ENGINEERING DOCUMENTATION REPORT NO.

THE DALLES DAM,
COLUMBIA RIVER BASIN,
THE DALLES, OREGON

The Dalles AWS Backup Debris Management EDR

Final Report

Prepared By:
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Portland District

September 2023

EXECUTIVE SUMMARY

- **BRIEF DISCUSSION OF PROBLEM STATEMENT**

The Dalles Lock and Dam is 192 miles upriver from the mouth of the Columbia River and two miles east of the city of The Dalles, OR. The Dalles Dam is the second dam upstream from the mouth of the Columbia River.

The purpose of The Dalles Auxiliary Water Supply (AWS) Backup Debris Management project is to provide an alternative means for removing the debris from the trashracks at the intake of the East Fish Ladder AWS Backup System. Currently operations staff need to turn off the AWS backup and allow the river currents to remove debris from the screens. The original AWS supplies approximately 5000 cubic feet per second (cfs) attraction water to the east, west, and south fish ladder entrances to attract upstream migrating adult fish into the fish ladder from the tailrace. The attraction water is currently supplied to the AWS by two “fish turbine” adjustable blade units located on the west end of the powerhouse. If one or both fish turbine units fail, water supplied to the AWS would be severely limited or eliminated. The East Fish Ladder AWS Backup System was designed and constructed to provide an emergency backup supply of water to the auxiliary water system (AWS). This Auxiliary Water Backup system was designed to provide a temporary (maximum 1 year) backup supply of water (approx. 1400 – 1600 cfs) to the AWS, when both fish turbine units fail, and the design AWS flow (approx. 5000 cfs) is not available.

For dam safety purposes, the AWS backup system contains redundant flow closure devices including a closure gate at the intake and three butterfly valves, one 10-foot and two 7-foot butterfly valves. (Only the valves can be closed under flow.) Cycling these valves is Operation’s main method of shutting down the system. Initially, a concern existed that the valves had a design life of only 1400 cycles. However, after further discussion with the manufacturer, this concern appears to be unsupported.

Expected construction date for Fish Unit Rehabilitation Project is the year 2028 ~~2027~~, per current System Asset Plan (SAP). This project requires the AWS backup system to operate during the rehab to provide adequate flow for fish attraction. This was coordinated during Fish Unit Rehab Phase 1A. Fish Unit Rehab duration is one (1) year per unit for a total of two (2) years. Flow tests have shown that the AWSBS trashracks have had periodic debris issues and require a more robust debris management strategy during Fish Unit Rehab. Following Fish Unit Rehab, the backup AWS will be used if one or both of the new propeller Fish Units are forced out of service during adult fish passage season.

A trash rake was recommended during the backup AWS Design Documentation Report. During Plans & Specs the PDT in collaboration with the region decided to eliminate the trash rake mainly due to the long-term maintenance burden of equipment for a system that would only be used in an emergency when both Fish Units fail. Emergency only use of the backup AWS was expected to be infrequent and of short duration.

The purpose of this EDR is to evaluate the alternatives and make a recommendation for a debris management system that meets the requirements listed in sections 3.3.1 and 3.3.2.

- **BRIEF DISCUSSION OF CRITERIA AND CONSTRAINTS.**

Criteria and constraints serve as evaluation metrics for screening and evaluating alternatives. The criteria and constraints were developed by PDT. Section 2 of this report describes the criteria and constraints.

- **ALTERNATIVES CONSIDERED**

Fifteen alternatives were considered by the PDT. The Value Management (VM) team, which included some of the PDT members, proposed nine additional alternatives. The alternatives were evaluated based on the criteria and constraints, and a matrix was developed for the evaluations. Weighted paired comparisons were used to develop performance criteria for ranking existing alternatives and new proposals. All proposals, as well as the team's assessment of the top five existing potential alternatives, were evaluated against the performance criteria developed using the weighted paired comparisons.

- **RECOMMENDED ALTERNATIVES**

During the 60% EDR phase, the PDT discussed the remaining concepts to determine the preferred and second-best alternatives. The PDT concluded that no single concept would sufficiently and confidently manage debris at the intake. Therefore, both the preferred and second-best alternative combine multiple concepts to create a multi-faceted approach to debris management.

- **PREFERRED ALTERNATIVE**

The preferred alternative chosen by the PDT combines Alternative 4-1 (debris boom), Alternative 11 (dedicated hoist operated trash brush), and Alternative ME-1 (level sensors). Sections 3.1 and 3.2 of this report discuss the description of the alternatives.

- **SECOND-BEST ALTERNATIVE**

The second-best alternative chosen by the PDT combines Alternative 4-1 (debris boom), Alternative 10 (new trashrack with dedicated hoist operated trash brush), and Alternative ME-1 (level sensors).

Both alternatives are a three-pronged strategy, with the debris boom (4-1) and backup AWSBS valve cycling with the aid of level sensors (ME-1) being recommended as the initial two approaches.

- **Construction Schedule**

Expected construction date for Fish Unit Rehabilitation Project is the year 2028 ~~2027~~, per current System Asset Plan (SAP). The schedule for construction of the debris removal system will need to be prior to the Fish Unit Rehabilitation and is assumed to be approximately 2 years, with construction beginning in late 2026.

- **COST OF PREFERRED ALTERNATIVE (CAPITAL)**

Construction cost Class 3 for the Preferred Alternative which includes Alt 4-1, Alt 11 and ME-1 is estimated at $1.3 million (2023 dollars), after applying 13% inflation and 54% contingency the total construction cost is $2.3 million. The total project cost (design and construction) estimated at the 90% EDR phase is $3.3 million. The construction contract will take less than a year including procurement of materials. The onsite work would be complete in the in-water work period.

- **COST OF SECOND-BEST ALTERNATIVE (CAPITAL)**

Construction cost Class 3 for Second Best Alternative which includes Alt 4-1, Alt 10 and Alt ME-1 is estimated at $3.1 million (2023 dollars), after applying 13% inflation and 57%contingency the total construction cost is $5.5 million. The total project cost (design and construction) estimated at the 90% EDR phase is $7.9 million. The construction contract will take less than one year including procurement of materials.

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CONTENTS

EXECUTIVE SUMMARY i
TABLE OF CONTENTS iii
PERTINENT DATA vi
PREVIOUS MEMORANDUMS vii
ACRONYMS AND ABBREVIATIONS iv

EXECUTIVE SUMMARY II
- **BRIEF DISCUSSION OF PROBLEM STATEMENT** II
- **BRIEF DISCUSSION OF CRITERIA AND CONSTRAINTS.** III
- **ALTERNATIVES CONSIDERED** III
- **RECOMMENDED ALTERNATIVES** III
- **PREFERRED ALTERNATIVE** III
- **SECOND-BEST ALTERNATIVE** IV
- **CONSTRUCTION SCHEDULE** IV
- **COST OF PREFERRED ALTERNATIVE (CAPITAL)** IV
- **COST OF SECOND-BEST ALTERNATIVE (CAPITAL)** IV

SECTION 1 - PURPOSE AND INTRODUCTION 1-1
1.1 PURPOSE 1-1
1.2 BACKGROUND INFORMATION 1-3
1.2.1 Trash Rake Design Removal During P&S 1-4
1.2.2 Existing Trashracks 1-5
1.2.3 Existing Trashrack Guides 1-6
1.3 PARTICIPANTS AND ROLES 1-8

SECTION 2 - CRITERIA AND CONSTRAINTS 2-1
2.1 ENVIRONMENTAL AND CULTURAL RESOURSES CONSIDERATIONS 2-1
2.2 BIOLOGICAL CRITERIA AND CONSTRAINTS 2-2
2.2.1 Criteria 2-7
2.2.2 Constraints 2-7
2.3 OPERATIONS CRITERIA AND CONSTRAINTS 2-8
2.3.1 Criteria 2-9
2.3.2 Constraints 2-9
2.3.3 AWSBS Operations Data 2-9
2.4 HYDRAULICS CRITERIA AND CONSTRAINTS 2-10
2.4.1 Design References 2-10
2.4.2 Criteria 2-11
2.4.3 Constraints 2-14
2.4.4 The Dalles Project Hydrologic Conditions 2-15
2.4.5 River Conditions around AWS Backup System Intake 2-18
2.4.6 Debris Levels 2-20
2.5 STRUCTURAL CRITERIA AND CONSTRAINTS 2-21

2.5.1 Design References 2-21
2.5.2 Engineering Properties of Construction Materials 2-22
2.5.3 Service Life 2-23
2.5.4 Loads 2-23
2.6 MECHANICAL CRITERIA AND CONSTRAINTS 2-25
2.6.1 Design References 2-25
2.6.2 Criteria 2-26
2.7 ELECTRICAL CRITERIA AND CONSTRAINTS 2-29
2.7.1 Design References 2-29
2.7.2 Criteria 2-29
2.7.3 Constraints 2-29
2.8 LIST OF POSSIBLE ALTERNATIVES 2-30

SECTION 3 - ALTERNATIVE EVALUATIONS 3-1

3.1 POSSIBLE ALTERNATIVES (BY PDT) 3-1
3.1.1 Alternative 1: No action, continue operation as is and cycle the valves off and on to allow the debris to naturally flow off the trashrack. 3-2
3.1.2 Alternative 2: Use an air bubbler system to divert the debris further downstream/upstream. 3-3
3.1.3 Alternative 3: Use an air bubbler system to flush debris off the trashracks 3-6
3.1.4 Alternative Group 4: Install a new exclusion system in front of the trashracks which will passively divert the debris downstream/upstream. 3-10
3.1.5 Alternative 4-1: Floating debris boom to deflect surface entrained debris. .. 3-11
3.1.6 Alternative 4-2: Floating curtain to deflect debris down to the depth of the curtain. 3-15
3.1.7 Alternative 4-3: Full depth steel deflection structure to divert all debris past the intake, assuming one direction of flow. 3-16
3.1.8 Alternative 4-4: Full depth steel deflection structure to divert all debris past the intake, assuming two directions of flow. 3-18
3.1.9 Alternative 5: Contract out a diver to remove clogged debris when cycling the valves to allow the currents to remove the debris doesn't work. 3-21
3.1.10 Alternative 6: Automation of valve cycling. 3-22
3.1.11 Alternative 7: Pressure wash the debris off the trashracks from the intake deck using a water tank. 3-23
3.1.12 Alternative 8: Install variable-porosity plate between trashrack and intake to provide uniform flow through the trashrack. 3-25
3.1.13 Alternative 9: Travelling screen with debris catchment bin that can be periodically removed. 3-26
3.1.14 Alternative 10: Design and install new seamlessly connected trashracks. Clean new trashracks with a simple nylon brushing system, actuated by a dedicated hoist. 3-29
3.1.15 Alternative 11: Design and install a brush system capable of cleaning the current trashracks. Operate the new brush system with a dedicated hoist. 3-32
3.1.16 Alternative 12: Use a mobile crane for raking the new trashracks 3-38
3.2 PROPOSED ALTERNATIVES (BY VE TEAM) 3-39

3.2.1 Alternative IR-2: Test debris boom for effectiveness in reducing debris build up on trashracks 3-40
3.2.2 Alternative ME-1: Install level sensors to tie into project SCADA system 3-43
3.2.3 Alternative ME-2: Modify entrances to ladders to use less flow 3-43
3.2.4 Alternative MF-2: Construct a travelling horizonal backspray manifold to remove debris while the AWSBS is operating 3-45
3.2.5 Alternative ML-2: Acquire spare parts for the 7-foot butterfly valves 3-46
3.2.6 Alternative ML-4: Replace 7-foot butterfly valve seals after completing fish unit rehab 3-46
3.2.7 Alternative PF-2: Pull the racks at night or during a shutdown for manually cleaning3-47
3.2.8 Alternative PF-3: Construct additional racks so existing may be pulled and rotated for thorough cleaning 3-48
3.2.9 Heading 3 Alternative PF-3: Convey running tally on 7-foot butterfly valve cycles to operators 3-49
3.3 PROJECT ANALYSIS 3-49
3.3.1 Evaluation criteria list (By PDT) 3-50
3.3.2 Performance Criteria List (By VE Team) 3-50
3.3.3 Paired Comparisons (By VE Team) 3-51
3.3.4 Alternative Ranking (By VE Team) 3-52
3.3.5 Paired Comparisons (By PDT) 3-52
3.3.6 Alternative Ranking (By PDT) 3-53
3.4 ALTERNATIVES DEPRIORITIZATION 3-53
3.4.1 Alternatives Deprioritized 3-53
3.4.2 Rationales for deprioritizing alternatives 3-55
3.4.3 Most Feasible Alternatives 3-67

SECTION 4 - COST ESTIMATES FOR ALTERNATIVES 3-76

4.1 OVERVIEW 3-76
4.2 MOST FEASIBLE ALTERNATIVE COST ASSUMPTIONS 3-76
4.2.1 Alternative 4 – Debris Boom Installation 3-76
4.2.2 Alternative 10 – New Trashrack and Brush System 3-76
4.2.3 Alternative 11 – New Long Brush System 3-77
4.2.4 Alternative ME-1 – New Radar Level sensor to SCADA system 3-77
4.3 TOTAL PROJECT COST SUMMARY (TPCS) 3-78
4.3.1 Preferred Alternative 3-78
4.3.2 Second Best Alternative 3-78

SECTION 5 - PREFERRED AND SECOND-BEST ALTERNATIVES 5-79

5.1 PRIORITIZED CONCEPTS 5-79
5.2 PREFERRED ALTERNATIVE 5-79
5.2.1 Layout 5-79
5.2.2 Operation 5-80
5.2.3 Effectiveness 5-80
5.2.4 Cost 5-81
5.3 SECOND-BEST ALTERNATIVE 5-81
5.3.1 Cost 5-82

SECTION 6 - CONCLUSIONS AND RECOMMENDATIONS 6-1

6.1 CONCLUSIONS 6-1
6.2 RECOMMENDATIONS 6-2

SECTION 7 - REFERENCES 7-1

TABLES

Table 1-1. Participants and Roles 1-8
Table 2-1. The Dalles Dam Adult Fish Count Period and Peak Passage Timing (based on yearly counts since 1957, except lamprey since 2000). 2-3
Table 2-2. Route specific passage proportions CH1 and STH at TDA 2010 and 2011.2-5
Table 2-3. AWSBS Operation Data 2-9
Table 2-4. Engineering properties of construction material 2-22
Table 3-1. Alternatives Using Existing Trashracks 3-1
Table 3-2. Alternatives with Modified Trashracks 3-2
Table 3-3. Proposed Alternatives, VE 3-40
Table 3-4. Deprioritized Alternatives 3-54
Table 3-5. Most Feasible Alternatives 3-67

FIGURES

Figure 1-1. The Dalles Dam Fish Ladder System (USACE 2022) 1-2
Figure 1-2. The Dalles Dam East Fish Ladder (USACE 2022)..................................... 1-3
Figure 1-3. The Dalles AWS Backup System Trashrack, Elevation 1-5
Figure 1-4: The Dalles AWS Backup System Trashrack, Section 1-6
Figure 1-5. The Dalles AWS Backup System Trashrack Dewatering Structure 1-7
Figure 1-6. The Dalles AWS Backup System Trashrack Guide 1-8
Figure 2-1. Diel Distribution of Adult Salmonids at The Dalles Dam Fishway Entrances and Exits (Keefer & Caudill 2008). 2-4
Figure 2-2. Existing Trashrack Head Differential versus Percent of Blockage 2-15
Figure 2-3. Flow Duration Curve, Calendar Year, 1990 to 2021 2-17
Figure 2-4. River Surface Velocity Observation 2-18
Figure 2-5. Prototype River Velocity Data April 2015; (a) No Spill, (b) 40% Spill 2-20
Figure 2-6. Photo of Forebay on top of AWS intake.. 2-28
Figure 3-1. Photo of Rack of Air Burst Nozzles at Minto Fish Facility 3-4
Figure 3-2. Air burst array designed to sit behind juvenile fish screens at the Minto Fish Facility 3-7
Figure 3-3. Top-down view of Minto Fish Facility air burst, as installed and operating. 3-8
Figure 3-4. Schematic of Alternative 4-1: Floating Debris Boom............................... 3-12
Figure 3-5. Preliminary Floating Debris Boom Alignment with Prototype Flow Data. . 3-13
Figure 3-6. Schematic of Alternative 4-3: One-way Diversion Structure..................... 3-17
Figure 3-7. Schematic of Alternative 4-4; Two-way Diversion Structure..................... 3-19
Figure 3-8. Travelling Screen Example, Alternative 9 3-27
Figure 3-9. Plan View 3-30
Figure 3-10. Brush Access Options.. 3-33
Figure 3-11. Section View of Current Panel 3-35
Figure 3-12. Brush Frame Concept Overview 3-36
Figure 3-13. Test Debris Boom, Triangular 3-41
Figure 3-14. Test Debris Boom, Semicircular... 3-42
Figure 3-15. Ladder Entrances... 3-44
Figure 3-16. Travelling Back Spray Manifold.. 3-45
Figure 3-17. Potential Manual Cleaning Area... 3-47
Figure 3-18. Construct Additional Racks 3-48
Figure 3-19. Paired Comparison, VE.. 3-51
Figure 3-20. Alternative Ranking, VE 3-52
Figure 3-21. Paired Comparison, PDT 3-52
Figure 3-22. Alternative Ranking, PDT... 3-53
Figure 3-23. Alternative Ranking Votes.. 3-53

APPENDICES

APPENDIX A COORDINATION
APPENDIX B PLATES
APPENDIX C CALCULATIONS
APPENDIX D REVIEW CERTIFICATION
APPENDIX E FISH AGENCIES COMMENTS
APPENDIX F VALUE MANAGEMENT (VM) STUDY DRAFT REPORT
APPENDIX G WORKING COST ESTIMATE
APPENDIX H AS-BUILTS
APPENDIX I DEBRIS ROV ANALYSIS
APPENDIX J FOREBAY VELOCITY MEASUREMENTS

PERTINENT DATA

PERTINENT PROJECT DATA THE DALLES LOCK AND DAM - LAKE CELILO		
GENERAL		
Location	Columbia River, Oregon and Washington, River Mile 192	
Drainage area	Square miles	237,000
RESERVOIR – LAKE CELILO (elevations referenced to 1929 datum 1947 adjustment)		
Normal minimum pool elevation	Feet, msl	155
Normal maximum pool elevation	Feet, msl	160
Maximum pool elevation (PMF regulated, 2009)	Feet, msl	178.4
Minimum tailwater elevation[1]	Feet, msl	76.4
Maximum tailwater elevation (PMF regulated, 2009)	Feet, msl	127.2
Reservoir length (to John Day Dam)	Miles	23.5
Reservoir surface area – normal maximum power pool (EL 160.0)	Acres	9,400
Storage capacity (EL. 160.0)	Acre-feet	332,500
Power drawdown pool (EL. 155)	Acre-feet	53,500
Length of shoreline at full pool (EL. 160.0)	Miles	55
FLOOD CONDITIONS		
Probable maximum flood (unregulated)	- $feet^3/s$	2,660,000
Probable maximum flood (regulated)	- $feet^3/s$	2,060,000
Standard project flood (unregulated)	- $feet^3/s$	1,580,000
Standard project flood (regulated)	- $feet^3/s$	840,000
100-year flood event (regulated)	- $feet^3/s$	680,000
SPILLWAY		
Type	Gate-controlled Gravity Overflow	
Length	Feet	1,447
Elevation of crest	Feet, msl	121
Number of gates		23
Height (apron to spillway deck)	Feet	130

[1] The minimum tailwater 76.4 feet as shown above is based on an approximate median Bonneville Forebay of 74 feet NGVD 29 and a river flow of 100,000 cfs. Both values do go lower and the minimum tailwater elevation recorded between 1990 – 2021 was 71.6 feet.

PERTINENT PROJECT DATA THE DALLES LOCK AND DAM - LAKE CELILO		
NAVIGATION LOCK		
Type	Single Lift	
Lift – normal	Feet	87.5
Lift – maximum	Feet	90
Net clear length	Feet	650
Net clear width	Feet	86
Normal depth over upper sill	Feet	20
Minimum depth over upstream sill	Feet	15
Minimum depth over downstream sill	Feet	15
POWER PLANT		
Powerhouse type	Conventional (indoor)	
Powerhouse width	Feet	239
Powerhouse length	Feet	2,089
Number of Main Generating Units		***22***
Installed power capacity	Kilowatts	1,806,800
Peak generating efficiency flow	- feet^3/s	260,000
Maximum flow capacity	- feet^3/s	320,000
Fishway Units (Not Included Above)		***2***
Installed power capacity	Kilowatts	28,000
Peak generating efficiency flow	- feet^3/s	2,500
Maximum flow capacity	- feet^3/s	2,500
Station Service Units (Not Included Above)		***2***
Installed power capacity	Kilowatts	6,000
Peak generating efficiency flow	- feet^3/s	300
Maximum flow capacity	- feet^3/s	300
FISH FACILITIES		
Adult ladders		2
Ladder designations		North and East
North ladder width	Feet	24
East ladder width	Feet	30
Ladder slope (typical)		1v:16h
Ladder elevation change (typical)	Feet	84
NORTHERN WASCO PEOPLE'S UTILITY DISTRICT POWER PLANT (OPERATING AT THE NORTH FISH LADDER AWS)		
Powerhouse type	Conventional (indoor)	

PERTINENT PROJECT DATA THE DALLES LOCK AND DAM - LAKE CELILO		
Powerhouse width	Feet	44
Powerhouse length	Feet	48
Intake Structure width	Feet	25
Intake Structure length	Feet	125
Number of Main Generating Units		***1***
Installed power capacity	Kilowatts	5,000
Peak generating efficiency flow	- $feet^3/s$	800
Maximum flow capacity	- $feet^3/s$	800

PREVIOUS AND PLANNED REPORTS

Status	Title	Date
Previous report	The Dalles East Fish Ladder Auxiliary Water Backup System DDR	March 2014
Previous report	The Dalles AWS Backup Debris Management EDR Criteria and Constraints	8-6-2021
Previous report	The Dalles AWS Backup Debris Management EDR Alternative Evaluation	1-16-2023
Previous report	The Dalles AWS Backup Debris Management EDR Draft Final Report	4-25-2023
Final Report	The Dalles AWS Backup Debris Management EDR Final Report	9-29-2023

ACRONYMS

Acronym	Description
ADCP	Acoustic Doppler Current Profile
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
ATS	Automatic Transfer Switch
AWS	Auxiliary Water Supply
AWSBS	Auxiliary Water Supply Backup System
BiOp	Biological Opinion
CFD	Computational Fluid Dynamics
CFS	Cubic Feet Per Second
CH1	Spring Chinook
CRS	Columbia River System
DAF	Dynamic Amplification Factor
DDR	Design Documentation Report
E	Earthquake
EDR	Engineering Design Report
EFL	East Fish Ladder
EM	Engineer Manual
EPA	Environmental Protection Agency
ER	Engineer Regulation
ERDC	U.S. Army Research and Development Center
ESA	Endangered Species Act
ETL	Engineering Technical Letter
FEMA	Federal Emergency Management Agency
FFDRWG	Fish Facility Design Review Work Group
FGE	Fish Guidance Efficiency
Fn	Natural Frequency
FPOM	Fish Passage and Operations Maintenance
FPP	Fish Passage Plan
FR	Frequency Ratios
ft/s	Feet Per Second

Acronym	Description
ft^3	Cubic Foot
FU	Fish Unit
Fv	Shedding Frequency
GDACS	General Data Acquisition Supervisory Control System
HDC	Hydraulic Design Criteria
HEPA	High Efficiency Particulate Air
HMI	Human Machine Interface
H_s	Hydrostatic Water
HSS	Hydraulic Steel Structure(s)
IEEE	Electrical and Electronic Engineers
in	Inch
lb	Pound
JDA	John Day Dam
Kcfs	1000 cfs
LBP	Lead Based Paint
LRFD	Load And Resistance Factor Design
MCC	Motor Control Center
MSL	Mean Sea Level
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NGVD	National Geodetic Vertical Datum
NMFS	National Marine Fisheries Service
NOAA	Oceanic and Atmospheric Administration
NWD	Northwestern Division
NWDR	Northwester Division Regulation
NWP	Portland District
O&M	Operation and Maintenance
OBE	Operational Basis Earthquake
P&S	Plans and Specifications
PDT	Product Development Team
PGA	Peak Ground Acceleration
PM	Program Manager
POC	Point of Contact
PPE	Personal Protective Equipment
psi	Pounds Per Square Inch
PW	ProjectWise
Q	Operating Load

Acronym	Description
QC	Quality Control
RO	Regulating Outlet
ROM	Rough Order of Magnitude
ROV	Remotely Operated Vehicle
RPA	Reasonable and Prudent Alternative
SAP	System Asset Plan
SCADA	Supervisory Control and Data Acquisition
SE	Standard Errors
STH	Steelhead
TDA	The Dalles Dam
TL	Technical Lead
UFC	Unified Facilities Criteria
USACE	U.S. Army Corps of Engineers
V	Volt
VE	Value Engineering
VGP	Vessel General Permit
VM	Value Management
VMP	Value Engineering Management Plan
XFR	X-R Fluorescence

Note: MSL and NGVD 29 represent the same Datum.

SECTION 1 - PURPOSE AND INTRODUCTION

1.1 PURPOSE

The Dalles Dam is the second dam upstream from the mouth of the Columbia River. The vast majority of Columbia Basin salmon and steelhead, including seven Endangered Species Act (ESA) listed fish populations, must pass this dam in order to arrive at their spawning grounds. Since 2009, over 1 million adult salmon (estimates range from 1.1 to 1.3 million) have passed through the fish ladders at The Dalles each year. The adult fish passage facilities at The Dalles Dam consist of the North Fish Ladder and the East Fish Ladder (EFL). See Figure 1-1 and Figure 1-2. Approximately 80 percent of all adult salmon and steelhead pass the dam via the EFL. A deep, submerged canyon, which is the original river's thalweg, leads directly to the EFL entrances. The bathymetry and the L-shaped configuration of the dam where bulk flow from the powerhouse provides a significant attractant to upstream migrants are believed to be the primary reasons for higher EFL usage.

The primary routes to pass downstream migrants through the Project are the spillway and the ice and trash sluiceway. The 2022 Fish Passage Plan spring and summer target spill levels (24 hrs/day) from April 10 - August 14 is 40 percent of the total river flow and is spilled through spill bays 1-8. Thirty percent (24 hrs/day) is the target spill level from August 15 - August 31. This results in passing about 80 percent of all downstream-migrating juvenile salmon and steelhead over the spillway. At high spill levels of ≥ 100,000 cfs, it has been observed via radio telemetry that smaller adult salmon, such as sockeye and Chinook jacks, use the north fish ladder less frequently and cross the river to the EFL (Jepson et al. 2011; Burke et al., 2014, USACE Portland District, 2013). This behavior does not appear to affect the overall passage time for these fish; however, with an auxiliary water supply (AWS) outage resulting in little to no attraction flow at the EFL entrances, it is probable that passage of smaller adult individuals and all adult salmonids which include ESA listed stocks, would be significantly delayed, especially at high spill levels.

The AWS system provides auxiliary water to fish ladder entrances, maintaining criteria for optimal adult fish attraction and entrance efficiency. Given that the majority of adult fish pass The Dalles Dam via the EFL, it is important that the AWS be operable at all times during the fish passage season. The existing AWS system consists of two small turbine units that supply 5,000 cfs, both of which are more than 50 years old (without rehabilitation). A 2008 risk failure analysis report for the fish turbines confirmed that the probability of fish turbine unit failure within 10 years is elevated (USACE 2008). Individually, they are at high risk of failure (25 percent). While the risk of both units failing simultaneously is substantially lower (1.4 percent), the consequences are severe. This scenario may be catastrophic for some species, such as Snake River sockeye salmon stocks, resulting in ESA take and diminished Tribal harvest, hatchery returns, and sport fishery opportunities. Therefore, a reliable auxiliary water supply for the EFL is critical to the overall success of adult fish passage at The Dalles Dam.

To address the potential risks to adult fish passage, the 2008 Biological Opinion (BiOp) (NMFS 2008) included a requirement for the U.S. Army Corps of Engineers (USACE) to implement a backup auxiliary water supply system at The Dalles (Reasonable and Prudent Alternative [RPA] 28.2) as a backup to the fish turbines in case of simultaneous failure of both units. Construction of the backup auxiliary water supply system was completed in 2020.

Finally, there is the expected construction for Fish Unit Rehabilitation Project in 2028. The rehab project requires the AWS backup system to augment the fish ladder operation and entrance attractions flows. The Phase 1 study for the rehab projected that each Fish Unit Rehab would require one (1) year per for a total of two (2) years. Following Fish Unit Rehab, the backup AWS will be used if one or both of the new propeller Fish Units are forced out of service during adult fish passage season. The future ability to rely on the design discharge from the AWS backup system was a factor in the selection of the preferred alternative fish turbine design in the Phase 1 Study.

Figure 1-1. The Dalles Dam Fish Ladder System (USACE 2022)

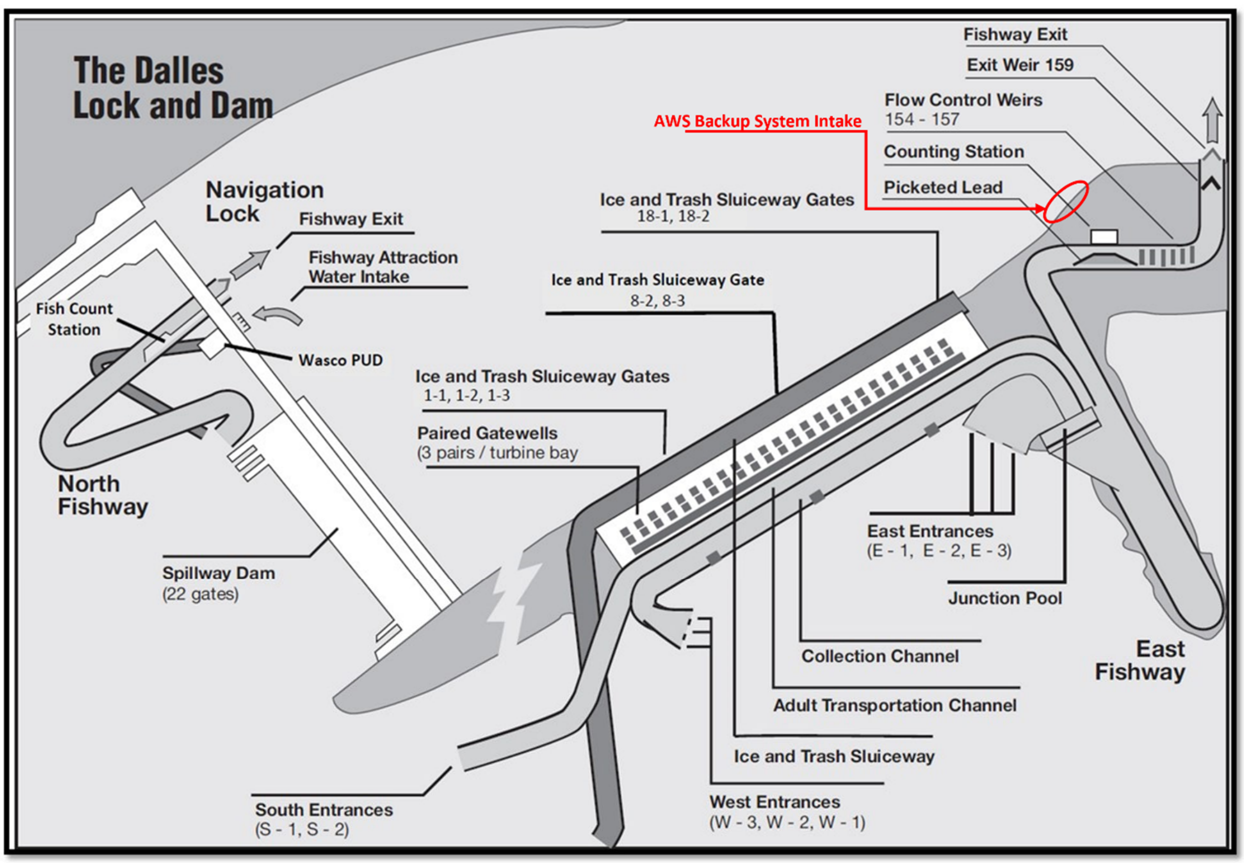
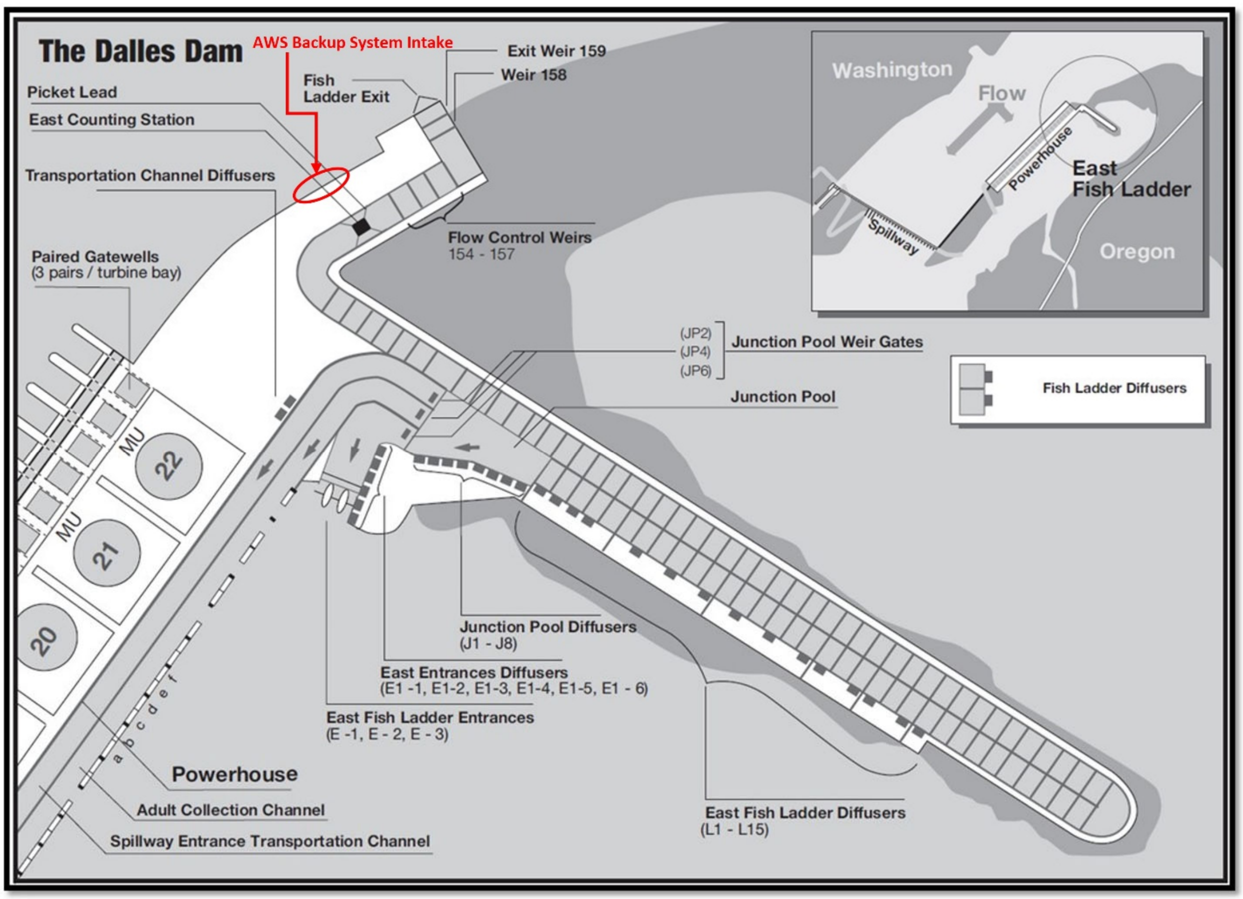


Figure 1-2. The Dalles Dam East Fish Ladder (USACE 2022)



1.2 BACKGROUND INFORMATION

The EFL AWS supplies water to the east, west, and south fish ladder entrances in order to attract upstream migrating adult fish. Water is currently supplied to the AWS by two Fish Units (FU) located on the west end of the powerhouse.

With both FUs operating the total fish attraction discharge is approximately 5,000 cfs to the fish ladder. Presently, both fish units must be in operation to maintain full entrance flow criteria conditions. However, results of the recent operational testing of the fish units and the AWS Backup System (AWSBS) at the end of 2018 demonstrated the capability to provide minimum acceptable fish flow attraction water with only one FU operating in conjunction with the AWSBS. This testing confirmed that the AWS could be operated continuously during any season, 24/7, to reliably augment attraction flow of the FUs.

The Dalles AWSBS is a 10-foot diameter penstock through the concrete non-overflow dam designed to discharge at least 1400 cfs from forebay to the AWS conduit near the East Entrance of the ESL. The system includes a forebay intake and trashrack upstream of the dam penetration. After passing through the dam, the 10-foot penstock bifurcates into two 7-foot pipes, each equipped with 7-foot Butterfly valves for flow control. The initial design purpose was to serve as an emergency source of attraction water to operate only if both Fish Units were shut down. However as noted above, post commissioning testing also revealed that if a single FU went down, the added simultaneous operation of the AWSBS would provide significant improvements to the performance of the ESL fish ladder. The AWSBS was commissioned in 2018 and completed after a follow-on contract in 2020.

In November 2018, The Dalles AWSBS was successfully operated simultaneously with a single FU. The fish turbines and fish ladder were monitored during the tests and showed no adverse conditions developed in either system. The tests included the startup and shut down of the AWSBS while a FU was operating—which would represent a typical scenario following an outage of one of the fish units. The estimated combined discharge was 3,900-4,100 cfs. The East entrance met optimal entrance criteria, the West entrance met criteria marginally and the South entrance did not meet criteria. Given the results of the tests, the Portland District decided to operate the AWSBS in conjunction with one FU in an emergency situation when one of the two FUs is forced out of service during fish passage season.

Fish Unit Rehab, starting in the year 2028 ~~2027~~, requires the AWSBS to operate during construction to provide adequate flow for fish attraction. Fish Unit Rehab duration is one (1) year per unit for a total of two (2) years.

1.2.1 Trash Rake Design Removal During P&S

The Auxiliary Water Backup system was designed to provide a temporary (maximum 1 year) backup supply of water to the AWS, when both fish turbine units fail, and the normal 5000-cfs AWS flow is not available. A trash rake was considered in the DDR. The main reason that the trash rake design was removed during the P&S was that the possibility of both fish units failure was estimated to be 1.4 percent within 10 years, per a 2008 risk failure analysis report documented in DDR. The possibility of trashracks accumulating debris was considered to be low for the reasons listed below:

1. The depth of the inlet is approximately 50 feet.
2. River flow is parallel to the trashrack.
3. The debris will be cleared when the system is shutdown.
4. Initial cost and maintenance cost.
5. Fish Units trashracks are never raked.

1.2.2 Existing Trashracks

The existing trashracks were fabricated with 0.75 inch clear opening to prevent debris from accumulating in the AWS diffuser system and exclude adult lamprey from the AWS. The trashrack screen is made of standard platform grating with vertical bar opening of ¾" and horizontal bars with 2" spacing at the upstream side of the rack. The trashrack gratings are installed with angles and members that are not in the same plane as the gratings. The vertical bars do not form a continuous flat upstream surface. Thus, the trashrack and the framing are not a normal configurations to utilize a standard trash rake. See Figure 1-3, Figure 1-4 and reference drawing SK505.

The trashracks were designed for 5 feet head differential per EM 1110-2- 2400, Structural Design and Evaluation of Outlet Works.

Figure 1-3. The Dalles AWS Backup System Trashrack, Elevation

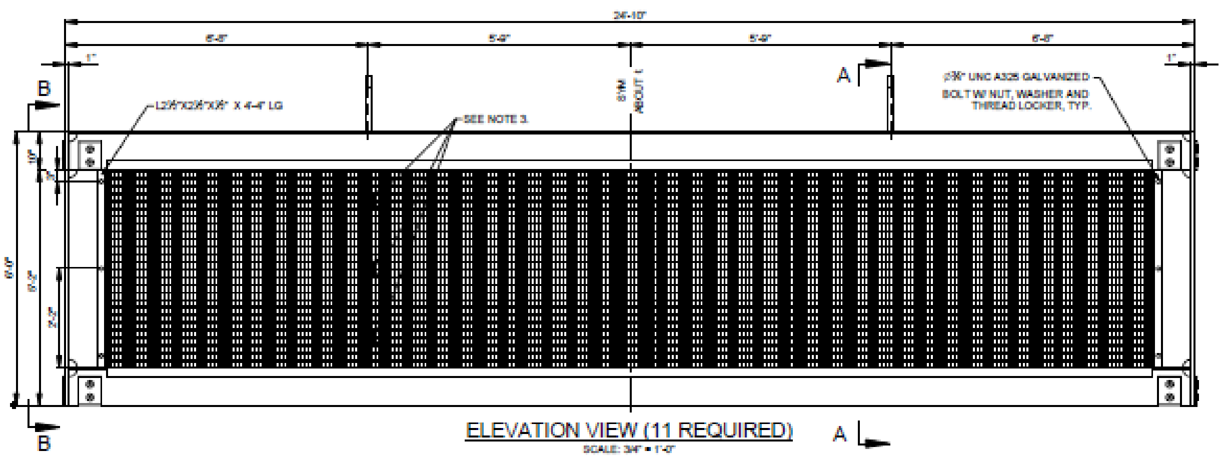
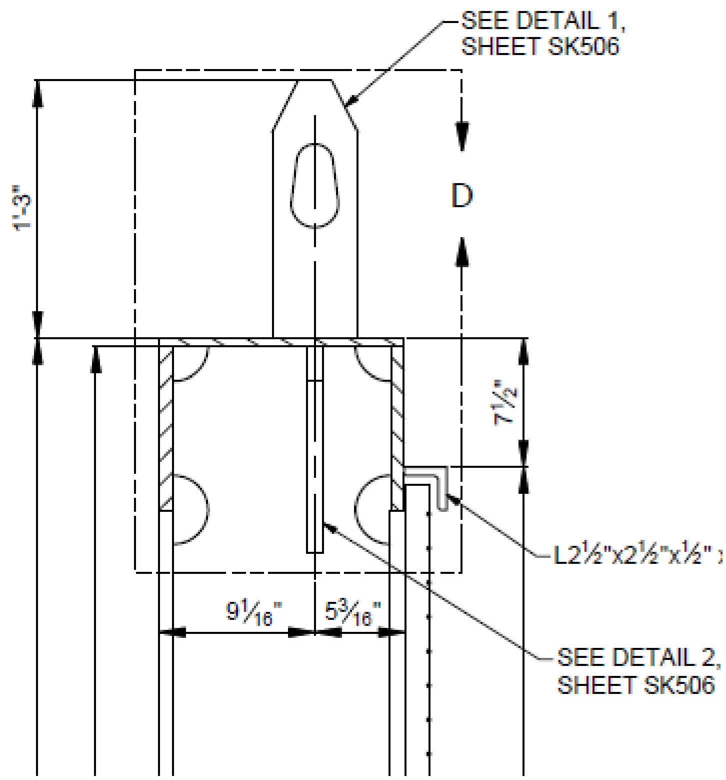


Figure 1-4: The Dalles AWS Backup System Trashrack, Section



1.2.3 Existing Trashrack Guides

The dewatering structure for AWS Backup system consists of precast units with guides for closure gate and bulkheads. The guides for the bulkheads are used for the trashracks also. The guides for the trashracks are vertical slots. The trashracks sit on a concrete slab at elevation 104 feet with a full pool elevation of 160 feet. See Figure **1-5**, Figure 1-6, and reference drawings SC202, SC203, and SK517.

Figure 1-5. The Dalles AWS Backup System Trashrack Dewatering Structure

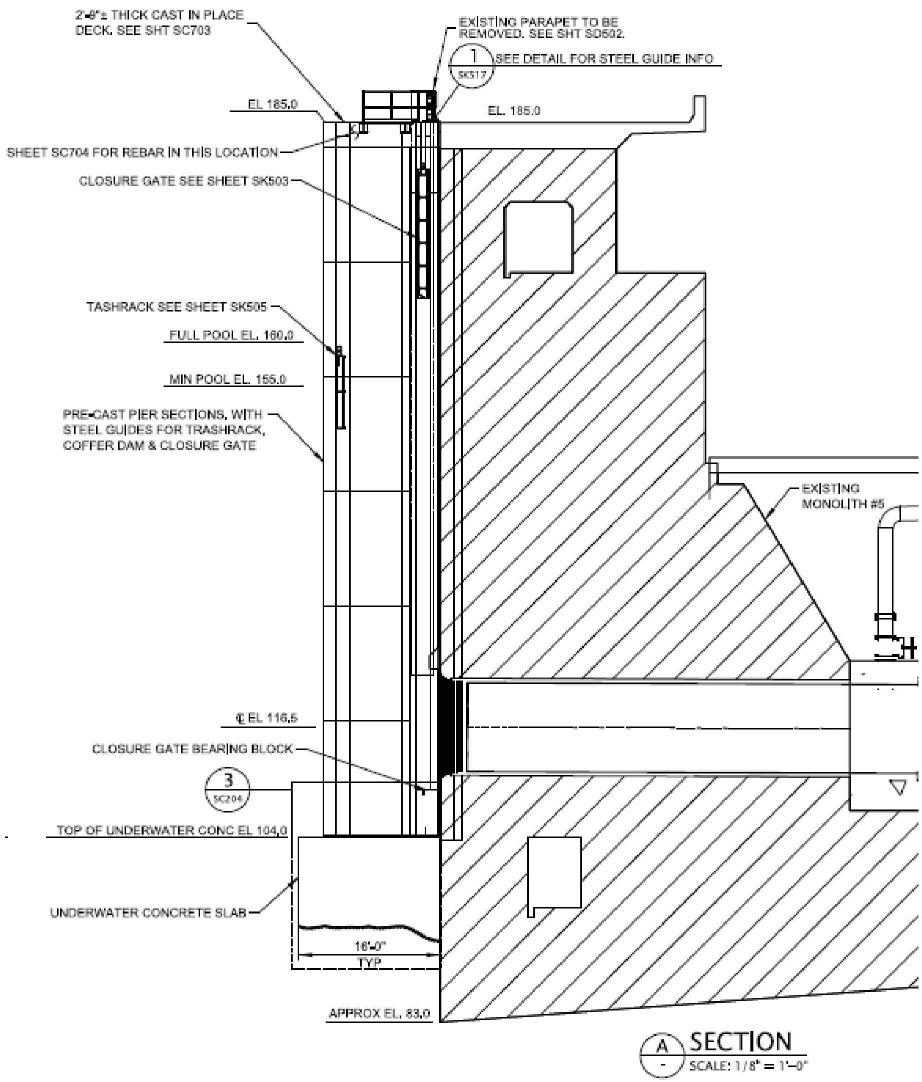
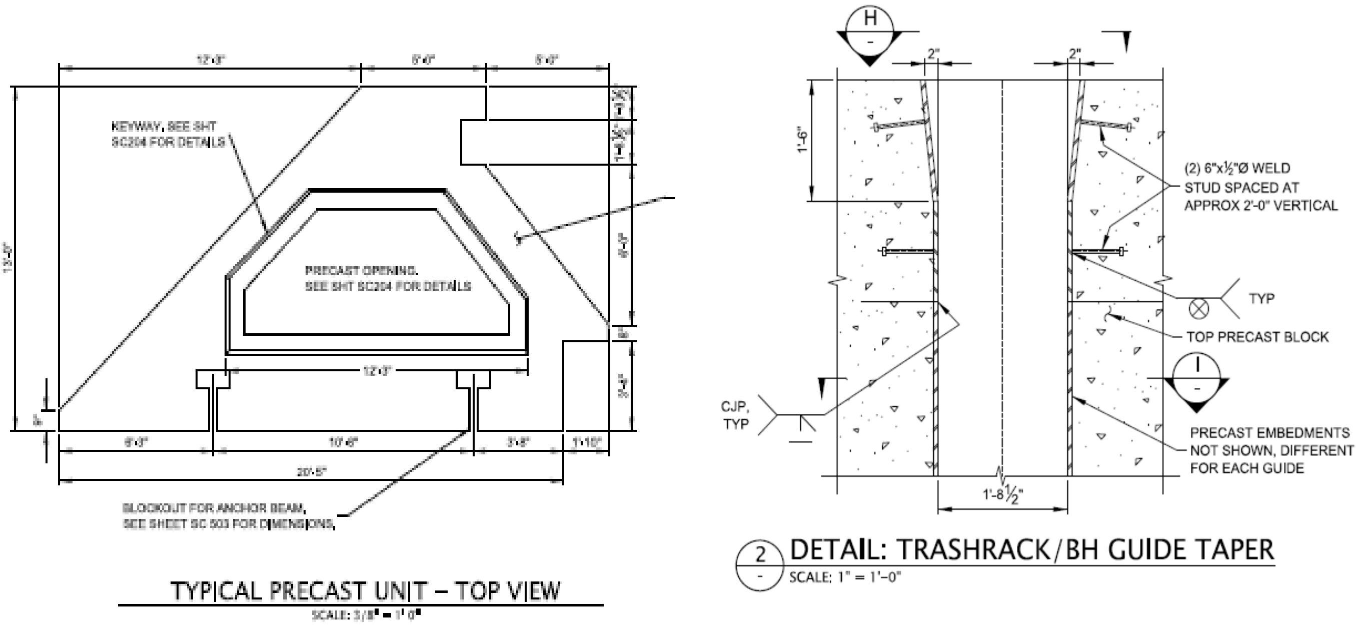


Figure 1-6. The Dalles AWS Backup System Trashrack Guide



1.3 PARTICIPANTS AND ROLES

Table 1-1. Participants and Roles

Office Code	Name	Title	Role
CENWP-ODT-F	Erin Kovalchuck	Project Manager	Project management
CENWP-ENC-DS	Mehdi Roshani	Team Lead Technical Lead	Day-to-day execution of project and coordination of technical disciplines
CENWP-ENC-DS	Norberth Marticorena	Structural Engineer	Design and analysis of trashrack debris management structural components
CENWP-ENC-DS	Erica Tarbox	Structural Engineer	Structural technical reviewer
CENWP-ENC-DM	Cole Marfise	Mechanical Engineer	Design and analysis of trashrack debris management mechanical components
CENWP-ENC-DM	Ryan Souders	Mechanical Engineer	Mechanical technical reviewer
CENWP-ENC-DE	Liana Lau	Electrical Engineer	Design and analysis of trashrack debris management electrical components
CENWP-ENC-DE	Gene Rimkeit	Electrical Engineer	Electrical technical reviewer
CENWP-ENC-HD	Steve Schlenker	Senior Hydraulic Engineer	Hydraulic design and flow analysis of trashrack debris management components
CENWP-ENC-HD	Laurie Ebner	Hydraulic Engineer	Hydraulic design and flow analysis technical reviewer
CENWP-ENC-C	Carolina Andes	Cost Engineer	Cost and construction of trashrack debris management components
CENWP-ENC-C	Jeff Sedey	Civil Engineer	Cost and construction technical

Office Code	Name	Title	Role
			reviewer
CENWP-OD-D	Bob Cordie	Biologist	The Dalles Dam POC and Biologist
CENWP-OD-D	Jeff Randall	Biologist	The Dalles Dam POC and Biologist
CENWP-PM-E	Rebecca Cates	Fish Biologist	Fish Biologist
CENWP-PM-E	Jon Rerecich	Fish Biologist	Fish Biologist and Fish Agencies liaison
CENWP-PM-E	Brad Eppard	Biologist	Biological document reviewer

SECTION 2 - CRITERIA AND CONSTRAINTS

The purpose of this section is to describe the design criteria, considerations, and assumptions used to develop, evaluate, and determine feasibility of alternatives for the evaluation of debris management for The Dalles AWS Backup system.

2.1 ENVIRONMENTAL AND CULTURAL RESOURSES CONSIDERATIONS

Environmental and cultural resources/historic properties protection and compliance should be considered during all design work and repairs. The Dalles Lock and Dam (TDA) is considered a *historic* structure by virtue of age (i.e., >50^{+} years old), being that construction began in 1952 and the complex was placed into service in 1957. The USACE completed a National Register of Historic Places (NRHP) eligibility evaluation for TDA in 2015 and determined that it meets multiple NRHP criteria for evaluation regarding the property's age, integrity, and historic significance. TDA is eligible for listing in the NRHP at the state level of significance under criteria A and C for association with the areas of *Conservation*, *Engineering*, *Ethnic Heritage* (Native American), *Industry* and *Transportation*. Until the determination is *officially* coordinated with the Washington Department of Archaeology and Historic Preservation (DAHP), Oregon State Historic Preservation Office (SHPO), Columbia River Treaty Tribes, Advisory Council on Historic Preservation (ACHP) and other interested parties pursuant to 36 CFR 800, as amended, TDA shall be treated as eligible for the NRHP. Furthermore, efforts will be made, per compliance with the National Historic Preservation Act (NHPA) and other related cultural/historic resources protection laws and regulations, to ensure evaluation and protection of significant cultural and historic resources that may be impacted by any proposed TDA redesigns, structural modifications and other work activities associated with to-be-determined AWS Backup system debris management alternatives and activities. Any proposed repair, maintenance, alteration, or replacement of TDA's various operational components, including installation of in-water features or other physical modifications, will be evaluated to determine if and how such activities may affect the historic significance of the TDA property, its contributing components and/or other cultural resources, historic properties, or areas of cultural significance located in the immediate vicinity. As appropriate, all design and repair work, locations, potential impact perimeters and determinations of effect expected to result from the planned project activities will be consulted with the DAHP and SHPO, affected Native American Tribes/Tribal Historic Preservation Offices (THPOs) and any other interested parties, per compliance with NHPA, prior to commencement of any physical alterations or associated ground-disturbing work. The USACE will ensure that concurrence with all work plans and determinations of effect have been achieved prior to the project implementation, and, that any necessary cultural/historic resources avoidance or agreed-upon mitigation measures are implemented throughout the course of the project.

2.2 BIOLOGICAL CRITERIA AND CONSTRAINTS

This alternatives study will comply with the National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), 2020 Columbia River System (CRS) BiOp.

Anadromous salmonid and lamprey passage criteria for the backup AWS, the primary fish of concern with respect to operation of the EFL, were described in the DDR, The Dalles East Fish Ladder Auxiliary Water Backup System, Prepared by the U.S. Army Corps of Engineers, Walla Walla District January 2014.

The criteria for adult and juvenile salmon passage is taken from the *Anadromous Salmonid Passage Facility Design* Report (NMFS 2011 & 2022).

Passage criteria specific to The Dalles Dam and EFL is provided in the *Fish Passage Plan* (USACE 2022). The Fish Passage Plan (FPP) is a document published annually by the USACE Northwestern Division that includes descriptions of the juvenile and adult passage facilities as well as their operating criteria and maintenance. This includes spill management, adult ladder and juvenile passage facilities operating criteria, and turbine unit operations and maintenance. The FPP is regionally coordinated through the Fish Passage Operations and Maintenance (FPOM) technical work group with members including the Action Agencies, Federal, State, and Tribal representatives.

Chapter 3, Section 1.2.1.1 of the 2022 FPP has criteria specific to the backup AWS and maintenance of adult fish facilities, “A backup auxiliary water supply, unscreened for juveniles, can provide 1.5 kcfs if needed. The backup system can be used in conjunction with a single fish unit. Annual maintenance of adult fish facilities is scheduled during the winter maintenance period (December through February) to minimize impacts on upstream migrants. One ladder is dewatered at a time unless otherwise coordinated through FPOM.”

Lamprey criteria continue to evolve as new information is acquired and are under development by the scientific community specific to lamprey passage.

Agency Coordination

Alternatives will be reviewed by regional fish and wildlife agencies through the Fish Facility Design Review Work Group (FFDRWG). The 30/60/90% EDR milestones will be distributed to FFDRWG representatives. USACE shall provide written responses to agency comments during EDR reviews. Comments received are documented in Appendix E.

Fish Passage Background at The Dalles Dam

The Dalles Dam has two primary fish ladders referred to as the North and East Fish

Ladders (EFL). The EFL has east, south, and west entrances for upstream migrating fish. The east entrance leads directly to the EFL. The south and west entrances direct fish into channels that pass along the downstream side of the powerhouse and join the EFL upstream of the east entrance at a junction pool. Fish exit the EFL (Fig. 1-1 and 1-2) in the forebay upstream of the powerhouse to the east and in close proximity to the backup AWS intake.

Species of fish migrating past The Dalles Dam include Chinook (*Oncorhynchus tshawytscha*), Coho (*O. kisutch*), and sockeye (*O. nerka*) salmon, steelhead (*O. mykiss*), Pacific lamprey (*Entosphenus tridentatus*), white sturgeon (*Acipenser transmontanus*), and American shad (*Alosa sapidissima*). Bull trout (*Salvelinus confluentus*) have also been observed occasionally in the fish ladders. Upstream migrants are present at the dam year-round, whereas downstream migrating juvenile salmonids and shad are present primarily from April through November.

<u>Adult Salmon</u>

Table 2-1 is from the 2022 Fish Passage Plan and includes The Dalles Dam adult fish count period with the earliest and latest peaks in passage timing.

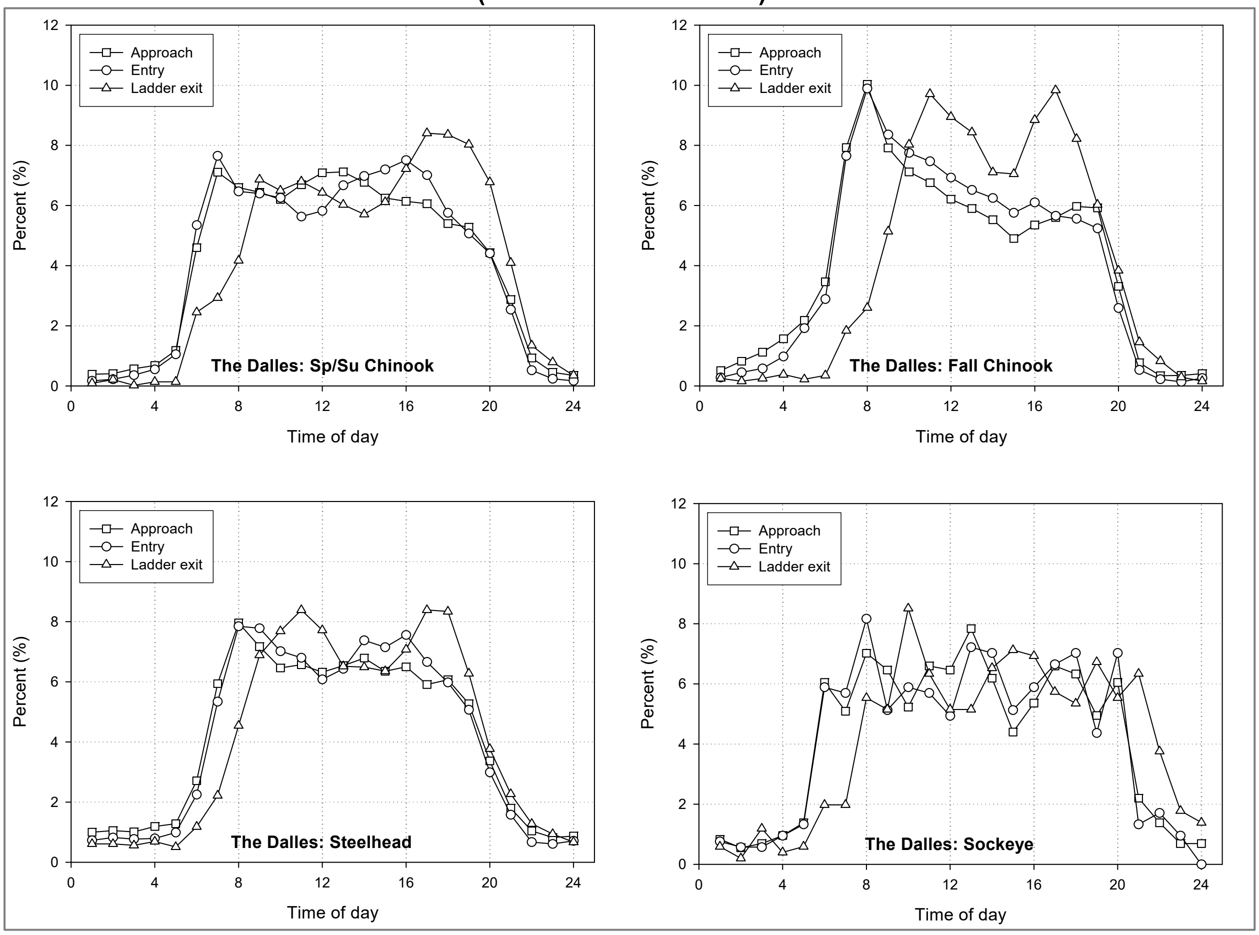
Table 2-1. The Dalles Dam Adult Fish Count Period and Peak Passage Timing (based on yearly counts since 1957, except lamprey since 2000).

Species	Count Period	Earliest Peak	Latest Peak
Spring Chinook	Apr 1 – Jun 3	Apr 13	May 23
Summer Chinook	Jun 4 – Aug 3	Jun 6	Aug 1
Fall Chinook	Aug 4 – Oct 31	Sep 2	Sep 23
Sockeye	Apr 1 – Oct 31	Jun 20	Jul 10
Steelhead	Apr 1 – Oct 31	Jul 9	Sep 23
Coho	Apr 1 – Oct 31	Sep 3	Oct 25
Lamprey	Apr 1 – Oct 31	Jun 29	Aug 1

The Dalles Dam is the second dam in the system, and therefore affects many fish, including all seven interior basin Evolutionarily Significant Units. Regardless of operation, most salmonids pass via the East ladder. This indicates that an east ladder attraction water outage would lead to passage delay and blockage of fish which may result in impacts such as adult passage delay, Zone 6 harvest issues, sport fishery effects, hatchery returns, reduced adult lamprey passage success and blocked sturgeon passage. The backup AWS system provides the ability to maintain emergency 1400 cfs flow out of the east entrance of the EFL. This entrance of the EFL has the highest passage proportions of adult migrating salmonids and was a significant consideration of the design and operation of the backup AWS.

Diel passage timing of adult salmonids typically occurs during daylight hours. Figure 2-1 from the 2022 Fish Passage Plan displays approach, entry, and ladder exit percentages by time hour of the day for Spring/Summer Chinook, Fall Chinook, steelhead and sockeye at The Dalles Dam.

Figure 2-1. Diel Distribution of Adult Salmonids at The Dalles Dam Fishway Entrances and Exits (Keefer & Caudill 2008).



Juvenile Salmon

Approximately 80 percent of juvenile salmonids pass over the spillway (Johnson et al. 2007). Many others pass through the ice and trash sluiceway, with the remainder passing through turbines. Studies conducted in spring 2010 and 2011 by Ploskey et al., 2012 provided estimates of route specific passage proportions and survival of acoustic tagged juvenile Chinook and steelhead at The Dalles Dam. A virtual paired release model was used to estimate route specific survival rates in both years. Table 2-2 are 2010 and 2011 passage proportions and survival with standard errors (SE) by route for spring Chinook (CH1) and steelhead (STH) smolts at TDA.

Table 2-2. Route specific passage proportions CH1 and STH at TDA 2010 and 2011.

Species	Route	2010 Passage Proportion	SE	2010 Survival	SE	2011 Passage Proportion	SE	2011 Survival	SE
CH1	Sluiceway	0.106	0.0068	0.993	0.015	0.173	0.0058	0.991	0.0078
CH1	Spillway	0.841	0.0081	0.966	0.0099	0.658	0.0073	0.961	0.0075
CH1	Turbines	0.053	0.0050	0.876	0.0355	0.169	0.0057	0.930	0.0117
STH	Sluiceway	0.077	0.0059	0.944	0.0204	0.138	0.0053	1.010	0.0092
STH	Spillway	0.877	0.0073	0.958	0.0098	0.754	0.0066	1.004	0.0083
STH	Turbines	0.046	0.0046	0.888	0.0339	0.109	0.0047	0.919	0.0165

To enhance north ladder upstream passage during an east ladder AWS outage where both fish units and the backup AWS are not operable for a significant period of time, spill patterns developed for juveniles would likely need to be altered. Spill pattern and powerhouse operations changes to assist adult passage may result in decreased juvenile survival by changing passage proportions and survival through the various routes of passage.

Adult Lamprey

A significant portion of lamprey passage into ladder systems at The Dalles and mainstem dams occurs at night (FPC 2022). Salmon tend to continue to search for migration paths upstream when faced with obstacles to migration at mainstem dams such as suboptimal hydraulic conditions whereas lamprey are not as persistent in their fishway approach and entry attempts. Fishway entrance retention can be a problem for lamprey at mainstem dams (Moser et al. 2002a & 2002b).

University of Idaho Technical Report 2012-8, *ADULT PACIFIC LAMPREY PASSAGE: DATA SYNTHESIS AND FISHWAY IMPROVEMENT PRIORITIZATION TOOLS,* summarized data on Pacific lamprey that were detected at The Dalles Dam or in The Dalles tailrace over ten years (1997-2002, 2007-2010). A total 652 unique radio-tagged lamprey approached monitored fish ladder entrances a total of 2,096 times at The Dalles Dam for a combined total of 3.2 fishway approaches/lamprey. The distribution of first fishway approach sites averaged 28% at the east entrance, 21% at the west entrance,10% at the south spillway entrance, and 36% at the north entrance; another 5% were at the East Fish Ladder, but exact entrance locations were unknown. Distributions of total approach events were very similar to first approaches.

A total of 597 unique radio-tagged lamprey entered monitored fishway entrances a total of 1,123 times at The Dalles Dam for a combined total of 1.9 fishway entries/lamprey. The distribution of first fishway entry sites averaged 28% at the east entrance, 14% at the west entrance, 8% at the south spillway entrance, and 36% at the north entrance; another 14% were at the East Fish Ladder, but exact entrance locations were unknown. Distributions of total entry events were very similar to first entries.

Unique lamprey entrance efficiency varied widely among the four fishway entrances monitored at The Dalles Dam, and among years at each entrance. Efficiency was lowest at the west entrance (*median* = **0.47**, *n* = 9 years) and at the south spillway entrance (**0.64**, *n* = 9). Median estimates were highest at the east (**0.76**, *n* = 9) and north (**0.89**, *n* = 9) entrances.

In 2018 and 2019, a University of Idaho adult lamprey research and monitoring project addressed experimental reductions in nighttime fishway entrance velocity at The Dalles dam. Nighttime entrance water velocities were altered between ‘normal’ and ‘reduced’ conditions in a randomized block design from 1 June to 31 in the east fishway in 2019 (similar to 2018 operational protocols). At The Dalles East Fish Ladder, the two target head differences were 0.45 m for the control condition (normal) and 0.21 m for the treatment condition (reduced). In a previous study by Johnson et al. (2012), head differentials in this range at Bonneville Dam corresponded to mean fishway entrance velocities of >1.96, and 1.2 m sec-1, respectively. On nights when the reduced velocity occurred, the operation was for six hours from 22:00 h to 04:00 h. At The Dalles Dam, the east entrance weirs were adjusted to alter the entrance slot geometry and thereby head and velocity at the entrance during nighttime (i.e., there were no changes in discharge and the experimental effects were restricted to the entrance areas).

Of the 116 double-tagged lampreys detected approaching a fishway in 2019, 109 entered, and 51 subsequently exited back into the tailrace one or more times. The highest percentage of tagged fish made their first approach at the North Fish Ladder (55%), followed by the east (25%), west powerhouse (14%), and south spillway (6%) entrances. Slightly less than 60% of all first entries occurred at the North Fish Ladder entrance, followed by the east (24%), west powerhouse (11%), and south spillway (6%) entrances.

Double-tagged lampreys that approached fishways in 2019 were significantly more likely to enter The Dalles Dam east fishway during the reduced velocity treatment than during the ‘normal’ treatment, which was consistent with the 2018 experimental results at the same location.

The debris management alternatives evaluation should consider the AWSBS operations and their potential impacts to lamprey passage at fish ladder entrances.

<u>Juvenile Lamprey</u>

Information is limited at The Dalles Dam regarding downstream migrating ammocoetes and juvenile Pacific lamprey passage behaviors but it is highly likely that they are present during the winter and spring (and to a lesser extent in the summer) based on what is known about their outmigration and their temporal presence at John Day Dam (JDA) upstream and Bonneville Dam downstream, both equipped with screened bypass systems that monitor passage of salmonids and other species including juvenile lamprey. Significant numbers of juvenile lamprey have passed through the screen bypass system and collected at the JDA through the Smolt Monitoring Program. These bypass systems have been evaluated for fish guidance efficiency (FGE) that included run-of-river juvenile lamprey fyke net catch data. NMFS John Day Dam FGE evaluations and lamprey catches occurred during the spring study periods. Vertical distribution of juvenile lamprey collected in the screened bypass and fyke nets of the JDA Units 6 and 7 intakes appear to be opposite that of juvenile salmon out-migrating during the same time period where the vast majority of lamprey passed low in the water column under the screens (Brege et al., 2001 and 2004).

East Fish Ladder Auxiliary Water Supply

The two Fish Unit AWS water turbines are more than 50 years old, and there is currently no way to complete a turbine rehabilitation without taking the east ladder out of criteria. A reliable backup AWS debris management system and use of the back-up AWS with a single Fish Unit would allow Fish Unit rehab, one unit at a time, while being close to maintaining ladder criteria per the FPP. One Fish Unit and the backup AWS will provide approximately 4000 cfs of the 5000 cfs supplied by both units. A debris management system will provide reliability in allowing approximately 1400 cfs to be provided to the east entrance of the EFL if there is a failure of the operating unit during Fish Unit rehab. Following rehab, use of the backup AWS would be beneficial during the infrequent occurrence of a single or dual Fish Unit outage or when Fish Units are operating at reduced flow capacity. Based on post construction debris loading information collected during FFDRWG and FPOM coordinated backup AWS run-time evaluations (Section 2.3.3), the backup AWS and adult passage would benefit with a reliable debris management alternative.

2.2.1 Criteria

During development of the AWSBS DDR coordination in 2014, NMFS did not require juvenile fish screen criteria to be enforced at the intake. This is because the existing back-up AWS design minimizes entrainment potential of listed juvenile salmon due to the depth (40-45 feet) of the AWS backup system intake. Also, the location in the forebay is much less likely to entrain juvenile salmon. The existing 0.75” trashrack clear spacing is being carried forward as a design criterion for maximum clear spacing for alternatives in this EDR.

2.2.2 Constraints

In Water Work (IWW) Period

The general the IWW period established for construction and installation of an alternative is December 1st through February 28th of the designated work seasons. The Fish Passage Plan Section 2.1.1. (2022) states “Research, non-routine maintenance, fish-related activities, and construction will not be conducted within 100’ of any fishway entrance or exit, within 50’ of any other part of the adult fishway, or directly in, above, or adjacent to any fishway, unless coordinated with FPOM or FFDRWG by the Project, District Operations and/or Planning or Construction office”. The construction timeline, diving and use of floating plants stationed near the east fish ladder exit, or excessive noise and vibration during construction within 50’ proximity to the ladder structures may be considerations during alternatives evaluation when evaluating ease of implementation of an alternative and impacts to fish passage.

Fish Ladders

Debris management alternatives shall not be stationed near or block the flow into or egress from any operating Fish Ladder exit when the ladder is in service. A clear flow path along the shore shall be maintained at all times such that fish exiting the ladder are not delayed in reaching the forebay and migration upriver.

Trashracks

As mentioned in Section 1.2.2, the vertical bar opening of ¾" should be maintained for adult lamprey exclusion and prevent debris from accumulating in the AWS diffuser system. While adult fish interactions with the AWSBS intake structure are likely to be minimal, the entrainment and fallback of adult fish is not possible with the existing design. During tests at Bonneville Dam, no adult lamprey were able to pass through grating with ¾-inch spacing (Moser et al. 2007). Fallback of adult Pacific lamprey at the Dalles Dam was lower for those using the EFL (2.6 percent) than the north fish ladder (11.8 percent) (Clabough et al. 2011). Adult Pacific lamprey can achieve short-term burst speeds exceeding 12 fps (Moser et al. 2002b); therefore, impingement on trashracks is not a concern. Maintaining the fine trashrack spacing criteria will exclude adult salmonids and lamprey from physically entering the AWSBS intake.

The maximum 5-foot head differential will also stay the same for any screen option.

Design Flow

The design elevation and location of this AWSBS intake is sufficiently low in the water column with velocities low enough to minimize the potential for adult and juvenile salmonid as well as lamprey attraction to the structure. Design flow velocities upstream of the trashracks should not appreciably increase with alternatives.

Edges

Features of alternatives that are permanently installed in water should have rounded edges to reduce the potential for contact injury of fish.

2.3 OPERATIONS CRITERIA AND CONSTRAINTS

Many factors can contribute to complications in the overall operation and maintenance of any additional system installed on the AWSBS. These need to be considered through the selection process.

2.3.1 Criteria

The entire east fishway is inspected to assure compliance with Fish Passage Plan criteria. During AWSBS operation, the intake will be inspected by a fisheries biologist 7 days/week as part of routine daily fishway inspections. A tape or laser measure will be used to compare water level upstream and downstream of the trashrack. If AWSBS intake differential is >2’, the AWSBS will be closed and reopened to float off debris.

A cleaning system or operation that can be applied 24/7 is preferred, so an operator can take necessary steps on nights and weekends. However, realizing this may be cost preventative, a system requiring other disciplines (crane operator and riggers) may be necessary.

2.3.2 Constraints

The forebay deck needs to remain open to deck traffic, so as not to interfere with ongoing dam operation and maintenance functions.

Project fisheries operations and maintenance (O&M) budget does not account for additional equipment maintenance. A new system should have minimal annual maintenance expenditures.

Long term consequences of the solution should be considered in the design and evaluation of the alternatives. As the debris management system will be needed primarily for 2 years during fish unit rehab, a large complex and high-cost alternative with significant O&M burden that is rarely used following fish unit rehab should be considered when selecting the preferred alternative.

2.3.3 AWSBS Operations Data

AWSBS Operations and on/off cycle for debris flush out and the outage duration are being collected and monitored. See Table 2-3. This table will be updated as the information changes.

Table 2-3. AWSBS Operation Data

Dates	Days	Reason	Debris cycle	Differential	River Q highest day Avg
1/17/19-2/8/19	22	Valve 10 vibration	no	OK	142K
3/21/19-3/31/19	10	Valve 7 flooding	no	OK	185K
4/2/19-4/8/19	6		no	OK	202K
2/5/20-2/10/20	5	FU breaker replace	yes, 2/9 (12hr)	3'	222K
2/25/2020	1	commissioning	no	OK	159K
6/12/20-6/29/20		F1 pump plate	yes, 6/18 (12hr) and 6/24 (8hr)	2' and 2.5'	320K
2/16/21-2/17/21			no	OK	
4/6/21-4/21/21			no	OK	

4/21/21-5/19/21		FU grounding repair	yes 5/11 (1 hr) and 5/18 (1/2hr)	1.5' and 1.3'	200K
8/9/21-8/11/21			no	OK	
8/16/21-8/19/21			no	OK	
4/26/22-4/28/22			no	OK	
11/26/22-12/1/22	5	ROV inspection of AWSBS Trashracks and FU1 Trashracks	no, 9 hours of float time before ROV inspection	11/27: 0.3' 12/1: 0.6'	

On December 1st, 2022, a remotely operated vehicle (ROV) recorded video of the AWSBS trashrack panels after approximately 5 days of consistent operation. The video was taken nine hours after shutdown of the system. More debris than expected was seen on the panels. A full writeup and analysis, including still images from the video can be seen in Appendix I.

2.4 HYDRAULICS CRITERIA AND CONSTRAINTS

This section describes the criteria and constraints for the hydraulic design of the new of The Dalles AWSBS trashrack/trash rake system and other potential debris management alternatives.

2.4.1 Design References

This section outlines the hydraulic design criteria for the design of structural/mechanical components.

a. Blevins (2001 reprint), Flow Induced Vibration

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2.4.2 Criteria

2.4.2.1 Trashrack Flow Rates

a. Minimum design flow rate per DDR (USACE 2021 Draft) = 1400 cfs.

b. Estimated range of operating discharge through trashrack:

   1440 – 1600 cfs

c. Flow changes resulting from modifications:

- System flow rates shall not be reduced by more than 10 cfs.
- This flow restriction translates to an added headloss of 1 foot.
  - This represents a limit in the increase in the systemic headloss as the result of modifications to the trashrack, added piping and/or porosity plate; and/or any new upstream structure.
- The 10 cfs flow reduction limit is based on the following assumptions:
  - Minimum forebay = 155 ft NGVD 29
  - Maximum design AWS conduit Water level = 89.5 feet
  - System design head loss coefficients increased by 5%
  - Computed AWS discharge = 1410 cfs.
  - Minimum AWS discharge per criteria = 1400 cfs
  - Net difference: 10 cfs.
- Any proposed modifications should not cause an increase the intake velocities at or near the surface. (Increased surface velocities could entrain juvenile fish.)

2.4.2.2 Trashrack approach velocities:

a. Average over intake opening: 1.2 – 1.3 ft/s

b. Average through screen openings: 1.7 – 1.9 ft/s

c. Estimated local maximum near Intake: 2.5 – 4.5 ft/s
(1) At approximately 40 feet depth

Concerns regarding juvenile fish entrainment were addressed in the Biology Section of the original TDA AWS BS DDR (USACE draft 2021). The risks were identified as low given more than 80% of the juvenile fish are distributed within the upper 30 feet of the water column. Adult salmon and lamprey were not expected and have not been observed to be impinged upon the trashrack, given the intake is located downstream (approximately 65 feet) and deeper (more than 30 feet) the fish ladder exit to the forebay.

2.4.2.3 Trashrack Loads:

The potential loads on a trashrack include drag loads on the trashrack members and head differential acting on the trashrack.

The drag loads are estimated from the maximum potential velocity through a clean trashrack. The following equations apply concerning velocity and drag loads:

- $V = \frac{Q}{A_i \cdot P}$
  - V = velocity passing trashrack members
  - Q = maximum flow through trashrack
  - A_i = area of intake opening
  - P = porosity of trashrack opening
- $FD = \frac{\rho \cdot CD \cdot A_m V^2}{2}$
  - ρ = density of fluid
  - CD = drag coefficient based on shape of member
  - A_m = projected area of member exposed to flow

There is different guidance on maximum head differential criteria for trashracks. EM 1110-2-2400 requires 5 feet of head differential. EM 1110-2-3001 (pertaining to Hydropower trashracks) requires 20 feet of head differential. Recommend the following criteria on head differential criteria:

- 5-feet head; IF either
  - trashrack is equipped with trash rake or
  - trashrack is easily accessible for routine manual cleaning

        - Trashrack is visible from surface where debris accumulation and head drop across the trashrack can be observed.
        - Other features that may permit the 5-foot head differential:
            - Travelling screen
            - Air burst or water jet system
            - Brush cleaning system
    - 20-feet head assuming none of the conditions for 5-foot head are met, such as a deep intake.
    - Different criteria may be applied based on-site specific conditions, such as 50% blockage.

- In coordination with Structural Design, the design head differential is 5 feet.

2.4.2.4 Trashrack Vibration:

The bars and members of the trashrack are exposed to potential fluid induced vibration and thus should be evaluated for vibration under maximum flow conditions.

The goal of a vibrational analysis is to determine a design that will prevent the vortex shedding frequency (fv) from resonating with any of the natural frequency (fn) modes of the bar. One way to determine this is by using the frequency ratio (FR = fn/fv), which compares the fundamental frequency (first mode) to the vortex shedding frequency. There is limited documentation on an appropriate frequency ratio. Recommendations vary between 2 - 5. An important factor of consideration was that previous analyses of the existing John Day Powerhouse trashracks (A. Williams, CENWP-ENC-HD, June 2018) showing that 50-year old (baseline) bars have held up under a range of frequency ratios (FR) of 3.54 - 1.94 between 1% lower and 1% upper limits of the powerhouse, using pinned-pinned support assumptions. On the summation of the above information, the following criteria is recommended:

- $FR = fn/fv \geq 3$
- In which:
    - fn = natural frequency of structural member exposed to flow (hertz)

$$fn = \frac{\lambda^2}{2\pi \cdot L^2}\sqrt{\frac{E \cdot I}{m}}$$

    - λ = assumed boundary condition based on rigidity of supports
        - pinned-pinned (λ = π) is default
        - Less conservative assumptions are contingent on structural consent:
            - pinned-fixed (λ = 3.927)
            - fixed-fixed (λ = 4.730)

  - L = unsupported length between supports (including crossing members)
  - E = modulus of elasticity of material of members
  - I = moment of inertia about the axis parallel to the flow direction.
  - m = mass of member + added fluid mass, per unit length

- fv = forcing frequency from fluid flow (hertz) $fv = \frac{V \cdot S}{t}$
  - V = average velocity passing members
  - S = Strohal number based on member geometry and Reynolds number
  - t = thickness or width of bar or member perpendicular to flow

The existing trashrack does currently meet vibration criteria stated above. In general, factors that improve resistance to vibration include the following:

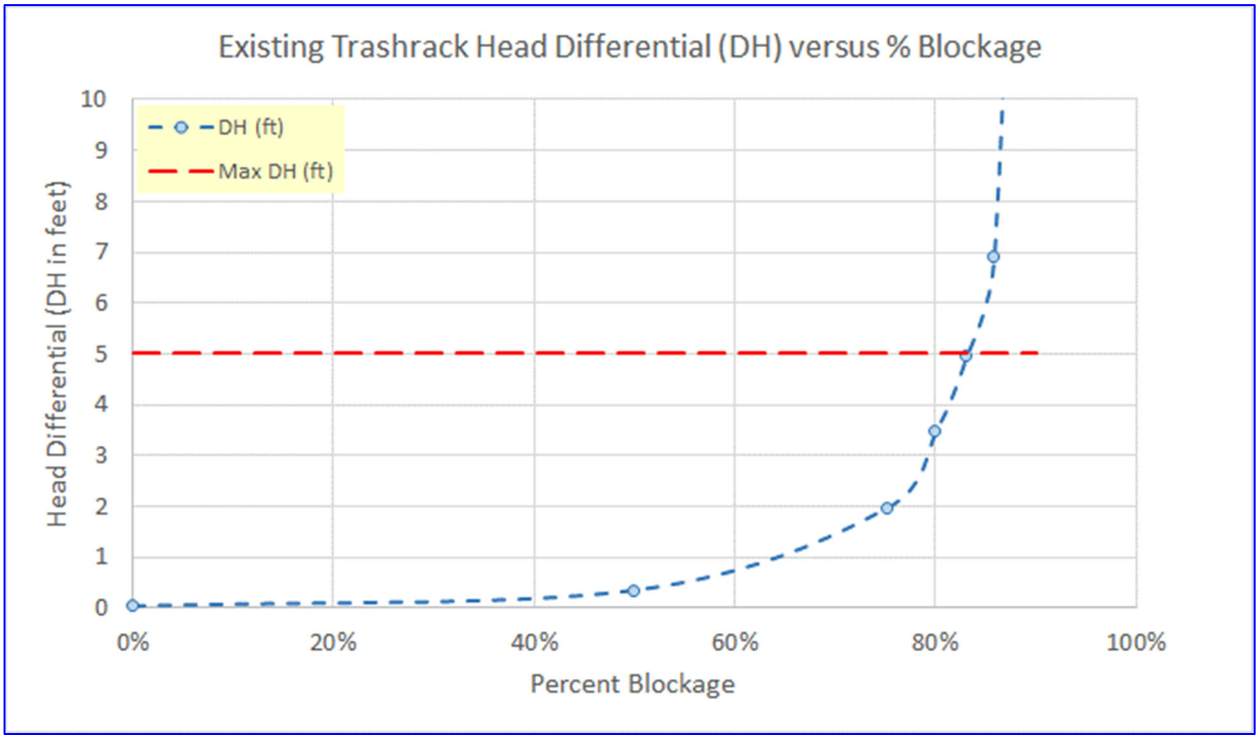
- Increased natural frequency (i.e. inertia) of bars (e.g. bar thickness)
- Reduced spacing of support bars or beams
- Reduction of maximum velocities through bars.

None of the above are required for the existing screens.

2.4.3 Constraints

The maximum allowable head differential due to trash blockage for the existing trashrack is 5.0 feet per EM-1110-2-2400. This corresponds to an estimated 83% blockage. The estimated head differential (in feet) versus percent of existing screen opening area that is blocked is shown in Figure 2-2.

Figure 2-2. Existing Trashrack Head Differential versus Percent of Blockage



The existing clean screen porosity is 70%. Trashrack modifications should not reduce porosity by more than 10% unless a cleaning mechanism is installed.

The calculation for head loss and vibration analysis for the existing trashracks is included in Appendix C.

2.4.4 The Dalles Project Hydrologic Conditions

The following section describes the general hydrologic conditions throughout the calendar year. The water elevations are provided in National Geodetic Vertical Datum NGVD 29.

2.4.4.1 Forebay Elevations

The forebay elevations are controlled by the difference between Project inflow and discharge operations. The forebay does not follow any seasonal trends and primarily varies due to operational discretion and power operations.

- Minimum 155 feet
- Maximum 160 feet
- Median 158.8 feet
- Normal range 157.0 to 159.5 feet
- Forebay is within the normal range 98% of time based on daily forebay data collected between 1990 and 2021.

The maximum forebay is 178.4 feet under the probable maximum flood (PMF = 2,060,000 cfs) regulated by the Columbia River dam system.

2.4.4.2 River Flow Rates and Discharge Duration Curves

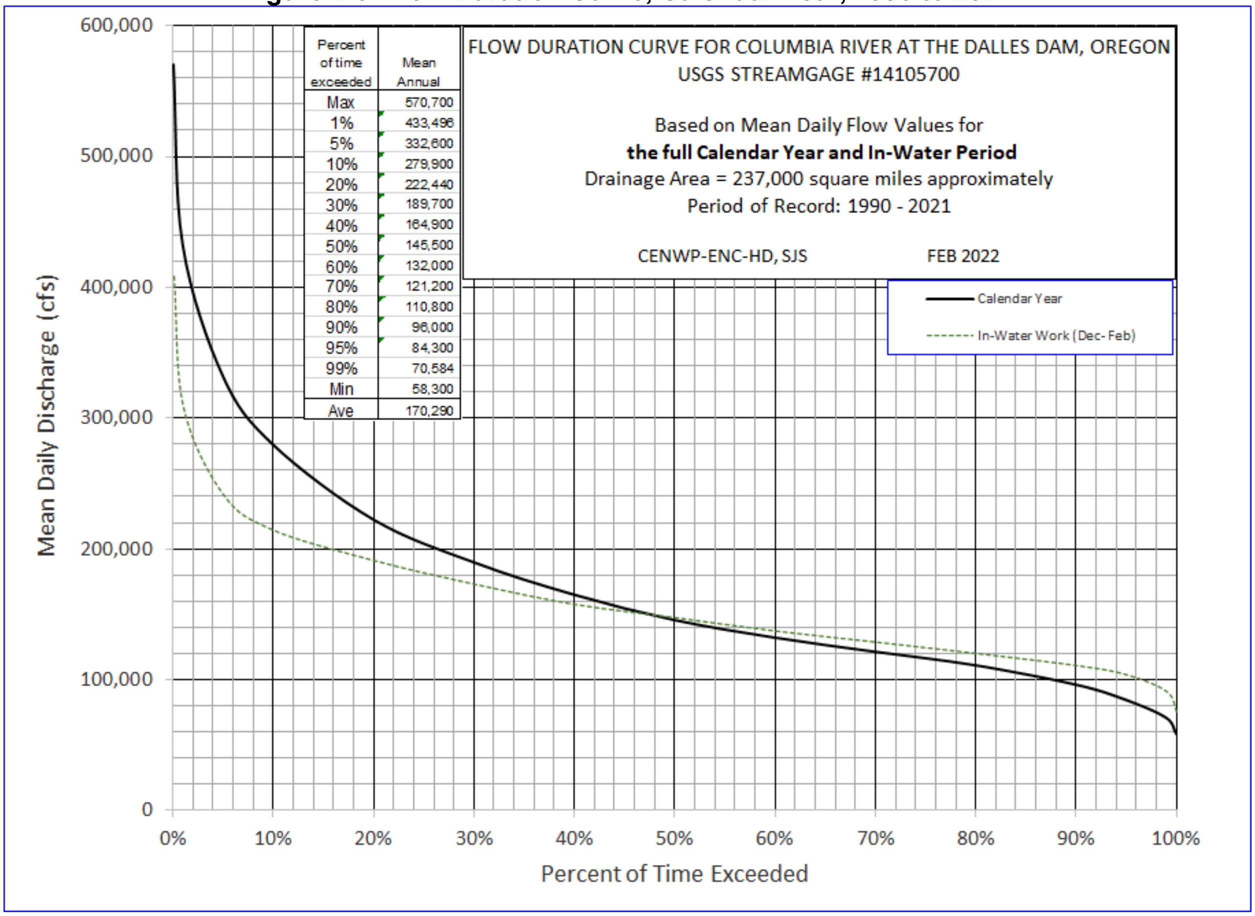
Pertinent mean daily river flow rates over the year (record 1990 to 2021) include:

- Minimum 58.3 kcfs
- 95% exceedance 84.3 kcfs
- 90% 96.6 kcfs
- 70% 121.2 kcfs
- Median (50% exceedance) 145.1 kcfs
- Average annual 170.3 kcfs
- 30% 189.7 kcfs
- 10% 279.9 kcfs
- 5% exceedance 333.6 kcfs
- Maximum 570.7 kcfs

The Dalles Dam river flow duration curves are defined as the flow rate versus percent of time exceeded on a daily or hourly basis. Figure 2-3 provides a chart showing daily discharge versus percent of time (days) in which the project discharge was exceeded during the calendar year. This chart is based on a mean daily discharge record from 1990 to 2021.

The flow rates during a 24-hour day can vary as much as 120,000 cfs. The flow changes cause larger stage variations in the tailrace rather than the deeper forebay. The flow variations are caused by changing power operations and adjustments from upstream dams.

Figure 2-3. Flow Duration Curve, Calendar Year, 1990 to 2021



2.4.4.3 Annual Exceedence Probability (AEP) Events

The annual exceedence probability (AEP) discharge events are listed below, mostly for regulated (by the upstream dam system) conditions.

	(kcfs)
• 2% AEP, or 50-year return	635
• 1% AEP, 100 year	680
• 0.2 % AEP, Spillway Project Flood (regulated), 500 yr	840
• 0.1 % AEP, 1000 year	1,000
• SPF (unregulated)	1,580
• PMF (regulated)	2,060

2.4.5 River Conditions around AWS Backup System Intake

The TDA AWS backup System DDR noted that a protruding earthen embankment location upstream of the intake creates a hydraulic shadow from the river flow. Surface velocity observations show active flow appears from the edge of the earthen dam protrusion in the river and eddies back to the dam, as shown in Figure 2-4. Eddies shed off the active flow into the shelter, creating stagnant and sometimes upstream flow at the face of the dam near the intake.

Figure 2-4. River Surface Velocity Observation

In 2014 and 2014, prior to the construction of The Dalles AWS Backup system, the river current velocities were measured in an approximately 200-feet longitudinal x 320-feet lateral grid pattern surrounding the future intake location. Acoustic doppler current profile (ADCP) data were collected during the following times and conditions in order to anticipate diver working conditions:

Prototype data was collected at the proposed AWS intake in November 2014 and April 2015 using an ADCP survey from 20 – 300 feet out (northward) from the dam face.

- November 4 – 6, 2014: 110 kcfs river flow with no spill
    - Powerhouse operations were varied from:
        - Normal loading Nov 4

        - West loaded Nov 5
        - East Loaded Nov 6
    - Velocities were less than 0.5 ft/ds within 50 feet out.
    - Velocities around 1 ft/s at 100 feet out.
    - Little difference with Powerhouse loading
- April 9 -10, 2015: 180-185 kcfs river flow
    - April 9 tests, 180 kcfs with no spill
    - April 10 tests, 185 kcfs with 40% spill
        - Velocities were ≤1 ft/s at the proposed intake site.
        - Velocities around 1.5 ft/s at 50 feet out.
        - Velocities around 1.8 ft/s at 100 feet out
        - Comparative results were similar between adjacent days; deeper water slightly faster during the 40% spill day.

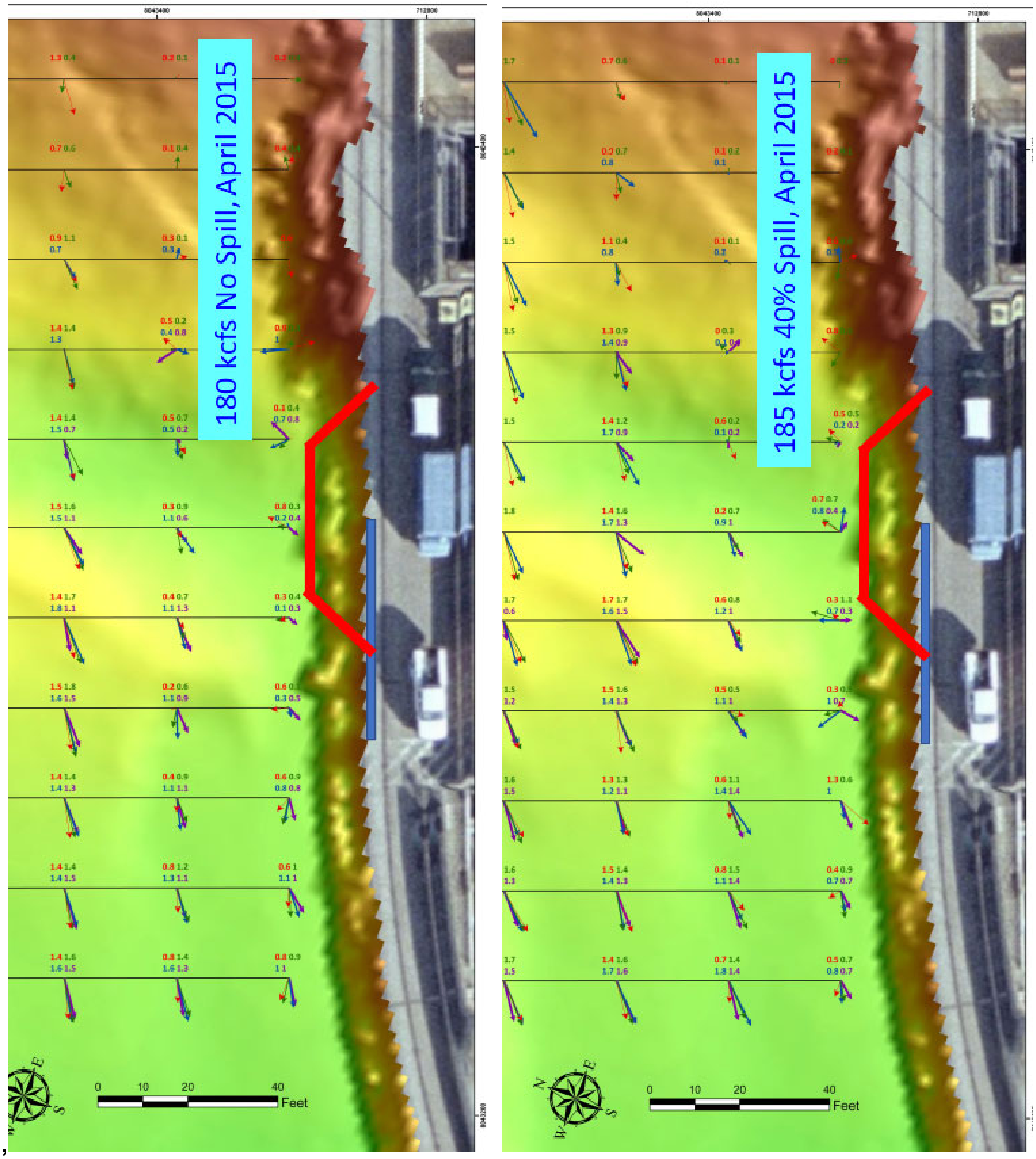
A PDF of the data plots for the April 2015 data surveys (180-185 kcfs, No spill and Spill) are provided in Appendix J.

It was generally considered safe for divers for river flowrates below 200 kcfs. However, due to the added projection of the intake into the forebay since the measurements were taken, the assumption of the safe river conditions for diving probably has to be reduced, perhaps approximately 150 kcfs. (It is recommended that this be tested under similar test operations during DDR phase of this project.)

Figure 2-5 shows excerpts from the above described ADCP forebay data collected in April 2015. The left side shows 180 kcfs river discharge under no spill, and the right side shows 185 cfs discharge under 40% spill. The velocity vectors are shown color coded with respect to depth: 5 feet (red), 20 feet (green), 35 feet (blue), and 50 feet (purple). These data were collected prior to the installation of the intake. The intake location is outlined in red. The vector directions are mixed in front of the intake and there does not appear to be any trend with respect to flow depth.

Since construction and operation of the AWS backup system, Project biologists have normally observed an upstream surface flow direction past the intake. However, they suspect there have been conditions where the flow direction changes and are in the process of investigating what river condition or project operations where this might occur.

Figure 2-5. Prototype River Velocity Data April 2015; (a) No Spill, (b) 40% Spill



2.4.6 Debris Levels

ROV survey and videos were taken of the AWSBS intake trashrack in December 2022 and for the trashracks for the two Fish Units (FU) in August 2022. See Appendix I for full documentation and photos of the AWSBS intake survey, and discussion on differences between AWSBS and FUs.

In summary, the AWSBS debris was largely concentrated in the middle depths at or above the penstock intake, with little debris in the top three panels or very bottom panel. Conversely, the FU trashracks were solidly blocked between the surface down to 60 – 70 feet, with progressively less debris below 70 feet down to 125 feet.

The greater concentration of debris between midway and the relatively deep AWSBS penstock intake indicates much of the debris was likely drawn from upper levels towards the pipe intake. With FUs being downstream of the uniform velocity inflow into the main powerhouse units, the debris is likely spread more uniformly across a greater depth than might be typical in the river (see Appendix I for more details).

2.5 STRUCTURAL CRITERIA AND CONSTRAINTS

This section describes the criteria and constraints for the design of the new structural components of The Dalles AWS trashracks, trash rakes, and other potential debris management alternatives.

2.5.1 Design References

This section outlines the design criteria that shall be adhered to for the design of structural components. These criteria are taken from codes, standards, and other guidance that is mandatory or best practice.

- **ER 1110-2-1806 Earthquake Design and Analysis for Corps of Engineers Projects.** This regulation provides guidance and direction for the seismic design and evaluation for all civil works projects.
- **EM 1110-2-2107 Design of Hydraulic Steel Structures.** This manual prescribes guidance for designing new HSS according to the provisions for LRFD.
- **EM 1110-2-2104 Strength Design for Reinforced Concrete Hydraulic Structures**. This manual provides guidance for designing reinforced concrete hydraulic structures by the strength design method.
- **EM 1110-2-2400, Structural Design and Evaluation of Outlet Works.** This manual provides guidance for the planning, structural design, and analysis of intake structures and other outlet works features used on USACE projects for the purposes of flood control, water supply, water quality and temperature control, recreation, or hydropower.
- **Engineer Manual 1110-2-3400, Painting: New Construction and Maintenance.** This manual provides painting guidance to engineering, operations, maintenance, and construction personnel and other individuals responsible for the protection of U.S. Army Corps of Engineers (USACE) structures. It gives broad-base instructions on corrosion and corrosion protection using protective coating and state-of-the-art procedures that can be employed on Corps projects, which can aid in attaining better and, from a long-range viewpoint, more economical paint jobs.
- **American Concrete Institute (ACI 318-19), Building Code Requirements for Reinforced Concrete.**
- **ASCE 7-16, Minimum Design Loads for Buildings and Other Structures.** This standard provides the minimum load requirements for buildings and other structures.

This manual should be used to aid in the development of the loads for the low pool slide gates works other than hydraulic load cases.

- **American Institute of Steel Construction (AISC), Manual of Steel Construction, 15th Edition.** This manual is used for structural steel member capacities in HSS design as modified per ETL-1110-2-584.
- **American Welding Society, Structural Welding Codes, Current Editions of D1.1** This code covers the general welding of any steel structure using common carbon steel and also low-alloy steel.

2.5.2 Engineering Properties of Construction Materials

The engineering properties of construction materials are shown in Table 2-4.

Table 2-4. Engineering properties of construction material

Concrete Mix Design: All Cast-in-Place Structures	
New cast-in-place concrete at 28 days	f'c=4,500 psi
Existing Dam concrete (minimum values)	f'c=3,000 psi
Existing pre-cast Concrete	f'c=5,000 psi
Grout: Non-shrink at 7 days	f'c=5,000 psi
Steel Reinforcement: All Structures	
New: Deformed bars (non-weldable), ASTM A615, Grade 60	fy=60,000 psi
New: Deformed bars (Weldable), ASTM A706, Grade 60	fy=60,000 psi
New: Welded Wire Reinforcing, ASTM A1064	
Existing pre-cast Concrete: ASTM A615 Grade 60	fy=60,000 psi
Structural Steel and Connectors: All Structures	
ASTM A36 (carbon steel: plates, bars, angles, beams)	fy=36,000 psi
ASTM A500 Grade B (carbon steel: round hss)	fy=42,000 psi
ASTM A500 Grade B (carbon steel: square, rectangular hss)	fy=46,000 psi
ASTM A992 (carbon steel: beams)	fy=50,000 psi
ASTM A53 Grade B (carbon steel: pipe)	fy=35,000 psi
ASTM A572 Grade 50 (carbon steel: plates, bars, beams)	fy=50,000 psi

ASTM B209 Type 6061-T6 (Structural Aluminum)	fy=40,000 psi Un-welded fy=24,000 psi Welded
ASTM B429 Type 6061-T6 (Structural Aluminum, Pipe and Tube)	fy=35,000 psi
ASTM A276 Type 304 (stainless steel: bars and shapes)	fy=30,000 psi
ASTM A240 Type 304 (stainless steel: plates, bars)	fy=30,000 psi
ASTM F1554, Grade 55 (Anchor rods)	fy=55,000 psi
ASTM F3125, Grade A325 (Bolts, nuts, and washers not included in the seismic force resisting system or collectors)	fu=120,000/105000 psi
ASTM F3125, Grade A490 Slip Critical, Class B (Bolts, nuts, and washers not included in the seismic force resisting system or collectors)	fu=150,000 psi
Welding electrodes E70XX	fy=70,000 psi

ASTM = American Society for Testing Materials.
f'c = Specified compressive strength of concrete.
fy = Specified yield strength.
fu = Specified ultimate strength.

2.5.3 Service Life

The service life is 100 years, as required by ETL 1110-2-584.

2.5.4 Loads

Loads will be categorized into the following three categories.

Usual. The Usual loading category represents daily or frequent operational conditions that require highly reliable performance. The design criteria for the **Usual** loading category apply to load cases with the predominant load (or joint loads) having a mean return period (Tr) between 1 and 10 years.

Unusual. The Unusual loading category represents infrequent operational conditions that require a defined level of performance, and that can be reasonably expected to occur within the service life of the project. The design criteria for the **Unusual** loading category apply to load cases with the predominant (or joint loads) having a mean return period (Tr) between 10 and 300 years.

Extreme. The Extreme loading category represents possible conditions that are not likely to occur within the service life of the project. The design criteria for **Extreme** load cases are applicable if the predominant load (or joint loads) has a mean return period (Tr) greater than 300 years.

2.5.4.1 *Dead Load, D*

Self-weight or dead load includes the total weight of the structure and its components. Self-weight is computed based on the nominal cross-section of the members. To account for attachments, appurtenances, fasteners, welds, and any coating system an additional 10 percent will be added to the structure. Self-weight will be treated as a **Usual** load category.

2.5.4.2 *Gravity Loads, G*

Gravity loads consist of silt, debris, and ice. Silt and debris loads are based on site conditions and past experience. A minimum of 1-inch thick layer of silt is assumed acting in all areas where silt can accumulate without regard to drainage features. The unit weight of silt is assumed to be 90 lbs/ft3. Ice loads are determined using ASCE 7. Loads are determined based on-site specific conditions. Gravity loads are considered **Usual** loads.

2.5.4.3 *Hydraulic Loads*

Hydrostatic Loads. Loads caused by hydrostatic water (Hs) shall consist of the hydraulic head differential across the trashrack with due consideration from any tailwater effects. The magnitude of load is a function of the load category defined as usual, unusual, and extreme. These loads are determined in coordination with a hydraulic engineer.

Hydrodynamic Loads. The magnitude of hydrodynamic load is a function of load category defined as usual, unusual, and extreme. These loads are determined in coordination with a hydraulic engineer.

Wave Loads. Wave loads shall be considered for all structures subject to significant wind and fetch and will be additive to the coincident hydrostatic load, if applicable.

Flow Induced Vibrations. Vibrations shall be minimized through proper detailing in coordination with a hydraulic engineer and operations considerations.

2.5.4.4 *Operational Loads*

Usual. Usual loads are those caused by normal structure operation. Usual operational loads include machinery loads directly applied to the structure, resistance to motion of the structure through friction between moving parts such as bearing, bushings, or seals, and resistance to the operation from externally applied loads.

<u>Unusual.</u> Loads cause by abnormal structure operation, where abnormal structure operation includes unbalanced hoists, unbalanced operation, or jammed structure condition where machinery is operated up to its safe limit. The safe limit is that imposed within the machinery design through use of load-limiting devices.

<u>Extreme.</u> Loads caused by a jammed structure subject to the full capacity of the machinery. The structure shall be designed to function as needed when subjected to this load. Structure machinery loads shall be coordinated with the project mechanical engineer.

2.5.4.5 *Environmental Loads*

Environmental loads include wind acting on structure and loads induced through thermal movement, which are classified as unusual loads only.

2.5.4.6 *Impact Loads*

Impact loads include floating debris and ice.

2.5.4.7 *Earthquake*

The following criteria are used in the seismic design per ETL 1110-2-584:

- The directions of ground motions are assumed to be in both horizontal directions, but the vertical direction is assumed to be negligible.
- When the structure is submerged, the inertial effects due to the structure's gravity loads are insignificant relative to the hydrodynamic forces and, thus, are ignored.
- Hydrodynamic forces are estimated by the use of the Westergaard's equation.
- The earthquake load (E) shall be based on the OBE. The OBE is defined as an earthquake having a 50 percent chance of being exceeded in 100 years.

2.5.4.8 *Deflection*

Deflections will be limited to ensure that bearing, and other moving parts are not overstressed, seals function properly, machinery loads are not exceeded, and design assumptions are not compromised.

2.6 MECHANICAL CRITERIA AND CONSTRAINTS

2.6.1 Design References

- **EM 1110-2-2610 Mechanical and Electrical Design for Lock and Dam Operating Equipment.** This engineering manual provides design guidance for electrical and mechanical equipment on navigation locks and dams. While it mostly pertains to equipment outside the scope of this project, some mechanical reference information may be used.

- **USEPA 800-R11-002.** This reference defines EPA criteria for environmentally acceptable lubricants. Any mechanical systems which are submerged or enter the water will require the use of environmentally acceptable lubricants as defined in this document.

- **ETL 1110-2-584.** This manual provides guidance for the design of hydraulic steel structures and sets service life for various components. Design of a new trashrack would be governed by this document.

2.6.2 Criteria

2.6.2.1 *Compatibility with Trashracks*

It has not yet been determined if this project will use the existing trashracks (Alternative 11) or replace with new trashracks (Alternative 10). The mechanical system must be compatible with the chosen trashrack system.

2.6.2.2 *Low Maintenance*

The backup AWS is projected to be used during the fish unit rehabilitation projects. When those projects are complete, it is expected that the backup AWS system would be used infrequently to augment attraction flow as the Fish Units will have high reliability and forced outages are expected to be infrequent and of short duration. It is desirable for any permanent mechanical features be designed to only need minimal maintenance. Project fisheries O&M does not have additional room for on-going maintenance of a new system during fish unit rehabilitation.

2.6.2.3 *General Mechanical Systems*

Mechanical systems must comply with EM 1110-2-2610 and its design criteria.

2.6.2.4 *Debris Filtering*

The type of debris which needs filtering here is different than some other traditional trashracks. Small beaver sticks and the river plant milfoil are the two primary sources of debris which clog the existing trashracks. Furthermore, debris rates and types are very seasonal and subject to change, per reports from the project.

2.6.2.5 *Valve Cycle Count*

Initial USACE reports and background information for this system say that the large water control butterfly valves (2x84", 1x120") have an expected life of 1400 cycles. One cycle is defined as an opening or closing of the valve, where a full movement from closed to open to closed counts as two cycles. It was unclear where the 1400 number originated, as there was no documentation from a manufacturer or design analysis to support the claim.

The Italian valve manufacturer, Vanessa, is owned by an international parent company, Emerson. Technical representatives from Emersons local subsidiary, Applied Controls, were contacted to verify the origin of the supposed cycle limit. Copies of this correspondence will be added as an appendix to the final EDR report.

In summary, the manufacturer recommends a full performance evaluation of the valves at 1400 cycles. They do not expect the valves to cease functioning or fail at this point, but highly recommend a thorough investigation to look for any leakage, changes in operation time, increased actuation demand, etc. Over time, the seals and valve packing will inevitably start to decay and wear down, but this failure will be progressive and gradual, initially starting as a slow leakage of water past the closed valve. In Vanessa/Emerson's experience, valves of this nature have been observed to last upwards of twenty years without any leakage.

As a result of this clarification, all valve cycle constraints have been removed from consideration of design alternatives.

Operations personnel at the Dalles currently maintain a log of AWSB valve operations in an excel spreadsheet. The spreadsheet is the most up to date record of valve cycles, and should continue to be maintained by the project staff.

2.6.2.6 *Continuous Flow*

Continuous flow through the AWS is beneficial for fish passage. The AWS supplies attraction flow to the lower fishladder weirs and entrances. The purpose is to attract adult fish in the tailrace into the entrances and provide hydraulic conditions in the lower ladder to assure fish will continue to progress up the ladder system under variable tailwater elevations. Any system this project implements should try to maintain continuous flow through the AWS if safe for both personnel and the system.

2.6.2.7 *Mobile Crane*

The project's mobile crane will not be used as part of a debris management solution for this project.

After the ROV investigation on December 1st, 2022, the project became concerned with the frequency of operation of a mobile crane operated brush system. Due to the unknowns surrounding the frequency of use, a standalone hoist is preferred. A full writeup can be seen in Appendix I detailing this decision.

2.6.2.8 *Limited Space*

There is not much available space on the forebay for adding in additional systems. Any new mechanical systems must fit into existing spaces.

Figure 2-6. Photo of Forebay on top of AWS intake.

2.6.2.9 *Oil in Water*

Most mechanical systems require oil or grease for lubrication. This system operates either directly in or over water, so there is a high likelihood that oil will enter the river at some point in product lifecycle. Any oil used must be VGP compliant as defined by the EPA. Any systems used must be able to operate with VGP oils/lubricants.

2.6.2.10 *Flow Rates*

The hydraulics section has outlined the requirements for flow rates through the AWSBS and the maximum allowable reduction (10 cfs) in total AWSBS flow caused by any modifications. If an air burst system or other mechanical feature is put into the water, it must comply with the hydraulic criteria and constraints.

2.7 ELECTRICAL CRITERIA AND CONSTRAINTS

This section describes the criteria and constraints for the electrical design of The Dalles AWS trash rake system and/or other potential debris management alternatives.

2.7.1 Design References

This section outlines the design criteria that shall be adhered to for the design of electrical components. These criteria are taken from codes, standards, and other guidance that is mandatory or best practice.

a. National Fire Protection Association: NFPA 70, National Electrical Code, 2023 Edition
b. National Fire Protection Association: NFPA 101, Life Safety Code, 2021 Edition
c. Unified Facilities Criteria: UFC 3-550-01 Exterior Electrical Power Distribution (1 November 2019)
d. Unified Facilities Criteria: UFC 3-520-01 Interior Electrical Systems (12 April 2021)
e. USACE Engineering Manual EM 1110-2-2610, Mechanical and Electrical Design for Lock and Dam Operating Equipment (30 June 2013)

2.7.2 Criteria

The electrical power requirements are dependent on the design alternatives of the mechanical system. At this time in the list of possible alternatives in Section 2.8, the air bubbler and new trash rake system will require electrical power and operating controls. For the automation of the value cycling alternative, modifications to the existing 10' valve control panel (BV10CC) will include pressure or level sensors to measure the minimum and maximum differential of flow rate. This alternative will also include new controller and human-machine interface(s) (HMI) to cycle the valve automatically or manually from BV10CC and/or in the control room. Associated conductor and conduit runs will be installed or modified as necessary.

2.7.3 Constraints

Electrical power availability is limited in the work area. The nearest power source is at FCQ7 Motor Control Center (MCC) in the monolith adjacent to the work area. Core drilling through the monolith bulkheads will be required from FCQ7 MCC to the work area to meet electrical requirements. Another likely option would be to route the conduit feeder to the East, crossing the asphalt roadway, then surface mounting the conduit back West to the work location. Trenching the roadway will be needed. NEC 110.26, Working space requirements for electrical equipment, must be met for any new panel installations. This may be a constraint if there is not enough space near the hoist area for new panels.

Constraints for automating control of the valves also includes conduit routing. Trenching the new parking lot would likely be required to route the conduit between the 10ft butterfly valve control panel and the 7ft butterfly valve control panel. Routing along the bottom of the fishway could be another option.

The work area also presents a challenge due to space availability. If a control panel enclosure is required, mounting options are limited. The control panel enclosure itself will have to be configured/designed with a minimal profile to not protrude into the vehicle pathway/right of way at the work area. Outdoor enclosures will comply with the requirements of National Electrical Manufacturers Association (NEMA).

2.8 LIST OF POSSIBLE ALTERNATIVES

Below is the list of the potential alternatives to be considered for evaluation separated by either using the existing trashracks or fabricating new trashracks.

1. The existing trashracks will be used without modification:

   a. Use an air bubbler system to divert the debris further downstream/upstream.

   b. Use an air bubbler system to flush debris off the trashracks.

   c. Install a new exclusion system in front of the trashracks which will passively divert the debris downstream/upstream.

      i) Within this group there are 4 alternatives:
         (1) Debris boom
         (2) Debris Curtain
         (3) One-way diversion structure
         (4) Two-way diversion structure

   d. Contract out an underwater dive team to manually remove clogged debris when/if valve cycling is unable to remove enough debris to restore a safe head differential.

   e. Design a new lifting beam which works with existing trashracks and doesn't have the design deficiencies of existing system. (This is an optional item which isn't mutually exclusive with other actions, see AWS trash screen deficiencies document: AWS Trash Screen Deficiencies.pdf)

   f. No action, continue operation as is and cycle the valves off and on to allow the debris to naturally flow off the trashrack.

g. Automation of valve cycling. If the maximum differential value for flow rates is reached, the system automatically cycles the valves to clear the debris from the screen and/or a manual push button in the control room panel could be implemented.

h. Pressure wash the debris off the trashracks from the intake deck using a water tank.

i. Install a variable-porosity plate between the trashrack and the intake to assure uniform flow through the trashrack. This option could be combined with other alternatives, such as a trash rake or debris boom.

j. Travelling screen with debris catchment bin that can be periodically removed.

2. New trashracks designed for raking with the following possible components:

   a. New dedicated hoist for the trash rakes with new seamless and flat upstream faced trashracks designed to interface with the rakes.

   b. Use a flexible brush to vertically sweep debris off the rack, actuated by a dedicated overhead hoist.

   c. Use a mobile crane for raking the new trashracks.

SECTION 3 - ALTERNATIVE EVALUATIONS

3.1 POSSIBLE ALTERNATIVES (BY PDT)

Identify possible alternatives. Alternatives shall be comprehensive and approached at the system level to understand their ability to satisfy the criteria and constraints, costs, and impact to operations and maintenance.

Table 3-1. Alternatives Using Existing Trashracks

Alternatives Using Existing Trashracks		
Alternatives	Description	Notes
Alternative 1	No action, continue operation as is and cycle the valves off and on to allow the debris to naturally flow off the trashrack.	
Alternative 2	Use an air bubbler system to divert the debris further downstream/upstream.	
Alternative 3	Use an air bubbler system to flush debris off the trashracks	
Alternative 4	Install a new exclusion system in front of the trashracks which will passively divert the debris downstream/upstream.	
Alternative 4-1	Floating debris boom to deflect surface entrained debris.	
Alternative 4-2	Floating curtain to deflect debris down to the depth of the curtain.	
Alternative 4-3	Full depth steel deflection structure to divert all debris past the intake, assuming one direction of flow.	
Alternative 4-4	Full depth steel deflection structure to divert all debris past the intake, assuming two directions of flow.	
Alternative 5	Contract out a diver to remove clogged debris when cycling the valves to allow the currents to remove the debris doesn't work.	
Alternative 6	Automation of valve cycling. If the maximum differential is reached, the system automatically cycles the valves to clear the debris or an operator initiates the valve cycling with new controls.	
Alternative 7	Pressure wash the debris off the trashracks from the intake deck using a water tank.	
Alternative 8	Install variable -porosity plate between trashrack and intake to assure uniform flow through the trashrack. This option could be used augment either a new trash rake or no other action alternatives.	
Alternative 9	Travelling screen with debris catchment bin that can be periodically removed.	

Table 3-2. Alternatives with Modified Trashracks

Alternatives with Modified or New Trashracks		
Alternative	Description	Notes
Alternative 10	Design and install new seamlessly connected trashracks. Clean new trashracks with a simple nylon brushing system, actuated by a dedicated hoist.	
Alternative 11	Design and install a brush system capable of cleaning the current trashracks. Operate the new brush system with a dedicated hoist.	
Alternative 12	Use a mobile crane for raking the new trashracks.	

3.1.1 Alternative 1: No action, continue operation as is and cycle the valves off and on to allow the debris to naturally flow off the trashrack.

This alternative was deprioritized during the 90% EDR phase. For rationale behind this decision, see section 3.4.2.

3.1.1.1 *Modifications*

No modifications are required for this alternative.

3.1.1.2 *Operations*

This alternative requires the operators shut off the flow passage through AWS backup system by cycling the valves off and on to allow the debris to naturally flow off the trashracks. The shutdown duration required is typically 8 - 12 hours and appears to depend the magnitude of the head differential and concentration of debris in the river. The 4th column in Table 2-3 shows a record of previous shutdown durations.

3.1.1.3 *Design and Construction Considerations*

No design and construction considerations are required for this alternative.

3.1.1.4 *Advantages*

For this alternative there won't be requirements to replace or modify the existing trashracks.

- No design and construction of debris removal systems are required.
- It has been demonstrated that valve cycling can be an effective method to reduce debris build-up.

3.1.1.5 *Disadvantages*

- Turning the system on and off continuously may quickly use up the design life of the butterfly valves. During design of the backup AWS, the existing butterfly valves on the AWS system were assumed to be designed for a life of 1,400 cycles. There is no certainty on the cycle life of the valves. (See section 2.6.2.6)

- While valve cycling has been effective at reducing debris build-up, it may not be sufficient as a standalone alternative to reduce all types of debris.

- The existing system valve cycling occurs during the day when personnel are present. This operation would reduce attraction flow at the entrances when one or both fish units are forced out of service.

- Spare parts must be acquired for the AWS butterfly valves to reduce downtime if the valves were to fail in fatigue.

- In the summer of 2022, project personnel observed a rare debris load on the Fish Unit trashracks. An ROV inspection conducted in August, estimated 95% debris load on the FU trashracks from the top of the trashracks down to the 70' depth. Cycling the Fish Units off/on did temporarily decrease the gatewell differential but was unsuccessful at debris removal from the trashracks. This unusual circumstance should be considered as a disadvantage for the reliability of the no action alternative.

3.1.2 Alternative 2: Use an air bubbler system to divert the debris further downstream/upstream.

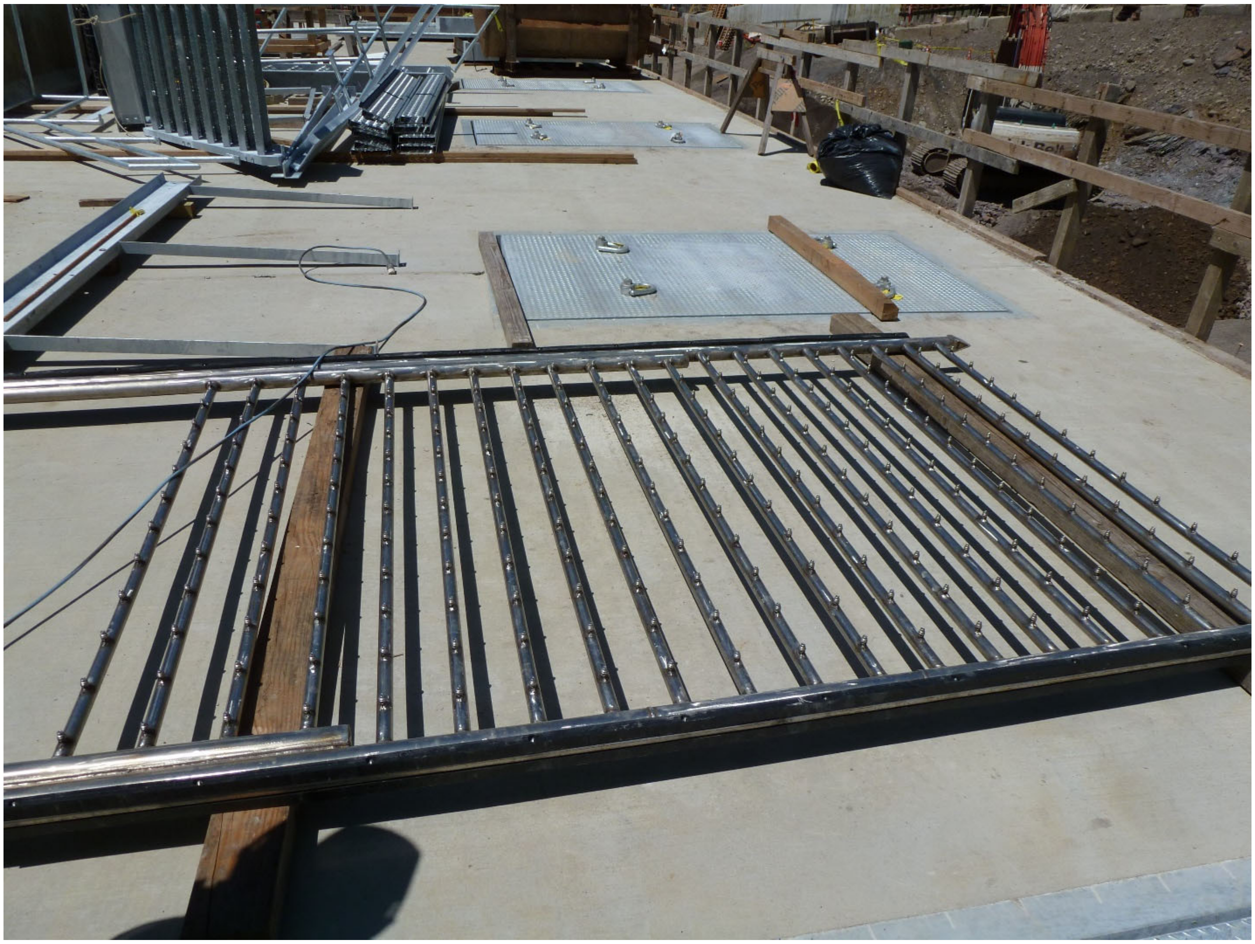
This alternative was deprioritized during the 60% EDR phase. For rationale behind this decision, see section 3.4.2.

The idea behind this system is to use a continuous or intermittent air bubbler system near the AWSBS intake to push debris away from the intake while still allowing water to flow in. This will need to be set up in two directions since the river flow changes at that location.

3.1.2.1 *Modifications*

An air compressor and compressed air lines will need to be installed near the AWSBS intake. Two air bubbler systems will need to be installed on both sides of the AWSBS intake. Figure **3-1** below shows a photo of a rack of air burst nozzles used to blast debris off the fish screens at Minto Fish Facility.

Figure 3-1. Photo of Rack of Air Burst Nozzles at Minto Fish Facility



3.1.2.2 *Operations*

For this system to work it will need to be turned on whenever the AWSBS is passing water.

3.1.2.3 *Design and Construction Considerations*

a. Mechanical

Because the flow at the intake can change directions from either upstream or downstream then the system will need to be designed to work in either direction. This can be done by adding in bubblers on both sides of the AWSBS intake so that the bubbler system is omnidirectional.

The bubbler system must be strong enough to push air bubbles into the river until the flow becomes sideways compared to the AWSBS intake.

b. Structural:

Depending on the desired direction of the air bubbler system, a concrete support beam may be required to anchor the air bubbler system correctly in the desired direction. Vertical concrete slots will be used to fit the system in place. Another option is to install steel angles/brackets to existing concrete to provide the desired direction of the air bubbler system. These brackets would support vertical steel slot channels to fit the system in place.

c. Electrical:

The air compressor will need power to start and fill the air compressor tanks for the air bubbler system. Two possible locations for power sources have been scoped during the site visit, but a system load analysis will have to be performed to verify the loading on the motor control center's (MCC's) existing bus and if there is sufficient capacity to add the new air bubbler system. The two power sources that could power the bubbler system are located at FCQ7 MCC and the powerhouse road deck receptacles near the AWS gate. FCQ7 is the only power source located in the area. If there is not enough spare capacity on FCQ7, then 13.8kV power will need to be pulled and an additional transformer and MCC unit installation is required.

The control panel to operate the air bubbler system should be able to operate in manual or auto depending on operations preference and be mounted near the trashrack to visually verify bubbler is system properly operating. Fault alarms for the bubble system will need to be routed to the projects alarm systems to monitor system functionality. It can tie into the Fish SCADA system by using the existing PLC located in the MCC gallery. If the existing PLC does not have additional spare I/O points, then new cabinets will need to be installed which could be costly.

d. Hydraulics:

A hydraulic analysis will need to be performed to determine the distance the bubble curtains must be placed out into the forebay to sufficiently divert the debris to be entrained in the passing river currents and avoid the influence of the flow net entering the trashrack intake. In addition to deflecting debris away from the intake, the design must avoid permitting a significant mass of air to be drawn back into the AWSBS.

Given that the typical river velocities in the intake area tend to be usually lesser or equal to the average intake inflow velocities, this distance may need to be significant in terms of longitudinal distances from the intake and projection out into the river.

Some preliminary one-dimensional analysis may be performed to gage feasibility. However, if this emerges as a potentially viable alternative, CFD modelling will need to be performed.

e. Biological:

Intensity of the bubble curtain would have to be evaluated due to its proximity to the adult fish ladder exit. The system running continuously may attract predatory fish to use the curtain as cover for feeding opportunities on juvenile salmon.

f. Operations:

Increased maintenance and would need to be removeable.

3.1.2.4 *Advantages*

- If the system works, then it will not require closing the valves to prevent debris from building up on the trashracks.

3.1.2.5 *Disadvantages*

- This system will require continuous operation while the AWSBS intake is open and passing water. This will require continuous power to the air compressor. Given the high use of the air compressor it will need to be inspected on a regular basis with frequent preventative maintenance.

3.1.3 Alternative 3: Use an air bubbler system to flush debris off the trashracks

This alternative was deprioritized during the 60% EDR phase. For rationale behind this decision, see section 3.4.2.

3.1.3.1 *Modifications*

An air bubbler (or air burst) system works by having an array of pipes with one-way nozzles which spray out compressed air. These arrays are located on the downstream side of the trashrack. When activated, these systems spray compressed air and clean off debris from the trashrack. The AWSBS intake will need to be modified to have an air burst array setup directly behind the trashracks. Additionally, piping to the array will most likely require drilling through concrete. An air compressor and compressed air tank will be needed to supply air to the system. This should be located close by to minimize piping and energy loss. The photo below shows a rack of air burst nozzles used to blast debris off the NOAA juvenile criteria fish screens at Minto Fish Facility.

Figure 3-2. Air burst array designed to sit behind juvenile fish screens at the Minto Fish Facility

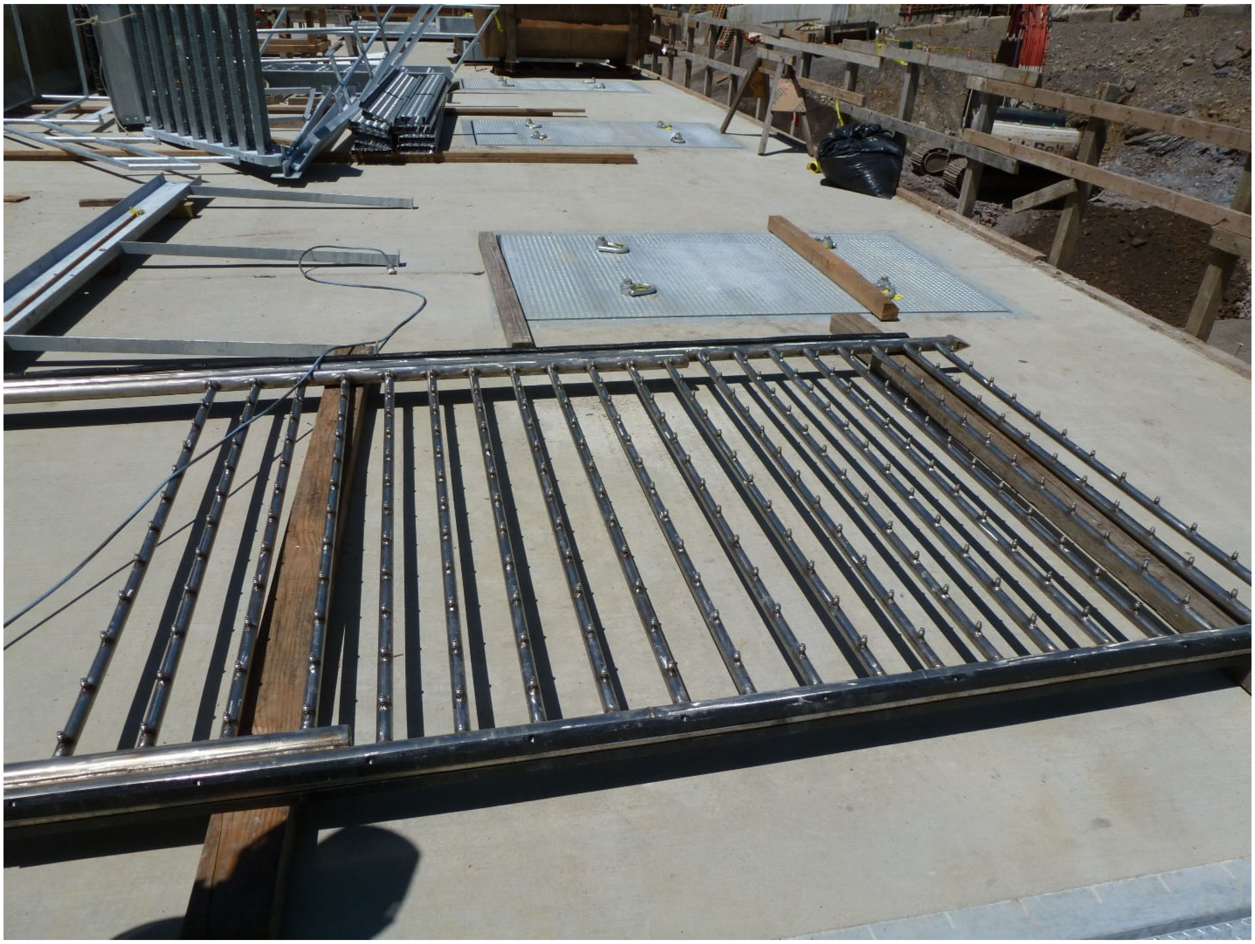
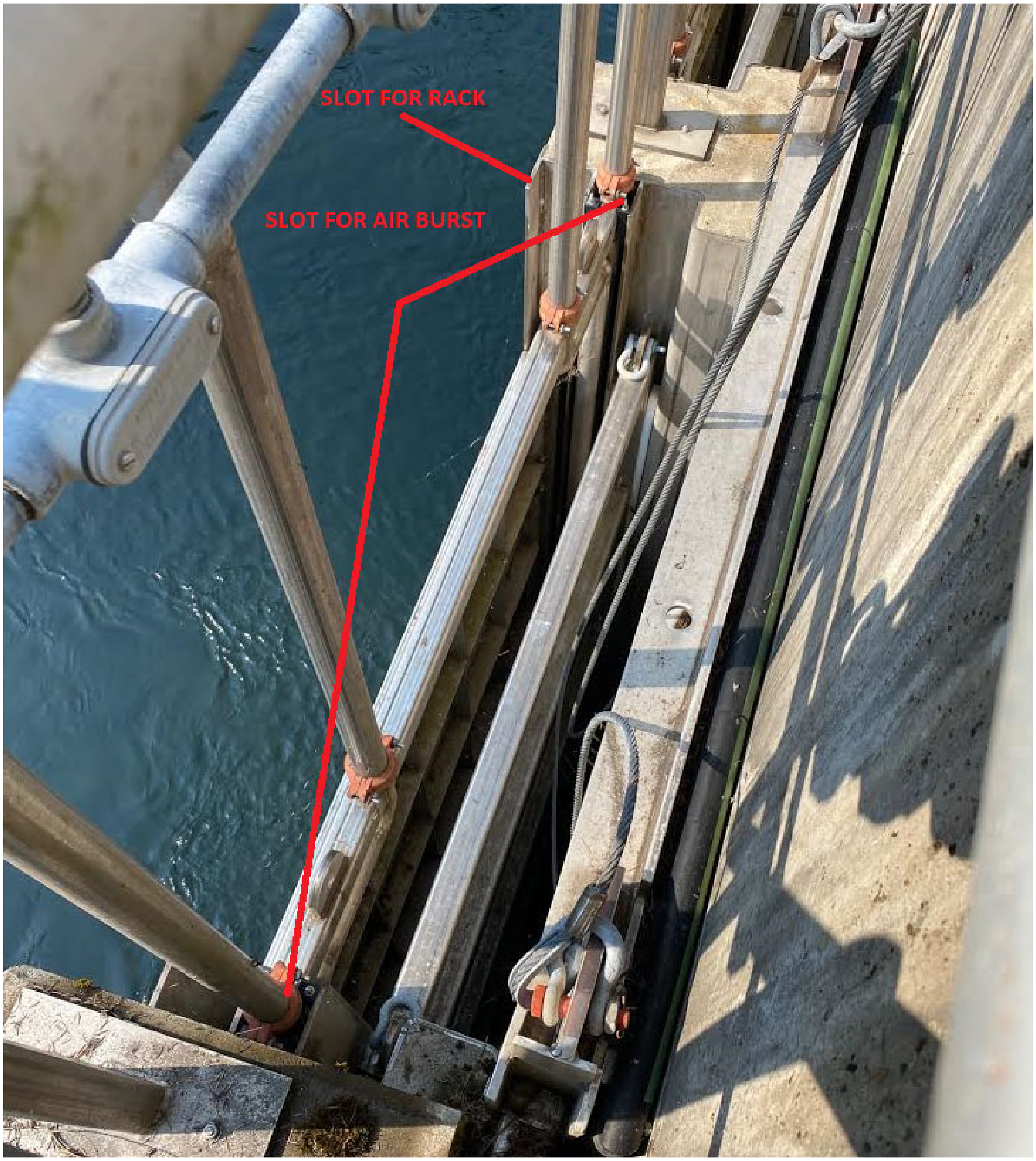


Figure 3-3. Top-down view of Minto Fish Facility air burst, as installed and operating.



3.1.3.2 *Operations*

Operation of this system may require closure of the AWSBS valves to operate. The water going into the AWSBS intake has a high velocity. An air burst system needs to overcome the water velocity to clean debris off of the trashracks. Regardless, the air bubbler system needs to supply sufficient force to move the debris far enough into the river to float away and not get sucked back into the trashracks.

3.1.3.3 *Design and Construction Considerations*

a. Mechanical:

The river flow at the AWSBS intake is sometimes upstream and sometimes downstream. This depends on the total flow going through the river. Upstream of the AWSBS intake is the intake for the fish ladder. The design should be made so as to not send the debris directly into the fish ladder.

b. Structural:

New vertical concrete slots may be used to fit the system in place. This will require to cut the concrete. Likewise, vertical steel channels may be put in place and anchored to existing concrete to fit the system in place.

c. Electrical:

The air compressor will need power to start and fill the air compressor tanks for the air bubbler system. Two possible locations for power sources have been scoped during the site visit, but a system load analysis will have to be performed to verify the loading on the motor control center's (MCC's) existing bus and if there is sufficient capacity to add the new air bubbler system. The two power sources that could power the bubbler system are located at FCQ7 MCC and the powerhouse road deck receptacles near the AWS gate. FCQ7 is the only power source located in the area. If there is not enough spare capacity on FCQ7, then 13.8kV power will need to be pulled and an additional transformer and MCC unit installation is required.

The control panel to operate the air bubbler system should be able to operate in manual or auto depending on operations preference and be mounted near the trashrack to visually verify bubbler is system properly operating. Fault alarms for the bubble system will need to be routed to the projects alarm systems to monitor system functionality. It can tie into the Fish SCADA system by using the existing PLC located in the MCC gallery. If the existing PLC does not have additional spare I/O points, then new cabinets will need to be installed which could be costly.

d. Hydraulics:

The sweeping velocity of the river current is often less than 1 ft/s and can change directions. The average screen intake velocity is about 2 ft/s and the estimated maximum intake velocity (at the pipe intake level) is about 4.5 ft/s. If the intent is to operate the air burst cleaning system while in AWSBS operation, the air burst jets should be released across the full width of the trashrack for a long enough duration to assure the upstream debris is swept past the trashrack before potentially being drawn back into the intake. Assuming the sweeping velocity is 0.5 ft/s, this translates to at least 60 seconds.

This alternative might work better with the inclusion of a porosity plate (see section 3.1.12, alternative 8) downstream of the trashrack to even out the inflow velocities. The air burst outlets would need to be placed between the trashrack and porosity plate.

The air burst cleaning system will be more effective when the AWSBS is not in operation.

e. Biological:

The direction of the bubble system would need to flush debris and the air jet away from the ladder exit area. Adult fish could be prone to falling back or moving downstream from the ladder exit if interacting with the system while running. Nighttime operation would be beneficial to avoid any interaction with migratory fish passing the ladder during daytime hours.

f. Operations:

This could be operated by Fisheries staff and not require an Operator. It could be flushed more frequently if the AWSBS does not need to be turned off. Storage of the rack would have to be figured out when the AWSBS is not in use.

3.1.3.4 *Advantages*

- The main advantage to the system is that it is easy to operate and can quickly remove debris from the trashracks.

3.1.3.5 *Disadvantages*

- Air bubbler systems have a limited lifespan and will require maintenance to have a robust system. Some air bubbler systems in Willamette Valley have recently experienced issues with debris remaining on the screens. If the air bubbler pipe array becomes corroded, then maintenance crews will need to go back to manually cleaning the trashracks. This might not be viable to use while the AWS intake is open. If that’s the case, then the valves will need to be closed for this to work. This system will require preventative maintenance for the air compressor.

3.1.4 Alternative Group 4: Install a new exclusion system in front of the trashracks which will passively divert the debris downstream/upstream.

The group of alternatives are passive debris exclusion alternatives. There are four alternatives fall into this group:

1) Alternative 4-1: Floating debris boom to deflect surface entrained debris.

2) Alternative 4-2: Floating curtain to deflect debris entrained down to the depth of the curtain.

3) Alternative 4-3: Full depth steel deflection structure to divert all debris past the intake, assuming one direction of flow.

4) Alternative 4-4: Full depth steel deflection structure to divert all debris past the intake, assuming two directions of flow.

3.1.4.1 *Hydraulic design complications concerning debris exclusion structures*

There are two significant hydraulic complications pertaining to passive debris exclusion structure options:

a) The river typically flows in the upstream direction where it passes the intake structure. However, there are observations that the river directions are reversed under different river flow rates or project operations.

b) The location of the maximum intake velocity is approximately 40-feet below forebay. This largely renders surface-oriented solutions ineffective unless the boom or curtain is located a large distance out from the intake so that the river currents can convey the debris away from the influence of the underwater intake flow net.

3.1.5 Alternative 4-1: Floating debris boom to deflect surface entrained debris.

This alternative was prioritized for consideration in the preferred alternative during the 60% EDR phase. For rationale behind this decision, see section 3.4.3.

3.1.5.1 *Modifications*

A floating debris boom would be installed to encompass the intake to divert and pass surface debris to downstream locations. This debris boom would need to be secured with anchors or dolphins.

Figure 3-4 shows a schematic of a preliminary debris boom alignment with respect to pertinent project features (AWSBS Intake, Fish ladder Exit and Unit 22 Intake). The preliminary alignment has the boom alignment located 55 feet out from the upstream dam face. The east end of the boom intersects with the existing earthen embankment at the normal high pool elevation 160 feet. The west end of the boom ties into the east end of Unit 22 intake. The upper corner inset shows some of the bathymetry and topography in the same area.

Figure 3-4. Schematic of Alternative 4-1: Floating Debris Boom.

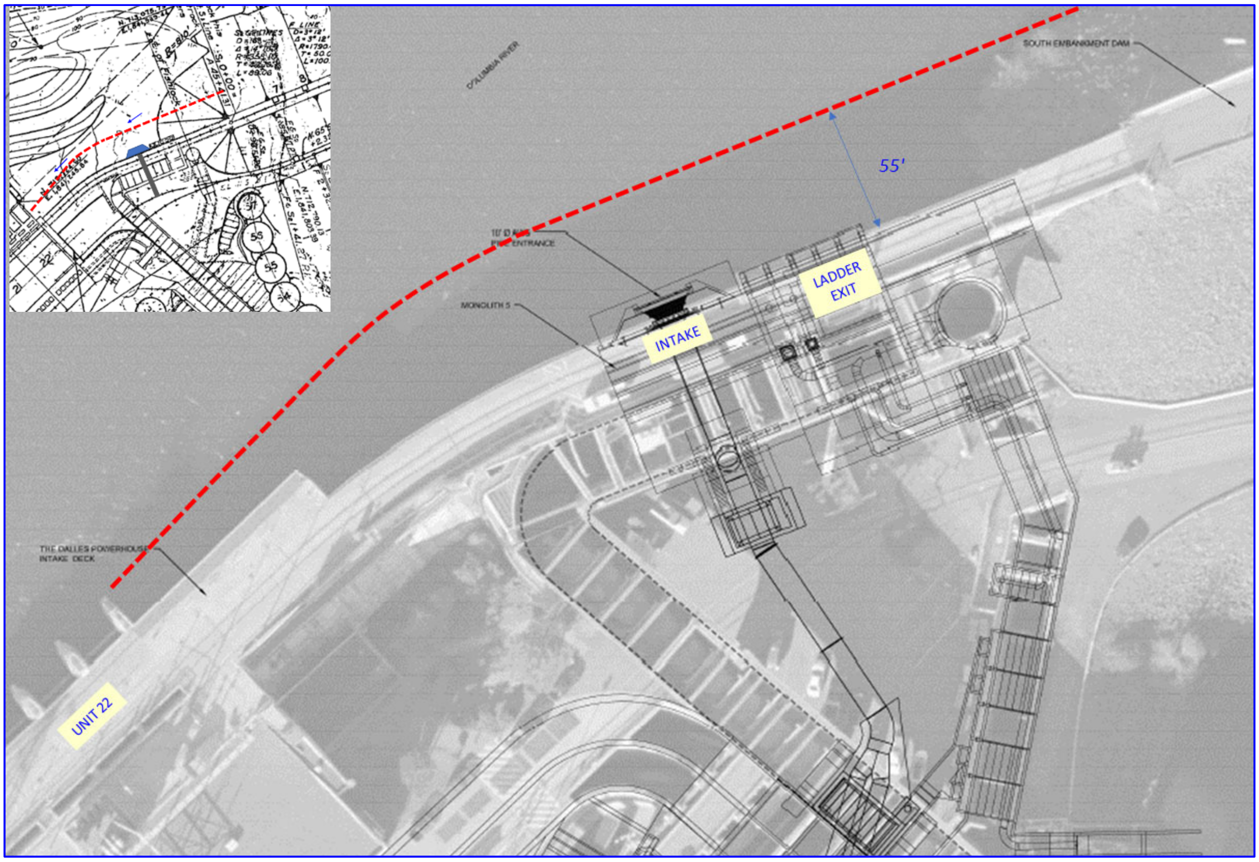
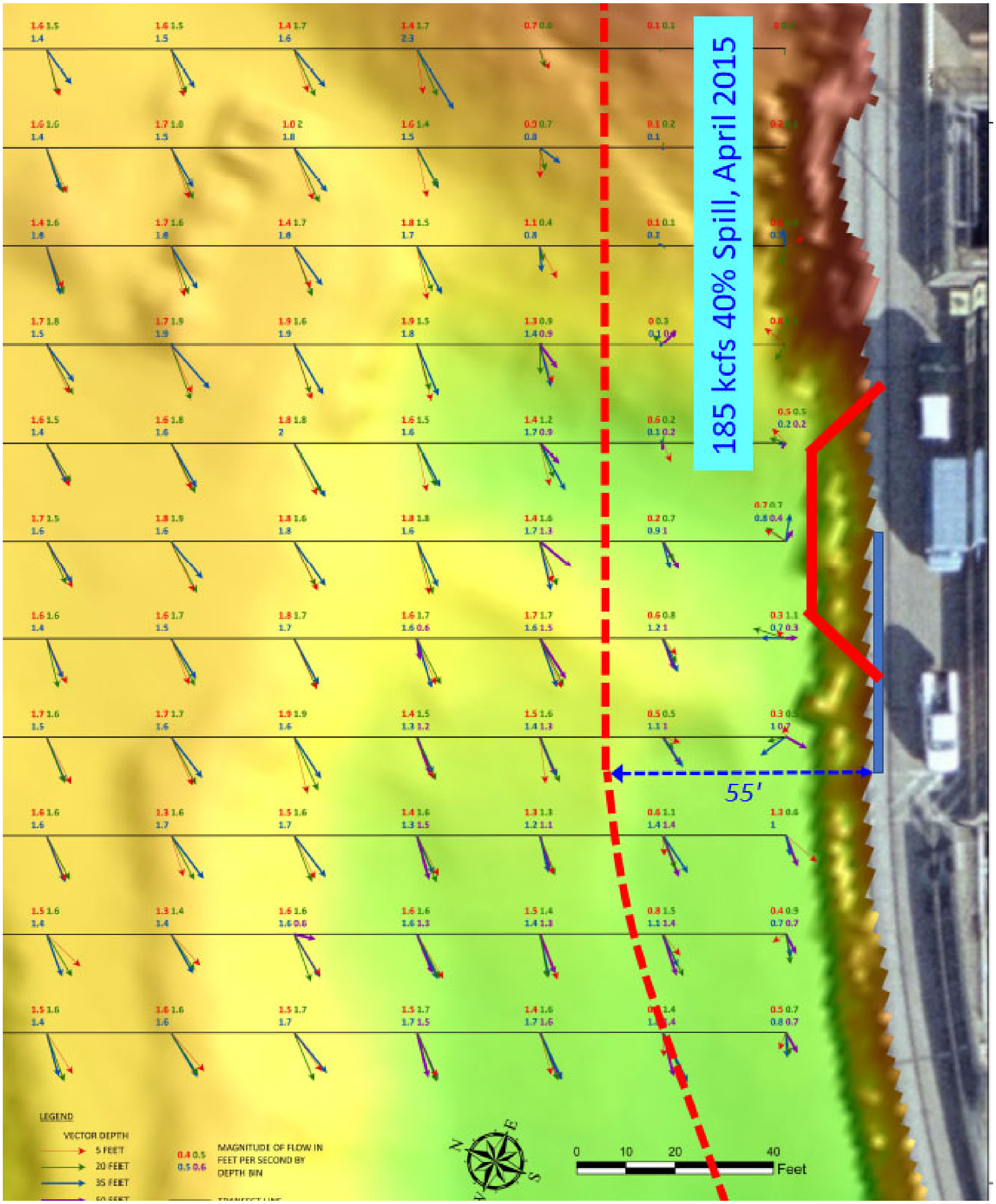


Figure 3-5 shows the preliminary boom alignment with respect to the prototype data collected April 10, 2015. Under this condition, the project flow was 185 kcfs with 40% spill. These represents a typical early spring flow condition when moderate to ample debris will be present.

Figure 3-5. Preliminary Floating Debris Boom Alignment with Prototype Flow Data.



3.1.5.2 *Design and Construction Considerations*

a. Structural:

The floating debris boom would need to be secured via anchors or dolphins.

b. Mechanical

Not Applicable.

c. Hydraulics:

The debris boom would need to encompass the area around the intake to address the changing river currents, as noted in paragraph b under 3.1.4.1.

The effectiveness debris boom is limited by its surface orientation compared to 40 feet-depth of intake pipe, as noted in paragraph a under 3.1.4.1. However, project biologists report having to routinely remove the same type of debris from the trashrack for the nearby fish ladder exit. The invert to the fish ladder exit is elevation 147 feet, or 3 to 8 feet below the forebay water surface.

The preliminary alignment is located about 55 feet out from the upstream face of the dam. Most of the flow vectors from the prototype data (see Figure 2-5 and Figure 3-5) are oriented in the downstream direction at this distance out. Therefore, there is reasonable evidence that a portion of the debris can be intercepted and passed on to the downstream Powerhouse units.

d. Biological:

The debris boom should be void of sharp edges and corners that could injure fish if they came in to contact with the structure. The design should limit potential resting areas for piscivorous birds or aquatic mammals loafing or feeding on the structure.

e. Operations:

A boom is a passive prevention method that doesn't require much Operational support.

Some periodic barge cleanups may be expected to avoid passage of accumulated debris on boom, being pulled under boom toward intake.

3.1.5.3 *Advantages*

- Used at other projects with partial success, reduces but does not prevent all debris.
- By diverting a portion of the debris, this alternative may work well in combination with other alternatives. May reduce the frequency of valve shutdowns.

3.1.5.4 *Disadvantages*

- Effectiveness will be reduced by the deeper flow draw from low level AWSBS pipe intake.

3.1.6 Alternative 4-2: Floating curtain to deflect debris down to the depth of the curtain.

This alternative was deprioritized during the 60% EDR phase. For rationale behind this decision, see section 3.4.2.

3.1.6.1 *Modifications*

This alternative would have a floating curtain to deflect debris entrained down to the depth of the curtain. This curtain would have to encompass the AWSBS intake, but not the fish ladder exit. This would need to be secured with anchors or dolphins.

3.1.6.2 *Design and Construction Considerations*

a. Mechanical:

Not Applicable.

b. Structural:

The floating curtain would need to be secured with anchors or dolphins.

c. Hydraulics:

The debris curtain would need to be shaped in a vee or semicircular shape to envelope the area around the intake to address the changing river currents, as noted in paragraph b under 3.1.4.1.

The effectiveness will improve with depth of curtain compared to the debris boom (as noted in paragraph a under 3.1.4.1.), however the hydraulic loads increase with curtain depth and the extent of the curtain may have to be reduced. This in turn may force the curtain closer to the intake, which will cause yet greater hydraulic loads.

A flow net may reduce the hydraulic loading, however it likely become entangled with woody or milfoil debris over time.

The flow net or curtain must not surround or encompass the existing fish ladder exit to the forebay, located about 45 feet to the east of the AWSBS intake (see Figure 3-4). Therefore, a debris curtain cannot utilize an alignment similar to the preliminary debris boom alignment as shown in that figure.

d. Biological: The floating curtain should be void of sharp edges and corners that could injure fish if they came in to contact with the structure. Material shape and size should limit the risk of entanglement and potential entrainment inside the structure. The design should limit potential resting areas for piscivores birds or aquatic mammals loafing or feeding on the structure. Areas of the structure should be limited in size as to not provide cover for predatory fish.

e. Operations: A boom is a passive prevention method and only requires preventative maintenance.

   Some periodic barge cleanups may be expected to avoid reduce load of entangled debris assuming a flow net is deployed.

3.1.6.3 *Advantages*

- Debris curtain is likely more effective at dealing with deeper intake inflow than debris boom (Alternative 4-1).

3.1.6.4 *Disadvantages*

- The curtain material is an uncertainty:
    - Flow net reduces hydraulic loads by allowing flow through passage, but likely becomes entangled with debris or develops tears in the fabric over time.
- The debris curtain is more of an unknown than debris boom, likely reduces but does not prevent all debris.
- The hydraulic loading on a curtain will be significantly higher with increased depth of the curtain compared to a debris, the extent or length of a curtain is reduced compared to a debris boom. Also, the curtain cannot be placed too close to trashrack due to increased hydraulic loading from the inflow net.
- The alignment of the curtain must separate the openings for the AWSBS intake and the fish ladder exit (45-feet apart). This section of the curtain will likely accumulate debris.

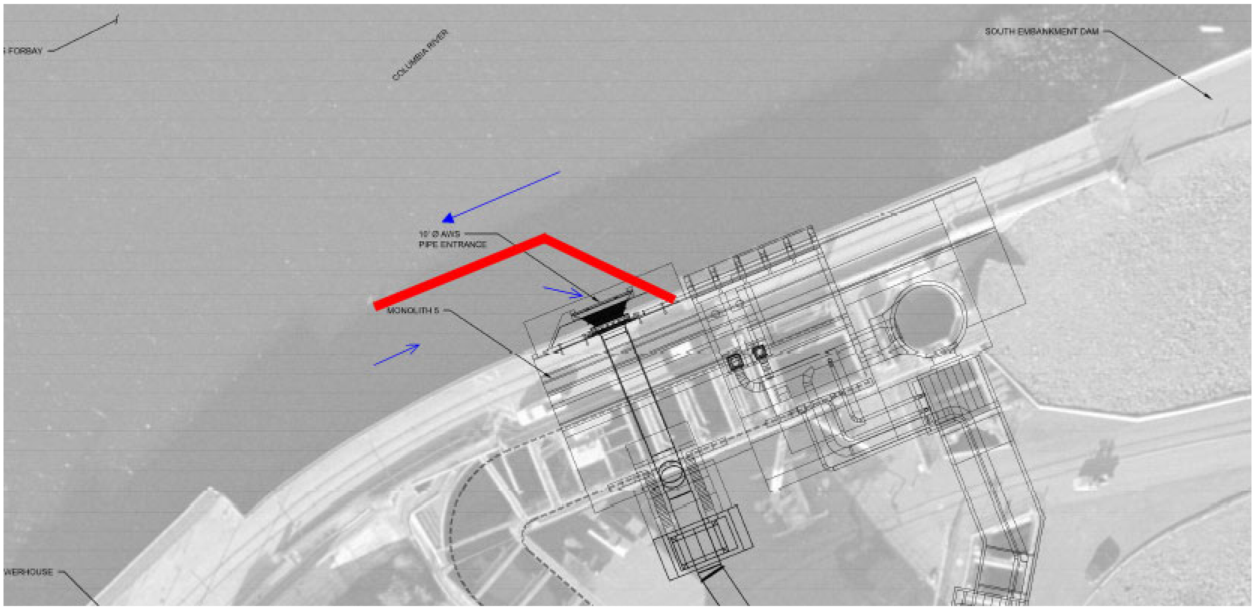
3.1.7 Alternative 4-3: Full depth steel deflection structure to divert all debris past the intake, assuming one direction of flow.

This alternative was deprioritized during the 60% EDR phase. For rationale behind this decision, see section 3.4.2.

3.1.7.1 *Modifications*

This alternative is a full-depth diversion structure that is intended to physically divert any debris past the intake. This design is based on the assumption that the primary direction of the sweeping flow of the river passing intake is in the downstream direction.

Figure 3-6. Schematic of Alternative 4-3: One-way Diversion Structure.



a. Design and Construction Considerations

b. Mechanical:

Not Applicable.

c. Structural:

An additional concrete pad will need to be extended out into the river to support the weight of the diversion structure.

d. Hydraulics:

This alternative addresses the intake flow depth concern improve (as noted in paragraph a under 3.1.4.1.).

The diversion structure will be oriented in the downstream flow direction, rendering it potentially effective as long as the river flows in the same direction. This is based on the prototype flow direction being generally consistent in the downstream direction about 40 feet out from the face of the dam. However, the debris problem will become exacerbated if the river changes direction (as noted in paragraph b under 3.1.4.1.). When this occurs, the debris will be trapped inside and there will be no means of allowing the river to clear it off by closing the downstream 7-foot valves.

The outer wall of the one-way diversion structure has been estimated to be 40 feet out from the dam face. This was determined to maintain flow velocities lower than 0.8 ft/s at the downstream opening of the diversion structure. Nevertheless, there will be an eddy off the downstream end of the diversion wall and there will likely be some unknown amount of debris drawn in and back toward the intake.

The hydraulic loads will be very large on this structure, particularly under high flow events. Significant loads will also be exerted on the structure from the intake flow net.

Given the proposed diversion structure out front of the intake, the inflow will be uneven or unsymmetrical entering the trashrack. This may lead to intake vortices or more rapid buildup of debris on one side of the trashrack.

e. Biological:

The steel deflection structure should be void of sharp edges and corners that could injure fish if they came in to contact with the structure. The design should limit potential resting areas for piscivorous birds or aquatic mammals loafing or feeding on the structure. Areas of the structure should be limited in size as to not provide cover for predatory fish.

f. Operations:

If or when the river sweeping flow changes directions, there will be additional debris intrusions that will require extra cleanup and system shutdowns.

3.1.7.2 *Advantages*

- Potentially effective at all depths.

3.1.7.3 *Disadvantages*

- Not feasible when river current changes direction from assumed norm.
- No means of self-cleaning if debris accumulates on intake trashrack.
- Unknown design will require CFD if design is brought to fruition.
- Significant structural and installation costs can be expected.

3.1.8 Alternative 4-4: Full depth steel deflection structure to divert all debris past the intake, assuming two directions of flow.

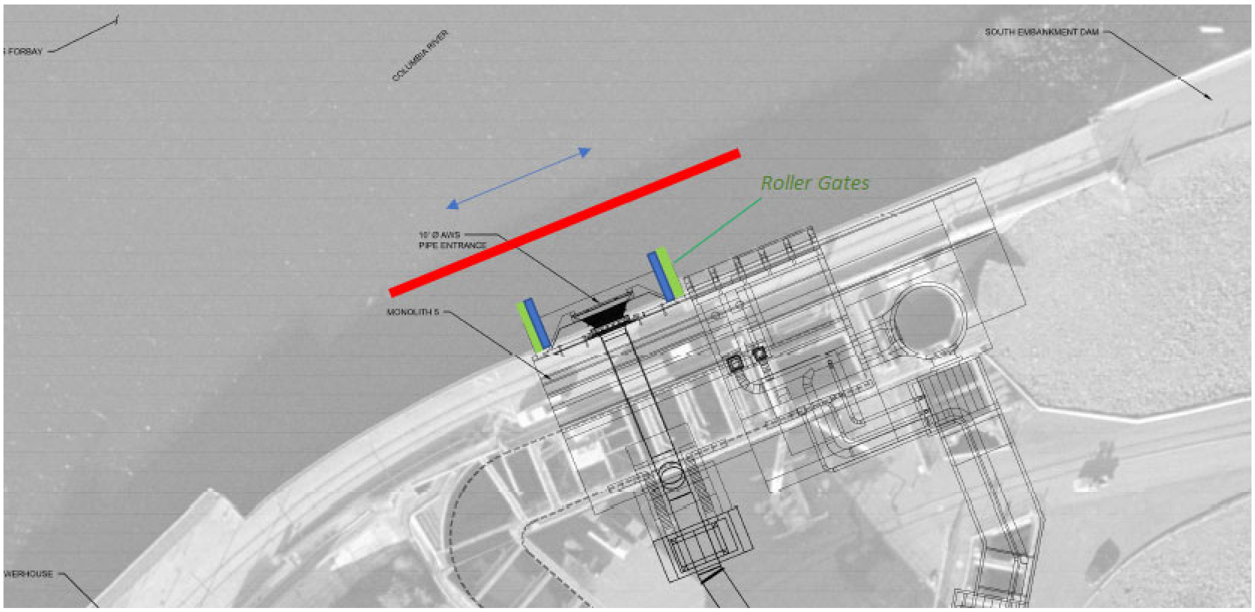
This alternative was deprioritized during the 60% EDR phase. For rationale behind this decision, see section 3.4.2.

3.1.8.1 *Modifications*

This alternative is a full-depth diversion structure that is intended to physically divert any debris past the intake. Unlike Alternative 4-3, this alternative does not rely on a single direction of the sweeping flow of the river passing the intake. It does require two 60-

foot-deep roller gates that can open or close under river flow conditions. One gate would be closed at a time to block flow from pushing debris into the trashrack. The other gate will be open to allow inflow to the trashrack from the direction in debris has been diverted.

Figure 3-7. Schematic of Alternative 4-4; Two-way Diversion Structure.



3.1.8.2 *Design and Construction Considerations*

a. Mechanical:

Two 60-foot-deep x 20-foot-long roller gates must be able to be alternately closed under river flow (not AWS intake flow) conditions. The hydraulic loads on these large gates during operational or static conditions may render this alternative infeasible, particularly as projected out in the river.

b. Structural:

An additional concrete pad will need to be added and extended out into the river to support the weight of the diversion structure. This would require an even longer pad than with alternative 4-3, because this structure will be designed to pass debris in opposite directions.

c. Electrical:

Power and automatization of the roller gates would be required. There are two possible locations for power sources for the roller gates that have been scoped during the site visit, but a system load analysis will have to be performed to verify the loading on the motor control center's (MCC's) existing bus with the new roller gates system power requirements. The two power sources are located at FCQ7 MCC and the powerhouse road deck receptacles near the AWS gate. FCQ7 is the only power source located in the area. If there is not enough spare capacity on FCQ7, then 13.8kV power will need to be pulled and an additional transformer and MCC unit installation is required.

The roller gates system can be operated manually or automatically depending on operations preference and be mounted near the trashrack to visually verify the roller gates system are properly operating. Fault alarms for the system will need to be routed to the projects alarm systems to monitor system functionality.

d. Hydraulics:

This alternative address both the intake flow depth concern (as noted in paragraph a under 3.1.4.1.) and the change in river flow direction (as noted in paragraph b under 3.1.4.1.)

The outer wall of the one-way diversion structure has been estimated to be 40 feet out from the dam face. This was determined to maintain flow velocities lower than 0.8 ft/s at the downstream opening of the diversion structure. Nevertheless, there will be an eddy off the downstream end of the diversion wall and there will likely be some unknown amount of debris drawn in and back toward the intake regardless of which flow direction is selected.

The diversion structure will allow system adjustments to changes in river flow direction by switching the open/close positions of the roller gates. Both gates would need to be open to perform self-cleaning operation.

The hydraulic loads will be very large on this structure, particularly under high flow events.

Given the proposed diversion structure out front of the intake, the inflow will be uneven or unsymmetrical entering the trashrack. This may lead to intake vortices or more rapid buildup of debris on one side of the trashrack.

e. Biological:

The steel deflection structure should be void of sharp edges and corners that could injure fish if they came in to contact with the structure. The design should limit potential resting areas for piscivores birds or aquatic mammals loafing or feeding on the structure. Areas of the structure should be limited in size as to not provide cover for predatory fish.

f. Operations:

Extra O&M and reliability concerns with respect to the roller closure gates.

3.1.8.3 *Advantages*

- Theoretically works when river current changes direction.

- Both gates could be opened for self-cleaning operation if debris accumulates on intake trashrack.

3.1.8.4 *Disadvantages*

- Control and structural design of large roller gates extending out into river are likely not feasible.
- Unknown design will require CFD if design is brought to fruition.
- Doubtful feasibility of proposed tall gates that must be moved laterally.
- Significant structural and installation costs can be expected.

3.1.9 Alternative 5: Contract out a diver to remove clogged debris when cycling the valves to allow the currents to remove the debris doesn't work.

This alternative was deprioritized during the 60% EDR phase. For rationale behind this decision, see section 3.4.2.

3.1.9.1 *Modifications*

No modifications are required for this alternative.

3.1.9.2 *Design and Construction Considerations*

No design or construction are required for this alternative.

a. Hydraulics:

The diver operations are generally limited to river flow conditions less than 200 kcfs (However with the new projection of the intake out into the forebay, this assumed flow value may now be lower than 200 kcfs). This diver safety estimate was determined from prototype data collected in April 2015 and November 2014, prior to the intake construction. This prevents diver operations during typical May - June conditions when debris is abundant.

Finding and securing a good window to dive at this project is difficult. Prior anticipation and coordination with the District Dive Safety Office, TDA project, RCC, BPA and the fisheries region will be required.

b. Biological:

Coordination of dive activities would need approval through regional forums as adjustments to ladder entrances would need to take place as the system would need to be shut down due to safety issues with dive activities. This alternative would increase the frequency of valve cycling and decrease fish ladder performance for the duration of the cleaning.

3.1.9.3 *Advantages*

- No advantages.

3.1.9.4 *Disadvantages*

- Limited to river flow conditions lower than 200 kcfs (or lower with new intake).
- Significant coordination with the District Dive Safety Office, The Dalles Project, RCC, BPA and the Fisheries Region will be required to assure safe diver conditions.
- Could be problematic to have the diver available if emergency situation occurs.
- The AWSBS is required to be turned off for the duration of cleaning.

3.1.10 Alternative 6: Automation of valve cycling.

This alternative was deprioritized during the 60% EDR phase. For rationale behind this decision, see section 3.4.2.

If the maximum differential is reached, the system automatically cycles the valves to clear the debris or maybe just a button in the control room called “Flush AWSBU Debris”.

3.1.10.1 *Design and Construction Considerations*

a. Mechanical:

The mechanical actuator will need to be linked up with electrical controls so that the actuator can be automatically used with the electrical controls or when the maximum differential is reached. No change or replacement is needed for the existing mechanical systems beyond this.

b. Structural:

Some anchorage of the components may be required.

c. Electrical:

A pressure transducer would need to be installed before and after the AWSBS trashracks to measure the differential pressure. Digital readouts for the pressure transducers will be placed in the existing Butterfly Valve Control Cabinet 10 (BVCC10), along with a programmable logic controller (PLC). The PLC will measure the differential pressure of water and monitor the front panel switches. If the front panel HOA switch is set to “AUTO” then the 10-foot butterfly valve will cycle open following the PLC programming. If the HOA switch is set to “MANUAL”, the operator will control the valve manually. Hence, if the PLC were to fail, the operator can run the valve regardless of the condition of the PLC. Alarms for faults and differential measurements are required to be programmed in the PLC to provide accurate system operability. Fault alarms for the system will need to be routed to the projects alarm systems to monitor system functionality.

Power for the pressure transducer, programmable logic controller, and associated equipment should be available in BVCC10 but a system load analysis will have to be performed to verify the loading on the BVCC10 bus if any new systems are to be added to this bus.

d. Biological:

This alternative does not reduce the frequency of valve cycling compared to the no action alternative. However, if the valve cycling automation can be programmed to only occur at night, this would be an advantage to diurnal fish passage in the EFL ladder.

3.1.10.2 *Advantages*

- Automatic closured of the AWS backup system when the maximum pressure differential is reached ensures that the trashracks will not break.

3.1.10.3 *Disadvantages*

- Could be problematic for the valves open and close without an Operator's presence.

3.1.11 Alternative 7: Pressure wash the debris off the trashracks from the intake deck using a water tank.

This alternative was deprioritized during the 60% EDR phase. For rationale behind this decision, see section 3.4.2.

This alternative is to continue existing operations and cycling the valves to release debris from the trashracks. If cycling the valves does not remove the debris then the mobile crane will be used to remove the trashracks from their slot and set the racks on the intake deck. A pressure washer will then be used to remove debris from the trashracks.

3.1.11.1 *Modifications*

A water tank will need to be installed on the forebay deck. A hose can then connect the tank to a portable pressure washer to spray debris off the trashracks. A pump and water pipes will need to be installed to pump water from the reservoir into the tank.

3.1.11.2 *Operations*

Cycle the valves to remove debris like normal. If debris buildup does not go down from this operation, then operations personnel will remove the trashracks for cleaning. Once the trashracks are cleaned, they can be put back into place to continue normal operation.

3.1.11.3 *Design and Construction Considerations*

The water tank will need to be installed somewhere out of the way. It should be slightly elevated above the forebay deck elevation so that it can feed water to the pressure washer using only gravity.

a. Mechanical:

A large water tank, at least 500 gallons, will need to be installed on the intake deck. A pressure washer will need to be either purchased or rented if operations staff does not currently have one.

b. Electrical:

A pump would need to be installed. Power to start and control the pump would be from the FCQ7 MCC. A system load analysis will have to be performed to verify the load of the motor control center's (MCC's) bus if the pump is to be added to the MCC.

c. Hydraulics:

If debris is to be washed back into the forebay, the location of the deck screen cleaning should be located west (downstream) at a minimum west of Unit 22 (east most unit). Otherwise, the debris is likely to return to the AWSBS intake area.

d. Biological:

If the debris does not float off during normal valve cycling, the AWSBS has to be shut down again to facilitate trash rack removal for cleaning. This alternative will increase valve cycling, reduce attraction flows at the EFL entrances, and delay passage for the duration of the cleaning. In the event of both Fish Units failing, the EFL will have no auxiliary flow for the duration of trash rack cleaning. If this alternative is further analyzed, the water pump intakes for the power wash tank supply should be designed in such a way to minimize juvenile fish entrainment.

3.1.11.4 *Advantages*

- This will provide a way to clean the racks in the event that cycling the valves does not clean off the debris.

3.1.11.5 *Disadvantages*

- This is a very labor-intensive effort.

- The dam access would likely be blocked while trashracks are being removed, cleaned, and replaced requiring space for the crane and for the cleaning and stacking the screens.
- Require Project mobile crane that might be needed for other purposes.
- Fish may be trapped in the intake area while the trashracks are removed (especially given the proximity to the fish ladder exit).

3.1.12 Alternative 8: Install variable-porosity plate between trashrack and intake to provide uniform flow through the trashrack.

This alternative was deprioritized during the 60% EDR phase. For rationale behind this decision, see section 3.4.2.

3.1.12.1 *Modifications*

A multi-porosity plate would be installed about 1.5 – 2.5 feet downstream of the trashrack to provide a more uniform velocity through the trashracks.

This option could be used augment either a new trash rake or no other action alternatives.

3.1.12.2 *Design and Construction Considerations*

a. Mechanical:

Not Applicable.

b. Structural:

New angled irons or C-channels would need to be installed downstream of the trashrack. The angle irons or C-channels would need to be custom fabricated to match the taper angle of the concrete.

Given the wide span of the plates, they need to have support braces.

c. Hydraulics:

The intent of the porosity plate is to provide a uniform velocity along the depth and width of the trashrack. The porosity would be lowest in the vicinity of the intake pipe (40 feet underwater) and lower near the surface.

The more uniform trashrack velocity may reduce debris buildup by itself. However, this alternative may be most effective in conjunction with other alternatives such as a trash rake or water jets.

Recommend hole diameters of at least two inches to avoid blockage from debris that passes through the trashrack.

d. Biological:

With the velocities raised nearer to the surface, the risk for juvenile fish entrainment into the AWS backup system is increased. However, the footprint of the hydraulic change is small. Reducing hot spots may lead to reduced frequency of AWSBS shutdowns and an advantage for maintaining operation of the adult ladder.

e. Operations:

The size of the holes in the porosity plate would need to be sized to prevent the need to frequently pull the porosity plates for debris removal.

3.1.12.3 *Advantages*

- Useful if applied in conjunction with other alternatives.
    - Provides uniform velocity over trashracks,
    - Minimizes hot spots for concentrated debris accumulation.
    - Improves chances of trash rake or other screen cleaning mechanisms.

3.1.12.4 *Disadvantages*

- Increased intake surface velocity potential to attract juvenile fish may be a fatal flaw.
- The porosity plate would add at least an estimated 6 inches of headloss to the trashrack system.

3.1.13 Alternative 9: Travelling screen with debris catchment bin that can be periodically removed.

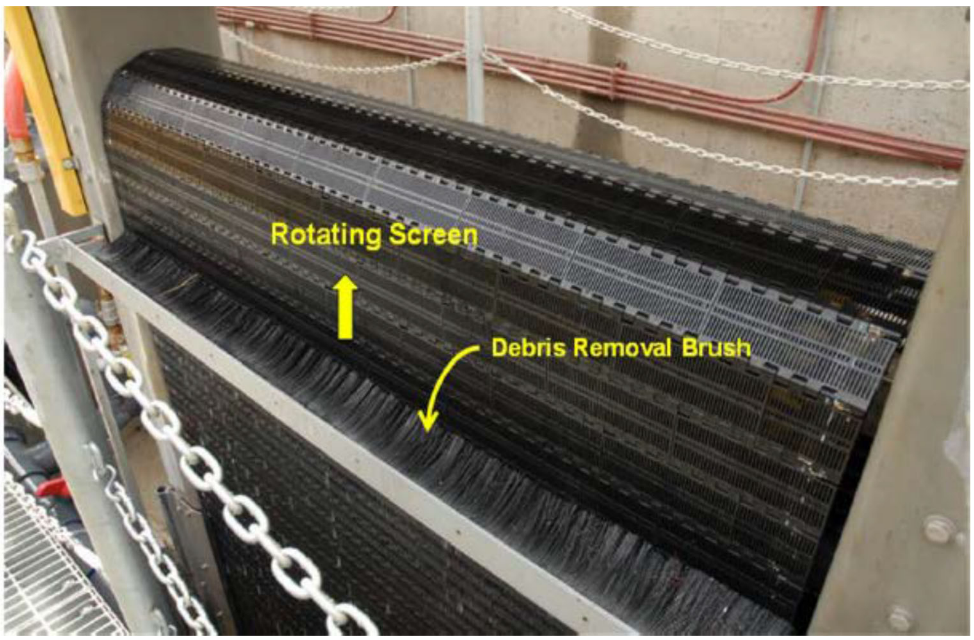
This alternative was deprioritized during the 60% EDR phase. For rationale behind this decision, see section 3.4.2.

3.1.13.1 *Modifications*

This alternative is to replace the existing trashracks with a traveling screen structure to remove debris. These screens operate with sectional perforated plates all linked together. The screens rotate around a motorized drum which powers the traveling of the screen. Normally traveling screens are used in fish facilities and the trash gets washed downstream on the rotation on the other side. For this facility, trash cannot be washed through the AWS tunnel. Therefore, a brush with a debris catchment bin will need to be installed on the traveling screen to clean the debris off the screen. The picture below shows an example of what this type of structure could look like. The traveling screen shown is from a fish facility with very small slots for flow. This new structure must maintain the existing maximum spacing of 0.75” to preclude adult salmon and lamprey from fallback.

To determine when to actuate the screen, some form of head differential measurement will be needed. Close consultation with the travelling screen manufacturer would be required to determine the acceptable levels of head differential, and a controlling feature would be needed to either automatically activate the screen or alert the project to do so.

Figure 3-8. Travelling Screen Example, Alternative 9



3.1.13.2 *Design and Construction Considerations*

a. Mechanical:

The screen will need to have a motor to rotate the drum/gear which moves the screen. The screen will also need a debris removal brush and potentially a high pressure spray bar positioned directly above the brush to ensure that debris does not travel behind the screen. Ideally this debris is sprayed and brushed downwards into the water and is pulled back into the river’s sweeping flow.

b. Structural:

This system will require attaching steel beam(s) to support the rotating screens and drum. Steel beams will attach to concrete on each side through expansion anchors. Depending on the weight of the system, a structural analysis will be needed to specify the size, section and vertical spacing.

Consultation with a travelling screen manufacturer has confirmed that the 23' wide intake is too large for an off the shelf screen system. A center pier would need to be installed to support two narrower travelling screens. A construction project of this effort is likely unfeasible and will be a major challenge with implementing a travelling screen.

c. Electrical:

Power to start and control the rotating traveling screen system would be from the FCQ7 MCC. A system load analysis will have to be performed to verify the loading of the motor control center's (MCC's) bus if the new roller gates system is to be added to the MCC.

The control panel to operate the rotating traveling system would be designed to operate in manual or auto mode depending on operations preference and be mounted near the trashrack to visually verify the system is properly operating. Fault alarms for the system will need to be routed to the projects alarm systems to monitor system functionality. It can tie into the Fish SCADA system by using the existing PLC located in the MCC gallery. If the existing PLC does not have additional spare I/O points, then new cabinets will need to be installed which could be costly.

d. Hydraulics:

The clear spacing of the travelling screen can be configured to match the existing trashrack and should experience similar headlosses as the existing system.

As the intake pipe is centered within the intake, they hydraulic effects due to a large central support pier likely make this concept unfeasible.

e. Biological:

Rotating screens should be designed to minimize impingement and entrainment of juvenile fish. The maximum spacing on the screens should be 0.75" to preclude adult salmon and lamprey from falling back into the system.

f. Operations:

The traveling screen will not need to be turned on all the time. Operating this will only be necessary when the debris builds up on the screen. This does require a motor and thus will require regular O&M maintenance.

3.1.13.3 *Advantages*

- These screens guarantee that the debris will be removed.

3.1.13.4 *Disadvantages*

- The one drawback is that all the debris will need to be properly disposed once removed.

3.1.14 Alternative 10: Design and install new seamlessly connected trashracks. Clean new trashracks with a simple nylon brushing system, actuated by a dedicated hoist.

This alternative was updated and prioritized for consideration in the most feasible alternatives during the 60% EDR phase. For rationale behind this decision, see section 3.4.3.

Originally, this concept was titled "New overhead bar and crane fixture for the trash rake with new trashracks which fit together". This has been modified to the above concept, which would completely replace the current trashracks with a new, seamless design while still maintaining the required ¾" bar spacing. Vertical guides would be installed on the flat, vertical concrete walls directly in front of the rack. A simple horizontal brush and scraper would be designed to span the width of the new trashrack, travel in the new vertical guides, and be operated as needed by a dedicated overhead hoisting system.

Analysis to size the hoisting system is underway and will be completed during the DDR phase. The main challenge with installing a dedicated hoist will be providing electrical power and fitting the support structure within the narrow footprint of the existing intake structure.

3.1.14.1 *Modifications*

The current trashrack panels have protruding L-brackets which sit on top of the grating of the rack panels. Furthermore, the rack material is standard deck grating, with flush horizontal and vertical members. In order to guarantee a brush is able to effectively remove impinged debris from the rack, an entirely new design is needed with a seamless face and open vertical channels (i.e., no protrusions or horizontal bars on the face of the rack). The newly designed trashracks would require ¾" clearance between the vertical members and cover an area approximately 25 feet wide by 65 feet tall.

Originally, this concept intended to clean the new trashracks with a standard rake, where metal protruding "teeth" slide between the vertical members. However, due to the tight ¾" clear spacing and the required height of 65 feet, there is a large risk that a rake would not properly interface. It would be very difficult to maintain a consistent ¾" spacing over the entire vertical span, as the rack would likely need to be constructed in several panels. Any misalignment between the panels or unintended bends in the vertical members would create a snag for the rake's teeth.

A dedicated dual electric-winch wire rope hoist will be installed on the deck to raise and lower the brush. As the new trashrack panels may need to be pulled on occasion for repair or deep cleaning, the hoists will need to be offset instead of directly above the brush, utilizing wire rope sheaves to route the rope down the sides of the face of the intake.

The brush system for this alternative will be simple strip brushes. Replacing the rack will allow for much stiffer bristles which will increase the effectiveness of debris removal.

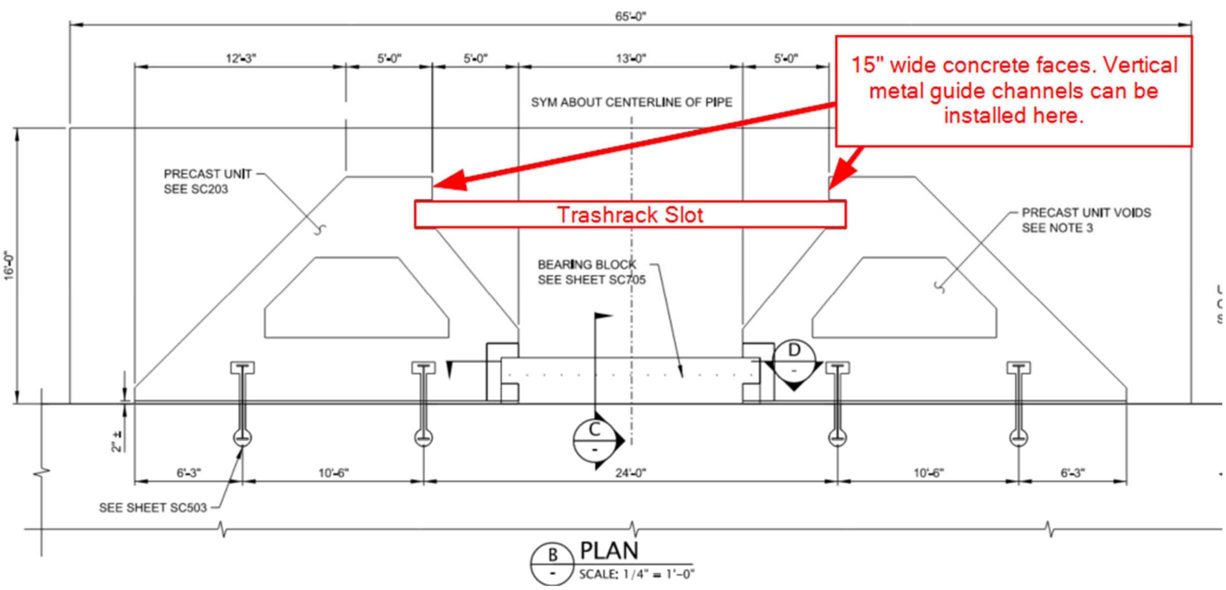
Additionally, an HDPE wedge will be installed on the top and bottom of the frame to scrape the face of the rack, physically cutting stiffer debris.

3.1.14.2 *Operations*

The brush system will only be operated when the system is shut down for a debris cycling operation. Currently, when the head differential limit across the rack is reached operations shuts down the intake and allows the rivers natural sweeping flow to backflush debris from the rack. Given enough down time, this method has proven effective to date at removing enough debris to resume safe operation. The brush system will simply speed up this process, assisting in freeing debris from the rack to be pulled out into the rivers sweeping flow.

Due to the high sweeping flow, the PDT anticipates that most of the debris freed by the brush will be quickly pulled away by the sweeping flow of the river. It is therefore not anticipated that operational personnel will have to manually remove debris from the brush with each operation. Access to the brush will however still be needed by the project staff to replace brushes and remove debris if needed.

Figure 3-9. Plan View



3.1.14.3 *Design and Construction Considerations*

During construction, the current trashrack panels will need to be removed and replaced with the new design. This will involve use of a mobile crane to hoist each of the 11 panels out of the slot.

Furthermore, the guide channels for the brush will need to be installed on the 15" wide vertical concrete faces directly in front of the trashrack slot. This will require the use of a dive team to install the guides and will require a mobile crane to lower the guides into the water.

a. Mechanical:

Design of the brush, the brush frame, the brush hoisting system, and the vertical guides of the brush will need to be completed. Coordination between mechanical and structural will be required to complete many of these tasks.

b. Structural:

A new trashrack structural design will be required. This new trashrack will need to be designed to fit within the original trashrack slot and will need a seamless face with no protrusions.

A structural design will need to be completed for the hoist machinery supports.

c. Electrical:

Power will need to be provided to the overhead hoist from FCQ7 MCC. A system load analysis will have to be performed to verify the loading on of the motor control center's (MCC's) bus to determine if the overhead crane can be added to the MCC. FCQ7 MCC is in the MCC gallery and conduit routing to the roadway near the trash rack area may require core drilling through the upstream wall to add conduit between the MCC and the hoist. If conduit routing penetrates the upstream wall, scans of the wall will be required to verify existing conduits. A special scaffolding or manlift will be needed to access the area above water. The other conduit routing option would be a longer conduit run over to the East end of the dam and require trenching across the roadway to the upstream side.

The control panel to operate the hoist system would be designed to operate in manual or auto mode depending on operations preference and will need to be mounted near the trashrack.

d. Biological:

Trashracks must comply to the maximum 0.75" spacing to preclude adult Pacific Lamprey from entering the AWSBS. This criterion was previously coordinated with the region for this system.

The AWSBS intake is near the fish ladder exit. The brush system should be designed to minimize risk of increasing debris at the fish ladder exit.

3.1.14.4 *Advantages*

- Replacing the racks with a seamless design would allow the brush to easily and completely clean the racks with each operation.

- Due to the simple brush design, the system will experience a much more consistent hoisting force.

3.1.14.5 *Disadvantages*

- Considerable construction and modification is required to make this work.
- Due to the size of the new trashrack, the trashrack would most likely need to be made in smaller sections that stack together, similar to the current panel layout. Depending on the design of the panels, it may be difficult to maintain the 0.75" clear spacing between each interfacing section.
- If the river's sweeping flow is insufficient at removing debris from the brush, the project may have to occasionally remove debris manually from the brush. Operators may have to lift the brush out of the guide channels and set it on the deck to clean it fully.
- This brush will only be used in conjunction with valve cycling. The AWS Backup need to be shut down during operation.

3.1.15 Alternative 11: Design and install a brush system capable of cleaning the current trashracks. Operate the new brush system with a dedicated hoist.

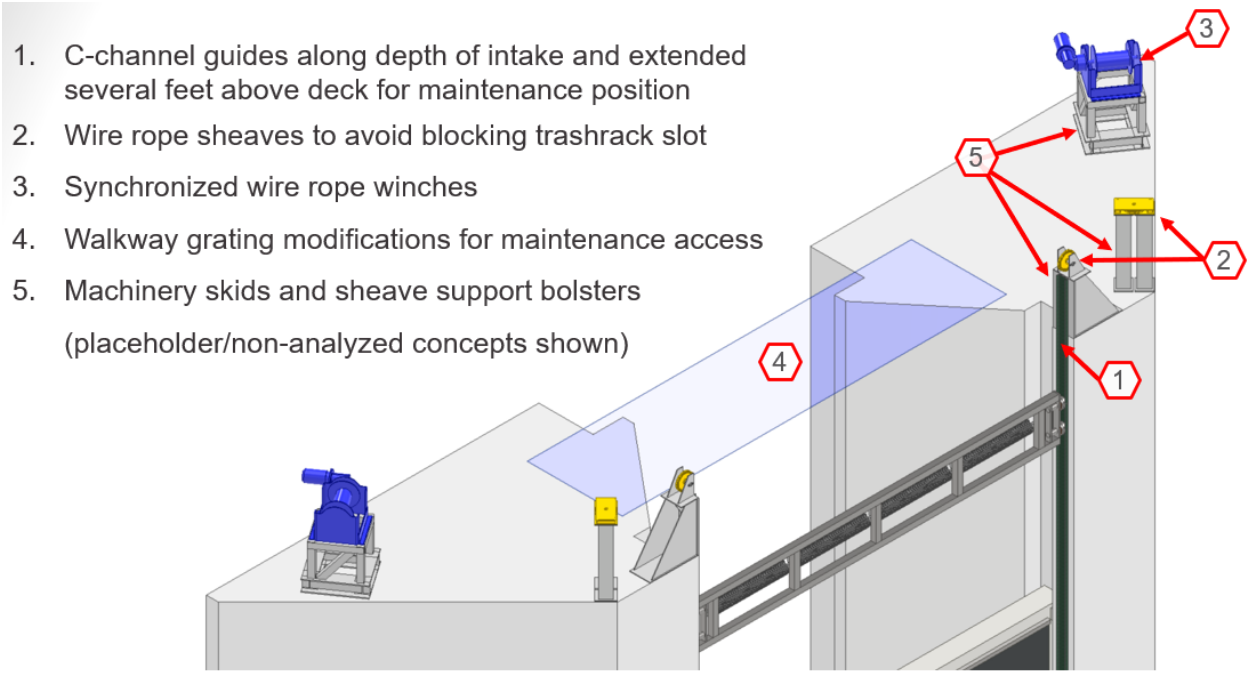
This alternative was updated and prioritized for consideration in the most feasible alternatives during the 60% EDR phase. For rationale behind this decision, see section 3.4.3.

This alternative originally was titled "Use a nylon brush instead of a rake. This would be similar to the system recently installed at Bonneville Dam." This concept has been modified to the above title and involves the design and fabrication of a custom brushing system. This brush would need to interface with the current trashrack panels and work around or over the protruding L-brackets. The brush would require vertical guide slots similarly to alternative 10. As with alternative 10, the brush will be operated with a dedicated hoist.

3.1.15.1 *Modifications*

An isometric view of a conceptual model is shown in Figure 3-10 below. Descriptions of the expected modifications follow.

Figure 3-10. Brush Access Options



The first modification will be the installation of vertical guide channels on the 15” wide concrete faces directly infront of the trashrack slots. The size of these channels will be determined during the DDR phase but will need to extend above the current deck height to bring the brush to a maintenance accessible position. An extension support device will need to be designed to raise the c-channels.

Second, this alternative will require the design and construction of a dedicated electric-winch, wire-rope hoist to actuate the brush. Due to the wide span of the brush device, approximatley 23 feet, the system will likely need to be hoisted from both ends to prevent skew and tilt while lifting. The capability to remove the trashrack panels needs to be maintained, so the hoist will have to be offset on the deck, utilizing wire rope sheaves to route the rope in front of the slot.

While full details of the hoist will be determined during the DDR phase, the dual sided electric winches will need to be synchronized. Synchronization can be accomplished using a VFD, position feedback and skew control, or potentially a selsyn motor type system. Full details of the control of the hoist will be developed during the DDR phase. Sizing of the hoists will also be completed during the DDR phase, but initial expectations based on the weight of the brush frame indicate both hoists will be in the 3 to 5 horsepower range.

Operators will need to periodically access the brush after installation to maintain and replace the brush inserts. In addition to raising the C-channels above the deck height, the existing walkway grating will need to be modified to allow for closer access when the brush is raised. Ideally the walkway grating modification will not interfere with trashrack slot access, and therefore will need to be something that can be temporarily placed and removed.

Finally, because the upper position of the brush frame will be above the deck height, the hoisting system will also need to be elevated. Structural support will be needed to design bolsters/stands for the winch and routing sheaves.

3.1.15.2 *Operations*

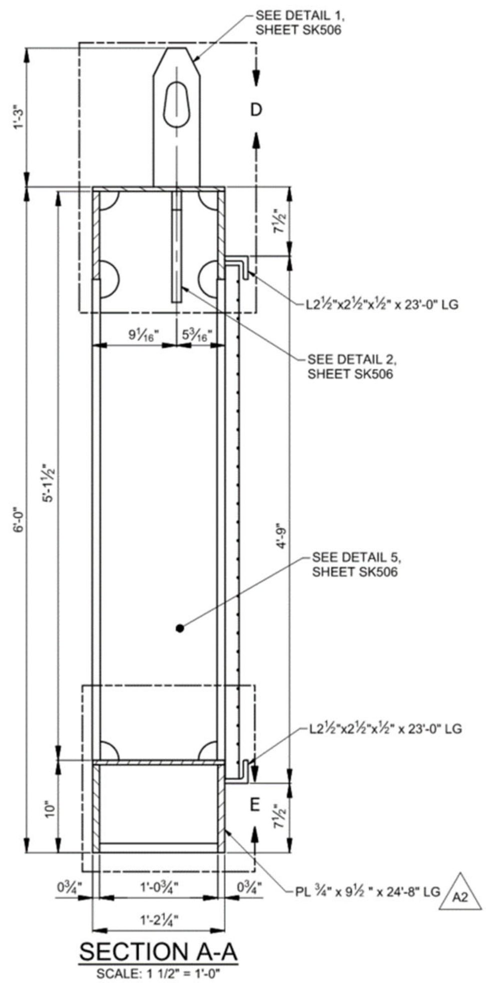
The brush system will only be operated when the system is shut down for a debris cycling operation. Currently, when the head differential limit across the rack is reached operations shuts down the intake and allows the rivers natural sweeping flow to backflush debris from the rack. Given enough down time, this method has proven effective to date at removing enough debris to resume safe operation. The brush system will simply speed up this process, assisting in freeing debris from the rack to be pulled out into the rivers sweeping flow.

Due to the high sweeping flow, the PDT anticipates that most of the debris freed by the brush will be quickly pulled away by the sweeping flow of the river. It is therefore not anticipated that operational personnel will have to manually remove debris from the brush with each operation. Access to the brush will however still be needed by the project staff to replace brushes and remove debris if needed.

3.1.15.3 *Brush Design and Construction Considerations*

a. Mechanical:

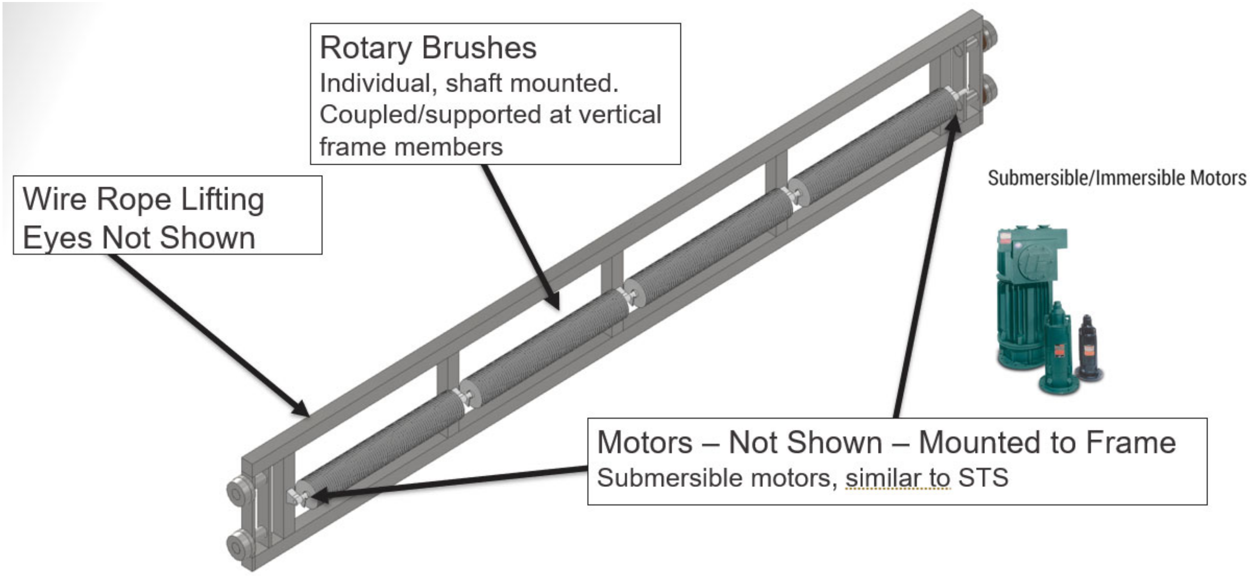
Figure 3-11. Section View of Current Panel



The figure above shows a section through the middle of the current trashrack panels. Each panel has an L-bracket at the top and bottom of the grating material. The bracket is 2.5" long from the face of the panel and made of ½" thick steel. The grating is made of 1-1/2" x 3/16" bearing bars. As estimated from the above drawing, the bracket protrudes ~1" from the upstream face of the grating.

The upstream face of the steel grating has both vertical and horizontal bars, as compared to a standard trashrack which only has vertical bars.

Figure 3-12. Brush Frame Concept Overview



The brush system will need to be made from a flexible nylon material. Consultation with one brush manufacturer suggested utilizing 6/12 nylon, with 4" long, .022 level bristles. According to brush manufacturers, motorized rotary brushes will be more effective at removing debris than a standard strip brush and will be the primary target of design, however if this proves to be infeasible static strip brushes can be used.

Rotary brushes will require actuation. Chain drives or other above water rotary transmissions spanning the entire length of the brush travel are likely infeasible due to the 80+ feet of travel distance. The primary design for actuating the rotary brushes will be submersible motors (IP 68 rated for continued use at 65' depth) mounted to the brush frame, similar to what has been used on ESBS screens. Power would need to be fed to the drive motors via an automatically spooling cable reel.

If electrical constraints prevent the use of powered motors, there may be a complex, non-motorized solution to spin the brushes. If the wire rope is rerouted back to the top deck instead of terminating at a pick point on the brush frame, an adjustable tension friction shive could potentially be designed to interface with the rope as it moves. The friction shive could then be coupled to the rotary brushes. This will be less reliable and more complex than powered motors and will be used as a backup option.

Due to the protruding L-brackets and horizontal members of the grating, the nylon brushes will likely wear down quicker than other typical brush applications. Therefore, extra brushes may need to be purchased and stored so they can be replaced as needed. Initially, it is also recommended that several different types of brush bristle and size are acquired to test for the most effective during commissioning of the device.

As seen in the above Figure 3-12, the brush will need to be several smaller discrete sections rather than one long span. This configuration will allow for individual sections of brush to be replaced as they wear down but will require coupling and supporting between each shaft section.

Further analysis is required and underway to determine the optimal bristle size and frame angle, but initial conversations with a brush manufacturer suggest starting with 4" long, 0.022" 6/12 Nylon Bristles.

The brush frame will be constructed of square HSS sections. Steel roller wheels with self-lubricating bushings will be mounted to steel shafts that are fixed to the brush frame. The roller wheels will be designed to interface with the c-channels installed on the intake. Lifting eyes will also need to be designed to accept wire rope terminations. Current illustrations are conceptual only, with full support and design details being developed in the DDR phase.

Additionally, an HDPE wedge will likely be installed along the DS bottom edge of the frame. The purpose of the wedge is to provide an angled edge that pulls loose grass and debris downward, assisting with freeing debris for the brushes to then contact. The wedge will be much more effective when used with new trashracks in Alternative 10, as it will be able to scrape against the flush upstream face of the racks. With alternative 11, the wedge will not be able to make contact with the grating due to the L-bracket protrusions and will sit ~1" in front of the upstream face of the grating but will still be effective at protecting the brushes from any large debris.

b. Structural:

Structural support will be needed to design the anchorage of the vertical guides for both brush concepts. Additionally, structural support may be needed for the design of the brush frame.

A structural design will need to be completed for the guides and support of the hoisting structure. Space constraints will likely make this process difficult.

c. Electrical:

Power will need to be provided to the hoist from FCQ7 MCC. A system load analysis will have to be performed to verify the loading on of the motor control center's (MCC's) bus to verify that the MCC can support the new hoist. FCQ7 MCC is in the MCC gallery and conduit routing to the roadway near the trash rack area may require core drilling through the upstream wall. If conduit routing penetrates the upstream wall, scans of the wall will be required to verify existing conduits. Special scaffolding or manlift will be needed to access the area above water. The other conduit routing option would be a longer conduit run over to the East end of the dam and require trenching across the roadway to the upstream side.

The control panel to operate the hoist system would be designed to operate on manual or auto mode depending on operations preference and will need to be mounted near the trash rack.

d. Hydraulics:

This should be effective as long as the sweeping flow of the passing river stays in the same direction (typically upstream direction). However, there is evidence that the passing river flow may change directions under certain flow regimes or project operations. Ideally, the direction of the sweeping can be changed when needed, so that it is aligned with the direction of the sweeping flow.

e. Biological:

Since this brush will work in conjunction with the existing trashrack panels, adult salmon and lamprey fallback is precluded and juvenile fish entrainment is expected to be minimal.

The AWSBS intake is near the fish ladder exit. The brush system should be designed to minimize risk of increasing debris at the fish ladder exit.

3.1.15.4 *Advantages*

- The main advantage to this system is that it would be compatible with the existing trashracks.

3.1.15.5 *Disadvantages*

- If the river's sweeping flow is insufficient at removing debris from the brush, the project may have to occasionally remove debris manually from the brush. Operators will require access to the brush as referenced in figure 3-11.
- Brushing over the protrusions will increase wear on the brush bristles, in turn increasing maintenance on the system. Depending on frequency of use, bristles will need to be replaced as a regular maintenance item.
- This system will only be used as a backup to valve cycling.
- Both brush concepts will be unproven designs and may have unforeseen drawbacks or difficulties.

3.1.16 Alternative 12: Use a mobile crane for raking the new trashracks

This alternative was deprioritized during the 60% EDR phase. For rationale behind this decision, see section 3.4.2.

While de-prioritized, this concept is no longer up to date with the project expectations. The project's mobile crane was momentarily approved for use with a brush system, so long as the hoisting force is kept to a relative constant value. While both alternative 10 and 11 could be designed to provide a relatively even hoisting force, the December 1st ROV footage caused the team to switch back to a dedicated hoist. For more detail regarding this decision, see appendix I. The original text of this alternative is as follows:

This alternative is to use a mobile crane to operate a new trash rake. Using a mobile crane is beneficial because then the project staff do not need to maintain additional mechanical and electrical equipment. However, the existing project crane does not have the operational availability to operate this new trash rake. For this alternative to work operations will either need to acquire a new crane or temporarily rent a crane whenever trash rake operation is required.

3.1.16.1 *Modifications*

A new overhead bar and trash rake system will need to be installed similar to alternative 10. For this alternative, the assembly will not have a built-in motor to operate the trash rake. A crane will be used to lower and lift the trash rake. This alternative will also require new trashracks which will interface with new the new trash rake.

3.1.16.2 *Operations*

No regular O&M will be needed since there are no mechanical or electrical parts in the assembly. A crane could be rented during high use periods to operate the trash rake when the debris builds up.

3.1.16.3 *Design and Construction Consideration*

a. Mechanical:

The system will be designed to operate with the use of a crane.

b. Structural:

A new trashrack structural design will be required for the new system. Anchorage design will need to be performed to attach the crane to existing concrete.

c. Biological:

This alternative is not expected to require more frequent valve cycling compared to the no action alternative.

3.2 PROPOSED ALTERNATIVES (BY VE TEAM)

The value team developed nine value proposals for consideration by the project team. The team reviewed all of the proposals presented in the value study report and have created a “recommended” list of value proposals. This set of recommended value proposals was viewed to offer the best overall value to the project considering performance, criteria, and constraints. Some of the PDT members were involved in developing these proposed alternatives. A draft report is located at ProjectWise link below:

FY21-006 TDA AWSBS Debris Management Value Study Report-DRAFT-2021-0910.pdf

Table 3-3. Proposed Alternatives, VE

No.	Proposal Title	Initial Cost Avoidance	LCC Cost (Gross)	Schedule Savings	Preliminary Decision
IR-2	Test debris boom for effectiveness in reducing debris build up on trashracks	TBD	TBD	TBD	TBD
ME-1	Install level sensors to tie into project SCADA system	TBD	TBD	TBD	TBD
ME-2	Modify entrance to ladders to use less flow	TBD	TBD	TBD	TBD
MF-2	Construct a travelling horizonal backspray manifold to remove debris while the AWSBS is operating	TBD	TBD	TBD	TBD
ML-2	Acquire spare parts for the 7-foot butterfly valves	TBD	TBD	TBD	TBD
ML-4	Replace 7-foot butterfly valve seals after completing fish unit rehab	TBD	TBD	TBD	TBD
PF-2	Pull the racks at night or during a shutdown for manually cleaning	TBD	TBD	TBD	TBD
PF-3	Construct additional racks so existing may be pulled and rotated for thorough cleaning	TBD	TBD	TBD	TBD
PS-1	Convey running tally on 7-foot butterfly valve cycles to operators	TBD	TBD	TBD	TBD

3.2.1 Alternative IR-2: Test debris boom for effectiveness in reducing debris build up on trashracks

This alternative was deprioritized during the 60% EDR phase. For rationale behind this decision, see section 3.4.2.

This proposal suggests adding a floating debris boom with a floating debris curtain that will be tested to see if debris can be routed around the intake and debris buildupcan be reduced.

Figure 3-13. Test Debris Boom, Triangular

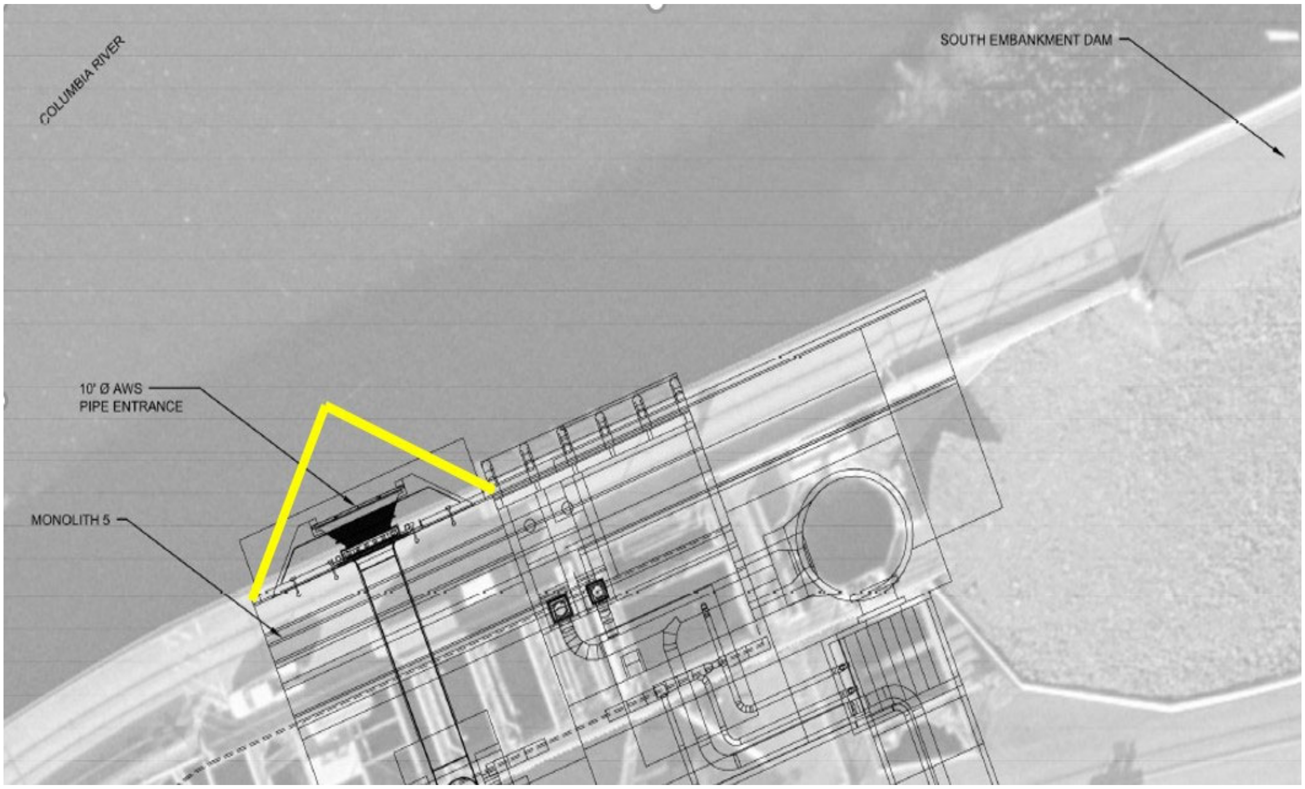
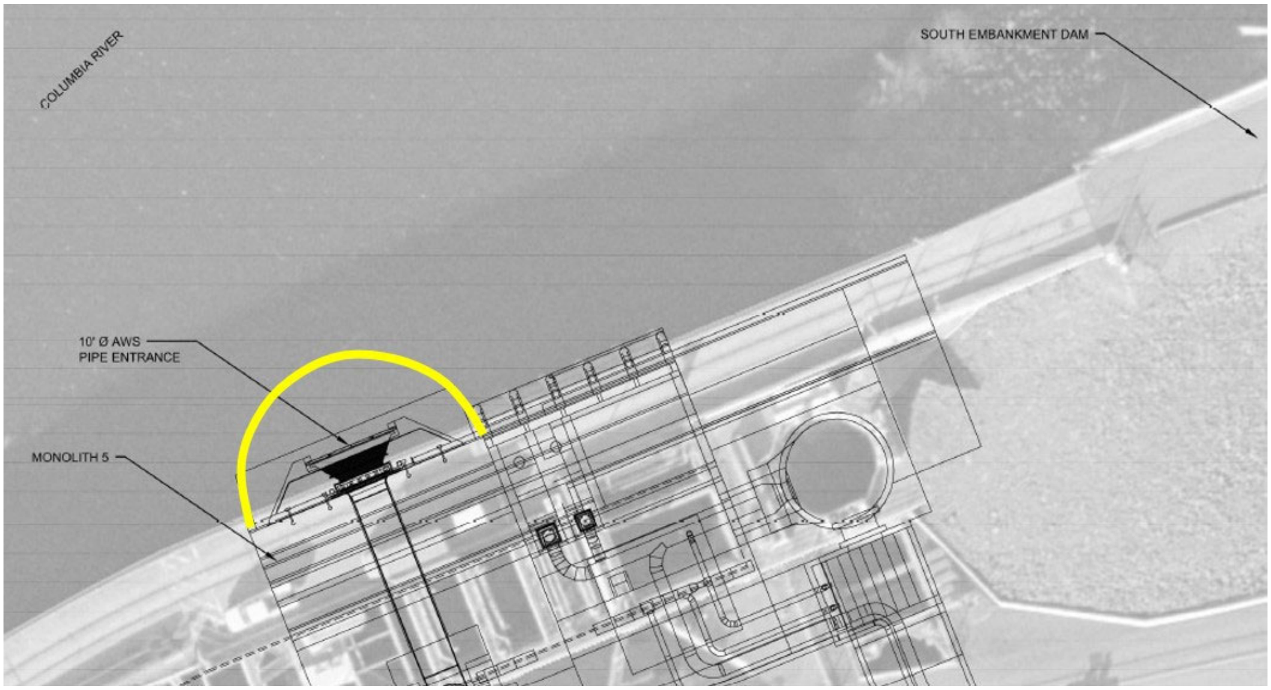


Figure 3-14. Test Debris Boom, Semicircular



Plan view of existing entrance to AWSBS with triangular and semicircular floating boom or floating curtain

3.2.1.1 *Advantages*

- Construction would take place in the reservoir – no need to drain the AWSBS.
- The debris boom can be readily installed.
- If the floating boom and the floating curtain are found to be ineffective, then they can be easily removed.
- To reduce fatigue on the floating boom or floating curtain, they could be deployed during the heavy debris season (May through November); installation could occur in April before the spring snowmelt flows arrive.

3.2.1.2 *Disadvantages*

- With the floating boom, debris management would be limited to the surface of the reservoir. Debris at deeper depths may still accumulate on the trashrack.
- With the floating curtain, debris may accumulate on the curtain.
- A debris boom with a curtain would reduce the sweeping flow for the surface area and potentially capture debris that has been clean from the trashrack resulting in the re- entrainment of the debris on the trashrack.

3.2.2 Alternative ME-1: Install level sensors to tie into project SCADA system

The idea of this proposal is to install ultrasonic level sensors to measure the water surface differential water level across the AWSBS trashrack.

3.2.2.1 *Advantages*

- Reduces the risk of the trashracks failing structurally during extreme debris loading.
- Allows the AWSBS to provide full flow and maintain optimal attraction flow when only one Fish Unit and the AWSBS are operating.
- Reduces the labor required to observe the conditions at the trashrack.
- Reduces the labor required to initiate cleaning of the trashrack if the cleaning system is automated.

3.2.2.2 *Disadvantages*

- Connection may be difficult at this location to achieve reliable communication between the level sensors and the SCADA system

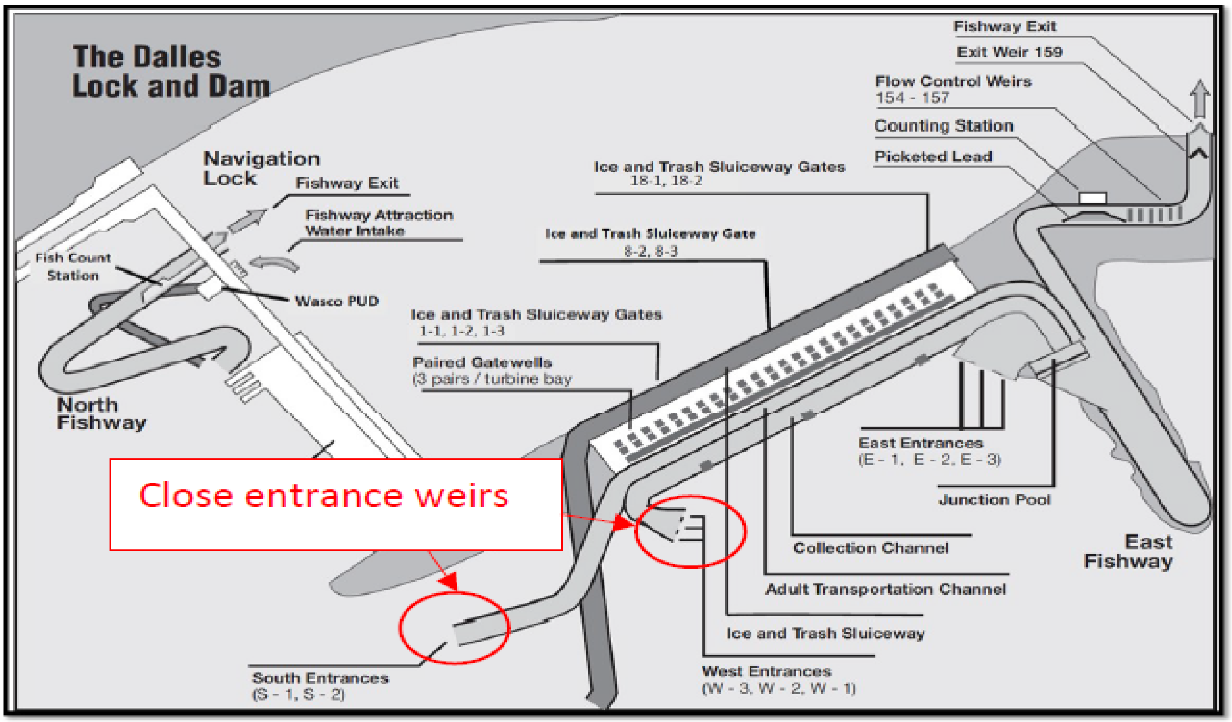
3.2.3 Alternative ME-2: Modify entrances to ladders to use less flow

This alternative was deprioritized during the 90% EDR phase. For rationale behind this decision, see section 3.4.2.

The proposed concept would eliminate the need to operate the AWSBS by modifying the entrance operations and rely on flow from one fish unit for attraction flow; this would eliminate the cycling of the valves which would increase their longevity and reduce maintenance to the system.

Figure 3-15. Ladder Entrances

Proposal Concept Sketch



East Fish Ladder Entrances at The Dalles Dam

3.2.3.1 *Advantages*

- Limit the number of maintenance cycles
- Construction of new system not needed
- Approach velocities are eliminated

3.2.3.1 *Disadvantages*

- Fish ladder performance degraded
- No remote monitoring or operation
- Difficult to obtain regional approval

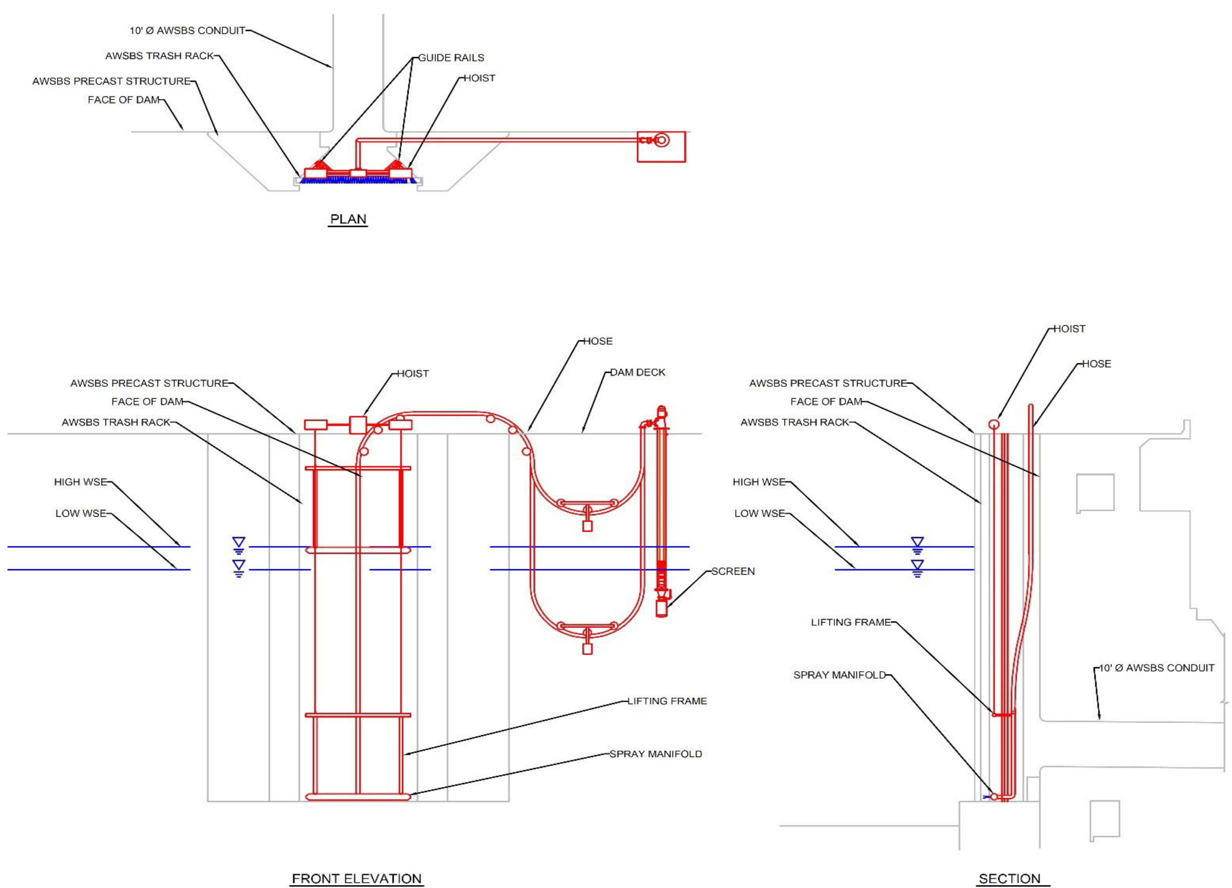
This alternative does not meet the requirements of one Fish Unit and AWSBS working together to provide adequate flow.

3.2.4 Alternative MF-2: Construct a travelling horizonal backspray manifold to remove debris while the AWSBS is operating

This alternative was deprioritized during the 60% EDR phase. For rationale behind this decision, see section 3.4.2.

This proposal suggests constructing a back spray system to clean the trashrack. The system would be located behind the trashrack and consist of a horizonal manifold that can spray water jets across the entire width of the existing trashrack.

Figure 3-16. Travelling Back Spray Manifold



AWSBS with Backwash System

3.2.4.1 *Advantages*

- Reduces the risk of the trashracks failing structurally during extreme debris loading by providing effective and fast cleaning.

- The backspray jets will push the debris several feet out into the forebay and reduce the risk of the debris re-entraining on the trashrack.
- Allows the AWSBS to operate continuously at optimal attraction flow when only one fish unit and the AWSBS are operating.
- Reduces the risk of harm to fish by maintaining low approach velocity through the upper portion of the trashrack (where fish vulnerable to entrainment or impingement are likely to be)
- Reduces the cycling of the 7-foot diameter butterfly valves.
- Most of the work can be constructed within an area isolated by stoplogs and is therefore not subject to the in-water-work period once the area is isolated.

3.2.4.2 *Disadvantages*

- Annual maintenance associated with cleaning the system would increase

3.2.5 Alternative ML-2: Acquire spare parts for the 7-foot butterfly valves

This alternative was deprioritized during the 60% EDR phase. For rationale behind this decision, see section 3.4.2.

This proposal would acquire spare parts for the butterfly valves to maintain system reliability and compliance with fish passage criteria.

3.2.5.1 *Advantages*

- New seals on the 7-foot valves will reset the 1,400-cycle life expectancy and ensure reliability of the AWSBS after the fish unit rehabilitation contract

3.2.5.2 *Disadvantages*

- None noted

3.2.6 Alternative ML-4: Replace 7-foot butterfly valve seals after completing fish unit rehab

This alternative was deprioritized during the 60% EDR phase. For rationale behind this decision, see section 3.4.2.

This proposal would replace the seals on the 7-foot butterfly valves after the fish unit rehabilitation contract.

3.2.6.1 *Advantages*

- New seals on the 7-foot valves will reset the 1,400-cycle life expectancy and ensure reliability of the AWSBS after the fish unit rehabilitation contract.

3.2.6.2 *Disadvantages*

- None noted

3.2.7 Alternative PF-2: Pull the racks at night or during a shutdown for manually cleaning

This alternative was deprioritized during the 60% EDR phase. For rationale behind this decision, see section 3.4.2.

This proposal would provide a backup system if existing operations and valve cycling are not sufficient to prevent debris buildup.

Figure 3-17. Potential Manual Cleaning Area

Plan view of potential work area for cleaning trashrack

3.2.7.1 *Advantages*

- This approach for debris removal would be more efficient than the proposed baseline concept of cycling valves

3.2.7.2 *Disadvantages*

- Operations at nighttime may be needed

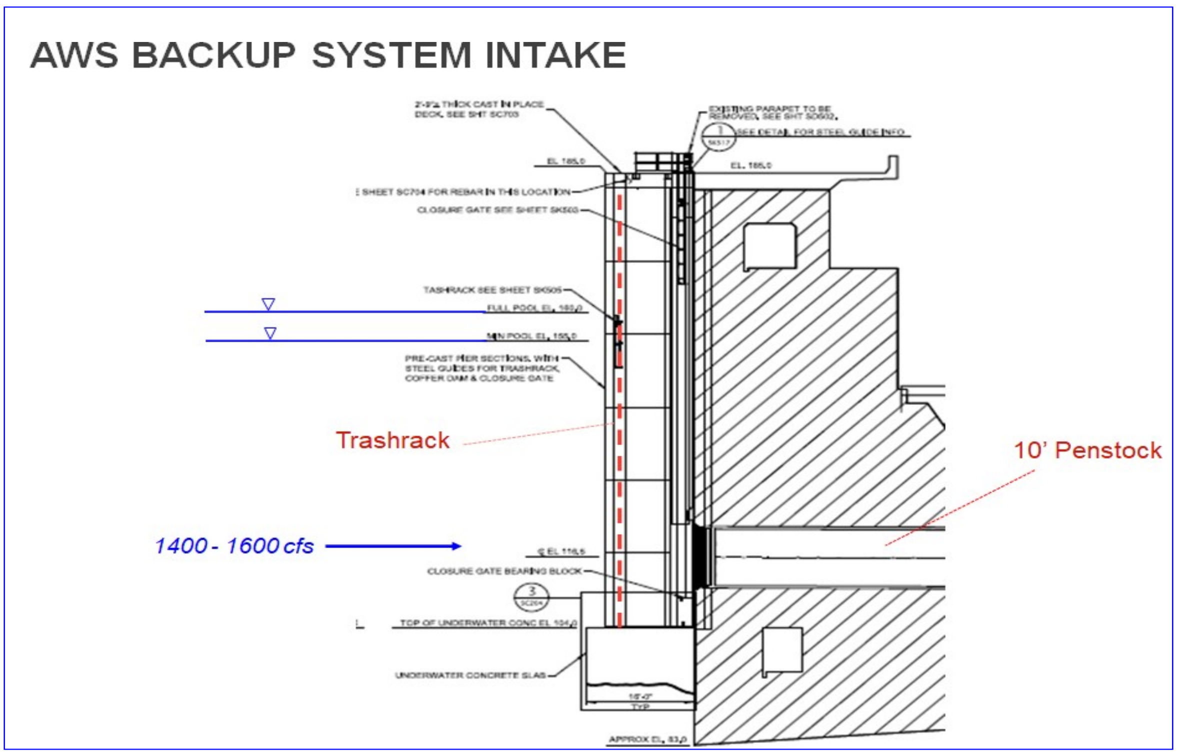
- This is a very labor-intensive effort.
- The dam access would likely be blocked while trashracks are being removed, cleaned, and replaced requiring space for the crane and for the cleaning and stacking the screens.
- Fish may be trapped in the intake area while the trashracks are removed (especially given the proximity to the fish ladder exit)
- May increase the duration of shutdowns.

3.2.8 Alternative PF-3: Construct additional racks so existing maybe pulled and rotated for thorough cleaning

This alternative was deprioritized during the 60% EDR phase. For rationale behind this decision, see section 3.4.2.

This proposal would construct additional racks to replace existing racks to reduce the frequency of shutdowns.

Figure 3-18. Construct Additional Racks



Elevation View with Location of Trashrack

3.2.8.1 *Advantages*

- Reduces the frequency of shutdowns.

- Reduces valve cycling due to periodic resetting conditions with clean racks.
- Access to spare screen members reduces the downtime that currently occurs when the existing racks must be pulled, cleaned, and then reinserted.

3.2.8.2 *Disadvantages*

- Need to store and transport the spare racks.
- More frequent operations and maintenance effort in switching trashracks.

3.2.9 Heading 3 Alternative PF-3: Convey running tally on 7-foot butterfly valve cycles to operators

This alternative was deprioritized during the 60% EDR phase. For rationale behind this decision, see section 3.4.2.

The proposal concept would run 7-foot valve operation cycles assuring management awareness of the valve status with respect to life expectancy and provides timely information to react appropriately beforehand as needed.

3.2.9.1 *Advantages*

- Automatic means of maintaining a tally of valves cycles
- Maintains management awareness of valve cycling status with respect to valve life expectancy.
- Reduces likelihood of management being caught off guard by sudden valve failure and prolonged valve outages.

3.2.9.2 *Disadvantages*

- Added counting component may require minor periodic maintenance.

3.3 PROJECT ANALYSIS

To assist the PDT during the Criteria and Constraints phase, a value study was held to utilize the Value Methodology to both evaluate the 16 potential alternatives based on the project Criteria and Constraints previously identified in the EDR, as well as identify new potential alternatives. The Value Study team included the key PDT members also. During the value study, various tools were used to help the project team identify existing alternatives and develop new proposals to best meet project criteria. Weighted paired comparisons was used to develop performance criteria for ranking existing alternatives and new proposals. All proposals, as well as the team's assessment of the top five existing potential alternatives, were evaluated against the performance criteria developed using the weighted paired comparisons.

After receiving the Draft Value Study Report, PDT further evaluated the weighted paired comparisons, prepared by the Value Study team, and updated the values and the evaluation criteria list. The PDT modified the alternative ranking of all the potential alternatives and the selected new potential alternatives proposed by the Value Study team. The sections below include Evaluation Criteria, Paired Comparisons, and Alliterative Rankings developed by both Value Study team and PDT members.

The criteria of “minimize shutdowns” was initially prioritized due to concerns about a potentially low lifecycle of the large butterfly valves. After further discussion with the manufacturer, the PDT has confirmed that there is no imminent threat to the lifecycle of the valves. The PDT has decided that minimizing shutdowns is still a valid and important criterion to consider, for the following two main reasons:

First, the valves do not have an infinite life. The initially reported 1400 cycle number is not a hard limit, but rather a point in time determined by the manufacturer when a performance review and inspection should occur. There is still however a direct correlation between valve cycle count (shutdowns) and the longevity of the valves and valve actuators. More shutdowns will lead to a quicker degradation of the valves, and if an alternative can reduce the quantity of shutdowns, then it should be given a higher priority.

Second, and more importantly, shutdowns reduce flow through the fish ladder, and therefore reduce fish ladder performance. The amount of time that the ladder is operating at reduced flow during shutdowns should be minimized to the greatest extent possible. Alternatives that both require a single shutdown to remove debris may not receive the same score, as the time required to complete cleaning during the shutdown is of greater importance than just the number of shutdowns alone.

3.3.1 Evaluation criteria list (By PDT)

List below is the evaluation criteria developed by PDT:

a. Fish Ladder Performance
b. Intake Trashrack Head Differential <2 ft
c. Monitor Remotely
d. Minimize Shutdowns
e. Operate Remotely
f. Complexity of Maintenance Cycles
g. Construction Schedule
h. Construction Complexity

3.3.2 Performance Criteria List (By VE Team)

Weighted paired comparisons was used to develop performance criteria for ranking existing alternatives and new proposals.

a. Fish Ladder Performance

b. Intake Trashrack Head Differential <2 ft
c. Monitor Remotely
d. Minimize Shutdowns
e. Operate Remotely
f. Complexity of Maintenance Cycles
g. Construction Schedule
h. Measure Approach Velocity
i. Construction Complexity

3.3.3 Paired Comparisons (By VE Team)

Paired comparisons was used to develop performance criteria and to prioritize the relative importance for ranking alternatives and the VE proposal.

Figure 3-19. Paired Comparison, VE

WEIGHTED PAIRED COMPARISON SCORING FOR EVALUATION CRITERIA

EVALUATION CRITERIA		Preferred Criteria If both meet criteria, which is more important to improve: Score (1= slightly more important; 3= significantly more important)															RAW SCORE	%-AGE
		A	B	C	D	E	F	G	H	I	J	K	L	M	N			
A	Fishladder Performance	letter weight	B 2.2	A 2.6	A 4.8	A 4.7	A 5.6	A 5.5	A 5.6	A 6.5						A	35.3	30.3
B	Head Differential <2 ft			B 1.2	B 2.6	B 3.6	B 4	B 4.6	B 4.3	B 4.4						B	26.9	18.1
C	Monitor Remotely				C 1.4	C 3.4	C 2.7	C 4.8	C 5	C 6.4						C	23.7	16.2
D	Minimize Shutdowns					D 3.3	D 1.2	D 4.5	D 4.2	D 4.8						D	18	11.7
E	Operate Remotely						E 1.4	E 2.6	E 3.5	E 3.3						E	10.8	6.8
F	# & Complexity of Maintenance Cycles							F 2	F 1.6	F 3.1						F	6.7	6.6
G	Construction Schedule								G 2	G 2.6						G	4.6	4.3
H	Measure Approach Velocities									I 1.4						H	0	3.1
I	Construction Complexity															I	1.4	2.9
J	J															J	0	0.0
K	K															K	0	0.0
L	L															L	0	0.0
M	M															M	0	0.0
N	N															N	0	0.0
																TOTAL	127.4	100

3.3.4 Alternative Ranking (By VE Team)

Figure 3-20. Alternative Ranking, VE

ALTERNATIVE RANKING

	EVALUATION CRITERIA	FACTOR %x10	ALT #0X Baseline - Trash Rake	ALT #01 No Action, Continue Cycling	ALT #4.1 Add a Floating Debris Boom	ALT #06 Automate Valve Cylcing	ALT #07 Power Wash Racks	ALT #11 Use a Brush instead of a Rake	ME-1 Install Level Sensors to tie into Project SCADA	ME-2 Modify Ladder Entrance	MF-2 Horizontal backspray manifold	PF-3 Additional Trash Racks
A	Fishladder Performance	303.0	5.7	6.0	5.0	6.2	4.2	6.8	7.4	2.5	6.3	6.2
			1727.1	1818.0	1499.9	1878.6	1272.6	2060.4	2242.2	757.5	1908.9	1878.6
B	Head Differential <2 ft	181.0	6.3	6.0	5.0	7.8	4.4	6.8	7.2	5.8	6.8	6.3
			1140.3	1077.0	905.0	1411.8	796.4	1230.8	1303.2	1049.8	1230.8	1140.3
C	Monitor Remotely	162.0	3.3	0.5	2.2	8.8	1.0	4.3	8.5	2.1	4.5	2.1
			534.6	81.0	356.4	1425.6	162.0	696.6	1377.0	340.2	729.0	340.2
D	Minimize Shutdowns	117.0	5.9	3.9	4.2	4.9	4.3	6.9	5.9	6.5	6.8	4.1
			690.3	456.3	491.4	573.3	503.1	807.3	690.3	760.5	795.6	479.7
E	Operate Remotely	68.0	3.3	1.0	3.2	8.5	1.0	3.5	7.0	2.1	3.7	1.1
			224.4	68.0	217.6	578.0	68.0	238.0	476.0	139.4	251.6	74.8
F	# & Complexity of Maintenance Cycles	66.0	4.3	3.8	4.3	6.2	4.1	6.9	6.3	6.3	5.1	5.1
			283.8	250.8	280.5	409.2	270.6	455.4	415.8	415.8	336.6	336.6
G	Construction Schedule	43.0	4.3	8.9	5.2	6.5	6.1	3.8	6.8	5.0	4.9	6.2
			184.9	382.7	223.6	279.5	262.3	163.4	292.4	215.0	210.7	266.6
H	Measure Approach Velocities	31.0	3.3	3.3	2.1	3.9	2.1	2.8	5.1	2.5	3.1	2.0
			102.3	102.3	65.1	120.9	63.6	86.8	158.1	77.5	96.1	62.0
I	Construction Complexity	29.0	3.9	9.6	5.9	6.1	5.8	3.1	5.9	5.0	4.6	6.6
			113.1	278.4	171.1	176.9	168.2	89.9	171.1	145.0	133.4	191.4
	TOTAL	1000.0	5000.8	4514.5	4210.6	6853.8	3566.8	5828.6	7126.1	3900.7	5692.7	4770.2
	ORDER OF MAGNITUDE FIRST COST											
	COST PER POINT		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	ORDER OF MAGNITUDE LIFE CYCLE COST											
	COST PER POINT		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00

3.3.5 Paired Comparisons (By PDT)

Figure 3-21. Paired Comparison, PDT

WEIGHTED PAIRED COMPARISON SCORING FOR EVALUATION CRITERIA

Preferred Criteria: If both meet criteria, which is more important to improve: Score (1= slightly more important; 9= significantly more important)

	EVALUATION CRITERIA	A	B	C	D	E	F	G	X	H		RAW SCORE	%-AGE
A	Fishladder Performance	letter weight	A 1	A 2.6	A 4.8	A 4.7	A 5.6	A 5.5	A 9	A 6.5	A	39.7	22.4%
B	Head Differential <2 ft			B 1.2	B 2.6	B 3.6	B 4	B 4.6	B 9	B 4.4	B	29.4	16.6%
C	Monitor Remotely				D 1.4	C 3.4	C 3	C 4.8	C 9	C 6.4	C	26.6	15.0%
D	Minimize Shutdowns					D 3.3	D 1.2	D 4.5	D 9	D 4.8	D	24.2	13.7%
E	Operate Remotely						F 5	G 4	E 9	I 3.3	E	9	5.1%
F	# & Complexity of Maintenance Cycles							F 4	F 9	F 4	F	22.0	12.4%
G	Construction Schedule								G 9	G 1	G	14	7.9%
X	Measure Approach Velocities									I 9	X	0	0.0%
H	Construction Complexity										H	12.3	6.9%
											TOTAL	177.2	100%

3.3.6 Alternative Ranking (By PDT)

The PDT implemented the paired comparisons developed by the PDT team to develop the alternative ranking. Five feasible VE proposals were considered for the alternative ranking by the PDT. The result is shown in the table (Figure 3-22) below and is located at the PW link: PDT Existing FY21-006 TDA AWSBS CombinEX Analysis -2021-0929.xlsx

Figure 3-22. Alternative Ranking, PDT

	EVALUATION CRITERIA	FACTOR %x10	Alternative 1: No action, continue operation as is	Alternative 2: Use an air bubbler system to divert the debris further downstream/ upstream	Alternative 3: Use an air bubbler system to flush debris off the trash racks	MF-2 Horizontal backspray manifold	Alternative 4-1: Install passive exclusion system. Floating debris boom to deflect surface entrained debris.	Alternative 4-2: Install passive exclusion system. Floating curtain to deflect debris down to the depth of the curtain.	Alternative 4-3: Install passive exclusion system. Full depth steel deflection structure to divert all debris past the intake, assuming one direction of flow.	Alternative 4-4: Install passive exclusion system. Full depth steel deflection structure to divert all debris past the intake, assuming two directions of flow.	Alternative 5: Contract out a diver to remove clogged debris when floating debris off doesn't work	Alternative 6: Automation of valve cycling.	ME-1 Install Level Sensors to tie into Project SCADA Standalone	ME-1 Install Level Sensors to tie into Project SCADA With ALT 6	Alternative 7: Pressure wash the debris off the trash racks from the intake deck using a water tank	PF-3 Additional Trash Racks With ALT 7	Alternative 8: Install variable-porosity plate between trash rack and intake to provide uniform flow through the trash rack.	Alternative 9: Travelling screen with debris catchment bin that can be periodically removed.	Alternative 10: Design and install new seamlessly connected trashracks. Clean new trashracks with a simple nylon brushing system, actuated by a dedicated hoist.	Alternative 11: Design and install a brush system capable of cleaning the current trashracks. Operate the new brush system with a dedicated hoist.	Alternative 12: Use a mobile crane for raking the new trash racks. Requires new trash racks.	ME-2 Modify Ladder Entrance
A	Fishladder Performance	224.0	3.29	6.14	6.00	6.43	6.71	6.86	6.43	6.57	5.00	6.29	6.71	6.86	4.71	4.86	5.71	5.71	7.71	7.29	6.29	4.64
			737.09	1375.61	1344.24	1440.58	1503.31	1536.92	1440.58	1471.95	1120.20	1409.22	1503.31	1536.92	1055.23	1088.84	1279.27	1279.27	1727.35	1633.26	1409.22	1039.55
B	Head Differential <2 ft	165.9	3.86	5.71	5.86	6.14	6.14	6.29	5.86	5.71	5.43	6.43	6.71	7.00	5.14	4.86	4.79	5.71	7.00	6.71	5.42	5.43
			640.43	947.37	972.26	1018.71	1018.71	1043.60	972.26	947.37	900.91	1066.83	1113.28	1161.40	852.80	806.34	794.73	947.37	1161.40	1113.28	899.26	900.91
C	Monitor Remotely	150.1	5.00	5.14	5.21	5.21	5.00	5.00	5.00	5.00	5.00	6.00	8.00	8.00	5.00	5.00	5.00	5.57	6.00	6.00	5.57	5.00
			750.56	771.58	782.09	782.09	750.56	750.56	750.56	750.56	750.56	900.68	1200.90	1200.90	750.56	750.56	750.56	836.13	900.68	900.68	836.13	750.56
D	Minimize Shutdowns	136.6	2.14	5.79	4.50	5.00	6.21	6.21	5.93	5.93	3.58	4.00	4.43	4.57	3.14	3.29	4.14	4.86	5.79	5.64	4.86	3.86
			292.26	790.73	614.56	682.84	848.09	848.09	809.85	809.85	488.92	546.28	605.00	624.12	428.83	449.31	565.40	663.72	790.73	770.25	663.72	527.16
E	Operate Remotely	50.8	4.00	5.43	5.43	5.14	4.57	5.14	4.57	4.64	4.57	7.57	6.29	7.14	4.57	4.57	4.40	5.00	5.14	5.29	4.57	4.71
			203.16	275.79	275.79	261.06	232.11	261.06	232.11	235.67	232.11	384.48	319.47	362.64	232.11	232.11	223.48	253.95	261.06	268.68	232.11	239.22
F	# & Complexity of Maintenance Cycles	124.2	5.29	5.00	4.93	4.21	5.71	5.64	4.57	4.75	4.29	5.86	7.00	6.71	4.00	4.43	5.43	4.43	6.29	5.93	5.71	6.29
			656.77	620.77	612.08	522.69	708.92	700.23	567.38	589.73	532.62	727.54	869.07	833.07	496.61	550.00	674.15	550.00	780.93	736.23	708.92	780.93
G	Construction Schedule	79.0	9.00	3.57	3.57	3.57	4.86	4.43	2.71	2.57	6.43	5.86	5.43	5.14	6.14	4.64	4.00	2.79	2.64	3.79	3.71	4.43
			711.06	282.05	282.05	282.05	383.97	350.00	214.11	203.05	508.01	462.98	429.01	406.09	485.10	366.59	316.03	220.43	208.58	299.44	293.12	350.00
H	Construction Complexity	69.4	8.14	3.71	3.57	3.57	4.57	4.07	3.21	3.14	5.43	5.29	6.71	5.57	6.57	5.21	4.00	3.29	3.57	3.71	5.57	5.43
			565.0	257.5	247.8	247.8	317.2	282.5	222.8	218.0	376.9	367.2	465.8	386.6	456.0	361.6	277.7	228.4	247.8	257.5	386.6	376.9
TOTAL		1000.0	4556.4	5321.4	5130.9	5237.8	5762.9	5773.0	5209.7	5226.1	4910.3	5865.2	6505.8	6511.8	4757.3	4605.4	4881.3	4979.2	6078.5	5979.3	5429.1	4965.2

3.4 ALTERNATIVES DEPRIORITIZATION

Alternatives considered not feasible are listed as deprioritized alternatives. PDT voted on the alternatives and discussed the rationales to deprioritize some alternatives. The result is shown in the table (Figure 3-23) below and is located at the PW link: PDT TDA AWSBS Alternative Screening Decision 8-24-22.xlsx

Figure 3-23. Alternative Ranking Votes

Alternatives	FACTOR %x10	Alternative 1: No action, continue operation as is	Alternative 2: Use an air bubbler system to divert the debris further downstream/ upstream	Alternative 3: Use an air bubbler system to flush debris off the trash racks	MF-2 Horizontal backspray manifold	Alternative 4-1: Install passive exclusion system. Floating debris boom to deflect surface entrained debris.	Alternative 4-2: Install passive exclusion system. Floating curtain to deflect debris down to the depth of the curtain.	Alternative 4-3: Install passive exclusion system. Full depth steel deflection structure to divert all debris past the intake, assuming one direction of flow.	Alternative 4-4: Install passive exclusion system. Full depth steel deflection structure to divert all debris past the intake, assuming two directions of flow.	Alternative 5: Contract out a diver to remove clogged debris when floating debris off doesn't work	Alternative 6: Automation of valve cycling.	ME-1 Install Level Sensors to tie into Project SCADA Standalone	ME-1 Install Level Sensors to tie into Project SCADA With ALT 6	Alternative 7: Pressure wash the debris off the trash racks from the intake deck using a water tank	PF-3 Additional Trash Racks With ALT 7	Alternative 8: Install variable-porosity plate between trash rack and intake to provide uniform flow through the trash rack.	Alternative 9: Travelling screen with debris catchment bin that can be periodically removed.	Alternative 10: Design and install new seamlessly connected trashracks. Clean new trashracks with a simple nylon brushing	Alternative 11: Design and install a brush system capable of cleaning the current trashracks. Operate the new brush system with a dedicated	Alternative 12: Use a mobile crane for raking the new trash racks. Requires new trash racks	ME-2 Modify Ladder Entrance
TOTAL	1000.0	4556.4	5321.4	5130.9	5237.8	5762.9	5773.0	5209.7	5226.1	4910.3	5865.2	6505.8	6511.8	4757.3	4605.4	4881.3	4979.2	6078.5	5979.3	5429.1	4965.2
Deprioritize Vote		Yes: 4	Yes: 6	Yes: 6	Yes: 4	Yes: 2	Yes: 5	Yes: 6	Yes: 6	Yes: 6	Yes: 4	Yes: 1	Yes: 2	Yes: 4	Yes: 3	Yes: 6	Yes: 4	Yes: 3	Yes: 2	Yes: 3	Yes: 4
		No: 2	No: 1	No: 1	No: 1	No: 4	No:	No: 1	No: 1	No:	No:	No: 5	No: 4	No: 2	No: 3	No:	No: 1	No: 4	No: 4	No: 2	No:
		Not Sure: 1	Not Sure:	Not Sure:	Not Sure: 2	Not Sure: 1	Not Sure: 2	Not Sure:	Not Sure:	Not Sure: 1	Not Sure: 3	Not Sure: 1	Not Sure: 1	Not Sure: 1	Not Sure: 1	Not Sure: 1	Not Sure: 2	Not Sure:	Not Sure: 1	Not Sure: 2	Not Sure: 3
Require Valve Cycling?		Yes	Yes	Yes	Yes	No	No	No	No	Yes	Yes	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No
PDT's Decision for Deprioritization		yes	yes	yes	yes	No	yes	yes	yes	yes	Yes	No	yes	yes	yes	Yes	yes	No	No	yes	yes

3.4.1 Alternatives Deprioritized

Below is the table for the deprioritized alternatives:

Table 3-4. Deprioritized Alternatives

Deprioritized Alternatives		
Alternatives	Description	Notes
Alternative 1	No action, continue operation as is and cycle the valves off and on to allow the debris to naturally flow off the trashrack.	
Alternative 2	Use an air bubbler system to divert the debris further downstream/upstream.	
Alternative 3	Use an air bubbler system to flush debris off the trashracks	
Alternative 4-2	Floating curtain to deflect debris down to the depth of the curtain.	
Alternative 4-3	Full depth steel deflection structure to divert all debris past the intake, assuming one direction of flow.	
Alternative 4-4	Full depth steel deflection structure to divert all debris past the intake, assuming two directions of flow.	
Alternative 5	Contract out a diver to remove clogged debris when cycling the valves to allow the currents to remove the debris off doesn't work.	
Alternative 6	Automation of valve cycling. If the maximum differential is reached, the system automatically cycles the valves to clear the debris or maybe just a button in the control room called "Flush AWSBU Debris".	
Alternative 7	Pressure wash the debris off the trashracks from the intake deck using a water tank.	
Alternative 8	Install variable -porosity plate between trashrack and intake to assure uniform flow through the trashrack. This option could be used augment either a new trash rake or no other action alternatives.	
Alternative 9	Travelling screen with debris catchment bin that can be periodically removed.	
Alternative 12	Use a mobile crane for raking the new trashracks.	
MF-2	Construct a travelling horizonal back spray manifold to remove debris while the AWSBS is operating	
ME-1, with alternative 6	Install level sensors to tie into project SCADA system, with alternative 6	
PF-3, with alternative 7	Additional trashracks, with alternative 7	
ME-2	Modify ladder entrance	

3.4.2 Rationales for deprioritizing alternatives

3.4.2.1 *Alternative 1: No action, continue operation as is and cycle the valves off and on to allow the debris to naturally flow off the trashrack.*

a. Mechanical:

At a minimum, level sensors to measure the pressure differential across the trashracks are desired, which automatically removes alternative one from consideration. Because the AWSBS will be in near constant operation during construction, an increase in the amount of debris is likely to be observed. Therefore, a physical means of removing those debris other than cycling is also desired.

b. Structural:

No Structural Considerations.

c. Electrical:

No electrical considerations.

d. Hydraulics:

The 2022 debris experience with the existing Fish unit trashracks does not assure that the status quo will be always reliable at the AWSBS trashracks.

e. Biological:

Continuing operation of AWSBS as-is will result in no added impacts to fish interactions in the forebay as this alternative keeps the existing configuration of the AWSBS intake structure. However, cycling the valves off and on to allow debris to naturally flow off the trashracks introduces degradation to fish ladder performance and increases valve shutdown cycles. Performing valve cycling will require the AWSBS to shut off, resulting in decreased attraction flow to EFL entrances for the duration of the cycling. Depending on the time of year, valve cycling may be required multiple times a day which would negatively impact adult salmonid and lamprey passage. In the event of both fish units being forced out of service simultaneously, this no action alternative will result in no flow to the EFL during valve cycling which would be detrimental to adult fish migration.

f. Operations and Maintenance:

Cycling has been successful to date. Cycling can range from once a month to every day depending on river flow and aquatic vegetation loading. Operator can respond within 30 minutes with cycling taking another 30 minutes. This alternative requires a backup plan of cycling does not clear the trashrack. Cycling needs to occur without allowing vegetation to impinge on trashrack. Increased maintenance needs will likely be required with this much valve operation.

3.4.2.2 *Alternative 2: Use an air bubbler system to divert the debris further downstream/upstream.*

a. Mechanical:

Diverting debris upstream and downstream would require a large and costly construction effort in front of the intake. This zone experiences fast moving and changing currents and would require a large enough air system to overcome the incoming flow rates.

b. Structural:

Significant structural design would be required to support the air bubbler system. High loads would be exerted on the steel/concrete structure that will support system. The structural and construction work effort do not offset the benefits.

c. Electrical:

A power feed from FCQ7 MCC will be required for the air bubbler system. If there are no spare buckets in the MCC or available capacity, then an additional power source will be needed. This could be costly if a long conduit run or new panel is required. The necessary controls will come as a pre-packaged skid assembly with the air compressor and no additional power circuits are required.

d. Hydraulics:

Due to the high intake velocities and an average 1 ft/s bubble rise velocity, the air bubbler system would have to be positioned about 30 - 50 feet west and out from the intake trashrack to avoid significant volumes of air entering the AWSBS system. In order to assure an effective blockage line of bubbles, the required length of the system likely requires an infeasible quantity of air flow supply. If the river currents periodically change direction, bubbler system is not effective.

e. Biological:

Having continuous operation of the air bubbler system to divert debris away does eliminate the need of valve cycling. The elimination of valve cycle maintains optimal fish ladder attraction flow and ladder performance. Fish interactions with the bubble curtain would have to be evaluated to ensure salmon, lamprey, and sturgeon are not negatively impacted and that the bubble curtain does not harbor cover to predatory fish. The omnidirectional air bubble system must not divert debris into the EFL exit as per constraint section 2.2.2. for clear fish ladder flow.

f. Operations and Maintenance:

Will require planning for increased equipment maintenance. Access to equipment could be a concern during a failure.

3.4.2.3 *Alternative 3: Use an air bubbler system to flush debris off the trashracks*

a. Mechanical:

An air bubbler system at the trashrack would need to be able to push debris off the racks with sufficient power to overcome the incoming flow. Due to the high intake velocity, the air system would most likely need to be unfeasibly large, unless the AWSBS is shut down while the air flush occurs. This does not then solve the issue of cycling the valves.

g. Structural:

New vertical concrete slots will require precise concrete cuts or extensive steel rails to create the slot for the air bubbler system. Divers are required for installation and construction.

b. Electrical:

A power feed from FCQ7 MCC will be required for the air bubbler system. If there are no spare buckets in the MCC or available capacity, then an additional power source will be needed. This could be costly if a long conduit run or new panel is required. The necessary controls will come as a pre-packaged skid assembly with the air compressor and no additional power circuits are required.

c. Hydraulics:

Maximum intake velocities (2.5 – 4.5 ft/s) are likely too much for air burst system to reliably overcome while AWS backup system is operating. Most air burst system are effectively applied to juvenile fish screens where average screen velocities are less than 0.4 ft/s.

d. Biological:

This alternative requires increased valve cycling to ensure air burst flushing of the trashracks is feasible. Shutting down the AWSBS system for cleaning reduces EFL performance and causes attraction flow at the fish ladder entrances to be below the required attraction flow criteria set by the FPP. Fish interactions with bubble curtain would have to be evaluated to ensure fish in the vicinity of the intake are not negatively impacted.

e. Operations and Maintenance:

Operation should be simple, similar to valve cycling. Added equipment for maintenance, but easily accessible from deck. Could be considered adequate plan B if the cycling alone does not work.

3.4.2.4 *Alternative 4-2: Floating curtain to deflect debris down to the depth of the curtain.*

a. Mechanical:

This alternative does not include mechanical considerations.

b. Structural:

No structural considerations.

c. Electrical:

No electrical considerations.

d. Hydraulics:

An online review of various debris management strategies of different plant intakes did not reveal any examples of flow curtains. Curtains must be able to withstand hydraulics force from the intake and river, including during flood events.

a. If a flow-through net is used, there will be a gradual accumulation of debris that will increase hydraulic forces and maintenance burden. The flow-through net should not be extended over the existing ladder exit.

b. If a flow blocking curtain is deployed, the effectiveness will probably increase with depth, however the hydraulic forces rise disproportionately with depth. The deeper the curtain, the lower the length of curtain becomes structurally feasible and draw increasing volumes of sediment. Reducing the length will draw the curtain closer to the AWS backup intake, where hydraulic forces from the intake will become increasingly significant.

c. A possible feasible option may be to extend a limited depth curtain to hang from the debris boom presented in Alternative 4-1. The depth of the curtain must not interfere with adult passage.

e. Biological:

This alternative reduces the requirement of AWSBS valve cycling which maintains fish ladder attraction flow criteria but raises concern over fish interaction with the curtain. The depth of the debris curtain (45-50’) poses a risk of both entanglement and obstruction to adult lamprey and salmon exiting the ladder, 45 feet upstream of the AWSBS intake. The depth of the curtain also impacts juvenile salmon, lamprey, and sturgeon that may become entangled during their downstream migration. However, we expect this risk to be very minimal. The impacts to demersal juveniles (sturgeon and lamprey) are expected but even less so to juvenile salmon, as lamprey and sturgeon are typically deeper in the water column in comparison to juvenile salmon (Hatten and Parsley 2009, Brege et al., 2001 and 2004, Long 1968).

f. Operations and Maintenance:

Good preventative idea with no moving parts for operating and maintaining. Would like to require annual inspection during the off season. It could be combined with the project oil boom that is presently installed for protection against in river oil spills that covers the fish ladder intake.

3.4.2.5 *Alternative 4-3: Full depth steel deflection structure to divert all debris past the intake, assuming one direction of flow.*

a. Mechanical:

There are no mechanical considerations for this alternative, but it is not desired to due it's complexity and the requirement of a large construction project.

b. Structural:

The size of the steel structure will require a big setting effort and costly fabrication.

c. Electrical:

No electrical considerations.

d. Hydraulics:

Deflected debris will track along the surface of the structure. With the high AWSBS intake flow, there is a good probability that the east facing opening will end up pulling a significant proportion of the debris back toward the intake. Once debris has been pulled in, it is trapped and there is no longer the option to use the already proven method of valve cycling.

e. Biological:

With the high probability of an eddy coming off the full depth structure, there is concern that debris will become trapped on the intake. This will reduce the AWSBS flow leading to a reduction in EFL performance and the potential need to implement valve cycling. With concern over eddy flow and high intake velocity, this increases the risk of any juvenile fish near the intake may not be able to overcome the intake velocity and become impinged on the trashracks or entrained in the system. The full depth one-way structure may also create habitat for predatory fish to hide in and/or structures for piscivorous birds to perch on.

f. Operations and Maintenance:

Not sure what is meant by full depth. Steel panels can be problematic for maintaining. No operation necessary. Annual inspection would be required.

3.4.2.6 *Alternative 4-4: Full depth steel deflection structure to divert all debris past the intake, assuming two directions of flow.*

a. Mechanical:

Same reasoning as 3.4.2.5

b. Structural:

The size of a steel divert structure will require a big setting effort and costly fabrication.

c. Electrical:

No electrical considerations.

d. Hydraulics:

The hydraulic forces acting on the slide gates will render this option infeasible and impractical. When one or both gates are opened and extended outward, the flow drag exerted on these cantilevered gates will be immense.

e. Biological:

If this alternative is not feasible hydraulically and structurally, then this alternative is not biologically feasible due to the likelihood of this alternative not working.

f. Operations and maintenance:

Comment same as Alt3.

3.4.2.7 *Alternative 5: Contract out a diver to remove clogged debris when cycling the valves to allow the currents to remove the debris doesn't work.*

a. Mechanical:

No mechanical considerations.

b. Structural:

No structural considerations.

c. Electrical:

No electrical considerations.

d. Hydraulics:

Safe diver access is limited to river flow rates below about 200 kcfs (or lower with new intake). Debris is most likely to accumulate during spring freshets, during which flow rates are higher. Significant coordination between several parties required as discussed in sub-section 3.1.9.2.

e. Biological:

The AWSBS would need to be shut down to facilitate safe access for the divers for the duration of the cleaning. In addition to shutting down the AWSBS, the EFL would likely need to have reduced flow to facilitate safe working conditions for divers, further reducing passage performance. The uncertainty over the time required to acquire divers and how long the cleaning would take, makes this alternative not acceptable due to biological impacts from degraded system performance.

f. Operations and Maintenance:

The AWS would need to be shut down for safe removal of debris. Too many unknowns in the time required to get the diver onsite. A long delay will impact flow through the ladder. Cleaning process could take days. Destination of debris can also be an issue. If removed from river it would need to be hauled and disposed.

3.4.2.8 *Alternative 6: Automation of valve cycling.*

a. Mechanical:

Redundancy in whichever sensor is chosen to automate the valves would be required. Operations has also expressed the desire to always have a human check on the reading prior to cycling, so mechanical automation is unnecessary.

b. Structural:

No structural considerations.

c. Electrical:

Updates to control cabinets will be required for the automation of valve cycling. The controls are currently manually and operated with push buttons. Sensors to measure flow rates and components to automate valves to open and close when desired flow rates are detected will be required. Manual operation would be a more cost-efficient option if automation is not crucial.

d. Hydraulics:

No hydraulic considerations.

e. Biological:

Automation of valve cycling would shut down the AWS at any time when the criteria for >2’ differential is exceeded. Valve cycling would reduce attraction flow to the EFL entrance temporarily. During operations while both fish units are out of service, valve cycling will result in a delay of adult fish passage due to no attraction flow and poor collection channel performance.

f. Operations and Maintenance:

Preferred for an operator to cycle the valves to provide an extra layer of redundancy. Cycling operation is relatively fast/easy for operators to complete. Automation system requires added electrical maintenance.

3.4.2.9 *Alternative 7: Pressure wash the debris off the trashracks from the intake deck using a water tank.*

a. Mechanical:

No mechanical considerations.

b. Structural:

No structural considerations.

c. Electrical:

No electrical considerations.

d. Hydraulics:

No hydraulic considerations.

e. Biological:

When trashracks are removed from the slots to be power washed, adult salmon and lamprey exiting the fish ladder could mill around in the cavity of the trashracks while they are removed and experience an increased risk of being entrained in the system. Juvenile salmon, lamprey, and sturgeon could also get stuck within the AWSBS structure. However, we expect these risks to be minimal as the AWSBS will be shut down and closed for cleaning. The AWSBS has to be shut down during trashrack cleaning for a full day each time cleaning is required. This alternative will increase valve cycling, reduce attraction flows at the EFL entrances, and delay passage for the duration of the cleaning.

f. Operations and Maintenance:

The time to remove, clean, and replace all 11 trashracks would require a full day shutdown of the AWS, and be very labor intensive for operations. Added maintenance takes away from other maintenance needs.

The time to remove, clean, and replace all 11 trashracks would require a full day shutdown of the AWS, and be very labor intensive for operations.

3.4.2.10 *Alternative 8: Install variable-porosity plate between trashrack and intake to provide uniform flow through the trashrack.*

a. Mechanical:

No mechanical considerations.

b. Structural:

New angled irons or C channels would need to be installed downstream of the trashrack. Custom fabrication is required to taper angle to concrete. Given the wide span of the plates, they will require bracing.

c. Electrical:

No electrical considerations.

d. Hydraulics:

The porosity plates would make the intake velocities more uniform rather than the existing high velocities at 50-foot depth. While this may make it the trashrack easier to clean, it will also raise the intake velocities at shallower depths and thereby potentially draw significantly more juvenile fish into the AWSBS.

e. Biological:

The increased surface velocity at the shallower depths of the intake can potentially impinge juvenile fish on the trashracks or entrain in the system compared to the no action alternative. The increased flow in shallower depths could attract adult fish that are exiting the EFL, however the presence of the trashracks will preclude adult salmonids and lamprey from fallback so impacts would be minimal.

f. Operations and Maintenance:

No operation needed. Periodic inspection required via removal or ROV.

3.4.2.11 *Alternative 9: Travelling screen with debris catchment bin that can be periodically removed.*

a. Mechanical:

This alternative would require a major overhaul to the intake. Discussions with a travelling screen manufacturer have confirmed that the intake is too wide for a single screen and would require a split design with two narrower systems. The intake would need an entirely new concrete or steel pier structure centered in the intake to support the two screens. As the pipe intake is placed directly in the center of the intake, the pier would likely cause large hydraulic issues.

The mechanical systems required for two large travelling screens, in addition to the massive construction effort to install an entirely new concrete pier in the center of the intake make this alternative practically unfeasible.

b. Structural :

The structural design effort required to develop this system is more extensive than alternative 11. Additionally, more periodic inspections will need to take place to maintain the system.

c. Electrical:

A power feed from FCQ7 MCC will be required for the travelling screen. If there are no spare buckets in the MCC or available capacity, then an additional power source will be needed. This could be costly if a long conduit run or new panel is required.

d. Hydraulics:

Not sure travelling screens work at intakes with the high velocity at the intake depth.

e. Biological:

The use of traveling screens and debris catchment bin reduce the need of valve cycling of the AWSBS. This maintains fish ladder performance at the entrances.

f. Operations and Maintenance:

Would require additional operational support to maintenance the moving system and clean the debris bin. Extensive maintenance is required, as seen with STSs at other projects. Debris would need to be hauled somewhere.

3.4.2.12 *Alternative 12: Use a mobile crane for raking the new trashracks*

a. Mechanical:

Use of a mobile crane other than the projects crane is not preferred over installing a fixed hoist. Each time raking would be required, a mobile crane would need to be rented and brought onsite, incurring significant downtime of the system.

b. Structural:

No structural considerations.

c. Electrical:

A power feed from FCQ7 MCC will be required for the mobile crane. If there are no spare buckets in the MCC or available capacity, then an additional power source will be needed. This could be costly if a long conduit run or new panel is required. A new control panel will be required for the crane. Safe mounting options for the panels are limited in the area due to it being on the start of the roadway leading to the powerhouse/navlock and the installation of bollards to protect the control panel may be needed.

d. Hydraulics:

No hydraulic input or impact.

e. Biological:

Uncertainty over whether the AWSBS would have to be shut down to implement raking needs to be considered. Since the project does not have a crane available for use, the time to acquire the crane for trash raking could negatively impact fish passage in the ladder as the AWSBS would not be operating at full flow or any flow (in the event of both fish units are out of service) while waiting to be cleaned.

f. Operations and Maintenance:

Mobile crane would need to be rented every time raking is required. Mobile crane would block the roadway. Project has a mobile crane that is usually being used for other project needs. Blocking roadway this often can be a problem for daily dam operation.

3.4.2.13 *Alternative ME-2: Modify entrances to ladders to use less flow*

a. Mechanical:

No mechanical considerations.

b. Structural:

No structural considerations.

c. Electrical:

No electrical considerations.

d. Hydraulics:

Do not recommend modifying the entrances, which have proven to work well historically and would require extensive numerical/physical modelling to verify performance of altered entrances. One plausible option is to reduce the number of open entrance weirs from two to one at the South Entrance (where each entrance weir opening is 15 feet. However, the south channel velocities may be rendered too low.   Some adjustment of the south entrance diffusers may help.

e. Biological:

Requires regional fish manager approval and may impact the preferred alternative for fish unit rehab. This alternative eliminates the need of valve cycling since the AWSBS would not be used. Closing the south and west weir entrances of the EFL greatly reduces fish ladder performance and available routes which delays adult fish passage. Without flow coming from the closed weir entrances, fish will have a harder time locating the EFL, which has the highest proportion of use for upstream passage at the dam. This alternative is not expected to impact juvenile fish migrating downstream.

f. Operations and Maintenance:

No issues, simple to achieve by modifying south entrance weir operation. Does not address problem at intake in the event of both fish units out of service.

3.4.2.14 *Alternative MF-2: Construct a travelling horizonal back spray manifold to remove debris while the AWSBS is operating*

a. Mechanical:

Analysis of this alternative, even operating during a shutdown, suggest a 60+ HP pump would be required. Due to the large electrical upgrades required to install such a pump, and the uncertainties regarding the back spray effectiveness, this does not seem to be a more mechanically feasible alternative than brushing.

b. Structural:

A large pour of concrete or extensive steel rails would be required to form a proper slot to fit the backspray system. Because the intake behind the racks is slanted inwards, the backspray manifold will have to be smaller than trashrack panels, reducing it's effectiveness in the corners of the rack. The construction effort to install these guides would be large, as bulkheads and dewatering would be required.

c. Electrical:

A power feed will be required for the back spray system. There is around a maximum of 15 HP of available capacity on FCQ7 MCC and therefore cannot be used for this 60HP pump. A new 13.8kV feeder, transformer and MCC installation will be needed to power the 60HP pump. Another option could be to re-feed the current FCQ7 MCC and add a section on to FCQ7 for the new pump. Both options would require a long feeder run with multiple areas of core drilling to get to the gallery and up to the roadway.

d. Hydraulics:

Maximum intake velocities (2.5 – 4.5 ft/s) are likely too much for water jet system to reliably overcome while AWS backup system is operating. Most water jet backflush systems are effectively applied to juvenile fish screens where average screen velocities are less than 0.4 ft/s.

While a shutdown could occur prior to cleaning, there are still uncertainties regarding the effectiveness of a waterjet system travelling 16 inches through the thick trashrack panels and successfully removing debris.

e. Biological:

The large amount of back spray velocity required to overcome the maximum intake velocities to clean the trashrack raise concern for feasibility of this alternative to work while the AWSBS is operating. If the AWSBS has to be shut down for the spray manifold to be effective, this increases valve cycling and reduces attraction flow for the EFL ladder. Evaluations of how fish interact with the spray and how the spray impacts the flow at the trashracks are needed. The back spray could reduce the approach velocities at the trashracks which would be beneficial to juvenile fish, as it minimizes the risk of impingement on the trashracks.

f. Operations and Maintenance:

Operation similar to valve cycling. More maintenance needs due to added equipment.

3.4.3 Most Feasible Alternatives

Below is the table for the most feasible alternatives:

Table 3-5. Most Feasible Alternatives

Most feasible Alternatives		
Alternative	Description	Notes
Alternative 4-1	Floating debris boom to deflect surface entrained debris.	
Alternative 10	Design and install new seamlessly connected trashracks. Clean new trashracks with a simple nylon brushing system, actuated by a dedicated hoist.	
Alternative 11	Design and install a brush system capable of cleaning the current trashracks. Operate the new brush system with a dedicated hoist.	
ME-1	Install level sensors to tie into project SCADA	

3.4.3.1 *Alternative 4-1: Floating debris boom to deflect surface entrained debris.*

3.4.3.1.1 Summary

- This alternative installs a long surface level debris boom to deflect surface entrained debris from reaching the intake and moves the debris past the intake.
- The proposed alignment of the debris boom is positioned 55 feet out from the dam in order to deflect a greater percentage of the more surface-oriented debris before it is drawn into the eddies and deeper currents found closer to the intake.

3.4.3.1.2 Rationale

a. Mechanical:

While this option does not require any mechanical design efforts, it would be beneficial by reducing the amount of debris that are able to reach the trashrack. Any decrease in debris will reduce the frequency of rack cleaning, whether that be with a brush system or by cycling the valves.

b. Structural:

Structurally, to estimate the size and scope of that connection will require a fairly extensive engineering analysis. Booms are not an effective way to exclude vegetative debris, as the current just pushes the debris under the boom. That means the boom needs a much deeper skirt than our typical oil booms, so that the debris will tend to push around, instead of under. The extra drag that will cause, in a very heavy wave and current area, will cause very high loads on the anchors.

c. Electrical:

No electrical considerations.

d. Hydraulics:

At the AWSBS intake, the normal river flow condition is an eddy zone where the flow passes the intake in an upstream (east) direction. The eddy zone extends approximately 40 - 50 feet out (north) from the intake, beyond the river flows in the normal downstream direction. By positioning the proposed floating boom about 55 feet out from intake, it will utilize the normal downstream (westward) river currents to divert surface debris past the AWSBS intake. The boom can prevent surface debris from being drawn back in the eddy and conveyed back to the AWSBS Intake. By diverting a significant portion of the debris, this alternative should work well in combination with other alternatives (e.g., level sensors, brush, rake, etc.). This should also help reduce the frequency of valve cycles operations. Previous oil booms have been observed to reduce debris in The Dalles East fishladder and particularly at the nearby ladder exit trashrack.

e. Biological:

Floating debris and oil booms are frequently implemented at exits and entrances of fishway structures and are not expected to negatively impact adult and juvenile fish passage. Evaluations should be conducted on a site-by-site basis to evaluate the hydraulic conditions and adult passage impacts with the floating configuration due to the proximity of the EFL exit. The floating debris boom should minimize the possibility of creating piscivorous bird perches. The debris boom should reduce the frequency of valve cycling. Planning should be in place if there should be a need to clear debris if it collects on the floating boom with an excessive volume.

f. Operations and Maintenance:

An oil boom was installed in the winter of 2022 across the East Fish Ladder Exit. Could consider modifications to serve as debris deflection if the oil boom was extended across to the AWSBS intake. Requires annual inspection and basic preventative maintenance.

Assumptions for construction:

1. The approximate length of the debris boom will be 400 feet and 55' away from the face of the dam.
2. Provide concrete anchorage to boom to both ends and provide anchor in river. This could be challenging as river bottom in this area has a series of deep/steep valleys, which will make it difficult to get an anchor in the desired location.
3. Install the anchors on vertical rails for sliding to accommodate the forebay elevation changes.

3.4.3.2 *Alternative 10: Design and install new seamlessly connected trashracks. Clean new trashracks with a simple nylon brushing system, actuated by a dedicated hoist.*

3.4.3.2.1 Summary

- This alternative replaces the current trashracks with new, seamless face racks.
- This alternative utilizes a simple brushing device to clean the new racks.
- A dedicated deck mounted hoisting system will be designed and constructed to actuate the brush.
- The current racks have several protrusions and horizontal members that will make manual cleaning difficult. To guarantee a vertically hoisted brush can fully clean the racks, new trashracks would be needed.

3.4.3.2.2 Rationale

a. Mechanical:

This option was initially kept as a feasible alternative while more information was acquired about the differences in feasibility between alternatives 10 and 11. The idea behind keeping this alternative was that if the trashracks would need to be replaced in both alternatives 10 and 11, it may be easier and cheaper to clean with a conventional rake than a brush. The alternative has since been modified to use new trashracks and a simple brush instead of a rake. It is still feasible and more effective than alt. 11, as a new trashrack could be designed such that a brush is very effective at cleaning the entire surface.

b. Structural:

A new structural design of the trashrack will need to be developed. Vertical guides for the brush system can be anchored to concrete via post-installed anchors. An anchorage or support structure for the electric hoist will need to be developed to attach the hoist to the deck.

c. Electrical:

Power will need to be provided to the overhead hoist from FCQ7 MCC. A system load analysis will have to be performed to verify the loading on of the motor control center's (MCC's) bus to determine that there is sufficient power available for the new hoist. FCQ7 MCC is in the MCC gallery and conduit routing to the roadway near the trash rack area may require core drilling through the upstream wall. If conduit routing penetrates the upstream wall, scans of the wall will be required to verify existing conduits. Special scaffolding or manlift will be needed to access the area above water. The other conduit routing option would be a longer conduit run over to the East end of the dam and require trenching across the roadway to the upstream side.

The control panel to operate the hoist system will be designed to be manual or auto depending on operations preference and be mounted near the trash rack.

d. Hydraulics:

The AWSBS will need to be shut off during the vertical brush cleaning operation to allow assistance from the sweeping flow.

Installation with divers: With the assumed safe river flow for dive operation at some value lower than 200 kcfs, finding and securing a good window to dive will be difficult. Prior anticipation and coordination with the District Dive Safety Office, TDA project, RCC, BPA and the fisheries region will be required.

e. Biological:

New trashracks must maintain the existing trashrack criteria with maximum 0.75" spacing requirements by NMFS (2022) for adult Pacific lamprey preclusion to the intake. The addition of a raking system should reduce the frequency of valve cycling and maintain optimal fish ladder performance. Since screening for juveniles per NMFS standards is not required as coordinated during the development of the AWS Backup System DDR, there is no added risk to juveniles when compared to the existing configuration.

f. Operations and Maintenance:

The dedicated hoist will give the project a quick way to clean the racks if valve cycling does not fully restore the head differential.

Assumptions for construction:

1. Removal of current 11 trashrack panels using the existing lifting beam and a mobile crane

2. Design, fabrication, and installation of a new coated steel trashrack, measuring roughly 70' tall and 25' wide, and weighing approximately 32,000 lbs.
    - The weight estimate was acquired by looking at several smaller trashrack designs with similar spacing, which weighed roughly 15 lbs. per square foot of screen area. A multiplier of 1.25 was then applied to account for extra bracing and panel support.
    - This will likely have to be constructed in several panels, similar to the current design, with special caution taken to not have protrusions.

3. Design, fabrication, and installation of a new coated steel brush frame with attached brushes which could interface with the new rack design.
    - Brush frame would be welded together from steel HSS members.
        - 6x6 HSS, 85 total feet required.
    - Brush assembly would require 4 guide wheel assemblies, similar to vertical gate rollers.
        - 8" diameter steel wheel (4 total)
        - 3" diameter, 12" long steel shaft (4 total)
        - 36" x 6" x ½" steel support plates for shaft (4 total)
        - 3" inner diameter self-lubricated bushing (4 total)
    - Brushes will likely be 6/12 Nylon Strip Brushes
        - 40 total feet of 4" long, 0.022" bristle strip brushes
        - Backup brushes with varying bristle thickness and length would be acquired, assume additional 120 feet (three extra sets)
    - HDPE wedge bolted to frame
        - Consumable, assume 50 total feet required
        - Fabricated from 7"x1" rectangular bar

4. The brush would require vertical guides which would need to be anchored to the wall segment directly in front of the trashrack slot. Installation would require a dive team.
    - Vertical guides would be made of metal c-channels, 85' long, 8" C-channel (Two required, total length of 170')
    - Significant prior and on-going coordination with several parties required for dive operations.

5. Brush will be hoisted with a dual sided electric winch style wire rope hoist
    - 10 HP capacity.
        - Assumption made by looking at product catalogs for applicable hoisting systems that could lift 10 kips @ 100 feet of rope length.
        - According to conceptual inventor model of brush frame, estimated weight is 3 kips. Wheel friction will be negligible as little side loading is expected when brush is operated, as AWSB will be turned off. Friction and forces from Nylon brushes will be minimal

but will be analyzed during DDR phase. A factor of safety of 3 has been applied to the brush frame weight to provide a highly conservative estimate for the overall hoist size.

- Assume 200' of 0.5" diameter steel wire rope.
- Assume 4 total wire rope sheaves, 2 on each side of the deck intake.
- Steel support structures to elevate hoist and sheaves.

6. Wall scans for core drilling and special scaffolding may be required for conduit routing.

7. Hoist motors will be at most 10HP, but most likely less. FCQ7 MCC is close to full capacity and will not be able to hold more than 10HP.

3.4.3.3 *Alternative 11: Design and install a brush system capable of cleaning the current trashracks. Operate the new brush system with a dedicated hoist.*

3.4.3.3.1 Summary

- This alternative leaves the original trashracks in place.
- This alternative utilizes a more complex rotary brushing system (as compared to alternative 10) which would partially clean the panels.
- The brushing system would require several unique design features to accommodate the protrusions and horizontal members of the current racks.
- A dedicated deck mounted hoisting system will be designed and constructed to actuate the brush.

3.4.3.3.2 Rationale

a. Mechanical:

This is the preferred physical mechanical option for removing debris from the rack. It has been prioritized due to the belief that a custom design will be able to brush the current trashrack panels with reasonable effectiveness. Installation of a new rack would be very cost intensive for a solution that needs to work primarily during the two year fish unit construction window, so avoiding this is preferred.

b. Structural.

Not complex structural design is involved in the development of this alternative. Vertical guides can be anchored to concrete via post-installed anchors. Since the system will move vertically, there will be no high pull-out stresses exerted on the anchors and concrete.

c. Electrical:

Power will need to be provided to the overhead hoist from FCQ7 MCC. A system load analysis will have to be performed to verify the loading on of the motor control center's

(MCC's) bus to determine that there is sufficient power available for the new hoist. FCQ7 MCC is in the MCC gallery and conduit routing to the roadway near the trash rack area may require core drilling through the upstream wall. If conduit routing penetrates the upstream wall, scans of the wall will be required to verify existing conduits. Special scaffolding or manlift will be needed to access the area above water. The other conduit routing option would be a longer conduit run over to the East end of the dam and require trenching across the roadway to the upstream side.

The control panel to operate the hoist system will be designed to be manual or auto depending on operations preference and be mounted near the trash rack.

d. Hydraulics:

The AWSBS will need to be shut off during the vertical brush cleaning operation to allow assistance from the sweeping flow.

e. Biological:

Brushed off debris must not enter the adult fish ladder, but this will likely be avoided since the river current should pull debris downstream of the intake.

f. Operations and Maintenance:

Same as Alt10.

Assumptions for construction:

1. Design and fabrication of a custom brush frame with a rotary brush system.
    - Brush frame would be welded together from steel HSS members. Assume 6x6 HSS, 85 total feet required.
    - Brush assembly would require 4 guide wheel assemblies, similar to vertical gate rollers.
        - 8" diameter steel wheels (4 total)
        - 3" diameter, 12" long steel shaft (4 total)
        - 36" x 6" x ½" steel support plates for shaft (4 total)
        - 3" inner diameter self-lubricated bushing (4 total)
    - Rotary brushes
        - 6/12 nylon bristles, 4" long, 0.022" diameter
        - Shaft/tube mounted cylindrical brushes, 5' long (4 total)
        - Submersible self-lubricated bushings for shaft support (4 total)
        - Submersible motors and gearboxes (2 total)
        - Backup brushes with varying bristle thickness and length, assume three extra sets.
    - HDPE Wedge bolted to frame.
        - Consumable, assume 50 total feet required.
        - Fabricated from 7" x 1" rectangular bar.
2. The brush guides and hoisting system would be identical to that described in section 3.4.3.2.2, items 4 and 5.

3. Wall scans for core drilling and special scaffolding may be required for conduit routing.
4. Combined hoist motor will be at most 10HP, but most likely less. FCQ7 MCC is close to full capacity and will not be able to hold more than 10HP.

3.4.3.4 *Alternative ME-1: Install level sensors to tie into project SCADA*

3.4.3.4.1 Summary

- This alternative install level sensors on each side of the intake rack to measure the head differential.
- Currently operators take this measurement by hand. Since the AWSBS will be constantly used during the turbine rehabilitation project, it will be necessary to constantly monitor the head differential.
- Digitally tracking the head differential will inform operators when they need to cycle the valves to clean the system.

3.4.3.4.2 Rationale

a. Mechanical:

No mechanical considerations.

b. Structural:

No structural considerations.

c. Electrical:

Two ultrasonic level sensors will be installed and measure the water surface differential water level across the AWSBS trashrack. The level sensors will be located on the upstream and downstream faces of the trashrack and tie into the Fish SCADA system by using the existing PLC located in the MCC gallery. A warning light will be installed near the trashrack or in a useful location for operations, which will warn operators when a certain water differential threshold has been reached. Water levels can be displayed locally on the PLC or in the fish office. Conduit routing for the sensors will follow the same routing as the hoist power. If the existing PLC does not have additional spare I/O points, then new cabinets will need to be installed which could be costly.

BVCC10 and/or BVCC7 will continue to be operated manually. The butterfly valves are currently manually operated with pushbuttons on the front of the control cabinets.

d. Hydraulics:

Real time data will assist operations in planning valve cycle operations. The data record will also provide valuable information on tracking the rate of change in head differential across the intake trashrack.

e. Biological:

Installing AWSBS level sensors informs project personnel when the AWSBS is not at full flow performance due to high differential readings caused by debris loads. Using the level sensors and valve cycling at night does have a biological advantage for diurnal fish passage by optimizing ladder entrance criteria.

f. Operations and Maintenance:

Sensors would alleviate the needs to manually check levels via tape or laser. SCADA probably not needed. Simple flashing light on deck could be sufficient when threshold hit.

Assumptions for construction:

- Two Ultrasonic level sensors 4-20mA
- Stilling wells are not needed for sensors and will be installed above deck level on swinging arm (similar to other existing level sensors on site).
- Local butterfly control panels are currently operated manually via pushbutton. The butterfly valves will not have automatic operation.
- Option photovoltaic system to power local transmitters
- Existing spare analog inputs and digital outputs are available in the existing PLC system and a new PLC is not needed
- Butterfly valve control panels currently have limited space and would need additional enclosures to add any new PLC control system

SECTION 4 - COST ESTIMATES FOR ALTERNATIVES

4.1 OVERVIEW

This section compares the construction costs associated with the most feasible alternatives to determine the preferred alternative. Additionally, a Total Project Cost Summary (TPCS) estimate is provided for the Preferred Alternative which includes a combination of the most feasible alternatives. TPCS is defined as the Construction cost, the Planning/Engineer/Design (PED) cost, and the Construction Management cost. See Appendix G for detailed documentation of estimated costs.

4.2 MOST FEASIBLE ALTERNATIVE COST ASSUMPTIONS

4.2.1Alternative 4 – Debris Boom Installation

Construction cost Class 3 for Alt 4 is estimated at $0.6 million (2023 dollars), after applying 10.3% inflation and a 51% contingency the total construction cost is $1.1 million.

Key assumptions guiding the construction cost estimate include:

- Specific production rates for all major activities (i.e., anchor installation, workboat usage) are identified including assumptions and basis for the estimates.
- In-water work would be undertaken with a crane-mounted barge operation consisting of crane-mounted barge, materials work barge, work boat (skiff), and tug depending on project timing constraints.
- For cost estimating purposes, a 4-foot-deep skirt was assumed based on the maximum available skirt depth based on a preliminary scan of vender sites. (The skirt will help deflect debris below the surface.)
- Contractor equipment rental and labor costs are based on assumed equipment rental costs, crew size, average hourly labor rate, and overtime.
- Miscellaneous project costs (i.e., mob/demob, jobsite overhead, home office overhead, construction bond, contractor profit, and taxes,) are assumed as direct cost of the site-specific total cost.
- Cost source for material and equipment rates are from RS Means.

4.2.2Alternative 10 – New Trashrack and Brush System

Construction cost Class 3 for Alternative 10 is estimated at $2.3 million (2023 dollars), after applying 13% inflation and a 59% contingency the total construction cost is $4.2 million.

Key assumptions guiding the construction cost estimates include:

- Specific production rates for all major activities (i.e., removal and install of trash racks, diver services, metal fabrication) are identified including assumptions and basis for the estimates.

- In-water work would be undertaken with the removal and install of new Trashrack and brush System including crane operation and depending on project timing constraints.
- Contractor equipment rental and labor costs are based on assumed equipment rental costs, crew size, average hourly labor rate, and overtime.
- Miscellaneous project costs (i.e., mob/demob, jobsite overhead, home office overhead, construction bond, contractor profit, and taxes,) are assumed as direct cost of the site-specific total cost.
- Cost source for material and equipment rates are from RS Means.

4.2.3Alternative 11 – New Long Brush System

Construction cost Class 3 for Alternative 11 is estimated at $0.58 million (2023 dollars), after applying 13% inflation and a 59% contingency the total construction cost is $1 million.

Key assumptions guiding the construction cost estimates include:

- Specific production rates for all major activities (i.e., brush rake and c-channel install, diver services, metal fabrication) are identified including assumptions and basis for the estimates.
- In-water work would be undertaken with the installation of new brush System including crane operation and depending on project timing constraints.
- Contractor equipment rental and labor costs are based on assumed equipment rental costs, crew size, average hourly labor rate, and overtime.
- Miscellaneous project costs (i.e., mob/demob, jobsite overhead, home office overhead, construction bond, contractor profit, and taxes,) are assumed as direct cost of the site-specific total cost.
- Cost source for material and equipment rates are from RS Means.

4.2.4Alternative ME-1 – New Radar Level sensor to SCADA system

Construction cost Class 3 for Alternative ME-1 is estimated at $0.22 million (2023 dollars), after applying 10.3% inflation and a 51% contingency the total construction cost is $0.37 million.

Key assumptions guiding the construction cost estimates include:

- Specific production rates for all major activities (i.e., crane usage above water, and long and challenge conduit route install) are identified including assumptions and basis for the estimates.
- In-water work would be undertaken with the removal and install of new Trashrack and brush rake including crane operation and depending on project timing constraints.
- Contractor equipment rental and labor costs are based on assumed equipment rental costs, crew size, average hourly labor rate, and overtime.

- Miscellaneous project costs (i.e., mob/demob, jobsite overhead, home office overhead, construction bond, contractor profit, and taxes,) are assumed as direct cost of the site-specific total cost.
- Cost source for material and equipment rates are from RS Means.

4.3 TOTAL PROJECT COST SUMMARY (TPCS)

4.3.1 Preferred Alternative

The preferred alternative chosen by the PDT, in addition to the cycling of the valves, combines Alternative 4-1 (debris boom), Alternative 11 (hoist operated Brush System), and Alternative ME-1 (level sensors).

Construction cost Class 3 for Preferred Alternative which includes Alt 4-1, Alt 11 and ME-1 is estimated at $1.3 million (2023 dollars), after applying 13% inflation and 54% contingency per the total construction cost is $2.3 million. The total project cost (design and construction) estimated at the 90% EDR phase is $3.3 million. The construction contract will take less than a year including procurement of materials.

4.3.2 Second Best Alternative

The second best alternative chosen by the PDT combines Alternative 4-1, Alternative 10 (new Trashrack with hoist operated Brush System), and Alternative ME-1.

Construction cost Class 3 for Second Best Alternative which includes Alternative 4-1, Alt 10 and Alt ME-1 is estimated at $3.1 million (2023 dollars), after applying 13% inflation and 57% contingency the total construction cost is $5.5 million. The total project cost (design and construction) estimated at the 90% EDR phase is $7.9 million. The construction contract will take less than a year including procurement of materials.

SECTION 5 - PREFERRED AND SECOND-BEST ALTERNATIVES

During the 60% EDR phase, the PDT discussed the remaining concepts which had not been deprioritized to determine the preferred and second-best alternatives. The PDT quickly concluded that no single concept would sufficiently and confidently manage debris at the intake. Therefore, both the preferred and second-best alternative combine multiple concepts to create a multi-phased approach to debris management at the AWSBS intake.

5.1 PRIORITIZED CONCEPTS

The non-deprioritized concepts which were discussed during this phase are summarized above in section 3.4.3.

5.2 PREFERRED ALTERNATIVE

The preferred alternative chosen by the PDT, in addition to the cycling of the valves, combines Alternative 4-1 (debris boom), Alternative 11 (hoist operated trash brush), and Alternative ME-1 (level sensors). Sections 3.1 and 3.2 of this report discuss the descriptions of the alternatives.

5.2.1 Layout

The selected alternative has a three-pronged approach to debris management. The surface level debris boom (4-1) serves as a constant and passive deflection device to reduce the overall debris load on the intake. The approximate proposed alignment is also intended to minimize the tendency for debris to circulate back toward the intake via the normal eddy currents.

The level sensors (ME-1) provide the project with the real-time head differential across the intake. If the head differential reaches two feet, the project will cycle the valves. this initial valve cycling should occur at night or during non-peak passage hours, if possible, to minimize fish impacts. Per discussions with project personnel, the river's natural sweeping flow effectively and quickly cleans the racks of debris when the system is shut down. Per ongoing discussions with the valve manufacturer, Vanessa/Emerson, the initial concern of a 1,400-cycle life on the valves appears to be unsupported and lower than expected.

While the AWSBS has been operated for several days at a time, it will be required to operate much longer and much more frequently during the turbine rehabilitation project. As stated by the project staff, cycling the valves has been effective at cleaning the racks. However, debris in the river is not consistent or entirely predictable.

Even with the passive debris boom, the PDT is concerned that longer operations of the AWSBS may result in situations where more debris accumulates on the intake than past experiences. Cycling the valves may sweep most of the debris away, but over time enough small debris may become impinged in the screen and won't float off when the system is cycled. If this gets to a point where the head differential cannot be restored to below two feet, a manual cleaning method would be required.

For this reason, the PDT has included alternative 11, a hoist operated brushing system which will be designed to interface with the current trashracks. This device would only be utilized if valve cycling is unable to restore a less than two-foot head differential. In this scenario, the system would remain shut down until the project is able to operate the brush.

5.2.2 Operation

The PDT expects the buildup of impinged debris which does not float off during valve cycling to be gradual and observable via the level sensors. The project should therefore be able to reasonably predict when, if at all, the brush will need to be operated.

As discussed in the Section 3 breakdown of Alternative 11, the brush will utilize flexible bristles capable of passing over the protrusions. Due to the wide span of the trashrack face, the brush will need to be broken down into several smaller segments, likely four, five-foot brush segments. Portions of the trashrack face will be inaccessible by the brush, such as the area under the protruding L-brackets and areas where the brush bearings and motors are located.

5.2.3 Effectiveness

The PDT recommends alternative 11 for the following reasons:

- Per the latest cost estimate, replacing the trashracks will require more funding than is currently requested.
- The passive debris boom and more informed valve cycling due to the level sensors will decrease the rate of debris accumulation.
    - Current operational data from the AWSB showed a worst-case debris accumulation in February 2020, where after four days of operation during high river flows a head differential of three feet was observed.
    - Best case debris accumulation during operation occurred in January and February of 2019, where the system operated without a noticeable head differential for twenty-two days of consistent operation.
    - If worst-case debris accumulation is assumed with a cleaning operation every four days for the two years this system will be needed, 183 temporary shutdowns would be required. This worst-case assumption is extremely unlikely to occur, as debris rates will be reduced by the debris boom, and debris flows are highly seasonal. (365 days * 2 years = 730 days / 4 days/shutdown = 183 shutdowns).
- The rack does not need to be perfectly cleaned, as a head differential of up to two feet is safe to operate. Per "Figure 2-2. Existing Trashrack Head Differential

versus Percent of Blockage", if the brush is able to reliably free 50% of debris, it would be able to restore a head differential of approximately 0.5 feet.
- The system will be shut down while brushing occurs, so impinged debris may only need a small "push" to be freed by the rivers sweeping flow.
- If the debris boom, valve cycling, and the alternative 11 brush still fail to restore a 2-foot head differential, the project can pull the trashrack panels and manually pressure wash debris from the grating. This is not expected to occur and would be a major hinderance to project staff but would be the worst-case solution.

5.2.4 Cost

Construction cost Class 3 for the Preferred Alternative which includes Alt 4-1, Alt 11 and ME-1 is estimated at $1.47 3 million (2023 dollars), after applying 11.713% inflation and 5354% contingency the total construction cost is $2.6 3 million. The total project cost (design and construction) estimated at the 90% EDR phase is $3.6 3 million. The construction contract will take less than a year including procurement of materials.

5.3 SECOND-BEST ALTERNATIVE

The second-best alternative chosen by the PDT combines Alternative 4-1, Alternative 10 (new trashrack with hoist operated trash brush), and Alternative ME-1.

This alternative is also a three-pronged strategy, with the debris boom (4-1) and level sensors plus valve cycling (ME-1) being recommended as the initial two approaches. The second-best incurs significantly less risk but more cost by choosing Alternative 10 (i.e. new trashrack) over Alternative 11.

Alternative 10 would replace the entire intake trashrack, approximately 65' tall and 25' wide, with a new design. The new design would have a seamless face (i.e. no protrusions), and have no horizontal members flush with the outer plane of the rack. This would involve a significant design effort and incur a much higher cost but would allow for a simple brush system capable of cleaning the entire trashrack.

The tradeoffs made with the Alt. 11 brush, namely the flexible bristles and increased mechanical complexity due to mechanized rotation, would not be made with this alternative. The PDT feels much more confident in the capability of the Alt. 10 brush to clean the entire rack of debris.

Cost estimates price this "second best alternative" higher than the overall project budget and would run the risk of a delay while additional funding is requested. As valve cycling has proven to be an effective method for cleaning the rack, the PDT is reasonably confident that the brush will only be needed as a backup even with the increased operational time of the intake. Additionally, the brush will not need to clean the entire rack and will only need to assist in freeing debris while the system is shut down to restore to a safe operating head differential of <2.0'. Because of this, the PDT is willing to accept slightly more risk by recommending Alternative 11 over Alternative 10.

5.3.1 Cost

Construction cost Class 3 for Second Best Alternative which includes Alt 4-1, Alt 10 and Alt ME-1 is estimated at $3.1 million (2023 dollars), after applying 13% inflation and 57%contingency the total construction cost is $5.5 million. The total project cost (design and construction) estimated at the 90% EDR phase is $7.9 million. The construction contract will take less than one year including procurement of materials.

SECTION 6 - CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

Flow tests have shown that the AWSBS trashracks have had periodic debris issues and require a more robust debris management strategy during Fish Unit Rehab. Following Fish Unit Rehab, the backup AWS will be used if one or both new propeller Fish Units are forced out of service during adult fish passage season.

The main issue with debris management on the current system is the uniquely designed trashrack. The existing trashrack design, stacked panels with metal walkway grating held in place by protruding L-brackets, did not consider longer term regular use of the backup AWS and ease of debris removal a high priority.

The PDT, with the Value Management team proposed alternatives to both limit the amount of debris reaching the rack, and to remove debris impinged on the rack. The PDT concluded that no single concept would sufficiently and confidently manage debris at the intake. Therefore, both the preferred and second-best alternative combine multiple concepts to create a multi-faceted approach to debris management.

The existing method of cleaning the rack, namely shutting down the system and letting the river's natural sweeping flow remove debris, has been effective. However, the amount of time required to remove enough debris to restore a safe operating head differential has varied and has not been successfully analyzed or understood.

Both the preferred and second-best alternative utilize three approaches to debris management – preventing debris from reaching the screen via a debris boom, real time tracking of the head differential via level sensors, and a last resort brushing device to physically free impinged debris from the screens. The brushing system is intended to be used when the system is shut down, freeing debris from the screen into the sweeping flow of the river.

The difference between the two alternatives is that the preferred will leave the current trashrack panels in place and utilize a brush designed to overcome the protruding L-brackets. The second-best calls for completely redesigning and replacing the trashracks to have a flat, seamless upstream face which is more suited for brushing and debris removal. The preferred alternative incurs slightly more risk, as it will make design of a brush more difficult and likely less effective. This risk is deemed acceptable for two reasons. First, the AWSBS is planned to operate during the 2-year fish turbine rehab construction period and should seldomly be required afterwards. Second, the goal is not to remove all debris from the rack but manage debris enough to maintain a safe head differential to reliably provide augmented attraction flow to the East Fish Ladder.

6.2 RECOMMENDATIONS

The preferred alternative chosen by the PDT, in addition to the cycling of the valves, has a three-pronged approach to debris management and combines Alternative 4-1, (debris boom), Alternative 11 (hoist operated trash brush), and Alternative ME-1 (level sensors). Sections 3.1 and 3.2 of this report discuss the descriptions of the alternatives.

The PDT recommends developing a design that will include the following primary components:

- Debris boom (depth, alignment, and length)
- Note: During 90% EDR FFDRWG review, written comments were provided regarding the cost effectiveness of the debris management system and the criteria to be used in modeling the design of the debris boom. During final report preparation, the PDT determined that additional investigation is warranted due to uncertainty surrounding the effectiveness of the debris boom and its contribution to overall debris management of the backup AWS. This is based on field observations of debris accumulation across project forebay water intakes and the most prevalent types of material that have impacted the backup AWS system intake, neutrally buoyant and seasonal vegetative debris. The PDT will continue to investigate methods to evaluate debris effectiveness of the boom during DDR, possibly using CFD modeling already planned to identify boom design requirements.
    - Anchor (locations and sizes), and cables (lengths, catenary and diameters).
    - For cost estimating purposes, a 4-foot-deep skirt was assumed based on the maximum available skirt depth based on a preliminary scan of vendor sites. The DDR will investigate deeper options for the debris boom, seeking to strike a balance between boom depth against the increased hydraulic loads and consequent structural requirements to maintain the boom alignment.
- Ultrasonic level sensors
    - Installed on the upstream and downstream faces of the trashrack
    - Provides real time head differential
    - Long term data can help better understand debris buildup
- Vertically Hoisted Debris Brush
    - Vertically hoisted along upstream face of trashracks using electric winch and wire rope
    - Utilizes roller and steel channel system, with steel c-channel installed on concrete face upstream of racks.
    - Utilizes rotary nylon brushes to help free grass and debris from racks
    - Operated while system is shut down
- New Trashrack Design (Second Best Alternative Only)

  - New trashrack with seamless face, i.e., no protruding L-brackets
  - Would make manual debris removal more effective and less mechanically complex.

The following are studies or actions that were identified as being needed during the DDR phase:

- Computational fluid Dynamic (CFD) modelling will be used in the DDR design of the debris boom. This is done to refine the following parameters:
  - Debris boom alignment
  - Debris boom depth
  - Determine hydraulic forces for structural design of the boom, cables, and anchors.
  - The CFD model can be initially validated by comparison with the 4 cases of prototype measurement data collected prior to the construction of the AWS backup system.
- Design analysis of brushing system
  - Load analysis
    - Frame and load analysis
    - Brush friction
    - Wheel friction
    - C-Channel sizing
    - Hoist Sizing
    - Wire Rope Sheave Analysis and Design
    - Electrical load – Submersible brush motors and hoisting system will be further analyzed in DDR. If friction and weight analysis require a hoist capacity that exceeds the 10HP of available power, a MCC panel upgrade or new panel may be required.
    - MCC Panel upgrade analysis and cost, if required.
      - Analysis of updating existing FCQ7 MCC or installing new MCC
      - Location of new transformer and MCC, if required
      - Routing of medium voltage cables including core drilling

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