US Army Corps
of Engineers®
Portland District

The Dalles Dam

Columbia River Basin, Washington - Oregon

Hydraulic Evaluation of Lower Columbia River Adult Bypass Systems (HELCRABS)

The Dalles Dam North Fish Ladder

Hydraulic/Operational Evaluation

DRAFT

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Table of Contents

LIST OF ACRONYMS ..... **IV**

EXECUTIVE SUMMARY ..... **V**

GENERAL V
HELCRABS COMPUTER MODEL V
FISHERIES CRITERIA VI
EVALUATION OF EXISTING OPERATION VI
RECOMMENDED CHANGES TO THE OPERATION VII
POTENTIAL STRUCTURAL IMPROVEMENTS VIII
RECOMMENDATIONS FOR FUTURE MODEL IMPROVEMENTS IX

1.0 INTRODUCTION **1**

2.0 FISHWAY SYSTEM FEATURES **3**

2.1 GENERAL DESCRIPTION OF FISHWAY 3

3.0 NUMERICAL MODEL **11**

3.1 MODEL OPERATION 11
3.2 NUMERICAL MODEL EVALUATION 13
3.3 EVALUATION PROCEDURES 13
3.3.1 Field Measurements *13*
3.3.2 Evaluation of Program Code and Geometry Files *15*
3.3.3 Comparison with Field Measurements *22*
3.4 MODEL EVALUATION CONCLUSIONS 25

4.0 FISHWAY EVALUATIONS **27**

4.1 OPERATIONAL CRITERIA 27
4.2 EVALUATION PROCEDURES 27
4.3 FISHWAY EVALUATION CONCLUSIONS 28
4.3.1 Current Operations Plan *28*

5.0 RECOMMENDATIONS **33**

6.0 REFERENCES **42**

APPENDIX A: THE DALLES NORTH FISHWAY PROGRAM AND GEOMETRY FILE EVALUATON AND MODIFICATIONS **59**

CENWP-EC-HD MEMORANDUM, COMPUTATIONAL PROBLEMS WITH NHC COMPUTER MODEL FEBRUARY 15, 2005, PAUL WILLIAMS 60
CENWP-EC-HD MEMORANDUM, EVALUATION OF HELCRABS SIMULATION PROGRAM FOR THE DALLES NORTH FISH LADDER SEPTEMBER 2, 2005, NATALIE RICHARDS 64

APPENDIX B: TRIP REPORTS AND MEMORANDUMS **110**

CENWP-EC-HD MEMORANDUM, DATA COLLECTION TRIP NOVEMBER 10 2004, PAUL WILLIAMS 111
CENWP-EC-HD MEMORANDUM, DATA COLLECTION TRIP MAY 18 2005, NATALIE RICHARDS 112
CENWP-EC-HD MEMORANDUM, EXIT CONTROL TEST AUGUST 12, 2005, STEPHEN SCHLENKER 120
CENWP-EC-HD MEMORANDUM, DEWATERED SYSTEM SITE VISIT FEBRUARY 11, 2005, PAUL WILLIAMS 124
CENWP-EC-HD MEMORANDUM, AWS PLUNGE POOL MEASUREMENTS DECEMBER 16, 1997, STEVEN SCHLENKER 129

APPENDIX C: MODEL OUTPUT FOR DATA COLLECTION CONDITIONS.....131

LIST OF FIGURES

Figure 1: The Dalles Dam North Fish Ladder General Overview..... 3
Figure 2: The Dalles Dam North Fish Ladder. 4
Figure 3: Entrance Weirs N-1 and N-2 (Bulkheaded off for Winter Maintenance), View from Tailrace Side..... 5
Figure 4: AWS Intake Tainter Gate and Juvenile Bypass Screen; Looking Downstream . 6
Figure 5: Wasco PUD Turbine Draft Tubes and Tie-in to AWS Conduit..... 7
Figure 6: AWS Plunge Pool and Connection to AWS Conduit..... 8
Figure 7: Fish ladder Weirs and Orifices Looking Downstream..... 9
Figure 8: Exit Section Vertical Slot and Orifice with Make-up water Diffuser Basin in Floor..... 10

LIST OF TABLES

Table 1: Comparison of Original NHC Model and CENWP-EC-HD Revised Model with Measured Data, Part 1 (System Inflows) 24
Table 2: Comparison of Original NHC Model and CENWP-EC-HD Revised Model with Measured Data, Part 2 (Entrance Heads & Discharge Rates and Channel Velocities) 25
Table 3:Existing Operation of The Dalles North Fishway: Model Simulation Results for Tailwater Levels Between 73 and 88 Feet NGVD Based on Fish Passage Plan and Current Programmable Logic Control Commands (Forebay 158.5.0 feet NGVD assumed for all runs)..... 29
Table 4: Recommended Operations for Diffuser Gate settings..... 36
Table 5: Increased submergence with increased TW 37
Table 6: Comparison of Two Minor Structural Alternatives with Existing Operation at Tailwater Elevations 73, 78, and 88; Option 1--Remove Ladder Weirs 70-73; Option 2--Lower Ladder Diffuser Stovepipe Weir Crest Elevations by 1 foot. 38
Table 7: Comparison of Two Major Structural Alternatives with Existing Operation at Tailwater Elevations 73, 78, and 88; Option 3—Additional Turbine Unit; Option 4—Operate Plunge Pool Gates Simultaneously. 39

LIST OF PLATES

Plate 1: The Dalles North Fishway Site Location..... 43
Plate 2: Plan Wasco County P. U. D. System and Modified AWS Intake System..... 44
Plate 3: The Dalles North Fishway Plan..... 45
Plate 4: Weir and Diffusion Chamber Details 46

Plate 5: Entrance Weir Details 47
Plate 6: Ladder Elevations 48
Plate 7: Detailed Profile of Ladder and AWS Conduit Section 49
Plate 8: Ladder & Ladder Diffuser Chamber 50
Plate 9: AWS Intake and Wasco County P. U. D. Juvenile Bypass Screens 51
Plate 10: Plan of Turbine Connection to AWS Conduit 52
Plate 11: Profile Wasco P. U. D. Turbine Unit and Connection to AWS Conduit 53
Plate 12: Wasco County P. U. D. Turbine Rating Curves 54
Plate 13: Schematic of The Dalles North AWS-Layout of Nodes and Links for NHC Net Pressurized Conduit Simulation 55
Plate 14: Control Section, Exit Section, and Counting Station Plan 56
Plate 15: Exit Section Profile 57
Plate 16: Existing Operations Matrix 58

LIST OF ACRONYMS

AWS- Auxiliary Water System
BiOp- National Marine Fisheries 1995 and 2000 Biological Opinion
CENWP-OP- Portland District Corps of Engineers Operations Division
CFD- Computational Fluid Dynamics
Cfs- cubic feet per second
CENWP-EC-HD- Portland District Corps of Engineers Hydraulic Design Section
EGL- Energy Gradeline
EPA- Environmental Protection Agency
FCRPS-Federal Columbia River Power System
FPOM- Fish Passage Operations and Maintenance Group
FPP- Corps of Engineers Fish Passage Plan
ft/s- feet per second
GUI- Graphical User Interface
H1- Upstream head above weir crest
H2 –Downstream head above weir crest or submergence
HELCRABS- Hydraulic Evaluation of Lower Columbia River Adult Bypass Systems
HGL- Hydraulic Gradeline (water surface elevation)
MOP- Minimum Operating Pool
MW- Megawatts
N-1- Entrance Weir in North Bay (normally operated)
N-2- Entrance Weir in South Bay (normally closed)
N-3- Side Entrance Weir to Spillbay (closed permanently)
NGVD- National Geodetic Vertical Datum
NHC- Northwest Hydraulic Consultants
NMFS- National Marine Fisheries Service
NOAA- National Oceanic and Atmospheric Administration
Q – Flow rate, cubic feet per second, cfs
PLC- Programmable Logic Controller
PUD-Public Utility District
RPA- Reasonable Prudent Alternative
TW- Tailwater
V - Velocity

Executive Summary

General

The purpose of the "Hydraulic Evaluation of The Lower Columbia River Adult Bypass Systems" (HELCRABS) study program is to assess the performance of each lower Columbia River adult passage system. Each fishway evaluation is conducted with respect to Salmonid Passage Facility Guidelines and Criteria developed by National Oceanic and Atmospheric Administration (NOAA) Fisheries (also formerly known as National Marine Fisheries Service or NMFS). Specifically the HELCRABS study program encompasses the eight fishway systems that bypass upstream migrating adult salmonids around Bonneville Dam, The Dalles Dam, and John Day Dam. The HELCRABS program was created in response to questions and directives regarding Fishways in the NMFS 1995 and 2000 Biological Opinion for the Columbia River (BiOp). In the BiOp, the Operations Division of the Portland District (CENWP-OP) is to furnish NMFS evaluation reports for each fishway. Each report shall contain (a) an assessment of the existing performance of a fishway with respect to hydraulic fisheries criteria, (b) recommendations for operational changes to optimize the fishway performance, and (c) recommendations on a need for structural changes if adequate performance is unattainable with the existing fishway system. CENWP-OP has tasked the Hydraulic Design Section (CENWP-EC-HD) to conduct this hydraulic study in coordination with the three projects. The HELCRABS program is scoped to proceed in three phases: (Phase 1) the evaluation reports for CENWP-OP, (Phase 2) the field data verification and correction/refinement of the numerical models used to conduct the evaluations, and (Phase 3) linking the models to fishway control systems so that operations can be set in the project control rooms. This report describes the results of the evaluation of The Dalles North Fishway.

The Dalles North Fishway is one of two ladder systems at The Dalles Project complex that provides bypass routes for upstream migrating adults past the dam. This system is located on the north shore of the Columbia River between the Navigation Lock and the Spillway, and collects fish swimming up the north side of the Dalles spillway tailrace channel. (The Dalles East Fishway is the other system—a much larger system built around the powerhouse and south end of the spillway on the south side of the Columbia River.) The Dalles North is a relatively small fishway system with one entrance area and an auxiliary water system (AWS) supplied by the Wasco County Public Utility District (PUD) turbine unit.

HELCRABS Computer Model

This fishway evaluation uses the HELCRABS numerical computer model created to simulate the hydraulic conditions in The Dalles North Fishway. The model was developed by Northwest Hydraulic Consultants (NHC) in 1998 and was calibrated from limited prototype field data. A verification of this model was warranted by concerns regarding the limited calibration data and issues revealed in prior detailed model evaluations from earlier HELCRABS studies. Prior to using the model for fishway

evaluation, CENWP-EC-HD first embarked on a plan to verify/correct the model by performing prototype flow measurements and reviewing the internal program. The model evaluations identified a number of shortfalls, and therefore a portion of the Phase 2 scope (field measurements and model corrections) had to be completed in order to conduct the Phase 1 (fishway evaluation) portion. For this model, an Excel macro, originally created for Bonneville Second Powerhouse model, was modified to compensate for critical shortcomings in the hydraulic computations of the model. In addition, the Wasco PUD Turbine unit is not included in the NHC model simulation. The most pertinent geometry corrections and calibrations to the model were made so that CENWP-EC-HD could proceed with the fishway evaluation. The remaining model deficiencies are not serious and may be corrected in a later phase of the HELCRABS study.

Fisheries Criteria

The standard and current adult fisheries passage criteria are described in the 2005 Fish Passage Plan as the following:

- Elevation entrance weir crest or sluice opening invert ≥ 8 feet below tailrace level (or entrance submergence ≥ 8 feet);
- Head difference across entrances should be between 1 – 2 feet, 1.5 feet optimum;
- Channel velocities should be between 1.5 - 4 feet per second (ft/s), 2 ft/s optimum;
- Ladder head should be 1.0 foot (± 0.1 feet) for non-shad passage season and 1.3 feet (± 0.1 feet) for shad passage season (shad passage > 5000 shad /count station/ day).
- Diffuser efflux velocities ≤ 0.5 ft/s.
- The hydraulic drop per pool shall be between 0.5 and 1.0 feet in the exit channel section.

Additional Operational Criteria include

- Minimum tailrace elevation of 70 feet NGVD (to assure 8 feet of submergence).
- Operate one entrance weir, either N-1 or N-2 regardless of spill operation. Entrance weirs must be operated only by Project biologists when in manual control.
- If Wasco County operates the weirs in automatic control, their programmable logic control (PLC) shall be required to maintain entrance criteria. Their PLC typically maintains 1.3-foot entrance head and at least 8.5 feet of entrance submergence.
- The two slide gates for the plunge pool bypass is operated when the Wasco PUD unit is down.

Evaluation of Existing Operation

In general, The Dalles North Fishway meets entrance criteria at the full range of tailrace levels. The channel velocity criteria are not met most of the time at the upstream end of the lower fishway channel. As the tailwater rises, the low velocity problems spread

downstream to most the lower fishway channel. The evaluation of the current operation of the existing Dalles North Fishway revealed the following cases where fishway criteria are not met:

- Channel velocities are lower than 1.5 ft/s on upstream side of the lower fishway channel (just downstream of weir 70) at the all tailwater levels above the minimum 73 feet NGVD (over 99% of the time).

The low velocity problem occurs near the base of the ladder and is a common problem area for most ladder systems throughout the Columbia River system. The low velocities are caused by low rates of inflow from the ladder section and a general limitation of AWS inflow.

- Channel velocities are lower than 1.5 ft/s within the entire lower fishway channel when tailwater levels exceed approximately 84 feet NGVD (about 6% of the time).

As the tailwater elevation rises, the system outflows tend to decrease from reduced turbine discharge caused by lower available net turbine head. The net turbine head is the difference between forebay and head in the AWS conduit, which is a function of tailwater level and AWS discharge rate. At the same time, the channel depths grow deeper with rising tailrace. These factors combine to cause low velocities throughout the lower fishway channel when the tailwater elevation becomes higher.

Recommended Changes to the Operation

Few operational changes can be recommended with the current system limitations. There are two possible areas which can be altered: decrease channel diffuser settings and entrance weir submergence.

- Close lower fishway diffusers as tailwater rises to induce more flow to the upstream side of the system and create higher velocities in the lower fishway channel. Drawback to this approach will be reduced overall system flow and entrance head.

- Open entrance weir to levels deeper than 8.5-feet submergence at higher tailwater levels (> 78 feet NGVD).

  This practive is partially implemented in that Wasco PUD operates at a 9.0 feet of submergence as it tends to maximize turbine output. The increased submergence up to 10 feet was explored, which showed increased channel velocities and PUD turbine production.

The recommended operation of the diffuser gates is displayed in tabular form in Table 4 for tailwater levels between 73 and 88 feet NGVD. (For comparison, the existing operation schedule is shown in Table 3.)

Potential Structural Improvements

Recommended potential alternatives for structural changes or corrections include minor (Options 1 and 2) (see Table 6) and major (Options 3 and 4) structural improvements (see Table 7):

- Option 1—Remove lower ladder weirs 70 -73.

Weirs 70-73 are always submerged. The minimum daily tailrace on record is 72.7 feet, placing the minimum lower fishway channel water level at 74 feet. Weirs 70-73 present unnecessary fish impediments and Fishway system energy losses. The removal of these weirs would present marginal hydraulic improvements and potentially greater biological benefits to the Fishway performance.

- Option 2—Lower ladder diffuser stove-pipe weirs by 12 inches

Currently, the elevation of the stove-pipe weirs for the ladder diffusers are 2 feet higher than the ladder weir crest elevation on the downstream end of the receiving diffuser pool. At Bonneville 2nd Powerhouse Fishway, the highest performing fishway system on the Lower Columbia River, that difference is only 6 inches. Reducing the elevation of each of the stovepipe weirs will effectively increase the AWS system conveyance. It is anticipated that this would produce higher flow rates and velocities at the base of the fishladder where it is needed most; however, the model did not show appreciable increases. During the Phase 2, lowering the Pipe Weirs by another 6 to 12 inches can be completed.

- Option 3—Add second turbine unit to AWS.

Assuming a turbine unit of equivalent capacity and variable speed options, there is potential to operate two entrance weirs in criteria at tailwater elevations at or above 78 feet (about 50% of the time). If the second entrance weir is allowed to be operated below submergence criteria (while maintaining the primary weir in criteria) the channel velocity criteria could be met at the full range of tailwater levels. The turbine unit would need to be equipped with an additional juvenile bypass system similar to the existing unit and would probably require the space currently occupied by the plunge pool and approach channel. Drawbacks to this strategy include: significant construction costs and reduced Wasco PUD power production per unit. However, Wasco County PUD might be willing bear the costs for the additional total power production, which would be increased on the order of 50-75% depending on the operation of the fishway and the design of the new turbine unit. The maximum velocities in the diffusers could reach up to 0.8ft/s (exceeding 0.5 ft/s criteria in both options), but this comes from an unlikely operation at TW 73 that creates an unacceptable channel velocity of about 7 ft/s at the channel bend. At TW 78 and above, the diffuser velocities will increase to a maximum of 0.4 ft/s. Assuming a Variable Speed Turbine and limiting the channel velocity to 5 ft/s, the maximum diffuser velocity will be 0.5 ft/s for any Tailwater level

- Option 4—Operate the Plunge Pool Slide Gates with PUD unit.

The plunge pool and approach channel exits as a backup system for the turbine. The current plunge pool and rock lined approach channel would need significant repairs (concrete lining) if it were to be used continuously. If it were run along side the turbine unit, there is potential to operate two entrance weirs in criteria at tailwater elevations at or above 78 feet (about 50% of the time). If the second entrance is allowed to be operated below submergence criteria (while maintaining the primary weir in criteria) the channel velocity criteria could be met at the full range of tailwater levels. Numerous drawbacks to this strategy include: significant construction costs, probable reduced life of the turbine unit due to the surging and aeration caused by the turbulent plunge pool operation; no juvenile screened bypass system (or install maintenance intensive screen in forebay) for the plunge pool flow, and reduced Wasco PUD power production. The maximum velocities in the diffusers could reach up to 0.8ft/s (exceeding 0.5 ft/s criteria) in both options, but this comes from an unlikely operation at TW 73 that creates an unacceptable channel velocity of about 7 ft/s at the channel bend. At TW 78 and above, the diffuser velocities will increase to a maximum of 0.4 ft/s.

Potentially Options 1 and 2 can be combined with either Option 3 or Option 4 to produce maximum benefit.

Another area of improvement includes measures to pass lamprey more efficiency or safely in the system. Project biologists have been investigating several options in this area at John Day North Fishway—such as modification of diffuser spacing size to prevent lamprey entry into the AWS.

- Consider structural modifications for lamprey passage at the entrances.

Structural modifications at the entrances could help lamprey enter the fishway for upstream bypass. Such measures might include rounded sections that cover the entrance weir and bulkhead guides that impede lamprey or a fixed shaped weir with rounded edges.

Recommendations for Future Model Improvements

In addition, CENWP-EC-HD recommends that work proceed on with the rest of Phase 2 and possibly Phase 3 of the HELCRABS study program for this fishway. This will ensure greater model accuracy and allow the project personnel to make greater use of the model to monitor and adjust the fishway performance to the changing field conditions. Since a portion of the Phase 2 work was required to complete Phase 1, it is also recommended that the scopes of work for the remaining fishway systems be merged into two phases rather than three described earlier. Phase 1 would conduct the fishway evaluations with the necessary corrections to the model and Phase 2 would comprise final corrections, refinements and enhancements to the model.

1.0 Introduction

The Dalles Dam is a concrete gravity dam located within Klickitat County, Washington on the Columbia River at river mile 192. Construction began in 1952 and the project began operating in 1957. The project consists of a navigation lock, spillway, powerhouse, adult fish passage facilities and various recreational facilities. In addition, the North Wasco Public Utility District operates small hydropower facility adjacent to the North fishway exit.

The Hydraulic Evaluation of Lower Columbia River Adult Bypass Systems (HELCRABS) is a program developed to respond to the NMFS 1995 (Reasonable Prudent Alternative (RPA) 16) and 2000 (RPA 120-124) Biological Opinion (BiOp). The BiOp in Section 9.6.1.6.3 Adult Fishway Operating Criteria states "The Corps annual fish passage plan stipulates operating criteria for the Federal Columbia River Power System (FCRPS) hydro project adult fishways. Where these criteria are not satisfied, incremental adverse effects to adult migrants (such as delay) may occur. Actions to enhance compliance with fishway criteria include auxiliary water system assessments and upgrades. Other actions address the issue of inadequate fishway entrance weir submergence during low tailwater elevations".

The BiOp also states under Reasonable and Prudent Action (RPA) 120: "The Corps shall develop improved conditions for adult fishway main entrances at FCRPS dams so that the best possible attraction conditions are provided for adult migrants, both at the Columbia River hydro projects and the four lower Snake hydro projects (where reservoir elevations are held near minimum operating pool (MOP). The Corps shall report the findings of fishway entrance flow-balancing investigations in a report to National Marine Fisheries Service (NMFS) by the end of 2001[1] and shall continue to work through the Fish Passage Operations and Maintenance (FPOM) group to evaluate and implement, as warranted, structural changes to satisfy fish passage plan fishway entrance criteria".

Under previous scopes of work in the HELCRABS Program, the Portland District (CENWP) contracted Northwest Hydraulic Consultants (NHC) to develop computerized numerical models to analyze the hydraulics for adult fishways at NWP Columbia River Dams. Computer models have been developed for Bonneville Dam Fishways – A and B Branches, Cascades Island, Bonneville Second Powerhouse, John Day Dam Fishways – North and South, The Dalles Dam Fishways – North and East. During operation and further review of the model, a number of deficiencies or limitations were identified in each model.

The HELCRABS Program scope is currently planned to progress in three phases. This evaluation report is the product of Phase 1. Phase 2 includes field verification measurements and corrections and refinements to the model. Phase 3 will introduce

[1] The HELCRABS reports are being developed for this purpose in spite of the expired deadline.

possible long-term plans integrating the model with the project control system. For this report, portions of Phase 2 were completed to ensure an accurate evaluation for Phase 1.

This report documents the evaluation of the North Fish Ladder using the numerical model. The evaluation of the existing operations is described in Section 4. Some minor recommendations are presented for revised fishway operations to improve fish passage criteria performance in Section 5. Potential structural improvements of various scales are also presented there. An evaluation of the numerical model is also provided in the report (Section 3.0 and the Memorandum in Appendix A) including the field verification measurements, the findings on model limitations, required corrections made to the model to conduct the evaluation, and recommendations for future corrections and refinements to the model (See Appendices A and B).

2.0 Fishway System Features

2.1 General Description of Fishway

The Dalles North Fish Ladder is located on the north end of the dam between the navigation lock and spillway bay 1. The fish ladder is 1761 feet long, 24 feet wide and has a slope of 1 on 16. There are three main entrances in the fish ladder. The entrances are located adjacent to spillway 1. Fish use these entrances to enter the fish ladder from the tailrace. The ladder is a weir and orifice type that rises in one-foot increments that allow fish to ascend over the north side of The Dalles Dam. Figure-- shows a general photo of the The Dalles North Fish Ladder and exit section and Figure 2 shows a detailed photo of The Dalles North Fish Ladder.

Water for the fish ladder is supplied by the fish ladder exit and from one turbine unit that is connected to the auxiliary water system that feeds the lower portion of the fish ladder. The turbine began operation in 1991 and is operated by the Northern Wasco County Public Utility District. Prior to the addition of the turbine, auxiliary water was supplied through a gravity feed system. The gravity system is now used as a backup water supply when the turbine is out of operation.

Figure 1: The Dalles Dam North Fish Ladder General Overview.

Figure 2: The Dalles Dam North Fish Ladder.

Fishway History

The Dalles Dam project was authorized by the River and Harbor Flood Control Act of 17 May 1950. Construction was initiated in 1952 and the project began operating in 1957. The project consists of a navigation lock, spillway, powerhouse, adult fish passage facilities, and various recreational facilities.

The north fishway is intended to provide upstream passage to anadromous fish migrating along the north shore of the river.

Major modifications to the north fish ladder are: exit section and counting station modifications (late 1980's) and a 5 MW hydroelectric facility operated by the Wasco County Public Utility District (began operation in 1991). This facility uses water from the auxiliary water supply taken from the forebay. Discharge from this facility enters a diffusion chamber at the lower portion of the north fish ladder to provide entrance attraction flows.

Entrances

Fish access to the ladder comes through three main entrances adjacent to spillway bay 1. The entrances are labeled North Entrance 1 (N1), North Entrance 2 (N2) and North Entrance 3 (N3). Each entrance weir crest is 15 feet long. The weirs consist of 3 leaves, each approximately 6 feet 9 inches tall. The minimum weir or sill elevation is 62 feet NGVD, which assures submergence criteria can be met for tailwater elevations down to 70 feet NGVD. (The minimum recorded daily tailwater level is much higher at 72.7 feet NGVD.) During normal operation one entrance is operated, either N1 or N2 regardless of spill. N3 is permanently closed. Entrance locations are shown in Plate-1. A plan view is shown in Figure 2 and a view looking upstream is shown in Figure 3 of the entrance location. Plate-5 shows the entrance weir details.

Figure 3: Entrance Weirs N-1 and N-2 (Bulkheaded off for Winter Maintenance), View from Tailrace Side.

Auxiliary Water System

The AWS system is supplied by the North Wasco County PUD turbine Unit. The unit is rated at 800 cfs and 5 megawatts (MW). The system is equipped with a screened juvenile bypass system that bypasses 10 cfs of the AWS intake flow to transport fish though a pipe for release into the tailrace in the discharge flux of entrance N-1. The remainder of

the intake flow passes through the fish screen and is directed into a penstock for turbine usage. After dissipating most of the available Forebay energy, the turbine releases flow into the AWS conduit between diffusers L-3 and L-4 and beneath weir pool 77 (see Figure 5). The turbine is normally run at 90% gate opening to avoid cavitation on the impellers and attain better power generation efficiency. While the unit is rated for 800 cfs, the field data collection trips indicated the PUD unit actually runs between 870-940 cfs --about 6% higher the rating curve for full gate opening and equivalent net head.

Figure 4: AWS Intake Tainter Gate and Juvenile Bypass Screen; Looking Downstream

Figure 5: Wasco PUD Turbine Draft Tubes and Tie-in to AWS Conduit

The original AWS system now serves as the backup auxiliary water supply when the Wasco PUD hydroelectric facility is out of service. The back up system consists of an intake structure, 20 foot by 17 foot tainter gate, two 6-feet by 7-feet slide gates, upper and lower plunge pools and a 20 foot wide trapezoidal channel that is cut in the rock between the upper and lower plunge pools. There is a 25 foot drop between the tainter gate apron and the bottom of the upper plunge pool. The drop into the lower plunge pool is 73 feet. A 15 foot high weir separates the lower plunge pool from the entrance into the AWS channel (see Figure 6). Flow then enters a diffusion chamber at the lower portion of the north fish ladder.

Figure 6: AWS Plunge Pool and Connection to AWS Conduit.

Overflow Ladder Weirs

The north fish ladder is 24 feet wide and extends from weir 70 to weir 153 on a 1 on 16 slope with each 6 foot high weir on 16 foot centers. All weirs are full 24 foot wide overflow and have two orifices 21 inches wide by 23 inches high, which can be seen in Figure 7. This shows two overflow sections and one non-overflow section. The orifices are located at the base of the weirs with the orifice centerline located 3 feet from the outside walls. The weir numbers correspond to the crest elevation of the weir.

Plate-3 shows the plan view and Plates-6 & 7 show the profile of the fish ladder. One of the unique features of this system is that most of the fishladder weirs were built inside an excavated rock-lined channel (see Figure 7).

Figure 7: Fish ladder Weirs and Orifices Looking Downstream

Exit Section

The make-up or auxiliary water channel was built inside the original 24-foot wide channel. Modifications were made to the original exit section and count station in the late 1980's. The exit control section weirs are vertical slot type weirs spaced 14 feet on center. Flow through the fish ladder was approximately 75 -102 cfs, depending on ladder control head. A make up water supply conduit is added along the south fish ladder wall. This conduit continues downstream just past weir 152. The fish ladder channel in this area is reduced from the original 24 foot width to a 20 foot inside width. Flow through the make up water supply conduit is regulated by a sluice gate and discharged through a floor diffuser (see Figure 8).

The counting station is located between weir 151 and weir 152. It has an underwater viewing window and horizontal crowder capable of varying the slot wide from one to three feet. The counting station is flanked by fish leads to guide fish past the window.

Plates-14 & 15 shows the exit section plan and profile.

Figure 8: Exit Section Vertical Slot and Orifice with Make-up water Diffuser Basin in Floor.

3.0 Numerical Model

The Dalles North Fishway numerical model was developed by Northwest Hydraulic Consultants (NHC) under the HELCRABS program in 1998. This numerical HELCRABS model produces a simulation of the hydraulic conditions within the lower and middle portions of the ladder system. The results are used to evaluate the fishway performance with respect to fisheries criteria and develop operational plans for a full range of boundary conditions (tailrace and a median forebay elevation). The program simulates conditions at the entrances, collection channel, diffusers, and overflow ladder system up to the picket lead, where the upstream ladder head is controlled by the forebay exit and head control system (the forebay exit and ladder head control systems are not included in the simulations). The WASCO PUD turbine rating curves are also not incorporated in the program. The program requires the following input parameters from the user:

- Tailrace level
- Entrance weir elevations
- Open diffusers, operated as opened or closed
- Energy gradeline at Turbine outlet into AWS system (node 30)
- Head above weir crest at upstream picket lead

The program then produces the following output information:

- Entrance head and flow rates at each entrance opening
- Channel velocities and water levels in the entrance channels, lower fishway channel and lower to mid level ladder channels between weir 70 and weir 93.
- Diffuser discharge rates and velocities
- Head, flow rates and velocities across overflow ladder weirs and orifices
- Output defaults can be changed before a run so that the output from the pressurized system can be obtained. This includes flow rates, velocities, and hydraulic grade line throughout the AWS conduits and diffuser branches.

3.1 Model Operation

The Dalles North model is run from a DOS command prompt by entering the following in the command line:

FISHWAY [INPUT] [OUTPUT]

The [INPUT] file name has to be consistent for the two required input files the [INPUT].in and the [INPUT].inp file. The [OUTPUT] file can be any name except FISH, which is an intermediate file name generated by the program. Once the FISHWAY command and file names are entered, the program is executed and an

input screen appears that allows for changing diffuser, entrance settings, and other values relevant to the model operations.

Once the desired settings are set in the input screen, the program is set to iterate and find a solution. The program operates two main subprograms to produce a final solution. Subprograms, 'NHCFISH' and 'NCHNET', are alternately run to iterate towards a convergence in flow rates between open channel and closed conduit systems. NHCFISH simulates the open channel portion of the system including ladders, collection channel and entrances. NHCNET operates the closed conduit portion of the system (AWS), including fish valves, conduits, gates and diffusers. At completion, NHCFISH provides water levels at each diffuser to NHCNET. Conversely, NCHNET runs to return diffuser discharge rates to NHCFISH. This iterative procedure continues until the differences in flow rates between the two program routines are brought within specified tolerances.

NHC developed NHCNET as a modification of the widely used EPANET program, developed by the Environmental Protection Agency (EPA) to simulate circular closed conduit systems for tracking contaminants in municipal system. Both codes are written in C language. The difference with NHCNET is that it simulates rectangular conduit systems, which describe all AWS conduits. NHC also added a subroutine for weir valves. A weir valve opens when the AWS HGL exceeds a certain threshold level, after which the weir equation is used to estimate flow through that valve opening.

There are three geometry files that are read by the program to conduct the simulation:

- INP File - file created from the Graphical Users Interface (GUI) interface by the user; user inputs forebay & tailrace levels, open entrances, and fish valve settings. This is the file the user opens to run each simulation.
- INI file - file contains geometry information and pertinent head loss coefficients for the open channel portions of the system including the entrances, collection channel, ladder weirs, and diffuser efflux pools. Once the model is calibrated, the user does not alter this file unless there is a geometry change.
- IN file - file contains geometry information and head loss coefficients (friction and minor loss) for the pressurized AWS systems including the conduits, diffuser gates, and diffusers. This is also the location where Node 30 is set and the GUI imports diffuser gate status, either open or closed. Once the model is calibrated, the user does not alter this file unless there is a geometry change.

Normally, the user will open just one file (INP). The latter two files (INI and IN) are not normally altered between simulations. A knowledgeable user of the program can modify these geometry files (without actually modifying the model code) to test how changes to the system geometry might affect fishway performance.

After a successful simulation, the open channel flow output is written to [OUTPUT].prn and AWS pressurized flow results are written to [OUTPUT].txt, both of which can be viewed in any text editor or printed. The files [OUTPUT].in and [OUTPUT].inp are also generated so that the model run can be repeated without having to spend time reentering information into the input screen of the program.

3.2 Numerical Model Evaluation

CENWP-EC-HD evaluated The Dalles North model by comparing the model outputs to our analytical expectations and prototype data collected. Through use of the model and a more detailed review of the model functions as part of this study, the following concerns were identified:

- Only hydraulic head data (without flow measurements) was collected in the field to calibrate the model.
- The entrance heads are not accurately simulated.
- Open channel flow energy losses caused by upward flow from the diffusers were not accounted for (i.e. spatially varied flow must use force + momentum balance equations to properly compute results) in the open channel (powerhouse channel) water surface profiles.
- Flows in ladder diffusers are not correctly computed.
- Unrealistic discontinuities occur in the water surface across points where fishway channel sections are joined or merged at junction pools.
- Errors were found in AWS and fishway geometry files.

As part of this study, The Dalles North model was evaluated to identify and correct these deficiencies so that the model could be best applied for accurate evaluation of the ladder system operation. Many of the most essential corrections were made in the geometry file so that the program could be used for this evaluation. However, a special model adjustment Excel Macro had to be developed to ensure reasonably accurate simulation of AWS flow rates and system pressures. A complete description of the evaluation, findings, and corrections to the model is presented in the following sections.

3.3 Evaluation Procedures

The evaluation process took a two-pronged strategy. Phase 1 was the collection of field data (including flow rates) that could be used to test the validity of the model over a range of tailwater and valve settings. Phase 2 was an examination of the program code and the geometry files. The results of both were used to revise the model for more accurate simulations of prototype hydraulic conditions. The following two subsections describe each process.

3.3.1 Field Measurements

Two data collection trips were conducted to provide data sets for model validation. The data collection trips were conducted on November 10, 2004, and May 20, 2005. The November 2004 trip represented a ‘low tailwater’ data collection trip with an

average tailrace level of 75.3 feet. The May 2005 trip was a 'high tailwater, trip done at an average tailwater level of 79.6 feet. A brief third site visit was also conducted on August 12, 2005 to obtain upper ladder flows with 1.3 feet ladder head at The Dalles North and The Dalles East exit sections. All trips were completed in coordination with the Project Biologists and WASCO County PUD. These trips included flow measurements at the following locations:

- Fishway exit to Forebay,
  - Exit pool channel discharge
  - Makeup water channel discharge
  - Velocity through counting station viewing slot (trip 1 only)
- Lower Fishway channel one diffuser downstream of weir 70
- Entrance N-1 discharge, entrance head and weir submergence
- AWS intake inflow just downstream of Tainter gate and upstream of dewatering system juvenile bypass and turbine penstock intake.

The total system inflow (exit + AWS intake) is compared against the system outflow (Entrance N-1) to check continuity of flow (system inflow ≈ system outflow). The results show that the entrance measurements were consistently higher than the sum of the inflows. Both inflow measurement locations represented generally ideal conditions for flow measurements since the directions of the velocity vectors were well established in the direction of the channel guidewalls and were oriented normal to the measuring transects. By comparison, the entrance channel measurement transect was located just downstream of the 180º channel bend and just upstream of the entrance weir. The velocity vectors at the entrance transect had significant cross flow and vertical components. For these, reasons, the inflow measurements were given greater credence over the entrance flow measurements, and in the evaluation and calibrations of the model, the entrance discharges were assumed to equal the sum of the inflows. In addition to flow measurements, the fishway settings (i.e., turbine megawatts, entrance weir elevations, and diffuser openings) and water surface measurements were recorded. WASCO PUD personnel assisted by recording the turbine megawatts, forebay and tailrace elevations, and entrance heads at 30 minute intervals during the test days. (Hourly Project forebay and tailrace data was also obtained from The Dalles control room). The forebay, tailwater, and other water level measurements are accurate to the nearest 0.1 feet. Trip reports were prepared to provide detailed accounts of each data collection trip; which include data collection worksheets, collection conditions, data limitations and figures showing the specific locations of data collection. The trip reports are located in Appendix B.

Flow measurements were taken using a Price Meter. The Price Meter measures flow by counting the rotation of propeller cups placed into the flow. The rotation count is then converted to a velocity required to move the propeller at that speed. With fewer rotations come lower count numbers and therefore greater percent error is introduced into the measurement. Given the same count duration, locations with lower velocities (< 1 ft/s) will produce higher percent errors. Within the past year, CENWP-EC-HD acquired an AquaCount which records a specific time (greater than 40 seconds) in which a number of complete revolutions are counted. Thus errors from counting or

partial revolutions are prevented. Both inflow locations were measured using the AquaCount. A number of other factors can affect the accuracy of measurements such as channel geometry, lateral or vertical flow components, and sampling locations along the transect or cross-section of flow area. These were minimized by the choice of transect locations and sampling points within the transect.

3.3.2 Evaluation of Program Code and Geometry Files

The results of a detailed evaluation of program code and geometry files are presented in the CENWP-EC-HD memorandum: *Evaluation of HELCRABS Simulation Program for The Dalles North Fish Ladder*, prepared by Natalie Richards, August 2005. This memo is located in Appendix B or in the project directory under the electronic file located in the following directory: ..\..\Calculations\TDA_North\Natalie's work\Evaluation Phase\Evaluation of HELCRABS Simulation Program for The Dalles North Fish Ladder.pdf

In general, the following problems, listed in order of significance to the model accuracy were found in the code and geometry files:

1. Discharge in ladder diffusers (with stovepipe orifice/weirs) are incorrectly computed and frequently underestimated in NHCNET.
2. No turbine rating curve (Flow versus output and net head) is included in model simulation.
3. Significant differences in discharge and head remain between the open channel (NHCFISH) output and closed conduit (NHCNET) output after simulation convergence.
4. Program output for the lower fishway channel computations report the water surface elevations at locations that are offset one position upstream from their correct location.
5. Errors in geometry or inappropriate head loss coefficients in geometry files for the closed conduit or AWS systems (IN file).
6. Errors in open channel geometry (INI file).
7. Equations for the entrance weir coefficients need to be revised to more adequately fit theoretical curves.
8. No accounting for energy losses from upward diffuser flows in open channel analyses in powerhouse channel.
9. Output does not reiterate all of the input data, which makes for an incomplete document upon future review. Other I/O corrections would improve the ease of user operation.

The effect of each of these problems is as follows:

Problem 1: incorrect computation of ladder diffuser discharge. This is a significant shortfall in The Dalles North computer model, and in other models that have stovepipe weir diffusers and use NHCNET for AWS simulations. The weir equation in the subroutine is incorrect as the upstream head is taken to the square root rather

than the power of 1.5. Also as the head rises, there comes a point when the control in these diffuser conduit system transfers from weir to orifice control. The subroutine significantly underestimates ladder diffuser discharges for low and medium tailwater levels, and will likely be incorrect at upper tailwater levels.

Problem 1 was addressed by the development of the Weir Valve Correction Excel macro that is described in the following subsection 3.3.2.1. This macro fully corrected the analytical inaccuracies in the model caused by the Problem 1.

3.3.2.1 Weir Valve Correction Macro

This Excel macro was created to compensate for the analytical error in the NHCNET weir valve subroutine for weir valves used for ladder diffusers (problem 1). There are two errors of concern in the application of this subroutine: (1) ladder diffuser discharge is erroneously computed as a function of H1 (upstream head) to the 0.5 power instead of the 1.5 power; (2) as the H1 becomes high then orifice control prevails instead of weir flow.

NHCNET

$$Qd = C * L * \sqrt{H1} * \left[1 - \left(\frac{H1}{H2}\right)^{1.5}\right]^{0.385}$$

CORRECT EQUATION

$$Qd = C * L * H1^{1.5} * \left[1 - \left(\frac{H1}{H2}\right)^{1.5}\right]^{0.385}$$

In which,

Qd = Ladder Diffuser Flow (cfs)
C = Weir Coefficient = 3.2
L = Length of stovepipe weir (feet)
H1 = Upstream head (AWS HGL) above stovepipe weir crest
H2 = Downstream head above stovepipe weir crest

Note: both equations use the Villemonte correction for weir submergence.

The objective of the macro is to factor in H1 into the NHCNET equations to correct the error. In short, the Macro alters each diffuser weir coefficient based on the results of the HELCRABS output and replaces the coefficients in the .INI file. The standard weir coefficient (3.2) is adjusted by multiplying it by the latest upstream head computation (H1 = AWS HGL – ladder diffuser orifice invert). When the upstream head (H1) exceeds 5 feet (which is above the top of the orifice opening), the macro converts the weir valve into a short pipe with an associated loss coefficient in the INI file. This latter adjustment changes the manner of computation from weir to orifice flow for the higher heads.

The Macro essentially uses the information from the HELCRABS output to correct the IN data file so that the weir equation is correctly applied in the subsequent HELCRABS runs. It also checks to see if each ladder diffuser should instead be simulated as orifice flow instead of weir flow and adjusts

the IN file accordingly. The HELCRABS program is rerun until the macro detects the differences between output results have become negligible.

More specifically the macro needs to extract a respective H1 value from the HELCRABS model output to apply each active ladder diffuser. With this information, the weir coefficient is multiplied by H1 to incorporate the missing head factor in the equation and replace the previous weir coefficient for that link in the IN file. The macro also checks to see if H1 exceeds a threshold value (in this case 5 feet) at each weir valve location. If so, a weir valve is converted to a pipe in the IN file and that diffuser is computed as orifice instead of weir flow when the HELCRABS program is rerun. These steps are repeated until the all H1 factors produce differences of a small enough magnitude falls within a set level of tolerance.

The use of the macro makes total ladder diffusers discharges almost twice as high as the original.

The basic inputs, steps and outputs of the macro are listed below.

MACRO INPUTS:

- Weir Valve Invert Elevations (from IN file)
- Initial C value for weir (≈3.2 x 1.5) [•*]
- Tailwater level

MACRO PROGRAM STEPS:

1. Insert initial weir coefficients into IN file
    - If the tailwater is high, some of the weir valves will be initially changed beforehand to pipe links in the IN file.
2. Macro sets aside current H1 values for comparison with new H1 values from next HELCRABS run.
3. User runs HELCRABS program and macro sends output to internal excel sheets.
4. Compute the upstream head (H1) for each ladder diffuser from extracted AWS hydraulic gradeline (HGL) data.
    - H1 = HGL elevation at upstream node of weir valve – weir valve elevation
5. At each weir valve, where H1 exceeds preset orifice threshold value (5 feet) for transition to orifice flow, convert weir valve to pipeline with loss coefficient in the IN file (if not already done so)

[•*] 3.2 is the weir coefficient, 1.5 is the initial guess for H1 at all the active ladder diffusers.

6. The reverse is done for the diffusers that were treated as orifices in previous run and subsequently have H1 values less than the preset orifice threshold value.
7. For all remaining weir valves, the respective weir coefficient is computed as
   - $Cw = 3.2 * H1^{\nabla **}$
8. Insert new H1 values into IN file and compare with previous H1values; if the differences in H1 for all active ladder diffusers are less than the set tolerance level (0.1 feet): then done. Otherwise go to step 9.
9. Repeat steps 2-8 until the all differences in H1 between runs go below tolerance. A tolerance of 0.1 feet for each active diffuser was used in this study.

MACRO RESULTS:

Ladder diffusers computations are now hydraulically correct and create better simulations of the ladder system. This macro is documented in detail in the CENWP-EC-HD memorandum: *Weir Valve Adjustment Macro for HELCRABS Second Powerhouse Model* by Sean Askelson, (The problem was initially encountered in the evaluation of the Bonneville 2nd Powerhouse Fishway).

Problem 2: No turbine discharge rating curve in model. No data entry is requested for turbine production (Megawatts or MW) or net head[2] across turbine to run the simulation. Other models (Bonneville 2nd Powerhouse, The Dalles East, etc.) include turbine rating curves in the ini data file and require input for turbine MW and net head to run the simulations. The reason for this omission for turbine data in The Dalles North model is unknown; perhaps the data was not available at the time of the model development. The consequence of the exclusion is that the users will not know when their computed AWS discharges are outside the operational capabilities of the PUD turbine.

In order to run the model, the AWS head at the turbine outlet and the connection into the AWS system (Node 30) must be entered. The resulting simulation will yield a discharge for the entrance. The computed turbine flow is the difference between the computed entrance discharge minus the ladder inflow. Determining Node 30 is done by trial and error in that a value is picked, the model is then run until convergence is achieved, and then the channel head reading is checked. If this value is 1.3, a wise guess was made and the run is complete. If it is too low, then Node 30 must be raised. If it is too high, Node 30 must be lowered. This iteration process can be very time consuming and can become unstable at TW of 80 or above when the HD picket lead is changed from 1 to 1.3. Figures 5,5a and 5b are provided as a guide in future endeavors.

$^{\nabla **}$ The inclusion of H1corrects the error in NHCNET that uses $H1^{0.5}$ instead of $H1^{1.5}$:
$CW \times (H1)^{0.5} = (3.2 \times H1) * (H1)^{0.5} = 3.2 \times (H1)^{1.5}$

[2] Net Head = Difference of Turbine intake head – head at turbine outlet. Typically, Net Head = Forebay – AWS head at turbine outlet.

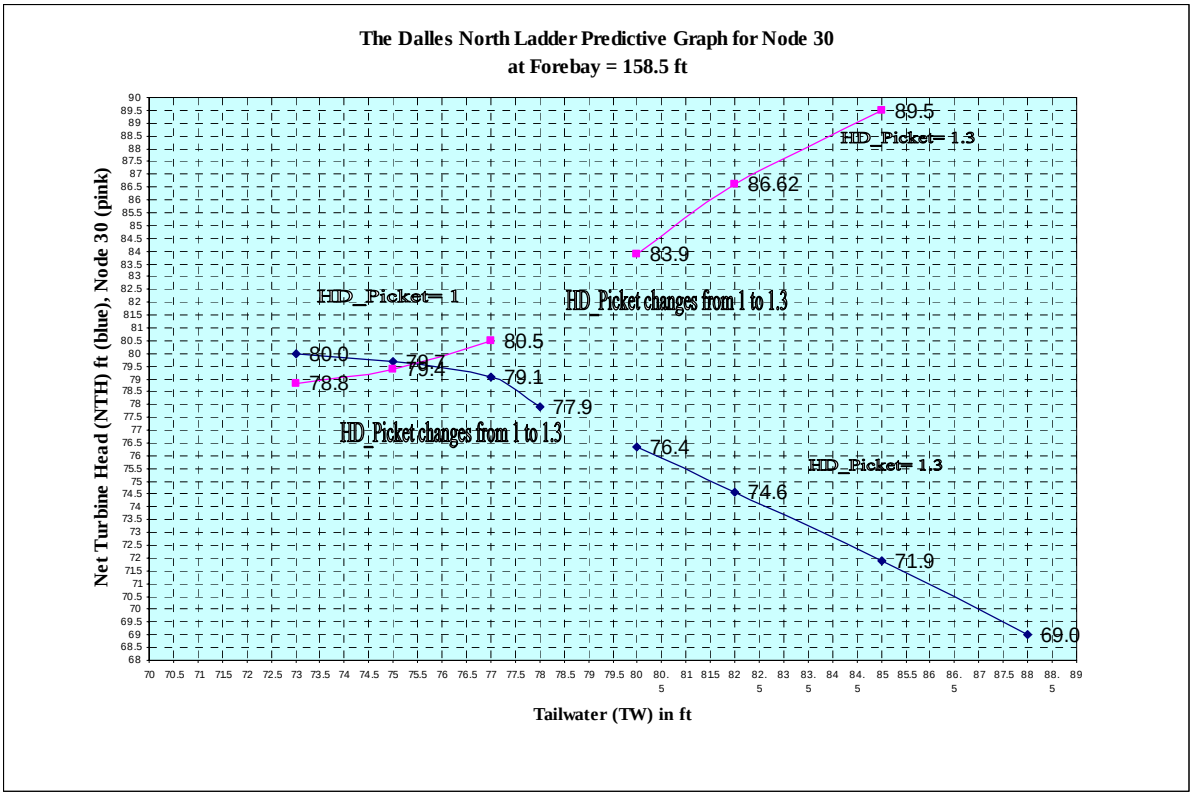


Figure 5- Node 30 Predictive Graph for Normal Operations

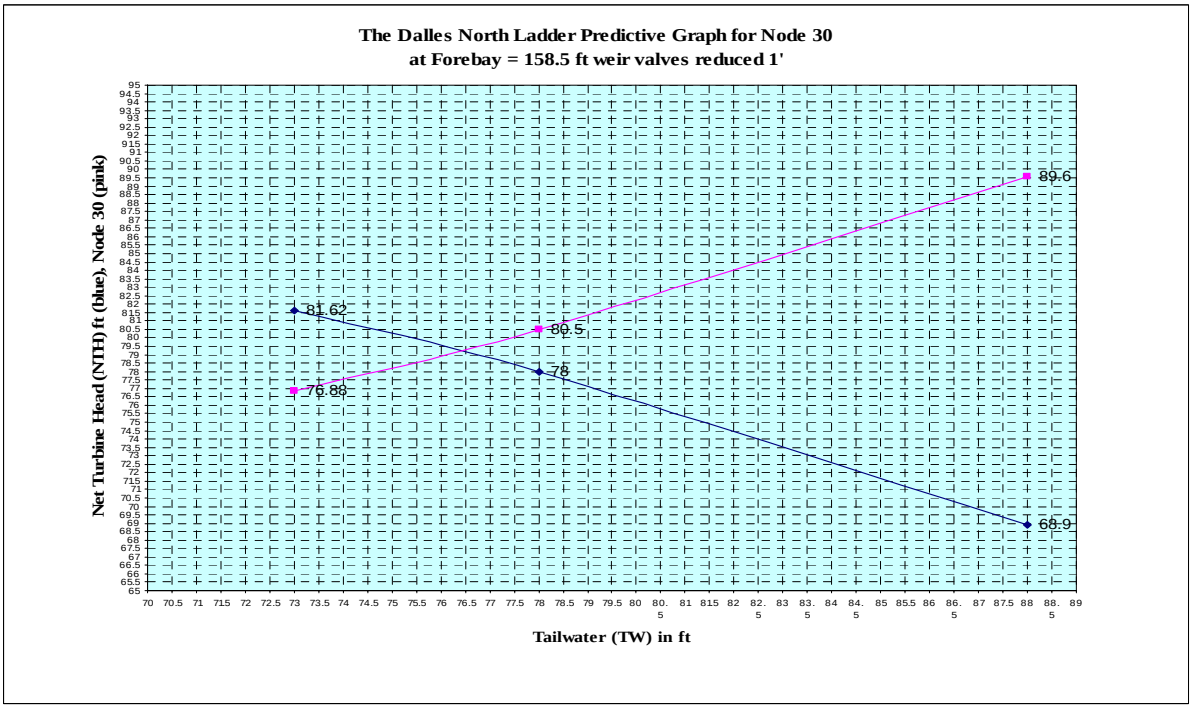


Figure 5a- Node 30 Predictive Graph for Weir Valves reduced by 1 foot

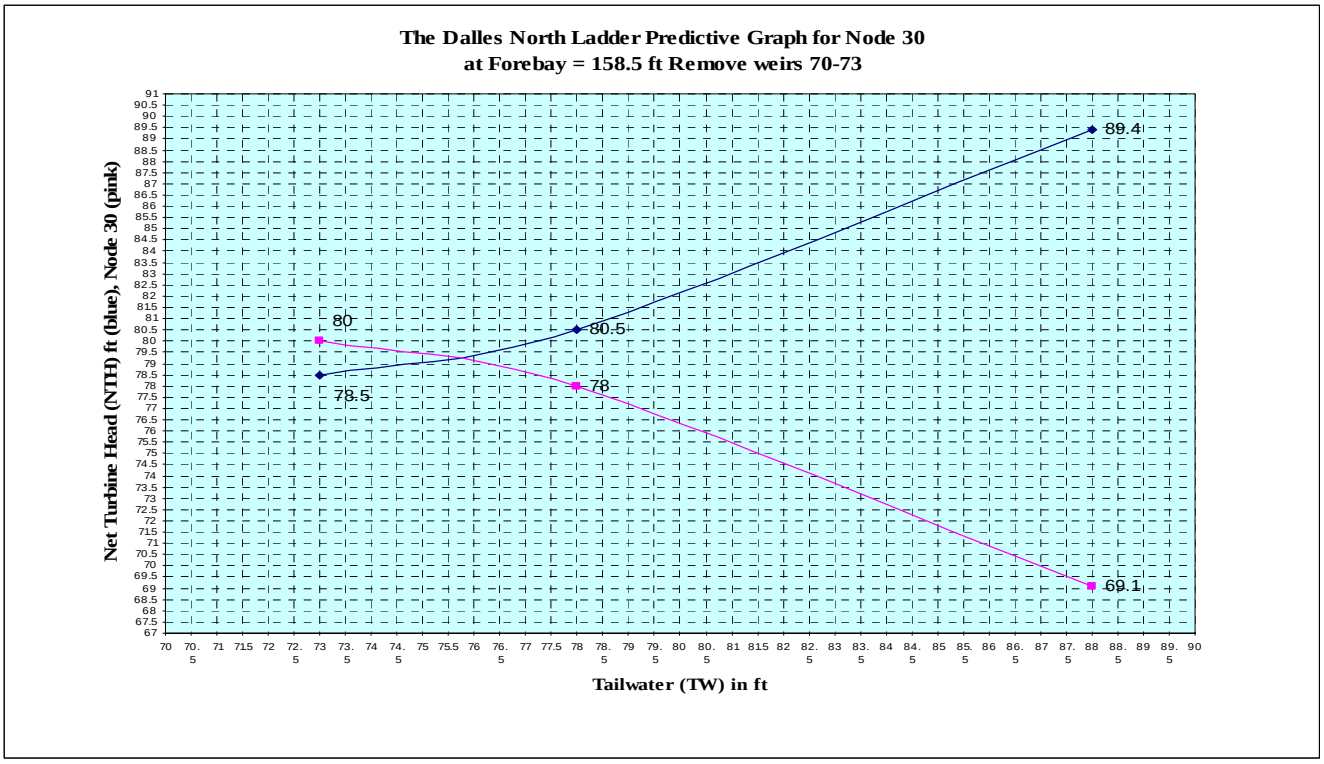


Figure 5b- Node 30 Predictive Graph for Weirs 70 through 73 Removed

Once the run is completed and the net head is determined (see foot note 2 on page 18) from the Node 30 reading, the turbine megawatt reading is determined manually from the turbine curve information provided. The discharge is checked against the maximum discharge that the turbine can supply at that net head. If the discharge exceeds the turbine capacity, Node 30 is reduced until the discharge meets the turbine capacity. This lowers the Channel Head which affects the ladders ability to meet the fish criteria.

To perform the evaluation, CENWP-EC-HD would verify that the computed AWS discharge fell within the operational constraints of the WASCO PUD turbine. The rating curves were provided by WASCO County and CENWP-EC-HD adjusted the curves to the field data. In both tests, the measured AWS inflow (less 10 cfs juvenile bypass flow) exceeded the turbine rating by 6% for equivalent net heads. (WASCO County typically runs the turbine at 90% capacity to avoid approaching cavitation potential.) The rating curves were thus adjusted 6% upwards for the analyses from the full gate rating curves.

Problem 3: Differences between open channel output and closed conduit output. Comparing the outputs for the existing operation, the computed turbine discharge (Turbine Q = Entrance Q – Ladder Q, or sum of diffuser flows) from open channel output (NHCFISH) was always higher than the computed discharge at node 30 in the closed conduit output (NHCNET). The amounts of difference vary depending on tailrace level: the lowest percent difference at low tailrace (2%), moderate differences (6%) at median tailrace levels, up to large differences at the maximum Tailwater elevations (20%). Similarly, comparative differences will be found in the individual diffuser discharge rates and in the diffuser pool elevations. The problem results from poor convergence between the two model operating subprograms, NCHFISH and NHCNET. While this problem is disquieting, there is no way to correct the problem without intensely investigating the cause, and subsequently recompiling the program. Since most users view only the open channel output, CENWP-EC-HD concentrated on calibrating the open channel output to the field data. For the evaluation, only the open channel data was applied.

Problem 4: Water surface elevation reported in wrong location in open channel output. For a given cross-section of location along the lower fishway channel, the program output includes flow rate (Q), velocity (V), and water surface elevation (WS). The appropriated water surface elevation for a given location is incorrectly reported at one station upstream. This problem does not impair the computation of the model, since it is only an output reporting error. Thus far, the error has been found in all of the NHC models and cannot be corrected without recompiling the model. It is mentioned here so that future users are aware of this glitch.

The number of geometry or head loss coefficient errors mentioned in problems 5 and 6 above were relatively few and were replaced with corrections or calibrations made to the geometry (INI & IN) files. Specifically, the revised The Dalles North model incorporates revisions to cross sectional flow areas, minor loss coefficients, and entrance weir coefficients that better fit theoretical values and measured flow data. More details on the revised The Dalles North Fishway computer model outputs files are provided in Appendix A.

Problems 7-9 above cannot be fully corrected without either revision to the program code or a development of a new model, both of which are beyond the scope of this phase of the study. The model's accuracy is not seriously compromised by these problems.

In summary, problems 1-6 were either corrected or effectively mitigated. The process of running the revised model is less convenient with the added steps of the Excel macro program that must be exercised between each HELCRABS model run until a solution is found. However, comparisons between revised model and field data (see section 3.3.3.2) are acceptable and the model has been deemed sufficiently accurate to proceed confidently with an evaluation of the fishway operations.

3.3.3 Comparison with Field Measurements

To verify the HELCRABS model, the results of the computer model compared to the actual field measurements for two different tailwater levels. The model simulations were run with the same boundary conditions (tailrace & forebay levels) and operational settings (entrances openings, diffuser openings, fish valve settings, and head on control weir 67) recorded during the collection of field data. The following tables show detailed comparisons between the field measurement and model, both original and revised.

3.3.3.1 Original Model Data Comparison

Table 1 shows part 1 of the comparison with both the original NHC model and the CENWP-EC-HD Revised model. Part 1 covers system inflows including AWS turbine and ladder flows, plus a comparison of the measured flows versus the turbine rating curves.

Table 2 shows part 2 of comparison with both the original NHC model and the CENWP-EC-HD revised model. Part 2 covers the entrance head and discharge rates, lower fishway channel velocities and differences between AWS hydraulic gradeline and tailwater level.

In both tables, the comparative results from the original model are listed on the left side of the table under the orange headings.

The chief problems with the original model in comparison with the measurement data are the following:

- Percent differences in entrances heads vary between -15% at high tailwater to 21% at low tailwater.
- Underestimates the lower fishway channel velocities by about 38%.
- Underestimates the ladder inflow for by an average of 9% and 17% for the measured 1.35-foot ladder head condition.
- Underestimates the hydraulic gradeline in the north AWS conduit by about 0.3 feet or about 19% of the difference from AWS HGL to tailrace.

Based on the initial results, the following changes were made to the original model to better match field measurements:

- *Applied weir valve MACRO to address the weir valve problem in NHCNET*
- *Revised entrance weir coefficients.*
- *Correcedt geometry of AWS conduits and diffusers to match flow areas.*
- *Revised ladder weir and orifice coefficients to better match the data.*
- *To better simulate flows and pressures in the AWS system, the conduit/diffuser loss coefficients were increased.*

3.3.3.2 Revised Model Data Comparison

Referring back to Tables 1 and 2, the results from the CENWP-EC-HD revised model are shown on the right side of both tables under the light blue headings. The two tables show that all main problems with the model are significantly improved.

The entrance heads are improved within ± 2%. The maximum deviations are ± 0.03 feet for both tailwater conditions. The improvements came from adjusted entrance weir coefficients described in Appendix B or ..\..\Calculations\TDA_North\Natalie's work\Evaluation Phase\Evaluation of HELCRABS Simulation Program for The Dalles North Fish Ladder.pdf

- The lower fishway channel velocities were improved to average about 2% higher than the measured prototype velocities with maximum deviations within ± 2%.

- Discharges in ladder diffusers were increased over the original model, which allows the model to more correctly simulate the lower channel velocities.

- Ladder flows are brought within 1% of the average ladder lows. Ladder flows still have differences up to 10% difference due to the differences in the 1.0-foot ladder head measurements. However, a 1.35 ft ladder head improved ladder flow to 4% compared to 17% in the original model.

- The AWS HGL in the north conduit is simulated to within ± 0.2 feet and averages less than 0.1 feet above prototype data. For computed difference between AWS HGL and tailrace, this represents an improved average within 5% of prototype with a maximum deviation of 16%, versus the 19% average error with the original model.

- All total inflow and outflow rates are brought with ±4 % of the measured flows.

- The model was considered accurate as long as the model results were within the sampling error of the particular flow location (i.e., > 5% for the entrances and ladder). Except for a few isolated cases, the revised model and prototype data were in very good agreement.

Table 1: Comparison of Original NHC Model and CENWP-EC-HD Revised Model with Measured Data, Part 1 (System Inflows)

THE DALLES DAM NORTH FISHWAY

SUMMARY COMPARISON OF ORIGINAL and REVISED MODELS WITH FIELD DATA

PART 1: SYSTEM INFLOWS

Average Project Forebay Conditions (ft)

Test Date	11/10/04	5/18/05	8/12/2005
TW	75.3	79.5	
Forebay	157.9	157.2	157.7

A. Ladder Flow (cfs)

	Original NHC				EC-HD- Revised Model			
Test Date	11/10/04	5/18/05	8/12/2005	Average	11/10/04	5/18/05	8/12/2005	Average
Ladder Head	1.0	1.0	1.35		1.0	1.0	1.35	
Measured	81	68	102	84	81	68.0	102	84
Model	72	72	85	76	75	75.1	98	83
% Diff	*-11%*	*6%*	*-17%*	*-9%*	*-7%*	*10%*	*-4%*	*-1%*

B. Comparison of Measured Turbine Flow versus Rating Curve (cfs)

	Original NHC			EC-HD- Revised Model		
Test Date	**11/10/04**	**5/18/05**	**Average**	**11/10/04**	**5/18/05**	**Average**
Turbine MW	**5.4**	**4.9**		**5.4**	**4.9**	
Net Head (ft)	**78.8**	**75.1**		**78.8**	**75.1**	
Measured	934	905	920	**934**	**905.0**	920
Rating Curve	***875.0***	**850**	863	**875**	**850.0**	863
Diff	*-59.0*	*-55.0*	*-6%*	*-59.0*	*-55.0*	*-6%*

C. Net Head and Discharge through Turbine UNIT (cfs)

	Original NHC			EC-HD- Revised Model		
Test Date	11/10/04	5/18/05	Average	11/10/04	5/18/05	Average
Turbine MW	**5.4**	**4.9**		**5.4**	**4.9**	
Net Head (ft)						
Measured	78.8	75.1	77.0	78.8	75.1	77.0
Model	78.8	75.1	77.0	78.8	75.1	77.0
Diff	*0.0*	*0.0*	0%	*0.0*	*0.0*	0%
Discharge						
Measured	934	905	920	934	905	920
Model	1004	839	921	968	858	913
% Diff	*7%*	*-7%*	*0%*	*4%*	*-5.1%*	*-1%*

D. Total System Inflow (cfs)

	Original NHC			EC-HD- Revised Model		
Test Date	**11/10/04**	**5/18/05**	**Average**	**11/10/04**	**5/18/05**	**Average**
Meas & curves	1015	973	994	1015	973	994
Model	1076	911	993	1043	934	988
% Diff	*6%*	*-6%*	*0%*	*3%*	*-4%*	*-1%*

Table 2: Comparison of Original NHC Model and CENWP-EC-HD Revised Model with Measured Data, Part 2 (Entrance Heads & Discharge Rates and Channel Velocities)

THE DALLES NORTH FISHWAY

SUMMARY COMPARISON OF ORIGINAL and REVISED MODELS WITH FIELD DATA

PART 2: ENTRANCE HEADS & DISCHARGE RATES,
LOWER CHANNEL VELOCITY AND WATER LEVEL DATA

Average Project Tailrace Conditions (ft)

Test Date	11/10/04	5/18/05
Tailrace	75.3	79.5
Proj FB	157.90	157.2

E. E-1 Entrance Head

	Original NHC			EC-HD- Revised Model		
Test Date	11/10/04	5/18/05	Average	11/10/04	5/18/05	Average
weir submerg.	8.5	9.5		8.5	9.5	
Measured	1.3	1.3	1.3	1.3	1.2	1.3
Model	1.6	1.1	1.4	1.3	1.2	1.3
% Diff	*21%*	*-15%*	*3%*	*2%*	*1%*	*2%*

F. Entrance Discharge Rates (cfs)

	Original NHC			EC-HD- Revised Model		
Test Date	11/10/04	5/18/05	Average	11/10/04	5/18/05	Average
weir submerg.	8.5	9.5		8.5	9.5	
Measured	1015	973	994	1017	973	995
Model	1075	912	994	1043	933	988
% Diff	*6%*	*-6%*	*0%*	*3%*	*-4%*	*-1%*

G. Fishladder Channel Velocities (feet per second)

Measured one strut d/s of Weir 70

	Original NHC			EC-HD- Revised Model		
	Test Date	11/10/04	Average	11/10/04	5/18/05	Average
Proj. Tailrace	75.3	79.5		75.3	79.5	
Measured	1.4	1.2	1.3	1.4	1.2	1.3
Model	0.9	0.7	0.8	1.5	1.2	1.3
% Diff	*-0.3*	*-0.4*	*-0.4*	*5.7%*	*1.7%*	*3.9%*

H. Head Difference between AWS Conduit and Tailrace

AWS HGL (at I-E)- Tailwater (ft)

	Original NHC			EC-HD- Revised Model		
	AWS HGL (at I-E) - Tailwater (ft)					
Test Date	11/10/04	5/18/05	Average	11/10/04	5/18/05	Average
Measured	2.1	1.4	1.7	2.2	1.4	1.8
Model	1.7	1.1	1.4	2.1	1.6	1.9
Diff	*-0.4*	*-0.3*	*-0.3*	*-0.1*	*0.2*	*0.1*

3.4 Model Evaluation Conclusions

There were some deficiencies discovered in both the geometry files and the program code. The general items of concern are listed in Paragraph 3.3.2 (See Appendix B or ..\..\Calculations\TDA_North\Natalie's work\Evaluation Phase\Evaluation of HELCRABS Simulation Program for The Dalles North Fish Ladder.pdf for a detailed report of the changes made to the geometry files and recommended program code corrections).

The geometry files have been corrected or adjusted so that the program will provide reasonably accurate simulations. A macro (developed last year for the Bonneville 2nd Powerhouse system) was adapted to The Dalles North Fishway model and applied to correct the erroneous procedures in the AWS simulations for the ladder diffusers. With these adjustments, CENWP-EC-HD was able to proceed with an effective evaluation of the system performance with respect to fish criteria. The program code was written with considerable flexibility by making geometry files available for user access, and as such, the most important changes could be made through the geometry files. However, there remain deficiencies in the program code that, when corrected, will provide clearer output and greater simulation accuracy.

With the numerous model modifications, the program operation has become more cumbersome for the user. There is some difficulty in getting model convergence at the higher tailwater levels because there are more ladder diffusers in play. At higher tailwater levels, the head on the ladder stovepipe weirs are much higher and thus lead to a high degree of sensitivity to small adjustments in head. Thus it often takes extra attempts of different node 30 inputs before a converged solution is attained. Also if the user chooses to make a large change in tailwater elevations between simulations, it is best to make this change in multiple simulations by incrementally going from one tailwater to the other. While the modifications have made the model more difficult to operate, these steps were deemed necessary to provide an accurate evaluation of The Dalles North Fishway system.

4.0 Fishway Evaluations

Upon completion of the calibration and modifications to the numerical model (as described in Section 3), the model was used to conduct an evaluation of The Dalles North Fishway. The purpose of the evaluation was to determine whether current operational procedures are adequate to meet fish passage requirements throughout the ladder (excluding the exit control section which is not included in The Dalles North Model and is reported to perform well according to project biologists). If model simulations show the current operating scheme fails to meet hydraulic criteria, an alternate operating scheme was developed using the modified model. The following section describes the operational criteria used to evaluate the ladder, an evaluation of the ladder as it is currently operated, and an explanation of an alternate operating plan developed to improve performance of the ladder with respect to the operational criteria.

4.1 Operational Criteria

The Corps of Engineers Fish Passage Plan (FPP), the document of Corps operational policy pertaining to the fish passage systems on the Columbia, lists a number of hydraulic criteria agreed by regional agencies to be beneficial to the passage of fish through the projects. These criteria, though still being researched, are used in this evaluation. The primary hydraulic characteristics desired in this fishway are as follows:

- Head drop across ladder entrance – 1.0 feet to 2.0 feet with 1.5 feet optimum
- Minimum entrance weir submergence – 8 feet;
- Head over overflow ladder weirs:
    - 1.0 feet ± 0.1 feet during non-shad season (Aug 16- May 14) and
    - 1.3 feet ± 0.1 feet during shad passage season (May 15 – Aug 15)
- Exit section head criteria – 0.5 feet to 1.0 feet between pools;
- Channel velocities – 1.5 to 4 ft/s with 2 ft/s optimum;
- Diffuser velocities – 0.5 ft/s maximum.

Plate-16 provides a summary matrix of the current operational procedure, including fish turbine output (assuming a median forebay 158.5 feet NGVD), entrance weir crest elevations, and diffuser settings for ladder operations consistent with the FPP.

4.2 Evaluation Procedures

In order to evaluate the current fishway, the model was used to simulate hydraulic conditions for a number of project tailrace elevation conditions. The numerical model was used first to evaluate the current operations by checking the resulting hydraulic conditions from those operations. Specifically, model runs were conducted at the median forebay level of 158.5 feet NGVD and eight tailwater elevations between 73 and 88 feet NGVD. During the fish passage season (March- November), the tailwater elevation at The Dalles North Fishway is between these levels more than 99% of time. The hydraulic conditions in the fishway were compared to the fisheries criteria described above. The following assumptions regarding the existing operation were applied in the simulations:

- One entrance weir (N-1) operated;
- Weir submergence = 8.5 feet;
- PUD PLC controls N-1 weir to maintain 1.3 feet of entrance head; and
- No diffuser settings are changed over range of tailwater elevations.
    - All diffuser gates open except diffuser gate 2000 closed and diffuser gate 1900 half blocked.

Results and conclusions from this evaluation are provided in Section 4.3.1.

4.3 Fishway Evaluation Conclusions

4.3.1 Current Operations Plan

The current operation is outlined in a matrix for incremental tailwater levels between 73 and 88 feet NGVD in Table 3, showing an operational matrix table with the existing operational settings for each tailrace elevation between 73and 88 feet NGVD. The middle of the matrix tables lists the diffuser settings and the number of active ladder diffusers. On the top of the matrix Table 6, the estimated turbine megawatt output and discharge rates are listed based on an assumed median forebay of 158.5 feet and respective net heads and the entrance weir crest elevations for each tailwater level.

4.3.1.1 Performance with Respect to Criteria

Table 3 shows the model simulation results for the existing fishway operation for the range tailwater conditions between 73 feet and 88 feet NGVD. The upper section of the tables provides the operational settings for the PUD turbine, the ladder head, and entrance weir crest elevation. The middle section provides the computed discharge rates through the same components and the total system discharges. The bottom section shows the system performance according to fisheries criteria.

The third section covers the system wide performance with respect to fisheries criteria over the range of tailwater levels. (The upper part of this section contains the AWS hydraulic gradeline level near the turbine discharge connection to the AWS conduit.) The lower half of this section lists entrance head and the channel velocities at two points along the lower fishway channel—one located downstream at the channel bend, the other located upstream about 20 feet downstream of weir 70. The bottom of the table contains maximum diffuser velocities in both diffuser sections. Criteria violations are shown in highlighted cells: the yellow (lighter shade) for general fisheries criteria and orange (darker) for both general fisheries and design or operation criteria.

Table 3:Existing Operation of The Dalles North Fishway: Model Simulation Results for Tailwater Levels Between 73 and 88 Feet NGVD Based on Fish Passage Plan and Current Programmable Logic Control Commands (Forebay 158.5.0 feet NGVD assumed for all runs)

The Dalles North Fishway Existing Operation Table in Accordance with Fish Passage Plan and PLC operation								
Tailwater	**73**	**75**	**77**	**78**	**80**	**82**	**85**	**88**
Percent exceedence (Mar 1 - Nov 30)	99%	95%	65%	45%	25%	12%	5%	1%
SETTINGS:								
Inflow: Fishurbines and ladder								
WASCO PUD Fish Turbine Output								
Net Turbine Head[1] (ft)	81.5	79.7	78.6	78.0	76.4	74.6	71.9	69.0
Power (Megawatts)	5.5	5.4	5.3	5.2	5.1	4.9	4.6	4.4
Weir 152 Ladder Head (ft)	1.0	1.0	1.0	1.0	1.3	1.3	1.3	1.3
Outflow: (weir elevations, ft)								
Entrance Bay-1 (N-1)	64.5	66.5	68.5	69.5	71.5	73.5	76.5	79.5
Entrance Bay-2 (N-2)	closed	closed	closed	closed	closed	closed	closed	closed
Side Entrance (N-3)	closed permanently							
DISCHARGE:								
Inflow: (cfs)								
WASCO PUD inflow (modeled)	**937**	**936**	**835**	**814**	**741**	**699**	**661**	**635**
(HD Picketed) Weir 152 Ladder Flow	75	75	75	75	94	94	94	94
Total System Inflow (modeled)	**1012**	**1011**	**910**	**889**	**836**	**793**	**755**	**729**
WASCO PUD Turbine (from turbine curves)	946	936	931	928	919	907	890	871
(HD Picketed) Weir 152 Ladder Flow	75	75	75	75	94	94	94	94
Total System Inflow (cfs)	1021	1012	1006	1003	1013	1001	984	965
Outflow: (cfs)								
Entrance Bay-1 (N-1)	1013	1011	909	890	836	794	754	728
Entrance Bay-2 (N-2)	0	0	0	0	0	0	0	0
Total System Discharge (cfs)	1013	1011	909	890	836	794	754	728
WATER LEVEL, HGL, AND PRESSURE DATA								
Tailrace (ft)	73.0	75.0	77.0	78.0	80.0	82.0	85.0	88.0
Entrance Aproach Channel Water Level (ft)	73.9	76.3	78.3	79.3	81.3	83.3	86.3	89.3
HGL AWS (near ladder diffuser L-8) (ft)	76.9	78.7	79.8	80.5	82.1	83.8	86.6	89.3
Δ AWS (psi)	1.3	1.1	0.7	0.5	0.3	0.2	0.1	0.0
No. of submerged ladder weirs (DH < 0.5 ft)	4	7	10	10	11	13	16	19
PASSAGE CRITERIA:								
Entrance Head (E.H.) (ft)	0.9	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Required Entrance Weir Submergence (ft)	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Channel Velocities near Base of Ladder (ft/s)	1.5	1.4	1.2	1.2	1.1	1.0	0.8	0.8
Channel Velocities at Bend to Entrances (ft/s)	4.2	3.4	2.6	2.4	2.0	1.7	1.4	1.2
Max Ladder Diffuser Velocities (ft/s)	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.1
Max Lower Channel Diffuser Velocities (ft/s)	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.1

NOTES:
1. Median Forebay 158.5 is assumed in all runs. The Net Head = FB - AWS HGL
2. Fish Criteria Violations highlighted in Yellow as follows:
   The shade of yellow shade indicates signficance or degree of violation:
3. The turbine flow capacity was exceeded at TW=73 so the turbine was adjusted to account for to maximum turbine- 1161 (E. H.=1.3) down to 1029.7 (E.H.=1.1)

Cha Vel.	Diff Vel.
> 4 ft/s	0.5 ft/s max
< 1.5 ft/s	

The following is a list of general assessments of the fishway performance with respect to criteria, based on the evaluation using the revised HELCRABS computer model.

Entrance Submergence. The entrance submergence criteria can be for the full range of tailwater elevations. The Dalles North Fishway has a minimum weir or sill elevation of 62 feet, which assures submergence criteria can be met for tailwater elevations down to 70 feet. The minimum tailwater recorded between 1974 and 1999 was 72.7 feet.

Entrance Heads. According to upgraded model simulations, the current The Dalles North Fishway operation meets entrance head criteria (1.0 – 2.0 feet) at all tailwater elevations as long as only one entrance weir is operated. There is no condition in which two entrances can be operated simultaneously within submergence and head criteria. The original AWS was supplied by the plunge pool system, which has more capacity than the turbine unit. The original design criterion was less rigorous in terms of flow and submergence requirements at the entrances. These two factors allowed for dual entrance operations. WASCO PUD requested more flow capacity for their turbine unit during the planning stage but was limited by the Corps (and maybe BPA) to an 800 cfs unit. This limitation--plus the change in entrance criteria--prevents the operation of more than one entrance in criteria.

Channel Velocities. In general, the current The Dalles North Fishway operation meets the channel velocity criteria (1.5 – 4 ft/s) at the downstream section of the lower fishway channel and fails to meet criteria at the upstream end of the channel.

- At the downstream end of the channel (near the bend), velocity criteria is met for all cases except high tailwater levels (TW > 85 feet) or about 10% of the time.
- At the upstream end (10 feet downstream of weir 70), the current operation does not meet the minimum velocity criteria (1.5 ft/s) except at very low tailwater elevations (TW < 75 feet) or about 5% of the time (or fails to meet criteria 95% of time).

Low channel velocities is a problem is typically found near the base of the fish ladder weirs at most fishway systems in the lower Columbia basin. This problem is caused by the physical limitations of ladder diffusers and limited AWS water supply. There is no adjustment that can be made to the existing operation that would substantially improve the velocities; instead structural and mechanical measures are required to address this problem as discussed in Section 5.

Diffuser Velocities. The 0.5 ft/s criteria diffuser velocity is met for the full range of tailwater levels in the existing operation.

Exit Channel Head Drop between Pools. The range of head drops between pools meets the criteria for the exit section in most conditions. The current criteria for the exit section are between 0.5 – 1.0 foot. This criteria is met except at very low forebay elevations (FB < 157 feet NGVD): The average head drop in the exit section is about 0.3 feet at minimum operating forebay (155 feet NGVD), 0.7 feet at median forebay (158.5 feet NGVD) and 0.9 feet at maximum forebay (160 feet NGVD).

4.3.1.2 Issues beyond Criteria

There are other issues that should be considered beyond the realm of criteria evaluation, which may need solutions in the future.

Lamprey Passage. The upstream movement of lamprey is a growing concern in the Lower Columbia system. Once lampreys enter a fish ladder, they can slowly make their way up as long as the walls are smooth and straight or rounded. Lampreys progress up the ladder by swimming and adhering to the sidewalls and floors. Unfortunately, the entrances and exit channels sections present impassible obstacles to them. Project Biologists have devised clever means to collect and bypass lamprey around the baffled exit channel. But The Dalles North Fishway does not offer a means for lamprey to enter the system since the bulkhead guides for the entrance weir will impede the lamprey.

Rounded edges were added to the fixed entrances weirs at Bonneville Cascades Island and B Branch Fishways in 2002 to help lamprey enter those systems.

Diffuser screens are sized to prevent adult salmon entry, but lamprey may pass through them. Once in the auxiliary water systems, the lamprey may not find a means of escape.

Experimental designs are being placed in fishways and tested by NOAA Fisheries to improve lamprey passage efficiency.

Fish Passage Delay in Lower Fishway System. There is an endemic delay problem found in all fishway systems in the sections between the entrance and the base of ladders. Once adult fish enter a fishway system, they often turn around and go back out one of the entrances. The reasons are complicated and remain to be quantified. In general terms relevant to all ladder systems, some of the possible reasons for this behavior are the following:

- Different water temperature from the AWS, often fed from lower depths in the forebay, compared to the tailwater;
- Low velocities in the collection channel;
- Change in configuration from collection channel to ladder;
- Minimum fishway channel velocities at the base of the ladder;
- Low head across typically submerged ladder weirs at the base of the ladder provide little head to attract fish through the orifices, which they normally prefer to use.

Water temperature is not a factor at The Dalles North Fishway. The AWS turbine flow is drawn from the upper 10 to 15 feet of the forebay water column. The Dalles North Fishway evaluation does reveal that velocities are usually low near the base of the ladder and several ladder weirs are continuously submerged. The field operational testing revealed low velocities at the base of the fish ladder, which are below the 1.5 ft/s criteria except when the tailwater is at elevations 73 feet and 75. This could account for fish turning around or delaying in the entrance. Only structural modifications can improve these conditions.

The next step of the evaluation examined the improvement of The Dalles North Fishway with respect to the operational and fisheries criteria. There is little available room for operational adjustments that would substantially improve the system performance. The evaluation of the existing operation does indicate the turbine unit has additional capacity above the fishway requirements for a single entrance weir at 8.5 feet of submergence and 1.3 feet entrance head when the tailwater is higher than 77 feet NGVD. Thus the entrance weir submergence could be increased as the tailwater increases, which could provide further operational flexibility for Wasco PUD operation. Most significant performance improvements call for structural modifications. The main focus of improvement is the low velocities in the lower fishway channel.

5.0 Recommendations

There are a number of recommendations as a result of this model evaluation study. They primarily consist of operational or structural changes to improve performance of The Dalles North ladder with respect to operational criteria. Most of the recommendations present structural alternatives. Suggestions for model improvements are also discussed. Recommendations for the fishway are provided in the following paragraphs.

5.1 Fishway Operational Modifications

Once the evaluations were completed, the model was run for several diffuser gate scenarios in order to try to meet the fishery criteria.

For tailwater elevation 73 under the three scenarios (all the diffuser gates open, diffuser gate 2000 model (project location 1-A) closed and diffuser gate 2000 model (project location 1-A) closed along with diffuser gate 1900 model (project location 1-B) half blocked) and elevation 75 will all diffuser gates open, the fishery criteria can be met; however, the turbine capacity is exceeded suggesting that more flow from another turbine would be helpful in meeting criteria.

The fishery criteria can be met at:

- a TW of 75 with diffuser gates 2000-1700 (model) closed (project location 1-A through 1-D)
- a TW of 77 with diffuser gates 2000-1600 (model) closed (project location 1-A through 1-E)
- a TW of 78 with diffuser gates 2000- 1500 (model) closed (project location 1-A through 1-F)
- a TW of 80 with diffuser gates 2000-1400 (model) closed (project location 1-A through 1-G)

These scenarios do require special consideration for the Node 30 elevation, however. (See Recommended Operations Table 4) From tailwater elevation 85 to 88, the criterion is rarely met and the velocities are very slow (0.8 to 1.2 ft/sec).

The fishery criteria can be met by increasing of the submergence as the tailwater increases from 8.5 feet submergence at TW elevation 78 to 9 feet submergence at TW elevation 80 to 10 feet submergence at TW 82-88 which increases the velocities at the bend to greater than 1.6 to 2.4 ft/sec. (See Table 5)

5.2 Fishway Structural Operations

Since the only time the ladder meets fishery criteria is at a very low tailwater of elevation 73, structural modifications would be needed to the ladder and ladder diffuser systems. The following structural modifications were evaluated at Low (TW=73), Medium (TW=78) and High (TW=88) and the following are recommendation provided for consideration. (See Table 6)

- **Option 1-Remove weirs 70-73-** The minimum recorded tailwater since 1974 is 72.7 feet. Assuming the normal 1.3 feet of entrance head, the minimum channel water level is 74 feet. This means ladder weirs 70 through 73 are always submerged. A removal of weirs 70-73 could allow more flow could be added to the system which increases the velocities to help meet fishery criteria. It also removes weirs that are continuously submerged and represent potential fish impediments due to the low head across them.

  Pros- This option removes unnecessary fish impediments and energy losses created by constantly submerged weirs. Also slightly improves channel velocities
  Cons- The construction cost for removing the weirs.

- **Option 2-Reduce the crest elevations of the ladder diffuser weir valves to increase flow from the ladder diffusers into the ladder section-** Only 12 inches of the weir valves (stove pipe weir) could be removed to assure that the flow did not come back through the system. This reduction is effective in improving lower channel velocities by about 10 -20% at the upstream end.
  Pros- Improves lower channel velocities.
  Cons- The construction cost incurred to cut each stovepipe weir lower.

- **Option 3-Add another turbine to increase AWS flow-** The installation of another turbine would most likely be housed next to the current turbine. The footprint for the existing plunge pool channel and pool could be used to place the new unit plus an additional juvenile bypass system. If a turbine unit of equivalent capacity were installed, two entrance weirs could be operated in criteria for tailwater elevations above 78 feet. If the Fisheries Agencies permitted the operation of the second entrance weir below submergence criteria (the first weir would be remain in submergence criteria) at the lower tailwater conditions, the entrance head and the channel velocity criteria could be met for all conditions. The maximum velocities in the diffusers could reach up to 0.8ft/s (exceeding 0.5 ft/s criteria in both options), but this comes from an unlikely operation at TW 73 that creates an unacceptable channel velocity of about 7 ft/s at the channel bend. At TW 78 and above, the diffuser velocities will increase to a maximum of 0.4 ft/s. Assuming a Variable Speed Turbine and limiting the channel velocity to 5 ft/s, the maximum diffuser velocity will be 0.5 ft/s for any Tailwater level

  Pros- This would provide more flow to meet fishery criteria and allow the operation of two entrance weirs in criteria for tailwater levels above 78 feet.
  Cons- Space constrictions may be very tight to add another turbine unit, the costs of a new turbine and the installation.

- **Option 4-Ultilize the two existing plunge pool side gates to augment the Attraction Water Supply System (AWS) Channel from the forebay-** This rock-lined channel and plunge pool was used to provide the AWS water supply in the original ladder system, but has only served as an emergency bypass since the turbine was installed in 1989. The deteriorating plunge pool was repaired in

1998, but pool and channel would need much more extensive repairs (concrete lining) before it could be operated continuously. Adding the inflow from the plunge pool, two entrance weirs could be operated in criteria for tailwater elevations above 78 feet. If the Fisheries Agencies permitted the operation of the second entrance weir out of submergence criteria (the first would remain in criteria) at the lower tailwater conditions, the entrance head and channel velocity criteria could be met for all conditions. The maximum velocities in the diffusers could reach up to 0.8ft/s (exceeding 0.5 ft/s criteria in both options), but this comes from an unlikely operation at TW 73 that creates an unacceptable channel velocity of about 7 ft/s at the channel bend. At TW 78 and above, the diffuser velocities will increase to a maximum of 0.4 ft/s.

In attempting to use both the PUD turbine and plunge pool bypass system simultaneously, one of the large drawbacks is that the plunge pool inflow has a detrimental effect on the turbine operation. There is a considerable amount of surging and pressure fluctuations emanating from the plunge pool area that would probably shorten the effective life of the turbine unit. Also air entrainment transported in from the plunging inflow effectively reduces the hydraulic efficiency in the AWS conduit. CENWP-EC-HD performed tests in 1997 to measure the AWS flow through the plunge pool side gates during conditions where the PUD was either shut off or turned on. The 1997 data shows that the AWS hydraulic gradeline (measured in the plunge pool) becomes much higher as a function of the percent of total flow added by the plunge pool operation. (However, no measurements were taken directly from the AWS conduit.) So while the plunge pool gates can significantly increase the total AWS discharge, the Megawatt production from the PUD will be reduced by about 7% on average. There exists no juvenile bypass system with the existing plunge pool slide gate configuration. Without making extensive modifications to the existing slide gate intake basin, the only place for a juvenile screen is out in the forebay—which would be a significant cost and Project maintenance item.

Pros-The plunge pool channel already exists and could provide more flow to help attain fishery criteria and allow the operation of two entrance weirs in criteria for tailwater levels above 78 feet.
Con- The current turbine operation would be impacted and likely reduce the working life of the unit. Construction funds are needed to concrete lined the plunge pool and approach channel, which may require energy dissipation. No screened juvenile bypass is provided for this inflow.

Recommended Operations for Diffuser Gates (DG)

	Link	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1010	900	800	700	600	500	400	300	200	100	10	Fish Criteria 1.3	Fish Criteria=Over 1.5, 2 ft/sec optimum	Fish Criteria=Over 1.5, 2 ft/sec optimum	Comment
		DG 1-A	DG 1-B	DG 1-C	DG 1-D	DG 1-E	DG 1-F	DG 1-G	DG 1-H	DG 1-I	DG 1-J	DG N-1	DG N-2	DG N-3	DG N-4	DG N-5	DG N-6	DG N-7	DG N-8	DG N-9	DG N-10	DG N-11	Entrance Head in (ft)	Velocity 800 to 900 (ft/sec)	Velocity 200 to 100 (ft/sec)	
TW=73	Existing Operation-Recommended	Closed	1/2 Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.9	4.9	**However the Turbine capcity is exceeded**
TW=73	Existing Operation-Recommended	Closed	1/2 Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	0.9	1.5	4.2	At turbine capacity
TW=73	Recommended	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.4	1.9	4.8	**However the Turbine capcity is exceeded**
TW=73	Recommended	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	0.9	1.4	3.9	At turbine capacity
TW=73	Recommended	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.9	5.0	**However the Turbine capcity is exceeded**
TW=73	Recommended	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	0.9	1.5	4.1	At turbine capacity
TW=73		Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.2	1.9	4.8	Turbine capcity exceeded
TW=73		Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	0.9	1.5	4.1	At turbine capacity
TW=75	Existing Operation	Closed	1/2 Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.5	3.4	**However the Turbine capcity is exceeded**
TW=75	Existing Operation	Closed	1/2 Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.2	1.4	3.1	At turbine capacity
TW=75		Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.4	1.4	3.3	**Turbine capcity exceeded**
TW=75		Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.2	1.2	3.1	At turbine capacity
TW=75		Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.5	3.4	**Turbine capcity exceeded**
TW=75		Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.4	3.4	At turbine capacity
TW=75		Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.2	1.5	3.3	
TW=75		Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.2	1.6	3.3	At Turbine capcity, Node 30= 79.1 for a net head of 79.4
TW=75		Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.7	3.4	**Turbine capcity exceeded,** Node 30= 79.3 for a net head of 79.2
TW=75		Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.7	3.4	**Turbine capcity exceeded,** Node 30= 79.3 for a net head of 79.2
TW=75		Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.7	3.3	At turbine capacity, Node 30=79.4 for a Net head of 79.1
TW=75		Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.7	3.4	**Turbine capcity exceeded**
	Link	**2000**	**1900**	**1800**	**1700**	**1600**	**1500**	**1400**	**1300**	**1200**	**1100**	**1010**	**900**	**800**	**700**	**600**	**500**	**400**	**300**	**200**	**100**	**10**				
TW=77	Existing Operation	Closed	1/2 Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.2	2.6	
TW=77		Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.2	2.5	Node 30=79.9 for a net head of 78.6
TW=77		Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.2	2.6	
TW=77		Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.2	1.2	2.5	
TW=77		Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.3	2.6	Node 30=80.1 for a net head of 78.4
TW=77		Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.4	2.7	Node 30=80.3 for a net head of 78.2
TW=77		Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.4	2.6	Node 30=80.4 for a net head of 78.1
TW=77		Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.5	2.6	Node 30=80.75 for a net head of 77.75
	Link	**2000**	**1900**	**1800**	**1700**	**1600**	**1500**	**1400**	**1300**	**1200**	**1100**	**1010**	**900**	**800**	**700**	**600**	**500**	**400**	**300**	**200**	**100**	**10**				
TW=78	Existing Operation	Closed	1/2 Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.2	2.4	
TW=78		Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.4	1.2	2.3	Node 30=80.6 for a net head of 77.9
TW=78		Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.2	2.4	
TW=78		Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.2	1.2	2.3	
TW=78		Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.3	2.3	Node 30=80.8 for a net head of 77.7
TW=78		Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.3	2.3	Node 30=81.00 for a net head of 77.5
TW=78		Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.4	2.3	Node 30=81.25 for a net head of 77.25
TW=78		Closed	Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.5	2.4	Node 30=81.25 for a net head of 77.25
	Link	**2000**	**1900**	**1800**	**1700**	**1600**	**1500**	**1400**	**1300**	**1200**	**1100**	**1010**	**900**	**800**	**700**	**600**	**500**	**400**	**300**	**200**	**100**	**10**				
TW=80	Existing Operation	Closed	1/2 Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.1	2.0	
TW=80		Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.4	1.1	1.9	
TW=80		Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.1	2.0	Node 30=82.15 for a net head of 76.35
TW=80		Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.1	1.9	
TW=80		Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.2	1.1	1.9	
TW=80		Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.1	1.1	1.8	
TW=80		Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.0	1.1	1.8	
TW=80		Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.3	2.0	Node 30=82.60 for a net head of 75.9
TW=80		Closed	Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.3	2.0	Node 30=82.90 for a net head of 75.6
TW=80		Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.4	1.5	2.0	Node 30= 83.5 for a net head of 75
TW=80		Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.7	2.0	Node 30= 84.25 for a net head of 74.25
	Link	**2000**	**1900**	**1800**	**1700**	**1600**	**1500**	**1400**	**1300**	**1200**	**1100**	**1010**	**900**	**800**	**700**	**600**	**500**	**400**	**300**	**200**	**100**	**10**				
TW=82	Existing Operation	Closed	1/2 Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.0	1.7	
TW=82		Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.0	1.6	
TW=82		Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.0	1.7	
TW=82		Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.0	1.7	
TW=82		Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.2	1.0	1.6	
TW=82		Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.1	1.0	1.6	
TW=82		Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.5	1.3	1.8	Node 30= 84.6 for a net head of 73.9
TW=82		Closed	Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.4	1.3	1.8	
TW=82		Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.1	1.2	1.5	Model bombs past Node 30= 84.4, NTH= 74.1
TW=82		Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.0	1.2	1.4	
	Link	**2000**	**1900**	**1800**	**1700**	**1600**	**1500**	**1400**	**1300**	**1200**	**1100**	**1010**	**900**	**800**	**700**	**600**	**500**	**400**	**300**	**200**	**100**	**10**				
TW=85	Existing Operation	Closed	1/2 Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	0.8	1.4	
TW=85		Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	won't converge			
TW=85		Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.2	0.8	1.4	
TW=85		Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.2	0.9	1.3	
TW=85		Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	0.9	1.4	
	Several close options in here not evaluated																									
TW=85		Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	0.9	1.0	1.2	Model bombs past this Node 30
	Link	**2000**	**1900**	**1800**	**1700**	**1600**	**1500**	**1400**	**1300**	**1200**	**1100**	**1010**	**900**	**800**	**700**	**600**	**500**	**400**	**300**	**200**	**100**	**10**				
TW=88	Existing Operation	Closed	1/2 Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	0.8	1.2	
TW=88		Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	0.8	1.2	
	Several close options in here not evaluated																									
TW=88		Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.4	1.1	1.2	
TW=88		Closed																					0.11	0.41	0.41	

Table 4: Recommended Operations for Diffuser Gate settings

Table 5: Increased submergence with increased TW

The Dalles North Fishway Operation Table in Accordance with Fish Passage Plan and PLC operation								
INCREASED Submergence				At turbine capacity	Exceed turbine capacity	At turbine capacity	Exceed turbine capacity	At turbine capacity
Tailwater	**78**	**78**	**80**	**82**	**82**	**85**	**85**	**88**
Percent exceedence (Mar 1 - Nov 30)	45%	45%	25%	12%	12%	5%	5%	1%
SETTINGS:	Existing at 8.5' submergence	9' submergence	9' submergence	10' submergence				
Inflow: Fishurbines and ladder								
WASCO PUD Fish Turbine Output								
Net Turbine Head[1] (ft)	78.0	78.0	75.8	74.0	74.0	71.3	71.2	68.5
Power (Megawatts)	5.2	5.2	5.1	4.8	4.8	4.6	4.6	4.4
Weir 152 Ladder Head (ft)	1.0	1.0	1.3	1.3	1.3	1.3	1.3	1.3
Outflow: (weir elevations, ft)								
Entrance Bay-1 (N-1)	69.5	69.0	71.0	72.0	72.0	75.0	75.0	78.0
Entrance Bay-2 (N-2)	closed	closed	closed	closed	closed	closed	closed	closed
Side Entrance (N-3)	Permanently Closed							
DISCHARGE:								
Inflow: (cfs)								
WASCO PUD inflow	**814**	**787**	**900**	**910**	**949**	**885**	**928**	**878**
(HD Picker) Weir 152 Ladder Flow	75	75	94	94	94	94	94	94
Total System Inflow	**889**	**862**	**995**	**1004**	**1044**	**979**	**1022**	**972**
WASCO PUD Turbine from turbine curves	928	928	916	903	903	884	884	870
(HD Picker) Weir 152 Ladder Flow	75	75	94	94	94	94	94	94
Total System Inflow (cfs)	1003	1003	1010	997	997	978	978	964
Outflow: (cfs)								
Entrance Bay-1 (N-1)	890	863	995	1004	1043	980	1023	972
Entrance Bay-2 (N-2)	0	0	0	0	0	0	0	0
Total System Discharge (cfs)	890	863	995	1004	1043	980	1023	972
WATER LEVEL, HGL, AND PRESSURE DATA								
Tailrace (ft)	78.0	78.0	80.0	82.0	82.0	85.0	85.0	88.0
Entrance Aproach Channel Water Level (ft)	79.3	79.0	81.5	83.3	83.4	86.4	86.5	89.5
HGL AWS (near ladder diffuser L-8) (ft)	80.5	80.3	82.7	84.4	84.5	87.1	87.2	89.6
Δ AWS (psi)	0.5	0.5	0.5	0.5	0.5	0.3	0.3	0.1
No. of submerged ladder weirs (DH < 0.5 ft)	10	10	12	13	14	16	16	19
PASSAGE CRITERIA:								
Entrance Head (E.H.) (ft)	1.3	1.0	1.5	1.3	1.4	1.4	1.5	1.5
Required Entrance Weir Submergence (ft)	8.5	9.0	9.0	10.0	10.0	10.0	10.0	10.0
Channel Velocities near Base of Ladder (ft/s)	1.2	1.2	1.3	1.2	1.3	1.1	1.2	1.0
Channel Velocities at Bend to Entrances (ft/s)	2.4	2.3	2.3	2.1	2.2	1.8	1.9	1.6
Max Ladder Diffuser Velocities (ft/s)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Max Lower Channel Diffuser Velocities (ft/s)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1

NOTES:
1. Median Forebay 158.5 is assumed in all runs. The Net Head = FB - AWS HGL
2. Fish Criteria Violations highlighted in Yellow as follows:
   The shade of yellow shade indicates signficance or degree of violation:
3. The turbine flow capacity was exceeded at TW=73 so the turbine was adjusted to account for to maximum turbine- 1161 (E. H.=1.3) down to 1029.7 (E.H.=1.1)

Cha Vel.	Diff Vel.
> 4 ft/s	0.5 ft/s max
< 1.5 ft/s	

Table 6: Comparison of Two Minor Structural Alternatives with Existing Operation at Tailwater Elevations 73, 78, and 88; Option 1--Remove Ladder Weirs 70-73; Option 2--Lower Ladder Diffuser Stovepipe Weir Crest Elevations by 1 foot.

The Dalles North Fishway
Comparison of Minor Structural Alternatives with Existing Operation

Tailwater Elevation	Tailwater 73			Tailwater 78			Tailwater 88		
Structural Alternative:	Existing	Option 1- Take out weir 70-73	Option 2=Reduce WV by 12"	Existing	Option 1- Take out weir 70-73	Option 2=Reduce WV by 12"	Existing	Option 1- Take out weir 70-73	Option 2=Reduce WV by 12"
SETTINGS:							See note 3.		
Inflow: Fishurbines and ladder									
WASCO PUD Fish Turbine Output									
Net Turbine Head[1] (ft)	81.5	81.6	81.5	78.0	77.9	78.0	69.0	69.0	69.0
Power (Megawatts)	5.5	5.5	5.5	5.3	5.3	5.3	4.4	4.4	4.4
Weir 152 Ladder Head (ft)	1.0	1.0	1.0	1.0	1.0	1.0	1.3	1.3	1.3
Outflow: (weir elevations, ft)									
Entrance Bay-1 (N-1)	64.5	64.5	64.5	69.5	69.5	69.5	79.5	79.5	79.5
Entrance Bay-2 (N-2)	closed	closed	closed	closed	closed	closed	closed	closed	closed
Side Entrance (N-3)	closed permanently								
DISCHARGE:									
Inflow: (cfs)									
WASCO PUD inflow	**937**	**938**	**938**	**814**	**834**	**818**	**635**	**624**	**644**
Weir 152 Ladder Flow	75	75	75	75	75	75	94	94	93
Total System Inflow	**1012**	**1013**	**1013**	**889**	**909**	**893**	**729**	**718**	**737**
WASCO PUD Turbine from turbine curves	946	947	946	928	927	928	871	871	871
Weir 152 Ladder Flow	75	75	75	75	75	75	94	94	94
Total System Inflow (cfs)	1021	1022	1021	1003	1002	1003	965	965	965
Outflow: (cfs)									
Entrance Bay-1 (N-1)	1013	1013	1013	890	910	893	728	719	738
Entrance Bay-2 (N-2)	0	0	0	0	0	0	0	0	0
Total System Discharge (cfs)	1013	1013	1013	890	910	893	728	719	738
WATER LEVEL, HGL, AND PRESSURE DATA									
Tailrace (ft)	73.0			78.0			88.0		
Entrance Aproach Channel Water Level (ft)	73.9	73.9	73.9	79.3	79.4	79.3	89.3	89.3	89.3
HGL AWS (near ladder diffuser L-8) (ft)	76.9	76.8	76.8	80.5	80.5	80.5	89.3	89.2	89.3
Δ AWS (psi)	1.3	1.2	1.3	0.5	0.5	0.5	0.0	0.0	0.0
No. of submerged ladder weirs (DH < 0.5 ft)	4	0	5	10	6	10	19	15	20
PASSAGE CRITERIA:									
Entrance Head (E.H.) (ft)	0.9	0.9	0.9	1.3	1.4	1.3	1.3	1.3	1.3
Required Entrance Weir Submergence (ft)	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Channel Velocities near Base of Ladder (ft/s)	1.5	1.5	1.6	1.2	1.2	1.2	0.8	0.7	0.8
Channel Velocities at Bend to Entrances (ft/s)	4.2	4.2	4.2	2.4	2.4	2.4	1.2	1.2	1.2
Max Ladder Diffuser Velocities (ft/s)	0.4	0.4	0.3	0.2	0.2	0.2	0.1	0.1	0.1
Max Lower Channel Diffuser Velocities (ft/s)	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1

NOTES:

1. Option 1: Remove Ladder Weirs 70, 71, 72, and 73
2. Option 2: Lower Ladder Diffusers weir elvations by 1 foot
3. Convergence is difficult to achieve

STANDARD NOTES:

A. Median Forebay 158.5 is assumed in all runs. The Net Head = FB - AWS HGL

B. Fish Criteria Violations highlighted in Yellow as follows:

	Cha Vel.	Diff Vel.
The shade of yellow shade indicates signficance or degree of violation:	> 4 ft/s	0.5 ft/s max
	< 1.5 ft/s	

C. The turbine flow capacity was exceeded at TW=73 so the turbine was adjusted to account for to maximum turbine- 1161 (E. H.=1.3) down to 1029.7 (E.H.=1.1)

Table 7: Comparison of Two Major Structural Alternatives with Existing Operation at Tailwater Elevations 73, 78, and 88; Option 3—Additional Turbine Unit; Option 4—Operate Plunge Pool Gates Simultaneously.

The Dalles North Fishway									
Comparison of Major Structural Alternatives with Existing Operation									
Tailwater Elevation	**Tailwater 73**			**Tailwater 78**			**Tailwater 88**		
Structural Alternative:	Existing*	Option 3	Option 4	Existing	Option 3	Option 4	Existing	Option 3	Option 4
SETTINGS:									
Inflow: Fishurbines and ladder									
WASCO PUD Turbine Output									
Net Turbine Head[1] (ft)	81	73	67	78	73	70	69	68	67
Power (Megawatts) per Unit	5.5	4.7	4.2	5.2	4.7	4.5	4.4	4.3	4.2
Number of Units	1	2	1	1	2	1	1	2	1
Total Power (Megawatts)	5.5	9.4	4.2	5.2	9.5	4.5	4.4	8.5	4.2
Weir 152 Ladder Head (ft)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Outflow: (weir elevations, ft)									
Entrance Bay-1 (N-1)	64.5	64.5	64.5	69.5	69.5	69.5	79.5	79.5	79.5
Entrance Bay-2 (N-2)	closed	69.0	68.0	closed	70.0	70.0	closed	78.0	78.0
Side Entrance (N-3)	closed permanently								
DISCHARGE RATES:									
Inflow: (cfs)									
WASCO PUD inflow									
Existing Unit	937	895	859	928	897	859	871	863	860
New Unit	0	**895**	0	0	**897**	0	0	**863**	0
PLUNGE POOL SLIDE GATES (2)									
Percent Opening	closed	closed	45%	closed	closed	45%	closed	closed	45%
Gates Discharge	0	0	920	0	0	920	0	0	920
(HD Picker) Weir 152 Ladder Flow	75	75	75	75	75	75	75	75	75
Total System Inflow	**1012**	**1865**	**1854**	**1003**	**1869**	**1854**	**946**	**1802**	**1855**
Outflow: (cfs)									
Entrance Bay-1 (N-1)	1013	1317	1239	890	889	893	728	721	712
Entrance Bay-2 (N-2)	0	492	596	0	967	971	0	1063	1050
Total System Discharge (cfs)	1013	1810	1835	890	1856	1864	728	1785	1763
WATER LEVEL, HGL, AND PRESSURE DATA									
Tailrace (ft)	73.0			78.0			88.0		
Entrance Aproach Channel Water Level (ft)	73.9	74.5	74.4	79.3	79.4	79.4	89.3	89.3	89.3
HGL AWS (Node 30) (ft)	77	86	91	81	85	88	90	91	91
PASSAGE CRITERIA:									
Entrance Head (E.H.) (ft)	0.9	1.5	1.4	1.3	1.3	1.4	1.3	1.3	1.3
N-2 Entrance Weir Submergence (ft)	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
N-1 Entrance Weir Submergence (ft)	0	4.0	5.0	0	8.0	8.0	0	10.0	10.0
Channel Velocities at Bend to Entrances (ft/s)	4.2	6.8	7.0	2.4	4.9	4.9	1.2	2.9	2.8

NOTES:

1. Option 3: 2 Turbines; New Unit Equivalent to Existing Unit
2. Option 4: Operate Both Plunge Pool Slide Gates

STANDARD NOTES:

A. Median Forebay 158.5 is assumed in all runs. The Net Head = FB - AWS HGL

B. Fish Criteria Violations highlighted in Yellow as follows:

The shade of yellow shade indicates signficance or degree of violation:

Cha Vel.
> 4 ft/s
< 1.5 ft/s

5.3 Numerical Model Modification

The original model is run in conjunction with an Excel macro file, which accounts for changes discussed under **Section 3. Numerical Model** above.

5.3.1 Numerical Model and Excel Macro file Limitations

- The macro is very helpful in iterating to a solution. Sometime, however, the iteration gets stuck at the "PIPE" (For example, the 1st iteration- **3.03**, 2nd iteration- **-2.57**, 3rd iteration is back to- **3.03**.) The convergence (no highlighted red numbers) needs to be achieved in order to get realistic discharges and head calculations.
- The model is very sensitive to Node 30 and little to no information is provided about obtaining this value in the *Dalles Dam Computer Model and Hydraulic Evaluation of the North Fishway Facility Adult Bypass System* by NHC.
- There are 3 error messages that occur during the running of the model Code 300, "*Trail 300 (values listed), transferring results to file writing to output and report files Fish.TX2 warning: one or more warning conditions*" and "*Cannot open error file "LF90.EER", ERROR #94 run-time error R6001- null pointer assignment"*. Code 300 or R6001 could not be found in the error information about the open channel model development or the EPANET version 1.1e user manual and the Fish.TX2 file does not provide helpful information making it difficult to know how to proceed.
- There is no information in *The Dalles Dam Computer Model and Hydraulic Evaluation of the North Fishway Facility Adult Bypass System* by NHC about the content of the Dalles.ini file. Clarification for each line is recommended.
- The modeling of two turbines is discussed in *The Dalles Dam Computer Model and Hydraulic Evaluation of the North Fishway Facility Adult Bypass System* by NHC but does not provide more flow to the system, which will have to be analyzed during Phase 2 work.

5.3.2 Recommendations for improvements for the Numerical Model

Section 3. Numerical Model provides a summary of all model deficiencies that are corrected with the macro. The following improvements are recommended in order to make the model more user-friendly:

- Provide training on the use of the macro and how it iterates within the Excel file to the MSDOS prompt. This could be accomplished by providing a cover page in the Excel Macro that discusses how to run the model. (See Appendix B or..\..\Calculations\TDA_North\Natalie's work\Evaluation Phase\Evaluation of HELCRABS Simulation Program for The Dalles North Fish Ladder.pdf
- Incorporate Node 30 plots directly into the Excel macro such that curves are utilized to guess this value for of typical scenarios. Convergence can be achieved and the proper channel head and discharge can be determined quickly.
- Provide instructions as to what to do when the convergence appears to be going in a circle discussed above.
- Incorporate the turbine curve information directly into the Excel macro such that the calculated turbine discharge would be checked against the turbine flow

capacity. By setting a limit, the iteration process could be curtailed once this limit is met saving time in checking it by hand then going back into the model and readjusting Node 30.

- Provide a report macro that calculated and extract all values needed for various tailwater.

5.4 Summary of Recommendations

Field verification of Table 4 is recommended during FY06. All diffuser gates being open will facilitate achievement of the fishery criteria for tailwater elevations 73 to 75; however the turbine cannot supply enough flow suggesting another turbine would be beneficial. Reducing to the turbine discharge capacity reduces the channel head below 1.3 ft.

The fishery criteria can be met at:

- a TW of 75 with diffuser gates 2000-1700 (model) closed (project location 1-A through 1-D)
- a TW of 77 with diffuser gates 2000-1600 (model) closed (project location 1-A through 1-E)
- a TW of 78 with diffuser gates 2000- 1500 (model) closed (project location 1-A through 1-F)
- a TW of 80 with diffuser gates 2000-1400 (model) closed (project location 1-A through 1-G)

Providing more submergence as the tailwater goes up with help meet fishery criteria.

Structural modifications need to be further investigated especially the Weir Valve reduction in that the model does not show a significant difference; however, Hydraulic Engineering experience says it would provide more flow.

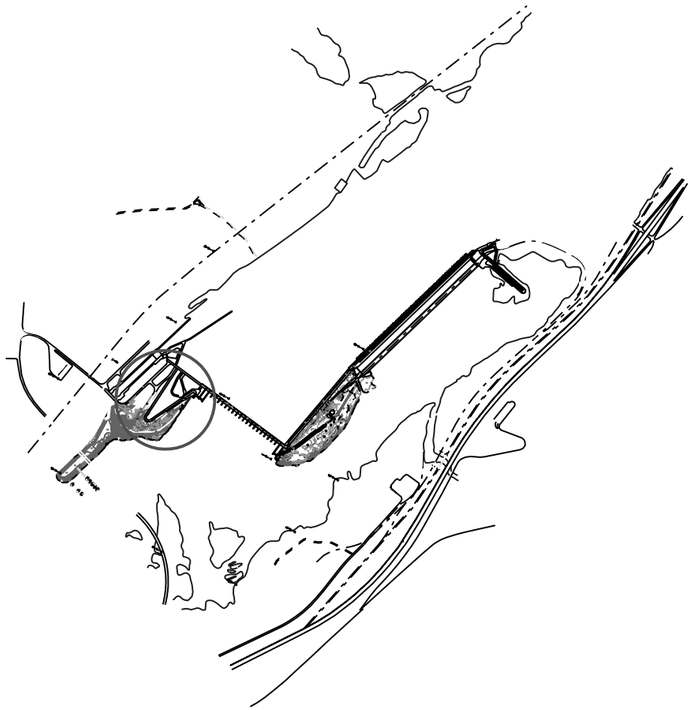
The anticipated alternatives from least to most costly are:

- Elimination of weirs 70-73
- Reduction of the weir valves by 12 inches
- Opening of the side gate to the existing water supply system (AWS)
- Providing another turbine

As for the numerical model, many changes have been made to correct the model with the addition of the Excel macro. Further enhancements are recommended in order to make the model more user-friendly.

6.0 References

1. Askelson, Sean, *Weir Valve Adjustment Macro for HELCRABS Second Powerhouse Model*
2. Brater, E. F., King, H. W., *Handbook of Hydraulics,* 1976.
3. CH2M Hill, *Feasibility Assessment Report, The Dalles Dam North Fishway Attraction Water Power Unit (FERC Project No. 7046) prepared for Northern Wasco County People's Utility District*. (Draft) March 1981.
4. CH2M Hill, Supplement 1 to the *Feasibility Assessment Report for The Dalles Dam North Fishway Attraction Water Power Unit prepared for Northern Wasco County People's Utility District*. July 1981.
5. Chow, V. T., *Open Channel Hydraulics,* (1959)
6. Corps of Engineers, Waterways Experiment Station, *Hydraulic Design Criteria.* Revised 1954.
7. Corps of Engineers, Portland District. *The Dalles Dam, Design Memorandum No. 6, Navigation Lock, North Fishway, and Non-overflow Dam between Lock and Spillway*. 1953 and *Supplement No. 2.*
8. Corps of Engineers, Portland District. *The Dalles Project, Design Memorandum No. 8, Fish Facilities*. 1953.
9. Corps of Engineers, Portland District. *The Dalles Dam, Supplement to Design Memorandum No. 6, Navigation Lock, North Fishway, and Non-overflow Dam between Lock and Spillway*. 1954.
10. Corps of Engineers, *Hydraulic Design of Reservoir Outlet works, EM 1110-2-1602,* 1980.
11. Corps of Engineers, Portland District. *The Dalles Dam, Design Memorandum No. 25, North Fishway Powerhouse and Intake*. January 1981.
12. Corps of Engineers, Portland District. *The Dalles Lock and Dam Design Memorandum No. 6 Supplement No.2 North Fish Ladder Counting Station and Weir Modifications.* January 1985.
13. Corps of Engineers, Northwest Division. *Fish Passage Plan*. 2005.
14. Henderson, F.M., *Open Channel Flow,* (1966)
15. Miller, D.S., *Internal Flow Systems,* (1978)
16. Northwest Hydraulics Consultants Inc. *The Dalles Dam, Computer Model and Hydraulic Evaluation of the North Fishway Facility Adult Bypass System.* Prepared for Corps of Engineers, Portland District. December 1998.



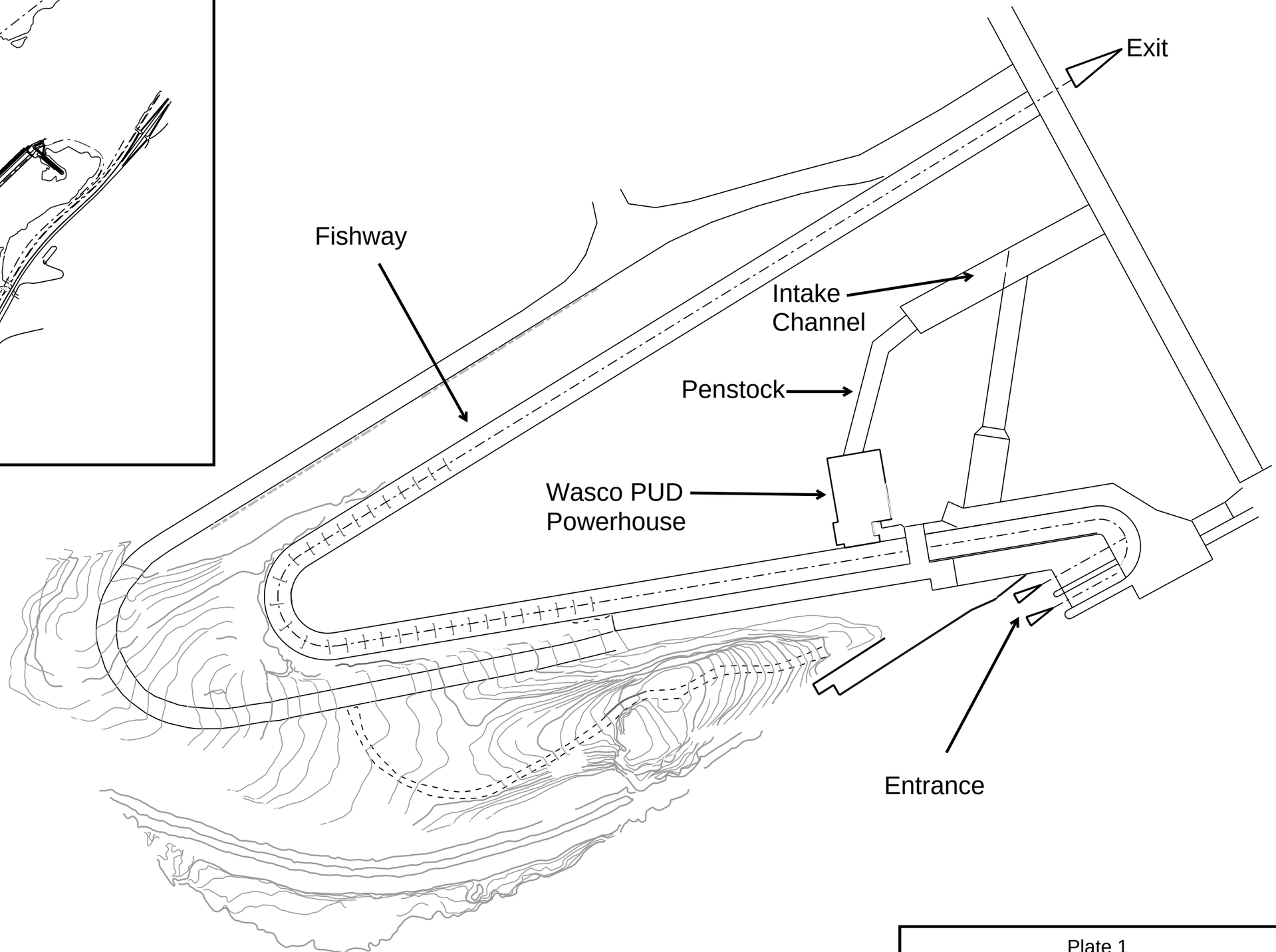


Plate 1
The Dalles North Fishway Site Location

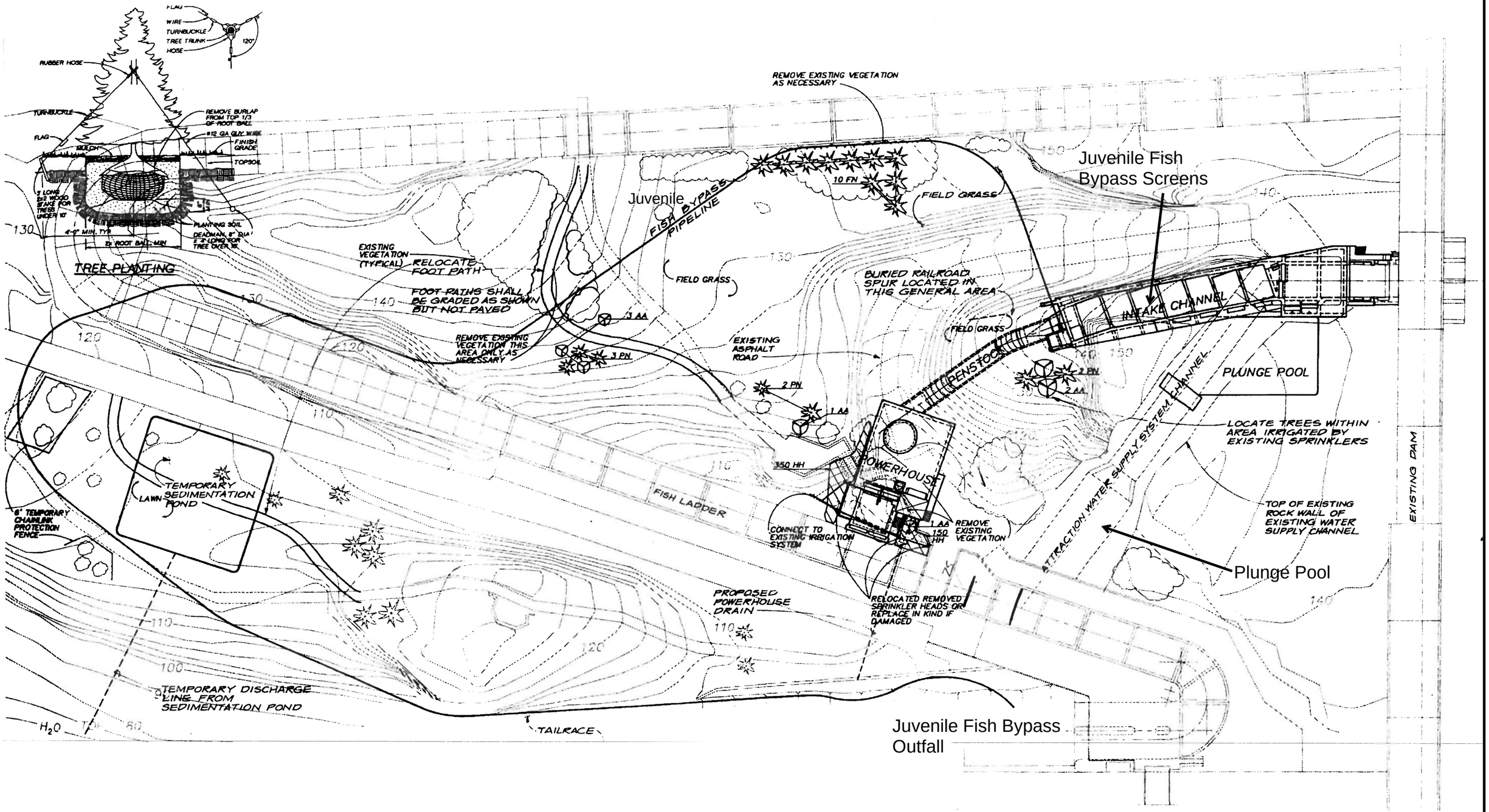


Plate 2
Plan Wasco County P.U.D. System and Modified AWS Intake System

8"Φ Open Joint Drain Tile Continued On Dwg. DDN-1-4-2/34. Location And Elevation Of Drain Outlet May Be Changed To Suit Field Conditions. See dwg. DDD-1-4-3/4 for section.

794.11

Match Line See Dwg. DDN-1-4-1/1

Fill To Elev. 168

Roadway

Staff Gage

Counting Station

Sta. 17+30

Sta. 17+60

Sta. 17+90

Stillwell

Fill to Elev. 140

100'

Stillwell

Sta. 18+50

Sta. 18+80

Sta. 19+10

Gate Block

Elev. 130.00

Elev. 120

Intake Channel

Penstock

Wasco PUD Powerhouse

Sta. 19+70

Stillwell

Sta. 20+30

Non-Overflow Dam Axis

Sta. 20+90

Sta. 21+17.04

Limit Of This Contract

Sta. 21+50

Sta. 21+85

Bay 1

Bay 2

Flow

Service Bridge

Guides for Picketed Leads

Stilling Basin

Staff Gage

Existing rock on slope

Elev. 55

Stillwells

Elev. 110

Slope

Elev. 105

Fill To Elev. 105

149.81'

N 710,837.27
E 1,837,533.18

Elev. 123.05

Elev. 85

Staff Gage

Elev. 105

Bridge Weir 14

Vent Shaft
Diffusion Chambers
Grating over Diffusion Water

Gate Access

t Road

693.00

N 710,482.01
E 1,836,936.47

45° R.

P.T.

P.C.

16'

Weir 110

Weir 115

Weir 120

Weir 125

Weir 130

Weir 135

Weir 140

Weir 150

Weir 105

Weir 100

Weir 95

Weir 90

UNIT 9

N 33°20'42" E

S 55°31' W

S 16°29' E

S 53°29' E

50'-0"

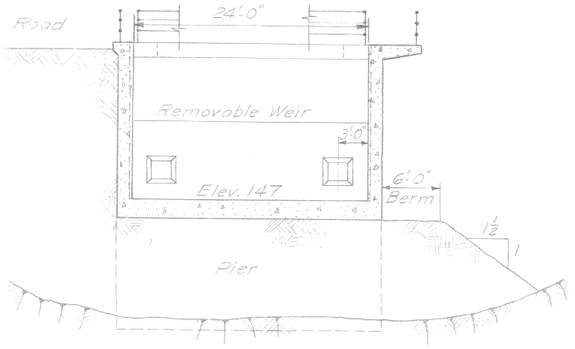
Drain Outlet
Elev. 126.0

NORTH

20'-0"

PLAN
Scale: 1" = 40'-0"

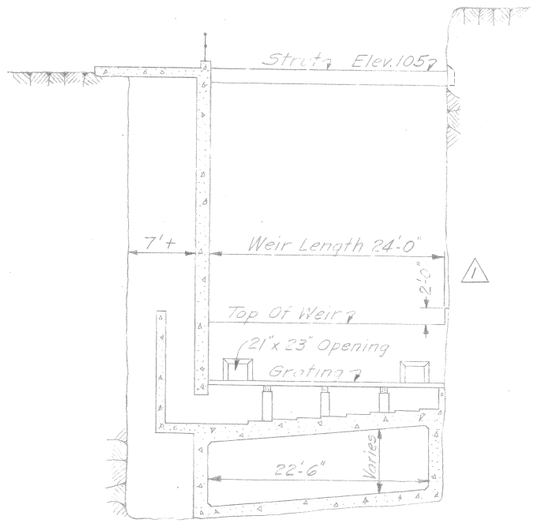
Plate 3
The Dalles North Fishway Plan



SECTION B-B

Showing Typical Fishway on Piers

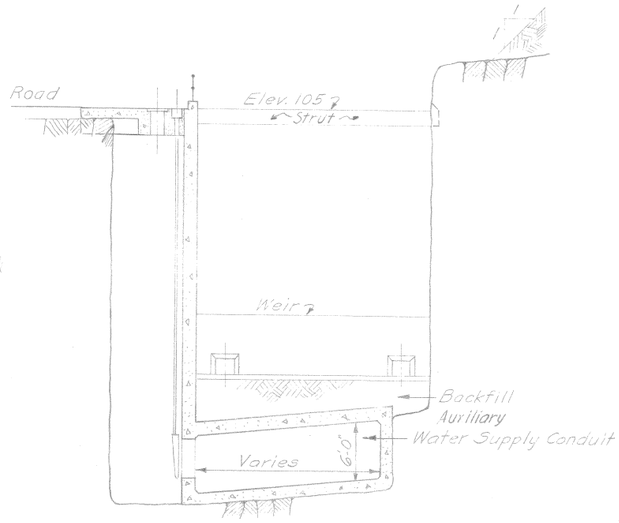
Scale: 1/8" = 1'-0"



SECTION D-D

Showing Typical Diffusion Chamber

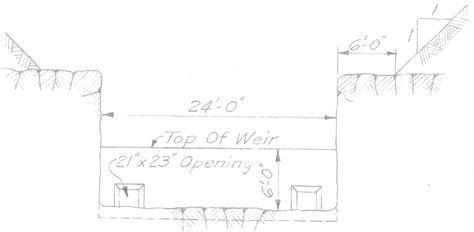
Scale: 1/8" = 1'-0"



SECTION H-H

Typical Thru Gate Opening

Scale: 1/8" = 1'-0"

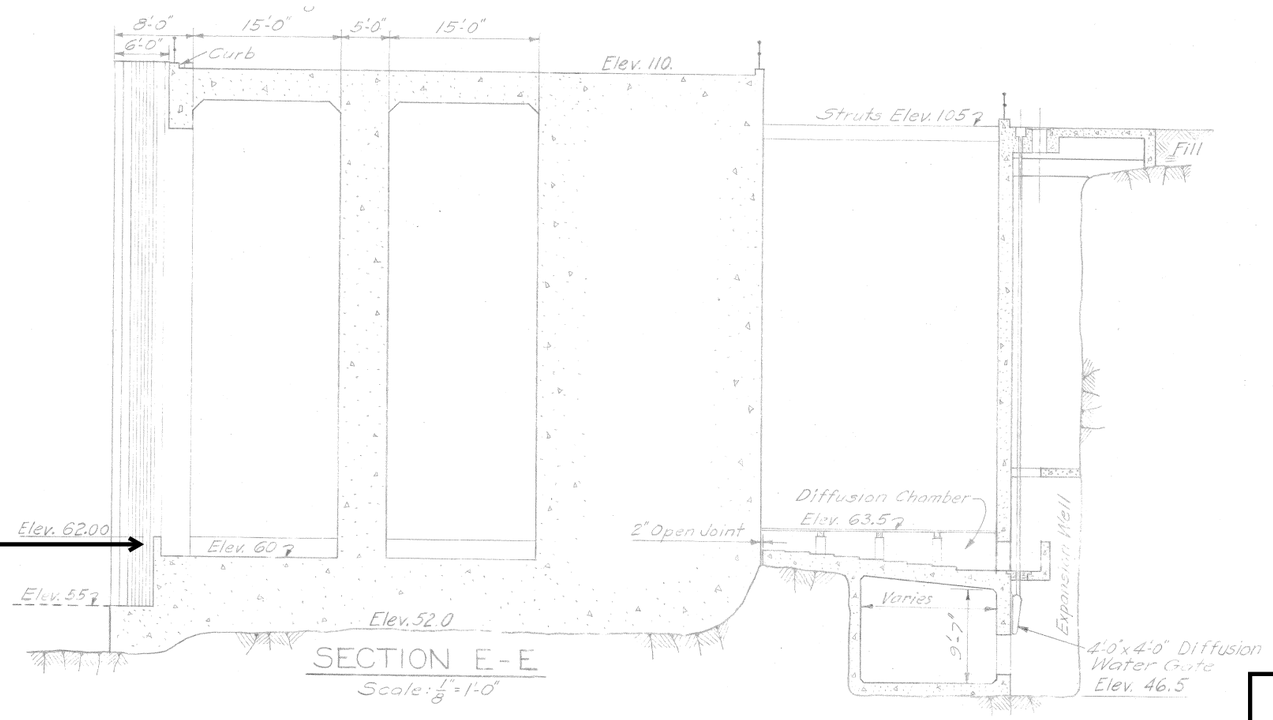


SECTION C-C

Showing Typical Weir In Rock Cut

Scale: 1/8" = 1'-0"

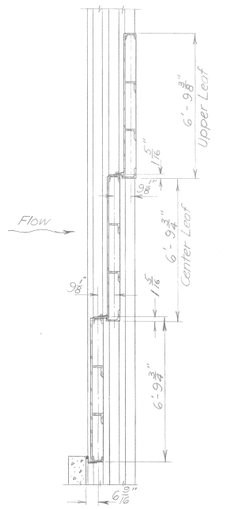
Entrance Sill



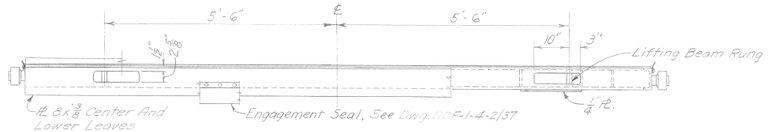
SECTION E-E

Scale: 1/8" = 1'-0"

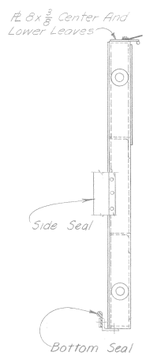
Plate 4
Weir and Diffusion Chamber Details



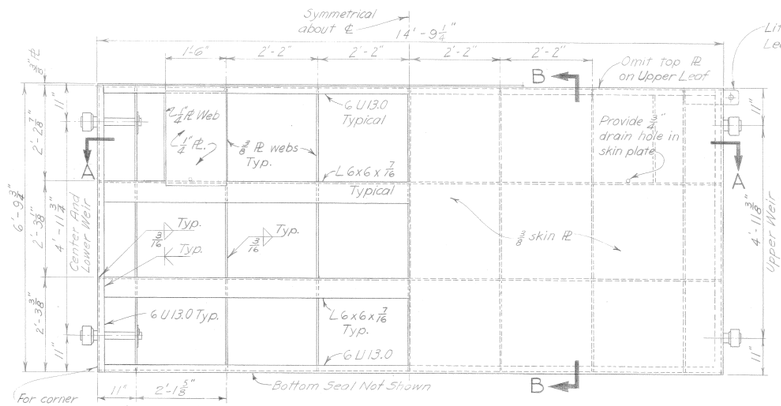
VERTICAL SECTION
THRU ENTRANCE WEIR
Scale: 3/8"=1'-0"



PLAN

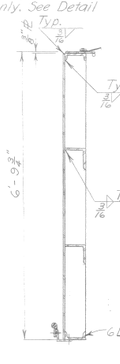


END ELEVATION

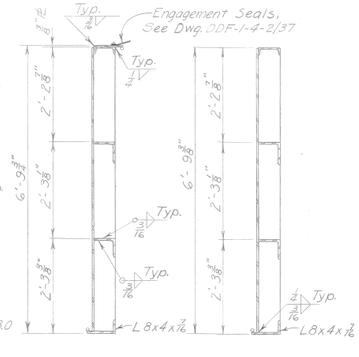


HALF ELEVATION
Downstream Side

HALF ELEVATION
Upstream Side



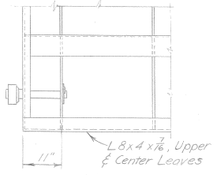
LOWER LEAF



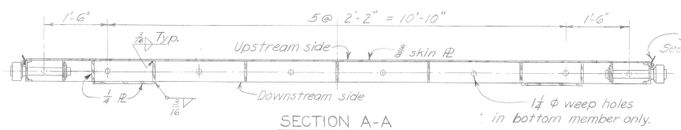
CENTER LEAF

UPPER LEAF

SECTION B-B

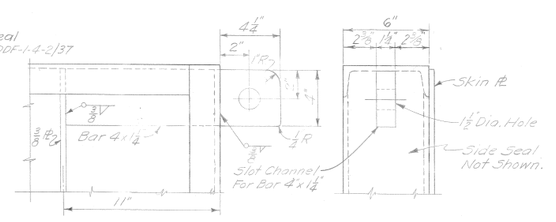


DETAIL C
Upper And Center Leaves

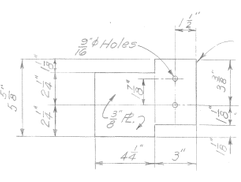


SECTION A-A

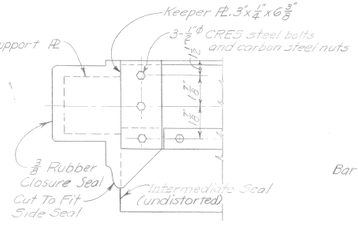
ENTRANCE WEIRS
Lower Leaf Shown, Upper And Center Leaves Similar Except As Shown.
Scale: 3/4"=1'-0"
Structural Steel Type II



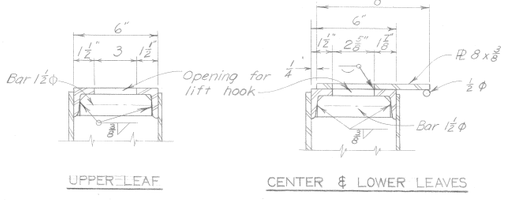
LIFTING EYE ASSEMBLY DETAILS
Upper Leaf
Scale: 3"=1'-0"



SUPPORT PLATE
Scale: 3"=1'-0"



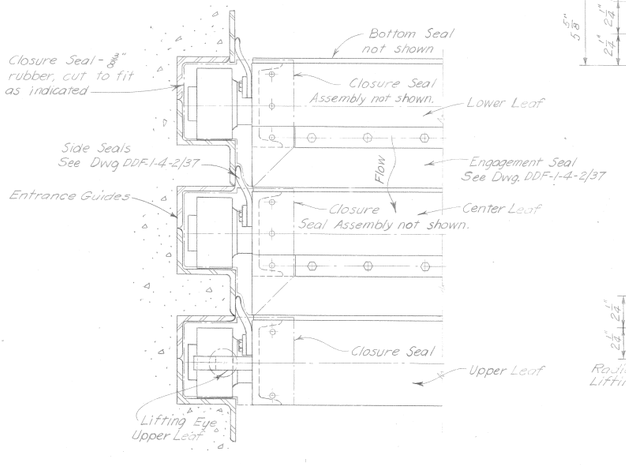
CLOSURE SEAL ASSEMBLY
Center And Lower Leaves
Scale: 3"=1'-0"



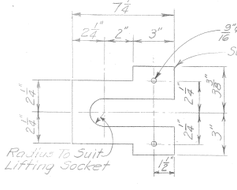
UPPER LEAF

CENTER & LOWER LEAVES

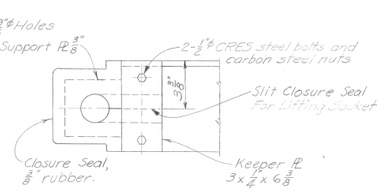
LIFTING BEAM RUNG DETAILS
Scale: 3"=1'-0"



WEIR ASSEMBLY DETAILS
Scale: 3"=1'-0"



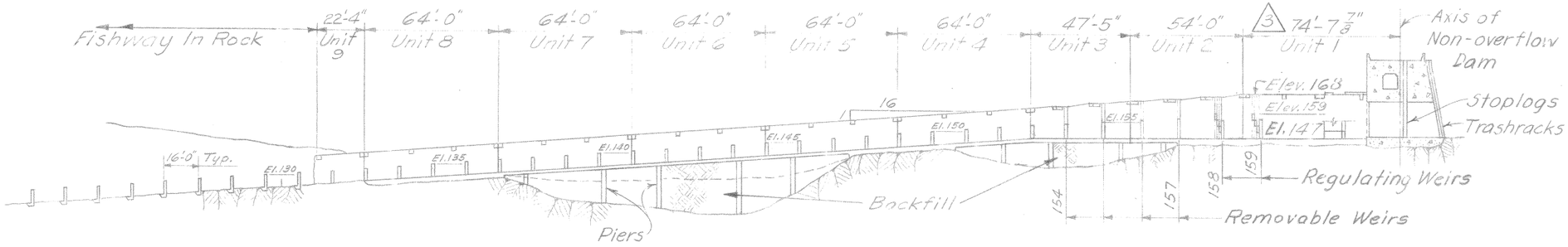
SUPPORT PLATE
Scale: 3"=1'-0"



CLOSURE SEAL ASSEMBLY
Upper Leaf
Scale: 3"=1'-0"

Notes:
For Details See Dwg.-
For Guides See Dwg.-
For Structural Steel I
Entrance Weirs Comple

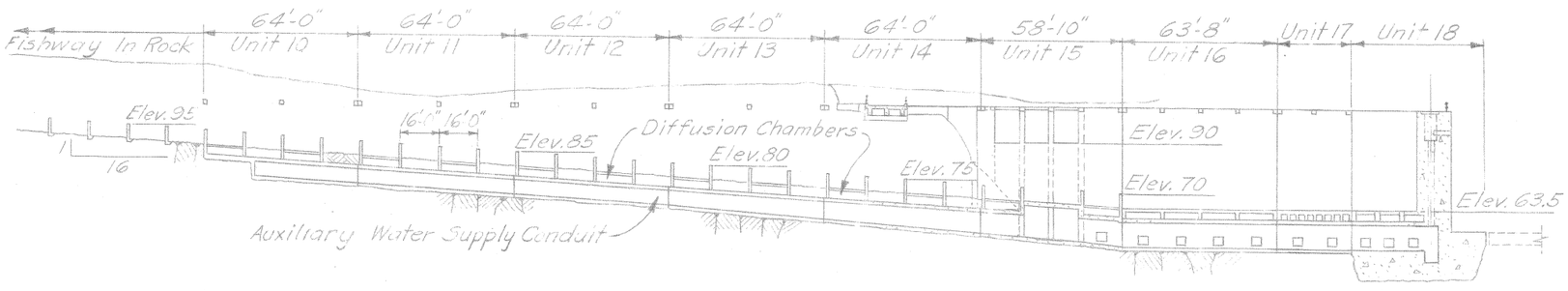
Plate 5
Entrance Weir Details



SECTION A-A

Scale: 1"=40'-0"

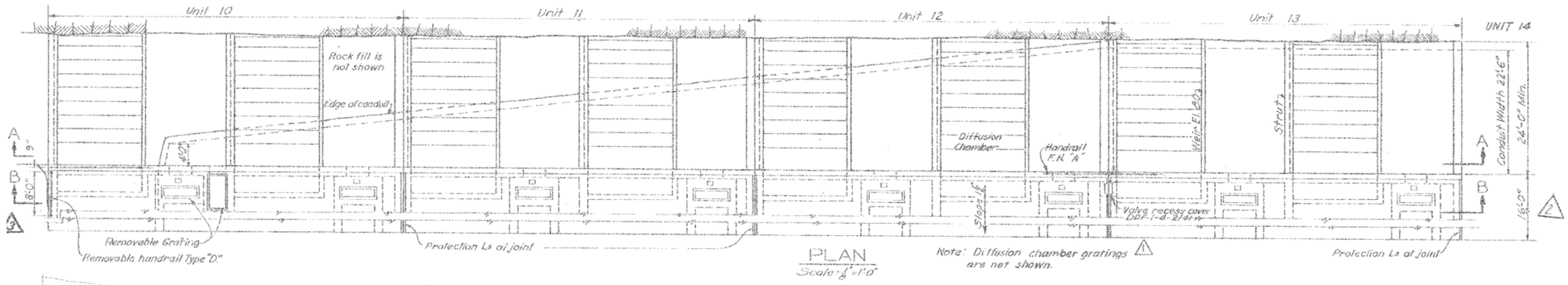
Scale: 1"=40'-0"



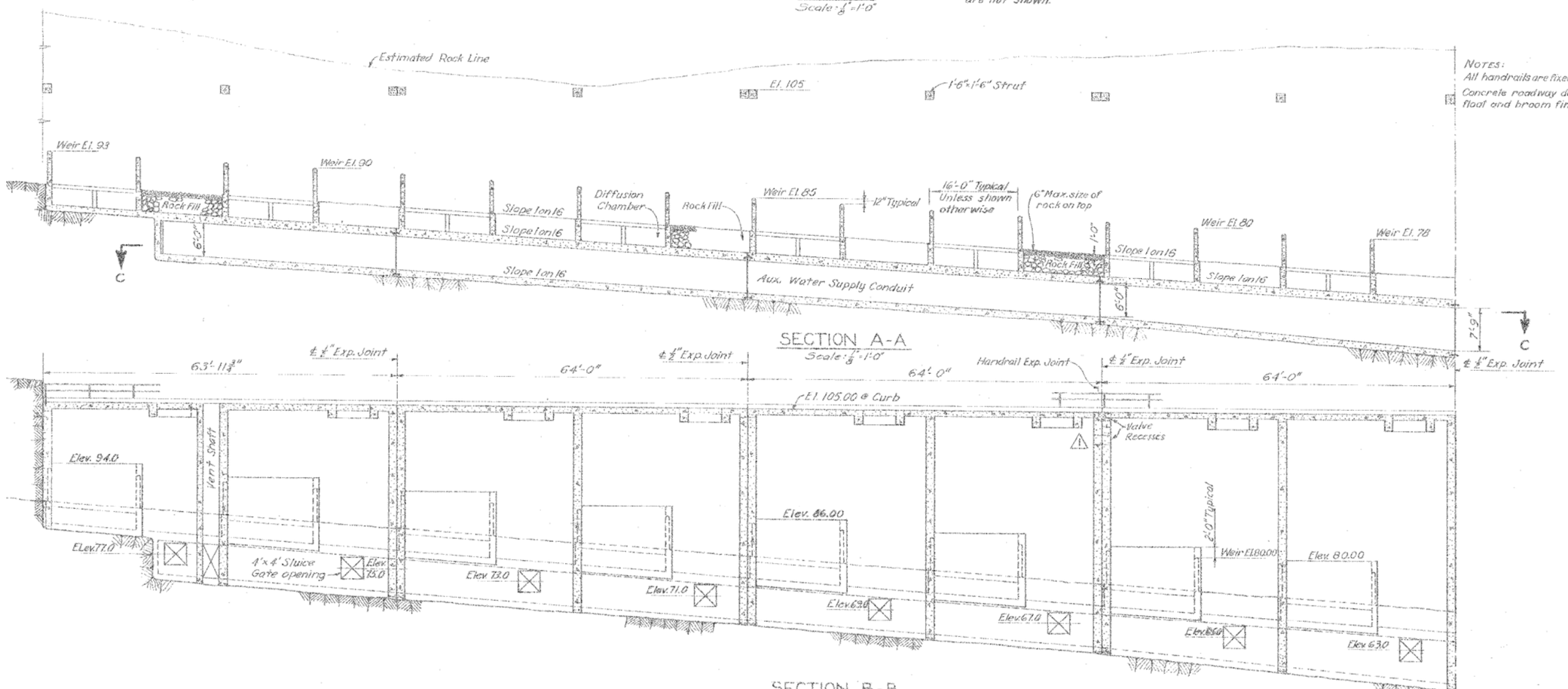
SECTION F-F

Scale: 1"=40'-0"

Plate 6
Ladder Elevations

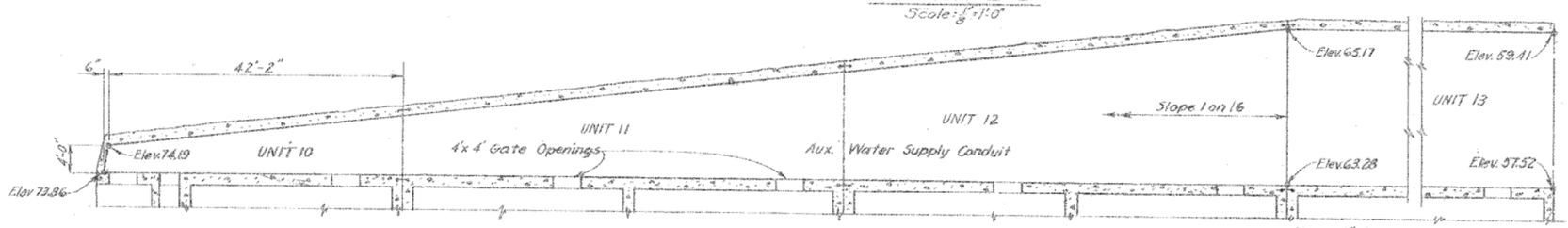


PLAN
Scale: $\frac{1}{8}$" = 1'-0"



SECTION A-A
Scale: $\frac{1}{8}$" = 1'-0"

SECTION B-B
Scale: $\frac{1}{8}$" = 1'-0"

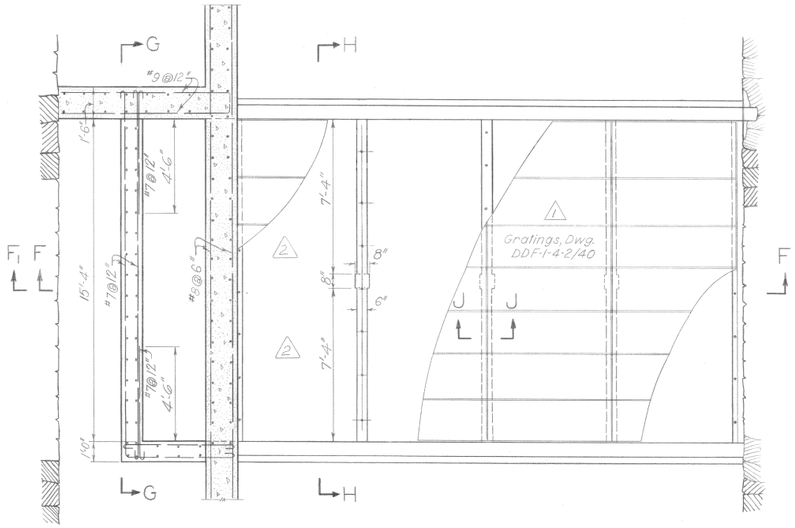


SECTION C-C
Scale: $\frac{1}{8}$" = 1'-0"

Note: 6" fillets in conduit are not shown. For location of points with marked elevations of the floor of the conduit, see Sec. F-F, DDF-1-4-2/17

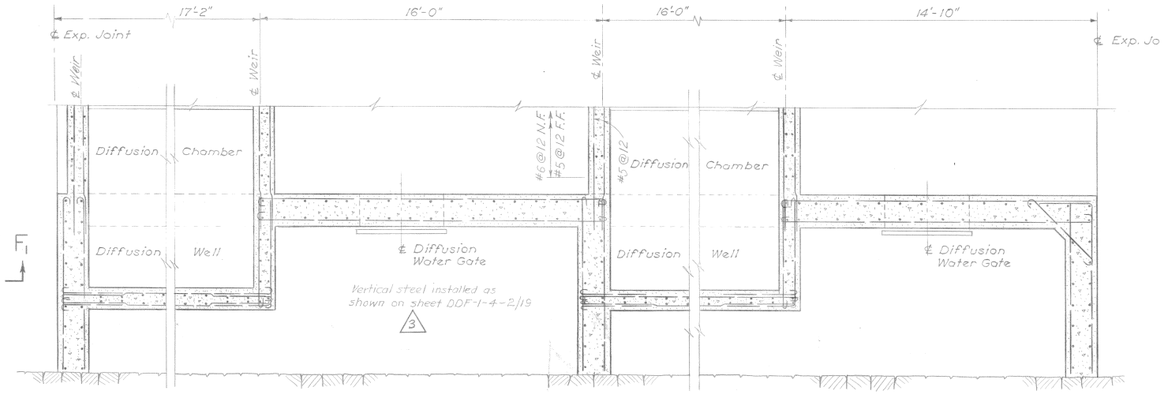
NOTES:
All handrails are fixed type A, except as shown.
Concrete roadway deck shall have wood float and broom finish.

Plate 7
Detailed Profile of Ladder and AWS Conduit Section



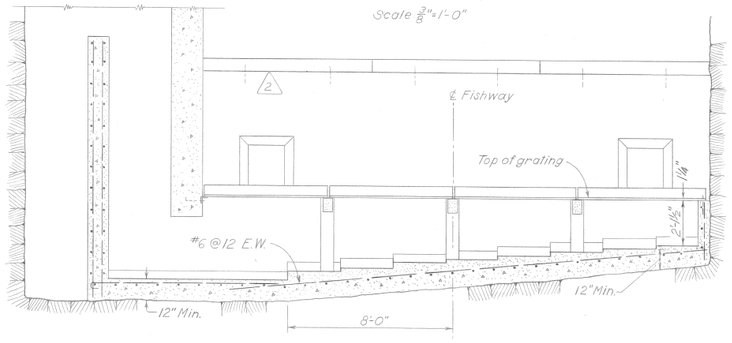
PLAN OF DIFFUSION CHAMBER

Scale: $\frac{3}{8}$"=1'-0"



SECTION E-E (DDF-1-4-2/16)

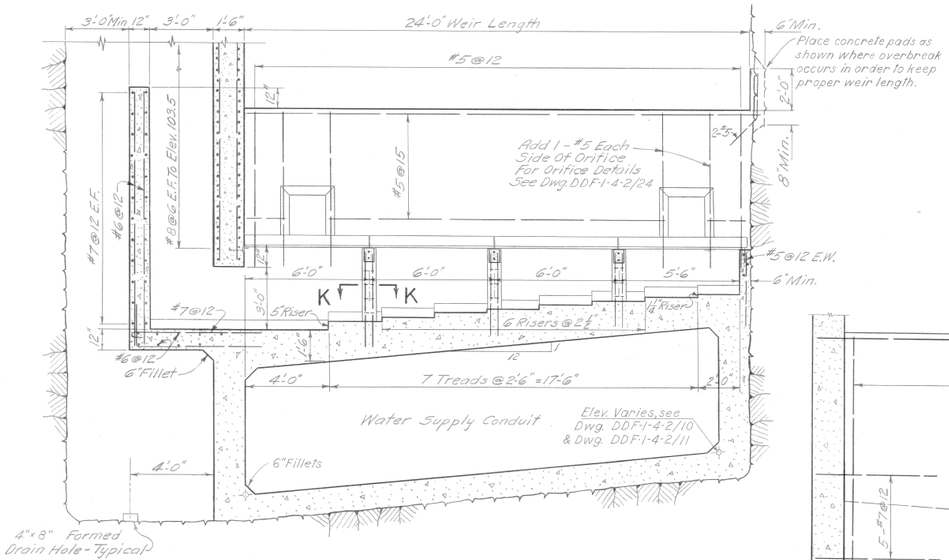
Scale $\frac{3}{8}$"=1'-0"



SECTION F_1-F_1

Showing reinforcement in diffusion chamber floor slab on rock in Unit 10. Other details are the same as in Sec. F-F

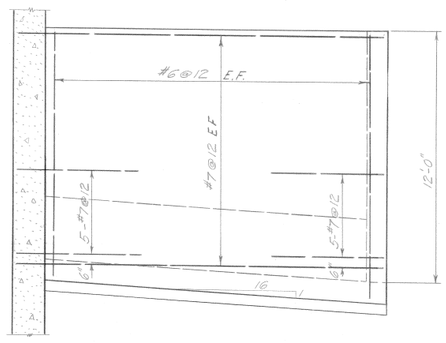
Scale $\frac{3}{8}$"=1'-0"



SECTION F-F

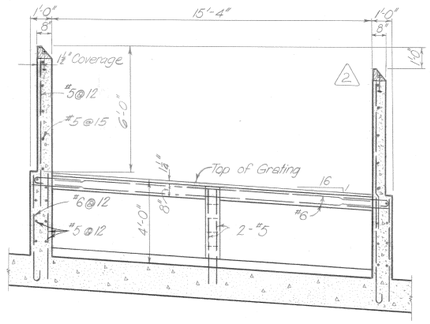
Typical section thru diffusion chamber with conduit under

Scale: $\frac{3}{8}$"=1'-0"



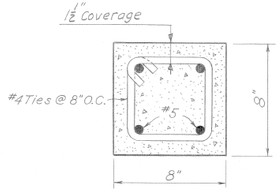
SECTION G-G

Scale: $\frac{3}{8}$"=1'-0"



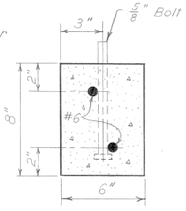
SECTION H-H

Scale: $\frac{3}{8}$"=1'-0"



SECTION K-K

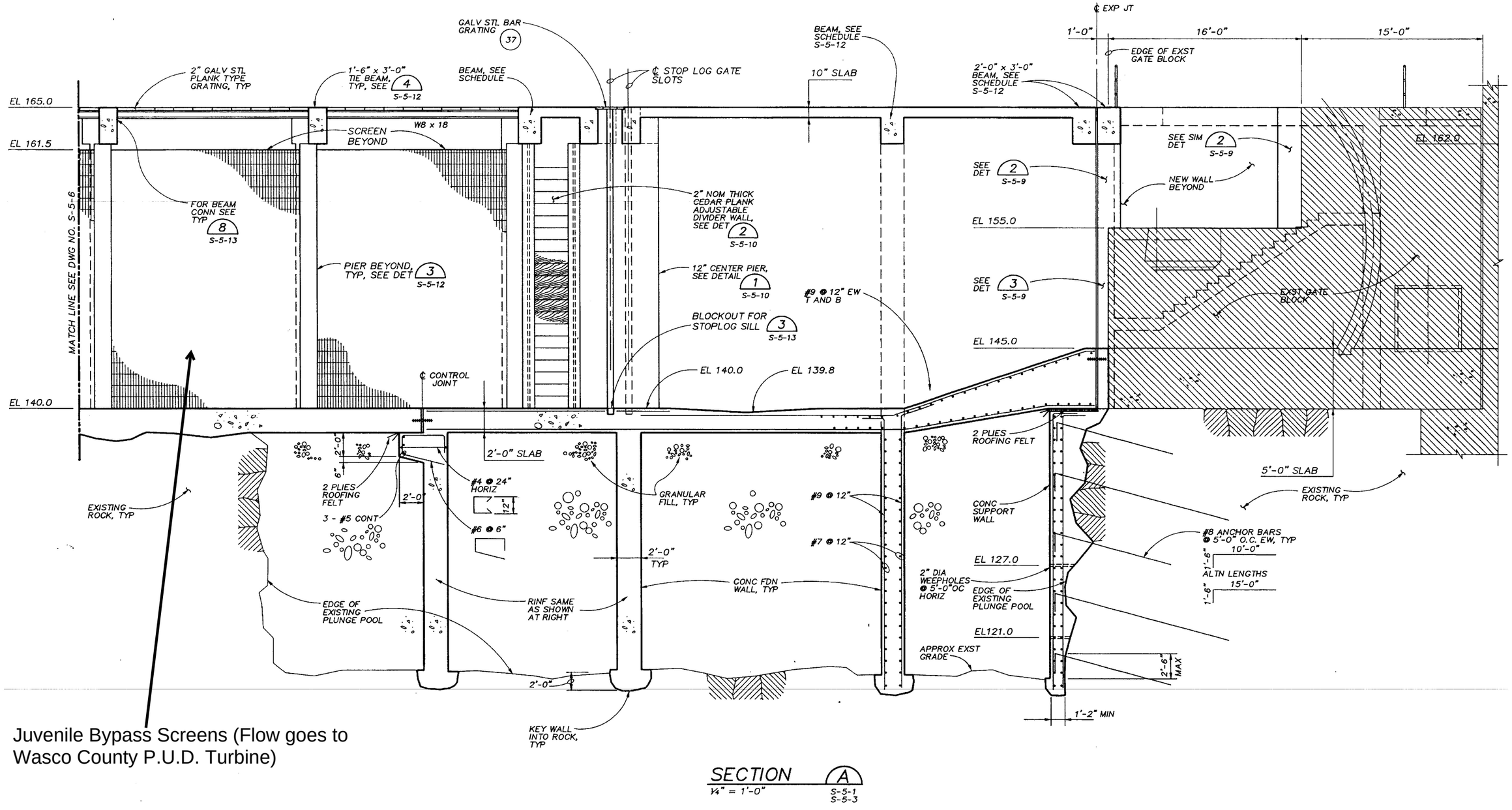
Scale 3"=1'-0"



SECTION J-J

Scale 3"=1'-0"

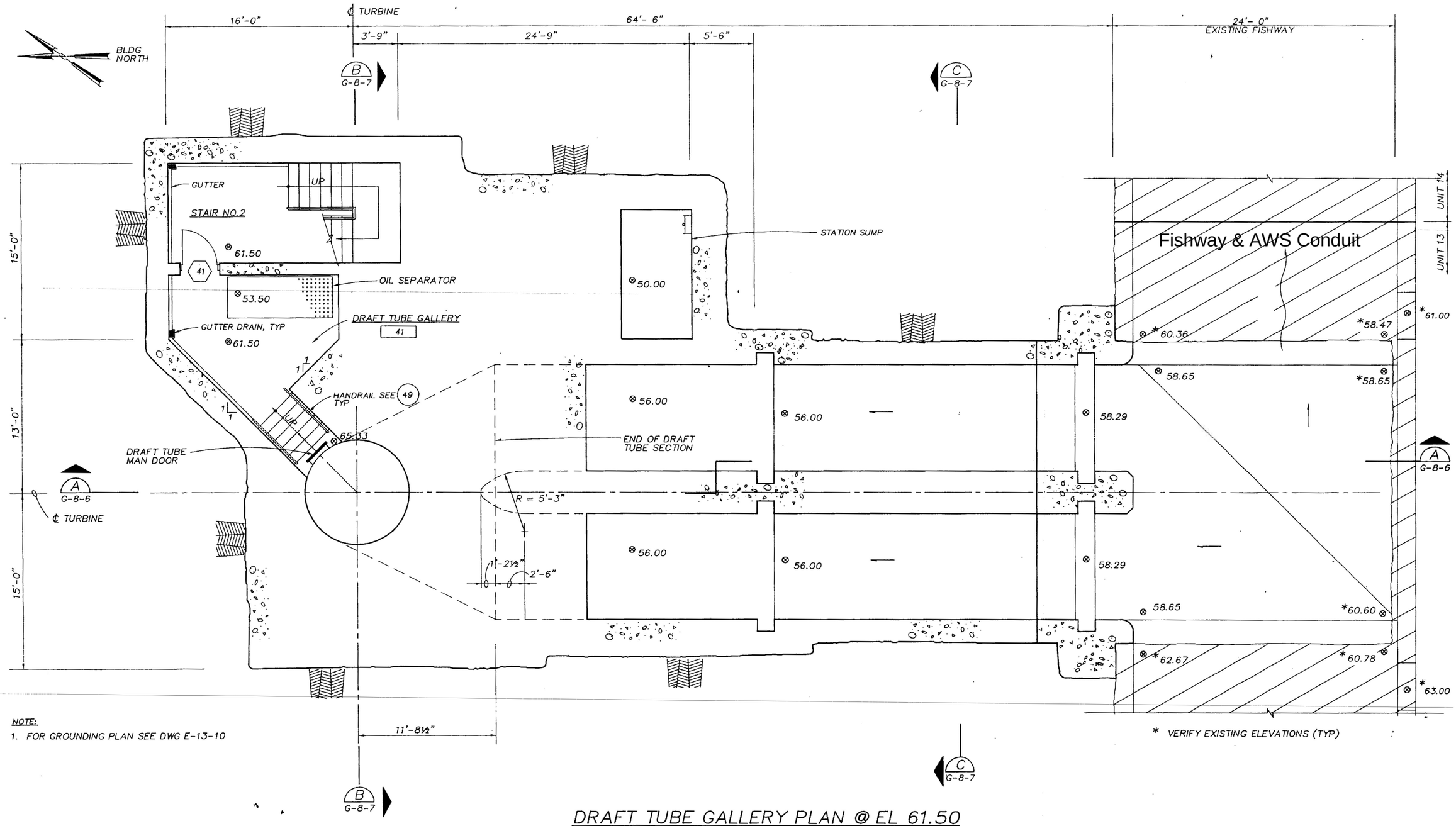
Plate 8
Ladder & Ladder Diffuser Chamber



Juvenile Bypass Screens (Flow goes to Wasco County P.U.D. Turbine)

SECTION A
1/4" = 1'-0"
S-5-1
S-5-3

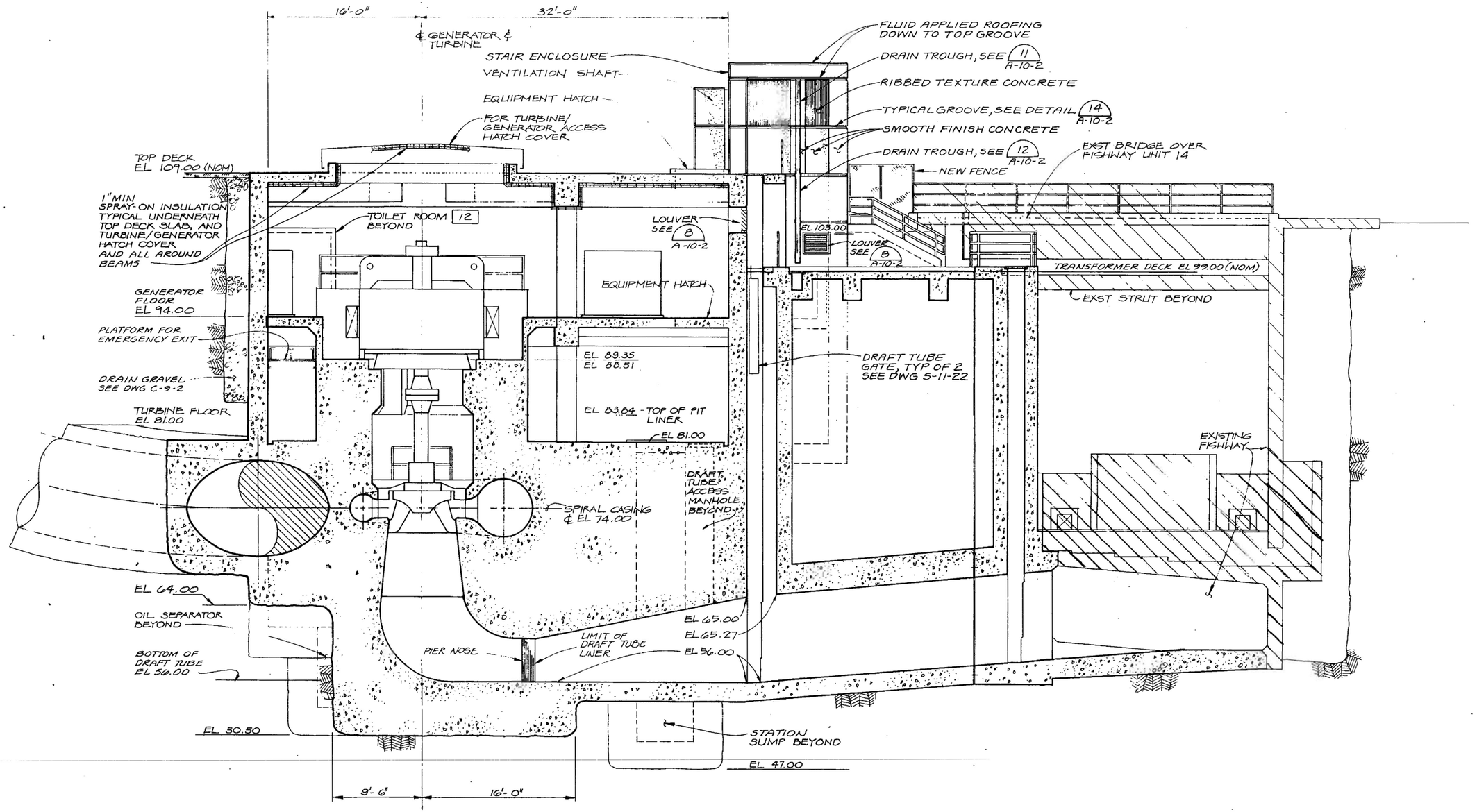
Plate 9
AWS Intake and Wasco County P.U.D. Juvenile Bypass Screens



DRAFT TUBE GALLERY PLAN @ EL 61.50

1/4" = 1"- 0"

Plate 10
Plan of Turbine Connection to AWS Conduit



SECTION A
3/16" = 1'-0"

G-8-1
G-8-2
G-8-3
G-8-4
G-8-5

Plate 11
Profile Wasco PUD Turbine Unit and Connection to AWS Conduit

S435

共12张 第12张

TURBINE OUTPUT (HP)

1.5mw 2.2mw 3.0mw 3.7mw 4.5mw 5.2mw

2000 3000 4000 5000 6000 7000

EFFICIENCY OF TURBINE (%)

95 93 91 89 87 85 83 81 79

NET HEAD=67FT FULL GATE
OUTPUT = 5588 HP

NET HEAD=77FT OUTPUT=6491 HP (800 CFS)

NET HEAD=77FT FULL GATE
OUTPUT = 6839 HP

NET HEAD=83FT OUTPUT=7027HP (800 CFS)

NET HEAD=83FT FULL GATE
OUTPUT = 7677HP (900 CFS)

THE CAVITATION LIMIT FOR THE TAILWATER ELEVATION AT 78 FT

TURBINE DISCHARGE (CFS)

900 800 700 600 500 400 300

2000 3000 4000

TURBINE OUTPUT (HP)

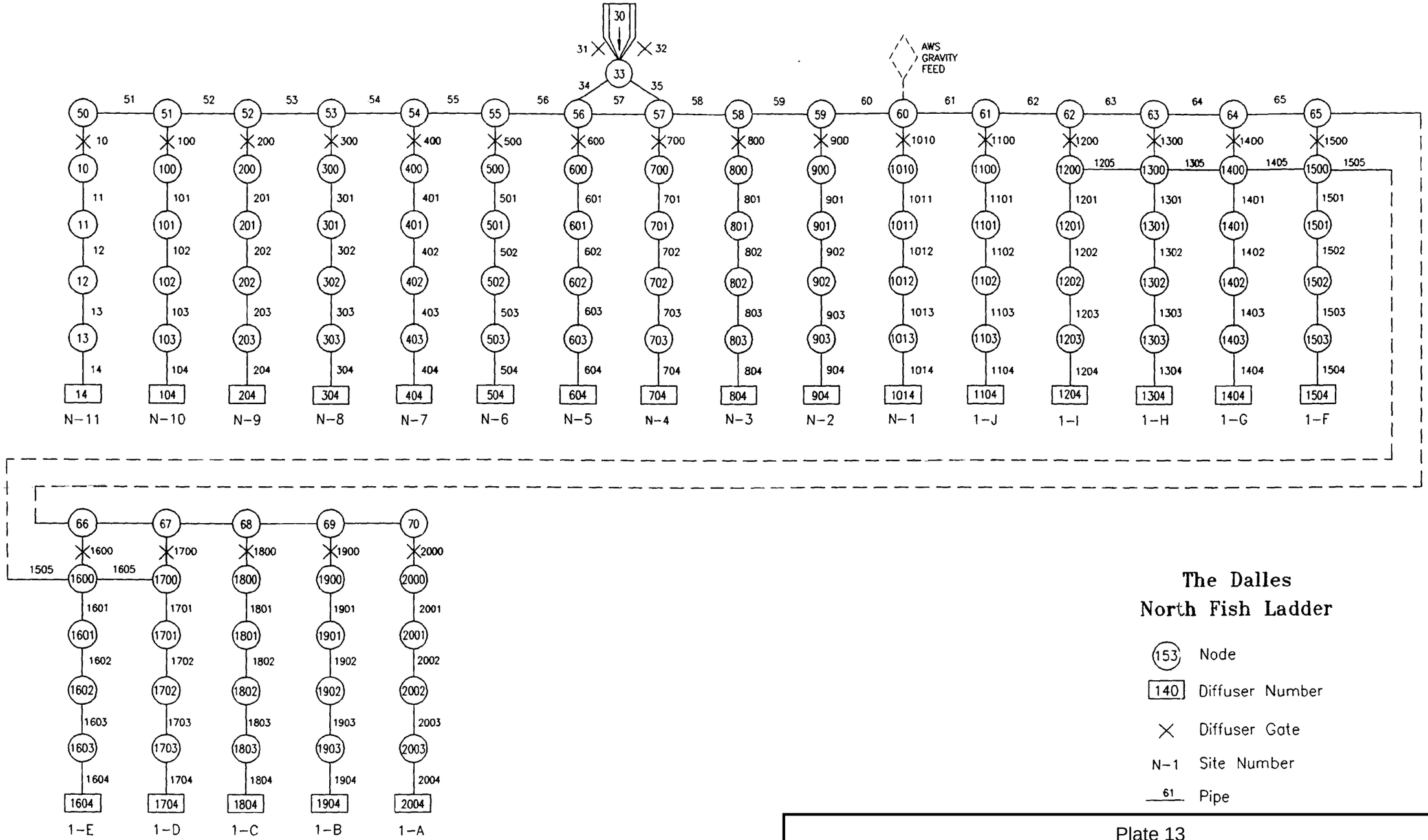
DONG FANG ELECTRICAL MACHINERY WORKS
SICHUAN—CHINA

GUARANTEED PERFORMANCE CURVES OF TURBINE
RATED SPEED 200 RPM

设计	倪兆达	-- --	DALLES DAM PROJECT
校核	刘子杰		
审查	王在当	1981.1	DRAWING NO YQ-11

Plate 12
Wasco County P.U.D. Turbine Rating Curves

Wasco County PUD
Turbine



The Dalles
North Fish Ladder

(153) Node

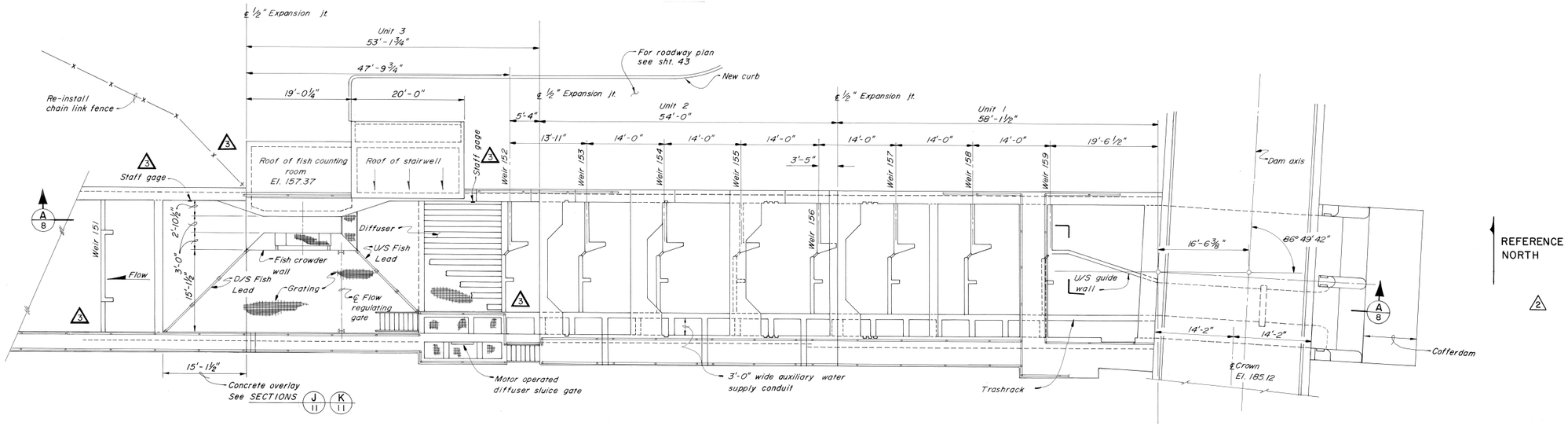
[140] Diffuser Number

× Diffuser Gate

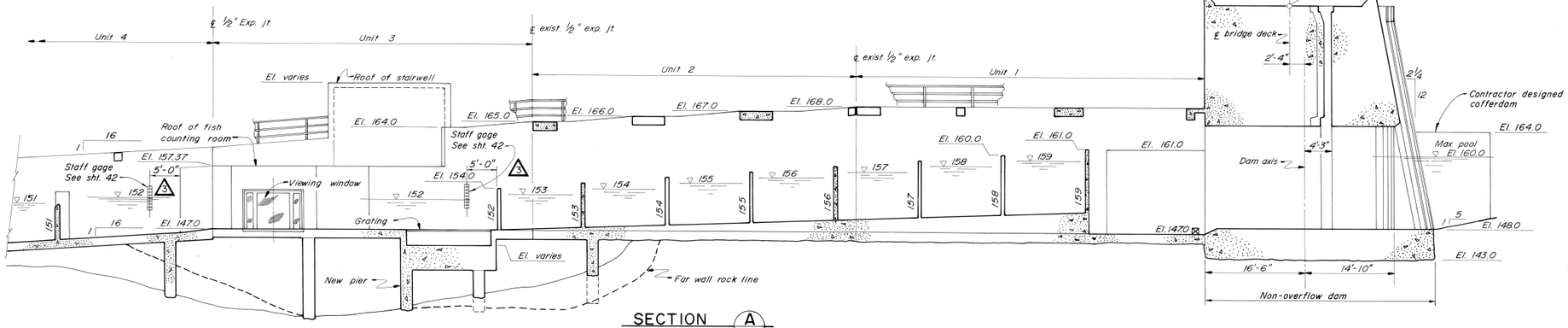
N-1 Site Number

61 Pipe

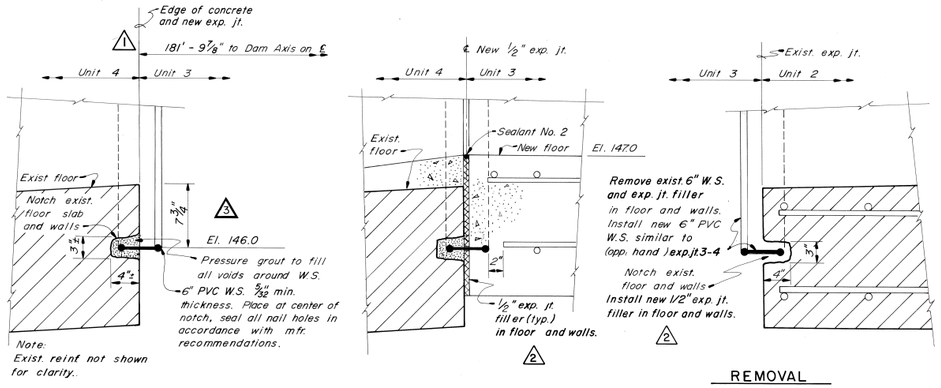
Plate 13
Schemattic of The Dalles North AWS-Layout of Nodes and Links for NHC Net Pressurized Conduit Simulation



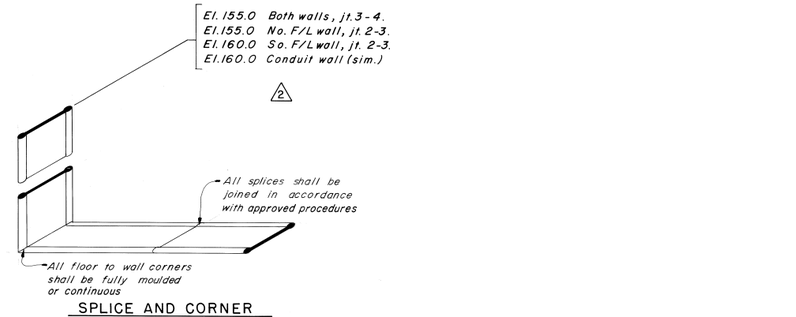
PLAN
1/8" = 1'-0"



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

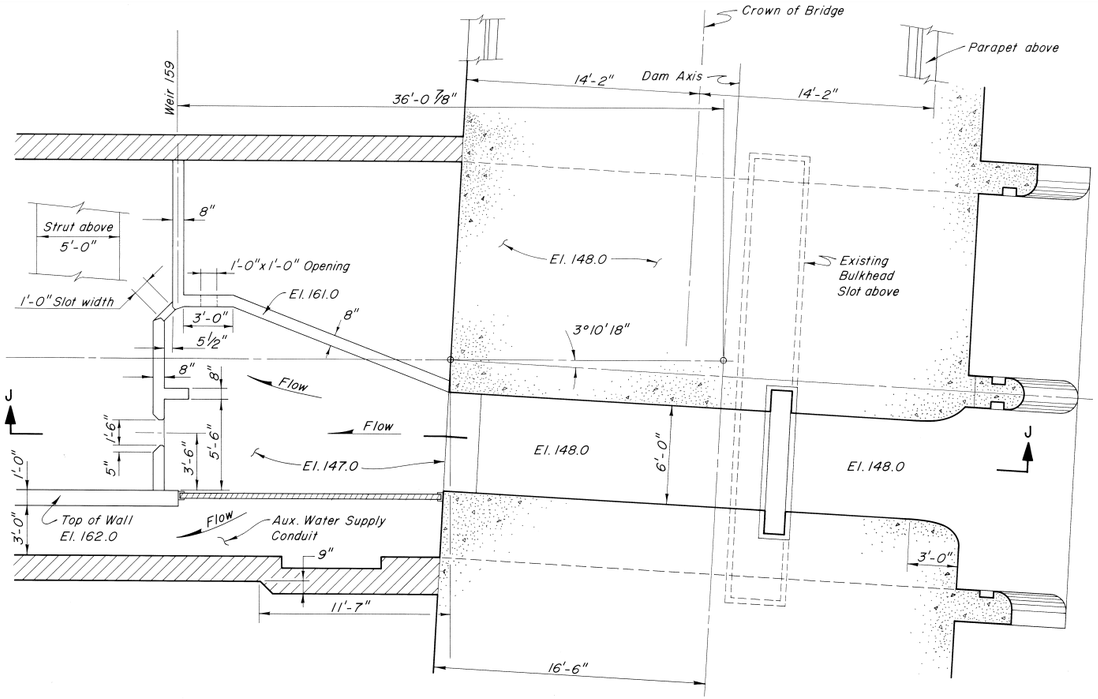


EXPANSION JOINT DETAIL
1½" = 1'-0"



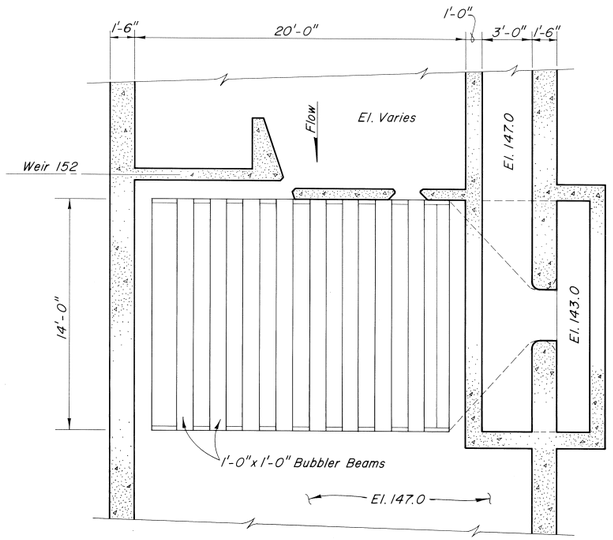
WATERSTOP DETAIL
N.T.S.

Plate 14
Control Section, Exit Section and Counting Station Plan



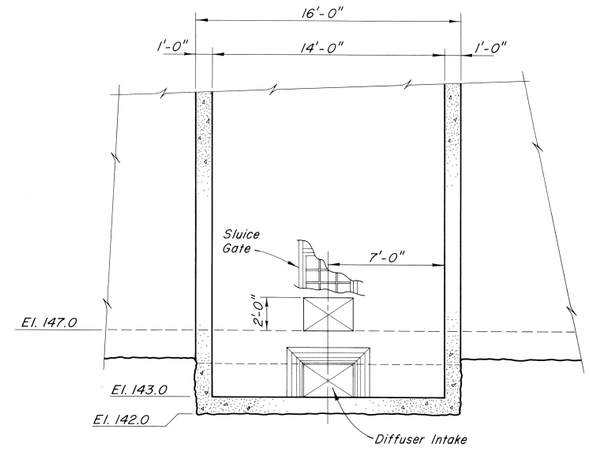
PLAN - EL. 164.5

5 0 5 10
FEET



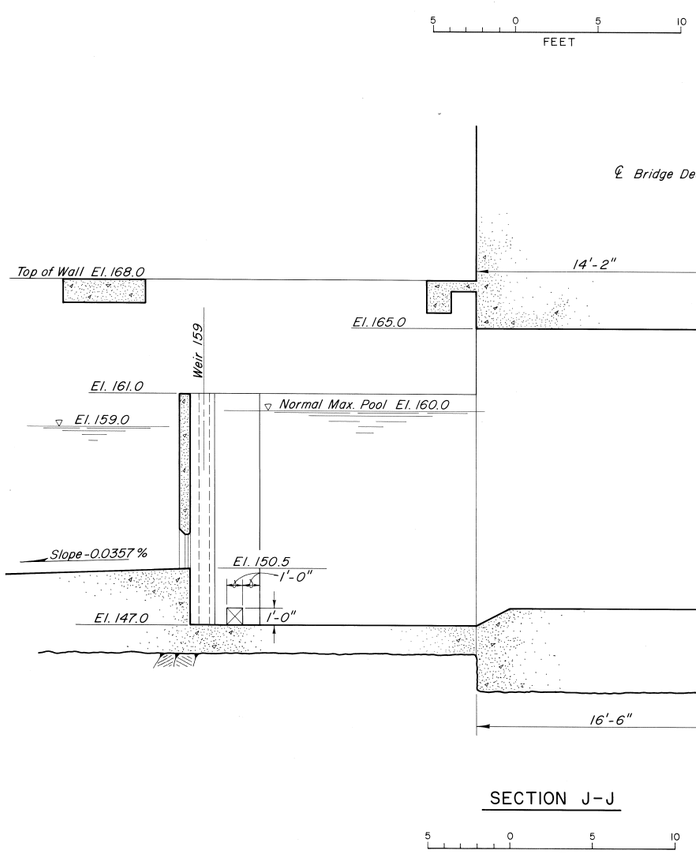
SECTION F-F

5 0 5 10
FEET



SECTION H-H

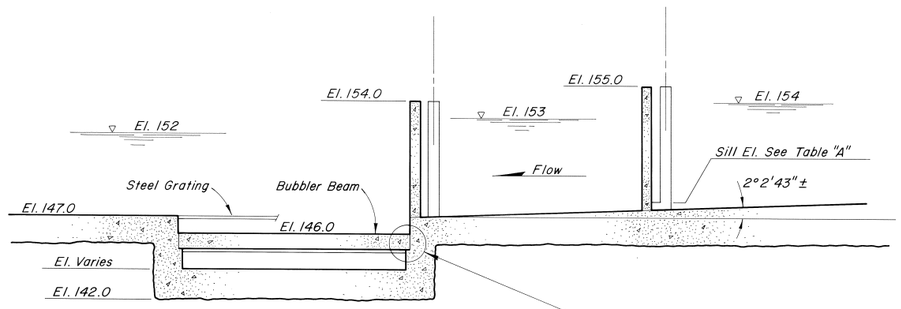
5 0 5 10
FEET



SECTION J-J

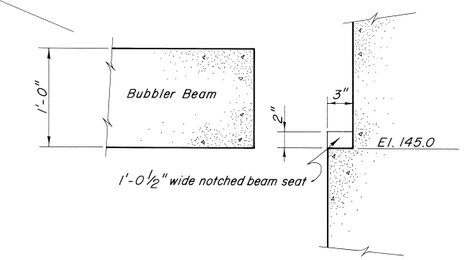
5 0 5 10
FEET

Forebay



SECTION G-G

5 0 5 10
FEET



EXPLODED VIEW

0 1 2
FEET

Plate 15
Exit Section Profile

EXISTING OPERATION

WASCO PUD Turbine

TW (ft)	NET HEAD (ft)[1]	Turbine Output (MW)[1]	Turbine Discharge (cfs)[1]
72	83	5.5	945
73	81	5.5	940
74	80	5.4	940
75	80	5.4	935
76	79	5.3	930
77	78	5.2	930
78	77	5.2	925
79	77	5.1	920
80	76	5.0	915
81	75	4.9	910
82	74	4.9	905
83	73	4.8	900
84	72	4.7	895
85	72	4.6	885
86	71	4.5	880
87	70	4.4	875
88	69	4.3	870
89	67	4.2	865
90	66	4.2	860

DIFFUSERS

Col Cha. Diffusers	L Diffusers (Ladder)
N-1 - N-9	L1 - L15
manual	*passive open*[4]
OPEN	3 ACTIVE
OPEN	3 ACTIVE
OPEN	4 ACTIVE
OPEN	4 ACTIVE
OPEN	4 ACTIVE
OPEN	5 ACTIVE
OPEN	5 ACTIVE
OPEN	6 ACTIVE
OPEN	6 ACTIVE
OPEN	6 ACTIVE
OPEN	7 ACTIVE
OPEN	7 ACTIVE
OPEN	8 ACTIVE
OPEN	8 ACTIVE
OPEN	9 ACTIVE
OPEN	9 ACTIVE
OPEN	9 ACTIVE
OPEN	10 ACTIVE
OPEN	10 ACTIVE

Fishway Entrances

Entrance Weir Gate Crest Elevations (ft)				Powerhouse Channel Floating Orifices (12 total)	TW (ft)
N-1	N-2	N-3	Weir submerg.		
64	closed	CLOSED PERMANENTLY	8	ALL OPEN	72
64.5	closed		8.5	ALL OPEN	73
65.5	closed		8.5	ALL OPEN	74
66.5	closed		8.5	ALL OPEN	75
67.5	closed		8.5	ALL OPEN	76
68.5	closed		8.5	ALL OPEN	77
69.5	closed		8.5	ALL OPEN	78
70.5	closed		8.5	ALL OPEN	79
71.5	closed		8.5	ALL OPEN	80
72.5	closed		8.5	ALL OPEN	81
73.5	closed		8.5	ALL OPEN	82
74.5	closed		8.5	ALL OPEN	83
75.5	closed		8.5	ALL OPEN	84
76.5	closed		8.5	ALL OPEN	85
77.5	closed		8.5	ALL OPEN	86
78.5	closed		8.5	ALL OPEN	87
79.5	closed		8.5	ALL OPEN	88
80.5	closed		8.5	ALL OPEN	89
81.5	closed		8.5	ALL OPEN	90

1. Forebay level of 158.5 feet assumed for net head, turbine Megawatts and discharge rates.
   Net Head = FB- AWS HGL

2. L Diffusers are passively open via stovepipe weirs. L diffusers will flow if the AWS HGL (dependant on tailwater level) exceeds the invert of the respective stove pipe weir.
   The stove pipe weir levels are set 2' above ladder weir crest elevation of the diffuser chamber pool.
   The number of flowing L diffusers are estimated using an assumed AWS difference of 3' above tailwater level.

Plate 16
Existing Operations Matrix

APPENDIX A: THE DALLES NORTH FISHWAY PROGRAM AND GEOMETRY FILE EVALUATON AND MODIFICATIONS

MEMORANDUM FOR FILES **15-Feb-2005**

FROM: Paul Williams, CENWP-EC-HD

SUBJECT: Computational problems with NHC computer model.

Contraction in Channel Width

NHC computer model is incorrectly calculating the water surface elevation upstream of the entrances weir. The main fishway channel is 24 feet wide upstream of the fishway entrance, as the flows exit the fishway entrance the channel section is reduced to 15 feet wide. The reduction in channel width has an associated head loss do to the gradual contraction from 24 feet to 15 feet. NHC has calculated an energy gain through the contraction instead of an energy loss. The head loss through a contraction when the edges are rounded is $H_l = 0.1 * \frac{V_2^2}{2 * g}$, in which V_2 is the velocity at a section in the narrower part, where the flow has almost become uniform. Based on the equation above the water surface elevation upstream of the contraction is 76.95 feet (tailwater 75.35 feet), NHC water surface elevation is 76.69 feet, for the same tailwater. The differences is only 3 inches, but this error is carried through the back water computation and also incorrect interpolation of the entrance weir head.(see attached calculation)

Entrances discharge

NHC computer model has a very small error in calculating the entrances weir discharge. NHC computed model entrances weir discharge is 1097 cfs for tail water 75.35 feet. The theoretical hand calculated entrance weir discharge is 1112 CFS for the same tailwater.(see attached calculation)

Fish Ladder discharge

NHC computer model calculation portion of the unsubmerged fish ladder weir report different values. For example at weir 93 NHC report a weir discharge of 53.57 cfs and a orifice discharge of 27.45 cfs then at weir 79 NHC reports a weir discharge of 55.06 cfs and a orifice discharge of 25.96 cfs. The discrepancies may seem very small but both ladder are unsubmerged weir and should use the same weir discharge equations, the discharge should be the same for both weir. Table below list the values from the NHC report and hand computation of the submerged portion of the ladder. The percent differences in the table are for NHC ladder Q compared to hand computation of ladder Q.

NHC computer model calculation portion for the submerged weir is using the same discharge coefficient for all portions of the fish ladder weir. The fish ladder

is constructed into two parts an overflow section and a non-overflow section. The overflow and non-overflow section have difference shape and the discharge coefficient in general are based on the shape of the weir, so each section should have a different discharge coefficient.

Weir No.	NHC Computer Model			Hand Compution			Percent
	Ladder Q (cfs)	Weir Q (cfs)	Orifice Q (cfs)	Ladder Q (cfs)	Weir Q (cfs)	Orifice Q (cfs)	Differences
70	370.57	362.97	7.6	376.66	368.9	7.76	-1.64
71	280.99	274.19	6.8	280.75	271.65	9.1	0.09
72	280.99	271.98	90.1	283.22	274.12	9.1	-0.79
73	198.03	189.84	8.19	198.94	190.71	8.23	-0.46
74	198.03	185.73	12.29	197.85	185.58	12.27	0.09
75	125	113.06	11.94	125.24	113.28	11.96	-0.19
76	125	105.58	19.42	124.08	104.67	19.41	0.74

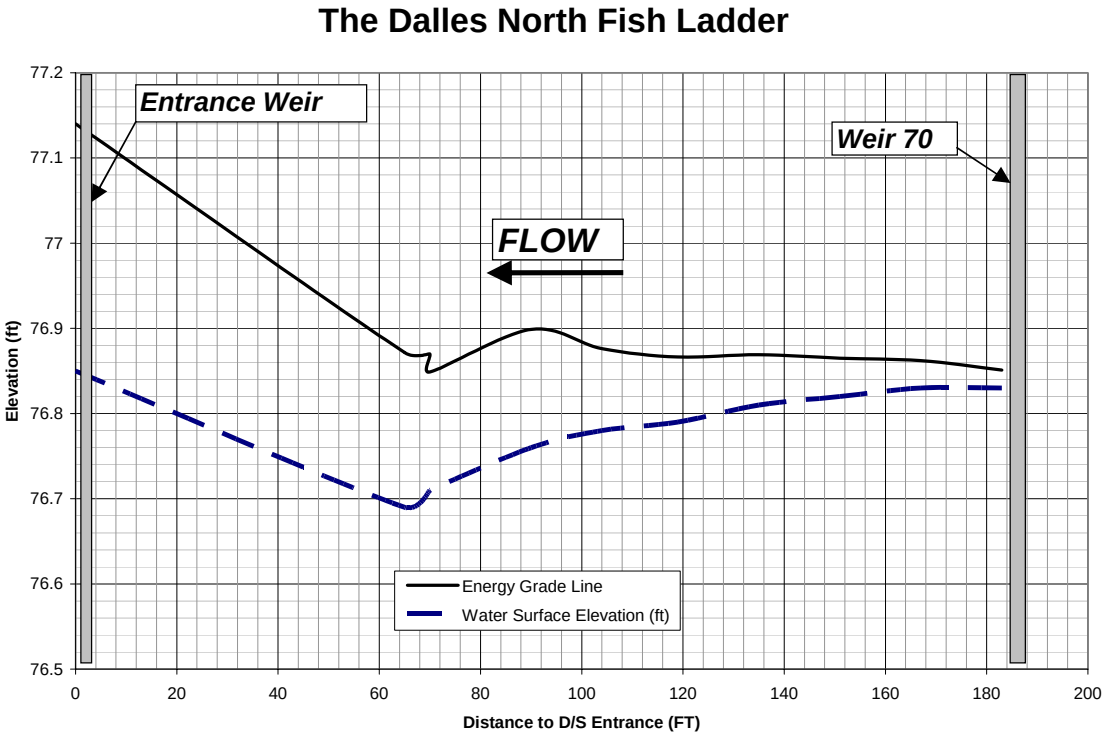
The table below list the NHC reported water surface elevation and the field data collected during the same tailwater and fish ladder settings. The values are very close except for weir 76. The field data shows that the head differences are significantly increasing between weir 76 and 77, where as NHC occurs at between weir 75 and 76.

Weir No.	NHC Water Surface Elevation	Field Data Collection
70	76.91	77.1
71	76.97	77.1
72	77.08	77.3
74	77.37	77.5
75	77.56	77.6
76	78.06	77.8
77	78.45	78.4
78	79.14	79.2
79	80.03	80.2
80	81.01	81.2
81	82	82.2

Back Water Profile and Energy Grade Line

NHC computer model is incorrectly calculating the water surface profile along fishway channel between stations 65+00 to 183+00. NHC water surface profile differences from stations 65+00 to 183+00 is 1.68 inches. Hand calculation back water computation differential from stations 65 to 183 is 0.42 inches, which is

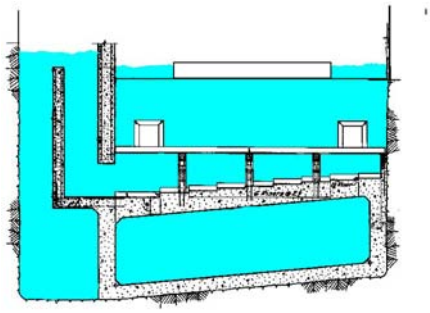
very conservative because in the hand calculation it assumes all of the flow initiates at station 183, instead of the addition flow being added along the channel. The water surface elevation were collected in the fishway channel during the field testing, the data collected between station 80 to 183 indicated on changes in water surface profile. Illustration below is a plot of the NHC energy grade line and water surface profile along the fishway channel. The NHC energy grade line is up and down along the channel, theoretical it should be gradual sloping down from station 183+00.



Weir Valve pipe calculation

NHC computer model is incorrectly using the depth from downstream water surface weir to crest. The waters surface elevation at any single diffuser is base on the summation of initial ladder flow, addition flow add by the diffuser upstream of that diffuser and the flow contributed by that diffuser. NHC is only use the water surface elevation contributed by that diffuser.

Weir No	Weir Valve Elevation (ft)	Final Water Surface Profile (Ft)	EPA Output Grade (ft)	Node No.
70	72	76.78	76.61	1204
72	74	76.96	76.44	1014
74	76	77.28	76.63	904
76	80	78.01	77.02	804



CENWP-EC-HD

MEMORANDUM FOR RECORD 2September2005

From: Natalie Richards, PE

Subject: Evaluation of HELCRABS Simulation Program for The Dalles North Fish Ladder

Objective:

The Hydraulic Design Section (EC-HD) has conducted an evaluation of the The Dalles North Fishway System under the Hydraulic Evaluation of the Lower Columbia River Adult Bypass Systems (HELCRABS) as required by the Reasonable and Prudent Action (RPA) 120 of the 2000 Biological Opinion (Bi-OP). Field data was used to evaluate, correct and calibrate the NHC model to more accurately simulate the hydraulic behavior within the system.

Fisheries Criteria:

The simulations were run with an objective to meet the following Fisheries Criteria for Columbia River Fishway Systems taken from the Fish Passage Plan dated February 2005:

- Elevation entrance weir crest or sluice opening invert ≥ 8 feet below tailrace level (or entrance submergence ≥ 8 feet);
- Maintain a minimum tailwater at 70 msl;
- Head difference across entrances should be between 1 – 2 feet, 1.5 feet optimum;
- Channel velocities should be between 1.5 - 4 feet per second (ft/s), 2 ft/s optimum;
- Ladder head should be 1.0 foot (± 0.1 feet) for non-shad passage season (Aug 16-May 14) and 1.3 feet (± 0.1 feet) for shad passage season (May 15-Aug 15).
- The hydraulic drop per pool shall be between 0.5 and 1.0 feet in the exit channel section.

Objectives:

1. Review program simulation methodology; equations and assumptions
2. Review program code.
3. Review program output that describes hydraulic behavior of system components (entrances channel, etc.)
4. Identify deficiencies and quantify errors.
5. Present changes in geometry files to improve model accuracy.

1.0 Background- Existing Project Features.

The Dalles Dam is the second dam located on the Columbia River near The Dalles, Oregon. The powerhouse contains 22 main units with 2 fish units. Adult fish passage is composed of two separate fishladder systems, one located to the north of the spillway and one on the east side of the powerhouse with 3 entrance locations. The north fish ladder (or TDAN) is itself composed of an entrance location with 3 weir openings.

The entire Fishway flow is typically dischnarged to the tailrace through one entrance opening (E-1) The inflow from an Auxiliary water supply (AWS) WASCO County {ublic Utility District (PUD) turbine and the fish ladder. (See Figure 1) The AWS is provided by a turbine system which comes into the AWS conduit beneath weir 79 at Node 30 to 33 to 56 and 57 with Link 57 (Unit 15) (See Figure 2). This turbine, which utilizes the forebay, is the major component of the water supply to the upstream fish passage system at The Dalles Dam North. The flow is then discharged into the fishway channel through diffusers by means of upward flow. (See Figure 3) Diffuser Gate 2000 is permanently closed and 1900 is half blocked. During the inspection conducted February 11, 2005 of the fish ladder, it was determined that there were notches on the top of the gates that cuts off area for the flow. This reduced area is accounted for in the *.in file.

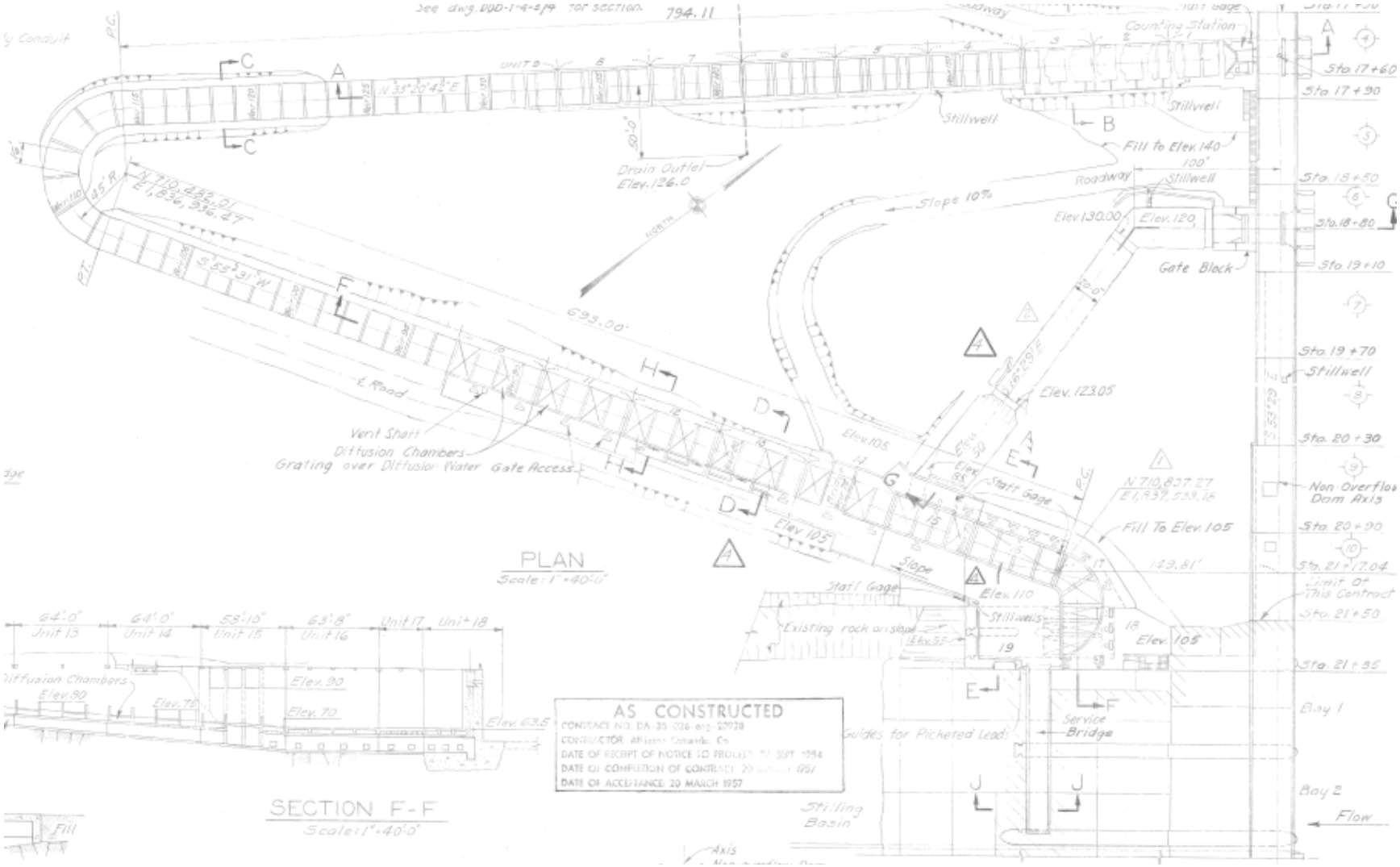


Figure 1- TDAN Ladder plan view from sheet DDF-1-4-2/1

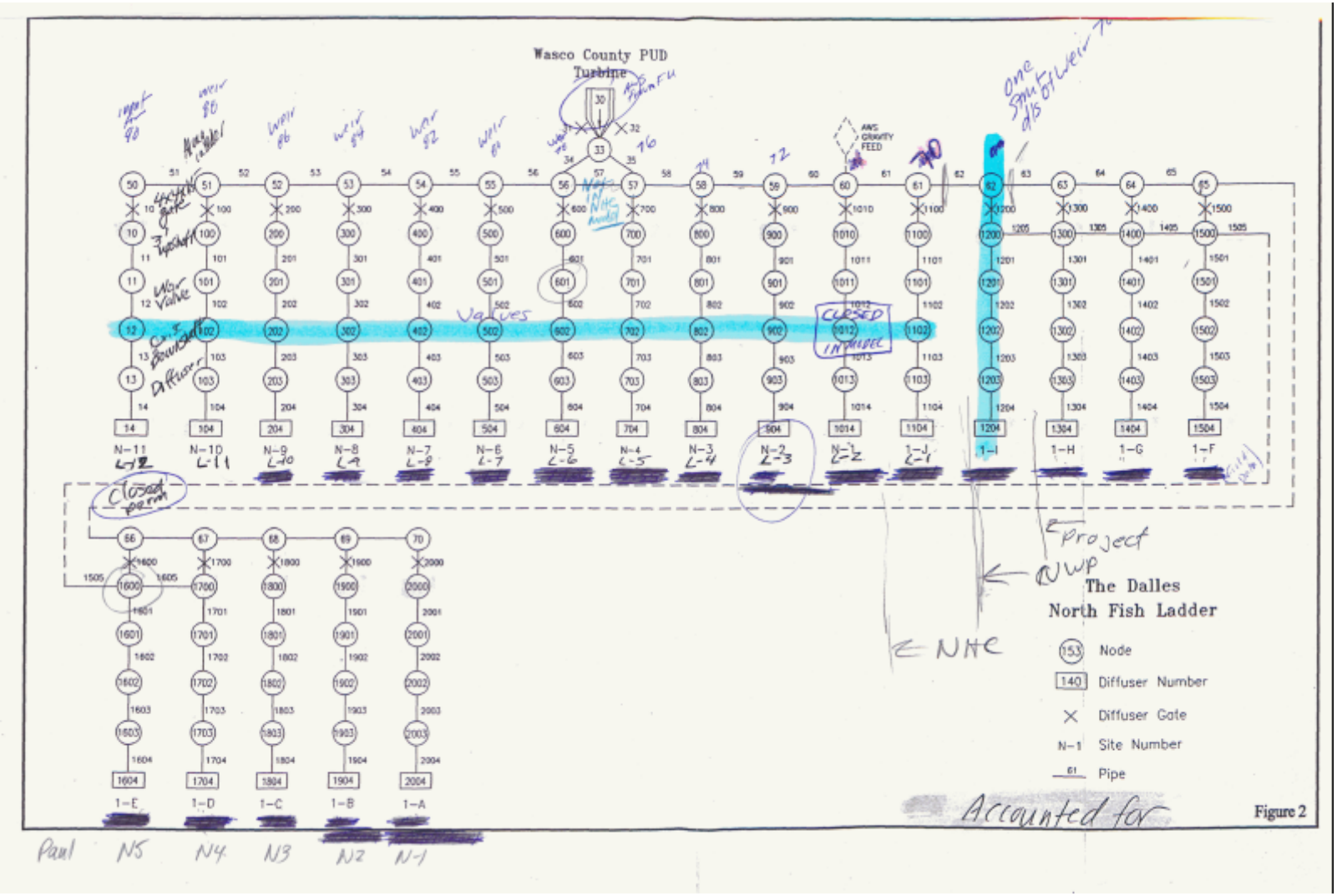


Figure 2: AWS System Schematic (original NHC model)

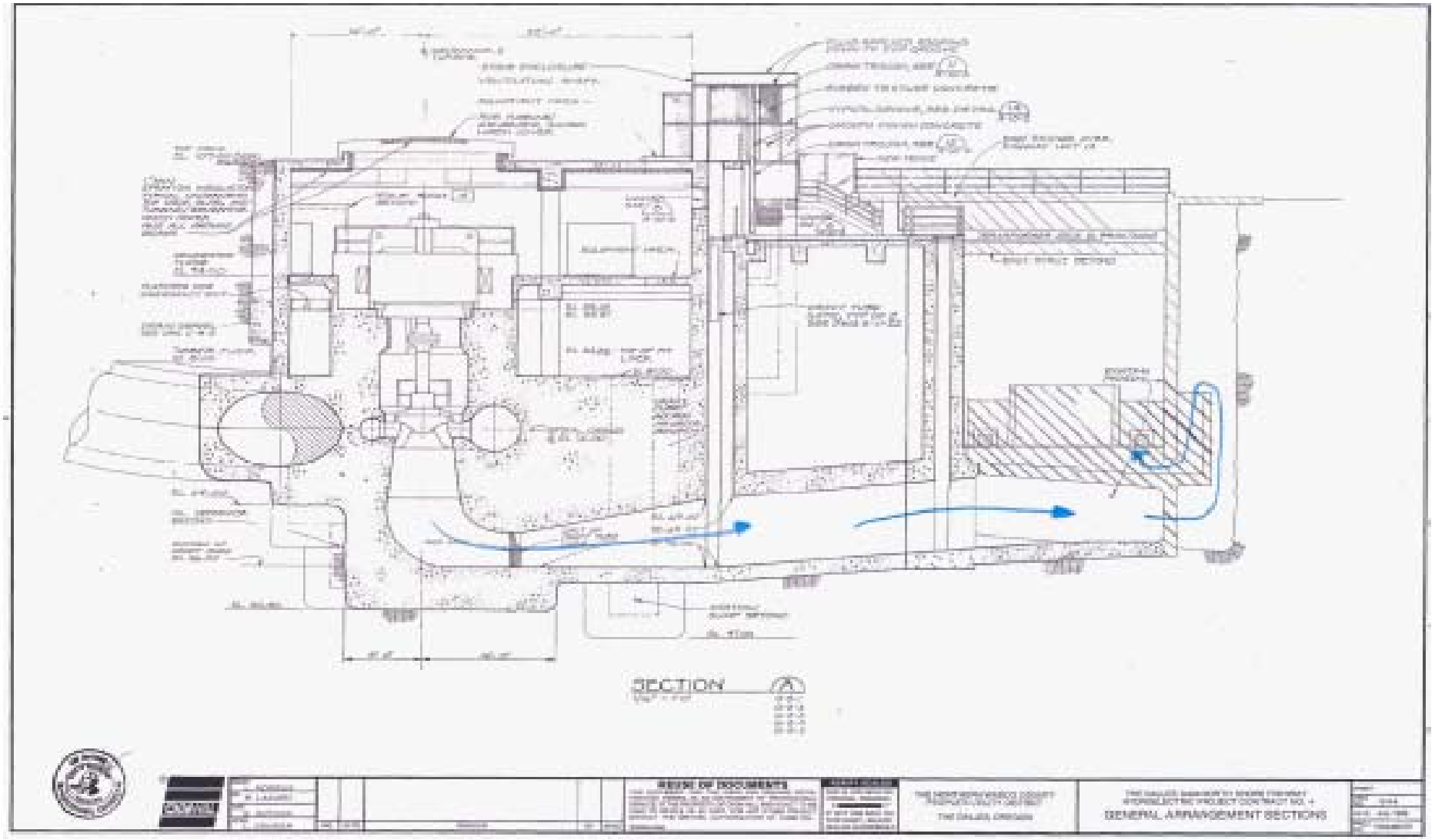


Figure 3- Turbine flow into the ladder system Node 30 to 33 to 56 and 57

In summary, the The Dalles North Fish Ladder consists of the following hydraulic components:

- 134 conduits,
- 21 floor diffusers and diffuser gates (Project designation 13, 12, 11,10, 9, 8,7,6,5,4,3,2,1-I through-1-A)
- 106 fixed grade nodes (FGNS),
- 14 locations to measure the water surface directly near the Fishway floor-diffuser locations along the ladder,
- 2 gatewells and 3 Main Fish Entrance weirs of which two are operated-(1-C, 1-B, 1-A) or (output file-100, 200, 300) or (N1, N2, N3) depending on the reference is being used. N3 is permanently closed.
- AWS System from the WASCO PUD turbine which feed the AWS conduit starting at link 57 and 58

2.0 Background-HELCRABS The Dalles North Fish Ladder Model Methodology, Assumptions, Description etc.

2.1 General Model Algorithm

The HELCRABS simulation model of the The Dalles North Fish Ladder system is a significant undertaking involving the use of steady state, one-dimensional hydraulics and mathematics to simulate the prototype system. In December 1998, Northwest Hydraulics Consultants (NHC) developed two separate computer programs for the hydraulic analysis of The Dalles North fishway facilities. These computer programs are linked to run as a single program called FISHWAY. (See Figure 4 below) The program simulates:

- The AWS system closed conduit flow;
- The open channel flow portion of the fish ladder and the fishway entrances.

The model does not simulate the control and exit section at the upstream end of the fish ladder.

The open channel flow characteristics of the fish ladder and fishway entrances are simulated using a NHC developed site-specific fishway analysis program (**nhcfish**). The Hydraulic characteristics of the AWS system are simulated using the pipe network simulation program (**nhcnet**) which is based on the C program of EPANET version 1.1e and modified by NHC to allow rectangular conduits and internal weirs. The pipe network was created using as-built drawings of the fish ladder. The Environmental Protection Agency (EPA) developed EPANET as a Windows program that performs extended period simulation of hydraulic and water-quality behavior within pressurized pipe networks. A network will consist of pipes, nodes (pipe junctions) and can include a turbine.

Hydraulic analysis of the fishway system involves a trial and error solution using both **nhcfish** and **nhcnet** to achieve a solution. To facilitate the computer application, the two programs have been linked by a third computer program (**fishstep**), which enables sequential operation of these two programs. The linking program converts the output from **nhcnet** to input to **nhcfish**, runs

fishstep, checks the results against the input to **nhcnet** to determine if a solution has been achieved. **Fishstep** compares the channel water surface elevation at each diffuser used by **nhcnet** to compute the diffuser discharge. If the assumed and computed elevation balance is within 0.02 ft or the discharge does not change by more than 0.1 cfs, the simulation is completed; if not, iterations continue until a solution is obtained within these limits. If a solution has not been achieved within the set tolerances, **fishstep** resets input to **nhcnet**, then both **nhcnet** and **nhcfish** are run again. This procedure is repeated until a solution is achieved. Once convergence is attained, the program writes the final results to the output file. It is noted that there have been no structural changes to the ladder since this work was completed by NHC in December 1998.

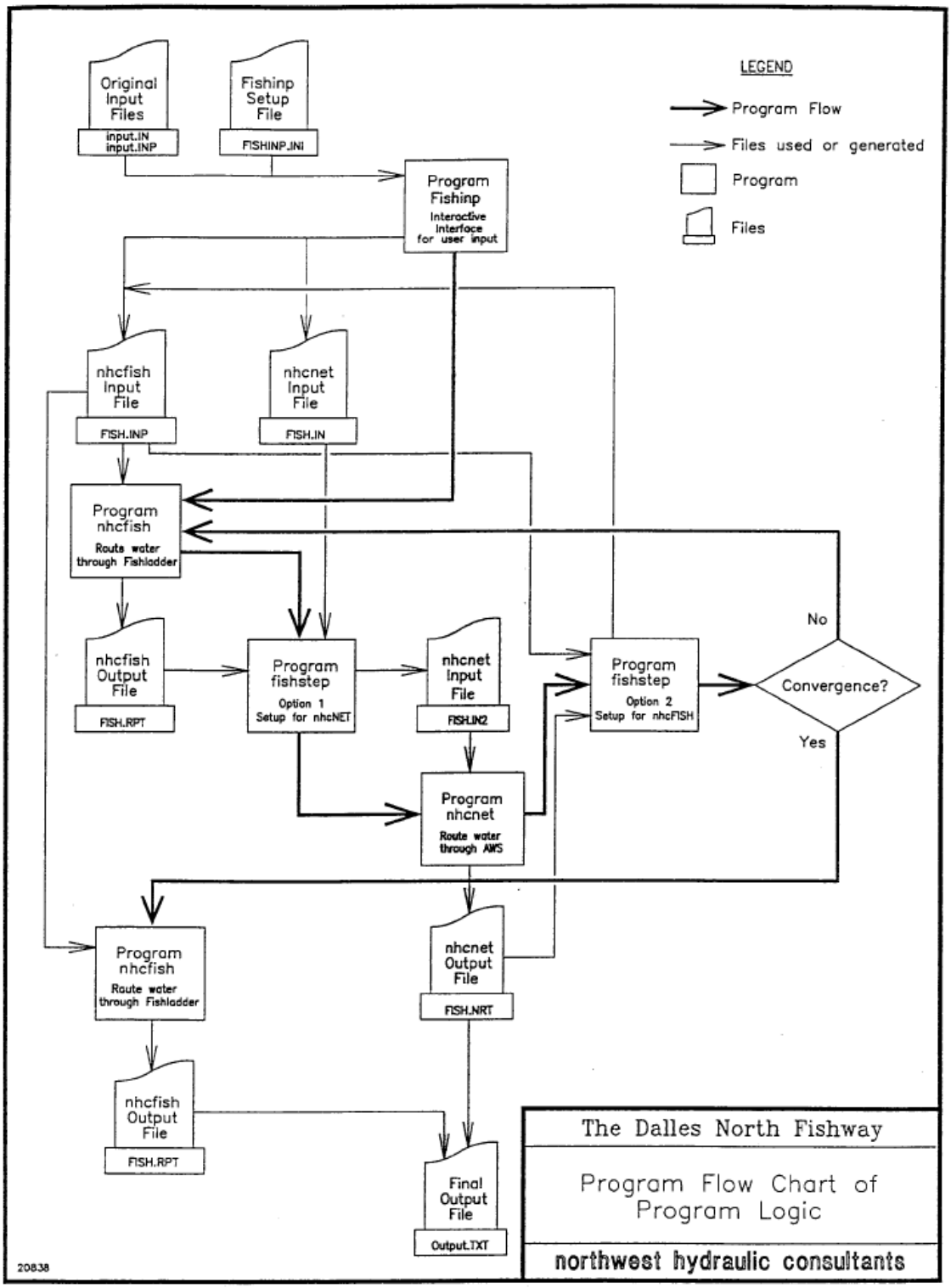


Figure 4: Program Flow Chart of Program Logic

2.2 Geometry Input Files

There are three geometry files that are read by the program to conduct the simulation.

- INP File—file created from the GUI interface by the user each time the main program FISHWAY is run. It contains the variable hydraulic conditions and normal operational options including tailrace levels, entrance weir elevations, open diffusers, and ladder head. Essentially, the data in this file represents the Project and Fishway operation.
- INI file--file includes the unchanging geometry information and pertinent head loss coefficients for the open channel portions of the system. This includes the entrances, diffuser locations, ladder weirs and orifices. This file should only be modified in the event of structural changes, geometry corrections or needed revisions to weir, entrance and orifice coefficients. Only an experienced hydraulic engineer (who is familiar with the program) should make such modifications.
- IN file—file contain unchanging geometry information and head loss coefficients (friction and minor loss) for the pressurized AWS systems. This includes the conduits, weir valves (also known as stovepipe weir valves), diffuser gates and diffuser basins. Like the INI file, only hydraulic engineers should modify this file when geometry or loss coefficient data needs to be revised.

2.3 NHCNET & AWS Simulation

The subprogram **nhcnet** simulates the AWS system by a series of links representing specific conduit sizes, branches, gates, internal weirs and nodes representing junctions and inflow (turbine) and outflow locations (diffusers). Between successive nodes, the links are described by the conduit height, width, roughness dimension (for Darcy-Weisbach Application), length, and the summation of the shape loss coefficients associated with that portion of the conduit.

The shape loss coefficient, k, defines the hydraulic head loss, h_L, of features such as bends, expansions, contractions, valves, branches of dividing and combining flows, etc. as function of the velocity head, $h_L=k(V^2/2g)$. above depicts a schematic of the AWS system, from the NHC model user manual[1], that defines all the interior nodes, pipes, and FGNS used in the **nhcnet** input.

The **nhcnet** program computes the total discharge in the AWS system, the discharge in each pipe, and the discharge from each diffuser. The outflow discharge at each diffuser FGNS is transferred to **nhcfish**, the Fishway analysis program, by **fishstep** for comparison. The process is reiterated until the convergence is attained between the output of **nhcnet** and **nhcfish**.

The Corps of Engineers Portland District Hydraulic Design Section (EC-HD) checked, evaluated, and in several cases, revised the AWS geometry and the loss coefficients included in the original IN file of the NHC model. EC-HD revised most of the shape loss coefficients based on data presented in Corps *Hydraulic Design Criteria* (HDC), *Internal Flow Systems*, BHRA 1978 (D.S. Miller) and *Handbook of Hydraulics*, 1976 (Brater and King). Diffuser system loss coefficients estimated from reference sources. The diffusers grating loss coefficients are not readily available the Miller or HDC references (unlike normal elbows, expanding and contracting pipes). Twenty one

[1] Table 2 in the main report shows this layout in enlarged format, plus a geometry revision by EC-HD.

links and specifically Link 62 (where flow switch from the north to the south) were used to calibrate the model to field data, which are noted on Table 2 below.

CENWP-EC-HD added link 57 which was omitted from the original NHC program. All links were checked with respect to geometry measurements and loss coefficients. All changes made to the IN geometry file by EC-HD are documented in Table 2 at the end of this memorandum for the record. The discharge rates from fish ladder diffusers are a function of the AWS hydraulic gradeline (HGL) and inflows are passively controlled by the crest elevations of twelve weir valves.

Further investigation revealed that there were two problems with the original model's low discharge in the fish ladder and ladder diffusers: (1) a very low AWS hydraulic grade line (corrected above with revised loss coefficients), and (2) the weir valve equation was wrong in **nhcnet** program. The incorrect equation is in the C programming portion of the **nhcnet** code. EC-HD does not have the complete model code or necessary tools to recompile, and are therefore unable to directly correct the equation in the code. To remedy this program deficiency, EC-HD created an excel spreadsheet macro that adjusts the weir coefficient (which is accessible in the IN file). However, this requires a time-consuming, interactive iterative process to converge on a solution.

2.3.1 Excel Macro

The weir valve problem was corrected by the development of an Excel spreadsheet macro to compensate for the error in the **nhcnet** weir valve subroutine for weir valves used for ladder diffusers. Errors in the weir valve equation are: (1) ladder diffuser discharge is erroneously computed as a function of H1 (upstream head) to the 0.5 power instead of the 1.5 power; (2) as the H1 becomes high then orifice (or pipe) control prevails instead of weir flow.

NHCNET EQUATION

$$Qd = C * L * \sqrt{H1} * \left[1 - \left(\frac{H1}{H2}\right)^{1.5}\right]^{0.385}$$

CORRECT EQUATION

$$Qd = C * L * H1^{1.5} * \left[1 - \left(\frac{H1}{H2}\right)^{1.5}\right]^{0.385} \quad (1)$$

In which,
Qd = Ladder Diffuser Flow (cfs)
C = Weir Coefficient = 3.2
L = Length of stovepipe weir (ft)
H1 = Upstream head (AWS HGL) - stovepipe weir crest elevation
H2 = Downstream head above stovepipe weir crest

Note: both equations use the Villemonte correction for weir submergence.

Due to the geometry of the AWS system in the weir valve section, when H1 becomes sufficiently high (5 ft in this case), the weir acts more like an orifice (or a tight 180 degree bend) than a weir. A better approximation of the system (when H1 exceeds 5 ft) is to change the simulation approach from weir flow to pipe flow. The macro converts the weir valves to pipes in the IN file where the respective H1 exceeds 5 feet.

The macro uses information from the HELCRABS output file to make adjustments to the IN data file so that the weir equation is correctly applied in the subsequent HELCRABS runs. It also checks to see if each ladder diffuser should be simulated as orifice (pipe) flow instead of weir flow and adjusts the IN file accordingly. The HELCRABS program is rerun until the Macro determines the differences between output results have become negligible.

For The Dalles North Fish Ladder HELCRABS model, the use of the Macro makes total ladder diffusers discharges two times greater than the original model:

Table 1- Comparison of Ladder Flow Estimates by Model

Ladder Diffuser Locations	NHC Model-5/18/2005 (cfs)	EC-HD-Calibrated Model-5/18/2005 (cfs)
Weir 70	46	81
Weir 72	0	78
Weir 74	46	77
Weir 76	39	75
Weir 78	41	45
Weir 80	3	0
Weir 82	0	0
Weir 84	0	0
Weir 86	0	0
Weir 88	0	0
Weir 90	0	0
Weir 92	0	0
Total	**176**	**356**

This Excel Macro corrects theoretical deficiencies in the The Dalles North Fish Ladder HELCRABS model through iterations of HELCRABS runs and corresponding adjustments to the IN file. Although the iterations have to be completed manually and the ranges of weir coefficients are no longer theoretically realistic (if taken as absolute values), the macro enables a better simulation of the AWS system through the weir valves of the respective fish ladders.

After the initial incorporation of the Macro into the data handling Excel workbook, information on the turbine rating curves are available from the manufacturer and a separate

computational sheet was incorporated into the workbook that computed the turbine discharge after convergence is achieved. The model does not simulate the operation of the turbine.

A detailed description of the macro development and operation is documented in the EC-HD memorandum *Weir Valve Correction Macro for John Day South and Bonneville Second Powerhouse HELCRABS models* by Sean Askelson, October 4 2004 and was modified by Mr. Williams for The Dalles North.

2.4 FISHWAY and Fishway Simulation

The sub-program **nhcjds** computes the discharge rates, water surface elevations, average channel and diffuser velocities and head differentials that occur in the open channel portion of the Fishway, including entrances and fish ladder. The **nhcjds** describes the open channel portions of the fish facility by continuity, energy, and Manning's friction loss equations. The Manning's roughness n values were determined by NHC in their original model calibration. The computations of the hydraulic characteristics are based on the geometric shape and associated hydraulic head losses that occur throughout the open channel portion of the fishway. The input to **nhcjds** includes the outflow discharge from each operating diffuser (computed by **nhcnet**), the tailwater elevation at the main entrance areas and the depth of flow over the most upstream fish ladder weir. The program uses the INI file for system geometry and coefficients for discharge and channel losses.

Sections 2.41 and 2.42 and Equations 2-12 are excerpts from NHC's The Dalles North Fishway Facility Adult Bypass System.

2.4.1 Channel Simulations

Open Channel Computation Problems

A problem exits with the open channel simulation of the HELCRABS in that the output for the water level elevation is reported out of place or staggered with respect to the concurrent channel flow rate and velocity at each given location along the powerhouse channel output. The water level output for the powerhouse channel is reported one spot upstream from the location it should be assigned. This was discovered when the computed velocities failed to match the reported velocities and it was discovered that the energy gradeline did not rise uniformly in the upstream direction. The correct equation for channel velocity for a given location 'i' along the channel is shown below:

$$V_i = \frac{Q_i}{B_i * (WS_i - Z_i)} \qquad (2)$$

In which;

Q_i = Flow rate at location i

WS_i = Water level elevation at location i

Z_i = Invert elevation at location i

Unfortunately V_i reported in the model does not match the V_i provided in the above equation because the water level (WS_i) is improperly reported in the output. As it turns out, the water level reported at location i+1 is the correct water level that goes into the i location spot and will yield the

correct velocity. Consequently to match the reported velocity in the output, the above equation has to be modified by replacing WS_i with WS_{i+1}:

$$V_i = \frac{Q_i}{B_i * (\mathbf{WS_{i+1}} - Z_i)} \qquad (3)$$

Table 1 includes an excerpt from the program output that illustrates the improper assignment of water level with respect to location. The green shaded cell for the water elevation (col 7) does not go with the green shaded cells representing channel discharge (col. 5) and channel velocity (col. 6). If it is used to solve for the velocity it will produce a difference results than shown in the green cell for velocity. However, if the yell shaded cell for water surface elevation (col 7) is used with the green cell for discharge, the resulting velocity matches that in the green cell for velocity. Also note the Energy gradeline (EGL) computations on the right side (columns 9 and 10). EGL1 represent the computes EGL based on the green cells for V and WS elev. EGL2 is based on the green cell for V and the yellow cell for WS elev. Note that the EGL1 is actually descending in the upstream direction; whereas EGL2 is rising properly in the upstream direction.

Table 1-- Output showing wrong placement of water surface elevation data

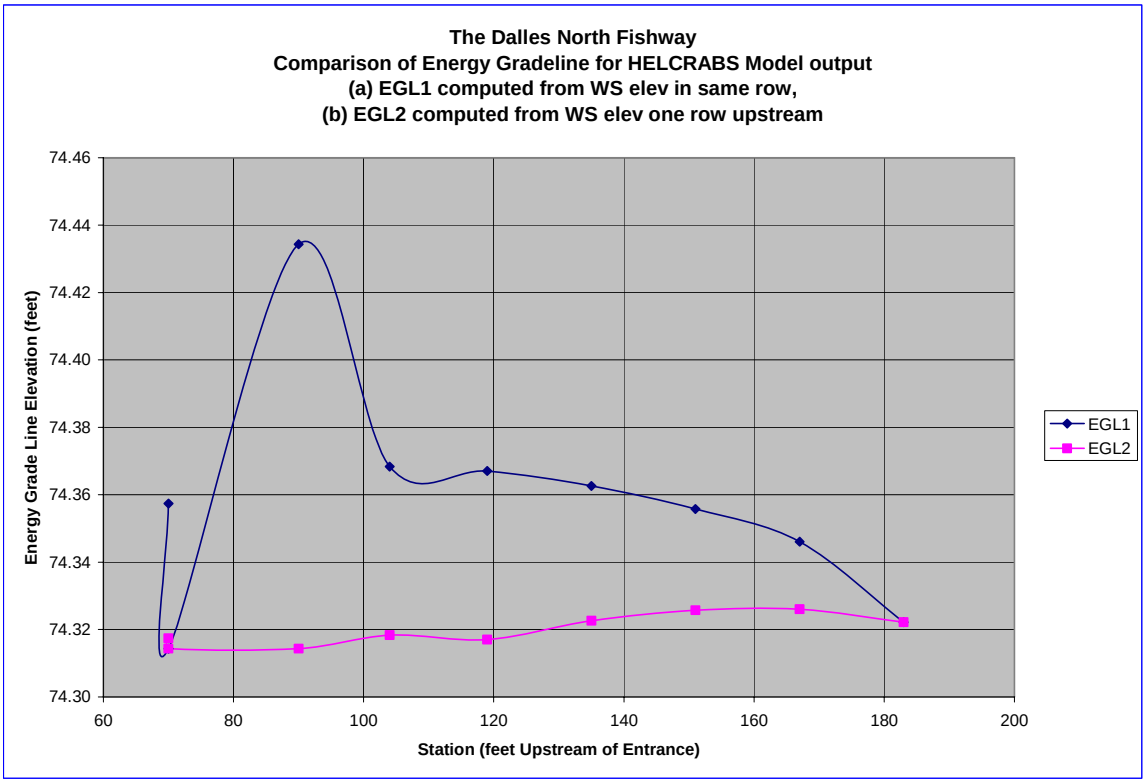
1	2	3	4	5	6	7	8		9	10
row no. (i)	Basin No.	Diffuser Discharge (cfs)	Diffuser Velocity (ft/s)	Channel Discharge (cfs)	Channel Velocity (ft/s)	WS Elev (ft)	Distance to-D/S Entrance (ft)		EGL1 (ft)	EGL2 (ft)
4	600	116.19	0.33	838.2	3.28	74.2	119	Q	74.37	74.32
3	500	117.41	0.27	955.6	3.75	74.15	104		74.37	74.32
2	400	119.01	0.28	1074.61	4.64	74.1	90		74.43	74.31
1	300	94.31	0.41	1168.93	4.64	73.98	70		74.31	74.31
NOTES:										
	74.43	EGL1 in row 2 is considerably higher than				74.15	improper value for green shaded row			
	74.37	EGL1 in ustream rows 3 and 4				74.10	Correct value for green shaded row			

Figure 1 shows a comparative plot of the two different means of computing the energy gradelines: EGL1 and EGL2 based on the relative position the WS extracted to compute EGL. Neither EGL curve progresses upwards perfectly in the upstream direction, However, the EGL2 (yellow cell for WS elev) shows a more uniform rising pattern and far fewer cases where an adjacent EGL value is actually less than the previous EGL value. With EGL1 data, the values are much more erratic. Consequently, the data has to be interpreted by factoring in the relative location of the WS elev output into the analyses.

$$EGL1 = WS_i + \frac{V_i^2}{2g} \qquad \text{(Green cell for WS elev)} \qquad (4)$$

$$EGL2 = \mathbf{WS_{i+1}} + \frac{V_i^2}{2g} \text{ (Yellow cell for WS elev)} \qquad (5)$$

Figure 1-- Comparison of Energy Gradeline (EGL) Computations from HELCRABS Output of The Dalles Lower Fishway Channel: (a) EGL1 is based on WS Elev from same row, (b) EGL2 is based on WS Elev fro upstream row.



The HELCRABS program starts the at the north entrance and solves continuity between each diffuser as it steps upstream in the backwater profile computation. It then calculates the frictional loss to the next inlet/outlet to determine the next upstream water surface elevation. The Manning equation is the basis for the computation of water level change between points in the channel:

Continuity equation:

$$Q=V\cdot A \tag{6}$$

Energy equation

$$Z_1+d_1+\frac{\alpha\cdot V_1^{\,2}}{2\cdot g}=Z_2+d_2+\frac{\alpha\cdot V_2^{\,2}}{2\cdot g}+H_L \tag{7}$$

Manning's equation

$$H_{Lf}=\left(\frac{Q\cdot n}{1.49\cdot A\cdot R^{\frac{2}{3}}}\right)^2\cdot L \tag{8}$$

In which:

Q = channel discharge (cfs)
V = average channel velocity (fps)
A = area of water in channel section (ft^2)
H_{Lf} = head loss resulting from friction (ft)
Z = elevation of datum (ft)

g = gravitational constant (ft/s^2)
d = depth of water in channel section (ft)
L = length of conduit (ft)
R = hydraulic radius (ft)
n = transportation channel loss coefficient (not to be confused with Manning's friction coefficient)
H_L = Total head loss, friction and shape loss

2.4.2 General Equations for the Weir and Orifice Simulations

The equation for entrance flow is shown below and applies to any system of units:

Unsubmerged weir:

$$Q_w=C_w \cdot L \cdot h_1 \cdot (2 \cdot g \cdot h_w)^{0.5} \quad (9)$$

Submerged weir:

$$Q_w=C_w \cdot C_v \cdot L \cdot h_1 \cdot (2 \cdot g \cdot h_w)^{0.5} \quad (10)$$

Orifice:

$$Q_o=C_o \cdot A \cdot (2 \cdot g \cdot h_o)^{0.5} \quad (11)$$

The main entrance weirs to the fish facility are described by the following equation:

$$Q_e=5.35 \cdot C_v \cdot C_r \cdot h_1^{1.5} \cdot L \cdot (1-C_L) \quad (12)$$

The discharge coefficient C_R, for the main entrance submerged weirs was empirically derived based on Rehbock's weir equation, (Reference 8 ENSR report):

$$K_r=\frac{h_1}{P} \quad (13)$$

When K_r is equal to or less than 2.5:

$$C_R=0.611+0.08 \cdot K_r \quad (14)$$

When K_r is greater than 2.5:

$$C_R=0.6+\frac{0.5275}{K_r} \quad (15)$$

The discharge correction coefficient for weir submergence C_V was computed based on the Villamonte's equation (ENSR report reference 9):

$$C_V=\left[\left(1-\frac{h_2}{h_1}\right)^{1.5}\right]^{0.385} \quad (16)$$

In which:

Qw = Ladder weir discharge
Qo = Ladder orifice discharge
Qe = Main entrance weir discharge
Cw = Discharge coefficient for weir
Cv = Villamonte's correction coefficient for weir submergence
C_L = Contraction coefficient
L = Length of entrance weir crest (ft).
P = Depth of channel below weir crest
h_1 = Depth from upstream water surface to weir crest
h_2 = Depth from downstream water surface to weir crest

h_o = Head on orifice = h_1- h_2
h_w = Head on weir= h_1- h_2
A = Area of orifice

2.4.3 Ladder Flow Simulations

The equation for ladder weir flow is shown below and applies to any system of units:

$$Qw = C * Lw * H1^{1.5} * \left[1 - \left(\frac{H1}{H2}\right)^{1.5}\right]^{0.385} \quad (17)$$

In which:
Qw = Flow over ladder weir (cfs)
C = Ladder weir coefficient.
Lw = Length of ladder weir crest (ft).
H1 = Upstream head on weir (ft) from approach channel.
H2 = Difference between d/s water level and weir crest elevation (ft).

The last term (brackets taken to 0.385 power) is the Villemonte equation, which corrects for weir submergence below tailwater.

The equation for the ladder orifice is the following and also applies to any system of units:

$$Qo = Co * Ao * \sqrt{2g * (H1 - H2)} \quad (18)$$

In which:
Qo = Flow through orifice (cfs)
Co = Orifice discharge coefficient.
Ao = Flow Area of Orifice (ft^2)
H1 = Upstream head on ladder weir (ft).
H2 = Difference between d/s water level and weir crest elevation (ft).

Total ladder flow = Qw + 2 * Qo. The next section reports that the original HELCRABS model underestimated the total ladder flow by about 3%. The ladder coefficients, C and Co, were raised in the INI files for revised model to reasonably match the prototype data.

3.0 Review and Comparison of Program Output with Measured Data:

EC-HD personnel measured the flow, water levels and the boundary conditions at The Dalles North Fish Ladder on two separate dates with different tailwater conditions: low tailwater of 75.3 ft NGVD on 11NOV2004 and high tailwater of 79.5 ft NGVD on 18MAY2005. Access to the field data is provided in data collection trip reports, located in Appendix B (covered in the main report). This data consists of flow measurements at the main entrances and exit section, heads in the pools of the ladder and exit section, elevations of the water surfaces, entrances heads, forebay and tailwater elevations.

3.1 Measured Data Compared to Original HELCRABS Model Simulations

The measured data taken on 11NOV2004 and 18MAY2005 were input to the HELCRABS program. Some of the comparisons of the measured data and the simulation are presented in Table 1. This table compares the differences between the measured data and results from the original model.

Table 2: Summary Comparison of Original Model with Field Data

THE DALLES DAM NORTH FISHWAY

SUMMARY COMPARISON OF ORIGINAL and REVISED MODELS WITH FIELD DATA

PART 1: SYSTEM INFLOWS

Average Project Forebay Conditions (ft)

Test Date	11/10/04	5/18/05	8/12/2005
TW	75.3	79.5	
Forebay	157.9	157.2	157.7

A. Ladder Flow (cfs)

	Original NHC				EC-HD- Revised Model			
Test Date	11/10/04	5/18/05	8/12/2005	Average	11/10/04	5/18/05	8/12/2005	Average
Ladder Head	1.0	1.0	1.35		1.0	1.0	1.35	
Measured	81	68	102	84	81	68.0	102	84
Model	72	72	85	76	75	75.1	98	83
% Diff	*-11%*	*6%*	*-17%*	*-9%*	*-7%*	*10%*	*-4%*	*-1%*

B. Comparison of Measured Turbine Flow versus Rating Curve (cfs)

	Original NHC			EC-HD- Revised Model		
Test Date	11/10/04	5/18/05	Average	11/10/04	5/18/05	Average
Turbine MW	5.4	4.9		5.4	4.9	
Net Head (ft)	78.8	75.1		78.8	75.1	
Measured	934	905	920	934	905.0	920
Rating Curve	*875.0*	850	863	875	850.0	863
Diff	*-59.0*	*-55.0*	*-6%*	*-59.0*	*-55.0*	*-6%*

C. Net Head and Discharge through Turbine UNIT (cfs)

	Original NHC			EC-HD- Revised Model		
Test Date	11/10/04	5/18/05	Average	11/10/04	5/18/05	Average
Turbine MW	5.4	4.9		5.4	4.9	
Net Head (ft)						
Measured	78.8	75.1	77.0	78.8	75.1	77.0
Model	78.8	75.1	77.0	78.8	75.1	77.0
Diff	*0.0*	*0.0*	0%	*0.0*	*0.0*	0%
Discharge						
Measured	934	905	920	934	905	920
Model	1004	839	921	968	858	913
% Diff	*7%*	*-7%*	*0%*	*4%*	*-5.1%*	*-1%*

D. Total System Inflow (cfs)

	Original NHC			EC-HD- Revised Model		
Test Date	11/10/04	5/18/05	Average	11/10/04	5/18/05	Average
Meas & curves	1015	973	994	1015	973	994
Model	1076	911	993	1043	934	988
% Diff	*6%*	*-6%*	*0%*	*3%*	*-4%*	*-1%*

THE DALLES NORTH FISHWAY

SUMMARY COMPARISON OF ORIGINAL and REVISED MODELS WITH FIELD DATA

PART 2: ENTRANCE HEADS & DISCHARGE RATES,

LOWER CHANNEL VELOCITY AND WATER LEVEL DATA

Average Project Tailrace Conditions (ft)

Test Date	11/10/04	5/18/05
Tailrace	75.4	79.6
Proj FB	157.90	157.2

E. E-1 Entrance Head

	Original NHC			EC-HD- Revised Model		
Test Date	11/10/04	5/18/05	Average	11/10/04	5/18/05	Average
weir submerg.	8.5	9.5		8.5	9.5	
Measured	1.32	1.30	1.31	1.31	1.23	1.27
Model	1.60	1.10	1.35	1.34	1.24	1.29
% Diff	*21%*	*-15%*	*3%*	*2%*	*1%*	*2%*

F. Entrance Discharge Rates (cfs)

	Original NHC			EC-HD- Revised Model		
Test Date	11/10/04	5/18/05	Average	11/10/04	5/18/05	Average
weir submerg.	8.5	9.5		8.5	9.5	
Measured	1015	973	994	1016.8	973.0	995
Model	1075	912	994	1043.3	932.8	988
% Diff	*6%*	*-6%*	*0%*	*3%*	*-4%*	*-1%*

G. Fishladder Channel Velocities (feet per second)

Measured one strut d/s of Weir 70

	Original NHC			EC-HD- Revised Model		
	Test Date	11/10/04	Average	11/10/04	5/18/05	Average
Proj. Tailrace	75.4	79.6		75.4	79.6	
Measured	1.38	1.18	1.28	1.5	1.2	1.3
Model	0.90	0.70	0.80	1.5	1.2	1.3
% Diff	*-34.78%*	*-40.68%*	*-37.50%*	*2.1%*	*1.7%*	*1.9%*

H. Head Difference between AWS Conduit and Tailrace

AWS HGL (at I-E)- Tailwater (ft)

	Original NHC			EC-HD- Revised Model		
	AWS HGL (at I-E) - Tailwater (ft)					
Test Date	11/10/04	5/18/05	Average	11/10/04	5/18/05	Average
Measured	2.09	1.36	1.72	2.15	1.40	1.78
Model	1.70	1.10	1.40	2.08	1.62	1.85
Diff	*-0.39*	*-0.26*	*-0.32*	*-0.07*	*0.22*	*0.08*

3.1.1 Discussion of Summary Comparison Table with Original Model (See Table 1 above)

There are several problem areas revealed by the comparison between original HELCRABS model output and field data.

- Average Ladder flow was low by 3%.
- Average Entrances heads were high by 3%.
- Difference in AWS head and tailrace 0.32 feet lower.
- Average Channel velocities are 38% lower.

3.2 Comparison of Revised HELCRABS Model Simulations to Measured Data

The model was calibrated from two field measurements taken during 2004 and 2005. The 'high tailwater' test was taken at 79.5 feet on 18MAY2005, and the 'low tailwater' test was taken at tailwater 75.3 on 11NOV2004. The boundary and operational conditions for the measured data taken were input to the revised HELCRABS program. The comparisons of the measured data and the revised simulations are given in the following tables, which compare the differences between the measured data and results from the revised HELCRABS model.

3.2.1 Discussion of Summary Comparison of Revised HELCRABS Model Simulations to Measured Data (See Table 1 above)

The following list shows where the revised HELCRABS model is significantly improved in comparison with field data.

- Average Ladder flow was high by 1%
- Average Entrances heads were high by 2%.
- Average difference in AWS head and tailrace 0.1 feet higher.
- Average Channel velocities are 2% higher.

4.0 Background-Program Modifications:

The HELCRABS program was revised in fundamentally three ways:

(1) Excel macro was develop to correct analytical flaw in **nhcnet** computation of flow through weir valves (ladder diffusers).

(2) The program does not evaluate the turbine operation; however Node 30 is used to set up the turbine outflow hydraulic gradeline (HGL) elevation.

i. Figure 5 is used to estimate Node 30. For example at TW=79 with HD_Picket =1, the Net Turbine Head (NTH) 77.2. At a forebay of 158.5-77.2=81.3which is input for Node 30 in the *.in file.

ii. Start iterations with the Excel macro

iii. Check for Entrance head=1.3. If it is less than 1.3, increase Node 30. If it is more that 1.3, lower Node 30 then rerun.

iv. Once convergence is achieved, determine the turbine discharge from the Turbine Rating curves and compare this to the inflow for the turbine. If the inflow is higher, the turbine cannot produce this amount of flow and the model will not accurately simulate the TW condition.

v. The turbine curves were provided by Mr. Bob Guidinger, WASCO PUD (541-298-3325). They use a 90% wicket gate setting instead of the 100% assumed on the curves along with the information obtained at the turbines during the field testing Nov 10, 2004 and May 18, 2005, the curves were readjusted 17%. (TO DO ADD short paragraph about flow adjustment)

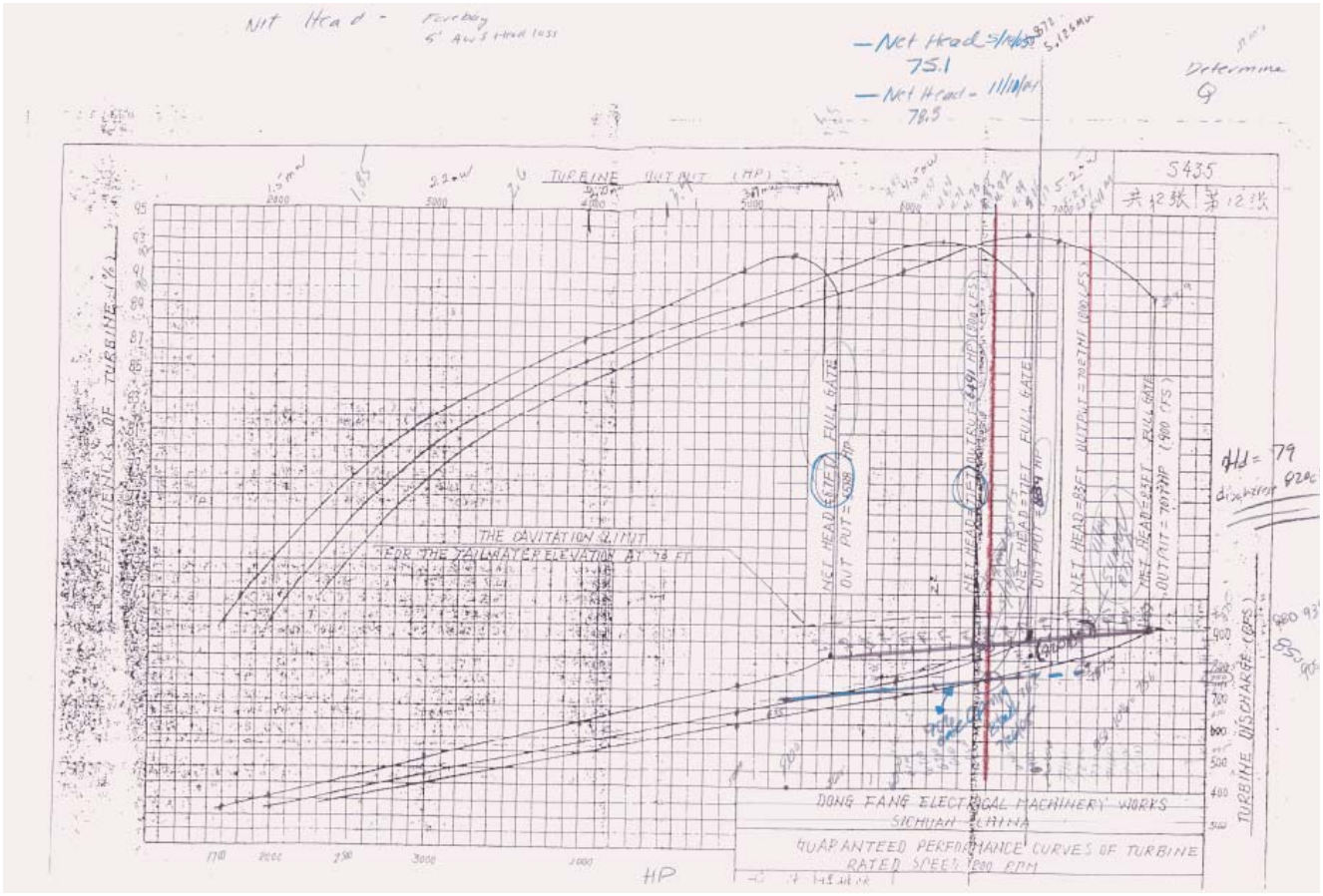


Figure 2- Turbine curve adjustment.

vi. Once the convergence is completed, the turbine flow is calculated by subtracting the Q_{inflow} from the Q_{ladder} flow and this is checked against the Turbine curves. If the flow exceeds the turbine curve, then the Node 30 needs to adjusted down in order to get the Q turbine down. This new head tends to be less than 1.3.

(3) IN and INI geometry files were revised for corrections in geometry and loss coefficients.

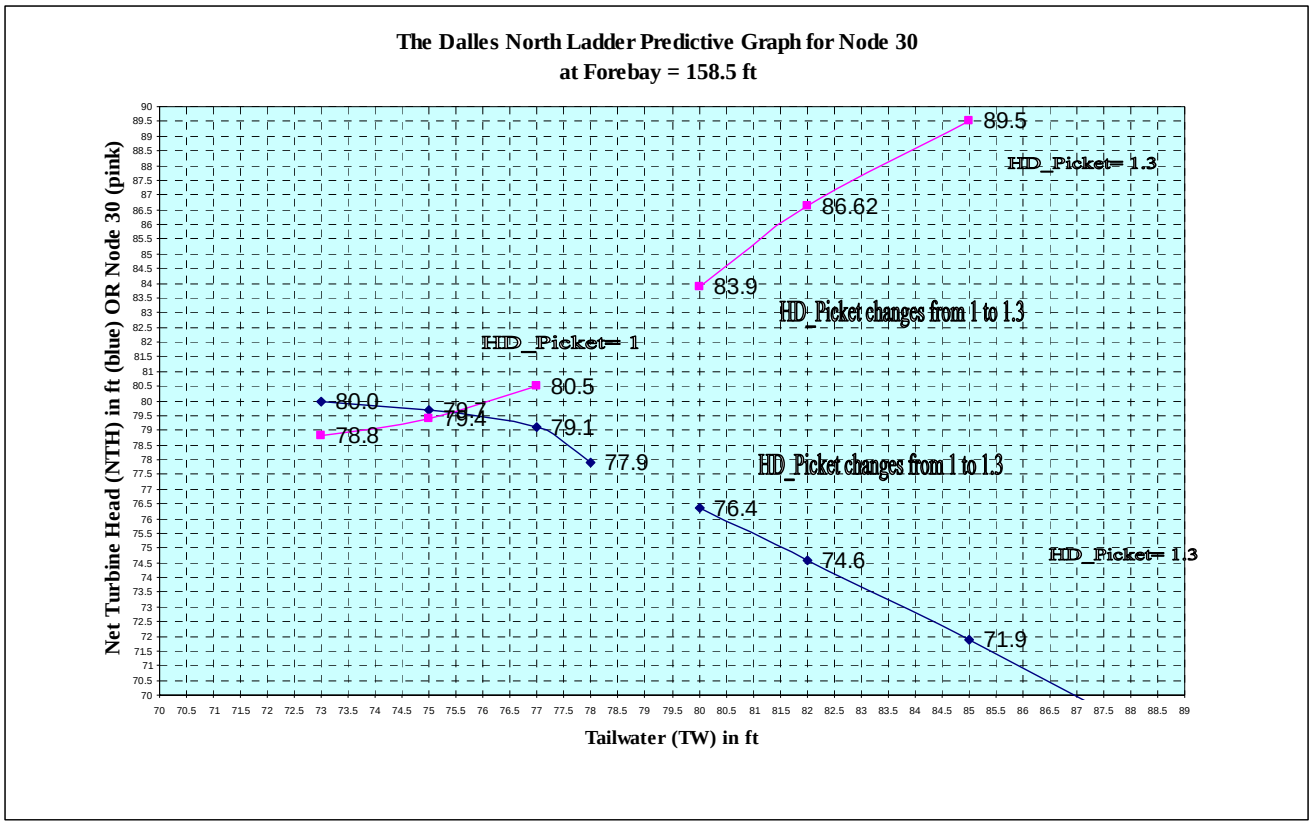


Figure 3- The Dalles North Ladder Graph for Node 30

4.1 Changes to Geometry Files; IN and INI Files.

EC-HD has devoted considerable time to studying the geometry and methodology to simulating the AWS. The changes to the geometry and head loss parameter file in HELCRABS have been cataloged in Table 2. Most of the changes were implemented to either correct geometrical or theoretical errors or deficiencies. However, several loss coefficients (diffuser basin, AWS, channel roughness, and entrance and ladder coefficients—described earlier in the text) were developed through calibration with prototype data. The following tables list the changes made to the IN and INI files.

A special case was made for the diffuser gates. An inspection of the dewatered fishway (See Appendix B (covered in the main report) for the Memorandum for the Record (MFR) dated February 11, 2005 by Paul Williams) revealed that structural ribs for the diffusers gates protrude over 2 inches into the gate portal. This not only reduces the flow area slightly through the gate opening but also creates additional head loss. Normally the coefficient through a square edged gate opening would be 1.5. But the above factors were incorporated and the sum of the areas of the protrusion was deducted from the gate area and the head loss coefficient was raised to 1.7.

- Reasons for IN file changes are indicated in the rightmost column:
    - A—The as-built drawings showed different geometry than indicated by IN file or INI file of original model; correction made to reflect as-built geometry.
    - B—No references were provided for the minor loss coefficients used in NHC's original IN file. The loss coefficients were changed to match the values from the Miller or HDC references, where differences were found.

- C—Link geometry was beyond scope of Miller and HDC references; these loss coefficients were calibrated to match prototype data.

Table 2 – Revised Geometry Changes to the IN file

IN File Location :											Changes to File Geometry
			File Changes								
Link ID	Head Node	Tail Node	Length		Width		Height		Minor Loss		Reason for change
			From	To	From	To	From	To	From	To	
10	10	50	1.5	1.5	4.0	4.0	4.0	3.9	1.0	1.7	B
11	11	10	17.0	15.3	13.1	7.0	7.0	8.0	1.4	1.5	A
12	12	11	1.0	1.0	15.3	15.3	3.0	3.0	3.2	1.5	B
13	13	12	10.3	15.3	16.0	11.5	3.0	3.0	0.6	1.2	A,B
14	14	13	15.0	15.3	14.4	24.0	11.1	1.0	2.6	860.0	A,C
51 South	50	51	33.0	32.0	5.7	5.0	6.0	6.0	0.4	0.3	A
52 South	51	52	33.0	32.0	9.0	9.3	6.0	6.0	0.4	0.1	A
53 South	52	53	33.0	32.0	12.3	12.0	6.0	6.0	0.4	0.1	A
54 South	53	54	33.0	32.0	15.5	16.0	6.0	6.0	0.4	0.0	A
55 South	54	55	33.0	32.0	18.9	18.7	6.0	6.0	0.1	0.4	A
56 South	55	56	33.0	32.0	21.5	21.3	6.3	6.0	0.4	0.0	A
57 South	56	57	0.0	32.0	0.0	22.5	0.0	7.0	0.0	6.3	No node provided
58 South	57	58	33.0	32.0	22.5	22.5	7.9	7.9	0.4	0.0	A
59 South	58	59	33.0	32.0	22.5	22.5	9.0	9.0	0.4	0.0	A
60 South	59	60	33.0	32.0	22.5	22.5	11.8	9.5	0.4	0.1	A
61 (Flow Switches sides here) North	60	61	27.0	28.0	22.5	21.5	12.1	9.6	0.4	0.0	A, B
62 North	61	61	17.0	18.0	20.3	22.5	10.4	10.0	0.4	5.0	A,C
63 North	62	63	15.6	16.0	18.6	17.5	10.6	9.6	0.4	0.1	A, B
64 North	63	64	15.6	16.0	16.5	15.5	10.5	9.6	0.4	0.0	A, B
65 North	64	65	15.6	16.0	14.3	13.5	10.4	9.6	0.4	0.0	A, B
66 North	65	66	20.0	18.0	11.2	10.6	10.3	9.9	0.4	0.1	A, B
67 North	66	67	18.4	20.0	8.2	7.8	10.2	9.6	0.4	0.2	A, B
68 North	67	68	17.5	17.0	6.6	8.0	10.1	10.0	0.4	0.0	A, B
69 North	68	69	6.0	10.0	5.5	8.0	10.0	9.6	0.4	0.1	A, B

Table 2 continued – Revised Geometry Changes to the IN file

Link ID	Head Node	Tail Node	Length		Width		Height		Minor Loss		Reason for change
			From	To	From	To	From	To	From	To	
70 North	69	70	10.0	10.0	4.5	4.0	10.0	9.6	0.4	0.1	A, B
100	100	51	1.5	1.5	4.0	4.0	4.0	3.9	1.0	1.7	B
101	101	100	17.0	15.5	14.5	7.0	5.0	8.0	1.4	1.2	A
102	102	101	1.0	1.0	15.3	15.3	3.0	3.0	3.2	1.5	B
103	103	102	10.3	15.3	16.0	24.0	3.0	1.0	0.6	1.2	A,B
104	104	103	15.0	1.0	14.4	24.0	11.1	15.3	2.6	860.0	A,C
200	200	52	1.5	1.5	4.0	4.0	4.0	3.9	1.0	1.7	B
201	201	200	17.0	15.5	14.5	7.0	5.0	8.0	1.4	1.2	A
202	202	201	1.0	1.0	15.3	15.3	3.0	3.0	3.2	1.5	B
203	203	202	10.3	15.3	16.0	11.5	3.0	3.0	0.6	1.2	A,B
204	204	203	15.0	1.0	14.4	24.0	11.1	15.3	2.6	860.0	A,C
300	300	53	1.5	1.5	4.0	4.0	4.0	3.9	1.0	1.7	B
301	301	300	17.0	15.5	14.5	7.0	5.0	8.5	1.4	1.2	A
302	302	301	1.0	1.0	15.3	15.3	3.0	3.0	3.2	1.5	B
303	303	302	10.3	15.3	16.0	11.5	3.0	3.0	0.6	1.2	A,B
304	304	303	15.0	1.0	14.4	24.0	11.1	15.3	2.6	860.0	A,C
400	400	54	1.5	1.5	4.0	4.0	4.0	3.9	1.0	1.7	B
401	401	400	17.0	15.5	14.5	7.0	5.0	8.0	1.4	1.2	A
402	402	401	1.0	1.0	15.3	15.3	3.0	3.0	3.2	1.5	B
403	403	402	10.3	15.3	16.0	11.5	3.0	3.0	0.6	1.2	A,B
404	404	403	15.0	1.0	14.4	24.0	11.1	15.3	2.6	860.0	A,C
500	500	55	1.5	1.5	4.0	4.0	4.0	3.9	1.0	1.7	B
501	501	500	17.0	15.5	14.5	7.0	5.0	8.0	1.4	1.2	A
502	502	501	1.0	1.0	15.3	15.3	3.0	3.0	3.2	1.5	B
503	503	502	10.3	15.3	16.0	11.5	3.0	3.0	0.6	1.2	A,B
504	504	503	15.0	1.0	14.4	24.0	11.1	15.3	2.6	860.0	A,C
600	600	56	1.5	1.5	4.0	4.0	4.0	3.9	1.0	1.7	B

Table 2 continued – Revised Geometry Changes to the IN file

Link ID	Head Node	Tail Node	Length		Width		Height		Minor Loss		Reason for change
			From	To	From	To	From	To	From	To	
601	601	600	17.0	15.5	14.5	7.0	5.0	8.5	1.4	1.2	A
602	602	601	1.0	1.0	15.3	15.3	3.0	3.0	3.2	1.5	B
603	603	602	10.3	1.0	14.4	24.0	11.1	15.3	2.6	860.0	A,B
604	604	603	15.0	15.3	14.4	24.0	11.1	1.0	2.6	860.0	A,C
700	700	57	1.5	1.5	4.0	4.0	4.0	3.9	1.0	1.7	B
701	701	700	17.0	15.5	14.5	7.0	5.0	8.5	1.4	1.2	A
702	702	701	1.0	1.0	15.3	15.3	3.0	3.0	3.2	1.5	B
703	703	702	10.3	15.3	16.0	11.5	3.0	3.0	0.6	1.2	A,B
704	704	703	15.0	1.0	14.4	24.0	11.1	15.3	2.6	860.0	A,C
800	800	58	1.5	1.5	4.0	4.0	4.0	3.9	2.0	1.7	B
801	801	800	17.0	15.5	14.5	7.0	5.0	8.5	1.4	1.2	A
802	802	801	1.0	1.0	15.3	15.3	3.0	3.0	3.2	1.5	B
803	803	802	10.3	15.3	16.0	11.5	3.0	3.0	0.6	1.2	A,B
804	804	803	15.0	1.0	14.4	24.0	11.1	15.3	2.6	860.0	A,C
900	900	59	1.5	1.5	4.0	4.0	4.0	3.9	1.0	1.7	B
901	901	900	17.0	15.5	14.5	7.0	5.0	8.5	1.4	1.2	A
902	902	901	1.0	1.0	15.3	15.3	3.0	3.0	3.2	1.5	B
903	903	902	10.3	15.3	16.0	11.5	3.0	3.0	0.6	1.2	A,B
904	904	903	15.0	1.0	14.4	24.0	11.1	15.3	2.6	860.0	A,C
1010	1010	60	1.5	1.5	4.0	4.0	4.0	3.9	1.0	1.7	B
1011	1011	1010	17.0	15.5	14.5	7.0	5.0	8.5	1.4	1.2	A
1012	1012	1011	1.0	1.0	15.3	15.3	3.0	3.0	3.2	1.5	B
1013	1013	1012	10.3	15.3	16.0	11.5	3.0	3.0	0.6	1.2	A,B
1014	1014	1013	15.0	1.0	14.4	24.0	11.1	15.3	2.6	860.0	A,C
1100	1100	61	1.5	1.5	4.0	4.0	4.0	4.0	1.0	1.3	B

Table 2 continued – Revised Geometry Changes to the IN file

Link ID	Head Node	Tail Node	Length		Width		Height		Minor Loss		Reason for change
			From	To	From	To	From	To	From	To	
1101	1101	1100	17.0	15.5	14.5	7.0	5.0	8.0	1.4	1.2	A
1102	1102	1101	1.0	1.0	15.3	15.3	3.0	3.0	3.2	1.5	B
1103	1103	1102	10.3	15.3	16.0	11.5	3.0	3.0	0.6	1.2	A,B
1104	1104	1103	15.0	1.0	14.4	24.0	11.1	15.3	2.6	860.0	A,C
1200	1200	62	1.5	1.5	4.0	4.0	4.0	3.9	1.0	1.7	B
1200	62	1200	1.5	1.5	4.0	4.0	2.5	4.0	3.2	3.5	A
1201	1201	1200	11.5	11.0	16.0	16.0	5.0	7.0	1.6	1.5	A
1202	1202	1201	1.0	1.0	15.3	15.3	3.0	3.0	3.2	1.5	B
1203	1203	1202	3.0	5.0	16.0	16.0	3.0	3.0	0.6	3.0	A,B
1204	1204	1203	15.0	1.0	14.4	24.0	11.1	15.3	2.6	860.0	A,C
1300	1300	63	1.5	1.5	4.0	4.0	4.0	3.9	1.0	1.7	B
1301	1301	1300	11.5	13.0	16.0	16.0	5.0	7.0	1.6	1.5	A
1302	1302	1301	1.0	1.0	15.3	15.3	3.0	3.0	3.2	1.5	B
1304	1304	1303	15.0	1.0	14.4	24.0	11.1	15.3	2.6	860.0	A,C
1400	1400	64	1.5	1.5	4.0	4.0	4.0	3.9	1.0	1.7	B
1401	1401	1400	11.5	13.0	16.0	16.0	5.0	7.0	1.6	1.5	A
1402	1402	1401	1.0	1.0	15.3	15.3	3.0	3.0	3.2	1.5	B
1403	1403	1402	3.0	5.0	16.0	16.0	3.0	3.0	0.6	3.0	A,B
1404	1404	1403	15.0	1.0	14.4	24.0	11.1	15.3	2.6	860.0	A,C
1500	1500	65	1.5	1.5	4.0	4.0	4.0	3.9	1.0	1.7	B
1501	1501	1500	11.5	13.0	16.0	16.0	5.0	7.0	1.6	1.5	A
1502	1502	1501	1.0	1.0	15.3	15.3	3.0	3.0	3.2	1.5	B
1503	1503	1502	3.0	5.0	16.0	16.0	3.0	3.0	0.6	3.0	A,B
1504	1504	1503	15.0	1.0	14.4	24.0	11.1	15.3	2.6	860.0	A,C
1600	1600	66	1.5	1.5	4.0	4.0	4.0	4.0	1.0	1.3	B
1601	1601	1600	11.5	13.0	30.0	16.0	5.0	7.0	1.6	1.5	A

Table 2 continued – Revised Geometry Changes to the IN file

Link ID	Head Node	Tail Node	Length		Width		Height		Minor Loss		Reason for change
			From	To	From	To	From	To	From	To	
1602	1602	1601	1.0	1.0	15.3	15.3	3.0	3.0	3.2	1.5	B
1603	1603	1602	3.0	5.0	30.0	16.0	3.0	3.0	0.6	3.0	A,B
1604	1604	1603	15.0	1.0	14.4	24.0	11.1	15.3	2.6	860.0	A,C
1700	1700	67	1.5	1.5	4.0	4.0	4.0	4.0	1.0	1.3	B
1701	1701	1700	11.5	13.0	30.0	16.0	5.0	7.0	1.6	1.5	A
1702	1702	1701	1.0	1.0	15.3	15.3	3.0	3.0	3.2	1.5	B
1703	1703	1702	3.0	5.0	30.0	16.0	3.0	3.0	0.6	3.0	A,B
1704	1704	1704	15.0	1.0	14.4	24.0	11.1	15.3	2.6	860.0	A,C
1800	1800	68	1.5	1.5	4.0	4.0	4.0	4.0	1.0	1.3	B
1801	1800	1801	11.5	11.5	8.0	8.0	4.0	4.0	1.6	1.5	B
1802	1802	1801	1.0	1.0	15.3	15.3	3.0	3.0	3.2	1.5	B
1803	1803	1802	3.0	3.0	8.0	8.0	3.0	3.0	0.6	3.0	B
1804	1804	1804	20.3	1.0	7.2	36.0	16.5	8.0	2.6	860.0	A,C
1900	1900	69	1.5	1.5	4.0	4.0	4.0	1.9	1.0	1.3	B, 1/2 closed
1901	1900	1901	11.5	11.5	8.0	8.0	7.0	7.0	1.6	1.5	B
1902	1902	1901	1.0	1.0	15.3	15.3	3.0	3.0	3.2	1.5	B
1903	1903	1902	3.0	3.0	8.0	8.0	3.0	3.0	0.6	3.0	
1904	1904	1904	21.0	1.0	7.2	36.0	15.3	8.0	2.6	860.0	A,C
2000	2000	70	1.5	1.5	4.0	4.0	4.0	4.0	1.0	1.3	B
2001	2001	2002	11.5	11.5	12.0	12.0	7.0	7.0	1.6	1.5	B
2002	2002	2001	1.0	1.0	15.3	15.3	3.0	3.0	3.2	1.5	B
2003	2003	2002	3.0	3.0	12.0	12.0	3.0	3.0	0.6	3.0	B
2004	2004	2003	21.0	1.0	7.2	24.0	11.7	8.0	2.6	860.0	A,C

[VALVES]							
;	Head	Tail	Weir	Loss			
;	ID	Node	Node	Width	Type	Normal Setting	Reduce Weir Valve by 12" Setting
	12	11	12	16	WV	94	93
	102	101	102	16	WV	92	91
	202	201	202	16	WV	90	89
	302	301	302	16	WV	88	87
	;402	401	402	16	WV	86	85
	;502	501	502	16	WV	84	83
	;602	601	602	16	WV	82	81
	;702	701	702	16	WV	80	79
	;802	801	802	16	WV	78	77
	;902	901	902	16	WV	76	75
	;1012	1011	1012	16	WV	74	73
	;1102	1101	1102	16	WV	72	71

Table 2a- Weir Valve changes

Table 3- Revised Dalles.ini input file

		Change to File			
Variable	Variable name in function	From	To	Take out weir 70-73	Purpose of Change
CC_INVERT		60	63.5		Check As-built
CC_WIDTH		35	24		Check As-built
CC_WIDTH		28, 175	24, 175	24.0, 227.0	Check As-built
MANNINGS		0 0.02	175, 0 0.013	227.0, 0.013	Change to calibrate model
MANNINGS		0.02	0.013		Change to calibrate model
TOTAL_WIDTH		35	24		Check As-built
OPEN_AREA		4.5	5.35		Change to calibrate model
WEIR_COEFFICIENT		4.87	4.2		Change to calibrate model
ORIFICE_COEFFICIENT		0.76	0.8		Change to calibrate model
ENTRANCE1	cont.coef, width	0.0, 15.00	0.33 15.00		Change to calibrate model
ENTRANCE2	cont.coef, width	0.0, 15.00	0.20 15.00		Change to calibrate model
ENTRANCE3	cont.coef, width	0.0, 15.00	0.0 15.00		Change to calibrate model
ENTRANCE1	chnnl invert, H1/P barrier	60.0 2.5	60.0 2.2		Change to calibrate model
ENTRANCE2	chnnl invert, H1/P barrier	60.0 2.5	60.0 3.0		Change to calibrate model
ENTRANCE3	chnnl invert, H1/P barrier	60.0 2.5	60.0 2.5		Change to calibrate model
ENTRANCE1	c1(low), c2(low)	0.611 0.08	0.65 0.34		Change to calibrate model
ENTRANCE2	c1(low), c2(low)	0.611 0.08	0.65 0.2		Change to calibrate model
ENTRANCE3	c1(low), c2(low)	0.611 0.08	0.611 0.08		Change to calibrate model
ENTRANCE1	c1(hi), c2(hi)	0.6 0.5275	1.387 0		Change to calibrate model
ENTRANCE2	c1(hi), c2(hi)	0.6 0.5275	1.25 0		Change to calibrate model
ENTRANCE3	c1(hi), c2(hi)	0.6 0.5275	0.6 0.528		Change to calibrate model
ENTRANCE1	n(exp), v(exp)	1.5 0.385	1.5 0.385		Change to calibrate model
ENTRANCE2	n(exp), v(exp)	1.5 0.385	1.5 0.385		Change to calibrate model
ENTRANCE3	n(exp), v(exp)	1.5 0.385	1.5 0.385		Change to calibrate model
ENTRANCE1	target submergence, xxx	8.0 0.	8.0 0.		Change to calibrate model
ENTRANCE2	target submergence, xxx	8.0 0.	8.0 0.		Change to calibrate model
ENTRANCE3	target submergence, xxx	8.0 0.	8.0 0.		Change to calibrate model
ENTRANCE1	min/max elevation of wier	62.0 107.0	62.0 107.0		Change to calibrate model
ENTRANCE2	min/max elevation of wier	62.0 107.0	62.0 107.0		Change to calibrate model
ENTRANCE3	min/max elevation of wier	62.0 107.0	62.0 107.0		Change to calibrate model
TW_HI		85	92		Change to run model at 88
DATA= 75		75	75	75	
DATA= 74		74	74	74	
DATA= 73		73	73		Weir taken out
DATA= 72		72	72		Weir taken out
DATA= 71		71	71		Weir taken out
DATA= 70		70	70		Weir taken out
DATA=2		904 -74 0.0	904 -74 0.0	904 -74 242.0	To run model properly
DATA=1		1014 -72 0.0	1014 -72 0.0	1014 1 242.0	To run model properly
DATA=999		1104 -70 183.0	1104 -70 183.0	1104 1 183.0	To run model properly

Model and Excel Macro Limitations-

1) The macro is very helpful in iterating to a solution. Sometime, however, the iteration gets stuck at the "PIPE" (For example, the 1st iteration- **3.03**, 2nd iteration- **-2.57**, 3rd iteration is back to- **3.03**.) The convergence (no highlighted red numbers) needs to be achieved in order to get realistic discharges and head calculations.

2) The node is very sensitive to Node 30 and little to no information is provided about obtaining this value in the *The Dalles Dam Computer Model and Hydraulic Evaluation of the North Fishway Facility Adult Bypass System* by NHC. Determining this value is done by Trial and Error in that a value is picked, the model is then run until convergence is achieved, then the Channel Head reading is checked. If this value is 1.3, you guessed wisely and are done. If it is too low, then Node 30 must be raised. If it is too high, Node 30 must be lowered. This iteration process can be very time consuming and gets very tricky at TW of 80 or above when the HD_picket is change from 1 to 1.3. Figure 3 is provided to help in this endeavor.

3) There are 2 error messages that occur during the running of the model Code 300 and warnings occurred then references Fish.TX2. Neither of these messages could be found in the error information about the open channel model development or the EPANET version 1.1e user manual making it difficult to know how to proceed.

Recommendations for improvement-

This model is not very user friendly. In order to make it more so the following is recommended:

1) Provide training on the use of the macro and how it iterates within the excel file to the MSDOS prompt.
2) Provide a cover page in the Excel Macro that discusses how to run the model:
    1. Change the *.inp file to reflect current settings
    2. Change *.in file predict Node 30 in the hidden files of the Excel macro file
    3. Change the settings on the main sheet
    4. Save file
    5. Press Create New *.in
    6. Say Yes when prompted on the first iteration
    7. Bring up a MSDOS prompt and type in Fishway *input file name same file name as out*
       C:> Fishway rev17may rev17may
    8. Iterate
    9. Go back to Excel file and press Open *in and *inp
    10. Always say Yes when prompted.
    11. If there are red number that appear, press Create New *.in
    12. This time say NO
    13. Once red is gone, go back to the MSDOS prompt and iterate.
    14. Continue this until there is no more red that appears in the Excel Macro file
    15. See results in name.txt (looks like writing on it)
    16. Readjust Node 30 as needed to get to the Channel Head required. (discussed above)
    17. Note- Changing diffuser gate settings can be accomplished below [PIPE] in the *.in file (within the Excel Macro file or while you are running the MSDOS prompt (before iterating open the gate setting and toggle to open or closed for each gate). For anything other than full closure, the height must be adjusted accordingly.

3) Provided plot(s) that define Node 30 guesses for typical scenarios that Fishery Biologists would be running so that they can get to convergence and the proper channel head quickly.

4) Provide instructions as to what to do when the convergence appears to be going in a circle.

5. Observations and Discussion:

5.1 Initial Findings

The Initial Findings from the November Testing are documented below by Mr. Williams in the following MFR after the testing completed in November of 2004.

MEMORANDUM FOR FILES **15-Feb-2005**

FROM: Paul Williams, CENWP-EC-HD

SUBJECT: Computational problems with NHC computer model.

Contraction in Channel Width

NHC computer model is incorrectly calculating the water surface elevation upstream of the entrances weir. The main fishway channel is 24 feet wide upstream of the fishway entrance, as the flows exit the fishway entrance the channel section is reduced to 15 feet wide. The reduction in channel width has an associated head loss do to the gradual contraction from 24 feet to 15 feet. NHC has calculated an energy gain through the contraction instead of an energy loss. The head loss through a contraction when the edges are rounded is $H_l = 0.1 * \frac{V_2^2}{2 * g}$, in which V_2 is the velocity at a section in the narrower part, where the flow has almost become uniform. Based on the equation above the water surface elevation upstream of the contraction is 76.95 feet (tailwater 75.35 feet), NHC water surface elevation is 76.69 feet, for the same tailwater. The differences is only 3 inches, but this error is carried through the back water computation and also incorrect interpolation of the entrance weir head.(see attached calculation)

Entrances discharge

NHC computer model has a very small error in calculating the entrances weir discharge. NHC computed model entrances weir discharge is 1097 cfs for tail water 75.35 feet. The theoretical hand calculated entrance weir discharge is 1112 CFS for the same tailwater.(see attached calculation)

Fish Ladder discharge

NHC computer model calculation portion of the unsubmerged fish ladder weir report different values. For example at weir 93, NHC report a weir discharge of 53.57 cfs and an orifice discharge of 27.45 cfs then at weir 79 NHC reports a weir discharge of 55.06 cfs and a orifice discharge of 25.96 cfs. The discrepancies may seem very small but both ladder are unsubmerged weir and should use the same weir discharge equations, the discharge should be the same for both weir. Table below list the values from the NHC report and hand computation of the submerged portion of the ladder. The percent differences in the table are for NHC ladder Q compared to hand computation of ladder Q.
NHC computer model calculation portion for the submerged weir is using the same discharge coefficient for all portions of the fish ladder weir. The fish ladder is constructed into two parts an overflow section and a non-overflow section. The overflow and non-overflow section have difference shape and the discharge coefficient in general are based on the shape of the weir, so each section should have a different discharge coefficient.

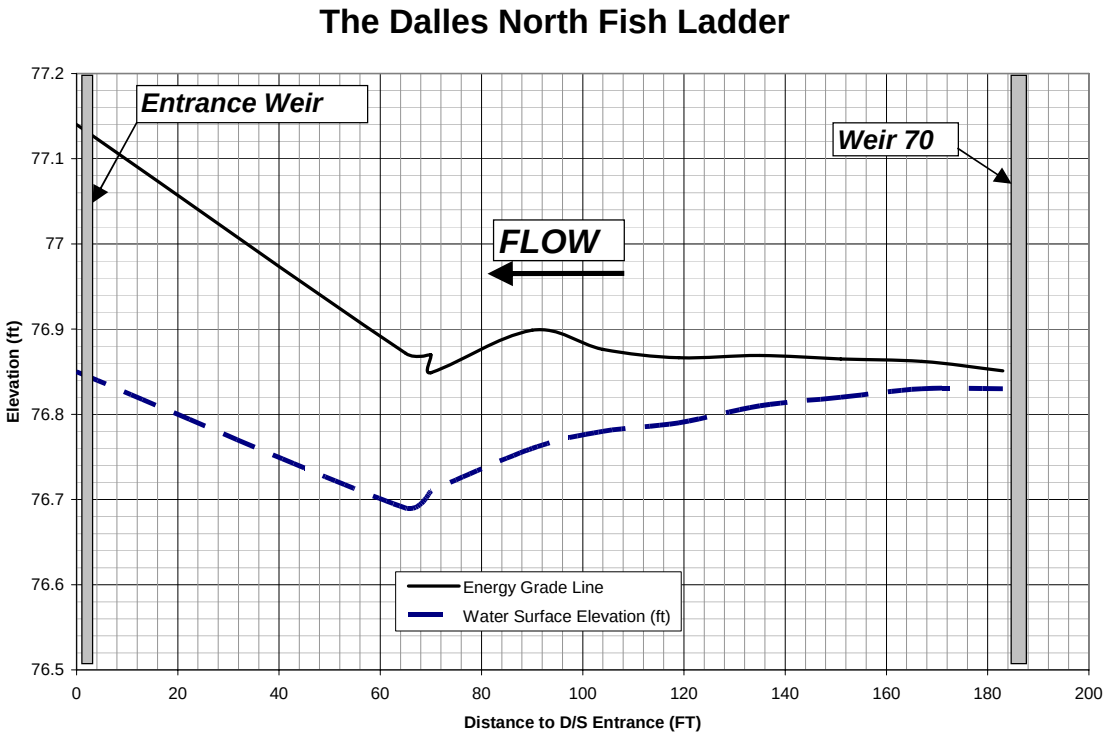
Weir No.	NHC Computer Model			Hand Compution			Percent
	Ladder Q (cfs)	Weir Q (cfs)	Orifice Q (cfs)	Ladder Q (cfs)	Weir Q (cfs)	Orifice Q (cfs)	Differences
70	370.57	362.97	7.6	376.66	368.9	7.76	-1.64
71	280.99	274.19	6.8	280.75	271.65	9.1	0.09
72	280.99	271.98	90.1	283.22	274.12	9.1	-0.79
73	198.03	189.84	8.19	198.94	190.71	8.23	-0.46
74	198.03	185.73	12.29	197.85	185.58	12.27	0.09
75	125	113.06	11.94	125.24	113.28	11.96	-0.19
76	125	105.58	19.42	124.08	104.67	19.41	0.74

The table below list the NHC reported water surface elevation and the field data collected during the same tailwater and fish ladder settings. The values are very close except for weir 76. The field data shows that the head differences are significantly increasing between weir 76 and 77, where as NHC occurs at between weir 75 and 76.

Weir No.	NHC Water Surface Elevation	Field Data Collection
70	76.91	77.1
71	76.97	77.1
72	77.08	77.3
74	77.37	77.5
75	77.56	77.6
76	78.06	77.8
77	78.45	78.4
78	79.14	79.2
79	80.03	80.2
80	81.01	81.2
81	82	82.2

Back Water Profile and Energy Grade Line

NHC computer model is incorrectly calculating the water surface profile along fishway channel between stations 65+00 to 183+00. NHC water surface profile differences from stations 65+00 to 183+00 is 1.68 inches. Hand calculation back water computation differential from stations 65 to 183 is 0.42 inches, which is very conservative because in the hand calculation it assumes all of the flow initiates at station 183, instead of the addition flow being added along the channel. The water surface elevation were collected in the fishway channel during the field testing, the data collected between station 80 to 183 indicated on changes in water surface profile. Illustration below is a plot of the NHC energy grade line and water surface profile along the fishway channel. The NHC energy grade line is up and down along the channel, theoretical it should be gradual sloping down from station 183+00.



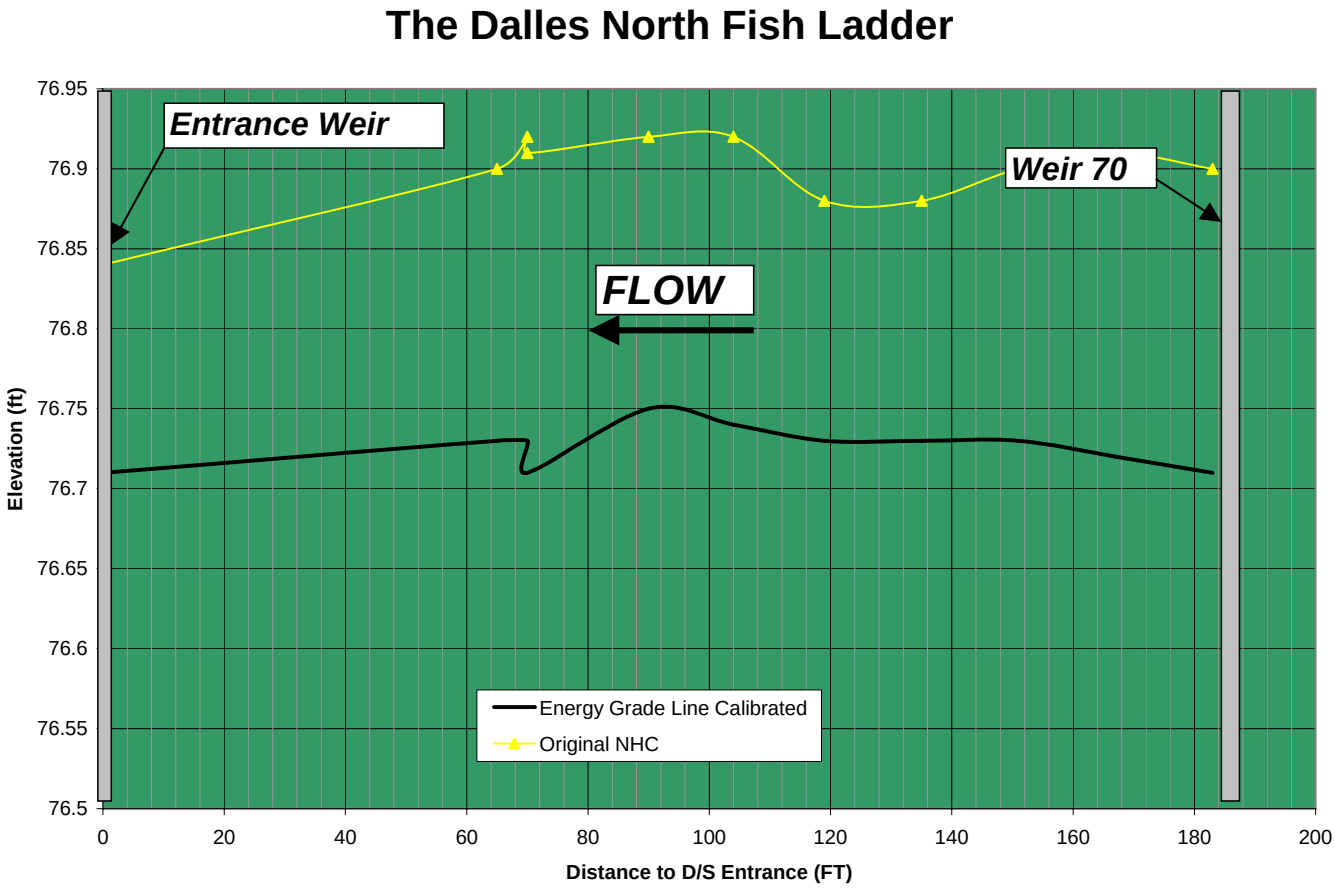


Figure 6-EGL-Updated 7/14/2004 NHC Original (Yellow) and EC-HD Calibrated Model (black)

Weir Valve pipe calculation

The NHC computer model is incorrectly using the depth from downstream water surface weir to crest. The waters surface elevation at any single diffuser is based on the summation of initial ladder flow, additional flow added by the diffusers upstream of that diffuser and the flow contributed by that diffuser. The NHC model is only using the water surface elevation contributed by that diffuser.

Weir No	Weir Valve Elevation (ft)	Final Water Surface Profile (Ft)	EPA Output Grade (ft)	Node No.
70	72	76.78	76.61	1204
72	74	76.96	76.44	1014
74	76	77.28	76.63	904
76	80	78.01	77.02	804

Update-8/4/2005						
Node No.	**Weir No**	**Weir Valve**	**Final Water Surface Profile-PW Model-11/10/04**	**EPA Grade-11/10/04 run of NHC model**	**Calibrated model-11/10/04**	**Difference from the Calibrated model**
1204	70	72	76.78	76.61	76.6	-0.18
1014	72	74	76.96	76.44	76.69	-0.27
904	74	76	77.28	76.63	77.07	-0.21
804	76	80	78.01	77.02	77.84	-0.17

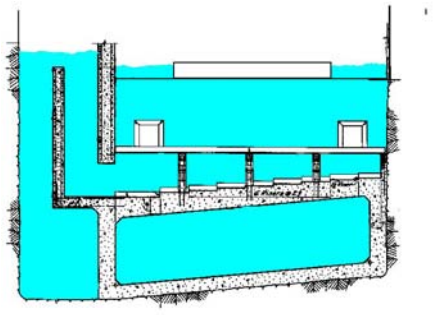


Figure 7- Schematic of ladder with flow

5.2 Findings after May 2005 testing

Once the model was calibrated by both data sets, several operations were evaluated in order to determine check the criteria for the fish ladder and the following Tables 4 provide a summary of the results

Table 4-Operational Scenarios Evaluation

The Dalles North Fishway Existing Operation Table in Accordance with Fish Passage Plan and PLC operation								
Tailwater	**73**	**75**	**77**	**78**	**80**	**82**	**85**	**88**
Percent exceedence (Mar 1 - Nov 30)	99%	95%	65%	45%	25%	12%	5%	1%
SETTINGS:								
Inflow: Fishurbines and ladder								
WASCO PUD Fish Turbine Output								
Net Turbine Head[1] (ft)	81.5	79.7	78.6	78.0	76.4	74.6	71.9	69.0
Power (Megawatts)	5.5	5.4	5.3	5.2	5.1	4.9	4.6	4.4
Weir 152 Ladder Head (ft)	1.0	1.0	1.0	1.0	1.3	1.3	1.3	1.3
Outflow: (weir elevations, ft)								
Entrance Bay-1 (E-1)	64.5	66.5	68.5	69.5	71.5	73.5	76.5	79.5
Entrance Bay-2 (E-2)	closed	closed	closed	closed	closed	closed	closed	closed
Side Entrance (E-3)	closed permanently							
DISCHARGE:								
Inflow: (cfs)								
WASCO PUD inflow	**937**	**936**	**835**	**814**	**741**	**699**	**661**	**635**
(HD Picker) Weir 152 Ladder Flow	75	75	75	75	94	94	94	94
Total System Inflow	**1012**	**1011**	**910**	**889**	**836**	**793**	**755**	**729**
WASCO PUD Turbine from turbine curves	946	936	931	928	919	907	890	871
(HD Picker) Weir 152 Ladder Flow	75	75	75	75	94	94	94	94
Total System Inflow (cfs)	1021	1012	1006	1003	1013	1001	984	965
Outflow: (cfs)								
Entrance Bay-1 (E-1)	1013	1011	909	890	836	794	754	728
Entrance Bay-2 (E-2)	0	85	0	0	0	0	0	0
Total System Discharge (cfs)	1013	1096	909	890	836	794	754	728
WATER LEVEL, HGL, AND PRESSURE DATA								
Tailrace (ft)	73.0	75.0	77.0	78.0	80.0	82.0	85.0	88.0
Entrance Aproach Channel Water Level (ft)	73.9	76.3	78.3	79.3	81.3	83.3	86.3	89.3
HGL AWS (near ladder diffuser L-8) (ft)	76.9	78.7	79.8	80.5	82.1	83.8	86.6	89.3
Δ AWS (psi)	1.3	1.1	0.7	0.5	0.3	0.2	0.1	0.0
No. of submerged ladder weirs (DH < 0.5 ft)	4	7	10	10	11	13	16	19
PASSAGE CRITERIA:								
Entrance Head (E.H.) (ft)	0.9	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Required Entrance Weir Submergence (ft)	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Channel Velocities near Base of Ladder (ft/s)	1.5	1.4	1.2	1.2	1.1	1.0	0.8	0.8
Channel Velocities at Bend to Entrances (ft/s)	4.2	3.4	2.6	2.4	2.0	1.7	1.4	1.2
Max Ladder Diffuser Velocities (ft/s)	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.1
Max Lower Channel Diffuser Velocities (ft/s)	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.1

NOTES:
1. Median Forebay 158.5 is assumed in all runs. The Net Head = FB - AWS HGL
2. Fish Criteria Violations highlighted in Yellow as follows:
   The shade of yellow shade indicates signficance or degree of violation:

	Cha Vel.	Diff Vel.
	> 4 ft/s	0.5 - 1.0 ft/s
	< 1.5 ft/s	> 1.0 ft/s

3. The turbine flow capacity was exceeded at TW=73 so the turbine was adjusted to account for to maximum turbine- 1161 (E. H.=1.3) down to 1029.7 (E.H.=1.1)

The Dalles North Fishway
Comparison of Minor Structural Alternatives with Existing Operation

Tailwater Elevation	Tailwater 73			Tailwater 78			Tailwater 88		
Structural Alternative:	Existing	Option 1- Take out weir 70-73	Option 2=Reduce WV by 12"	Existing	Option 1- Take out weir 70-73	Option 2=Reduce WV by 12"	Existing	Option 1- Take out weir 70-73	Option 2=Reduce WV by 12"
SETTINGS:							See note 3.		
Inflow: Fishurbines and ladder									
WASCO PUD Fish Turbine Output									
Net Turbine Head[1] (ft)	81.5	81.6	81.5	78.0	77.9	78.0	69.0	69.0	69.0
Power (Megawatts)	5.5	5.5	5.5	5.3	5.3	5.3	4.4	4.4	4.4
Weir 152 Ladder Head (ft)	1.0	1.0	1.0	1.0	1.0	1.0	1.3	1.3	1.3
Outflow: (weir elevations, ft)									
Entrance Bay-1 (E-1)	64.5	64.5	64.5	69.5	69.5	69.5	79.5	79.5	79.5
Entrance Bay-2 (E-2)	closed	closed	closed	closed	closed	closed	closed	closed	closed
Side Entrance (E-3)	closed permanently								
DISCHARGE:									
Inflow: (cfs)									
WASCO PUD inflow	**937**	**938**	**938**	**814**	**834**	**818**	**635**	**624**	**644**
Weir 152 Ladder Flow	75	75	75	75	75	75	94	94	93
Total System Inflow	**1012**	**1013**	**1013**	**889**	**909**	**893**	**729**	**718**	**737**
WASCO PUD Turbine from turbine curves	946	947	946	928	927	928	871	871	871
Weir 152 Ladder Flow	75	75	75	75	75	75	94	94	94
Total System Inflow (cfs)	1021	1022	1021	1003	1002	1003	965	965	965
Outflow: (cfs)									
Entrance Bay-1 (E-1)	1013	1013	1013	890	910	893	728	719	738
Entrance Bay-2 (E-2)	0	0	0	0	0	0	0	0	0
Total System Discharge (cfs)	1013	1013	1013	890	910	893	728	719	738
WATER LEVEL, HGL, AND PRESSURE DATA									
Tailrace (ft)	73.0			78.0			88.0		
Entrance Aproach Channel Water Level (ft)	73.9	73.9	73.9	79.3	79.4	79.3	89.3	89.3	89.3
HGL AWS (near ladder diffuser L-8) (ft)	76.9	76.8	76.8	80.5	80.5	80.5	89.3	89.2	89.3
Δ AWS (psi)	1.3	1.2	1.3	0.5	0.5	0.5	0.0	0.0	0.0
No. of submerged ladder weirs (DH < 0.5 ft)	4	0	5	10	6	10	19	15	20
PASSAGE CRITERIA:									
Entrance Head (E.H.) (ft)	0.9	0.9	0.9	1.3	1.4	1.3	1.3	1.3	1.3
Required Entrance Weir Submergence (ft)	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Channel Velocities near Base of Ladder (ft/s)	1.5	1.5	1.6	1.2	1.2	1.2	0.8	0.7	0.8
Channel Velocities at Bend to Entrances (ft/s)	4.2	4.2	4.2	2.4	2.4	2.4	1.2	1.2	1.2
Max Ladder Diffuser Velocities (ft/s)	0.4	0.4	0.3	0.2	0.2	0.2	0.1	0.1	0.1
Max Lower Channel Diffuser Velocities (ft/s)	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1

NOTES:

1. Option 1: Remove Ladder Weirs 70, 71, 72, and 73
2. Option 2: Lower Ladder Diffusers weir elvations by 1 foot
3. Convergence is difficult to achieve

STANDARD NOTES:

A. Median Forebay 158.5 is assumed in all runs. The Net Head = FB - AWS HGL

B. Fish Criteria Violations highlighted in Yellow as follows:
The shade of yellow shade indicates signficance or degree of violation:

	Cha Vel.	Diff Vel.
	> 4 ft/s	0.5 - 1.0 ft/s
	< 1.5 ft/s	> 1.0 ft/s

C. The turbine flow capacity was exceeded at TW=73 so the turbine was adjusted to account for to maximum turbine- 1161 (E. H.=1.3) down to 1029.7 (E.H.=1.1)

Table 5- Minor Structural Changes

6. Conclusions:

In summary and upon review of the fisheries criteria, all parameters but two are met; however, they are the most important related to fish and may be causing fish to delay or reverse direction at the entrance of the ladder. They are:

1) Head across entrances should be 1-2 feet, 1.5 feet optimum and
2) Channel Velocities should be 1.5- 4 feet per second, 2 ft/sec optimum.

Field operational testing reveals low velocities at the base of the fish ladder, which are below the 1.5 ft/s criteria except when the tailwater is at elevation 73 feet. This problem is largely independent of the operation, which can be seen in the Recommended Operations (see Table below) and would require structural modifications to the ladder and ladder diffuser systems to correct it.

Recommended Operations for Diffuser Gates (DG)

	Link	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1010	900	800	700	600	500	400	300	200	100	10	Fish Criteria 1.3	Fish Criteria=Over 1.5, 2 ft/sec optimum	Fish Criteria=Over 1.5, 2 ft/sec optimum	Comment
		DG 1-A	DG 1-B	DG 1-C	DG 1-D	DG 1-E	DG 1-F	DG 1-G	DG 1-H	DG 1-I	DG 1-J	DG N-1	DG N-2	DG N-3	DG N-4	DG N-5	DG N-6	DG N-7	DG N-8	DG N-9	DG N-10	DG N-11	Entrance Head in (ft)	Velocity 800 to 900 (ft/sec)	Velocity 200 to 100 (ft/sec)	
TW=73	Existing Operation-Recommended	Closed	1/2 Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.9	4.9	However the Turbine capcity is exceeded
TW=73	Existing Operation-Recommended	Closed	1/2 Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	0.9	1.5	4.2	At turbine capacity
TW=73	Recommended	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.4	1.9	4.8	However the Turbine capcity is exceeded
TW=73	Recommended	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	0.9	1.4	3.9	At turbine capacity
TW=73	Recommended	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.9	5.0	However the Turbine capcity is exceeded
TW=73	Recommended	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	0.9	1.5	4.1	At turbine capacity
TW=73		Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.2	1.9	4.8	Turbine capcity exceeded
TW=73		Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	0.9	1.5	4.1	At turbine capacity
TW=75	Existing Operation	Closed	1/2 Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.5	3.4	However the Turbine capcity is exceeded
TW=75	Existing Operation	Closed	1/2 Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.2	1.4	3.1	At turbine capacity
TW=75		Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.4	1.4	3.3	Turbine capcity exceeded
TW=75		Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.2	1.2	3.1	At turbine capacity
TW=75		Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.5	3.4	Turbine capcity exceeded
TW=75		Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.4	3.4	At turbine capacity
TW=75		Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.2	1.5	3.3	
TW=75		Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.2	1.6	3.3	At Turbine capcity, Node 30= 79.1 for a net head of 79.4
TW=75		Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.7	3.4	Turbine capcity exceeded, Node 30= 79.3 for a net head of 79.2
TW=75		Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.7	3.4	Turbine capcity exceeded, Node 30= 79.3 for a net head of 79.2
TW=75		Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.7	3.3	At turbine capacity, Node 30=79.4 for a Net head of 79.1
TW=75		Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.7	3.4	Turbine capcity exceeded
	Link	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1010	900	800	700	600	500	400	300	200	100	10				
TW=77	Existing Operation	Closed	1/2 Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.2	2.6	Node 30=79.9 for a net head of 78.6
TW=77		Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.2	2.5	
TW=77		Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.2	2.6	
TW=77		Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.2	1.2	2.5	
TW=77		Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.3	2.6	Node 30=80.1 for a net head of 78.4
TW=77		Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.4	2.7	Node 30=80.3 for a net head of 78.2
TW=77		Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.4	2.6	Node 30=80.4 for a net head of 78.1
TW=77		Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.5	2.6	Node 30=80.75 for a net head of 77.75
	Link	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1010	900	800	700	600	500	400	300	200	100	10				
TW=78	Existing Operation	Closed	1/2 Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.2	2.4	
TW=78		Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.4	1.2	2.3	Node 30=80.6 for a net head of 77.9
TW=78		Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.2	2.4	
TW=78		Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.2	2.3	
TW=78		Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.2	1.2	2.2	
TW=78		Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.3	2.3	Node 30=80.8 for a net head of 77.7
TW=78		Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.3	2.3	Node 30=81.00 for a net head of 77.5
TW=78		Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.4	2.3	Node 30=81.25 for a net head of 77.25
TW=78		Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.5	2.4	Node 30=81.25 for a net head of 77.25
	Link	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1010	900	800	700	600	500	400	300	200	100	10				
TW=80	Existing Operation	Closed	1/2 Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.1	2.0	
TW=80		Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.4	1.1	1.9	
TW=80		Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.1	2.0	Node 30=82,15 for a net head of 76.35
TW=80		Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.1	1.9	
TW=80		Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.2	1.1	1.8	
TW=80		Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.1	1.1	1.8	
TW=80		Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.0	1.1	1.8	
TW=80		Closed	Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.3	2.0	Node 30=82.60 for a net head of 75.9
TW=80		Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.3	2.0	Node 30=82,90 for a net head of 75.6
TW=80		Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.4	1.5	2.0	Node 30= 83.5 for a net head of 75
TW=80		Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.7	2.0	Node 30= 84.25 for a net head of 74.25
	Link	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1010	900	800	700	600	500	400	300	200	100	10				
TW=82	Existing Operation	Closed	1/2 Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.0	1.7	
TW=82		Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.0	1.6	
TW=82		Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.0	1.7	
TW=82		Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	1.0	1.6	
TW=82		Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.2	1.0	1.6	
TW=82		Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.1	1.0	1.6	
TW=82		Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.5	1.3	1.8	Node 30= 84.6 for a net head of 73.9
TW=82		Closed	Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.4	1.3	1.8	
TW=82		Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.1	1.2	1.5	Model bombs past Node 30= 84.4, NTH= 74.1
TW=82		Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.0	1.2	1.4	
	Link	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1010	900	800	700	600	500	400	300	200	100	10				
TW=85	Existing Operation	Closed	1/2 Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	0.8	1.4	
TW=85		Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	won't converge			
TW=85		Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	0.8	1.4	
TW=85		Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.2	0.9	1.3	
TW=85		Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	0.9	1.4	
		Several close options in here not evaluated																								
TW=85		Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	0.9	1.0	1.2	Model bombs past this Node 30
	Link	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1010	900	800	700	600	500	400	300	200	100	10				
TW=88	Existing Operation	Closed	1/2 Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	0.8	1.2	
TW=88		Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.3	0.8	1.2	
		Several close options in here not evaluated																								
TW=88		Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open	1.4	1.1	1.2	
TW=88								Closed															0.11	0.41	0.41	

Table of Recommended Operations with Diffuser Gates

6.1 Preliminary Structural Recommendations

Since the only time the ladder meets fishery criteria is at a very low tailwater of elevation 73, structural modifications would be needed to the ladder and ladder diffuser systems. The following structural modifications were evaluated at Low (TW=73), Medium (TW=78) and High (TW=88) and the following are recommendation provided for consideration. (See Tables 5 and 6)

Table 6- Summary of Major Structural Changes

The Dalles North Fishway									
Comparison of Major Structural Alternatives with Existing Operation									
Tailwater Elevation	**Tailwater 73**			**Tailwater 78**			**Tailwater 88**		
Structural Alternative:	Existing*	Option 3	Option 4	Existing	Option 3	Option 4	Existing	Option 3	Option 4
SETTINGS:									
Inflow: Fishurbines and ladder									
WASCO PUD Turbine Output									
Net Turbine Head[1] (ft)	81	73	67	78	73	70	69	68	67
Power (Megawatts) per Unit	5.5	4.7	4.2	5.2	4.7	4.5	4.4	4.3	4.2
Number of Units	1	2	1	1	2	1	1	2	1
Total Power (Megawatts)	5.5	9.4	4.2	5.2	9.5	4.5	4.4	8.5	4.2
Weir 152 Ladder Head (ft)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Outflow: (weir elevations, ft)									
Entrance Bay-1 (N-1)	64.5	64.5	64.5	69.5	69.5	69.5	79.5	79.5	79.5
Entrance Bay-2 (N-2)	closed	69.0	68.0	closed	70.0	70.0	closed	78.0	78.0
Side Entrance (E-3)	closed permanently								
DISCHARGE RATES:									
Inflow: (cfs)									
WASCO PUD inflow									
Existing Unit	937	895	859	928	897	859	871	863	860
New Unit	0	**895**	0	0	**897**	0	0	**863**	0
PLUNGE POOL SLIDE GATES (2)									
Percent Opening	closed	closed	45%	closed	closed	45%	closed	closed	45%
Gates Discharge	0	0	920	0	0	920	0	0	920
(HD Picker) Weir 152 Ladder Flow	75	75	75	75	75	75	75	75	75
Total System Inflow	**1012**	**1865**	**1854**	**1003**	**1869**	**1854**	**946**	**1802**	**1855**
Outflow: (cfs)									
Entrance Bay-1 (N-1)	1013	1317	1239	890	889	893	728	721	712
Entrance Bay-2 (N-2)	0	492	596	0	967	971	0	1063	1050
Total System Discharge (cfs)	1013	1810	1835	890	1856	1864	728	1785	1763
WATER LEVEL, HGL, AND PRESSURE DATA									
Tailrace (ft)	73.0			78.0			88.0		
Entrance Aproach Channel Water Level (ft)	73.9	74.5	74.4	79.3	79.4	79.4	89.3	89.3	89.3
HGL AWS (Node 30) (ft)	77	86	91	81	85	88	90	91	91
PASSAGE CRITERIA:									
Entrance Head (E.H.) (ft)	0.9	1.5	1.4	1.3	1.3	1.4	1.3	1.3	1.3
N-2 Entrance Weir Submergence (ft)	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
N-1 Entrance Weir Submergence (ft)	0	4.0	5.0	0	8.0	8.0	0	10.0	10.0
Channel Velocities at Bend to Entrances (ft/s)	4.2	6.8	7.0	2.4	4.9	4.9	1.2	2.9	2.8

NOTES:

1. Option 3: 2 Turbines; New Unit Equivalent to Existing Unit
2. Option 4: Operate Both Plunge Pool Slide Gates

STANDARD NOTES:

A. Median Forebay 158.5 is assumed in all runs. The Net Head = FB - AWS HGL

- **Option 1-Take out weirs 70-73-** Since the weir from 70-73 are not needed due to the minimum tailwater being elevation 73, more flow could be added to the system which increases the velocities to help meet fishery criteria.
  Pros- Meets fishery criteria
  Cons- The construction cost to taking them out

- **Option 2-Reduce the crest elevations of the ladder diffuser weir valves to increase flow from the ladder diffusers into the ladder section-** Only 12" of the weir valves (stove pipe weir) could be removed to assure that the flow did not come back through the system. This reduction is effective in meeting the fish criteria by increasing the velocity up to tailwater elevation 73.
  Pros- Meets fishery criteria
  Cons- The construction cost incurred to cut each weir valve down

- **Option 3-Provide a side gate to feed the Attraction Water Supply System (AWS) Channel bringing more water in from the forebay-** In the original ladder, this channel exists but was no longer utilized once the turbine was installed in 1989.
  Pros-The second channel already exists and could provide more flow to the system and help attain fishery criteria.
  Con- The current turbine operation could be affected in ways that would have to be carefully analyzed.

- **Option 4-Add another turbine to increase flow-** The installation of another turbine would most likely be housed next to the current turbine.
  Pros- This would provide more flow to meet fishery criteria
  Cons- Is there space available to add another turbine? The costs of a new turbine and the installation.

With the current configuration, The Dalles North Fishway meets entrance criteria at the full range of tailrace levels; however, the fish criteria related to velocity and channel head are not met. More flow is needed which will require structural modifications to the ladder which range from cutting off of the weir valves to adding another turbine.

Natalie Richards, PE

REVIEW PROCESS:
PDT- review
HD- Steve Schlenker, PhD, Kyle McCune and Randy Lee

References

1. Army Corps of Engineers, Fisheries Handbook of Handbook of Engineering Requirements and Biological Criteria, 1991
2. Brater, E. F., King, H. W., *Handbook of Hydraulics,* 1976.
3. Chow, V. T., *Open Channel Hydraulics,* (1959)
4. Corps of Engineers, Waterways Experiment Station, *Hydraulic Design Criteria.* Revised 1954
5. Corps of Engineers, *Hydraulic Design of Reservoir Outlet works, EM 1110-2-1602,* 1980.
6. Corps of Engineers, Northwest Division. *Fish Passage Plan*. 1992 and 2004, Corps of Engineers Projects, March 1992.
7. Henderson, F.M., *Open Channel Flow,* (1966)
8. Miller, D.S., *Internal Flow Systems,* (1978)
9. Northwest Hydraulics Consultants Inc. The Dalles Dam, *Computer Model and Hydraulic Evaluation of the North Fishway Facility Adult Bypass System.* Prepared for Corps of Engineers, Portland District. December 1998.
10. Rossman, Lewis, Hydraulic and Water Quality Simulator for Water Distribution Networks EPANET, US Environmental protection Agency, RREL.
11. Army Corps of Engineers, As-built drawings of The Dalles Dam North fishway facility.
12. Handbook of Hydraulics, Seventh Edition, King and Brater, et al, McGraw-Hill, 1963
13. Army Corps of Engineers, "Hydraulic Data fir Adult Bypass Fishways, The Dalles Dam-December 1995," Summit Technology Inc.
14. Engineering Hydraulics, Rouse, 1995

Appendix A- Geometric Validation

Figure 8- WASCO Turbine Performance Curve
Figure 9- Ladder Section from DDF-1-4-2/17
Figure 9a- Identification Number (ID) Clarification from DDF-1-4-2/17
Figure 10- Plan View of ladder from DDF-1-4-2/17- (Diffuser Area documented at 15.33 X 24=367.92 ft^2) See Table 2 Entrance 1 Data 11 thru 99
Figure 11- Length measurement for links 51-57 from DDF-1-4-2/11
Figure 12 Link measurements for ID numbers 58, 59, 60, 61, 62 from DDF-1-4-2/10
Figure 12a- Link Measurements for Width and Height, Links 59, 60, 61 from DDF-1-4-2/18
Figure 13- Plan and Sections view measurements of Links 61-67 from DDF-1-4-2/8
Figure 13a- Width and link measurements for Links 61-66 from DDF-1-4-2/9
Figure 14- Measurements for Links 68, 69, 70 from DDF-1-4-2/7
Figure 14a- Cross Section 1804 and 1904 from DDF-1-4-2/6
Figure 14b- Height used for Velocity Calculation "G"

Appendix B (covered in the main report)- Field Testing MFR's dated 11 Nov 2004 and 18 May 2005 and Trip Report dated February 11, 2005

Appendix C- Loss Coefficients

Figure 15- Minor Loss and 180 degree bend- Links 11, 12, 13
Figure 16- Sudden Expansion and Contraction for AWS Figure 12- PW
Figure 17- Expansion Estimate Loss Curve for AWS Figure 12- (PW)
Figure 18- Contraction Estimate Loss Curve for AWS Figure 12- (PW)
Figure 19- Auxiliary Water Supply (AWS) Loss Estimates- (PW)- Links 51, 52, 53, 54, 55, 56, 58, 59, 50, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70
Figure 20- Gate Loss Estimates- (PW) - Don't know where this was used
Figure 21- Loss Coefficient Estimate for Link 10 from IFS- NR
Figure 22- Loss Coefficient Estimate for Links 50, 11 and 13 from IFS- NR
Figure 23- Loss Estimate for 180 degree bend for Link 12 from IFS pg 152- NR
Figure 24- Loss Coefficient Estimate References for Link 12- 180 degree bend at Weir Valve from Chow, pg 381- NR
Figure 25- Loss Coefficient for Link 14 and possibly Link 10 from IFS pg 263

APPENDIX B: TRIP REPORTS AND MEMORANDUMS

MEMORANDUM FOR RECORD

FROM: Paul Williams

SUBJECT: Report on data collection on the Dalles Dam North Fish Ladder

DATE: 10 NOV 2004

Attendees: Schlenker, Steve EC-HD
Higa, Nathan, EC-HD
Williams, Paul, EC-HD
Bryon, Mason, EC-HD

Trip Objectives:

1. Collect prototype data to be used in calibrating the Dalles Dam North Fish Ladder (TDAFL) HELCRABS numerical model. This prototype data was collected in a manner that provided information for steady state flow conditions at a low tailwater condition (Tailwater 76.0 feet). A similar test will be conducted in MAY 2005 for the high tailwater condition (tailwater above 78.0 feet).

Project Conditions:
Forebay: 157.9 feet ±0.2 feet
Tailrace: 75.3 feet ±0.2 feet
Total PUD Turbine Generation: __ MW average total.
Ladder head: 1.0 foot
Fishway Operation: Normal.

Data Collection:

The members of the data collection team arrived at the project and organized at the TDAFL at approximately 0800. Data was collected at five locations in the ladder: the fish ladder exit, the counting station, fish ladder channel, AWS Intake and fish ladder entrance. Figure 1 shows the areas where data was taken. The data collection took place under fixed forebay and tailrace conditions that had been coordinated with the Reservoir Control Center (RCC) prior to the trip. The window for the fixed tailrace was 9:00 AM to 12:00 AM. In addition to the data recorded for the active components of the Fishway facility, Wasco County personnel provided that static components. These included the turbine data, entrance gate settings, and diffuser gate settings. All velocities were measured using price meters. Weights of various amounts, and sometimes ropes, were used to maintain the position of the meters in high velocity conditions. All water

level and head measurements were taken from a sounding tape, or e-tape, form know reference locations. Wasco County PUD also provided both data and assistance.

Ladder Flow

The total flow in the ladder section was measured at the exit section. A portion of the water enters an auxiliary water supply conduit that was added inside the existing channel and along the south fish ladder wall. This conduit continues downstream just past weir 152. The fish ladder channel in this area is reduced from its original 24-foot width to a 20-foot inside width. The flow in the AWS channel supplement the fish counting station. Velocity measurements were taken inside the AWS channel. The total ladder flow was 81 cfs, which includes 35 cfs in the ladder AWS channel.

The head over the ladder weirs was read as 1.0 ft from a staff gage downstream of the counting station (head on weir 151). Head differential was also measured between the pools of the exit section; the head drops ranged between 0.8 feet at pool 157 and 0.6 feet at pool 156. The average was 0.7 feet.

Lower Ladder Auxiliary Water System

Water supplied to the Fishway facility originates from two sources: the fishladder exit on the upstream face of the dam and the turbine that is connected to conduits and diffusers referred to as the Auxiliary Water Supply (AWS) that feeds the lower portion of the Fishway. The turbine was added to the facility in 1989 and is operated by Wasco Country P.U.D. Prior to the addition of the turbine, water was supply through a gravity feed system, which is currently used as a backup water supply system when the turbine is out of operation. The backup water supply system (gravity feed system) was not in operation during the data collection visits.

The intake pool supplies water to the turbine. The intake pool extend downstream of the exiting spillway, flow from the pool enter the penstock and then into the powerhouse. The intake pool has the capability to retain 45 feet of water depending on the forebay elevation. Inside the supply pool is a vertical fish screen, which prevents the entrance of downstream migrant fingerlings into the turbine unit. The vertical screen is oriented so that it effectively narrows the channel width in the downstream direction. The dewatering screen is designed to remove the entire turbine flow (800-900 cfs) from the intake channel and leave 10 cfs in channel for fish bypass. Velocity measurements were take down stream of the existing tainter gate and prior to the intake pool, thus capturing the total flow into turbine unit minus 10 cfs used for fingerling transport.

The forebay averaged 157.84 ft during our testing period. The tailrace according to Wasco data averaged 75.35 ft. Direct measurement during testing averaged 75.27 ft for the north tailrace.

Entrances

Dalles north fish ladder has three entrances label E-1, E-2 and E-3. The entrances weirs E-2 and E-3 were closed during the test period, the project is planning to close E-3 gate (side weir) permanently; therefore only two entrance gates are available. Velocity measurements were taken directly downstream of E-1 entrance weir. The total measured flow through E-1 entrance was 1147 cfs, which is questionable because the maximum turbine discharge is 900 cfs and the maximum ladder discharge is 120 cfs thus the combine flow of 1020 cfs.

Due to unstable fast flow at the location of the velocity measurement, it was hard to maintain the velocity measuring devise (price meter) in one place. The meter tends to move around, which in turn distorts the reading on the high side. Also, the proximity to the 180-degree bend created an imbalance of flow favoring the north side of the entrance channel. The location of the meter was influenced by this flow imbalance, resulting in disproportionate representation of the north side of the channel where the velocities are higher. For these reasons, the sum of the inflows is believed to be more representative of the total system flow than the entrance flow measurement.

Velocities

Additional velocity measurements were taken in fish collection channel. The measurements were taken 16 feet downstream of weir 70.

Summary

The measurement for the AWS intake is within 4% of the rated curve for the PUD. The difference between system outflow (entrance) and sum of inflows (PUD + ladder flow) is 125 cfs, or 12%. The normal goal is to attain continuity of 5%. Greater credence is given to the system inflow total than the system outflow since the flow conditions were more optimal (uniform flow fields with little fluctuation) for measuring at the inflow measuring sites.

A summary table of the data is shown below. Figure 1 shows a system schematic with measuring locations on the next page. The detailed data sheets for all of the flow and head measurements are attached in the Appendix following Figure 1.

Summary Table with Overall Continuity of Tests:

The Dalles North Fishway Measurements Summary, Nov 10, 2004						
Location	**Average Velocity ft/sec**	**Flow cfs**	**Water Surface Elev. (ft)**	**Head Difference (ft)**	**Weir Submerg-ence (ft)**	**Tailwater Level (ft)**
INFLOWS						
Fish Ladder Exit Section (channel)	1.33	81	158.2	1.00		
AWS Intake	3.62	944	158.1			
Makeup Water Channel	1.08	35	157.9	5.80		
Wasco County PUD (AWS intake Q)		*944*		73.6	**ave MW =**	
Total Inflow (fish Units + Ladder flow)		1025				
CHANNELS						
Ladder Channel below weir 70	1.39	450	77.0			
ENTRANCES				entr		
NE-1 Entrance	4.76	1150	76.6	1.32	8.50	75.3
NE-2 Entrance						
Total System Discharge (entrances)		1150				

	diff	% diff
Differences: Inflow - meas Outflow =	-125	-12.2%

Difference AWS Discharge

Measured AWS flow	944	cfs
JBS (nominal)	10	cfs
Measured Turbine (AWS-JBS)	934	cfs
Rated Turbine flow at same time	900	cfs
diff	34	cfs
% diff	3.6%	

FB (WASCO)	Average	157.89 ft	min	157.70 ft	max	157.96 ft
TW (Measured) 9:00 am to 11:00 am	Average	75.27 ft	min	75.10 ft	max	75.44 ft
TW (WASCO) 9:00 am to 11:00 am	Average	75.35 ft	min	75.21 ft	max	75.47 ft
Entrances Head (WASCO) 9:00 am to 11:00 am	Average	1.18 ft	min	1.13 ft	max	1.21 ft

Flow Measuring Locations (See Red Circles in Figure 1)

1. Entrance E-1
2. Lower ladder channel (below weir 70)
3. AWS intake (for lower ladder and PUB turbines)
4. Total exit section
5. Ladder make-up water channel (AWS)

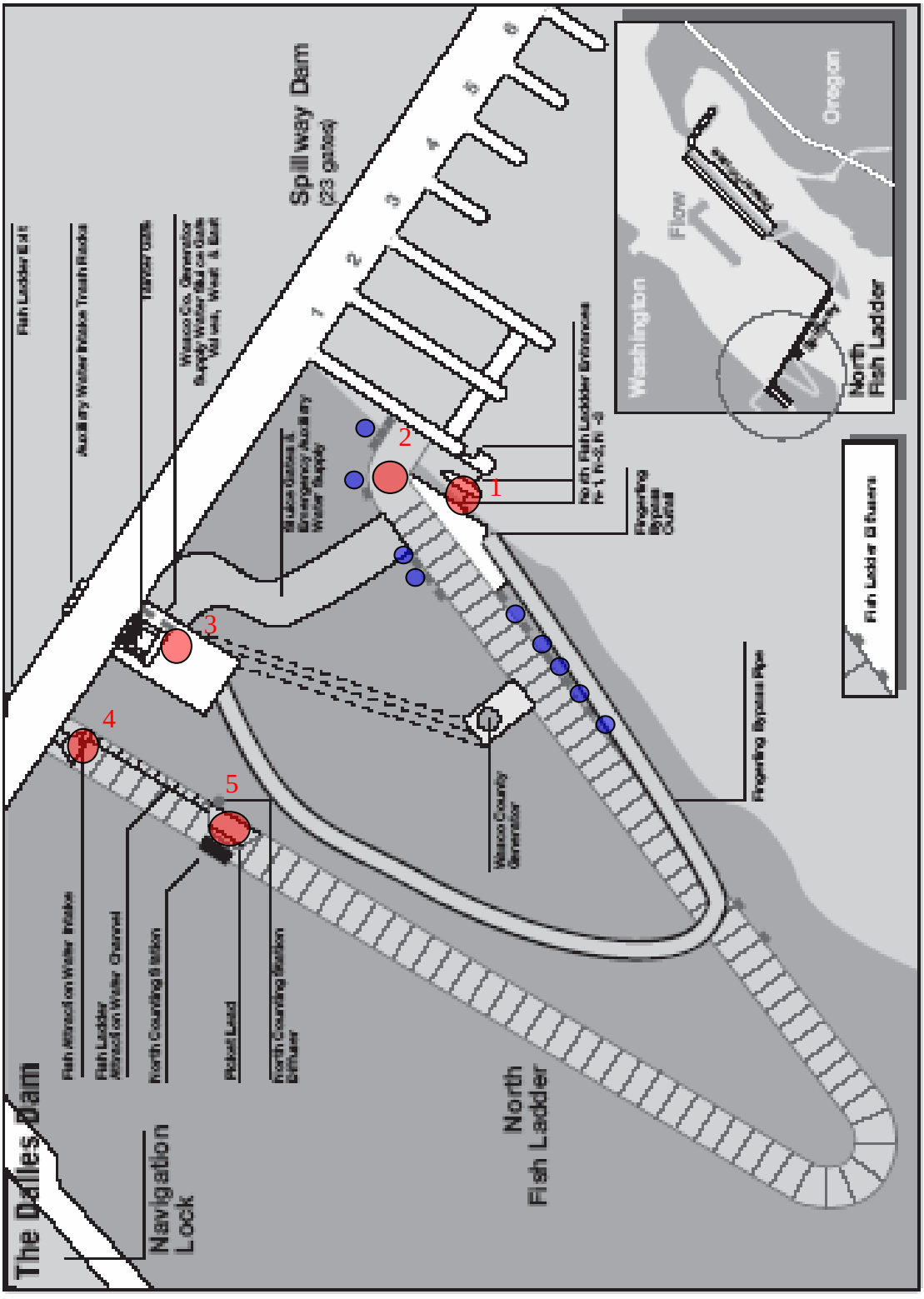


Figure 1- Project Schematic with Measurement Locations (Red dots are velocity and head measurements, blue are head measurements)

APPENDIX

DALLES NORTH FISHWAY VELOCITY DATA

EXIT CHANNEL (Total Flow) **Data Collectors:** S.A | R.M | S.S

Inside of Tunnel Through Dam, 4 ft Upstream (East) from D/s Opening, and wall flare

Upstream of Makeup Water Intake Screen, and upstream of invert step @ d/s end of tunnel

		start	end
Date:	10-Nov-04 **Time:**	12:00	12:45
Forebay Level =		158.60	158.40

Head on Weir 151 = start 1.00, end 1.00

INSTRUMENT

Price Meter X

Price Meter Rotations per Count = 1.00

V = 0.0178 + 2.2048 * (rotations/time)

POINT VELOCITY AND FLOW MEASUREMENTS:

	start	end	
Z_{15} = Meas. Dist. to WS =			ft (from 161 level)
WS = Water Surface Elev. =	**158.20**	**158.10**	ft (= 161 - Z_{15})
Y = Meas. Channel Depth =	10.20	10.10	ft (=WS - 148)

B = Channel Width = **6.00** ft

Deck Elves = **161.0** ft

Walkway deck Elves *168.0* ft

Zi = INVERT = **148.0**

X1 = Side Edge width incr = **2** ft — **1.0** ft — Div by

Y1 = Vertical edge height incr = **2** ft — 4.0 — 8

3.0 — 6

Horiz. No.:	Formula for depth below surface (pm)	Depth from Surface (ft)	Vert. Sect. No. :	1	2	3	Average Velocity		
			Est Dist. from Left Edge (ft)	1.00	3.00	5.00			
			Actual	1.00	3.00	5.0			
1	0.5 * Y1	**1.00**	Counts	37	26	23			
			duration	60	45	45			
			VELOCITY	1.38	1.29	1.14	1.27	ft/s	2.12
2	Y1 + (Y-2*Y1)/6	**3.00**	Counts	39	29	29			
			duration	60	45	45			
			VELOCITY	1.45	1.44	1.44	1.44	ft/s	
3	Y/2	**5.10**	Counts	30	26	25			
			duration	45	45	45			
			VELOCITY	1.49	1.29	1.24	1.34	ft/s	
4	Y1 + 5* (Y-2*Y1)/6	**7.20**	Counts	29	27	27			
			duration	45	45	45			
			VELOCITY	1.44	1.34	1.34	1.38	ft/s	
5	Y - 0.5*Y1	**9.20**	Counts	28	27	27			
			duration	45	45	45			
			VELOCITY	1.39	1.34	1.34	1.36	ft/s	

Total Average Integrated Velocity = **1.33** ft/s

Total Computed FLOW RATE = **81** cfs (= B * Y * V)

DALLES NORTH FISHWAY VELOCITY DATA

MAKEUP WATER CHANNEL

Data Collectors: P.W. | B.M

Anywhere Midway Between Intake Screen and Sluice Gate

		start	end
Date:	10-Nov-04	12:00	12:30
Forebay Level =			
		158.6	158.4

	start	end	
Head on Weir 151 =	1.00	1.00	ft
Sluice Gate Opening	10.00		ft
Dist to D/s Water Level	9.9		ft
D/s Water Level	152.10		ft

INSTRUMENT ref. 162

Price Meter X

Price Meter Rotations per Count = 1.00

V = 0.0178 + 2.2048 * (rotations/time)

POINT VELOCITY AND FLOW MEASUREMENTS:

	start	end			
Z_{15} = Meas. Dist. to WS =	10.10		ft (from 168 level)	**B = Channel Width =**	**3.00** ft
WS = Water Surface Elev. =	**157.90**		ft (= 168 - Z_{15})	**Wall Top Elev =**	**168.0** ft
Y = Meas. Channel Depth =	10.90		ft (=WS - 147)	**Zi = INVERT =**	**147.0**

X1 = Side Edge width incr = **1** ft — **0.5** ft — Div by

Y1 = Vertical edge height incr = **2** ft — 4.0 — 8

3.0 — 6

Horiz. No.:	Formula for depth below surface (pm)	Depth from Surface (ft)	Vert. Sect. No. :	1	2	3	Average Velocity
			Est Dist. from Left Edge (ft)	0.50	1.50	2.50	
			Actual		1.50		
1	0.5 * Y1	1.00	Counts		17		
			duration		40.1		
			VELOCITY		0.95		0.95 ft/s
2	Y1 + (Y-2*Y1)/6	3.10	Counts		23		
			duration		41		
			VELOCITY		1.25		1.25 ft/s
3	Y/2	5.50	Counts		21		
			duration		41.8		
			VELOCITY		1.13		1.13 ft/s
4	Y1 + 5* (Y-2*Y1)/6	7.80	Counts		21		
			duration		41.6		
			VELOCITY		1.13		1.13 ft/s
5	Y - 0.5*Y1	9.90	Counts		19		
			duration		41.6		
			VELOCITY		1.02		1.02 ft/s

Total Average Integrated Velocity = **1.08** ft/s

Total Computed FLOW RATE = **35** cfs (= B * Y * V)

THE DALLES NORTH FISHWAY VELOCITY DATA

Counting Station **Data Collectors:** P.W. B.M S.S

Date: 10-Nov **Time:** start 11:15 end 13:20

Forebay Level = start end

Head on Weir 151 u/s of counting slot = start end

Head on Weir 151 d/s of counting slot = 1.00 1.00

INSTRUMENT **Price Meter** X

Propeller Meter X

Price meter rotation per count= 1.00

V = 0.0178 + 2.2048 * (rotations/time)

measure fron d/s side of bridge on u/s end of count slot

check ft

Bs = counting slot Width = **3.25** ft

POINT VELOCITY AND FLOW MEASUREMENTS:

Z_{15} = Meas. Distance to WS = ft (from 157.37 level)

WS = Water Surface Elev. = ft (= 157.37- Z_{15})

Y = Meas. Channel Depth = 5.00 158.1

B3 18.13 b4 15.13

B2 = Channel Width = **21.38** ft

upper Deck Elves = **157.37** ft

lower deck *156.45* ft

Zi = INVERT = **147.0** ft

Zi = 147- (15.13 -dist from left side)/16

Aprrox internal dimension = **4.6** ft Div by

X1 = Side Edge width incr = **3** ft Number of Internal X Increments = 4.0 8

Y1 = Vertical edge height incr = **2** ft Number of Internal Y Increments = 3.0 6

Horiz. No.:	Formula for depth below surface (pm)	Depth from Surface (ft)	Vert. Sect. No. :	1	2	3	4	5	Average Velocity (Counting Slot)
			Est Dist. from Left Edge (ft)	1.0	3.0	5.0	16.1	Count Slot	
			Actual Dist (ft) from Ft side	37.0	26.0	23.0		middle	
1	0.5 * Y1	**1.00**	Counts	*prop meter*		*prop meter*	*prop meter*	56	
			duration					40.6	
			VELOCITY	*0.33*		*0.88*	*0.82*	3.06	3.06 ft/s
2	Y1 + (Y-2*Y1)/4	**2.50**	Counts					57	
			duration					40.5	
			VELOCITY					3.12	3.12 ft/s
3	Y1 + 3(Y-2*Y1)/4	**3.50**	Counts					50	
			duration					40.5	
			VELOCITY					3.20	3.20 ft/s

Total Average Integrated Velocity = **3.06** ft/s

Total Computed FLOW RATE = **50** cfs (= B * Y * V)

The DALLES NORTH FISHWAY VELOCITY DATA

AWS INTAKE
Just Downstream of Tainter Gate (Fully Open)

		Start	End				
Date:	11/10/2004	**Time:**	11:40	12:30	**Data Collectors:**	N.H	B.M	S.A
								initially

E-Tape Measurements

	Distance to Water		Ref Location	Ref EL	WATER LEVEL ELEV:		Staff Gage		
	start	end			start	end		start	end
Forebay Level			FB Road Deck	**185.06**			**Forebay**		
			Top of wall	**188.56**					
				Ref EL				start	end
AWS Channel			AWS deck	**165.00**			**AWS Channel**		

INSTRUMENT **Price Meter** X Price Meter Rotations per Count = 1

POINT VELOCITY AND FLOW MEASUREMENTS IN CHANNEL:

	start	end			CHECK
Z15 =Distance to Water Surface =	6.95		ft (from 165 deck)	**B = Channel Width =**	**20.0** ft	*24?*
WS = Water Surface Elevation =	158.05		ft (= 165 - Z_{15})	**Deck ELEV. =**	**165.0** ft	
Y = Measured Channel Depth =	13.05		ft (=WS - 145)	**Zi = INVERT =**	**145.0** ft	
Edge Effort Weighting Factor =	0.5					

		Aprrox internal dimension =	3.5 ft	Div	
X1 = Side Edge width inc=	3	Number of Internal X Increments =		4.0	8
Y1 = Vertical edge height incr =	2	Number of Internal Y Increments =		4.0	8

Horiz. No.:	Formula for Distance from surface	Depth from Surface (ft)	Vert. Sect. No:	1	2	3	4	5	6	Ave. Integr. Vel.
			Distance From Left	1.5	4.8	8.3	11.8	15.3	18.5	
			Actual	1.5	4.8	8.3	11.8	15.3	18.5	
1	0.5 * Y1	1.00	Counts	65	66	63	64	66	65	
			duration	40.1	40.4	40.2	40.1	40.2	40.1	
			VELOCITY	3.59	3.62	3.47	3.54	3.64	3.59	3.59 ft/s
2	Y1 + (Y-2*Y1)/6	3.50	Counts	50	67	58	62	67	61	
			duration	40.7	40.4	40.3	40.1	40	40.3	
			VELOCITY	2.73	3.67	3.19	3.43	3.71	3.36	3.54 ft/s
3	Y/2	6.50	Counts	38	69	62	65	70	62	
			duration	41.1	40.3	40.1	40.3	40	40.4	
			VELOCITY	2.06	3.79	3.43	3.57	3.88	3.40	3.40 ft/s
4	Y1 + 5* (Y-2*Y1)/6	9.50	Counts	69	71	68	69	72	70	
			duration	40.3	40.1	40.1	40.3	40.5	40.2	
			VELOCITY	3.79	3.92	3.76	3.79	3.94	3.86	3.86 ft/s
5	Y - 0.5*Y1	12.30	Counts	59	64	71	67	67	67	
			duration	40.1	40.1	40.2	40.4	40	40	
			VELOCITY	3.26	3.54	3.91	3.67	3.71	3.71	3.71 ft/s

Total Average Integrated Velocity = **3.62** ft/s

Total Computed AWS FLOW RATE = **944** cfs (= B * Y * V)

The DALLES NORTH FISHWAY VELOCITY DATA

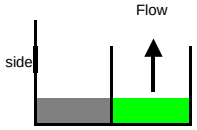
ENTRANCE CHANNEL MEASUREMENTS

Measurements from D/s Side of Bridge between piers (rope required)

Data Collectors: S.A. | N.H. | S.J.S.

Date: 11/10/2004 **Time:** Start 9:30 End 11:00

North →



	Stillwell Dials start	end	ave
Tailrace	75.10	75.44	75.27
	start	end	
Approach Cha	76.42	76.75	76.59

Weir Gates Data

Weir Crest Elevations	NE-3	NE-2	NE-1	
			66.66	start
			66.81	end

E-Tape Measurements

	Distance to Water: start	end	Ref EL	WATER LEVEL ELEV: start	end
Tailrace Level:	35.70		110.75	75.05	
			Ref EL		
U/s stllwll Loc:	34.05		110.75	76.70	

INSTRUMENT
Price Meter X

Price Meter Rotations per Count = 5
Price Meter Rotations per Count = 1

	strat	end
Measured Distance to Curb to Weir beam	31.9	31.75
Distance from top of beam to weir crest	12.1875	12.1875
Weir Elevation	66.66	66.81

POINT VELOCITY AND FLOW MEASUREMENTS IN ENTRANCE:

	start	end	
Z15 =Distance to Water Surface =	34.85	34.40	
WS = Water Surface Elevation =	75.90	76.35	ft (From U/s Gage)
Y = Measured AWS Channel Depth =	15.90	16.35	ft (=WS - 60)
Edge Effort Weighting Factor =	0.5		

B = Channel Width = 15.0 ft per cha.
BRIDGE Curb ELEV. = 110.75 ft
Zi = INVERT = 60.0 ft

X1 = Side Edge width inc= 4
Y1 = Vertical edge height incr = 2

Aprrox internal dimension = 3.0 Div
Number of Internal X Increments = 4.0 8 2.8
Number of Internal Y Increments = 4.0 8

Horiz. No.:	Formula for Distance from surface	Depth from Surface (ft)	Ver Sec	1	2	3	4	5	Average Integrated Velocity
			Distance From Left	2.0	4.8	7.5	10.3	13.0	
			Actual (ft)	2.0	4.8	7.5	10.3	13.0	
1	0.5*Y1	1.00	Counts	104	21	24	23	20	
			duration	40	41.7	41.1	41.6	40.2	
			VELOCITY	5.75	5.57	6.46	6.11	5.50	5.85 ft/s
2	Y1 + (Y-2*Y1)/8	3.50	Counts	111	21	24	22	21	
			duration	40	40.5	41.2	41.4	40.3	
			VELOCITY	6.14	5.73	6.44	5.88	5.76	5.99 ft/s
3	Y1 + 3* (Y-2*Y1)/8	6.50	Counts	110	25	25	23	21	
			duration	40.2	41.4	40.5	41.7	42	
			VELOCITY	6.05	6.67	6.82	6.10	5.53	6.17 ft/s
4	Y1 + 5* (Y-2*Y1)/8	9.40	Counts	98	19	19	20	20	
			duration	40.1	40.2	40.8	41.5	41.9	
			VELOCITY	5.41	5.23	5.15	5.33	5.28	5.29 ft/s
5	Y1 + 7* (Y-2*Y1)/8	12.40	Counts	66	13	14	11	12	
			duration	40.4	41.9	41.7	40	40.9	

The DALLES NORTH FISHWAY VELOCITY DATA

LOWER FISHWAY CHANNEL MEASUREMENT
1 STRUT d/s of Weir 70, 4 STRUTS upstream from u/s side of bend
Upstream (West) Edge of Strut

		Start	End				
Date:	11/10/2004	**Time:**	9:30	10:30	**Data Collectors:**	P.W.	B.M	R.M.

INSTRUMENT **Price Meter** X Price Meter Rotation per Count = 1

POINT VELOCITY AND FLOW MEASUREMENTS IN CHANNEL:

	start	end			
Z15 =Distance to Water Surface =	76.13	27.95	ft (from 105 deck)	1 **B = Channel Width =**	**24.0** ft
WS = Water Surface Elevation =	**76.87**	**77.05**	ft (= 105 - Z_{15})	**Upper (south) Curb ELEV. =**	**105.0** ft
Y = Measured Channel Depth =	13.37	13.55	ft (=WS - 63.5)	*Lower (north) Curb ELEV. =*	*105.00* ft
Edge Effort Weighting Factor =	0.5			**Zi = INVERT =**	**63.5** ft

158.2	158.1	Aprrox internal dimension =	4.0 ft	Div	
X1 = Side Edge width inc= 10.2	10.1	Number of Internal X Increments =		1.0	2
Y1 = Vertical edge height incr =	2	Number of Internal Y Increments =		4.0	8

Horiz. No.:	Formula for Distance from surface	Depth from Surface (ft)
1	0.5 * Y1	1.00
2	Y1 + (Y-2*Y1)/6	3.60
3	Y/2	6.70
4	Y1 + 5* (Y-2*Y1)/6	9.80
5	Y - 0.5*Y1	12.40

Vert. Sect. No. :	1	2	3	4	5	Ave. Integr. Vel.
Distance From Left Edge (ft)	**5.1**	**12.0**	**19.0**	**19.0**	**19.0**	
	2.0	7.0	12.0	17.0	22.0	
Counts	50	62	80	65	53	
duration	60	60	60	60	60	
1	1.86	2.30	2.96	2.41	1.97	2.30 ft/s
60	20	40	82	53	52	
duration	60	60	60	60	60	
VELOCITY	0.75	1.49	3.03	1.97	1.93	1.85 ft/s
60	13	50	51	34	42	
duration	60	60	60	60	60	
VELOCITY	0.50	1.86	1.89	1.27	1.56	1.42 ft/s
45	14	21	20	20	34	
duration	68	60	60	60	60	
VELOCITY	0.47	0.79	0.75	0.75	1.27	0.81 ft/s
45	12	15	21	17	29	
duration	60	60	60	60	60	
VELOCITY	0.46	0.57	0.79	0.64	1.08	0.71 ft/s

Total Average Integrated Velocity = **1.39**

Total Computed AWS FLOW RATE = **450** cfs (= B * Y * V)

SPECIAL MEASUREMENT at WEIR 70 (d/s Side)

Height of Price meter above bottom of lead fish = 6.75 ft

ORIFICE VELOCITY MEASUREMENT

Target Elevation Above Floor= 0.75 ft

Target Distance from wall = 3 ft

Orifice Sq Dimension = 18 in

actual elves above floor = 0.80

actual dist. from edge = 3.00

OVERFLOW WEIR VELOCITY

Target Level is midway between water surface level and weir crest (70')

Water Level @ weir **1** 77.10 ft

Distance from wall : **duration** 3 ft

Depth from Surface 3.50 (WS el - 70)/2

actual dist. from edge = 3.00

ORIFICE VELOCITY		
COUNTS	22.00	29.00
DURATION	60.00	60.00
VELOCITY	0.83	1.08

WEIR VELOCITY		
COUNTS	47.00	52.00
DURATION	60.00	60.00
VELOCITY	1.74	1.93

The DALLES NORTH FISHWAY Wier DATA

SUPPLEMENTAL DATA (Turbine Output, Diffuser & AWS HGL Data) P.W

Date:	11/10/2004	Time:	11:30	12:30

Lower Ladder DIFFUSERS HGL Levels: Entrances → Weir 70

Diff No.	N-1	N-2	N-3	N-4	N-5	N-6	N-7	N-8
Ref Elev.	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0
open?	C	O	O	O	O	O	O	O
Dist to Ws	27.60	27.50	27.80	27.60	27.60	27.60	27.60	27.60
HGL	77.4	77.5	77.20	77.40	77.40	77.40	77.40	77.40

DIFFUSER DATA

Collection Channel Diffusers (d/s weir 70) From South EAST Corner

	ENTRANCE DIFFUSERS			Bend		BETWEEN BEND & WEIR 70			
	N-1	N-2	N-3	N-4	N-5	N-6	N-7	N-8	N-9
open?	closed	2.5' open	O	O	O	O	O	O	O

Lower Ladder DIFFUSERS HGL Levels: BRIDGE → South

Diff No.	L-1		L-2		L-3	3	L-4		L-5	
d/s weir	weir 70		Weir 72			26	wier 76		weir 78	
Ref Elev.	105.0		105.0			45.0	105.0		105.0	
open?	O		O				o		O	
Dist to Ws	27.60		27.53				27.30		26.45	
HGL	77.4		77.47			29	77.7		78.55	
open?						45				

Lower Ladder DIFFUSERS HGL Levels: Reference Elevatio 105.0 ft

Diff No.	L-6		L-7		L-8	26	L-9		L-10	
d/s weir	Weir 80		Weir 82		45	45	45		Weir 88	
Ref Elev.	105.0		105.0		105.0		105.0		105.0	
open?	O		o		o		o		o	
Dist to Ws	26.00		25.90		25.90	27	25.90		25.90	
HGL	79.00		79.1		79.1	45	79.1		79.1	
open?										

OTHER DATA

The Dalles North Fish Ladder Wier Data

SUPPLEMENTAL LADDER DATA (East END)

S.A | R.M | P.W.

Date: 10-Nov-04 **Time:** 11:00 | 12.25

EXIT SECTION HEAD DATA (From Upstream end)

South

	Dist to WS	Ref EL	Water level	Head Diff.			Dist to WS	Ref EL	Water level	Head Diff.
FOREBAY			158.6	158.4		Wry 159	9.80	168.0	158.2	
					West					
Wry 158	10.50	168.0	157.5	0.7		Wry 157	11.30	168.0	156.7	0.8
Wry 156	11.90	168.0	156.1	0.6		Wry 155	12.10	167.5	155.4	0.7
					West					
WRY 154	11.80	166.5	154.7	0.7		Wry 153		166.0		
WRY 152		165.0				u/s Ct Sta		164.0		
					West					
WRY 151		157.4								

WEIR HEAD DATA (From Downstream end)

WEST

	Dist to WS	Ref EL	Water level	Head Diff.			Dist to WS	Ref EL	Water level	Head Diff.
d/s 70		105.8				Pool 70		105.8		
Pool 71		105.8				Pool 72	28.45	105.8	77.3	
Pool 73		105.8				Pool 74	28.30	105.8	77.5	
Pool 75	28.20	105.8	77.6	0.1	BRIDGE betwn WEIRS 75 & 76	Pool 76	28.00	105.8	77.8	0.2
Pool 77	27.40	105.8	78.4	0.6		Pool 78	26.60	105.8	79.2	0.8
Pool 79	25.60	105.8	80.2	1.0		Pool 80	24.60	105.8	81.2	1.0
Pool 81	23.60	105.8	82.2	1.0	*A BRANCH Resumed*	Pool 82	22.60	105.8	83.2	1.0
Pool 83	21.60	105.8	84.2	1.0						

NOTE

REF 105

Wier Pool 73

Distances to water 27.7

Water Surfaces 77.30

MEMORANDUM FOR RECORD

FROM: Paul Williams

SUBJECT: Inspection of Dalles North Fish Ladder
February 11, 2005

DATE: February 11, 2005

Attendees: Paul Williams, EC-HD
Steve Schlenker, EC-HD
Zyndol Miroslaw, Dalles-Biologist
Robert Guidinger, PUD

Trip Objectives:

1. The objectives of the site visit were to visual inspection the AWS and measures critical components of the AWS and compare the field dimension to the As-build drawings.

Water supplied to the fishway facility originates from two sources: the fish ladder exit on the upstream face of the dam and from one turbine that is connected to conduits and diffusers referred to as the Auxiliary Water Supply (AWS) that feeds the lower portion of the fishway. The turbine was added to the facility in 1989 and is operated by Wasco County P.U.D.

Measurement were taken of the draft tube exit section that connection the exiting AWS system. The draft tube exit section measurements were 9'-0" tall and 9'-6" wide. NHC reported that the measurements of the daft tube were 7.8 feet tall and 21.3 feet wide.

Figure 1: Draft Tube Exit Section

All diffuser orifices opening were check against the As-build dimension. The only problem with the orifice opening is that the slide gate extended 1.5 inches into the opening and also the slide gate has two securing bracket that extend into the orifice opening. The sizes of the brackets are 7" tall by 3" wide. With the gate not fully opening and the securing bracket extending into the orifice opening will reduces flow into the diffusers. This was examined on all the diffuser orifices in the AWS system. At ladder diffusers 8 which is between weir 84 and 85 the gate was extending 14 inches into the orifices opening.

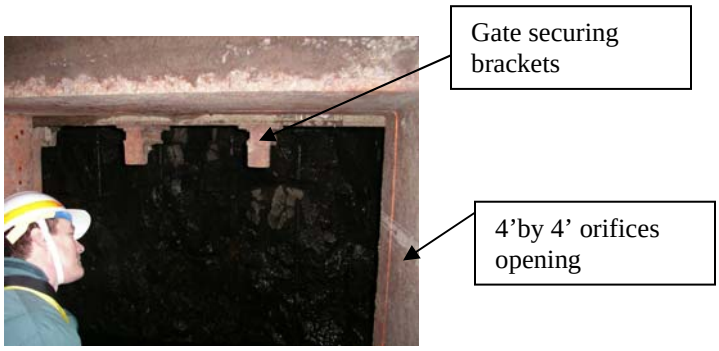


Figure 2: Typical Diffuser Orifices Opening

Figure 3: Ladder Diffuser 8

Figure 4: Diffuser Slide Gates

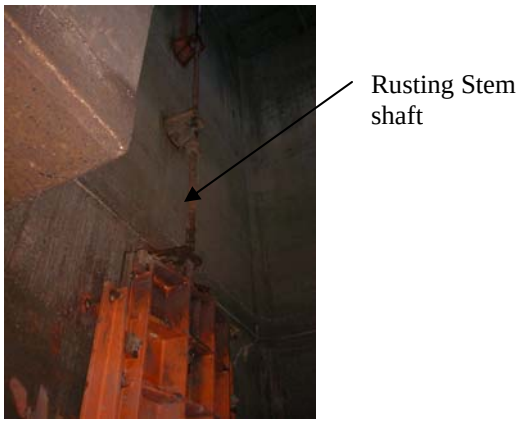


Figure 5: Slide Gate Stem

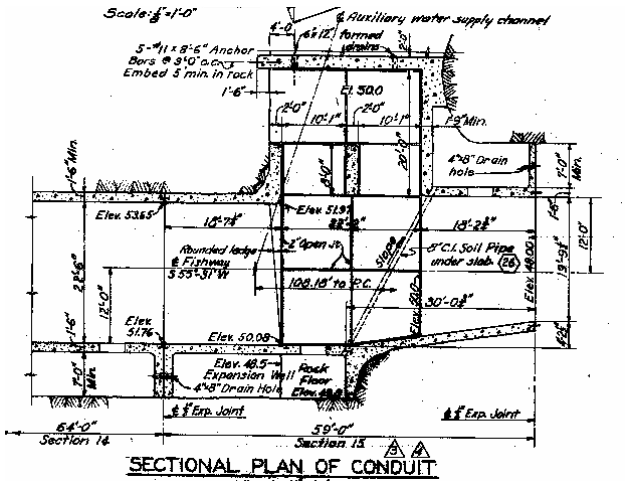
The stove pipe well that supplies the fish ladder diffuser were examined. The portion of the stove pipe well facing the AWS system is concrete by the back wall and floor is exposed rock. The rock wall is very rough and not very uniform in width this would lead to using a higher major loss coefficient in the computer program.

Figure 6: Stove pipe well

Figure 7: Strove Pipe Well

Figure 8: Stove Pipe Well

Prior to the addition of the turbine, water was supplied through a gravity feed system which is currently used as a backup water supply system when the turbine is out of operation.



SECTIONAL PLAN OF CONDUIT

MEMORANDUM FOR RECORD

FROM: Stephen Schlenker

SUBJECT: Report on data collection on the Dalles Dam North Exit Section

DATE: August 12 2005

Attendees: Schlenker, Steve EC-HD
Stenkamp, Justin, EC-HD
Holzapfel, Eric, EC-HD

Trip Objectives:

1. Collect prototype data at exit section with ladder head at 1.3 feet at The Dalles Dam North Fish Ladder (TDAFL) to verify the HELCRABS numerical model for higher control head ladder flow rates.

Project Conditions:

Forebay:	*157.7 feet*	*±0.3 feet*	*Tailrace: 74.9 feet*	*±0.2 feet*
Ladder head:	*1.35 feet*	*±0.05 feet*	*Fishway Operation:*	*Normal*.

Data Collection:

Two comprehensive system-wide data collection trips were completed for low tailwater and high tailwater conditions in November 2004 and May 2005. During all previous tests, the ladder control was operating at 1.0 foot ladder head (optimum for salmon passage) at both The Dalles North Fishway and The Dalles East Fishway exit sections. Consequently, a return trip was scheduled to measure the exit section and upper ladder flow rates when the control head is set at 1.3 feet (optimum for shad passage) at both Fishway systems. (See Site 4 in Figure 1 of previous trip reports for measurement location.) Prior to the trip, Justin Stenkamp coordinated with Miro Zyndol, Project Biologist, to arrange the date that the ladder head would be set to 1.3 feet at both fishway systems. All water level and head measurements were taken from a sounding tape or project staff gages. All velocities were measured using the Price Meter and the AquaCount.

Ladder Flow

The total flow in the ladder section was measured at the exit section. A portion of the water enters a three-foot wide auxiliary or make-up water channel that runs along the south fish ladder wall. This conduit continues downstream just past weir 152 and discharges back into the main channel through a floor diffuser. The make-up water control gate adjusts as needed depending on the head at the control fish ladder weir 151. The 20-feet wide fish ladder channel in this section consists of vertical slots and pools. Velocity measurements were taken inside the AWS channel. The total ladder flow was

102 cfs, which includes 58 cfs in the ladder make-up water channel. The remainder of the exit flow (44 cfs) goes down the fish ladder channel with the vertical slots.

The head over the ladder weirs was read at weir 151 at 1.3 ft at the start of the test and 1.4 feet at the end of it. Head differential was also measured between the pools of the fish ladder channel of the exit section; the head drops ranged between 0.9 feet at pool 157 and 0.3 feet at pool 156. (Much of the head variation is likely caused by the uncertainty of the reference elevations on the top of the sloping north guidewall from which the water surface elevations were measured.) The average drop was 0.6 feet.

Summary

A summary table of the data is shown below. The detailed data sheets for all of head and flow measurements are attached in the following Appendix.

Summary Table with Overall Continuity of Tests:

The Dalles North Fishway Measurements Summary, Aug 12, 2005						
Location	**Average Velocity ft/sec**	**Flow cfs**	**Water Surface Elev. (ft)**	**Head Difference (ft)**	**Weir Submerg-ence (ft)**	**Tailwater Level (ft)**
INFLOWS						
Fish Ladder Exit Section (channel)	1.8	102	157.7	1.35		
Makeup Water Channel	1.8	58	86.7			
Esimated Flow in Vertical Slot Channel for Fish =		44	cfs *(= Exit Q - Makeup Water Q)*			
Head drops between V-slot Pools:	Ave	0.6 ft	Min	0.3 ft	max	0.9 ft
Project Forebay (feet)	Average	157.7 ft	min	157.30 ft	max	157.90 ft

APPENDIX

The Dalles North Fish Ladder Wier Data

SUPPLEMENTAL LADDER DATA (East END) R.M **SJS**

Date: **12-Aug-05** **Time:** 11:40 11:55 North Wall (Flat Spots)

EXIT SECTION HEAD DATA (From Upstream end) **South**

	Dist to WS	Ref EL	Water level	Head Diff.			Dist to WS	Ref EL	Water level	Head Diff.
FOREBAY			157.7			**Wry 159**		168.0	157.7	
					West					
Wry 158	11.00	168.0	157.0	0.7		**Wry 157**	11.50	168.0	156.5	0.5
Wry 156	12.20	168.0	155.8	0.7		**Wry 155**	12.00	167.5	155.5	0.3
					West					
WRY 154	11.70	166.5	154.8	0.7		**Wry 153**	12.00	166.3	154.2	0.6
WRY 152	12.00	165.5	153.5	0.7		**u/s Ct Sta**	11.40	165.0	152.6	0.9
					West					
WRY 151		157.4	152.4	0.2						

DALLES NORTH FISHWAY VELOCITY DATA

EXIT CHANNEL (Total Flow) **Data Collectors:** EH JS SJS

Inside of Tunnel Through Dam, 4 ft Upstream (East) from D/s Opening, and wall flare

Upstream of Makeup Water Intake Screen, and upstream of invert step @ d/s end of tunnel

		start	end
Date:	12-Aug-05 **Time:**	11:30	12:00

	start	end
Forebay Level =	157.50	157.90

Head on Weir 151 = start 1.30 end 1.40

INSTRUMENT

Price Meter X

Price Meter Rotations per Count = 1.00

V = 0.0178 + 2.2048 * (rotations/time)

POINT VELOCITY AND FLOW MEASUREMENTS:

	start	end	
WS = Water Surface Elev. =	**157.50**	**157.90**	ft (staff gage)
Y = Meas. Channel Depth =	9.50	9.90	ft (=WS - 148)

B = Channel Width = **6.00** ft

Deck Elves = **161.0** ft

Zi = INVERT = **148.0**

X1 = Side Edge width incr = **2** ft

Y1 = Vertical edge height incr = **2** ft

1.0 ft Div by

4.0 8

3.0 6

Horiz. No.:	Formula for depth below surface (pm)	Depth from Surface (ft)	Vert. Sect. No. :	1	2	3	Average Velocity
			Est Dist. from Left Edge (ft)	1.00	3.00	5.00	
			Actual	1.00	3.00	5.0	
1	0.5 * Y1	**1.0**	Counts	30	31	32	
			duration	41.2	40.4	40	
			VELOCITY	1.62	1.71	1.78	1.70 ft/s
2	Y1 + (Y-2*Y1)/6	**2.9**	Counts	35	35	33	
			duration	40.8	40.5	41	
			VELOCITY	1.91	1.92	1.79	1.87 ft/s
3	Y/2	**4.8**	Counts	33	34	35	
			duration	40.3	40	41	
			VELOCITY	1.82	1.92	1.90	1.88 ft/s
4	Y1 + 5* (Y-2*Y1)/6	**6.6**	Counts	34	35	35	
			duration	40.3	40.7	40.3	
			VELOCITY	1.88	1.91	1.93	1.91 ft/s
5	Y - 0.5*Y1	**8.6**	Counts	35	35	32	
			duration	40.5	40.5	40.2	
			VELOCITY	1.92	1.81	1.77	1.84 ft/s

Total Average Integrated Velocity = **1.79** ft/s

Total Computed FLOW RATE = **102** cfs (= B * Y * V)

DALLES NORTH FISHWAY VELOCITY DATA

MAKEUP WATER CHANNEL — **Data Collectors:** EH, JS, SJS

Anywhere Midway Between Intake Screen and Sluice Gate

		start	end
Date:	12-Aug-05	12:05	12:15
Forebay Level =		157.90	157.65

	start	end	
Head on Weir 151 =	1.40	1.35	ft
Sluice Gate Opening	16'3"	16'3"	
Dist to D/s Water Level			
(staff gage) D/s Water Level	152.50	152.50	ft

INSTRUMENT — ref. 162

Price Meter X

Price Meter Rotations per Count = 1.00

V = 0.0178 + 2.2048 * (rotations/time)

POINT VELOCITY AND FLOW MEASUREMENTS:

	start	end			
Z_{15} = Meas. Dist. to WS =	10.25	10.40	ft (from 168 level)	**B = Channel Width =**	**3.00** ft
WS = Water Surface Elev. =	**157.75**	**15.60**	ft (= 168 - Z_{15})	**Wall Top Elev =**	**168.0** ft
Y = Meas. Channel Depth =	10.75	10.60	ft (=WS - 147)	**Zi = INVERT =**	**147.0**

X1 = Side Edge width incr = **1** ft — **0.5** ft — Div by

Y1 = Vertical edge height incr = **2** ft — 4.0 — 8

3.0 — 6

Horiz. No.:	Formula for depth below surface (pm)	Depth from Surface (ft)	Vert. Sect. No.	1	2	3	Average Velocity
			Est Dist. from Left Edge (ft)		1.50		
			Actual		1.50		
1	0.5 * Y1	1.00	Counts		23		
			duration		41.5		
			VELOCITY		1.24		1.24 ft/s
2	Y1 + (Y-2*Y1)/6	3.10	Counts		38		
			duration		40.5		
			VELOCITY		2.09		2.09 ft/s
3	Y/2	5.40	Counts		42		
			duration		40.5		
			VELOCITY		2.30		2.30 ft/s
4	Y1 + 5* (Y-2*Y1)/6	7.60	Counts		27		
			duration		40.5		
			VELOCITY		1.49		1.49 ft/s
5	Y - 0.5*Y1	9.70	Counts		36		
			duration		40.2		
			VELOCITY		1.99		1.99 ft/s

Total Average Integrated Velocity = **1.79** ft/s

Total Computed FLOW RATE = **58** cfs (= B * Y * V)

Final MEMORANDUM FOR RECORD
FROM: Natalie Richards, PE
SUBJECT: The Dalles North Fish Ladder- Data Collection- May 18, 2005 with the analysis of the North Ladder System
DATE: May 20 and 26, 2005
Attendees: Natalie Richards, EC-HD
Steve Schlenker, EC-HD
Sean Askelson, EC-HD
Nathan Higa, EC-HD
Laurie Rice, EC-HR
Kenton Mathewson- 5/18/2005-PUD
Paul Ebdon- 5/18/2005-PUD

Pre-Trip Preparation-
Coordinated with RCC (Cindy at BPA and Cathy Hlebechuk and Julie Amman from RCC) to get the highest Tailrace that could be held constant within +/- 1 foot.
Nathan, Sean, Justin and Natalie put together the equipment needed:
2 water level tapes + Borrowed 1 from TDA and 1 from HG
1 ADV box and cables
1 extension cord
1 plug in strip
3 headphones
1 aquadot counter- This was very helpful in calm water but reset a lot at the East entrance in the very turbulent conditions. Recommend buying more to speed up the process.
4 clip boards
Spools of rope
Various sized lead fish - most of the ones we have
Tool box - screwdrivers, pliers, 3 stopwatches
5 price meters- the 6 one is broken and needs to be fixed
3 reels- one has a tracking brass wheel that is broken and needs to be fixed
3 bridge boards
2 sawhorses
1 gun case with prop. Meter
Tape measures from home
Toughbook computer (with ADV), a camera and a video camera.
Ford Excursion from EC-HR and a minivan along with Sean's and Natalie's POV
Borrowed from TDA-1-3/16" or 1-1/8" socket wrench to undo the grate opening bolts
With new security gates going up, we did not have keys for them @ East Fish Ladder to check the diffuser level

Trip Objectives:

Collect velocity and water surface elevations data under high tailwater level (elevation > 79 feet). This data will be used to calibrate The Dalles North HELCRABS model developed by Northwest Hydraulics Consulting (NHC). This information is critical to addressing RPA 120 in the Biological Opinion. (The summary of results and the testing locations are attached below)

Project Conditions:
Forebay- 157.2 ± 0.2'
Tailrace- 79.55 ± 1.5'
Total PUD Turbine Generation- 4.9 MW
Ladder head: 1 ft
Fishway Operations: Normal

Schedule:
May 18, 2005-Collecting Data for the North Ladder- We started at about 10:30 am and finished about 5:30 pm.

1) Laurie, Natalie, Nathan and Steve started with the ladder entrance from The Dalles Forebay.
2) Then Nathan, Sean and Laurie moved to test the intake to the PUD Turbine and main AWS system, located just downstream/west of the tainter gate. Natalie and Steve took water level elevations (WSE) at the ladder and entrance diffusers.
3) Nathan, Natalie, Steve and Laurie completed data collection at the fish entrance next to Spill bay 1.
4) Nathan, Natalie, Steve and Laurie measured the velocities in the lower collection channel, just downstream of weir 70. The tests were finished about 5:30 pm, and Laurie left to go back to Portland.
5) During the testing day, Ken Mathewson of WASCO County PUD, recorded data from the PUD readout boards at 30-minute intervals. This data included digital readouts of Forebay, Tailwater, Entrance weir elevation, entrance head, and turbine megawatts.
6) The team stayed overnight in The Dalles to collect data at The Dalles East Fishway the next day.

Summary of the Calculations
Since the same data was collected as was collected November 10, 2004, Mr. Paul Williams' format is updated below.

Ladder Flow
The total flow in the ladder section was measured at the exit section. A portion of the water enters an auxiliary water supply conduit that was added inside the existing channel and along the south fish ladder wall. This conduit continues downstream just past weir 152. The fish ladder channel in this area is reduced from its original 24-foot width to a 20-foot inside width. The flow in the AWS channel supplement the fish counting station. Velocity measurements were taken inside the AWS channel. The total ladder flow was 68 cfs, which includes 29 cfs in the ladder AWS channel.
The head over the ladder weirs was read as 1.0 ft from a staff gage downstream of the counting station (head on weir 151).

Lower Ladder Auxiliary Water System
Water supplied to the Fishway facility originates from two sources: the fishladder exit on the upstream face of the dam and the turbine that is connected to conduits and diffusers

referred to as the Auxiliary Water Supply (AWS) that feeds the lower portion of the Fishway. The turbine was added to the facility in 1989 and is operated by Wasco Country P.U.D. Prior to the addition of the turbine, water was supply through a gravity feed system, which is currently used as a backup water supply system when the turbine is out of operation. The backup water supply system (gravity feed system) was not in operation during the data collection visits.

The intake pool supplies water to the turbine. The intake pool extend downstream of the exiting spillway, flow from the pool enter the penstock and then into the powerhouse. The intake pool has the capability to retain 45 feet of water depending on the forebay elevation. Inside the supply pool is a vertical fish screen, which prevents the entrance of downstream migrant fingerlings into the turbine unit. The vertical screen is oriented so that it effectively narrows the channel width in the downstream direction. The dewatering screen is designed to remove the entire turbine flow (800-900 cfs) from the intake channel and leave 10 cfs in channel for fish bypass. Velocity measurements were take down stream of the existing tainter gate and prior to the intake pool, thus capturing the total flow into turbine unit minus 10 cfs used for fingerling transport.

The forebay averaged 157.17 ft during our testing period. The tailrace according to Wasco data averaged 79.26 ft. Direct measurement during testing averaged 79.50 ft for the north tailrace.

Entrances

Dalles north fish ladder has three entrances label E-1, E-2 and E-3. The entrances weirs E-2 and E-3 were closed during the test period, the project is planning to close E-3 gate (side weir) permanently; therefore only two entrance gates are available. Velocity measurements were taken directly downstream of E-1 entrance weir. The total measured flow through E-1 entrance was 1075 cfs, which is a little more than expected because the maximum turbine discharge is 900 cfs and the maximum ladder discharge is 120 cfs thus the combine flow of 1020 cfs. The measurement was difficult even with a 75 lb fish and pulling the measuring device up into the entrance to provide more uniform flow.

Summary

The difference between system outflow (entrance) and sum of inflows (PUD + ladder flow) is 91 cfs, or 9.3%. The normal goal is to attain continuity of 5%. Greater credence is given to the system inflow total than the system outflow since the flow conditions were more optimal (uniform flow fields with little fluctuation) for measuring at the inflow measuring sites.

The individual data sheets are attached at the end of the report.

Respectfully Submitted by,
Natalie Richards, PE, 5/26/2005

Summary Table with Overall Continuity of Tests:
The Dalles North Fishway Measurements Summary, May 18, 2005

The Dalles North Fishway Measurements Summary, May 18, 2005						
Location	**Average Velocity ft/sec**	**Flow cfs**	**Water Surface Elev. (ft)**	**Head Difference (ft)**	**Weir Submerg-ence (ft)**	**Tailwater Level (ft)**
INFLOWS						
Fish Ladder Exit Section (channel)	1.25	68	157.2	1.00		
AWS Intake	3.78	915	157.0			
Makeup Water Channel	1.07	29	157.2			
Wasco County PUD (AWS intake Q -10)		*905*		75.1	**ave MW =**	4.9
Total Inflow (fish Units + Ladder flow)		984				
CHANNELS						
Ladder Channel below weir 70	1.18	499	81.2			
ENTRANCES				entr		
NE-1 Entrance	3.45	1075	80.9	1.30	9.5	79.6
NE-2 Entrance						
Total System Discharge (entrances)		1075				
		diff	% diff			
Differences: Inflow - meas Outflow =		-91	-9.3%			

Difference AWS Discharge

Measured AWS flow	915	cfs
JBS (nominal)	10	cfs
Measured Turbine (AWS-JBS)	905	cfs
Rated Turbine flow at same time	900	cfs

		diff	5	cfs				
		% diff	0.6%					
FB (WASCO)	Average		157.17 ft	min	157.22 ft	max	156.93 ft
TW (Measured) 9:00 am to 11:00 am	Average		79.50 ft	min	79.45 ft	max	79.55 ft
TW (WASCO) 9:00 am to 11:00 am	Average		79.26 ft	min	79.12 ft	max	79.38 ft
Entrances Head (WASCO) 9:00 am to 11:00 am	Average		1.40 ft	min	1.38 ft	max	1.48 ft

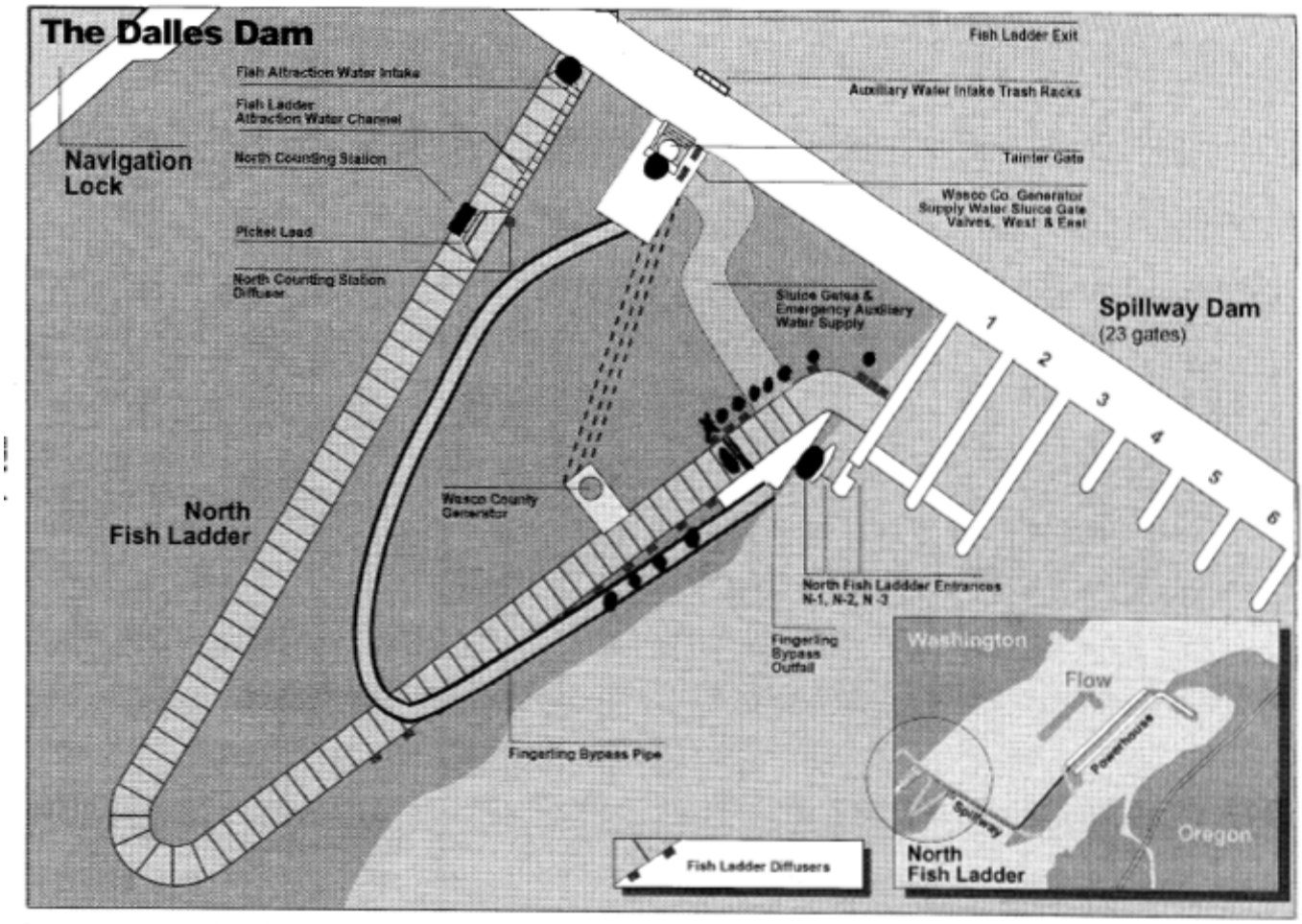


Figure 1- Project Schematic with Measurement Locations

The DALLES NORTH FISHWAY Wier DATA

SUPPLEMENTAL DATA (Turbine Output, Diffuser & AWS HGL Data)

NAR | SJS

Date: 5/18/2005 **Time:** 12:50

Lower Ladder DIFFUSERS HGL Levels:

Entrances → Weir 70

	1-I	1-H	1-G	1-F	1-E	1-D	1-C	1-B	1-A
Diff No.	N-2	N-3	N-4	N-5	N-6	N-7	N-8		
Ref Elev.	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0
open?	O	O	O	O	O	O	O	O	O
Dist to Ws	24.20	24.20	24.30	24.40	24.40	24.30	24.30	24.30	24.30
HGL	80.8	80.80	80.70	80.60	80.60	80.70	80.70	80.70	80.70

DIFFUSER DATA

Collection Channel Diffusers (d/s weir 70) From South EAST Corner

	ENTRANCE DIFFUSERS			Bend		BETWEEN BEND & WEIR 70			
	N-1	N-2	N-3	N-4	N-5	N-6	N-7	N-8	N-9
open?	closed	2.5' open	O	O	O	O	O	O	O

Lower Ladder DIFFUSERS HGL Levels:

BRIDGE → South

Diff No.	L-1		L-2		L-3	3	L-5		L-6
d/s weir	weir 70		Weir 72			26	wier 78		weir 80
Ref Elev.	105.0		105.0			45.0	105.0		105.0
open?	O		O				o		O
Dist to Ws	24.30		24.20				24.30		
HGL	80.7		80.80			29	80.7		
open?	flow		flow			45	flow		

Lower Ladder DIFFUSERS HGL Levels:

Reference Elevatio 105.0 ft

Diff No.	L-7		L-8			26	L-9		L-10
d/s weir	Weir 82		Weir 84			45	45		Weir 88
Ref Elev.	105.0		105.0				105.0		105.0
open?	O		o				o		o
Dist to Ws	24.00		22.80			27	22.80		22.80
HGL	81.00		82.2			45	82.2		82.2
open?	flow		no flow				no flow		no flow

OTHER DATA

TW		App Chann	Entrance Head
12:50	79	80.66	1.66
1:35	79.2	80.75	1.55

Double Beam @ 7

Plunge Pool distance to 105- (WS 26.3-3)= WS 81.7'

The DALLES NORTH FISHWAY

SUPPLEMENTAL DATA (Time,Forebay,Tailwater,Entrances Head)

Data Collector: Mathewson Wasco PUD

Date: 5/18/2005 **Time:** 12:30

TURBINE OUTPUT DATA

	Time	12:30	Time	13:00	Time	13:30	Time	14:00	
	FB	156.93	FB	157.06	FB	157.22	FB	157.22	ft
	screen loss	0.00	screen loss	0.00	screen loss	0.01	screen loss	0.00	ft
	TW	79.12	TW	79.21	TW	79.38	TW	79.32	ft
	Entrance head	1.48	Entrance head	1.43	Entrance head	1.29	Entrance head	1.38	ft
	AWS HGL		AWS HGL		AWS HGL		AWS HGL		ft
	net head	77.81	net head	77.85	net head	77.84	net head	77.9	ft
	MW	Flow (cfs)	MW	Flow (cfs)	MW	Flow (cfs)	MW	Flow (cfs)	
WASCO PUD	4.91		4.93		4.91		4.9		

TURBINE OUTPUT DATA

	Time	14:30	Time	15:00	Time	15:30	Time	16:00
	FB	157.24	FB	157.23	FB	157.26	FB	157.25
	screen loss	0.00	screen loss	0.00	screen loss	0.01	screen loss	0.00
	TW	79.64	TW	79.75	TW	79.78	TW	79.56
	Entrance head	1.32	Entrance head	1.25	Entrance head	1.32	Entrance head	1.21
	AWS HGL		AWS HGL		AWS HGL		AWS HGL	
	net head	77.6	net head	77.48	net head	77.48	net head	77.69
	MW	Flow (cfs)	MW	Flow (cfs)	MW	Flow (cfs)	MW	Flow (cfs)
WASCO PUD	4.83		4.84		4.85		4.86	

TURBINE OUTPUT DATA

	Time	16:30	Time	17:00
	FB	157.34	FB	157.40
	screen loss	0.00	screen loss	0.00
	TW	80.04	TW	79.65
	Entrance head	1.11	Entrance head	1.46
	AWS HGL		AWS HGL	
	net head	77.3	net head	77.75
	MW	Flow (cfs)	MW	Flow (cfs)
WASCO PUD	4.89		4.89	

Average MW 4.881

DALLES NORTH FISHWAY VELOCITY DATA

MAKEUP WATER CHANNEL

Data Collectors: NAR | SJS |

Anywhere Midway Between Intake Screen and Sluice Gate

		start	end
Date:	18-May-05	12:50	
Forebay Level =		157.20	

	start	end
Head on Weir 151 =	1.00	1.00 ft
Sluice Gate Opening		1.00 ft
Dist to D/s Water Level		ft
? Not collected? D/s Water Level	157.20	157.20 ft

INSTRUMENT ref. 162

Price Meter X

Price Meter Rotations per Count = 1.00

V = 0.0178 + 2.2048 * (rotations/time)

POINT VELOCITY AND FLOW MEASUREMENTS:

	start	end			
Z_{15} = Meas. Dist. to WS =	10.80	10.80	ft (from 168 level)	**B = Channel Width =**	**3.00** ft
WS = Water Surface Elev. =	**157.20**	**157.20**	ft (= 168 - Z_{15})	**Wall Top Elev =**	**168.0** ft
Y = Meas. Channel Depth =	9.20	9.20	ft (=WS - 147)	**Zi = INVERT =**	**147.0**

X1 = Side Edge width incr = **1** ft — **0.5** ft — Div by

Y1 = Vertical edge height incr = **2** ft — 4.0 — 8

3.0 — 6

Horiz. No.:	Formula for depth below surface (pm)	Depth from Surface (ft)	Vert. Sect. No. :	1	2	3	Average Velocity
			Est Dist. from Left Edge (ft)	0.50	1.50	2.50	
			Actual		1.50		
1	0.5 * Y1	**1.00**	Counts		17		
			duration		42.5		
			VELOCITY		0.90		0.90 ft/s
2	Y1 + (Y-2*Y1)/6	**2.80**	Counts		23		
			duration		40.2		
			VELOCITY		1.28		1.28 ft/s
3	Y/2	**4.60**	Counts		25		
			duration		41.1		
			VELOCITY		1.36		1.36 ft/s
4	Y1 + 5* (Y-2*Y1)/6	**6.30**	Counts		18		
			duration		40.9		
			VELOCITY		0.99		0.99 ft/s
5	Y - 0.5*Y1	**8.10**	Counts		18		
			duration		41.1		
			VELOCITY		0.98		0.98 ft/s

Total Average Integrated Velocity = **1.07** ft/s

Total Computed FLOW RATE = **29** cfs (= B * Y * V)

The DALLES NORTH FISHWAY VELOCITY DATA

LOWER FISHWAY CHANNEL MEASUREMENT
1 STRUT d/s of Weir 70, 4 STRUTS upstream from u/s side of bend
Upstream (West) Edge of Strut

	Start	End	Data Collectors:	LAR	NAR	SJS
Date: 5/18/2005	**Time:**	16:05	17:35			

INSTRUMENT **Price Meter** X Price Meter Rotation per Count = 1

POINT VELOCITY AND FLOW MEASUREMENTS IN CHANNEL:

	start	end			
Z15 =Distance to Water Surface =	29.55	29.55	ft (from 105 deck)	**B = Channel Width =**	**24.0** ft
WS = Water Surface Elevation =	**81.20**	**81.20**	ft (= 105 - Z_{15})	**Upper (south) Curb ELEV. =**	**110.8** ft
Y = Measured Channel Depth =	17.70	17.70	ft (=WS - 63.5)	*Lower (north) Curb ELEV. =*	*105.00* ft
Edge Effort Weighting Factor =	0.5			**Zi = INVERT =**	**63.5** ft

	158.2	158.1	Aprrox internal dimension =	4.0 ft	Div	
X1 = Side Edge width inc=	10.2	10.1	Number of Internal X Increments =		1.0	2
Y1 = Vertical edge height incr =		2	Number of Internal Y Increments =		4.0	8

Horiz. No.:	Formula for Distance from surface	Depth from Surface (ft)
1	0.5 * Y1	**1.00**
2	Y1 + (Y-2*Y1)/6	**4.30**
3	Y/2	**8.90**
4	Y1 + 5* (Y-2*Y1)/6	**13.40**
5	Y - 0.5*Y1	**16.70**

Vert. Sect. No. :	1	2	3	4	5	Ave. Integr. Vel.
Distance From Left Edge (ft)	**2.0**	**7.0**	**12.0**	**19.0**	**22.0**	
	2.0	7.0	12.0	17.0	22.0	
Counts	27	30	38	34	32	
duration	41.4	41.5	40.7	40.3	41.7	
1	1.46	1.61	2.08	1.88	1.71	1.75 ft/s
60	30	32	40	26	11	
duration	40.8	40.7	40.4	42	40.8	
VELOCITY	1.64	1.75	2.20	1.38	0.61	1.53 ft/s
60	24	32	34	22	8	
duration	41.6	40.8	40.7	40.9	41.9	
VELOCITY	1.29	1.75	1.86	1.20	0.44	1.32 ft/s
45	22	12	9	9	9	
duration	40	46.8	40.7	43.4	41.9	
VELOCITY	1.23	0.58	0.51	0.48	0.49	0.65 ft/s
45	18	13	15	6	8	
duration	40.2	40.2	40.8	42.5	42.1	
VELOCITY	1.01	0.73	0.83	0.33	0.44	0.67 ft/s

Total Average Integrated Velocity = **1.18**

Total Computed AWS FLOW RATE = **499** cfs (= B * Y * V)

DALLES NORTH FISHWAY VELOCITY DATA

EXIT CHANNEL (Total Flow)

Data Collectors: NAR | LAR | NH | SJS

Inside of Tunnel Through Dam, 4 ft Upstream (East) from D/s Opening, and wall flare

Upstream of Makeup Water Intake Screen, and upstream of invert step @ d/s end of tunnel

		start	end
Date:	18-May-05	**Time:** 11:07	12:45

	start	end			start	end
Forebay Level =	157.10	157.20	**GATE OPENING= 12.5"?**	Head on Weir 151 =		1.00

INSTRUMENT

Price Meter X

Price Meter Rotations per Count = 1.00

V = 0.0178 + 2.2048 * (rotations/time)

POINT VELOCITY AND FLOW MEASUREMENTS:

	start	end			
Z_{15} = Meas. Dist. to WS =			ft (from 161 level)	**B = Channel Width =**	**6.00** ft
WS = Water Surface Elev. =	**157.10**	**157.20**	ft (= 161 - Z_{15})	**Deck Elves =**	**161.0** ft
Y = Meas. Channel Depth =	9.10	9.20	ft (=WS - 148)	*Walkway deck Elves*	*168.0* ft
				Zi = INVERT =	**148.0**

X1 = Side Edge width incr = **2** ft — **1.0** ft — Div by

Y1 = Vertical edge height incr = **2** ft — 4.0 — 8

3.0 — 6

Horiz. No.:	Formula for depth below surface (pm)	Depth from Surface (ft)	Vert. Sect. No. :	1	2	3	Average Velocity		
			Est Dist. from Left Edge (ft)	1.00	3.00	5.00			
			Actual	1.00	3.00	5.0			
1	0.5 * Y1	**1.00**	Counts	24	22	26			
			duration	41	42.2	41.2			
			VELOCITY	1.31	1.17	1.41	1.30	ft/s	2.14
2	Y1 + (Y-2*Y1)/6	**2.85**	Counts	23	23	25			
			duration	41	40.1	41			
			VELOCITY	1.25	1.28	1.36	1.30	ft/s	
3	Y/2	**4.55**	Counts	22	24	23			
			duration	41.6	40.8	40.7			
			VELOCITY	1.18	1.31	1.26	1.25	ft/s	
4	Y1 + 5* (Y-2*Y1)/6	**6.25**	Counts	24	26	21			
			duration	41.4	40.2	41.3			
			VELOCITY	1.30	1.44	1.14	1.28	ft/s	
5	Y - 0.5*Y1	**8.10**	Counts	23	27	22			
			duration	40.5	41.6	40.4			
			VELOCITY	1.27	1.45	1.22	1.30	ft/s	

Total Average Integrated Velocity = **1.25** ft/s

Total Computed FLOW RATE = **68** cfs (= B * Y * V)

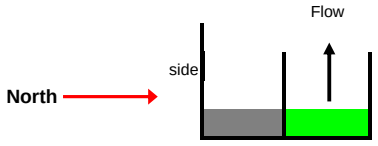
The DALLES NORTH FISHWAY VELOCITY DATA

ENTRANCE CHANNEL MEASUREMENTS

Measurements from D/s Side of Bridge between piers (rope required)

Data Collectors: LAR | NAR | S.J.S. | NH

Date: 5/18/2005 **Time:** Start 14:15 End 16:00



	Stillwell Dials start	end	ave	
Tailrace	79.45	79.55	79.5	ft
	start	end		
Approach Cha	81.20	81.33	81.27	ft
entrance head			1.77	ft

Weir Gates Data

Weir Crest Elevations	NE-3	NE-2	NE-1	
			70.20	start
			70.40	end

E-Tape Measurements

	Distance to Water: start	end	Ref EL	WATER LEVEL ELEV: start	end
Tailrace Level:	31.20	31.05	110.75	79.55	79.70
			Ref EL		
U/s stllwll Loc:	29.90	29.75	110.75	80.85	81.00
			entrance head	1.30	1.30 ft

INSTRUMENT

Price Meter X

Price Meter Rotations per Count = 5

Price Meter Rotations per Count = 1

	strat	end
Measured Distance to Curb to Weir beam	28.5	28.43
Distance from top of beam to weir crest	12.1875	12.1875
Weir Elevation	70.06	70.13

POINT VELOCITY AND FLOW MEASUREMENTS IN ENTRANCE:

	start	end	
Z15 =Distance to Water Surface =	30.00	30.00	
WS = Water Surface Elevation =	80.75	80.75	ft (From U/s Gage)
Y = Measured AWS Channel Depth =	20.75	20.75	ft (=WS - 60)
Edge Effort Weighting Factor =	0.5		

B = Channel Width = 15.0 ft per cha.

BRIDGE Curb ELEV. = 110.75 ft

Zi = INVERT = 60.0 ft

X1 = Side Edge width inc= 4

Y1 = Vertical edge height incr = 2

Aprrox internal dimension = 3.0 Div

Number of Internal X Increments = 4.0 8 2.8

Number of Internal Y Increments = 4.0 8

Horiz. No.:	Formula for Distance from surface	Depth from Surface (ft)	Ver Sec	1	2	3	4	5	Average Integrated Velocity
			Distance From Left	2.0	4.8	7.5	10.3	13.0	
			Actual (ft)	2.0	4.8	7.5	10.3	13.0	
1	0.5*Y1	1.00	Counts	19	17	16	18	17	
			duration	41.4	41.4	41.6	42.2	41.1	
			VELOCITY	5.08	4.54	4.26	4.72	4.58	4.66 ft/s
2	Y1 + (Y-2*Y1)/8	4.10	Counts	20	21	20	20	18	
			duration	46.8	47.7	41.3	45	45.9	
			VELOCITY	4.73	4.87	5.36	4.92	4.34	4.80 ft/s
3	Y1 + 3* (Y-2*Y1)/8	8.30	Counts	15	18	16	16	16	
			duration	42.1	41.9	42.6	47.5	45.4	
			VELOCITY	3.95	4.75	4.16	3.73	3.90	4.07 ft/s
4	Y1 + 5* (Y-2*Y1)/8	12.50	Counts	14	12	13	13	13	
			duration	49.7	44.8	46	50.5	50.3	
			VELOCITY	3.12	2.97	3.13	2.86	2.87	2.99 ft/s
5	Y1 + 7* (Y-2*Y1)/8	16.70	Counts	11	11	8	12	12	
			duration	54.9	52.8	57.5	56	45.9	
			VELOCITY	2.23	2.31	1.55	2.38	2.90	2.31 ft/s
6	Y - 0.5 * Y1	19.80	Counts	8	10	5	11	10	
			duration	51.3	47.5	56.6	54.8	54.3	
			VELOCITY	1.74	2.34	0.99	2.23	2.05	1.85 ft/s

Total Average Integrated Velocity = **3.45** ft/s

Total Computed AWS FLOW RATE = **1075** cfs (= B * Y * V)

NOTES:

THE DALLES NORTH FISHWAY VELOCITY DATA

Counting Station **Data Collectors:** P.W. B.M S.S

	start	end
Date: 10-Nov **Time:**	11:15	13:20
Forebay Level =		

Head on Weir 151 u/s of counting slot = (start: , end:)

Head on Weir 151 d/s of counting slot = (start: 1.00, end: 1.00)

INSTRUMENT **Price Meter** X

Propeller Meter X

Price meter rotation per count= 1.00

V = 0.0178 + 2.2048 * (rotations/time)

measure fron d/s side of bridge on u/s end of count slot

check ft

Bs = counting slot Width = **3.25** ft

POINT VELOCITY AND FLOW MEASUREMENTS:

Z_{15} = Meas. Distance to WS = ft (from 157.37 level)

WS = Water Surface Elev. = ft (= 157.37- Z_{15})

Y = Meas. Channel Depth = 5.00

158.1

B3 18.13

b4 15.13

B2 = Channel Width = **21.38** ft

upper Deck Elves = **157.37** ft

lower deck *156.45* ft

Zi = INVERT = **147.0** ft

Zi = 147- (15.13 -dist from left side)/16

X1 = Side Edge width incr = **3** ft

Y1 = Vertical edge height incr = **2** ft

Aprrox internal dimension = **4.6** ft

Number of Internal X Increments = 4.0 Div by 8

Number of Internal Y Increments = 3.0 Div by 6

Horiz. No.:	Formula for depth below surface (pm)	Depth from Surface (ft)	Vert. Sect. No. :	1	2	3	4	5	Average Velocity (Counting Slot)
			Est Dist. from Left Edge (ft)	1.0	3.0	5.0	16.1	Count Slot	
			Actual Dist (ft) from Ft side	37.0	26.0	23.0		middle	
1	0.5 * Y1	**1.00**	Counts	*prop meter*		*prop meter*	*prop meter*	56	
			duration					40.6	
			VELOCITY	*0.33*		*0.88*	*0.82*	3.06	3.06 ft/s
2	Y1 + (Y-2*Y1)/4	**2.50**	Counts					57	
			duration					40.5	
			VELOCITY					3.12	3.12 ft/s
3	Y1 + 3(Y-2*Y1)/4	**3.50**	Counts					50	
			duration					40.5	
			VELOCITY					3.20	3.20 ft/s

Total Average Integrated Velocity = **3.06** ft/s

Total Computed FLOW RATE = **50** cfs (= B * Y * V)

OTHER DATA / NOTES

1.0

0 0 0 0

3.00

The DALLES NORTH FISHWAY VELOCITY DATA

AWS INTAKE
Just Downstream of Tainter Gate (Fully Open)

Date:	5/18/2005	Time:	Start 12:30	End 13:50	Data Collectors:	LAR	NH	SKA

E-Tape Measurements

	Distance to Water start	Distance to Water end	Ref Location	Ref EL	WATER LEVEL ELEV: start	WATER LEVEL ELEV: end
Forebay Level			FB Road Deck	185.06		
			Top of wall	188.56		
				Ref EL		
AWS Channel	8.00	7.80	AWS deck	165.00	157.00	157.20

Staff Gage	start	end
Forebay		
	start	end
AWS Channel	157.00	157.20

INSTRUMENT **Price Meter** X Price Meter Rotations per Count = 1

POINT VELOCITY AND FLOW MEASUREMENTS IN CHANNEL:

	start	end			CHECK
Z15 =Distance to Water Surface =	8.00	7.80	ft (from 165 deck)	**B = Channel Width =**	**20.0** ft
WS = Water Surface Elevation =	157.00	157.20	ft (= 165 - Z_{15})	**Deck ELEV. =**	**165.0** ft
Y = Measured Channel Depth =	12.00	12.20	ft (=WS - 145)	**Zi = INVERT =**	**145.0** ft
Edge Effort Weighting Factor =	0.5				

		Aprrox internal dimension =	3.5 ft	Div
X1 = Side Edge width inc=	3	Number of Internal X Increments =	4.0	8
Y1 = Vertical edge height incr =	2	Number of Internal Y Increments =	4.0	8

Horiz. No.:	Formula for Distance from surface	Depth from Surface (ft)	Vert. Sect. No:	1	2	3	4	5	6	Ave. Integr. Vel.
			Distance From Left	1.5	4.8	8.3	11.8	15.3	18.5	
			Actual	1.5	4.8	8.3	11.8	15.3	18.5	
1	0.5 * Y1	1.00	Counts	68	65	64	66	68	69	
			duration	40	40.1	40.5	40.5	40.5	40.3	
			VELOCITY	3.77	3.59	3.50	3.61	3.72	3.79	3.64 ft/s
2	Y1 + (Y-2*Y1)/6	3.30	Counts	68	68	62	66	67	71	
			duration	40	40	40.4	40.2	40	40.3	
			VELOCITY	3.77	3.77	3.40	3.64	3.71	3.90	3.72 ft/s
3	Y/2	6.00	Counts	52	70	70	64	69	72	
			duration	40	40	40.2	40.1	40.6	40.3	
			VELOCITY	2.88	3.88	3.86	3.54	3.76	3.96	3.96 ft/s
4	Y1 + 5* (Y-2*Y1)/6	8.70	Counts	73	75	73	71	74	73	
			duration	40	40.5	40	40	40.1	40	
			VELOCITY	4.04	4.10	4.04	3.93	4.09	4.04	4.04 ft/s
5	Y - 0.5*Y1	11.00	Counts	72	77	75	72	76	73	
			duration	40	40	40.2	40.3	40.3	40	
			VELOCITY	3.99	4.26	4.13	3.96	4.18	4.04	4.04 ft/s

Total Average Integrated Velocity = **3.78** ft/s

Total Computed AWS FLOW RATE = **915** cfs (= B * Y * V)

NOTES:

MEMORANDUM TO THE FILES Feb. 3, 1999

SUBJECT: Flow Measurements at The Dalles AWSS taken on December 16, 1997

INTRODUCTION AND PURPOSE

On 12/16/97, CENWP-PE-HD conducted flow measurements at the intake for Auxiliary Water Supply System (AWSS) for The Dalles North Fishway. WASCO county PUD personnel operated the turbine unit and two sluice gates. The Dalles Project personnel were also present. The purpose of the measurements was to determine flow capacities in the plunge pool system with and without turbine flow. PE-HD also needed to develop comparative discharge coefficients for the two sluice gates with and without turbine operation.

Flow from both the turbine and the plunge pool feed the diffuser system for The Dalles North fish ladder. Direct flow into the plunge pool is regulated by the two sluice gates. They are six feet by seven feet in dimension and are oriented 90 degrees with respect to the turbine system entrance.

MEASUREMENTS METHODS

The measurements were taken using a Price meter equipped with a counter, which provides the number of propeller rotations during a specified duration of time. The number of propeller rotations recorded over a certain time duration provides the average flow velocity at the measurement location.

All measurements were taken from the railing just downstream (west) of the forebay tainter gate. This would insure the combined flow into the gates and turbine would be measured. The 20-foot wide channel width was divided into four evenly spaced measurement columns with velocities taken at four different depths in each column. The velocities computed from each point was averaged and multiplied by the measured flow depth to obtain the flow quantities for each test.

During each test, the water surface elevations in the plunge pool were measured from the bridge deck (elevation 105 feet) on between the pool and the fish ladder.

The following five flow tests were performed:

a) Turbine shut off; sluice gates 33% open
b) Turbine shut off; sluice gates 68% open
c) Turbine shut off; sluice gates 94% open
d) Turbine on ; sluice gates 33% open
e) Turbine on ; sluice gates 50% open

Stephen Schlenker, PE-HD

FLOW MEASUREMENTS AT DALLES AWWS INTAKE: 12/16/97

Auxilary Water Supply System for Dalles North Fish Ladder

1	2	3	4	5	6	7	8	9
			Sluice Gates	PUD rating	**ACTUAL MEASUREMENTS:**			
Test No.	TURBINE ON	TURBINE OFF	Opening Percentage	curve (cfs)	**Total AWSS Flow (cfs)**	Flow into Plunge Pool (cfs)	Assumed Turbine Flow (cfs)	Maximum Water Surface EL. in Plunge Pool (ft.)
1		X	33%	550	**723**	723		**81.5**
2		X	68%	1000	**1219**	1219		**86.4**
3		X	94%	1350	**1368**	1368		**88.3**
4	X		33%	1350	**1449**	649	800	**84.0**
5	X		50%	1600	**1747**	947	800	**86.3**

Forebay Elevation = 156.3' - 156.5'

Tailwater Elevation = 76.1' (in morning)

APPENDIX C: MODEL OUTPUT FOR DATA COLLECTION CONDITIONS

APPENDIX A- Calibration Output Files

TW=79.5

Dalles North Fishladder

Dalles North FishLadder
Revised Model
Calibration Run

Single Fishladder and Collection Channel Adult Fish Bypass Model
written for Portland District by northwest hydraulic consultants
US Army Corps of Engineers (206)241-6000 nhc@nhc-sea.com

Tailwater Elevation:79.5000

Weir no.	Weir Width	Crest Len	Crest Elev	W.S. Elev	Q	Weir Q	Orifice Q	h0	h1	h2	Weir Vel	Weir Coef
Base of Fishladder				80.72								
70	24.00	24.00	70.00	80.76	420.58	415.04	5.54	0.04	10.76	10.72	1.79	4.20
Ladder Diffuser 999 Discharge: 77.51 Vel: 0.21												
71	24.00	24.00	71.00	80.79	343.07	338.12	4.94	0.03	9.79	9.76	1.62	4.20
72	24.00	24.00	72.00	80.83	343.07	337.23	5.83	0.04	8.83	8.79	1.81	4.20
Ladder Diffuser 1 Discharge: 76.13 Vel: 0.21												
73	24.00	24.00	73.00	80.86	266.95	261.86	5.09	0.03	7.86	7.83	1.61	4.20
74	24.00	24.00	74.00	80.91	266.95	260.64	6.30	0.05	6.91	6.86	1.86	4.20
Ladder Diffuser 2 Discharge: 74.59 Vel: 0.20												
75	24.00	24.00	75.00	80.94	192.36	187.04	5.32	0.03	5.94	5.91	1.60	4.20
76	24.00	24.00	76.00	81.01	192.36	185.20	7.16	0.06	5.01	4.94	1.97	4.20
Ladder Diffuser 3 Discharge: 72.32 Vel: 0.20												
77	24.00	24.00	77.00	81.04	120.03	114.31	5.72	0.04	4.04	4.01	1.61	4.20
78	24.00	24.00	78.00	81.15	120.03	110.81	9.22	0.10	3.15	3.04	2.24	4.20
Ladder Diffuser 4 Discharge: 44.94 Vel: 0.12												
79	24.00	24.00	79.00	81.27	75.09	65.11	9.98	0.12	2.27	2.15	2.29	4.20
80	24.00	24.00	80.00	81.60	75.09	58.42	16.67	0.33	1.60	1.27	3.32	4.20
Ladder Diffuser 5 Discharge: 0.00 Vel: 0.00												

81	24.00	24.00	81.00	82.21	75.09	52.44	22.65	0.61	1.21	0.60	3.93	4.20
82	24.00	24.00	82.00	83.06	75.09	48.53	26.56	0.85	1.06	0.21	4.17	4.20
Ladder Diffuser 6 Discharge: 0.00 Vel: 0.00												
83	24.00	24.00	83.00	84.01	75.09	46.87	28.22	0.95	1.01	0.06	4.20	4.20
84	24.00	24.00	84.00	85.00	75.09	46.35	28.74	0.99	1.00	0.01	4.20	4.20
Ladder Diffuser 7 Discharge: 0.00 Vel: 0.00												
85	24.00	24.00	85.00	86.00	75.09	46.23	28.86	1.00	1.00	0.00	4.20	4.20
86	24.00	24.00	86.00	87.00	75.09	46.21	28.88	1.00	1.00	0.00	4.20	4.20
Ladder Diffuser 8 Discharge: 0.00 Vel: 0.00												
87	24.00	24.00	87.00	88.00	75.09	46.20	28.89	1.00	1.00	0.00	4.20	4.20
88	24.00	24.00	88.00	89.00	75.09	46.20	28.89	1.00	1.00	0.00	4.20	4.20
Ladder Diffuser 9 Discharge: 0.00 Vel: 0.00												
89	24.00	24.00	89.00	90.00	75.09	46.20	28.89	1.00	1.00	0.00	4.20	4.20
90	24.00	24.00	90.00	91.00	75.09	46.20	28.89	1.00	1.00	0.00	4.20	4.20
Ladder Diffuser 10 Discharge: 0.00 Vel: 0.00												
91	24.00	24.00	91.00	92.00	75.09	46.20	28.89	1.00	1.00	0.00	4.20	4.20
92	24.00	24.00	92.00	93.00	75.09	46.20	28.89	1.00	1.00	0.00	4.20	4.20
Ladder Diffuser 11 Discharge: 0.00 Vel: 0.00												
93	24.00	24.00	93.00	94.00	75.09	46.20	28.89	1.00	1.00	0.00	4.20	4.20

---Entrance-----		----CC Diffuser----------			-------CC----------		--Distance to-
Gate No.	Discharge (cfs)	No.	Discharge (cfs)	Velocity (fps)	Discharge (cfs)	Velocity (fps)	Elev (ft)	D/S Entrance (ft)
					420.58			
					420.58	1.02	80.72	183.
		900	70.57	0.20				
					491.15	1.19	80.72	167.
		800	68.28	0.20				
					559.43	1.35	80.72	151.
		700	68.54	0.20				
					627.96	1.52	80.71	135.
		600	68.92	0.20				
					696.88	1.69	80.70	119.
		500	69.37	0.16				
					766.25	1.86	80.70	104.

400 69.77 0.16

836.03 2.16 80.69 90.

300 55.24 0.24

891.27 2.16 80.67 70.

200 39.30 0.20

930.56 2.26 80.67 70.

100 0.00 0.00

930.56 2.25 80.66 65.

1 930.25

Weir Elev: 70.30 ft

********** 80.74 0.

Head: 1.24 ft

2 0.00

Weir Elev:****** ft

********** 80.74 0.

3 0.00

Weir Elev:****** ft

******** 0.00 80.74 0.

Head: 1.24 ft

| Summary Table |

|

| Tailwater Elevation(s): 79.50 |

| Channel Head: 1.24 |

|

| Inflows Q V Outflows |

| ------- -------- |

|Fish Ladder Discharge : 75.09 |

| Ladder Diffuser 4: 44.94 0.12 Entrance 1: 930.25 |

| Ladder Diffuser 3: 72.32 0.20 Entrance 2: 0.00 |

| Ladder Diffuser 2: 74.59 0.20 Entrance 3: 0.00 |

Ladder Diffuser 1: 76.13 0.21
Ladder Diffuser 999: 77.51 0.21
CC Diffuser 900: 70.57 0.20
CC Diffuser 800: 68.28 0.20
CC Diffuser 700: 68.54 0.20
CC Diffuser 600: 68.92 0.20
CC Diffuser 500: 69.37 0.16
CC Diffuser 400: 69.77 0.16
CC Diffuser 300: 55.24 0.24
CC Diffuser 200: 39.30 0.20

Total Inflow: 930.56	Total Outflow: 930.25


```
**********************************************************************
*                    N H C N E T                     *
*          modified from EPANET version 1.1e             *
*          by northwest hydraulic consultants            *
*       Seattle, Washington  USA     (206) 241-6000       *
*              Hydraulic for Pipe Networks               *
*                    Version 1.0                     *
**********************************************************************
```

The Dalles North Fishladder

Input Data File FISH.IN2
Output Report File ..... FISH.NRT
Verification File .....
Hydraulics File .....

Number of Pipes 126
Number of Nodes 128
Number of Tanks 22
Number of Pumps 0
Number of Valves 8
Headloss Formula ..... Darcy-Weisbach
Hydraulic Accuracy 0.010000
Maximum Trials 300
Specific Gravity 1.00
Kinematic Viscosity ..... 1.00e-005 sq ft/sec
Reporting Criteria:
All Nodes
All Links

Node Results:

Node	Elev. ft	Demand cfs	Grade ft	Pressure psi
10	0.00	0.00	81.97	35.52
11	0.00	0.00	81.97	35.52
12	0.00	0.00	93.01	40.30
13	0.00	0.00	93.01	40.30
33	0.00	0.00	82.02	35.54
50	0.00	0.00	81.97	35.52
51	0.00	0.00	81.97	35.52
52	0.00	0.00	81.97	35.52
53	0.00	0.00	81.97	35.52
54	0.00	0.00	81.97	35.52
55	0.00	0.00	81.97	35.52
56	0.00	0.00	81.97	35.52
57	0.00	0.00	81.97	35.52
58	0.00	0.00	81.96	35.51

59	0.00	0.00	81.95	35.51
60	0.00	0.00	81.94	35.51
61	0.00	0.00	81.94	35.50
62	0.00	0.00	81.60	35.36
63	0.00	0.00	81.59	35.35
64	0.00	0.00	81.58	35.35
65	0.00	0.00	81.58	35.35
66	0.00	0.00	81.57	35.34
67	0.00	0.00	81.56	35.34
68	0.00	0.00	81.56	35.34
69	0.00	0.00	81.56	35.34
70	0.00	0.00	81.56	35.34
100	0.00	0.00	81.97	35.52
101	0.00	0.00	81.97	35.52
102	0.00	0.00	91.02	39.44
103	0.00	0.00	91.02	39.44
200	0.00	0.00	81.97	35.52
201	0.00	0.00	81.97	35.52
202	0.00	0.00	89.04	38.58
203	0.00	0.00	89.04	38.58
300	0.00	0.00	81.97	35.52
301	0.00	0.00	81.97	35.52
302	0.00	0.00	87.05	37.72
303	0.00	0.00	87.05	37.72
400	0.00	0.00	81.97	35.52
401	0.00	0.00	81.97	35.52
402	0.00	0.00	85.06	36.86
403	0.00	0.00	85.06	36.86
500	0.00	0.00	81.97	35.52
501	0.00	0.00	81.97	35.52
502	0.00	0.00	83.13	36.02
503	0.00	0.00	83.13	36.02
600	0.00	0.00	81.97	35.52
601	0.00	0.00	81.97	35.52
602	0.00	0.00	81.57	35.34

603	0.00	0.00	81.57	35.34
700	0.00	0.00	81.75	35.42
701	0.00	0.00	81.74	35.42
702	0.00	0.00	81.17	35.17
703	0.00	0.00	81.13	35.15
800	0.00	0.00	81.40	35.27
801	0.00	0.00	81.36	35.25
802	0.00	0.00	81.30	35.23
803	0.00	0.00	81.20	35.18
900	0.00	0.00	81.35	35.25
901	0.00	0.00	81.31	35.23
902	0.00	0.00	81.25	35.20
903	0.00	0.00	81.13	35.16
1010	0.00	0.00	81.31	35.23
1011	0.00	0.00	81.26	35.21
1012	0.00	0.00	81.20	35.18
1013	0.00	0.00	81.08	35.13
1100	0.00	0.00	81.27	35.22
1101	0.00	0.00	81.23	35.20
1102	0.00	0.00	81.16	35.17
1103	0.00	0.00	81.04	35.11
1200	0.00	0.00	81.12	35.15
1201	0.00	0.00	81.11	35.15
1202	0.00	0.00	81.11	35.14
1203	0.00	0.00	81.02	35.11
1300	0.00	0.00	81.12	35.15
1301	0.00	0.00	81.11	35.15
1302	0.00	0.00	81.07	35.13
1303	0.00	0.00	80.99	35.09
1400	0.00	0.00	81.12	35.15
1401	0.00	0.00	81.11	35.15
1402	0.00	0.00	81.07	35.13
1403	0.00	0.00	80.99	35.09
1500	0.00	0.00	81.12	35.15
1501	0.00	0.00	81.11	35.15

1502	0.00	0.00	81.07	35.13	
1503	0.00	0.00	80.99	35.09	
1600	0.00	0.00	81.12	35.15	
1601	0.00	0.00	81.11	35.15	
1602	0.00	0.00	81.07	35.13	
1603	0.00	0.00	80.99	35.09	
1700	0.00	0.00	81.12	35.15	
1701	0.00	0.00	81.11	35.15	
1702	0.00	0.00	81.07	35.13	
1703	0.00	0.00	80.99	35.09	
1800	0.00	0.00	81.27	35.21	
1801	0.00	0.00	81.20	35.19	
1802	0.00	0.00	81.19	35.18	
1803	0.00	0.00	80.98	35.09	
1900	0.00	0.00	80.93	35.07	
1901	0.00	0.00	80.92	35.06	
1902	0.00	0.00	80.91	35.06	
1903	0.00	0.00	80.80	35.01	
2000	0.00	0.00	80.61	34.93	
2001	0.00	0.00	80.61	34.93	
2002	0.00	0.00	80.61	34.93	
2003	0.00	0.00	80.61	34.93	
14	93.01	0.00	93.01	0.00	Reservoir
104	91.02	0.00	91.02	0.00	Reservoir
204	89.04	0.00	89.04	0.00	Reservoir
304	87.05	0.00	87.05	0.00	Reservoir
404	85.06	0.00	85.06	0.00	Reservoir
504	83.13	0.00	83.13	0.00	Reservoir
604	81.57	-0.00	81.57	0.00	Reservoir
704	80.97	44.42	80.97	0.00	Reservoir
804	80.78	71.02	80.78	0.00	Reservoir
904	80.68	73.82	80.68	0.00	Reservoir
1014	80.60	75.80	80.60	0.00	Reservoir
1104	80.53	77.67	80.53	0.00	Reservoir
1204	80.68	64.49	80.68	0.00	Reservoir

1304	80.67	62.60	80.67	0.00	Reservoir
1404	80.66	62.97	80.66	0.00	Reservoir
1504	80.66	63.40	80.66	0.00	Reservoir
1604	80.65	64.01	80.65	0.00	Reservoir
1704	80.64	64.59	80.64	0.00	Reservoir
1804	80.62	51.14	80.62	0.00	Reservoir
1904	80.62	36.38	80.62	0.00	Reservoir
2004	80.61	0.00	80.61	0.00	Reservoir
30	82.07	-812.30	82.07	0.00	Reservoir

Link Results:

Link	Start Node	End Node	Width ft	Height ft	Flow cfs	Velocity fps
51	51	50	6.00	5.00	0.00	0.00
10	50	10	3.87	4.00	0.00	0.00
11	10	11	8.00	7.00	0.00	0.00
13	12	13	3.00	11.50	0.00	0.00
14	13	14	15.33	24.00	0.00	0.00
52	52	51	6.00	9.30	0.00	0.00
100	51	100	3.87	4.00	-0.00	0.00
101	100	101	8.00	7.00	0.00	0.00
103	102	103	3.00	11.50	0.00	0.00
104	103	104	15.33	24.00	0.00	0.00
53	53	52	6.00	12.00	0.00	0.00
200	52	200	3.87	4.00	-0.00	0.00
201	200	201	8.00	7.00	0.00	0.00
203	202	203	3.00	11.50	0.00	0.00
204	203	204	15.33	24.00	0.00	0.00
54	54	53	6.00	16.00	0.00	0.00
300	53	300	3.87	4.00	0.00	0.00
301	300	301	8.00	7.00	0.00	0.00
303	302	303	3.00	11.50	0.00	0.00

304	303	304	15.33	24.00	0.00	0.00
55	55	54	6.00	18.70	0.00	0.00
400	54	400	3.87	4.00	0.00	0.00
401	400	401	8.00	7.00	0.00	0.00
403	402	403	3.00	11.50	0.00	0.00
404	403	404	15.33	24.00	0.00	0.00
56	56	55	6.00	21.30	0.00	0.00
500	55	500	3.87	4.00	-0.00	0.00
501	500	501	8.00	7.00	-0.00	0.00
503	502	503	3.00	11.50	0.00	0.00
504	503	504	15.33	24.00	0.00	0.00
31	30	33	9.00	9.50	406.15	4.75
32	30	33	9.00	9.50	406.15	4.75
34	33	56	9.00	9.50	395.41	4.62
57	57	56	7.00	22.50	-395.41	2.51
600	56	600	3.87	4.00	0.00	0.00
601	600	601	8.00	7.00	0.00	0.00
603	602	603	3.00	11.50	0.00	0.00
604	603	604	15.33	15.33	-0.00	0.00
35	33	57	9.00	9.50	416.89	4.88
700	57	700	3.87	4.00	44.42	2.87
701	700	701	8.00	7.00	44.42	0.79
703	702	703	3.00	11.50	44.42	1.29
704	703	704	15.33	24.00	44.42	0.12
58	57	58	7.90	22.50	767.88	4.32
800	58	800	3.87	4.00	71.02	4.59
801	800	801	8.00	7.00	71.02	1.27
803	802	803	3.00	11.50	71.02	2.06
804	803	804	15.33	24.00	71.02	0.19
59	58	59	9.00	22.50	696.86	3.44
900	59	900	3.87	4.00	73.82	4.77
901	900	901	8.00	7.00	73.82	1.32
903	902	903	3.00	11.50	73.82	2.14
904	903	904	15.33	24.00	73.82	0.20
60	59	60	9.50	22.50	623.04	2.91

1010	60	1010	3.87	4.00	75.80	4.90
1011	1010	1011	8.00	7.00	75.80	1.35
1013	1012	1013	3.00	11.50	75.80	2.20
1014	1013	1014	15.33	24.00	75.80	0.21
61	60	61	9.58	21.50	547.25	2.66
1100	61	1100	3.87	4.00	77.67	5.02
1101	1100	1101	8.00	7.00	77.67	1.39
1103	1102	1103	3.00	11.50	77.67	2.25
1104	1103	1104	15.33	24.00	77.67	0.21
62	61	62	10.00	22.50	469.58	2.09
1200	62	1200	3.87	4.00	62.67	4.05
1201	1200	1201	7.00	16.00	64.49	0.58
1202	1201	1202	7.00	16.00	64.49	0.58
1203	1202	1203	3.00	16.00	64.49	1.34
1204	1203	1204	15.33	24.00	64.49	0.18
63	62	63	9.58	17.50	406.90	2.43
1300	63	1300	3.87	4.00	64.70	4.18
1301	1300	1301	7.00	16.00	62.60	0.56
1302	1301	1302	3.00	16.00	62.60	1.30
1303	1302	1303	3.00	16.00	62.60	1.30
1304	1303	1304	15.33	24.00	62.60	0.17
64	63	64	9.58	15.50	342.20	2.30
1400	64	1400	3.87	4.00	64.41	4.16
1401	1400	1401	7.00	16.00	62.97	0.56
1402	1401	1402	3.00	16.00	62.97	1.31
1403	1402	1403	3.00	16.00	62.97	1.31
1404	1403	1404	15.33	24.00	62.97	0.17
65	64	65	9.58	13.50	277.79	2.15
1500	65	1500	3.87	4.00	64.15	4.14
1501	1500	1501	7.00	16.00	63.40	0.57
1502	1501	1502	3.00	16.00	63.40	1.32
1503	1502	1503	3.00	16.00	63.40	1.32
1504	1503	1504	15.33	24.00	63.40	0.17
66	65	66	9.58	10.60	213.64	2.10
1600	66	1600	3.87	4.00	63.52	4.10

1601	1600	1601	7.00	16.00	64.01	0.57
1602	1601	1602	3.00	16.00	64.01	1.33
1603	1602	1603	3.00	16.00	64.01	1.33
1604	1603	1604	15.33	24.00	64.01	0.17
67	66	67	9.58	7.75	150.13	2.02
1700	67	1700	3.87	4.00	62.61	4.04
1701	1700	1701	7.00	16.00	64.59	0.58
1702	1701	1702	3.00	16.00	64.59	1.35
1703	1702	1703	3.00	16.00	64.59	1.35
1704	1703	1704	15.33	24.00	64.59	0.18
68	67	68	10.00	8.00	87.51	1.09
1800	68	1800	3.87	4.00	51.14	3.30
1801	1800	1801	4.00	8.00	51.14	1.60
1802	1801	1802	7.50	8.00	51.14	0.85
1803	1802	1803	3.00	8.00	51.14	2.13
1804	1803	1804	8.00	36.00	51.14	0.18
69	68	69	9.58	8.00	36.38	0.47
1900	69	1900	1.87	4.00	36.38	4.86
1901	1900	1901	7.00	8.00	36.38	0.65
1902	1901	1902	7.50	8.00	36.38	0.61
1903	1902	1903	3.00	8.00	36.38	1.52
1904	1903	1904	8.00	36.00	36.38	0.13
70	69	70	9.58	4.00	-0.00	0.00
2000	70	2000	3.87	4.00	0.00	Closed
2001	2000	2001	7.00	12.00	0.00	0.00
2002	2001	2002	7.50	12.00	0.00	0.00
2003	2002	2003	3.00	12.00	0.00	0.00
2004	2003	2004	8.00	24.00	0.00	0.00
1205	1200	1300	7.00	12.00	-1.82	0.02
1305	1300	1400	7.00	12.00	0.29	0.00
1405	1400	1500	7.00	12.00	1.73	0.02
1505	1500	1600	7.00	12.00	2.47	0.03
1605	1600	1700	7.00	30.00	1.98	0.01
802	801	802	3.00	15.30	71.02	1.55
902	901	902	3.00	15.30	73.82	1.61

1012	1011	1012	3.00	15.30	75.80	1.65
1102	1101	1102	3.00	15.30	77.67	1.69
12	11	12	16.00 El: 94.00		0.00	Closed WV
102	101	102	16.00 El: 92.00		0.00	Closed WV
202	201	202	16.00 El: 90.00		0.00	Closed WV
302	301	302	16.00 El: 88.00		0.00	Closed WV
402	401	402	16.00 El: 86.00		0.00	Closed WV
502	501	502	16.00 El: 84.00		0.00	Closed WV
602	601	602	16.00 El: 82.00		0.00	Closed WV
702	701	702	16.00 El: 80.00		44.42	0.22 WV

TW=75.3

Dalles North Fishladder

Dalles North FishLadder
Revised Model
Calibration Run

Single Fishladder and Collection Channel Adult Fish Bypass Model
written for Portland District by northwest hydraulic consultants
US Army Corps of Engineers (206)241-6000 nhc@nhc-sea.com

Tailwater Elevation:75.3000

Weir no.	Weir Width	Crest Len	Crest Elev	W.S. Elev	Q	Weir Q	Orifice Q	h0	h1	h2	Weir Vel	Weir Coef
Base of Fishladder				76.62								
70	24.00	24.00	70.00	76.74	370.61	360.56	10.05	0.12	6.74	6.62	2.66	4.20
Ladder Diffuser 999 Discharge: 103.47 Vel: 0.28												
71	24.00	24.00	71.00	76.82	267.14	258.73	8.42	0.08	5.82	5.74	2.27	4.20
72	24.00	24.00	72.00	76.97	267.14	256.07	11.08	0.15	4.97	4.82	2.74	4.20
Ladder Diffuser 1 Discharge: 99.00 Vel: 0.27												
73	24.00	24.00	73.00	77.06	168.15	159.39	8.76	0.09	4.06	3.97	2.23	4.20
74	24.00	24.00	74.00	77.27	168.15	154.95	13.20	0.21	3.27	3.06	2.95	4.20
Ladder Diffuser 2 Discharge: 71.14 Vel: 0.19												
75	24.00	24.00	75.00	77.44	97.01	85.18	11.83	0.17	2.44	2.27	2.62	4.20
76	24.00	24.00	76.00	77.88	97.01	77.81	19.20	0.44	1.88	1.44	3.76	4.20
Ladder Diffuser 3 Discharge: 21.92 Vel: 0.06												
77	24.00	24.00	77.00	78.36	75.09	55.11	19.98	0.48	1.36	0.88	3.69	4.20
78	24.00	24.00	78.00	79.11	75.09	50.04	25.05	0.75	1.11	0.36	4.09	4.20
Ladder Diffuser 4 Discharge: 0.00 Vel: 0.00												
79	24.00	24.00	79.00	80.03	75.09	47.44	27.65	0.92	1.03	0.11	4.20	4.20
80	24.00	24.00	80.00	81.01	75.09	46.51	28.58	0.98	1.01	0.03	4.20	4.20
Ladder Diffuser 5 Discharge: 0.00 Vel: 0.00												
81	24.00	24.00	81.00	82.00	75.09	46.27	28.82	1.00	1.00	0.01	4.20	4.20

82 24.00 24.00 82.00 83.00 75.09 46.21 28.88 1.00 1.00 0.00 4.20 4.20

Ladder Diffuser 6 Discharge: 0.00 Vel: 0.00

83 24.00 24.00 83.00 84.00 75.09 46.20 28.89 1.00 1.00 0.00 4.20 4.20

84 24.00 24.00 84.00 85.00 75.09 46.20 28.89 1.00 1.00 0.00 4.20 4.20

Ladder Diffuser 7 Discharge: 0.00 Vel: 0.00

85 24.00 24.00 85.00 86.00 75.09 46.20 28.89 1.00 1.00 0.00 4.20 4.20

86 24.00 24.00 86.00 87.00 75.09 46.20 28.89 1.00 1.00 0.00 4.20 4.20

Ladder Diffuser 8 Discharge: 0.00 Vel: 0.00

87 24.00 24.00 87.00 88.00 75.09 46.20 28.89 1.00 1.00 0.00 4.20 4.20

88 24.00 24.00 88.00 89.00 75.09 46.20 28.89 1.00 1.00 0.00 4.20 4.20

Ladder Diffuser 9 Discharge: 0.00 Vel: 0.00

89 24.00 24.00 89.00 90.00 75.09 46.20 28.89 1.00 1.00 0.00 4.20 4.20

90 24.00 24.00 90.00 91.00 75.09 46.20 28.89 1.00 1.00 0.00 4.20 4.20

Ladder Diffuser 10 Discharge: 0.00 Vel: 0.00

91 24.00 24.00 91.00 92.00 75.09 46.20 28.89 1.00 1.00 0.00 4.20 4.20

92 24.00 24.00 92.00 93.00 75.09 46.20 28.89 1.00 1.00 0.00 4.20 4.20

Ladder Diffuser 11 Discharge: 0.00 Vel: 0.00

93 24.00 24.00 93.00 94.00 75.09 46.20 28.89 1.00 1.00 0.00 4.20 4.20

---Entrance-----		----CC Diffuser----------			-------CC----------		--Distance to-
Gate No.	Discharge (cfs)	No.	Discharge (cfs)	Velocity (fps)	Discharge (cfs)	Velocity (fps)	Elev (ft)	D/S Entrance (ft)
					370.61			
					370.61	1.18	76.62	183.
		900	92.08	0.26				
					462.69	1.47	76.62	167.
		800	89.10	0.26				
					551.80	1.76	76.61	151.
		700	89.63	0.26				
					641.43	2.05	76.59	135.
		600	90.30	0.26				
					731.73	2.34	76.57	119.
		500	91.19	0.21				
					822.92	2.63	76.55	104.
		400	92.03	0.21				

914.95 3.17 76.53 90.

300 72.90 0.32

987.85 3.17 76.48 70.

200 51.86 0.26

1039.71 3.34 76.48 70.

100 0.00 0.00

1039.71 3.30 76.46 65.

1 1040.46

Weir Elev: 66.74 ft

********** 76.63 0.

Head: 1.33 ft

2 0.00

Weir Elev:****** ft

********** 76.63 0.

3 0.00

Weir Elev:****** ft

******** 0.00 76.63 0.

Head: 1.33 ft

| Summary Table |

| |

| Tailwater Elevation(s): 75.30 |

| Channel Head: 1.33 |

| |

| Inflows Q V Outflows |

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|Fish Ladder Discharge : 75.09 |

| Ladder Diffuser 3: 21.92 0.06 Entrance 1: 1040.46 |

| Ladder Diffuser 2: 71.14 0.19 Entrance 2: 0.00 |

| Ladder Diffuser 1: 99.00 0.27 Entrance 3: 0.00 |

| Ladder Diffuser 999: 103.47 0.28 |

CC Diffuser 900: 92.08 0.26	
CC Diffuser 800: 89.10 0.26	
CC Diffuser 700: 89.63 0.26	
CC Diffuser 600: 90.30 0.26	
CC Diffuser 500: 91.19 0.21	
CC Diffuser 400: 92.03 0.21	
CC Diffuser 300: 72.90 0.32	
CC Diffuser 200: 51.86 0.26	

Total Inflow: 1039.71	Total Outflow: 1040.46


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**********************************************************************
*                    N H C N E T                     *
*          modified from EPANET version 1.1e             *
*          by northwest hydraulic consultants            *
*        Seattle, Washington  USA     (206) 241-6000       *
*              Hydraulic for Pipe Networks               *
*                    Version 1.0                     *
**********************************************************************
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The Dalles North Fishladder

Input Data File FISH.IN2
Output Report File ..... FISH.NRT
Verification File .....
Hydraulics File .....
Number of Pipes 124
Number of Nodes 128

Number of Tanks 22
Number of Pumps 0
Number of Valves 10
Headloss Formula ..... Darcy-Weisbach
Hydraulic Accuracy 0.010000
Maximum Trials 300
Specific Gravity 1.00
Kinematic Viscosity ..... 1.00e-005 sq ft/sec
Reporting Criteria:
All Nodes
All Links

Node Results:

Node	Elev. ft	Demand cfs	Grade ft	Pressure psi
10	0.00	0.00	78.96	34.21
11	0.00	0.00	78.96	34.21
12	0.00	0.00	93.01	40.30
13	0.00	0.00	93.01	40.30
33	0.00	0.00	79.02	34.24
50	0.00	0.00	78.96	34.21
51	0.00	0.00	78.96	34.21
52	0.00	0.00	78.96	34.21
53	0.00	0.00	78.96	34.21
54	0.00	0.00	78.96	34.21
55	0.00	0.00	78.96	34.21
56	0.00	0.00	78.96	34.21
57	0.00	0.00	78.96	34.21
58	0.00	0.00	78.94	34.20
59	0.00	0.00	78.93	34.20
60	0.00	0.00	78.91	34.19

61	0.00	0.00	78.91	34.19
62	0.00	0.00	78.27	33.92
63	0.00	0.00	78.25	33.90
64	0.00	0.00	78.24	33.90
65	0.00	0.00	78.23	33.90
66	0.00	0.00	78.22	33.89
67	0.00	0.00	78.19	33.88
68	0.00	0.00	78.19	33.88
69	0.00	0.00	78.19	33.88
70	0.00	0.00	78.19	33.88
100	0.00	0.00	78.96	34.21
101	0.00	0.00	78.96	34.21
102	0.00	0.00	91.02	39.44
103	0.00	0.00	91.02	39.44
200	0.00	0.00	78.96	34.21
201	0.00	0.00	78.96	34.21
202	0.00	0.00	89.03	38.58
203	0.00	0.00	89.03	38.58
300	0.00	0.00	78.96	34.21
301	0.00	0.00	78.96	34.21
302	0.00	0.00	87.04	37.72
303	0.00	0.00	87.04	37.72
400	0.00	0.00	78.96	34.21
401	0.00	0.00	78.96	34.21
402	0.00	0.00	85.05	36.85
403	0.00	0.00	85.05	36.85
500	0.00	0.00	78.96	34.21
501	0.00	0.00	78.96	34.21
502	0.00	0.00	83.06	35.99
503	0.00	0.00	83.06	35.99
600	0.00	0.00	78.96	34.21
601	0.00	0.00	78.96	34.21
602	0.00	0.00	81.07	35.13
603	0.00	0.00	81.07	35.13
700	0.00	0.00	78.96	34.21

701	0.00	0.00	78.96	34.21
702	0.00	0.00	79.17	34.30
703	0.00	0.00	79.17	34.30
800	0.00	0.00	78.89	34.18
801	0.00	0.00	78.88	34.18
802	0.00	0.00	77.88	33.74
803	0.00	0.00	77.87	33.74
900	0.00	0.00	78.38	33.96
901	0.00	0.00	78.34	33.95
902	0.00	0.00	77.57	33.61
903	0.00	0.00	77.47	33.57
1010	0.00	0.00	77.86	33.74
1011	0.00	0.00	77.78	33.70
1012	0.00	0.00	77.68	33.66
1013	0.00	0.00	77.48	33.57
1100	0.00	0.00	77.73	33.68
1101	0.00	0.00	77.65	33.64
1102	0.00	0.00	77.53	33.59
1103	0.00	0.00	77.31	33.50
1200	0.00	0.00	77.39	33.53
1201	0.00	0.00	77.37	33.53
1202	0.00	0.00	77.36	33.52
1203	0.00	0.00	77.20	33.45
1300	0.00	0.00	77.39	33.53
1301	0.00	0.00	77.37	33.53
1302	0.00	0.00	77.30	33.49
1303	0.00	0.00	77.15	33.43
1400	0.00	0.00	77.39	33.53
1401	0.00	0.00	77.37	33.53
1402	0.00	0.00	77.30	33.49
1403	0.00	0.00	77.15	33.43
1500	0.00	0.00	77.39	33.53
1501	0.00	0.00	77.37	33.53
1502	0.00	0.00	77.29	33.49
1503	0.00	0.00	77.14	33.43

1600	0.00	0.00	77.39	33.53	
1601	0.00	0.00	77.37	33.53	
1602	0.00	0.00	77.29	33.49	
1603	0.00	0.00	77.14	33.42	
1700	0.00	0.00	77.39	33.53	
1701	0.00	0.00	77.37	33.53	
1702	0.00	0.00	77.29	33.49	
1703	0.00	0.00	77.13	33.42	
1800	0.00	0.00	77.65	33.64	
1801	0.00	0.00	77.53	33.59	
1802	0.00	0.00	77.50	33.58	
1803	0.00	0.00	77.10	33.41	
1900	0.00	0.00	77.00	33.37	
1901	0.00	0.00	76.99	33.36	
1902	0.00	0.00	76.97	33.35	
1903	0.00	0.00	76.77	33.26	
2000	0.00	0.00	76.41	33.11	
2001	0.00	0.00	76.41	33.11	
2002	0.00	0.00	76.41	33.11	
2003	0.00	0.00	76.41	33.11	
14	93.01	-0.00	93.01	0.00	Reservoir
104	91.02	-0.00	91.02	0.00	Reservoir
204	89.03	-0.00	89.03	0.00	Reservoir
304	87.04	0.00	87.04	0.00	Reservoir
404	85.05	0.00	85.05	0.00	Reservoir
504	83.06	0.00	83.06	0.00	Reservoir
604	81.07	0.00	81.07	0.00	Reservoir
704	79.17	0.00	79.17	0.00	Reservoir
804	77.83	22.08	77.83	0.00	Reservoir
904	77.06	70.22	77.06	0.00	Reservoir
1014	76.69	97.75	76.69	0.00	Reservoir
1104	76.43	103.18	76.43	0.00	Reservoir
1204	76.56	87.60	76.56	0.00	Reservoir
1304	76.55	85.02	76.55	0.00	Reservoir
1404	76.54	85.62	76.54	0.00	Reservoir

1504	76.52	86.51	76.52	0.00	Reservoir
1604	76.50	87.51	76.50	0.00	Reservoir
1704	76.48	88.61	76.48	0.00	Reservoir
1804	76.43	70.21	76.43	0.00	Reservoir
1904	76.43	49.94	76.43	0.00	Reservoir
2004	76.41	0.00	76.41	0.00	Reservoir
30	79.09	-934.25	79.09	0.00	Reservoir

Link Results:

Link	Start Node	End Node	Width ft	Height ft	Flow cfs	Velocity fps
51	51	50	6.00	5.00	0.00	0.00
10	50	10	3.87	4.00	0.00	0.00
11	10	11	8.00	7.00	-0.00	0.00
13	12	13	3.00	11.50	-0.00	0.00
14	13	14	15.33	24.00	-0.00	0.00
52	52	51	6.00	9.30	0.00	0.00
100	51	100	3.87	4.00	-0.00	0.00
101	100	101	8.00	7.00	-0.00	0.00
103	102	103	3.00	11.50	-0.00	0.00
104	103	104	15.33	24.00	-0.00	0.00
53	53	52	6.00	12.00	-0.00	0.00
200	52	200	3.87	4.00	-0.00	0.00
201	200	201	8.00	7.00	-0.00	0.00
203	202	203	3.00	11.50	0.00	0.00
204	203	204	15.33	24.00	-0.00	0.00
54	54	53	6.00	16.00	0.00	0.00
300	53	300	3.87	4.00	0.00	0.00
301	300	301	8.00	7.00	0.00	0.00
303	302	303	3.00	11.50	0.00	0.00
304	303	304	15.33	24.00	0.00	0.00
55	55	54	6.00	18.70	0.00	0.00

400	54	400	3.87	4.00	0.00	0.00
401	400	401	8.00	7.00	0.00	0.00
403	402	403	3.00	11.50	0.00	0.00
404	403	404	15.33	24.00	0.00	0.00
56	56	55	6.00	21.30	0.00	0.00
500	55	500	3.87	4.00	-0.00	0.00
501	500	501	8.00	7.00	0.00	0.00
503	502	503	3.00	11.50	0.00	0.00
504	503	504	15.33	24.00	0.00	0.00
31	30	33	9.00	9.50	467.13	5.46
32	30	33	9.00	9.50	467.13	5.46
34	33	56	9.00	9.50	454.80	5.32
57	57	56	7.00	22.50	-454.80	2.89
600	56	600	3.87	4.00	0.00	0.00
601	600	601	8.00	7.00	0.00	0.00
603	602	603	3.00	11.50	0.00	0.00
604	603	604	15.33	15.33	0.00	0.00
35	33	57	9.00	9.50	479.45	5.61
700	57	700	3.87	4.00	-0.00	0.00
701	700	701	8.00	7.00	0.00	0.00
703	702	703	3.00	11.50	0.00	0.00
704	703	704	15.33	24.00	0.00	0.00
58	57	58	7.90	22.50	934.25	5.26
800	58	800	3.87	4.00	22.08	1.43
801	800	801	8.00	7.00	22.08	0.39
803	802	803	3.00	11.50	22.08	0.64
804	803	804	15.33	24.00	22.08	0.06
59	58	59	9.00	22.50	912.17	4.50
900	59	900	3.87	4.00	70.22	4.54
901	900	901	8.00	7.00	70.22	1.25
903	902	903	3.00	11.50	70.22	2.04
904	903	904	15.33	24.00	70.22	0.19
60	59	60	9.50	22.50	841.95	3.94
1010	60	1010	3.87	4.00	97.75	6.31
1011	1010	1011	8.00	7.00	97.75	1.75

1013	1012	1013	3.00	11.50	97.75	2.83
1014	1013	1014	15.33	24.00	97.75	0.27
61	60	61	9.58	21.50	744.20	3.61
1100	61	1100	3.87	4.00	103.18	6.67
1101	1100	1101	8.00	7.00	103.18	1.84
1103	1102	1103	3.00	11.50	103.18	2.99
1104	1103	1104	15.33	24.00	103.18	0.28
62	61	62	10.00	22.50	641.02	2.85
1200	62	1200	3.87	4.00	85.45	5.52
1201	1200	1201	7.00	16.00	87.60	0.78
1202	1201	1202	7.00	16.00	87.60	0.78
1203	1202	1203	3.00	16.00	87.60	1.82
1204	1203	1204	15.33	24.00	87.60	0.24
63	62	63	9.58	17.50	555.58	3.31
1300	63	1300	3.87	4.00	88.21	5.70
1301	1300	1301	7.00	16.00	85.02	0.76
1302	1301	1302	3.00	16.00	85.02	1.77
1303	1302	1303	3.00	16.00	85.02	1.77
1304	1303	1304	15.33	24.00	85.02	0.23
64	63	64	9.58	15.50	467.36	3.15
1400	64	1400	3.87	4.00	87.81	5.67
1401	1400	1401	7.00	16.00	85.62	0.76
1402	1401	1402	3.00	16.00	85.62	1.78
1403	1402	1403	3.00	16.00	85.62	1.78
1404	1403	1404	15.33	24.00	85.62	0.23
65	64	65	9.58	13.50	379.55	2.93
1500	65	1500	3.87	4.00	87.45	5.65
1501	1500	1501	7.00	16.00	86.51	0.77
1502	1501	1502	3.00	16.00	86.51	1.80
1503	1502	1503	3.00	16.00	86.51	1.80
1504	1503	1504	15.33	24.00	86.51	0.24
66	65	66	9.58	10.60	292.10	2.88
1600	66	1600	3.87	4.00	86.59	5.59
1601	1600	1601	7.00	16.00	87.51	0.78
1602	1601	1602	3.00	16.00	87.51	1.82

1603 1602 1603 3.00 16.00 87.51 1.82
1604 1603 1604 15.33 24.00 87.51 0.24
67 66 67 9.58 7.75 205.51 2.77
1700 67 1700 3.87 4.00 85.35 5.51
1701 1700 1701 7.00 16.00 88.61 0.79
1702 1701 1702 3.00 16.00 88.61 1.85
1703 1702 1703 3.00 16.00 88.61 1.85
1704 1703 1704 15.33 24.00 88.61 0.24
68 67 68 10.00 8.00 120.16 1.50
1800 68 1800 3.87 4.00 70.21 4.54
1801 1800 1801 4.00 8.00 70.21 2.19
1802 1801 1802 7.50 8.00 70.21 1.17
1803 1802 1803 3.00 8.00 70.21 2.93
1804 1803 1804 8.00 36.00 70.21 0.24
69 68 69 9.58 8.00 49.94 0.65
1900 69 1900 1.87 4.00 49.94 6.68
1901 1900 1901 7.00 8.00 49.94 0.89
1902 1901 1902 7.50 8.00 49.94 0.83
1903 1902 1903 3.00 8.00 49.94 2.08
1904 1903 1904 8.00 36.00 49.94 0.17
70 69 70 9.58 4.00 -0.00 0.00
2000 70 2000 3.87 4.00 0.00 Closed
2001 2000 2001 7.00 12.00 0.00 0.00
2002 2001 2002 7.50 12.00 0.00 0.00
2003 2002 2003 3.00 12.00 0.00 0.00
2004 2003 2004 8.00 24.00 0.00 0.00
1205 1200 1300 7.00 12.00 -2.15 0.03
1305 1300 1400 7.00 12.00 1.05 0.01
1405 1400 1500 7.00 12.00 3.24 0.04
1505 1500 1600 7.00 12.00 4.18 0.05
1605 1600 1700 7.00 30.00 3.26 0.02
1012 1011 1012 3.00 15.30 97.75 2.13
1102 1101 1102 3.00 15.30 103.18 2.25
12 11 12 16.00 El: 94.00 0.00 Closed WV
102 101 102 16.00 El: 92.00 0.00 Closed WV

202	201	202	16.00	El: 90.00	0.00	Closed	WV
302	301	302	16.00	El: 88.00	0.00	Closed	WV
402	401	402	16.00	El: 86.00	0.00	Closed	WV
502	501	502	16.00	El: 84.00	0.00	Closed	WV
602	601	602	16.00	El: 82.00	0.00	Closed	WV
702	701	702	16.00	El: 80.00	0.00	Closed	WV
802	801	802	16.00	El: 78.00	22.08	0.11	WV
902	901	902	16.00	El: 76.00	70.22	0.35	WV