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:

Art Anderson Associates
Value Beyond Engineering®

R2

HDR

ALDEN
Solving Flow Problems Since 1894

CES
Construction Estimating Services

60 Percent DDR
5/2018

THIS PAGE INTENTIONALLY LEFT BLANK

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

Mechanical Marty McKay, P.E.	Naval Architect Eric Snyder, P.E.
Civil Patrick Vasicek, P.E.	Electrical Donald Best, P.E.
Fisheries and Hydraulic Peter Christensen, P.E.	Civil Mike Garello, P.E.

Hydraulic Modeling Shari Dunlop, P.E.	Fisheries and Civil Dan Turner, P.E.

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 Surface 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 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 – Sept 2018
- Plans and Specifications: Oct 2018 – Apr 2020
- Construction: Oct 2020 – Jun 2023

Phase 2 of Downstream Fish Passage – Floating Screen Structure:

- DDR in support of Phase 1: Apr 2017 – Sept 2018
- DDR in support of Phase 2: Jun 2021 – Dec 2022
- Plans and Specifications: Jan 2022 – Jun 2024
- Construction: Nov 2024 – Aug 2027

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

This 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 provide a downstream juvenile fish passage facility that meets National Marine Fisheries Service (NMFS) criteria for Endangered Species Act (ESA) listed fish and provides a safe working environment for the operators. The parameters used to establish the design criteria for the FSS and 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 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 long, width of 101.5 feet, and depth (height) of 48 feet. The operating draft is 35 feet with a displacement of 40,917 kips. The maintenance draft is roughly 4.25 feet with a displacement of 9,575 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 Fall of 2024. Commissioning will occur immediately after construction is complete. Section 11 and Appendix H discuss the schedule in detail.

Operations During Construction

This will be added to the 90% DDR.

Cost

The estimated total project cost is $343 million. See Appendix H Cost Estimate and Schedule for more details.

TABLE OF CONTENTS

Tables

Figures

Appendices

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
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
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
L	Length Overall
lb(s)	Pound(s)
LCG	Longitudinal Center of Gravity
LED	Light Emitting Diode
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 & 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
TDH	Total Dynamic Head
temp	Temperature
TLI	Tank Level Indicator
TM	Technical Manual
TYP	Typical
UFC	Unified Facilities Criteria
UL	Underwriters Laboratories
UPS	Uninterrupted Power Supply
USACE	United States Army Corps of Engineers
USFWS	U.S. Fish & Wildlife Service
USGS	United States Geological Survey
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 provide a downstream juvenile fish passage facility that meets National Marine Fisheries Service (NMFS) criteria for Endangered Species Act (ESA) listed fish and provides a safe working environment for the operators. The parameters used to establish the design criteria for the FSS and 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 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, 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 and Reservoir, North Santiam River, Oregon, was authorized by the Flood Control Act approved June 28, 1938 (Public Law 761, House Resolution No. 10,618). The law approved the general comprehensive plan for flood control, navigation, and other purposes in the Willamette River Basin as set forth in House Document Numbered 544, Seventy-fifth Congress, Third session. The Flood Control Act approved June 30, 1948 (Public Law No. 858, Eightieth Congress, Second Session) modified the Flood Control Act of June 28, 1938, to provide for the installation of hydroelectric power-generating facilities at Detroit Dam, and included the construction of Big Cliff Reregulating Dam and Reservoir as a part of the Detroit project, in accordance with plans on file in the Office, Chief of Engineers.

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

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

1.3 Project Specific References

Reports and Studies used in the Design Documentation Report:

- Detroit and Big Cliff Long Term Temperature Control and Downstream Fish Passage Final Engineering 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 truck and transported downstream.

The FSS (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 40,917 kips. The maintenance draft is roughly 4.25 feet with a displacement of 9,575 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 fully coordinated with NMFS, the Oregon Department of Fish and Wildlife (ODFW), Native American tribal representatives, and the Oregon Department of Environmental Quality. Coordination with other agencies will be conducted as necessary. 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 also allowed
Screen Material	Corrosion Resistant	NMFS 2011 11.7.1.4	Sufficiently durable to maintain smooth surface
Minimum Open Area	27%	NMFS 2011 11.7.1.6	
Screen Cleaning	Automatic Screen Cleaning	NMFS 2011 11.10.1.2	Required for active screen design criteria
Trashrack Bar Spacing	8 inches clear	NMFS 2011 4.8.2.5	Fish ladder exit rack 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 Operating Water Temperature	70 degrees F	USACE(c)	Maximum surface (35 ft depth) temperature in August (not peak run time)
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 Truck Density	0.15 cf/lb (6.7 lb/cf)	NMFS 2011 6.7.2.1	Will also be used for short-term transfer tank (hopper) if operating plan is to hold in hopper less than one hour
Tank Freeboard – Adults	5 feet	NMFS 2011 6.5.1.4	To minimize jumping; alternatively use sprinklers, cover, or nets
Max. Crowder Panel Bar Spacing - Adult	7/8-inch clear between bars	NMFS 2011 6.5.1.7	
Max. Crowder Panel Bar Spacing - Juveniles	1.75 mm	NMFS 2011 11.7.1.2	Screen criteria

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 is currently developing design values for species timing and numbers based on life stages and seasons. At the time of this 60% DDR this information is not yet available.

Table 2-3 - Fish Species Criteria

Criteria	Design Value	Source	Notes
Spring Chinook Salmon – ESA Listed Species			
Peak Annual Run	TBD	USACE	
Peak Daily Run	TBD	USACE	
Average Adult Weight	15 lb	Bell 1991 Page 5.2	
Average Smolt Weight	10 fish/lb	Bell 1991 Page 30.2	Assumes average smolt length of 6 inches (152 mm)
Timing	TBD		
Winter Steelhead Trout – ESA Listed Species			
Peak Annual Run	TBD	USACE	
Peak Daily Run	TBD	USACE	
Average Adult (Kelt) Weight	8 lbs	Bell 1991 Page 5.8	
Average Smolt Weight	5 fish/lb	Bell 1991 Page 30.2	Assumes average smolt length of 8 inches (203 mm)
Timing	TBD		

2.3 Biological Considerations

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

2.3.1 FSS Design Operations

The Detroit powerhouse includes two turbine units each rated at 50 MW. The 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 the majority of the flow would be through the low-level withdrawals.

The USACE produced a memorandum Detroit FSS: Recommended Design Flow Rates (dated 8/4/2017, 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 in holding tanks 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 tank circulation water flow for holding juvenile fish needs to be increased to meet recommendation in Senn 1984. 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 tanks need to be sized to handle the maximum estimated number of fish expected to arrive at the facility between off-loading transfer events. Therefore, the temperature that is significant from the standpoint of design is the maximum estimated temperature during the peak outmigration period; 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). At the time of the writing of this report, the maximum daily run of fish, and during which months that peak may occur, has not yet been established. After receipt of that information, the design capacity values for the facilities described in this report will be refined based on the historic surface temperatures during the reported peak migration season.

2.3.3 Transport Truck Operations

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

3 NAVAL ARCHITECTURE

3.1 General

The Detroit Reservoir Floating Screen Structure (FSS) is a barge-like floating structure 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, 268 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 17 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. The port flotation cell contains two openings adjacent to the SWS intakes. Here, the flotation cell extends from the main deck down 21 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, 20 feet behind trash racks at the extreme forward end, an expansion channel, primary screen channel, and 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 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 tanks for transporting off of the FSS. The sampling area, located above the main deck level, houses facilities for scientifically processing sampled fish collected in 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 so as 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. If needed, dedicated variable ballast tanks are provided to adjust for this weight change and maintain a 5-foot freeboard. The variable ballast tanks will be located as 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.

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	6,290,393	6.625,966	11.93	123.04	0.90
200	Propulsion Plant	0	0			
300	Electrical Plant	20,000	22,400	21.50	99.25	20.00
400	Command and Control	500	560	40.00	118.00	0.00
500	Auxiliary Systems	505,115	541,561	12.10	148.83	-3.93
600	Outfit and Furnishings	8,800	9,856	43.00	168.00	0.00
700	Fish Collection System	1,956,790	2,186,591	26.07	158.29	-0.02
	Subtotal	8,781,598	9,386,934	15.29	132.73	0.45
	Builder's Margin (2%)	175,632	187,739	15.29	132.73	0.45
	Service Life Margin	0	0			
	Estimated Lightweight	8,957,230	9,574,673	15.29	132.73	0.45

3.4 Hydrostatics

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

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

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.

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

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

Intact stability calculations to be included in the 90% DDR.

3.5.2 Damage Stability

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

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

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

- The FSS remains afloat and upright,
- Damage equilibrium trim is no more than 5 degrees,
- Damage equilibrium heel is no more than 15 degrees, and
- The FSS has at least 18 inches of GM.

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

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

Damage stability calculations to be included in the 90% DDR.

3.6 Operating Considerations

At all flow rates from a minimum 1000 cfs to the design maximum 4500 cfs the fish attraction channel hydraulics are designed to capture fish with the FSS level with zero trim, zero heel, and a freeboard of 5 feet (35 foot draft above the top of the belly tanks). For 1000 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. During operation flow through the FSS results in water levels in the expansion sections, primary screen sections, secondary screen sections, and plenum to be drawn down below the reservoir level. The amount of drawdown depends on the flow rate. This drawdown effectively acts as removing weight from the FSS that changes its draft trim and potentially heel. Consequently, with no flow the FSS must be ballasted so that when flow commences removal of the drawdown water brings it to 5-foot freeboard with zero trim and zero heel. Calculated volume (hence weight) of drawdown water for various flow rates is given in Table 3-3.

Table 3-3 - Added 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

The 5600 cfs flow rate is an extreme condition during which fish collection operations are not required.

Total FSS weight, or displacement, changes as the flow rate changes as a result of drawdown resulting in a change in freeboard, or draft. If the size of the freeboard change is too great variable ballast must be taken on board or discharged to compensate. If needed, dedicated variable ballast tanks are arranged to provide the necessary compensation.

The number, location, and size of variable ballast tanks to be included in the 90% DDR.

The complete FSS with all ballast tanks, trim tanks, and variable ballast tanks empty, and without operating liquids in fish handling equipment, fish sorting equipment, holding tanks, and transfer tanks, is termed the lightweight (empty) condition. In the lightweight condition, the FSS will float with the top of the belly tanks above water. When in this condition, maintenance can be performed in the dry on those portions of the FSS that are submerged during normal operations. Hence, this condition is also termed the Maintenance Condition. Lightweight characteristics are shown in Table 3-4.

Table 3-4 - Lightweight (Maintenance) Condition Characteristics

Displacement	Freeboard to Top of Belly Tanks (feet)				Trim	Heel
[kips]	Fwd Port	Fwd Stbd	Aft Port	Aft Stbd	[deg]	[deg]
9,574.673	4.36	4.01	0.50	0.15	0.826	0.200

All FSS operating conditions with flow through the fish attraction channels occur at a freeboard of 5 feet (35-foot draft above the top of the belly tanks) with zero trim and zero heel. Ballasting (filling ballast tanks, trim tanks, and variable ballast tanks to prescribed levels and adding operating liquids to fish handling equipment, fish sorting equipment, holding tanks, and transfer tanks) brings the FSS to the operating condition from the lightweight condition. Tanks must be filled and operating liquids added in a precise, calculated sequence to avoid excessive trim and heel while transitioning from the lightweight condition subject to drawdown at the flow rate. With no flow through the fish channels, such as would occur with both attraction channels closed by operation of the intake weirs or with weir gates in the SWS closed, the FSS must be ballasted to include the added weight of the drawdown water. This results in forward trim and freeboard less than 5.00 feet.

Tanks must be filled and operating liquids added in a precise, calculated sequence to avoid excessive trim and heel while transitioning from the lightweight condition to the operating condition plus added weight of drawdown water. Metacentric height (GM) must be greater than 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 lightweight condition to the operating condition plus added weight of drawdown water 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 operating condition plus added weight of drawdown water to the lightweight condition empties tanks and removes operating liquids 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.

A ballasting/deballasting sequence identifying the order in which tanks are filled and operating liquids added to be included in the 90% DDR

4 HYDRAULIC DESIGN

4.1 General

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

4.2 Hydraulic Criteria and Considerations

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

- At a minimum, the hydraulic conditions in the reservoir during FSS operation should not inhibit fish access to the FSS. The general layout of the FSS and SWS is assumed to be fixed at this stage of design; therefore, the focus of this consideration is the pumped flow alternative. The CFD model results will be reviewed, 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.

4.3 Selective Withdrawal Structure

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

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

Surface flows into the FSS will be controlled by operation of the SWS. Passage of flow from the FSS to the SWS will occur through two deep slots in the west wall of the SWS, each 20 feet wide. Flow through the SWS slots will be controlled by multi-leaf overflow weir 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 multi-leaf overflow weir 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 lower SWS intake gates 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 and lower intakes to the SWS tower will be controlled by the openings of the SWS lower gates and upper weir gates in the slots, based on temperature gage readings of the overall powerhouse discharge. Ultimately, if only flow through the SWS lower gates is desired, the SWS upper weir gates can be fully raised to above the reservoir level closing off the surface flow component, redirecting all of the SWS inflow to the SWS lower gates, and shutting off flow to the FSS.

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

The FSS is designed to integrate provisions for the future installation of attraction pumps, should it be determined by USACE that fish collection be needed during periods when the turbines are not operated and when no flow is passing from the FSS to the SWS. Future provisions for pumped attraction flow will accommodate 1,000 cfs to drive flow through the FSS, and continue attracting and collecting fish from the forebay. The integration of the attraction flow pumps may be part of a phased approach to implementation based upon biological performance of the system under power peaking operations. Implementation strategies are being developed by the USACE in collaboration with the regional fish managers. It is recommended that if this operational scenario occurred in the future, the SWS upper weir gates would need to be fully closed (raised to above the reservoir level) to hydraulically isolate the SWS from the FSS.

4.5 Hydraulic Modeling

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

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

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

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

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

4.6 Floating Screen Structure

Given the wide range of operating flows, with a 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, and during the future low-flow pumping operation the open channel is operating at a flow of 1,000 cfs, slightly less than half the design flow rate rather than less than a quarter of the design flow rate if the FSS had been designed with a single channel, which would become hard to control and might not have encouraged fish to continue downstream through the FSS. The use of two channels also greatly reduces the overall length of the FSS, allowing it to fit between the spillways and the SWS location, and allowing fish to pass the length of the screen channel in a timely manner. A plan view of the FSS and SWS is provided in Figure 4-1.

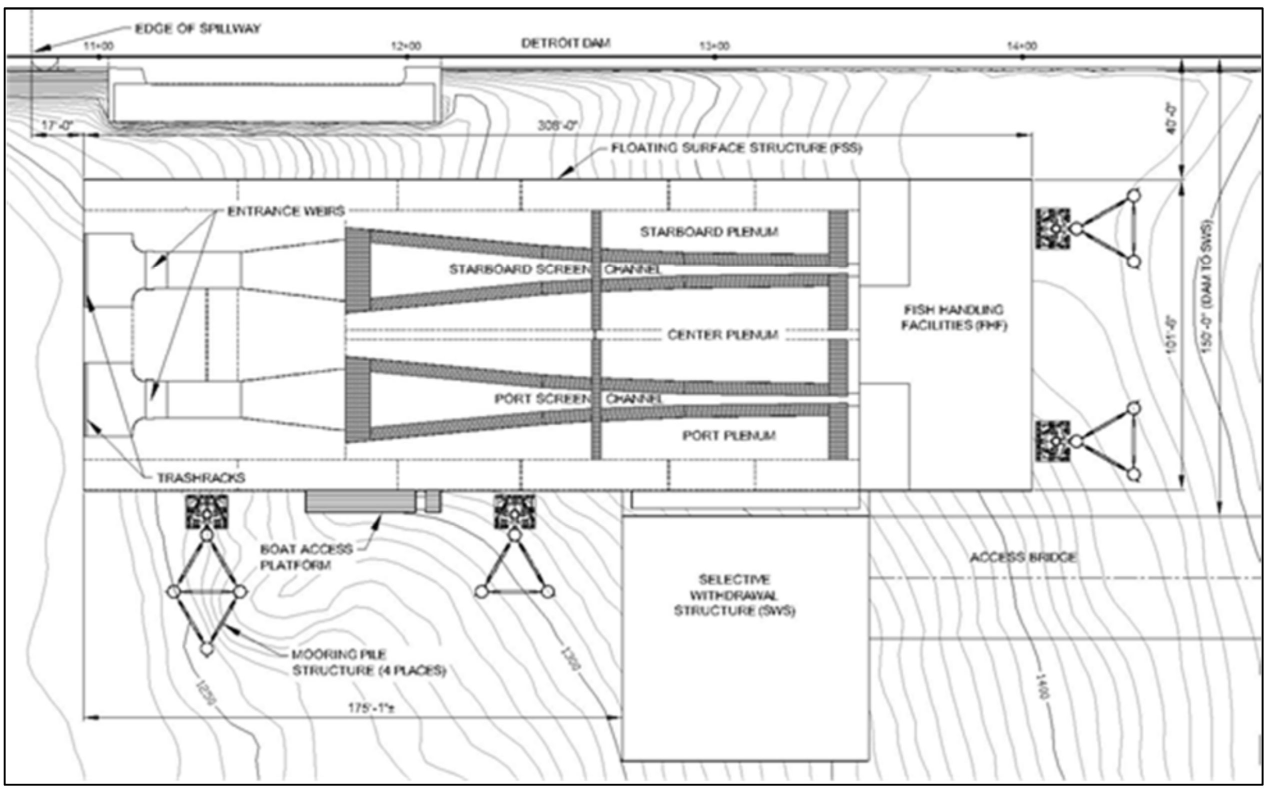


Figure 4-1 - Plan View of the FSS and SWS

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. 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. 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 should not exceed 4 fps at any location Figure 4-2 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.

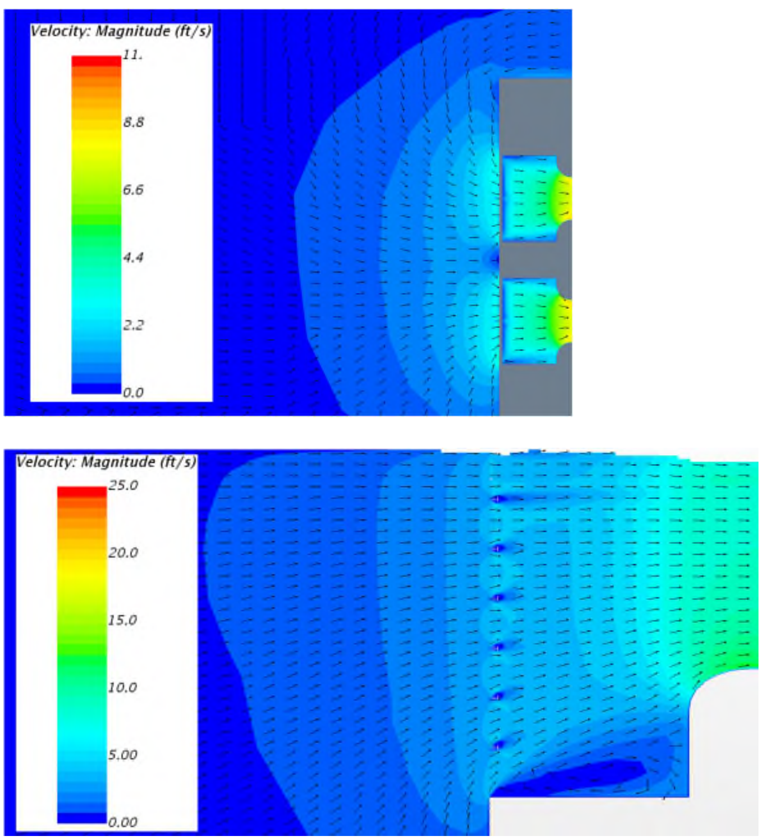


Figure 4-2 - Plan and Section Results of Trashrack Hydraulics from USACE CFD Model

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 one or two additional bars between the main bars to increase the quantity of floating debris excluded from the channel flow. Assuming ½-inch-thick bars, a single additional bar would create clear spaces of 3.75 inches, and two additional bars would create clear spaces of 2.33 inches. In at least 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. Material and strength requirements will mostly be dictated by the requirements and loads placed on the rack by the Trash Rake. Therefore, it is recommended that, consistent with the description above, the final design of the Trashracks 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 4-3. Details concerning the Trash Rake will be included in the Mechanical Design section of this DDR.

Figure 4-3 - 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 smooth 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.

The Entrance Weirs consist of a triple-leaf vertical wheeled gate panels with an elliptical crest extending 7.0 feet downstream from the upstream face of the upper slide gate leaf, and rising 3.91 feet above the top of the gate leaf. Figure 4 4 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 in excess of 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.

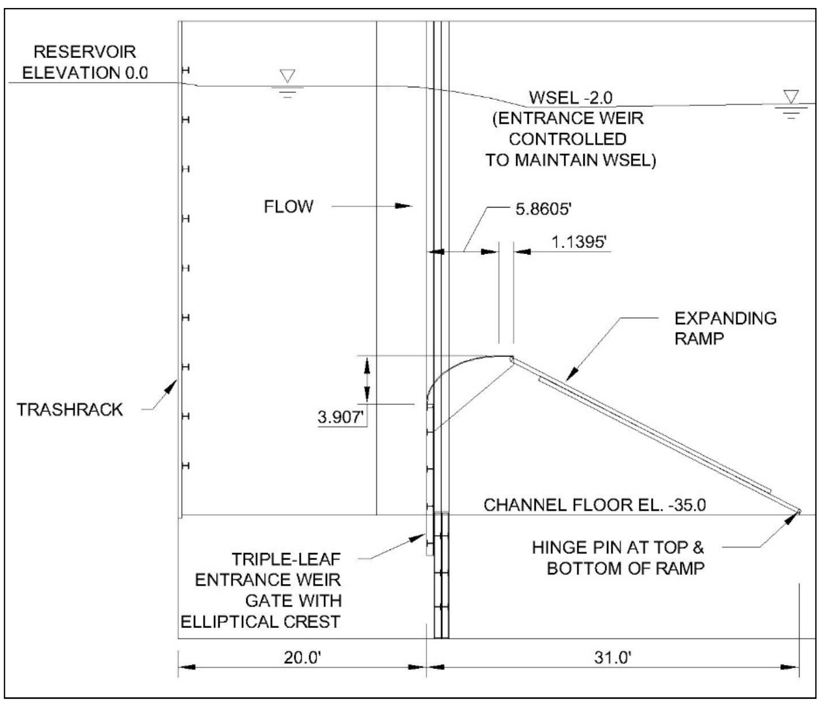


Figure 4-4 - Entrance Weir with Elliptical Shaped Crest

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

The Entrance Weir will be designed to automatically adjust vertically to maintain the 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 will be provided in the Mechanical Design section of the DDR. Figure 4-5 shows the approximate settings of the weirs at four significant settings. Settings A and B in Figure 4-5 are the settings of the two weirs during the potential low-flow 1,000-cfs pumped operation during periods of no power generation, 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 4-5 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.

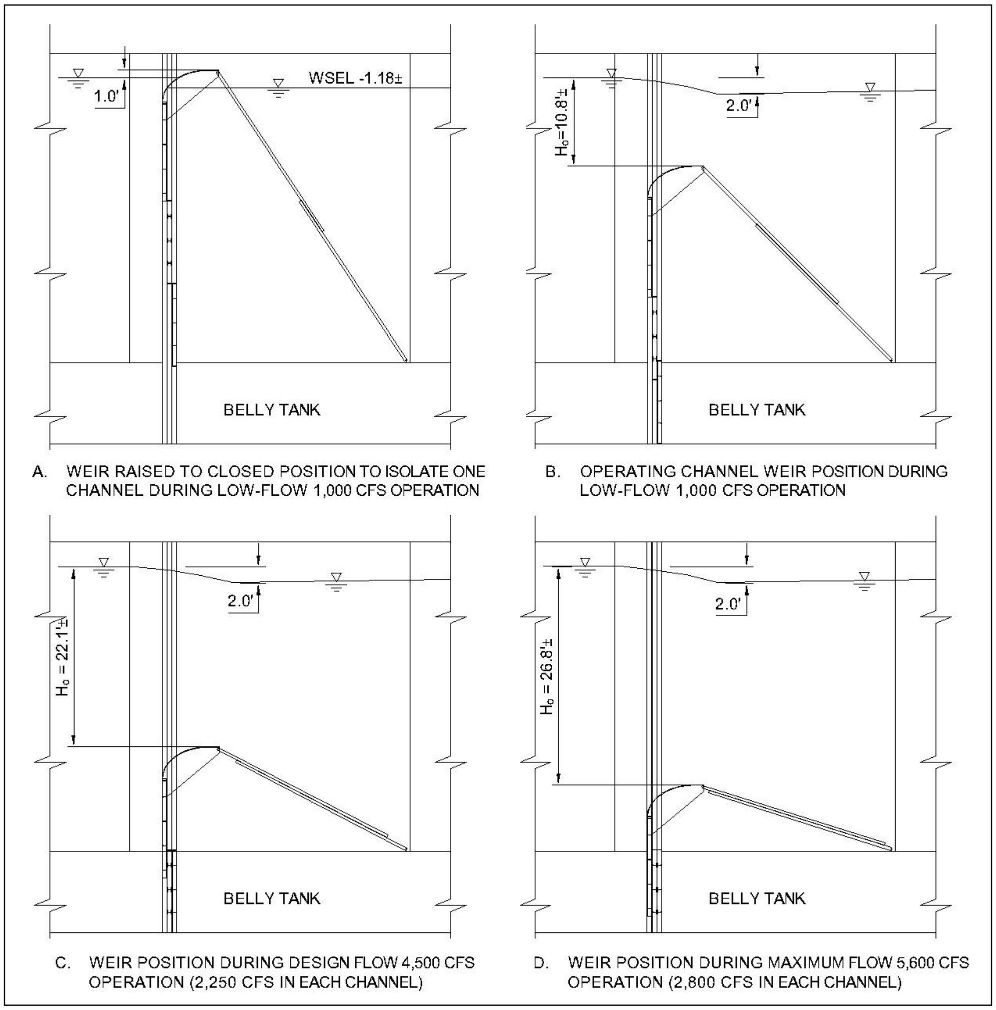


Figure 4-5 - Entrance Weir with Elliptical Shaped Crest - Four Entrance Weir Settings

The actual 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 SWS gates the 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 4-1 provides the estimated 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 4-1 - 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 4-6.

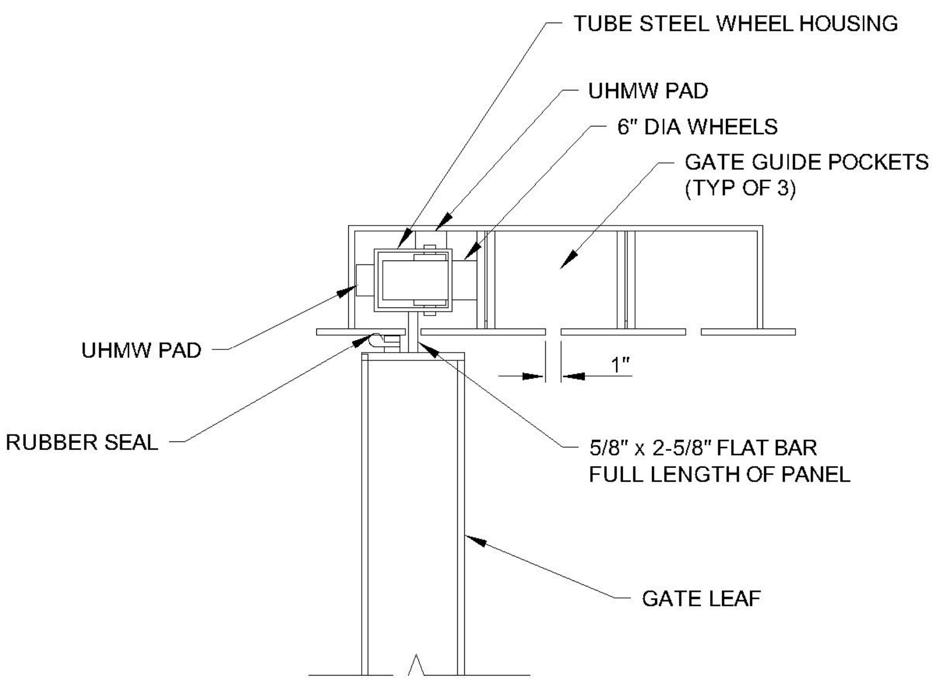


Figure 4-6 - Weir Gate Panel Wheel and Guide Configuration

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 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. 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 4-7. 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 4-8) 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.

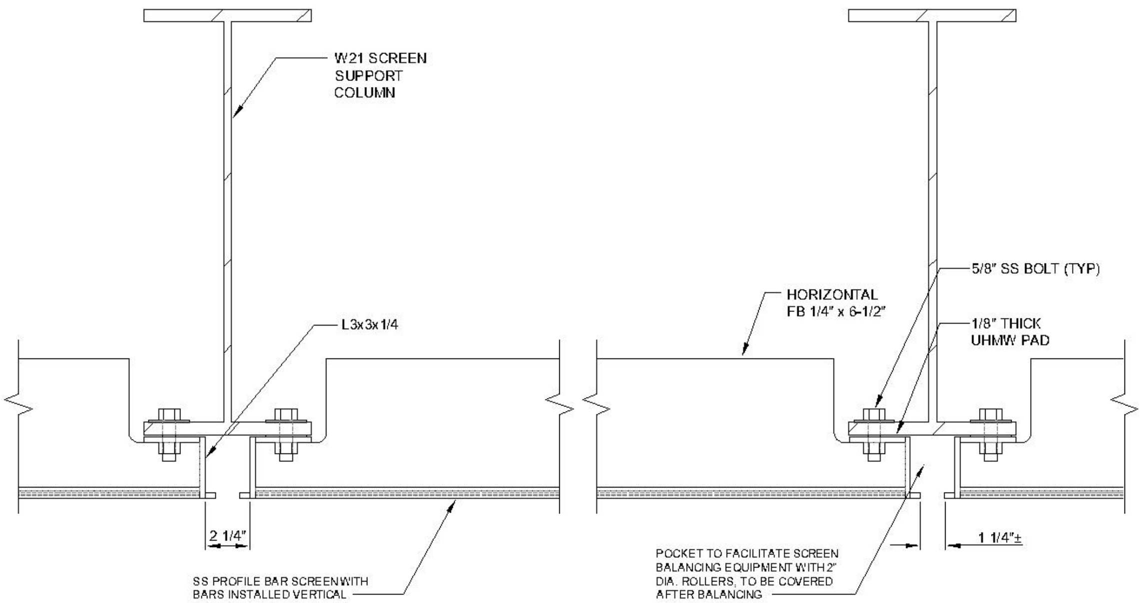


Figure 4-7 - Typical Screen Panel Section View

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

4.6.4.1 Primary Screens

After passage through the Trashracks, the flow and fish enter the Primary Screen Channel. The purpose of the primary screen section is to remove the majority of the incoming flow from the screen channel while the velocities are still relatively low. Plan and profile views of the Primary Screen Channel are shown in Figure 4-8. 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.

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%.

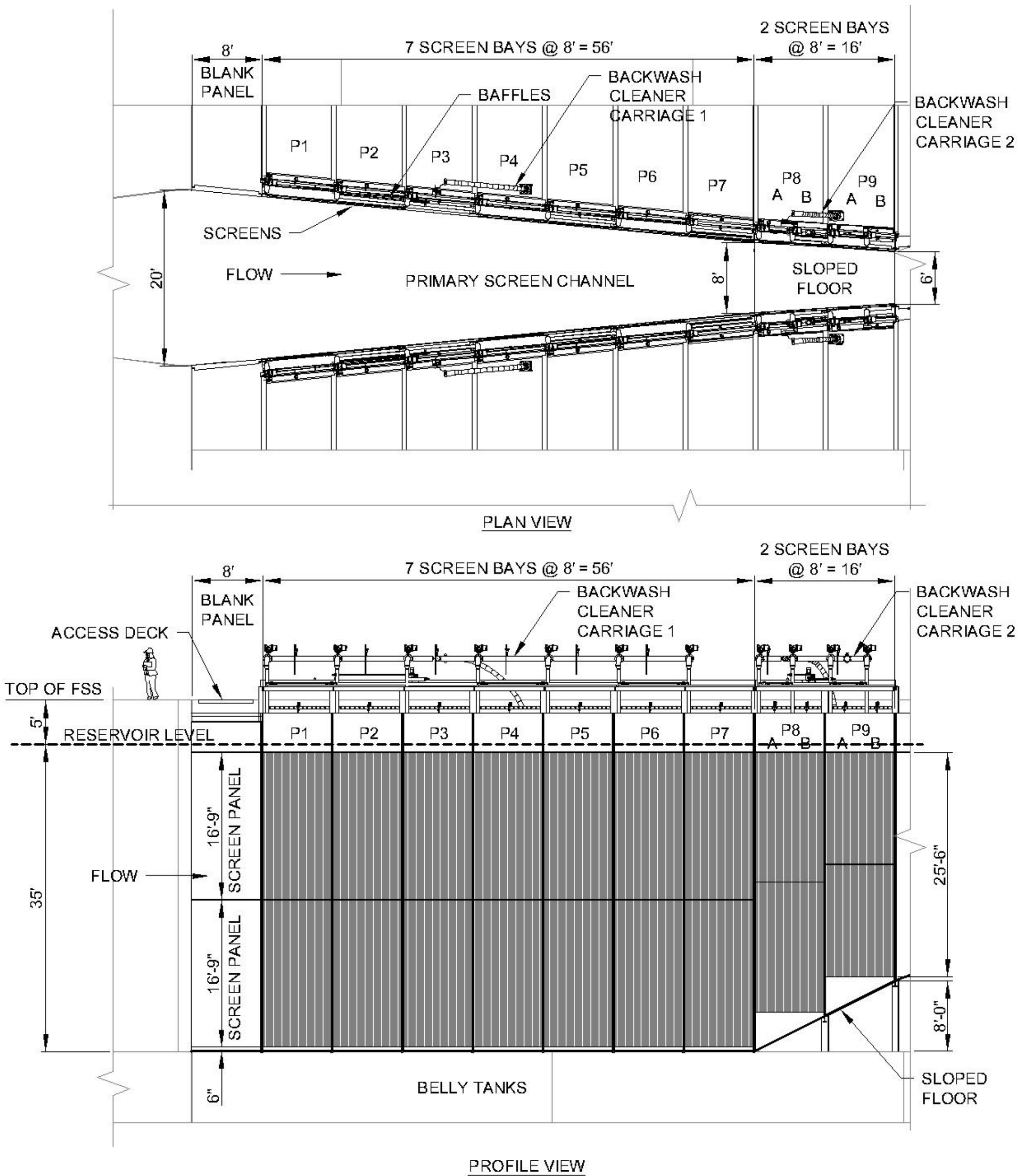


Figure 4-8 - Primary Screen Channel, Plan & Profile (elevations relative to reservoir)

Over the final 16 feet of the Primary Screen Channel the width further reduces from 8 feet to 6 feet, a reduction of 1.5 inches per foot. The floor through this section rises 8 feet (6 inches per foot) to begin the necessary reduction in channel depth as the flow is further reduced. There are two screens on each side of the channel over this 16 feet (labeled P8 and P9), with four hydraulically isolated sections. Each of the two screens is functionally divided in half with a plate mounted behind the screen that extends perpendicularly back to the baffle frame. This creates two hydraulically isolated sections within each screen (labeled A and B). An additional 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 side to the back side of the screen is greatest) does not exceed 0.44 feet per second, which is the NMFS criterion for maximum ‘hot spots’ on the screen.

At the end of the primary screen channel there is a 3-foot-long section of unscreened channel. 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 4-2 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 4-2 - Primary Screen Channel Hydraulics Providing Flows (cfs) and Velocities (ft/s)

	Design Flow 4,500 cfs			Maximum Flow 5,600 cfs			Moderate Flow 2,750 cfs			Minimum Flow 1,000 cfs**		
Primary Screen Channel Location	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 are conservatively calculated assuming only 90% of the gross screen area is available.

** Minimum flow of 1,000 cfs is a potential condition if pumps are added to operate during turbine down time with only one screen channel used.

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 4.9. 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 8.0 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.

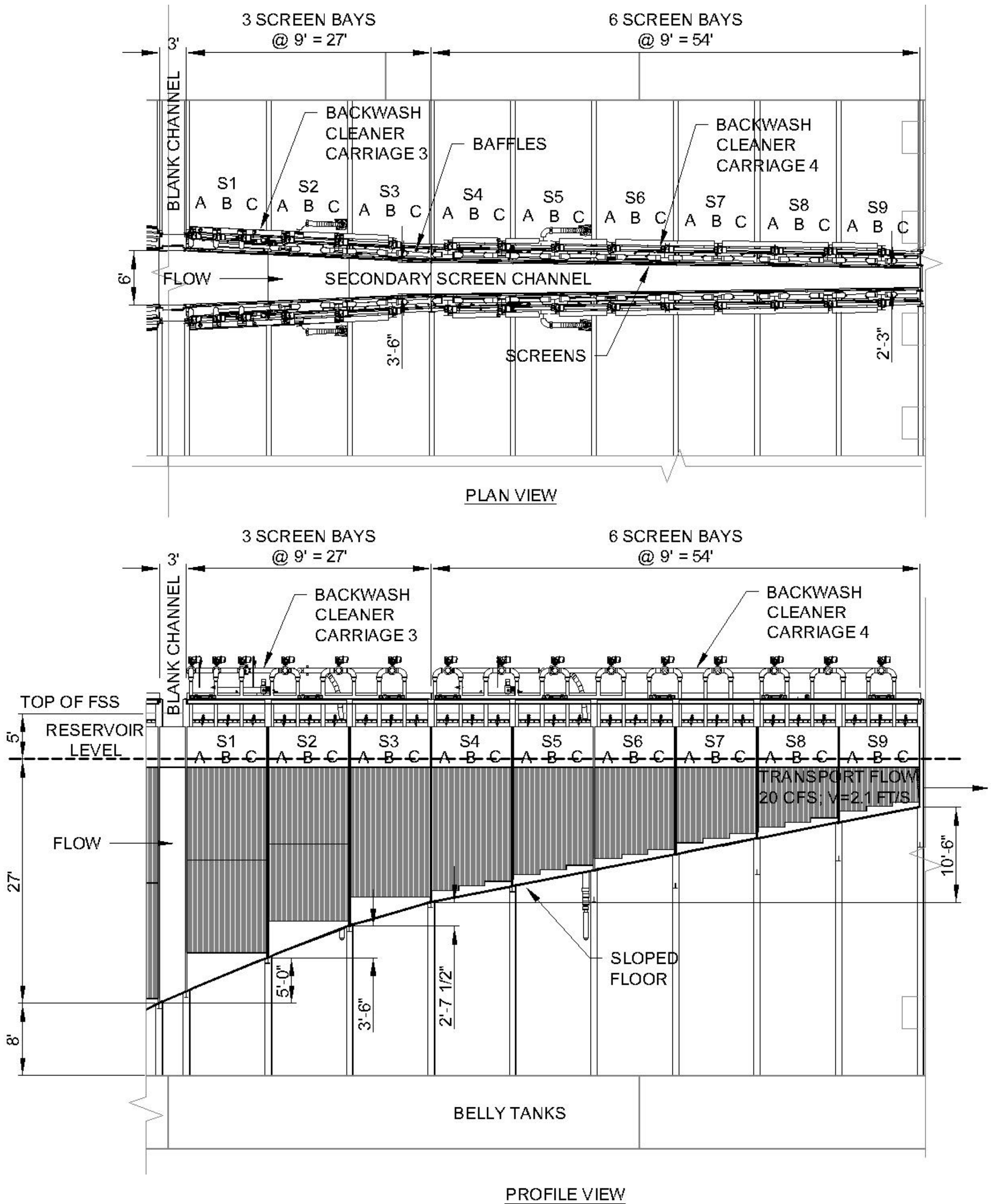


Figure 4-9 - Secondary Screen Channel, Plan & Profile (elevations relative to reservoir)

The initial 27 feet of the Secondary Screen Channel is referred to as the acceleration channel. The purpose of this section is to 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 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 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 7 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 with a velocity of about 6.9 feet per second, at the design flow rate of 2,250 cfs in each channel (4,500 cfs total). At the maximum potential flow of 2,800 cfs per channel (5,600 cfs total) the flow at this maximum velocity point would be approximately 419 cfs at a velocity of about 8.6 feet per second. At the potential minimum flow of 1,000 cfs if pumped attraction flow were to be integrated, there is not enough flow in a single channel to achieve a trapping velocity at any location in the screen channel; however, fish that enter the FSS are still trapped and committed to the FSS when they pass over the Entrance Weir. Under these minimum flow conditions, the flow at the maximum velocity point would be approximately 159 cfs at a velocity of about 3.1 feet per second. Table 4-3 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).

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

		Design Flow 4,500 cfs			Maximum Flow 5,600 cfs			Moderate Flow 2,750 cfs			Minimum Flow 1,000 cfs**		
	Secondary Screen Channel Location	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 are conservatively calculated assuming only 90% of the gross screen area is available.

** Minimum flow of 1,000 cfs is a potential condition if pumps are added to operate during turbine down time with only one screen channel used.

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.

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 4-4 provides estimated water surfaces at locations throughout the length of the screen channel.

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

		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**
	Channel Location				
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
	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. 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 is a potential condition if pumps are added to operate during turbine down time with only one screen channel used.

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 to 7.5 inches on center horizontally (depending upon the overall width of the particular baffle. This results in a fully-open porosity of approximately 25% to 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 4-10 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.

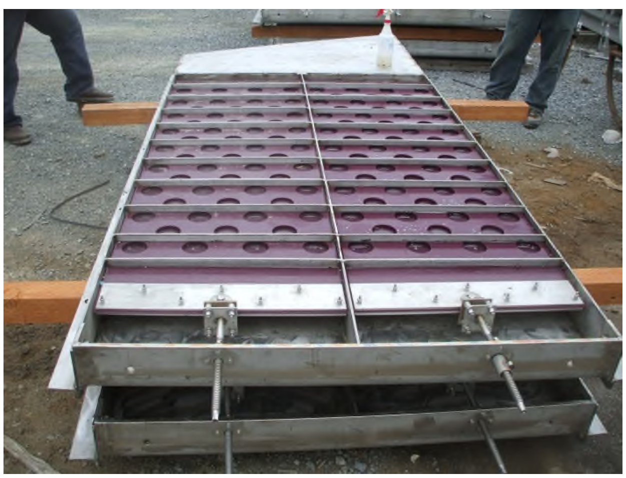


Figure 4-10 - Individual Baffle Panels and Baffles Installed on Floating Surface Collector

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 plenums. Table 4-5 provides the estimated water levels in the three plenums expressed as feet below the reservoir level. 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. The estimated baffles settings in percent open area are provided in Table 4-6. 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 4-5 - Estimated Water Levels in the Plenums in Feet Below Reservoir Level

	Water Surface in Feet Below Reservoir Level		
FSS Operating Flow	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 4-6 - Estimated Baffle Settings for Initial Startup of the FSS

		Baffle Setting Percent Open Area			
		Starboard Channel		Port Channel	
	Baffle Panel	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%
	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 4-11. 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 included nine zones with two spray bars in each zone, with a butterfly valve isolating each zone. Figure 4-12 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 4-13 provides a section view of cleaner carriage 1 installed into the primary screens.

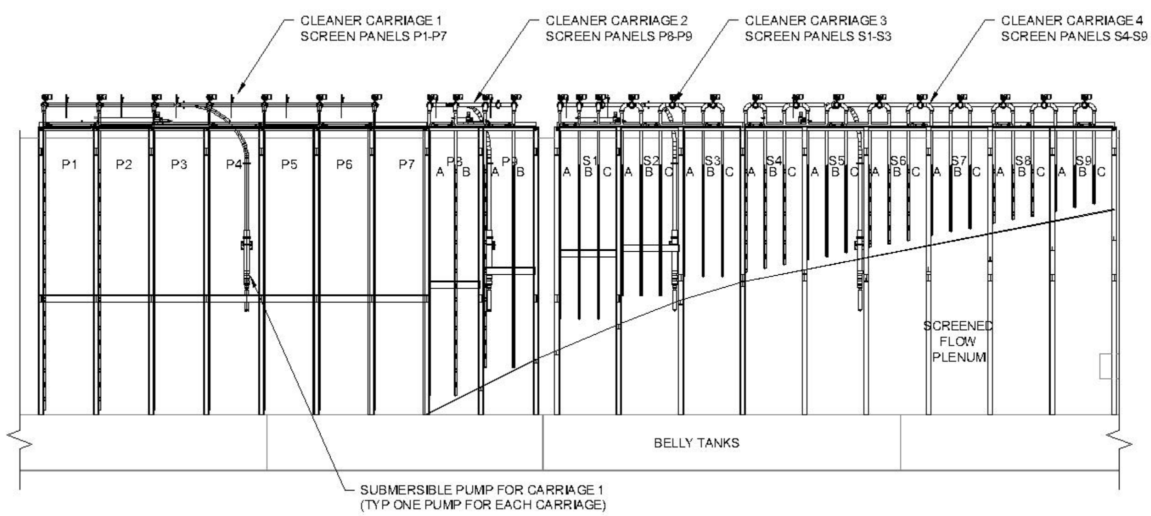


Figure 4-11 - General Arrangement of the Screen Cleaners

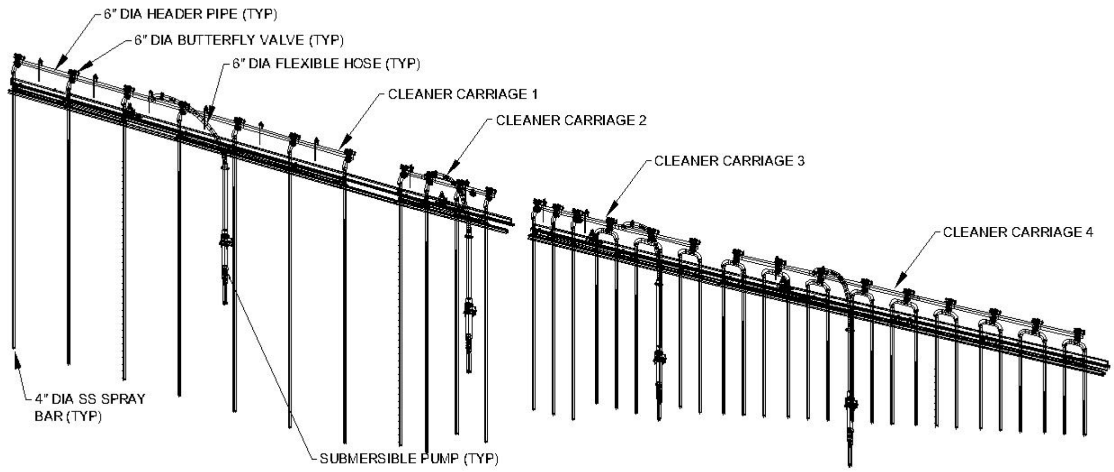


Figure 4-12 - Isometric View of Screen Cleaners

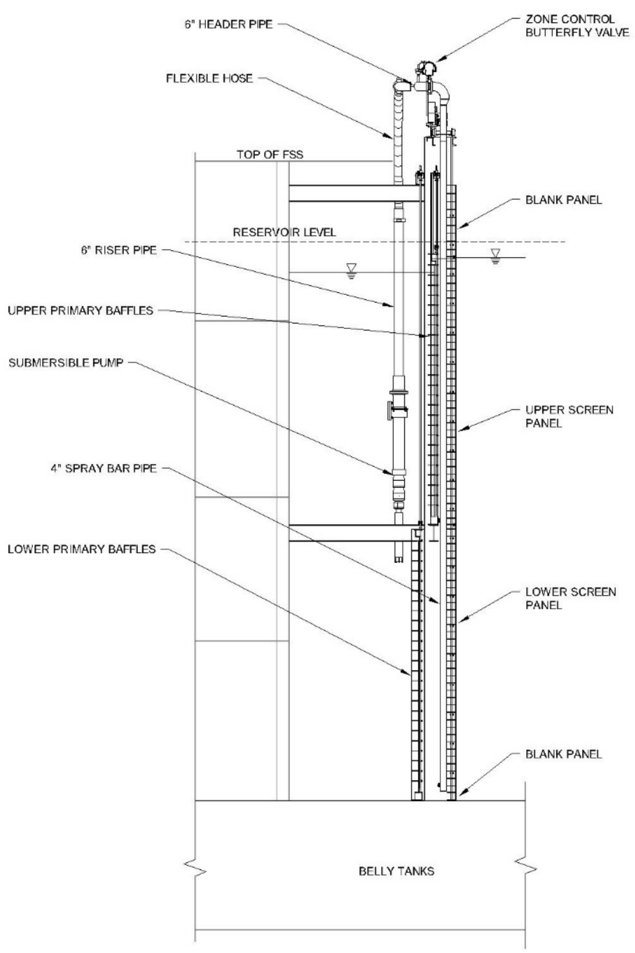


Figure 4-13 - Section View through Cleaner Carriage 1

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 them 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.

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 variable speed pumps downstream in the FHF. These FHF facilities provide for dewatering the majority of the transport flow, final removal of debris and in-line separation of juvenile-sized fish from adult fish, fish holding and sampling, and transfer of fish to the transport truck loading station above. The estimated peak daily and seasonal fish migration numbers have not been determined for the FSS project at the 60% DDR phase. The design approach for the FHF is to conservatively size the facility based on facilities implemented in other river basins, and report the capacity of the Detroit Dam FHF components based on the design criteria. Figure 4-14 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 for controlling the final fish flow rate, Juvenile Fish Separators, Juvenile Holding Tanks and subsample diversion, Adult Holding Tank, a Sampling Station, and numerous Transport Pods. The following sections provide descriptions of the components of the FHF.

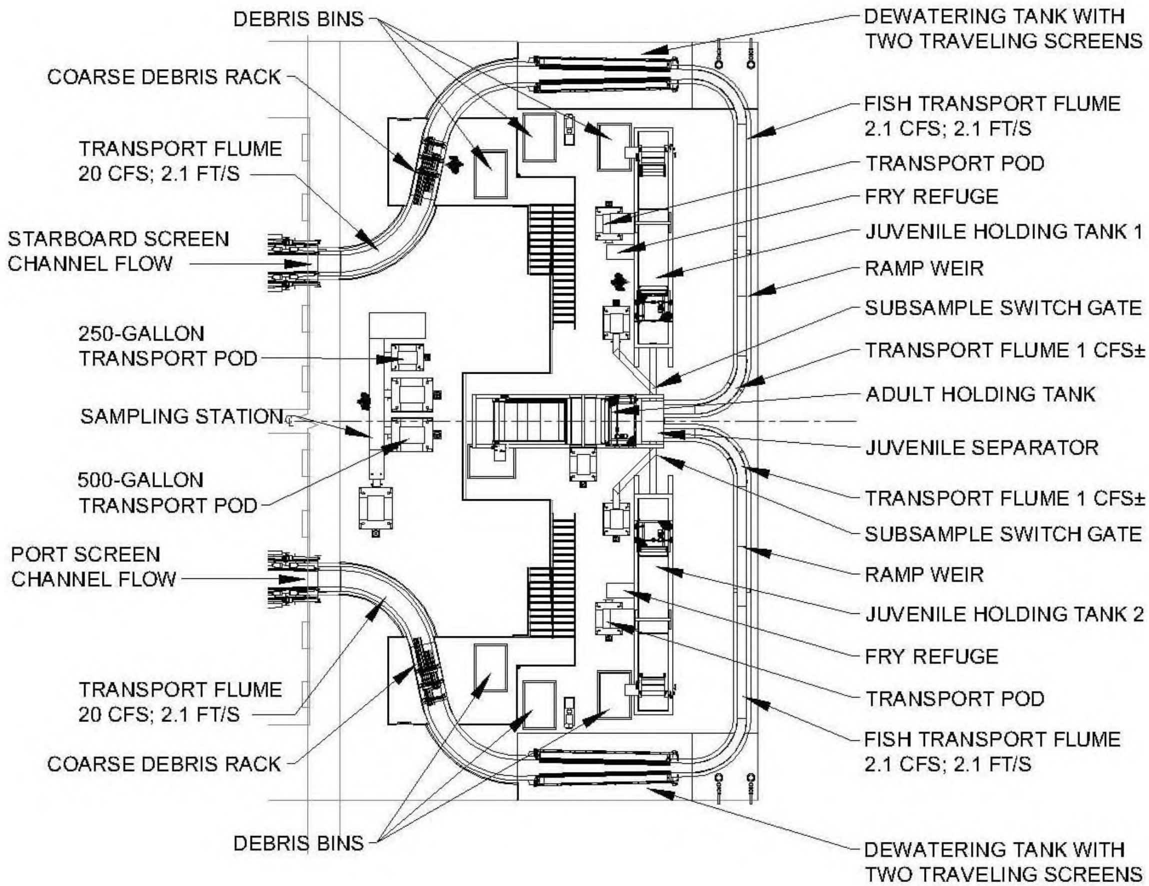


Figure 4-14 - Plan View of the Fish Handling Facilities

4.6.7.1 Emergency Shutoff Gates

Immediately downstream 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 FSS flow stops and power to the dewatering pumps in the FHF is lost. These gates are necessary to prevent flooding of the FHF area. Details of the Emergency Shutoff Gates and their operation will be provided with the 90% DDR.

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 upstream 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 fish holding tanks.

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 this preliminary 30% design. The optimal number of racks, spacing between racks, number of pipes within each rack, and the spacing of the pipes can be experimented with to determine the optimal arrangement to keep large debris out of the transport 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 4-15 provides photos of the debris racks at the North Fork FSC, and Figure 4-16 shows the debris bin at the North Fork FSC with the type of debris that is removed at the coarse debris rack. It should be noted that the transport 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.

Figure 4-15 - Photos of the Debris Rack in the North Fork FSC Transport Flume

Figure 4-16 - 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 30 feet long and 6 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. This design is successfully used at the North Fork tertiary screen structure (TSS) to dewater and remove debris from the combined flow from two downstream migrant collectors before the fish enter the downstream bypass pipe. Figure 4-17 provides a photo of the North Fork TSS traveling screen installation showing the screen with debris pegs, and the ability of the pegs to retain the debris on the screen face.

Figure 4-17 - Photos of the North Fork TSS Traveling Screens with Debris Pegs

Two pumps are located at the aft end of each Dewatering Tank to provide for the screen flow. Pumped flow will be returned to the reservoir through the side walls of the FSS. The pumps will be operated with variable frequency drives (VFDs) to allow for flow control, which in turn controls the fish flow in the transport flumes. Only one pump is required to provide the design screen flow, but a second pump is included as a redundant back up, given the crucial nature of this flow to attract fish through the transport flumes, and to prevent flooding of the FHF area. Pump rating curves will be programmed into the PLC allowing it to control the speed of the pumps via the VFDs based on the desired flow setpoint (manually entered into the PLC) and measurements of the water level difference between the pump sump and the reservoir level.

Debris that is carried up over the top of the traveling screen will fall off and/or be sprayed off of the screen belt into a debris trough on the back side of the screen. 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 through 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 by the truck loading crane on the access bridge above.

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 2.1 cfs. An adjustable Ramp Weir is incorporated into the flume, with a fixed screen panel along one wall. 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 2.1 cfs approaching the weir will pass out through the wall screen and be piped to the pump sump at the aft end of the Dewatering Tanks. The magnitude of the screened flow, and the distribution of the flow over the screen area, will be controlled with small adjustable baffles on the back side of the screen.

Downstream of the weir crest the weir plate and remaining flume section slope downward to rapidly move the fish and remaining flow (assumed at the time of this 60% DDR to be approximately 1.0 cfs) to the Juvenile Separator downstream. The final flow rate is adjustable, and can be optimized through experience after startup of the facility.

4.6.7.5 Juvenile Fish Separator and Subsampling

Downstream of the Ramp Weir, the fish flow passes onto a Juvenile Fish Separator. The Juvenile Separator consists of a downwardly sloping flume with a porous bottom. The porous bottom is an aluminum rack made from 1-inch-diameter tubes spaced adequately to allow juvenile fish to pass through between them. The tubes run lengthwise along the slope of the flume. Various racks can be provided and easily changed out with different clear spacing for different species and/or seasons depending upon the size of fish to be separated. 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 racks is a tank with fish-friendly outlet control gates on each side leading to small flumes (6 to 9 inches in width) heading out from the tank in the port and starboard directions. Although each incoming flume is associated with an individual separator rack, the tank below should be common, with the ability to slide a separation wall down the middle if it is desired to isolate fish that entered the port side Screen Channel to the port side Juvenile Tank and visa-versa for the starboard side. The exit flumes include bifurcations and switch gates directing the juvenile fish to one of two directions. If the switch gate is set to pass fish straight down the flume then they will pass into the Juvenile Holding Tank. Otherwise, they will be diverted out of the main flume and deposited into a Transport Pod for temporary holding prior to sampling. In this way a percentage of the fish passing into the FHF can be provided as a subsample of the population. Subsampling in this way is usually accomplished with a timed sample. For example, if a timer in the PLC is set to divert fish to the subsample pod for three minutes every half hour throughout the day it would be assumed that 10% of the juvenile fish passing through the system were diverted into the subsample pod.

4.6.7.6 Juvenile Holding Tanks

There are two identical Juvenile Holding Tanks. Each tank includes a main holding area, a fry refuge tank, a traveling screen for removing debris, a crowder, and a brail system for moving fish out of the tank into transport pods. The main holding area of each tank is the smolt holding area, which is 22 feet long, 4 feet wide, and 5 feet deep. Each tank can hold up to 8,800 steelhead smolts with an average length of 8 inches, or 17,600 Chinook smolts with an average length of 6 inches. Near the far end of smolt holding area (opposite from where the fish enter) is a fry refuge area. The refuge area is 4 feet by 4 feet and is located adjacent to the side of the smolt holding area. The refuge area is hydraulically connected to the smolt holding area, but separated by a fry isolation screen. The fry isolation screen allows fry-sized fish to pass into the refuge area but prevents smolt-sized fish from entering. Circulation water in the juvenile tanks will flow from the upstream end of the tank, where the fish enter, downstream toward the fry refuge areas, to help encourage the fry to move downstream toward the refuge areas, additionally some of the circulation water will be passed through the fry refuge area to further encourage the fry to pass through the isolation screen. A vertically rising brail system in the fry refuge area would be used to transfer the fry to the adjacent transport pod for removal from the FSS, or transfer to the sampling station.

At the far end of the Juvenile Holding Tank there is a sloped traveling screen. The tank circulation water passes through this screen before being passed out of the tank and pumped back to the reservoir. In this way, the traveling screen will be continuously removing any debris that has made its way downstream to the holding tank. The screen is sized for a very low average approach velocity (less than 0.1 ft/s) so that the fish will not be impinged on the screen and can easily avoid it. The traveling screen will deposit debris into the same debris container used for the debris from the screens in the Dewatering Tank adjacent to it.

Each Juvenile Holding Tank includes a horizontally travelling crowder for moving fish toward the downstream end of the tank. Near the downstream end of the tank, just beyond the fry refuge area and just before the toe of the traveling screen, there is a floor brail. The tank crowder travel range ends at the upstream edge of the brail. An isolation screened barrier panel would be lowered into the tank where the traveling screen breaks the water line and then gently slid down along the screen face to the toe of the screen and then set vertically in place at the downstream end of the brail. This effectively isolates the brail between the crowder panel, the barrier panel, and the two walls of the tank. For this reason, the traveling screens in the holding tanks should not include the debris pegs described for the larger traveling screens in the Dewatering Tanks. The brail can then be raised vertically to move the fish toward the surface where they can be transferred to a Fish Transport Pod for removal from the FSS or transfer to the sampling station. During the initial crowding activity, when the crowder panel is lowered into the tank at the upstream end, where the fish are entering, it is recommended that fish be precluded from passing toward the tank to prevent them from colliding with the back side of the crowder panel. This can be accomplished by either manually setting the flume switch gate to temporarily place incoming fish in the associated subsample pod, or the discharge gates on the separator box could be adjusted to temporarily send all fish to the Juvenile Holding Tank on the other side of the FSS.

4.6.7.7 Adult Holding Tank

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

The Adult Holding Tank is 10 feet long by 6 feet wide, with a water depth of 5 feet. It has a capacity to hold about 150 adults at an average weight of 8 pounds per fish, in 50º F water. The capacity should be halved to 75 fish of the same weight if the temperature is 70º F. As with the Juvenile Holding Tanks the Adult Holding Tank has a sloped traveling screen at the downstream end to remove debris that has accumulated in the tank. It also has a horizontally travelling crowder and a brail system similar to the described for the Juvenile Holding Tanks, used to crowd fish and lift them for transfer into a transport pod for removal from the FSS or transfer to the Sampling Station.

4.6.7.8 Sampling Station

A Fish Sampling Station is located on the main deck of the FSS, at midship just downstream of the Screen Channels. The Sampling Station is used during sampling for identifying and sorting the fish into one of three 250-gallon or 500-gallon transport pods. A sorting 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, where the fish are transferred out of a transport pod into the anesthesia water. 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 (similar to a transport pod) for removal from the FSS and disposal at the existing Minto facility. The table will have a splash board along the back side with three opening ports, each leading to a hose attachment to be used for placing fish into one of the three 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 lifted off the FSS by the crane located above at the transport truck loading station on the SWS access bridge. The crane on the access bridge is being designed by the USACE, and details can be found in the DDR document for the SWS. The transport trucks will be specially-designed flatbed trucks designed to accommodate the transport pods and to provide oxygenation to the pods during transport.

All age classes of fish (fry, smolt, or adult) can be made available for sampling if necessary. Ultimately, all fish held in the FHF are eventually placed into transport pods, and any transport pod could be lifted and moved to the Sampling Station if required. The smolt holding facilities provide a system to allow for the separation of a timed subsample. Holding facilities for other life stages (fry and adult) do not have this feature, but it is anticipated that if sampling of these life stages is required then all of the fish would be sampled because the numbers of individual fish in these life stages is not anticipated to be excessive.

4.6.7.9 250/500 Gallon Transport Pods

Fish will be transported from the FHF to release points downstream (or in some cases upstream) of the dam in either 250-gallon or 500-gallon Transport Pods. The Transport Pods are rectangular box shaped containers constructed of either aluminum or stainless steel. 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 250/500-gallon capacities work as a modular system, that can be used independently or in combination with the existing larger 1500-gallon transport truck. The 250/500-gallon Transport Pods could be used to move fish from the FHF for transfer into the existing 1500-gallon trucks on the SWS access bridge if needed. However, the design intent is that the pods could be loaded on a specially-designed flatbed truck for transport directly to the release sites, eliminating the additional risk and time associated with an additional fish transfer process.

4.6.8 SWS Flow

The screened flow from the two large screen channels is all combined in a large plenum and discharges to the SWS through a large opening 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 4-4). At the maximum flow of 5,600 cfs the plenum level would be 2.61 feet below the reservoir. Flow into the SWS will be controlled by the SWS multi-leaf weir gates, as described in the SWS DDR. Based on conversations with the USACE, the SWS weir 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 weir gates is being 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, 304 feet long by 101.5 feet wide by 48 feet high. Structural arrangement is designed to allow breakdown into a series of modules that are intended to be fabricated off site and trucked to a site on the Detroit reservoir for assembly into the complete structure. Field welding is required to join modules together at the assembly site. It is intended that modules be pre-outfitted prior to delivery to the assembly site as much as practicable. However, various outfitting activities such as pulling electrical cable, installation of screen cleaners, and the like must be accomplished after the FSS structure is fully assembled.

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

Preliminary 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. Further structural calculations in accordance with design standards and loads will be provided in the 90% DDR. 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:

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

Additional design standards and references to be included in the 90% DDR.

5.1.3 Performance and Serviceability Criteria

The FSS design service life is 50 years. A key element of this criteria is the ability to service the structure on site and in the water when the FSS is 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 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 FSS 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 the 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 (x,z) plane will need to be carefully managed because the FSS will be located in close proximity to the SWS. This will likely require that the mooring dolphins be placed on both planes of the FSS hull. Four dolphins located around the FSS may be required to handle motion in all six degrees of freedom. Increasing the number of FSS mooring positions to four could allow for substantial reduction in the diameter of the required piling. With this tight tolerance, binding problems could occur in the pile hoop and tracks. This could create damage, and will need to be evaluated.
- It is likely that the FSS and SWS would collide in a seismic event, as both structures would have different modes and frequencies of vibration. If the two structures are less than one foot apart, a fender system would likely be essential to mitigate damage from collision in an earthquake. Also, strong consideration should be given to a connection between the FSS and SWS. This connection would require coordination between the designs of the FSS and the SWS, including seismic analysis results, which would likely benefit both structures by providing damping and support for asymmetric load scenarios.
- Assuming the use of guide piles for FSS moorings, it will be necessary to consider potential interference with crane operation to handle fish hoppers.
- If the piles are driven plumb, then the pile frames (two) could serve as templates for driving. The piles would serve as portals for drilling equipment.
- Frames will need to be floating (not connected to the piles), thus underwater work will be required to fix the collars for the intermediate frame either by fixing the frame brackets via welding or threaded rods.
- Batter piles are probably not feasible except perhaps on the highway side, depending on pile lengths required. The use of batter piles eliminates the ability to use intermediate frames, and potentially buckling will be an issue.
- Corrosion will not be a serious concern as this is fresh water – anodes not required.
- The current concept design for the FSS mooring employs large diameter steel pipe pile that could weigh over 100 tons each. The feasibility of both transport and installation of such heavy and large piles should be considered.

5.2.3.2 FSS Dimensions

- FSS Length = 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) = 10,044 ft^2
  - Longitudinal Projected Current Area (SWS shielding) = 940 ft^2
  - Longitudinal Projected Wind Area (No shielding) = 13,484 ft^2
  - Longitudinal Projected Current Area (No shielding) = 1,340 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) = 8,724 ft^2
  - Longitudinal Projected Wind Area (No shielding) = 2,660 ft^2
  - Longitudinal Projected Current Area (No shielding) = 12,164 ft^2
  - Front Transverse Projected Wind Area = 2,537.5 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

5.2.3.5 Steel Pipe Piles

- ASTM A53 Grade B
- Yield Strength Fy = 36 ksi
- Ultimate Strength Fu = 60 ksi
- Elastic Modulus E = 29,000 ksi
  - 48” Diameter 1” or 1.5” wall – in the event composite piles are ever reconsidered, diameter to thickness ratio D/t will be kept less than 0.09E/Fy (=52.2) for concrete filled piles in order to keep the shape compact for flexure.

5.2.3.6 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 5-1 - Wind Load Criteria for Use in Mooring System Design

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

	Operational Wind Speed	40 mph	This speed serves for calculating “Usual” wind and wave forces.

5.2.4.2 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 guidepiles (in the x and z directions) will be able to impose any movement in the FSS. The cyclic motion of the piles inside the pile hoops, assuming it is greater than the tolerance between the pile and the UHMW bearings, could potentially cause damage to the UHMW bearings. Whether damage occurs, and the degree of any damage, is dependent on the frequency and amount of translation invoked into the guidepiles by the movement of the earth at the base of the guidepiles. Since the piles themselves are flexible (springs), it is doubtful that much, if any, movement of the top of the 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. Therefore, a fender system should be designed to allow for proper dissipation of the energy of these collisions into the FSS – in this way the FSS combined with its guidepile mooring system could act as a damping system for the SWS in the z direction (East-West).

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:

- 22.96 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.

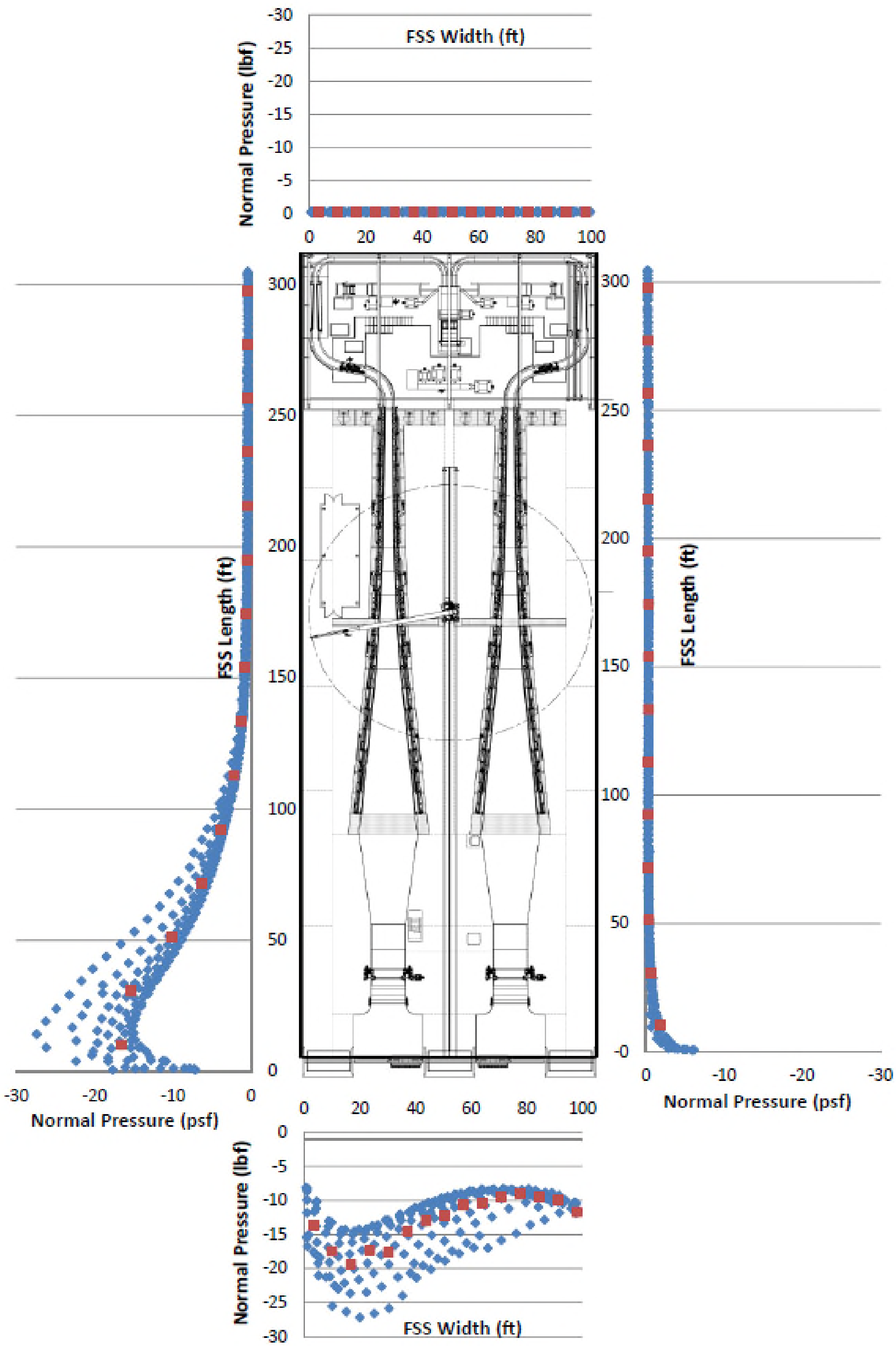


Figure 5-2 - Distribution of Hydrodynamic Current Forces on Each Surface of the FSS (not to scale)

5.2.4.3.3 *Suction and Momentum Change*

An analysis is conducted in the appendix of the forces caused due to momentum changes, both caused by suction and via change in direction of the flow inside the FSS. This was conducted to ensure that these loads are or are not significant as they could influence the mooring geometry and design. A maximum flow through the FSS of 5,600 cfs is assumed.

Maximum suction force from the north F_x = 76 kips

Net maximum thrust force in the -x (North) direction F_x = 43.4 kips

Maximum thrust force in the z (East) direction F_z = 32.6 kips

Thus, the thrust forces on the FSS due to momentum changes are much greater than the normal environmental loads on the FSS and must be considered in the mooring design analysis.

5.2.5 Environmental Load Combinations

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

1) Operating Load Combination 1:
    a. Assumptions:
        i. FSS will be ballasted (freeboard = 5ft, draft = 43 ft)
        ii. Wind and waves on upstream face.
        iii. FSS is partially shielded from the wind by the SWS.
        iv. Usual wind and waves from East (Wind – 40 mph).
        v. Maximum operational flow will be used (5,600 cfs)
        vi. Dam will not be spilling
        vii. Unprotected length of FSS = 228 ft
    b. Wind force = 6.3 kips/228 ft (unprotected area) = 0.028 kip/ft (W)
    c. Wave force = 0.77 kips/228 ft = 0.0034 kips/ft (W)
    d. Operational Forces:
        i. S direction = 43.4 kips/101.5 ft = 0.427 kips/ft
        ii. W direction = 32.6 kips/80 ft = 0.408 kips/ft
2) Operating Load Combination 2:
    a. Assumptions:
        i. Same conditions as operational load combination 1, except wind will be assumed to come from the southeast, and act simultaneously on the stern and upstream faces.
        ii. Wind force on each face will be assumed to be 75% of the maximum perpendicular force on that face.
    b. Wind force (upstream face) = 4.8 kips/228 ft = 0.021 k/ft
    c. Wind force (front face) = 3.1 kips/101.5 ft = 0.031 k/ft

   d. Wave force (upstream face) = 0.577 kips/228 ft = 0.0025 k/ft
   e. Wave force (front face) = 0.257 kips/101.5 ft = 0.0025 k/ft
   f. Operational forces:
      i. S direction = 43.4 kips/101.5 ft = 0.427 kips/ft
      ii. W direction = 32.6 kips/80 ft = 0.408 kips/ft

3) Survival Load Combination No. 1:
   a. Assumptions:
      i. FSS is not in operational mode.
      ii. FSS is de-ballasted (current force reduced to 15% of ballasted spilling case)
      iii. Dam is spilling
      iv. Maximum winds/waves from the East (wind - 91 mph)
   b. Wind force = 147 kips/228 ft (unprotected area) = 0.65 kip/ft (W direction)
   c. Wave force = 14.3 kips/228 ft = 0.063 kips/ft (W direction)
   d. Current force = 0.15*(distributed load varies linearly from 0.850 k/ft at the FSS bow to 0.08 k/ft at 112 ft aft of the bow and then reducing linearly to 0.014 k/ft at the stern (W) and 0.8 k/ft at the bow closest to the Dam to 0.4 k/ft at the bow furthest from the Dam (S)).

4) Survival Load Combination No. 2:
   a. Assumptions:
      i. FSS is not in operational mode.
      ii. FSS is ballasted
      iii. Dam is spilling
      iv. Maximum winds/waves from the East
   b. Wind force = 33.2 kips/228 ft (unprotected area) = 0.146 kip/ft (W direction)
   c. Wave force = 3.3 kips/220 ft = 0.014 kips/ft (W direction)
   d. Current force = distributed load varies linearly from 0.850 k/ft at the FSS bow to 0.014 k/ft at the stern (W) and 0.8 k/ft at the bow closest to the Dam to 0.4 k/ft at the bow furthest from the Dam (S).

5) Survival Load Case No. 3
   a. Assumptions:
      i. FSS is not in operational mode.
      ii. FSS is de-ballasted
      iii. Dam is spilling
      iv. Maximum winds/waves from the South
   b. Wind force = 54.0 kips/101.5 ft (unprotected area) = 0.53 kip/ft (N direction)
   c. Wave force = 6.4 kips/101.5 ft = 0.063 kips/ft (N direction)
   d. Current force = distributed loads vary on two surfaces linearly from 0.15*(0.850 k/ft at the FSS bow to 0.014 k/ft at the stern (W) and 0.8 k/ft at the bow closest to the Dam to 0.4 k/ft at the bow furthest from the Dam (S)).

6) Survival Load Case No. 4
    a. Assumptions:
        i. FSS is not in operational mode.
        ii. FSS is de-ballasted
        iii. Dam is not spilling (no current)
        iv. Maximum winds (no waves) from the West
    b. Wind force = 214 kips/308 ft (unprotected area) = 0.70 kip/ft (E direction)
7) Survival Load Case No. 5
    a. Assumptions:
        i. FSS is not in operational mode
        ii. FSS is de-ballasted
        iii. Dam is spilling
        iv. Maximum wind/waves from the SW
    b. Wind force (W) = 111 kips/228 ft = 0.485 k/ft
    c. Wind force (N) = 40.5 kips/101.5 ft = 0.399 k/ft
    d. Wave force (W) = 10.7 kips/228 ft = 0.047 k/ft
    e. Wave force (N) = 4.77 kips/101.5 ft = 0.047 k/ft
    f. Current (S) = 8,725 lbs/308 ft = 0.028 k/ft
    g. Current (W) = 8,576 lbs/101.5 ft = 0.084 k/ft

5.2.6 Model Configuration

Table 5-2 – Piling Configuration

	Detroit Mooring Dolphin Configuration 5/2/2018								
Pile No.	**Pile Tip - Rock Socket depth Elevation (ft)**	**Assumed Point of Fixity Elevation (ft)**	**Top of rock Elevation (ft)**	**Pile Top End Elevation (ft)**	**Length of Pile (ft)**	**Pile Size**	**Tyoe Member**	**Shape**	**Material**
PILE 1A	1240	1250	1260	1581	341	PIPE_48_1.5	Column	Pipe	A53 Gr.B - Submerged
PILE 1B	1255	1265	1275	1581	326	PIPE_48_1.5	Column	Pipe	A53 Gr.B - Submerged
PILE 1C	1230	1240	1250	1581	351	PIPE_48_1.5	Column	Pipe	A53 Gr.B - Submerged
PILE 1D	1233	1243	1253	1581	348	PIPE_48_1.5	Column	Pipe	A53 Gr.B - Submerged
PILE 2A	1286	1296	1306	1581	295	PIPE_48	Column	Pipe	A53 Gr.B - Submerged
PILE 2B	1285	1295	1305	1581	296	PIPE_48	Column	Pipe	A53 Gr.B - Submerged
PILE 2C	1262	1272	1282	1581	319	PIPE_48	Column	Pipe	A53 Gr.B - Submerged
PILE 3A	1372	1382	1392	1613.5	241.5	PIPE_48	Column	Pipe	A53 Gr.B - Submerged
PILE 3B	1372	1382	1392	1613.5	241.5	PIPE_48	Column	Pipe	A53 Gr.B - Submerged
PILE 3C	1372	1382	1392	1613.5	241.5	PIPE_48	Column	Pipe	A53 Gr.B - Submerged
PILE 4A	1372	1382	1392	1613.5	241.5	PIPE_48	Column	Pipe	A53 Gr.B - Submerged
PILE 4B	1372	1382	1392	1613.5	241.5	PIPE_48	Column	Pipe	A53 Gr.B - Submerged
PILE 4C	1372	1382	1392	1613.5	241.5	PIPE_48	Column	Pipe	A53 Gr.B - Submerged

Table 5-3 - Mooring System Material Take-off

Grade	Shape	F_y (ksi)	F_u (ksi)	Pieces	Length (ft)	Weight (K)	Notes
A500 Gr.B - Submerged	HSS10x10x5	46	58	132	3999.1	131	*
A500 Gr.B - Submerged	HSS20x8x12	46	58	52	338	37	**
A53 Gr.B - Submerged	PIPE_30"x5/8"	35	60	4	816	138.9	*
A53 Gr.B - Submerged	PIPE_48x1"	36	60	9	2269	988.8	*
A53 Gr.B - Submerged	PIPE_48_1.5	36	60	4	1326	857.6	*
A992	W44x335	50	65	14	301	100.9	
Totals				**215**	**9049.1**	**2254.2**	
* Weight Adjusted for Buoyant Force on Steel Section Area Only (filled with water)							
** Prior to welding, fill with ballast to match buoyant force of empty space.							

5.2.7 Load Combination – RISA Model results

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

The size of the piles and the wall thicknesses are strongly influenced by a single criteria factor – that which requires the ability 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.

The tall profiles of the mooring towers cause the use of internal concrete to be much less feasible, since the framing members will 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' 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.

Perhaps some grout could be added at the bottom of some of the piles to offset the larger uplift reactions in those piles.

The mooring system was analyzed in RISA under each environmental load combination. 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 combination 1, where pile 1A reaches 81% of its code capacity. The maximum deflection and uplift under each load combination are listed in the table below.

Table 5-4 - Load Combination Results Summary

	Maximum Deflection (inches)	Maximum Pile Uplift (kips)
Operating LC1	7.8	83
Operating LC2	8.0	93
Survival LC1	9.2	428
Survival LC2	6.1	155
Survival LC3	3.9	0
Survival LC4	14.9	467
Survival LC5	6.1	115
Seismic MCE	7.2	N/A

5.2.7.1 Operational Load Combination Scenario 1

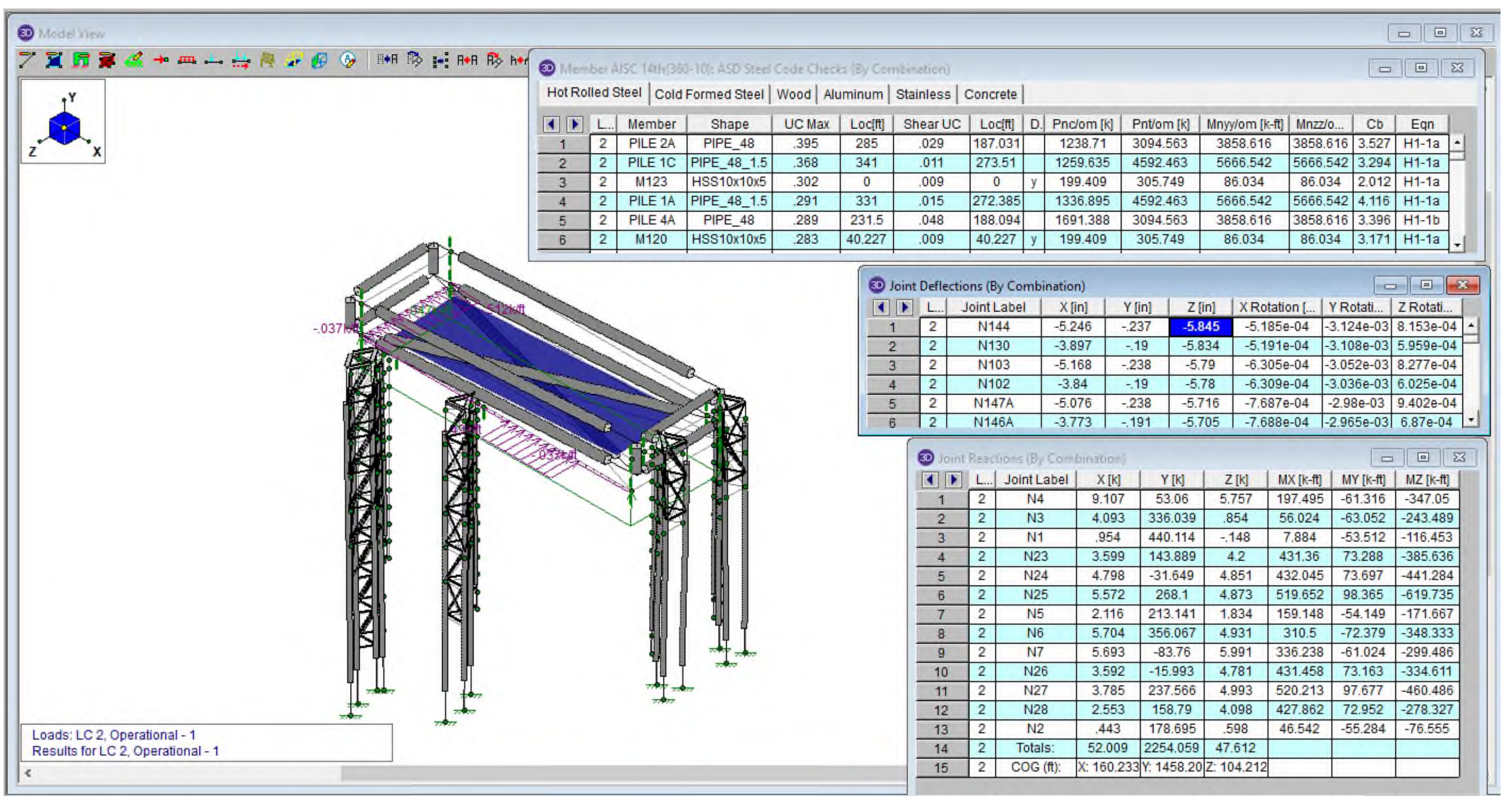


Figure 5-3 - Operational Load Combination Scenario 1

Under this operational scenario under one of the most extreme operating conditions expected, movement of the stern of the FSS is 5.8" in the negative z direction (West) and 5.2" in the negative x direction (South) for a total deflection of 7.8". At the bow of the FSS movement in both directions is less than at the stern. All members are experiencing stresses well below capacity. Two piles are experiencing uplift with the maximum at Pile 2B with about 83 kips of uplift.

5.2.7.2 Operational Load Combination Scenario 2

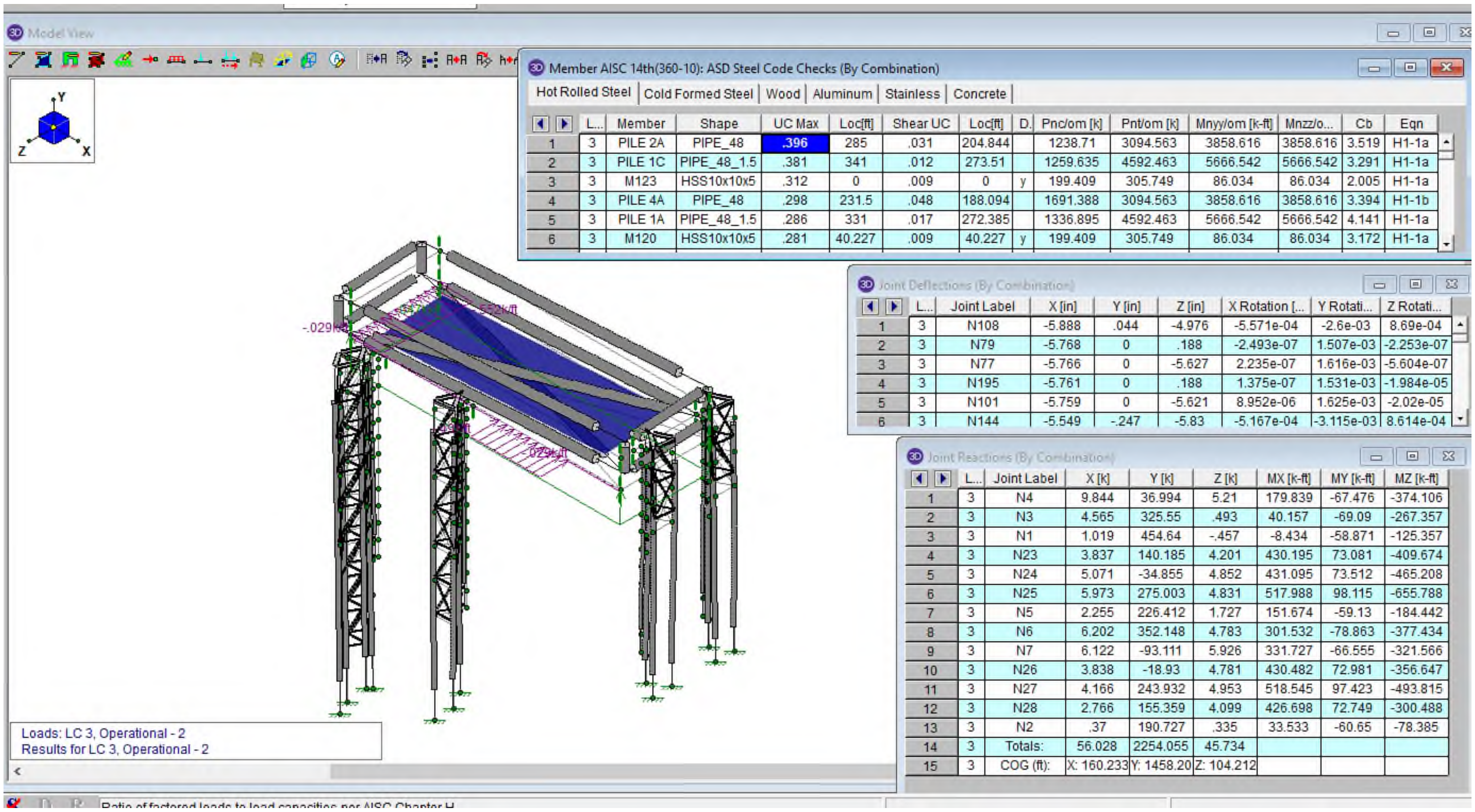


Figure 5-4 - Operational Load Combination Scenario 2

Under this operational scenario under the most extreme operating conditions expected, movement of the stern of the FSS is 5.8” in the negative z direction (West) and 5.5” in the negative x direction (South) for a total deflection of 8.0”. At the bow of the FSS movement in both directions is less than at the stern. All members are experiencing stresses well below capacity. Note that Pile 2B is experiencing about 93 kips of uplift.

5.2.7.3 Survival Load Combination Scenario No. 1

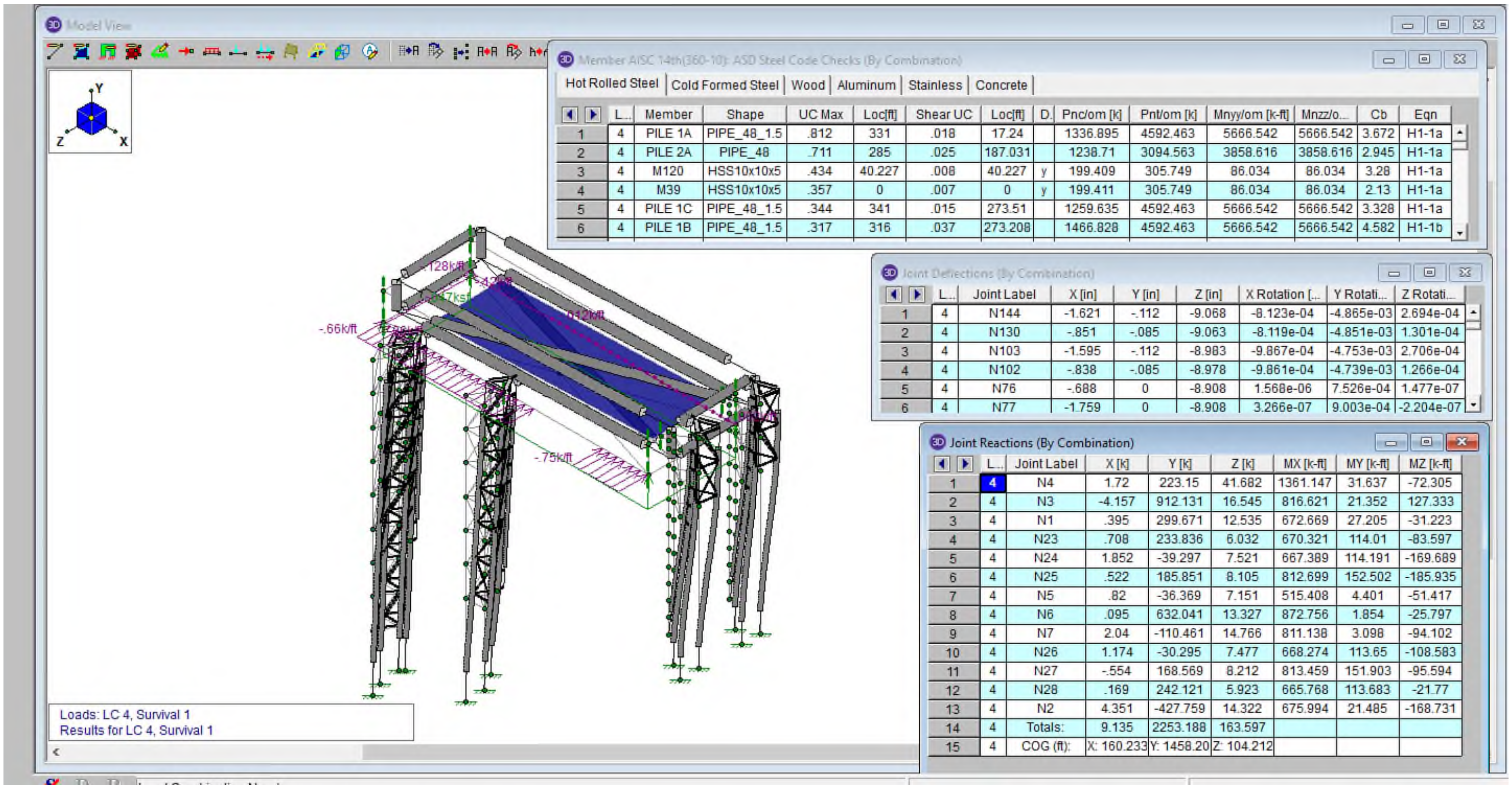
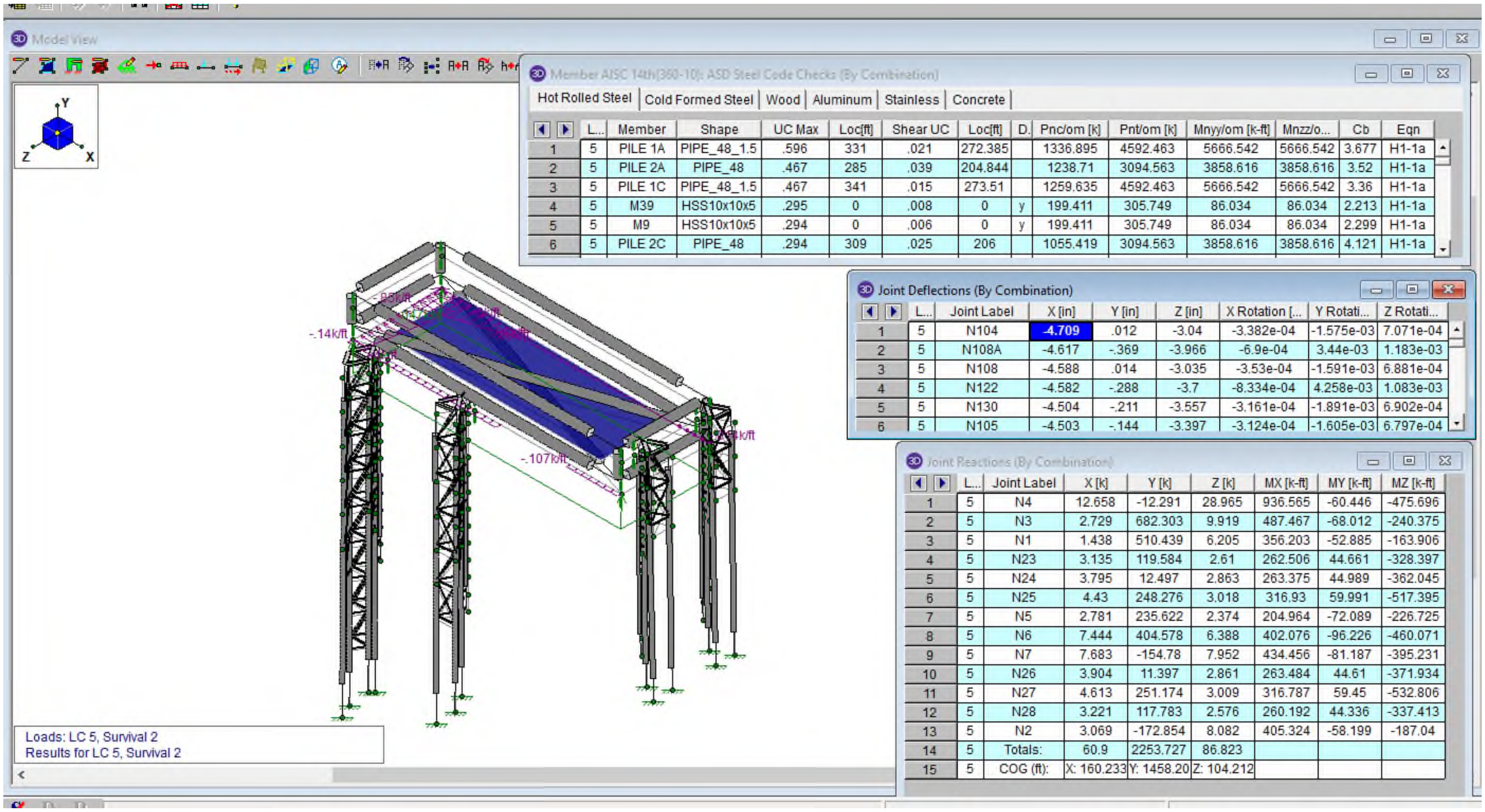


Figure 5-5 - Survival Load Combination Scenario No. 1

This is the load combination that produces the highest stress in any piling (piling 1A) and is the major reason why the dolphin 1 piles were upsized to a 1.5" wall. Under this load combination the movement of the stern of the FSS is 9.1" in the negative z direction (West) and 1.6" in the negative x direction (South) for a total deflection of 9.2". At the bow of the FSS movement in both directions is the same as that at the stern. All members are experiencing stresses well below capacity, except that piling 1A is stressed to 81% of capacity under the steel code. Note that four piles are experiencing uplift, the greatest of which is pile 1D at 428 kips.

5.2.7.4 Survival Load Combination Scenario No.2



	L...	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	D...	Pnc/om [k]	Pnt/om [k]	Mnyy/om [k-ft]	Mnzz/o...	Cb	Eqn
1	5	PILE 1A	PIPE_48_1.5	.596	331	.021	272.385		1336.895	4592.463	5666.542	5666.542	3.677	H1-1a
2	5	PILE 2A	PIPE_48	.467	285	.039	204.844		1238.71	3094.563	3858.616	3858.616	3.52	H1-1a
3	5	PILE 1C	PIPE_48_1.5	.467	341	.015	273.51		1259.635	4592.463	5666.542	5666.542	3.36	H1-1a
4	5	M39	HSS10x10x5	.295	0	.008	0	y	199.411	305.749	86.034	86.034	2.213	H1-1a
5	5	M9	HSS10x10x5	.294	0	.006	0	y	199.411	305.749	86.034	86.034	2.299	H1-1a
6	5	PILE 2C	PIPE_48	.294	309	.025	206		1055.419	3094.563	3858.616	3858.616	4.121	H1-1a

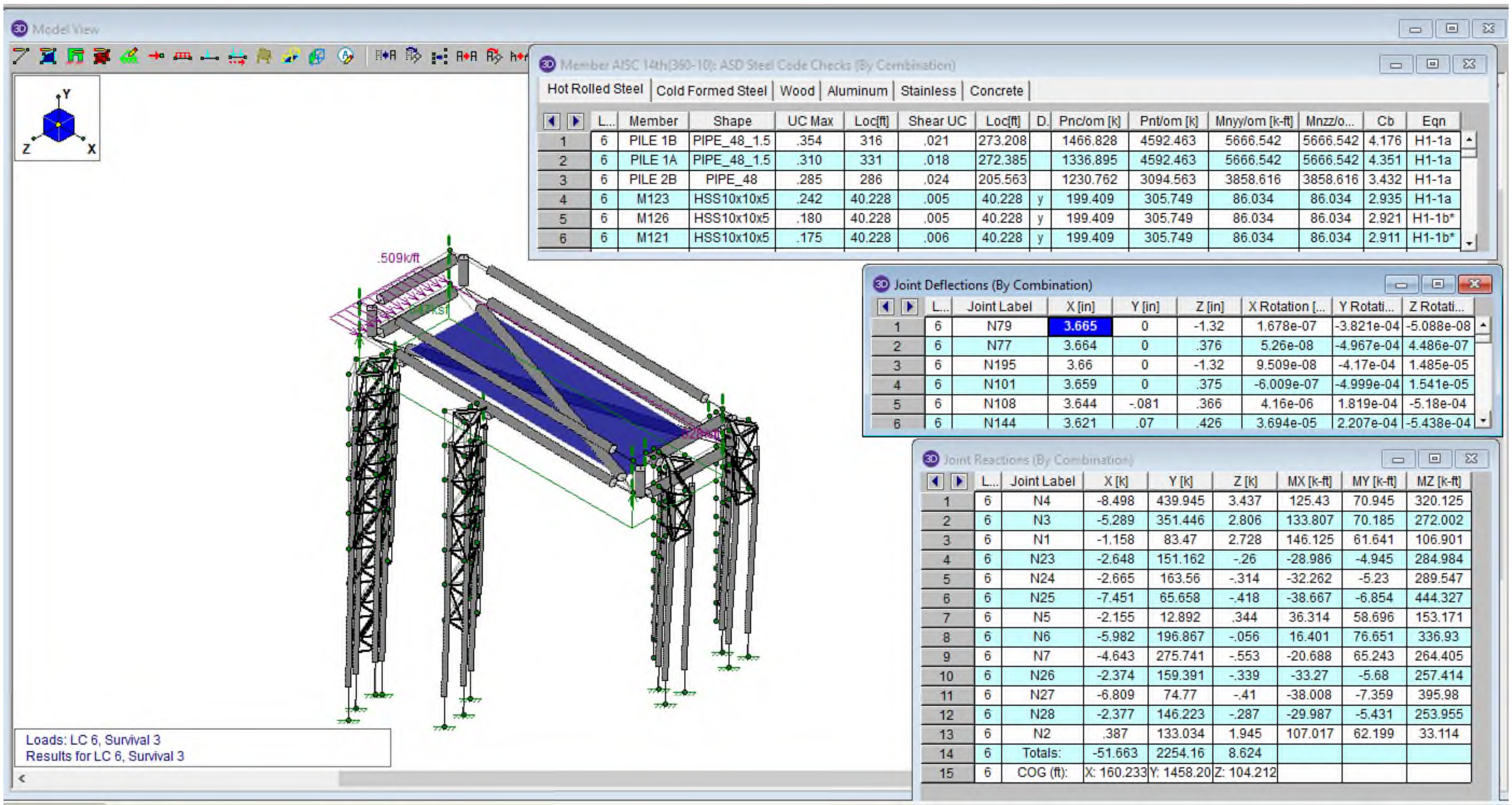
	L...	Joint Label	X [in]	Y [in]	Z [in]	X Rotation [...	Y Rotati...	Z Rotati...
1	5	N104	-4.709	.012	-3.04	-3.382e-04	-1.575e-03	7.071e-04
2	5	N108A	-4.617	-.369	-3.966	-6.9e-04	3.44e-03	1.183e-03
3	5	N108	-4.588	.014	-3.035	-3.53e-04	-1.591e-03	6.881e-04
4	5	N122	-4.582	-.288	-3.7	-8.334e-04	4.258e-03	1.083e-03
5	5	N130	-4.504	-.211	-3.557	-3.161e-04	-1.891e-03	6.902e-04
6	5	N105	-4.503	-.144	-3.397	-3.124e-04	-1.605e-03	6.797e-04

	L...	Joint Label	X [k]	Y [k]	Z [k]	MX [k-ft]	MY [k-ft]	MZ [k-ft]
1	5	N4	12.658	-12.291	28.965	936.565	-60.446	-475.696
2	5	N3	2.729	682.303	9.919	487.467	-68.012	-240.375
3	5	N1	1.438	510.439	6.205	356.203	-52.885	-163.906
4	5	N23	3.135	119.584	2.61	262.506	44.661	-328.397
5	5	N24	3.795	12.497	2.863	263.375	44.989	-362.045
6	5	N25	4.43	248.276	3.018	316.93	59.991	-517.395
7	5	N5	2.781	235.622	2.374	204.964	-72.089	-226.725
8	5	N6	7.444	404.578	6.388	402.076	-96.226	-460.071
9	5	N7	7.683	-154.78	7.952	434.456	-81.187	-395.231
10	5	N26	3.904	11.397	2.861	263.484	44.61	-371.934
11	5	N27	4.613	251.174	3.009	316.787	59.45	-532.806
12	5	N28	3.221	117.783	2.576	260.192	44.336	-337.413
13	5	N2	3.069	-172.854	8.082	405.324	-58.199	-187.04
14	5	Totals:	60.9	2253.727	86.823			
15	5	COG (ft):	X: 160.233	Y: 1458.20	Z: 104.212			

Figure 5-6 - Survival Load Combination Scenario No.2

Under this load combination the movement of the stern of the FSS is 4.0” in the negative z direction (West) and 4.6” in the negative x direction (South) for a total deflection of 6.1”. At the bow of the FSS movement in both directions is the same as that at the stern. All members are experiencing stresses well below capacity. Note that three piles are experiencing uplift, the greatest of which is Pile 2B at 155 kips.

5.2.7.5 Survival Load Combination Scenario No.3



	L...	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	D.	Pnc/om [k]	Pnt/om [k]	Mnyy/om [k-ft]	Mnzz/o...	Cb	Eqn
1	6	PILE 1B	PIPE_48_1.5	.354	316	.021	273.208		1466.828	4592.463	5666.542	5666.542	4.176	H1-1a
2	6	PILE 1A	PIPE_48_1.5	.310	331	.018	272.385		1336.895	4592.463	5666.542	5666.542	4.351	H1-1a
3	6	PILE 2B	PIPE_48	.285	286	.024	205.563		1230.762	3094.563	3858.616	3858.616	3.432	H1-1a
4	6	M123	HSS10x10x5	.242	40.228	.005	40.228	y	199.409	305.749	86.034	86.034	2.935	H1-1a
5	6	M126	HSS10x10x5	.180	40.228	.005	40.228	y	199.409	305.749	86.034	86.034	2.921	H1-1b*
6	6	M121	HSS10x10x5	.175	40.228	.006	40.228	y	199.409	305.749	86.034	86.034	2.911	H1-1b*

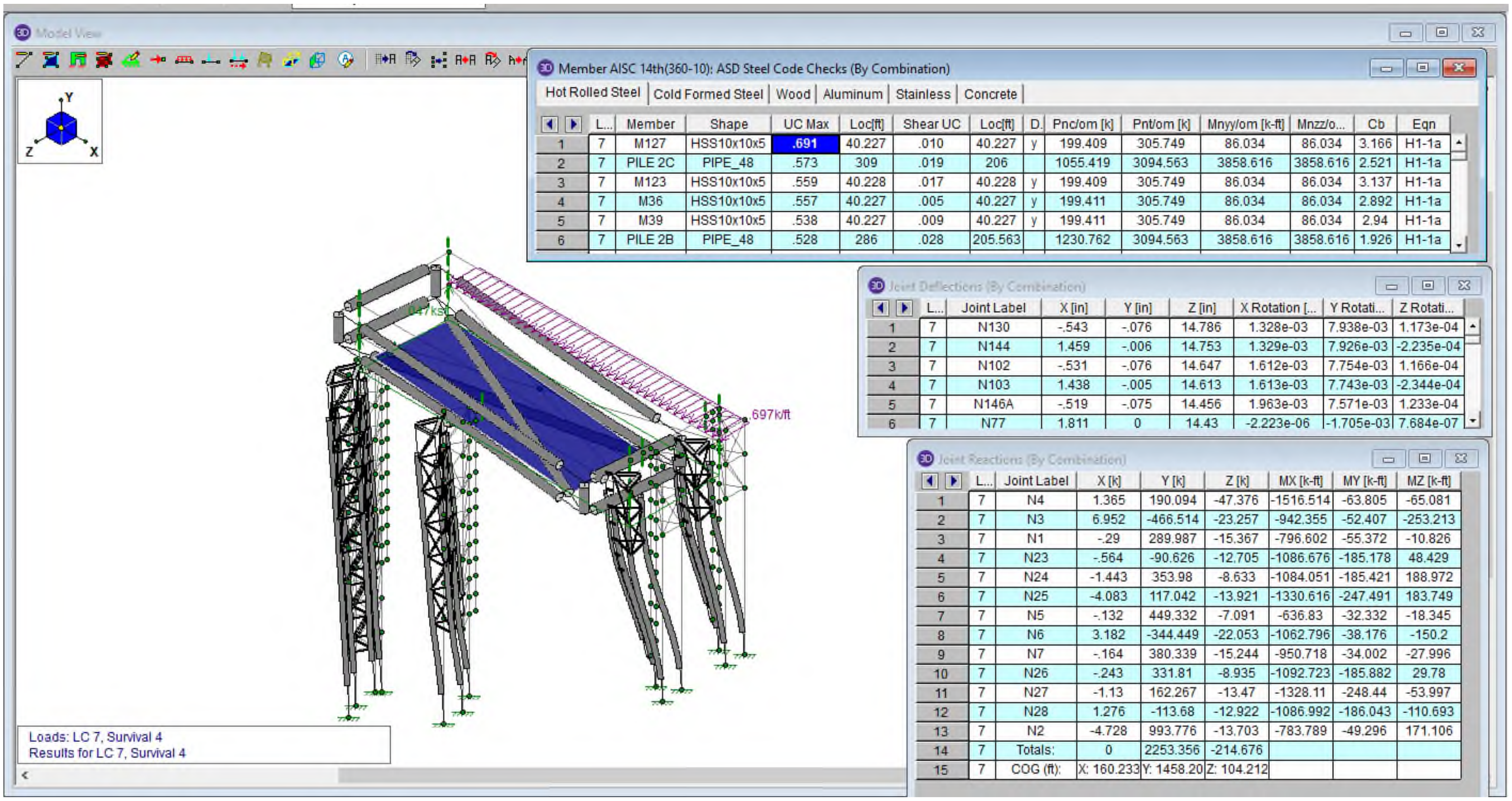
	L...	Joint Label	X [in]	Y [in]	Z [in]	X Rotation [...	Y Rotati...	Z Rotati...
1	6	N79	3.665	0	-1.32	1.678e-07	-3.821e-04	-5.088e-08
2	6	N77	3.664	0	.376	5.26e-08	-4.967e-04	4.486e-07
3	6	N195	3.66	0	-1.32	9.509e-08	-4.17e-04	1.485e-05
4	6	N101	3.659	0	.375	-6.009e-07	-4.999e-04	1.541e-05
5	6	N108	3.644	-.081	.366	4.16e-06	1.819e-04	-5.18e-04
6	6	N144	3.621	.07	.426	3.694e-05	2.207e-04	-5.438e-04

	L...	Joint Label	X [k]	Y [k]	Z [k]	MX [k-ft]	MY [k-ft]	MZ [k-ft]
1	6	N4	-8.498	439.945	3.437	125.43	70.945	320.125
2	6	N3	-5.289	351.446	2.806	133.807	70.185	272.002
3	6	N1	-1.158	83.47	2.728	146.125	61.641	106.901
4	6	N23	-2.648	151.162	-.26	-28.986	-4.945	284.984
5	6	N24	-2.665	163.56	-.314	-32.262	-5.23	289.547
6	6	N25	-7.451	65.658	-.418	-38.667	-6.854	444.327
7	6	N5	-2.155	12.892	.344	36.314	58.696	153.171
8	6	N6	-5.982	196.867	-.056	16.401	76.651	336.93
9	6	N7	-4.643	275.741	-.553	-20.688	65.243	264.405
10	6	N26	-2.374	159.391	-.339	-33.27	-5.68	257.414
11	6	N27	-6.809	74.77	-.41	-38.008	-7.359	395.98
12	6	N28	-2.377	146.223	-.287	-29.987	-5.431	253.955
13	6	N2	.387	133.034	1.945	107.017	62.199	33.114
14	6	Totals:	-51.663	2254.16	8.624			
15	6	COG (ft):	X: 160.233	Y: 1458.20	Z: 104.212			

Figure 5-7 - Survival Load Combination Scenario No.3

For this load combination the movement of the stern of the FSS is 1.3” in the negative z direction (West) and 3.7” in the positive x direction (North) for a total deflection of 3.9”. At the bow of the FSS movement in both directions is the same as that at the stern. All members are experiencing stresses well below capacity. No pilings will experience uplift.

5.2.7.6 Survival Load Combination Scenario No.4



	L...	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	D.	Pnc/om [k]	Pnt/om [k]	Mnyy/om [k-ft]	Mnzz/o...	Cb	Eqn
1	7	M127	HSS10x10x5	.691	40.227	.010	40.227	y	199.409	305.749	86.034	86.034	3.166	H1-1a
2	7	PILE 2C	PIPE_48	.573	309	.019	206		1055.419	3094.563	3858.616	3858.616	2.521	H1-1a
3	7	M123	HSS10x10x5	.559	40.228	.017	40.228	y	199.409	305.749	86.034	86.034	3.137	H1-1a
4	7	M36	HSS10x10x5	.557	40.227	.005	40.227	y	199.411	305.749	86.034	86.034	2.892	H1-1a
5	7	M39	HSS10x10x5	.538	40.227	.009	40.227	y	199.411	305.749	86.034	86.034	2.94	H1-1a
6	7	PILE 2B	PIPE_48	.528	286	.028	205.563		1230.762	3094.563	3858.616	3858.616	1.926	H1-1a

	L...	Joint Label	X [in]	Y [in]	Z [in]	X Rotation [...	Y Rotati...	Z Rotati...
1	7	N130	-.543	-.076	14.786	1.328e-03	7.938e-03	1.173e-04
2	7	N144	1.459	-.006	14.753	1.329e-03	7.926e-03	-2.235e-04
3	7	N102	-.531	-.076	14.647	1.612e-03	7.754e-03	1.166e-04
4	7	N103	1.438	-.005	14.613	1.613e-03	7.743e-03	-2.344e-04
5	7	N146A	-.519	-.075	14.456	1.963e-03	7.571e-03	1.233e-04
6	7	N77	1.811	0	14.43	-2.223e-06	-1.705e-03	7.684e-07

	L...	Joint Label	X [k]	Y [k]	Z [k]	MX [k-ft]	MY [k-ft]	MZ [k-ft]
1	7	N4	1.365	190.094	-47.376	-1516.514	-63.805	-65.081
2	7	N3	6.952	-466.514	-23.257	-942.355	-52.407	-253.213
3	7	N1	-.29	289.987	-15.367	-796.602	-55.372	-10.826
4	7	N23	-.564	-90.626	-12.705	-1086.676	-185.178	48.429
5	7	N24	-1.443	353.98	-8.633	-1084.051	-185.421	188.972
6	7	N25	-4.083	117.042	-13.921	-1330.616	-247.491	183.749
7	7	N5	-.132	449.332	-7.091	-636.83	-32.332	-18.345
8	7	N6	3.182	-344.449	-22.053	-1062.796	-38.176	-150.2
9	7	N7	-.164	380.339	-15.244	-950.718	-34.002	-27.996
10	7	N26	-.243	331.81	-8.935	-1092.723	-185.882	29.78
11	7	N27	-1.13	162.267	-13.47	-1328.11	-248.44	-53.997
12	7	N28	1.276	-113.68	-12.922	-1086.992	-186.043	-110.693
13	7	N2	-4.728	993.776	-13.703	-783.789	-49.296	171.106
14	7	Totals:	0	2253.356	-214.676			
15	7	COG (ft):	X: 160.233	Y: 1458.20	Z: 104.212			

Figure 5-8 - Survival Load Combination Scenario No.4

This load combination produces the largest deflections. For this load combination the movement of the stern of the FSS is 14.8" in the positive z direction (East) and 1.5" in the negative x direction (South) for a total deflection of 14.9". At the bow of the FSS movement in both directions is slightly less than that at the stern. All members are experiencing stresses well below capacity. Piling 1A will experience 467 kips of uplift and three other piles will also experience significant uplift. Note that this load scenario will likely push the FSS into the SWS. Thus, it may be important to consider whether de-ballasting is essential when the reservoir is at high pool during an extreme wind storm. This comment also applies to Survival Load Scenario No. 1, as the loads experienced during high winds at high pool during a de-ballasted condition causes the need for much larger pilings and significantly more uplift resistance. If the FSS could be ballasted in this situation, even if the dam is not spilling (as spilling would partially mitigate the wind forces), the resultant forces caused by the wind will be much less demanding on the mooring system.

5.2.7.7 Survival Load Combination Scenario No.5

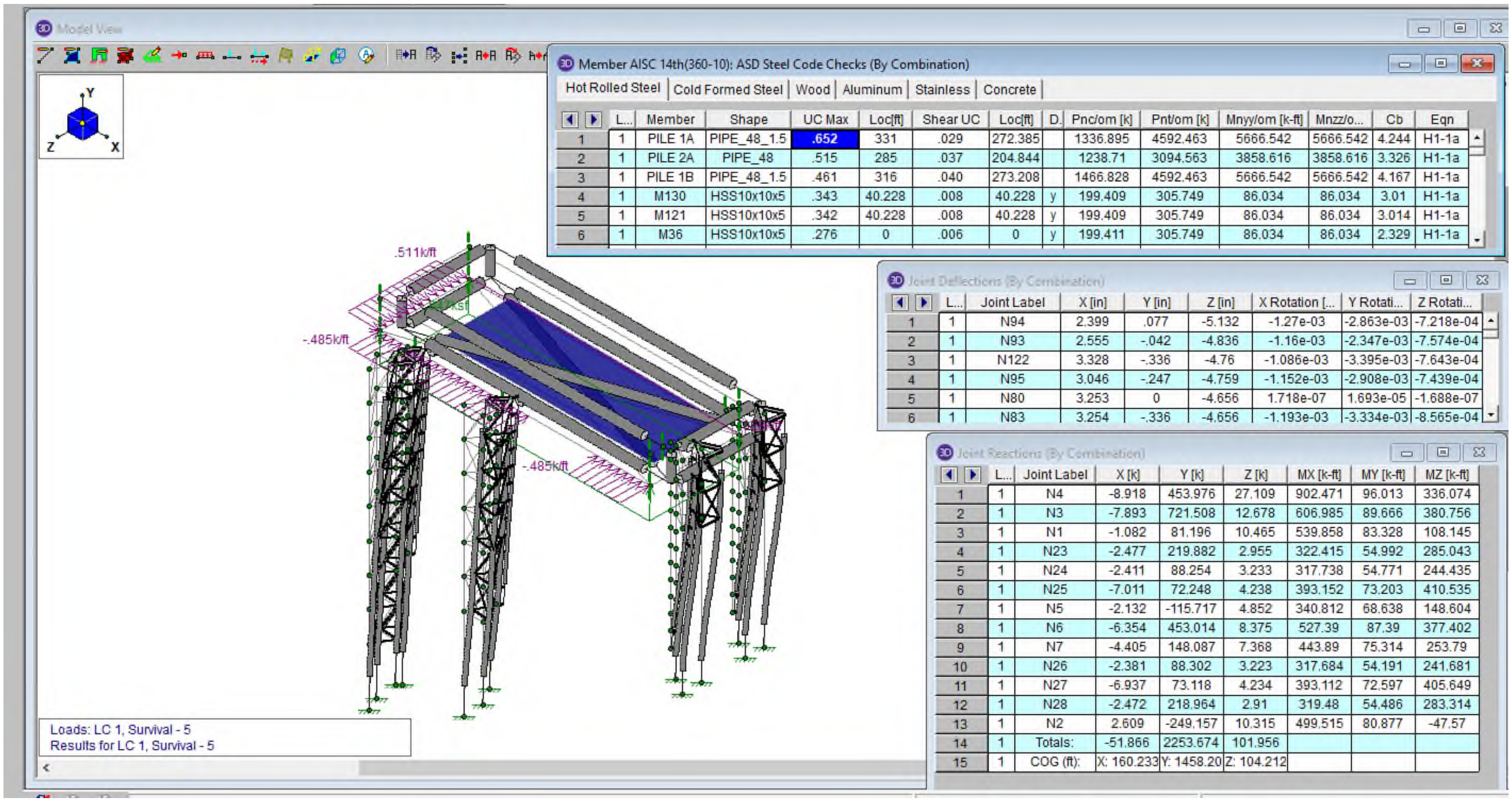


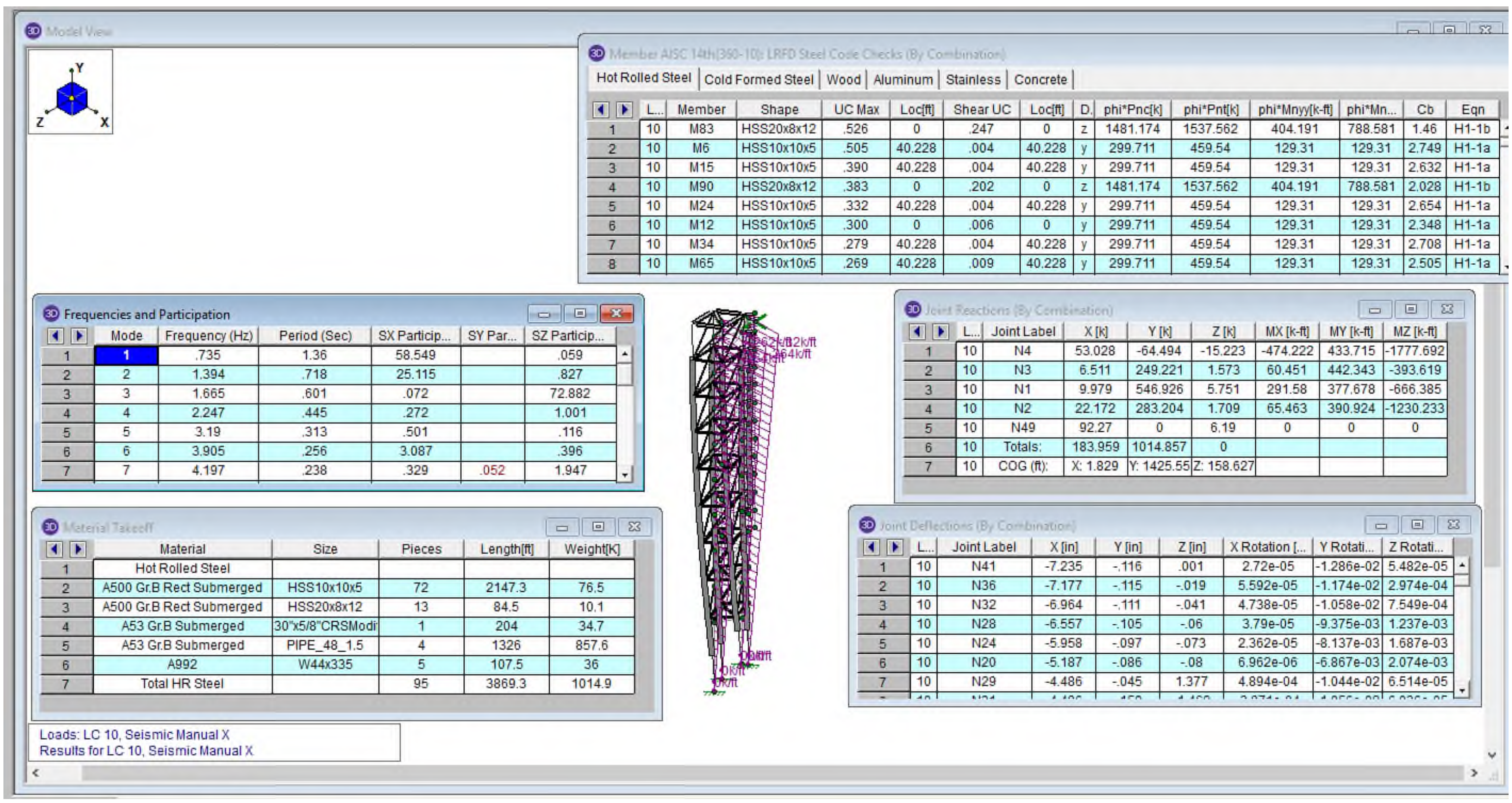
Figure 5-9 - Survival Load Combination Scenario No.5

For this load combination the movement of the bow of the FSS is 5.1" in the negative z direction (West) and 3.3" in the positive x direction (North) for a total deflection of 6.1". At the stern of the FSS movement in both directions is nearly the same as that at the bow. All members are experiencing stresses well below capacity. Piling 1D will experience 249 kips of uplift and Pile 2C will also experience 115 kips of uplift

5.2.7.8 Seismic effects – RISA Model results

As indicated in Section 5.2.4.2 above, each dolphin acts as an inverted pendulum, but will be intermittently isolated from interaction with the FSS via the gaps in the pile hoops. The seismic movement/oscillation of the dolphins and the individual pilings is also dampened by the hydrostatic resistance of the water due to its viscosity and any momentary interaction between the FSS mooring yoke mechanism and the dolphin itself. Because of the very large mass of the FSS, any interaction between the FSS mooring yokes and the individual dolphins is not expected to generate any movement of the FSS, and thus the FSS serves as a damping mechanism for the dolphin structures. It is possible that the interactions under these circumstances could damage the UHMW bearings in the yoke mechanism, thus requiring repair after the event.

In this context, then, each mooring dolphin is independent from all the others, and a very conservative analysis can be carried out on the dolphins individually as standalone structures subject to earthquake forces. The worst case will be the tallest and heaviest of the four – the four-pile dolphin. It is assumed that each member is filled with water and is submerged (except the pile cap). Thus the water inside each pile must be considered as additional mass for determining seismic shear. Water sloshing can only occur at the very top of the pile and will operate at much lower periods than the rest of the structure, and will serve to disrupt any harmonics – thus an additional damping mechanism. Furthermore, the top of pile 1A is essentially fixed by the FSS, so deflection is nearly zero at the top, so sloshing will likely not occur in that pile at all. The analysis ignores the benefits from the hydrostatic and hydrodynamic resistance of the water column to movement of the piles – this damping mechanism could be significant, but is ignored in the interest of insuring the analysis is conservative. Note the below analysis uses the required procedure in ASCE-7-2010 and 2016, in section 12 to manually distribute the base shear over the length of the pile. This worst case seismic event under operational loads (from the x direction) will cause deflection at the top of the outboard pile of 7.2” and stresses are well below capacity.



	L...	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	D.	phi*Pnc[k]	phi*Pnt[k]	phi*Mnyy[k-ft]	phi*Mn...	Cb	Eqn
1	10	M83	HSS20x8x12	.526	0	.247	0	z	1481.174	1537.562	404.191	788.581	1.46	H1-1b
2	10	M6	HSS10x10x5	.505	40.228	.004	40.228	y	299.711	459.54	129.31	129.31	2.749	H1-1a
3	10	M15	HSS10x10x5	.390	40.228	.004	40.228	y	299.711	459.54	129.31	129.31	2.632	H1-1a
4	10	M90	HSS20x8x12	.383	0	.202	0	z	1481.174	1537.562	404.191	788.581	2.028	H1-1b
5	10	M24	HSS10x10x5	.332	40.228	.004	40.228	y	299.711	459.54	129.31	129.31	2.654	H1-1a
6	10	M12	HSS10x10x5	.300	0	.006	0	y	299.711	459.54	129.31	129.31	2.348	H1-1a
7	10	M34	HSS10x10x5	.279	40.228	.004	40.228	y	299.711	459.54	129.31	129.31	2.708	H1-1a
8	10	M65	HSS10x10x5	.269	40.228	.009	40.228	y	299.711	459.54	129.31	129.31	2.505	H1-1a

	Mode	Frequency (Hz)	Period (Sec)	SX Particip...	SY Par...	SZ Particip...
1	1	.735	1.36	58.549		.059
2	2	1.394	.718	25.115		.827
3	3	1.665	.601	.072		72.882
4	4	2.247	.445	.272		1.001
5	5	3.19	.313	.501		.116
6	6	3.905	.256	3.087		.396
7	7	4.197	.238	.329	.052	1.947

	L...	Joint Label	X [k]	Y [k]	Z [k]	MX [k-ft]	MY [k-ft]	MZ [k-ft]
1	10	N4	53.028	-64.494	-15.223	-474.222	433.715	-1777.692
2	10	N3	6.511	249.221	1.573	60.451	442.343	-393.619
3	10	N1	9.979	546.926	5.751	291.58	377.678	-666.385
4	10	N2	22.172	283.204	1.709	65.463	390.924	-1230.233
5	10	N49	92.27	0	6.19	0	0	0
6	10	Totals:	183.959	1014.857	0			
7	10	COG (ft):	X: 1.829	Y: 1425.55	Z: 158.627			

	Material	Size	Pieces	Length[ft]	Weight[K]
1	Hot Rolled Steel				
2	A500 Gr.B Rect Submerged	HSS10x10x5	72	2147.3	76.5
3	A500 Gr.B Rect Submerged	HSS20x8x12	13	84.5	10.1
4	A53 Gr.B Submerged	30"x5/8"CRSModi	1	204	34.7
5	A53 Gr.B Submerged	PIPE_48_1.5	4	1326	857.6
6	A992	W44x335	5	107.5	36
7	Total HR Steel		95	3869.3	1014.9

	L...	Joint Label	X [in]	Y [in]	Z [in]	X Rotation [...	Y Rotati...	Z Rotati...
1	10	N41	-7.235	-.116	.001	2.72e-05	-1.286e-02	5.482e-05
2	10	N36	-7.177	-.115	-.019	5.592e-05	-1.174e-02	2.974e-04
3	10	N32	-6.964	-.111	-.041	4.738e-05	-1.058e-02	7.549e-04
4	10	N28	-6.557	-.105	-.06	3.79e-05	-9.375e-03	1.237e-03
5	10	N24	-5.958	-.097	-.073	2.362e-05	-8.137e-03	1.687e-03
6	10	N20	-5.187	-.086	-.08	6.962e-06	-6.867e-03	2.074e-03
7	10	N29	-4.486	-.045	1.377	4.894e-04	-1.044e-02	6.514e-05

Figure 5-10

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). 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.

- 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 =	110 mph
Wind Importance Factor, I_W =	1.0
Exposure Category =	C
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

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, the ballasting and trim system, 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. Other mechanical equipment includes ballast pumps and other devices associated with the floatation of the vessel as discussed in Section 3, and attraction channel screen cleaners as discussed in Section 4.

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. 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 secondary plenum. Preliminary modeling of the collector hydraulics estimates that the static pumping head will be approximately 1.2 feet.

When there is no flow drawn through the FSS into the SWS, pumping is 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. 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. Cones are added to the discharge end of the pumps to reduce headloss back to the reservoir.

Based on the hydraulic calculations and consideration for minor and major pumping losses, the total dynamic pumping head (TDH) envisioned is approximately 2.5 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). USACE does not want variable frequency drives for the attraction pumps so VFDs 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, a control valve would be required for each pump to introduce an artificial head loss. The additional head loss is required to keep the pump operating in a safe range while not drawing more flow than necessary. 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 3 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. 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	Peerless Vertical Turbine 54PL	Goulds Axial Flow 54x54-54
Design Head	ft	2	6	4

Design Alternative		Alternative 1	Alternative 2	Alternative 3
Capital Cost	-	$1,560,000	$2,800,000	$4,800,000
Price per Pump*	-	$60,000	$350,000	$600,000
Power Cost per Hour	$/hr	$18.60	36.68	$30.80
Number of Pumps	-	25	7	7
Spare Pumps	-	1	1	1
Flow per Pump	cfs	40	150	150
Pump TDH	ft	2	8	6
Eff. at Design Head**	-	37%	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)***	ft	4.5 x 3.5 x 6	20 x 8 x 6	26 x 5 x 9
Discharge Diameter	in	30	54	54
*Includes pump, motor, rails (mixer only), throttling valve, and baseplates. Does not include VFDs, starters, controls, or electrical equipment. **Pump & motor efficiency. ***General size. See pump detail sheets for detailed dimensions.				

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.	• High number of pumps for current Flygt models available
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.

Pump Type	Advantages	Disadvantages
Axial Flow (Enclosed-syle)	• 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, & 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 cfs at 4 ft of TDH. However, Flygt has also provided custom mixer pumps of similar heads that pass 250 cfs each at PSE's two Baker River FSCs.

As such, the potential to reduce the number of pumps needed and pursue a larger, custom version of the Flygt PP series pumps which could pass approximately 125 cfs each at 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 using the FSS bridge crane and SWS access bridge crane.

In design discussions with Flygt, they expressed interest in developing a pump specific to the Detroit FSS application using standard parts to the extent possible. Pertinent physical characteristics envisioned for each 125 cfs mixer pump are shown below in Table 6-3. 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	37 inches
Bell Diameter	38 inches
Unit Length	5.5 ft
Motor Size	80 HP
Unit Weight, Including Guide Rails	3,500 lbs

Based on the sizing shown above, and a flow rate of 125 cfs, a preliminary pumping plant layout was completed using guidance from ANSI/HI 9.8-2012, American National Standard for Rotodynamic Pumps for Pump Intake Design. Pump bay dimensions and operational constraints are summarized in Table 6-4, 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	15 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 6 in increasing to 6 ft 6 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 2 feet; without the discharge cones it would be approximately 4.5 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 Table 6-2.

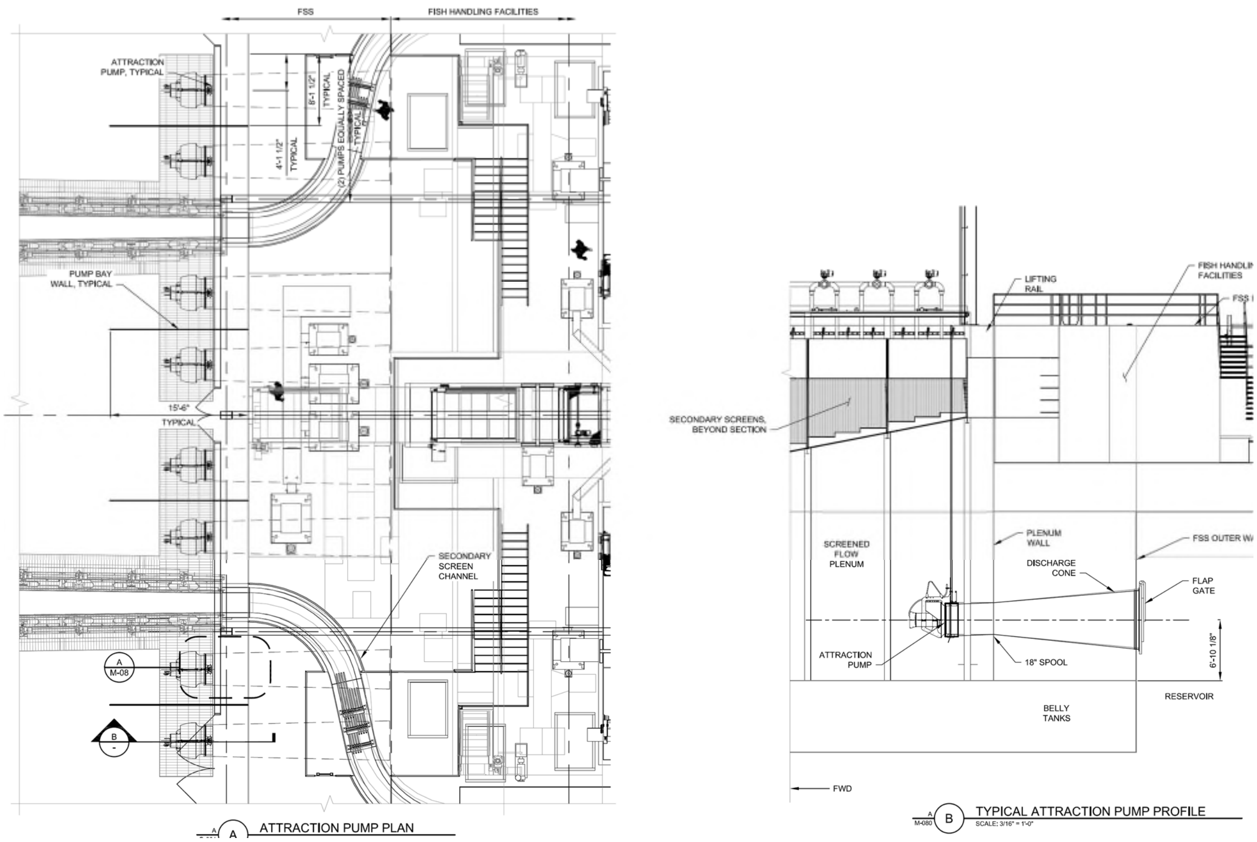


Figure 6-2 - Preliminary Pumping Plant Layout

6.4 Motor Operated Actuator for Elliptical Weir

6.4.1 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 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. 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, and other features to ensure smooth and safe operation.

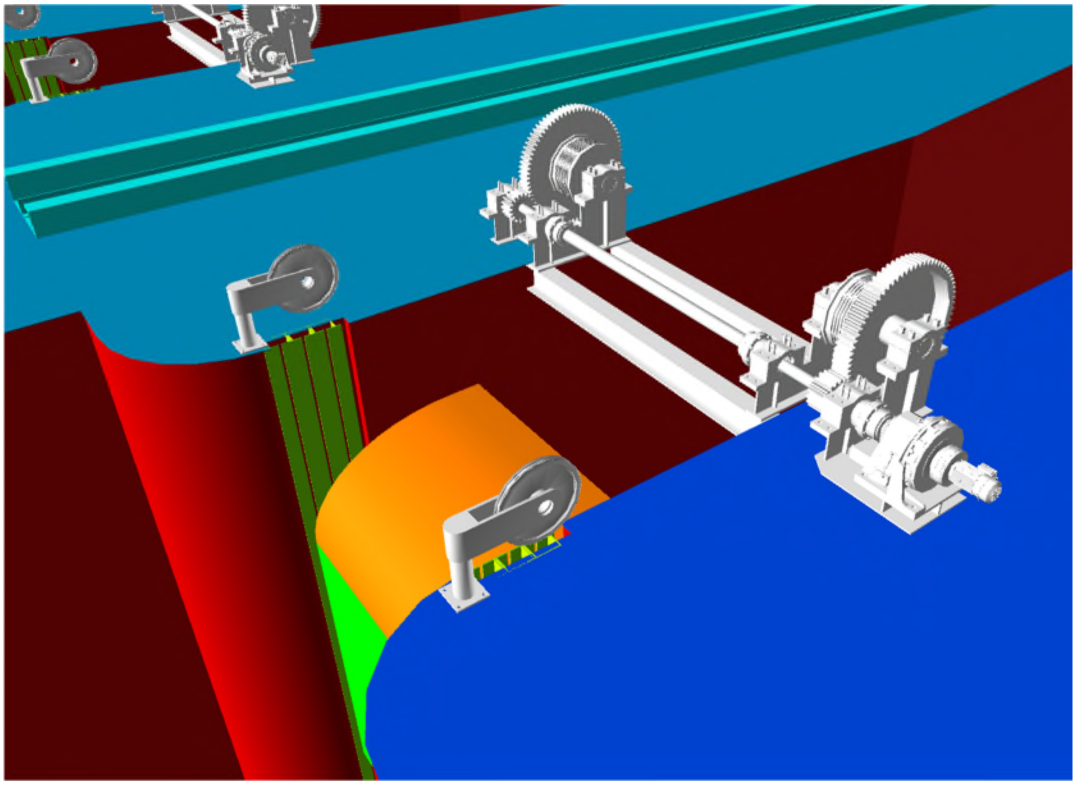


Figure 6-3 - Entrance Weir Gate Section

6.4.2 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
- ANSI/AWWA C542 Electric Motor Actuators for Valves and Slide Gates
- ANSI/AWWA C561 Fabricated Stainless-Steel Slide Gates
- 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

6.4.3 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 1 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 28.8 ft from full open with all leafs collapse 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 6-5 - 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	8051
Lower Ramp	7836
Guide Friction (Rollers or Plates TBD)	[TBD]
Seal Friction	[TBD]
Mud Load	[TBD]

The gate actuator will be used to lift the gate, including crest and ramps, only. At this level of development 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.

6.4.4 Gate Actuator Alternatives

Two gate actuator alternatives were considered for the design. 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. Consideration of the alternatives resulted in the final selection of a drum wire rope hoist. These alternatives are briefly discussed in the paragraphs below.

6.4.4.1 Stem Actuator

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 and the expected greater construction cost associated with such sized equipment.

6.4.4.2 Stem Sizing

The stem diameter would have been determined by the material used and the vertical loads in the system, combined with the unsupported length of the stem. Corrosion resistant materials would have been used for stems. The tension and compression design loads would be those caused by 1.5 times the output thrust of the unit in the stalled motor condition applied to one screw stem actuator. The tension load would not exceed 20% of the ultimate strength of stem material. The compression design load would not have been less that the critical buckling load as determined by the Euler Column formula, where C = 2. The design load for manual actuation (or electric motor actuators in manual mode) is the tension load caused by the application of an 80-lb effort on the crank or hand wheel or a 100-ft-lb torque on a wrench nut. The following Euler column formula would have been used to determine critical buckling load on the stem:

$P = C \pi 2 EA(r/l)2$

Where P is the axial load on stem, C defines end restraint conditions, E is the modulus of elasticity, l is the length or span between supports, r is the radius of gyration, and A is the area of stem at the minor diameter for threaded portion of stem.

6.4.4.3 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. 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.

Should it be determined that the gate actuator would need to drive the gate down, the wire rope gate actuator would be configured in a down-haul/up-haul arrangement with a lower sheave being placed at the bottom of gate travel just above the top of the ballast tanks. Values for these elements have not yet been developed and will be completed in a later submittal.

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

6.5.1 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 debris bins, fish hoppers, pumps, and other major equipment to the designated staging location where they will be removed from the FSS by an access crane (designed by USACE) mounted to the SWS or the access bridge. From the SWS or access bridge 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 will needed to move some items to locations where they can be lifted by the FSS bridge crane, knuckle-boom crane, and/or the SWS/access bridge 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.

If required for servicing the bridge crane, suitable access ladders and platforms will be provided to facilitate access to the bridge crane trolley and hoist equipment. However, USACE may choose to utilize temporary ladders or man-lifts for these activities at its discretion. If required by USACE, the crane will be equipped with additional safety features, as applicable, such as walkways, platforms, handrails and ladders, or fall protection features for the proper functioning, access and maintenance of important components of the crane. Servicing of the knuckle-boom crane should be straightforward, as the boom can be raised or lowered to a convenient position for maintenance activities.

6.5.2 References for Cranes and Lifting Devices

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

- American Institute of Steel Construction Manual, 9th Edition
- American Association of State Highway and Transportation Officials (AASHTO) LRFD Moveable Highway Bridge Design Specifications
- The Guide to Hydropower Mechanical Design, by the ASME Hydro Power Technical Committee
- EM 1110-2-2610 - Mechanical and Electrical Design for Lock and Dam Operating Equipment
- EM 1110-2-2702: Design of Spillway Tainter Gates
- EM 1110-2-3006 – Hydroelectric Power Plants – Electrical Design
- EM 1110-2-4205 – Hydroelectric Power Plants – Mechanical Design
- EM 1110-2-3200 – Wire Rope Selection Criteria for Gate Operating Devices
- EM 385-1-1 – Safety and Health Requirements Manual
- Crane Manufacturer’s Association of America (CMAA) No. 70, 2015 – Specifications for Top Running Bridge & Gantry Type Multiple Girder Electric Overhead Traveling Cranes, or No. 74, 2015 – Specifications for Top Running & 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

6.5.3 Articulating (Knuckle) Boom Crane Design Criteria

The main deck of the FSS will include an articulating knuckle-boom crane with winch designed to service equipment located on the deck of the FSS. Activities to be performed by this crane include handling of port and starboard trash bins that will hold debris removed by the trash raking system, the attraction pumps, port and starboard screen baffle panels, and other miscellaneous mechanical equipment if and when needed. The maximum design load for this crane is 10,000 pounds. However, the maximum working load anticipated for this crane is anticipated to be a full debris bin, estimated to weigh a maximum of 6,680 pounds. The knuckle-boom crane will be mounted in the center of the FSS and travel the length of the open deck (fore/aft travel direction). As depicted in Figure 6-4 and Figure 6-5, 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 would be the trash bin (6,680 pounds) at a lifting radius of about 43 feet (port or starboard sides). These bins will need to be deposited at the aft end of the

FSS near the base of the SWS, where they will be picked up by the crane mounted to the SWS or the access bridge. The longest-reach requirement for this crane will be miscellaneous mechanical equipment stationed approximately 50 feet from the centerline of rotation. Therefore, the knuckle-boom crane will need to have a minimum boom reach of 50 feet and a rated load of at least 5 tons (or approximately 6,680 pounds with a factor of safety. See Drawing M-018 in Appendix A for more details on the Articulating Boom Crane design.

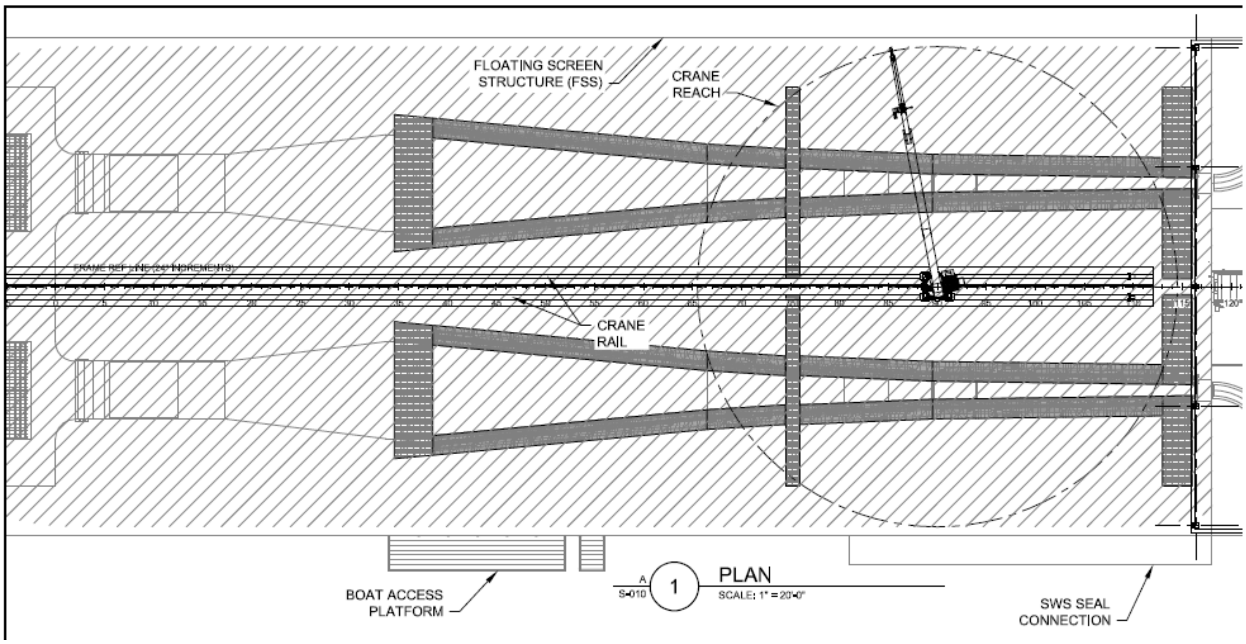


Figure 6-4 - Articulating (Knuckle) Boom Crane Conceptual Layout

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.

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 50 seconds, and a folding time (in/out) of approximately 50 seconds. Power consumption is anticipated to be approximately 34 kW.

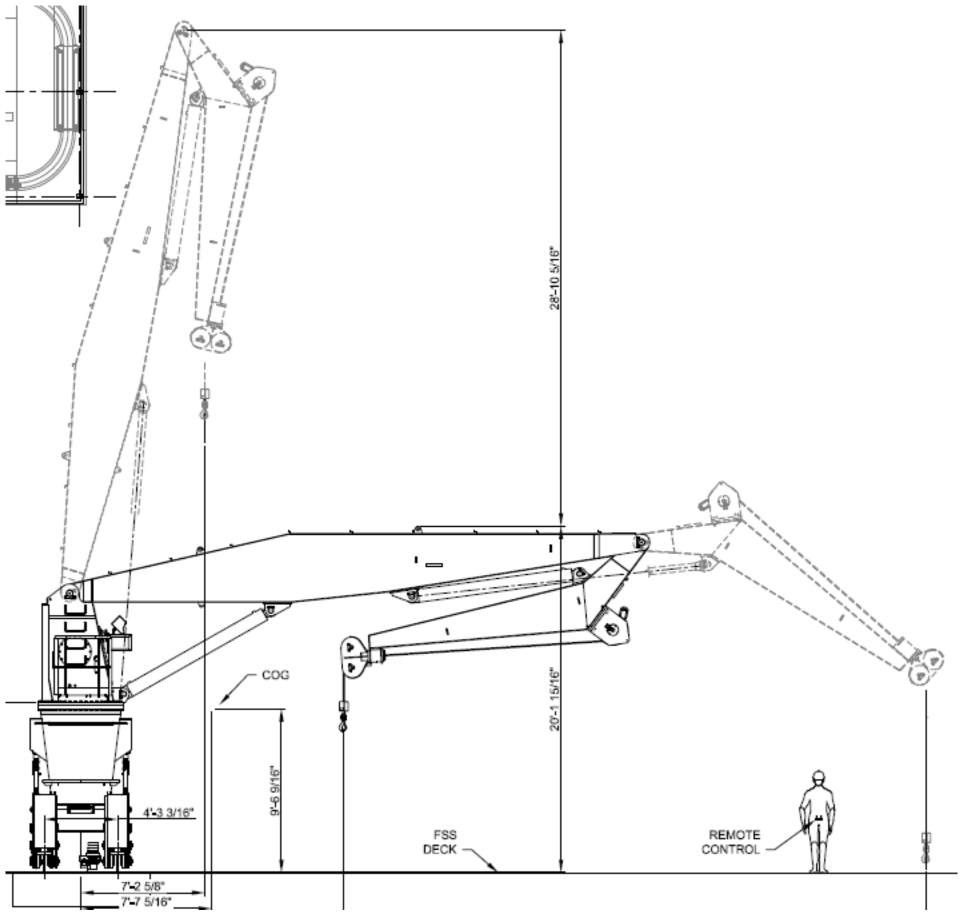


Figure 6-5 - Articulating (Knuckle) Boom Crane

6.5.4 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 hoppers and other equipment picked up inside the building to be transferred outside of the building for removal by the SWS crane, and for new or repaired equipment to be brought into the FHF Building. The largest anticipated load will be a hopper full of fish, at approximately 6,000 pounds (3-tons), plus the weight of the lifting slings and tackle. Since “standard” sizes for hoists are normally 3-tons and 5-tons, a 5-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.

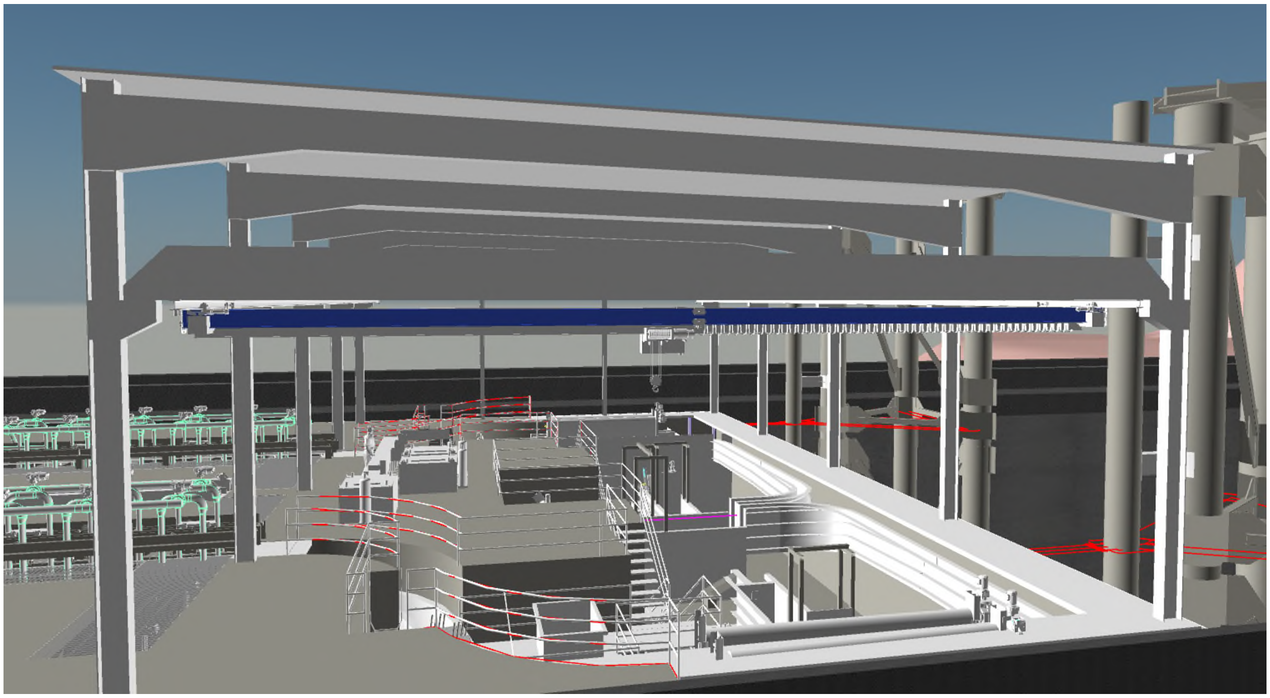


Figure 6-6 - Fish Handling Facility Building Bridge Crane

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.

6.5.4.1 Hoist

The crane will have one hoist, rated for 5 tons, with a total vertical lift of approximately 33 feet, to be confirmed as the design progresses. High hook will be at elevation 56.4 feet and low hook at elevation 24.5 feet. 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 10 HP.

6.5.4.2 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 2 HP.

6.5.4.3 Bridge

The bridge will have a nominal span of approximately 59 feet and a nominal travel length of approximately 100 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. The bridge motors (two) are anticipated to be approximately 1 HP each.

6.5.4.4 Controls

The crane will have a pendant controller along with radio remote control for operation of all motions. Two remotes will be provided with spare batteries and stored in a designated location at the site to be determined by USACE. Standard industrial radio systems that operate in the 2.4 GHz band and use frequency-hopping spread spectrum technology are 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 bridge and remote control stations can be provided that indicates the load being lifted by the crane.

6.5.4.5 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.

6.5.4.6 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.

6.5.4.7 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. 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.

6.6 Trashrack Cleaner

The trashracks located at the FSS entrance (refer to Section 4.6.3) are anticipated to collect significant amounts of buoyant and semi buoyant debris composed primarily of small to medium sized wood. On occasion, large debris in the form of trees with anticipated diameters up to 6 to 12 inches could collect on the trashracks and limit flow into the facility. 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 will 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.

6.6.1 Trashrack Cleaner Options

There are several North American manufacturers that make vertically lifting, raker systems for trashracks. They include: Atlas Polar; Duperon; Hydro Component Systems: Lakside Equipment; and Transco. Other international manufacturers include: Cross Machine, Inc.; and Ovivo (formerly Bracket Green-Bosker).

A debris conveyor system was considered; however, the site is expected to have large debris that will need to be removed from the Trashracks. A debris conveying system is not compatible with the larger debris that is expected at site. The automatic rake system is able to transfer the debris straight into a designated debris receptacle that can be moved to the SWS or access bridge and hauled away by a truck.

Various general arrangement options were considered for the trashrack cleaner system as well. First, there's the L-shaped option as pictured in Figure 6-7. The L-shape option allows for three debris receptacles, two rake assemblies and a laydown area for the rake assembly to set large debris down before being broken up into smaller pieces that fit into the debris receptacles. The advantage of this layout is the incorporated laydown area for large debris. The rake assemblies can handle larger logs and could immediately unblock the trashrack while the facility is operating under maximum flow conditions.

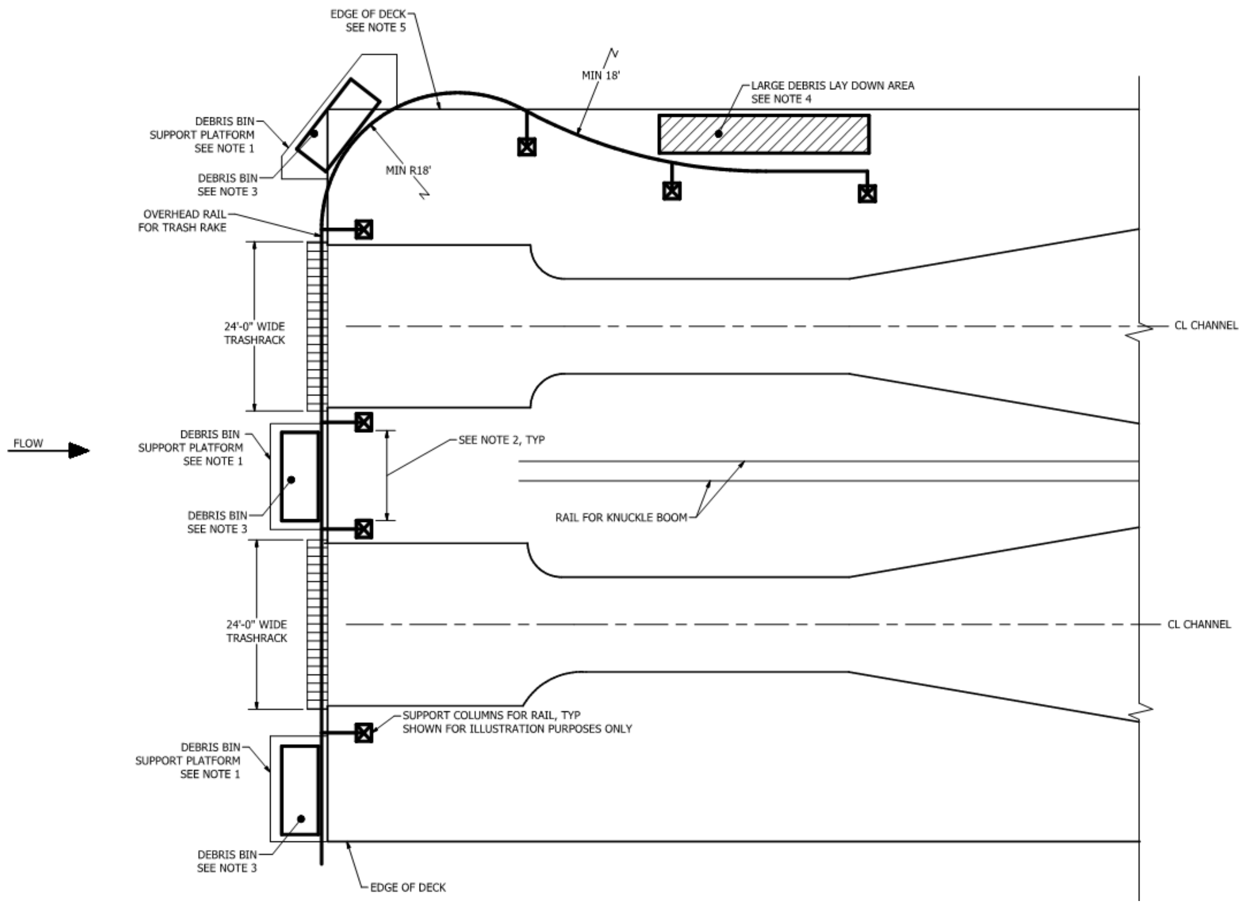


Figure 6-7 - Trash Rake General Arrangement, L-shaped Option

The other option is a straight track option as pictures in Figure 6-8. The straight option also allows for three debris receptacles and two rake assemblies. This option stays within the port and starboard confines of the FSS deck, but protrudes from the bow just as the L-shape option does. 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. Since there is no laydown area the rake assembly can take debris to, contingency options much be utilized to clear the trashracks for debris that is too large to fit within the debris receptacles. This would imply that large debris collected on the trashrack, would stay in place until contingency actions took place. Large debris will prohibit routine clearing of the affected trashracks until cleared. Possible contingency methods to clear the trashracks of large debris could be:

1) Use knuckle-boom to clear the trashrack,
2) Wait until facility shuts down at night and remove the debris by use of a boat.

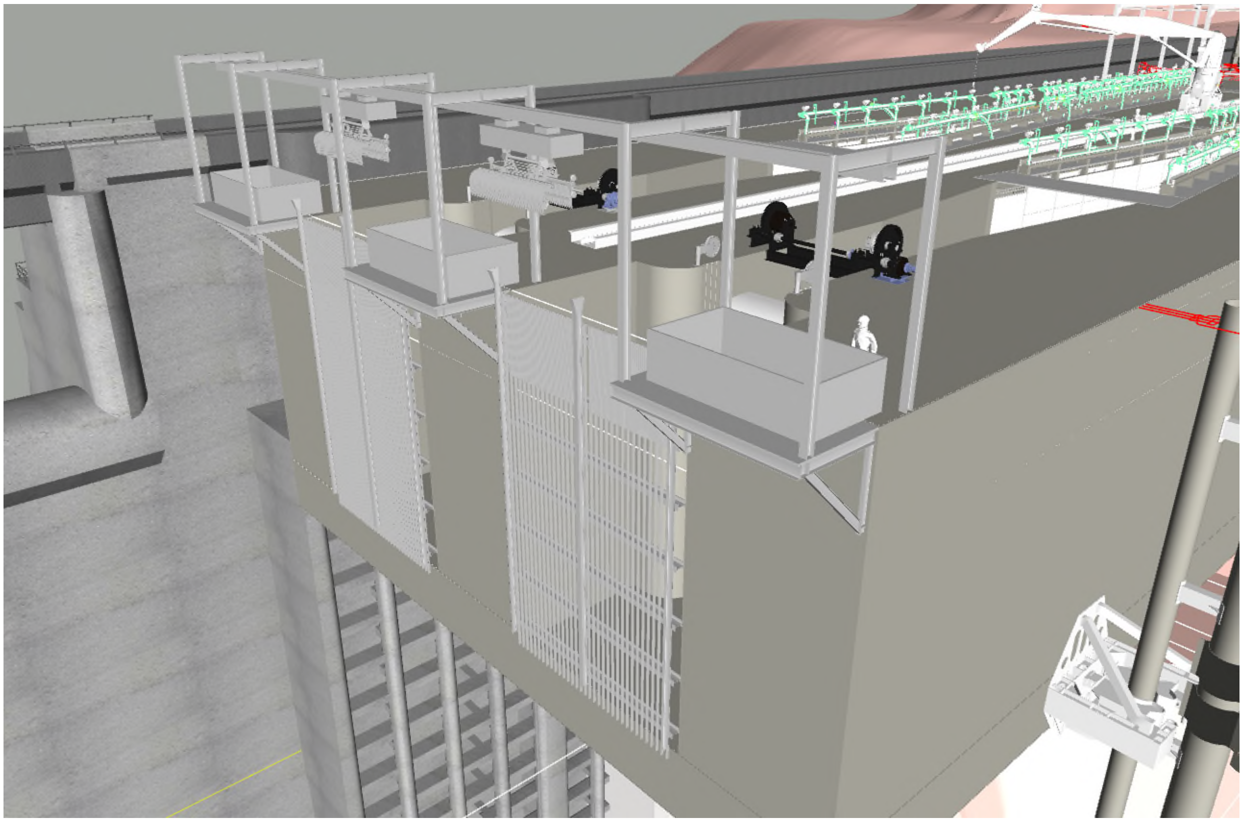


Figure 6-8 - Trash Rake General Arrangement, Straight Option

6.6.2 Selected Trashrack Cleaner System

The cleaning chassis will be a rake assembly comprised of an electro-mechanically operated trolley, hoist, hydraulically actuated rake head attachment, complete with a steel superstructure that provides a rail for the trolley to travel horizontally on, debris receptacle, telescoping boom, service platforms, safety equipment, and fully integrated control system. The rake assembly that is shown and discussed in the design is the Ultra Duty model of the Ovivo Brackett Bosker Raking system.

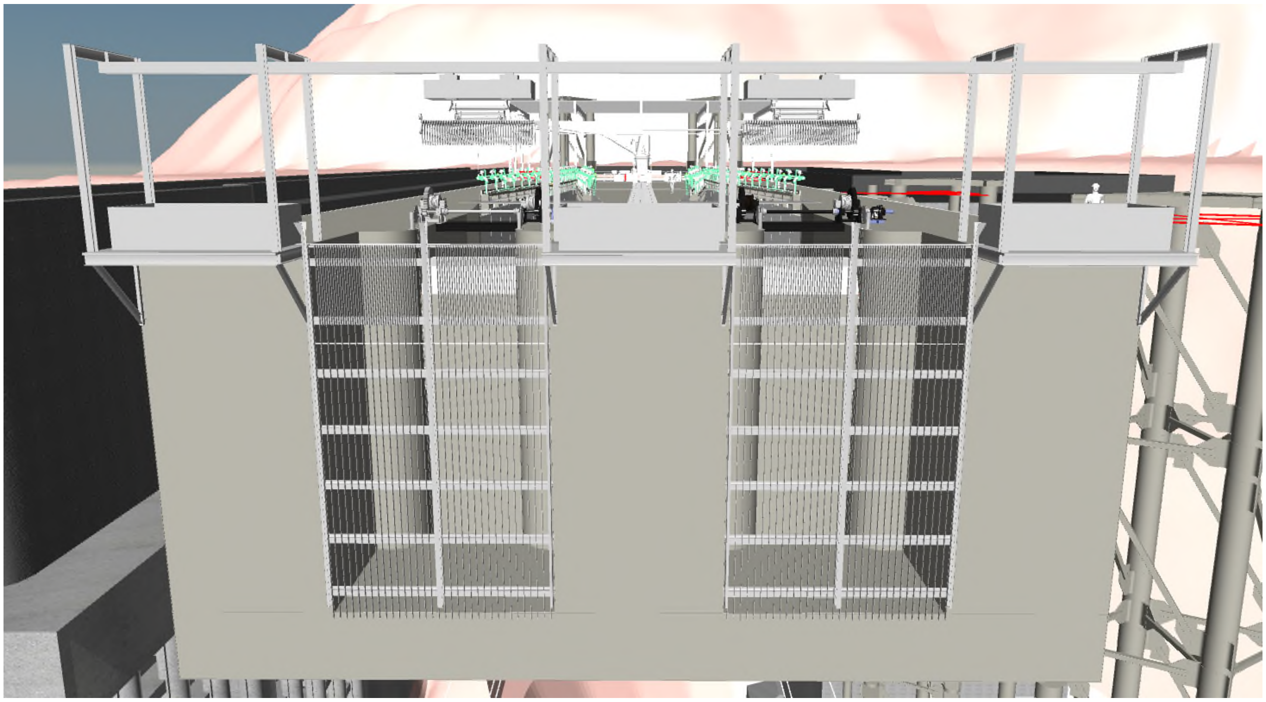


Figure 6-9 - Front Elevation View of Trashrack and Rake Assemblies

6.6.2.1 Rake Assembly

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

- Trolley,
- Hoist, and
- Rake head attachment

The trolley travels horizontally along a rail attached to 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 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 28-horsepower.

6.6.2.2 Steel Superstructure

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

A service platform shall be incorporated so that access to the rake assembly can be safely provided for the purpose of performing all required maintenance and repair operations on both the port and starboard sides. When on rake is out of service for maintenance, one debris receptacle will also be out of service as that will be the parking location for the rake assembly.

6.6.2.3 Instrumentation and Controls

Under automatic control mode, the trash rake system will initiate a single cleaning cycle on an elapsed timer or hydraulic differential across the trash rake (whichever comes first). A single cleaning cycle can be set for one trashrack (port or starboard) or both trashracks as required. Each cleaning cycle is initiated with an initial move of the 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 Trashrack. At the lowest point of the trashrack, 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. After releasing the debris, the rake assembly returns to the next position on the trash rack and performs another sweep. 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 22 minutes, but can vary upon manufacturer and final design configuration. The estimated time to clean both Trashracks are estimated in the table below, Table 6-66, 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 receptacles from the FSS. If the amount of trash is expected to be excessive, making trash removal time critical to operations, consideration should be given to having multiple debris receptacles on both the port and starboard sides of the FSS.

Table 6-6 - Estimated Cleaning Time

No. Rake Assemblies	Cleaning Time
1 Rake Assembly	44 minutes
2 Rake Assemblies	22 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 enters the collection channel, and careful maneuvering of the debris rack is required for removal.

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

6.6.2.4 Debris Receptacle and Disposal

The collected debris will be deposited into the debris receptacles on either the center, port or starboard sides. The debris receptacles will then be hoisted to another location by means of the articulating knuckle-boom so that a truck can dispose the debris to an off-site location. Facility staff may have to cut awkward shaped debris, such as long logs, to fit within the receptacle for the knuckle boom and/or the trucking portion. The knuckle boom rides on slide rails down the center of the site and is capable of reaching and moving both receptacles to the trucking location.

The debris receptacle will need to be capable of handling three swipes worth of debris for an efficient trashrack cleaning operation. In turn, the knuckle boom and truck will need to be capable of handling the debris load plus the weight of the debris receptacle.

6.6.2.5 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 6.6.2.2. 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 two of the three debris receptacles.

6.7 FSS Ballast and Trim System

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

6.7.2 Design Standards and References

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

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

5) American Society for Testing and Material (ASTM), Vol 01.07, Ships and Marine Technology

6.7.3 Ballast System Description

The ballast system's primary purpose is to ballast the FSS near the required operational draft. The system consists of tanks, pumps, piping, valves, and other components interconnected to transfer water from the reservoir to the various tanks and vice versa. Additionally, the ballast system is designed to pump out the water trapped in the fish channel during the maintenance periods. An abbreviated diagram of the ballast system is shown in Figure 6.10.

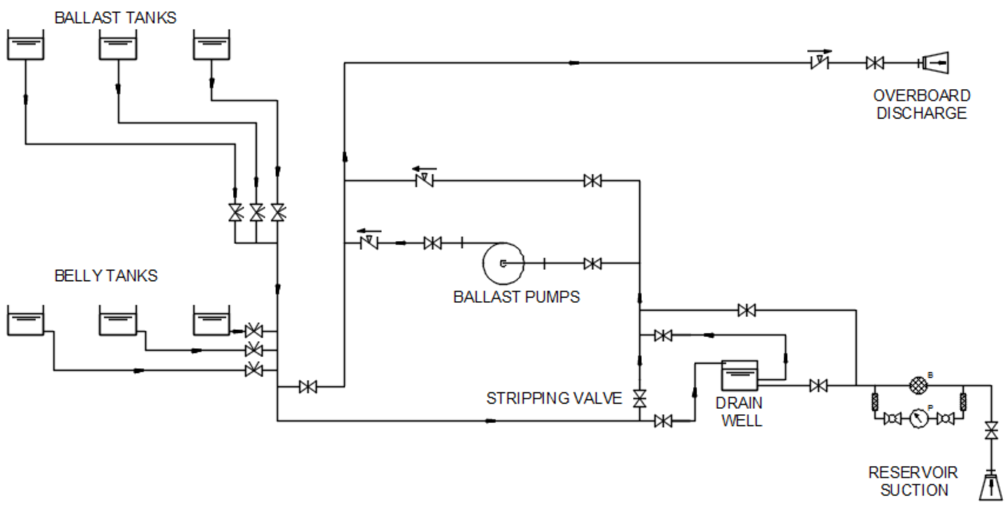


Figure 6-10 - Full FS Ballast System

During ballasting, a series of valves are aligned to the reservoir and water is allowed to free flood into the belly and ballast tanks in a predetermined sequence to maintain stability. Once the FSS is ballasted down to a point where free flooding has slowed due to the decrease in head difference, the ballast pumps will fill the remaining tanks to achieve the full ballast volume. This free flooding will allow for ballasting without the need for pumping during the majority of water inflow.

6.7.3.1 Tanks

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

Table 6-7 - Belly and Ballast Tank Volume (Subject to change in the 90% DDR)

Belly Tank	Approx. Vol. (cuft)		Ballast Tank	Approx. Vol. (cuft)
BT-H-1	11613		BA-H-3	9310
BT-H-0	16562		BA-H-4	9310
BT-H-2	11613		BA-00-1	33884
BT-17-1	10873		BA-00-0	28087
BT-17-2	10873		BA-00-2	33884
BT-34-1	9523		BA-17-1	20384
BT-34-0	13581		BA-17-0	19002
BT-34-2	9523		BA-17-2	20384
BT-55-1	9290		BA-43-1	15680
BT-55-0	13250		BA-43-2	15680
BT-55-2	9290		BA-63-1	8938
BT-75-1	12078		BA-63-2	6703
BT-75-0	17224		BA-87-1	10976
BT-75-2	12078		BA-87-2	5762
BT-101-1	11613		BA-101-1	9310
BT-101-0	16562		BA-118-0	35749
BT-101-2	11613		BA-118-2	2979
-	-		BA-126-1	5871
-	-		BA-126-0	5407
-	-		BA-126-2	5871
Total	195546		Total	303171

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

6.7.3.1.1 *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.

6.7.3.2 Pumps

The ballast system will utilize 4 ballast pumps running. This offers redundancy and allows multiple tanks to be filled or emptied in a shorter amount of time. Typically, centrifugal pumps offer ease of use, maintenance, and offer suitable operating range for ballast system. For these reasons, the ballast pumps will be centrifugal type pumps. Due to the total volume of ballast water necessary and the operation 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 de-ballasting. 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 6-11 and Appendix G. This is a 10" end-suction centrifugal pump designed to operate at up to 2,500 gallons per minute, depending on available suction head.

Figure 6-11 - Single Stage Vertical End-Suction Pump (Pioneer SC Series)

6.7.3.2.1 *Strainers*

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

6.7.3.2.2 *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 in to 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 6-12. 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 6-12 - Vacuum Priming System

6.7.3.3 **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 6-13.

The number of tanks and overall size of the FSS will dictate the amount of ballast piping installed. Based on the overall size, it is anticipated the labor cost of the installation of the piping will out weight the cost of the piping. Other considerations include bulkhead penetrations, overboard discharge, and modular construction. These items will be discussed further in the 90% DDR.

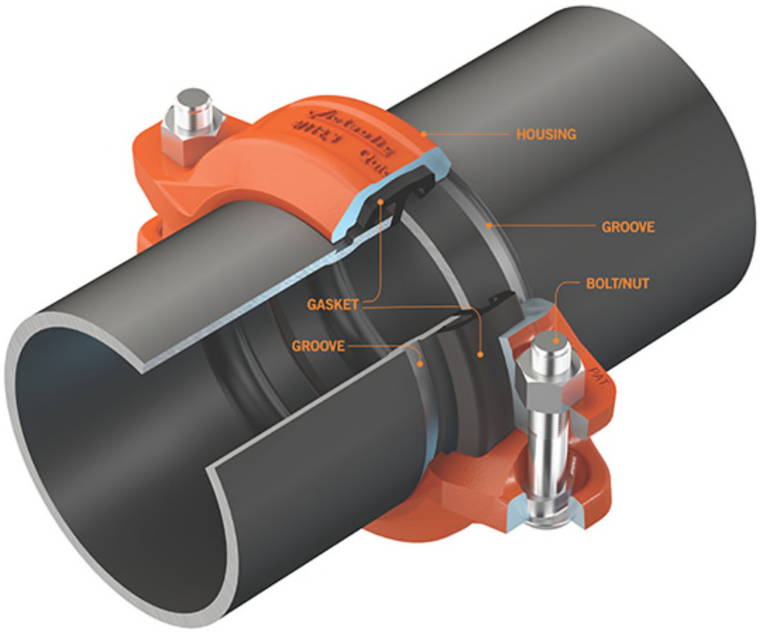


Figure 6-13 - Standard Grooved Coupling

6.7.3.4 **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.

6.7.3.4.1 *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.

6.7.3.4.2 *Gate Valves*

Gate valves are used for positive closure and for minimal pressure loss applications. The seachest should have a full port gate valve to provide positive closure and decrease the pressure loss on the suction side of the pumps. Each pump will also have full port gate valves on the suction and discharge side of the pumps. to isolate the pumps. This allows maintenance personnel to work on the pumps with minimal interruption to the system. Additional gate valves will be installed within the system, these will be identified in the 90% DDR.

6.7.3.4.3 *Globe Valves*

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

6.7.3.4.4 *Butterfly valves*

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

6.7.3.4.5 *Manifolds*

Manifolds are a series of valves connected to a common header, this provides a compact centralized location to control several valves serving similar purposes. 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.

6.7.3.4.6 *Electric Valve Actuators*

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

The need for electric valve actuation will depend heavily on the desired operation of the ballast system and will be developed during the 90% DDR.

6.7.3.5 Operation

It is recommended that the ballast system be manually operated. The operating station will have the pump controls and tank level readouts for each tank. The motorized or manual valve operation will be determined in the 90% DDR.

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. This is the average flowrate required during free flooding and the average pump flow during de ballasting. Rough simulations have shown that it is possible to free flood the ballast and belly tanks in the specified time. As the final level of the ballast tank will be above the waterline of the FSS, some pumping will be required at the end of the ballasting sequence to attain the final tank levels for operation. Conversely, a preliminary simulation has shown that using 4 pumps as described in Section 6.7.3.2**,** it is possible to de-ballast the FSS in under 8 hours. See Appendix G for additional information These simulations will be refined and updated to reflect the design status for the 90% DDR.

6.7.4 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 6 tanks, four pumps, piping, valves, and other components interconnected to transfer water from the between the trim and variable ballast tanks, and to and from the reservoir. A diagram of the trim system is provided below in Figure 6-14.

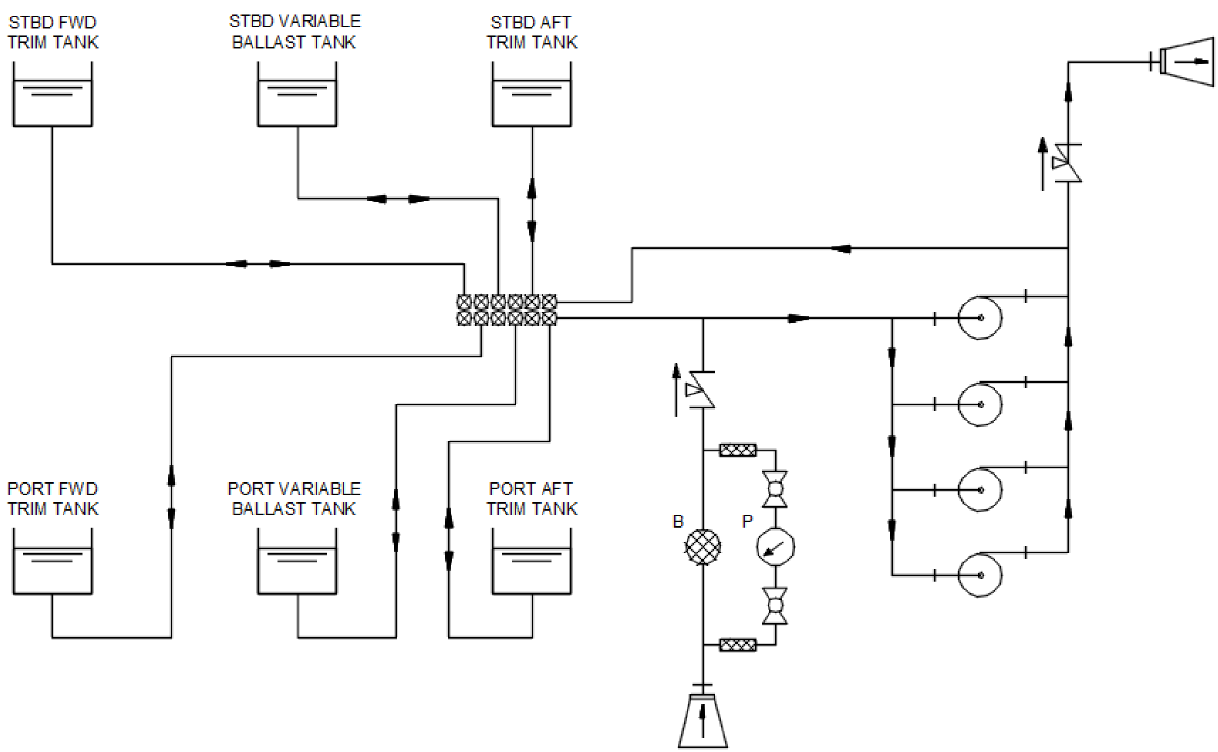


Figure 6-14 - Trim System Diagram

6.7.4.1 Tanks

The system has four trim tanks near the corners of the FSS and two variable ballast tanks near 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 6-8 - Trim and Variable Ballast Tank Volume (Subject to change in the 90% DDR)

Tank	Type	Approx. Vol. (cuft)
TT-H-1	Trim	10290
TT-H-2	Trim	10290
TT-101-1	Trim	10290
TT-101-2	Trim	10290
VB-63-1	Var Blst	9878
VB-63-2	Var Blst	9878

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

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

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

6.1.1.1 Pumps

Due to the high volume of ballast which is necessary during changes in the channel flow rate, it is likely that several high-volume pumps will be required to meet the demands of the 15-minute window for flow changes. The number and type of trim pumps is highly dependent on the amount of water required to maintain operations and will be developed in the 90% DDR.

6.1.1.2 Piping

To facilitate operation of the trim system, a run of piping will be required from the pump room to each corner of the FSS. The size of the piping will be dictated by the ballast and trimming volumes necessary to maintain the optimum operational conditions of the FSS. The piping size will be determined in the 90% DDR

6.1.1.3 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 developed in the 90% DDR. At a minimum each trim pump will require a pair of gate valves to facilitate maintenance and an angles check valve to prevent back flow.

6.1.1.3.1 Manifolds

Manifolds are a series of valves connected to a common header, this provides a compact centralized location to control several valves serving similar purposes. The trim and variable ballast tanks must have an independent valve to control the flow to and from each tank. A manufactured or custom-built manifold is ideally suited for this application. Manufactured manifolds are typically constructed using angle globe check valves and are much more compact than custom-built manifolds. Custom-built manifolds can be constructed of any type of valve, but are typically constructed using butterfly valves. 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 but their functionality is necessary in the trim system.

The trim system will require the use of a 6-place duplex manifold as seen in Figure 6-14 above. This manifold will be located in the pump room and will be controlled by automatic valve actuators. The size of the manifold will be determined in the 90% DDR when the variable ballast and trim volumes are finalized.

6.1.1.4 Operation

Due to the variations in fish channel flow, it is recommended that the trim system be automated. The level of automation and operator control should be discussed. A manual operating station will have the pump controls and tank level readouts for each tank. The operation will be developed further in the 90% DDR.

The timeframe for the FSS to transition between the various operational fish channel flow rates is approximately 15 minutes. Impacts of this design criteria will be identified in the 90% DDR.

6.8 HVAC

Ventilation systems for the manned spaces such as the pump room, stairwells, and above deck structures will be required. These systems will incorporate heating elements but not cooling coils as air conditioning is unnecessary. Systems will incorporate supply and exhaust ducting to facilitate a minimum two (2) air changes per hour. The heating temperatures for the pump room, electrical room, and Fish Handling Facility shall be 40, 60, and 40 degrees Fahrenheit, respectively. Duct air velocities shall not exceed 1500 feet per minute. To facility the required air change rate, supply and exhaust ducting for the pump room, with a volume of 23305 cubic feet, shall have a nominal area of approximately 75 square inches.

The HVAC system will be further developed in the 90% DDR.

6.9 FSS to SWS Seal

Between the SWS and the FSS a sealing device will be 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 will be needed. 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 account for approximately 129 feet of vertical travel as the reservoir water level can vary from 1445’ at low pool to 1574’ high pool. The SWS is to be equipped with a weir which will travel vertically with the changing water level of the reservoir. The seal will make contact with the SWS at the edges and with the weir in the middle. To simplify the design concept of the seal, the frames of motion are best broken into two categories; large vertical motion induced by changing reservoir levels and small motions allowed by the moorings. The seal design concept, not to scale, is shown in Figure 6-15 below.

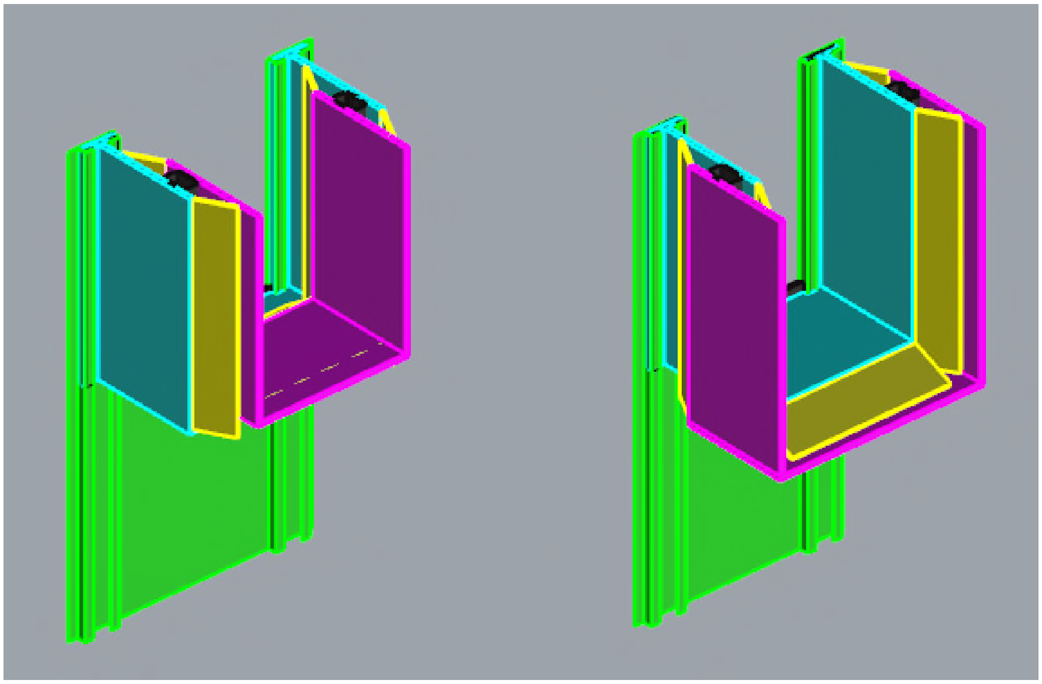


Figure 6-15 - FSS to SWS Seal Concept

The seal concept is composed of two concentric channels with approximately 12 inches separating the two. Two options are presented in Figure 6-15; one with the outer channel attached to the FSS and one with the outer channel attached to the SWS. Between the two channels, and attached to the outer channel, is an inflatable seal. As the channels move in relation to each other due the mooring-allowed motions the seal is able to expand on one side to fill the gap and contract on the other. On both the inside and outside spring-loaded plates, show in yellow, protect the seal from debris and direct the majority of the water into the inner channel and away from the seal. 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 12 inches of separation between the channels. This inflatable seal will likely need to be custom made to the specifications of the project by a company such as Trelleborg.

At left in Figure 6-15 the outer channel, shown in the figure as cyan, is connected to a series of rails attached to the face of the SWS. This outer channel is only allowed to translate in the vertical direction and uses UHMW or a similar material against the face of the SWS to maintain the seal. The inner channel, shown in the figure as purple, is rigidly connected to the FSS. For this option to function, a method of maintaining the height of the outer seal, such as a lifting mechanism or gear drive, would be necessary. This would aid in dewatering and in storm conditions as the outer channel could be lowered away from, and freeing, the FSS.

At right in Figure 6-15 the inner channel, shown in the figure as cyan, is connected to a series of rails attached to the face of the SWS. This inner channel is only allowed to translate in the vertical direction and uses UHMW or a similar material against the face of the SWS to maintain the seal. The outer channel, shown in the figure as purple, is rigidly connected to the FSS. The outer channel, connected to the FSS, carries the inner channel up and down the face of the SWS as the water level in the reservoir rises and falls. This option would still require a lifting device or structure of some sort to facilitate removing the inner channel in the event that the FSS would need to be moved away from the FSS.

One complication which may arise pertains to the presence of crossmembers located in front of the weir gate placed at specified intervals. If such cross members as used, the bottom part of the inner channel where it meets the face of the dam will need to be able to retrace the thickness of the cross member while maintaining the seal. This could likely be accomplished with a sliding floor plate and a second seal located at the contact edge of the plate. These cross members would likely increase the seal leakage and would best be avoided if possible in design and construction of the SWS.

7 ELECTRICAL DESIGN

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

7.1 References

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

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

7.2 Seismic Considerations for Electrical Equipment

Typical seismic restraints for floor-mounted equipment will 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 and the transformer/service switchgear on the barge to step the power down for the 480 volt power distribution system. How power will be transferred to from shore to the barge will be further detailed out for the 90% design drawing submittal.

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

7.4 Electrical Distribution and Equipment

7.4.1 Distribution

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

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 emergency/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 emergency and standby electrical loads are currently under evaluation and will be available at the 90% DDR.

7.4.3 Grounding and Bonding:

The electrical system will be solidly grounded and the installation shall comply with article 250 and article 555 of the NEC.

A separate 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 and/or remote control of the FSS. The PLC will also provide status/indication and alarming to the powerhouse control rooms. Touch screens located at the FSS and powerhouse control room will display local alarms & system status. An industrial fieldbus will be utilized to connect all sensors, drives, actuators, remote I/O, power meters, and other devices supporting the monitoring and control system. Process devices such as level sensors will require a 4-20mA transmitter, as fieldbus units are not commonly available. The processor power supply shall be backed-up by a small UPS so PLC operation will not experience disruptions during generator testing or short power failures. How the barge PLC will communicate with the powerhouse control room on-shore will be determined for the 90% DDR submittal.

7.5.2 Supervisory Control and Data Acquisition (SCADA)

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

7.5.3 Communications

Telephone service will be furnished for communications to the control room at the Detroit Dam facility. How the telephone service will connect to the control room on-shore will be determined for the 90% design drawing submittal.

It is anticipated that communications, both telecommunications and Controls will be transmitted across 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 bridge and knuckle-boom crane operations.

7.6.2 Bridge Crane

Floodlights will be designed in accordance with Illuminating Engineering Society standards to produce accurate color rendition and provide an average illumination level of approximately 15- to 25-foot candles at the deck level underneath the crane, with a target minimum design level of 15-foot candles at any given point. Accurate color rendition is critical if crane lights are being used to illuminate activities involving 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.

7.7 Feature Specific Electrical Loads

7.7.1 Attraction Flow Pumps

Loads to be estimated for the 90% DDR submittal.

7.7.2 Dewatering and Auxiliary Flow Pumps

Loads to be estimated for the 90% DDR submittal.

7.7.3 Motor Operated Gate Actuators

Loads to be estimated for the 90% DDR submittal.

7.7.4 Bridge and Articulating (Knuckle) Boom Crane

The total bridge crane electrical load has been estimated to be 6 HP plus any required electrical cabinet heating, cooling, or ventilation requirements. The articulating boom crane electrical load has been estimated to be 34 kW.

7.7.5 Heating and Ventilation Equipment

Loads to be estimated for the 90% DDR submittal.

7.7.6 Lighting and Receptacles

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

8 ENVIRONMENTAL AND CULTURAL RESOURCES

8.1 General

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

8.2 References

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

to Oregon Chub, Bull Trout, and Bull Trout Critical Habitat Designated Under the Endangered Species Act. USFWS, Portland, Oregon.

8.3 Environmental Planning

8.3.1 National Environmental Policy Act (NEPA)

All actions that are federally funded, permitted, or constructed must satisfy the requirements of the National Environmental Policy Act (NEPA) of 1969, as amended (42 U.S.C. 4321 et seq.). The project team should seek to avoid and minimize environmental impacts in the design and construction of the Detroit downstream juvenile fish passage project. In order to comply with NEPA, a draft Environmental Impact Statement (EIS) will be distributed for a 30-day public review and comment period for the proposed Detroit Downstream Fish Passage Facility. The draft EIS will address alternatives analyses and temporary and permanent environmental and impacts associated with project elements. 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.

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 (threatened (T), endangered (E), proposed (P), or Candidate (C)): 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), Fender's blue butterfly (E) . (Source – Center for Biological Diversity - http://www.biologicaldiversity.org/programs/population_and_sustainability/T_and_E_map/) Listed species under the jurisdiction of National Marine Fisheries Service (NMFS) include: Upper Willamette River Chinook salmon (Oncorhynchus tshawytscha) and Upper Willamette River steelhead (Oncorhynchus mykiss). The Detroit Dam Selective Withdrawal Structure is incorporated in the concurrently issued July 11, 2008, NMFS and USFWS ESA Section 7(a)(2) Consultation Biological Opinions (BiOps) on the "Willamette River Basin Flood Control Project". The Detroit Dam Selective Withdrawal Structure designs should also adhere to the NMFS 2008 Anadromous Salmonid Passage Facility Design Standards. Additionally, a summary describing anticipated effects and the significance assessment will be submitted to NMFS and USFWS for their take determination. The consultation pathway will depend on whether any of the effects could qualify as "take" under the ESA regardless of whether the net effect of the project will be beneficial. Based on conversations with NMFS and USFWS General Counsel, even if NMFS or USFWS finds the effects rise to the level of "take," NMFS and USFWS currently believe they will be able to provide take coverage through the existing BiOp rather than an individual consultation, however, this is subject to change based on the legal advice provided by wither agencies' councils or the USACE council.

8.3.3 Magnuson-Stevens Fishery Conservation and Management Act

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

8.3.4 Fish and Wildlife Conservation Act (FWCA)

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

8.3.5 Coastal Zone Management Act (CZMA)

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

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

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

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

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

Temporary impacts to water quality should be avoided and minimized during the project's construction and staging. An Erosion and Sediment Control Plan must be developed and implemented in compliance with the Corps' existing general NPDES 1200-CA permit issued by

DEQ for during-construction stormwater management. A guide for proper installation and maintenance of appropriate Best Management Practices (BMPs) for both uplands and in-water work can be found in the DEQ Erosion and Sediment Control Manual. Low Impact Development (LID) techniques including infiltration and protection of existing soils and vegetation should be implemented wherever appropriate. Site grubbing and clearing as much as possible should be kept to the minimum required for the permanent project footprint.

Additionally, all in-water work will require an in-water 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. DEQ usually defers to the Oregon Department of Fish and Wildlife (ODFW) and NMFS regarding appropriateness of proposed fish salvage and exclusion measures, and may simply require documentation of their acceptability to the agencies. Turbidity monitoring reports will be required during all in-water work.

Construction of some of the facility structures will require temporary in-water work below ordinary high water (OHW) to complete. Cofferdams may be required for construction. The cofferdam will partially dewater and will likely be .

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. Changes to channel dynamics are expected to remain localized and should avoid inducing significant up or downstream channel or bank instability. Blasting should be scheduled to occur during the in-water work window and additional appropriate BMPs should be applied in order to minimize impacts to listed species. Also, an ODFW blasting permit will be required. 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. This plan must address all contributing impervious areas and provide treatment designed per a DEQ-accepted manual or its equivalent.

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 these 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. Any additional wetland impacts will also require mitigation, although none are expected. Any mitigation will be reviewed by DSL and DEQ when considering replacement of water quality function. The 2008 Biological Opinion 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.

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

The ODFW recommends specific in-water work windows (IWWW) for the protection of endangered species. The IWWW for the North Santiam River above Detroit Dam is from June 1 - August 31. In-water work must be conducted within this window unless an exemption or extension is obtained through the approval of ODFW and NMFS, and the Corps must coordinate with these agencies in order to demonstrate approval as required in the DEQ WQC and by DSL. An exemption will likely be required for in-water work at as the construction of the will occur over several seasons.

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

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

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

8.3.10 National Historic Preservation Act (NHPA)

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

9 CONSTRUCTION

9.1 General

The proposed site for FSS assembly and launch is at the Mongold Day Use area of the Detroit Lake State Park, which is approximately 2.9 miles southeast of the Detroit Dam. The existing site currently consists of a swimming area, grass beach, picnic facilities, restrooms, several docks, and a boat launch. There are 120 parking spaces. Using this site as the FSS construction site would restrict all recreational use of the area. The assembly area will require a dewatered perimeter, the size of which depends on the crane selection and assembly strategy. The preliminary proposal is 100 feet and 50 feet of extra space beyond the FSS dimensions on the sides. The site also requires designated space for laydown, excavation storage, staging, and access, and a plan for launching the FSS when it is ready.

Water surface elevation is a key driving factor in the design of the assembly and launch site. The facility will need to accommodate extreme high water of elevation 1,568 feet. Also, the facility will have to accommodate the possibility of launching at water as low as 1,510 feet. The minimum extreme reservoir elevation is 1,425 feet. Seasonal reservoir water surface elevation variation over past years is shown in Figure 9-1 below.

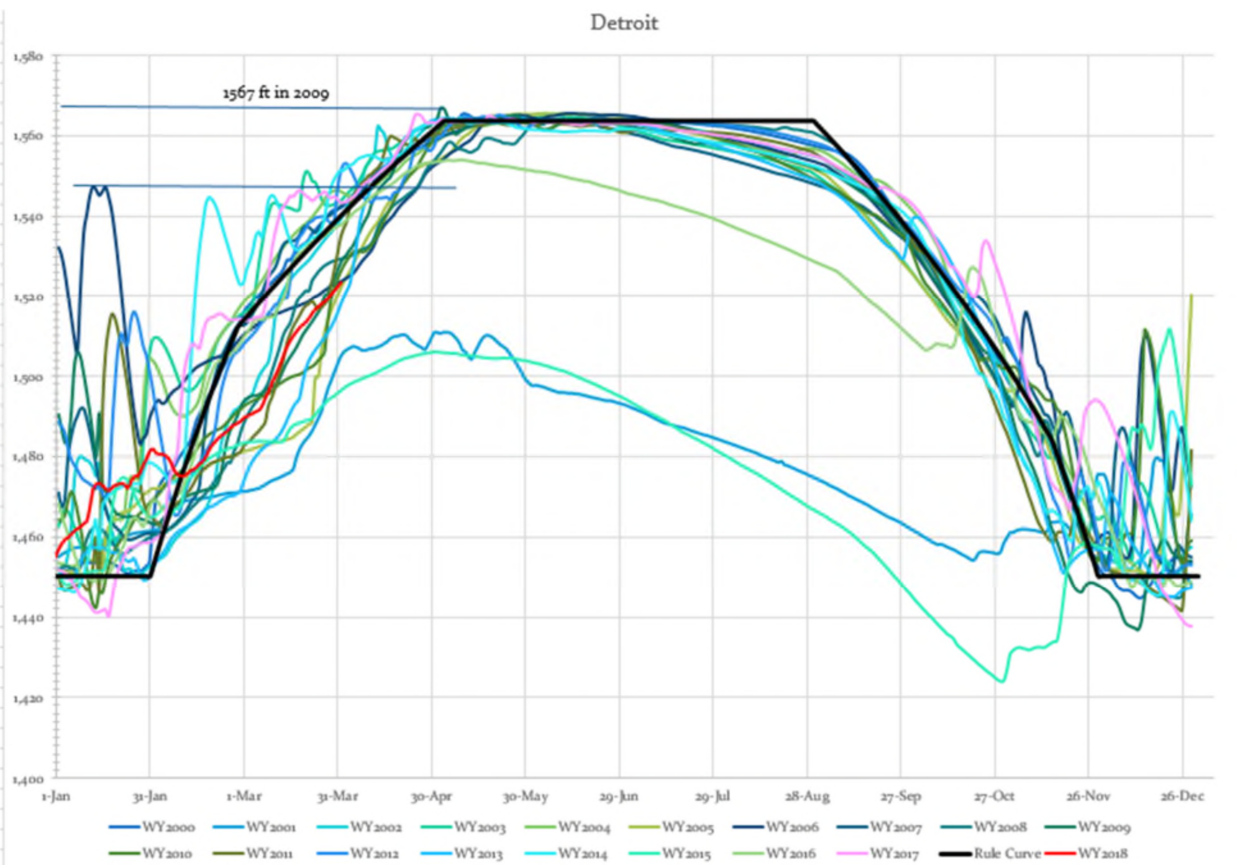


Figure 9-1 – Seasonal Reservoir Water Surface Elevation Variation

9.2 Primary Alternative: Cofferdam and Roll-Out Launch

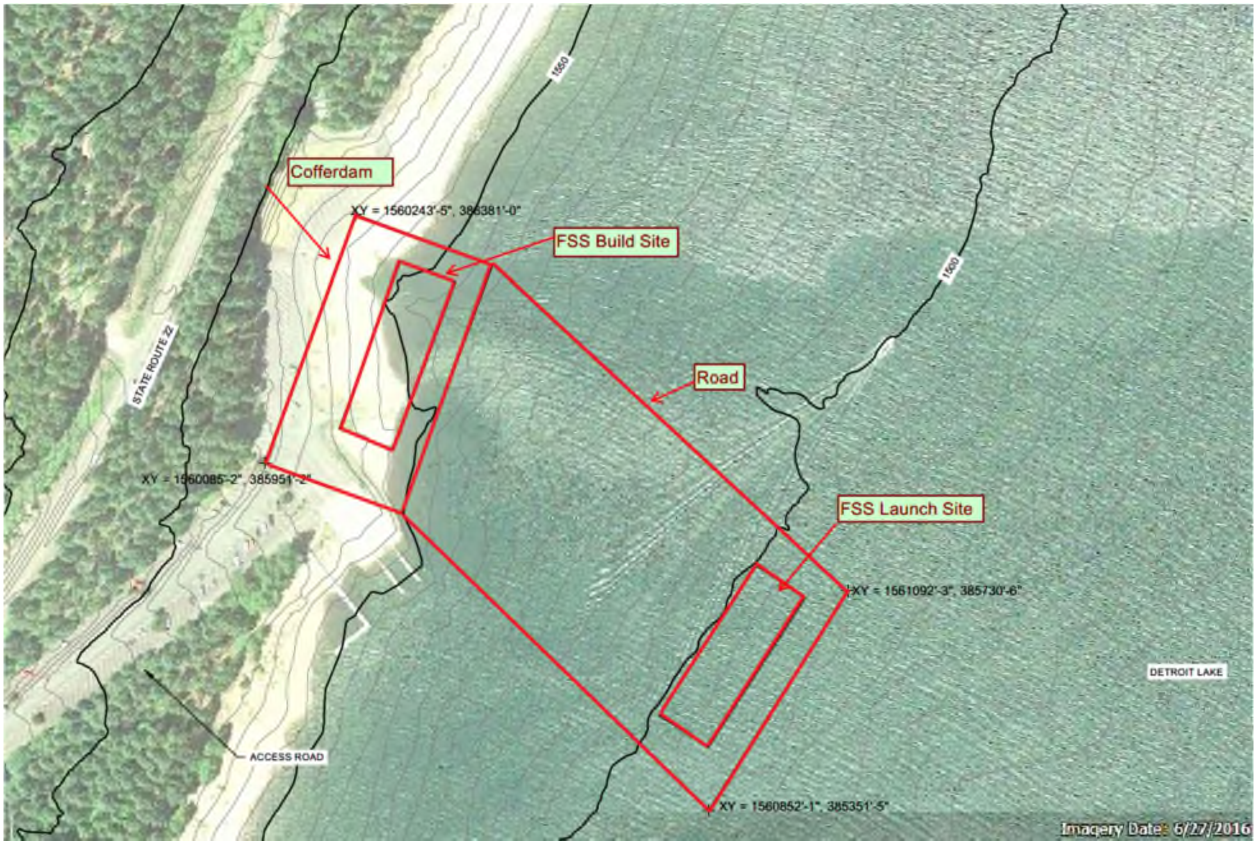


Figure 9-2 - Proposed Site and Launch Layout at Mongold Day Use Area

The tree line where the land starts sloping up towards Highway 22 roughly follows the 1,575 elevation contour in the targeted work area, and the shore slopes at roughly 10% from 1,575 towards the water. This leaves very little shoreline at extreme high reservoir levels. Thus, some form of cofferdam will be required for all launch alternatives. A cofferdam constructed down near the 1,510 elevation level would have to retain around 70 feet or more of water when the reservoir is at extreme high, which is not economically practical. This suggests the cofferdam work area should be constructed as high up as possible to minimize the water level to be retained. Likewise, this means the FSS will need to be moved down to the water level, as low as 1,510 feet, when ready to launch.

9.2.1 Cofferdam

The cofferdam serves the purpose of enclosing a dry, flat work area to assemble the FSS. Within the cofferdam, the FSS modules can be assembled on a series of concrete eco-blocks. The cofferdam, as proposed, will retain in the range of 30 to 40 feet of water at its lowest point. A perimeter of about 1,400 feet is estimated. For a cofferdam of this size, sheet pile cells are a likely option. 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 required embedment depth. Cells will need to factor in considerations for 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 pumps and wells. Seepage will only be an issue when the water level is higher than the work surface elevation.

9.2.2 Launch

To launch, the FSS would need to be transported down to the water level, as low as 1510 feet elevation. A road would be built to transport the FSS down to launch elevation. Large flatbed trucks can be used to carry the FSS. To launch at water levels as low as 1,510 feet, the FSS launch footprint will be entirely below the 1,500 foot contour, to account for several feet of blocks, and the FSS deballasted draft of approximately 5 feet. The average grade perpendicular to the contours is around 10%. EM 385-1, Safety and Health Requirements, requires a maximum grade of 10% for haul and access roads. It is recommended that the FSS road be angled to the elevation gradient to reduce the grade safely below 10%. This will slightly increase the length of road, but reduced grade will make the transportation of the FSS on flatbed trucks safer and more feasible. The length of road will be on the order of 1,000 feet.

Once unloaded onto blocks at launch elevation, the FSS will float with rising water. This removes the need for specific launching infrastructure, other than transporting the FSS, and a flat spot for it to sit. 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.

9.3 Other Considerations

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 is meant to accommodate any of these conditions, from high water to drought. 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 much 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

To be included in 90% DDR

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 60 percent DDR phase is $343 million. The construction contract, including escalation to the midpoint of construction and a 30 percent contingency, is estimated to cost $255 million. For additional information see Appendix H.

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. Per the 60% SWS DDR, the FSS construction start date will be November 2024.

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 Mongold boat ramp, 4 miles past Detroit Dam on highway 22. From the Mongold boat ramp marine vessels will travel 4 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 60% 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 60% 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 $49 million.

11.10.2 Construction Management (31 Account)

The 60% 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 $40 million.

11.10.3 Annual Operations and Maintenance

Annual operations and maintenance will be estimated in the 90% DDR.

12 RECOMMENDATION

To be included on 90% DDR.