UNITED STATES OF AMERICA135 FERC ¶ 62,234
FEDERAL ENERGY REGULATORY COMMISSION

PPL Montana, LLC P-1869-053

ORDER APPROVING FISH LADDER—FISHWAY OPERATIONS MANUAL

(Issued June 17, 2011)

1. On December 15, 2010, PPL Montana, LLC, licensee for the Thompson Falls Project, filed its Fish Ladder—Fishway Operations Manual (manual), pursuant to the Federal Energy Regulatory Commission's (Commission) Order Approving Construction and Operation of Fish Passage Facilities (passage order)[1] and term and condition 1c of the U.S. Fish and Wildlife Service's (FWS) Biological Opinion (BO).[2] The Thompson Falls Project is located on the Clark Fork River in Sanders County, Montana.

BACKGROUND

2. The Commission's passage order requires the licensee to follow the FWS' terms and conditions numbers 1 through 7 of the FWS' BO in order to be exempt from the take prohibitions of Section 9 of the Endangered Species Act (ESA). In part, term and condition 1c of the BO requires that the licensee prepare, in consultation with the Technical Advisory Committee (TAC)[3] and approval by the FWS, operational procedures for the passage facility and a written operation and procedure manual. The manual would be updated as needed.

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[1] 126 FERC ¶ 62,105 (February 12, 2009).

[2] Filed with the Commission on November 4, 2008.

[3] The TAC consists of members from PPL Montana, U.S. Forest Service, Montana Fish Wildlife and Parks, Montana Department of Environmental Quality, and Confederated Salish and Kootenai Tribes.

LICENSEE'S PLAN

Ladder and Trap

3. The licensee states that the fish ladder is designed to collect fish up to a spill discharge of approximately 25,000 cubic feet per second (cfs) which equates to a project discharge of 48,000 cfs at full powerhouse capacity. The licensee reports that the fish ladder has 48 pools (each approximately 5 feet wide by 6 feet long, with an average depth of 4.5 feet and design maximum discharge of 6 cfs) and prefabricated weir partitions that may be operated in either notched weir mode or orifice mode. The licensee states that pools 1 through 44 may be operated in either mode by raising or lowering a gate leaf in each weir, and that this allows an assessment of bull trout passage in each operational mode.

4. The fish ladder is equipped with an auxiliary water system (AWS) which routes attraction water from the forebay to augment the pool-to-pool flow of 6 cfs and provides the majority of total attraction flow at the fish ladder entrance and into the tailrace to attract fish (maximum AWS flow is 54 cfs). The licensee states that an additional 20 cfs can be discharged directly into the tailrace via a high-velocity jet in order to improve fish attraction (flow is regulated by a control valve and could be adjusted to a different discharge value as needed). The licensee states that the fish ladder has two entrance ports: a low-tailwater entrance which operates during non-spill periods, and a high-flow entrance which operates during spill periods. When the tailwater rises during spill, attraction flow to the entrance of the lower ladder weirs is reduced; the licensee states that pools 3, 5, and 7 are equipped with add-in floor diffusers to increase attraction. The licensee states that a trash rack at the AWS will limit debris handling costs and fishway operations shutdowns, as the screens are designed to block any debris larger than $^{3}/_{32}$-inch. The licensee proposes using a self-cleaning screen and spray nozzles to help remove finer debris.

5. The licensee describes that the upper ladder of the Thompson Falls fishway is equipped with a trap-sample loop at pool 45 which allows fish to pass freely upstream (passage mode of operation) or redirects fish into an off-ladder holding pool where they can be locked into a sampling area for biological data collection and tagging (sampling mode). Elevation ranges from El. 2395.5 to 2397.0 and at the higher forebay elevation, flow through the pools increases to near 7 cfs; flows below pool 45 can be reduced to the desired 6 cfs conditions via the pool 45 flow control gate.

6. The licensee states that fish collection in an off-ladder holding pool (OLHP) occurs until it is time to initiate a trapping cycle, which involves shutting down attraction water into the OLHP, lowering the diffusers, and crowding fish into a vertical fish lock which is raised to a higher level where fish may be sampled. Once a cycle of fish is

ready to enter the forebay, the pool 48 diffuser gate will be removed to allow fish to pass through the exit pool, trash rack, and into the reservoir. The licensee states that inflow to pool 45 will be reduced during fish trap cycling and consequently will reduce flow down the ladder temporarily. The licensee proposes adjustment of flow control gates if needed, though impacts to fish below pool 45 may be small enough that adjustment is unnecessary.

Winterization

7. The licensee states that the fish ladder will be dewatered during the winter months due to issues with icing and cold weather operation. The licensee's plan describes the procedures and steps necessary to prepare the ladder, AWS travelling screen and intake, exit pool, AWS distribution piping, AWS attraction flow pipe, AWS high velocity jet flow pipe, sampling facilities water supply, and lock pump for dewatering and winterization.

Power Distribution

8. The licensee reports that the fish ladder receives power from a 50 kVA single phase transformer to the north of the ladder. The licensee's plan describes the control panel location and the operating procedures for features of the sampling facilities; AWS screen, attraction flow and high velocity jet; and passive integrated transponder (PIT) tag detectors.

Operations Procedures

9. The licensee's plan describes operations procedures for when the trap and sampling facilities are, and are not, operating. The licensee states that operation of the ladder can be ladder-only (without routing fish through the sampling facilities), or trapping (forcing fish to pass into the OLHP, lock, and sampling facilities by blocking them from ascending above pool 45). For ladder operations without the trap-sampling facilities, the licensee describes the steps for: watering up the ladder (during non-spill); daily operating procedures (assuming ongoing operations, not start-up or shut down); checking for and removing debris; and controlling or adjusting flow in the ladder (during spill and non-spill periods). The licensee states that the correct operation of the fish ladder is a pre-requisite for any discussion of fish trapping facilities operations. Additionally, the licensee states that operation of the trap-sample loop entails either the initial water-up process or daily continuation of the trapping operations. For operation of the ladder with operation of the off-ladder fish sampling loop, the licensee describes the process for initially watering up the trap to route all fish from pool 45 to the OLHP, as well as the process for beginning fish cycling through the trap when it is already watered

up. The licensee's plan also describes the process for dewatering the trap when ladder operations are continuing.

Maintenance and Inspection

10. The licensee states that no maintenance other than periodical cleaning and operation of the sluice or slide gates is required. The licensee proposes greasing all fittings on manual operators at least twice a year. Additionally, the licensee states that gates should be exercised every 3 months and that operating stems and lift nuts must be cleaned and greased every 6 months in order to ensure their proper operation and life. Regarding valves, the licensee describes the necessary maintenance, if any, for butterfly valves and actuators, AWS control valves, and pumps, including performing a test run, checking for unusual noises, visible problems, ensuring there is no leakage. The licensee proposes weekly, monthly, and semi-annual maintenance checks for the travelling screen. The licensee states that the PIT tag detectors do not require regular maintenance. The licensee states that it will check the concrete and metal features of the ladder for damage or wear and perform necessary repairs.

AGENCY CONSULTATION

11. The licensee's fish ladder—fishway operations manual was developed in consultation with MFWP, Montana Department of Environmental Quality, the Confederated Salish and Kootenai Tribes, and the FWS. The FWS approved the plan on December 15, 2010.

CONCLUSION

12. The licensee's plan describes the operational procedures for the fish ladder at Thompson Falls Dam. The licensee's plan meets the requirements of the Commission's fish passage order and term and condition 1c of FWS' Biological Opinion, and should be approved.

The Director orders:

(A) The Fish Ladder—Fishway Operations Manual filed on December 15, 2010, by PPL Montana, licensee for the Thompson Falls Project, is approved.

(B) This order constitutes final agency action. Any party may file a request for rehearing of this order within 30 days from the date of its issuance, as provided in section 313(a) of the Federal Power Act, 16 U.S.C. § 8251 (2006), and the Commission's regulations at 18 C.F.R. § 385.713 (2010). The filing of a request for rehearing does not operate as a stay of the effective date of this order, or of any other date specified in this order. The licensee’s failure to file a request for rehearing shall constitute acceptance of this order.

Thomas J. LoVullo
Chief, Aquatic Resources Branch
Division of Hydropower Administration
and Compliance

OEP/DHAC Frank, Holly: hjf 6/16/2011 041

PPL Montana, 45 Basin Creek Road, Butte, Montana 59701

PPL MONTANA, LLC

PPLM-Thompson Falls-2711

Kimberly D. Bose
Secretary
Federal Energy Regulatory Commission
888 First Street
Washington, D.C. 20426

December 15, 2010

RE: Filing Thompson Falls (Project No. 1869) Fish Ladder – Fishway Operations Manual

Dear Secretary Bose:

On February 12, 2009 the Commission issued an Order Approving Construction and Operation of Fish Passage Facilities for the Thompson Falls Hydroelectric Project (No. 1869). Enclosed is the Thompson Falls (Project No. 1869) Fish Ladder – Fishway Operations Manual required by this Order and United States Fish and Wildlife Service (USFWS) Biological Opinion Terms and Conditions #1c. PPL Montana developed this Plan in consultation with Montana Fish, Wildlife, and Parks; Montana Department of Environmental Quality; the Confederated Salish and Kootenai Tribes; and the USFWS. Signature of approval for this Plan from the USFWS is included on the following page.

Sincerely,

Jon Jourdonnais
Manager Hydro Licensing and Compliance

Enclosure

cc: Andy Welch, MDEQ
Wade Fredenberg, USFWS
Tim Bodurtha, USFWS
Mark Wilson, USFWS
Jon Hanson, MFWP
Ladd Knotek, MFWP
Craig Barfoot, CSKT
Brent Mabbott, PPLM
Frank Pickett, PPLM
Gordon Criswell, PPLM
Dave Kinnard, PPLM
Ginger Gillin, GEI
Kristi Webb, MMI

By signature below, the USFWS approves this Thompson Falls Fish Ladder – Fishway Operations Manual 1.0 filing with the Commission.

R. Mark Wilson
____
Name

__Field Supervisor, Montana Ecological Services Office__
USFWS Position

____December 15, 2010___________
Date

FINAL
Thompson Falls Fish Ladder – Fishway Operations Manual 1.0

Submitted to:
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45 Basin Creek Road
Butte, Montana 59701

Submitted by:
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December 9, 2010
Project 100070

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1.0 Introduction

PPL Montana is owner and operator of Thompson Falls Hydroelectric Project No. 1869 (Project), located on the Clark Fork River near Thompson Falls, Montana. The current Federal Energy Regulatory Commission (FERC or Commission) License was issued in 1979 and will expire December 31, 2025.

In 1998, bull trout (*Salvelinus confluentus*) were listed under the federal Endangered Species Act (ESA) as a threatened species (Federal Register, 1998); and critical habitat was designated in 2005 (Federal Register, 2005). Because bull trout are present within the Project area, a draft Biological Evaluation was prepared for the Thompson Falls Project and submitted to the United States Fish and Wildlife Service (USFWS or Service) and the Commission in 2003.

After 5 years of study and consultation with resource management agencies and the Confederated Salish and Kootenai Tribes (CSKT), PPL Montana filed a new Biological Evaluation discussing the effects of the Thompson Falls Project on bull trout and proposed conservation measures with the Commission on April 7, 2008. PPL Montana's Biological Evaluation identified several factors directly related to Project operation that negatively impact bull trout in the Clark Fork River. Blockage of upstream migration and access to spawning habitat caused by the Thompson Falls Dam were identified as major concerns. Consequently, PPL Montana proposed to install a full-height fishway at the Thompson Falls Project and filed 90-percent drawings for the structure on April 7, 2008. The filing also contained a Memorandum of Understanding (MOU) signed by PPL Montana, the CSKT, Montana Fish, Wildlife and Parks (MFWP), and the USFWS (MOU, 2008).[1]

The Commission concluded that the Thompson Falls Project is adversely affecting bull trout and the proposed conservation measures will reduce, but not totally eliminate, the Project's adverse effects on bull trout. The 2008 Biological Evaluation was adopted as the Commission's final Biological Assessment and submitted to the USFWS on May 1, 2008.

On November 4, 2008 the USFWS filed with the Commission a Biological Opinion and associated incidental take statement, which includes reasonable and prudent measures and Terms and Conditions to minimize incidental take of bull trout. The USFWS concluded in its Biological Opinion that the Thompson Falls Project is currently adversely affecting bull trout and PPL Montana's proposed conservation measures will reduce, but not totally eliminate, adverse impacts of the Thompson Falls Project.

[1] The MOU provides Terms and Conditions regarding the collaboration between the Licensee and the USFWS, MFWP, and CSKT, and the implementation of minimization measures for bull trout.

On February 12, 2009 the Commission issued an Order Approving Construction and Operation of Fish Passage Facilities for the Thompson Falls Hydroelectric Project. This order included the reasonable and prudent measures, Terms and Conditions, and conservation recommendations from the USFWS's Biological Opinion. Construction of the upstream fish passage facility at Thompson Falls Dam commenced in 2009 and was completed in fall 2010. The passage facility was tested in August and September 2010 and is scheduled to be operational in 2011.

1.1 Existing Hydropower Facilities

The Project is a run-of-the-river hydropower facility on the Clark Fork River in northwestern Montana. It is located near the town of Thompson Falls, and is the third hydroelectric project on the Clark Fork, upstream of Lake Pend Oreille, in Idaho. The general location of the Project is shown on Figure 1.1.

The Project consists of: (1) a concrete gravity arch Main Dam, approximately 1,016 feet (ft) -long and 54-ft high; (2) a concrete gravity auxiliary dam known as the Dry Channel Dam, approximately 449 ft long and 45-ft-high; (3) a 1,446-acre, 12-mile-long reservoir with a usable storage capacity of 15,000 acre-feet (ac-ft); (4) a 450-ft-long, 80-ft-wide intake channel cut through rock; (5) a steel framed and masonry powerhouse containing six generating units with a total capacity of 40 megawatts (Mw); (6) an additional powerhouse, built in 1994, containing one generating unit with a capacity of 52.6 Mw; (7) a 75-ft-wide, 300-ft-long intake channel; (8) a 1,000-ft-long tailrace channel, (9) a 1,000-ft access road; and (10) a 360-ft-long bridge (FERC, 1990; FERC, 1994). The project operates at about 62 ft of maximum head with headwater ranging from elevation (El.) 2395.5 to 2397.0 ft and a powerhouse tailwater range of El. 2335 to 2373 ft (approximate 5-year flood event). The fish ladder-trap is located at the right abutment (west side) of the Main Dam Spillway, which has a static head of 48 ft during normal non-spill forebay operating conditions.

The combined flow-thru capacity of the generating units is approximately 23,000 cubic feet per second (cfs). When river inflows exceed this capacity or there is a generating load rejection, spill is initiated at the Main Dam Spillway. This structure is the furthest upstream facility of the hydropower project and was constructed at the falls that gave name to the town of Thompson Falls. The Main Dam Spillway has 36 spill bays, with 34 bays having six manually-operated lift panels, and two bays having large radial gates. Lift panels are 4-ft-wide and 8-ft-high, and are manually raised and lowered during daylight hours by tracked lifts. Each lift panel passes approximately 230 cfs. Two large center-dam radial gates in spill bays 16 and 17 are each 41-ft-wide, with a combined hydraulic capacity of approximately 22,000 cfs. Their primary function is to maintain the forebay pool at a constant elevation and to maintain reserve emergency load-rejection capacity. A forebay trash boom extending from the right bank shoreline to a connection point between spill bays 14 and 15 retains most coarse debris, where it can then be passed through the radial gates. An abandoned concrete sluiceway on the right abutment was partially modified for construction of the new fishway.

The Dry Channel Dam is a second spillway between the Main Dam Spillway and the two powerhouses, and typically operates primarily at or near the peak of the hydrograph.

1.2 Purpose

The purpose of this Fishway Operations Manual (SOP Manual) is to provide PPL Montana project biologists and project operations/maintenance personnel (and designated others) a description of the fish ladder and trapping/sampling facilities. The SOP Manual establishes operating guidelines and instructions for adaptively managing the system to maximize operational efficiency and timely, safe and efficient fish passage. This SOP Manual is to be considered a living document, and should be periodically updated to reflect lessons learned during operations, and resulting staff operating preferences.

2.0 Fish Ladder Description

2.1 Fish Ladder

The Thompson Falls fish ladder is located at the right abutment of the Main Dam Spillway (MDS), and has a maximum water surface differential of approximately 48 ft at normal forebay pool and zero spill (Figure 2.1). The ladder is designed to collect fish up to a spill discharge of approximately 25,000 cfs, which equates to a project discharge of 48,000 cfs at full powerhouse capacity. Appendix A shows the spillway schedule developed to improve fish passage to the fish ladder tailrace near the right spillway abutment. It is the basis for design of the fish ladder, but may be modified to also address total dissolved gas abatement and operator efficiency concerns. Appendix B includes the fishway and left spillway abutment tailwater curve, which is the basis for fishway design and operation. The fish ladder contains 48 pools, and has prefabricated weir partitions between pools that can be operated in either the *notched over-flow weir* or *orifice* modes. Pool elevation difference per pool is 1.0 ft. Typical fish ladder pool size is 5-ft-wide and 6-ft-long, with an average depth of 4.5 ft and a design maximum discharge of 6 cfs. The entrance pool (pool 1) and turning pools are larger. Main components of the fish ladder are the entrance and lower ladder pools (pools 1 to 7), the middle ladder (pools 8 to45) and the exit-control section (pools 46 to 48). The auxiliary water system (AWS) routes attraction water from the forebay to augment the 6 cfs ladder pool-to-pool flow and provides the majority of total attraction flow at the ladder entrance and into the tailrace to attract fish. At pool 45, fish ascending the ladder can be routed either directly to the forebay through the exit-control section, or into the fish trap-sample loop for handling by biologists. These components of the fish ladder are further described in the following sections. Appendix C includes fishway design criteria used for the project fish ladder and trap.

2.2 Entrance and Lower Ladder Pools

The fish ladder has two entrance ports, through which fish can enter the ladder entrance pool (pool 1). One is the 24-inch-wide by 36-inch-high low-tailwater entrance, designated as EG-1 (EG-1, Figure 2.2), which is designed to operate during non-spill periods. The other is the 30-inch by 48-inch high-flow entrance (EG-2), which is designed to operate during spill. Both are upward-opening gates, and only one should be raised at a time. Closure gates should never operate at a partially opened setting. (*See* Operating Procedures, Section 6.)

Entrances attraction flow into the tailrace is a combination of ladder pool-to-pool flow (maximum 6 cfs) and auxiliary water flow (maximum 54 cfs). AWS flow is introduced into pool 1 through a wall diffuser, with a maximum uniform velocity of 1 ft per second (fps). The entrance pool (pool 1) is configured to enable fish to readily find the ladder pool-to-pool flow during the low-flow, non-spill period. During spill, tailwater rises and submerges the lower ladder weirs, thus reducing velocity and attractiveness of the 6 cfs ladder flow. Therefore, pools 3, 5, and 7 have add-in floor diffusers to increase lower ladder flow, velocity, and attraction to help fish ascend the lower ladder pools. Bulkheads above weirs 1, 3, and 5 limit cross-sectional area and maintain high enough transport velocities to attract fish from pool 1.

2.3 Fish Ladder Pools and Weir Options (Notched Weir or Orifice)

Prefabricated aluminum weirs between fish ladder pools 1 to 44 can be operated in either the *notched weir* or *orifice* mode. This was requested by biologists to allow bull trout passage assessment with each mode of operation. A gate leaf in each weir can be raised to allow orifice operation, and lowered to allow notched weir operation. Due to hydraulic constraints relating to AWS flow, weirs 1 to 6 should only be operated in the notched weir mode. Fish passage performance and other considerations (such as ease of dewatering and salvaging fish from pools) will determine long-term operations preference.

2.4 Pool 45 – Fish Routing and Ladder Flow-Control

Pool 45 is the upper pool of the middle ladder and has several important features. First, fish can be blocked from ascending the ladder by lowering vertical diffusers D-3 and D-4. Flow from either pools 46 to 48, or from both pools 46 to 48 and the sample loop, can be controlled by raising or lowering control gate FCG-1 so that a maximum of 6 cfs passes to pool 44 and down the ladder. In the trapping-sampling mode, fish may choose to fall back rather than enter the off-ladder holding pool. Thus, a finger weir can be placed on the upstream face of weir 44/45 to block fish fall-back. *See* Figure 2.3 for locations of these features.

2.5 Orifice Exit-Control Section (Tunnel/Exit Pool/Trash Rack)

The orifice exit-control section is composed of pools 46 to 48 and is designed to modulate dam forebay elevation changes relative to flow into the fish ladder. At the Project, the design forebay elevation ranges from El. 2395.5.0 to 2397.0. Orifices separate each pool, and design flow at the lower forebay elevation is 6 cfs. At the higher forebay elevation, flow through each orifice increases to near 7 cfs. The larger pool 45 inflow can be reduced back to 6 cfs (or lower) at the pool 45 flow control gate (FCG-2), allowing the desired flow conditions below pool 45. A pool 45 staff gage (SG-8) aids adjustment to attain desired downstream hydraulic conditions in the middle ladder pools.

If the ladder is operated in trapping mode, and Diffusers D-3 and D-4 are lowered, and fish will have no choice but to enter the off-ladder holding pool. Conversely, if the ladder is in passage mode, fish can ascend from pool 45 to pool 48, pass through the exit tunnel through the dam, into the exit pool, and into forebay through the exit trash rack.

2.6 Auxiliary Water System (AWS)

The auxiliary water system adds attraction water to the lower ladder, by discharging through one of the fishway entrances into the tailrace to attract fish to the ladder. Auxiliary flow enters from the forebay through the coarse trash rack and auxiliary water traveling screen, then passes through the 36-inch by 36-inch isolation gate, G-2, immediately downstream of the traveling water screen. The 30-inch diameter flow control valve CV-2 throttles AWS discharge quantity, and routes flow into a stilling pool. Energy is dissipated in this stilling pool before flow passes through a set of vertical baffles, a porosity plate, and add-in diffuser panel, into the entrance pool. Flow passing through the pool 1 add-in diffuser has reduced levels of residual turbulence, and passes uniformly through the wetted diffuser surface area.

At low design tailwater (non-spill), AWS flow is added to pool 1 only. At low spill levels (less than 5,000 cfs), the secondary AWS stilling basin (between the vertical baffles and porosity plate) is designed to be 1 ft higher than the pool 1 water surface tailwater, which is the purpose of the porosity plate (*see* Figure 2.2). In turn, the pool 1 water surface is to be 1 ft higher than tailwater. The 1 ft drops between these three points remain as tailwater. Pool 1 and the secondary AWS stilling basin water surfaces rise and progressively inundate the lower ladder pools. When weir 2/3 (between pools 2 and 3) becomes inundated, a portion of AWS flow passively overtops the first chimney and through the pool 3 floor diffuser. As tailwater continues to rise in 2-ft increments, chimneys for pools 5 and 7 are also overtopped, passively sending some AWS flow to those pools. The purpose of AWS floor diffusers in pools 3, 5, and 7 is to create a perceivable attraction flow over inundated lower ladder weirs at progressively higher tailwater elevations.

Pool 1 discharge is designed to pass 26 cfs through entrance gate EG-1 during non-spill, with an AWS discharge of 20 cfs augmenting the 6 cfs ladder flow. During spill, pool 1 discharge increases to 60 cfs through EG-2, with 54 cfs AWS discharge augmenting the 6 cfs ladder flow. Depending on tailwater elevation, a portion of the AWS will overtop one or more chimneys, and pass floor diffusers in pools 3, 5, and 7. Each floor diffuser will pass approximately 5 cfs. The desired 1.0-ft static head differential between pool 1 and tailwater occurs when the difference in readings at staff gages 5 and 6 readings is 1.0 ft.

Additionally, another 20 cfs can be discharged directly into the tailrace in the form of a high-velocity jet. Its purpose is to improve fish attraction to the ladder, as needed. This is accomplished by fully opening Gate G-1. The 20 cfs flow is regulated by control valve CV-1, located in the valve vault upstream of the AWS stilling basin. This control valve is pre-set to the 20 cfs discharge but could be adjusted to a different discharge value in the future by simple modifications to the valve itself.

2.6.1 Trash Rack and Traveling Screen

It is essential to limit debris handling costs and fishway operations shutdowns. The AWS trash rack protects the traveling water screen from being damaged by coarse debris. The trash rack and screen pass a maximum total AWS flow of 80 cfs, which includes the high-velocity jet and trap water supply flow. Screen openings are designed to block any debris larger than 3/32-inch from passing into the AWS, where it could otherwise become impinged on add-in diffusers and impede flow to the entire AWS and trap-sampling facilities. Fine debris passing through the trash racks becomes impinged on the upstream vertical face of the traveling screen, and must be cycled frequently enough to avoid occluding the screen face open area. The self-cleaning screen runs on a conveyor type system, where the upstream screen face rises, and impinged debris is sprayed by internal nozzles into a chute. The chute routes debris over the dam at a location above the lift gate nearest the fishway. During low debris periods, the screen can be set to cycle once per day. During periods with greater debris loads, the screen can be set to cycle more frequently. Inadequate cycling frequency can cause the traveling screen open area to be blocked and hydrostatic forces to increase, resulting in significant damage to the screen. The traveling screen and AWS trash rack are shown in Figure 2.4.

2.6.2 AWS Closure and Flow-Control Gates

Immediately downstream of the AWS traveling screen, there are three upward-opening slide gates: G-1, G-2, and G-3. Each of these is to be fully opened or closed. G-1 is the high-velocity jet closure gate, G-2 is the AWS augmentation flow to the stilling basin and pool 1, and G-3 is the trap water supply closure gate. When gate G-1 is opened, flow is routed to the pre-set flow control valve CV-1 in the AWS gate vault, and needs no further adjustment. Gate G-2 routes AWS pipeline flow to the stilling basin, for introduction into pool 1. Flow rate is controlled by flow control valve CV-2 (Figure 2.2), which is located in the AWS gate vault. Gate G-3 flow passes into the trap-sampling facilities pipeline. The AWS gate and valve locations are shown in Figure 2.4.

2.6.3 High-Velocity Attraction Jet (HVJ)

The high velocity attraction jet (HVJ) is designed to discharge 20 cfs through control valve CV-1. The jet discharges through a 14-inch diameter orifice, which produces a discharge jet velocity of approximately 19 fps into the tailrace. The HVJ is designed to operate during spill, but can be evaluated (if necessary) to assess whether there is a benefit of operating during non-spill to aid in attracting fish into the fishway. Other attraction alternatives during non-spill include partially opening an adjacent spillway lift gate near to the ladder entrance.

2.6.4 Stilling Pool, Baffles, and Ladder Pool 1 Add-In Diffusers

Since it is routed from forebay, AWS flow can only be added to pool 1 (and passively to pools 3, 5, or 7 during spill) once its energy has been dissipated. AWS flows through the 30-

inch diameter control valve discharge into the primary stilling basin and then through baffles to the secondary stilling basin. It then passes the porosity plate and pool 1 add-in diffusers shown in Figure 2.2 to introduce attraction flow into pool 1. The porosity plate is backset from the add-in diffusers, and passes the maximum 60 cfs flow uniformly through the entire diffuser area. The porosity plate also has a total open area sized to induce a 1 ft drop when passing 54 cfs.

2.6.5 Pools 3, 5, and 7 Chimneys and Add-In Diffusers

These pools each add approximately 5 cfs from the AWS once tailwater rises during the onset of spill operations. As tailwater elevation is designed to be 1 ft lower than the pool 1 water surface, which is 1 ft lower than the AWS secondary stilling pool elevation, each additional incremental rise in tailwater results in a similar rise in pool 1 and the stilling pool. At tailwater El. 2350, the secondary stilling pool water surface begins to overtop the pool 3 chimney, and up to 5 cfs passes into the pool 3 floor diffuser. Once tailwater, pool 1 and stilling pool water surface rise another 2 ft with increasing spill, the pool 5 chimney is overtopped and discharges up to 5 cfs into both pools 3 and 5. The same applies to the pool 7 chimney. At the high design tailwater elevation, approximately 5 cfs is being passed through pools 3, 5, and 7, for a total discharge over submerged weir 1/2 of approximately 21 cfs into pool 1, at a transport velocity of more than 1.0 fps. The purpose of this transport velocity is to attract fish up the ladder at higher flows, when the lower ladder weirs are inundated by high tailwater elevations (and it is unlikely fish would otherwise be attracted above pool 1).

3.0 Fish Trap Description

The Thompson Falls Fish Ladder has a trap-sample loop in the upper ladder, which allows fish to be routed into an off-ladder holding pool (OLHP). This is accomplished by first lowering diffusers D-3 and D-4 into the "down position" to block fish from passing into pools 46 through 48. Attraction water can then be routed through the OLHP and discharged through a trapping mechanism set in the trap channel between the OLHP and pool 45. Either a vee-trap or finger weir will be installed in the trap channel. *See* Figure 2.3 for general layout of trapping facilities.

Fish collection in the OLHP occurs until it is time to initiate a trapping cycle. Fish accumulating in the OLHP will be cycled up into the fish sampling facilities at an appropriate frequency, depending on the protocol agreed to by PPL Montana and stakeholders. Cycling entails first shutting down attraction water into the OLHP, then crowding them into the vertical fish lock. Once in the lock, fish are raised to a higher level sampling area to allow tagging, enumeration, and other sampling activities to occur. Fish can then be routed back to pool 48, returned to the tailrace, or anesthetized and transported.

3.1 Pool 45 Fish Barrier Diffusers

Pool 45 has two fish barrier diffusers, D-3 and D-4, which are lowered to the down positions when fish are to be routed to the OLHP. Each diffuser has a hoist for lowering the barrier into place. With the two-diffuser configuration, the upstream diffuser spreads flows more uniformly through the downstream diffuser to reduce fish jumping.

3.2 Trapping Mechanisms (Vee-Trap or Finger Weir)

Once the pool 45 diffusers are lowered, blocked fish will be routed through the trapping channel between pool 45 and the OLHP. A trapping mechanism consisting of either a vee-trap or finger weir (depending on operator experience and preference) will be installed in slots in the trapping channel. With the horizontal crowder is moved to the weir wall on the opposite side of the OLHP from the lock, attraction flow is routed through trapping channel, and fish pass into the holding pool via the vee-trap (or finger weir). Once through the trapping mechanism, fish are impeded from returning to pool 45. A second finger weir is to be installed at weir 44/45, to prevent fall back of bull trout (who may attempt to leave the fish ladder rather than pass the small vee-trap opening).

3.3 Off-Ladder Fish Holding Pool (OLHP), Flow-Control Gate, and Crowder

Up to 3 cfs can be routed through the OLHP and the trapping channel to attract fish from pool 45. Experience will dictate how much flow is required to attract fish into the OLHP.

Butterfly valve CV-4 controls the upwell flow through the fish lock floor brail and into the holding pool. Additional flow, controlled by CV-3, can be routed through the OLHP side add-in diffuser panel, as deemed appropriate.

Concurrently, the target design outflow from pool 45 is 6 cfs. With the OLHP added flow, total inflow into pool 45 increases to over 7 cfs. Up to 3 cfs more may be added to pool 45 from the OLHP. However, flow control gates FCG-1 and FCG-2 are designed to bleed off excessive trap flow so that the pool 45 staff gage SG-8 reads elevation 93.0, to assure desired ladder hydraulics below pool 45. FCG-1 controls how much flow passes the vee-trap or finger weir, for fish attraction into the OLHP. Some flow through the off-ladder holding pool can be routed through the lowered vertical screen of the crowder and over FCG-2 in the OLHP. Experience will dictate optimum flow split of bleed-off between FCG-1 and FCG-2.

Once cycling of trapped fish commences, attraction flow to pool 45 through the vee-trap or finger weir is stopped, diffuser D-2 (Figure 2.3) is installed, and fish are crowded by the horizontal crowder into the lock. Lock gate LKG-1 is then closed and fish are ready to be locked to a higher elevation for sampling.

Note that pool 45 inflow is reduced during trap fish cycling, when OLHP flow is diminished or shut off. Flow down the ladder will be temporarily reduced, lowering the SG-8 reading. This will adversely impact hydraulics in downstream pools, and experience will dictate whether adjustment of FCG-1 to attain a SG-8 reading of 93.0. However, adverse fish impacts to fish below pool 45 may be deemed small enough to negate the need for ladder flow adjustment.

3.4 Fish Lock

Once the lock closure gate is fully lowered, the lock pump is started. Lock water level rises and passes over an overflow lip to a chute that sends fish to the sorting table. Floor brail can be lifted to crowd fish vertically; however, it is not designed to lift fish above the lock water surface. Pump and floor brail operations are controlled by start-stop and raise-lower-stop buttons at the sampling facilities control panel. If there are many fish in the lock, starting and stopping the lock pump, and raising/lowering the floor brail will allow only the desired number of fish to be routed to the sorting table during any time increment.

3.5 Sample Facilities Control Gates

Gate G-1, located on the AWS gate wall, should be opened when trap and sample facilities are to operate. CV-4 controls gravity flow to the lock and provides attraction flow through the trap channel to pool 45. By opening CV-3, additional gravity flow passes through the diffuser D-5, on the side of the holding pool. When fish cycling begins, CV-4 is closed (CV-3 can be opened/closed at operator's discretion), and the lock pump is started to fill the lock. Flow-control gate FCG-1 and FCG-2 control the flow split to pool 45 and the water level in the OLHP. *See* Figure 2.3 for gate and valve locations.

3.6 Lock Chute and Sorting Table

Once fish are crowded into the lock, the lock closure gate LKG-1 is closed, the lock pump is started, and the water surface rises. Once lock inflows overtop the chute lip, water passes over a floor screen, which dewaters nearly all lock pump flow. Crowded fish slide down the chute and onto the sorting table, where they can be routed in different directions. It is expected that most fish in the ladder will be non-target species, which will be routed quickly over the sorting table and back to pool 48. There are hose bibs at multiple sampling facility locations, which can be used to lubricate return pipes prior to passing fish to their respective destinations. (A booster pump and storage tank are located under the sorting table.)

3.7 Anesthesia Tank and Work-Up Table

For target species (such as bull trout), fish can be routed from the sorting table to the anesthetic tank. Once anesthetized, they can be moved to the work-up table, where they can be tagged, measured, interrogated, or transported.

3.8 Recover Tank and Pool 48 Return Pipe

Anesthetized fish that are targeted for release back into pool 48 and the forebay without transporting will be transferred to the recovery tank. Once recovered from anesthesia, these fish can be routed into the pre-lubricated pool 48 return pipe.

3.9 Pool 48 Diffuser Gate (D-1)

Diffuser gate D-1 (Figure 2.3) is located at the downstream end of the 3 ft diameter tunnel through the dam, and is to be closed when fish are being cycled. After all fish are routed back to pool 48 or elsewhere, there is still an opportunity for trap operators to net any target fish that may have mistakenly been returned to pool 48. Once a cycle of fish is ready to enter the forebay, diffuser gate D-1 will be removed to allow fish to pass through the exit pool, trash rack, and into the reservoir.

3.10 Transportation of Trapped Bull Trout

PPLM will adhere to the transport protocol guidance to be provided by the USFWS.

4.0 Winterization

4.1 General

The ladder will be dewatered during the winter months due to issues with icing and cold weather operation.

4.2 Ladder

The following procedures should be followed to prepare the ladder for winter:

1. The exit pool gate, EPG-1, should be in the fully closed position and the ladder dewatered.
2. All prefabricated weir plates should be in the raised position.
3. All movable diffusers should be in the raised position.
4. The entrance pool gates should be in the fully raised position.

4.3 AWS Traveling Screen and Intake

The following procedures should be followed to prepare the AWS traveling screen for winter:

1. Remove the screen pump from the water, dewater, and store in a dry place for winter.
2. Install and operate agitators adjacent to the gate wall and the AWS intake to prevent forebay ice from locking within the AWS structure and damaging the screen, intake, and gate stems.
3. To the extent possible, install plywood and/or plastic sheeting to enclose/minimize direct exposure of fish screens to ambient freezing/wind conditions. This includes both upstream and downstream exposure to the screens, and exposure from above.

4.4 Exit Pool

1. Install and operate an agitator adjacent in the exit pool to prevent forebay ice from locking within the exit pool structure and damaging the trashrack and gate stem.
2. Install plywood/plastic sheeting to limit exposure of ambient air conditions both through the trash rack, and from above (through walkway grating).

4.5 AWS Distribution Piping

It is imperative that the AWS pipes are properly dewatered to prevent damage to the pipes and valves due to freezing.

4.5.1 AWS Attraction Flow Pipe

The following procedures should be followed to dewater the AWS attraction flow pipe:

1. Close valve CV-2.
2. Close gate G-2.
3. Open valve CV-2 to partially dewater the pipe. The valve requires a differential pressure of about 10 feet of head on the valve to operate. Therefore, the valve alone will not fully dewater the pipe.
4. Once the valve has dewatered the pipe as much as possible, drain the remaining water in the pipe into the valve control vault with the small drain ball valve located on the upstream side of the valve. Leave the drain valve opened.
5. Remove the water in the valve diaphragm per the manufacturer's instructions.

4.5.2 AWS High Velocity Jet Flow Pipe

The following procedures should be followed to dewater the AWS attraction flow pipe:

1. Close valve CV-1.
2. Close gate G-1.
3. Open valve CV-1 to partially dewater the pipe. The valve requires a differential pressure of about 10 feet of head on the valve to operate. Therefore, the valve alone will not fully dewater the pipe.
4. Once the valve has dewatered the pipe as much as possible, drain the remaining water in the pipe into the valve control vault with the small drain ball valve located on the upstream side of the valve.
5. Remove the water in the valve diaphragm per the manufacturer's instructions.

4.5.3 Sampling Facilities Water Supply

The following procedures should be followed to dewater the AWS attraction flow pipe:

1. Close gate G-3.
2. Open the 2-inch diameter ball valve adjacent to pool 24 to dewater the upstream portions of the 12-inch diameter pipe.
3. Open the 12-inch butterfly valve and 6-inch butterfly valves in the sampling facilities.
4. Open the lock drain valve near pool 19 to dewater the lock sump.
5. Follow the manufacturer's instructions for winterizing the lock pump.
6. Open the lock pump suction line at the foot valve connection to dewater downstream of the foot valve.
7. Drain the pressure tank on the sampling deck.
8. Dewater the water supply pump per the manufacturer's instructions.

9. Remove the water from the water supply pump suction line. The line has a check valve at the bottom to maintain prime.

4.5.4 Lock Pump

The following instructions are the manufacturer's recommended winterization procedures. It is important that the pump is properly winterized to prevent damage to the pump system components.

1. Turn all pump HOA switches to "off" position.
2. Switch all pump power disconnects to the "off" position.
3. Isolate the pumping system from the supply line with a valve not subject to freezing, or rain the entire system.
4. Isolate the inlet water supply (booster stations only) with a valve not subject to freezing, or rain the inlet water supply.
5. Open all isolation valves.
6. Open all drain valves.
7. Open electric ball valve on Automatic Wye-Strainer, and loosen strainer cover to drain all water out of Wye-Strainer.
8. After all water has been drained out of the pumping system, remove any control valve pilot assembly and store in a place where there is no danger of freezing.
9. Remove the Control Valve Cover, and install a solution of 50% water and 50% antifreeze
10. Disconnect and drain all gauge tubing.

5.0 Power Distribution/Electrical

5.1 Electric Service

Power to the fish ladder is provided by a 50 kVA single phase transformer to the north of the ladder. An electric meter and 200 amp primary service breaker is located at the north end of the main dam. Switching this breaker to the off position terminates all power to the ladder.

The service is routed from the primary service breaker to the main breaker panelboard located on the crest of the main dam, adjacent to pool 40. Within the panelboard are individual breakers for all of the electric facilities.

5.2 Sampling Facilities

The control panel for the sampling facilities contains the motor starters and operational controls for the valve actuators, pumps, and crowder motors. Breakers and surge protectors are located within the control panel as well.

5.2.1 Lock Pump

The lock pump is a self-contained unit located between the lock and pool 46. The lock pump has a three phase motor which requires use of a variable frequency drive (VFD) to operate on single phase power. Prior to operating the lock pump, the following procedures must be followed:

1. If the lock pump has not been operated for a long period of time or has been dewatered, the suction (intake) line will need to be primed. Open the valve labeled "suction prime" in the lock pump housing and open the lock priming valve under the sorting table. Once water begins to flow out of the clear plastic hose to the right of the lock pump, close the "suction prime" valve and close the lock priming valve under the sorting table.
2. Rotate the main power knob on the control panel within the pump housing counterclockwise. The main power knob is red and green and is located on the right side of the control panel.
3. Wait approximately 10 seconds for the VFD to power up. An audible click will be heard.
4. Turn the switch labeled "motor" from off to on.
5. The pump will begin running at this time.
6. A remote power control at the sampling facilities control panel can be used to regulate the pumped flow and turn the pump on and off.

7. To turn the pump off, reverse the operations. The main power knob should be turned to the off position when sampling personnel are not present.

5.2.2 *Sampling Facilities Valves*

There are three butterfly valves (BFV) in the sampling facilities; a 12-inch diameter BFV for the lock water supply (CV-4), a 6-inch diameter BFV to route water into the OLHP (CV-3), and a 6-inch diameter BFV to partially drain the lock so that the lock gate may be safely opened. The controls for these BFV actuators are on the sampling facilities control panel. The valves may also be manually opened or closed with hand wheels located on the valves.

5.2.3 *Horizontal Crowder*

The 2-horsepower horizontal crowder motor is controlled with a push button switch box that is accessible from the grating adjacent to the OLHP.

5.2.4 *Vertical Crowder*

The vertical crowder hoist motor is controlled with push button switches on the sampling facilities control panel.

5.2.5 *Lock Gate*

The lock gate (LKG-1) hoist motor is controlled with push button switches on the sampling facilities control panel.

5.2.6 *Sampling Water Supply Pump*

The sampling water supply pump is located under the sorting table. The pump must be primed after winterization or potentially after periods without use. To prime, remove the plug on the right side of the pump (facing the rock wall), and fill with water until it overflows. Replace the cap and turn the pump on. The pump will operate until the pressure tank reaches the preset pressure and will automatically turn off.

5.3 AWS Traveling Screen

Controls for the AWS traveling screen are located to the left of the traveling screen (facing the forebay). The controls have an automatic operational setting for running the screen and the pump at preset intervals. The controls also have a manual setting for running the screen and pump on command.

5.4 AWS Attraction Flow

Flow from the 30-inch diameter AWS control valve CV-2 is controlled from the dam crest. The control panel has a digital readout which displays the current valve discharge as well as the set valve discharge. The valve is designed to open and close over a minimum period of 5 minutes. The discharge can be set by hitting the + and – buttons to increase or decrease the flow. A "fast" button on the control panel can be held down during adjustment to quickly increase or decrease the speed at which the settings change.

5.5 AWS High Velocity Jet

Flow from the 16-inch diameter AWS high velocity jet CV-1 is adjusted on the valve itself. The valve is preset to be fully opened with a 20 cfs discharge or fully closed with no flow. The valve is operated by opening or closing the red handled ¼ turn ball valve on the right side of the valve.

5.6 Pit Tag Detectors

Pit tag detectors have been installed at several locations within the ladder. The locations and components have been selected by PPL, separately installed, and are not covered in this operations manual.

6.0 Operations Procedures – Fish Ladder

This section describes fish ladder operations when the trap and sampling facilities are not in operation. Section 7 describes ladder operations when the trap-sampling facilities are operating.

6.1 Fish Ladder Watering Up Process

The following procedures are for watering up the ladder during periods of non-spill.

1. Close all lock valves and raise the holding pool gate FCG-2 (Figure 2.3) to the maximum height.
2. Fully open lowest entrance pool gate EG-1 and close the upper entrance pool gate EG-2.
3. Verify that the exit pool trash rack TR-1 and diffuser D-1 are clear of debris. Rake and remove any observed debris.
4. Place the FCG-1 gate crest elevation 1.5 ft (18 inches) above the concrete sill elevation immediately upstream of the gate.
5. Slowly raise the exit pool slide gate EPG-1 to allow water into the ladder. Raise slide gate to the fully-opened position.
6. Adjust pool 45 overflow gate FCG-1 to attain a staff gage (SG-8) reading of 93.0, which provides the desired flow down the ladder. FCG-1 may be raised/lowered to increase/reduce in-ladder flow below pool 45. The optimum pool 45 water level is SG-8 reading 93.0. FCG-1 should be adjusted to the desired staff gage SG-8 reading each time the ladder is watered-up.
7. Open the AWS control valve CV-2 to increase flow to the stilling basin until the pool 1 SG-5 reading rises to 1.0 ft above the SG-6 tailwater reading.
8. The fish ladder should now be operating correctly for non-spill operations.

Dewatering the fishway should occur by reversing order of steps listed above.

6.2 Daily Fish Ladder Operating Procedures

The following is a list of daily operating checks for the Thompson Falls fish ladder, and is for daily use by project operators and/or biologists responsible for its operation and performance. The correct operation of the fish ladder is a pre-requisite for any discussion of fish trapping facilities operations. Refer to Figures 2.2, 2.3, and 2.4 relative to fish ladder features designations referenced below.

This criteria assumes ongoing daily operations and not start-up or shut-down of the ladder. Thus, it is assumed that auxiliary water gate G-2 is already fully opened. G-1 is only open during spill, as described below, and G-3 is only open during sample loop operations described in Section 7. Operating criteria presented in this section only apply to operation of the fish ladder.

6.2.1 Debris Control Checks – Remove Debris Accumulations

1. Observe and record project forebay elevation at project office or, if no debris is on TR-1, record staff gage SG-1 reading.
2. Observe and record SG-1 elevation, immediately downstream of exit pool trash rack (TR-1). Remove visible trash rack debris.
3. If fish are being trapped in off-ladder holding pool, diffuser gate D-1 should be in the "down position." Check pool 48 staff gage (SG-2) reading to assess debris accumulation on D-1. If SG-1 minus SG-2 reading is greater than 0.1 ft, raise D-1 and remove debris, then lower D-1 and leave closed for the next sample fish cycling.
4. Observe and record of visible trash rack debris on auxiliary water trash rack TR-2 Figure 2.4). Remove visible trash rack debris.
5. Make record of debris amount on upstream auxiliary water system (AWS) traveling screen, cycle the screen manually to start each day. If debris is accumulating, set for more frequent cleaning cycles at the screen control panel to assure screen remains clean (NOTE: if excessive differential due to debris accumulates on the screen, it will result in an abrupt and damaging screen failure).
6. Observe and record of visible debris on pool 45 diffuser racks (D-3 and D-4), which are only lowered when fish are being routed to the off-ladder holding pool. Remove debris from both panels.
7. Observe pool 45 flow bleed-off screen (S-1) for FCG-1, and record of debris presence, brush and remove debris from screen surface.

6.2.2 Discharge Control Checks

1. Observe and record the pool 45 staff gage SG-8 water level.
2. Adjust flow control gate FCG-1 as necessary to attain reading 93.0 at SG-8.
3. Observe and record the tailwater staff gage SG-4 reading from the main dam deck.

6.2.3 Entrance Gate and Attraction Discharge Adjustments

6.2.3.1 If there is no spill discharge:

1. Fully open the lower entrance gate EG-1 and close the upper entrance gate EG-2.
2. Observe, estimate, and record the stilling pool staff gage SG-4 reading.
3. Observe and record the entrance pool (pool 1) staff gage SG-5 level. Subtract the SG-5 reading from SG-4 reading. The difference should be 0.8 to 1.0 ft.
4. If SG-4 minus SG-5 is less than 0.8 to 1.0 ft, incrementally increase AWS valve CV-2 flow to attain a 0.8 to 1.0 ft differential.
5. If SG-4 minus SG-5 is greater than 0.8 to 1.0 ft, incrementally reduce flow through CV-2 to attain a 0.8 to 1.0 ft differential.

6.2.3.2 If there is spill discharge:

1. Fully open the upper entrance gate EG-2 and close the lower entrance gate EG-1.
2. Observe, estimate, and record the stilling pool staff gage SG-4 average water surface elevation.
3. Observe and record the entrance pool (pool 1) staff gage SG-5 level. Subtract the SG-5 reading from SG-4 reading. The difference should be 0.8 to1.0 ft.
4. If SG-4 minus SG-5 is less than 0.8 to 1.0 ft, incrementally increase AWS gate CV-2 opening to attain a 0.8 to 1.0 ft differential.
5. If SG-4 minus SG-5 is greater than 0.8 to 1.0 ft, incrementally reduce CV-2 opening to attain a 0.8 to 1.0 ft differential.
6. Subtract SG-5 reading from SG-4, if difference is greater than 3 ft, notify plant operations chief (as debris is accumulating on upstream face of pool 1 wall diffuser) to resolve the problem.
7. Depending on fishway operating experience, fully open G-1 and open the high-velocity jet control valve CV-1 to add attraction discharge into the tailrace. G-1 should remain opened once the high-velocity attraction jet pipe has been watered up. CV-1 can be opened or closed to operate the high-velocity attraction jet, but is not set to do so on a frequent basis.

7.0 Operations Procedures: Trap-Sampling Facilities

The following are assumptions for operation of the off-ladder sampling loop of the Thompson Falls fish ladder:

- Ladder-only operations: the ladder can be operated without routing fish through the sampling facilities, by allowing fish to pass pools 45 to 48, through the tunnel, and out the exit pool trash racks to the reservoir. For this to occur, sample loop facilities are closed down.

- Trapping Operations: operation of the sample loop blocks all fish from ascending above pool 45, diffuser D-3. Fish are forced to pass into the OLHP, lock, and sampling facilities prior to being returned to the ladder at pool 48. Handling protocols will be established for fish culled at the sorting table.

- Operation of the trap sample loop entails the initial water-up process or daily continuation of the trapping operations. Each process is explained in the following sections.

7.1 Initial Trap Watering-Up Process

1. Close water supply valves CV-3 and CV-4 at the sampling facilities control panel before watering-up the fish trapping system.
2. Open gate G-3 to route water to the sampling facilities.
3. Close the lock drain valve at sampling facilities control panel.
4. Either the vee-trap or finger weir and stoplogs should be installed and pre-set to the desired elevations.
5. The horizontal crowder should be in the back position, at the end of the holding pool, opposite the lock.
6. The lock brail should be in the lowered position.

(Note: Steps 4-6 prevent fish from entering and becoming trapped in a location where they cannot be readily recaptured.)

1. FCG-2 setting will be dependent on whether the vee-trap or finger weir is to be used during trapping operations. Set the FCG-2 weir crest at the pool 45 water surface elevation, so that water level in OLHP is same as pool 45 water level.
2. Removable diffuser panel D-2 should be in place to create a flush holding pool wall surface for crowding fish.

3. Lower diffuser panels D-3 and D-4 in pool 45 so that there are no bottom gaps that may pass fish.
4. Lock closure gate LKG-1 should be in the fully raised position.
5. Install the finger weir at the pool 44/45 weir to minimize fish fallback from pool 45.
6. Record the pool 45 staff gage SG-8 reading (should be 93.0) before routing flow to the sample loop.
7. The trap is now ready to be watered up for fish collection.
8. Raise diffuser panel D-2.
9. Partially open water supply valve CV-3 to route some flow to the north side holding pool water supply well.
10. Slowly open butterfly valve CV-4 to route gravity flow through the lock floor brail and into the holding pool. Increase the CV-4 opening while balancing holding pool inflows through both FCG-2 and the trapping channel. Raising the FCG-2 weir crest routes a larger percentage of lock inflow to pool 45, and raises the pool 45 water surface elevation.
11. Lower FCG-2 to attain the desired holding pool outflow conditions into pool 45 to attract fish from pool 45 through the trapping channel.
12. Adjust FCG-1 to attain the desired pool 45 water surface elevation (SG-8 reading of 93.0). Important: Added lock flow into pool 45 also creates increased turbulence in each ladder pool below pool 45. Adjust FCG-1 at pool 45 to attain SG-8 reading of 93.0.

The ladder and trap systems are now ready to route all fish from pool 45 to the OLHP.

7.2 Fish Cycling Process – Trap Already Watered Up

1. Record staff gage SG-8 water surface elevation in pool 45 (should be 93.0).
2. Close CV-3 and CV-4 to shut down inflow to the lock and holding pool.
3. Adjust FCG-2 as required to attain a holding pool water surface elevation on SG-7 that is the same as on SG-8 in pool 45. Note that without holding pool flow to pool 45, its water surface will drop during fish cycling. If this is problematic, adjust pool 45 FCG-1 accordingly.
4. Verify that the horizontal crowder is in the back position, against the FCG-2 gate wall.
5. Lower D-2 into place and assure that fish are not between D-2 and the vee-trap or finger weir.
6. Crowd fish towards the lock by operating the horizontal crowder.
7. Close the lock gate, LKG-1.
8. Start the lock fill pump.
9. Fill the lock until the water surface rises and overflows down the lock chute and reduce the lock pump flow.
10. Raise the lock floor brail (vertical crowder) to crowd fish upward, until the fish pass over the lip and onto the sloped chute toward the sorting table.

11. Turn the lock pump on/off and raise/lower the lift periodically to process the desired number of fish at a time.
12. Repeat brail crowding process until all fish are crowded from the lock and are sorted and sampled.
13. Stop the lock pump once all fish are removed from lock.
14. Lower the brail to the fully down position.
15. Open the lock drain valve and drain the lock to the OLHP water surface elevation.
16. Close the lock drain.
17. Open lock closure gate LKG-1.
18. Return the horizontal crowder to far end of holding pool prior to resuming fish trapping operations.
19. Remove diffuser D-2.
20. Open CV-3 and CV-4 to resume desired lock inflow levels, and re-balance flows using FCG-1 and FCG-2 to return pool 45 SG-8 elevation to 93.0.

7.3 Trap Dewatering Process

The following processes should be followed to dewater the trap when no additional trap usage is planned for an extended period of time, and the intent is to continue fish ladder operation.

1. Cycle fish as described in Section 7.2.
2. Install diffuser D-2.
3. Install stoplogs, into stoplog guides SLG-1, to completely isolate the sample loop from pool 45. Assure stoplog leakage from pool 45 to the off-ladder holding pool is minimized.
4. Shut down the water distribution booster pump at sample facilities distribution panel, and dewater the storage tank.
5. Close G-3 and open the 2-inch ball valve (accessible from the pool 24 access walkway) to drain the 12-inch diameter sampling water supply pipe.
6. Open lock drain valve (accessible from the pool 19 access walkway) to dewater holding pool and lock.
7. All drain valves and trap water supply valves (CV-3 and CV-4) should be opened to drain pipelines and avoid freezing damage.
8. Adjust FCG-1 to attain desired pool 45 SG-8 water surface elevation 93.0.
9. Continue to operate fish ladder without routing fish into the dewatered sample facilities, or prepare to dewater fish ladder.

8.0 Maintenance and Inspection

8.1 Gates

No maintenance other than periodical cleaning and operation of the sluice or slide gates is required. Gates should be exercised every three months. At least twice a year all grease fittings on manual operators should be lubricated with a small amount of heavy duty grease. To insure proper operation and life of operating stems and lift nuts, it is very IMPORTANT THAT OPERATING STEMS ARE CLEANED AND GREASED EVERY SIX MONTHS. (See manufacturer's manual for recommended lubricants)

8.2 Valves

8.2.1 Butterfly Valves and Actuators

If rarely operated, perform a test run about every 6 months. This ensures that the actuator is always ready to operate. Approximately six months after commissioning and then every year check bolts between part-turn actuator and valve/gearbox for tightness. If required, tighten applying the torques given in the manufacturer's operation manual.

8.2.2 AWS Control Valves

Observe valves for excessive noise (cavitation) and vibration.

8.2.3 Pumps

8.2.3.1 Sampling Facilities Pump

No regular maintenance is required.

8.2.3.2 AWS Pump

No regular maintenance is required.

8.2.3.3 Lock Pump

Daily Preventative Maintenance:

1. Check gauges, discharge, valve and pump operations.
2. Check for unusual sounds, visible problems, excessive vibrations, or smells.

Weekly Preventative Maintenance:
Make sure that no water is leaking from any part of the pump system.

Monthly Preventative Maintenance:

For horizontal applications: Rotate the motor shafts by hand once a month. Two to three rotations are sufficient. This will prevent brinelling of bearings and keep seal faces from sticking.

Quarterly Preventative Maintenance:

1. Inspect critical structural components for corrosion, wear and vibration.
2. Inspect and tighten all electrical terminations that can be de-energized from a power source (this does not include spliced motor lead connections). Inspect all limit switches.
3. Inspect, calibrate or replace gauges as necessary. Check operation or pressure recorder if applicable.
4. Exercise and determine proper operation of all drain valves. Exercise and determine proper operation of all isolation valves. Clean and inspect all strainers. Check pump shaft alignments.
5. Lube Motors with only manufacturer approved grease or change motor oil with manufacturer approved oil.
6. Check electrical and hydraulic controls. Test by running pumping system from zero flow to full flow then back down to zero flow. If the electrical and hydraulic controls are not functioning properly, contact the factory and a service technician will assist you.

Annual Preventative Maintenance:

1. Relubricate motor bearings before placing pump into operation if stored for over 1 year.
2. Inspect motor starter contacts and replace if necessary. Measure and record electrical system voltage at no load and again at near maximum electrical load. Measure and record each pump motor current drawn near shutoff head of the pump and at normal pump operation pressure.
3. Disassemble, clean and inspect any air release valves and replace any worn or damaged parts. Disassemble, clean and inspect all diaphragm pilot-operated control valves, and replace any worn or damaged parts.
4. Perform analysis of pumps and motors. Use touch up paint if necessary to prevent rust from forming.

8.3 Traveling Screen

Daily:

<u>Prior to Starting Equipment:</u>

1. Perform a visual inspection of the equipment for possible maintenance needs.

2. Remove any foreign objects that may be on or leaning against conveyor or equipment.

After Starting Equipment:

1. Perform a visual and auditory inspection of the equipment for possible maintenance needs.

Weekly:

1. Check drive chains for proper alignment, tension, or excessive wear. Adjust as required.
2. Lubricate drive chains with USDA approved chain lube.
3. Check drive belts for proper alignment tension, or excessive wear. Adjust as required.
4. Lubricate bearings with one (1) pump of grease and inspect bearings for wear.

Monthly:

1. Check gearbox fluid levels and add if required. Inspect fluid for water contamination and replace if necessary.
2. Verify that take-up rod jam nuts are tight Tighten as required.
3. Check sprockets for proper alignment, tension, or excessive wear. Adjust as required.
4. Check conveyor belt for proper alignment, tension, or excessive wear. Adjust as required.

Semi-Annually:

1. Replace gearbox fluid. If synthetic lube is used, inspect for contamination and replace only if necessary.
2. Check conveyor wear strips and replace as necessary.
3. Check conveyor belting for signs of wear and replace as necessary.
4. Check drive sprockets for signs of wear and replace as necessary.

8.4 PIT-Tag Detectors

No regular maintenance is required.

8.5 Concrete Inspection

When the ladder is dewatered, check concrete for cracks, spalls and other damage. Seal cracks and repair other identified defects.

8.6 Metal Works Inspection

Perform annual inspection of ladder metal works, noting corrosion, loose fasteners, and stressed or damaged components. Repair damaged coatings and tighten fasteners. Replace damaged or stressed metal works with equivalent materials.

9.0 References

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10.0 Figures

Figure 1.1. Location of Thompson Falls Dam and Powerhouse on the Clark Fork River near Thompson Falls, Montana

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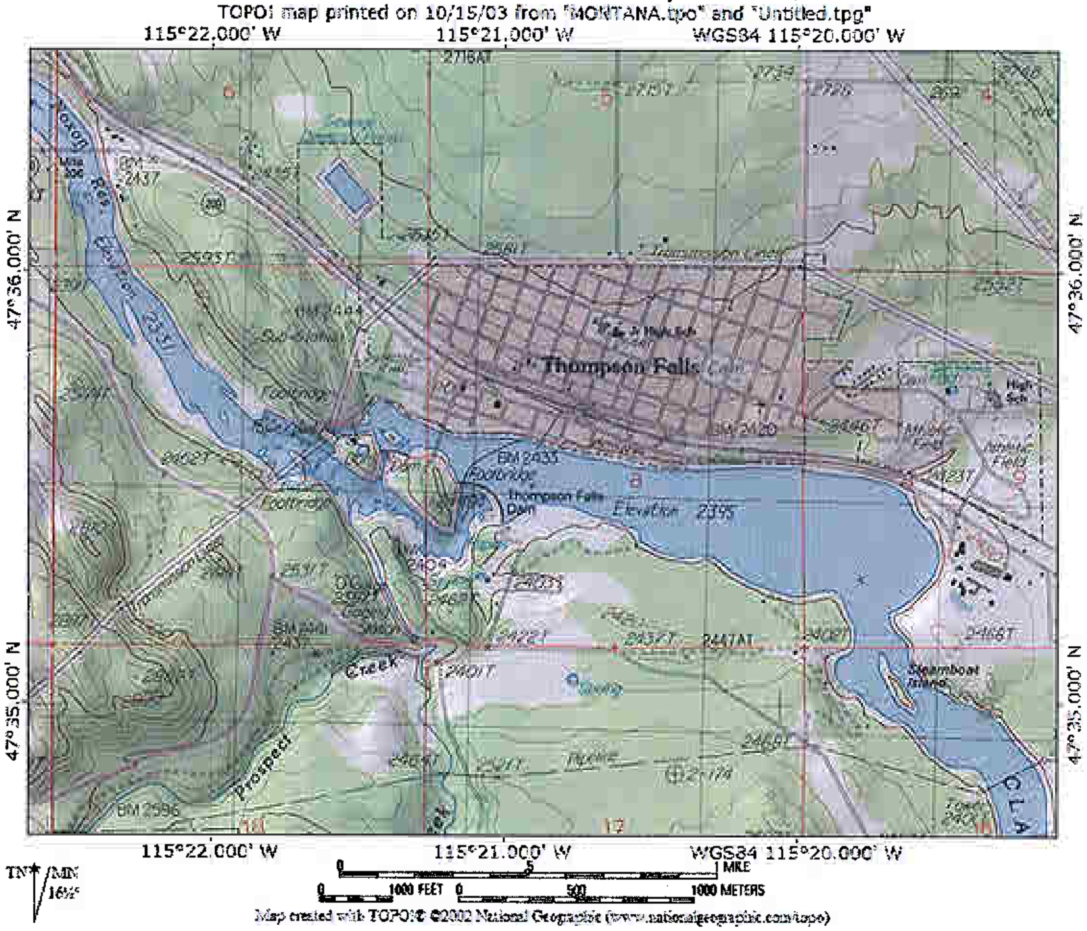

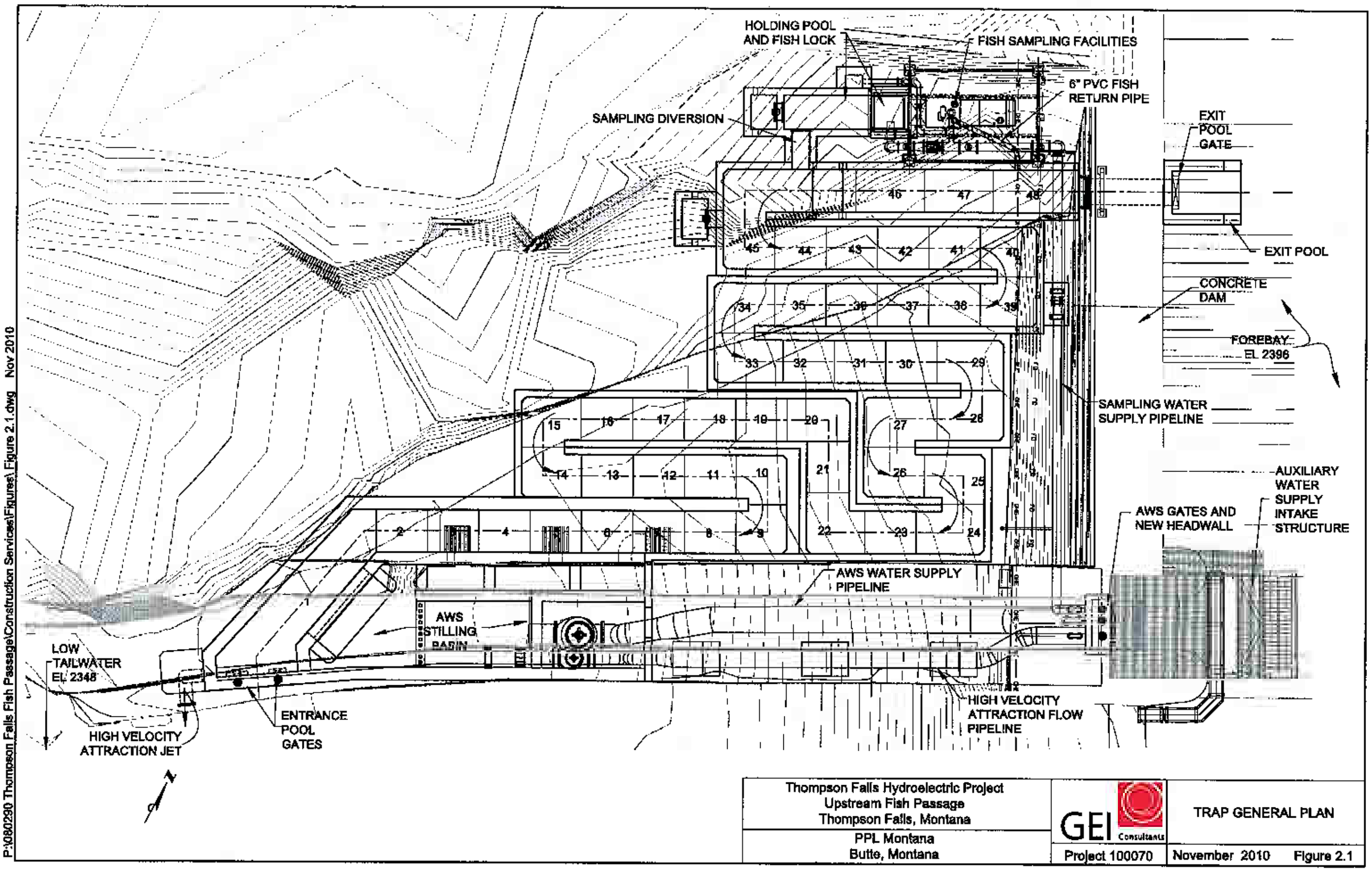

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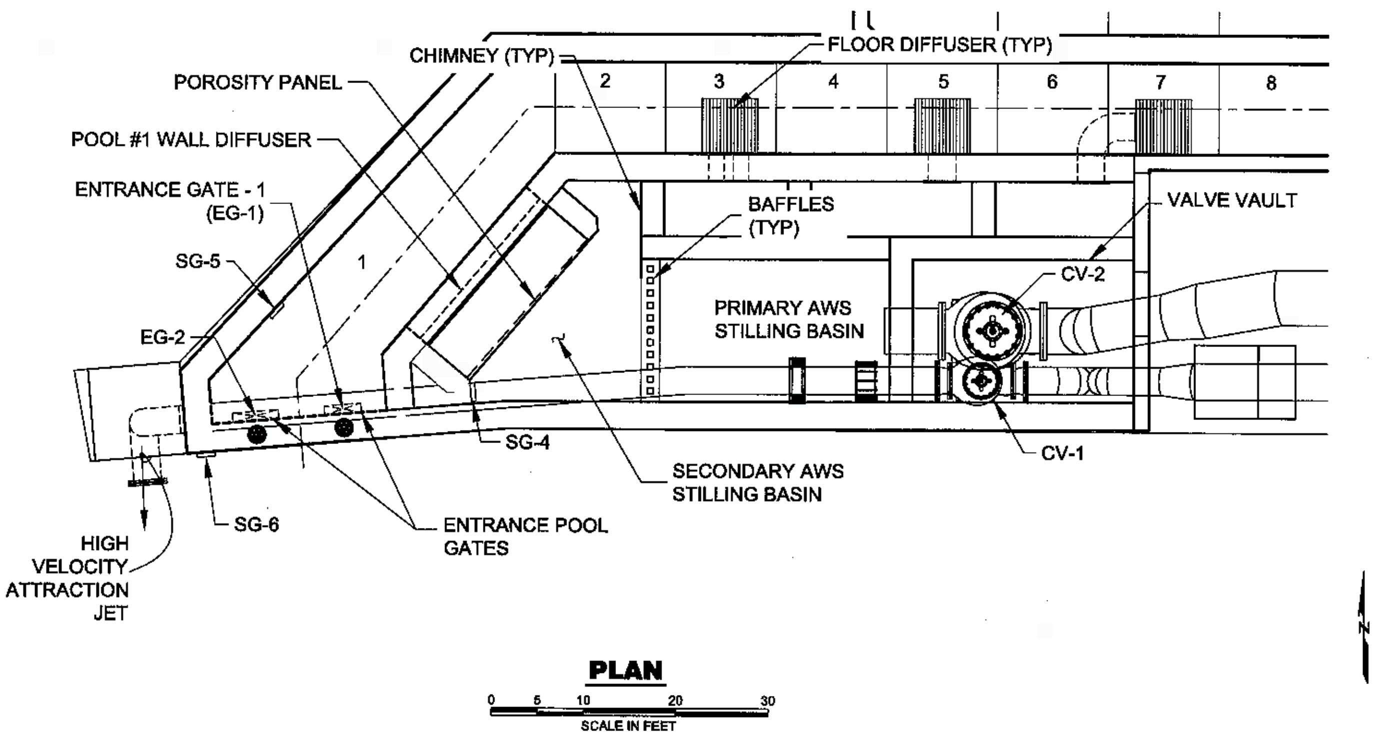

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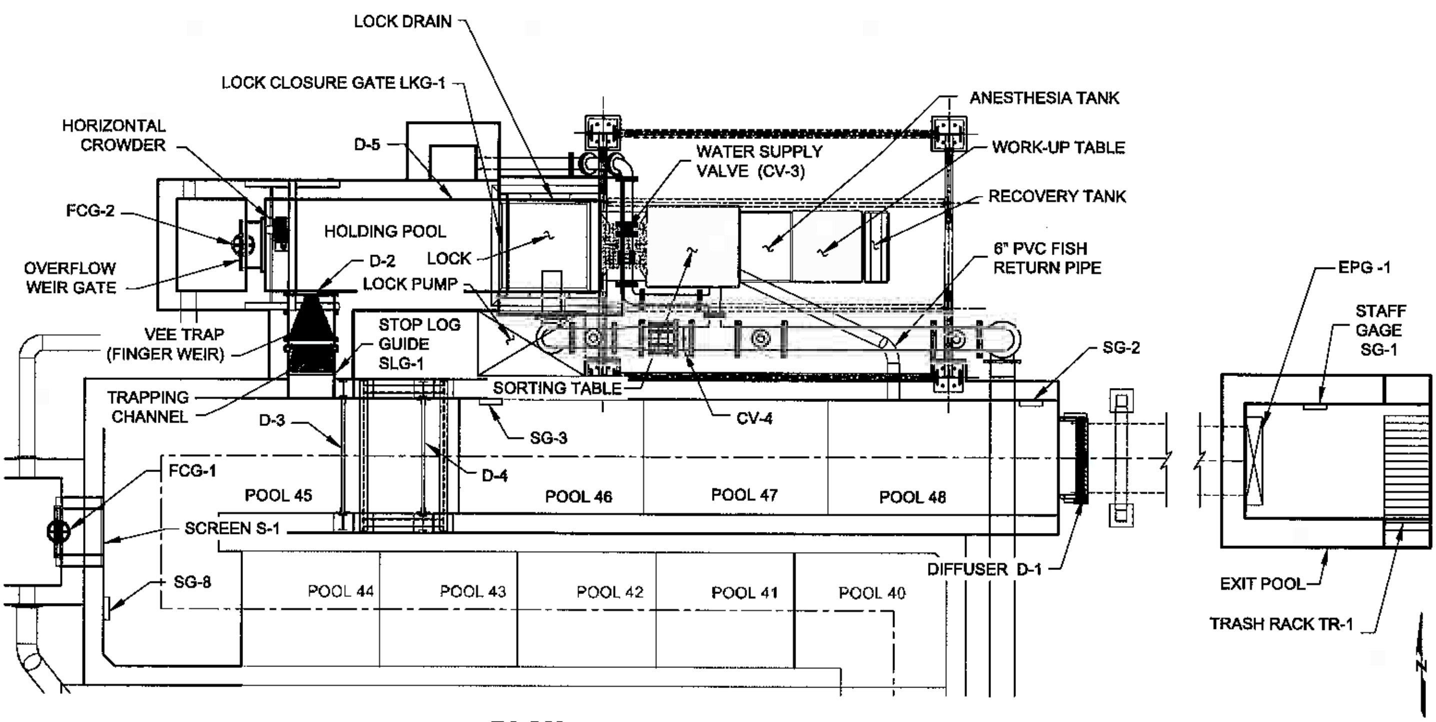
PPL Montana Butte, Montana	Project 100070	November 2010	Figure 2.2



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Thompson Falls Hydroelectric Project Upstream Fish Passage Thompson Falls, Montana	GEI Consultants	UPPER FISH LADDER COLLECTION AND SAMPLING FACILITIES
PPL Montana Butte, Montana	Project 100070	November 2010 Figure 2.3

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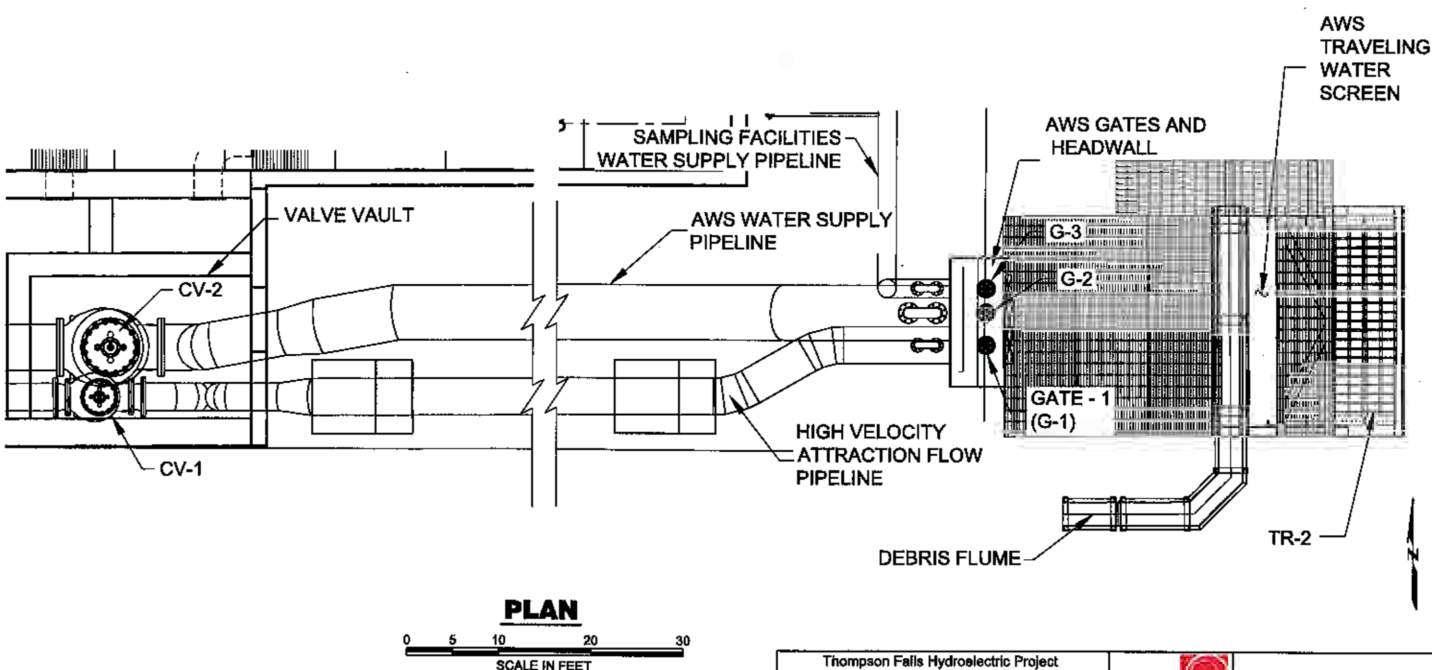

Thompson Falls Hydroelectric Project
Upstream Fish Passage
Thompson Falls, Montana

PPL Montana
Butte, Montana

GEI Consultants

AUXILIARY WATER SYSTEM INTAKE

Project 100070 | November 2010 | Figure 2.4

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Appendix A – Spillway Operations Schedule for Improved Fish Passage

The 2004-05 telemetry studies showed that tagged migrating bull trout (and tagged surrogate trout species) left the old and new powerhouses, and migrated upstream to the Main Dam Spillway, even when the only upstream discharge was leakage from spillway lift gates. Studies also showed that fish approach the spillway along the left shoreline, but have difficulty moving close to the dam during periods when the left-most spill gates are discharging. Since migrating fish appear to seek the "upstream terminus" of the main channel, it was hypothesized that fish approaching the left spillway abutment (east side of the Main Channel Dam) would fall back if they encountered excessive turbulence, then try to approach the right spillway abutment (west side of the Main Channel Dam). Tailwater bathymetry near the right abutment is more conducive to fish holding near the spillway apron; feasibility studies attest this is a far superior location for construction of a fish ladder than the left abutment.

Prior to the 2006 telemetry study, a fish passage spillway schedule (spreadsheet listing spillway lift gates to be open at each spillway discharge) was developed to create greater turbulence along the left side of the dam, and more attractive holding conditions in the tailwater zone adjacent to the right abutment. This was coordinated with the PPL Montana biological and operations staff and stakeholders, and reflected their input. The intent is that this spill schedule be a "living document" that can be used as a guide to improve the ability of migrating fish to find the fish ladder. The intent was that if there is new information that suggests a change to the spill schedule is needed, the spreadsheet can be updated as agreed to by PPL Montana and stakeholders.

A.1 Operations Considerations – Spill Greater than the High Fish Ladder Design Flow

The high spill discharge for which it is expected that fish may be able to find and enter the new fish ladder is approximately 25,000 cfs (total project discharge of approximately 48,000 cfs). Experience will affirm the threshold, on the rising hydrograph, when fish no longer enter the fishway, due to excessive spill. This discharge is considered the High Fish Ladder Design Flow, and if spill is expected to increase and stay above this magnitude, spillway operations prioritizing fish passage can be discontinued, in favor of the spill schedule developed for lower total dissolved gas uptake. While fish passage is only one of three spill priorities, total dissolved gas abatement and project operations priorities also will have an influence on the exact spill schedule to be used. Exact means of blending concurrent priorities will be reconciled over multiple years.

A.2 Total Dissolved Gas Considerations

At higher spill discharges, probably above the high fish ladder design flow, total dissolved gas levels can increase to a few percent higher than the previous PPL Montana spillway lift gate operation. However, at lower spill levels, the disparity in total dissolved gas levels is lower, and the benefits to upstream fish migration are expected to override the smaller incremental total dissolved gas difference. This issue continues to be discussed between PPL Montana and stakeholders.

A.3 Project Operator Requirements

Project operators have the difficult and dangerous task of raising and lowering the 4-ft-wide by 8-ft-high lift gates from the Main Dam Spillway during the rising/falling hydrograph each spring. There is a trash shear boom that extends from bay 15 upstream and at a low deflection angle. Coarse debris accumulates at large tainter gates in bays 16 and 17, and can be sluiced downstream by opening bay 16 and/or 17. Operator priority needs are to balance total spill flow on each side of the shear boom, and minimizing opening/closure redundancies to reduce labor.

The multi-agency Technical Advisory Committee (TAC) and PPL Montana project operations chief continue to discuss appropriate blending of priorities for the spill schedule. Table A.1 (below) shows the tentative 2011 spill schedule.

If the spill schedule deviates excessively from that used for the 2006 telemetry studies, migrating fish may have greater problems finding and passing the fish ladder.

Table A.1. Tentative 2011 spill schedule that is initially designed for fish attraction (light blue rows), then to total dissolved gas abatement (green rows).

Thompson Falls Main Dam Spillway -"Dual Mode" Spill Schedule

BAY NUMBER																																				Lift Gates	Total Flow (cfs)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
			1				1				1																									3	23,705
			1				1				1																	6	6	6	6	6	6	6	6	51	34,985
			1				1		6	6	1																	6	6	6	6	6	6	6	6	63	37,805
			1				1		6	6	1															6	6	6	6	6	6	6	6	6	6	75	40,625
			1				6	6	6	6	1															6	6	6	6	6	6	6	6	6	6	86	43,210
			1				6	6	6	6	1													6	6	6	6	6	6	6	6	6	6	6	6	98	46,030
			1		6	6	6	6	6	6	1													6	6	6	6	6	6	6	6	6	6	6	6	110	48,850
			1		6	6	6	6	6	6	1											6	6	6	6	6	6	6	6	6	6	6	6	6	6	122	51,670
			6	6	6	6	6	6	6	6	1											6	6	6	6	6	6	6	6	6	6	6	6	6	6	133	54,255
			6	6	6	6	6	6	6	6	1								6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	151	58,485
	6	6	6	6	6	6	6	6	6	6	1								6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	163	61,305
	6	6	6	6	6	6	6	6	6	6	1						6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	175	64,125
6	6	6	6	6	6	6	6	6	6	6	1						6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	181	65,535
DRY CHANNEL SPILLWAY (12 Bays)																																					
6	6	6	6	6	6	6	6	6	6	6	6																									72	82,455
Radial Gates (Bays 16 and 17)																																					
													Both - Full-Open - 11,000 cfs per bay																								104,455

Notes:

1. Numbers under each bay represent the six lift gates in each spill bay
2. Each bay should have all six lift gates opened, before opening lift gates from another bay
3. Closing sequence is opposite of the opening sequence
4. Bays 13 through 15 should never be opened
5. Bays 16 and 17 are radial gates, to be operated in a pre-set manner by operations for forebay elevation control, and load rejection purposes
6. This is a living document, and can be changed as necessary to depict past, non-fish Project spill operations

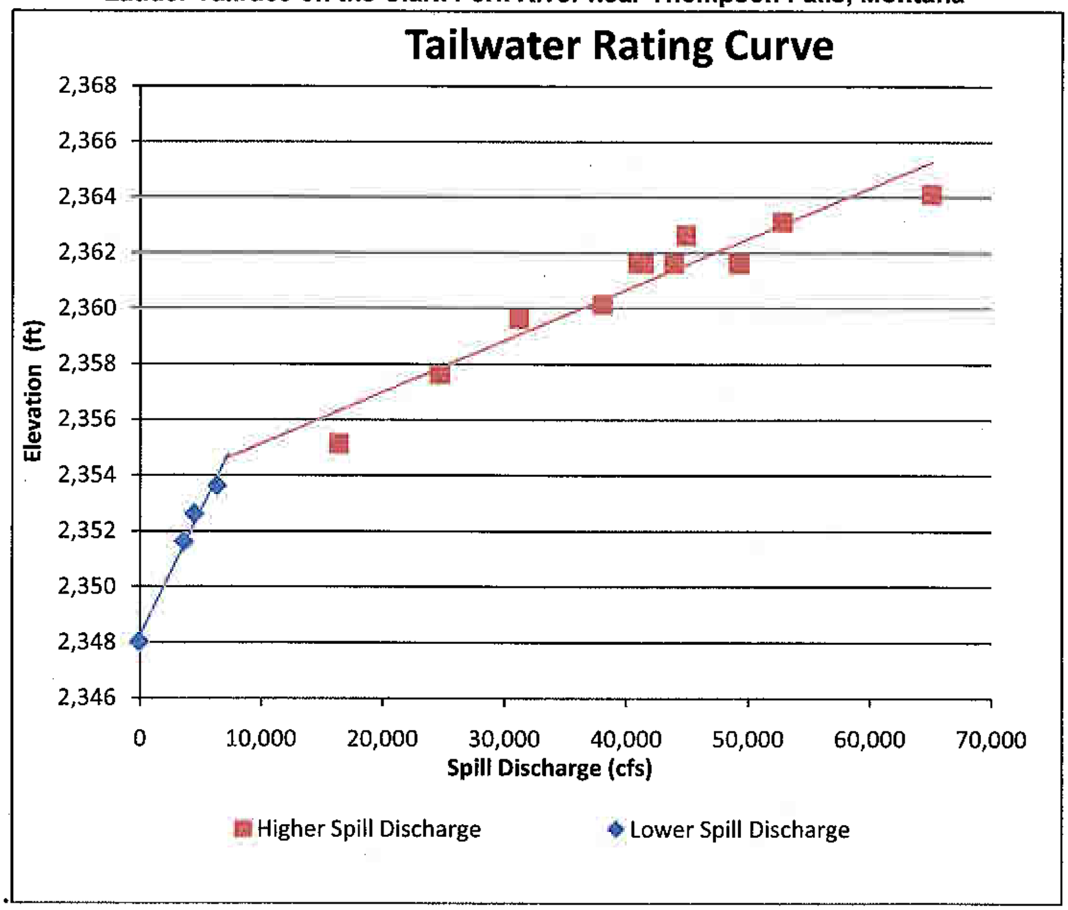
Appendix B – Fish Ladder Forebay and Tailwater Operating Elevations Descriptions

B.1 Tailwater Rating Curve

Figure B.1 depicts the right abutment fish ladder tailwater rating curve. Note that it relates to total spill, not total project discharge. This is because the historic Thompson Falls (immediately below the Main Dam Spillway) has a hydraulic gradient of greater than 10 ft during non-spill, and the falls is not backwatered until spill discharge appreciably exceeds the fish ladder high design flow. Thus, the greatest forebay to tailrace differential is 48 ft at the fish ladder, and 62 ft at the old and new powerhouse.

The fish ladder tailwater rating curve is based on the local PPL Montana datum. Readings were taken at the right abutment, during the 2008 season, by Jay Stuckey (MFWP). Discharge date is from the PPL Montana SCADA system.

Figure B.2: Location – Thompson Falls Dam Main Dam Spillway, Right Abutment Fish Ladder Tailrace on the Clark Fork River near Thompson Falls, Montana



B.2 Project Forebay Operations

The Thompson Falls forebay elevation ranges from El. 2395.5 to 97.0, and is highest during spill. Forebay elevation is maintained at nearer El. 2395.5 by controlling turbine 7 discharge during non-spill periods. During spill, when river discharge changes quickly, automated operation of large radial gates at spill bays 16 and 17 of the Main Dam spillway maintain forebay elevation nearer El. 2396.5.

Appendix C – Draft Design Criteria Table

The Thompson Falls Main Dam Spillway fish ladder and trap were designed to comply with the following design criteria:

#	Item	Criteria	Units	Comments
1	Type of fish	Primary: Bull Trout; Secondary: Westslope Cutthroat Trout	-	
2	Anticipated operational period	Approximately March 1 – Nov 15	-	To be determined on basis of on-site experience
3	Minimum Operating Tail Water Level	2,248	ft MSL	PPL local data; MSL – Mean Sea Level
4	Maximum Operating Tail Water Level	2,859	ft MSL	PPL local data
5	Minimum Operating Spill Flow	0	cfs	Spillgate leakage; cfs – cubic feet per second
6	Maximum Operating Spill Flow	25,000	cfs	Or as experience dictates
7	Flood Inundation Flow	Spill: 70,000 (powerhouse flow = 23,000 cfs)	cfs	Approximate 3-year flood, fishway entrance deck grating inundated
Fish Ladder Entrance				
8	Attraction Flow Jet	Entrance Flow		Streaming slot, or orifice flow
9	Attraction Flow (Ladder plus Auxiliary Water)	60	cfs	Flow from entrance, through the larger entrance gate
10	Hydraulic Drop	1.0	ft	NOAA Fisheries Criteria
11	Wall Diffuser Velocity	0.5	fps	fps – feet per second
12	AWS stilling pool energy dissipation rate (EDR)	16	ft-lb/s/ft^3	EDR $\leq (Q \times H)_{incoming} \times H_2O$ density/ receiving pool volume, where Q is AWS inflow and H is inflow velocity head
13	Entrance Opening Dimensions	30x48 large 24x36 small	inches	Dependent on tailwater elevation, only one to operate at a time, fully opened or

#	Item	Criteria	Units	Comments
				fully closed
Fish Ladder				
14	Ladder Type	Weir or Orifice		Either, dependent on prefabricated weir gate leaf settings
15	Ladder Flow	6	cfs	
16	Maximum Ladder Pool Drop	1.0	ft	NOAA Fisheries
17	Pool Dimensions	6 long x 5 wide x 4.5 deep	ft	
18	Energy Dissipation Rate (EDR)	3.5	$ft\text{-}lb/s/ft^3$	NOAA Fisheries: EDR $\leq (Q \times H)_{incoming} \times$ H_2O density/ receiving pool volume
19	Ladder Pool Freeboard at High Design Flow	1 minimum	ft	NOAA Fisheries
20	Orifice Dimensions	12-inch high x 14-inch wide (minimum)		
21	Fish Transport Velocity	1.5-4	fps	NOAA Fisheries
Intake Screens				
22	Max Slot Opening	3/32	inches	NOAA Fisheries Criteria
23	Min Open Area	27	percent	NOAA Fisheries Criteria
24	Max Average Approach Velocity	0.8	fps	NOAA – Waiver Granted by USFWS (vs. 0.4 fps)
25	Screen Cleaning Method	Backwash		Screen cleaning required for fish protection and operational reliability
Fish Trapping and Holding				
26	Number of Fish	640	fish	Assumes average 1.0 lb per fish
27	Average Pool Volume per fish	0.25	$feet^3$	Assumes maximum holding time of 24 hours
28	Flow Rate in Holding Tank	0.2	gpm per pound of fish	Assumes maximum holding time of 24 hours; gpm – gallons per minute
29	Holding Tank Volume	Minimum 160	cubic feet	

#	Item	Criteria	Units	Comments
30	Fish Removal	1	cycle	All fish will be removed from local holding at least once per day; water temperatures might dictate more trips
31	Vee Trap Opening Dimensions	4 x 6	inches	

Appendix D – Memo: Thompson Falls Hydro Project – September 29-30, 2010 Fish Ladder Tuning by GEI Engineers

Geotechnical
Environmental
Water Resources
Ecological

GEI Consultants

Memo

311 B Avenue Suite F
Lake Oswego, OR 97034
Tel. 503-697-1478 Fax 503-697-1482
www.geiconsultants.com

To: **Brent Mabbott, PPL Montana**

From: **Steve Rainey and Chad Masching, GEI Consultants**

Date: **September 30, 2010**

Re: **Thompson Falls Hydro Project – September 29-30, 2010 Fish Ladder Tuning by GEI Engineers**

We attended the subject two-day site visit for the purpose allowing the GEI fishway designers Steve Rainey and Chad Masching to observe the new fish ladder and trap in a watered-up state. In particular: it was important to (1) assure facilities were constructed according to plans and specifications; (2) instruct operators and biologists on the correct fishway and trap operations; and (3) tune facilities hydraulically to assure that most appropriate operations are listed in the Operations and Maintenance Manual, which is due in early November 2010. Those present on September 29, 2010 at the fishway were:

Jeff Monaco	COP Construction
Brent Mabbott and Jon Jourdonnais	PPL Montana
Jay Stuckey, Harvey Carlsmith, and Chris Horn	Montana Fish Wildlife and Parks

Contractor Progress

The contractor was still installing access grating, so many parts of the ladder were inaccessible. Also, the sorting area, off-ladder holding pool crowder, and fish lock were not operational, as the contractor was waiting on metal fabrication deliveries or had items on site awaiting installation. This impeded the benefit of GEI's visit, particularly for testing of the facilities for trapping and sampling. The contractor expects to have heavy lifting completed in the next few days, when he will start removing the work bridge and demobilize the large crane from the project site.

September 29

GEI handed out two double sided laminated pages which included the Daily Fish Ladder Operating Procedures and figures (2.2 to 2.4 from draft Fishway Operations Manual depicting the features of three main areas of the fishway). The initial task was to visit each of the three fishway areas and discuss each feature to assure that all understood the feature names, locations and functions.

Safety: PPL Montana is developing a protocol to assure ladder-trap safety, which includes calling the Great Falls office to inform them of intended operations for the coming day; how many people will be at the ladder-trap, etc.

Auxiliary Water System (AWS) Traveling Water Screens Observations:

- As currently installed, the operators will be unable to readily observe mesh and impinged debris on the upstream screen face. This can be addressed by installing an easily removable hatch, or Plexiglas windows.

- Current cover protects against freezing, but has many bolts and is time-consuming to remove and re-install.

- The replacement parts required to be provided from the manufacturer such as extra screen and rods were not yet delivered.

- GEI was informed that the screen manufacturer representative did not adequately perform his start-up services, as required in the specifications.

- Debris accumulation on the screen face will vary in type and abundance, depending on time of year, stream flows, and other variables. The AWS screen is designed to cycle at the appropriate frequency, based on manual setting of a timer in its control panel. Minimum frequency should be one cleaning cycle per 24 hours, when the AWS is operating. Maximum cleaning frequency should be continuous, for periods of extreme debris loading. Operators are responsible for setting screen cycling frequency. Inadequate screen cleaning frequency allows debris to occlude open area of the screen face, and creates a water surface differential across the screen. Structural failure will occur if the differential exceeds several feet, which results in the inability to pass flow through the trap/sample facilities, high-velocity jet, and ladder AWS flow control gates (G-1, G-2, and G-3) without ingesting debris and clogging each system. Mr. Monaco is to relay desired timer information to the electrical subcontractor, who will install the timer accordingly.

- A full-width vertical gap between the AWS trash rack (TR-2) raking access grating and forebay water surface allows exposure of severe cold weather to the screen face. PPL is to install a bubbler system to prevent icing at the screen water surface, thus preventing damage to the screen belt.

Fish Observed Between AWS Porosity Panel and Pool 1 Add-in Diffuser Panels: The AWS control valve, G-2, was opened for a short period, and approximately six small pike minnow (approximately 6-inches in length) were observed between the porosity panel (Figure 2.2) and the pool 1 wall diffuser. However, since entrance gate EG-1 has been left open, it is possible that these fish entered the fishway and purposely passed upstream of the wall diffuser. When the AWS flow is operated on a sustained basis, upstream entry into this area by small fish is not expected.

Lock Pump Operations: Although the lock closure gate LKG-1, Figure 2.3, was not installed, we tried to operate the lock pump. After difficulties with pump start-up, the lock pump was finally primed and is expected to hold its prime with normal operational use. Start-up criteria and procedures is included in the Fishway Operations Manual.

Gate G-1, G-2, and G-3 (Figure 2.4) Winterization Protection: PPL has initiated efforts to create a bubbler system to protect operating gate stems for these three open-closure gates.

Diffuser gate D-1 will likely have debris accumulation problems during late summer and early fall, when aquatic vegetation nurtured by elevated summer water temperatures breaks loose. The fishway exit is adjacent to a shallow shoreline zone that supplies much of this debris. The AWS trash rack (TR-2) and traveling screen do not appear to collect as much of this debris, even though they pass 20-54 cfs, rather than 6 cfs through the upper ladder pools. (However, sustained operation of the AWS may increase debris loadings during this period.) The limited space between D-1 and the concrete downstream face of the dam causes some debris to fall off and impinge on the downstream diffuser D-4 when D-1 is raised to clean debris. An additional fine trash rack, designed to be easily raked, may be required upstream of the dam in the exit pool. Diffuser raked debris needs to be moved to below the dam, rather than back into the forebay where it will again be impinged and need re-raking.

Sorting: The horizontal crowder chain, and lock closure gate were not on site; sorting tables, tanks, and access grating were not installed. Thus, we were unable to access/operate the trap holding pool, lock, and handling features.

Pool 44-45 Finger Weir: Prior to initial sustained fish trapping operations, this should be installed to keep fish entering pool 45 from purposely exiting down the ladder rather than passing through the vee-trap.

Orifice Mode Ladder Operations

Spring 2011 ladder/trap evaluation will include two treatments: Pool weirs in orifice mode versus weirs in notched weir mode. Gate leafs are designed to be raised (to open orifice and close notched weir) or lowered (vice versa).

Weir 1 was temporarily in orifice mode for all operations, with a diffuser panel to keep fish from moving above this ladder location until sustained operation is initiated. Some flow passed over top of the panel as well as through the orifice and diffuser.

Water-Up and Dewatering: Orifice mode water-up time was less than 1 hour; however, it takes longer for the ladder to reach full equilibrium in orifice mode. Dewatering time was approximately 30 minutes

Weirs 1 to 6 in the lower ladder were operated in the notched weir mode (which is a requirement for spill, but not non-spill ladder operation).

Orifice Mode Fish Ladder Hydraulic Conditions: The forebay was at elevation (El.) 2395.5. The design forebay elevation range for orifice operation was between El. 2396.0 to 2397.0. In notched weir mode (as opposed to orifice mode), there is greater flexibility to control turbulence and upwelling by reducing pool to pool flows.

Orifice Hydraulic Observations:

- Pool 45 water surface was at El. (23)92.4 on staff gage SG-8, which is approximately 6 cfs design ladder pool flow, with a 3.1 ft differential from forebay El. 2395.5, with no flow passing over flow control gates FCG 1 or 2 (Figure 2.3). Target differential is 3.0 ft.

- Corner pools appeared to have substantial upwelling where orifice flow jet discharges into sidewalls, and creates a boil at the surface. Pool turbulence was appreciable. This is partially due to the 0.5 ft reduced depth of each pool, relating to the 0.5 ft lower forebay elevation referenced above.

- The prefabricated weir gate leafs have a ¼-inch gap between the weir plate and gate leaf, and orifice flow was accompanied by flow through the gaps, which discharged above each receiving pool water surface for each weir. This gap and related discharge may induce jumping. *If jumping is observed, a minimum 3/16-inch filler should be installed at the base of each weir notch to reduce this discharge.*

- The system has flexibility to add flow from the sample loop to pool 45, to provide the additional 0.5 ft pool depth and reduce turbulence in pools 44 and below. This overrides the issue of lower forebay operational levels. (Trap flow is controlled by Control Valves CV-3 and CV-4. CV-4 adds up to nearly 3 cfs, and opens/closes over several minutes.)

- Trial 1 – Reduce pool 45 water surface to below 92.4: By incrementally lowering FCG's 1 and 2, we were able to lower pool 45 (staff gage SG-8 reading) below 92.4, and reduce flow down the ladder. This tends to starve (therefore emptying) the upper pools, which resulted in greater drops in upper ladder pools and greater pool turbulence and upwelling (especially at turning pools). Reducing flow from pool 45 to the lower ladder is not advised.

- Trial 2 – Increase pool 45 water surface by opening trap flow valves CV-3 and/or CV-4: This increased inflow to pool 45 to an estimated 8-9 cfs (with FCG's 1 and 2 raised and passing no flow). This initiated a relatively long and slow transition that would have resulted in greater drops between upper pools, followed by the extra 2+ cfs passing over prefab weirs in orifice mode, once equilibrium was met. We noticed greater turbulence and upwelling at corner pools. By lowering FCG's 1 and 2 (at operators discretion to control flow through the vee-trap), and with CV-3 and 4 open, we were able to raise pool 45 water surface above El. 2392.4 to attain approximately 6 cfs design flow below pool 45, coupled with added pool depth and reduced turbulence in lower pools.

Therefore:

- **In orifice mode, and forebay elevation below El. 2396.0: Operate CV-4 (and CV-3, at operators discretion) to pass flow from holding pool through vee-trap (or finger weir), and bleed off flow at FCG-1 (and FCG-2 at operators discretion) to attain SG-8 reading of 93.0. This provides approximately 6 cfs,**

while also yielding the added depth and reduced turbulence in each lower ladder pool).

- **In orifice mode, and forebay elevation at El. 2396.0 to 2397.0: Adjust FCG-1 (and FCG-2 at operator's discretion) to attain SG-8 reading of 93.0. Operation of CV-3 and CV-4 are not required to provide 6 cfs and additional depth and reduced turbulence in ladder pools below pool 45.**

<u>**September 30**</u>

Notched Weir Mode Ladder Operations

The forebay was at El. 2395.5, 0.5 ft below the low design forebay elevation previously referenced. Operation on this day was converted to the notched weir mode, with prefabricated weir gate leafs in the "down position," to pass flow through the 2-ft-wide notched weirs.

Notched Weir Water-Up and Dewatering Times: Water-up took approximately 22 minutes; however, dewatering in this mode is through 3-inch diameter orifices, and takes nearer 4 hours (unless weir gate leafs are raised to accelerate the process. (Note: it is relatively hard to manually lift gate leafs for each weir when there is no flow, and harder to do so even when dewatering.)

Notched Weir Hydraulic Observations:

- With FCG-1 and 2 raised (zero flow passing), the pool 45 staff gage SG-8 reading was 92.9, with the forebay reading at staff gage SG-1 was at at 95.5 (and no debris on trash rack TR-1) – a differential of 2.6 ft (vs 3.0 ft design). Thus, flow down the ladder was less than 6 cfs (approximately 5.1 cfs).

- Pool turbulence was lower than with the orifice operation, and upwelling was reduced at corner pools

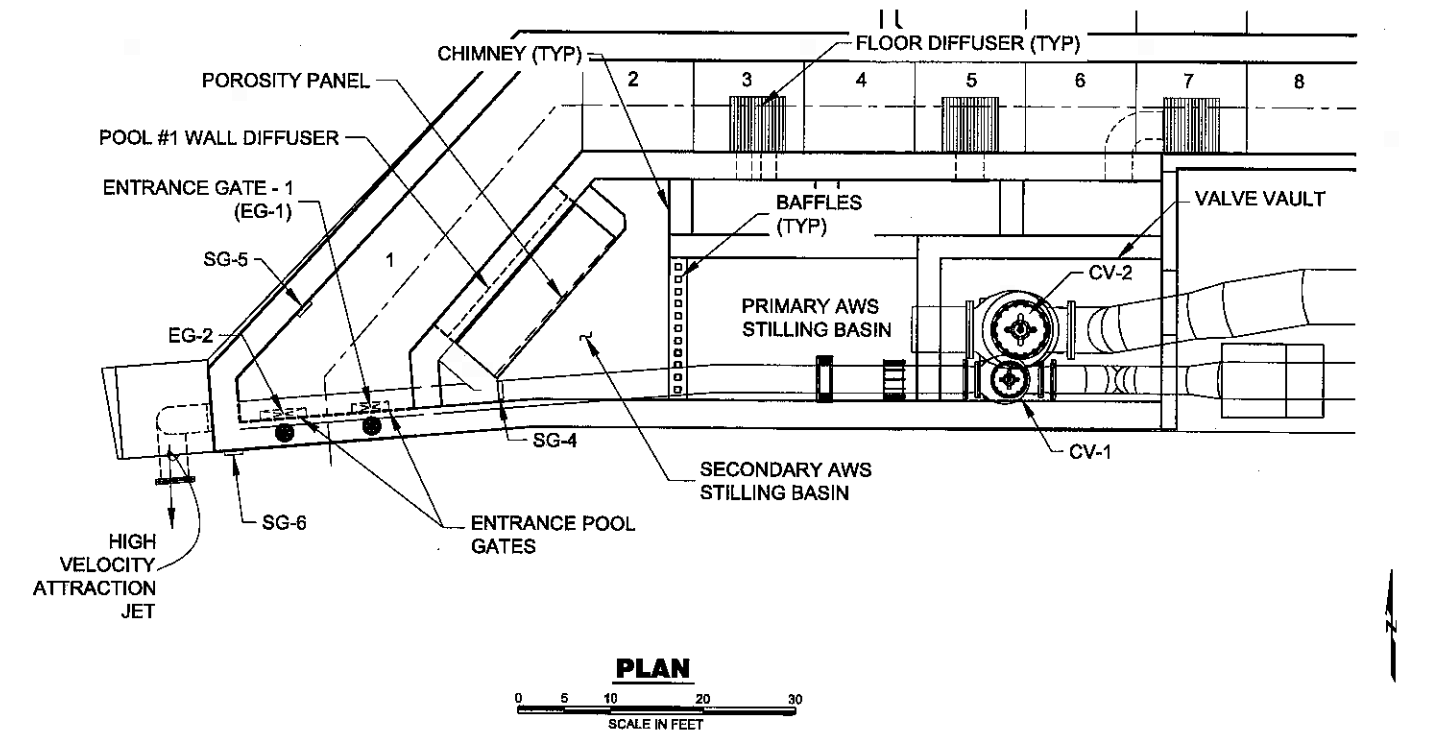
- Inflow to each pool below pool 45 was below the incoming notched weir crest elevation, and weir inflow nappes were fully ventilated (and approximately 0.1 to 0.2 ft above the receiving pool water surface). These conditions increases fish passage challenge, relative to a non-ventilated nappe, where fish can more easily swim (rather than jump) through the notched weir inflow. This condition means there is a need for a higher water surface at pool 45. Thus, CV-4 (gravity flow to the lock and through the holding pool to pool 45) must be opened at this forebay elevation. (At forebay elevation 2396.0 to 2397.0, the design range, CV-4 trap flow may not be required to raise the SG-8 water surface elevation in pool 45 to El. 93.0.

- We adjusted FCG-1 and 2, with CV-4 opened, to assess pool 45 SG-8 readings of 93.2 and 93.1. Both added enough flow below pool 45 to rid the ventilated nappe, thus increasing ladder flow between 1 and 2 cfs above the target design flow (6 cfs). Although turbulence increased slightly in lower pools, it was still lower than with the orifice mode operation.

Therefore:

- **At below Forebay El. 2396.0: SG-8 should initially be adjusted to operate at SG-8 reading of 93.1 in the notched weir mode. This requires trap/sample loop flow (CV-4 open).**

- **At Forebay El. 2396.0 to El 2397.0, SG-8 should be operated at 93.1, and trap/sample loop flow (CV-4) may not be required.**



Thompson Falls Hydroelectric Project Upstream Fish Passage Thompson Falls, Montana	GEI Consultants	LOWER FISH LADDER	
PPL Montana Butte, Montana	Project 100070	November 2010	Figure 2.2

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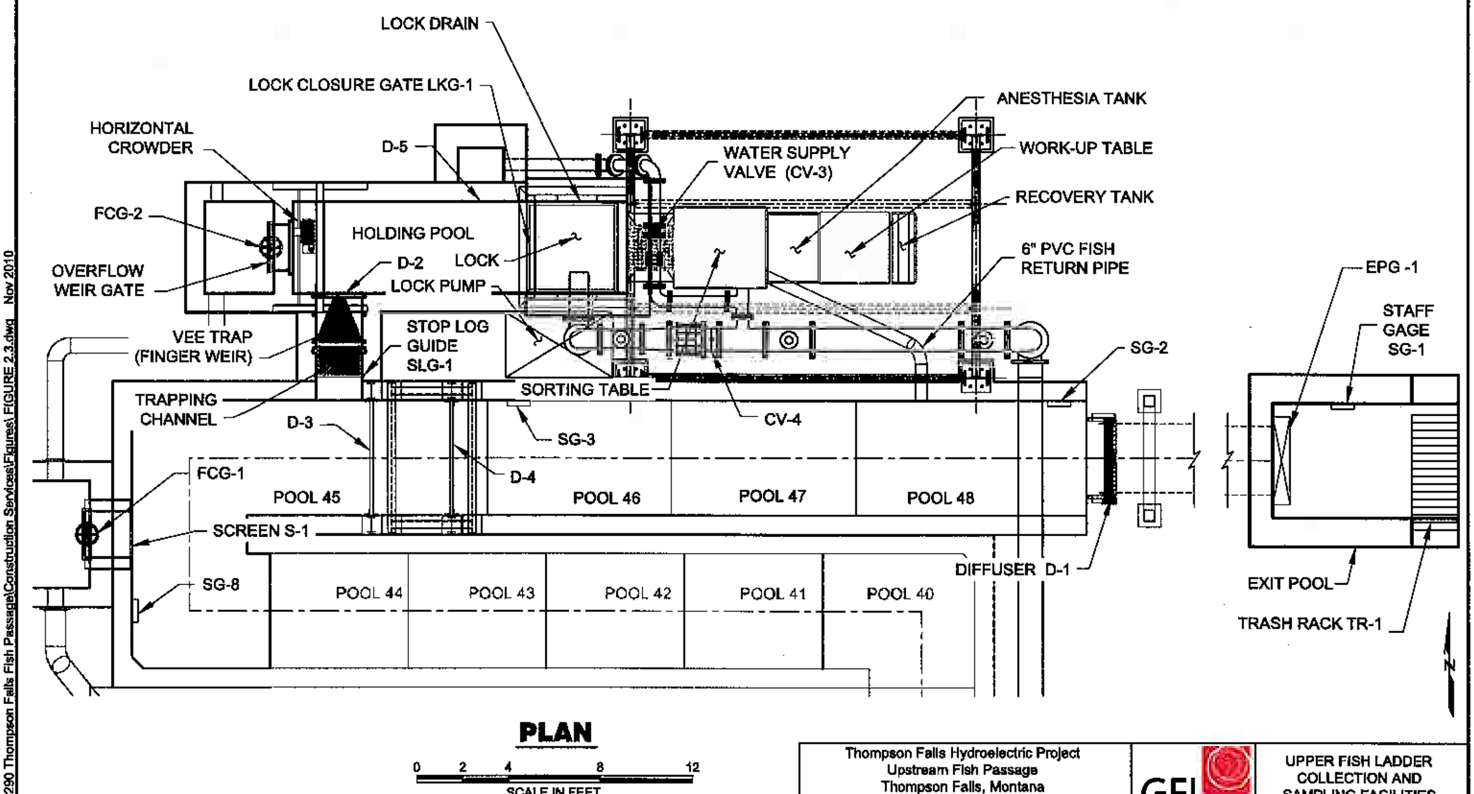


Thompson Falls Hydroelectric Project
Upstream Fish Passage
Thompson Falls, Montana

PPL Montana
Butte, Montana

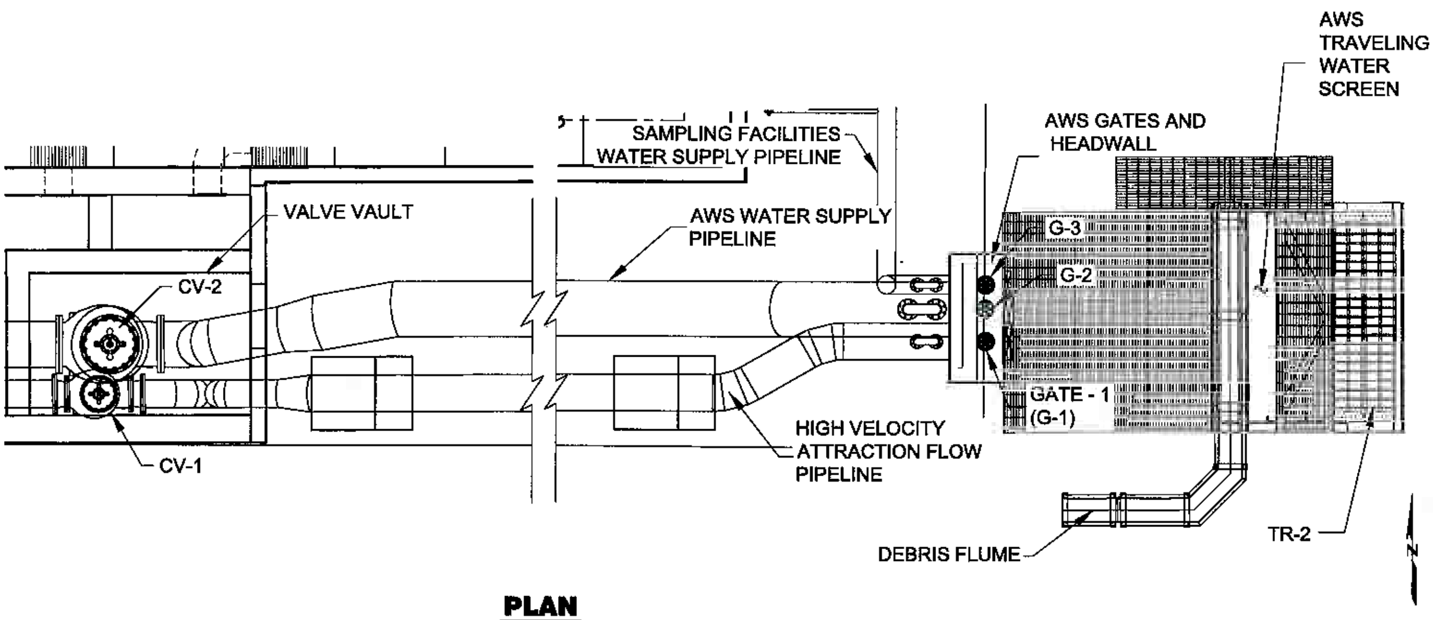
GEI Consultants

Project 100070

UPPER FISH LADDER COLLECTION AND SAMPLING FACILITIES

November 2010

Figure 2.3



PLAN

0 5 10 20 30
SCALE IN FEET

Thompson Falls Hydroelectric Project Upstream Fish Passage Thompson Falls, Montana PPL Montana Butte, Montana	GEI Consultants Project 100070	AUXILIARY WATER SYSTEM INTAKE November 2010 Figure 2.4

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Appendix E – Daily Fish Ladder Operating Procedures

The following is a condensed list of daily operating checks for the Thompson Falls fish ladder (Section 6.2), and is for daily use by project operators and/or biologists responsible for fish ladder operation and performance.

E.1 Daily Fish Ladder Operating Procedures – November 4, 2010

1. Observe and record project forebay elevation at project office (Target El. = 2395.5 - 2397.0)

2. Observe and record staff gage (SG-1) elevation, immediately downstream of exit pool trash rack (TR-1) - remove visible trash rack debris (Fig 2.3)

3. If fish are being trapped, diffuser gate D-1 should be in the down positions. Observe pool 48 staff gage (SG-2) reading. If SG-1 minus SG-2 reading > 0.1 ft, raise D-1, remove debris, lower D-1 and leave closed for next sample fish cycling (Fig 2.3).

4. Observe and record visible trash rack debris from auxiliary water trash rack (TR-2) – remove same (Fig 2.4)

5. Observe and record debris amount on upstream auxiliary water traveling screen, cycle the screen manually to start each day; if debris load is noticeable, set for more frequent cleaning cycles to assure screen stays clean. NOTE: if excessive differential due to debris accumulates on the screen, structural failure will occur. (Fig 2.4)

6. Observe and record visible debris on pool 45 diffuser racks (D-2 and D-3), to be installed when fish are being trapped - remove debris from both panels. (Fig 2.3) Remove any debris passed down from D-1

7. Observe pool 45 flow bleed-off screen S-1, record debris presence, brush screen surface to remove debris. (Fig 2.3)

E.3 Discharge Control Checks

1. Observe and record the pool 45 staff gage SG-3 water level (Fig 2.3)

2. Adjust flow control gate FCG-1 as necessary to attain reading 93.0 at SG-3. (Fig 2.2)

3. Observe and record tailwater staff gage SG-4 reading from the main dam deck. (Fig 2.2)

E.4 Entrance Gate and Attraction Discharge Adjustments (Fig 2.2)

If there is **no** spill discharge:

1. Fully open the lower entrance gate EG-1 and close the upper entrance gate EG-2.
2. Observe, estimate and record the stilling pool staff gage SG-4 reading.
3. Observe and record the entrance pool (Pool 1) staff gage SG-5 level. Subtract the SG-5 reading from SG-4 reading. The difference should be 0.8 – 1.0 ft.
4. If SG-4 minus SG-5 $<$ 0.8 – 1.0 ft, incrementally increase AWS valve CV-2 flow to attain a 0.8 – 1.0 ft differential.
5. If SG-4 minus SG-5 $>$ 0.8 – 1.0 ft, incrementally reduce flow through CV-2 to attain 0.8 – 1.0 ft differential.

If there **is** spill discharge:

1. Fully open the upper entrance gate EG-2 and close the lower entrance gate EG-1.
2. Observe, estimate and record the stilling pool staff gage SG-4 average water surface elevation.
3. Observe and record the entrance pool (Pool 1) staff gage SG-5 level. Subtract the SG-5 reading from SG-4 reading. The difference should be 0.8 – 1.0 ft.
4. If SG-4 minus SG-5 $<$ 0.8-1.0 ft, incrementally increase AWS gate CV-2 opening to attain a 0.8 – 1.0 ft differential.
5. If SG-4 minus SG-5 $>$ 0.8-1.0 ft, incrementally reduce CV-2 opening to attain 0.8 –1.0 ft differential.
6. Subtract SG-5 reading from SG-4, if difference $>$ 3 ft, notify plant operations chief (as debris is accumulating on upstream face of Pool #1 wall diffuser)…trouble-shoot the problem.
7. Depending on fishway operating experience, fully open G-1 (Fig 2.3) to initiate high-velocity jet attraction flow to the tailrace.

Appendix F – Manufacturer's Information for Project Features

This is a list of Installation/Care Manuals for Equipment at Thompson Falls Fish Ladder. These manuals are available in separate files, provided on CD with this report.

10.1 Electrical Controls and VFDs

GRUNDFOS INSTRUCTIONS
CUE, 0.55-90 kW

DriveIT Low Voltage AC Drives
ACS550-01 Drives (0.75...110 kW)
ACS550-U1 Drives (1...150 HP)

CERUS Industrial
GS Series VFD V2.1

Titan: CERUS Industrial
GS Series Compact Space Vector VFD
Variable Frequency and Sensorless Vector Control
.5-5 HP, 3 phase, 200-230VA
.5-5 HP, 3 phase, 380-480VA

10.2 Sampling Facility Butterfly Valves

AUMA Actuators SG 05.1 -- SG 12.1
Electric part-turn actuators
SG 05.1 – SG 12.1
SGR 05.1 – SGR 12.1
AUMA NORM
for flange type FA

10.3 Lock Pump

Badger® 200 Series (has various models)

Metron
Fluke 87 V
Digital, Battery

10.4 Auxiliary Water Supply (AWS) Control Valves

CLA-VAL CO
Electronic Interface Control Valve (24" and Larger)

CLA-VAL CO
Rater of Flow Valve with Manual Bypass Control
100-01 Hytrol Valve
100-20 600 Series Hytrol Valve
CDHS-18 3/8" Differential Control
X52E Orifice Plate Assembly
X43 Strainer
CV Flow Control
CV 3/8" Flow Control

CLA-VAL CO
133VF Valve Flow Measurement

CLA-VAL CO
50-01/650-01
Pressure Relief, Pressure Sustaining & Back Pressure Valve

CLA-VAL CO
131 VC-1
1/4 DIN Process Controller

photo called, "TFalls Fish Passage 16" in line"

10.5 Sampling Facilities Water Supply

Grundfos (one of two docs)
JPF-A, JPS-A, JDF-A

Grundfos (two of two docs)
JPS 4, JPF 3 & 4, JDF 2 & 4, JPF 5

Pro-source Steel Pressure Tanks
Signature 2000 4" Submersible Pumps 1/2 HP - 5 HP

Pentair Water, Pro-source Steel Pressure Tanks
Models: PSP19S-T02; PSP19T-T02; PSP32-T03; PSP35-T05; PSP50-T50; PSP62-T51; PSP85-T52; PSP119-TR50

10.6 Sampling Facilities Horizontal Crowder

Browning
CbN Series 3000

10.7 Ladder and Holding Pool Gates

Golden Harvest
Slide-Weir-Stop-bulkhead sluice gates and telescoping valves
EPCON A7 Series

Golden Harvest
MD GH-40 Aluminum Slide Gate, Pool #1 SG-1
MD GH-40 Aluminum Slide Gate, Pool #1 SG-2
MD GH-40 Aluminum Slide Gate, AWS Intake #1 SG-3
MD GH-40 Aluminum Slide Gate, AWS Intake #1 SG-4
MD GH-40 Aluminum Slide Gate, AWS Intake #1 SG-5
MD GH-40 Aluminum Slide Gate, Exit Pool #1 SG-6
MD GH-60 Aluminum Weir Gate, Pool 45 WG-1
MD GH-60 Aluminum Weir Gate, Holding Pool WG-2
Tripod Mounted Portable Electric Drill Motor Operator, TG-200

10.8 AWS Intake Sprayer

Grundfos (supply list)
Shaft seal
MS6, MS 402, MS 4000, MS 6000, MMS 6, MMS 6000, MMS 8000, MMS 10000, MMS 12000

Grundfos
MS, MMS (Installation and Operations of the above)

Grundfos
MS, MMS (English version only, Installation and Operations of the above)

Grundfos (two docs)
CUE Constant Pressue Quick Start Guide

10.9 AWS Traveling Screen

Hydrolox
Traveling Water Screen
Series 1800 Belt

Peerless-Winsmith & Se Encore: ILE-08

Hydrolox
Traveling Water Screen
Series 1800 Belt Installation and Maintenance
Nickle Plated Take Up Unites, Wide slot with optional bearing inserts:

Stainless Steel-SUCNPT
Hard Chrome Coated-CUCNPT
SUCNPT with Stainless Steel Bearing Inserts: # SUCNPT 210-31
Mounting Positions and Important Order Information: #M1
Mounting positions for helical geared motors: #M1
Parallel Helical Gear Units: # R..R..DT../DV..
Dimensions
Type R Gearmotors - Foot Mounted: #R97
Motor: DT 100
AC Motors and Brakemotors, Synchronous speed 1200 rpm @ 60Hz: #DT100L6
Motor Connection Diagrams: DT71 thru DV180
Martin: All steel stock sprokets No. 80 1" pitch: #80B17 and 80B32
Intralox Series 1800 Mesh top
Split collar retainer rings
Spray Nozzles

10.10 Hoists and Accessories

R&M: Loadmate LM05 Stepless Chain Hoist

R&M
RBC BEAM CLAMP – 1 TON TO 5 TONS
Type RBC 1 - 5

R&M
1/4 TON TO 3 TON CAPACITY
RL Manual Lever Puller

R&M
3/4 TON TO 6 TON CAPACITY
RLP PREMIUM MANUAL LEVER PULLER

R&M
RM Manual Chain Hoist
¼ TON to 3 TONS

R&M
RM SERIES II MANUAL CHAIN HOIST

R&M
LOADMATE® LM1-LM05-LM10-LM16/20/25
Electric Chain Hoist

R&M
RMP Premium Manual Chain Hoist

10.11 Lock Pump

Metron
Custom P4
Programmable Logic Controller
Flow Sensor
Surge Arrestor
Illuminated System HOA Switch
Local Audible Alarm Horn
Alarm/Fault Pilot Light

AP Aurora - Pentair Pump Group
340A Series

Metron
Storage Recommendations, preventative maintenance, and freeze protection

Metron
Ashcroft Commercial Hydraulic Guages
Type 3005, 3005P, ASME B 40.1 Grade B

Metron
CLA-VAL Automated Control Valves
50-01BKC
50-01/650-01 Pressure Relief, Pressure Sustaining & Back Pressure Valve
100-01 Hytrol Valve
X42N-2 Strainer and Needle Valve Assembly
CRL Pressure Relief Control
CRL 1/2" and 3/4" Pressure Relief Control
CK2 Cock/Ball Valve
3/8" and 1/2" CDC-1 Check Valve
CV Flow Control
CV 3/8" Flow Control
Repair Kits
Data Industrial, 200 Series Insert Style Flow Sensors
Keystone F221 Wafer style valves
Keystone F222 Lugged style valves
No. 74 Auto-Vent, 1/4" I.P. female connect, 150 psi, No. 7 series
Val-Matic's Swing-Flex Check Valve
Backflow Actuator Field Installation and Maintenance (Optional)
Mechanical Indicator (Optional)
Limit Switch (Optional)
Bottom Mounted Oil Dashpot Field Installation and Maintenance (Optional)

Intralox Water Screen

Tsurumi Pump
Models: PU; PN; PSF; TM