126 FERC ¶ 62,105
UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

PPL Montana, LLC | Project No. 1869-048

ORDER APPROVING CONSTRUCTION AND OPERATION OF FISH PASSAGE FACILITIES

(Issued February 12, 2009)

On April 7, 2008 PPL Montana, LLC (licensee) filed a Biological Evaluation (BE) for the Thompson Falls Project and 90-percent construction drawings for upstream fish passage at the Thompson Falls Dam. The BE discussed impacts of project operation and possible impacts of proposed upstream fish passage on federally listed as threatened bull trout (*Salvelinus confluentus*). The Thompson Falls Project is located on the Clark Fork River in Sanders County, Montana.

BACKGROUND AND CONSULTATION

On July 6, 2001 the Commission received a letter from the U.S. Fish and Wildlife Service (FWS) stating it believes that some of the activities related to the Thompson Falls Project may be incidentally taking federally listed as threatened bull trout. In the July 6 letter the FWS recommended that the Commission prepare a Biological Assessment (BA) to evaluate the effects of project operation on bull trout and other federally listed threatened and endangered species, and to determine if formal consultation under Section 7 of the Endangered Species Act (ESA) was necessary. The Commission received another letter from the FWS, pertaining to threatened bull trout at the Thompson Falls Project, on January 30, 2002. The letter stated that studies 50 miles downstream of the Thompson Falls Dam at the Clark Fork Project (FERC No. 2058) showed adverse impacts occurring to bull trout from habitat degradation behind the Noxon Reservoir Dam as well as incidental take due to fish passage barriers. The FWS also stated that it believes similar impacts are likely occurring at the Thompson Falls Project. Additionally, the FWS stated that non-native northern pike (*Esox lucius*) likely prey on juvenile bull trout in the impoundment created by the Thompson Falls Dam.

In a response dated March 13, 2002, to the FWS, the Commission stated that a definitive federal action is needed to trigger ESA consultation and it believed that there was no federal nexus to begin consultation. However, in a letter dated March 13, 2002, the Commission asked the licensee to respond to the FWS's letters. In the Commission's letter to the licensee, the FWS's recommendation to prepare a BA because the Thompson Falls Project operation may affect threatened bull trout was discussed. The Commission stated that it is their position to investigate the situation to determine what effects to bull trout if any, may be occurring, and what changes, if any, should be considered to avoid or mitigate those effects or to benefit the species. Additionally, the Commission also stated that if changes are necessary the Commission can institute a reopener proceeding to require changes or can entertain a voluntary amendment application from the licensee.

The licensee responded to the Commission's March 13, 2002 letter in a letter dated April 1, 2002. The licensee stated that it was their understanding that there was no federal action at the Thompson Falls Project that would require Section 7 consultation pursuant to the ESA. However, the licensee also stated that in the spirit of cooperation and under the guidelines of the Interagency Task Force Report (ITFR)[1] they requested to be designated as the Commission's non-federal representative for the purposes of initiating informal consultation on the potential effects of project operation on bull trout. In a letter dated May 3, 2002, the Commission designated the licensee as its non-federal representative for the purpose of conducting informal consultation with the FWS.

The licensee filed a BE for threatened and endangered species with the Commission on April 7, 2003. The Commission adopted the licensee's BE without modification and submitted it to the FWS as a final BA on May 5, 2003. In the May 5 letter, based on our analysis and the BE's findings, we concluded that operation of the Thompson Falls project likely adversely affects bull trout. Consequently, the Commission requested initiation of formal consultation with the FWS. The FWS responded to the Commissions BA in a letter dated March 8, 2004. The FWS stated they agreed to proceed as recommended in the ITFR. The FWS also stated that data gaps needed addressed in order to move forward with the process. Consequently, FWS stated it would work collaboratively with the licensee and other members of the Technical Advisory Committee (TAC)[2,3] to develop and conduct studies needed to gather the

[1] Interagency Task Force Report on Improving Coordination of ESA Section 7 Consultation with the FERC Licensing Process, December 12, 2000. The report can be found on the Commission website (http://www.ferc.gov/industries/hydropower/indus-act/itf/esa_final.pdf).

[2] The Interagency TAC was formed in 2003 to clarify regulatory issues, plan research activities, and develop conservation measures to address bull trout issues at the Thompson Falls Project. The committee consists of PPL Montana, U.S. Fish and Wildlife Service (FWS), Montana Fish Wildlife and Parks (FWP), Avista Corporation, Montana Department of Environmental Quality (DEQ) and Confederated Salish and Kootenai Tribes (CSKT).

[3] The January 15, 2008 Memorandum of Understanding created a new TAC and outlined its responsibilities. The new TAC consists of: PPL Montana, U.S. Forest Service, FWP, DEQ, and CSKT.

necessary data. The FWS stated that they would proceed with formal consultation once the necessary data was attained.

After five years of studies the licensee filed a new BE discussing the effects of the Thompson Falls Project on bull trout and proposed conservation measures with the Commission on April 7, 2008. The licensee's BE identified several factors directly related to project operation that negatively impact bull trout in the Clark Fork River. Inhibition of upstream migration and access to spawning habitat by the Thompson Falls Dam was identified as a major concern. Consequently, the licensee proposed to install a full height fishway at the project and filed 90-percent drawings for the structure on April 7, 2008 as well. The licensee's April 7 filing also contained a Memorandum of Understanding (MOU) signed by PPL Montana, the Confederated Salish and Kootenai Tribes of the Flathead Nation (CSKT), Montana Department of Fish Wildlife and Parks (FWP) and FWS.[4] Based on the our review and findings in the BE we 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 BE was adopted as the Commission's final Biological Assessment (BA) and submitted to the U.S. Fish and Wildlife Service on May 1, 2008. At this time the Commission requested initiation of formal consultation under Section 7 of the ESA.

On November 4, 2008 the FWS filed, with the Commission, a Biological Opinion (BO) and associated Incidental Take Statement (Appendix A), which includes reasonable and prudent measures and terms and conditions to minimize incidental take. The FWS stated that the BO is primarily based on the licensee's April 7, 2008 BE, which was adopted as the Commission's BA. The BO describes the effects of the Project on threatened bull trout and its designated critical habitat. Additionally, the BO also evaluates the effects of the licensee's proposed conservation measures. The FWS concluded in its BO that the Thompson Falls Project is currently adversely affecting bull trout and the licensee's proposed conservation measures will reduce, but not totally eliminate, adverse impacts of the Project.

LICENSEE'S PLAN

The Thompson Falls Project is a migratory barrier for bull trout in the Clark Fork River. In order to provide bull trout access to important habitat upstream of the Project the licensee proposes to build, operate, and maintain upstream fish passage. The licensee

---

[4] Facilitation and Funding of FERC License based Consultation Process and Implementation of Minimization Measures for Bull Trout. Signed January 15, 2008. The MOU provides terms and conditions regarding the collaboration between the licensee and the FWS, MFWP, and CSKT and the implementation of minimization measures for bull trout.

plans to construct a full height pool and weir fishway on the right abutment of the main dam, as shown in the design drawings. The proposed design incorporates a sequence of 48 concrete pools. The proposed pools would be 6-feet long by 5-feet wide by 4-feet deep and consist of a 2-foot wide notch that would pass approximately 6 cubic feet per second (cfs). There would be the option to convert the notches to orifices if this would benefit upstream fish passage. The licensee proposes to install an auxiliary water system (AWS) to increase flow in the downstream ladder pools and create a total discharge of 60 cfs at the entrance pool. Additionally, the licensee's plans include a 20 cfs high velocity attraction jet AWS to assist in attracting fish to the ladder entrance. The licensee proposes to operate the fishway during non-spill periods (flows < 23,000 cfs), approximately from July 1 to May 15 annually. The licensee also proposes that any fishway dewatering or maintenance would occur from December 1 to February 28 because bull trout are not typically migrating in the mainstem of the Clark Fork River at this time.

The licensee proposes to install a sampling loop at the upstream end of the fish ladder. The fish sampling plans include a fish trapping mechanism, fish holding pool, fish crowder, fish lock, fish sorting table, anesthetic tank, recovery tank, fish return flume to the ladder, and fish return pipe to the tailwater (to prevent upstream escape of non-intended fish i.e. invasive species). The licensee proposes to collect and record species, numbers, condition, and other pertinent data for fish passed at the Project. Additionally, the licensee plans to tag all collected bull trout with passive integrated transponders (PIT tags) to gather project passage data.

The licensee proposes to begin construction of the facility in spring 2009 and complete construction by fall 2010.

DISCUSSION AND CONCLUSION

Despite the loss of connectivity and bull trout habitat the Clark Fork River Basin still has the potential for recovery. Although low in numbers compared to historical populations bull trout are still widely distributed throughout the watershed. Additionally, the FWS has designated 1,136 miles of stream and 49,755 acres of bull trout critical habitat in the Clark Fork Basin, indicating that a substantial amount of quality habitat still exists.[5] Reestablishing bull trout access to spawning grounds is also increasing in the basin. As part of its new license for the Cabinet Gorge and Noxon Rapids hydroelectric

[5] See: Department of the Interior, Fish and Wildlife Service. September 26, 2005. 50 CFR Part 17. Endangered and Threatened Wildlife Plants; Designation of Critical Habitat for the Bull Trout; Final Rule.

developments[6] (located downstream of Thompson Falls) Avista Corporation implemented a trap and transport program for passing bull trout. Depending on the results of genetic testing to determine the captured fishes' natal streams, the fish are released either above Cabinet Gorge Dam, Noxon Rapids Dam, or Thompson Falls Dam. Additionally, the removal of Milltown Dam, located 157 miles upstream from the Thompson Falls Dam, began in 2008. Upon completion of the dam removal bull trout will have access to 274 miles of the Clark Fork River upstream of the Thompson Falls Dam.

Although implementing effective fish passage at Thompson Falls will not eliminate the impacts of dams, hydroelectric project operation, and habitat degradation it would be a vital part of the cumulative effort to restore connectivity in the Clark River Basin and meet the recovery goals. Combined with the trap and transport program at Cabinet Gorge and Noxon Rapids dams and removal of Milltown Dam, fish passage at Thompson Falls would provide migratory bull trout access to critical habitat that has been restricted for nearly 100 years. Construction of the Thompson Falls Dam eliminated access for bull trout in the lower Clark Fork River and Lake Pend Oreille to 90 percent of the Clark Fork watershed. Reconnecting waterways in the basin will increase access to spawning grounds, thermal refugia, and complex habitat necessary for all bull trout life stages, and also facilitate flow of genetic material between populations.

In order to gather more data concerning bull trout biology and their migratory behavior the licensee proposes to incorporate a sampling loop in the passage facility. The sampling loop would provide a means for safely collecting data to increase the knowledge of bull trout. Passage of bull trout is a relatively new endeavor and the sampling effort may provide data to enhance conservation measures for the species.

The FWS's incidental take statement concluded that some take of bull trout is anticipated due to construction of the proposed fishway. However, the construction related take would likely be non-lethal and be considered harassment under the ESA. The incidental take statement also concluded that some take is likely due to sampling efforts, but except in rare cases it is expected to be non-lethal. Additionally, the licensee is taking the appropriate precautions to prevent sedimentation and erosion stemming from construction. As a result, impacts to downstream water quality and habitat should be minor and temporary. Although some take will likely occur, the proposed action will be a net benefit for bull trout and other aquatic organisms in the Clark Fork system and should be approved.

---

[6] Order Issuing New License. Issued February 23, 2000. 90 FERC ¶ 61,167. The Cabinet Gorge and Noxon Rapids Developments are part of Avista Corporations' Clark Fork Project (FERC No. 2058).

In order for the Commission to ensure compliance with the Terms and Conditions of the Incidental Take Statement filed by the FWS and attached to this order as Appendix A, the licensee should file with the Commission, for approval, study and operational plans referenced in the FWS's Terms and Conditions numbers 1 through 7, after development and approval by the FWS and Technical Advisory Committee. In addition, the results of studies referenced, including the 5 and 10-year comprehensive reports referred to in the FWS's Terms and Conditions, should also be filed with the Commission at the same time that they are submitted to the FWS and TAC. Any proposed structural or operational modifications or additional conservation measures that are deemed necessary after scientific review of the referenced studies should be filed for Commission approval.

The licensee must follow the FWS's Terms and Conditions numbers 1 through 7 in order to be exempt from the take prohibitions of Section 9 of the ESA. In order for the Commission to ensure compliance with the FWS's Terms and Conditions the licensee should file with the Commission, by April 1 of each year through the remainder of the license, the annual report referenced in 7a of the FWS's Terms and Conditions. In addition to the requirements stipulated in 7a the report should also address the licensee's compliance with the FWS's Terms and Conditions. The Commission reserves the right to extend the expiration date for report filing.

In addition to the mandatory Terms and Conditions the FWS also filed conservation recommendations in its BO. These recommendations are meant to further the purposes of the ESA by carrying out conservation measures for the benefit of threatened and endangered species. To further minimize or avoid adverse effects of the Thompson Falls Project the licensee should continue to cooperate with FWP, CSKT, Avista Corporation and other entities to promote recovery of bull trout and to survey and monitor bull trout populations and habitat in the lower Clark Fork River core area and the greater Clark Fork basin. Additionally, during the fishway construction, the licensee should retrieve and remove all loose steel beams and other trash from the stilling basin that can be reasonably accessed from the construction roadway. The conservation recommendations are reasonable actions that will help protect bull trout and therefore, should be implemented by the licensee.

Pursuant to paragraphs 12.4, 12.11, and 12.40 of the Commission's regulations, a plans and specifications package and a quality control and inspection program should be submitted to the Regional Engineer at least 60 days prior to any construction of upstream fish passage facilities. Authorization to start construction activities will be given by the Regional Engineer after all preconstruction requirements are satisfied. In order to insure that the required facilities are constructed the licensee should file within 90 days of completion of the upstream fish passage facilities, for Commission approval, revised exhibit F drawings describing and showing the facilities, as built. Additionally, the Commission reserves the right to require changes to project structures, fish passage facilities, or operation, based on the studies and reports required by this order, to ensure effective passage of threatened bull trout.

The Director Orders:

(A) PPL Montana's (licensee), Upstream Fish Passage Design and Construction Plans, for the Thompson Falls Project, as proposed in its April 7, 2008 Biological Evaluation, are approved and shall be implemented pursuant to the approved schedules.

(B) The licensee shall comply with the Terms and Conditions numbers 1 through 7 included in the U.S. Fish and Wildlife Service's November 4, 2008 Incidental Take Statement, and attached to this order as Appendix A.

(C) Study and operational plans referenced in the U.S. Fish and Wildlife Service's (FWS) Terms and Conditions numbers 1 through 7, after development and approval by the FWS and Technical Advisory Committee (TAC), shall be filed with the Commission, for approval, and shall summarize the status of any extensions that may be necessary. In addition, the results of studies referenced, including the five and ten-year comprehensive reports referred to in the FWS's Terms and Conditions, shall also be filed with the Commission at the same time that they are submitted to the FWS and TAC. Any proposed structural or operational modifications or additional conservation measures that are deemed necessary after scientific review of the referenced studies shall be filed for Commission approval.

(D) In order for the Commission to ensure compliance with the U.S. Fish and Wildlife Service's (FWS) Terms and Conditions the licensee shall file with the Commission, by April 1 of each year through the remainder of the license, the annual report referenced in 7a of the FWS's Terms and Conditions. In addition to the requirements stipulated in 7a the report shall also address the licensee's compliance with the FWS's Terms and Conditions. The Commission reserves the right to extend the expiration date for report filing.

(E) To further minimize or avoid adverse effects of the Thompson Falls Project the licensee shall continue to cooperate with U.S. Fish and Wildlife Service, Confederated Salish and Kootenai Tribes, Avista Corporation and other entities to promote recovery of bull trout and to survey and monitor bull trout populations and habitat in the lower Clark Fork River core area and the greater Clark Fork basin. Additionally, during the fishway construction, the licensee should retrieve and remove all loose steel beams and other trash that may be hazardous to bull trout.

(F) Pursuant to paragraphs 12.4, 12.11, and 12.40 of the Commission's regulations, a plans and specifications package and a quality control and inspection program shall be submitted to the Regional Engineer at least 60 days prior to any construction of upstream fish passage facilities. Authorization to start construction activities will be given by the Regional Engineer after all preconstruction requirements are satisfied.

(G) Within 90 days of completion of the upstream fish passage facilities the licensee shall file, for Commission approval, revised exhibit F drawings describing and showing the facilities, as built.

(H) The Commission reserves the right to require changes to project structures, fish passage facilities, or operation, based on the studies and reports required by this order, to ensure effective passage of threatened bull trout.

(I) This order constitutes final agency action. Request for rehearing by the Commission may be filed within 30 days from the date of the issuance of this order, pursuant to 18 CFR § 385.713.

George H. Taylor
Chief, Biological Resources Branch
Division of Hydropower Administration
and Compliance

Appendix A

Reasonable and Prudent Measures,

Terms and Conditions,

and

Conservation Recommendations from the

Biological Opinion filed November 4, 2008

by the U.S. Fish and Wildlife Service

Reasonable and Prudent Measures

The Service believes that the following reasonable and prudent measures are necessary and appropriate to minimize take:

1. PROVIDE SAFE AND EFFECTIVE UPSTREAM FISH PASSAGE: Identify adult bull trout attempting to travel upstream of Thompson Falls Dam from Lake Pend Oreille, Cabinet Gorge Reservoir, or Noxon Reservoir and in a timely manner, agreed to by the Service and coordinated with the Avista projects, facilitate upstream fish passage, operated in accordance with an approved Operational Plan, to enhance spawning migrations. Successful upstream passage will reduce or eliminate incidental take from blockage of migrants by the dam, including delayed/deferred spawning, restriction of access to thermal refugia, and migratory delay or interruption.

2. PROVIDE SAFE AND EFFECTIVE DOWNSTREAM FISH PASSAGE: Identify juvenile bull trout attempting to travel downstream from Thompson River, Flathead River, and upstream core areas and provide safe, timely and efficient downstream fish passage to facilitate bull trout migration to Noxon Rapids and Cabinet Gorge Reservoirs or Lake Pend Oreille. Successful downstream passage will reduce or minimize incidental take related to dam effects on juvenile fish, including intermittent effects from any gas supersaturation and chronic effects from blocked access to thermal refugia and migratory delay or interruption.

3. REDUCE EFFECTS OF GAS SUPERSATURATION ON BULL TROUT IN PROJECT AREA: Further evaluate the mechanism and impacts of dissolved gas supersaturation on bull trout at Thompson Falls Dam; first establishing the degree to which the Thompson Falls Project contributes to the systemic problem and secondly with an objective of participating in control, mitigation, and monitoring programs to reduce incidental take of bull trout by effects of gas bubble disease at the Thompson Falls Project.

4. DEVELOP IMPLEMENTATION STRATEGIES FOR THE MOU AND TAC: Implement provisions of the Thompson Falls Project MOU under the guidance of an interagency Technical Advisory Committee (TAC) that call for enhancing, acquiring or protecting sensitive upstream habitat that is used by migratory bull trout for spawning or rearing.

5. REDUCE OR MITIGATE ADVERSE EFFECTS TO BULL TROUT FROM OPERATIONS OF THOMPSON FALLS RESERVOIR: Initiate a comprehensive evaluation of bull trout use of Thompson Falls Reservoir and determine the primary migratory pathway through the reservoir and interaction of bull trout with predatory and competing nonnative species in Thompson Falls Reservoir. These investigations should be carried out over a 10-year period as a prelude to further evaluation of downstream passage concerns associated with future relicensing discussions.

6. PROVIDE PERIODIC MONITORING AND EVALUATION ACROSS THE CORE AREA: Contribute to coordinated genetic assessment and monitoring of bull trout populations in the Lower Clark Fork Core Area and, to a lesser extent, connected upstream core areas as related to impacts of Thompson Falls Dam.

7. REPORTING: Implement reporting and consultation requirements as outlined in the terms and conditions in order to minimize take of bull trout related to implementation of the Plan and other fisheries monitoring activities.

TERMS AND CONDITIONS

To be exempt from the prohibitions of section 9 of the Act, the FERC must comply with the following terms and conditions which implement the reasonable and prudent measures described above. These terms and conditions are non-discretionary.

It is the intent of Service and the FERC, as agreed to with the licensee, that implementation of fish passage at Thompson Falls will occur in systematic phased steps:

Phase 1 – Fishway Preconstruction and Construction Phase; (through 2010) includes the planned development and construction of a full-height fishway.

Phase 2 – Fishway Post-Construction Monitoring and Evaluation; (mid-2010 through 2020) includes a comprehensive assessment and iterative enhancement of the safe, timely and efficient passage of bull trout (and other species) both upstream and downstream through the facility as well as examination of other bull trout limiting factors in the Project action area.

Phase 3 - Pre-Licensing and Ongoing Fishway Operations; (2021 and beyond) is currently not described, but will involve optimal operation of the fishway and become preparatory to FERC relicensing of the Thompson Falls Dam, scheduled to be in process up to five years before the license expires at the end of 2025.

TC1. The following terms and conditions are established to implement reasonable and prudent measure #1. UPSTREAM PASSAGE:

a. During 2009 and 2010, PPL Montana will construct a fish passage facility (permanent fishway) to provide timely and efficient upstream passage at the right abutment of the main dam, as agreed to by the Service and through oversight of the TAC (as provided for in the interagency Thompson Falls MOU).

b. During construction and cleanup, PPL Montana will follow permit procedures as required by the Service, the State of Montana, and U.S. Army Corps of Engineers so that minimal impacts to downstream aquatic resources occur during construction.

c. PPL Montana will determine operational procedures for the passage facility and develop a written operation and procedure manual (SOP) by the end of 2010, with input from the TAC and approval by the Service, updated as needed.

d. For the remaining term of the license (expiring December 31, 2025), PPL

Montana will ensure that operation of the fish passage facility is adequately funded and conducted in compliance with the approved SOP; including activities such as biological studies, transport of bull trout (as needed), and assessment of ladder efficiency.

e. During the Phase 2 evaluation period (2010 through 2020), PPL Montana will provide adequate funding for genetic testing to determine the likely natal tributary of origin of all adult bull trout which ascend the fishway and enter the sample loop, as well as those otherwise captured at the base of Thompson Falls Dam. In order to positively identify natal origin of bull trout at the project, PPL Montana will institute a permanent fish tagging system for all bull trout handled during monitoring and for other fisheries investigation activities in the Project area.

f. During the Phase 2 evaluation period (2010 through 2020), PPL Montana will make a fish transport vehicle available, and provide staff to transport any adult bull trout that is captured at Thompson Falls Dam and determined by the SOP to require transport to upstream waters.

g. In consultation with the TAC, PPL Montana will prepare by January 1, 2011, for Service approval, an action plan for Phase 2 of the evaluation period (2010 through 2020) to evaluate efficiency of the upstream passage facility. The goal will be to assess how effective the ladder is at passing bull trout, the potential length of any delay, the amount of fallback, and the optimal operational procedures to achieve the highest efficiency. During this Phase 2 evaluation period (2010 through 2020) a routine feedback loop will be established and used, as agreed to by the Service, to fine tune operations and will be combined with a variety of experimental and evaluative studies. It may be necessary to conduct research on surrogate species (e.g., rainbow trout) at the discretion of the TAC, in order to facilitate certain of these evaluations. At a minimum, for the remaining term of the license (through 2025), PPL Montana will support a sampling method to annually estimate the total numbers of all species passing through the ladder and adequately characterize the timing of such movements.

h. During the entire Phase 2 evaluation period (2010-2020), the TAC, subject to approval of the Service and with PPL Montana support, will provide adequate oversight of scientific aspects, surveys, studies, and protocols associated with the fish passage aspects of the Project. At the end of the Phase 2 evaluation period (2010-2020), and upon completion and adequate distribution and consideration of a comprehensive ten-year report (due December 31, 2020), PPL Montana will convene a structured scientific review of the project, guided by the TAC. This scientific review will be completed by April 1, 2021 and will develop a set of recommendations to be submitted to the Service for evaluation, modification, and approval; including specific conclusions as to whether the fishway is functioning as intended and whether major operational or structural modifications of the fishway are needed. The review process will culminate, by December 31, 2021, in a revised operating plan for the fishway during the remainder of the existing term of the FERC license (2022 through 2025).

TC2. The following terms and conditions are established to implement reasonable and prudent measure #2. DOWNSTREAM PASSAGE:

a. PPL Montana will provide annual funding to the TAC, as approved by the Service and specified in the Thompson Falls MOU, to conduct offsite habitat restoration or acquisition in important upstream bull trout spawning and rearing tributaries. The purpose is to boost recruitment of juvenile bull trout. This funding is provided to partially mitigate for incidental take of bull trout caused by downstream passage through the turbines and spillways. The annual $100,000 contribution specified for the first term of the MOU (2009-2013) is subject to renegotiation during succeeding terms of the MOU to run from 2014-2020.

TC3. The following terms and conditions are established to implement reasonable and prudent measure #3. GAS SUPERSATURATION:

a. For the remainder of the license (through 2025), in consultation with the TAC and subject to Service approval, PPL Montana will develop and implement operational procedures to reduce or minimize the total dissolved gas production at Thompson Falls Dams during periods of spill. Future modifications to prescribed operations may be determined from ongoing evaluations, as necessary and determined appropriate by Montana Department of Environmental Quality.

b. For the remainder of the license (through 2025), in consultation with the TAC and subject to Service approval, PPL Montana will continue to collaborate with MDEQ, Avista, MFWP, and other entities toward reducing the overall systemic gas supersaturation levels in the Clark Fork River, occurring from a point downstream of Thompson Falls Dam to below Albeni Falls Dam.

c. For the remainder of the license (through 2025), all bull trout detained through the sampling loop at the Thompson Falls Fish Ladder will routinely be examined for signs of gas bubble trauma; with results of such observations permanently recorded. Should GBT symptoms be discovered, then PPL Montana will consult the TAC on the need for immediate corrective actions and subsequently implement any new studies or potential operational changes (to the ladder or the dam) which may be required by the Service and DEQ, in order to mitigate GBT concerns.

TC4. The following term and condition is established to implement reasonable and prudent measure #4. MOU and TAC:

a. Upon completion of construction of the Thompson Falls Fish Ladder (currently scheduled for 2010) and concurrent with initiation of the Phase 2 review period (mid-2010 through 2020) PPL Montana will review the Thompson Falls MOU and collaborate with the signatory agencies as to the need to revise and restructure the MOU. Any such revision should be developed around the 2010-2020 Phase 2 evaluation period and may include appropriate changes to the TAC and its operation. Subsequent revision may occur again in 2021, or as needed based on adaptive principles and subject to approval of the Service and PPL Montana.

TC5. The following terms and conditions are established to implement reasonable and prudent measure #5. THOMPSON FALLS RESERVOIR:

a. During the first five years of the Phase 2 evaluation (2010 through 2015) PPL Montana, with TAC involvement and Service approval, will conduct a prioritized 5-year evaluation of factors contributing to the potential loss or enhancement of migratory bull trout passage through Thompson Falls Reservoir. Goals and objectives for this assessment and scientifically-based methodology will be developed through the TAC and approved by the Service no later than the end of 2010 and will focus at a minimum on better understanding temperature and water current gradients through the reservoir; travel time, residence time, and pathways that juvenile and subadult bull trout select in moving through the reservoir; and an assessment of impacts of predatory nonnative fish species on juvenile and subadult bull trout residing in or passing through the reservoir. The initial findings will be summarized and supported with scientifically based conclusions, no later than the end of 2015, with a goal of adaptively improving survival of juvenile bull trout in Thompson Falls Reservoir as they pass downstream or reside in the system. A second, more comprehensive summary of conclusions and recommendations regarding reservoir impacts will be submitted as part of the scientific review package by the end of 2020 (see TC1h).

b. Based on the interim Thompson Falls Reservoir Assessment (a., above), a timely evaluation of the site specific need for a nonnative species control program in Thompson Falls Reservoir will be conducted by PPL Montana, in collaboration with the TAC agencies (see TC7b., below), no later than the end of 2015, with final recommendations to be approved by the Service.

TC6. The following terms and conditions are established to implement reasonable and prudent measure #6 SYSTEMWIDE MONITORING:

a. For the remainder of the license (through 2025), PPL Montana will ensure that actions at the Thompson Falls Fish Ladder, including tagging, transport, and any tracking of fish movement, are adequately funded and fully coordinated with the Avista project and the management agencies MFWP, CSKT, and the Service. This coordination will include routine communications through the TAC and may require participation in special meetings or discussions to ensure that there is a single seamless fish passage effort for the lower Clark Fork projects.

b. For the remainder of the license (through 2025) PPL Montana will contribute a proportional amount of funding to ensure that fish sampled at the Thompson Falls Fish Passage Facility are processed, analyzed, and integrated into annual updates of the systemwide Clark Fork River genetic database.

c. In consultation with the TAC and with approval of the Service, for the remainder of the license (through 2025), PPL Montana will fund the technology required to track transmittered fish that pass the project as they move through the system. This may include an integrated PIT-Tag scanner at the fishway, mobile PIT-Tag scanning capabilities (wand(s) for use in the field), and radio implantation and tracking of bull trout that move through the sample loop in the ladder. Obligations for tracking transmittered fish by PPL Montana will include at a minimum the portions of the Lower Clark Fork Core Area upstream of Thompson Falls Dam (i.e., mainstem Clark Fork River from Thompson Falls Dam to the confluence of the Flathead River, including tributaries such as the Thompson River) Note: in the lower Flathead River, Jocko River, and other Flathead Reservation waters primary responsibility for tracking is assumed by the CSKT, but close coordination with the Tribes will be maintained by PPL Montana. Broader tracking needs upstream will be determined through cooperation with other entities in the basin (as in TC6a., above).

TC7. The following terms and conditions are established to implement reasonable and prudent measure #7 REPORTING:

a. Annually, by April 1 of each year for the remainder of the license (expires 2025), PPL Montana will prepare and submit to the Service for approval a report of the previous years activities, fish passage totals, and next year's proposed activities and other fisheries monitoring that may result in intentional as well as incidental take of bull trout. The report will quantify the number of bull trout proposed to be incidentally taken by each activity and summarize the cumulative extent of incidental take from all previous year activities.

b. By December 31, 2015, after the first five years of the Phase 2 evaluation period (as described per TC1g., above), PPL Montana will present to the TAC and the Service a comprehensive written assessment of the first five years of fishway operation. This report is partially for the purpose of assessing the need for major mid-Phase 2 modifications to the facility and its operations as well as for consideration of the need for supporting additional bull trout passage or transport above the dam.

c. Annually, by April 1 of each year beginning in 2010 and for the remainder of the license (expires 2025), PPL Montana will archive electronic versions of all biological progress reports (described in TC 1 through TC 7 and dating back to 2005) generated through the Thompson Falls Project. PPL Montana will provide to TAC agencies at no cost, upon request, updated CDs or web-based access to those reports

d. For the remainder of the license (expires 2025), upon locating dead, injured, or sick bull trout, or upon observing destruction of redds, notification must be made within 24 hours to the Service's Division of Law Enforcement Special Agent (Richard Branzell, P.O. Box 7488, Missoula, MT, 59807-7488; (406) 329-3000). Instructions for proper handling and disposition of such specimens will be issued by the Division of Law Enforcement. Dead, injured, or sick bull trout should also be reported to the Service's Kalispell Field Office (406-758-6882).

e. For the remainder of the license (expires 2025), during project implementation the FERC or applicant shall promptly notify the Service of any emergency or unanticipated situations arising that may be detrimental for bull trout relative to the proposed activity.

The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize incidental take that might otherwise result from the proposed action. With implementation of these measures the Service believes that the likelihood of incidental take will be minimized. If, during the course of the action, the level of incidental take is exceeded, such incidental take represents new information requiring review of the reasonable and prudent measures provided. The FERC must immediately provide an explanation of the causes of the taking and review with the Service the need for possible modification of the reasonable and prudent measures.

For convenience, these Terms and Conditions are summarized in Table 12. Refer to the wording of the Terms and Conditions (above) for more specificity and fuller guidance.

Table 12. Terms and Conditions for Implementing the Reasonable and Prudent Measures Described in the Bull Trout Consultation for the Thompson Falls Hydroelectric Project.

T&C	Phase 1 2008 - 2010 Fishway Preconstruction and Construction	Phase 2 Late 2010 - 2020 Fishway Post-Construction Monitoring & Eval.	Phase 3 2021 - 2025 Pre-Licensing and Ongoing Fishway Operations
1a	Construct Fishway		
1b	Comply with Construction Permits		
1c		Develop Fishway Operations Manual (SOP) by 12/31/10	
1d		Oversee and Fund Fishway Operations	Oversee and Fund Fishway Operations
1e		Conduct Bull Trout Genetic Testing and Permanent Tagging	
1f		Transport Tank, Staff As Needed	
1g	Plan Efficiency Studies	Passage Efficiency Action Plan by 1/1/11; Implement Action Plan and Generate Annual Passage Estimates	Implement Action Plan and Generate Annual Passage Estimates
1h		Support Scientific Oversight by TAC; Comprehensive Phase 2 Scientific Report by end of 2020; Begin Development of Revised 5-year Fishway Operations Plan;	Conduct Scientific Review by 4/1/2021; Adopt and Implement Revised 5-Year Fishway Operations Plan 2021-2025;

T&C	Phase 1 2008 - 2010 Fishway Preconstruction and Construction	Phase 2 Late 2010 - 2020 Fishway Post-Construction Monitoring & Eval.	Phase 3 2021 - 2025 Pre-Licensing and Ongoing Fishway Operations
2a	Implement and Fund Adaptive Management Funding Account (AMFA)	Continue Annual AMFA and Conduct Upstream Offsite Mitigation thru 2013; Renegotiate MOU and Renew AMFA for 2014-2020	
3a	Implement TDG Minimization Measures	Implement TDG Minimization Measures	Implement TDG Minimization Measures
3b	Collaborate With Systemwide Gas Abatement Effort	Collaborate With Systemwide Gas Abatement Effort	Collaborate With Systemwide Gas Abatement Effort
3c.		Systematic GBT Exam; Corrective Measures as Required	Systematic GBT Exam; Corrective Measures as Required
4a.		Revise MOU and TAC, as Needed (2010)	Revise MOU and TAC, as Needed (2021)
5a.	Develop goals, objectives, and methodology for T Falls reservoir Assessment by end of 2010.	Implement T Falls Reservoir Assessment and Submit Interim Report by 12/31/2015; Submit Final T Falls Reservoir Assessment for TC1h Science Review	
5b.		Recommendation on Need For T Falls Reservoir Predator Control by 12/31/2015	
6a.	Participate in Seamless Systemwide Fish Passage Coordination	Participate in Seamless Systemwide Fish Passage Coordination	Participate in Seamless Systemwide Fish Passage Coordination
6b.	Contribute Proportionally to Genetic Database	Contribute Proportionally to Genetic Database	Contribute Proportionally to Genetic Database
6c.	Support Tracking of Transmittered Bull Trout Through Lower Clark Fork Core Area	Support Tracking of Transmittered Bull Trout Through Lower Clark Fork Core Area	Support Tracking of Transmittered Bull Trout Through Lower Clark Fork Core Area

T&C	Phase 1 2008 - 2010 Fishway Preconstruction and Construction	Phase 2 Late 2010 - 2020 Fishway Post-Construction Monitoring & Eval.	Phase 3 2021 - 2025 Pre-Licensing and Ongoing Fishway Operations
7a.	Annual Activity, Fish Passage and Take Report by March 1.	Annual Activity, Fish Passage and Take Report by March 1.	Annual Activity, Fish Passage and Take Report by March 1.
7b.		5-year ladder assessment report due 12/31/2015	
7c.		Annually, by April 1, Update Archived Reports	Annually, by April 1, Update Archived Reports
7d.	Report Dead or Injured Bull Trout	Report Dead or Injured Bull Trout	Report Dead or Injured Bull Trout
7e.	Notification of Emergencies	Notification of Emergencies	Notification of Emergencies

Conservation Recommendations

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

Continue to cooperate with MFWP, CSKT, Avista and other entities to promote recovery of bull trout, and to survey and monitor bull trout populations and habitat in the lower Clark Fork River core area and the greater Clark Fork basin.

During the fishway construction, retrieve and remove all loose steel beams and other “junk” from the stilling basin that can be reasonably accessed from the construction roadway.

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

PPL MONTANA, LLC

PPLM-TFalls-2218

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, DC 20426

Re: PPL Montana, LLC, Thompson Falls Project No. 1869, filing of a Biological Evaluation for bull trout under Section 7 Endangered Species Act consultation

April 4, 2008

Dear Secretary Bose:

By letter dated May 3, 2002, the Commission designated PPL Montana as its non federal representative for the purpose of informal consultation with the US Fish and Wildlife Service (USFWS) pursuant to Section 7 of the Endangered Species Act on the potential effects of the Thompson Falls Project on bull trout. As required by this Section 7 process, PPL Montana hereby submits a Biological Evaluation (BE) describing effects of the Thompson Falls Project on bull trout to the Commission. PPL Montana anticipates it will file an amendment of the Thompson Falls License with the Commission to incorporate conservation and minimization measures for bull trout prescribed by this process.

Since 2003, PPL Montana, agencies (MDEQ, MFWP and USFWS), and Tribes (CSKT) have actively consulted and conducted numerous studies on Thompson Falls Project effects on bull trout (and other species) including development of proposed fish passage designs and other conservation measures for bull trout. PPL Montana, USFWS, MFWP and CSKT have signed (see Appendix C of the attached BE) a formal Memorandum of Understanding between these parties which describes a process to facilitate and fund FERC License based consultation and implementation of minimization measures for bull trout at the Thompson Falls Project.

The attached Thompson Falls BE provides both Public and Critical Energy Infrastructure Information (CEII) as follows:

Public Information

- Biological Evaluation for Bull Trout, Thompson Falls Project
- Appendix A – Total Dissolved Gas (TDG), Thompson Falls Project
- Appendix C – Thompson Falls Project Memorandum of Understanding

CEII Information

- Appendix B (Large Format) 90% Construction Drawings for Thompson Falls Project Fish Passage
- Appendix B – Specifications for 90% Construction Drawings

An original, two hard copies and nine CDs of the BE and Appendices A and C are being filed as public information. An original, two hard copies and three CDs of Appendix B (upstream fish passage design drawings and specifications) are being filed as CEII under cover of this letter. PPL Montana requests that Appendix B CEII information be placed in the Commission's non-public files.

The USFWS, MFWP, MDEQ and CSKT have approved the Thompson Falls BE and support its filing with the Commission. We attach below additional letters of support for the BE from the USFWS and MFWP.

Sincerely,

Jon Jourdonnais
Director Hydro Licensing and Compliance

Cc (public CD version only):

Jean Ramer, COE
Mark Wilson, USFWS
Tim Bodurtha, USFWS
Wade Fredenberg, USFWS
Jon Hanson, MFWP
Ladd Knotek, MFWP
Chris Hunter, MFWP
Jim Vashro, MFWP
Craig Barfoot, CSKT
Brent Mabbott, PPLM
Frank Pickett, PPLM
Carrie Harris, PPLM
Pete Simonich, PPLM
Dave Kinnard, PPLM
Ginger Gillin, GEI
John Pizzimenti, GEI
Steve Rainey, GEI
Erich Gaedeke, FERC Portland
Blake Condo, FERC DC
Ann Harrie, MDEQ
Kristi Webb, M-M

United States Department of the Interior

U.S. DEPARTMENT OF THE INTERIOR · MARCH 3, 1849

FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
MONTANA FIELD OFFICE
585 SHEPARD WAY
HELENA, MONTANA 59601
PHONE (406) 449-5225, FAX (406) 449-5339

March 20, 2008

PPL Montana
Attn: Jon Jourdonnais
45 Basin Creek Road
Butte, Montana 59701

Dear Jon:

This letter is intended to demonstrate support from the U.S. Fish and Wildlife Service, Montana Field Office, for the planned submittal to FERC of the Biological Evaluation for the proposed fish passage improvements (fish ladder) at Thompson Falls Dam. The Service has been in informal consultation with PPL Montana and their agents for a number of years and we agree that it is in the best interests of the resource to move forward with the fish ladder at this time. We are satisfied that the preliminary biological and engineering evaluations have resulted in a multi-party consensus proposal that will provide a major step forward in the conservation of bull trout and other native fish species at this facility. We look forward to an in-depth evaluation of the proposal and development of a Biological Opinion after this proposal is submitted to the FERC.

The Service wishes to congratulate PPL Montana on their proactive efforts leading to attainment of this milestone and we anticipate the continuation of a strong collaborative working relationship.

Sincerely,

R. Mark Wilson

R. Mark Wilson
Field Supervisor

File: LTR_03_24_2008_Wilson_PPLMT_Support4BE

Montana Fish, Wildlife & Parks

Fisheries Division
P.O. Box 200701
Helena, MT 59620-0701
(406) 444-2449
Fax: 406-444-4952
March 31, 2008

Jon Jourdonnais
PPL Montana
45 Basin Creek Road
Butte, MT 59701

Dear Mr. Jourdonnais:

Montana Fish, Wildlife & Parks (FWP) supports PPL Montana's commitment to fish passage goals at Thompson Falls Dam. The main dam right bank fish ladder will assist in providing connectivity for the Lower Clark Fork River and connect hundreds of miles of river habitat. The benefits to the State of Montana with regards to fish conservation measures are commendable and will assist the state in managing healthy native and sport fisheries within the Clark Fork River Basin.

The collaborative approach PPL Montana has taken to provide upstream fish passage and creation of a Technical Advisory Committee (TAC) to offer assistance in minimizing the effects of Thompson Falls Dam is a pro-active approach that FWP applauds. FWP has been part of the TAC process since its inception in 2002 and is also a signatory to the Memorandum of Understanding, which provides for the continuing operation of the TAC to allocate annual funds provided by PPL Montana to minimize bull trout take. PPL Montana's active participation and initiation of the process to mitigate for impacts of the Thompson Falls Hydroelectric Dam is recognized by the state.

FWP maintains a positive working relationship with PPL Montana and supports their efforts on the Biological Evaluation for Bull Trout at Thompson Falls Dam and the pro-active commitment they are making towards fish conservation.

Sincerely,

Chris Hunter
Administrator

I:\Chris Correspondence\pplmtltr.doc

Geotechnical
Environmental &
Water Resources
Engineers

GEI Consultants

Technical Memo

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

To: Thompson Falls Interagency Technical Team

From: Steve Rainey, GEI Consultants, Inc.

Date: 5/14/2007

Re: Total Dissolved Gas (TDG) at Thompson Falls

The purpose of this memorandum is to give a short description of the total dissolved gas (TDG) issue at many Pacific Northwest hydro projects, then to briefly summarize apparent implications on TDG dynamics at Thompson Falls Hydroelectric Project (Thompson Falls), in order to initiate dialogue about how this project actually reduces TDG levels at all except the highest river discharges, relative to historic dissolved gas levels below the falls. *The implication is that the project may not need to mitigate for elevated TDG levels, either structurally or operationally*.

Background

Current Thompson Falls Hydroelectric Project Total Dissolved Gas Data Monitoring Program

The US Fish and Wildlife Service asked PPL Montana (PPLM) to monitor total dissolved gas at Thompson Falls, during development of the Biological Evaluation, as part of the Endangered Species Act consultation process. Since hydro projects often impound water, and spill is common during the spring freshet, elevated TDG levels downstream of spillways occur for a few months each year. An important issue is whether the data reflects TDG levels greater than the maximum allowable (110 percent) level referenced in the Clean Water Act (CWA). When spillway gas levels increase above the CWA TDG cap, there may be an effort by the state or federal government to induce implementation of TDG abatement measures. This memorandum addresses that potential occurrence.

(Note: this memorandum also addresses the manner in which TDG uptake is thought to occur below the Main Dam spillway and falls. In 2004, TDG measurements were taken from a monitoring station in the immediate Main Dam spillway tailrace. A discussion of why the measurements at this monitoring station may be misleading, and how that influences the issue of whether TDG abatement mitigation measures are required at Thompson Falls, is presented at the end of this memorandum.)

General Description of Typical Hydro Project Operations with Elevated Total Dissolved Gas Levels

Spill at hydroelectric dams usually increases downstream TDG levels, and occurs when river discharge exceeds turbine hydraulic capacity. Since no additional flow can pass the project's turbines, it must pass over the spillway. Since the height of dam typically provides much of the energy head for generation of power, spillway flow transfers much of that potential energy to the spillway tailrace, where turbulence dissipates that excess energy. During spill, total dissolved gas supersaturation occurs, and often exceeds the 110 percent saturation limit stipulated in the CWA. The CWA is intended to protect fish from lethal levels of TDG, which can create gas bubble trauma symptoms. It has been shown that TDG levels on the order of 140 percent result in embolisms and the appearance of tiny gas bubbles in fish tissues, resulting in elevated mortality rates. Conversely, it has been shown that Columbia and Snake River juvenile salmon and steelhead have no gas bubble trauma symptoms at levels of ≤120 percent TDG in spillway tailraces. Gas bubble trauma studies downstream of Cabinet Gorge, where TDG levels reach 135%, showed little sign of adverse impacts to non-anadromous species in 2000 (need citation).

Cause of Total Dissolve Gas Supersaturation and Related Information

As spill discharge passes into the spillway tailrace, it typically plunges into a deep armored stilling basin, designed with enough volume to dissipate energy for the maximum design flood discharge. The intent is to confine energy dissipation in the armored zone, so that erosion does not scour and undermine the spillway or other dam features – thereby leading to potential structural failure.
As spill plunges into a deep spillway stilling basin, a turbulent energy dissipation zone is created, characterized by unsteady flow and high shear forces. Vertical circulation cells often take turbulence aeration to depth, where hydrostatic pressure collapses bubbles, *forcing them into solution* and elevating TDG levels (gas absorption).

TDG carrying capacity depends on temperature and ambient pressure, consistent with Gauss's Law. (The same amount of total dissolved gas content that constitutes 100 percent saturation at one water temperature will be supersaturated if the water temperature is higher and ambient pressure is the same.) This memorandum is not intended to address gas absorption in that degree of detail.

TDG supersaturation is an unstable condition, and if the river channel downstream of a spillway is sufficiently wide and shallow, and with an appreciable enough hydraulic gradient, channel boundary roughness will force flow to "tumble" in a manner where there is increased water surface exposure of ambient air conditions. Where this kind of open-channel flow conditions occur, TDG levels rapidly drop back to near the stable, 100 percent saturation level in less than a mile (distance varies from site to site).

However, if there is a reservoir backed up to near the powerhouse tailrace, as at Thompson Falls, the normal river gradient is reduced and the flow regime becomes more stable. Lower reservoir velocities result in less turbulence, and elevated TDG levels are locked in after entering the impoundment. If there are elevated wind levels, enough shear can be created to induce the vertical circulation necessary to reduce TDG levels in the reservoir. Otherwise, the elevated reservoir TDG levels wane slowly, and on the basis of delayed replenishment by lower level TDG inflows.

Other relevant information

- Spillway stilling basins have their own signature, and induce an outflow TDG level that is higher than the forebay TDG level. As spillway flow passes into a deep spillway stilling basin, memory of forebay TDG levels is erased. TDG level downstream of a spillway is a direct result of the spillway signature (stilling pool configuration and inflow hydraulic conditions), air and water temperatures, and atmospheric pressure.

- For that component of flow passing through turbines, there is very little TDG uptake. Turbine energy is extracted at a high rate (through generation of power), and little energy remains as flow discharges from turbine draft tubes. (In 2003, PPLM had TDG monitors stationed downstream of the new powerhouse. This monitor showed that under normal operating conditions, flow passing through the powerhouse did not have elevated TDG levels.) While there is a turbine boil in the powerhouse tailrace, aeration from turbulence is at a lower level, resulting in a powerhouse tailrace TDG level nearly the same as the forebay. Therefore, *passing flow through a turbine is a way to minimize TDG uptake*.

- Tailrace Mixing and the Gas Balance Equation: *(Turbine Flow x PH Tailrace TDG) + (Spillway Flow x Spillway Tailrace TDG) divided by Total River Discharge = Composite (mixed) TDG downstream of the project*. This assumes a reservoir backwater just downstream of the powerhouse (as at Thompson Falls). Therefore, *passing a larger percentage of total river discharge through the powerhouse reduces downstream composite TDG during spill periods*.

Previous Total Dissolved Gas Abatement Efforts

The U.S. Army Corps of Engineers (USACE) initiated a comprehensive five-year study of total dissolved gas supersaturation and abatement at their Lower Snake and Columbia River hydroelectric projects in the mid-1990's, titled the Dissolved Gas Abatement Study (DGAS). This effort was based on the perceived need (by the fisheries agencies and tribes) to increase survival of juvenile salmon outmigrants, by passing as many as possible over the spillway rather than through turbines or intake screen and bypass systems. However, the number of fish that could be passed in spill discharge was limited by CWA TDG limits (110 percent). The conundrum was that water quality standards for TDG were designed to protect aquatic species, but these regulations were forcing more fish to pass through lethal turbines. The study included a gas bubble trauma monitoring program, which concluded that a TDG level of 120 percent below spillways could be sustained without detectable damage to salmon and steelhead, and an annual waiver was granted so that higher spill levels could route more fish over spillways. (Note: the effects of 120 percent TDG were not studied in the context of non-migratory fishes, so the regulatory agencies were not willing to grant annual waivers indefinitely.)

Meanwhile, an entire array of gas abatement measures at spillways was investigated. The common denominator for these design approaches was to keep turbulence downstream of spillways from going to depth, thereby limiting gas absorption. The principles of the approaches studied can be considered at other hydro projects where gas abatement may be required (including Thompson Falls). (Note: one option was to increase turbine capacity at hydro projects, thereby reducing spill levels by the added turbine discharge capacity.)

Site-Specific Subjective Assessment of Total Dissolve Gas Dynamics at Thompson Falls

Generally, TDG levels downstream of the spillway increase as spill discharge increases. In Figure 1 the blue data points and regression curve (Blue Curve) from 2006 TDG field data show this is true at Thompson Falls. These data were collected at the high bridge (HB), several hundred yards downstream of the spillway and falls. However, there are unusual and mitigating circumstances at this location, relative to other hydro power projects. Figure 2 is an aerial view of the Main Dam spillway tailrace. Note that there is no formal spillway stilling basin. There doesn't need to be, as the spillway is built on bedrock and erosion/scour is not a concern. Further, the depth on the bedrock shelf immediately downstream of the spillway apron appears *not* to be deep enough (though there are a few deeper pools) for appreciable gas absorption to occur on the basis of required hydrostatic pressure. The rock shelf extends downstream to the falls, and to a deeper downstream pool where there *is* enough depth for appreciable TDG uptake. (Therefore, TDG measurements collected at the base of the spillway, and above the falls, may not be accurate. See the last section of this memorandum for additional discussion of this issue.)

Three Configurations and Operating Conditions

Three configuration and operating conditions relating to the Main Dam spillway and falls (and TDG readings at the HB, TDG monitoring site) are referenced below, and in the subsequent discussion of the central issue – whether Thompson Falls increases TDG levels.

1. The true baseline is the **Pre-Dam condition**, where all total river discharge passed over the falls and increased TDG at the HB location. TDG readings for the Pre-Dam condition can be never attain since the spillway structure is in place and influences readings downstream of the falls. However, as river discharge increased, can assume that river plunge into the deep natural pool below the falls would have increased TDG levels at the HB site.

2. For the current **Normal Dam Operating condition**, spill discharge passing the Main Dam spillway entails gas uptake from the composite of flow passing over the spillway and falls, and into the deep natural pool below the falls. This is based on TDG measurements at HB. However, the first 23,000 cfs of river discharge is normally passed through the powerhouses (when operating at full turbine

capacity). That amount of total river discharge passing the powerhouse (as depicted from 2003 TDG data collection below the new powerhouse), does not have higher TDG reading than forebay, and may actually be slightly lower. Only the flow above turbine capacity passes over the spillway and falls (as represented by the Blue Curve).

3. On occasion, the **Turbine Load-Rejection condition** will occur. This happens when electrical generation cannot be delivered onto the regional power grid, due to an unexpected emergency. Powerhouse turbines go off-line, and all flow passes the spillways. This happens intermittently for brief periods of time. In 2003, PPLM had TDG monitors stationed downstream of the new powerhouse (Figure 2). These showed that under normal operating conditions, flow passing through the powerhouse did not have elevated TDG levels. However, during load rejection, when the powerhouse was off-line, discharge passing this gage was exclusively from the Main Dam spillway and TDG levels abruptly increased until turbines were back on line. (Note: total river discharge was approximately 30,000 cfs during the dates shown in Figure 2, and there were not enough data points to develop a regression curve.) These 2003 data points represent TDG levels close to the Pre-Dam Operation.

The Figure 1 Blue Curve depicts 2006 HB TDG readings as a function of total river discharge for the Normal Dam Operating condition, (2) above. Note that conditions (1) and (3) would also have their own HB TDG data points and regression curve, if that data were available. Further, if the respective curves were to the left of the Blue Curve, HB TDG levels would be higher for a given total river discharge than for the Blue Curve. (Conversely, if the curves were to the right of the Blue Curve, HB TDG levels would be lower than for the Blue Curve.) Paraphrased, higher TDG levels would be generated at the HB, with the same total river discharge and all flow passing over the falls. The implication is that the Normal Dam Operating condition results in lower TDG at HB than the Turbine Load-Rejection condition, at all river discharges. The only uncertainty is whether the same is true for the Pre-Dam condition.

Total River Discharge Ranges

It is useful to discuss three levels of total river discharge, when assessing whether Thompson Falls increases TDG uptake at the location with the highest total dissolved gas readings – the HB monitoring location.

Low River Discharge Level (total river discharge ≤ 23,000 cfs) – This range of river discharge occurs 85 percent of the time (Figure 5). There is no spill during Normal Dam Operations and HB TDG readings are less than if total river discharge were passing the falls with either the Pre-Dam or Turbine Load-Rejection conditions.

High River Discharge Level (total river discharge > 80,000 cfs) – This high river discharge occurs less than one (1) percent of the time, and has not occurred since before 2003. It was stated earlier that HB TDG levels below the falls generally increase as spillway discharge increases for each condition described above. However, when total river discharge is very high, the tailwater elevation downstream of the spillway and falls rises enough to backwater the falls, and there is a reduced plunging action into the deep pool below the falls. It is unknown whether the rate of increase in HB TDG at very high total river discharges tapers off, or even drops to a lower level, during river discharges in this range. The Normal Dam Operating and Turbine Load-Rejection conditions could be expected to have higher HB TDG readings than the Pre-Dam condition during very high river discharges, since the spillway adds approximately 35-40 feet of energy during this condition. The positive TDG abatement influence of passing 23,000 cfs through the powerhouse turbines (at lower river discharges) no doubt has a very small influence over HB TDG levels for very high river total discharges.

Middle River Discharge Level (23,000 – 80,000 cfs total river discharge) – At the lower end of this total river discharge range, spill discharge is at a lower level (e.g., < 20,000 cfs spill) for the Normal Dam Operating condition, and HB TDG readings are relatively low (< 115 percent). Examples of different river discharges and HB TDG levels are discussed below and describe the positive influence on HB TDG of routing a large percentage of flow through turbines. At the higher end of the middle river discharge range, a bigger percentage of river discharge passes over the spillway for Normal Dam Operating condition, and it is suspected that HB TDG levels for the Normal Dam Operating and Turbine Load-Rejection conditions exceed levels for the Pre-Dam condition. At some intermediate total river discharge, I suspect there is a *cross-over river discharge,* above which the HB TDG would be higher for both the Normal Dam Operating and Turbine Load-Rejection conditions than for the Pre-Dam condition. Although the cross-over discharge magnitude is unknown (as there is no Pre-Dam HB TDG regression curve), it is expected that the percentage of time river discharge is at, or above, this level is less than five (5) percent as depicted on Figure 4.

Premise
Normal Dam Operating Condition Total Dissolve Gas Levels at High Bridge are nearly always lower than for the Pre-Dam Condition

Reason
The primary TDG uptake is in the deep pool immediately downstream of the Main Dam and falls, as measured at the HB site. Prior to the dam, the total river discharge passed the deep pool below the falls, and created progressively higher TDG levels at higher river discharges. The current Normal Dam Operating condition routes up to 23,000 cfs through the two powerhouses (where TDG does not increase for this component of total river discharge). With up to 23,000 cfs less river flow passing the pool below the falls, HB TDG readings are proportionately lower for the Normal Dam Operating condition than for the Turbine Load-Rejection and Pre-Dam conditions (if the Pre-Dam conditions data were available).

Discussion
The Blue Curve in Figure 1 represents the 2006 TDG levels at HB for the Normal Dam Operating condition, relative to total river discharge. The red data points and regression curve (Red Curve) in Figure 1 are meant to represent the condition where the total river discharge is the same, but turbines are not operating and the entire river discharge is passing over the spillway and falls. As noted, TDG data for the Pre-Dam condition does not exist, and only a few 2003 data points for the Load Rejection condition (Figure 2). Therefore, for illustration, we have developed the Red Curve as a surrogate for the Load Rejection Curve, and subtracted 23,000 cfs from the total river discharge for each data point on the Blue Curve. (For example, 40,000 cfs river discharge in 2006 gave Blue Curve HB TDG levels of 112-113 percent, which included 23,000 cfs through the turbines and 17,000 cfs over the spillway. To attain the related Red Curve data points, it was assumed that the total river discharge of 17,000 cfs, and zero turbine discharge, created the same 112-113 percent TDG levels. This supposes that 17,000 cfs spill creates the same HB TDG level, whether the turbines pass zero or 23,000 cfs. Concurrently, if the assumption is made that the entire 40,000 cfs were passing the spillway, with no turbines operating, HB TDG levels increase to 122 percent. Again, this assumes that 40,000 cfs spill creates the same HB TDG whether turbines are operating or not.)

The Red Curve, as described above, could represent either the Pre-Dam condition, or the Turbine Load Rejection condition. The primary difference in the two conditions is believed to be the additional energy that enters the falls tailrace with the spillway structure in place (the Turbine Load-Rejection condition). The Turbine Load-Rejection condition results in higher energy flow (due to passage over the 50- foot high spillway, at a lower river stage), which increases turbulence in the pool below the falls, and takes more aeration to depth. This means the Turbine Load-Rejection condition results in incrementally higher TDG uptake below the falls, relative to the Pre-Dam Condition.

The 2003 data showed that HB TDG levels of 114-116 percent occurred during Load Rejection conditions for river discharges of approximately 30,000 cfs, compared to the Red Curve TDG HB readings of 118 percent and Blue Curve TDG HB readings of approximately 108 percent.

Geotechnical
Environmental &
Water Resources
Engineers

GEI Consultants

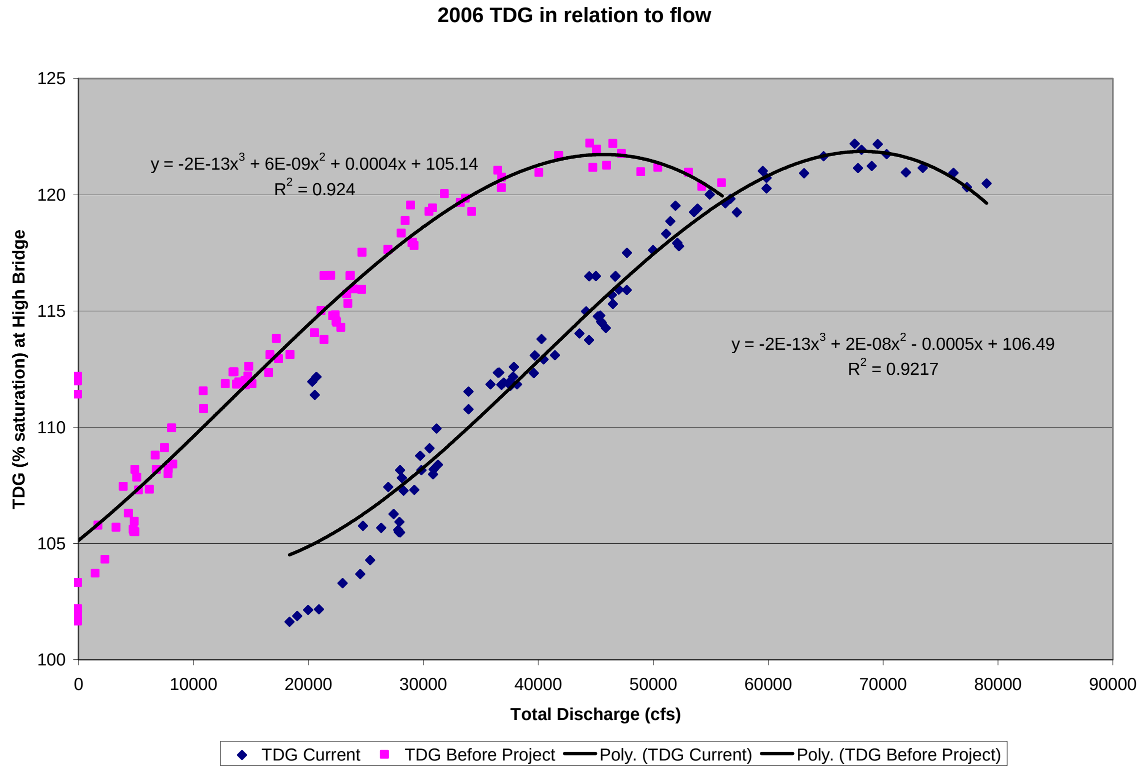

Figure 1 – Total Dissolved Gas Levels at the Thompson Falls High Bridge Monitoring Station, before and after hydro development (see above explanation).

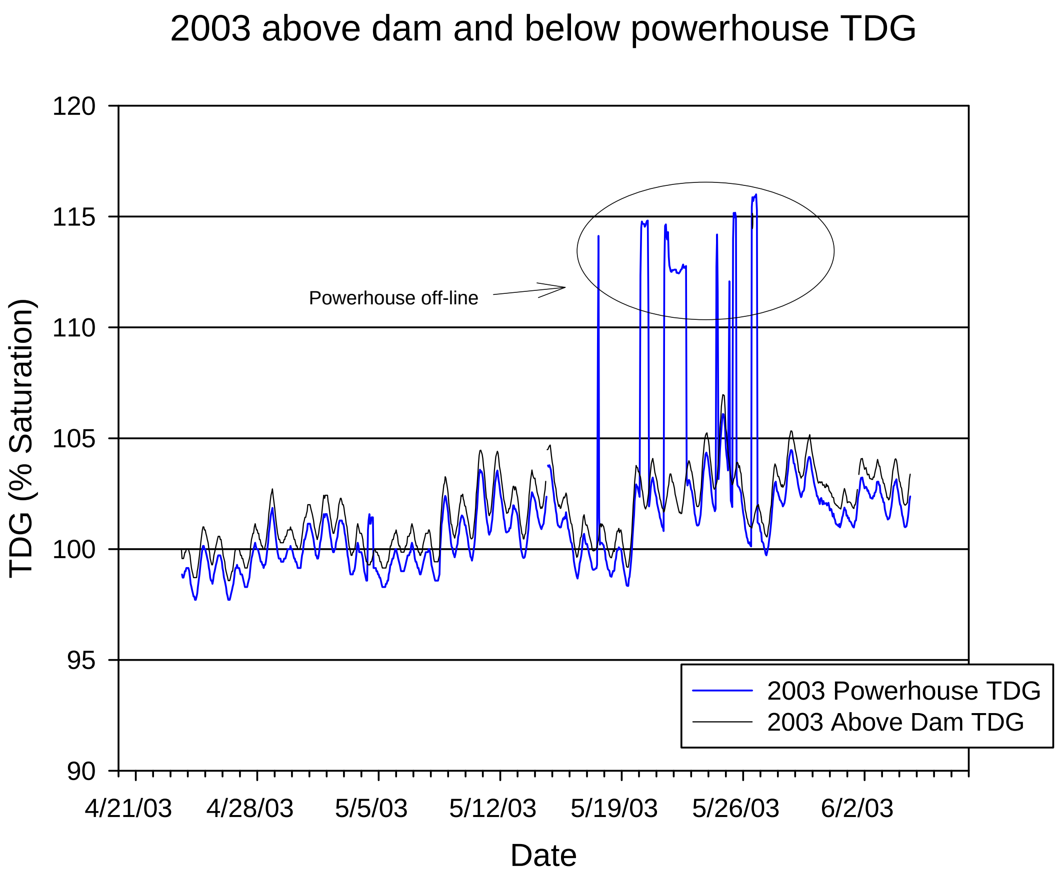

Figure 2 – TDG as measured above the dam and below the new powerhouse in 2003.

Figure 3 – Aerial photo of Main Dam Spillway.

Total Dissolve Gas Levels at the High Bridge Monitoring Station for Different Total River Discharge Levels

As examples of TDG abatement benefits of passing the first 23,000 cfs of river discharge through turbines, different levels of spill are considered below. In each case, the Blue Curve (Normal Dam Operating condition) HB TDG levels are compared with the Red Curve (which approximate the Turbine Load-Rejection and Pre-Dam conditions).

Low Normal Dam Operation Spill Levels (33,000 cfs total river discharge and 10,000 cfs spill):

Normal Dam Operation (Blue Curve) - Figure 4 shows the roughness of the channel downstream of the spillway apron, and upstream of the deep pool below the falls. At low levels of spill, there is a hydraulic jump near the downstream end of the spillway apron that dissipates some of the energy from spill. Additional energy is lost as spill flow passes over the rough channel in Figure 4, before plunging into the deep pool below the falls. Whereas the forebay TDG level was approximately 102–104 percent, a spill discharge of 10,000 cfs (assuming a river discharge of 33,000 cfs and powerhouse discharge of 23,000 cfs from Figure 1) increases TDG at the high bridge to 110 percent. Mixing downstream of the two powerhouses reduces the total river discharge TDG to below 110 percent (the gas balance formula can be used to get approximate Birdland Bay TDG readings).

Turbine Load-Rejection and Pre-Dam Conditions (Red Curve, Figure 1) – At low levels of spill with the Normal Dam Operation (river discharge = 33,000 cfs and spill discharge = 10,000 cfs), TDG levels are lower at the high bridge than the Pre-Dam condition, where the entire river (33,000 cfs) would be passing over the falls and plunging into the deep pool immediately downstream of the falls. Figure 1 shows that the TDG levels would be approximately 119 percent at HB if spill is 33,000 cfs (the entire river discharge). *Therefore, the hydro project development reduces TDG levels approximately nine (9) percent during the low spill scenario, by passing 23,000 cfs through turbines. Further, 119 percent TDG occurred in 2006 at a river discharge of 56,000 cfs spill (Normal Dam Operations – 33,000 cfs spill and 23,000 cfs powerhouse discharge).*

Figure 4 – Steep center thalweg and “falls” roughness.

Mid-Level Spill (25,000 cfs)

Normal Dam Operations - For 25,000 cfs spill, the river discharge in Figure 1 is 48,000 cfs (23,000 cfs powerhouse and 25,000 cfs spill). The Blue Curve shows TDG at approximately 116 percent.

Load Rejection and Pre-Dam Conditions (Red Curve, Figure 1) – For the same river discharge of 48,000 cfs, the Pre-Dam condition entailed the total river discharge of 48,000 cfs over the falls. From Figure 1, this would yield a TDG level of approximately 121 percent. Further, to get a 121 percent TDG with current configuration and 23,000 cfs through the powerhouse, a river discharge of 70,000 cfs (48,000 cfs spill and 23,000 cfs powerhouse) would be required. *Therefore, the hydro project development reduces TDG levels approximately five (5) percent during the referenced mid-level spill scenario, by passing 23,000 cfs through turbines.*

High Level Spill Discharges

As total river discharge increased from 33,000 cfs to 48,000 cfs, the influence of passing 23,000 cfs through the powerhouse turbines diminished from a nine (9) percent TDG reduction to a five (5) percent TDG reduction. As discussed, under the “Total River Discharge Ranges” section (page 4), the positive gas abatement influence of passing 23,000 cfs through turbines diminishes as total river discharge increases, until a *cross-over discharge* is reached. Above that unknown river discharge, it is suspected that both the Normal Dam Operating and Turbine Load-Rejection conditions increase TDG levels, relative to the Pre-Dam condition. One explanation for the lower Pre-Dam TDG levels at higher river discharges is the considerably higher tailrace elevation below the falls, which increases 10 feet at the two powerhouses between 10,000 and 50,000 cfs total river discharge. This backwaters and reduces the plunge of spilled discharge at the falls, which may decrease the rate of HB TDG increase, relative to total discharge. However, there is still appreciable turbulence from the high spill discharge creating vertical circulation in the deep pool, taking aeration to depth and increasing TDG uptake, just not to the same degree as at lower levels of spill.

Whether an asymptote is reached for the Normal Dam Operating condition (where TDG does not increase above a limiting TDG level) is not known, since data collection in the last few years has not measured TDG at a total river discharge above 79,000 cfs (in 2006). Figure 5 shows that total river discharge does not exceed 80,000 cfs over one (1) percent of the time, and the high river discharge of 79,000 cfs (2006) was the greatest discharge during TDG data collection that commenced in 2003.

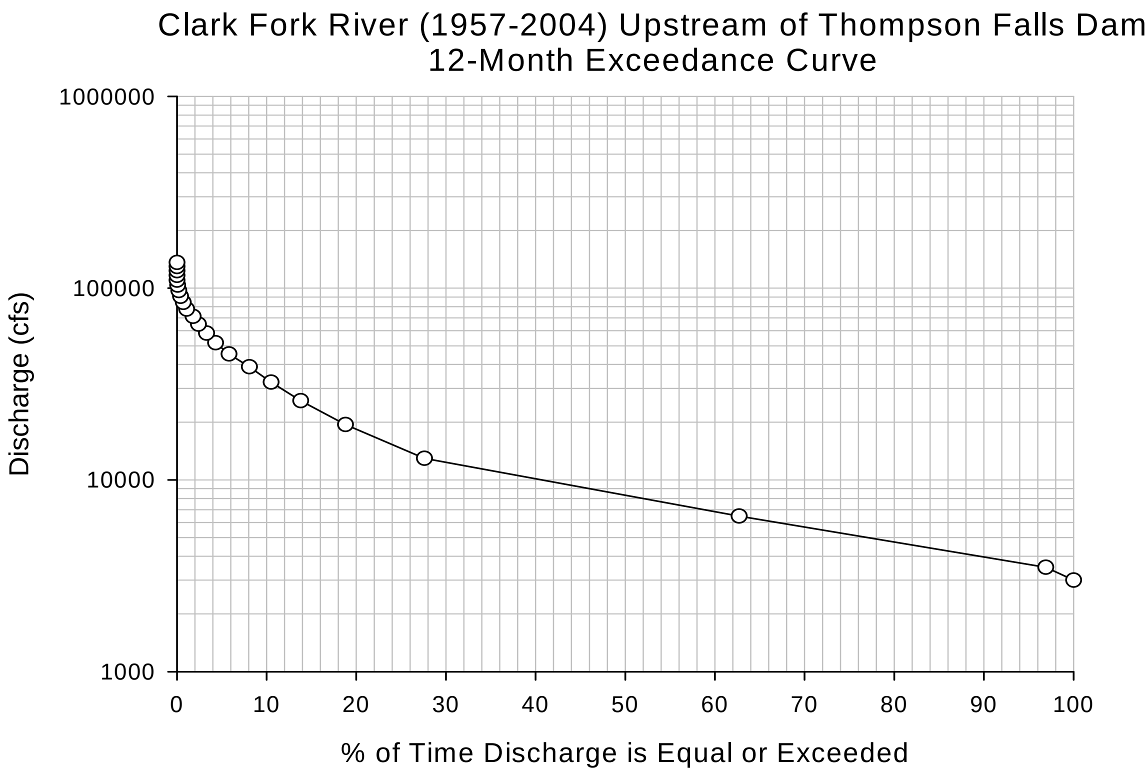

Figure 5 – River Discharge Exceedence Curve.

Reduced Downstream Total Dissolve Gas Levels Due to Mixing of Spill and Powerhouse Discharges

Figure 6 shows that mixing of lower TDG powerhouse discharge and higher TDG spillway discharge results in intermediate gas levels downstream of the Thompson Falls project than at the High Bridge monitoring station. The gas balance formula (page 3) gives a close indication of the Birdland Bay TDG readings. Note that this monitor is less than two miles downstream of where the powerhouses discharge into the Clark Fork River. The highest river discharge and TDG levels for 2003-2006 were 79,000 cfs and 117 percent. This shows how mixing influences the highest High Bridge monitoring station readings (123 percent). It also shows that the High Bridge TDG readings of 123% were confined to a several hundred yard reach of river between the deep gas uptake pool below the spillway/falls and the two powerhouses. At this location, mixing and dilution of higher TDG spillway discharge with lower TDG (the same as the forebay TDG level) occurred.

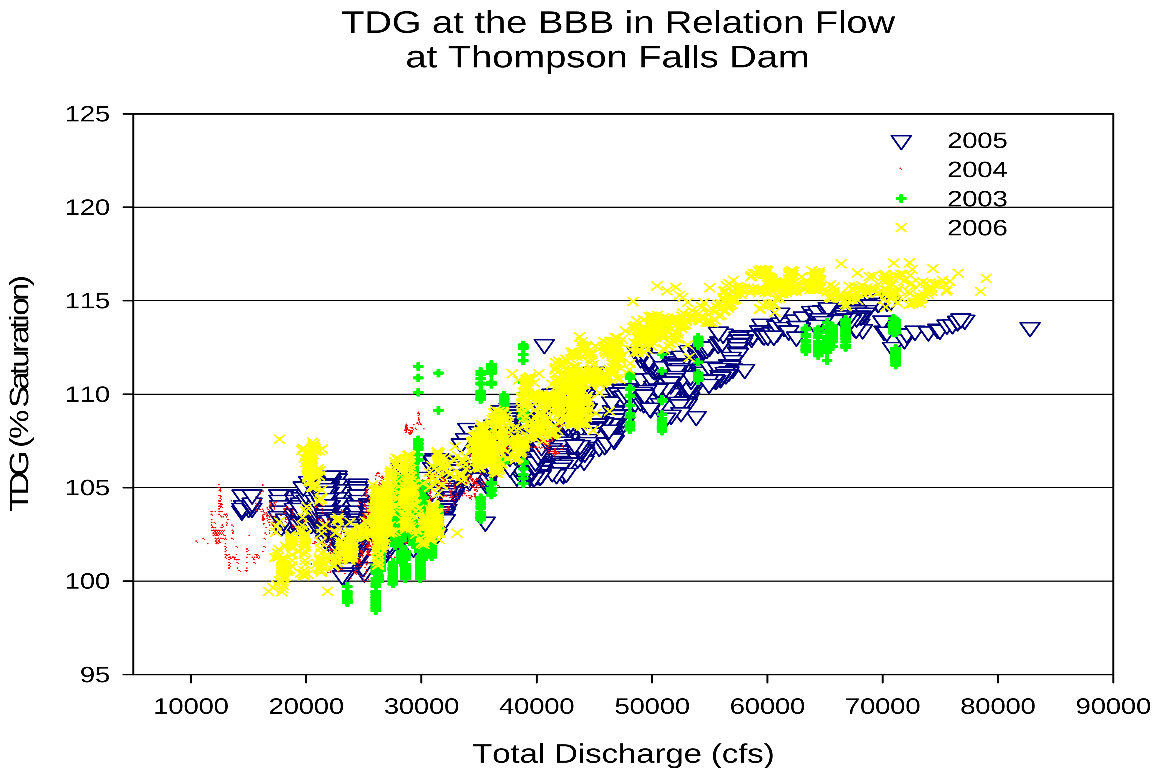

Figure 6 – TDG at the Birdland Bay Monitoring Station, 2003 - 2006

Conclusions: Thompson Falls Gas Abatement

1. The primary question addressed in this memorandum is whether the Normal Dam Operation results in higher TDG levels. The baseline is presumed to be the Pre-Dam condition.

2. The location of greatest total dissolved gas uptake is believed to be, on the basis of accumulated data at different PPLM monitoring stations, the HB location.

3. TDG levels at Thompson Falls did not exceed 123 percent during the 2003-06 TDG monitoring period, at a maximum total river discharge of 79,000 cfs. This is far lower than locations such as Cabinet Gorge, where spillway tailrace TDG levels reach 140 percent.

4. TDG levels two miles downstream of Thompson Falls, at the Birdland Bay monitoring station, did not exceed 117 percent during the 2003-06 TDG monitoring period.

5. It was shown in the Columbia and Snake Rivers, though extensive research, that TDG levels of ≤120 percent did not result in detectable gas bubble trauma symptoms. It is unknown, however, whether non-anadromous fish species would be adversely impacted from relatively short exposure to 123 percent TDG levels at Thompson Falls. However, it is questionable whether the 123 percent TDG level at Thompson Falls has any adverse impact on indigenous fish populations.

6. The Normal Dam Operating condition abates TDG, relative to the Pre-Dam condition, by routing up to 23,000 cfs around the primary TDG uptake zone (below the spillway and falls), and through turbines.

7. The Normal Dam Operating condition abates TDG, relative to the Turbine Load-Rejection condition, by routing up to 23,000 cfs around the TDG uptake zone, and through turbines.

8. I believe the Pre-Dam condition did not increase TDG uptake below the spillway and falls as much as the Turbine Load-Rejection condition, because of the additional 30-50 feet of energy added by the presence of the spillway in the Turbine Load-Rejection condition (which increased turbulence and conditions increasing TDG uptake below the falls).

9. The Red Curve in Figure 1 is probably most representative of the Turbine Load-Rejection condition, although it predicts TDG HB readings slightly higher than the 2003 Turbine Load-Rejection data for the approximately 30,000 cfs river discharges during those dates.

10. Both the Red Curve and limited 2003 Turbine Load-Rejection data suggest that the Normal Dam Operating condition TDG HB levels are always lower than the Turbine Load-Rejection condition levels, for any total river discharge.

11. For the first 23,000 cfs of total river discharge (lower river discharge levels), the Normal Dam Operating condition entails less flow passing into the deep pool below the falls, and thus entails lower TDG HB levels than the Pre Dam condition (where all river discharge passed the falls and deep pool immediately downstream.)

12. For higher river discharges (above 80,000 cfs), Normal Dam Operating condition spill discharge is high enough that the TDG benefit of passing the first 23,000 cfs through turbines is overridden, and I believe the Normal Dam Operating condition will yield higher HB TDG levels than the Pre-Dam condition. However, this occurs less than approximately one (1) percent of the time.

13. For total river discharges of 23,000 – 80,000 cfs, there is a *cross-over discharge* below which HB TDG levels are lower than the Pre-Dam condition, and above which HB TDG levels are higher than the Pre-Dam condition. If that change-over level is 50,000 cfs total river discharge, Figure 5 suggests that the Normal Dam Operating condition would have lower HB TDG levels 96 percent of the time. If that cross-over discharge is 70,000 cfs, the Normal Dam Operating condition would reduce HB TDG relative to the Pre-Dam condition 98 percent of the time. However, further monitoring will not resolve the magnitude of the cross-over total river discharge, since Pre-Dam HB TDG data is not available.

14. Therefore, the question of whether it is appropriate to continue to monitor TDG levels, or investigate structural measures to abate TDG, is raised. In theory, additional TDG monitoring should lead to additional information that will aid in resolving outstanding questions and/or issues. TDG data collection from 2003 -2006 has given a reasonable scope of understanding of TDG dynamics at Thompson Falls. It appears timing is appropriate to address what additional measures are necessary, if any.

15. Gas abatement measures at Thompson Falls, if required by the state or federal government, would not be successful if employed at the spillway structure. Since the TDG uptake zone is the deep pool immediately downstream of the falls, that is where direct structural measures would be required. The primary means of reducing TDG uptake at this location would be to add turbine capacity (probably not economically viable) or fill and cap deep zones in the bypass reach to keep turbulence from going to depth. This would be costly, entail a considerable length of the bypass reach channel, and would transfer energy further downstream.

This analysis suggests that TDG levels below the spillway and falls rarely exceed 123 percent, which is a low level compared to hydro projects such as Cabinet Gorge (TDG reaches 140 percent). There is no research that suggests 123 percent TDG exposure for short periods may induce adverse impacts to non-anadromous fish. Routing 23,000 cfs through project turbines also routes flow around the primary gas uptake area at the falls below the spillway. The Pre-Dam passage of total river discharge at the falls increased TDG levels, especially at low – medium stages. These observations beg the question of whether enough TDA monitoring at Thompson Falls has occurred, and whether there is a need for additional studies and monitoring. In short, it is reasonable for PPLM to request that the resource agencies provide a sound rationale and appropriate next steps, for committing additional resources to TDG monitoring and/or gas abatement studies.

Appendix

Total Dissolve Gas Data Collection Immediately Below the Spillway

In 2004, TDG readings were taken at the base of the Main Dam spillway, and at the HB location. Figure 7 shows the difference in TDG readings at the two sites. The first impression is that Thompson falls is not contributing an appreciable amount to TDG uptake. However, I believe that there is insufficient depth for much TDG uptake in the shallow bedrock channel between the spillway and falls. Rather, appreciable spill energy is being transferred to the deep pool below the falls, where turbulence is dissipated. This deep pool is where most of the TDG uptake is occurring.

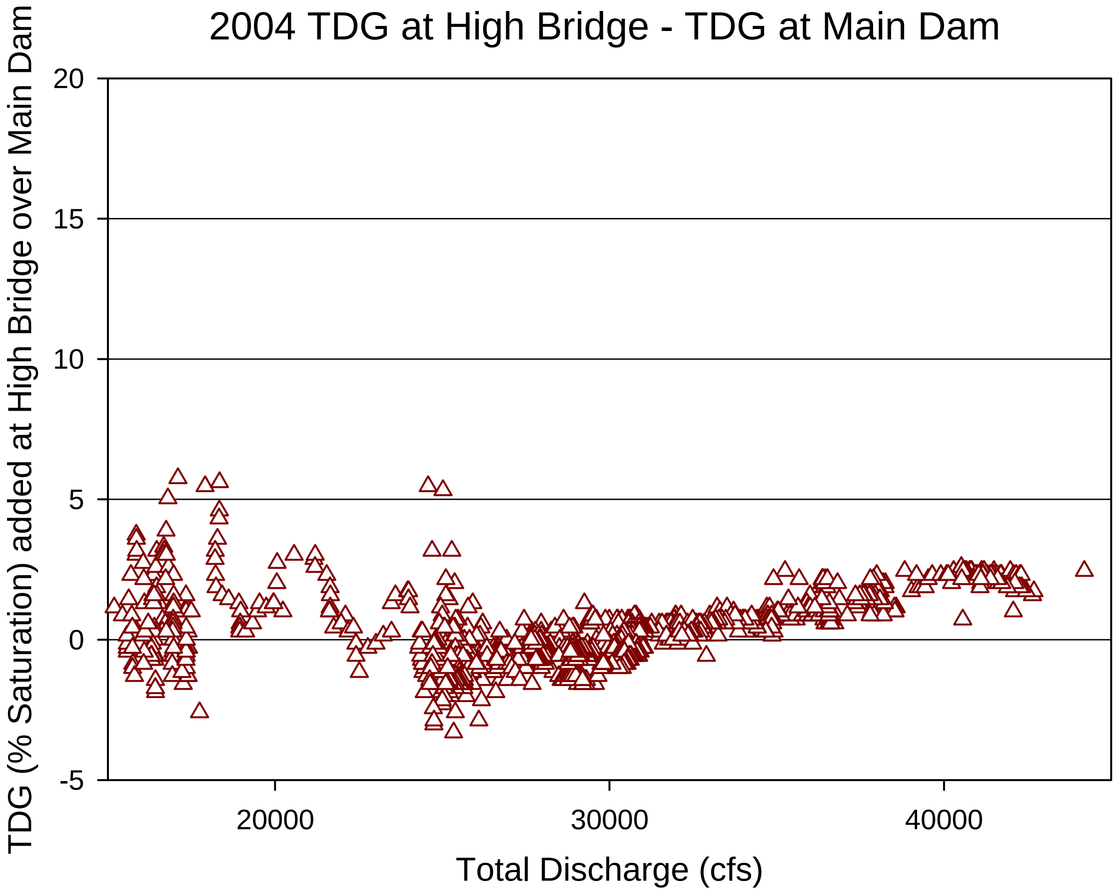

Figure 7 – Apparent TDG component of the 2004 HB TDG reading contributed by the falls.

The following is an excerpt from the USACE's report on the Dissolved Gas Abatement Study, which pertains to this issue:

(ES1.08. SUMMARY OF INVESTIGATIONS)

a. Field Investigations.

Much experience and knowledge has been gained through the data collection efforts and the near-field investigations conducted below the Corps projects. Initially, measurements of TDG were made by boat at a distance of 2,500 feet or more downstream of the spillway stilling basins where TDG levels were expected to be the highest near the end of the aerated spillway plume. With advances in instrumentation and on-board data logging, the Corps was able to develop methods for deploying instruments directly below the spillway. Peak TDG levels much higher than previously measured or expected were observed. TDG levels as high as 170 percent were measured near the spillway's endsill of the non-deflected Ice Harbor spillway. The TDG levels dropped off very rapidly to less than 130 percent within the first 2,500 feet downstream of the stilling basin and then began to stabilize at levels less than 125 percent as the flow continued to move downstream. Similar trends have been observed at other projects both with and without spillway flow deflectors. The near-field tests have shown that a significant and rapid decrease in TDG occurs within the aerated plume exiting the spillway's stilling basin. Because flows from the spillway flow deflectors tend to force higher energy flow out into the tailrace channel, they not only prevent the flow from plunging deep into the spillway stilling basin (reducing the initial uptake in TDG), they also promote a rapid decrease in TDG by extending the boundaries of a more turbulent aerated plume.

The following is surmised, relative to where TDG uptake is occurring at Thompson Falls

- If TDG measurements are in a highly turbulent zone (such as immediately below a spillway), readings will be artificially high relative to a downstream location such as the HB, because the TDG levels drop in intervening zones of waning turbulence. This is due to residual "tumbling" of water that releases unstable TDG in solution to the atmosphere.

- Since there are few areas of depth in the immediate spillway tailrace, but appreciable turbulence and aeration, little absorption of TDG should be occurring in this zone during spill. Therefore, there is uncertainty whether elevated 2004 TDG readings below the spillway were artificially influenced by a high density of aeration bubbles in this turbulent zone.

- At low spill levels, some of the energy is dissipated between the spillway and falls, due to surface roughness and the hydraulic jump at the base of the spillway apron. But residual energy combines with the vertical drop at the falls to transfer composite energy to the deep pool below the falls. I believe this is where the primary TDG uptake occurs during spill.

- Since the primary energy dissipation appears to occur in the deep falls tailrace pool, the TDG levels upstream (in the immediate spillway tailrace) are erased when they pass into the deeper pool below the falls. That is where the presence of (1) pool volume and (2) pool depth combine to create the vertical circulation necessary to take aeration to depth, and expose it to the hydraulic pressures required for TDG uptake.

- Therefore, TDG readings at the base of the spillway appear to be misleading, and the HB reading (at a location far enough downstream to reflect a more stable TDG level) appears to be the most useful for measuring the *composite* TDG uptake for the spillway and falls.

- It is inappropriate to try to segment TDG uptake downstream of the Main Dam spillway at Thompson Falls, since the spillway and falls are a composite system.

MEMORANDUM OF UNDERSTANDING

Thompson Falls Hydroelectric Project

FERC No. 1869

PPL Montana

Facilitation and Funding of FERC License based Consultation Process and Implementation of Minimization Measures for Bull Trout

January 15, 2008

CONTENTS

MEMORANDUM OF UNDERSTANDING

This Memorandum of Understanding (MOU) is made and entered into effective January 15, 2008, by and between PPL MONTANA , LLC, a Delaware limited liability company ("PPL Montana"), the UNITED STATES FISH AND WILDLIFE SERVICE ("USFWS"), MONTANA FISH, WILDLIFE AND PARKS ("MFWP"), and THE CONFEDERATED SALISH AND KOOTENAI TRIBES OF THE FLATHEAD NATION (CSKT), the later three organizations being collectively referred to herein as "TAC Agencies".

WITNESSETH:

WHEREAS, PPL Montana consulted with the USFWS, MFWP, CSKT, Montana Department of Environmental Quality (MDEQ), and the Federal Energy Regulatory Commission (FERC) in the development of a Biological Evaluation (BE) to be filed with FERC, assessing potential impacts to bull trout, which are federally listed as "threatened" under the Endangered Species Act (ESA), as a result of operations and proposed modifications at the Thompson Falls Hydroelectric Project; and

WHEREAS, the FERC will, at it's discretion, issue a Biological Assessment (BA) to the USFWS based in part on PPL Montana's BE assessing potential impacts to bull trout as a result of operations and proposed modifications at the Thompson Falls Hydroelectric Project; and

WHEREAS, based on FERC's BA, the USFWS will, at it's discretion, issue a Biological Opinion (BO) to FERC and PPL Montana, its non-Federal designated representative, containing reasonable and prudent measures and associated terms and conditions to minimize impacts to the federally listed bull trout at the Thompson Falls Project; and

WHEREAS, PPL Montana will, at it's discretion, file an Application for Amendment of the Thompson Falls Project License to include minimization measures for bull trout contained in the USFWS BO, to the FERC; and

WHEREAS, the FERC will, at it's discretion, require PPL Montana to implement minimization measures for bull trout at the Thompson Falls Project in an Order Approving Amendment of the License, per the reasonable and prudent measures and associated terms and conditions in the USFWS BO; and

WHEREAS, the parties hereto acknowledge that the Thompson Falls License may be revised on rehearing and may be further revised from time to time over the term of the MOU, thus references herein to the "License" shall refer to the then-effective Thompson Falls License; and

WHEREAS, the License provides that PPL Montana has responsibilities for hydro operations and certain other natural and cultural resources in relation to the License; and

WHEREAS, PPL Montana, as licensee for Thompson Falls is willing to accept the obligations imposed by the License and understands that implementation of bull trout minimization measures contained in the License shall occur in collaboration with the USFWS, MFWP, CSKT, and other agencies responsible for resource management; and

WHEREAS, minimization measures for bull trout in the License were developed in consultation with PPL Montana, FERC, USFWS, MFWP, CSKT, and other interests to address minimization measures for bull trout, however unforeseen circumstances may arise that necessitate change; and

WHEREAS, this MOU generally addresses the implementation of bull trout minimization measures for the duration of the term of the existing FERC License No.1869 for the Thompson Falls Project, together with any extension thereof prior to the issuance of a new license; and

WHEREAS, the parties to this MOU agree to seek cooperation leading to more efficient and effective resource management than could be achieved individually; and

WHEREAS, having voluntarily agreed to enter into this MOU, the parties hereby acknowledge that they do not intend this MOU to create contractual obligations and further acknowledge that this MOU shall not be enforceable by or before any federal or state agency, or any court.

NOW, THEREFORE, the parties agree as follows:

I. Purpose

A. The purpose of this MOU is to establish the terms and conditions for collaboration between PPL Montana and TAC Agencies in PPL Montana's implementation of minimization measures for bull trout as specified in the Thompson Falls License or other resource conservation measures related thereto taken voluntarily by PPL Montana.

B. This MOU provides for the continuing operation of a TAC made up of representatives of PPL Montana and TAC Agencies. This TAC shall function as the means for collaboration on the expenditure of mitigation funds and the implementation of bull trout minimization measures as specified in the License or other resource conservation measures related thereto taken voluntarily by PPL Montana.

C. This MOU provides for the allocation of annual TAC funds provided by PPL Montana. PPL Montana will bear ultimate responsibility for ensuring that bull trout minimization measures or other resource conservation measures taken voluntarily by PPL Montana are implemented in a manner consistent with requirements of the License.

D. To the extent consistent with the License, this MOU sets out provisions for adaptive implementation of minimization measures or voluntary minimization measures that may be appropriate due to advancement in technology, project experience that dictates alternative methods implementation, and adequate response to unforeseen or changed circumstances or discoveries during the term of the MOU.

E This MOU provides assurances to interested agencies, stakeholders, and various publics that minimization measures to reduce impacts to bull trout at the Thompson Falls Project will be faithfully implemented in a timely fashion by PPL Montana and that operations and maintenance of the Thompson Falls Project shall be in compliance with the Endangered Species Act.

II. Definitions

A. Resource Management - As used herein refers to management of required bull trout minimization measures in the Thompson Falls FERC license.

B. Adaptive Management (AM) – Is embodied by this MOU through prior consultation with the USFWS, MFWP, CSKT, and other agencies in preparation of the Thompson Falls Project BE, BA, BO and the Application to FERC to amend the project license. Adaptive management is natural resource management where decisions are made as part of an ongoing science-based process. Results are used to modify future management methods and policy. As improved conservation technologies and science become available or new management priorities are collaboratively established, minimization or conservation funds may be redirected to accommodate the changing technology and needs of the resource and society within the requirements of the license. The adaptive management process emphasizes collaboration but still places ultimate responsibility upon PPL Montana to comply with the license and other applicable laws. PPL Montana believes that this management approach is entirely consistent with the spirit of the Federal Power Act and the interests of the people of Montana as expressed directly through TAC agencies.

C. Minimization Measures – These are the reasonable and prudent measures that serve to minimize take and that are identified in the USFWS biological opinion under the Incidental Take Statement (ITS). The associated terms and conditions in the ITS set out the specific methods by which the reasonable and prudent measures are to be accomplished.

D. Thompson Falls Hydroelectric Project - This includes all of the dam, spillway and all associated structures located on the Clark Fork River including the reservoir impoundment upstream of the dam and spillway and any associated structures and/or facilities needed to maintain and operate the hydroelectric facilities within the FERC project boundary.

III. Committees

A. Technical Advisory Committee (TAC) – A committee made up of willing representatives from PPL Montana, USFWS, U.S. Forest Service (USFS), MDFWP, MDEQ,CSKT and other public or private interests whose purpose is to address potential impacts to bull trout from the operation and maintenance at the Thompson Falls Project on the Clark Fork River in western Montana. PPL Montana, USFWS, CSKT, and MFWP are formal voting members of the TAC whereas other interests are non-voting and advisory.

1. Representatives of TAC Agencies and their replacements from time to time shall be determined by each participating entity. Initial members of the TAC are listed in Exhibit "A".

2. PPL Montana will provide the TAC annual updates and annual work plans for review and approval. The TAC members will have a minimum of 30 business days, unless otherwise agreed to time period for review, to provide comments for all review materials provided by PPL Montana, including annual reports and work plans. PPL Montana will provide materials for review in advance of the 30 day notice to the extent practicable.

3. With regard to the TAC, federal, state, and CSKT government agencies do not waive or diminish in any way, the exercise of their authorities and rights

with respect to this or other proceedings. The USFWS expressly reserves authority under the ESA and Federal Power Act (FPA) with regard to procedures, policy, and regulations related to addressing impacts to bull trout from project operations and maintenance at the Thompson Falls Project.

B. PPL Montana Steering Committee. The PPL Montana Steering Committee for the Thompson Falls Project will consist of representatives of PPL Montana listed in Exhibit "A". At its discretion, PPL Montana may replace its representatives from time to time. This PPL Montana Steering Committee will provide general policy and regulatory guidance to the PPL Montana representatives on the Thompson Falls TAC but will otherwise not directly participate in TAC business or the TAC decision making process.

IV. <u>Adaptive Management Funding Account (AMFA)</u>

The TAC will apply the concept of adaptive management where applicable, when determining bull trout minimization priorities and schedules for funds to be paid out of the AMFA. PPL Montana will provide an account for funding downstream passage minimization measures approved by the TAC that meet the requirements of the BO. PPL Montana will provide $100,000 per year for downstream passage measures for five years beginning on January 1, 2009 and will allow a maximum of $250,000 to accrue (from unspent or transferred annual TAC funds) in a capital account for use by the TAC during this same five year time period.

Annual payments to the TAC, beginning January 1, 2010, will be increased with a cost of living increase of 2.5% each year. All funding accounts will be internally managed by PPL Montana. However, no AMFA funds will be spent without prior approval from the TAC.

1. Annual payment. For the purpose of this MOU, PPL Montana will provide $100,000 in discretionary annual funding (with cost of living adjustments) to the TAC for five calendar years, beginning January 1, 2009, for implementation of the downstream passage minimization measures in addition to License required studies,

monitoring activities, reports, upstream fish passage minimization measures, gas abatement monitoring, predator control measures, and other means of reducing impacts on bull trout caused by operation of the Thompson Falls as described in Exhibit "B". Increases or decreases in MOU funding, provided by PPL Montana, to comply with FERC-mandated minimization measures in the License can be addressed within provisions of this MOU. Per this MOU, PPL Montana may increase or decrease funds in any single year to support implementation of TAC-approved minimization measures for bull trout and to meet the requirements of the BO. Factors such as monitoring or study results, changing technology, or other needs of the resource may necessitate changes (increases or decreases) in funding amounts and schedules over time. This MOU is not intended to relieve PPL Montana of the obligation to make such funding changes. PPL Montana further anticipates that this MOU may be renewed or revised every 5 years during the current FERC Project License term or extensions thereof. MOU renewal, if any, after 2025, with appropriate minimization funding level commitments will be based on PPL Montana's remaining compliance requirements within the License.

2 Bull trout minimization measures, including upstream and downstream fish passage structures, gas abatement measures, habitat restoration, or other minimization measures required by the FERC will be fully funded by PPL Montana if the cost of such measures is more or less than specified in this MOU.

V. PPL Montana Operations/Obligations

V.1. PPL Montana Steering Committee Funds. PPL Montana estimates that a total of one-half employee full-time equivalent (0.5 FTE) will be required to manage PPL Montana responsibilities on the TAC, coordinate implementation of bull trout minimization measures, and to facilitate consultation between the FERC, state and federal agencies and the CSKT. PPL Montana will be responsible for funding the appropriate level of PPL Montana or outside consultants required staff required for adequate and timely project management of implementation, monitoring, and reporting on the effectiveness of bull trout minimization measures . PPL Montana will prepare and implement an internal budget appropriate for Steering Committee activities. The

TAC will be responsible for advising PPL Montana should PPL Montana not fulfill its responsibilities in this regard.

V.2 PPL Montana administrative and other support. PPL Montana will provide reasonable administrative, clerical and support facilities for the TAC. PPL Montana will be responsible for preparing proposed agendas, and for the management and preservation of licensing data and studies including the provision of reasonable public access to such data and studies. PPL Montana shall provide assistance to the TAC for the purpose of identifying collaborative funding opportunities, application for grants, and managing any land transactions related to conservation activities such as conservation easement or fee title acquisition where needed and practicable.

V.3 PPL Montana will fully and faithfully perform all obligations to conserve, protect, and reduce impacts to bull trout per the FERC License Order and requirements in the USFWS BO.

V.4 PPL Montana shall promptly notify the USFWS if for any reason PPL Montana is unlikely or unable to fulfill any obligation per the FERC License order or per the USFWS BO.

V.5 PPL Montana will use its best efforts to help resolve disputes that may occur among TAC members, agency officials, local officials, or private parties with respect to the implementation of minimization measures per the FERC License agreement using dispute resolution process described herein.

V. 6 PPL Montana will implement timely monitoring and reporting requirements per the FERC License Order, USFWS BO, and any other TAC approved agreement related to bull trout minimization measures.

D. Minimization Measures – minimization measures referred to herein are a specific reference to those bull trout minimization measures required by the License.

VI. Authority

A. Authority to enter into MOU.

1. PPL Montana is authorized to enter this MOU by PPL Montana, LLC, general corporate authority.
2. MFWP is authorized to enter into this MOU pursuant to Montana Code Annotated Sections 23-1-102, 23-1-107, and 87-1-201.
3. USFWS is authorized to enter into this MOU pursuant to the Fish and Wildlife Service Coordination Act (16 U.S.C. 661 et. seq.)
4. CSKT is authorized to enter into this MOU pursuant to CSKT Constitution Article VI.

B. Funding, authority, and operating limitations. It is understood that operating plans, procedures, schedules and agreements may be developed, as needed, by the participants to implement the specific objectives of this MOU. Nothing in this MOU or subsequent plans, procedures, or agreements will be construed as affecting the authorities of PPL Montana or TAC agencies as binding beyond their respective authorities or prerogatives for decision-making, or to require any of the TAC agencies to obligate or expend funds in excess of appropriated funds.

C. Limitations. Nothing herein shall be construed as obligating any Federal agency to expend or as involving the United States in any contract or other obligations for the future payment of money in excess of appropriations authorized by law and administratively allocated for any work under this MOU. PPL Montana's funding obligations in the context of this MOU will be limited to and governed by the License and PPL Montana's obligation as Licensee. If one or more of the TAC Agencies fails to fulfill any of its commitments made pursuant to this MOU, PPL Montana or any other TAC member, reserves the right to withdraw from this MOU or to renegotiate the terms set forth herein.

VII. TAC Operations

A. PPL Montana Responsibility. PPL Montana will be responsible for managing the TAC AMFA for bull trout conservation and for providing technical input related to the implementation of bull trout minimization measures for the Thompson Falls Project. PPL Montana will also be responsible for seeing that minimizations funds and measures are authorized and spent for appropriate projects that comply with the License. In consultation with TAC members, PPL Montana will convene, facilitate and chair TAC meetings to fulfill implementation requirements of the License, and, with regular disclosure to TAC members, manage the TAC AMFA.

B. Meetings and Quorum. The TAC will meet on a regularly scheduled basis to develop annual work plans, prioritize the implementation of bull trout conservation measures in the license, and discuss the annual accounting of how funds have been used to implement measures and future funding strategies. A TAC quorum is herein defined as one voting representative from PPL Montana, USFWS, CSKT and MDFWP. Quorum decisions by the TAC will require each of these agencies to be present in person or by proxy.

C. Meeting participation. All TAC meetings are open to the public. TAC subcommittees and working groups may be organized as appropriate. Subcommittees and working groups may include staff personnel of PPL Montana or TAC Agencies, outside consultants or others. Any such subcommittees or working groups will be advisory to the TAC.

D. TAC decision-making. PPL Montana will bear ultimate responsibility for ensuring that the License conditions and bull trout minimization measures are implemented and funded in a manner consistent with requirements of the License. PPL Montana will seek to attain consensus among the voting members of the TAC in implementing minimization measures. Multiple representatives of PPL Montana and TAC Agencies may actively participate in TAC meetings. However, PPL Montana and each TAC agency will designate one person to officially represent their organization (for

TAC quorum voting) at each TAC meeting. All parties commit to a good-faith effort to resolve any differences in a timely and cooperative manner. In the event a consensus cannot be achieved among the voting members of the TAC, the TAC may elect to enter voluntary dispute resolution as set forth below:

> Any dispute that arises in the implementation of this MOU and any implementation measure, or in any committees formed under this MOU, shall, in the first instance, be the subject of informal negotiations between the affected parties. If negotiations fail, a party or parties may refer a dispute to the TAC, along with a written statement outlining the dispute and any areas where the parties are in agreement. The TAC shall be convened by PPL Montana and, will develop consensus recommendations for the resolution of the dispute. During this informal dispute resolution period, any party may request the Director of FERC's Office of Dispute Resolution, or the Director's designee, to participate in the negotiations to assist in resolving the dispute. If no resolution is reached during the informal process, the disputing party or parties shall have thirty (30) days following the notice of the TAC recommendations to refer the dispute to FERC for expedited dispute resolution. All disputes taken to FERC under this MOU shall be governed by the alternate means of dispute resolution contained in FERC's Rules of Practice and Procedure, 18 C.F.R. Section 385.604, as amended from time to time or any succeeding FERC regulations governing alternative means of dispute resolution. The proposed TAC recommendations and all supporting documents, may be submitted to the FERC. If a disputing party does not refer a dispute to the FERC within the thirty-day (30) time period, the TAC recommendations will become binding on all parties.

E. Conduct of Meetings. Guidelines for the conduct of TAC meetings are attached in Exhibit "C" as may be amended from time to time by mutual consent of PPL Montana and the TAC agencies.

VIII. General provisions

A. Re-openers – The parties to this MOU generally agree they will not invoke or rely upon any re-opener clause contained in the License with respect to any matter covered by this MOU unless the party determines that new information reasonably demonstrates that applicable provisions of this MOU are inconsistent with the public interest and affords the TAC, at least ninety (90) days to consider the new information and that party's position. Said party shall not be required to comply with this ninety (90) day notice provision if it believes an emergency situation exists, or is necessary to comply with the Endangered Species Act. Notwithstanding the provision of this paragraph, the parties agree that a TAC Agency may seek re-opening of the License as necessary to comply with any state or federal law and implementing regulations not pre-empted by the Federal Power Act, but this provision shall not be deemed to represent PPL Montana's or other parties consent to any such request by a TAC agency. In addition, the USFWS may seek re-opening of the License pursuant to its authority under the Federal Power Act, but this provision shall not be deemed to represent PPL Montana's or other parties consent to any such request by the USFWS.

B. Cooperate in Studies – The parties to this MOU agree to cooperate in conducting studies and monitoring activities implemented pursuant to the License and in providing reasonable assistance in any approval or permitting process that may be required for implementation of or specific conservation measures; provided that any of TAC Agencies are not, by this commitment compromising or relinquishing any legal authority they may have in those situations where they may be the permitting agency.

C. Separate agreements. For each minimization measure implemented pursuant to this License, the parties understand and agree that separate agreements between PPL Montana and participating agencies may be executed as necessary to complete that project.

D. Term of MOU.

1. Duration. This MOU shall be effective upon execution by all parties and shall remain in effect through December 31, 2013, or termination of the License, whichever is later.

2. Renewal of the MOU. This MOU may be renewed by mutual consent of PPL Montana and TAC Agencies every five years until the term of the current FERC license, or any extension thereof, expires.

E. Termination of the MOU. This MOU may be terminated at any time by mutual written agreement of all parties.

F. Binding effect. As set forth herein, this MOU shall inure to the benefit of, and shall be binding upon the respective successors and permitted assigns of the parties hereto.

G. Assignment. The parties hereto may not assign this MOU without consent of other parties; provided that such consent will not be unreasonably withheld.

H. Modification. This MOU may be modified only in writing by mutual agreement of all the parties; provided that such consent will not be unreasonably withheld, and provided that PPL Montana may assign its rights and obligations hereunder to any other entity that becomes licensee of the Thompson Falls Project under the License.

I. Execution in counterparts. This MOU may be executed in counterparts, each of which shall be deemed an original, but all of which together shall be one and the same instrument.

J. Precedent. Parties to this MOU understand and agree that this MOU establishes no principles or precedents with regard to any issue addressed herein or with regard to any party's participation in any future proceeding and that none of the parties to this agreement will cite either this MOU or its approval by FERC as establishing any principles or precedents except with respect to matters to which the parties have herein agreed.

K. PPL Montana will keep the TAC reasonably informed of the status of License compliance filings and, in the event that any such filing is disputed, PPL Montana shall notify all parties of the dispute and make copies of its filing available to all parties.

IN WITNESS WHEREOF, the parties have executed this Thompson Falls MOU on the dates indicated below.

PPL MONTANA, LLC

By Peter J Simonich

Its Manager, Generation Assets

Date 1/3/08

MONTANA FISH, WILDLIFE AND PARKS

By Chris Hunter

Its Chris Hunter, Chief of Fisheries

Date 12/13/07

UNITED STATES FISH AND WILDLIFE SERVICE

By R. Mark Wilson

Its Montana Field Supervisor

Date December 17, 2007

THE CONFEDERATED SALISH AND KOOTENAI TRIBES OF THE FLATHEAD NATION

By James H Steele Jr

Its Chairman

Date 1/15/08

EXHIBIT "A"

Initial members of the PPL Montana Steering Committee and Thompson Falls Technical Advisory Committee (TAC):

PPL Montana Steering Committee
Pete Simonich (PPL Montana)
Dave Kinnard (PPL Montana)
Jon Jourdonnais (PPL Montana)
Brent Mabbott (PPL Montana)
Frank Pickett (PPL Montana)

Thompson Falls TAC
PPL Montana
MFWP
USFWS
MDEQ
CSKT
USFS

EXHIBIT "B"

Adaptive Management Fund Account
PPL Montana 5 Year (beginning 1/1/09) Commitment

PPL Montana Steering Committee (0.5 FTE)	-FERC license administration -interagency TAC management -implement minimization and conservation measures -agency and NGO cost share program coordination

PPL Montana will provide $100,000 annually for five calendar years beginning January 1, 2009 and will allow a maximum of $250,000 to accrue (from unspent or transferred annual TAC funds) in a capital account for use by the TAC during this same five year time period for TAC bull trout downstream passage measures. In addition, PPL Montana will be responsible for costs required to implement TAC-approved bull trout minimization measures per the FERC License and USFWS BO. These measures include any required studies, monitoring, reports, upstream and downstream fish passage minimization measures, gas abatement monitoring, predator control measures, and other means of reducing impacts on bull trout caused by operation of the Thompson Falls Project.

EXHIBIT "C"

CONDUCT OF TAC MEETINGS

I. Agendas. Agendas for TAC meetings will be developed by PPL Montana in consultation with agency TAC members. At minimum, a TAC meeting will be held twice annually through the term of this MOU, first to review progress and approve the annual report of the previous year's implementation work and subsequently to approve an annual work plan for each upcoming year.

II. Meeting Summaries. PPL Montana will prepare TAC meeting summaries. The summaries will identify action items and decisions reached by the TAC. Summaries will be sent to TAC members as a mechanism for information exchange and coordination.

III. Open Meetings. Non-TAC members (including the general public) can attend and observe TAC meetings in progress. However, only a designated portion of each TAC meeting may be open to comments from non-TAC members.

IV. Caucus. Any TAC member may declare a caucus break. Caucus members will be asked to conclude their discussions in a timely manner so as not to unduly restrict the completion of the scheduled meeting agenda. Caucusing may continue as needed outside of and independent of TAC meetings.

V. Good Faith. TAC members agree to act in good faith with respect to the concerns of the others to reach an agreement within this consultation process. Proposals, positions taken, written statements, and materials used will not be considered as TAC commitments unless TAC agreement is achieved. TAC members agree to participate in a free, open, and mutually respectful exchange of ideas, views, and information in attempting to achieve agreement. Personal attacks and prejudicial statements will not be tolerated. All TAC participants will be given an equal opportunity to be heard.

VI. Public Statements. TAC members may describe proposals under discussion and develop positions in consultation with constituencies as required by respective agency process. With the exception of information shared in confidence, a participant may make such public statements, including to the press, describing topics under discussion and their own views about these topics. No TAC member will describe or characterize the position of any other party in public statements or in the discussions with the press. As an exception, in any statements that a TAC member makes in an open public meeting to inform its governing entity, that member may describe the position of other participants. In doing so, participants shall consult those other participants and make a good faith effort to accurately describe their positions. All members agree not to divulge information shared by others in confidence nor will any party seek to place blame on any other party, even if that party withdraws from the process or the process is discontinued.

VII. Rights in Other Forums. Participation in a TAC does not limit the right or obligations of any individual or organization. Members will make a good faith effort to notify one another in advance, if litigation, or other action outside the committee process will be initiated, which will affect the terms of agreements or actions being taken by the committee.

VIII. Meeting Process. TAC meetings will be chaired and facilitated by PPL Montana. PPL Montana may also provide a meeting facilitator to conduct the meetings. PPL Montana or facilitator will work to insure that the TAC consultation process runs smoothly. The role of PPL Montana (or its designated facilitator) includes developing agendas, chairing meetings, working with TAC members both at and between meetings to resolve questions and to encourage and assist progress in accomplishing TAC goals, resolving any impasses that may arise, preparing meeting summaries, assisting in the location and circulation of background materials and materials prepared by participants, and other functions at the request of TAC members. In the event an outside facilitator is used, PPL Montana will pay for facilitation services with PPL Montana Steering Committee funds.

IX. FERC Communication Process. PPL Montana will, in consultation with TAC agencies, maintain appropriate correspondence and consultation with FERC staff and make required written filings with the FERC regarding implementation of, and any amendments to, the License. TAC agencies also have an equal right to consult with FERC on Thompson Falls issues within the discretion of their respective agency and FERC rules governing consultation.

X. Public Participation. Each TAC meeting agenda will provide a specific time period for public comment. Members of the public will be able to observe TAC meetings in progress and offer comments during a specified public comment period at the invitation of TAC member(s). TACs may form subgroups to work on specific issues and may choose to include members of the public in the subgroup process. TAC members representing public agencies will be expected to reflect, take actions, and represent positions that reflect their respective public involvement responsibilities. Further, TAC members will assume responsibility as appropriate for directing public comment and public participation through appropriate forums within their respective agencies.

Biological Evaluation for Bull Trout
Thompson Falls Project
(FERC No. 1869)

Submitted to:
Federal Energy Regulatory Commission

Prepared by:
PPL Montana, LLC
45 Basin Creek Road
Butte, Montana 59701

With assistance from:
GEI Consultants, Inc.
8050 Springtime Road
Missoula, MT 59803

April 4, 2008

Table of Contents

List of Tables

List of Figures

List of Photos

List of Appendices

Executive Summary

PPL Montana is owner and operator of the Thompson Falls Dam (No. 1869), located on the Clark Fork River near Thompson Falls, Montana. The current Federal Energy Regulatory Commission (FERC or Commission) license was issued to Montana Power Company (now PPL Montana) in 1979 and is scheduled to expire on December 31, 2025. In 1998, the bull trout (*Salvelinus confluentus*) was federally listed under the 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 (BE) was prepared for the Thompson Falls Project and submitted to the U.S Fish and Wildlife Service (USFWS) and FERC in 2003.

The draft BE concluded that the Thompson Falls Project was likely to adversely affect bull trout. Issues identified in the draft BE included the lack of upstream adult fish passage, potential for delay or mortality during downstream passage, and potential water quality impacts from increases in total dissolved gas (TDG) during high spill time periods.

An Interagency Technical Advisory Committee (TAC) was established with participation of the USFWS; Montana Fish; Wildlife and Parks (MFWP); Avista Corporation; NorthWestern Energy; Montana Department of Environmental Quality (MDEQ); and the Confederated Salish and Kootenai Tribes (CSKT). The TAC has been advising PPL Montana on bull trout concerns in the Project area, studies that are needed to further define bull trout issues in the Project area, and possible conservation measures.

The TAC process has been on-going since 2002, and culminated in the signing of a Memorandum of Understanding (MOU) in 2007, which establishes the terms and conditions for collaboration between PPL Montana and TAC agencies in PPL Montana's implementation of minimization measures for bull trout as specified in the Thompson Falls License or other resource conservation measures taken voluntarily by PPL Montana.

The MOU is included with this BE in Appendix C. The MOU has been signed by PPL Montana, the USFWS, MFWP, and the CSKT, collectively known as the TAC agencies. The MOU provides for the continuing operation of a TAC made up of representatives of PPL Montana and TAC Agencies. The TAC shall function as the means for collaboration on the expenditure of mitigation funds and the implementation of bull trout minimization measures. The MOU also provides for the allocation of annual TAC funds provided by PPL Montana. PPL Montana will bear ultimate responsibility for ensuring that bull trout minimization measures or other resource conservation measures taken voluntarily by PPL Montana are implemented in a manner consistent with requirements of the License.

To the extent consistent with the License, this MOU sets out provisions for adaptive implementation of minimization measures or voluntary minimization measures that may be appropriate due to advancement in technology, project experience that dictates alternative methods implementation, and adequate response to unforeseen or changed circumstances or discoveries during the term of the MOU. The MOU provides assurances to interested agencies, stakeholders, and various public entities that minimization measures to reduce impacts to bull trout at the Thompson Falls Project will be faithfully implemented in a timely fashion by PPL Montana, and that operations and maintenance of the Thompson Falls Project is in compliance with the ESA.

Studies conducted in the project area over the last five years have resulted in clarification of the nature of the potential impacts of the Project on bull trout, and appropriate conservation measures to reduce these impacts, as described below.

ES.1 Upstream Passage

Upstream fish passage has been blocked at Thompson Falls Dam since construction of the dam in 1913. Local anglers have long reported pooling of trout in the spring season below the spillways of the dam. In 2001, a fish tracking study was conducted by PPL Montana and MFWP. Bull trout, rainbow trout *(Oncorhynchus mykiss)*, and cutthroat trout *(Oncorhynchus clarki)* were captured either by angling or in a trap downstream of the dam and then radio tagged and transported upstream of the dam. All three species showed significant upstream movements into potential spawning tributaries. In addition, a small trap placed on the left bank of the river just downstream of the Main Dam Spillway has consistently collected a wide variety of fish, including occasional bull trout, in the early spring, indicating that fish are attempting to migrate upstream past Thompson Falls Dam.

The draft BE concluded that the Thompson Falls Project is having a potential adverse impact on bull trout by blocking the upstream movement of adult fish. As a result, PPL Montana submitted a plan (Thompson Falls Dam Fish Passage Study Plan: Pre-design Phase) to the TAC (GEI, 2003) to develop adult upstream fish passage at Thompson Falls Dam. This plan identified the steps needed to locate and design an upstream adult fishway in the Project tailrace. Data needs identified in this long-term plan were addressed through implementation of annual fish behavior studies that were developed by PPL Montana, with assistance from GEI Consultants, Inc. (GEI), from 2004-2006.

The overall goal of these studies was to identify movement patterns of tagged fish in the Thompson Falls tailrace through the use of a stationary radio telemetry receiver array. Analysis of fish behavior and movement facilitated the understanding of where the ideal location for a permanent fish passage facility could be constructed. Telemetry data were analyzed to distinguish fish movement and behavior related to the three main areas of the Thompson Falls Project area (Main Dam Spillway, Dry Channel Dam, and the powerhouse tailraces). Telemetry data analyzed from 2004 and 2005 indicated the Main Dam Spillway as the most likely location for a fish passage facility. In 2006, the study was fine-tuned to focus primarily on monitored fish behavior and response to manipulating the flashboard operations at the Main Dam Spillway. The Main Dam Spillway was monitored with four antennae (left, center, right, and right abutment). Telemetry data from 2006 further evaluated and defined the optimal location for an entrance to a fish passage facility at the Main Dam Spillway area.

The 2006 telemetry results also indicated that releasing a small amount of water at the Main Dam Spillway in the early spring prior to spill attracted fish to the Main Dam Spillway area. In addition, fish could be attracted to the right bank by modifying hydraulic conditions at the Main Dam Spillway.

A letter report finalized in June 2006 concluded that the Main Dam Spillway was the optimum location for the new fishway. Once this general location was agreed upon by the members of the TAC, an alternatives evaluation was conducted to assess the risks and benefits of different styles and locations of potential fishways at the Main Dam Spillway location (GEI, 2007a).

ES.1.1 Upstream Passage Conservation Measures

The fish behavior study and upstream passage alternatives evaluations were presented to the TAC in conjunction with site visits to tour the Project area. The TAC concluded, based on the results of the fish behavior and engineering alternative studies, that the best alternative to provide fish passage at the Thompson Falls Project is a full height fish ladder at the right bank of the Main Dam Spillway.

The Preliminary Design Report was completed for the right bank full height fish ladder in January 2007 (GEI, 2007b). This report was submitted to the TAC for comments, which were addressed at subsequent TAC meetings and incorporated into the ladder design.

At the time of this writing (March 2008), the fish ladder design is 90% complete. Construction drawings for the Thompson Falls Hydroelectric Project upstream fish passage (90% Submittal) are included in Appendix B of this document. It is anticipated that permitting and design will be complete for the ladder in 2008, with construction to start in 2009.

This ladder will provide volitional fish passage at the Main Dam Spillway. In addition, it will be possible for small numbers of fish to be transported around the dam, should this be desired in the future. Fish can be trapped in the ladder, removed to a holding tank, and hauled via truck to an upstream location.

The Draft Recovery Plan for bull trout prepared by the USFWS in 2001, identified restoration of connectivity as one of the recovery criteria for the Lower Clark Fork River drainage. Since that time, several actions have been taken to restore connectivity in the drainage, including development of a trap and haul fish passage program at Cabinet Gorge and Noxon Rapids Dams downstream of Thompson Falls, and the removal of Milltown Dam, upstream of Thompson Falls (scheduled for 2008). Providing fish passage at Thompson Falls is one more step towards reconnection of the Clark Fork River and subsequent recovery of migratory bull trout.

ES.2 Downstream Passage

One of the major environmental issues for hydroelectric power plants is fish mortality due to turbine passage. When the dam is spilling, fish can migrate downstream via spillway, outlet works, or through the turbines. During non-spill periods, the primary means of downstream passage is through the turbines. Any form of dam passage poses some quantifiable risk of injury or mortality to migrating fish. Studies done on anadromous fish have generally indicated that passage via spill poses less risk than via turbine. Mortality is typically zero to two percent for standard spill bays and five to 15 percent for turbine passage at most hydropower plants. However, mortality at a specific facility can vary depending on the specific configuration of the turbines and spillways and type and timing of fish being passed. Therefore, there may be some direct and indirect mortality as a result of fish passage through turbines or over the spillway at the Thompson Falls Project.

In general, at any given time throughout the year, approximately 50 to 70 percent of the Clark Fork River at Thompson Falls flows through the Kaplan unit. Based on an assumed 1:1 ratio of fish to flow, we assume that 50 to 70 percent of the migrants that pass through the turbines at the Project pass through the new Kaplan unit during non-spill time periods. If spillway efficiency is 1:1, the number of migrants passing the dam in spill is similar in proportion to water being spilled. Based on combined survival estimates for passage through the Francis turbines, the Kaplan turbine, and the spillway, the average downstream passage survival at the Project for trout measuring greater than 100 millimeters (mm) is likely 91 to 94 percent.

Thompson Falls Dam also creates Thompson Falls Reservoir on the Clark Fork River. This reservoir contains slow-moving, backwater-type habitats, suitable for nonnative predators such as northern pike, smallmouth bass, and largemouth bass. The reservoir may therefore pose a higher predation risk to downstream migrating salmonids than would be present in a free flowing river environment.

ES.2.1 Downstream Passage Conservation Measures

Numerous costly efforts have been undertaken to address the issue of safe downstream fish passage at hydropower projects. Many of these efforts have not been evaluated for effectiveness, and some are so new that their benefit has yet to be established. Most of these projects have been done in rivers with anadromous fish, which must migrate downstream in order to complete their life-history. Measures that are warranted for anadromous fish may not be logical or reasonable for rare non-anadromous fish.

An alternative approach for the Project that would have a higher likelihood of benefiting bull trout, and incidentally westslope cutthroat trout, is off-site mitigation. This approach may be more sensible, less costly, and have a greater beneficial impact on bull trout and other lower Clark Fork River fish than any type of downstream trap and transport, or fish screening and bypass at the Project.

The Thompson Falls Project MOU establishes a TAC to manage off-site mitigation efforts in the Middle Clark Fork River. The MOU will guide the implementation of conservation measures for bull trout in future years. The MOU includes a management framework for future consultation with the managing agencies, and a funding mechanism to implement conservation measures.

ES.3 Total Dissolved Gas

Montana Water Quality Standards limit TDG to 110 percent of saturation. This standard is meant to protect aquatic life, which can experience gas bubble trauma (GBT) when water is supersaturated. It has been shown that excessive TDG results in embolisms and the appearance of tiny gas bubbles in fish tissues, resulting in elevated mortality rates.

At most dams, spill discharge plunges into a deep armored stilling basin, designed with enough volume to dissipate energy for the maximum design flood discharge. The intent is to confine energy dissipation in the armored zone, so that erosion does not scour and undermine the spillway or other dam features, thereby leading to potential structural failure. As spill plunges into a deep spillway stilling basin, vertical circulation cells often take turbulence aeration to depth, where hydrostatic pressure collapses bubbles, forcing them into solution, and elevating TDG levels (gas absorption). However, spillways at the Thompson Falls Project are built on bedrock, so erosion is not a concern. For this reason, the Thompson Falls Project spillways do not have plunge pools, which reduces the amount of TDG added to spilled water by the Project.

Monitoring of TDG downstream of the Thompson Falls Project indicates that TDG levels exceed 110 percent during spill, although no GBT to fish has been documented. It appears that elevated TDG levels downstream of the Project is, in part, a result of water plunging at Thompson Falls, a natural river feature downstream of the Main Dam Spillway. The Project may actually reduce TDG levels at low to moderate spill levels, in comparison to the pre-Project condition. This is because the Project routes approximately 23,000 cfs through the powerhouse. Water passing through the turbines is slightly de-gassed by about two percent, so outflow from the powerhouse has lower levels of TDG than water in the forebay. Prior to Project construction, this water would have passed over Thompson Falls, increasing flow over the falls and TDG levels. At high levels of spill, perhaps above about 50,000 cfs, TDG is likely increased by the Project in comparison to the pre-dam condition.

ES.3.1 TDG Conservation Measures

As mentioned, GBT has not been noted in fish in the Thompson Falls Project area; however, no direct attempt has been made to monitor for this condition. In spring 2008, fish will be monitored in the tailrace to determine the incidence of GBT, if any. Fish will be collected by electrofishing and examined to assess the level of GBT.

Gas supersaturation is inversely proportional to depth. A fish 2 meters deep experiences TDG pressures of 100 percent saturation when the TDG at the surface is 120 percent saturation. Therefore, fish behavior is a factor that determines the risk to fish health posed by high TDG levels. In 2008, depth monitoring radio transmitters will be installed in fish in the tailrace to assess fish exposure to high TDG conditions. In addition, monitoring of TDG levels in the forebay and tailrace, including attempts to measure the contribution of the Main Dam Spillway as distinct from Thompson Falls, will be continued until questions about TDG impacts to bull trout are resolved.

ES.4 Conclusion

This BE describes the threats to bull trout and the conservation measures proposed to reduce these threats, as agreed upon by the TAC. These conservation measures will be implemented through a collaboration between PPL Montana and the USFWS, MFWP, and the CSKT as described in the project MOU. Conservation measures will reduce, but not totally eliminate, impacts of the Project. By ESA standards of the USFWS, this Project is likely adversely affecting bull trout.

This BE will be used by the USFWS to develop a biological opinion (BO) for the Thompson Falls Project. The BO will need to be completed before the proposed conservation measures can be fully implemented.

1 Introduction

1.1 Background

PPL Montana is the owner of the Thompson Falls Dam built in 1917 on the Clark Fork River near Thompson Falls, Montana (Figure 1). Integral with Thompson Falls Dam is a 92.6 Mw hydropower facility contained in two powerhouses. FERC relicensed Thompson Falls Dam (Project No. 1869) to the Montana Power Company (now PPL Montana) in 1979, and amended the license to include the new powerhouse in 1990.

The current FERC license is scheduled to expire on December 31, 2025. In 1998, the bull trout (*Salvelinus confluentus*) was federally listed under the 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 BE was prepared for the Thompson Falls Project by PPL Montana and submitted to the USFWS and FERC in 2003. The purpose of this BE was to assess the impacts that Thompson Falls Dam and powerhouse may be having on bull trout and to make recommendations about conservation measures to reduce those impacts. Section 7 of the ESA requires federal agencies to ensure on-going Project actions are not likely to jeopardize the continued existence of federally listed threatened or endangered species or to destroy or adversely modify designated critical habitat. PPL Montana is the designated non-federal representative for the Thompson Falls Project Section 7 ESA consultation.

The 2003 Draft BE concluded that the Thompson Falls Project was likely to adversely affect bull trout. Issues identified in the draft BE included the lack of upstream adult fish passage, potential for delay or mortality during downstream passage, and potentially water quality impacts from increases in TDG during high spill time periods. Section 9 of the ESA and Federal Regulations prohibits the “take” of endangered and threatened species. Take is defined as “to harass, harm, pursue, hunt, shoot, wound, trap, and capture, collect or attempt to engage in any such conduct.” The USFWS further defines harm to include “significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering.”

The determination that the Project was “likely to adversely affect” bull trout led to a process to determine conservation measures to reduce “take.” An Interagency TAC was established with participation of the USFWS, MFWP, Avista, NorthWestern Energy, MDEQ, and the CSKT. PPL Montana has been working cooperatively with the TAC over the last five years to clarify the regulatory issues, plan research activities, and develop conservation measures appropriate to address bull trout issues at the Thompson Falls Project.

This BE describes the threats to bull trout and the conservation measures proposed to reduce these threats, as agreed upon by the TAC. In addition, an MOU is included, which will guide the operations of the TAC during implementation of the proposed conservation measures. This BE will be submitted to the Commission to aid them in developing a biological assessment (BA) to be submitted to the USFWS. The BA will be used by the USFWS to develop a BO for the Thompson Falls Project. The BO will need to be completed before the proposed conservation measures can be fully implemented.

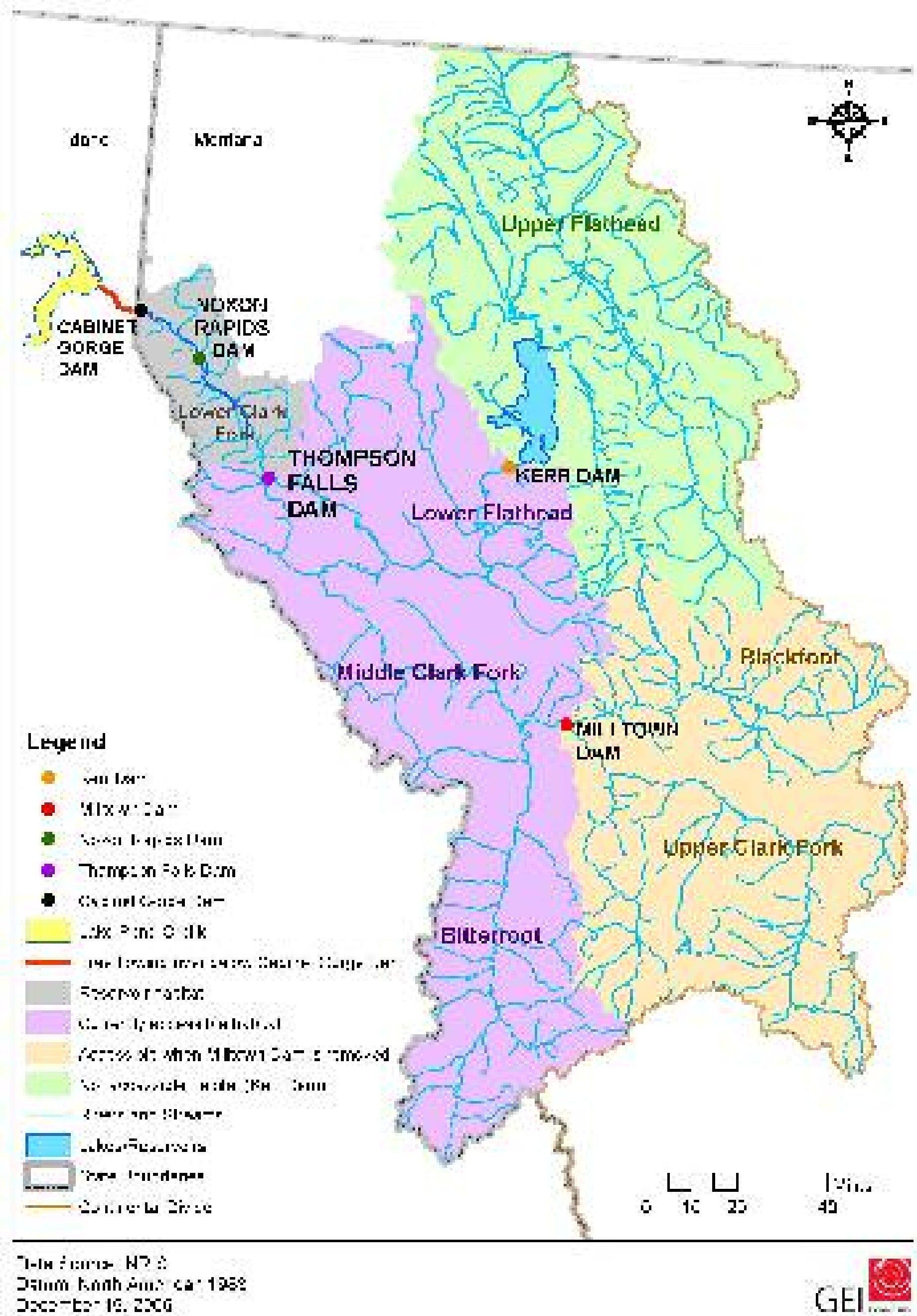

Figure 1. Map of the Clark Fork River Drainage and the Location of Thompson Falls Dam.

2 Project Description

2.1 Project Area

Bull trout occur throughout the lower and upper Clark Fork River drainage and their tributaries. The Draft Recovery Plan for bull trout prepared by the USFWS in 2001, identified restoration of connectivity as one of the recovery criteria for the Lower Clark Fork River drainage. For these reasons, the geographic area covered by this review extends beyond the Thompson Falls Project Boundary. The Thompson Falls Project Boundary is defined in the FERC license for the Thompson Falls Hydroelectric Project. It includes the powerhouses, dams, and the reservoir. This biological evaluation addresses a broader project vicinity as the potential ‘impact area’ for bull trout.

Upstream of Thompson Falls Dam there are approximately 157 miles of free-flowing Clark Fork River. The only other fish passage barrier on the Clark Fork River upstream of Thompson Falls is Milltown Dam, located at river mile (RM) 220. This dam is scheduled for removal in 2008. At the present time, fish in the Clark Fork River upstream of the Project have free access to 157 miles of the Clark Fork River, 77 miles of the Flathead River, 84 miles of the Bitterroot River, 39 miles of St. Regis River, and thousands of miles of suitable tributary streams (total of 357 mainstem river miles). Once Milltown Dam is removed, the number of miles of accessible habitat on the Clark Fork River will increase to 274 miles. The Blackfoot River, mainstem of 127 miles, and all of its tributaries will also become accessible to fish migrating from downstream areas (Figure 1).

The Flathead River is a major tributary to the Clark Fork River, and enters the Clark Fork just upstream of the town of Paradise, Montana. Kerr Dam, located at RM 77 on the Flathead River, will be the only fish passage barrier on a major river upstream of Thompson Falls Dam once Milltown Dam is removed. Therefore, there are 357 miles of mainstem river that are currently accessible to fluvial bull trout, and this number is soon to increase to 601 miles.

Immediately downstream of Thompson Falls Dam, there are two dams/reservoirs: Noxon Rapids Reservoir and Cabinet Gorge Reservoir. Downstream of Cabinet Gorge Dam there are approximately 7 miles of free flowing river before the Clark Fork River enters Lake Pend Oreille. Lake Pend Oreille is a natural lake with lake levels controlled by the Albeni Falls Hydroelectric Dam.

Bull trout collected below Thompson Falls Dam, tagged with radios, and transported upstream of the dam in 2001, moved upstream in the Clark Fork River and entered the

Thompson River (MFWP unpublished file data, 2002). Westslope cutthroat trout radio tagged in this same study moved upstream in the Clark Fork River to St. Regis River and Cedar Creek and downstream to Marten Creek Bay in Noxon Rapids Reservoir. Therefore, Thompson Falls Dam potentially affects fisheries from Noxon Rapids Dam to the Clark Fork River at Superior, Montana and the tributaries within this reach, including the lower Flathead River (Figure 1).

2.1.1 Project Hydrology

Thompson Falls Dam is located on the Clark Fork River, the largest river in the State of Montana in terms of flow. The annual hydrograph of the Clark Fork River just upstream of Thompson Falls Dam from 1957 to 2004 is shown in Figure 2. The hydrograph shows the minimum, mean, and maximum monthly mean flows over a 48-year period based on the addition of flows taken from U.S. Geological Survey (USGS) gages on the Clark Fork River near Plains (#12389000) and the Thompson River (#12389500). The annual hydrograph indicates that the ascending limb of the hydrograph begins between mid- and late March, peaks between late May and mid-June, and descends to base flow levels around mid-August. Of course these trends may vary in dry or wet years, but on average Figure 2 portrays the expected hydrology in the Clark Fork River upstream of Thompson Falls Dam. The average annual discharge of the Clark Fork River near Plains, Montana from 1911 to 1998 was 19,773 cubic feet per second (cfs) (USGS, 2002).

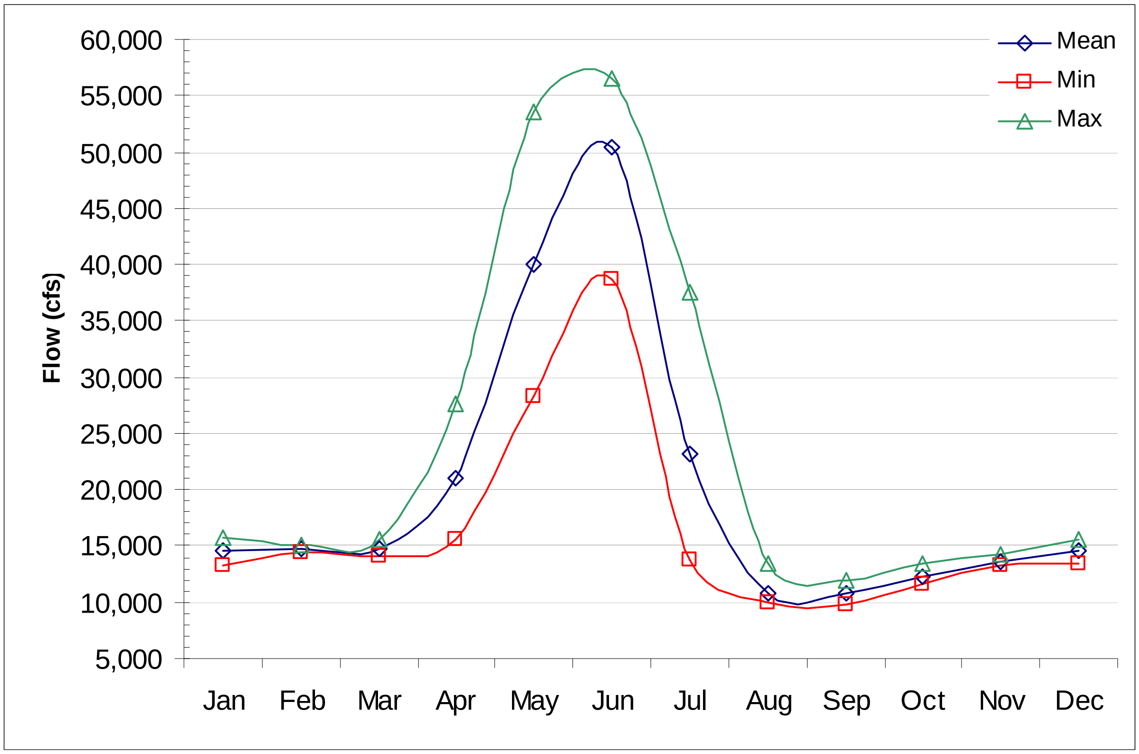

Figure 2. **Maximum, Mean, and Minimum Mean Monthly Flow in the Clark Fork River at Thompson Falls Dam based on USGS gages on the Clark Fork River near Plains (#12389000) and the Thompson River (#12389500).**

Plant capacity at the Project is approximately 23,000 cfs. River flow in excess of this amount is routed over the spillways. Typically, spill begins in late April, peaks in early June, and ends in mid-July (Figure 3).

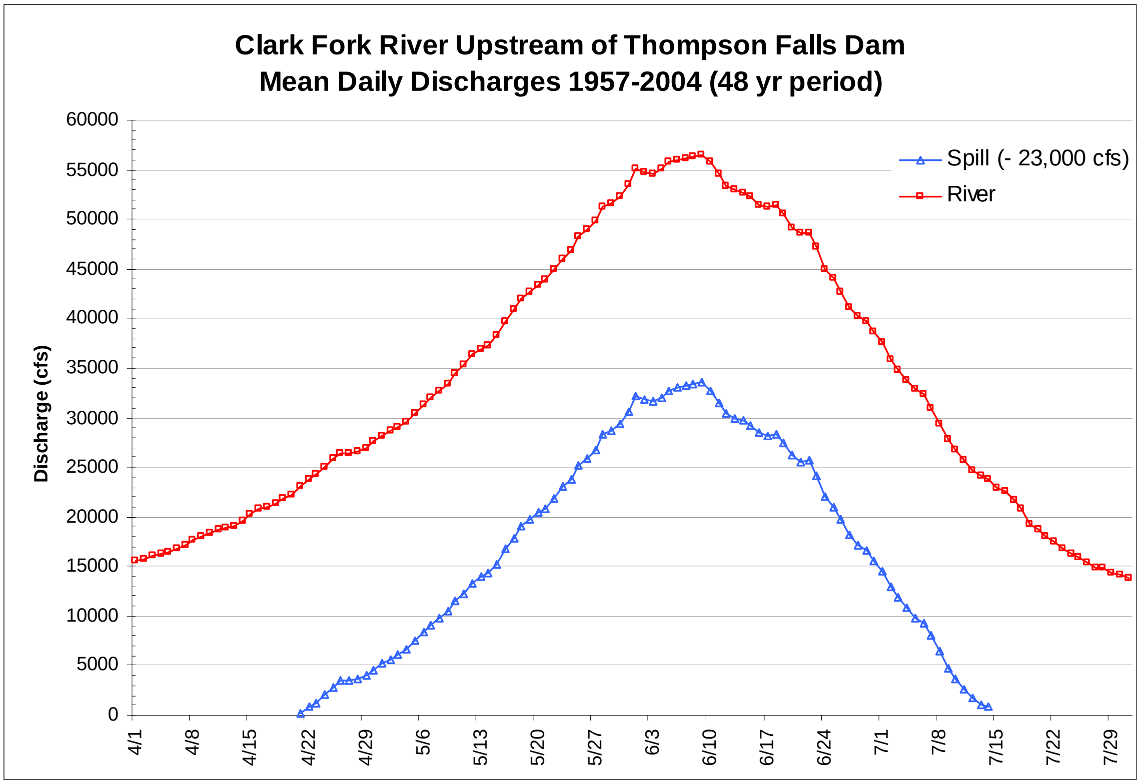

Figure 3. Mean of Daily River Discharges (cfs) and Spill Discharges (cfs) between April 1 and July 30 from 1957-2004.

2.2 Project Features

In 1912, the Thompson Falls Power Company began construction of the Thompson Falls Project. The original license expired in 1975. The current license was issued to Montana Power Company (now PPL Montana) in 1979 and is scheduled to expire on December 31, 2025. A major order amending the license was issued in 1990 allowing for construction of an additional powerhouse and generating unit, which was completed in 1995.

The Thompson Falls Project consists of: (1) a concrete gravity arch Main Dam Spillway, 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 (Photo 1) (FERC, 1990; FERC, 1994). The Project operates at about 62 ft of maximum head with headwater at 2,397 ft above mean sea level (amsl) and tailwater at 2,335 ft amsl depending on discharge and flashboard/reservoir conditions. More typical operating heads are around 59 ft (PPL Montana Operators).

2.2.1 Powerhouses and Operations

The old powerhouse is on the right bank looking downstream (Photo 1). It is watered by a canal or modified channel along the right bank and discharges roughly perpendicular to the river flow. A wing wall that bilaterally divides the river and separates the flows in the main channel guards the tailrace. The new powerhouse and Dry Channel Spillway section and Main Dam Spillway sections all discharge into this main or center channel section (Photo 1). The turbine-generator configuration in the old powerhouse consists of six similar Francis units (Nos. 1-6) each with about 6.5 Mw capacity and hydraulic capacities up to 1,850 cfs, for an aggregate capacity of 40 Mw and powerhouse discharge of 10,800 cfs. Units 1 and 3 have been upgraded to new runners in 2000 and 2002, respectively, and these units average about 1 Mw more capacity than the old units (Bonnes, PPL Montana, personal communication, 2002). The Francis runners are 11 ft in diameter and have 13 buckets. Unit 7 in the new powerhouse is an adjustable blade Kaplan runner 28 ft in diameter. It has a hydraulic capacity of 13,000 cfs or about 57 percent of the total plant capacity of the Project. New governors exist on the newest units (Nos. 1, 3, and 7) and these units are automated to maintain constant reservoir elevation during normal run-of-river operations. During peaking operations, the plant is operated at full gate for the number of hours that will enable refill within a 24-hour period and stay within the restricted headwater elevations of 2,393 to 2,397 ft amsl. The old powerhouse intakes are about 16 ft square and the invert is about 35 ft below forebay surface elevation. The top of the intake is about 20 ft below the surface. The intakes are guarded by a steel trashrack with openings of 2-5/8 inch between the bars in the old powerhouse and 5-1/2 inch spacing in the new powerhouse.

When discharge is less than 13,000 cfs, the new powerhouse is preferentially operated to maximize peak efficiency of the Project. Two units, typically Nos. 1 and 3, are operated as auxiliary power to No. 7 to maintain heat in the old powerhouse and to exercise these other units during low flows. Units 2, 4, 5, and 6 are operated at high flows, as they are the least efficient and the smallest units at the Project.

Photo 1. Photo of the Thompson Falls Project looking upstream.

2.2.2 Reservoir and Its Operation

Thompson Falls Reservoir covers 1,500 surface acres and 12 linear miles of river at a normal pool elevation of 2,396 ft amsl. Drawdown is limited to 4 feet. The reservoir has a total storage capacity of 15,019 ac-ft at normal pool, and has a maximum depth of 45 ft. The Project is capable of discharging its total storage pool of 15,000 ac-ft in slightly less than 8 hours minus the inflows (FERC, 1990). The Project operates on average as a run-of-the-river plant for about eight months of the year with peaking restricted to the late summer and early fall months.

2.2.3 Spillways and Their Operations

When river discharge exceeds the combined hydraulic capacity of both powerhouses (23,000 cfs), two tainter gates enable automatic spill operations up to 10,000 cfs each. The tainter gates have openings of 41 ft wide and 14 ft high when fully open. As the runoff proceeds, 4 ft by 8 ft spillway panels on the Main Dam Spillway are removed for additional spill capacity. As flows increase, more panels are removed to balance flows across the length of the Main Dam Spillway spill section until all 228 panels have been removed. In most years, when the peak flood discharge is less than 70,000 cfs, spill is restricted to the Main Dam Spillway section. If flows exceed 70,000 cfs, there are 72 Dry Channel Dam spill panels (each 4 ft by 8 ft) available to increase spill capacity. Operation of the Dry Channel Spillway occurs infrequently (approximately every 10 years) according to dam operators.

2.3 FERC License Conditions

The 1990 FERC license amendment allows the Project (No. 1869) to operate as a peaking facility as described above. Peaking is limited by the minimum Project discharge of 6,000 cfs and by a maximum drawdown to 2,393 ft amsl (FERC, 1990). Other license requirements, which relate to fisheries issues at Thompson Falls Dam, are as follows (FERC, 1979; 1990):

> **Article 15.** *The Licensee shall, for the conservation and development of fish and wildlife resources, construct, maintain, operate, or arrange for the construction, maintenance, and operation of such reasonable facilities, and comply with such reasonable modifications of the Project structures and operation, as may be ordered by the Commission upon its own motion or upon the recommendation of the Secretary of the Interior or the fish and wildlife agency or agencies of any State in which the Project of part thereof is located, after notice and opportunity for hearing.*
>
> **Article 16.** *Whenever the United States shall desire, in connection with the Project, to construct fish and wildlife facilities or to improve the existing fish and wildlife facilities at its own expense, the Licensee shall permit the United States or its designated agency to use, free of cost such of the Licensee's lands and interests in lands, reservoirs, waterways, and Project works as may be reasonably required to complete such facilities or such improvements, thereof. In addition, after notice and opportunity for hearing, the Licensee shall modify the Project operation as may be reasonably prescribed by the Commission in order to permit the maintenance and operation of the fish and wildlife facilities constructed or improved by the United States under the provisions of this article. This article shall not be interpreted to place any obligation on the United States to construct or improve fish and wildlife facilities or to relieve the Licensee of any obligation under this license.*
>
> **Article 38.** *Licensee shall, in consultation with Montana Wildlife, Fish and Parks, U.S. Forest Service, U.S. Fish and Wildlife Service, and any other appropriate state and local agencies, take such actions found necessary for the protection and enhancement of the natural resources and values of the Project. The Commission reserves the right to require*

> *any changes in the Project works or operations that may be necessary to Project and enhance those values.*
>
> **Article 410.** *To take into account, to the fullest extent practicable, the Columbia River Basin Fish and Wildlife Program (developed and amended in accordance with the Pacific Northwest Electric Power Planning and Conservation Act), the Commission, upon its own motion or upon the recommendation of federal, or state fish and wildlife agencies or affected Indian Tribes, reserves the authority to order alternations of Project structures and operations.*
>
> **Article 411.** *To protect and enhance the aquatic resources of the Clark Fork River, the licensee shall discharge from the Thompson Falls Project a continuous minimum flow of 6,000 cfs or inflow to the Project reservoir, whichever is less. These flows may be temporarily modified if required by operating emergencies beyond the control of the licensee and for short periods on mutual agreement between the licensee and the Montana Wildlife, Fish and Parks.*

Also included in the 1990 Order amending the license, but not included as a license article, is a provision for Montana Power Company to deposit $250,000 in a trust fund for the annual purchase of 10,000 ac-ft of water from Painted Rocks Reservoir to augment streamflows in the Bitterroot River. These flows were intended as mitigation for the impacts of the Thompson Falls Project on resident fish. This money was deposited in the trust fund prior to the issuance of the Order amending the license on April 30, 1990.

3 Methods

GEI gathered background material on fisheries and wildlife in the Project area from the following companies or agencies: MFWP, Avista, PPL Montana, the CSKT, MDEQ, the USFWS, and the Environmental Protection Agency (EPA).

In addition, GEI worked with PPL Montana to become familiar with the configuration and operation of Thompson Falls Dam. GEI reviewed PPL Montana documentation, drawings and reports on Thompson Falls Dam, hydrologic and hydraulic data on reservoir and tailwater elevations, plant operations, spillway hydraulics, design of intakes, turbines and other hydraulic passage routes, data on fisheries and water quality, and other technical literature.

Since 2001, a variety of fisheries and water quality studies have been implemented in the Project area, in consultation with the TAC. Data from these studies were also incorporated into this BE.

Using existing information, current aquatic habitat conditions and subpopulation conditions from the literature are described. The evaluation of the Project's impacts on bull trout was completed using the guidance contained in the USFWS's publication "*A Framework to Assist in Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Bull Trout Subpopulation Watershed Scale*." To the extent appropriate, the matrix provided in the USFWS publication (see Section 7) was used to evaluate the environmental and subpopulation baseline conditions. The "Framework" document recommends the BE analysis be conducted on a 6th hydrologic unit code (HUC) watershed scale.[1] This scale is not well suited to mainstem river projects. Consequently, professional judgment and knowledge of bull trout biology in the Clark Fork River was applied to determine the most appropriate analysis scale, which was the middle and lower Clark Fork River drainages.

[1] Montana is divided into 110 hydrologic units, which define major drainages in the state. Each hydrologic unit has a unique number. Hydrologic units can be subdivided into smaller sized units by the addition of a digit to the hydrologic unit code (HUC). For example, 5th HUC are approximately 40,000 to 250,000 acres in size. This sized unit can be broken down even smaller, 6th HUC.

4 Bull Trout Subpopulation Characteristics

4.1 Historic Status

Historically, bull trout were likely present throughout the Clark Fork River drainage with unlimited access from Lake Pend Oreille upstream to the headwaters of the Clark Fork River (Pratt and Huston, 1993; MBTSG; 1996a). Prior to the development of hydroelectric facilities, there were no natural barriers along the Clark Fork River to inhibit fish movement through the drainage. After the construction of Thompson Falls in 1913, over 90 percent of the Clark Fork River drainage was inaccessible to Lake Pend Oreille migratory bull trout (Montana Bull Trout Restoration Team, 2000).

Pratt and Huston (1993) noted that newspaper articles from 1895 to 1912 discuss char in excess of 10 pounds (lbs) during July and August in the Thompson Falls area. Other reports in the area indicate that fishing was a primary activity for Native American settlements along the lower Clark Fork River (Malouf, 1952 and 1982). The relative importance of bull trout in the harvest is unclear; however, bull trout were one of the largest fish to inhabit the waters at that time and presumably a logical target species for fishermen.

4.2 Current Status

4.2.1 Upper Columbia River

Three major genetically differentiated groups of bull trout have been identified and include coastal, Snake River, and the Upper Columbia River. The Upper Columbia River basin includes the mainstem Columbia River and all tributaries upstream of Chief Joseph Dam in Washington, Idaho, and Montana. Habitat in the Upper Columbia River system has been fragmented by numerous dams and degraded resulting in isolation of 71 bull trout subpopulations in 9 major river systems. Of the 71 subpopulations, 50 subpopulations are considered at risk of extirpation because of naturally occurring events due to isolation, single life-history form, and low abundance. There are some strong subpopulations (defined as a subpopulation of 5,000 individual bull trout or 500 spawners) present in the Upper Columbia River system (USFWS, 2002) with the majority of these subpopulations located in isolated watersheds in headwater tributaries where migratory life history is lost or restricted (USFWS, 1998).

4.2.2 Clark Fork River

The Clark Fork River Recovery Unit is within the range of the Upper Interior Columbia River Recovery Unit. The Clark Fork River Recovery Unit is one of the largest and most diverse watersheds with respect to the range of bull trout contributing to the Columbia River basin (USFWS, 2006). The Clark Fork River Recovery Unit provides approximately 1,136 miles of streams and 31,916 acres of lakes/reservoirs (USFWS, 2006).

In 2006, the USFWS found that functional biological connectivity in the Lower Clark Fork has been and continues to be progressing through successful fish passage activities. The USFWS judged, that based on best available science, recovery measures related to connectivity described in the Draft Recovery Plan, are now being partially met (USFWS, 2006a). Successful upstream fish passage has been restored to a significant degree by the Avista trap and transport program. As a result, the USFWS reorganized bull trout core areas in the Clark Fork River drainage (USFWS, 2006a). This decision resulted in the Lower Clark Fork River, previously described as a recovery unit, being referred to as a single core area (Figure 4). A core area is defined as:

> … Core areas require both habitat and bull trout to function and the number (replication and characteristics of local population inhabiting a core area) provide a relative indication of the core area's likelihood to persist. A core area represents the closest approximation of a biologically functioning unit for bull trout. Local population within a core area have the potential to interact because of connected aquatic habitat. (USFWS, 2006)

The Lower Clark Fork River core area represents a consolidation of the four *initial* core areas (Figure 4). The *initial* core areas were delineated by artificial boundaries including Cabinet Gorge Dam, Noxon Rapids Dam, and Thompson Falls Dam (Figure 4) (USFWS, 2006a). Currently, in the Lower Clark Fork River core area, there are an estimated 14 local bull trout populations identified (Table 1) (USFWS, 2006a; Fredenberg, USFWS, personal communication, February 2008). A local population is defined as:

> A group of bull trout that spawn within a particular stream or portion of a stream system. Multiple local populations may exist within a core area. A local population is considered to be the smallest group of fish that is known to represent an interacting reproductive unit…. (USFWS, 2006)

Table 1. Summary of the 14 Local Bull Trout Populations (in bold) identified within the Lower Clark Fork River Core Area (USFWS, 2002 and 2006a).

<table>
<tr><th>Artificially Bounded Sections</th><th colspan="2">Local Bull Trout Populations</th></tr>
<tr><td rowspan="2">Lower Flathead River Drainage</td><td>Mission Creek (only a migratory corridor)</td><td>Post Creek
Mission Creek
Dry Creek</td></tr>
<tr><td>Jocko River</td><td>South Fork Jocko River
Middle Fork Jocko River
North Fork Jocko River</td></tr>
<tr><td rowspan="2">Clark Fork River Section 3
(Thompson Falls Dam upstream to the Confluence of the lower Flathead River)</td><td colspan="2">West Fork Thompson River</td></tr>
<tr><td colspan="2">Fishtrap Creek</td></tr>
<tr><td rowspan="3">Noxon Rapids Reservoir (Noxon Dam upstream to Thompson Falls Dam)</td><td colspan="2">Prospect Creek</td></tr>
<tr><td colspan="2">Graves Creek</td></tr>
<tr><td colspan="2">Vermilion River</td></tr>
<tr><td rowspan="2">Cabinet Gorge Reservoir (Cabinet Gorge Dam upstream to Noxon Dam)</td><td colspan="2">Rock Creek</td></tr>
<tr><td colspan="2">Bull River</td></tr>
</table>

In the summer of 2006, there were an estimated 100 bull trout redds in the Lower Clark Fork core area with approximately 15 to 20 percent of those redds likely created by bull trout that were passed over the Cabinet Gorge and/or Noxon Rapids Dams (USFWS, 2006b). From 2001 to 2005, fish passage programs conducted within the Lower Clark Fork core area have successfully passed between 29 and 42 adult bull trout annually (USFWS, 2006b). Due to the fecundity of each adult female bull trout, each fish passed upstream to spawn has the potential to make a substantial genetic contribution (USFWS, 2006b). In addition, data collected between 2001 and 2006 have documented at least one juvenile bull trout tagged and transported downstream of Cabinet Gorge Dam that was recaptured as an adult at the base of dam, indicating that at least some migratory bull trout are now able to complete their lifecycle in the Lower Clark Fork core area.

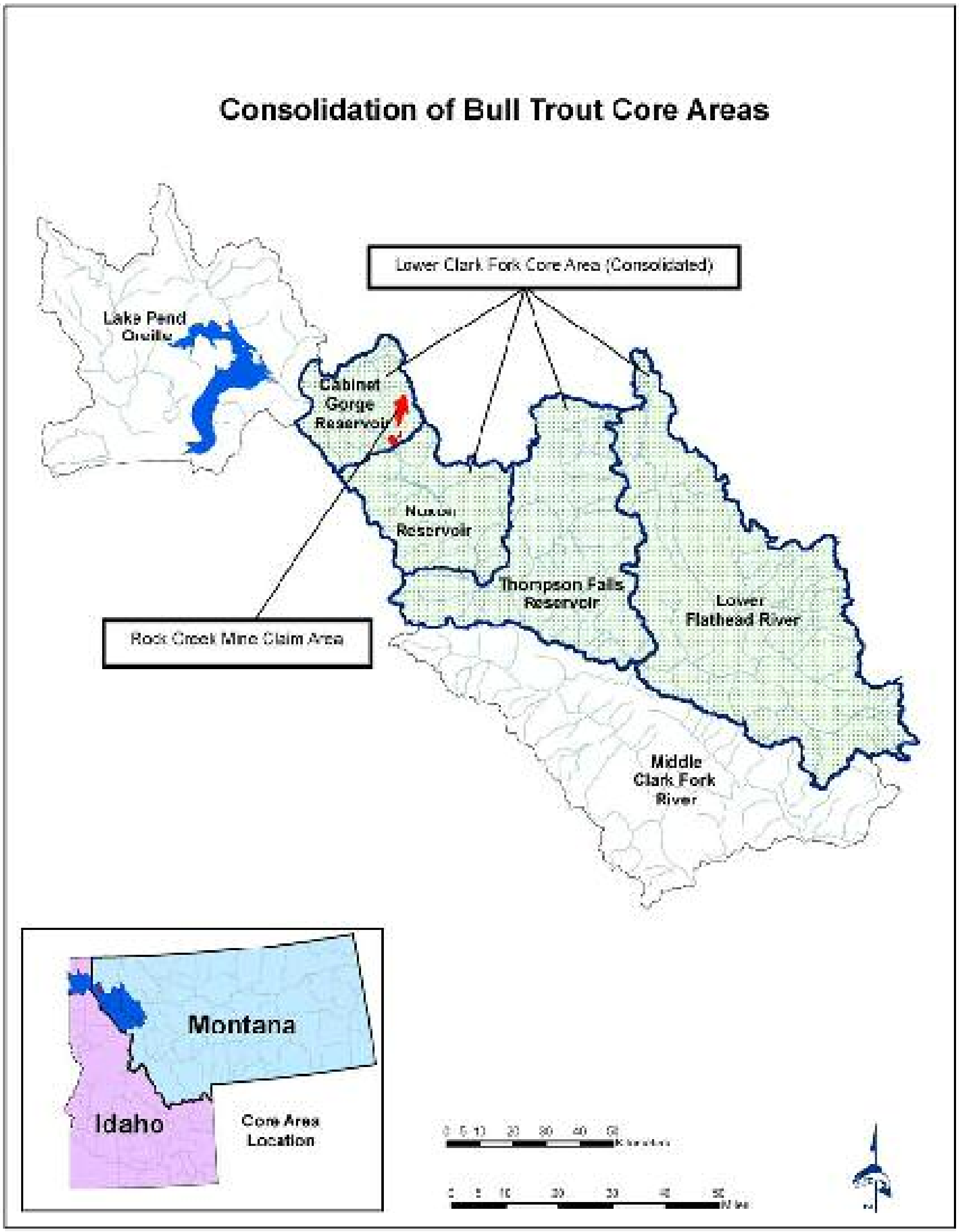

Figure 4. Map of the three core areas in the lower Clark Fork River Basin. Outlined in blue are the four consolidated core areas that form the Lower Clark Fork Core Area. ***Source:*** **USFWS 2006b.**

4.2.3 Upstream of the Thompson Falls Project Area

Since the construction of Thompson Falls Dam (1913), numerous dams located downstream and upstream compounded by degraded habitat have fragmented bull trout habitat and isolated fish populations (USFWS, 1998). Thompson Falls Dam specifically prevents upstream migration to known bull trout tributaries in the Thompson River, the lower Flathead River (Jocko River and Mission Creek drainages) downstream of Kerr Dam, and the middle Clark Fork River drainage. In addition, juvenile bull trout from the Blackfoot River drainage and Rock Creek, near the town of Clinton, are believed to migrate downstream of Thompson Falls Dam (Table 2). Genetic data analyzed from adult bull trout collected at the base of Cabinet Gorge Dam in the lower Clark Fork River drainage have verified that the specific natal tributaries for some of the returning bull trout are upstream of Thompson Falls Dam (Bernall, Avista Corporation, personal communication, February 2008).

Table 2. Summary of Rapid Genetic Assessment for Bull Trout Captured Below Cabinet Gorge Dam between 2001 and 2007 (Bernall, Avista Corporation, personal communication, February 2008).

Area	**Drainage**	**Tributary of origin (local population)**	**# of Bull Trout**
Lower Clark Fork	Thompson River	Fishtrap Creek	41
		W.F. Thompson	7
	Lower Flathead	S.F. Jocko River	1
Middle Clark Fork	St. Regis	Little Joe Creek	5
	Middle Clark Fork	Fish Creek	5
		Cedar Creek	1
		Rattlesnake Creek	5
Blackfoot	Blackfoot	Monture Creek	5
		N.F. Blackfoot River	2
Upper Clark Fork	Upper Clark Fork	Rock Creek (Clinton)	11
Total			**83**

Avista captured a total of 266 adult bull trout below Cabinet Gorge Dam between 2001 and 2007. Of the 266 bull trout, 83 were identified, through genetic testing, as belonging to tributaries upstream of Thompson Falls Dam, Region 4 (Bernall, Avista Corporation, personal communication, February 2008). Of the 83 bull trout having natal tributaries upstream of Thompson Falls Dam, over half (59%) originated from the Thompson River and lower Flathead River drainage (Table 2). The remaining bull trout (34 adults) represented local populations from the Middle Clark Fork River drainage, Blackfoot River drainage, and Rock Creek in the Upper Clark Fork River drainage (Table 2). In addition, in 2008, two adult bull trout were captured below Noxon Rapids Dam and assigned to tributaries upstream of Thompson Falls Dam (Meadow Creek and Cedar Creek) (Bernall, Avista Corporation, personal communication, February 2008). These data indicate bull trout movements are not limited to the lower Clark Fork River and that the adfluvial migratory life history of bull trout still exists in the Lower Clark Fork River core area. However, the only method to retain the adfluvial migratory traits will be to continue bull trout passage over the dams in the lower Clark Fork River, thus allowing adult bull trout to return to their natal stream to spawn.

4.2.3.1 Thompson River

Migratory bull trout are known to be present upstream in two tributaries of the Thompson River, West Fork Thompson River, and Fishtrap Creek (Liermann, 2003; Liermann et al., 2003). Surveys conducted from 2001 to 2004 (Liermann et al., 2003; Moran, 2005) and telemetry data have identified radio-tagged bull trout, passed upstream from below Thompson Falls Dam, entering both the West Fork Thompson River and Fishtrap Creek watersheds (Gillin and Haddix, 2005). In addition, genetic analyses of bull trout captured below Cabinet Gorge Dam between 2001 and 2007 have assigned several fish to the West Fork Thompson River and Fishtrap Creek (see Table 2).

Density estimates through electrofishing efforts have been calculated for Fishtrap Creek and the West Fork Thompson River. Electrofishing surveys conducted from 2000 to 2007 in two reaches within the Fishtrap Creek drainage found bull trout density (bull trout greater than 75 mm) varied substantially between years. In Fishtrap Creek, the Basin Draw reach, densities ranged between 3.1 and 28 bull trout per 100 meter, and in the Ten-Mile reach, densities ranged between 9.5 and 43 bull trout per 100 meter (Liermann et al., 2003; Liermann and Tholl, 2005, Hanson personal communication, March 2008).

Bull trout density estimates from electrofishing data collected between 2000 and 2007 in the West Fork Thompson River were slightly less variable than observed in Fishtrap Creek. The two West Fork Thompson River reaches surveyed included 1.1 mile with annual densities ranging from 4.5 to 13.6 bull trout per 100 meter, and 4.0 mile with annual densities ranging between 33.6 and 71.2 bull trout per 100 meter (Liermannn et al,. 2003; Liermann, 2003; Liermann and Tholl, 2005; Hanson personal communication, March 2008).

4.2.3.2 Lower Flathead River

The confluence of the lower Flathead River (near Paradise, Montana) is located approximately 103 miles (165 km) upstream of Lake Pend Oreille. The lower Flathead River system is bounded upstream by Kerr Dam. Currently, there are two tributary drainages with bull trout populations in the lower Flathead River (DeHaan et al., *in press*), the Jocko River and Mission Creek.

The construction of dams, irrigation diversions, and canals within the Jocko River and Mission Creek drainages has substantially reduced connectivity and isolated some local bull trout populations. However, genetic information from fish collected in the lower Flathead River and mainstem Jock River indicate that a migratory bull trout life history persists in the drainage. In addition, genetic information from bull trout captured in the lower Clark Fork River at the mainstem dams suggest individual bull trout from the lower Flathead River drainage are migrating downstream (DeHaan and Ardren *unpublished data* cited in DeHaan et al. *in press*).

Based on a 2007 study by DeHaan et al. (*in press*) four local bull trout populations were identified in the lower Flathead River drainage including the North Fork Jocko River, South Fork Jocko River, Post Creek, and Dry Lake Creek. The estimated effective population size (N_e) for these populations was between 3.3 and 12.6 in the North Fork Jock River, South Fork Jocko River, and Dry Lake Creek, collectively, and 58.2 in Post Creek (DeHaan et al. in press). Results from this study indicate lower genetic diversity and effective population size for bull trout populations with limited migratory connectivity for adults compared to other populations in the lower Clark Fork River core area.

4.2.3.3 Middle Clark Fork River

As previously described, the middle Clark Fork River extends from the confluence of the lower Flathead River upstream to the confluence of the Blackfoot River (Milltown Dam). Within this stretch of the Clark Fork River (excluding the Bitterroot River drainage), six tributaries consisting of bull trout spawning grounds have been identified. These spawning tributaries include Little Joe Creek (within the St. Regis River drainage), Cedar Creek, Trout Creek, Fish Creek, Albert Creek, and Rattlesnake Creek (L. Knotek, Montana Fish, Wildlife and Parks, person communication, February 2008). Temperature is one common factor among these tributaries. These tributaries maintain relatively cool water temperatures during the summer months, typical of high quality bull trout streams. Peak daytime stream temperatures generally stay between 14 an 16 °C during the summer months (MFWP, unpublished).

The majority of bull trout spawning tributaries (four of six) mentioned above are suspected to support fluvial and resident bull trout. Data from Fish Creek indicate that only fluvial bull trout spawn in this tributary (MFWP, unpublished). Albert Creek is assumed to only support resident bull trout and westslope cutthroat trout. This assumption is supported because of the presence of a fish barrier (perched culvert), intermittency (natural dewatering and irrigation withdrawals), and size of the overall drainage compared to others supporting fluvial fish.

Genetic analyses for 266 adult bull trout captured below Cabinet Gorge Dam between 2001 and 2007 and two adult bull trout captured below Noxon Dam in 2008 assigned a total of 17 bull trout to four tributaries in the Middle Clark Fork River: Cedar Creek, Fish Creek, Little Joe Creek, and Rattlesnake Creek (see Table 2) (Bernall, Avista, personal communication, February 2008). The genetic analyses indicate adfluvial bull trout life history may still persist in the middle Clark Fork River drainage.

Dry Creek is not known to support spawning bull trout, but does provide important bull trout refugia (L. Knotek, Montana Fish, Wildlife and Parks, person communication, February 2008).

4.3 Life History

Although the general life history pattern is the same for all bull trout, it is clear that many details of bull trout life history can vary by drainage and region (Montana Bull Trout Restoration Team, 2000; GEI, 2005). Research on bull trout in the lower Clark Fork River is beginning to uncover specific aspects of the life history of the species in this drainage. The following section describes the general life history requirements of bull trout, with specific references to bull trout in the lower Clark Fork River where information is available.

Several authors have reported the life history characteristics of bull trout (Pratt, 1985 and 1992; Fraley and Shepard, 1989; Brown, 1992; Thomas, 1992; McPhail and Baxter, 1996; Nelson et al., 2002). In Montana, bull trout have three life history patterns: resident, fluvial, and adfluvial. Resident bull trout spend their entire lives in the same (or nearby) streams in which they were hatched. Resident bull trout adults and juveniles generally confine their migrations to their natal streams. In fluvial and adfluvial populations, the adults spawn in tributary streams where the young rear for a few years (Fraley and Shepard, 1989). The juvenile bull trout then migrate downstream to a larger body of water, either a lake (adfluvial fish) or a river (fluvial fish), where they grow to maturity.

It has been suggested that the ability for bull trout to express multiple life history forms is an adaptive mechanism to variable environmental conditions (Nelson et al., 2002). For example, adfluvial and fluvial migration movement to lakes and larger rivers may take advantage of more abundant food sources allowing for greater growth and fecundity (Gross et al., 1987 cited in Nelson et al., 2002). The resident life history form may be an adaptation to the presence of migration barriers/restrictions or where growth opportunities in the headwaters are greater than the cost of migration (Nelson et al., 2002).

Historically, migratory bull trout were common in North America; however, this life history form has been in decline as the historical range declines and habitat fragmentation increases for bull trout (Nelson et al., 2002). Migratory and resident bull trout have been observed to co-exist in the middle Clark Fork River tributaries (MFWP unpublished data) and the Bitterroot River drainage (Jakober et al., 1998). However, it is unclear if the two coexisting life histories can give rise to one another or are genetically distinct, and the extent that environmental conditions influence the expression of a life history (Rieman and McIntyre, 1993).

Nelson et al. (2002) conducted a study to examine whether the migratory life form in the Bitterroot River drainage had been lost from three headwater streams, and if so, the potential for re-establishment of migratory life form. The headwater streams in this study were not “pristine” and were influenced by irrigation structures and low head dams. Migratory bull trout were present in one stream, but rare or absent in the other two streams. Results from the study indicate that fish migration barriers were not the only cause for decline in migratory life history. Other downstream conditions such as an increased presence of nonnative species and associated predation as well as increased temperatures in the lower portions of the streams were contributing factors (Nelson et al., 2002).

4.3.1 Spawning

The general spawning cycle of bull trout involves mature adults migrating upstream to spawn in headwater streams during the fall (September and October). In the lower Clark Fork River drainage spawning activity peaks in September (Katzman and Hintz, 2003; Katzman, 2003; Moran, 2003) when stream temperatures are generally less than 8°C (McPhail and Baxter, 1996; Pratt, 1996). Sexually mature adult bull trout may spawn in multiple years, although they do not necessarily spawn in consecutive years (Pratt, 1996). In the upper Flathead River system, bull trout have been observed spawning every year, every other year, and every third year (Weaver, MFWP, personal communication, 1992). In Rock Creek (near Clinton, Montana), bull trout were observed to spawn in consecutive years (Carnefix, 2002).

In the lower Clark Fork River drainage, there appears to be a wide season, approximately between April and August, when adult bull trout leave Lake Pend Oreille to begin their upstream migrations (Normandeau Associates, 2001). The timing of movement into the tributaries varies as well. Timing of bull trout spawning movements into the East Fork Bull River can occur between the middle of July and the middle of October. Radio telemetry data indicate a relatively wide range of time during which bull trout move into spawning areas (Lockard et al., 2002; 2003; 2004).

In the Rock Creek drainage (upper Clark Fork River drainage), bull trout (97 bull trout monitored) displayed two types of migration patterns, simple and complex (Carnefix, 2002). Simple movements were the most common (65%) and represented bull trout moving from the mainstem Rock Creek into the tributary and back. Complex movements included multiple migrations into and back out of multiple tributaries. Bull trout migrations in the drainage were generally observed to begin between April and July (Carnefix, 2002).

Although dams in the lower Clark Fork River drainage prevent bull trout from migrating long distances to spawn, there have been several instances documenting long distance travel by adult bull trout to spawning areas (Schmetterling, 2003; Wydoski and Whitney, 2003). In the upper Clark Fork River drainage, fluvial bull trout can migrate over 100 km (Schmetterling, 2003), while adfluvial bull trout have been documented migrating more than 200 km in the Flathead River drainage (Wydoski and Whitney, 2003). In contrast, a study conducted in 1998 and 1999 in Rock Creek (near Clinton) found a substantial portion of bull trout complete a fluvial migratory life history entirely within the Rock Creek drainage (Carnefix, 2002).

The specific timing of bull trout migrations in the Thompson Falls Project area has not been well documented. The available data indicate that the upstream migratory season for adult bull trout is roughly between April and July in the Project area. Based on data collected between 1999 and 2006, April is the month when the majority of bull trout have been collected (15 out of 26 bull trout handled) in the Thompson Falls Dam tailrace (PPL Montana unpublished data). It should be noted that it is impossible to safely sample the tailrace of Thompson Falls Dam during high water, and trapping and electrofishing efforts are stopped when water temperatures are high in the summer to reduce the risk of injury to bull trout. Therefore, sampling has been limited to early spring and late summer/fall months.

The date and size of every bull trout handled during PPL Montana's sampling program in the tailrace of Thompson Falls Dam since 1999 are provided in Table 3. A total of only 26 bull trout have been collected in eight years (between one and seven per year) implementing multiple collection techniques, including trapping, electrofishing, and angling.

Bull trout have specific spawning requirements and only use a small percentage of the available stream habitat for spawning (MBTSG, 1998). Typical bull trout spawning grounds are described as being low gradient (less than two percent), having gravel/cobble substrate, having a water depth range from 0.1 to 0.6 meters, and having stream velocity between 0.09 meters per second (m/s) and 0.61 m/s (Montana Bull Trout Restoration Team, 2000).

After spawning, bull trout emigrate downstream to a river or stream. Studies conducted by Avista in the lower Clark Fork River downstream of Thompson Falls Dam have found some radio-tagged bull trout moved downstream through Cabinet Gorge Dam volitionally. Survival rates on these fish have been high. Of the 25 fish detected or recaptured below Cabinet Gorge Dam after having been transported upstream of the dam, 19 have either definitely or likely survived passage through or over the dam (Lockard et al., 2004).

Although the status of the other fish was unknown, one was suspected to have not survived passage through the dam (Lockard et al., 2004).

Table 3. Bull Trout Collected in the Tailrace of Thompson Falls Dam, 1999 – 2006. A = angling, EF = electrofishing, T = trapping.

Date	Length (mm)	Weight (gram)	Sampling Method
5/07/1999	505	1247	A
5/18/1999	395	400	EF
5/03/2000	517	1180	A
4/11/2001	323	264	A
6/01/2001	545	1390	T
7/20/2001	644	2275	T
5/03/2002	414	568	A
8/07/2002	780		T
4/03/2003	274	182	EF
3/29/2004	109	n	EF
4/07/2004	487	1225	T
4/13/2004	523	1483	T
4/19/2004	372	393	EF
4/19/2004	535	1275	EF
4/19/2004	718	3660	EF
5/05/2004	505	1185	T
4/11/2005	118	13	EF
4/11/2005	102	9	EF
4/12/2005	167	30	EF
4/12/2005	162	31	EF
4/21/2005	730	5021	EF
4/21/2005	300	202	EF
3/09/2006	245	103	EF
4/06/2006	341	560	T
4/13/2006	485	1115	EF
5/03/2006	775	3941	EF

4.3.2 Fry and Juvenile Behavior and Habitat

Fry emerge in spring within approximately 210 to 240 days after egg deposition (Montana Bull Trout Restoration Team 2000). Fry remain closely associated to shallow margins of streams where water velocity is low, utilize the lower 25 percent of the water column, and rely on habitat such as unembedded rocks, woody debris, interstitial spaces in the gravel, and other velocity breaks for cover (McPhail and Baxter 1996).

Large amounts of fine materials (fines) in the substrate and extreme streamflows are common causes of mortality to bull trout eggs and alevins. Weaver and Fraley (1991) found a significant inverse relationship between the percent of the substrate less than 6.35 mm in diameter and emergence success. Weaver and Fraley (1991) concluded that any increase in fine materials in spawning areas could significantly reduce the emergence success of bull trout fry.

The length of time that juvenile bull trout rear in the tributaries is highly variable and can range from one (McPhail and Murray, 1979; Fraley and Shepard, 1989) to four years (Rieman and McIntyre, 1993). In general, juveniles emigrate in spring or fall to the lake if adfluvial, or mainstem river if fluvial (Downs et al. 2003; Katzman and Hintz 2003). In the Flathead River system, emigration of juveniles from the tributaries takes place largely from June to August (Fraley and Shepard, 1989).

4.4 Critical Habitat

Critical habitat for bull trout has been defined as a habitat unit that can maintain and support viable bull trout core areas (70 FR 56212). The Project is not located within bull trout critical habitat (Figure 5). However, several nearby tributaries (Prospect Creek and the Thompson River) have been designated as critical habitat.

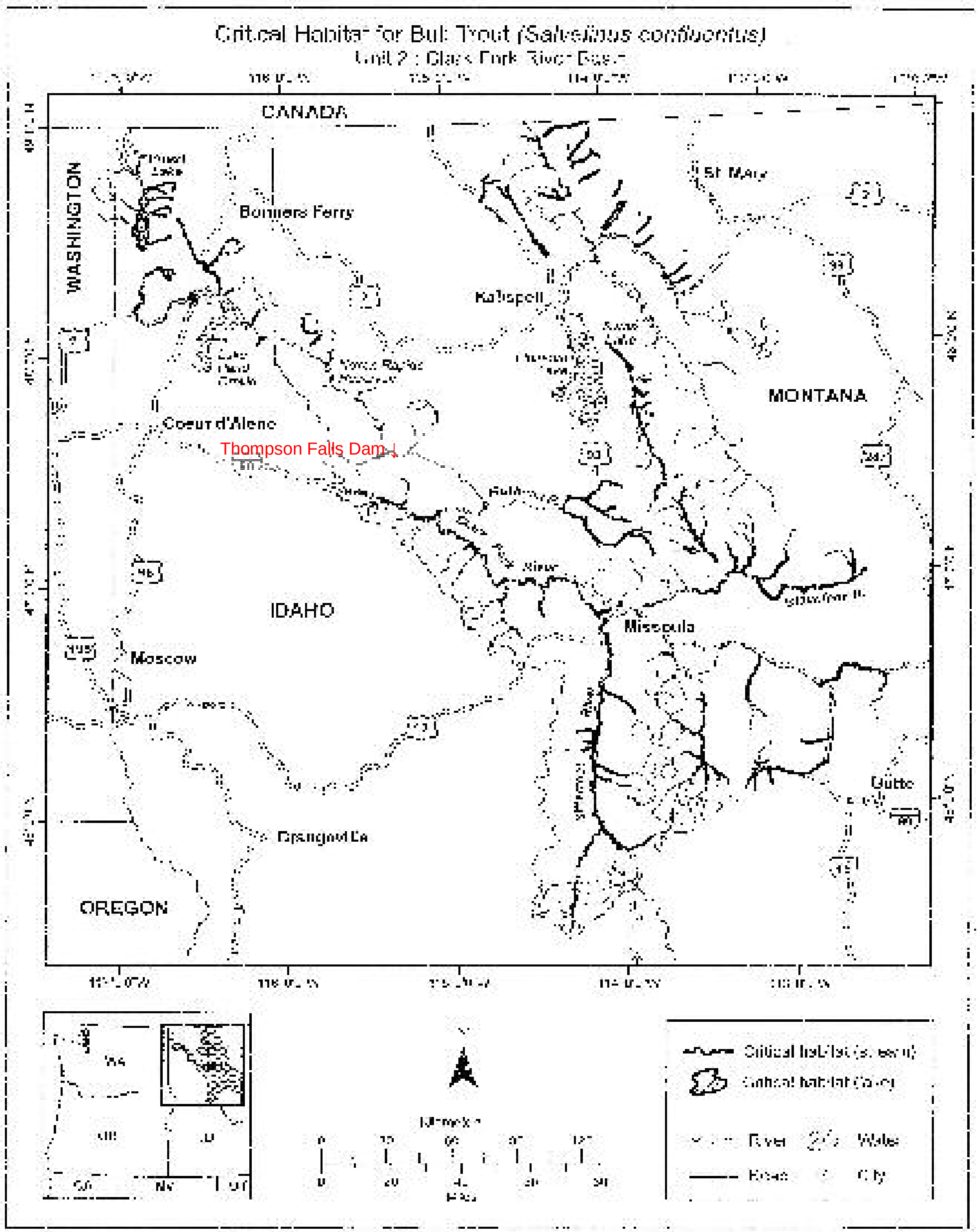

Figure 5. Critical Habitat for Bull Trout in the Clark Fork River Drainage. *Source:* **USFWS, 2005.**

Within the designated critical habitat units, the primary constituent elements (PCEs) for bull trout are those habitat components that are essential for bull trout survival, with emphasis and focus on the primary biological needs of foraging, reproducing, rearing of young, dispersal, genetic exchange, or sheltering (70 FR 56212).

The PCEs are as follows (70 FR 56212):

(1) Water temperatures that support bull trout use. Bull trout have been documented in streams with temperatures from 32 to 72 °F (0 to 22 °C) but are found more frequently in temperatures ranging from 36 to 59 °F (2 to 15 °C). These temperature ranges may vary depending on bull trout life-history stage and form, geography, elevation, diurnal and seasonal variation, shade, such as that provided by riparian habitat, and local groundwater influence. Stream reaches with temperatures that preclude bull trout use are specifically excluded from designation;

(2) Complex stream channels with features such as woody debris, side channels, pools, and undercut banks to provide a variety of depths, velocities, and instream structures;

(3) Substrates of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. This should include a minimal amount of fine substrate less than 0.25 inch (0.63 centimeter) in diameter;

(4) A natural hydrograph, including peak, high, low, and base flows within historic ranges or, if regulated, currently operate under a biological opinion that addresses bull trout, or a hydrograph that demonstrates the ability to support bull trout populations by minimizing daily and day-to-day fluctuations and minimizing departures from the natural cycle of flow levels corresponding with seasonal variation. This rule finds that reservoirs currently operating under a biological opinion that addresses bull trout provides management for PCEs as currently operated;

(5) Springs, seeps, groundwater sources, and subsurface water to contribute to water quality and quantity as a cold water source;

(6) Migratory corridors with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and foraging habitats, including intermittent or seasonal barriers induced by high water temperatures or low flows;

(7) An abundant food base including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish; and

(8) Permanent water of sufficient quantity and quality such that normal reproduction, growth, and survival are not inhibited.

The following section discusses anthropogenic activities that have adversely impacted bull trout and their habitat, or PCEs. The more substantial influences from human activities and their associated legacy impacts to bull trout survival are summarized in Table 4. The summary provided in Table 4 is not exhaustive but provides a general overview of the major activities contributing to the degradation of bull trout populations.

Table 4. Summary of Human Influences that Contribute to the Degradation of PCEs and the Associated Impacts to Bull Trout Survival (USFWS, 2007). *This table is not an exhaustive list.*

Contributing Factors that Degrade PCEs	Impacts to Bull Trout
Dams	Eliminate Habitat, Impede Migratory Movement
Water Diversions	Eliminate Habitat, Impede Migratory Movement
Alter Water Flow	Reduce/Degrade Habitat, Impede Migratory Movement
Alter Temperature Regime	Degrade Spawning and Rearing Habitat
Alteration of Sediment Rates	Degrade Spawning and Rearing Habitat
Introduction of Nonnative Species	Create Potential Competition with Bull Trout for Resources, Increase Chance for Hybridization
Land Development *(mines, urban, rural, etc.)*, Forest Roads, Transportation, Agriculture	Degrade Foraging, Migration, Overwintering Habitats *(potential influences to temperature, sediment load, substrate composition, hydrology)*

5 Impacts to Bull Trout Habitat

5.1 General Impacts to Bull Trout Habitat in the Project Area

The draft Bull Trout Recovery Plan (USFWS, 2002) describes general habitat conditions in the lower Clark Fork River drainage. Human impacts that are identified as affecting bull trout habitat include: dams, forestry management, mining, transportation, urban and rural development, agriculture and grazing, and fisheries management including stocking of nonnative fish species (USFWS, 2002).

5.1.1 Dams

According to the USFWS Draft Bull Trout Recovery Plan, dams have been one of the key factors in reducing the bull trout population of the Clark Fork Recovery Unit (USFWS, 2002). The presence of barriers can isolate bull trout subpopulations, eliminate individuals from populations, reduce or eliminate genetic exchange, and separate spawning areas from productive overwintering and foraging areas. The USFWS (2002) notes that the three dams on the lower Clark Fork River have significantly reduced the amount of spawning and rearing habitat available to Lake Pend Oreille migratory bull trout. Since no dams in the Clark Fork River Recovery Unit have ever had fish ladders, the adult bull trout populations have been undergoing about a century of increasing fragmentation due to dams as well as other physical and biotic barriers to movement.

As previously mentioned, after the construction of Thompson Falls Dam in 1913, over 90 percent of the Clark Fork River was inaccessible to Lake Pend Oreille migratory bull trout (Montana Bull Trout Restoration Team, 2000). The lower Clark Fork River drainage was further dissected after the construction of Cabinet Gorge and Noxon Rapids dams in 1952 and 1958, respectively. In addition to upstream migratory impacts, hydroelectric turbines cause varying degrees of direct mortality when fish move downstream and pass through the mechanical and hydraulic structures (Bell, 1986). Spillways may provide safer routes of passage depending on the type of hydropower installation (Coutant and Whitney, 2000). Hydroelectric operations can also fluctuate pool levels and tailwater levels. However, these fluctuations do not seem to be of significant concern at Thompson Falls because of both the limited time and limited elevations available for peaking.

The construction of the three lower Clark Fork River dams has led to habitat modification of the mainstem lower Clark River from a riverine environment to a reservoir environment. Reservoirs in the Clark Fork River, including Thompson Falls, can provide a mix of advantages and disadvantages for bull trout. Reservoirs can increase growth potential due to open water for bull trout especially when large forage base populations are present (USFWS, 1998). However, complications exist where nonnative species have been introduced that either compete or prey on bull trout themselves. Additionally, water temperatures are warm in the summer months in the reservoirs of the lower Clark Fork River, which is not favorable to native salmonids.

5.1.2 Forestry Management

The USFWS (2002) also notes that forestry management practices have affected bull trout in the lower Clark Fork drainage. The USFWS states:

> *"For over 100 years, forestry practices have caused major impacts to bull trout habitat throughout the Clark Fork Recovery Unit. And because forestry is the primary landscape activity in the basin, the impacts have been widespread. Primary effects of timber harvest, such as road construction, log skidding, riparian tree harvest, clear cutting, splash dams, and others, have been reduced by the more recent development of more progressive practices. However, the legacy effects of the past century have included lasting impacts to bull trout habitat, including increased sediment in streams, increased peak flows, hydrograph and thermal modifications, loss of instream woody debris and of channel stability, and increased accessibility for anglers and poachers. These impacts will continue and are irreversible in some drainages. In addition, insufficient funding to maintain the existing road system has resulted in maintenance deficiencies, even on some well-designed roads. Consequently, impacts of the existing road system are compounded." (USFWS, 2002)*

Logging roads in the lower Clark Fork River drainage are commonly located in the riparian zone adjacent to the stream (USFWS, 2002). For example, upstream of the Project, the Thompson River has a main logging haul road along one side of the stream and a county road along the other side of the stream for nearly its entire length.

Silviculture has also been identified as a source of impaired water quality within the lower Clark Fork River drainage in Noxon Rapids Reservoir, Beaver, Elk, Fishtrap, Graves, Marten, Pilgrim, Prospect, Snake, and Swamp creeks, and in the Middle Fork Bull, Thompson, and Vermilion rivers, to name some of the major drainages (MDHES, 1994). Bull trout in Prospect Creek, the Vermilion River, and the Bull River have been particularly impacted by past logging activities (Pratt and Huston, 1993). Deposited sediment levels in the Bull River and Rock Creek are high enough to significantly reduce bull trout survival to emergence (Huston, 1988; Smith, 1993).

5.1.3 Agriculture and Grazing

The USFWS overall identified agricultural impacts to bull trout habitat to be minor in the lower Clark Fork River drainage (USFWS, 2002). Grazing affects some isolated areas in the lower Clark Fork River including Thompson River, Elk Creek, Pilgrim Creek, and portions of the Bull River, but overall grazing is not one of the high risk factors (MBTSG, 1996a).

5.1.4 Transportation

Transportation systems were a major contributor to the decline of bull trout in the Clark Fork River Recovery Unit (USFWS, 2002). The mainstem Clark Fork River is a major transportation corridor. Separating the direct effect of the roads and railroads from the development associated with their construction is difficult. Separating the effects of transportation corridors in forested habitat from the legacy effects of forest management is also difficult. Construction methods during the late 19th and early 20th centuries primarily included channelization and meander cutoffs. These methods caused major impacts on many tributaries to the lower Clark Fork River and caused impacts that are still being manifested. Such impacts seldom occur with new roads which are built to a higher standard. However, significant problems remain and are associated with passage barriers, sediment production, unstable slopes, improper maintenance, and high road densities (USFWS, 2002).

5.1.5 Mining

Montana has had a long history of mining. Although some areas have not been materially impacted by mining, environmental impacts related to mining activities often occur outside the physical boundaries of a mine.

Mining activities began in the Clark Fork River drainage over a century ago. In addition, impacts to aquatic ecosystems have continued long after mining activities have ceased. To this day there are areas that have contaminated streambeds, streambanks, and floodplains from mine tailings. In addition, some reaches of stream remain fishless or with severely depressed fish populations because of mining wastes (USFWS, 2002). The most severely impacted areas remain in the upper Clark Fork River drainage as a result of mining and smelting activity in the Butte and Anaconda areas resulting in the designation of the nation’s largest Superfund site with the EPA (USFWS, 2002).

Several tributaries in the middle Clark Fork River have been impacted by placer mining. These tributaries include St. Regis River, Ninemile Creek, Cedar Creek, Trout Creek, and Quartz Creek (MBTSG, 1996b). Impairment to water quality in other streams including Cache, Cedar, Crow, Josephine, Kennedy, Little McCormick, and Trout creeks were also linked to mining (USFWS, 2002). Mining effluent has also impaired waters in the headwaters of the Blackfoot River drainage.

Contaminated sediments from the Blackfoot River and upper Clark Fork River deposited behind Milltown Dam remain a threat to waters downstream. At the writing of this BE (March 2008), Milltown Dam has yet to be completely removed. Therefore, downstream impacts from the sediments that will be flushed downstream are still unknown.

Other areas in the Clark Fork River drainage face the challenge of proposed mining operations and potential future impacts. In 2006, the USFWS prepared a BO regarding a proposed mining operation in the Rock Creek drainage near Noxon. The proposed mining operation was for an underground copper/silver mine and mill that could produce 10,000 tons of ore per day (USFWS, 2002). The USFWS anticipated that certain activities associated with the proposed mining activity would likely result in degradation of bull trout habitat causing some incidental take. Anticipated habitat degradation included: 1) an increase in sediment; 2) degradation in water quality; and 3) alterations in channel and habitat complexity (USFWS, 2006b). These impacts to the habitat were described to have the potential to "*result in a take of egg, larval, and juvenile life history stages by harming or impairing feeding, breeding, and sheltering patterns of adult and juvenile bull trout*" (USFWS, 2006b). The duration of impacts were estimated to last, at a minimum, the life of the mine, with possible long-term effects that could continue indefinitely after the mine closure.

5.1.6 Urban and Rural Development

In the Clark Fork drainage, some areas have experienced increases in residential development. In the 1990s, Lincoln, Sanders, Lake, and Mineral counties grew between 7.8 and 26 percent (USFWS, 2002). Growth was particularly common in tributary drainages to the Clark Fork River that were bordered by private lands, such as Bull and Jocko rivers that provide important bull trout habitat (USFWS, 2002). Residential development, which is likely to continue to increase in the future, brings associated risks to bull trout restoration. Development can impact bull trout habitat through activities including, but not limited to, the removal of the riparian corridor, removal of large woody debris, construction of roads resulting in the increase of sediment or bedload to the stream, or alterations to the floodplain (e.g., dredging) (USFWS, 2002).

5.1.7 Fisheries Management

The USFWS (2002) concluded that of all the threats to bull trout recovery, the expanding presence of nonnative invasive species may prove to be the most intractable. The principle nonnative species of concern interacting with native salmonids in tributary systems to the

Clark Fork River are brown trout (*Salmo trutta*), brook trout (*Salvelinus fontinalis*), and rainbow trout (*Oncorhynchus mykiss*).

Fish densities in the middle Clark Fork are estimated to be approximately 250-600 rainbow trout per mile, 17-55 westslope cutthroat trout per mile, and 1-2 bull trout per mile (Berg, 1999; MFWP unpublished data). Brown trout numbers in the middle Clark Fork River are too low to estimate, but the data indicate approximately 20 catchable brown trout (>7 inches) per mile (Berg, 1999). Additionally, no hybridization has been detected through genetic analysis in bull trout collected in the middle Clark Fork River (MFWP unpublished).

Brown trout were introduced in the late 1940s to the lower Clark Fork River drainage. Higher densities of brown trout are most often found in lower reaches of tributaries (WWP, 1996; Nelson et al., 2002). Brown trout propose a potential threat to bull trout populations. Brown trout spawn later in the year compared to bull trout, but use similar spawning habitat that may lead to superimposition on bull trout redds. Superimposition may result in lower bull trout egg survival (Chadwick Ecological Consulting, 2002). Superimposition of brown trout redds on bull trout has been documented in the lower Clark Fork River drainage in Prospect Creek, Vermilion River, and Bull River watersheds (Moran, 2003; 2004; 2005). Brown and bull trout also utilize similar microhabitats as juveniles, but the interactions and effects at this life stage are unknown (Pratt and Huston, 1993).

Brook trout were introduced in the mid-1930s to the lower Clark Fork River drainage and are found throughout the system (WWP, 1996). Brook trout pose a threat to bull trout populations, but for different reasons than brown trout. It is suspected that bull trout and brook trout compete and exploit similar food and habitat resources. Compared to bull trout, brook trout have a wider array of suitable habitat conditions, shorter life cycle, ability to hybridize with bull trout, and tendency to overpopulate a stream, all of which provide brook trout with an advantage over bull trout and greater likelihood of displacing bull trout (Kanda et al., 2002). Kanda et al. (2002) concluded that hybridization wasted more reproductive potential for bull trout because eggs contain more energy than sperm and the majority of hybridization was found between female bull trout and male brook trout. Additionally, female bull trout take longer to reach maturity than do male brook trout leading to a net loss in reproductive potential for bull trout in comparison to brook trout.

5.2 Impacts to Bull Trout Related to the Project

The following text provides an overview of the impacts that the Thompson Falls Project may have on bull trout. Topics discussed include the upstream fish passage, downstream fish passage, and water quality.

5.2.1 Upstream Passage

Dams built in the early and mid-1900s in the lower Clark Fork River prevented bull trout upstream migration for well over 50 years. Only recently have operators of hydroelectric facilities attempted to move fish upstream of these barriers.

At the Thompson Falls Project, local anglers have long reported pooling of trout in the spring season below the spillways of the dam. These reports prompted PPL Montana to install a small Denil ladder and fish trap at the left bank of the Project (looking downstream) of the Main Dam Spillway in 1999. This fishtrap has consistently collected a wide variety of fish, including an occasional bull trout, in the early spring, indicating that fish are attempting to migrate upstream past the Thompson Falls Project.

In 2001, a fish tracking study was conducted by PPL Montana and MFWP. Bull, rainbow, and cutthroat trout were captured either by angling or in the fishtrap downstream of the Main Dam Spillway, then radio tagged and transported upstream of Thompson Falls Dam. All three species showed significant upstream movements into potential spawning tributaries (Table 5). Bull trout (n=2) moved an average of 26.5 km upstream of the dam. Cutthroat trout (n=13) moved an average of 48.8 km upstream of the dam, and rainbow trout (n=6) moved an average of 58.4 km.

The two 2001 radio tagged bull trout ascended the Thompson River. Total upstream movement averaged 26.5 km. One bull trout was transported above the Thompson Falls Dam on April 11 and the other on June 1. Both bull trout moved upstream at an average rate of 0.3 km/day. It took between 86 and 92 days for the bull trout to reach their upstream-most location.

In addition to data collected by PPL Montana, a radio telemetry study was conducted by the CSKT in 1999. CSKT documented one bull trout, initially captured in the lower Flathead River downstream of Mission Creek in April 1999, moving downstream into Thompson Falls Reservoir in May 1999 (Barfoot, CSKT, personal communication, May 2002). Cutthroat trout radio tagged in the Flathead River were also documented moving downstream into the Clark Fork River near Quinn's Hot Springs (upstream of the Project) over the winter (Barfoot, CSKT, personal communication, May 2002). These movements indicate the wide range trout utilize when barriers are not present.

All of these bull trout studies have shown how the presence of a barrier without passage can impair the ability of an adult bull trout to reach its natal stream and spawn. Based on these data, it has been concluded that the Thompson Falls Project has a potentially adverse effect on bull trout by blocking the upstream movement of adult fish.

Table 5. Upstream Movements of Salmonids Transported Above Thompson Falls Dam, 2001. Source: PPL Montana and MFWP unpublished file data

Species (n)	Date captured	Date last located	Days tracked	Date most upstream	Days to move upstream	km moved upstream	Rate moved upstream (km/day)	Tributary Selected
Bull trout (n = 2)	11-Apr	3-Aug	114	6-Jul	86	25.4	0.3	Thompson R
	1-Jun	5-Oct	127	31-Aug	92	27.5	0.3	Thompson R
Mean					**89**	**26.5**	0.3	
SD					**4.2**	**1.5**	**0.0**	
Rainbow (n = 6)	21-Mar	3-Oct	196	27-Jun	98.0	91.4	0.9	Jocko R
	26-Mar	25-May	60	25-May	60.0	69.9	1.2	Flathead R
	26-Mar	23-Jun	89	13-Apr	18.0	12.6	0.7	Thompson R
	26-Mar	3-Aug	130	2-Apr	7.0	3.5	0.5	None
	26-Mar	20-Apr	25	20-Apr	25.0	86.1	3.4	Clark Fork above Flathead
	17-Apr	20-Apr	3	20-Apr	3.0	87.1	29.0	Clark Fork above Flathead
Mean					**35.2**	**58.4**	**6.0**	
SD					**36.9**	**39.8**	**11.4**	
Cutthroat (n = 13)	21-Mar	25-May	65	25-May	65	41.9	0.6	Combest Ck
	22-Mar	24-Aug	33	23-Mar	1	0.2	0.2	None
	22-Mar	11-Oct	203	22-May	62	2.4	0.0	Cherry Ck
	31-Mar	19-Aug	142	22-Jun	84	4.3	0.1	Thompson R
	3-Apr	15-Jun	73	29-May	56	30.6	0.5	Fishtrap Ck
	5-Apr	10-May	35	10-May	35	13.8	0.4	Thompson R
	11-Apr	18-Oct	190	25-May	44	125.6	2.9	St Regis R
	17-Apr	29-Jun	73	26-Jun	70	19.2	0.3	Thompson R
	17-Apr	17-Jul	61	1-Jun	45	125.3	2.8	Cedar Ck
	19-Apr	15-Jun	57	25-Apr	6	4.2	0.7	None
	23-Apr	22-Sep	152	2-May	9	28.8	3.2	None
	23-Apr	3-Oct	163	21-Jun	59	132.2	2.2	St Regis R
	25-Apr	16-Aug	113	15-Jun	51	106.6	2.1	St Regis R
Mean					**45.1**	**48.8**	**1.2**	
SD					**25.9**	**52.8**	**1.2**	
All species (n = 21) Mean					**46.5**	**49.5**	**2.5**	
SD					**31.0**	**46.3**	**6.2**	

5.2.2 Downstream Passage

5.2.2.1 Background

Much attention has been paid to downstream fish passage in the Columbia River system, which supports anadromous salmon and trout. Bull and cutthroat trout life histories in Montana differ from that of anadromous Pacific salmon in that they do not migrate to the ocean, they do not die after spawning, and both migratory and non-migratory life history patterns are expressed.

Therefore, the downstream passage issue is different for salmonids in Montana than for anadromous fish in the Columbia River. For anadromous fishes, outmigration of juveniles to the ocean is an obligatory component of the life history. Juveniles must successfully pass downstream through a hydropower system in order to survive to adulthood. Fishes in Montana often migrate, but they can also be non-migratory. In either case, they stay within the freshwater system and may never migrate to a large lake or reservoir. Trout in Montana do not die after spawning and can spawn more than once in a lifetime. Adults may move both upstream and downstream within a river system. Therefore, the need to provide downstream juvenile passage at the dams in Montana is less clear.

Thus, until recently, there have been limited efforts to provide downstream passage of adult salmonids through the Columbia River hydropower system, and even less effort to provide downstream passage at hydropower projects in Montana.

There are limited data pertaining to the effects of run-of-the-river dams on inland fisheries (Cada and Sale, 1993). Fortunately, a comprehensive study regarding bull trout movement in the mid-Columbia River hydropower system was conducted from 2001 to 2004. Seventy-nine bull trout were tagged from 2001 to 2002 on the mid-Columbia River to study the operational effects of multiple hydropower projects on adult bull trout (BioAnalysts, 2004). Of the 79 tagged bull trout tracked from 2001 to 2003, eight individuals moved downstream after exiting the fish ladders at Rocky Reach Dam and Wells Dam. However, 11 total downstream events were documented, thus indicating multiple upstream and downstream passages. For example, the five downstream passage events documented in 2002 at Rocky Reach Dam were undertaken by three individuals. The downstream route was not obtainable for each event, but both spillway and turbine passage were documented. No fish were significantly harmed during their downstream movements (BioAnalysts, 2004; RRBTMP, 2006). Researchers concluded that the operations of the hydropower projects on the mid-Columbia River do not negatively affect adult bull trout survival (BioAnalysts, 2004).

Avista, owner and operator of the two dams (Cabinet Gorge and Noxon Rapids) on the Clark Fork River downstream of Thompson Falls, is involved in a trap-and-haul fish passage program for bull trout. Adult bull trout are captured downstream of Cabinet Gorge Dam and, depending on the results of genetics testing that is conducted to determine the likely natal stream, released upstream of either Cabinet Gorge Dam, Noxon Rapids Dam, or Thompson Falls Dam. Many of these fish are radio tagged and their movements tracked. Lockard et al. (2004) report that 15 of these transported adult bull trout passed back downstream through Cabinet Gorge Dam. While the fate of all 15 of these fish has not been documented, at least eight have been recaptured and, therefore, survived passage through the dam (Lockard et al., 2004).

At this time there are no site-specific data to indicate the degree to which the Thompson Falls Project is an impediment to downstream passage of adult bull trout. Neither of the two bull trout that were passed upstream over Thompson Falls Dam in 2001 as part of the PPL Montana radio telemetry study is known to have returned downstream past the dam. However, it should be noted that fish were tracked for an average of 100 days during the 2001 radio telemetry study. Some radio tagged fish may have moved downstream past the dam after the batteries died in the radios. For example, one of the radio tagged bull trout was last tracked on August 3, 2001, before the start of the bull trout spawning season and well before downstream post-spawning movements would be expected to occur (PPL Montana unpublished data).

No site-specific information on the timing of juvenile bull trout outmigration through Thompson Falls Reservoir is available. In other areas of the lower Clark Fork River drainage, bull trout seem to have a bimodal outmigration pattern. Downstream of the Project in the Bull River, juvenile bull trout outmigrate in the spring (approximately between March and July) and with rain events in the fall (October and November). In Fishtrap Creek and West Fork Thompson River, tributaries to the Thompson River, the spring pattern is unknown, but outmigration in the fall generally occurs with rain events from the end of September through early November (Katzman, MFWP, personal communication, July 2002; Liermann 2003).

In 2004, the Avista captured 84 juvenile bull trout (less than 300 mm) moving downstream in the East Fork Bull River. Although a few of these fish were collected in the spring (April and May), most were collected between July and October. September had the highest number of outmigrating juvenile bull trout (n=16). Recent studies in Trestle Creek, tributary of Lake Pend Oreille in Idaho, also found two pulses of outmigration for bull trout. The timing of the pulses again was spring (April through June) and fall (September through November). The two pulses accounted for 92 to 93 percent of the total outmigrants sampled in the April to November time period (Downs, Idaho Department of Fish and Game, personal communication, November 2002).

Further upstream in the middle Clark Fork River, juvenile bull trout have been found to pass downstream through Milltown Reservoir during a relatively short window during high water in May. This migration has been detected through monitoring of the stomach contents of northern pike in the Milltown Reservoir (Schmetterling, 2001b). Therefore, juvenile bull trout moving downstream through Thompson Falls Reservoir could conceivably be entering Thompson Falls Reservoir before, during, or after the spill season.

Reservoirs can often provide good habitat for predators, creating hazards to downstream migrating fishes. Several native and nonnative predacious species are found in Thompson Falls Reservoir. Several of these species, most notably the northern pike, are better adapted to slow moving, shallow weedy habitats, such as those found in Thompson Falls Reservoir, than they are to fast moving rivers. Therefore, it can reasonably be assumed that the creation of the reservoir enhanced the habitat for predacious fishes and the risks to migrating bull trout. The extent to which these fish are feeding on bull trout is unknown as food habit studies have just begun. Therefore the impact of the Project cannot be quantified at this time.

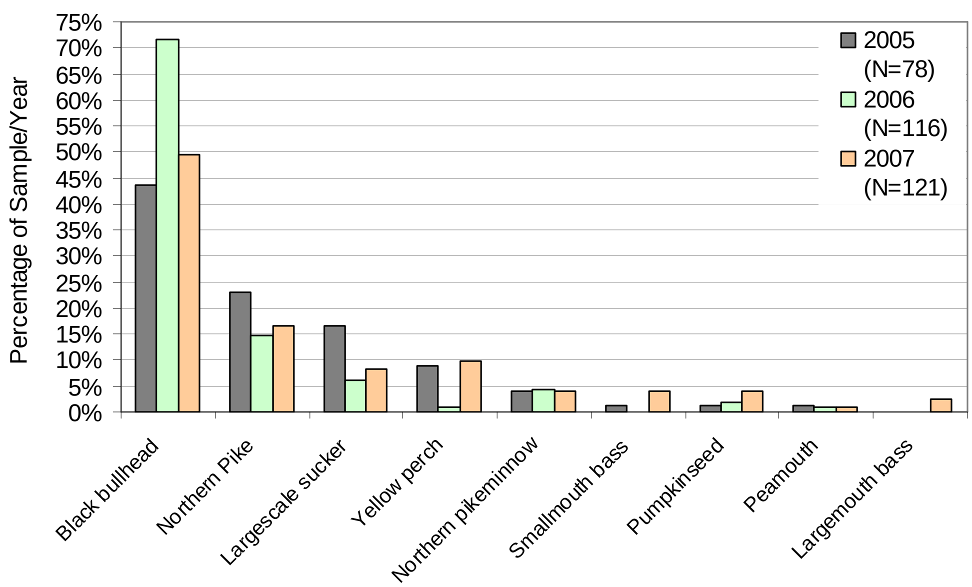

Figure 6. Summary of Species Captured During Gill Net Sampling From Thompson Falls Reservoir in October 2005, 2006, and 2007 (PPL Montana data).

In 2005, 2006, and 2007 a total of ten gill nets were set each October by PPL Montana and MFWP to identify the fish species composition in Thompson Falls Reservoir (Figure 6). Over the years, a total of ten species have been observed, including northern pike, largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), yellow perch (*Perca flavescens*), pumpkinseed (*Lepomis gibbosus*), northern pikeminnow (*Ptychochelius oregonensis*), largescale sucker (*Cataostomus macrocheilus*), peamouth

(*Mylocheilus caurinus*), and black bullhead (*Ameiurus melas*). Black bullhead and northern pike have dominated the gill net samples representing between 44 and 72 percent, and between 15 and 23 percent of the fish captured from 2005 to 2007, respectively. Overall, species composition has been similar, with bullhead and northern pike the most predominant species followed by yellow perch and largescale suckers. Other species were not always present year-to-year and represent no more than four percent of the species composition in a given sample year.

5.2.2.2 Downstream Passage at the New Powerhouse

Passage through the turbines poses risks of direct (immediate) mortality from mechanically induced injuries such as blade strike or mortality induced from such forces as shear, cavitation, turbulence, or high pressure gradients (Cada, 2001; Coutant and Whitney, 2000). Indirect (delayed) effects of turbine passage include physiological stress, disorientation, and increased susceptibility to predation (Kleinschmidt Associates and Sverdrup Civil, 1997; Coutant and Whitney, 2000). Indirect injuries may result in damage to the immune system or other protective systems; and subsequent death from these types of injuries is not easily correlated with turbine-passage (Pavlov et al., 2002).

Downstream fish passage through spillways is generally considered to be less risky than passage through turbines. However, spillway passage can also result in physical injury to fish and indirect mortality. Fish mortality is typically zero to two percent for standard spill bays and five to 15 percent for turbine passage, with Kaplan turbines generally at the lower end of this mortality range and Francis turbines generally greater (Whitney et al., 1997).

5.2.2.3 Downstream Passage Through Turbines

There are no site-specific data on fish survival during downstream passage at Thompson Falls Dam. The turbine/generator configuration in the old powerhouse consists of six similar Francis units (Nos. or Units 1-6) rated at 5 Mw each, each with hydraulic capacities of 1,700 cfs and a total turbine capacity of 10,200 cfs. The Francis runners are 11 ft (3.4 m) in diameter, have 13 buckets, and rotate at a speed of 100 revolutions per minute (rpm). The wicket gate at the old powerhouse is 4 ft (1.2 m) tall and has a spacing of 14 inches when fully open (Bonnes, PPL Montana, personal communication, November 18, 2002).

The new powerhouse is immediately upstream of the old powerhouse, and has one large 62 Mw Kaplan turbine (No. or Unit 7) with a capacity of approximately 13,000 cfs. Unit 7 is among the most modern of Kaplan-type turbines with four adjustable blades. The runner is large, 262 inches (28 ft or 8.5 m) in diameter, and it rotates at a speed of 94.7 rpm. The wicket gate at the new powerhouse is 8.5 ft (2.6 m) tall and has a 36-inch spacing when fully open.

Operational scenarios may be altered depending on the time of year and flow rates (Beckman, PPL Montana, personal communication, December 2006). When total river discharge is less than 23,000 cfs, the new powerhouse is preferentially operated to maximize peak efficiency of the Project, with between 50 and 70 percent of the river flow typically going through Unit 7. Two Francis units, typically No. 1 and No. 3, operate as auxiliary power to Unit 7 to maintain heat in the old powerhouse and to exercise these other units during low flows. Generally, Units 2, 4, 5, and 6 are operated at high flows, as they are the least efficient and smallest units at the Project.

New governors exist on the newest units (Nos. 1, 3, and 7) and these units are automated to maintain constant reservoir elevation during normal run-of-river operations. During peaking operations, the plant is operated at full gate for the number of hours that will enable the reservoir to refill within a 24-hour period and stay within the restricted headwater elevations of 2,393 to 2,397 ft amsl. The powerhouse intakes at the old powerhouse are about 16 ft square and the invert is about 35 ft below the forebay surface elevation. The top of the intake is about 20 ft below the surface. The intakes are guarded by a steel trash rack with openings of 2-5/8 inches between the bars in the old powerhouse and 5-1/2 inch spacing in the new powerhouse.

Francis Versus Kaplan Type Turbines

Kaplan units are significantly safer for fish than Francis-type turbines (Franke et al., 1997). The differences may be related to the fact that Francis units spin faster and have more blades and more confined hydraulic passages compared to Kaplan turbines. Francis-type turbines could be made safer for fish by increasing the clearance between the wicket gate blades and the runner blades (Monten, 1985).

Data for downstream fish passage survival through Francis turbines at this Project are not available. However, data collected at six other hydroelectric facilities using Francis-type units similar to the old powerhouse are presented in Table 6. The turbine passage survival at these comparable projects varied from 61 percent to 98 percent among the different tests on mostly salmonids ranging in size from 110 to 317 mm (Table 6). The Thompson Falls Project is most similar to EJ West in configuration, thus, fish passage survival is expected to be in the 65 to 96 percent range.

Table 6. Selected Turbine Fish Survival Data for Francis Units Similar to the Units at Thompson Falls' Old Powerhouse. Sample Methods: Net = tailrace netting; Hi-Z = balloon tags; Fyke Net

Station	Ref	Method	Species	Test and Control (N)	Length (mm)	Survival (%)	Discharge (cfs)	Type	Blades or Buckets (#)	Head (ft)	Diameter (ft)	RPM
Ruskin	1	Fyke net	Sockeye	12125	86	89.5	3990	FRAN	-	130	12.4	120
Rogers	2	Net	Rainbow Trout	30	108	89.9	381	FRAN	15	39	5	150
				30	317	61.2						
EJ West	3	Net	Salmonids	280	<100	65.2	2700	FRAN	15	63	10.9	113
				160	175	90.6						
				160	> 250	95.6	2700					
Alcona	4	Net	Rainbow Trout	40	108	100	1667	FRAN	16	43	8	90
				40	317	89						
Mineto	5	Net	Salmonids	397	<100	92	1501	FRAN	16	17	12	72
				291	175	91						
				337	>250	92						
Stevens Creek	6	Hi-Z	Bluegill	220	122	95	1000	FRAN	14	28	11	75
			B.B.Herring	251	203	95						
			Sucker/Perch	240	165	98						
Thompson Falls Nos. 1-6	**--**	**--**	**Trout**	**--**	**--**	**--**	**1850 each**	**FRAN**	**13**	**61**	**11**	**100**

Reference: 1 –Eicher 1987; 2 –LMS 1991, 3 – KA 1996, 4 – Lawler, Matusky and Skelly (1991), 5 – Kleinschmidt Associates, 1996a, and 6 – RMC (1994) all cited in Franke et al. 1997.

Fish survival estimates from other projects using similar Kaplan units to the one installed in the new powerhouse at the Thompson Falls Project are presented in Table 7. The range of survival found in these studies for salmonids ranged from 86 to 100 percent. The runner speed at Thompson Falls is quite low compared to many other comparable units, but the blade tips travel at comparable speeds due to the large radius (Table 7). At 61 ft of operating head and with the large diameter, the Thompson Falls Kaplan unit is more similar to projects in the Columbia River Basin like Big Cliff, than to projects in the mid-west or east coast where heads are relatively lower (Table 7).

Table 7. Selected Turbine Survival Data for Kaplan Units Similar to the Units at Thompson Falls' New Powerhouse (Franke et al. 1997).

Station	Ref	Method	Species	Test and Control (N)	Length (mm)	Survival (%)	Discharge (cfs)	Type	Blades or Buckets (#)	Head (ft)	Diameter (ft)	RPM
Big Cliff	1	Net	Chinook	37,500	100	90-95	2292	KAP	6	71-91	12	164
Lower Monumental	4	PIT Tag	Chinook	-	-	86.5	18000	KAP	6	94	26	90
Lower Granite	4	PIT Tag	Chinook	3200	151	92.7	18000	KAP	6	98.	26	90
Herrings	2	Net	Salmonids	165	100	96	1201	KAP	4	19	9	138
				167	175	99						
				188	250	99						
Townsend	3	Hi-Z	Rainbow Trout	106	139	94	802	KAP	3	16	9	152
				103	344	87						
				21	139	100	1501					
Thompson Falls No.7	--	--	Trout	--	--	--	Max 13,000	KAP	4	61	28	95

Reference: 1 – Oligher and Donaldson (1966); 2 – Kleinschmidt Associates, 1996, 3 – RMC (1994), 4- Muir et al (1995) all cited in Franke et al. 1997.

The large size of the Kaplan unit means much larger hydraulic openings for water and fish. The trash bar openings are 5-1/2 inches compared to the 2-5/8 inch openings of the old powerhouse. The wicket gates have 3-ft by 8.5-ft-wide openings compared to 14-inch by 4-ft-wide openings in the old powerhouse Francis unit. The Kaplan unit is a modern, high-efficiency unit with adjustable blades and a relatively flat efficiency curve over the entire range of operation discharges. The Kaplan unit can operate from 10 Mw to 50 Mw.

In the past it was generally believed that units with higher efficiencies were more fish friendly than units with lower efficiencies because loss of efficiency is usually accompanied by turbulence and cavitation, factors known to injure fish (Bell, 1991). Inefficient turbine operation is a result of a poor blade-to-wicket gate relationship, where efficiency drops due to turbulence that results from the rotating machinery (hub and blades) being misaligned with the hydraulic flow field coming off the stationary but adjustable wicket gates. However, a statistical relationship between turbine efficiency and fish survival has not been observed (Ferguson et al., 2005)

5.2.2.4 Downstream Passage through the Spillways

The Project is operated as a daily peaking power facility about four months of the year and as a run-of-the-river facility during the high flow and winter months. When river discharge exceeds the combined hydraulic capacity of both powerhouses (23,000 cfs), the two tainter gates enable automatic spill operations up to 10,000 cfs each. The tainter gates have openings 41-ft wide and 14-ft high when fully open. As the runoff proceeds, 4-ft by 8-ft spillway panels on the east side (toward the left bank) of the Main Dam Spillway are removed for additional spill capacity (see Photo 1). As flows increase, more panels are removed to balance flows across the length of the Main Dam Spillway spill section until all 228 panels have been removed. In most years, when the peak flood discharge is less than 70,000 cfs, spill is restricted to the Main Dam Spillway section. If flows exceed 70,000 cfs, there are 72 Dry Channel Dam spill panels (each 4-ft by 8-ft) available to increase spill capacity. Operation of the Dry Channel Spillway occurs infrequently according to PPL Montana dam operators.

Thompson Falls Dam is an intermediate-high head dam (61 ft) that should have relatively high survival for fish passing the dam via spill. However, observations by GEI of spill at Thompson Falls during the 2002 runoff suggest hydraulically violent conditions exist at some locations more than others, at least during high flow events (Photos 2-7). Spill over the Dry Channel Dam passes via a complex set of downstream rapids and much of the energy is dissipated against the rocky substrate for a distance of up to 400 ft depending on location of passage (Photo 5). Survival over this spillway is unknown. Bickford and Skalski (2000) noted that the spillways in the Columbia River with survival less than 100 percent contained exposed rebar, pitted concrete, or exposed rocks. The Thompson Falls Project spillway contains exposed steel I-beams and large boulders. Thus, it would be reasonable to assume that survival could be less than 100 percent.

Photo 2. Main Dam Spillway at Thompson Falls, low flow (March 20, 2006).

Photo 3. Main Dam Spillway at Thompson Falls, high flow (June 10, 2002, total river flow approximately 77,000 cfs).

Photo 4. Dry Channel Dam at Thompson Falls, low flow.

Photo 5. Dry Channel Dam at Thompson Falls, high flow (June 10, 2002, total river flow approximately 77,000 cfs).

Photo 6. Dry Channel Spillway, looking upstream.

Photo 7. Dry Channel Spillway, from above.

5.2.2.5 Summary of Downstream Passage Impacts

In order to estimate overall survival for downstream trout passage through the Project, the following assumption were made:

- Spillway effectiveness (proportion of fish passing the project via spill compared to the proportion of water spilled) is 1:1, so fish will pass the Project in numbers proportional to flow. That is, if 50 percent of the flow is through the spillway, then 50 percent of the fish will pass over the spillway.
- Fish will also pass the two powerhouses in proportion to flow.
- Survival estimates are assumed: Kaplan 94 percent, Francis 85 percent, and Spillway 98 percent.

The Spillway survival estimate of 98 percent was based on Ferguson et al. (2005), who noted that fish survival through spillways can be very high (near 1.00) and is often higher than turbine or bypass system survival when spill passage conditions are optimal. However, as noted previously, survival through spillways with deflectors or shallow basins or exposed rocks and rebar can be considerably less (Bickford and Skalski, 2000).

Based on the comparison between fish survival at similar projects with Francis-type turbines in Table 6, the survival estimate of 85 percent was selected to represent survival through the Francis turbines at Thompson Falls Project. The 94 percent survival estimates for the Project's Kaplin unit in the new powerhouse was also based on the comparison of projects with similar Kaplan turbines displayed in Table 7.

Overall survival by month was calculated (Table 8) and based on the bulleted assumptions above. Downstream fish passage survival at Thompson Falls Project is estimated to be approximately 91 to 94 percent.

Table 8. Immediate Downstream Fish Passage Survival Estimates at Thompson Falls Dam Project.

Month	Monthly mean Flow *(cfs)	% Flow Kaplan	% Flow Francis	% Flow Spillway	Estimated % Survival
January	12,155	70.0	30.0	0.0	91.3
February	12,043	70.0	30.0	0.0	91.3
March	12,201	70.0	30.0	0.0	91.3
April	20,026	70.0	30.0	0.0	91.3
May	45,406	28.6	22.0	49.3	94.0
June	55,403	23.5	18.0	58.5	94.7
July	25,987	50.0	38.5	11.5	91.0
August	11,239	70.0	30.0	0.0	91.3
September	9,811	70.0	30.0	0.0	91.3
October	10,696	70.0	30.0	0.0	91.3
November	11,647	70.0	30.0	0.0	91.3
December	12,264	70.0	30.0	0.0	91.3

In the calculations provided in Table 8, spillway effectiveness (spillway passage/percent spill flow) is assumed to have a 1:1 relationship because of the lack of site-specific data to indicate otherwise. On the Columbia and Snake rivers, spillway effectiveness is greater than 1:1 when the spillway is downstream of the powerhouse, and less than 1:1 when the spillway is upstream of the powerhouse (Rainey, GEI Consultants, personal communication, 2006). Since the Project spillway is upstream of both powerhouses, the Project spillways could reasonably be expected to have an effectiveness of less than 1:1. In addition, bull trout are substrate-oriented fish and may be less likely than anadromous smolts to pass the Project via spill. Thus, the estimates for downstream survival during spill (May and June) presented in Table 8 may be overestimated.

During time periods when less than 25 percent of the flow is passing through a given route, studies in the Columbia and Snake rivers have found a higher percentage of the fish tend to go with the greater (bulk) flow (Rainey, GEI Consultants, personal communication, 2006). Therefore, a greater number of fish are expected to pass through the new powerhouse versus the old powerhouse because the new powerhouse is located further upstream. On average, 30 percent of the flow passes the old powerhouse, but the amount varies and at times can be less. Therefore, during times when less than 25 percent of the flow is passing the old powerhouse, the new powerhouse (with its higher estimated survival) may be passing greater than 90 percent of fish. In this scenario, downstream survival estimates (Table 8) during non-spill periods may be underestimated.

5.3 Water Quality

5.3.1 Total Dissolved Gas

Spill at hydroelectric dams usually increases downstream TDG levels, and occurs when river discharge exceeds turbine hydraulic capacity. Since no additional flow can pass the Project's turbines, it must pass over the spillway. Since the height of the dam typically provides much of the energy head for generation of power, spillway flow transfers much of that potential energy to the spillway tailrace, where turbulence dissipates that excess energy. As spill discharge passes into the spillway tailrace, it typically plunges into a deep armored stilling basin, designed with enough volume to dissipate energy for the maximum design flood discharge. The intent is to confine energy dissipation in the armored zone, so that erosion does not scour and undermine the spillway or other dam features, leading to potential structural failure. As spill plunges into a deep spillway stilling basin, a turbulent energy dissipation zone is created, characterized by unsteady flow and high shear forces. Vertical circulation cells often take turbulence aeration to depth, where hydrostatic pressure collapses bubbles, forcing them into solution and elevating TDG levels (gas absorption).

However, at Thompson Falls Dam there is no formal spillway stilling basin because the spillway is built on bedrock, so erosion and scour are not a concern. This configuration reduces the risk of the Project producing excessive levels of TDG.

TDG supersaturation is an unstable condition, and if the river channel downstream of a spillway is sufficiently wide and shallow, and with an enough hydraulic gradient, channel boundary roughness will force flow to “tumble” in a manner where there is increased water surface exposure of ambient air conditions. Where this kind of open-channel flow conditions occur, TDG levels rapidly drop back to near the stable, 100 percent saturation level in less than a mile (distance varies from site to site).

However, if there is a reservoir backed up to near the powerhouse tailrace, as at Thompson Falls, the normal river gradient is reduced and the flow regime becomes more stable. Lower reservoir velocities result in less turbulence, and elevated TDG levels are locked in after entering the impoundment. If there are elevated wind levels, enough shear can be created to induce the vertical circulation necessary to reduce TDG levels in the reservoir. Otherwise, the elevated reservoir TDG levels wane slowly and on the basis of delayed replenishment by lower level TDG inflows.

Montana Water Quality Standards limit TDG to 110 percent of saturation. This standard is meant to protect aquatic life, which can experience GBT when water is supersaturated. It has been shown that excessive TDG results in embolisms and the appearance of tiny gas bubbles in fish tissues, resulting in elevated mortality rates.

The monitoring of TDG at Thompson Falls Dam has been carried out annually since 2003. Table 9 is a summary of the maximum flows and the maximum levels of TDG measured during the years of this monitoring program. Monitoring of TDG downstream of the Thompson Falls Project indicates that TDG levels exceed 110 percent during spill, although no GBT to fish has been documented.

Table 9. Thompson Falls Total Dissolved Gas Monitoring Results Summary.

RESULTS	**2003**	**2004**	**2005**	**2006**	**2007**
Peak Flow for the Year as Daily Average (cfs)	70,130	41,750	69,687	79,013	49,410
Peak Flow Median 1960-2005	73,200	73,200	73,200	73,200	73,200
Peak Flow % of 1960-2005 Median	96	57	95	108	68
Peak Spill for the Year as Daily Average (cfs)	48,120	18,690	48,539	56,853	23,955
Spill Period (days)	79	63	69	95	91
Above Dam Max (TDG%)	106.4	106.1	107.6	107.2	105.8
Below Dam Max (TDG%)		111.5			
High Bridge Max (TDG%)		113.8	120.5	123.6	118.5
Birdland Bay Bridge Max (TDG%)	114.1	108.5	115.1	117.0	112.2
Net Project Max (BBB-Above Dam) (TDG%)	12.6	6.3	11.3	12.9	10.0

It appears that elevated TDG levels downstream of the Project are, in part, a result of water plunging at Thompson Falls, a natural river feature downstream of the Main Dam Spillway.

The Project may actually reduce TDG levels at low to moderate spill levels, in comparison to the pre-Project condition. This is because the Project routes approximately 23,000 cfs through both powerhouses. Water passing through the turbines is slightly de-gassed by about two percent, so outflow from the powerhouse has lower levels of TDG than water in the forebay. Prior to Project construction, this water would have passed over Thompson Falls, increasing flow over the falls and TDG levels. At high levels of spill, perhaps above about 50,000 cfs, TDG is likely increased by the Project in comparison to the pre-Project condition. A more detailed explanation of these conclusions, and the rationale for them, is provided in Appendix A.

There is concern that modifying spillway operation to enhance fish passage may slightly increase TDG at higher levels of spill. Only two years of data documenting TDG under the modified spillway operation are available, so there is some uncertainty about this conclusion. Further experimentation may be warranted to minimize TDG levels while attempting to maximize fish passage efficiency.

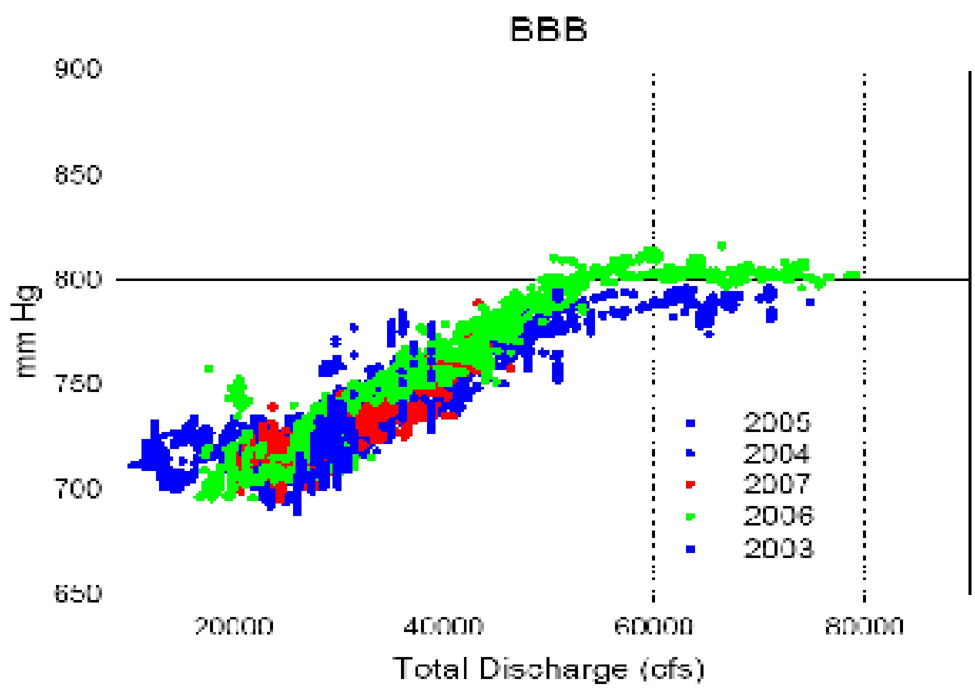

Figure 7. Total dissolved gas at Birdland Bay Bridge (BBB), Clark Fork River, at varying discharge for 5 years of record.

5.3.2 Temperature

Clark Fork River temperature above and below Thompson Falls Dam was monitored in 2007. Thermograph data collected from March through November 2007 illustrate stream temperatures increasing into the summer months with peak temperatures (greater than 75°F) occurring in July (Figure 8). There was less than 1 degree of variation between temperatures recorded below and above the Thompson Falls Dam (Figure 9). The largest deviation in stream temperatures (approximately ±0.80 degrees) occurred in July when maximum stream and air temperatures were the warmest (Figures 8-10). Throughout the season monitored (March through November), stream temperatures at the two thermograph sites provided similar trends (Figure 8).

Peak river temperatures at the project coincided with peak air temperatures measured in Thompson Falls, Montana (Figure 10). July 2007 was the warmest month of the summer with maximum air temperatures ranging from 84 °F to 105°F. During this same period, daytime stream temperatures ranged from approximately 70 °F to 77°F.

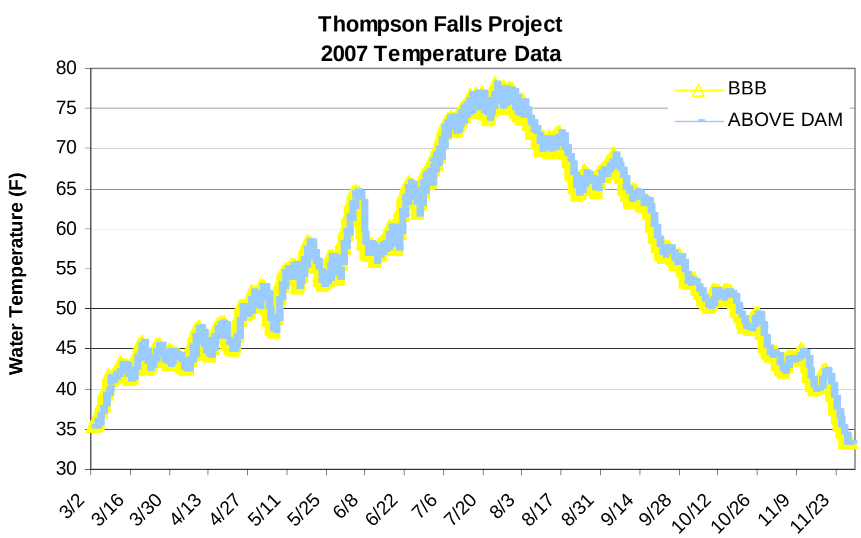

Figure 8. Thermograph data for the Clark Fork River collected Above Thompson Falls Dam (Above Dam) and Below Thompson Falls Dam (BBB – Birdland Bay Bridge) from March 2007 through November 2007.

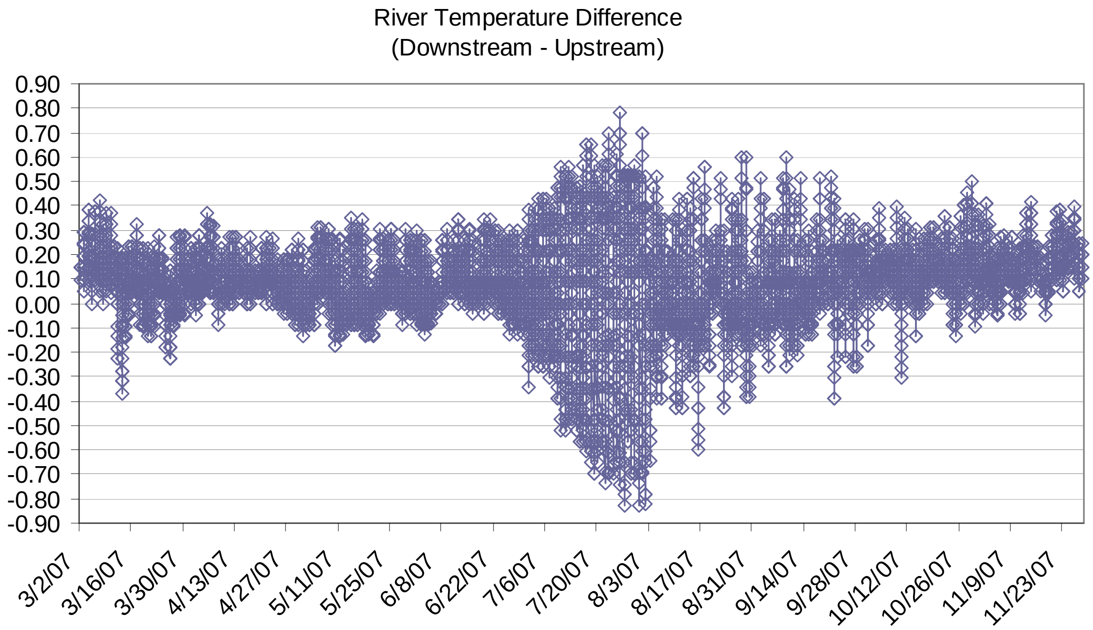

Figure 9. Difference between Birdland Bay Bridge (Below the Dam) and Above Dam thermograph measurements collected in the Clark Fork River from March 2007 through November 2007.

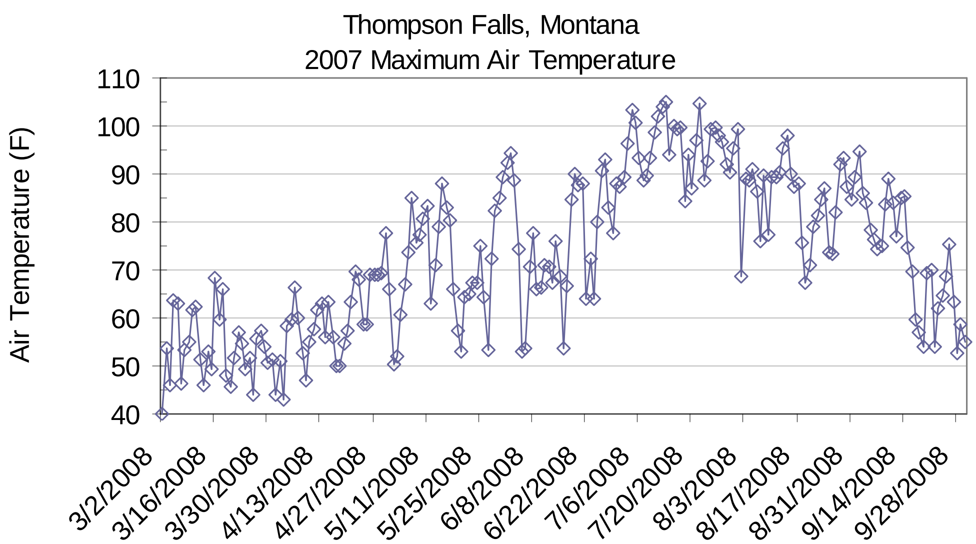

Figure 10. Maximum air temperature in Thompson Falls, Montana from March through September 2007. (Montana USA Weather Data, http://pnwpest.org/cgi-bin/ddmodel.pl).

5.4 Critical Habitat

Since the Project is not located in critical habitat, no impacts to critical habitat are associated with the ongoing operation of the Project. However, Prospect Creek is designated critical habitat. The mouth of Prospect Creek is just downstream of the Project's spillways. Construction of the fish ladder, proposed as a conservation measure for the Project's impact to upstream fish passage, will add sediment to the Clark Fork River during the construction period.

Most of the sediment that will enter the Clark Fork River as a result of fish ladder construction will be deposited downstream in the short reach of the Clark Fork River between Thompson Falls Dam and Noxon Reservoir, or in Noxon Reservoir itself. However, some portion of this sediment may be deposited at the mouth of Prospect Creek. It is anticipated that this sediment deposition will be temporary, and would be flushed during the next high river flow. Any impacts would be limited to a very small area, at the mouth of Prospect Creek, and a short time period (during construction).

It should be noted that the PCE for bull trout critical habitat that is related to sediment calls for substrates of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. This should include a minimal amount of fine substrate less than 0.25 inch (0.63 centimeter) in diameter. The mouth of Prospect Creek is not a bull trout spawning area. Bull trout migrate up Prospect Creek to spawn, rather than using the area near the mouth. Therefore, sediment deposition at the mouth of the stream is unlikely to have any impact on egg and embryo survival, overwinter survival, fry emergence, or young-of-the-year and juvenile survival.

The benefits of constructing the fish ladder (providing volitional upstream adult fish passage) would be long-term and would potentially benefit populations of bull trout throughout the Clark Fork River drainage.

6 Conservation Measures

An MOU is included in Appendix C that has been signed by PPL Montana, the USFWS, MFWP, and the CSKT, collectively known as the TAC agencies. The purpose of the MOU is to establish the terms and conditions for collaboration between PPL Montana and TAC Agencies in PPL Montana's implementation of minimization measures for bull trout as specified in the Thompson Falls License or other resource conservation measures taken voluntarily by PPL Montana.

The MOU provides for the continuing operation of a TAC made up of representatives of PPL Montana and TAC Agencies. The TAC shall function as the means for collaboration on the expenditure of mitigation funds and the implementation of bull trout minimization measures. The MOU also provides for the allocation of annual TAC funds provided by PPL Montana. PPL Montana will bear ultimate responsibility for ensuring that bull trout minimization measures or other resource conservation measures taken voluntarily by PPL Montana are implemented in a manner consistent with requirements of the License.

To the extent consistent with the License, this MOU sets out provisions for adaptive implementation of minimization measures or voluntary minimization measures that may be appropriate due to advancement in technology, project experience that dictates alternative methods implementation, and adequate response to unforeseen or changed circumstances or discoveries during the term of the MOU. The MOU provides assurances to interested agencies, stakeholders, and various public entities that minimization measures to reduce impacts to bull trout at the Thompson Falls Project will be faithfully implemented in a timely fashion by PPL Montana and that operations and maintenance of the Thompson Falls Project are in compliance with the ESA.

6.1 Upstream Passage

The 2003 Draft BE identified the lack of upstream fish passage to be one of the factors that is likely adversely affecting bull trout at the Thompson Falls Project. The following section describes the process that was used to develop the fishway design at Thompson Falls Dam. The Thompson Falls' fishway design has been, and remains, a multi-disciplined initiative with maximum biological-engineering overlap. GEI and PPL Montana have worked with the agencies/tribes to fully incorporate their comments into the fishway design.

Highlights of the Thompson Falls' fishway design development in chronological order are as follows:

- *Pre-design Phase Fish Passage Study Plan, 2003.* First, PPL Montana developed a plan to lay out the steps needed to locate and design adult upstream fish passage at

Thompson Falls Dam. This plan was submitted to the TAC in 2003. The plan identified the need for additional fish behavior data, primarily for bull trout, and Project operations data, prior to the development of a permanent fish passage facility at Thompson Falls Dam.

- *Annual Study Plans, 2004 – 2007.* These study plans were developed in collaboration with the TAC and identified in detail how fish behavior and operations data, as well as other needed information, would be collected. A multi-year radio telemetry study was initiated to track the timing and locations of trout migrations in the tailrace.

- *Thompson Falls Radio Telemetry Studies, 2004-05* – After the 2004 and 2005 telemetry studies, it was apparent that bull trout (only a few of which were tagged and re-entered the tailrace) and other salmonid species migrating upstream during spring, pre-freshet months, were quickly leaving the two downstream powerhouses (discharge up to 23,000 cfs), and moving to the upstream terminus below the Main Dam Spillway, where only spill gate leakage flow (100 cfs +/-) was discharged.

- *Site Selection Letter Report* – Agencies reviewed the draft 2006 Site Selection Letter Report (GEI 2006a), and a meeting was convened in January 2006. The meeting resulted in a consensus that the Main Dam Spillway was the optimum location for an upstream passage fishway. The agencies and tribes requested that a left fishway site be included in the subsequent feasibility study, to which PPL Montana agreed. The feasibility study was completed June 16, 2006 (GEI 2006b).

- *April 2006 Fishway Tour of Columbia, Umatilla (OR), and Yakima (WA) River sites* – Two USFWS and one MFWP representatives accompanied PPL Montana and GEI engineers and biologists on a trip to the Bonneville 2nd Powerhouse, 3-Mile Dam, and Roza Dam adult trapping facilities sites. The purpose of this trip was to observe fish trapping facilities in operation, which would ensure that different features were discussed and understood by all, prior to commencement of the Thompson Falls fishway design development process. This trip enhanced the common understanding of fishway design concepts.

- *Upstream Fishway Feasibility Study* – This study commenced in March 2006, and included an investigation of three fishway alternatives: a right Main Dam Spillway full-height ladder, a right Main Dam Spillway fish lock trap and haul facility, and a left Main Dam Spillway full-height ladder (as requested by the agencies and tribes). Meetings to attain agency and tribal feedback occurred in June and October 2006. At the October 2006 meeting, the USFWS recommended a full-height ladder at the right Main Dam Spillway shore. Note that there were drawbacks to the full-height ladder option, which included potential fall-back (over the spillway to the tailrace) of fish passing the ladder, forebay predation potential that would not have been a concern with the lock trap and haul fishway option, and access limitations for larger fish transport trucks. However, the USFWS was clear that these were not big concerns. PPL Montana agreed to design the full-height ladder, and fish trapping/sampling (but not transport loading) facilities in the upper ladder. The Upstream Fish Passage Alternatives Evaluation - Final Report (GEI 2007a) was completed January 2007.

- *Spillway Gate Opening/Closing Schedule (Spill Schedule)* – On the basis of topography /bathymetry observations, surveys, and experience, it was apparent that a left bank fishway would be complex and costly, and that high- and low-flow entrances at different locations would be needed. This would still not ensure optimum fish passage at the left shore. Yet, 2005 telemetry studies (with normal spill gate deployment operations) showed that fish initially approached the MSD on the left shoreline during spill operations. Therefore, GEI developed a spillway schedule that would satisfy the operational and safety concerns of project operators, and was designed to address the hypothesis that satisfactory tailrace hydraulic conditions could be controlled (through a range of Main Dam Spillway discharges) to block the fish approach to the spillway apron at the left spillway abutment and mid-spillway, while creating attractive fish holding tailrace hydraulic conditions near the right spillway abutment. MFWP staff took many photos of tailrace hydraulic conditions at different spill discharges to assist GEI in refining the spill schedule. The rationale being that upstream-migrating fish will approach and hold at a barrier after approaching using the avenue of least turbulent resistance. The spill schedule was designed to induce fish movement into the spillway right tailrace zone (fishway near-field), where they would perceive a strong attraction flow from (or near) the fishway. The expectation is that these fish will then investigate, find the entrance attraction flow, and pass the fishway. Outcome: 2006 telemetry evaluations would test this hypothesis as a primary 2006 objective.

- *2006 Radio Telemetry Study* – This study was a continuation of baseline telemetry studies in 2004-05, designed to test the hypothesis that tagged fish approaching the Main Dam Spillway along the left shoreline would cross to the right shore and enter the attractive tailrace holding conditions near the right Main Dam Spillway abutment. Outcome: Study conclusions were that tagged bull trout and surrogate salmonid species did approach the spillway and approach the Main Dam Spillway along the right shoreline where they entered the near-field fishway zone at the right abutment. These results were presented at the October 2006 Feasibility Study meeting, where USFWS and the agencies/tribes selected the right bank full-height ladder as the preferred upstream fishway alternative.

- *Thompson Falls Ladder and Trap Preliminary Design* – The further design development of the feasibility study preferred alternative was initiated immediately after the October 2006 meeting with the agencies and tribes. The draft preliminary design, which is equivalent to the 30 percent final design, was sent to the agencies and tribes in mid-January 2007, and a follow-up meeting with the agencies and tribes occurred in early February 2007. Note that the initial site-plan drawings of the full-height ladder and trap were preliminary and showed appreciable excavation of the high rock face adjacent to the fish ladder footprint. It was emphasized that this design needed appreciable refinement to minimize both ladder rock excavation and concrete yardage to keep costs from extending beyond PPLM's budget restrictions. GEI received affirmation from USFWS and other representatives to proceed with design refinements that would reduce costs, but would not compromise fish passage. This included *receiving a verbal waiver to adopt 0.8 ft/sec* (rather than 0.4 ft/sec) approach velocity criteria for the auxiliary water intake screen, which reduced the required screen and intake structure sizes by 50 percent.

- *December 11, 2007 Thompson Falls Fish Passage Interagency Work Group Meeting* – GEI reviewed the updated design with the work group. The primary concern was the relatively new information that a temporary tailrace access embankment from the left to right bank fish ladder construction site would probably be needed during the early part of construction (perhaps from mid-July through October) for the purpose of removing part of the old sluiceway, building a cofferdam to enclose the lower fish ladder footprint for construction, and providing staging for associated equipment. A similar embankment had been constructed in the 1980s when the large spill bay 15 and 16 radial gates were constructed. A concern about possible turbine load-rejection events was also discussed, which would scour portions of the access embankment and induce the need to re-construct possibly the middle third of the embankment. After the lower ladder is constructed, the embankment would be removed. Although other means of accomplishing sluiceway demolition and lower ladder construction is possible, it would entail barge access, and be more costly. A discussion of NOAA/USFWS fishway design criteria not adopted for the ladder design also occurred. Rationale for why these several criteria were not followed was presented and discussed (see details presented in section 6.1.4.1).

- *Construction Drawing for the Thompson Falls Hydroelectric Project Upstream Fish Passage (90% Submittal) January 2008* – The construction drawings (90% Submittal) for the project were prepared by GEI and submitted to PPL Montana in February 2008 and are attached to this BE.

It is anticipated that permitting and design will be complete for the ladder in 2008, with construction to start in 2009.

6.1.1 Primary Ladder Components

The low tailwater elevation, for which fish are present and actively migrating, is at the zero spill operation. 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. Telemetry studies and tailwater turbulence observations suggest that fish trying to approach the Main Dam Spillway are unsuccessful, and those holding immediately below the dam are swept downstream at spill discharges above 25,000 cfs. At spill discharges and tailwater elevations above the 25,000 cfs level, it is envisioned that the fish ladder may be suspended by shutting off ladder inflow to prevent flood damage.

The fish ladder or fishway will be constructed using concrete. Dark additives will be added to the concrete when building the new fishway. A dark colored concrete will suit bull trout nocturnal activities. The final color choice will be determined by the TAC in advance of construction. Shading and overhead cover may also be an option that the TAC will consider during construction.

6.1.1.1 Auxiliary Water System

Attraction flow released from a fish ladder (to attract fish in the spillway tailrace) is often composed of a lower discharge flow passing from pool to pool in the ladder, combined with auxiliary water system (AWS) discharge. The purpose of an AWS is to minimize the size of each fish ladder pool (and overall ladder cost) by dissipating energy from the larger AWS discharge in a stilling pool, then re-introducing it in a quiescent manner into the lower ladder. Since pool-type ladders are designed to allow fish to hold/rest in each pool (by balancing ladder flow, turbulence, and pool volume), passing the entire attraction flow from pool to pool would greatly enlarge the required volume of each fish ladder pool.

The Thompson Falls AWS intake will extend upstream of the dam, near the pier noses of the existing (blocked) entrance to the original sluiceway. The AWS trash racks and screens will be enclosed in this intake structure, and will be large enough to protect juvenile bull trout by essentially negating fish entrainment and passage through the high-velocity pipelines and the turbulent stilling basin. Loads will be transferred directly to bedrock below and immediately upstream of the dam.

Flow passing the AWS intake structure and destined for the lower ladder will pass into two pipelines and be routed into the stilling pool (a zone of extreme turbulence, especially during low tailwater conditions). The volume of water in the stilling pool will dissipate energy from the pipe jets before flow passes through energy dissipation baffles at the downstream end of the stilling pool. Flow passing the baffles will be aerated but residual downstream surging will be minimized. At low design tailwater, flow passing to the entrance pool (pool 1) add-in diffuser will first pass through porosity plates that are designed to induce a hydraulic drop of 1.0 ft with two AWS pipelines operating.

At progressively higher tailwater elevations some AWS discharge will pass over different "chimney" elevations, which are designed to allow AWS flow to be added to pools 3, 5, and 7 as the lower ladder weirs (or orifices) become inundated. These features ensure that fish entering the ladder at high tailwater elevations are able to perceive the increased flow passing inundated lower ladder weirs (6 cfs plus total flow passing through pool 3, 5, and 7 add-in diffusers) and ascend the lower ladder.

A separate component of the AWS is the attraction jet to tailwater. This 20 cfs discharge is for the purpose of attracting fish to the tailwater proximity of the fish ladder entrance by discharging a high-velocity jet into tailwater. It is located where fish attracted by the jet will readily find the fish ladder entrance. Forebay flow is routed through the AWS trash rack, screens, flow-control valve, and pipeline discharging to tailwater.

6.1.1.2 Ladder Pool Design Type

The central ladder section (between the upstream exit control section and the ladder entrance section) passes a constant flow from pool to pool. At Thompson Falls, the "weir" design between pools allows either the 2-ft notched weir to pass the 6 cfs ladder flow, or the 2-ft notch can be blocked and a 12-inch wide by 14-inch high orifice opened to pass the same flow. "Weirs" between successive ladder pools will be adjustable to allow operation in either the notched weir or orifice mode. The purpose of dual options is to best pass bull trout. Biologists desire flexibility to assess which weir design will perform best. Note that in the case of the notched weir, a small orifice will be designed at the base of each weir to allow dewatering of the ladder.

6.1.1.3 Ladder Exit Control Section

The purpose of the fish ladder exit section is to control ladder discharge and modulate flow changes into the ladder associated with varied forebay elevations. Weirs 46-47, 47-48, and 48-49 are not weirs at all but orifices. These three orifices control flow passing into the fish ladder, and are designed to permanently operate as orifices. At the forebay elevation 2,396.0 ft amsl, orifices are sized to pass 6 cfs, which passes from the ladder exit to the lower ladder. During spill, at forebay elevation up to 2,397.0 ft amsl, hydraulic drop at each exit section orifice increases from 1.0 ft to 1.33 ft, thereby increasing ladder inflow to approximately 7 cfs. A bleed-off screen and backset gated overflow allows the extra fish ladder inflow to be controlled, so that hydraulic conditions in the lower ladder are as desired.

6.1.1.4 Ladder Exit Pool and Trash Rack

As fish pass through the tunnel, an exit pool provides holding space where fish may accumulate prior to passing through the trash rack and into the dam forebay. This pool and trash rack must also be attached to the dam and be accessible to personnel for raking the trash rack. A fish ladder dewatering gate will be located at the upstream end of the tunnel. A drilled-shaft column will be constructed to support vertical loadings.

6.1.1.5 Existing Sluiceway Removal and Replacement Wall Adjoining Spillway Apron

A large downstream portion of the existing sluiceway will be demolished to provide room for the AWS stilling basin. The concrete of the sluiceway will be saw-cut vertically at a distance approximately 53 ft (downstream) from the centerline of the non-overflow section of the dam. Based on existing construction drawings and site observations, limited rebar reinforcing was used in the original construction. However, exposed rebar was observed in the invert of the sluiceway at the base of the structure.

Historical construction drawings for the sluiceway indicate a bedrock contact elevation at approximately 2,345 ft amsl. The required excavation for the AWS stilling basin is anticipated to be primarily through the sluiceway concrete with only minimal bedrock excavation.

A new exterior wall for the stilling basin will be constructed adjacent to the existing spillway apron. The wall will extend to 2,366 ft amsl, the estimated tailwater elevation of the 10-year flood, and will be designed for a full unbalanced hydrostatic loading with the stilling basin empty and the forebay at the 10-year flood stage.

6.1.1.6 Tunnel through Dam

A 3-ft-diameter steel-lined tunnel will be constructed through the existing non-spill section of the dam near the right (west) abutment, with a tunnel invert at 2,393.0 ft amsl. We anticipate that the hole for the tunnel will be oversized by approximately 6 inches around the finished size. A steel liner will be inserted into the opening and grouted in place.

At least two methods of tunnel construction could be utilized. For the first method, a pilot hole or holes would be drilled through the concrete from the downstream face of the dam. A diamond wire saw would then be used for cutting the required circular shape through the dam. For the second method, a rectangular section of the dam would be cut from the top of the dam to the required invert with a diamond wire saw. The 3-ft-diameter steel liner would be grouted in place. Dowels would be epoxy-grouted into the vertical edges of the saw cut, and the remaining void would be backfilled with structural concrete. It is anticipated that waterstops would also be required to be embedded for this method and minimum temperature and shrinkage rebar reinforcement would be used.

A temporary cofferdam on the upstream face of the non-spill section of the dam, or approved alternative, will be required for either construction method.

6.1.2 Sample Facility Components

Functional features of the fish sampling facility at the proposed fish ladder were agreed upon by the TAC. In general, the TAC agreed that the fish sampling facility should accommodate the following functional needs, and should:

- Be designed for handling by one person;
- Include options for anaesthetizing, sorting, fish recovery, scanning for Passive Integrated Transponder (PIT) tags (by a portable scanner), and returning fish to the ladder so fish can pass to the forebay;
- Include an option for returning fish to the tailrace;
- Be sized to handle a large volume of fish;
- Maintain good access to the fish ladder pool 46 so that fish can be netted if needed;
- Include a fail-safe provision (diffuser gate at upstream end of pool 49) to ensure that a fish accidentally released into the ladder can be prevented from passing into the forebay; and
- Allow truck-transport of a few fish at a time.

6.1.2.1 Design Features

The design includes the following fish sampling facility features in fish ladder pool 46 and the fish sampling loop:

- Fish trapping mechanism space (compatible with either a vee-trap or finger weir);
- Fish holding pool (adjacent to ladder pool 46);
- Fish crowder;
- Fish lock;
- Fish sorting table;
- Anesthetic tank;
- Recovery tank;
- Return flume to fish ladder pool 49;
- Fish return pipe to tailwater; and

- Grating at the tunnel outlet that can easily be raised/lowered as a fail-safe measure to prevent accidental escape of a non-intended fish (e.g., invasive species) from reaching the forebay.

While the preliminary design of the sampling facilities has been completed, the completion of the detailed design of fish sampling facilities will be delayed until later in 2008. However, the current plan is for concurrent construction of the fish ladder and sampling facility in 2009. Drawings in Appendix B show the sample facility's plan view; the design of which was developed to ensure compatibility with the new fish ladder design. Note that the upstream portion of the holding pool is also the lock interior.

6.1.2.2 Sample Facilities Operations

To operate the sample facility, it is necessary to route flow from the fish lock (screened flow originating from the AWS intake) to the downstream end of the holding pool and through the screen and backset weir gate to a downwell and drain pipe. The sampling holding pool has its own water supply and drain system and will pass 0.5 cfs regardless of whether flow is being discharged into the holding pool through the lock.

To transition into the trapping mode, two diffuser panels in fish ladder pool 46 are lowered to create uniform velocity at the (downstream) fish barrier diffuser panel and to block fish from ascending further upstream and exiting the fish ladder. When sampling/trapping is completed, the diffuser panels will be raised to re-establish fish passage to the upper ladder, tunnel, and ladder exit pool.

With both diffuser panels in place, gravity attraction flow can be routed from the fish lock through the trapping mechanism, and blocked fish will then be attracted by flow (up to 2 cfs) from the holding pool and can pass the trapping mechanism to enter the holding pool. The design includes operational flexibility to use one of two types of trapping mechanisms (finger weir or vee-trap) in a short channel between pool 46 and the holding pool. The need for two options is based on uncertainty over which design will best trap bull trout, whose behavioral response to entering the holding pool from the ladder is uncertain. A discharge of up to 2 cfs can be passed through the fish lock and holding pool to pool 46.

Flow into pool 46 will be from the ladder exit and from the holding pool. However, a constant discharge from pool 46 to pool 45 is desired. There is flexibility to vary flow passing into and out of pool 46, such as when 2 cfs passes through the trapping mechanism (during trapping), or when the 2 cfs discharge is interrupted (during crowding and locking of fish). The pool 46 bleed-off downwell with flush screen, backset porosity plate, and backset adjustable weir gate can be adjusted to balance flow entering and leaving pool 46, thereby ensuring the desired discharge passes downstream to the lower ladder.

When trapping fish, the fish work-up cycle is initiated by lowering a closure plate on the holding pool side of the short trapping mechanism channel, then shutting off the holding pool water supply from the fish lock by closing a valve supplying gravity inflow to the fish lock. The fish crowder then crowds fish into the fish lock. The lock closure gate is closed and water is pumped into the lock (below the floor brail) to raise the lock water level. Fish and pumped flow overtop a lock transition lip elevation and pass onto a sloped flume. A chute floor-screen allows pumped lock water to bleed off while fish slide down the chute onto a sorting table. The floor brail in the lock can be raised and lowered remotely by the operator to control the number of fish passing out of the lock and toward the work-up table, so that all fish do not pass onto the sorting table at once. Since only a few target fish are expected to be present, most fish will be returned from the work-up table directly to fish ladder pool 49. The work-up table will also have a tailrace return pipe to send invasive (or other non-target) species fish back to the tailrace.

Target fish can be scanned by a portable PIT tag detector and routed from the work-up table into an anesthetic tank. While biologists may decide that target fish will not be anesthetized, fish can be detained in this tank while awaiting transport, tagging, or other sampling activities. A recovery tank is also provided so that anesthetized target fish can be revived before being returned to pool 49 or transported manually in a small portable tank to a utility truck. All fish returned to pool 49 will accumulate until a diffuser panel is opened at the tunnel outlet. The purpose of the diffuser panel is to ensure that fish not allowed in the forebay, such as invasive species, are not accidentally allowed to pass through the tunnel. If an invasive nonnative fish enters pool 49, it can be netted. Once this diffuser panel is opened, target fish can pass through the fish ladder tunnel, exit pool, and trash rack to enter Thompson Falls Dam Reservoir and proceed upstream.

6.1.3 Appurtenant Facilities

6.1.3.1 Fencing

The ladder will be accessible from two directions, the left (east) abutment via the Main Dam Spillway and the right (west) abutment via the Gallatin Street Bridge (currently load limited) and walking trail. Existing fencing at the left abutment will be sufficient to control left abutment ladder access. The existing locked gate entrance on the non-spill section of the dam will block public access from the island walking trail. However, removal of this gate may be required to facilitate construction of the fish ladder. Additional barriers along the rock walls adjacent to the ladder will be needed to prevent the public from accessing the ladder and sampling facility. PPL Montana will have final decision on fence placement.

6.1.3.2 Access Walkway

Non-slip steel grating and steps will be installed to allow access to all pools of the ladder, sampling facility, stilling basin, and intake and exit trash racks. The grating will be designed to meet Occupational and Safety Health Administration (OSHA) requirements. The stilling basin will be completely covered with grating to minimize the risk of trash and debris entering the stilling basin from above.

6.1.3.3 Electrical Design

The fish passage facility will have 120 volt power outlets and lighting strategically placed to power hand tools and maintenance equipment throughout the fish ladder system. Electrical power will be distributed to automated components of the ladder system as required by the control system. All control circuits will be powered by single phase power. Three phase power will be required to operate the lock water supply pump at a location to be determined. Lighting for the surrounding area will be installed to illuminate all walkways including the ladder, sampling facility, stilling basin, lock, and trash racks. Flexibility to turn some, or all, lighting off at night is needed, as bull trout are known to pass fish ladders at night, and may pass more effectively if lights are turned off.

6.1.3.4 Temporary Latrine

Currently there is a load limitation for the Gallatin Street Bridge. Due to the Gallatin Street Bridge reduced load limitations, a temporary latrine cannot be installed on the right abutment. Bridge renovations are needed to increase the weight limitations of the bridge, which will then allow a mobile latrine and its support vehicle to reach the right abutment for installation. The crane shack area on the left abutment is the closest location for portable latrine installation at this time.

6.1.4 NOAA Fisheries Design Criteria

6.1.4.1 Application and Intent of the NOAA Fishway Design Criteria and Guidelines

The Thompson Falls Fishway complies with NOAA/FWS Fish Design Criteria. The following are excerpts from the "Forward" page 4 of 114, of the "*2007 NOAA Anadromous Salmonid Passage Facility Design*" document.

For the purposes of this document, a criterion is preceded by the word "must". A guideline is a recommended design, maintenance or operational feature that will generally result in safe and efficient fishway facility design, and for the purposes of this document are preceded by the word "should"... It is the responsibility of the applicant to provide compelling evidence in support of any proposed waiver of criteria or modification of a guideline for NOAA approval, well in advance of a proposed Federal action.

Since these design guidelines and criteria are general in nature, there may be cases where site constraints or extenuating biological circumstances dictate that certain criteria can be waived or guidelines can be modified without delaying migration or otherwise adversely impacting anadromous fishes. In addition, there may be instances where NOAA Fisheries provides written approval for use of alternative passage standards, if NOAA Fisheries determines that the alternative standards provide equal or superior protection as compared to the guidelines and criteria listed herein, for a particular site or for a set of passage projects within the Northwest Region.

Steve Rainey, lead designer for the this project and primary author of the NOAA/USFWS Fishway Design Criteria, identified that the intent of the criteria is not to force developers to design and build the largest and most costly possible fishway. Rather, the <u>intent is to ensure that a satisfactory fishway is implemented, which will safely and quickly pass fish, and satisfy accepted fish passage performance standards</u> (Rainey, GEI Consultants, personal communication, 2008).

The waiver provision leaves the door open for the developer to initiate necessary investigations so that specific fish behavior, site configuration, and localized hydraulic conditions can be integrated as the basis for designing, but not over-designing, the new fishway. These investigations also reduce the risk that the new fishway performance will be sub-standard. As an example, the attraction discharge *"guideline"* requiring 5-10 percent of mean annual discharge through the fishway gives the option of either (1) building the more expensive fishway option that has a moderate probability of being successful while saving by not conducting, in advance, tailrace hydraulic and/or fish behavior studies; or (2) conducting investigations early to gain a better understanding of indigenous fish behavior, which will allow development of a fishway design on the basis of site-specific considerations, and the intent to achieve similar fish passage performance with a more economical design. The pivotal requirement, as in the criteria waiver provision, is that a *compelling* case be made in favor of compromising each criterion under consideration (see following text).

From the perspectives of the USFWS, PPL Montana, and other stakeholders, the optimum fishway at Thompson Falls is one that best satisfies site-specific project configuration, fish behavior, operational, and economical needs. Building a larger fishway at the selected site, including passing 10 percent of mean Clark Fork River discharge, would easily double the construction costs, without the prospect of improved fishway passage performance. Rather, PPL Montana invested in several years of radio-telemetry studies, and a methodical and comprehensive fishway site-selection and design development process to select a design that all stakeholders endorsed. On-site investigations suggest that this fishway design will be successful and affordable (relative to other options). Thus, the Thompson Falls fishway design is considered in compliance with NOAA/USFWS Fishway Design Criteria. Further, PPL Montana takes responsibility for the fishway performance and understands that if the fishway does not perform in the optimum manner, other fish passage initiatives at Thompson Falls will be sought by stakeholders.

6.1.4.2 Evidence in Support of NOAA/USFWS Fishway Design Criteria/Guideline Waiver Requests

There are three instances where NOAA/USFWS Fishway Design Criteria and Guidelines were not followed in the Thompson Falls ladder and trap design. These criteria were discussed in various meetings with the agencies/tribes and are presented below.

Guideline #1 - Modification of the 5-10% of Mean River Discharge Fishway Attraction

Guideline wording from NOAA/USFWS Fishway Design Criteria and Guidelines:
Attraction flow from the fishway entrance <u>should</u> be between 5% and 10% of fish passage design high flow for streams, with mean annual streamflows exceeding 1000 cfs. For smaller streams, when feasible, use larger percentages (up to 100%) of streamflow. Generally speaking, the higher the percentage of total river flow used for attraction into the fishway, the more effective the facility will be in providing upstream passage.

During the writing of the NOAA/USFWS Fishway Design Criteria and Guidelines, there is no sound scientific basis for either the 5 percent or the 10 percent in the referenced attraction flow guideline (Rainey, GEI Consultants, personal communication, 2008). There are examples of fishways that successfully pass fish at far less than 5 percent, and fishways that are marginally successful passing fish at over 10 percent. That is one reason this is a <u>guideline</u>, and not a more hard-fast criterion. There is a lot more that differentiates successful passage at one fishway vs. another than just total attraction flow. Examples are discussed below.

At Thompson Falls, three years of radio-telemetry studies were conducted to identify fish behavioral trends of bull trout and surrogate species (2004-06). This resulted in a more specific understanding of tailrace fish behavior and the type and location of facility required to attract and pass upstream migrating fish.

It was learned that radio-tagged fish leave the large downstream discharge area of the two powerhouses (up to 23,000 cfs) and head to the upstream terminus of the main river channel (the Main Dam Spillway), even during non-spill periods. Discharge attracting tagged fish to the Main Dam Spillway amounted to approximately 100 cfs from cumulative leakage at the small and large spill gates across the entire spillway.

During non-spill (leakage only) operations, a temporary baffled (denil) fishway was used to collect migrating fish during pre-spring freshet migrations months and (to a lesser extent) during the summer and fall. Its discharge was only 2 cfs.

A distinction was made, and accepted by the agencies/tribes, that bull trout generally display more assertive upstream migration behavior from March through the peak of the spring freshet in mid-June. After the peak of the hydrograph in mid-June, tagged bull trout and other tagged salmonids dropped downstream and generally out of the project area.
During non-spill operations, the current discharge at the spillway is approximately 100 cfs. Thus, attraction flow would be defined as a percentage of the **overall discharge at the spillway (100 cfs)**.

During *non-spill operations* in the spring (river flow less than 23,000 cfs), the fishway design entails the flexibility to discharge 6 cfs (ladder flow only, 6 percent of spill leakage flow), 24 cfs (ladder plus one auxiliary water flow pipeline, 24 percent of spill leakage flow), 42 cfs (ladder plus the other auxiliary water flow pipeline, 42 percent of spill leakage flow), 60 cfs (ladder plus both auxiliary water flow pipelines, 60 percent of spill leakage flow), or 80 cfs (high-velocity jet discharge plus 60 cfs attraction flow from ladder entrance, 80 percent of spill leakage flow). During non-spill, the NOAA/USFWS attraction water ratio of 5-10 percent of total discharge (total spill in this case) can be discharged to attract fish. Field experience will dictate the amount necessary to pass fish during non-spill operations, but there is operational flexibility to exceed guidelines.

2004-2006 Thompson Falls Telemetry Studies showed that during upstream migration periods, fish appeared to undertake more search-type forays and did not appear to hold in any one location for long periods of time. These more frequent and active forays suggest that fish are engaged in a search for a viable upstream passage route and continue looking until they either find one, lose that migration urge, or are displaced back downstream by high river discharges during the late spring freshet.

It is not just total attraction flow that determines whether fish will find and enter a fish ladder, it is also the location of the fishway entrance. If the fishway discharges 20 percent of the mean river discharge at a marginal location, fish will not enter the fishway. Conversely, if the location is ideal relative to where fish hold when earnestly migrating upstream, a very small discharge is all that is required to attract and pass these fish. For example, at Thompson Falls fish pass with the total turbine discharge of up to 23,000 cfs and are attracted upstream a few thousand feet to the MSD tailrace, where ± 100 cfs of gate leakage is enough to draw these fish. Fish appear to be drawn not to total discharge but to the upstream terminus of the original river channel where they were trapped by the 2 cfs baffled chute deployed by PPL Montana and agency personnel. It is emphasized that 2 cfs is far below the 5-10 percent criteria in the NOAA/USFWS Criteria.

The distinction is made between the near-fishway tailwater zone and the far-fishway tailwater zone. A greater attraction discharge is required to attract more fish from the far-fishway zone, which is further away from the fishway. Once fish pass into the near-fishway zone, the fish follows a lesser attraction flow (when presented in an appropriate manner into tailwater with suitable fish holding hydraulic conditions) into the fishway.

Below Round Butte Dam (Deschutes River, OR) in the immediate tailrace, there is a small nitch at the absolute upstream terminus of the original river channel below the powerhouse that is an ideal location for bull trout holding. A pool has been constructed and a finger weir has been adapted to collect fish at that site. Since the near-fishway tailwater zone location is excellent for bull trout holding, only a few cfs are discharged. The end result is that bull trout trying to migrate upstream readily enter the pool. (Trap pool discharge is approximately 4 cfs, and turbine capacity is approximately 6,000 cfs at Round Butte.) Again, it is emphasized that location is often far more important to fishway passage performance than quantity of attraction water discharge.

It is conceivable that Thompson Falls' new fishway would have been constructed near one of the powerhouses where over 99.9 percent of total river discharge occurs during non-spill operations had PPL Montana not initiated telemetry studies to identify site-specific fish behavior. Even with a fishway that would discharge 2,300 cfs (10 percent of peak turbine discharge), telemetry studies suggest that many fish would readily leave this project area and migrate to the upstream terminus at the MSD, a few thousand feet upstream. Since telemetry studies were conducted at Thompson Falls, the risk of not meeting fish passage performance standards was greatly reduced for this project. This reduction of risk of poor fishway performance is based on compelling telemetry evidence that the selected Thompson Falls' fishway is at the optimum location.

A high-velocity jet (HVJ) attraction feature (20 cfs and over 20 ft/sec velocity) has been added as a flexibility feature to attract fish that hold in the far-fishway tailwater zone out of the right quadrant of the Main Dam Spillway tailrace (such as referenced in the 2006 telemetry study) during non-spill operations. During spill operations, the spill schedule will leave the right Main Dam Spillway near-field tailwater zone as the only suitable holding zone near the spillway apron. Fish behavioral studies show that upstream migrating fish are attracted to high-velocity discharges even though they may not be able to pass. If the HVJ is near a fishway entrance, experience has shown the fish will be attracted to, enter, and pass the fishway. Once fish detect and approach the HVJ, it is expected that they will move (along the outside of the HVJ perimeter) to the upstream jet discharge point, which is only a few feet from the new fishway high flow and low flow entrances where up to 60 cfs attraction is to be discharged at 8 ft/sec. It is expected that fish from the far-fishway tailwater zone will be more readily attracted to the near fishway tailwater zone by the HVJ (because of the higher velocity energy dissipation in the tailrace) than by the 60 cfs attraction jet at 8 ft/sec. Thus, the HVJ will augment attraction to the new fishway. HVJs are used at numerous fishway locations throughout the Northwest (Rainey, GEI Consultants, personal communication, 2008).

During spill operations, the Main Dam Spillway tailrace becomes highly turbulent, and tailwater elevation rises quickly. A spillway gate opening-closing sequence (spillway schedule) was developed to create tailrace hydraulic conditions suitable for fish holding at the upstream terminus and near the right bank Main Dam Spillway abutment, while increasing tailrace turbulence at the left and center Main Dam Spillway. The 2006 telemetry study's primary objective was to see if tagged fish would enter the right bank near-fishway tailwater holding zone where they could detect, enter, and pass the new fishway. It was concluded that fish did enter and hold in the right bank near-fishway tailwater zone. Thus, it was concluded that fish would be able to detect and pass a right fishway that did not pass attraction discharge equaling the full 5-10 percent of spillway discharge.

During spill operations, the current ladder design has multiple attraction flow options that can be deployed: (1) up to 60 cfs discharged through the ladder entrance; (2) a 20 cfs HVJ with over 20 ft/sec discharge velocity, which is located next to the ladder entrances and will discharge parallel to the apron spring-point; and (3) a third attraction feature that does not route flow through the fishway, the adjacent spillway lift gates (233 cfs each).

It is emphasized that not all attraction discharge needs to pass *through* the fishway to attract fish from the far-fishway tailwater zone to the near-fishway tailwater zone. If there is no spill and fish are not otherwise attracted to the right near-fishway area, a partially or fully opened spill gate(s) will certainly attract fish to this zone. Telemetry studies suggest many migrating fish will move around the entire tailrace seeking an upstream route during the peak few weeks or months of their upstream migration. Therefore, it is expected that the same fish that found and entered the 2 cfs baffled chute trap below the MSD apron would also find and enter the new right bank fish ladder.

If the attraction flow from the fish entrance is assumed to be 60 cfs plus 20 cfs HVJ attraction discharge during spill operations (again, ignoring powerhouse discharge of up to 23,000 cfs, upstream of which fish move to approach the Main Dam Spillway), the percentage of attraction flow during a spill discharge of 10,000 cfs is 0.8 percent. But, as previously expressed, the spill schedule is designed to reduce the footprint of the location of optimum fish holding to the near field of the new right fishway. Therefore, it is not only the total discharge that is expected to attract fish to the new fishway near-tailwater zone, but the optimum tailwater holding zone hydraulic conditions associated with the above-referenced spill schedule. Coupled with aggressive searching forays demonstrated by migrating bull trout and other salmonid species during telemetry studies, it is expected that these fish will readily find the new fishway and pass it. If additional attraction water is required to attract fish into this zone, there is flexibility to open one or more spillway lift gates (233 cfs each) to attract fish into the near-fishway tailwater zone. With two spillway lift gates open (466 cfs) and a total of 80 cfs from the fishway and HVJ, the ratio of total attraction flow to spillway discharge is 546 cfs to 10,000 cfs, or 5.46 percent.

With the spill discharge of 25,000 cfs, which is near the high design discharge for operation of the new ladder within criteria, operation of 80 cfs from the new fishway combined with 466 cfs from two opened spillway lift gates gives an attraction ratio of 646 cfs to 25,000 cfs, or 2.6 percent.

Guideline #2 - Modification of the Turning Pool Length

The wording from NOAA/USFWS Fishway Design Criteria and Guidelines is as follows: Turning pools (i.e., where the fishway bends more than 90°) should be at least double the length of a standard fishway pool, as measured along the centerline of the fishway flow path. The orientation of the upstream weir to the downstream weir must be such that energy from flow over the upstream weir does not affect the hydraulics of the downstream weir.
The following information is provided as the basis for reducing fish ladder turning pool size, relative to the guidelines referenced above. This assessment explains why reducing turning pool size, but not volume, is deemed permissible for this design. The intent of this guideline is to address in a generic and broad-brush manner the observations of steelhead jumping at a few fish ladder pools in the Northwest. As the incoming jet turns, its jet may upwell on the outside wall of the turnpool. This upwell can induce jumping in fish with steelhead trout-like behavior. This problem is not uniformly observed at all fish ladders with steelhead nor does every steelhead jump at the few sites in questions. The requirement for double pool length is also a *guideline* and not a criterion.

In the Thompson Falls fish ladder, there are 48 pools and 47 weirs plus the fishway entrance. The design is in its advanced stages, with 90% design complete (*Construction Drawing for the Thompson Falls Hydroelectric Project Upstream Fish Passage (90% Submittal) January 2008* in Appendix B). The length of the fish ladder is approximately 300 ft. The ladder is to be constructed in the triangular footprint immediately downstream of the non-overflow section of the Main Dam Spillway right abutment, and the footprint is flanked by a nearly vertical 40-ft-high bedrock face. Currently, the construction of this fish ladder entails removal of hundreds of yards of bedrock. The fish ladder currently has seven switchbacks with two successive 90° bend pools each.

At the 30% (preliminary) design phase, each switchback entailed one pool with double length, according to the guideline. This ladder layout entailed encroachment into the adjacent vertical rock face and more than twice the excavation yardage of bedrock than with the current design. As discussed in the February 2007 Preliminary Design meeting, this 100 percent increase in rock excavation greatly increased ladder implementation costs for PPL Montana. It was understood by all stakeholders that rock excavation costs needed to be reduced, while minimizing adverse fish passage impacts. The modification to the pool length in the 90% design plan, which addressed cost issues, resulted in an approach comparable to the guidelines. The design modification is summarized below.

The ladder length was shortened, relative to the preliminary design layout, by changing the 180°, double-length pools to two 90° turn pools at each switchback. However, rather than reducing 90° turn pools to the 6-ft length of non-turn ladder pools, the 90° pools were designed with an 8-ft length. Additionally, each 8-ft pool is 2-ft deeper than the non-turn pool depths. This gives nearly the same pool volume as the guidelines for 180° turn pools. The reduced length does not create excessively turbulent conditions in turn pools that limit areas where fish can hold before ascending the next weir. The 90° turn pools are still deeper and longer than non-turn pools and thus less turbulent (since greater pool volume reduces turbulence for the same inflow and drop from the upstream pool). This means the Energy Dissipation Coefficient (EDC) for turn pools is lower than for the non-turn pools.

For example, non-turn pools have a volume of 5 ft wide x 6 ft long x 4.5 ft average depth. Combined with 6 cfs inflow and a 1.0 ft head, the EDC is 2.77. As a frame of reference, the maximum allowable anadromous salmon fish ladder pool EDC is 4.00, so the turbulence level in Thompson Falls non-turn pool is approximately 70 percent of that in salmon fish ladders. For turn pools (for which the minimum length is 7.25 ft) volume is 5 ft wide x 7.33 ft long x 5 ft deep. Combined with 6 cfs inflow and 1.0 ft head, the maximum turn pool EDC is 2.04. Turbulence in the smallest turn pool is 73 percent of that in non-turn pools.
In conclusion, there will be plenty of fish holding space in turn pools for indigenous migratory species seeking to pass the new ladder at Thompson Falls. As an additional flexibility feature, there is the ability to adjust ladder flow in the 44 lower ladder pools, consisting of a screened bleed-off overflow weir. This weir can reduce ladder flow to approximately 5 cfs, which would further reduce turbulence in each pool, if necessary. Careful review of the guideline indicates that double length pools are not required for 90° pools, just for 180° pools. Thus, the Thompson Falls ladder does not conflict with guidelines as they are currently written.

The most important issue at the new Thompson Falls, in terms of fish passing the new ladder, appears to be whether non-steelhead species will be adversely impacted. And if adverse impacts are observed, what should be done to reduce those impacts? Jumping out of the ladder, or sustaining strike-type injuries, are the primary apparent uncertainties. Currently, jumping in the few fish ladders where the problem is documented tends to occur in one or two pools and not in every pool in the entire ladder.

Fish passing the new ladder at Thompson Falls include bull trout, rainbow trout, westslope cutthroat trout, and other trout and non-trout species. It is possible that some of these species will have jumping tendencies, especially over the notched (prefabricated) weirs between pools. Flow over the weir, however, is designed to not plunge so that fish can readily swim over the weir without jumping.

The ladder design entails a 2 ft freeboard above design ladder pool water surfaces. This will prevent jumping fish from passing over the sidewalls. Half of each ladder pool is covered by walkway grating, which will limit the number of fish jumping out of the ladder entirely. If fish do jump, another approach is to reduce the risk of injury. This can be done by providing netting, neoprene, or similar soft surface material to absorb jump impact and negate blunt force bruising or laceration-type injuries.

Preliminary shakedown operations of the new fish ladder at Thompson Falls should allow assessment of whether there is a jumping issue. One provision that will directly influence jumping is changing ladder flow hydraulic conditions. Switching from notched weir to orifice flow (or vice versa) at each pre-fabricated weir offers flexibility to potentially negate any jumping problems encountered.

The sample facilities at Thompson Falls will be used to enumerate, tag, and otherwise interrogate fish. It will also allow an examination of whether fish show signs of recent injuries (such as from jumping). Thus, if there is a problem, it can be readily identified and corrected.

6.1.5 Construction Process

It is anticipated that construction will commence in 2009. Staging and mobilization of materials will occur in the winter and spring of 2009, so that construction can begin immediately once the spring freshet is complete. Construction would target early spring 2010 for completion of in-river work, prior to the beginning on the spring freshet. The entire project is expected to be completed by fall 2010.

The ladder construction will require permits from the State of Montana and the U.S. Army Corps of Engineers. Applications for these permits will be made during 2008. These permits will require plans to control erosion and provide emergency response plans in the event of a fuel spill.

6.1.5.1 Access to Construction Site

The ladder location is on the right bank of the main dam spillway. This bank is on an island. A bridge provides access to the island; however, load restrictions on the bridge (8,000 lbs/axel) will limit access to heavy equipment. The contractor will be responsible for developing the detailed construction plan. It is expected that the contractor will use a barge to bridge heavy equipment and supplies to the site. In addition, access to the fish ladder location from the left bank of the main dam will require improvements to the tailwater area directly below the main dam. By manipulating the existing boulders that are distributed across the tailwater, the contractor could construct a navigable access road while reducing the amount of temporary fill required to create a smooth driving surface.

The temporary access road construction would require grading approximately 750 ft of boulders approximately 50 to 100 ft downstream of the main dam. Design criteria for the construction of this access road would require the contractor to utilize a washed gravel fill, such as a washed No. 57 standard rock gradation (1/2-inch nominal rock size) with a maximum fines content of 3 percent. The contractor could be required to place a geotextile fabric between the graded boulders and the gravel base. This would provide additional stabilization of the access road as well as allow removal of a greater percentage of the gravel fill upon completion of the project.

A 15-ft-wide access road with a nominal gravel base depth of 12-inches and provisions for vehicle turn around areas would require approximately 500 cubic yards of temporary gravel fill if a geotextile is utilized. It has been estimated that approximately 75 percent of this total volume could be removed upon completion of the access road utilization.

Temporary culverts would be required at the deeper sections of the crossing to pass leakage flow through the main dam stop logs. However, it may not be practical to require the contractor to provide a culvert area large enough to pass flow from radial gate operation.

Access to the tailwater would require cut and fill near the south abutment in an area that was disturbed during the installation of the 2 radial gates of the main dam. Native material from any excavations in this area would be used for fill of the ramp.

The contractor will also have the option to utilize materials such as timbers or temporary polymer mats for tailwater access. However, the relative cost of either of these options may outweigh the economic incentive of the tailwater crossing to the contractor.

6.1.6 Schedule

A summarized Project schedule is provided in Table 10.

Table 10. Summary of Thompson Falls Project Schedule.

Activity	Date
Biological evaluation submitted from PPL Montana to USFWS	March 10, 2008
Comments from USFWS on BE (conference call)	March 26, 2008
Make final revisions to BE and submit to FERC	April 4, 2008
FERC submits BA to USFWS (assumed date)	April 25, 2008
Completed plans and specifications	May 16, 2008
Final design report	June 13, 2008
USFWS Final biological opinion	September 15, 2008
Contractor selected	September 15, 2008
Begin implementation of recommendations that can be implemented without FERC order	September 30, 2008
Apply for USACOE and State permits	September 30, 2008
Application to amend license	October 30, 2008
Receive USACOE and State permits	December 30, 2008
Final FERC Order	January 2009
Start construction	Spring 2009
Complete construction	Fall 2010

6.1.7 Monitoring and Evaluation

PPL Montana will develop the monitoring and evaluation plan at a later date in consultation with the TAC. The goal of the monitoring plan will be to determine the best operational strategy for the ladder and to assess the effectiveness of the ladder in passing bull trout and other migratory species. The design of the ladder provides many opportunities for adjustments to attraction flow and in-ladder conditions. The ladder can be operated with a wide range of attraction flows. Pool to pool passage can be through orifice or weirs. In addition, the spillway panel opening pattern can be adjusted to enhance ladder effectiveness. It is anticipated that the monitoring program will take place over a number of years while experiments are conducted to find the most effective configuration and operational strategy.

A monitoring plan, agreed upon by the TAC, will be in place prior to the first year's operation, anticipated to be 2011.

6.2 Downstream Passage

The TAC has agreed that fish screens and bypass facilities are not recommended for Thompson Falls at this time, although they would like to leave the door open on this topic in the event new information or new technology changes the situation. The TAC feel that downstream passage is desirable, and want to pursue the concept of returning free and open passage in both directions in the Clark Fork River. Trap and transport of downstream migrating juveniles may be desired in the future but this is not the proposed plan at the present time.

The conservation measure that will be implemented immediately is the establishment of a formal TAC, set in place with a Memorandum of Understanding (MOU) (provided in Appendix C). The TAC will be responsible for making recommendations on the expenditure of the funds that PPL Montana will provide for fish habitat protection and improvement. PPL Montana will provide $100,000 per year, and the TAC will determine the means to use funds to leverage additional funding for project work. Fish habitat protection and improvement work may focus on, as an example, identified bull trout spawning tributaries in the middle Clark Fork River extending upstream of Thompson Falls to the mouth of the Blackfoot River.

6.3 Water Quality

Gas bubble trauma (GBT) has not been noted in fish in the Thompson Falls Project area; however, no direct attempt has been made to monitor for this condition. In the spring of 2008, fish will be monitored in the tailrace to determine the incidence of GBT, if any. Fish will be collected by electrofishing and examined to assess the level of GBT.

Gas supersaturation is inversely proportional to depth. A fish 2 meters deep experiences TDG pressures of 100 percent saturation when the TDG at the surface is 120 percent saturation. Therefore, fish behavior is a factor that determines the risk to fish health posed by high TDG levels. In 2008, depth monitoring radio transmitters will be installed in fish in the tailrace to assess fish exposure to high TDG conditions. In addition, monitoring of TDG levels in the forebay and tailrace will be continued until questions about TDG impacts to bull trout are resolved.

As described previously, the TDG monitoring program has been in place for five years. PPL Montana proposes that the TDG monitoring program continue on an annual basis, as determined by the Thompson Falls TAC, using the principle of adaptive management.

Additional monitoring objectives that are supported by the information collected so far are as follows:

1. In general, for the five years this program has been in effect, river flow levels have been near average to below average. The effects of the Dam and natural Thompson Falls on TDG of daily average flows above 80,000 cfs have not been measured. Although it appears that TDG levels level off (Figure 7) as river flow approaches 60,000 cfs, the question of the maximum effect of the project on TDG remains.
2. Starting in spring of 2006 and continuing through the present, the operation of the spillway panels was changed for the benefit of the fishway feasibility study. The order of the panel removal was changed to provide flows attractive to migrating fish on the right side of the dam, while discouraging migrating fish on the left side of the dam. The graph of TDG pressure vs. total flow for years 2003-2007 (Figure 7) indicates that the change in operation may have resulted in slightly increased TDG tensions. Additional monitoring is needed to verify or refute this preliminary finding.
3. An additional TDG monitoring site will be added in the spring of 2008, immediately below the main dam spillway and upstream of Thompson Falls. Data from this site will be used to assess the relative contribution of TDG from the dam and from the falls.

The monitoring objectives spelled out above are not intended to be studied indefinitely. Through the use of adaptive management, when sufficient information is obtained, the program will either be discontinued because concerns have been resolved or will change focus to generate new information on worthwhile objectives that have been developed by the Thompson Falls TAC.

6.3.1 Methods

Methods used in this program will follow the current monitoring program. Data will be collected each spill season from the onset of spill until the cessation of spill over Thompson Falls Dam, a period of approximately 3 months. Water quality parameters (date, time, temperature, pH, specific conductivity, dissolved oxygen, turbidity, depth, and TDG) will be measured with Hydrolab DataSonde Series 4 or Series 5 equipment programmed to read at hourly intervals. All equipment time will be calibrated to +/- one minute. At each site, a DataSonde will be deployed in a vertical pipe that was perforated at the bottom end to allow free exchange of water. DataSondes will be positioned at a minimum depth of six feet.

Deployment intervals between cleaning and calibration will be about four weeks. Hourly barometric pressure readings will be measured with Onset Computer Corporation HOBO equipment. The barometer will be located on the Control Room Floor of the Thompson Falls Powerhouse.

Data will downloaded from the DataSondes to MS Excel spreadsheets and stored in electronic files at PPL Montana offices in Butte.

6.3.2 Monitoring Sites

Monitoring sites that may be used in the course of this monitoring program are shown below:

Above Dam — Upstream Face of Dry Channel Dam
Latitude DMS — N 47° 35’ 35.1”
Longitude DMS — W 115° 21’ 25.5”

Dry Channel Dam — Downstream from Dry Channel Dam 100 yd. East Bank
Latitude DMS — N 47° 35’ 31.7”
Longitude DMS — W 115° 21’ 25.2”

Main Dam — Downstream of Main Dam Spillway, upstream of falls

High Bridge — High Bridge on Main Dam Channel, North Bank
Latitude D — N 47° 35’ 26.6”
Longitude D — W 115° 21’ 17.4”

Birdland Bay Bridge — Downstream from T. Falls Dam 3.3 miles, West Bank
Latitude DMS — N 47° 37’ 18.4”
Longitude DMS — W 115° 23’ 31.8”

Monitoring sites will be used that are appropriate for the hydrologic conditions and specific objectives. The Dam and Birdland Bay Bridge sites will generally be used each year that data collection is necessary. The other sites will be used under Adaptive Management as conditions and objectives dictate.

6.3.2.1 Operational Records

Hourly records of flow, spill, and spillway panel position will be drawn from Thompson Falls operational records.

6.3.2.2 Data Quality Control and Quality Assurance

Hydrolab equipment will be calibrated and programmed at 4 week intervals using the attached calibration worksheet. Hydrolab TDG sensors will be tested at multiple pressures.

6.3.2.3 Spot Monitoring of TDG

One Hydrolab will be available to the fisheries crew to make spot measurements during fish tracking studies and other times of high spill.

6.3.3 Reporting

Annual reports will be prepared by April 1 of the following year.

7 Determination of Effect

Conservation measures described in this BE will reduce, but not totally eliminate, impacts of the Project. By ESA standards of the USFWS, the Thompson Falls Project is likely adversely affecting bull trout.

Conservation measures will be implemented through a collaboration between PPL Montana and the USFWS, MFWP, and the CSKT, as described in the project MOU.

This BE will be used by the USFWS to develop a BO for the Thompson Falls Project. The BO will need to be completed before the proposed conservation measures can be fully implemented.

8 References

Bell, M.C. 1986. Fisheries Handbook of Engineering Requirements and Biological Criteria. U.S. Army Corps of Engineers, Office of the Chief Engineers, Fish Passage Development and Evaluation Program, Portland, Oregon.

Bell, M.C. 1991. Fisheries Handbook of Engineering Requirements and Biological Criteria. U.S. Army Corps of Engineers, Fish Passage Development and Evaluation Program, Office of the Chief Engineers, North Pacific Division, Portland, Oregon.

Berg, R.K. 1992. Clark Fork/Blackfoot River Fishery Investigation. Montana Department of Fish, Wildlife and Parks, Fisheries Division. Job Progress Report. F-46-R-5. 25 pages.

Berg, R.K. 1999. A Compilation of Fishery Survey Information for the Middle Clark Fork River Drainage 1984-1996. Montana Fish, Wildlife & Parks, Missoula, Montana.

Bickford, S.A. and J.R. Skalski. 2000. Reanalysis and Interpretation of 25 Years of Snake–Columbia River Juvenile Salmonid Survival Studies. North American Journal of Fisheries Management. 20: 53-68.

BioAnalysts, Inc. 2004. Movement of Bull Trout Within the Mid-Columbia River and Tributaries, 2001-2004 Final, Rocky Reach Hydroelectric Project No. 2145. Public Utility District No. 1 of Chelan County, Wenatchee, WA.

Brown, L. G. 1992. Draft management guide for the bull trout *Salvelinus confluentus* (Suckley) on the Wenatchee National Forest. Washington Department of Wildlife, Wenatchee, Washington.

Cada, G.F. and M.J. Sale. 1993. Status of Fish Passage Facilities at Nonfederal Hydropower Projects. Fisheries, 18(7):4-12.

Cada, G.F. 2001. The Development of Advanced Hydroelectric Turbines to Improve Fish Passage Survival. Fisheries, 26(9):14-23.

Carnefix, G., C. Frissell, and E. Reiland. 2002. Movement Patters of Fluvial Bull Trout in Relation to Habitat Parameters in the Rock Creek Drainage, Missoula and Granite Counties, Montana. Master Thesis, University of Montana, Missoula, Montana.

Coutant, C.C. and R.R. Whitney. 2000. Fish Behavior in Relation to Passage Through Hydropower Turbines: A Review. Transactions of the American Fisheries Society. 129:351-380.

Crouse, M.R., C.A. Callahan, K.W. Malueg, and S.E. Dominguez. 1981. Effects of Fine Sediments on Growth of Juvenile Coho Salmon in Laboratory Streams. Transactions of the American Fisheries Society. 110:281-286.

DeHaan, P.W., C.A. Barfoot, and W.R. Ardren. *In press*. Genetic Analysis of Bull Trout Populations on the Flathead Indian Reservation, Montana. *Presented at* the Wild Trout IX Symposium, October 11, 2007, West Yellowstone, Montana.

Downs, C.C., R. Jakubowski, and S.P. Moran. 2003. Lake Pend Oreille/Clark Fork Fishery Research and Monitoring Progress Report 1999-2001, Idaho Tributary Habitat Acquisition and Enhancement Program, Appendix A. Prepared for Avista Corporation, Noxon, Montana.

Federal Energy Regulatory Commission (FERC). 1979 Order Issuing License (major), Project No. 1869. Montana Power Company.

Federal Energy Regulatory Commission (FERC). 1990. Order Amending License (major), April 30, 1990. Project No. 1869-003. Montana Power Company.

Federal Energy Regulatory Commission (FERC). 1994. Order Amending License, March 29, 1994. Project No. 1869-018 Montana. Montana Power Company.

Federal Register, 1998. Department Of The Interior Fish and Wildlife Service, 50 CFR Part 17 RIN 1018–AB94, Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for the Klamath River and Columbia River Distinct Population Segments of Bull Trout. Final rule. June 10, 1998.

Federal Register, 2005. 50 CFR Part 17. Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for the Klamath River and Columbia River Populations of Bull Trout; Final Rule. September 26, 2005.

Ferguson, J.W., G.M. Matthews, R.L. McComas, R.F. Absolon, D.A. Brege, M.H. Gessel, and L.G. Gilbreath. 2005. Passage of adult and juvenile salmonids through federal Columbia River power system dams. U.S. Dept. of Commerce, NOAA Technical Memo. NMFS-NWFSC-64, 160 p.

Fraley, J.J. and B.B. Shepard. 1989. Life history, Ecology, and Population Status of Migratory Bull Trout (*Salvelinus confluentus*) in the Flathead Lake and River system, Montana. Northwest Science. 63:133-143.

Franke, G.F. and 9 others. 1997. Development of Environmentally Advanced Hydropower Turbine System Design Concepts. Idaho National Engineering and Environmental Laboratory, Renewable Energy Products Department, Lockheed Martin Idaho Technologies Company, Idaho Falls, Idaho. 83415. Prepared for the Department of

Energy, Energy Efficiency and Renewable Energy and Hydropower Research Foundation, Inc. Under DOE Idaho Operations Office, Contract DE-AC07-94ID13223.

GEI Consultants, Inc. (GEI). 2003. Thompson Falls Dam Fish Passage Study Plan: Pre-design Phase, Thompson Falls, Montana. Prepared for PPL Montana, Butte, Montana.

GEI Consultants, Inc. (GEI). 2005. Lower Clark Fork River Drainage Habitat Problem Assessment. Submitted to Avista Corporation, Noxon, Montana.

GEI Consultants, Inc. 2006a. Thompson Falls Upstream Fishway Site Selection, Thompson Falls Hydroelectric Project, Final Letter Report. Submitted to PPL Montana, Butte, Montana, 59701.

GEI Consultants, Inc. (GEI). 2006b. Draft Feasibility Study: Thompson Falls Upstream Fishway Alternatives Evaluation. Submitted to PPL Montana, 45 Basin Creek Road, Butte, Montana 59701.

GEI Consultants, Inc. (GEI). 2007a. Upstream Fish Passage Alternatives Evaluation – Final Report. Submitted to PPL Montana, 45 Basin Creek Road, Butte, Montana 59701.

GEI Consultants, Inc. (GEI). 2007b. Thompson Falls Dam Fish Ladder Preliminary Design Report – DRAFT. Submitted to PPL Montana, 45 Basin Creek Road, Butte, Montana 59701.

Gillin, G. and T. Haddix. 2005. Thompson Falls Dam Fish Passage Studies Annual Report for 2004, Thompson Falls, Montana. Prepared for PPL Montana, Butte, Montana.

Huston, J.J. 1988. Montana Fish, Wildlife, and Parks Fisheries Division Job Progress Report, July 1, 1987 through June 30, 1988. Montana Fish, Wildlife and Parks, Helena, Montana.

Kanda, N., R.F. Leary, and F.W. Allendorf. 2002. Evidence of Introgressive Hybridization Between Bull Trout and Brook Trout. Transactions of the American Fishereis Society, 131:772-782.

Katzman, L. 2003. Prospect Creek westslope cutthroat trout and bull trout life history final report-2000, Fish Passage/Native Salmonid Restoration Plan, Appendix C, report to Avista Corporation, Spokane, Washington, Montana, Fish, Wildlife and Parks, Thompson Falls, Montana.

Katzman, L. and L. Hintz. 2003. Bull River Westslope Cutthroat Trout and Bull Trout Life History Study, Final Report-2000, Fish Passage/Native Salmonid Restoration Plan, Enhancement Program, Appendix B. Report to Avista Corporation, Spokane, Washington. Montana Fish, Wildlife and Parks, Thompson Falls, and Avista Corporation, Noxon, Montana.

Kleinschmidt Associates and Sverdrup Civil. 1997. Cabinet Gorge Fish Passage and Protection Study, Phase I Report. Prepared for Washington Water Power Company Clark Fork Relicensing Team, Fisheries Working Group.

Leathe, S.A. and M.D. Enk. 1985. Cumulative Effects of Micro-Hydro Development on the Fisheries of the Swan River Drainage, Montana. Report Prepared for Bonneville Power Administration, Division of Fish and Wildlife. 114 Pages, Appendices.

Liermann, B.W. 2003. Thompson River fishery Investigations Comprehensive Report 2000-2002, Montana Tributary Habitat Acquisition and Recreation Fishery Enhancement Program, Appendix B. Report to Avista Corporation, Spokane, Washington. Montana Fish, Wildlife and Parks, Thompson Falls, Montana.

Liermann, B.W., L. Katzman, and J. Boyd. 2003. Thompson River Fishery Investigations Progress Report 2000/2001, Montana Tributary Habitat Acquisition and Recreation Fishery Enhancement Program, Appendix B. Report to Avista Corporation, Spokane, Washington. Montana Fish, Wildlife and Parks, Thompson Falls and Avista Corporation, Noxon, Motana.

Lockard, L., S. Wilkinson, and S. Skaggs. 2002. Experimental adult fish passage studies, annual progress report-2001, Fish Passage/Native Salmonid Program, Appendix C. Report to Avista Corporation, Spokane, Washington, U.S. Fish and Wildlife Service, Creston, and Avista Corporation, Noxon, Montana.

Lockard, L., S. Wilkinson, and S. Skaggs. 2003. Experimental adult fish passage studies, annual progress report-2002, Fish Passage/Native Salmonid Program, Appendix C. Report to Avista Corporation, Spokane Washington. U.S. Fish and Wildlife Service, Creston, and Avista Corporation, Noxon, Montana.

Lockard, L., L. Hintz, S. Wilkinson, and S. Skaggs. 2004. Experimental Adult Fish Passage Studies. Annual progress report – 2003. Fish Passage/Native Salmonid Program, Appendix C. Prepared for Avista Corporation, Natural Resource Field Office, Noxon, Montana.

Malouf, C. 1952. Economy and Land Use By the Indians of Western Montana, USA. Missoula, Montana. Montana State Library.

Malouf, C. I. 1982. A study of the pre-historic and historic sites along the Lower Clark Fork River Valley, western Montana. Contributions to Anthropology, No. 7. University of Montana, Missoula, Montana 59812.

McPhail, J.D. and J.S. Baxter. 1996. A Review of Bull Trout (*Salvelinus confluentus*) Life-History and Habitat Use in Relation to Compensation and Improvement Opportunities. Fisheries Management Report No. 104.

McPhail, J.D., and C.B. Murray. 1979. The Early Life-History and Ecology of Dolly Varden (*Salvelinus malma*) in the Upper Arrow Lakes. Department of Zoology and Institute of Animal Resources, University of British Columbia, Vancouver, British Columbia. 113 pages.

Montana Bull Trout Restoration Team. 2000. Restoration Plan for Bull Trout in the Clark Fork River Basin and Kootenai River Basin, Montana. Montana Fish, Wildlife and Parks

Montana Bull Trout Scientific Group (MBTSG). 1996a. Lower Clark Fork River Drainage Bull Trout Status Report (Cabinet Gorge Dam to Thompson Falls). Prepared for the Montana Bull Trout Restoration Team, Helena, Montana.

Montana Bull Trout Scientific Group (MBTSG). 1996b. Middle Clark Fork River Drainage Bull Trout Status Report (From Thompson Falls to Milltown, including the Lower Flathead River to Kerr Dam). Report Prepared for the Montana Bull Trout Restoration Team, Helena, Montana.

Montana Bull Trout Scientific Group (MBTSG). 1998. The Relationship Between Land Management Activities and Habitat Requirements of Bull Trout. Report Prepared for the Montana Bull Trout Restoration Team. Montana Fish, Wildlife and Parks, Helena. 78 Pages.

Montana Department of Health and Environmental Sciences (MDHES). 1994. Montana Water Quality 1994. The Montana 305(b) Report. Water Quality Division, Helena.

Monten, J.F. 1985. Fish and Turbines: Fish Injuries During Passage Through Power Station Turbines. Stockholm: Vattenfall, 111pp.

Moran, S. 2003. Lower Clark Fork River, Montana-Avista Project Area-2002 Annual bull and brown trout redd survey report, Fish Passage/Native Salmonid Program, Appendix C. Avista Corporation, Noxon, Montana.

Moran, S. 2004. Fisheries Survey of Prospect Creek, Montana-2003 Final Report, Fish Passage/Native Salmonid Program, Appendix C. Avista Corporation, Noxon, Montana.

Moran, S. 2005. Lower Clark Fork River, Montana 2004 Annual Bull and Brown Trout Redd Survey Report. Prepared for Avista Corporation, Noxon, Montana.

Moyle, P.B. 1976. Fish Introductions in California: History and Impacts of Native Fishes. Biological Conservation 9:101-118.

Nelson, M.L., T.E. McMahon, and R.F. Thurow. 2002. Decline of the Migratory Form in Bull Charr, *Salvelinus confluentus*, and Implications for Conservation. Environmental Biology of Fishes, 64:321-332.

Normandeau Associates. 2001. Movement and Behavior of Adfluvial Bull Trout Downstream of the Cabinet Gorge Dam, Clark Fork River, Idaho. Prepared for Avista Corporation, Spokane, Washington.

Pavlov, D.S., A.I. Lupandin, and V.V. Kostin. 2002. Downstream Migration of Fish Through Dams of Hydroelectric Power Plants. Trans. T. Albert, trans. ed. G.F. Cada. ORNL/TR-02/02. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Peters, D.J. and D.A. Schmetterling. 1996. Statewide Fisheries Investigation: Clark Fork River Creel Census Rock Creek to Flathead River. F-78-1. Montana Fish, Wildlife, and Parks, 3201 Spurgin Road, Missoula, Montana.

Pratt, K.L. 1984. Habitat Selection and Species Interactions of Juvenile Westslope Cutthroat Trout (*Salmo clarki Lewisi*) and Bull Trout (*Salvelinus confluentus*) in the Upper Flathead River Basin. University of Idaho, Moscow, Idaho. M.S. Thesis.

Pratt, K.L. 1985. Habitat preferences of juvenile bull trout in the Flathead River Basin. In D.D. McDonald, ed. Proceedings of the Flathead Basin bull trout biology and population dynamics modeling exchange. Fisheries Branch, British Columbia Ministry of the Environment, Cranbrook, British Columbia.

Pratt, K.L. 1992. A Review of Bull Trout Life History. Pages 5-9 *in* Howell, P.J. and D.V. Buchanan, eds. Proceedings of the Gearhart Mountain Bull Trout Workshop. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon.

Pratt, K.L. 1996. Bull trout and westslope cutthroat trout in three regions of the lower Clark Fork River between Thompson Falls, Montana and Albeni Falls, Idaho: A Discussion of Species Status and Population Interaction. Report of Trout Unlimited, National Office, Idaho Council and Montana Council.

Pratt, K.L. and J.E. Huston. 1993. Status of Bull Trout (*Salvelinus confluentus*) in Lake Pond Oreille and Lower Clark Fork River: DRAFT. Washington Water Power, Spokane, Washington.

Riehle, M., W. Weber, A. M. Stuart, S. L. Thiesfeld and D. E. Ratliff. 1997. Progress Report of the Multi-Agency Study of Bull Trout in the Metolius River System, Oregon. Pages 137-144 *in* Mackay, W. C., M. K. Brewin and M. Monita, editors. Friends of the Bull Trout Conference Proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary.

Rieman, B.E. and J.D. McIntyre. 1993. Demographic and Habitat Requirements For Conservation of Bull Trout. U.S. Forest Service General Technical Report INT-302.

Rocky Reach Bull Trout Management Plan (RRBTMP). 2006. *In* Rocky Reach Comprehensive Plan. Attachment B to the Rocky Reach Settlement Agreement – Final. FERC Project No. 2145. Public Utility District No. 1 of Chelan County, Wenatchee, Washington.

Schmetterling, D.A. 2001a. 2000 Northern Pike Investigations in Milltown Reservoir. Final Report to Montana Fish, Wildlife and Parks, The Chutney Foundation, Montana Power Company, and the BLM Montana Field Office. Montana Fish, Wildlife and Parks, Missoula, Montana.

Schmetterling, D.A. 2001b. Seasonal Movements of Fluvial Westslope Cutthroat Trout in the Blackfoot River Drainage, Montana. North American Journal of Fisheries Management. 12:507-520.

Schmetterling, D.A. 2003. Reconnecting Fragmented River: Movements of westslope cutthroat trout and bull trout after transport upstream of Milltown Dam, Montana. North American Journal of Fisheries Management, 23:721-731.

Selong, J.H., T.E. McMahon, A.V. Zale, and F.T. Barrows. 2001. Effect of Temperature on Growth and Survival of Bull Trout, with Application of an Improved Method for Determining Thermal Tolerance in Fishes. Transactions of the American Fisheries Society, 130:1026-1307.

Sexauer, H.M. and P.W. James. 1997. Microhabitat Use by Juvenile Bull Trout in Four Streams Located in the Eastern Cascades, Washington. Pp. 361-370 *in* Friends of the Bull Trout Conference Proceedings (Mackay, W.C., M.K. Brewin, and M. Monita, eds.). Bull Trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary, Alberta.

Smith, R.W. 1993. Tributary Survey, Lower Clark Fork River Drainage, Montana. Final Report: Preliminary Study Section I. Prepared for Washington Water Power Company, Spokane, Washington.

Stelfox, J.D. 1997. Seasonal Movements, Growth, Survival and Population Status of the Adfluvial Bull Trout Population in Lower Kananaskis Lake, Alberta. Pp. 309-316 *in*

Friends of the Bull Trout Conference Proceedings (Mackay, W.C., M.K. Brewin, and M. Monita, eds.). Bull Trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary, Alberta.

Thomas, G.G. 1992. Status Report: Bull Trout in Montana. Ginger Thomas Consultant, Missoula, Montana. Prepared for Montana Fish, Wildlife, and Parks, Helena, Montana.

U.S. Fish and Wildlife Service (USFWS). 1998. Endangered and Threatened Wildlife and Pants; Determination of Threatened Status for the Klamath River and Columbia River Distinct Population Segments of Bull Trout. Federal Register 63:31647-31674.

U.S. Fish and Wildlife Service (USFWS). 2002. Chapter 3, Clark Fork River Recovery Unit, Montana, Idaho, and Washington. 285p. U.S. Fish and Wildlife Service. Bull Trout (*Salvelinus confluentus*) Draft Recovery Plan.

U.S. Fish and Wildlife Service (USFWS). 2005. Endangered and Threatened Wildlife Plants; Designation of Critical Habitat for the Bull Trout; Final Rule. September 26, 2005. Federal Register Vol. 70 No. 185 Page 56212.

U.S. Fish and Wildlife Service (USFWS). 2006a. Memorandum – Consolidation of Bull Trout Core Areas on the Lower Clark Fork River, July 14, 2006. Prepared by USFWS, Montana Ecological Service Field Office, Helena, Montana.

U.S. Fish and Wildlife Service (USFWS). 2006b. Biological Opinion on the Rock Creek Mine.

U.S. Fish and Wildlife Service (USFWS). 2007. Biological Opinion for the Priest Rapids Project License Renewal. Prepared by the USFWS Central Washington Field Office, Wenatchee.

U.S. Geological Survey (USGS). 2002. Water Resources Data, Montana Data Report. Helena, Montana.

Washington Water Power (WWP). 1996. Lower Clark Fork River Tributary Survey. Final Report. Volumes I of II. Washington Water Power, Spokane, Washington.

Weaver, T.M. and J.J. Fraley. 1991. Fisheries Habitat and Fish Populations: Flathead Basin Forest Practices, and Fisheries Cooperative Program. Flathead Basin Commission, Kalispell, Montana.

Whitney, R.R., L.D. Calvin, M.W. Erho, Jr., and C.C. Coutant. 1997. Downstream passage for salmon at hydroelectric projects in the Columbia River basin: development, installation, evaluation. Northwest Power Planning Council (NPPC) Report 97-15, Portland, Oregon.

Wydoski, R.S. and R.R Whitney. 2003. Inland Fishes of Washington. Second Edition Revised and Expanded. University of Washington Press, Seattle, American Fisheries Society, Bethesda, Maryland.

Personal Communication

Barfoot, Confederated Salish and Kootenai Tribes, personal communication, May 2002.

Bernall, Avista Corporation, personal communication, February 28, 2008.

Beckman, PPL Montana, personal communication, December 19, 2006.

Bonnes, PPL Montana, personal communication, November 18, 2002.

Downs, Idaho Fish and Game, personal communication, November 2002.

Fredenberg, U.S. Fish and Wildlife Service, personal communication, 2008.

Hanson, Montana Fish, Wildlife and Parks, personal communication, March 2008

Katzman, Montana Fish, Wildlife and Parks, personal communication, July 2002.

Knotek, Montana Fish, Wildlife and Parks, personal communication, February 2008.

Rainey, GEI Consultants, personal communication, 2006.

Rainey, GEI Consultants, personal communication, 2008.

Weaver, Montana Fish, Wildlife and Parks, personal communication, 1992.

9 Acronyms

Abbreviation	**Name**
ac	acres
ac-ft	acre-foot
amsl	above mean sea level
AWS	auxiliary water system
BA	Biological Assessment
BBB	Birdland Bay Bridge
BE	Biological Evaluation
BO	Biological Opinion
C	Celsius
cfs	cubic feet per second
Commission	Federal Energy Regulatory Commission
CSKT	Confederated Salish and Kootenai Tribes
EDC	Energy Dissipation Coefficient
EPA	Environmental Protection Agency
ESA	Endangered Species Act
f^3/lb	cubic feet per pound
FERC	Federal Energy Regulatory Commission
fps	feet per second
ft	feet
GBT	gas bubble trauma
GEI	GEI Consultants Inc.
gpm/lb	gallons per minute per pound
HDPE	high density polyethylene
HUC	Hydrologic Unit Code
HVJ	High-velocity Jet
km	kilometers
lb	pound
MBTSG	Montana Bull Trout Scientific Group
MDEQ	Montana Department of Environmental Quality
MFWP	Montana Fish, Wildlife and Parks
mm	millimeters
MOU	Memorandum of Understanding
NOAA	National Oceanic and Atmospheric Administration
OSHA	Occupational Safety and Health Administration
PCE	Primary constituent elements
PIT	Passive Integrated Transponder
Project	Thompson Falls Dam Project
rpm	revolutions per minute
RRBTMP	Rocky Reach Bull Trout Management Plan
SD	Standard Deviation

Abbreviation	Name
TAC	Interagency Technical Advisory Committee
TDG	Total Dissolved Gas
USACOE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

Appendix A – Technical Memo on Total Dissolved Gas

Appendix B – Construction Drawings for the Thompson Falls Hydroelectric Project Upstream Fish Passage (90% Submittal), January 2008

Critical Energy Infrastructure Information – CEII
Do Not Release

Construction drawings and specifications are non-public information (CEII) and are bound separately. To request a copy, contact the Federal Energy Regulatory Commission for information on how to apply (http://www.ferc.gov/legal/ceii-foia.asp)

Appendix C - Memorandum of Understanding

Document Content(s)