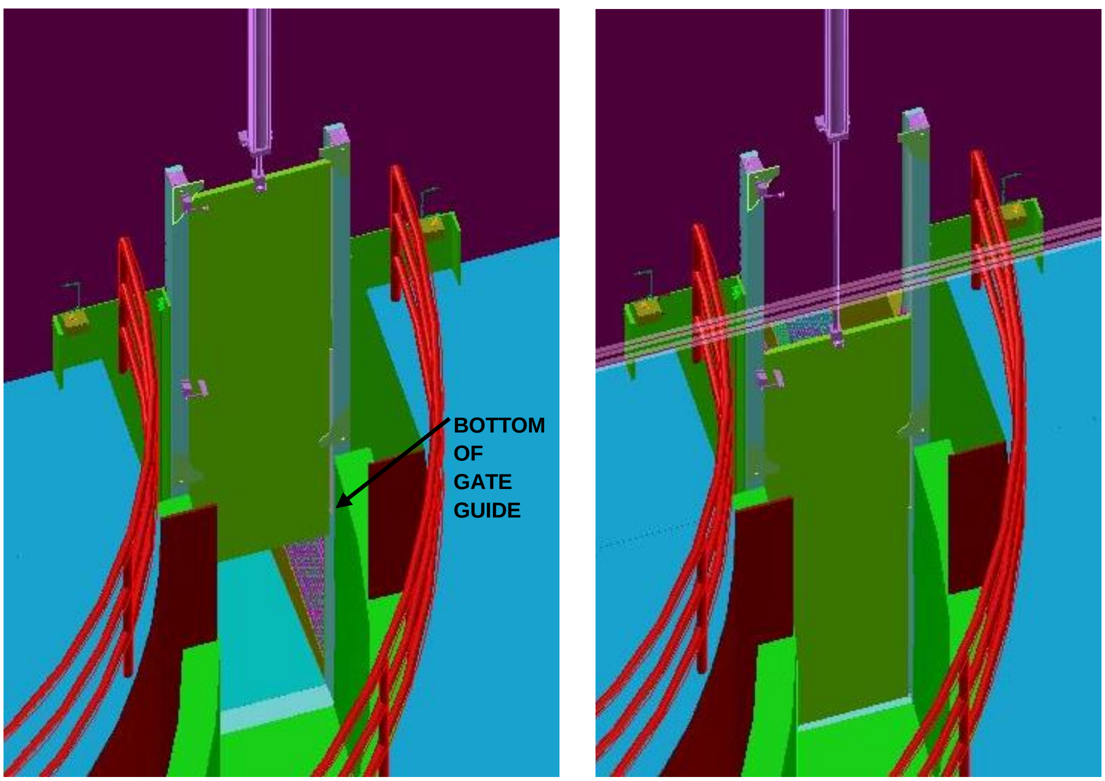

Figure 4-21 – Emergency Shutoff Gate Shown Open (Left) and Closed (Right)

4.6.7.2 Coarse Debris Racks

Coarse debris racks are positioned within the transport flumes to remove larger woody debris that is small enough to have passed through the Trashracks at the entrance but is too large to be effectively removed automatically by the traveling screens downstream. Accumulations of larger debris further downstream in the FHF could plug the fish separator and/or cause problematic conditions in the smaller flumes 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 aluminum pipes sloped back at 30 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 and the flume wall. This will result in the furthest pipe from the wall being approximately halfway across the flume. The spacing between the racks along the length of the flume is also adjustable, with each subsequent rack occupying the opposite side of the flume 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 attached plates, which work well at the North Fork FSC, and fits well into the straight section of flume between the two flume curves. A fourth rack could be installed, but it would begin to protrude into the curved flume section upstream. 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 flume while allowing for safe fish passage. The coarse debris racks in the transition flume should be checked on a daily basis and any debris caught in the racks 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 4-22 provides photos of the debris racks at the North Fork FSC, and Figure 4-23 shows the debris bin at the North Fork FSC with the manual rake and the type of debris that is removed at the coarse debris rack. It should be noted that the transport flume 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. Also, the channel depth at North Fork is about 2 feet (approximately half the depth for the Detroit design) but the velocities are similar, 2.0 to 2.5 feet per second.

Figure 4-22 - Photos of the Debris Rack in the North Fork FSC Transport Flume

Figure 4-23 - Type of Debris Removed at the North Fork FSC Coarse Debris Rack

4.6.7.3 Dewatering Tanks

Downstream of the coarse debris racks the flumes continue to the dewatering tanks. The tanks are located on the port and starboard sides of the FHF area. Each tank is approximately 40 feet long and 8 feet wide and includes two banks of traveling screens along the sides of the flume as it passes through the tank. The screens on the sides of the flume angle slightly inward resulting in a flume width of 1.25 feet at the downstream end of the screens. The floor of the flume also slopes up 3.4 feet over the length of the screens, resulting in a depth of approximately 0.80 feet in the flume at the downstream end of the screens. As the flow is reduced, and the flume cross-sectional area diminishes, the velocity remains at 2.1 feet per second throughout the length of this section. The screens are sized to dewater approximately 18 cfs from each flume, while meeting all NMFS criteria for juvenile fish screening. The screens are vertical, to maintain the rectangular flume shape, which is not ideal for keeping impinged debris on the screen face as it rises out of the water, therefore 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. Debris pegs are 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. However, the North Fork TSS traveling screens are sloped back from vertical at 37.5 degrees, which also helps to retain the debris on the screens. Figure 4-24 provides a photo of the North Fork TSS traveling screen installation showing the screens with debris pegs, and the ability of the pegs to retain the debris on the screen face.

Figure 4-24 - Photos of the North Fork TSS Traveling Screens with Debris Pegs

At the forward end of each dewatering tank is an adjustable weir for controlling the FHF flow. The PLC will automatically control the weirs to maintain the desired FHF flow rate. Two submersible pumps are located forward of the weir (on the downstream side of the weir) to return the FHF flow to the plenum for ultimate discharge into the SWS. The pumps will be operated with variable frequency drives (VFDs) to allow for control of the water level in the pump sump. The PLC will adjust the VFD (speed of the pumps) to maintain a water level just below the crest of the adjustable weir, thus minimizing the turbulence in the pump sump. Only one pump is required to provide the design FHF flow, but a second pump is included as a redundant back up, given the crucial nature of this flow to attract fish from the screen channel into the transport flumes, and to prevent flooding of the FHF area.

Debris that is carried up over the top of the traveling screens will fall off and/or be sprayed off of the screen belt into a debris trough on the back side of the screens. During operation of the screens, water would also be sprayed into the trough to move the debris to the end of the trough. The trough behind the outboard screen will horseshoe around at the end, pass over the flume and sluice the debris into the trough behind the inboard screen. 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 FHF bridge crane and moved over to the port side of the FHF area to be lifted off the FSS, similar to the Fish Transport Pods, as described below.

4.6.7.4 Ramp Weir

Downstream of the dewatering tanks, the fish continue downstream in the 1.25-foot-wide flume in a flow of approximately 2 cfs, turning 90 degrees and running parallel to the FSS transom. An adjustable ramp weir is incorporated into the flume, with fixed screen panels along walls. The ramp weir consists of two long plates that meet at a hinge point in the center, which acts as the crest of the weir and can be moved up and down. This effectively creates a gently rising sloped floor on the upstream side of the crest, and a downwardly sloping floor on the downstream side of the crest. The setting of the weir crest below the water level in the flume will control the rate of the final fish flow downstream of the weir. The remaining portion of the flow approaching the weir will pass out through the wall screens and be piped to the pump sump located midship under the adult holding tank. The magnitude of the screened flow will be controlled by a valve on the drain line, and the distribution of the flow over the screen area, will be controlled with small adjustable baffles on the back side of the screen. The screens are small and will be manually cleaned and should be checked and cleaned at least once daily. A cleaning interval should be established based on experience and will likely vary based on season and environmental conditions.

Downstream of the weir crest the weir plate and remaining flume section slope downward to rapidly move the fish and remaining flow approximately 1.0 cfs or less, to the Juvenile Separator downstream. The final flow rate is adjustable and can be optimized through experience after startup of the facility. Isometric views of the ramp weirs are provided in Figure 4-25.

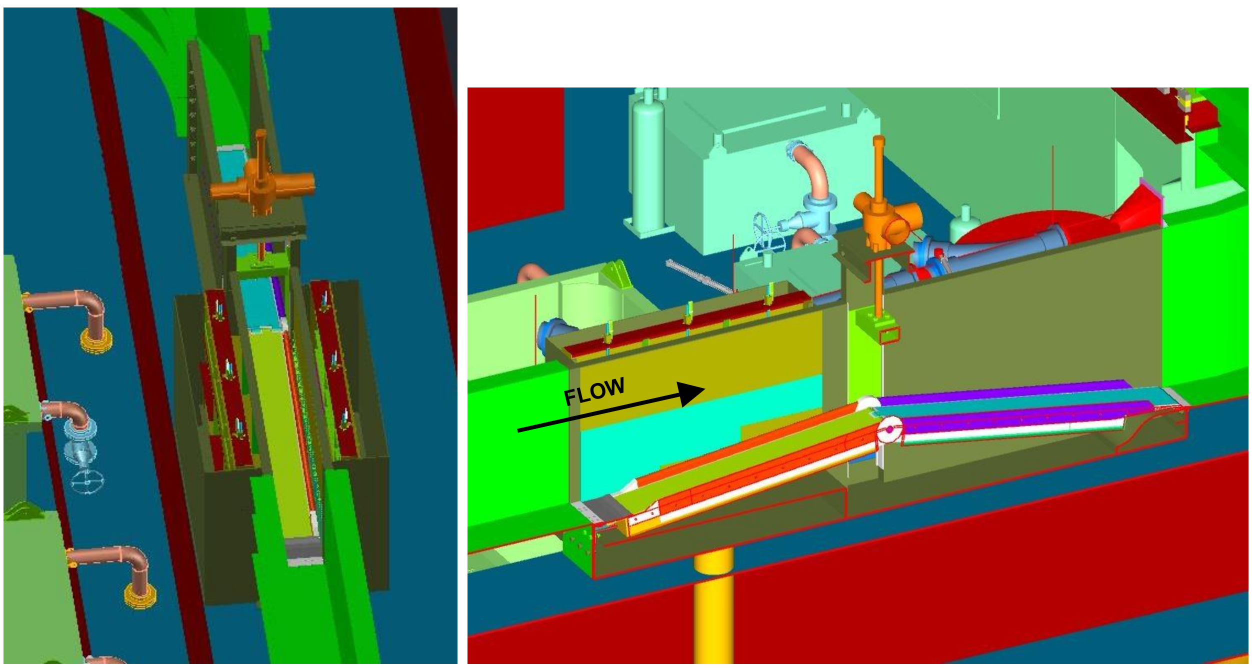

Figure 4-25 – Isometric Views of the Ramp Weir and Screens

4.6.7.5 Juvenile Fish Separator and Fish Distribution

Downstream of the ramp weir, the fish flow passes onto a Juvenile Fish Separator. The separator is located midship and combines the flow and fish from both the port and starboard fish flumes. The Juvenile Fish 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. A typical rack for this type of separator would have the tubes spaced with 1.25-inch clear spaces between the tubes, which would separate out all fish less than about 10 inches long. The entire flow passing from the ramp weir 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 smooth fish-friendly outlets on each side leading to small 6- inch-wide exit flumes heading out from the tank in the port and starboard directions. In this way the fish are directed out of the separator box and into the flumes, which direct the fish to the Fish Transport Pods. The exit flumes include bifurcations and diverter gates directing the juvenile fish to a particular transport pod. There are eight pods on each side (port and starboard) including seven 750-gallon pods and one 250-gallon pod. There are seven diverter gates in the flume, associated with each of the first seven pods, with the end of the flume terminating at the eighth pod. A fish counter is located at the upstream end of the flume and will provide a running real-time fish count to the PLC which will in turn control the flume diverter gates. The first diverter gate is used to direct fish to the 250-gallon pod, which is used to obtain a timed subsample of the fish. For example, if a timer in the PLC is set to divert fish to the subsample pod for three minutes every half hour (or one minute every ten minutes) throughout the day it would be assumed that 10% of the juvenile fish passing through the system were diverted into the subsample pod. This is a commonly used practice for obtaining a timed subsample of a population. The subsequent diverter gates are used to direct all of the fish in the flume to one of the 750-gallon pods. Initially, all the remaining diverter gates would be directing fish straight down the flume, filling the eighth pod with fish. When the fish counter identified that the eighth pod is at capacity, the seventh diverter gate will switch to divert fish to the seventh pod. This process will continue, sequentially filling the pods progressing upstream.

The separator tank will include an internal floor screen, below the exit flume outlets, to remove some of the flow coming in with the fish, as this much flow might overwhelm the flumes and transport pods. The screen will be sized for a very low approach velocity (less than 0.1 feet per second) and will be outfitted with an air-burst cleaning system. The air will be low pressure, since it won’t take much to push the debris up high enough to redirect it toward the exit flumes, and there will be an adjustable pressure reducing valve on the air supply line to optimize the pressure for removing the debris while not harming the fish. Below the screen, the tank will have a discharge drain pipe with a valve to control the amount of dewatering. This valve will be used to control the water level in the separator box, which will in turn control flow rate in the exit flumes.

4.6.7.6 Juvenile Holding and Fish Transport Pods

The juvenile holding facilities have been modified from the 60% DDR design. Rather than placing the fish into holding tanks and then transferring them to Fish Transport Pods the fish will be placed directly into the Fish Transport Pods for temporary holding and ultimate transfer off the FSS. There are 14 identical Juvenile Fish Transport Pods, with seven on each side (port and starboard). There are also two smaller pods, one on each side, for capturing subsamples of the overall fish run. Each of the 14 larger pods has a capacity of 750 gallons, and can safely hold 401 pounds of fish for up to 24 hours. This represents up to 2005 steelhead smolts at an average weight of 0.2 pounds, or 3038 Chinook Salmon smolts at an average weight of 0.132 pounds (see Table 2-3). The combined volume and holding capacity of the 14 Fish Transport Pods (5,614 pounds of fish) is significantly greater than the holding capacity of the two holding tanks described in the 60% DDR. Additionally, placing the fish directly into the Transport Pods eliminates the need to crowd and lift the fish for transfer from holding tanks into the pods, which would have represented an additional source of potential injury to the fish. Circulation water will be provided to the pods while they are holding fish, prior to transfer off the FSS. The circulation water will be gravity fed from the Dewatering Tanks described in Section 4.6.7.3. Each 750-gallon pod will be supplied with up to 60 gpm circulation water to meet the requirement cited in Table 2-2. Each pod is also outfitted with an oxygen tank and oxygenation system. Immediately prior to transfer of the pods off the FSS, the circulation water and drain hose connections will be removed from the pods and the oxygenation system will be turned on. Figure 4-26 provide isometric views of a 750-gallon Fish Transport POD. The internal dimensions of the pod are 5-foot square in plan by approximately 4.25 feet deep. The pod cover includes holes for inserting the fish entry hose, and a hinged door for visual inspection of the inside of the pod. A slide gate is located along the bottom of one wall for discharging the water and fish at the release site.

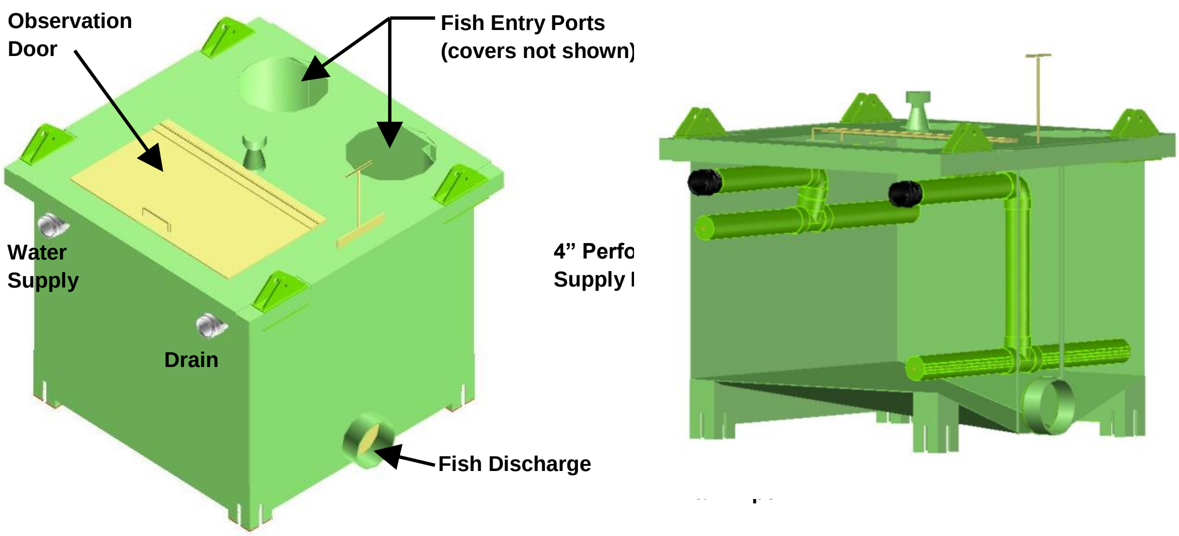

Figure 4-26 - External (Left) and Internal (Right) Isometric Views of 750-Gallon Fish Transport Pod

The two smaller pods have a capacity of 250 gallons and are used for holding a subsample of the fish for transfer to the Sampling Station. These pods have a similar design to the 750-gallon pod design with internal dimensions of 4'-4" by 3'-6" with a depth of approximately 2.33 feet. The smaller pods also have all of the circulation water, oxygenation, and fish release features described for the larger pods. Metered discharge of fish from these pods at the Sampling station is described below in Sampling Station.

4.6.7.7 Adult Holding Tank

Fish too large to fit between the tubes of the Juvenile Fish Separator will slide off the ends of the separator panel 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 forebay and 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 includes a fish holding volume and a drain sump. The fish holding volume of the Adult Holding Tank is 12 feet long by 6 feet wide, with a water depth of 5 feet. It has a capacity to hold about 180 adults at an average weight of 8 pounds per fish, in 50º F water. The capacity should be halved to 90 fish of the same weight if the temperature is 60º F. The tank includes a horizontally travelling crowder for moving fish toward the downstream end of the tank, and a brail system for raising the fish up to the discharge chute. On the downstream side of the brail is an isolation screen panel that defines the downstream end of the fish holding volume. The crowder travels to the upstream end of the brail, isolating the fish above the brail between the crowder panel and the isolation screen panel. The brail is then raised to vertically crowd the fish up toward the surface where they are sluiced into a 250-gallon Transport Pod for removal from the FSS or transfer to the Sampling Station. A 250-gallon Transport Pod can hold up to 27 adult fish at an average weight of 8 pounds if they are going to be transported in short order and not held in the pod for an extended period of time.

Beyond the isolation screen panel, the tank extends for another 6 feet constituting the drain sump. An overflow vertical drain pipe passes the tank circulation water out of the tank and into the FHF drain sump below the tank. The adult tank is provided with 135 gpm (0.3 cfs) circulation water, which is gravity fed from the dewatering tanks described in Section 4.6.7.3.

4.6.7.8 Sampling Station

A Fish Sampling Station is located in the FHF building on the main deck of the FSS, at forward end of the building. The Sampling Station is used during sampling for identifying and sorting the fish into one of three 250-gallon Fish Transport Pods. A sampling table serves as a work table for any activities such as sampling, tagging, or miscellaneous fish handling. An anesthetic tank is built into one end of the sampling table, along with a dewatering screen, where the fish are transferred out of a Transport Pod into the anesthesia water. Associated with the Sampling Station is a discharge hose assembly used to slowly remove the water and fish from the Transport Pod in small increments to not overload the anesthetic tank. The pod is placed on a lift platform that is located to the port side of the sampling table. A 10-inch-diameter hose extends from the platform to a short dewatering screen attached to the port end of the sampling table, where the anesthetic tank is located. Initially the lift platform is fully lowered, and the pod placed on it will be entirely below the level of the sampling table. The hose is then attached to the quick-disconnect fitting on the pod discharge outlet and the discharge gate on the pod is opened fully. The lift platform is then slowly raised and as the water level in the pod rises above the level of the table the water and fish start to discharge onto the screen, and the fish will slide into the anesthetic tank. When enough fish are in the anesthetic tank, the platform is lowered until the flow stops. The fish are then sampled, and the process is repeated until the pod is empty. It is recommended that after the pod is about half empty a person opens the cover door on the pod and monitors the remainder of the discharge, removing floating debris from the pod as appropriate and ensuring that all the fish ultimately exit the pod. The sampling station fish discharge system is designed only for the 250-gallon pods, and the 750-gallon pods are solely used for holding and transporting of fish to release sites off the FSS.

As requested by the USACE, the facility will be designed to use AQUI-S anesthetic. Used anesthetic water will be placed into a dedicated container for removal from the FSS and disposal at the existing Minto facility, or other location approved by the USACE. The sampling 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 transport pods. 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 transport pods will be sealed and transferred off the FSS for transport downstream.

All age classes of fish (juvenile and adult) can be made available for sampling if necessary. The juvenile holding facilities provide a system to allow for the separation of a timed subsample placed into 250-gallon pods. Adult fish are also placed into 250-gallon pods, which are identical to the juvenile subsample pods.

4.6.8 Fish Transport

Fish will be transported from the FSS to release points downstream (or in some cases upstream) of the dam in either 250-gallon or 750-gallon Fish Transport Pods (as described in Section 4.6.7.6. The pods are equipped with removable/refillable oxygen tanks and internal diffusers that provide life support for the fish while in transit to the desired release point. The pods are also outfitted with a release gate mechanism designed to safely release the fish into an attached hose for discharge at the release site. The USACE has opted to transport the fish from the FSS to the appropriate release site(s) with Amphibious Vehicles (AVs). The Fish Transport Pods will be loaded onto an AV tied to a floating dock alongside the FSS. An AV will be capable of transporting one 750-gallon pod plus one 250-gallon pod simultaneously. The AV will travel across the forebay, then drive up a boat ramp to the highway and downstream to the Minto facility where the fish will be discharged in a dedicated recovery tank. The fish will then ultimately be released into the lower river downstream of Minto Dam. In some cases, the, when necessary, the AV might travel up the reservoir to a release location upstream for fish that need to be released back into the reservoir. The USACE is currently working with AV manufacturers to determine the optimal size and requirements of the AV for this project, and more details will be provided in subsequent DDR submittals.

4.6.9 SWS Flow

The screened flow from the two large screen channels is all combined in a large plenum and discharges to the SWS through two large openings in the port side wall of the FSS. The water level in the plenum will be a function of the FSS operating flow at the time. With the current design settings, at the design flow rate of 4,500 cfs and relatively clean screens, the water level on the port side of the plenum would be 2.00 feet below the reservoir level (Table 4-6). At the maximum flow of 5,600 cfs the plenum level would be 2.61 feet below the reservoir. Flow into the SWS will pass over the upper HIW intakes in the SWS, as described in the SWS DDR. Based on conversations with the USACE, the HIW gates will be designed for a maximum head drop of 0.75 feet. Therefore, under normal clean operating conditions the water level in the SWS should remain less than 3.5 feet below the reservoir level at all flow rates.

A relatively water-tight sealed connection between the FSS and the SWS slots and HIW gates has been designed that will allow for some differential movement between the FSS and the SWS tower. Details of this design are provided in the mechanical section of this DDR below.

5 STRUCTURAL DESIGN

5.1 FSS Structural Design

5.1.1 General

The FSS is an all-welded, rectangular-shaped, floating steel structure, 308 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 structural calculations are in Appendix F. Further detail of the design theory is identified as well as plate and shape sizing for the primary longitudinal and transverse members in the belly tanks and flotation cells. The weight estimate is updated to reflect the selected structural members. Due to the large hydrostatic head acting on the belly tank structure when the FSS is submerged to its operating depth, high strength steel (ASTM A992) members are identified. This allows a reduction in size of the transverse frames, saving weight and allowing for easier construction and maintenance.

5.1.2 Design Standards and Reference

The structural design will conform to the following. Design standards of the American Bureau of Shipping Rules for Building and Classing Steel Barges 2018 are adjusted to suit unique features of the FSS and its operating location.

- 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). Rules for minimum required section modulus of structural members include a parameter, h, to account for the hydrostatic head of a uniform load. For all structural members, except main deck structure, hydrostatic head is taken to the main deck at edge in lieu of a height above the main deck as prescribed by the rules. Hydrostatic head for main deck structure is taken as prescribed by the rules. 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.

The FSS uses four primary steel types, as identified below:

Table 5-1 – Structural Steel Specifications

Structural Steel Specifications	
Wide Flange / WT Shapes	ASTM A992
Shapes, Plates, Channels and Bars	ASTM A36
Structural Tubing	ASTM A500 GR B
Pipe	ASTM A53 GR B

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 deballasted with fish attraction channel elements above water. This also allows internal inspection of belly tanks. It is intended that all surfaces that are submerged, exposed to reservoir water, under any loading condition 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 Protective Coatings

All exterior steel surfaces of the FSS structure exposed to the water, including surfaces in the ramp and expansion sections of the fish channels and the plenum, are to be painted with a protective coating with a service life of 50 years. An example two-coat 50-year coating system used on previous floating surface collectors consists of:

- 1st coat: Zinc primer applied 3.0 – 5.0 mils DFT
- 2nd cost: Epoxy enamel applied 80 mils DFT

All interior steel surfaces are to be painted with a protective coating with a service life of 30 years. Example three-coat 25-year coating systems used on previous floating surface collectors consists of:

- 1st coat: Zinc primer applied 3.0 to 5.0 mils DFT
- 2nd (tie) coat: Coal tar epoxy or epoxy enamel depending on location, e.g. tank interior, interior decks, weather desks, or manned spaces, applied up to 8.0 mils DFT
- 3rd (top) coat: Epoxy enamel or aliphatic polyurethane depending on location, e.g. tank interior, interior decks, weather desks, or manned spaces, applied up to 8.0 mils DFT. Weather deck coatings will include non-skid.

Surface preparation and application of all coatings shall be in strict accordance with manufacturer's requirements and applicable environmental regulations.

All FSS modules will be surface prepared and coated prior to their delivery to the assembly site. Upon assembly of the modules to form the FSS, all exposed metal located at module boundaries or elsewhere shall be surface prepared and coated in the field. Prior to launching the FSS, special attention to the lower exterior modules shall be taken to ensure acceptable coverage and condition of the coating.

5.1.5 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.

$h = 0.02\ L = 5.91$ feet; where L is defined by ABS as 96% of the FSS's overall length.

For fresh water, $h = 5.91$ feet is equivalent to 369 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 299 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 Appendix F.

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* Performance and Serviceability Criteria

5.2.3 Performance and Serviceability Criteria

5.2.3.1 Operational, Geometric, and Constructability Constraints

Translation in the horizontal plane needs to be carefully managed primarily to allow functionality of the seal between the FSS and SWS. This led to the design with mooring dolphins placed on both planes of the FSS hull. Four dolphins are located around the FSS to handle motion in all six degrees of freedom. Four mooring positions 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.

Both the FSS and SWS would have different modes and frequencies of vibration in a seismic event. If drift analysis of the SWS shows a chance of colliding with the FSS, a fender system would be essential to mitigate damage from collision in an earthquake. For this 90% DDR, the decision was made for a non-structural seal to go between the FSS and SWS, and no structural connection between the two structures was to be made. However, it remains that there would be benefits of 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.

Consideration is needed into potential interference between the mooring guide piles and crane operation to handle fish pods.

If the piles are driven plumb, then the pile frames could serve as templates for driving. The piles would serve as portals for drilling equipment.

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 were not used since they would need to very long, eliminate the ability to use intermediate frames, and create greater constructability challenges.

Corrosion will not be a serious concern as this is fresh water – anodes are not required.

The feasibility of both transport and installation of the heavy and large piles is a nontrivial challenge.

5.2.3.2 FSS Dimensions

- FSS Length = 308 feet
- FSS Width = 101.5 feet
- FSS Overall Height = 48 feet
- De-ballasted Condition:
  - Freeboard = 42.9 feet
  - Draft = 5.1 feet
  - Longitudinal Projected Wind Area (SWS shielding) = 10,164 ft^2
  - Longitudinal Projected Current Area (SWS shielding) = 1140 ft^2
  - Longitudinal Projected Wind Area (No shielding) = 13,604 ft^2
  - Longitudinal Projected Current Area (No shielding) = 1,540 ft^2
  - Front Transverse Projected Wind Area = 6394.5 ft^2
  - Front Transverse Projected Current Area = 507.5 ft^2
- Operating Condition:
  - Freeboard = 5 feet
  - Draft = 43 feet
  - Longitudinal Projected Wind Area (Including SWS shielding) = 2,260 ft^2
  - Longitudinal Projected Current Area (Including SWS shielding) = 9,044 ft^2
  - Longitudinal Projected Wind Area (No shielding) = 2,660 ft^2
  - Longitudinal Projected Current Area (No shielding) = 12,484 ft^2
  - Front Transverse Projected Wind Area = 2,537.5 ft^2

- Front Transverse Projected Current Area = 4,364.5 ft^2

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

5.2.3.4 Material Properties

5.2.3.4.1 *Steel Pipe Piles*

- ASTM A53 Grade B
- Yield Strength Fy = 35 ksi
- Ultimate Strength Fu = 60 ksi
- Elastic Modulus E = 29,000 ksi

48” Diameter 1” or 1.5” wall – shape compact for flexure per AISC 360-10.

5.2.3.4.2 *Composite Pile Concrete Fill*

At this time, the pipe piles will not be filled with reinforced concrete to form a composite member, although this remains a possibility in the future.

The effective stiffness of a 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.

5.2.4 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.

5.2.4.1 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 5-2 - 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.

The design wind speed may be obtained from regional climactic wind data, as opposed to the general wind speed design maps from the Oregon Structural Specialty Code, the International Building Code, and ASCE 7-10. Per ASCE 7-10 26.5.3 and commentary section C26.5.3, this would require an analysis based on approved extreme-value statistical analysis, as well as appropriate considerations for length of data collection record, sampling error, averaging time, anemometer height, data quality, and terrain exposure of the anemometer. If the sampling time is short, it is likely that a large statistical factor of safety would need to be applied to obtain a statistically significant result, and a reduction in design wind speed may not be possible.

If an accurately conducted local wind study determines a lower design wind speed can be used, the wind loads on the FSS mooring system would need to be recalculated, and the design on the mooring structures would be subject to change.

5.2.4.2 Seismic

Seismic ground motions will impact structures attached to the ground, meaning the dam, the SWS, and any FSS mooring ground connections. Forces will be transferred to the 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 mooring piles 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 piles by the movement of the earth at the base of the piles. Since the piles themselves are flexible, it is doubtful that much, if any, movement of the top of the inboard piles 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. If this becomes the case, 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 pile mooring system could act as a damping system for the SWS in the East-West direction.

Seismic design parameters are obtained from a site-specific study conducted by AMEC-Quest in 2009, as printed in the SWS 60% DDR.

Table 5.2 - Seismic Design Parameters

	OBE (50% in 100 years)		MCE (Cascadia)	
	Horizontal	Vertical	Horizontal	Vertical
S_s	.0732	.0404	.5654	.3274
S_1	.0223	.0118	.3443	.1917
PGA	.0331	.0202	.2356	.1437

5.2.4.3 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 net unbalanced hydrostatic forces are negligible for mooring design purposes.

5.2.4.3.1 *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)

Figure 5-1 shows the fetch, which is approximately 2.3 miles to the southeast of the Detroit Dam.

Figure 5-1 - Fetch Distance to Detroit Dam

5.2.4.3.2 ***Current***

Current forces are generated in the reservoir due to dam operations, including flow over the spillway and through the penstocks. A far-field dynamic computational fluid dynamics (CFD) model was constructed to generate hydrodynamic current forces on the FSS for the case of a ballasted FSS with the dam spilling. For a deballasted FSS, it will be assumed that current forces are 15% of the current on the ballasted FSS.

Figure 5-2 below shows the approximate distribution of current forces on the FSS. Forces on each face act to pull the FSS towards the dam and away from the shore.

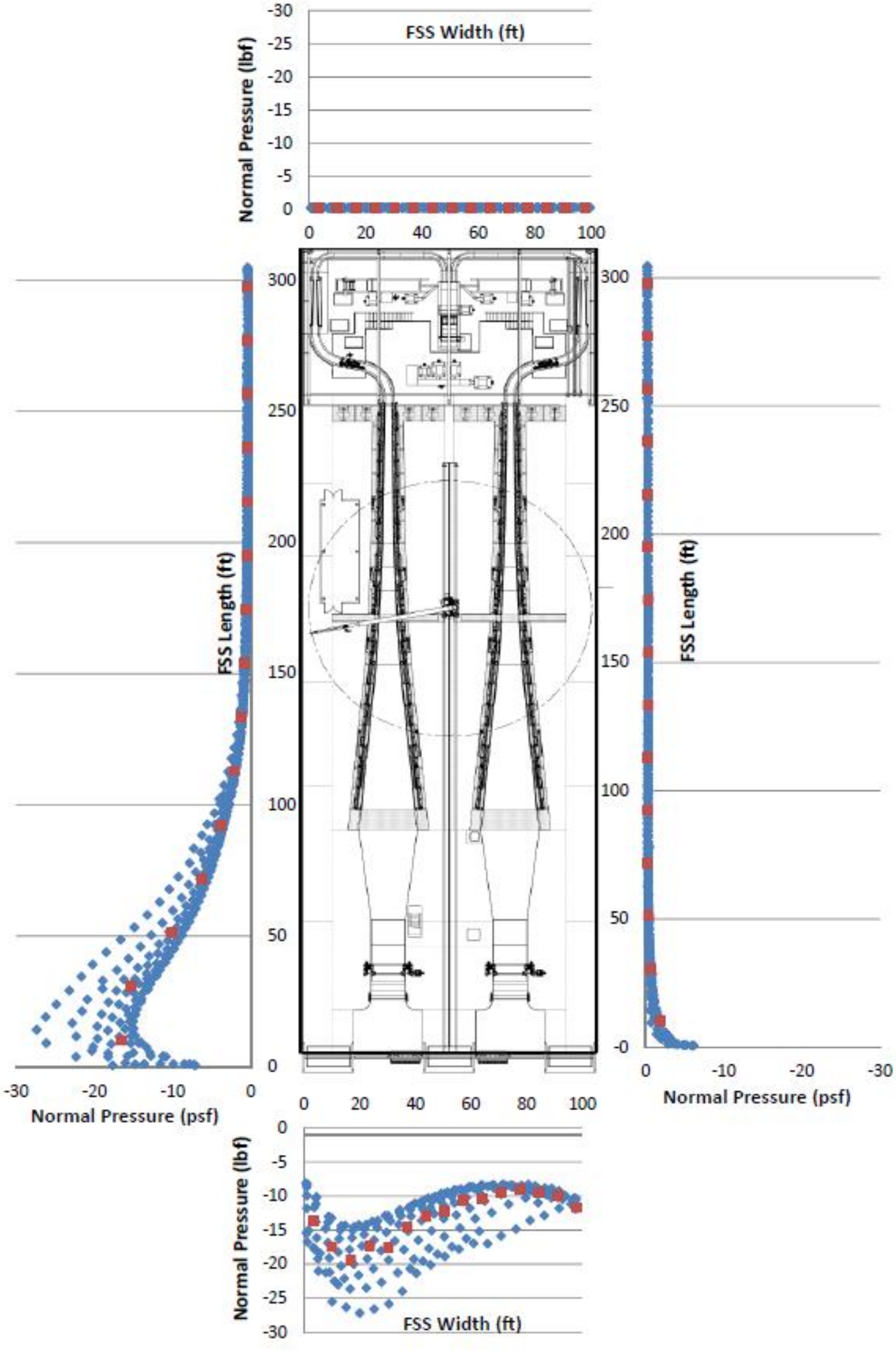

Figure 5-2 - Distribution of Hydrodynamic Current Forces on Each Surface of the FSS (Not to scale)

5.2.4.3.3 *Suction and Momentum Change*

An analysis is conducted in the Appendix F 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 determine if these loads are or are not significant as they could influence the mooring geometry and design. A maximum flow through the FSS of 5,600 cfs is assumed. The thrust forces on the FSS due to momentum changes are much greater than the operational environmental loads on the FSS and must be considered in the mooring design analysis.

5.2.5 Environmental Load Cases

The following logical load cases are developed to determine the worst-case design scenario for the FSS mooring system:

1) Operating Load Case 1: FSS ballasted and operating with Usual winds from the east.
2) Operating Load Case 2: FSS ballasted and operating with Usual winds from the southeast.
3) Survival Load Case No. 1: FSS deballasted, dam spilling, Unusual winds from the east.
4) Survival Load Case No. 2: FSS ballasted, dam spilling, Unusual winds from the east.
5) Survival Load Case No. 3: FSS deballasted, dam spilling, Unusual winds from the south.
6) Survival Load Case No. 4: FSS deballasted, Unusual winds from the west.
7) Survival Load Case No. 5: FSS deballasted, dam spilling, Unusual winds from the southeast.

5.2.6 Model Results and Discussion

The mooring system was analyzed using RISA-3D structural analysis software under each environmental load case. Pile deflection, stress, and uplift results are of primary interest. Uplift refers to a tensile reaction at the base of the pile resisting overturning on the dolphin. The largest pile stress results from survival load case 1, where pile 1A reaches 81% of its code capacity. A summary of important results is listed in the table below.

Table 5-3 - Load Case Results Summary

Load Case	Steel Code Unity Check for Member with Highest Stress	Member with Highest Stress	Maximum Deflection (inches)	Maximum Deflection Direction	Maximum Pile Uplift (kips)	Pile With Maximum Uplift
Operating LC1	0.333	Pile 1C	4.8	SW	38	4C
Operating LC2	0.341	Pile 1C	4.9	SW	41	4C
Survival LC1	0.861	Pile 1A	7.0	W	485	1D
Survival LC2	0.621	Pile 1A	5.5	SW	212	1D
Survival LC3	0.312	Pile 1B	3.0	N	0	N/A
Survival LC4	0.917	Pile 1D	9.4	E	486	1A
Survival LC5	0.673	Pile 1A	5.4	NW	279	1D
Seismic MCE	0.309	Frame	4.3	N-S	N/A	N/A

To deal with relatively high loads at elevations exceeding 350 feet above the mudline, it was necessary to design the mooring towers using 48-inch diameter X 1-inch wall steel pilings and space framing employing bolted 10”X10”X0.291” HSS tubing down to about 60 feet above the mudline. Dolphin 1, being over 340 feet tall required 1.5-inch wall 48-inch piles to meet codes for all scenarios.

The size of the piles and the wall thicknesses are primarily driven by the need for the FSS to be de-ballasted at high pool during an extreme wind event. If operations could be restricted to require ballasting down during an extreme wind event at high pool, then the piles diameters and wall thicknesses could be reduced. At this time, those operational constraints were deemed unreasonable and so these extreme wind cases are incorporated in the design.

The tall profiles of the mooring towers cause the use of internal concrete to be much less feasible. The framing members would need to be upsized to avoid failure in a seismic event due to the high mass of the structure and its inverted pendulum shape. This additional mass will further increase the seismic base shear, thus there is little advantage to be gained and there would be an increased risk of failure. Additionally, the pumping of concrete into a 340-foot tall pile, underwater at about 10 atmospheres will be time consuming, technically difficult and expensive. The seismic issues triggered by the high weight present a technical challenge that appears to outweigh any potential benefit.

The current strategy will employ post-tensioned anchoring to deal with uplift forces.

Other strategies that may be used for uplift resistance are strand tendon anchors, or concrete or grout fill. As discussed earlier, concrete fill has not been employed due to seismic concerns, but it may be a solution in a different design iteration.

5.3 Fish Handling Facility Pre-Engineered Metal Building Design

5.3.1 Architectural

The Fish Handling Facility (FHF) located at the North end of the FSS is proposed to be enclosed using a Pre-Engineered Metal Building (PEMB). Primary and secondary framing will be hot-dipped galvanized with exterior paint and finish to reflect the final painting schedule of the FSS. Paint and finish of the building shall limit the reflection of light and heat onto the deck of the FSS. The building will have a prefinished standing seam metal roof and metal wall panels. Roof and walls will be insulated. The building will house a moveable traveling bridge crane which will be supported on the PEMB columns. Man doors will be located on the south side of the building. A large sliding door will also be located on the south side of the building in the east corner. A proposed slope of ¼” per foot will be used to drain water from the roof toward the north end of the FSS. Plans and sections illustrating the FHF PEMB, with preliminary dimensions and member sizes, are located in Appendix F, Plates S-20 and S-22.

5.3.2 Design Standards and References

The architectural design will conform to the following Codes and Standards.

- The 2017 State of Oregon Electrical Specialty Code (OESC)
- The 2017 State of Oregon Plumbing Specialty Code (OPSC)
- The 2014 State of Oregon Mechanical Specialty Code (OMSC)
- The 2017 State of Oregon Energy Efficiency Specialty Code (OEESC)
- All applicable Code referenced standards

Codes and Standards for heating, ventilation, and air conditioning (HVAC) are provided in Section 6.8.

5.3.3 Structural Design

The PEMB will be enclosed with the primary structural framing composed of steel rigid frames. Secondary framing will consist of cold-formed or hot rolled steel shapes. All structural steel members will be hot-dipped galvanized. Primary frames will be rigid frames with pinned bases. Lateral resistance perpendicular to the primary frames will be provided by cross-bracing.

Design Standards and References

The structural design will conform to the following Codes and Standards.

- ASCE 7-10
- The 2017 State of Oregon Structural Specialty Code (OSSC)
- All applicable referenced standards
- AISC 360-10, Specification for Structural Steel Buildings, American Institute of Steel Construction
- AISC, Steel Design Guide Series 3, Serviceability Design Considerations for Low-Rise Buildings, Second Edition, 2003
- MBMA, Metal Building Systems Manual, Metal Building Manufacturers Association
- AWS D1.1 Structural Welding Code, American Welding Society (AWS), 2010
- Structural Engineers Association of Oregon, 2007, Snow Load Analysis for Oregon

5.3.4 Design Loads and Load Combinations

The following design loads are considered applicable to the building for structural analysis and design:

Dead Loads - Self weight of the structure.

Super-Imposed Dead Loads - Additional dead load resulting from the weight of ceiling loads, suspended mechanical equipment, electrical equipment, plumbing, and cranes will be applied to the structure as required.

Live Loads – Applicable minimum uniformly-distributed live loads and minimum concentrated live loads will be used for structural design as given the Building Code.

Wind Loads – Applicable wind design loads as given in the Building Code and ASCE 7-10 will be used. Wind loading data for a Risk Category II structure located at Detroit Dam, Oregon is as follows:

Wind Speed, V =	115 mph
Wind Importance Factor, I_W =	1.0
Exposure Category =	D
Topographic Factor, K_{ZT} =	1.0

Seismic Loads – Not applicable.

Snow Loads – Roof snow loading will be as determined by the State of Oregon Structural Specialty Code and ASCE 7-10. Snow load design data for a Risk Category II structure located at Detroit Dam, Oregon is as follows:

Ground Snow Load, p_g =	28 psf
Wind Importance Factor, I_s =	1.0
Exposure Factor, C_e =	0.90
Thermal Factor, C_t =	1.2
Flat Roof Snow Load =	21.17 psf

Design load combinations shall be applied per ASCE 7-10.

5.4 Electrical and MCC Buildings

5.4.1 Architectural

The Electrical and MCC buildings are proposed to be pre-engineered self-framing structures. Primary and secondary framing will be hot-dipped galvanized with exterior paint and finish to reflect the final painting schedule of the FSS. Paint and finish of the building shall limit the reflection of light and heat onto the deck of the FSS. Roofs and walls will be insulated. Man doors will be located on both buildings. A proposed slope of ¼” per foot will be used to drain water from the roofs.

5.4.2 Design Standards and References

The architectural and structural design will conform to the following Codes and Standards.

- The 2017 State of Oregon Electrical Specialty Code (OESC)
- The 2017 State of Oregon Plumbing Specialty Code (OPSC)
- The 2014 State of Oregon Mechanical Specialty Code (OMSC)
- The 2017 State of Oregon Energy Efficiency Specialty Code (OEESC)
- All applicable Code referenced standards

Codes and Standards for heating, ventilation, and air conditioning (HVAC) are provided in Section 6.8.

5.4.3 Structural Design

The Electrical and MCC buildings will be self-supporting structures using wall and roof panels made of corrugated steel and light gauge metal framing. All structural steel will be hot-dipped galvanized and finish coat painted.

Design Standards and References

The structural design will conform to the following Codes and Standards.

- ASCE 7-10
- The 2017 State of Oregon Structural Specialty Code (OSSC)
- All applicable referenced standards
- AISC 360-10, Specification for Structural Steel Buildings, American Institute of Steel Construction
- AISC, Steel Design Guide Series 3, Serviceability Design Considerations for Low-Rise Buildings, Second Edition, 2003
- MBMA, Metal Building Systems Manual, Metal Building Manufacturers Association
- AWS D1.1 Structural Welding Code, American Welding Society (AWS), 2010
- Structural Engineers Association of Oregon, 2007, Snow Load Analysis for Oregon

5.4.4 Design Loads and Load Combinations

The following design loads are considered applicable to the building for structural analysis and design:

Dead Loads - Self weight of the structure.

Super-Imposed Dead Loads - Additional dead load resulting from the weight of ceiling loads, suspended mechanical equipment, electrical equipment, plumbing, and cranes will be applied to the structure as required.

Live Loads – Applicable minimum uniformly-distributed live loads and minimum concentrated live loads will be used for structural design as given the Building Code.

Wind Loads – Applicable wind design loads as given in the Building Code and ASCE 7-10 will be used. Wind loading data for a Risk Category II structure located at Detroit Dam, Oregon is as follows:

Wind Speed, V =	115 mph
Wind Importance Factor, I_W =	1.0
Exposure Category =	D
Topographic Factor, K_{ZT} =	1.0

Seismic Loads – Not applicable.

Snow Loads – Roof snow loading will be as determined by the State of Oregon Structural Specialty Code and ASCE 7-10. Snow load design data for a Risk Category II structure located at Detroit Dam, Oregon is as follows:

Ground Snow Load, p_g =	28 psf
Wind Importance Factor, I_s =	1.0
Exposure Factor, C_e =	0.90
Thermal Factor, C_t =	1.2
Flat Roof Snow Load =	21.17 psf

Design load combinations shall be applied per ASCE 7-10.

6 MECHANICAL DESIGN

6.1 General

The major mechanical components on the Detroit Floating Screen Structure include the attraction flow pumps, elliptical weir operators, cranes and hoists for handling equipment onboard the FSS, Trashrack cleaner, ballasting and trim systems, dewatering screen backwash cleaners, traveling screens, assorted fish handling equipment, and HVAC. This section discusses the primary features and functions of this equipment as well as the design criteria and assumptions used in development of the design of this equipment.

All mechanical equipment will be designed to operate year-round in the environmental conditions expected at Detroit Dam. The expected climactic variance was obtained from the Western Regional Climate Center (https://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?or2292), Detroit, Oregon.

- Detroit Dam, dataset 1892-2012
- Extreme recorded maximum temperature: 107 Degrees F
- Extreme minimum recorded temperature: 5 Degrees F

Equipment that requires heating or ventilation to operate satisfactorily at these extremes will be so equipped.

6.2 Seismic Considerations for Mechanical Equipment

Seismic loads are not transmitted to mechanical equipment via structures floating on water in the same manner or magnitude that they are for structures founded on land. Seismic considerations required for mechanical equipment on land-based structures does not apply for mechanical equipment on-board the FSS given that the structure is floating in a reservoir.

6.3 Attraction Flow Pumps

6.3.1 General

Provisions are 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, or the surface component of the power flow is inadequate for fish attraction. These pumps will be added at the discretion of USACE, should pumped flow be necessary. Based on the hydraulic design criteria presented in Section 4, the attraction flow pumps shall be capable of collectively drawing 1,000 cfs through the FSS entrance, dewatering screens, and plenum. Preliminary modeling of the collector hydraulics estimates that the static pumping head will be approximately 1.2 feet.

When there is inadequate, or no flow drawn through the FSS into the SWS, pumping may be required to maintain fish attraction. To achieve the desired flow the pumps will provide sufficient driving head to pull flow through the FSS. 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 is minimal and is described with greater detail in Section 4.6.4. The largest anticipated need for pump head is due to losses across the entrance weirs, through the fish screens and porosity control baffles, and in discharge from the pumps back into the reservoir through the diffuser panels. Cones are added to the discharge end of the pumps to reduce headloss back to the diffusion chamber. Openings in the diffuser porosity plates are preliminarily sized to limit additional head losses to less than 6 inches (refer to Section 6.3.5 for diffusion system details).

Based on the hydraulic calculations and consideration for minor and major pumping losses, the total dynamic pumping head (TDH) envisioned is approximately 3.5 feet.

6.3.2 References for Attraction Flow Pumping Plant Design

The design of the attraction flow pumps is based on 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 Pumping Alternatives Analysis

An alternatives analysis was conducted to evaluate tradeoffs between different pumping strategies and to identify a pump type best suited for attraction flow at the facility. Horizontal mixer pumps, vertical turbine pumps, and axial flow pumps (enclosed style) were compared for the number of pumps needed, pump availability, pump weight, pump flow and head, pump efficiency, and lifecycle cost (includes capital, energy, and maintenance costs). Attraction pump operation will be performed with on-off service; therefore, variable frequency drives (VFDs) for the attraction pumps were not considered.

6.3.3.1 Number of Pumps

When determining the number of pumps needed to best attain the total flow requirements, consideration was given to providing the best compromise between lifecycle cost, spatial requirements, maintenance, and reliability. With limited space available within the FSS, ten pumps or less was preferred.

6.3.3.2 Pump Availability

Off-the-shelf pumps were evaluated more favorably than custom pumps as off-the-shelf pumps allow for quick procurement of replacement parts and have better maintenance support. However, the pumping requirements for this facility are unique compared to those of other pumping facilities, therefore custom pumps were considered, but evaluated with more scrutiny based upon their ability to meet the performance and maintenance requirements of the facility.

6.3.3.3 Pump Size and Weight

The size and weight of each of the three pump types is presented in Table 6-1. The vertical turbine and axial flow pumps are significantly larger and heavier than the Flygt mixer pumps.

6.3.3.4 Pump Head

Vertical turbine pumps are typically used when the pumping head is within the range of 20 to 80 feet with maximum values above 100 feet. 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, VFDs or a control valve would be required for each pump to slow the pump motors or 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. Use of vertical turbine pumps would result in additional power costs versus the other considered pump types in order to pump against the increased head.

6.3.3.5 Pump Efficiency

The pump efficiency shown in Table 6-1 shows a lower efficiency for the mixer pumps than the other two pump alternatives. However, it is difficult to make a direct comparison of pump efficiency between the three pump alternatives as both the vertical turbine and axial flow pumps were unable to meet the target design head of 2 to 4 feet. These pumps would need to have a valve installed in order to maintain operation on their pump curves. The head loss across the valves would result in pump efficiency losses.

6.3.3.6 Costs

Total capital cost, price per pump, and power cost per hour are provided in Table 6-1 for each of the pump types. Mixer pumps are significantly lower in both capital and operational costs than the other two alternatives.

6.3.3.7 Results of Pump Alternative Analysis

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. These types of pumps are used on numerous existing forebay collectors and have a proven operational and maintenance record for this type of application. Preliminary pump selection data and calculations to support this conclusion are provided in Appendix G, and in Table 6-1 below. A comparison of advantages and disadvantages of each pump type is provided in Table 6-2.

Table 6-1 – Summary of Pumping Alternatives

Design Alternative		Alternative 1	Alternative 2	Alternative 3
Pump Manufacturer / Model		Flygt Mixer 4680[4]	Peerless Vertical Turbine 54PL	Goulds Axial Flow 54x54-54
Design Head	ft	2	6	4
Capital Cost	-	$1,560,000	$2,800,000	$4,800,000
Price per Pump[1]	-	$60,000	$350,000	$600,000
Power Cost per Hour	$/hr	$18.60	36.68	$30.80
Number of Pumps	-	16	7	7
Spare Pumps	-	1	1	1
Flow per Pump	cfs	65	150	150
Pump TDH	ft	2	8	6
Eff. at Design Head[2]	-	45%	65%	68%
Pump Nameplate Power	hp	40	200	200
Pump Weight	lbs/ea	1,200	26,000	30,000
Pump Size (L x W x H)[3]	ft	4.5 x 3.5 x 6	20 x 8 x 6	26 x 5 x 9
Discharge Diameter	in	30	54	54

[1]Includes pump, motor, rails (mixer only), throttling valve, and baseplates. Does not include VFDs, starters, controls, or electrical equipment.

[2]Pump and motor efficiency.

[3]General size. See pump detail sheets for detailed dimensions.

[4] Flygt Mixer 4680 performance information from operational data at the North Fork FSC owned by Portland General Electric.

Table 6-2 - Pump Type Advantages and Disadvantages

Pump Type	Advantages	Disadvantages
Horizontal Mixer	• Used for Low head, High flow applications • Low capital costs • Significantly lower horsepower and low power costs per hour. • Most common type of pump used on similar FSC and FSS facilities. • Proven performance and maintenance record for this application. • Very easy access through quick connect rail system.	• High number of pumps for current Flygt models available

Pump Type	Advantages	Disadvantages
Vertical Turbine	• Low number of pumps • High flow models available.	• TDH is outside of targeted range of 2 to 4 feet. • A flow valve would be needed to provide artificial head. Pumping against the increased head would increase power costs. • High capital costs. • High horsepower and high power costs per hour.
Axial Flow (Enclosed-style)	• Low number of pumps • High flow models available.	• High capital costs • High horsepower and high power costs per hour. • High pump arrangement complexity

As noted in Section 6.3.3.4 and in Table 6-2 above, the vertical turbine pump is not a good fit for this application because the typical TDH for these pumps is higher than our target TDH of 2 to 4 feet; artificially induced headloss via a control valve or throttling using a VFD would be required to achieve flow and efficiency targets. For this reason and because of the high costs, the vertical turbine pumps were removed from consideration.

The enclosed-style axial flow pump alternative was eliminated from consideration due to the high cost as well as complexity of the pumping arrangement in relation to the mixer-style axial flow pumps.

6.3.4 Attraction Pump Design

6.3.4.1 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 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, and Submersible Power Cable

Flygt mixer pumps have been used successfully at several existing floating structures, including the USACE's Cougar FFC, Puget Sound Energy's (PSE) two Baker River Project floating surface collectors (FSCs), PacifiCorp's Swift FSC, and Portland General Electric's (PGE) North Fork FSC. Based on experience with the design and use of these pumps on other floating surface collector 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.

6.3.4.2 Pump Selection and design criteria

The primary disadvantage of the horizontal mixer pumps evaluated during the alternatives analysis was the high number of pumps that would be required. Discussions with Flygt, indicated that the largest standard pump they offered of the mixer type was the PP-4680 series, which would pass approximately 50 to 60 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 and the Rocky Reach Fish Collector on the Columbia River.

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 approximately 2 to 3 feet of TDH was evaluated. With a minimum required total pumping rate of 1,000 cfs, only eight pumps would be needed to achieve the desired attraction flow. 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 in the same way the Fish Transport Pods are removed from the FSS.

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 6-3. These characteristics are representative of Flygt's estimated design of 125 cfs pumps.

Table 6-3 - Estimated Mixer Pump Physical Characteristics

Pump Characteristic	Value
Impeller Diameter	43 inches
Bell Diameter	48 inches
Unit Length	5.5 ft
Motor Size	100 HP
Unit Weight, Including Guide Rails	3,000 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 6-4, as derived from the Hydraulic Institute calculations.

Table 6-4 - 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
Minimum Bay Width	6 ft 3 in
Design Bay Width	8 ft 1.5 in
Bay Training Wall Length	18 ft
Bay Water Velocity at 125 cfs	0.6 ft/s
Minimum Required Submergence	15 ft
Assumed Submergence	27 ft
Discharge Cone Diameter	3 ft 7 in increasing to 6 ft 7 in
Discharge Cone Length	19 ft 10 in

Based on a total of 8 pumps, a bay width of 8'-1.5", and allowance for training wall thickness, the required width is approximately 70 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). TDH with the discharge cones has been evaluated to be approximately 3.5 feet; without the discharge cones it would be approximately 6 feet. 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 6-2.

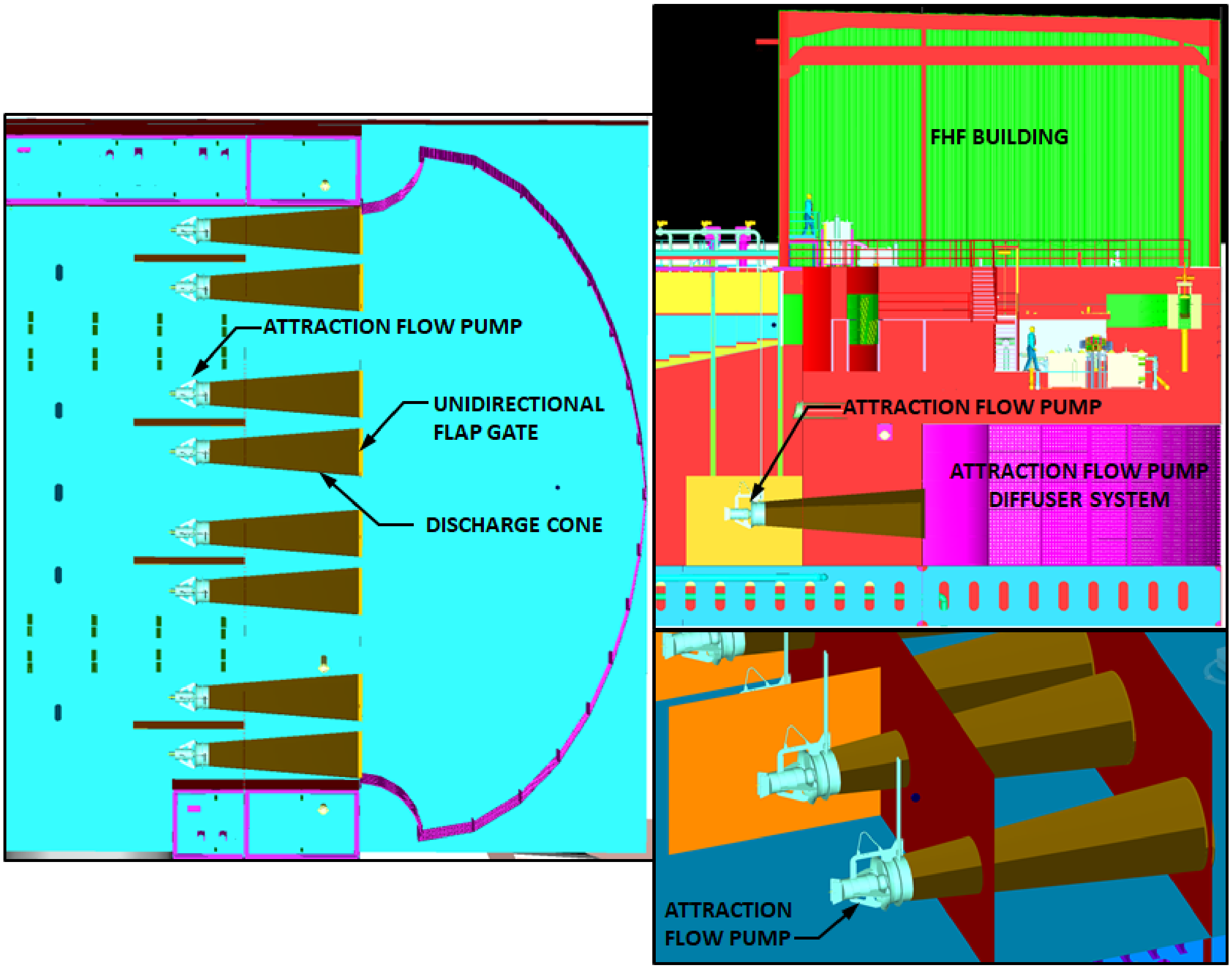

Figure 6-2 - Plan (left), Section (top right), and oblique (bottom right) layout of Optional Attraction Flow Pumping Arrangement

6.3.5 Attraction Pump Diffuser System Design

6.3.5.1 Diffuser System Layout Alternatives

The objective of the diffuser system for the attraction water pumps is to maintain currents within the reservoir that are favorable to fish attraction and thermal stratification. This is achieved by slowing and diffusing the flow jets originating from the attraction flow pumps before they enter the reservoir and reducing the influence that pump discharges have on reservoir circulation patterns. Through a series of near field CFD modeling runs, it was determined that uniformly distributed flow velocities discharged across an elliptically shaped array of porosity panels configured on the stern of the FSS (under the FHF) could achieve this goal. Three potential options were examined during the initial formulation of the diffuser system arrangements. A brief description of each is provided in the following list:

1) **Circular and Straight Layout**: One option consisted of a single line of porosity panels consisting of adjustable, perforated porosity plate attached to structural framing. The porosity of each panel is manually adjustable to allow operators to refine the hydraulic discharge conditions as the water passes into the reservoir. The panels are arranged in half circles on the port and starboard sides, meeting at a 40 foot long straight section of porosity panels at the center, aft end of the FSS.
2) **Elliptical Pump Chamber Layout**: The second diffuser system option consists of a single line of porosity panels with fixed, perforated porosity plates attached to structural framing. Porosity panels are arranged in an elliptical shape running port to starboard, bending in the aft direction. Full height, solid steel walls from the wall at the discharge end of the attraction pump discharge cones to the porosity panels separate each pair of pumps into pump chambers. The porosity of each panel is not adjustable. Variable speed drives (VFDs) would be provided on the attraction water pumps to allow for adjustment of the flow between each of the four pump chambers, allowing operators to reduce or eliminate adverse flow patterns in the reservoir produced by non-uniform flow distribution across the porosity panels.
3) **Elliptical Layout:** The third diffuser system option considered consists of a single line of porosity panels consisting of fixed, perforated porosity plate attached to structural framing. Porosity panels are arranged in an elliptical shape running port to starboard, bending in the aft direction. Flow from all the pumps enters the same single chamber and is diffused through the porosity panels into the reservoir. The intent of this layout is that the porosity of the panels is low enough to produce uniform outflow across the face of all the porosity panels without inducing a headloss detrimental to attraction pump operation.

Given that each of the options followed the primary strategy of providing uniform, radial diffusion from an elliptical array of porosity panels, selection of the diffuser system layout was based on two primary requirements: 1) simplicity of operation and 2) impact to headloss imparted on the fish attraction flow pumps. Given these objectives, the single set of fixed porosity plate panels (third option considered) was determined to provide the simplest operation and low fabrication complexity. The near-field CFD modeling also suggests that the backpressure imparted on the attraction flow pumps would be equivalent to 3 to 6-inches of hydraulic head. A more thorough description of the selected option is provided below.

6.3.5.2 Diffuser System Layout

The selected diffuser system is located downstream of the discharge cones for the attraction water pumps. The system consists of 16 perforated porosity plate panels arranged in an elliptical shape as well as 2 wall panels arranged in quarter circle shapes adjacent to the port and starboard attraction pump cones (see Plate M-082; Figure 6-3). The panels are located in the space between the belly tanks and lower deck below the FHF.

Each porosity panel contains a stainless steel perforated porosity plate roughly 18’-10” high by 8’-0” wide. Structural framing for each porosity panel consisting of stainless steel rectangular tubes and angles support each porosity plate. The plate is held to the framing by stainless steel flat bars on the downstream face of the plate that are bolted through the panel, to angles on the back (upstream) side, as shown in Plate M-083. The framing, flat bars, and porosity plate make up the porosity panels.

Each wall panel contains a solid stainless steel plate roughly 18’-10” high by 15’-8” wide. Structural framing for each wall panel consisting of stainless steel rectangular tubes and angles support the wall plate. The plate is bent to create a quarter circle in five (5) vertical sections of equal width. Framing behind the plate is angled in five (5) sections to support the plate through its bends. The plate is bolted to the tubes and angles of the framing.

Each porosity and wall panel is held in place in the space above the belly tanks by steel angles that are welded to the belly tanks and under-side of the FHF deck. The porosity and wall panel frames are bolted to the angles on the belly tanks and under-side of the FHF deck.

The framing for the porosity and wall panels are designed for the range of hydraulic conditions the plates will experience during normal operation of the attraction water pumps. During ballasting and de-ballasting of the FSS, it is assumed that water will pass through the holes in the porosity plate quickly enough such that there is negligible head differential across the panels. Holes will be added to the wall panels during final design to provide adequate space for water behind the wall panels to drain without inducing a head differential greater than what will be encountered during normal operation. The manufacturer of the porosity and wall panels and the construction contractor must provide temporary support for each panel during transport and installation as the panels will warp and permanently deform when raised and lowered if additional temporary support is not provided.

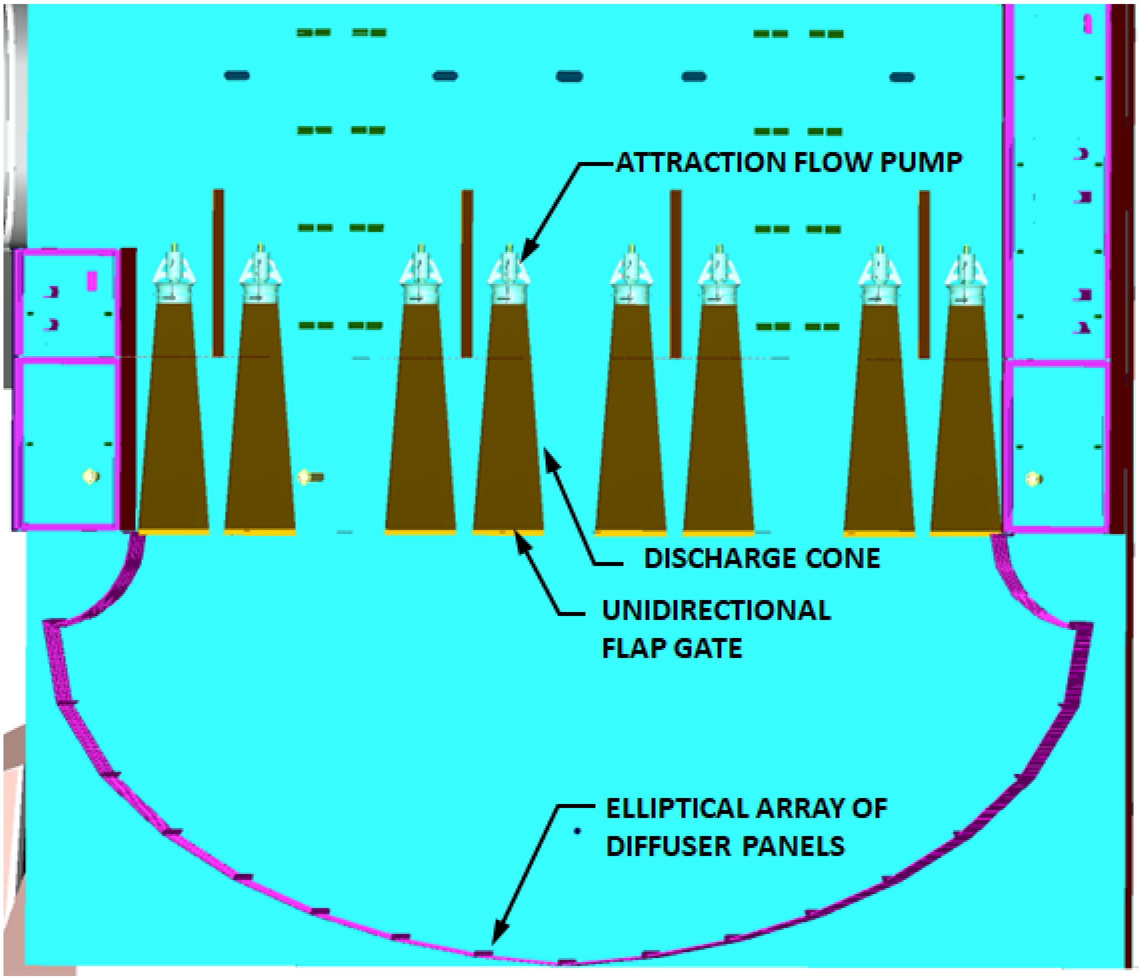

Figure 6-3: Plan View of Elliptical Diffuser System Arrangement.

6.3.5.3 Diffuser System Hydraulic Analysis

Of the three diffuser system layouts presented, the elliptical shape was the best hydraulic shape to diffuse the jets from the pumps before the water entered the reservoir. Solid walls in quarter-circle shapes were added in the upstream port and starboard corners to smooth and redirect the jets from the port and starboard pumps, improving the potential for uniform diffusion across the ellipse. CFD modeling of the proposed diffuser layout was conducted to assess the performance of the selected diffuser option. The model was run for a variety of panel porosities. Initial results determined that a 15.3% porosity produced the most favorable hydraulic conditions and resulted in a headloss of four (4) inches across the panel. Four inches of headloss is determined to be well within the operating range for the attraction water pumps.

The CFD model shows how the elliptical porosity panel array provides some dissipation of the flow jets from the attraction water pumps and more evenly distributes it across the ellipse. However, as shown in Figure 6-4, flow is still concentrated along the centerline of the FSS into the reservoir, albeit at lesser velocity than at the outlet of the discharge cones. Initial CFD modeling results also indicate that there may be “hot spots,” or areas of greater velocity at the port and starboard sections of the ellipse. As shown in Figure 6-5, the higher more concentrated velocities are nearly twice the magnitude of the velocity at the center of the ellipse (centerline of the FSS).

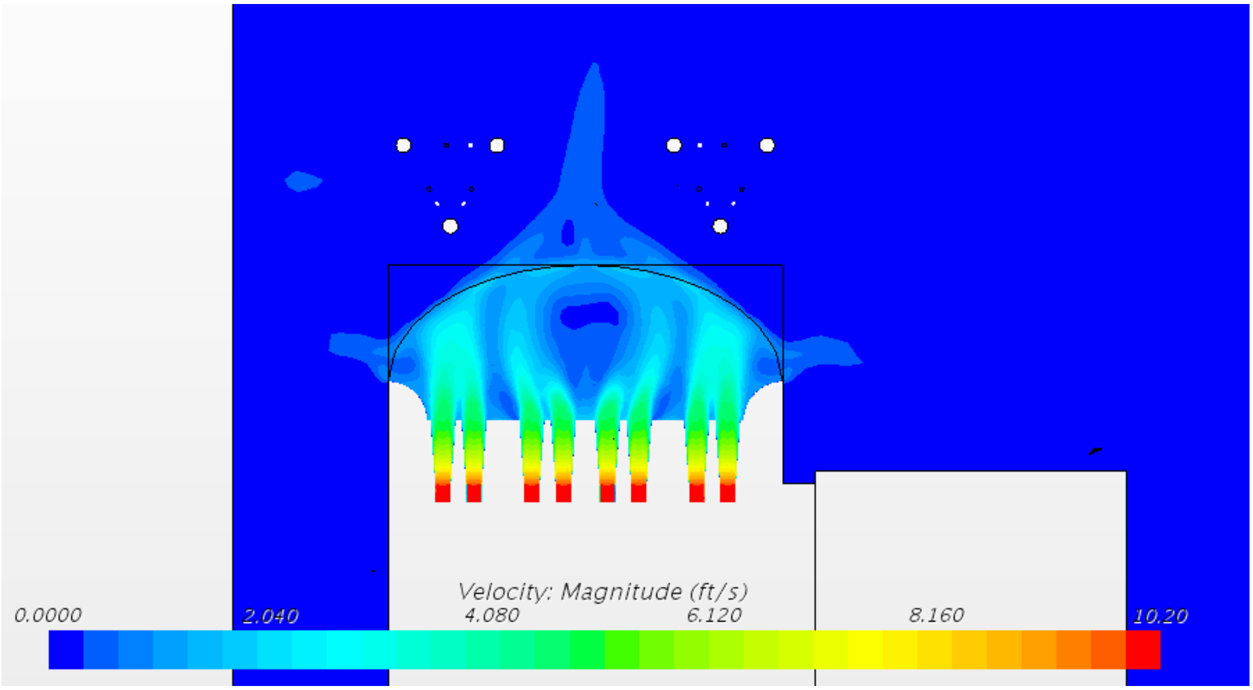

Figure 6-4: Plan View of Flow Velocity Heat Map Showing Pumped Discharge Through the Diffuser System

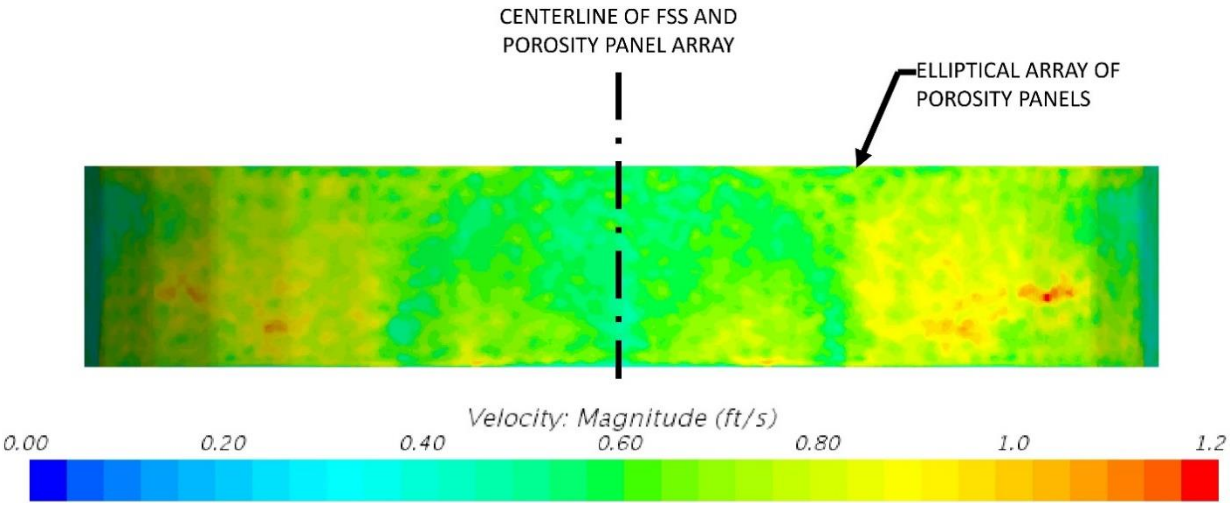

Figure 6-5: Heat Map of Exit Velocities at Face of Elliptical Porosity Panel

CFD modeling results also indicate that there will be a strong vertical component to the flow exiting the elliptical porosity panel array. Figure 6-6 provides a small scale perspective of the velocity vectors as flow exits the pump cones and passes through the elliptical porosity panel array and into the reservoir. Figure 6-7 shows the velocity vectors in a larger scale perspective of the reservoir. The dominant vectors through the diffuser panels have an upward trajectory towards the surface of the reservoir and are not currently anticipated to disrupt the thermocline. Additional CFD or physical modeling is recommended prior to final design to further investigate the risk of destabilizing thermal stratification in the reservoir.

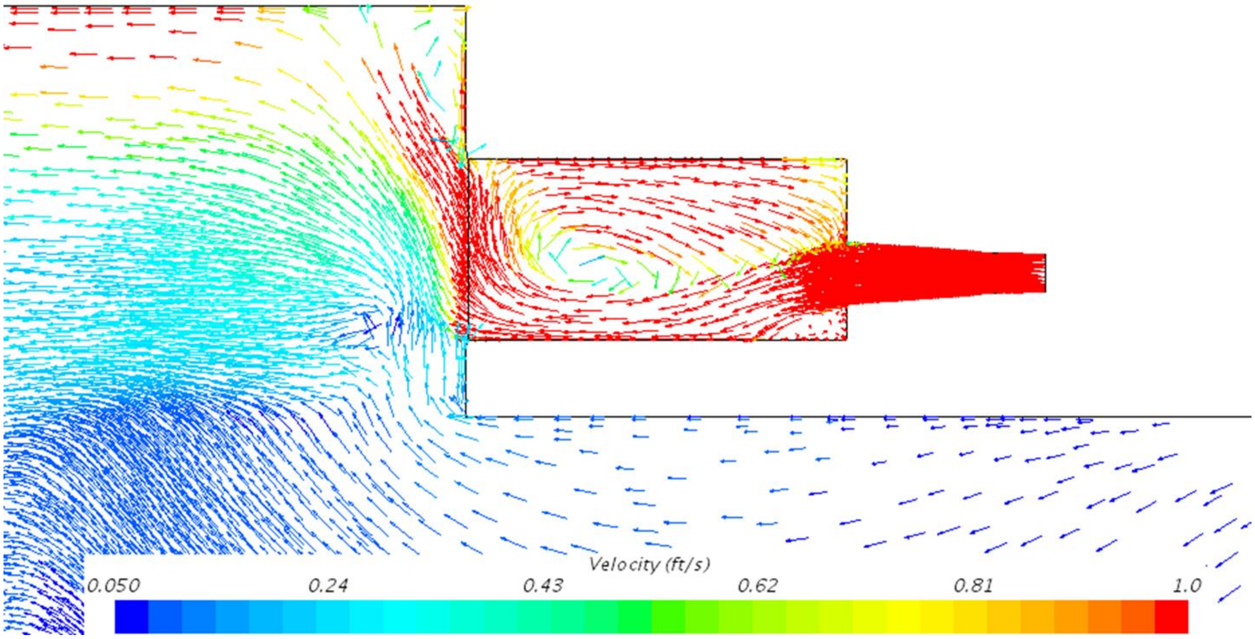

Figure 6-6 - Elevation View along the Centerline of the Center Pump Showing Velocity Vectors Within the Elliptical Diffusion Panel Array and the Adjacent Reservoir (Smaller Scale).

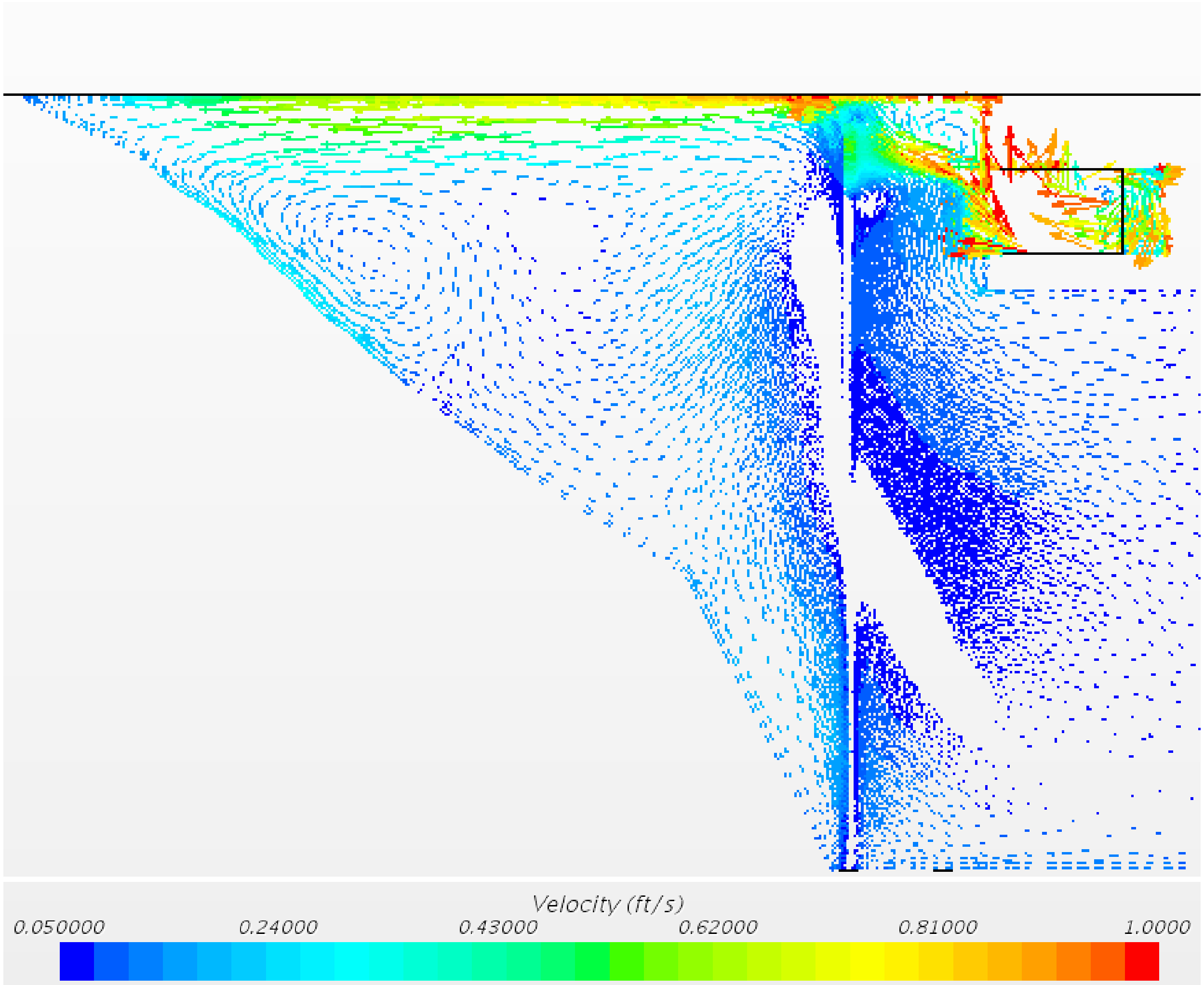

Figure 6-7 - Elevation View Along the Centerline of the Center Pump Showing Velocity Vectors within the Elliptical Diffusion Panel Array and the Adjacent Reservoir (Larger Scale)

From a larger-scale perspective, the CFD modeling results provide indications that attraction flow discharge through the diffuser system will produce reservoir flow patterns different from those that occur during non-pumped operation which may have some level of influence on fish attraction to the FSS. As shown in Figure 6-8 the modeling results suggest that an upstream oriented velocity current may develop along the right bank of the shoreline. If this current were to develop, fish may experience flow conditions in the reservoir that could result in disorientation and milling behavior as they attempt to pass downstream out of the reservoir. Additional refinement and modeling of the diffuser system in future design phases is recommended to resolve this potential condition. See Appendix D for a more detailed description of the modeling methods and results.

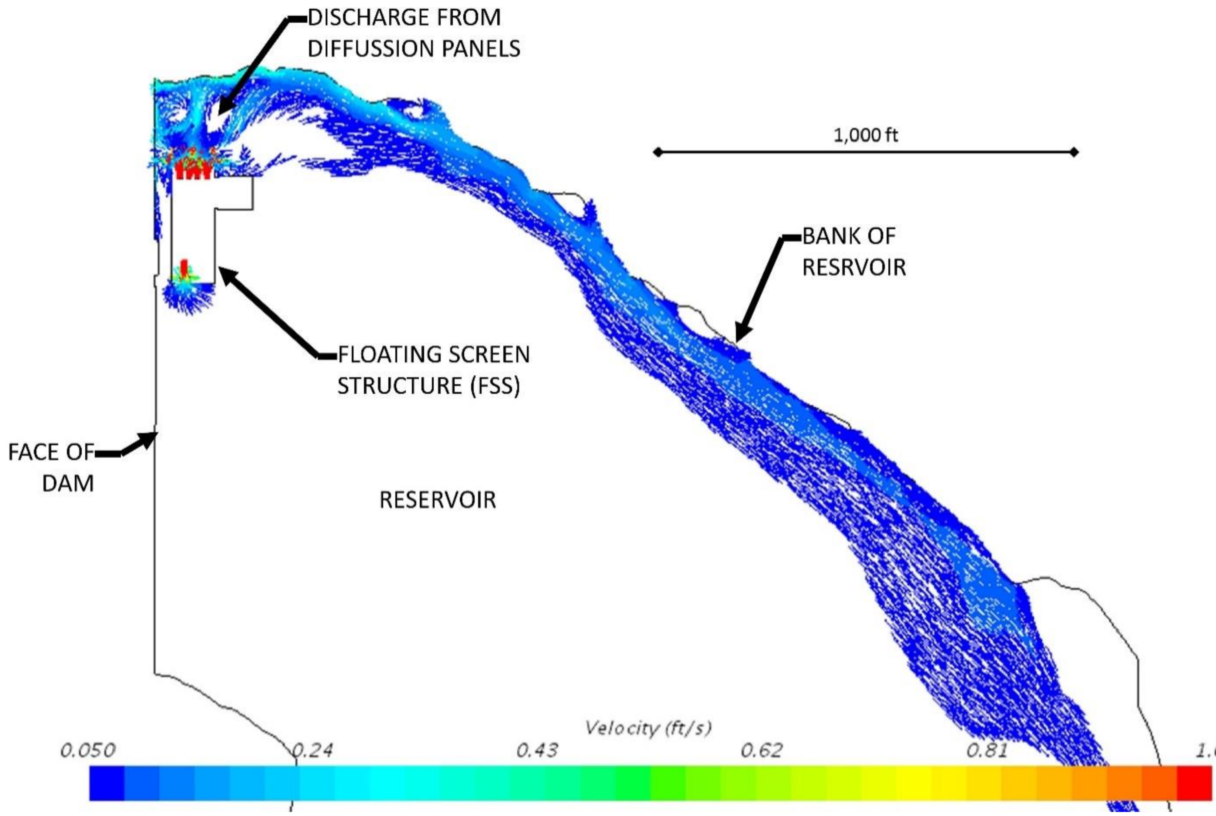

Figure 6-8 - Larger Scale Plan View of Reservoir Flow Patterns during Attraction Pump Operation

6.4 FHF Pumps

6.4.1 FHF Sump Pumps

A common FHF drain sump is planned for drainage collection from both the port and starboard sides of the FHF facility. The sump will be supplied with four submersible pumps (2 standby, 2 duty) that will pump flow from the sump to outlets in the dewatering tanks. Each pump will be sized for 1,250 gpm at 10' TDH. The sump pumps will be controlled on VFDs to compensate for the flow variation coming into the sumps and to maintain water level in the sump. Water level will be monitored in the sump and provided to the facility PLC, which will control the sump pumps to maintain a water level with adequate pump submergence and initiate alarms if the water level rises above a preset value. The FHF sump pump sizing and design criteria is provided in Table 6-5 below.

Table 6-5 – FHF Sump Pump Sizing and Design Criteria

Pump Characteristic	Value
Flow per Pump	1,250 gpm
Number of Pumps	4
Pump Type	Submersible
Drive Type	VFD

Pump Characteristic	Value
Motor Size	5.5 HP
Unit Weight, Including Guide Rails	300 lbs

The FHF sump pumps will need to have backup power supplied by the emergency generator system in the event of a power outage.

6.4.2 FHF Flow Return Pumps

The flow return pumps are needed to pass flow from the two dewatering tanks on the port and starboard sides of the FHF facility and return it to the plenum. This flow is a combination of flow from the traveling dewatering screens and the drain sump pumps (which includes flow from the ramp weir screens, pod circulation flows, adult tank circulation flow, and any other dewatering of the fish flume flows). In this way it as a closed system where all flow that enters the FHF from the FSS screen channels is cycled through the dewatering tanks and pumped back to the FSS plenum. Two flow return pumps are located immediately forward of each dewatering tank (1 duty, 1 standby). Each pair of pumps is located within a 10’ X 10’ chamber forward of the dewatering tank weirs (See Section 4.6.7.3 and Figure 4-20). Horizontal mixer pumps have been selected for the FHF flow return pumps. Vertical Turbine pumps were considered but not selected due to the relatively low head requirements and their excessive noise has hindered fish attraction on other projects. The required flow and total dynamic head for the FHF pumps is 20 cfs and 3 to 4 ft, respectively. The Flygt PP-4660 pump has been selected for this service. The KSB Amaline 400 mixer pump will be evaluated as an alternative to the Flygt pump. The FHF dewatering pumps will be controlled by VFDs to maintain the water level in the pump chamber at a level just below the crest of the dewatering tank control weir. The FHF Dewatering pump sizing and design criteria is presented in Table 6-6 below.

Table 6-6 – FHF Flow Return Pump Sizing and Design Criteria

Pump Characteristic	Value
Flow per Pump	20 cfs
Number of Pumps	4
Pump Type	Horizontal Mixer
Drive Type	VFD
TDH	3 to 4 feet
Impeller Diameter	23.2 inches
Bell Diameter	30.5 inches
Unit Length	4.03 ft
Motor Size	15 HP
Unit Weight, Including Guide Rails	750 lbs

The FHF flow return pumps will need to have backup power supplied by the emergency generator system in the event of a power outage.

6.4.3 FHF High Pressure Service Water Pump

The FHF facility will require service water for wash down of the fish sampling areas, and for final filling of the fish transport pods prior to transfer off the FSS. A high pressure service water pump will supply water from the plenum to a bladder tank, on both the port and starboard sides of the FHF facility. The service water pumps will start and stop based on the pressure in the bladder tanks (40 psi start and 60 psi stop). Each bladder tank will in turn supply service water at a pressure between 40 and 60 psi. The FHF service water pump sizing and design criteria is provided in Table 6-7 below.

Table 6-7 – FHF Service Water Pump Sizing and Design Criteria

Pump Characteristic	Value
Flow per Pump	100 gpm
Number of Pumps	2
Pump Type	Vertical Multistage Centrifugal
Drive Type	VFD
Motor Size	2 HP
Unit Weight, Including Guide Rails	100 lbs

6.4.4 FHF Sampling Station Supply Pump

A dedicated pump will be needed at the FHF for supplying continuous water flow at low pressure to the Sampling Station including circulation water to the three sampling fish pods and water supply to the sampling table. The flow needed for the Sampling Station supply is estimated to be approximately 0.5 cfs and would be supplied from the plenum.

Table 6-8 – FHF Sampling Station Supply Pump Sizing and Design Criteria

Pump Characteristic	Value
Flow per Pump	.5 cfs
Number of Pumps	1
Pump Type	Horizontal End Suction
Drive Type	Continuous
Motor Size	2 HP
Unit Weight	100 lbs

6.5 Motor Operated Actuator for Elliptical Weir

6.5.1 General

The entrance weir gates are 3-leaf, downward acting, slide gates located at the weir entrances. These gates are described in detail in Section 4.6.2. These wheeled-gates are self-opening (lowering) under their own weight, overcoming the seal friction caused by differential hydraulic head across the gate crest. As such, mechanical assistance in opening (lowering) is not anticipated to be required at this level of design. Consequently, an electric, motor driven, double-drum, wire rope hoist is used to raise and lower each of the two entrance gates. Initial sizing of the hoist has been performed, but the components of hoist will be confirmed as the design progresses. It is expected that the gate operators will be custom-designed machines. Current best practices in motor operated gate actuators will be applied, including those provided in USACE Engineering Manuals.

The actuators are controlled by a PLC and will automatically adjust to maintain a user setpoint for water surface differential across the top of the weir. Controlled ramp rates for smooth start/stop operation, and safety features appropriate to avoid overloading of the gates, operating machinery, or physical structures are included in the PLC logic. The gate operators will include torque limiters, slip clutches, motor current limiters, or other features to ensure smooth and safe operation.

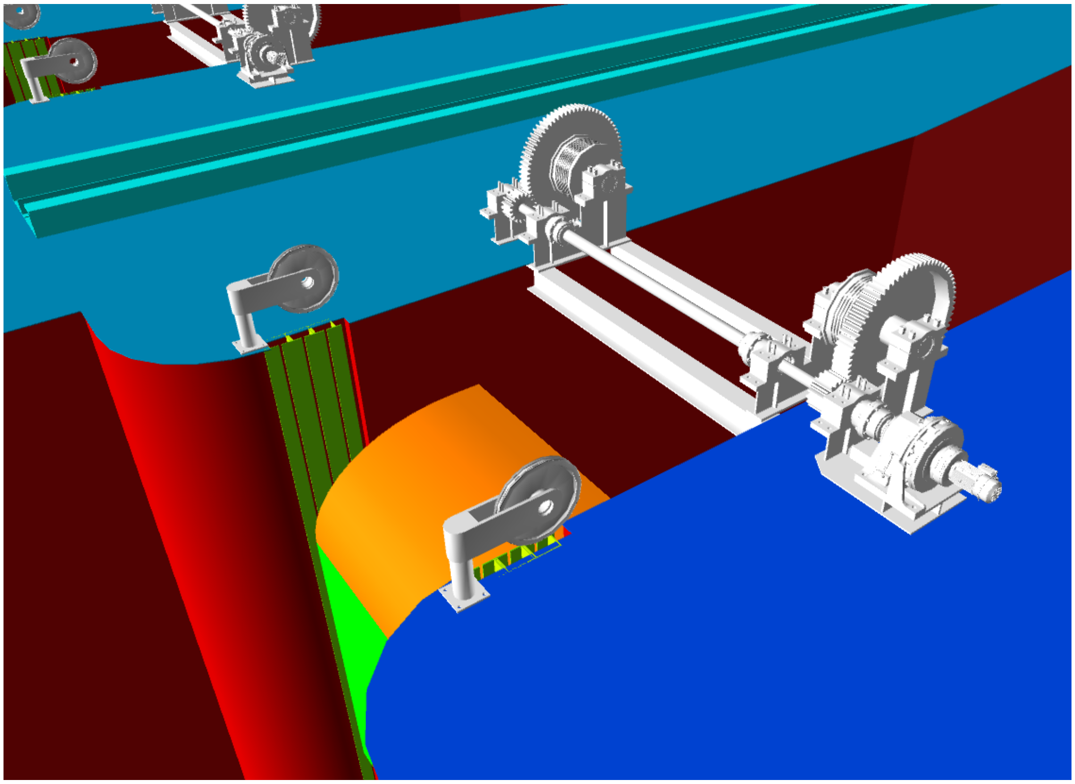

Figure 6-9 - Entrance Weir Gate Section

6.5.2 References for Gate Actuators

All gate actuators for this project comply with the applicable portions of the American Society of Mechanical Engineers (ASME) B30 Series standards and the standards of the American Water Works Association (AWWA), in addition to applicable standards established by USACE. 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 Hydropower 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
- 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): B30.7 Base-Mounted Drum Hoists
- Federal Wire Rope Specification RR-W-410
- OSHA 1926 Safety and Health Regulations for Construction

6.5.3 Gate Actuator Performance Criteria

The gate actuator will be designed to meet the performance demands described below:

- The gate will be operated at a single raise and lower speed of a minimum of approximately 4 foot per minute. The gate actuator motor will be a continuous-duty motor and will allow for a continuous open/close cycle.
- Target design life of the gate actuator components will be 25 years assuming a pre-determined number of movements per day.
- The gate actuator will be able to operate the gate for a range of 27.8 ft from full open with all leafs fully lowered to full closed with the elliptical crest 1.0 ft above the upstream water level. The gate actuator will not be designed to lift the gate assembly above the deck.
- The gates will be actuated by manual back-up means either through a hand crank or drill input.

Table 6-9 - Loads Taken Into Consideration for the Sizing of the Actuator

Load	Weight (lb)
Dead Loads	
Upper Gate Leaf	5051
Middle Gate Leaf	4665
Lower Gate Leaf	4491
Elliptical Crest	7422
Upper Ramp	9271
Lower Ramp	7703
Live Load (lifting load due to hydraulic load)	[TBD]
Wheel Friction	950
Teflon-Coated Seal Friction	800

The gate actuator will be used to lift the gate, including crest and ramps, only. At this level of development, it is assumed that the dead load of the gate will be adequate to overcome any friction caused by hydraulic differential across the gate crest, and lower under its own weight. Preliminary live loads due to hydraulic loads on the gate indicate that further design will need to be performed to size the hoist to either carry the load or create structural features on the weir assembly that reduce the hydraulic and dead loads on the hoist machinery during operation.

6.5.4 Wire Rope Actuator

The wire rope gate actuator will have one motor, rated for 3 HP, driving two drums at either side of the gate with a total lift of 30 feet. Each drum is sized to accept the entire 30 feet, plus any additional dead wraps, on a single layer with no overlapping. The drums will be connected to the motor via intermediate gearing and a cross shaft that spans the intake channel. The gearing driving the wire rope drums will be self-locking. Each wire rope drum will have a single, 1-1/8” nominal diameter wire rope which will run over a deflector sheave at deck level and be connected via an adjustable take-up to the upper gate leaf. The hoist assembly will be positioned downstream from the gate assembly such that there is enough room to vertically remove all gate leaves and the elliptical crest from the gate slots without interference to the hoist. The deflector sheaves at the deck level could be pivoted clear of the gate slots. The gates would be fitted with a dogging device to allow for the gates to be secured in the fully raised vertical position before disconnecting the gate actuator.

6.5.5 Gate Actuator Alternatives

Two gate actuator alternatives were considered for the design prior to the completion of the 90% DDR: 1) wire rope actuated and 2) stem actuator actuated. Both were expected to meet the performance criteria above and could be modified to drive the gate down if the design of the gates required it. Based on initial hydraulic modeling performed in the development of the 90% DDR, hydraulic loading of the gate during operating flows did not require the hoist to drive down the elliptical weir gate. Consideration of the alternatives resulted in the final selection of a drum wire rope hoist. The stem driven alternative is briefly discussed in the paragraphs below.

6.5.5.1 Stem Actuator Alternative

The stem actuator development was concluded at the 60% design DDR and after it was determined that the elliptical weir gate would not need to be driven down under flow. The stem actuator would have consisted of a central electric-motor rated for 15 HP driving two fixed stem drives with a lower bearing and traveling nut in a lead screw arrangement. The central motor would have been connected to the stem drives via a cross shaft and couplings. The stems and traveling nuts would have been self-locking threads and be of a 5 ½” nominal thread size. The traveling nuts would have been structurally connected to the upper gate leaf. It’s expected that standard manufactured units with limited customization would be used.

Regardless of the need to drive down the gate, the screw stem hoist would have been sized to take into consideration tension loads during gate closing and buckling which becomes critical during opening. It’s expected that standard manufactured units with limited customization would be used. The stem actuator concept has not been developed further due to the equipment potentially being beyond the standard sizing of most manufacturers, the impacts to the sizing and arrangement of the gate leaf connection, and the expected greater construction cost associated with such sized equipment. If such an alternative was explored further, the gate leafs and guides would also need to be enlarged to accept the stem thrust imparted by the actuator.

6.6 Lifting Devices - Bridge Crane, Articulating (Knuckle) Boom Crane, and Other Lifting Devices

6.6.1 General

The FSS will include an articulating, traveling knuckle-boom style crane on the FSS deck, an overhead bridge crane (with a telescoping trolley rail) inside the Fish Handling Facility Building, and other lifting devices. The bridge crane and knuckle-boom crane will be designed to lift and transport fish transport pods, pumps, and other major equipment to the designated staging location where they will be removed from the FSS by the knuckle-boom crane to either an amphibious vehicle (AV) or the boat access platform. From the access platform items can be collected and transported offsite. The bridge crane and knuckle-boom crane capacities, spans, travel limits, and high/low hook elevations were established with the intent that job-specific hoists may be needed to move some items to locations where they can be lifted by the FSS bridge crane and/or knuckle-boom crane. Due to the telescoping trolley beam on the bridge crane, it could be a custom-designed crane although several manufacturers have been identified who can manufacture these type cranes and it is possible that it could be a standard design. Multiple crane manufacturers can provide a standard knuckle-boom crane in the size anticipated for this project. Per USACE requirements, an additional factor of safety of 2.0 has been applied to the design loads for the lifting devices.

Additional safety features, such as walkways, platforms, handrails and ladders, or fall protection features required for the proper functioning, access and maintenance of important components of the crane will be provided as part of subsequent design phases. Servicing of the majority of the knuckle-boom crane should be straightforward, as the boom can be raised or lowered to a convenient position for maintenance activities.

6.6.2 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 and Gantry Type Multiple Girder Electric Overhead Traveling Cranes, or No. 74, 2015 – Specifications for Top Running and Under Running Single Girder Electric Traveling Cranes Utilizing Under Running Trolley Hoist, depending on the type of crane selected by the manufacturer.

- 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, B30.22 Articulating Boom Cranes, B30.8 Floating Cranes and Floating Derricks, 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
- American Petroleum Institute (API) 2C, Offshore Pedestal-mounted Cranes
- American Petroleum Institute (API) 2D, Operation and Maintenance of Offshore Cranes

6.6.3 Articulating (Knuckle) Boom Crane Design Criteria

The main deck of the FSS will include an articulating knuckle-boom crane with winch along the port side of the FSS designed to transfer the fish transport pods from the FHF and service some equipment located on the deck of the FSS. Additional activities to be performed by this crane on the deck (outside of the FHF) include handling of attraction pumps and other miscellaneous mechanical equipment if and when needed. Note that a single overhead rail is provided to transfer all attraction pumps to a point within reach of the knuckle-boom crane. The maximum design load for this crane is 20,000 pounds. However, the actual maximum working load anticipated for this crane is anticipated to be a full fish transport pod, estimated to weigh a maximum of 8,500 pounds, plus the weight of rigging. The knuckle-boom crane will be mounted along the port side of the FSS and travel from the FHF to the AV docking area (fore/aft travel direction). As depicted in Figure 6-10 and Figure 6-11, the boom will be able to fold and rotate 360 degrees. The distance from the centerline of rotation to the picked load is defined as the lifting radius. The longest pick distance for this crane could be the full fish transport pod (8,500 pounds) at a lifting radius of about 32 feet (most likely along the port side). These fish transport pods will need to be picked just outside of the entrance to the FHF and deposited on the AV. The longest-reach requirement for this crane will be miscellaneous mechanical equipment stationed approximately 49 feet from the centerline of rotation. Therefore, the knuckle-boom crane will need to have a minimum boom reach of 49 feet and a rated load of at least 5 tons (or approximately 10,000 pounds, and with a factor of safety of two applied will be specified for a design load of 10 tons (20,000 pounds). See Drawing M-018 in Appendix A for more details on the Articulating Boom Crane design.

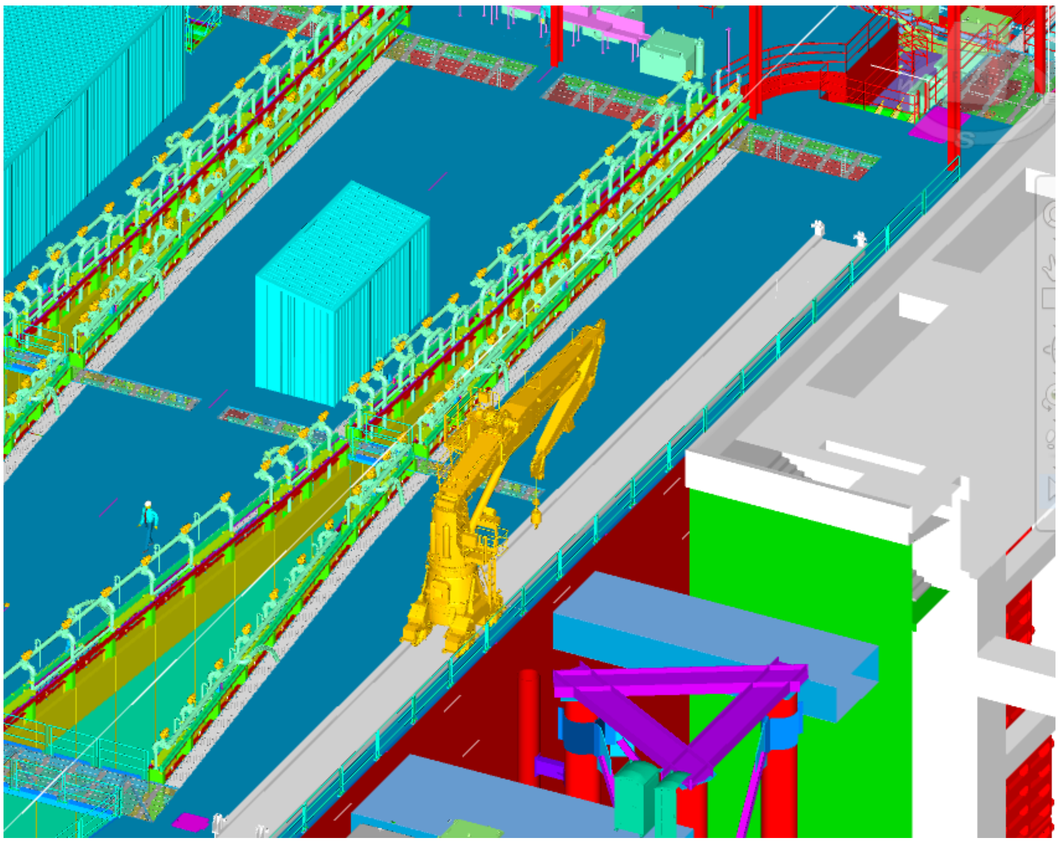

Figure 6-10 – Oblique View of Articulating (Knuckle) Boom Crane Conceptual Layout

The knuckle-boom crane will be mounted to two rails at its base. The capacity of these cranes is generally limited by the moment at their base; therefore, the crane base supporting structure will need to be adequately supported by the deck of the FSS. Further, the knuckle-boom crane will need to accommodate the tolerances associated with operating on a floating barge and the maximum degrees of trim and heel of the FSS will need to be incorporated into the design and specifications and performance criteria.

The knuckle boom crane will be required to have a nominal outreach of 49 feet, hook travel of approximately 98 feet (allowing equipment below deck level also to be lifted), full load hook speed of approximately 65 feet per minute, a gantry travel speed of approximately 13 feet per minute, a slewing (rotating) speed of approximately 0-1.0 rpm (variable), a luffing time (up/down) of approximately 60 seconds, and a folding time (in/out) of approximately 60 seconds. Power consumption is anticipated to be approximately 75 kW (100 HP).

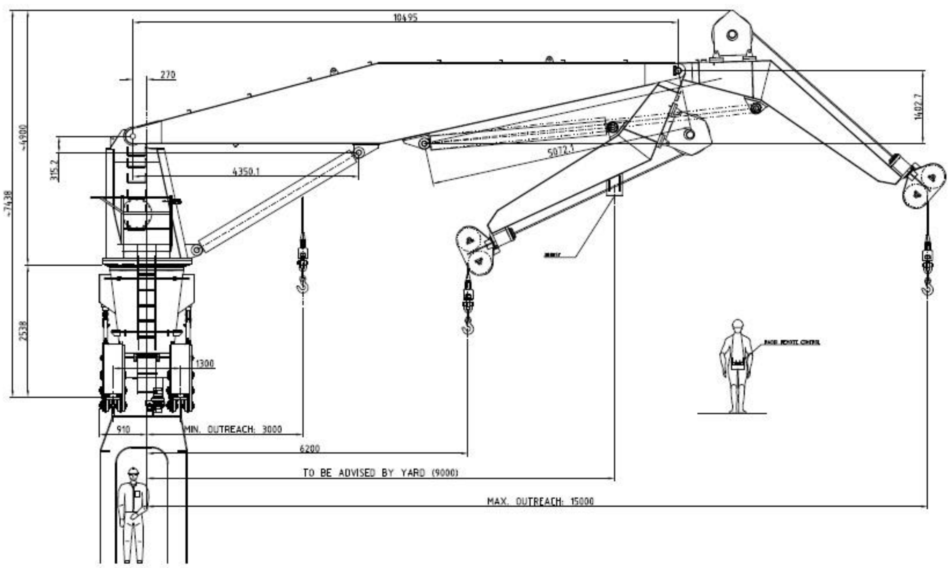

Figure 6-11 - Articulating (Knuckle) Boom Crane

6.6.4 Bridge Crane Design Criteria

The Fish Handling Facility (FHF) Building will incorporate a bridge crane designed to service equipment located inside the building. The bridge crane will be designed with a telescoping trolley beam that can be extended through an open door at the forward, port corner of the building (see Appendix A) to set equipment and materials outside. The trolley beam extension will allow fish transport pods and other equipment picked up inside the building to be transferred outside of the building for removal by the knuckle-boom crane, and for new or repaired equipment to be brought into the FHF Building. The largest anticipated load will be a transport pod full of fish, at approximately 8,500 pounds (4.25-tons), plus the weight of the lifting slings and tackle. Since “standard” sizes for hoists are desired, with the 2.0 factor of safety added, a 10-ton crane has been selected, pending final design of the components to be installed in the building. The bridge crane will also be designed to handle miscellaneous mechanical equipment and fish totes inside the building. 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. See Drawing M-017 for details of the bridge crane arrangement.

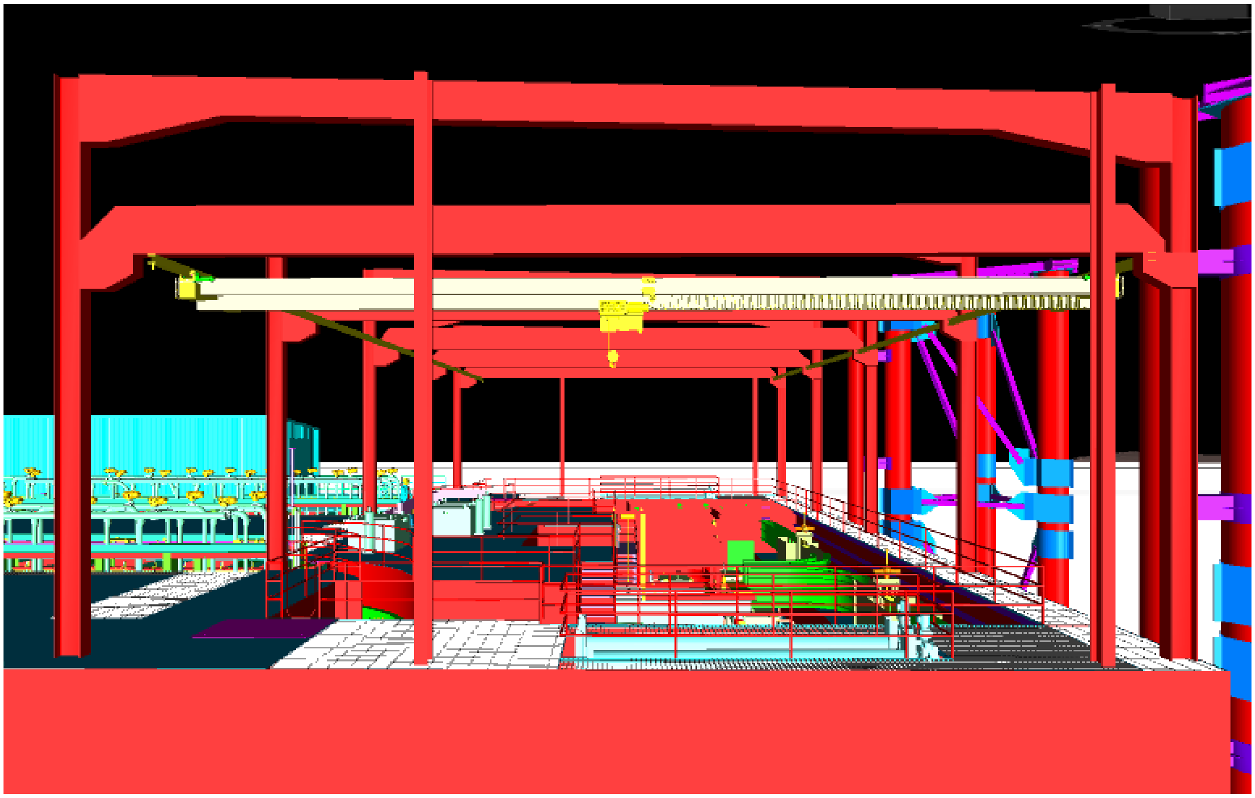

Figure 6-12 - Fish Handling Facility Building Bridge Crane

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.

6.6.4.1 Hoist

The crane will have one hoist, rated for 10 tons, with a total vertical lift of approximately 33 feet to accommodate objects from the floor of the FHF (elevation 24.50 feet) and the main deck (elevation 40.0 feet). High hook will be at elevation 58.9 feet (approximately 34 feet above the main deck) and low hook at elevation 24.5 feet (at the FHF floor elevation). Rated hook speed will be approximately 30 feet per minute and will include a variable frequency drive (VFD) controller providing approximately a 100:1 ratio between low and high speed. The hoist motor is anticipated to be approximately 20 HP.

6.6.4.2 Trolley

The crane will have a single trolley with a rated speed of approximately 80 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. The trolley motor is anticipated to be approximately 5 HP.

6.6.4.3 Bridge

The bridge will have a nominal span of approximately 52 feet and a nominal travel length of approximately 90 feet, and will travel at a rated speed of approximately 120 feet per minute. It will include a Variable Frequency Drive (VFD) controller providing approximately a 100:1 ratio between low and high speed. The bridge will travel on two permanently mounted crane rails supported by the FHF Building structure and will be part of the FHF Building contractor's responsibility. To the extent 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 inside the FHF Building to the designated pick point outside the Fish Handling Facility Building in accordance with CMAA and ASME requirements. Additional alignment requirements for the bridge crane with respect to barge heel, list and torsion of the barge deck may be added at the time of final design of the FSS. The bridge motors (two) are anticipated to be approximately 2 HP each.

6.6.4.4 Controls

The crane will have a pendant controller along with radio remote control (i.e. "belly box") 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 recommended 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.

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

6.6.4.5 Crane Lighting

It is anticipated that general building lighting will be sufficient for normal operation. 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 for situations when additional lighting is required. Refer to Section 7.6.2 for specific information.

6.6.4.6 Crane Power

The bridge crane will be powered by a conductor rail permanently mounted to the FSS Building 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 FHF Building 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, 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. E-stop buttons 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. A minimum, four E-stops will be provided, one near each corner of the building, within convenient access to the crane operator. The crane power supply will be 480 volts AC and integrated with the FSS power supply. The total motor horsepower requirements for the bridge crane (bridge drives, trolley drive, and hoist drive) will be approximately 6 HP excluding lighting circuits. Convenience circuits on the crane have not been considered. Convenience circuits will be provided as part of the FHF Building power design. Where required, control panels will incorporate heating, cooling, or ventilation.

6.6.4.7 Safety/Environmental

All enclosures will be environmentally rated for their installation location and provided with interior climate-control equipment as needed. All panels and enclosures installed will be NEMA 250 Type 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. Load blocks and wire ropes for the FHF bridge crane are not to be submerged in water. Lubricants for wire ropes and load block sheaves should comply with one of the following:

- Officially represented to be in compliance with EPA 800-R-11-002 (EPA 2011), ‘Environmentally Acceptable Lubricants’ (EPA 800), through certified test results.
- Officially represented to be VGP compliant by the manufacturer. VGP means the Vessel General Permit for Discharges Incidental to the Normal Operation of Vessels (EPA 2013).
- Granted EAL certification by the European Ecolabel (EEL).

Where exposed to the outdoor environment, components are to 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. These may not apply if the crane will be serviced using temporary ladders, man-lifts, or other portable access equipment:

- 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 platforms, walkways, handrails and ladders will be galvanized. With the exception of the telescoping trolley beam, all parts of the bridge crane will be inside the FHF Building under cover, but not in a climate-controlled location.
- If required for access to the crane, 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.

6.7 Trashrack Cleaner

The Trashracks located at the FSS entrance (refer to Section 4.6.1) 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 anticipated diameters up to 12 inches could collect on the Trashracks which can increase head loss. An automated trash rake system will be installed to actively retrieve any accumulated debris from the Trashracks, remove it from the FSS entrance, and place it in trash bins that will be offloaded from the FSS by USACE personnel. Accumulations of debris that are not removed in a timely manner may impact fish collection hydraulics, fish survival, and the performance of other equipment located downstream of the trash racks.

An active Trashrack cleaning system will be required to achieve the following performance requirements:

- 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.
- The cleaning system shall be capable of starting cleaning cycles based on head differential, timer, and manual pushbutton (digital or physical);
- Capable of cleaning both Trashracks at 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.

6.7.1 Trashrack Cleaner General Arrangement

The Trashrack cleaner is composed of a dual telescoping bridge crane as pictured in Figure 6-13. Although not shown in this figure, the dual telescoping bridge crane allows for access to two debris receptacle barges utilizing two rake assemblies. This option stays within the starboard confines of the FSS deck, but protrudes from the bow, and port sides of the FSS deck. This configuration would induce less wear on the tracks and allow for slightly longer periods for inspection and maintenance of the trolley wheels and track. The deck residing underneath the bridge crane structure can be utilized as a laydown area for debris that is too large to fit in the debris receptacle should the need arise. Another option for handling large debris is to leave the debris in place until a work boat can be used in conjunction with the rake to remove the debris. Large debris will prohibit routine clearing of the affected Trashracks until cleared. See further discussion below regarding debris handling in Section 6.7.1.4.

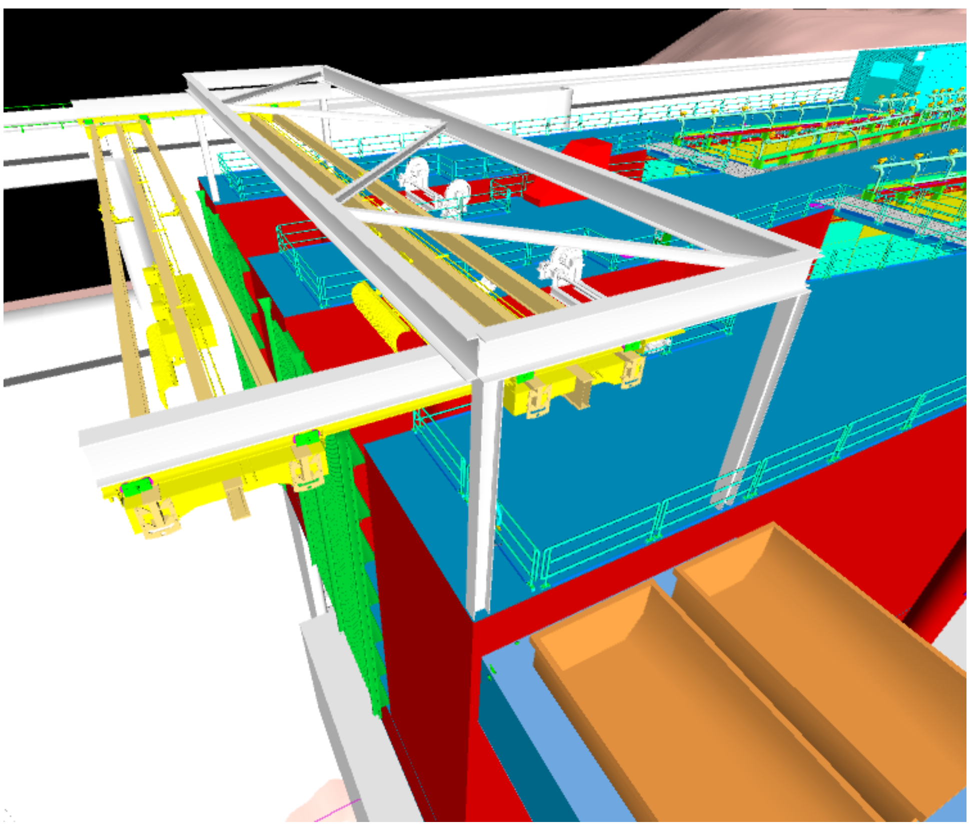

Figure 6-13 – Oblique View of Trashrake General Arrangement

The cleaning chassis includes a two-rake assembly comprised of two separate electro-mechanically operated bridge cranes with trolley, hoist, and hydraulically actuated rake head attachment. The rake and bridge crane assemblies are mounted on an independent steel superstructure that provides a rail for the bridge crane to travel horizontally on. The rake assembly that is shown and discussed in the design is most like the Ultra Duty model of the Monorail Raking System designed by manufacturers such as Ovivo Brackett Bosker.

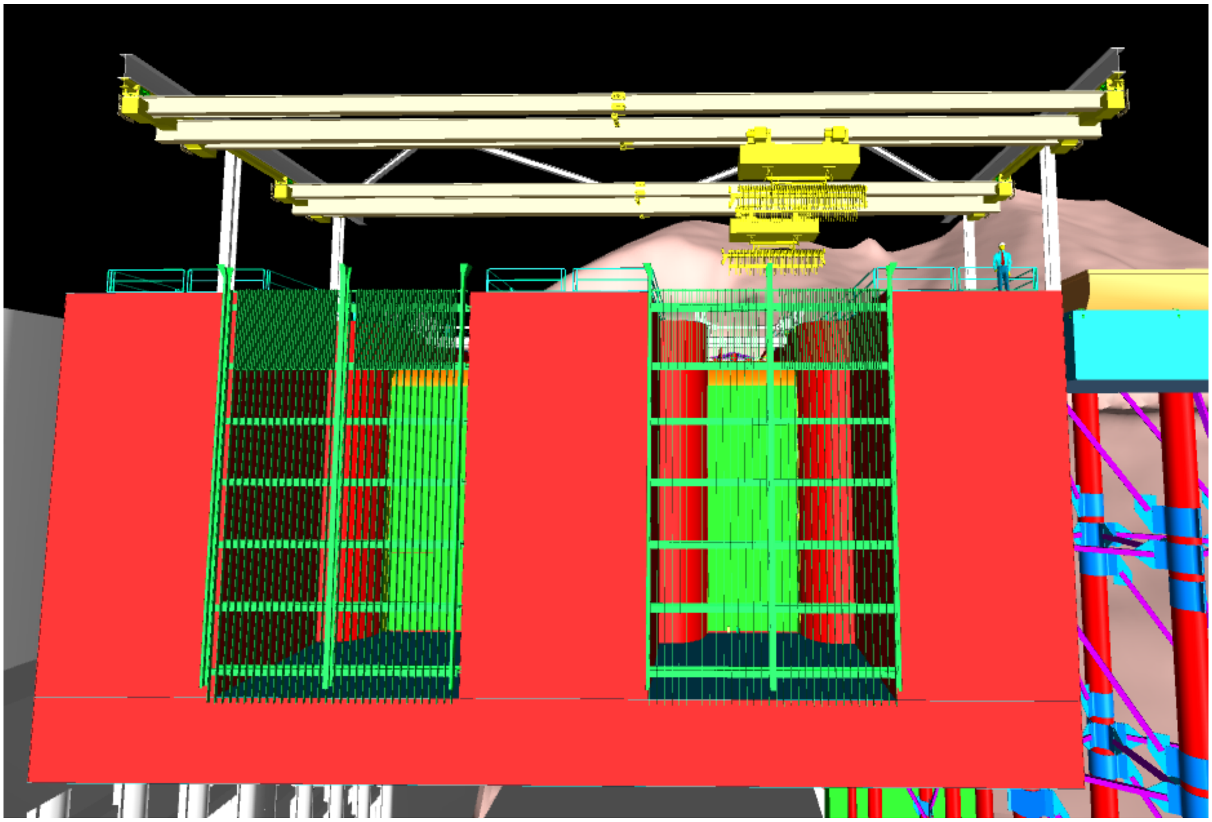

Figure 6-14 - Front Elevation View of Trashrack and Rake Assemblies

6.7.1.1 Rake Assembly

The rake assembly is comprised of four main parts, they are the:

- Bridge with telescoping girder,
- Trolley,
- Hoist, and
- Rake head attachment

The trolley travels horizontally along a bridge which rides on rails on the steel superstructure and transports the hoist, rake head attachment, and any collected debris with it. The motors for the rake assembly, which include the bridge motor(s), trolley motor, hoist motor and hydraulic motor for the rake head attachment to clamp onto debris are housed in a weather proof casing to protect it from the elements.

The hoist, which lowers and raises the rake head attachment, will have two cables that maintain equal tension through a spring tension system. The dual cables prevent the rake head attachment from twisting out of the trashrack plane. The rake assembly will need to have the capability of lifting up to 2,000-pounds of debris. The ultra-duty model of Ovivo's Brackett Bosker Rake has the ability to lift up to 6,600-pounds of debris. Though it has the ability to lift 6,600-pounds, the debris weight per swipe of the rake assembly is anticipated to be approximately 600-pounds. That is based on debris such as wet grass and small branches.

The rake head attachment will descend and ascend along guide rails attached to the Trashrack for the full travel.

There will be hydraulic cylinders mounted directly on it which allows the proper grip needed for various types of debris. The rake head is open sided on both ends to allow extraction of long or awkward debris geometry such as driftwood or tree trunks and can lift logs with diameters up to 18-inches and 26-feet in length.

The total weight of one rake assembly, plus a full load of debris, is estimated to be 13,200-pounds. The total horsepower of one rake assembly, based on Ovivo's Brackett Bosker Rake catalog, is estimated to be 35-horsepower.

6.7.1.2 Steel Superstructure

The steel superstructure is an overhead structure to support and facilitate debris transfer. The travel rails will be mounted underneath the overhead steel beam of the superstructure so as to allow full travel of the rake assemblies across either Trashrack and to allow for delivery of debris to the debris receptacle barges. The rake assembly, which is a self-propelled unit, travels along the rail system.

A service platform shall be incorporated so that access to the rake assemblies can be safely provided for the purpose of performing all required maintenance and repair operations on both the port and starboard sides. When one rake is out of service for maintenance, the other rake assembly will be able to cover the removal of debris from both trash racks and remove debris to the trash receptacle barges. The steel superstructures shall extend beyond the bow and toward the stern of the FSS to allow either of the two bridges to be moved completely out of the range of the other bridge to fully service both Trashracks and reach both debris receptacle barges.

6.7.1.3 Instrumentation and Controls

Under automatic control mode, the trash rake system will initiate a single cleaning cycle on an elapsed timer or when a setpoint hydraulic differential is measured across the trashrack (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 rake assembly from home position to a point along the Trashrack where the rake head attachment is lowered into the guide rails and travels vertically down to the bottom of the upper reduced-spacing portion of the Trashrack. At this point, the rake head attachment's mechanical thumb contracts to retain debris on the rake head. The hoist then raises the rake head, full of debris, to the fully raised position. The trolley travels to the designated debris receptacle barge. After releasing the debris, the rake assembly returns to the same position on the Trashrack, travels to the bottom of the Trashrack and performs another sweep. After releasing the second load of debris, the rake assembly travels to the next position on the Trashrack and performs another cycle. The cycles continue until the face of each Trashrack has been cleaned. When all cycles are complete, the rake assembly 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 under an hour but can vary upon manufacturer and final design configuration. The estimated time to clean both Trashracks are estimated in the table below, Table 6-10, and is directly tied to the number of rake assemblies present on site. Note this calculation is only for cleaning the racks and does not include the time required to remove the debris receptacle barges from the FSS. If the amount of debris is expected to be excessive, making trash removal time critical to operations, consideration should be given to having multiple debris receptacle barges queued up along the port side of the FSS.

Table 6-10 - Estimated Cleaning Time

No. Rake Assemblies	Cleaning Time
1 Rake Assembly	60 minutes
2 Rake Assemblies	30 minutes

The local control panel is set to manual for manual control. After doing so, a single cycle can be initiated, or the rake assembly can be operated solely by a technician using a remote control device. Such control is useful when large debris is impinged on the Trashrack, and careful maneuvering of the debris rake is required for removal.

As per the manufacturer Ovivo, the maximum expected inrush current for the rake assemblies is 70-Amps.

6.7.1.4 Debris Receptacle Barges and Disposal

The collected debris will be deposited into the debris receptacles mounted on a barge docked on the port side of the FSS, in line with the bridge extensions. Once full, the debris receptacle barges will then be towed to another location by means of a work boat to dispose the debris to an off-site location. If large or awkward sized debris does not fit within the debris receptacles, the debris will remain in place until a work boat is able to tow the debris to a disposal site. In order for a work boat to access the front of the FSS, the facility must be shut down and the spillway gates must be closed.

The current configuration of the debris receptacle barges allows for a barge to be positioned under the extension of both of the bridges for the trash rake assembly allowing both bins to be potentially loaded by either rake assembly. Though there is a drip pause built into the automatic mode of the cleaning system, water will continue to drip off of the debris and accumulate in the bottom of each debris receptacle. Holes will be provided at the bottom of each debris receptacle. Depending on the barge configuration, a hose may need to be provided to route the excess water to the edge of the barge.

The debris receptacle barges will need to be capable of handling a full Trashrack worth of debris for an efficient Trashrack cleaning operation. In turn, the work boat will need to be capable of handling at least one debris receptacle barge, but it is expected that multiple barges could be secured together and transported at the same time. A system of the work boat ferrying filled and empty debris receptacle barges could be implemented such that the FSS is never without at least 2 empty barges.

6.7.1.5 Redundancy

There will be two rake assemblies on the steel superstructure. If one rake assembly is out of service for maintenance, it will be parked in the maintenance location as described in Section 6.7.1.2. Should one of the rake assemblies be down for maintenance, the other will be able to travel the rail length such that it'll be able to clear both Trashracks and access the two debris receptacle barges.

6.8 Maintenance Rail for FHF Attraction Flow Pumps

6.8.1 General

There are eight attraction flow pumps onboard the FSS and they need to have the ability to be swapped out when maintenance is required, as it is critical to the fish collection function of the facility. A maintenance rail positioned above the center of gravity of the pumps will be provided to lift and lower the pumps as needed.

6.8.2 Design Considerations

The design considerations for the rail are as follows:

- Be positioned high enough to provide clearance over the telescoping girder coming out of the FHF building and allow the attraction flow pumps to be raised to the deck level.
- Be able to carry the weight of the trolley plus the weight of the pumps with a safety factor of two
- Have a chainfall hoist on one side above the trolley rail so a trolley can be hoisted on and off the rail as needed

6.8.3 Maintenance Rail Description

The maintenance rail will be a wide flange beam capable of handling the trolley and pump loads. The rail will be supported off of the FHF building columns such that it lines up with the center of gravity of the pumps.

6.8.3.1 Trolley Hoist

The hoist must have a motorized trolley and be a wire rope type with an integrated block and hook. The hoist will be wired directly using a dedicated circuit for the hoist. Power cable storage must be provided with the hoist and the cable must not interfere with trolley travel and surrounding machinery components. Hoist motor will have a run time of at least 20 minutes and the capacity of the hoist will have a factor of safety of 2 with respect to the lifted pump load. The hoist will be operated from a pendant pushbutton station within the vicinity of the attraction pumps. The minimum lift must be able to move the pumps from the installed position up to the deck level in a single lift. The hoist and trolley will be adequately suited to resist the weather.

6.9 FSS Ballast and Trim System

6.9.1 General

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 serve several purposes: aides with construction and transportation, helps with major maintenance of the fish channel and provides trim, heel, and freeboard compensation for varying operational conditions.

6.9.2 Design Standards and References

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

- American Bureau of Shipping (ABS), Rules for Building and Classing Steel Barges 2017
- 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
- Society of Naval Architects and Marine Engineers (SNAME), Marine Engineering, 1992
- American Society for Testing and Material (ASTM), Vol 01.07, Ships and Marine Technology

6.9.3 Ballast System Description

The ballast system's primary purpose is to facilitate positioning of the FSS near the required operational draft. During normal operation the system will take on water to increase the weight of the FSS and thus sit lower in the water with the fish channels at the optimal height with regards to the reservoir. During maintenance operations, the system will pump water from the tanks to the reservoir which will lighten the FSS and allow it to float higher facilitating dry maintenance operations. Additionally, the ballast system is designed to pump out the water trapped in the fish channel during the maintenance periods. 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. An abbreviated diagram of the ballast system is shown in Figure 6-15.

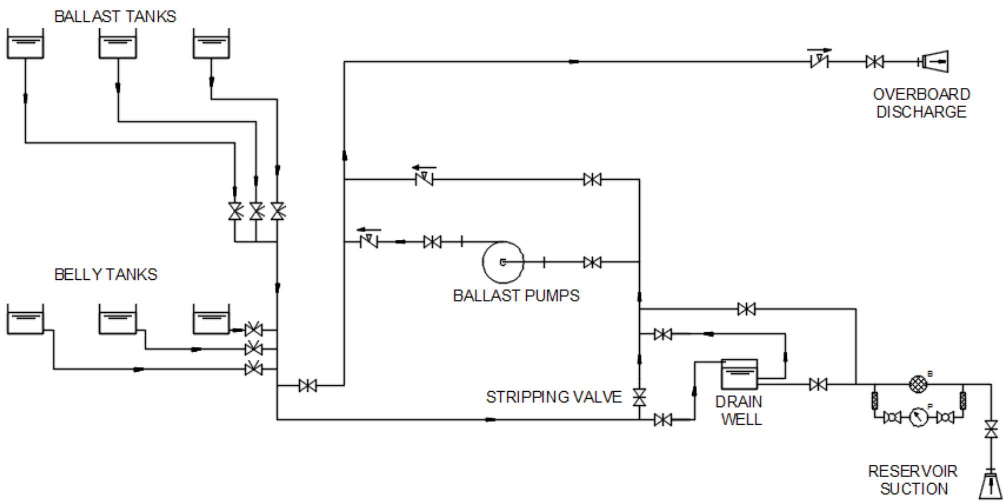

Figure 6-15 - Full FS Ballast System

During ballasting, the system is aligned to take suction from the reservoir and water is pumped into the tanks in a predetermined sequence to maintain stability. As the tanks sets are filled, the level is monitored, and each tank is closed as it reaches the pre-determined maximum level via a motor-controlled valve in the pump room. See Figure 6.16.

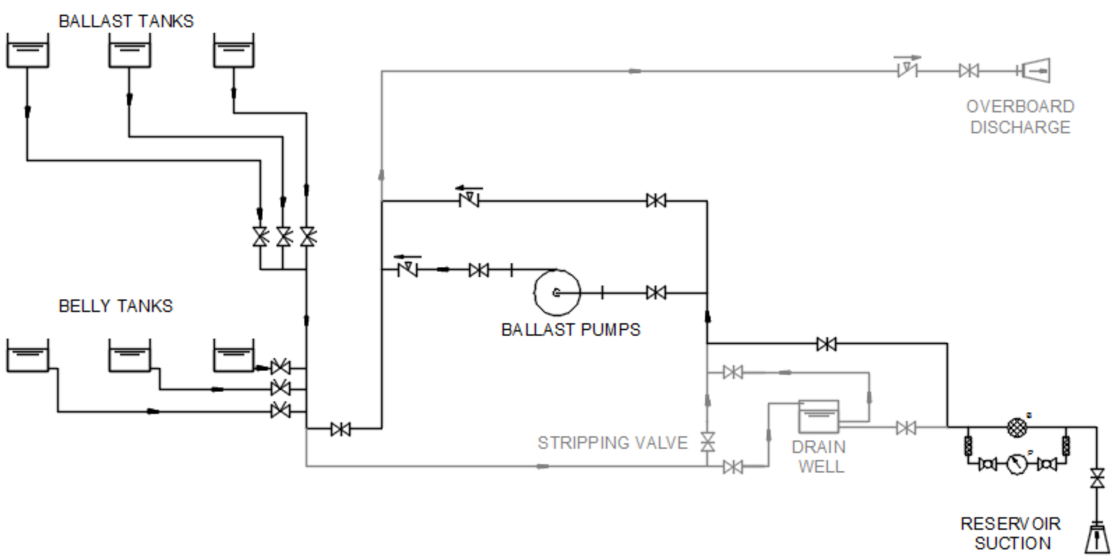

Figure 6-16 - FSS Ballast System, Ballasting Mode

During de-ballasting, the valves will be aligned such that the ballast tanks drain to a large belly tank, here in described as the drain well. The ballast pumps will draw suction from this drain well and discharge overboard. The drain well allows for a constant supply to the pumps and will facilitate draining the tanks in sets to maintain stability. A stripping valve is located between the tanks and the pumps which served to bypass the drain well and facilitates the complete removal of water from the tanks. See Figure 6-17.

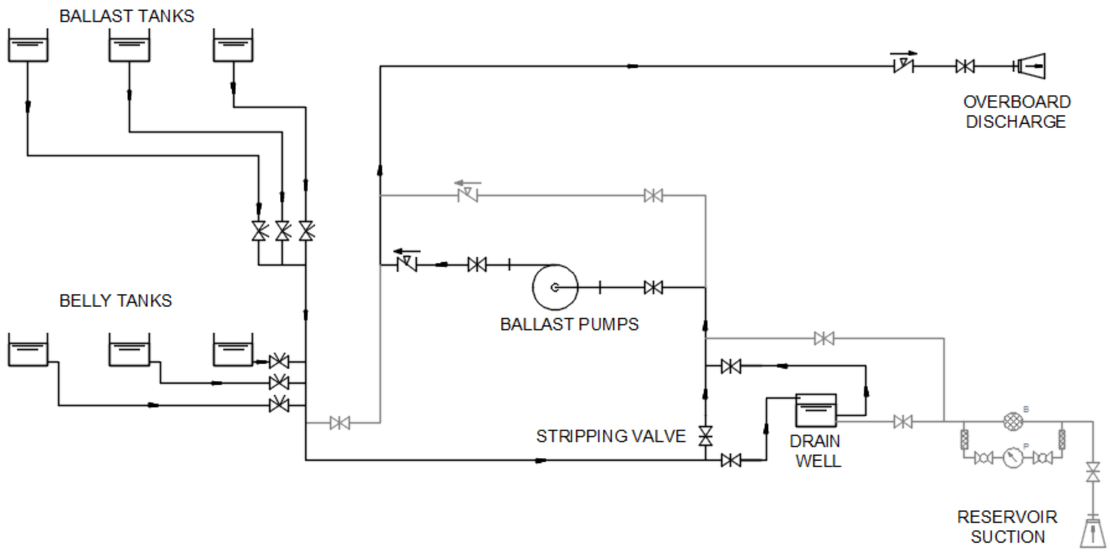

Figure 6-17 – FSS Ballast System, De-ballasting mode

6.9.3.1 Tanks

The ballast system has two types of tanks; belly tanks and ballast tanks. Both types of tanks are integral to the structure. The difference between the belly tanks 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 tanks 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 preliminary volumes.

Table 6-11 - Belly and Ballast Tank Volume

Belly Tank	Approx. Vol. (cuft)		Ballast Tank	Approx. Vol. (cuft)
BT-H-0	16,562		BA-00-0	28,092
BT-H-1	11,613		BA-00-1	33,887
BT-H-2	11,613		BA-00-2	33,887
BT-17-1	10,873		BA-00-3	13,328
BT-17-2	10,873		BA-00-4	13,328
BT-34-0	13,581		BA-17-0	19,013
BT-34-1	9,523		BA-17-1	20,384
BT-34-2	9,523		BA-17-2	20,384
BT-55-0	13,250		BA-43-1	12,544
BT-55-1	9,290		BA-43-2	12,544
BT-55-2	9,290		BA-86-1	11,760
BT-75-0	17,224		BA-86-2	9,212
BT-75-1	12,078		BA-101-1	13,328
BT-75-2	12,078		BA-126-0	11,593

Belly Tank	Approx. Vol. (cuft)		Ballast Tank	Approx. Vol. (cuft)
BT-101-0	16,562		BA-126-1	8,129
BT-101-1	11,613		BA-126-2	8,129
BT-101-2	11,613		-	-
BT-126-0	13,250		-	-
BT-126-1	9,290		-	-
BT-126-2	9,290		-	-
Total	238,985		Total	269,542

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 vent pipes will be of similar material to those used for filling and emptying the tanks.

6.9.3.2 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. It is recommended that Radar TLIs be used.

6.9.3.3 Pumps

The ballast system will utilize 4 pumps for filling and emptying the tanks. This offers redundancy and allows multiple tanks to be filled or emptied in a shorter amount of time. These pumps will take suction from the reservoir during ballasting and will discharge to the reservoir during deballasting. 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. Due to the total volume of ballast water necessary and the operational limitation of de-ballasting in 8 hours, the ballast pumps will be required to move, at a minimum, a combined 8,000 gallons per minute. Additionally, due to the height of the FSS, the pumps will be required to operate over a wide range of net positive suction heads depending on the state of operations. Based on a preliminary model of the system, the pump will be required to operate with a discharge head of 48 ft and a suction head varying from 26.9 ft to 50.2 ft. One pump capable of operating at this flowrate and accommodating the varying available net positive suction heads is the Pioneer Pumps SC1010C14, pictured below, see Figure 6-19 and Appendix G. This is a 10" end-suction centrifugal pump designed to operate at up to 3,500 gallons per minute, depending on available suction head. The pump will use an Environmentally Acceptable Lubricant (EAL) and will not require an oil/water separator on the FSS

Figure 6-18 - Single Stage Vertical End-Suction Pump (Pioneer SC Series)

During ballasting operations each of the 4 pumps operates between 1,500 and 3,400 gallons per minute. The average pump efficiency is 75% with a maximum efficiency of 82% and a minimum efficiency of 62%. During deballasting operations each of the 4 pumps operates between 800 and 2,300 gallons per minute. The average pump efficiency is 75% with a maximum efficiency of 80% and a minimum efficiency of 30%. Pump flowrates and efficiencies during deballasting are seen on the pump curve shown in Figure 6-19.

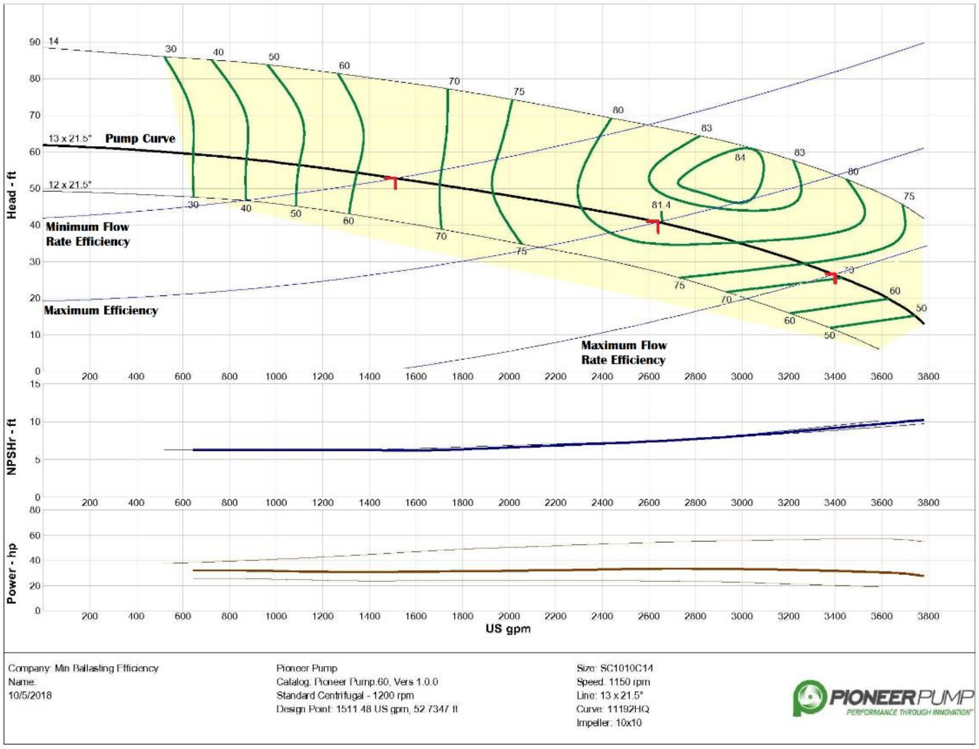

Figure 6-19 - Pump Curve During Ballasting Operations

6.9.3.3.1 *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 debris are less likely to be 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. While duplex strainers are typically preferred, as designed the ballast system has built-in redundancy which would eliminate the need for the redundancy of a duplex strainer. Additionally, duplex strainers are typically twice the size of simplex strainers due to the additional basket and thus utilizing the simplex strainers will facilitate a more accessible pump room.

6.9.3.3.2 *Pump Priming system*

The level of the pumps has been determined to be near the water level when the FSS is de-ballasted. To pump ballast water back into the FSS, priming of pumps will be necessary. Additionally, in some cases ballast may 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,

Figure 6-20. 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.

Figure 6-20 - Vacuum Priming System

6.9.3.4 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 6-21.

The ballast system will utilize 10, 16, and 20-inch diameter piping. The pipe runs from the pump room to the individual tanks will be 10-inch diameter combining to a 20-inch header in the pump room. Piping runs from the pump room to the individual tanks will vary from 30 feet for tanks near the pump room to 275 feet for the furthest aft tanks. The individual pump suctions off the header will be 10-inch and the discharges will combine to a pair of 16-inch overboard discharges.

Figure 6-21 - Standard Grooved Coupling

6.9.3.5 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, butterfly valves, and gate valves.

6.9.3.5.1 *Check Valves*

Check valves are used in applications where reverse flow is unwanted. The discharge of each pump will have an angled check valve to prevent excessive back pressure or reverse flow, which could damage the pumps. The overboard discharge(s) will have an angled check valve(s) to ensure the reservoir water does not flow back into the discharge piping. The free flooding system will have an angled check valve to prevent flow of water back to the reservoir during ballasting.

6.9.3.5.2 *Gate Valves*

Gate valves are used for positive closure and for minimal pressure loss applications. The sea chest 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.

6.9.3.5.3 *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. Butterfly valves will be used for controlling the flow to and from belly and ballast tanks. These will be motorized wafer type valves with a quarter turn to close allowing for rapid actuation via the control architecture.

6.9.3.5.4 *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. 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.

At this point in the design it is unlikely that a manifold will be used for the ballast system. The operation of the ballasting system is such that fluid transfer between tanks is not necessary and tanks will be drained or filled completely. In place of a manifold, a header will likely be used with branches for each ballast tanks controlled by a butterfly valve.

6.9.3.5.5 *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. Electric valve actuation add cost, but due to the number, size, and location of the valves, it is recommended to provide electric valve actuators.

6.9.3.6 Operation

It is recommended that the ballast system be controlled via direct human input at the ballast operating console within the pump room. The operating console will have the pump controls, valve controls, and tank level readouts for each tank. Each belly and ballast tank will have a motor operated valve that will be controlled from the operating station. The operator will be required to select which pumps are online and manually control, via the digital control system, when the motor operated valves for each tank will open and close during ballasting and deballasting.

The timeframe for the FSS to transition from the maintenance draft to the operational draft, and vice versa, is 8 hours. Dividing the total calculated ballast volume by the time required to ballast or de ballast gives an approximate figure of 8000 gallons per minute. Simulations have shown that it is possible to fill the ballast and belly tanks in approximately 6 hours . Similarly, a simulation has shown it is possible to de-ballast the FSS in approximately 8 hours. See Appendix G for additional information.

6.9.4 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 4 Trim Tanks, 2 Variable Ballast Tanks, 8 pumps, piping, valves, and other components interconnected to transfer water into and out of the trim and tanks. Filling the trim tanks is accomplished by the operation of the ballast pumps. Discharging from the Trim Tanks is accomplished by 2 local pumps at each tank for redundancy. Separate pumps for filling and discharge of the trim tanks is necessary as weight will need removed from one end while being added at the other. This weight transfer would typically require would require a manifold however the local pumps eliminate the need for excess piping to and from the tanks as well as a manifold in the pump room. The estimated flow rate of these local pumps is 150 gallons per minute as determined by the amount of trim weight shift needed.

The variable ballast tanks are used to control the FSS freeboard depending upon the fish channel flow rate. At higher fish channel flowrates, more water will be pumped into the variable ballast tanks to account for the weight reduction due to the fish channel draw-down. Conversely, during lower fish channel flow rates, water will be pumped out of the variable ballast tanks. Filling and discharge of the variable ballast tanks is accomplished with the ballast pumps and does not require a manifold as the same operation, either filling or discharging, will always be occurring in both tanks simultaneously. The variable ballast tanks will be filled from and discharged to the reservoir. An abbreviated diagram of the trim system is provided below in Figure 6-22.

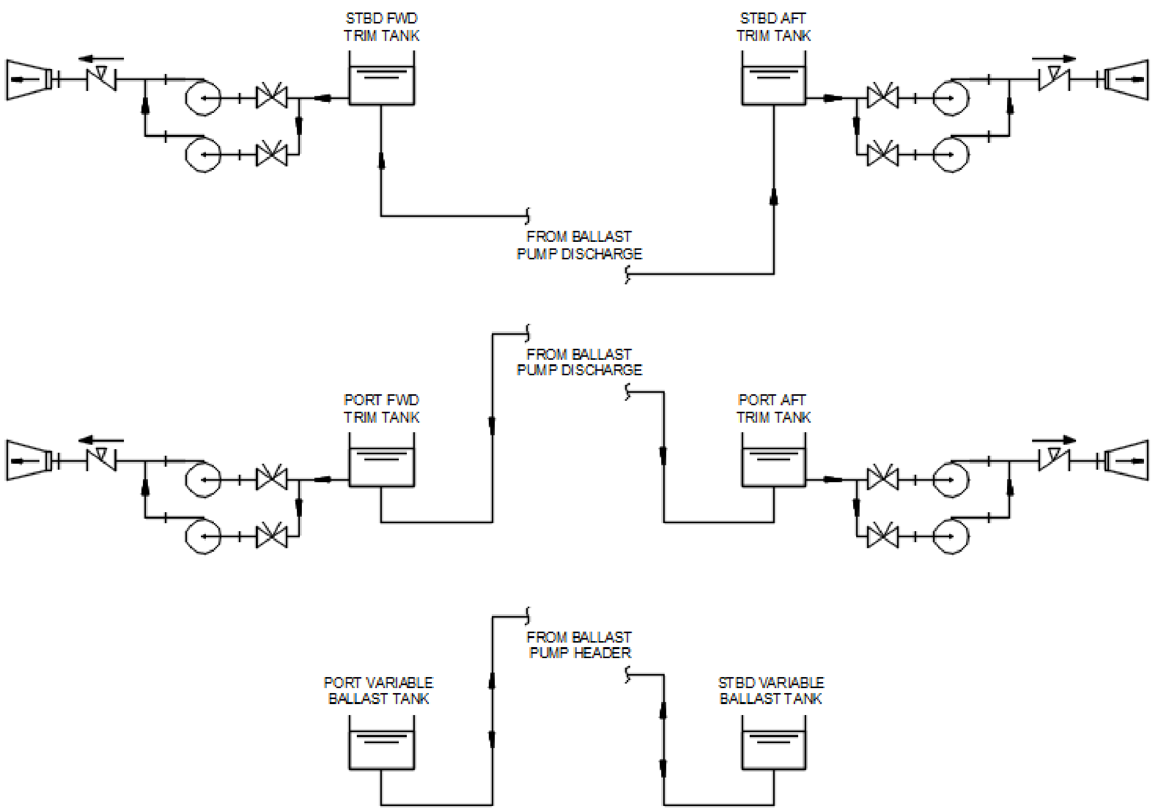

Figure 6-22 - Trim System Diagram

6.9.4.1 Tanks

The system has four trim tanks near the corners of the FSS and two larger variable ballast tanks midships. 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 trim and heel conditions of the FSS. The variable ballast tanks are used to counter the effect of changing the volume flow rate through the FSS. When flows are lower, more ballast volume is necessary to maintain the 5 foot design draft. Below is a table of the tank volumes.

Table 6-12 – Trim and Variable Ballast Tank Volume

Tank	Type	Approx. Vol. (cuft)
TT-H-1	Trim	11,054
TT-H-2	Trim	11,054
TT-118-1	Trim	13,750
TT-118-2	Trim	13,750
VB-59-1	Var Blst	21,168
VB-59-2	Var Blst	21,168

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.

6.9.4.1.1 *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 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. It is recommended that Radar TLIs be used.

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.

6.9.4.1.2 *Pumps*

Based upon the current estimate for the weight shift needed to account for trim and heel induced by fish channel flow changes and natural effects, two sets of pumps are needed. To account for fish channel flow changes, which will require large changes in the variable ballast tanks, the ballast pumps will be utilized to transfer water during these events. The flow rates necessary are estimated to be in the range of 8,000 gpm depending upon the amount of fish channel flow change and the time requirement. The current ballast pumps specified in Section 6.9.3.3 are sufficient to meet these flow requirements if all four pumps are in operation.

For smaller amounts trim and heel induced by natural forces such as wind and current, 8 local pumps will be used, 2 near each tank. It is currently estimated that the flowrate required to account for these small trim and heel moments would be approximately 150 gpm, or less. A single pump such as a Goulds 6CNHC series vertical turbine pump would be sufficient for this operation. These pumps would be mounted in pairs within each trim tank for 100% redundancy. Vertical turbine pumps are configured with a pump bowl at the bottom of the tank and a line shaft connected to a motor in the dry above the tank. This configuration eliminates the need for a submersible pump or a sealed, dry, pump chamber in each tank. Traditional pumps would not be sufficient to provide the 40 feet of lift that could be seen if the trim tanks are nearly empty and would require a dry location at the bottom of the tank.

6.9.4.1.3 *Piping*

To facilitate operation of the trim system, piping will be required from the pump room to each of the trim tanks. The size of the piping will be dictated by the ballast and trimming volumes necessary to maintain the optimum operational conditions of the FSS. It is currently estimated that the pipe size will need to be 10 inches from the pump room to the trim tanks to accommodate filling and emptying the Trim Tanks during ballasting and deballasting operations. For the variable ballast tanks, the pipe size is currently estimated at 10 inches from the pump room to the tanks, however this is subject to change depending upon the final variable ballast weight change.

6.9.4.1.4 *Valves*

The number and type of valves used in the trim system is highly dependent on the amount of water and flow rates required to maintain operations and will be finalized with the final design of the trim system. At a minimum each local trim pump will require a pair of gate valves to facilitate maintenance and an angles check valve to prevent back flow. Additionally, the piping from the ballast system to the trim and variable ballast tanks will require motor operated valves to accommodate the automated trimming system.

6.9.4.1.5 *Operation*

Due to the variations in fish channel flow and environmental conditions, it is recommended that the trim and variable ballast system be automated. An operating console will have system controls, override controls, and tank level readouts for each tank in the trim and variable ballast system. A PLC will control the pumps and motor-controlled valves for the trim and variable ballast tanks. Trim and/or heel will monitored by appropriate sensors located throughout the FSS. Preset trim and heel limits will be programed into the PLC. As these trim and/or heel limits are reached, the PLC will direct water into and/or out of, the appropriate tanks as necessary. An example of the trim system operation would be the system actions if the trim sensors indicated the bow of the FSS was trimmed down greater than the allowable distance. In this case, water would be transferred out of the forward trim tanks and into the aft ballast tanks until the trim sensors indicated the FSS was within the predefined limits. Similar actions would occur for athwartships and diagonal trim. The ballast pumps will be used to fill the trim tanks and local vertical turbine pumps will be used to empty the trim tanks as needed. The pumps for the system will have 100% redundancy as described in Section 6.9.4.

The timeframe for the FSS to transition between the various operational fish channel flow rates is approximately 15 minutes. This limited time frame will require a large flowrate in piping to the variable ballast tanks. This may impact the size of the piping and could potentially increase the size in future design work. Operationally, as the flow rate is changing through the fish channels, the PLC will align the pumps and valves as necessary to either add or remove water from the variable ballast tanks. The starting point for variable ballast tank levels will be the Off-peak operating point as described in Section 3.6. This off-peak point will see the variable ballast tanks filled such that they would be at the optimal volume for a fish channel flow rate of 3500 cfs. The operator will be required to input the desired fish channel flow rate which will allow the PLC to determine the final amount of water needed to be transferred. If the desired fish channel flow rate is between Off-peak (3500 cfs) and peak (5600 cfs) flowrate, water will be transferred into the variable ballast tanks to the appropriate level as determined by the PLC. Conversely if the fish channel flowrate is below the off-peak flow rate, water will be transferred out of the variable ballast tanks to the appropriate level as determined by the PLC.

6.10 HVAC

Ventilation systems for the manned spaces such as the pump room, fish handling facility, and above deck structures will be required. These systems will incorporate heating elements and air conditioning as required by the space and equipment within.

6.10.1 Design Standards and References

The HVAC system design will conform to the following:

- American Bureau of Shipping (ABS), Rules for Building and Classing Steel Barges 2017
- American Society of Heating, Refrigerating and Air Conditioning Engineers, 2009 Fundamentals
- Society of Naval Architects and Marine Engineers (SNAME), Marine Engineering, 1992
- American Society for Testing and Material (ASTM), Vol 01.07, Ships and Marine Technology

6.10.2 Pump Room

The pump room is necessary to the ballast and trim systems required for flotation of the FSS and therefore requires personnel to occasionally occupy. Due to the personnel occupying the area it is necessary to supply fresh air to the space and maintain a minimum space temperature to reduce condensation.

Systems will incorporate supply and exhaust ducting to facilitate a minimum of one complete air change every 3 minutes. The total pump room volume has been calculated to be 13,500 ft^3. Based on the space volume, the ventilation system the flow rate calculated at 4,500 ft^3/min. The duct air velocities should not exceed 2,000 ft per minute for quiet and efficient operation. To facilitate the required air change rate, supply and exhaust ducting for the pump room shall have a nominal area of approximately 2.25 square feet.

6.10.2.1 Heating System

The pump room heater is sized so the pump room temperature will not drop below 40 DegF. To facilitate heating, a duct heater will be necessary. A 30” x 30” duct expansion at the heater allows the air to slow to approximately 770 ft^3/min while it is heated before passing through the duct system and maintaining the pump room temperature. The heater in the pump room HVAC system will be located at the beginning of the run near the intake. Based on the flowrate of the system the heater will require a minimum of 26 kW, in order to efficiently heat the air passing through. From the Greenheck catalogue an IDHB Flange heater with 0.5-39.9 kW range will be sufficient for this HVAC system.

The pump room is surrounded by ballast tanks, which could potentially be holding 40 DegF reservoir water. To minimize condensation on the interior of the pump room it is recommended the heater set point be 60 DegF. Future design considerations should include thermal insulation and/or specific thermal coating systems.

6.10.2.2 Duct System

The supply system will utilize a square 20” x 20” duct for the majority of the system except for at the heater which expands up to 30” x 30”. After it passes through the heater it contracts back to the 20 x 20 inch, the ducting then splits into smaller ducts while maintaining a constant air velocity of ~1,800 ft^2/min to the diffusers. The exhaust ducting size will match the supply system and be natural exhaust. The total estimated pressure loss including duct fitting heater, is calculated as 1.875 in wg.

6.10.2.3 Fan

Based on the flowrate and duct size requirements and the estimated pressure loss of the system, a *Greenheck TBI-CA-5L18 Axial Fan* was determined to be appropriate for the system’s needs.

6.10.3 Electrical Control Building

The electrical control building located on the upper deck will be heated and cooled to protect the electrical equipment but not for occupant comfort. The interior design setpoints will be 60 DegF for heating and 75 DegF for cooling. The exterior design temperatures are 5 DegF for heating and 92 DegF for cooling. The estimate electrical load, with diversity, is estimated at 110,000 BTU/H.

Three 5-ton, vertical packaged heat pumps will be provided to meet the load and provide redundancy. A controller will be provided to stage the units and cycle between each unit.

6.10.4 Fish Handling Facility

The fish handling facility is a normally unoccupied area but needs spot heating in several locations where personnel will be working, this included the fish sorting areas and screen areas. The spot heating will be accomplished by using electric radiant heaters that are corrosion resistant and suitable for wash-down. The radiant heaters will be provided with local on/off timer switches to ensure that the heaters do not remain on when personnel are not present.

6.11 FSS to SWS Seal

Between the FSS and the SWS a continuous open channel flow occurs, and a sealing device is required to prevent the entrainment of water flow from the reservoir which has not passed thought the FSS. Because the water levels within the FSS will be lower than those in the surrounding reservoir, a robust sealing mechanism is specified. Several planes of motion need to be considered when designing such a sealing mechanism. First, small movements of the FSS are allowed by the pile hoop moorings. The pile hoops allow for approximately 6 inches of motion in the fore/aft and port/starboard directions. Additionally, the moorings allow for trim of the FSS either up or down by the bow. This will induce an angular component at the seal of approximately 1 degree. The third degree of motion is induced by the water level in the reservoir. The sealing mechanism will need to be able to seal throughout the range of reservoir water elevations during normal operation and account for approximately 129 feet of vertical travel as the reservoir water level can vary from 1445’ at low pool to 1574’ high pool. An additional motion that effects the seal mechanism is that the SWS is specified (by the SWS design team) as equipped with a weir which will travel vertically with the changing water level of the reservoir. The seal mechanism will make contact with the FSS through a semi-permanent bolted connection. The seal mechanism will make contact with the SWS at the edges (inline with the channel flow) and with the weir in the middle (perpendicular to channel flow). Motion effecting seal design are best broken into two categories; large macro vertical motion induced by changing reservoir pool levels and small differential motions allowed by the moorings especially from effects of wind and waves against the FSS. The seal design concept, is shown in Figure 6-23 and Figure 6-24.

Figure 6-23 - FSS to SWS 2 Parallel Seal Mechanisms

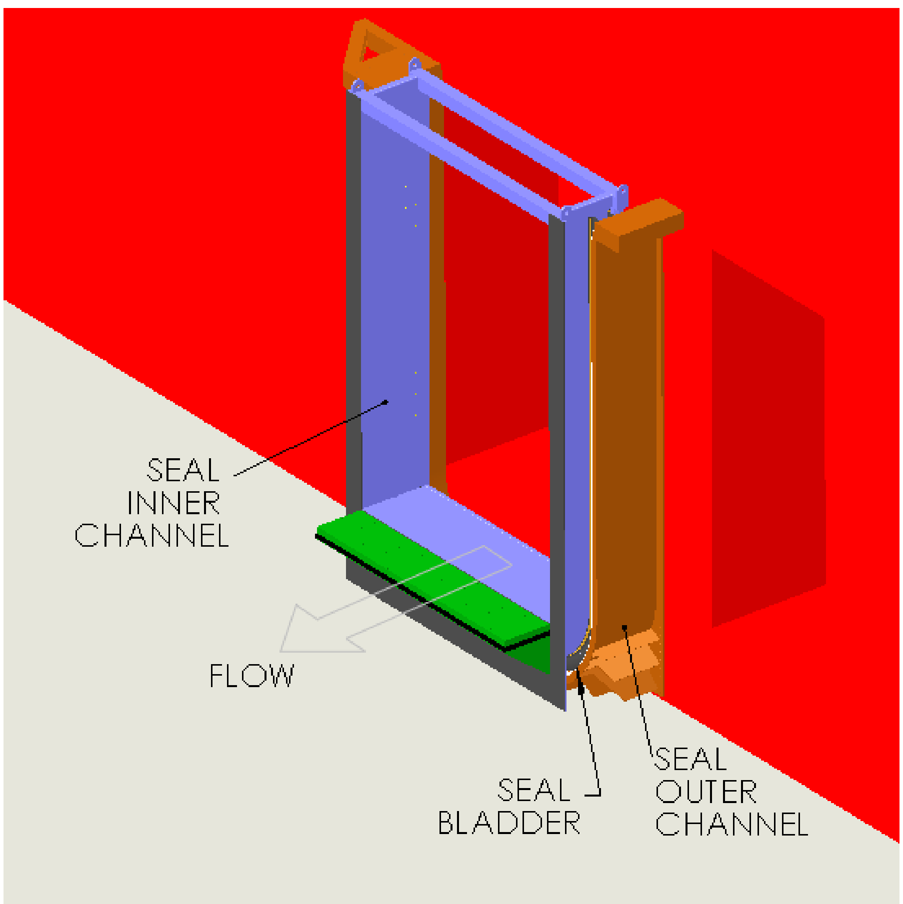

Figure 6-24 – FSS to SWS Seal Mechanism Concept

The recommended seal mechanism is composed of two pairs of concentric channels with approximately 15 inches separating the inner and outer channels. The left and right channel pairs are identical, as shown in Figure 6-23. The difference in water elevation between the surrounding pool (outside the channel), and the discharge water inside the channel ranges from approximately 1.2 feet at minimum discharge flow to approximately 2.6 feet (see Table 4-6) at maximum discharge flow rate, See Figure 6-32**.**

Design considerations include assembly, maintenance, emergency repair, and abnormal conditions which are outside normal operating range.

The preferred embodiment of the seal mechanism design includes the seal outer channel chute attached directly to the FSS by bolting at the time of FSS construction and before FSS launching. The seal outer channel chute would be field replaceable in the event that it was ever inadvertently damaged. There are no moving pieces or regular maintenance items in the preferred embodiment of the outer chute.

The seal inner channel chute of the preferred embodiment of the seal mechanism is readily removable for pneumatic seal service, inspection, or periodic maintenance. The seal inner channel chute assembly includes three distinct seals, 1) the pneumatic seal bladder that seals the inner and outer channels, 2) the non-pneumatic face seal between the inner chute and the face of the SWS which is perpendicular to the channel flow, and 3) the small pneumatic seal between the discharge lip of the inner channel and the face of the weir of the SWS, shown in Figure 6-25 below.

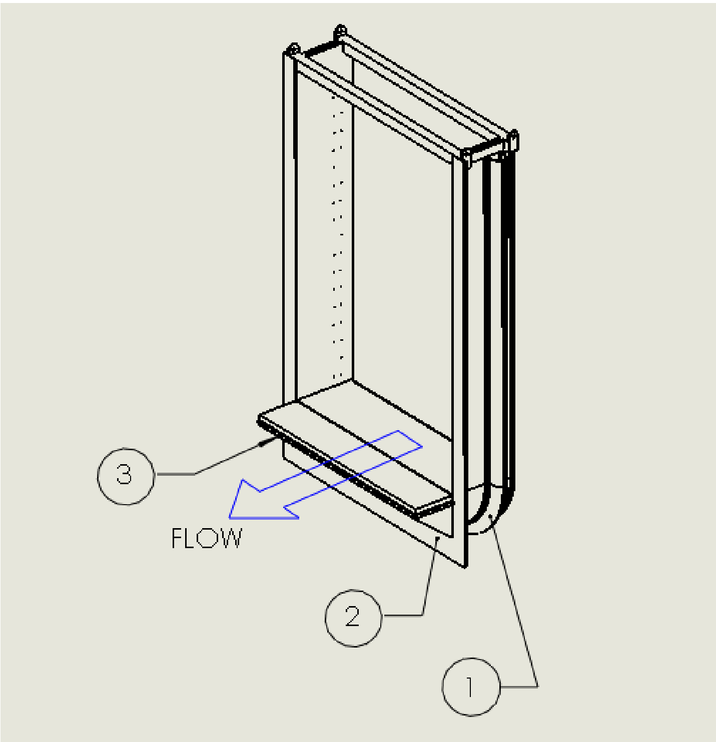

Figure 6-25 - Three Seals of the FSS to SWS Sealing Mechanism

As the seal outer channel chute moves in relation to the seal inner channel chute, due to the mooring-allowed motions the primary seal is able to expand on one side to fill the gap and contract on the other. As the FSS moves port and starboard, the inner channel slides in and out of the outer channel. Movement fore and aft is countered by the expansion and contraction of the inflatable seal. Similarly, trim and heel angles up to roughly 1 degree can be accounted for with the 15 inches of separation between the channels, shown in Figure 6-26 below.

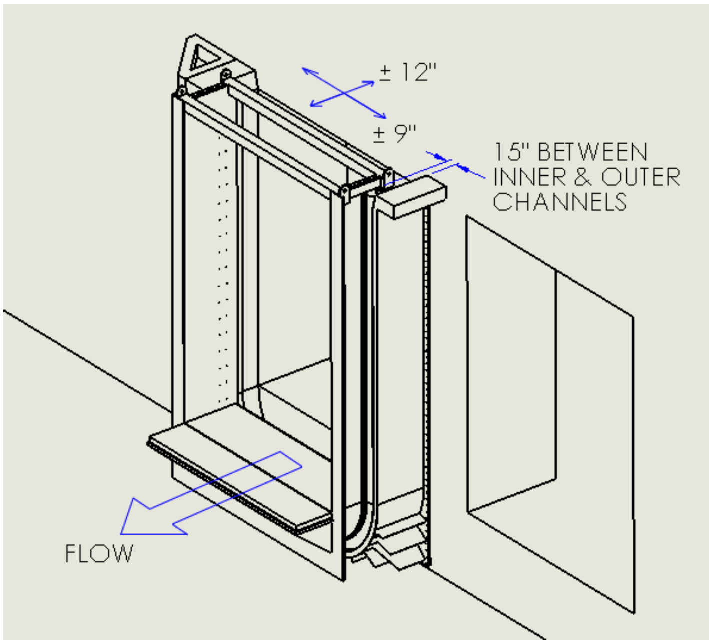

Figure 6-26 - Design Range of Motion of FSS to SWS Seal

The primary seal, which is the seal in between the FSS channel and the SWS channel, is comprised of individual bladder chamber segments and a contiguous outer cover as shown in Figure 6-27 and Figure 6-28 below.

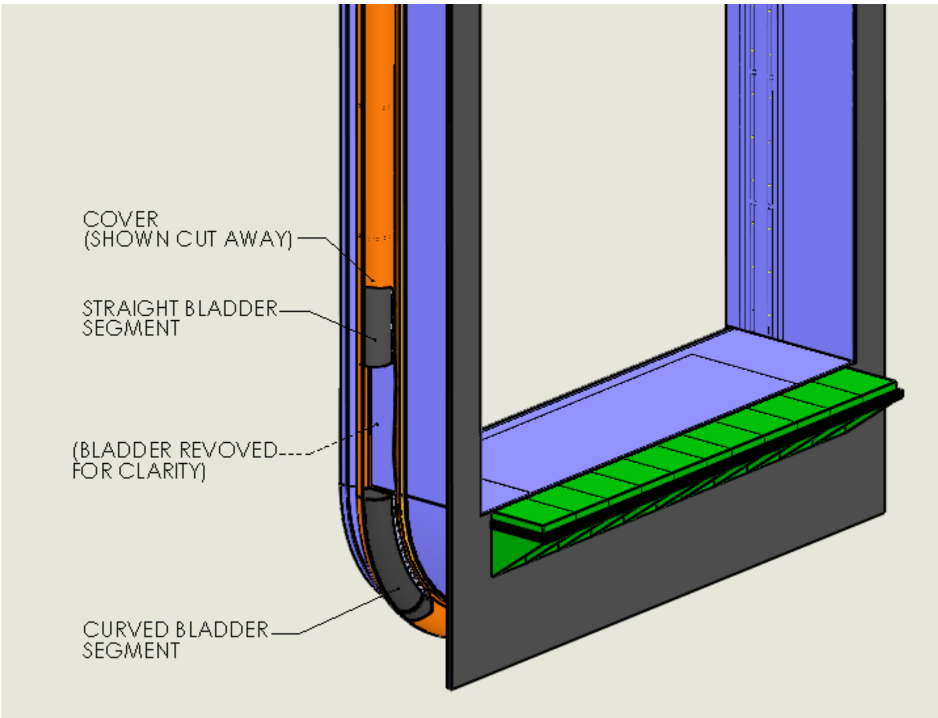

Figure 6-27 - Internal Cut Away View of Primary FSS to SWS Seal

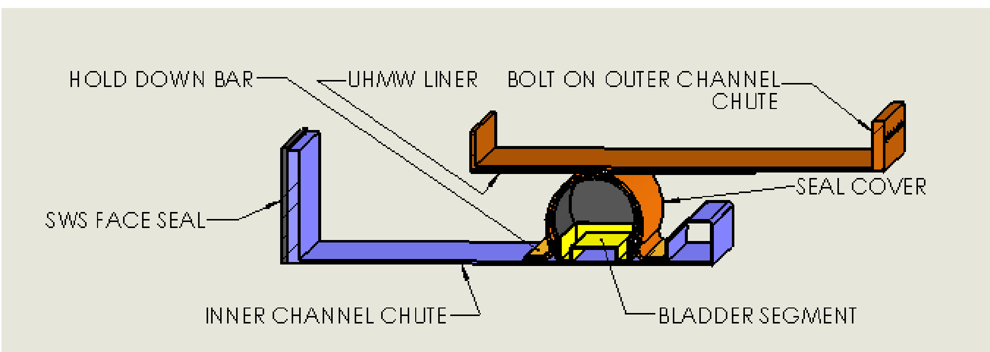

Figure 6-28 - Cross Section View of Primary FSS to SWS Seal Assembly

Inflatable bladder segments are comprised of a steel pan with a custom molded rubber bladder top and a perimeter connecting band as shown in Figure 6-29 below.

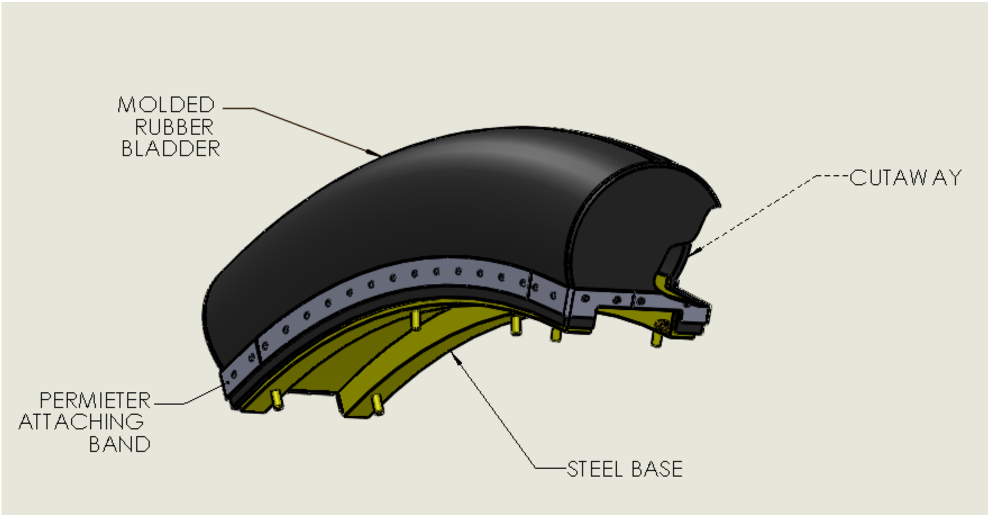

Figure 6-29 -- Primary Seal Bladder Segment with Cut Away

Channel area in the underside of the steel base pan provides a routing location for bladder inflation hoses. The inflatable rubber bladder segment is a single piece of molded 1/2" thick SVR rubber cold bonded (glued) to the steel base pan. Perimeter steel banding attaches the rubber bladder section to the base pan. Studs are welded into the base to provide fastening means to the main inner channel. Inflatable bladder segments are made in two shapes: curved and straight as shown in the cutaway view Figure 6-29 above.

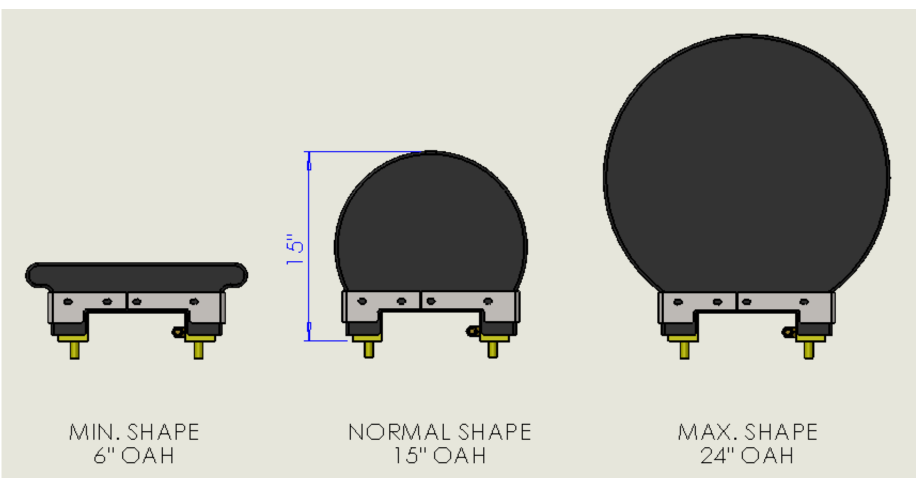

Figure 6-30 - Primary Seal Bladder Segment - Expansion Shapes

The bladders stretch and deform, as shown in Figure 6-30 above, to a maximum working expansion of 250% of the molded shape.

Bladder segments are built as individual segments of about 5-foot-long by about 12 in wide to allow ease of manufacturing as shown in Figure 6-30. Molding companies in industry have identified these as good dimensions to design to for formability.

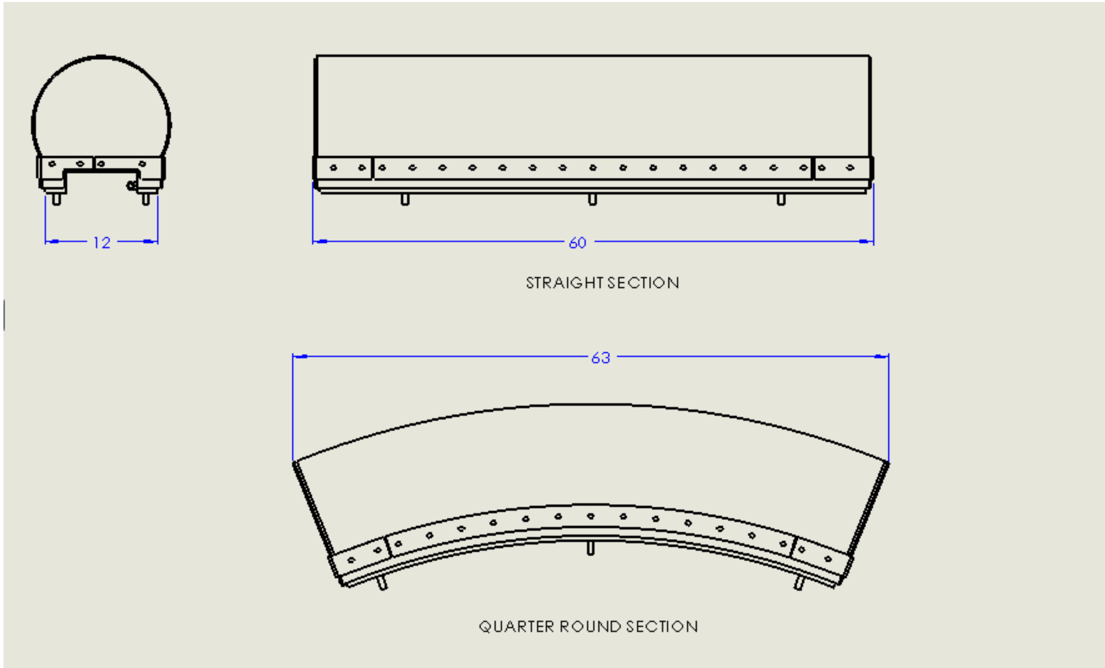

Figure 6-31 - Primary Seal Bladder Segment - Fabrication Dimensions

A sealing solution allowing the use of bladder segments is important because of the gradient requirements for sealing according to varying depths, and due to the differential head inside the channel and outside the reservoir pool. The plenum level at the FSS to SWS seal shown in Figure 6-32 demonstrates the pressure gradient inside and outside of the seal channel.

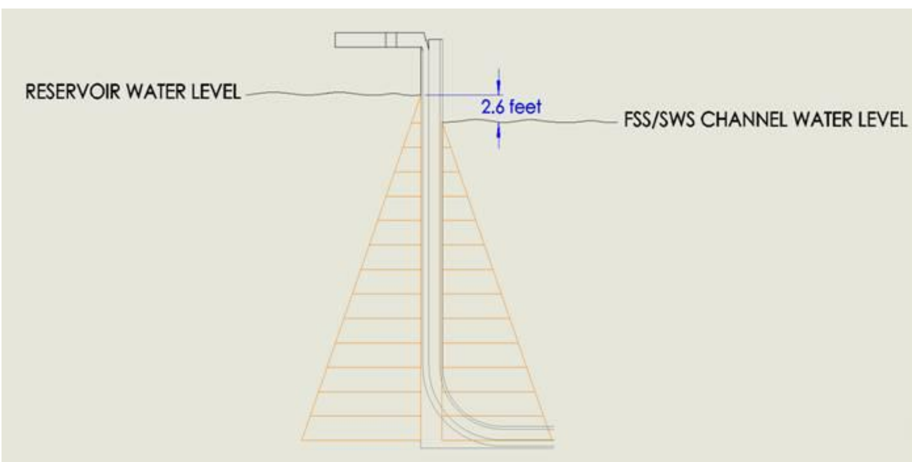

Figure 6-32 - to SWS Seal Pressure Gradient

The pressure difference inside and outside of the channel due to the head difference inside and outside the FSS/SWS seal channel is 5psi. The pressure at the bottom of the seal, 37 feet below the reservoir pool water surface, is 16 psi. The pressure of the seal should be kept to a nominal 5 psi higher than the head pressure of the water attempting to infiltrate into the seal channel, therefore the design pressure for the system ranges from 8 psi minimum to 21 psi maximum.

Straight primary seal bladder segments at the top should be charged after assembly to 8 psi, while primary seal bladder segments at the bottom should be charged after assembly to 21 psi, and the intermediate bladder sections should be grouped by zones and the charge pressures regulated linearly in between these two values. Zones should be connected left and right to assist filling and evacuating left side and right-side bladders under heavy wind loads. This will also prevent over pressurization. Total air volume of the system at rest is approximately: 78 cubic feet. Total air volume of the system at maximum deflection is approximately: 102 cubic feet. Although there are other working fluid alternatives, dry air is the preferred working fluid for pressurizing seal bladders.

6.11.1 Removal From SWS

The dead load weight of the removable seal inner channel chute assembly is approximately 53 kips. The counterweight shown in Figure 6-33 is an additional 38 kips.

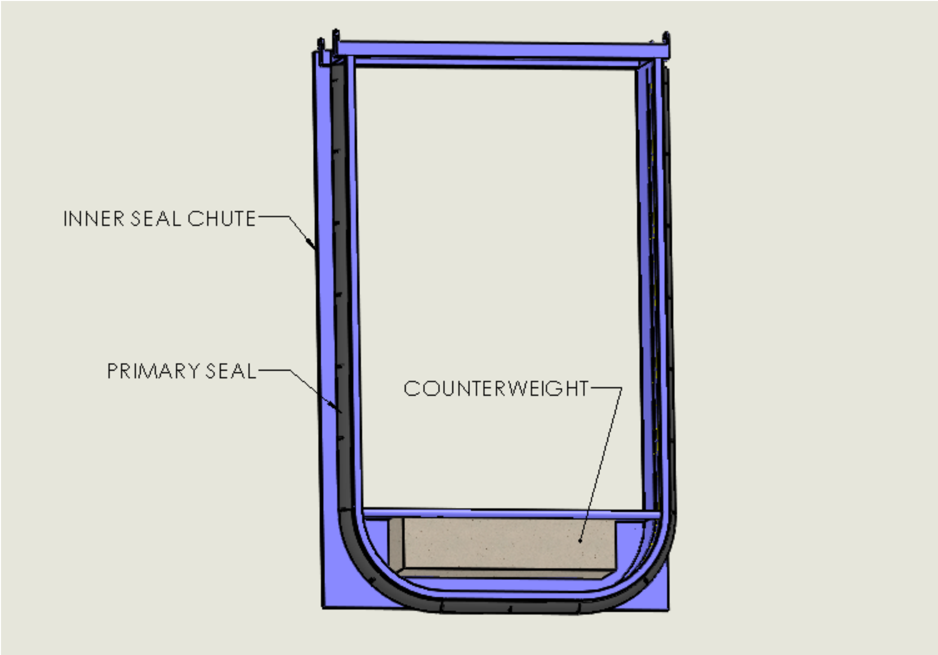

Figure 6-33 - Seal Inner Channel Chute Assembly

The crane capacity of the Liebherr LTM-1070-4.2 project crane is 105 kips at 15 feet. Space must be provided atop the SWS for this short radius lift. The buoyancy force induced by the combined head losses through the FSS and through the FSS to SWS seal (2.6 feet of head) is approximately 40 kips. The maximum air in the bladders gives an additional 11 kips buoyancy.

Attachment of the seal inner channel chute assembly is by gravity. The FSS goes up and down with the elevation of the water in the reservoir and so the FSS to SWS seal is free to ride with the water level. The seal inner channel chute assembly is suspended by constant tension jib cranes, see Figure 6-34.

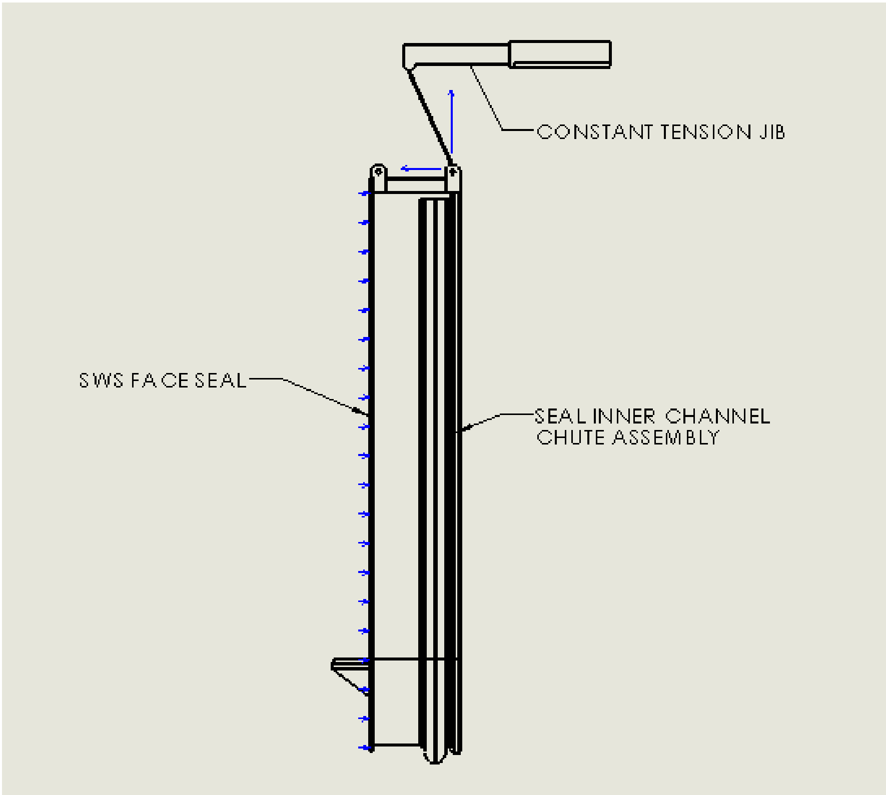

Figure 6-34 - Seal Inner Channel Chute Sealing Force and Secondary Sealing Surface

The constant tension provides the lateral sealing force. The face seal for the SWS which is mounted to the inner channel chute assembly is low durometer rubber sheet. A more complex pneumatic seal could be used on this surface if the SWS cannot be produced in an as-built flat surface condition. The SWS design by others needs to take into account the seal and attachment means to integrate this design.

The inner channel chute assembly is lowered by the project crane into capture angles that loosely capture the flange of the inner channel chute and the crane lowers the assembly until it cradles into the outer channel chute. The SWS should be equipped with capture angles and stainless steel sliding surfaces at the left and right corners of the weir openings. See Figure 6-35**.**

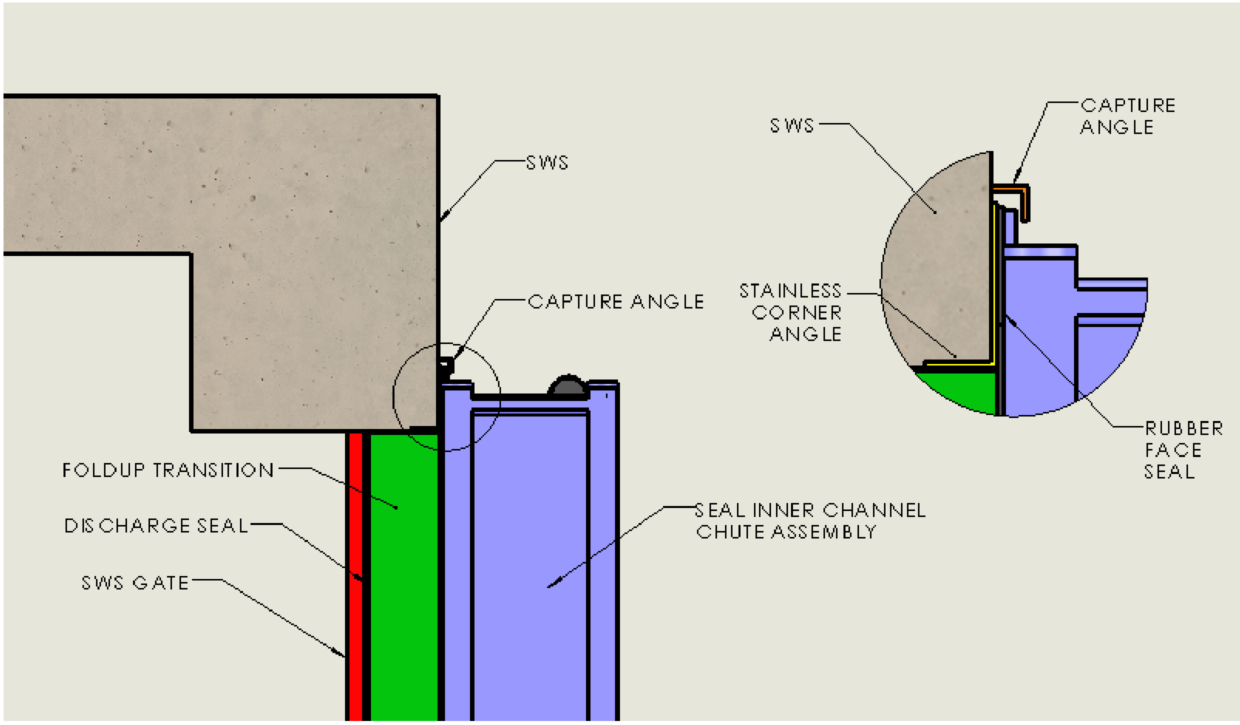

Figure 6-35 - Seal Inner Channel Chute Sealing Force and Secondary Sealing Surface

The foldup transition is a mechanism that is retracted and folded into the seal inner channel during installation or removal of the seal inner channel chute assembly. During operation the foldup transition is placed in the down position. Figure 6-36 shows the foldup transition in operation.

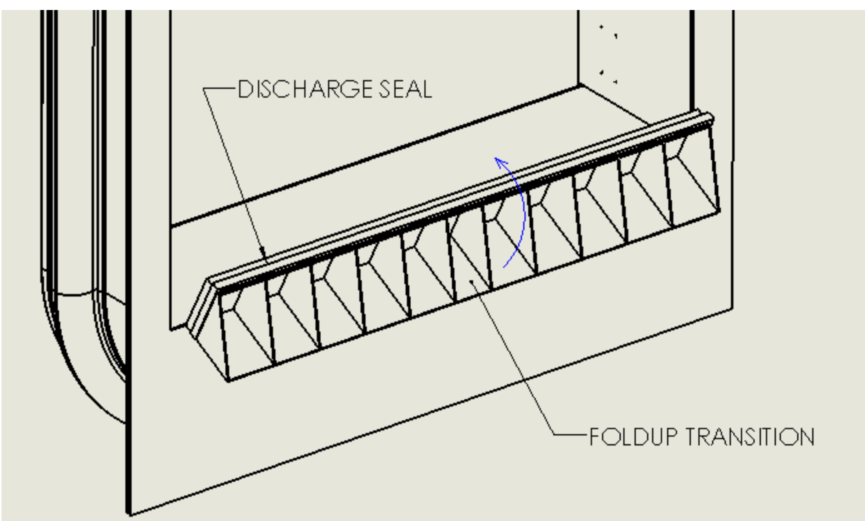

Figure 6-36 - Foldup Transition Rotation

The foldup transition has a discharge seal around three sides which is a pneumatic seal by Trelleborg (Airseal VMQ 946-5).

The preferred embodiment of the seal mechanism is a series of expanding seal bladder chambers shrouded with an outer cover made of sheet rubber. The outer cover expands within the 250% operating expansion range of the rubber as do the custom molded bladder segments. The outer cover is the contiguous membrane that makes the actual seal between the inner and outer section of the seal mechanism. The sealing system has been developed in conjunction with industry leading rubber forming and application professionals. Parts have been developed to utilize industry standard fabrication processes for custom rubber fabrication.

An alternate embodiment is to use a non-expanding outer cover and a series of similar bladder segments. Companies that make these types of bladders also commonly make fuel cells of the same type and configuration and use them for both liquid storage and as pneumatic bladders in marine, industry, and aerospace applications.

6.12 Compressed Air

6.12.1 Description

The FSS structure requires compressed air to operate some of its auxiliary systems. The compressed air system connections will be strategically placed in areas where most efficient use would be required, I.E. fish handling area, pump room, debris collection area, as well as necessary maintenance locations. Routing and pneumatic diagrams for this need to be further defined once the final equipment and configuration is determined. A compressed air system will also extend to further include areas that are to be determined necessary for future considerations.

6.12.2 FSS to SWS Seal

One of the more important functions of the air system will be to feed compressed air into the seal between the FSS and SWS. Because the seal will not be in a fixed position a flexible airline will be used to allow the seal to operate in various vertical and horizontal orientations. Future design will be required to determine the minimum pressures, volumes, and control systems for the proper operation of the FSS to SWS seal.

6.12.3 Piping

The compressed air system will utilize ASTM A 106 GR B Carbon Steel Piping. This is a typical Marine grade compressed air steel pipe commonly found throughout the industry. The piping will be supported by hangers at varying intervals depending upon the size of the pipe.

6.12.4 Airburst Screen Cleaner

The juvenile fish separator includes a dewatering screen below the separator panel which will be cleaned with an airburst backwash system. The system includes a series of pipes located below the horizontally mounted screen panel, with small holes along the length of the pipes for releasing compressed air upward through the screen. The air bubbles will dislodge the debris and drive it upward where it should get sluiced out via the fish distribution flumes and ultimately be discharged into the fish transport pods. The compressed air will be provided to the pipes through an adjustable pressure regulator so that the optimal pressure can be determined that effectively dislodges the debris but is still low enough to not injury the fish in the separator box above the screen. Operation of the airburst cleaner is described in Section 10.

6.12.5 Emergency Shutoff Gates

The two emergency shutoff gates, located in the fish flumes immediately downstream of the secondary screens, are held up out of the water by one-way pressurized pneumatic cylinders. In the event there is a loss on main and backup power, the FHF drain sump pumps and the FHF flow return pumps would shut down so flow to the FHF area would need to be stop to prevent flooding of the FHF area. Upon complete loss of power, solenoid valves attached to the emergency shutoff gate pneumatic cylinders would open releasing the air from the cylinders and the gate leafs would drop under their own weight shutting off the FHF flume flow. Upon recovery of power, the solenoid valves would close, and compressed air would be provided to the cylinders reopening the emergence shutoff gates and restarting the FHF flow.

6.12.6 Fish Flume Diverter Gates

The juvenile fish distribution flumes include diverter gates to distribute juvenile fish to the fish transport pods. These diverter gates are operated pneumatically, and switch positions very rapidly (in less than one second). There are a total of 14 diverter gates (seven in each of two distribution flumes). Two-way pneumatic cylinders control the operation of the gates. The layout of the diverter gates are described in Section 4 (and depicted on the plates in Appendix A), and their operation is described in Section 10.

6.13 Potable Water and Sewage

Fixed potable water and sewage systems will not be a part of the FSS design. Restroom facilities will be managed by portable restrooms which are stationed on the access float. Workers will also have access to sanitizing stations integrated into these portable restrooms facilities. The portable restrooms will require service and cleaning to be performed in place.

6.14 Deck Washdown

Cleaning of the upper deck will be facilitated via a pressurized water system (see Section 6.4.3). Drainage for the system will be placed in critical areas as deemed necessary and will utilize the deck drain system as described in Section 6.17. A more detailed layout for pumping of deck washdown water will be detailed in future designs.

6.15 Noise and Vibration Mitigation

Noise and vibration mitigation will be accounted for and implemented in the most critical areas with a more detailed analysis in the final design report. In particular, the pump room will have thermal and sound insulation. Pumps and other vibration-producing equipment shall be fitted with vibration absorbing mounts such that minimal vibration is transmitted to the FSS. Any equipment which produces noise at a level which may cause hearing loss shall be fitted with silencers and/or sound insulating material. Any confined spaces where noise levels may cause hearing loss shall have affixed to all entry points signage which denotes the appropriate hearing protection for the space.

6.16 Lifesaving and Safety

6.16.1 Guard Rails and Life Rings

Guard rails which meet all OSHA standards for height, strength and location will be provided on the FSS and will surround the entirety of the deck edge at a minimum. Guard rails will be made from typical carbon steel SCH 40 pipe. Ladders will be designed in accordance with OSHA regulations and platforms must be installed where maximum ladder length is exceeded. Lifesaving equipment on board the FSS will consist of life rings with a minimum of 90 ft of rope and will be located on the FSS deck around the perimeter.

6.16.2 Fire Protection

Fire protection will also be implemented on the FSS structure. A fixed fire suppression system is not required; however, USCG approved handheld fire extinguishers will be installed around the FSS.

6.17 Deck Drainage

Drainage of the top deck will rely on overboard drain scuppers to facilitate adequate water runoff from rain, cleaning, and miscellaneous sources. Below the main deck and in areas such as the fish handling facility, accumulated water will drain to the circulation water sump or back to the plenum. The use of bilge pocket sumps will allow water to accumulate and be removed by a bilge system for the majority of areas on the FSS. The pump room will require a portable pump system as drain wells will not be possible. The bilge system will consist of 1 or more pumps, piping, valves and a holding tank for bilge water. A suction hose will be provided from the pump and will be capable of reaching all locations at the bottom of the pump room for the removal of accumulated water.

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 and 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.
- 46 CFR ShippingTP 127E Ships Electrical Standards, (Canada) Rev 3, May 2018.
- IEEE Standard 142-1991, Recommended Practice for Grounding of Industrial and Commercial Power Systems.

7.2 Seismic Considerations for Electrical Equipment

Typical seismic restraints for floor-mounted equipment will not be required.

7.3 Electrical Service

The shore side electrical supply is to be medium voltage distribution via hard pipe to a disconnecting means on the shore. Power will then be distributed via submersible flexible cable to the barge disconnecting means. The cable will then be routed to the transformer/service switchgear on the barge to step the power down for the 480 volt power distribution system. MV cables will be protected in accordance with NEC.

Power for the FSS will be distributed from the dam electrical distribution system in a simple radial configuration at 480 VAC to supply the various loads including a lighting and power transformers, combination starters, variable frequency drives, and 480 V welding receptacles. 208Y/120V panelboards will be provided for lighting, receptacles and other small branch circuits.

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 normal and standby power required for the proposed FSS.

7.4 Electrical Distribution and Equipment

7.4.1 Distribution

The electrical distribution system consists of a double ended substation at 13.8kV primary, 480V secondary. The electrical distribution on the barge will be 480V 3 phase, 3 wire. The ground system shall be a high resistance ground system. There will be step down transformers to 208Y/120V panels, 3 phase, 4 wire to feed 208V and 120V loads.

The main switchboard (MSB) substation unit will be located in the electrical building. This is the location identified as well for the facility control panel(s).

Power is distributed throughout the barge via conduit and wire to Motor Control Centers (MCCs) and distribution panels strategically placed in order to minimize voltage drop.

There are 5 MCCs identified, based on system loads to be supplies and the location of the equipment, as well as three sets of 480V panels feeding step down transformers which in turn supply the 208Y/120V panels. Raceways:

- Rigid Metal Conduit (RMC) will be required for all exposed work.
- Flexible metal conduit (FMC) and liquid-tite flexible metal conduit (FLMC) will be provided for all conduits connecting to vibrating equipment.

7.4.2 Standby Generator

USACE will design and provide stand-by power to the FSS via generator located on the SWS or the dam. This will provide power to the barge in the event of loss of utility power from the dam. There is no provision at this time to provide standby power on the barge outside of egress lighting and the UPS systems for the controls. Minimum standby electrical loads are identified in the Electrical Equipment Schedule.

Standby power shall be provided to the FSS via submersible cable at 480V, to a designated standby power panel on the FSS.

7.4.3 Grounding and Bonding:

The electrical system shall be a high resistance ground system in compliance with the NEC.

A separate equipment grounding conductor will be provided for all circuits.

7.5 Electrical Features

7.5.1 Control System:

A Programmable Logic Controller (PLC) system will be utilized to provide automatic control of the FSS. The Control System will include the capability for remote monitoring and alarm notification at the Powerhouse Control Room. Control panels with touch-screen graphics panels will be located in the FSS Electrical Room, Pump Room, and Fish Handling facility. The graphics panels will provide the operator interface to the control system. An industrial Ethernet network will be utilized to connect all sensors, drives, actuators, remote I/O, power meters, and other devices supporting the monitoring and control system. Process devices such as level sensors will require a 4-20mA transmitter, as units with Ethernet communications 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. The barge PLC will communicate with the powerhouse control room on-shore via fiber optic routed adjacent to the electrical service cable back to the control room on shore.

7.5.2 Supervisory Control and Data Acquisition (SCADA)

The FSS Control system will not be incorporated into the existing SCADA system at the Detroit Dam facility. Remote status and alarm monitoring will be provided via a separate system.

7.5.3 Communications

Telephone service will be furnished for communications to the control room at the Detroit Dam facility. The telephone service shall connect via fiber optic routed adjacent to the electrical service cable back to the control room on shore.

It is anticipated that communications, both telecommunications and controls will be transmitted across to shore via fiber, incorporated with the submersible power feeders from shore to the barge.

7.6 Lighting and Illumination

7.6.1 General

All lighting will follow Illuminating Engineering Society standards. General lighting for security and local lighting for operation and maintenance will be provided on the FSS using LED light fixtures. Additional lighting will be provided for deck illumination during night or emergency operations as well as flood lighting supporting trashrack and knuckle-boom crane operations. Coordination of lighting requirements for crane operations, fish handling, and personnel safety will be provided based on final equipment selection and placement on the structure.

7.6.2 Bridge Crane

Bridge crane lighting in the fish handling facility 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 color-coded electrical wiring.

7.6.3 Emergency Lighting

Back-up lighting systems with battery back-up will be provided to support egress during unforeseen power outages.

There will be minimal supplemental lighting to enable orderly shutdown of fish handling operations in the event of a power outage. It is not anticipated that fish operations would continue beyond addressing the fish already in the system, should facility power fail.

7.7 Preliminary Electrical Load Analysis

Preliminary load analyses were performed in order to estimate the electrical loads under different conditions. Refer to the Electrical Equipment Schedule in Appendix H for additional information.

7.7.1 Connected Load

Loads were calculated based on the requirements of the NEC in order to determine proposed equipment sizing. All loads must be included unless they are designated as non-coincident loads (i.e. they will never operate while another specified load is operating) such as redundant pumps.

7.7.2 Normal Operational Load

This analysis identifies what the typical electrical consumption would be under normal operating conditions. Loads are based on identified equipment operational procedures. For example, they assume that backwash pumps and larger motors will not all operate simultaneously. It is anticipated that one bank of screens will undergo backwash/cleaning at a time, though two banks of valves may operate at a time – one set of valves closing while the other set opens.

7.7.3 Maximum Peak Demand Load

This load analysis is essentially the connected load analysis, except that the NEC required demand factors are applied.

7.7.4 Standby Generator Load

This load analysis is based on anticipated equipment that may be required to operate in the event of utility power failure in order to complete fish handling/moving operations. All loads are anticipated to be non-life safety, with the egress lighting needs provided via battery back-up light fixtures.

7.7.5 Heating and Ventilation Equipment

Estimated loads for equipment have been provided and are indicated on the Electrical Equipment Schedule. Heating and cooling is anticipated for the electrical building, fish handling building, MCC building and the pump room. Currently, cooling is anticipated for the electrical building with the MV transformers located inside the building. Should the transformers be located exterior of the electrical building, the cooling loads for that facility would be substantially reduced.

7.7.6 Lighting and Receptacles

Facility lighting, maintenance and operation lighting, and general maintenance receptacles will be provided. Security requirements such as camera placement will be addressed during the design phase based on coordination with USACE.

Coordination with facility operations staff to effectively locate receptacles and supplemental lighting shall be implemented during subsequent design phases of the facility once equipment is located. Anticipated minimum receptacle locations are identified on the drawings. NEC requires receptacles to be located within 25 feet of mechanical and other equipment requiring servicing.

7.8 Other Systems

7.8.1 Fire Alarm

Only local fire detection devices are included in the design. There is no addressable system provided. Fire suppression consists of fire extinguishers.

7.8.2 Lighting Protection

No lightning protection requirements have been established at this time.

7.8.3 Cyber-Security

No cyber-security requirements have been established at this time.

7.8.4 Security/CCTV

No specific security or CCTV provisions have been established for this project at this time.

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 Santiam River. The natural cycle of water temperatures was altered when the Detroit Dam Project began operation in 1953. The change from the natural cycle disturbed 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. 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 and Magnuson-Stevens Fishery Conservation and 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 Detroit Downstream Fish Passage Project. In order to comply with NEPA, a draft Environmental Impact Statement (EIS) will be distributed for a 45-day public review and comment period. The draft EIS will address the alternatives analysis as well as the temporary and permanent environmental impacts associated with project elements. Major project elements are describe in Section 1.4. After the public notice period has closed, any comments will be addressed in the final EIS, and a Record of Decision (ROD) will be completed based on the assessment. No decision on a proposed action will be made until 60 days after notice of the final EIS availability has been published in the Federal Register by the Environmental Protection Agency.

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 Linn and Marion Counties include[1] (Threatened (T), Endangered (E), Proposed (P), or Candidate (C)): Magnuson-Stevens Fishery Conservation and Management Act.

- North American wolverine (P),
- Water howellia (T),
- Streaked Horned lark (T),
- Bradshaw's desert-parsley (E),
- Yellow-billed Cuckoo (T),
- Marbled murrelet (T),
- Nelson's checker-mallow (T),
- golden paintbrush (T),
- Willamette daisy (E),
- Kincaid's Lupine (T),
- Northern spotted owl (T),
- Whitebark pine (C),
- bull trout (T),

[1] Source – Center for Biological Diversity - http://www.biologicaldiversity.org/programs/population_and_sustainability/T_and_E_map/

- Fender's blue butterfly (E)

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 SWS is incorporated in the 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 SWS designs should adhere to the NMFS 2011 Anadromous Salmonid Passage Facility Design Standards. Additionally, a summary identifying the potential amount and extent of take (defined as “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct”) associated with construction and operation of the Detroit Dam SWS will be submitted to NMFS and USFWS. Even if the net effect of the Project is beneficial, the consultation pathway will depend on whether any of the effects qualify as "take" under the ESA. Based on conversations with NMFS General Counsel, even if the effects rise to the level of "take," NMFS currently believes take coverage can be provided through the existing BiOp rather than an individual consultation.

8.3.3 Magnuson-Stevens Fishery Conservation and Management Act (MSA)

In compliance with the Magnuson-Stevens Fishery Conservation and Management Act, an Essential Fish Habitat 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 BiOp.

8.3.4 Fish and Wildlife Conservation Act (FWCA)

To maintain compliance with the Fish and Wildlife Conservation Act, input from the USFWS and state fish and wildlife agencies concerning this proposal is being provided through the WFFDWG and their review will be requested during the public notice comment period for the draft EIS. Further, the Detroit Dam SWS 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. Additionally, some requirements of this Act have been simultaneously addressed in conjunction with the ESA consultations referenced above. The project team did informally coordinate with the USFWS and NMFS on applicability of FWCA and they concurred with the Corps’ determination.

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, and 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. In order to comply with Section 404 of the Clean Water Act, dredge and fill activities proposed at the Detroit Dam Temperature Control Structure 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/or minimized, to the greatest possible extent, 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 National Pollutant Discharge Elimination System (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 techniques that include infiltration and protection of existing soils and vegetation should be implemented wherever appropriate. As much as possible, site grubbing and clearing should be kept to the minimum required for the permanent project footprint.

Additionally, all in-water work will require a work isolation plan for control of turbidity and plans for fish salvage and exclusion. The plans will be submitted with the JPA and reviewed during DEQ's WQC evaluation. The DEQ often defers to the ODFW and NMFS regarding appropriateness of proposed fish salvage and exclusion measures and may require just a document of acceptability issued to the agencies from those organizations. Turbidity monitoring reports will be required during all in-water work.

The project will result in permanent impacts to wetlands and waters. These include: permanent fill and removal of in-water materials essential to constructing the SWS foundation. Changes to channel dynamics are expected to remain localized and should avoid inducing significant up or downstream channel or bank instability. An ODFW blasting permit will be required; blasting should be scheduled to occur during the in-water work window. As appropriate, additional BMPs should be applied in order to minimize impacts to listed species. This plan must address all contributing impervious areas and provide treatment designed per a DEQ-accepted manual or its equivalent. Impervious surfaces contribute to water quality degradation because they act as deposition and conveyance surfaces for accumulated air and traffic pollutants. Water quality treatment to avoid these impacts should be described in the SWMP.

Point source discharges for the facility operation will need to be covered under an NPDES permit issued by the DEQ.

Restoration of water quality function will be required to address the impacts to waters of the State. Restoration of riparian vegetation and stream banks must be reflected in a site restoration and enhancement plan to be included with the JPA. Although none are expected, any additional wetland impacts will also require mitigation. Any mitigation will be reviewed by DSL and DEQ when considering replacement of water quality function. The 2008 BiOp also describes water quality and habitat restoration measures that should be considered in the mitigation and restoration plan development. Opportunities to meet these obligations likely exist on site.

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.

Under the Clean Water Act, the Corps is required to comply with state and/or local requirements, including obtaining permits and paying reasonable service charges and respecting the control and abatement of water pollution. This will include obtaining a Section 401 Water Quality Certificate (WQC) from the DEQ. The WQC will likely require that in-water work occur within the ODFW preferred time window, which for the North Santiam River above Detroit Dam is June 1 - August 31. Under State law, DEQ requires that the activity is compatible with local land use plans. This can be achieved if Marion and Linn Counties sign the City/County Planning Department Land Use Affidavit section of the JPA for the WQC. Under federal law, the Corps is required to comply only with the local requirements governing control and abatement of water pollution and is not obligated to comply with local land use laws. Therefore, any requirements by the County must be based solely on water quality-related matters. The Corps may need to obtain a permit from the DSL for the discharge of fill material into waters of the United States. Any mitigation should be based on direct habitat losses, with the use of adaptive management (including monitoring) to ensure mitigation for wetlands incurs no net loss. The Corps should attempt to align any DSL requirements consistent with its own CWA Section 404(b)(1) evaluation of the impacts.

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 are 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 an elevation below the minimum conservation pool of 1,450ft has the potential to expose documented archeological sites and to reveal new sites. Exposed areas 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 a drawdown, law enforcement, or rangers, will need to increase patrols along the shoreline to guard against potential looting as sites are exposed. Consultation on the Area of Potential Effect, which is assumed to include the dam, staging areas, and areas exposed by the deep drawdown, will take place with the State Historic Preservation Office and the tribes.

9 CONSTRUCTION

9.1 General

Four potential sites were considered for FSS assembly and launch. A trade off analysis, provided in Appendix I was conducted to determine the most desirable site. Alternative Site 1, located at the Detroit Lake State Park Maintenance Yard, was chosen after the analysis and discussion with USACE. This site is approximately 4.8 miles upstream of the Detroit Dam along State Highway 22. The Maintenance Yard is located on a wedge of land just off Highway 22, with a beach, and a combination of trees, brush, and clearings. Maintenance personnel predominately use the north side of the land, and the FSS construction activities could likely make use of the south side. The south side of the existing site consists of some picnic tables, an old shed, a brush pile, trailer parking used by the park employees, trees, and undergrowth.

The overall construction site will consist of access and staging areas, the FSS assembly area, and the FSS launch area. A dewatered perimeter bounds the assembly area, the size of which depends on the crane selection and assembly strategy. A 450-foot by 250-foot cofferdam is recommended as the assembly area. The launch area will be a constructed road to move the FSS down to an elevation required to launch. Mooring piles, flexi-floats, floating cranes, and other large floating equipment needed for the overwater installation can also be launched at this construction site. Figure 9-1 shows the recommended locations of the staging area, cofferdam assembly area, and launch road. Detailed design of the cofferdam and launch road will likely be performed by the construction contractor.

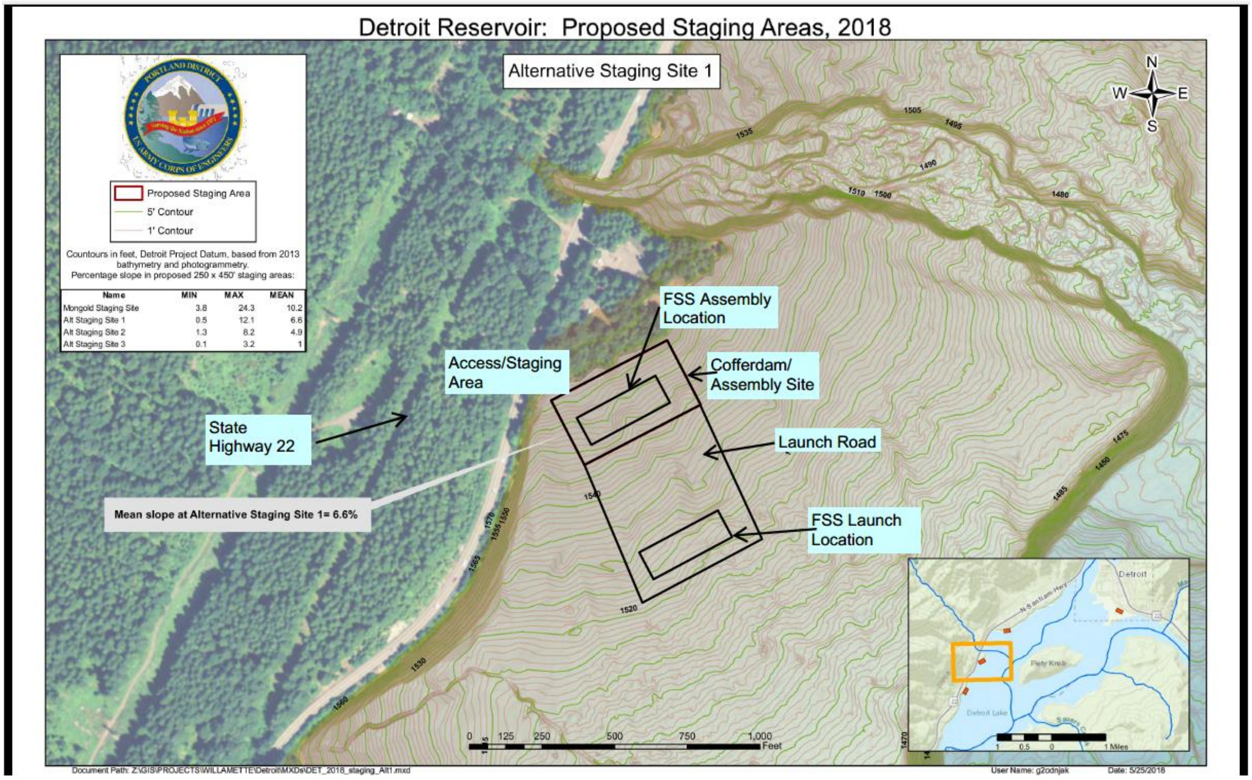

Figure 9-1 – Recommended Site Layout for FSS Construction and Launch.

9.2 Access and Staging

Access to the construction site will be from two-lane State Highway 22. There is adequate sight distance on the highway at the location of the proposed construction driveway into the maintenance yard. As this is a state highway, it is anticipated to have sufficiently large turning radii, bridge loading capacity, and other relevant transportation design features to enable the transportation of heavy construction equipment and materials to the site. This may need to be verified during a later stage.

The south side of the maintenance yard land can be cleared and graded to serve as access for construction vehicles, contractor staging, material laydown, and storage. This will require clearing of brush, trees, and a few minor site features

9.3 Cofferdam

Water surface elevation is a key driving factor in the design of the assembly and launch areas. The staging and assembly areas will need to be kept dry in extreme high water conditions of elevation 1,568 feet. Also, the facility will have to accommodate the possibility of launching at water as low as 1,540 feet. The minimum extreme reservoir elevation is 1,425 feet. Seasonal reservoir water surface elevation variation over past years is shown in Figure 9-2 below.

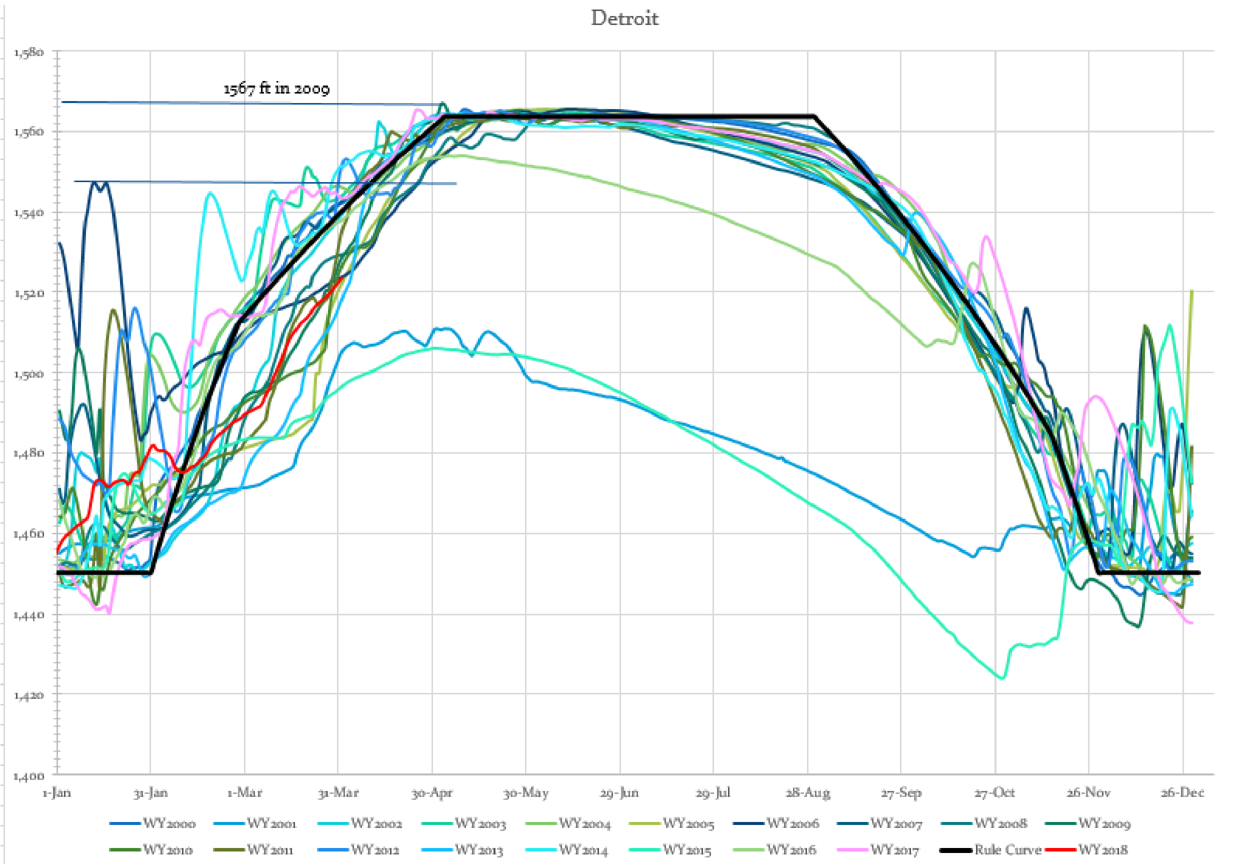

Figure 9-2 – Seasonal Reservoir Water Surface Elevation Variation

At this site, there is very little beach area at extreme high reservoir levels. To keep the assembly area dry, a cofferdam will be required. The cofferdam, which will essentially serve as the perimeter for the assembly area, should be located at as high an elevation as possible to minimize height and drastically reduce cost. In this case the FSS will need to be moved down to the water level, as low as 1,540 feet, when ready to launch.

Cofferdam design and construction shall satisfy the requirements of EM 385-1-1 Chapter 25.E. The cofferdam serves the purpose of enclosing a dry, flat work area to assemble the FSS. The area inside the cofferdam will be graded to be flat to accommodate FSS assembly and construction operation. Within the cofferdam, the FSS modules can be assembled on a series of concrete eco-blocks. As proposed, the cofferdam will retain a maximum of around 30 feet of water. A perimeter of about 1,400 feet is estimated. For a cofferdam of this size, sheet pile cells are recommended. The use of cells will reduce the required embedment depth of the sheet piles.

Design of the sheet pile cells is dependent on further geotechnical analysis of the site. To be feasible, it is assumed that suitable soil conditions exist for sheet pile driving – relatively free of large boulders or rock masses down to a required embedment depth. Cell design will need to factor in scour, saturation within the cell fill, static and dynamic water pressure, earth pressure, any surcharges, and seepage.

Control of water seepage through the bottom will need to be analyzed. Control may be accomplished through a system of trenches, well points, drainage piping, and storage filtration tanks for the discharge. Seepage will only be an issue when the water level is higher than the work surface elevation.

9.4 Launch

A launch road is required to launch the FSS at water levels as low as 1,540 feet. The FSS footprint at launch will need to be entirely below the 1,530-foot contour, to account for several feet of blocks plus the FSS deballasted draft of approximately 5 feet. The average grade perpendicular to the contours is around 6.6% at this site, yielding a length of road on the order of 500 feet.

A specialty structural relocation contractor recommended skid mounts for transporting the FSS down the launch elevation. Dolly flatbed trucks are also an option. Once settled at the necessary launch elevation, the FSS will float with rising water. Under this scenario, the water level will need to be monitored, and towing connections and vessels will be set up and ready to go as water levels approach the FSS deballasted draft. It is important that the tow plan developed for moving the FSS to its final location interfaces with the launching plan.

9.5 Other Considerations

The above sections present the recommended strategy for the FSS construction and launch site. However, there are aspects of the site that will be dependent on environmental conditions, further site surveys, and geotechnical studies. These considerations are herein discussed. There is a degree of uncertainty regarding the water elevation that will occur in Detroit Lake year to year. As shown in the rule curve plot, the water has risen above 1,550 feet for 15 of the past 17 years. It failed to reach 1,520 during two drought years. The build and launch plan proposed will accommodate any water level above 1540 feet. However, the final construction facility design will need to adjust to conditions at the time. For example, if the water level is anticipated to rise to normal, non-drought levels, then a shorter road will be needed.

If water levels reach near maximum levels, a dry-dock launch becomes a possibility. The cofferdam may be flooded for a drydock style launch, with no road needed. For this to be an option, the floor of the cofferdam would need to be 10 feet below the launch water level, to allow for the height of blocks and the FSS deballasted draft. The cofferdam would be flooded, and the cells on one side removed to allow the FSS to be floated out. The complication with this option is that it will not be possible if the reservoir doesn't reach sufficient elevation. Therefore, even if the cofferdam is constructed to accommodate a dry dock launch, it will still have to accommodate a roll-out option as a contingency plan for low water.

Another more economical option is to construct the FSS in the same timeframe as the SWS construction. During SWS construction, the reservoir will be drained to a controlled, low elevation. This level of predictability in water level would benefit the construction and launch plan for the FSS. A cofferdam dry dock launch could be accomplished with an economical sized cofferdam.

A roll-out option could also be executed, without the need for transporting the FSS a large distance down to the water level. It could be constructed on blocks closely adjacent to the water level, and then rolled into the water using marine airbags. If the water level is predictable enough, a cofferdam may not even be needed. A challenge to this option is that the FSS, SWS, and FSS mooring towers would need to be on parallel construction schedules, and a delay in the schedule of any of these facilities may impact the construction of the others and lengthen the time the reservoir is drained down.

10 OPERATIONS AND MAINTENANCE

10.1 General

The Detroit Reservoir Floating Screen Structure (FSS) will be operated and maintained by the USACE as described in this section of the DDR.

10.2 Features

This subsection describes the operations and maintenance (O&M) of facility features. Reliability and maintainability of the fish facility components should be considered during design. Where possible, components/materials that reduce maintenance requirements and improve reliability should be selected. Components that require inspection, adjustment or periodic replacement should be safely and easily accessible to maintenance personnel. As possible, stock “off the shelf” items should be used rather than custom designed items that may require long lead times.

10.2.1 FSS Steel Structure

10.2.1.1 External Preservation

The FSS steel structure will be used to house the fish attraction equipment and the fish handling facility. The compartmentation will allow it to ballast up or down to maintain stable trim and freeboard with variable internal hydraulic conditions depending on changing flow rates and the needs of the fish attraction process. When fully deballasted all functional internal components of the FSS are above the waterline and available for dry inspection and maintenance. The means of operation are similar to floating drydock.

The exterior of the FSS will be coated with a 50-year protective coating. An annual inspection will take place to verify that there is no exposed bare metal and no chipping or cracking in the coating. Locations of concern for inspection will be the area near the waterline that may be exposed due to reservoir debris along with the combination of water and UV light.

10.2.1.2 Internal Tank Preservation

The interior of the ballast tanks will be coated with a 30-year protective coating. It is assumed that the tanks will be emptied annually for maintenance. Since the FSS operates in freshwater and is not exposed to large dynamic forces, damage to the tank coating should be nonexistent. To minimize the frequency and the complications involved with certifying the tanks gas-free for personnel to enter, internal inspection of the tanks should be conducted on a 5-year interval.

10.2.1.3 Deck Structure and Grating

To traverse the locations above the plenum area that is not made up of steel deck plating, McNichols MS I-4015 fiberglass pultruded I-bar grating will be used. The deck grating support structure will be made up of manufactured steel shapes to support reasonable lengths of grating. The grating will be secured in place by corrosion resistant clips that are attached by metal fasteners.

10.2.1.3.1 *Maintenance and Inspection*

A regular visual inspection of the clips and fasteners will need to be conducted to minimize tripping hazards and maintain a secure connection between the grating and its support structure. All steel support structure needs to be inspected annually for signs of failure or corrosion. All deficiencies shall be fixed in a prompt manner to ensure a safe working environment. The fiberglass grating is corrosion resistant and maintenance free however it shall be inspected for cracking or loose corners due to abrasion. Any pieces of grating found unfit for a safe working environment shall be replaced.

10.2.2 Mooring Structure

10.2.2.1 Mooring Dolphins

There will be four mooring dolphins each with a pile guide installed in the Detroit reservoir used for securing the FSS in place. The dolphins are meant to provide a means of preventing horizontal movement while allowing the FSS to raise and lower in the water from both ballasting and changes in reservoir water levels. The one dolphin that is located at the forward port side corner will be constructed using four piles since will receive the largest horizontal loading. The remaining dolphins will be constructed using three piles. Each of the piles will be constructed out of a steel pipe employing steel strand rock anchors to resist high uplifts in two of the piles. Each of the piles will be connected by steel collars and other steel support structure and be coated with the same 50-year protective coating used for the FSS structure.

10.2.2.1.1 *Maintenance and Inspection*

An annual inspection will take place to verify that there is no exposed bare metal and no chipping or cracking in the coating. Due to the varying reservoir level throughout the year the locations of concern for inspection will be the areas of the dolphin that are exposed to both the water and UV light. This approximately 125-foot section will be more susceptible to corrosion along with physical damage to the protective coating due to collisions from floating debris.

10.2.2.2 Pile Yokes

The pile yokes will be constructed steel with a [UHMW] liner where attached to the guide pile. There will also be four rubber fenders integrated between the connection to the guide pile and the pile yokes’ external structure. These rubber fenders will be orientated and designed to dampen lateral movement and reduce stress, away from the solid connection points. The pile yokes are to be considered a part of the mooring structure rather than the FSS. The attachment point of the pile yolks on the FSS will be strengthened accordingly with steel structure to accommodate the increase in local loading. At this time, an unspecified number of bolts will be utilized at the attachment point.

10.2.2.2.1 *Maintenance and Inspection*

A visual inspection will be conducted of the attachment bolts, rubber fenders and UHMW sleeve liners annually. Attachment locations will be inspected for damage to all hardware associated, along with elongation or deformation of attachment holes from stress. Any damage found to attachment points should be further inspected and repaired as needed to maintain a secure mooring connection. The annual inspection of the internal rubber fenders should look for degradation due to the environment, permanent deformation and/or tears due to uneven loading on the mooring piles. All damaged rubber fenders should be replaced to consistently maintain some form of dynamic damping. The UHMW sleeve liners will act as the first line of defense against metal on metal wear. Replacement and maintenance of the UHMW will be more frequent based on the nature of the design of how the yoke rides on the guide pile. All aspects of the pile yoke should be inspected directly after the occurrence of any seismic event.

10.2.3 Auxiliary Floating Structures

There will be three floating support structures that will be required for the desired operational functions of the FSS. A trash float will be constructed to house the debris bins that store the trash and debris collected by Trashrack. There will also be a loading float that is primarily utilized for the transfer of personnel and equipment to and from the FSS. This float will also incorporate a mooring location for amphibious vehicles where the loading and unloading of the fish pods will occur. Varying small marine craft will also have ability to moor to his float, when needed to accomplish FSS operations. The final float will be solely utilized as a transition from the loading float to the SWS staircase and be directly located between two. This float will utilize all safety standards required for emergency egress to the SWS staircase.

10.2.3.1.1 *Maintenance and Inspection*

An annual inspection will take place to verify that there is no exposed bare metal and no chipping or cracking in the coating. Locations of concern for inspection will be the area near the waterline that may be exposed due to reservoir debris along with the combination of water and UV light. All mooring connections will be visually inspected. Any noted discrepancies or degradation will be fixed in timely manner to ensure that all the trash, personnel, equipment and fish pods can be safely transferred to and from the FSS.

10.2.4 Fish Hydraulic Attraction Equipment

10.2.4.1 Trashracks

There are two 24 foot wide x 35 foot deep trash racks located at the FSS collector’s entrance which are designed to prevent large debris from entering and potentially plugging or damaging the screen channel. They are designed to collect the majority of buoyant and semi-buoyant debris composed of mostly small to medium sized pieces of wood as well as the occasional larger pieces of debris such as logs and tree sections that may be caught in trash rack. Large debris items should be removed in a timely manner upon knowledge of their existence as they will interfere with the flow into the FSS and result in potential impacts to collection hydraulics and could prevent the Trashrack cleaning system from operating. The Trashracks will be equipped with an active Trashrack cleaning system to remove and retrieve accumulated debris. See Section 10.2.6.1 and 10.2.6.2.2 for further discussion and maintenance requirements.

10.2.4.2 Entrance Weirs

Downstream of the Trashracks, the submerged triple-leaf, vertical weirs are designed to automatically provide a 2-foot head drop across the weirs and average velocities that will capture and commit the fish to the FSS. See Section 10.2.6.3.1 for further discussion and maintenance requirements.

10.2.4.3 Expansion Channels

Downstream of the entrance weirs, the walls of the channels gently expand to a width of 20 feet prior to the screen channels for control of water flow and velocity. This section would require only an annual inspection of the channel surfaces for any damage to the coatings or accumulations of foreign matter.

10.2.4.4 Screen Channels

Downstream of the expansion channels are the screen channels which consist of the primary screens and the secondary screens. The screens are vertically orientated along both sides of the channel. The width of the channel decreases in the downstream direction and the screens are specifically oriented for control of channel flow and velocity. See the following sections for the primary and secondary Screens data.

10.2.4.5 Primary Screens

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. 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. The primary screen section reduces in cross-sectional area by narrowing allowing flow rate to reduce while maintaining the same average velocity to encourage fish to continue downstream. This full-depth condition remains through the first seven primary screen panels (P1 through P7), which 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%. Through the final two primary screen panels (P8 and P9) the floor will also slope up, reducing the depth along with the width resulting in a mild increase in average velocity as the flow rate reduces. These screen panels 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%, and the panels will each be divided into two independently controlled sections (P8-A, P8-B, P9-A, and P9-B) to maintain relatively even approach velocity conditions in the variable channel velocity environment.

10.2.4.5.1 *Maintenance and Inspection*

Screen cleaning will be accomplished with horizontally-sweeping pressure backwash cleaners located between the screen and baffle panels on each side of the channel. See Section 10.2.4.8 for further information.

10.2.4.6 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. 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. 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). 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%. Additionally, the panels will each be divided into three independently controlled sections (S1-A, S1-B, S1-C, S2-A,S9-C) to maintain relatively even approach velocity conditions in the variable channel velocity environment.

10.2.4.6.1 *Maintenance and Inspection*

Screen cleaning will be accomplished with horizontally-sweeping pressure backwash cleaners located between the screen and baffle panels on each side of the channel. See Section 10.2.4.8 for further information.

10.2.4.7 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. Once the FSS is in operation and the desired screen flow distribution is achieved by fine-tuning the porosity, there should be no reason for the baffles to be adjusted any longer.

10.2.4.7.1 *Maintenance and Inspection*

Perform annual inspections of baffles to check for foreign materials and to verify all baffles are intact.

10.2.4.8 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. The vertical spray bars will be attached carriages that move and clean in the direction of upstream to downstream along the screen sections. There will be four spray bar carriages on either side of both sets of screens on both the port and starboard channels. The size of each carriage and the amount and length of vertical spray bars will vary depending on which section of the screens it is responsible for cleaning. This is due to the non-uniform shapes and sizes of 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. A pre-programmed logic will be integrated into the facility's PLC that will control the pumps, valves and trolleys associated with the backwash cleaners. Individual dedicated pumps are provided for each carriage to minimize piping requirements and complication, and to facilitate operating all the cleaner carriages simultaneously in a rare extreme debris event that might otherwise overload the screen structural support and/or the SWS tower. Future design considerations will consider an automatically operated system that is controlled by either timer or a sensor in response to an out of parameter head loss across the screens.

10.2.4.8.1 *Maintenance and Inspection*

Perform annual inspections to verify proper operation of the carriage butterfly valves, wheels, and drive motors. Perform routine maintenance of the drive motors and submersible turbine pumps feeding each carriage as per the manufacturers' recommendations.

10.2.5 Fish Handling Facility

Downstream of the Secondary Screen Channel the fish and flow enter the Fish Handling Facility (FHF). Flow into the FHF is approximately 40 cfs, with 20 cfs from each screen channel (port and starboard). The actual flow is somewhat adjustable, within bounds as described below, to optimize effectiveness. The following sections describe the components of the FHF.

10.2.5.1 Emergency Shutoff Gates

Attached to the downstream end of the secondary screens is an emergency shutoff gate. The operating function of the gate is to shutoff flow to the FHF in the event that power is lost to the FHF flow return pumps. This condition should only occur if there is loss to both the main and emergency backup power. During normal operation, the gates are open, with the gate leaf raised above the water surface in the channel. The gate leaf is a heavy 1-inch-thick stainless steel plate, held up in the open position by a pneumatic cylinder. Upon loss of power, a solenoid opens allow the air to empty from the cylinder and the gate leaf to drop under its own weight.

10.2.5.1.1 *Maintenance and Inspection*

The gate leaf itself is corrosion resistant stainless steel, mounted in UHMW-lined guides, and should not require routine maintenance; however, routing inspection of the pneumatic cylinder should be performed per the manufacturer's recommendations and the bulb seals should be visually inspected for damage and replaced in necessary. It is also recommended that during the annual shutdown and maintenance of the FSS, the power to the solenoid be removed to ensure that the gate leaf does drop successfully under its own weight with water in the channel (i.e. prior to deballasting the FSS). Any binding or hesitation in the gate leaf's downward motion should be investigated and corrected.

10.2.5.2 Coarse Debris Racks

Coarse debris racks will be positioned within the transport flumes to remove larger woody debris that is small enough to have passed through the trash racks upstream but is too large to be effectively removed by the traveling screens downstream and could be problematic in the smaller flumes and fish separator downstream. Each rack will be made from 1-inch schedule 40 stainless steel pipes sloped back at 45 degrees from vertical. Each pipe will be mounted to horizontally positioned Unistrut guides, allowing for adjustment to their spacing. 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 at least once daily 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. Frequency of cleaning will vary with seasons and the climatic conditions at the time.

10.2.5.2.1 *Maintenance and Inspection*

As part of the daily check for debris, verify that all rack pipe components are intact and not bent or dented from impacts.

10.2.5.3 Dewatering Tanks

Each flume (port and starboard) has a dewatering tank for removing the majority of the approximately 20 cfs from the channel/ The dewatering tank will have a bank of plastic traveling belt screens on each side of the flume that will dewater the majority of the flume flow and remove smaller debris that passed through the coarse debris racks. The screens will be vertical and will have uniformly spaced debris pegs (one-inch-long hooked plastic pegs) attached to the screen belt material to further increase the ability of the screen to hold onto the debris. Debris that is carried up over the top of the traveling belt screen will fall off and/or be sprayed off 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 FHF bridge crane and moved over to the staging area for lifting items on and off of the FSS, located just forward of the FHF building on the port side.

The dewatering tanks are also used as head tanks for the gravity supply of circulation water to the fish holding tank and pods. All of the flow remaining in the flumes with the fish, plus all of the circulation water, ultimately is drained to a drain sump and booster pumps return it to the dewatering tank for discharge into a pump sump where it is pumped into the FSS plenum to remove it from the FHF. This creates a closed system where all flow that enters the FHF ultimately passes through and is discharged from the dewatering tank. At the forward end of each dewatering tank is an adjustable overflow weir for controlling the FHF flow rate. The design flow rate in each of the two flumes is 20 cfs; however, adjustments of the flow rate can be accomplished by varying the weir level with an upper limit being the safe screening flow plus the safe and effective fish transport flow downstream of the dewatering screens. The optimum flow rate will be determined by experience operating the facility.

10.2.5.3.1 *Maintenance and Inspection*

Routine inspections of the belt screens will be needed to locate damaged portions of the belt or wear to the gears used for driving the belt. Any damage caught in these inspections shall be corrected in a timely manner to ensure no more extensive damage to other moving parts or electric motors. Spray down nozzles shall be inspected and cleaned or replaced as needed to maintain a sufficient spray velocity for the debris removal from the belt screens. All pumps, electric motors and controllers for the traveling screens and the overflow weir will be maintained in accordance with the manufacturer’s specifications for maintenance and lubrication.

10.2.5.4 Ramp Weirs

Downstream of the dewatering tanks, each fish flume (port and starboard) includes an adjustable ramp weir incorporated into the flume, with fixed screen panels along walls. The ramp weir and screens are used to control the final fish flow rate to the fish separator. The final fish flow rate is controlled by the depth of the weir crest below the water surface in the flume, and the excess flume flow is removed through the wall screens. The weir operator will be controlled by the facility PLC based on a fish flow setpoint and a weir flow equation. The amount of dewatering will be controlled by a manual valve on the drain line, and the distribution of the flow over the screen area, will be controlled with small adjustable baffles on the back side of the screen. In this way, the combination of PLC fish flow setpoint and the setting of the drain valve will control the flume flow exiting the dewatering tank with the fish. The screened flow will be piped to the drain sump located midship under the adult holding tank. The wall screens are small and shallow and will be manually cleaned. The screens should be checked and cleaned at least once daily. A cleaning interval should be established based on experience and will likely vary based on season and environmental conditions.

10.2.5.4.1 *Maintenance and Inspection*

The wall screens at the ramp weir should be cleaned from above as necessary (at least once daily) with a long-handled brush, with the debris lifted out to the extent possible. The debris can be placed in buckets and then dumped into one of the FHF debris tanks for future removal from the FSS. The adjustable screen baffles will be set manually during the startup of the facility and should not require readjustment. The ramp weir operator should be inspected and maintained based on the manufacturer’s recommendations.

10.2.5.5 Juvenile Fish Separator

Just downstream of the ramp weirs the fish flow passes onto a juvenile fish separator, common to both flumes. The top of the juvenile fish 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 down through between them. The tubes run lengthwise along the slope of the flume. Various racks with different clear spacing for different species and/or seasons depending upon the size of fish to be separated will be provided and can be easily changed out. The entire flow passing from the ramp weirs 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 fish-friendly outlets on each side (port and starboard) leading to distribution flumes. The flumes include a series of bifurcations with diverter gates directing the juvenile fish to a particular fish transport pod. Below the fish outlets on the sides, the separator box includes a floor screen for removing some of the incoming flow, so as not to overwhelm the flumes. Under the floor screen, the bottom of the separator box includes a valved drain line leading to the common drain sump under the adult tank. The drain valve is manually controlled to establish a water depth in the separator box the results in the desired flow rate in the distribution flumes. This depth, and the resulting flow in the flumes, will be determined based on experience with the system to optimize operations. The floor screen inside the separator box will include an air-burst cleaning system that will be activated by the facility PLC if the water level in the box is rising.

10.2.5.5.1 *Maintenance and Inspection*

Some debris will tend to accumulate on the separator rack and should be manually removed. The separator rack should be checked regularly throughout the day to ensure that debris accumulations do not represent a potential fish injury source. The surface of the rack should remain smooth to the touch, and a damaged rack should be removed and replaced. The proper functioning of the air-burst screen cleaner should be checked on a regular basis to ensure that the air pressure setting is low enough to not injure fish. This can be done by placing live, uninjured fish into the box immediately before activating the cleaner system, with the distribution diverter gates set to direct all exiting fish to the smaller sample pods so they can be transferred to the sampling station and checked for signs of injury. If injury is found the air pressure should be reduced and the system rechecked.

10.2.5.6 Juvenile Holding and Transport

On each side of the juvenile separator there will be seven large 750-gallon pods, and one smaller 250-gallon pod, for holding and transporting the juvenile fish. The pods are arranged in two rows with a distribution flume running down the center between them. The distribution flume has seven diverter gates to direct fish and flow either into one of the pods or further down the flume. The end of the flume leads fish into the eighth and final pod. Upstream of the first diverter gate is a fish counter. The fish counter will provide the facility PLC with a real-time count of fish passing down the flume.

Initially, the pods will be set in place using the FHF bridge crane. The circulation water and drain hoses will be attached to the pods and the circulation water valves will be opened to fill the pods. When flow starts to pass out of the drain lines the pods are ready to accept fish, and the system can be started. Circulation water is left flowing and will pass out of each pod through the drain lines. Assuming all eight pods are in place and ready to accept fish, the system operates as follows. All seven gates are initially set to pass fish down the main flume to the end and into the eighth pod. A setpoint will be input on the PLC interface screen defining the percentage of the fish that are anticipated to be sampled that day. The PLC will then set a timer to operate the first diverter gate to direct fish into the first pod (the smaller 250-gallon pod) for that percentage of the time (e.g. if the setpoint is set to 10% the PLC could set the gate to divert fish out of the main flume for one minute out of every ten minutes). A second setpoint will be input to the PLC providing the estimated number of fish per pound anticipated that day, which will vary with season and predominant fish species. The PLC will use this to determine the number of fish that a pod can safely hold. When that number of fish has been counted the PLC will automatically activate the furthest diverter gate in the flume and start filling the next pod inboard and will provide a signal that the first pod is full and ready for transport. This process will continue filling each subsequent pod moving inboard.

Note that the system can operate continuously and automatically, and ideally would only need to be started up as described above after an annual maintenance shutdown. However, it is also critical that when a pod is not in place and ready to accept fish that the diverter gate associated with that pod location be locked out by the PLC from diverting fish out of the main flume.

When a pod is full of fish, it is ready for transport, but needs to be prepared before it can be removed. Prior to transport, the circulation water would be turned off, and the oxygen system would be turned on. The pod would be allowed to drain until no water is coming out through the drain line. The water supply and drain line hose attachments would be removed from the pod, and blind caps would be placed over the fillings on the pod. The fish inlet hose would be removed from the pod and from the diverter gate, and the inlet hole on the top of the pod would be capped. Service water would then be used to fill the pod to the top. The pod is then ready to be lifted with the FHF bridge crane and ultimately removed from the FSS for transport to the fish release site. If it is a heavy fish run period, then a new pod should be put in the location of the removed pod as soon as possible and prepared for accepting fish as described above.

10.2.5.6.1 *Maintenance and Inspection*

Pods should be rinsed clean and any residual debris removed after transport and prior to reuse. The flume diverter gates should be observed occasionally during activation to ensure they are operating quickly and completing their full stroke, and that all surfaces are smooth. All hoses should be routinely inspected for signs of wear or loss of flexibility and replaced if problems are found.

10.2.5.7 Adult Holding, Sampling, and Transfer

Fish too large to fit between the tubes of the juvenile separator rack will slide off the ends of the rack tubes and be deposited into an adult holding tank. The adult holding tank will have a horizontally traveling crowder and vertically rising brail system to crowd fish and lift them for transfer into a transport pod for removal from the FSS or transfer to the Sampling Station. The crowder panel will be raised up out of the water during trapping operations. When it is time to transfer the fish from the holding tank to a transport pod the crowder assembly would be moved to the aft end of the tank (above the separator) and the crowder panel would be lowered down into the holding tank. The crowder would then be slowly moved forward, crowding the fish toward the forward end of the tank. The crowder would stop at the upstream end of the brail, confining the fish between the crowder panel and the screen panel in the tank, in the area above the brail. A short extension section of pipe would be placed on top of the tank drain stand pipe causing the water level in the tank to rise, starting a flow of water into the outlet flume leading to the transport pod. Fish should find this flow and start passing out of the tank into the pod. The brail would slowly be lifted to further encourage fish to exit the tank. The crowder and brail are mechanically operated, but not automated. The crowding and discharge operations require an operator to be present to operate the equipment and monitor the fish. If more fish are in the tank than can safely be placed into a pod then the process will need to be done steps, with fish counted as they exit the tank and the process temporarily stopped while the full pod is removed, and a new fresh pod is set in place.

10.2.5.7.1 Maintenance and Inspection

The crowder incorporates a number of mechanical components including the drive motor and drive train, wheels, crowder panel hoist and limit switches. The brail assembly also includes a hoist for lifting and lowering the brail. All mechanical equipment should be routinely inspected and maintained as per the manufacturer's recommendations. The crowder panel and brail screens and seals should be inspected during the annual dewatering maintenance and any damaged components should be repaired or replaced as required to ensure safe conditions for the fish.

10.2.5.8 Sampling Station

When a pod of fish is ready to be sampled it is lifted and transferred to the lifting platform at the sampling station. The platform is designed only for lifting and sampling fish from the 250-gallon pods. The discharge hose associated with the sampling station is attached to the quick-disconnect fitting on the pod discharge outlet and the discharge gate on the pod is opened fully. The lift platform is then slowly raised and as the water level in the pod rises above the level of the table the water and fish start to discharge onto the screen adjacent to the anesthetic tank, and the fish will slide into the anesthetic tank. When enough fish are in the anesthetic tank, the platform is lowered until the flow stops. The fish are then sampled and the process is repeated until the pod is empty. It is recommended that after the pod is about half empty a person opens the cover door on the pod and monitors the remainder of the discharge, removing floating debris from the pod as appropriate and ensuring that all the fish ultimately exit the pod.

Anesthetized fish will be identified, sampled, and handled as per the USACE protocols to fulfill the needs of their study programs and/or FSS efficiency documentation. As requested by the USACE, the facility is designed to use AQUI-S anesthetic, the same anesthetic used at the Minto facility downstream. Used anesthetic water at the FSS will be placed into dedicated small containers for removal from the FSS and disposal at the existing Minto facility. The sampling 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 three transport pods. 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 transport pods will be sealed and transferred off the FSS for transport to the appropriate release sites.

10.2.5.8.1 Maintenance and Inspection

The lift platform should be routinely inspected and maintained as per the manufacturer's recommendations. All other components of the sampling station; including the discharge hose, dewatering screen anesthetic tank, sample table, and distribution hoses to the transport pods should be inspected during the annual dewatering maintenance and any damaged components should be repaired or replaced as required to ensure safe conditions for the fish.

10.2.6 Mechanical Equipment

10.2.6.1 Attraction Flow Pumps

The FSS is designed to integrate provisions for the future installation of attraction pumps. The Detroit powerhouse is operated as a power peaking facility, resulting in extended periods (typically at night) when the powerhouse is off line. Additionally, the flow to the powerhouse will be provided through the SWS which blends surface flow and deep flow to achieve the desired temperature of flow discharged downstream. At certain times of the year the majority of the SWS flow may be from the deep intakes. Fish attraction to the FSS entrances will be achieved by passing the surface flow component of the SWS flow through the FSS. If it is determined by the USACE that overall fish attraction to the FSS is inadequate, due to extended periods of inadequate FSS flow, the need for the attraction pumps to be used may arise. The attraction pumps will be designed to create a minimum flow of 1,000 CFS through the entire FSS when surface flow through the SWS is non-existent or inadequate to achieve attraction. To achieve this requirement there will be [8] horizontal mixer pumps installed. This option of pumps was chosen to meet the FSS's needs through comparison of similar needs that were met in other structures of this nature.

10.2.6.1.1 *Maintenance and Inspection*

All maintenance on Flygt Mixer 4680 pumps should be done in accordance with manufacturer's specifications. It would be recommended to coordinate all maintenance involved with the pumps to coincide with the annual deballasting, this would allow for visual inspection of the pump and its foundation while installed. However, for emergency repairs, all [8] of the attraction pumps installed will have the capability to being easily removed while the FSS is fully submerged in its operational position.

10.2.6.2 Trashrack and Cleaner

The Trashracks located in the FSS entrance are designed to prevent large debris from entering and potentially plugging or damaging the screen channels. They are anticipated to collect the majority of buoyant and semi-buoyant debris composed of mostly small to medium sized pieces of wood. On occasions larger pieces of debris such as logs and trees may be caught in Trashrack, which will increase headloss into the FSS and could result in fish injury passing through the debris jam, and need to be removed. Large debris items should be removed in a timely manner upon knowledge of their existence. There is an automated rake system which is placed on a cantilever bridge crane type track and is designed to clear the debris and transfer it to trash receptacles that are located on a debris float located off of the forward port side of the FSS structure. Very large items that cannot be handled by the rake system will need to be removed in a timely manner to allow for continued use of the rake. This will likely need to be done with a work boat during a period of turbine shut down when there is little or no flow into the FSS.

10.2.6.2.1 *Maintenance and Inspection*

Inspection of the Trashrack grating should be performed annually during the facility shutdown and deballasting to ensure there is no damage to the Trashracks due to debris. Damage to the Trashrack grating or different tolerances in the rack bar gaps can lead to damage to the automated cleaning system. All machinery associated with the automated cleaning system should be inspected for visual defects before use and all maintenance should be done in accordance with the manufacturer’s specifications outlined in their provided maintenance and lubrication schedule.

10.2.6.3 Entrance Weirs

The design calls for 3-leaf vertical slide gate weirs located in the FSS entrances. These weirs will be operated automatically by the facility PLC to maintain a 2-foot difference in head across the weirs. This head differential will result in average fluid flow velocities vital to the needs of the fish capture process. The gate leaves will have wheels to essentially eliminate friction due the head pressure and will be heavy enough to drop under their own weight.

10.2.6.3.1 *Maintenance and Inspection*

The wire rope operator and the weir gate panel wheels should be inspected and maintained in accordance with the manufacturer’s recommendations. The design will allow for inspection of the panel wheels in the dry during the annual deballasting and maintenance period. Removal of entrance weirs will require a crane barge on site to lift the gates in and out of place; however, there will be no routine maintenance needs requiring removal of the weirs so this should be a very rare need.

10.2.7 FSS Ballast System

The FSS ballast and trim system primary purpose is to maintain the FSS at its designed operational draft while keeping the heel and trim as close to zero as possible. This system also aids in other events outside of its primary purpose, including deballasting for maintenance on an annual basis, dewatering the plenum if the need arises, along with aiding in the transit of the FSS from its construction site to its permanent location at the SWS.

10.2.7.1 Tanks

There will be two different types of tanks all integral to the structure of the FSS, belly tanks and ballast tanks. The ballasting of the FSS will utilize a combination of free-flooding and pumps to achieve the proper ballast. Belly tanks will be the first tanks to be filled in the ballasting sequence, any tank located below the fish plenum area has the designation of belly tank. All tanks located above the plenum area that surround the fish channels are the ballast tanks. Each tank will be outfitted with a vent tube no smaller than 125% the size of the inlet pipe as per ABS rules.

10.2.7.1.1 *Maintenance and Inspection*

All tanks will need to be certified gas-free and safe for personnel to enter every five years. An internal inspection of the tanks will be conducted at this time to ensure no damage or corrosion on internal coatings and structural members. Ballast tanks should be cleaned of any marine growth and sediments if build up is noted.

10.2.7.2 Tank Level Indicators

Each tank will have a sounding tube along with a tank level indicator (TLI). Where possible, tanks with straight run vertical sounding tubes will have TLIs affixed to the top of them. The location of the TLI at the top of the sounding tub allows for ease of maintenance and does not require a separate penetration into the tank.

10.2.7.2.1 *Maintenance and Inspection*

TLI calibration should be verified annually. The reading between the sounding tube and the TLI should be consistent. Any discrepancies found should be fixed prior to any ballasting operations take place to ensure safe operation.

10.2.7.3 Pumps

There will be four pumps associated with the filling and draining the ballast tanks. This offers redundancy and allows multiple tanks to be filled or emptied in a shorter amount of time. To achieve the design parameter of deballasting in an 8 hour period the ballasts pumps will need to move, at a minimum, a combined 8,000 gallons per minute. The height of the FSS requires a pump to be able to operate over a wide range of net positive suction heads. The pump in consideration for this is the Pioneer Pumps SC1010C14, which is a 10” end-suction centrifugal pump designed to operate at up to 2,500 gallons per minute, depending on available suction head. Pumps will be installed with an integrated vacuum priming system, to prevent damage to pumps that lose their prime between pumping intervals.

10.2.7.3.1 *Maintenance and Inspection*

Visual inspections of ballast pumps should be conducted on a regular basis to ensure there is no leaks or physical damage. Pumps found with degraded operational capabilities should be replaced in a timely manner to ensure safe operation of the FSS. All preventative and corrective maintenance shall be accomplished in accordance with the manufacturers’ specifications. Differential pressure across the ballast pumps will be monitored by a provided gauge. Low differential pressure is indicative of low pump flowrates and will require further inspection of the system and pump to determine the cause. Normal FSS operations will likely require at least one of the ballast pumps to operate daily. Daily pump operations should cycle between each of the four pumps and at a minimum each pump should be operated at least monthly for inspection purposes. Excessive heat, noise, and/or vibration will require pump diagnostics and potentially pump rebuild

10.2.7.4 Strainers

The seachest strainers are responsible for protecting the ballast pumps from damage from debris when taking suction from the reservoir. Protecting the pumps from debris is crucial for a reliable, well operating ballast system. The first line of defense for the pumps is the perforation plate located on the inlet side of the seachest. The strainers which are located in between the seachest and the pump suction will have a 1/8 inch perforated basket designed to prevent smaller foreign debris from entering the pump.

10.2.7.4.1 *Maintenance and Inspection*

To clean a simplex strainer the operator must isolate the flow through the strainer before removing the basket. Once basket is removed visual inspection for damage or corrosion of the strainer housing and basket should be conducted. Any loss in suction or pumping issues, the strainers should be inspected and cleaned.

10.2.7.5 Valves

There will be several types of valves in the ballast system including, check valves, butterfly valves, and gate valves to control where the flow travels.

Angled check valves will be installed on discharge side of ballast pumps to prevent reverse flow and excessive back pressure. Overboard discharges will have angled check valves to ensure the water from the reservoir cannot flow back into discharge piping.

Gate valves will be installed on either side of the discharge pump to provide a positive closure and minimal pressure loss during flow. Gates valves will allow the isolation of individual pumps for maintenance and repairs while minimizing the impact on the entire ballast system. The seachest will also be outfitted with gate valves to create a positive closure when needed.

Butterfly valves are thin, inexpensive and quick acting make them ideal in many applications. A high-performance butterfly valve will be used in our numerous applications for controlling the flow to and from the belly and ballast tanks. A motorized actuator will be used to control the valves remotely.

10.2.7.5.1 *Maintenance and Inspection*

All valves should be visually inspected on a regular basis to ensure there are no leaks or physical damage to them. During operations any valve shown to not operate properly should be repaired or replaced in accordance with manufacturers’ specifications.

10.2.8 FSS Trim System

The trim system’s primary purpose is to maintain the FSS in its’ optimal operational condition to collect fish, at a five foot of freeboard with zero trim and zero heel. The system will consist of six individual tanks, two variable ballast tanks and four trim tanks along with eight pumps and numerous valves and piping to achieve its primary purpose. Due to the variations in fish channel flow, it is recommended that the trim system be automated. A manual operating station will have the pump controls and tank level readouts for each tank. The timeframe for the FSS to transition between the various operational fish channel flow rates is approximately 15 minutes, which aligns with the startup and shutdown timing of the powerhouse.

10.2.8.1 Tanks

The four trim tanks will be located at the forward and aft corners of the flotation cells on both the port and starboard side. These tanks are designed to transfer between each other automatically to control the forward and aft trim along with the port and starboard heel. Trim tanks will be maintained at 50% of their full capacity and will typically operate between 20-80% when transferring. The two variable ballast tanks which will be centered port and starboard, located longitudinally at the average LCF which will be designated as the variable ballast tanks. These variable ballast tanks will be designed to compensate for the reduction in weight due to the different drawdown values associated with the varying volumetric flowrates in the fish channels. As the flow increases, the variable ballast tanks will be filled to make up the weight lost due to increased drawdown.

10.2.8.2 Tank Level Indicators

Each tank will have a sounding tube along with a tank level indicator (TLI). Where possible, tanks with straight run vertical sounding tubes will have TLIs affixed to the top of them. The location of the TLI at the top of the sounding tub allows for ease of maintenance and does not require a separate penetration into the tank.

10.2.8.2.1 *Maintenance and Inspection*

TLI calibration should be verified annually. The reading between the sounding tube and the TLI should be consistent. Any discrepancies found should be fixed prior to any ballasting operations take place to ensure safe operation.

10.2.8.3 Pumps

The trim system will utilize the 4 ballast pumps to fill the trim and variable ballast tanks. Emptying the variable ballast tanks will be accomplished with the same 4 ballast pumps. The trim tanks will utilize a pair of vertical turbine pumps in each tank to empty.

10.2.8.3.1 *Maintenance and Inspection*

Visual inspections of trim pumps should be conducted on a regular basis to ensure there is no leaks or physical damage. Pumps found with degraded operational capabilities should be replaced in a timely manner to ensure safe operation of the FSS. All preventative and corrective maintenance shall be accomplished in accordance with the manufacturers' specifications. Differential pressure across the ballast pumps will be monitored by a provided gauge. Low differential pressure is indicative of low pump flowrates and will require further inspection of the system and pump to determine the cause. Normal FSS operations will likely require at least one of the ballast pumps to operate daily. Daily pump operations should cycle between each of the four pumps and at a minimum each pump should be operated at least monthly for inspection purposes. Excessive heat, noise, and/or vibration will require pump diagnostics and potentially pump rebuild.

10.2.8.4 Valves and Piping

The trim system will require 10-inch piping from the pump room to each trim and variable ballast tank. Additionally, there will be 4-inch discharge piping for each of the 8 vertical turbine pumps located in each trim tank. Each pipe run will require a motor-controlled butterfly valve and the overboard discharges will require a swing check valve.

10.2.8.4.1 *Maintenance and Inspection*

All valves should be visually inspected on a regular basis to ensure there are no leaks or physical damage to them. During operations any valve shown to not operate properly should be repaired or replaced in accordance with manufacturers' specifications.

10.2.9 Lifting Devices

A bridge crane will be installed over the fish handling facility on the interior of the building structure. The bridge rails will span the entire breadth of the FSS structure and be located on the fore and aft end of the fish handling area. There will be one trolley with a single lifting device that will primarily be used in relocating the fish transfer pods and debris tanks to a staging area where they can be lifted off the FSS and onto the specified amphibious vehicles for transfer. A cantilever section of the trolley will be included in the bridge crane design to accommodate the transfer of the fish pods to a staging area on the port side of the FSS, just forward of the fish handling facility building.

A knuckle boom crane will be installed on a traveling rail system located on the port side of the FSS. It is designed to pick the fish transfer pods from the staging area just forward of the fish handling area and transport them to a location where they can be lifted onto the amphibious vehicles. Crane will be designed to safely lift the 750 gallon fish pods at 25 foot radius to ensure proper working reach when transferring equipment between the loading float and the FSS.

The Trashrack cleaner will utilize a cantilever bridge crane that is integrated into its design. The sole purpose of this lifting device is to perform the task of transferring the trash and debris collected on the Trashrack into the trash receptacle located on the debris staging float.

10.2.9.1 Maintenance and Inspection

All Maintenance and Inspection to be conducted on the knuckle boom crane and two bridge cranes will be accomplished in accordance with their respective manufacturer's maintenance and lubrication guidelines and the requirements found in the applicable ASME standards. All lifting devices and rigging will require inspections prior to each use, and if damaged equipment is found, it will need to be taken out of service until it can be inspected and repaired by qualified personnel.

10.2.10 HVAC

Ventilation will be required to any of the manned spaces such as pump room, fish handling facility and above deck structures. The system will provide air circulation and heating elements for all space, and air conditioning for the electrical rooms as required. Heaters will be sized to prevent freezing and, where required, the heating set point of 60 degrees Fahrenheit will be used to avoid condensation.

10.2.10.1 Maintenance and Inspection

All blowers, fans and controllers will be maintained per manufacturers required maintenance schedule. Visual inspection of the ducting and its' related support structure will be conducted on an annual basis to ensure proper airflow and ventilation to the required spaces.

10.2.11 FSS to SWS Seal

A seal will have to be maintained between the FSS and the SWS tower to prevent flow that does not travel through the FSS into the SWS tower. The seal will be composed of two concentric steel channels constructed with an approximate gap between them of 15 inches. The channels will be open on the top and an inflatable seal along the vertical and bottom sections of the channels. Though the FSS will be moored in place by four pile attachments, the tolerance in these connections allows for some translation in the seal due to the FSS's slight change in trim and heel. To accommodate the change in trim the inflatable seal can expand on one side to fill the gap and contract on the other. Further design is required on the seal.

10.2.12 Electrical System

10.2.12.1 Electrical Service

Electrical power distribution to the FSS will go through a transformer located on its' main deck to a 480-volt power distribution system. Service connection from the shore has not been determined yet.

10.2.12.2 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 standby 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 standby power to the FSS.

10.2.12.3 Control System

10.3 Fish Pod Transferring (Amphibious Vehicle)

Fish Transport Pods will be transferred from the FSS to the amphibious vehicles, which will be moored to the loading/unloading float located on the port side of the FSS. The amphibious vehicles will be used to haul the fish pods to the fish holding and release center, located downstream of the dam at the Minto facility.

10.3.1 Maintenance and Inspection

The operations, maintenance, and inspection of the amphibious vehicle are outside the scope of this DDR.

10.4 Operational Costs

Staffing needs for the Detroit FSS are currently not fully defined. We have used the information provided by USACE and restated it below. See Appendix B for information provided.

The staffing requirements assume that the FSS will be staffed 24 hours/day, seven days a week for the entire year. At any time of the day there will a total of three FSS Technicians (1x GS-05 and 2x GS-07) onboard the FSS. For a 10-hour segment of the day during fish transfer the FSS will also be staffed with one fisheries biologist (GS-09), and two amphibious vehicle drivers (WG-10).

To accomplish the typical maintenance requirements for the FSS, it is assumed an I grade mechanic, I grade electrician and a K grade technician will be utilized to maintain the FSS in proper working order. The mechanic and electrician are assumed to conduct 20 hours/month and 160 hours/year, while the technician is assumed to conduct 10 hours/month and 80 hours/year. It will also be assumed that personnel to represent utility needs will conduct 160 hours/year of maintenance to support the FSS operations.

To estimate the indirect staffing costs, 36% the direct staffing cost was assumed to cover management, support staff, admin, timekeeping, budget, purchasing, warehousing, maintenance job planning, environmental inspections, hazardous waste accountability, handling, disposal, environmental program management, safety inspections and support, safety programs management, security program management, GSA (vehicle/WEX), oil/diesel testing, security maintenance contract, ppe/ppg testing program, toilet maintenance (best pots), janitorial, rags contract. To estimate for unanticipated corrective maintenance, 18% of the direct staffing cost was used.

To operate the FSS 24 hours/day, 11 months out of the year and the 1-month maintenance period, the estimated operational cost is $3,057,805. Art Anderson also conducted an estimate for maintenance cost based on equipment cost and type. It predicted an annual maintenance cost of $1,520,200 compared to $466,444.78 in the USACE estimate. This includes 20% contingency for direct construction related costs.

10.5 Safety

Components that will be used as isolation points for hazardous energy control should have provisions for installation of clearance locks/tags. New equipment should be placed in locations that do not restrict personnel access or require use of personnel fall protection equipment for normal operation or maintenance of equipment. Electrical and control systems are to be checked and inspected every five (5) years or in accordance with Manufacturer’s specifications.

10.6 Environmental

Environmental protection should be considered during design of the fish facility. Risk of oil/grease spill into the river should be mitigated where feasible. Where practical, Environmentally Acceptable Lubricants (EALs) should be employed, if commercially available. It is recommended to have easily deployable floating oil containment booms located and stored in close proximity to the FSS and SWS structure to minimize the reservoir contamination.

10.7 Documentation

A System Operations and Maintenance Manual will be produced for the facility during the Engineering Construction phase. Existing drawings will need to be “as-built” and subsequently revised to reflect changes.

10.8 Training

Prior to commissioning of the fish facility, project personnel should receive training on all aspects of O&M for the facility. Preliminary manuals and drawings should be on hand during training.

10.9 Commissioning

Commissioning testing should be performed following construction of the facility to verify all functional aspects prior to placing the facility in service.

11 COST ESTIMATES

11.1 General

This section covers the cost estimate for Detroit Floating Screen Structure, as presented in this report. The Total Project Cost (TPC, design and construction) estimated at the 90 percent DDR phase is $397 million. The construction contract, including escalation to the midpoint of construction and a 30 percent contingency, is estimated to cost $294 million. For additional information see Appendix J.

11.2 Criteria

ER 1110-2-1302, Engineering and Design Civil Works Cost Engineering, provides policy, guidance, and procedures for cost engineering for all Civil Works projects in the US Army Corps of Engineers. For a project at this phase, the cost estimates are to include construction features, lands and damages, relocations, environmental compliance, mitigation, engineering and design, construction management, and contingencies. The cost estimating methods used are intended to establish reasonable costs to support a confident budgetary amount. The design and cost estimate are at a preliminary level (30%).

11.3 Basis of the Cost Estimate

The cost estimate is based on costs for equipment, labor, and materials for items with sufficient design detail, and historical costs and parametric unit costs where designs are less detailed.

11.4 Cost Items

The major cost items are the floating screen structure, mooring dolphins, and assembly area.

11.5 Construction Schedule

It is anticipated that the total construction schedule will be approximately 46 months in duration.

11.6 Acquisition Strategy

The cost estimate assumes competitive pricing will be obtained by an unrestricted request for proposals with a best value trade off source selection. FSS construction is scheduled to take place after the SWS has been constructed.

11.7 Subcontracting Plan

The cost estimate is based on the work being accomplished by a prime contractor with marine construction experience. It is expected that the contractor will self-perform setup of the assembly area, and job office overhead functions. It is anticipated that the prime contractor will subcontract design of contractor-designed features, FSS fabrication, installation of piling, trucking and diving.

11.8 Project Construction

It is assumed that the pool level will not be controlled to assist with construction. Access to the project is from Highway 22. This allows road access directly to the top of the dam for trucks, equipment and personnel. Marine access to the project is anticipated to be from the Detroit Lake State Park Maintenance Facility, 5 miles past Detroit Dam on highway 22. It is assumed this will be the FSS Assembly Area location. From this location marine vessels will travel 5 miles in the reservoir to the FSS location at the upstream face of the dam. FSS fabrication, pilings, concrete, reinforcing steel, fill materials, and other materials required for the project are available from commercial sources. The nearest established suppliers are in the Salem area, about 45 miles from the site. Materials are also available from Eugene (90 miles), Albany (55 miles), and Portland (90 miles). The estimate assumes inclusion of the Buy American Act in the construction contract.

11.9 Cost and Schedule Risk Analysis

The 90% DDR cost estimate includes a 30 percent contingency as requested by the NWP Cost Engineer. A formal cost and schedule risk analysis (CSRA) will be performed by NWP prior to completion of the DDR. Results and conclusions of the CSRA will be included in the final DDR document.

11.10 Functional Costs

11.10.1 Planning, Engineering and Design (30 Account)

The 90% engineering and design costs are percentages of the construction cost, as computed in the Total Project Cost Summary sheet. The 30 account costs are based on the expected design and engineering efforts. These costs include engineering costs for design and development of a contract package (Plans and Specifications), District review, contract advertisement, award activities, and engineering during construction. This effort is estimated to cost $57 million.

11.10.2 Construction Management (31 Account)

The 90% construction management costs are percentages of the construction cost, as computed in the Total Project Cost Summary sheet.

The 31 account costs are based on the expected efforts required for supervision, administration and quality assurance for the construction contract. This effort is estimated to cost $45 million.

11.10.3 Annual Operations and Maintenance

See Section 10.4 for annual operations and maintenance cost.

Appendix A

Plates

Appendix B

USACE Provided Technical Information

Appendix C

Naval Architecture and Calculations

Weight Estimate

Hydrostatics

Drawdown Volume Calculation

FHF Flooding Calculation

Appendix D

CFD Modeling Report

Computational Fluid Dynamics Modeling Report

Appendix E

Screen Structure and Hydraulic Design and Calculations

Entrance Weir

Backwash Screen Cleaner Hydraulics

Screen Baffle Blank Design

Channel - Column Design

Channel Floor Design

Channel - Backwash Cleaner Support and Carriage

Fish Handling

Ramp Weir Vortex Shedding

Screen Channel Hydraulics

Fish Handling Facility Calculations

Appendix F

Structural Design and Calculations

Structural Calculations

Mooring Calculations

RIS Model

PEMB Calculations

Appendix G

Mechanical Design and Calculations

Attraction Flow Design Calculations

FHF Pumps

Rake System

Rake System Structural Support

Elliptical Weir Hoist Sizing

Ballast Pump Sizing

Knuckleboom Support Sizing

Pump Room HVAC

Minimum Elevation FHF

Trashraker Weight

Appendix H

Electrical Design and Calculations

Electrical Load Summary

Electrical Distribution Equipment Manufacturer Drawing

Luminaire Cutsheets

Fish Handling Facility Illumination Layout

Appendix I

Construction Appendix

Appendix J

Construction Cost Estimate