Adult Fish Ladder Cooling Concept Evaluation

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Lower Monumental, Ice Harbor McNary & John Day Dams
23 September 2025

Adult Fish Ladder Cooling Concept Evaluation

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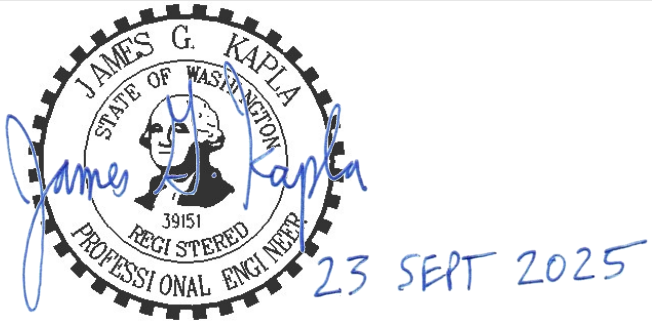

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Executive Summary

This Study supports efforts to improve adult upstream fish passage at four dams located on the lower Snake and Columbia Rivers and is focused on identifying and evaluating methods to reduce delays in fish migration due to seasonal temperature differentials within the fishways. The Walla Walla District of the U.S. Army Corps of Engineers operates the Lower Monumental, Ice Harbor and McNary Dams. The Portland District USACE operates the John Day Dam.

Reservoir thermoclines typically exist from June through September which result in temperature differentials between the fishway entrances located in the tailrace (cooler water) and the fishway exits located in the forebay (warmer water). Adult salmonids ascending the fishway can experience thermal differentials that delay or disrupt normal upstream migration.

This Study identifies and evaluates alternatives for conditioning water in the fishways to reduce the seasonal temperature differentials. The objective is to identify and evaluate alternatives that have the potential to reduce temperature differentials between the forebay exit and tailrace entrance to no more than 1.0°C (1.8°F).

Historical temperature data, in conjunction with the unique physical and operational attributes of each project, were considered during the development and evaluation of alternatives. Alternatives were evaluated on the basis of anticipated thermal performance; fish behavior; operational feasibility and reliability; impacts/risks to project operations; and cost.

Various methods of conditioning the temperature of the water in the fishways were evaluated, including a Spray Bar approach currently installed and operating at the Lower Granite and Little Goose Dams. Nine alternatives were developed for consideration, and two alternatives were selected for further evaluation at each project site. Note that these alternatives are intended in some cases to be applicable to more than one project site, even if not indicated below.

Table ES-1. Alternatives Selected for Further Evaluation

Project Site	Alternatives	
Lower Monumental	Modified Spray Bar	Pumped Fish Exit
Ice Harbor	Bubbler	Pumped Fish Exit
McNary	Air Lift Pump	Gravity Chimney
John Day	Air Lift Pump	Submerged Jet

The location and general configuration of each alternative is presented in Appendix A. The alternatives selected for further evaluation are feasible and appear to have the ability to meet the fishway thermal performance criteria. Key construction and permitting considerations are identified, and rough order-of-magnitude construction cost estimates were prepared. It is anticipated that the annual fishway outage periods starting in January would be utilized for installation of in-water components.

Recommendations for implementation are also provided by project and by discipline. This may include additional data collection, modeling, or prototype testing to further validate assumptions and to refine concepts. Post-construction monitoring and evaluation of fish behavior, water quality or other metrics may also be beneficial.

It is recommended that the following approaches be considered for implementing fishway cooling at each project site:

Table ES-2. Recommended Approach

Project Site	Recommended Approach
Lower Monumental	Implement Pumped Fish Exit.
Ice Harbor	Prototype Bubbler for site conditions with Pumped Fish Exit as alternate.
McNary	Implement Gravity Chimney (with Pumped Fish Exit at surface).
John Day	Implement Bubbler.

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Acronyms and Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
A	amp
AACEI	Association for the Advancement of Cost Engineering International
AHJ	authority having jurisdiction
aka	also known as
AWS	auxiliary water supply
BEP	best efficiency point
BiOp	Biological Opinion
BPA	Bonneville Power Administration
CENWD	USACE, Northwest Division
CENWP	USACE, Portland District
CENWW	USACE, Walla Walla District
CFD	computational fluid dynamics
CFM	cubic feet per minute
cfs	cubic feet per second
CROHMS	Columbia River Operational Hydrometeorological Management System
CWA	Clean Water Act
CTCR	Confederated Tribes of the Colville Reservation
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
CTWS	Confederated Tribes of the Warm Springs
NEC	National Electrical Code
Dia	diameter
EAL	environmentally-acceptable lubricant
ESA	Endangered Species Act
FFDRWG	Fish Facility Design Review Work Group
FPC	Fish Passage Center
HLD	Ice Harbor Lock and Dam

HSE	Health, safety and environment
IDFG	Idaho Department of Fish and Game
IDIQ	Indefinite delivery / indefinite quantity
I&C	instrumentation and controls
JDA	John Day Lock and Dam
LGS	Little Goose Lock and Dam
LMN	Lower Monumental Lock and Dam
LWG	Lower Granite Lock and Dam
MATOC	Multiple Award Task Order Contract
MCC	motor control center
MCE	maximum credible earthquake
MNA	McNary Lock and Dam
MOP	minimum operating pool
msl	Mean Sea Level
NEC	National Electrical Code
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NMFS	National Marine Fisheries Service
NPT	Nez Perce Tribe
O&M	operations and maintenance
ODFW	Oregon Department of Fish and Wildlife
OR	Oregon
O&M	Operations and maintenance
psi	pounds per square inch
PL	Public Law
PLC	programmable logic controller
RM	river mile
ROV	remotely operated vehicle
SCFM	standard cubic feet per minute

TDG	total dissolved gas
UFGS	Unified Facilities Guide Specifications
USACE	United States Army Corps of Engineers
USBR	United States Bureau of Reclamation
USFWS	United States Fish and Wildlife Service
V	volt
WA	Washington
WDFW	Washington Department of Fish and Wildlife
YN	Confederated Tribes and Bands of the Yakama Nation

1. Introduction

1.1 General

This Study supports efforts to improve adult upstream fish passage at four dams located on the lower Snake and Columbia Rivers and is focused on identifying and evaluating methods to reduce delays in fish migration due to seasonal temperature differentials within the fishways. The Walla Walla District of the U.S. Army Corps of Engineers (USACE) operates the Lower Monumental (LMN), Ice Harbor (HLD) and McNary (MNA) Dams. The Portland District USACE operates the John Day (JDA) Dam.

Reservoir thermoclines typically exist from June through September which result in temperature differentials between the fishway entrances located in the tailrace (cooler water) and the fishway exits located in the forebay (warmer water). Adult salmonids ascending the fishway can experience thermal differentials that delay or disrupt normal upstream migration.

This Study identifies and evaluates alternatives for conditioning water in the fishways to reduce the seasonal temperature differentials. Alternatives are evaluated on the basis of anticipated thermal performance; fish behavior; operational feasibility and reliability; impacts/risks to project operations; and cost. Two alternatives are evaluated in further detail at each project site and recommendations for implementation are provided.

1.2 Project Authorizations

Structural changes to the dams are within USACE's authority to manage the projects for fish and wildlife conservation purposes. Modifications to the projects for fish passage are funded under appropriations made for the Columbia River Fish Mitigation Program. The following provides a summary of authorizations by project.

Table 1-1. Project Authorizations

Project	Authorization	Authorized Purposes
Lower Monumental, Ice Harbor and McNary	River and Harbor Act of 1945 (PL 79-14)	Hydropower, navigation, irrigation, recreation, fish & wildlife conservation and water quality
John Day	Flood Control Act of 1950 (PL 81-516) and amended in 1957 by the Watershed Protection and Prevention Act (PL 83-566).	Hydropower, navigation, flood risk management, irrigation, recreation, fish & wildlife conservation and water quality

In addition, USACE is directed via the Columbia River System Biological Opinion (BiOp), where beneficial and feasible, to develop and implement operational or structural solutions to address maximum temperatures and temperature differentials in adult fish ladders at mainstem lower Snake and Columbia River dams (NMFS, 2020).

1.3 Purpose and Scope

This Study was completed in accordance with task order number W912EF24F9401 under Indefinite delivery / indefinite quantity (IDIQ) contract number W912EF-24-D-0001 for the Multidiscipline Small

Business Multiple Award Task Order Contract (MATOC), including Amendment No. 1 dated 22 August 2024. Jacobs is subcontractor to the task order prime contractor Anderson Perry & Associates.

The objective of this project is to identify and evaluate alternatives that have the potential to reduce temperature differentials between the forebay exit and tailrace entrance to no more than 1.0°C (1.8°F). Various methods of conditioning the temperature of the water in the fishways were considered, including a Spray Bar approach currently installed and operating at the Lower Granite and Little Goose Dams. A single adult fishway is evaluated at each of the four projects, always the fishway located adjacent to the powerhouse where historical temperature differentials are typically the greatest. Biological performance evaluations for each alternative were led by USACE.

The project Kickoff Meeting was held in October 2024 and a site visit to the four projects was conducted in December 2024 with USACE staff. A Brainstorming Workshop was conducted in May 2025 with USACE and Agency staff (Appendix C). A Draft Report Review Meeting was conducted in August 2025 with USACE staff. This report documents the development of evaluation criteria, the identification and evaluation of alternatives, and the further development of the two alternatives selected for each site.

1.4 Agency Coordination

The USACE Walla Walla District, in conjunction with the Portland District and the Northwest Division, is coordinating this Study with the Fish Facility Design Review Work Group (FFDRWG) which includes review and input from the following additional parties:

- Bonneville Power Administration (BPA)
- Confederated Tribes of the Colville Reservation (CTCR)
- Confederated Tribes of the Umatilla Indian Reservation (CTUIR)
- Confederated Tribes of the Warm Springs (CTWS)
- Confederated Tribes and Bands of the Yakama Nation (YN)
- Idaho Department of Fish & Game (IDFG)
- National Marine Fisheries Service (NMFS)
- Nez Perce Tribe (NPT)
- Oregon Department of Fish & Wildlife (ODFW)
- U.S. Fish and Wildlife Service (USFWS)
- Washington Department of Fish & Wildlife (WDFW)

Data provided by USACE in support of this work is summarized in Appendix F.

1.5 Report Organization

This report is organized to document the process used to meet the Study objectives:

Section 1 introduces the information and background necessary to understand the scope of the report.

Section 2 describes the four existing project facilities and identifies site-specific design and operational considerations.

Section 3 describes the criteria used to develop and evaluate alternatives.

Section 4 describes the alternatives and evaluates them per the criteria.

Section 5 ranks the various alternatives and identifies select alternatives for further evaluation.

Section 6 further develops the selected alternatives.

Section 7 summarizes key construction and permitting considerations.

Section 8 provides capital construction costs and schedule information for the selected alternatives.

Section 9 provides a summary with conclusions and recommendations.

Section 10 documents key references used for preparation of this Study.

2. Existing Facilities and Operations

This Study considers two project sites located on the Lower Snake River (Lower Monumental and Ice Harbor), and two project sites located on the Columbia River (McNary and John Day) as shown on Appendix A, Plate G-1. All of the projects commonly experience periods of reservoir thermoclines in the late summer that affect upstream fish passage. Historical temperature data, in conjunction with the unique physical and operational attributes of each project, were considered during the development and evaluation of alternatives.

2.1 Lower Monumental

The following provides a summary of pertinent project data for Lower Monumental.

Table 2-1. Pertinent Project Data

LOCATION	
State	Washington
Counties	Franklin, Walla Walla, Whitman and Columbia
River	Snake River
River miles from mouth	41.6
Authorized purposes	Multi-purpose (hydropower, navigation, irrigation, recreation, fish & wildlife conservation and water quality)
Type of Project	Run-of-river
DAM	
Type	Concrete gravity with earthfill embankments on either abutment
Length, feet	3,791
Maximum structural height, feet	152
Deck elevation, feet mean sea level (msl)	553.0
RESERVOIR	
Name	Lake Herbert G. West
Length, miles	28.7
Surface area, acres	6,590 (elevation 540)
Normal forebay elevations, feet msl	537.0 to 540.0 (July through August)
POWERHOUSE	
Type of turbines	Kaplan
Completion date	1970
Number of units	6
Rated capacity, MW	810

Hydraulic capacity, cfs	130,000
Normal tailrace elevations, feet msl	437.0 to 446.0 (July through August)
SPILLWAY	
Type	Ogee crest, gate controlled
Number of bays	8
Crest elevation, feet msl	483
Design discharge, cfs	850,000 (pool elevation 548.3 feet)
ADULT FISHWAYS	
Location and description	North Shore Ladder (adjacent to powerhouse) and South Shore Ladder
Type	Ice Harbor-type fish ladder with vertical slot regulating section
Ladder flow, cfs (hydraulic differential, ft)	70 (1.1) to 75 (1.3)
Exit flow, cfs	29.5 to 37.1
Make-up water flow, cfs	25.4 to 45.5
Slope	1V : 10H
Exit invert, feet msl	530.5
Exit flow depth, feet	6.5 to 9.5
Exit water velocity, fps	0.76 to 0.78
Make-up water intake invert, feet msl	518.5 (516.5 at face of Dam)
Other features	Powerhouse collection channel and pump-turbine auxiliary water supply (AWS) system

An overall site plan and process flow diagram are shown on Appendix A, Plates LMN-2 and LMN-3, respectively.

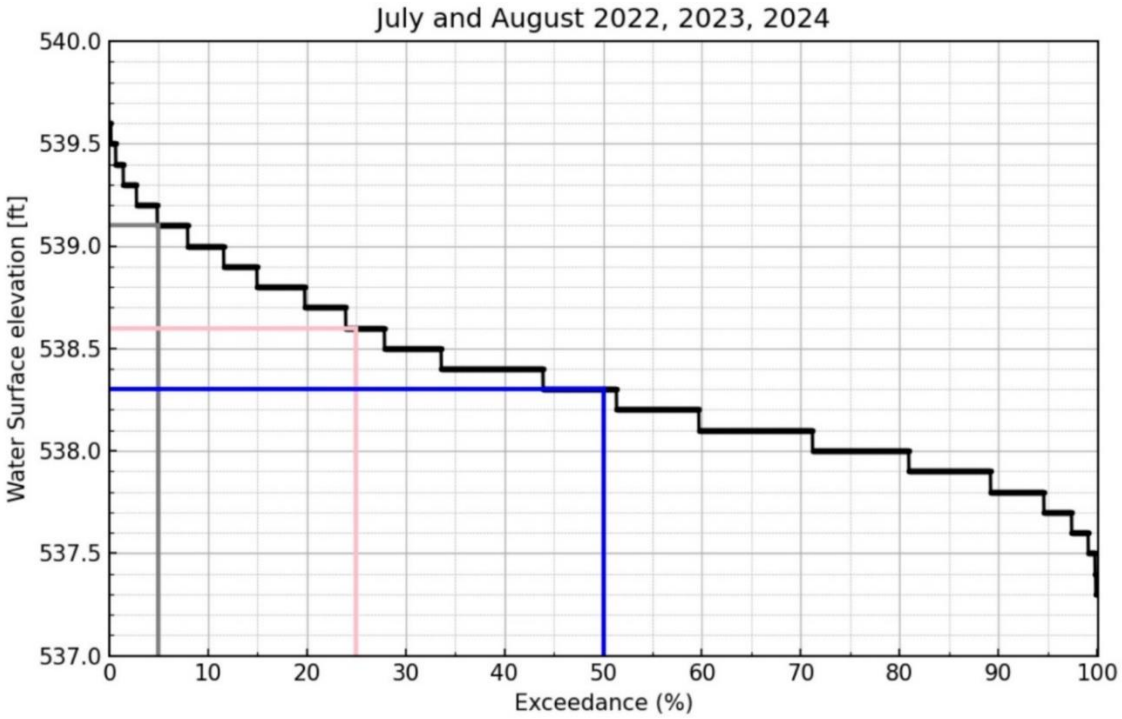
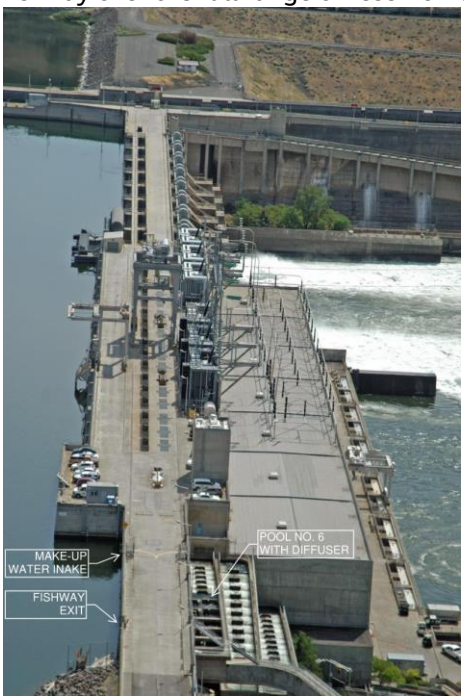


Figure 2-1. Lower Monumental Historical Reservoir Water Surface Elevations

The North Shore Ladder at Lower Monumental Dam includes a fishway exit and a make-up water intake located on the upstream face of the dam that supply water to the fishway by gravity. These facilities work in conjunction with the regulating section of the fish ladder and the diffuser to facilitate operation of the fishway over the full range of reservoir elevations.



Photograph 1: Lower Monumental Dam General Arrangement (Photo by BPA).

The fishway exit and make-up water intake include trashracks to exclude debris, and bulkheads (normally stowed) that can be installed for isolation. The regulating section of the fishway includes vertical slot openings with a sill, a rectangular orifice in the weir wall and another rectangular opening for lamprey. Gate GS6 located in the Service Gallery is operated to provide make-up water to Diffuser No. 6 to maintain 1.1 to 1.3 inches of head on the downstream weirs. The ladder below the regulating section and diffuser is an Ice Harbor-type ladder with two weirs and two orifices. Additional information is provided in Appendix A, Plates.

Photograph 2: Fishway Exit with Debris Boom and Bubbler Air Piping

Photograph 3: Diffuser No. 6 with Regulating Section Upstream (Photo by USACE).

Key considerations for the Lower Monumental project include the following:

Proximity of Embankment. The rip rap embankment on the right abutment adjacent to the fishway exit has a slope of 1V:2H along the face of the dam. The rip rap surface is very close to the fishway exit invert elevation at 530.5 feet, and results in a minimum water depth of 6.5 feet. This has implications for alternatives that require infrastructure to be placed at the face of the dam near the fishway exit.

Existing Debris Boom. A floating debris boom protects the fishway exit; however, debris moves into this area during periods of high forebay water surface elevations and tends to be trapped behind the barrier when forebay elevations fall. The debris boom may have to be relocated or removed to accommodate select alternatives.

Existing Fishway Exit Bubbler. An existing air compressor with diffuser piping is used periodically to clear debris away from the fishway exit area. The compressor is understood to be rated at approximately 500 CFM at 100 psi. Effectiveness may be limited by the debris boom and the material that collects in this area. USACE personnel also indicate that the bubbler does impact fish behavior and may temporarily impede the upstream movement of fish when in use.

Temperature Differentials. Hourly temperature information for the North Shore Ladder exit (i.e., reservoir thermistor) and the ladder entrance was evaluated for the years 2022, 2023 and 2024. The greatest differentials were found to occur in the year 2022, and that data was used to develop design values representing the median of extreme, moderate and normal temperature exceedance data sets as shown below.

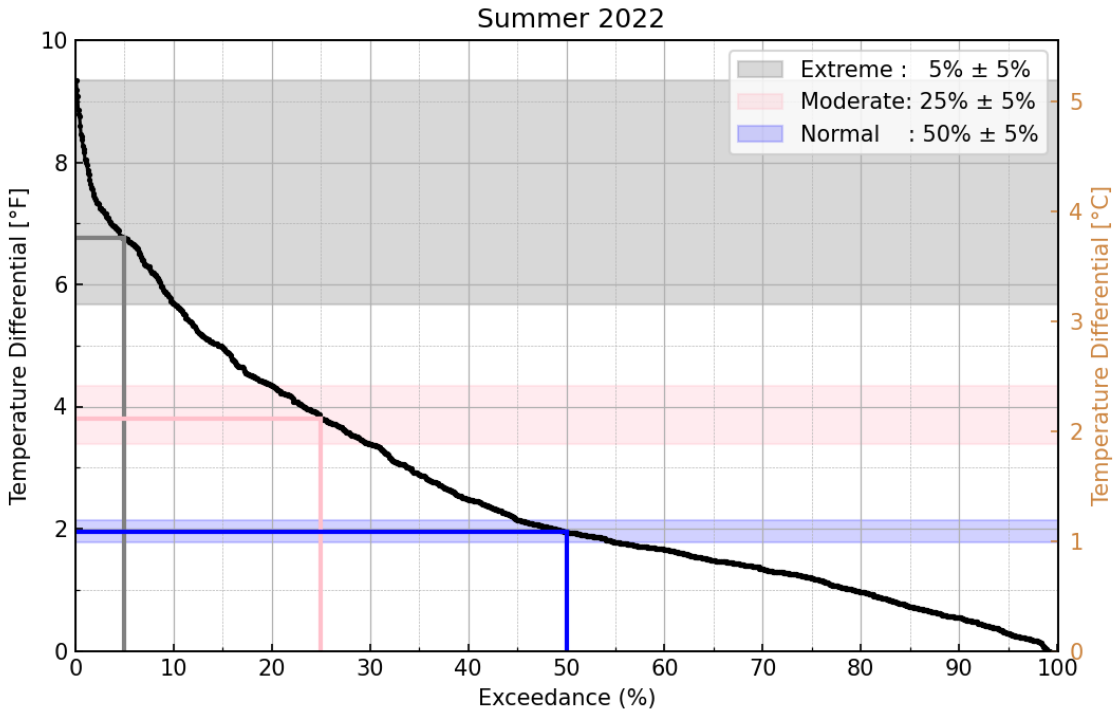


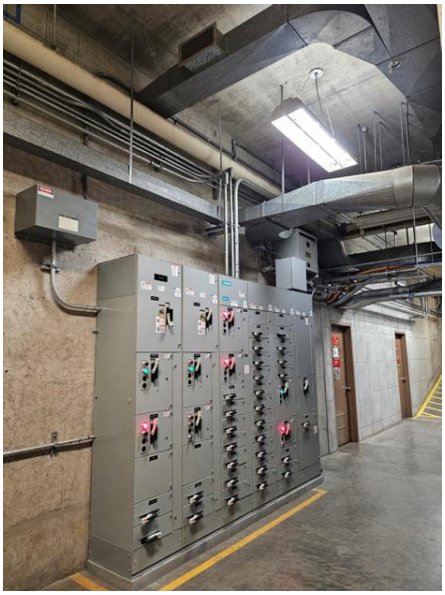
Figure 2-2. Lower Monumental Historical Temperature Exceedances

Table 2-2. Lower Monumental Historical Temperature Design Values (Summer 2022)

Location		Extreme [°F] 5% ±5%	Moderate [°F] 25% ±5%	Normal [°F] 50% ±5%
North Shore Ladder	Entrance	69.6	69.5	68.0
	Exit	76.3	73.2	69.9
	Differential (Exit-Entrance)	6.7	3.7	1.9

Additional information is provided in Appendix B. Thermal performance for the selected alternatives were evaluated using the extreme data set values.

Power Availability. Based discussions conducted during the site visit, it was determined that the existing electrical infrastructure is suitable for supporting the new load requirements, including the Motor Control Center (MCC) designated as "CQ04," located on Level 7. This MCC is a Siemens-manufactured unit rated at 480V and 600A and currently has two available spaces for additional connections. Electrical conduits originating from MCC CQ04 extend vertically to a junction box labeled "JB-1" on Level 8 and continue further upwards to Level 9.



Photograph 4: MCC CQ04 Located on Level 7

2.2 Ice Harbor

The following provides a summary of pertinent project data for Ice Harbor.

Table 2-3. Pertinent Project Data

LOCATION	
State	Washington
Counties	Franklin and Walla Walla
River	Snake River

River miles from mouth	9.7
Authorized purposes	Multi-purpose (hydropower, navigation, irrigation, recreation, fish & wildlife conservation and water quality)
Type of Project	Run-of-river
DAM	
Type	Concrete gravity with earthfill embankment
Length, feet	2,822
Maximum structural height, feet	213
Deck elevation, feet msl	453.0
RESERVOIR	
Name	Lake Sacajawea
Length, miles	31.9
Surface area, acres	8,375 (elevation 440)
Normal forebay elevations, feet msl	437.0 to 440.0 (July through August)
POWERHOUSE	
Type of turbines	Kaplan
Completion date	1962 (Units 1-3) 1976 (Units 4-6)
Number of units	6
Rated capacity, MW	603
Hydraulic capacity, cfs	106,000
Normal tailrace elevations, feet msl	335.0 to 340.0 (July through August)
SPILLWAY	
Type	Ogee crest, gate controlled
Number of bays	10
Crest elevation, feet msl	391
Design discharge, cfs	850,000 (pool elevation 446.4 feet)
ADULT FISHWAYS	
Location and description	North Shore Fish Ladder and South Shore Fish Ladder (adjacent to powerhouse).
Type	Ice Harbor-type fish ladder with vertical slot regulating section
Slope	1V : 10H
Ladder flow, cfs (hydraulic differential, ft)	142 (1.0) to 166 (1.3)
Exit flow, cfs	66.0 to 93.5

Exit invert, feet msl	431.0
Exit flow depth, feet	6 to 9
Exit water velocity, feet per second	0.87 to 0.92
Make-up water intake invert, feet msl	416.5
Other features	Powerhouse collection channel and junction pool with pumped AWS system.

An overall site plan and process flow diagram are shown on Appendix A, Plates HLD-2 and HLD-3, respectively.

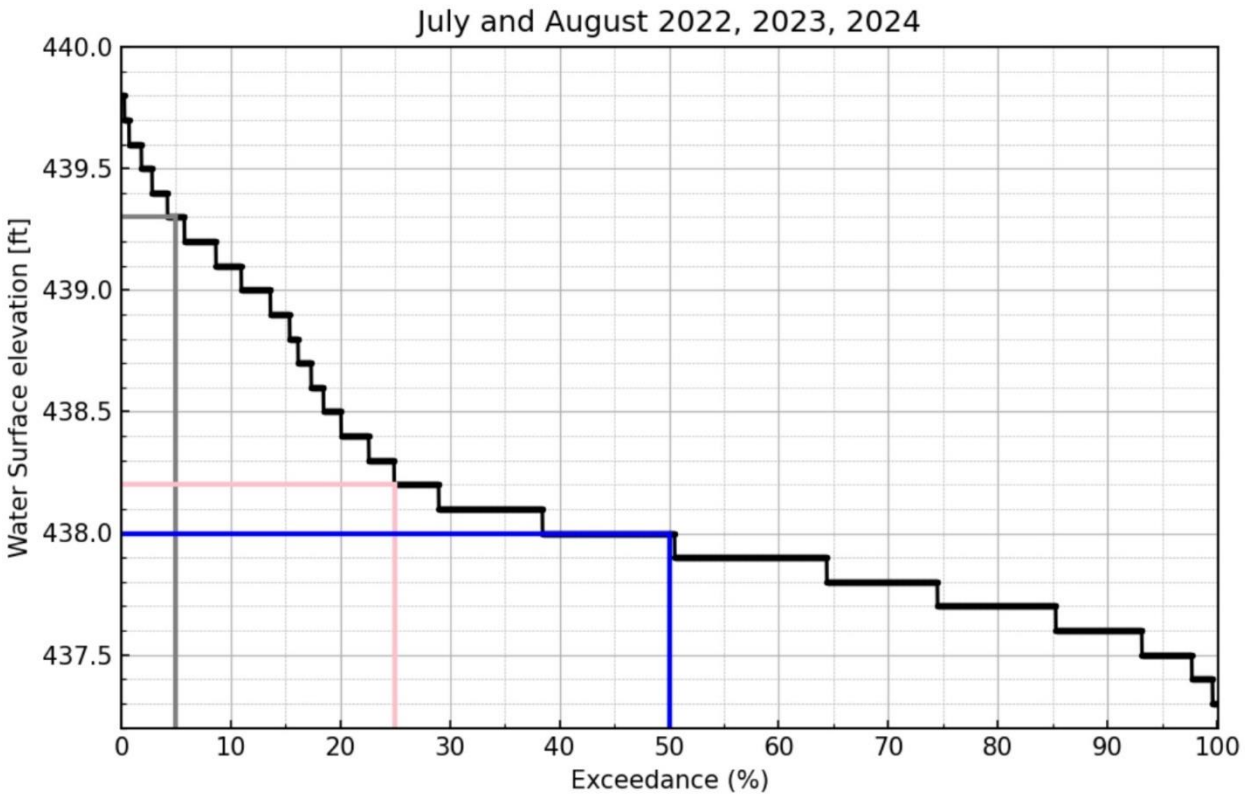
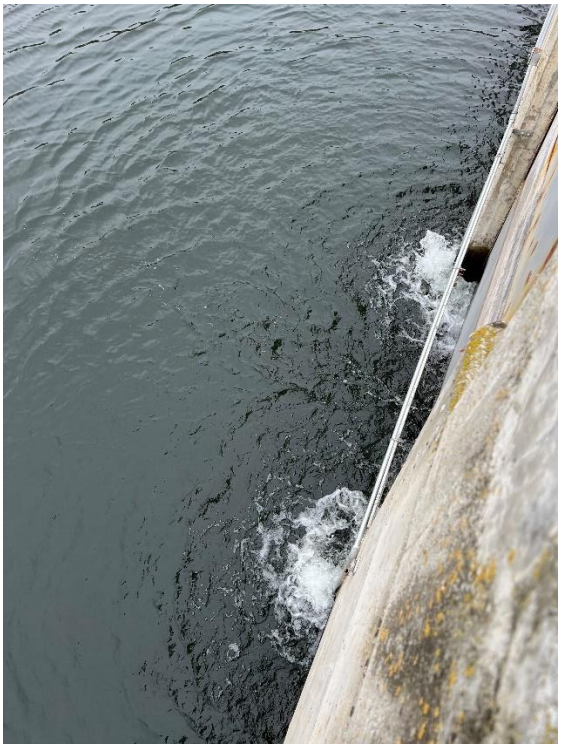


Figure 2-3. Ice Harbor Historical Reservoir Water Surface Elevations

The South Shore Ladder at Ice Harbor Dam includes a fishway exit and a make-up water intake located on the upstream face of the dam that supply water to the fishway by gravity. These facilities work in conjunction with the regulating section of the fish ladder and the diffuser to facilitate operation of the fishway over the full range of reservoir elevations.

Photograph 5: Ice Harbor Dam General Arrangement (Photo by BPA).

The fishway exit and make-up water intake include trashracks to exclude debris, and bulkheads (normally stowed) that can be installed for isolation. The regulating section of the fishway includes vertical slot openings with a sill and a rectangular orifice in the weir wall. Gate 12-1 located in the Service Gallery is operated to provide make-up water to Diffuser No. 12 to maintain 1.0 to 1.3 inches of head on the downstream weirs. The ladder below the regulating section and diffuser is an Ice Harbor-type ladder with two weirs and two orifices. Additional information is provided in Appendix A, Plates.



Photograph 6: Fishway Exit with Bubblers on Either Side

Photograph 7: Fishway Exit Channel (Photo by USACE).

Photograph 8: Fishway Regulating Section (Photo by USACE).

Key considerations for the Ice Harbor project include the following:

Fishway Exit Bubbler. An existing air compressor with diffuser piping is used periodically to clear debris away from the fishway exit area. The compressor is understood to be rated at approximately 400 CFM at 100 psi. USACE personnel indicate that the existing diffusers are slightly offset from the fishway exit so do not impede the upstream movement of fish. No significant delays have been observed.

Fishway Exit Channel. The exit channel is 12 feet wide and associated transport velocities may often be lower than the typical 1.5 to 4.0 fps recommended to avoid delay.

Temperature Differentials. Hourly temperature information for the South Shore Fish Ladder exit (i.e., reservoir thermistor) and the ladder entrance was evaluated for the years 2022, 2023 and 2024. The greatest differentials were found to occur in the year 2024, and that data was used to develop design values representing the median of extreme, moderate and normal temperature exceedance data sets as shown below.

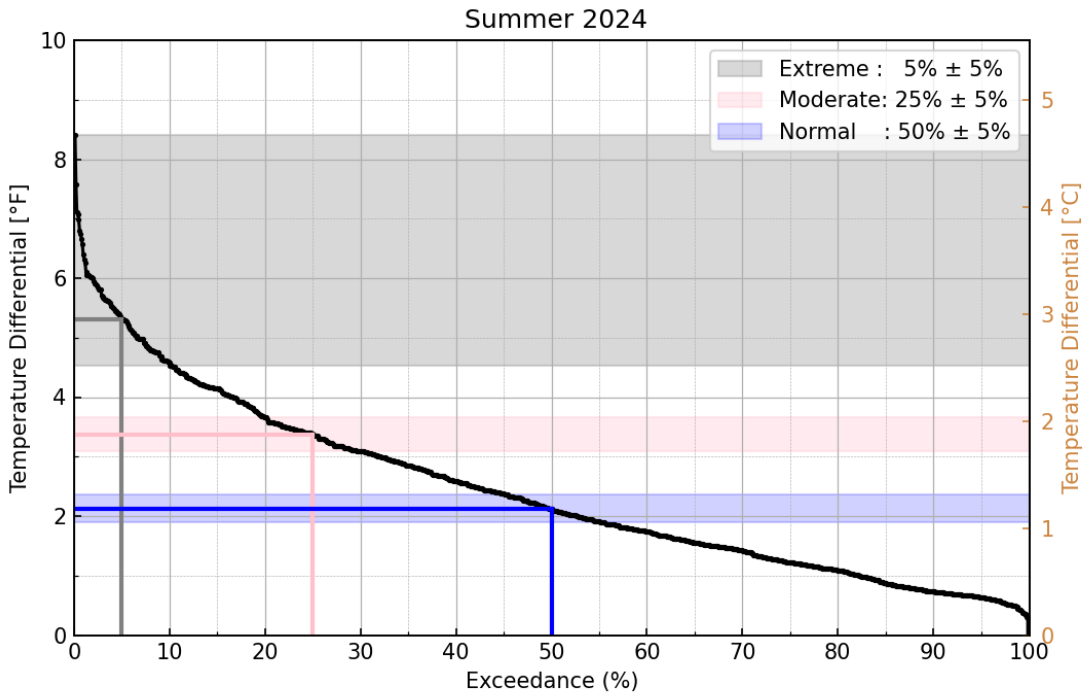


Figure 2-4. Ice Harbor Historical Temperature Exceedances

Table 2-4. Ice Harbor Historical Temperature Design Values (Summer 2024)

Location		Extreme [°F] 5% ±5%	Moderate [°F] 25% ±5%	Normal [°F] 50% ±5%
South Shore Fish Ladder	Entrance	67.6	71.5	71.1
	Exit	73.2	74.9	73.2
	Differential (Exit-Entrance)	5.6	3.4	2.1

Additional information is provided in Appendix B. Thermal performance for the selected alternatives were evaluated using the extreme data set values.

Power Availability. Based discussions conducted during the site visit, it was determined that the existing electrical infrastructure is suitable for supporting the new load requirements, including MCC "FCQ3," located on Level 7.5. MCC FCQ3 is a Westinghouse 480V unit equipped with a 225A main feeder breaker and includes two spare breaker positions. Additionally, MCC "CQ08," also a Westinghouse 480V unit, was identified as a potential source. This MCC is fitted with a 400A main breaker and has one available space for future load connections.

Photograph 9: MCC FCQ3

Photograph 10: MCC CQ08

2.3 McNary

The following provides a summary of pertinent project data for McNary Dam.

Table 2-5. Pertinent Project Data

LOCATION	
State	Washington and Oregon
Counties	Benton, Franklin and Walla Walla (WA), and Umatilla (OR)
River	Columbia River
River miles from mouth	292.0
Authorized purposes	Multi-purpose (hydropower, navigation, irrigation, recreation, fish & wildlife conservation and water quality)
Type of Project	Run-of-river
DAM	
Type	Concrete gravity with earthfill embankments on either abutment
Length, feet	7,365

Maximum structural height, feet	191
Deck elevation, feet msl	361.0 (365.0 at embankments)
RESERVOIR	
Name	Lake Wallula
Length, miles	61.6
Surface area, acres	38,800 (elevation 340)
Normal forebay elevations, feet msl	337.0 to 340.0 (July through August)
POWERHOUSE	
Type of turbines	Kaplan
Completion date	1957
Number of units	14
Rated capacity, MW	980
Hydraulic capacity, cfs	232,000
Normal tailrace elevations, feet msl	265.0 to 267.0 (July through August)
SPILLWAY	
Type	Ogee crest, gate controlled
Number of bays	22
Crest elevation, feet msl	291
Design discharge, cfs	2,200,000 (pool elevation 356.5 feet)
ADULT FISHWAYS	
Location and description	Washington Shore Fishway and Oregon Shore Fishway (adjacent to powerhouse).
Type	Pool-and-weir type fish ladder (30-foot wide linear weir with two orifices) and tilting weir regulating section
Slope	1V : 20H
Ladder flow, cfs (hydraulic differential, ft)	210 (1.0) to 246 (1.25)
Exit flow, cfs	210 (1.0) to 246 (1.25)
Exit invert, feet msl	330.0
Exit flow depth, feet	7 to 10
Exit water velocity, feet per second	1.24 to 1.76
Make-up water intake invert, feet msl	N/A
Other features	Powerhouse collection channel and junction pool with gravity and pumped AWS systems.

An overall site plan and process flow diagram are shown on Appendix A, Plates MNA-2 and MNA-3, respectively.

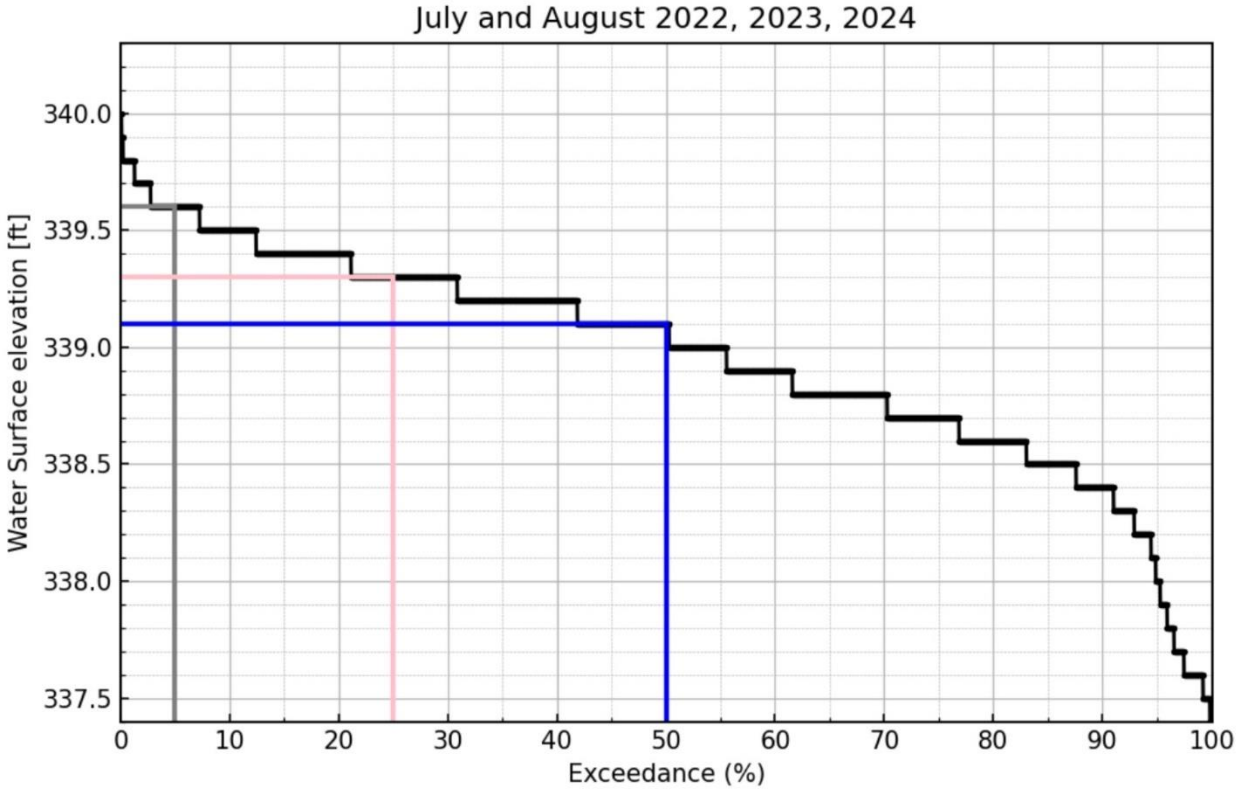


Figure 2-5. McNary Historical Reservoir Water Surface Elevations

The Oregon Shore Fishway at McNary Dam includes a fish exit located on the south side of the structure that supplies water to the fishway by gravity. This works in conjunction with the regulating section of the fishway to facilitate operation over the full range of reservoir elevations.

Photograph 11: McNary Dam Oregon Shore Fishway General Arrangement (Photo by BPA).

The fishway exit includes a trashrack to exclude debris and a bulkhead (normally stowed) that can be installed for isolation. The regulating section of the fishway includes a telescoping regulating weir and seven tilting weirs, all with rectangular orifices near the invert. The weirs are adjusted to maintain 1.0 to 1.25 inches of head on the downstream weirs. The fishway below the diffuser is a pool-and-weir ladder with a linear weir and two orifices.

A gravity AWS intake is located at the easterly end of the fish ladder structure. Two vertical traveling screens remove debris and direct any incidental fish into a bypass that discharges into the fishway entrance pool. An 8-foot diameter conduit provides gravity water supply to diffuser nos. 7 through 14 located in the lower fish ladder. Diffuser No. 7 is not typically used, and it is understood that the operating

gates for Diffuser nos. 8 through 14 are not reliable. An adjacent intake with a 4 x 6-foot conduit provides irrigation water to the United States Bureau of Reclamation (USBR) Umatilla Basin Project. Additional information is provided in Appendix A, Plates.

Photograph 12: Fishway Exit Opening (Downstream Side)

Photograph 13: Fishway Regulating Section

Key considerations for the McNary project include the following:

No Fishway Exit Bubbler. McNary does not have a bubbler system at the fishway exit for debris.

Existing Fishway Exit Configuration. Only the southerly fishway exit opening (8ft W x 13ft H) is currently utilized. The trashrack and bulkhead guides are located on the downstream side of the fishway exit opening. The north opening (17ft W x 13ft H) has a bulkhead installed and is not currently utilized.

Gravity AWS System. Water provided by the gravity AWS system intake is similar in temperature to the tailrace, including additional pumped AWS water that is introduced into the entrance pool. As a result, temperature differentials within the McNary Oregon Shore Ladder are confined to the upper ladder and only the fish exit water needs to be conditioned.

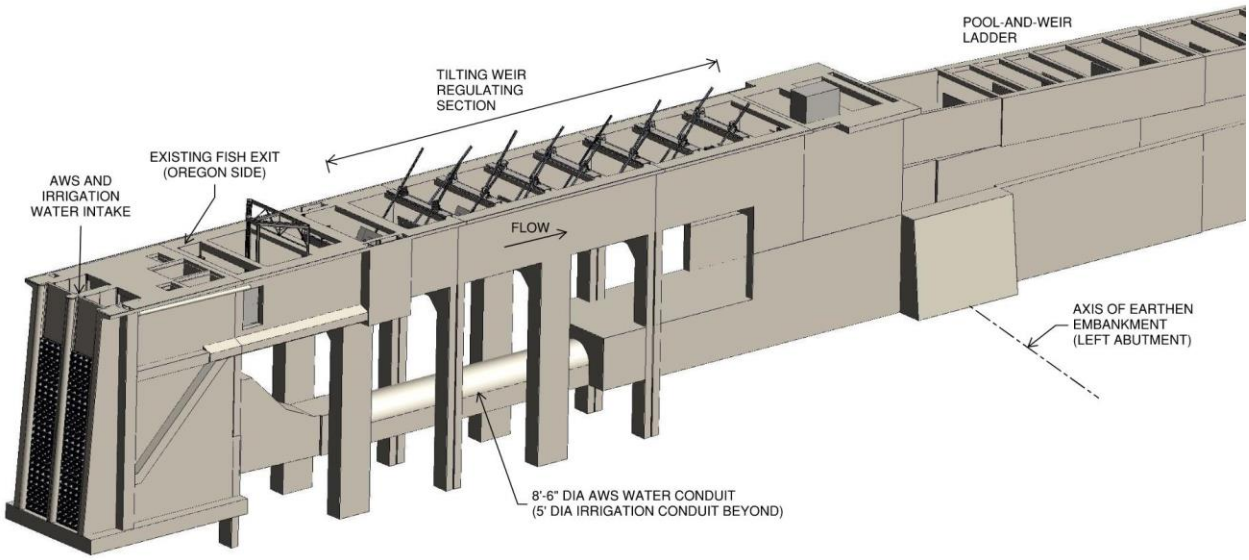


Figure 2-6. McNary Oregon Shore Fishway (Provided by USACE annotated by Jacobs)

Temperature Differentials. Hourly temperature information for the Oregon Shore Ladder Exit (i.e., reservoir thermistor) and the Ladder Entrance was evaluated for the years 2022, 2023 and 2024. The greatest differentials were found to occur in the year 2023, and that data was used to develop design values representing the median of extreme, moderate and normal temperature exceedance data sets as shown below.

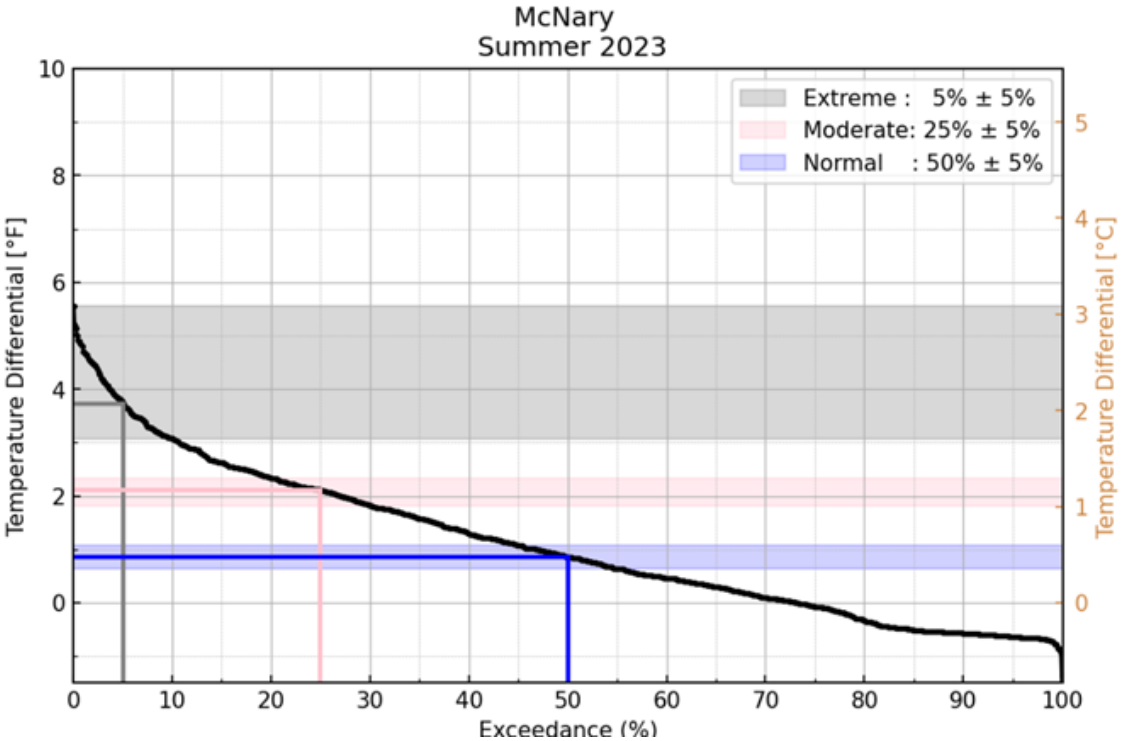


Figure 2-7. McNary Historical Temperature Exceedances

Table 2-6. McNary Temperature Design Values (Summer 2023)

Location		Extreme [°F] 5% ±5%	Moderate [°F] 25% ±5%	Normal [°F] 50% ±5%
Oregon Shore Fishway	Entrance	68.6	70.3	70.4
	Exit	72.4	72.4	71.3
	Differential (Exit-Entrance)	3.8	2.1	0.9
	Gravity AWS Diffuser	71.4	71.3	70.8
	AWS Differential (Diffuser-Entrance)	0.4	0.3	0.3

Additional information is provided in Appendix B. Thermal performance for the selected alternatives were evaluated using the extreme data set values.

Power Availability. Unlike the other three dam sites, McNary Dam lacks a MCC in proximity to the powerhouse. According to information provided by USACE, the only potentially usable electrical equipment is Panelboard "CQ1," located within the fish ladder control building. CQ1 is a 480V panelboard, and based on the 2002 panel schedule, it contains one spare 30A three-pole breaker and three single-pole spaces. This available capacity may be insufficient to support anticipated electrical loads.

2.4 John Day

The following provides a summary of pertinent project data for John Day Dam.

Table 2-7. Pertinent Project Data

LOCATION	
State	Washington and Oregon
Counties	Klickitat (WA), and Sherman (OR)
River	Columbia River
River miles from mouth	215.6
Authorized purposes	Multi-purpose (Hydropower, navigation, flood risk management irrigation, recreation, fish & wildlife conservation and water quality)
Type of Project	Storage
DAM	
Type	Concrete gravity with earthfill embankments on either abutment
Length, feet	5,543
Maximum structural height, feet	256
Deck elevation, feet msl	281

RESERVOIR	
Name	Lake Umatilla
Length, miles	76.4
Surface area, acres	51,532 (elevation 268)
Normal forebay elevations, feet msl	263.0 to 265.0 (July through August)
POWERHOUSE	
Type of turbines	Kaplan
Completion date	1972
Number of units	16
Rated capacity, MW	2,160
Hydraulic capacity, cfs	344,000
Normal tailrace elevations, feet msl	158.0 to 162.0 (July through August)
SPILLWAY	
Type	Ogee crest, gate controlled
Number of bays	20
Crest elevation, feet msl	210
Design discharge, cfs	2,250,000 (pool elevation 276.5 feet)
ADULT FISHWAYS	
Location and description	North Fish Ladder and South Fish Ladder (adjacent to powerhouse).
Type	Ice Harbor-type fish ladder with vertical slot regulating section with actuated wing gates
Slope	1V : 10H
Ladder flow, cfs (hydraulic differential, ft)	85 (1.0) to 113.4 (1.3)
Exit flow, cfs	54.1 to 67.6
Exit invert, feet msl	250.5
Exit flow depth, feet	12.5 to 14.5
Exit water velocity, feet per second	0.72 to 0.78
Make-up water intake invert, feet msl	239.5 (237.5 at face of Dam)
Other features	Three fishway entrances, powerhouse collection channel with floating orifice gates, and pumped AWS system

An overall site plan and process flow diagram are shown on Appendix A, Plates JDA-2 and JDA-3, respectively.

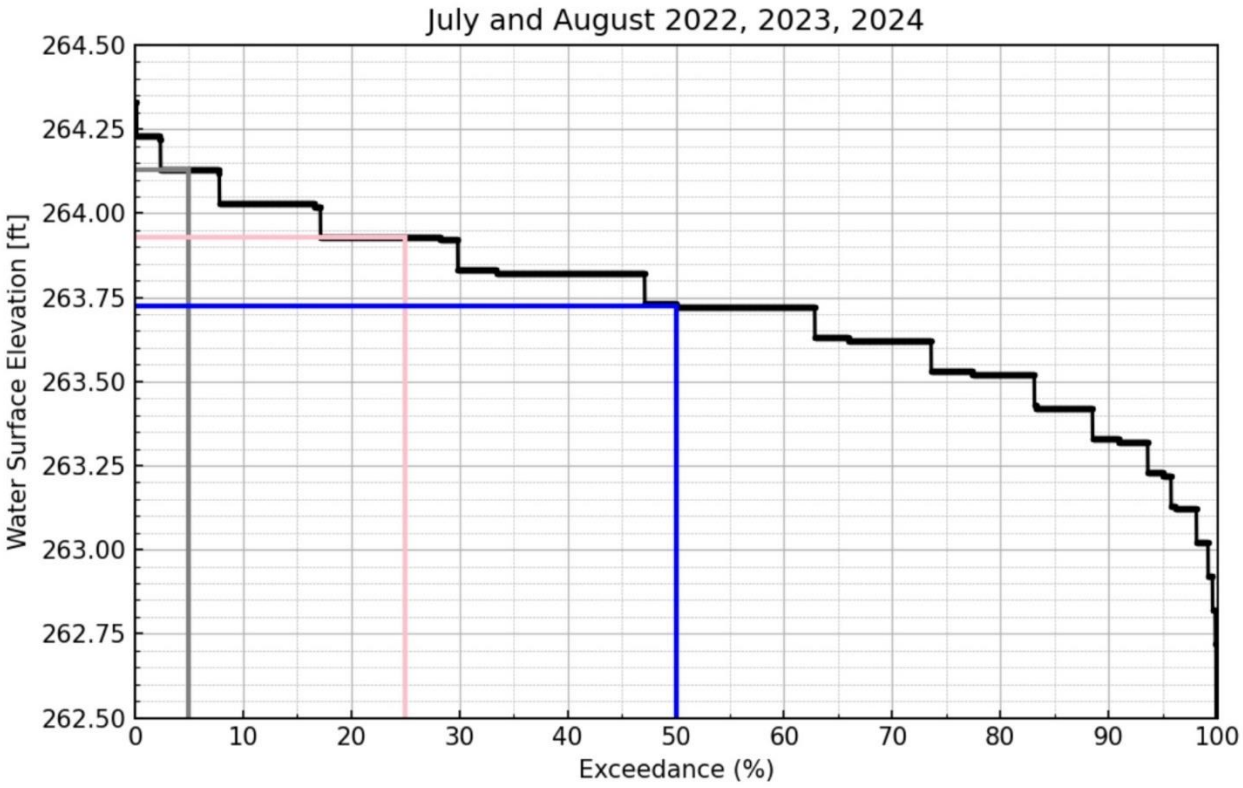
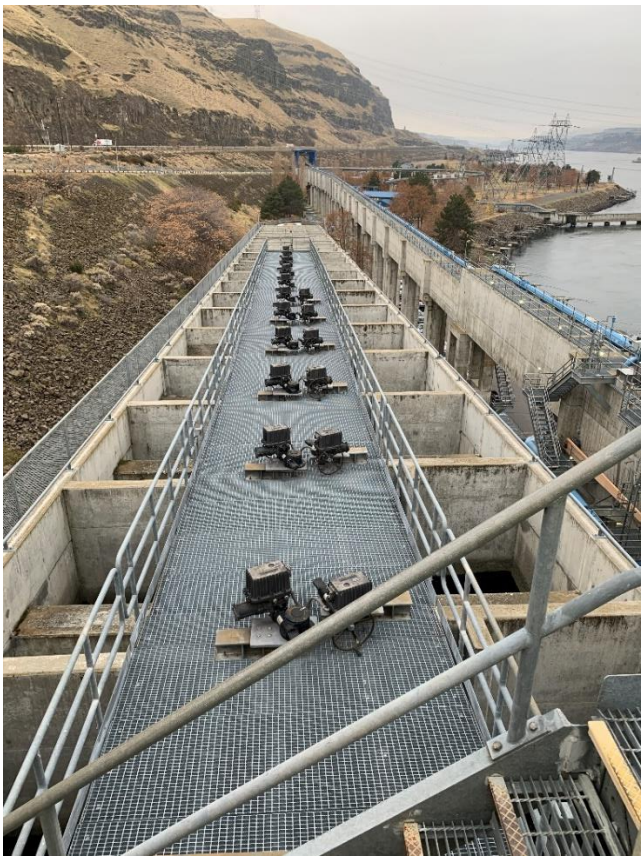


Figure 2-8. John Day Historical Reservoir Water Surface Elevations

The South Fish Ladder at John Day Dam includes a fishway exit and a make-up water intake located on the upstream face of the dam that supply water to the fishway by gravity. These facilities work in conjunction with the regulating section of the fish ladder and the diffuser to facilitate operation of the fishway over the full range of reservoir elevations.

Photograph 14: John Day Dam General Arrangement (Photo by BPA).

The fishway regulating section includes 12 baffles with vertical slot openings and wing gates (aka weir or sill gates). Butterfly gates are operated on two 24-inch diameter conduits to provide water to Diffuser No. 17 to maintain 1.0 to 1.3 feet of head over the downstream weirs. Additional information is provided in Appendix A, Plates.



Photograph 15: Fishway Regulating Section

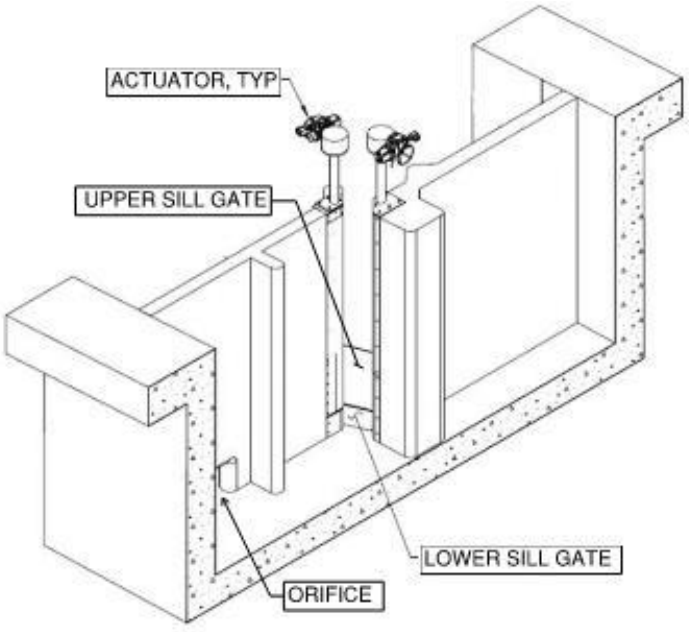


Figure 2-9. Typical Fishway Regulating Section Baffle (Provided by USACE annotated by Jacobs)

Key considerations for the John Day project include the following:

Fishway Exit Deflector. The fishway exit is protected by a floating debris deflector, in addition to the trashrack. Some debris may be inadvertently directed towards the adjacent to the make-up water intake; however, that intake opening is located approximately 18.5 feet below normal low water.

No Fishway Exit Bubbler. John Day does not have a bubbler system at the fish ladder exit.

Fish Exit Channel. The fishway narrows from 24 feet to 9 feet in the exit channel, and then to 6 feet at the exit. Transport velocities will vary accordingly; however, this is not anticipated to be an issue for fish passage.

Photograph 16: Fishway Exit with Deflector and Adjacent Make-up Water Intake

Temperature Differentials. Detailed monitoring of fishway temperatures at John Day began in 2016 in response to high reservoir temperatures in 2015 that contributed to low sockeye salmon passage and survival (USACE, 2022). Data was evaluated by USACE from the period 2011 to 2022, with high temperature differentials documented in 2015 and 2021.

While the period of data evaluated for the purposes of this Study is smaller (2022 to 2024), average temperature differentials and the percent of time exceeding the 1°C threshold were found to be similar between the two data sets.

Hourly temperature information for the South Fish Ladder exit (i.e., reservoir thermistor) and the ladder entrance was evaluated for the years 2022, 2023 and 2024. The greatest differentials were found to occur in the year 2024, and that data was used to develop design values representing the median of extreme, moderate and normal temperature exceedance data sets as shown below.

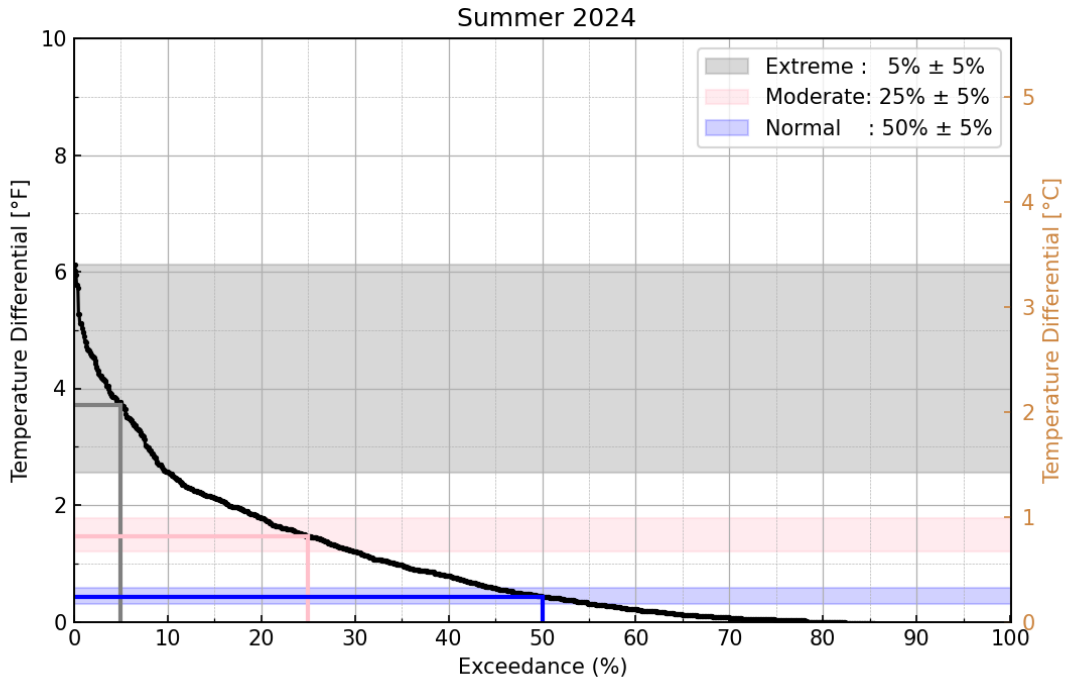


Figure 2-10. John Day Historical Temperature Exceedances

Table 2-8. John Day Temperature Design Values (Summer 2024)

Location		Extreme [°F] 5% ±5%	Moderate [°F] 25% ±5%	Normal [°F] 50% ±5%
South Fish ladder	Entrance	68.0	70.6	70.8
	Diffuser	71.8	72.2	71.2
	Differential (Diffuser-Entrance)	3.8	1.6	0.4

Additional information is provided in Appendix B. Thermal performance for the selected alternatives were evaluated using the extreme data set values.

Power Availability. Based on discussions conducted during the site visit, it was determined that the existing electrical infrastructure has limited capacity for supporting new load requirements at Panelboard "DQ1." This is a 480V panelboard that includes an available 50A three-pole breaker; however, that may be insufficient for the proposed electrical connections.

3. Evaluation Criteria

The general objectives and guidelines for the Study were considered when developing the various alternatives. This information was developed in coordination with USACE and the FFDRWG.

3.1 Objectives and Guidelines

General objectives and guidelines for the Study include the following:

Engineering Design

1. Reduce temperature differentials in the adult fishways between the fishway exit at the reservoir and the tailrace fishway entrances, with a targeted differential of no more than 1°C.
2. Consider the timing and magnitude of historical reservoir thermoclines at each project, and build in flexibility for changing future conditions.
3. For the purposes of this Study, only evaluate the fishways located adjacent to powerhouse where the seasonal temperature differentials are the most significant.
4. Develop concepts in consideration of typical hydraulic, structural, mechanical, electrical and I&C engineering requirements.
5. System should be oil free or use an environmentally-acceptable lubricant (EAL).
6. Avoid floating structures if possible.
7. Minimize capital and operations and maintenance (O&M) costs.

Fish Passage

1. Do not limit existing fishway operations or effectiveness, and minimize impact to adult (and juvenile) fish migration and survival.
2. Maintain or improve hydraulic conditions in the fishway in the interest of providing safe, timely and effective passage per NMFS, 2022.
3. Extend cooler water into the reservoir near the fishway exit to minimize delays or holding in this area.
4. Provide gradual temperature transitions that do not just re-locate the temperature differentials (and fish impacts or delay) to another location within the fishway.
5. Consider water supply temperatures for operation of the adult fish traps.

Operations

1. Minimize interruptions and impact to hydropower project operations.
2. Operate effectively across the range of normal forebay and tailrace water surface elevations.
3. Minimize the need for system adjustments during operation.

4. Facilitate normal operation of the fishway outside the seasonal period of reservoir thermoclines.
5. Minimize O&M requirements.

3.2 Criteria

The objectives and guidelines were consolidated into specific criteria for evaluation purposes in coordination with USACE and the FFDRWG. The evaluation criteria are summarized below.

Table 3-1. Evaluation Criteria

Evaluation Criteria	Description
Thermal Performance in Ladder	Ability to provide safe, timely and effective passage in fishway.
Thermal Performance at Exit	Ability to provide safe, timely and effective passage from fishway exit into reservoir.
Fish Behavior (Other)	Other impacts to fish behavior as a result of the alternative, including hydraulics (flow, velocity and vectors), bubbles, total dissolved gas (TDG), pump vibration, crowding, etc.
Operational Flexibility and Reliability	Precedence for selected technology, ability to accommodate off season operations, and flexibility for changing future conditions.
Impacts/Risks to Project Operations	Anticipated impacts or risks to project generation and other authorized purposes.
Capital Cost	Relative capital construction cost, including length of implementation schedule.
O&M Cost	Relative O&M cost, including labor, equipment maintenance and power costs.

The evaluation criteria was applied to provide an initial, high-level screening and relative ranking of alternatives (Section 4). Two alternatives were then selected for further evaluation at each project site (Section 5). Additional analysis (Section 6) was completed in accordance with the methodologies described below.

3.2.1 Thermal Performance in Ladder

Thermal performance in the ladder was evaluated by assessing the ability of each alternative to meet the 1°C criteria given the extreme values defined for each project using the historical temperature data. This included quantifying the anticipated amount of cool water provided by the alternative with various factors as follows:

Flow ratio. The flow ratio describes the amount of cool water delivered to the vicinity of the fishway exit (or make-up water intake) relative to the normal operating flow. This value is defined at high forebay and typically increases for the fish exit at lower forebays, with the exception of the McNary ladder which is assumed to have a constant ladder exit flow. The ratio for an alternative with pumps in the reservoir that have a free discharge (i.e., Spray Bar) typically increases at a reduced rate. The flow ratio is typically constant for a make-up water intake with a Gravity Chimney.

Thermal efficiency. The thermal efficiency describes the proportional amount of cool water delivered that enters the fishway exit (or make-up water intake) and is available to condition fishway water temperatures. It is assumed that the balance of cool water remains in the reservoir.

Overall efficiency. The overall efficiency is the product of the flow ratio and thermal efficiency, and is used to estimate the amount of fishway exit water (or make-up water) that is cool. The maximum value is 100%. This value is then used in the mass balance calculations to calculate the resulting temperature differential and associated performance of the alternative.

3.2.2 Thermal Performance at Exit

Thermal performance at the fishway exit was evaluated by considering the ability to provide fish a gradual transition into the reservoir, without areas of significant temperature differential. Lower thermal ratios are typically assumed to be an indication of better thermal performance at the exit.

3.2.3 Fish Behavior (Other)

USACE staff provided key observations and input regarding anticipated fish behavior for the various alternatives. This included observations associated with existing fish exit debris bubbler systems, and how they may inform evaluation of the Bubbler and Air Lift alternatives. Issues associated with total dissolved gas (TDG) were anticipated to be minimal. Observations of fish delay and holding within the existing fishways were also considered during the evaluation.

3.2.4 Operational Feasibility and Reliability

Operational feasibility and reliability was evaluated qualitatively with preference given to technologies that had established precedent at other projects; were simple to construct and operate; did not require complex mechanical or electrical components; and could easily accommodate off season operations.

3.2.5 Impacts/Risks to Project Operations

Impacts and Risks to Project Operations were evaluated qualitatively with preference given to technologies that avoided dam safety issues and did not have the potential to impact power generation, forebay debris management, navigation, recreation or other activities.

3.2.6 Capital Cost

The alternatives were initially ranked based on a relative comparison of anticipated capital construction costs. For each selected alternative, Association for the Advancement of Cost Engineering International (AACEI) Class 5 order-of-magnitude estimates were developed. Construction implementation schedules were also considered (Section 8).

3.2.7 O&M Cost

The alternatives were initially ranked based on a relative comparison of anticipated O&M costs. For each selected alternative, O&M costs were assumed to include power costs as well as a percentage of the installed capital cost.

4. Fish Ladder Cooling Alternatives

Alternatives were developed in consideration of the project objectives and guidelines.

1. Spray Bar
2. Modified Spray Bar
3. Bubbler
4. Air Lift Pump
5. Submerged Jet
6. Pumped Fish Exit
7. Gravity Chimney
8. Temperature Curtain
9. Mechanical Systems

The following provides an overview of each alternative, with a summary of advantages and disadvantages.

4.1 Spray Bar

The Spray Bar (aka status quo) alternative is the technology currently in use at the USACE Lower Granite and Little Goose projects on the Snake River. This alternative was identified conceptually during a previous alternatives analysis (Jacobs, 2011) and was implemented by USACE in 2016 and 2017 for the two projects respectively. A rigid curtain and an upwell chimney alternative were evaluated at the same time; however, they were not selected for implementation.

Pumps located in the forebays of both projects are used to convey water to a pipe manifold that discharges cool water above the fishway exit. A fabricated steel extension placed on the suction side of the pump inlets provides access to cooler water. A fabricated steel chimney placed at the make-up water intake extends to a similar depth.

Photograph 17: Lower Granite Pumps and Spray Bar (Photo provided by USACE)

Photograph 18: Lower Granite Spray Bar (Photo provided by USACE)

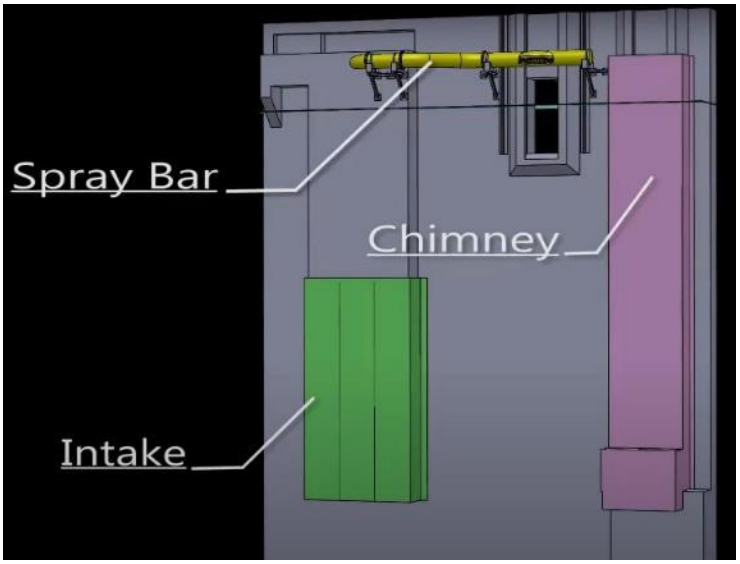


Figure 4-1. General Arrangement of Lower Granite Spray Bar (Provided by USACE)

The design flow rate at Lower Granite is approximately 45 cfs. It is understood that existing vertical turbine pumps were retrofitted for that project. Conical wire mesh screens are installed on the inlet bell of each pump.

Steel "teeth" located at the nozzle openings on the manifold at Lower Granite provide adjustability to accommodate one- or two-pump operation. The teeth also allow the manifold pressure to be increased from 4.0 to 6.5 psi, which improves flow distribution. However, a lower operating pressure may be desirable to provide more plunging flow rather than skimming flow which is anticipated to facilitate better performance.

Photograph 19: Little Goose Pumps and Spray Bar (Photo Provided by USACE)

The Spray Bar configuration for Little Goose is similar, with submersible pumps procured specifically for this project.

The debris screen at Little Goose is located at the bottom of the pump intake extension, and has 3-7/8 x 1-7/8-inch clear openings constructed with 1/8-inch flat bar. It is understood that the screen does not collect much debris and has not been cleaned since installation.

Advantages and disadvantages of this alternative are summarized below:

Advantages

- Provides relatively gradual temperature transition from fishway exit into reservoir for fish.
- Surface flow pushes debris away and significantly reduces the amount of debris entering the fish exit.
- USACE has experience and understanding regarding existing facility design, operation and performance.
- Opportunity for additional resiliency given common mechanical elements between projects, for example pumps, teeth or other components, subject to site-specific installation and operational requirements.
- Pumps can be easily be switched off when temperature conditioning is not needed; intake extension and make-up water chimney remain in place with no impacts to normal fishway operation.

Disadvantages

- Required flows are quite high, assuming 100 to 185% of fishway exit flow at Lower Granite for the high and low forebays respectively.
- Effectiveness is limited as a significant portion of the cold water is not drawn into the fishway exit.
- The abundance of spray and turbulence may delay or disrupt normal fish migration.
- Pump intake may entrain small fish; however, the intake is typically located at depth, includes wire mesh screens (LWG) or a bar rack (LGS), and has low approach velocities (LGS).
- Mechanical/electrical components (pumps and motors) require periodic maintenance.
- Anchorages to face of dam may cause issues if not property designed and installed.

4.2 Modified Spray Bar

The intent of this alternative is to identify modifications to the status quo Spray Bar alternative that can further improve performance. In 2017, CH2M Hill (now Jacobs) prepared a computational fluid dynamics (CFD) model of the fish ladder exit at Lower Granite (CH2M, 2017). It was concluded that most, if not all, of the cool water provided by the Spray Bar was prevented from entering the fish exit. The skimming spray directed the cool water away from the fish exit to where it was not available to enter the fishway. Warm water was instead drawn from along the face of the dam and into the fishway.

Increasing the Spray Bar flow rate had a marginal effect in lowering temperatures in the fishway. The teeth were also added to adjust the flow direction and to promote more plunging flow. However, an analysis of four years of field temperature data from 2020 to 2023 continued to show marginal thermal performance, with only 20 to 40 percent of the spray water entering the fish exit (Appendix D1).

This alternative includes further refining the nozzle/teeth design and providing a deflector boom as a physical barrier to contain flow from the Spray Bar in the immediate vicinity of the fish exit.

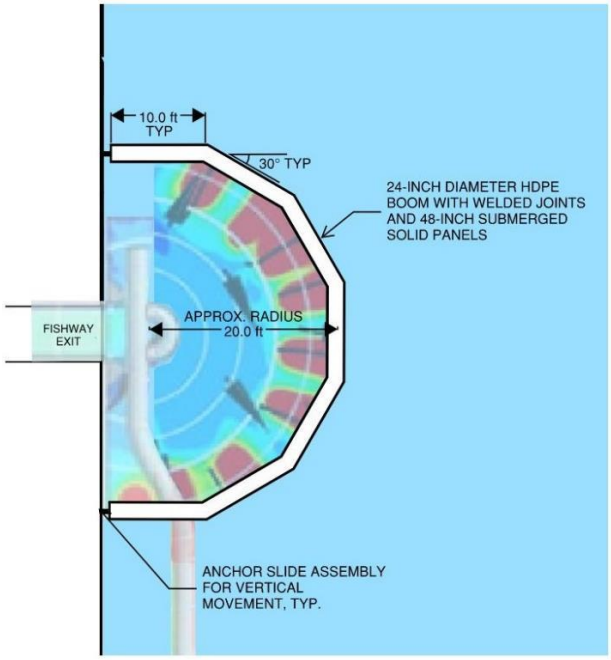


Figure 4-2. CFD Model Results with Plan View Depicting Modified Spray Bar with Deflector Boom

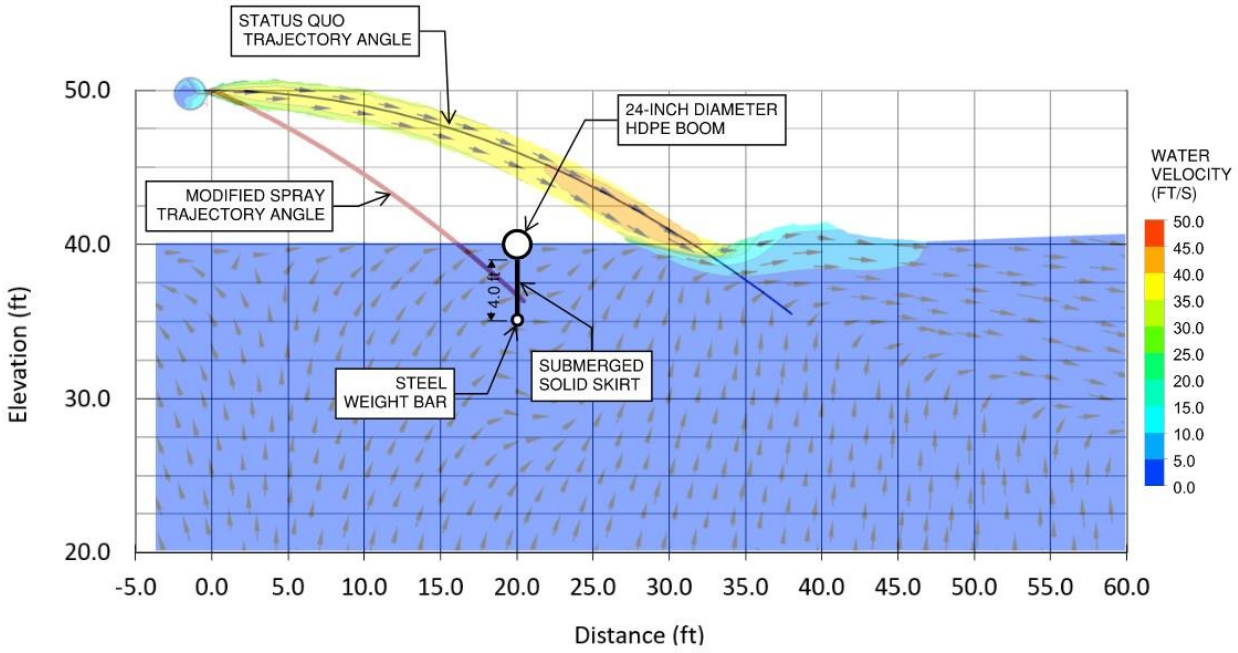


Figure 4-3. CFD Model Results with Section View Depicting Modified Spray Bar with Deflector Boom

Anticipated advantages and disadvantages of this alternative are summarized below:

Advantages

- Provides gradual temperature transition from fishway exit to reservoir for fish.
- USACE has experience and understanding regarding existing facility design, operation and performance.
- Opportunity for additional resiliency given common mechanical elements between projects, for example pumps, teeth or other components, subject to site-specific installation and operational requirements.
- Pumps can be easily be switched off when temperature conditioning is not needed; intake extension and make-up water chimney remain in place with no impacts to normal fishway operation.
- Improved effectiveness relative to the status quo alternative in that a larger volume of cold water is expected to be drawn into the fishway exit.

Disadvantages

- Required flows are quite high, assuming a proposed flow of 150% of the fishway exit flow at high forebay.
- Spray and turbulence may delay or disrupt normal fish migration.
- Floating boom may be susceptible to issues from icing, debris, etc., and require periodic maintenance.
- Pump intake may entrain small fish; however, the intake is typically located at depth, includes a bar rack and has low approach velocities.
- Existing electrical equipment does not have sufficient capacity to provide power to the new pumps. This will require a new source of power – equipment, conduits and wiring to serve the system.
- Mechanical/electrical components (pumps, motors and deflector boom) require periodic maintenance.

4.3 Bubbler

The Bubbler alternative considers the installation of diffuser in the reservoir that is connected to a pressurized air supply. The upwelling of the bubbles will draw cooler water upwards in the vicinity of the fish exit (and the make-up water intake if required).

A Bubbler concept was evaluated previously by a team of engineering students (University of Idaho, 2022). The concept included an air compressor, and air lines and a diffuser attached to the face of the dam. The system was apparently sized to provide approximately 75 cfs of water with an air flow of 21 CFM.

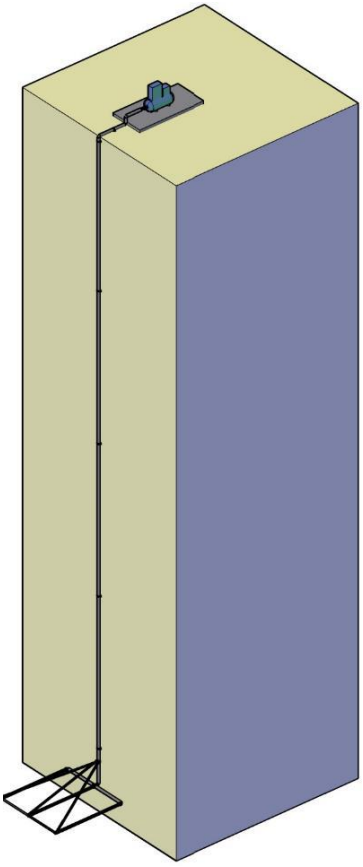
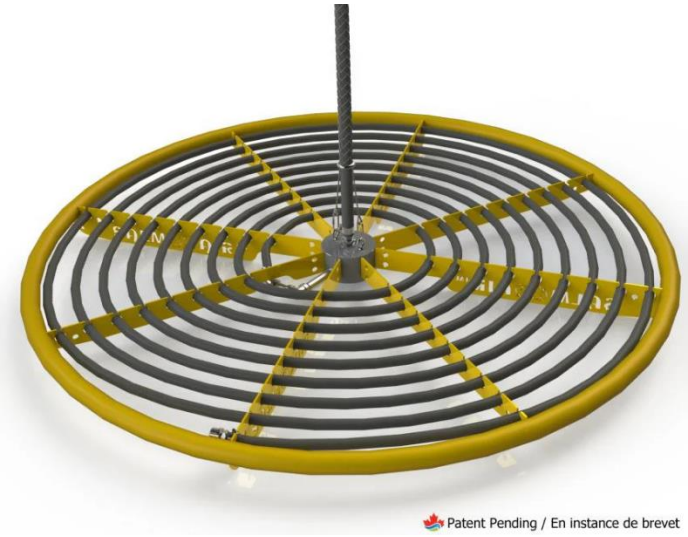


Figure 4-4. Bubbler Concept (University of Idaho, 2022).

Commercial bubble diffuser products are also marketed and used for various applications such as aeration, water treatment and deicing. It is anticipated that such products could be adapted for the upwelling of cool water in a reservoir.

Photograph 20: Upwelling Bubbles in a Lake (Photo by Canadianpond.ca Products, Ltd.)



Photograph 21: SalmoAir Industrial Diffuser (Photo by Candianpond.ca Products, Ltd.)

It is assumed that heat transfer from the compressor to the process air (and water) is minimal.

Anticipated advantages and disadvantages of this alternative are summarized below:

Advantages

- Provides gradual temperature transition from fishway exit to forebay for fish.
- Bubbles likely will not cause physiological damage to fish, i.e. no barotrauma.
- Bubbles may be entrained in fishway flow but impact to TDG levels downstream of dam will likely be negligible, based on observation of the relatively small fishway flow vs. auxiliary water supply (AWS) flow, powerhouse flow and spillway flow.
- Low capital costs and ability to prototype with minimal effort.

Disadvantages

- Bubbles may result in behavioral barrier at fishway exit that could cause delay or disruption of normal fish migration.
- Biofilm may clog diffusers; annual treatment and cleaning required.
- May not be effective in shallow areas, i.e. Lower Monumental or Ice Harbor fishway exits.
- Mechanical/electrical components (compressors) require periodic maintenance.

4.4 Air Lift Pump

Air lift pumps are commonly used in water treatment and aquaculture applications. Air is introduced at the base of a submerged riser conduit, and the resulting buoyant force displaces water upwards.

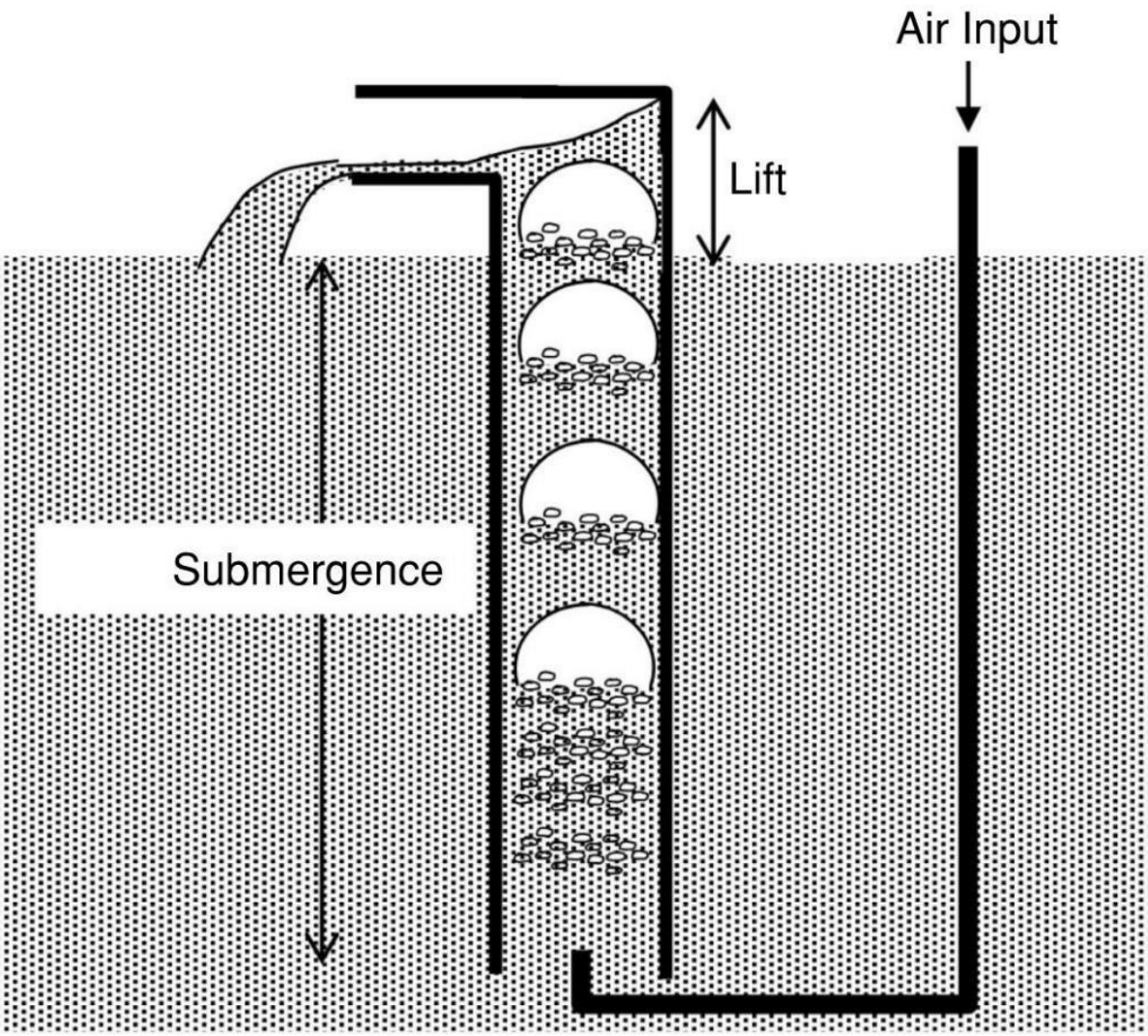


Figure 4-5. Air Lift Pump (Adapted from Timmons, et. al., 2010).

The water flowrate is a function of riser conduit diameter, riser conduit length, lift height and airflow. Total hydraulic differential is on the order of approximately 6 inches. Commercial products are available; however, air lift pumps are also commonly custom-fabricated to suit specific applications.

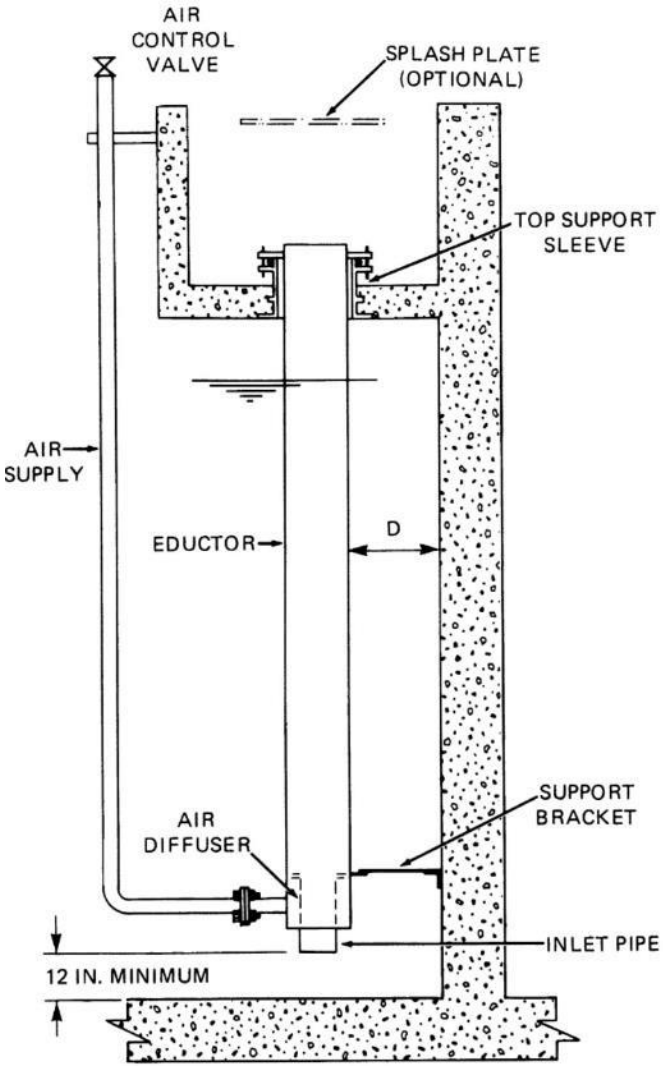


Figure 4-6. Air Lift Installation (Sanitaire / ITT Industries).

For the purposes of this Study, pumps supplied by Sanitaire/ITT and Ovivo were evaluated. A 32-inch diameter riser conduit (eductor) could provide a flow rate of approximately 12 cfs with an air rate of 160 SCFM. Water can be discharged either into a stilling well (as shown in the Figure above), or directly into a tank or reservoir. It is assumed that heat transfer from the compressor to the process air (and water) is minimal.

Anticipated advantages and disadvantages of this alternative are summarized below:

Advantages

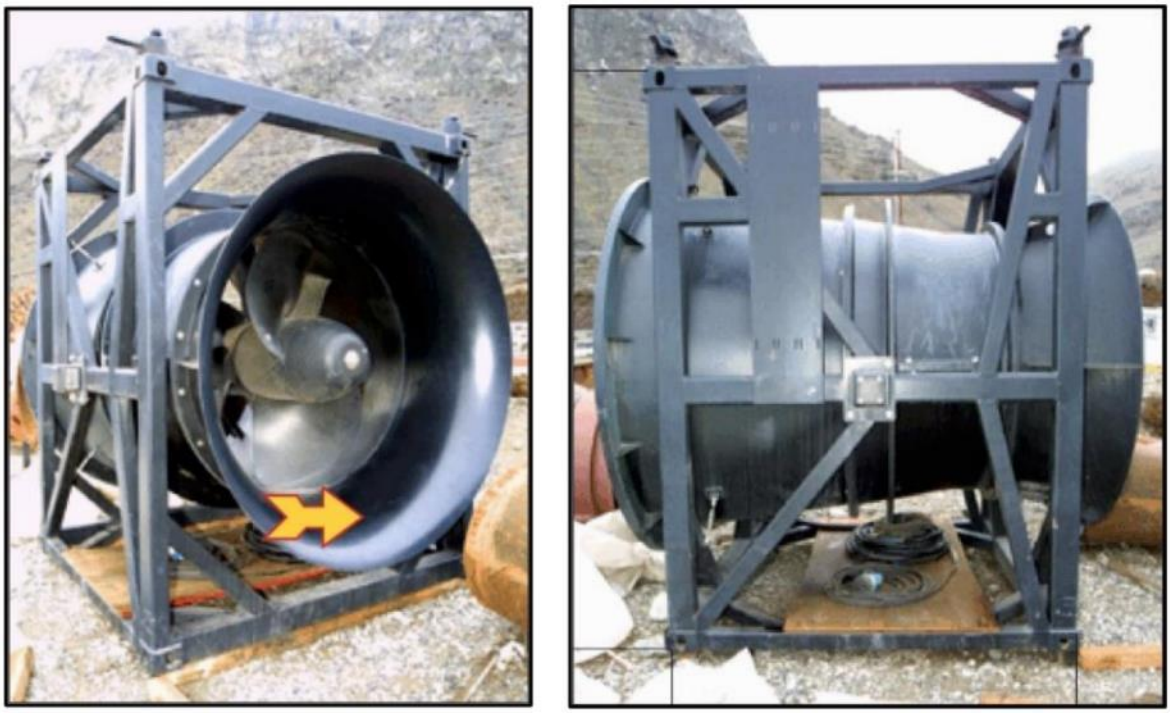
- Gradual temperature transition to forebay via wall diffusers.
- Bubbles can be removed prior to placing water in fishway exit and make-up water intake.
- Lower capital costs in comparison to other pumped alternatives.

Disadvantages

- Mechanical/electrical components that require periodic maintenance.
- Existing electrical equipment may not have sufficient capacity to provide the power necessary for the air compressor. Additional equipment, conduits and wiring will be required.
- May not be effective in shallow areas, i.e. LMN fishway exit.
- Conveyance efficiency is limited; relatively high O&M cost.

4.5 Submerged Jet

Pumps submerged in the reservoir with a free discharge directed towards the fish exit (or make-up water intake) were also evaluated for their ability to convey cool water. Submersible propeller pumps efficiently provide large volumes at low-head and were considered for this application.



Photograph 22: Submersible Propeller Pumps (Photos by Chelan PUD).

This style of pump has the ability to convey approximately 45 cfs at approximately 4 feet of head. Multiple pumps can be used to develop more flow as required. It is anticipated that dedicated hoists or cranes would be provided to raise the pump assemblies for inspection and maintenance. A trashrack would be provided at the pump inlet with a maximum approach velocity of 0.8 fps.

Anticipated advantages and disadvantages of this alternative are summarized below:

Advantages

- Provides temperature transition to forebay for fish.
- More effective in moving water than Bubbler or Air Lift Pump alternatives.

- Precedence of pump reliability (Chelan PUD Rocky Reach Juvenile Fish Facility located on mid-Columbia River)

Disadvantages

- Jet is not contained on forebay side which may dissipate in the reservoir and reduce efficiency (difficult to estimate without modeling).
- Pump intake may entrain small fish; however, the intake is typically located at depth where fish presence is reduced, includes a bar rack and has low approach velocities.
- Not effective in shallow areas, i.e. Lower Monumental or Ice Harbor fishway exit.
- Existing electrical equipment may not have sufficient capacity to provide the power necessary for the pumps. Additional equipment, conduits and wiring will be required.
- Submerged mechanical/electrical components that require regular maintenance.

4.6 Pumped Fish Exit

The Pumped Fish Exit alternative is similar to the status quo alternative with the exception that water would be delivered to submerged wall diffusers with a low velocity of 1 fps in the vicinity of the fish exit, rather than a Spray Bar having a high velocity jet directed away from the fish exit. Submersible propeller pumps could also be used to provide a large amount of flow very efficiently (high flow with low-head).

The cool water would be drawn from depth via a chimney or pipe inlet. A trashrack would be provided with a maximum approach velocity of 0.8 fps. The pumps would then deliver the water to the diffusers at a low velocity of approximately 1 fps to minimize false attraction.

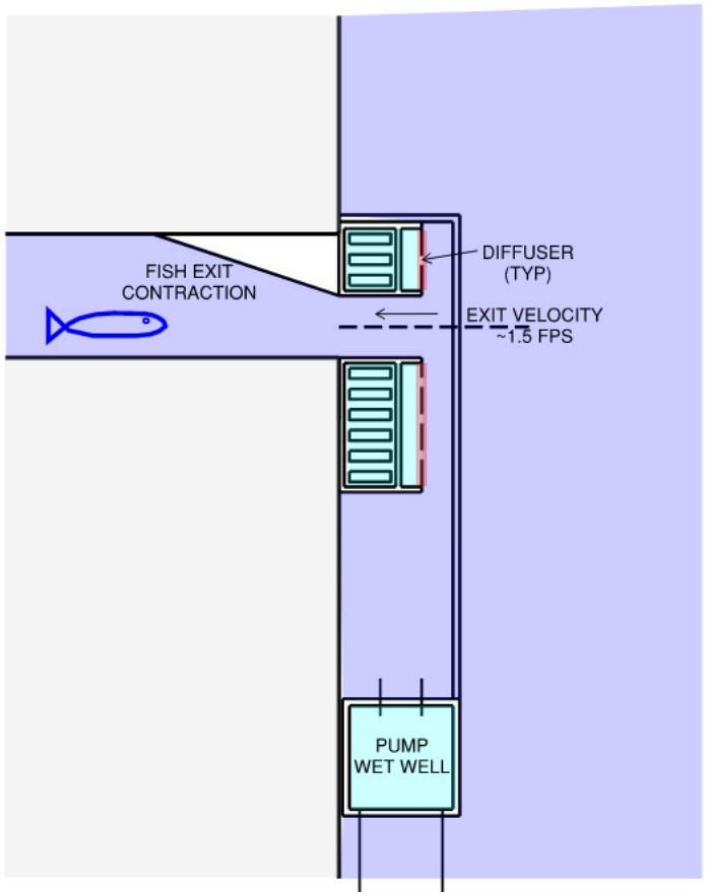


Figure 4 -7. Pumped Fish Exit Concept

Multiple pumps would be provided for redundancy, perhaps with a spare pump in storage. The pumps and fish exit structure would remain in place during the off season without incumbering operations. In other words, it would only need to be turned off when not in use and the fish exit would operate as normal.

Anticipated advantages and disadvantages of this alternative are summarized below:

Advantages

- Efficient conveyance of cool water that will be introduced to fish exit a low velocity
- Provides temperature transition to forebay
- Known and understood technologies (wall diffusers)
- Precedence of pump reliability (Chelan PUD Rocky Reach Juvenile Fish Facility)

Disadvantages

- Potential for pump noise and vibration in vicinity of fish exit.
- Pump intake may entrain small fish; however, the intake is typically located at depth, includes a bar rack and has low approach velocities.
- Submerged mechanical/electrical components require regular maintenance.

4.7 Gravity Chimney

This alternative is similar in concept to the existing make-up water chimneys at Lower Granite and Little Goose projects. The chimney would be placed at the fish exit and would provide cool flow by gravity to the fishway. The fishway regulating section would operate at a lower water surface elevation than typical, but well within the full operating range and capability of the fishway. Issues may occur when operating at the minimum operating pool (MOP); however, that is anticipated to be a rare occurrence. If required, a Gravity Chimney can be placed on the make-up water intake as well.

Fish exiting the fishway would move into the reservoir by sounding down to the elevation of the chimney opening. As an option, a surface exit opening could be provided with or without supplemental conditioned attraction water.

Anticipated advantages and disadvantages of this alternative are summarized below:

Advantages

- Efficient conveyance of cool water.
- No submerged mechanical/electrical components; no pump noise.

Disadvantages

- Fish may be reluctant to sound down to the elevation of the chimney opening; however, this could be mitigated with the provision of an optional surface exit opening.
- Less gradual temperature transition to forebay.
- More sensitive to changes in forebay water surface elevation.

Note that if a surface water exit opening with conditioned attraction water is provided, this alternative would include the additional advantages and disadvantages as described for the Pumped Fish Exit.

4.8 Temperature Curtain

The temperature curtain alternative considers seasonal installation of a floating boom in the reservoir upstream of the fish exit with an impermeable curtain hanging below. The curtain would retain warm water on the upstream side while allowing cooler water to pass below. The USBR has installed several curtains in reservoirs for thermal control in Northern California including projects at Lewiston (Trinity River), Whiskeytown (Clear Creek) and Shasta (Sacramento River).

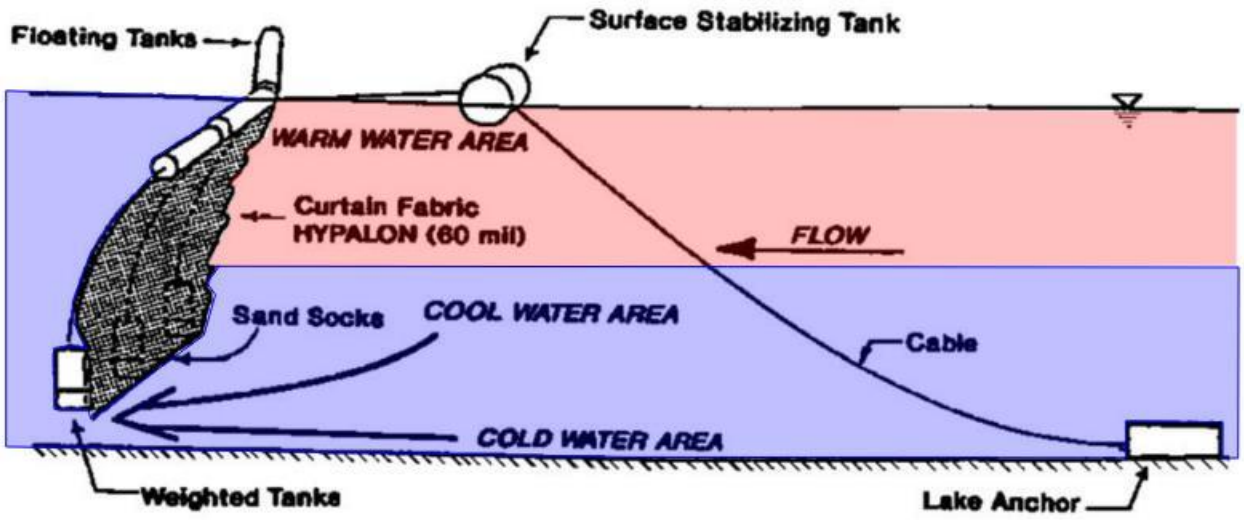


Figure 4-8. Temperature Curtain Concept (Adapted from Johnson, et. al. 1993).

Anticipated advantages and disadvantages of this alternative are summarized below:

Advantages

- Gradual temperature transition to forebay.
- No submerged mechanical/electrical components.

Disadvantages

- May delay or disrupt normal fish migration in reservoir, may collect debris and could harbor predators.
- May not be effective in shallow areas.
- Large anchorages required to handle loads.
- Requires significant labor for seasonal installation and removal.

4.9 Mechanical Systems

Mechanical systems represent an engineered solution for fishway cooling that relies on active refrigeration to reduce water temperatures at the fishway exit. Unlike passive or flow-driven alternatives, mechanical systems offer precise, on-demand temperature control, independent of ambient air temperature, reservoir stratification, or river flow conditions.

The core concept involves circulating chilled water through heat exchangers installed at or near the fishway exit. These exchangers operate similarly to chilled water coils in HVAC systems, transferring heat from the fishway water to the chilled water loop. This process reduces the temperature of water encountered by migrating fish as they exit the ladder, helping to maintain a vertical temperature gradient of ≤1°C and reduce the risk of migratory delay.

Two mechanical configurations were evaluated:

Air-Cooled Chillers

This configuration uses eight 500-ton trailer-mounted chillers per site, deployed seasonally. Chilled water is supplied at 45°F and returned at 60°F, circulated through heat exchangers via a temporary pump skid. The total cooling capacity required is approximately 3,927 tons at Lower Monumental and 3,987 tons at Ice Harbor, with chilled water flow rates of 6,284 GPM and 6,380 GPM, respectively. The estimated electrical demand is 5,242 kW at Lower Monumental and 5,322 kW at Ice Harbor. Air-cooled chillers reject heat to the atmosphere and are generally simpler to deploy but less energy efficient.

Photograph 23: Trailer-Mounted Chiller with 527 Ton Capacity (Photo by MacAllister Power Systems).

Water-Cooled Chillers with Cooling Towers

This alternative uses four 1,000-ton chillers per site, paired with evaporative cooling towers to improve thermodynamic efficiency. Like the air-cooled system, it uses trailer-mounted equipment and a temporary pump skid. Cooling capacity and chilled water flow requirements are identical to the air-cooled configuration. However, this system also requires cooling tower water flow of 9,426 GPM at Lower Monumental and 9,569 GPM at Ice Harbor. Power demand is slightly lower, at 3,829 kW and 3,886 kW, respectively.

Photograph 24: Skid-Mounted Water Chiller (Photo by Carrier Commercial Refrigeration).

Photograph 25: Trailer-Mounted Evaporative Coolers (Photo by Carrier Commercial Refrigeration).

Both configurations are designed for seasonal deployment and modular installation, minimizing permanent infrastructure impacts. While mechanical systems offer the highest level of thermal control among all alternatives, they also introduce significant power, space, and integration requirements, which must be carefully considered during site selection and design.

Anticipated advantages and disadvantages of this alternative are summarized below:

Advantages

- **Precise Control of Fishway Temperatures.** Mechanical systems provide the most precise and reliable temperature control among all evaluated alternatives. By using active refrigeration, these systems can maintain consistent water temperatures at the fishway exit, regardless of external conditions such as air temperature, river flow, or reservoir stratification. This level of control is particularly valuable during peak migration periods when thermal gradients are most pronounced.
- **Minimal Impacts to Existing Infrastructure.** The modular, trailer-mounted design allows for seasonal deployment and removal, minimizing permanent infrastructure impacts.

- **Minimal Fish Impacts.** Additionally, mechanical systems do not rely on flow manipulation or introduce turbulence, bubbles, or other hydraulic features that could deter fish. The water-cooled configuration, in particular, offers improved thermodynamic efficiency, making it a more energy-efficient option for high-capacity sites.

Disadvantages

Despite their technical strengths, mechanical systems present several significant challenges:

- **Large Power Demand.** Power demand is substantial, ranging from approximately 3,800 to over 5,300 kilowatts per site, which may exceed the available electrical capacity at some projects and may necessitate costly upgrades.
- **Large Footprint.** The physical footprint of the chillers, cooling towers, and pump skids is large, potentially conflicting with existing infrastructure or limiting access. Integration with existing fishway systems is complex and will require additional infrastructure to introduce the conditioned water into the fishway.
- **High Cost.** Capital and operational costs are high due to the need for specialized equipment, seasonal mobilization, and continuous energy consumption. Finally, mechanical refrigeration has limited precedent in fish passage applications, introducing uncertainty regarding long-term performance, biological effectiveness, and maintenance requirements.
- Equipment may be noisy.

5. Evaluation and Selection of Alternatives

Significant discussion and evaluation of alternatives took place during the Brainstorming Workshop in May 2025 (Appendix C). In addition, USACE discussed the advantages and disadvantages of the various alternatives with staff at each project site and conducted follow-up discussions with the FFDRWG.

The results of the screening and ranking are provided in the following table.

Table 5-1. Evaluation Matrix

	Fishway Cooling Alternative	Evaluation Criteria							Overall Rank
		Thermal Performance in Ladder	Thermal Performance at Exit	Fish Behavior (Other)	Operational Feasibility and Reliability	Impacts/Risk to Project Operations	Capital Cost	O&M Cost	
1	**Spray Bar**, aka status quo (Government-provided alternative). Similar to existing facilities at Lower Granite and Little Goose. Pumped water to fishway exit area via fabricated intake extension and discharge pipe with Spray Bar. Gravity water to make-up water intake via fabricated steel chimney.								7
2	**Modified Spray Bar**. Similar to Spray Bar Alternative, but may include adjustable nozzles, a flow deflector or other enhancements.								6
3	**Bubbler** (Government-provided alternative). Compressors with air lines discharging to manifolds located below the fishway exit and make-up water intake. Bubbles are un-contained; no pipe column.								2
4	**Air Lift Pump**. Similar to Bubbler Alternative but with pipe column to contain the bubbles and displaced water. Water discharged near fishway exit area via a fabricated transition channel with wall diffusers.								5
5	**Submerged Jet** (Government-provided alternative). Pumps in forebay at depth that direct water towards fishway exit and make-up water intake. May include submersible propeller pump or line shaft pump with motor located at deck level.								3
6	**Pumped Fish Exit**. Pumped water discharged near fishway exit area via a fabricated transition channel with wall diffusers. May utilize submersible propeller pumps or line shaft pumps with motors located at deck level. Make-up water intake may also be modified with pumped or gravity flow.								4
7	**Gravity Chimney**. Similar to Pumped Fish Exit Alternative but utilizes gravity flow rather than pumped flow. May include fish exits near the surface with supplemental pumped flow provided via diffusers.								1
8	**Temperature Curtain**. Curtains of Hypalon or similar material suspended from floating booms in the reservoir that force cool water at depth towards the fishway exit and make-up water intake. May include chain or weights at the bottom of the curtain to maintain shape.								9
9	**Mechanical Systems**. Evaporative coolers, mechanical chillers (air- or water-cooled), heat exchangers, etc. that can provide a cold water supply.								8

Application of Evaluation Criteria	Thermal Performance in Ladder	Thermal Performance at Exit	Fish Behavior (Other)	Operational Feasibility and Reliability	Impacts/Risks to Project Operations	Capital Cost	O&M Cost	Rank
Description	Ability to provide safe, timely and effective passage in fishway.	Ability to provide safe, timely and effective passage from fishway exit into reservoir.	Other impacts to fish behavior as a result of the alternative, including hydraulics (flow, velocity and vectors), bubbles, TDG, pump, vibration, crowding, etc.	Precedence for selected technology, ability to accommodate off season operations, and flexibility for changing future conditions.	Anticipated impacts or risks to project generation and other authorized purposes.	Relative capital construction cost, including length of implementation schedule.	Relative O&M cost, including labor, equipment maintenance and power costs.	Overall Rank is based on a summation of the evaluation criteria rankings for the alternative, with no weighting applied.
Ranking								
1	Excellent	Excellent	Excellent	Excellent	Low	Low	Low	
2	Very good	Very good	Very good	Very good	Below average	Below average	Below average	
3	Good	Good	Good	Good	Average	Average	Average	
4	Fair	Fair	Fair	Fair	Above average	Above average	Above average	
5	Poor	Poor	Poor	Poor	High	High	High	

Based on the rankings identified in the evaluation matrix and other site-specific considerations, the following alternatives were selected for further evaluation.

Table 5-2. Alternatives Selected for Further Evaluation

Project Site	Alternatives	
Lower Monumental	Modified Spray Bar	Pumped Fish Exit
Ice Harbor	Bubbler	Pumped Fish Exit
McNary	Air Lift Pump	Gravity Chimney
John Day	Air Lift Pump	Submerged Jet

Note that these alternatives are intended in some cases to be applicable to more than one project site, even if not indicated above. For example, a Bubbler alternative may also be appropriate for Lower Monumental and John Day. Further discussion and evaluation is provided in Sections 6 and 9.

6. Development of Alternatives

Two alternatives were developed in further detail for each project site. The location and general configuration of each alternative is presented in Appendix A.

6.1 Common Design Criteria

Common design criteria was utilized by discipline to further develop the selected alternatives as described below.

6.2 Fisheries and Hydraulic Criteria

Primary species of concern are ESA-listed salmon: Chinook salmon, sockeye salmon and steelhead. Other species of concern include coho salmon, lamprey and bull trout.

6.2.1 Fishway Operations

The fishways are typically operated in "shad mode" from approximately the end of May through mid- to late July. For the purposes of this Study, hydraulic performance was evaluated per the shad criteria. Thermal performance was evaluated per the salmon criteria.

Table 6-1. Fishway Operations

Project	Normal Forebay Range for July-August (feet, msl)	Shad Criteria				Salmon Criteria			
		Hydraulic Differential (feet)	Fish Exit Flow (cfs)	Make-up Water Intake Flow (cfs)	Total Flow (cfs)	Hydraulic Differential (feet)	Fish Exit Flow (cfs)	Make-up Water Intake Flow (cfs)	Total Flow (cfs)
LMN	537 - 540	1.3	30.0 – 45.0	45.0 – 30.0	75.0	1.1	30.0 – 45.0	40.0 – 25.0	70.0
HLD	437 - 440	1.3	66.0 – 93.5	100.0 – 72.5	166.0	1.0	66.0 – 93.5	76.0 – 48.5	142.0
MNA	337 - 340	1.25	246.0	N/A	246.0	1.0	210.0	N/A	210.0
JDA	263 - 265	1.3	54.1 – 67.6	59.3 – 45.8	113.4	1.0	54.1 - 67.6	30.9 – 17.4	85.0

Note: The MNA fishway does not include a make-up water intake. An AWS intake is located in the vicinity of the fishway exit but that water does not need to be conditioned.

6.2.2 Temperature

Temperature criteria included the following:

- Reservoir stratification typically occurs annually from June through September; however, the most significant differentials were found to be in July and August. As such, data from 1 July through 31 August was used for the purposes of this evaluation.

- The available temperature data set is small (three years from 2022 through 2024) and likely does not reflect the full range of potential variability. However, temperatures available from an extended data set at John Day compared favorably with the three years of data provided.
- Fishway temperatures of 68°F or greater typically require system start-up at the Lower Granite and Little Goose projects, and similar could be expected at the other project sites.

Temperature extremes are different for each project site and their occurrence varies (not necessarily coincident). Thermal performance for the selected alternatives were evaluated using the median of the extreme data set values.

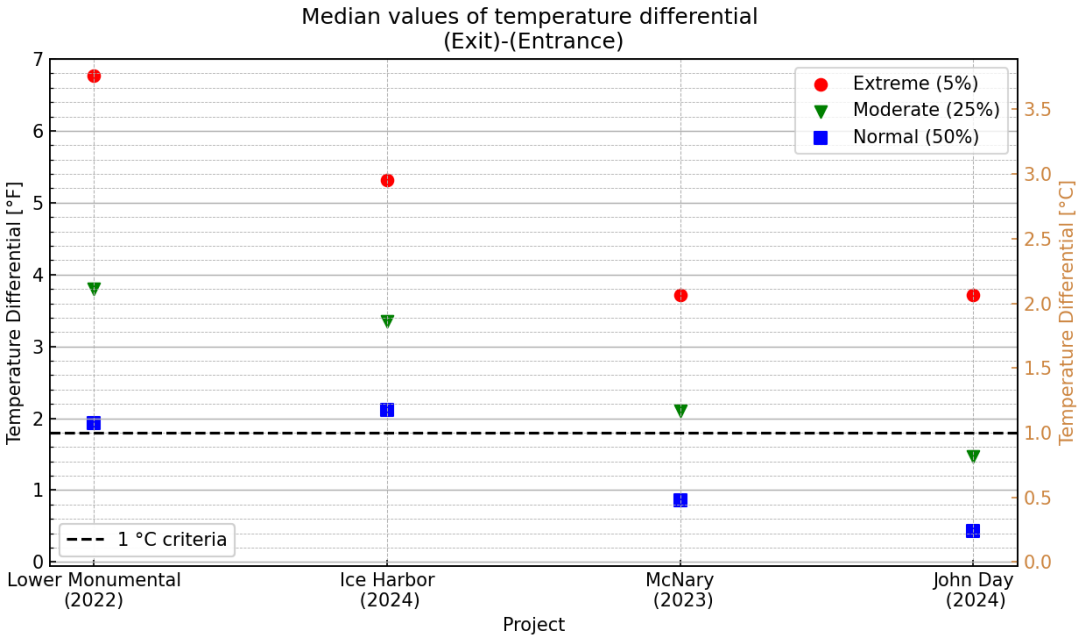


Figure 6-1. Temperature Differentials by Project

Additional temperature data by project site is provided in Appendix B.

6.2.3 Design Parameters

The flow ratio, thermal efficiency and resulting overall efficiency were defined by technology to support the relative comparison and evaluation of thermal performance between alternatives. These values are assumptions based on limited operational data for the Lower Granite Spray Bar (Appendix D2) as well as engineering judgement. Further investigation via hydraulic modeling and/or prototype testing may be required to confirm these values and the anticipated performance of the selected alternatives.

Table 6-2 provides a summary of design parameters by technology and project site. Calculations and additional details are provided in Appendix B1.

Table 6-2. Flow and Thermal Design Parameters

Project	Selected Alternatives	
LMN	**Modified Spray Bar** Flow ratio: 150% Thermal efficiency: 50% Overall efficiency: 75%	**Pumped Fish Exit** Flow ratio: 150% Thermal efficiency: 90% Overall efficiency: 100%
HLD	**Bubbler** Flow ratio: 150% Thermal efficiency: 50% Overall efficiency: 75%	**Pumped Fish Exit** Flow ratio: 150% Thermal efficiency: 90% Overall efficiency: 100%
MNA	**Air Lift Pump** Flow ratio: 75% Thermal efficiency: 90% Overall efficiency: 68%	**Gravity Chimney** Flow ratio: 100% Thermal efficiency: 90% Overall efficiency: 90%
JDA	**Air Lift Pump** Flow ratio: 125% Thermal efficiency: 90% Overall efficiency: 100%	**Submerged Jet** Flow ratio: 130% Thermal efficiency: 60% Overall efficiency: 78%

Notes:

1) Flow ratio is defined at high forebay with the greatest fish exit flow.

2) Air lift pump flow ratio for MNA is low due to the very large fishway flows at this location, and the impracticability of pumping the full rate with this technology.

6.3 Structural Criteria

The structural design was developed to a level where loads, overall geometry, significant demolition, construction methods, and construction costs could be adequately approximated. Various sources such as existing facilities, engineering judgement, and other designs provided a database of approximate quantities and construction costs for some elements. This information was supplemented with preliminary calculations to size new elements or verify previous experience.

Applicable Codes and Standards

- ASCE 7-22, Minimum Design Loads and Associated Criteria for Buildings and Other Structures
- AISC 360-22, AISC Specification for Structural Steel Buildings
- ACI 318-19, Building Code Requirements for Structural Concrete
- EM 1110-2-2104 Strength Design for Reinforced Concrete Hydraulic Structures, December 2024
- EM1110-2-2906 Design of Pile Foundations, January 1991
- EM1110-2-6053 Earthquake Design and Evaluation of Concrete Hydraulic Structures, May 2007

Design Loads

Design loads considered in all structural evaluations include gravity loads (dead and live), seismic forces, wind pressures, and ice accretion. Other design loads to consider for the design of the selected alternatives

will include hydrodynamic pressures or surge loads induced from the pumps or Spray Bar, ice loads, and debris impact loads. These loads reflect the environmental and operational demands expected on the structure. Final design will be based on the loads being combined to produce the maximum effects for a given limit state and varying load factors will be applied to achieve a consistent level of reliability in the final design.

The following tables summarize important structural design parameters at each site.

Table 6-3. Design Load Parameters

Parameter	Value			
	LMN	HLD	MNA	JDA
Risk Category	II	II	II	II
Basic Wind Speed	V_{ult} = 101 mph	V_{ult} = 101 mph	V_{ult} = 100 mph	V_{ult} = 99 mph
Nominal Ice Thickness	0.54 inch	0.61 inch	0.7 inch	0.91 inch
Concurrent Wind Speed on Ice, V_c	48 mph	47 mph	46 mph	40 mph
Short Period Spectral Response Acceleration	S_S = 0.36g	S_S = 0.39g	S_S = 0.42g	S_S = 0.44g
1-Second Spectral Response Acceleration	S_1 = 0.11g	S_1 = 0.12g	S_1 = 0.13g	S_1 = 0.15g
Site Class[1]	C	C	C	C
Seismic Design Category	B	B	B	C
Short Period Design Spectral Response Acceleration	S_{DS} = 0.26g	S_{DS} = 0.29g	S_{DS} = 0.31g	S_{DS} = 0.32g
1-Second Design Spectral Response Acceleration	S_{D1} = 0.10g	S_{D1} = 0.11g	S_{D1} = 0.12g	S_{D1} = 0.14g

Notes:

1) Site class to be confirmed by geotechnical engineer during future design of selected alternative.

Structural steel grade and strength is shown in table below.

Table 6-4. Structural Steel Grade and Strength

Item	Structural Steel Grade and Strength
Wide Flange and WT Shapes	ASTM A992, Fy = 50 ksi
Channels	ASTM A992, Fy = 50 ksi
Angles	ASTM A572, Grade 50
Plates and Bars	ASTM A572, Grade 50
Hollow Structural Sections (HSS)	ASTM A500, Grade C
Bolts	ASTM F3125, A325, or A490 with heavy hex nuts
Anchor Rods	ASTM F1554, Grade 55 (weldable), minimum

Item	Structural Steel Grade and Strength
Threaded Rod	ASTM A193, Grade B7
Welding Electrodes	E70XX (minimum)

Concrete is assumed to have a compressive strength, f'c = 3,000 psi.

6.4 Mechanical Criteria

The following standards apply to the mechanical equipment used in the Pumped Fish Exit and related alternatives:

Pump Systems (Pumped Fish Exit, Gravity Chimney and Submerged Jet Alternatives)

- ANSI/HI 1.3, 2.3, 3.3 – Rotodynamic Pumps: Design and Application
- ANSI/HI 9.6.6 – Pump Piping for Rotodynamic Pumps
- ANSI/HI 9.8 – Pump Intake Design
- ANSI/HI 14.6 – Rotodynamic Pumps for Hydraulic Performance Tests
- Manufacturer Guidelines – Flygt/Xylem design recommendations for ultra-low-head, high-flow submersible pumps

Compressed Air Systems (Bubbler and Air Lift Pump Alternatives)

- ASME B31.3 – Process Piping
- ASME B31.1 – Power Piping
- ASME Section VIII, Division 1 – Pressure Vessels
- ASME EA-4-2008 – Energy Assessment for Compressed Air Systems

6.5 Electrical Criteria

Applicable codes and standards:

- UFC 3-520-01, Interior Electrical Systems
- UFC 3-550-01, Exterior Electrical Power Distribution
- NFPA 101, Life Safety Code
- NFPA 70, National Electrical Code
- ASHRAE 90.1

The electrical engineering analysis focused on determining the power requirements associated with each proposed alternative. Where feasible, the use of existing electrical infrastructure is recommended to minimize cost and complexity. In cases where existing capacity is insufficient, recommended steps for system expansion and load integration have been outlined to ensure compliance with applicable codes and maintain system reliability.

Table 6-5. Electrical Load Summary

Alternative	Project Site	Pumps/ equipment	Pump/ equipment Quantity	Voltage (V)	Phase	Horse-power (hp)	Potential Power Source	Water Flow Rate (CFS)	Notes
Modified Spray Bar	LMN	High-flow, End-suction pump	3	460	3	141.1	N/A	22.7	Requires electrical system expansion
Pumped Fish Exit	LMN	Low-head, High-flow Pump	2	460	3	30	N/A	38.3	Requires electrical system expansion
Pumped Fish Exit	HLD	Low-head, High-flow Pump	3	460	3	30	MCC FCQ3 or CQ08	46.7	Requires load verification
Bubbler	HLD	30 HP Air Compressor	1	460	3	10	MCC FCQ3 or CQ08	310	Requires load verification
Air Lift Pump	MNA, JDA	250 HP Air Compressor	1	460	3	250	N/A	84	Requires electrical system expansion
Gravity Chimney	MNA	Low-head, High-flow Pump	2	460	3	9.83	N/A	22.7	Requires load verification
Submerged Jet	JDA	Low-head, High-flow Pump	2	460	3	39.9	N/A	44.3	Requires electrical system expansion

Based on the recommendations outlined in Section 9.2, the cost impact of the proposed electrical alternatives is expected to vary depending on the availability of existing infrastructure. Alternatives that can utilize existing MCCs or panelboards with sufficient spare capacity will likely incur lower costs, limited to breaker installation, wiring, and minor modifications. Alternatives requiring new power sources due to insufficient capacity will result in significant cost increases. These include expenses for new feeders, transformers, panelboards, and extended conduit runs. All alternatives will require metering and load analysis per National Electrical Code (NEC) 220.87, which may involve temporary metering equipment, engineering labor, and coordination with facility operations. Options requiring new infrastructure will also extend project timelines due to design, permitting, procurement, and construction phases. Installations involving new feeders, MCCs, or panelboards must comply with the NEC and local permitting requirements.

Construction considerations include the need for temporary or permanent metering to collect 30-day demand data, coordination with stakeholders, and mandatory inspections by the city before energizing the system. These requirements can significantly affect both project cost and schedule, especially when new infrastructure is needed.

6.6 Lower Monumental

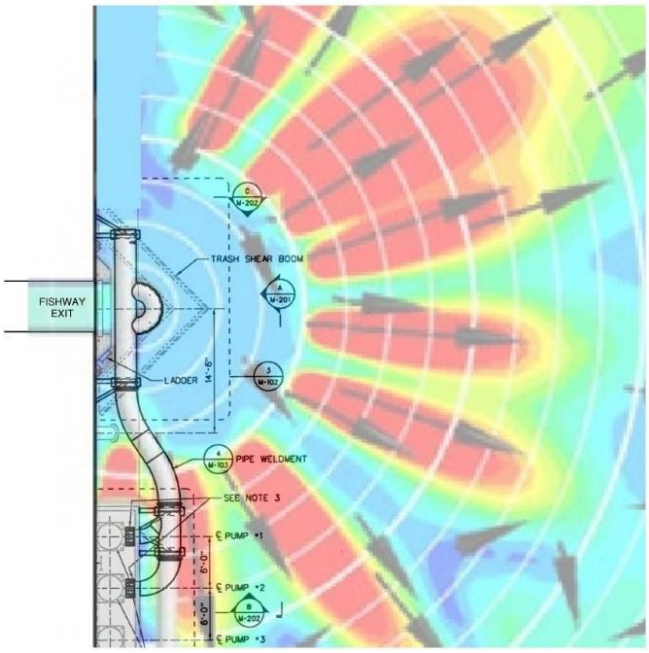
Alternatives selected for further evaluation at Lower Monumental include the Modified Spray Bar and the Pumped Fish Exit.

6.6.1 Modified Spray Bar

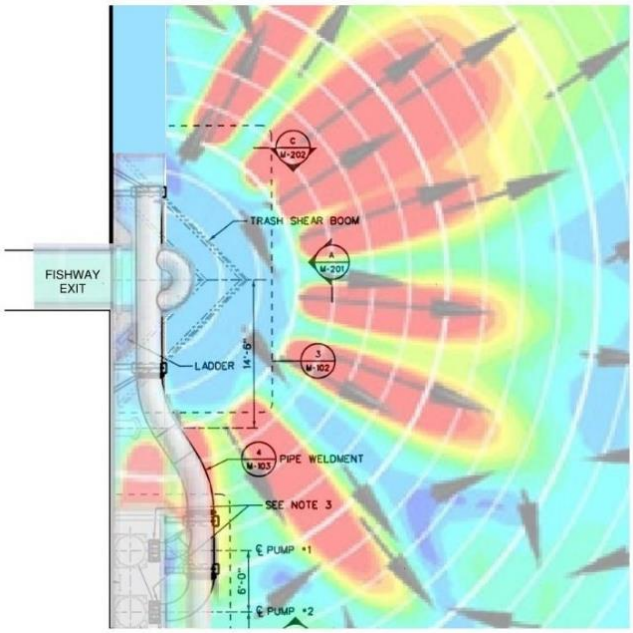
The Modified Spray Bar would be similar to the existing installations at Lower Granite and Little Goose, with modifications to improve performance.

Fisheries and Hydraulic Evaluation

Modifications to the status quo Spray Bar would likely focus on creating plunging flow rather than skimming flow conditions on the surface. This is anticipated to improve the conveyance of cool water into the fishway while maintaining a gradual transition for fish into the forebay. Field adjustment of flow, nozzles, teeth or other elements may be required to achieve optimum hydraulic conditions while not creating an undesirable false attraction issue for fish. The two conditions are presented in the following Figures.



Photograph 26: CFD Model Results at Lower Granite Depicting Skimming Flows Directed Radially Outwards into the Reservoir (CH2M, 2017).



Photograph 27: CFD Model Results at Lower Granite Spray Bar Depicting Plunging Flows with Modified Nozzles (CH2M, 2017).

It may be useful to monitor fish behavior via an underwater video camera, sonar (e.g. Didson or ARIS) or other means. This would provide additional data to evaluate the effectiveness of the Spray Bar alternative and to inform the need for adjustments if necessary. It is understood that similar studies were conducted following the installation of the Spray Bar at Lower Granite (Anchor, 2017).

Table 6-6. LMN Modified Spray Bar Thermal Performance

Scenario	Exit Flow Ratio	Exit Thermal Ratio	Make-up Thermal Ratio	Existing Exit Differential (°F)	Exit Differential (°F)	Ladder Differential (°F)
Modified Spray Bar Only	150	50	0	6.7	1.5	1.8
With Make-up Water	150	50	100	6.7	1.5	0.8

Note: Scenarios assume a high forebay of 540 feet msl which requires the greatest conditioning of the fish exit water.

Conditioning only the exit water results in a differential that is at the target 1.0°C (1.8°F) threshold. Therefore, conditioning of the make-up water intake flows would likely be required.

Structural Evaluation

The Modified Spray Bar alternative includes three main components including the Gravity Chimney for the make-up water intake, the pump intake extension with discharge to the Modified Spray Bar, and the HDPE boom with submerged solid skirt.

The 48-inch diameter suction pipe between these components would be supported by clamps or brackets, attached to the face of dam using post-installed drilled and grouted stainless-steel concrete anchors.

Where stainless-steel concrete anchors are used, washers or gaskets may be utilized as an isolation barrier to prevent galvanic corrosion. It is recommended that submerged steel components are coated in a vinyl paint such as Unified Facilities Guide Specifications (UFGS) paint system number 5-E-Z.

Gravity Chimney

The Gravity Chimney for the make-up water intake will be constructed of steel plate with external angle stiffeners and framing with a steel bar grating debris/fish screen located at the bottom of the chimney. The intake chimney will be fabricated in sections, with each successive section nesting into the proceeding section and bolted together either in the shop or on-site to ensure hydraulic continuity along the length of the chimney. The assembled intake chimney will be lowered into place using a crane from the deck and secured to the upstream face of the dam by divers using drilled and grouted stainless-steel concrete anchors through the flanged edge along the length of the chimney.

Pump Intake Extension

The pump intake extension and wet well will also be constructed of steel plate with external angle stiffeners and framing. It will be fabricated in sections as needed and bolted together either in the shop or on-site. The assembled intake extension will also be lowered into place using a crane from the deck and secured to the upstream face of the dam by divers using drilled and grouted stainless-steel anchors through the flanged edge along the length of the intake extension. The intake extension and wet well will house the pumps, drawing cooler water from depth and discharging via the Modified Spray Bar.

HDPE Boom with Skirt

The boom will be constructed of 24-inch diameter HDPE pipe with welded joints with a submerged solid skirt wall panel to contain flow in the immediate vicinity of the fish exit. The boom and solid skirt panels will be designed such that the self-weight and displaced volume of water is adequate to remain buoyant. The slide assembly anchorage that supports the 24-inch diameter HDPE boom will be designed to allow vertical movement of the boom for a range of reservoir water surface elevations while being restrained to resist design lateral forces. The slide assembly anchors will be accurately located and secured to the upstream face of the dam using drilled and grouted stainless-steel concrete anchors. Depending on the reservoir levels, this can be accomplished using divers or within a temporary blister cofferdam.

Photograph 28: Lower Granite Make-up Water Chimney During Installation (Photo Provided by USACE)

Mechanical Evaluation

The Modified Spray Bar alternative at Lower Monumental Dam utilizes three dry-installed, bearing-frame end-suction pumps operating in parallel to deliver a total flow of 68.0 cfs at a total dynamic head of 10.0 psi. Each pump is equipped with a 23-inch diameter, two-vane, non-clog impeller and operates at 507 RPM. The system is designed to entrain cooler water from depth and discharge it through a series of spray nozzles mounted on a deflector boom positioned upstream of the fishway exit.

Each pump achieves a shaft power of 73 horsepower and operates at 81.36% efficiency near the best efficiency point, ensuring optimal energy performance. The pumps are engineered for reliability and ease of maintenance, featuring a rear pull-out design, stainless-steel wear plates, and a universal stuffing box compatible with either packing or mechanical seals. The impeller is secured with a contoured stainless-steel nut and set screw to prevent fouling.

Electrical Evaluation

The proposed alternative requires the installation of three 480V, 3-phase pumps, each rated at approximately 73.06 horsepower. Preliminary assessment indicates that the existing MCC “CQ04” has two available spaces that are insufficient to serve these new pump loads. No additional power sources were identified during the site investigation and discussion with the dam engineers. This alternative presents significant challenges due to the lack of readily available electrical capacity. A new power source will need to be identified and potentially extended to the installation location.

6.6.2 Pumped Fish Exit

The Pumped Fish Exit would likely provide an efficient means of conveying cool water to the fishway, while also placing additional cool water in the forebay near the exit to provide a thermal transition for fish.

Fisheries and Hydraulic Evaluation

Cool water from an approximate depth of 66 feet would be required. It is anticipated that wall diffusers with velocities of less than 1 fps per National Marine Fisheries Service (NMFS) criteria would be utilized to direct water into the fishway and the forebay near the exit. The proximity of the riprap embankment to the fishway exit at Lower Monumental may make it difficult to convey water to the north side of the fishway however.

Photograph 29: LMN North Embankment with Fishway Exit Identified (Photo Provided by USACE)

Conditioning only the exit water results in a differential that is below the target 1.0°C (1.8°F) threshold. Therefore, conditioning of the make-up water intake flows would not be required.

Table 6-7. LMN Pumped Fish Exit Thermal Performance

Scenario	Exit Flow Ratio	Exit Thermal Efficiency	Make-up Thermal Efficiency	Existing Exit Differential (°F)	Exit Differential (°F)	Ladder Differential (°F)
Pumped Fish Exit Only	150	90	0	6.7	(0.3)	0.7
With Make-up Water	150	90	100	6.7	(0.3)	(0.3)

Note: Scenarios assume a high forebay of 540 feet msl which requires the greatest conditioning of the fish exit water.

Structural Evaluation

The basic components of the Pumped Fish Exit alternative include a pump intake pipe with downturned elbow and intake bell, a pump wet well which houses the pumps, drawing cooler water from depths and discharging through diffusers at the fish exit.

The pump wet well and diffuser chamber will be a single unit constructed of steel plate with external angle stiffeners and framing. The pump wet well and diffuser chamber will be fabricated in sections and bolted together either in the shop or on-site. The assembled pump wet well and diffuser chamber will be lowered into place using a crane from the deck and secured to the upstream face of the dam by divers using drilled and grouted stainless-steel concrete anchors through the flanged edge along the length of the pump wet well and diffuser chamber.

The 48-inch diameter pipe between these components would be supported by clamps or brackets and support for the intake bell would be designed and fabricated of rolled steel shapes. These steel supports would be attached to the face of dam using post-installed drilled and grouted stainless-steel concrete anchors.

Where stainless-steel concrete anchors are used, washers or gaskets may be utilized as an isolation barrier to prevent galvanic corrosion. It is recommended that submerged steel components are coated in a vinyl paint such as UFGS paint system number 5-E-Z.

Mechanical Evaluation

The Pumped Fish Exit alternative at Lower Monumental uses two Flygt PP 4680 submersible propeller pumps, each rated at 30 horsepower, to deliver a combined flow of 68.7 cfs at a total dynamic head of 3.2 feet. The pumps operate in parallel and are installed in a shallow wet well, drawing cool water from depth and discharging it through wall-mounted diffusers at the fishway exit.

Each pump features a 766 mm stainless-steel propeller, operates at 445 RPM, and achieves a pump efficiency of 54% and overall system efficiency of 43.8%. The total input power is 56.5 horsepower. The pumps are designed for semi-permanent wet installation, with corrosion-resistant construction, Class H motor insulation, and a double mechanical seal system for submerged reliability.

The diffusers are positioned below the fishway exit invert to introduce cool water at low velocity, minimizing turbulence and false attraction. The system is modular and seasonally operated, with the diffuser structure remaining in place year-round.

Electrical Evaluation

The proposed alternative requires the installation of two 480V, 3-phase pumps, each rated at approximately 56.5 horsepower. Preliminary assessment indicates that the existing MCC “CQ04” has two available spaces that may be utilized to serve these new pump loads.

In accordance with the NEC, specifically Article 220, the electrical contractor is required to obtain and evaluate meter and demand load data when integrating new loads into existing electrical systems. This ensures compliance with NEC requirements and verifies that the upstream electrical infrastructure has sufficient capacity to support the additional load.

Therefore, it is mandatory to collect current meter readings and demand load data for all equipment potentially impacted by this addition. This data will inform the load analysis and determine the feasibility

of utilizing MCC CQ04 for the proposed pumps. For further guidance, refer to Section 9.2, which outlines the recommended next steps.

6.7 Ice Harbor

Alternatives selected for further evaluation at Ice Harbor include the Bubbler and the Pumped Fish Exit.

6.7.1 Bubbler

The objective of the Bubbler alternative is to entrain cooler water from depth and introduce it into the vicinity of the fishway exit, thereby reducing the temperature of water in the fishway. This is achieved by injecting compressed air through a submerged diffuser. As air bubbles rise, they induce vertical mixing through buoyancy-driven flow and kinetic energy transfer, drawing cooler water upward from below the thermocline. A single or multiple Bubbler diffusers may be required.

Fisheries and Hydraulic Evaluation

While it may be possible to design and fabricate a custom diffuser for this application, an existing product with available field performance data was considered for the purposes of this analysis. The SalmoAir diffuser consists of ¾-inch Bubble Tubing® arranged in a spiral configuration within a 70-inch diameter frame. The total tubing length is approximately 100 feet. The diffuser is installed at a fixed depth with an appropriate thermal profile.

Performance validation for the SalmoAir diffuser was conducted by C-CORE and CanadianPond.ca (2025) through field trials and CFD modeling. At an airflow rate of 30 SCFM, the diffuser produced vertical water velocities up to 1.4 feet per second (0.43 m/s) at 16 feet (5 meters) below the surface. The highest velocities were concentrated near the center of the plume. The estimated upwelling flow rate under these conditions is approximately 197 cubic feet per second (cfs), based on calculations and field trial data reported in the same study. The CFD model, developed using STAR-CCM+, was validated by the authors against field measurements and confirmed the physical behavior of the plume, including vertical velocity profiles and thermal entrainment.

The summary in Table 6-8 assumes that the Bubbler can be located deep enough within the reservoir to entrain sufficiently cool water. Conditioning the exit water results in a differential that is below the target 1.0°C (1.8°F) threshold. Conditioning of make-up water intake flows is not required.

Table 6-8. HLD Bubbler Thermal Performance

Scenario	Exit Flow Ratio	Exit Thermal Ratio	Make-up Thermal Ratio	Existing Exit Differential (°F)	Exit Differential (°F)	Ladder Differential (°F)
Bubbler Only	150	50	0	5.6	0.7	1.2
With Make-up Water	150	50	100	5.6	0.7	0.1

Note: Scenarios assume a high forebay of 440 feet msl which requires the greatest conditioning of the fish exit water.

A diffuser depth of approximately 66 feet is required to provide the performance described above; however, it is understood that the water depth at the fishway exit is only approximately 20 feet. A Bubbler diffuser installed at the fishway exit would likely be unable to provide adequate cool water to the fishway,

even when the make-up water is conditioned (see Appendix D1 calculations). As such, multiple bubbler diffusers in the general vicinity of the fishway exit and make-up water intake may be required to meet the design objectives. See Section 9.2 Site Recommendations for further discussion.

Photograph 30: HLD South Embankment with Fishway Exit Identified (Photo Provided by USACE)

While the Bubbler is not expected to degrade water quality, the introduction of air into the water column may result in localized increases in TDG levels. This effect is expected to be minor relative to powerhouse and spillway flows but should be evaluated during system commissioning. TDG measurements could be made periodically during construction to optimize the diffuser location, airflow and other parameters. Permanent TDG sensors could also be installed in the reservoir and fishway to provide real-time data during normal operations.

Similar to the Modified Spray Bar, it may be useful to monitor fish behavior via an underwater video camera, sonar (e.g. Didson or ARIS) or other means. This would provide additional data to evaluate the effectiveness of the Bubbler alternative and to inform the need for adjustments if necessary.

Structural Evaluation

The components of the Bubbler alternative include a submerged diffuser ring with air supply, which is connected to a wire rope and hoist on a cantilevered retrieval arm to raise and lower for maintenance. The cantilevered retrieval arm can be designed and fabricated of rolled steel shapes or purchased off-the-shelf from a jib crane manufacturer. The cantilevered retrieval arm will be supported from the deck using post-installed drilled and grouted stainless-steel concrete anchors.

Where stainless-steel concrete anchors are used, washers or gaskets may be utilized as an isolation barrier to prevent galvanic corrosion. It is recommended that submerged steel components are coated in a vinyl paint such as UFGS system number 5-E-Z.

Mechanical Evaluation

The Bubbler alternative at Ice Harbor Dam would use compressed air to entrain cooler water from depth and deliver it to the fishway exit. Air is injected through a submerged diffuser to induce vertical mixing via buoyant plumes.

Compressed air is supplied at approximately 30 SCFM to the diffuser using a 10-horsepower rotary screw compressor operating at 100 psig. The discharge air temperature after the integrated aftercooler is estimated to be 105°F, assuming an 80°F ambient temperature and a 25°F cold temperature difference. Through spreadsheet analysis, it was determined that the compressed air cools to approximately 96.8°F through convective heat exchange with the surrounding water as it travels down to the diffuser depth of approximately 20 feet. Further study is needed to evaluate the thermal impact of introducing elevated-temperature air into the water column.

Existing 400 SCFM compressors at the site may be used for initial prototyping. A dedicated compressor would likely be installed for full-scale deployment and could potentially be located at the South end of the EL 440.0 Service Gallery.

Electrical Evaluation

The proposed alternative involves the installation of one 480V, 3-phase air compressor rated at approximately 10 horsepower and a hoist rated at approximately 10 horsepower. A preliminary evaluation indicates that the existing MCC “FCQ3” on Level 7.5 has two spare breaker positions, and MCC “CQ08” has one available space that may be utilized to support the new load.

In accordance with the NEC, specifically Article 220, the electrical contractor is required to obtain and analyze meter and demand load data prior to connecting new loads to existing electrical equipment. This ensures that the upstream distribution system has adequate capacity to accommodate the additional load without compromising system integrity.

Therefore, it is necessary to collect current meter readings and demand load data for all equipment that may be impacted by this addition. This data will inform the load analysis and confirm the feasibility of utilizing MCC FCQ3 or CQ08 for the proposed air compressor. Refer to Section 9.2 for detailed recommendations and the next steps.

6.7.2 Pumped Fish Exit

The Pumped Fish Exit would likely provide an efficient means of conveying cool water to the fishway, while also placing additional cool water in the forebay near the exit to provide a thermal transition for fish.

Fisheries and Hydraulic Evaluation

Cool water from an approximate depth of 66 feet would be required. It is anticipated that wall diffusers with velocities of less than 1 fps per National Marine Fisheries Service (NMFS) criteria would be utilized to direct water into the fishway and the forebay near the exit.

Table 6-9. HLD Pumped Fish Exit Thermal Performance

Scenario	Exit Flow Ratio	Exit Thermal Ratio	Make-up Thermal Ratio	Existing Exit Differential (°F)	Exit Differential (°F)	Ladder Differential (°F)
Pumped Fish Exit Only	150	90	0	5.6	(1.0)	0.1
With Make-up Water	150	90	100	5.6	(1.0)	(1.0)

Note: Scenarios assume a high forebay of 440 feet msl which requires the greatest conditioning of the fish exit water.

Conditioning only the exit water results in a differential that is less than the target 1.0°C (1.8°F) threshold. Therefore, conditioning of the make-up water intake flows would not be required.

Structural Evaluation

The basic components to the Pumped Fish Exit alternative include an intake pipe with downturned elbow and intake bell, a pump wet well which houses the pumps, drawing cooler water from depths and discharging through diffusers at the fish exit.

The pump wet well and diffuser chamber will be a single unit constructed of steel plate with external angle stiffeners and framing. The pump wet well and diffuser chamber will be fabricated in sections and bolted together either in the shop or on-site. The assembled pump wet well and diffuser chamber will be lowered into place using a crane from the deck and secured to the upstream face of the dam by divers using drilled and grouted stainless-steel concrete anchors through the flanged edge along the length of the pump wet well and diffuser chamber.

The 66-inch diameter pipe below these components would be supported by clamps or brackets and support for the intake bell would be designed and fabricated of rolled steel shapes. These steel supports would be attached to the face of dam using post-installed drilled and grouted stainless-steel concrete anchors.

Where stainless-steel concrete anchors are used, washers or gaskets may be utilized as an isolation barrier to prevent galvanic corrosion. It is recommended that submerged steel components are coated in a vinyl paint such as UFGS paint system number 5-E-Z.

Mechanical Evaluation

The Pumped Fish Exit system at Ice Harbor Dam utilizes three Flygt PP 4680 ultra-low-head, high-flow submersible propeller pumps, each rated at 30 horsepower, to deliver a total flow of 141.2 cfs at a total dynamic head of 3.5 feet. The pumps operate in parallel and are installed in a shallow wet well, drawing cool water from depth and discharging it through wall-mounted diffusers at the fishway exit.

Each pump is equipped with a 766 mm stainless-steel propeller set at a 13-degree blade angle and operates at 445 RPM. The system achieves a pump efficiency of 60.5% and an overall system efficiency of 49.7%, with a combined input power of 113.2 horsepower. The pumps are designed for semi-permanent wet installation, with corrosion-resistant stainless-steel construction, Class H motor insulation, and a double mechanical seal system for long-term submerged reliability.

For the purposes of maintenance and repair, a small permanent crane structure will be installed along with the new pumps. This crane structure will include a 5-ton steel cable hoist that can be permanently or temporarily installed during maintenance periods.

The diffusers are positioned below the fishway exit invert to introduce cool water at low velocity, minimizing turbulence and false attraction. The system is designed for seasonal operation, with the diffuser structure remaining in place year-round and the pumps operated only during critical migration periods.

Electrical Evaluation

The proposed alternative involves the installation of three 480V, 3-phase pumps, each rated at approximately 30 horsepower. Preliminary assessment indicates that MCC "FCQ3" has two spare breaker positions, and MCC "CQ08" has one available space that is insufficient to support the new pump loads.

In accordance with the NEC, specifically Article 220, the electrical contractor is required to obtain and evaluate meter and demand load data prior to the addition of new loads to existing electrical equipment. This ensures that the upstream electrical infrastructure has sufficient capacity to accommodate the proposed load without exceeding design limitations.

Therefore, it is necessary to collect current metering data and perform a demand load analysis for all equipment potentially impacted by this addition. The results of this analysis will determine whether the existing infrastructure can support the new pumps, or an additional available source is to be determined. For further guidance, refer to Section 9.2, which outlines the recommended next steps.

6.8 McNary

Alternatives selected for further evaluation at McNary include the Air Lift Pump and the Gravity Chimney.

6.8.1 Air Lift Pump

The air lift pump operates with air introduced at the base of a submerged riser conduit, and the resulting buoyant force displaces water upwards. Multiple diffusers and conduits are required to obtain the required flow rates.

Fisheries and Hydraulic Evaluation

Approximately 13 air lift conduits would be required for McNary.

Table 6-10. MNA Air Lift Thermal Performance

Scenario	Exit Flow Ratio	Exit Thermal Ratio	Existing Exit Differential (°F)	Exit Differential (°F)	Ladder Differential (°F)
Air Lift	75	90	3.8	0.4	0.4

Note: Scenario assumes a high forebay of 340 feet msl which requires the greatest conditioning of the fish exit water.

Conditioning the exit water results in a differential that is below the target 1.0°C (1.8°F) threshold. Conditioning of AWS water intake flows are not required at McNary.

Structural Evaluation

The structural components of the Air Lift Pump alternative will consist of internal horizontal and vertical steel framing members built-up in a semi-circular pattern supported on three 20-inch diameter steel pipe piles driven and socketed into bedrock. A total of thirteen 32-inch diameter steel airlift pipes will extend from elevation 327 to elevation 297 on the outside of the structural framing and secured using clamps or welded connections. Air will be supplied from the top of the dam to the bottom of each of the thirteen airlift pipes which displaces the cooler water from depths upwards towards the fish exit.

The internal horizontal and vertical steel framing members of the air lift structural system will be fabricated in sections and assembled on-site with the thirteen air lift pipes. The internal framing will include framed slots to accept the pipe piles with adequate clearances for installation. Once the pipe piles have been drilled and socketed into rock, they will be used as a guide for installing the air lift structural system. The structural framing system will be picked up and lowered onto the pipe piles with a crane and secured in-place to the pipe piles using divers.

It is recommended that submerged steel components are coated in a vinyl paint such as UFGS paint system number 5-E-Z.

Mechanical Evaluation

The Air Lift Pump alternative at McNary Dam lifts cooler water from depth to the fishway exit using compressed air injected at the base of seven submerged 32-inch riser conduits. The resulting air-water mixture rises through each conduit, displacing cooler water upward.

Compressed air is supplied by a 250-horsepower rotary screw compressor, delivering 2080 SCFM at 100 psig. Airflow is evenly distributed across the thirteen risers (160 SCFM each). The discharge air temperature is estimated at 92°F. As the air descends through a 5-inch delivery line to an approximate100 ft depth, it cools to approximately 89.4°F via convective heat transfer to the surrounding water. Further study is needed to assess the thermal effects of introducing elevated-temperature air.

Existing 500 SCFM compressors may be used for initial prototyping. A dedicated compressor would be required for full-scale operation. Due to the higher total air volume compared to the Bubbler alternative, the Air Lift Pump poses a greater risk of increasing TDG levels. This risk should be evaluated in subsequent design phases.

Electrical Evaluation

The proposed alternative involves the installation of a 480V, 3-phase air compressor rated at approximately 250 horsepower. Evaluation of existing infrastructure indicates that Panelboard “CQ1” (480V, 3PH, 100A), located near the fish ladder, is the only identified electrical source in the vicinity. However, CQ1 contains only one spare 30A three-pole breaker, which is insufficient to support the proposed load.

No additional power sources were identified near the fish ladder during the site investigation. As a result, this alternative presents significant challenges due to the lack of readily available electrical capacity. A new power source will need to be identified and potentially extended to the installation location.

From an electrical standpoint, this option is expected to have substantial impacts on both project cost and schedule due to the required infrastructure upgrades and extended installation timeline.

6.8.2 Gravity Chimney

The Gravity Chimney at McNary would include a fabricated steel structure installed at the fish exit and would provide cool water by gravity to the fishway. An integral fish exit located near the surface with a pumped water supply would preclude the need for fish to sound to the bottom of the chimney to exit.

Fisheries and Hydraulic Evaluation

The fishway regulating section would operate at a lower water surface elevation than typical, but well within the full operating range and capability of the fishway. Issues may occur when operating at the MOP; however, that is anticipated to be a rare occurrence during the period of operation.

Table 6-11. MNA Gravity Chimney Thermal Performance

Scenario	Exit Flow Ratio	Exit Thermal Ratio	Existing Exit Differential (°F)	Exit Differential (°F)	Ladder Differential (°F)
Gravity Chimney	100	90	3.8	(0.8)	(0.8)

Note: Scenario assumes a high forebay of 340 feet msl which requires the greatest conditioning of the fish exit water.

Conditioning the exit water results in a differential that is below the target 1.0°C (1.8°F) threshold. Conditioning of AWS water intake flows are not required at McNary.

Structural Evaluation

The basic components of the Gravity Chimney alternative include a gravity intake chimney with a deep opening and a pump wet well containing pumps which draw cooler water from the chimney and discharge it through diffusers at a surface fish exit opening.

The Gravity Chimney, pump well, and diffuser chamber will be a single unit constructed of steel plate with external angle stiffeners and framing members. The Gravity Chimney, pump well and diffuser chamber will be fabricated in sections and bolted together either in the shop or on-site. The assembled Gravity Chimney structure will be lowered into place using a crane from the deck and secured to the upstream face of the dam on one side by divers using drilled and grouted stainless-steel concrete anchors through the flanged edge along the length of the Gravity Chimney structure. Three 20-inch diameter pipe piles drilled and socketed into rock will also be installed to provide support for the Gravity Chimney structure at the remaining corners.

Where stainless-steel concrete anchors are used, washers or gaskets may be utilized as an isolation barrier to prevent galvanic corrosion. It is recommended that submerged steel components are coated in a vinyl paint such as system number 5-E-Z.

Mechanical Evaluation

The Gravity Chimney alternative at McNary Dam utilizes two ultra-low-head, high-flow submersible propeller pumps operating in parallel to deliver a total flow of 45.4 cfs at a total dynamic head of 2.2 feet. Each pump is equipped with a 580 mm stainless-steel propeller set at a 7-degree blade angle and operates at 590 RPM. The pumps are installed in a semi-permanent wet well configuration and are designed to draw cooler water from depth and convey it to the fishway exit via a gravity-fed conduit.

Each pump achieves a shaft power of 9.8 horsepower and operates at 57.2% hydraulic efficiency, with an overall system efficiency of 45.7%. The pumps are engineered for high reliability and sustained performance in low-head applications, featuring a short shaft overhang to reduce deflection, Class H motor insulation, and a double mechanical seal system for long-term submerged operation. The plug-in seal includes an active seal system, which prevents leakage into the motor and reduces the risk of bearing and stator failures.

The propeller design incorporates backswept blades and a wide hub to enhance clog resistance and maintain high efficiency when handling soft solids. The motor is optimized for submersible use, with heat concentrated in the stator core for improved cooling. The motor cable is developed specifically for submersible applications and includes double elastomer seal grommets at the cable entry for added protection.

The system is designed for seasonal operation, with the pumps deactivated during non-critical periods. The Gravity Chimney conduit and intake structure remain in place year-round, minimizing mobilization and demobilization requirements. Maintenance access is provided for pump retrieval and servicing via guide rails and lifting equipment.

Electrical Evaluation

The proposed alternative involves the installation of two 480V, 3-phase 9.83 horsepower pumps. Evaluation of existing infrastructure indicates that Panelboard "CQ1," located near the fish ladder, is the only identified electrical source in the vicinity. However, CQ1 contains one spare 30A three-pole breaker and three single-pole spaces. This could be used as a potential source of power.

In accordance with the NEC, specifically Article 220, the electrical contractor is required to obtain and evaluate meter and demand load data prior to the addition of new loads to existing electrical equipment. This ensures that the upstream electrical infrastructure has sufficient capacity to accommodate the proposed load without exceeding design limitations.

Therefore, it is necessary to collect current metering data and perform a demand load analysis for all equipment potentially impacted by this addition. The results of this analysis will determine whether the existing infrastructure can support the new pumps. For further guidance, refer to Section 9.2, which outlines the recommended next steps.

6.9 John Day

Alternatives selected for further evaluation at John Day include the Air Lift Pump and the Submerged Jet.

6.9.1 Air Lift Pump

The air lift pump operates with air introduced at the base of a submerged riser conduit, and the resulting buoyant force displaces water upwards. Multiple diffusers and conduits are required to obtain the required flow rates.

Fisheries and Hydraulic Evaluation

Approximately seven air lift conduits would be required for John Day.

Table 6-12. JDA Air Lift Thermal Performance

Scenario	Exit Flow Ratio	Exit Thermal Ratio	Make-up Thermal Ratio	Existing Exit Differential (°F)	Exit Differential (°F)	Ladder Differential (°F)
Air Lift Only	125	90	0	3.8	(0.8)	(0.1)
With Make-up Water	125	90	100	3.8	(0.8)	(0.8)

Note: Scenarios assume a high forebay of 265 feet msl which requires the greatest conditioning of the fish exit water.

Conditioning only the exit water results in a differential that is less than the target 1.0°C (1.8°F) threshold. Therefore, conditioning of the make-up water intake flows would not be required.

Structural Evaluation

The structural components of the Air Lift Pump alternative will consist of internal horizontal and vertical steel framing members built-up in a semi-circular pattern supported on three 20-inch diameter steel pipe piles driven and socketed into bedrock. A total of seven 32-inch diameter steel airlift pipes will extend from elevation 253 to elevation 213 on the outside of the structural framing and secured using clamps or welded connections. Air will be supplied from the top of the dam to the bottom of each of the thirteen airlift pipes which displaces the cooler water from depths upwards towards the fish exit.

The internal horizontal and vertical steel framing members of the air lift structural system will be fabricated in sections and assembled on-site with the seven air lift pipes. The internal framing will include framed slots to accept the pipe piles with adequate clearances for installation. Once the pipe piles have been drilled and socketed into rock, they will be used as a guide for installing the air lift structural system. The structural framing system will be picked up and lowered onto the pipe piles with a crane and secured in-place to the pipe piles using divers.

It is recommended that submerged steel components are coated in a vinyl paint such as UFGS paint system number 5-E-Z.

Mechanical Evaluation

The Air Lift Pump alternative at John Day Dam is proposed to lift cooler water from depth and deliver it to the fishway exit using compressed air injected at the base of submerged riser conduits. The resulting air-water mixture rises through each conduit, displacing cooler water upward into the fishway.

Compressed air is supplied by a 250-horsepower rotary screw compressor, delivering 1120 SCFM at 100 psig. Airflow is distributed across seven 32-inch riser conduits, with each receiving approximately 160 SCFM. The discharge air temperature is estimated at 92°F. As the air descends through a 3-inch delivery line to a depth of approximately 63 feet, it cools to about 89.4°F through convective heat exchange with the surrounding water. Further study is needed to evaluate the thermal impact of introducing elevated-temperature air into the water column.

Existing 500 SCFM compressors at the site may be used for initial prototyping. A dedicated compressor would be required for full-scale operation. Due to the high total air volume, the Air Lift Pump alternative poses a greater risk of increasing TDG levels compared to lower-airflow alternatives. This risk should be evaluated in subsequent design phases.

Electrical Evaluation

The proposed alternative requires the installation of a 480V, 3-phase air compressor rated at approximately 250 horsepower. A review of the existing electrical infrastructure indicates that Panelboard "DQ1" is the only identified power source at the site. DQ1 is a 480V panelboard with a single available 50A three-pole breaker, which is insufficient to support the proposed load.

Discussions with the dam operations team confirmed that no additional power sources are currently available in the vicinity. As a result, this alternative presents significant implementation challenges due to the lack of adequate electrical capacity. A new power source will need to be identified and routed to the installation location.

From an electrical perspective, this option is expected to have a substantial impact on both project cost and schedule due to the need for major infrastructure upgrades and extended installation timelines.

6.9.2 Submerged Jet

The Submerged Jet would include propeller pumps submerged in the reservoir with a free discharge directed towards the fish exit (or make-up water intake). The pumps would be mounted on guides attached to the face of the dam and could be brought to the surface for inspection and maintenance.

Fisheries and Hydraulic Evaluation

Table 6-13. JDA Submerged Jet Thermal Performance

Scenario	Exit Flow Ratio	Exit Thermal Ratio	Make-up Thermal Ratio	Existing Exit Differential (°F)	Exit Differential (°F)	Ladder Differential (°F)
Submerged Jet Only	130	60	0	3.8	0.2	0.7
With Make-up Water	130	60	100	3.8	0.2	0.0

Note: Scenarios assume a high forebay of 265 feet msl which requires the greatest conditioning of the fish exit water.

Conditioning only the exit water results in a differential that is less than the target 1.0°C (1.8°F) threshold. Therefore, conditioning of the make-up water intake flows would not be required.

Structural Evaluation

The components of the Submerged Jet alternative include submersible propeller pumps and retrievable support frame, bar rack to prevent debris/fish from entering propeller pumps, vertical guide rails to allow travel of the retrievable support frame, wire rope and hoist on a cantilevered retrieval arm to raise and lower the propeller pump support frame, and a grated platform for access to the hoist.

Where stainless-steel concrete anchors are used, washers or gaskets may be utilized as an isolation barrier to prevent galvanic corrosion. It is recommended that submerged steel components are coated in a vinyl paint such as UFGS paint system number 5-E-Z.

Cantilevered Retrieval Wire Rope Hoist

The cantilevered retrieval hoist can be designed and fabricated of rolled steel shapes or purchased off-the-shelf from a jib crane manufacturer. The cantilevered retrieval hoist will be cantilevered over the upstream face of the dam and supported from the deck using post-installed drilled and grouted stainless-steel concrete anchors.

Grated Access Platform

The grated access platform will allow access by personnel to the retrieval wire rope hoist to raise and lower the submersible pump for maintenance. The access platform will be cantilevered off the dam and consist of rolled steel shape frames with steel grating and steel handrailing. The access platform frame will be secured by structural steel bracing members and anchored using post-installed drilled and grouted stainless-steel concrete anchors.

Bar Rack

The bar rack at the pump suction inlet will consist of stainless-steel rolled shape frame with 4 inch x1/2 inch vertical bars spaced at 2 inches on center placed on the bottom and all sides of the frame. The bar rack frame will be lowered into place and secured to the face of the dam by diver using drilled and grouted stainless-steel concrete anchors.

Pump Retrieval Frame

The submersible propeller pump retrieval frame will consist of stainless-steel rolled shape frame sized to fit within the bar rack when in the lowered position. The height of the frame will be sized for the selected pump manufacturer and will allow for connection of the wire rope.

Mechanical Evaluation

The Submerged Jet alternative at John Day Dam uses two Flygt PP 4680 ultra-low-head, high-flow submersible propeller pumps, each rated at 40 horsepower, to deliver a total flow of 88.5 cfs at a total dynamic head of 4.0 feet. The pumps operate in parallel and are installed on vertical guide rails, allowing for seasonal deployment and retrieval.

Each pump is equipped with a 766 mm stainless-steel propeller set at a 13-degree blade angle and operates at 445 RPM. The system achieves a pump efficiency of 60.6% and an overall system efficiency of 49.9%, with a combined input power of 79.7 horsepower. The pumps are designed for semi-permanent wet installation, with corrosion-resistant stainless-steel construction, Class H motor insulation, and a double mechanical seal system for long-term submerged reliability.

The pumps discharge through a reducing elbow and jet nozzle, producing a horizontal jet velocity of approximately 16 fps. The jet is directed along the dam face to promote attachment and reduce dispersion, helping to entrain cooler water from depth and extend its influence toward the fishway exit. The system is designed to operate during the migration season and can be removed or serviced during the off season.

Electrical Evaluation

The proposed alternative involves the installation of two 480V, 3-phase pumps, each rated at approximately 40 horsepower and a hoist rated at approximately 10 horsepower. Evaluation of the existing electrical infrastructure indicates that Panelboard “DQ1” is the only available power source at the

site. DQ1 is a 480V panelboard with a single spare 50A three-pole breaker, which is insufficient to support the combined load of the proposed pumps.

Discussions with the dam operations team confirmed that no additional or alternate power sources are currently available in the vicinity. As such, this alternative presents significant implementation challenges due to the lack of readily accessible electrical capacity. A new power source will need to be identified and routed to the installation location.

From an electrical standpoint, this option is expected to have a considerable impact on both project cost and schedule, primarily due to the need for new infrastructure development and extended installation timelines.

7. Construction and Permitting Considerations

Construction and permitting considerations will likely apply at each project site regardless of which alternatives are selected for implementation.

7.1 Key Construction Considerations

Key construction considerations include the following:

- Additional field investigations to support final design including structural and bathymetric surveys, underwater inspections via remotely operated vehicle (ROV), power availability analysis, etc.
- Procurement of long-lead equipment and materials.
- Site access and review of health, safety and environmental (HSE) factors.
- Utilization of marine and underwater construction techniques, including divers at depths of up to 80 feet.
- In-water work scheduled around the annual fishway outage period.
- Start-up and commissioning, including operator training.

7.2 Key Permitting Considerations

Allowances should be included in the overall project schedule and budget for obtaining required permits. It is anticipated that required permits may include the following:

- Building permits from local jurisdictions.
- Clean Water Act (CWA) compliance.
- Endangered Species Act (ESA) and Columbia River System Biological Opinion (BiOp) review.
- Historic preservation project review.
- National Environmental Policy Act (NEPA) categorical exclusion.
- National Pollutant Discharge Elimination System (NPDES) permit.

8. Capital Construction Costs and Schedule

8.1 General

Capital construction costs were developed in accordance with the AACEI methodology. The costs are AACEI Class 5 rough order-of-magnitude estimates with an accuracy range of -50% to +100%.

8.2 Criteria

Applicable codes and standards:

- ER 1110-2-1302 Engineering and Design Civil Works Cost Engineering

8.3 Basis of Estimate

A summary of construction cost estimates is provided below. Additional information is provided in Appendix E.

Table 8-1. Construction Cost Estimates

Project	Selected Alternatives	
Lower Monumental	**Modified Spray Bar** Estimate: $5.9M High: $11.8M Low: $3.0M	**Pumped Fish Exit** Estimate: $4.0M High: $8.0M Low: $2.0M
Ice Harbor	**Bubbler** Estimate: $0.4M High: $0.7M Low: $0.2M	**Pumped Fish Exit** Estimate: $3.8M High: $7.7M Low: $1.9M
McNary	**Air Lift Pump** Estimate: $3.9M High: $7.7M Low: $1.9M	**Gravity Chimney** Estimate: $4.6M High: $9.2M Low: $2.3M
John Day	**Air Lift Pump** Estimate: $3.7M High: $7.5M Low: $1.9M	**Submerged Jet** Estimate: $2.2M High: $4.4M Low: $1.1M

8.4 Construction Schedule

The mid-point of construction was assumed to be January 2028 for all alternatives for the purposes of the construction cost estimates. Per discussions with USACE, this reflects a reasonable timeframe for project planning, funding, final design and construction contracting. It is anticipated that construction at an initial project site would take place on this schedule, however work at the other locations would follow in subsequent years.

Planned fishway outages take place annually to allow for routine maintenance. It is anticipated that this same period would be utilized for installation of the in-water components of the fishway cooling alternatives. An extension of this annual outage period (or multiple seasons) may be required to implement the more complex alternatives.

Table 8-2. Annual Fishway Outages

Project Site	Annual Fishway Outage
Lower Monumental	1 January through 28 February
Ice Harbor	1 January through 28 February
McNary	1 January through 28 February
John Day	1 December through 28 February

Procurement of long-lead items, shop fabrication and other activities would take place during the months prior to this period. Other site work, including electrical and I&C, could likely be scheduled outside the in-water work period if required.

9. Summary

This report documents an evaluation of nine alternatives, including modifications to the existing status quo alternative (Spray Bar) and two government-provided alternatives (Bubbler and Submerged Jet), to improve adult fishway thermal performance at four project sites located on the lower Snake and Columbia Rivers. Evaluation criteria was developed in coordination with USACE and the FFDRWG. Following an initial screening of alternatives, two alternatives were selected for further evaluation at each site. Recommendations by project site and technical discipline are also provided.

9.1 Conclusions

Each site has unique characteristics and operating requirements, so no single technology is suitable for all locations. However, the alternatives identified for each project site are feasible and appear to have the capability to meet the fishway thermal performance criteria.

Table 9-1. Alternatives Selected for Further Evaluation

Project Site	Alternatives	
Lower Monumental	Modified Spray Bar	Pumped Fish Exit
Ice Harbor	Bubbler	Pumped Fish Exit
McNary	Air Lift Pump	Gravity Chimney
John Day	Air Lift Pump	Submerged Jet

It should be noted that a variety of different alternatives were selected for detailed evaluation in part to enhance the overall understanding of each technology, regardless of project site. Certain alternatives, for example the Bubbler alternative, may also be appropriate for other project sites such as Lower Monumental and John Day.

9.2 Site Recommendations

Recommendations are provided below by project site.

Lower Monumental

The shallow water depth and existing riprap slope located near the fish exit at the Lower Monumental North Shore Ladder limits the potential feasibility of alternatives at this location. It is anticipated that the Modified Spray Bar alternative could be accommodated within the space available, however CFD modeling should be performed to evaluate hydraulic performance especially given the shallow water depths in this area.

The Pumped Diffuser Exit alternative includes dredging and handling of riprap on the existing slope. Placing all the required wall diffusers on the south side of the fish exit structure may reduce the amount of dredging necessary but may also impact hydraulic performance and fish egress. It is anticipated that the existing electrical system would also need to be upgraded.

While not specifically evaluated at this location, a Bubbler alternative could be prototyped at Lower Monumental given the relatively small investment required. It is anticipated that the shallow water depth at the fishway exit would limit the effectiveness of a diffuser placed near the fishway exit. Therefore, multiple diffusers may need to be installed at various locations and depths to provide sufficient cooling across a large portion of the forebay adjacent to the right abutment.

Ice Harbor

The shallow water depth and existing riprap slope located near the fish exit at the Ice Harbor South Shore Ladder limits the potential feasibility of alternatives at this location. The Pumped Diffuser Exit alternative is likely not affected, however the performance of the Bubbler alternative would likely be impacted by the limited water depth in the immediate vicinity of the fishway exit.

Given the relatively small investment required, including the availability of an existing air compressor, the Bubbler alternative could be implemented for prototype testing. Multiple diffusers would need to be located at depth in an array to provide sufficient cooling across a large portion of the forebay adjacent to the left abutment.

A key objective would be to observe fish behavior in the vicinity of the diffusers, and to evaluate the potential for holding or delay. Underwater video cameras or sonar (e.g. Didson or ARIS) could be used for this purpose. It is anticipated that parameters such as the diffuser locations, number of diffusers, quantity of air supplied, thermal effectiveness, and other variables could also be tested and evaluated.

Loads would also need to be verified to determine electrical system requirements.

McNary

The Air Lift Pump alternative at McNary is effective but perhaps not as efficient as the Gravity Chimney Alternative. The Gravity Chimney alternative can be implemented in conjunction with a Pumped Fish Exit at the surface to address the potential concern of fish sounding down to exit the chimney.

It is recommended that a thermistor string be installed at McNary on the north side of the Oregon Shore fishway structure in the vicinity of the existing bulkhead. The current analysis relies on data from a thermistor string located across the forebay that may not accurately represent localized conditions. Water from the vicinity of the fishway structure is conveyed by gravity to supply the existing AWS system, and temperature data from that location indicates reasonable correlation with the forebay data. However, a thermistor string installed adjacent to the fishway could help further validate both the proposed Gravity Chimney and the Air Lift Pump alternatives.

Loads would also need to be verified to determine electrical system requirements.

John Day

The narrow roadway and difficult access from the deck above the fishway exit at John Day limits the potential feasibility of alternatives at this location. Discussions with operators are recommended to identify solutions that can be reasonably operated, inspected and maintained given the space available. The availability of space and power supply for support equipment (i.e., air compressors) are additional concerns.

Both the Air Lift Pump and Submerged Jet alternatives appear to be feasible at this location. While not specifically evaluated for John Day, a Bubbler alternative could also be implemented given the relatively small investment required. It is anticipated that the deep water at the fishway exit may enhance the effectiveness of a system installed at this location. Thermal calculations presented in Appendix D1 confirm that a Bubbler alternative at the fishway exit can meet the required performance criteria. Conditioning of the make-up water is not necessary. Placement of the Bubbler at a water depth of approximately 66 feet is required.

A key objective would be to observe fish behavior in the vicinity of the diffuser, and to evaluate the potential for holding or delay. Underwater video cameras or sonar (e.g. Didson or ARIS) could be used for this purpose. It is anticipated that parameters such as the diffuser location and depth, quantity of air supplied, thermal effectiveness, and other variables could also be tested and evaluated. Such information could be utilized to inform the installation of Bubblers at other project locations if necessary.

Loads would also need to be verified to determine electrical system requirements.

Table 9-2. Recommended Approach

Project Site	Recommended Approach
Lower Monumental	Implement Pumped Fish Exit.
Ice Harbor	Prototype Bubbler for site conditions with Pumped Fish Exit as alternate.
McNary	Implement Gravity Chimney (with Pumped Fish Exit at surface).
John Day	Implement Bubbler.

9.3 Discipline Recommendations

Recommendations are provided below by discipline.

Fisheries and Hydraulics

- Perform additional field investigations to support final design, including structural and bathymetric surveys and ROV inspections.
- Perform CFD modeling to confirm and optimize the assumed flow ratio, thermal efficiency and overall efficiency values, given that the size of the proposed facilities are proportional to these factors. For example, the identified flow ratios were applied at high forebay levels with the highest fish exit flow. The flow ratios rise as the forebay levels and fish exit flows decrease which is conservative. It may be advisable to apply the flow ratios at a median or average forebay range in conjunction with the associated fish exit flows to optimize facility sizing.
- Perform prototype or post-construction monitoring and evaluation, including evaluation of fish behavior.
- Collect additional water quality data including TDG to support evaluation of Bubbler and Air Lift alternatives. Temporary or permanent real-time sensors could be used for this purpose.

Structural

- Perform additional field investigations to support final design, including geotechnical explorations to confirm bearing capacities.

- Review proposed fabrication and assembly approach for large structural elements to confirm controlling load cases.
- Confirm materials, coatings and other elements provide adequate cathodic protection, particularly for submerged metal components.

Mechanical

- Evaluate schedule implications of long-lead time equipment items.
- Refine pump selection and conveyance design based on optimized hydraulic requirements.
- Perform operability, inspection and maintenance reviews with local project staff to confirm that the design facilitates all required activities.

Electrical

To evaluate the feasibility of the proposed electrical alternatives and ensure compliance with applicable codes and standards, the following steps are recommended:

1. Metering and Load Data Collection
    a. In accordance with NEC Article 220.87, obtain actual demand data using metering equipment for a minimum 30-day period, or utilize existing metering infrastructure if available.
    b. Collect real-time and historical demand data for all relevant electrical equipment, including panelboards and MCCs identified as potential sources.
    c. Verify the accuracy of existing panel schedules and breaker configurations.
2. Load Analysis
    a. Perform a detailed load calculation using the collected meter data to determine the total connected and demand loads on each electrical source.
    b. Evaluate the impact of the proposed equipment (e.g., pumps, air compressors) on the existing electrical infrastructure.
3. Capacity Verification
    a. Confirm that upstream distribution equipment (e.g., feeders, transformers, main breakers) has sufficient capacity to support the additional load.
    b. Identify any limitations or constraints that may affect the integration of new equipment.
4. Infrastructure Assessment
    a. For locations where no adequate power source is available, conduct a feasibility study to identify potential new sources and routing options.
    b. Assess the physical, logistical, and structural requirements for extending power to remote or underserved areas.
5. Stakeholder Coordination
    a. Engage with the electrical contractor, facility operations team, and engineering staff to review findings and confirm installation feasibility.
    b. Ensure all proposed modifications are reviewed and approved by the authority having jurisdiction.

6. Documentation and Reporting
    a. Update single-line diagrams, panel schedules, and load summaries to reflect proposed changes.
    b. Prepare a formal load analysis report, including metering data and capacity verification, for review and approval prior to procurement or installation.

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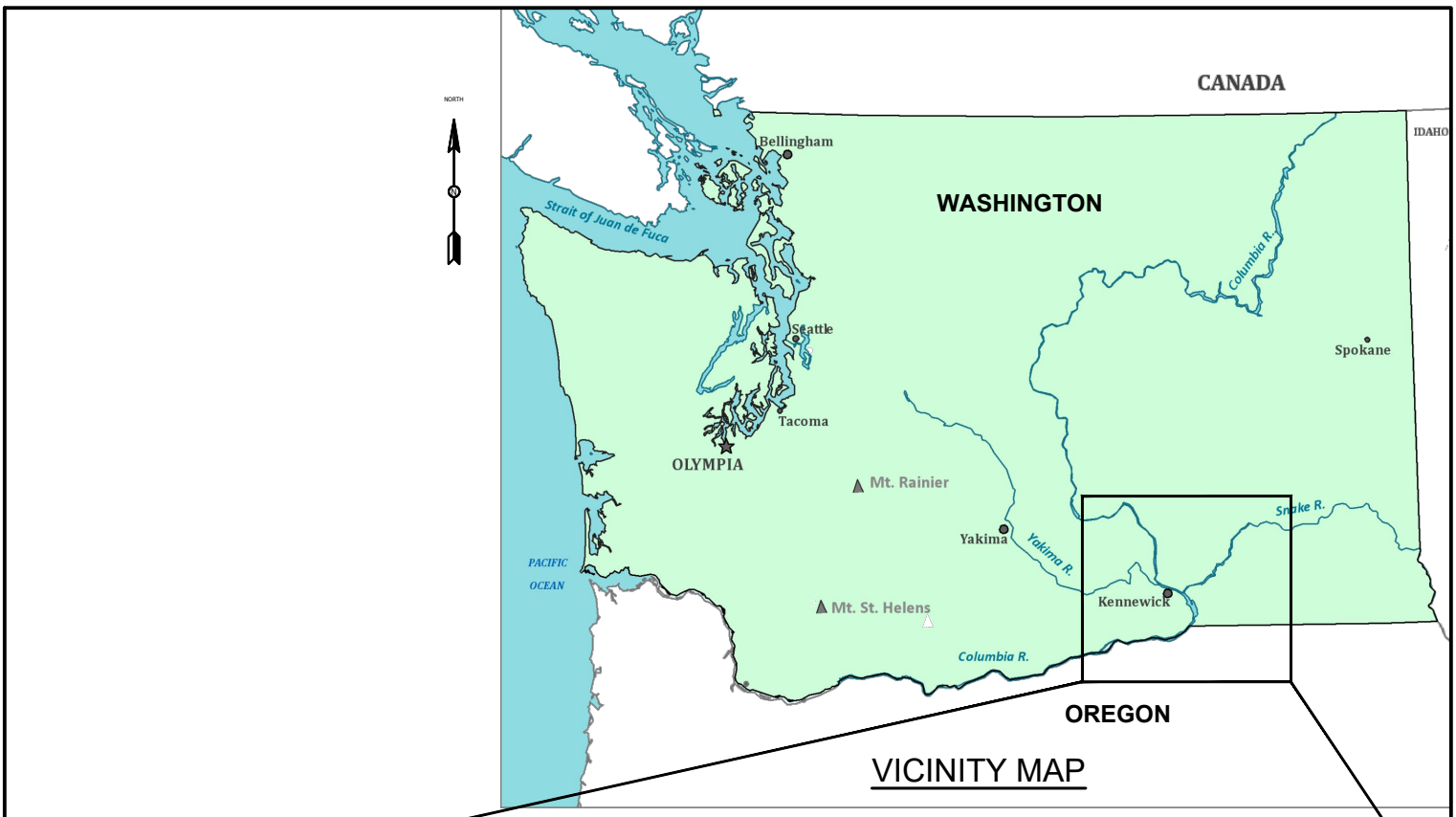
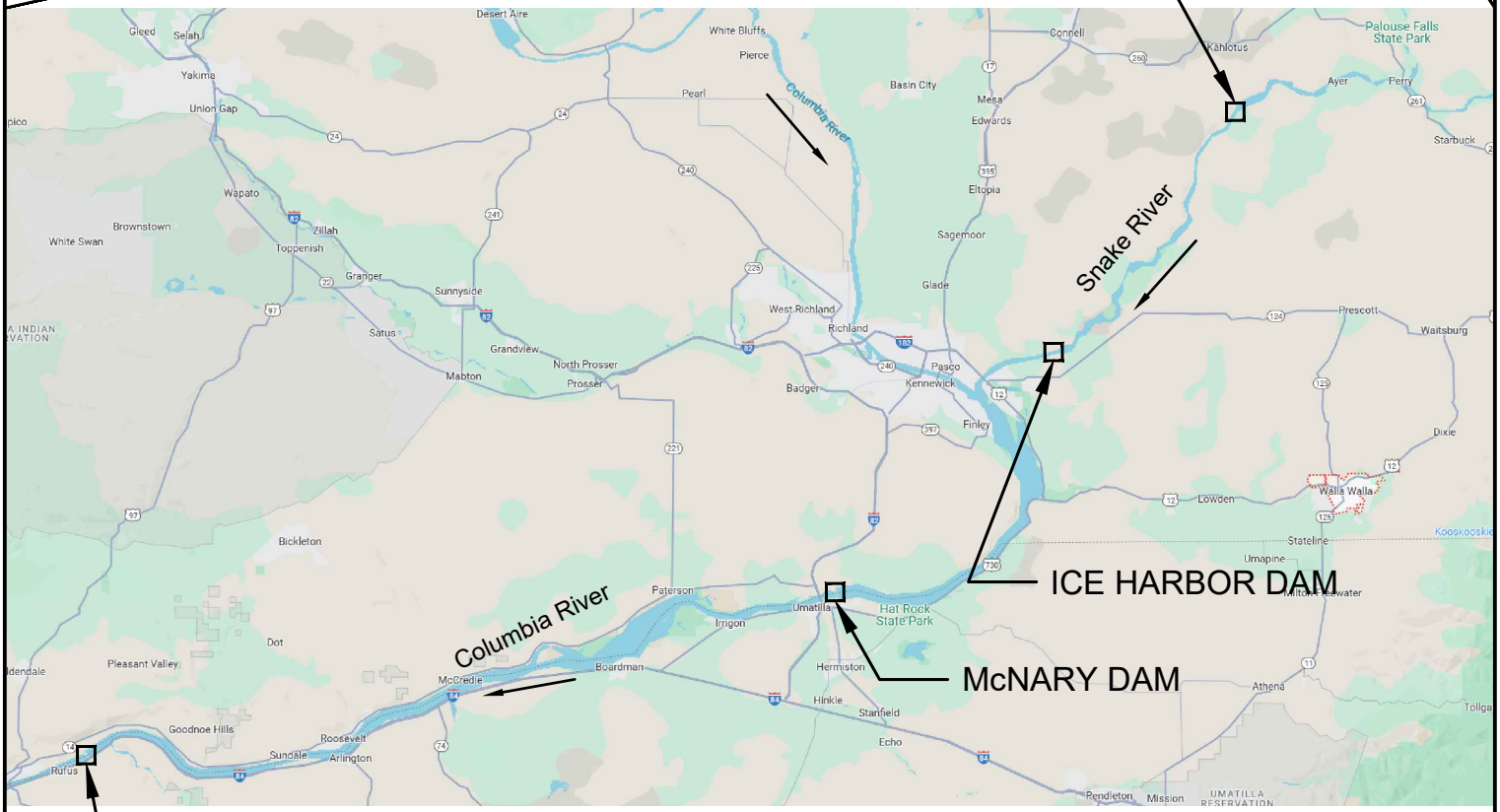
Appendix A. Plates



VICINITY MAP

LOWER MONUMENTAL DAM

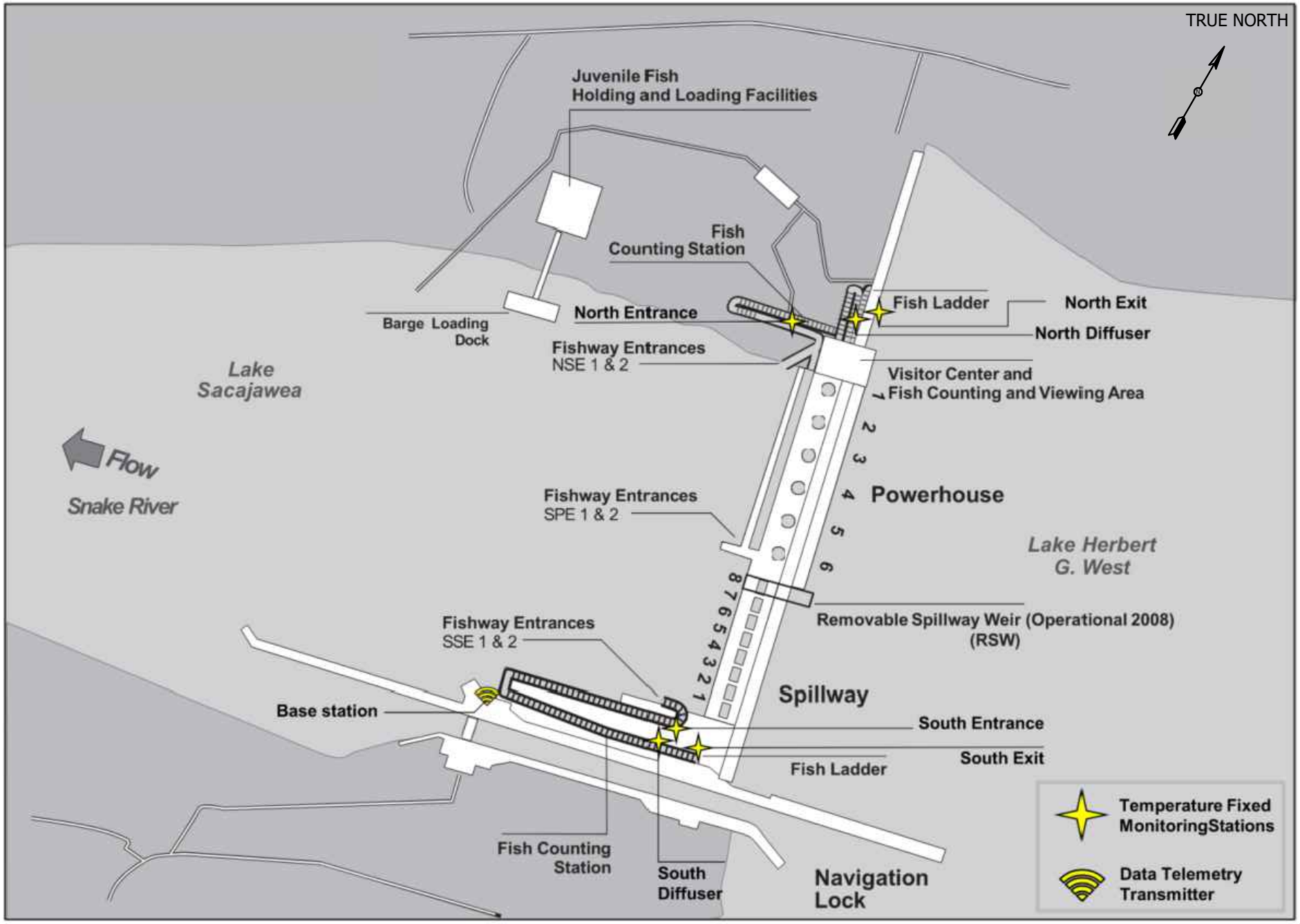


PROJECT LOCATION

JACOBS®

US Army Corps of Engineers
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE G-1
VICINITY MAP AND
PROJECT LOCATIONS



OVERALL SITE PLAN
N.T.S.

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US Army Corps of Engineers
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

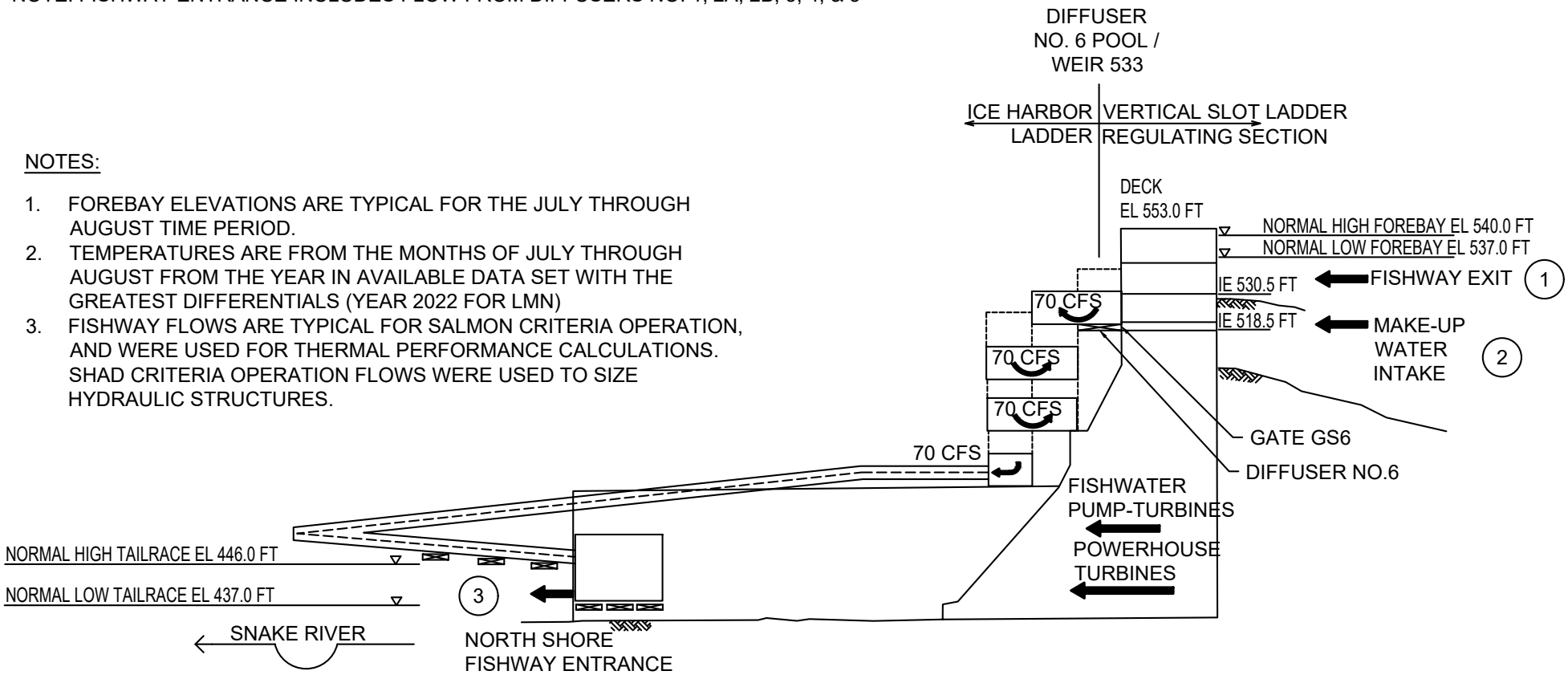
PLATE LMN-2
LOWER MONUMENTAL LOCK AND DAM
OVERALL SITE PLAN

FISHWAY FLOW AND TEMPERATURE DATA (JULY THROUGH AUGUST)			
	(1) FISHWAY EXIT	(2) MAKEUP WATER INTAKE	(3) FISHWAY ENTRANCE
FLOW RANGE (CFS)	30 - 45	40 - 25	460 - 747
T5% (ºF)	76.3	72.1	69.6
T25% (ºF)	73.2	71.5	69.5
T50% (ºF)	69.9	70.0	68.0

NOTE: FISHWAY ENTRANCE INCLUDES FLOW FROM DIFFUSERS NO. 1, 2A, 2B, 3, 4, & 5

NOTES:

1. FOREBAY ELEVATIONS ARE TYPICAL FOR THE JULY THROUGH AUGUST TIME PERIOD.
2. TEMPERATURES ARE FROM THE MONTHS OF JULY THROUGH AUGUST FROM THE YEAR IN AVAILABLE DATA SET WITH THE GREATEST DIFFERENTIALS (YEAR 2022 FOR LMN)
3. FISHWAY FLOWS ARE TYPICAL FOR SALMON CRITERIA OPERATION, AND WERE USED FOR THERMAL PERFORMANCE CALCULATIONS. SHAD CRITERIA OPERATION FLOWS WERE USED TO SIZE HYDRAULIC STRUCTURES.

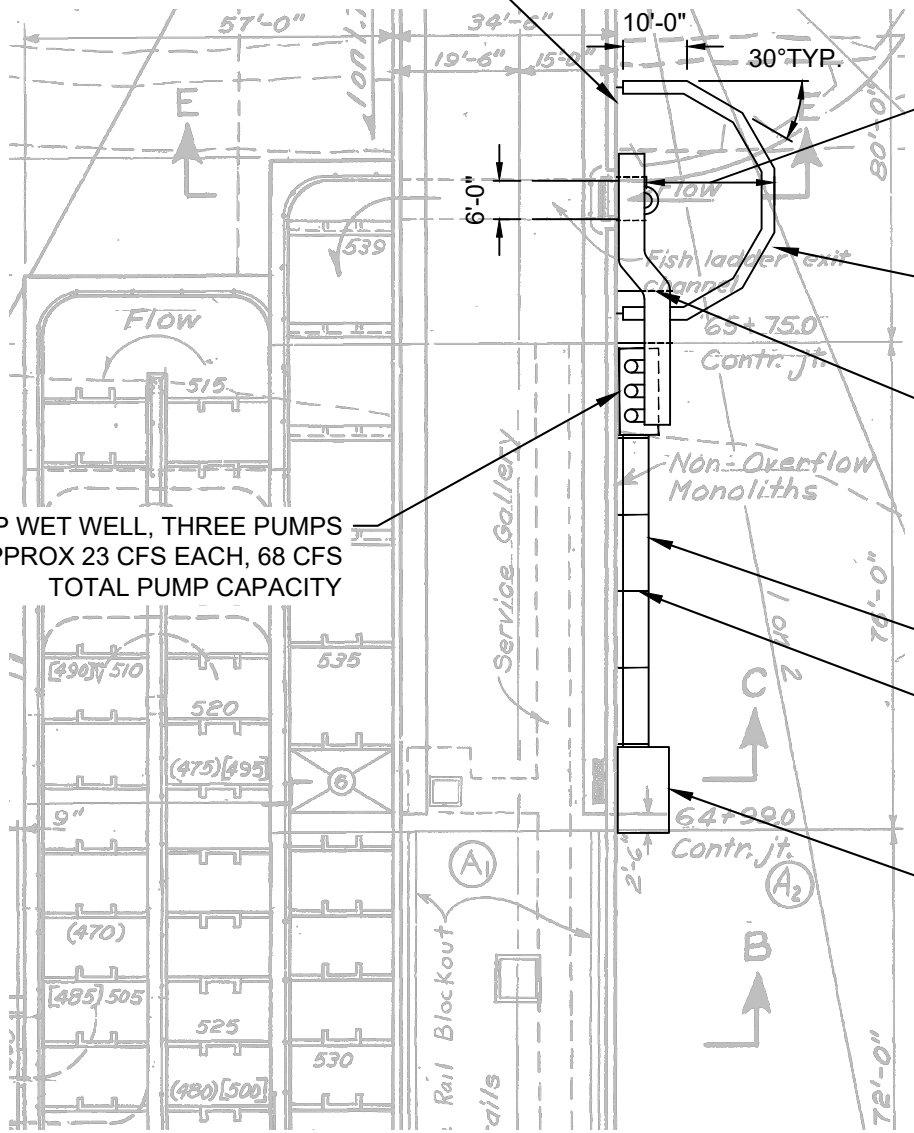


PROCESS FLOW DIAGRAM
N.T.S

JACOBS®

US Army Corps of Engineers
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE LMN-3
LOWER MONUMENTAL LOCK AND DAM
NORTH SHORE FISHWAY
PROCESS FLOW DIAGRAM



SITE PLAN
1" = 30'-0"

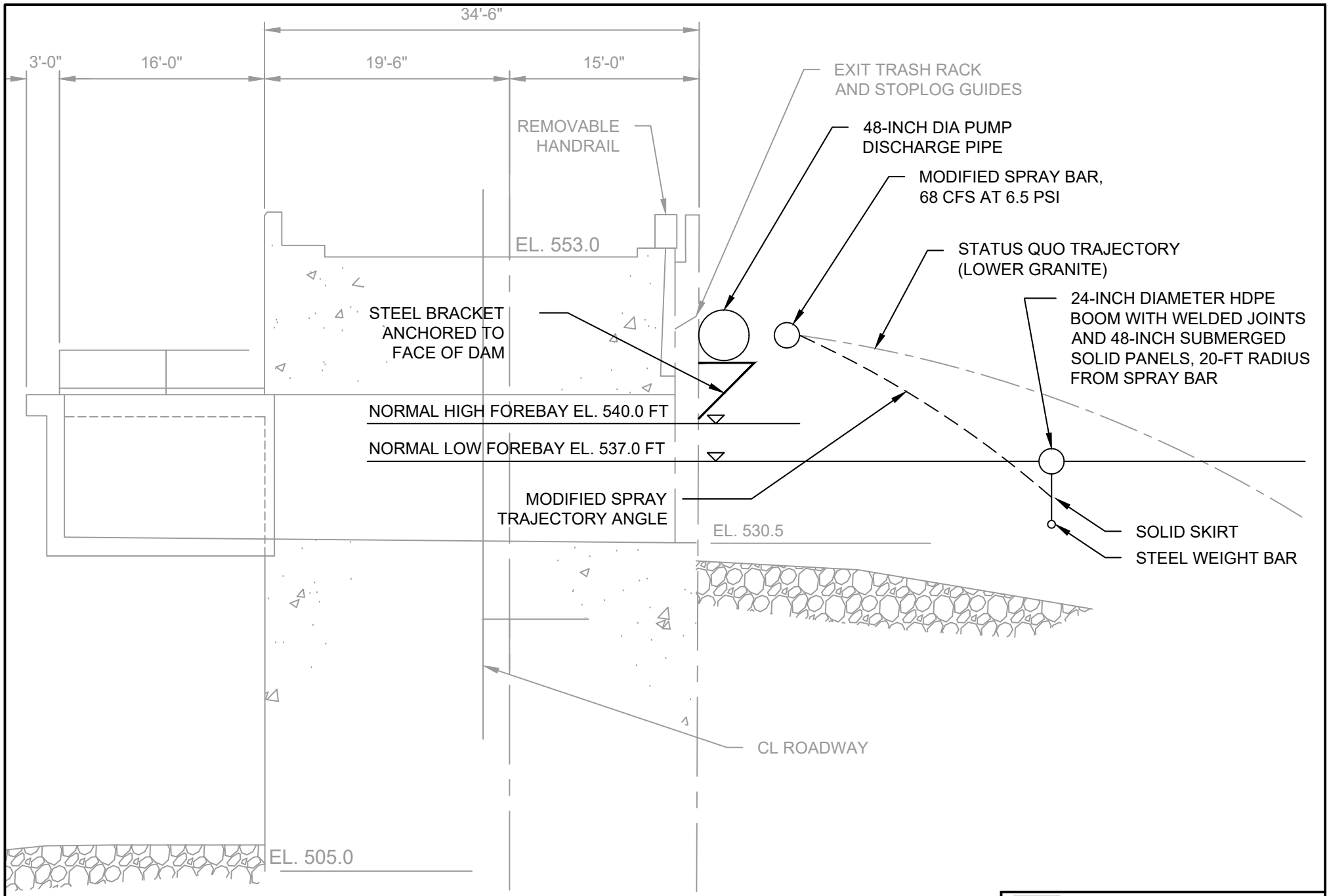
0 30' 60'

PROJECT GRID

JACOBS®

US Army Corps of Engineers
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE LMN-4A
LOWER MONUMENTAL LOCK AND DAM
NORTH SHORE FISHWAY
MODIFIED SPRAY BAR SITE PLAN



SECTION E-E
1" = 10'-0"

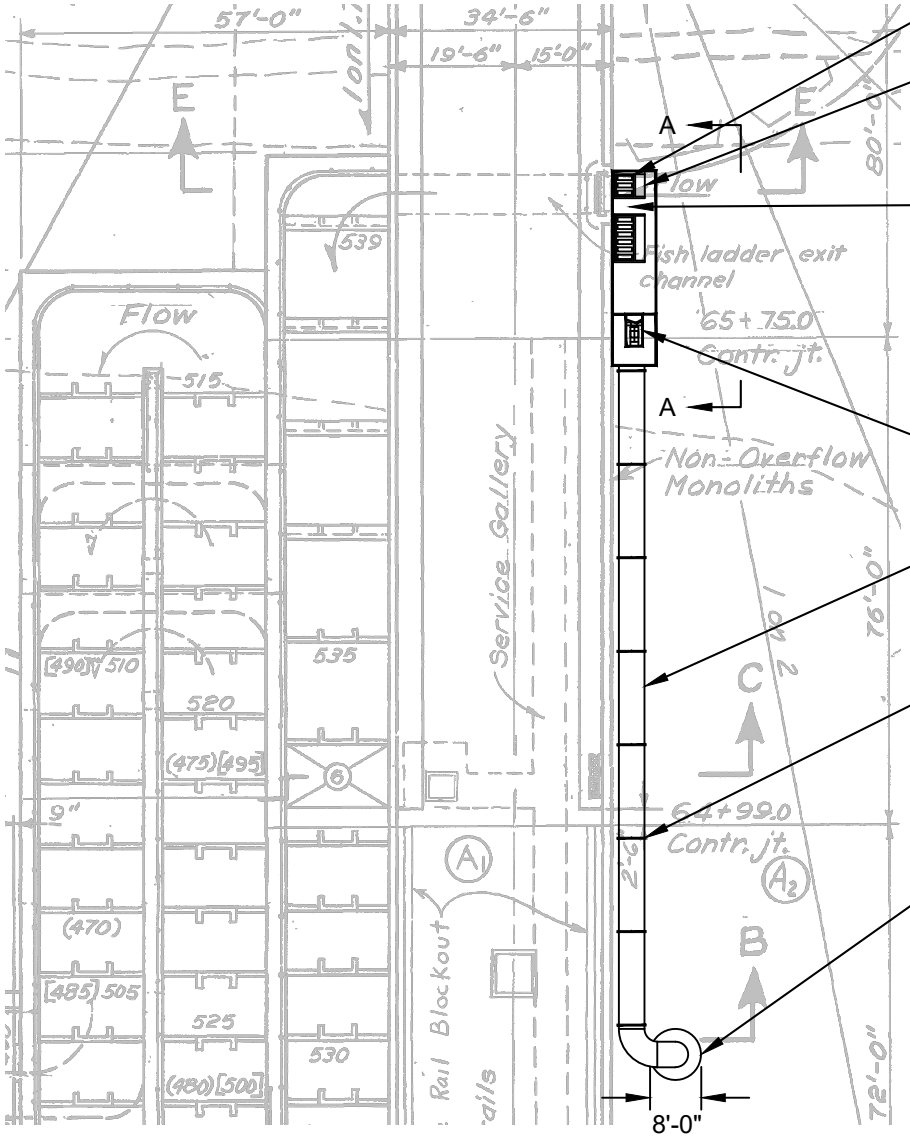
0 10' 20'

JACOBS®

US Army Corps of Engineers
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE LMN-5A
LOWER MONUMENTAL LOCK AND DAM
NORTH SHORE FISHWAY
MODIFIED SPRAY BAR SECTION 2

PROJECT GRID



POROSITY CONTROL BAFFLE (TYP)

DIFFUSER (TYP)

FISH EXIT CONTRACTION TO 3-FT WIDTH,
EXIT VELOCITY APPROX. 1.5 FPS

PUMP WET WELL, TWO LOW-HEAD
PROPELLER PUMPS AT 34 CFS EACH,
68 CFS TOTAL PUMP CAPACITY

48-INCH DIA
SUCTION PIPE

STEEL CLAMP
ANCHORED TO
FACE OF DAM

DOWNTURNED ELBOW WITH 8-FT DIA. INTAKE BELL.
COARSE BASKET TYPE BAR RACK, 2-FT HEIGHT
WITH MAXIMUM 0.8 FPS APPROACH VELOCITY.
BAR SPACING TO EXCLUDE PACIFIC LAMPREY.

SITE PLAN
1" = 30'-0"

0 30' 60'

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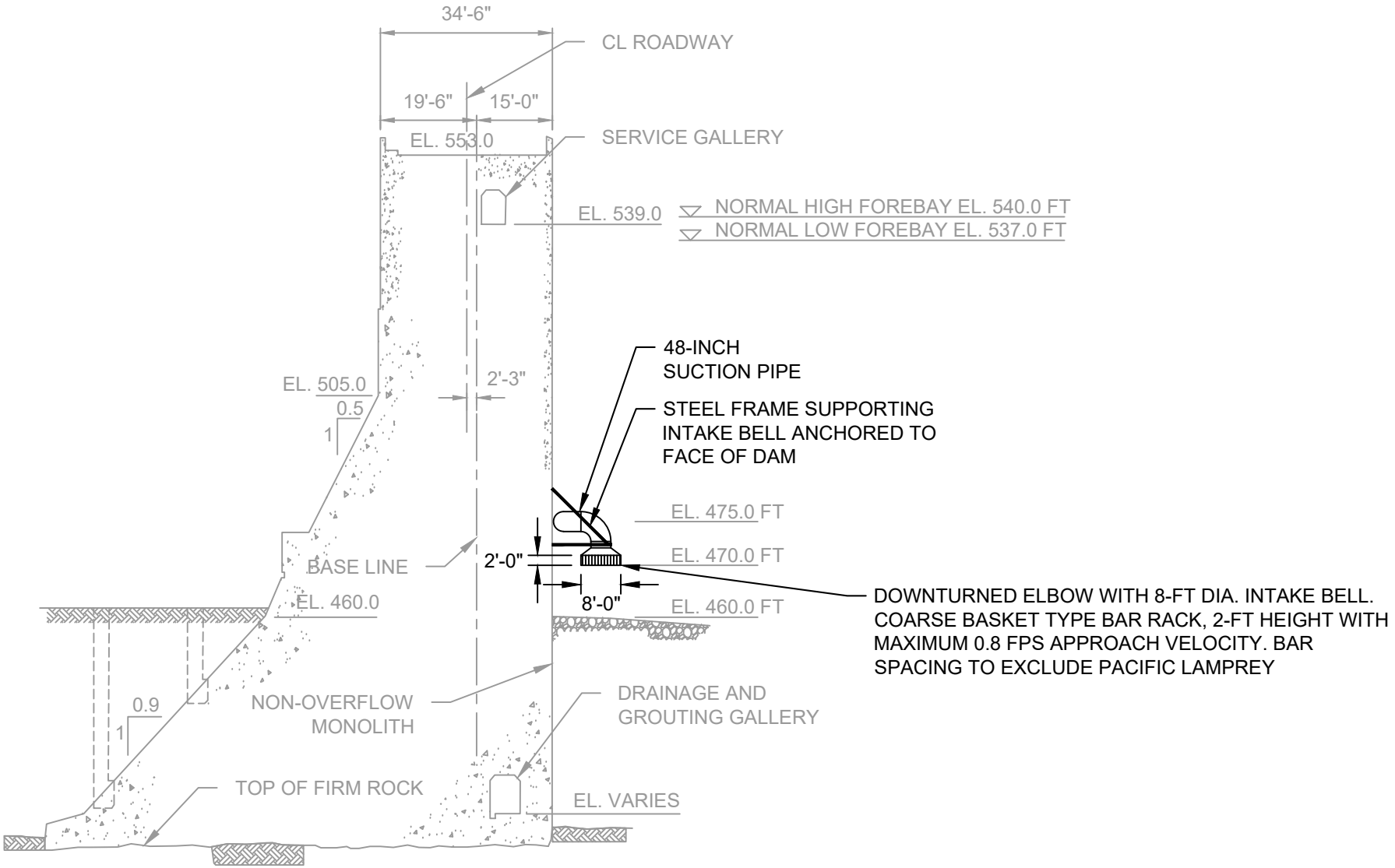
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE LMN-4B
LOWER MONUMENTAL LOCK AND DAM
NORTH SHORE FISHWAY
PUMPED FISH EXIT SITE PLAN

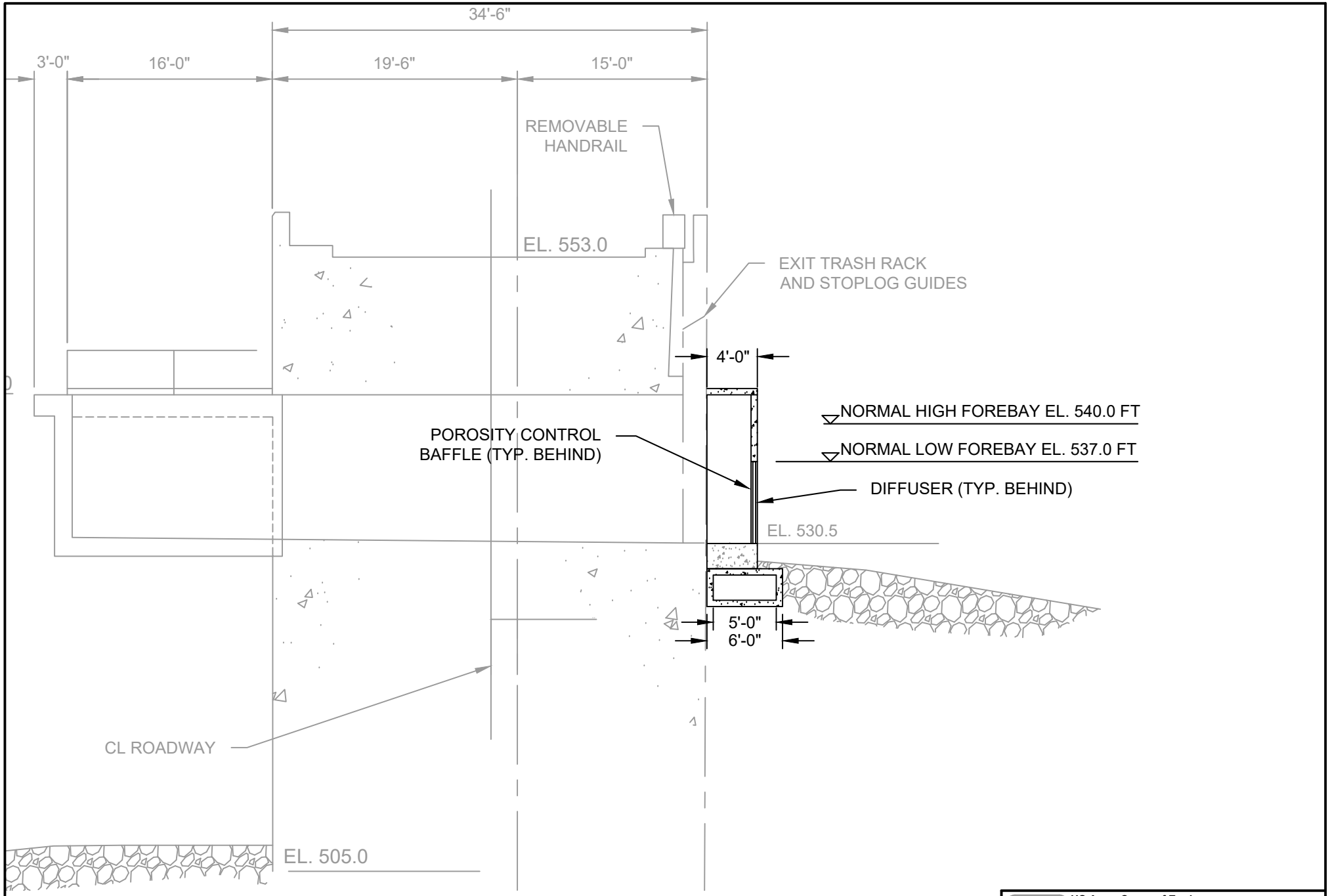


SECTION B-B
1" = 30'-0"

JACOBS®

US Army Corps of Engineers
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE LMN-5B
LOWER MONUMENTAL LOCK AND DAM
NORTH SHORE FISHWAY
PUMPED FISH EXIT SECTION 1



SECTION E-E
1" = 10'-0"

0 10' 20'

JACOBS®

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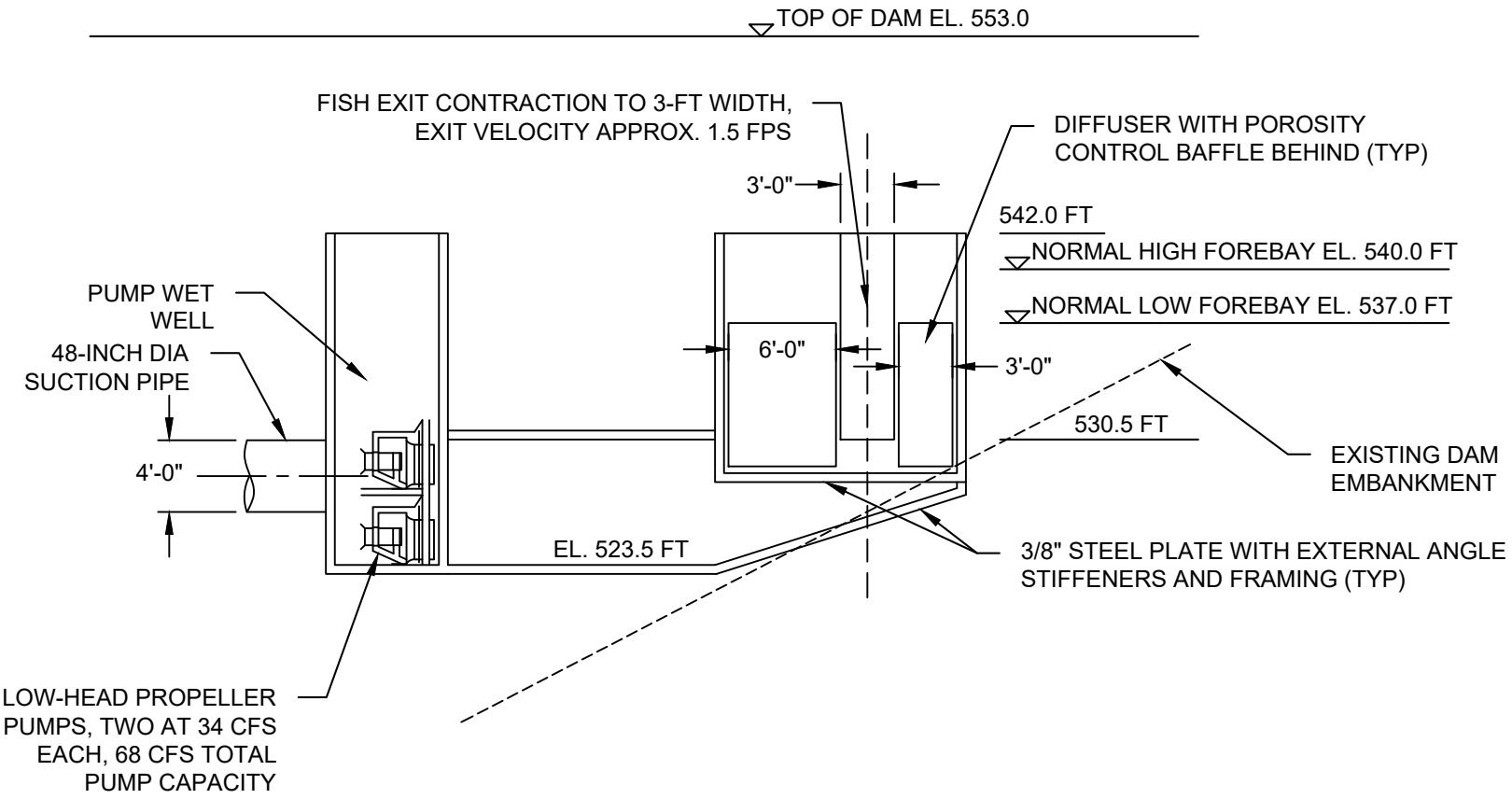
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE LMN-6B
LOWER MONUMENTAL LOCK AND DAM
NORTH SHORE FISHWAY
PUMPED FISH EXIT SECTION 2



ELEVATION A
1" = 10'-0"

0 10' 20'

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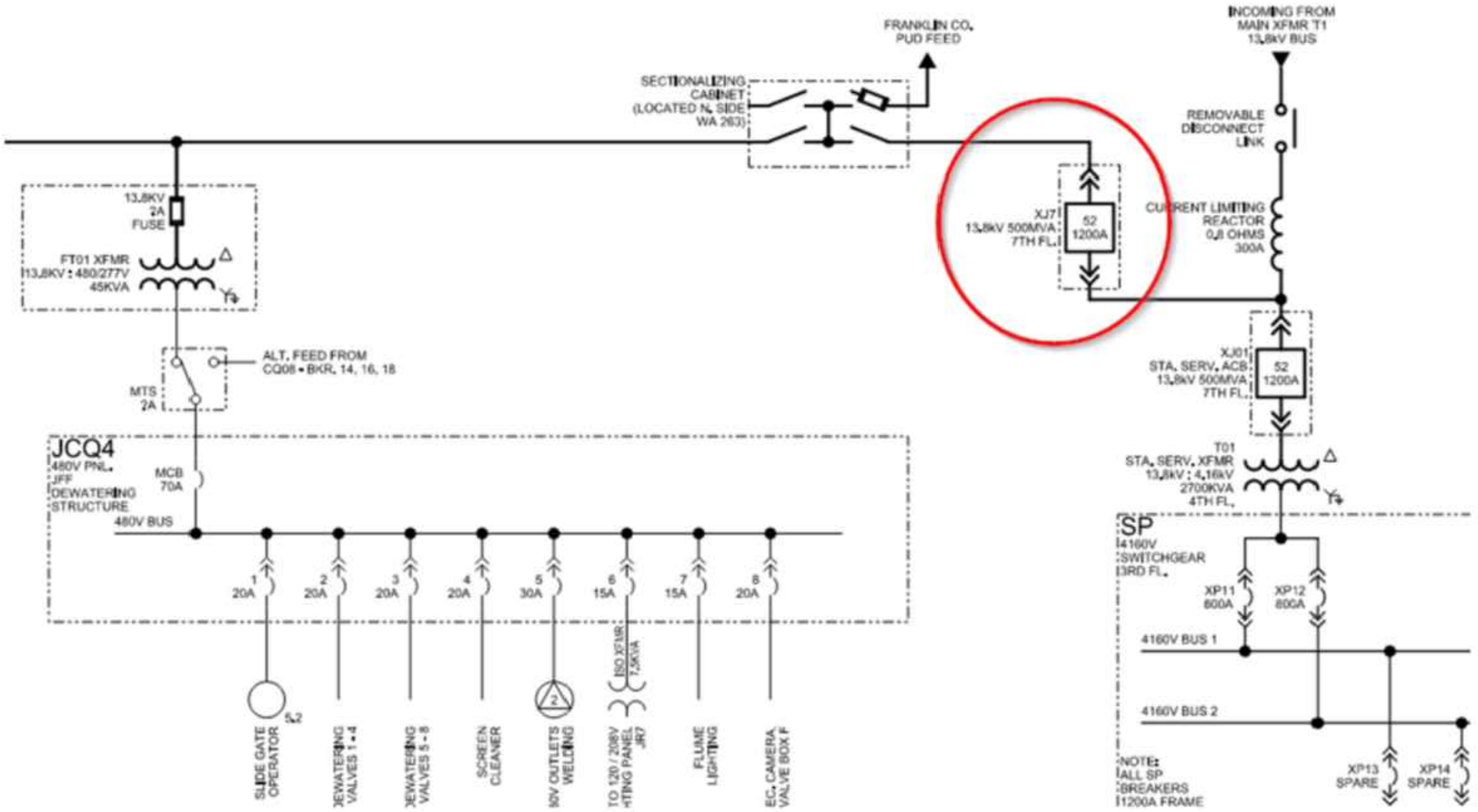
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE LMN-7B
LOWER MONUMENTAL LOCK AND DAM
NORTH SHORE FISHWAY
PUMPED FISH EXIT ELEVATION



PARTIAL ONE-LINE DIAGRAM

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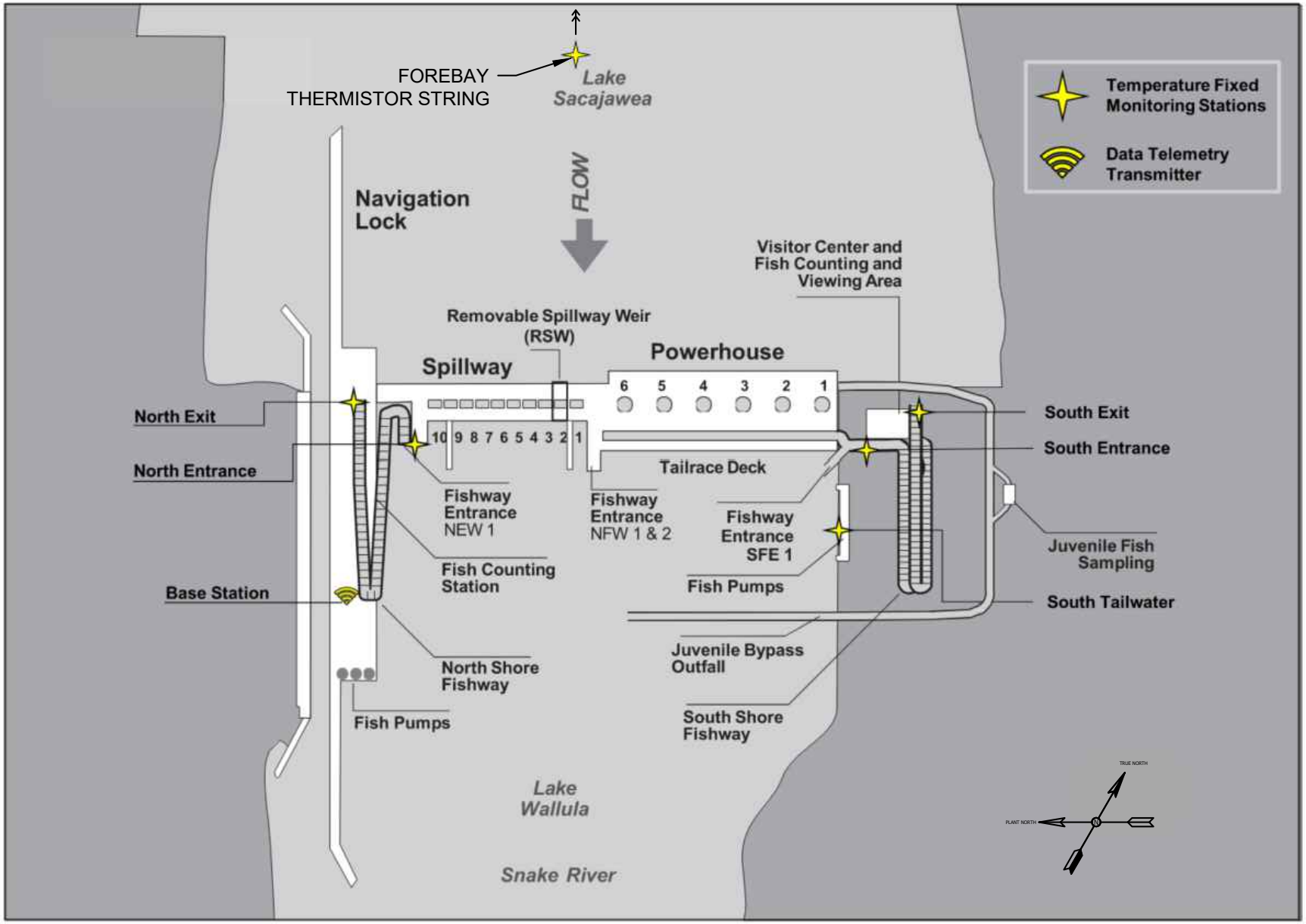
US Army Corps of Engineers
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE LMN-9
LOWER MONUMENTAL LOCK AND DAM
NORTH SHORE FISHWAY
ELECTRICAL ONE-LINE



OVERALL SITE PLAN
N.T.S.

JACOBS®

US Army Corps of Engineers
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

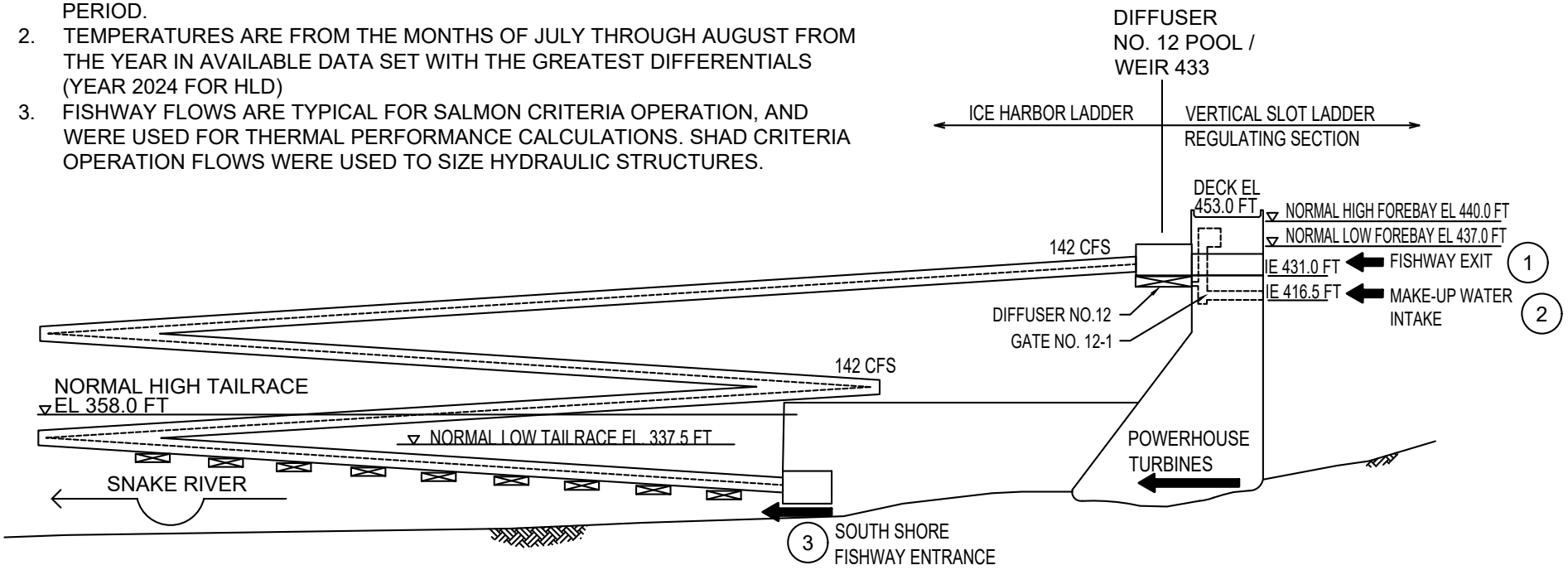
PLATE HLD-2
ICE HARBOR LOCK AND DAM
OVERALL SITE PLAN
ELECTRICAL ON-LINE

FISHWAY FLOW AND TEMPERATURE DATA (JULY THROUGH AUGUST)			
	(1) FISHWAY EXIT	(2) MAKEUP WATER INTAKE	(3) FISHWAY ENTRANCE
FLOW RANGE (CFS)	66.0 - 93.5	76.0 - 48.5	347 - 911
T5% (ºF)	73.2	69.8	67.6
T25% (ºF)	74.9	73.0	71.5
T50% (ºF)	73.2	72.1	71.2

NOTE: FISHWAY ENTRANCE INCLUDES FLOW FROM DIFFUSERS NO. 2 THOUGH 11

NOTES:

1. FOREBAY ELEVATIONS ARE TYPICAL FOR THE JULY THROUGH AUGUST TIME PERIOD.
2. TEMPERATURES ARE FROM THE MONTHS OF JULY THROUGH AUGUST FROM THE YEAR IN AVAILABLE DATA SET WITH THE GREATEST DIFFERENTIALS (YEAR 2024 FOR HLD)
3. FISHWAY FLOWS ARE TYPICAL FOR SALMON CRITERIA OPERATION, AND WERE USED FOR THERMAL PERFORMANCE CALCULATIONS. SHAD CRITERIA OPERATION FLOWS WERE USED TO SIZE HYDRAULIC STRUCTURES.

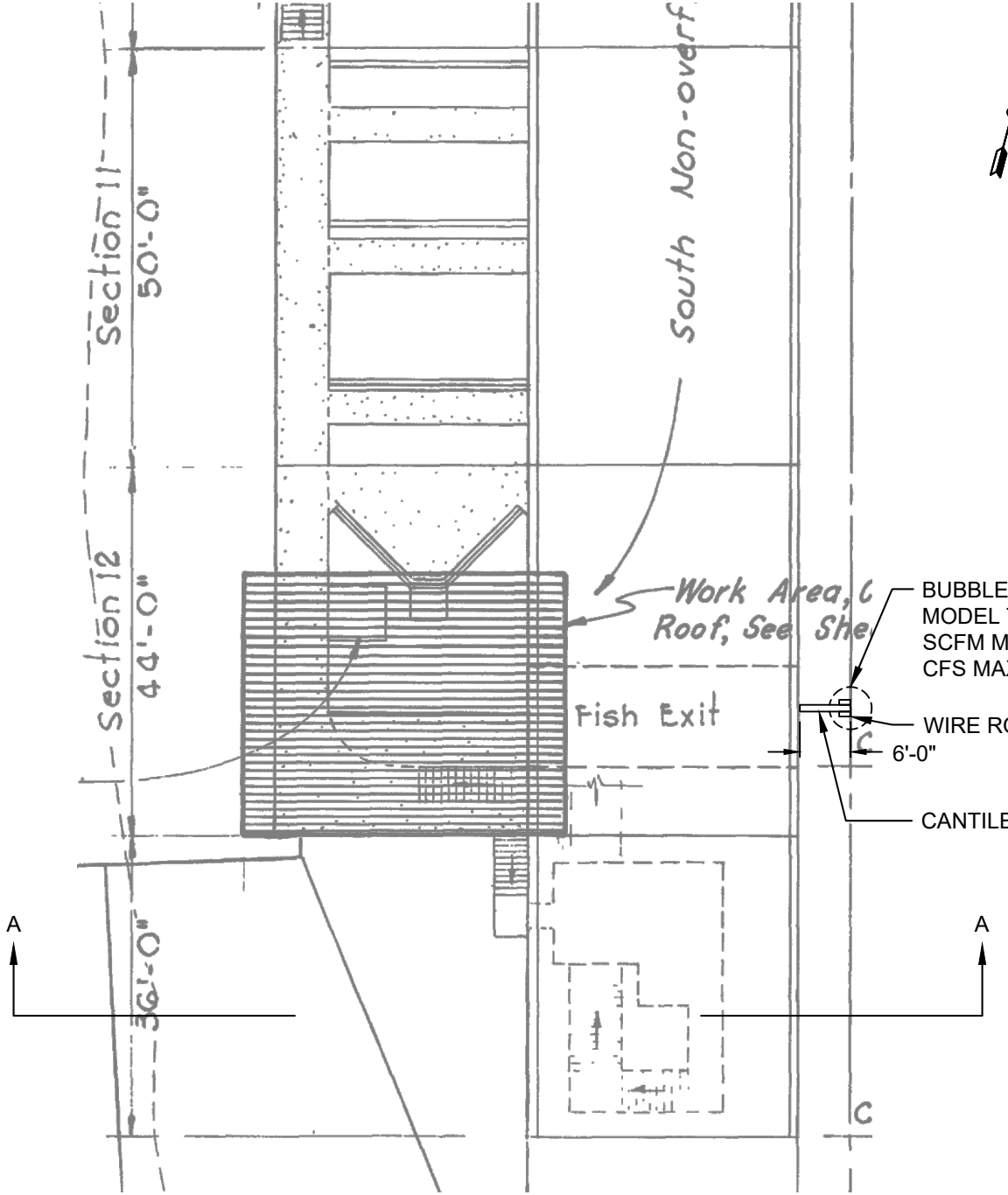


PROCESS FLOW DIAGRAM
N.T.S

JACOBS®

US Army Corps of Engineers
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE HLD-3
ICE HARBOR LOCK AND DAM
SOUTH SHORE FISHWAY
PROCESS FLOW DIAGRAM



BUBBLER RING (BELOW, EL 377.0'), 70-INCH DIA. MODEL TYPE "SALMOAIR" TO OPERATE UP TO 30 SCFM MAXIMUM AIR FLOW RATE, APPROX 200 CFS MAXIMUM UPWELLING WATER FLOW RATE

WIRE ROPE HOIST

6'-0"

CANTILEVERED RETRIEVAL ARM

SITE PLAN
1" = 20'-0"

0 20' 40'

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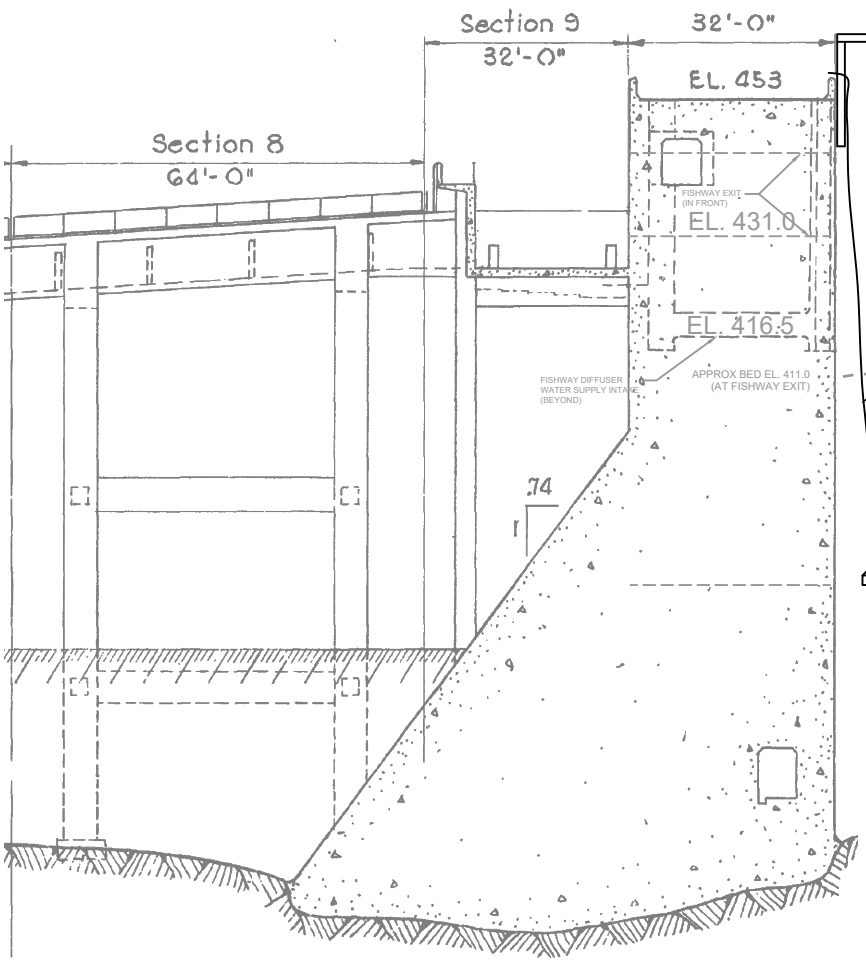
US Army Corps of Engineers
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE HLD-4A
ICE HARBOR LOCK AND DAM
SOUTH SHORE FISHWAY
BUBBLER SITE PLAN



EL 463.0 = TOP OF HOIST SUPPORT

EL 440.0 = NORMAL HIGH FOREBAY LEVEL (JULY - AUGUST)

EL 437.0 = NORMAL LOW WATER LEVEL (JULY - AUGUST)

WIRE ROPE

AIR TUBING

BUBBLER RING (BELOW, EL 377.0'), 70-INCH DIA. MODEL TYPE "SALMOAIR" TO OPERATE UP TO 30 CFM MAXIMUM AIR FLOW RATE, APPROX 200 CFS UPWELLING MAXIMUM WATER FLOW PER MANUFACTURER DEFINED WATER TO AIR UPWELLING RATIO (395:1)

EL 377.0 = BUBBLER ELEVATION IN FULLY LOWERED POSITION

SECTION
1" = 30'-0"

0 30' 60'

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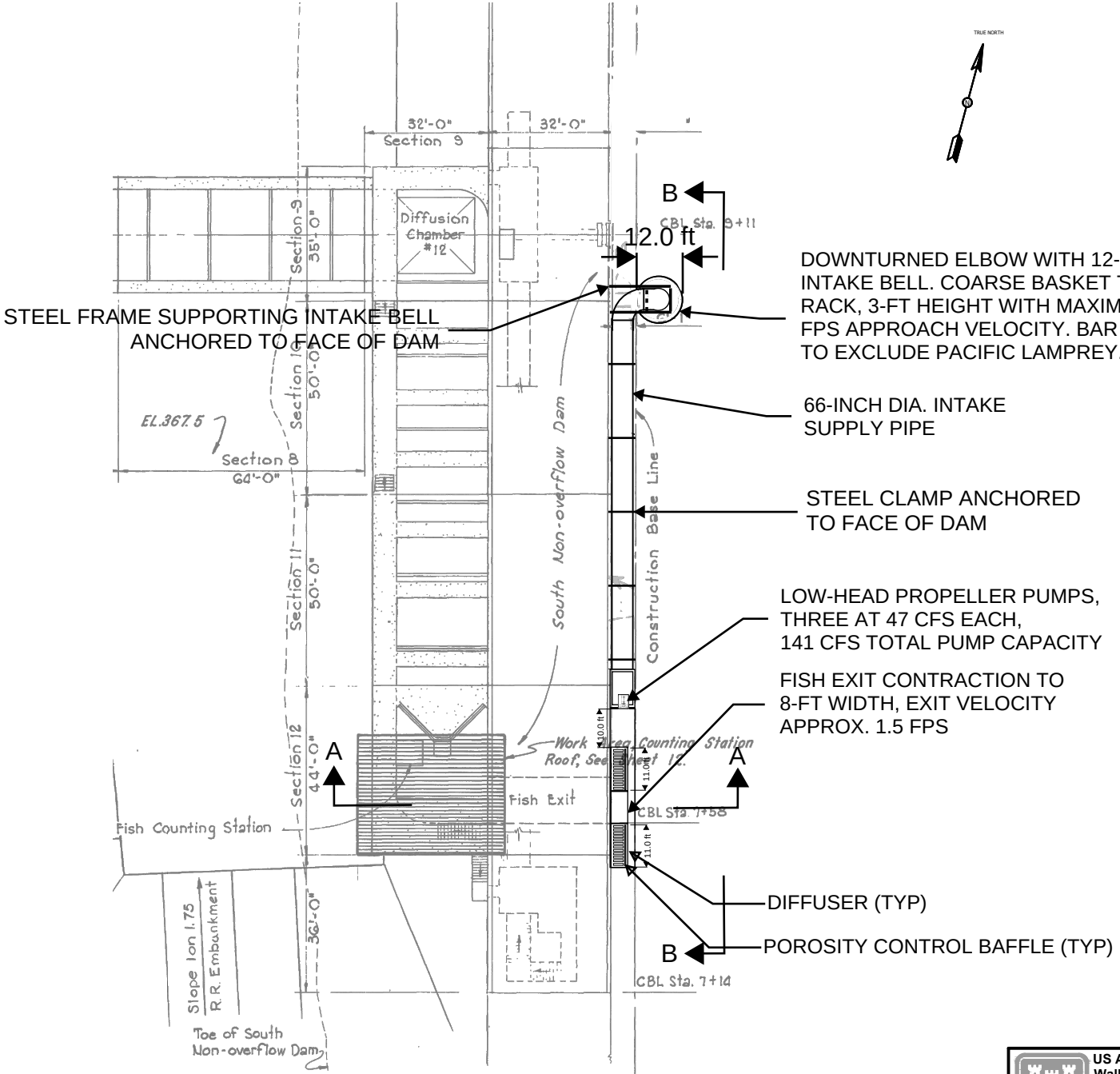
US Army Corps of Engineers
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE HLD-5A
ICE HARBOR LOCK AND DAM
SOUTH SHORE FISHWAY
BUBBLER SECTION

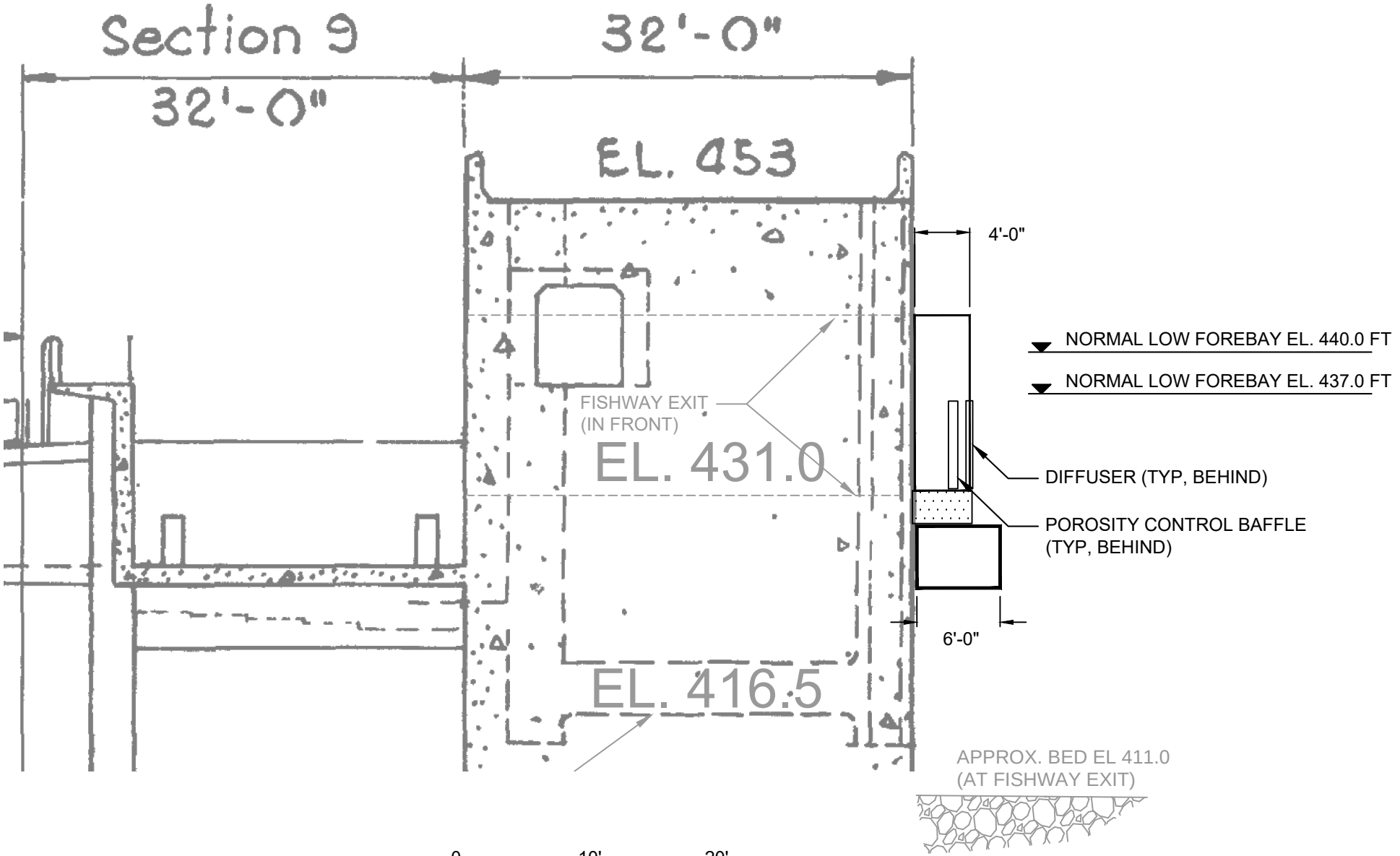


SITE PLAN
1" = 40'-0"

JACOBS®

US Army Corps of Engineers
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE HLD-4B
ICE HARBOR LOCK AND DAM
SOUTH SHORE FISHWAY
PUMPED FISH EXIT SITE PLAN



SECTION A-A
1" = 10'-0"

0 10' 20'

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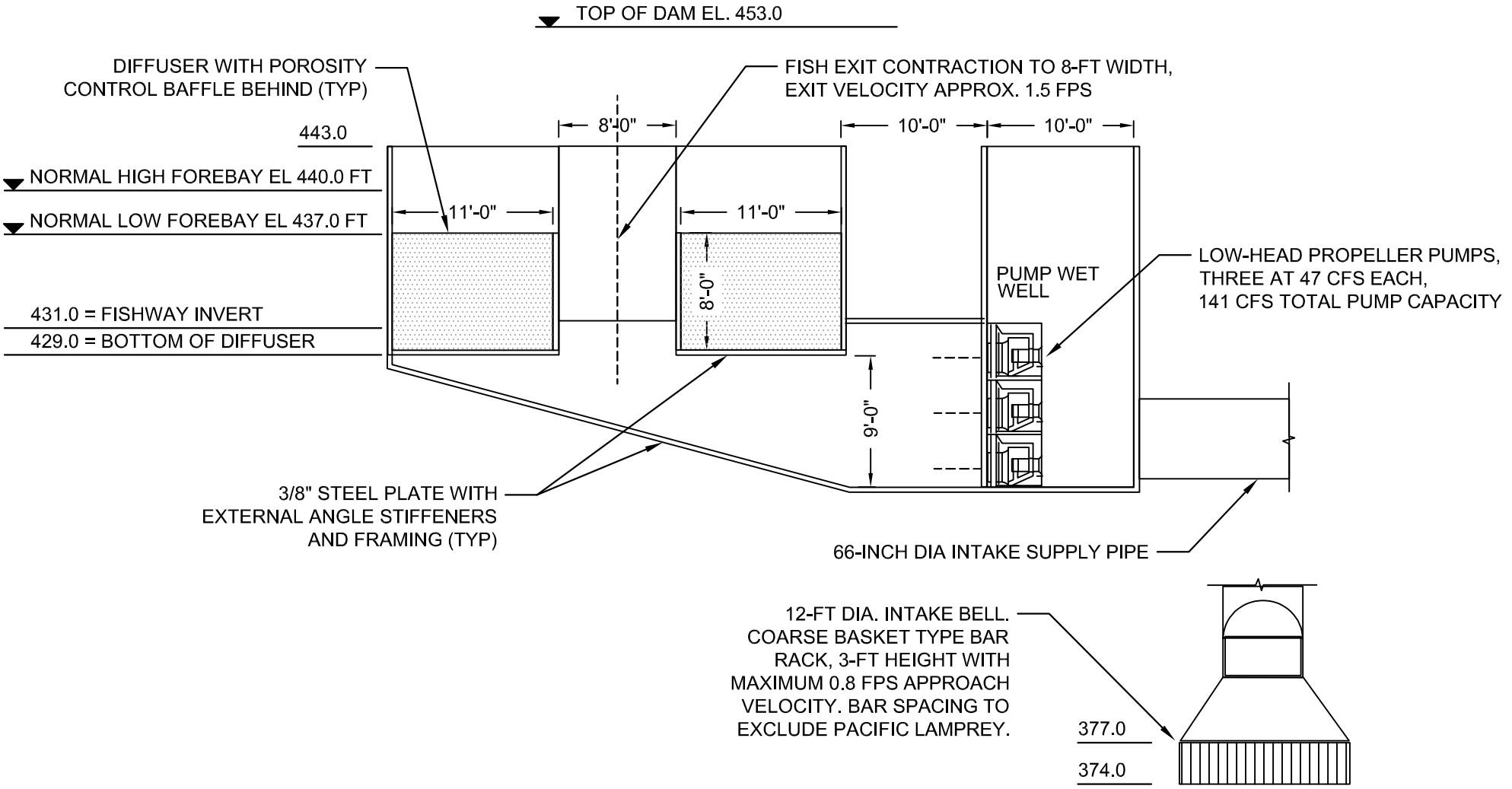
US Army Corps of Engineers
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE HLD-5B
ICE HARBOR LOCK AND DAM
SOUTH SHORE FISHWAY
PUMPED FISH EXIT SECTION



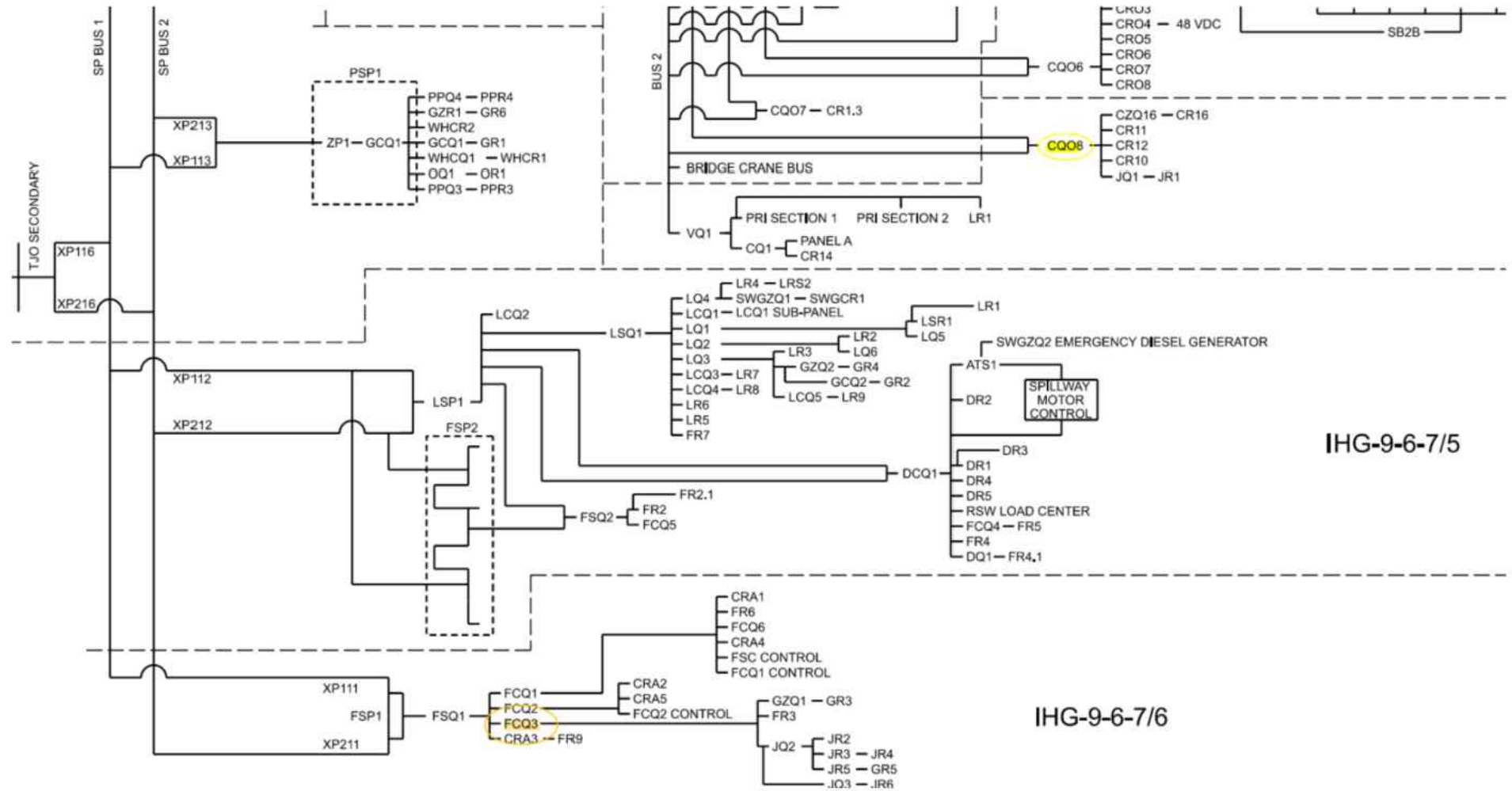
ELEVATION B-B
1" = 10'-0"

0 10' 20'

JACOBS®

US Army Corps of Engineers
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE HLD-6B
ICE HARBOR LOCK AND DAM
SOUTH SHORE FISHWAY
PUMPED FISH EXIT ELEVATION

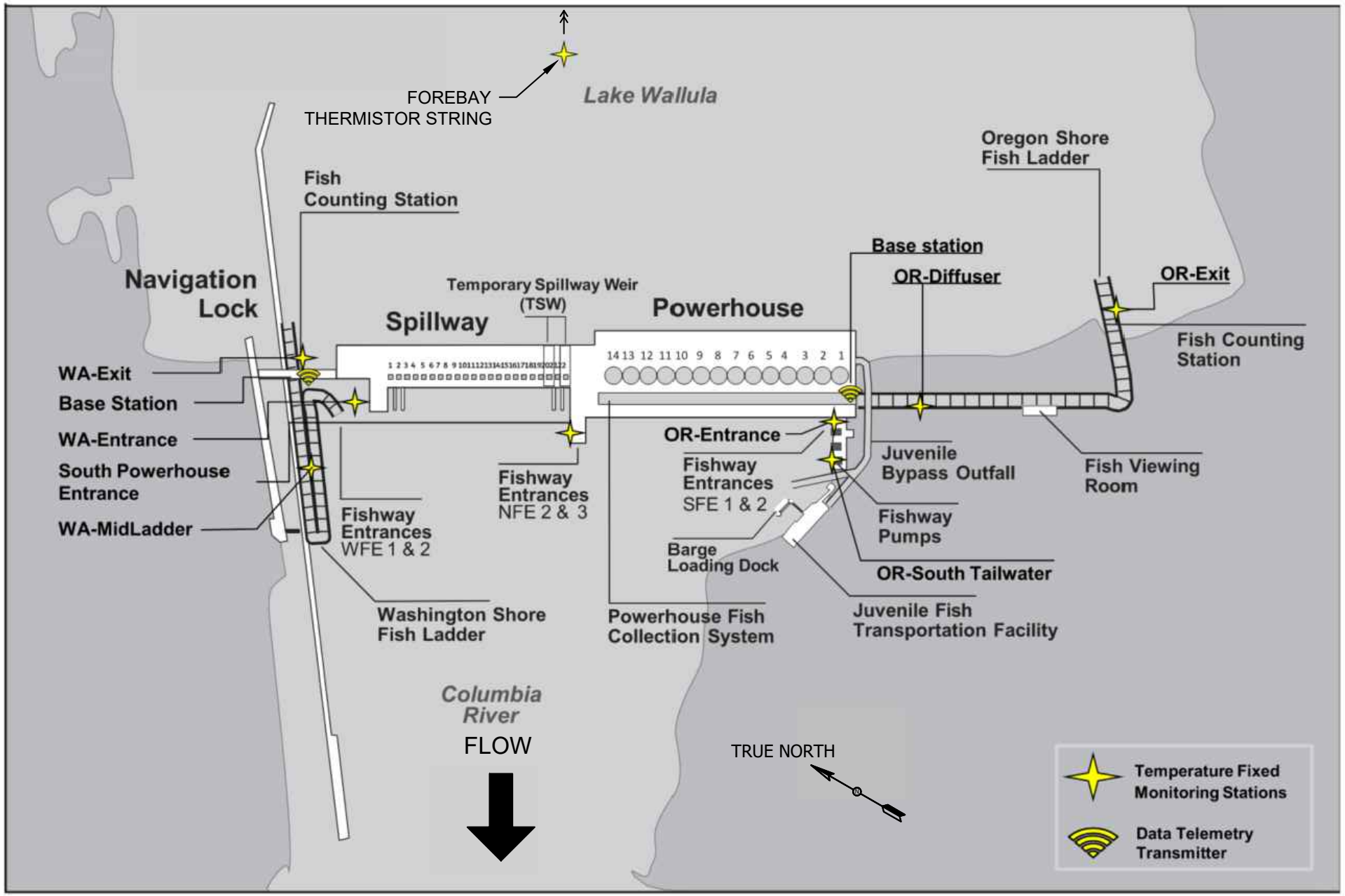


PARTIAL ONE-LINE DIAGRAM

JACOBS®

US Army Corps of Engineers
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE HLD-8
ICE HARBOR LOCK AND DAM
SOUTH SHORE FISHWAY
ELECTRICAL ONE-LINE



OVERALL SITE PLAN
N.T.S.

JACOBS®

US Army Corps of Engineers
Walla Walla District
ADJUST FISH LADDER COOLING
CONCEPT EVALUATION

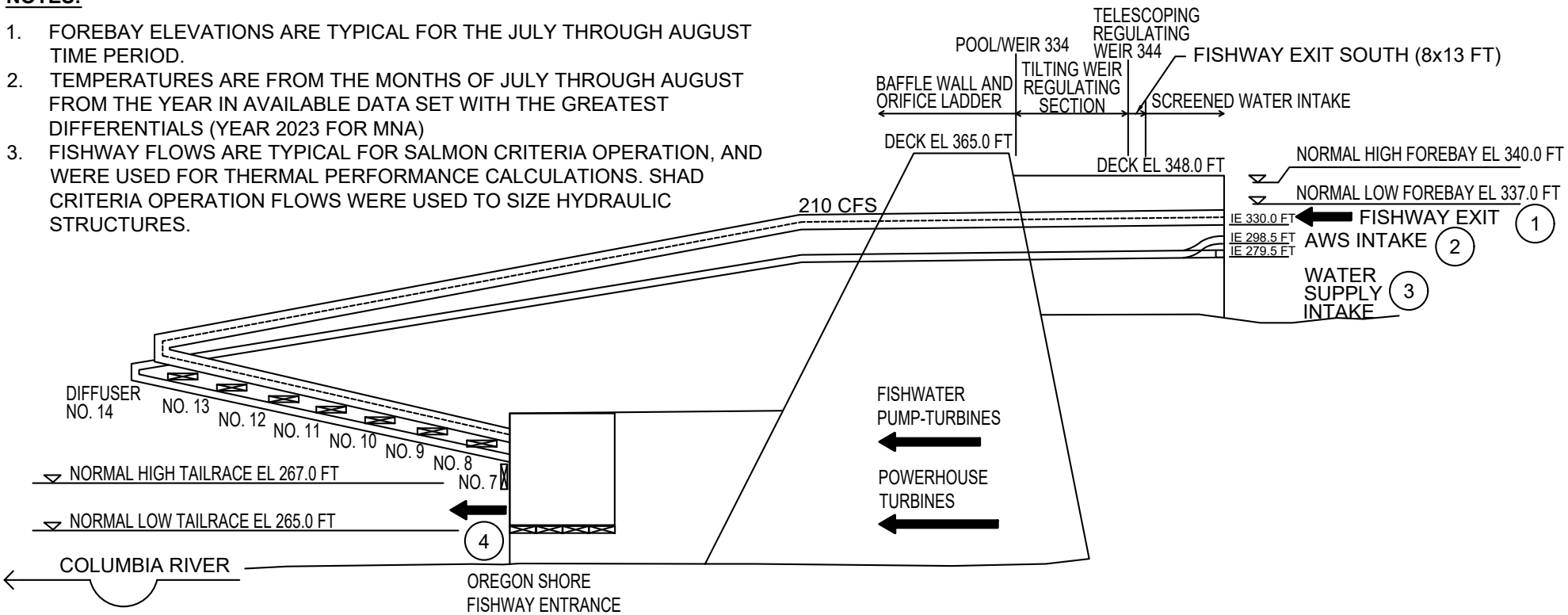
PLATE MNA-2
MCNARY LOCK AND DAM
OVERALL SITE PLAN

FISHWAY FLOW AND TEMPERATURE DATA (JULY THROUGH AUGUST)				
	(1) FISHWAY EXIT	(2) AWS INTAKE	(3) WATER SUPPLY INTAKE	(4) FISHWAY ENTRANCE
FLOW RANGE (CFS)	210	N/A	N/A	2,294 - 2,410
T5% (ºF)	72.4	N/A	N/A	68.6
T25% (ºF)	72.4	N/A	N/A	70.4
T50% (ºF)	71.4	N/A	N/A	70.4

NOTE: FISHWAY ENTRANCE INCLUDES FLOW FROM DIFFUSERS NO. 1 THOUGH 6

NOTES:

1. FOREBAY ELEVATIONS ARE TYPICAL FOR THE JULY THROUGH AUGUST TIME PERIOD.
2. TEMPERATURES ARE FROM THE MONTHS OF JULY THROUGH AUGUST FROM THE YEAR IN AVAILABLE DATA SET WITH THE GREATEST DIFFERENTIALS (YEAR 2023 FOR MNA)
3. FISHWAY FLOWS ARE TYPICAL FOR SALMON CRITERIA OPERATION, AND WERE USED FOR THERMAL PERFORMANCE CALCULATIONS. SHAD CRITERIA OPERATION FLOWS WERE USED TO SIZE HYDRAULIC STRUCTURES.



PROCESS FLOW DIAGRAM
N.T.S.

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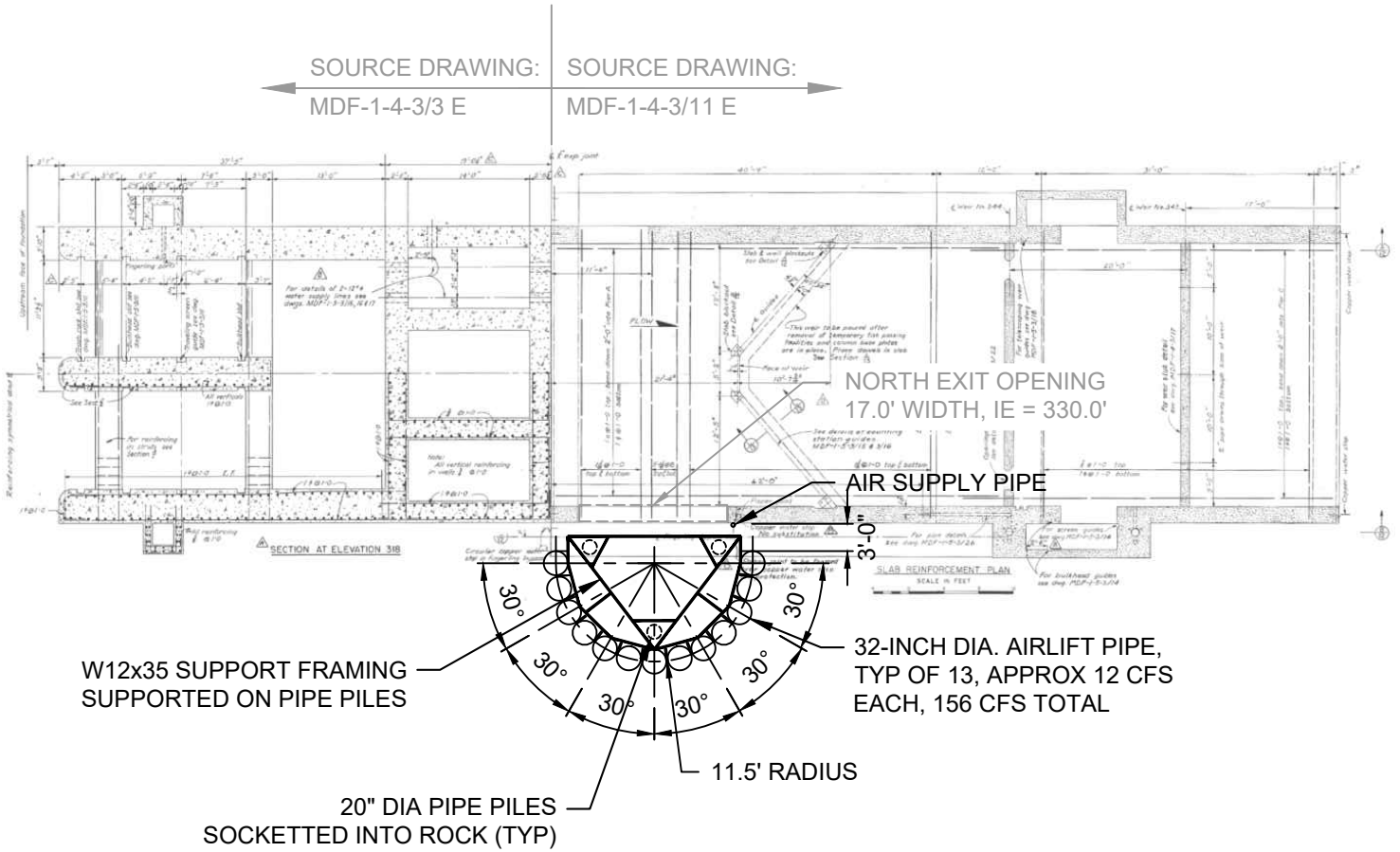
US Army Corps of Engineers
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE MNA-3
MCNARY LOCK AND DAM
OREGON SHORE FISHWAY
PROCESS FLOW DIAGRAM



SITE PLAN
1' = 20'-0"

0 20' 40'

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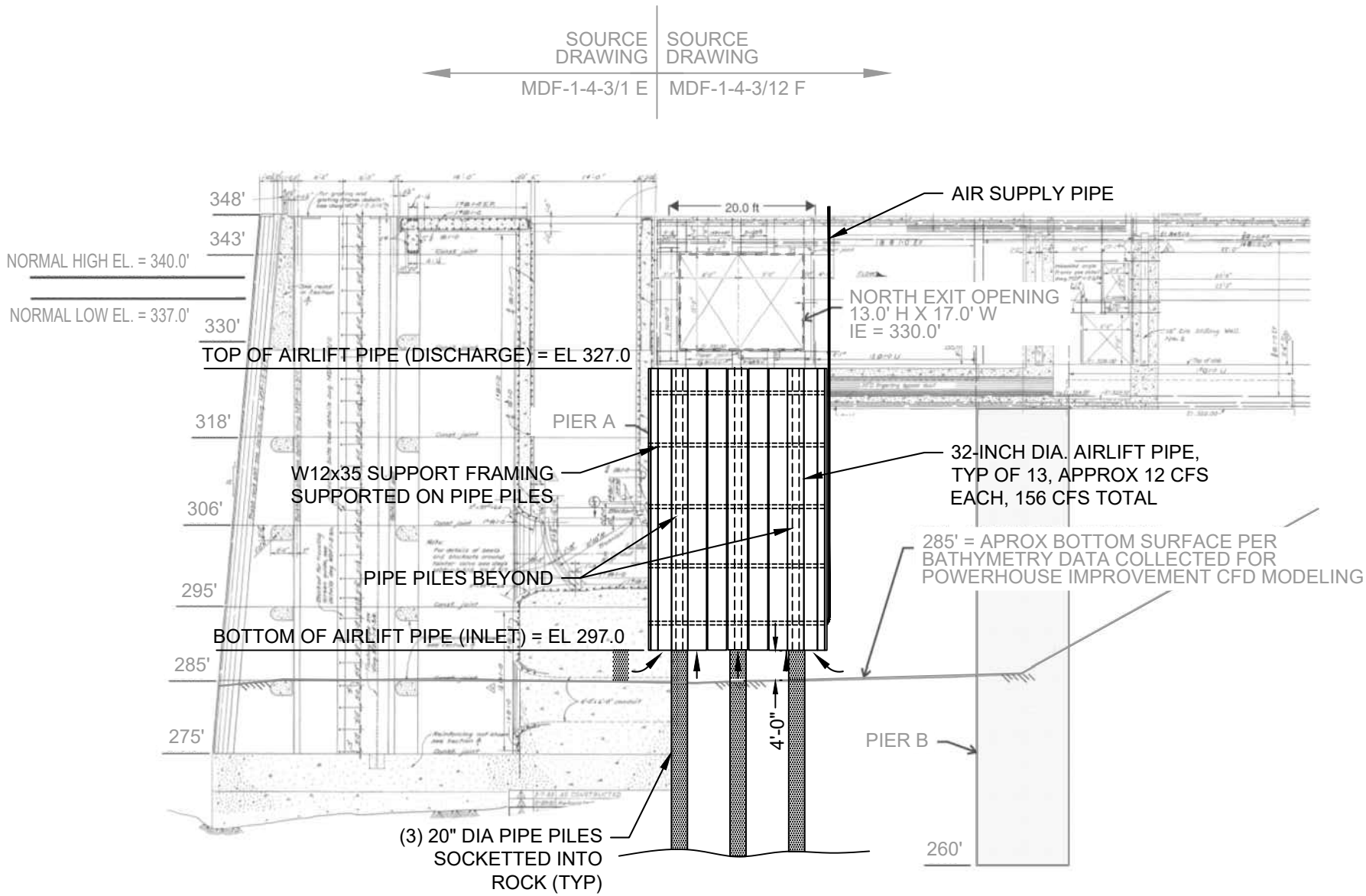
US Army Corps of Engineers
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE MNA-4A
MCNARY LOCK AND DAM
SOUTH SHORE FISHWAY
AIR LIFT SITE PLAN



SITE PLAN
1' = 20'-0"

0 20' 40'

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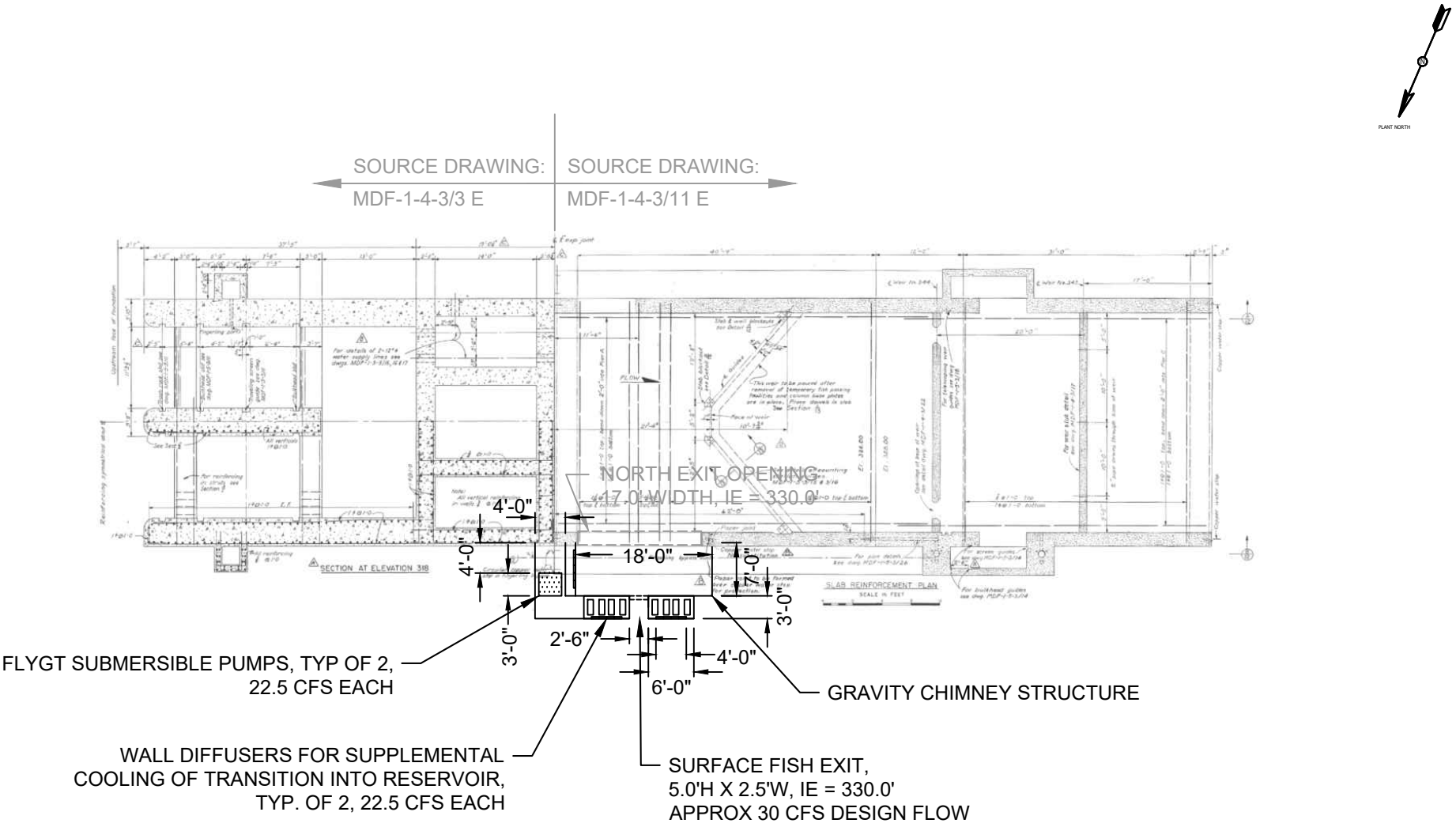
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE MNA-5A
MCNARY LOCK AND DAM
SOUTH SHORE FISHWAY
AIRLIFT SECTIONS



SITE PLAN
1' = 20'-0"

0 20' 40'

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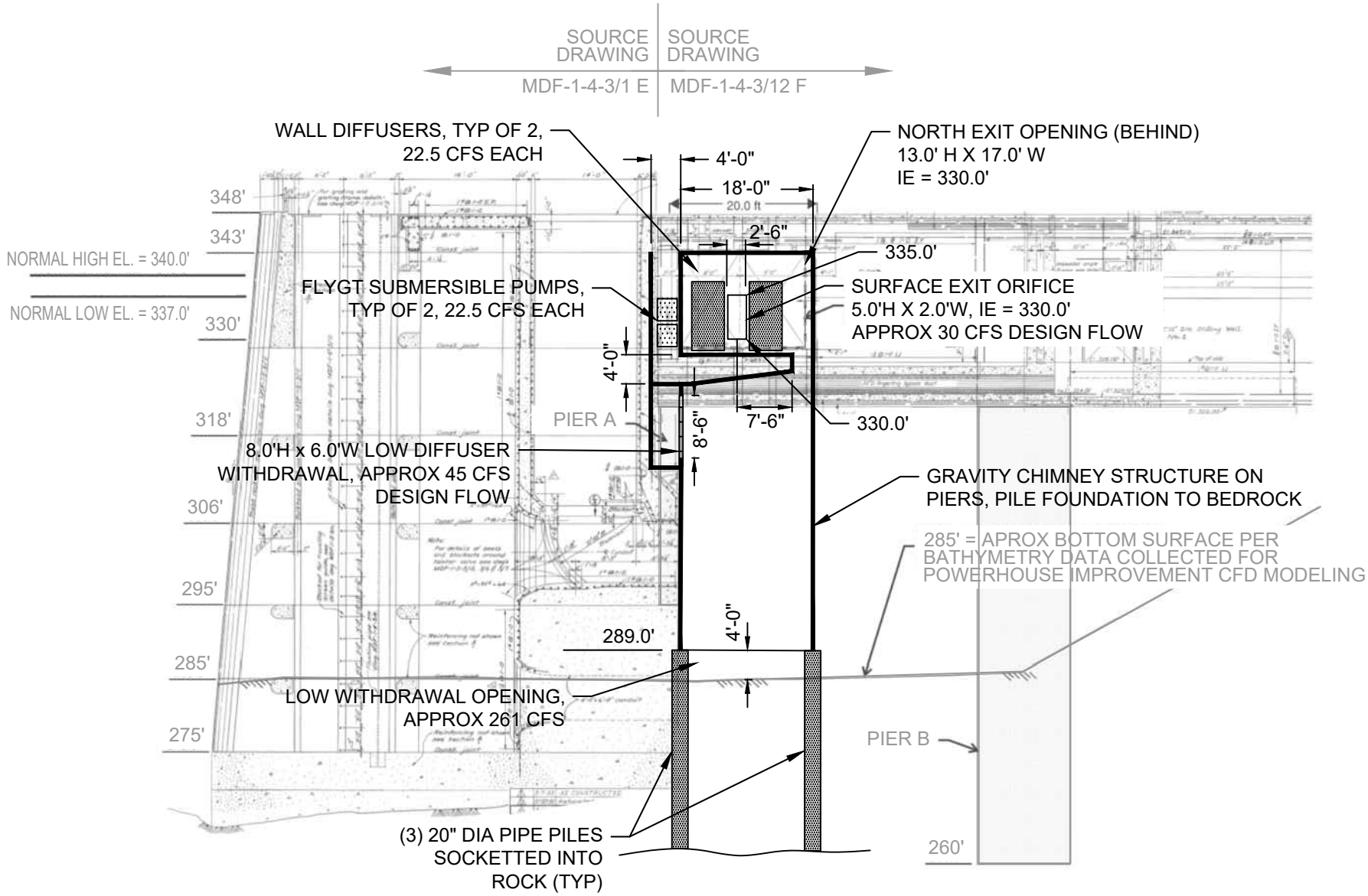
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE MNA-4B
MCNARY LOCK AND DAM
SOUTH SHORE FISHWAY
GRAVITY CHIMNEY SITE PLAN



ELEVATION
1' = 20'-0"

0 20' 40'

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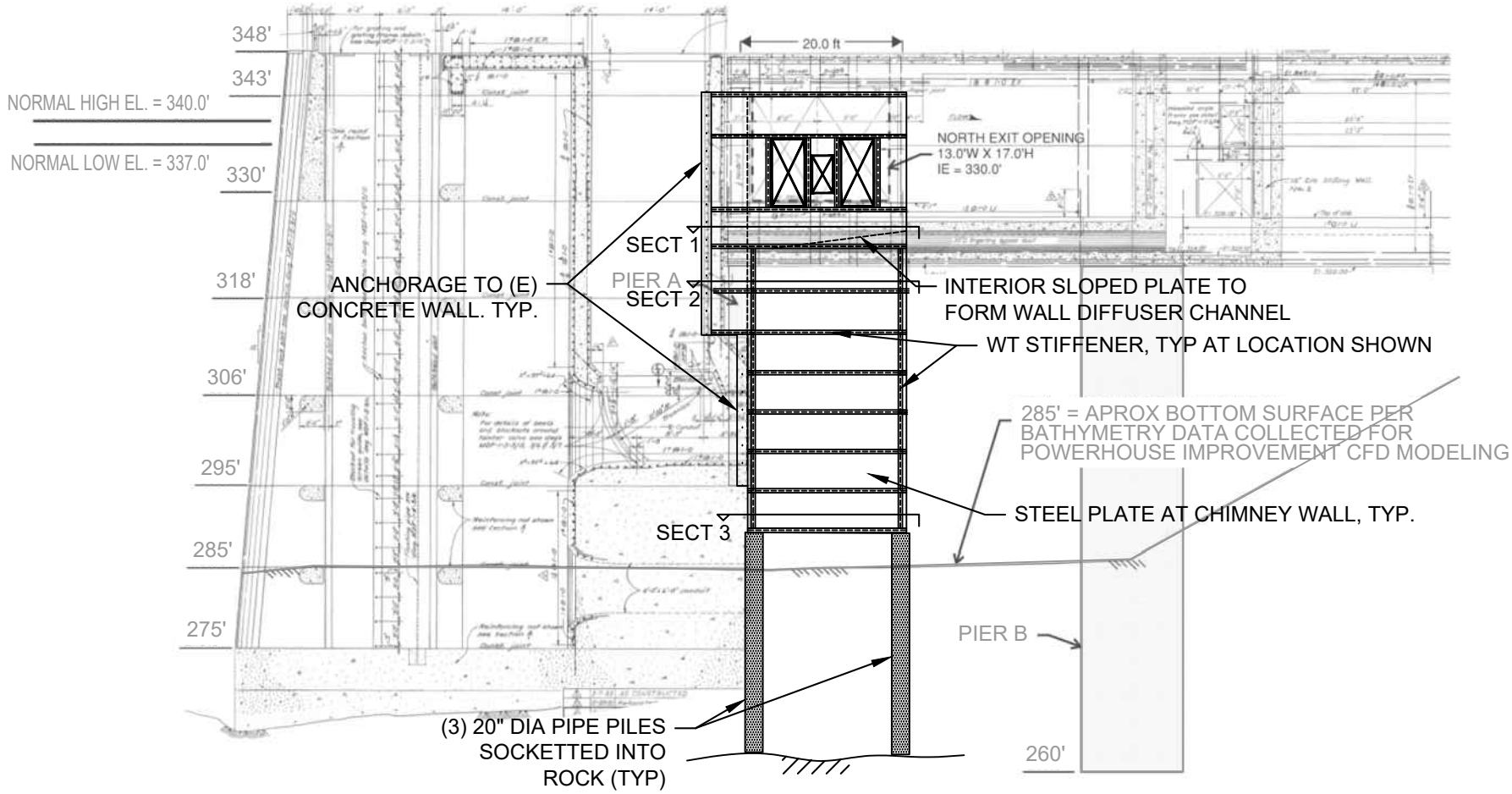
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE MNA-5B
MCNARY LOCK AND DAM
SOUTH SHORE FISHWAY
GRAVITY CHIMNEY ELEVATION 1

SOURCE DRAWING MDF-1-4-3/1 E

SOURCE DRAWING MDF-1-4-3/12 F



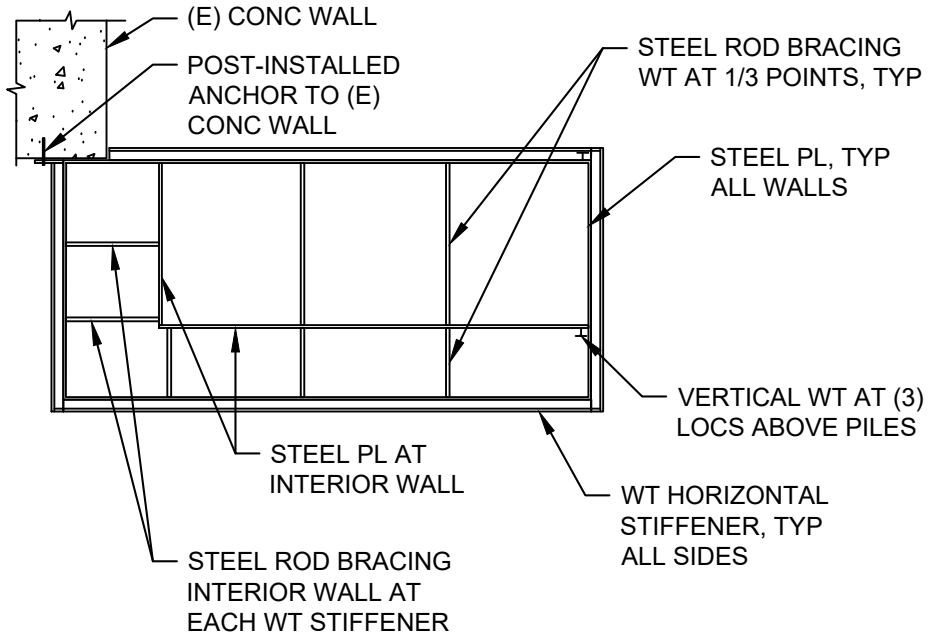
ELEVATION
1' = 20'-0"

0 20' 40'

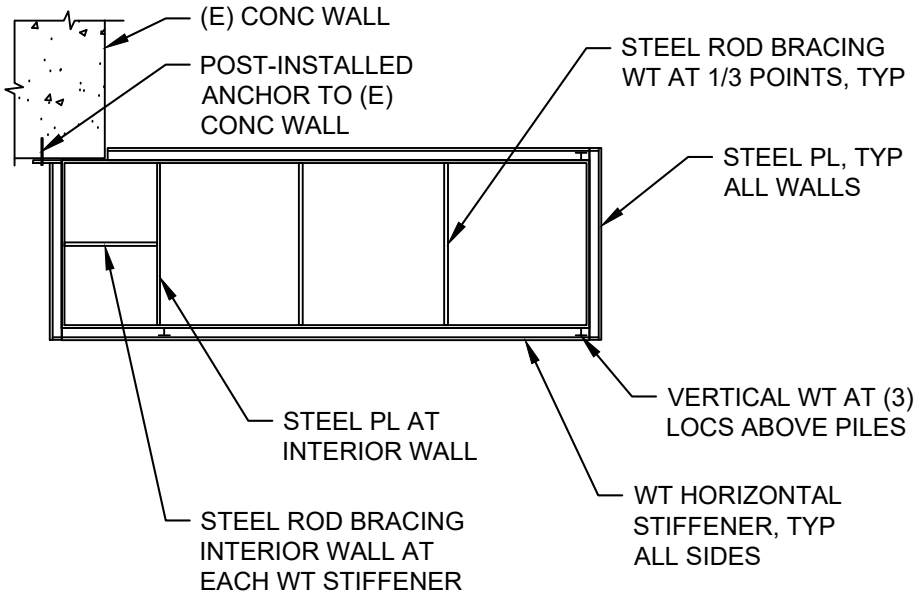
JACOBS®

US Army Corps of Engineers
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

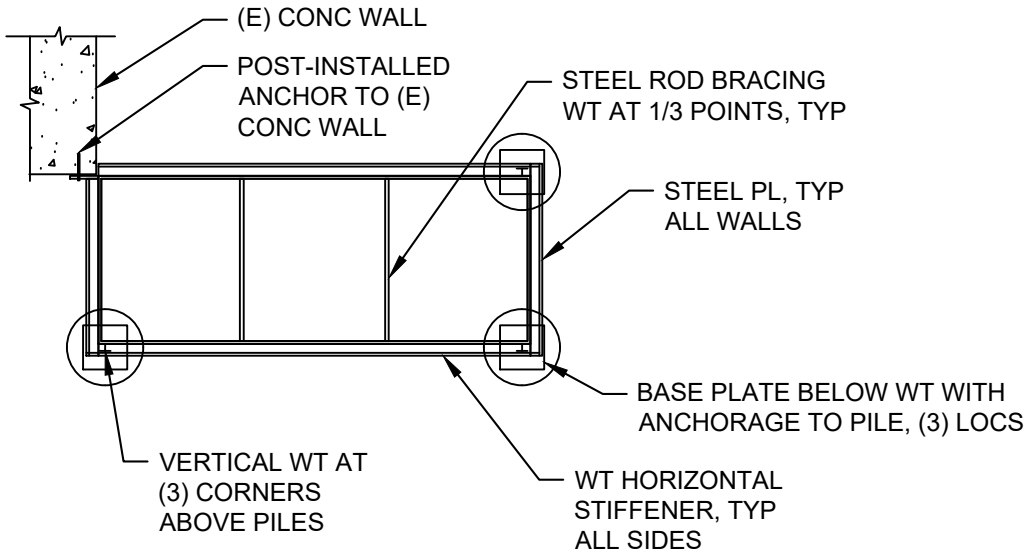
PLATE MNA-6B
MCNARY LOCK AND DAM
SOUTH SHORE FISHWAY
GRAVITY CHIMNEY ELEVATION 2



SECTION 1
N.T.S.



SECTION 2
N.T.S.

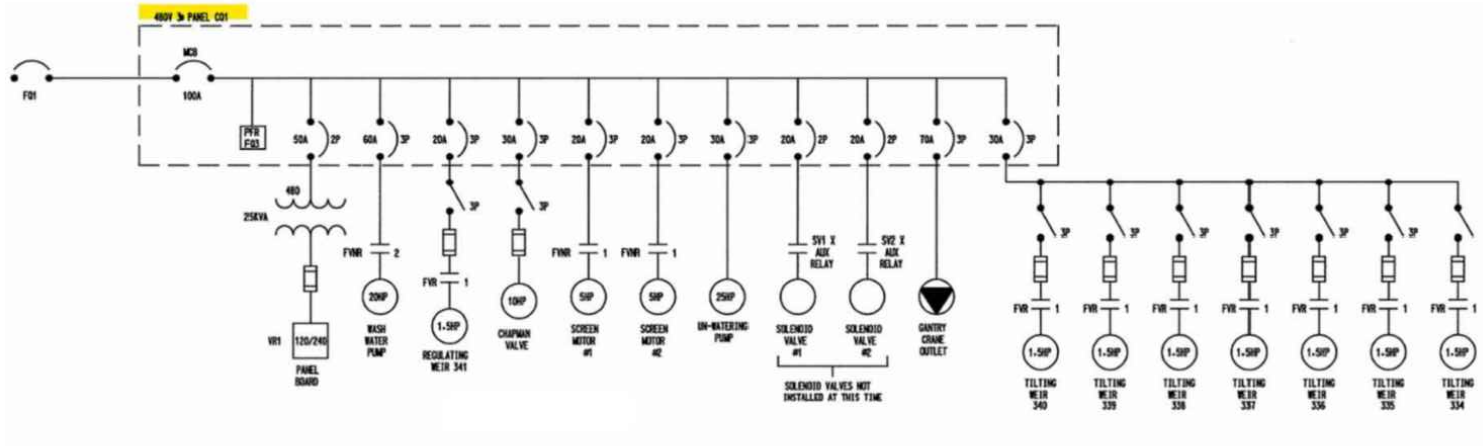


SECTION 3
1/8" = 1'-0"

JACOBS®

US Army Corps of Engineers
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE MNA-7B
MCNARY LOCK AND DAM
SOUTH SHORE FISHWAY
GRAVITY CHIMNEY DETAILS

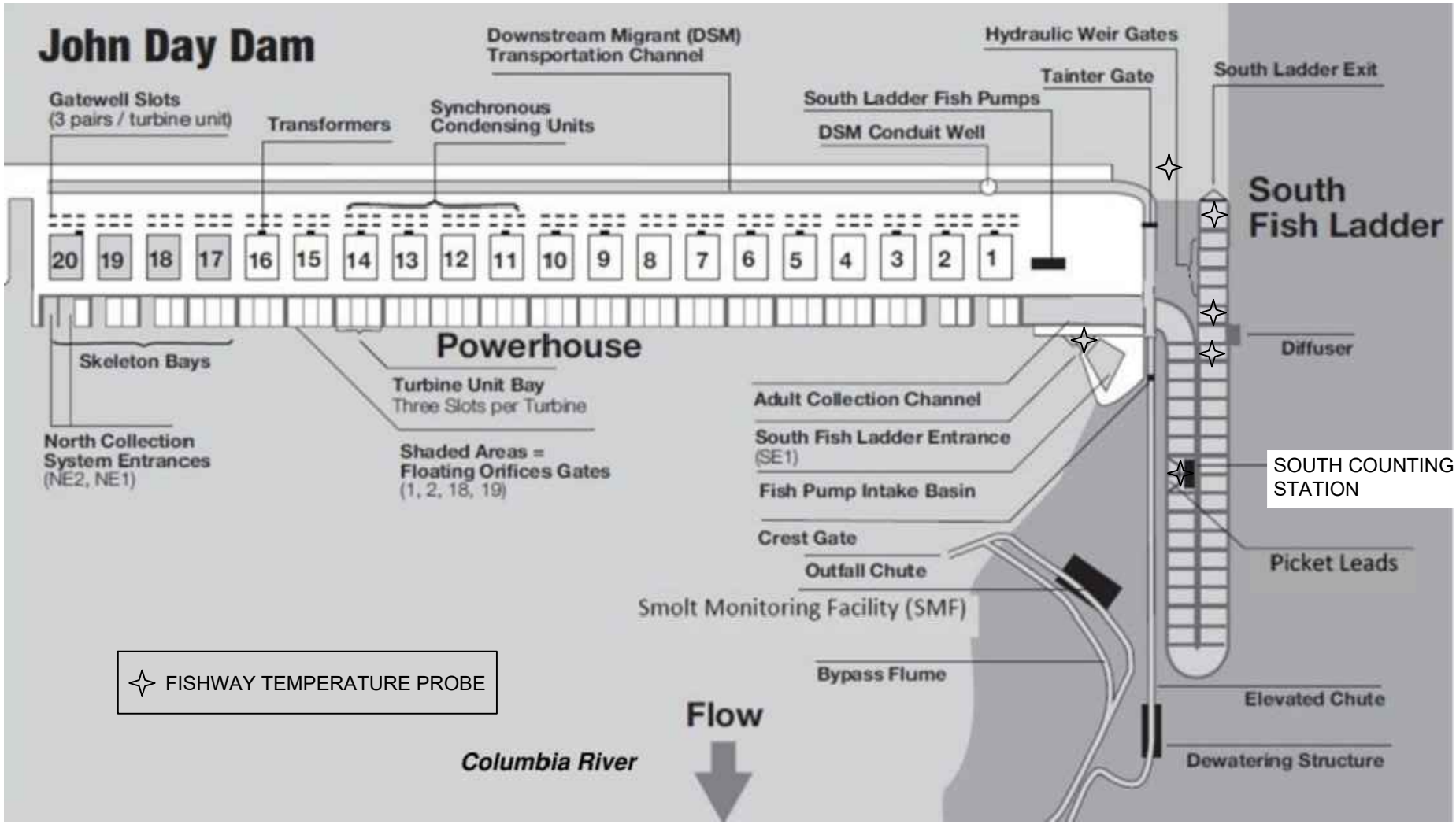


PARTIAL ONE-LINE DIAGRAM (CQ1 ONLY)
N.T.S

JACOBS®

US Army Corps of Engineers
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE MNA-7
MCNARY LOCK AND DAM
SOUTH SHORE FISHWAY
DETAILS



OVERALL SITE PLAN
N.T.S.

JACOBS®

US Army Corps of Engineers
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

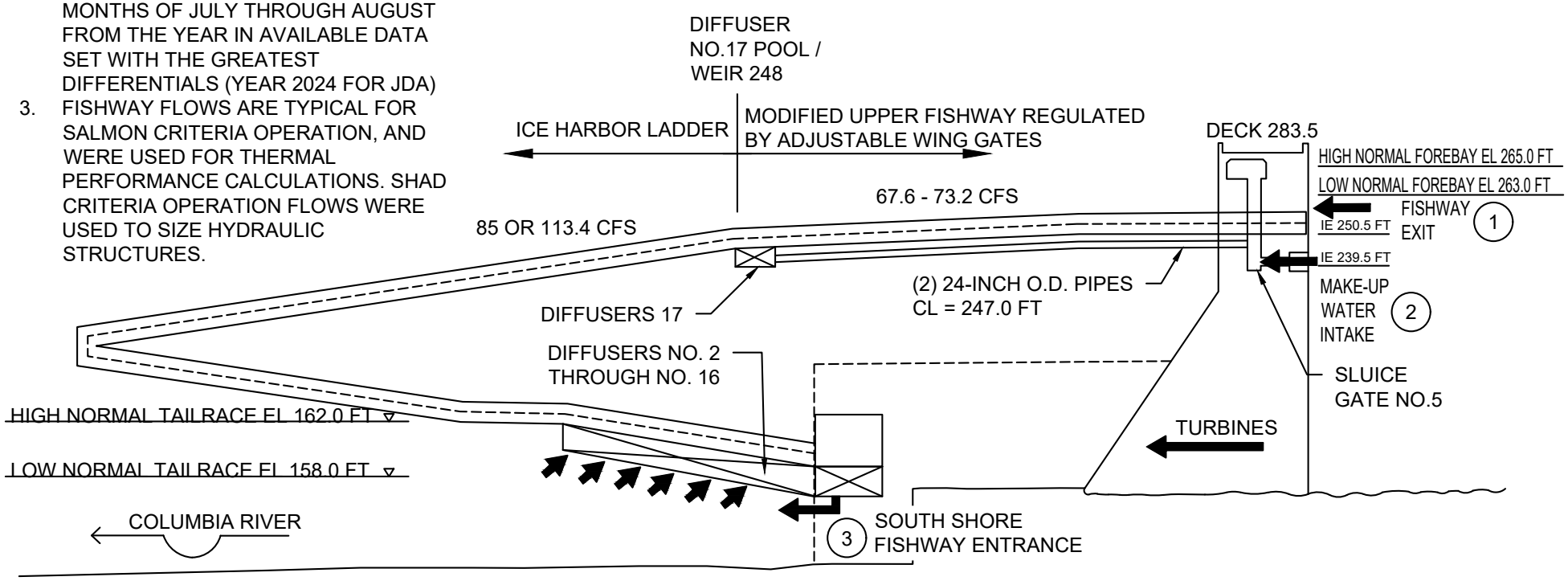
PLATE JDA-2
JOHN DAY LOCK AND DAM
OVERALL SITE PLAN

FISHWAY FLOW AND TEMPERATURE DATA (JULY THROUGH AUGUST)			
	(1) FISHWAY EXIT	(2) MAKEUP WATER INTAKE	(3) FISHWAY ENTRANCE
FLOW RANGE (CFS)	54.1 - 67.6	30.9 - 17.4	N/A
T5% (ºF)	71.8	70.8	68.0
T25% (ºF)	72.2	71.6	70.7
T50% (ºF)	71.2	71.2	70.8

NOTE: FISHWAY ENTRANCE INCLUDES FLOW FROM DIFFUSERS NO. 1 THROUGH 16

NOTES:

1. FOREBAY ELEVATIONS ARE TYPICAL FOR THE JULY THROUGH AUGUST TIME PERIOD.
2. TEMPERATURES ARE FROM THE MONTHS OF JULY THROUGH AUGUST FROM THE YEAR IN AVAILABLE DATA SET WITH THE GREATEST DIFFERENTIALS (YEAR 2024 FOR JDA)
3. FISHWAY FLOWS ARE TYPICAL FOR SALMON CRITERIA OPERATION, AND WERE USED FOR THERMAL PERFORMANCE CALCULATIONS. SHAD CRITERIA OPERATION FLOWS WERE USED TO SIZE HYDRAULIC STRUCTURES.

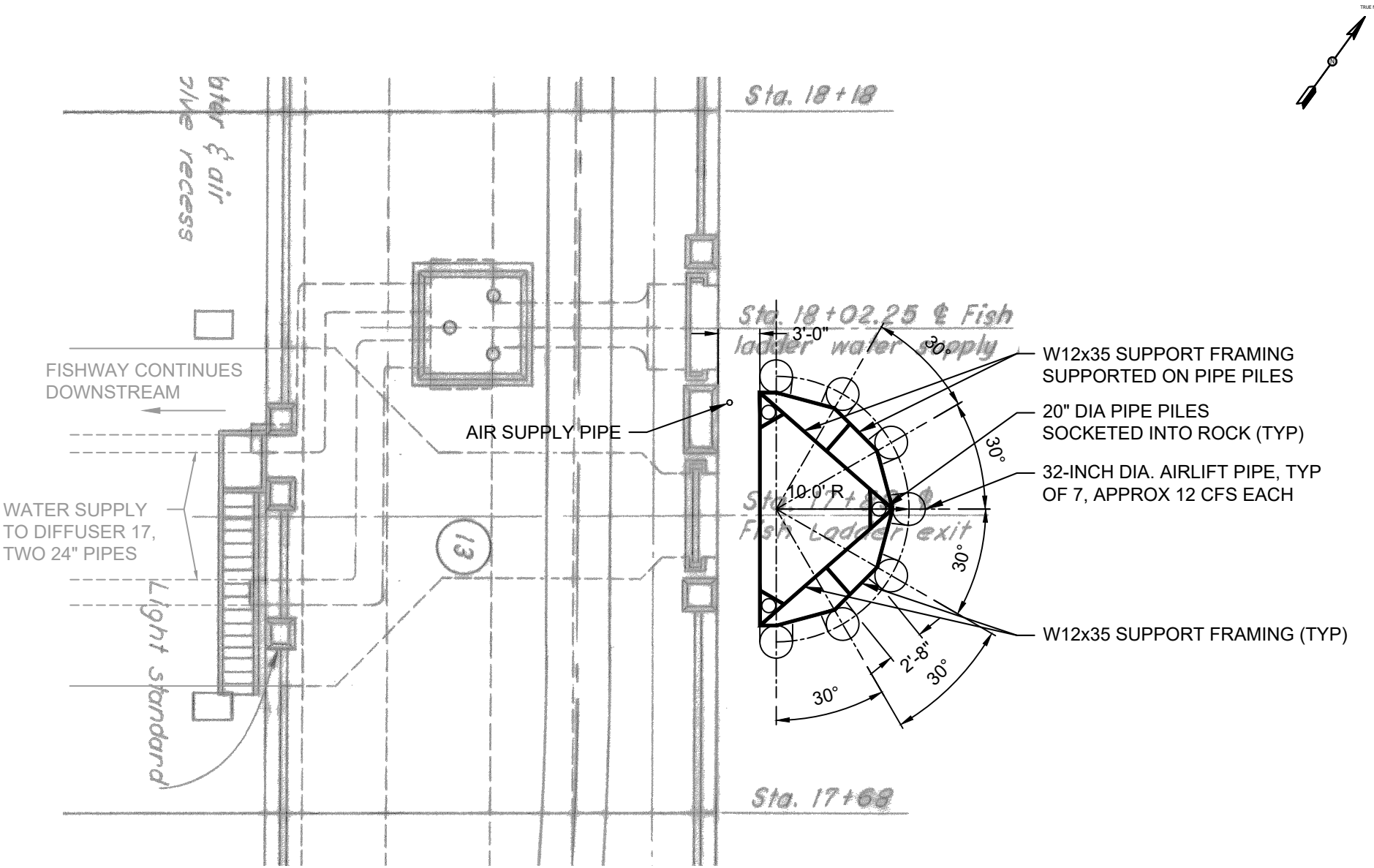


PROCESS FLOW DIAGRAM
N.T.S.

JACOBS®

US Army Corps of Engineers
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE JDA-3
JOHN DAY LOCK AND DAM
SOUTH SHORE FISH LADDER
PROCESS FLOW DIAGRAM



SITE PLAN
1' = 10'-0"

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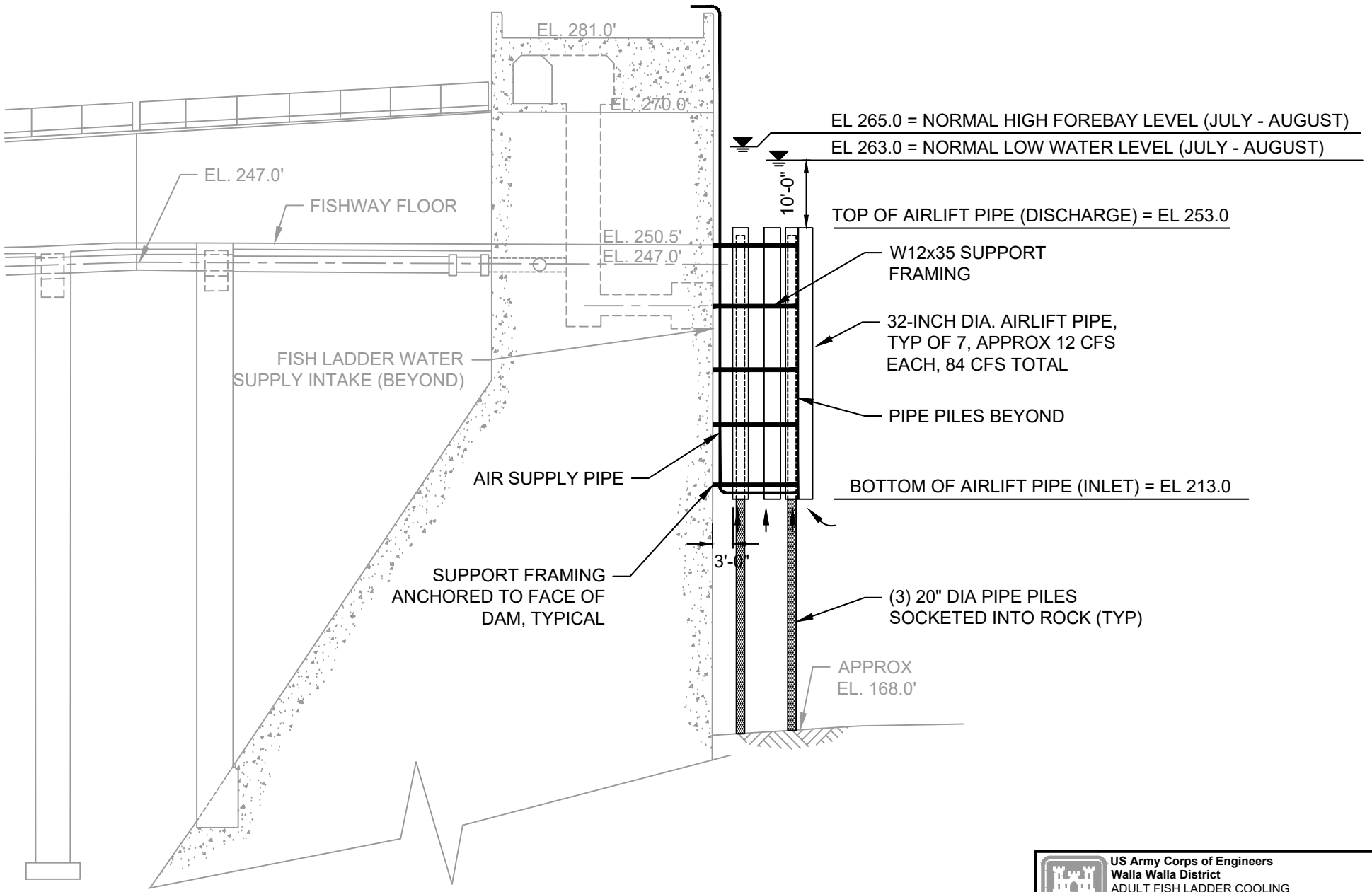
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE JDA-4A
JOHN DAY LOCK AND DAM
SOUTH SHORE FISH LADDER
AIR LIFT SITE PLAN



SECTIONS
1' = 20'-0"

0 20' 40'

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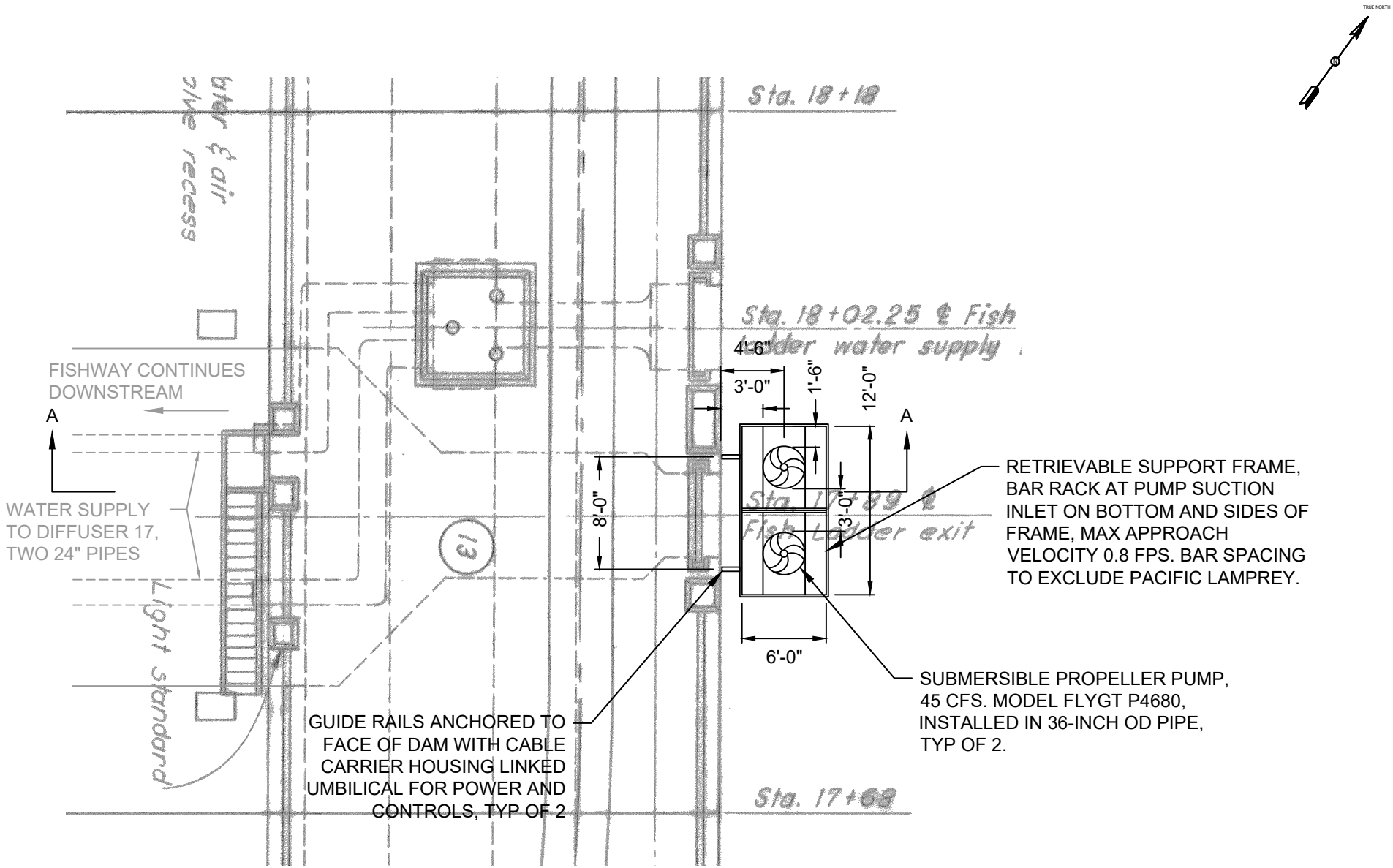
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE JDA-5A
JOHN DAY LOCK AND DAM
SOUTH SHORE FISH LADDER
AIR LIFT SECTIONS



SITE PLAN, EL. 229.0'
1' = 10'-0"

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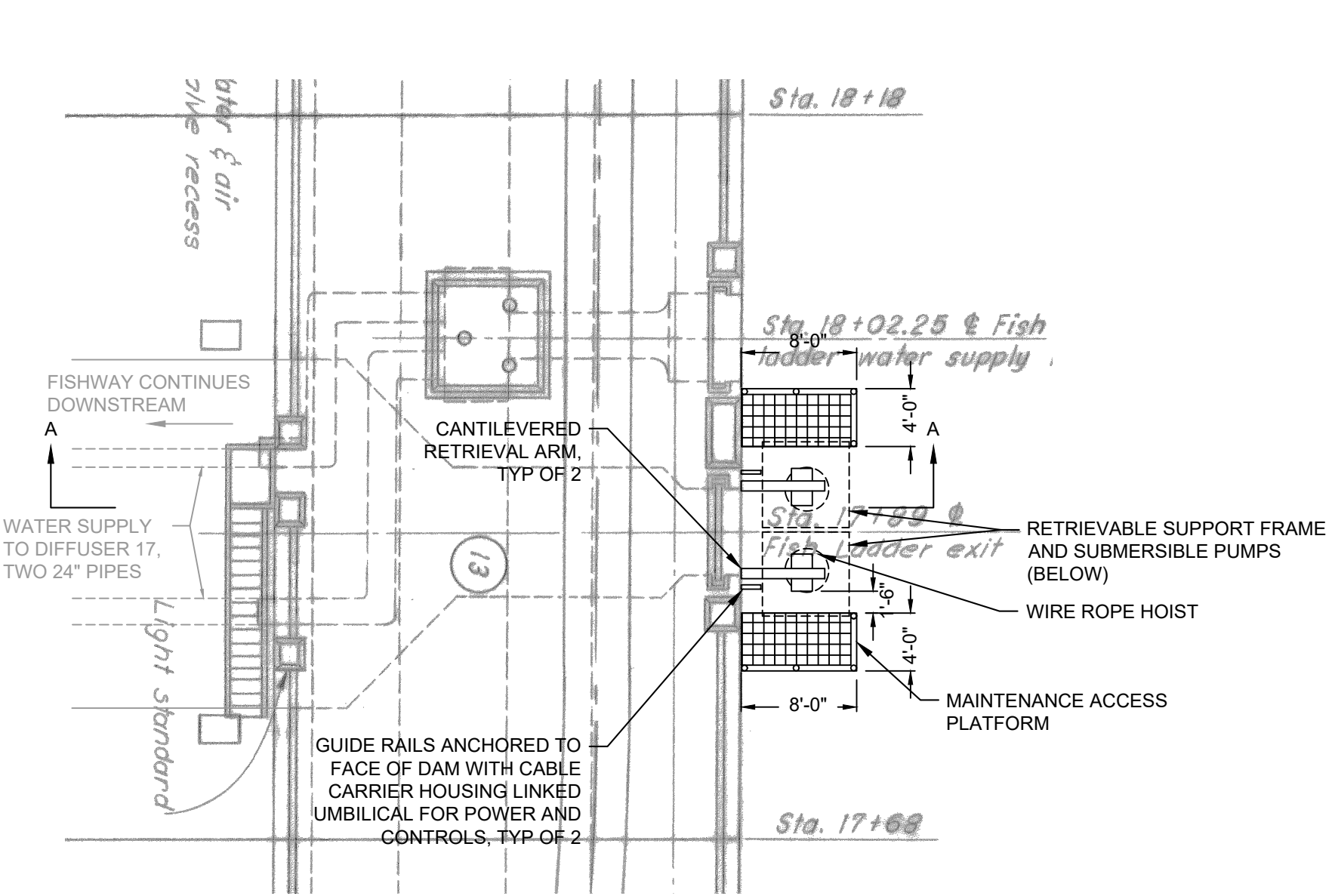
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE JDA-4B
JOHN DAY LOCK AND DAM
SOUTH SHORE FISH LADDER
SUBMERGED JET SITE PLAN 1



SITE PLAN, TOP DECK
1' = 10'-0"

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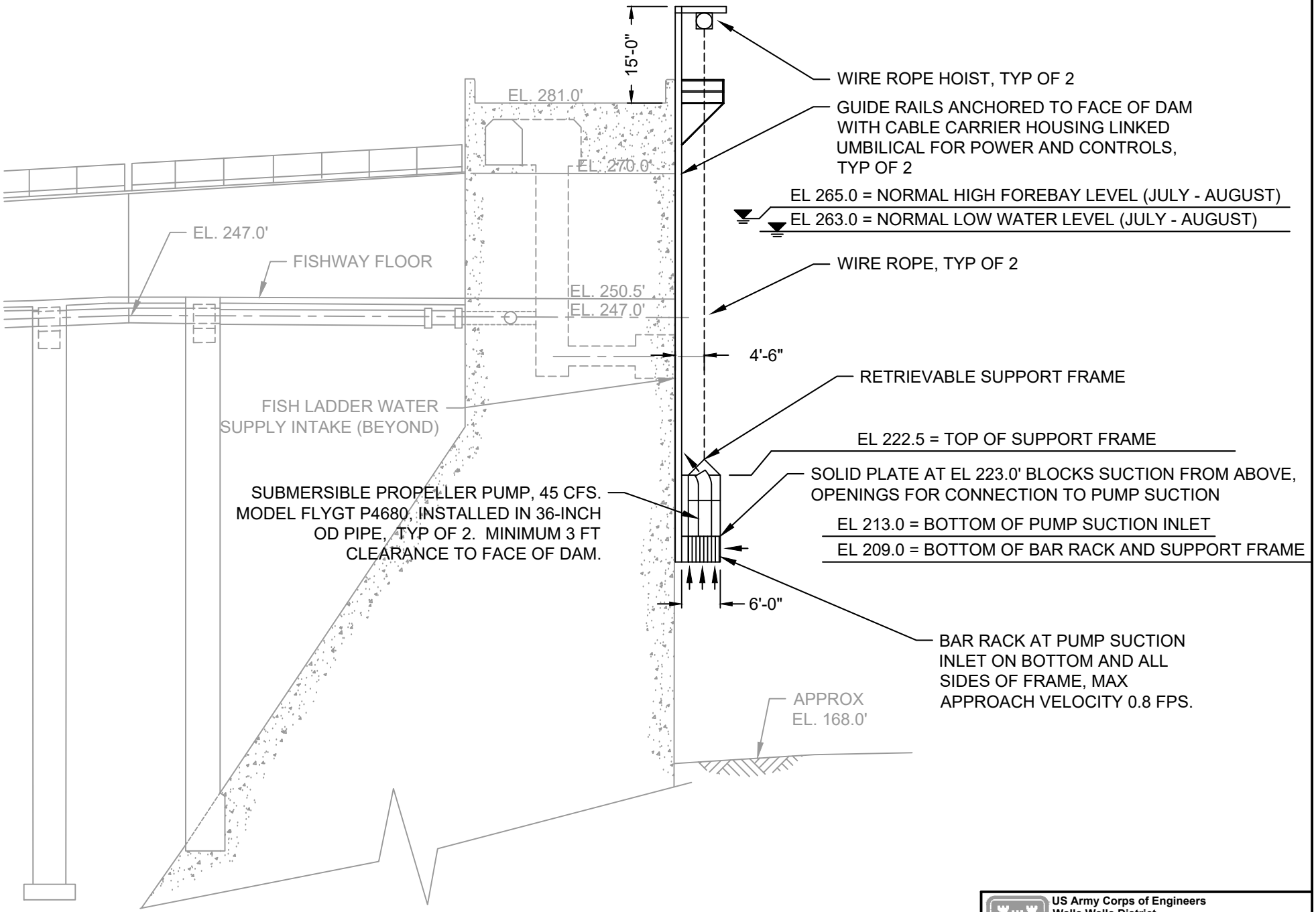
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE JDA-5B
JOHN DAY LOCK AND DAM
SOUTH SHORE FISH LADDER
SUBMERGED JET SITE PLAN 2



SECTION A-A
1' = 20'-0"

0 20' 40'

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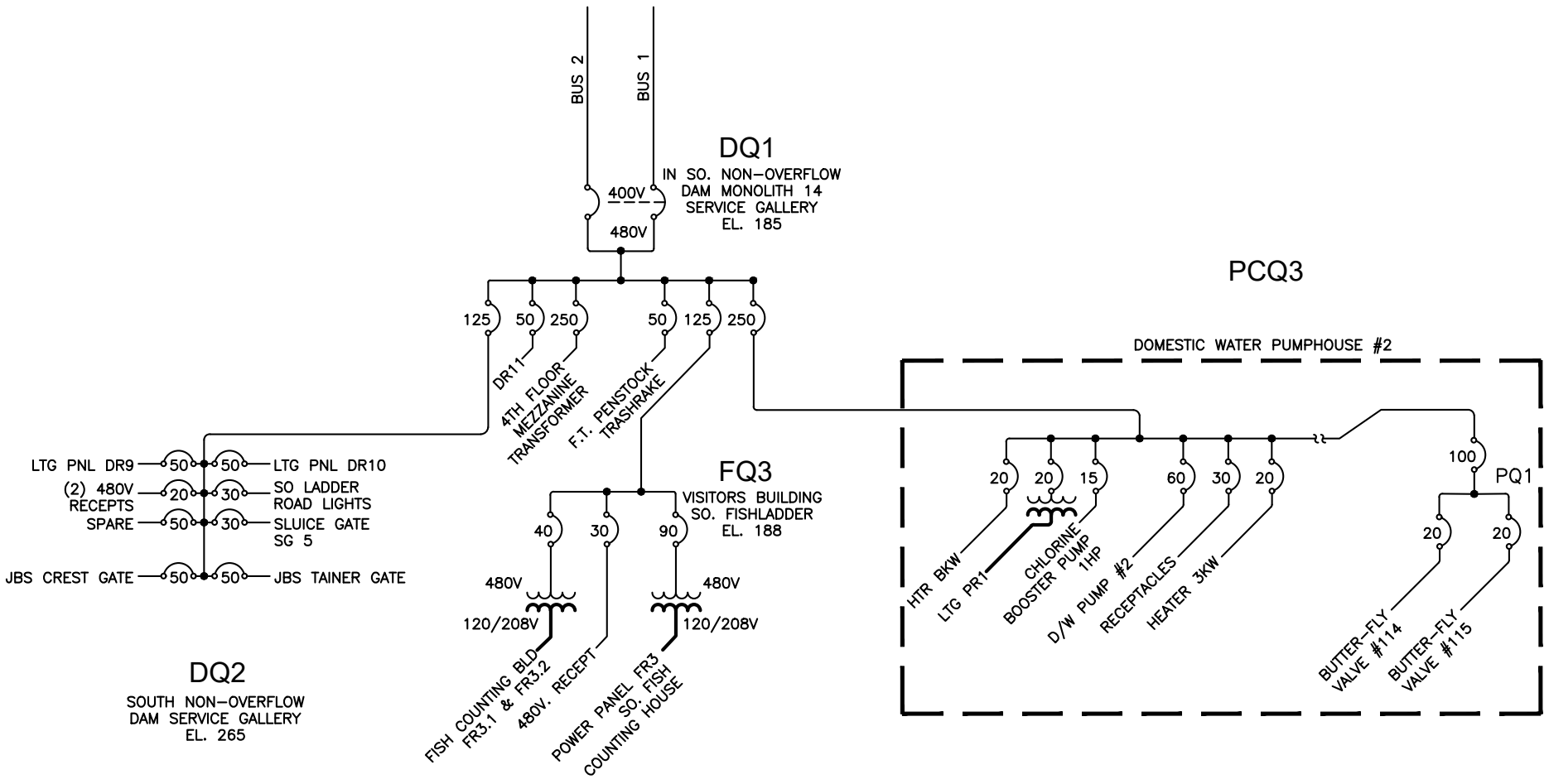
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE JDA-6B
JOHN DAY LOCK AND DAM
SOUTH SHORE FISH LADDER
SUBMERGED JET SECTIONS



PARTIAL ONE-LINE DIAGRAM

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US Army Corps of Engineers
Walla Walla District
ADULT FISH LADDER COOLING
CONCEPT EVALUATION

PLATE JDA-8
JOHN DAY LOCK AND DAM
SOUTH SHORE FISH LADDER
ELECTRICAL ONE-LINE

Appendix B. Temperature Data

USACE Fishway Cooling – Temperature Data

1. Background

Temperature data at two lower Snake River dams, Lower Monumental and Ice Harbor, and two Columbia River Dams, McNary and John Day, was collected and analyzed to inform the evaluation of various alternatives for conditioning water in the adult fish ladders. The analysis categorizes the fish ladder temperature differentials between the fish entrances and the exits into ranges of Extreme, Moderate, and Normal. Associated reservoir temperatures by depth were also characterized.

Reservoir thermoclines typically exist from June through September. During this period, the fish entrances in the tailrace are typically cooler than the fish exits in the reservoir, with the majority of the entrance water being attraction water pumped from the tailrace and comprised primarily of turbine flows which originate deep in the reservoir. The fish exit water is drawn primarily from warmer surface water in the forebay. The analysis was performed using data from three consecutive years of 2022, 2023, and 2024. The following sections outline the methodology, available data and results for each project site.

2. Methodology

Hourly data was evaluated from the fishway facilities and the forebay to identify representative values corresponding to the highest water temperature differentials between the fish entrance and the fish exit. The sources and temporal extent of the temperature datasets utilized in the analysis are outlined in the next section. Since the fish ladder temperatures clearly show a seasonal pattern, with the highest values in July and August, the analysis focused on these two months across all three years (2022, 2023, 2024). The following procedure was followed for each site:

1. Compute Exit-Entrance temperature differentials in the fishway. The analysis focuses on the summer periods (July and August) for the three years of analysis.
2. Generate an exceedance curve of the temperature differentials for each year to determine the distribution to extract the extremes (see example in Figure 2-1). Recognizing that a single exceedance value would have limited data, a 10% range of plus 5% and minus 5% was utilized. Three ranges based on exceedance percentages values are defined as follows:
    a. **Extreme:** 5% ± 5% exceedance.
    b. **Moderate:** 25% ± 5% exceedance.
    c. **Normal:** 50% ± 5% exceedance.

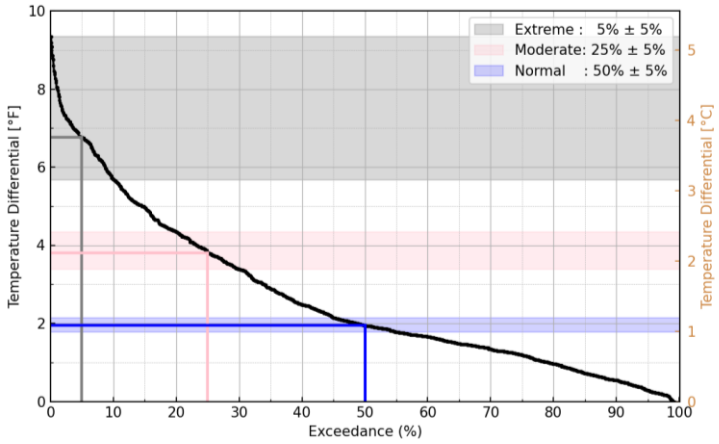


Figure 2-1. Lower Monumental. Exceedance curve Exit-Entrance differentials. Summer 2022.

3. Identify forebay temperature data from temperature string measurements corresponding to the data identified as Extreme, Moderate and Normal.

4. Calculate the values of forebay and fishway temperatures for each year and classification category of Extreme, Moderate, and Normal.

5. Select the year with the highest values of Exit-Entrance temperature differentials for each site to represent the extreme for the performance evaluation of the various alternatives.

3. Data available

Hourly forebay temperature and reservoir level data were obtained from the Columbia River Operational Hydrometeorological Management System (CROHMS) website, and hourly fish ladder temperature data was provided by USACE. An overview of the temperature dataset by site for the analysis period is provided below.

3.1 Lower Monumental

The temperature monitoring stations on the fish ladder are situated in the locations indicated in Figure 3-1. For the analysis, hourly data was used from the three monitoring stations of the North fish ladder: North Entrance (EntranceN), North Exit (ExitN) and Diffuser (DiffuserN). Figure 3-2 shows the temporal extent of the data set from 2022 to 2024. Exit and Entrance temperatures are available from June to August 2022, and June 2023 to August 2024, while Diffuser temperatures are only available from August 2023 to August 2024.

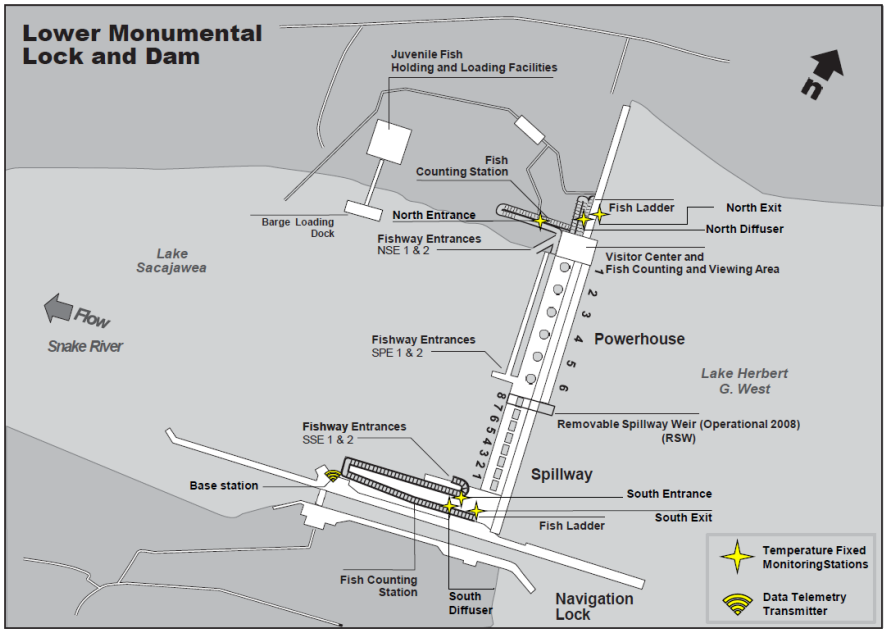


Figure 3-1. Lower Monumental. General Site plan and temperature monitoring stations. Source: USACE

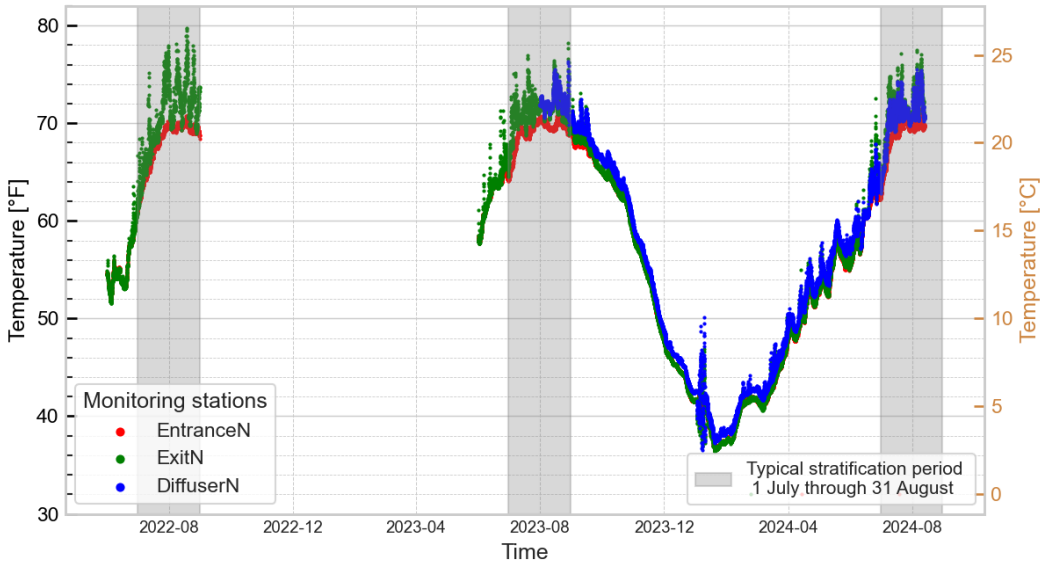


Figure 3-2. Lower Monumental. North fish Ladder data: 2022, 2023 and 2024

A clear seasonal trend is observed, with peak temperatures occurring in July and August. Fish ladder temperatures range from 70 °F to 80 °F in the summer, with winter minimum temperatures dropping below 40 °F. As anticipated, exit temperatures are higher than Entrance temperatures. Some of these temperature differences (Exit-Entrance differentials) exceed 5 °F in the summer months.

Figure 3-3 illustrates the frequency distribution of Exit-Entrance differentials by year. The boxes represent the interquartile range, defined by the 25th and 75th percentiles (or equivalently, the 75% and 25% exceedance values), and the whiskers correspond to the 5th and 95th percentiles (or 95% and 5%

exceedance values). The largest differentials are observed in 2022, with almost 25% of the data exceeding 3.8 °F. The median value over the three years is approximately 1.9 °F (1.1 °C), suggesting that Exit-Entrance differentials rise above the 1 °C threshold at least half of the time.

Forebay temperature data for the site consists of string measurements taken at 10 depths: 0.5, 1.5, 3, 5, 10, 15, 20, 25, 30 and 35 meters. Contours presenting the temperature by depth in the forebay for the summers of 2022, 2023 and 2024 are shown in Figure 3-4. Measurements depths have been converted to elevations using hourly reservoir level data available on the CHROMS website. The normal reservoir water level fluctuates from elevation 537 to 540 feet (July through August).

Summer stratification in the reservoir is clearly shown in Figure 3-4, with temperature differences sometimes exceeding 8 °F between the shallowest (0.5 m) and the deepest (35 m) measurements. Figure 3-5 presents the same hourly temperature data, displaying temperature in the y-axis and measurement depth in feet indicated by color markers. This visualization enables simultaneous comparison of forebay and fish ladder temperature data within a single plot. The fish ladder Exit temperature trend aligns with forebay temperatures at depths less than 5 m (16.4 ft), whereas Entrance temperatures resemble forebay trends between depths of 15 m (49.2 ft) and 20 m (65.5 ft).

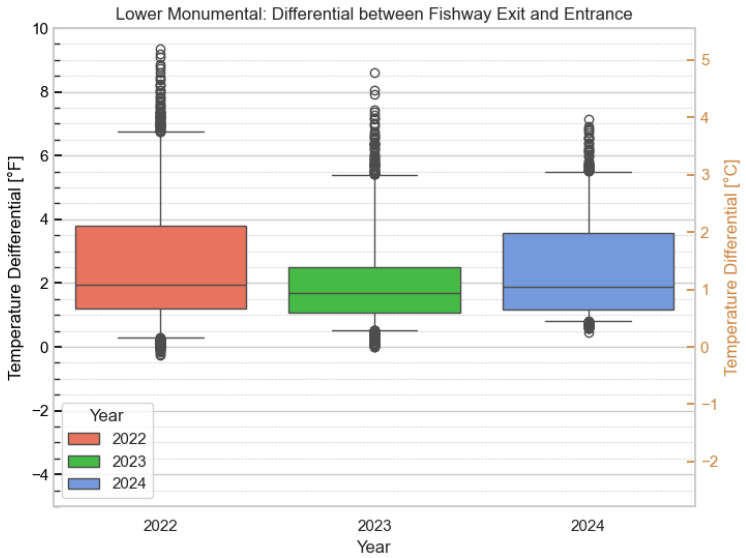


Figure 3-3. Lower Monumental. Frequency distribution of temperature differentials Exit-Entrance. Summer 2022, 2023 and 2024. Whiskers represent the 95% and 5% percentages of exceedance.

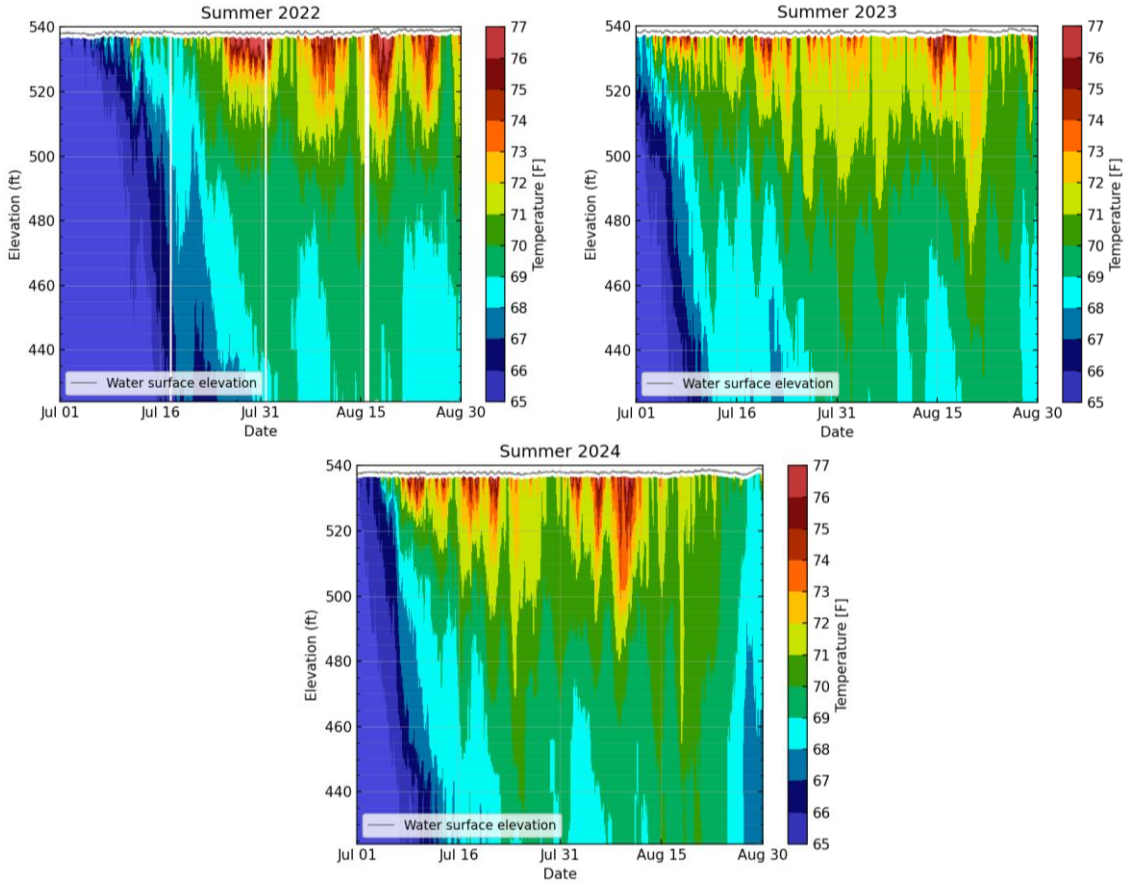
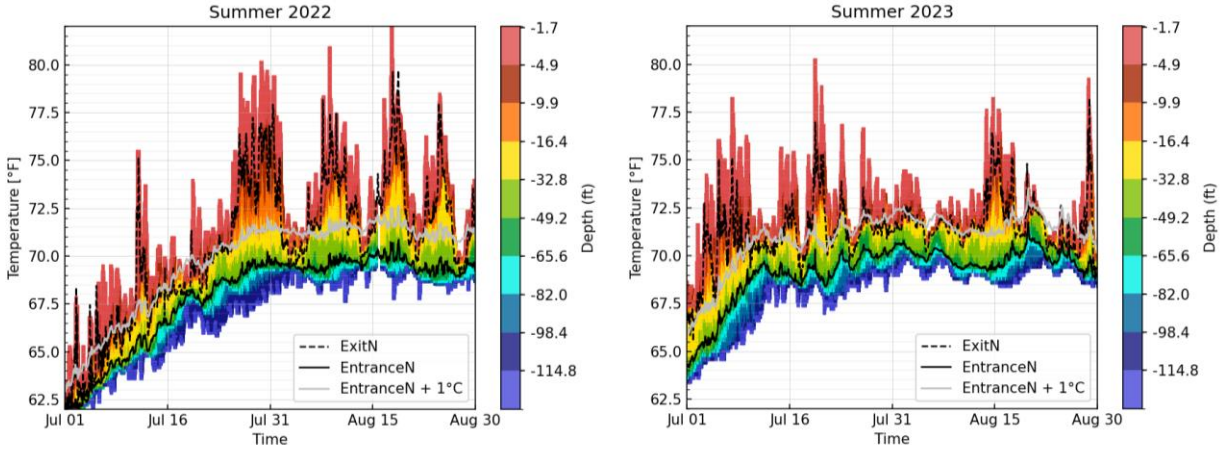


Figure 3-4. Lower Monumental. Temperature string data are available for 2022, 2023 and 2024. Depth is converted to elevation using the mean pool elevation value available on the CHROMS website.



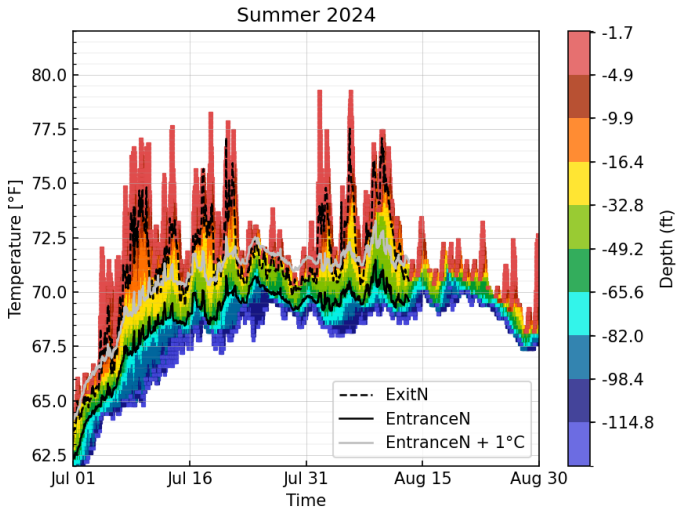


Figure 3-5. Lower Monumental. Temperature string data and hourly fishway data. Summer 2022, 2023, 2024

3.2 Ice Harbor

Figure 3-6 shows the location of the temperature monitoring stations on the fish ladder. Hourly data from two of the monitoring stations at the South fish ladder were used: South Entrance (EntranceS) and South Exit (ExitS). The temporal extent of temperature data at the South fish ladder is illustrated in Figure 3-7. Exit and Entrance temperatures are available from June to August 2022, and June 2023 to mid-August 2024.

As expected, a seasonal trend is observed with hourly temperatures exceeding 70 °F in July and August. The temperature differences between Exit and Entrance (Exit-Entrance differentials) peak during the Summer. These differentials show a frequency distribution described by the box plots in Figure 3-8. The lowest differentials are observed in 2022 with more than 75% of the observations below the 1 °C threshold that year. Differentials are larger for 2023 and 2024 with values surpassing the 1 °C threshold at least half of the time.

Temperature string measurements are available at 10 depths: 0.5, 1.5, 3.5, 10, 15, 20, 25 and 35 meters. Temperature contours for the summer of 2022, 2023 and 2024 are presented in Figure 3-9, where measurement depth have been converted to elevation using hourly reservoir water level data from the CHROMS website. The normal reservoir water level fluctuates from 437 to 440 feet (July through August). Stratification in the reservoir is noticeable during the summer months, with temperature differences between the shallowest (0.5 m) and the deep reaching more than 6 °C. Figure 3-10 shows the same temperature string measurements, with temperature plotted on the y-axis and depth represented by color makers. Fish ladder temperatures are presented in the same plot suggesting that Entrance temperatures tend to align with forebay temperature at depths between 15 m (49.2 ft) and 5 m (16.4 ft).

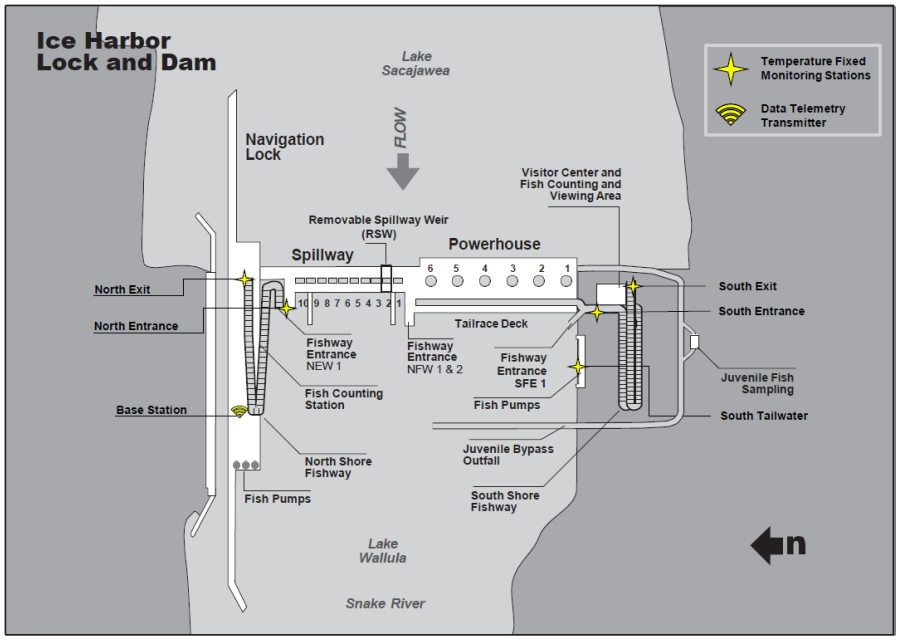


Figure 3-6. Ice Harbor. General Site plan and temperature monitoring stations. Source: USACE

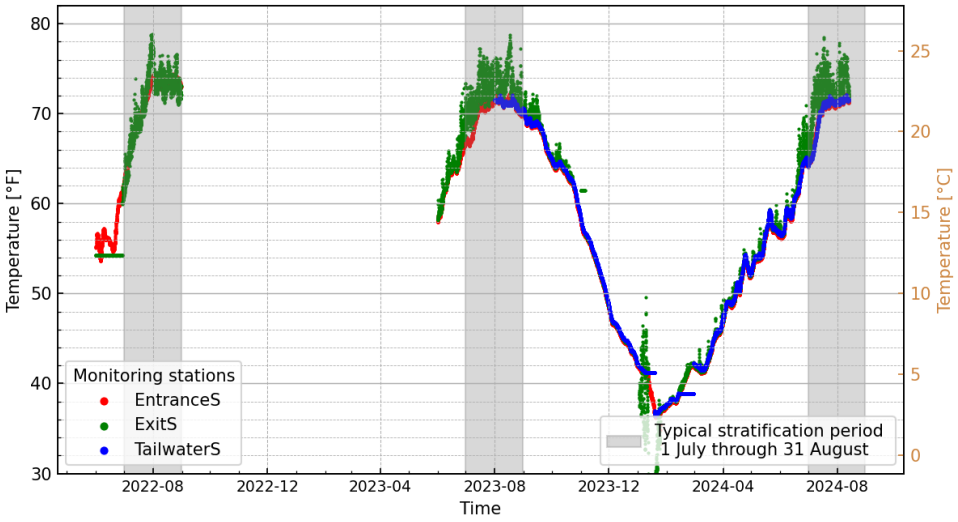


Figure 3-7. Ice Harbor. South fish Ladder data: 2022, 2023 and 2024

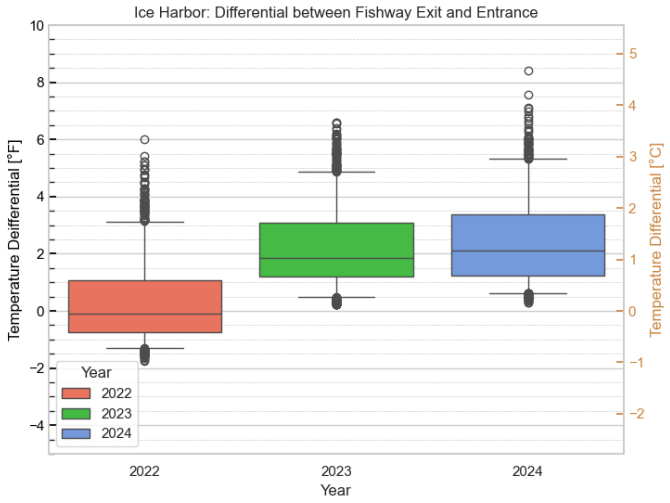


Figure 3-8. Ice Harbor. Frequency distribution of temperature differentials Exit-Entrance. Summer 2022, 2023 and 2024. Whiskers represent the 95% and 5% percentages of exceedance.

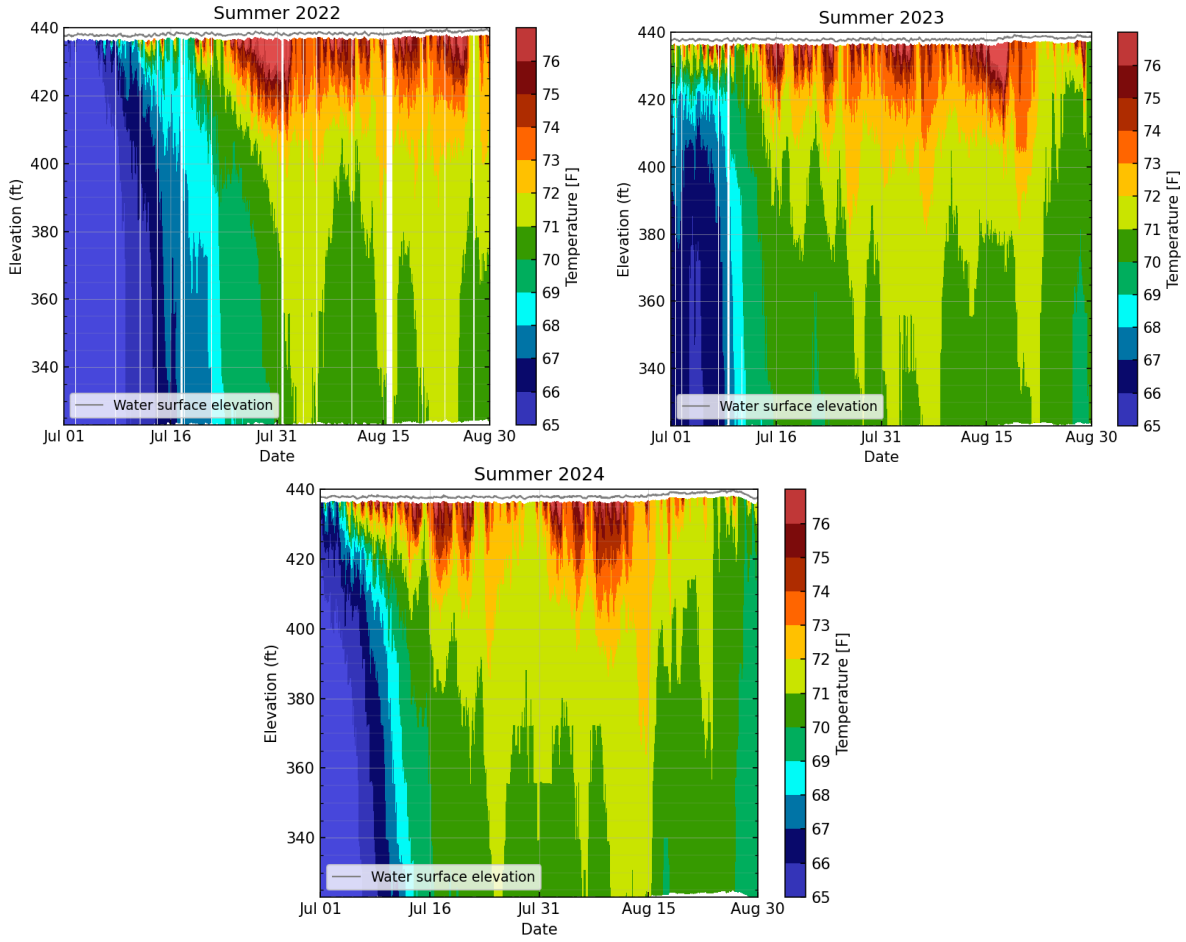


Figure 3-9. Ice Harbor. Temperature string data and hourly fishway data. Summer 2022, 2023, 2024.

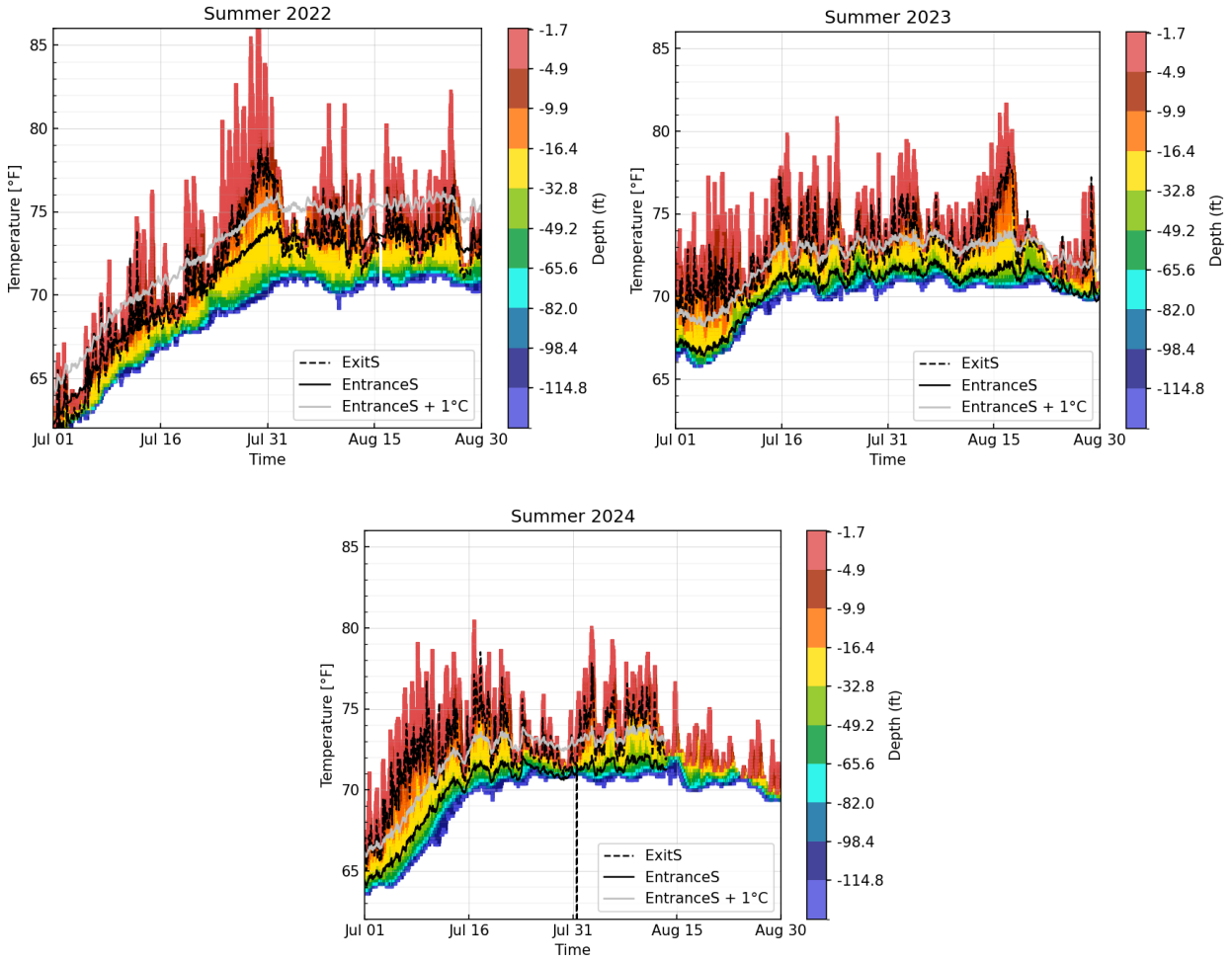


Figure 3-10. Ice Harbor. Temperature string data and hourly fishway data. Summer 2022, 2023, 2024.

3.3 McNary

Figure 3-11 presents a general site plan showing the locations of the temperature monitoring stations. The analysis focused on the data taken on the Oregon shore fish ladder, specifically at the Entrance (OR-Entrance), Exit (OR-Exit) and Diffuser (OR-Diffuser). Exit and Entrance temperatures are available from June to August 2022, and June 2023 to August 2024. Diffuser temperatures are only available from August 2023 to mid-August 2024. The temporal extent of the data is illustrated in Figure 3-12.

Figure 3-13 shows the frequency distribution of the temperature differences between monitoring stations for the summer months by year. The top panel presents box plots for the differences between Exit and Entrance (Exit-Entrance differentials), while the bottom panel shows box plots for the differences between Diffuser and Entrance (Diffuser-Entrance differentials). The diffuser at McNary is different than the other projects in that it serves as attraction flow for the fish entrance that is coming from the forebay versus being fish ladder makeup water introduced just downstream of the fish exits. Exit-Entrance differentials are larger than Diffuser-Entrance differentials. In 2023 and 2024, approximately 25% of the Exit-Entrance differentials exceeded the 1 °C threshold. In contrast, none of the Diffuser-Entrance differentials surpassed this value, with a median difference below 0.25 °C.

Temperature string measurements in the forebay are available at 8 depths: 0.5, 1.5, 3, 5, 10, 15, 20 and 21 meters. Figure 3-14 shows temperature contours for the summer of 2022, 2023 and 2024, where depths have been converted to elevations using reservoir water level information available online. Normal reservoir levels fluctuate from elevation 337 to 340 feet (July through August).

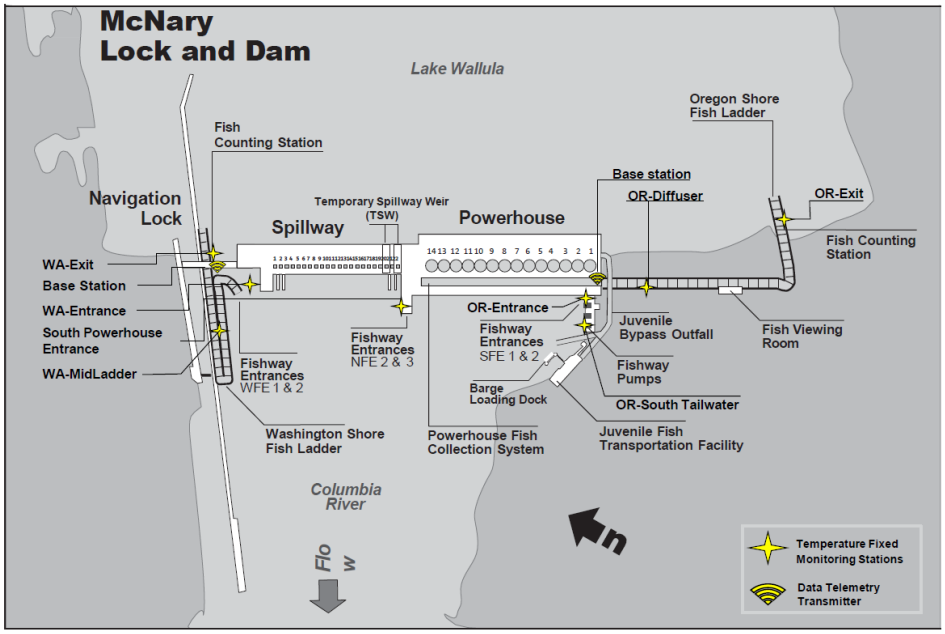


Figure 3-11. McNary. General Site plan and temperature monitoring stations. Source: USACE

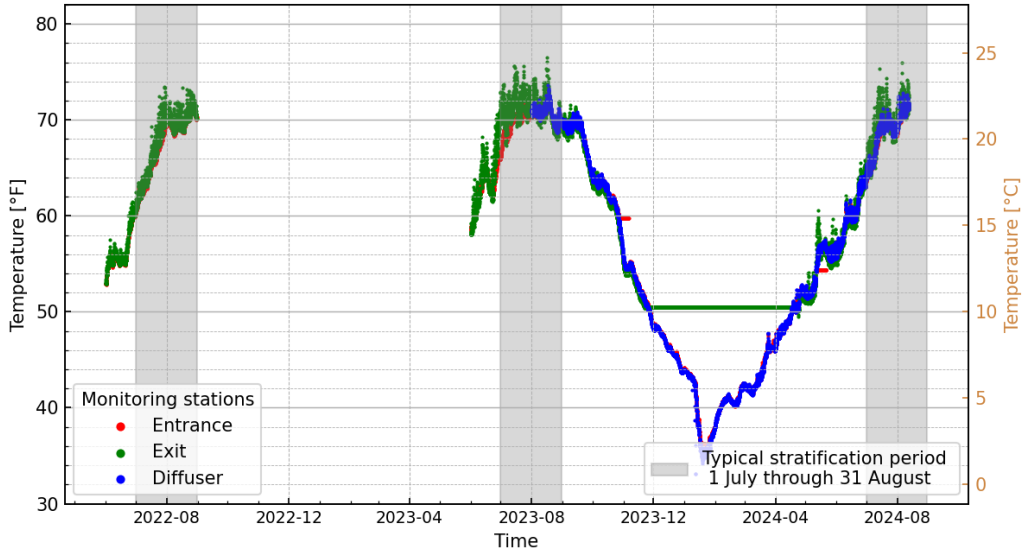


Figure 3-12. McNary. Oregon Shore fish Ladder data: 2022, 2023 and 2024.

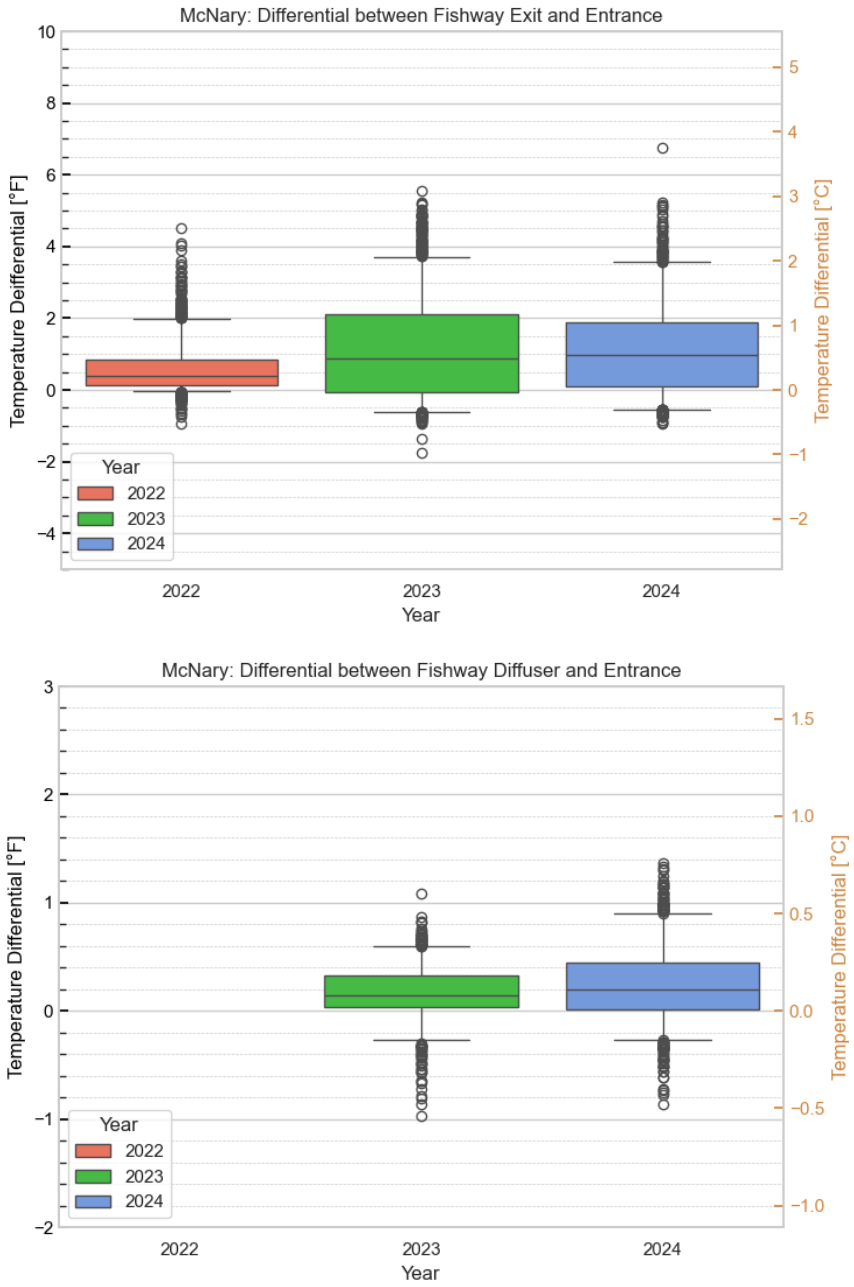


Figure 3-13. McNary. Frequency distribution of temperature differentials Exit-Entrance (top) and Diffuser-Entrance (bottom). Summer 2022, 2023 and 2024. Whiskers represent the 95% and 5% percentages of exceedance.

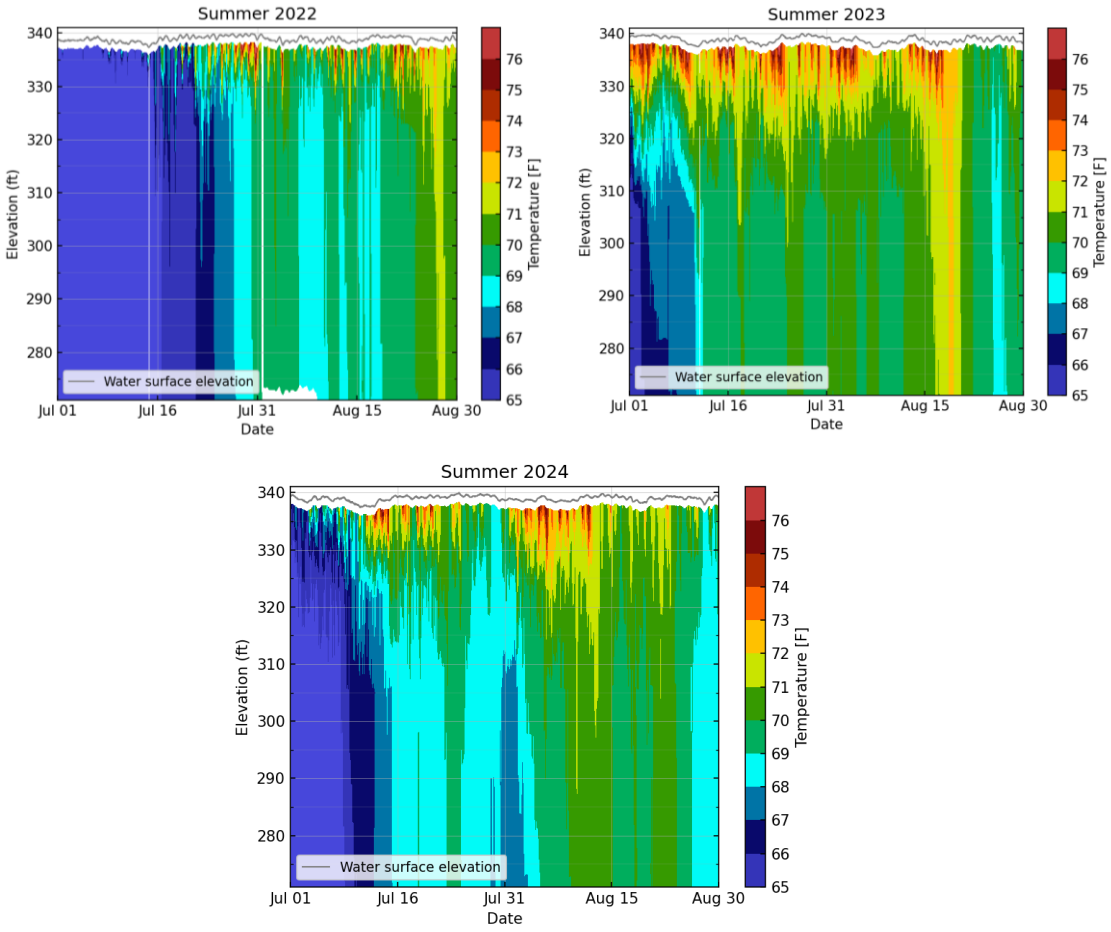


Figure 3-14. McNary. Temperature string data and hourly fishway data. Summer 2022, 2023, 2024.

3.4 John Day

The location of the temperature monitoring stations on the South fish ladder is indicated in Figure 3-15. For the analysis, the hourly temperature data was used from the Entrance and the Diffuser, collected during the summer months (July and August) of 2022, 2023 and 2024. Figure 3-16 illustrates the recorded temperatures and highlights the typical stratification period that served as the focus of the analysis.

The distribution of summer temperature differences between the Entrance and the Diffuser (Diffuser-Entrance differentials) is shown in Figure 3-17 using box plots. At least 75% of the observations fell below the 1 °C threshold, demonstrating similar behavior across all three years. The largest differentials (approximately 5% of the values) ranged from 3.5 °F to 6 °F.

Temperature string measurements in the forebay are available at 11 depths: 5, 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 feet. Contours illustrating the temperatures in the forebay for the summer (July and August) of 2022 are presented in Figure 3-18. Depths have been converted to elevations using reservoir level data available on the CROHMS website. Normal reservoir level elevations fluctuate between 263 and 265 feet (July through August).

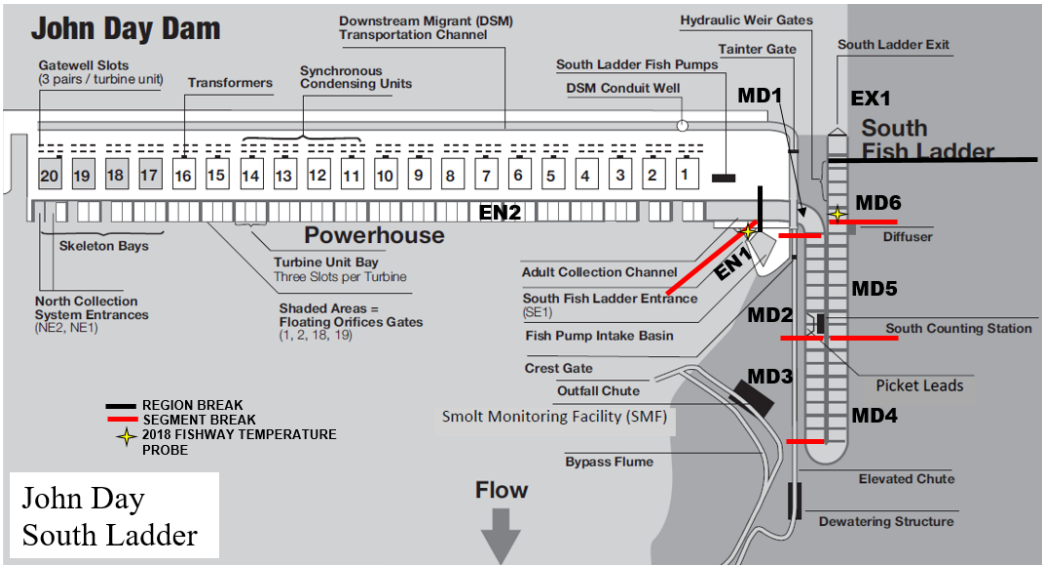


Figure 3-15. John Day. General Site plan and temperature monitoring stations. Source: USACE

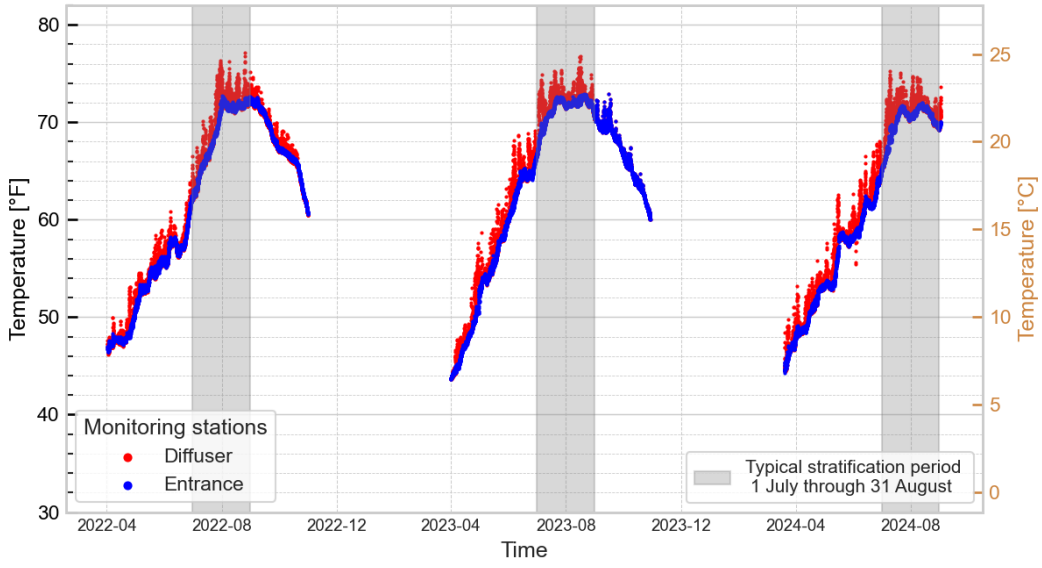


Figure 3-16. John Day. South fish Ladder data: 2022, 2023 and 2024

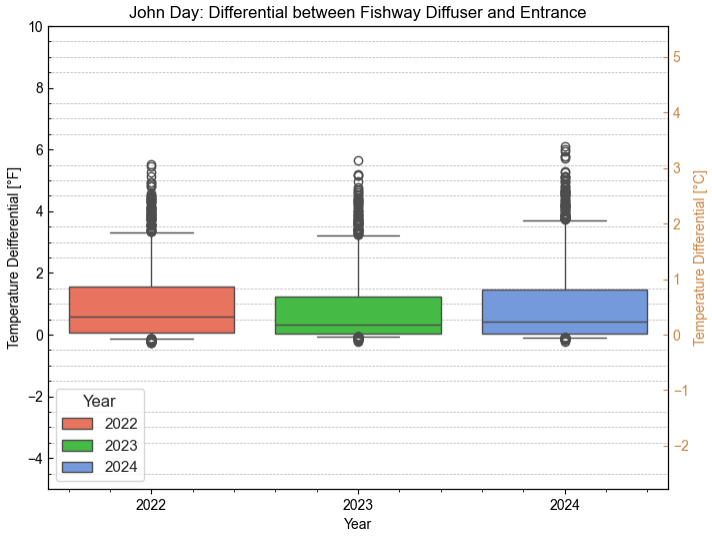


Figure 3-17. John Day. Frequency distribution of temperature differentials Exit-Entrance. Summer 2022, 2023, 2024. Whiskers represent the 95% and 5% percentages of exceedance.

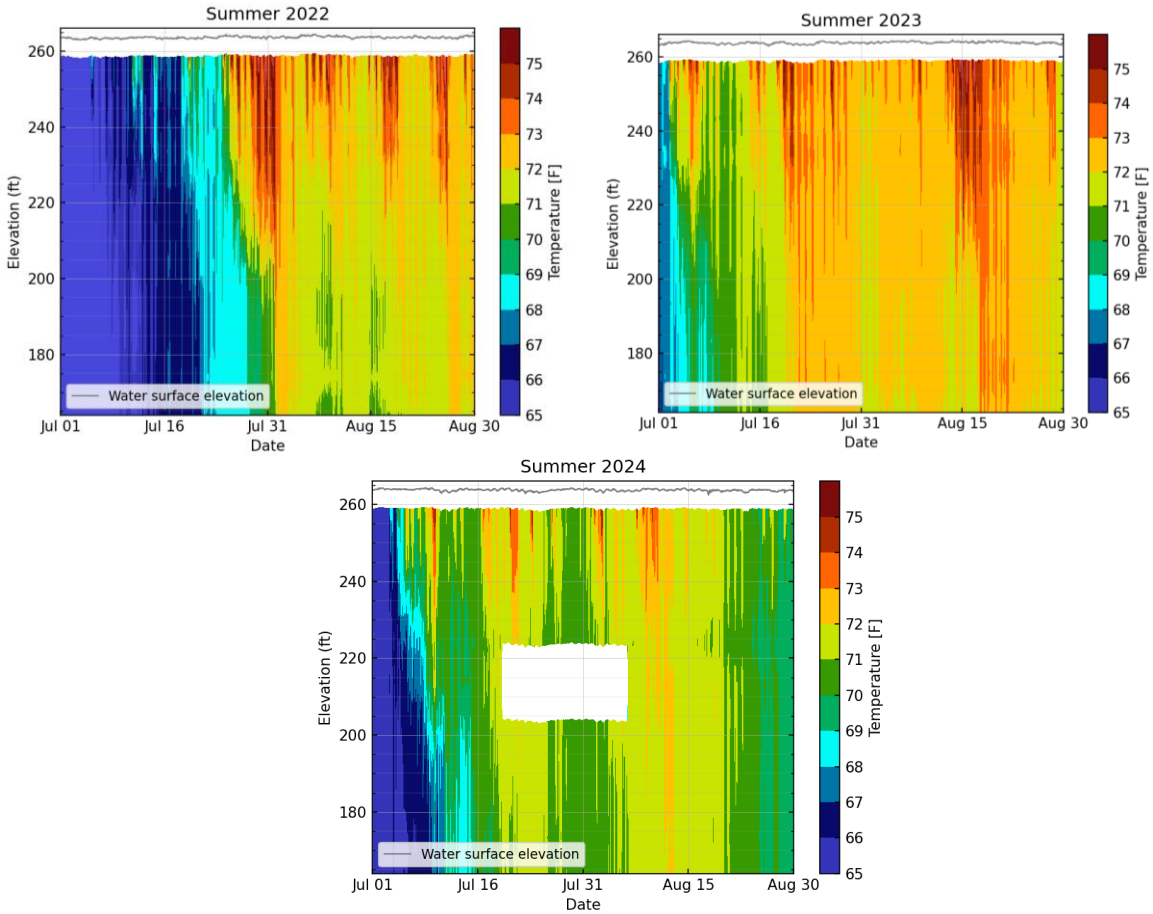


Figure 3-18. John Day. Temperature string data and hourly fishway data. Summer 2022, 2023, 2024.

4. Results

Following the classification of Exit-Entrance temperature differentials into Extreme, Moderate and Normal categories by year, the corresponding forebay temperatures were extracted for each classification. Exceedance curves of temperature differentials for each site are presented below, accompanied by a summary of forebay temperatures by category, with emphasis on the year showing the highest Exit-Entrance differentials at each site. The years with highest differentials were 2022 at Lower Monumental, 2024 at Ice Harbor, 2023 at McNary, and 2024 at John Day.

Figure 4-1 summarizes the temperature differentials by site. Values are reported for the year in which the largest differentials occurred within the analysis period (2022, 2023, 2024).

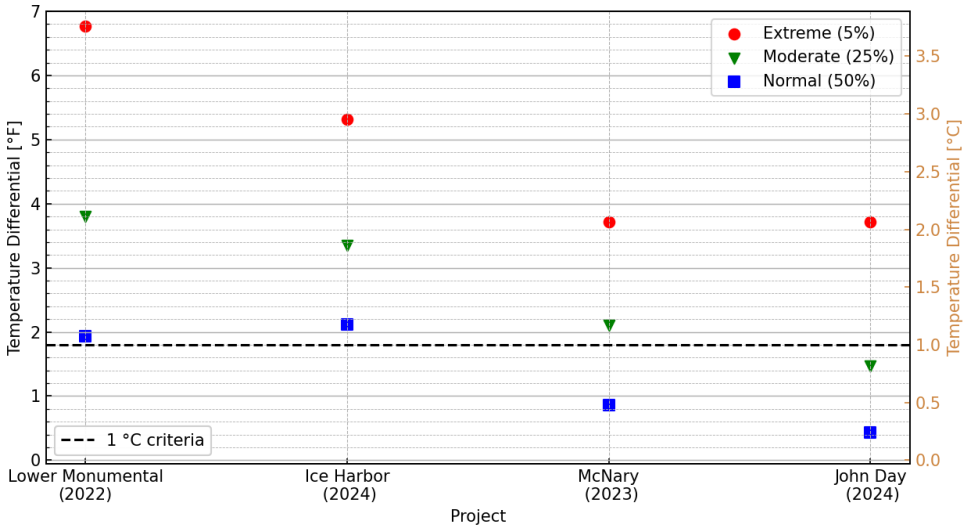
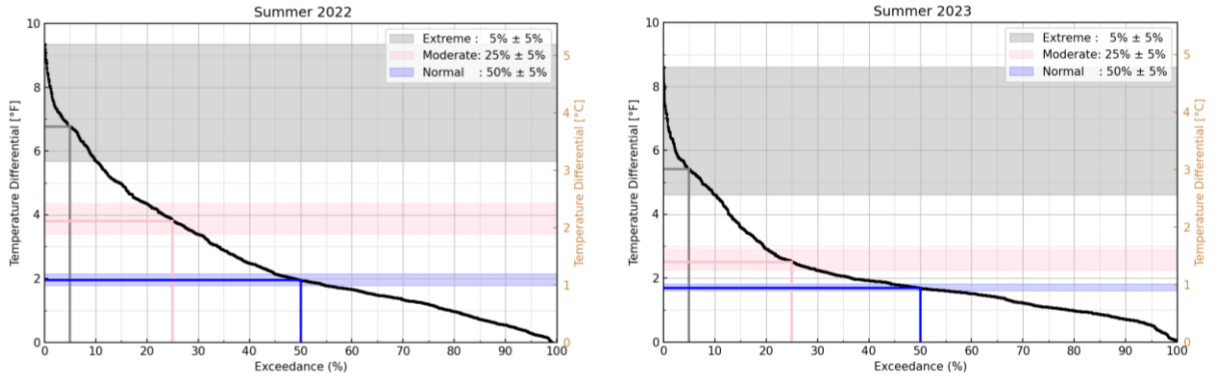


Figure 4-1. Temperature differentials for the year with the highest values at each site within the analysis period.

4.1 Lower Monumental

Figure 4-2 shows the exceedance curve of temperature differentials for the summers of 2022, 2023 and 2024, indicating the regions classified as Extreme, Moderate and Normal for each year. At Lower Monumental, the largest Exit-Entrance differentials are observed in 2022. Table 4-1 presents the 2022 temperature information by category and location.



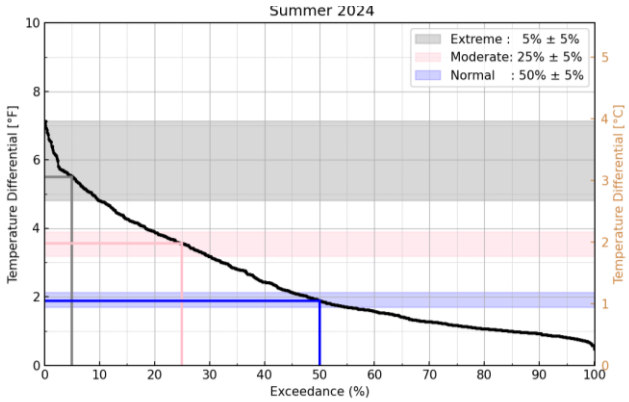


Figure 4-2. Lower Monumental exceedance curves of temperature differentials for the summers of 2022, 2023, 2024.

Table 4-1. Lower Monumental representative temperature information for Summer 2022 by category.

Location		Extreme [°F] 5% ±5%	Moderate [°F] 25% ±5%	Normal [°F] 50% ±5%
Fish ladder	Entrance	69.6	69.5	68.0
	Exit	76.3	73.2	69.9
	Exit-Entrance	6.7	3.7	1.9
Forebay, depth:	0.5 m (1.64 ft)	77.3	74.0	70.8
	1.5 m (4.92 ft)	75.9	73.4	70.6
	3 m (9.84 ft)	73.9	72.5	70.2
	5 m (16.4 ft)	72.1	71.5	70.0
	10 m (32.81 ft)	70.7	70.5	68.6
	15 m (49.21 ft)	69.6	69.5	68.1
	20 m (65.62 ft)	69.3	69.0	67.7
	25 m (82.02 ft)	69.0	68.7	67.3
	30 m (98.43 ft)	68.7	68.5	67.0
	35 m (114.83 ft	68.3	68.4	66.3

4.2 Ice Harbor

The exceedance curve of summer temperature differentials is presented in Figure 4-3 for 2022, 2023 and 2024. At Ice Harbor, the largest Exit-Entrance differentials were measured in 2024. Table 4-2 lists the 2024 temperature information by category and location.

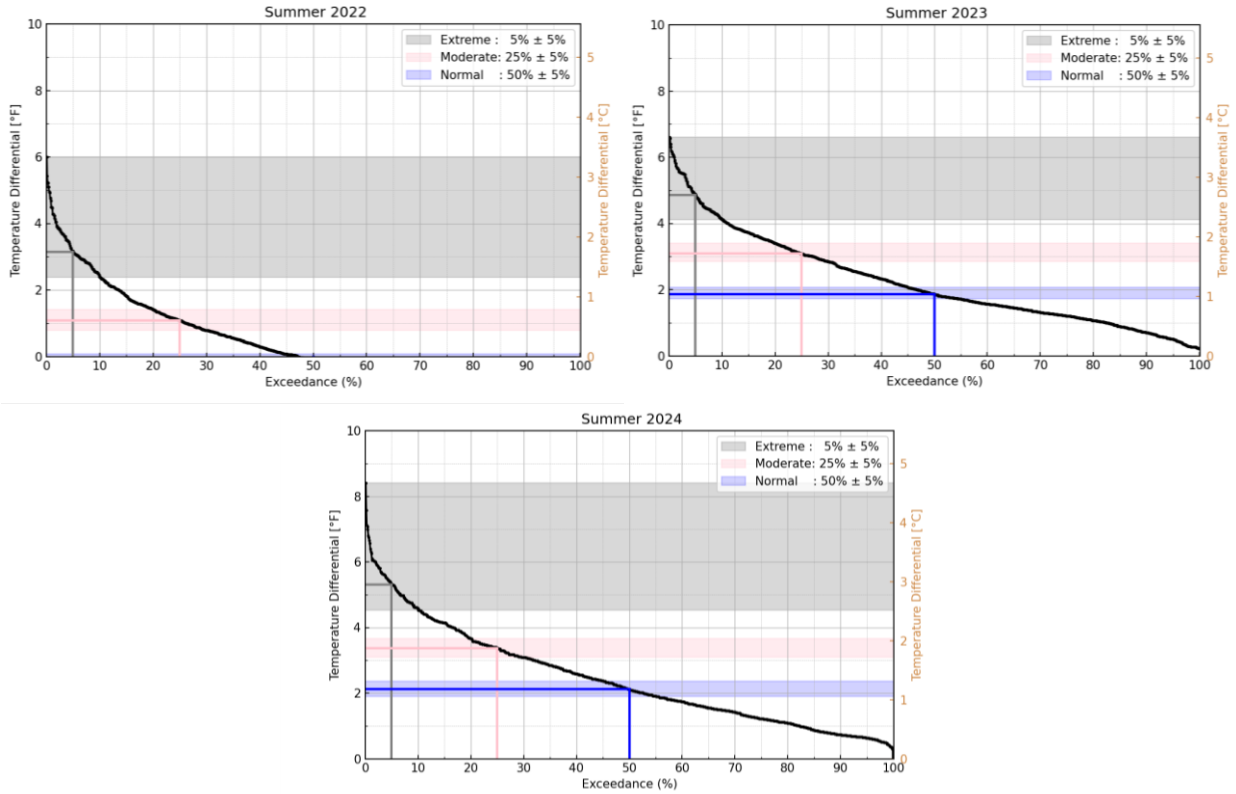


Figure 4-3. Ice Harbor exceedance curves of temperature differentials for the summers of 2022, 2023, 2024.

Table 4-2. Ice Harbor representative temperature information for Summer 2024 by category.

Location		Extreme [°F] 5% ±5%	Moderate [°F] 25% ±5%	Normal [°F] 50% ±5%
Fish ladder	Entrance	67.6	71.5	71.1
	Exit	73.2	74.9	73.2
	Exit-Entrance	5.6	3.4	2.1
Forebay, depth:	0.5 m (1.64 ft)	74.7	75.7	74.3
	1.5 m (4.92 ft)	72.8	75.0	73.4
	3 m (9.84 ft)	71.3	74.3	72.7
	5 m (16.4 ft)	69.8	73.0	72.1
	10 m (32.81 ft)	67.6	71.6	71.4
	15 m (49.21 ft)	67.0	71.1	71.0
	20 m (65.62 ft)	66.6	70.9	70.7
	25 m (82.02 ft)	66.2	70.7	70.6

Location		Extreme [°F] 5% ±5%	Moderate [°F] 25% ±5%	Normal [°F] 50% ±5%
	30 m (98.43 ft)	66.1	70.6	70.5
	35 m (114.83 ft	65.9	70.5	70.0

4.3 McNary

Figure 4-4 illustrates the exceedance curve of temperature differentials for the summer of 2022, 2023 and 2024. The differentials classified as Extreme, Moderate and Normal are highlighted in each case. At McNary, the largest Exit-Entrance differentials are observed in 2023. Table 4-3 summarizes the 2023 temperature information by category and location.

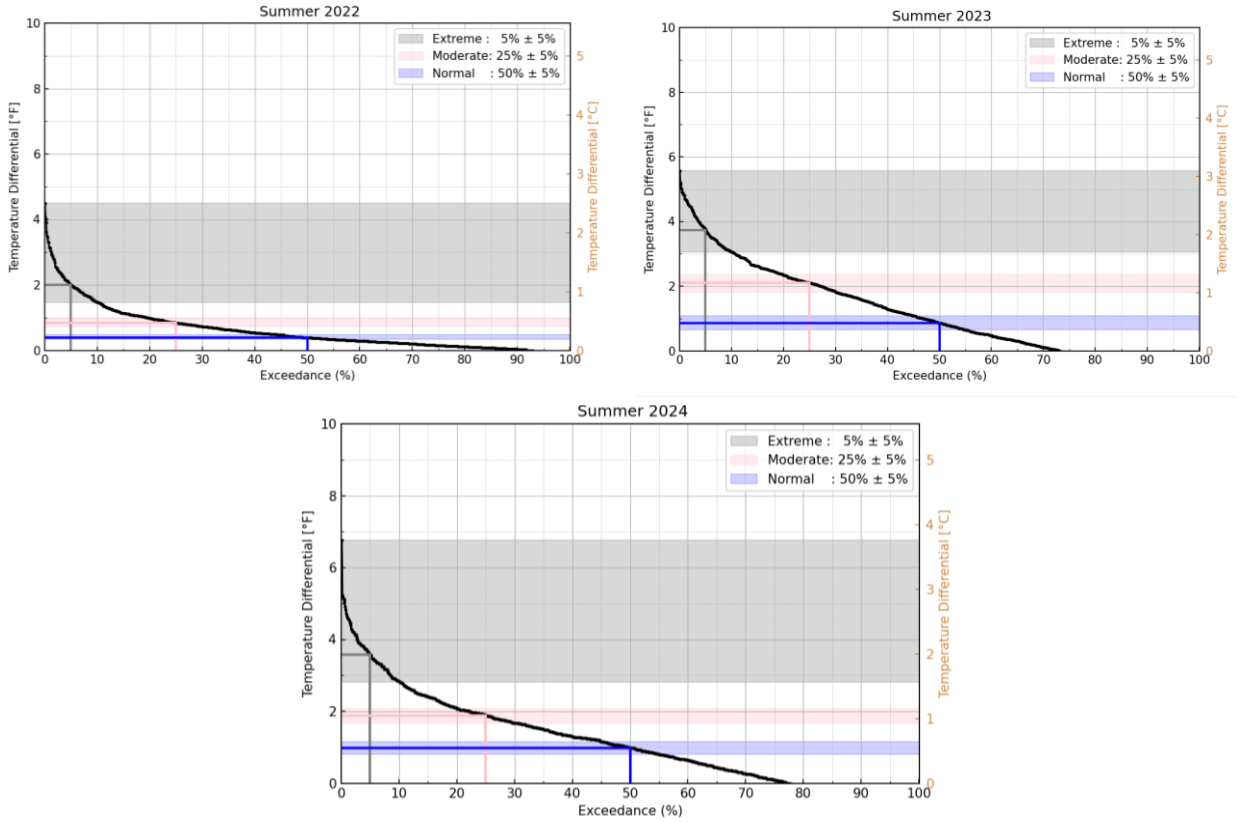


Figure 4-4. McNary exceedance curves of temperature differentials for the summers of 2022, 2023, 2024.

Table 4-3. McNary representative temperature information for Summer 2023 by category.

Location		Extreme [°F] 5% ±5%	Moderate [°F] 25% ±5%	Normal [°F] 50% ±5%
Fish ladder	Entrance	68.6	70.3	70.4
	Exit	72.4	72.4	71.3
	Diffuser	71.4	71.3	70.8
	Exit-Entrance	3.8	2.1	0.9
Forebay, depth:	0.5 m (1.64 ft)	75.0	73.4	72.2
	1.5 m (4.92 ft)	73.2	72.5	71.6
	3 m (9.84 ft)	71.2	71.6	71.1
	5 m (16.4 ft)	69.6	70.5	70.3
	10 m (32.81 ft)	67.3	69.4	69.8
	15 m (49.21 ft)	67.3	69.4	70.0
	20 m (65.62 ft)	67.1	69.4	70.0
	21 m (68.9 ft)	67.1	69.3	69.8

4.4 John Day

Exceedance curves of temperature differentials for the summer of 2022, 2023 and 2024 are shown in Figure 4-5, highlighting the regions classified as Extreme, Moderate or Normal for each year. The largest Diffuser-Entrance differentials at John Day are observed in 2024. The 2024 temperature information are listed in Table 4-4 by category and location.

Table 4-4. John Day representative temperature information for Summer 2024 by category.

Location		Extreme [°F] 5% ±5%	Moderate [°F] 25% ±5%	Normal [°F] 50% ±5%
Fish ladder	Entrance	68.0	70.6	70.8
	Diffuser	71.8	72.2	71.2
	Diffuser-Entrance	3.8	1.6	0.4
Forebay, depth:	5 ft	71.8	72.0	71.2
	10 ft	71.4	71.8	71.2
	20 ft	70.8	71.6	71.2
	30 ft	70.2	71.3	71.1
	40 ft	69.4	71.0	70.9
	50 ft	68.1	70.4	70.7

Location		Extreme [°F] 5% ±5%	Moderate [°F] 25% ±5%	Normal [°F] 50% ±5%
	60 ft	67.2	70.7	71.0
	70 ft	66.8	70.4	70.8
	80 ft	66.7	70.3	70.7
	90 ft	66.6	70.15	70.6
	100 ft	66.5	70.15	70.6

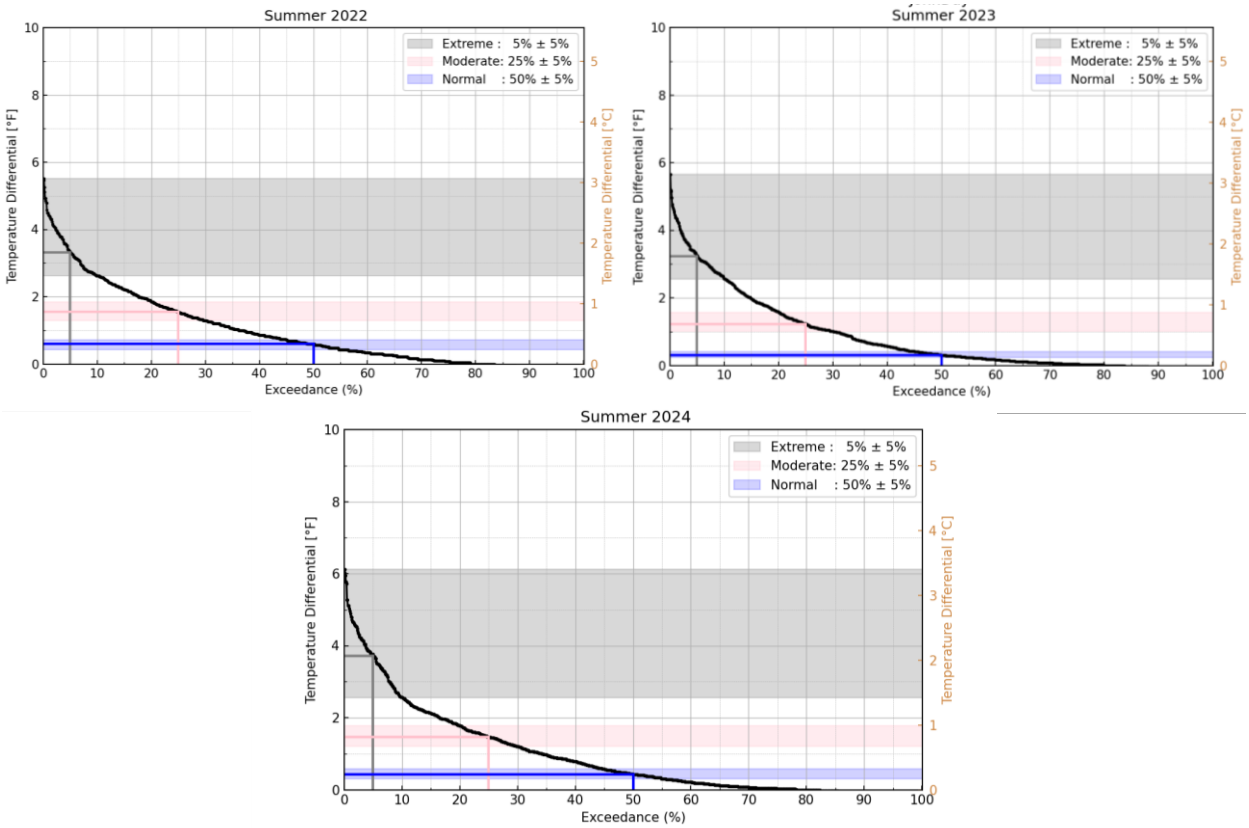


Figure 4-5. John Day exceedance curves of temperature differentials for the summers of 2022, 2023, 2024.

Appendix C. Brainstorming Workshop

Challenging today.
Reinventing tomorrow.

Fish Ladder Cooling Brainstorming Workshop

Lower Monumental | Ice Harbor | McNary | John Day

7 May 2025

Conformed presentation; Includes notes, updates and clarifications received during the workshop.

Agenda

Welcome and Introductions 8:00 – 8:30 PDT

- Culture of caring moment
- Meeting goals and objectives

Project Objectives and Evaluation Criteria 8:30 – 9:00

Basis of Design (LMN, HLD, MNA and JDA) 9:00 – 10:30

- Project configuration and operation; power availability
- Temperature data

Conceptual Alternatives 10:30 – 12:00

Lunch Break 12:00 – 12:30

Site-Specific Application of Alternatives 12:30 – 1:30

Evaluation of Alternatives 1:30 – 3:30

- Selection of preferred alternative by site

Summary and Wrap-Up 3:30 – 4:00

- Next steps and action items
- Project schedule

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List of Attendees

USACE
Ryan Ashcraft
Chuck Barnes
Amory Cervarich
Travis Foster
Bobby Johnson
Mark Jones
Ryan Laughery
Michael Lotspeich
Jake Macdonald
Ben McArthur
David Miller
Bennett Moore
Anthony O'Hare
Eli Stadnik
Tiffany Stoeckig-Dixon
Bryce Thompson
Lisa Wright
Karen Zelch

Jacobs
Ralph Field
Ken Hansen
Brian Hansen (Anderson Perry)
Eric Higgins (360 Cost Consulting)
Kashifa Kabeer
James Kapla
Randy Kirchner (360 Cost Consulting)
Mark Parent
James Teeter
Russell Prentice (360 Cost Consulting)

Partners
Carolina Andes/ BPA
Paula Calvert/ BPA
Darren Chase/ PSMFC
Trevor Conder/ NOAA Fisheries
Erin Cooper/ FPC
Jay Hesse/ Nez Perce Tribe
Mark Leonard/ PSMFC
Tom Lorz/ CRITFC
Tammy Mackey/ BPA
Emi Melton/ NOAA Fisheries
Charles Morrill/ WDFW
Christine Peterson/ BPA
Thomas Starkey-Owens/ WA DOE
David Swank/ FWS
Kelsey Swieca/ NOAA Fisheries

Unknown
19712667553
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15095923331
13605133725
15037166598
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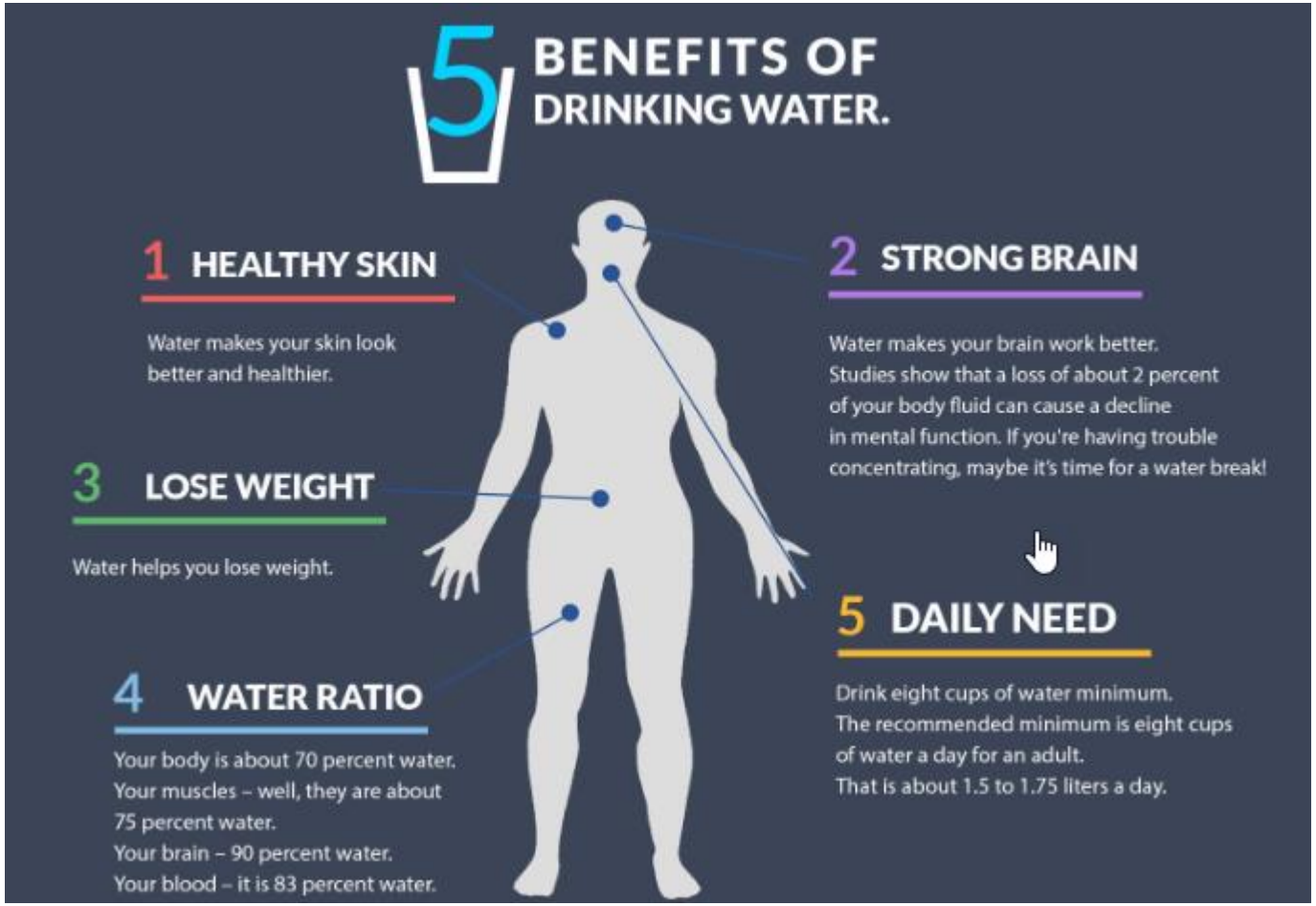
19714690784

Welcome and Introductions – Culture of Caring Moment

Tips to stay hydrated

- Hydrate throughout the day
- Know the signs of dehydration
- Check urine color
- Consider avoiding diuretics
- Cool down to avoid losing fluids
- Eat fruits and vegetables
- Replenish when you sweat
- Choose water during flights
- Infuse with flavor and electrolytes



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Welcome and Introductions – Meeting Goals and Objectives

- Discuss project objectives and confirm evaluation criteria.
- Identify site-specific design and operational considerations.
- Discuss pros and cons of each conceptual alternative.
- Rank alternatives utilizing the evaluation criteria.
- Select a preferred alternative for each site for further evaluation.

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Project Objectives and Evaluation Criteria

Project Objectives

Reservoir thermoclines exist annually during August and September. Adult salmonids ascending the fishways during these periods can experience thermal differentials causing passage delay or blockage.

The objective of this project is to reduce temperature differentials between the forebay exit and tailrace entrance to no more than 1°C.

The existing fishway cooling system at Lower Granite is typically started up when temperatures reach 20-22 degrees C (68.0-71.6 degrees F). Little Goose is started up at 17.8 degrees C (64 degrees F). Temperatures are based on the forebay thermistor string readings at a depth of 0.5m.

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Project Objectives (continued)

Other objectives include the following:

- Extend cooler water into the forebay near the fishway exit to reduce holding.
- Match fishway and adult fish trap water supply temperatures.
- Do not limit fishway operations or effectiveness, including juvenile fishways.
- Maintain or improve hydraulic conditions per NMFS, 2022.
- Operate within normal forebay and tailwater elevations.
- Minimize interruptions to hydropower project operations.
- Minimize O&M costs.
- System shall be oil free, or use an EAL.
- Concepts shall be designed in consideration of typical hydraulic, structural, mechanical, electrical and I&C engineering requirements.

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Evaluation Criteria

Evaluation Criteria	Description
Thermal Performance in Ladder	Ability to provide safe, timely and effective passage in fishway.
Thermal Performance at Exit	Ability to provide safe, timely and effective passage from fishway exit into reservoir.
Fish Behavior (Other)	Other impacts to fish behavior as a result of the alternative, including hydraulics (flow, velocity and vectors), bubbles, TDG, pump vibration, crowding, etc.
Operational Flexibility and Reliability	Precedence for selected technology, ability to accommodate off-season operations, and flexibility for changing future conditions.
Impacts/Risks to Project Operations	Anticipated impacts or risks to project generation and other authorized purposes.
Capital Cost	Relative capital construction cost, including length of implementation schedule.
O&M Cost	Relative O&M cost, including labor, equipment maintenance and power costs.

Pump reliability has been an issue for the existing fishway cooling system at Little Goose. Frequency of maintenance should be considered for any electrical/mechanical solutions.

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Basis of Design

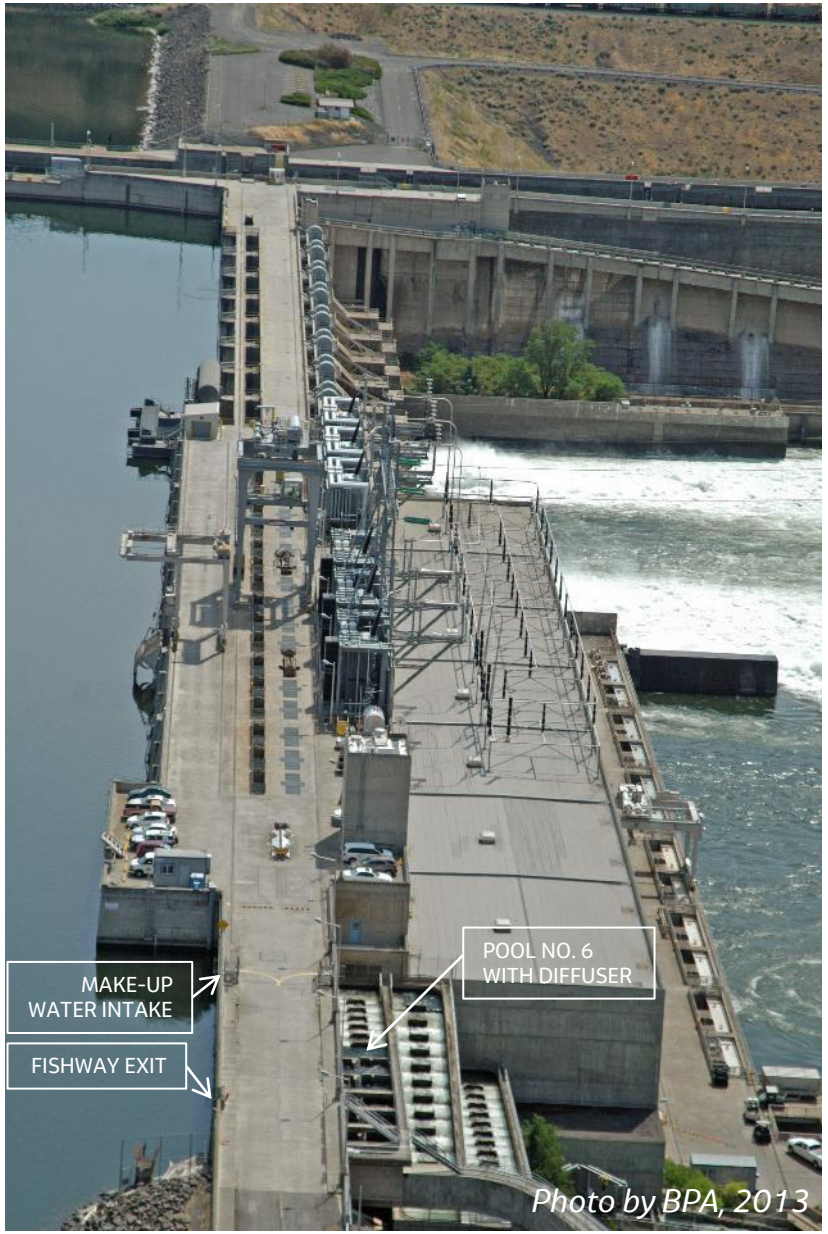
Lower Monumental | Ice Harbor | McNary | John Day

Basis of Design – Lower Monumental

Basis of Design – Lower Monumental

Fishway Exit

Pool No. 6
with Diffuser



North Shore Ladder

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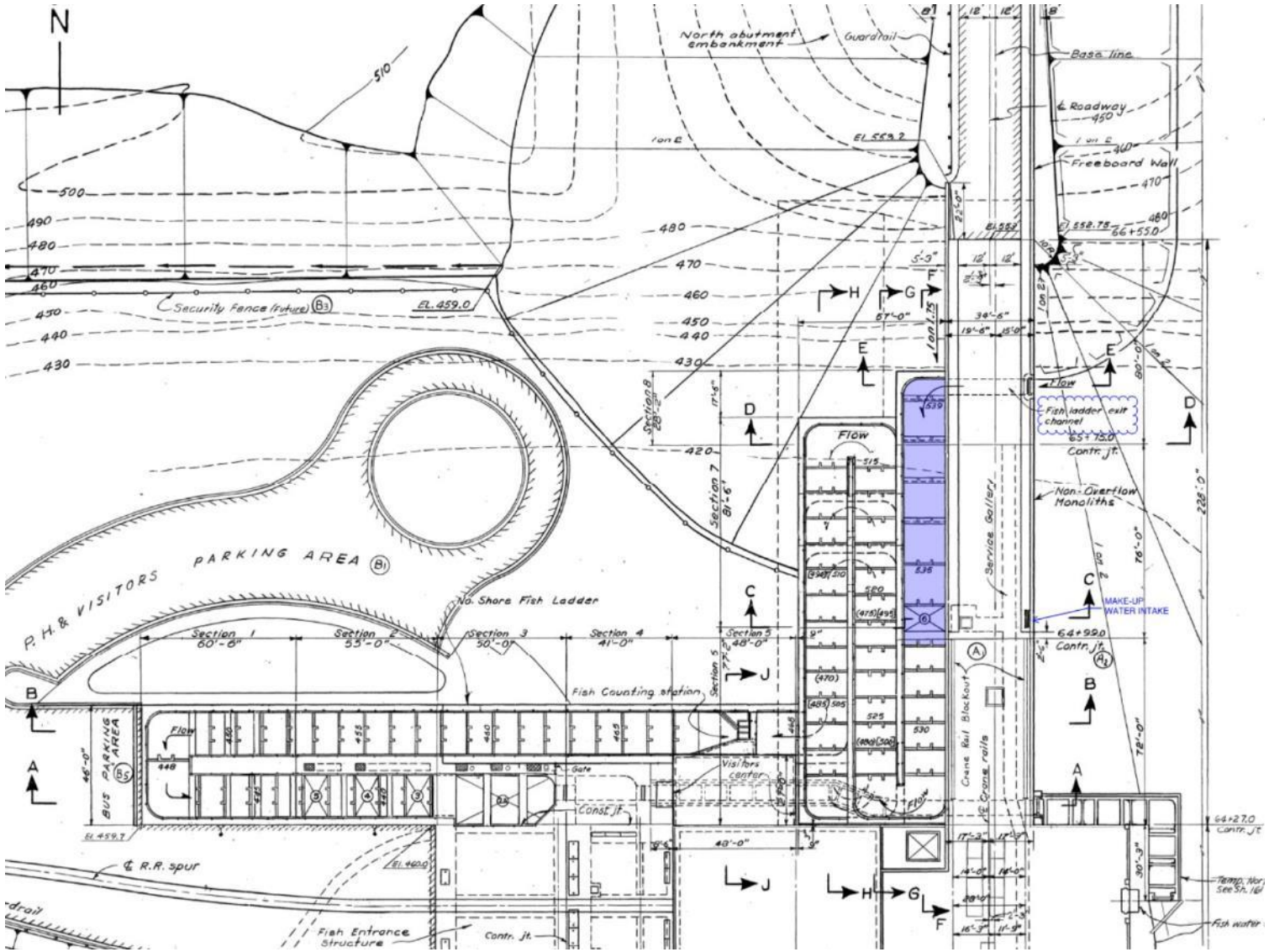
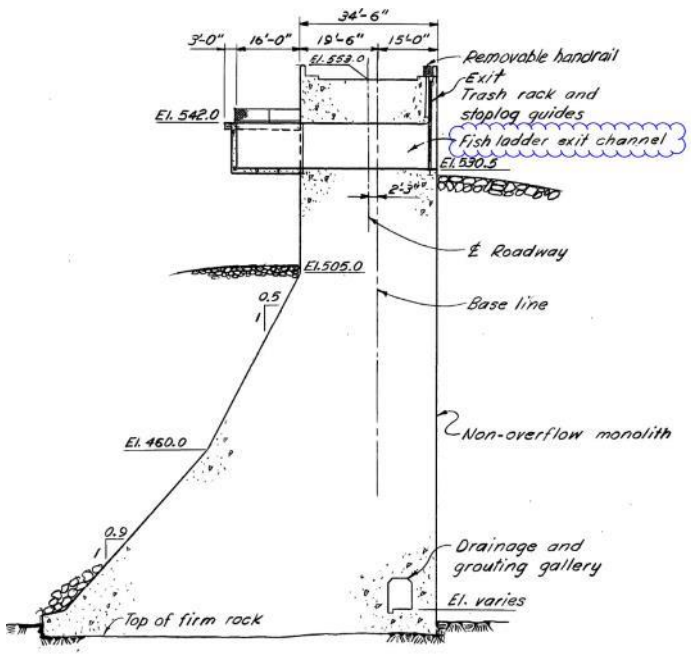
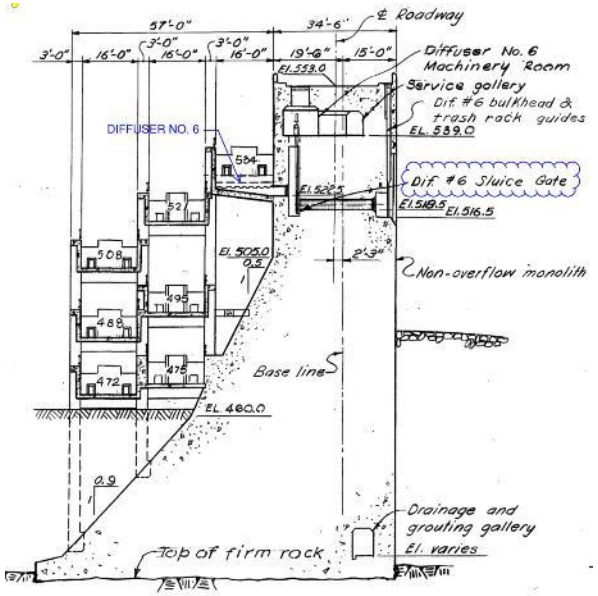
Basis of Design – Lower Monumental





SECTION E-E



SECTION C-C

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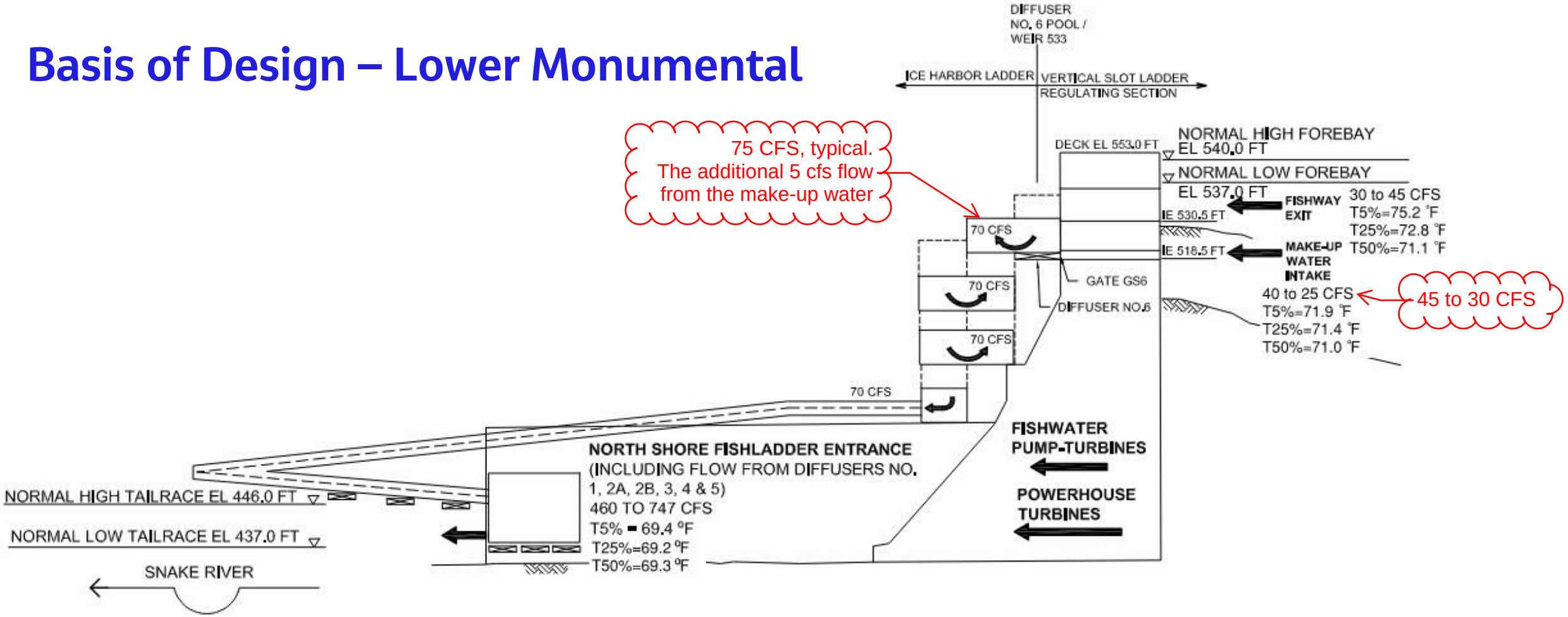
Basis of Design – Lower Monumental



PROCESS FLOW DIAGRAM
N.T.S

NOTE: Forebay elevations, fishway flows and temperatures are typical for the July through August time period.

Basis of Design – Lower Monumental

Key Considerations

- A debris boom protects the fishway exit area.
- The elevation of the rip rap embankment is very close to the fishway exit invert elevation at 530.5 feet. This results in a minimum water depth of 6.5 feet. The embankment slopes towards the make-up water intake at 1V:2H.
- The fishway regulating section includes vertical slot openings with a sill, a rectangular orifice and another opening for lamprey.
- Gate GS6 is operated to provide water to Diffuser No. 6 to maintain ~~12 inches~~ of head on the downstream weirs, with a flow of approximately ~~70 cfs~~.
- The lower fishway is an Ice Harbor-type ladder on a 1V:10H slope.

1.1 to 1.3 feet (13 to 16 inches)

75 cfs at 13 inches.

A hydraulic head of 1.1 to 1.3 feet (13 to 16 inches) is typically maintained during May and June (shad criteria), The flow is approximately 75 cfs at 1.1 feet. For the purposes of this Study, thermal performance will be evaluated at 1.1 feet and hydraulic performance will be evaluated at 1.3 feet with a peak flow to be determined.

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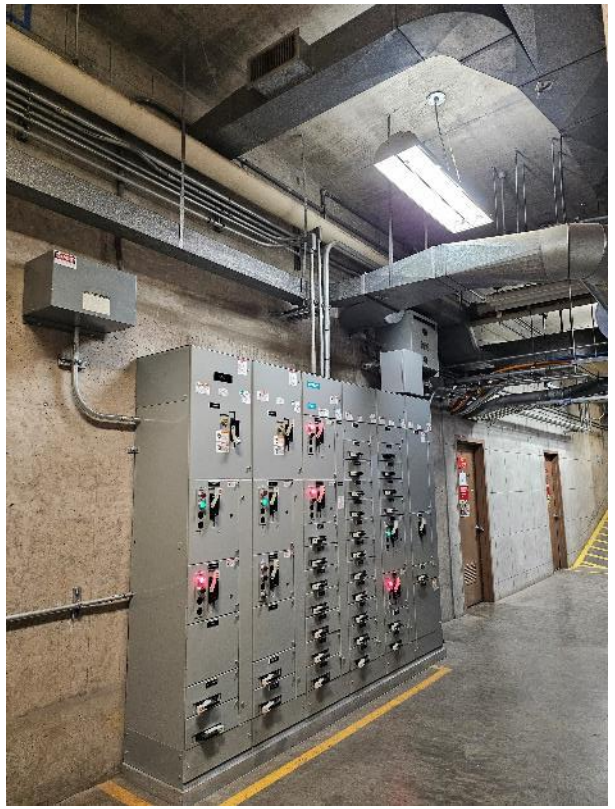
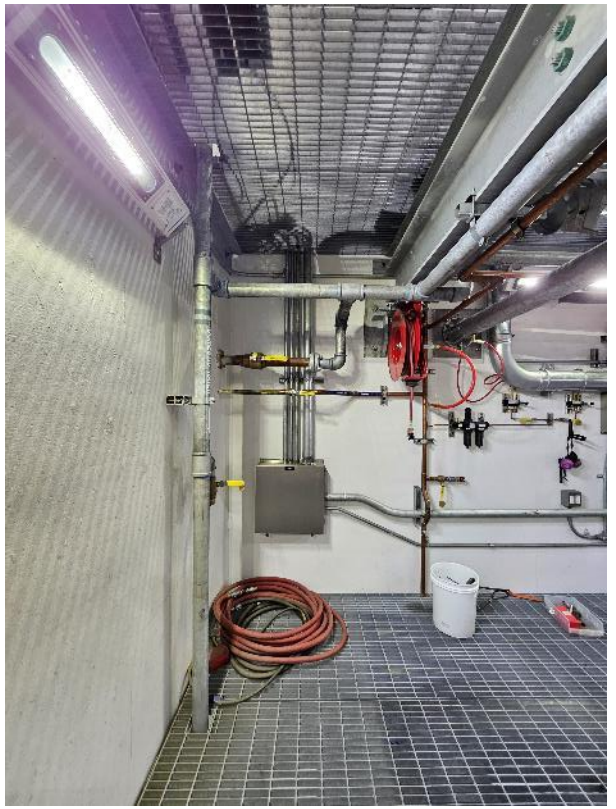
Basis of Design – Lower Monumental

Power Availability

- Per site investigation and conversations on site, existing electrical equipment that could be used to feed the new loads: Motor Control Center (MCC) “CQO4” located on level 7.
- This is a Siemens 480V, 600A MCC which has two spaces.
- The conduits from this MCC then go up to a junction box “JB-1” on level 8 and then up to level 9.

A separate HVAC project is planned for LMN.





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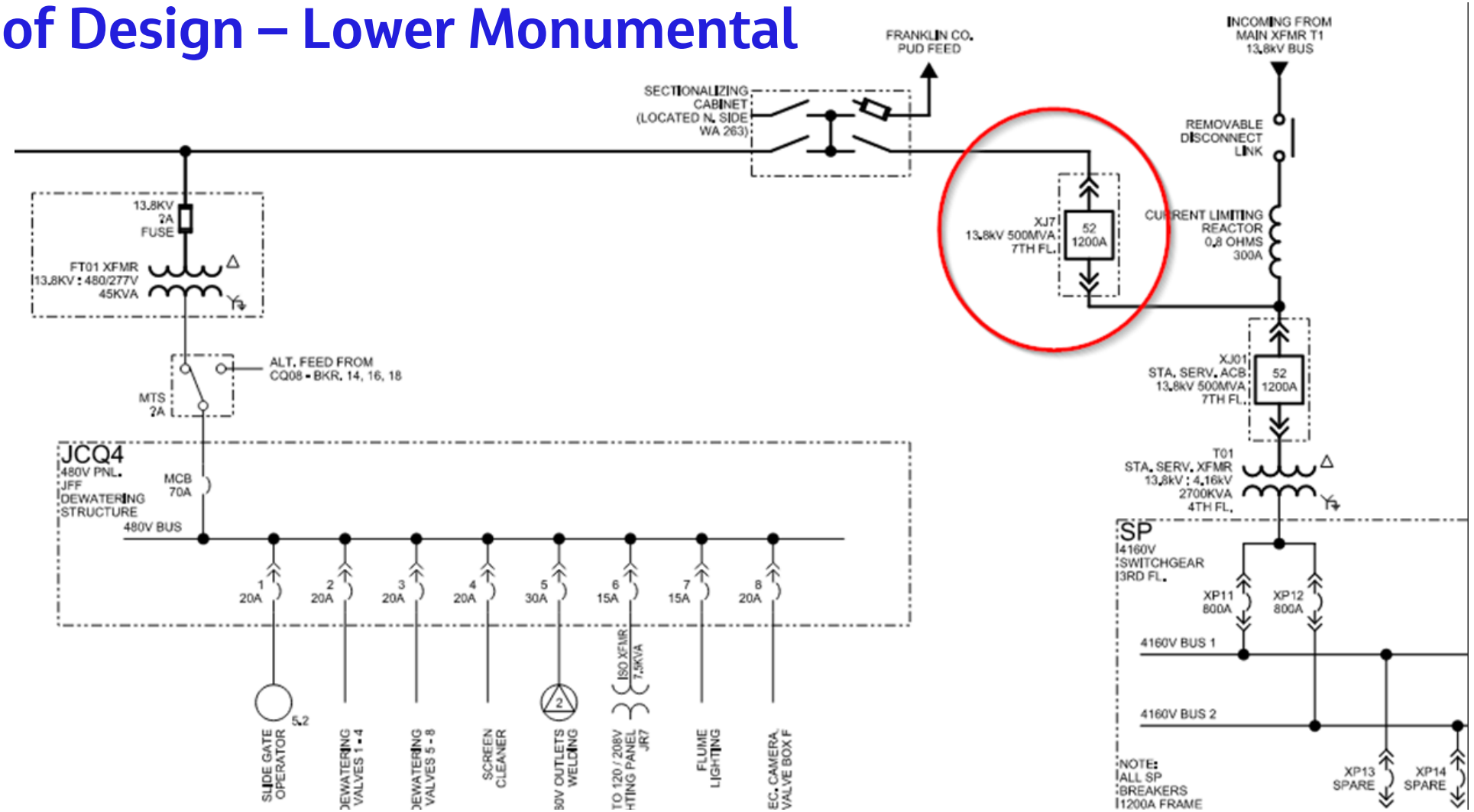
Basis of Design – Lower Monumental



Partial One-Line Diagram

Per info received from USACE, power source for new equipment could be transformer "XJ7".

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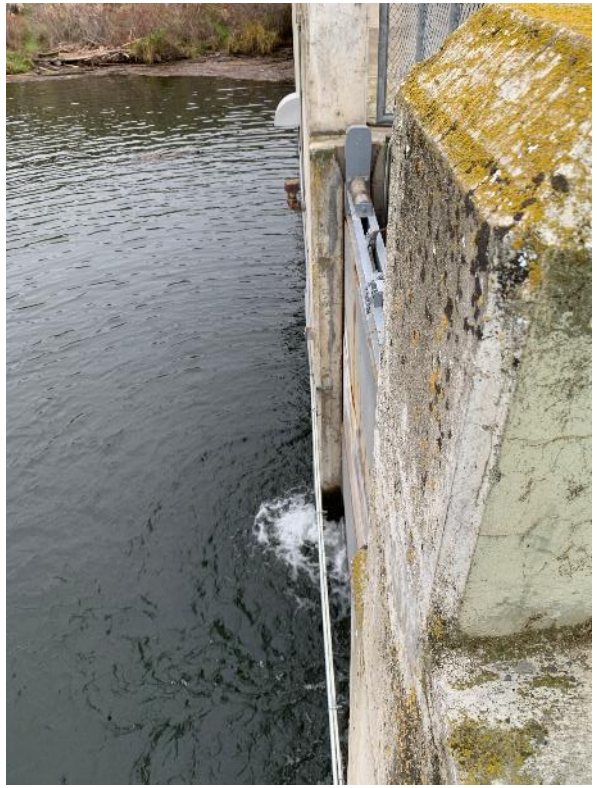
Basis of Design – Ice Harbor

Basis of Design – Ice Harbor



Fishway Exit

Fishway Exit Channel

Regulating Section

South Shore Ladder

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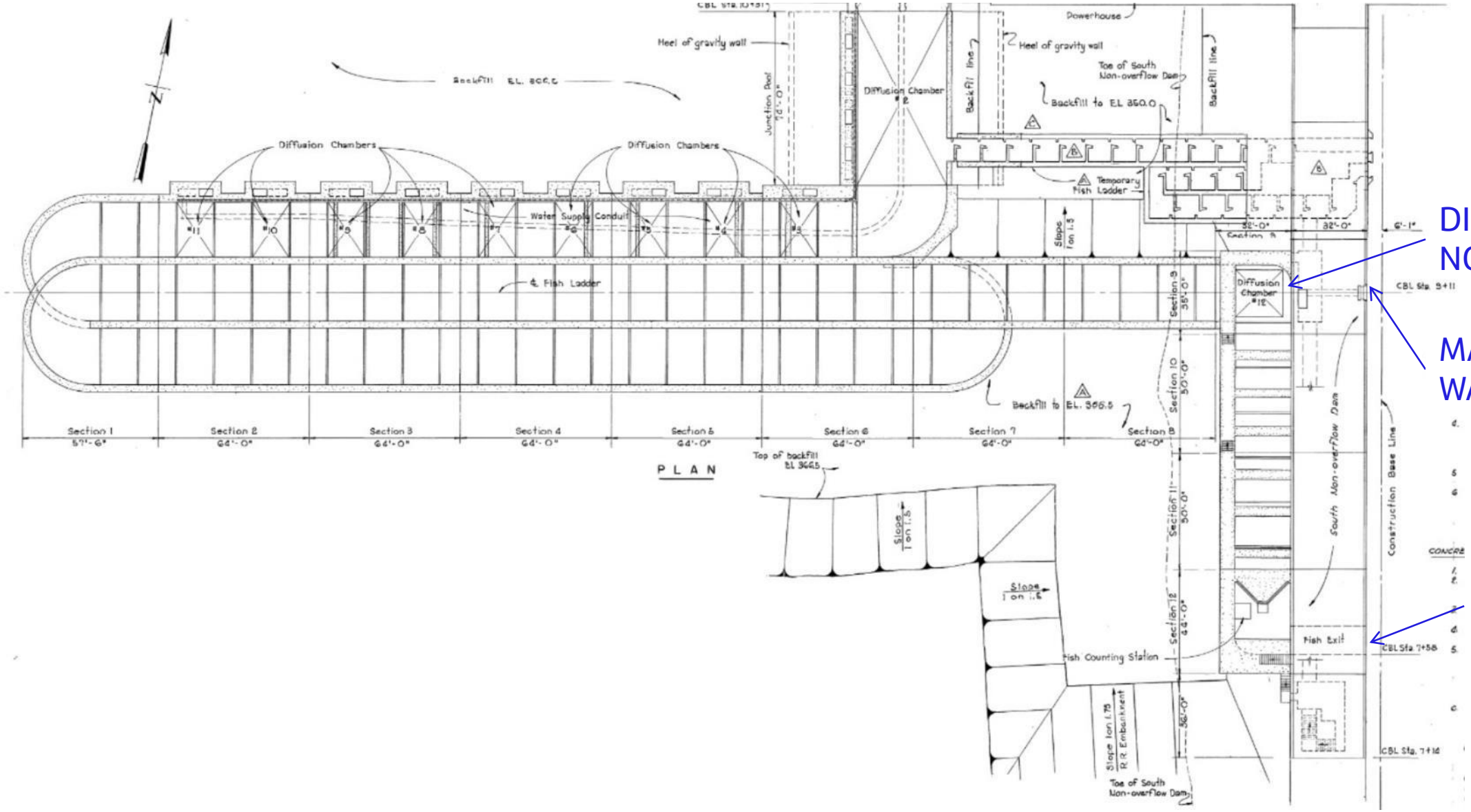
Basis of Design – Ice Harbor



DIFFUSER NO. 12

MAKE-UP WATER INTAKE

FISHWAY EXIT

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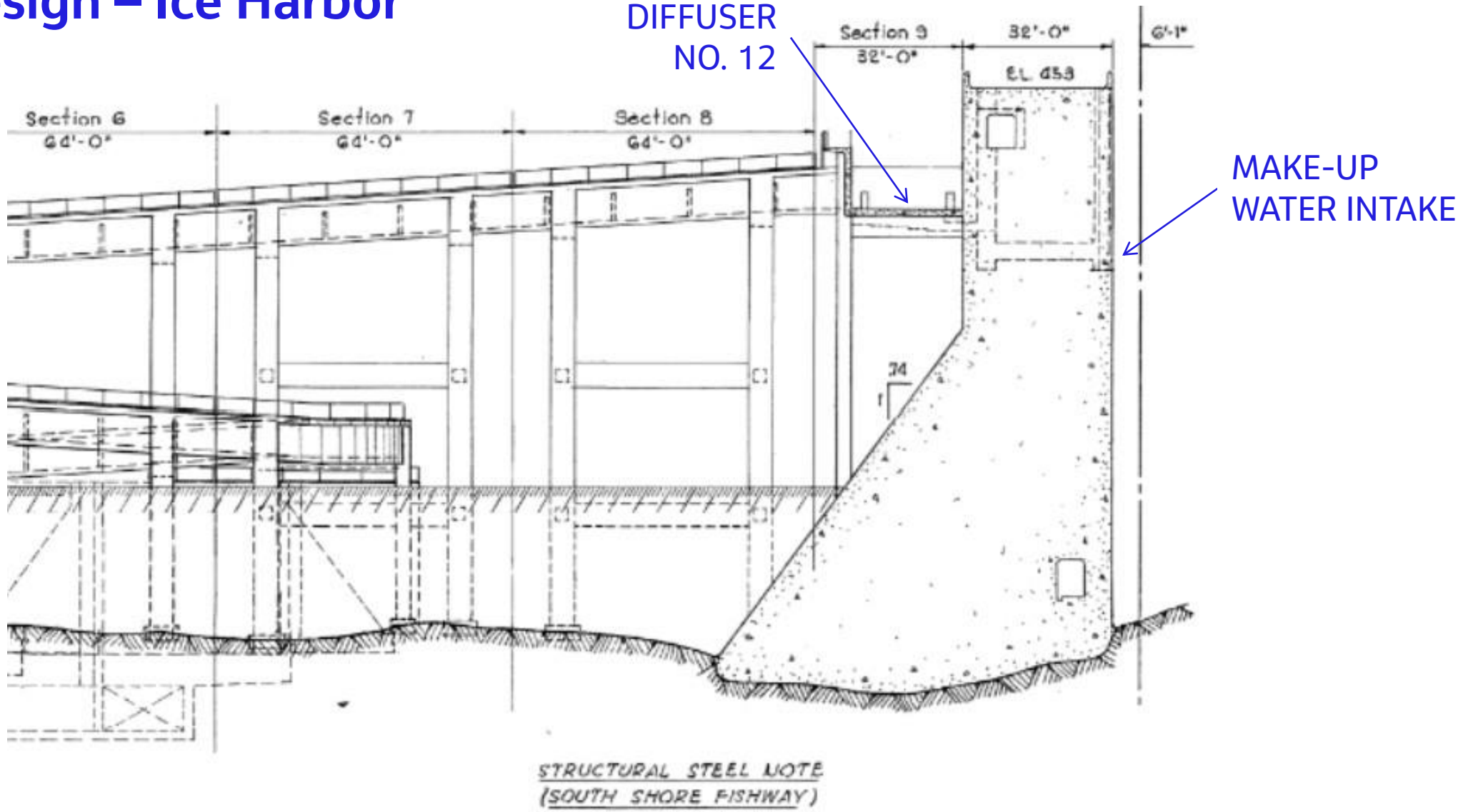
Basis of Design – Ice Harbor



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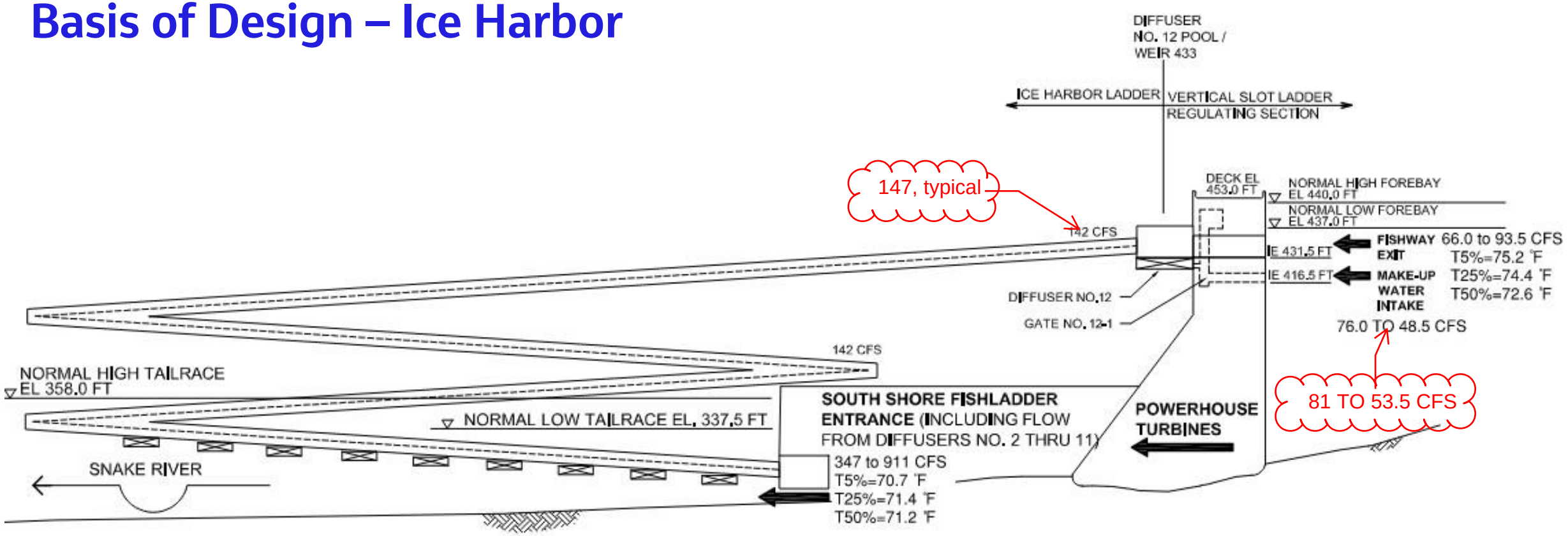
Basis of Design – Ice Harbor



PROCESS FLOW DIAGRAM
N.T.S

NOTE: Forebay elevations, fishway flows and temperatures are typical for the July through August time period.

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Basis of Design – Ice Harbor

Key Considerations

- Bubblers are used at the fishway exit to exclude debris.
- The exit channel is 12 feet wide and associated transport velocities may be low.
- The fishway regulating section includes vertical slot openings with a sill and a rectangular orifice.
- Gate 12-1 is operated to provide water to Diffuser No. 12 to maintain ~~10–12 inches~~ 1.0 to 1.3 feet (12 to 16 inches) of head on the downstream weirs, ~~with a flow of approximately 142 cfs (or~~ 13 inches with a flow of approximately 147 cfs~~)~~.
- The lower fishway is an Ice Harbor-type ladder on a 1V:10H slope.

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Basis of Design – Ice Harbor

Power Availability

- Per site investigation and conversations on site, existing electrical equipment that could be used to feed the new loads: Motor Control Center (MCC) “FCQ3”. It is located on level 7.5.
- It is a Westinghouse 480V MCC with a 225A main feeder breaker with 2 spares.
- Option 2: MCC “CQ08”, Westinghouse 480V with a 400A main breaker and a space.

A separate HVAC and Life Safety project is planned for HLD.
No existing breakers will be utilized.

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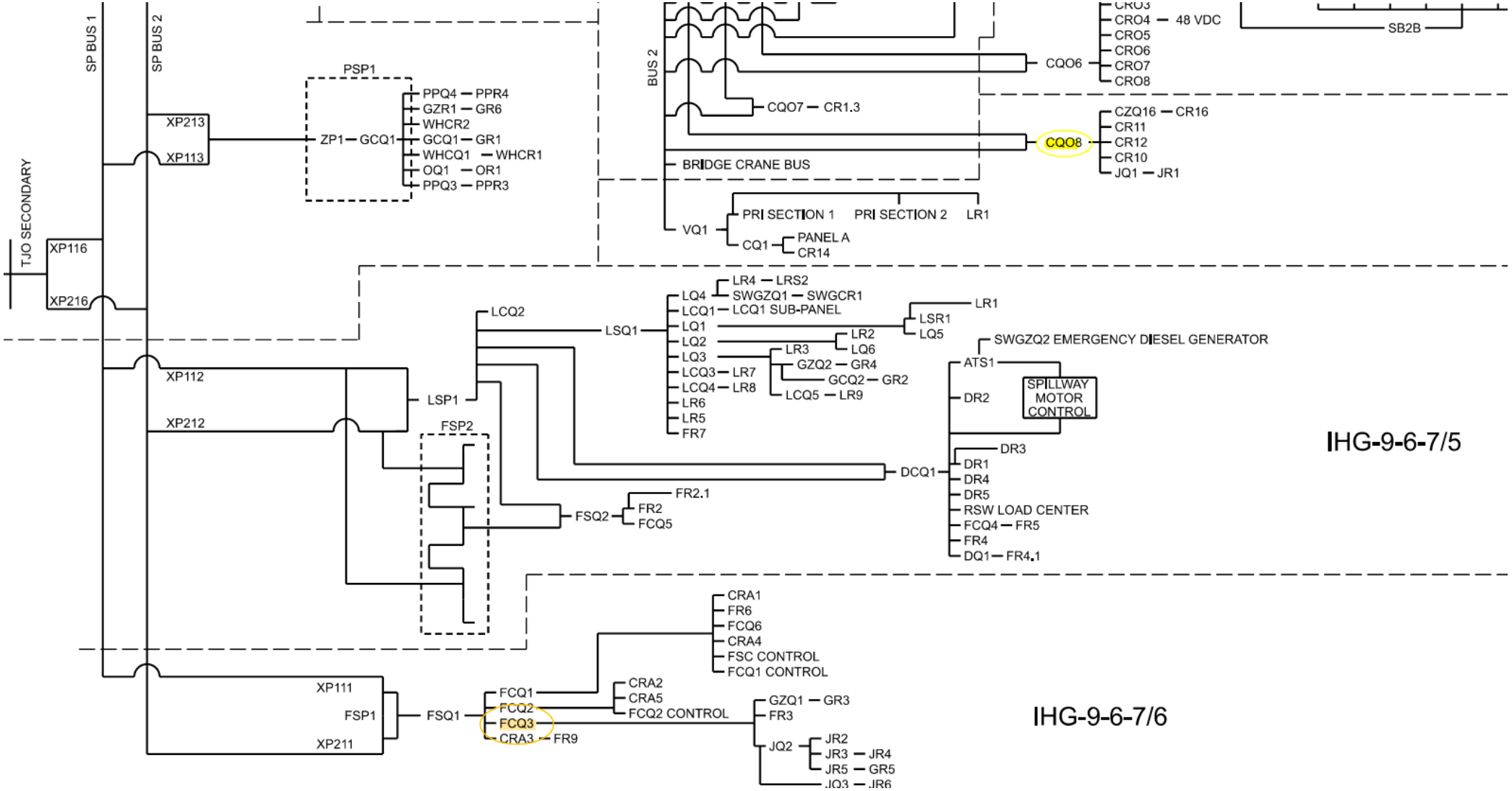
Basis of Design – Ice Harbor



Partial One-Line Diagram

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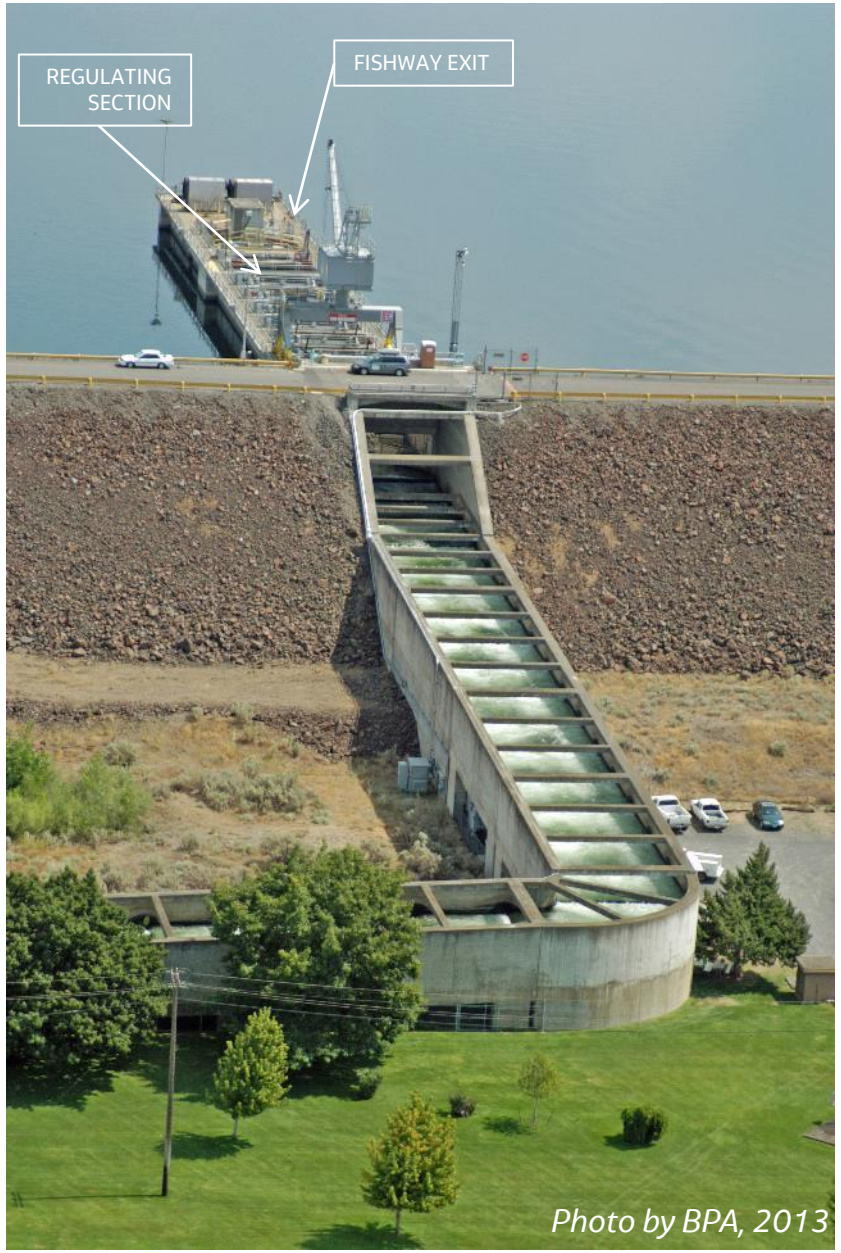
Basis of Design – McNary

Basis of Design – McNary

Fishway Exit Pool

Regulating Weir

Tilting Weirs



Oregon Ladder

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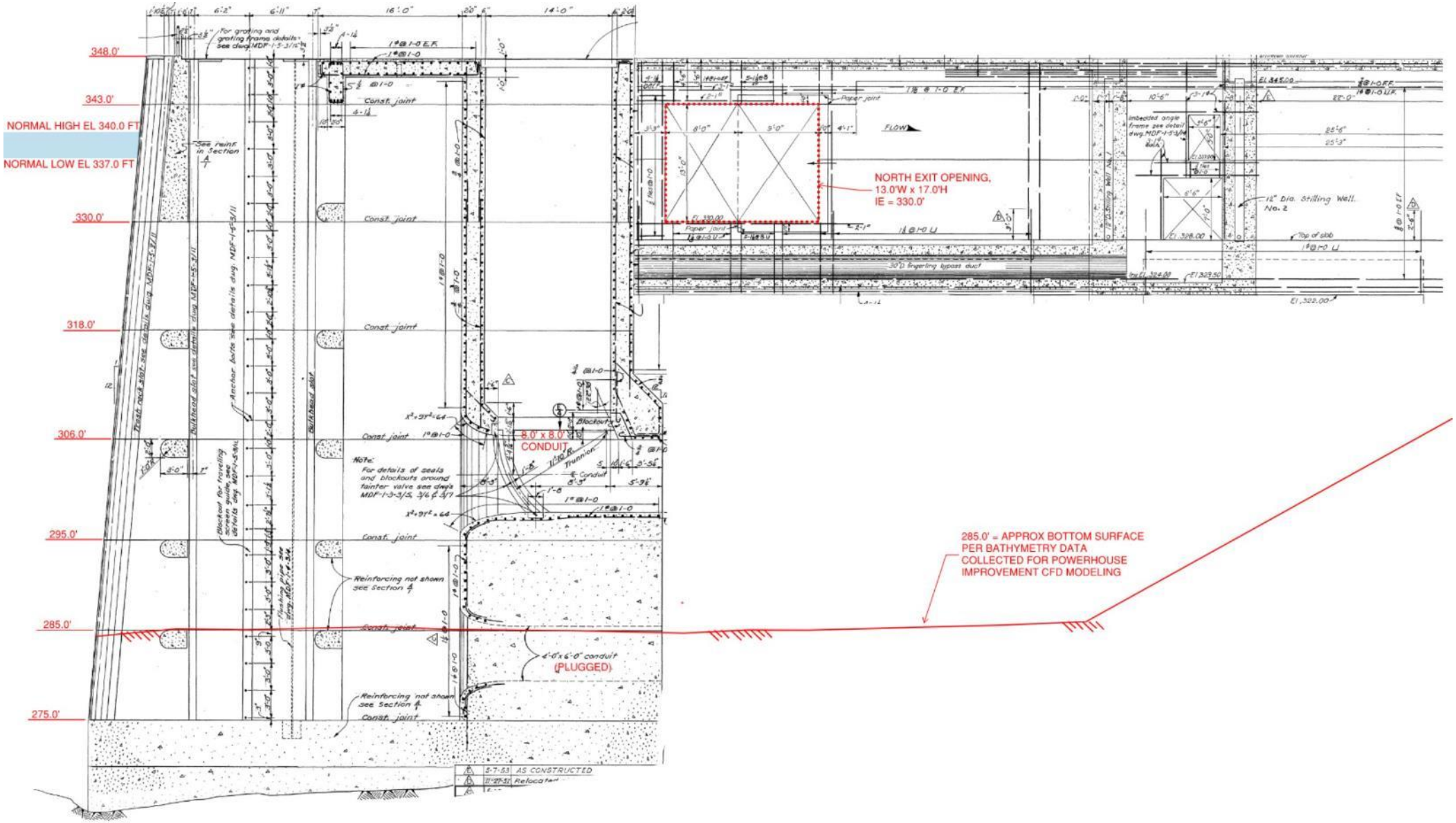
Basis of Design – McNary



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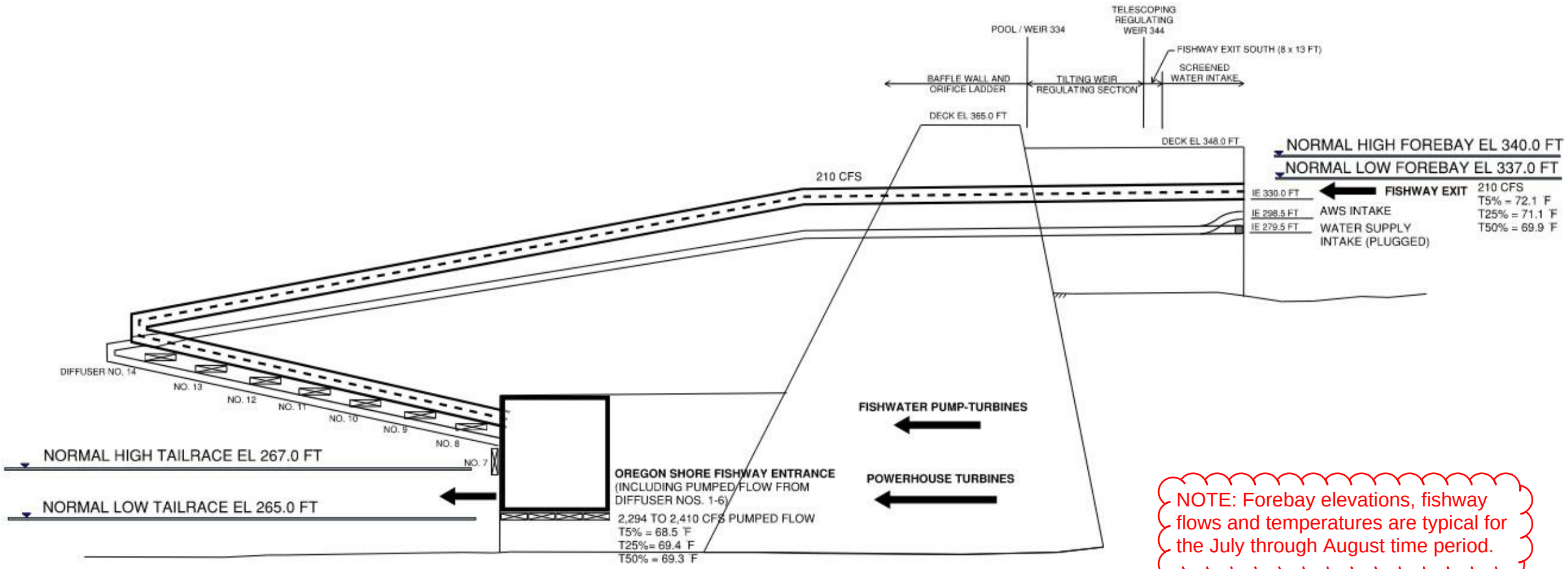
Basis of Design – McNary



NOTE: Forebay elevations, fishway flows and temperatures are typical for the July through August time period.

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Basis of Design – McNary

Key Considerations

- Only the southerly fishway exit opening (8ft W x 13ft H) is currently utilized. The north opening (17ft W x 13ft H) has a bulkhead installed.
- The fishway regulating section includes a telescoping regulating weir (Weir No. 344) and seven tilting weirs, all with two orifices each.
- The lower fishway has a slope of 1V:20H and includes linear, 30-foot wide weir walls with two orifices. The design flow is approximately 210 cfs. Head over the weirs may vary from 12 to ~~18~~ 16 inches.
- The AWS intake with vertical traveling screens provides gravity water supply to diffuser Nos. 7 through 14. Diffuser No. 7 is typically not used. The operating gates for Diffuser Nos. 8 through 14 are not reliable.
- The water supply intake in the same vicinity ~~is not used and has a concrete plug.~~ serves a USBR canal system.

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During the December site visit, a hydraulic differential was observed between the reservoir and exit pool at the upstream end of the fishway at the southerly exit. In a typical fishway, the hydraulic differentials through this area are be negligible. It is understood that the forebay elevation was low the day of the site visit with the regulating weir and tilting weirs being adjusted too far to compensate. Specific settings relative to forebay elevation had not yet been implemented.

Operation of the tilting weirs is automated and controlled by the PLC; however, manual adjustments are frequently made to optimize performance.

USACE will provide operational water level in the fish exit pool relative to the forebay.

USACE will provide updated reservoir bathymetry if available.

Basis of Design – McNary

Power Availability

- This is different from the other 3 dams, there is no MCC close to the powerhouse.
- Per information received from mechanical engineer, possible equipment that can be used is “CQ1” located in fish ladder control building. This is a 480V panelboard and only has a 30A - 3 pole spare and three single pole spaces per panel schedule from 2002 which might not be sufficient to serve new loads.

PANEL SCHEDULE: CQ1 | FEED | 480VAC | ENCLOSURE NEMA TYPE 3R
MAINS | 225A | 14,000 A.I.C. | * 3 | MOUNT ON BACK PANEL
MAIN BREAKER | 100A | 4W | LOCATION FQ3

CKT NO	BREAKER POLES	BREAKER TRIP		CONN KVA	PH	CONN KVA		BREAKER TRIP	BREAKER POLES	CKT NO
1	3	30A	EXIT WEIRS 334 THRU 340	2.61	A	.37	REG. GATE - 1.5HP	20A	3	2
3	---	---	---	2.61	B	.37	---	---	---	4
5	---	---	---	2.61	C	.37	---	---	---	6
7	3	60A	WASH WATER PUMP - 20HP	4.97	A	2.49	** CHAPMAN VALVE	30A	3	8
9	---	---	---	4.97	B	2.49	---	---	---	10
11	---	---	---	4.97	C	2.49	---	---	---	12
13	2	50A	LIGHTING TRANSFORMER	12.5	A		SPARE	30A	3	14
15	---	---	---	12.5	B		---	---	---	16
17			SPACE		C		---	---	---	18
19	2	20A	* SOLENOID VALVE #1	.25	A	.25	* SOLENOID VALVE #2	20A	2	20
21	---	---	---	.25	B	.25	---	---	---	22
23			SPACE		C		SPACE			24
25	3	20A	SCREEN MOTOR #1 - 5HP	1.24	A	1.24	SCREEN MOTOR #2 - 5HP	20A	3	26
27	---	---	---	1.24	B	1.24	---	---	---	28
29	---	---	---	1.24	C	1.24	---	---	---	30
31	3	30A	UN-WATERING PUMP	7.20	A	15.00	** GANTRY CRANE OUTLET			32
33	---	---	---	7.20	B	15.00	---			34
35	---	---	---	7.20	C	15.00	---			36

CONNECTED KVA | PHASE A 48.29 | PHASE B 48.29 | PHASE C 35.62 | TOTAL CONNECTED KVA 132.20 | DEMAND KVA
TOTAL CONNECTED FLA | DEMAND FLA

REMARKS: * SOLENOID VALVE NOT INSTALLED AT THIS TIME.
**CONTRACTOR SHALL RE - CONNECT EXISTING CONDUCTORS.

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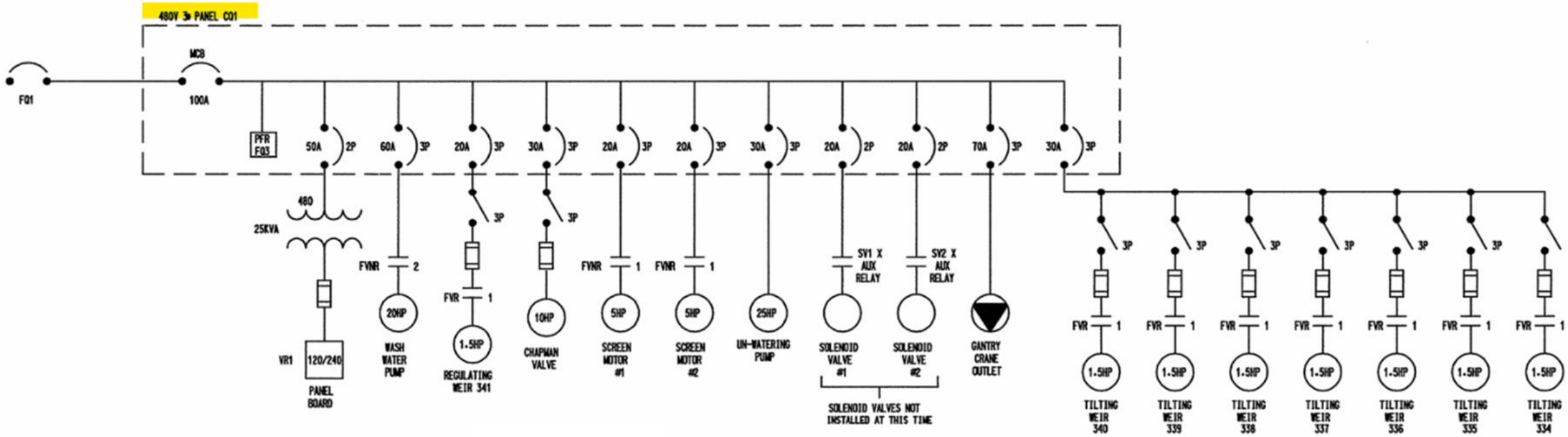
Basis of Design – McNary



Partial One-Line Diagram (CQ1 only)

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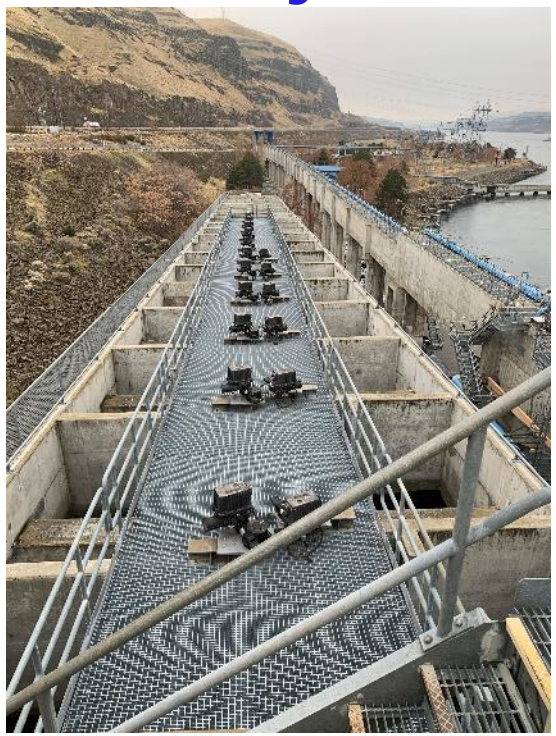
Basis of Design – John Day

Basis of Design – John Day

Fishway Exit and
Make-up Water Intake



Regulating Section

South Shore Fish Ladder

Weir Gate Control Panel

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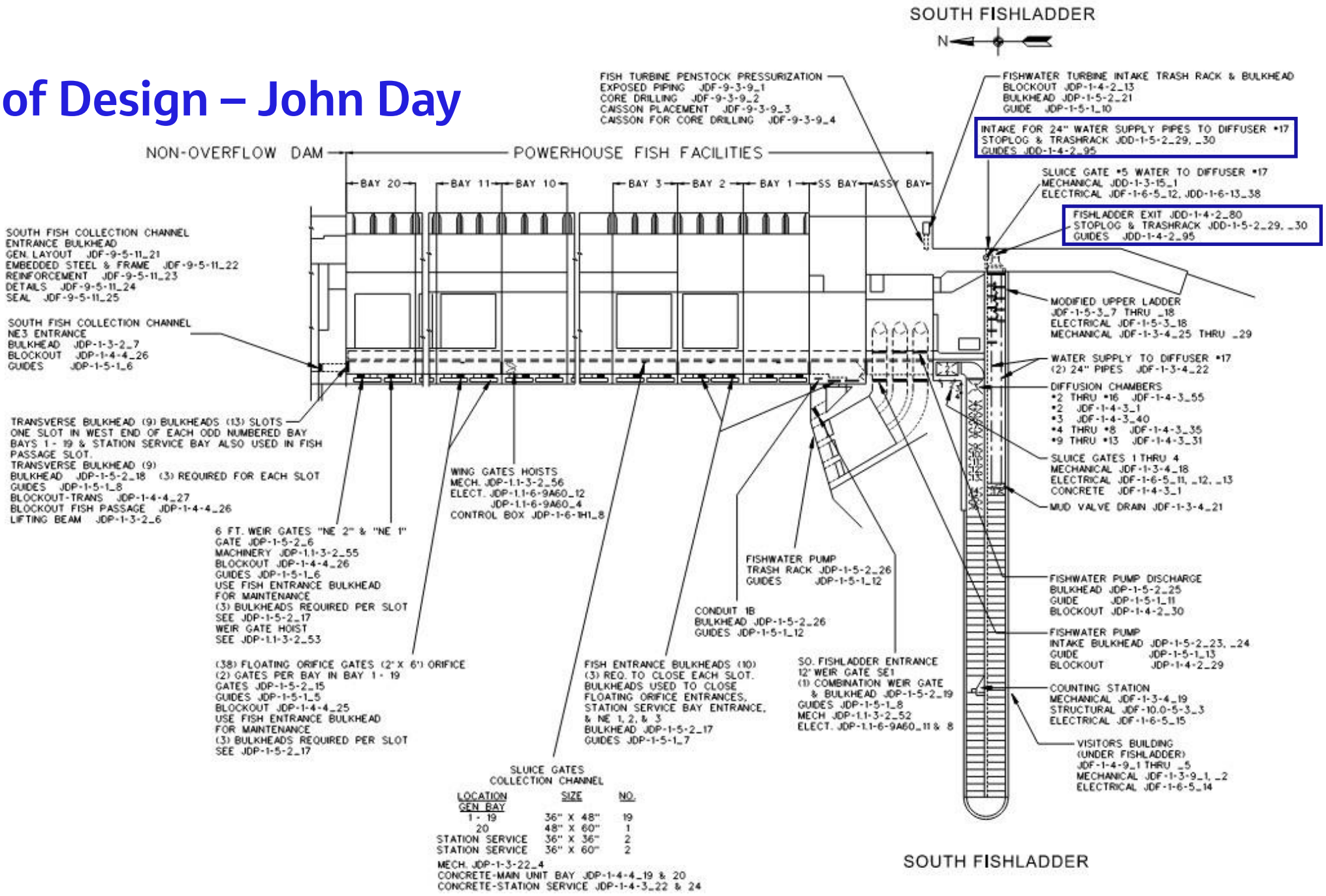
Basis of Design – John Day



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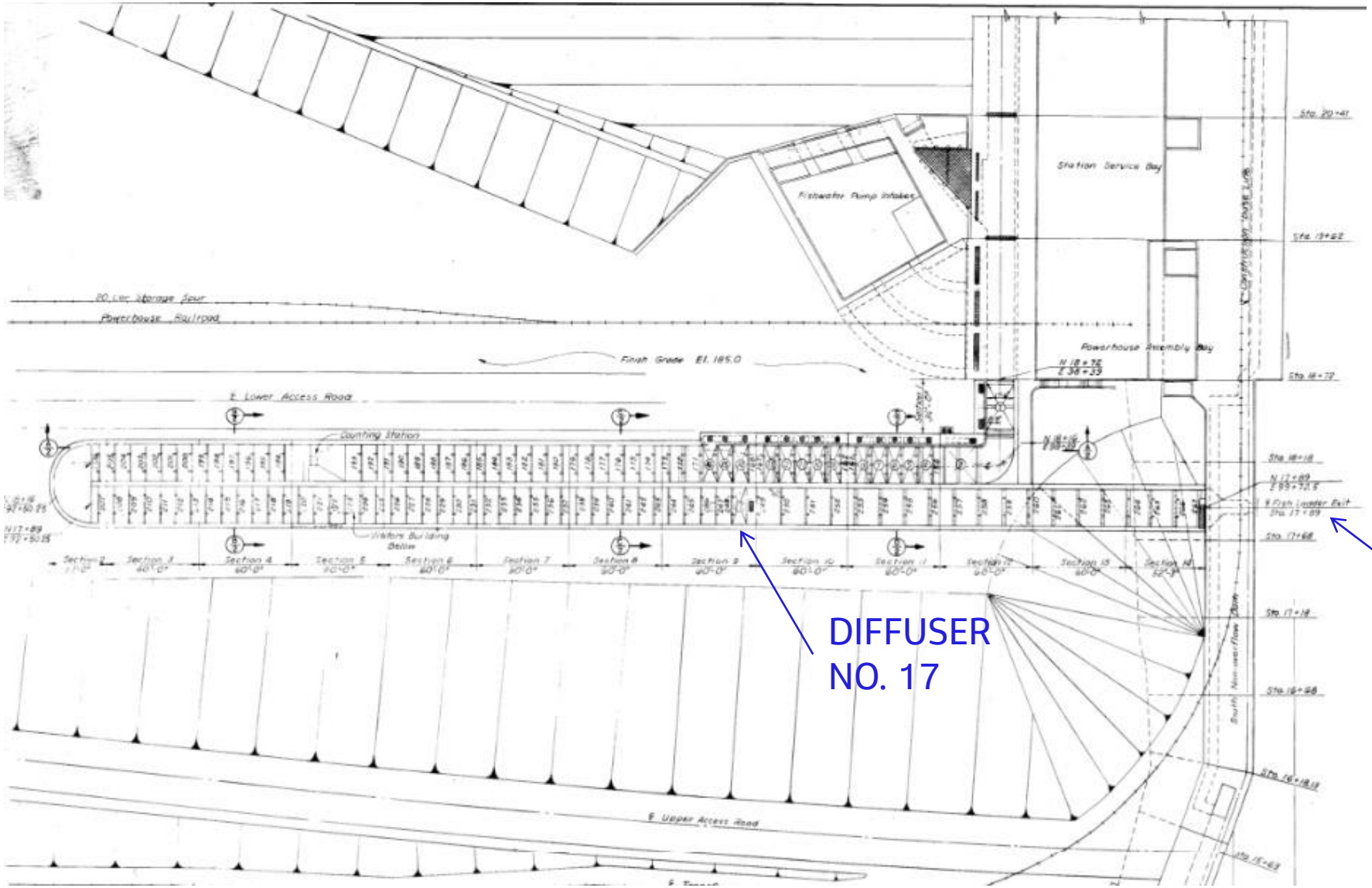
Basis of Design – John Day



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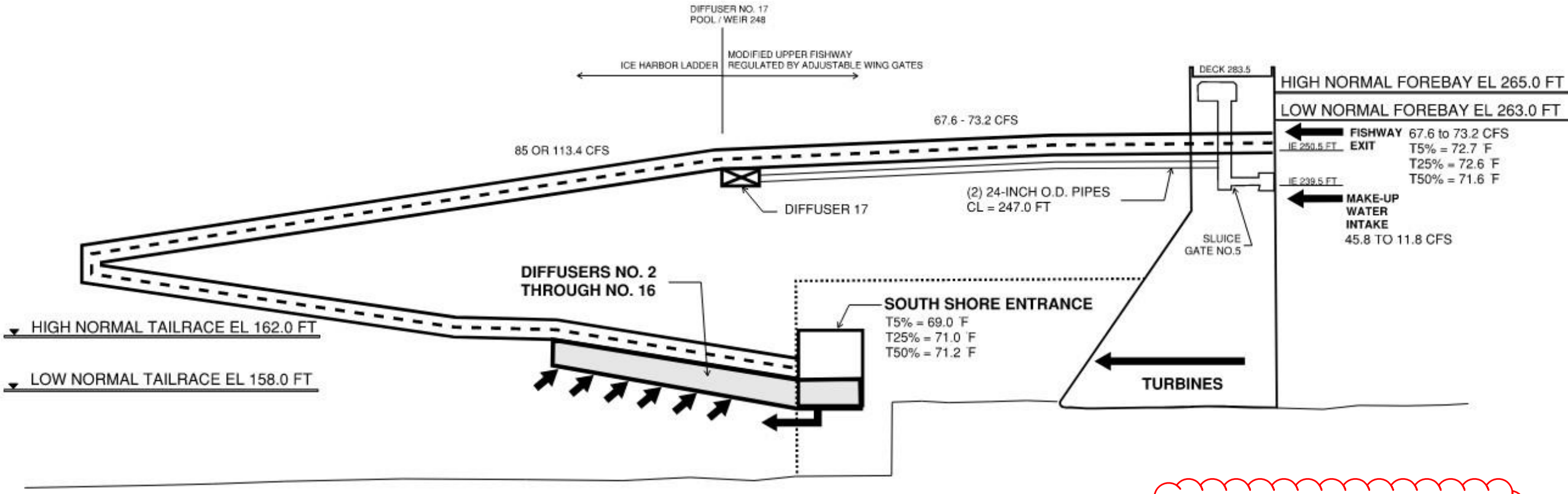
Basis of Design – John Day



NOTE: Forebay elevations, fishway flows and temperatures are typical for the July through August time period.

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Basis of Design – John Day

Key Considerations

- The fishway exit is protected by a debris deflector, and is adjacent to the make-up water intake.
- The fishway narrows from 24 feet to 9 feet in the exit channel, and then to 6 feet at the exit.
- The fishway regulating section includes 12 baffles with vertical slot openings and wing gates (aka weir or sill gates).
- Two butterfly gates are operated to provide water to Diffuser No. 17 to maintain ~~10~~ 12 to 16 inches over the downstream weirs, with a flow of approximately 85.0 or 113.4 cfs.
- The lower fishway is an Ice Harbor-type ladder on a 1V:10H slope.

JDA is typically operated in "salmon mode" with 1.0 foot of hydraulic differential. When over 5,000 shad pass Bonneville, JDA is operated in "shad mode" with 1.3 feet of hydraulic differential. This occurs typically from around the 29th of May through the 19th of July. For the purposes of this Study, thermal performance will be evaluated at 1.0 feet and hydraulic performance will be evaluated at 1.3 feet.

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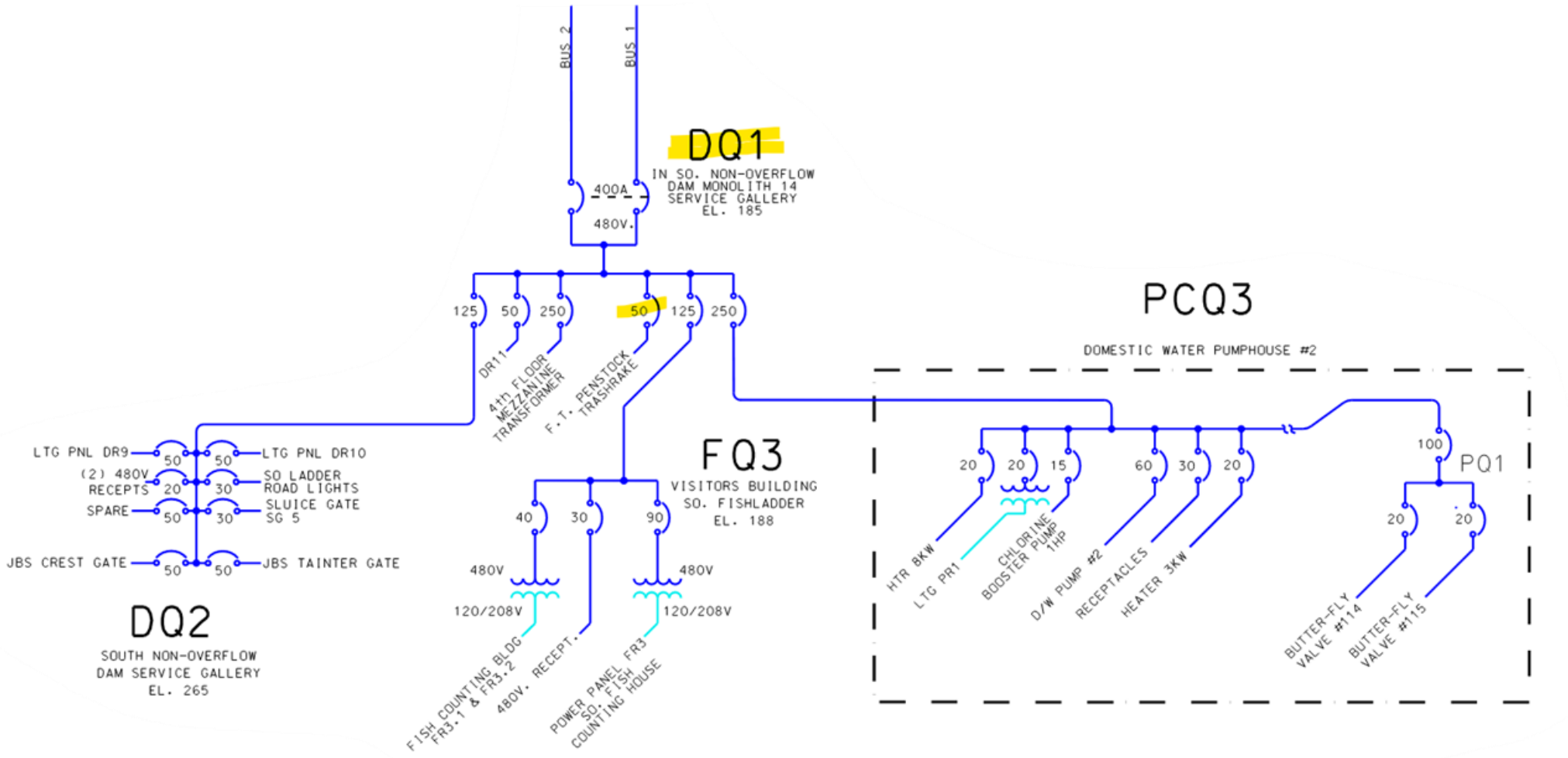
Basis of Design – John Day



Partial One-Line Diagram

Per information received from engineering team at John Day, existing electrical equipment that could be used to feed new loads is “DQ1”. This is a 480V panelboard and has a 50A 3pole breaker that could be used.

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Basis of Design – Temperature Data

Lower Monumental | Ice Harbor | McNary | John Day

Basis of Design

General Considerations

- Fishway temperatures of 68°F typically require system start-up at Lower Granite and Little Goose.
  - 64 degrees F at
  - at 50% capacity.
- Period of reservoir stratification is 1 July through 31 August.
- Temperature extremes are different for each project and occurrence varies (not necessarily coincident).
- The available temperature data set is small (three years), and likely does not reflect the full range of potential variability.

Historical temperature extremes were noted anecdotally to have occurred during June 2015 and June 2021. These events were not captured in the data sets evaluated.

The extremes developed for the data set will be used to make a relative comparison of performance for the alternatives with some determination of historical events that can be found outside the data set. June events may potentially have a greater temperature difference (fish exit - fish entrance), but will likely be associated with cooler water temperatures.

For the purposes of this Study, fishway cooling systems will be assumed to start up at approximately 68 degrees F per the project biological evaluations.

The need for additional flexibility and reliability may necessitate earlier start-up (say 65 degrees F), and/or evaluation of a longer season, say from June through September.

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Basis of Design – Temperature Data (LMN)

Basis of Design - Temperature Data (LMN)

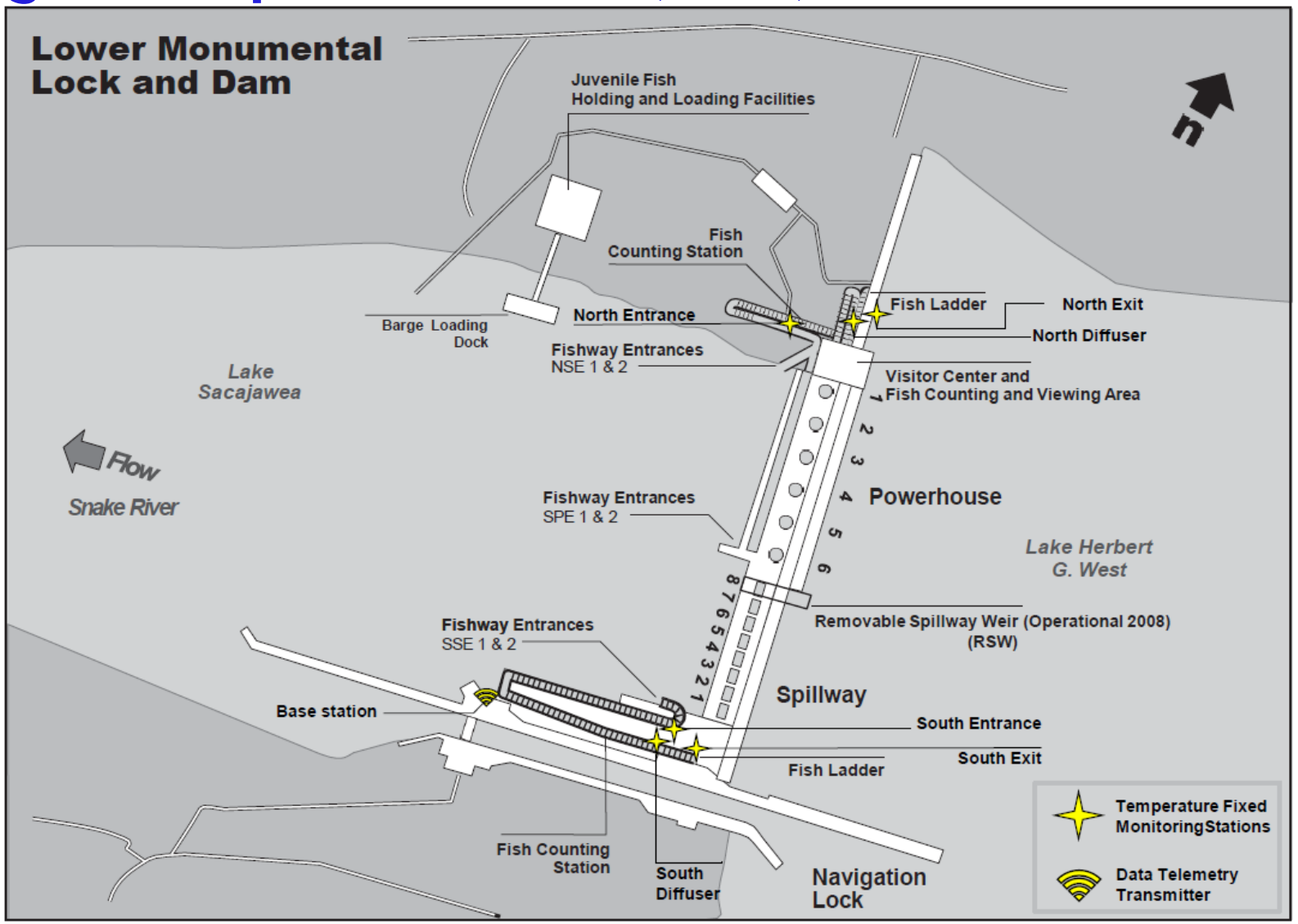

Figure LMN-1 Lower Monumental Lock and Dam General Site Plan

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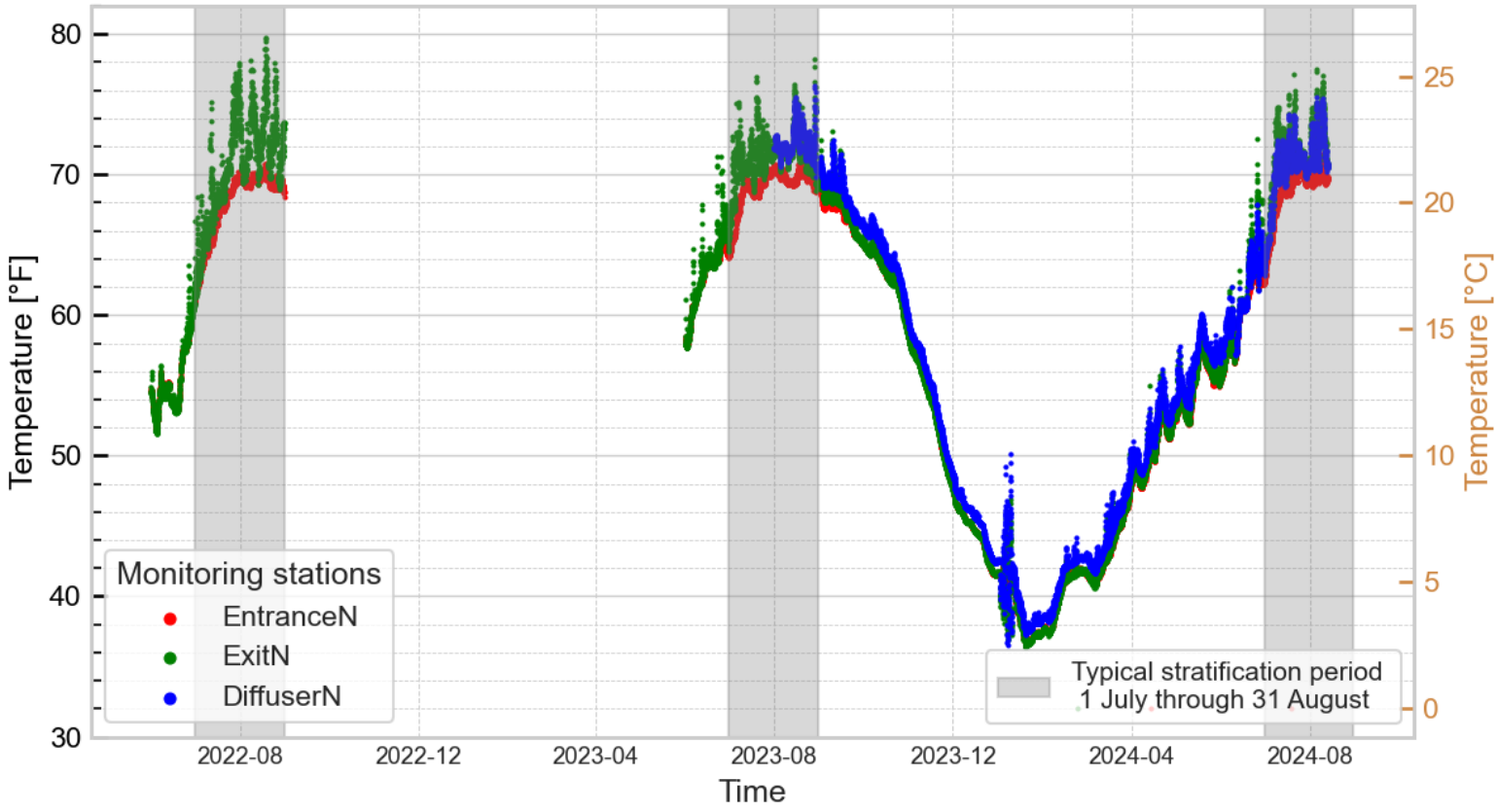
Basis of Design - Temperature Data (LMN)

Available Data

- Temperature data for the North Entrance (EntranceN) and North Exit (ExitN) is available from June to August 2022 and June 2023 to August 2024.
- Temperature data for the North Diffuser (DiffuserN) is only available from August 2023 to August 2024.
- Hourly fishway temperature data source: USACE



Note: Hourly temperature data to the forebay is available for the full period of record above

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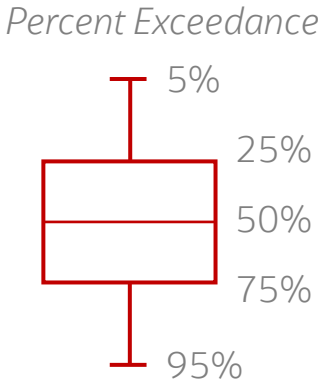
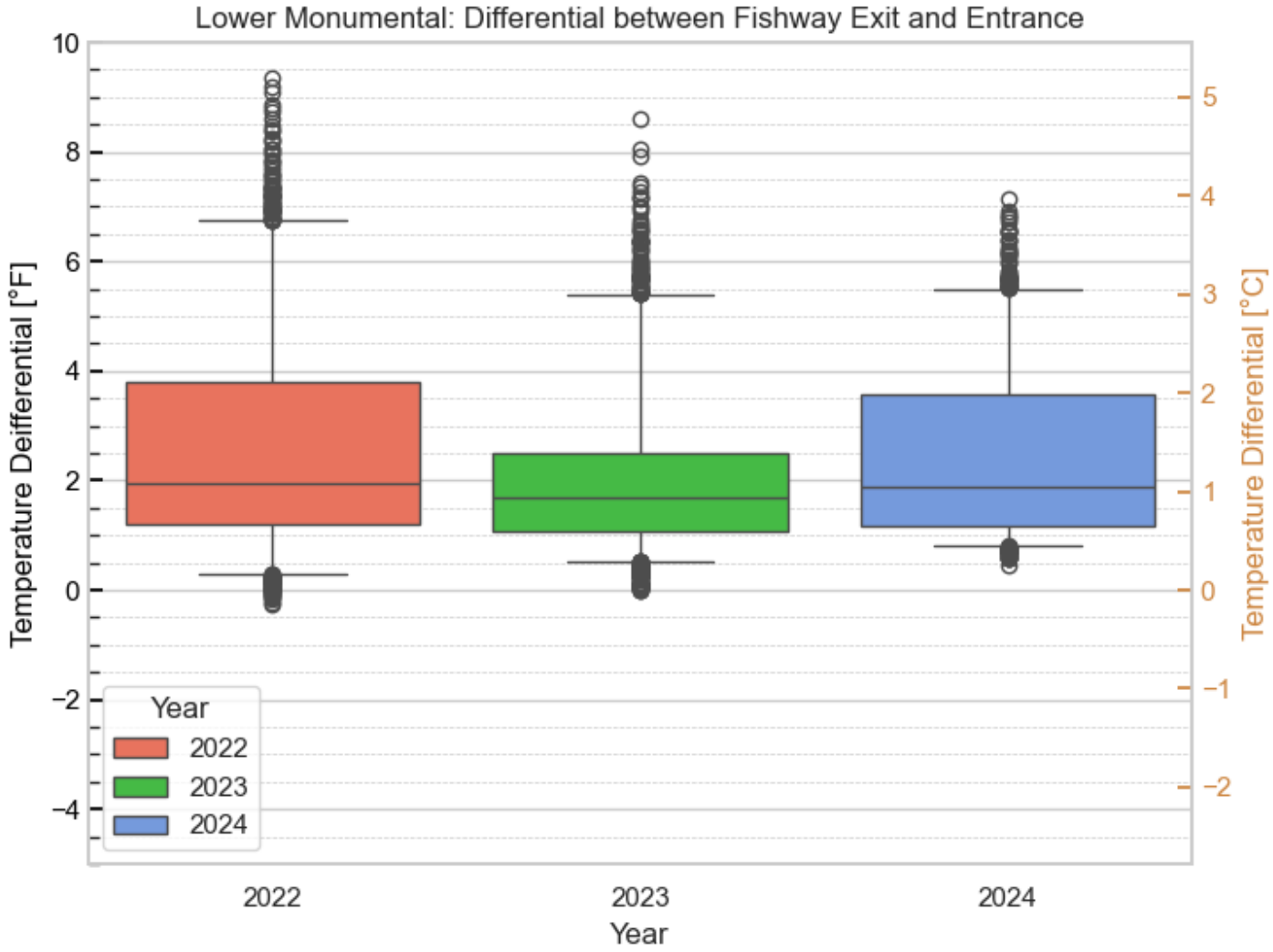
Basis of Design - Temperature Data (LMN)

Differentials

- The median is close to the 1 °C criteria, which would indicate that approximately 50% of the data exceeds the desired criteria.
- Temperatures from 2023 had less variability than 2022 and 2024
- Hourly fishway temperature data source: USACE





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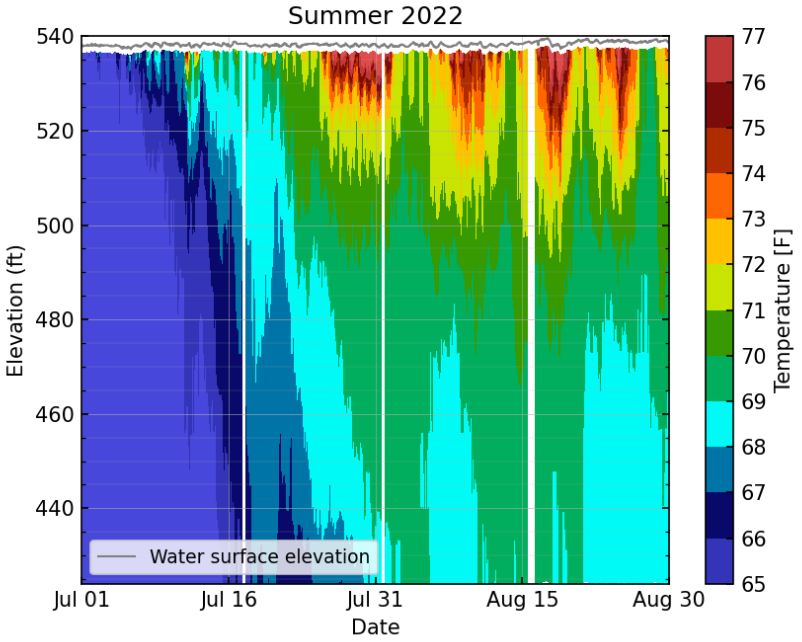
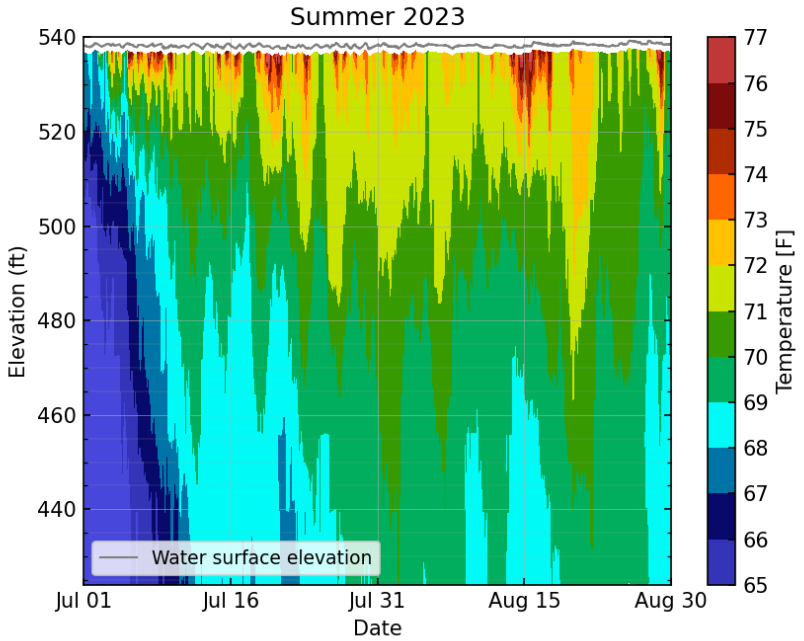
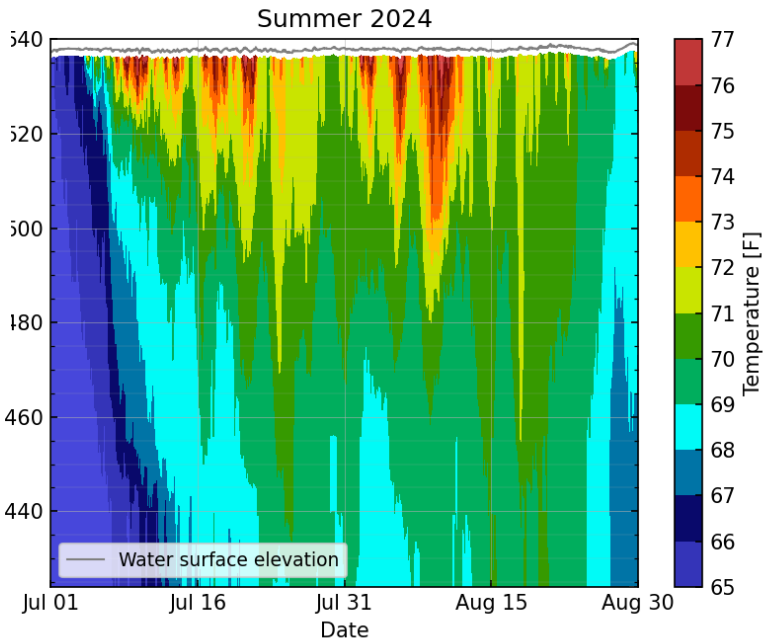
Basis of Design - Temperature Data (LMN)

vs. Forebay Elevation

- Hourly forebay temperature and water surface elevation data source: Columbia River Operational Hydrometeorological Management System (CHROMS) website.
- Normal reservoir fluctuation from elevation 537 to 540 feet.
- Fishway exit invert is 530.5 ft, and diffuser intake invert elevation is 518.5 ft.



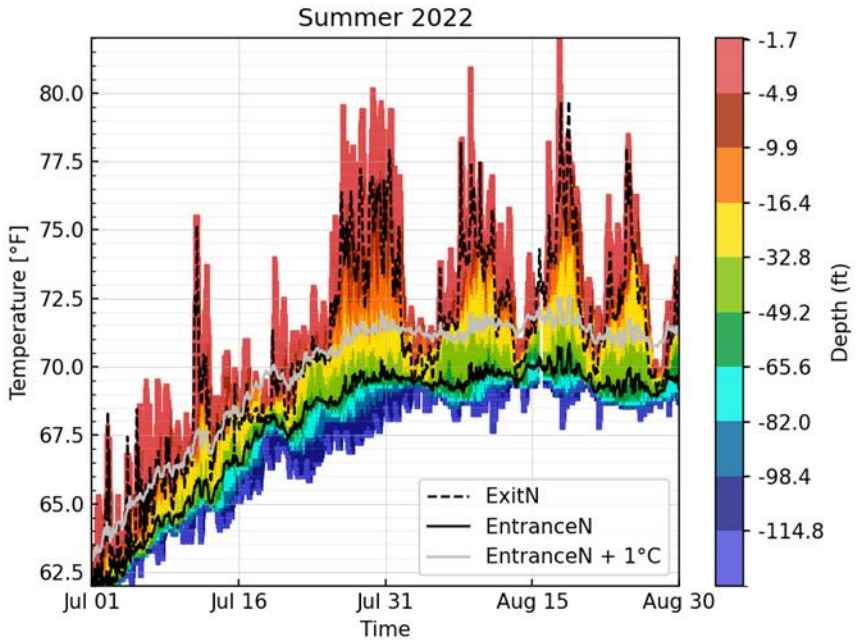


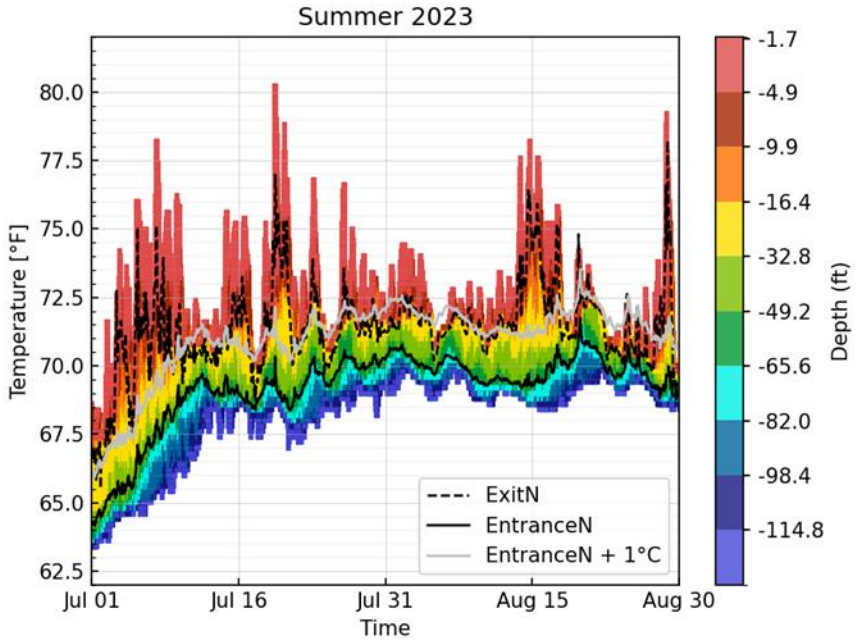


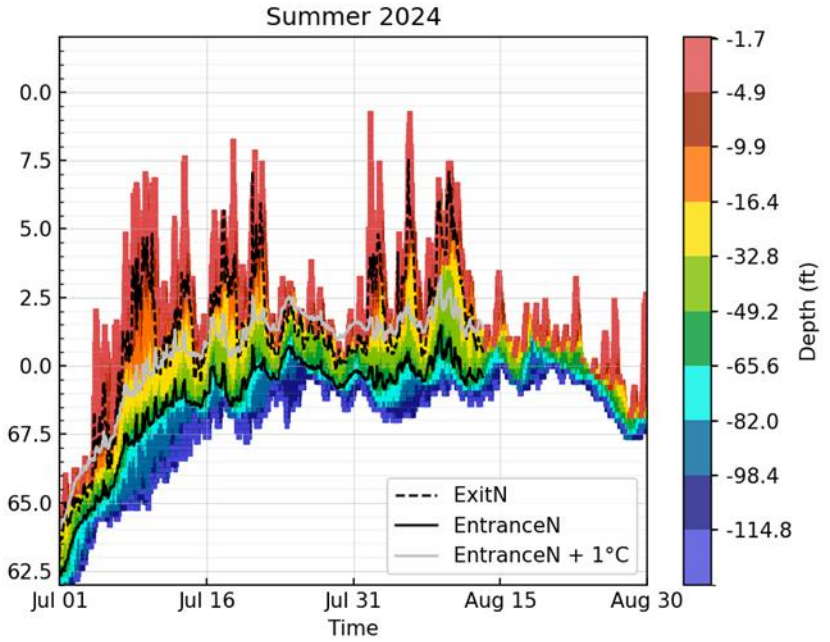
Basis of Design - Temperature Data (LMN)

vs. Forebay Depth

- Hourly fishway temperature data source: USACE (Grayscale lines).
- Hourly forebay temperature data source: Columbia River Operational Hydrometeorological Management System (CHROMS) website (colored contours)



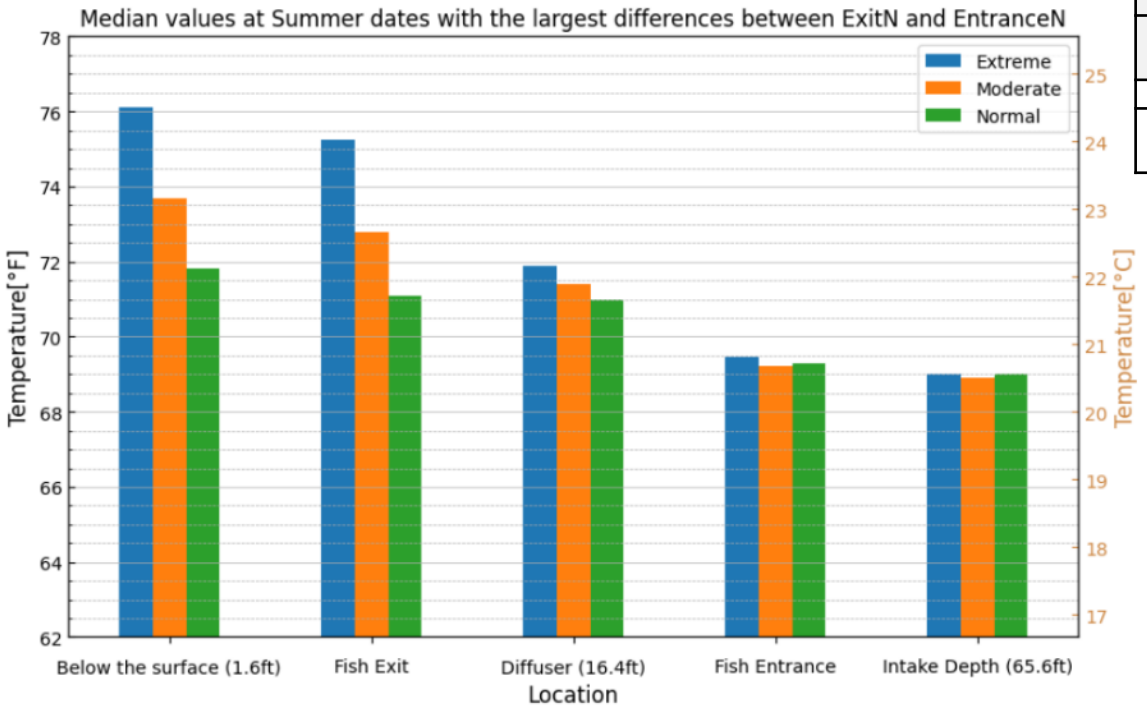




Basis of Design - Temperature Data (LMN)

Median Values: 2022, 2023 and 2024

	Extreme [°F]	Moderate [°F]	Normal [°F]
	5% ±5% Exceedance	25% ±5% Exceedance	50% ±5% Exceedance
Fish exit	75.2	72.8	71.1
Fish Entrance	69.4	69.2	69.3
Delta Temperature (Exit – Entrance)	5.84	3.56	1.82
Below the surface (1.6ft)	76.1	73.7	71.8
Diffuser (16.4ft)	71.9	71.4	71.0
Intake depth (65.6ft)	69.0	68.9	69.0
No. of data points	400	213	411



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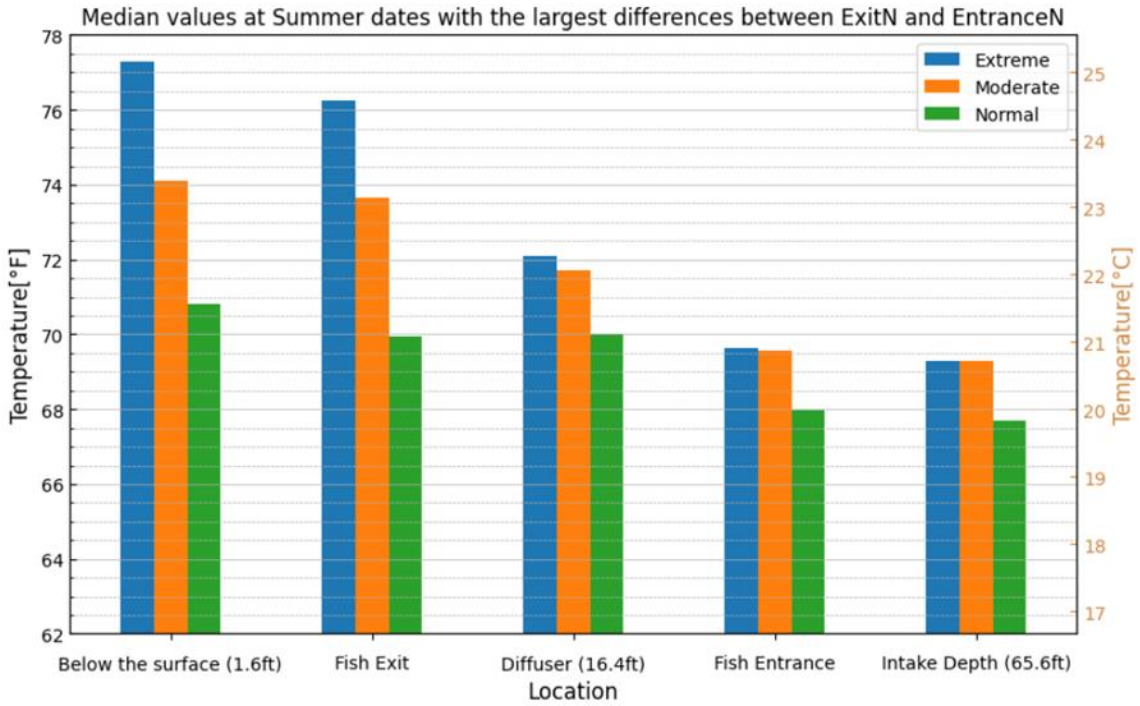
Basis of Design - Temperature Data (LMN)

Median Values: 2022

	Extreme [°F]	Moderate [°F]	Normal [°F]
	5% ±5% Exceedance	25% ±5% Exceedance	50% ±5% Exceedance
Fish exit	76.3	73.6	70.0
Fish Entrance	69.6	69.5	68.0
Delta Temperature (Exit – Entrance)	6.77	4.09	1.92
Below the surface (1.6ft)	77.3	74.1	70.8
Diffuser (16.4ft)	72.1	71.7	70.0
Intake depth (65.6ft)	69.3	69.3	67.7
No. of data points	145	76	151



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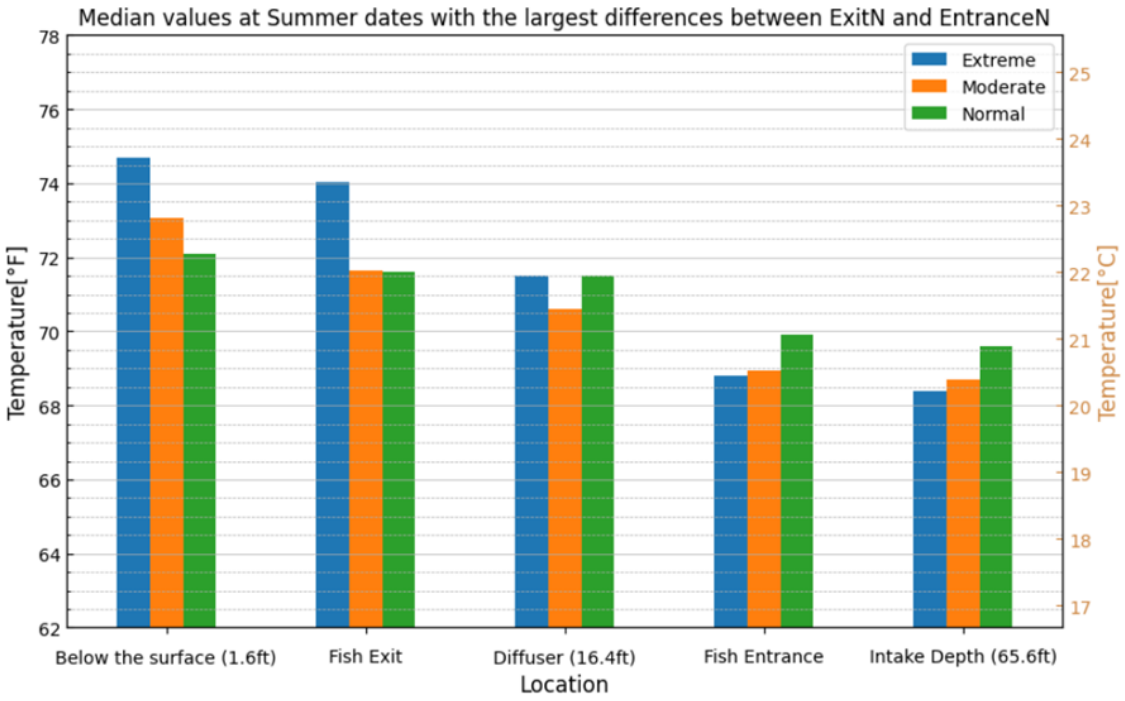
Basis of Design - Temperature Data (LMN)

Median Values: 2023



	Extreme [°F]	Moderate [°F]	Moderate [°F]
	5% ±5% Exceedance	25% ±5% Exceedance	50% ±5% Exceedance
Fish exit	74.0	71.6	71.6
Fish Entrance	68.8	68.9	69.9
Delta Temperature (Exit – Entrance)	5.42	2.65	1.67
Below the surface (1.6ft)	74.7	73.0	72.1
Diffuser (16.4ft)	71.5	70.6	71.5
Intake depth (65.6ft)	68.4	68.7	69.6
No. of data points	149	74	157

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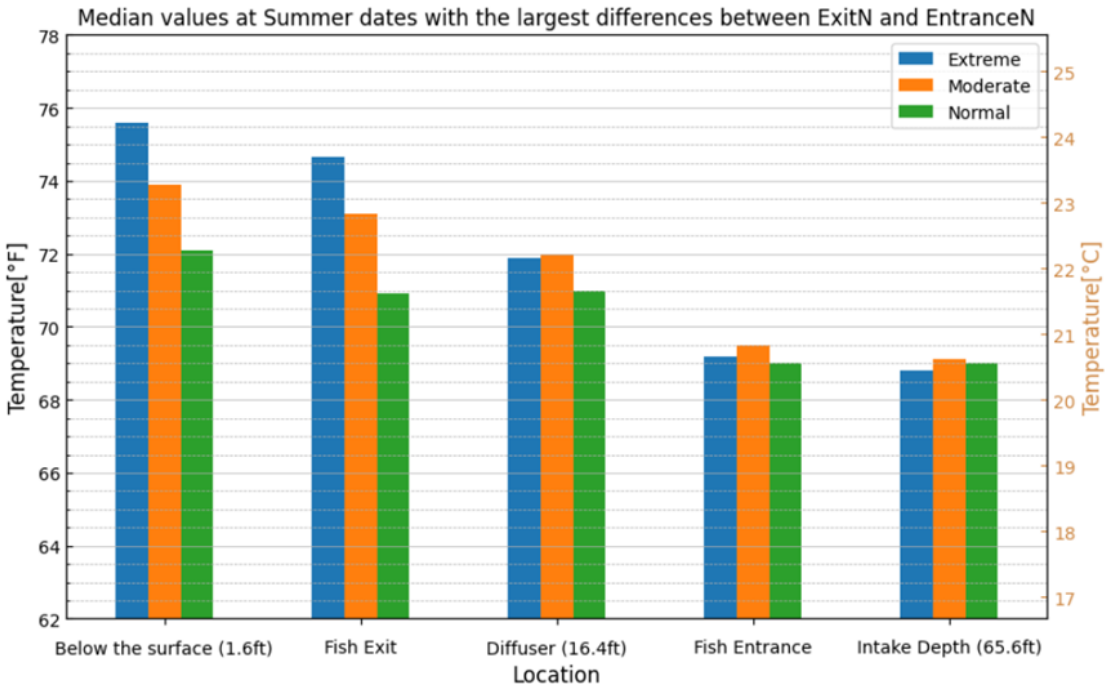
Basis of Design - Temperature Data (LMN)

Median Values: 2024



	Extreme [°F]	Moderate [°F]	Moderate [°F]
	5% ±5% Exceedance	25% ±5% Exceedance	50% ±5% Exceedance
Fish exit	74.6	73.1	70.9
Fish Entrance	69.2	69.5	69.0
Delta Temperature (Exit – Entrance)	5.49	3.69	1.87
Below the surface (1.6ft)	75.6	73.9	72.1
Diffuser (16.4ft)	71.9	72	71.0
Intake depth (65.6ft)	68.8	69.1	69.0
No. of data points	105	53	103

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Basis of Design - Temperature Data (LMN)

Median Values: 2022, 2023 and 2204

	Extreme [°F]	Moderate [°F]	Normal [°F]
	5% ±5% Exceedance	25% ±5% Exceedance	50% ±5% Exceedance
Fish exit	75.2	72.8	71.1
Fish Entrance	69.4	69.2	69.3
Delta Temperature (Exit – Entrance)	5.84	3.56	1.82
Below the surface (1.6ft)	76.1	73.7	71.8
Diffuser (16.4ft)	71.9	71.4	71.0
Intake depth (65.6ft)	69.0	68.9	69.0
No. of data points	400	213	411

Median Values: 2022

	Extreme [°F]	Moderate [°F]	Normal [°F]
	5% ±5% Exceedance	25% ±5% Exceedance	50% ±5% Exceedance
Fish exit	76.3	73.6	70.0
Fish Entrance	69.6	69.5	68.0
Delta Temperature (Exit – Entrance)	6.77	4.09	1.92
Below the surface (1.6ft)	77.3	74.1	70.8
Diffuser (16.4ft)	72.1	71.7	70.0
Intake depth (65.6ft)	69.3	69.3	67.7
No. of data points	145	76	151

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Basis of Design – Temperature Data (HLD)

Basis of Design - Temperature Data (HLD)

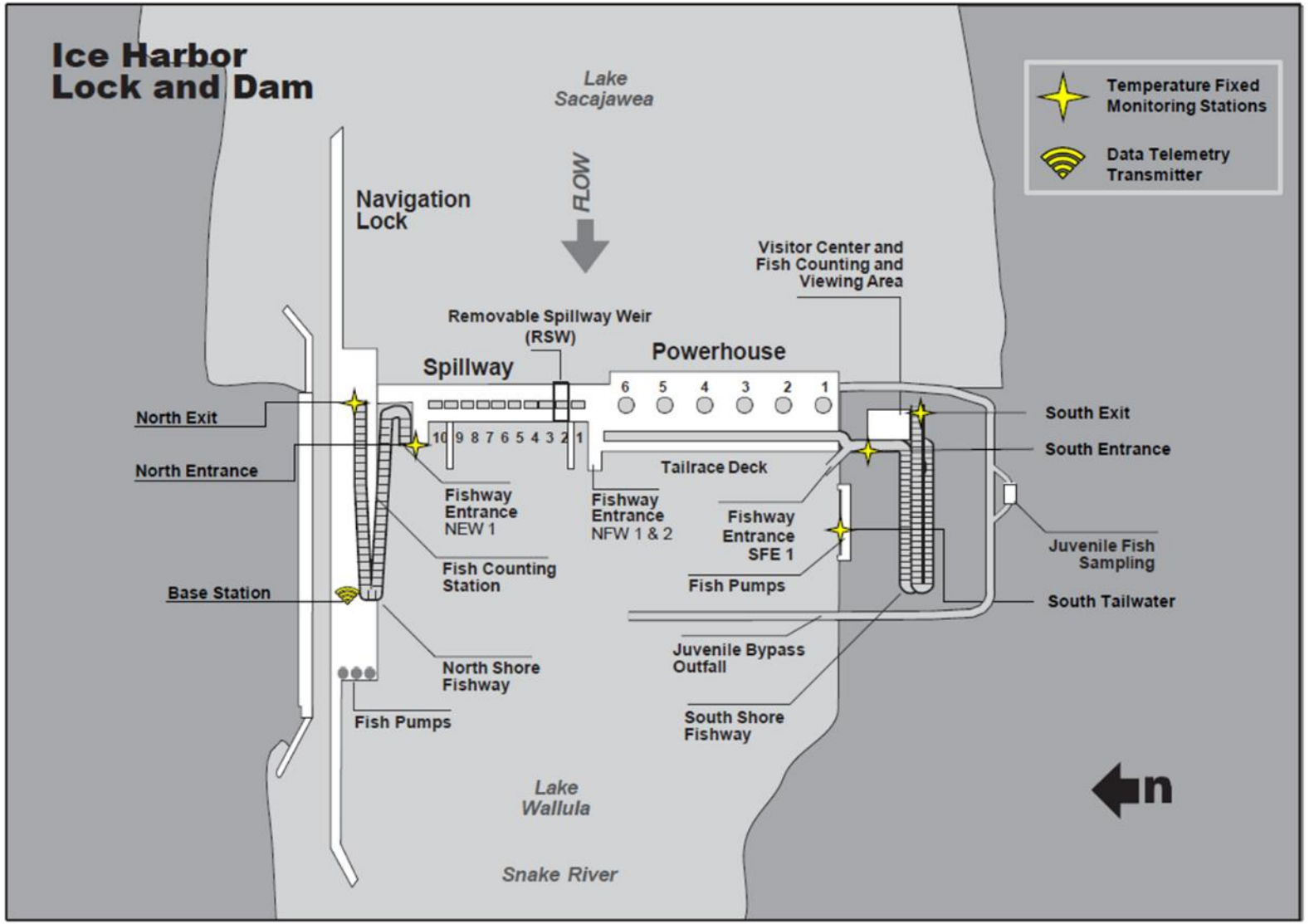

Figure IHR-1 Ice Harbor Lock and Dam General Site Plan

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Basis of Design - Temperature Data (HLD)

Ice Harbor. Medians: 2022_ 2023_ 2024

	Extreme	Moderate	Normal
0.5m	76.0	75.5	73.4
1.5m	74.8	74.9	73.2
3m	73.4	73.9	73.0
5m	71.9	72.8	72.5
10m	70.7	71.4	71.6
15m	70.3	71.1	71.2
20m	70.1	70.8	70.9
25m	69.9	70.6	70.8
30m	69.9	70.5	70.7
35m	69.6	70.4	70.5
EntranceS	70.664	71.438	71.204
ExitS	75.182	74.354	72.626
(ExitS)-(EntranceS)	4.608	2.898	1.422

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Basis of Design - Temperature Data (HLD)

Ice Harbor. Medians: 2022

	Extreme	Moderate	Normal
0.5m	77.65	74.8	73.8
1.5m	77.2	73.3	73.5
3m	75.8	72.4	72.9
5m	74.0	71.75	72.2
10m	71.3	70.2	71.3
15m	70.6	69.8	70.9
20m	70.25	69.45	70.6
25m	70.1	69.2	70.4
30m	70.0	69.2	70.4
35m	69.7	69.0	70.1
EntranceS	73.274	71.771	73.184
ExitS	76.676	72.968	73.13
(ExitS)-(EntranceS)	3.15	1.206	-0.09

Ice Harbor. Medians: 2023

	Extreme	Moderate	Normal
0.5m	77.2	75.25	73.85
1.5m	76.2	74.4	73.4
3m	74.6	73.45	73.1
5m	72.6	72.5	72.6
10m	71.5	71.3	71.6
15m	71.0	70.9	71.1
20m	70.7	70.6	70.8
25m	70.6	70.45	70.6
30m	70.6	70.4	70.5
35m	70.5	70.1	70.4
EntranceS	71.33	71.204	71.15
ExitS	75.884	74.426	73.022
(ExitS)-(EntranceS)	4.788	3.24	1.854

Ice Harbor. Medians: 2024

	Extreme	Moderate	Normal
0.5m	74.7	75.65	74.3
1.5m	72.8	74.9	73.45
3m	71.3	74.4	72.75
5m	69.8	73.05	72.1
10m	67.6	71.6	71.4
15m	67.0	71.1	71.0
20m	66.6	70.85	70.7
25m	66.2	70.7	70.6
30m	66.1	70.6	70.5
35m	65.9	70.5	70.05
EntranceS	67.586	71.483	71.15
ExitS	73.184	74.993	73.202
(ExitS)-(EntranceS)	5.31	3.483	2.124

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Basis of Design – Temperature Data (MNA)

Basis of Design - Temperature Data (MNA)

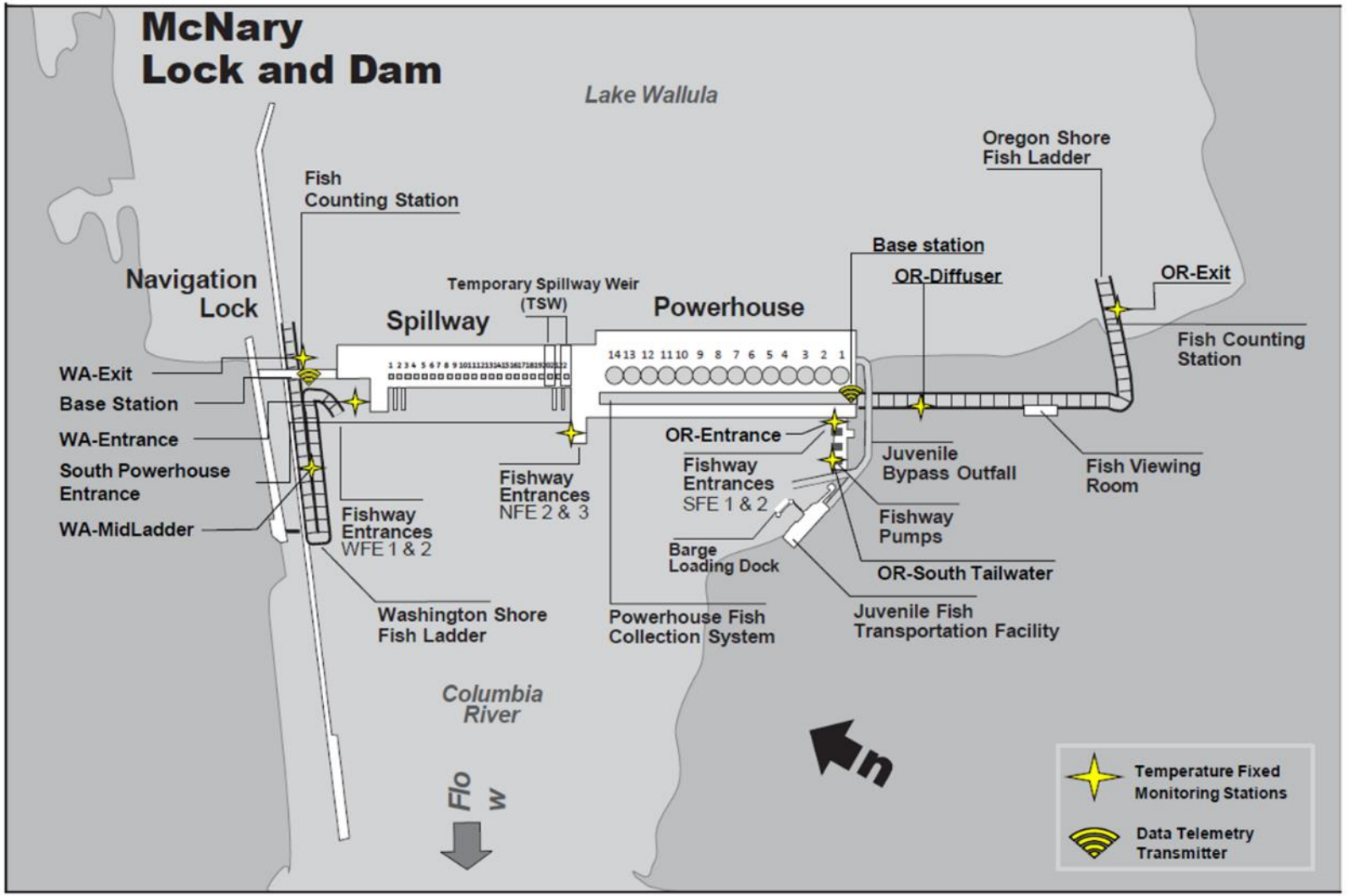

Figure MCN -1 McNary Lock and Dam General Site Plan

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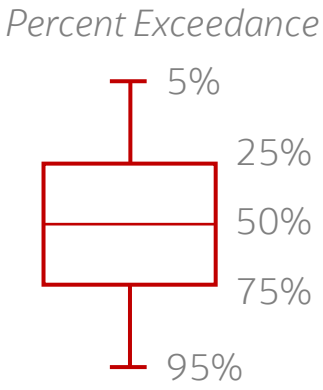
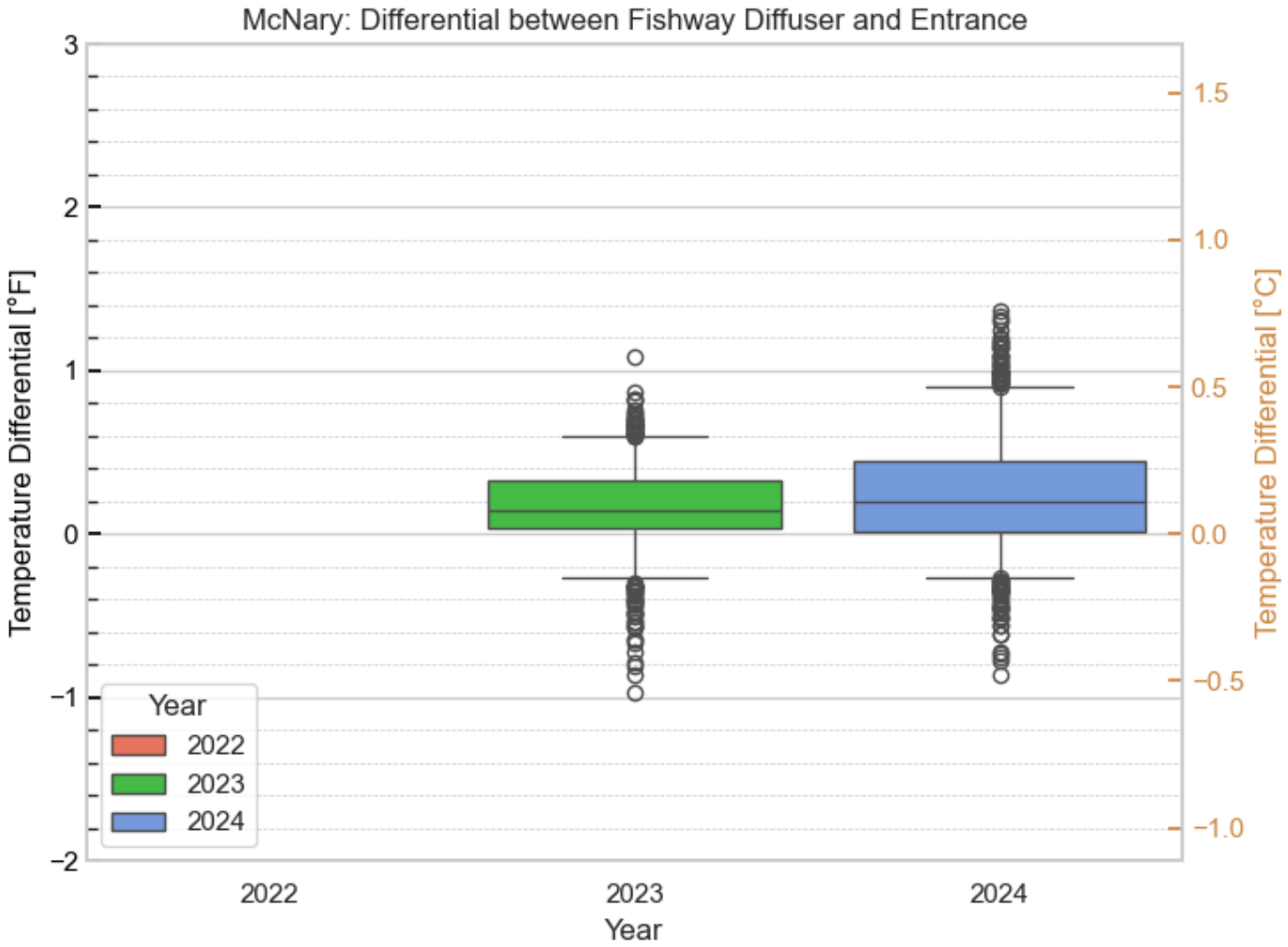
Basis of Design - Temperature Data (MNA)

Diffuser vs. Entrance Differential

- Values are below the 1 °C criteria
- No diffuser data received for 2022; however, temperatures from 2022 had less variability than 2024.
- Hourly fishway temperature data source: USACE





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Basis of Design - Temperature Data (MNA)

McNary. Medians: 2022_ 2023_ 2024

	Extreme	Moderate	Normal
0.5m	74.1	72.9	70.9
1.5m	72.3	71.7	70.0
3m	70.5	70.5	69.4
5m	68.9	69.4	69.1
10m	67.5	68.7	68.9
15m	67.3	68.7	68.9
20m	67.3	68.6	68.9
21m	67.3	68.5	68.9
Entrance	68.54	69.413	69.278
Exit	72.113	71.105	69.908
Diffuser	69.17	69.386	70.34
(Exit)-(Entrance)	3.258	1.71	0.612
(Diffuser)-(Entrance)	0.504	0.333	0.18

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Basis of Design - Temperature Data (MNA)

McNary. Medians: 2022

	Extreme	Moderate	Normal
0.5m	72.95	70.7	69.7
1.5m	70.7	69.1	68.9
3m	68.9	68.7	68.5
5m	68.4	68.4	68.4
10m	68.2	68.2	68.4
15m	68.2	68.4	68.4
20m	68.3	68.4	68.4
21m	68.2	67.5	65.7
Entrance	68.684	68.468	68.648
Exit	70.898	69.404	69.026
Diffuser	nan	nan	nan
(Exit)-(Entrance)	1.998	0.9	0.396
(Diffuser)-(Entrance)	nan	nan	nan

McNary. Medians: 2023

	Extreme	Moderate	Normal
0.5m	75.0	73.4	72.2
1.5m	73.2	72.7	71.6
3m	71.2	71.6	71.1
5m	69.6	70.3	70.3
10m	67.3	69.4	69.8
15m	67.3	69.4	70.0
20m	67.1	69.4	70.0
21m	67.1	69.3	69.8
Entrance	68.558	70.358	70.412
Exit	72.428	72.572	71.348
Diffuser	71.42	71.258	70.844
(Exit)-(Entrance)	3.708	2.196	0.864
(Diffuser)-(Entrance)	0.432	0.342	0.324

McNary. Medians: 2024

	Extreme	Moderate	Normal
0.5m	73.0	71.3	71.2
1.5m	71.2	70.8	70.9
3m	69.3	69.35	70.0
5m	67.6	68.5	69.4
10m	67.1	67.8	68.5
15m	67.3	67.8	68.5
20m	67.1	67.8	68.5
21m	67.1	67.8	68.4
Entrance	68.216	68.702	69.422
Exit	71.816	70.736	70.466
Diffuser	68.882	69.17	69.494
(Exit)-(Entrance)	3.582	1.962	0.972
(Diffuser)-(Entrance)	0.558	0.297	0.198

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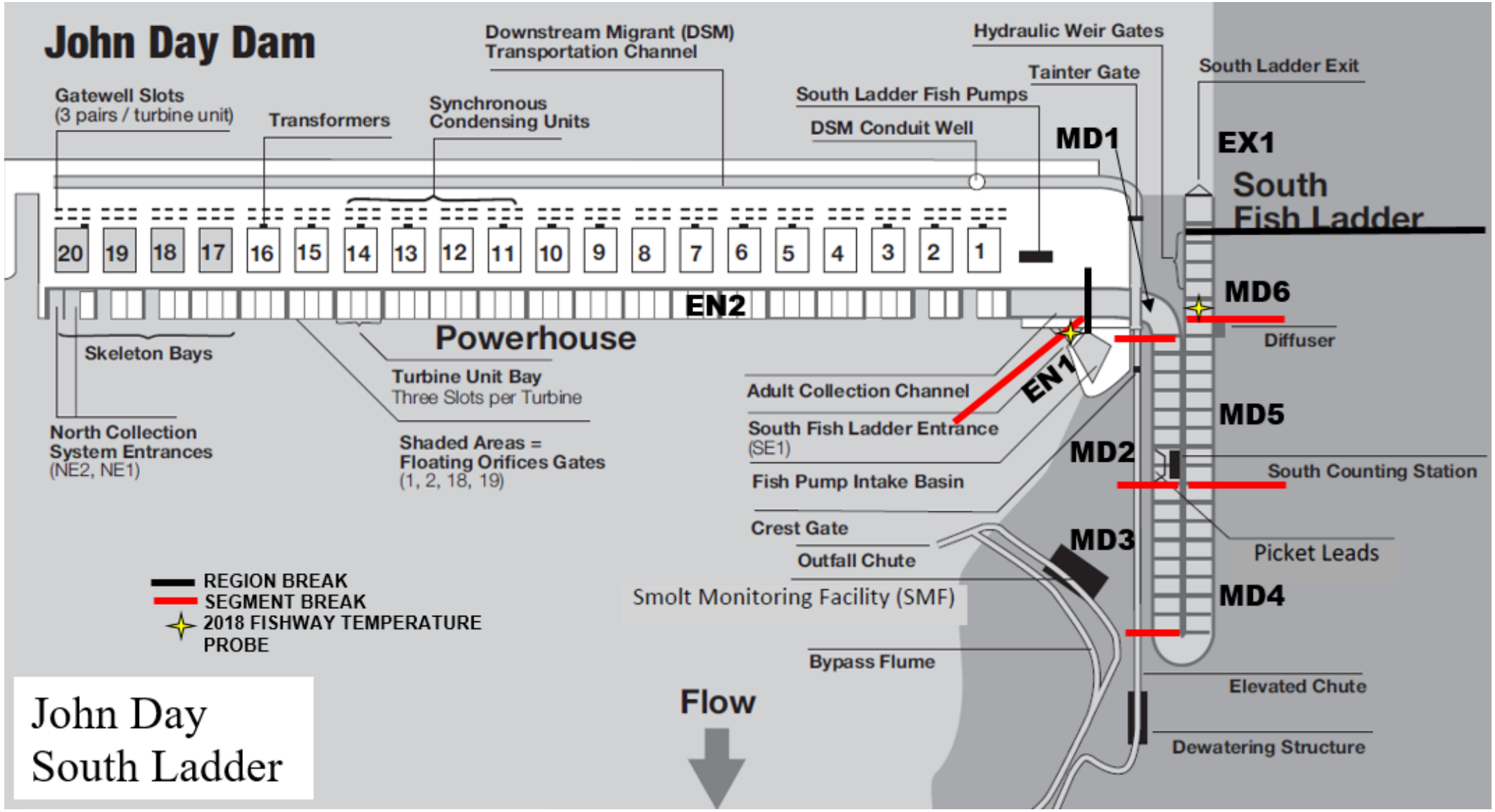
Basis of Design – Temperature Data (JDA)

Basis of Design - Temperature Data (JDA)



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Evaluation of temperature data for JDA only considered the diffuser and entrance monitoring locations. It is understood that additional data may be available from up to six different stations in the ladder; however, observed temperatures are typically very consistent from the top of the ladder down to the fish counting station.

Fish delay issues arise when temperatures of 68 degrees F or higher are observed for a length of 50 feet or more in the vicinity of the AWS system diffusers.

Basis of Design - Temperature Data (JDA)

John Day. Medians: 2022_ 2023_ 2024

	Extreme	Moderate	Normal
5	73.256	72.696	71.748
10	72.653	72.351	71.704
20	71.834	71.834	71.62
30	71.49	71.65	71.57
40	70.587	71.19	71.317
50	69.682	71.06	71.47
60	68.999	71.017	71.361
70	68.571	70.8	71.231
80	68.527	70.673	71.13
90	68.527	70.63	71.06
100	68.313	70.502	70.974
Entrance	69.02	71.03	71.18
Diffuser	72.69	72.63	71.62
(Diffuser)-(Entrance)	3.4	1.58	0.43

*Note: Diffuser temperature sensor at JDA is located immediately **upstream** of diffuser, and represents fish exit water temperature rather than make-up water temperature.*

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Basis of Design - Temperature Data (JDA)

John Day. Medians: 2022

	Extreme	Moderate	Normal
5	74.943	73.558	69.878
10	74.295	72.826	69.492
20	73.04	71.877	69.042
30	72.696	71.704	69.235
40	71.704	71.103	68.956
50	70.887	71.017	68.656
60	69.6	71.017	68.656
70	69.386	70.93	68.506
80	69.3	70.93	68.206
90	69.386	71.06	68.334
100	69.129	70.846	68.12
Entrance	70.29	71.45	68.615
Diffuser	73.99	73.17	69.125
(Diffuser)-(Entrance)	3.31	1.68	0.56

*Note: Diffuser temperature sensor at JDA is located immediately **upstream** of diffuser, and represents fish exit water temperature rather than make-up water temperature.*

John Day. Medians: 2023

	Extreme	Moderate	Normal
5	73.256	73.904	72.567
10	72.826	73.472	72.437
20	72.136	72.826	72.221
30	71.791	72.61	72.437
40	70.759	72.178	72.264
50	69.858	72.05	72.2
60	69.557	71.834	72.178
70	69.343	71.704	72.05
80	68.913	71.704	72.007
90	68.871	71.834	72.093
100	68.657	71.62	71.834
Entrance	69.02	71.92	71.79
Diffuser	72.63	73.29	72.11
(Diffuser)-(Entrance)	3.24	1.37	0.31

John Day. Medians: 2024

	Extreme	Moderate	Normal
5	71.78	72.37	71.17
10	71.4	72.14	71.22
20	70.76	71.795	71.23
30	70.2	71.33	71.08
40	69.4	71.215	70.89
50	68.085	70.53	70.68
60	67.23	70.86	71.02
70	66.8	70.48	70.84
80	66.74	70.41	70.69
90	66.59	70.19	70.56
100	66.55	70.24	70.57
Entrance	68.0	70.855	70.8
Diffuser	71.82	72.43	71.22
(Diffuser)-(Entrance)	3.72	1.6	0.43

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Basis of Design – Summary

Basis of Design - Summary

Medians
All years

	Lower Monumental	Ice Harbor	McNary	John Day
Extreme_2022	6.77	3.15	2.0	3.31
Extreme_2022_ 2023_ 2024	5.49	4.61	3.58	3.4
Extreme_2023	5.42	4.79	3.71	3.24
Extreme_2024	5.49	5.31	3.58	3.72
Moderate_2022	3.8	1.08	0.85	1.54
Moderate_2022_ 2023_ 2024	3.56	2.7	1.87	1.41
Moderate_2023	2.5	3.1	2.11	1.23
Moderate_2024	3.56	3.35	1.87	1.47
Normal_2022	1.93	-0.09	0.4	0.56
Normal_2022_ 2023_ 2024	1.87	1.42	0.97	0.43
Normal_2023	1.67	1.85	0.86	0.31
Normal_2024	1.87	2.12	0.97	0.43

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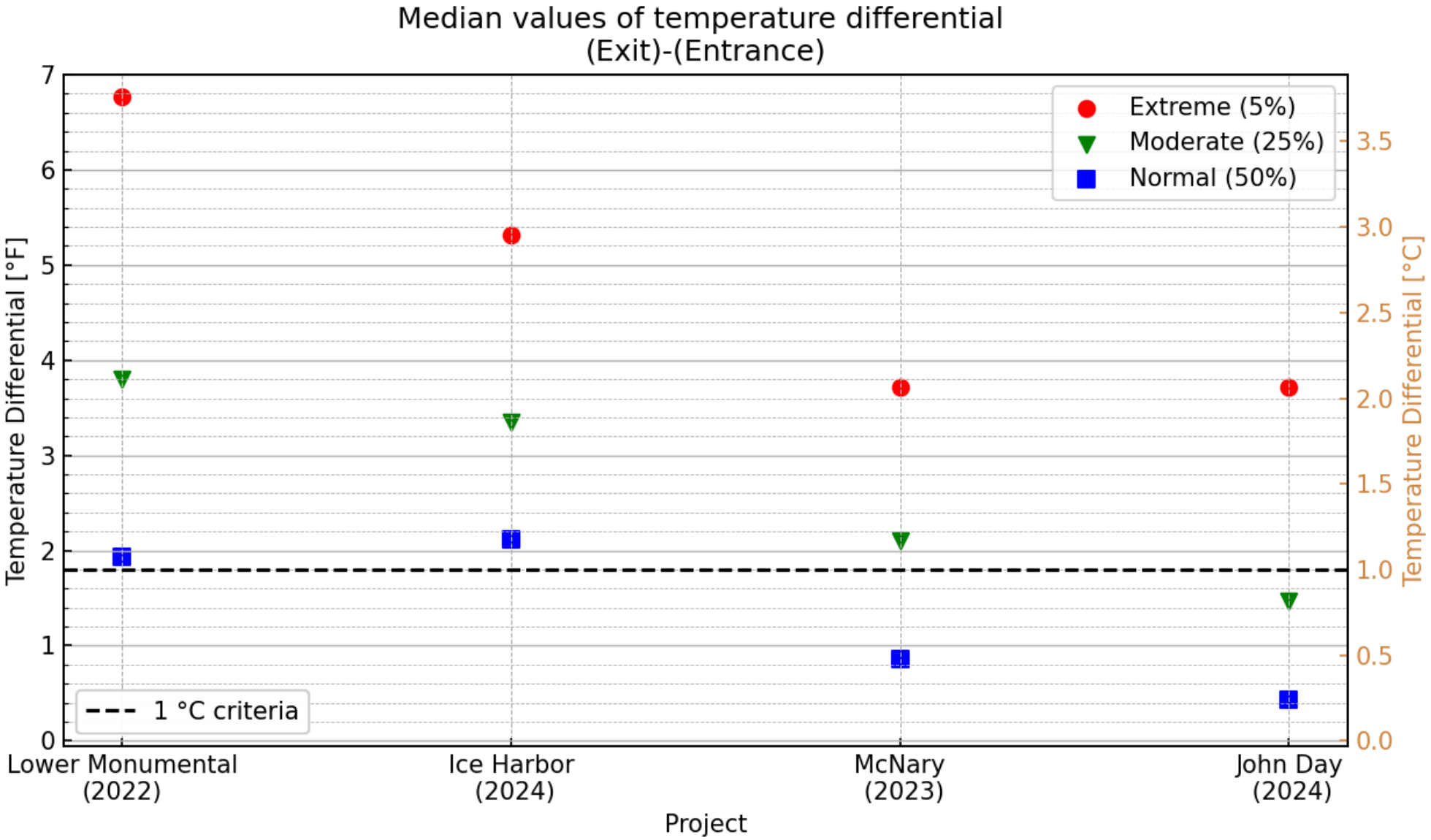
Basis of Design – Summary Temperature Differential



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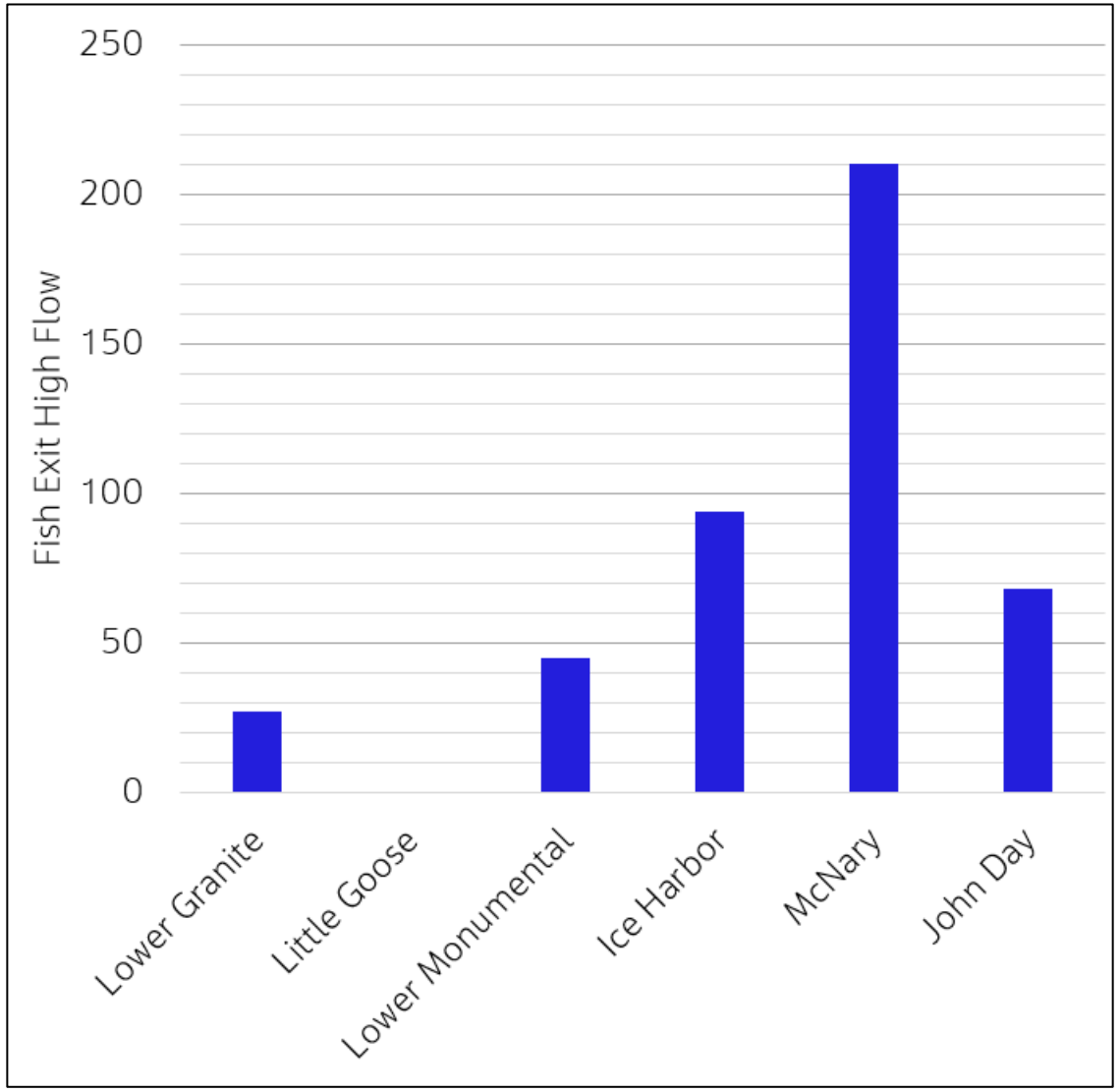
Basis of Design – Summary Fish Exit Flows (Warm Water)



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Conceptual Alternatives

Conceptual Alternatives

1 – Spray Bar, aka status quo

1a – Modified Spray Bar

2 – Bubbler

2a – Air Lift Pump

3 – Submerged Jet

4 – Pumped Fish Exit

5 – Gravity Chimney

6 – Temperature Curtain

7 – Mechanical Systems

Others?

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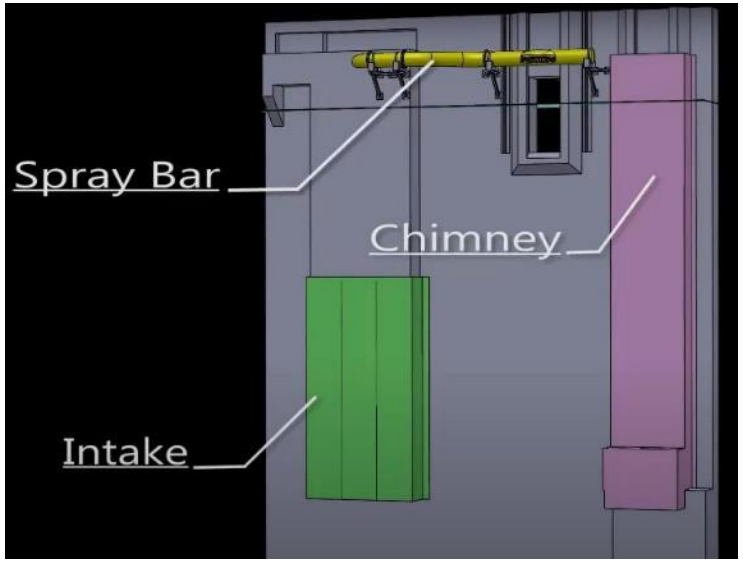
Conceptual Alternatives – 1 Spray Bar, aka status quo

Existing Lower Granite Spray Bar



Pumped flowrates at Lower Granite and Little Goose are approximately 45 cfs each. Reliability has been an issue for the off-the-shelf pumps at Little Goose.

Fish jumping at the spray bar has been an issue at Lower Granite.

Photos and rendering from USACE.

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Conceptual Alternatives – 1 Spray Bar, aka status quo (continued)

Key Advantages:

- Provides relatively gradual temperature transition from fishway exit into reservoir for fish.
- USACE has experience and understanding regarding existing facility design, operation and performance.
- Pumps can be easily switched off for the off-season; intake extension and make-up water chimney remain in place.

Key Disadvantages:

- Effectiveness is limited as a portion of the cold water is not drawn into the fishway exit.
- Spray and turbulence may be a behavioral barrier to fish.
- Mechanical/electrical components (pumps and motors) require periodic maintenance.

Existing Little Goose Spray Bar

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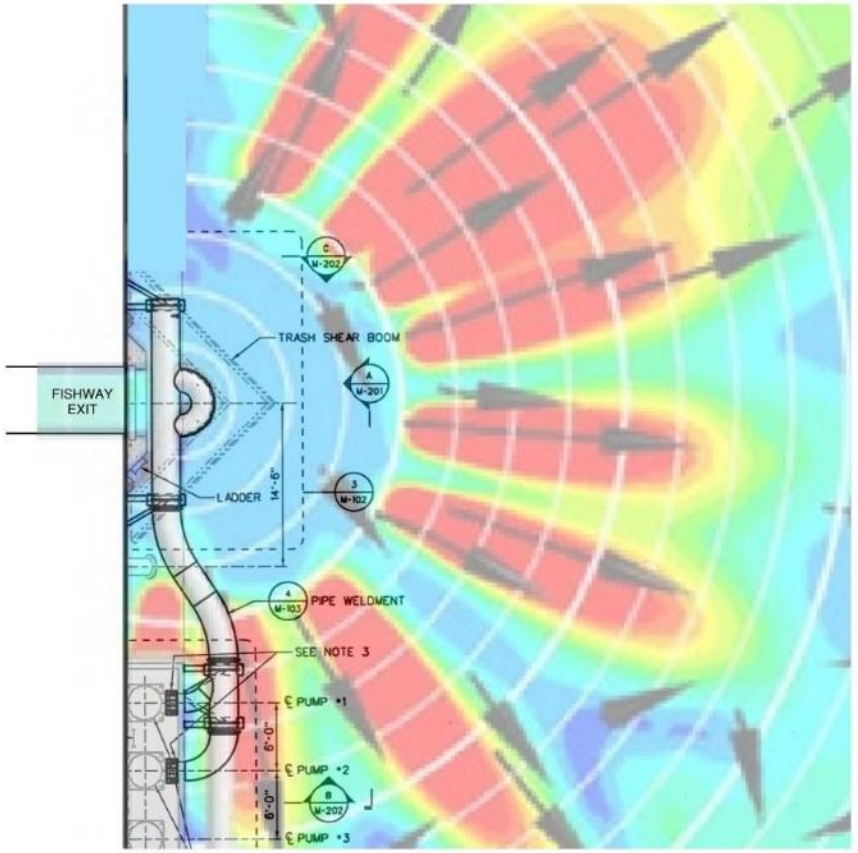
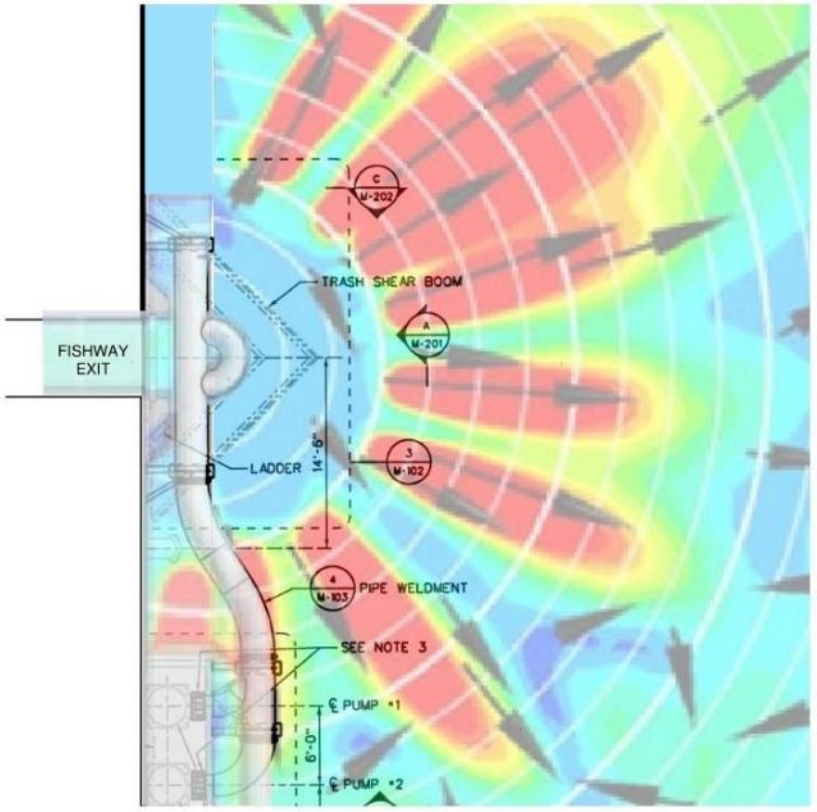
Conceptual Alternatives – 1a Modified Spray Bar



Existing at Lower Granite



Modified Nozzles
(turned down)

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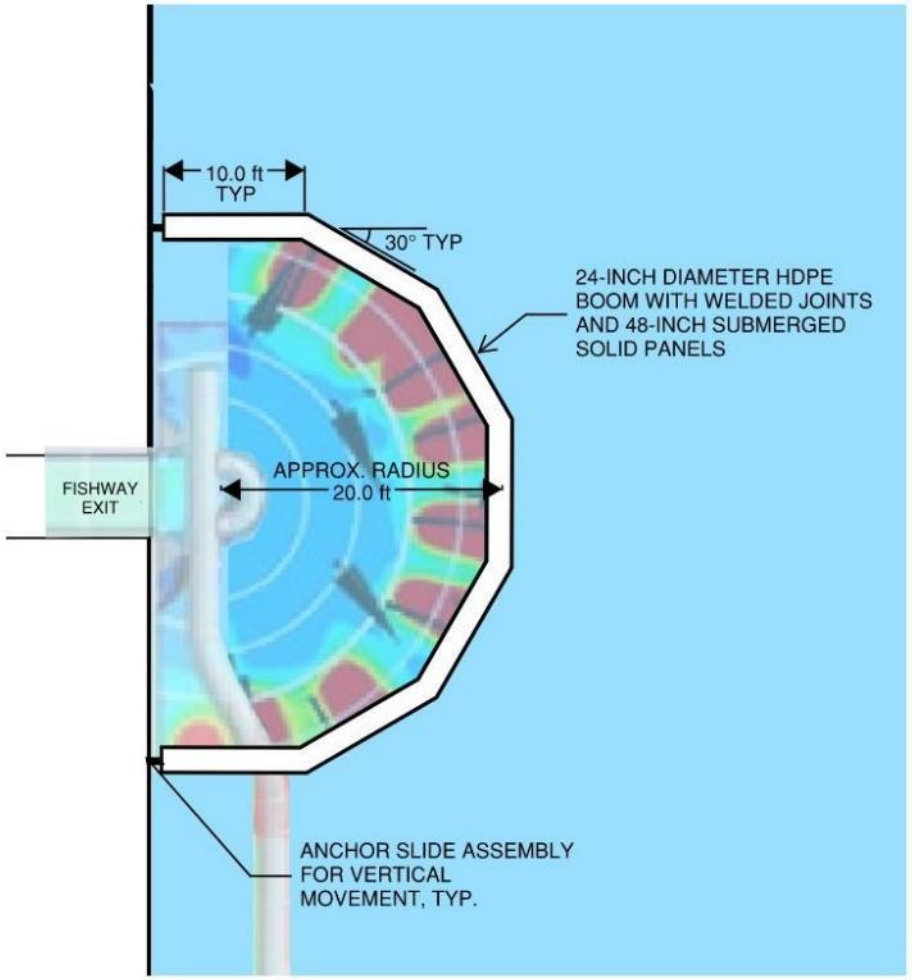
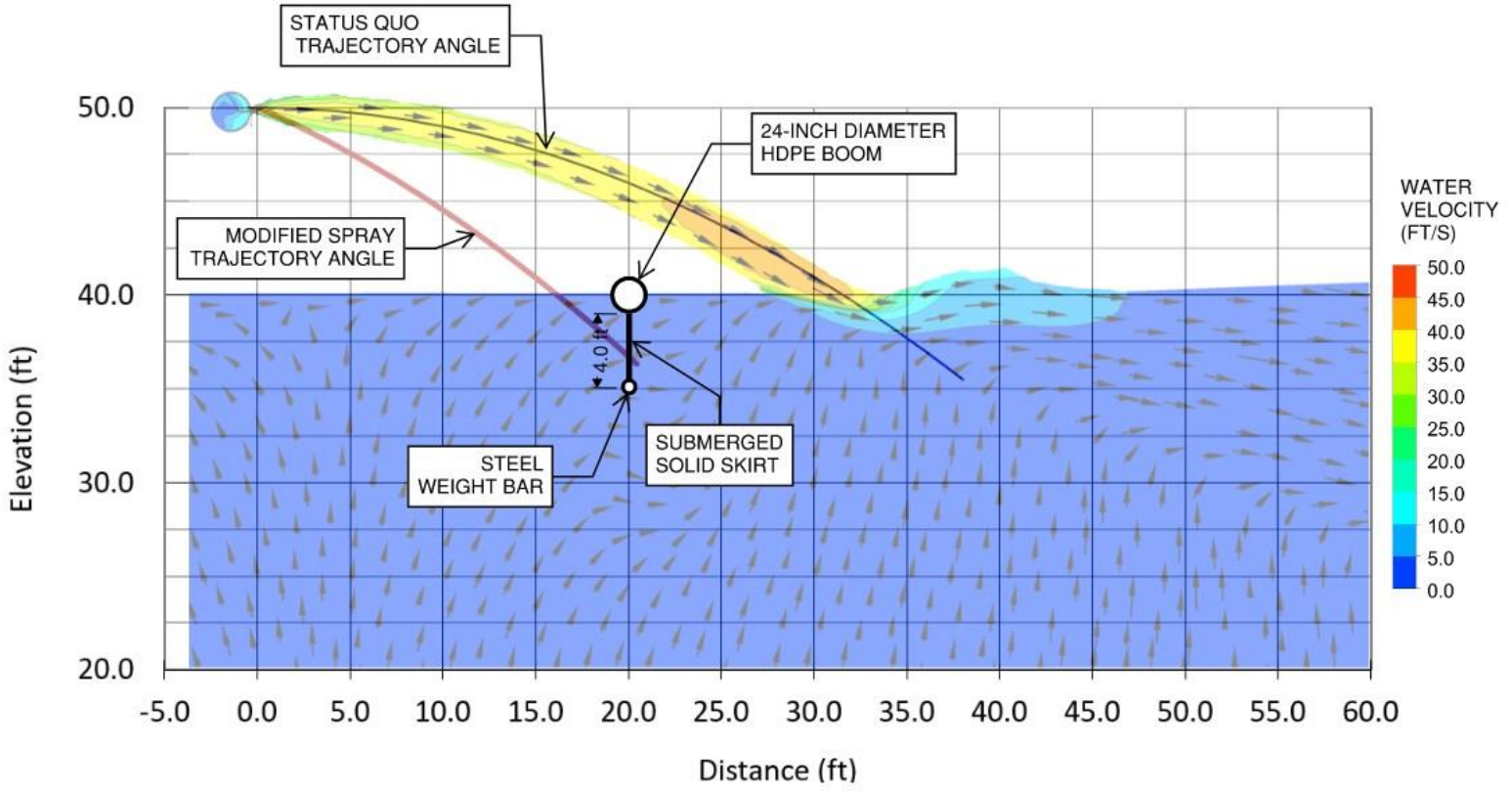
Conceptual Alternatives – 1a Modified Spray Bar (continued)





Modified Nozzles with Deflector Boom

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Conceptual Alternatives – 1a Modified Spray Bar (continued)

Key Advantages:

- Provides gradual temperature transition from fishway exit to reservoir for fish.
- USACE has experience and understanding regarding existing facility design, operation and performance.
- Pumps can be easily switched off for the off-season; intake extension and make-up water chimney remain in place.
- **Improved effectiveness relative to the Status Quo Alternative in that a larger volume of cold water is expected to be drawn into the fishway exit.**

Key Disadvantages:

- **Required flows are quite high, assuming 200% of fishway exit flow per Lower Granite.**
- Spray and turbulence may be a behavioral barrier to fish.
- Mechanical/electrical components (pumps, motors and deflector boom) require periodic maintenance.

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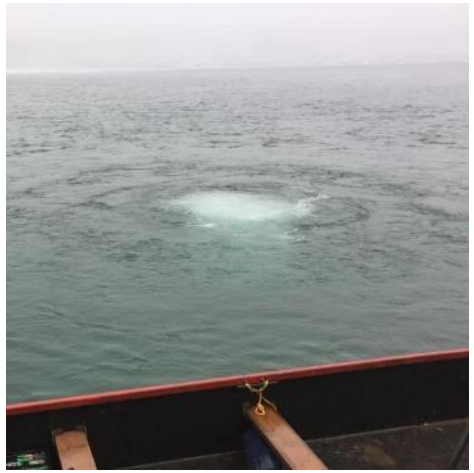
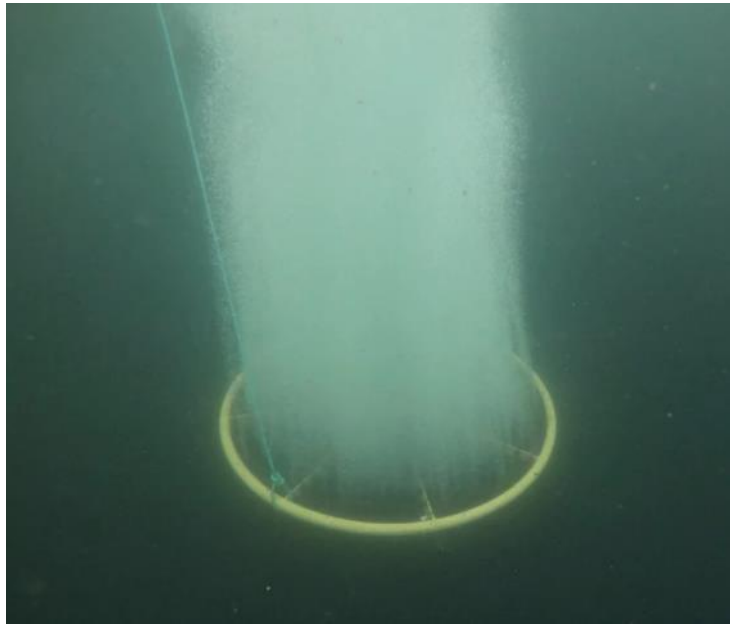
It was stated that Sockeye may not want to dive below a deflector with a deep curtain. However, fish were observed sounding at Lower Granite during a previous biological study, and could potentially benefit from a plunging jet (rather than skimming jet).

Water for this alternative could also potentially be delivered by the proposed HDPE pipe boom itself, providing water jets in a semi-circle configuration. This would be considered experimental and not meet current criteria. For the purposes of this Study, the preference is for alternatives that meet current criteria.

Conceptual Alternatives – 2 Bubbler

- One diffuser can provide approximately 75 CFM at 60 psi.
- A 50 Hp rotary screw compressor could accommodate approximately three diffusers.





Photos from Candianpond.ca Products, Ltd.

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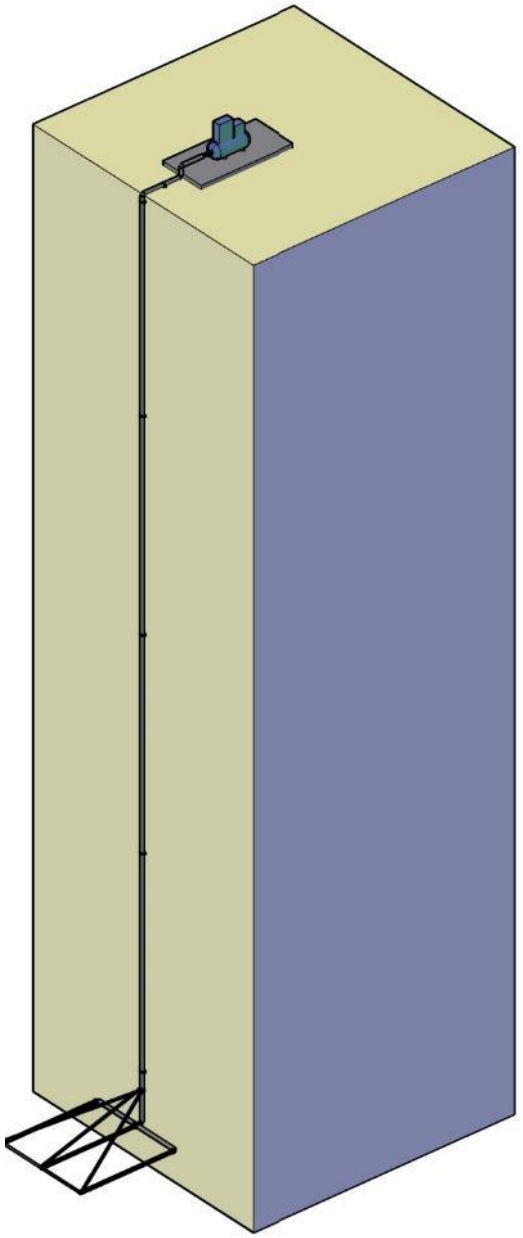
Conceptual Alternatives – 2 Bubbler (continued)

Key Advantages:

- Provides gradual temperature transition from fishway exit to forebay for fish.
- Bubbles likely won't cause physiological damage to fish, i.e. no barotrauma.
- Bubbles may be entrained in fishway flow but impact to total dissolved gas (TDG) levels downstream of dam will likely be negligible, based on observation of the relatively small fishway flow vs. auxiliary water supply (AWS) flow, powerhouse flow and spillway flow.
- Low capital costs.

Key Disadvantages:

- Bubbles may result in behavioral barrier at fishway exit that could cause delay.
- Biofilm may clog diffusers.
- May not be effective in shallow areas, i.e. LMN fishway exit.
- Mechanical/electrical components (compressors) require periodic maintenance.
- Relatively high O&M cost.



University of Idaho "MEGA Engineering" Concept

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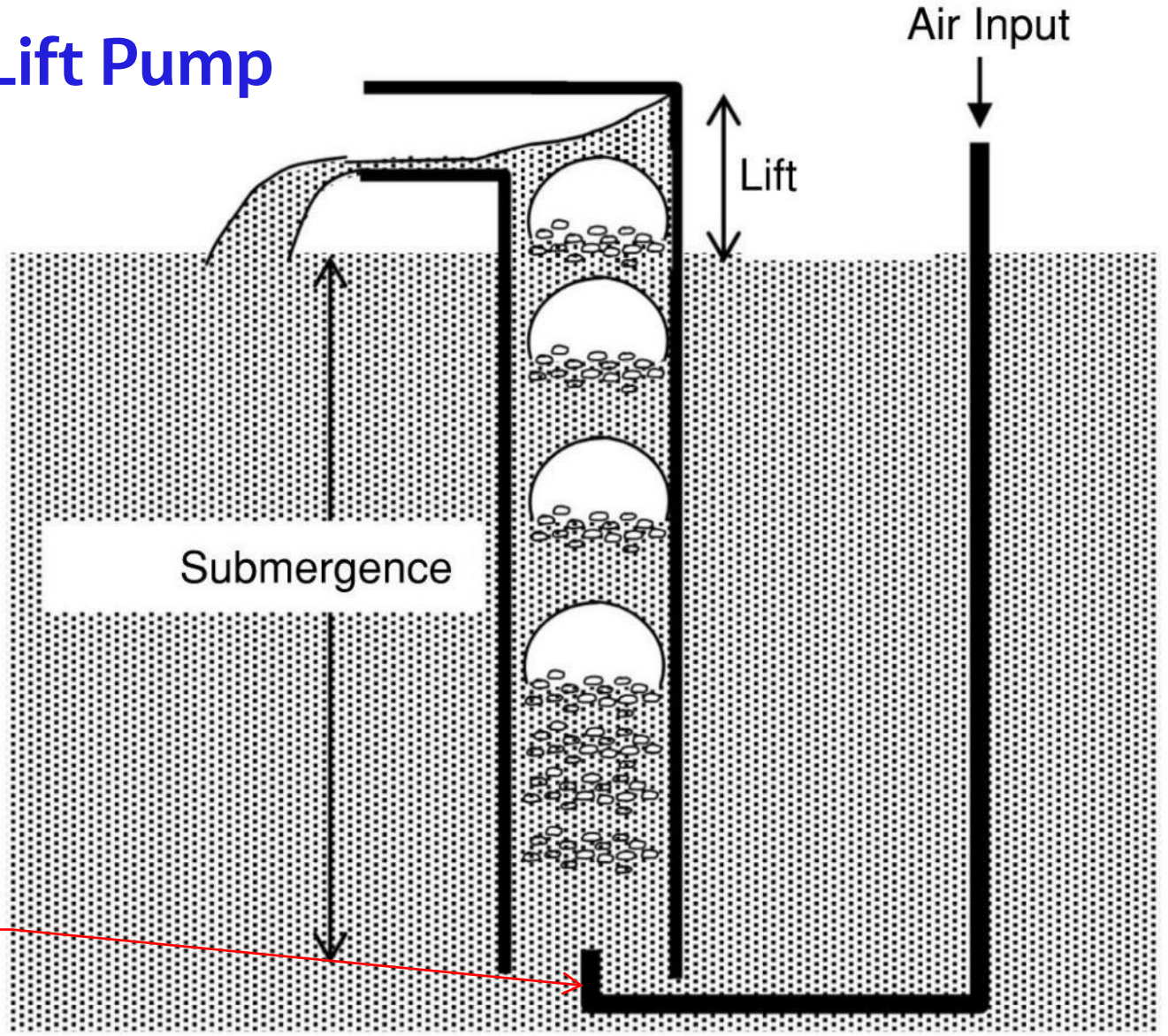
Conceptual Alternatives – 2a Air Lift Pump

- Air is introduced at the base of a submerged riser conduit, and the resulting buoyant force displaces water upwards.
- Water flowrate is a function of riser conduit diameter, riser conduit length, lift height and airflow.
- Lift height is on the order of approximately 6 inches.



Need to check heat transfer from compressed air to river water

Adapted from Timmons et. al., 2010.

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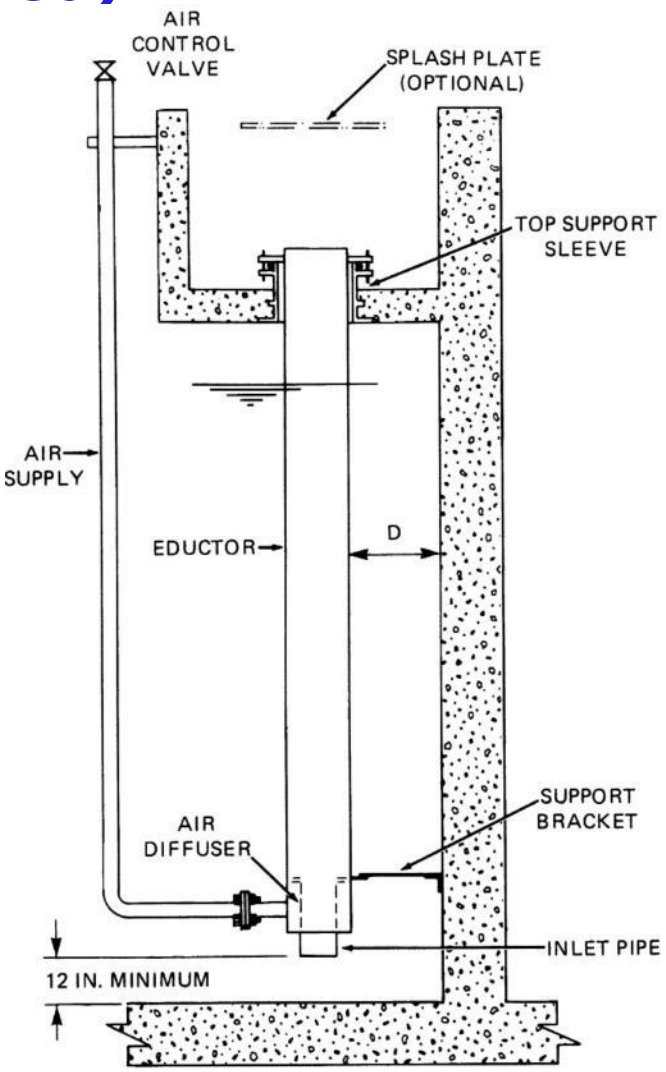
Conceptual Alternatives – 2a Air Lift Pump (continued)

- Commercial products are supplied by Sanitaire/ITT and Ovivo.
- A 32-inch diameter riser conduit (eductor) could provide a flow rate of approximately 12 cfs with an air rate of 160 SCFM.
- A 100 Hp rotary screw compressor could accommodate approximately three air lift pumps (36 cfs).

Operation of the compressor will generate heat, and a question was asked how much of this heat is transferred to the air (and then to the water in the fishway). Jacobs will evaluate this issue and provide an explanation in the Draft Alternatives Report.



From Sanitaire / ITT Industries.

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Conceptual Alternatives – 2a Air Lift Pump (continued)

Key Advantages:

- Gradual temperature transition to forebay via wall diffusers.
- Bubbles can be removed prior to placing water in fishway exit and make-up water intake.
- Lower capital costs in comparison to other pumped alternatives.

Key Disadvantages:

- Mechanical/electrical components that require periodic maintenance.
- May not be effective in shallow areas, i.e. LMN fishway exit.
- Conveyance efficiency is limited; relatively high O&M cost.

It was noted that air lift riser conduits terminating below the water surface could convey cold water close to the fishway exit, while providing a gentle transition to the forebay. Gaps or spaces could be provided to allow fish to move between the rising columns of bubbles.

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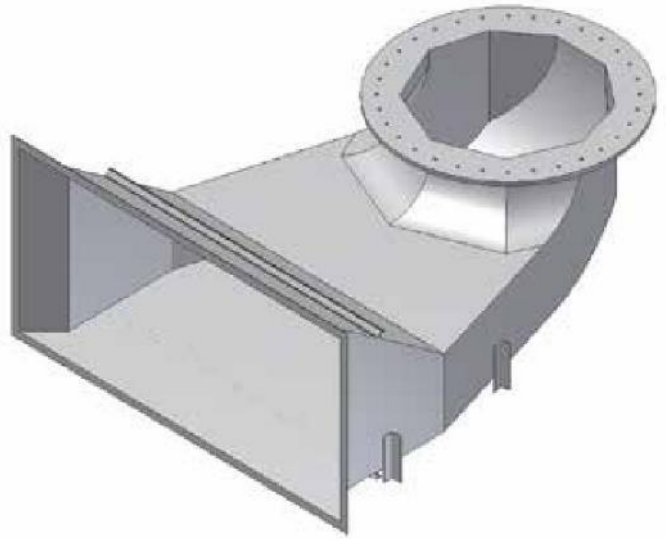
Conceptual Alternatives – 3 Submerged Jet

- Submersible propeller pumps efficiently provide large volume at low head.

Photos from Chelan PUD.



Suction inlet from Xylem/Flygt.

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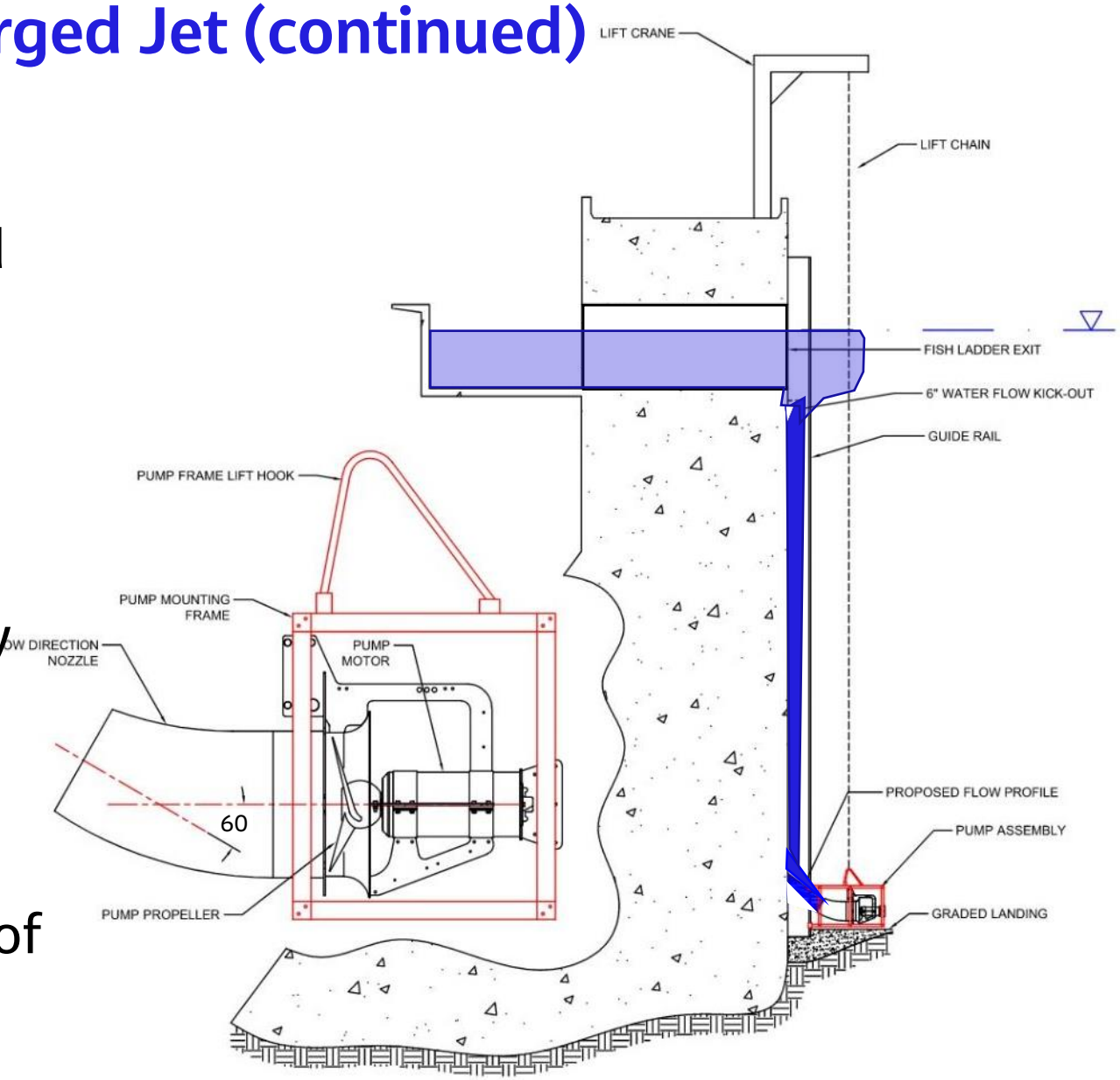
Conceptual Alternatives – 3 Submerged Jet (continued)

- Multiple pumps are low head (~4 feet) at high flow (~45 cfs)
- Pump head all converted to velocity head with reducing elbow with 24" outlet
- Jet velocity is approximately 16 fps
- Jet deflected onto dam face for less dispersion (jet will attach to wall)
- I-Beams serves to channel jet horizontally while also providing a guide for raising/ lowering pump
- I-beams will also take pump thrust loads
- Crane to raise and lower pump assembly of ~1,500 to 2,000 pounds
- Does Pump Inlet need to meet 0.8 fps?



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Conceptual Alternatives – 3 Submerged Jet (continued)

Key Advantages:

- Provides temperature transition to forebay for fish.
- More effective in moving water than bubbler or air lift alternatives.

Key Disadvantages:

- Submerged mechanical/electrical components that require regular maintenance.
- Jet is not contained on forebay side which may dissipate in reservoir and reduce efficiency (difficult to estimate without modeling).
- Not effective in shallow areas, i.e. LMN fishway exit.

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Annual fishway outages are typically in the January and February time frame with a duration of approximately two weeks. Outages can be extended to approximately six weeks if needed for a specific project.

Unscreened intakes could present a problem for spring Chinook, lamprey, sturgeon and other species, even when located deep in the forebay. Debris and the ability to clean a screen are also considerations. Decision was made to utilize the Little Goose trashrack criteria, and to make it removable if possible.

A lot of debris is present at JDA, and cleaning would be difficult. Cleaning of the trashracks at The Dalles could be a proxy for what could be expected at JDA.

Pumps would be picked using a lifting beam and/or rigging positioned over the center of gravity of the pump assembly to minimize racking and binding. Rail systems should be designed to avoid conflicts with the existing fishway exit, and guides for the trashrack and bulkhead. A minimal occlusion is not considered a fish passage conflict given the low water velocity of the fish exit.

Crane access at JDA is limited.

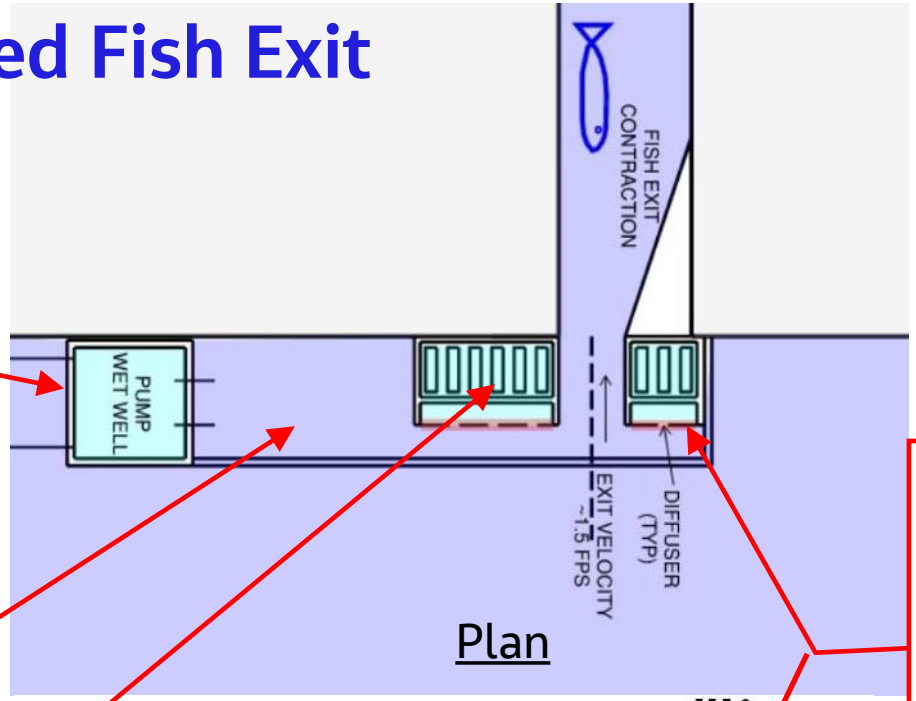
A CFD model with particle tracking could be utilized to evaluate the effectiveness of the submerged jet alternative, including an estimate of how much cold water enters the fishway via the exit. This is beyond the scope of the current Study but could be performed during a subsequent phase of work. For the purposes of this Study, it will be assumed that a skin plate could be added to form a chimney for the jet to provide the cool water a reasonable opportunity of reaching the fish exit.

Conceptual Alternatives – 4 Pumped Fish Exit

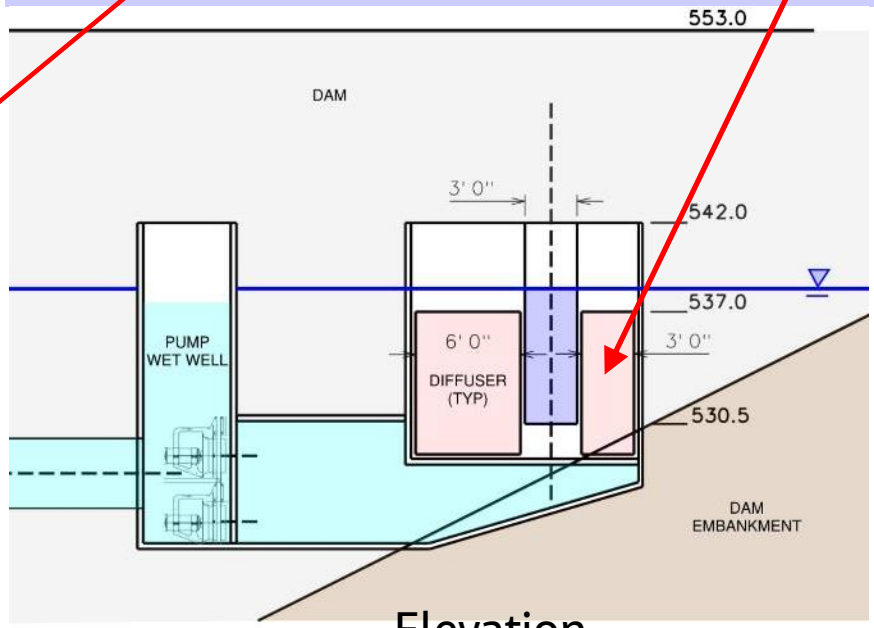
Submersed Propeller Pumps near surface draws water from depth via pipe or chimney

Square Pipe conveys flow under fish exit and disperses pump discharge

Ports to discharge flow into well for diffusers



Plan



Elevation

Diffusers introduces cold water at fish exit with low velocity and low attraction

Diffusers are below invert to improve draw of cold water into Fish Exit

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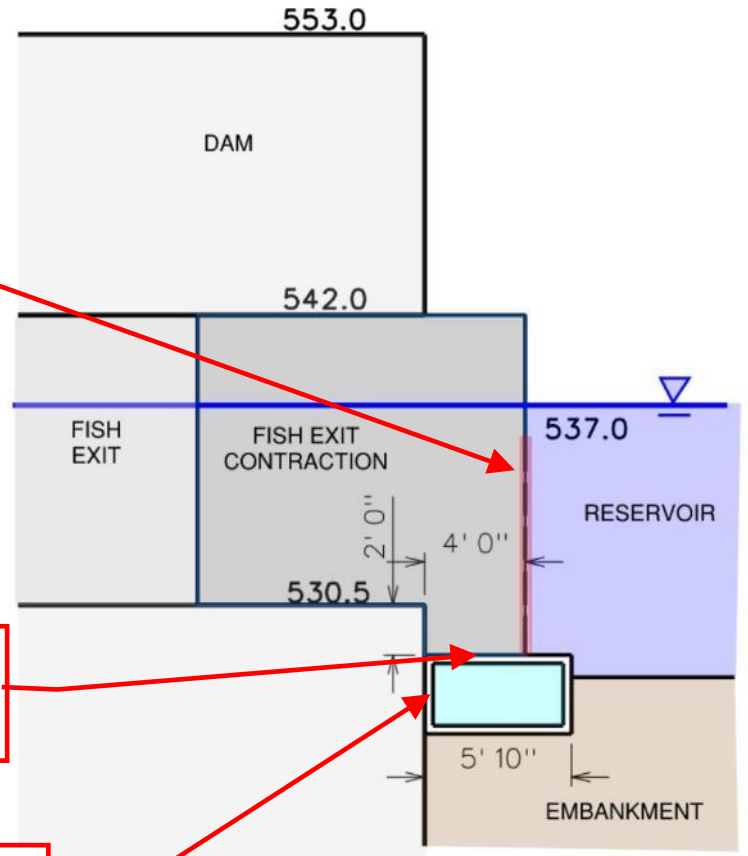
Conceptual Alternatives – 4 Pumped Fish Exit (continued)

Diffusers introduces cold water at fish exit with low velocity and low attraction

Ports to discharge flow into well for diffusers

Square Pipe conveys flow under fish exit and disperses pump discharge



Fishway Exit - Section

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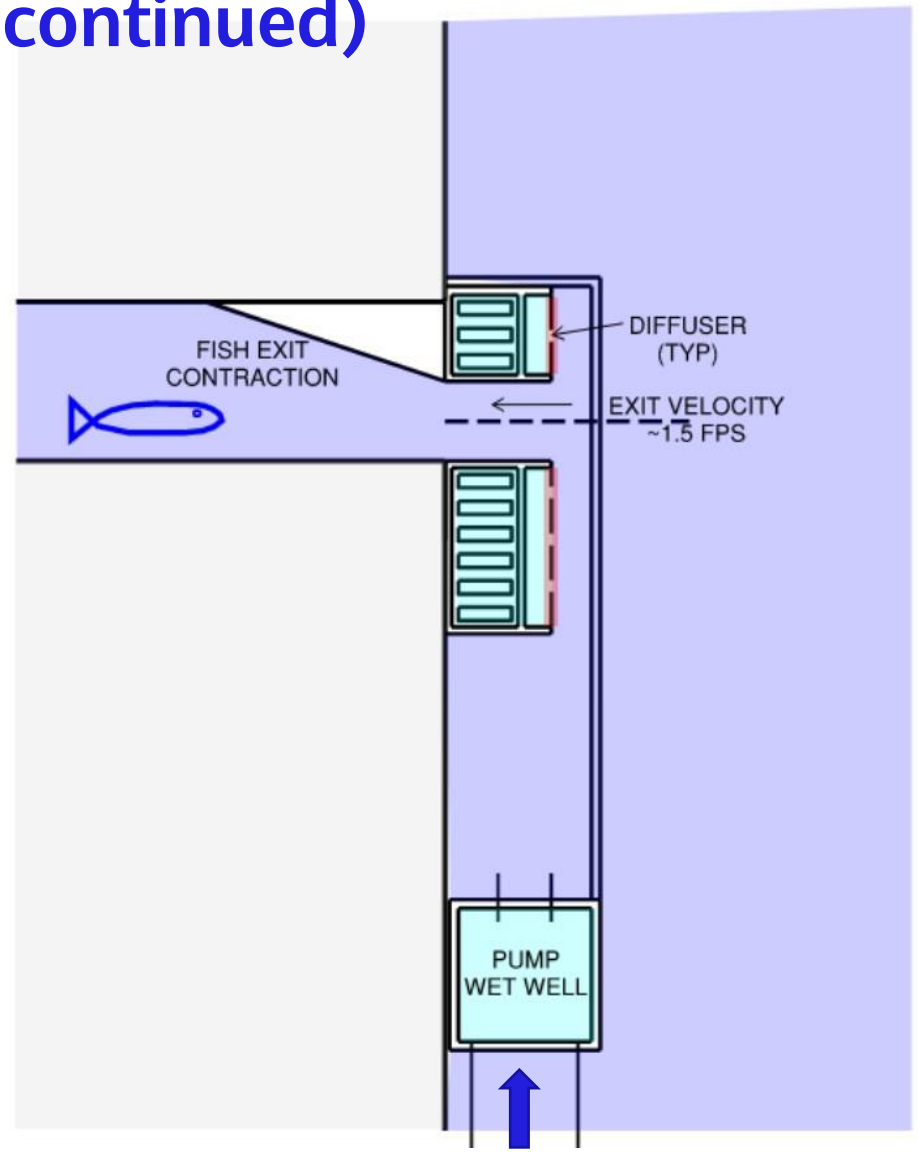
Conceptual Alternatives – 4 Pumped Fish Exit (continued)

- Cool water is conveyed from depth via chimney or pipe
- Submersible Propeller Pump in Shallow Wet Well pulls cool water from depth and supplies water to diffusers at fish exit. Could utilize line shaft pumps with motors located at deck level
- Multiple pumps for redundancy with a spare on deck
- Wall diffusers introduce cold water with low velocity at fish exit (minimizes false attraction)
- Diffuser structure can be left in-place during off season (Pumps ON when needed and OFF when not)
- If required, make-up water intake may also be modified with pumped or gravity flow.



Fishway Exit - Plan

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Conceptual Alternatives – 4 Pumped Fish Exit (continued)

Key Advantages:

- Efficient conveyance of cool water that will be introduced to fish exit a low velocity
- Provides temperature transition to forebay
- Known and understood technologies (wall diffusers)
- Precedence of pump reliability (Rocky Reach JFF)

Key Disadvantages:

- Submerged mechanical/electrical components require regular maintenance.
- Potential for pump noise and vibration in vicinity of fish exit.

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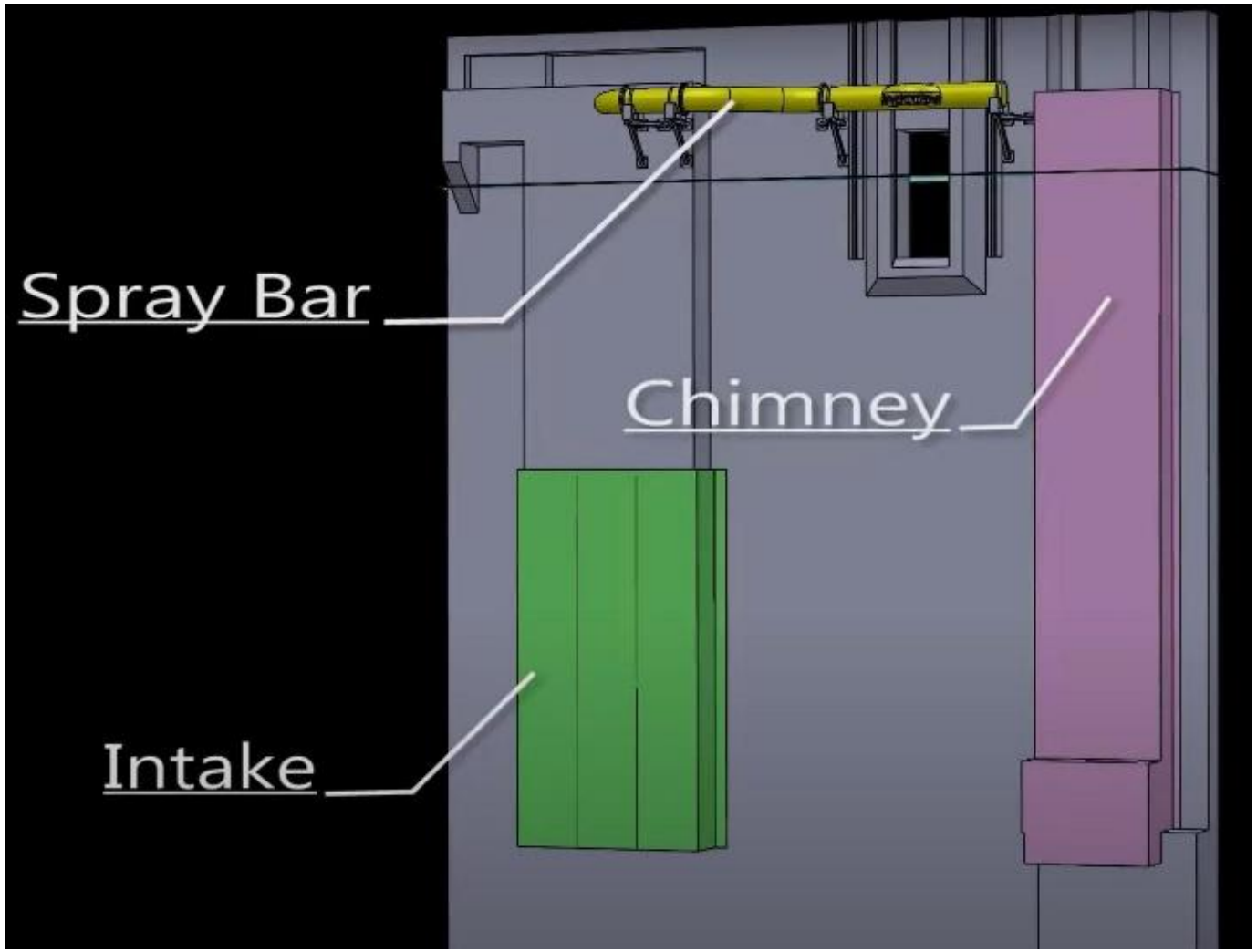
Conceptual Alternatives – 5 Gravity Chimney

- Similar in concept to make-up water chimneys at Lower Granite and Little Goose.
- Fish may leave fishway and enter reservoir via an exit gate or by sounding down to the elevation of the chimney opening.



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Conceptual Alternatives – 5 Gravity Chimney (continued)

Key Advantages:

- Efficient conveyance of cool water.
- No submerged mechanical/electrical components; no pump noise.

Key Disadvantages:

- Less gradual temperature transition to forebay.
- More sensitive to changes in forebay water surface elevation.

Three potential gravity chimney configurations are possible:

1) Conduit for cold water only, similar to Lower Granite and Little Goose make-up water intakes.

2) Conduit for cold water and fish, with fish needing to sound at depth to pass from the fishway exit into the forebay.

3) Conduit for cold water and fish, with additional exits provided near the surface for fish egress, e.g. orifice or keyhole weir. It is anticipated that supplemental cold water would be pumped and diffused into the vicinity of the exits to create a more gradual temperature transition into the forebay.

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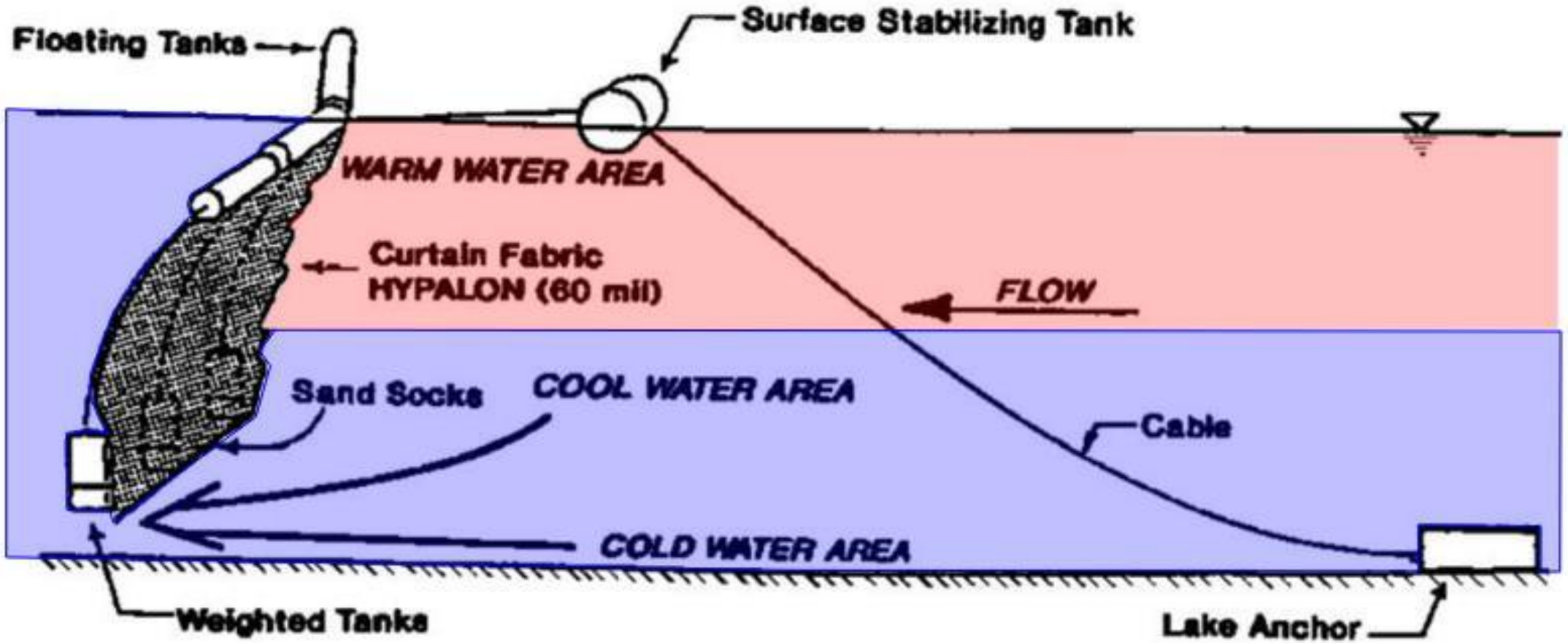
Conceptual Alternatives – 6 Temperature Curtain



Adapted from Johnson et. al., 2000.

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Conceptual Alternatives – 6 Temperature Curtain (continued)

Key Advantages:

- Gradual temperature transition to forebay.
- No submerged mechanical/electrical components.

Key Disadvantages:

- May delay fish movement in reservoir.
- May not be effective in shallow areas, i.e. LMN fishway exit.
- Large anchorages required to handle loads.

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Conceptual Alternatives – 7 Mechanical Systems

Air Chiller, Trailer Mounted:

Eight 500 ton trailer mounted chillers, air cooled

Lower Monumental

- 3,927 ton total capacity needed
- 6,284 chiller GPM
  - 45° F chilled water supply (CHWS) 60° F chilled water return (CHWR).
- 5,242 kW total electrical load

527 Ton Chiller from MacAllister Power Systems.

Ice Harbor

- 3,987 ton total capacity needed
- 6,380 chiller GPM
  - 45° F CHWS 60° F CHWR.
- 5,322 kW total electrical load

Photo from Carrier.

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Conceptual Alternatives – 7 Mechanical Systems (continued)

Water Chiller With Cooling Tower:

Four 1000 ton trailer mounted chillers, water cooled

Lower Monumental

- 3,927 ton total capacity needed
- 6,284 chiller GPM, 9,426 tower GPM
  - 45°F CHWS 60°F CHWR, 90°F condenser water supply (CWS) 80°F condenser water return (CWR).
- 3,829 kW total electrical load

Ice Harbor

- 3,987 ton total capacity needed
- 6,380 chiller GPM, 9,569 tower GPM
  - 45°F CHWS 60°F CHWR, 90°F CWS 80°F CWR.
- 3,886 kW total electrical load

Photos from Carrier.

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Conceptual Alternatives – 7 Mechanical Systems (continued)

Reservoir Heat Exchanger:

- Placed at fishway exit.
- Custom, high-flow.
- Upstream trashrack.
- Requires large structural component for mounting.

From Dimpleflo Heat Transfer Technology.

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Conceptual Alternatives – 7 Mechanical Systems (continued)

Key Advantages:

- Mechanical systems can be operated independently of the reservoir, and don't require a cold water source.
- Allows for precise control of fishway temperatures.
- Offers non-permanent installation with the use of temporary rental units.

Key Disadvantages:

- Very large capital and O&M costs.
- Very high power usage.
- Large footprint.
- Difficult to introduce cool water to fishway

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Conceptual Alternatives – Any Other Ideas?

A question was asked whether the temperature issues exist at every project, and whether an "Alternative No. 8 - Do Nothing" should be included. Concerns were also raised regarding the potential O&M costs for the alternatives vs. current budgets which are limited at each project site.

It was stated that the need for the Study was based on biological evaluations and field data collected at each project. This is also only an Alternatives Study at this stage, and any decisions regarding implementation will be made in the future on a project-by-project basis. Conclusion was to not have a "Do Nothing" alternative.

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Lunch Break

Site-Specific Application of Alternatives

Site-Specific Application of Alternatives

General Considerations

- Need to maintain ability to seasonally install fishway exit bulkheads (and make-up water intake bulkheads).
- Deep intakes should adhere to smolt approach velocity criteria (0.8 fps).

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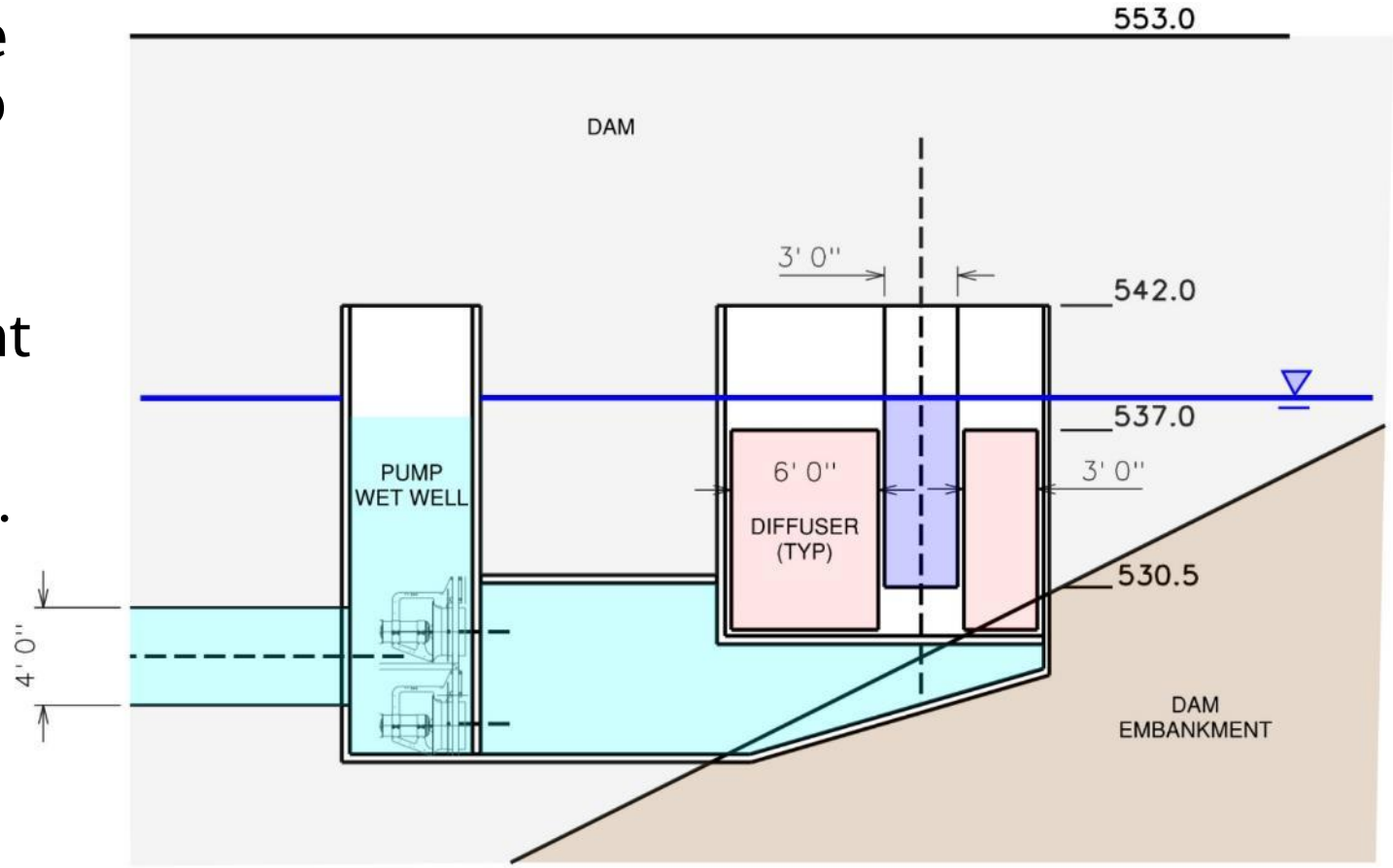
Site-Specific Application of Alternatives – Pumped Fish Exit (LMN)

- Attached to Dam
- Fish Exit opening narrows to provide diffuser area without excavating into dam embankment while improving transport velocity of approx. 1.5 fps
- Minimal impact to dam embankment (rock shell only)
- Design flow of approximately 68 cfs. vs. peak fishway exit flow of 45 cfs.
- Two pumps for redundancy, each at 50% capacity.
- Chimney at make-up water intake.



Fishway Exit - Elevation

The northerly diffuser at LMN is smaller to minimize impacts to the existing embankment. It is anticipated that diffusers for other projects would likely be symmetric about the fish exit opening.

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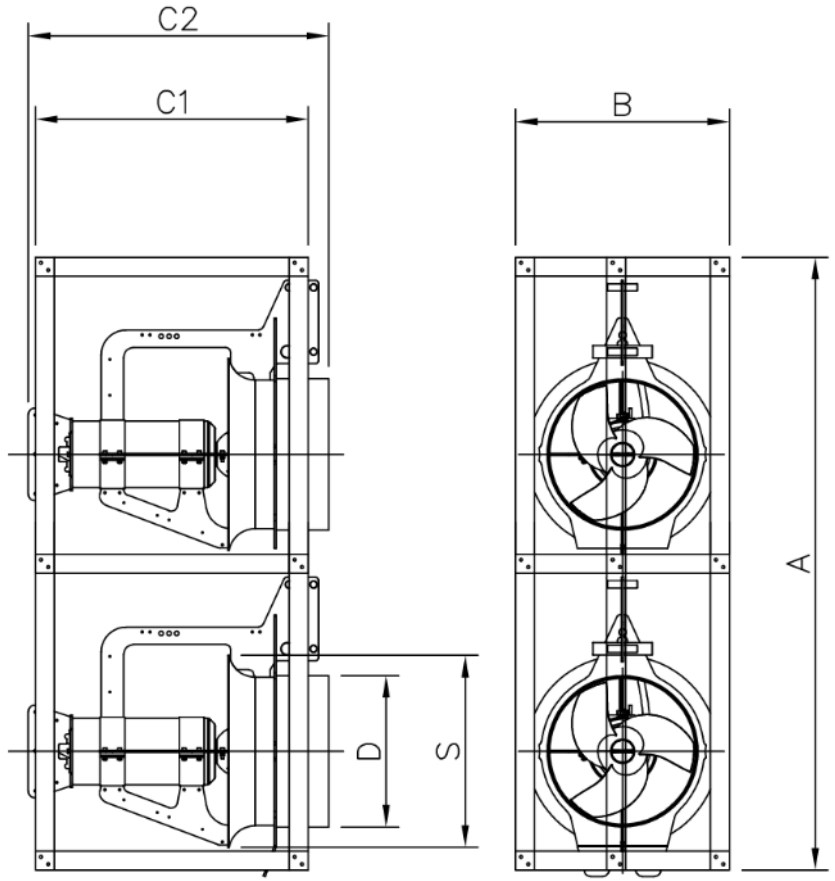
Site-Specific Application of Alternatives – Pumped Fish Exit (LMN)

Lower Monumental

- 67 CFS, 2.4 ft head
- 2 pumps rated 30 hp
- Total input power: 45.4 hp

Ice Harbor/John Day

- 94 CFS, 2.6 ft head
- 2 pumps rated 30 hp
- Total input power: 60 hp



PUMP DIMENSIONS (IN.)						
MODEL	A	B	C1	C2	D	S
PP 4660	97	34	43	48	24	30
PP 4680	130	45	58	64	32	41

PUMP WEIGHTS (LBS.)			
MODEL	INDIVIDUAL WEIGHT	FRAME WEIGHT	TOTAL WEIGHT
PP 4660	585	197	1367
PP 4680	1200	264	2664

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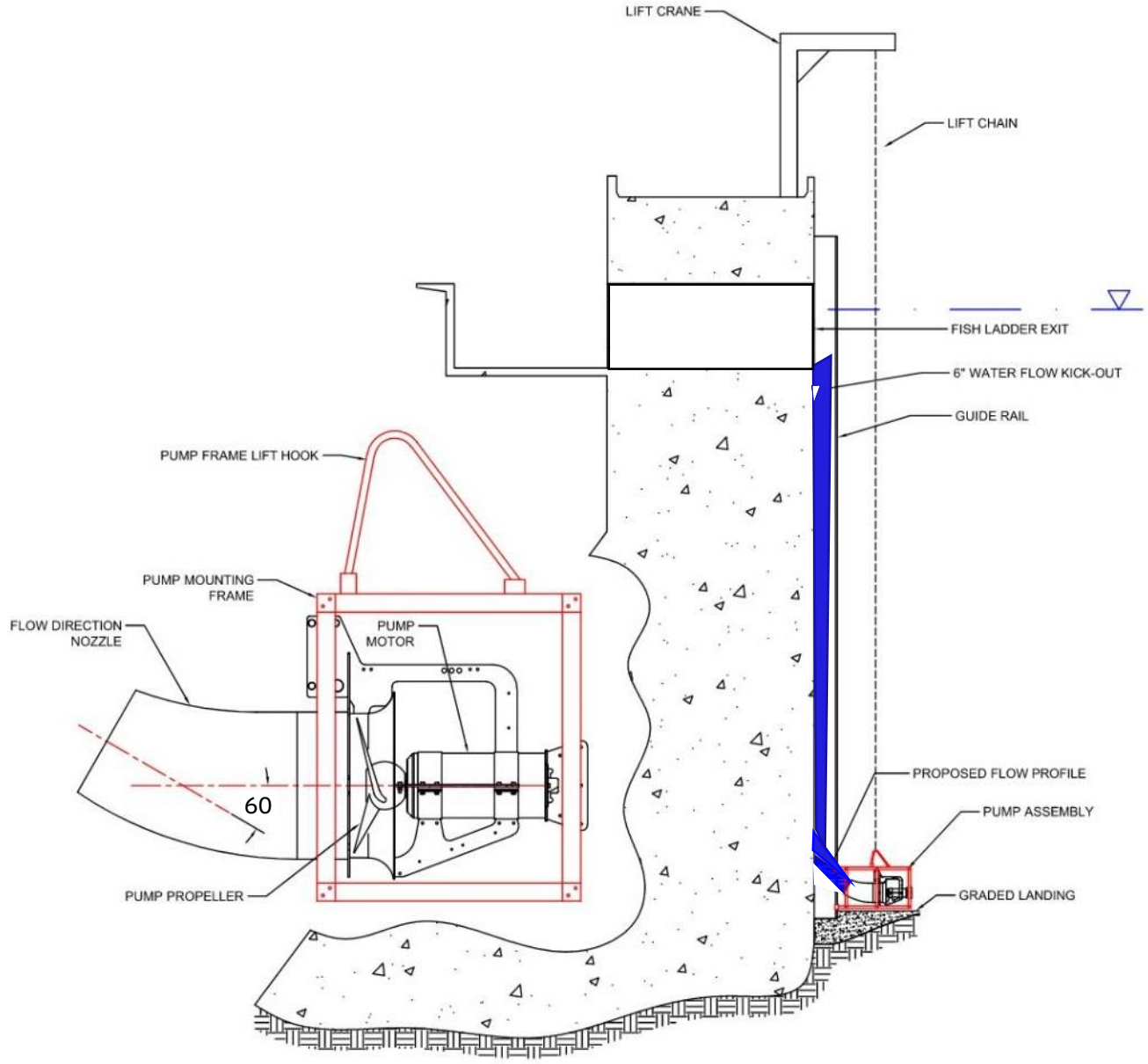
Site-Specific Application of Alternatives – Submerged Jet (HLD, MNA, JDA)

- Ice Harbor/John Day
  - 90 CFS, 4.0 ft head, Jet Velocity 16 ft/s
  - 2 pumps rated 40 hp
  - Total input power: 80 hp
- McNary
  - 180 CFS, 4.0ft head
  - 4 pumps rated 40 hp
  - Total input power: 160 hp

PUMP WEIGHT (LBS.)				
MODEL	INDIVIDUAL WEIGHT	FRAME WEIGHT	NOZZLE WEIGHT	TOTAL WEIGHT PER PUMP ASSEMBLY
PP 4680	1200	175	150	1525



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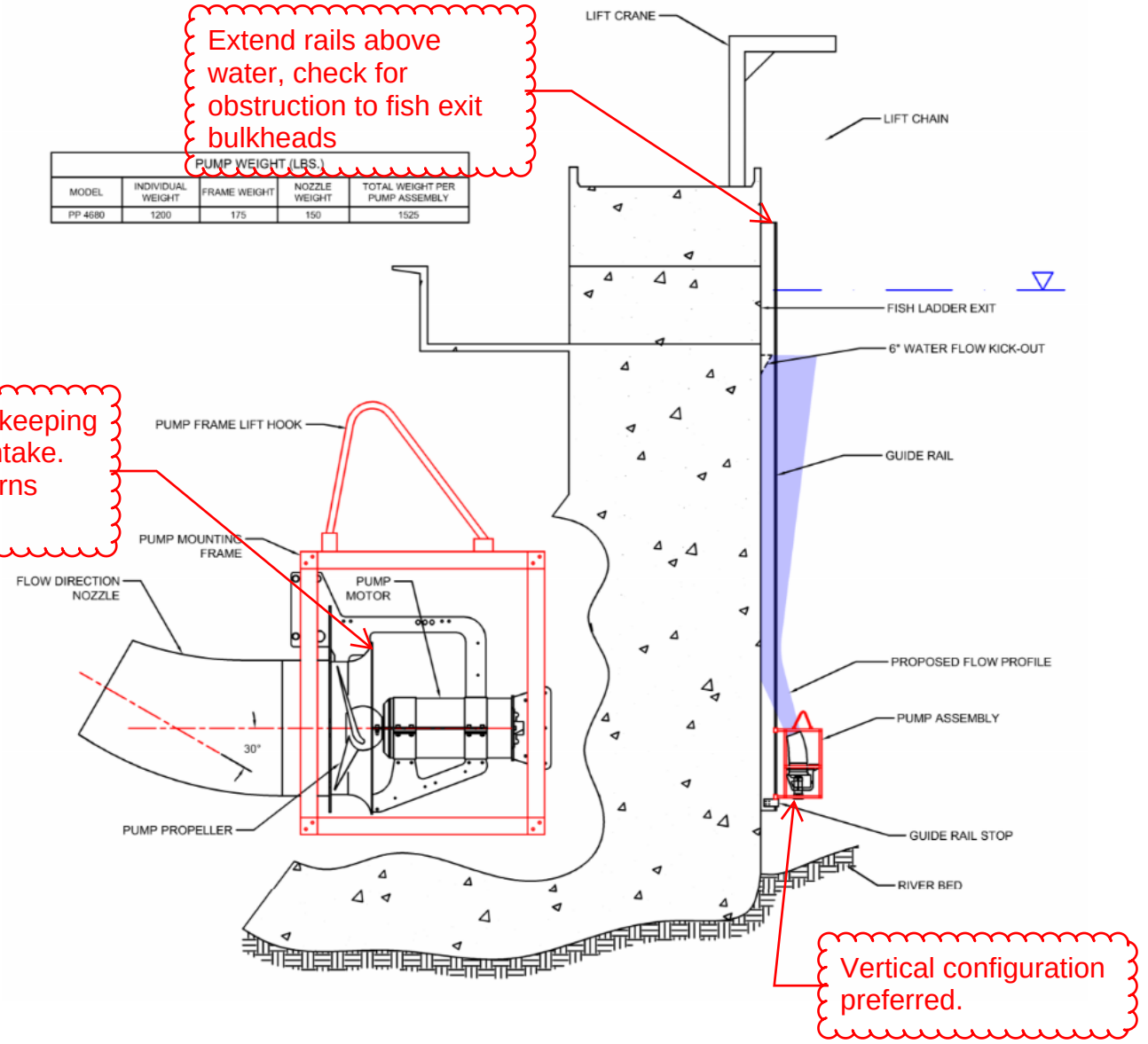
Site-Specific Application of Alternatives – Submerged Jet (Vertical)

- Ice Harbor/John Day
  - 90 CFS, 4.0 ft head, Jet Velocity 16 ft/s
  - 2 pumps rated 40 hp
  - Total input power: 80 hp
- McNary
  - 180 CFS, 4.0ft head
  - 4 pumps rated 40 hp
  - Total input power: 160 hp

Concern was expressed around keeping small fish away from the pump intake. Fine mesh screens raised concerns regarding screen cleaning, etc.

PUMP WEIGHT (LBS.)				
MODEL	INDIVIDUAL WEIGHT	FRAME WEIGHT	NOZZLE WEIGHT	TOTAL WEIGHT PER PUMP ASSEMBLY
PP 4680	1200	175	150	1525



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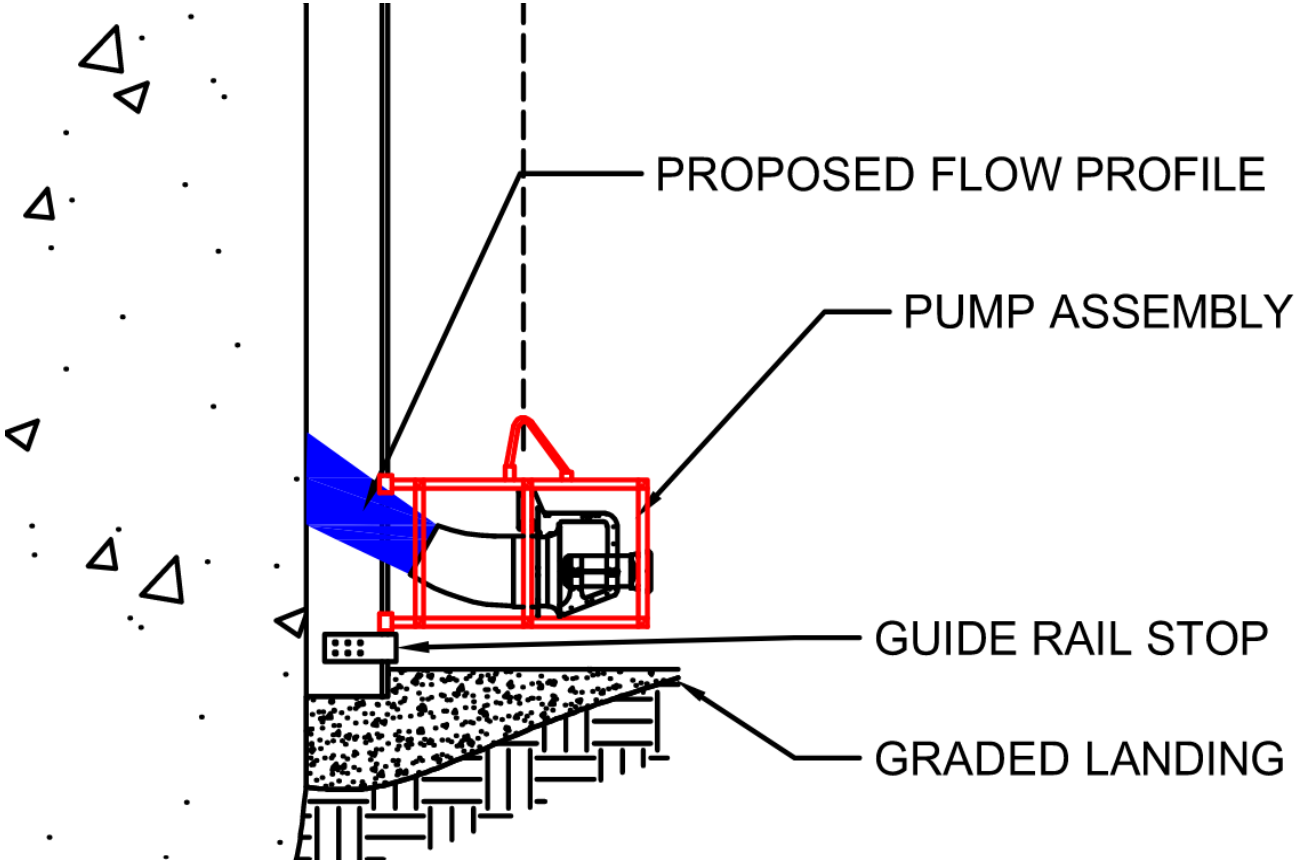
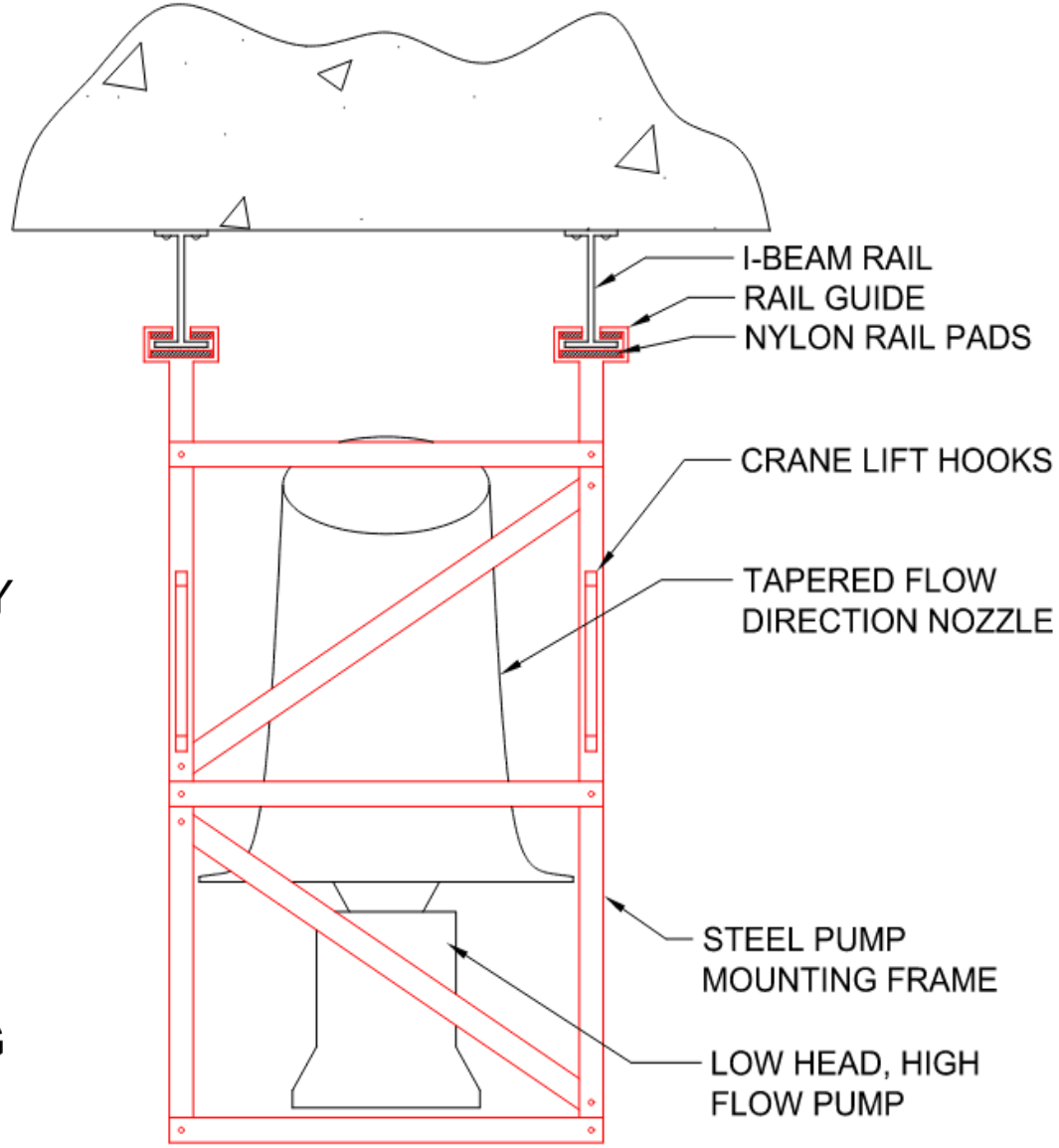
Site-Specific Application of Alternatives – Submerged Jet (HLD, MNA, JDA)

- Pump frame guide rails
- Sits on guide rail stop





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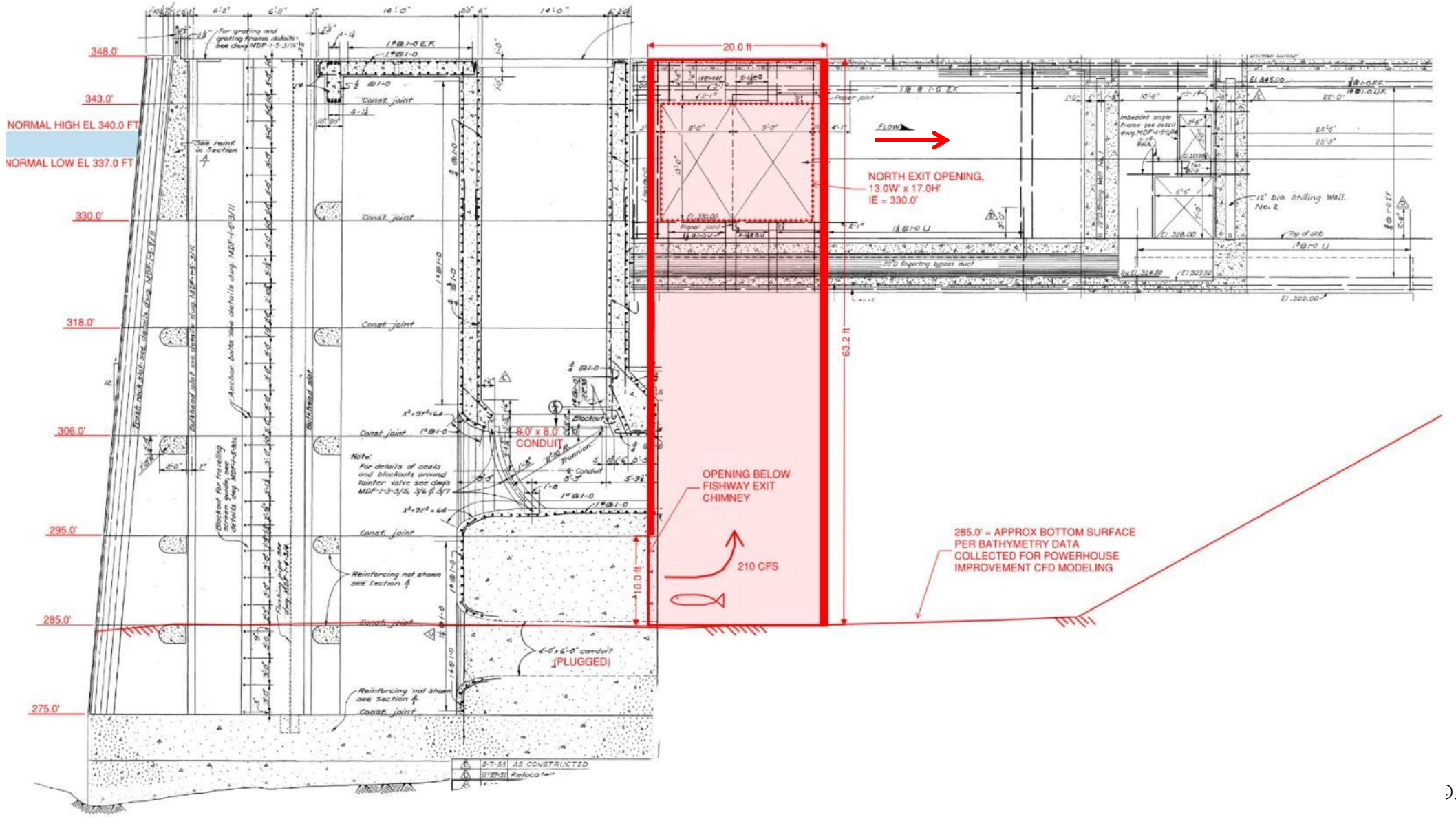
Site-Specific Application of Alternatives – Gravity Chimney (MNA)



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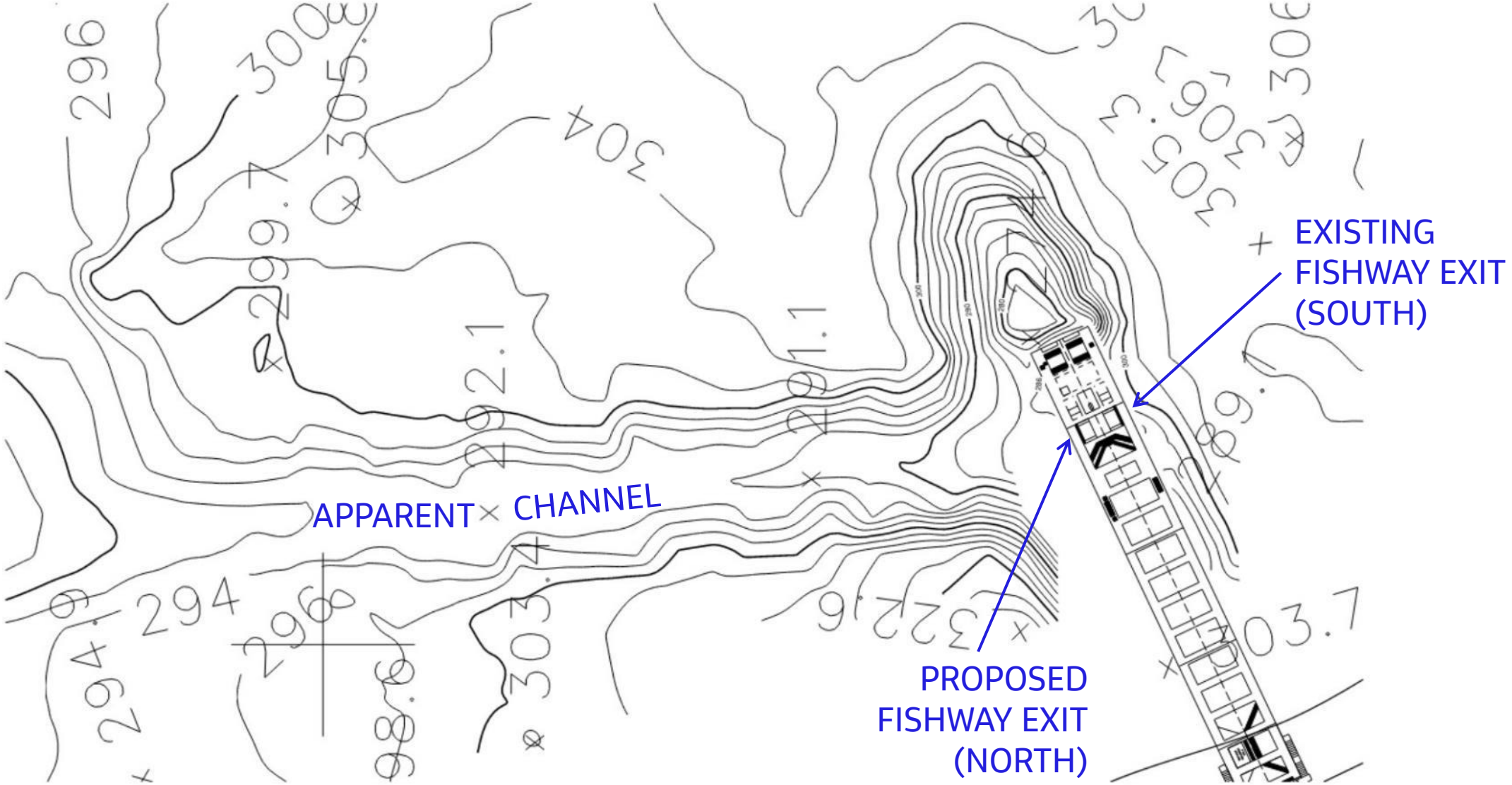
Site-Specific Application of Alternatives – Gravity Chimney (MNA)



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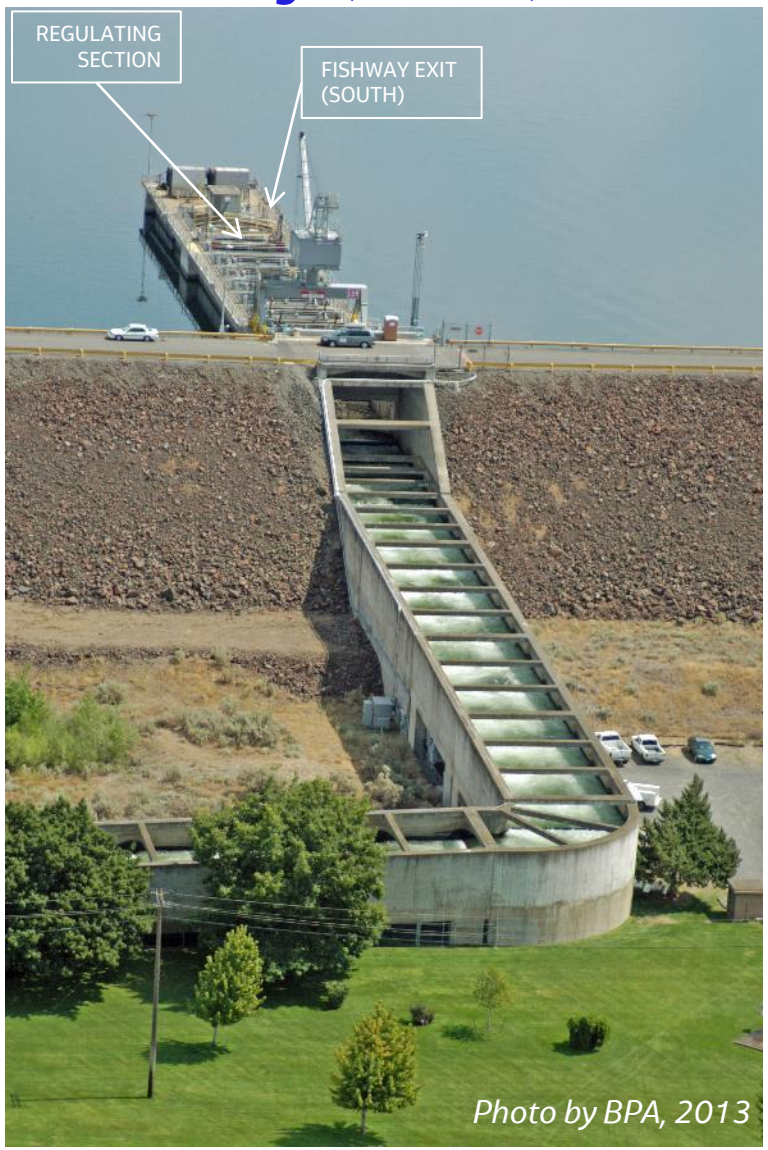
Site-Specific Application of Alternatives – Gravity Chimney (MNA)

- Concept may only be applicable to the northerly fishway exit; the southerly exit may be too shallow.
- Fish will need to sound approximately 50 feet to leave the fishway exit chimney.
- Fallback towards adjacent AWS intake and power intakes could be an issue.



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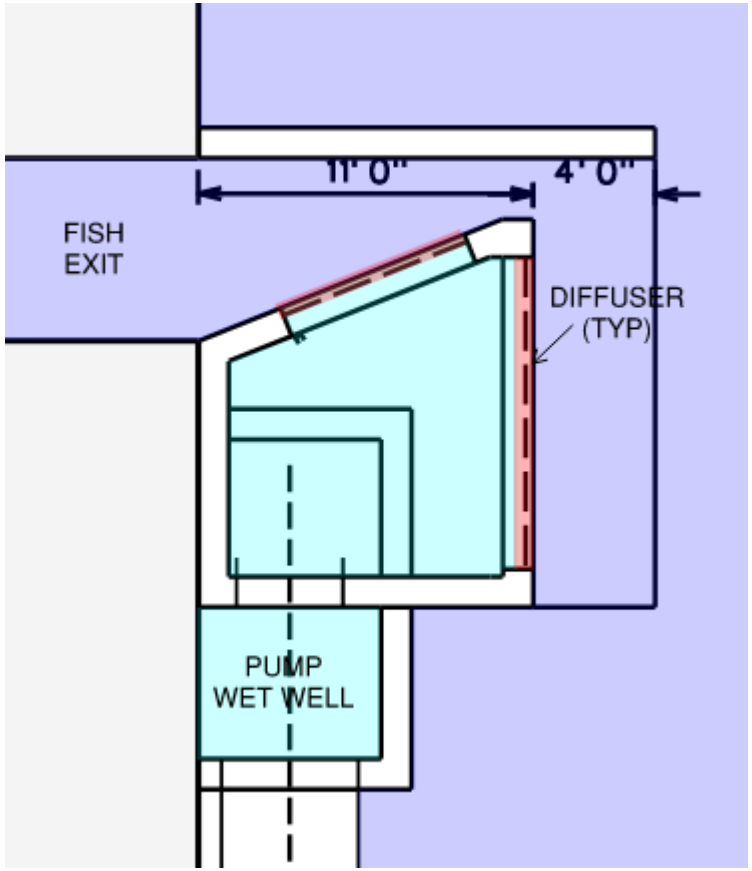
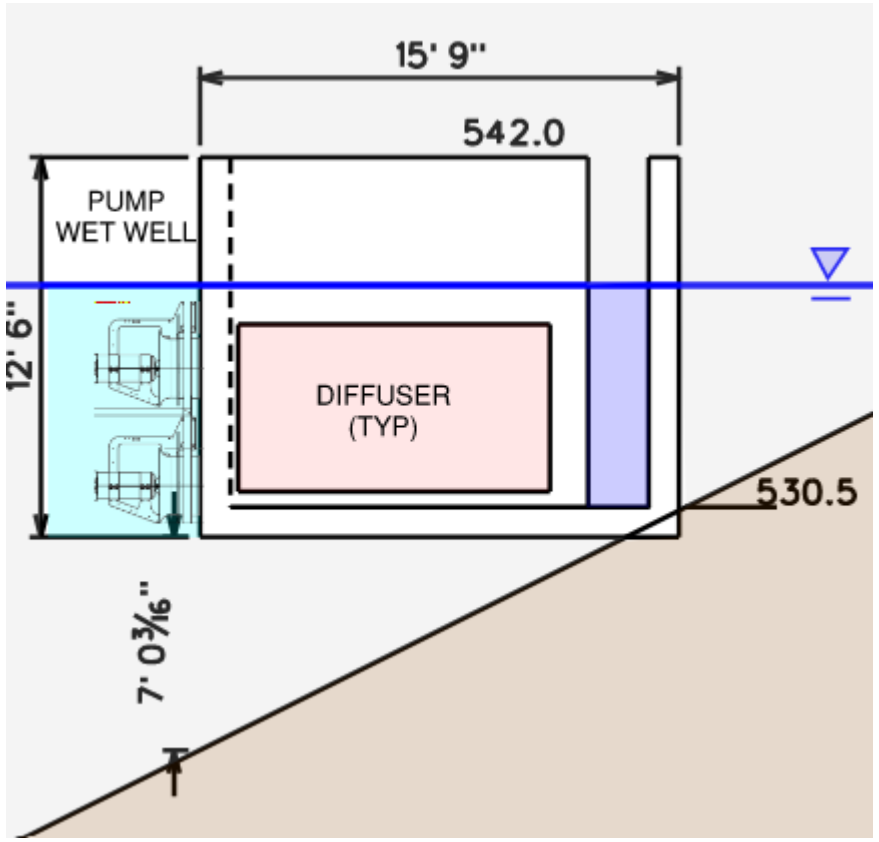
Site-Specific Application of Alternatives – Potential Fatal Flaws

Alternative w/Potential Fatal Flaws (1 of 3)
Pumped Fish Exit Detached (LMN with shallow fish exit)



Fishway Exit - Plan



Fishway Exit - Elevation

- Support of Structure on dam using micropiles
- Dam embankment has detailed construction of rip rap, rock shell, filtering zones.
- Dam Safety will be a challenge with nominal or no benefit to the Pumped Fish Exit

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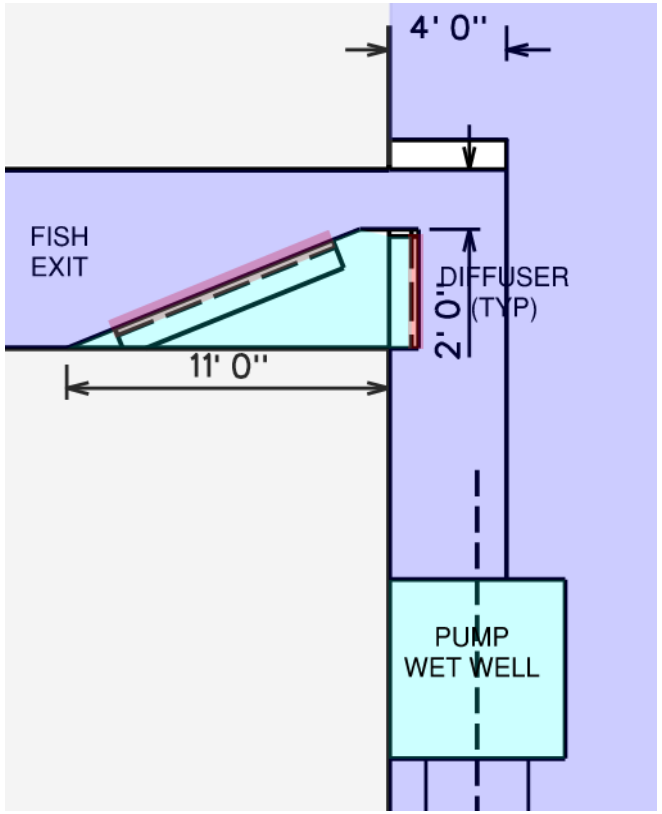
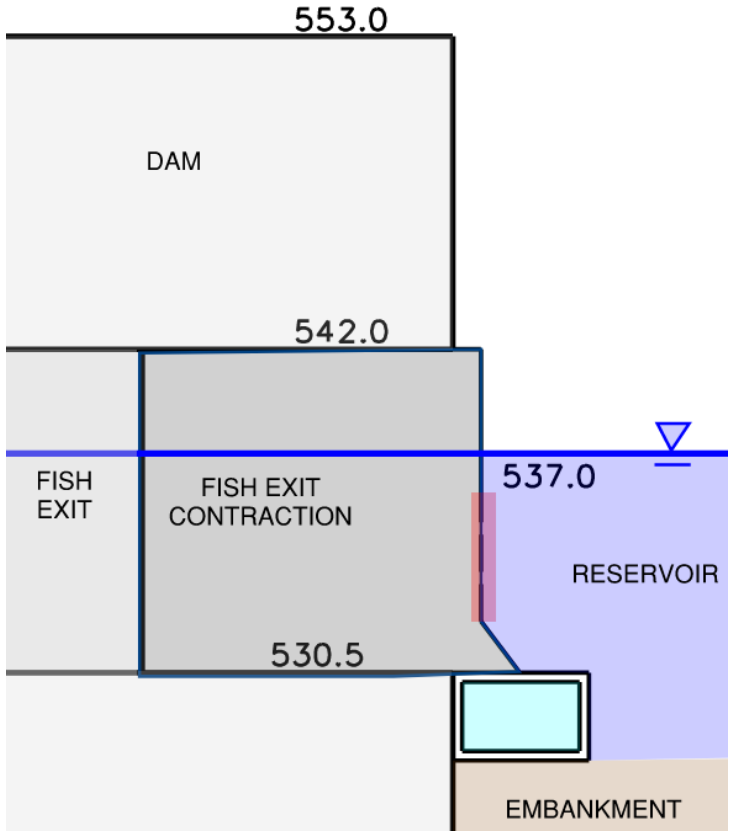
Alternative w/Potential Fatal Flaws (2 of 3)
Pumped Fish Exit Channel



Fishway Exit - Plan



Fishway Exit - Section

- Difficult to get flow inside fish exit channel (limited width) resulting in short forebay diffuser
- Flow limited by low forebay while maintaining a fish exit velocity
- No head space or access area for maintenace
- Requires a modified bulkhead
- No benefit to the Pumped Fish Exit

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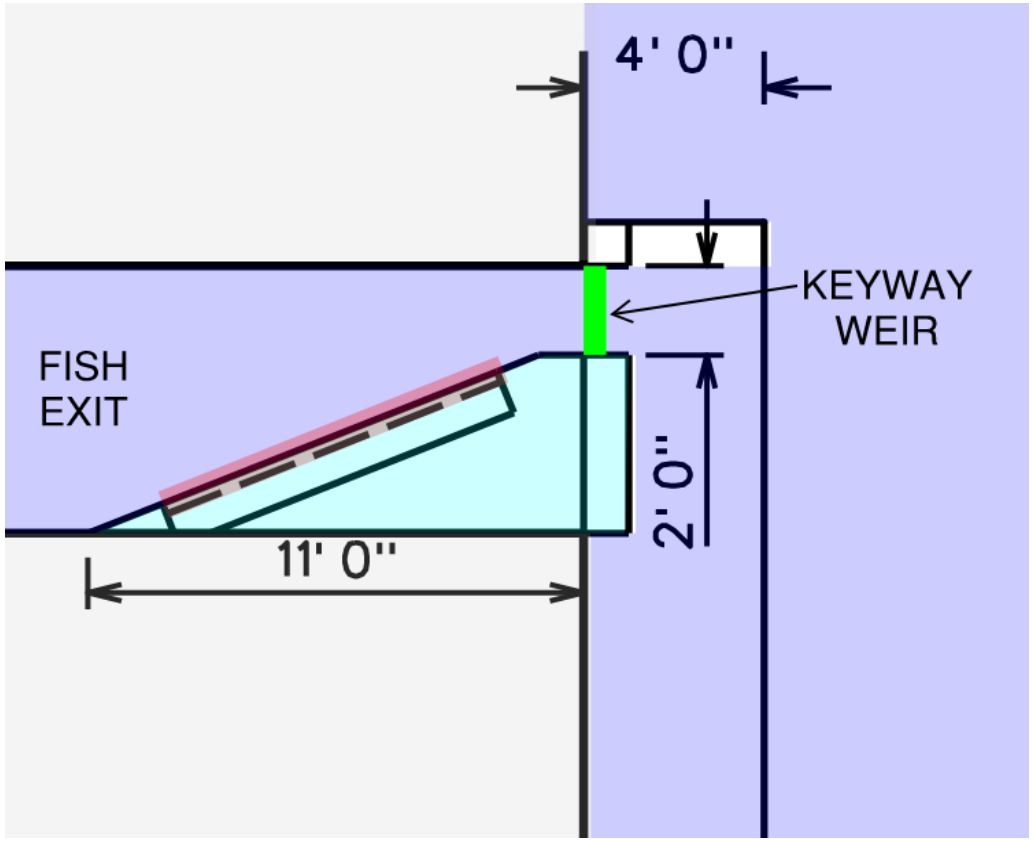
Alternative w/Potential Fatal Flaws (3 of 3)
Gravity Fish Exit Channel



Fishway Exit - Plan

- Difficult to get flow inside fish exit channel (limited width) resulting in short forebay diffuser
- **Flow limited by low forebay** while maintaining a fish exit velocity
- No head space or access area for maintenace
- Requires a modified bulkhead
- THERMAL BARRIER with no temperature transition into forebay - "will fish exit the fish exit?"
- No benefit to the Pumped Fish Exit

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Evaluation of Alternatives – Preferred Alternatives by Site

- Lower Monumental – Modified spray bar, Pumped fish exit
- Ice Harbor – Pumped fish exit, Submerged jet
- McNary – Gravity chimney, Submerged jet
- John Day - Pumped fish exit, Submerged jet

This preliminary list of preferred alternatives to be refined based on the information gathered at the brainstorming workshop, and subsequent meetings to occur at the project sites.

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Site-Specific Application of Alternatives – Summary (LMN)

Lower Monumental - High Forebay and High Entrance Flow in 2022 with Extreme Temperature Difference

			Thermal Efficiency				
	Flow Ratio	Conditioned Exit Flow (cfs)	Exit	Make-Up	Exisiting Exit Delta (F)	Exit Delta (F)	Ladder Delta (F)
Modified Spray Bar	200%	89	60%	**0%**	6.7	2.5	**2.5**
Modified Spray Bar	200%	89	60%	**100%**	6.7	2.5	**1.5**
Pumped Fish Exit	150%	67	90%	**0%**	6.7	0.4	**1.2**
Pumped Fish Exit	150%	67	90%	**100%**	6.7	0.4	**0.1**

Conditioning of make-up water is required to meet criteria for the Modified Spray Bar.

Performance of spray bar can be better estimated from Lower Granite data to be provided by USACE.

The Pumped Fish Exit can meet criteria without the need to condition the make-up water.

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Site-Specific Application of Alternatives – Summary (HLD)

Ice Harbor - High Forebay and High Entrance Flow in 2024 with Extreme Temperature Difference

			Thermal Efficiency				
	Flow Ratio	Conditioned Exit Flow (cfs)	Exit	Make-Up	Exisiting Exit Delta (F)	Exit Delta (F)	Ladder Delta (F)
Pumped Fish Exit	100%	94	90%	**0%**	5.6	-0.3	0.6
Pumped Fish Exit	100%	94	90%	**100%**	5.6	-0.3	-0.6
Submerged Jet	100%	94	60%	**0%**	5.6	1.6	1.8
Submerged Jet	100%	94	60%	**100%**	5.6	1.6	0.7

Both the Pumped Fish Exit and the Submerged Jet can meet criteria without the need to condition the make-up water.

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Site-Specific Application of Alternatives – Summary (MNA)

McNary - 2023 with Extreme Temperature Difference

			Thermal Efficiency				
	Flow Ratio	Conditioned Exit Flow (cfs)	Exit	Make-Up	Exisiting Exit Delta (F)	Exit Delta (F)	Ladder Delta (F)
Gravity Chimney	100%	210	90%	**0%**	3.8	-0.8	-1.2
~~Gravity Chimney~~	~~100%~~	~~210~~	~~90%~~	~~**100%**~~	~~3.8~~	~~0.8~~	~~1.2~~
Submerged Jet	100%	210	60%	**0%**	3.8	0.7	-0.9
~~Submerged Jet~~	~~100%~~	~~210~~	~~60%~~	~~**100%**~~	~~3.8~~	~~0.7~~	~~0.9~~

Temperature criteria can be met for both the Gravity Chimney and Submerged Jet by conditioning only the fish exit water. In addition, it may be possible to only condition a portion of the fish exit water, which allows the use of supplemental surface exits (Gravity Chimney) and a smaller flow ratio or fewer pumps (Submerged Jet).

The MNA fishway does not have a make-up water system. There is a gravity AWS system that does not need to be temperature-conditioned.

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Site-Specific Application of Alternatives – Summary (JDA)

John Day - High Historical Forebay with High Entrance Flow in 2024 with Extreme Temperature Difference

			Thermal Efficiency				
	Flow Ratio	Conditioned Exit Flow (cfs)	Exit	Make-Up	Exisiting Exit Delta (F)	Exit Delta (F)	Ladder Delta (F)
Pumped Fish Exit	100%	68	90%	**0%**	3.8	-0.5	0.9
Pumped Fish Exit	100%	68	90%	**100%**	3.8	-0.5	-0.7
Submerged Jet	100%	68	60%	**0%**	3.8	0.9	1.8
Submerged Jet	100%	68	60%	**100%**	3.8	0.9	0.1

Criteria can be met for both the Pumped Fish Exit and the Submerged Jet by conditioning only the fish exit water.

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Evaluation of Alternatives

Evaluation of Alternatives

To be completed by USACE and Jacobs in subsequent meetings and shared with Team.

	Fishway Cooling Alternative	Evaluation Criteria: Thermal Performance in Ladder	Thermal Performance at Forebay	Fish Behavior (Other)	Operational Feasibility and Reliability	Impacts/Risk to Project Operations	Capital Cost	O&M Cost	Other Key Issues/Concerns
1	**Spray Bar**, aka status quo (Government-provided alternative). Similar to existing facilities at Lower Granite and Little Goose. Pumped water to fishway exit area via fabricated intake extension and discharge pipe with spray bar. Gravity water to makeup water intake via fabricated steel chimney.								
1a	**Modified Spray Bar.** Similar to Spray Bar Alternative, but may include adjustable nozzles, a flow deflector or other enhancements.								
2	**Bubbler** (Government-provided alternative). Compressors with air lines discharging to manifolds located below the fishway exit and make-up water intake. Bubbles are un-contained; no pipe column.								
2a	**Air Lift Pump.** Similar to Bubbler Alternative but with pipe column to contain the bubbles and displaced water. Water discharged near fishway exit area via a fabricated transition channel with wall diffusers.								
3	**Submerged Jet** (Government-provided alternative). Pumps in forebay at depth that direct water towards fishway exit and make-up water intake. May include submersible propeller pump or line shaft pump with motor located at deck level.								
4	**Pumped Fish Exit.** Pumped water discharged near fishway exit area via a fabricated transition channel with wall diffusers. May utilize submersible propeller pumps or line shaft pumps with motors located at deck level. Make-up water intake may also be modified with pumped or gravity flow.								
5	**Gravity Chimney.** Similar to Pumped Fish Exit Alternative but utilizes all gravity flow rather than pumped flow.								
6	**Temperature Curtain.** Curtains of Hypalon or similar material suspended from floating booms in the reservoir that force cool water at depth towards the fishway exit and make-up water intake. May include chain or weights at the bottom of the curtain to maintain shape.								
7	**Mechanical Systems.** Evaporative coolers, mechanical chillers (air- or water-cooled), heat exchangers, etc. that can provide a cold water supply.								
8									

Application of Evaluation Criteria	Thermal Performance in Ladder	Thermal Performance at Exit	Fish Behavior (Other)	Operational Feasibility and Reliability	Impacts/Risks to Project Operations	Capital Cost	O&M Cost
Description	Ability to provide safe, timely and effective passage in fishway.	Ability to provide safe, timely and effective passage from fishway exit into reservoir.	Other impacts to fish behavior as a result of the alternative, including hydraulics (flow, velocity and vectors), bubbles, TDG, pump, vibration, crowding, etc.	Precedence for selected technology, ability to accommodate off-season operations, and flexibility for changing future conditions.	Anticipated impacts or risks to project generation and other authorized purposes.	Relative capital construction cost, including length of implementation schedule.	Relative O&M cost, including labor, equipment maintenance and power costs.
Ranking							
	Excellent	Excellent	Excellent	Excellent	Low	Low	Low
	Very good	Very good	Very good	Very good	Below average	Below average	Below average
	Good	Good	Good	Good	Average	Average	Average
	Fair	Fair	Fair	Fair	Above average	Above average	Above average
	Poor	Poor	Poor	Poor	High	High	High

Alternative Compatibility	LMN	HLD	MNA	JDA
1	✓	✓	✓	✓
1a	✓	✓	✓	✓
2	x	✓	✓	✓
2a	x	✓	✓	✓
3	x	✓	✓	✓
4	✓	✓	✓	✓
5	✓	✓	✓	✓
6	✓	✓	✓	✓
7	✓	✓	✓	✓

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Summary and Wrap-up

Summary and Wrap-Up

- Next Steps
- Action Items
- Project Schedule

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Summary and Wrap-Up

Next Steps

- Further evaluate selected alternatives, including detailed drawings and cost information.
- Prepare Draft Alternatives Analysis Report.
- Conduct Review Meeting to discuss comments.
- Prepare Final Alternatives Analysis Report.

Action Items

- Address data gaps (if any).
- Refine approach based on feedback from this workshop.

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Summary and Wrap-Up

Schedule

Task Order Schedule	Revised Date
Brainstorming Meeting (Walla Walla)	Wednesday, May 7, 2025
Submit Draft Concept Evaluation Report	Tuesday, July 15, 2025
USACE Review Period with DrChecks Comments	Tuesday, August 5, 2025
Review Meeting to discuss comments	Tuesday, August 12, 2025
Submit Final Conceptual Design Evaluation Report	Tuesday, September 2, 2025
USACE Final Backcheck and closeout	Tuesday, September 16, 2025

Future reviews and discussions will be scheduled in coordination with FFDRWG meetings if possible.

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Fish Ladder Cooling Brainstorming Workshop

Lower Monumental | Ice Harbor | McNary | John Day

Thank you!

Jacobs

Challenging today.
Reinventing tomorrow.

Appendix D. Design Calculations

Appendix D1. Hydraulic and Thermal Calculations

LOWER MONUMENTAL - FISHWAY HYDRAULIC AND THERMAL CALCULATIONS

Table LMN-1, Lower Monumental Temperature Performance with a Modified Spray Bar for the 2022 Extreme Thermocline.

		Forebay	Ladder Flow (cfs)	Exit Flow (cfs)	Fish Exit			Makeup	Cool Flow (cfs)			Existing Delta (F)		Delta Condition Temp (F)		Existing Temperature (F)					Conditioned Temp (F)	
	Status	WSE			Flow Ratio	Thermal	Effective	Thermal	Total	Exit	Forebay	Exit	Ladder	Exit	Ladder	Exit	Makeup	Entrance	Deep	Ladder	Exit	Ladder
Modified Spray Bar	High	*540.0*	*70.0*	*44.6*	**150%**	**50%**	75%	**0%**	66.9	33.5	33.5	6.7	5.2	1.5	1.8	76.3	72.1	69.6	69.3	74.8	71.1	71.4
	Median	*538.5*	*70.0*	*37.1*	180%	50%	90%	0%	66.9	33.5	33.5	6.7	4.7	0.4	1.4	76.3	72.1	69.6	69.3	74.3	70.0	71.0
	Low	*537.0*	*70.0*	*29.5*	227%	50%	100%	0%	66.9	29.5	37.4	6.7	4.3	-0.3	1.3	76.3	72.1	69.6	69.3	73.9	69.3	70.9
Modified Spray Bar & Makeup	High	540.0	70.0	44.6	**150%**	**50%**	75%	**100%**	66.9	33.5	33.5	6.7	5.2	1.5	0.8	76.3	72.1	69.6	69.3	74.8	71.1	70.4
	Median	538.5	70.0	37.1	180%	50%	90%	100%	66.9	33.5	33.5	6.7	4.7	0.4	0.1	76.3	72.1	69.6	69.3	74.3	70.0	69.7
	Low	537.0	70.0	29.5	227%	50%	100%	100%	66.9	29.5	37.4	6.7	4.3	-0.3	-0.3	76.3	72.1	69.6	69.3	73.9	69.3	69.3

Table LMN-2, Lower Monumental Temperature Performance with a Pumped Diffuser for the 2022 Extreme Thermocline.

		Forebay	Ladder Flow (cfs)	Exit Flow (cfs)	Fish Exit			Makeup	Cool Flow (cfs)			Existing Delta (F)		Delta Condition Temp (F)		Existing Temperature (F)					Conditioned Temp (F)	
	Status	WSE			Flow Ratio	Thermal	Effective	Thermal	Total	Exit	Forebay	Exit	Ladder	Exit	Ladder	Exit	Makeup	Entrance	Deep	Ladder	Exit	Ladder
Pumped Diffuser	High	*540.0*	*70.0*	*44.6*	**150%**	**90%**	100%	**0%**	66.9	44.6	22.3	6.7	5.2	-0.3	0.7	76.3	*72.1*	*69.6*	*69.3*	74.8	69.3	70.3
	Median	*538.5*	*70.0*	*37.1*	180%	90%	100%	0%	66.9	37.1	29.8	6.7	4.7	-0.3	1.0	76.3	72.1	69.6	69.3	74.3	69.3	70.6
	Low	*537.0*	*70.0*	*29.5*	227%	90%	100%	0%	66.9	29.5	37.4	6.7	4.3	-0.3	1.3	76.3	72.1	69.6	69.3	73.9	69.3	70.9
Pumped Diffuser & Makeup	High	540.0	70.0	44.6	**150%**	**90%**	100%	**100%**	66.9	44.6	22.3	6.7	5.2	-0.3	-0.3	76.3	72.1	69.6	69.3	74.8	69.3	69.3
	Median	538.5	70.0	37.1	180%	90%	100%	100%	66.9	37.1	29.8	6.7	4.7	-0.3	-0.3	76.3	72.1	69.6	69.3	74.3	69.3	69.3
	Low	537.0	70.0	29.5	227%	90%	100%	100%	66.9	29.5	37.4	6.7	4.3	-0.3	-0.3	76.3	72.1	69.6	69.3	73.9	69.3	69.3

ICE HARBOR - FISHWAY HYDRAULIC AND THERMAL CALCULATIONS

Table HLD-1, Ice Harbor Temperature Performance with a Bubbler (shallow 20-foot depth at fishway exit; deep at makeup water intake) for the 2024 Extreme Thermocline.

	Forebay		Ladder Flow (cfs)	Exit Flow (cfs)		Fish Exit		Makeup	Cool Flow (cfs)			Existing Delta (F)		Delta Condition Temp (F)		Existing Temperature (F)					Conditioned Temp (F)	
	Status	WSE			Flow Ratio	Thermal	Effective	Thermal	Total	Exit	Forebay	Exit	Ladder	Exit	Ladder	Exit	Makeup	Entrance	Deep	Ladder	Exit	Ladder
Bubbler	High	*440.0*	*142.0*	*93.5*	**150%**	**50%**	75%	**0%**	140.3	70.1	70.1	5.6	4.4	3.1	2.8	73.2	*69.8*	*67.6*	*69.8*	72.0	70.7	70.4
	Median	*438.5*	*142.0*	*79.8*	176%	50%	88%	0%	140.3	70.1	70.1	5.6	4.1	2.6	2.4	73.2	69.8	67.6	69.8	71.7	70.2	70.0
	Low	*437.0*	*142.0*	*66.0*	213%	50%	100%	0%	140.3	66.0	74.3	5.6	3.8	2.2	2.2	73.2	69.8	67.6	69.8	71.4	69.8	69.8
Bubbler & Makeup	High	440.0	142.0	93.5	**150%**	**50%**	75%	**100%**	140.3	70.1	70.1	5.6	4.4	3.1	1.7	73.2	69.8	67.6	69.8	72.0	70.7	69.3
	Median	438.5	142.0	79.8	176%	50%	88%	100%	140.3	70.1	70.1	5.6	4.1	2.6	1.0	73.2	69.8	67.6	69.8	71.7	70.2	68.6
	Low	437.0	142.0	66.0	213%	50%	100%	100%	140.3	66.0	74.3	5.6	3.8	2.2	0.5	73.2	69.8	67.6	69.8	71.4	69.8	68.1

Table HLD-1a, Ice Harbor Temperature Performance with a Bubbler (deep at both fishway exit and makeup water intake) for the 2024 Extreme Thermocline.

	Forebay		Ladder Flow (cfs)	Exit Flow (cfs)		Fish Exit		Makeup	Cool Flow (cfs)			Existing Delta (F)		Delta Condition Temp (F)		Existing Temperature (F)					Conditioned Temp (F)	
	Status	WSE			Flow Ratio	Thermal	Effective	Thermal	Total	Exit	Forebay	Exit	Ladder	Exit	Ladder	Exit	Makeup	Entrance	Deep	Ladder	Exit	Ladder
Bubbler	High	*440.0*	*142.0*	*93.5*	**150%**	**50%**	75%	**0%**	140.3	70.1	70.1	5.6	4.4	0.7	1.2	73.2	*69.8*	*67.6*	*66.6*	72.0	68.3	68.8
	Median	*438.5*	*142.0*	*79.8*	176%	50%	88%	0%	140.3	70.1	70.1	5.6	4.1	-0.2	0.9	73.2	69.8	67.6	66.6	71.7	67.4	68.5
	Low	*437.0*	*142.0*	*66.0*	213%	50%	100%	0%	140.3	66.0	74.3	5.6	3.8	-1.0	0.7	73.2	69.8	67.6	66.6	71.4	66.6	68.3
Bubbler & Makeup	High	440.0	142.0	93.5	**150%**	**50%**	75%	**100%**	140.3	70.1	70.1	5.6	4.4	0.7	0.1	73.2	69.8	67.6	66.6	72.0	68.3	67.7
	Median	438.5	142.0	79.8	176%	50%	88%	100%	140.3	70.1	70.1	5.6	4.1	-0.2	-0.6	73.2	69.8	67.6	66.6	71.7	67.4	67.0
	Low	437.0	142.0	66.0	213%	50%	100%	100%	140.3	66.0	74.3	5.6	3.8	-1.0	-1.0	73.2	69.8	67.6	66.6	71.4	66.6	66.6

Table HLD-2, Ice Harbor Temperature Performance with a Pumped Diffuser for the 2024 Extreme Thermocline.

	Forebay		Ladder Flow (cfs)	Exit Flow (cfs)		Fish Exit		Makeup	Cool Flow (cfs)			Existing Delta (F)		Delta Condition Temp (F)		Existing Temperature (F)					Conditioned Temp (F)	
	Status	WSE			Flow Ratio	Thermal	Effective	Thermal	Total	Exit	Forebay	Exit	Ladder	Exit	Ladder	Exit	Makeup	Entrance	Deep	Ladder	Exit	Ladder
Pumped Diffuser	High	*440.0*	*142.0*	*93.5*	**150%**	**90%**	100%	**0%**	140.3	93.5	46.8	5.6	4.4	-1.0	0.1	73.2	*69.8*	*67.6*	*66.6*	72.0	66.6	67.7
	Median	*438.5*	*142.0*	*79.8*	176%	90%	100%	0%	140.3	79.8	60.5	5.6	4.1	-1.0	0.4	73.2	69.8	67.6	66.6	71.7	66.6	68.0
	Low	*437.0*	*142.0*	*66.0*	213%	90%	100%	0%	140.3	66.0	74.3	5.6	3.8	-1.0	0.7	73.2	69.8	67.6	66.6	71.4	66.6	68.3
Pumped Diffuser & Makeup	High	440.0	142.0	93.5	**150%**	**90%**	100%	**100%**	140.3	93.5	46.8	5.6	4.4	-1.0	-1.0	73.2	69.8	67.6	66.6	72.0	66.6	66.6
	Median	438.5	142.0	79.8	176%	90%	100%	100%	140.3	79.8	60.5	5.6	4.1	-1.0	-1.0	73.2	69.8	67.6	66.6	71.7	66.6	66.6
	Low	437.0	142.0	66.0	213%	90%	100%	100%	140.3	66.0	74.3	5.6	3.8	-1.0	-1.0	73.2	69.8	67.6	66.6	71.4	66.6	66.6

MCNARY - FISHWAY HYDRAULIC AND THERMAL CALCULATIONS

Table MNA-1, McNary Temperature Performance with a Air Lift Pump for the 2023 Extreme Thermocline.

		Forebay	Ladder Flow (cfs)	Exit Flow (cfs)		Fish Exit		Makeup	Cool Flow (cfs)			Existing Delta (F)		Delta Condition Temp (F)		Existing Temperature (F)					Conditioned Temp (F)	
	Status	WSE			Flow Ratio	Thermal	Effective	Thermal	Total	Exit	Forebay	Exit	Ladder	Exit	Ladder	Exit	Makeup	Entrance	Deep	Ladder	Exit	Ladder
Air Lift	High	*340.0*	*210.0*	*210.0*	**75%**	**90%**	68%	**0%**	157.5	141.8	15.8	3.8	3.8	0.4	0.4	72.4	67.3	68.6	67.3	72.4	69.0	69.0
	Median	*338.5*	*210.0*	*210.0*	75%	90%	68%	0%	157.5	141.8	15.8	3.8	3.8	0.4	0.4	72.4	67.3	68.6	67.3	72.4	69.0	69.0
	Low	*337.0*	*210.0*	*210.0*	75%	90%	68%	0%	157.5	141.8	15.8	3.8	3.8	0.4	0.4	72.4	67.3	68.6	67.3	72.4	69.0	69.0
Air Lift & Makeup	High	340.0	210.0	210.0	**75%**	**90%**	68%	**0%**	157.5	141.8	15.8	3.8	3.8	0.4	0.4	72.4	67.3	68.6	67.3	72.4	69.0	69.0
	Median	338.5	210.0	210.0	75%	90%	68%	0%	157.5	141.8	15.8	3.8	3.8	0.4	0.4	72.4	67.3	68.6	67.3	72.4	69.0	69.0
	Low	337.0	210.0	210.0	75%	90%	68%	0%	157.5	141.8	15.8	3.8	3.8	0.4	0.4	72.4	67.3	68.6	67.3	72.4	69.0	69.0

Table MNA-2, McNary Temperature Performance with a Gravity Chimney for the 2023 Extreme Thermocline.

		Forebay	Ladder Flow (cfs)	Exit Flow (cfs)		Fish Exit		Makeup	Cool Flow (cfs)			Existing Delta (F)		Delta Condition Temp (F)		Existing Temperature (F)					Conditioned Temp (F)	
	Status	WSE			Flow Ratio	Thermal	Effective	Thermal	Total	Exit	Forebay	Exit	Ladder	Exit	Ladder	Exit	Makeup	Entrance	Deep	Ladder	Exit	Ladder
Gravity Chimney	High	*340.0*	*210.0*	*210.0*	**100%**	**90%**	90%	**0%**	210.0	189.0	21.0	3.8	3.8	-0.8	-0.8	72.4	67.3	68.6	67.3	72.4	67.8	67.8
	Median	*338.5*	*210.0*	*210.0*	100%	90%	90%	0%	210.0	189.0	21.0	3.8	3.8	-0.8	-0.8	72.4	67.3	68.6	67.3	72.4	67.8	67.8
	Low	*337.0*	*210.0*	*210.0*	100%	90%	90%	0%	210.0	189.0	21.0	3.8	3.8	-0.8	-0.8	72.4	67.3	68.6	67.3	72.4	67.8	67.8
Gravity Chimney & Makeup	High	340.0	210.0	210.0	**100%**	**90%**	90%	**0%**	210.0	189.0	21.0	3.8	3.8	-0.8	-0.8	72.4	67.3	68.6	67.3	72.4	67.8	67.8
	Median	338.5	210.0	210.0	100%	90%	90%	0%	210.0	189.0	21.0	3.8	3.8	-0.8	-0.8	72.4	67.3	68.6	67.3	72.4	67.8	67.8
	Low	337.0	210.0	210.0	100%	90%	90%	0%	210.0	189.0	21.0	3.8	3.8	-0.8	-0.8	72.4	67.3	68.6	67.3	72.4	67.8	67.8

JOHN DAY - FISHWAY HYDRAULIC AND THERMAL CALCULATIONS

Table JDA-1, John Day Temperature Performance with a Air Lift Pump for the 2024 Extreme Thermocline.

	Forebay		Ladder Flow (cfs)	Exit Flow (cfs)		Fish Exit		Makeup	Cool Flow (cfs)			Existing Delta (F)		Delta Condition Temp (F)		Existing Temperature (F)					Conditioned Temp (F)	
	Status	WSE			Flow Ratio	Thermal	Effective	Thermal	Total	Exit	Forebay	Exit	Ladder	Exit	Ladder	Exit	Makeup	Entrance	Deep	Ladder	Exit	Ladder
Air Lift	High	*265.0*	*85.0*	*67.6*	**125%**	**90%**	100%	**0%**	84.5	67.6	16.9	3.8	3.6	-0.8	-0.1	71.8	70.8	68.0	67.2	71.6	67.2	67.9
	Median	*264.0*	*85.0*	*60.9*	139%	90%	100%	0%	84.5	60.9	23.7	3.8	3.5	-0.8	0.2	71.8	70.8	68	67.2	71.5	67.2	68.2
	Low	*263.0*	*85.0*	*54.1*	156%	90%	100%	0%	84.5	54.1	30.4	3.8	3.4	-0.8	0.5	71.8	70.8	68	67.2	71.4	67.2	68.5
Air Lift & Makeup	High	265.0	85.0	67.6	**125%**	**90%**	100%	**100%**	84.5	67.6	16.9	3.8	3.6	-0.8	-0.8	71.8	70.8	68	67.2	71.6	67.2	67.2
	Median	264.0	85.0	60.9	139%	90%	100%	100%	84.5	60.9	23.7	3.8	3.5	-0.8	-0.8	71.8	70.8	68	67.2	71.5	67.2	67.2
	Low	263.0	85.0	54.1	156%	90%	100%	100%	84.5	54.1	30.4	3.8	3.4	-0.8	-0.8	71.8	70.8	68	67.2	71.4	67.2	67.2

Table JDA-2, John Day Temperature Performance with a Submerged Jet for the 2024 Extreme Thermocline.

	Forebay		Ladder Flow (cfs)	Exit Flow (cfs)		Fish Exit		Makeup	Cool Flow (cfs)			Existing Delta (F)		Delta Condition Temp (F)		Existing Temperature (F)					Conditioned Temp (F)	
	Status	WSE			Flow Ratio	Thermal	Effective	Thermal	Total	Exit	Forebay	Exit	Ladder	Exit	Ladder	Exit	Makeup	Entrance	Deep	Ladder	Exit	Ladder
Submerged Jet	High	*265.0*	*85.0*	*67.6*	**130%**	**60%**	78%	**0%**	87.9	52.7	35.2	3.8	3.6	0.2	0.7	71.8	70.8	68.0	67.2	71.6	68.2	68.7
	Median	*264.0*	*85.0*	*60.9*	144%	60%	87%	0%	87.9	52.7	35.2	3.8	3.5	-0.2	0.7	71.8	70.8	68	67.2	71.5	67.8	68.7
	Low	*263.0*	*85.0*	*54.1*	162%	60%	97%	0%	87.9	52.7	35.2	3.8	3.4	-0.7	0.6	71.8	70.8	68	67.2	71.4	67.3	68.6
Submerged & Makeup	High	265.0	85.0	67.6	**130%**	**60%**	78%	**100%**	87.9	52.7	35.2	3.8	3.6	0.2	0.0	71.8	70.8	68	67.2	71.6	68.2	68.0
	Median	264.0	85.0	60.9	144%	60%	87%	100%	87.9	52.7	35.2	3.8	3.5	-0.2	-0.4	71.8	70.8	68	67.2	71.5	67.8	67.6
	Low	263.0	85.0	54.1	162%	60%	97%	100%	87.9	52.7	35.2	3.8	3.4	-0.7	-0.7	71.8	70.8	68	67.2	71.4	67.3	67.3

Table JDA-3, John Day Temperature Performance with a Bubbler for the 2024 Extreme Thermocline.

	Forebay		Ladder Flow (cfs)	Exit Flow (cfs)		Fish Exit		Makeup	Cool Flow (cfs)			Existing Delta (F)		Delta Condition Temp (F)		Existing Temperature (F)					Conditioned Temp (F)	
	Status	WSE			Flow Ratio	Thermal	Effective	Thermal	Total	Exit	Forebay	Exit	Ladder	Exit	Ladder	Exit	Makeup	Entrance	Deep	Ladder	Exit	Ladder
Bubbler	High	*265.0*	*85.0*	*67.6*	**150%**	**50%**	75%	**0%**	101.4	50.7	50.7	3.8	3.6	0.4	0.9	71.8	70.8	68.0	67.2	71.6	68.4	68.9
	Median	*264.0*	*85.0*	*60.9*	167%	50%	83%	0%	101.4	50.7	50.7	3.8	3.5	0.0	0.8	71.8	70.8	68	67.2	71.5	68.0	68.8
	Low	*263.0*	*85.0*	*54.1*	187%	50%	94%	0%	101.4	50.7	50.7	3.8	3.4	-0.5	0.7	71.8	70.8	68	67.2	71.4	67.5	68.7
Bubbler & Makeup	High	265.0	85.0	67.6	**150%**	**50%**	75%	**100%**	101.4	50.7	50.7	3.8	3.6	0.4	0.1	71.8	70.8	68	67.2	71.6	68.4	68.1
	Median	264.0	85.0	60.9	167%	50%	83%	100%	101.4	50.7	50.7	3.8	3.5	0.0	-0.3	71.8	70.8	68	67.2	71.5	68.0	67.7
	Low	263.0	85.0	54.1	187%	50%	94%	100%	101.4	50.7	50.7	3.8	3.4	-0.5	-0.6	71.8	70.8	68	67.2	71.4	67.5	67.4

Appendix D2. Lower Granite Spray Bar Efficiency

USACE Fishway Cooling - Evaluation of Spray Bar Efficiency at Lower Granite Dam

1. Summary

Reservoir forebay and fish ladder temperatures at Lower Granite Dam were analyzed to estimate spray bar efficiency under three different operational modes. The analysis used temperature data provided by USACE over four consecutive years (2020, 2021, 2022, 2023). Three operational modes were tested over that period: one pump running ("1-Pump Spray"), two pumps running ("2-Pump Spray"), and "1-and-1" where one pump is spraying and one pipe discharges cold water directly into the fishway exit.

Spray bar efficiency is estimated based on the temperature differentials between the fish ladder flow and the temperature of contributing flows from both surface and deep water. As described in the following section, efficiency is computed using two metrics: thermal efficiency and overall efficiency. The average values for the summer months (July and August) of each year are listed in Table 1-1.

Table 1-1. Mean values of efficiency and flow ratio by year.

Year	Operational mode	Flow ratio	Thermal Efficiency	Overall Efficiency
2020	2-Pump Spray	1.36	0.26	0.47
2021	2-Pump Spray	1.15	0.24	0.35
2022	1-and-1	1.18	0.46	0.61
2023	1-Pump Spray	0.94	0.38	0.45

2. Methodology

To estimate the contribution of cold water from deeper elevations to the inflow of the fishway exit, we assume the incoming flow is a combination of surface and deep water. The analysis uses the following variables:

Q_{exit}: Total flow rate entering the fishway. Known variable computed from rating curve using reservoir water surface elevation data. A readily-estimated variable.

T_{exit} : Temperature of the total flow entering the fishway exit. Known variable from temperature measurements in the fish ladder.

$Q_{surface}$: Flow rate of water entering the fish exit that has not been conditioned by the spray bar flow and is primarily surface flow. Unknown variable.

$T_{surface}$: Temperature of water entering the fish exit that has not been conditioned by the spray bar flow and is primarily from near the surface. It is a readily-estimated variable by adjusting the forebay temperature string data available near the surface (0.5 meters deep). The forebay temperature data values were reduced by 1 °F to account for the

temperature of the water entering the fish exit at a depth of 6.5 to 9.5 feet. That estimate was made from the data readily available from Lower Monumental. It could be refined using historical values from Lower Granite and correlated with the thermal string data for the range of temperatures.

$\boldsymbol{Q_{deep}}$: Flow rate of deep water or cold water entering the fishway. Unknown variable.

$\boldsymbol{T_{deep}}$: Temperature of the deep water entering the fishway. Estimated variable from temperature string measurements in the forebay (30 meters deep).

$\boldsymbol{Q_{spray}}$: Spray bar flow rate. Known constant. The discharge from the spray bar depends on the type of operation. Three operations were evaluated: "1-Pump Spray", "2-Pump Spray" and "1-and-1."

The combination surface and deep water in the fishway exit is expressed as a system of two equations and two unknowns:

$$Q_{exit}\, T_{exit} = Q_{surface}\, T_{surface} + Q_{deep}\, T_{deep} \qquad (1)$$

$$Q_{exit} = Q_{surface} + Q_{deep} \qquad (2)$$

To find unknown variables, Q_{deep} and $Q_{surface}$, we start by replacing Eq. (2) in Eq. (1):

$$Q_{exit}\, T_{exit} = (Q_{exit} - Q_{deep})\, T_{surface} + Q_{deep}\, T_{deep}$$

Solving for Q_{deep},

$$Q_{exit}\, T_{exit} - Q_{exit}\, T_{surface} = -Q_{deep}\, T_{surface} + Q_{deep}\, T_{deep}$$

$$Q_{exit}\,(T_{exit} - T_{surface}) = Q_{deep}\,(T_{deep} - T_{surface})$$

$$Q_{deep} = Q_{exit}\,\frac{T_{exit} - T_{surface}}{T_{deep} - T_{surface}}$$

$Q_{surface}$ is then obtained from Eq. (2),

$$Q_{surface} = Q_{exit} - Q_{deep}$$

Spray bar efficiency

After estimating the contributions of surface and deep water to the fishway outflow, we calculate two spray bar efficiency metrics: thermal efficiency and overall efficiency. The thermal efficiency is estimated as the ratio between the cold water entering the fish exit and the total spray bar flow rate:

$$Thermal\ efficiency = \frac{Q_{deep}}{Q_{spray}}$$

The overall efficiency of the spray bar in cooling the fishway flow is calculated as the ratio of cold water to the total fishway flow.

$$Overall\ efficiency\ = \frac{Q_{deep}}{Q_{exit}}$$

Another factor to consider when evaluating the spray bar efficiency is the ratio of the amount of water discharged by the spray bar compared to the total fishway flow.

$$Flow\ ratio\ = \frac{Q_{spray}}{Q_{exit}}$$

3. Data available

USACE provided temperature data from summer periods over four years (2020, 2021, 2022, 2023) at the fish ladder exit, and the forebay. The analysis focuses on two forebay temperatures, one close to the surface measured at a depth of 0.5 meters, and one at deep-water, measured at an elevation comparable to the intake elevation of the spray bar. Both forebay temperature datasets (surface and deep-water) were collected at locations sufficiently distant from the fishway and are therefore assumed to be unaffected by the operation of the spray bar.

Figure 3-1 shows the temporal extent of data at the three locations of interest: fish ladder exit (T_{exit}), forebay surface ($T_{surface}$), and deep water in the forebay (T_{deep}). Operational modes varied across years: in 2020 and 2021, the system operated under the "2-Pump Spray" configuration; in 2022, the "1-and-1" configuration was used; and in 2023, the system operated under the "1-Pump Spray" mode.

Water surface elevation (WSE) data for the reservoir were used to estimate the flow rate through the fish ladder. A linear relationship between WSE and flow rate was assumed, based on reference data points provided by USACE: 25 cfs at a WSE of 733 ft, and 50 cfs at a WSE of 737 ft. Hourly WSE data for the four years of analysis was obtained from the USACE website.

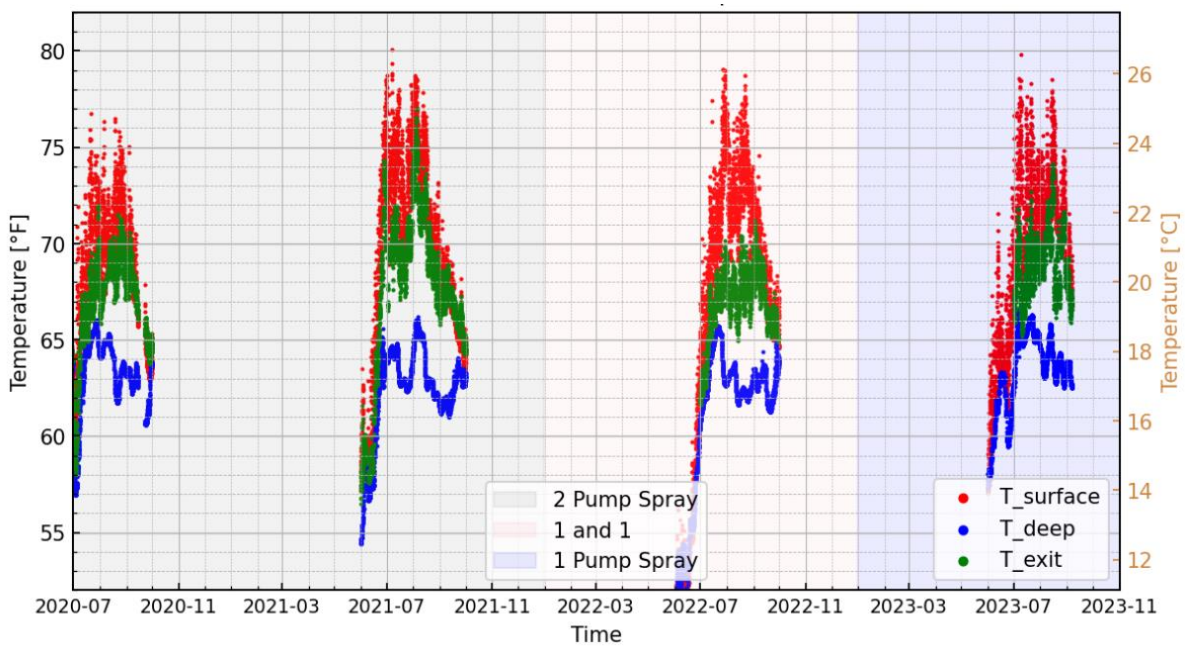

Figure 3-1. Lower Granite. Summer temperature data for the three operational modes of the spray bar

4. CFD Calculation

A calculation of the estimated efficiencies using the CFD thermal modeling was performed (CH2M, 2017). It is noted that the actual field conditions can vary with operating conditions and particularly the inclusion of the surface radiation on the stagnate water surface not accounted for in the sectional model. The sectional model provided a relative comparison of how much of the cool water was entering. The calculations were performed using the same equations and assumptions as the field data with the exception of $T_{surface}$ was used from the baseline CFD results with no spray bar. The results are shown in Figure 4-1.

Strong with 50cfs pump			Moderate with 25cfs pump			Moderate with 50cfs pump		
T_exit	70.6	°F	T_exit	67.1	°F	T_exit	67.1	°F
T_surface	72.1	°F	T_surface	67.8	°F	T_surface	67.8	°F
T_deep	64.2	°F	T_deep	65.7	°F	T_deep	66.0	°F
Q_spray	50	cfs	Q_spray	25	cfs	Q_spray	50	cfs
Q_exit	27	cfs	Q_exit	27	cfs	Q_exit	27	cfs
Q_deep	5.13	cfs	Q_deep	9	cfs	Q_deep	10.5	cfs
Q_surface	21.87	cfs	Q_surface	18	cfs	Q_surface	16.5	cfs
Thermal efficiency: Q_deep/Q_spray	0.10		**Thermal efficiency:** Q_deep/Q_spray	0.36		**Thermal efficiency:** Q_deep/Q_spray	0.21	
Overall Efficiency: Q_deep/Q_exit	0.19		**Overall Efficiency:** Q_deep/Q_exit	0.33		**Overall Efficiency:** Q_deep/Q_exit	0.39	
Flow ratio: Q_spray/Q_exit	1.85		**Flow ratio:** Q_spray/Q_exit	0.93		**Flow ratio:** Q_spray/Q_exit	1.85	

Figure 4-1. Computed Efficiencies using the Lower Granite CFD results (CH2M, 2017) for two operational modes of the spray bar for two different intensities of Thermocline.

5. Results

The computed flow rates, $Q_{surface}$ and Q_{deep}, are presented in Figure 5-1. Water surface elevation data is included to highlight operational differences across the four years.

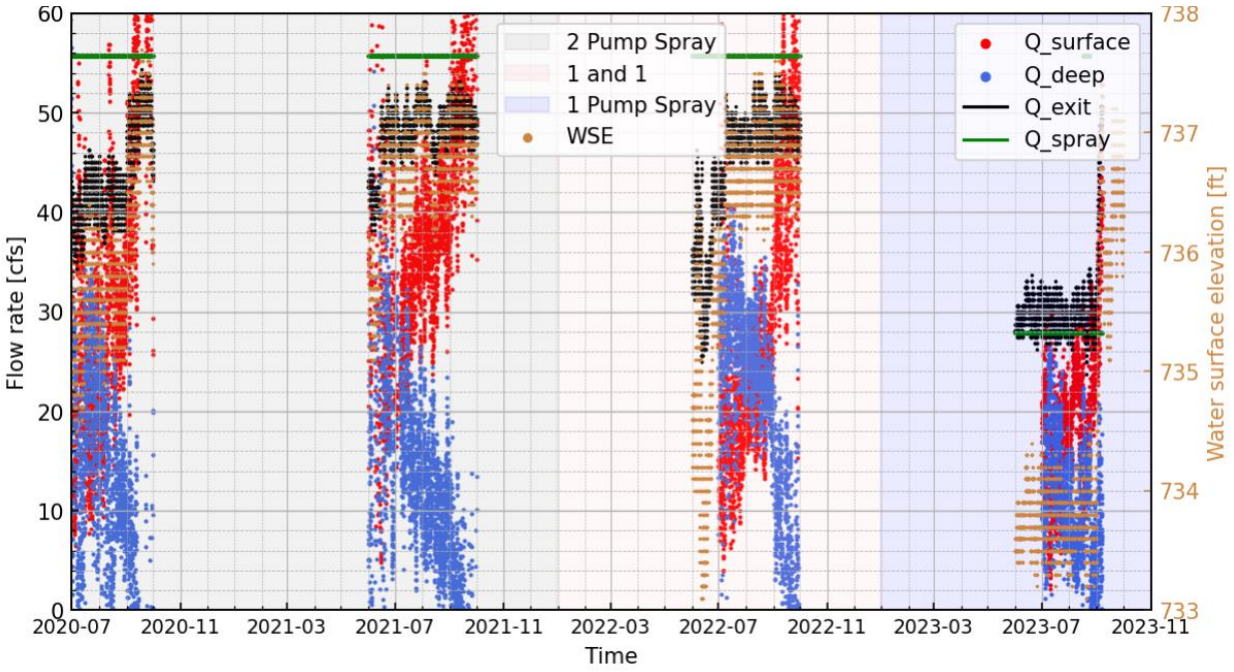

Figure 5-1. Lower Granite. Computed flow rates for the three operational modes of the spray bar.

Computed thermal and overall efficiencies are presented in Figure 5-2 and Figure 5-3, including a ten-day moving average. For reference, Figure 5-4 shows the flow ratio associated with each operational mode. The average values by year and operational mode are listed in Table 1-1.

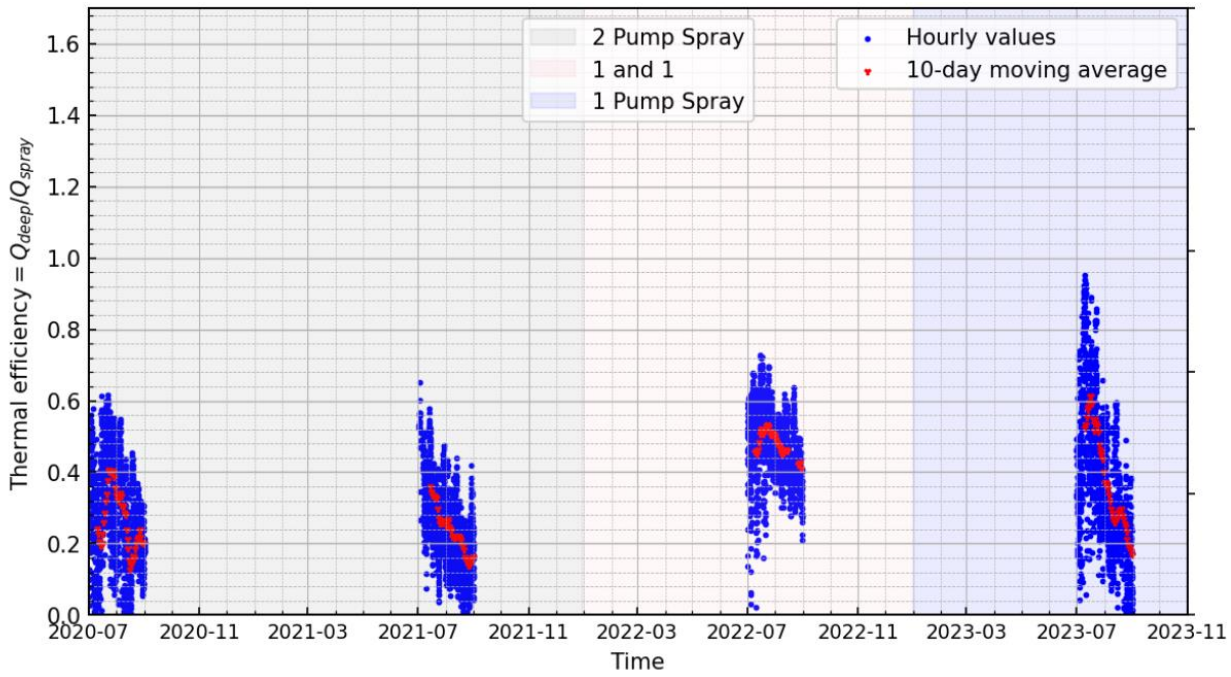

Figure 5-2. Lower Granite. Thermal efficiency for the three operational modes of the spray bar.

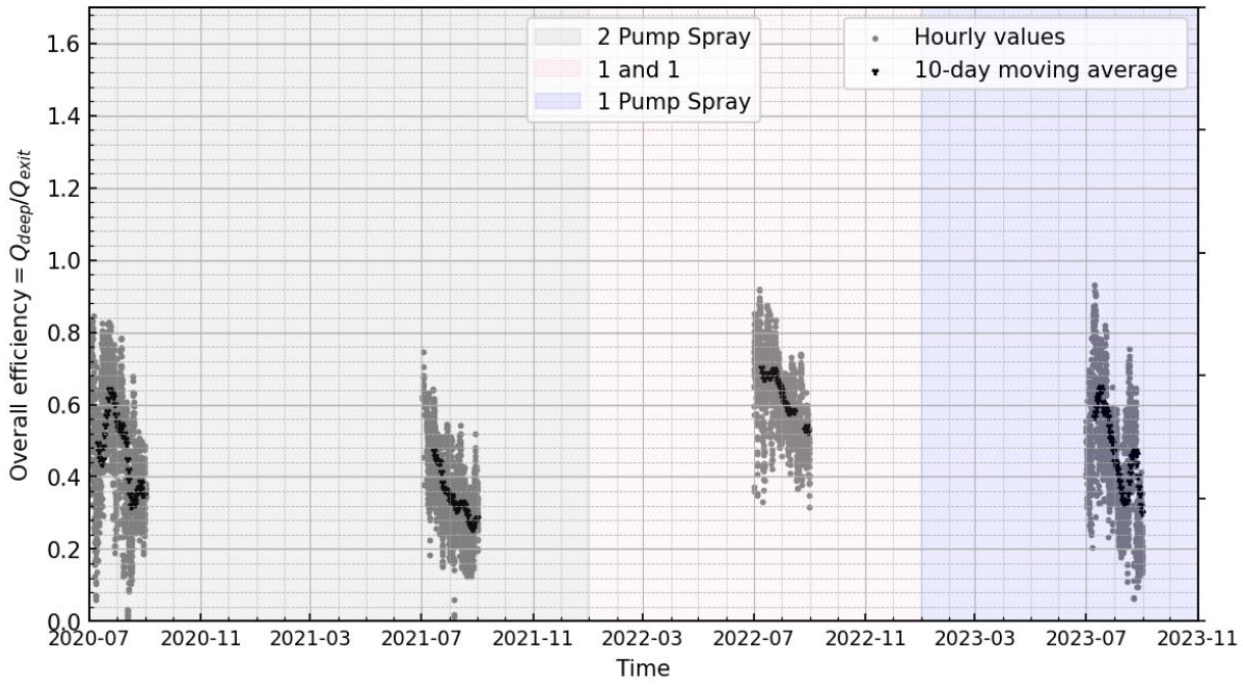

Figure 5-3. Lower Granite. Overall efficiency for the three operational modes of the spray bar.

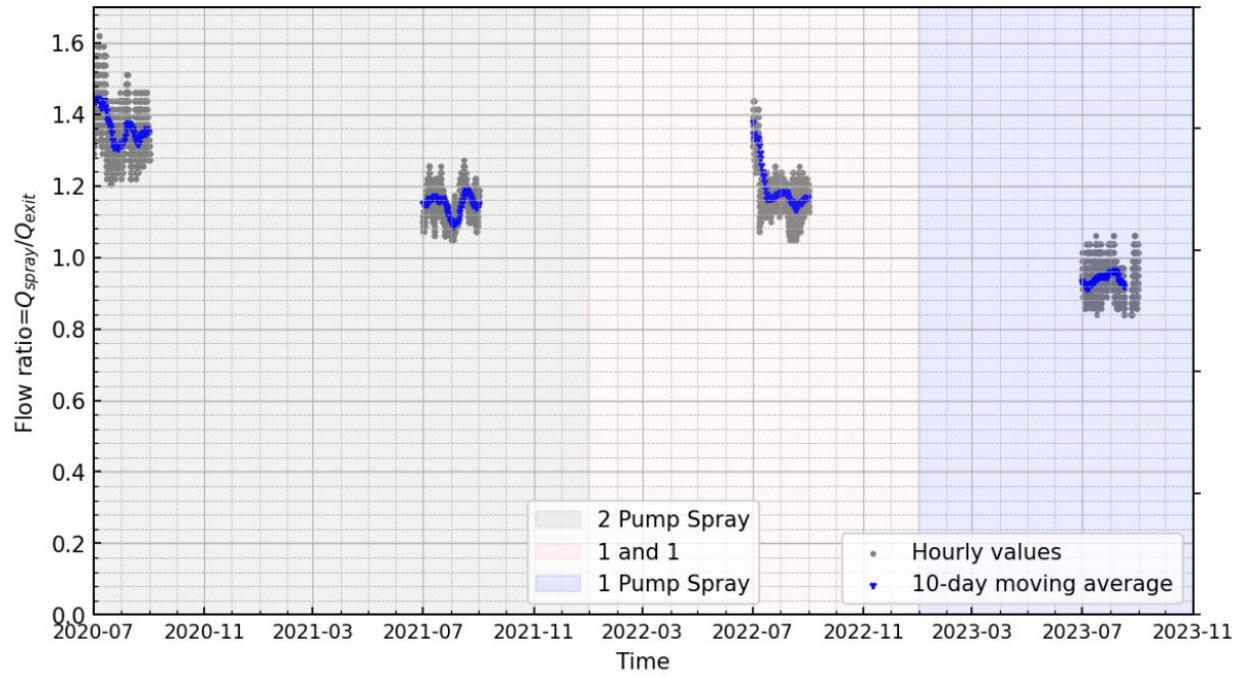

Figure 5-4. Lower Granite. Computed flow ratio for the three operational modes of the spray bar.

Appendix D3. Mechanical Calculations

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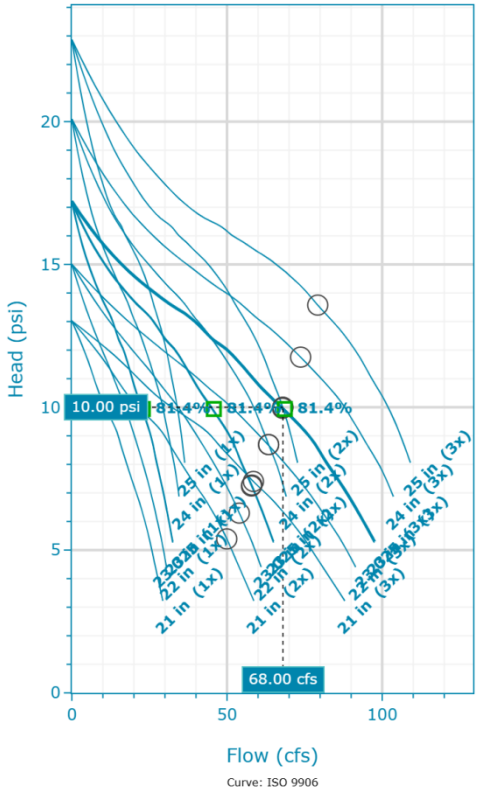
20 X 20 X 25 507 RPM

Created On: 7/16/25

LOWER MONUMENTAL - MODIFIED SPRAY BAR

20 x 20 x 25 507 rpm | Configuration Summary



Dry installed two vane shrouded non-clog bearing frame pumps for vertical and horizontal mounting. Medium capacity (AC Series)

GENERAL

Explosion Proof
No

Model Type
Model 100

Impeller Diameter
23.025 in

MATERIAL AND COATING

MOTOR

INSTALLATION

20 x 20 x 25 507 rpm | Product Details

Description

Flygt NSY

NSY Designs Offer Outstanding Advantages

- Standardized design offers maximum interchangeability of parts and helps reduce spare parts inventory. All parts except the casing suction cover and impeller are completely interchangeable within a given frame group. Seven pump sizes are built on only four power frames.
- Tapered shaft on the impeller end of the shaft and the impeller bore are designed for reliability and ease of maintenance.
- Impeller nut is a contoured stainless steel nut that is provided to prevent material from hanging up. The nut is secured by a stainless steel set screw.
- Rear back pull-out design allows the complete rotating element to be removed from the pump without disturbing the suction or discharge piping. Fewer crafts are required to service the pump.
- Flexibility of discharge position by allowing clockwise or counterclockwise rotation to be supplied. Discharge nozzle can be arranged in any one of eight positions for either rotation to suit the piping arrangement.
- Engineered for dependability with two vane non-clog impellers with smooth water passages capable of passing soft solids without clogging.
- Maximum shaft and bearing life is achieved by large diameter shafts that minimize deflection and increase packing life. Bearings are selected in accordance with the Anti-Friction Bearing Manufacturers Association (AFBMA) to provide for maximum life expectancy.
- Simple impeller clearance adjustment is achieved by adding or removing shims between the outboard bearing cartridge.
- Stuffing box design is a universal type stuffing box that will accept either packing or mechanical seal.
- Wear plates are standard in hardened 410 stainless steel on the suction cover and impeller.

Product Features

- Flows to 20,000 GPM (4,500 m3/h)
- Heads to 100' TDH (31m)
- 10" to 24" discharge

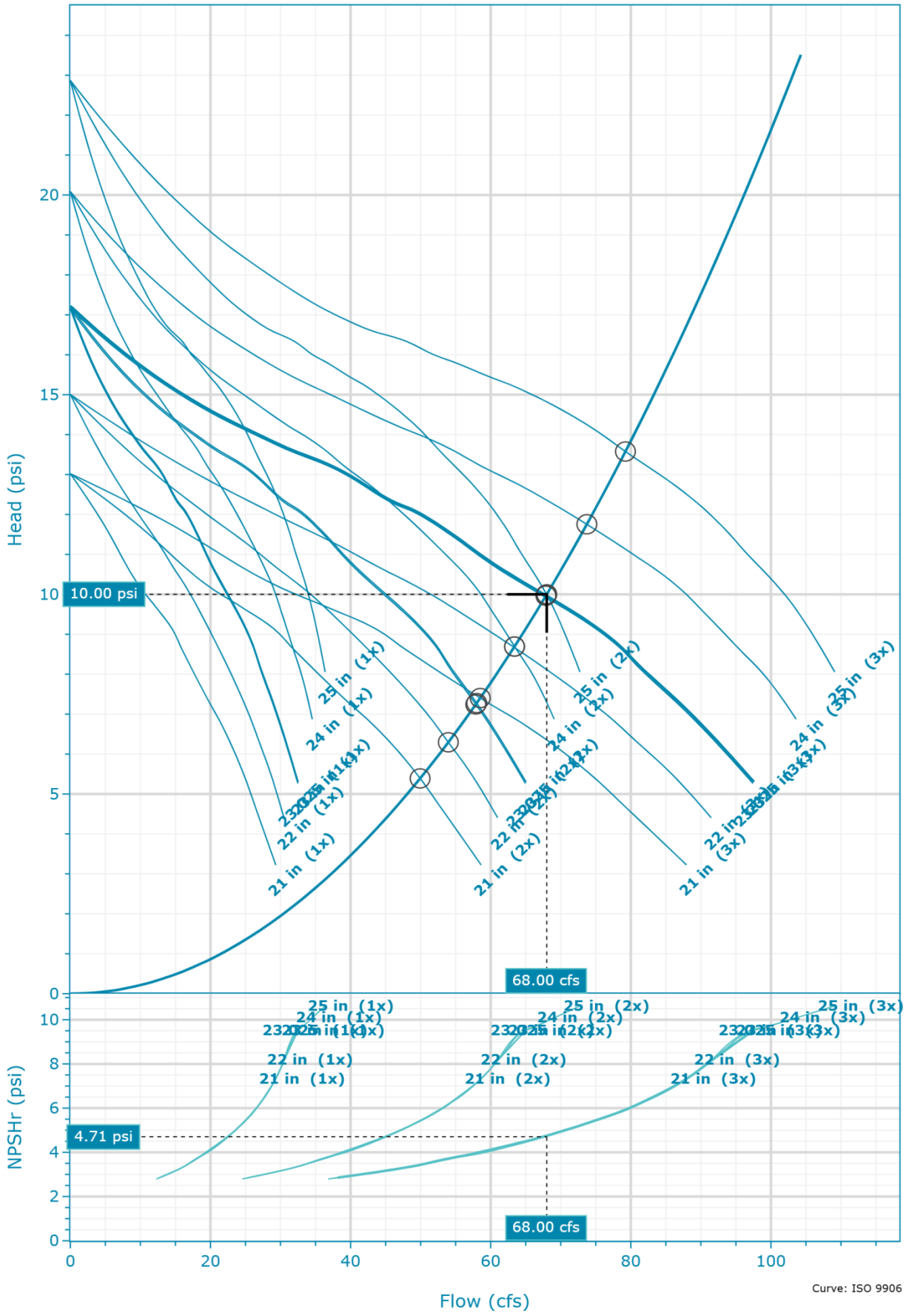
Construction Materials

There is no information available for the given configuration.

Motor

There is no information available for the given configuration.

20 x 20 x 25 507 rpm | Hydraulic Data & Performance Curve



Selection

Series NSY	Impeller Diameter 23.025 in
Name 20 x 20 x 25 507 rpm	Inlet Diameter 20 in
Frequency	Outlet Diameter

Fluid

Fluid Type Water	Density 62.428 lb/ft³
Fluid Temperature 39.2 °F	Dynamic Viscosity 1.567212 cP
Specific Gravity	Fluid Vapor Pressure

60 Hz	20 in	1	0.118 psi

Total Flow
68.00 cfs

Number Of Vanes
2

Total Head
10.00 psi

Pump Flow
22.6667 cfs

Pump Head
10.00 psi

System Type
Parallel Pumps

Operating Pumps
3

Standby Pumps
No Standby Pump

Design Point - Single Pump

Flow (1x)
22.67 cfs

NPSHr (1x)
4.71 psi

Head (1x)
10 psi

Flow To BEP Ratio (1x)
99.1 %

Pump Efficiency (1x)
81.36 %

Shaft power (P2) (1x)
73.06 Hp

Design Point - System

Flow
68 cfs

NPSHR
4.71 psi

Head
10 psi

Flow To BEP Ratio
99.1 %

Pump Efficiency (ηp)
81.36 %

Shaft power (P2)
219.18 Hp

Design Curve - Single Pump

Rated Speed
60 Hz

BEP Flow (1x)
22.88 cfs

Max Flow (1x)
32.52 cfs

BEP Head (1x)
9.94 psi

H@QMin (1x)
17.22 psi

Max P2 (1x)
74.81 Hp

H@QMax (1x)
5.3 psi

BEP (1x)
81.4 %

Design Curve - System

Rated Speed
60 Hz

BEP Flow
68.63 cfs

Max Flow
97.57 cfs

BEP Head
9.94 psi

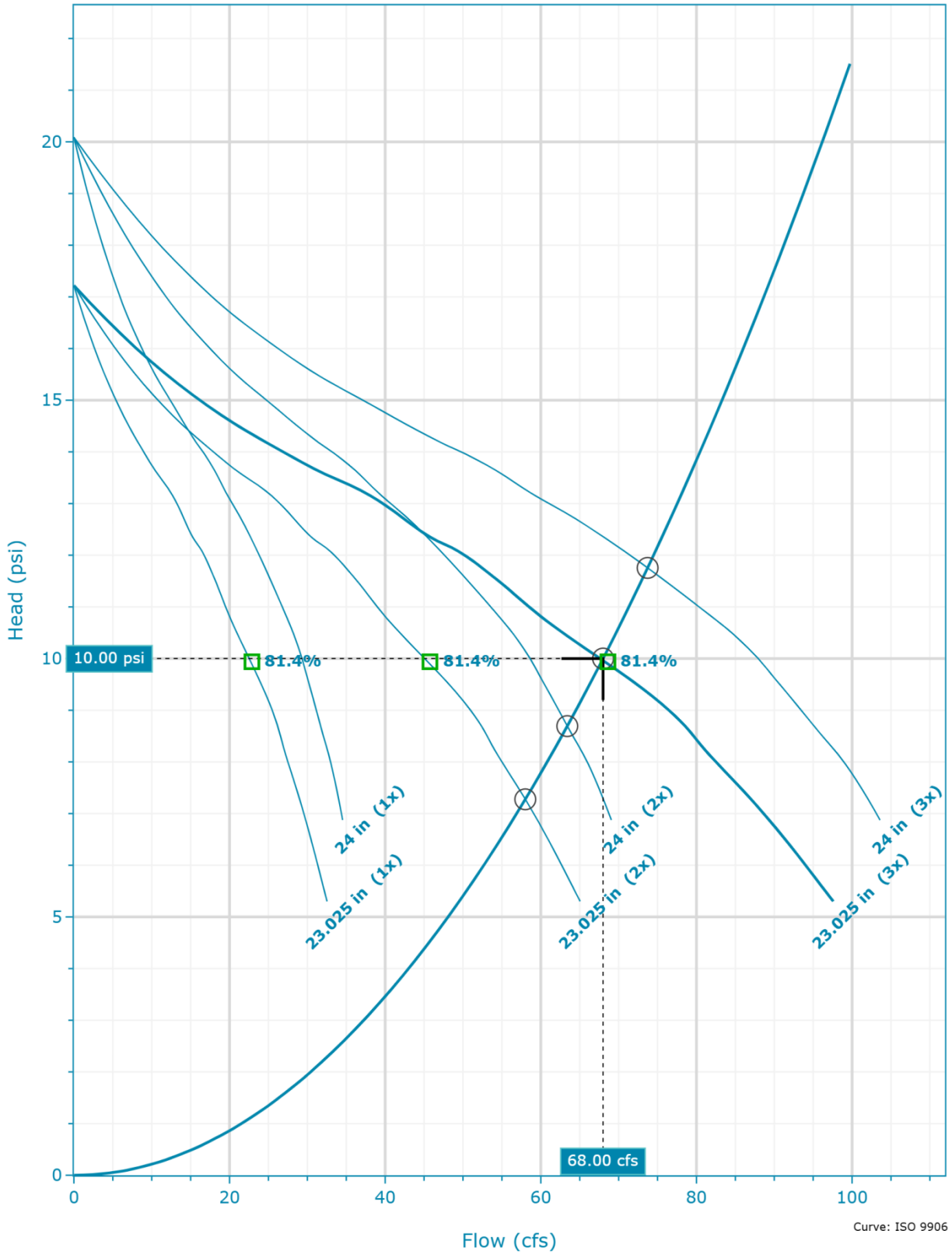
H@QMin
17.22 psi

Max P2
224.43 Hp

H@QMax
5.3 psi

BEP
81.4 %

20 x 20 x 25 507 rpm | Duty Analysis



Name	Q (1x) [cfs]	H (1x) [psi]	P2 (1x) [Hp]	Q [cfs]	H [psi]	P2 [Hp]	ηp [%]	SE [kWh/mGal]	NPSHr [psi]
DP @ 1x	0	0	0	0	0	0	0	0	0
DP @ 2x	29	7.28	72.29	58	7.28	144.59	76.4	0	7.14
DP @ 3x	22.67	10	73.06	68	10	219.18	81.36	0	4.71

Project:	Created By:	Created On:	Last Update:
20 x 20 x 25 507 rpm	James Teeter	7/16/25	-

Company	Jacobs Engineering
Contact	James Teeter
Phone No.	7149433408
Email	James.teeter@jacobs.com

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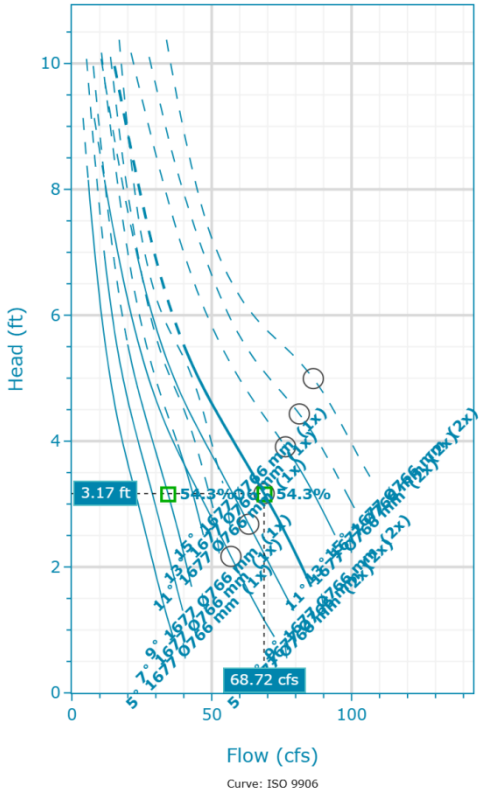
PP 4680 3~ 1677

Created On: 9/2/25

LOWER MONUMENTAL - PUMPED FISH EXIT

PP 4680 3~ 1677 | Configuration Summary

Horizontal flow propeller pumps with fixed pitch blades for high capacity low head pumping of clean or slightly contaminated liquids. The pumps are extremely compact, using multipole motors instead of mechanical gearing.



Curve: ISO 9906

Nominal (mean) data shown. Under- and over-performance from this data should be expected due to standard manufacturing tolerances. Please consult your local Flygt representative for performance guarantees.

GENERAL

Explosion Proof No	Blade Angle 9
Max. Pumped Media Temp. 104 °F	Propeller Diameter 766 mm
Type of Approval Not Applicable	Vortex Suppressor No

MATERIAL AND COATING

Impeller Material
Stainless Steel

Volute Material
Stainless Steel

Material Grade Stainless steel (ASTM 316L)	O-Ring Material Nitrile rubber (NBR)

Outer Seal Material
Cemented carbide (WCCR) - Cemented carbide (WCCR)

CABLES

Number of Power Cables 1 (recommended)	Ambient Max Temperature 32 °F
Power Cable Length 32.81 ft	Power Cable Type SUBCAB 4G35+S(2x0,5)
Power Cable Sizing Standard IEC 60364	Mounting Correction 1.00 (1 Cable Free)
Motor Start Method Direct-On-Line (DOL) Start	Cable Entry 1.38 - 1.46 in

Prepared for Cable Protection
Unthreaded

MOTOR

Rated Voltage 480 V	Motor Efficiency Class Standard
Coupling D	Rated Power 30 Hp
Voltage 460 V D	Rated Current 65.0 A

Voltage Stage
460-480 V D

MONITORING AND CONTROL

Stator House Leakage Sensor
Without

INSTALLATION

Installation Type
P - Semi-Permanent, Wet

Lifting Handle
Without

Project:	Created By:	Created On:	Last Update:
PP 4680 3~ 1677	James Teeter	9/2/25	-

PP 4680 3~ 1677 | Product Details

Description

P 4680

Ultra-Low-Head High-Flow Wastewater Pump

Flygt ultra-low-head high-flow wastewater pumps are engineered for versatility and lean installation, and offer highly efficient and reliable pumping of highly contaminated fluids. Few components, straightforward service routines and simple installation make Flygt ultra-low-head pumps an economical choice for a wide range of applications, including activated sludge treatment, stormwater and other low-head high-flow duties. Pumping efficiency is kept sustained high with backswept propeller blades and wide-hub propeller design.

Flexible and Modular Design

All external parts manufactured for excellent corrosion-resistance. Major parts in stainless steel.

- High efficiency stainless steel propeller with backswept propeller blades for high clog resistance.
- Optional Hard-Iron impeller for abrasive applications.
- Short shaft overhang – reduces shaft deflection and increases seal and bearing life.
- Motor designed for submersible use – heat is concentrated to the stator core for improved cooling properties.
- High performance motor with Class H motor insulation provides thermal overload protection and extra long service life.
- Double mechanical seal system – Two sets of mechanical shaft seals work independently to provide double security. Available in Tungsten carbide (WCCR) or Silicone carbide (SiC) depending on pumped media.
- Plug-in seal with the Active Seal system, offering increased sealing reliability and zero leakage into the motor, thereby reducing the risk of bearing and stator failures.
- Motor cable SUBCAB® - specially developed for submersible use.
- Cable entry with double elastomer seal grommets – for double security.

Product Features

- State of the art ultra-low-head high-flow wastewater pump
- Robust and reliable direct drive
- Sustained high efficiency with fiber-handling hydraulics
- High reliability with Class H insulated motor and Active Seal system Plug-in seal

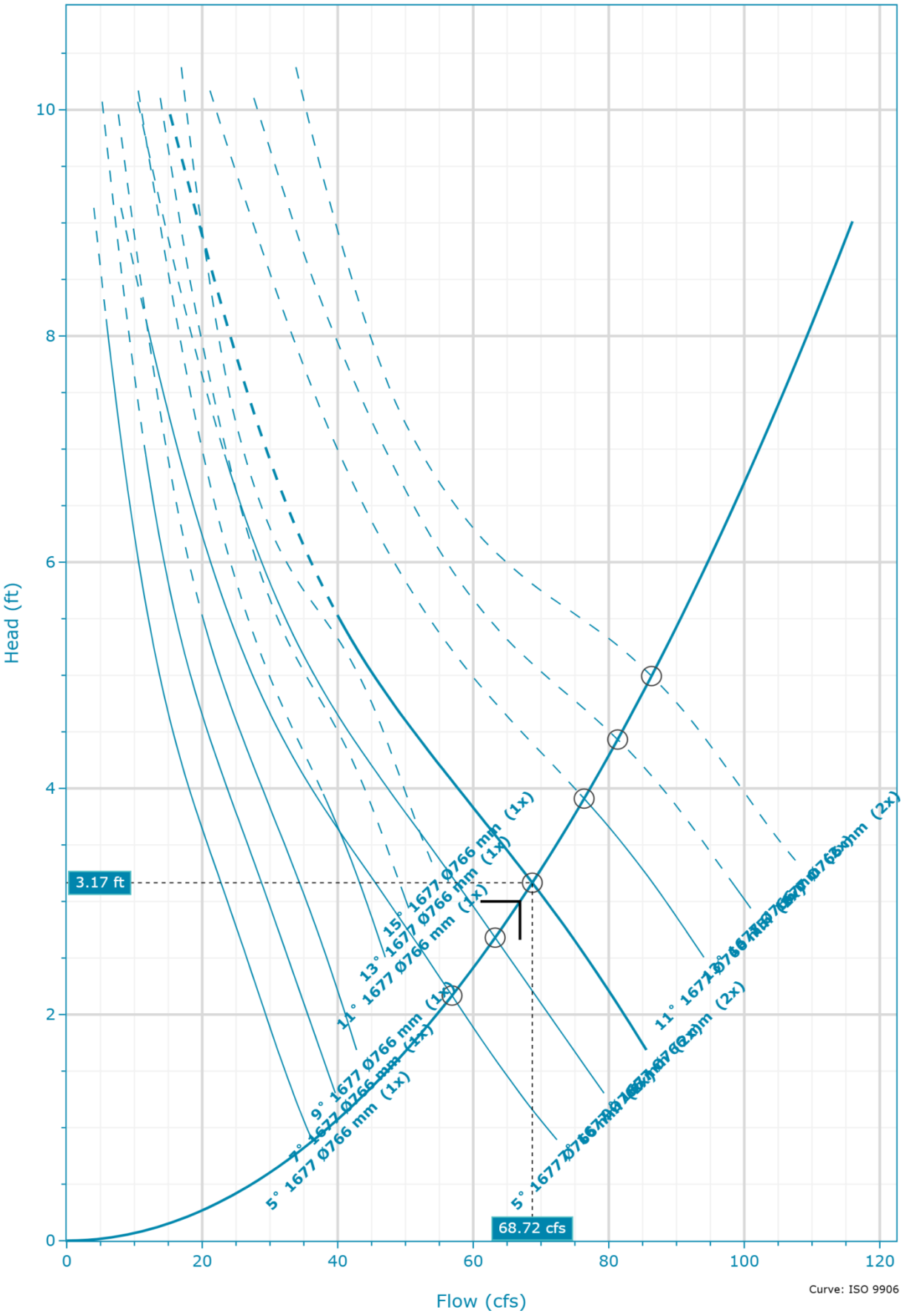
Construction Materials

Impeller Material	Volute Material	Stator Cover Material
Stainless Steel	Stainless Steel	-

Motor

Rated Power 30 Hp	Number Of Phases 3	Start Current Ratio 3.32	Motor Issue 14
Motor Denomination 35-32-16AA	Rated Motor Speed 445 RPM	Insulation Class H	Locked Rotor Code H
Motor Efficiency Class Standard	Rated Voltage 480 V	Approval Standard	Max starts per hour 30
Version Code 412	Rated Current 70 A	Total moment of inertia 25.6332 ft²lbf	Power Factor 100% 0.47
Frequency 60 Hz	Start Current 231 A	Type of duty S1	Power Factor 75% 0.4
Max P2 (1x) 44.03 Hp	Starting Current, Direct Starting 231 A	Stator Variant 39	Power Factor 50% 0.31
Number Of Poles 16	Starting Current, Star Delta 77 A	Motor Module 142	Efficiency 100% 80.6 %
			Efficiency 75% 78.3 %
			Efficiency 50% 73 %

PP 4680 3~ 1677 | Hydraulic Data & Performance Curve



Nominal (mean) data shown. Under- and over-performance from this data should be expected due to standard manufacturing tolerances. Please consult your local Flygt representative for performance guarantees.

Selection

Series PP 4600	Curve Code 1677
Name PP 4680 3~ 1677	Propeller Diameter 766 mm

Fluid

Fluid Type Water	Density 62.318 lb/ft³
Fluid Temperature 68 °F	Dynamic Viscosity 1.001577 cP

Frequency
60 Hz

Inlet Diameter
780 mm

Specific Gravity
0.998

Fluid Vapor Pressure
0.339 psi

Total Flow
66.90 cfs

Outlet Diameter
780 in

Total Head
3.00 ft

Number Of Vanes
3

Pump Flow
33.45 cfs

Pump Head
3.00 ft

System Type
Parallel Pumps

Operating Pumps
2

Standby Pumps
No Standby Pump

Design Point - Single Pump

Flow (1x)
34.36 cfs

Input Power (P1) (1x)
28.23 Hp

Head (1x)
3.17 ft

Shaft power (P2) (1x)
22.74 Hp

Overall Efficiency (1x)
43.75 %

Flow To BEP Ratio (1x)
99.8 %

Pump Efficiency (1x)
54.31 %

Design Point - System

Flow
68.72 cfs

Input Power (P1)
56.45 Hp

Head
3.17 ft

Shaft power (P2)
45.48 Hp

Overall Efficiency (ηo)
43.75 %

Flow To BEP Ratio
99.8 %

Pump Efficiency (ηp)
54.31 %

Design Curve - Single Pump

Rated Speed
60 Hz

BEP Flow (1x)
34.43 cfs

Max Flow (1x)
42.78 cfs

BEP Head (1x)
3.15 ft

H@QMin (1x)
9.96 ft

Max P2 (1x)
44.03 Hp

H@QMax (1x)
1.69 ft

BEP (1x)
54.3 %

Design Curve - System

Rated Speed
60 Hz

BEP Flow
68.87 cfs

Max Flow
85.55 cfs

BEP Head
3.15 ft

H@QMin
9.96 ft

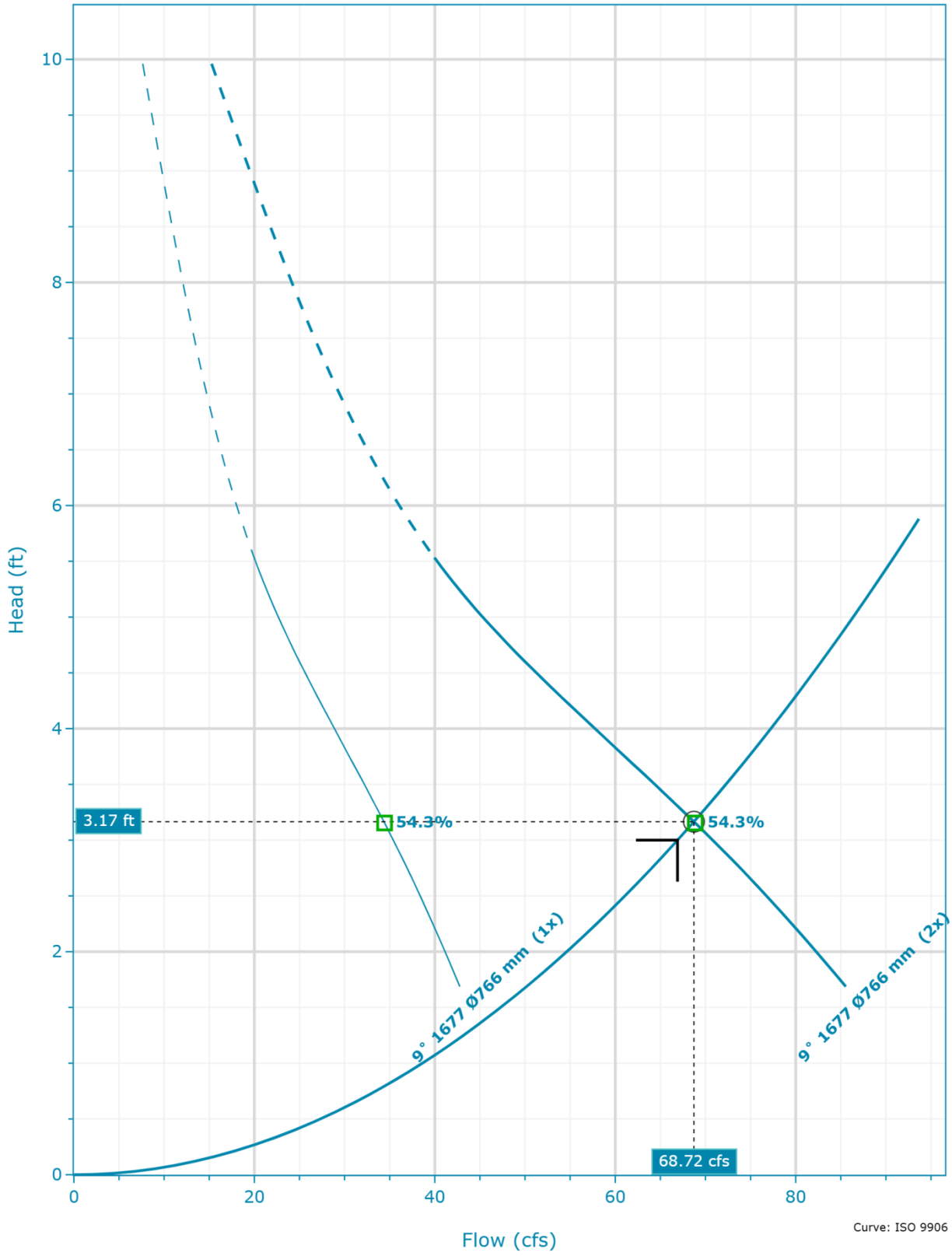
Max P2
88.05 Hp

H@QMax
1.69 ft

Specific Energy
23 kWh/mGal

BEP
54.3 %

PP 4680 3~ 1677 | Duty Analysis

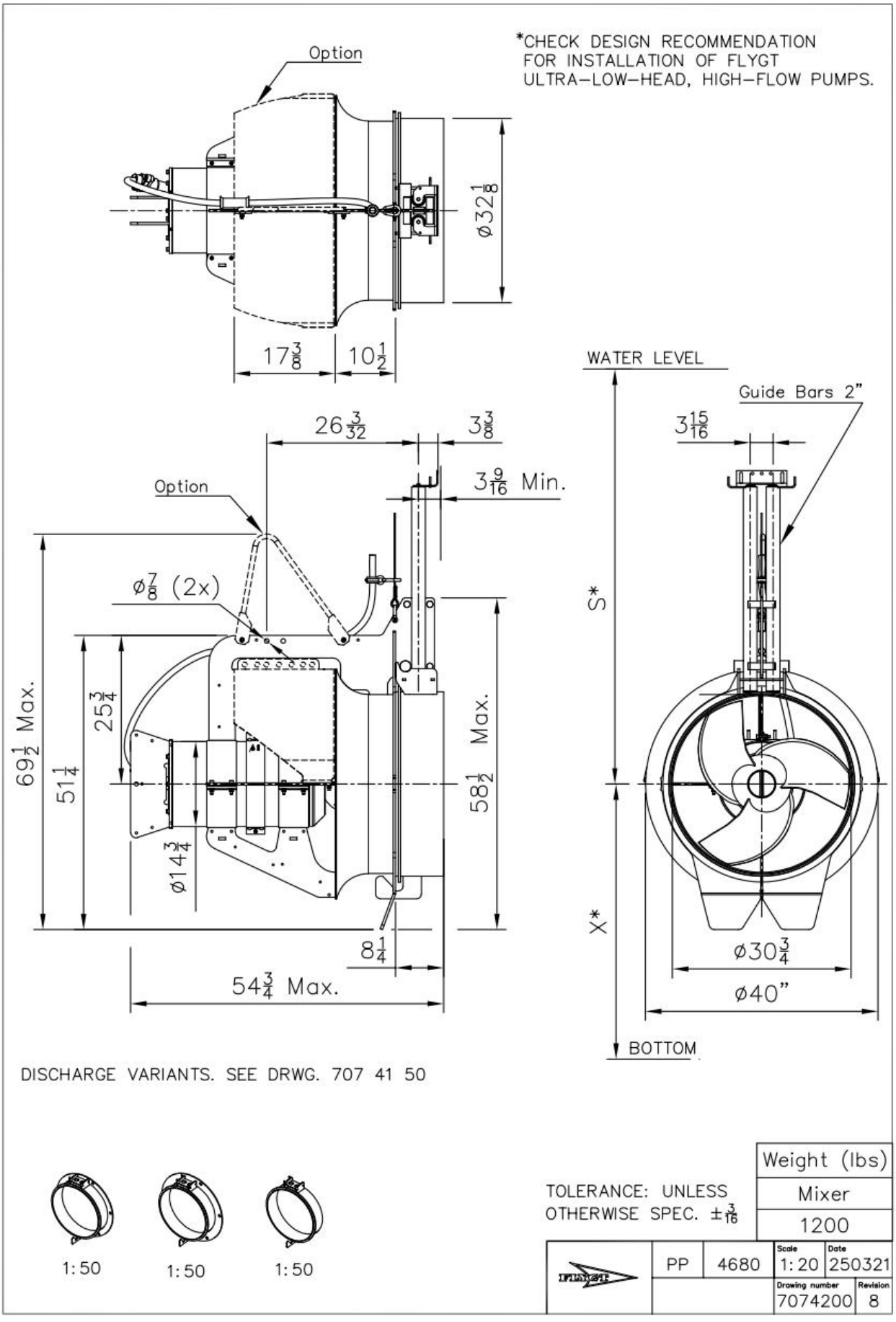


Nominal (mean) data shown. Under- and over-performance from this data should be expected due to standard manufacturing tolerances. Please consult your local Flygt representative for performance guarantees.

Name	Q (1x) [cfs]	H (1x) [ft]	P2 (1x) [Hp]	Q [cfs]	H [ft]	P2 [Hp]	ηp [%]	SE [kWh/mGal]	NPSHr [ft]
DP @ 1x	0	0	0	0	0	0	0	0	0
DP @ 2x	34.36	3.17	22.74	68.72	3.17	45.48	54.31	22.75	0

Project:	Created By:	Created On:	Last Update:
PP 4680 3~ 1677	James Teeter	9/2/25	-

PP 4680 3~ 1677 | Dimensional Data & Drawing



Company	Jacobs Engineering
Contact	James Teeter
Phone No.	7149433408
Email	James.teeter@jacobs.com

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ICE HARBOR - BUBBLER - COMPRESSED AIR TEMPERATURE PROFILE

Assumptions		
Diffuser Model	SalmoAir	
Diffuser Airflow Rate	30	CFM
Velocity	83.31	ft/s
Fish Ladder Flow	140.3	CFS
Upwell Flow	197.8	CFS
Compressor Room Amb.	80	F
CTD	25	F
Compressed Air Discharge Temperature	105	F
Discharge Pressure	100	PSIG
Sample Temperature Location	John Day	
Pipe Material	316 Stainless Steel sch 40	
Nominal Diamter	3/4"	
Internal Diameter	1.049	in
Hydraulic Diameter	0.0874	ft
Surface Area per Foot	0.275	sqft/ft

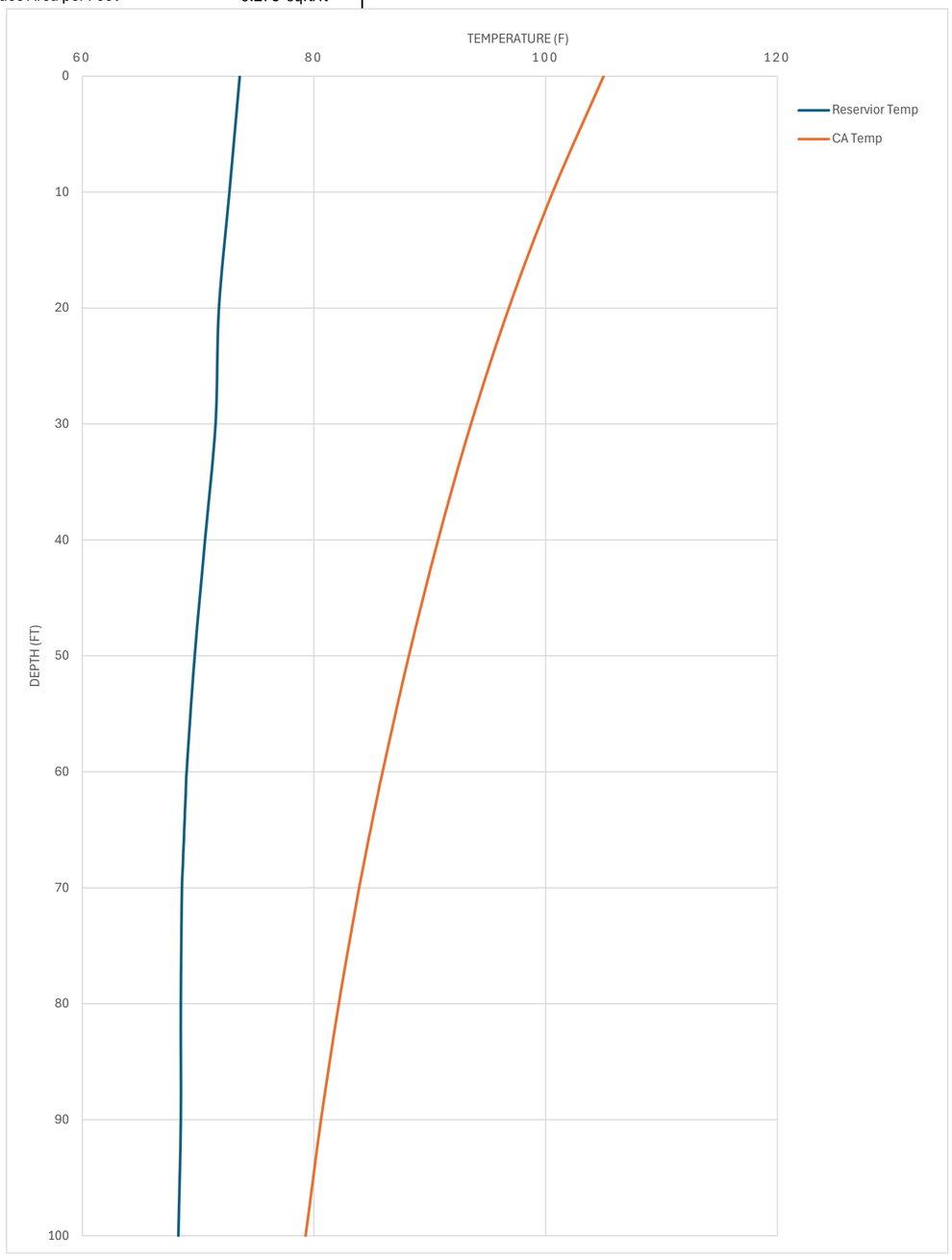
Depth (ft)	Reservior Temp
0	73.6
5	73.3
10	72.7
20	71.8
30	71.5
40	70.6
50	69.7
60	69.0
70	68.6
80	68.5
90	68.5
100	68.3

Assuming a CA intercooler that reduces initial temp to a point that doesn't induce boiling.

Assuming a worst case condition of still reservior water

Compressed air intercooler performance

ΔT 0.0 F



Depth (ft)	Reservior Temp	CA Temp	Film Temp	h, air	h, water	Q, btuh/ft	U	Re, air	Nu, air	Nu, water	Pr, air	Pr, water
0	73.6	105.0	89	1360.51	13.14	112.22	13.01	9.89E+06	247.78	4.68	6.12E-06	4.58E-05
10	72.7	100.6	87	1383.85	12.79	97.13	12.67	1.00E+07	250.50	4.54	6.12E-06	4.77E-05
20	71.8	96.8	84	1404.49	12.46	84.89	12.35	1.01E+07	252.88	4.41	6.12E-06	4.94E-05
30	71.5	93.6	83	1422.60	12.11	72.75	12.01	1.03E+07	254.97	4.28	6.12E-06	5.07E-05
40	70.6	90.7	81	1438.57	11.85	64.95	11.76	1.03E+07	256.80	4.17	6.12E-06	5.22E-05
50	69.7	88.2	79	1453.03	11.62	58.50	11.53	1.04E+07	258.45	4.08	6.12E-06	5.36E-05
60	69.0	85.9	77	1466.14	11.38	52.46	11.29	1.05E+07	259.94	3.99	6.12E-06	5.48E-05
61	69.0	85.7	77	1467.38	11.35	51.80	11.27	1.05E+07	260.08	3.98	6.12E-06	5.49E-05
62	68.9	85.5	77	1468.60	11.33	51.16	11.24	1.05E+07	260.22	3.97	6.12E-06	5.50E-05
63	68.9	85.3	77	1469.82	11.30	50.53	11.22	1.05E+07	260.36	3.96	6.12E-06	5.52E-05
64	68.8	85.1	77	1471.01	11.28	49.91	11.19	1.05E+07	260.50	3.95	6.12E-06	5.53E-05
65	68.8	84.9	77	1472.20	11.25	49.30	11.16	1.05E+07	260.63	3.94	6.12E-06	5.54E-05
66	68.8	84.7	77	1473.37	11.22	48.70	11.14	1.05E+07	260.76	3.93	6.12E-06	5.55E-05
67	68.7	84.5	77	1474.52	11.20	48.11	11.12	1.06E+07	260.89	3.92	6.12E-06	5.56E-05
68	68.7	84.3	76	1475.67	11.17	47.53	11.09	1.06E+07	261.02	3.91	6.12E-06	5.57E-05
69	68.6	84.1	76	1476.80	11.15	46.96	11.07	1.06E+07	261.15	3.90	6.12E-06	5.58E-05
70	68.6	83.9	76	1477.91	11.13	46.41	11.04	1.06E+07	261.28	3.89	6.12E-06	5.59E-05
80	68.5	82.1	75	1488.32	10.85	40.35	10.77	1.06E+07	262.46	3.79	6.12E-06	5.67E-05
90	68.5	80.6	75	1497.42	10.58	34.95	10.50	1.07E+07	263.48	3.69	6.11E-06	5.74E-05
100	68.3	79.3	74	1505.42	10.36	31.02	10.29	1.07E+07	264.38	3.61	6.11E-06	5.80E-05

RELEASED 28/Apr/2021 11:45:33 GMT

ICE HARBOR - BUBBLER

Ingersoll Rand

ENGINEERING DATA SHEET

WS7.5S
60 Hz

CCN:	47698052001
Rev.:	C
ECN:	1422533
Sheet:	1 of 1
Date:	February-2021

Model		WS7.5S-A116-E	WS7.5S-A145-E
GENERAL PERFORMANCE DATA			
Rated Discharge Pressure	barg (psig)	8.0 (116)	10.0 (145)
Nominal Power	kW (HP)	7.5 (10)	7.5 (10)
Capacity FAD (1)			
@ 6.9 barg (100 psig)	m³/min (CFM)	0.90 (31.9)	
@ 8.0 barg (116 psig)	m³/min (CFM)	0.88 (31.0)	
@ 8.6 barg (125 psig)	m³/min (CFM)		0.73 (25.8)
@ 10.0 barg (145 psig)	m³/min (CFM)		0.72 (25.3)
Maximum Operating Ambient Temperature	°C (°F)	40 (104)	40 (104)
Minimum Operating Ambient Temperature	°C (°F)	0 (32)	0 (32)
Airend Speed	rpm	3750	3216
Total Package Input Power			
@ 6.9 barg (100 psig)	kW (HP)	7.43 (10.0)	
@ 8.0 barg (116 psig)	kW (HP)	7.76 (10.4)	
@ 8.6 barg (125 psig)	kW (HP)		6.79 (9.1)
@ 10.0 barg (145 psig)	kW (HP)		7.06 (9.5)
Specific Power (2)			
@ 6.9 barg (100 psig)	kW/(m³/min) (kW/100CFM)	8.23 (23.3)	
@ 8.0 barg (116 psig)	kW/(m³/min) (kW/100CFM)	8.83 (25.0)	
@ 8.6 barg (125 psig)	kW/(m³/min) (kW/100CFM)		9.30 (26.3)
@ 10.0 barg (145 psig)	kW/(m³/min) (kW/100CFM)		9.86 (27.9)
SOUND LEVEL (3)			
Standard Package	dB(A)	73	73
COOLING DATA			
Heat Rejection (4)	kW (Btu/min)	7.0 (400)	7.0 (400)
Aftercooler CTD	°C (°F)	13.9 (25)	13.9 (25)
Cooling Fan Flow	m³/min (CFM)	22.1 (780)	22.1 (780)
PIPING CONNECTIONS			
Air Discharge	Inches NPT	3/4"	3/4"
Package Condensate Drain	Inches NPT	1/4"	1/4"
DIMENSIONS AND WEIGHT			
Length, Width, Height	mm (inches)	1168 / 762 / 711 (46 / 30 / 28)	1168 / 762 / 711 (46 / 30 / 28)
Weight	kg (lb.)	367 (810)	367 (810)
ELECTRICAL DATA			
Motor Protection		TEFC	TEFC
Drive Motor speed	rpm	3530	3530
Motor service factor		1.15	1.15
Motor Insulation Class		F	F
Full Load Package Current (5)			
	Amps @ 230V, 3PH	23.0	23.0
	Amps @ 380V, 3PH	13.9	13.9
	Amps @ 460V, 3PH	11.5	11.5
	Amps @ 575V, 3PH	9.2	9.2

Notes :

1. Tested per ISO 1217 : 2009 Annex C
2. Specific power guaranteed in accordance with ISO 1217 : 2009 Annex C at rated discharge pressure.
3. Measured in free field conditions per ISO 2151 using Parallelepiped Method, tolerance ± 3dB, based upon total system operation.
4. Based on total system in operation
5. Conductors for small motors shall not be smaller than 14AWG per NEC 430.22(G)

Product Improvement is a continuing goal at Ingersoll Rand. Design and specifications are subject to change without notice or obligation.

SALMOAIR™ Bubble Tubing®

ICE HARBOR - BUBBLER

Specialized Aquaculture Diffuser: Aerating / Mixing / Upwelling

The SalmoAir™ is a specialized, fully assembled, anti-fouling coated, corrosion protected fine bubble air diffuser designed for the aquaculture market.

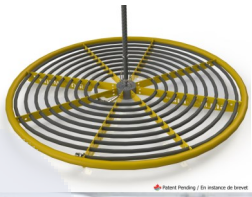
Invented by CanadianPond.ca Products Ltd. Incorporating Bubble Tubing®, which holds the world's leading SOTE (Standard Oxygen Transfer Efficiency) of any linear diffuser.

The SalmoAir™ features a completely smooth surface devoid of sharp angles, protects valuable salmon and other fish from scale damage or injury. Reducing wounds, disease and increases end market value.

The Yellow Thermoplastic NSF coating creates a barrier that furthermore protects the metal frame, preventing corrosion issues in salt water. The Coating also limits and controls biological fouling, simplifying the maintenance process like pressure washing to remove mussels and barnacles growth.

Features

- Designed Exclusively for the Aquaculture industry.
- Made in Canada
- Patent Pending
- The SalmoAir™ is easily identifiable thanks to its unique yellow color on the market.
  — *Color included in the trademark*



SALMOAIR™

Benefits

- Operating costs are considerably lower than competition.
- Upwells cold water rich in dissolved oxygen.
- 3rd party tested at C-CORE and Fisheries and Marine Institute
- Prevents fish injuries
- Non-fouling, low maintenance, reliable, easily serviced above and below the water!
- Best oxygen transfer rate.
- Best lift rate on the market
- Durable lifespan, possibly amortized over 5 years.

Specifics:

- Operates as low as 17 up to 50 m³/h (10 up to 30 CFM). Can handle up to 170 m³/h (100 CFM) if needed.
- Stainless Steel frame with NSF Thermoplastic Coating
- 177.8 cm (70')' diameter
- 45 Kg (100 lbs)
- ISO 9001: 2015 Construction
- 2 years manufacturing warranty
- Trademark and Patent Pending
- Ships in Protected Wooden Crates.
- Exclusive Central hub with integrated check valve.

Upwelling and lift rate validated by third party research.

C-Core Engineering + Marine Institute Newfoundland, Canada 2023

For details on performance, sizing, installation and pricing, please contact us.

570 Knowlton, Lac-Brome, Québec J0E 1V0 CANADA

T: 450 243-0976 info@bubbletubing.com bubbletubing.com

Bubble Tubing® is a trademark of Canadianpond

xylem
Let's Solve Water

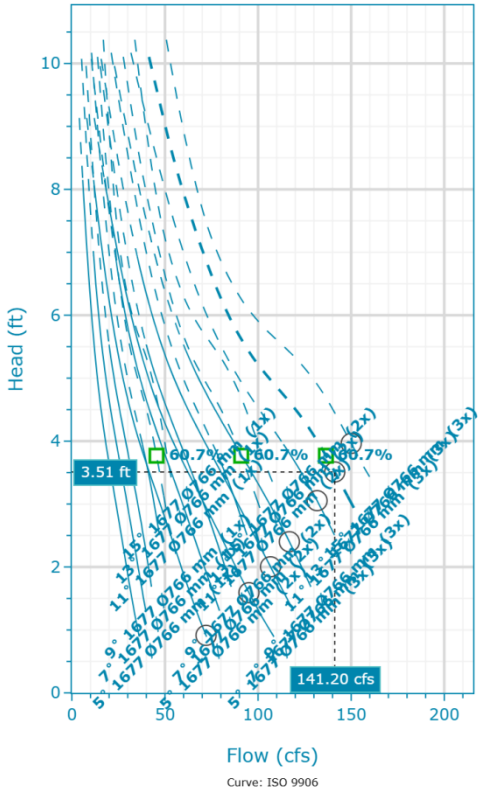
PP 4680 3~ 1677

Created On: 8/21/25

ICE HARBOR - PUMPED FISH EXIT

PP 4680 3~ 1677 | Configuration Summary

Horizontal flow propeller pumps with fixed pitch blades for high capacity low head pumping of clean or slightly contaminated liquids. The pumps are extremely compact, using multipole motors instead of mechanical gearing.



Curve: ISO 9906

Nominal (mean) data shown. Under- and over-performance from this data should be expected due to standard manufacturing tolerances. Please consult your local Flygt representative for performance guarantees.

GENERAL

Explosion Proof	Blade Angle
No	13
Max. Pumped Media Temp.	Propeller Diameter
104 °F	766 mm
Type of Approval	Vortex Suppressor
Not Applicable	No

MATERIAL AND COATING

Impeller Material
Stainless Steel

Volute Material
Stainless Steel

Material Grade	O-Ring Material
Stainless steel (ASTM 316L)	Nitrile rubber (NBR)

Outer Seal Material
Cemented carbide (WCCR) - Cemented carbide (WCCR)

CABLES

Number of Power Cables	Ambient Max Temperature
1 (recommended)	32 °F
Power Cable Length	Power Cable Type
32.81 ft	SUBCAB 4G35+S(2x0,5)
Power Cable Sizing Standard	Mounting Correction
IEC 60364	1.00 (1 Cable Free)
Motor Start Method	Cable Entry
Direct-On-Line (DOL) Start	1.38 - 1.46 in

Prepared for Cable Protection
Unthreaded

MOTOR

Rated Voltage	Motor Efficiency Class
480 V	Standard
Coupling	Rated Power
D	30 Hp
Voltage	Rated Current
460 V D	65.0 A

Voltage Stage
460-480 V D

MONITORING AND CONTROL

Stator House Leakage Sensor
Without

INSTALLATION

Installation Type
P - Semi-Permanent, Wet

Lifting Handle
Without

Project:	Created By:	Created On:	Last Update:
PP 4680 3~ 1677	James Teeter	8/21/25	-

PP 4680 3~ 1677 | Product Details

Description

P 4680

Ultra-Low-Head High-Flow Wastewater Pump

Flygt ultra-low-head high-flow wastewater pumps are engineered for versatility and lean installation, and offer highly efficient and reliable pumping of highly contaminated fluids. Few components, straightforward service routines and simple installation make Flygt ultra-low-head pumps an economical choice for a wide range of applications, including activated sludge treatment, stormwater and other low-head high-flow duties. Pumping efficiency is kept sustained high with backswept propeller blades and wide-hub propeller design.

Flexible and Modular Design

All external parts manufactured for excellent corrosion-resistance. Major parts in stainless steel.

- High efficiency stainless steel propeller with backswept propeller blades for high clog resistance.
- Optional Hard-Iron impeller for abrasive applications.
- Short shaft overhang – reduces shaft deflection and increases seal and bearing life.
- Motor designed for submersible use – heat is concentrated to the stator core for improved cooling properties.
- High performance motor with Class H motor insulation provides thermal overload protection and extra long service life.
- Double mechanical seal system – Two sets of mechanical shaft seals work independently to provide double security. Available in Tungsten carbide (WCCR) or Silicone carbide (SiC) depending on pumped media.
- Plug-in seal with the Active Seal system, offering increased sealing reliability and zero leakage into the motor, thereby reducing the risk of bearing and stator failures.
- Motor cable SUBCAB® - specially developed for submersible use.
- Cable entry with double elastomer seal grommets – for double security.

Product Features

- State of the art ultra-low-head high-flow wastewater pump
- Robust and reliable direct drive
- Sustained high efficiency with fiber-handling hydraulics
- High reliability with Class H insulated motor and Active Seal system Plug-in seal

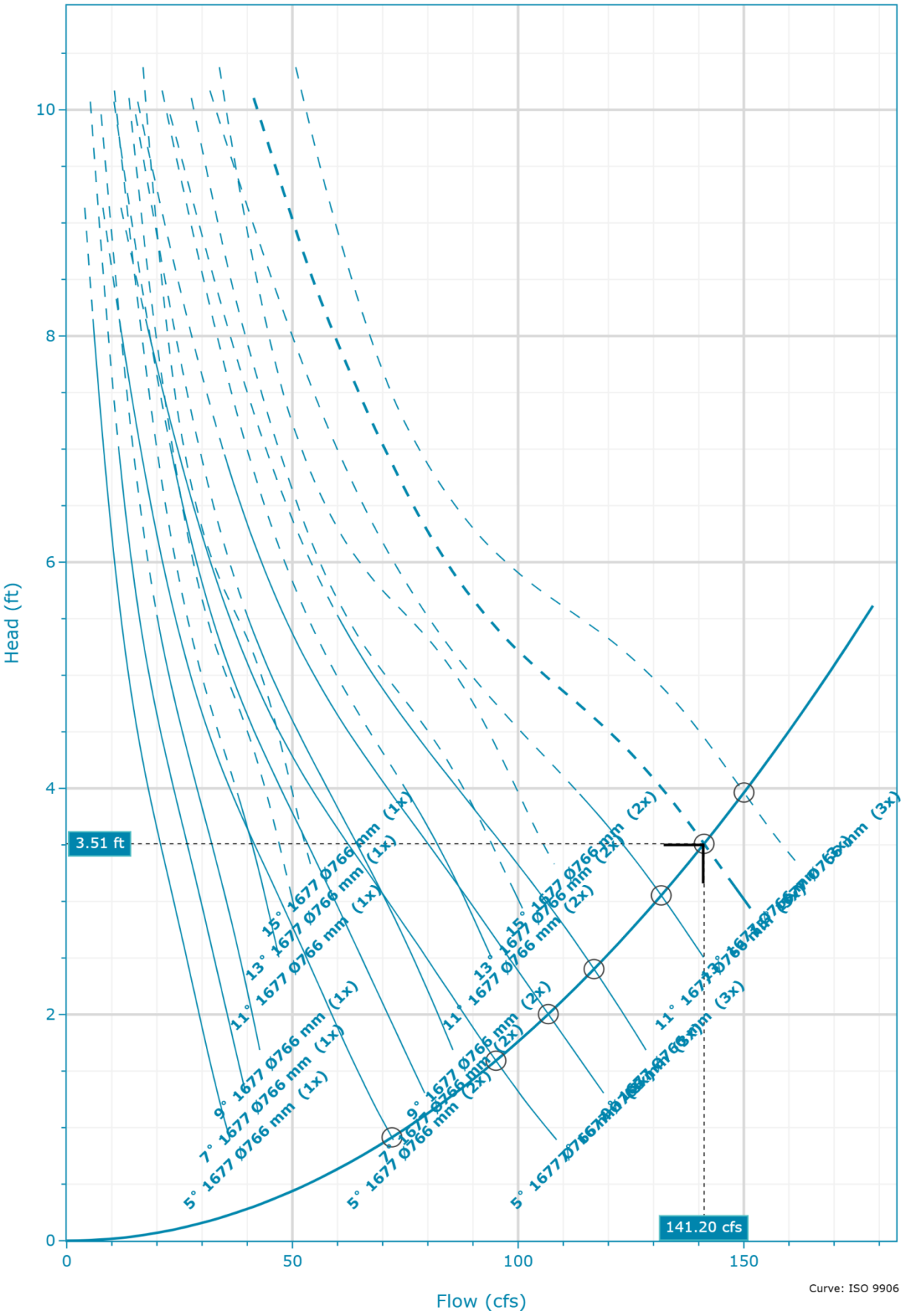
Construction Materials

Impeller Material	Volute Material	Stator Cover Material
Stainless Steel	Stainless Steel	-

Motor

Rated Power 30 Hp	Number Of Phases 3	Start Current Ratio 3.32	Motor Issue 14
Motor Denomination 35-32-16AA	Rated Motor Speed 445 RPM	Insulation Class H	Locked Rotor Code H
Motor Efficiency Class Standard	Rated Voltage 480 V	Approval Standard	Max starts per hour 30
Version Code 412	Rated Current 70 A	Total moment of inertia 25.6332 ft²lbf	Power Factor 100% 0.47
Frequency 60 Hz	Start Current 231 A	Type of duty S1	Power Factor 75% 0.4
Max P2 (1x) 56.15 Hp	Starting Current, Direct Starting 231 A	Stator Variant 39	Power Factor 50% 0.31
Number Of Poles 16	Starting Current, Star Delta 77 A	Motor Module 142	Efficiency 100% 80.6 %
			Efficiency 75% 78.3 %
			Efficiency 50% 73 %

PP 4680 3~ 1677 | Hydraulic Data & Performance Curve



Nominal (mean) data shown. Under- and over-performance from this data should be expected due to standard manufacturing tolerances. Please consult your local Flygt representative for performance guarantees.

Selection

Series PP 4600	Curve Code 1677
Name PP 4680 3~ 1677	Propeller Diameter 766 mm

Fluid

Fluid Type Water	Density 62.318 lb/ft³
Fluid Temperature 68 °F	Dynamic Viscosity 1.001577 cP

Frequency
60 Hz

Total Flow
141.00 cfs

Total Head
3.50 ft

Pump Flow
47.00 cfs

Pump Head
3.50 ft

System Type
Parallel Pumps

Operating Pumps
3

Standby Pumps
No Standby Pump

Inlet Diameter
780 mm

Outlet Diameter
780 in

Number Of Vanes
3

Specific Gravity
0.998

Fluid Vapor Pressure
0.339 psi

Design Point - Single Pump

Flow (1x)
47.07 cfs

Head (1x)
3.51 ft

Overall Efficiency (1x)
49.72 %

Pump Efficiency (1x)
60.47 %

Input Power (P1) (1x)
37.72 Hp

Shaft power (P2) (1x)
31.02 Hp

Flow To BEP Ratio (1x)
103.5 %

Design Point - System

Flow
141.2 cfs

Head
3.51 ft

Overall Efficiency (ηo)
49.72 %

Pump Efficiency (ηp)
60.47 %

Input Power (P1)
113.17 Hp

Shaft power (P2)
93.05 Hp

Flow To BEP Ratio
103.5 %

Design Curve - Single Pump

Rated Speed
60 Hz

Max Flow (1x)
50.48 cfs

H@QMin (1x)
10.1 ft

H@QMax (1x)
2.94 ft

BEP (1x)
60.7 %

BEP Flow (1x)
45.48 cfs

BEP Head (1x)
3.77 ft

Max P2 (1x)
56.15 Hp

Design Curve - System

Rated Speed
60 Hz

Max Flow
151.45 cfs

H@QMin
10.1 ft

H@QMax
2.94 ft

BEP
60.7 %

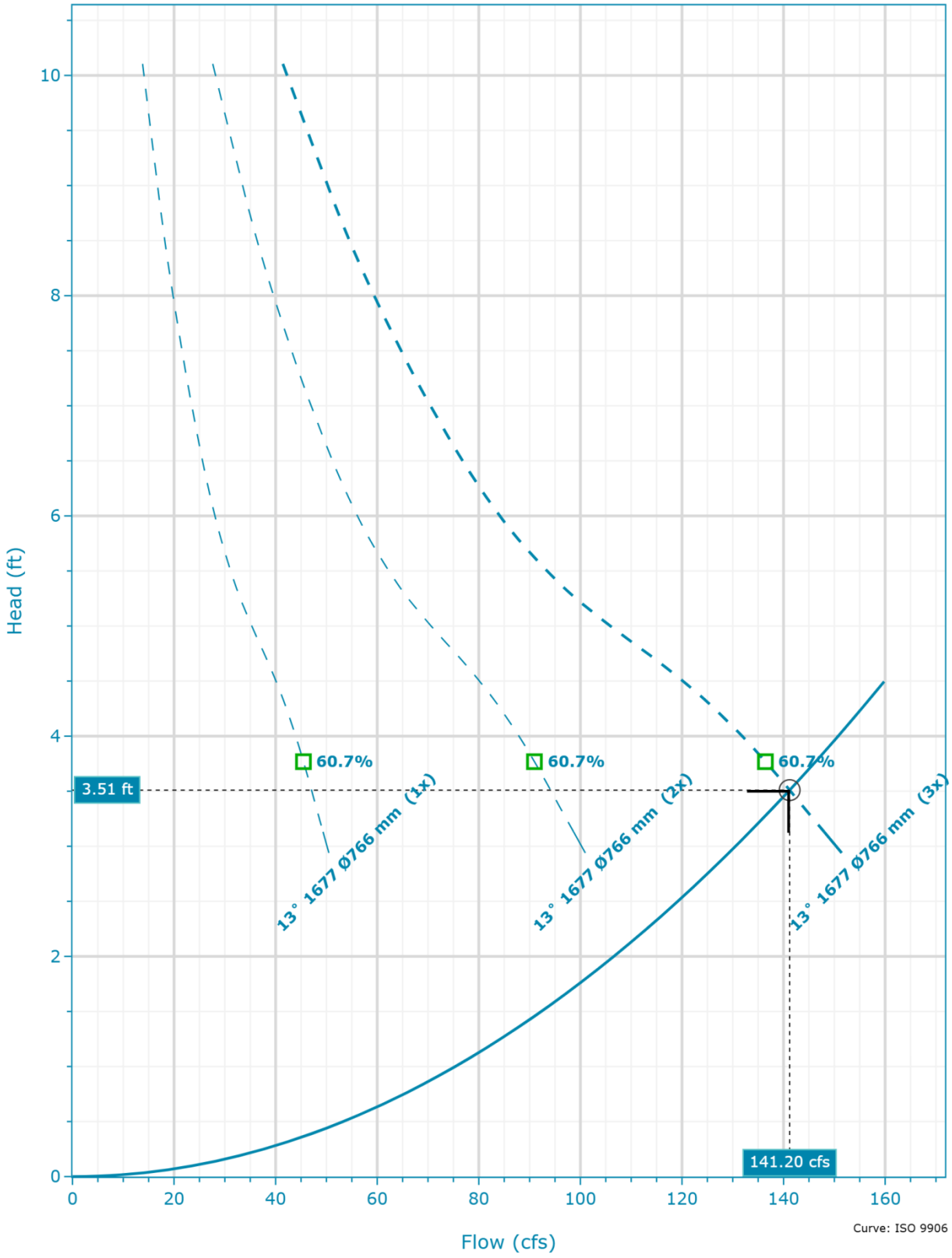
BEP Flow
136.43 cfs

BEP Head
3.77 ft

Max P2
168.44 Hp

Specific Energy
22 kWh/mGal

PP 4680 3~ 1677 | Duty Analysis



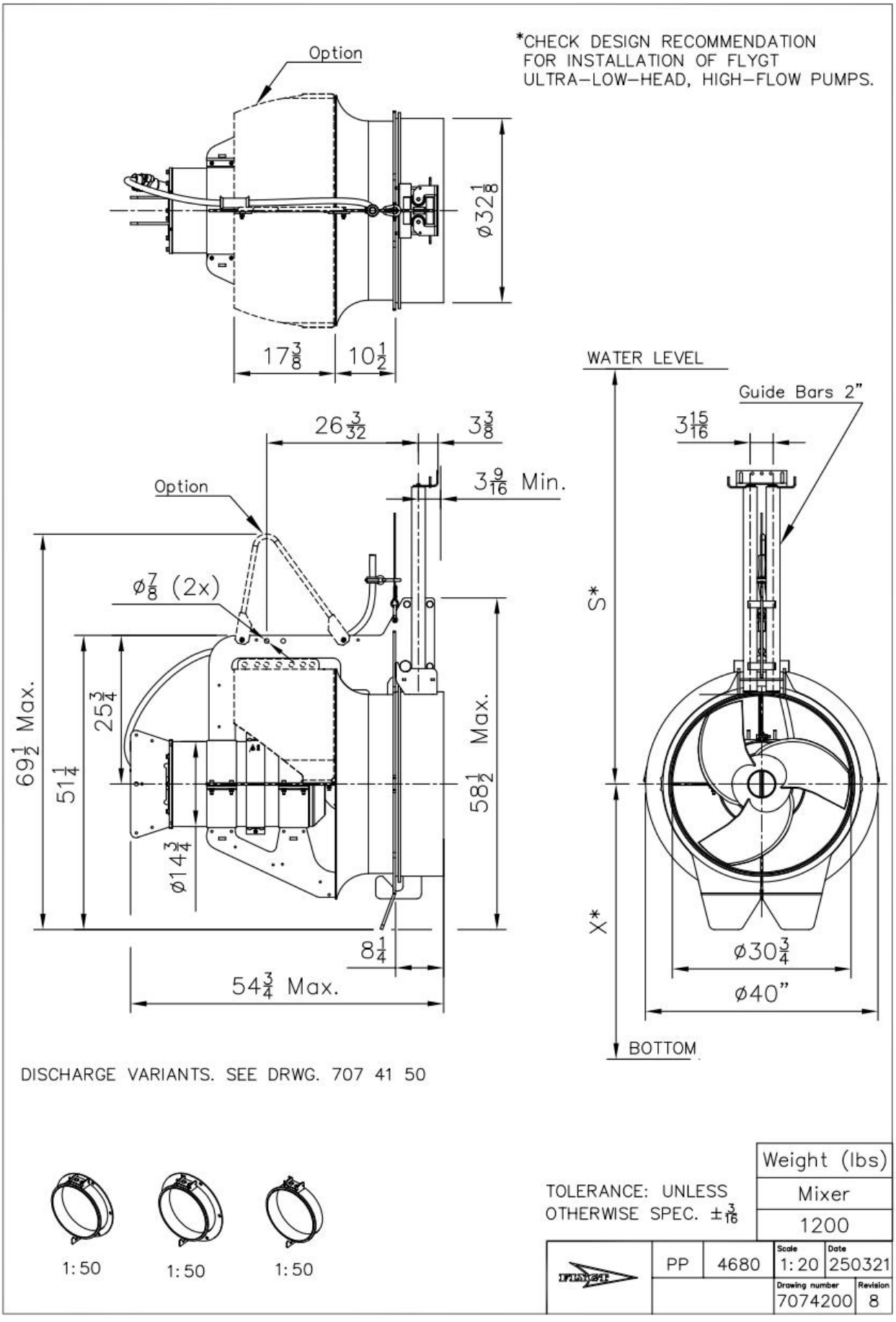
Nominal (mean) data shown. Under- and over-performance from this data should be expected due to standard manufacturing tolerances. Please consult your local Flygt representative for performance guarantees.

Name	Q (1x) [cfs]	H (1x) [ft]	P2 (1x) [Hp]	Q [cfs]	H [ft]	P2 [Hp]	ηp [%]	SE [kWh/mGal]	NPSHr [ft]
DP @ 1x	0	0	0	0	0	0	0	0	0
DP @ 2x	0	0	0	0	0	0	0	0	0

Project:	Created By:	Created On:	Last Update:
PP 4680 3~ 1677	James Teeter	8/21/25	-

DP @ 3x	47.07	3.51	31.02	141.2	3.51	93.05	60.47	22.19	0

PP 4680 3~ 1677 | Dimensional Data & Drawing



Company	Jacobs Engineering
Contact	James Teeter
Phone No.	7149433408
Email	James.teeter@jacobs.com

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MCNARY - AIR LIFT PUMP - COMPRESSED AIR TEMPERATURE PROFILE

Assumptions		
Diffuser Model	Airlift	
Diffuser Airflow Rate	2080	CFM
Velocity	249.53	ft/s
Fish Ladder Flow	210	CFS
Upwell Flow	157.5	CFS
Compressor Room Amb.	80	F
CTD	12	F
Compressed Air Discharge Temperature	92	F
Discharge Pressure	100	PSIG
Sample Temperature Location	John Day	
Pipe Material	316 Stainless Steel sch 40	
Nominal Diamter	5"	
Internal Diameter	5.047	in
Hydraulic Diameter	0.4206	ft
Surface Area per Foot	1.321	sqft/ft

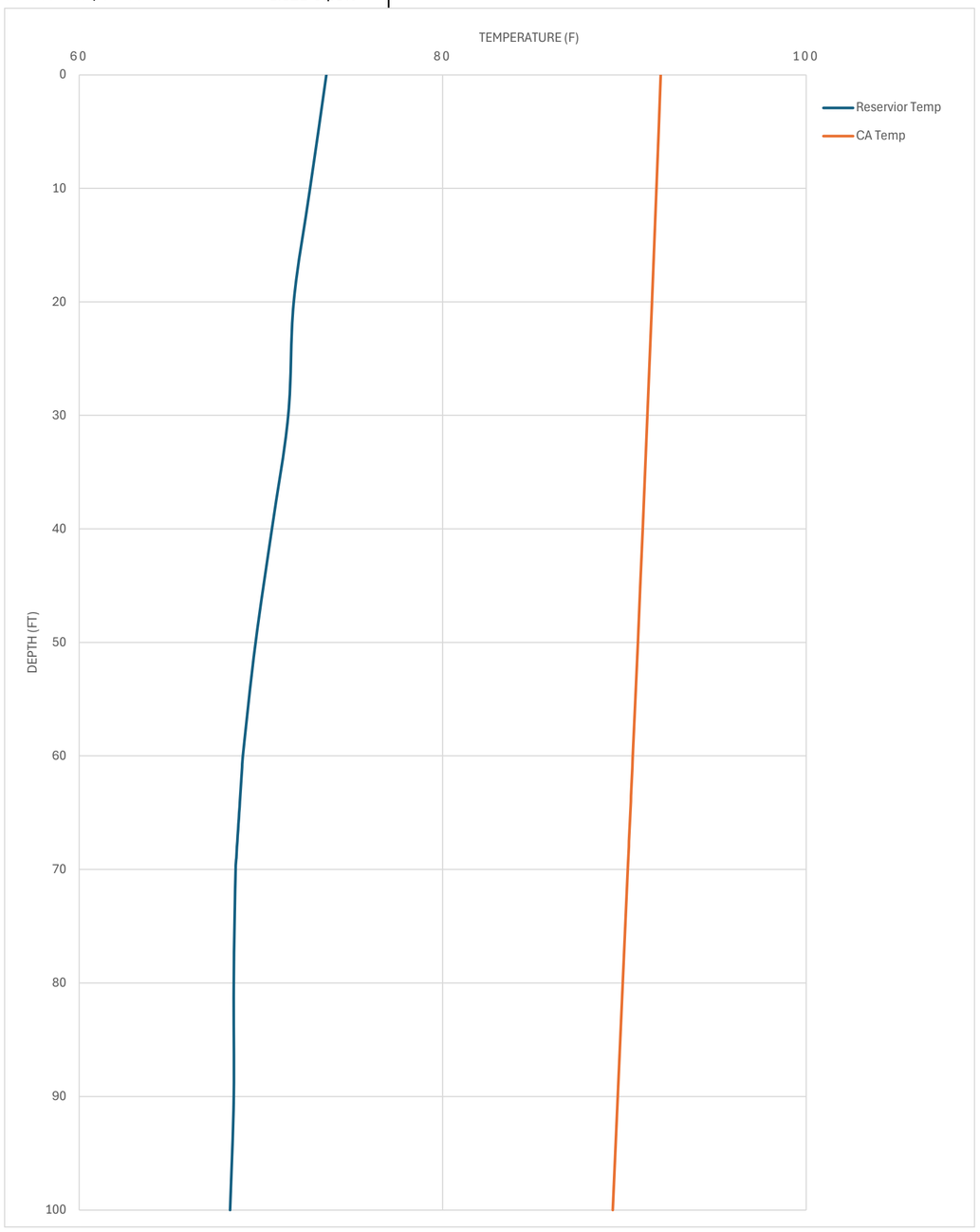
Depth (ft)	Reservior Temp
0	73.6
5	73.3
10	72.7
20	71.8
30	71.5
40	70.6
50	69.7
60	69.0
70	68.6
80	68.5
90	68.5
100	68.3

Assuming a CA intercooler that reduces initial temp to a point that doesn't induce boiling.

Assuming a worst case condition of still reservior water

Compressed air intercooler performance

ΔT 0.0 F



Depth (ft)	Reservior Temp	CA Temp	Film Temp	h, air	h, water	Q, btuh/ft	U	Re, air	Nu, air	Nu, water	Pr, air	Pr, water
0	73.6	92.0	83	58201.92	16.21	394.10	16.21	1.49E+08	2163.38	5.73	6.12E-06	5.05E-05
10	72.7	91.8	82	58256.15	16.32	411.04	16.32	1.49E+08	2164.67	5.76	6.12E-06	5.10E-05
20	71.8	91.5	82	58312.98	16.43	427.77	16.42	1.49E+08	2166.03	5.79	6.12E-06	5.14E-05
30	71.5	91.3	81	58371.17	16.43	428.80	16.42	1.49E+08	2167.41	5.79	6.12E-06	5.16E-05
40	70.6	91.0	81	58430.51	16.52	445.33	16.52	1.49E+08	2168.82	5.82	6.12E-06	5.21E-05
50	69.7	90.7	80	58492.14	16.61	461.66	16.61	1.49E+08	2170.29	5.85	6.12E-06	5.25E-05
60	69.0	90.5	80	58555.72	16.67	472.56	16.66	1.49E+08	2171.80	5.86	6.12E-06	5.29E-05
61	69.0	90.4	80	58562.16	16.67	472.86	16.67	1.49E+08	2171.95	5.86	6.12E-06	5.30E-05
62	68.9	90.4	80	58568.61	16.67	473.15	16.67	1.49E+08	2172.11	5.86	6.12E-06	5.30E-05
63	68.9	90.4	80	58575.06	16.67	473.44	16.67	1.49E+08	2172.26	5.86	6.12E-06	5.30E-05
64	68.8	90.4	80	58581.52	16.67	473.73	16.67	1.49E+08	2172.41	5.86	6.12E-06	5.31E-05
65	68.8	90.3	80	58587.98	16.67	474.02	16.67	1.49E+08	2172.57	5.86	6.12E-06	5.31E-05
66	68.8	90.3	80	58594.45	16.67	474.31	16.67	1.49E+08	2172.72	5.86	6.12E-06	5.31E-05
67	68.7	90.3	79	58600.92	16.68	474.60	16.67	1.49E+08	2172.87	5.86	6.12E-06	5.31E-05
68	68.7	90.2	79	58607.40	16.68	474.89	16.67	1.49E+08	2173.03	5.86	6.12E-06	5.32E-05
69	68.6	90.2	79	58613.88	16.68	475.18	16.67	1.49E+08	2173.18	5.86	6.12E-06	5.32E-05
70	68.6	90.2	79	58620.36	16.68	475.47	16.67	1.49E+08	2173.34	5.86	6.12E-06	5.32E-05
80	68.5	89.9	79	58684.98	16.64	470.51	16.64	1.49E+08	2174.87	5.85	6.12E-06	5.34E-05
90	68.5	89.6	79	58748.83	16.59	463.04	16.59	1.50E+08	2176.39	5.83	6.12E-06	5.35E-05
100	68.3	89.4	79	58812.04	16.57	460.90	16.57	1.50E+08	2177.89	5.82	6.12E-06	5.37E-05

RELEASED 29/Mar/2021 00:12:02 GMT

MCNARY, JOHN DAY - AIR LIFT PUMP

Ingersoll Rand

ENGINEERING DATA SHEET

RS185
60Hz

CCN:	47584706001
Rev.:	E
ECN:	1414695
Sheet:	1 of 2
Date:	Dec-2020

Model			RS185ie-A110	RS185ie-A125	RS185ie-A145	RS185ie-A200
GENERAL PERFORMANCE DATA						
Maximum Target Operating Pressure	(2)	barg (psig)	7.6 (110)	8.6 (125)	10.0 (145)	13.8 (200)
Rated Discharge Pressure		barg (psig)	6.9 (100)	7.9 (115)	9.3 (135)	13.1 (190)
Minimum Operating Pressure		barg (psig)	4.5 (65)	4.5 (65)	4.5 (65)	4.5 (65)
Maximum Operating Ambient Temperature		°C (°F)	46 (115)	46 (115)	46 (115)	46 (115)
Minimum Operating Ambient Temperature		°C (°F)	2 (36)	2 (36)	2 (36)	2 (36)
Maximum System Temperature Setting		°C (°F)	109 (228)	109 (228)	109 (228)	109 (228)
Nominal Power - Main Motor		kW (HP)	187 (250)	187 (250)	187 (250)	187 (250)
Main Motor Efficiency	(3)	%	96.2%	96.2%	96.2%	96.2%
Capacity FAD	(1)	m^3/min (CFM)	40.9 (1444)	39.3 (1388)	36.0 (1271)	30.1 (1063)
Package Input Power with Fan - Air Cooled	(4)	kW	223.4	229.3	228.1	228.1
Specific Power - Air Cooled	(4)(5)	kW/m^3/min (kW/100CFM)	5.5 (15.5)	5.8 (16.5)	6.3 (17.9)	7.6 (21.5)
SOUND LEVEL	(6)					
Noise Level Standard Package - Air Cooled		Sound Pressure - dB(A)	75	75	75	75
Noise Level Standard Package - Air Cooled		Sound Power - dB(A)	95	95	95	95
COOLING DATA (@ Maximum Ambient Temperature & Maximum Discharge Pressure)						
Heat Removal (Oil Cooler)		kW (1000 Btu/hr)	175.1 (597)	181.9 (621)	183.2 (625)	187.6 (640)
Heat Removal (Oil and Aftercooler)		kW (1000 Btu/hr)	240.2 (820)	244.6 (835)	240.8 (822)	236.0 (805)
Permitted Additional Static Pressure		Pa (in H_2O)	63 (.25)	63 (.25)	63 (.25)	63 (.25)
Fan Air Flow		m^3/min (CFM)	453 (15998)	453 (15998)	453 (15998)	453 (15998)
Fan Motor Nominal Power		kW	8.0	8.0	8.0	8.0
Cooling Air Temperature Rise @ 30°C		°C (°F)	24 (43)	25 (44)	24 (44)	24 (44)
Aftercooler CTD	(7)	°C (°F)	7 (12)	6 (12)	6 (11)	6 (11)
AIR END DATA						
STG1 Male Rotor Speed		RPM	1142	1106	1003	846
STG1 Rotor Tip Speed		m/sec	20.87	20.21	18.33	15.46
STG2 Male Rotor Speed		RPM	1306	1262	1138	953
STG2 Rotor Tip Speed		m/sec	17.57	16.98	15.31	12.82
Full Load Shaft Power		kW	205.5	211.1	210.0	210.0
COOLANT LUBRICATION DATA	(12)					
Total Coolant Capacity - Air Cooled		litres (US gal)	121 (32.0)	121 (32.0)	121 (32.0)	121 (32.0)
PIPING CONNECTIONS	(8)					
Air Discharge		Inches FLANGE	4.00 (8xM16; 7.5 IN B.C)	4.00 (8xM16; 7.5 IN B.C)	4.00 (8xM16; 7.5 IN B.C)	4.00 (8xM16; 7.5 IN B.C)
Package Automatic Condensate Drain		Inches NPT	.38 (FEMALE)	.38 (FEMALE)	.38 (FEMALE)	.38 (FEMALE)
Coolant Drain - Hose Size		Inches	0.875	0.875	0.875	0.875
Diameter of Power Inlet		mm (Inches)	110 (4.3)	110 (4.3)	110 (4.3)	110 (4.3)
DIMENSIONS AND WEIGHT						
Length, Width, Height		mm (inches)	4045, 2150, 2504 (159.3, 84.6, 98.6)	4045, 2150, 2504 (159.3, 84.6, 98.6)	4045, 2150, 2504 (159.3, 84.6, 98.6)	4045, 2150, 2504 (159.3, 84.6, 98.6)
Net Weight - Air Cooled		kg (lb.)	7341 (16184)	7341 (16184)	7341 (16184)	7341 (16184)
GA Drawing Number - Air Cooled			47713461	47713461	47713461	47713461
ELECTRICAL DATA	(13)					
Motor Protection			TEFC, IP55	TEFC, IP55	TEFC, IP55	TEFC, IP55
Full Load Package Current - Air Cooled	(9)					
		Amps @ 380V	440	451	449	449
		Amps @ 460V	363	373	371	371
		Amps @ 575V	291	298	297	297
Main Motor Locked Rotor Current	(14)					
		Amps @ 380V	2966	2966	2966	2966
		Amps @ 460V	2450	2450	2450	2450
		Amps @ 575V	2142	2142	2142	2142
Package Power Factor			0.85	0.85	0.85	0.85
Electrical Installation						
Recommended Supply Cable Size	(10)					
		mm^2/Cu (Kcmil) @ 380V	500 (900)	500 (900)	500 (900)	500 (900)
		mm^2/Cu (Kcmil) @ 460V	400 (700)	400 (700)	400 (700)	400 (700)
		mm^2/Cu (Kcmil) @ 575V	300 (500)	300 (500)	300 (500)	300 (500)
Maximum Recommended Fuse Rating	(10)(11)					
		Amps @ 380V	700	700	700	700
		Amps @ 460V	600	600	600	600
		Amps @ 575V	500	500	500	500

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ENGINEERING DATA SHEET

RS185

60Hz

CCN:	47584706001
Rev.:	E
ECN:	1414695
Sheet:	2 of 2
Date:	Dec-2020

Model		RS185ie-A110	RS185ie-A125	RS185ie-A145	RS185ie-A200
MEDIUM VOLTAGE MODEL - ELECTRICAL DATA					
Motor Protection		IP55	IP55	IP55	IP55
Main Motor Current - Air Cooled					
	Amps @ 2300V	72	72	72	72
	Amps @ 4160V	41	41	41	41
Main Motor Locked Rotor Current					
	Amps @ 2300V	396	396	396	396
	Amps @ 4160V	226	226	226	226
Blower Motor Current - Air Cooled					
	Amps @ 380V	19	19	19	19
	Amps @ 460V	16	16	16	16
	Amps @ 575V	13	13	13	13
DIMENSIONS AND WEIGHT					
Length, Width, Height	mm (inches)	5140, 2150, 2504 (202.4, 84.6, 98.6)	5140, 2150, 2504 (202.4, 84.6, 98.6)	5140, 2150, 2504 (202.4, 84.6, 98.6)	5140, 2150, 2504 (202.4, 84.6, 98.6)
Net Weight - Air Cooled	kg (lb.)	9598 (21160)	9598 (21160)	9598 (21160)	9598 (21160)
GA Drawing Number - Air Cooled		47589261	47589261	47589261	47589261

Notes:

1. FAD (Free Air Delivery) is full package performance including all losses. Tested per ISO 1217 : 2009 Annex C
2. Maximum pressure at package discharge, value at which compressor will stop when unit operating at maximum target pressure
3. IE3 efficiency motor
4. Measured at rated capacity and rated pressure
5. Specific power guaranteed in accordance with ISO 1217 : 2009 Annex C
6. Measured in free field conditions per ISO 2151 using Hemispherical Method; ducted inlet and outlet, with + 3 dB(A) tolerance
7. CTD based on 100°F/38°C inlet air at 40% Relative Humidity. For Canada, CTD of CRN Cooler is 11.1°C (20°F) (For alternate conditions contact Ingersoll Rand)
8. BSPT or NPT, depending on regional standard
9. Maximum current includes 10% additional current due to fouled filters and elements
10. 90°C copper cables. Always apply local electrical codes for sizing cables and system protection
11. Time delay fuse recommended. Apply local electrical codes for fuse sizing
12. Coolant volumes listed are approximate. See operator manual for coolant fill proceedure
13. 60Hz (±0.5%) motor voltage tolerance: (208)±10% ; (220)±10% ; (230)±10% ; (380)-6/+10% ; (440) ±10% ; (460) ±10% ; (575) -6/+10%
14. Star-Delta starting current inrush is about 33% of direct starting current
15. During the Star-Delta open-starting transition, the in-rush current value could instantaneously peak from 1.8 to 2.8 times the noted Locked-Rotor-Amperage (LRA) values

Product Improvement is a continuing goal at Ingersoll Rand. Design and specifications are subject to change without notice or obligation.

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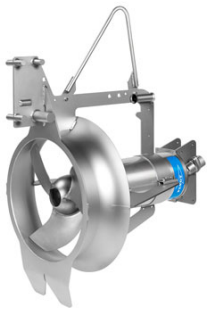
PP 4660 3~ 1258

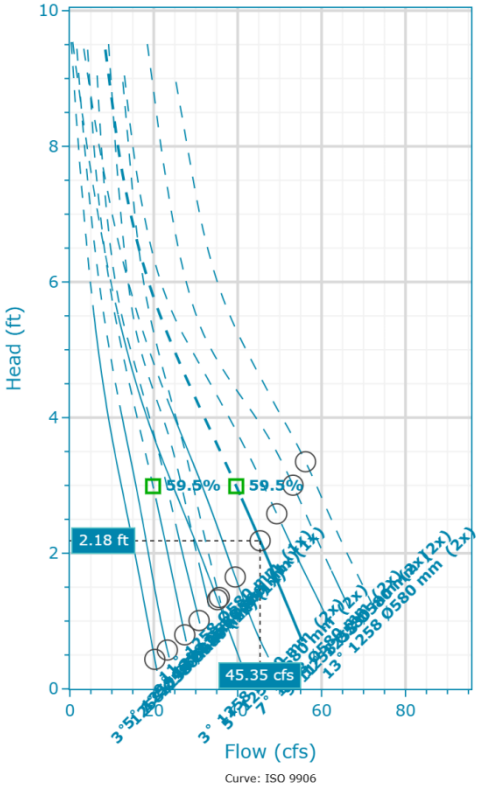
Created On: 7/3/25

MCNARY - GRAVITY CHIMNEY

PP 4660 3~ 1258 | Configuration Summary



Horizontal flow propeller pumps with fixed pitch blades for high capacity low head pumping of clean or slightly contaminated liquids. The pumps are extremely compact, using multipole motors instead of mechanical gearing.



Curve: ISO 9906

Nominal (mean) data shown. Under- and over-performance from this data should be expected due to standard manufacturing tolerances. Please consult your local Flygt representative for performance guarantees.

GENERAL

Explosion Proof	Blade Angle
No	7
Max. Pumped Media Temp.	Propeller Diameter
104 °F	580 mm

MATERIAL AND COATING

Impeller Material
Stainless Steel

MOTOR

Rated Voltage	Motor Efficiency Class
460 V	Standard
Coupling	Rated Power
Y	11 Hp

INSTALLATION

Installation Type
P - Semi-Permanent, Wet

Project:	Created By:	Created On:	Last Update:
PP 4660 3~ 1258	James Teeter	7/3/25	-

PP 4660 3~ 1258 | Product Details

Description

P 4660

Ultra-Low-Head High-Flow Wastewater Pump

Flygt ultra-low-head high-flow wastewater pumps are engineered for versatility and lean installation, and offer highly efficient and reliable pumping of highly contaminated fluids. Few components, straightforward service routines and simple installation make Flygt ultra-low-head pumps an economical choice for a wide range of applications, including activated sludge treatment, stormwater and other low-head high-flow duties. Pumping efficiency is kept sustained high with backswept propeller blades and wide-hub propeller design.

Flexible and Modular Design

All external parts manufactured for excellent corrosion-resistance. Major parts in stainless steel.

- High efficiency stainless steel propeller with backswept propeller blades for high clog resistance.
- Optional Hard-Iron impeller for abrasive applications.
- Short shaft overhang – reduces shaft deflection and increases seal and bearing life.
- Motor designed for submersible use – heat is concentrated to the stator core for improved cooling properties.
- High performance motor with Class H motor insulation provides thermal overload protection and extra long service life.
- Double mechanical seal system – Two sets of mechanical shaft seals work independently to provide double security. Available in Tungsten carbide (WCCR) or Silicone carbide (SiC) depending on pumped media.
- Plug-in seal with the Active Seal system, offering increased sealing reliability and zero leakage into the motor, thereby reducing the risk of bearing and stator failures.
- Motor cable SUBCAB® - specially developed for submersible use.
- Cable entry with double elastomer seal grommets – for double security.

Product Features

- State of the art ultra-low-head high-flow wastewater pump
- Robust and reliable direct drive
- Sustained high efficiency with fiber-handling hydraulics
- High reliability with Class H insulated motor and Active Seal system Plug-in seal

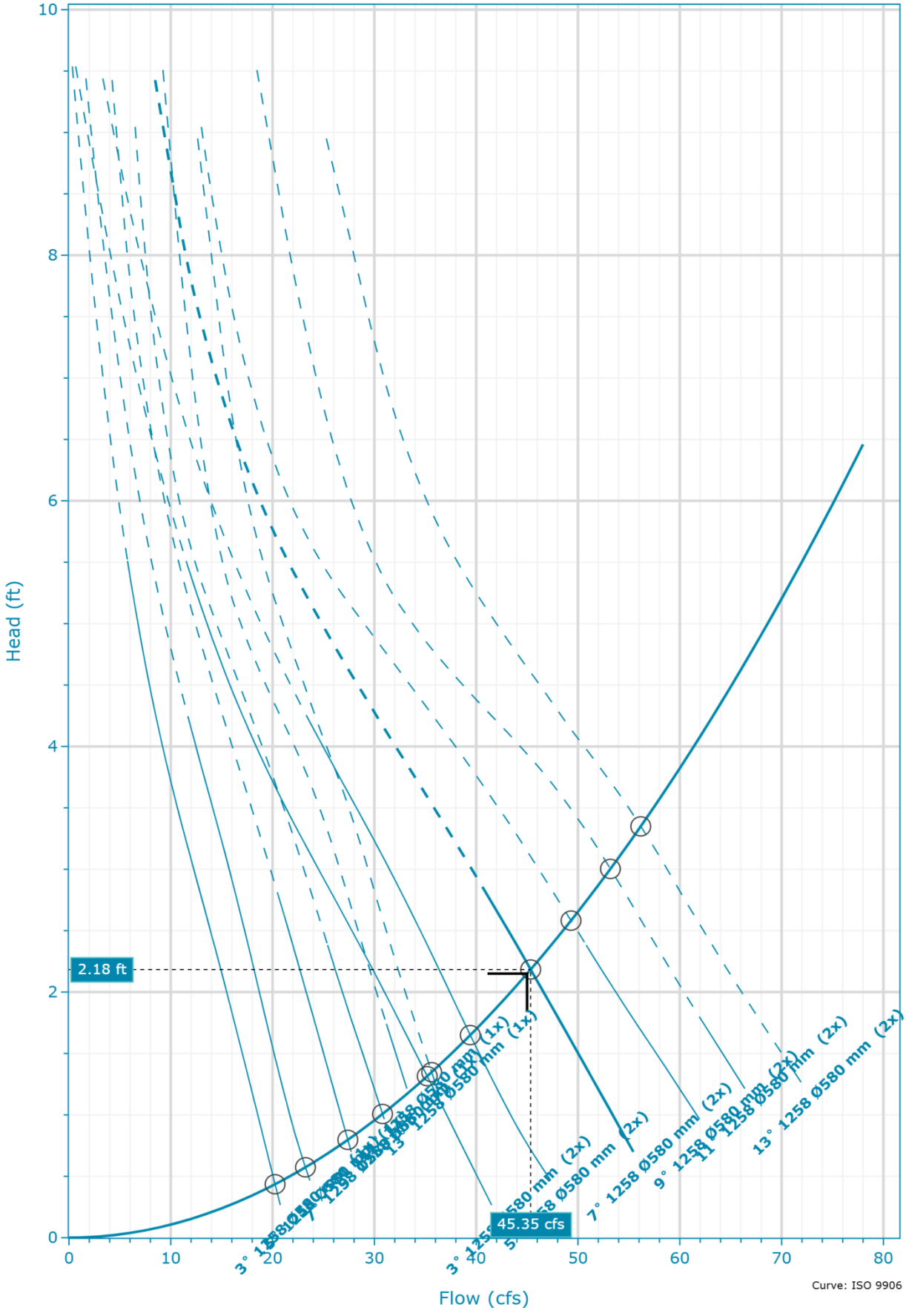
Construction Materials

Impeller Material	Volute Material	Stator Cover Material
Stainless Steel	-	-

Motor

Rated Power 11 Hp	Number Of Phases 3	Start Current Ratio 3.7	Motor Issue 16
Motor Denomination 25-26-12AA	Rated Motor Speed 590 RPM	Insulation Class H	Locked Rotor Code H
Motor Efficiency Class Standard	Rated Voltage 460 V	Approval Standard	Max starts per hour 30
Version Code 412	Rated Current 24 A	Total moment of inertia 8.7817 ft^2lbf	Power Factor 100% 0.54
Frequency 60 Hz	Start Current 87 A	Type of duty S1	Power Factor 75% 0.46
Max P2 (1x) 21.53 Hp	Starting Current, Direct Starting 87 A	Stator Variant 31	Power Factor 50% 0.35
Number Of Poles 12	Starting Current, Star Delta 29 A	Motor Module 142	Efficiency 100% 80.2 %
			Efficiency 75% 78.8 %
			Efficiency 50% 74.6 %

PP 4660 3~ 1258 | Hydraulic Data & Performance Curve



Nominal (mean) data shown. Under- and over-performance from this data should be expected due to standard manufacturing tolerances. Please consult your local Flygt representative for performance guarantees.

Project:	Created By:	Created On:	Last Update:
PP 4660 3~ 1258	James Teeter	7/3/25	-

Selection

Series PP 4600	Curve Code 1258
Name PP 4660 3~ 1258	Propeller Diameter 580 mm
Frequency 60 Hz	Inlet Diameter 590 mm
Total Flow 45.00 cfs	Outlet Diameter 590 in
Total Head 2.15 ft	Number Of Vanes 3
Pump Flow 22.50 cfs	
Pump Head 2.15 ft	
System Type Parallel Pumps	
Operating Pumps 2	
Standby Pumps No Standby Pump	

Fluid

Fluid Type Water	Density 62.428 lb/ft³
Fluid Temperature 39.2 °F	Dynamic Viscosity 1.567212 cP
Specific Gravity 1	Fluid Vapor Pressure 0.118 psi

Design Point - Single Pump

Flow (1x) 22.68 cfs	Input Power (P1) (1x) 12.31 Hp
Head (1x) 2.18 ft	Shaft power (P2) (1x) 9.83 Hp
Overall Efficiency (1x) 45.68 %	Flow To BEP Ratio (1x) 114.4 %
Pump Efficiency (1x) 57.20 %	

Design Point - System

Flow 45.35 cfs	Input Power (P1) 24.61 Hp
Head 2.18 ft	Shaft power (P2) 19.66 Hp
Overall Efficiency (ηo) 45.68 %	Flow To BEP Ratio 114.4 %
Pump Efficiency (ηp) 57.20 %	

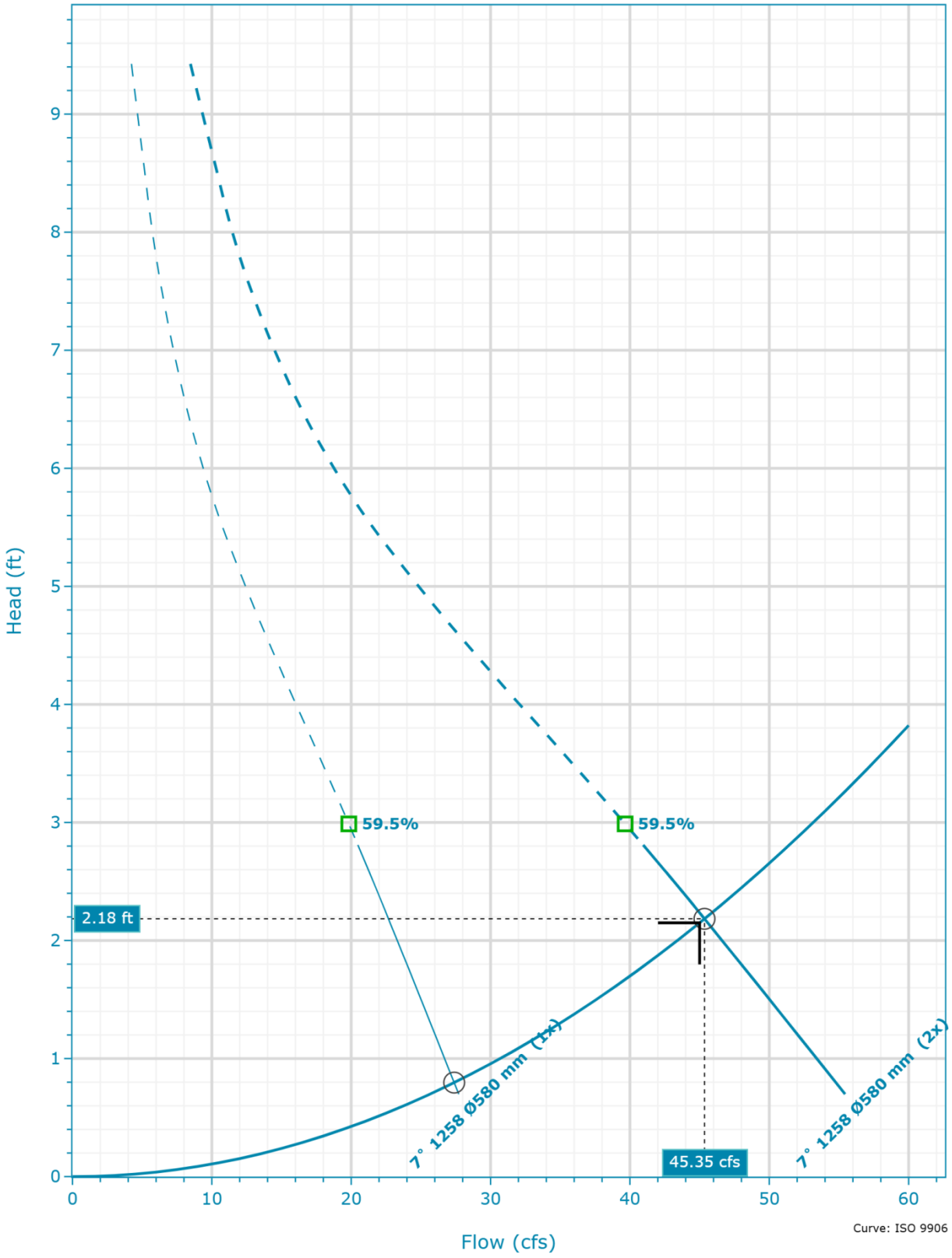
Design Curve - Single Pump

Rated Speed 60 Hz	BEP Flow (1x) 19.83 cfs
Max Flow (1x) 27.72 cfs	BEP Head (1x) 2.99 ft
H@QMin (1x) 9.43 ft	Max P2 (1x) 21.53 Hp
H@QMax (1x) 0.7 ft	
BEP (1x) 59.5 %	

Design Curve - System

Rated Speed 60 Hz	BEP Flow 39.66 cfs
Max Flow 55.44 cfs	BEP Head 2.99 ft
H@QMin 9.43 ft	Max P2 43.05 Hp
H@QMax 0.7 ft	Specific Energy 15 kWh/mGal
BEP 59.5 %	

PP 4660 3~ 1258 | Duty Analysis

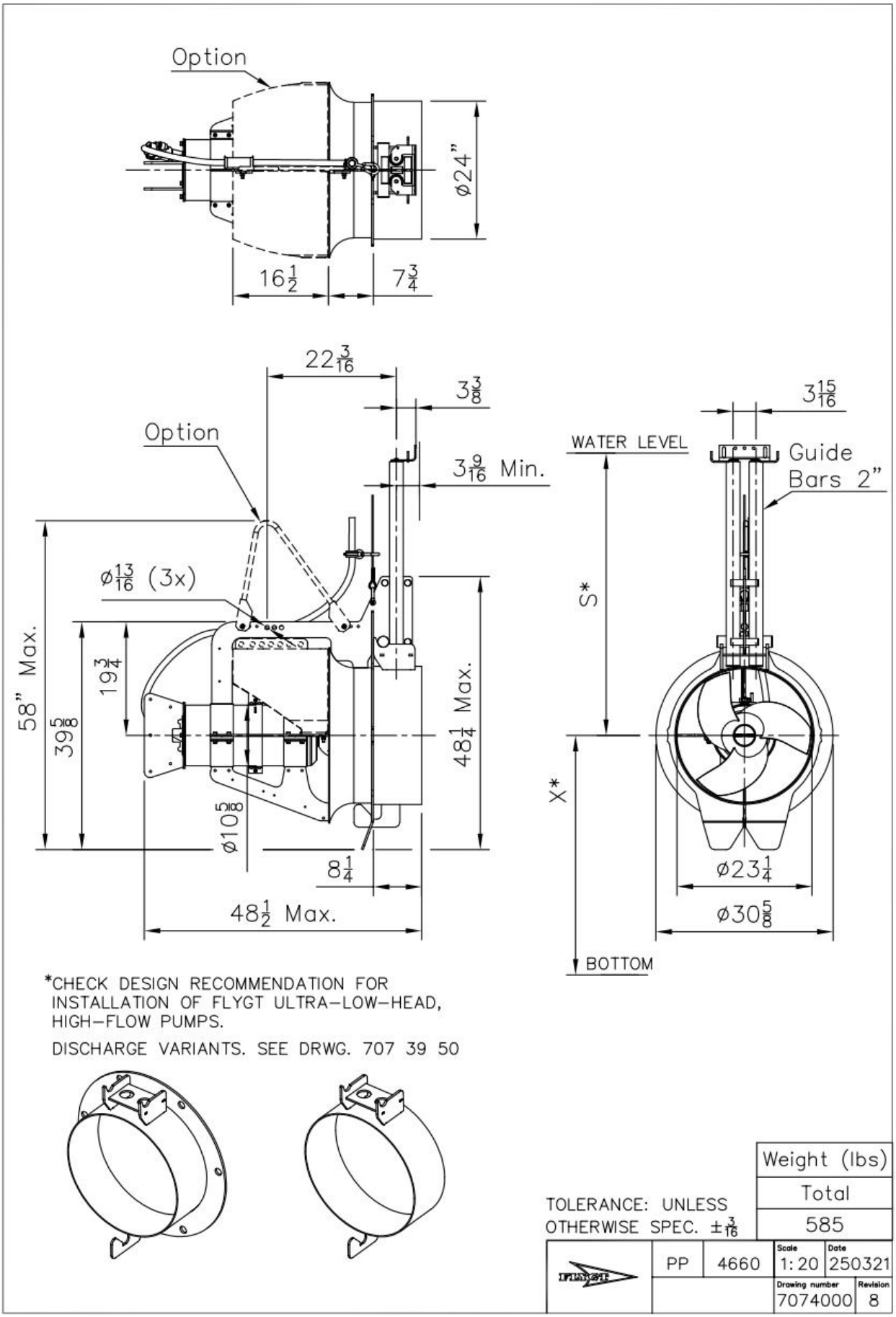


Nominal (mean) data shown. Under- and over-performance from this data should be expected due to standard manufacturing tolerances. Please consult your local Flygt representative for performance guarantees.

Name	Q (1x) [cfs]	H (1x) [ft]	P2 (1x) [Hp]	Q [cfs]	H [ft]	P2 [Hp]	ηp [%]	SE [kWh/mGal]	NPSHr [ft]
DP @ 1x	27.39	0.8	6.81	27.39	0.8	6.81	36.29	8.94	0
DP @ 2x	22.68	2.18	9.83	45.35	2.18	19.66	57.2	15.03	0

Project:	Created By:	Created On:	Last Update:
PP 4660 3~ 1258	James Teeter	7/3/25	-

PP 4660 3~ 1258 | Dimensional Data & Drawing



Company	Jacobs Engineering
Contact	James Teeter
Phone No.	7149433408
Email	James.teeter@jacobs.com

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JOHN DAY - AIR LIFT PUMP - COMPRESSED AIR TEMPERATURE PROFILE

Assumptions		
Diffuser Model	Airlift	
Diffuser Airflow Rate	1120	CFM
Velocity	363.60	ft/s
Fish Ladder Flow	67.6	CFS
Upwell Flow	84.5	CFS
Compressor Room Amb.	80	F
CTD	12	F
Compressed Air Discharge Temperature	92	F
Discharge Pressure	100	PSIG
Sample Temperature Location	John Day	
Pipe Material	316 Stainless Steel sch 40	
Nominal Diamter	3"	
Internal Diameter	3.068	in
Hydraulic Diameter	0.2557	ft
Surface Area per Foot	0.803	sqft/ft

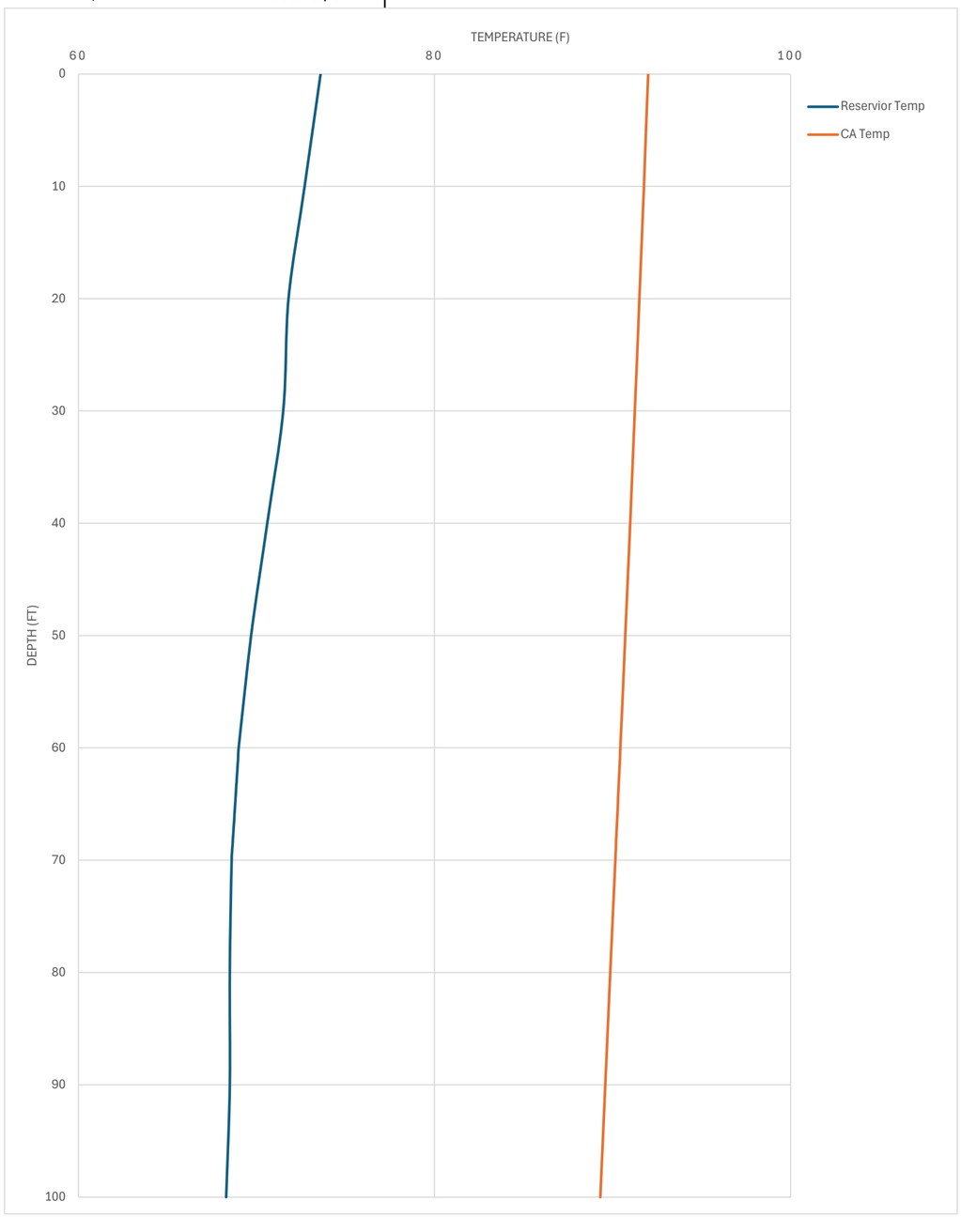
Depth (ft)	Reservior Temp
0	73.6
5	73.3
10	72.7
20	71.8
30	71.5
40	70.6
50	69.7
60	69.0
70	68.6
80	68.5
90	68.5
100	68.3

Assuming a CA intercooler that reduces initial temp to a point that doesn't induce boiling.

Assuming a worst case condition of still reservior water

Compressed air intercooler performance

ΔT 0.0 F



Depth (ft)	Reservior Temp	CA Temp	Film Temp	h, air	h, water	Q, btuh/ft	U	Re, air	Nu, air	Nu, water	Pr, air	Pr, water
0	73.6	92.0	83	32108.90	14.59	215.49	14.58	1.32E+08	1963.36	5.15	6.12E-06	5.05E-05
10	72.7	91.8	82	32139.28	14.68	224.68	14.68	1.32E+08	1964.55	5.18	6.12E-06	5.10E-05
20	71.8	91.5	82	32171.10	14.77	233.75	14.77	1.32E+08	1965.79	5.21	6.12E-06	5.14E-05
30	71.5	91.3	81	32203.68	14.77	234.26	14.77	1.32E+08	1967.07	5.21	6.12E-06	5.16E-05
40	70.6	91.0	81	32236.89	14.86	243.22	14.85	1.32E+08	1968.37	5.23	6.12E-06	5.21E-05
50	69.7	90.7	80	32271.37	14.94	252.08	14.93	1.32E+08	1969.72	5.26	6.12E-06	5.26E-05
60	69.0	90.4	80	32306.94	14.99	257.97	14.98	1.32E+08	1971.11	5.27	6.12E-06	5.30E-05
61	69.0	90.4	80	32310.55	14.99	258.12	14.98	1.32E+08	1971.25	5.27	6.12E-06	5.30E-05
62	68.9	90.4	80	32314.15	14.99	258.28	14.98	1.32E+08	1971.39	5.27	6.12E-06	5.30E-05
63	68.9	90.4	80	32317.76	14.99	258.43	14.98	1.32E+08	1971.53	5.27	6.12E-06	5.30E-05
64	68.8	90.3	80	32321.37	14.99	258.59	14.98	1.32E+08	1971.67	5.27	6.12E-06	5.31E-05
65	68.8	90.3	80	32324.99	14.99	258.74	14.98	1.32E+08	1971.81	5.27	6.12E-06	5.31E-05
66	68.8	90.3	80	32328.60	14.99	258.89	14.99	1.32E+08	1971.95	5.27	6.12E-06	5.31E-05
67	68.7	90.2	79	32332.22	14.99	259.05	14.99	1.32E+08	1972.10	5.27	6.12E-06	5.31E-05
68	68.7	90.2	79	32335.85	14.99	259.20	14.99	1.32E+08	1972.24	5.27	6.12E-06	5.32E-05
69	68.6	90.2	79	32339.47	14.99	259.35	14.99	1.32E+08	1972.38	5.27	6.12E-06	5.32E-05
70	68.6	90.2	79	32343.10	15.00	259.50	14.99	1.32E+08	1972.52	5.27	6.12E-06	5.32E-05
80	68.5	89.9	79	32379.23	14.96	256.74	14.96	1.32E+08	1973.93	5.26	6.12E-06	5.34E-05
90	68.5	89.6	79	32414.93	14.92	252.62	14.91	1.33E+08	1975.33	5.24	6.12E-06	5.35E-05
100	68.3	89.3	79	32450.26	14.90	251.40	14.89	1.33E+08	1976.71	5.23	6.12E-06	5.37E-05

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MCNARY, JOHN DAY - AIR LIFT PUMP

Ingersoll Rand

ENGINEERING DATA SHEET

RS185
60Hz

CCN:	47584706001
Rev.:	E
ECN:	1414695
Sheet:	1 of 2
Date:	Dec-2020

Model			RS185ie-A110	RS185ie-A125	RS185ie-A145	RS185ie-A200
GENERAL PERFORMANCE DATA						
Maximum Target Operating Pressure	(2)	barg (psig)	7.6 (110)	8.6 (125)	10.0 (145)	13.8 (200)
Rated Discharge Pressure		barg (psig)	6.9 (100)	7.9 (115)	9.3 (135)	13.1 (190)
Minimum Operating Pressure		barg (psig)	4.5 (65)	4.5 (65)	4.5 (65)	4.5 (65)
Maximum Operating Ambient Temperature		°C (°F)	46 (115)	46 (115)	46 (115)	46 (115)
Minimum Operating Ambient Temperature		°C (°F)	2 (36)	2 (36)	2 (36)	2 (36)
Maximum System Temperature Setting		°C (°F)	109 (228)	109 (228)	109 (228)	109 (228)
Nominal Power - Main Motor		kW (HP)	187 (250)	187 (250)	187 (250)	187 (250)
Main Motor Efficiency	(3)	%	96.2%	96.2%	96.2%	96.2%
Capacity FAD	(1)	m^3/min (CFM)	40.9 (1444)	39.3 (1388)	36.0 (1271)	30.1 (1063)
Package Input Power with Fan - Air Cooled	(4)	kW	223.4	229.3	228.1	228.1
Specific Power - Air Cooled	(4)(5)	kW/m^3/min (kW/100CFM)	5.5 (15.5)	5.8 (16.5)	6.3 (17.9)	7.6 (21.5)
SOUND LEVEL	(6)					
Noise Level Standard Package - Air Cooled		Sound Pressure - dB(A)	75	75	75	75
Noise Level Standard Package - Air Cooled		Sound Power - dB(A)	95	95	95	95
COOLING DATA (@ Maximum Ambient Temperature & Maximum Discharge Pressure)						
Heat Removal (Oil Cooler)		kW (1000 Btu/hr)	175.1 (597)	181.9 (621)	183.2 (625)	187.6 (640)
Heat Removal (Oil and Aftercooler)		kW (1000 Btu/hr)	240.2 (820)	244.6 (835)	240.8 (822)	236.0 (805)
Permitted Additional Static Pressure		Pa (in H_2O)	63 (.25)	63 (.25)	63 (.25)	63 (.25)
Fan Air Flow		m^3/min (CFM)	453 (15998)	453 (15998)	453 (15998)	453 (15998)
Fan Motor Nominal Power		kW	8.0	8.0	8.0	8.0
Cooling Air Temperature Rise @ 30°C		°C (°F)	24 (43)	25 (44)	24 (44)	24 (44)
Aftercooler CTD	(7)	°C (°F)	7 (12)	6 (12)	6 (11)	6 (11)
AIR END DATA						
STG1 Male Rotor Speed		RPM	1142	1106	1003	846
STG1 Rotor Tip Speed		m/sec	20.87	20.21	18.33	15.46
STG2 Male Rotor Speed		RPM	1306	1262	1138	953
STG2 Rotor Tip Speed		m/sec	17.57	16.98	15.31	12.82
Full Load Shaft Power		kW	205.5	211.1	210.0	210.0
COOLANT LUBRICATION DATA	(12)					
Total Coolant Capacity - Air Cooled		litres (US gal)	121 (32.0)	121 (32.0)	121 (32.0)	121 (32.0)
PIPING CONNECTIONS	(8)					
Air Discharge		Inches FLANGE	4.00 (8xM16; 7.5 IN B.C)	4.00 (8xM16; 7.5 IN B.C)	4.00 (8xM16; 7.5 IN B.C)	4.00 (8xM16; 7.5 IN B.C)
Package Automatic Condensate Drain		Inches NPT	.38 (FEMALE)	.38 (FEMALE)	.38 (FEMALE)	.38 (FEMALE)
Coolant Drain - Hose Size		Inches	0.875	0.875	0.875	0.875
Diameter of Power Inlet		mm (Inches)	110 (4.3)	110 (4.3)	110 (4.3)	110 (4.3)
DIMENSIONS AND WEIGHT						
Length, Width, Height		mm (inches)	4045, 2150, 2504 (159.3, 84.6, 98.6)	4045, 2150, 2504 (159.3, 84.6, 98.6)	4045, 2150, 2504 (159.3, 84.6, 98.6)	4045, 2150, 2504 (159.3, 84.6, 98.6)
Net Weight - Air Cooled		kg (lb.)	7341 (16184)	7341 (16184)	7341 (16184)	7341 (16184)
GA Drawing Number - Air Cooled			47713461	47713461	47713461	47713461
ELECTRICAL DATA	(13)					
Motor Protection			TEFC, IP55	TEFC, IP55	TEFC, IP55	TEFC, IP55
Full Load Package Current - Air Cooled	(9)					
		Amps @ 380V	440	451	449	449
		Amps @ 460V	363	373	371	371
		Amps @ 575V	291	298	297	297
Main Motor Locked Rotor Current	(14)					
		Amps @ 380V	2966	2966	2966	2966
		Amps @ 460V	2450	2450	2450	2450
		Amps @ 575V	2142	2142	2142	2142
Package Power Factor			0.85	0.85	0.85	0.85
Electrical Installation						
Recommended Supply Cable Size	(10)					
		mm^2/Cu (Kcmil) @ 380V	500 (900)	500 (900)	500 (900)	500 (900)
		mm^2/Cu (Kcmil) @ 460V	400 (700)	400 (700)	400 (700)	400 (700)
		mm^2/Cu (Kcmil) @ 575V	300 (500)	300 (500)	300 (500)	300 (500)
Maximum Recommended Fuse Rating	(10)(11)					
		Amps @ 380V	700	700	700	700
		Amps @ 460V	600	600	600	600
		Amps @ 575V	500	500	500	500

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ENGINEERING DATA SHEET

RS185

60Hz

CCN:	47584706001
Rev.:	E
ECN:	1414695
Sheet:	2 of 2
Date:	Dec-2020

Model		RS185ie-A110	RS185ie-A125	RS185ie-A145	RS185ie-A200
MEDIUM VOLTAGE MODEL - ELECTRICAL DATA					
Motor Protection		IP55	IP55	IP55	IP55
Main Motor Current - Air Cooled					
	Amps @ 2300V	72	72	72	72
	Amps @ 4160V	41	41	41	41
Main Motor Locked Rotor Current					
	Amps @ 2300V	396	396	396	396
	Amps @ 4160V	226	226	226	226
Blower Motor Current - Air Cooled					
	Amps @ 380V	19	19	19	19
	Amps @ 460V	16	16	16	16
	Amps @ 575V	13	13	13	13
DIMENSIONS AND WEIGHT					
Length, Width, Height	mm (inches)	5140, 2150, 2504 (202.4, 84.6, 98.6)	5140, 2150, 2504 (202.4, 84.6, 98.6)	5140, 2150, 2504 (202.4, 84.6, 98.6)	5140, 2150, 2504 (202.4, 84.6, 98.6)
Net Weight - Air Cooled	kg (lb.)	9598 (21160)	9598 (21160)	9598 (21160)	9598 (21160)
GA Drawing Number - Air Cooled		47589261	47589261	47589261	47589261

Notes:

1. FAD (Free Air Delivery) is full package performance including all losses. Tested per ISO 1217 : 2009 Annex C
2. Maximum pressure at package discharge, value at which compressor will stop when unit operating at maximum target pressure
3. IE3 efficiency motor
4. Measured at rated capacity and rated pressure
5. Specific power guaranteed in accordance with ISO 1217 : 2009 Annex C
6. Measured in free field conditions per ISO 2151 using Hemispherical Method; ducted inlet and outlet, with + 3 dB(A) tolerance
7. CTD based on 100°F/38°C inlet air at 40% Relative Humidity. For Canada, CTD of CRN Cooler is 11.1°C (20°F) (For alternate conditions contact Ingersoll Rand)
8. BSPT or NPT, depending on regional standard
9. Maximum current includes 10% additional current due to fouled filters and elements
10. 90°C copper cables. Always apply local electrical codes for sizing cables and system protection
11. Time delay fuse recommended. Apply local electrical codes for fuse sizing
12. Coolant volumes listed are approximate. See operator manual for coolant fill proceedure
13. 60Hz (±0.5%) motor voltage tolerance: (208)±10% ; (220)±10% ; (230)±10% ; (380)-6/+10% ; (440) ±10% ; (460) ±10% ; (575) -6/+10%
14. Star-Delta starting current inrush is about 33% of direct starting current
15. During the Star-Delta open-starting transition, the in-rush current value could instantaneously peak from 1.8 to 2.8 times the noted Locked-Rotor-Amperage (LRA) values

Product Improvement is a continuing goal at Ingersoll Rand. Design and specifications are subject to change without notice or obligation.

xylem
Let's Solve Water

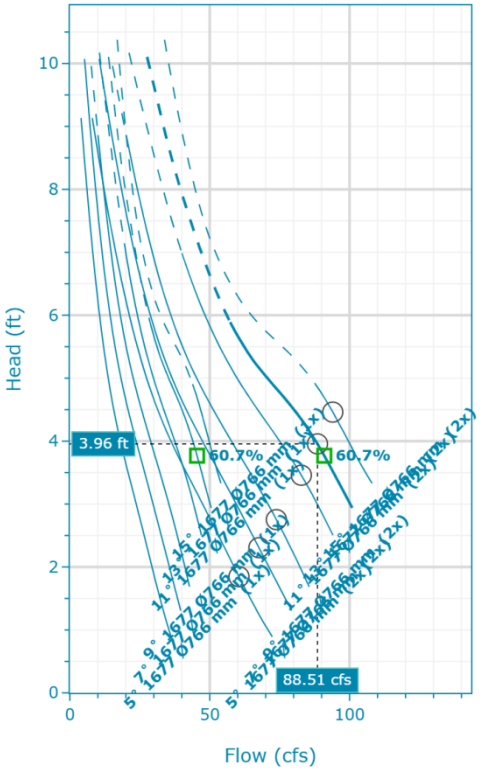
PP 4680 3~ 1677

Created On: 5/5/25

JOHN DAY - SUBMERGED JET

PP 4680 3~ 1677 | Configuration Summary

Horizontal flow propeller pumps with fixed pitch blades for high capacity low head pumping of clean or slightly contaminated liquids. The pumps are extremely compact, using multipole motors instead of mechanical gearing.



Curve: ISO 9906

Nominal (mean) data shown. Under- and over-performance from this data should be expected due to standard manufacturing tolerances. Please consult your local Flygt representative for performance guarantees.

Installation

Installation Type
P - Semi-Permanent, Wet

Motor

Rated Voltage
460 V

Coupling
D

Motor Efficiency Class
Standard

Rated Power
40 Hp

Materials

Impeller Material
Stainless Steel

Volute Material
Stainless Steel

Performance

Explosion Proof
No

Max. Pumped Media Temp.
104 °F

Blade Angle
13

Propeller Diameter
766 mm

Project:	Created By:	Created On:	Last Update:
PP 4680 3~ 1677	James Teeter	5/5/25	-

PP 4680 3~ 1677 | Product Details

Description

P 4680

Ultra-Low-Head High-Flow Wastewater Pump

Flygt ultra-low-head high-flow wastewater pumps are engineered for versatility and lean installation, and offer highly efficient and reliable pumping of highly contaminated fluids. Few components, straightforward service routines and simple installation make Flygt ultra-low-head pumps an economical choice for a wide range of applications, including activated sludge treatment, stormwater and other low-head high-flow duties. Pumping efficiency is kept sustained high with backswept propeller blades and wide-hub propeller design.

Flexible and Modular Design

All external parts manufactured for excellent corrosion-resistance. Major parts in stainless steel.

- High efficiency stainless steel propeller with backswept propeller blades for high clog resistance.
- Optional Hard-Iron impeller for abrasive applications.
- Short shaft overhang – reduces shaft deflection and increases seal and bearing life.
- Motor designed for submersible use – heat is concentrated to the stator core for improved cooling properties.
- High performance motor with Class H motor insulation provides thermal overload protection and extra long service life.
- Double mechanical seal system – Two sets of mechanical shaft seals work independently to provide double security. Available in Tungsten carbide (WCCR) or Silicone carbide (SiC) depending on pumped media.
- Plug-in seal with the Active Seal system, offering increased sealing reliability and zero leakage into the motor, thereby reducing the risk of bearing and stator failures.
- Motor cable SUBCAB® - specially developed for submersible use.
- Cable entry with double elastomer seal grommets – for double security.

Product Features

- State of the art ultra-low-head high-flow wastewater pump
- Robust and reliable direct drive
- Sustained high efficiency with fiber-handling hydraulics
- High reliability with Class H insulated motor and Active Seal system Plug-in seal

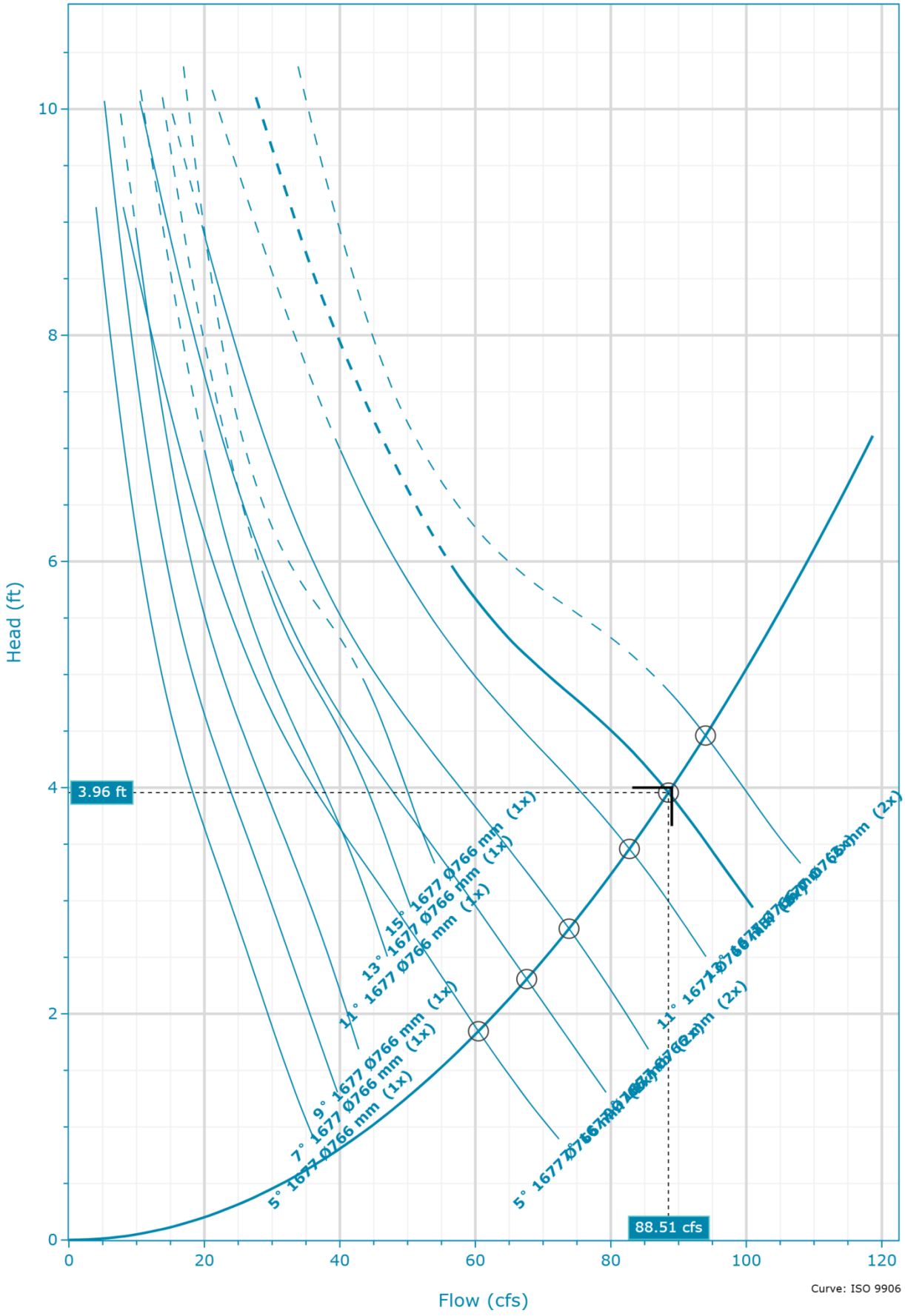
Construction Materials

Impeller Material	Volute Material	Stator Cover Material
Stainless Steel	Stainless Steel	-

Motor

Rated Power 40 Hp	Number Of Phases 3	Start Current Ratio 2.84	Motor Issue 14
Motor Denomination 35-32-16AA	Rated Motor Speed 445 RPM	Insulation Class H	Locked Rotor Code E
Motor Efficiency Class Standard	Rated Voltage 460 V	Approval Standard	Max starts per hour 30
Version Code 412	Rated Current 84 A	Total moment of inertia 25.6332 ft^2lbf	Power Factor 100% 0.55
Frequency 60 Hz	Start Current 240 A	Type of duty S1	Power Factor 75% 0.48
Max P2 (1x) 56.15 Hp	Starting Current, Direct Starting 240 A	Stator Variant 38	Power Factor 50% 0.38
Number Of Poles 16	Starting Current, Star Delta 80 A	Motor Module 154	Efficiency 100% 81.7 %
			Efficiency 75% 81.2 %
			Efficiency 50% 77.8 %

PP 4680 3~ 1677 | Hydraulic Data & Performance Curve



Nominal (mean) data shown. Under- and over-performance from this data should be expected due to standard manufacturing tolerances. Please consult your local Flygt representative for performance guarantees.

Project:	Created By:	Created On:	Last Update:
PP 4680 3~ 1677	James Teeter	5/5/25	-

Selection

Series PP 4600	System Type Parallel Pumps
Name PP 4680 3~ 1677	Operating Pumps 2
Frequency 60 Hz	Standby Pumps No Standby Pump
Total Flow 89.00 cfs	Curve Code 1677
Total Head 4.00 ft	Propeller Diameter 766 mm
Pump Flow 44.50 cfs	Inlet Diameter 780 mm
Pump Head 4.00 ft	Outlet Diameter 780 in
	Number Of Vanes 3

Fluid

Fluid Type Water	Density 62.318 lb/ft³
Fluid Temperature 68 °F	Dynamic Viscosity 1.001577 cP
Specific Gravity 0.998	Fluid Vapor Pressure 0.339 psi

Design Point - Single Pump

Flow (1x) 44.25 cfs	Input Power (P1) (1x) 39.86 Hp
Head (1x) 3.96 ft	Shaft power (P2) (1x) 32.81 Hp
Overall Efficiency (1x) 49.87 %	Flow To BEP Ratio (1x) 97.3 %
Pump Efficiency (1x) 60.59 %	

Design Point - System

Flow 88.51 cfs	Input Power (P1) 79.72 Hp
Head 3.96 ft	Shaft power (P2) 65.62 Hp
Overall Efficiency (ηo) 49.87 %	Flow To BEP Ratio 97.3 %
Pump Efficiency (ηp) 60.59 %	

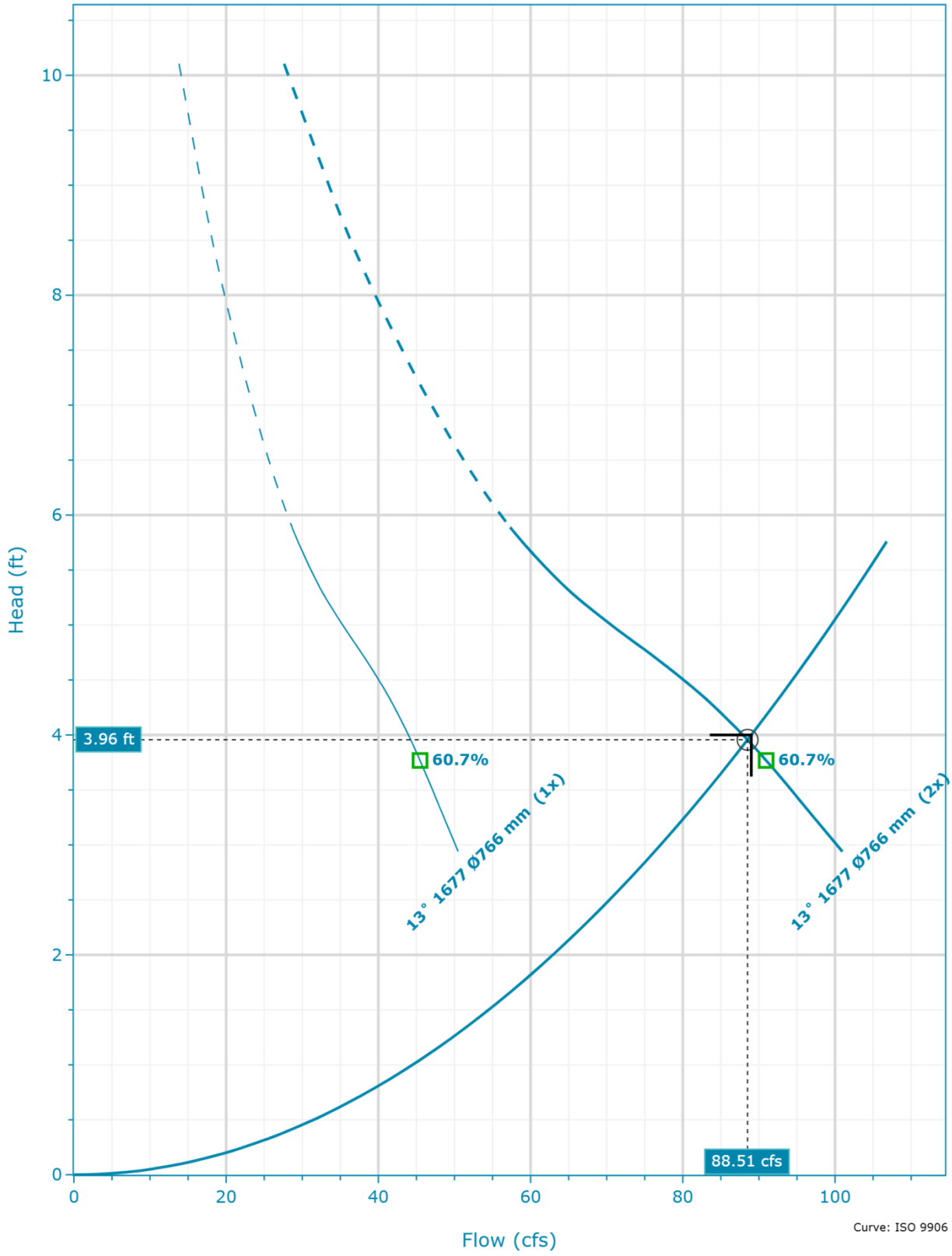
Design Curve - Single Pump

Rated Speed 60 Hz	BEP Flow (1x) 45.48 cfs
Max Flow (1x) 50.48 cfs	BEP Head (1x) 3.77 ft
H@QMin (1x) 10.1 ft	Max P2 (1x) 56.15 Hp
H@QMax (1x) 2.94 ft	
BEP (1x) 60.7 %	

Design Curve - System

Rated Speed 60 Hz	BEP Flow 90.95 cfs
Max Flow 100.96 cfs	BEP Head 3.77 ft
H@QMin 10.1 ft	Max P2 112.29 Hp
H@QMax 2.94 ft	Specific Energy 25 kWh/mGal
BEP 60.7 %	

PP 4680 3~ 1677 | Duty Analysis

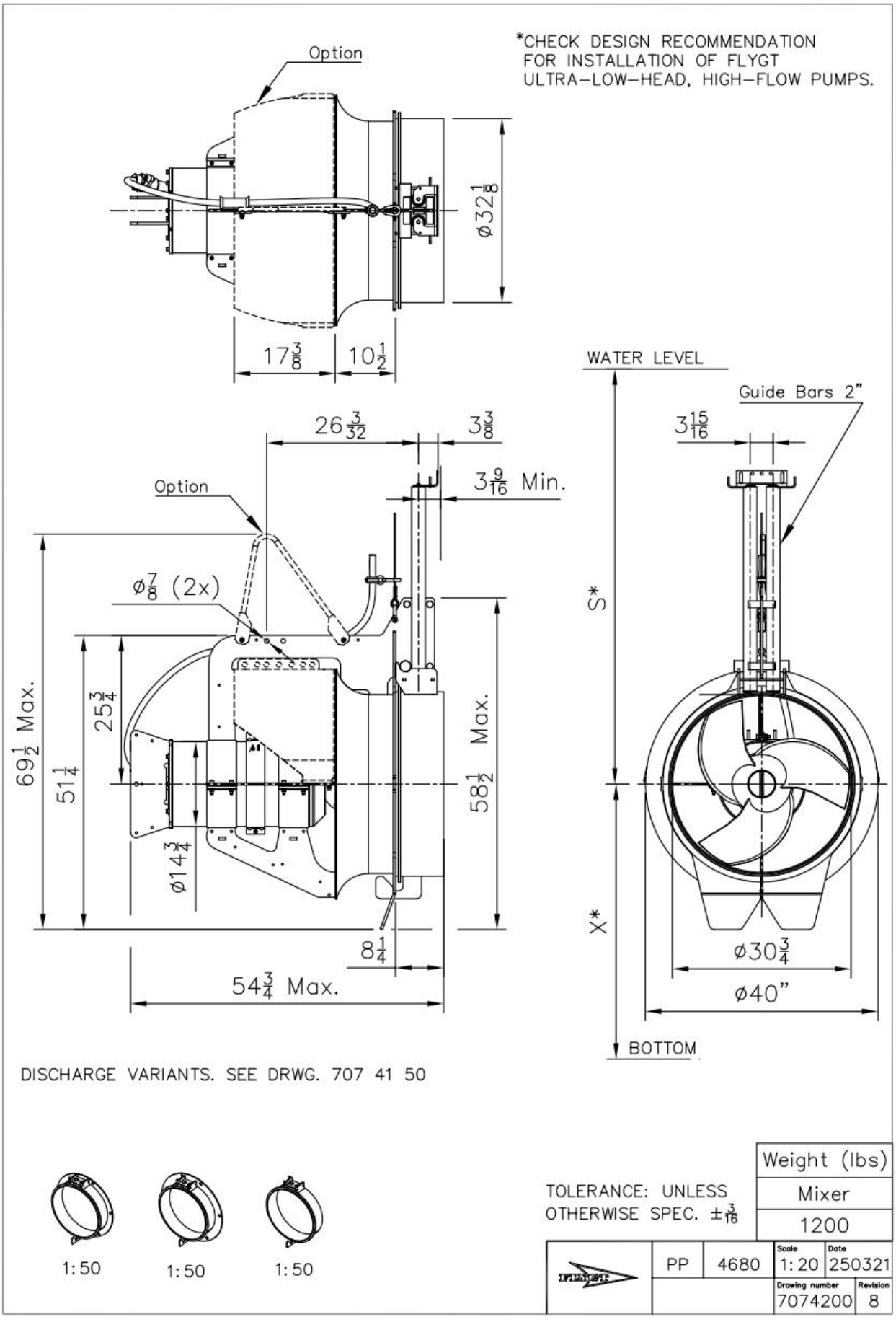


Nominal (mean) data shown. Under- and over-performance from this data should be expected due to standard manufacturing tolerances. Please consult your local Flygt representative for performance guarantees.

Name	Q (1x) [cfs]	H (1x) [ft]	P2 (1x) [Hp]	Q [cfs]	H [ft]	P2 [Hp]	ηp [%]	SE [kWh/mGal]	NPSHr [ft]
DP @ 1x	0	0	0	0	0	0	0	0	0
DP @ 2x	44.25	3.96	32.81	88.51	3.96	65.62	60.59	24.94	0

Project:	Created By:	Created On:	Last Update:
PP 4680 3~ 1677	James Teeter	5/5/25	-

PP 4680 3~ 1677 | Dimensional Data & Drawing



Company	Jacobs Engineering
Contact	James Teeter
Phone No.	7149433408
Email	James.teeter@jacobs.com

xylem
Let's Solve Water

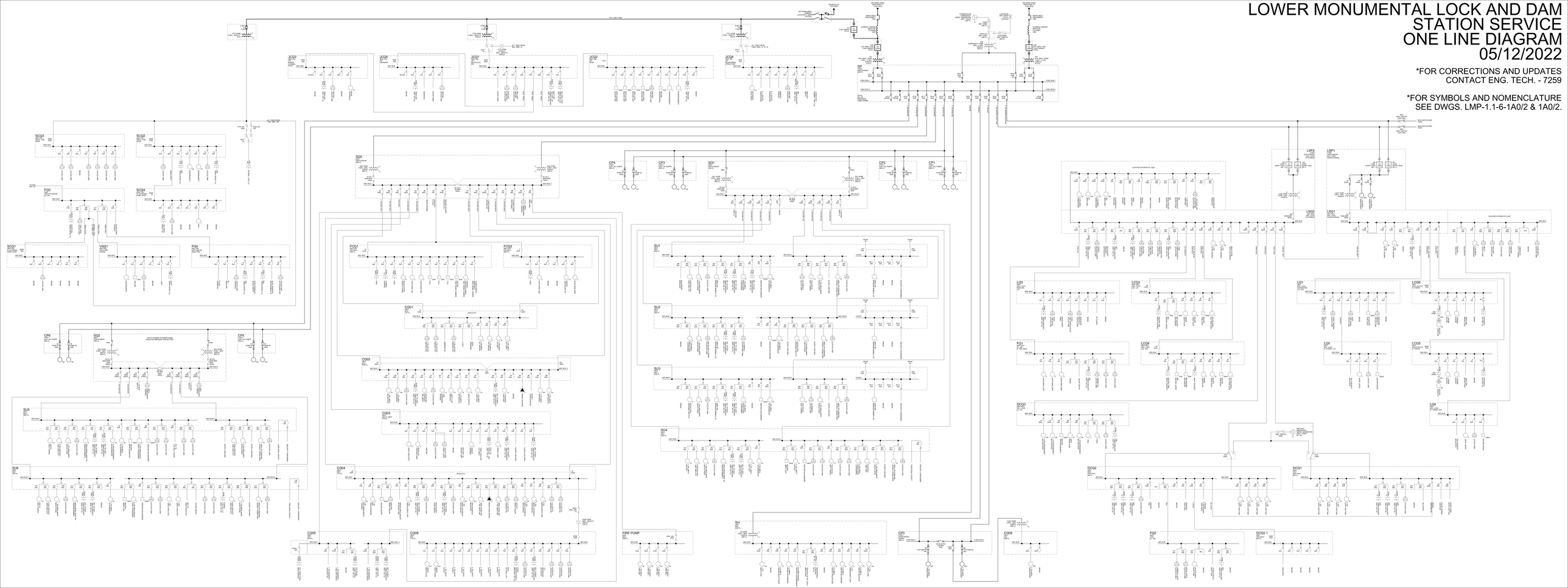
Appendix D4. Electrical References

LOWER MONUMENTAL NORTH FISH LADDER MASTER ONE-LINE DIAGRAM

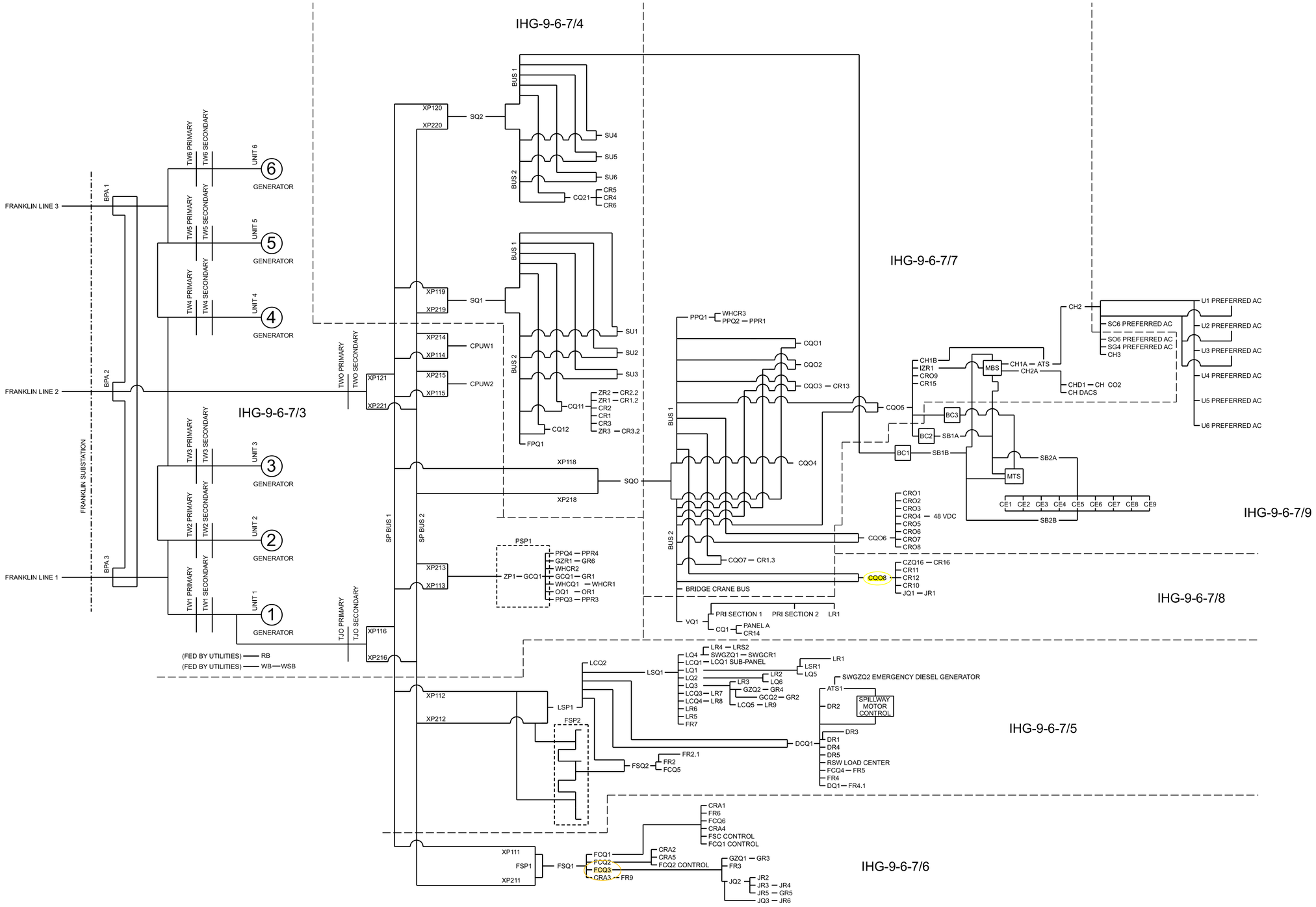
LOWER MONUMENTAL LOCK AND DAM
STATION SERVICE
ONE LINE DIAGRAM
05/12/2022

*FOR CORRECTIONS AND UPDATES
CONTACT ENG. TECH. - 7259

*FOR SYMBOLS AND NOMENCLATURE
SEE DWGS. LMP-1.1-6-1A0/2 & 1A0/2.



ICE HARBOR SOUTH FISH LADDER
MASTER ONE-LINE DIAGRAM



A1 DETAIL: STATION SERVICE ELECTRICAL ONE LINE DIAGRAM SHEET INDEX
NOT TO SCALE

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE

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DS:
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4:15:10 PM 11/16/2021

DESIGNED BY:	
DRAWN BY:	E.BROWN
CHECKED BY:	S.HUXOLL
SUBMITTED BY:	S.THOMPSON
SIZE	FILE NO:
ANSI D	IHG-9-6-14/6
ISSUE DATE:	
SOLICITATION NO.:	NOT APPLICABLE
CONTRACT NO.:	NOT APPLICABLE
WORK BY:	

U.S. ARMY CORPS OF ENGINEERS
WALLA WALLA DISTRICT
ICE HARBOR LOCK AND DAM
BURBANK WASHINGTON 99323

ICE HARBOR LOCK AND DAM
SNAKE RIVER, OREGON, WASHINGTON AND IDAHO
OPERATIONS AND MAINTENANCE

GENERAL - ELECTRICAL
STATION SERVICE ONE LINE DIAGRAM
SHEET INDEX

SHEET ID
E-601

O&M DRAWING

%PRODUCTION DATA 1%
%PRODUCTION DATA 4%
%PRODUCTION DATA 3%
%PRODUCTION DATA 2%

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE
A	AS-BUILT BY PROJECT PERSONNEL	NOV 2024

DESIGNED BY: S.HUXOLL
DRAWN BY: E.BROWN
CHECKED BY:
SUBMITTED BY: S.THOMPSON
FILE NAME: ANSI-D
ISSUE DATE:
SOLICITATION NO.: NOT APPLICABLE
CONTRACT NO.: NOT APPLICABLE
WORK BY%: %OPTIONAL VALUE 1%
PROJECT NO.: HP-0-6-7-6

U.S. ARMY CORPS OF ENGINEERS
WALLA WALLA DISTRICT
ICE HARBOR LOCK AND DAM
BURBANK WASHINGTON 99323

ICE HARBOR LOCK AND DAM
SNAKE RIVER, OREGON, WASHINGTON AND IDAHO
OPERATIONS AND MAINTENANCE

POWERHOUSE - ELECTRICAL
STATION SERVICE ONE LINE DIAGRAM
SHEET 6 OF 9

SHEET ID
E-606

O&M DRAWING

MCNARY SOUTH FISH LADDER
PARTIAL ONE-LINE DIAGRAM, SCHEDULES, AND PHOTOS

PANEL SCHEDULE: VR1			FEED 120/240VAC					ENCLOSURE NEMA TYPE 3R			
MAINS			100A 10,000 A.I.C.		●	1		MOUNT ON BACK PANEL			
MAIN BREAKER			LUGS ONLY			3W		LOCATION FQ3			
CKT NO	BREAKER POLES	BREAKER TRIP		CONN KVA	P H	CONN KVA		BREAKER TRIP	BREAKER POLES	CKT NO
1	1	20A	●● RADIO OUTLET	.18	A	1.5	●● CONTROL HOUSE LIGHTS	20A	1	2
3	1	20A	●● DECK LIGHTS – N	.75	B	.5	●● CONTROL HOUSE OUTLETS	20A	1	4
5	1	20A	●● DECK LIGHTS – N	.75	A	.5	●● DECK OUTLETS – SE	20A	1	6
7	1	20A	●● DECK LIGHTS – S	.75	B	.5	●● DECK OUTLETS – NE	20A	1	8
9	1	20A	●● DECK LIGHTS – S	.75	A		SPARE	20A	1	10
11	1	20A	PANEL HEATERS	1.6	B	.32	ENCLOSURE FAN	20A	1	12
13	2	20A	UNIT HEATER – 3KW	1.5	A	.18	FQ3 OUTLETS	20A	1	14
15	---	---	---	1.5	B	2.25	UPS OUTLET	20A	1	16
17	1	20A	CABINET LIGHTS	.03	A	.5	●● DECK OUTLETS – SW	20A	1	18
19	1	20A	CONTACTOR TIMECLOCK	.05	B	.5	●● DECK OUTLETS – SW	20A	1	20
21	1	20A	●● DECK LIGHTS – E	.5	A	.5	●● DECK OUTLETS – NW	20A	1	22
23	1	20A	●● DECK LIGHTS – E	.5	B	.5	●● DECK OUTLETS – NW	20A	1	24
CONNECTED KVA			PHASE A 6.89	PHASE B 9.72		TOTAL CONNECTED KVA 16.61		DEMAND KVA		
						TOTAL CONNECTED FLA		DEMAND FLA		
REMARKS:			●●CONTRACTOR SHALL RE – CONNECT EXISTING CONDUCTORS.							

PANEL SCHEDULE: CO1			FEED			480VAC		ENCLOSURE NEMA TYPE 3R		
MAINS			225A 14,000 A.I.C.		●	3		MOUNT ON BACK PANEL		
MAIN BREAKER			100A			4W		LOCATION FQ3		
CKT NO	BREAKER POLES	BREAKER TRIP		CONN KVA	P H	CONN KVA		BREAKER TRIP	BREAKER POLES	CKT NO
1	3	30A	EXIT WEIRS 334 THRU 340	2.61	A	.37	REG. GATE – 1.5HP	20A	3	2
3	---	---	---	2.61	B	.37	---	---	---	4
5	---	---	---	2.61	C	.37	---	---	---	6
7	3	60A	WASH WATER PUMP – 20HP	4.97	A	2.49	●● CHAPMAN VALVE	30A	3	8
9	---	---	---	4.97	B	2.49	---	---	---	10
11	---	---	---	4.97	C	2.49	---	---	---	12
13	2	50A	LIGHTING TRANSFORMER	12.5	A		SPARE	30A	3	14
15	---	---	---	12.5	B		---	---	---	16
17			SPACE		C		---	---	---	18
19	2	20A	● SOLENOID VALVE #1	.25	A	.25	● SOLENOID VALVE #2	20A	2	20
21	---	---	---	.25	B	.25	---	---	---	22
23			SPACE		C		SPACE			24
25	3	20A	SCREEN MOTOR #1 – 5HP	1.24	A	1.24	SCREEN MOTOR #2 – 5HP	20A	3	26
27	---	---	---	1.24	B	1.24	---	---	---	28
29	---	---	---	1.24	C	1.24	---	---	---	30
31	3	30A	UH-WATERING PUMP	7.20	A	15.00	●● GANTRY CRANE OUTLET			32
33	---	---	---	7.20	B	15.00	---			34
35	---	---	---	7.20	C	15.00	---			36
CONNECTED KVA			PHASE A 48.29	PHASE B 48.29	PHASE C 35.62	TOTAL CONNECTED KVA 132.20		DEMAND KVA		
						TOTAL CONNECTED FLA		DEMAND FLA		
REMARKS:			● SOLENOID VALVE NOT INSTALLED AT THIS TIME. ●●CONTRACTOR SHALL RE – CONNECT EXISTING CONDUCTORS.							

BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	MANUFACTURER	PART #	NOTES
1	1	4-SECTION ENCLOSURE	HOFFMAN	P-F22106 & 2266	
2	4	ENCLOSURE BACK PANEL	HOFFMAN	P-F2210 & 226	
3	2	PANEL HEATER	HOFFMAN	D-AH8001B	
4	1	FOLDING SHELF	HOFFMAN	A-CSHELF12	
5	2	PANEL LIGHTS	HOFFMAN	A-LF16D18	
6	1	PANEL FAN	HOFFMAN	T-FP61	
7	1	FAN THERMOSTAT	HOFFMAN	ATEMND	
8	1	EXHAUST GRILLE	HOFFMAN	A-VK66	
9	1	EXHAUST FILTER	HOFFMAN	A-FLT66	
10	2	PANEL RECEPTACLE	HUBBELL	CR53521G	
11	1	TOUCH SCREEN	CUTLER-HAMMER	1785T	
12	1	24VDC POWER SUPPLY	SOLA	SDN-5-24-100	
13	3	TRANSFORMER	SOLA	E500WB	
14	115	TERMINAL BLOCK	ALLEN-BRADLEY	1492-W4	
15	115	TERMINAL BLOCK MARKERS	ALLEN-BRADLEY	1492-SM6x12	
16	3	TERMINAL BLOCK END BARRIER	ALLEN-BRADLEY	1492-EB3	
17	6	TERMINAL BLOCK END ANCHORS	ALLEN-BRADLEY	1492-EA35	
18	3	TERMINAL BLOCK GROUP MARKER	ALLEN-BRADLEY	1492-GM35	
19	3	DIN RAIL	ALLEN-BRADLEY	199-DR1	
20	1	GROUND BAR	CH	GBK-14	
21	1	PHASE FAILURE RELAY	TIME-MARK	A257B	
21A	1	PHASE FAILURE RELAY 8-PIN BASE	TIME-MARK	51X120	
22	1	UPS	APC	SU3000NET	
23	2	ENVIRORANGER LEVEL TRANSMITTER	SIEMENS	ERS500	
24	1	ANNUNCIATOR PANEL	SERIES90	SDN102206042W1A4YYNNAN	
25	1	120/240V PANEL BOARD	SQUARE D	VR1	
26	1	480V 3● PANEL BOARD	SQUARE D	CO3	
27	LOT	PANDUIT	HOFFMAN	A300300WH	
28	LOT	PANDUIT	HOFFMAN	A200200WH	
29	1	UPS TRAY	SMK	1714AL	
30	1	PLC	SOFTPLC	6P5161K-A	
31	1	MEDIA CONVERTER	N-TRON	202MC	
32	1	ETHERNET SWITCH	N-TRON	405TX	
33	1	PLC POWER SUPPLY	MTL	PS-170	
34	1	POWER SUPPLY ADAPTER	MTL	PSC-24	
35	2	DISCRETE OUTPUT BASE	MTL	TEF09-5AM	
36	1	DISCRETE OUTPUT MODULE	MTL	DO125D-16	
37	1	DISCRETE OUTPUT MODULE	MTL	DO230A-16	
38	1	DISCRETE INPUT BASE	MTL	TE01-M	
39	1	DISCRETE INPUT MODULE	MTL	DI24D-32	
40	1	ANALOG INPUT BASE	MTL	TE08-M	
41	1	ANALOG INPUT MODULE	MTL	AIH-16	
42	1	TERMINATING RESISTOR	MTL	RS-50-2	
43	6	FUSE	SHAWMUT	ATQR2	
44	3	FUSE	SHAWMUT	ATQR5	
45	6	FUSE	SHAWMUT	ATQR20	
46	3	FUSE	SHAWMUT	ATQR60	
47	3	OVERLOAD AUX CONTACTS	SQUARE D	9999-ACO4	
48	1	UPS RECEPTACLE	BRYANT	T0530-FR	

BILL OF MATERIAL (CONT.)

ITEM	QTY	DESCRIPTION	MANUFACTURER	PART #	NOTES
49	2	FUSED DISCONNECT	SQUARE D	9421-NC2	
50	1	FUSED DISCONNECT	SQUARE D	9421-ND3	
51	2	FULL VOLTAGE NON-REVERSING STARTER	SQUARE D	8536-SC08H10S	
52	1	FULL VOLTAGE NON-REVERSING STARTER	SQUARE D	8536-SD01H10S	
53	3	PILOT LIGHT	SQUARE D	9001-KP1G31	
54	3	PILOT LIGHT	SQUARE D	9001-KP1R31	
55	4	3-POSITION SWITCH	SQUARE D	9001-KS43BH2	
56	6	AUX CONTACTS	SQUARE D	9999-SX8	
57	3	ENCLOSURE RESET PUSH BUTTONS	SQUARE D	9066RA1	
58	6	24 HOUR ELECTRONIC TIMECLOCK	TORK	ET100C	
59	3	8-POLE LIGHTING CONTACTOR	SIEMENS	CLM82031	
60	1	DPDT 8-PIN RELAY (PFR FQ3 AUX)	OMRON	MK2P-S	
60A	1	8-PIN RELAY BASE	DAYTON	5X852M	
61	1	125V 20A RECEPTACLE (RED)	BRYANT	5361-RED	
62	2	POWER RELAY (SV1 X & SV2 X)	SQUARE D	C016V20	
63	2	DIN RAIL MOUNTED 5A CIRCUIT BREAKER	SQUARE D	9080-GCB-50	
64	1	25KVA LIGHTING TRANSFORMER	SOLA	SSH25S	
65					

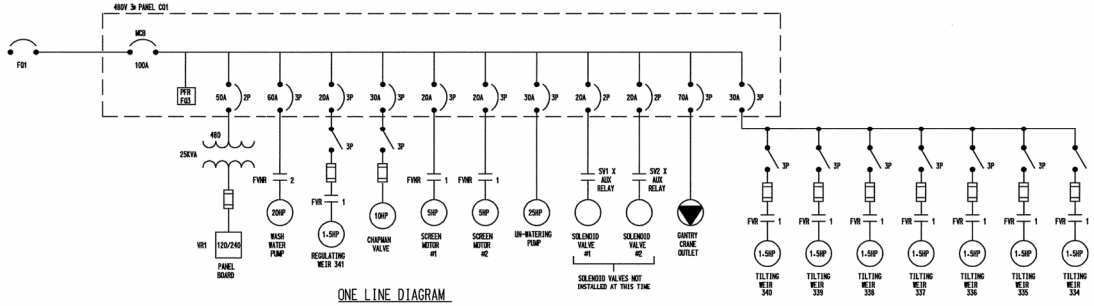
LEGEND

---------- FIELD WIRING

PANEL WIRING NUMBER

XX PANEL WIRING

[XX] WIRING TERMINAL



ONE LINE DIAGRAM

REV	DESCRIPTION	DATE	BY
0	REVISED PER RFP-0001, RFP-0002, RFI No. 0002, RFI No. G-0006, AND COE REVIEW COMMENTS	1/25/03	RBC
1	REVISED PER COE REVIEW COMMENTS "APPROVED AS NOTED"	2/21/03	RBC
2	FINAL AS-BUILT	3/1/04	MCR

TITLE:
OREGON FQ3
INSTRUMENTATION AND POWER PANEL

PROJECT: FISH LADDER EXIT MODIFICATIONS
McNARY PROJECT
CONTRACT NO. DACW68-03-C-0002

SHEET 4 OF 7
SCALE: NONE

DRAWN BY	CHECKED BY	APPROVED BY	DATE	REV
RAJ			12-03-2002	2

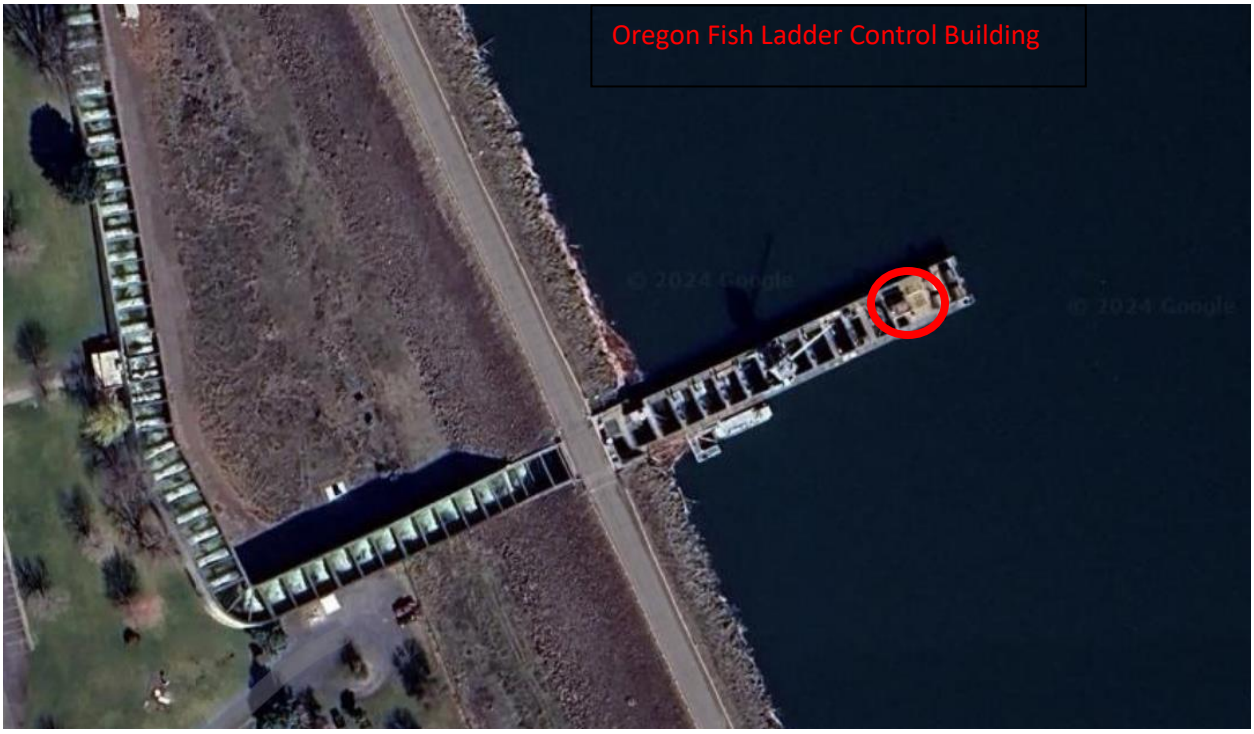
POWER CITY ELECTRIC

DWG SIZE: D

DRAWING NO.: ORIPPFQ3-4
3-0326

...\ORIPPFQ3\ 4 OF 7 FQ3E FINAL.dgn 16-JUL-2004 08:07:42

PHONE INSIDE
EXT: 264


Oregon Fish Ladder Control Building

JOHN DAY SOUTH FISH LADDER
MASTER ONE-LINE DIAGRAM

JOHN DAY LOCK & DAM

ONE LINE DIAGRAM

COLOR CODE	
COLOR	VOLTAGE
BROWN	500 KV
ORANGE	13.8 KV
GREEN	4160 V
DARK BLUE	480 V
LIGHT BLUE	120/240 V
BLACK	125/250 VDC

TERMINAL EQUIPMENT	
DSG	480V SWITCHGEAR (NON-OVERFLOW DAM/SPILLWAY)
FSC	FISHWAY SWITCHBOARD
FSP	4160V FISHWAY SWITCHGEAR
FTG	480V FISHWAY SWITCHGEAR
S	GENERATOR SWITCHBOARD
SW	4160V SWITCHGEAR
SP	4160V SWITCHGEAR
SQ	480V SWITCHGEAR
SU	MAIN UNIT SWITCHGEAR

LOAD CENTERS	
SP	4160V MCC
SQ	480V MCC OR PANEL
SR	120/240V OR 120/208V PANEL
SQS	480V MCC (NON-OVERFLOW DAM / SPILLWAY)
SQ	480V (NON-OVERFLOW DAM / SPILLWAY)
TC	480V MCC (POWERHOUSE ROOM)
TCS	480V MCC (FISHWAY)
TS	480V PANEL (FISHWAY)
TR	120/240/3Ø 120/208 PANEL (FISHWAY)
LCQ	480V MCC (NAVIGATION LOCK)
LQ	480V PANEL (NAVIGATION LOCK)
LR	120/240/3Ø 120/208 PANEL (NAVIGATION LOCK)
PCQ	480V MCC (DOMESTIC WATER)
PQ	480V PANEL (DOMESTIC WATER)
PR	120/240/3Ø 120/208 PANEL (DOMESTIC WATER)
SBQ	480V SWITCHGEAR (SERVICE BUILDING)

MODIFYING TERMS	
HC	HEAD COVER
K	115.5KV
O	STATION SERVICE
P	4160V
Q	480V
R	120/240V OR 120/208V
SCQ	SYNCHRONOUS CONDENSER
STS	SUBMERGED TRAVELING SCREEN
W	500KV

APPARATUS	
ETC	13.8kV ELBOW TERMINAL CABINET
FTC	4160V ELBOW TERMINAL CABINET
T	TRANSFORMER
X	BREAKER
Y	DISCONNECTING SWITCH

JOHN DAY SUBSTATION

BIG EDDY · MARION · GRIZZLY 1 · GRIZZLY 2

500 KV WEST BUS #2 · 500 KV EAST BUS #1

CP-SCO

J.D. SUB S.S.

SB01

FC05

C002

C003

C003.1

C005

C001

C004

C007.1 · C007.2

C009

C012

EV01 · EV02

C008

C011

DO1

PC03

FO3

DO2

FC04

C006

COSTS

FSP1 · FSQ1 · FSQ2

LC01 · LC02

LO1 · LO2 · LO3 · LO4 · LO5 · LO6

DSQ1 · DSQ2 · DC01 · DC02 · DC03 · DC04 · DC05

FO1 · FO2 · FO4 · FO5 · FO6

PC01 · PC02 · PC04

CPO1 · SU1 · SQ1 · SQ2 · C0HC

FC01 · FC02 · FC03

SH1

SO01 · SO02

T1 · T2 · T3 · T4 · TO1 · TO2 · TO3

XJ01 · XJ02 · XJ03 · XJ04 · XJ05 · XJ06

CP0 · CPQ1 · CPQ2 · CPQ3 · CPQ4

JTC1 · JTC2 · JTC3 · JTC4

SO1 · SO2 · SO3 · SO4

PTC-1 · PTC-2 · PTC-3

XP01 · XP02 · XP03 · XP04 · XP05 · XP06 · XP07 · XP08 · XP09 · XP10 · XP11 · XP12 · XP13 · XP14 · XP15 · XP16 · XP17 · XP18 · XP19 · XP20 · XP21 · XP22 · XP23 · XP24 · XP25 · XP26 · XP27 · XP28 · XP29 · XP30 · XP31 · XP32 · XP33 · XP50

DC01 · DC02 · DC03 · DC04

EMERGENCY DIESEL 350KW

EFV INTAKE DOCK
NAVLOCK EL. 172.5
FISHWAY CONTROL ROOM
EMERGENCY TIE
NORTH SHORE EMERGENCY BACKUP POWER FROM KLICKITAT PUD
KLICKITAT PUD 12.470 VOLTS
HOLD RECLOSER
OIL FIXED OUTAGE
TRANSFORMER TO NO NUMBERS
DOMESTIC WATER PUMP HOUSE #1
DOMESTIC WATER PUMP HOUSE #2
DOMESTIC WATER PUMP #3
CHLORINE BOOSTER PUMP
ROOM 478
480V RECEPTS
SPARE
LIGHTS
RECEPTS
SPILL BAY 18 EL. 277
SPILL BAY 19 EL. 273
SPILL BAY 8 EL. 273
SPILLWAY TAINTER GATES 15 WF BAYS 19-10
SPILLWAY TAINTER GATES 15 WF BAYS 11-15
SPILLWAY TAINTER GATES 15 WF BAYS 9-10
SPILLWAY TAINTER GATES 15 WF BAYS 1-8
GOVERNOR OIL PUMPS (125 HP)
UNIT 1 · UNIT 2 · UNIT 3
TO SUS-1,4-15,16 T-4 FANS & T1 - 20 HIGH BAY LTG
TO SUS-13,17,12 T-3 FANS
TO SUS-8,9,7,6 T-2 FANS & CONC LIGHTS
TO SUS-2,3,5,10 T1 FANS & CONC LIGHTS
SUS-1 THRU SUS-18 AND THE 125 VDC BATTERY CHARGER

Appendix E. Construction Cost Estimate

360 COST CONSULTING

BASIS OF COST ESTIMATE

ADULT FISHWAY COOLING CONCEPT EVALUATION

USACE Walla Walla & Portland Districts

ALTERNATIVE ANALYSIS REPORT COST ESTIMATE

Package Date: September 2, 2025

SUBMITTED TO:

Jacobs

1100 112th Avenue NE #500
Bellevue, WA 98004

360 Cost Consulting
7509 NE 173rd Place
Vancouver, WA 98682

360costconsulting.com
Office: (360) 984-3348
SBA Certs: SBE, WOSB, DBE

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PROJECT DESCRIPTION

- This study supports efforts to improve adult upstream fish passage at four dams located on the Lower Snake and Columbia Rivers, and is focused on identifying and evaluating methods to reduce delays in fish migration due to seasonal temperature differentials within the fishways. The Walla Walla District of the U.S. Army Corps of Engineers (USACE) operates the Lower Monumental, Ice Harbor and McNary Dams. The Portland District USACE operates the John Day Dam. This study identifies and evaluates alternatives for reducing the seasonal temperature differentials. Alternatives are evaluated on the basis of anticipated thermal performance; fish behavior; operational feasibility and reliability; impacts/risks to project operations; and cost. Two alternatives are selected for further evaluation at each project site and recommendations for implementation are provided.

BASIC REQUIREMENTS

- The Standard Work Breakdown Structure (WBS) must be used inside of the MCACES MII estimating software, incorporating cost line items from the latest version of the RSMeans Cost Book.

- User-created items that have an extended direct cost greater than or equal to $10,000 or 5% of the total direct cost should be supported by a detailed vendor quotation.

- The detail for each cost estimate must be commensurate with the level of project development required for the corresponding submittal. Contact the USACE DM/PM prior to submission to confirm the project's authorized construction cost

360 COST CONSULTING

ESTIMATE SUMMARY SHEET

ALTERNATIVE ANALYSIS REPORT COST ESTIMATE

LOWER MONUMENTAL (LMN) - MODIFIED SPRAY BAR	5,907,587
STRUCTURAL	1,178,006
MECHANICAL	3,816,518
ELECTRICAL	913,064
LOWER MONUMENTAL (LMN) - PUMPED FISH EXIT	4,007,932
STRUCTURAL	1,586,203
MECHANICAL	2,100,914
ELECTRICAL	320,815
ICE HARBOR (HLD) - BUBBLER	359,915
STRUCTURAL	22,028
MECHANICAL	230,394
ELECTRICAL	107,493
ICE HARBOR (HLD) - PUMPED FISH EXIT	3,825,741
STRUCTURAL	1,105,031
MECHANICAL	2,399,896
ELECTRICAL	320,815
MCNARY (MNA) - AIR LIFT PUMP	3,861,271
STRUCTURAL	2,254,664
MECHANICAL	1,002,942
ELECTRICAL	603,664
MCNARY (MNA) - GRAVITY CHIMNEY	4,598,859
STRUCTURAL	3,804,952
MECHANICAL	660,998
ELECTRICAL	132,908
JOHN DAY (JDA) - AIR LIFT PUMP	3,735,013
STRUCTURAL	2,128,406
MECHANICAL	1,002,942
ELECTRICAL	603,664
JOHN DAY (JDA) - SUBMERGED JET	2,193,100
STRUCTURAL	292,868
MECHANICAL	1,395,680
ELECTRICAL	504,552

SCOPE BASIS OF ESTIMATE

- 360 Cost Consulting is tasked to provide cost engineering services for the Alternative Analysis Report phase of the Adult Fishway Cooling Concept Evaluation at dams serviced by the USACE Walla Walla & Portland Districts. Services for this deliverable include the following:
  - Basis of Cost Estimate including Estimate Summary Sheet, Scope Basis, Cost Basis, Cost Book Adjustment Process, & Assumptions, Exclusions, and Allowances.
  - Alternative Analysis Report cost estimate in MCACES MII format; detailed MCACES MII report follows the Basis of Cost Estimate

- The following documents were used to determine the scope of work for this project:
  - USACE Fishways Cooling - Alternative Analysis Report, 8/29/2025, Jacobs
  - USACE Plates Full Set, 8/29/2025, Jacobs

- Included in the Cost Basis detail are the following:
  - Material markups based on industry conditions at the time of the estimate
  - Bidder market, detailing the minimum bidders expected to achieve cost estimate value
  - Prime Contractor markups and scope of work completed
  - Sub-Contractor markups and scope of work completed
  - Design Contingencies, Bonds, and Taxes
  - MCACES MII software will be used to organize and compile cost estimate detail. The most updated cost book will be used inside the MCACES MII program.
  - BlueBeam software is used to measure quantities; a copy of the takeoffs is available upon request.

- The estimate included in this package should be deemed a Class 4 cost estimate

Class	Project Definition	End Usage	Methodology	Accuracy Range
1	50% to 100%	Bid or Backcheck	Detailed Takeoff & Costs	-10% to +15%
2	30% to 70%	Control or Pre-Bid	Detailed Takeoff & Costs	-15% to +20%
3	10% to 40%	Budget Authorization	Assembly T/O & Semi-Detailed Costs	-20% to +30%
4	1% to 15%	Feasibility Study	Parametric Model	-30% to +50%
5	0% to 2%	Conceptual Study	Judgement or Factors	-50% to +100%

COST ESTIMATE MARKUPS

- **MATERIAL MARKUPS** are applied to specific items that have had a volatile market over the past two years. Certain items have crested but they are still elevated beyond a straight markup from the 2024 cost book data. These markups are strictly applied to materials only, not labor or equipment.

Structural Steel / Sheet Metal	12.50%
Concrete / Rebar	5.00%

- **PRIME & SUBCONTRACTOR MARKUPS** are applied to the direct costs based on contractor assignments**.**

	PRIME	SUB	SUB (MPE/DIVER)
Job Office Overhead (JOOH)	25.00%	15.00%	15.00%
Home Office Overhead (HOOH)	3.25%	7.50%	7.50%
Profit (Prime Calculated in Program)	8.93%	12.00%	15.00%
Bond	1.50%	------	------
Competition Premium	10.00%	10.00%	10.00%

- **CONTRACT MARKUPS** are applied following the contractor markups to alter the cost book figures to pricing applicable at the midpoint of construction; per NAVFAC direction these markups are for escalation from the cost book date for material and equipment pricing, escalation from the source date for labor, productivity adjustments, design contingency, and area cost factor

Productivity (Increases Labor Costs by 33.33%)	75.00%
Sales Tax (www.sale-tax.com/WallaWallaWA)	8.90%
Material / Subs Escalation	4.24% *
Equipment Escalation	1.47% *
Design Contingency	35.00%
Area Cost Factor	4.50%

*Per Cost Index (8/1/2025)

- **OWNER MARKUPS** are applied to the contract costs following contract markups**.**

Market Escalation (to Midpoint of Construction)	16.19% *

*Per Cost Index (8/1/2025)

COST BOOK ADJUSTMENTS

- **LABOR RATES** are adjusted using up-to-date Federal Davis-Bacon Act for the county in which the project is located. Where required additional travel and per-diem expenses will be added to individual trade labor rates.
    - Walla Walla County Washington Region Davis-Bacon Act Rates August 2025

- **COST BOOK ITEM ADJUSTMENTS & USER CREATED LINE ITEMS** need to be modified in many occasions due to inability to locate the exact description in the RSMeans Cost Book. The line item adjustments are based off the following backup:

    - **ARCHITECTURAL/STRUCTURAL/SITEWORK:** Unit rates for major materials such as concrete, rebar, steel, drywall, studs/framing, flooring and ceilings are updated at regular intervals. Production rates are modified based on analysis of the project difficulty as based on project documents and meeting information.

    - **MECHANICAL / PLUMBING**: Costs are determined using a proprietary, historical cost database created using industry verified material and labor pricing along with verification using RS Means. Periodically, and as needed for larger mechanical equipment, these prices are updated through contact with local mechanical vendors in current project areas. Labor rates are updated based on current Federal Davis-Bacon determinations along with local Unions in large metropolitan areas.

    - **ELECTRICAL / COMMUNICATIONS / LIFE SAFETY:** Costs are determined using a proprietary, historical cost database created using industry verified material and labor pricing along with verification using RS Means. Periodically, and as needed for larger switchgear / standby generator items, these prices are updated through contact with local electrical vendors in current project areas. Labor rates are updated based on current Federal Davis-Bacon determinations along with local IBEW Unions in large metropolitan areas.

EXCLUSIONS

- The following items are excluded from the cost estimate but my be included in the overall project cost using other funding sources:
    - Furniture, Fixtures, and Equipment (FF&E)
    - Equipment by Other Appropriations

- Other Exclusions not part of the Project Estimate Scope:
    - Architectural / Engineering fees
    - Construction Management fees
    - Land and easement acquisition
    - Permits and fees
    - Testing and inspection
    - Cost associated with a phased construction schedule
    - Accelerated construction schedule
    - Night or weekend hours

- Certain costs may be included in the overall project costs but are excluded from the construction costs in the MII cost estimate for this submittal:
    - Cybersecurity Features
    - Antiterrorism
    - Special Costs
        - Post Construction Award Services (PCAS)
        - Post Award Design Services (PADS)
        - Third Party Commissioning
        - Cybersecurity Commissioning
        - Geospatial Surveys and Mapping
        - Temporary Batch Plant
    - Operations and Maintenance Support Information (OMSI)
    - Owner Contingency
    - Supervision, Inspection, and Overhead (SIOH)
    - Design-Build Fee

Adult Fish Ladder Cooling Concept Evaluation

DIRECT ESCALATION

NAVFAC BUILDING COST (BCI) 2025Q2

AREA COST FACTOR MAY 2025 1.045 (Hybrid of Spokane 1.04 & Yakima 1.05)

MATERIAL / SUBS ESCALATION

BCI INDEX JANUARY 2024: 7905

BCI INDEX APRIL 2025: 8240

= 8240 / 7905

= 1.0424

= 4.24%

EQUIPMENT ESCALATION

BCI INDEX SEPTEMBER 2024: 8121

BCI INDEX APRIL 2025: 8240

= 8240 / 8121

= 1.0147

= 1.47%

Estimated by 360 Cost Consulting

Designed by Jacobs

Prepared by Russ Prentice / Randy Kirchner / Eric Higgins

Preparation Date 9/2/2025

Effective Date of Pricing 4/15/2028

Estimated Construction Time 365 Days

MARKET ESCALATION

BCI INDEX APRIL 2025: 8240

BCI INDEX JANUARY 2028: 9574

= 9574 / 8240

= 1.1619

= 16.19%

CONTRACT AWARD: MAY 2027

CONTRACT DURATION: 548 DAYS (18 MONTHS)

CONSTRUCTION START: OCTOBER 2027

CONSTRUCTION DURATION: 365 DAYS (12 MONTHS)

MIDPOINT: JANUARY 2028

IN-WATER WORKING PERIOD: JANUARY THRU MARCH 2028

CONSTRUCTION FINISH: OCTOBER 2028

PROJECT COMPLETION: NOVEMBER 2028

Estimated by	360 Cost Consulting
Designed by	Jacobs
Prepared by	Russ Prentice / Randy Kirchner / Eric Higgins

Preparation Date	9/2/2025
Effective Date of Pricing	4/15/2028
Estimated Construction Time	365 Days

Adult Fish Ladder Cooling Concept Evaluation 1

1 LOWER MONUMENTAL (LMN) - MODIFIED SPRAY BAR 1

STRUCTURAL 1

Barge & Crane 1

Boom & Skirt 1

Gravity Chimney 1

Steel Bracket 2

Diver Crew 2

MECHANICAL 2

ELECTRICAL 3

2 LOWER MONUMENTAL (LMN) - PUMPED FISH EXIT 4

STRUCTURAL 4

Wet Well & Fish Exit 4

Intake Bell & Trashrack 4

Diver Crew 5

Rip Rap 5

Barge & Crane 5

MECHANICAL 5

ELECTRICAL 6

3 ICE HARBOR (HLD) - BUBBLER 7

STRUCTURAL 7

Hoist 7

MECHANICAL 7

ELECTRICAL 7

4 ICE HARBOR (HLD) - PUMPED FISH EXIT 8

STRUCTURAL 8

Wet Well & Fish Exit 8

Intake Bell & Trashrack 8

Diver Crew 9

MECHANICAL 9

ELECTRICAL 9

5 MCNARY (MNA) - AIR LIFT PUMP 10

STRUCTURAL 10

Barge & Crane 10

Air Lift Pipe & Frame 10
Piles (3 EA) 11
Diver Crew 11
MECHANICAL 11
ELECTRICAL 12
6 MCNARY (MNA) - GRAVITY CHIMNEY 13
STRUCTURAL 13
Barge & Crane 13
Piles (3 EA) 13
Gravity Chimney 13
Diver Crew 14
MECHANICAL 14
ELECTRICAL 14
7 JOHN DAY (JDA) - AIR LIFT PUMP 15
STRUCTURAL 15
Barge & Crane 15
Air Lift Pipe & Frame 15

Piles (3 EA) 15

Diver Crew 16

MECHANICAL 16

ELECTRICAL 16

8 JOHN DAY (JDA) - SUBMERGED JET 17

STRUCTURAL 17

Barge & Crane 17

Guide Rails 17

Hoists 18

Retreivable Support Frame 18

Platforms 18

Diver Crew 18

MECHANICAL 19

ELECTRICAL 19

Hoist Power 20

Description	Quantity	UOM	DirectCost	SubCMU	PrimeCMU	OwnerMarkup	ProjectCost
Adult Fish Ladder Cooling Concept Evaluation			**10,667,095.14**	**5,390,683.25**	**8,461,902.92**	**3,969,736.40**	**28,489,417.71**
1 LOWER MONUMENTAL (LMN) - MODIFIED SPRAY BAR	**1.00**	**LS**	**2,199,098.00**	**1,130,654.96**	**1,754,666.53**	**823,167.52**	**5,907,587.01**
			447,239.11				*1,178,005.58*
STRUCTURAL	**1.00**	**EA**	**447,239.11**	**216,732.07**	**349,890.23**	**164,144.16**	**1,178,005.58**
			20,268.11				*53,385.19*
Barge & Crane	**1.00**	**EA**	**20,268.11**	**9,821.93**	**15,856.42**	**7,438.73**	**53,385.19**
			17.87			*16.19*	*47.06*
EP M10XX005 Flat deck cargo barge	80.00	HR	1,429.40	692.69	1,118.27	524.61	3,764.98
			270.31			*16.19*	*711.98*
RSM 015436501700 Mobilization or demobilization, crane, truck-mounted, up to 75 ton, (driver only)	2.00	EA	540.62	261.98	422.94	198.42	1,423.96
			1,485.00			*16.19*	*3,911.42*
USR CRANE001 Crane, 12 ton, rental per day	5.00	DAY	7,425.00	3,598.16	5,808.83	2,725.10	19,557.08
			2,174.62			*16.19*	*5,727.83*
RSM 015419500100 Crane crew, daily use for small jobs, 12-ton truck-mounted hydraulic crane, portal to portal	5.00	DAY	10,873.09	5,269.10	8,506.38	3,990.60	28,639.17
			51,953.12				*136,841.93*
Boom & Skirt	**1.00**	**EA**	**51,953.12**	**25,176.48**	**40,644.67**	**19,067.65**	**136,841.93**
			369.93			*16.19*	*974.39*
RSM 221113780146 Pipe, plastic, high density polyethylene (HDPE), single wall, straight, welded, based on 10' length, 24" diam., DR 11, add 1 weld per joint	70.00	LF	25,895.38	12,548.90	20,258.83	9,504.04	68,207.15
			1,841.66			*16.19*	*4,850.85*
RSM 221113780596 Elbow, 30 Deg., plastic, high density polyethylene (HDPE), single wall, welded, 24" diam., DR 11, add 1 weld per joint	6.00	EA	11,049.98	5,354.82	8,644.77	4,055.53	29,105.09
			304.86			*16.19*	*802.98*
RSM 221113784160 Welding, plastic, high density polyethylene (HDPE), single wall, labor per joint, cost based on the thickest wall for each diameter, 24" pipe size, weld, excludes welding machine	12.00	EA	3,658.30	1,772.81	2,862.01	1,342.66	9,635.79
			84.15			*16.19*	*221.66*
RSM 051223400720 Steel weight bar, 4" diameter	70.00	LF	5,890.78	2,854.67	4,608.55	2,162.01	15,516.01
			31.44			*16.19*	*82.81*
RSM 050521901500 Welding structural steel in field, single pass, 0.3 lb/LF, 1/4" thick, continuous fillet, down welding, type 6011 (Note: Allowance for additional field welding)	70.00	LF	2,200.89	1,066.55	1,721.83	807.76	5,797.04
			11.08			*16.19*	*29.17*
RSM 097730100090 Fiberglass reinforced plastic panel, on masonry, nylon rivet mounted, smooth surface, .090" thick	280.00	SF	3,101.42	1,502.95	2,426.34	1,138.27	8,168.98
			78.18			*16.19*	*205.93*
RSM 031519100100 Anchor bolt, J-type, 2-bolt set, plain steel, 1/2" dia x 6" L, incl nut & washer, job-built 2-hole template	2.00	SET	156.36	75.77	122.33	57.39	411.86
			313,534.01				*825,833.00*
Gravity Chimney	**1.00**	**EA**	**313,534.01**	**151,938.58**	**245,288.22**	**115,072.18**	**825,833.00**
			715.20			*16.19*	*1,883.81*
RSM 051223174500 Structural tubing, square, 4" x 4" x 1/4" x 12'-0", incl shop primer (Note: Frame for Gravity Chimney)	16.00	EA	11,443.26	5,545.40	8,952.45	4,199.87	30,140.98

Description	Quantity	UOM	DirectCost	SubCMU	PrimeCMU	OwnerMarkup	ProjectCost
			31.49			*16.19*	*82.95*
RSM 050521901500 Welding structural steel in field, single pass, 0.3 lb/LF, 1/4" thick, continuous fillet, down welding, type 6011 (Note: Allowance for field welding and cutting)	400.00	LF	12,596.87	6,104.44	9,854.95	4,623.26	33,179.52
			132.26			*16.19*	*348.36*
RSM 051223652240 Steel plate, 1" T, warehouse price, no shop fabrication, welded in field	2,150.00	SF	284,354.68	137,798.28	222,460.25	104,362.88	748,976.09
			98.76			*16.19*	*260.13*
RSM 031519100140 Anchor bolt, J-type, 2-bolt set, plain steel, 3/4" dia x 12" L, incl nut & washer, job-built 2-hole template	6.00	SET	592.57	287.16	463.58	217.48	1,560.79
			42.10			*16.19*	*110.89*
HNC 055313130007 Floor grating, steel, 1" x 1/8" bearing bars @ 15/16" O.C., cross bars @ 4" O.C., up to 300 S.F., field fabricated from panels	108.00	SF	4,546.64	2,203.30	3,556.99	1,668.69	11,975.61
			13,855.51				*36,494.73*
Steel Bracket	**1.00**	**EA**	**13,855.51**	**6,714.38**	**10,839.63**	**5,085.20**	**36,494.73**
			119.19			*16.19*	*313.94*
RSM 051223652220 Steel plate, 1/2" T, warehouse price, shop fabrication, welded in place (Note: Two 6' x 5' brackets, two 4' x 5' brackets)	100.00	SF	11,918.84	5,775.87	9,324.51	4,374.41	31,393.64
			31.19			*16.19*	*82.15*
RSM 050521901500 Welding structural steel in field, single pass, 0.3 lb/LF, 1/2" thick, continuous fillet, down welding, type 6011 (Note: Allowance for field welding and cutting)	50.00	LF	1,559.35	755.66	1,219.94	572.31	4,107.26
			94.33			*16.19*	*248.46*
RSM 031519100140 Anchor bolt, J-type, 2-bolt set, plain steel, 3/4" dia x 12" L, incl nut & washer, job-built 2-hole template	4.00	SET	377.32	182.85	295.19	138.48	993.83
			47,628.36				*125,450.74*
Diver Crew	**1.00**	**EA**	**47,628.36**	**23,080.70**	**37,261.27**	**17,480.40**	**125,450.74**
			289.05			*16.19*	*761.35*
USR DIVER Diver	80.00	HR	23,124.35	11,206.06	18,090.96	8,487.02	60,908.40
			161.77			*16.19*	*426.10*
USR DIVERTENDER Diver Tender	80.00	HR	12,941.83	6,271.61	10,124.83	4,749.87	34,088.14
			289.05			*16.19*	*761.35*
USR DIVER Diver Supervisor	40.00	HR	11,562.18	5,603.03	9,045.48	4,243.51	30,454.20
			1,413,655.93				*3,816,517.92*
MECHANICAL	**1.00**	**EA**	**1,413,655.93**	**737,486.63**	**1,133,578.95**	**531,796.41**	**3,816,517.92**
			354,148.39			*16.19*	*956,112.18*
HTW 221123112909 Bearing-frame pump, end-suction, 73.06 hp, 24" discharge, w/ controls (Note: per engineer's estimate plus $1500 /EA freight)	3.00	EA	1,062,445.16	554,264.36	851,950.91	399,676.12	2,868,336.55
			1,634.43			*16.19*	*4,412.55*
RSM 331413401140 Water supply distribution piping, pipe, black steel, plain end, welded, 5/8" wall thickness, 48" diameter (Note: suction and discharge)	120.00	LF	196,131.44	102,319.32	157,273.39	73,781.74	529,505.89
			64.46			*16.19*	*174.02*
RSM 331413401635 Water supply distribution piping, pipe coating, coal tar epoxy, pipe, black steel, 48" OD, material add only (Note: inside and out)	240.00	LF	15,469.97	8,070.49	12,405.02	5,819.57	41,765.05

Description	Quantity	UOM	DirectCost	SubCMU	PrimeCMU	OwnerMarkup	ProjectCost
			8,392.95			*16.19*	*22,658.87*
RSM 331413401490 Water supply distribution piping, fitting, pipe, black steel, 48" pipe size (Note: suction and discharge)	3.00	EA	25,178.85	13,135.49	20,190.36	9,471.91	67,976.61
			2,322.09			*16.19*	*6,269.06*
RSM 221113449650 Pipe, steel, Welding labor per joint	6.00	EA	13,932.54	7,268.43	11,172.19	5,241.22	37,614.38
			1,312.83			*16.19*	*3,544.31*
RSM 220529100470 Pipe hanger / support, clamp, alloy steel, high temperature, to 1050 Deg.F, 48" pipe size	5.00	EA	6,564.14	3,424.43	5,263.64	2,469.33	17,721.55
			76.90			*16.19*	*207.61*
RSM 031519100100 Anchor bolt, J-type, 2-bolt set, plain steel, 1/2" dia x 6" L, incl nut & washer, job-built 2-hole template	5.00	SET	384.49	200.58	308.31	144.64	1,038.03
			639.04			*16.19*	*1,725.25*
RSM 331413401080 Water supply distribution piping, pipe, black steel, plain end, welded, 3/8" wall thickness, 24" diameter, excludes excavation or backfill (Note: modified spray bar)	80.00	LF	51,123.10	26,670.28	40,994.47	19,231.75	138,019.61
			3,109.06			*16.19*	*8,393.67*
RSM 331413401460 Water supply distribution piping, coupling, dresser, pipe, black steel, 24" pipe size, PE style 38 (Note: modified spray bar)	6.00	EA	18,654.33	9,731.73	14,958.49	7,017.48	50,362.04
			2,322.09			*16.19*	*6,269.06*
RSM 221113449650 Pipe, steel, Welding labor per joint	9.00	EA	20,898.81	10,902.65	16,758.29	7,861.82	56,421.57
			1,436.55			*16.19*	*3,878.32*
RSM 015113500830 Temporary equipment, welding machine, 100 amp, incl. disconnect	2.00	MO	2,873.09	1,498.86	2,303.87	1,080.81	7,756.63
			338,202.96				*913,063.51*
ELECTRICAL	**1.00**	**EA**	**338,202.96**	**176,436.26**	**271,197.36**	**127,226.94**	**913,063.51**
			49,411.32			*16.19*	*133,398.23*
RSM 262923101210 Variable frequency drives, custom-engineered, 460 volt, 75 HP motor size (Note: add 30% for NEMA 4)	3.00	EA	148,233.97	77,331.81	118,865.49	55,763.42	400,194.69
			819.14			*16.19*	*2,211.48*
HNC 260583162216 Motor connections, 3 phase, 1800 RPM, 460 volt, 75 HP, incl 1-1/2" flex conduit w/4@2/0, incl connection, termination, rotation testing	3.00	EA	2,457.42	1,282.01	1,970.55	924.45	6,634.43
			1,073.53			*16.19*	*2,898.26*
RSM 260533182500 Pull boxes, steel, type SC, raintight & weatherproof, 24" L x 24" W x 10" D, NEMA 4	3.00	EA	3,220.59	1,680.14	2,582.52	1,211.54	8,694.79
			100.70			*16.19*	*271.87*
RSM 260533140640 Rigid galvanized steel conduit, 3" diameter, to 10' high, includes 11 couplings per 100'	1,000.00	LF	100,703.46	52,535.74	80,751.85	37,883.15	271,874.20
			1,302.68			*16.19*	*3,516.91*
RSM 260519901650 Wire, copper, stranded, 600 volt, 2/0, type THWN-THHN, normal installation conditions in wireway, conduit, cable tray	31.00	CLF	40,383.08	21,067.35	32,382.29	15,191.52	109,024.24
			1,302.68			*16.19*	*3,516.91*
RSM 260526803800 Insulated ground wire, copper, stranded, 2/0	11.00	CLF	14,329.48	7,475.51	11,490.49	5,390.54	38,686.02
			450.28			*16.19*	*1,215.64*
RSM 260526800100 Grounding rod, copper clad, 10' long, 3/4" diameter	3.00	EA	1,350.84	704.72	1,083.21	508.17	3,646.93
			54.18			*16.19*	*146.28*
RSM 260526800250 Ground clamp, bronze, 3/4" diameter	3.00	EA	162.55	84.80	130.34	61.15	438.84

Description	Quantity	UOM	DirectCost	SubCMU	PrimeCMU	OwnerMarkup	ProjectCost
			8,384.07			*16.19*	*22,634.90*
RSM 262419300350 Motor control center, starters, class 1, type B, combination MCP, FVNR, with control XFMR, size 4, 75 HP, 24" high, incl starters & structures	3.00	EA	25,152.22	13,121.60	20,169.00	9,461.89	67,904.70
			2,209.34			*16.19*	*5,964.68*
HNC 260913130015 Switchboard instruments, metering instrumentation volt, amp, watt hour (Note: analyze demand load data)	1.00	MO	2,209.34	1,152.59	1,771.62	831.12	5,964.68
2 LOWER MONUMENTAL (LMN) - PUMPED FISH EXIT	**1.00**	**LS**	**1,499,234.07**	**759,797.05**	**1,190,432.55**	**558,468.17**	**4,007,931.83**
			602,214.47				*1,586,202.95*
STRUCTURAL	**1.00**	**EA**	**602,214.47**	**291,833.13**	**471,132.67**	**221,022.69**	**1,586,202.95**
			378,813.84				*997,776.80*
Wet Well & Fish Exit	**1.00**	**EA**	**378,813.84**	**183,573.18**	**296,358.83**	**139,030.95**	**997,776.80**
			31.44			*16.19*	*82.81*
RSM 050521901500 Welding structural steel in field, single pass, 0.3 lb/LF, 1/4" thick, continuous fillet, down welding, type 6011 (Note: Allowance for field welding and cutting)	500.00	LF	15,720.66	7,618.23	12,298.80	5,769.74	41,407.43
			129.94			*16.19*	*342.24*
RSM 051223652240 Steel plate, 1" T, warehouse price, no shop fabrication, welded in field	2,240.00	SF	291,056.41	141,045.93	227,703.23	106,822.52	766,628.09
			153.44			*16.19*	*404.16*
HTW 027116130013 Passive water treatment, debris baffle	176.00	SF	27,005.75	13,086.99	21,127.51	9,911.56	71,131.80
			1,957.75			*16.19*	*5,156.62*
RSM 233713104522 Diffuser, 1" steel bars @ 2" OC, 96" wide	22.00	LF	43,070.57	20,872.00	33,695.56	15,807.61	113,445.75
			98.02			*16.19*	*258.19*
RSM 031519100140 Anchor bolt, J-type, 2-bolt set, plain steel, 3/4" dia x 12" L, incl nut & washer, job-built 2-hole template	20.00	SET	1,960.45	950.03	1,533.73	719.52	5,163.73
			28,282.91				*74,495.77*
Intake Bell & Trashrack	**1.00**	**EA**	**28,282.91**	**13,705.90**	**22,126.67**	**10,380.29**	**74,495.77**
			31.44			*16.19*	*82.81*
RSM 050521901500 Welding structural steel in field, single pass, 0.3 lb/LF, 1/4" thick, continuous fillet, down welding, type 6011 (Note: Allowance for field welding and cutting)	50.00	LF	1,572.07	761.82	1,229.88	576.97	4,140.74
			26.97			*16.19*	*71.04*
RSM 076510100300 Sheet metal, aluminum, flexible,.050" thick (Note: Intake Bell & Supply Pipe)	897.00	SF	24,193.34	11,724.09	18,927.27	8,879.36	63,724.06
			69.21			*16.19*	*182.29*
RSM 051223652220 Steel plate, 1/2" T, warehouse price, shop fabrication, welded in place (Note: 29' of bracket)	29.00	SF	2,007.04	972.61	1,570.17	736.62	5,286.44
			31.44			*16.19*	*82.81*
RSM 050521901500 Welding structural steel in field, single pass, 0.3 lb/LF, 1/2" thick, continuous fillet, down welding, type 6011 (Note: Allowance for field welding and cutting)	10.00	LF	314.41	152.36	245.98	115.39	828.15
			98.02			*16.19*	*258.19*
RSM 031519100140 Anchor bolt, J-type, 2-bolt set, plain steel, 3/4" dia x 12" L, incl nut & washer, job-built 2-hole template	2.00	SET	196.04	95.00	153.37	71.95	516.37

Description	Quantity	UOM	DirectCost	SubCMU	PrimeCMU	OwnerMarkup	ProjectCost
			47,628.36				*125,450.74*
Diver Crew	**1.00**	**EA**	**47,628.36**	**23,080.70**	**37,261.27**	**17,480.40**	**125,450.74**
			289.05			*16.19*	*761.35*
USR DIVER Diver	80.00	HR	23,124.35	11,206.06	18,090.96	8,487.02	60,908.40
			161.77			*16.19*	*426.10*
USR DIVERTENDER Diver Tender	80.00	HR	12,941.83	6,271.61	10,124.83	4,749.87	34,088.14
			289.05			*16.19*	*761.35*
USR DIVER Diver Supervisor	40.00	HR	11,562.18	5,603.03	9,045.48	4,243.51	30,454.20
			90,625.08				*238,701.96*
Rip Rap	**1.00**	**EA**	**90,625.08**	**43,916.92**	**70,899.06**	**33,260.91**	**238,701.96**
			2,561.63			*16.19*	*6,747.19*
HTW 028113110001 Collection of sludges, debris and sediment, 170 HP, 60 CY/hr., 1200 GPM pump, 8' x 34', dredging (using rentals), hydraulic (rent per day)	5.00	DAY	12,808.13	6,206.82	10,020.23	4,700.79	33,735.96
			616.10			*16.19*	*1,622.79*
RSM 313713100110 Rip-rap and rock lining, random, broken stone, 3/8 to 1/4 C.Y. pieces, machine placed for slope protection (Note: Excavator on barge)	120.00	SY	73,932.48	35,827.68	57,839.87	27,134.44	194,734.46
			1,942.24			*16.19*	*5,115.77*
RSM 312316304300 Bathymetric survey	2.00	EA	3,884.48	1,882.42	3,038.96	1,425.67	10,231.53
			56,864.28				*149,777.69*
Barge & Crane	**1.00**	**EA**	**56,864.28**	**27,556.43**	**44,486.84**	**20,870.13**	**149,777.69**
			17.87			*16.19*	*47.06*
EP M10XX005 Flat deck cargo barge	80.00	HR	1,429.40	692.69	1,118.27	524.61	3,764.98
			270.31			*16.19*	*711.98*
RSM 015436501700 Mobilization or demobilization, crane, truck-mounted, up to 75 ton, (driver only)	2.00	EA	540.62	261.98	422.94	198.42	1,423.96
			1,485.00			*16.19*	*3,911.42*
USR CRANE001 Crane, 12 ton, rental per day	15.00	DAY	22,275.00	10,794.47	17,426.48	8,175.29	58,671.24
			2,174.62			*16.19*	*5,727.83*
RSM 015419500100 Crane crew, daily use for small jobs, 12-ton truck-mounted hydraulic crane, portal to portal	15.00	DAY	32,619.26	15,807.29	25,519.15	11,971.81	85,917.51
			778,188.38				*2,100,914.26*
MECHANICAL	**1.00**	**EA**	**778,188.38**	**405,971.15**	**624,011.79**	**292,742.94**	**2,100,914.26**
			216,103.02			*16.19*	*583,424.19*
RSM 221123112280 Submerible pump, propeller, stainless steel, 445 RPM, 30 H.P. (Note: per engineer's estimate + $750 /EA freight)	2.00	EA	432,206.05	225,476.49	346,576.32	162,589.51	1,166,848.37
			1,608.00			*16.19*	*4,341.21*
RSM 331413401140 Water supply distribution piping, pipe, black steel, plain end, welded, 5/8" wall thickness, 48" diameter (Note: suction and discharge)	160.00	LF	257,280.76	134,220.16	206,307.67	96,785.21	694,593.80
			63.06			*16.19*	*170.24*
RSM 331413401635 Water supply distribution piping, pipe coating, coal tar epoxy, pipe, black steel, 48" OD, material add only	320.00	LF	20,178.22	10,526.73	16,180.46	7,590.75	54,476.16

Description	Quantity	UOM	DirectCost	SubCMU	PrimeCMU	OwnerMarkup	ProjectCost
(Note: inside and out)							
			8,245.82			*16.19*	*22,261.65*
RSM 331413401490 Water supply distribution piping, fitting, pipe, black steel, 48" pipe size (Note: suction and discharge)	3.00	EA	24,737.45	12,905.22	19,836.41	9,305.86	66,784.95
			2,322.09			*16.19*	*6,269.06*
RSM 221113449650 Pipe, steel, Welding labor per joint	6.00	EA	13,932.54	7,268.43	11,172.19	5,241.22	37,614.38
			1,285.60			*16.19*	*3,470.81*
RSM 220529100470 Pipe hanger / support, clamp, alloy steel, high temperature, to 1050 Deg.F, 48" pipe size	8.00	EA	10,284.84	5,365.47	8,247.18	3,869.00	27,766.49
			76.53			*16.19*	*206.62*
RSM 031519100100 Anchor bolt, J-type, 2-bolt set, plain steel, 1/2" dia x 6" L, incl nut & washer, job-built 2-hole template	8.00	SET	612.26	319.41	490.95	230.32	1,652.94
			1,413.73			*16.19*	*3,816.71*
RSM 015113500830 Temporary equipment, welding machine, 100 amp	2.00	MO	2,827.45	1,475.05	2,267.27	1,063.65	7,633.41
			16,128.82			*16.19*	*43,543.78*
RSM 221113781280 Reducer, plastic, high density polyethylene (HDPE), single wall, welded, 96" x 48" diam., DR 26, add 1 weld per joint, excludes hangers, trenching, backfill, hoisting or digging equipment (Note: custom intake bell per engineer)	1.00	EA	16,128.82	8,414.20	12,933.34	6,067.42	43,543.78
			118,831.22				*320,814.61*
ELECTRICAL	**1.00**	**EA**	**118,831.22**	**61,992.76**	**95,288.09**	**44,702.54**	**320,814.61**
			20,762.58			*16.19*	*56,053.79*
RSM 262923101170 Variable frequency drives, custom-engineered, 460 volt, 30 HP motor size (Note: add 30% for NEMA 4)	2.00	EA	41,525.16	21,663.16	33,298.10	15,621.15	112,107.57
			353.36			*16.19*	*953.98*
HNC 260583162213 Motor connections, 3 phase, 1800 RPM, 460 volt, 30 HP, incl 1" flex conduit w/4#6, incl connection, termination, rotation testing	2.00	EA	706.72	368.69	566.70	265.86	1,907.96
			1,062.84			*16.19*	*2,869.40*
RSM 260533182500 Pull boxes, steel, type SC, raintight & weatherproof, 24" L x 24" W x 10" D, NEMA 4	2.00	EA	2,125.68	1,108.94	1,704.54	799.65	5,738.81
			99.50			*16.19*	*268.63*
RSM 260533140640 Rigid galvanized steel conduit, 3" diameter, to 10' high, includes 11 couplings per 100'	500.00	LF	49,751.19	25,954.57	39,894.36	18,715.66	134,315.78
			412.94			*16.19*	*1,114.84*
RSM 260519901350 Wire, copper, stranded, 600 volt, #6, type THWN-THHN, normal installation conditions in wireway, conduit, cable tray	15.50	CLF	6,400.60	3,339.12	5,132.50	2,407.81	17,280.03
			412.94			*16.19*	*1,114.84*
RSM 260526803740 Insulated ground wire, copper, #6	5.50	CLF	2,271.18	1,184.85	1,821.21	854.39	6,131.63
			447.68			*16.19*	*1,208.62*
RSM 260526800100 Grounding rod, copper clad, 10' long, 3/4" diameter	2.00	EA	895.35	467.10	717.96	336.82	2,417.23
			53.99			*16.19*	*145.77*
RSM 260526800250 Ground clamp, bronze, 3/4" diameter	2.00	EA	107.99	56.34	86.59	40.62	291.54
			6,419.00			*16.19*	*17,329.69*
RSM 262419300300 Motor control center, starters, class 1, type B, combination MCP, FVNR, with control XFMR, size 3, 30 HP, 24" high, incl starters & structures	2.00	EA	12,837.99	6,697.42	10,294.50	4,829.46	34,659.38

Description	Quantity	UOM	DirectCost	SubCMU	PrimeCMU	OwnerMarkup	ProjectCost
			2,209.34			*16.19*	*5,964.68*
HNC 260913130015 Switchboard instruments, metering instrumentation volt, amp, watt hour (Note: analyze demand load data)	1.00	MO	2,209.34	1,152.59	1,771.62	831.12	5,964.68
3 ICE HARBOR (HLD) - BUBBLER	**1.00**	**LS**	**133,517.86**	**69,344.43**	**106,901.52**	**50,150.76**	**359,914.58**
			8,363.04				*22,027.84*
STRUCTURAL	**1.00**	**EA**	**8,363.04**	**4,052.73**	**6,542.69**	**3,069.38**	**22,027.84**
			8,363.04				*22,027.84*
Hoist	**1.00**	**EA**	**8,363.04**	**4,052.73**	**6,542.69**	**3,069.38**	**22,027.84**
			5,365.59			*16.19*	*14,132.70*
HNC 412223190001 Hoists, Material Handling, wire rope, light/medium duty, electric operated, 2,000 lb capacity, beams not included	1.00	EA	5,365.59	2,600.17	4,197.68	1,969.26	14,132.70
			178.87			*16.19*	*471.13*
RSM 051223177150 Column, structural, 2-tier, W12x50, A992 steel, incl shop primer, splice plates, bolts (Note: Retrieval arm supports)	15.00	LF	2,683.04	1,300.20	2,099.03	984.72	7,066.99
			31.44			*16.19*	*82.81*
RSM 050521901500 Welding structural steel in field, single pass, 0.3 lb/LF, 1/4" thick, continuous fillet, down welding, type 6011 (Note: Allowance for additional field welding)	10.00	LF	314.41	152.36	245.98	115.39	828.15
			85,338.85				*230,393.59*
MECHANICAL	**1.00**	**EA**	**85,338.85**	**44,520.21**	**68,431.31**	**32,103.21**	**230,393.59**
			46,123.14			*16.19*	*124,520.97*
RSM 221519106120 Compressor, air, rotary screw, tank mounted, pressure lubricated, heavy duty, 2 stage, 3 phase, 10 H.P. (Note: per Ingersoll Rand quote #CTS-487248 dated 8/28/2025 plus $1400 freight)	1.00	EA	46,123.14	24,061.87	36,985.11	17,350.84	124,520.97
			26,692.02			*16.19*	*72,061.78*
RSM 465136100180 Stainless steel fine bubble diffuser system, 70" diameter, incl 300 LF tubing, excludes air supply (Note: SalmoAir diffuser per engineer's estimate)	1.00	EA	26,692.02	13,924.89	21,403.73	10,041.14	72,061.78
			100.96			*16.19*	*272.57*
RSM 221113645080 Pipe, stainless steel, threaded, 1" diameter, schedule 80, type 304, includes couplings and hangers 10' OC	100.00	LF	10,096.03	5,266.97	8,095.78	3,797.98	27,256.76
			153.62			*16.19*	*414.72*
RSM 221113667100 Elbow, 90 Deg., stainless steel, threaded, 150 lb., 1", type 304	6.00	EA	921.70	480.84	739.09	346.73	2,488.35
			108.33			*16.19*	*292.45*
RSM 221113667520 Coupling, stainless steel, straight, threaded, 150 lb., 1", type 304	5.00	EA	541.63	282.56	434.32	203.75	1,462.27
			964.34			*16.19*	*2,603.47*
HNC 221519132009 Compressor accessory, pressure regulator, rated 250 psi, heavy duty, 2-125 psi, 1" N.P.T.	1.00	EA	964.34	503.08	773.28	362.77	2,603.47
			39,815.96				*107,493.15*
ELECTRICAL	**1.00**	**EA**	**39,815.96**	**20,771.49**	**31,927.52**	**14,978.17**	**107,493.15**
			353.36			*16.19*	*953.98*
HNC 260583162213 Motor connections, 3 phase, 1800 RPM, 460 volt, 30 HP, incl 1" flex conduit w/4#6, incl connection, termination, rotation testing	1.00	EA	353.36	184.34	283.35	132.93	953.98
			1,062.84			*16.19*	*2,869.40*
RSM 260533182500 Pull boxes, steel, type SC, raintight & weatherproof, 24" L x 24" W x 10" D, NEMA 4	1.00	EA	1,062.84	554.47	852.27	399.82	2,869.40

Description	Quantity	UOM	DirectCost	SubCMU	PrimeCMU	OwnerMarkup	ProjectCost
			99.50			*16.19*	*268.63*
RSM 260533140640 Rigid galvanized steel conduit, 3" diameter, to 10' high, includes 11 couplings per 100'	300.00	LF	29,850.71	15,572.74	23,936.62	11,229.40	80,589.47
			412.94			*16.19*	*1,114.84*
RSM 260519901350 Wire, copper, stranded, 600 volt, #6, type THWN-THHN, normal installation conditions in wireway, conduit, cable tray	9.30	CLF	3,840.36	2,003.47	3,079.50	1,444.69	10,368.02
			412.94			*16.19*	*1,114.84*
RSM 260526803740 Insulated ground wire, copper, #6	3.30	CLF	1,362.71	710.91	1,092.73	512.63	3,678.98
			447.68			*16.19*	*1,208.62*
RSM 260526800100 Grounding rod, copper clad, 10' long, 3/4" diameter	1.00	EA	447.68	233.55	358.98	168.41	1,208.62
			53.99			*16.19*	*145.77*
RSM 260526800250 Ground clamp, bronze, 3/4" diameter	1.00	EA	53.99	28.17	43.30	20.31	145.77
			634.96			*16.19*	*1,714.23*
HNC 262416331027 Circuit breakers, 3 pole, 10 k A I.C., 480 volt, 15 to 60 amp	1.00	EA	634.96	331.25	509.16	238.86	1,714.23
			2,209.34			*16.19*	*5,964.68*
HNC 260913130015 Switchboard instruments, metering instrumentation volt, amp, watt hour (Note: analyze demand load data)	1.00	MO	2,209.34	1,152.59	1,771.62	831.12	5,964.68
4 ICE HARBOR (HLD) - PUMPED FISH EXIT	**1.00**	**LS**	**1,427,297.48**	**729,043.80**	**1,136,318.50**	**533,081.62**	**3,825,741.40**
			419,533.65				*1,105,030.76*
STRUCTURAL	**1.00**	**EA**	**419,533.65**	**203,306.01**	**328,215.31**	**153,975.80**	**1,105,030.76**
			346,139.88				*911,715.22*
Wet Well & Fish Exit	**1.00**	**EA**	**346,139.88**	**167,739.38**	**270,796.89**	**127,039.07**	**911,715.22**
			31.44			*16.19*	*82.81*
RSM 050521901500 Welding structural steel in field, single pass, 0.3 lb/LF, 1/4" thick, continuous fillet, down welding, type 6011 (Note: Allowance for field welding and cutting)	500.00	LF	15,720.66	7,618.23	12,298.80	5,769.74	41,407.43
			129.94			*16.19*	*342.24*
RSM 051223652240 Steel plate, 1" T, warehouse price, no shop fabrication, welded in field	2,240.00	SF	291,056.41	141,045.93	227,703.23	106,822.52	766,628.09
			153.44			*16.19*	*404.16*
HTW 027116130013 Passive water treatment, debris baffle	176.00	SF	27,005.75	13,086.99	21,127.51	9,911.56	71,131.80
			472.57			*16.19*	*1,244.73*
RSM 233713104522 Diffuser, 1" steel bars @ 2" OC, 96" wide	22.00	LF	10,396.62	5,038.20	8,133.62	3,815.73	27,384.17
			98.02			*16.19*	*258.19*
RSM 031519100140 Anchor bolt, J-type, 2-bolt set, plain steel, 3/4" dia x 12" L, incl nut & washer, job-built 2-hole template	20.00	SET	1,960.45	950.03	1,533.73	719.52	5,163.73
			25,765.41				*67,864.81*
Intake Bell & Trashrack	**1.00**	**EA**	**25,765.41**	**12,485.92**	**20,157.15**	**9,456.33**	**67,864.81**
			31.44			*16.19*	*82.81*
RSM 050521901500 Welding structural steel in field, single pass, 0.3 lb/LF, 1/4" thick, continuous fillet, down welding, type 6011 (Note: Allowance for field welding and cutting)	50.00	LF	1,572.07	761.82	1,229.88	576.97	4,140.74
			26.97			*16.19*	*71.04*
RSM 076510100300 Sheet metal, aluminum, flexible,.050" thick	897.00	SF	24,193.34	11,724.09	18,927.27	8,879.36	63,724.06

Description	Quantity	UOM	DirectCost	SubCMU	PrimeCMU	OwnerMarkup	ProjectCost
(Note: Intake Bell & Supply Pipe)							
			47,628.36				*125,450.74*
Diver Crew	**1.00**	**EA**	**47,628.36**	**23,080.70**	**37,261.27**	**17,480.40**	**125,450.74**
			289.05			*16.19*	*761.35*
USR DIVER Diver	80.00	HR	23,124.35	11,206.06	18,090.96	8,487.02	60,908.40
			161.77			*16.19*	*426.10*
USR DIVERTENDER Diver Tender	80.00	HR	12,941.83	6,271.61	10,124.83	4,749.87	34,088.14
			289.05			*16.19*	*761.35*
USR DIVER Diver Supervisor	40.00	HR	11,562.18	5,603.03	9,045.48	4,243.51	30,454.20
			888,932.61				*2,399,896.02*
MECHANICAL	**1.00**	**EA**	**888,932.61**	**463,745.03**	**712,815.10**	**334,403.28**	**2,399,896.02**
			216,103.02			*16.19*	*583,424.19*
RSM 221123112280 Submerible pump, propeller, stainless steel, 445 RPM, 30 H.P. (Note: per engineer's estimate + $750 /EA freight)	2.00	EA	432,206.05	225,476.49	346,576.32	162,589.51	1,166,848.37
			2,174.19			*16.19*	*5,869.76*
RSM 331413401140 Water supply distribution piping, pipe, black steel, plain end, welded, 5/8" wall thickness, 66" diameter (Note: suction and discharge)	160.00	LF	347,869.98	181,479.42	278,949.12	130,863.53	939,162.05
			88.28			*16.19*	*238.33*
RSM 331413401635 Water supply distribution piping, pipe coating, coal tar epoxy, pipe, black steel, 66" OD, material add only (Note: inside and out)	320.00	LF	28,249.51	14,737.42	22,652.65	10,627.05	76,266.62
			11,245.25			*16.19*	*30,359.35*
RSM 331413401490 Water supply distribution piping, fitting, pipe, black steel, 66" pipe size (Note: suction and discharge)	3.00	EA	33,735.74	17,599.51	27,051.93	12,690.88	91,078.06
			2,322.09			*16.19*	*6,269.06*
RSM 221113449650 Pipe, steel, Welding labor per joint	6.00	EA	13,932.54	7,268.43	11,172.19	5,241.22	37,614.38
			1,920.97			*16.19*	*5,186.15*
RSM 220529100470 Pipe hanger / support, clamp, alloy steel, high temperature, to 1050 Deg.F, 66" pipe size	7.00	EA	13,446.81	7,015.03	10,782.69	5,058.49	36,303.02
			76.53			*16.19*	*206.62*
RSM 031519100100 Anchor bolt, J-type, 2-bolt set, plain steel, 1/2" dia x 6" L, incl nut & washer, job-built 2-hole template	7.00	SET	535.72	279.48	429.58	201.53	1,446.32
			1,413.73			*16.19*	*3,816.71*
RSM 015113500830 Temporary equipment, welding machine, 100 amp	2.00	MO	2,827.45	1,475.05	2,267.27	1,063.65	7,633.41
			16,128.82			*16.19*	*43,543.78*
RSM 221113781280 Reducer, plastic, high density polyethylene (HDPE), single wall, welded, 96" x 48" diam., DR 26, add 1 weld per joint, excludes hangers, trenching, backfill, hoisting or digging equipment (Note: custom intake bell per engineer)	1.00	EA	16,128.82	8,414.20	12,933.34	6,067.42	43,543.78
			118,831.22				*320,814.61*
ELECTRICAL	**1.00**	**EA**	**118,831.22**	**61,992.76**	**95,288.09**	**44,702.54**	**320,814.61**
			20,762.58			*16.19*	*56,053.79*

Description	Quantity	UOM	DirectCost	SubCMU	PrimeCMU	OwnerMarkup	ProjectCost
RSM 262923101170 Variable frequency drives, custom-engineered, 460 volt, 30 HP motor size (Note: add 30% for NEMA 4)	2.00	EA	41,525.16	21,663.16	33,298.10	15,621.15	112,107.57
			353.36			*16.19*	*953.98*
HNC 260583162213 Motor connections, 3 phase, 1800 RPM, 460 volt, 30 HP, incl 1" flex conduit w/4#6, incl connection, termination, rotation testing	2.00	EA	706.72	368.69	566.70	265.86	1,907.96
			1,062.84			*16.19*	*2,869.40*
RSM 260533182500 Pull boxes, steel, type SC, raintight & weatherproof, 24" L x 24" W x 10" D, NEMA 4	2.00	EA	2,125.68	1,108.94	1,704.54	799.65	5,738.81
			99.50			*16.19*	*268.63*
RSM 260533140640 Rigid galvanized steel conduit, 3" diameter, to 10' high, includes 11 couplings per 100'	500.00	LF	49,751.19	25,954.57	39,894.36	18,715.66	134,315.78
			412.94			*16.19*	*1,114.84*
RSM 260519901350 Wire, copper, stranded, 600 volt, #6, type THWN-THHN, normal installation conditions in wireway, conduit, cable tray	15.50	CLF	6,400.60	3,339.12	5,132.50	2,407.81	17,280.03
			412.94			*16.19*	*1,114.84*
RSM 260526803740 Insulated ground wire, copper, #6	5.50	CLF	2,271.18	1,184.85	1,821.21	854.39	6,131.63
			447.68			*16.19*	*1,208.62*
RSM 260526800100 Grounding rod, copper clad, 10' long, 3/4" diameter	2.00	EA	895.35	467.10	717.96	336.82	2,417.23
			53.99			*16.19*	*145.77*
RSM 260526800250 Ground clamp, bronze, 3/4" diameter	2.00	EA	107.99	56.34	86.59	40.62	291.54
			6,419.00			*16.19*	*17,329.69*
RSM 262419300300 Motor control center, starters, class 1, type B, combination MCP, FVNR, with control XFMR, size 3, 30 HP, 24" high, incl starters & structures	2.00	EA	12,837.99	6,697.42	10,294.50	4,829.46	34,659.38
			2,209.34			*16.19*	*5,964.68*
HNC 260913130015 Switchboard instruments, metering instrumentation volt, amp, watt hour (Note: analyze demand load data)	1.00	MO	2,209.34	1,152.59	1,771.62	831.12	5,964.68
5 MCNARY (MNA) - AIR LIFT PUMP	**1.00**	**LS**	**1,451,095.70**	**725,271.55**	**1,146,871.50**	**538,032.35**	**3,861,271.10**
			856,001.14				*2,254,664.43*
STRUCTURAL	**1.00**	**EA**	**856,001.14**	**414,818.15**	**669,678.54**	**314,166.60**	**2,254,664.43**
			56,864.28				*149,777.69*
Barge & Crane	**1.00**	**EA**	**56,864.28**	**27,556.43**	**44,486.84**	**20,870.13**	**149,777.69**
			17.87			*16.19*	*47.06*
EP M10XX005 Flat deck cargo barge	80.00	HR	1,429.40	692.69	1,118.27	524.61	3,764.98
			270.31			*16.19*	*711.98*
RSM 015436501700 Mobilization or demobilization, crane, truck-mounted, up to 75 ton, (driver only)	2.00	EA	540.62	261.98	422.94	198.42	1,423.96
			1,485.00			*16.19*	*3,911.42*
USR CRANE001 Crane, 12 ton, rental per day	15.00	DAY	22,275.00	10,794.47	17,426.48	8,175.29	58,671.24
			2,174.62			*16.19*	*5,727.83*
RSM 015419500100 Crane crew, daily use for small jobs, 12-ton truck-mounted hydraulic crane, portal to portal	15.00	DAY	32,619.26	15,807.29	25,519.15	11,971.81	85,917.51
			310,741.40				*818,477.39*
Air Lift Pipe & Frame	**1.00**	**EA**	**310,741.40**	**150,585.28**	**243,103.47**	**114,047.24**	**818,477.39**
			736.77			*16.19*	*1,940.60*

Description	Quantity	UOM	DirectCost	SubCMU	PrimeCMU	OwnerMarkup	ProjectCost
RSM 331413401090 Water supply distribution piping, pipe, black steel, plain end, welded, 3/8" wall thickness, 30" diameter, excludes excavation or backfill	390.00	LF	287,338.58	139,244.28	224,794.65	105,458.02	756,835.53
			178.87			*16.19*	*471.13*
RSM 051223177150 Column, structural, W12x50, A992 steel, incl shop primer, base plate, bolts	80.00	LF	14,309.53	6,934.40	11,194.83	5,251.84	37,690.60
			704.03			*16.19*	*1,854.39*
RSM 051223174500 Structural tubing, square, 4" x 4" x 1/4" x 12'-0", incl shop primer (Note: Frame for Airlift Piping)	7.00	EA	4,928.24	2,388.22	3,855.53	1,808.74	12,980.73
			31.44			*16.19*	*82.81*
RSM 050521901500 Welding structural steel in field, single pass, 0.3 lb/LF, 1/4" thick, continuous fillet, down welding, type 6011 (Note: Allowance for field welding and cutting)	120.00	LF	3,772.96	1,828.38	2,951.71	1,384.74	9,937.78
			98.02			*16.19*	*258.19*
RSM 031519100140 Anchor bolt, J-type, 2-bolt set, plain steel, 3/4" dia x 12" L, incl nut & washer, job-built 2-hole template	4.00	SET	392.09	190.01	306.75	143.90	1,032.75
			4,897.41				*12,899.54*
Piles (3 EA)	**90.00**	**VLF**	**440,767.10**	**213,595.74**	**344,826.95**	**161,768.83**	**1,160,958.61**
			2,561.63			*16.19*	*6,747.19*
HTW 028113110001 Collection of sludges, debris and sediment, 170 HP, 60 CY/hr., 1200 GPM pump, 8' x 34', dredging (using rentals), hydraulic (rent per day)	5.00	DAY	12,808.13	6,206.82	10,020.23	4,700.79	33,735.96
			15,699.62			*16.19*	*41,352.02*
RSM 310660150520 Mobilization, to 36", set up and remove drill rig, for caissons, maximum	1.00	EA	15,699.62	7,608.04	12,282.34	5,762.02	41,352.02
			153.81			*16.19*	*405.12*
RSM 316223134200 Concrete-filled steel piles, steel, pipe piles, concrete filled, 50' long, 20" diameter, 59 lb./L.F., excludes mobilization or demobilization	90.00	VLF	13,842.76	6,708.20	10,829.66	5,080.52	36,461.14
			158.65			*16.19*	*417.86*
RSM 316326130400 Fixed end caisson piles, open style in stable ground, to 50' deep, 20" diameter, 0.262 CY/LF, machine drilled, includes excavation, concrete, 50 lb. reinforcing/C.Y., excludes mobilization, boulder removal, disposal, casings or ground water	90.00	VLF	14,278.05	6,919.14	11,170.20	5,240.28	37,607.68
			160.06			*16.19*	*421.58*
RSM 315216102300 Cofferdams, soldier beams & lagging, H-piles with metal sheeting horizontal between piles, dewatering	2,400.00	SF	384,138.54	186,153.54	300,524.52	140,985.21	1,011,801.81
			47,628.36				*125,450.74*
Diver Crew	**1.00**	**EA**	**47,628.36**	**23,080.70**	**37,261.27**	**17,480.40**	**125,450.74**
			289.05			*16.19*	*761.35*
USR DIVER Diver	80.00	HR	23,124.35	11,206.06	18,090.96	8,487.02	60,908.40
			161.77			*16.19*	*426.10*
USR DIVERTENDER Diver Tender	80.00	HR	12,941.83	6,271.61	10,124.83	4,749.87	34,088.14
			289.05			*16.19*	*761.35*
USR DIVER Diver Supervisor	40.00	HR	11,562.18	5,603.03	9,045.48	4,243.51	30,454.20
			371,494.46				*1,002,942.26*
MECHANICAL	**1.00**	**EA**	**371,494.46**	**193,804.02**	**297,893.07**	**139,750.71**	**1,002,942.26**
			325,057.94			*16.19*	*877,575.25*
RSM 221519106130 Compressor, air, rotary screw, pressure lubricated, heavy duty, 2 stage, 3 phase, 250 H.P. (Note: per Ingersoll Rand quote #CTS-445711 dated 6/26/2025 plus $10,000 freight)	1.00	EA	325,057.94	169,578.66	260,656.66	122,281.98	877,575.25

Description	Quantity	UOM	DirectCost	SubCMU	PrimeCMU	OwnerMarkup	ProjectCost
			225.52			*16.19*	*608.84*
RSM 221113643640 Pipe, stainless steel, threaded, 4" diameter, schedule 40, type 304, includes couplings and hangers 10' OC	100.00	LF	22,551.72	11,764.95	18,083.72	8,483.62	60,884.02
			507.15			*16.19*	*1,369.16*
RSM 221113667580 Coupling, stainless steel, straight, threaded, 150 lb., 4", type 304	5.00	EA	2,535.73	1,322.86	2,033.34	953.90	6,845.82
			694.26			*16.19*	*1,874.34*
RSM 221113667160 Elbow, 90 Deg., stainless steel, threaded, 150 lb., 4", type 304	6.00	EA	4,165.58	2,173.13	3,340.28	1,567.03	11,246.01
			79.24			*16.19*	*213.92*
RSM 221113643600 Pipe, stainless steel, threaded, 1-1/2" diameter, schedule 40, type 304, includes couplings and hangers 10' OC	100.00	LF	7,923.85	4,133.77	6,353.96	2,980.84	21,392.42
			135.59			*16.19*	*366.06*
RSM 221113667540 Coupling, stainless steel, straight, threaded, 150 lb., 1-1/2", type 304	5.00	EA	677.95	353.68	543.63	255.03	1,830.29
			205.19			*16.19*	*553.95*
RSM 221113667120 Elbow, 90 Deg., stainless steel, threaded, 150 lb., 1-1/2", type 304	6.00	EA	1,231.12	642.26	987.21	463.13	3,323.71
			3,193.12			*16.19*	*8,620.62*
RSM 221113667624 Reducer, stainless steel, concentric, threaded, 150 lb., 4", type 304	2.00	EA	6,386.24	3,331.62	5,120.98	2,402.41	17,241.25
			964.34			*16.19*	*2,603.47*
HNC 221519132009 Compressor accessory, pressure regulator, rated 250 psi, heavy duty, 2-125 psi, 1-1/2" N.P.T.	1.00	EA	964.34	503.08	773.28	362.77	2,603.47
			223,600.10				*603,664.41*
ELECTRICAL	**1.00**	**EA**	**223,600.10**	**116,649.37**	**179,299.90**	**84,115.04**	**603,664.41**
			2,515.07			*16.19*	*6,790.07*
HNC 260583162219 Motor connections, 3 phase, 1800 RPM, 460 volt, 250 HP, incl 3" flex conduit w/4@350 kcmil, incl connection, termination, rotation testing	1.00	EA	2,515.07	1,312.08	2,016.78	946.13	6,790.07
			1,062.84			*16.19*	*2,869.40*
RSM 260533182500 Pull boxes, steel, type SC, raintight & weatherproof, 24" L x 24" W x 10" D, NEMA 4	1.00	EA	1,062.84	554.47	852.27	399.82	2,869.40
			99.50			*16.19*	*268.63*
RSM 260533140640 Rigid galvanized steel conduit, 3" diameter, to 10' high, includes 11 couplings per 100'	1,000.00	LF	99,502.38	51,909.15	79,788.72	37,431.32	268,631.57
			2,789.85			*16.19*	*7,531.91*
RSM 260519902600 Wire, copper, stranded, 600 volt, 350 kcmil, type THWN-THHN, normal installation conditions in wireway, conduit, cable tray	31.00	CLF	86,485.45	45,118.38	69,350.74	32,534.54	233,489.10
			2,789.85			*16.19*	*7,531.91*
RSM 260526803850 Insulated ground wire, copper, stranded, 350 kcmil	11.00	CLF	30,688.38	16,009.75	24,608.33	11,544.52	82,850.97
			447.68			*16.19*	*1,208.62*
RSM 260526800100 Grounding rod, copper clad, 10' long, 3/4" diameter	1.00	EA	447.68	233.55	358.98	168.41	1,208.62
			53.99			*16.19*	*145.77*
RSM 260526800250 Ground clamp, bronze, 3/4" diameter	1.00	EA	53.99	28.17	43.30	20.31	145.77
			634.96			*16.19*	*1,714.23*
HNC 262416331027 Circuit breakers, 3 pole, 10 k A I.C., 480 volt, 15 to 60 amp	1.00	EA	634.96	331.25	509.16	238.86	1,714.23
			2,209.34			*16.19*	*5,964.68*
HNC 260913130015 Switchboard instruments, metering instrumentation volt, amp, watt hour	1.00	MO	2,209.34	1,152.59	1,771.62	831.12	5,964.68

Description	Quantity	UOM	DirectCost	SubCMU	PrimeCMU	OwnerMarkup	ProjectCost
(Note: analyze demand load data)							
6 MCNARY (MNA) - GRAVITY CHIMNEY	**1.00**	**LS**	**1,738,646.74**	**853,454.41**	**1,365,949.12**	**640,808.34**	**4,598,858.60**
			1,444,580.12				*3,804,952.19*
STRUCTURAL	**1.00**	**EA**	**1,444,580.12**	**700,043.53**	**1,130,143.70**	**530,184.83**	**3,804,952.19**
			116,927.60				*307,981.48*
Barge & Crane	**1.00**	**EA**	**116,927.60**	**56,663.11**	**91,476.40**	**42,914.37**	**307,981.48**
			17.87			*16.19*	*47.06*
EP M10XX005 Flat deck cargo barge	160.00	HR	2,858.81	1,385.38	2,236.54	1,049.23	7,529.96
			270.31			*16.19*	*711.98*
RSM 015436501700 Mobilization or demobilization, crane, truck-mounted, up to 75 ton, (driver only)	2.00	EA	540.62	261.98	422.94	198.42	1,423.96
			2,700.00			*16.19*	*7,111.67*
USR CRANE001 Crane, 40 ton, rental per day	20.00	DAY	54,000.00	26,168.40	42,246.02	19,818.89	142,233.31
			2,976.41			*16.19*	*7,839.71*
RSM 015419500300 Crane crew, daily use for small jobs, 40-ton truck-mounted hydraulic crane, portal to portal	20.00	DAY	59,528.17	28,847.35	46,570.90	21,847.83	156,794.25
			5,440.43				*14,329.81*
Piles (3 EA)	**90.00**	**VLF**	**489,638.28**	**237,278.71**	**383,060.52**	**179,705.36**	**1,289,682.87**
			2,561.63			*16.19*	*6,747.19*
HTW 028113110001 Collection of sludges, debris and sediment, 170 HP, 60 CY/hr., 1200 GPM pump, 8' x 34', dredging (using rentals), hydraulic (rent per day)	5.00	DAY	12,808.13	6,206.82	10,020.23	4,700.79	33,735.96
			15,699.62			*16.19*	*41,352.02*
RSM 310660150520 Mobilization, to 36", set up and remove drill rig, for caissons, maximum	1.00	EA	15,699.62	7,608.04	12,282.34	5,762.02	41,352.02
			289.65			*16.19*	*762.93*
RSM 316223134200 Concrete-filled steel piles, steel, pipe piles, concrete filled, 50' long, 20" diameter, 59 lb./L.F., excludes mobilization or demobilization	90.00	VLF	26,068.85	12,632.96	20,394.54	9,567.70	68,664.04
			158.65			*16.19*	*417.86*
RSM 316326130400 Fixed end caisson piles, open style in stable ground, to 50' deep, 20" diameter, 0.262 CY/LF, machine drilled, includes excavation, concrete, 50 lb. reinforcing/C.Y., excludes mobilization, boulder removal, disposal, casings or ground water	90.00	VLF	14,278.05	6,919.14	11,170.20	5,240.28	37,607.68
			175.33			*16.19*	*461.80*
RSM 315216102300 Cofferdams, soldier beams & lagging, H-piles with metal sheeting horizontal between piles, dewatering	2,400.00	SF	420,783.63	203,911.75	329,193.21	154,434.56	1,108,323.16
			742,757.52				*1,956,386.37*
Gravity Chimney	**1.00**	**EA**	**742,757.52**	**359,940.29**	**581,084.24**	**272,604.31**	**1,956,386.37**
			6,605.70			*16.19*	*17,399.08*
HNC 051223512402 Structural steel member, tees, WT, MT, ST, 34 to 50 plf, A992 steel, shop fabricated, incl shop primer, bolted connections	16.50	TON	108,994.03	52,818.51	85,269.71	40,002.62	287,084.86
			31.44			*16.19*	*82.81*
RSM 050521901500 Welding structural steel in field, single pass, 0.3 lb/LF, 1/4" thick, continuous fillet, down welding, type 6011 (Note: Allowance for field welding and cutting)	400.00	LF	12,576.53	6,094.58	9,839.04	4,615.79	33,125.95
			129.94			*16.19*	*342.24*
RSM 051223652240 Steel plate, 1" T, warehouse price, no shop fabrication, welded in field	4,750.00	SF	617,195.50	299,092.94	482,852.84	226,520.97	1,625,662.25
			98.02			*16.19*	*258.19*

Description	Quantity	UOM	DirectCost	SubCMU	PrimeCMU	OwnerMarkup	ProjectCost
RSM 031519100140 Anchor bolt, J-type, 2-bolt set, plain steel, 3/4" dia x 12" L, incl nut & washer, job-built 2-hole template	6.00	SET	588.13	285.01	460.12	215.86	1,549.12
			41.50			*16.19*	*109.32*
HNC 055313130007 Floor grating, steel, 1" x 1/8" bearing bars @ 15/16" O.C., cross bars @ 4" O.C., up to 300 S.F., field fabricated from panels	82.00	SF	3,403.32	1,649.25	2,662.53	1,249.08	8,964.18
			95,256.72				*250,901.47*
Diver Crew	**1.00**	**EA**	**95,256.72**	**46,161.41**	**74,522.54**	**34,960.80**	**250,901.47**
			289.05			*16.19*	*761.35*
USR DIVER Diver	160.00	HR	46,248.71	22,412.12	36,181.92	16,974.04	121,816.80
			161.77			*16.19*	*426.10*
USR DIVERTENDER Diver Tender	160.00	HR	25,883.66	12,543.22	20,249.66	9,499.73	68,176.28
			289.05			*16.19*	*761.35*
USR DIVER Diver Supervisor	80.00	HR	23,124.35	11,206.06	18,090.96	8,487.02	60,908.40
			244,836.85				*660,998.33*
MECHANICAL	**1.00**	**EA**	**244,836.85**	**127,728.32**	**196,329.17**	**92,103.99**	**660,998.33**
			122,418.42			*16.19*	*330,499.17*
RSM 221123112280 Submerible pump, propeller, stainless steel, 590 RPM, 10 H.P. (Note: per engineer's estimate + $750 /EA freight)	2.00	EA	244,836.85	127,728.32	196,329.17	92,103.99	660,998.33
			49,229.77				*132,908.08*
ELECTRICAL	**1.00**	**EA**	**49,229.77**	**25,682.56**	**39,476.25**	**18,519.51**	**132,908.08**
			12,516.02			*16.19*	*33,790.12*
RSM 262923101130 Variable frequency drives, custom-engineered, 460 volt, 10 HP motor size (Note: add 30% for NEMA 4)	1.00	EA	12,516.02	6,529.45	10,036.31	4,708.34	33,790.12
			254.68			*16.19*	*687.57*
HNC 260583162208 Motor connections, 3 phase, 1800 RPM, 460 volt, 10 HP, incl 1/2" flex conduit w/4#12, incl connection, termination, rotation testing	1.00	EA	254.68	132.86	204.22	95.81	687.57
			1,062.84			*16.19*	*2,869.40*
RSM 260533182500 Pull boxes, steel, type SC, raintight & weatherproof, 24" L x 24" W x 10" D, NEMA 4	1.00	EA	1,062.84	554.47	852.27	399.82	2,869.40
			99.50			*16.19*	*268.63*
RSM 260533140640 Rigid galvanized steel conduit, 3" diameter, to 10' high, includes 11 couplings per 100'	300.00	LF	29,850.71	15,572.74	23,936.62	11,229.40	80,589.47
			174.57			*16.19*	*471.29*
RSM 260519901200 Wire, copper, stranded, 600 volt, #12, type THWN-THHN, normal installation conditions in wireway, conduit, cable tray	9.30	CLF	1,623.47	846.94	1,301.83	610.73	4,382.97
			174.57			*16.19*	*471.29*
RSM 260526803710 Insulated ground wire, copper, #12	3.30	CLF	576.07	300.53	461.94	216.71	1,555.25
			447.68			*16.19*	*1,208.62*
RSM 260526800100 Grounding rod, copper clad, 10' long, 3/4" diameter	1.00	EA	447.68	233.55	358.98	168.41	1,208.62
			53.99			*16.19*	*145.77*
RSM 260526800250 Ground clamp, bronze, 3/4" diameter	1.00	EA	53.99	28.17	43.30	20.31	145.77
			634.96			*16.19*	*1,714.23*
HNC 262416331027 Circuit breakers, 3 pole, 10 k A I.C., 480 volt, 15 to 60 amp	1.00	EA	634.96	331.25	509.16	238.86	1,714.23

Description	Quantity	UOM	DirectCost	SubCMU	PrimeCMU	OwnerMarkup	ProjectCost
			2,209.34			*16.19*	*5,964.68*
HNC 260913130015 Switchboard instruments, metering instrumentation volt, amp, watt hour (Note: analyze demand load data)	1.00	MO	2,209.34	1,152.59	1,771.62	831.12	5,964.68
7 JOHN DAY (JDA) - AIR LIFT PUMP	**1.00**	**LS**	**1,403,160.87**	**702,042.33**	**1,109,370.46**	**520,439.48**	**3,735,013.13**
			808,066.31				*2,128,406.47*
STRUCTURAL	**1.00**	**EA**	**808,066.31**	**391,588.93**	**632,177.50**	**296,573.72**	**2,128,406.47**
			56,864.28				*149,777.69*
Barge & Crane	**1.00**	**EA**	**56,864.28**	**27,556.43**	**44,486.84**	**20,870.13**	**149,777.69**
			17.87			*16.19*	*47.06*
EP M10XX005 Flat deck cargo barge	80.00	HR	1,429.40	692.69	1,118.27	524.61	3,764.98
			270.31			*16.19*	*711.98*
RSM 015436501700 Mobilization or demobilization, crane, truck-mounted, up to 75 ton, (driver only)	2.00	EA	540.62	261.98	422.94	198.42	1,423.96
			1,485.00			*16.19*	*3,911.42*
USR CRANE001 Crane, 12 ton, rental per day	15.00	DAY	22,275.00	10,794.47	17,426.48	8,175.29	58,671.24
			2,174.62			*16.19*	*5,727.83*
RSM 015419500100 Crane crew, daily use for small jobs, 12-ton truck-mounted hydraulic crane, portal to portal	15.00	DAY	32,619.26	15,807.29	25,519.15	11,971.81	85,917.51
			263,715.37				*694,613.17*
Air Lift Pipe & Frame	**1.00**	**EA**	**263,715.37**	**127,796.47**	**206,313.42**	**96,787.91**	**694,613.17**
			736.77			*16.19*	*1,940.60*
RSM 331413401090 Water supply distribution piping, pipe, black steel, plain end, welded, 3/8" wall thickness, 30" diameter, excludes excavation or backfill	280.00	LF	206,294.37	99,970.25	161,391.03	75,713.45	543,369.10
			131.53			*16.19*	*346.43*
RSM 051223751520 Structural steel beam or girder, 100-ton project, 1 to 2 story building, W12x35, A992 steel, shop fabricated, incl shop primer, bolted connections	410.00	LF	53,925.47	26,132.28	42,187.72	19,791.54	142,037.02
			31.44			*16.19*	*82.81*
RSM 050521901500 Welding structural steel in field, single pass, 0.3 lb/LF, 1/4" thick, continuous fillet, down welding, type 6011 (Note: Allowance for field welding and cutting)	80.00	LF	2,515.31	1,218.92	1,967.81	923.16	6,625.19
			98.02			*16.19*	*258.19*
RSM 031519100140 Anchor bolt, J-type, 2-bolt set, plain steel, 3/4" dia x 12" L, incl nut & washer, job-built 2-hole template	10.00	SET	980.22	475.02	766.86	359.76	2,581.86
			4,887.31				*12,872.94*
Piles (3 EA)	**90.00**	**VLF**	**439,858.30**	**213,155.33**	**344,115.97**	**161,435.28**	**1,158,564.87**
			2,561.63			*16.19*	*6,747.19*
HTW 028113110001 Collection of sludges, debris and sediment, 170 HP, 60 CY/hr., 1200 GPM pump, 8' x 34', dredging (using rentals), hydraulic (rent per day)	5.00	DAY	12,808.13	6,206.82	10,020.23	4,700.79	33,735.96
			15,626.82			*16.19*	*41,160.28*
RSM 310660150520 Mobilization, to 36", set up and remove drill rig, for caissons, maximum	1.00	EA	15,626.82	7,572.76	12,225.39	5,735.30	41,160.28
			153.59			*16.19*	*404.55*
RSM 316223134200 Concrete-filled steel piles, steel, pipe piles, concrete filled, 50' long, 20" diameter, 59 lb./L.F., excludes mobilization or demobilization	90.00	VLF	13,823.01	6,698.63	10,814.21	5,073.27	36,409.13
			158.35			*16.19*	*417.10*

Description	Quantity	UOM	DirectCost	SubCMU	PrimeCMU	OwnerMarkup	ProjectCost
RSM 316326130400 Fixed end caisson piles, open style in stable ground, to 50' deep, 20" diameter, 0.262 CY/LF, machine drilled, includes excavation, concrete, 50 lb. reinforcing/C.Y., excludes mobilization, boulder removal, disposal, casings or ground water	90.00	VLF	14,251.85	6,906.44	11,149.70	5,230.66	37,538.65
RSM 315216102300 Cofferdams, soldier beams & lagging, H-piles with metal sheeting horizontal between piles, dewatering	2,400.00	SF	*159.73* 383,348.49	185,770.68	299,906.44	*16.19* 140,695.25	*420.72* 1,009,720.85
Diver Crew	**1.00**	**EA**	*47,628.36* **47,628.36**	**23,080.70**	**37,261.27**	**17,480.40**	*125,450.74* **125,450.74**
USR DIVER Diver	80.00	HR	*289.05* 23,124.35	11,206.06	18,090.96	*16.19* 8,487.02	*761.35* 60,908.40
USR DIVERTENDER Diver Tender	80.00	HR	*161.77* 12,941.83	6,271.61	10,124.83	*16.19* 4,749.87	*426.10* 34,088.14
USR DIVER Diver Supervisor	40.00	HR	*289.05* 11,562.18	5,603.03	9,045.48	*16.19* 4,243.51	*761.35* 30,454.20
MECHANICAL	**1.00**	**EA**	*371,494.46* **371,494.46**	**193,804.02**	**297,893.07**	**139,750.71**	*1,002,942.26* **1,002,942.26**
RSM 221519106130 Compressor, air, rotary screw, pressure lubricated, heavy duty, 2 stage, 3 phase, 250 H.P. (Note: per Ingersoll Rand quote #CTS-445711 dated 6/26/2025 plus $10,000 freight)	1.00	EA	*325,057.94* 325,057.94	169,578.66	260,656.66	*16.19* 122,281.98	*877,575.25* 877,575.25
RSM 221113643640 Pipe, stainless steel, threaded, 4" diameter, schedule 40, type 304, includes couplings and hangers 10' OC	100.00	LF	*225.52* 22,551.72	11,764.95	18,083.72	*16.19* 8,483.62	*608.84* 60,884.02
RSM 221113667580 Coupling, stainless steel, straight, threaded, 150 lb., 4", type 304	5.00	EA	*507.15* 2,535.73	1,322.86	2,033.34	*16.19* 953.90	*1,369.16* 6,845.82
RSM 221113667160 Elbow, 90 Deg., stainless steel, threaded, 150 lb., 4", type 304	6.00	EA	*694.26* 4,165.58	2,173.13	3,340.28	*16.19* 1,567.03	*1,874.34* 11,246.01
RSM 221113643600 Pipe, stainless steel, threaded, 1-1/2" diameter, schedule 40, type 304, includes couplings and hangers 10' OC	100.00	LF	*79.24* 7,923.85	4,133.77	6,353.96	*16.19* 2,980.84	*213.92* 21,392.42
RSM 221113667540 Coupling, stainless steel, straight, threaded, 150 lb., 1-1/2", type 304	5.00	EA	*135.59* 677.95	353.68	543.63	*16.19* 255.03	*366.06* 1,830.29
RSM 221113667120 Elbow, 90 Deg., stainless steel, threaded, 150 lb., 1-1/2", type 304	6.00	EA	*205.19* 1,231.12	642.26	987.21	*16.19* 463.13	*553.95* 3,323.71
RSM 221113667624 Reducer, stainless steel, concentric, threaded, 150 lb., 4", type 304	2.00	EA	*3,193.12* 6,386.24	3,331.62	5,120.98	*16.19* 2,402.41	*8,620.62* 17,241.25
HNC 221519132009 Compressor accessory, pressure regulator, rated 250 psi, heavy duty, 2-125 psi, 1-1/2" N.P.T.	1.00	EA	*964.34* 964.34	503.08	773.28	*16.19* 362.77	*2,603.47* 2,603.47
ELECTRICAL	**1.00**	**EA**	*223,600.10* **223,600.10**	**116,649.37**	**179,299.90**	**84,115.04**	*603,664.41* **603,664.41**
HNC 260583162219 Motor connections, 3 phase, 1800 RPM, 460 volt, 250 HP, incl 3" flex conduit w/4@350 kcmil, incl connection, termination, rotation testing	1.00	EA	*2,515.07* 2,515.07	1,312.08	2,016.78	*16.19* 946.13	*6,790.07* 6,790.07

Description	Quantity	UOM	DirectCost	SubCMU	PrimeCMU	OwnerMarkup	ProjectCost
			1,062.84			*16.19*	*2,869.40*
RSM 260533182500 Pull boxes, steel, type SC, raintight & weatherproof, 24" L x 24" W x 10" D, NEMA 4	1.00	EA	1,062.84	554.47	852.27	399.82	2,869.40
			99.50			*16.19*	*268.63*
RSM 260533140640 Rigid galvanized steel conduit, 3" diameter, to 10' high, includes 11 couplings per 100'	1,000.00	LF	99,502.38	51,909.15	79,788.72	37,431.32	268,631.57
			2,789.85			*16.19*	*7,531.91*
RSM 260519902600 Wire, copper, stranded, 600 volt, 350 kcmil, type THWN-THHN, normal installation conditions in wireway, conduit, cable tray	31.00	CLF	86,485.45	45,118.38	69,350.74	32,534.54	233,489.10
			2,789.85			*16.19*	*7,531.91*
RSM 260526803850 Insulated ground wire, copper, stranded, 350 kcmil	11.00	CLF	30,688.38	16,009.75	24,608.33	11,544.52	82,850.97
			447.68			*16.19*	*1,208.62*
RSM 260526800100 Grounding rod, copper clad, 10' long, 3/4" diameter	1.00	EA	447.68	233.55	358.98	168.41	1,208.62
			53.99			*16.19*	*145.77*
RSM 260526800250 Ground clamp, bronze, 3/4" diameter	1.00	EA	53.99	28.17	43.30	20.31	145.77
			634.96			*16.19*	*1,714.23*
HNC 262416331027 Circuit breakers, 3 pole, 10 k A I.C., 480 volt, 15 to 60 amp	1.00	EA	634.96	331.25	509.16	238.86	1,714.23
			2,209.34			*16.19*	*5,964.68*
HNC 260913130015 Switchboard instruments, metering instrumentation volt, amp, watt hour (Note: analyze demand load data)	1.00	MO	2,209.34	1,152.59	1,771.62	831.12	5,964.68
8 JOHN DAY (JDA) - SUBMERGED JET	**1.00**	**LS**	**815,044.42**	**421,074.74**	**651,392.74**	**305,588.18**	**2,193,100.07**
			111,189.68				*292,868.09*
STRUCTURAL	**1.00**	**EA**	**111,189.68**	**53,882.52**	**86,987.44**	**40,808.46**	**292,868.09**
			21,697.51				*57,150.17*
Barge & Crane	**1.00**	**EA**	**21,697.51**	**10,514.61**	**16,974.69**	**7,963.35**	**57,150.17**
			71.47			*16.19*	*188.25*
EP M10XX005 Flat deck cargo barge	40.00	HR	2,858.81	1,385.38	2,236.54	1,049.23	7,529.96
			270.31			*16.19*	*711.98*
RSM 015436501700 Mobilization or demobilization, crane, truck-mounted, up to 75 ton, (driver only)	2.00	EA	540.62	261.98	422.94	198.42	1,423.96
			1,485.00			*16.19*	*3,911.42*
USR CRANE001 Crane, 12 ton, rental per day	5.00	DAY	7,425.00	3,598.16	5,808.83	2,725.10	19,557.08
			2,174.62			*16.19*	*5,727.83*
RSM 015419500100 Crane crew, daily use for small jobs, 12-ton truck-mounted hydraulic crane, portal to portal	5.00	DAY	10,873.09	5,269.10	8,506.38	3,990.60	28,639.17
			27,814.22				*73,261.28*
Guide Rails	**1.00**	**EA**	**27,814.22**	**13,478.77**	**21,760.00**	**10,208.28**	**73,261.28**
			178.87			*16.19*	*471.13*
RSM 051223177150 Column, structural, 2-tier, W12x50, A992 steel, incl shop primer, splice plates, bolts (Note: Vertical guide rails (2 @ 72 VLF))	144.00	LF	25,757.16	12,481.92	20,150.69	9,453.30	67,843.08
			41.14			*16.19*	*108.36*
RSM 050521901500 Welding structural steel in water, single pass, 0.3 lb/LF, 1/4" thick, continuous fillet, down welding, type 6011 (Note: Allowance for field welding below water surface)	50.00	LF	2,057.06	996.85	1,609.31	754.98	5,418.20

Description	Quantity	UOM	DirectCost	SubCMU	PrimeCMU	OwnerMarkup	ProjectCost
			8,786.43				*23,143.01*
Hoists	**2.00**	**EA**	**17,572.85**	**8,515.80**	**13,747.83**	**6,449.53**	**46,286.01**
			5,788.97			*16.19*	*15,247.87*
HNC 412223190001 Hoists, Material Handling, wire rope, light/medium duty, electric operated, 2,000 lb capacity, beams not included	2.00	EA	11,577.95	5,610.67	9,057.82	4,249.30	30,495.74
			178.87			*16.19*	*471.13*
RSM 051223177150 Column, structural, 2-tier, W12x50, A992 steel, incl shop primer, splice plates, bolts (Note: Retrieval arm supports (2 @ 15 VLF))	30.00	LF	5,366.08	2,600.40	4,198.06	1,969.44	14,133.97
			31.44			*16.19*	*82.81*
RSM 050521901500 Welding structural steel in field, single pass, 0.3 lb/LF, 1/4" thick, continuous fillet, down welding, type 6011 (Note: Allowance for additional field welding)	20.00	LF	628.83	304.73	491.95	230.79	1,656.30
			9,542.38				*25,134.14*
Retreivable Support Frame	**1.00**	**EA**	**9,542.38**	**4,624.24**	**7,465.32**	**3,502.21**	**25,134.14**
			95.55			*16.19*	*251.66*
RSM 119216160120 Retreivable support frame, 6' x 7'-6" with bar rack and blocking plate	90.00	SF	8,599.14	4,167.14	6,727.39	3,156.03	22,649.70
			31.44			*16.19*	*82.81*
RSM 050521901500 Welding structural steel in field, single pass, 0.3 lb/LF, 1/4" thick, continuous fillet, down welding, type 6011 (Note: Allowance for additional field welding)	30.00	LF	943.24	457.09	737.93	346.18	2,484.45
			10,748.54				*28,311.13*
Platforms	**1.00**	**EA**	**10,748.54**	**5,208.74**	**8,408.95**	**3,944.89**	**28,311.13**
			63.59			*16.19*	*167.50*
HNC 055313130017 Floor grating, steel, galvanized, 1-3/4" x 3/16" bearing bars @ 15/16" O.C., cross bars @ 4" O.C., 12.5 #/S.F., up to 300 S.F., field fabricated from panels (Note: The cost for this HNC/HTRW task was last updated in the 2023 Cost Book)	64.00	SF	4,070.01	1,972.33	3,184.11	1,493.76	10,720.20
			118.26			*16.19*	*311.50*
RSM 055213500540 Railing, pipe, steel, galvanized, 2 rails, 3'-6" high, posts @ 5' OC, 1-1/4" diameter, shop fabricated	24.00	LF	2,838.32	1,375.45	2,220.51	1,041.71	7,475.98
			648.18			*16.19*	*1,707.28*
RSM 051223174500 Structural tubing, square, 4" x 4" x 1/4" x 12'-0", incl shop primer (Note: Frame for grating)	4.00	EA	2,592.73	1,256.44	2,028.38	951.58	6,829.13
			31.19			*16.19*	*82.15*
RSM 050521901500 Welding structural steel in field, single pass, 0.3 lb/LF, 1/4" thick, continuous fillet, down welding, type 6011 (Note: Allowance for field welding)	40.00	LF	1,247.48	604.53	975.95	457.85	3,285.81
			23,814.18				*62,725.37*
Diver Crew	**1.00**	**EA**	**23,814.18**	**11,540.35**	**18,630.64**	**8,740.20**	**62,725.37**
			289.05			*16.19*	*761.35*
USR DIVER Diver	40.00	HR	11,562.18	5,603.03	9,045.48	4,243.51	30,454.20
			161.77			*16.19*	*426.10*
USR DIVERTENDER Diver Tender	40.00	HR	6,470.92	3,135.81	5,062.41	2,374.93	17,044.07
			289.05			*16.19*	*761.35*

Description	Quantity	UOM	DirectCost	SubCMU	PrimeCMU	OwnerMarkup	ProjectCost
USR DIVER Diver Supervisor	20.00	HR	5,781.09	2,801.52	4,522.74	2,121.76	15,227.10
			516,966.42				*1,395,680.20*
MECHANICAL	**1.00**	**EA**	**516,966.42**	**269,694.92**	**414,543.76**	**194,475.10**	**1,395,680.20**
			216,103.02			*16.19*	*583,424.19*
RSM 221123112280 Submerible pump, propeller, stainless steel, 445 RPM, 40 H.P. (Note: per engineer's estimate + $750 /EA freight)	2.00	EA	432,206.05	225,476.49	346,576.32	162,589.51	1,166,848.37
			293.67			*16.19*	*792.82*
RSM 221113780170 Pipe, plastic, high density polyethylene (HDPE), single wall, straight, welded, based on 40' length, 36" diam., DR 26, add 1 weld per joint, excludes hangers, trenching, backfill, hoisting or digging equipment	40.00	LF	11,746.61	6,128.06	9,419.34	4,418.90	31,712.91
			4,188.78			*16.19*	*11,308.67*
RSM 221113781280 Reducer, plastic, high density polyethylene (HDPE), single wall, welded, 36" x 32" diam., DR 17, add 1 weld per joint, excludes hangers, trenching, backfill, hoisting or digging equipment	1.00	EA	4,188.78	2,185.24	3,358.89	1,575.76	11,308.67
			325.42			*16.19*	*878.54*
RSM 221113784190 Welding, plastic, high density polyethylene (HDPE), single wall, labor per joint, cost based on the thickest wall for each diameter, 36" pipe size, weld, excludes welding machine	1.00	EA	325.42	169.77	260.94	122.42	878.54
			1,413.73			*16.19*	*3,816.71*
RSM 015113500830 Temporary equipment, welding machine, 100 amp	1.00	MO	1,413.73	737.52	1,133.63	531.82	3,816.71
			16,771.46			*16.19*	*45,278.75*
HTW 025213133002 Pump accessories, suction inlet / outlet air nozzle (Note: per engineer - manufacturer suction inlet + custom outlet air nozzle - on set per pump)	4.00	EA	67,085.84	34,997.84	53,794.63	25,236.70	181,115.00
			186,888.32				*504,551.78*
ELECTRICAL	**1.00**	**EA**	**186,888.32**	**97,497.30**	**149,861.55**	**70,304.62**	**504,551.78**
			20,762.58			*16.19*	*56,053.79*
RSM 262923101170 Variable frequency drives, custom-engineered, 460 volt, 40 HP motor size (Note: add 30% for NEMA 4)	2.00	EA	41,525.16	21,663.16	33,298.10	15,621.15	112,107.57
			353.36			*16.19*	*953.98*
HNC 260583162213 Motor connections, 3 phase, 1800 RPM, 460 volt, 40 HP, incl 1" flex conduit w/4#6, incl connection, termination, rotation testing	2.00	EA	706.72	368.69	566.70	265.86	1,907.96
			3.80			*16.19*	*10.27*
RSM 260519700300 Portable cord, type SO, 600 volt, 4 conductor, #12, in tray or exposed	200.00	LF	760.69	396.84	609.98	286.16	2,053.67
			1,062.84			*16.19*	*2,869.40*
RSM 260533182500 Pull boxes, steel, type SC, raintight & weatherproof, 24" L x 24" W x 10" D, NEMA 4	2.00	EA	2,125.68	1,108.94	1,704.54	799.65	5,738.81
			99.50			*16.19*	*268.63*
RSM 260533140640 Rigid galvanized steel conduit, 3" diameter, to 10' high, includes 11 couplings per 100'	1,000.00	LF	99,502.38	51,909.15	79,788.72	37,431.32	268,631.57
			412.94			*16.19*	*1,114.84*
RSM 260519901350 Wire, copper, stranded, 600 volt, #6, type THWN-THHN, normal installation conditions in wireway, conduit, cable tray	31.00	CLF	12,801.21	6,678.23	10,265.00	4,815.63	34,560.07
			412.94			*16.19*	*1,114.84*
RSM 260526803740 Insulated ground wire, copper, #6	11.00	CLF	4,542.36	2,369.69	3,642.42	1,708.77	12,263.25
			447.68			*16.19*	*1,208.62*

Description	Quantity	UOM	DirectCost	SubCMU	PrimeCMU	OwnerMarkup	ProjectCost
RSM 260526800100 Grounding rod, copper clad, 10' long, 3/4" diameter	2.00	EA	895.35	467.10	717.96	336.82	2,417.23
			53.99			*16.19*	*145.77*
RSM 260526800250 Ground clamp, bronze, 3/4" diameter	2.00	EA	107.99	56.34	86.59	40.62	291.54
			634.96			*16.19*	*1,714.23*
HNC 262416331027 Circuit breakers, 3 pole, 10 k A I.C., 480 volt, 15 to 60 amp	2.00	EA	1,269.92	662.50	1,018.32	477.73	3,428.47
			2,209.34			*16.19*	*5,964.68*
HNC 260913130015 Switchboard instruments, metering instrumentation volt, amp, watt hour (Note: analyze demand load data)	1.00	MO	2,209.34	1,152.59	1,771.62	831.12	5,964.68
			10,220.75				*27,593.48*
Hoist Power	**2.00**	**EA**	**20,441.51**	**10,664.08**	**16,391.59**	**7,689.79**	**55,186.97**
			86.69			*16.19*	*234.04*
RSM 260533160350 Outlet boxes, pressed steel, 4-11/16" square	4.00	EA	346.75	180.90	278.05	130.44	936.15
			27.53			*16.19*	*74.33*
RSM 260533140540 Rigid galvanized steel conduit, 1" diameter, to 10' high, includes 11 couplings per 100'	500.00	LF	13,765.34	7,181.20	11,038.12	5,178.32	37,162.97
			174.57			*16.19*	*471.29*
RSM 260519901200 Wire, copper, stranded, 600 volt, #12, type THWN-THHN, normal installation conditions in wireway, conduit, cable tray	15.50	CLF	2,705.79	1,411.57	2,169.71	1,017.88	7,304.94
			174.57			*16.19*	*471.29*
RSM 260526803710 Insulated ground wire, copper, #12	5.50	CLF	960.12	500.88	769.90	361.18	2,592.08
			447.68			*16.19*	*1,208.62*
RSM 260526800100 Grounding rod, copper clad, 10' long, 3/4" diameter	2.00	EA	895.35	467.10	717.96	336.82	2,417.23
			53.99			*16.19*	*145.77*
RSM 260526800250 Ground clamp, bronze, 3/4" diameter	2.00	EA	107.99	56.34	86.59	40.62	291.54
			685.01			*16.19*	*1,849.34*
HNC 262416331027 Circuit breakers, 3 pole, 10 k A I.C., 480 volt, 15 to 60 amp	2.00	EA	1,370.01	714.72	1,098.58	515.38	3,698.69
			145.08			*16.19*	*391.68*
HNC 262726330005 Switch, SPST, 120 volt, 20 amp, exposed, complete	2.00	EA	290.16	151.37	232.68	109.16	783.37

Appendix F. Data Log

USACE Fishway Cooling – Data Log

This purpose of this document is to briefly summarize data provided by USACE to Jacobs, and other data sources that were utilized in support of this study.

Data Type and Description	Project	Notes
Data		
Fishway temperature data	LMN, HLD, MNA, JDA	Telemetry data from various fixed monitoring stations in the fishways.
Fishway hydraulic data	LMN, HLD, MNA, JDA	Operating water surface elevations, hydraulic differentials and flow rates.
Reservoir temperature string data	LMN, HLD, MNA, JDA	From Columbia River Operational Hydrometeorological Management System (CROHMS).
Drawings		
Adult fish ladder as-built drawings	LMN, HLD, MNA, JDA	Various drawings provided in PDF, TIFF, JPEG and DGN formats.
General site plan drawings	LMN, HLD, MNA, JDA	With temperature monitoring station locations.
Spray bar shop drawings for Lower Granite	LWG	Prepared by Waite Specialty Machine, Inc. (2017).
Spray bar contract drawings for Little Goose	LGS	Prepared by USACE (2015).
Email and General Correspondence		
Email from Ryan Laughery/USACE to Ken Hanson/Jacobs dated 7 July 2025 regarding existing spray bar pressures.	LWG	Included 4 photos of Lower Granite spray bar. Teeth are adjusted from approximately 4.0 to 6.5 psi to provide appropriate flow distribution and plunging jet.
Ladder Cooling Alternatives Evaluation	LMN, HLD, MNA, JDA	USACE provided summary of project-specific discussions following Brainstorming Meeting, as well as selected alternatives for further evaluation.
Email from Bennett Moore/USACE to Jacobs dated 25 August 2025 regarding Ice Harbor forebay.	HLD	Included 3 historical construction photos dated 3 March 1959 indicating that the HLD forebay is perhaps approximately 20 feet below the invert of the southerly fishway exit.
A-E Scope of Work provided by USACE dated 26 August 2024.	LMN, HLD, MNA, JDA	Provides project description and operational information.
Photos		
Photos of dewatered diffuser from January 2025.	LMN	Make-up water floor diffuser in Pool No. 6.
Photos of dewatered fishway from January 2025.	HLD	Various locations throughout the fishway.
Photos in PowerPoint presentation of dewatered fishway.	MNA	Various locations throughout the fishway.

Papers and Reports		
2024 Fish Passage Plan, Lower Columbia & Snake River Hydropower Projects, March 2025-February 2026, USACE Northwestern Division, Columbia Basin Management, Reservoir Control CENWD-PDW-R	General	General project configuration and operational information.
Anchor QEA. 2017. Lower Granite Adult Passage and Post-passage Behavior Report. Prepared for USACE. March.	LWG	Provides spray bar post-construction fish evaluation data.
C-CORE & CanadianPond.ca. 2025. *Validation and verification field trials of air diffuser systems for upwelling applications*. Proceedings of the ASME 2025 44th International Conference on Ocean, Offshore and Arctic Engineering (OMAE2025), Vancouver, BC, Canada.	General	Provides empirical data in support bubbler alternative evaluation.
CH2M Hill. 2017. Computational Fluid Dynamics Modeling of Thermal Influence on Operational Scenarios at Lower Granite Dam – Fish Ladder Exit Model. Prepared for USACE Walla Walla District. 25 October.	LWG	Provides thermal model data for spray bar.
Fish ladder operations/maintenance manual excerpts.	LMN, HLD, MNA, JDA	Provides additional detail on fishway operations.
Jacobs. 2011. In association with AECOM. Alternative Analysis Report for Lower Granite Adult Fishway – Reduction in Temperature Differential. Prepared for the USACE Walla Walla District. 27 January.	LWG	Alternatives evaluation for LWG
University of Idaho. 2022. Student design project by Moore, Lauren, et. al. (MEGA Engineering). *USACE Fish Ladder Design Lower Monumental Dam.* Drawings and calculations depicting a conceptual bubbler system. 28 April.	LMN	Includes drawings and calculations for a bubbler concept at LMN.
USACE. 2022. *Memorandum for the Record, South Fish Ladder Temperatures*. Prepared by CENWP-OD-J (Portland District Operations Manager). 18 October.	JDA	Summary and evaluation of temperature data at JDA.
USACE. 2022a. Adult Fishway Temperatures and Fish Passage during 2021. Prepared by Chris Peery and Karl Anderson, USACE Walla Walla District. 10 January.	LWG, LGS, LMN, HLD, MNA	PowerPoint presentation evaluating temperatures and fish passage.
USACE. 2021. Memorandum for the Record: Cooling Water Potential and NWW Projects. 2 July.	LMN, HLD, MNA	Provides historical temperature data.
USACE (2011, 2011, 1989 and 2017) Water Control Manuals	LMN, HLD, MNA, JDA	Provides pertinent project information, water control data and associated design criteria.

Appendix G. Review Comments

Comment Report: All Comments
Project: (FY250729) Adult Fish Ladder Cooling Concept Eval Review: Draft Adult Fish Ladder Cooling Concept Eval
Displaying 42 comments for the criteria specified in this report.
547 ms to run this page

Id	Discipline	Section/Figure	Page Number	Line Number
11461228	Biology-Ecology	n/a	n/a	n/a
Comment Classification: **UNCLASSIFIED (U)** Looks like the meetings we had so I have no comments to add. Submitted By: Bobby Johnson (541-922-2212). Submitted On: Jul 30 2025				
1-0	Evaluation **Concurred** No action. Submitted By: Ralph Field (3606330435) Submitted On: Aug 04 2025			
1-1	Backcheck Recommendation **Open Comment** I had email exchanges with Ryan Laughery about tower facing north, tracking fish to see they go to the powerhouse and heavy debris loads near the exit. I am trusting Ryan's judgement. Submitted By: Bobby Johnson (541-922-2212) Submitted On: Sep 11 2025			
1-2	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Bobby Johnson (541-922-2212) Submitted On: Sep 11 2025			
	Current Comment Status: **Comment Closed**			
11469641	Biology-Ecology	Advantages	4-4	n/a
Comment Classification: **UNCLASSIFIED (U)** Redundancy would be an advantage. Using the same system/pumps for each cooling water system at all projects would potentially allow for quicker repairs with part sharing among projects. Submitted By: Ryan Ashcraft (509-527-7262). Submitted On: Aug 05 2025				
1-0	Evaluation **Concurred** The spray bar alternatives may have mechanical elements (for example, pumps or nozzles) that are common between projects and could enhance resiliency, subject to site-specific installation and operational requirements. James Kapla Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025			
1-1	Backcheck Recommendation **Close Comment** Submitted By: Ryan Ashcraft (509-527-7262) Submitted On: Aug 27 2025			
	Current Comment Status: **Comment Closed**			
11469644	Biology-Ecology	Disadvantages	4-4	n/a
Comment Classification: **UNCLASSIFIED (U)** Is barrier the correct term? "The abundance of spray and turbulence may disrupt normal fish migration". Submitted By: Ryan Ashcraft (509-527-7262). Submitted On: Aug 05 2025				

1-0	Evaluation **Concurred** "...may delay or disrupt normal fish migration." James Kapla Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ryan Ashcraft (509-527-7262) Submitted On: Aug 27 2025
	Current Comment Status: **Comment Closed**

11469653	Biology-Ecology	Disadvantages	4-6	n/a

Comment Classification: **UNCLASSIFIED (U)**

Additional disadvantage: In water infrastructure needed. is the deflector floating? Debris catch, would it be in the way of any maintenance procedures, boats, barges?

Submitted By: Ryan Ashcraft (509-527-7262). Submitted On: Aug 05 2025

1-0	Evaluation **Concurred** Deflector boom is floating and could be susceptible to issues from icing or debris, requiring periodic maintenance. Issues associated with normal maintenance procedures (for example, installation of bulkheads) or navigation are anticipated to be minimal. James Kapla Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ryan Ashcraft (509-527-7262) Submitted On: Aug 27 2025
	Current Comment Status: **Comment Closed**

11469656	Biology-Ecology	Disadvantages	4-6	n/a

Comment Classification: **UNCLASSIFIED (U)**

Same as previous barrier comment.

Submitted By: Ryan Ashcraft (509-527-7262). Submitted On: Aug 05 2025

1-0	Evaluation **Concurred** "...may delay or disrupt normal fish migration." James Kapla Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ryan Ashcraft (509-527-7262) Submitted On: Aug 27 2025
	Current Comment Status: **Comment Closed**

11469689	Biology-Ecology	Disadvantages	4-8	n/a

Comment Classification: **UNCLASSIFIED (U)**

"Relatively high O&M cost", What is making the cost so high relative to other alternatives?

Submitted By: Ryan Ashcraft (509-527-7262). Submitted On: Aug 05 2025

1-0	Evaluation **Concurred** This disadvantage has been removed as O&M costs are now anticipated to be average relative to the other alternatives, given revision of the required compressor capacity. James Kapla Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ryan Ashcraft (509-527-7262) Submitted On: Aug 27 2025
	Current Comment Status: **Comment Closed**

11469715	Biology-Ecology	Disadvantages	4-12	n/a

Comment Classification: **UNCLASSIFIED (U)**

Additional Disadvantage: Lamprey and other small fish/aquatic organisms may have negative interactions with propellers.

Submitted By: Ryan Ashcraft (509-527-7262). Submitted On: Aug 05 2025

1-0	Evaluation **Check and Resolve** Agreed, however risk is anticipated to be small given depth of the intake and low approach velocities at bar screen. This risk is also common with the other pumped alternatives. James Kapla Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ryan Ashcraft (509-527-7262) Submitted On: Aug 27 2025
	Current Comment Status: **Comment Closed**

11469720	Biology-Ecology	Disadvantages	4-13	n/a

Comment Classification: **UNCLASSIFIED (U)**

Additional Disadvantage: Fish Behavior. Concerns fish would not sound down to exit chimney.

Submitted By: Ryan Ashcraft (509-527-7262). Submitted On: Aug 05 2025

1-0	Evaluation **For Information Only** The gravity chimney alternative (modified following the Brainstorming Workshop) includes a fish exit gate opening near the surface to accommodate fish that don't want to sound towards the deep opening. James Kapla Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ryan Ashcraft (509-527-7262) Submitted On: Aug 27 2025
	Current Comment Status: **Comment Closed**

11469733	Biology-Ecology	Fishway Operations	6-1	n/a

Comment Classification: **UNCLASSIFIED (U)**

Chum Salmon are not a concern at John Day and up.

Submitted By: Ryan Ashcraft (509-527-7262). Submitted On: Aug 05 2025

1-0	Evaluation **Concurred** Chum salmon have been removed as a species of concern. James Kapla Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ryan Ashcraft (509-527-7262) Submitted On: Aug 27 2025
	Current Comment Status: **Comment Closed**

11469748	Biology-Ecology	Fisheries and Hydraulic Evaluation	6-7	n/a

Comment Classification: **UNCLASSIFIED (U)**

Plunging flow could create negative fish behavior (jumping) simulating waterfall?

Submitted By: Ryan Ashcraft (509-527-7262). Submitted On: Aug 05 2025

1-0	Evaluation **Concurred** Plunging flow was found to be more effective than skimming flow per the CFD model study; however, fish behavior is somewhat unknown. Following sentence has been added: "Field adjustment of flow, nozzles or other elements may be required to achieve optimum hydraulic conditions while not creating a false attraction issue for fish." James Kapla Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ryan Ashcraft (509-527-7262) Submitted On: Aug 27 2025
	Current Comment Status: **Comment Closed**

11469803	Biology-Ecology	Agency Coordination	1-2	n/a

Comment Classification: **UNCLASSIFIED (U)**

Bonneville Power Administration (BPA)
Confederated Tribes of the Colville Reservation (CTCR)
Confederated Tribes of the Umatilla Indian Reservation (CTUIR)
Confederated Tribes of the Warm Springs (CTWS)
Confederated Tribes and Bands of the Yakama Nation (YN)
Idaho Department of Fish and Game (IDFG)
National Marine Fisheries Service (NMFS)
Nez Perce Tribe (NPT)
Oregon Department of Fish and Wildlife (ODFW)
U.S. Army Corps of Engineers- Northwestern Division (NWD)
U.S. Army Corps of Engineers- Portland District (NWP)
U.S. Army Corps of Engineers- Walla Walla District (NWW)
U.S. Fish and Wildlife Service (USFWS)
Washington Department of Fish and Wildlife (WDFW)

Submitted By: Ryan Ashcraft (509-527-7262). Submitted On: Aug 05 2025

1-0	Evaluation **Concurred** FFDRWG participate list has been updated accordingly. James Kapla Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025

1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ryan Ashcraft (509-527-7262) Submitted On: Aug 27 2025
	Current Comment Status: **Comment Closed**

11471367	Biology-Ecology	n/a	n/a	n/a

Comment Classification: **UNCLASSIFIED (U)**

Note, adult fish facilities winter maintenance periods. Each alternative will require some level of coordinated outage, some more than others.
LoMo Winter Maintenance 1/1/26-2/28/26.
Ice Harbor Winter Maintenance 1/1/26-2/28/26.
McNary Winter Maintenance 1/1/26-2/28/26.
John Day Winter Maintenance 12/1/25-2/28/26.

Submitted By: Ryan Ashcraft (509-527-7262). Submitted On: Aug 06 2025

1-0	Evaluation **Concurred** Thank you. This information has been added to Section 7 - Construction and Permitting Considerations. James Kapla Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ryan Ashcraft (509-527-7262) Submitted On: Aug 27 2025
	Current Comment Status: **Comment Closed**

11471754	Mechanical	n/a	25	n/a

Comment Classification: **UNCLASSIFIED (U)**

Ice Harbor air compressors are rated for 417 CFM. So closer to 400 CFM than 500 CFM.

Submitted By: Bennett Moore (541-349-3009). Submitted On: Aug 06 2025

1-0	Evaluation **Concurred** 500 CFM has been updated to 400 CFM. James Teeter Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Bennett Moore (541-349-3009) Submitted On: Sep 15 2025
	Current Comment Status: **Comment Closed**

11471878	Commissioning	n/a	75	n/a

Comment Classification: **UNCLASSIFIED (U)**

Will contractor evaluate TDG levels at the project site during system commissioning? Is the expectation for NWW to perform this?

Submitted By: Bennett Moore (541-349-3009). Submitted On: Aug 06 2025

Revised Aug 06 2025.

1-0	Evaluation **Check and Resolve** The following sentences have been added: "TDG measurements could be made periodically during construction to optimize the diffuser location, airflow and other parameters. Permanent TDG sensors could also be installed in the reservoir and fishway to provide real-time data during normal operations." James Kapla Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Bennett Moore (541-349-3009) Submitted On: Sep 15 2025
	Current Comment Status: **Comment Closed**

11471905	Other	n/a	102	n/a

Comment Classification: **UNCLASSIFIED (U)**

Illustration of the retrieval arm, wire rope hoist, and bubbler ring in Plate HLD-4A is not the same as the location in Plate HLD-5A. Plate HLD-5A seems to be the correct location.

Submitted By: Bennett Moore (541-349-3009). Submitted On: Aug 06 2025

1-0	Evaluation **Concurred** Thank you. Plate HLD-4A will be revised accordingly. James Kapla Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Bennett Moore (541-349-3009) Submitted On: Sep 15 2025
	Current Comment Status: **Comment Closed**

11471929	Mechanical	n/a	75	n/a

Comment Classification: **UNCLASSIFIED (U)**

Plate HLD-5A shows an elevation change from forebay (440') to fully lowered bubbler position (377') of 63'. This does not align with the mechanical evaluation from page 75 below:

"Through spreadsheet analysis, it was determined that the compressed air cools to approximately 116.2°F through convective heat exchange with the surrounding water as it travels down to the diffuser depth (~100 ft)."

63' is maximum water column height. Not 100'. Should re-evaluate thermal impact.

Submitted By: Bennett Moore (541-349-3009). Submitted On: Aug 06 2025

1-0	Evaluation **Concurred** Thermal impact evaluation has been updated to 63'. James Teeter Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Open Comment** Upon further investigation Ice Harbor project has determined the depth of water to be around 20 feet at south shore fish ladder exit. The Thermal impact at elevation 63' below surface may be accurate, but it's not possible to lower a bubbler 63' deep in front of the south shore fish ladder exit. This may need to be corrected again. Thermal impacts at or around 20 feet of water depth should be evaluated. Submitted By: Bennett Moore (541-349-3009) Submitted On: Sep 15 2025
2-0	Evaluation **Concurred** The depth of the diffuser has been updated, as well as the thermal impact. Because the depth at this

	location is 20 feet, rather than 63-100 feet, verbiage has been added to the bubbler section indicating that a single bubbler located below the fish exit is no longer a viable alternative for this location. James Teeter Submitted By: Ralph Field (3606330435) Submitted On: Sep 17 2025
2-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Bennett Moore (541-349-3009) Submitted On: Sep 17 2025
	Current Comment Status: **Comment Closed**

11471989	Mechanical	n/a	75	n/a

Comment Classification: **UNCLASSIFIED (U)**

Where exactly would the bubbler air compressor be located?

Submitted By: Bennett Moore (541-349-3009). Submitted On: Aug 06 2025

1-0	Evaluation **Concurred** Ice Harbor compressor will be located at the South end of the "EL 440.0 Service Gallery". The report has been updated as such. James Teeter Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Open Comment** Submitted By: Bennett Moore (541-349-3009) Submitted On: Sep 15 2025
1-2	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Bennett Moore (541-349-3009) Submitted On: Sep 15 2025
	Current Comment Status: **Comment Closed**

11472162	Electrical	n/a	102	n/a

Comment Classification: **UNCLASSIFIED (U)**

Where will wire rope hoist electrical power be sourced?

Submitted By: Bennett Moore (541-349-3009). Submitted On: Aug 06 2025

1-0	Evaluation **Concurred** This will be determined and included in the final report. Kashifa Kabeer Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Bennett Moore (541-349-3009) Submitted On: Sep 15 2025
2-0	Evaluation **For Information Only** Per Sections 2.2 and 6.7.1.4, it is assumed that power would be sourced from MCC "FCQ3" or "CQ08" located on Level 7.5. Submitted By: Shannon Daisey (562-619-5127) Submitted On: Sep 02 2025
	Backcheck not conducted
	Current Comment Status: **Comment Closed**

11472184	Electrical	n/a	76	n/a

Comment Classification: **UNCLASSIFIED (U)**

Would all three Flygt PP 4680 pumps be powered from the same circuit breaker in FCQ3? If so, then all three pumps would operate simultaneously, and you could not operate just one or two pumps independently if something happens to the other(s).

What would happen if each pump needed their own breaker?

Submitted By: Bennett Moore (541-349-3009). Submitted On: Aug 06 2025

Revised Aug 06 2025.

1-0	Evaluation **For Information Only** The pumps can be fed from individual breakers in FCQ3 or the space in CQ08 can be used. Kashifa Kabeer Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Open Comment** Flygt PP 4680 Pumps are dirven by 30 or 40 HP motors. FLA for a 30 h.p. motor is around 40A. There is 1 spare 70A breaker and two spare 15A breakers. How would the three pumps be powered safely? Submitted By: Bennett Moore (541-349-3009) Submitted On: Sep 15 2025
2-0	Evaluation **Concurred** "Text updated to this, please advise if this is acceptable - ""The proposed alternative involves the installation of three 480V, 3-phase pumps, each rated at approximately 30 horsepower. Preliminary assessment indicates that MCC "FCQ3" has two spare breaker positions, and MCC "CQ08" has one available space that is insufficient to support the new pump loads. In accordance with the NEC, specifically Article 220, the electrical contractor is required to obtain and evaluate meter and demand load data prior to the addition of new loads to existing electrical equipment. This ensures that the upstream electrical infrastructure has sufficient capacity to accommodate the proposed load without exceeding design limitations. Therefore, it is necessary to collect current metering data and perform a demand load analysis for all equipment potentially impacted by this addition. The results of this analysis will determine whether the existing infrastructure can support the new pumps or an additional available source is to be determined. For further guidance, refer to Section 9.2, which outlines the recommended next steps. """ Kashifa Kabeer Submitted By: Shannon Daisey (562-619-5127) Submitted On: Sep 16 2025
2-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Bennett Moore (541-349-3009) Submitted On: Sep 17 2025
	Current Comment Status: **Comment Closed**

11472198	Electrical	n/a	76	n/a

Comment Classification: **UNCLASSIFIED (U)**

FCQ3 has one (x1) spare 70A breaker. What is the maximum current draw on the Flygt PP 4680 pump? Would three pumps exceed the spare breaker size

Submitted By: Bennett Moore (541-349-3009). Submitted On: Aug 06 2025

Revised Aug 06 2025.

1-0	Evaluation **For Information Only** FCQ3 has 2 spares and CQ08 has 1 space, the report outlines the use of these to serve the pumps.

	Kashifa Kabeer Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Bennett Moore (541-349-3009) Submitted On: Sep 15 2025
	Current Comment Status: **Comment Closed**

11472268	Electrical	n/a	76	n/a

Comment Classification: **UNCLASSIFIED (U)**

Plate HLD-6B indicates 3 propeller pumps.
Table 6-8 indicates 3 pumps are needed for the pumped fish exit.
Section 6.7.2.3 states the Ice Harbor Pumped Fish Exit system utilizes TWO propeller pumps...
Section 6.7.2.4 states three propeller pumps are needed.

Mechanical section needs to be corrected.

Submitted By: Bennett Moore (541-349-3009). Submitted On: Aug 06 2025

1-0	Evaluation **Concurred** Mechanical section has been updated to match other sections. James Teeter Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Bennett Moore (541-349-3009) Submitted On: Sep 15 2025
	Current Comment Status: **Comment Closed**

11472279	Mechanical	n/a	76	n/a

Comment Classification: **UNCLASSIFIED (U)**

How will the two/three submerged propeller pumps be lowered into the forebay and be removed for maintenance and repair?

Submitted By: Bennett Moore (541-349-3009). Submitted On: Aug 06 2025

1-0	Evaluation **Concurred** The pumped fish exit alternative will have the option to install a small permanent crane structure above the pump pit on which a permanent or temporary 5-ton steel cable hoist can be installed for use during maintenance and repair. James Teeter Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Bennett Moore (541-349-3009) Submitted On: Sep 15 2025
	Current Comment Status: **Comment Closed**

11484174	Electrical	n/a	n/a	n/a

Comment Classification: **UNCLASSIFIED (U)**

I have reviewed the concept evaluation and have no comments.

Submitted By: Eleya Stadnik ((509) 527-7561). Submitted On: Aug 13 2025

1-0	Evaluation **Concurred** Noted. Kashifa Kabeer Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Mark Jones (509-527-7219) Submitted On: Sep 12 2025
	Current Comment Status: **Comment Closed**

11490396	Biology-Ecology	n/a	n/a	n/a

Comment Classification: **UNCLASSIFIED (U)**

From Dave Swank (USFWS): For Modified spray bar (#1A), we would need a way to monitor fish behavior upon exiting ladder (video system?). Could you explain why the required flows ("200% of fishway exit flow") are so high.

Submitted By: Ryan Ashcraft (509-527-7262). Submitted On: Aug 18 2025

1-0	Evaluation **Concurred** Have included an additional statement related to monitoring of fish behavior via underwater video camera or sonar (e.g. Didson). The flow ratio of 150% is an assumed value based in part on data from Lower Granite and Little Goose, and supports a relative comparison with the other alternatives. James Kapla Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ryan Ashcraft (509-527-7262) Submitted On: Aug 27 2025
	Current Comment Status: **Comment Closed**

11490405	Biology-Ecology	n/a	n/a	n/a

Comment Classification: **UNCLASSIFIED (U)**

From Dave Swank (USFWS): For Submerged jet (#3), how much of the jet will reach the ladder exit? Currently hard to determine.

Submitted By: Ryan Ashcraft (509-527-7262). Submitted On: Aug 18 2025

1-0	Evaluation **For Information Only** The submerged jet is assumed to have a flow ratio of 130% (amount of water delivered to vicinity of exit) and a thermal ratio of 60% (amount of cool water that enters the fishway), for an overall effectiveness of 78%. The overall effectiveness should be confirmed with CFD modeling or other means prior to final design and construction. James Kapla Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ryan Ashcraft (509-527-7262) Submitted On: Aug 27 2025
	Current Comment Status: **Comment Closed**

11490409	Biology-Ecology	n/a	n/a	n/a

Comment Classification: **UNCLASSIFIED (U)**

From Dave Swank (USFWS): Gravity Chimney (#5) – Unclear to me how it will convey much cold water to fishway exit. I don't think we should depend on fish sounding down to chimney opening.

Submitted By: Ryan Ashcraft (509-527-7262). Submitted On: Aug 18 2025

1-0	Evaluation **For Information Only** The gravity chimney is assumed to have a flow ratio of 100% (amount of water delivered to vicinity of exit) and a thermal ratio of 90% (amount of cool water that enters the fishway), for an overall effectiveness of 90%. This alternative includes a fish exit gate opening near the surface to accommodate fish that don't want to sound to the deep opening. James Kapla Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ryan Ashcraft (509-527-7262) Submitted On: Aug 27 2025
	Current Comment Status: **Comment Closed**

11492563	Structural	n/a	n/a	n/a

Comment Classification: **UNCLASSIFIED (U)**

Most structural evaluations will be provided with the final report. No comments for this draft at this time.

Submitted By: Lex Andrade (509-527-7272). Submitted On: Aug 19 2025

1-0	Evaluation **For Information Only** Noted. Garrett Van Ruiten Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
	Backcheck not conducted
2-0	Evaluation **Concurred** Noted. Structural evaluations have been provided. Submitted By: Shannon Daisey (562-619-5127) Submitted On: Sep 02 2025
2-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Lex Andrade (509-527-7272) Submitted On: Sep 12 2025
2-2	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Lex Andrade (509-527-7272) Submitted On: Sep 17 2025
	Current Comment Status: **Comment Closed**

11492789	Mechanical	n/a	n/a	n/a

Comment Classification: **UNCLASSIFIED (U)**

Per email - 7/31/25 Required air flow rate to match results in the ASME paper for SalmoAir is 30 SCFM (10.2 ACFM @ 20 meter depth , 28 psi).
Confirmed with personal communication with Jon Bruce.

Compressed Air Supply needed for single SalmoAir providing similar performance.
3.8 CFM @100 psi
3.2 CFM @125 psi
2.8 CFM @145 psi

This would result in a small rotatory screw drive on the order of less than 4hp and sub $5k ish.

The SalmoAir was listed at $2.5k

Cost estimate for two items around $70kish for initial price seems a little high.
This alternative is seen as the most likely alternative to prototype while design continues, so a little more interest in pinning it down.

Submitted By: Ryan Laughery (509 527 7252). Submitted On: Aug 19 2025

1-0	Evaluation **Concurred** The discrepancy in pricing largely comes from a difference in initial assumptions for water flow requirements. The initial concept included an assumption that the fish ladder exit would need a total of 150 CFS water flow and that the bubbler would be approximately 50% effective at delivering that water flow. This required the use of the OctoAir-60 at 100 SCFM and 100 PSI, which produced a larger compressor requirement than a smaller assumption would have. This number has room for refinement during subsequent design efforts. James Teeter Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ryan Laughery (509 527 7252) Submitted On: Sep 15 2025
	Current Comment Status: **Comment Closed**

11494696	Hydraulics	n/a	n/a	n/a

Comment Classification: **UNCLASSIFIED (U)**

I think it may be worth exploring and/or testing the submerged bubbler option at Lower Monumental as well. Directly below the fish ladder exit is not deep enough, but if they could be placed upstream and south of the exit they would potentially cool the entire area around the exit and also the diffuser suction. This could be a very attractive exit for the fish if the entire area is cooled effectively and it has a gradual temperature gradient as they get further into the Forebay.

Submitted By: Bryce Thompson (541 922 1368). Submitted On: Aug 20 2025

1-0	Evaluation **Check and Resolve** Agree that this concept is worth considering at LMN, and also at HLD where we recently received updated information regarding water depths at the fishway exit. A CFD forebay model may help evaluate the effectiveness of such an approach. James Kapla Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Open Comment** The final report, table 5-2, still shows the selected alternatives for further evaluation as the "modified spray bar" and "pumped fish exit". I feel that the bubbler option should also be included in this table. Submitted By: Bryce Thompson (541 922 1368) Submitted On: Sep 03 2025
2-0	Evaluation **Concurred** Alternatives selected for further evaluation were provided to the A-E by CENWW and were intended in some cases to be applicable to more than one project site even if not explicitly shown that way in the table. A note has been added to identify the potential for a bubbler at LMN. James Kapla Submitted By: Ralph Field (3606330435) Submitted On: Sep 17 2025
2-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Mark Jones (509-527-7219) Submitted On: Sep 18 2025
	Current Comment Status: **Comment Closed**

11495456	Project Management	n/a	n/a	n/a

Comment Classification: **UNCLASSIFIED (U)**

Out of the two proposed plans, the gravity chimney least impacts O&M.

Submitted By: Anthony O'Hare (5419221321). Submitted On: Aug 21 2025

1-0	Evaluation **Concurred** Agree that the gravity chimney alternative has below average O&M costs, but be aware that it does include 2 submersible propeller pumps for operation of the surface exit (added following the Brainstorming Workshop). James Kapla Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Anthony O'Hare (5419221321) Submitted On: Sep 15 2025
	Current Comment Status: **Comment Closed**

11495841	General	n/a	n/a	n/a

Comment Classification: **UNCLASSIFIED (U)**

I have reviewed and have no comments.

Submitted By: Charles Barnes ((509) 527-7257). Submitted On: Aug 21 2025

1-0	Evaluation **For Information Only** Noted. James Kapla Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Mark Jones (509-527-7219) Submitted On: Sep 12 2025
	Current Comment Status: **Comment Closed**

11496027	Biology-Ecology	n/a	n/a	n/a

Comment Classification: **UNCLASSIFIED (U)**

During the last internal meeting that we had to discuss the alternatives, we discussed the air lift pump and the bubbler systems for John Day. We expressed that our preference would be for the bubbler system as our 1st choice and the air lift as a 2nd choice. This was mainly due to the O&M friendlier nature of those two systems. To see the submerged jet alternative as one of the two selected alternatives instead of the bubbler is a little frustrating. Also, having a system with all mechanical components being easily accessible for maintenance is preferred.

Submitted By: David Miller (541-739-1063). Submitted On: Aug 21 2025

1-0	Evaluation **Check and Resolve** "Noted. It is understood that a wide variety of alternatives were selected by CENWW for detailed evaluation in part to enhance the overall understanding of each technology, regardless of project site. As such, certain alternatives (including the bubbler) are intended to be somewhat interchangeable between projects, and changes are anticipated as evaluations progress ahead of detailed design and construction. The Appendix D1 Hydraulic and Thermal Calculations for JDA will be updated to include a separate evaluation of a bubbler alternative at that project." James Kapla

	Submitted By: Shannon Daisey (562-619-5127) Submitted On: Aug 26 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: David Miller (541-739-1063) Submitted On: Sep 15 2025
	Current Comment Status: **Comment Closed**

11500112	Mechanical	n/a	n/a	n/a

Comment Classification: **UNCLASSIFIED (U)**

No Comments to add

Submitted By: James McPherson ((509)527-7610). Submitted On: Aug 22 2025

1-0	Evaluation **Concurred** Noted. Submitted By: Ralph Field (3606330435) Submitted On: Sep 02 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Mark Jones (509-527-7219) Submitted On: Sep 12 2025
	Current Comment Status: **Comment Closed**

11518766	Hydrology	Table ES-2	ii	n/a

Comment Classification: **UNCLASSIFIED (U)**

Consider adding a comment that explains why the recommended approach for John Day is not included as one of the selected alternatives for John Day.

Submitted By: Amory Cervarich (503.808.3755). Submitted On: Sep 05 2025

1-0	Evaluation **Concurred** Alternatives selected for further evaluation were provided to the A-E by CENWW, and were intended in some cases to be applicable to more than one project site even if not explicitly shown that way in the table. A note has been added to identify the preference for a bubbler at John Day. James Kapla Submitted By: Shannon Daisey (562-619-5127) Submitted On: Sep 16 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Amory Cervarich (503.808.3755) Submitted On: Sep 18 2025
	Current Comment Status: **Comment Closed**

11518779	Hydrology	n/a	ii, viii, ix, x	n/a

Comment Classification: **UNCLASSIFIED (U)**

Consider removing the extraneous page number on the left side of the footer.

Submitted By: Amory Cervarich (503.808.3755). Submitted On: Sep 05 2025

1-0	Evaluation **Concurred** Thanks for catching this Amory; we'll remove them. James Kapla Submitted By: Shannon Daisey (562-619-5127) Submitted On: Sep 16 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Amory Cervarich (503.808.3755) Submitted On: Sep 18 2025
	Current Comment Status: **Comment Closed**

11518816	Hydrology	Tables 2.1, 2.3, 2.5, and 2.7	n/a	n/a

Comment Classification: **UNCLASSIFIED (U)**

Numerous inconsistencies in tabled values including dam length; dam maximum structural height, feet; reservoir length, miles; reservoir surface area, acres; normal forebay elevations, feet msl; spillway crest elevation, feet msl; spillway design discharge, cfs (include reference elevation). Please coordinate with USACE for correct values.

Submitted By: Amory Cervarich (503.808.3755). Submitted On: Sep 05 2025

1-0	Evaluation **Concurred** Forebay water surface elevations in the Pertinent Project Data tables are intended to describe the full range of normal elevations on an annual basis. Thermal calculations utilize normal forebay water surface elevations from the period of June through September which in some cases may vary from the normal annual range. Clarifications and corrections have been made accordingly. James Kapla Submitted By: Shannon Daisey (562-619-5127) Submitted On: Sep 16 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Amory Cervarich (503.808.3755) Submitted On: Sep 18 2025
	Current Comment Status: **Comment Closed**

11518826	Hydrology	n/a	5-1	n/a

Comment Classification: **UNCLASSIFIED (U)**

Consider providing a brief explanation of how "Overall Rank" determined.

Submitted By: Amory Cervarich (503.808.3755). Submitted On: Sep 05 2025

1-0	Evaluation **Concurred** An explanation has been provided to the table: "Overall Rank is a summation of the evaluation criteria rankings for the alternative, with no weighting applied." James Kapla Submitted By: Shannon Daisey (562-619-5127) Submitted On: Sep 16 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Amory Cervarich (503.808.3755) Submitted On: Sep 18 2025
	Current Comment Status: **Comment Closed**

11518837	Hydrology	n/a	B-10	n/a

Comment Classification: **UNCLASSIFIED (U)**

"Normal reservoir levels fluctuate from elevation 335 to 340 feet." This range is consistent with the Water Control Manual but inconsistent with Table 2.5. Confirm value and use same value consistently throughout document.

Submitted By: Amory Cervarich (503.808.3755). Submitted On: Sep 05 2025

1-0	Evaluation **Concurred** Forebay water surface elevations in the Pertinent Project Data tables are intended to describe the full range of normal elevations on an annual basis. Thermal calculations utilize normal forebay water surface elevations from the period of June through September which in some cases may vary from the normal annual range. Clarifications and corrections have been made accordingly. James Kapla Submitted By: Shannon Daisey (562-619-5127) Submitted On: Sep 16 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Amory Cervarich (503.808.3755) Submitted On: Sep 18 2025
	Current Comment Status: **Comment Closed**

11518845	Hydrology	n/a	B-12	n/a

Comment Classification: **UNCLASSIFIED (U)**

"Normal reservoir level elevations fluctuate between 257 and 268 feet." This range is inconsistent with the Water Control Manual and Table 2.7. Confirm value and use same value throughout document.

Submitted By: Amory Cervarich (503.808.3755). Submitted On: Sep 05 2025

1-0	Evaluation **Concurred** Forebay water surface elevations in the Pertinent Project Data tables are intended to describe the full range of normal elevations on an annual basis. Thermal calculations utilize normal forebay water surface elevations from the period of June through September which in some cases may vary from the normal annual range. Clarifications and corrections have been made accordingly. James Kapla Submitted By: Shannon Daisey (562-619-5127) Submitted On: Sep 16 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Amory Cervarich (503.808.3755) Submitted On: Sep 18 2025
	Current Comment Status: **Comment Closed**

11526432	Structural	Table 6-3. Design Load Parameters	6-4	n/a

Comment Classification: **UNCLASSIFIED (U)**

"Default" was used for the Site Classification. Use Geotech data to determine actual Site Classification. Should be somewhere around a "B" or "C", this will change seismic design category.

Submitted By: Lex Andrade (509-527-7272). Submitted On: Sep 12 2025

1-0	Evaluation **Concurred** For this alternatives study, project/site geotechnical information is not yet available. Site class assumption has been revised to "C" to better match expected soil conditions. Site class "C" was conservatively selected since it results in a higher SDC, Sds, and Sd1 than site class "B". Site class should be confirmed by a geotechnical engineer as part of future design of a selected alternative. Garrett Van Ruiten Submitted By: Shannon Daisey (562-619-5127) Submitted On: Sep 15 2025

1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Lex Andrade (509-527-7272) Submitted On: Sep 17 2025
	Current Comment Status: **Comment Closed**

11526434	Structural	n/a	n/a	n/a

Comment Classification: **UNCLASSIFIED (U)**

Include paint system for submerged steel components.

Submitted By: Lex Andrade (509-527-7272). Submitted On: Sep 12 2025

1-0	Evaluation **Concurred** Recommended paint system for submerged steel components is a vinyl paint system (System 5-E-Z). Garrett Van Ruiten Submitted By: Shannon Daisey (562-619-5127) Submitted On: Sep 15 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Lex Andrade (509-527-7272) Submitted On: Sep 17 2025
	Current Comment Status: **Comment Closed**

11526440	Structural	n/a	n/a	n/a

Comment Classification: **UNCLASSIFIED (U)**

Will submerged stainless steel anchors and carbon steel cause any galvanic corrosion? If so, should there be some kind of isolation kit?

Submitted By: Lex Andrade (509-527-7272). Submitted On: Sep 12 2025

1-0	Evaluation **Concurred** Stainless steel is the preferred anchor material for underwater or submerged applications. Use of washers or gaskets may be utilized as an isolation barrier to prevent corrosion. Garrett Van Ruiten Submitted By: Shannon Daisey (562-619-5127) Submitted On: Sep 15 2025
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Lex Andrade (509-527-7272) Submitted On: Sep 17 2025
	Current Comment Status: **Comment Closed**

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