Thompson Falls Hydroelectric Project
FERC Project No. 1869

Comprehensive Phase 2 FINAL Fish Passage Report

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List of Abbreviations and Acronyms

° C	degrees Celsius
° F	degrees Fahrenheit
#	number
%	percent
AWS	auxiliary water system
Avista	Avista Corporation
BE	Biological Evaluation
BiOp	Biological Opinion
CFD	computational fluid dynamics
cfs	cubic feet per second
CHU	Critical Habitat Unit
CHRU	Columbia Headwater Recovery Unit
CHSU	Critical Habitat Subunit
Ck	creek
Commission	Federal Energy Regulatory Commission
CPUE	catch per unit effort
CSKT	Confederated Salish and Kootenai Tribes of the Flathead Nation
El.	elevation
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
ft	feet
FDX	full-duplex
FLA	Final License Application
FWP	Montana Fish, Wildlife and Parks
FWS or Service	U.S. Fish and Wildlife Service
g	gram
GIS	Geographic Information System
HDX	half-duplex
HVJ	high-velocity jet
hrs	hours
ILP	Integrated Licensing Process
km	kilometer
L	length
ladder	Thompson Falls Upstream Fish Passage Facility
Licensee	NorthWestern Energy Corporation
Main Dam	Main Channel Dam
MDEQ	Montana Department of Environmental Quality
m	meter
mm	millimeter
MOU	Memorandum of Understanding
MVA	Megavolt amperes
MW	megawatts
MWMT	maximum weekly maximum temperature
n	number
NMFS	National Marine Fisheries Service

NOAA	National Oceanic and Atmospheric Administration
NorthWestern	NorthWestern Energy Corporation
PAD	Pre-Application Document
PIT	passive integrated transponder
Project	Thompson Falls Hydroelectric Project
rpm	repetitions per minutes
SKQ	Seli'š Ksanka Qlispe' Dam (formerly Kerr Dam)
TAC	Technical Advisory Committee
TCs	Terms and Conditions
TDG	total dissolved gas
TFalls	Thompson Falls
TL	total length
USFS	U.S. Forest Service
USGS	U.S. Geological Survey

List of Fish Abbreviations, Species Common Name, and Scientific Name

Fish Abbreviation	Common Name	Scientific Name
BL BH	Black Bullhead	*Ameiurus melas*
BULL	Bull Trout	*Salvelinus confluentus*
EB	Brook Trout	*Salvelinus fontinalis*
LL	Brown Trout	*Salmo trutta*
LMB	Largemouth Bass	*Micropterus salmoides*
LN SU	Longnose Sucker	*Catostomus castostomus*
LS SU	Largescale Sucker	*Catostomus macrocheilus*
LT	Lake Trout	*Salvelinus namaycush*
MWF	Mountain Whitefish	*Prosopium williamsoni*
NP	Northern Pike	*Esox lucius*
N PMN	Northern Pikeminnow	*Ptychocheilus oregonensis*
PEA	Peamouth	*Mylocheilus caurinus*
PUMP	Pumpkinseed	*Lepomis gibbosus*
RBxWCT	Rainbow x Westslope Cutthroat Trout hybrid	*Oncorhynchus clarkii lewisi and Oncorhynchus mykiss*
RB	Rainbow Trout	*Oncorhynchus mykiss*
SMB	Smallmouth Bass	*Micropterus dolomieu*
WCT	Westslope Cutthroat Trout	*Oncorhynchus clarkii lewisi*
WE	Walleye	*Sander vitreus*
YP	Yellow Perch	*Perca flavescens*

Executive Summary

ES 1.1 Project Description

NorthWestern Energy (NorthWestern; Licensee) owns and operates the Thompson Falls Hydroelectric Project (Project), located on the lower Clark Fork River near Thompson Falls, Montana. Project construction began in May 1913. Six generating units were placed in service by May 1917 and an additional powerhouse with a seventh-generating unit was completed in 1995 to yield a total installed capacity of 92.6 megawatt (MW). The Project consists of two curved concrete gravity dams (Dry Channel and Main Channel) with overflow spillways and the two powerhouses. NorthWestern purchased the Project from PPL Montana LLC in 2014 and has since been operating it as a part of its integrated electrical system.

The current Federal Energy Regulatory Commission (FERC or Commission) License (License) for the Project was issued December 28, 1979. The License was amended on April 30, 1990 to allow construction of a new powerhouse to house a seventh generating unit and extended the term of the License that was amended again on February 12, 2009 to approve construction and operation of the existing upstream fish passage facility. The present License will expire on December 31, 2025. NorthWestern intends to pursue a new License for the Project using FERC's Integrated Licensing Process (ILP).

The Project's FERC boundary is 0.3 mile downstream and 12 miles upstream of the Project dams. The License allows the Project to operate as a peaking facility, limited by a minimum Project discharge of 6,000 cfs or inflow, whichever is less. It also requires that the reservoir is maintained between elevation (El.) 2396 (full pool) feet and 2,392 feet. Thompson Falls Reservoir has a total storage capacity of approximately 15,000 acre-feet (covering 1,446 acres) at full pool. The Project can discharge its total storage pool of 15,000 acre-feet in slightly less than 8 hours minus inflows. The drainage area contributing flow to the lower Clark Fork River at the Project is 20,904 square miles including the Thompson, Flathead, Blackfoot, and Bitterroot rivers. Period of record (1956 to present) spring peak flows at the Project have reached 130,000 cfs, but average about 58,000 cubic feet per second (cfs).

The lower Clark Fork River drains into Lake Pend Oreille in Idaho, part of the upper Columbia River basin. About 33 miles (21 kilometers [km]) downstream of the Thompson Falls Project is Avista Corporation's (Avista) 742-MW Clark Fork River Project (FERC Project P-2058) consisting of Noxon Rapids Dam (479 MW) in Montana and Cabinet Gorge Dam (263 MW), about 19 miles (31 km) downstream of Noxon Rapids Dam near Lake Pend Oreille, Idaho. The 188-MW Seli'š Ksanka Qlispe' (SKQ) Dam (formerly Kerr Dam), on the Flathead River, is located 100 miles (161 km) upstream of the Project. The primary tributaries of the lower Clark

Fork River within the Project area are Thompson River and Cherry, Dry, Ashley and Prospect creeks.

ES 1.2 Background on Fish Passage at the Project

Bull Trout (*Salvelinus confluentus*) were federally-listed as a threatened species under the Endangered Species Act (ESA) in 1998. The Licensee-prepared 2003 Biological Evaluation (BE) concluded that the Project was likely adversely affecting Bull Trout. This determination led to a process to determine conservation measures to reduce "take." An interagency technical advisory committee (TAC) was established and includes, among others, the Licensee, U.S. Fish and Wildlife Service (FWS), Montana Fish, Wildlife and Parks (FWP), Avista, Montana Department of Environmental Quality (MDEQ), U.S. Forest Service (USFS), and Confederated Salish and Kootenai Tribes (CSKT).

From 2003 to 2008, the Licensee worked cooperatively with the other TAC members to clarify regulatory issues and conduct significant scientific and engineering evaluations and in-situ testing. The objectives of the evaluations and testing were to determine factors affecting Bull Trout and other fish passage behavior, full height fish ladder design and construction, and subsequent fish ladder and Project operations.

In 2008, a Memorandum of Understanding (MOU) was established between NorthWestern, the FWS, FWP, and CSKT (voting TAC members) which established the terms and conditions for collaboration between the Licensee and the TAC agencies for the implementation of Bull Trout conservation measures at the Project. The MOU also specifies how funding by NorthWestern is allocated annually to the TAC for the purpose of downstream Bull Trout and other fish passage mitigation measures. The MOU, which was originally signed by each party and implemented in 2008, was renewed in 2013, and will expire on December 31, 2020.

On November 4, 2008, the FWS filed a Biological Opinion (BiOp) with FERC, concluding that the Project adversely affects Bull Trout and that the Licensee's proposed conservation measures would reduce, but not eliminate, adverse impacts of the Project. The BiOp accepted the Licensee's proposal to construct a full-height pool and weir fishway. On February 12, 2009, FERC approved construction and operation of the upstream fish passage facility. The Thompson Falls Upstream Fish Passage Facility (fish ladder or ladder) was thereafter constructed in 2009 and 2010. Priorities for fish passage at the Thompson Falls fish ladder have been defined by the TAC as:

- Pass Bull Trout
- Pass native species
- Pass non-native salmonid sport fish, but not to the detriment to the first two objectives. (e.g., if Brown Trout expansion extends into Bull Trout systems)
- Overarching goal is volitional passage

However, volitional passage through the ladder has not been approved by FWP and FWS due to the presence of Walleye downstream of Thompson Falls Dam and the absence of an established Walleye population upstream.

The BiOp included a requirement for the Licensee to conduct Phase 2 fish passage evaluation studies from 2010 to 2020. At the end of the Phase 2 evaluation period, the Licensee is required to prepare a comprehensive 10-year report for filing with the Commission.

The BiOp specified that the comprehensive report would be completed by December 31, 2020. NorthWestern intends to pursue a new License for the Project using FERC's ILP. NorthWestern has developed a draft relicensing schedule based on the ILP and found that some adjustments in the compliance reporting schedule could better align the compliance schedule with the relicensing schedule. Specifically, NorthWestern requested, and FWS concurred, that the comprehensive report described in the BiOp would be submitted a year early, by December 31, 2019. This Comprehensive Phase 2 Fish Passage Report has been prepared, with guidance from the TAC, to summarize the results of the Phase 2 studies, through July 1, 2019.

The BiOp also requires the Licensee to convene a structured scientific review of the Project, guided by the TAC. This scientific review panel will utilize this Comprehensive Phase 2 Fish Passage Report, along with other publicly available reports, as-needed, to inform the review. The review panel will develop a set of recommendations to be submitted to the FWS for evaluation, modification, and approval; including specific conclusions as to whether the fishway is functioning as intended and whether operational or structural modifications of the fishway are needed.

The structured scientific review described in the BiOp will convene in January 2020 and be completed by April 1, 2020. The recommendations from the scientific review may be incorporated into NorthWestern's list of preliminary issues and studies to be included in its Pre-Application Document (PAD) for the FERC relicensing of the Project. The Licensee will also develop an updated fishway operating plan that will be submitted to FERC for approval as part of the Final License Application (FLA), due by December 31, 2023.

ES 1.3 Systemwide Monitoring

Systemwide coordinated monitoring (in consultation with resource agencies) for Bull Trout (and other) fish movement and passage in the lower Clark Fork River utilizes tagging, transport, and tracking options. Avista provides tagging, transport, and tracking support for fish initially captured within the Clark Fork Project area, downstream of Thompson Falls Dam. NorthWestern provides support for tagging, transport, and tracking effort within the immediate vicinity of the Thompson Falls Project area and upstream of Thompson Falls Dam, including the middle Clark Fork River drainage. NorthWestern's primary Project monitoring activities include: 1) Bull Trout passive integrated transponder (PIT) tagging in the Project area, 2) PIT-tag array detection in the fish ladder and in Thompson River and Prospect Creek, 3) tracking angler recapture reports, 4) Bull Trout transport and 5) Bull Trout genetics. Gillnetting and electrofishing are used to monitor fish populations in Thompson Falls Reservoir and in the Clark Fork River upstream of the Project.

ES 1.4 Upstream Fish Passage

The fish ladder, constructed on the right side (facing downstream) of the Main Channel Dam (Main Dam), was designed with consideration given to numerous agency-supported Licensee studies, conducted in the 2003-2008 timeframe and in general accordance with National Oceanic and Atmospheric Administration (NOAA) Fisheries Criteria (NMFS, 2008), used by FWS in the design of the Thompson Falls Bull Trout upstream passage facility. The fish ladder produces a 1-foot water drop into each of the 48 pools via internal weir plates to allow upstream passage of a diverse fish population.

The fish ladder typically operates annually from mid-March to mid-October. The ladder seasons ends (and the ladder is dewatered and shut down) when a fall freeze is imminent. Temporary closures during the season may occur due to high spring streamflows. The work station (3 cfs) and fish ladder (6 cfs pool-to-pool), including attractant flows (20 cfs from the high velocity jet and maximum of 54 cfs from the auxiliary water system), may utilize between 9 and 83 cfs. In addition to these operating and attractant flows at the ladder, NorthWestern may open part of one Main Dam spill panel near the fish ladder to provide an additional fish attractant flow of approximately 100 to 125 cfs.

As previously stated, the TAC has specified priorities for fish passage at the fish ladder: 1) Bull Trout passage; 2) other native species passage; and 3) passage of non-native salmonids, but only to the extent this does not interfere with the first two priorities. The overarching goal is to provide for volitional Bull Trout passage. No Walleye, Lake Trout, or Brook Trout (or Brook x Bull Trout hybrids) are to be passed. Other non-native species may be passed at the discretion of the fish ladder operators as directed by FWP or FWS. A total of 32,130 fish, including 17 Bull Trout, ascended the fish ladder from 2011 through July 1, 2019. Of these 17 Bull Trout, one fish ascended the ladder twice. Of the Bull Trout that ascended the ladder and were released upstream of Thompson Falls Dam, four Bull Trout were subsequently detected upstream in the Thompson River drainage, five Bull Trout (including 1 that initially migrated upstream to the Thompson River) were detected within 1 to 2 years downstream in either Prospect Creek, Graves Creek, Noxon Reservoir, and/or re-entering the lower pools of the fish ladder. Eight Bull Trout had no subsequent detections after their ladder ascent and release upstream.

In 2015 and 2016, a total of five untagged Bull Trout ascended the ladder and eight (previously PIT- tagged) Bull Trout entered the lower pools of the ladder but did not ascend. One of these eight Bull Trout had ascended the ladder successfully 6 months earlier while the other seven

Bull Trout were entering the ladder for the first time. These were the only years previously tagged Bull Trout were detected entering the ladder and not ascending.

There were 17 Bull Trout ladder ascents out of 25 known Bull Trout entering the ladder since 2011. The percentage of Bull Trout not ascending the ladder is similar to the movement patterns and behavior observed and documented among other tagged-salmonids. Approximately 20 to 30 percent of tagged-salmonids returning to the ladder in a given year did not ascend to the top.

The primary goal of the upstream fish passage facility at Thompson Falls Dam is to provide safe, timely, and effective fish passage for Bull Trout (FWS, 2008). Results at the ladder and Project area show the following:

- Bull Trout are rare in the Project area; however, Bull Trout do successfully find the ladder entrance (25 BULL detected in Pools 7/8) and ascend the ladder (17 BULL recorded in holding pool). At least 68% of Bull Trout detected in the ladder, ascended to the top.
- Bull Trout (n=4) were detected over 6 miles upstream in the Thompson River drainage following their ladder ascent and release upstream of Thompson Falls Dam.
- Bull Trout (n=6) have migrated downstream of Thompson Falls Dam following their ladder ascent and release upstream of the dam.
- Bull Trout (n=3) have returned to the ladder after an initial ascent and release upstream with one of the three Bull Trout ascending to the top of the ladder a second time.
- Of the 17 Bull Trout recorded at the ladder work station between 2011 and 2019, 1 ascended while the ladder operated in notch mode, one Bull Trout was captured in Pool 23 during a weir mode change, and the remaining 15 Bull Trout ascended the ladder (to the holding pool) while operating in orifice mode.

At this time, fish data collected at the fish ladder indicate the passage facility provides safe and timely passage. The fish ladder has successfully passed over 32,000 fish since 2011. Many ladder fish released upstream of the dam are detected upstream of the dam in lower Clark Fork River and middle Clark Fork River tributaries during spawning season (e.g., Thompson River, St. Regis River, Rattlesnake Creek) and the lower Flathead River. Many species either remain upstream for multiple years or return downstream of the dam and repeat their upstream journey (via the fish ladder) for 1 or more years.

Other notable conclusions from 9 years of fish ladder operations include:

- The fish ladder has captured 14 fish species and 3 hybrids. Fish passage was designed specifically for Bull Trout, but also provides upstream passage for a variety of salmonids and other native and non-native species. Low and sporadic numbers of

Walleye and Lake Trout have been captured in the ladder and returned downstream. Neither species are desired nor established directly upstream of the dam.

- Approximately 80% of the 32,130 fish ascending the ladder between 2011 through July 1, 2019 represent 7 native species plus one hybrid.
- Larger numbers of fish (all species) ascend the ladder during the descending limb (summer months) of the hydrograph when water temperatures are rising.
- Fish utilize the ladder during the entire operational season and peak fish movements by some species do not appear to be related or triggered by spawning.
- At the direction of the TAC, both modes of operating the fish ladder were tested. (Orifice mode provides an opening at the bottom of the weir for fish to pass through and notch mode provides overflow over the top of the weir for fish to move through.) More fish and more species pass upstream when the fish ladder is operated in orifice mode (vs. notch mode).
- The maximum design river flow for the fish ladder was 48,000 cfs, and in general, fish movement into the fish ladder declines above 43,000 cfs. However, fish passage has been documented to occur at flows up to 79,700 cfs. Bull Trout have ascended the fish ladder with river flow ranging from 8,100 to 56,100 cfs.
- Some fish, primarily Rainbow and Brown Trout, have returned multiple times to the fish ladder, often in subsequent years. One Brown Trout had 6 fish ladder ascents in 5 years.
- Approximately 30% of tagged salmonids released upstream of the fish ladder enter the Thompson River (6 miles upstream) within the same calendar year (some in as little as 5.5 hours travel time).
- Passive detection methods have found ladder fish traveling long distances (e.g., a Rainbow Trout near Rattlesnake Creek, 150 miles upstream) and many fish migrate both upstream and downstream.
- Freezing temperatures limit fish ladder operations, but also limit fish movement in the system.
- Higher streamflows limit ladder operations with temporary closures typically occurring when streamflows exceed 55,000 cfs. Higher spring streamflows often completely inundate the lower pools or result in accumulation of debris and sediment in the lower pools.

ES 1.5 Downstream Fish Passage

The BiOp requires the Licensee to conduct a prioritized evaluation of factors contributing to the potential loss or enhancement of migratory Bull Trout passage through Thompson Falls

Reservoir. In response to that requirement, the Licensee undertook agency-approved studies of Thompson Falls Reservoir habitat conditions and predatory non-native fish in Thompson Falls Reservoir.

The TAC identified the Thompson River as a critical drainage to concentrate Bull Trout conservation measures, due to its geographic proximity to the dam, and allocation of funding under the MOU. This was in addition to the TAC approved funding (under the MOU) for other critical Bull Trout conservation measures implemented in the middle Clark Fork River (e.g., Fish Creek, Cedar Creek) and downstream of the Thompson Falls Dam in Prospect Creek.

In 2013, the Licensee prepared a Bull Trout Enhancement and Recovery Plan for the Thompson River drainage and conducted studies of juvenile Bull Trout outmigration from the Thompson River drainage. The Thompson River Bull Trout Enhancement and Recovery Plan found that migratory Bull Trout utilize two subwatersheds in the Thompson River drainage, the West Fork Thompson River and Fishtrap Creek. That plan recommended that those two subwatersheds have top priority for any habitat improvement projects. In addition, the mainstem Thompson River downstream of Fishtrap Creek is the migratory corridor for Bull Trout. There is also evidence to indicate that this mainstem Thompson River is used for overwintering by migratory Bull Trout.

The BiOp estimated that at least 10 percent and perhaps as much as 25 percent of juvenile Bull Trout in the Thompson River drainage outmigrate to the Thompson Falls Reservoir and pass downstream of the Project. Recent data collection indicates that the adfluvial life history form in the Thompson River drainage is less dominant than expected. To date, based on recent tagging studies (Glaid, 2017; FWP, unpublished data), the percentage of juvenile Bull Trout found to outmigrate from the Thompson River drainage is less than 7 percent.

Studies of the fish population residing in Thompson Falls Reservoir indicate that Bull Trout do not reside in Thompson Falls Reservoir for any length of time. The evidence suggests that Thompson Falls Reservoir is used as a Bull Trout migratory corridor for juvenile adfluvial Bull Trout outmigrating from upstream tributaries, and for adult Bull Trout migrating upstream (after their passage through the fish ladder) and downstream.

The numbers of Bull Trout migrating through Thompson Falls Reservoir is lower than expected, based on tagging studies in the Thompson River. For those few Bull Trout that migrate through Thompson Falls Reservoir, the highest predation risk occurs in the Island Complex area, where Northern Pike densities are the highest. The April to May time period, when juvenile Bull Trout may be out migrating from upstream tributaries, presents the highest predation risk.

Habitat in Thompson Falls Reservoir is intermediate between lotic and lentic. The retention time of Thompson Falls Reservoir is very short, less than a day, and the reservoir does not stratify. There are localized areas of cool water where the Thompson River enters the reservoir, and near Cherry Creek, but there does not appear to be a cool water thermal plume that extends the length of the reservoir.

ES 1.6 Conclusions

Bull Trout in the Project area

Bull Trout are rare in the lower Clark Fork River, both upstream and downstream of the Thompson Falls Hydroelectric Project. The BiOp for the Project noted dams, forestry management, mining, transportation, urban and rural development, agriculture and grazing, and fisheries management including stocking of non-native fish species as affecting Bull Trout and their habitat. Although the FWS judged that recovery measures related to connectivity described in the 2002 Draft Recovery Plan (FWS, 2002) were being partially met (FWS, 2006), improving passage has not resulted in large increases in Bull Trout numbers in the drainage.

After 9 years (2011-2019) of upstream fish ladder operations at the Project, Bull Trout ladder ascents varied from zero to five Bull Trout per year, averaging 1.9 Bull Trout per year. The annual number of Bull Trout recorded at the ladder, while very low, appears to be reflective of the very low numbers of Bull Trout present in the Project area. However, there were eight tagged-Bull Trout detected entering the lower pools of the ladder (in 2015 and 2016) that did not ascend to the holding pool.

Evidence for this conclusion comes from sampling conducted over the past 2 decades in the Project area. For example, the numbers of Bull Trout captured downstream of the Project via multiple sampling methods (angling, electrofishing, and fish trapping) over a 7-year period (1999-2006) resulted in one to seven Bull Trout captured per year (an average of 3.3 Bull Trout per year). Additional seasonal sampling via a small scale Denil fish ladder in the Project Main Dam tailrace in 2001 and 2004 also found few Bull Trout in the area. In 2001 (March 21-September 28), three Bull Trout out of 4,259 fish were collected in the Denil trap. In 2004 (March 16-May 10), three Bull Trout out of 195 fish were collected at this trap.

Electrofishing downstream of the Project in the spring of 2011, 2012 and 2014 collectively sampled seven individual Bull Trout out of 2,222 fish handled. Bull Trout represented a small fraction of the fish community sampled each year with three Bull Trout sampled out of 1,109 fish in 2011, one Bull Trout out of 737 fish in 2012, and three Bull Trout out of 376 fish in 2014.

FWP samples fish in Noxon Reservoir downstream of the Project with annual gillnets in the fall. Between 2013 and 2015, 3,278 fish were collected, including two Bull Trout, for all years and locations combined (Kreiner and Tholl, 2016). This includes one Bull Trout in 2014 that had ascended the fish ladder at Thompson Falls Dam in the spring (and subsequently released upstream). Kreiner and Tholl (2016) noted that salmonids tend to be under-represented in the sampling in Noxon Reservoir, so the numbers of Bull Trout present may be higher than reflected in the gillnet catches. The timing and location of gillnet sampling was designed to avoid catching Bull Trout.

Upstream of the Project, eight Bull Trout have been collected in Thompson Falls Reservoir since the beginning of fish monitoring efforts in 2004 (after 15 years of annual fall gillnetting and 9 years of spring electrofishing surveys in two sections of Thompson Falls Reservoir). Annual fall gillnetting has never collected a Bull Trout. Spring electrofishing has captured six Bull Trout, one in the lower section and five in the upper section close to the Thompson River.

Spring gillnetting conducted over a 15-week period in 2009 in two sections of Thompson Falls Reservoir as part of a study of Northern Pike collected two Bull Trout. One Bull Trout was collected during gillnetting (in May) in the downstream sampling area and one Bull Trout was collected in a Northern Pike stomach from the Island Complex sampling area (*see* Figure 4-8).

Upstream of Thompson Falls Reservoir, 9 years of fall electrofishing conducted since 2009 in two separate sections (above the Island complex, and Paradise to Plains) sampled four Bull Trout. One Bull Trout was collected in the above Island complex section. Three Bull Trout were collected in the Paradise to Plains section. The Paradise to Plains section is located downstream of the confluence with the lower Flathead River and upper boundary of the lower Clark Fork River drainage.

Avista collects Bull Trout upstream of Lake Pend Oreille and downstream of Cabinet Gorge Dam. A fin clip from each Bull Trout is genetically tested to determine their natal stream so they can be transported to (or near) their tributary of origin. In some instances, Bull Trout captured as juveniles in their natal stream are returned to that stream, even if the genetic analysis does not concur. Avista has operated the adult Bull Trout transport program since 2001. Transport of Bull Trout to Region 4, upstream of Thompson Falls Dam began in 2007. For the last 12 years, Avista has transported an average 37 Bull Trout upstream of Cabinet Gorge Dam with about 21 percent (7 Bull Trout) transported to Region 4 each year.

Lake Pend Oreille was estimated to support a population of approximately 10,000 Bull Trout over 350 mm in length in 2008 (McCubbins et.al., 2016). It appears that the portion of the adfluvial population of Bull Trout originating from the Clark Fork River drainage is a relatively small overall proportion of the population based on the annual number of Bull Trout captured and transported upstream of Cabinet Gorge Dam. It also appears that an even smaller proportion of adfluvial Bull Trout outmigrating from tributaries upstream of Thompson Falls Dam reside in Noxon Reservoir. Therefore, the numbers of upstream migrating Bull Trout available to approach the Project fish ladder at Thompson Falls are limited.

Fish Ladder Effectiveness

NorthWestern's upstream fish ladder at the Main Dam Spillway became operational in March 2011. From 2011 through July 1, 2019, there were 17 Bull Trout out of 32,130 fish that ascended the ladder (representing 14 species; 3 hybrids). It is clear that the ladder is passable to a wide variety of fish species, including some weaker swimming species.

Not all fish that enter the ladder and are detected in the lower pools ascend to the top of the ladder. Since 2011, 25 Bull Trout were detected in the lower pools, and 17 of these fish ascended to the top. The number of salmonids ascending the ladder after being detected in the lower pools generally ranged between 70 and 80 percent each year.

In 2018 and 2019, two of five Bull Trout detected via the Prospect Creek PIT-tag array had known natal tributaries located upstream of Thompson Falls Dams. These fish were not detected entering the lower pools of the ladder in either year. These fish were presumably motivated to move upstream past Thompson Falls Dam but did not access the ladder.

In consultation with the TAC, experiments were conducted during this time period to assess the optimal fish passage operational scheme. This resulted in years with low total catches compared to others, such as in 2018 when only 227 fish were passed. These experiments generated valuable information on the impact of ladder operations on fish passage, which will inform efforts to improve fish passage numbers in the future.

Because the ladder was a pioneering structure in Bull Trout passage, it was designed with flexibility to allow operations of the ladder in "orifice" or "notch" modes. Raising the central sliding weir gate allows pool-to-pool flow through the bottom orifice (orifice mode). Lowering the weir gate allows pool-to-pool flow through the top weir (notch mode).

Tests of orifice and notch mode found that notch mode appears to select against the weaker swimmers so fewer native fish (e.g., Largescale Sucker and Northern Pikeminnow) ascended the ladder. Although the number of salmonids remain relatively constant during notch or orifice operations, notch mode appeared to select for salmonids capable of ascending the ladder more quickly than observed in orifice mode.

A hydraulic analysis of the ladder was conducted for both notch and orifice mode (NorthWestern, 2018a). Hydraulics analysis showed notch mode results in higher velocities and reduced areas of slack or calm water compared to orifice mode. The conclusion of both the hydraulic analysis and the empirical tests was that orifice mode provided more suitable upstream fish passage conditions for a broader group of fish species than notch mode. To best meet the TAC-agreed priorities for the ladder, NorthWestern recommended, and the TAC agreed, to operate the ladder in orifice mode in 2019.

The hydraulics study also concluded that there may be opportunities to improve operations in in the orifice mode, such as experimenting with a smaller orifice between Pools 18 and 19 and/or testing different internal baffle configurations. However, any changes made to an individual pool may affect all downstream pool hydraulics. NorthWestern recommends the use of a computational fluid dynamics (CFD) model of the ladder to test different weir configurations along one or more segments of the ladder and to evaluate potential downstream effects.

In 2019, NorthWestern further experimented with operation of the lower ladder pools in orifice mode, however, operating the lower ladder pools in orifice mode may interfere with the auxiliary water supply (AWS) system. NorthWestern recommends the operational mode of the lower pools be further evaluated in the upcoming modeling and hydraulic evaluation.

Fish Movement Patterns in the Thompson Falls Project Area

The challenge of evaluating fish ladder effectiveness in a river with potamodromous species, fish requiring movement in freshwater systems to complete their life cycle, is evident at Thompson Falls. Effectiveness needs to be evaluated based on the 'motivated' population, that proportion of the population motivated to pass a barrier. But as shown at Thompson Falls, assessing the proportion of the population that is 'motivated' is complex and challenging.

Salmonids in general, and Bull Trout in particular, have been found to move upstream, downstream, and into multiple tributaries. The timing of these movements is not strictly tied to spawning seasons. Bull Trout ascend the ladder most frequently in the spring, but the timing is variable, and they have ascended the ladder as late in the season as September, so the 'motivation' is unclear. An example of complex Bull Trout movement is the Bull Trout radio tagged in 2010 and found in both Fishtrap Creek (during spawning season) and then later in the Vermilion River (after spawning season), approximately 22 miles downstream of Thompson Falls Dam. Adult Bull Trout have been found in multiple tributaries, including tributaries that are not their natal stream even when the natal stream is accessible. For example, a Bull Trout PIT-tagged as a juvenile in Graves Creek was detected in Prospect Creek about a year later. The FWS (2015) states that the ability to migrate is important to the persistence of Bull Trout as it allows them to seasonally or temporally occupy habitat that may be advantageous on an intermittent basis. It appears that seasonal and temporal movements are an important part of the behavior of Bull Trout in the Project area.

Many fish have made round trips ascending the ladder, and some moving further upstream to the Thompson River, and then back downstream of the dam before ascending the ladder again, some multiple times (some consecutive years and other at varying intervals). Since 2011 (through July 1, 2019), nearly 10 percent of the 2,953 uniquely tagged fish released upstream at Thompson Falls Dam ascended the ladder more than once. The record for ascents is held by one Brown Trout that has ascended the ladder six times in 5 years.

For Bull Trout, the genetics database is helpful in assessing the natal tributary of origin and associated assumptions about where an individual fish may be trying to migrate to. However, the accuracy of the genetic assignment is not infallible, as was documented by genetic tests of juveniles collected in tributaries assumed to be their natal stream.

The use of the Thompson River by salmonids in the Thompson Falls Project has been affirmed by the number of fish that have been found to migrate into the Thompson River after passing upstream of the fish ladder. A minimum of 25 percent of the PIT-tagged fish that ascended the ladder between 2014 and 2018 were later detected in the Thompson River, including a minimum of 27 percent of the Bull Trout that were released upstream after ascending the fish ladder. The travel time for fish to reach the Thompson River from Thompson Falls Dam was often quite rapid, with the majority of fish reaching the Thompson River in 1 day or less.

Downstream Passage through Thompson Falls Reservoir

As described above, Bull Trout appear to use Thompson Falls Reservoir as a migratory corridor. The number of salmonids found in Thompson Falls Reservoir in general is quite low. The Reservoir is primarily habitat for native non-game species and non-native species including Black Bullhead and Northern Pike.

The BiOP (TC 5a) required the Licensee to assess the potential impacts of predatory non-native fish species on Bull Trout residing in or passing through the Thompson Falls Reservoir. The 2009 FERC Order expanded on this requirement and included TC 5b requiring the need for the Licensee to evaluate a non-native species control program for Thompson Falls Reservoir in collaboration with TAC agencies, with final recommendations to be approved by the FWS. The purpose of such a program would be to reduce predation on juvenile Bull Trout.

A juvenile Bull Trout was found in a Northern Pike (captured in the Island Complex area) stomach during a 2009 food habits study indicating that there is some risk of non-native species predation on juvenile Bull Trout. However, a multi-year study from 2014 to 2015 on out-migration of juvenile Bull Trout out of the Thompson River drainage and into the Thompson Reservoir did not identify non-native predation as a critical limiting factor. Therefore, NorthWestern and the TAC agencies did not identify, develop, or recommend a non-native species suppression program be instituted in Thompson Falls Reservoir because the efficacy of such a program for the purpose of Bull Trout restoration seems unlikely.

ES 1.7 Recommendations

As mentioned in part in this Executive Summary and otherwise addressed elsewhere in the report, NorthWestern recommends the following based on the Phase 2 fish passage evaluation studies:

- The fish ladder be operated in orifice mode for the remainder of the existing FERC license. This recommendation is consistent with agency goals of passing Bull Trout as first priority, and native species as a second priority.
- CFD modeling of the fish ladder followed by potential modifications to improve hydraulic conditions in orifice mode.

- Installation of one or more additional PIT tag arrays in the ladder to better evaluate fish movement between the lower pools and the holding pool and identify sections of the ladder that may present less than optimal conditions for upstream fish movement. Flat plate PIT tag detectors may be preferable to reduce impacts to ladder hydraulics.
- If the scientific review panel concludes delay for fish locating the ladder entrance is a concern, then radio telemetry studies could be considered for evaluating fish in the tailrace. However, the risk and stress to fish from handling and tagging should be considered when making this determination.
- Continued testing of new main channel radial gates (operational in 2019 season) timing and influence to fish movement to tailrace and ladder (as well as total dissolved gas [TDG] implications). This testing could include photo documentation of tailrace flow patterns to assess passage conditions at varying discharge and spillway operations.
- Continued monitoring of PIT tags in major tributary streams, Thompson River and Prospect Creek.
- No non-native fish suppression in Thompson Falls Reservoir.

NorthWestern will prepare an updated Fishway Operations Plan for submission with the Final FERC License Application, due December 31, 2023. This Plan will incorporate the results of the studies that will be undertaken during upcoming the relicensing period.

1. Introduction

Bull Trout (*Salvelinus confluentus*) were federally-listed as a threatened species under the Endangered Species Act (ESA) in 1998. The Licensee-prepared 2003 Biological Evaluation (BE) concluded that the Project was likely adversely affecting Bull Trout. This determination led to a process to determine conservation measures to reduce “take.” An interagency technical advisory committee (TAC) was established with, among others, the Licensee, U.S. Fish and Wildlife Service (FWS), Montana Fish, Wildlife and Parks (FWP), U.S. Forest Service (USFS), Avista, Montana Department of Environmental Quality (MDEQ), and Confederated Salish and Kootenai Tribes (CSKT).

The Licensee worked cooperatively with the TAC from 2003 to 2008 to clarify regulatory issues and conduct significant scientific and engineering evaluations and in-situ testing. The objectives of the evaluations and testing were to determine factors affecting Bull Trout and other fish passage behavior, full height fish ladder design and construction, and subsequent fish ladder and Project operations. On November 4, 2008, the FWS filed a Biological Opinion (BiOp) with FERC, concluding that the Project is currently adversely affecting Bull Trout and that the Licensee’s proposed conservation measures would reduce, but not eliminate, adverse impacts of the Project. The Thompson Falls Project fish ladder (fish ladder) was thereafter constructed in 2009 and 2010 to meet both FWS Section 7 (ESA) and FERC License requirements, which include provisions for restoring habitat connectivity for Bull Trout along the Clark Fork River above and below the Project.

The BiOp included a requirement for the Licensee to conduct Phase 2 studies from 2010 to 2020 to evaluate fish passage at the Project. At the end of the evaluation period the Licensee is required to prepare a comprehensive 10-year report. The BiOp specified that this report would be completed by December 31, 2020. However, the current FERC license for the Project expires December 31, 2025. NorthWestern intends to pursue a new license for the project using FERC’s Integrated Licensing Process (ILP). NorthWestern has developed a draft relicensing schedule based on the ILP and found that some adjustments in the compliance reporting schedule could better align the compliance schedule with the relicensing schedule. Specifically, NorthWestern requested, and the FWS concurred, that the comprehensive report described in the BiOp would be submitted a year early, by December 31, 2019 (Table 1-1). This Comprehensive Phase 2 Fish Passage Report was prepared, with guidance from the TAC, to summarize the results of the Phase 2 studies, through July 1, 2019.

The BiOp also requires the Licensee to convene a structured scientific review of the project, guided by the TAC. This scientific review will be completed by April 1, 2020 and will develop a set of recommendations to be submitted to the FWS 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 in an updated operating plan for the fishway.

The structured scientific review (described in TC1(h) of 2008 BiOp) will convene in January 2020 and will be completed by April 2020. Recommendations for studies (if any) that arise from the scientific review may be incorporated into NorthWestern's relicensing study plan, due to be filed with FERC in December 2020. NorthWestern's updated fishway operating plan will be submitted to FERC with the Final License Application (FLA) by December 31, 2023.

Table 1-1. Summary of the Schedule for the Comprehensive Scientific Review, Thompson Falls Fish Passage Project.

Activity	Deadline
Comprehensive Phase 2 Fish Passage Report, including the evaluation of migratory Bull Trout passage through Thompson Falls Reservoir and the results of fishway evaluation through July 1, 2019	December 31, 2019
Convene Scientific Review Panel	January 1, 2020
Scientific Review Panel Completes Review	April 1, 2020
Notice of Intent and Pre-Application Document filed with FERC	July 1, 2020
NorthWestern Energy's Thompson Falls Study Plan filed with FERC as part of Thompson Falls relicensing	December 13, 2020
NorthWestern Implements Studies as directed in FERC's Study Plan Determination	2021-2022
NorthWestern Files Final License Application for Thompson Falls Hydroelectric Project with FERC. Will include updated Fishway Operating Plan	December 31, 2023

1.1 Project Location

NorthWestern Energy Corporation, d/b/a NorthWestern (NorthWestern) is owner and operator of the Thompson Falls Hydroelectric Project (No. 1869) (Project), located on the lower Clark Fork River in Sanders County near Thompson Falls, Montana.

Preliminary development of the Project began in June 1912, by the Thompson Falls Power Company. Construction commenced in May 1913, and the first generating unit (Unit No. 1) was placed in service on July 1, 1915. The sixth generating unit (Unit No. 6) was placed in service in May 1917. Montana Power Company acquired the Project in 1929 and built an additional powerhouse containing a seventh unit (Unit No. 7) in 1995. Altogether, the Project has an installed capacity of 92.6 MW.

The current Federal Energy Regulatory Commission (FERC or Commission) License was issued to Montana Power Company in 1979 (purchased by PPL Montana in 1999 and subsequently purchased by NorthWestern in 2014) and is scheduled to expire on December 31, 2025. NorthWestern acquired the Thompson Falls Project in 2014 and has been operating it continuously since that time as a part of its integrated electric system.

The original License for the Project was issued effective January 1, 1938 and expired on December 31, 1975. The current License was issued December 28, 1979 and has been amended a number of times. The most significant amendments were the April 30, 1990 amendment to allow construction of the new powerhouse and extending the term of the License, and the February 12, 2009 amendment approving construction and operation of fish passage facility.

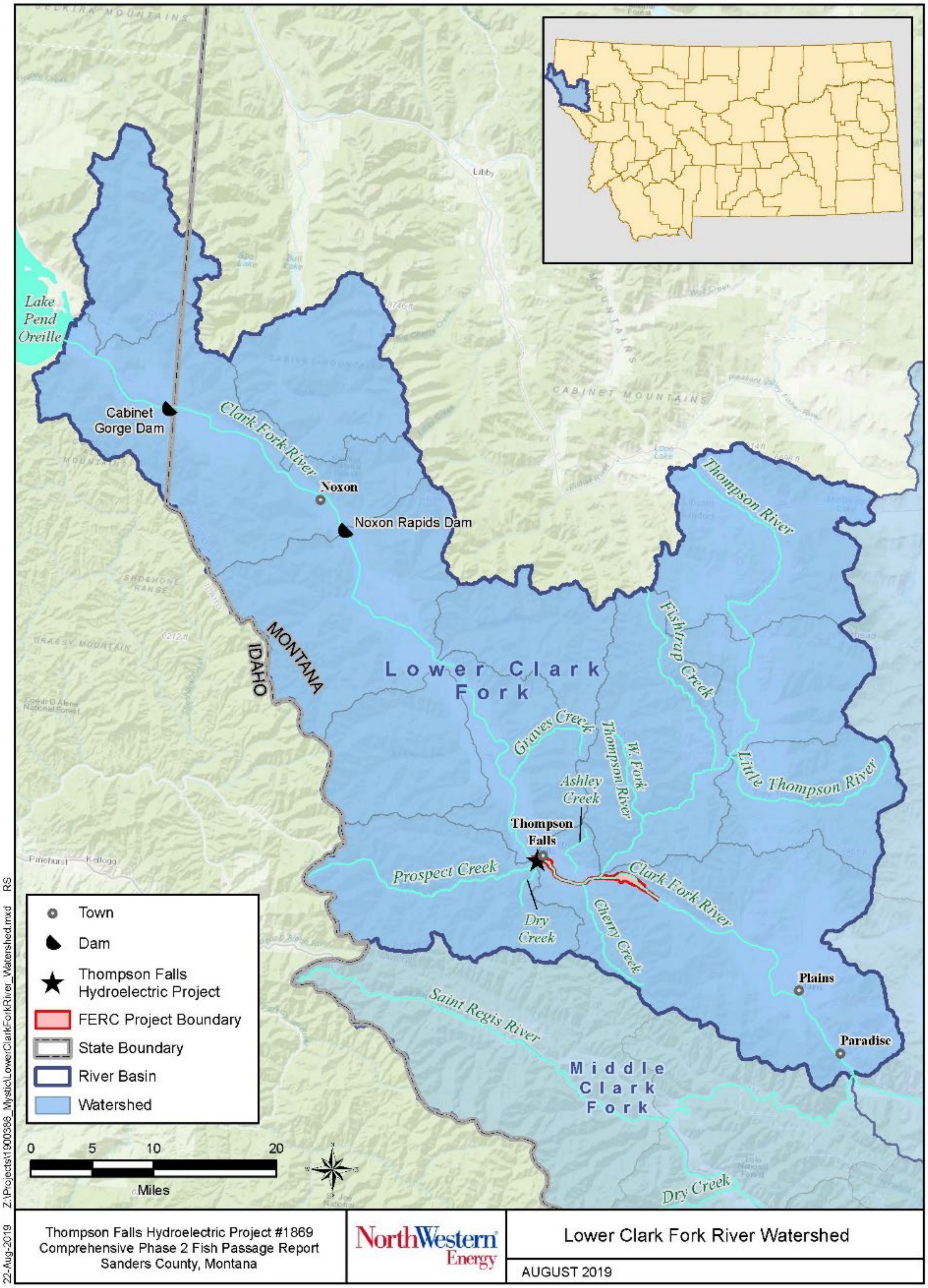
The Thompson Falls Project boundary is defined in the FERC License and is approximately 0.3 mile (0.5 km) downstream and 12 miles upstream of the Project (Figure 1-1). Thompson Falls Reservoir covers 1,446 acres (5.8 square kilometers [km^2]) at a normal pool El. 2396 feet (730 meters [m]). The drainage area that contributes flow to the Clark Fork River, at the Project is 20,904 square miles (mi^2 or 54,140 km^2) (U.S. Geological Service [USGS] StreamStats, 2018) and includes upstream flow from the Thompson, Flathead, Blackfoot, and Bitterroot rivers. The lower Clark Fork River drains into Lake Pend Oreille in Idaho and is part of the Upper Columbia River basin.

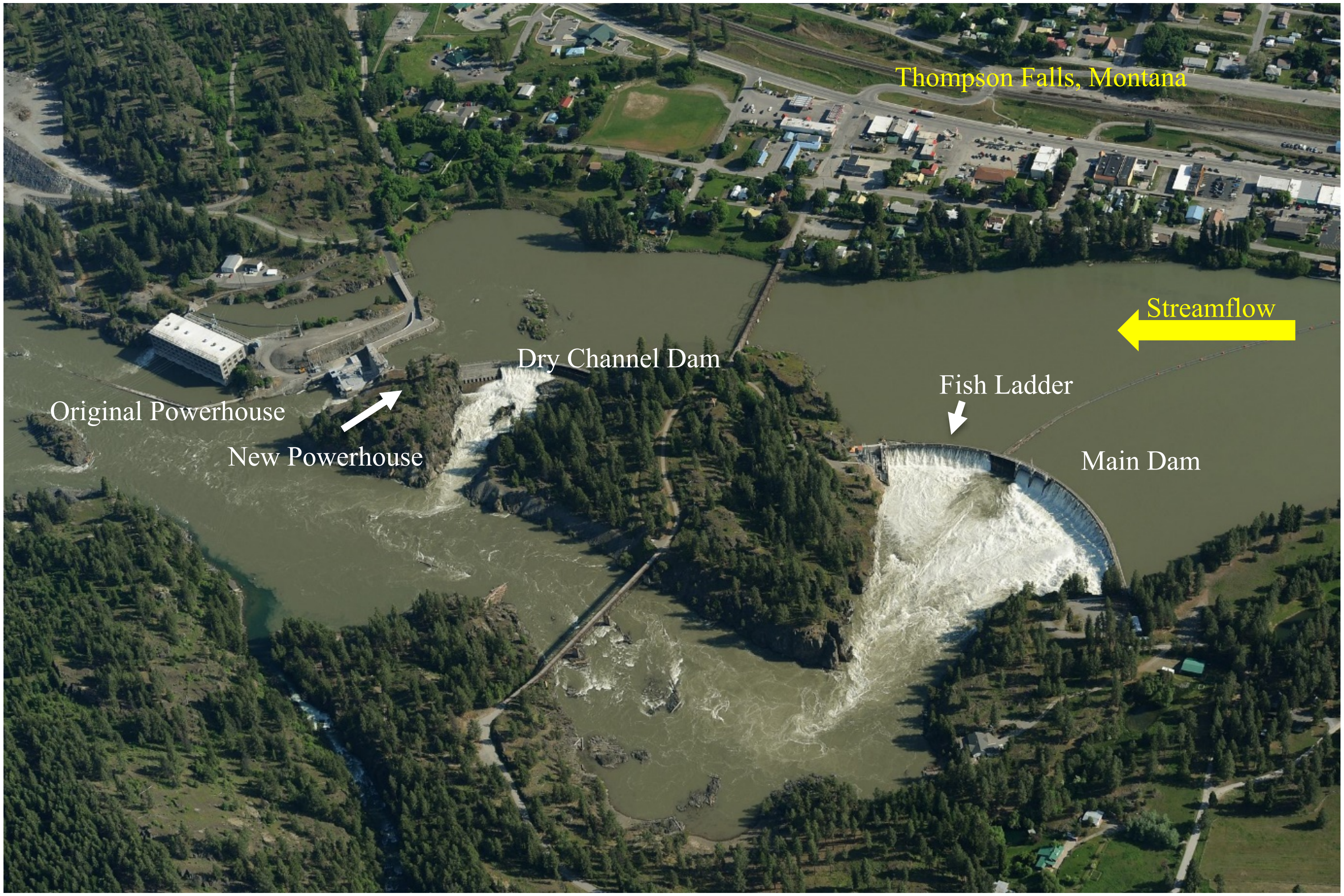
Downstream of the Thompson Falls Project is Avista Corporation's (Avista) 742-MW Clark Fork River Project (FERC Project P-2058) consisting of Noxon Rapids Dam (479 MW), located approximately 33 miles (21 km) downstream of the Thompson Falls in Montana and Cabinet Gorge Dam (263 MW), and approximately 19 miles (31 km) downstream of Noxon Rapids Dam near Lake Pend Oreille, Idaho.

Upstream of the Thompson Falls Project is the 188-MW Seli'š Ksanka Qlispe' (SKQ) Project (FERC Project P-5; formerly known as Kerr Dam), located on the Flathead River, approximately 100 miles (160 km) upstream. The Flathead River is tributary to the Clark Fork River. The CSKT are owners and its wholly owned, federally-chartered corporation, Energy Keepers, Inc. is operator of the SKQ Project. The only other major dam in the watershed upstream of the Thompson Falls Project is Hungry Horse Dam on the South Fork of the Flathead River, a 285-MW hydropower project managed by the Bureau of Reclamation.

The primary tributaries of the Clark Fork River within the Project area are the Thompson River and Cherry, Dry, Ashley and Prospect creeks (Figure 1-1). Prospect Creek flows into the Clark Fork River just downstream of the Main Channel Dam (Photograph 1-1). That stream flows eastward into the Clark Fork River from the mountain range separating Idaho-Montana. The Thompson River flows into the Clark Fork River approximately 6 miles (9.6 km) upstream of the Thompson Falls Dam.

Figure 1-1. Location of Thompson Falls Hydroelectric Project (No. 1869) near the town of Thompson Falls, Montana and the lower Clark Fork River drainage.





Photograph 1-1. Aerial photo of the Thompson Falls Project, taken June 2, 2014 with streamflows approximately 78,330 cfs (USGS Clark Fork River near Plains and Thompson River).

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1.2 Clark Fork River Hydrology

Thompson Falls Dam is within the lower Clark Fork River watershed, which has an area of 2,337 mi^2 (6053 km^2). The Clark Fork River United States Geological Survey (USGS) gage at Plains, Montana is approximately 30 miles (48 km) upstream of the Thompson Falls Project. There is only one tributary with significant flow between the Plains gage station and the Project site, the Thompson River. The Thompson River joins the Clark Fork River approximately 6 miles (9.7 km) upstream of the dam and contributes on average 2.0 percent of the flow in the Clark Fork River with a range of 0.7 percent up to 5.4 percent. The USGS also maintains a gage on the Thompson River. Therefore, the most accurate available flow statistics were derived by combining USGS gages on Clark Fork River at Plains, Montana (USGS gage 12389000) with Thompson River near Thompson Falls (USGS gage 12389500), to calculate minimum, mean, and maximum streamflow in Clark Fork River at the Project (Figure 1-2).

Figure 1-2. Daily minimum, maximum, and mean streamflow at the Thompson Falls Project from April 1, 1956 to present. Source: USGS Gage Stations 12389000 and 12389500.

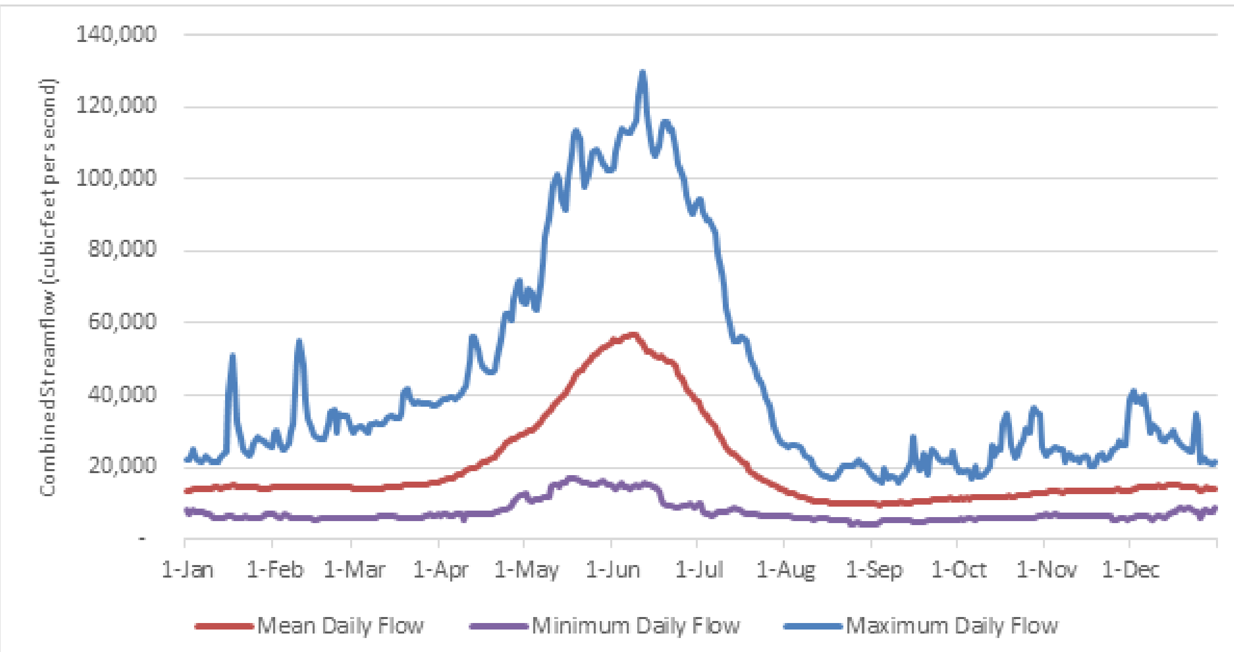
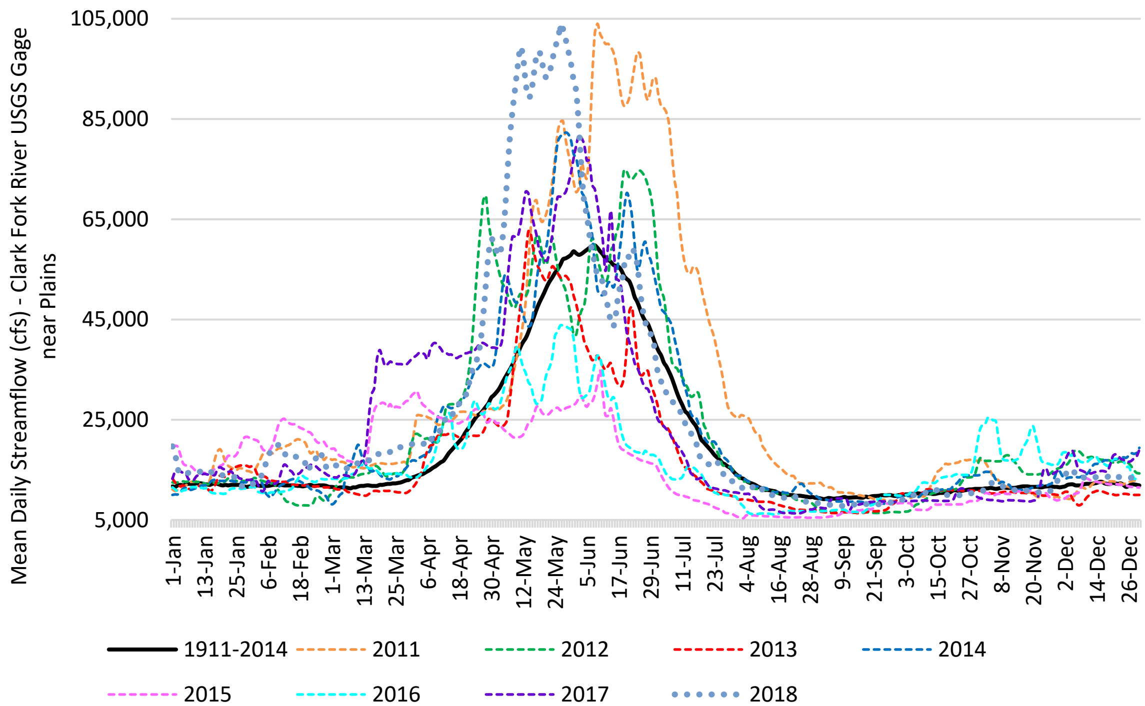


Figure 1-3 depicts the annual hydrographs for the years when the fish ladder has been in operation at the Thompson Falls Project (2011-2018). There were significantly higher than average peak flows in 2011 and 2018, and significantly lower than average peak flows in 2015 and 2016. The timing of peak flows has varied considerably over this time period as well, note that runoff in 2018 was much earlier than in 2011.

Figure 1-3. Annual mean daily streamflow at the USGS gage 12389000 for the Clark Fork River near Plains for 2011-2018 and the long-term average 1911-2014 (USGS, 2018).



1.3 Project Description

The existing Project structures consist of two curved concrete gravity dams (Dry Channel Dam and Main Channel Dam) with overflow spillways and two powerhouses (original powerhouse and new powerhouse) (Photograph 1-1).

1.3.1 *Powerhouses*

The original powerhouse consists of a mass concrete substructure, a masonry rock wall, concrete and structural steel superstructure, concrete floor, and roof slabs supported on steel framing. There are five generators rewound to 8.75 Megavolt amperes (MVA) each and one generator rewound to 7.5 MVA. The total installed capacity of the six turbine-generator units is approximately 40 MWs at a normal water head of 55 feet.

The Unit No. 7 powerhouse (new powerhouse), completed in 1995, is a cast-in-place reinforced concrete gravity structure founded on rock and includes an integral intake and headworks. A substantial portion of the new powerhouse is located below grade.

The turbine is a vertical shaft, double-regulated Kaplan type rated 52.6 MW at 54.5 feet net head and 94.7 revolutions per minute (rpm). The range of net head is 40 to 65 feet.

1.3.2 *Spillways*

The Main Dam is a curved gravity ogee spillway section, 913 feet long and an average height of 18 feet above the riverbed (Photograph 1-2). It contains 30 bays divided by concrete piers or permanent steel frames on 24-foot centers, which support flashboards and removable fixed wheel panels. The Main Dam spillway crest is at El. 2380 feet and the top of the fixed wheel panels establish the normal full pool El. 2396 feet. A concrete apron extends 30 to 50 feet downstream of the entire spillway section.

Two 41-foot-wide by 18-foot-high radial gates are located in Panels 16 and 17 (Photograph 1-2). In 2019, NorthWestern completed construction of two new radial gates near the left abutment on the Main Channel Dam. The new radial gates are similar in dimension and configuration to the older radial gates but located in bays 25 through 29. Each radial gate passes approximately 10,000 cfs, for a total spillway capacity through the radial gates of 40,000 cfs.

The fixed wheel panels are installed and removed by a crane, which travels along tracks on a 10-foot-wide bridge over the full length of the spillway. In a high flow event, the flashboards can be released by tripping or by torch cutting the bolt that secures the tripping latch and releasing the entire assembly free of the flashboard support structures.

Photograph 1-2. Thompson Falls Project Main Channel Dam, with the new radial gates. Photo credit: K. Bergstrom.

The Dry Channel Dam is located on a former channel of the river separated from the Main Channel Dam by an island. It is a curved concrete gravity dam and consists of two distinct structures. A non-overflow sluiceway section, 122 feet long and 38 feet high is located at the right side of the dam. It contains 10, 5-foot by 6.5-foot sluiceways that were originally controlled by slide gates operated from the crest of the dam (Photograph 1-3). The slide gates were permanently closed about 1942 and in 1990 bulkheads were constructed within each sluiceway. The second part of the dam is an overflow spillway with an ogee crest. It has an overall length of 289 feet and an average height of 17 feet above the riverbed. The overflow spillway contains 12 bays, each with six panels and steel flashboard supports on 24-foot centers. The Dry Channel spillway crest is at El. 2384 feet, but storage is increased by 4-foot flashboards and 8-foot fixed wheel panels similar to those on the Main Channel Dam, which brings the normal reservoir level to El. 2396 feet.

As with the Main Channel Dam, the flashboards of the Dry Channel Dam can be released by tripping or by torch cutting the bolt that secures the tripping latch and releasing the entire assembly from the flashboard support structures.

Photograph 1-3. Dry Channel Dam.

1.3.3 *Upstream Adult Fishway (Fish Ladder)*

The Thompson Falls Fish Ladder (ladder or fish ladder) was constructed between 2009 and 2010 to help restore habitat connectivity for Bull Trout along the Clark Fork River above and below the Project. Bull Trout were listed as a threatened species under the Endangered Species Act in 1998. The ladder was constructed on the right side (facing downstream) of the Main Channel Dam, adjacent to the non-overflow gravity dam section (Photograph 1-1). The Main Dam is the furthest upstream impoundment structure of the Project. The fish ladder was designed in general accordance with the National Oceanic and Atmospheric Administration Fisheries (NOAA) Criteria (NMFS, 2008), which is used by FWS in the design of upstream passage facilities.

The ladder was constructed with a sloping concrete floor, with 48 individual pools created by internal weir plates constructed across the concrete "U" section. Hydraulically, the ladder was designed to induce a 1-foot drop in the hydraulic grade line for each of the 48 pools to allow passage of a diverse population of fish over the Main Channel Dam. Additional details regarding the design of the fish ladder are found in Section 3.3 Fish Ladder Design.

1.3.4 *Thompson Falls Reservoir*

Thompson Falls Reservoir formed by the impounded water is about 12 miles (19.3 km) long with a maximum width of about 1,800 feet (548.6 m). Active storage capacity of the Thompson Falls Reservoir is approximately 15,000 acre-feet between crest El. 2380 feet and normal full pool El. 2396 feet. At the normal full pool reservoir El. 2396 feet, the reservoir surface area is approximately 1,446 acres (5.8 km^2).

Photograph 1-4. Thompson Reservoir – view upstream from bridge Jun 21, 2010). Photo credit: K. Webb.

1.3.5 *Project and Fish Ladder Operations*

The Project is operated to provide baseload and flexible generation while complying with the reservoir elevation requirements of the License. The facility is typically operated to maximize peak generation efficiency across all units with available flows. Unit No. 7 is used as the primary unit for efficiency followed by Units 1 and 3, and finally Units No. 2, 4, 5, and 6. Units are typically dispatched in this efficiency priority as flows allow.

The 1990 License Amendment allows the Project to operate as a peaking facility. Peaking is limited by a minimum Project discharge (flow) of 6,000 cfs or inflow, whichever is less, and by maximum reservoir drawdown to El. 2392 feet (FERC, 1990). During peaking and non-peaking operations, plant flows and generation will vary while maintaining the reservoir to the required elevation (2,392–2,396 feet).

The Thompson Falls Reservoir has a total storage capacity of approximately 15,000 acre-feet at normal pool. The Project can discharge its total storage pool of 15,000 acre-feet in slightly less than 8 hours minus the inflows (FERC, 1990).

When flow exceeds total powerhouse capacity (23,000 cfs), the spillway panels are used along with the radial gates to pass additional flow. As runoff increases, the 4- by 8-foot spillway panels on the Main Channel Dam are removed for additional spill capacity. As flows increase, more panels are removed to balance flows across the length of the Main Channel Spillway. In most years, when the peak flood discharge is less than 70,000 cfs, spill is restricted to the Main Channel Dam section. If flows exceed 70,000 cfs, there are 72 Dry Channel Dam spill panels (each 4' x 8') available to increase spill capacity. Operation of the Dry Channel Spillway has been used in 5 of the past 10 years.

The Thompson Falls Fish Ladder operates annually (since 2011), typically from mid-March to mid-October depending on weather. The ladder seasons ends (and the ladder is dewatered and shut down) when a fall freeze is imminent. Temporary closures may occur during the season due to high spring streamflows and associated debris and sediment accumulation in the lower pools of the ladder. The work station (3 cfs) and fish ladder (6 cfs pool-to-pool), including attractant flows (high velocity jet and auxiliary water system), may utilize between 9 and 83 cfs. Details of water flow through the system are provided in Section 3.3 (Fish Ladder Design). The elevation of Thompson Falls Reservoir has been near full pool (2,396') during fish ladder operations, providing the required 9 cfs (6 cfs down the ladder; 3 cfs through the fish working station) for fish ladder functionality. Lower reservoir elevations do not impact the optional 20 cfs from the high velocity jet (HVJ) and/or 54 cfs from the auxiliary water system (AWS) providing fish attractant flows that exit at the bottom of the fish ladder because the intakes for attractant flows (HVJ and AWS) are much lower on the dam. In addition to these flows through the ladder and at the entrance of the ladder, NorthWestern may partially open one dam spill gate near the fish ladder to provide an additional fish attractant flow.

1.4 Bull Trout in the Lower Clark Fork River Critical Habitat Subunit

1.4.1 *Bull Trout Life History*

Of native salmonids in the Pacific Northwest of the United States, Bull Trout have the most specific habitat requirements (Rieman and McIntyre, 1993), which are often referred to as "the four Cs": Cold, Clean, Complex, and Connected habitat (FWS, 2015). These requirements include cold water temperatures compared to other salmonids (often less than 12 degrees Celsius [°C] or 54 degrees Fahrenheit [°F]); the cleanest stream substrates; complex stream habitat including deep pools, overhanging banks and large woody debris; and connectivity between spawning and rearing areas and downstream foraging, migratory, and overwintering habitats (FWS, 2015).

In the Clark Fork River drainage, 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 1 to 4 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. Resident and migratory forms may be found together, and either form may give rise to offspring exhibiting either resident or migratory behavior (Rieman and McIntyre, 1993; Brenkman et al., 2007; Homel et al., 2008).

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 (70 °F) (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 (Downs et al., 2006).

Rearing habitat requirements for juvenile Bull Trout include cold summer water temperatures (less than 15 °C; 59 °F) provided by sufficient surface and groundwater flows. Juvenile Bull Trout are generally benthic foragers, rarely stray from cover, and they prefer complex forms of cover. Habitat characteristics that are important for juvenile Bull Trout of migratory populations are also important for stream resident subadults and adults.

Flathead Lake and Lake Pend Oreille are the two largest lakes in the range of Bull Trout, and they represent the "evolutionary heart" of the migratory adfluvial Bull Trout life history form (FWS, 2010). Bull Trout from those lakes historically grew to be large and migrated upstream up to 200 miles (322 km) to spawning and rearing habitats. Flathead Lake and Lake Pend Oreille are the primary refugia for the naturally occurring adfluvial form of Bull Trout across their range (FWS 2010). The lower Clark Fork River provides an important portion of the spawning and rearing habitat for Lake Pend Oreille, as well as an essential migratory corridor for Bull Trout from Lake Pend Oreille to be able to access productive watersheds upstream (FWS, 2010).

According to the 2015 Recovery Plan for the Coterminous United States Population of Bull Trout (FWS, 2015), the ability to migrate is important to the persistence of Bull Trout as it allows them to seasonally or temporally occupy habitat that may be advantageous on an intermittent basis. Both migratory and stream-resident Bull Trout move in response to developmental and seasonal habitat requirements (FWS, 2015). Migratory individuals can move great distances (up to 156 miles; 250 km) among lakes, rivers, and tributary streams in response to spawning, rearing, and adult habitat needs (MBTRT, 2000). Migrations facilitate gene flow among local populations when individuals from different local populations interbreed or stray to non-natal streams. Local populations that are extirpated by catastrophic events may also become reestablished by Bull Trout migrants (FWS, 2015).

1.4.2 *Bull Trout Endangered Species Listing and Designated Critical Habitat*

In 1998, the Bull Trout was federally-listed under the Endangered Species Act as a threatened species (Federal Register, 1998). Critical habitat was designated in 2005 and revised in 2010 (Federal Register, 2005; 2010). Critical habitat for Bull Trout is defined as a habitat unit that can maintain and support viable Bull Trout core areas (Federal Register, 2005). In 2015, FWS developed a recovery plan for Bull Trout (FWS, 2015). Bull Trout are present within the Project area.

The Thompson Falls Hydroelectric Project area is within the Columbia Headwater Recovery Unit (CHRU). Within the CHRU, FWS identified 32 Critical Habitat Units (CHUs), including the Clark Fork River Basin CHU (Federal Register, 2010). The Clark Fork River Basin CHU has 12 subunits including the Lower Clark Fork River Critical Habitat Subunit (CHSU) encompassing the Project area, located in Sanders and Missoula counties covering 295 miles (474.9 km) of stream and 9,719 acres (3,933 ha) of surface area as designated bull trout habitat (Federal Register, 2010).

The lower Clark Fork River CHSU provides essential foraging, migrating, and overwintering habitat for Bull Trout from potentially several local Bull Trout populations and included designated critical Bull Trout habitat (FWS, 2010). The lower Clark Fork River CHSU is part of the Lake Pend Oreille core area (FWS, 2015). As part of the critical habitat designation, the Thompson Falls Reservoir is considered a stream reach and not a lake due to the lack of reservoir storage capacity (Federal Register, 2010). Two tributaries near the Project including Prospect Creek, located immediately downstream of the Main Dam, and the Thompson River, located about 6 miles (9.7 km) upstream of the Main Dam, are designated Bull Trout critical habitat.

The Lake Pend Oreille core area connects Lake Pend Oreille and the lower Clark Fork River drainage to the middle and upper Clark Fork River. The middle Clark Fork River CHSU is a migratory corridor providing access for Bull Trout from Lake Pend Oreille and the lower Clark Fork River CHSU to the Blackfoot River, Rock Creek, and potentially Bitterroot River CHSU and Upper Clark Fork River CHSU. In addition, several important spawning and rearing tributaries enter the Clark Fork River in this CHSU (FWS, 2010). Table 1-2 identifies the lower and middle Clark Fork River reaches and respective local Bull Trout populations identified by FWS (2015).

Table 1-2. Bull Trout spawning and rearing tributaries to the lower and middle Clark Fork and lower Flathead River.

Upstream or Downstream of Project	River Reach Description	Bull Trout Spawning and Rearing Tributaries to the Clark Fork River/Flathead River
Downstream	Noxon Rapids Dam upstream to Thompson Falls Dam	Swamp Creek, Vermilion River, Graves Creek, Prospect Creek
Upstream	Lower Clark Fork River - ends at the confluence with the lower Flathead River	Thompson River
Upstream	Lower Flathead River	Jocko River, Mission Creek, Post Creek, Dry Creek
Upstream	Middle Clark Fork River - starts at the confluence with the lower Flathead River and ends at the confluence with the Blackfoot River	St. Regis River, Cedar Creek, Fish Creek, Petty Creek, Albert Creek, Grant Creek, Rattlesnake Creek

1.4.3 *Lower Clark Fork River Bull Trout Population Status*

As part of the Lake Pend Oreille core area, the lower Clark Fork River provides an important portion of the spawning and rearing habitat for Lake Pend Oreille, as well as an essential migratory corridor for Bull Trout from Lake Pend Oreille to be able to access productive watersheds upstream (FWS, 2010).

For over 70 years, three hydroelectric dams have been in operation on the lower Clark Fork River impacting migratory fish movement extending over 65 river miles near the inlet to Lake Pend Oreille upstream to Thompson Falls, Montana. In addition to the Thompson Falls Project, there are two projects owned and operated by Avista, Cabinet Gorge Dam (built in 1952) located just downstream of the Idaho and Montana state line and Noxon Rapids Dam (built in 1959) located approximately 28 river miles east of the state line. Upstream fish passage at these facilities has been limited to an adult Bull Trout fish passage program managed by Avista at Cabinet Gorge Dam since 2001, and the seasonal upstream fish passage facility operated and managed by NorthWestern at Thompson Falls Dam since 2011. Construction of a fishway at Cabinet Gorge Dam commenced in 2019 and is expected to be operational in the fall of 2021. A potential fishway/passage facility at Noxon Rapids dam will be considered once the Cabinet Gorge fishway is operational and has been evaluated.

In 2008, Lake Pend Oreille was estimated to support a population of approximately 10,000 Bull Trout over 350 mm in length. The Bull Trout population of Lake Pend Oreille was deemed to be stable at that time (McCubbins et al., 2016). However, it appears that only a small proportion of those fish are lower Clark Fork River adfluvial fish, which is in part because of the lack of upstream fish passage for decades following the construction of the dams on the lower Clark Fork River. Most Bull Trout in Lake Pend Oreille seem to have natal streams that are direct tributaries to Lake Pend Oreille.

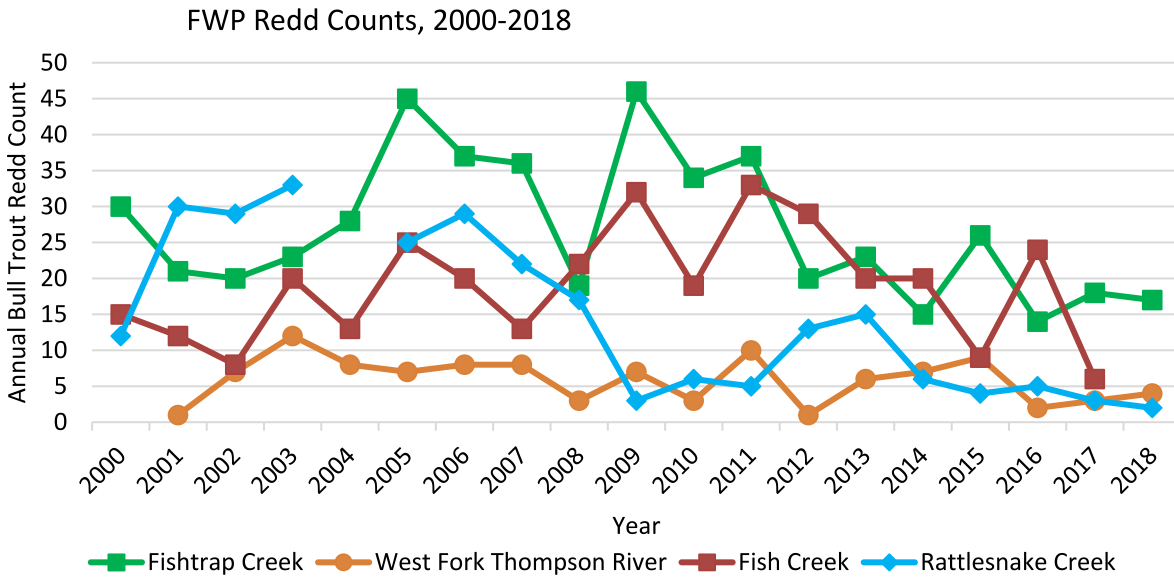
The evidence for that is the relatively large numbers of spawning Bull Trout that use Lake Pend Oreille tributaries, and the relatively small numbers that attempt to migrate upstream into the Clark Fork River. For example, a mark-recapture estimate in 1998 estimated a spawning escapement in Trestle Creek, tributary to Lake Pend Oreille, of 1,387 adults (Dunham et.al., 2001). The Lake Pend Oreille CHSU has averaged over 800 Bull Trout redds annually over the last 10 years (prior to 2010), with a high of greater than 1,250 redds in recent years (FWS, 2010). In contrast, Avista operates a program to collect and transport Bull Trout collected from the Clark Fork River upstream of Lake Pend Oreille. In the 18 years of the program (2001–2018), they have transported an average of 37 Bull Trout per year (Bernall and Duffy, 2019). Even if the capture efficiency is low, it is clear that the number of Bull Trout migrating upstream into the Clark Fork River from Lake Pend Oreille is relatively low.

No population estimate has been conducted for Bull Trout in the Clark Fork River upstream or downstream of the Thompson Falls Hydroelectric Project, primarily because numbers are too low to allow for an accurate estimate. Fish sampling in the Project area is described in more detail in the following chapters, but it is clear that the numbers of Bull Trout in the Project area are depressed.

Another Bull Trout population index is based on redd counts. FWP has monitored Bull Trout redds in spawning and rearing tributaries in the Thompson River and tributaries in the middle Clark Fork River (Cedar Creek, Fish Creek, St. Regis River, Rattlesnake Creek) between 2000 and 2018 (FWP, unpublished data). Not all tributaries were surveyed annually, and some tributaries present a mix of resident and fluvial/adfluvial Bull Trout populations, making the validity of a redd count index for fluvial/adfluvial Bull Trout populations difficult. However, these are the best available data for known Bull Trout populations that are most likely to benefit from upstream passage at Thompson Falls Dam.

Annual Bull Trout redd counts in the Thompson River (Fishtrap Creek and West Fork Thompson River) and in the middle Clark Fork River (Fish Creek and Rattlesnake Creek) provide the most consistent annual redd count data available since 2000 and are presented in Figure 1-4. Fishtrap Creek shows consistently the highest number of redds per survey year (peak of 46 redds in 2009) while West Fork Thompson River and Rattlesnake show the lowest number of redds per survey year (≤ 15 redds per a given survey year). Fish Creek represents West Fork and North Fork Fish Creek combined and the redd counts in Fish Creek have oscillated between 6 and 33 redd counts per survey year. The redd count data in more recent years show a declining trend in the tributaries (Figure 1-4). Regardless of the precision the redd count data provide, these data indicate that the number of fluvial/adfluvial juvenile Bull Trout outmigrating from upstream tributaries into the lower and middle Clark Fork River is low.

Figure 1-4. Bull Trout redd counts in the Thompson River (Fishtrap Creek and West Fork Thompson River) and middle Clark Fork River tributaries: Fish Creek (North Fork and West Fork) and Rattlesnake Creek, 2000–2018. *Source*: FWP, unpublished data.



1.5 Fish Passage Development at Thompson Falls Hydroelectric Project

Since 2003, the Licensee has coordinated with the interagency TAC to identify conservation measures to mitigate Project adverse impacts to Bull Trout (Table 1-3 summarizes the history of fish passage development at the Project since Bull Trout were listed as 'threatened'). The Licensee prepared the Thompson Falls Dam Fish Passage Study Plan (Pre-Design Phase Plan) to develop upstream adult fish passage at the Project and identified the need for additional fish behavior and project operations data prior to the development of a permanent fish passage facility (Gillin and Pizzimenti, 2003). Subsequent studies to implement the Pre-Design Phase Plan were developed cooperatively with the TAC. Radio-telemetry studies were designed and completed in 2004 with focus on fish behavior in the tailrace (Gillin and Haddix, 2005); in 2005 to assess the relationship between fish behavior and streamflow/spill in the Project (Haddix and Gillin, 2006); and in 2006 to further evaluate the optimal location for an entrance to a fish passage facility at the Main Channel Dam (GEI, 2007). Fish behavior studies focused on Bull Trout, but because the number of Bull Trout sampled in any given year was low, other fish such as native Westslope Cutthroat Trout and non-native sport-fish, Brown Trout, Rainbow Trout, and Rainbow x Westslope Cutthroat hybrids were included in the telemetry studies. A summary of the 2004–2006 telemetry studies are also available in Section 5.3 of the Thompson Falls Baseline Environmental Document (NorthWestern, 2018b).

The fisheries telemetry work concluded that fish were moving upstream to the uppermost terminus of the Project, the Main Dam spillway during the ascending the limb of the hydrograph and would leave the area and move downstream at peak flows. Fish were not sedentary and were constantly on the move. Initial monitoring efforts showed more fish moving to the left abutment than the right abutment. However, it was found that spill could be configured to attract fish to the right abutment (GEI, 2007). Based on the results of the fish behavior and movement studies (GEI, 2007), it was determined that the optimal location of the fishway was the uppermost terminus of the Project, the Main Dam spillway.

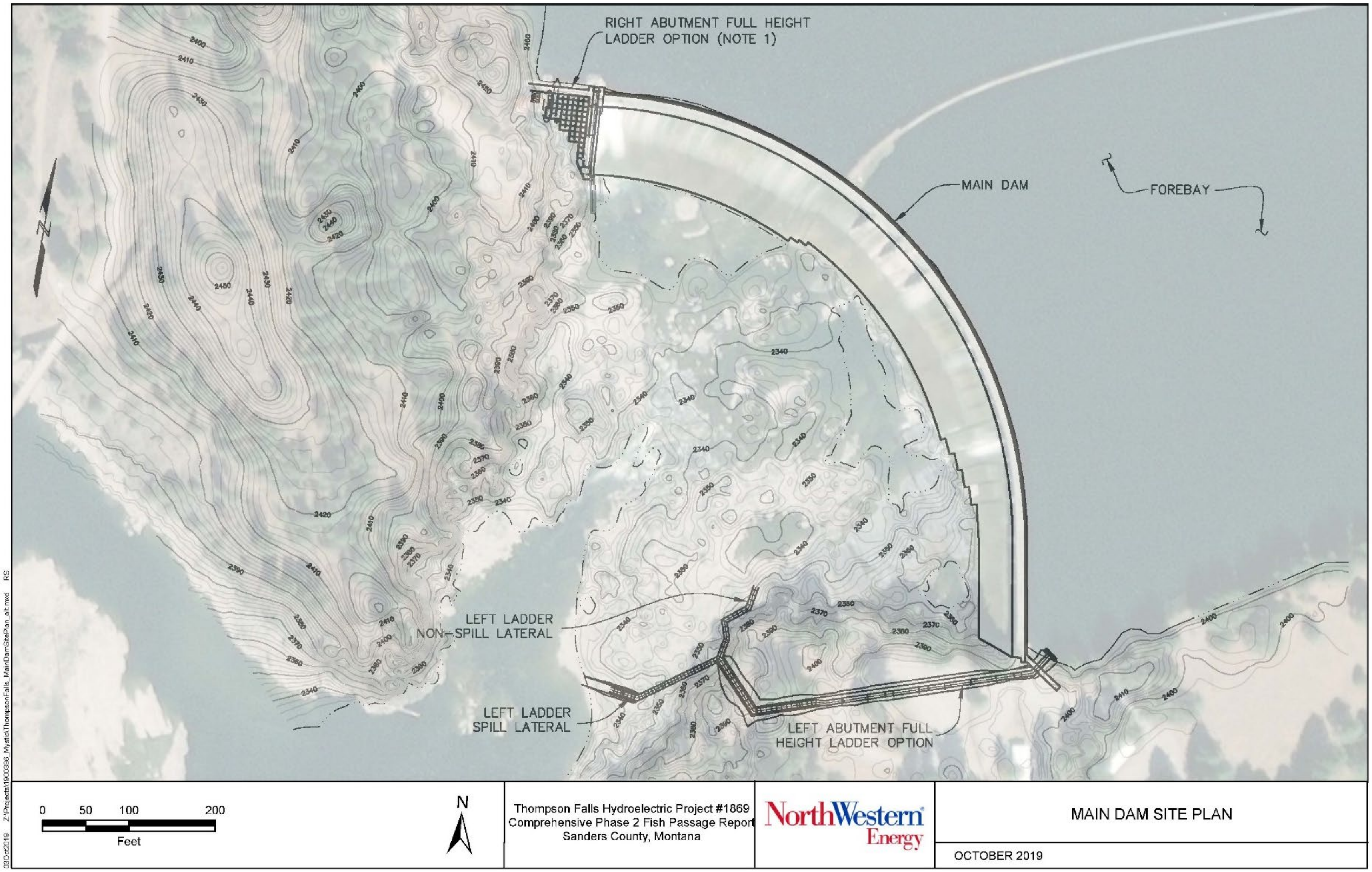
In 2006, FWS and FWP provided clarification on target species of the upstream fishway at Thompson Falls. FWS stated the target species and size ranges for the fishway included: Bull Trout, Westslope Cutthroat Trout, and Mountain Whitefish over 4 inches in length (GEI, 2007). FWP goals were to maintain and enhance native fish as much as possible and to enhance recreational fishing in general (including non-native trout). Non-native Brown and Rainbow Trout provide a significant recreational fishery in western Montana and the Clark Fork River. Other native and non-game species known to have significant migratory movements in the Project area include Longnose and Largescale suckers, Peamouth, and Northern Pikeminnow. However, ladder design did not focus on the native non-game species.

Next, the Licensee conducted a feasibility study and evaluated alternatives. The feasibility study incorporated fish behavior and movement data, input from the TAC and guidance from FWS and FWP on target species, and the NMFS 2008 Anadromous Salmonid Passage Facility Design Criteria (adopted by FWS for use in design of Bull Trout fish passage facilities through the Pacific Northwest) (GEI, 2007b). The 2008 criteria were established for anadromous salmonids in the Columbia River system. There were no guidelines or previous projects specific to Bull Trout, a non-anadromous inland-freshwater fish.

The feasibility study evaluated three alternatives: 1) full-height ladder along the right abutment at the Main Dam, 2) full-height ladder along the left abutment at the Main Dam, and 3) a fish lock trap and haul facility. The draft feasibility study was reviewed and discussed by the TAC and the preferred alternative (right bank, full height fish ladder) was documented in the final feasibility study (GEI, 2007b).

The right bank was selected as the location because the ladder could be constructed downstream of the non-overflow section of the spillway, providing protection of the ladder site (Figure 1-5). In addition, the right bank, full height fish ladder alternative had limited upstream tunneling construction needs, space available for fish sampling facilities, limited imported fill placement/removal, a small amount of rock excavation, and relatively low operations and maintenance requirements (GEI, 2007b).

Figure 1-5. Locations of the Fish Ladder Alternatives Evaluated During the Fish Passage Feasibility Study



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The left bank location was rejected because the steep gradient along the left shoreline is a barrier to fish during spill. Therefore, to successfully pass fish in both spill and non-spill seasons, two ladder entrances were needed, both a fair distance downstream of the spillway apron, and separated from each other. The entrance pool designed for use during spill operations would have discharged into a tailwater pool immediately downstream of the left shoreline bend. This is the upstream terminus for migrating fish approaching the Main Dam spillway along the left shoreline during spill.

The non-spill operations entrance would have been located downstream of the Main Dam apron, in the large backwatered pool that extends upstream from the two powerhouses (Figure 1-5). The non-spill ladder entrance would have been submerged at typical peak spring discharge, and thus the non-spill ladder entrance would be exposed to structural damage from coarse debris.

During transition periods between spill and non-spill, there would be a risk that fish would migrate past both the ladder entrances, and then not drop back to enter the ladder.

Other disadvantages of the left bank alternative were the extensive rock excavation required and greater expected maintenance and repair needs (GEI, 2007b).

Because passive volitional upstream fish passage was a priority, the trap and haul alternative was not preferred by FWS. FWS preferred the full-height ladder on the right abutment (with some type of trapping option) and recommended the left bank fishway was too risky and should be abandoned. FWP was also more comfortable with the full-height ladder on the right bank and thought the left bank option would not be effective at all the variable flows. FWP was also concerned about Walleye and wanted an option to monitor fish at the fishway. PPL Montana (Licensee at the time) was concerned about greater operations and maintenance issues likely associated with the trap and haul facility and the left bank fishway. The group concluded the full-height ladder along the right bank was the preferred alternative. Engineers requested the biologists provide a list of functional needs for the sample loop.

In 2008, the Licensee filed an updated BE (PPL Montana, 2008) and 90% Design Plans for the Fishway with the Commission. The BE discussed the effects of the Project on Bull Trout and proposed conservation measures. The 2008 BE was adopted as the Commission's Final Biological Assessment and submitted to FWS on May 1, 2008. The Biological Assessment concluded that the Project is adversely affecting Bull Trout and the proposed conservation measures will reduce, but not eliminate, the Project's adverse effects on Bull Trout.

On November 4, 2008 FWS filed with the Commission a BiOp concluding that the Project is currently adversely affecting Bull Trout and the Licensee's proposed conservation measures will reduce, but not eliminate, adverse impacts of the Project. The BiOp included an Incidental Take Statement, which includes reasonable and prudent measures and Terms and Conditions (TCs) to minimize incidental take of Bull Trout (FWS, 2008).

On February 12, 2009 the Commission issued an Order Approving Construction and Operation of Fish Passage Facilities for the Thompson Falls Hydroelectric Project. The 2009 Order included the reasonable and prudent measures, established TCs to implement the reasonable and prudent measures, and conservation recommendations from FWS's 2008 BiOp.

Table 1-3. Major Fish Passage Milestones at Thompson Falls Hydroelectric Project.

Year	Milestone	Source(s)
1998	Bull Trout federally-listed under the Endangered Species Act	Federal Register, 1998
1999-2001	Preliminary radio telemetry and trapping studies in Project area	FWP unpublished
2003	Draft Biological Evaluation submitted to FWS and FERC and concluded Project is "likely to adversely affect" Bull Trout	Pizzimenti and Gillin, 2003
2003-2004	PPL Montana prepares plan to develop upstream adult fish passage and identifies the need for additional fish behavior and project operations data prior designing a permanent fish passage facility	Gillin and Pizzimenti, 2003
2004-2006	Radio-Telemetry Studies to identify fish behavior (Bull Trout, Westslope Cutthroat Trout, Rainbow Trout) and determine optimal location for fishway	Gillin and Haddix, 2005; Haddix and Gillin, 2006; GEI, 2007
2005-2006	Review fish behavior studies, operational flexibility at the Project, and identify optimal fishway location	Gillin and Haddix, 2005; Haddix and Gillin, 2006; GEI, 2007; GEI, 2006
2006	FWS and FWP clarify position on target species for upstream fishway at Thompson Falls Dam	GEI, 2007
2006	Site Selection Letter Report, Fishway Tour of Columbia River sites (Umatilla, Oregon and Yakima, Washington) with FWS, FWP, and PPL Montana., Upstream Fishway Feasibility Study for three fishway alternatives	GEI, 2006; 2007b
2007	Preliminary Fish Design 30%	GEI, 2007a
2008	Biological Evaluation	PPL Montana, 2008
2008	FWS Biological Opinion	FWS, 2008
2009	FERC Order issued Approving Construction and Operation of the Fish Passage Facility for the Project, February 12, 2009	FERC, 2009
2009-2010	Upstream Fish Passage Facility Construction Period	

The implementation of fish passage at Thompson Falls was designed to be implemented in systematic steps (FWS, 2008):

Phase 1 – Fishway Preconstruction and Construction Phase (through 2010)

Phase 1 included design and construction of a full-height fishway. Phase 1 is complete. Construction of the upstream fish passage facility at Thompson Falls Dam commenced in 2009 and was completed in fall 2010.

Phase 2 – Fishway Post-Construction Monitoring and Evaluation (mid-2010 through 2020)
Phase 2 included 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 2 is nearing completion. As part of the monitoring and evaluation process during Phase 2, the Licensee has prepared annual reports for the fish ladder since operations began in 2011.

Phase 3 – Fishway Post-Construction Monitoring and Evaluation (2021 and beyond)
Phase 3 is the long-term operation of the fishway. The BiOp, TC1(h), stated,

> During the entire Phase 2 evaluation period (2010–2020), the Technical Advisory Committee (TAC), subject to approval of the Service [FWS] and with [Licensee] 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 10-year report (due December 31, 2020), the Licensee 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 [FWS] 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[1], in a revised operating plan for the fishway during the remainder of the existing term of the FERC license (2022 through 2025).

1.6 Fish Passage Goals at Thompson Falls Hydroelectric Project

During the planning for fish passage at Thompson Falls, the key fisheries managing agencies described their goals and objectives for fish passage. FWP prepared a Draft Position Paper on Fish Passage at lower Clark Fork River Dams (March 14, 2011), the FWS prepared Guiding Principles for Bull Trout Passage through the Clark Fork River Corridor, Montana and Idaho (March 31, 2011), and the CSKT prepared a letter in support of support fish passage at Thompson Falls Dam (with the exception of Walleye).

In February 2019, the TAC met and discussed Thompson Falls fish passage goals and objectives again, in light of the data collected at the fish ladder to date. At that meeting, the TAC came to

[1] This date was subsequently changed, with approval, to December 31, 2023

unanimous agreement that the priority for fish passage at Thompson Falls is, starting with highest priority:

- Pass Bull Trout
- Pass native species
- Pass non-native salmonid sport fish, but not to the detriment to the first two objectives. (e.g., if Brown Trout expansion extends into Bull Trout systems)
- Overarching goal is volitional upstream fish passage; however, volitional passage is not feasible with the presence of Walleye downstream of Thompson Falls Dam and the absence of Walleye upstream.

Currently, as documented in the TAC meeting notes from February 2019, the only species specifically not authorized by FWP to be released upstream of Thompson Falls Dam are Walleye and Lake Trout, Brook Trout, and Brook x Bull Trout hybrids. Other non-native sport fish can be passed. The decision on whether or not to pass Smallmouth Bass is left to the discretion of FWP and the ladder operators. Thus, no passage was provided for Smallmouth Bass that ascended the ladder in the 2019 season. This decision may be revisited in the future.

2. Systemwide Monitoring

2.1 Introduction

The Licensee-prepared 2003 BE, which stated that the Licensee will develop a monitoring and evaluation plan in consultation with the TAC. The FWS BiOp (2008) concurred with the monitoring need identified in the BE and identified a need to maintain systemwide monitoring of fish passage, with an emphasis on Bull Trout. Monitoring fish movement in the lower Clark Fork River drainage requires a systemwide approach involving representatives from NorthWestern, Avista, agencies, as well as other public and private entities. Avista manages the Clark Fork Project, including Noxon Rapids and Cabinet Gorge hydroelectric facilities located downstream of Thompson Falls Dam. NorthWestern manages data collection in the Thompson Falls Project area.

Coordination with the Avista's Clark Fork River Project and the management agencies is done through the TAC, which is a committee of representatives from the Licensee, FWS, MFWP, CSKT, MDEQ, the USFS, and other public and private interests[2]. A MOU was signed between the Licensee, FWS, MFWP, and the CSKT in 2008 (MOU, 2008) and updated and renewed in 2013 (MOU, 2013). The MOU describes the membership, operation, and funding of the TAC. The TAC meets at least annually, or more often as needed for Project coordination.

The FWS BiOp (2008) and FERC Order (2009) specifies in TC6 systemwide monitoring efforts through the remainder of the license (2025). TC6 identifies three areas of systemwide monitoring and coordinating efforts:

- Through 2025 the Licensee will ensure activities at the Thompson Falls fish ladder that include tagging, transport, and any tracking of fish movement are adequately funded and fully coordinated with Avista's Clark Fork Project (FERC No. 2058) and management agencies FWP, CSKT, and the FWS.
- Through 2025, the Licensee will contribute proportional funding to ensure fish sampled at the Thompson Falls fish ladder are processed, analyzed, and integrated into annual updates of the lower Clark Fork River genetic database.
- Through 2025, the Licensee will fund technology to track "transmittered" or tagged fish as that pass the Project as they move through the system. This may include passive integrated

[2] The Licensee, FWS, CSKT, and MFWP are formal voting members of the TAC, whereas other interests are non-voting and advisory.

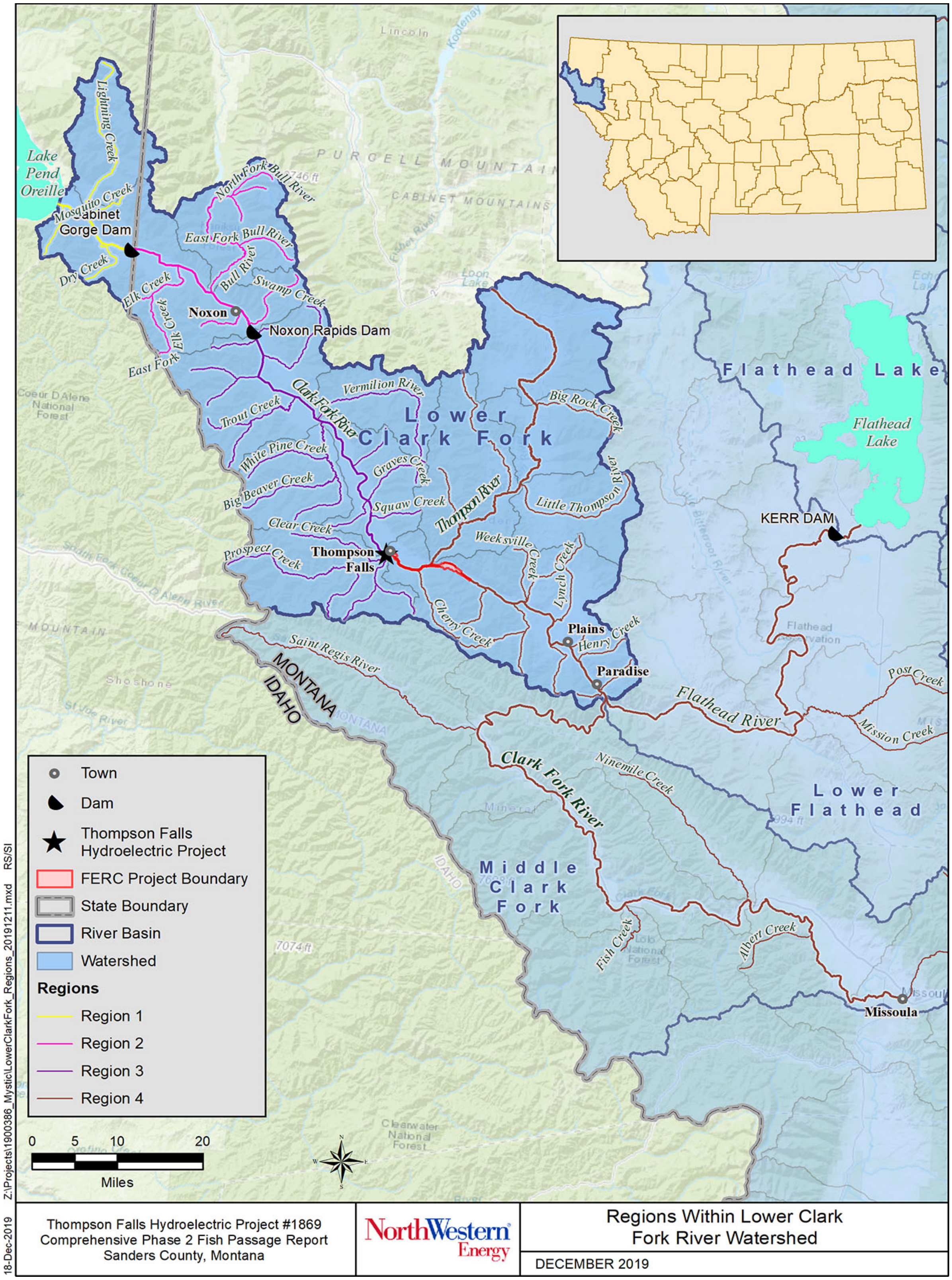
transponder (PIT) tag scanner at the fishway, mobile PIT-tag scanning capabilities, and radio implantation and tracking of Bull Trout that move through the sample loop in the ladder. Tracking obligations of the Licensee will include at a minimum the portions of the lower Clark Fork River core area upstream of Thompson Falls Dam (i.e., mainstem Clark Fork River from Thompson Falls Dam to the confluence with the Flathead River, including tributaries such as the Thompson River)

2.2 Systemwide Resources and Tools

Systemwide monitoring methods for fish movement and fish passage in the lower Clark Fork River utilize tagging, transport, and tracking options. Avista provides tagging, transport, and tracking support for fish initially captured within the Clark Fork Project area, downstream of Thompson Falls Dam. NorthWestern has provided support for tagging, transport, and tracking effort within the immediate vicinity of the Project area and upstream of Thompson Falls Dam, including the middle Clark Fork River drainage.

Note that for Bull Trout management purposes, the TAC has divided the lower Clark Fork River watershed into four regions based on genetic assignment: Region 1 is located downstream of Cabinet Gorge Dam; Region 2 is bounded by Cabinet Gorge Dam and Noxon Rapids Dam; Region 3 is bounded by Noxon Rapids Dam and Thompson Falls Dam; and Region 4 is located upstream of Thompson Falls Dam (Figure 2-1). Note that these regions (for genetic assignment) are not analogous to FWP management regions.

Figure 2-1. The lower Clark Fork River and Regions 1, 2, 3, and 4 of genetic assignment for the most likely population a Bull Trout originated.



2.2.1 *Thompson Falls Fish Database*

NorthWestern has developed a database to house all tagged fish data collected in the Project area (e.g., ladder fish, remote array data, Avista transport fish). The database provides an automated method for data entry of all fish worked up at the Thompson Falls fish ladder, an automated upload of remote PIT-tag array data from the mainstem Thompson River and ladder, manual method to upload of other uniquely tagged fish sampled in other studies as appropriate (e.g., Avista's transport program, FWP survey data, etc.), query capabilities of PIT or Floy tags, and continuity in data collection to optimize quality control. NorthWestern also has access to Biomark's remote system to monitor fish detections at the PIT-tag antenna arrays in Prospect Creek, Thompson River, and Thompson Falls fish ladder.

2.2.2 *Bull Trout Tagging*

In the lower Clark Fork River, Bull Trout tagging efforts have included radio telemetry, and PIT tags (half-duplex [HDX] and full-duplex [FDX]).

Tagging protocols at Thompson Falls fish ladder were initially outlined in the Phase 2 fish evaluation plan (PPL Montana, 2010a). Tagging and tracking efforts implemented in the Project area since 2011 include:

- ***Radio Telemetry*** – Preliminary studies (2003–2006) to evaluate fish behavior and timing for when fish approached Thompson Falls Dam and evaluate movement of fish moved upstream of Thompson Falls Dam (Pizzimenti and Gillin, 2003; Gillin and Haddix, 2005; Haddix and Gillin, 2006; GEI, 2007).
- No fish recorded at the ladder were implanted with radio tags since ladder operations began in 2011.
- Between 2008 and 2011, Avista radio-tagged 16 Bull Trout that were initially captured downstream of Cabinet Gorge Dam and genetically assigned to areas upstream of Thompson Falls Dam (PPL Montana, 2009; 2010; 2011; 2012). These fish were monitored through 2012 (PPL Montana, 2013). Half of the Bull Trout were transported upstream of Thompson Falls Dam, and half were transported to upstream of Noxon Rapids Dam in Vermilion Bay. These Bull Trout were monitored through 2012 (PPL Montana, 2013).
- A study evaluating outmigration of juvenile Bull Trout in the Thompson River included radio telemetry of 14 juvenile Bull Trout in addition to over 500 PIT-tagged juvenile Bull Trout in the drainage (Glaid, 2017).

2.2.3 *Bull Trout Tracking*

Fish tracking occurs through the following methods: 1) remote PIT-tag antenna array stations; 2) identification of tag during fisheries survey efforts or when sorting fish at the ladder work station; and 3) angler reporting.

NorthWestern and FWP manages remote PIT-tag arrays located upstream of Thompson Falls Dam in the mainstem Thompson River and in the Thompson River tributaries of Fishtrap Creek and West Fork Thompson River (Figure 2-2). The mainstem Thompson River array was established in late-September 2014 and is operational year-round. The data collection process is automated and can be accessed remotely via the NorthWestern's Thompson Falls fisheries database.

The Thompson River tributary arrays have operated seasonally since 2015. FWP currently manages manual data download and processing of the remote PIT-tag arrays in Fishtrap Creek and West Fork Thompson River. Due to the location of these two tributaries, an automated system that can communicate and sync to the Thompson Falls fish database is not feasible.

NorthWestern also cooperatively manages (with Avista) a remote PIT-tag array in Prospect Creek, a tributary of the Clark Fork River that flows into the Clark Fork just downstream of the Main Dam (Figure 2-2). The data collection from this array is also automated allowing for real-time data to be access remotely.

The Thompson Falls fish ladder has three tag-arrays, two located in the lower pools of the ladder (in Pools 7 and 8) and one located in the holding pool (Pool 45). These have been operational since 2011. Between 2011 and 2015, the data were manually downloaded and processed. Starting in May 2016, the system was automated for remote access. The tag array system in the ladder is remotely monitored via an automated system that tracks each tag and the corresponding antenna/pool, detection date, and time. The arrays read both FDX and HDX tags.

Avista also manages a remote PIT-tag array system downstream of Thompson Falls Dam in Graves Creek and in the Bull River, including one array in the mainstem and one array in the East Fork Bull River. Bull Trout tagged during NorthWestern's studies (and some tagged ladder fish) have been occasionally detected at the Graves Creek antenna (Figure 2-2). The Bull River is a tributary to the lower Clark Fork River located downstream of Noxon Rapids Dam. To date, no PIT-tagged ladder fish have been detected in the Bull River arrays.

Figure 2-2. Location of remote arrays in the Thompson River, Prospect Creek, and Graves Creek.

2.2.4 *Bull Trout Genetic Database*

The FWS Abernathy Fish Technology Center (Abernathy) has developed, in partnership with Avista, FWP, FWS, Idaho Fish and Game, and the Licensee, a genetic database for Bull Trout in the Clark Fork River drainage. The genetic database allows for rapid analysis of Bull Trout fin clip samples which are assigned to the most likely population of origin. The Licensee sets funds aside annually for genetic analysis of samples in the Clark Fork River drainage. Funding boundaries established by the TAC include the Clark Fork River drainage and its tributaries, extending from Thompson Falls Dam upstream to Rattlesnake Creek (near Missoula), including the lower Flathead River drainage.

2.2.4.1 Genetics Blind Study

Since 2001, Bull Trout captured downstream of Cabinet Gorge Dam are transported by Avista to their most likely region of origin based on genetic assignment results. In 2007, a study was conducted by Avista and partners (S. Bernall, Avista and J. Hanson, NorthWestern, personal communication, March 20, 2019) to test the accuracy of the genetic database for assigning adult Bull Trout to their region and tributary of origin within the Clark Fork River watershed.

In order to assess whether or not the genetic assignments are accurate, genetic samples from juvenile Bull Trout were collected in natal tributaries. These samples were submitted to the Abernathy laboratory without identification of the location where the samples were collected. The resulting genetic assignments were compared to the known location where the sample was collected.

The study also examined whether there are populations in the genetic data baseline that should not be used when assigning Bull Trout captured below Cabinet Gorge Dam to their most likely region of origin. Genetic samples were analyzed with and without including Region 4 tributaries upstream of the confluence of the Blackfoot and Clark Fork rivers (Upper Rock Creek, Monture Creek, Copper Creek, and the North Fork Blackfoot River) in the database.

2.3 Results

The following sections provide results on tagging, tracking, transport, and genetics information since ladder operations began in 2011 for Bull Trout. Data summarized for 2019 includes data collected through July 1 unless stated otherwise.

2.3.1 *Ladder Tagging Results*

Since 2011 over 4,000 fish, including 16 individual Bull Trout, that ascended the ladder were released upstream of Thompson Falls Dam with a unique tag (PIT or Floy).

2.3.2 *Bull Trout Tagging in Project Area*

Since 2011 (the first year of ladder operation), the Licensee has captured 34 Bull Trout (*representing 32 individuals*) in the Project area. Of the 32 individuals, 30 Bull Trout were uniquely PIT-tagged, including seven Bull Trout downstream of Thompson Falls Dam, 13 Bull Trout at the ladder, and 10 Bull Trout upstream of Thompson Falls Dam (Table 2-1). Following the initial tagging and release of the 30-Bull Trout, 11 of the fish were detected one or more times. This included eight (61.5%) of the 13 tagged Bull Trout that ascended the ladder and three (43%) of the seven Bull Trout initially tagged downstream of Thompson Falls Dam.

Since 2011, there were 17 Bull Trout recorded ascending the ladder representing 16 individuals, one fish ascended the ladder twice. Of the 16 individual Bull Trout, two were initially captured and PIT-tagged downstream of Thompson Falls Dam (1 electrofishing in tailrace in 2011; 1 by Avista downstream of Cabinet Gorge Dam in 2015). The remaining 14 Bull Trout were all tagged at the ladder; however, one PIT tag number was not recorded for the Bull Trout captured on June 7, 2013. Thus, the total number of Bull Trout PIT-tagged at the ladder is 13 fish (Table 2-1).

Of the 13 Bull Trout PIT-tagged at the fish ladder, four Bull Trout were subsequently detected upstream of Thompson Falls Dam in the Thompson River drainage, three were detected in the ladder (2 only entered the lower pools, 1 ascended to the top), and one was captured downstream in Noxon Reservoir during a fall gillnet survey (Table 2-1). Two of the Bull Trout detected in the mainstem Thompson River were also detected in known Bull Trout spawning tributaries, Fishtrap Creek and West Fork Thompson River. Additionally, one Bull Trout detected in the Thompson River was also detected 1 year later downstream of Thompson Falls Dam in Graves Creek.

One Bull Trout tagged downstream of the Thompson Falls Dam was later detected in the fish ladder in 2012 ascending to the top of the ladder and was released upstream. This same fish was subsequently detected in July 2013 back downstream of Thompson Falls Dam in Prospect Creek.

A Bull Trout initially captured in 2011 downstream of Cabinet Gorge Dam and released in Vermilion Bay (Region 3) with a radio tag was subsequently detected downstream of Thompson Falls Dam in 2011 and 2012. It was captured electrofishing downstream of Thompson Falls Dam in May 2014, and then in Prospect Creek in September 2014.

The second Bull Trout initially captured in 2015 downstream of Cabinet Gorge Dam was transported and released in St. Regis River (Region 4). This Bull Trout was subsequently captured again by Avista downstream of Cabinet Gorge Dam in July 2017 and transported a second time to St. Regis River. Most recently this Bull Trout ascended the Thompson Falls fish ladder on June 25, 2019 (recorded at work station and released upstream on June 26) with no subsequent detections at the time of this report.

There were no subsequent detections of 10 Bull Trout captured and tagged during baseline fisheries surveys upstream of Thompson Falls Dam between 2011 and 2016 (Table 2-1).

Table 2-1. Summary of the 32 individual Bull Trout (30 were PIT-tagged) captured by the Licensee in the Project area and subsequent detections, if any between 2011-2019.

Initial Date Captured	Length (mm)	Weight (g)	Method & Location	Most Likely Population of Origin	Subsequent Detection Date(s)	Subsequent Location(s)
2 Bull Trout Sampled in Project Area – Not Tagged						
4/7/2014	520	1500	Spring EF Downstream TFalls Dam – No Tag or Genetics Sample	NA	NA	NA
6/7/2013	596	1926	TFalls Ladder Ascent & Released Upstream – HDX Tag not recorded	Fishtrap Creek (R4)	NA	NA
7 Bull Trout Tagged Downstream of Thompson Falls Dam						
5/31/2011	482	966	Spring EF Downstream TFalls Dam	Meadow Creek (R4)	5/15/2012 7/7/2013	TFalls Ladder Ascent Prospect Creek (R3)
5/31/2011	180	50	Spring EF Downstream TFalls Dam	Fishtrap Creek (R4)	NA	
5/31/2011	247	130	Spring EF Downstream TFalls Dam	Fishtrap Creek (R4)	NA	
4/10/2012	272	150	Spring EF Downstream TFalls Dam	Graves Creek (R3)	NA	
6/2/2011	567	1640	Initial tagging by Avista LCFR-ID released to Vermilion Bay with radio tag 38 Spring EF Downstream TFalls Dam	Fishtrap Creek (R4)	2011-2012 5/28/2014 9/18/2014	Region 3 Downstream of TFalls Dam Prospect Creek (R3)
6/3/2014	509	1224	Spring EF Downstream TFalls Dam	Fishtrap Creek (R4)	NA	
8/11/2015	620	1608	Downstream of Cabinet Gorge Dam – transport to Region 4 (release St. Regis)	West Fork Fish Creek (R4)	7/13/2017 6/25/2019	Downstream of CGD – Transport St. Regis (R4); TFalls Ladder Ascent
13 Bull Trout Initially Tagged After Ascending Thompson Falls Ladder & Released Upstream						
4/13/2011	365	364	TFalls Ladder	West Fork Thompson River (R4)	NA	

Initial Date Captured	Length (mm)	Weight (g)	Method & Location	Most Likely Population of Origin	Subsequent Detection Date(s)	Subsequent Location(s)
4/26/2011	547	1438	TFalls Ladder	Fishtrap Creek (R4)	5/21/2012	2nd TFalls Ladder Ascent - Jumped out of Pool (Mortality)
4/30/2013	598	2306	TFalls Ladder	Fish Creek (R4)	NA	
5/6/2013	576	1694	TFalls Ladder	Fishtrap Creek (R4)	9/21/2014 5/5/2015 5/13/2015	Prospect Creek (R3) TFalls ladder – lower pools TFalls ladder – lower pools
5/7/2013	478	978	TFalls Ladder	Fishtrap Creek (R4)	NA	
8/9/2013	482	1058	TFalls Ladder	Fish Creek (R4)	NA	
5/16/2014	523	1264	TFalls Ladder	Fishtrap Creek (R4)	10/13/2014	Noxon Reservoir (R3) gillnet (Mortality)
5/17/2015	519	1334	TFalls Ladder	Fishtrap Creek (R4)	6/2/2015	Thompson River (R4) Big Hole (efishing)
6/3/2015	520	1112	TFalls Ladder	Fishtrap Creek (R4)	7/15-16-2015	West Fork Thompson River (R4)
4/18/2016	413	602	TFalls Ladder	Fishtrap Creek (R4)	10/2/2016	TFalls ladder – lower pools
5/18/2016	615	1934	TFalls Ladder	North Fork Fish Creek (R4)	9/18-9/28/2016 9/20/2017	Thompson River (R4) Graves Creek (R3)
6/6/2016	618	1950	TFalls Ladder	North Fork Fish Creek (R4)	NA	
9/18/2017	408	522	TFalls Ladder	West Fork Thompson River (R4)	10/23/2017 2/4/2018 3/28/2018 6/5/2018 9/16/2018	Thompson River (R4) Thompson River (R4) Thompson River (R4) Fishtrap Creek (R4) Fishtrap Creek (R4)
10 Bull Trout Tagged Upstream of Thompson Falls Dam						
4/16/2012	222	76	Spring EF Lower Section – TFalls Reservoir	Fishtrap Creek (R4)	NA	
4/17/2012	260	140	Spring EF Upper Section – TFalls Reservoir	Fishtrap Creek (R4)	NA	

Initial Date Captured	Length (mm)	Weight (g)	Method & Location	Most Likely Population of Origin	Subsequent Detection Date(s)	Subsequent Location(s)
10/30/2012	472	800	Autumn EF Paradise – Plains	Monture Creek (R4)	NA	
10/30/2012	444	678	Autumn EF Paradise – Plains	Fish Creek (R4)	NA	
4/10/2013	260	108	Spring EF Upper Section – TFalls Reservoir	Fishtrap Creek (R4)	NA	
4/15/2014	577	1446	Spring EF Upper Section – TFalls Reservoir (initial tagging by Avista Below Cabinet Gorge Dam & transport to R4, 6/9/2013)	Fishtrap Creek (R4)	NA	
10/28/2014	315	260	Autumn EF Paradise – Plains	NF Jocko (R4)	NA	
4/13/2015	219	88	Spring EF Upper Section – TFalls Reservoir	Fishtrap Ck (R4)	NA	
10/20/2015	651	1966	CFR – Above Islands (initial tagging by Avista Below Cabinet Gorge Dam & transport R4 4/14/2015)	Fishtrap Ck (R4)	NA	
4/11/2016	247	124	Spring EF Upper Section – TFalls Reservoir	WF Thompson River (R4)	NA	

Note: R1 = downstream of Cabinet Gorge Dam; R2= Cabinet Gorge Dam to Noxon Rapids Dam; R3 = Noxon Rapids Dam to Thompson Falls Dam; R4 = upstream of Thompson Falls Dam; Ck = creek; LCFR = Lower Clark Fork River.

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2.3.3 *Tracking Radio Telemetry*

Radio telemetry studies conducted during the fish ladder development concluded that the Main Dam was the optimal location for the fish passage facility (Pizzimenti and Gillin, 2003; Gillin and Haddix, 2005; Haddix and Gillin, 2006; GEI, 2007). These data concluded that spill operations could attract fish to the right abutment of the Main Dam. It was noted that fish do not remain in one location and appear to be searching and constantly on the move while in the Project area (GEI, 2007).

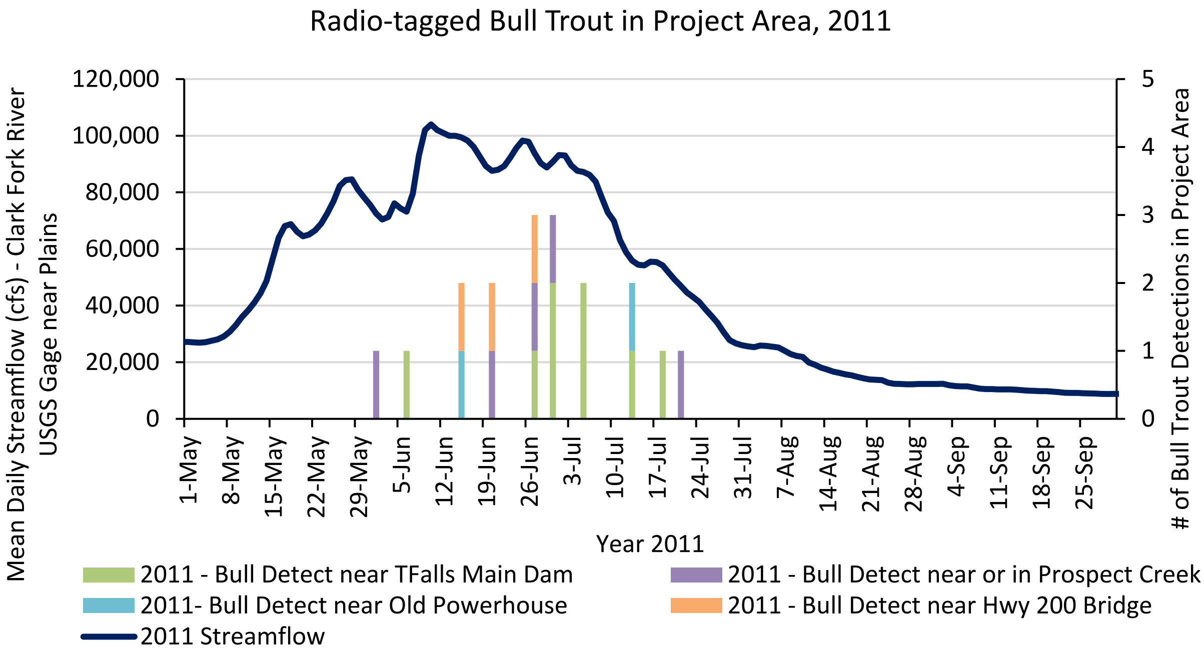
Between 2008 and 2010, Avista radio tagged eight Bull Trout captured below Cabinet Gorge Dam, and subsequently transported them upstream of Thompson Falls Dam (Region 4) where they were genetically assigned (Table 2-2). The movement of these fish was very diverse, some fish moving immediately downstream while others made upstream and downstream movements. The furthest upstream movement was to the Flathead River or the mouth of the Jocko River. The furthest downstream movement was downstream of Cabinet Gorge Dam. Four of the fish were detected moving into spawning tributaries (Fishtrap, Prospect creeks, and the Bull River).

During the first year of ladder operations (2011), 11 Bull Trout were captured and tagged (8 Bull Trout also received radio tags) by Avista downstream of Cabinet Gorge Dam, genetically assigned to Region 4, but were subsequently released in Vermilion Bay, Region 3 (Table 2-3). The objective of this study was to see if the fish would migrate the approximate 22-mile distance from Vermilion Bay upstream to Thompson Falls Dam tailrace, and then locate and ascend the fish ladder at Thompson Falls Dam.

Of the 11 Bull Trout, nine fish were subsequently detected either via radio telemetry or a remote tag array following their release. Four of the nine Bull Trout with subsequent detections moved downstream of Noxon Rapids Dam (two of these fish continued downstream of Cabinet Gorge Dam). Six of the nine Bull Trout remained in the Region 3 area, three fish were detected around Marten Creek, Graves Creek, or Vermilion River; while the other three fish were detected within the Project area, from the old powerhouse upstream to the Main Dam (PPL Montana, 2012).

The detections of the three radio-tagged Bull Trout near the Main Dam in 2011 occurred when streamflows were well above average peak flows (60,000 cfs) and the ladder was closed. In 2011, the ladder was not operationally for 84 days between May 25 and August 21 due to an extreme high-water year with peak streamflows exceeding 110,000 cfs at Thompson Falls Dam (PPL Montana, 2012). Figure 2-3 shows the mean daily streamflows in the Clark Fork River (USGS gage near Plains) when three of the radio-tagged Bull Trout were detected 18 times within the Project area between the old powerhouse and the Main Dam. One of the three Bull Trout was later detected upstream in the Prospect Creek drainage during the spawning season (PPL Montana, 2012).

Figure 2-3. Date when radio tagged Bull Trout were detected in the Project area, and corresponding mean daily streamflow in the Clark Fork River, May 1 through August 1, 2011.



The majority of the 2011 Bull Trout detections near the Main Dam occurred later in the season (July) than subsequent ladder visits and ascents by tagged Bull Trout recorded in subsequent years.

In addition, Avista detected two Bull Trout (radio code 52 and 100) near the Project area in 2011 that were initially captured and tagged downstream of Cabinet Gorge Dam in July 2010, genetically assigned to Region 3 (Graves Creek), and transported and released near Graves Creek. These fish approached the Project area (Main Dam and Highway 200 bridge) in late March and early April when streamflows were less than 30,000 cfs (PPL Montana, 2012). Although both Bull Trout were genetically assigned to Graves Creek, both Bull Trout were given a second genetic assignment of North Fork Jocko River (Region 4).

Table 2-2. Movement of eight Bull Trout collected downstream of Cabinet Gorge Dam and released upstream of Thompson Falls Dam between 2008 and 2010 (PPL Montana 2009, 2010).

Release Date Region 4	Radio Code	Genetic Assignment (Region 4)	Major Movement Following Release	Region of Last Detection	Downstream Movement at Thompson Falls Dam
4/28/2008	149.740	Upper Rock Creek (near Missoula)	Moved downstream of Thompson Falls Dam & Noxon Rapids Dam to Bull River Bay by 7/7/2008	2	Passed downstream spillway or turbines between 4/28/2008 and 7/7/2008
6/10/2009	148.500.55	Monture Creek (tributary to Blackfoot River)	Moved upstream to the lower Flathead River near the confluence with the Jocko River on 6/25/2009	4	Not Applicable
6/15/2009	PIT tag only	Fishtrap Creek	Thompson River; moved upstream into Fishtrap Creek by 7/21/2009	4	Not Applicable
6/30/2010	27	Fishtrap Creek	Remained upstream of Thompson Falls Dam about 2 months, below Thompson Falls Dam 9/27/2010, mouth of Prospect Creek 9/28/2010, Vermillion River 11/15/2010	3	Passed downstream through turbines between 8/23/2010 and 9/27/2010
5/19/2010	28	Rattlesnake Creek (near Missoula)	Downstream to mouth of Prospect within 5 days of release. Downstream of Noxon Rapids Dam and in Bull River in September & October 2010; downstream of Cabinet Gorge Dam in November 2010	1	Passed downstream spillway or turbines between 5/19/2010 and 5/24/2010
5/12/2010	30	Fishtrap Creek	Remained upstream Thompson Falls Dam in mainstem Clark Fork River between reservoir and near Weeksville Creek	4	Not Applicable
5/19/2010	31	Fishtrap Creek	Upstream into Fishtrap Creek by 7/12/2010, downstream into Thompson River until 7/27/2010, upstream into Fishtrap Creek until 9/24/2010, downstream of Thompson Falls Dam after 9/28/2010, in the Vermilion River 10/8/2010	3	Passed downstream through turbines between 9/28/2010 and 10/8/2010
5/5/2010	32	Fishtrap Creek	Moved downstream past Thompson Falls Dam within 6 days of release to Finley Flats area. Moved upstream to near the Original Powerhouse 6/2/2010 and again 10/8/2010, last detected near mouth of Marten Creek 10/26/2010	3	Passed downstream through turbines between 5/6/2010 and 5/11/2010

Table 2-3. Movement of 11 Bull Trout captured downstream of Cabinet Gorge Dam, genetically assigned to Region 4, and transported and released in Region 3 (Vermilion Bay) in 2011. Eight Bull Trout received radio tags.

Date Captured	Release Date (radio tag)	Major Movements	Genetic Assignment (Region 4)	Detections Near Thompson Falls Dam	Movement Details	Region of Last Detection
4/19/2011	4/22/2011 (26)	Upstream to Project area; Downstream of Cabinet Gorge Dam	Meadow Creek	Yes	Downstream of TFalls Dam Jun 1 & Jun 6, 2011; Prospect Creek Jun 27–Oct 24, 2011 downstream of Noxon Rapids Dam - Apr 27, 2012 downstream of Cabinet Gorge Dam, May 6, 2012	1
4/24/2011	4/27/2011 (29)	Downstream to Marten Creek	South Fork Jocko River	No	Marten Creek Rd Nov 18, 2011	3
5/17/2011	5/20/2011 (35)	Downstream of Cabinet Gorge Dam	Fishtrap Creek	No	Jun 25, 2011 downstream of Noxon Dam; Oct 26, 2011 downstream of Cabinet Gorge Dam	1
5/22/2011	5/25/2011 (37)	Downstream of Noxon Rapids Dam	WF Thompson River	No	Downstream of Noxon Dam Jun 21, 2011; near the mouth of Rock Creek Dec 6, 2011	2
6/2/2011	6/8/2011 (38)	Upstream to Project area; Prospect Creek	Fishtrap Creek	Yes	Between Old Powerhouse and Main Dam downstream of Thompson Falls Dam Jun 15, Jun 27, Jun 30, Jul 5, Jul 13, Jul 18, 2011; in Prospect Creek Jun 20, Jul 21, 2011; in Marten Creek Oct 7, 2011; upstream of Trout Creek Nov 18, Nov 28, Dec 5, 2011; downstream of Thompson Falls Dam May 28, 2014 (captured electrofishing); detected in Prospect Creek Sep 18, 2014	3
6/5/2011	6/8/2011 (36)	Upstream to Graves Creek, back to Vermilion Bay	Fishtrap Creek	No	Near Graves Creek Jul 18, 2011; detections in Aug 2011 and Jun 2012 near Vermilion Bay - believed that radio tag may be out of water	3
6/19/2011	6/23/2011 (39)	Downstream to Marten Creek Bridge	Fishtrap Creek	No	Marten Creek Bay Bridge Aug 30, 2011	3
6/21/2011	6/24/2011 (40)	Upstream to High Bridge near Project area	Fishtrap Creek	Yes	Thompson Falls State Park Jun 27, 2011; downstream of Thompson Falls Dam Jun 30 and Jul 5, 2011; High Bridge at Thompson Falls Jul 13, 2011	3
6/21/2011	6/24/2011	NA	Fishtrap Creek	No	PIT-tag only, not detected after release	NA
6/26/2011	6/29/2011	NA	Fishtrap Creek	No	PIT-tag only, not detected after release	NA
7/5/2011	7/8/2011	Upstream to Graves Ck	Fishtrap Creek	No	PIT-tag only, Graves Creek Sep 13–Oct 31, 2011	3

2.3.4 *Tracking Tag Array Detections – Ladder*

Remote arrays installed in the lower pools (Pools 7, 8) and the top of the ladder or holding pool (Pool 45) detect PIT-tagged fish that swim through. Efficiency of these remote arrays is not 100 percent but is assumed to be very high. These arrays only collect data from fish previously PIT-tagged. The majority of PIT-tagged fish detected were initially tagged after their first ladder ascent. Other potential sources of PIT-tagged Bull Trout in the system originate from Avista's tagging efforts downstream of the Project (e.g., downstream of Cabinet Gorge Dam), from Glaid's (2017) study of juvenile Bull Trout in the Thompson River, upstream of the Project, or FWP PIT tagging activities in tributaries.

The majority of fish PIT-tagged at the ladder are salmonids, specifically Rainbow and Brown Trout. Approximately 10 percent of all PIT-tagged fish have returned and ascended the ladder a second time (Table 2-4). Annual evaluations also show about 3 to 12 percent of salmonids PIT-tagged in a given year return and ascend the ladder the following year.

Table 2-4. Summary of the multiple ladder ascents by PIT-tagged fish, 2011-2019 (through July 1, 2019).

Species	Total Number PIT-Tagged Fish Ascend Ladder and Released Upstream, 2011-2019	Number of Ladder Ascents				
		2x	3x	4x	5x	6x
BULL	15	1	-	-	-	-
EB	4	-	-	-	-	-
LL	739	61	10	3	-	1
RB	1,560	157	18	6	-	-
RBxWCT	46	5	1	-	-	-
MWF	81	4	-	-	-	-
WCT	223	12	2	-	-	-
LS SU	125	3	-	-	-	-
LN SU	1	-	-	-	-	-
NPMN	159	4	1	-	-	-
TOTAL	**2,953**	**247**	**32**	**9**	**-**	**1**

PIT-tag detections in the ladder are also used to evaluate time fish spend ascending the ladder and percentage of fish that enter the lower pools ascending to the holding pool (*refer to* Section 3 Upstream Fish Passage *for results*). These evaluations include other species due to the low number of PIT-tagged Bull Trout in the area. Section 3 Upstream Fish Passage also provides more details on the timing of Bull Trout observed entering and ascending the ladder, including corresponding water temperatures and streamflows in the Clark Fork River.

2.3.5 *Tracking Tag Array Detections – Thompson River*

Between 2011 and 2018 there were 2,644 uniquely PIT-tagged fish released upstream of Thompson Falls Dam (NorthWestern, 2019). Although the Thompson River array was not in place until late September 2014, the detection data (2014–2018) indicate a minimum of 25 percent of the individually tagged-fish that ascended the ladder and released upstream of the dam were later detected in the mainstem of the Thompson River, including four of the 15 tagged-Bull Trout (Table 2-5). These Bull Trout were detected in the mainstem Thompson River in June and July 2015, September 2016, October 2017, February and March 2018 as well as in two critical spawning tributaries, Fishtrap Creek in 2018 and West Fork Thompson River in 2015 (NorthWestern, 2018).

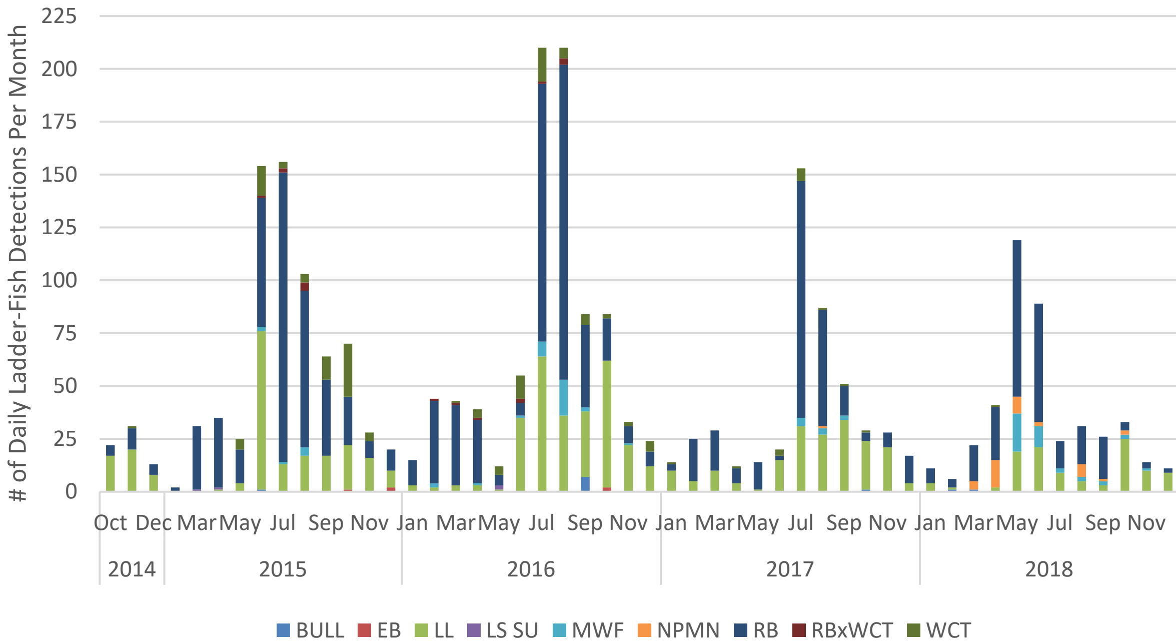
Table 2-5. Ladder-fish detected by the remote array in the Thompson River, 2014–2018[3]

Species	# of Ladder Fish Detected in the Thompson River drainage, 2014-2018	% of Species PIT-tagged and Released Upstream of Thompson Falls Dam entering Thompson River
BULL	4	27%
EB	2	50%
LL	270	39%
LS SU	2	10%
MWF	8	10%
NPMN	1	2%
RB	330	22%
RBxWCT	6	13%
WCT	41	20%
Total	**664**	**25%**

Between 2014 and 2018, there were 2,513 daily ladder-fish detections documented by the 664-individual ladder-fish. Ladder-fish detections in the Thompson River were primarily Rainbow and Brown Trout, which is expected because these two species represent just over 83 percent of the tagged-fish released upstream of the dam since 2011 (through 2018), and are the dominant salmonids found in the system. Figure 2-4 shows peak detections of ladder-fish occurring in June and July in 2015, July and August in 2016 and 2017, and May and June in 2018. The remote tag-array data indicate Thompson River provides important habitat (e.g., spawning, foraging, migration, overwintering) and likely thermal refugia for several species throughout the year.

[3] The PIT-tag array was not in place until 2014, so the percentage of ladder fish detected is a minimum value.

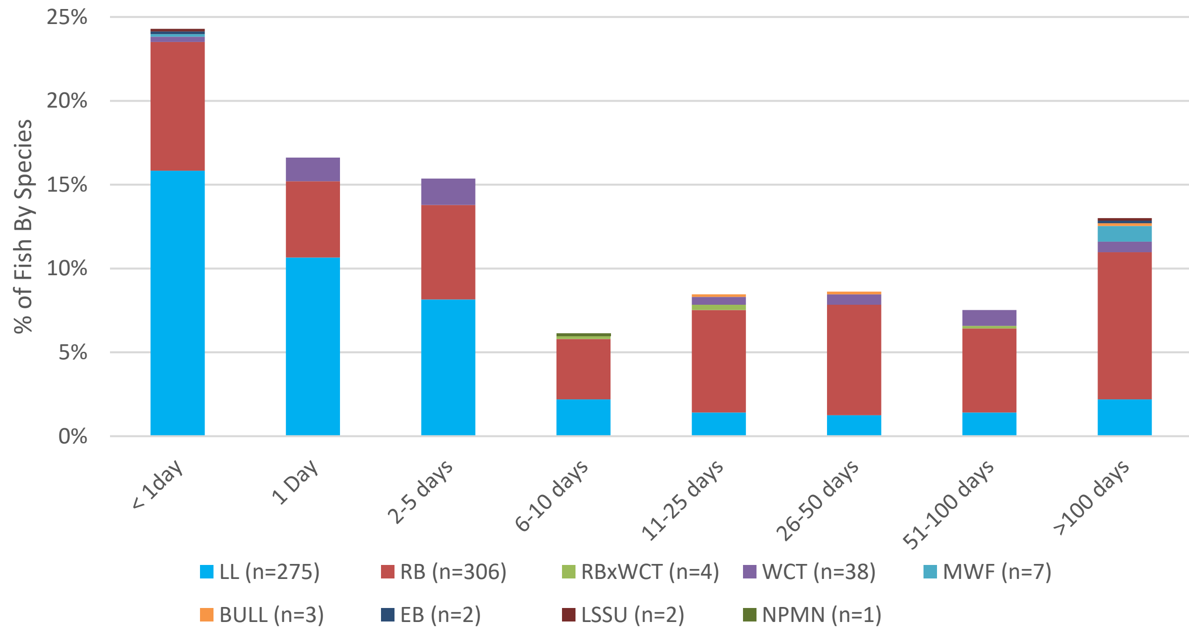
Figure 2-4. Summary of all 2,513 daily detections of ladder-fish in the Thompson River, 2014–2018.



The duration between when a fish was released upstream of Thompson Falls Dam after ascending the ladder and detection in the mainstem Thompson River was evaluated for the period the array was operating, September 26, 2014 through 2018 (2019 data not included). The travel time between Thompson Falls Dam and the Thompson River was calculated for 638 fish representing eight species and 1 hybrid. The travel time for fish to migrate the 6-mile distance varied from about 5.5 hours to 619 days. These data indicate many fish made a direct migration to the Thompson River, while others spent time elsewhere for over 1 year and in one case for nearly 2 years prior to being detected in the Thompson River. Figure 2-5 provides a summary of travel times and durations (in days) from known release date upstream of Thompson Falls Dam and the first detection in the mainstem Thompson River.

Three Bull Trout were detected in the Thompson River 16 days, 35 days, and 124 days after their release upstream of Thompson Falls Dam. The fourth Bull Trout released upstream of Thompson Falls Dam was not detected by the mainstem array, but was detected in the West Fork Thompson River, a tributary, 42 days after its ascent up the ladder and release upstream. Ladder fish detections in the Thompson River indicate many fish were capable of making the 6-mile journey upstream within hours. Nearly one-quarter of the ladder fish detected in the Thompson River migrated upstream in less than 24 hours after their release upstream of Thompson Falls Dam, and the majority of the ladder fish (62%) spent 10 days or less traveling upstream to the Thompson River (Figure 2-5).

Figure 2-5. Time (days) spent between release upstream of Thompson Falls Dam and first detection in the Thompson River, September 26, 2014 through 2018.



2.3.5.1 Bull Trout Detections

Between 2014 and 2018, there were 122 daily Bull Trout detections in the mainstem Thompson River representing 68 unique fish, 19 adults (Figure 2-6) and 49 juveniles (Figure 2-7). The juvenile Bull Trout were initially captured and tagged in Fishtrap Creek or West Fork Thompson River. The 14 adults included four adult Bull Trout that ascended the Thompson Falls fish ladder and were released upstream; 14 transported by Avista from downstream of Cabinet Gorge Dam upstream to Region 4; and one caught electrofishing in the mainstem Thompson River.

The array system in the Thompson River does not provide directionality but the array is very close to the confluence with the Clark Fork River, so juvenile detections generally indicate outmigration. The data collected from September 2014 through December 2018 indicate juvenile Bull Trout are moving in the mainstem in all months but are more common in the mainstem Thompson River in the spring (April–May) and late-fall to early winter (October–December). These detections support observations of spring and fall out migration, similar to pulses of juveniles in Trestle Creek (Idaho) into Lake Pend Oreille (Idaho), more than 65 miles downstream of the Project (Downs et al., 2006). However, a recent study on Bull Trout juvenile out-migration in the Thompson River drainage found a large proportion of juvenile Bull Trout overwintered in the Thompson River (Glaid, 2017).

Figure 2-6. Adult Bull Trout detections in the Thompson River, 2014–2018.

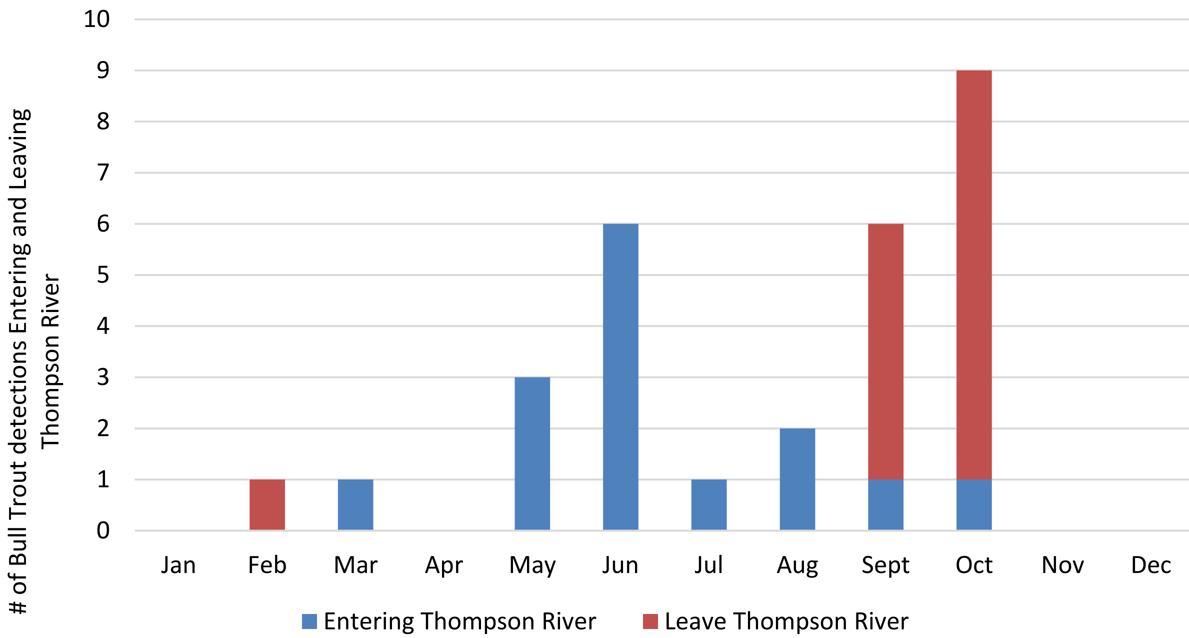
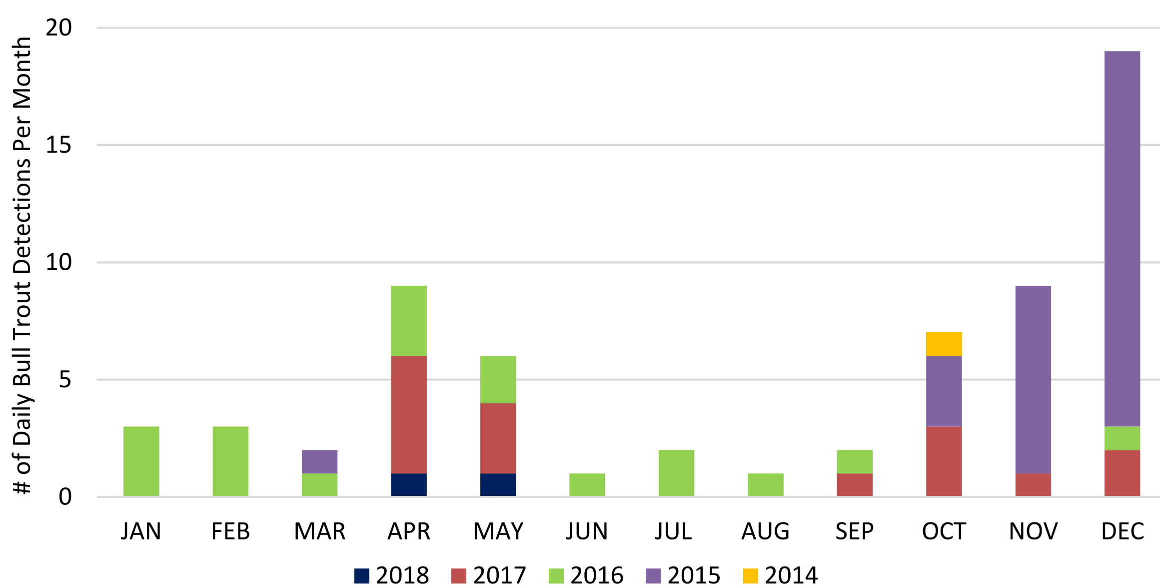


Figure 2-7. Summary of the juvenile Bull Trout detections in the Thompson River by month, 2014–2018.



Most of the tagged-juvenile Bull Trout (754) in Fishtrap Creek and West Fork Thompson River were initially PIT-tagged in 2014 and 2015 during a study of juvenile out-migration (Glaid, 2017). Since then, FWP has continued to PIT-tag juveniles in subsequent years but on a much-reduced scale. The juvenile Bull Trout detections in the Thompson River by year are shown in Figure 2-7, which display data from 64 juvenile Bull Trout detections representing 49 unique fish. The majority (44%) of the detections occurred in 2015 (44%), 2016 (28%), and 2017 (23%). There were very few juveniles detected in 2014 (2%) or in 2018 (3%) (NorthWestern, 2019).

In contrast to juvenile presence in the mainstem, adult Bull Trout have not been detected between November and January and were most commonly detected later in the spring (May–June) and late summer to early fall (August–October). The direction of adult movement in the Thompson River was often derived by the history of the tagging and release locations (e.g., ladder fish moving upstream and entering the Thompson River or Avista transport fish that were released upstream of the array station and migrate out of the Thompson River). Adult Bull Trout frequently enter the Thompson River in the spring, and exit in the fall, presumably after spawning (Figure 2-6).

2.3.5.2 Fishtrap Creek and West Fork Thompson River Arrays

Fishtrap Creek and West Fork Thompson River are critical spawning areas for Bull Trout in the Thompson River drainage. The PIT-tag arrays in Fishtrap Creek and in West Fork Thompson River functioned intermittently since installation (2014 in West Fork Thompson River and 2015 in Fishtrap Creek). FWP is leading the data collection effort in the tributaries and provides annual updates on the results of the fish detections in the two tributaries. This report only summarizes ladder fish detected in the tributaries through 2018 (NorthWestern, 2019).

Since 2014, 17 ladder fish have been detected in the two tributaries, eight fish (1 BULL, 4 LL, 3 RB) in West Fork Thompson River, and nine fish (1 BULL, 4 LL, 2 RB, 2 WCT) in Fishtrap Creek. The Bull Trout in West Fork Thompson River was detected in July 2015 after ascending the ladder and being released upstream of Thompson Falls Dam on June 3, 2015. The Bull Trout in Fishtrap Creek was detected in June 2018 and September 2018 after ascending the ladder and being released upstream of Thompson Falls Dam on September 18, 2017.

2.3.6 *Tracking Tag Array Detections – Prospect Creek*

The permanent PIT-tag antenna array system in Prospect Creek started operating in late August 2018. A summary of fish that have ascended Thompson Falls fish ladder and released upstream, then moved downstream of Thompson Falls Dam and were later detected in Prospect Creek is in Table 2-6. Due to the time interval between the initial ladder ascent and detection in Prospect Creek, these fish moved downstream either through the turbines or over the spillway at Thompson Falls Dam.

Since the Prospect Creek array began operations, the system has experience periods of elevated noise (primarily in the late evening), which impacts tag detectability. At this time the probability of tag detection during these periods of elevated noise is not known and the cause of the noise is also not known.

To date (through July 31, 2019), there have been five Bull Trout detected at the Prospect Creek array station (Table 2-6). Bull Trout #1 was initially captured by Avista downstream of Cabinet Gorge Dam as an adult (558 mm) in April 2015, genetically assigned to Fishtrap Creek (Region 4) and transported to the Thompson River, detected in the Thompson River (assume leaving the drainage) in May 2015, and the most recently detected in Prospect Creek in September 2018, over 3 years since its initial transport from Cabinet Gorge Dam to Region 4. It is unknown when this Bull Trout moved downstream of Thompson Falls Dam. Bull Trout #2 was initially captured and tagged upstream of Thompson Falls Dam in Fishtrap Creek as a juvenile (159 mm) in November 2015. Bull Trout #3 and #4 were initially tagged in Prospect Creek, one as an adult (555 mm) in July 2013, and one juvenile (200 mm) in August 2018. Bull Trout #5 was initially tagged as a juvenile in Graves Creek in July 2018 and approximately 1-year later was detected in Graves Creek in July 2019. The initially tagging locations of these Bull Trout and subsequent movements show the challenges in predicting movement and behavior based on genetic assignment or known natal stream information.

Table 2-6. Summary of the five individual Bull Trout detections in Prospect Creek since August 2018 and their known histories. These fish have no history at Thompson Falls fish ladder. "–" = no detections.

Bull Trout #	Initial Tag Date	Initial Tag Location	Initial Length (mm)	Genetic Assignment	Date in Prospect	Other Detections	Release Locations
1	4/14/2015	Below Cabinet Gorge Dam	558	Fishtrap (R4)	9/8/2018	5/22/2015, Thompson River	Thompson River
2	11/10/2015	Fishtrap Creek Weir	159	Juvenile from Fishtrap (R4)	9/12/2018	10/14/2017, Thompson River	Fishtrap Creek
3	7/5/2013	Prospect Creek Weir	555	No Data	9/27/2018	–	Prospect Creek
4	8/22/2018	Prospect Creek	200	No Data	4/11/2019	–	Prospect Creek
5	7/25/2018	Graves Creek	123	Juvenile from Graves (R3)	7/17/2019	–	Graves Creek

Between late-August 2018 and July 1, 2019, a total of eight ladder fish (4 RB, 3 LL, 1 WCT) were detected in Prospect (Table 2-7). These ladder fish have a history of ascending the ladder in 2015, 2016, 2017, and 2018. Only two of the eight fish (#1 and #7 in Table 2-7) have additional detections between their ladder ascent at Thompson Falls and detection in Prospect Creek.

Fish #1 (in Table 2-7), a Brown Trout ascended the ladder in August 2017, moved downstream through the turbines at the dam, entered the lower pools of the ladder in October 2017, returned to the ladder and ascended in September 2018, and moved downstream again through the turbines at the dam before being detected in Prospect Creek in October and November 2018. Fish #7, a Rainbow Trout ascended the ladder in April 2018, migrated upstream into the Thompson River within 24 hours, was detected again in the Thompson River on June 1, 2018 (likely leaving the system) before the most recent detection about 1 year later in Prospect Creek.

Table 2-7. Summary of fish detected in Prospect Creek (August 2018–July 1, 2019) with a history of ladder ascent(s), length recorded at the ladder, and other detections in the ladder or Thompson River, if any. All fish were initially tagged at Thompson Falls fish ladder. "–" = no detections.

Fish #	Species	Date of Ladder Ascent(s)	Length (mm)	Date(s) Detected in Prospect Creek	Thompson Falls Ladder - lower pools only	Thompson River Detection Date(s)
1	LL	8/16/2017 9/24/2018	485 532	10/24/2018; 11/13/2018	10/27/2017	–
2	LL	10/1/2018	322	6/5/2019 7/1/2019		
3	LL	10/31/2018	297	6/13/2019 6/23/2019 6/25-27/2019 7/1/2019		
4	RB	6/27/2017	365	3/25/2019; 4/15/2019	–	–
5	RB	4/27/2018	491	4/19/2019 5/3/2019 5/13/2019	–	–
6	RB	4/21/2015 5/1/2015	397 NA	4/20/2019	–	–
7	RB	4/23/2018	517	5/10/2019	–	4/24/2018; 6/1/2018
8	WCT	10/8/2018 10/19/2016	427 391	6/3/2019 6/25/2019		

2.3.7 *Tracking Tag Array Detections – Graves Creek*

There have been eight fish (3 RB, 2 LL, 2 BULL, 1 WCT) detected in Graves Creek with a history in the Thompson River drainage (upstream of Thompson Falls Dam) or ascending Thompson Falls fish ladder from 2011 through 2018 (Table 2-8). Seven of the eight fish were recorded ascending the fish ladder, while one fish, a Bull Trout (fish #5) was captured in Fishtrap Creek as a juvenile and later detected downstream in Graves Creek.

Table 2-8 lists the fish detected in Graves Creek in order of their initial tagging date. Three fish (#1-3) ascended the ladder in 2011 and within about 1 months' time, each fish was later detected downstream of Thompson Falls Dam in Graves Creek. The other five fish (#4-8) were all detected in Graves Creek between 2015 and 2017 with varying histories at the fish ladder and/or Thompson River.

Table 2-8. Summary of fish (in order of initial tagging date) with a history at Thompson Falls fish ladder or Thompson River drainage and were detected at the remote array station in Graves Creek, 2011-2018. "–" = no detections.

Fish #	Species	Initial Tag Date	Initial Tag Location	Initial Length (mm)	Date(s) In Graves Creek	Other Detections
1	RB	4/4/2011	Thompson Falls Fish Ladder	474	5/6/2011; 5/11/2011	-
2	RB	4/13/2011	Thompson Falls Fish Ladder	482	5/11/2011	-
3	WCT	5/11/2011	Thompson Falls Fish Ladder	371	6/10/2011; 6/19/2011	-
4	LL	5/22/2015	Graves Creek (Juvenile)	189	5/22/2015	7/1/2016 Thompson Falls Ladder; 6/23/2017 & 6/15/2018 Thompson River
5	BULL	8/3/2015	Fishtrap Creek (Juvenile)	163	3/28/2016	12/7/2015 Fishtrap; 12/16/2015 Thompson River
6	RB	8/2/2015	Thompson Falls Fish Ladder	490	6/3/2017	9/1/2015 Thompson River
7	BULL	5/18/2016	Thompson Falls Fish Ladder (genetic assignment NF Fish Creek – Region 4)	615	9/20/2017	9/18–28/2016 Thompson River
8	LL	8/16/2017	Thompson Falls Fish Ladder	485	11/16/2017; 11/25/2017	10/26–27/2017 & 9/24/2018 Thompson Falls Ladder; 10/24/2018 & 11/13/2018 Prospect Creek

Two fish (#4, 5) were initially captured as juvenile Bull Trout in tributary streams. Fish #4 (LL) was initially captured in Graves Creek as a juvenile in May 2015 migrated upstream and ascended the ladder in July 2016, then was detected in the Thompson River for 2 consecutive years (June 2017 & June 2018). Fish #5 (BULL) was initially captured as a juvenile in Fishtrap Creek (upstream of Thompson Falls Dam) in August 2015 and was later detected leaving the Thompson River drainage in December 2015 prior to being detected in Graves Creek in March 2016.

Fish #6 (RB) and #7 (BULL) were initially at the fish ladder and further upstream in the Thompson River prior to their last detection downstream in Graves Creek. The Bull Trout (#7) was genetically assigned to North Fork Fish Creek in Region 4, and after its ascent at the fish ladder and release upstream it was detected 4 months later (in September) in the Thompson River before being detected the following year downstream of Thompson Falls Dam in Graves Creek.

Fish #8 (LL) displayed a variety of upstream and downstream migrations over 2 years of detection. This Brown Trout ascended the fish ladder in August 2017, then moved downstream into Graves Creek in November 2017, then moved back upstream and ascended the fish ladder at Thompson Falls Dam again in September 2018 with another downstream migration 1 month later to Prospect

Creek in October and again in November 2019. There were no detections of this fish in the Thompson River.

2.3.8 *Tracking Angler Reports*

In 2017, salmonids started to receive a secondary tag (Floy) at the ladder prior to release as part of a study by FWP to study angling exploitation. Since 2017 (through July 1, 2019), FWP has provided a secondary tag (Floy) in 324 salmonids (190 RB, 102 LL, 26 WCT, 4 MWF, 2 RBxWCT). Anglers have captured and reported seven fish to FWP (Table 2-9). Four of these fish (1 LL, 2 RB, 1 WCT) were captured upstream of Thompson Falls Dam and three of these fish (2 RB, 1 LL) downstream of Thompson Falls Dam. Locations of these ladder fish have varied from 22 river miles downstream of Thompson Falls Dam to over 150 river miles upstream of Thompson Falls Dam (Table 2-9).

Table 2-9. Summary of ladder-fish (salmonids only) reported by anglers upstream (U) or downstream (D) from 2017 through July 1, 2019.

Species	Initial Tag Date	Angler Tag Return	Date Detected	Approximate River Miles Upstream(U) or Downstream(D) of Thompson Falls Dam	Duration Between Release at Dam and Angler Recap	Other Detections
RB	4/3/2019	Rattlesnake Creek (near Missoula, MT)	4/19/2019	150(U)	16 days	NA
RB	9/20/2017	Sloan Bridge – Lower Flathead River	10/12/2017	82(U)	23 days	NA
WCT	4/23/2018	St. Regis River	5/30/2018	65(U)	37 days	Thompson Falls Ladder, lower pool. October 2018; Thompson Falls holding pool April 2019
LL	unknown	Petty Creek (near Alberton, MT)	10/1/2018	52(U)	unknown	NA
RB	4/22/2019	Mouth of Prospect Creek	5/22/2019	0.5(D)	30 days	NA
RB	5/10/2019	Mouth of Prospect Creek	8/5/2019	0.5(D)	87 days	NA
LL	8/10/2018	Vermilion Bay	4/20/2019	22(D)	253 days	NA

The timing between the release of a fish upstream of Thompson Falls Dam and subsequent angler recapture has varied from 16 days to 253 days. Although the angler reports are limited, the data show fish are moving long distances, both upstream and downstream, and accessing areas previously unavailable until the fish passage facility became operational in 2011.

In one instance a Rainbow Trout reported in 2019 moved over 150 river miles upstream to Rattlesnake Creek in 16 days (estimated 9 miles per day). In another example, the only Westslope Cutthroat Trout reported first ascended the ladder in April 2018, later was recaptured by an angler approximately 65 river miles upstream in the St. Regis River in June 2018, was detected over 65 river miles downstream and in the lower pools of the Thompson Falls fish ladder in October 2018 and again in April 2019 before it ascended the ladder a second time in April 2019 and was released upstream of the dam. As summarized in the annual reports, Smallmouth Bass Floy-tagged in 2015 have also been reported in the lower Flathead River over 100 miles upstream of Thompson Falls Dam (NorthWestern, 2019).

2.3.9 *Bull Trout Transport*

No fish were transported via vehicle after ascending the Thompson Falls upstream fish passage facility since operations began in 2011. Avista manages the only transport program for adult Bull Trout at Cabinet Gorge Dam and provides information to NorthWestern annually regarding the number of Bull Trout transported and released to Region 4, upstream of Thompson Falls Dam and the release location. Avista's adult Bull Trout transport program began in 2001, and the transportation of Bull Trout to Region 4 (upstream of Thompson Falls Dam) began in 2007. Table 2-10 shows the number of Bull Trout Avista transported to Region 4 each year since 2007 (Bernall and Duffy, 2019). Avista transported an average of seven Bull Trout annually to Region 4 (Table 2-10).

Table 2-10. Summary of adult Bull Trout captured by Avista downstream of Cabinet Gorge Dam and transported to Region 4, 2007–2018 (Bernall and Duffy, 2019).

Year	# of Bull Trout Transported to R4
2018	5
2017	5
2016	2
2015	9
2014	12
2013	8
2012	8
2011	5
2010	9
2009	12
2008	8
2007	4

Year	# of Bull Trout Transported to R4
Annual Average	7
Total	87

2.3.10 *Genetic Assignment: Blind Evaluation Test of Accuracy*

There were 59 juvenile Bull Trout sampled from known locations used to analyze genetic assignment accurately. The results indicate genetic assignment accuracy at the Region level may range from 53 to 100 percent (Table 2-11). Of the 59 juvenile Bull Trout analyzed, 86 percent (51 fish) would have been passed upstream to the correct region of origin.

Table 2-11. Summary of the percent of Bull Trout assigned to the correct region.

Region	Capture #	Assignment #	Percent assigned to correct region
Region 1	19	19	100%
Region 2	10	9	90%
Region 3	15	8	53%
Region 4	15	15	100%

All Bull Trout collected from tributaries in Regions 1 and 4 were assigned to the correct Region. Of the 10 juvenile Bull Trout captured in Region 2 tributaries, one fish was incorrectly assigned to Region 1 and the remainder were correctly assigned. Of the 15 juvenile Bull Trout captured in Region 3 tributaries, 53 percent were correctly assigned to Region 3. The incorrect assignments are described in Table 2-12. Two fish were incorrectly assigned to Region 1; one to Region 2; and four to Region 4.

Table 2-12. Region assignment for seven fish sampled from Region 3 but assigned to other locations upstream and downstream of Region 3.

Capture Location in Region 3	Genetic Assignment Most Likely Pop.	Genetic Assignment Second Most Likely Pop.	Confidence
Prospect Creek	EF Lightning (R1)	Char (R1)	2.3
Graves Creek	Lightning (R1)	Graves (R3)	2.06
Vermilion River	EF Bull River (R2)	Johnson (R1)	6.3
Graves Creek	NF Jocko (R4)	SF Jocko (R4)	67.1
Graves Creek	SF Jocko (R4)	NF Jocko (R4)	6.17
Vermilion River	Upper Rock (R4)	Porcupine (R1)	500.3
Vermilion River	Upper Rock (R4)	Vermilion (R3)	2.81

When re-running the samples using the 2007 genetic data baseline, but without Region 4 tributaries upstream of the confluence of the Blackfoot and Clark Fork rivers, the most likely population of origin genetic assignment changed for only three of the 59 individuals (Table 2-13). One Bull Trout was more accurately assigned to Region 3 while the other two Bull Trout were not accurately assigned.

Table 2-13. Results of Bull Trout genetic assignment with and without Region 4 tributaries upstream of the Blackfoot River.

	Original Assignment (all tributaries)			Revised Assignment (Without Region 4 tributaries upstream of Blackfoot River)		
Capture Location	**Most Likely Pop.**	**Second Most Likely Pop.**	**Confidence**	**Most Likely Pop. w/o R4**	**Second Most Likely Pop. w/o R4**	**Confidence w/o R4**
Vermilion River (R3)	Upper Rock (R4)	Vermilion River (R3)	2.81	Vermilion River (R3)	Rattlesnake Creek (R4)	1.44
Vermilion River (R3)	Upper Rock (R4)	Porcupine Creek (R1)	500.3	Porcupine Creek (R1)	East Fork Bull River (R2)	4.9
Rattlesnake Creek (R4)	N.F. Blackfoot (R4)	Monture (R4)	2000000	Lightning Creek (R1)	Savage Creek (R1)	5.33

2.3.11 *TAC Funded Genetics*

Below is a summary of funds approved by the TAC annually since 2009 for genetic analysis and maintenance of the Bull Trout genetic database (Table 2-14). Additional contributions to the genetic baseline database were provided from Fishtrap Creek in 2011, Big Rock Creek in 2013, Fish and Cedar Creek and the North and South Fork Jocko rivers in 2014, and Little Joe and Albert creeks in 2016.

Table 2-14. Annual TAC funding approved (does necessarily equal funding spent) for Bull Trout genetic analysis in the Clark Fork River drainage, 2009–2019.

Year	Funds Approved by TAC	Genetic Samples Analyzed	Results	Source
2009	$ 5,000	1 Bull Trout sampled upstream of Thompson Falls Dam in 2009 by Licensee. No samples taken by FWP in 2009. Funding reallocated to 2010.	Fishtrap Creek (R4)	2009 Meeting Notes
2010	$5,000	No samples submitted in 2010 for analysis, funding reallocated to 2011.	NA	2010 Meeting Notes
2011	$ 5,000	5 Bull Trout (2 at Thompson Falls fish ladder, 3 downstream of Thompson Falls Dam via electrofishing) in 2011.	All Region 4	2012 Annual Report
		Approximately 50 juvenile Bull Trout samples from Fishtrap Creek to add to the baseline dataset for population assignments.	DeHaan et al., 2012)	2012 Annual Report
2012	$ 5,000	7 Bull Trout (2 at Thompson Falls fish ladder, 1 downstream of Thompson Falls Dam, 2 in Thompson Falls Reservoir, 2 in CFR Paradise-to-Plains reach).	6 Region 4, 1 Region 3	2012 Annual Report
2013	$ 10,000	6 Bull Trout (5 at Thompson Falls fish ladder, 1 in Thompson Falls Reservoir).	All Region 4	2013 Annual Report
		Samples from Big Rock Creek (Thompson River drainage) to improve baseline genetics database for tributary.	Baseline database	
2014	$ 20,000	samples from juvenile Bull Trout in Fish Creek (n=50), Cedar Creek (n=37).	Baseline database	2013 Annual Report, 2014 Annual Report
		Samples from North Fork (n=44) and South Fork (n=37) Jocko River to improve Bull Trout genetic baseline database.	Baseline database	2014 Annual Report
		5 Bull Trout (1 at Thompson Falls fish ladder, 2 Bull Trout downstream of Thompson Falls Dam, 1 Thompson Falls Reservoir, 1 Paradise-to-Plains reach).	All Region 4	2014 Annual Report, 2015 Annual Report
2015	$ 3,000	50 juvenile Bull Trout samples from Little Joe Creek to improve genetic baseline database.	Baseline database	2015 Annual Report
		3 Bull Trout (2 at Thompson Falls Ladder, 1 Thompson Falls Reservoir.		

Year	Funds Approved by TAC	Genetic Samples Analyzed	Results	Source
2016	$ 10,000	4 Bull Trout (3 at Thompson Falls Ladder, 1 Thompson Falls Reservoir).		2016 Annual Report
		Bull Trout samples from Albert Creek to improve genetic baseline database.	Baseline database	
2017	$ 16,500	1 Bull Trout (Thompson Falls fish ladder).	Region 4	2017 Annual Report, 2018 Annual Report
2018	$ 10,000	No samples submitted in 2010 for analysis, funding reallocated to 2011.	NA	2018 Annual Report
2019	$10,000*	*Funding available is part of $10,000 miscellaneous funds approved by TAC.		

2.4 Discussion

The Licensee and partners in the lower Clark Fork River system have uniquely tagged and monitored adult Bull Trout (and juvenile Bull Trout in more recent years) in the drainage since the early 2000s. The goals of tagging and monitoring Bull Trout have been to understand migratory fish movements and behavior and to help plan, design, and optimize fish passage. This report provides a summary of tagging efforts and results from preliminary fish ladder phase (2004–2006) and the first 9 years of ladder operations (2011–July 1, 2019).

During the fish passage preliminary studies, the Licensee monitored 12 radio-tagged adult Bull Trout (3 in 2004; 6 in 2005; 3 in 2006) downstream of Thompson Falls Dam (Gillin and Haddix, 2005; Haddix and Gillin, 2006; GEI, 2007). Between 2008 and 2011, the Licensee and partners monitored 16 radio-tagged Bull Trout that were transported by Avista upstream to Regions 3 and 4. Although the sample size was relatively low, general movement patterns indicated Bull Trout approached the Main Dam area in the spring and early summer when spring flows are increasing and are sometimes detected in the autumn.

Since the fish ladder operations began, the Licensee has handled 34 Bull Trout (32 individuals) in the Project area (10 upstream of the dam, 22 at the fish ladder or downstream of the dam), including the 17 Bull Trout that ascended the ladder. In addition, eight Bull Trout previously tagged were detected entering the ladder with varying genetic assignments to Regions 2, 3, and 4 (*refer to* Section 3 Upstream Fish Passage). Data collected at the ladder continue to support Bull Trout peak upstream movements occur in the spring while some Bull Trout are also detected in the ladder in the fall.

Avista's adult Bull Trout transport program has transported Bull Trout to Region 4 since 2007. Avista uses the rapid genetic assignment tool to assess the destination for Bull Trout captured downstream of Cabinet Gorge Dam to be transported upstream to the estimated natal stream. This tool is useful, however based on the blind test in 2007 genetic assignments are imperfect, particularly for Bull Trout assigned to Region 3.

There are on average 7 adult Bull Trout transported by Avista to Region 4 annually. Approximately 14 of these transport fish have been detected in the Thompson River drainage, from September 2014 through 2018. Data from the transport fish and ladder fish in the Thompson River drainage show Bull Trout are moving into spawning tributaries between March and October and then leaving the system in September and October.

Other remote arrays located downstream of Thompson Falls Dam detected five Bull Trout in Prospect Creek (none with any fish ladder history) and two Bull Trout in Graves Creek (one ascended the fish ladder). These Bull Trout represent a mix of subadult and adult fish with detections in the spring, summer, and fall months. Many of these fish were not genetically assigned to the respective stream of detection, thus the data add to the complexity of interpreting Bull Trout movements observed. Bull Trout clearly do not move linearly from upstream to downstream and downstream to upstream without deviations. The challenge is understanding the reasons for these deviations and determining if these deviations are related to existing habitat conditions and alterations to the system, predator-prey relationships, and/or something else.

The combination of radio telemetry and PIT-tag array detections have shown a variety of movement patterns for Bull Trout and other salmonids in the lower Clark Fork River. As reported in many studies, there is a generally upstream spring migratory movement pattern for adult Bull Trout, with more Bull Trout passing the fish ladder in the spring than in other seasons. However, some fish continue to move upstream after passing the fish ladder, and others return downstream. Some Bull Trout seem to have directed movement into their natal streams, but others move into multiple tributaries (non-natal streams) during a range of seasons. Bull Trout will use streams that are not their natal tributaries even when they have access to their natal streams (*refer to* Section 2.3.6 Tracking Tag Array Detections – Prospect Creek). These movement patterns are difficult to interpret based on the relatively low number of Bull Trout studied.

Since ladder operations began nearly 3,000 salmonids (16 BULL) were released upstream of the fish ladder (dam) with a unique tag. There have been many similarities in the variability of movement patterns recorded for salmonids and Bull Trout. Some salmonids that have ascended the ladder have also been found to move upstream long distances (>100 miles), sometimes quickly. They move in both an upstream and downstream direction, and sometimes make multiple round trips, ascending the ladder and moving upstream to the Thompson River and repeating the journey in subsequent year(s).

On an annual basis or even over the last 15 years, the number of Bull Trout sampled in the Project area remains too low to make definitive or statistically rigorous statements to predict or describe adult Bull Trout movement either approaching the Main Dam, ascending the ladder, or movements after being released upstream of the dam. Genetic assignments provide valuable information and are a useful tool for predicting natal streams and likely destinations for adult Bull Trout (DeHaan and Bernall, 2013). The data collected support the notion that inland freshwater fish like Bull Trout follow a general life history structure, but in between spawning (which may not be an annual interval), fish make upstream and downstream movements in the system and utilize available habitat.

3. Upstream Fish Passage

3.1 Compliance and Reporting Requirements

FWS 2008 BiOp requires the Licensee to,

> 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 FWS 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.

Additionally, FWS issued a Memorandum dated March 31, 2011 outlining, "guiding principles for Bull Trout passage through the Clark Fork River corridor, Montana and Idaho." FWS states their goal is to achieve, "full, volitional, unimpeded, safe, timely, and effective two-way passage of Bull Trout to their natural habitats as the standard approach to achieve recovery over all manmade obstacles... applying the best available science."

The Licensee built the Upstream Fish Passage Facility (Thompson Falls fish ladder) at Thompson Falls Dam in 2009 and 2010 (Photographs 3-1). The passage facility was tested in August and September 2010 and became operational in March 2011. The fish ladder has been operated from approximately March through October/November each year since 2011.

Per FWS BiOp (2008) and 2009 FERC Order, the License developed and implemented an evaluation plan for Phase 2 (2011–2020). The BiOP (FWS, 2008) requires the License to complete the following during the Phase 2 evaluation period of the fish ladder:

> …evaluate the 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.

In cooperation with the TAC and approval by FWS and FERC, the Licensee developed an upstream fish passage evaluation plan for Phase 2, *Passage Evaluation Plan, Phase 2 Action Plan, 2011–2020* (PPL Montana, 2010a). FERC issued an Order on June 9, 2011 approving the Licensee's *Passage Evaluation Plan, Phase 2 Action Plan, 2011–2020* (Phase 2 evaluation plan).

Photographs 3-1. Upstream Fish Passage Facility at Thompson Falls Dam (10/10/2012). Side-by-side photos of the Upstream Fish Passage Facility at Thompson Falls Dam (3/30/2015). Photo credit: K. Webb.

The Phase 2 evaluation plan outlines the Licensee's strategy for evaluating the effectiveness of fish ladder through various studies to be conducted to assess the ability of Bull Trout and other fish species to locate the ladder entrance and ascend the ladder.

The Phase 2 evaluation plan (PPL Montana, 2010a) identified the following objectives:

- Assess the effectiveness of the upstream fish ladder to pass Bull Trout
- Determine the optimal operational procedures to achieve the highest efficiency for upstream Bull Trout passage
- Assess the potential length of delay for upstream Bull Trout passage and devise strategies to minimize that delay
- Assess the amount of "fallback"

Fish passage criteria available during the planning and design phase originated from 2008 NOAA guidelines (NMFS, 2008), which was primarily for anadromous salmon in the Columbia River system. There were no criteria or guidelines available for the design and implementation of quantitative "success" for potadromous, fish requiring movement in freshwater systems to complete their life cycle, such as Bull Trout and other salmonids present in the lower Clark Fork River. FWS developed additional national fish passage engineering criteria in 2017 (FWS, 2017) to help define qualitative and quantitative analyses of, "safe, timely, and effective movement of fish past a barrier." The 2017 design criteria (FWS, 2017) have become the default fish passage guidance document since publication.

Results of fish recorded at the ladder and ladder operations are reported annually per TC1(h). The Licensee prepared and submitted annual reports to the FWS and FERC starting in 2009, prior to the upstream fish passage facility operations. These reports are available on the Project website (http://www.thompsonfallsfishpassage.com/reference.html).

3.2 General Ladder Operations

The fish ladder operates annually from mid/late-March to October/November. The ladder shuts down when a fall freeze is imminent. During operations, the fish ladder is monitored daily, when possible. The fish ladder is not operated during the winter due to ice limiting operability and increasing safety concerns. A summary of ladder operations is provided in Table 3-1.

Table 3-1. Summary of the ladder season and annual peak streamflow in the Clark Fork River (USGS gage #12389000) near Plains, 2011–2019. 2019 ladder season still in progress at the time of this report.

Year	Ladder Season (date opened and closed)	# Days in Operating Season	# of Days Ladder Open	# of Days Ladder Closed	Peak Streamflow (Date)
2011	Mar 17–Oct 17	215	131	84	104,000 June 10
2012	Mar 13–Oct 15	216	194	22	75,300 June 20
2013	Mar 13–Oct 15	217	203	14	63,700 May 15
2014	Mar 28–Oct 21	208	192	16	82,800 May 29
2015	Mar 16–Nov 9	238	230	8	36,600 June 11
2016	Mar 13–Oct 31	231	231	None	44,100 May 27
2017	Mar 21–Oct 31	224	210	14	82,100 June 3
2018	Mar 27–Nov 15	234	145	89	103,000 May 27-28
2019	Mar 22–Oct 16	209	204	5	68,100 May 19

The ladder utilizes 3 cfs to operate the work station and 6 cfs flowing pool-to-pool with the option of additional attractant flows from the auxiliary water system (maximum 54 cfs) and high velocity jet (20 cfs). Total flow available for operating the ladder and producing the maximum attractant flow at the ladder entrance is 83 cfs. In addition to these flows through the ladder, NorthWestern may open one or more spill gate to provide an additional fish attractant flow. The ladder has operated when the elevation of Thompson Reservoir was near full pool (2,396') providing the required 9 cfs (6 cfs down the ladder; 3 cfs through the fish working station) for fish ladder functionality.

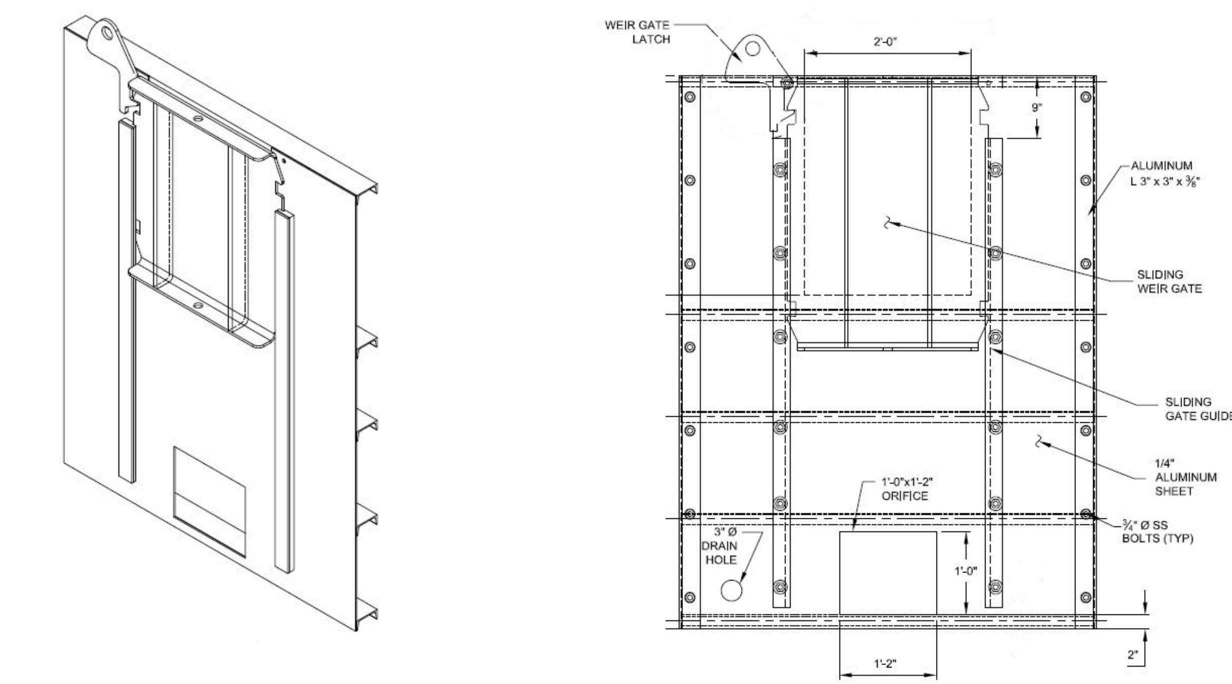
The fish ladder was designed to pass fish with streamflows up to 48,000 cfs. Operations at the ladder generally stop when streamflows exceed 60,000 cfs, which is about 12,000 cfs above the maximum design threshold. Sediment and debris build up occur in the lower pools when flows exceed 60,000 cfs and create safety concerns for personnel and operating challenges. Since ladder operations began in 2011, streamflows have exceeded the maximum design threshold annually except for the 2015 and 2016 seasons (Table 3-1).

3.3 Fish Ladder Design

The Thompson Falls fish ladder was designed in general accordance with the NOAA Fisheries Criteria (NMFS, 2008), which was used by FWS in the design of Bull Trout upstream passage facility. The fish ladder design incorporates a series of 48 pools, each 6 feet long by 5 feet wide by 4 feet deep (GEI, 2007as cited in FWS, 2008). At the time of the design there was considerable uncertainty regarding timing, efficiency, and effectiveness with which Bull Trout use of the fish ladder would occur (FWS, 2008).

Hydraulically, the ladder was designed to induce a 1-foot drop in the hydraulic grade line for each of the 48 pools to allow passage of a diverse population of fish over the Thompson Falls Main Channel Dam. Each pool is separated by an aluminum weir plate with a sliding weir gate leaf. The weir plate has a square orifice (1'-tall x 1' 2"-wide) at the bottom center of the plate and a 2-foot-wide weir notch cut into the top of the plate. Because the ladder was a pioneering structure in Bull Trout passage, it was designed with flexibility to allow operations of the ladder in one of two modes, identified as "orifice" or "notch" modes. The ladder was not designed for operating with a combination of the two modes. Raising the central sliding weir gate allows pool-to-pool flow through the bottom orifice (orifice mode). Lowering the weir gate allows pool-to-pool flow through the top weir (notch mode) (Figure 3-1). The upper pools (46-48) operate solely in orifice mode to reduce the effects of the forebay water level on the ladder hydraulics.

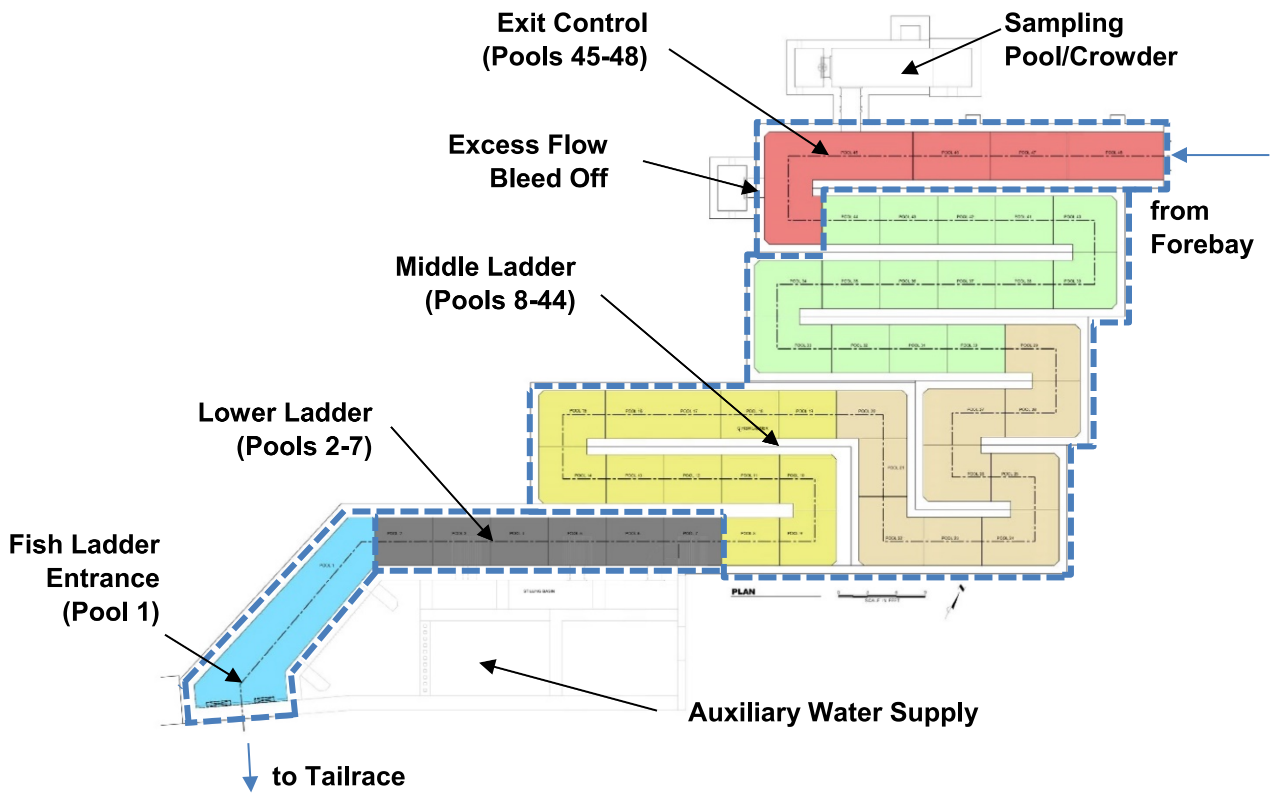
Figure 3-1. Isometric and front view of aluminum weir plates. By lowering the sliding weir gate down to cover the bottom orifice, the ladder, the ladder is operated in weir mode.



By design, the fish ladder has four distinct areas, as follows (Figure 3-2):

- Fish Ladder Entrance – Pool 1
- Lower Ladder Pools – Pools 2-7
- Middle Ladder Pools – Pools 8-44
- Exit Control Section – Pools 45-48

Figure 3-2. Thompson Falls Fish Ladder Flow Areas.



3.3.1 *Fish Entrance*

- The fish ladder entrance includes two entrance ports through which fish can enter the ladder entrance pool (Pool 1): one is a gated 24"-wide by 36"-high low-tailwater entrance, designed to operate during non-spill periods; the other is a gated 30"- by 48"-high-flow entrance, designed to operate during spill.
- Entrance attraction flow into the tailrace is a combination of ladder pool-to-pool flow (nominal 6 cfs) and auxiliary water flow (maximum 54 cfs).
- An adjacent high-velocity jet (HVJ) provides an additional means to increase attraction flow by 20 cfs.
- Auxiliary water supply (AWS) flow introduced into Pool 1 through a wall diffuser, with a maximum uniform velocity of 1 foot per second.
- The entrance pool is configured to enable fish to readily find the ladder pool-to-pool flow during the low-flow, non-spill period. During spill, auxiliary water flow is added in Pools 3, 5, and 7, successively.

3.3.2 *Lower Ladder (Pools 2-7)*

- Fish ladder is designed to operate within design criteria between the low design tailwater El. 2248 feet and the high design tailwater El. 2259 feet.

- Floor diffusers in Pools 3, 5, and 7 provide added auxiliary water successively to Pool 3, then Pool 5, then to Pool 7 as tailwater rises in 2-foot increments above low design tailwater. The purpose is to maintain fish attraction velocities/flow magnitudes over inundated weirs 2-7 during higher tailwater periods.
- Auxiliary water add-in system designed for notch-operation-only in these lower pools and will not add auxiliary flow if these pools are operated in orifice mode.
- The design was intended operate Pools 2-7 in the notch setting, regardless of whether Pools 8-45 are operated in notch or orifice mode. This was the case from 2011 through 2018 operating seasons. In 2019, Pools 2-7 were switched to orifice.

3.3.3 *Middle Ladder Pools (8-44)*

- Fish ladder designed to operate as a pool-type ladder with a 1-foot pool-to-pool differential at a ladder flow rate of 6 cfs.
- For pool-type fish ladders, design intent is to provide pool volume to fully dissipate energy from incoming flow. An energy dissipation criterion (NMFS, 2008 updated in NMFS, 2011) dictates required volume, for an appropriate turbulence level in each pool.
- Aluminum prefabricated weirs designed to enable changing from notch to/from orifice operating mode, by lowering/raising a gate leaf in each weir.
- Orifice and weir sizes both selected to provide a 1-foot drop in the hydraulic grade line along the ladder, based on assumed notch and orifice coefficients.
- Operating criteria also assumed a forebay El. of 2396.0–2396.5 feet for normal ladder operation.
- Lower ladder flow is determined by the water surface elevation in Pool 45, whether operation is in notch or orifice mode.
- No additional auxiliary water added or removed between Pool 8 and Pool 45.

3.3.4 *Exit Control Section (Pools 45-48)*

- Three orifice Pools (45-48), designed with a drop of approximately 1 foot between pools.
- Pool 45 design elevation target of El. 2393 feet.
- Flow to ladder pools below Pool 45 equals difference in total inflows and bleed-off outflows from Pool 45.
- Orifices between Pools 45-48 designed to modulate minor flow changes due to minor forebay pool fluctuations.
- Excessive flow into Pool 45 from forebay is bled off at a screened overflow weir, with a backset porosity control plate used to set Pool 45 water surface.
- Additional flow may be added through the trap holding pool to Pool 45.

3.3.5 *Attraction Flows*

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

At the Main Dam Spillway, spill occurs once streamflows exceed 23,000 cfs. At low design tailwater (non-spill), AWS flow is added to Pool 1 only. At low spill levels (less than 5,000 cfs), the secondary AWS stilling basin (between the vertical baffles and porosity plate) is designed to be 1 foot higher than the Pool 1 water surface tailwater, which is the purpose of the porosity plate. In turn, the Pool 1 water surface is to be 1 foot higher than tailwater. The 1-foot drops between these three points remains as tailwater, Pool 1, and the secondary AWS stilling basin water surfaces rise and progressively inundate the lower ladder pools. When Weir 2/3 (between Pools 2, 3) becomes inundated, a portion of AWS flow passively overtops the first chimney, and through the Pool 3 floor diffuser. As tailwater continues to rise in 2-foot increments, chimneys for Pools 5 and 7 are also overtopped, passively sending some AWS flow to those pools. The purpose of AWS floor diffusers in Pools 3, 5, and 7 is to create a perceivable attraction flow over inundated lower ladder weirs at progressively higher tailwater elevations.

Pool 1 discharge is designed to pass 26 cfs through entrance gate EG-1 during non-spill, with an AWS discharge of 20 cfs augmenting the 6 cfs ladder flow. During spill, Pool 1 discharge increases to 60 cfs through EG-2, with 54 cfs AWS discharge augmenting the 6 cfs ladder flow. Depending on tailwater elevation, a portion of the AWS will overtop one or more chimneys, and pass floor diffusers in Pools 3, 5, and 7. Each floor diffuser will pass approximately 5 cfs.

Another 20 cfs can be discharged directly into the tailrace in the form of an HVJ. Its purpose is to improve fish attraction to the ladder, as needed. This is accomplished by fully opening Gate G-1. The HVJ is designed to discharge 20 cfs through control valve CV-1. The jet discharges through a 14-inch diameter orifice, which produces a discharge jet velocity of approximately 19 feet per second into the tailrace. The HVJ was designed to operate during spill. Other attraction alternatives during non-spill include opening of an adjacent spillway panel(s) near to the ladder entrance. Since 2012, a partial panel near the ladder entrance has been opened providing an additional 125 cfs (estimate) attraction flow (B. Mabbott, NorthWestern, personal communication, January 25, 2018).

During spill operations (streamflows exceed 23,000 cfs), the Main Dam Spillway tailrace becomes highly turbulent, and tailwater elevation rises quickly. The spill bays on the Main Dam are shown in Photographs 3-12 and 3-13. Each spill bay contains six spill panels (each panel releases 233 cfs at full pool). A spillway gate/panel opening-closing sequence (spillway schedule) was developed in 2006 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 spillway schedule included a proposed “fish” spill schedule that would coincide with ladder operations compared to previous years when a “non-fish” schedule was in place. The proposed “fish” spill schedule was tested in 2006, 2007, and 2008. The “fish” spill schedule was successfully able to attract fish to the right bank of the Main Dam (GEI, 2007) and TDG levels were approximately 2 to 3 percent higher under the “fish” operating schedule when total streamflow was in excess of approximately 45,000 cfs (PPL Montana, 2013).

In 2010, a final spill schedule was developed (PPL Montana, 2010d). This schedule was developed in consultation with operators at the Project to enhance fish attraction to the right abutment of the Main Dam, promote adult upstream fish passage, and minimize potential impacts to TDG (PPL Montana, 2010d).

3.3.6 *Ladder Operations During Spill and Non-Spill Conditions*

Since 2011, the flow conditions at the ladder have varied annually with higher than average peak runoff in 2011 and 2018, and lower than average peak runoff in 2013, 2015, and 2016 (*see* Figure 1-3). Photographs 3-2 through 3-7 are of the Main Dam Spillway during various spill (2011, 2016, 2018, 2019) and non-spill conditions (2012, 2015, 2016).

Photographs 3-2. (left) June 8, 2011 flows 93,000 cfs and (right) June 10, 2011 flows 104,000 cfs; ladder closed.

Photographs 3-3. May 31, 2018 flows 98,600 cfs; ladder closed.

Photograph 3-4. May 9, 2016 flows 36,300 cfs 326 fish collected. Photo credit: K. Webb.

Photograph 3-5. May 6, 2015 flows 23,300 cfs 293 fish collected. Photo credit: K. Webb.

Photograph 3-6. View of attraction flows provided by HVJ and partial panel opening at the Main Dam spillway.

Photograph 3-7. May 23, 2019 flows 47,000 cfs. Note new radial gates on left bank (right side of photograph). Photo credit: J. Hanson.

3.4 Effectiveness of the Ladder

During the Phase 2 evaluation period, the Licensee is required to evaluate the efficiency of upstream fish passage and assess the effectiveness of passing Bull Trout, assess any potential delay, assess any potential fallback, and identify optimal operations to achieve the highest efficiency of Bull Trout passage (FWS, 2008).

The Phase 2 evaluation plan (PPL Montana, 2010a), approved by FWS and FERC, outlines the Licensee's strategy to evaluate the effectiveness of the fish ladder through various studies, focused on Bull Trout and other fishes to locate and ascend the ladder. The objectives of the Phase 2 evaluation plan are listed in Section 3.1 Compliance and Reporting Requirements.

3.4.1 *Methods*

The Thompson Falls fish ladder has a trap-sample loop in the upper ladder which allows fish to be routed into an off-ladder holding pool (Pool 45). Fish can then be locked into a sampling area for data collection. The ladder can be configured to either route fish into the sampling loop or opened to allow volitional (free) passage of fish. Although the overall goal for operations at the fish ladder is to provide volitional passage of fish, since 2011 all fish ascending the ladder are routed into the sampling loop and processed at the work station. All species with the exception of Lake Trout and Walleye are authorized by FWP to be released upstream after ascending the fish ladder. In 2016, an informal agreement between FWP and the Licensee was established following confirmation of a Brook Trout X Bull Trout hybrid ascending the ladder, and Brook Trout (and Brook Trout hybrids) were no longer permitted to be released upstream of Thompson Falls Dam.

The biological data for each fish (length and weight), including the tagging and marking information are recorded at the work station and maintained in an automated database along with details of the fish ladder operations. In cooperation with FWP, the Licensee has staff available to monitor fish ladder operations and oversee daily, seasonal, and annual data collection. These data are analyzed and summarized annually and submitted to FWS and FERC in an Annual Report.

At the Thompson Falls fish ladder, the primary target species is Bull Trout. The focus for the Phase 2 evaluation plan was also Bull Trout because of their federal threatened status, but fish passage effectiveness for other native fish and non-native sport salmonids is also a priority for the TAC.

The Phase 2 evaluation plan identifies effectiveness of the fish ladder as a qualitative assessment evaluated based on annual fish passage, including enumeration of fish using the facility, species using the facility, range and average size of species using the facility, and the timing of upstream passage by species (PPL Montana, 2010a). At the time the Phase 2 evaluation plan was written, there were no quantitative criteria to assess upstream fish passage specific to Bull Trout or other inland (non-anadromous) fishes.

In 2017, FWS published the *Fish Passage Engineering Design Criteria* that state the elements of a fishway are designed and implemented to provide ***safe, timely, and effective fish passage***. With the development of the 2017 fish passage criteria (FWS, 2017), the Licensee and TAC endeavored to better quantify fish passage effectiveness.

Effective passage is delineated into three components: 1) ***efficiency***, which is the quantitative measurement of the proportion of the population motivated to pass a barrier (i.e., motivated population) that successfully moves through the entire zone of passage; 2) ***attraction efficiency***, which is the proportion of the motivated population that is successfully attracted to the fishway; and 3) ***passage efficiency***, which is the proportion of the motivated population that successfully ascends the fishway, also referred to as “internal fishway efficiency” (FWS, 2017).

3.4.1.1 Efficiency

A challenge at the Thompson Falls fish ladder is quantifying the “motivated” fish population. As non-anadromous species, the “motivated population” (i.e., the proportion of the population motivated to pass a barrier) is unknown, and difficult to quantitatively assess. For this reason the evaluation of passage efficiency at Thompson Falls focuses on qualitative assessments including the data collected at the work station summarizing overall upstream fish passage such as the enumeration of fish using the facility; the species using the facility; range, average size of species using the facility; and the timing of movement and passage by each species.

3.4.1.2 Attraction efficiency

Attraction efficiency requires the enumeration of the “motivated population” and radio telemetry data monitoring fish movement in the tailrace and to the fish ladder entrance. Radio telemetry studies to address attraction efficiency were limited to the 2011 operational season. In 2011, Avista captured 11 Bull Trout, radio-tagged eight of the fish (*see* Table 2-3) downstream of Cabinet Gorge

Dam and transported the fish to Vermilion Bay, located in Region 3 approximately 22 miles downstream of Thompson Falls Dam. All 11 fish were genetically assigned to Region 4 (upstream of Thompson Falls Dam), thus it was assumed these fish were "motivated" to migrate upstream. However, in 2011 spring flows were higher than normal, which resulted in the ladder being closed for 84 days between May 25 and August 21 and prevented any manipulation or evaluation of attraction efficiency. A summary of the results from the 2011 radio-telemetry study is presented in Section 2.3.3 Tracking Radio Telemetry.

In 2012, the TAC agreed to cease radio telemetry work on fishes in the Project area. There was concern of stress to Bull Trout from handling and multiple tags (i.e., PIT-tag and radio tag).

3.4.1.3 Internal Efficiency

Internal efficiency evaluation assumes the motivated population can be quantified. For inland fisheries with potadromous life strategies, this quantitative assessment has not been possible. However, the Licensee has monitored movement of PIT-tagged-fish entering and ascending the ladder since 2011. Although the method does not account for the motivated population, the data provide some insight for internal fishway efficiency for fish that enter the ladder.

The Licensee has monitored internal fishway efficiency since 2011 through the use of three PIT tag arrays (*see* Section 2.3.4 Tracking Tag Array Detections – Ladder) installed within the ladder lower pools (Pools 7 and 8) and the holding pool (Pool 45, the top). It is assumed the tag detection efficiency is very high, but not 100 percent. One limitation of the system is that the first detection of a fish requires the fish to enter the ladder and swim through seven pools. Thus, it is possible for some fish to enter (up to Pool 6) and leave the ladder entrance and never be detected. Additionally, if a fish does not have an existing PIT-tag, no detection information is obtainable.

At the Thompson Falls fish ladder, the movement of PIT-tagged fish from the lower pools to the holding pool of the ladder can be quantified and is the current (and best) available method to evaluate internal fishway efficiency. The evaluation includes ladder ascent time and percentage of fish ascending the ladder after entry. These calculations require a tagged fish, most likely tagged at the ladder after its initial ascent, to enter the ladder a second time in order to be detected by the remote arrays in the ladder. In other words, this evaluation is based on data collected on non-naïve fish. Bull Trout were the focus of this study, but with low occurrence other salmonid species were utilized as surrogate indicators.

3.4.2 *Results – Fish Count*

From 2011 through July 1, 2019, there were 32,130 fish recorded at the ladder representing 14 species and three hybrids (Table 3-2). The majority (31,957 fish) were released upstream of Thompson Falls Dam except for Walleye, Lake Trout, Brook x Bull Trout hybrid, fish mortalities at the work station and Smallmouth Bass in 2019.

Since ladder operations began, a total of 151 fish mortalities were documented at the work station. Fish mortalities were primarily attributed to mechanical issues at the ladder (e.g., vertical crowder), which have been addressed. The majority of the fish mortalities at the ladder occurred in 2011 (n=82) and significantly declined in subsequent years (1 to 27 fish mortalities per year).

There was one Bull Trout mortality documented at the ladder, occurring in 2012. In April 2011, this Bull Trout ascended the ladder for the first time and was released upstream above the dam. It returned to the ladder in May 2012 and ascended the ladder a second time. At the top of the ladder, in Pool 45 (also known as the holding pool), the Bull Trout jumped out and died. This is the only documented Project-related Bull Trout mortality. A cover was initially installed over the holding pool (Pool 45) that was later replaced with a screen installed around the railing above the holding pool to mitigate the potential for this to occur in the future.

Table 3-2. Summary of all fish species recorded at the ladder annually, as well as weir mode, notch or orifice from 2011 through July 1, 2019*. (Note: LT and WE not authorized by FWP for release upstream. EB and EBxBULL not authorized for release by FWP starting in 2016. SMB not authorized for release by FWP starting in 2019.)

Year	2011	2012	2013	2014	2015	2016	2016	2017	2018	2018	2019*	TOTAL
Weir Mode	Weir Modes Alternated Weekly		Orifice				Notch	Notch	Notch	Orifice	Orifice	2011-2019 All Modes
Species												
BULL	2	2	5	1	2	3	-	1	-	-	1	17
EBxBULL	-	-	-	-	-	1	-	-	-	-	-	1
EB	-	-	-	1	2	1	-	-	-	-	-	4
RB	164	208	213	187	281	292	74	181	111	13	74	1,798
RBxWCT	9	7	13	12	4	5	-	1	1	-	1	53
WCT	21	21	48	36	37	32	4	14	8	6	13	240
LL	28	42	111	81	184	157	47	108	39	24	40	861
LS SU	418	1,403	3,041	2,802	6,327	2,270	-	34	6	-	786	17,087
LN SU	10	0	2	1	26	6	-	-	-	-	-	45
MWF	17	24	2	254	54	8	-	-	2	2	-	363
NPMN	1,000	926	387	1,003	3,356	697	10	66	10	-	132	7,587
PEA	-	-	-	-	120	2	-	-	-	-	-	122
PEAxNPMN	-	-	-	-	2	13	-	2	-	-	-	17
SMB	135	34	8	1,356	1,244	986	21	123	5	-	132	4,044
LMB	-	-	-	-	-	1	-	-	-	-	-	1
LT	1	1	-	1	6	-	-	-	-	-	1	10
WE	-	-	-	-	2	-	-	-	-	-	-	2
Native Fish	**1,468**	**2,376**	**3,485**	**4,097**	**9,924**	**3,031**	**14**	**117**	**26**	**8**	**932**	**25,478**
Salmonids	**242**	**305**	**392**	**573**	**570**	**499**	**125**	**305**	**161**	**45**	**130**	**3,347**
Non-Salmonids	**1,563**	**2,363**	**3,438**	**5,162**	**11,077**	**3,975**	**31**	**225**	**21**	**0**	**928**	**28,783**
TOTAL	**1,805**	**2,668**	**3,830**	**5,735**	**11,647**	**4,474**	**156**	**530**	**182**	**45**	**1,058**	**32,130**

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3.4.3 *Results – Fish Metrics*

Fish measurement protocols at the ladder have been consistent since 2011, with the goal of measuring all salmonids ascending the ladder for total length (TL) in millimeters (mm) and weight in grams (g). Sub-samples were taken for non-salmonids when large groups of non-salmonids enter the ladder at once.

Length and weight measurements were documented for approximately 97 percent of 3,347 salmonids and 30 percent of the 28,783 non-salmonids recorded at the ladder. The length of salmonids recorded at the ladder range from a 98 mm Rainbow Trout to a 785 mm Lake Trout. The size of non-salmonids recorded at the ladder range from a 69 mm Smallmouth Bass to a 610 mm Northern Pikeminnow. A summary of the mean length and weight by species is provided in each annual report.

The smallest fish to ascend the fish ladder and be released upstream was a 69 mm TL Smallmouth Bass. The largest fish to ascend the fish ladder and be released upstream was a 662 mm TL Brown Trout.

Bull Trout (n = 17) have averaged 527 mm TL, with a minimum TL of 365 mm and a maximum TL of 620 mm.

3.4.4 *Results – Multiple Ladder Ascents*

From 2011 through July 1, 2019, there were 2,953 uniquely PIT-tagged fish that ascended the fish ladder and were released upstream. The majority of PIT-tagged fish were salmonids (n=2,668) with 285 non-salmonids PIT tagged. Approximately 10 percent of the uniquely PIT-tagged fish (289 out of 2,953 PIT-tagged fish) returned and ascended the ladder two or more times between 2011 and 2019 (*refer to* Table 2-5). Additionally, about 6.5 percent of the 1,107 Smallmouth Bass Floy-tagged from 2011 to 2015 ascended the ladder two or more times (NorthWestern, 2018).

Several species (e.g., BULL, RB, WCT, MWF, LL, SMB) displayed various patterns of returning to the ladder, including annual, biennial, and triennial intervals. Although not all fish follow an annual, biennial, or triennial cycle, these movement patterns have been commonly observed among species at the ladder. The timing of these fish returning to the ladder on the exact date or within a week of the exact date 1, 2, and/or even 3 years later, supports the concept that fish movement is biological and a function of their circadian rhythm (Quinn, 2005; Davie et al., 2009; O'Malley et al., 2010). In contrast, some fish have only ascended the ladder once and then remain upstream in the Thompson River for several years following their release upstream of the dam (e.g., unpublished data on Rainbow and Brown trout ascents in 2014 followed by Thompson River detections through 2019). The variability in movement patterns indicate inland fish, specifically salmonids, utilization of the watershed is likely influenced by a multitude of factors related to the individual biological and physical needs for survival (Thurow, 2016).

3.4.5 *Results – Timing of Movement*

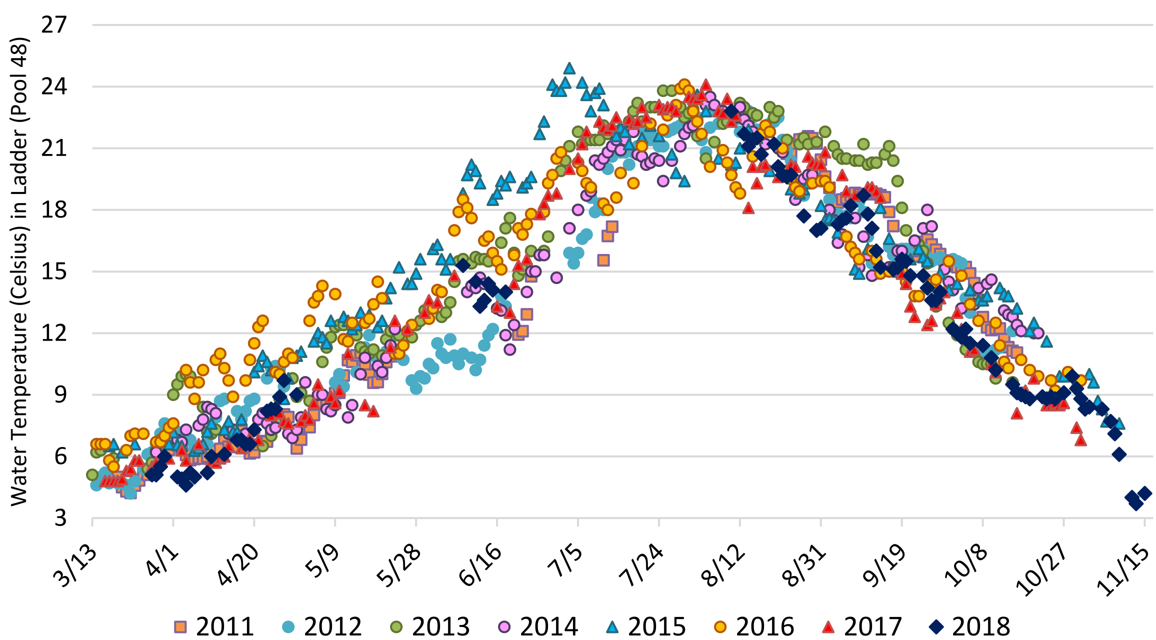
3.4.5.1 Hydrology and Water Temperature

The long-term average peak streamflow in the Clark Fork River, near Plains is approximately 60,000 cfs and occurs between the end of May and early June (*see* Figure 1-2). Peak streamflows between 2011 and 2019 varied, occurring as early as May 15 in 2013 and as late as June 20 in 2012 (*refer to* Table 3-1).

Water temperature data coinciding with each ladder check, 2011-2018 are shown in Figure 3-3. When the ladder was shut down, no temperature data were recorded. In most years, water temperature peaks in late July at about 24°C (75 °F) (Figure 3-3).

The warmest water year at the ladder was in 2015. In 2015, water temperatures warmed rapidly in the spring and peaked in early July (at 24.9 °C; 76.8 °F), streamflows remained less than 35,000 cfs, and a record number of fish (and number of species) ascended the ladder. The timing and duration of the warming trend each year has varied with streamflow and snowpack.

Figure 3-3. Summary of annual water temperatures in Thompson Falls Fish Ladder (Pool 48) recorded during each ladder check, 2011-2018.



The number of fish passing the ladder is limited when water temperatures are less than 9 °C (48 °F) (Figure 3-4), or when streamflows exceed 43,000 cfs. These temperatures are typical for early spring ladder operations in March and into April and in late October and early November (Figure 3-3). Additionally, the ladder is commonly closed at higher flows due to operational limitations that occur above 48,000 cfs.

Figure 3-4. Percentage of fish (n=31,072) recorded at the ladder and corresponding water temperature in ladder (Pool 48), 2011–2018.

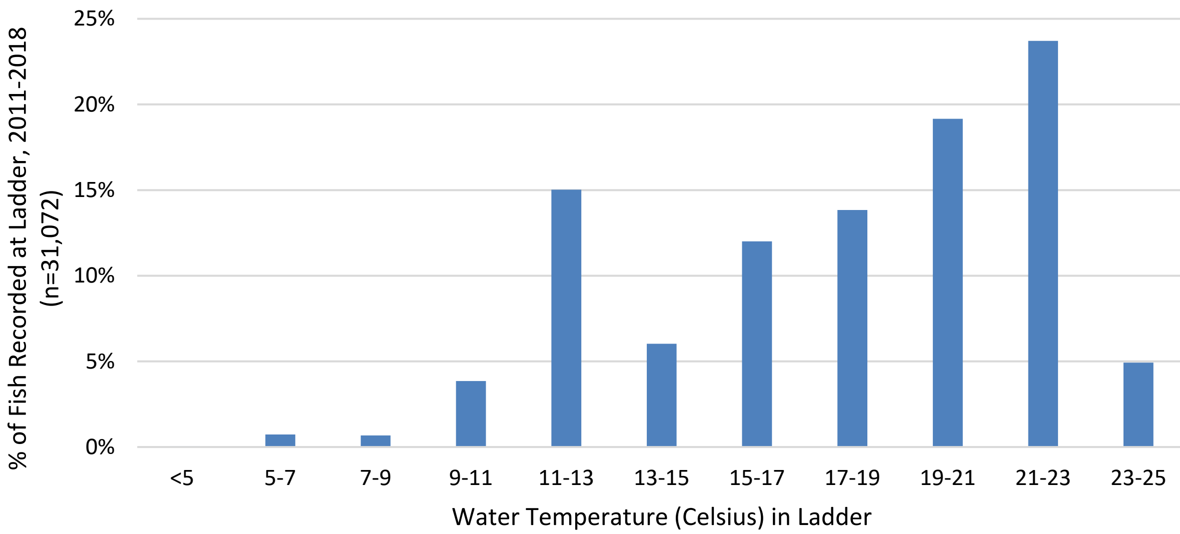
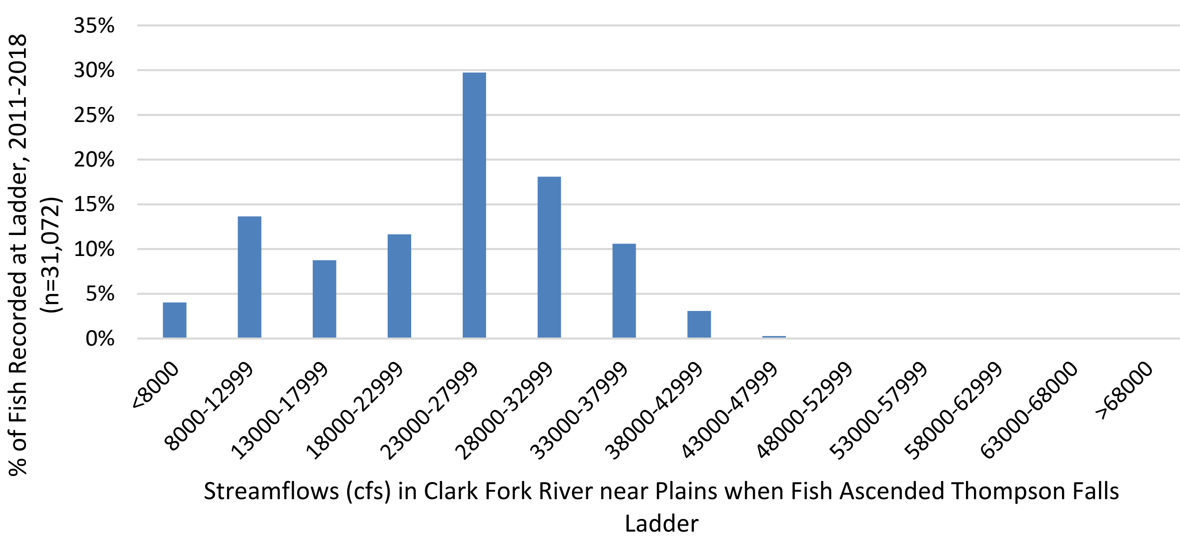


Figure 3-5. Percentage of fish (n=31,072) recorded at the ladder and corresponding streamflow measurement in the Clark Fork River, near Plains, 2011–2018.



3.4.5.2 Movement Timing by Species

Fish species recorded at the ladder display distinct and different movement strategies (NorthWestern, 2019). Salmonids have ascended the ladder in all months of operation but peak following the descending limb of the hydrograph in early summer (June/July) (Figure 3-6).

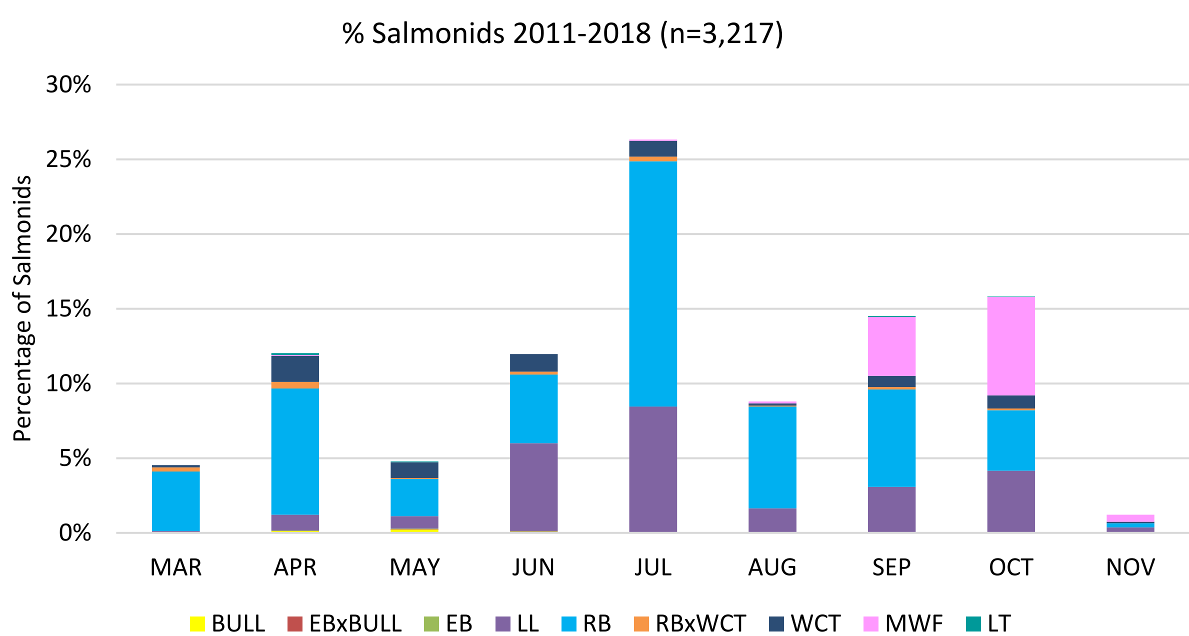
The timing of ascent of the ladder indicate many fish are not migrating upstream to immediately spawn. Rainbow Trout are spring spawning fish, but they ascend the ladder throughout the operational season (Figure 3-6). Passage of Rainbow Trout occurs in the spring, summer, and fall with minimal captures during the high flow periods of May and June. These dips in movement (May–June; October–November) may be partially a result of ladder closures, as well as less preferable/favorable river conditions. The passage of Rainbow Trout does not appear to be solely driven by a desire to migrate to spawning locations.

Brown Trout are fall spawning fish, but they also have passed through the ladder at all seasons, with the peak season of passage in June and July (Figure 3-6).

Mountain Whitefish have also been collected in the ladder as early as April, but passage of this species outside of the September through October time period is rare (Figure 3-6).

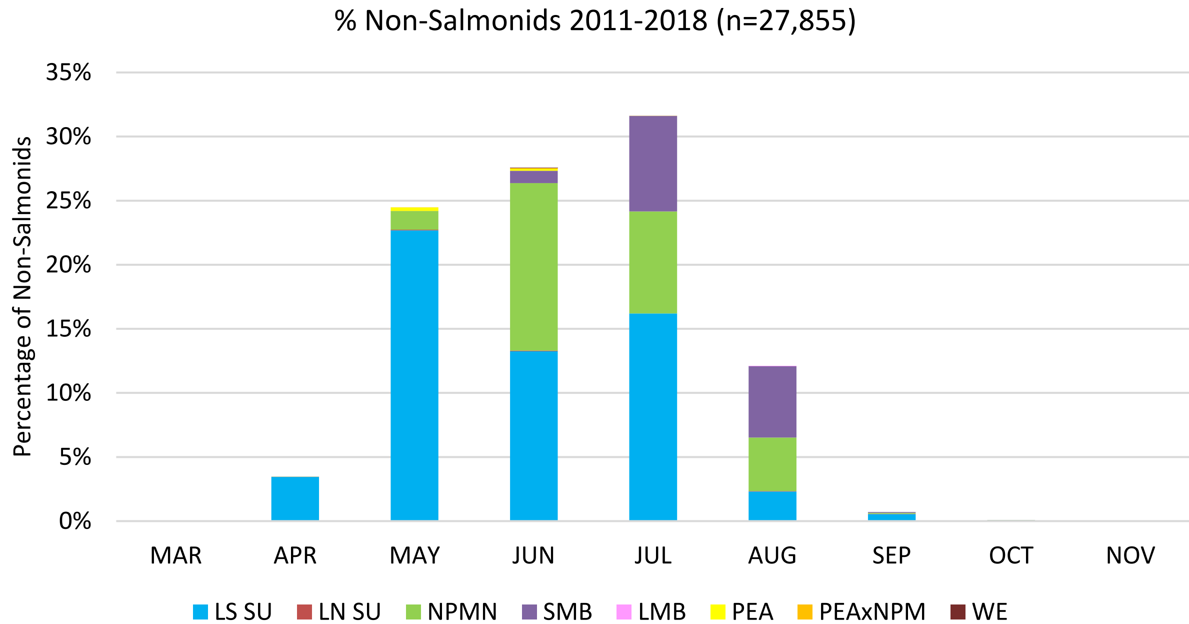
Tagged fish detections in the Thompson River add information on fish behavior after passage. Some spring spawning fish migrate upstream in the summer/fall months and remain upstream of the dam through the winter and then spawn in the Thompson River in the spring. They may subsequently leave the Thompson River drainage, migrate downstream to Noxon Rapids Reservoir, then migrate back upstream to the ladder, and repeat the process.

Figure 3-6. Salmonid passage by month at Thompson Falls fish ladder.



Non-salmonids are most common in warmer water months (May-August, depending on the year) and less common in the spring and fall months when water temperatures are cooler (Figure 3-7).

Figure 3-7. Non-Salmonid passage by month at Thompson Falls fish ladder.



3.4.6 *Results – Bull Trout Passage*

Since 2011, Bull Trout were documented entering the ladder with streamflows (measured at the USGS gage at Plains) ranging from 6,600 to 56,100 cfs (Figure 3-8) and water temperatures in the ladder (Pool 48) ranging from approximately 6.9 to 22.7 ºC or 44.4 to 72.9 °F (Figure 3-9). Figure 3-8 and Figure 3-9 show streamflow and water temperature data corresponding to when Bull Trout ascended to ladder and reached the holding pool (triangles) and when Bull Trout only entered the lower pools (squares) and did not ascend to the top. Note that some Bull Trout entered the lower pools on multiple dates, thus the symbols in Figure 3-8 and Figure 3-9 do not denote individual fish.

Figure 3-8. Clark Fork River streamflow (USGS gage #12389000) corresponding to when Bull Trout were detected at the fish ladder, 2011–2019.

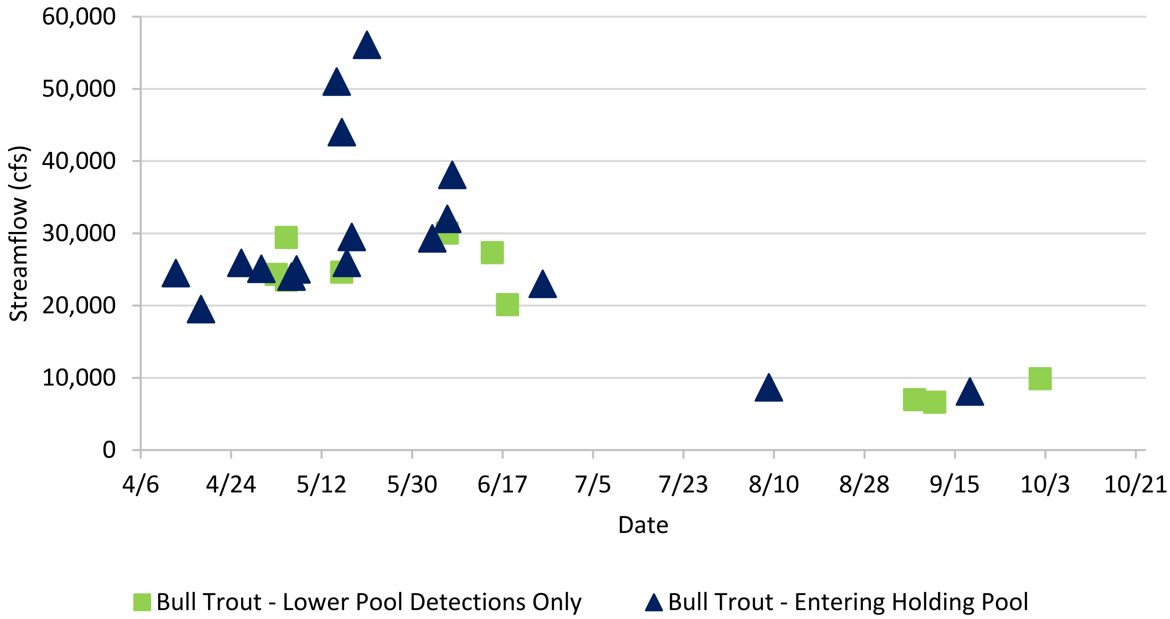
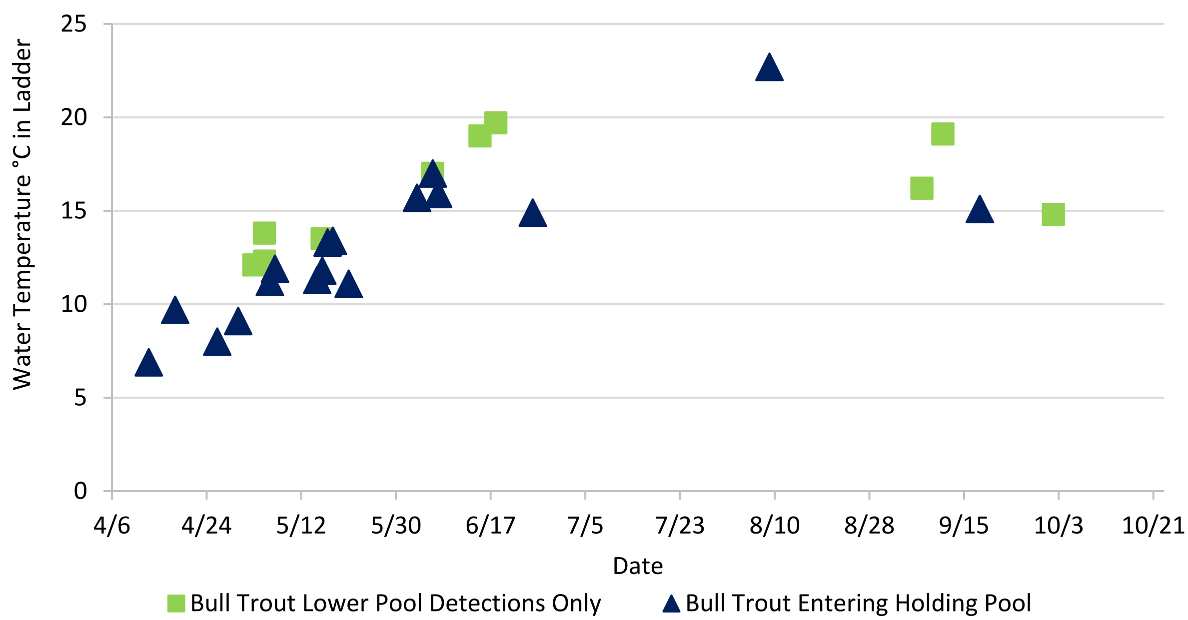
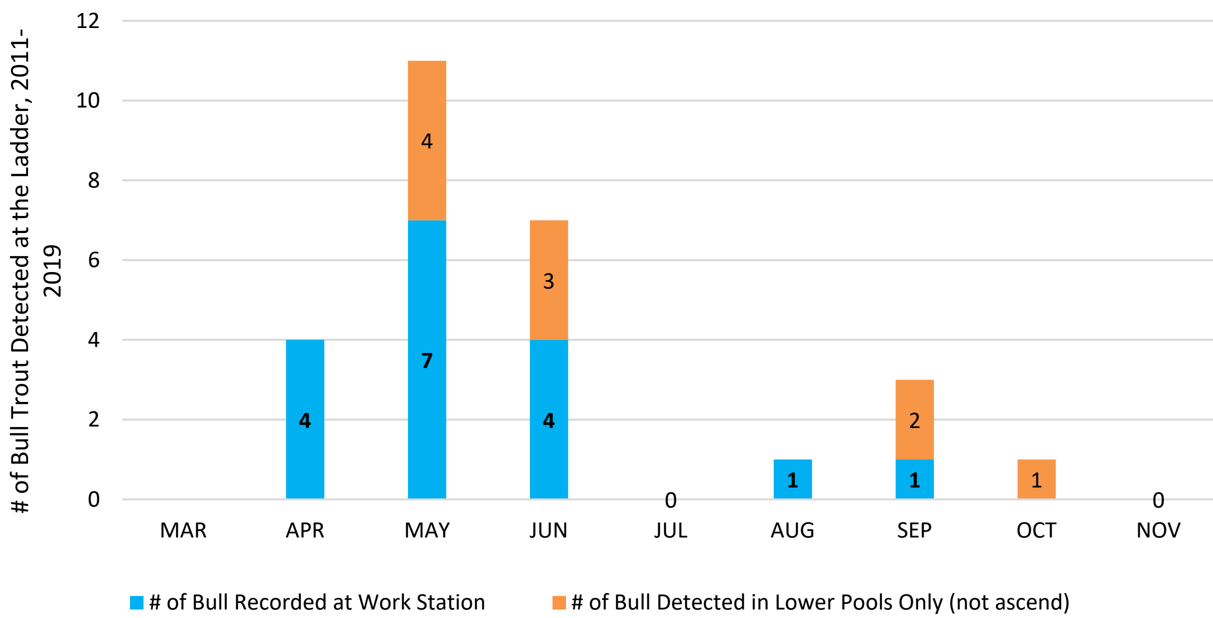


Figure 3-9. Water temperature in the ladder on dates when Bull Trout were detected at the ladder, 2011–2019.



Based on data collected at the ladder, the peak ladder use for Bull Trout (7 of 17 ascents) occurred in May (Figure 3-10), streamflows were between 24,000 and 56,100 cfs, and water temperature ranged from 11.1 to 13.8 °C or 51.9 to 56.8 °F. Most Bull Trout (15 of 17 ascents) ascended the ladder between April and June, while one Bull Trout was recorded ascending the ladder on August 9, 2013 and another Bull Trout was recorded ascending the ladder on September 18, 2017. The only months Bull Trout were not recorded ascending the ladder were March, July, October, and November. However, one Bull Trout that had previously ascended the ladder in April was detected entering the ladder in October in the same year (2016). No Bull Trout were detected in the ladder or ascending the ladder in 2018.

Figure 3-10. Number of Bull Trout detected in the Thompson Falls ladder by month, 2011–2019.



The maximum number of Bull Trout recorded at the top of the ladder for a given year was five (in 2013). The maximum number of Bull Trout detected either entering the lower pools or ascending to the top in a given year was seven (in 2015). These are minimum values because all fish detections require the fish to either ascend to the top and be handled at the work station or for the fish to already have a PIT-tag for detection in the lower pools or holding pool. A summary of the number of Bull Trout entering and/or ascending the ladder each year is provided in Table 3-3. Since 2011, there have been 25 Bull Trout detected in the ladder with 17 of them recorded ascending to the top (68%).

Table 3-3. The number of Bull Trout (with PIT tags) entering the ladder (Pools 7/8) and the number of Bull Trout that ascend to the top (holding pool) of the Thompson Falls fish ladder annually, 2011–2019.

Year	Known Number of Bull Trout Detected in the Ladder, 2011-2019	
	Enter Ladder	Ascend to Top of Ladder
2011	2	2
2012	2	2
2013	5	5
2014	1	1
2015	7	2
2016	6	3
2017	1	1
2018	-	-
2019	1	1
Total	**25**	**17**

The majority of Bull Trout (13 of 16 individuals) ascending the ladder were not previously PIT-tagged (*refer to* Table 2-2). Since ladder operations began, 11 previously PIT-tagged Bull Trout were detected entering the ladder (via remote tag arrays) with three fish ascending to the top (2 in 2012; 1 in 2019) and eight individuals (in 2015 and 2016) not ascending to the top (Table 3-3). Table 3-4 summarizes the known information about the eight Bull Trout detected in the lower pools of the fish ladder that did not ascend to the top.

The total number of Bull Trout entering the ladder and ascending the ladder between 2011 and July 1, 2019 is a minimum value because no data are available for untagged fish that may enter the ladder and not ascend to the top. Table 3-3 summarizes the 25 Bull Trout known to have entered the ladder and the 16 Bull Trout that ascended to the top of the ladder since 2011 plus one Bull Trout found in Pool 23 (in 2012) when changing weir modes in the ladder. A weir mode shift (orifice to notch or *vice versa*) require the ladder to be dewatered before the weirs can be changed.

One Bull Trout initially ascended the ladder in May 2013 and was genetically assigned to Fishtrap Creek. It was later detected in Prospect Creek in September 2014, re-entered the lower pools of the ladder in May 2015, then returned to Prospect in September 2015.

A Bull Trout genetically assigned to Fishtrap Creek ascended the ladder in April 2016 and was detected in the lower pools of the ladder over 5 months later in October 2016.

Table 3-4: Summary of eight Bull Trout entering the lower pools of fish ladder and not ascending to the top in 2015 and 2016. Sources: NorthWestern database; Avista PIT Tag database provided by S. Bernall, 2019.

Initial Date Captured and Location	Length (mm)	Detections in Lower Pools Only	Subsequent Detections and/or Transport	Genetic Assignment & Region
Initial tagging at Thompson Falls Ladder				
4/18/2016 TF Ladder (released upstream)	413	10/2/2016	-	FC R4
5/6/2013 TF Ladder (released upstream)	576	5/5 & 5/13/2015	9/21/2014 PC (array); 9/23/2015 PC (array)	FC R4
Initially Tagged downstream of Cabinet Gorge Dam (by Avista)				
10/3/2014 Twin Creek below CGD transported to WFT (R4)	570	5/5/2016 6/6/2016	-	WFT R4
9/14/2013 Twin Creek, 9/18/2013 transported and released to WFT (R4)	616	5/16/2015 9/11/2015	7/3/2015 PC (array); 9/6/2015 PC (array); 6/30 & 7/1/2016 GC (array)	TR R4
4/30/2015 captured below CGD and released into GC(R3) on 5/6/2015	655	6/15/2015	6/30/2015 PC (array); 7/4/2015 PC (array); 8/19 & 10/19–11/18/2015 GC; 8/15 & 9/26/2016 GC; 9/27/2016 GC – fish in rough condition	GC R3
Initially Tagged as Juvenile (by Avista)				
11/2/2010 juvenile in GC (R3)	694	9/7 & 9/8/2016	9/27/2013 Lake Pend Oreille gillnet; 9/17/2014 below CGD transported to GC	GC R3
8/22/2008 captured as juvenile in PC (R3) and transported downstream of CGD	718	6/18/2015	8/28/2013 captured below CGD & released in PC by Avista; 9/8/2013 captured in PC weir; 7/28/2014 captured below CGD and transported to PC 6/12 & 28/2015 PC (array)	Rock Creek R2
Initially Tagged as Adult in Prospect Creek, Region 3 (by Avista)				
8/28/2012 PC Weir	695	5/3/2015 5/8/2015 5/16/2015	8/5–8/13/2013 PC (array); 9/14/2014 PC (array); 8/4/2015 PC; 8/26/2015 PC (efish); 9/29/2015 PC (array)	TR R4

Notes:
CGD = Cabinet Gorge Dam PC = Prospect Creek
GC = Graves Creek TF = Thompson Falls Dam
TR = Thompson River WFT = West Fork Thompson River
FC = Fishtrap Creek - = none

Six Bull Trout were initially captured and tagged by Avista entered the lower ladder pools but did not ascend to the top, including five Bull Trout initially captured downstream of Cabinet Gorge Dam and transported upstream and one fish initially captured and tagged in Prospect Creek. These six fish were visiting the ladder for the first time. Five of the eight fish also had detections in tributaries downstream of Thompson Falls Dam, in Prospect and/or Graves creeks. Three of the eight Bull Trout made movements into Prospect Creek (located immediately downstream of Thompson Falls Dam). Two of the eight Bull Trout made movements into Prospect Creek and further downstream into Graves Creek. Prospect and Graves creeks are important Bull Trout spawning tributaries where Avista has installed remote tag-array systems. It is also possible the Bull Trout also moved into other tributaries that do not have a remote tag-array system installed.

Genetic analysis was conducted for all eight Bull Trout and the most likely genetic assignment was the Thompson River drainage in Region 4 for five fish, Graves Creek in Region 3 for two fish, and Rock Creek in Region 2 for one fish. One Bull Trout was initially captured as a juvenile in Prospect Creek (Region 3) but was genetically assigned downstream in Rock Creek (Region 2) (*see* Table 3-4).

3.4.7 *Results – Bull Trout Metrics*

Between 2011 and July 1, 2019, the Licensee sampled 34 Bull Trout (representing 32 individuals; *refer to* Table 2-2) in the Project area. Bull Trout recorded during electrofishing efforts in the Clark Fork River upstream and downstream of Thompson Falls Dam ranged in size from 180 to 651 mm in length, indicating these sampling efforts captured both juvenile and adult Bull Trout. Bull Trout recorded at the ladder ranged in size from 365 to 620 mm indicative of adult Bull Trout. The distribution of sizes for Bull Trout sampled in the Project area show that both juvenile and adult Bull Trout are in the Project area, but primarily adult Bull Trout are ascending the ladder. The length frequency and length-weight relationship for the Bull Trout sampled in the Project area is illustrated in Figure 3-11and Figure 3-12, respectively.

Figure 3-11. Percent distribution of the total lengths (mm) for 34 Bull Trout captured by the Licensee in the Thompson Falls Project area between 2011 and 2019.

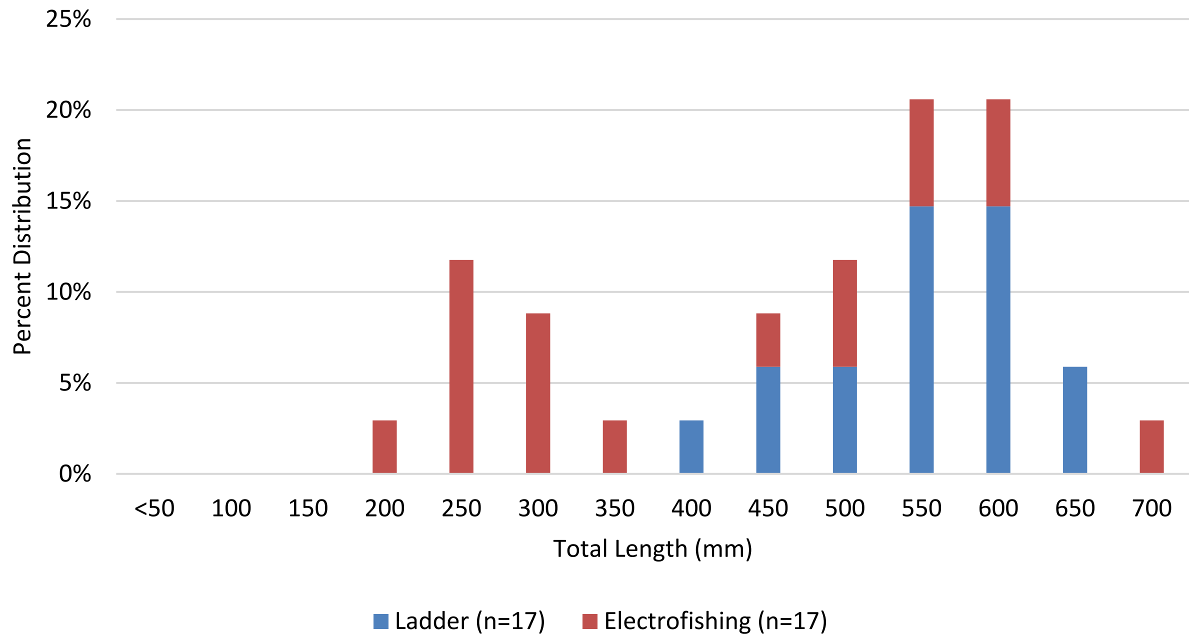
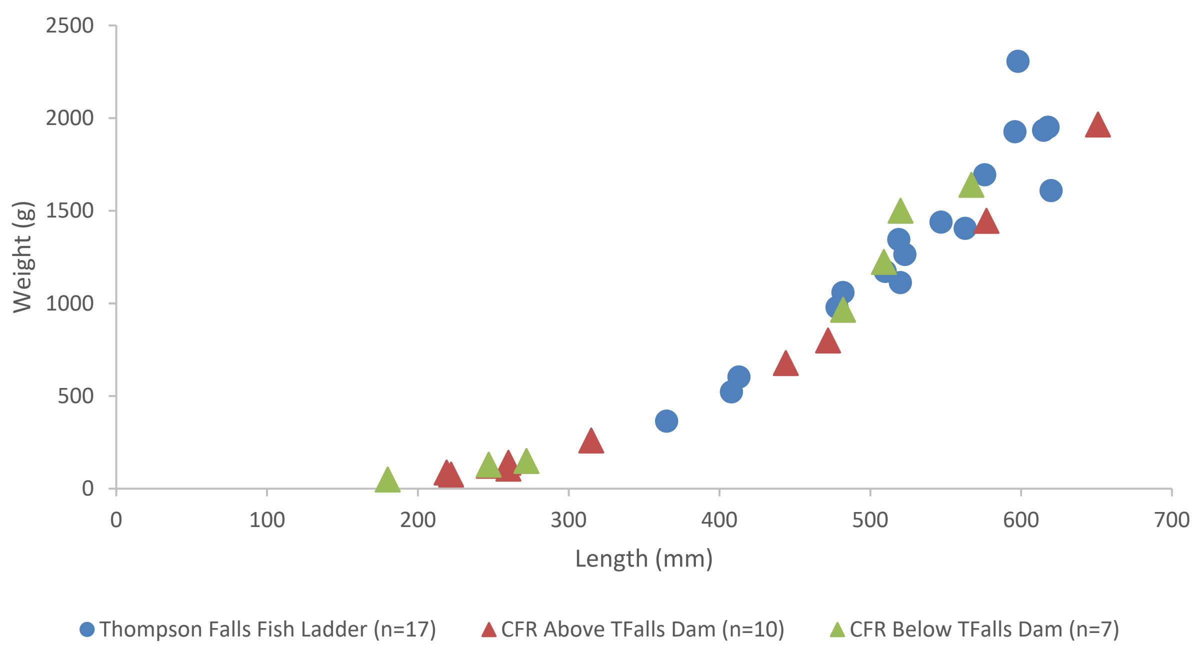


Figure 3-12. Weight (g) *vs.* length (mm) of Bull Trout captured by the Licensee in the Project area, 2011-2019.



3.4.8 *Results – Attraction Efficiency*

As described above, attraction efficiency is defined as the proportion of the motivated population that is successfully attracted to the fishway. The motivated population is the proportion of the population motivated to pass a barrier. Quantifying the motivated population presents challenges in an inland fishery where not all fish moving upstream to the Main Dam Spillway have the intention or are "motivated" to pass the barrier. As described earlier, the timing of fish passage at Thompson Falls Dam does not appear to be strongly tied to spawning migration. The 'motivation' of fish passing Thompson Falls Dam is more complex, and unclear. Therefore, attraction efficiency cannot be quantified.

However, qualitative observations can be made about attraction to the fish ladder. Fish are most likely to enter the ladder when flow in the Clark Fork River is less than 38,000 cfs (*refer to* Figure 3-5). The numbers of fish passed in 2015 was by far the largest of any year to-date. This was also the year with the lowest discharge, when flows remained below 35,000 cfs for the entire season.

Although fish counts are reduced at higher flows, the ladder has been successful at passing fish at flows up to 79,700 cfs. This is 31,700 cfs higher than the maximum design flow of 48,000 cfs.

Radio telemetry studies conducted during the fish passage planning period found peak fish activity in the Main Dam area prior to the spring freshet and a precipitous decline in fish activity during the steep ascending limb of the annual hydrograph and during peak run-off (Gillin and Haddix, 2005; Haddix and Gillin, 2006; GEI, 2007). Peak flows during the studies were within the range experienced during ladder operations: 40,800 cfs in 2004; 69,800 cfs in 2005; and 74,700 cfs in 2006. Thus, based on past radio telemetry studies at the Project site (2004–2006), it was not unexpected to see a reduction in fish at the ladder at higher streamflows. The large variety of species recorded ascending the ladder at lower flows (*see* Figure 3-5) indicates attraction flows are successful in drawing fish to the ladder. The success of relatively weak swimming fish, such as Largescale Sucker and Peamouth, in reaching the holding pool, indicate favorable passage conditions in the ladder itself.

3.4.9 *Results – Internal Fishway Ascent Times*

Between 2011 and 2019 (through July 1), NorthWestern collected ascent times for 337 salmonids, 258 ascending in orifice mode and 79 ascending in notch mode (*refer to* Figure 3-5). Data for non-salmonids is less consistent from year to year, does not represent all non-salmonids species, and is a relatively low sample size with data for 42 Largescale Sucker and five Northern Pikeminnow (*refer to* Figure 3-5). No Largescale Sucker with a PIT-tag was recorded ascending the ladder in notch mode and only three PIT-tagged Northern Pikeminnow were recorded ascending the ladder in notch mode. Maximum ascent times for salmonids and non-salmonids for each year and each operating mode are shown in Figure 3-5. Based on the ascent time data, most salmonids ascend the ladder more quickly than non-salmonids.

Table 3-5. Annual summary of salmonids and non-salmonids with ascent times during orifice and notch mode operations, 2011 – 2019 (through July 1).

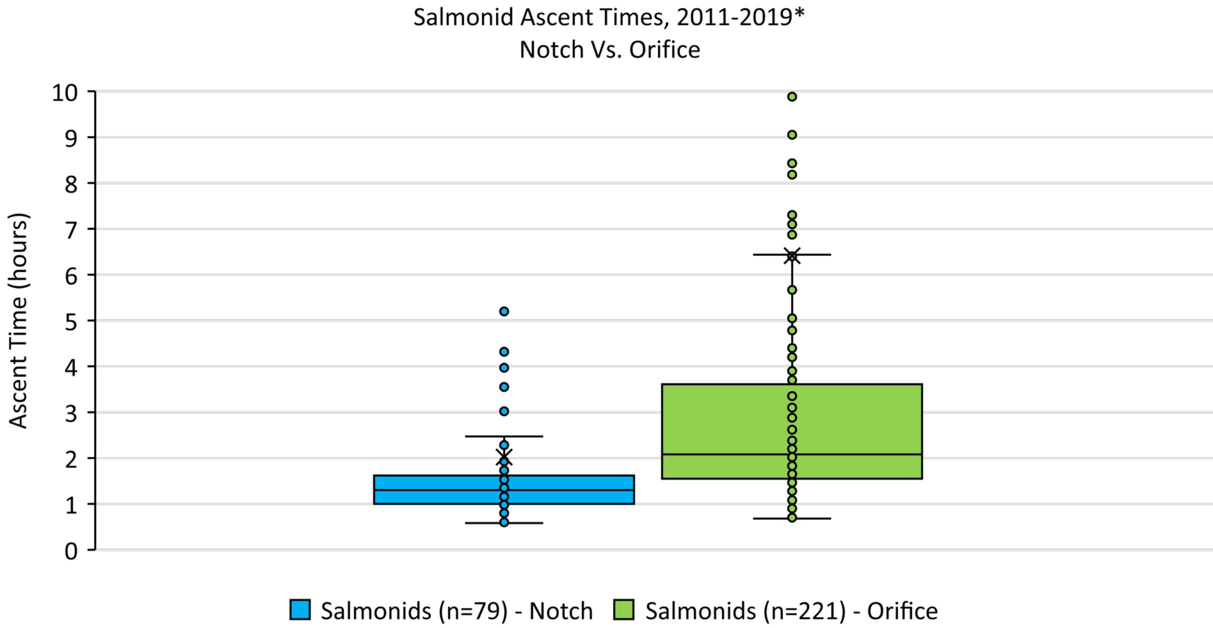
Year	Weir Mode Orifice or Notch	Salmonids Fish Count	Salmonids Median Time (hrs)	Salmonids Maximum Time (hrs)	Non-Salmonids Fish Count	Non-Salmonids Median Time (hrs)	Non-Salmonids Maximum Time (hrs)
2011	Orifice	12	4.5	19.7	1	3.6	3.6
	Notch	4	1.3	1.8	-		
2012	Orifice	10	3.1	3	4	6.6	8.3
	Notch	2	2.3	5.2	-		
2013	Orifice	42	1.8	40.8	10	8.2	31
2014	Orifice	32	1.6	6.4	-		
2015	Orifice	49	2.2	209	20	9.1	31
2016	Orifice	68	2.2	259	4	4.2	5.5
	Notch	20	1.2	4.3	-		
2017	Notch	35	1.4	27.6	-		
2018	Notch	18	1.4	17.2	3	1	1.1
	Orifice	7	2.0	4.4	-		
2019	Orifice	23	2.8	23.7	5	1.7	1.9
All years	**Orifice**	**243**	**2.2**	**259**	**44**	**7.1**	**31**
	Notch	**79**	**1.3**	**27.6**	**3**	**1**	**1.1**

In orifice mode, the minimum ascent time recorded for a salmonid was 42 minutes (RB) and 1 hour 25 minutes for a non-salmonid (LS SU). In notch mode, the minimum ascent time recorded of a salmonid was 36 minutes (RB) and 56 minutes for a non-salmonid (NPMN). There were no PIT-tagged Largescale Sucker were recorded ascending the ladder in notch mode.

The maximum time any fish took to ascend the ladder was 259 hours (10 days) in June 2016, orifice mode. This fish was a Brown Trout with a history of ascending the ladder six times in 5 different years (2013, 2015, 2016, 2017, 2018). This Brown Trout had five ascent times recorded ranging from 58 minutes to just over 10 days (259 hours) and was detected in the lower pools in the ladder for extended periods prior to ascending in 2017 (21 days) and 2018 (4 days). It ascended the ladder in the spring and fall months, ascended more quickly in notch mode than orifice mode, and was detected in the Thompson River annually since 2015. The variable ascent times did not appear to impede this Brown Trout's ability to continue migrating upstream and into the Thompson River after its release upstream of Thompson Falls Dam.

Details of the salmonid ascent times (notch *vs.* orifice) are illustrated in the box-and-whisker plot in Figure 3-13. Note there were some outliers (ascent times exceeding 10 hours) during orifice and notch mode that were excluded from the figures.

Figure 3-13. Box-and-Whisker Plot for salmonids ascending in orifice and notch mode in Thompson Falls ladder, 2011-2019 (2019 data through July 1)*.



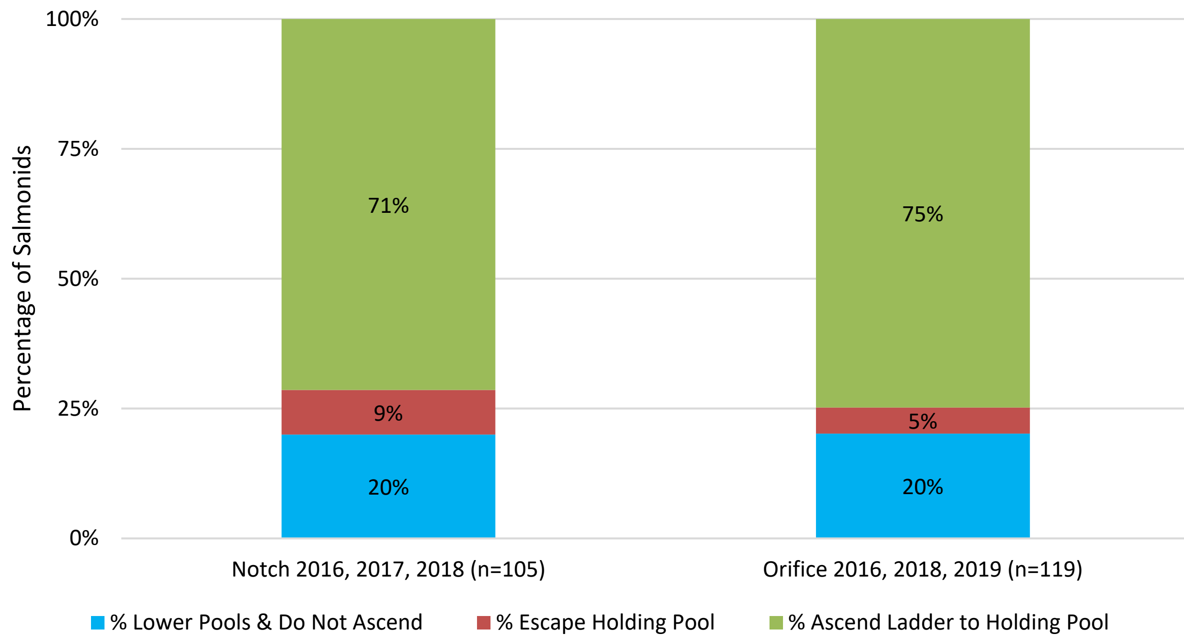
*Outliers beyond 10 hours are excluded from this graph. "x" shows the mean.

3.4.10 *Results – Internal Fishway Efficiency*

Remote arrays installed in the lower pools (Pools 7, 8) and the holding pool (the top of the ladder) of the ladder detect PIT-tagged fish that swim through. Between 2011 and 2015, PIT tag detection data were manually downloaded and processed, resulting in some omissions of PIT tag detections (estimated at 23%). Since 2016, remote tag array data storage was improved and automated, thus all fish detection records at Pools 7, 8, and 45 were available for analysis reducing the potential for missed detections. This analysis includes the 2019 data set through July 1.

Data collected since 2016 via the remote PIT-tag arrays, as well as fish recorded at the ladder work station, were used to investigate how many tagged salmonids entering the ladder ascended to the holding pool (Figure 3-14). Of the PIT-tagged salmonids entering the ladder, 71 to 75 percent swam to the holding pool. Another 5 to 9 percent of the PIT tagged salmonids were detected at the holding pool but escaped the holding pool. Approximately 20 percent of the PIT tagged salmonids entered the ladder but did not swim to the top. The opening/entrance to the holding pool was modified in 2017 to minimize the potential for a fish to exit/escape, thus lower percentage of 'escapes' in orifice mode is not a reflection of weir mode operations.

Figure 3-14. Percentage of salmonids detected in the lower pools of the ladder and that ascended during notch mode (2016, 2017, 2018) and orifice mode (2016, 2018, 2019) operations. 2019 data is through July 1.



3.4.11 *Discussion – Effectiveness of the ladder*

3.4.11.1 Bull Trout

The primary goal of the upstream fish passage facility at Thompson Falls Dam is to provide safe, timely, and effective fish passage for Bull Trout (FWS, 2008). Results at the ladder and Project area show the following:

- Bull Trout are rare in the Project area; however, Bull Trout do successfully find the ladder entrance (25 BULL detected in Pools 7/8) and ascend the ladder (17 BULL recorded in holding pool). At least 68 percent of Bull Trout detected in the ladder, ascended to the top.
- Bull Trout (n=4) were detected over 6 miles upstream in the Thompson River drainage following their ladder ascent and release upstream of Thompson Falls Dam.
- Bull Trout (n=5) have migrated downstream of Thompson Falls Dam following their ladder ascent and release upstream of the dam.
- Bull Trout (n=3) have returned to the ladder after an initial ascent and release upstream with one of the three Bull Trout ascending to the top of the ladder a second time.
- Of the 17 Bull Trout recorded at the ladder work station between 2011 and 2019, only one ascended while the ladder operated in notch mode, one Bull Trout was captured in Pool 23 during a weir mode change, and the remaining 15 Bull Trout ascended the ladder (to the holding pool) while operating in orifice mode.

Operational and data gathering/analysis challenges presented at the ladder include the following:

- Bull Trout peak movement is concurrent with the spring freshet, which often coincides with periods when the ladder is closed due to operational constraints at high flows.
- Fish detections in the PIT-tag array within the ladder require a fish to already have a unique PIT tag. The majority of salmonids detected in the ladder occurs following its initial ladder ascent to the top. Thus, data on most salmonid ascents are limited to fish that have previously ascended the ladder. In contrast, Bull Trout are studied/tagged by other studies (e.g., Avista and/or FWP) in addition to being tagged at the ladder. Thus, detections of tagged Bull Trout in the ladder include a mix of fish previously tagged at the ladder and fish tagged elsewhere, but not previous ladder fish.
- Data collection methods do not provide information on non-tagged Bull Trout entering the ladder and not ascending or the number of Bull Trout potentially in the area presumably to migrate upstream and not finding the ladder entrance.
- Motivation of Bull Trout (and other species) to ascend the ladder is unknown and likely related to multiple factors (e.g., food availability, species interactions/competition, river conditions, refugia, etc.).
- The small sample sizes of Bull Trout available for study make quantitative assessments difficult to complete.

Phase 2 evaluation period has qualitatively shown fish find the ladder entrance and successfully ascend the ladder. The challenge remains quantifying effective passage. Currently, the "motivated population" cannot be quantified, and there are no criteria to define "successful" passage for inland fish passage. The paradigm for inland fisheries is very different than anadromous systems where the large majority of fish migrating upstream migrate to spawn and subsequently die. Life history strategies for inland freshwater fish require adaptability to the environment likely resulting in a variety of motives for fish movement (Robichaud and Gingerich, 2017; Thurow, 2016).

Bull Trout are not necessarily annual spawners (Robichaud and Gingerich, 2017; Downs et al., 2006; Hogen and Scarnecchia, 2006; Fraley and Shepherd, 1989) making movements and behavior in a given year more difficult to interpret (Robichaud and Gingerich, 2017). Additionally, straying and exploration are adaptive strategies that Bull Trout utilize to address unpredictable food supplies, colonize new areas, and protect populations against catastrophic but local events (Power, 2002 in Robichaud and Gingerich, 2017; Kanda et al., 1997). Robichaud and Gingerich (2017) conclude that the complexities of Bull Trout life history strategies (e.g., straying/exploration, non-consecutive-year-spawning) preclude them from knowing if a given fish is motivated to perform a given migration regardless of where it spawned the previous year. Thus interpreting, predicting, and quantifying fish movements in a given year is challenging with varying motives for fish movement both upstream and downstream (e.g., spawning, competition, temperature, food, etc.).

3.4.11.2 Other Species

At this time, fish data collected at the ladder indicate the passage facility provides safe and timely passage for numerous species. The ladder has successfully passed over 32,000 fish since 2011. Many ladder fish released upstream of the dam are detected upstream of the dam in tributaries during spawning season (Thompson, St. Regis, middle Clark Fork, lower Flathead rivers). Many species either remain upstream for multiple years or return downstream of the dam and repeat their upstream journey (via the fish ladder) for 1 or more years.

At the time when the Thompson Falls fish ladder was being planned, the broad seasonality of upstream fish movement at this site was not understood. Most upstream movement of adult fish was assumed to be associated with spawning migration. The results to date indicate a much more complex pattern of movement for both Bull Trout and many other species. Some species show more specificity to seasonal movement trends (e.g., SMB, LS SU, MWF) than other species (e.g., RB, LL) that appear to ascend the ladder throughout the operating season.

With all the breadth of species and associated optimal habitat needs and variable swimming capabilities, it is notable to see 14 species and 3 hybrids are capable of ascending the ladder specifically designed for one species, Bull Trout. Based on the review of 65 articles from 1960 to 2011 that evaluated fish passage facilities, Noonan et al. (2012) found upstream passage efficiency for salmonids was close to 62 percent and non-salmonids was very poor (21%) in comparison. In addition, fish passage efficiency varied significantly among the various fishway types with the pool and weir, pool and slot, and natural fishways showing the highest efficiencies (Noonan et al., 2012).

Data at Thompson Falls fishway indicate over 70 percent of the salmonids that enter the ladder ascend to the top. Non-salmonid fish passage numbers support conclusions that non-target species (e.g., LS SU, NPMN, SMB) are capable of ascending the ladder in large numbers. The total fish count at the ladder indicates the location of the ladder and entrance function, thus supporting the findings from the preliminary radio telemetry completed between 2004 and 2006 (Gillin and Haddix, 2005; Haddix and Gillin, 2006; GEI, 2007).

Once fish enter the ladder, then ladder conditions are key to their successful ascent. Ladder operations in orifice mode provide the largest opportunity for the most fish and fish species to ascend. Based on recent hydraulic study (NorthWestern, 2018a), additional CFD modeling may identify additional adjustments to further optimize ladder hydraulics for upstream fish passage.

3.5 Ladder Operational Procedures

3.5.1 *Notch vs Orifice Mode Hydraulics*

In 2016 and 2017, NorthWestern contracted with GEI Consultants, Inc. (GEI) to conduct a ladder hydraulics study while the ladder operated in orifice and notch mode. GEI provided a summary of the study, including results and recommendations in their Fish Ladder Hydraulic Assessment

(NorthWestern, 2018a). The following sections summarize methods and results from the hydraulic assessment report.

3.5.1.1 Methods

In August 2016 and August 2017, hydraulic evaluations of ladder operations were conducted in orifice mode and "overflow weir mode" (or notch mode), respectively. These two operational modes describe the flow between each of the 48 internal pools within the ladder.

On August 2, 2016 GEI assessed the fish ladder operating in orifice mode. At the time of the 2016 observations, the forebay was operating at El. 2396.9 feet. The ladder was operated in notch mode for Pools 1 through 6 and in orifice mode for Pools 7 through 48. All fish were being diverted into the holding and sampling facilities at Pool 45.

On August 1, 2017 GEI assessed the ladder operating in notch mode. The ladder hydraulics were set with the Pool 45 water level at El. 2393.25 feet.

3.5.1.2 Results

Pool turbulence correlates with energy expended by fish trying to ascend a pool fishway. If there is excessive turbulence in enough pools, fish will not have adequate pool volume at the periphery to allow resting before ascending to the next pool. The 2016 and 2017 assessments indicate that there is more than enough volume in each pool to allow adequate energy dissipation, assuming a 1.0-foot drop per pool. However, the incoming notch/orifice jet for each pool needs to be directed/dispersed in a manner that utilizes more of the submerged pool volume to dissipate energy.

Pool type fish ladders are designed for normal flow conditions, where notch or orifice pool differentials are uniform and steady, with a uniform drop (1' for Thompson Falls) between pools. Unsteady flow conditions occur when there is a non-uniform (higher or lower) pool elevation in a channel. Higher pool elevation causing a backwater like condition occurs at turning pools, as weir depths increase, and incoming velocity head is absorbed. Initial ladder operations observed in 2016 and 2017 hydraulic assessments suggest that the ladder flow is unsteady in both operating modes.

3.5.1.2.1 Orifice Mode Findings (NorthWestern, 2018a)

- Operating the forebay at a higher water level is not detrimental to ladder operations as additional water can be bled off at the Pool 45 overflow weir. If the ladder is operated as a passive fish ladder (no crowding/sampling) in the future, this condition may need to be re-evaluated.
- The entrance pool, Pool 1, received flow from both the upper ladder, and the auxiliary water wall diffuser. Although the two fishway entrance gates were open simultaneously, in contrast with operation listed in the fishway operating manual (PPL Montana, 2010c), there is not a perceived need for changes to hydraulic conditions at the entrance pool during low tailwater.

- Pools 2 through 7 (set in notch mode) operate correctly at the observed low design tailwater elevation, with no auxiliary water being added to floor diffusers in Pools 3, 5, and 7. As spill commences, and tailwater rises, the AWS is designed to pass some of the auxiliary flow over chimneys and through floor diffusers at the referenced pools. At high tailwater conditions, the weir between Pool 6 and 7 should operate in notch mode.
- Hydraulic conditions in Pools 7 through 44 were observed to vary from as low as 0.33 foot to as high as 1.54 feet between pools. This is outside of the assumed 1-foot pool-to-pool drop. Pools 7 through 44 hydraulics do not currently fully dissipate energy in each pool, due to carry-over energy (and higher orifice coefficients) at some straight run pools. This occurs despite there being sufficient volume in each pool to dissipate incoming energy. Diffusing this jet would enable energy to be absorbed by the submerged volume in each pool.
- Hydraulics at the weir between Pool 19 and 20 are not optimal. A large drop in the hydraulic gradeline was observed, and the ladder operated at a lower depth below this elevation.
- Lower weir differentials appear to be primarily at straight runs of successive pools, while greater differentials are generally at turning pools. This suggests that there is energy carry-over from pool to pool at straight runs, where one orifice jet does not fully expand and dissipate energy before passing through the next downstream orifice. At turning pools, jets with excessive carry-over velocities/energy are slowed, creating an upwell, and dissipating carry-over energy from straight-pool runs. Note that this is not consistent at all straight pool runs nor all turning pools.
- Operation in Pools 45 through 48 has evolved to where the Pool 45 water surface is at El. 2393.6 feet, which is 0.6 foot higher than the design elevation of 2393.0 feet. This has a direct influence on orifice flow to Pool 44 (and the lower ladder).
- Based on hydraulic observations of the ladder operating with Pool 45 at El. 2393.6 feet and comparisons of data at lower Pool 45 water levels, the El. 2393.6 feet operating level is improving pool-to-pool hydraulics by providing an additional volume of water for energy dissipation.
- Operation of the fish ladder in orifice mode allows the operator to run the facility with Pool 45 set at a higher level, which increases the volume of water in each pool without significantly increasing the pool-to-pool flow. This provides greater energy dissipation between the pools. Pool volumes is the 2016 orifice mode study were 15 to 30 percent higher than volumes in notch mode observed in the 2017 hydraulic study.
- NorthWestern recommends installation of one or more additional PIT tag arrays in the ladder to help better identify if there is a specific ladder element that is contributing to unsuccessful passage attempts. A ladder antenna array could be installed between Pools 29

and 30 and just downstream of Pools 19 and 20. A plate type PIT tag antenna could be installed without adversely affecting the pool hydraulics.

3.5.1.2.2 Notch Mode Findings (NorthWestern, 2018a)

- The entrance pool, Pool 1, received flow from both the upper ladder, and the auxiliary water wall diffuser. Although the two fishway entrance gates were open simultaneously, in contrast with operation listed in the fishway operating manual (PPL Montana, 2010c), there is not a perceived need for changes to hydraulic conditions at the entrance pool.
- Pools 2-7 (set in notch mode) operated similar to the conditions observed in orifice weir mode.
- PIT-tag detectors in Weirs between Pools 7 and 8 and between Pools 8 and 9 were designed for orifice flow but were left in place during the 2017 notch mode operation. This created potentially major localized hydraulic discontinuity in 2017 and may have blocked passage of weaker swimming fish. The same PIT detectors should not be used in the future with notch operations.
- Ladder operators have also been running the ladder with a Pool 45 water level above the recommended El. 2393.0 foot-level for notch mode. A higher water level in notch mode significantly increases ladder flow and impairs the potential for successful ladder navigation by most fish species. If the ladder is to be operated in notch mode, Pool 45 should be set no higher than El. 2393.0 feet.
- In 14 of the 35 measured pools, the depth of weir submergence (backwater depth from the downstream pool compared to the invert of the weir) was less than 0.25 foot. In four locations, the submergence was less than 0.1 foot, and at the Pools 37/36 weir, the weir flow was actually plunging into Pool 36 by approximately 0.1 foot. The combination of high velocity (9 feet per second) and plunging flow in this pool alone could be challenging to weak swimming fish.
- Carryover energy from straight pool sections was indicated by increased flowline velocities and lower differential water levels between pools as the pools move downstream. Internal baffles could provide flow disruption and dissipate additional energy between pools.

3.5.2 Discussion on Optimal Weir Mode Operations

The hydraulics study in 2016 and 2017 concluded that both weir modes were not operating to their optimal design. However, any changes made to an individual pool may affect all downstream pool hydraulics. Therefore, when addressing localized hydraulic issues, GEI recommended the use of a CFD model of the ladder. A CFD model allows for NorthWestern to test different weir configurations along one or more segments of the ladder and to evaluate potential downstream effects.

The hydraulic assessment concluded orifice mode provided more suitable upstream fish passage conditions for a broader group of fish species. Potential areas of improvements for orifice mode include experimenting with a smaller orifice at Pool 18/19 weir and/or testing different internal baffle configurations. It is assumed that potential modifications to improve orifice mode will not necessarily have the same beneficial impacts in notch mode.

In 2019, NorthWestern further experimented with operation of the lower ladder pools in orifice mode. In prior years, the weir settings in the lower pools (Pools 2-7) were always in notch mode per ladder specifications outlined in the operation manual and as directed by design engineers. All but one of lower pools were tested in orifice mode for part of the 2019 season. It is not yet clear what hydraulic impact this change may have on upstream fish passage.

3.5.3 *Notch vs. Orifice Mode Fish Passage*

The Phase 2 evaluation plan identifies a weir mode study to evaluate the most effective weir mode for Bull Trout upstream fish passage. Before the ladder began operating, tests were done to know how the weir mode could be alternated between notch and orifice modes. Alternating between weir modes requires dewatering of the ladder, which takes about 1 hour (J. Hanson, NorthWestern, personal communication, June 7, 2019). Weir mode operations were evaluated over several years.

3.5.3.1 Methods

In 2011, the Licensee proposed to test weir operations by alternating weir modes weekly. Alternating modes on a weekly basis removes potential seasonal biases in the passage data (*refer to* Table 3-1).

Following the first year of data collection, the Licensee reviewed the results and determined if any design modifications were needed for 2012. No design modifications were identified. Due to the high-water year in 2011 and subsequent 84-day period when the ladder was closed, the Licensee continued the study in 2012. In 2013, 2014, and 2015 the ladder was operated in orifice mode only.

In 2016, the ladder operated most of the season in orifice mode with 2 weeks in notch mode. During the 2015 annual TAC meeting, the TAC agreed to alternate weir modes weekly when water temperatures were at or exceeded 19 ºC (66 °F) for a 4-week period to evaluate Smallmouth bass movement up the ladder. Starting on June 30 and ending on July 28, the weir mode alternated weekly between orifice and notch.

In 2017 and 2018, the TAC identified a need to continue operating the ladder in notch mode for a full season to provide a more thorough evaluation of the two operating modes.

The 2017 season (notch mode) was compared to the 2014 season (orifice mode). These 2 years are considered similar and comparable in operating time, ladder checks, and river conditions. It is understood that no 2 years are exactly alike, but from the available data these are the most comparable years with opposing weir modes running during the entire season.

The 2018 season experienced high-water (similar to 2011) resulting in 89 days of the ladder closed. At the end of the 2018 season, October 24, operators changed weir modes from notch to orifice in hopes of increasing fish passage.

In 2019, the ladder was operated in orifice mode for all pools, including Pools 2 through 7 (Table 3-1).

3.5.3.2 Results – Bull Trout Passage

Since 2011, 17 Bull Trout (representing 16 individuals) have ascended the ladder (*refer to* Table 3-2). The majority (15 Bull Trout) ascended the ladder in orifice, one Bull Trout ascended the ladder in notch mode, and one Bull Trout (in 2011), presumably ascending the ladder, was captured in Pool 23 during a weir mode switch (H. Carlsmith, FWP, personal communication, August 20, 2017). During a weir mode switch, the ladder is completely dewatered, and ladder operators would sometimes observe fish (like the Bull Trout in 2011) stuck in a pool during the process. Interestingly, the same Bull Trout returned to the ladder in May 2012 and ascended to the top (in orifice mode) before jumping out. The Bull Trout recorded in 2017 represented the first Bull Trout to ascend the ladder in September and ascend in notch mode.

3.5.3.3 Results 2011–2012

In both 2011 and 2012, the majority of fish ascended in orifice (94% in 2011, 86% in 2012). Non-salmonids appear to be the most impacted by weir mode with the majority (99% in 2011; 90% in 2012) ascending in orifice mode, whereas salmonids only showed a slight preference for orifice mode (59% in 2011; 55% in 2012). The 2011 data should be interpreted cautiously since the ladder opened in orifice mode after the 84-day shut-down and 85 percent of the fish ascending in 2011 ascended during the first week of operating again between August 22 and August 29 (PPL Montana, 2012).

3.5.3.4 Results 2016 Study

Peak fish movement at the ladder occurs in the summer months during the descending limb of the hydrograph. Peak Smallmouth Bass movement occurs primarily (99% of 3,912 SMB recorded at the ladder) when temperatures are 18 °C (64 °F) or greater. In 2016, operations alternated weekly in July (4 weeks) to test if weir mode would exclude (select against) Smallmouth Bass from fish passage. The ladder was checked eight times in each mode. Water temperatures in the ladder during the 4-week period varied from 18.6 to 21.1 °C (65.5 to 69.9 °F) during notch mode and from 18.0 to 23.1 °C (64.4 to 73.6 °F) during orifice mode. Mean daily streamflows in the Clark Fork River (USGS gage station near Plains) were declining from 18,000 cfs on June 30 to 10,000 cfs on July 28.

There were 565 fish (6 species) recorded in orifice mode in contrast to 156 fish (5 species) recorded in notch mode. Table 3-6 summarizes the 2016 results. The results found Smallmouth Bass ascend the ladder in either weir mode, but substantially fewer Smallmouth Bass were recorded in the ladder operating in notch mode *versus* orifice mode during the 4-week period in 2016. The total number of Smallmouth Bass was 21 fish in notch *versus* 468 fish in orifice mode. Results also found a higher number of Brown Trout, Rainbow Trout, and Westslope Cutthroat Trout ascending the ladder in notch (n=125) *versus* orifice (n=60) mode, but fewer Northern Pikeminnow and no Largescale Sucker in notch *versus* orifice mode. It is unclear why there were more salmonids recorded when the ladder operated in notch *versus* orifice mode in July 2016. However, when comparing salmonid counts at the ladder over an entire season operating in one weir mode (i.e., 2014 and 2017), results found more salmonids recorded in orifice *versus* notch mode (*see* Section 3.5.4 Discussion for Optimal Ladder Weir Operations).

Table 3-6. Summary of 4-week weir mode test in July 2016 and the total fish count at the ladder, by species during orifice and notch mode.

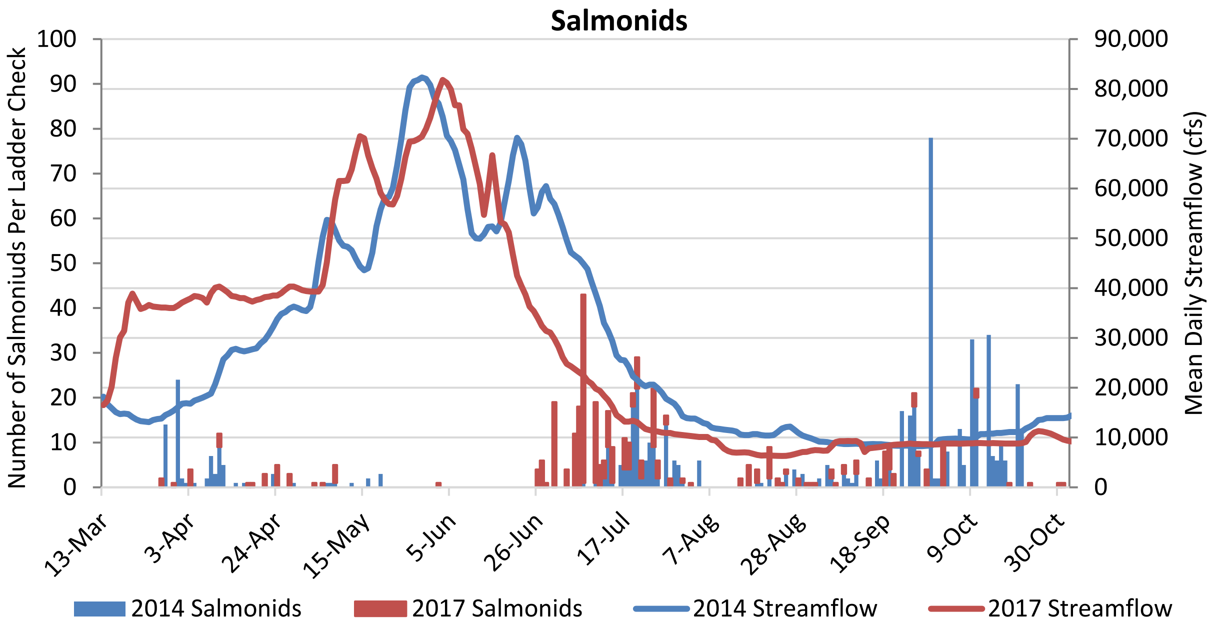
Species	July 7-12; July 21-28 Orifice	June 30-July 6; July 13-20 Notch
LL	15	47
LS SU	13	-
NPMN	24	10
RB	43	74
SMB	468	21
WCT	2	4
Total	**565**	**156**

3.5.3.5 Results 2014 *vs.* 2017

In 2014, the weir mode was set to orifice, and in 2017, the weir mode was set to notch for the entire ladder season (mid-March–October). The two seasons provide an opportunity to evaluate potential operational influences (notch *vs.* orifice) on fish movement in the ladder during relatively average, and similar, hydrologic years (Figure 3-15). The ladder was operated for 192 days in 2014 and for 210 in 2017. Operating seasons for both years were similar beginning the end of March and ending the latter part of October

An order of magnitude more fish ascended the ladder (n=5,735) in orifice mode than in notch mode (n=530). In orifice mode, there were nearly double the number of salmonids (n=573) compared to notch mode (n=305) and about 29 times the number of non-salmonids in orifice mode (n=5,162) compared to notch (n=225). Additionally, a larger percentage of the fish recorded in orifice mode were native species (salmonids and non-salmonids) than in notch mode. The proportion of native fish was higher in orifice mode in 2014 than in notch mode in 2017 (NorthWestern, 2018). The increase in proportion of non-native fish in notch mode was mostly likely attributed to the low numbers of native Largescale Sucker and Northern Pikeminnow in 2017 (n=100) that were so abundant in 2014 (n=3,806).

Figure 3-15. Number of salmonids recorded per ladder check and mean daily streamflow (cfs) in 2014 and 2017.



The non-parametric Chi-Square test of association was used to evaluate whether there is an association between the successful ladder ascent of salmonid or non-salmonid (native or non-native) fish and the mode of operation (orifice or notch). Days the ladder was closed or not checked (in both years) were excluded from analysis. All days the ladder was checked (in both years) were included in the analysis. This test weighted the categorical fish variables (i.e., salmonid or non-salmonid, native or non-native) based on the successful ascent of fish in both 2014 and 2017 and tested the association with the categorical mode of operation variables. However, this test does not provide inferences about causation. As noted above, the ladder was operated only in orifice mode for 2014 and only in notch mode for 2017.

The weir mode significantly influenced the successful ladder ascents of fish whether grouped by salmonid or non-salmonid (Table 3-7), or by native *versus* non-native (Table 3-8). The fish ladder facilitated the ascent of significantly more salmonids and non-salmonids during orifice mode than notch mode ($p < 0.05$, z-test on column outcomes), with non-salmonids accounting for most of the fish. Similarly, the fish ladder facilitated the ascents of significantly more native and non-native fish during orifice operation than notch operation ($p < 0.05$, z-test on column outcomes).

Table 3-7. Chi-Square test of association between weir mode operation and successful ladder ascents by salmonids or non-salmonids.

		Year		
		2014 (orifice)	2017 (notch)	Total
Non-Salmonids	Count	5162_a	225_b	5387
	Expected Count	4931.3	455.7	5387.0
Salmonids	Count	573_a	305_b	878
	Expected Count	803.7	74.3	878.0
Total	Count	5735	530	6265
	Expected Count	5735.0	530.0	6265.0

Each subscript letter denotes a subset of Year categories whose column proportions do not differ significantly from each other at the .05 level.

Table 3-8. Chi-Square test of association between weir mode operation and successful ascents by native or non-native fish.

		Year		
		2014 (orifice)	2017 (notch)	Total
Native Fish	Count	4097_a	117_b	4214
	Expected Count	3857.5	356.5	4214.0
Non-native Fish	Count	1638_a	413_b	2051
	Expected Count	1877.5	173.5	2051.0
Total	Count	5735	530	6265
	Expected Count	5735.0	530.0	6265.0

Each subscript letter denotes a subset of Year categories whose column proportions do not differ significantly from each other at the .05 level.

3.5.4 *Discussion for Optimal Ladder Weir Operations*

The ladder has operated under varying hydrologic conditions since 2011. The variable river conditions and periods when the ladder has been closed likely contribute to the total number of fish that migrate upstream in any given year. However, the proportion of fish (native *vs.* non-native; salmonid *vs.* non-salmonid) recorded at the ladder remained consistent between 2011 and 2016 before notably changing in 2017 and 2018 (NorthWestern, 2019). The shifts in species composition and decline in total number of fish recorded at the ladder appear to be related to ladder operations, specifically the weir mode. Notch mode appears to select against the weaker swimmers so fewer native fish such as Largescale Sucker and Northern Pikeminnow ascend the ladder.

In addition, notch mode also appears to select against some non-native species, such as Smallmouth Bass. To the extent that these non-native species are undesirable, then notch mode could be used to limit their passage. However, this would be at a cost to passage of native species.

Although the number of salmonids remain relatively constant during notch and orifice operations, notch mode appeared to select for salmonids capable of ascending the ladder more quickly than observed in orifice mode. Hydraulics analysis has shown notch mode results in higher velocities and reduction in areas of slack or calm water compared to orifice mode (NorthWestern, 2018a). Therefore, faster ascent times in notch mode do not necessarily translate into more fish or greater opportunity for upstream fish passage for all species. The faster ascent time may indicate limitations of access and potentially selection against some salmonid species (and other species) to ascend the ladder in notch *versus* orifice mode.

Results from the comparison of upstream fish passage at Thompson Falls Dam in orifice *versus* notch mode in 2014 and 2017, respectively, found the following (NorthWestern, 2018):

- There was a higher percentage of ladder checks in notch mode resulting in "no fish" recorded than in orifice mode.
- The weir mode significantly influenced ladder ascents of fish. Statistically more fish (salmonids, non-salmonids, native, and non-native) ascended the ladder in orifice than in notch mode.
- A lower proportion of native fish (out of the total fish count) were recorded at the ladder in notch *vs.* orifice mode.
- Fewer fish and species were recorded at the ladder in notch mode *vs*. orifice mode.
- The timing of peak movements of fish in the ladder does not appear to be related to weir mode, but more likely related to the species-specific movement patterns and behavior.
- Bull Trout have ascended the ladder in both orifice mode (n=1 in 2014) and notch mode (n=1 in 2017). Sample size is too low to evaluate mode preference.

In line with the objectives and goals identified by FWS and FWP to maximize fish passage for Bull Trout as top priority and other native species as a second priority, weir mode testing at the ladder shows orifice mode will maximize passage for native fishes. Non-native salmonids are the third priority for passage. This group of species also successfully passes in orifice mode.

3.5.5 *Evaluation of Attraction Flow*

Attraction flow released from the fish ladder (to attract fish to the entrance from the spillway tailrace) is composed of a lower discharge flow passing from pool to pool in the ladder (6 cfs) combined with the AWS discharge (up to 54 cfs maximum). Attractant flow can also be influenced by the HVJ (20 cfs). The maximum attractant flow contribution from the ladder (flow through the ladder, AWS, and HVJ) is 80 cfs. Other flow contributions can be provided by the spill panels (233 cfs per panel) and/or radial gates. Details of the attractant flow inputs via ladder operations as well as other gates (spill panels or radial gates) are presented in Section 3.2 General Ladder Operations of this report and SOP (PPL Montana, 2010c).

The Phase 2 evaluation plan outlines a study for the Licensee to evaluate upstream fish passage efficiency through manipulation of the attraction flows.

3.5.5.1 Methods

During manipulations of attractant flow, the Licensee evaluated the fish response, including overall number of fish and type of species ascending the ladder and the timing of fish upstream migration.

In 2011, the Licensee monitored movement of eight Bull Trout that Avista captured downstream of Cabinet Gorge and genetically assigned to Region 4. These Region 4 Bull Trout were transported to and transported to Region 3 (Vermilion Bay), when conditions permitted, and their upstream migration monitored. Three of the eight radio-tagged Bull Trout were detected in the Project area (*see* Section 2.3.3 Tracking Radio Telemetry). Details regarding each Bull Trout movement is summarized in Section 2.3.3. The ladder was closed when these Bull Trout were in the Project area and thus no attractant flow study was implemented.

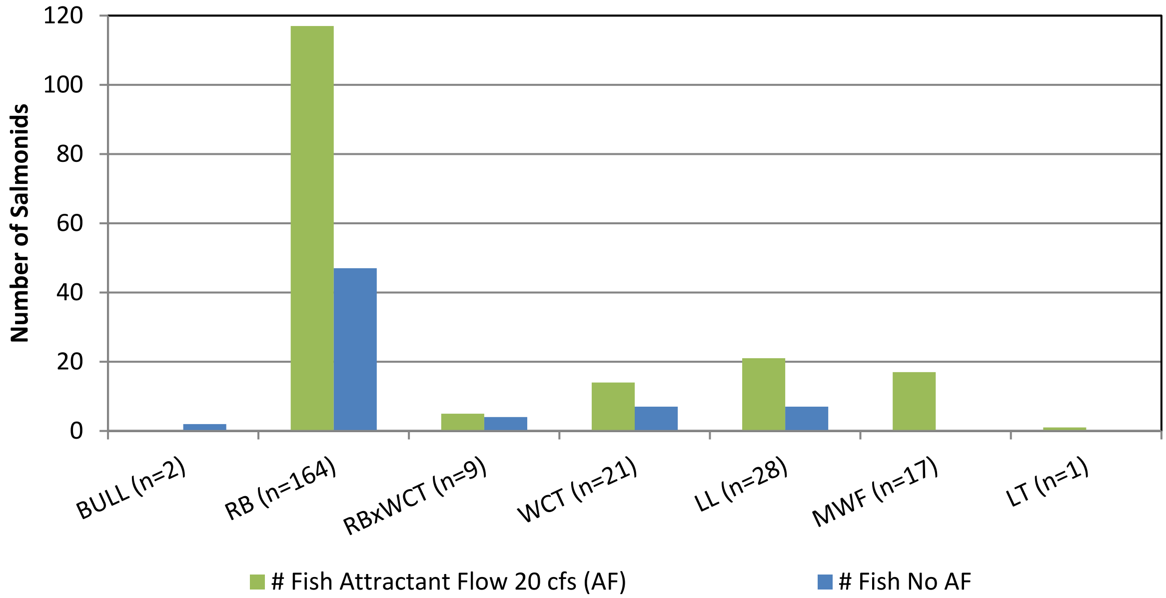
Due to the limited scope of the radio telemetry work, the following questions for evaluation identified in the Phase 2 evaluation plan (PPL Montana, 2010a) were not fully addressed.

- Under what range of discharges do fish move upstream through the narrow (falls) section of river to the tailrace?
- How long does it take fish to migrate past the falls to the tailrace?
- How long does it take fish to locate the ladder entrance once they are in the tailrace?
- What combination of attraction flows is most effective for fish to find the ladder entrance at varying levels of spill?

3.5.5.2 Results

In 2011, operators of the ladder tested the HVJ influence on fish attraction to the ladder entrance. In addition, operators were also alternating weir mode (orifice and notch) weekly and the ladder was closed for 84 days between May 25 and August 22, 2011. Salmonids appear to respond to the HVJ when present (Figure 3-16). However, conclusions from these data are compounded by other variables (weekly changing weir mode, seasonal influence, extreme high-water year).

Figure 3-16. Number of salmonids caught in the ladder with and without the HVJ attractant flow during the 2011 season.



After the first season (2011) and into the second (2012), observations of tailrace conditions at the Thompson Falls Dam indicate that, during non-spill periods, additional flow may improve conditions allowing fish to migrate upstream through the natural falls that are present downstream of the Main Dam (L. Mabbott, NorthWestern, personal communication, 2014). For this reason, both the AWS and the HVJ were operated throughout the non-spill season (as has been implemented annually since 2012) to allow fish to reach the entrance to the ladder. Additionally, since 2012 (and continued through subsequent operating seasons), panel #4 (adjacent spillway panel near the ladder) is partially opened allowing approximately 125 cfs to the ladder entrance (L. Mabbott, NorthWestern, personal communication, January 25, 2018).

Field observations also indicate attractant flow input from the ladder during spill periods become less effective when approaching and exceeding the design limit of the ladder. The fish ladder was designed to pass fish with streamflows up to 48,000 cfs. Since the ladder was operational in 2011, streamflows have exceeded the ladder design threshold (48,000 cfs) annually except for the 2015 and 2016 seasons.

From 2011 through July 1, 2019, the ladder was checked 115 times (out of 1,190 total ladder checks) when streamflows exceeded 48,000 cfs. Fish were recorded during 28 of the ladder checks, with 50 fish representing six species, including two Bull Trout. Ladder checks were completed with streamflows varying between 48,000 and 95,700 cfs (Table 3-9). The highest mean daily streamflow measured concurrent with a Bull Trout recorded at the ladder was 51,600 cfs in 2012.

Table 3-9. Summary of ladder checks and the number of fish (and species) recorded when streamflows exceeded 48,000 cfs at the USGS gage #12389000 in Plains during ladder operations, 2011-2019 (through July 1, 2019). Streamflows did not exceed 48,000 cfs in 2015 or 2016.

	2011	2012	2013	2014	2017	2018	2019
USGS Peak Streamflow (cfs)	104,000	75,300	63,700	82,800	82,100	103,000	68,100
Number of Ladder Checks when Flows >48,000 cfs	14	34	16	27	15	5	4
# of Ladder Checks with Flows > 48,000 cfs with Fish Recorded in Ladder	4	8	6	8	2	0	0
Species Recorded (Total Number) when flows >48,000	3 RB, 3 LS SU, 3 NPMN (9)	2 BULL, 9 RB, 1 WCT, 1 LS SU (13)	12 LS SU, 1 NPMN (13)	1 RB, 1 LL, 4 WCT, 4 LS SU (10)	5 RB (5)	-	-
Range of Flows (>48,000cfs) with Fish Recorded at Ladder	55,900-69,000	49,600-63,300	52,200-61,800	50,300-58,300	57,800 & 79,700	-	-
Max Streamflow During Ladder Check	95,700	74,800	62,600	66,700	79,700	58,600	60,700
Total # of Fish Recorded at Ladder	**1,805**	**2,668**	**3,830**	**5,735**	**525**	**227**	**1,058**

3.5.6 *Discussion on Attractant Flow*

The fishway design considers the location of the fishway entrance as a critical component that determines whether fish will find and enter a fish ladder, not just total attraction flow. A good example of this was the seasonal Denil trap located in the tailrace downstream of the Main Dam at Thompson Falls Dam. The Denil trap included a 2 cfs baffled chute, providing an attractant flow far below the 5 to 10 percent criteria by NOAA (NMFS, 2008) and captured over 4,000 fish, including three Bull Trout in 2004.

Fish counts at the fish ladder since 2011 (over 32,000 fish) indicate many fish and many species are finding the entrance and the location is likely appropriate. The question remains as to whether there is an opportunity to improve attraction of fish from the tailrace to the entrance.

When streamflows exceed the ladder design threshold of 48,000 cfs, attractant flows at the ladder are a lower percentage of overall flow and are therefore less effective. At high spill volumes, velocity and turbulence in the tailrace increases, and fish movement decreases, and fish passage through the ladder declines.

Spillway operations can be used to attract fish to the right bank where the fish ladder is located and discourage fish from the left bank which is a dead end. The spillway operational plan was designed to maintain ‘green water’ favorable for fish passage along the right bank, and ‘white water’ (high velocity and turbulence) along the left bank. This plan is effective as flows increase, but at very high flows, the entire tailrace becomes turbulent and fish movement declines.

Attractant flow management during flows less than 48,000 cfs remains a subject that has only been explored anecdotally. In 2011, ladder operators tested the use of the HVJ and its ability to attract more fish. However, this study was compounded by the weekly alternating weir mode study occurring concurrently. Some general observations in-the-field concluded having the HVJ on was beneficial and starting in 2012, the HVJ has remained on during non-spill and spill periods in addition to the removal of the half-panel near the ladder entrance.

There is still potential to further evaluate and fine-tune near-fishway attractant flows during non-spill periods and to assess if fish are being delayed as they approach the ladder (*see* Section 3.6 Delay). This type of study will require radio telemetry in order to determine fish behavior and movement and likely require surrogate species due to the low number of Bull Trout in the area. The benefit of such a study should be weighed against the risk to fish from additional handling and stress. In addition, the use of surrogate species to reflect Bull Trout behavior is not always supported, thus data collection may not provide definitive conclusions to guide future agency discussion and management decisions.

The new radial gates on the spillway will be tested in the coming season (2020) to assess their influence on hydraulic conditions in the tailrace and influence on TDG. NorthWestern proposes to photo document the tailrace over a variety of flows during the 2020 fish passage season. These photographs can be used to evaluate the optimal radial gate operation to benefit fish in the Project area.

It should also be noted that the new radial gates will reduce the frequency when stanchions need to be pulled to pass very high flows and increase spill capacity at the Main Dam. In years when the stanchions are pulled, the reservoir has to be drawn down to crest in order to replace the stanchions. The fish ladder is not operational when the reservoir is drawn down and has resulted in over 80-day non-operational period in 2011 and in 2019. Therefore, the new radial gates will increase the ladder operational season in years following very high flows and improve fish passage conditions in those years.

3.6 Delay

When the 2008 BiOp was prepared, FWS was primarily concerned about Bull Trout delay and potential adverse consequents of late arrival to spawning grounds and subsequent decline in spawning success, higher rate of egg superimposition, or increased adult mortality (FWS, 2008). FWS (2008) concerns about delay also included any period(s) when the ladder may be closed during a typical operating season, thus unable to move fish upstream and potentially impairing normal behavior and movement patterns that could affect foraging opportunities, use of cover, and other key aspects of their life history. However, at the time FWS prepared the 2008 BiOp, the frequency, timing and routes of upstream and downstream passage by Bull Trout were not well understood (FWS, 2008). FWS acknowledged, Bull Trout are present at very low densities compared to other fishes, and they have relatively unpredictable migration behavior (FWS, 2008).

In 2010, when the Phase 2 evaluation plan was prepared, there was insufficient literature available to determine a standard passing time for Bull Trout to migrate from Noxon Reservoir to the Thompson Falls Main Dam tailrace and ascend the ladder (PPL Montana, 2010a). Thus, the Phase 2 study regarding delay outlined gathering information regarding Bull Trout and other radio-tagged salmonid movement, timing, and behavior, starting in 2011 through 2013 (PPL Montana, 2010a).

The intent of the data collection was to better understand and potentially identify the factors that affect timing of fish passage at Thompson Falls Dam.

3.6.1 *Methods*

Data to assess the length of time for fish to migrate from Noxon Reservoir to Thompson Falls Main Dam tailrace are limited to studies completed by GEI between 2004 and 2006 (Gillin and Haddix, 2005; Haddix and Gillin, 2006; GEI, 2007) and eight Bull Trout radio-tagged by Avista in 2011 that were transported from downstream of Cabinet Gorge Dam upstream to Vermilion Bay (part of Noxon Reservoir).

During the annual TAC meeting in December 2011, the TAC decided not to radio-tag Bull Trout (or other species) at the ladder or in the Project area. There was concern regarding multiple tags and potential additive adverse impacts to fish. Thus, no telemetry work was conducted to specifically evaluate delay.

Current information available to address potential delay come from remote PIT-tag arrays in the ladder and other locations upstream and downstream of the Project. PIT tag array station(s) provide a more cost-effective method to assess large number of individuals representing many species (and sizes) at a site (Silva et al., 2018).

The following assessments regarding fish movement and behavior were evaluated at the ladder since 2011.

- Length of time for fish to ascend the ladder. These data are based on PIT-tag array stations located in the fish ladder in the lower pools, Pools 7 and 8, and Pool 45 (the top).
- Movement timing at the ladder is provided by the fish count and record of when fish (by species) are recorded at the ladder.

- Upstream migration behavior is based on fish that ascend the ladder and are recorded at the work station and released upstream combined with subsequent detection information upstream in the Thompson River drainage or by angler reports.

3.6.2 *Results – Fish Movement to the Tailrace*

In 2004, a total of 31 fish (19 RB, 7 WCT, 3 BULL, 2 LL) were radio-tagged in the Project area and released downstream of Thompson Falls Dam to assess fish movement and behavior (Gillin and Haddix, 2005). The 2004 study found 21 of the 31 fish moved rapidly upstream from the release back to the tailrace at Main Dam taking in general between 3 to 27 days (average 14 days) to travel 5.3 miles. The 21 fish consisted of 12 Rainbow Trout, five Westslope Cutthroat Trout, three Bull Trout, and one Brown Trout. Rainbow and Westslope Cutthroat Trout returned to the tailrace on average 14.5 and 11.5 days, respectively after their release. Bull Trout took on average 15 days to reach the dam, while the one Brown Trout was detected at the dam 23 days after its release. The shortest (1 day) and longest (81 days) migration interval were both completed by Rainbow Trout (Gillin and Haddix, 2005). Additional summary of the fish passage planning studies is provided in Section 2.0 Systemwide Monitoring of this report.

Radio telemetry data collected in 2011 indicate Bull Trout have navigated over 20 river miles of the Noxon Reservoir from their release location in Vermilion Bay and over 8 miles from Graves Creek to find the Main Dam tailrace (PPL Montana, 2012).

3.6.3 *Results – Length of Time to Ascend the Ladder*

Ladder ascent times are summarized in Section 3.4.9 Results – Internal Fishway Ascent Times of this report. In 2012, two (tagged) Bull Trout ascended the fish ladder in orifice mode and took 2.4 and 2.8 hours, respectively. These fish were 510 mm and 563 mm in length and ascended the ladder within 1 day of each other (May 14 and May 15). In 2019, one (tagged) Bull Trout took 7 hours (June 25) to ascend the ladder (Pools 7/8 to holding pool). This female Bull Trout was initially captured in August 2015 (616 mm, 2275 g) downstream of Cabinet Gorge Dam, genetically assigned to Region 4 (West Fork Fish Creek) and was transported to the middle Clark Fork River near St. Regis. Two years later (July 2017), she was re-captured (615 mm, 1984 g) downstream of Cabinet Gorge Dam and transported a second time upstream to the middle Clark Fork River. In 2019 (4 years after the initial record), this female Bull Trout entered the Thompson Falls fish ladder on June 25 measuring 620 mm and weighing1608 g. She was notably skinny and much smaller than recorded in 2015. It was estimated that this Bull Trout may be 9 to 10 years of age. As a result of her condition and age, this may explain a slower ascent time (7 hours) compared to the two Bull Trout recorded in 2012 (2.5 hours).

Interpreting the available data for Bull Trout is challenging due to the low sample size for previously PIT-tagged Bull Trout ascending the ladder compared to other salmonids. However, the variability observed in the three Bull Trout ascents were also recorded for other fishes. Other salmonids monitored in the ladder were recorded taking anywhere from 0.6 hours to just over

10 days to ascend the ladder. The median ascent time for salmonids is about 2.2 hours in orifice mode and 1.3 hours in notch mode (*see* Table 3-5).

3.6.4 *Results – Movement Behavior and Patterns After Passage at Thompson Falls Dam*

As described in Tracking Tag Array Detections – Thompson River of this report, approximately 25 percent of the ladder fish released upstream of Thompson Falls Dam after ascending the ladder were detected in the Thompson River. This includes four of the 15 individual Bull Trout (*refer to* Table 2-5). These fish can reach the Thompson River as quickly as 5.5 hours.

Angler reports of ladder fish captured upstream of Thompson Falls Dam is summarized in Section 2.3.8 Tracking Angler Reports of this report. Since 2011 (through July 1, 2019), there were four ladder fish (2 RB, 1 WCT, 1 LL) captured 50 to over 150 miles upstream of Thompson Falls Dam by anglers (*refer to* Table 2-9). The Westslope Cutthroat Trout captured in the St. Regis River (65 miles upstream) 37 days after its release upstream of the dam was detected in the lower pools of the ladder in October 2018 and ascended the ladder a second time in April 2019. These detections show some fish are making long migrations in short period of time after passage through the ladder. In some cases, fish are making this a round trip, with multiple passes through the fish ladder.

3.6.5 *Results – Straying*

The PIT-tag array data collected at the Thompson River (upstream of Thompson Falls Dam), Prospect Creek (downstream of Thompson Falls Dam), and Graves Creek (downstream of Thompson Falls Dam) are provided in Sections 2.3.5 through 2.3.7 in this report. The detection data for Bull Trout that ascended the ladder and were later detected in other tributaries upstream or downstream of the Project is limited. The majority of the ladder-fish detections in other tributaries (Thompson River, Graves, and Prospect creeks) include Rainbow Trout, Brown Trout, and Westslope Cutthroat. This is simply because there is a greater number of these species in the system, ascending the ladder, and consequently PIT-tagged and released back into the system.

The PIT-tag array detections do not provide definitive information regarding fish activity (e.g., spawning) once detected in a tributary, but do indicate some fish explore a vast area (upstream and downstream) and enter and exit one more tributary during their journey. The mechanisms for the movement patterns of one fish compared to another fish of the same species is not understood.

3.6.6 *Discussion*

As previously stated, there is insufficient information available to determine a standard passing time for Bull Trout to migrate from Noxon Reservoir to the Thompson Falls Main Dam tailrace and ascend the ladder.

The available radio telemetry data for Bull Trout in the Project area originate from Bull Trout initially captured and tagged by Avista downstream of Cabinet Gorge Dam, transported and released upstream in Region 3 (Noxon Rapids Reservoir) or radio telemetry studies done during fish ladder planning. These studies occurred either prior to the fish ladder being built (2004–2006) on primarily surrogate species, or while the ladder was closed (2011) during an extreme-high spring flow event.

Thirteen of the Bull Trout that ascended the ladder had no previous capture (tagging) history, thus their journey to the ladder is unknown. Ladder ascents by Bull Trout were completed primarily (15 of 17) when streamflows were less than 48,000 cfs (ladder design limit), with two Bull Trout ascending the ladder when streamflows were 51,000 and 56,100 cfs, respectively. Peak number of ascents and forays into the lower pools occurring when flows were between 23,000 and 33,000 cfs.

Bull Trout are most often observed at the ladder in the spring months (April through June), which is in concurrence with radio-telemetry studies in 2004–2006. However, the preliminary studies (2004–2006) and radio-telemetry work (2008–2011) found Bull Trout are in the Project area when streamflows are well above the fish ladder design limit (excess of 60,000 cfs). No Bull Trout have been detected in the ladder (2011–2019) when streamflows exceeded 56,100 cfs. This may reflect the fact that a Bull Trout must be previously tagged to be detected entering the ladder (if it is not going to ascend to the top) and/or the ladder has been closed at these higher streamflows when Bull Trout are making upstream movements. It is common practice for the ladder to be shut down when spring flows exceed 55,000 to 60,000 cfs. If the ladder is closed during these higher flows, there is potential for Bull Trout moving during higher flows to be delayed due to operational constraints at the ladder.

3.7 Fallback

Fallback is generally defined as a fish that successfully completes upstream passage of a fishway at a dam facility but later returns downstream of the dam (Rischel and Bjornn, 2003; Naughton et al., 2006, McLaughlin et al., 2013; Silva et al., 2018). The time between successful passage and detection downstream of the facility is also an important component of fallback analysis, but there is no set standard for evaluating fallback.

We evaluated three studies and found varying definitions of fallback. In the first study, fallback only applied to fish that were detected downstream in the tailrace within 24 hours of their initial upstream fish passage (Reischel and Bjornn, 2003). In the second study, fallback was reported if occurring within a range of less than 1 day to less than 7 days (Frank et al., 2009). In the third study by Boggs et al. (2004), fish were not defined as a fallback if the fish entered spawning areas during historic spawning periods. Based on Boggs et al. (2004) study between 1996 and 2001 in the Columbia River and Snake River dams, fallback was estimated at 22 percent for spring–summer Chinook salmon, 15 percent of fall Chinook salmon, and 21 percent of steelhead.

The concerns with fallback include fish becoming disoriented when exiting the fishway and moving in the wrong direction and no longer motivated to swim upstream as a result of the fishway experience or fish are no longer physically capable of continuing the upstream migration due to the demands of the fishway (McLaughlin et al., 2013). Even if a fish returns to the fishway and re-ascends, there are concerns of unwanted delay and corresponding consequences such as reduction in fitness, increase susceptibility to injury/mortality, decrease in reproductive success (McLaughlin et al., 2013). Another concern in the Columbia River system regarding anadromous fish is the potential for bias estimates of fish passage and escapement calculations which could also impact estimates of adult salmon run sizes, which have management (ecological and economic) implications for the fish stocks (Boggs et al., 2004). Fallback is also commonly associated as an adverse impact post-tagging (Frank et al., 2009).

At the Thompson Falls upstream fishway, FWS was primarily concerned with potential implications to Bull Trout spawning success and potential increase susceptibility to injury, predation, or mortality resulting from fallback (FWS, 2008). Due to the second concern, FWS required the Licensee to evaluate fallback. FWS wanted the Licensee to be prepared to address the need to transport Bull Trout upstream of Thompson Falls Dam by vehicle to mitigate the potential for fallback (FWS, 2008).

3.7.1 *Methods*

The Phase 2 evaluation plan (PPL Montana, 2010a) described a study to evaluate fish fallback at the Thompson Falls upstream fish passage facility. Fallback data are available from detection information from remote tag arrays located upstream (Thompson River) and downstream (Prospect and Graves creeks) of Thompson Falls Dam, and in the ladder (lower pools and holding pool).

The focus of the fallback study was Bull Trout, but other salmonids receiving PIT tags were also included in the evaluation due to the limited Bull Trout sample size. The FWS has stated that the long-term goal for Bull Trout is to minimize human handling and maximize safe, timely and efficient volitional passage (FWS, 2011). Therefore, none of the Bull Trout ascending the fish ladder have been transported. Bull Trout that ascended the fish ladder at Thompson Falls were uniquely PIT-tagged and then released immediately upstream of the Main Dam into the Thompson Reservoir. Bull Trout and other fishes ascending the ladder (uniquely tagged) and released upstream since 2011 were monitored for fallback.

The objective of evaluating fallback was to assess whether these fish are moving through the turbines or over the spillway and if there are operational modifications that could improve fish movement upstream after release into the Thompson Reservoir.

The combined capacity of the seven generating units at the Project is approximately 23,000 cfs. When river inflows exceed this capacity (except during plant trips or when any number of the generating units are offline), spill is initiated at the Main Dam spillway. Therefore, when streamflows are less than 23,000 cfs, it is assumed that all downstream fish passage is through the turbines. When streamflows are above 23,000 cfs, fish can pass downstream through the turbines or over the spillway.

The 2008 BiOp did not define the duration between upstream passage through the fishway and subsequent movement downstream of Thompson Falls Dam for analyzing fallback. Thus, the Licensee defined fallback as a fish that ascends the ladder, receives a PIT, Floy, or other unique identification tag, is released upstream, and then is later recaptured either downstream of the Thompson Falls Dam or at the ladder again within 30 days. In past annual reports (2011–2018), the Licensee took a more conservative approach and report fallback occurring within a calendar year.

Detecting fallback is limited to when a fish returns to the ladder or when a fish is recaptured/detected during sampling efforts downstream of the Thompson Falls Dam. Therefore, the number of fallback fish reported represents a minimum value. Also, the duration between the time a fish is released upstream of the dam and when it moves downstream of the dam is an estimate since tags are not detected moving over the spillway or at the turbines.

3.7.2 *Results*

Each year there were between 175 to 525 salmonids uniquely tagged at the ladder and released upstream. Approximately 27 salmonids (1%) of the PIT-tagged salmonids released upstream of Thompson Falls Dam between 2011 and July 1, 2019 were detected downstream of the dam within 30 days of their release. Annually, fallback of salmonids within 30 days of their release upstream was greatest in 2011 (8 RB, 2 WCT) and relatively low in all other years, ranging from zero to 1.7 percent of tagged salmonids (Table 3-10).

Table 3-10. Summary of the salmonids detected downstream of Thompson Falls Dam within 30 days of initial release upstream of the dam, 2011–2019. 2019 data through July 1, 2019.

Fish Species	Annual Salmonid Fallback within 30 days of release upstream of Thompson Falls Dam								
	2011	2012	2013	2014	2015	2016	2017	2018	2019
BULL	-	-	-	-	-	-	-	-	-
RB	8	-	-	1	1	3	-	1	1
RBxWCT	-	-	-	-	-	1	-	-	-
WCT	2	-	-	-	-	1	1	-	-
LL	-	-	-	2	1	4	-	-	-
Total	**10**	**-**	**-**	**3**	**2**	**9**	**1**	**1**	**1**
% of Tagged Salmonids	**4.6%**	**-**	**-**	**1.2%**	**0.4%**	**1.7%**	**0.4%**	**0.6%**	**0.9%**

A total of six Bull Trout (out of 17 that ascended the ladder) were subsequently detected downstream of Thompson Falls Dam after their release upstream (Table 3-11). None of the Bull Trout were classified as fallback with all downstream detections occurring past the 30-day threshold. It should be noted that these fish could have moved into spawning tributaries upstream of the Project during the spawning season, and then later passed downstream of the Project. Two of the six fish with subsequent detections downstream of the dam are confirmed mortalities;

one jumped out of the ladder during its second ascent and the second fish was captured during a gillnet survey in Noxon Reservoir.

Table 3-11. Bull Trout that ascended the Thompson Falls fish ladder subsequently detected downstream of Thompson Falls Dam.

Date of Ladder Ascent(s)	Most Likely Population of Origin	Bull Trout Detection Locations and Dates	Downstream Passage at Thompson Falls Dam
4/26/2011; 5/21/2012	Fishtrap Creek (R4)	Two ladder ascents over a year apart. Mortality after second ladder ascent – jumped out of holding pool.	Spillway or turbines between 4/26/2011 and 5/21/2012
5/15/2012	Meadow Creek (R4)	Tagged below TFalls Dam electrofishing on 5/31/2011; TFalls Ladder work station on 5/15/2012; Prospect Creek 7/7/2013.	Spillway or turbines between 5/15/2012 and 7/7/2013
5/6/2013	Fishtrap Creek (R4)	Prospect Creek on 9/21/2014; lower ladder arrays 5/5/2015 & 5/13/2015.	Spillway or turbines between 5/6/2013 and 9/21/2014
5/16/2014	Fishtrap Creek (R4)	Gillnet in Noxon Reservoir (Mortality) 10/13/2014.	Spillway or turbines between 5/16/2014 and 10/13/2014
4/18/2016	Fishtrap Creek (R4)	Detected in the lower pools of Thompson Falls fish ladder 10/2/2016 (did not ascend).	Spillway or turbines between 4/18/2016 and 10/2/2016
5/18/2016	North Fork Fish Creek (R4)	Thompson River 9/18–19; 9/21; 9/24/ 9/26–28/2016; Graves Creek 9/20/2017.	Spillway or turbines between 9/28/2016 and 9/20/2017

The following table summarizes the number of fish that likely moved downstream through the turbines based on the streamflows between the initial release of the fish upstream of Thompson Falls Dam and the subsequent detection (within 30 days of initial release upstream) downstream of Thompson Falls Dam (Table 3-12).

Table 3-12. Summary of the four salmonids (1 RB, 3 LL), classified as fallback with detections downstream of Thompson Falls Dam within 30-days of their initial release upstream, that most likely fell back through the turbines.

Species	Downstream Movement Through Turbines at Thompson Falls Dam								
	2011	2012	2013	2014	2015	2016	2017	2018	2019
BULL	-	-	-	-	-	-	-	-	-
RB	1	-	-	-	-	-	-	-	-
RBxWCT	-	-	-	-	-	-	-	-	-
WCT	-	-	-	-	-	-	-	-	-
LL	-	-	-	1	1	-	1	-	-
Total Turbines	**1**	**-**	**-**	**1**	**1**	**-**	**1**	**-**	**-**

Bull Trout fallback has not been documented at the Project. Fallback by other salmonids is infrequent and does not occur annually. Depending on the time of year, some fallback fish may move downstream through the turbines while others may move over the spillway. Overall the data show salmonids can survive downstream passage, either through the turbines or over the spillway, returning to the ladder (sometimes multiple times a year), and continuing to move upstream into the Thompson River or other locations.

3.7.3 *Discussion*

There is little consistency with fallback reporting in the literature (Frank et al., 2009). The type of movement associated with fallback, the temporal time frame when fallback occurs, and species evaluated vary greatly in the literature. The concerns and causations of fallback also vary and can range from adverse impacts to fish movement and behavior related to the fishway experience, post-tagging issues, location of a fishway exit, etc. (Frank et al., 2009; Bogg et al., 2004, Reischel and Bjornn, 2003).

At the Thompson Falls fishway, the focus was Bull Trout and other salmonids and whether fish would get disoriented after their fishway experience and release upstream, precluding them from reaching their spawning tributary. The data available for Bull Trout ascending the ladder do not indicate fish are disoriented after ascending the fishway. Four of the 16 individual Bull Trout that ascended the ladder were later detected over 6 miles upstream in the Thompson River drainage.

Note the Thompson River mainstem array was installed in late-September 2014 and seven Bull Trout ascended the ladder after the installation of the Thompson River tag-array system. So approximately 57 percent of the Bull Trout released upstream of Thompson Falls Dam were later detected in the Thompson River (while the array system was in operation). Additionally, four of the seven Bull Trout were genetically assigned to the Thompson River drainage while three Bull Trout were genetically assigned to Fish Creek drainage, located about 100 river miles upstream of Thompson Falls Dam. Concerns regarding disorientation after fish ascend the ladder and are released upstream of Thompson Falls Dam does not appear to be an issue.

In the lower Clark Fork River, adult Bull Trout initially captured by Avista from downstream of Cabinet Gorge Dam and transported upstream to Region 4 (upstream of Thompson Falls Dam) have been recorded returning downstream of Thompson Falls Dam, Noxon Rapids Dam, and even downstream of Cabinet Gorge Dam (over 65 river miles). Movement patterns of other salmonid species ascending the fish ladder at Thompson Falls have shown these fish make upstream and downstream movements of over 100 river miles and foray into several tributaries. The movement patterns are detected by remote PIT-tag array stations. In addition, some salmonids are observed ascending the ladder annually (sometimes to the day or within the same week). The movement data collected at the ladder and general area show fish movement and timing is not always predictable and motivations of movement are likely influenced by various factors such as feeding, refuge, and/or spawning (Silva et al., 2018).

At this time, fallback evaluated over a 30-day period does not appear to be a major issue at Thompson Falls Dam. Fish are not being immediately swept downstream (from disorientation or energy use) after their release upstream. There is no evidence that fallback is impeding the successful passage of Bull Trout, or any other salmonid species.

4. Downstream Passage Through Thompson Falls Reservoir

4.1 Introduction

TC(5)(a) of the BiOp states,

> During the first five years of the Phase 2 evaluation (2011 through 2015) the Licensee, 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 potential impacts of predatory non-native fish species on juvenile and subadult Bull Trout residing in or passing through the reservoir.

The BiOp stated that the initial findings would be summarized and supported with scientifically based conclusions, no later than the end of 2015. The deadline for that report was subsequently extended, to be completed at the same time as the comprehensive scientific report. Therefore, this report includes the results of both the upstream passage evaluations and the downstream passage evaluation required in TC (5)(a).

In compliance with TC(5)(a), the Licensee developed a 5-Year Reservoir Monitoring Plan (2011–2015) (PPL Montana, 2010). The 5-Year Reservoir Monitoring Plan was developed with the TAC and approved by the FWS in 2010. The Licensee submitted the 5-Year Reservoir Monitoring Plan to the FERC on June 22, 2010. The FERC issued an order approving the Plan on February 9, 2011.

The goal of the 5-Year Reservoir Monitoring Plan was to gather information to assist in developing recommendations to maximize survival of outmigrant juvenile and adult Bull Trout through Thompson Falls Reservoir and Dam. Additionally, there was an assumed to be a large enough Bull Trout population present in the Thompson River drainage to provide a reasonable sample size to study and gather more data to address the overall goal of the Plan.

The objectives identified in the Plan included:

- Characterization of Bull Trout in the Thompson River drainage.
- Characterization of the affect that Thompson Falls Reservoir has on Bull Trout emigrating from the Thompson River drainage (or elsewhere upstream, as these are not necessarily separable) and migrating downstream in the Clark Fork River.
- This section addresses the results of studies on juvenile Bull Trout outmigration through the Project area, habitat conditions in Thompson Falls Reservoir, and predation risk to Bull Trout from Northern Pike in the Project area.

4.1.1 *Bull Trout Outmigration Timing*

In order to understand the risks that Bull Trout face when moving through the Thompson Falls Hydroelectric Project area, it is necessary to understand the timing of when they are likely to be present in the Project area.

4.1.1.1 Subadult Bull Trout Outmigration

Out migration of subadult Bull Trout from tributary streams has been commonly reported to have a bimodal (spring and fall) pattern (Lacy et al., 2016; Downs et al., 2006; Muhlfeld and Marotz, 2005). Avista (Lacy et al., 2016) documented juvenile Bull Trout downstream movement out of Graves Creek occurring primarily in the fall (between September and November) with a second smaller movement recorded in early May. Downs et al. (2006) studied juvenile Bull Trout movement in Trestle Creek, Idaho and found that emigration of juveniles occurred in two pulses, one in spring that was associated with snowmelt runoff and increasing water temperatures and a second in fall as stream temperatures dropped and fall rains began. This trend was also document in the Upper Flathead River system by Muhlfeld and Marotz (2005).

In the Thompson River drainage, juvenile Bull Trout have been found to outmigrate in the fall (Glaid, 2017). In the Thompson River, weir traps placed in Fishtrap Creek, tributary of the Thompson River, found peak catch of downstream moving Bull Trout (≤300 mm) occurred during October. In the West Fork Thompson River, peak catch of downstream moving Bull Trout (≤300 mm) in weir traps also occurred primarily during October (Kreiner and Terrazas, 2018). However, weir traps are difficult to maintain in high flow conditions, and weir trapping efforts were limited during spring runoff (Liermann, 2003; Liermann et al., 2003).

Avista owns and operates the two hydroelectric dams downstream of Thompson Falls on the Clark Fork River, Noxon Rapids Dam and Cabinet Gorge Dam. As part of their mitigation program for their hydroelectric facilities, Avista collects subadult out migrating Bull Trout from the tributary streams and transports them downstream of Cabinet Gorge Dam in Idaho. From the inception of the downstream transport program through 2015, a total of 2,472 juvenile Bull Trout have been transported to Idaho. The majority (64%) of downstream-moving juvenile Bull Trout have been captured during September and October (Lacy et al., 2016).

4.2 Habitat Conditions in Thompson Falls Reservoir – Residence Time and Water Temperature

4.2.1 *Introduction*

The BiOp (FWS, 2008) requires the Licensee to, among other activities,

> …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 non-native fish species on juvenile and subadult Bull Trout residing in or passing through the reservoir.

4.2.2 *Residence Time Methods*

Residence time for the Thompson Falls Reservoir was calculated in 2010 (PPL Montana, 2011). Residence time is a calculated quantity expressing the mean time that water (or some dissolved substance) spends in a particular lake. At its simplest residence time is the result of dividing the lake volume by the flow in or out of the lake. The calculation estimates the amount of time it will take for a substance introduced into a lake to flow out of the lake again. The estimated residence time for the Thompson Falls Reservoir is of interest because it provides an approximation of the impediment that the relatively slow water velocities in the reservoir pose to out migrating juvenile salmonids.

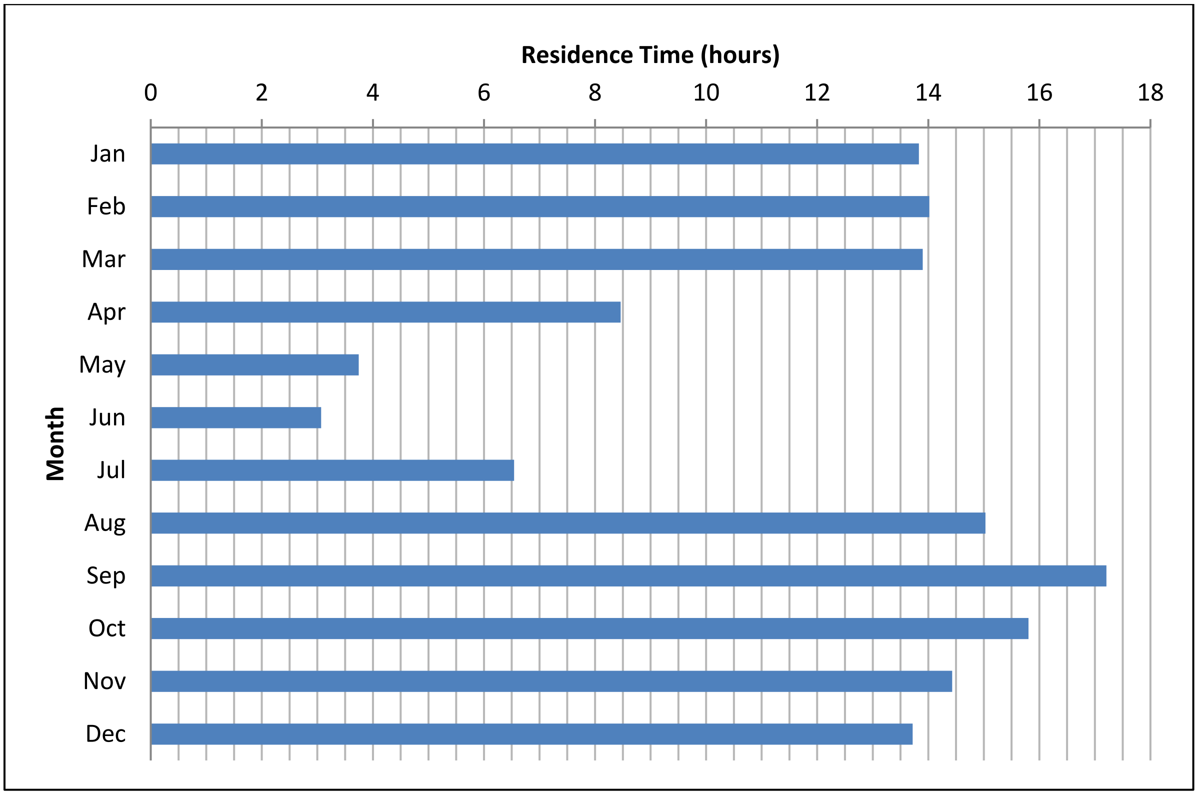
The mean monthly flows for the Clark Fork River and Thompson River were taken from the USGS gage stations #12389000 and #12389500, respectively. Quantities were available for the Clark Fork River from 1912 to 2010 and for the Thompson River from 1956 to 2010. The average discharge for both rivers for each month was combined and assumed to be the mean monthly inflow to the Thompson Falls Reservoir. To generate an average monthly residence time, the total storage capacity is divided by the average monthly inflow (PPL Montana, 2010b).

4.2.3 *Residence Time – Results*

Active storage capacity of the Thompson Falls Reservoir is approximately 15,000 acre-feet between crest El. 2380 feet and normal full pool El. 2396 feet, 1 foot below the Project boundary El. of 2397 feet. The reservoir is generally kept at full pool elevation, or close to it, throughout the year.

The monthly fluctuation of average residence time is displayed in Figure 4-1. The results indicate that residence time in Thompson Falls Reservoir is very short and less than 1 day throughout the year. Thompson Falls Reservoir has very little storage and generally, the outflow of the reservoir is approximately equal to the inflow.

Figure 4-1. Estimated average monthly residence time in Thompson Falls Reservoir.



4.2.4 *Water Temperature Methods*

4.2.4.1 Water Temperature Profiles

Water temperature data were collected on July 21, 2009 along three transects in Thompson Falls Reservoir (PPL Montana, 2010b). The locations of the three transects are shown on Figure 4-2. Each transects covered a horizontal section of water (right bank to left bank). Transect 1 was located 328 feet (100 m) downstream of the Thompson River mouth, from right bank to left bank. Transect 2 was approximately 1 mile (1.6 km) downstream of the Thompson River mouth, from right bank to left bank. Transect 3 was located approximately 2 miles (3.2 km) downstream of the Thompson River mouth near the Cherry Creek boat launch, from right bank to left bank. Two to three temperature profiles were taken along each transect. Temperature data was collected from the surface to the bottom of reservoir. Maximum depth for the temperature profile data ranged between approximately 6 to 47 feet (1.8 to 14.3 m).

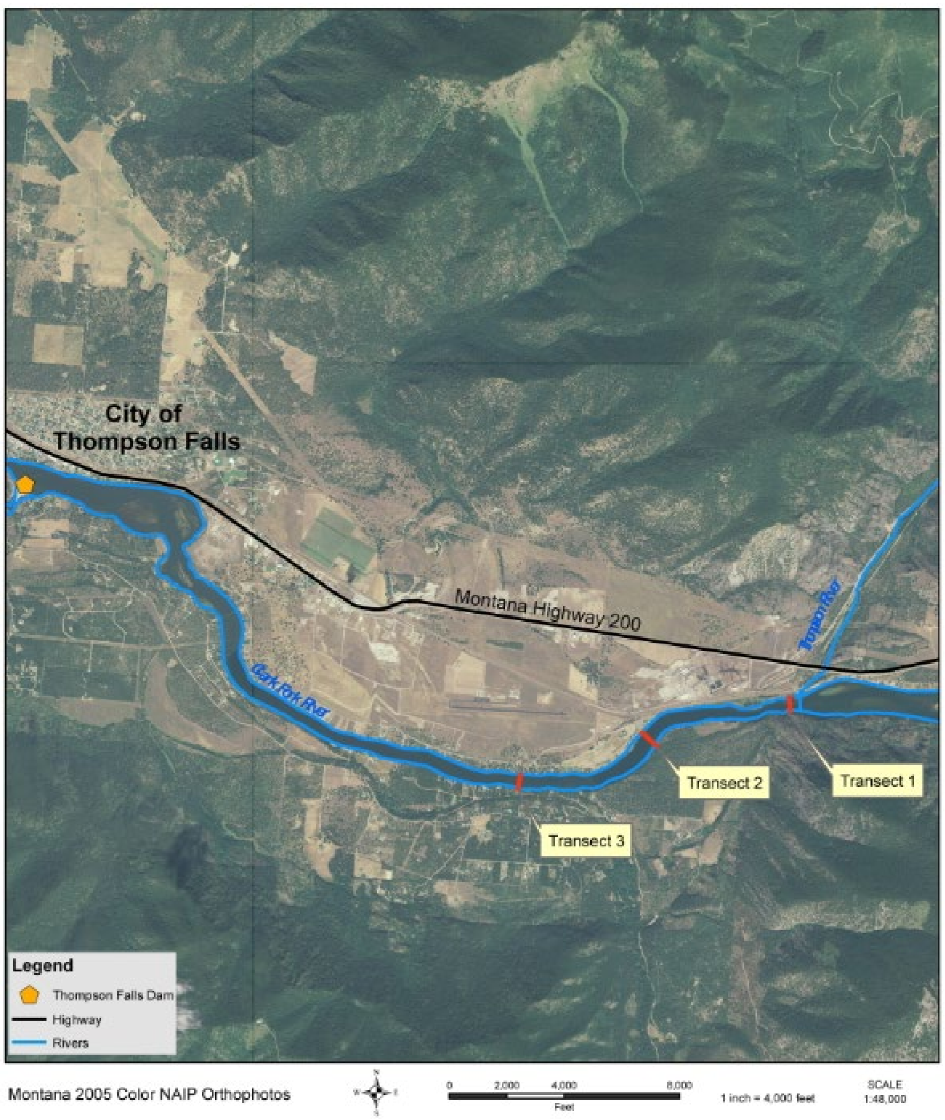
Water temperature data were also collected on July 30, 2009 in the Thompson Falls Reservoir (PPL Montana, 2010b). Water temperature data were collected in Thompson Falls Reservoir starting at the mouth of Thompson River and continuing downstream approximately 328 feet (100 m) until there was no cold water influence from the Thompson River. Several temperature profiles were taken from the surface to the bottom depth. Specific locations for data collected on July 30, 2009 are not available.

4.2.4.2 Continuously Recorded Water Temperature

Water temperature data was continuously recorded in Thompson Falls Reservoir 70 feet (21.3 m) upstream of the Cherry Creek boat ramp, immediately above the Dry Channel Dam, and at the Birdland Bay Bridge, downstream of the Thompson Falls Project, from early March to the end of November 2007.

Water temperature was continuously recorded in the Clark Fork River just upstream of the Thompson River and in Thompson Falls Reservoir immediately downstream of Cherry Creek from March 16, 2009 to October 19, 2009.

Figure 4-2. Location of water temperature transects in 2009 (PPL Montana 2010b).

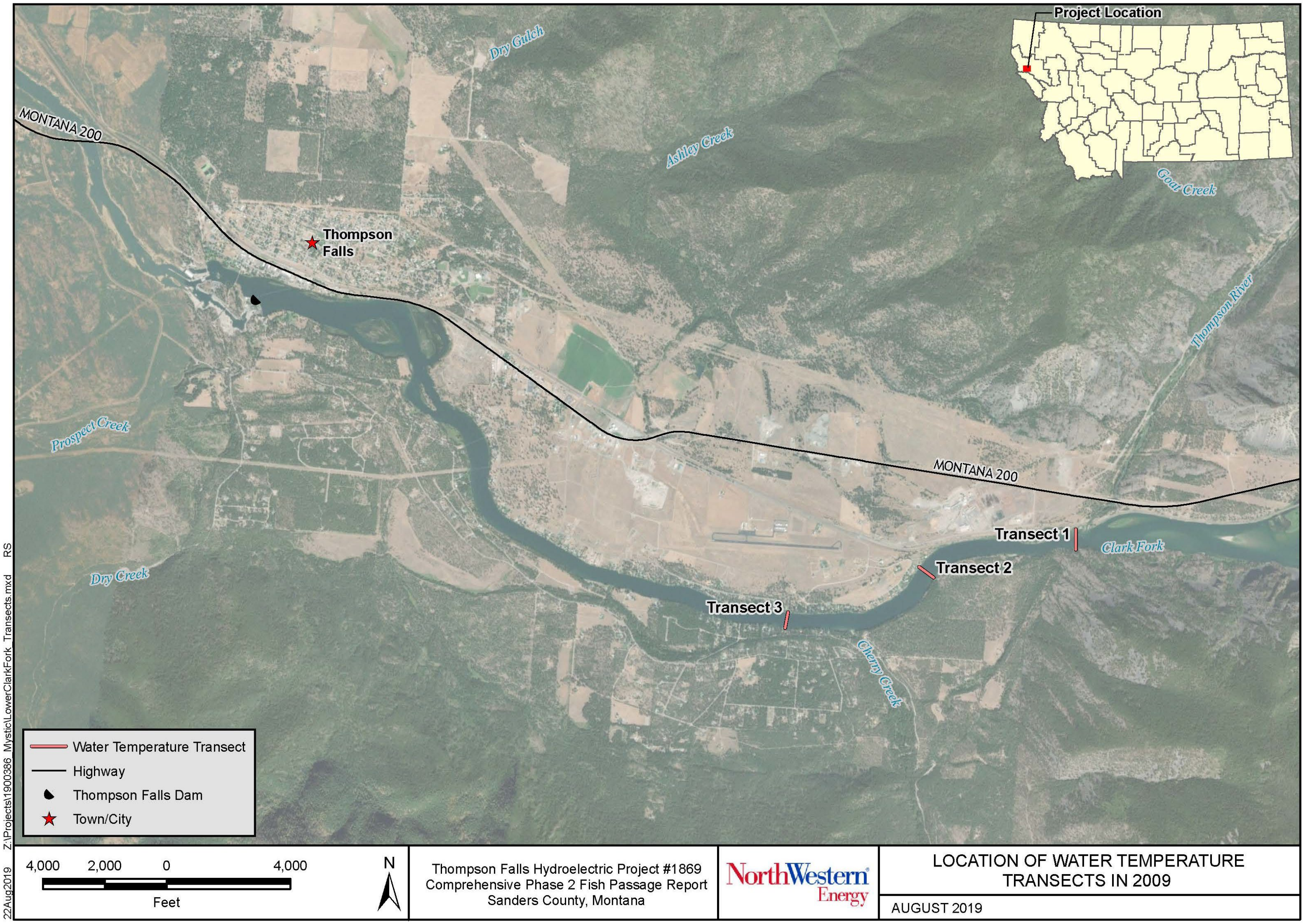


4.2.5 *Water Temperature Results*

4.2.5.1 Temperature Profiles Thompson Falls Reservoir

The temperature of Thompson Falls Reservoir was nearly uniform on July 21, 2009. Temperatures were approximately 68 °F (20 °C) at almost all locations and depths, except for Transect 1 Profiles A and B, which showed slightly colder temperatures (58–59 °F, 14–15 °C). Transect 1 was approximately 100 meters downstream of the confluence of the Thompson River within 50 meters of the right bank of the Thompson Falls Reservoir, so the cooler temperatures at Profiles A and B on Transect 1 seem to show the Thompson River influence (Figure 4-3). This was the only area of the reservoir that was found to be cooler than the main body of the reservoir (Figure 4-3). Transects 2 and 3 (1 and 2 miles or 1.6 and 3.2 km downstream from the confluence with the Thompson River, respectively) showed no cool water influence from the Thompson River (PPL Montana, 2010b).

Figure 4-3. Water Temperature Profiles, Thompson Falls Reservoir, July 21, 2009.



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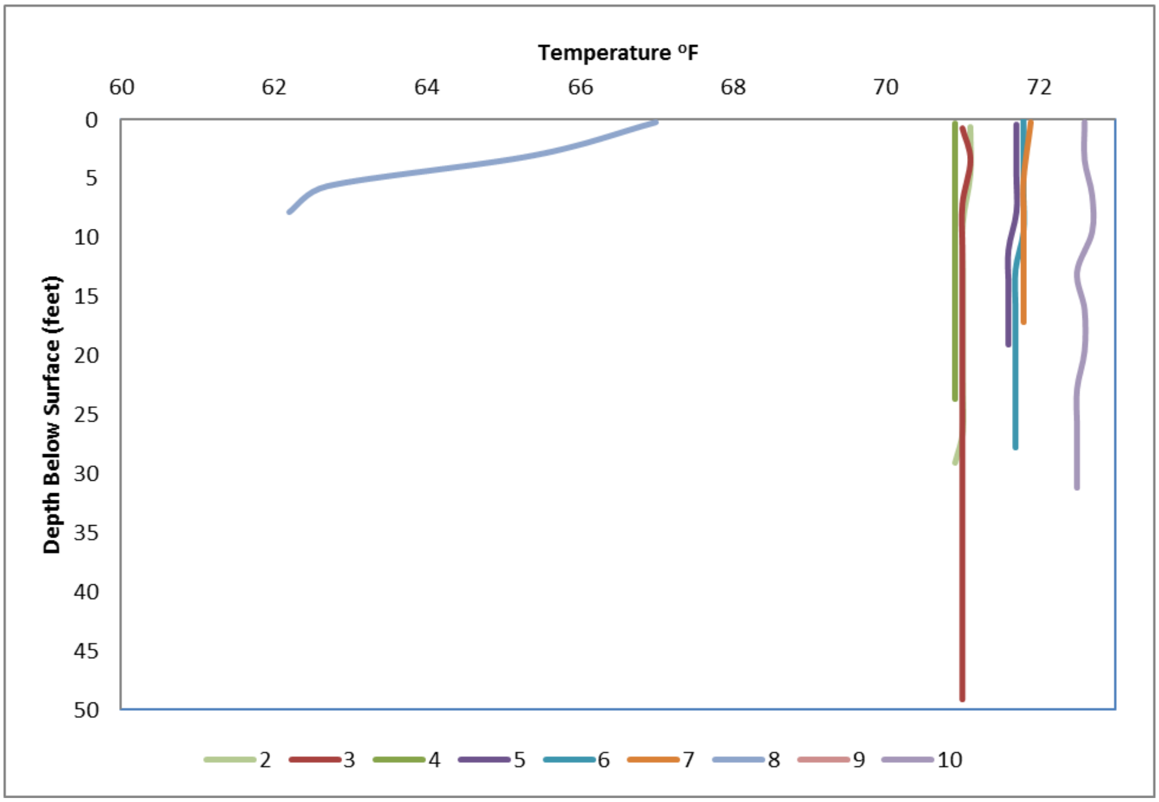
On July 30, 2009, water temperatures warmed, 71 to 73 °F (21.7–22.8 °C) Thompson Falls Reservoir (PPL Montana, 2010b). There was still no evidence of thermal plume extending from the Thompson River to Thompson Falls Dam. A cooler, shallow water temperature profile was recorded immediately downstream of the mouth of the Thompson River (Profile #8, Figure 4-4), but cooler temperatures were not detected approximately 328 feet (100 m) downstream of the confluence with the Thompson River. Most of the temperature profiles showed isothermal conditions between 71 and 73 °F, or 21.7 to 22.8 °C (Figure 4-4).

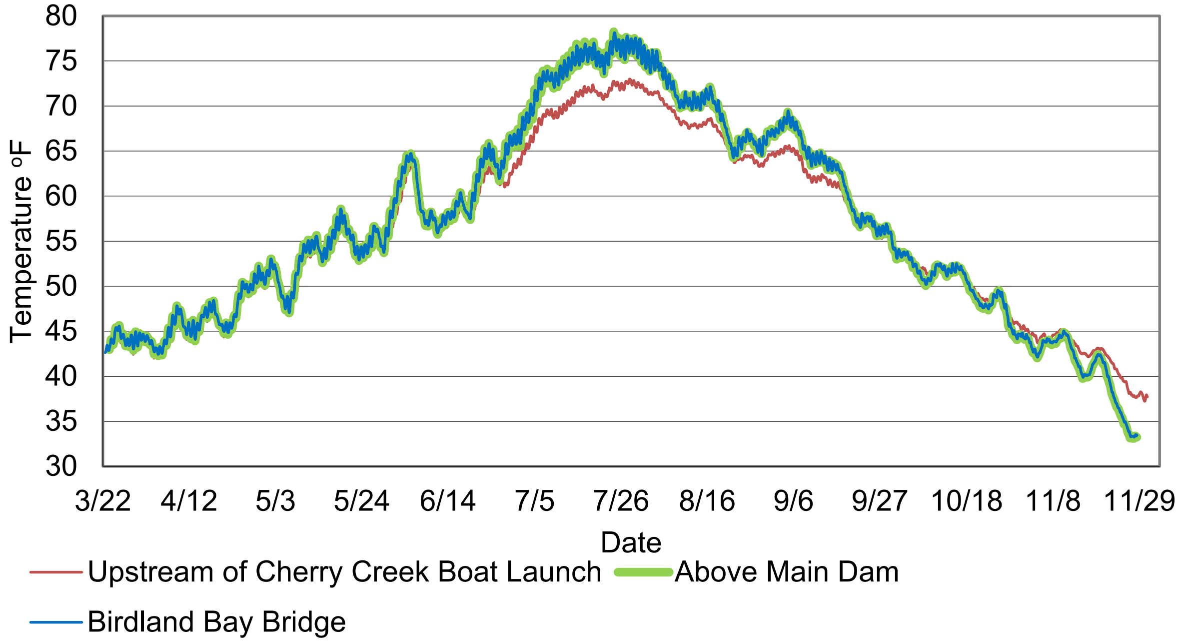
Figure 4-4. Water Temperature Profiles, profile numbers 2 to 9, Thompson Falls Reservoir, July 30, 2009 (PPL Montana 2010b).



4.2.5.2 Continuous Water Temperature Data

Temperature measurements made in 2007 show that water temperature at Thompson Falls Dam (immediately upstream of the Main Dam) and at the Birdland Bay Bridge (downstream of the Project) are nearly identical (Figure 4-5). In the spring and fall, water temperatures in the Thompson Falls Reservoir (near the Cherry Creek Boat Ramp) were very similar to temperatures downstream. In the summer months, Thompson Falls Reservoir at the Cherry Creek Boat launch is several degrees cooler than water at Thompson Falls Dam and at the Birdland Bay Bridge (Figure 4-5). In 2007, water temperature increased by several degrees between the Cherry Creek Boat launch and Thompson Falls Dam in the summer months.

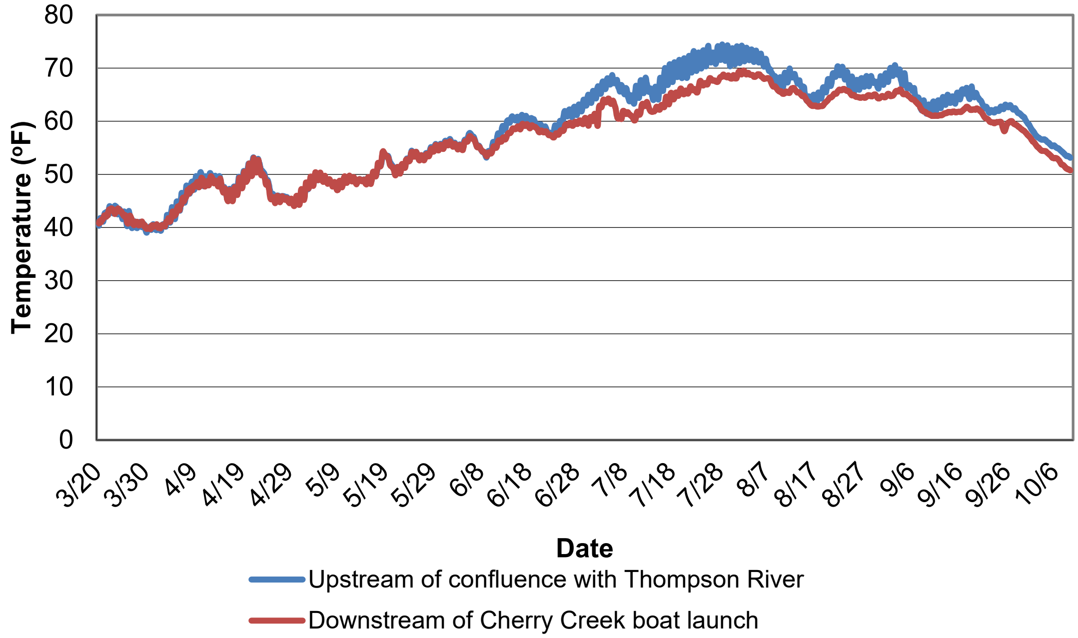
Figure 4-5. Water Temperature from March through November 2007 at two locations in Thompson Falls Reservoir and at the Clark Fork River at the Birdland Bay Bridge (BBB).



Water temperatures measured at two locations: the Clark Fork River upstream of the Thompson River and Thompson Falls Reservoir downstream of Cherry Creek were nearly identical during the spring of 2009. However, starting in early June, the Clark Fork River upstream of the Thompson River (upstream site) was slightly warmer than the site downstream of Cherry Creek (Figure 4-6). Maximum water temperature at the upper site on the Clark Fork River exceeded 70 °F (21 °C) from July 16 to August 6, 2009. Water temperature measured at the downstream site did not exceed 69 °F (20.6 °C).

In both 2007 and 2009, the coolest summer water temperatures in Thompson Falls Reservoir (including areas upstream and downstream on the Clark Fork River) were measured near the Cherry Creek Boat Launch. FWP conducted temperature monitoring in Cherry Creek, near the mouth in 2018 and found mean July and August temperatures at 12.4 °C and 12.5 °C (FWP, unpublished data). There may be some cool groundwater inflow in this location.

Figure 4-6. Water temperature in the Clark Fork River upstream of the Thompson River (blue) and in Thompson Falls Reservoir downstream of Cherry Creek (pink) in 2009. From continuous recorders.



4.2.6 *Discussion*

Water temperature data collected in Thompson Falls Reservoir in 2007 and 2009 indicate that Thompson River does not stratify and is generally thermally homogeneous. The cool water influence of the Thompson River only extends downstream in Thompson Falls Reservoir a short distance, approximately 328 feet (100 m) downstream of the Thompson River confluence and 50 feet (15.2 m) from the right bank. Additional water temperature data indicate there may also be some cool water potentially from groundwater inflow, near Cherry Creek, approximately 2 miles (3.2 km) downstream from the Thompson River. However, these small areas of cool water do not extend throughout the reservoir but appear to be highly localized. Based on the 2007 and 2009 data, it does not appear that there are large cool water zones in Thompson Falls Reservoir that could be used by Bull Trout as a migratory corridor through the reservoir upstream to Thompson River. Discrete locations at the mouths of Cherry Creek and Thompson River have been identified as small areas where these cold water inputs could provide refuge as Bull Trout move throughout the reservoir. However, these appear to be small areas that do not have much influence on overall temperatures within the reservoir.

The data also indicate that Thompson Falls Reservoir has a short retention time. This is consistent with the finding that the reservoir does not stratify. The habitat in the reservoir is intermediate between lentic and lotic habitat type.

4.3 Predatory Non-Native Fish

4.3.1 *Introduction*

Thompson Falls Reservoir contains slow-moving, backwater-type habitats, suitable for non-native 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. The BiOp (FWS, 2008) requires the Licensee to, among other activities, pursue, "an assessment of impacts of predatory non-native fish species on juvenile and subadult Bull Trout residing in or passing through the reservoir."

The Licensee has evaluated the population of non-native predatory fish in Thompson Falls Reservoir through annual fall gillnetting in Thompson Falls Reservoir (since 2004) and spring electrofishing the Thompson Falls Reservoir in the spring (upper and lower sections, since 2010). In addition, in 2009, the Licensee and FWP joined in a collaborative effort to investigate Northern Pike populations in the Thompson Falls Reservoir up to and including the Island Complex (PPL Montana, 2010b).

4.3.2 *Methods*

4.3.2.1 Fall Gillnetting

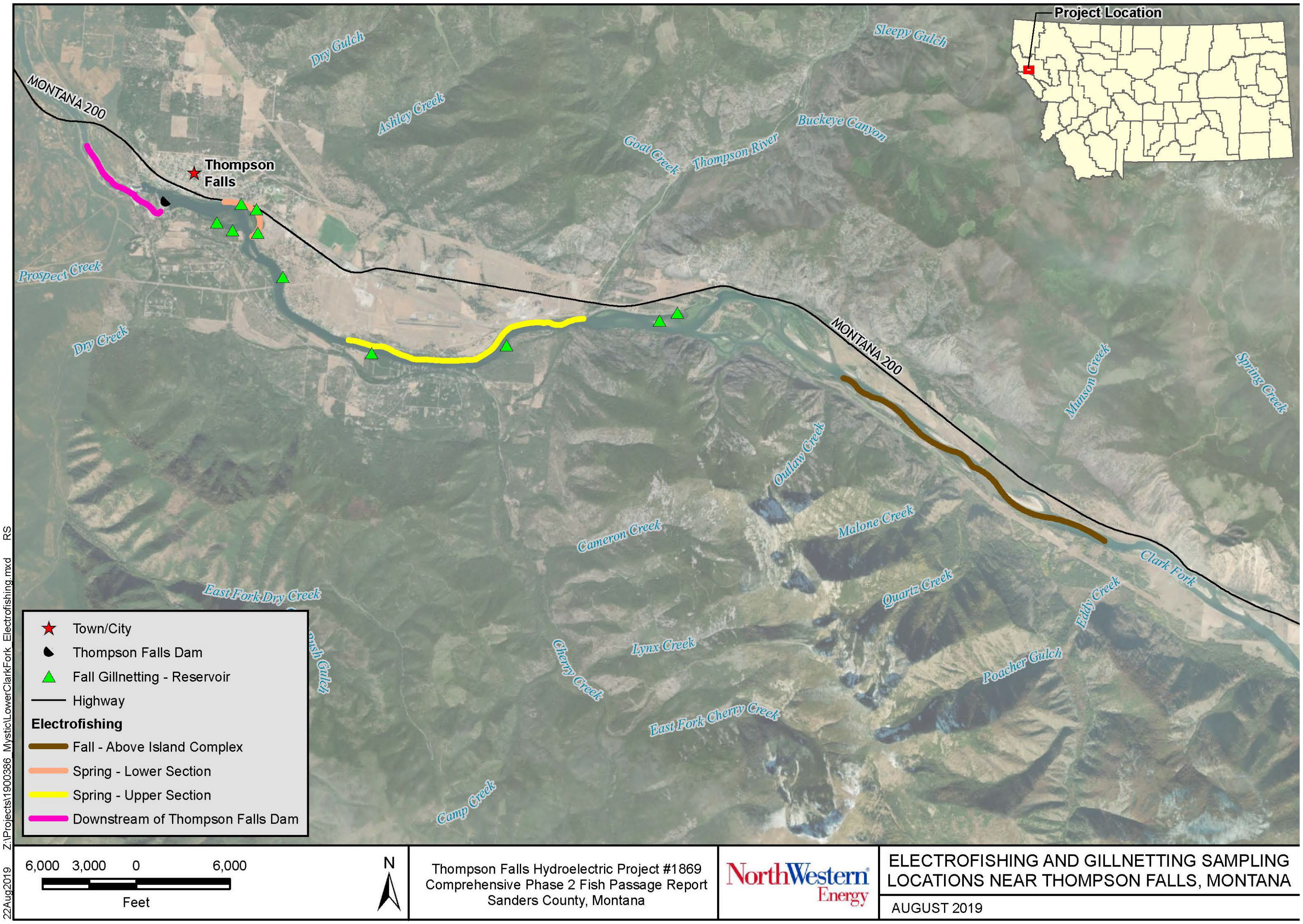
The established gillnet sampling sites in the Thompson Falls Reservoir are shown in Figure 4-7. The Licensee, with support from FWP, have deployed nylon multifilament experimental sinking gillnets, 125 feet long and 6 feet deep, with five separate 25-foot panels consisting of 0.75-, 1-, 1.25-, 1.5-, and 2-inch bar-measure square mesh each October since 2004. In 2004, six nets were deployed. In each year since then, 10 nets have been deployed annually.

4.3.2.2 Spring Electrofishing

Spring electrofishing in the Thompson Falls Reservoir consists of two locations, the lower section located immediately upstream of the Thompson Falls Dams and the upper section located immediately downstream of the confluence with the Thompson River (Figure 4-7). The upper section is on the right bank of the Clark Fork River from the confluence of the Thompson River to about 1 mile (1609 m) downstream of the Cherry Creek boat launch. The upper section has riverine characteristics, with noticeable flowing water, average widths around 459 feet (140 m), little to no aquatic vegetation, and some recreational docks. The lower section has substantially lower water velocity, mean widths near 1,673 feet, abundant aquatic vegetation, and is off the main river channel.

Spring electrofishing is conducted using boat-mounted electrofishing equipment. The boat is navigated slowly along the shoreline at night. The lower section is parallel with Highway 200 from the Wild Goose Landing boat launch, upstream to a location approximately 750 feet (229 m) above the pump house. The reservoir was surveyed annually from 2009 through 2016 with subsequent sampling scheduled for every other year (2018, 2020, etc.).

Figure 4-7. Electrofishing and gillnetting sampling locations near Thompson Falls, Montana (NorthWestern 2019).



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4.3.2.3 Northern Pike Study

Northern Pike are opportunistic feeders and prey upon the available food source, which can include Bull Trout. A study was conducted in 2009 to assess the potential impacts of Northern Pike predation on juvenile and subadult Bull Trout residing in or passing through Thompson Falls Reservoir (PPL Montana, 2010b).

The objectives of the 2009 Northern Pike study included an assessment of population characteristics, population estimate, diet composition, time of spawning, and movement. The 2009 study focused on two locations in the lower Clark Fork River, the lower Thompson Falls Reservoir (from the Thompson Falls Dam upstream approximately 2 miles), and the Island Complex located approximately 7 miles upstream of the Thompson Falls Dam (Figure 4-8).

Sampling was conducted with electrofishing, gillnetting, and angling. Sampling efforts were performed for 31 sampling days over 15 weeks, starting in late March and ending in July 2009. Northern Pike were captured on 25 days (PPL Montana, 2010b).

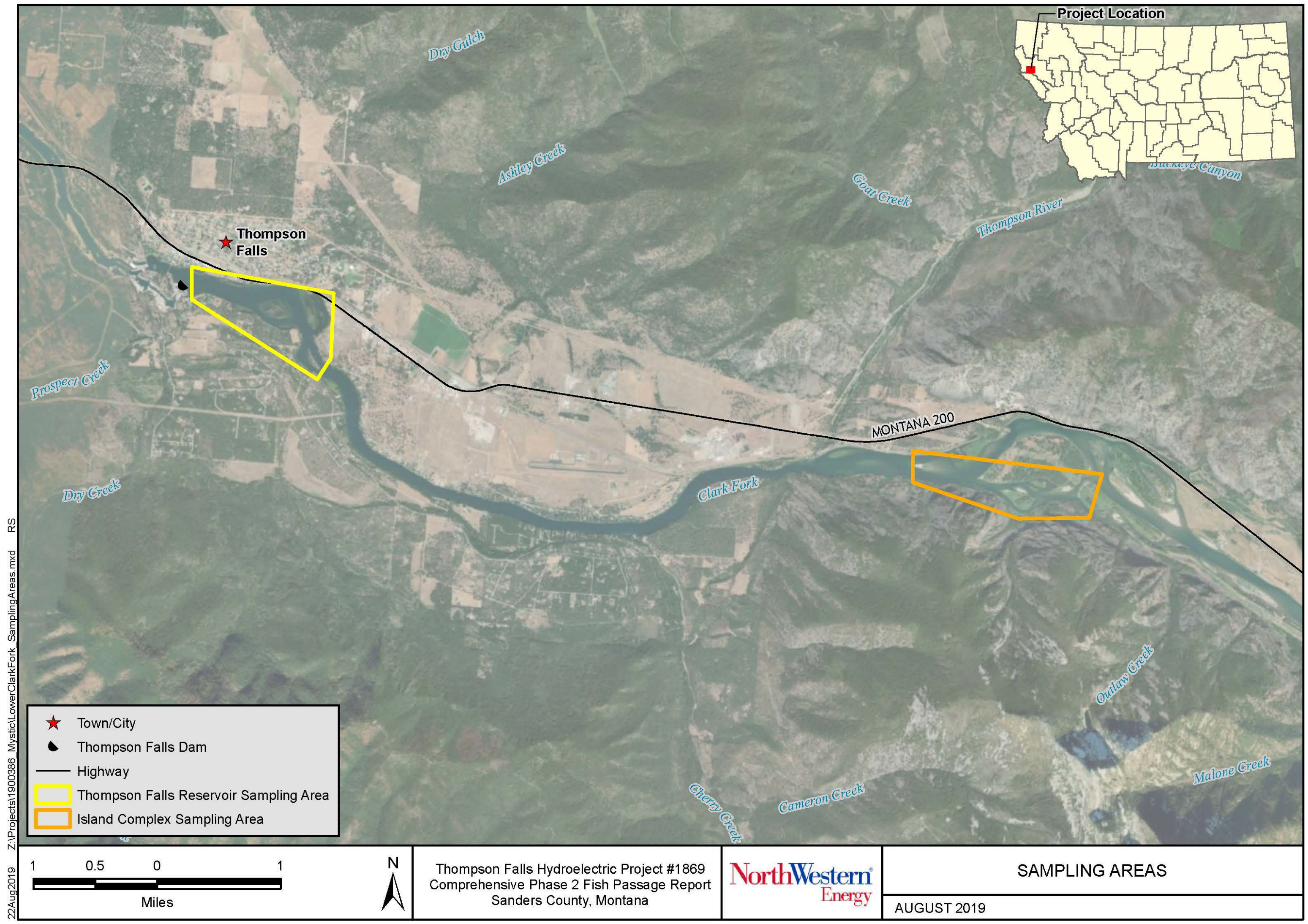
Gillnets were used for sampling Northern Pike between March and May 2009 in the lower Thompson Falls Reservoir sampling area and between March and July 2009 in the Island Complex sampling area. Each sampling effort included four to six gillnets of 1-inch mesh that were 150 feet long and 6 feet deep. The Licensee and FWP electrofished during the daytime hours by boat between April and May 2009 in the lower Thompson Falls Reservoir and between April and June 2009 in the Island Complex. Angling was attempted with hook and line, using smelt for bait. Angling efforts had minimal success and was not considered an effective method of sampling Northern Pike at either sampling area.

Northern Pike characteristics including length, weight, scales for age analysis, and sex were recorded. Age was determined by observing scales under magnification and counting growth annulus. Sex was determined by applying pressure to the abdomen to induce passage of gametes from the urogenital pore. All fish captured were released back into the river with an orange Floy tag implanted on the posterior end of the dorsal fin. Recaptured fish were recorded during subsequent sampling events.

Gastric lavage was performed on Northern Pike longer than 250 mm. Gastric lavage provides an efficient method of removing the stomach contents of live fish. No fish mortality resulted from gastric lavage. Stomach samples were either identified in the field or taken to the lab for identification using a microscope. Stomach content was identified and enumerated, but not weighed.

The Schumacher-Eschmeyer (Ricker, 1975, taken from Schneider, 1998) formula for multiple sampling was applied to calculate population estimates of Northern Pike in the Thompson Falls Reservoir and Island Complex.

Figure 4-8. 2009 Northern Pike Sampling Areas, Thompson Falls, Montana (PPL Montana 2010b).



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4.3.3 *Results – Fall Gillnetting*

Over the 15 years of fall gill net data collection, 14 different fish species have been collected in Thompson Falls Reservoir (Table 4-1). No Bull Trout were sampled during fall gillnetting, but one Bull Trout was sampled during a spring sampling event in 2009 (*see* Section 4.3.5 Results – Northern Pike Study). Salmonids have been found to be rare in Thompson Falls Reservoir in general. Rainbow Trout have been found more commonly than Brown or Westslope Cutthroat Trout, but Rainbow Trout were still very uncommon, averaging 0.1 fish per net (or an average of one fish per year). The most common species in Thompson Falls Reservoir are Black Bullhead, with Northern Pike being the second-most common species.

Table 4-1. Catch per net, by species, during annual October gillnetting series on Thompson Falls Reservoir 2004–2018 average, minimum, and maximum catch per net. A dash indicates no (zero) fish of that species was captured.

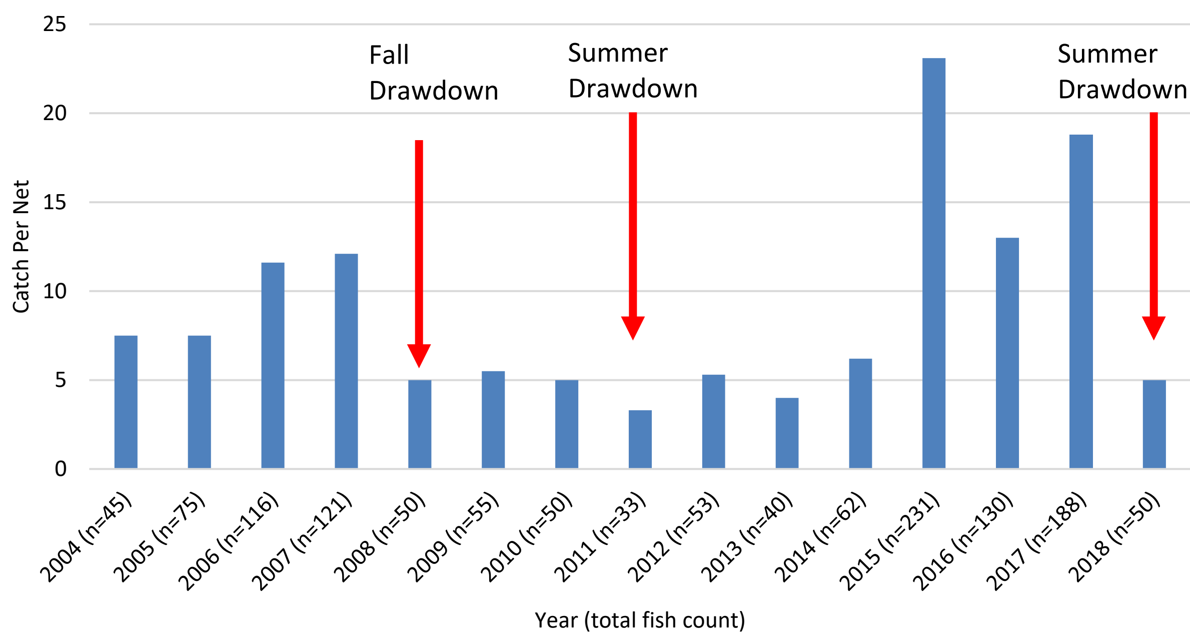
Species	2004-2018		
	Avg	Min	Max
BL BH	3.7	-	14.1
LL	-	-	0.2
LMB	0.1	-	0.3
LN SU	0.1	-	0.5
LS SU	0.8	0.2	1.3
NP	2.5	1.0	4.9
N PMN	0.4	-	1.0
PEA	-	-	0.1
PUMP	0.3	-	1.8
RB	0.1	-	0.4
SMB	0.2	-	0.5
WCT	-	-	0.2
YP	0.8	0.1	1.8
YL BL	-	-	0.1
Total	**8.9**	**3.3**	**23.1**

In years when the Clark Fork River peak flow approaches or exceeds 100,000 cfs, flow is passed over the spillways by releasing stanchions to increase spillway capacity. The stanchions are then replaced after high water. However, the reservoir must be drawn down to crest level (16 feet below full pool at El. 2380 feet) in order to execute the stanchion repair. This can result in the reservoir being drawn down to crest for several weeks in the summer. (It should be noted that the new radial gates will increase spill capacity at the Main Dam and will reduce the frequency when stanchions need to be pulled to pass very high flows and, *see* Discussion on Attractant Flow (*refer to* Section 3.3.5 Attraction Flows) for more information. Reservoir drawdowns for the purpose of repairing the stanchions are much deeper than the 4-foot operational range allowed in the current license.) For example, in the summer of 2011, the

Licensee drew down the reservoir in order to replace stanchions on the dam. The maintenance work resulted in the reservoir drawdown of about 10 feet by the end of July and an additional 3 feet (total 13' below full pool) between August 7 and 19. These drawdowns result in a riverine environment in the reservoir area, which substantially reduced the lacustrine habitat typically available at full pool. These drawdowns have occurred three times since fall gill net data collection in Thompson Falls Reservoir began (fall 2008, summer 2011, 2018).

Some fish species abundance in Thompson Falls Reservoir appears to be reduced by extended drawdowns. Annual gillnetting results since 2004 are shown in Figure 4-9. Total fish caught and catch per net declined from the previous year in years following a deep drawdown. For example, the low number of fish caught in the gillnets in 2011 (the lowest total number of fish caught via gillnetting since monitoring began in 2004) may be a result of the Thompson Falls Reservoir drawdown of up to 13 feet below full pool in August 2011.

Figure 4-9. Summary of the Thompson Falls Reservoir gillnetting efforts 2004-2018. Substantial drawdowns occurred in the summer of 2008, 2011, 2018 prior to the autumn sampling for that year.



The impact of reservoir drawdowns on the numbers of Black Bullhead has been most apparent. Black Bullhead were the most abundant fish species caught in the years before the 2008 drawdown. After a drawdown in fall 2008, no Black Bullheads were caught in 2009 or 2010. The 2008 drawdown began during the 2008 gillnetting efforts thus impacts to the fish community was likely not apparent in 2008. Not all species of fish are equally susceptible to gillnetting, so there may be more Smallmouth Bass present than is reflected in these data.

Northern Pike catch per net also declined from 4.2 to 4.9 fish per net between 2015 and 2017 and to 1.9 fish per net in 2018, which may have also been a response to a deep drawdown in the summer of 2018.

4.3.4 *Results – Spring Electrofishing*

Spring electrofishing surveys in the lower section of the reservoir have observed between 34 and 207 individual fish, representing between seven and 15 species caught per sampling event in 9 years of sampling conducted since 2009 (NorthWestern, 2019). Non-salmonids are more common in the lower section than salmonids. No Bull Trout have been collected during spring electrofishing surveys.

In the upper section of the reservoir, the number of fish captured per sample event has ranged from 63 to 253 individual fish representing nine to 13 species since 2009. Salmonids are more common in the upper section than the lower section, varying from a low of 10 salmonids in 2009 to a high of 115 salmonids in 2013 (NorthWestern, 2019).

Since the fish ladder began operating in 2011, four fish tagged at the Thompson Falls fish ladder (3 RB, 1 WCT) were recorded in the lower electrofishing section and seven ladder fish (4 LL, 3 RB) were subsequently detected in the upper electrofishing section. Three of the four fish collected in the lower electrofishing section were subsequently detected in the Thompson River (NorthWestern, 2019).

The catch per unit effort (CPUE) of salmonids is greater in the upper section than the lower section, averaging 29 salmonids per hour. The lower section averages five salmonids per hour. Non-salmonids such as Largemouth Bass, Northern Pike, Pumpkinseed, and Yellow Perch are on average the most common species captured in the lower section; whereas, Largescale Suckers, Northern Pikeminnow, and Rainbow Trout are on average the most common species captured in the upper section. The differences in species composition and abundance of salmonids is likely related to habitat conditions in each survey section. The upper sampling section is more of a riverine environment. The lower sampling section, which is closer to Thompson Falls Dam, is more lacustrine (lake-like).

4.3.5 *Results – Northern Pike Study*

As a result of 15 weeks of sampling the lower Thompson Falls Reservoir and Island Complex, 170 Northern Pike were captured via gillnetting, electrofishing, and angling. Table 4-2 summarizes the total number of Northern Pike captured, including recaptures, by sampling method and sampling location.

Table 4-2. Summary of Northern Pike sampled in the lower Thompson Falls Reservoir and Island Complex using three sampling methods between March and July 2009 (PPL, Montana, 2010b).

Sampling Method	Number of Northern Pike Sampled		
	Total	Lower Thompson Falls Reservoir (Recaptures)	Island Complex (Recaptures)
Gillnet	59	17 (2)	38 (2)
Electrofishing	101	16 (2)	65 (18)
Angling	10	1 (0)	9 (0)
Total	**170**	**34 (4)**	**112 (20)**

Gillnetting efforts from March 26 through July 9, 2009 also resulted in the capture of nine species other than Northern Pike, including one Bull Trout (PPL Montana, 2010b). The Bull Trout was captured via gillnetting in the Thompson Falls Reservoir on May 1, 2009. The Bull Trout was 271 millimeters (mm) long and weighed 174 grams (g). Genetic results indicate the fish was assigned to Fishtrap Creek, a tributary to Thompson River.

4.3.5.1 Population Characteristics

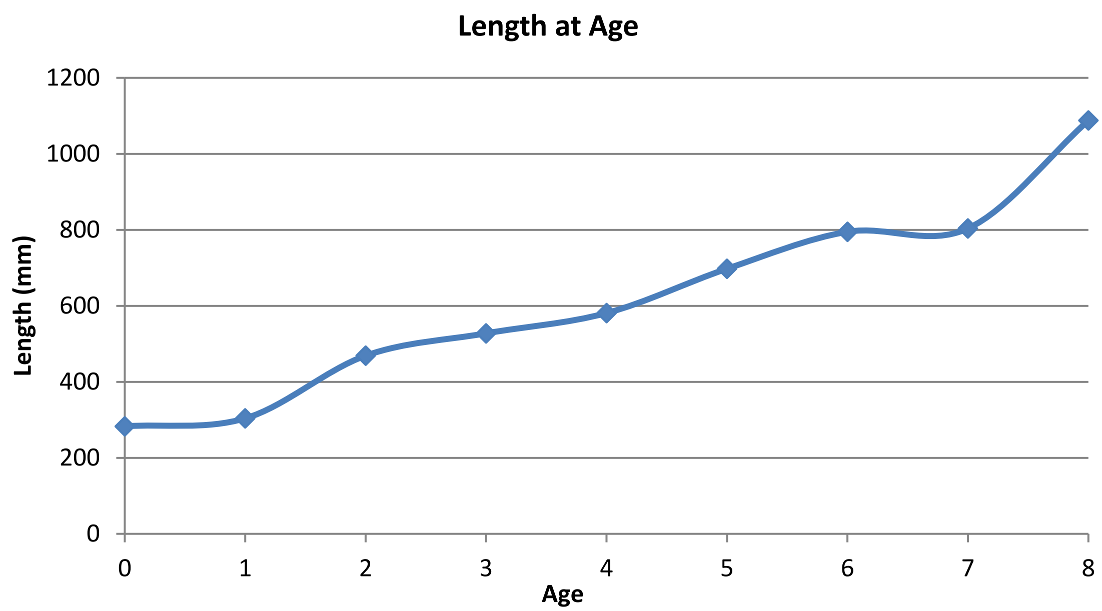
Table 4-3 summarizes Northern Pike length (mm) and weight (g) by sample location. The data below reflect sampling efforts between March and July 2009 and do not include recaptured Northern Pike.

Table 4-3. Summary of population characteristics for Northern Pike sampled between March and July 2009 in the Thompson Falls Reservoir and Island Complex via gillnetting, electrofishing, and angling (PPL Montana, 2010b).

Location and Sampling Method	Length (mm)			Weight (g)		
	N	Average	Range	N	Average	Range
Thompson Falls Reservoir	34	538	290-801	33	1,479	150-4,810
Island Complex	111	594	228-1,088	109	2,006	66-12,000
TOTAL	**145**	**581**	**228-1,008**	**142**	**1,884**	**66-12,000**

Of the 170 Northern Pike captured, 116 were aged by scale analysis. Age data represents both sampling locations and ranges from 0 to 8 years. A summary of the age data is present in Figure 4-10.

Figure 4-10. Age estimate and length for 116 Northern Pike sampled via gillnetting, electrofishing, and angling in the Thompson Falls Reservoir and Island Complex (PPL Montana, 2010b).



Population estimates were calculated for the lower Thompson Falls Reservoir and Island Complex locations using the Schumacher-Eschmeyer method (PPL Montana, 2010b). All sampling techniques were included in the population estimate approximation. Population estimates and 95 percent confidence intervals are presented in Table 4-4.

Table 4-4. Summary of the population estimates (N) and approximate 95 percent confidence limits for Northern Pike in the Thompson Falls Reservoir and Island Complex (PPL Montana, 2010b).

Location	N	95% Lower Confidence Limit	95% Upper Confidence Limit
Thompson Falls Reservoir	177	98	918
Island Complex	562	309	636

4.3.5.2 Spawning

Northern Pike typically spawn in the spring after ice-out between March and May (Holton, 2003). Typically, Northern Pike will spawn once water temperatures range between 46 and 53 °F (7.8–11.7 °C) (Casselman and Lewis, 1996).

During the sampling efforts between March and July 2009, the gender of 81 Northern Pike (63 males and 18 females) was recorded. The gender of the remaining 89 Northern Pike was either unknown or not recorded. Of the 63 males, 60 males were classified as ripe (meaning having fully mature gametes). Ripe males were observed in the Thompson Falls Reservoir and Island Complex from April 6 through May 27 (PPL Montana, 2010b).

Of the 18 females, 5 females were classified as gravid and 4 females were classified as spent. Gravid females were observed from April 20 through April 30. The four spent females were observed between April 30 and May 27. Gravid and spent females were only documented in the Island Complex. Female Northern Pike were observed in the Thompson Falls Reservoir; however, none were observed to be gravid or spent.

From March to June 2009, river temperatures ranged between 40 and 59 °F (4.4–15 °C). When gravid females were observed in April, water temperatures were between 43 and 50 °F (6.1–10 °C). Temperatures recorded in the field were within the range suitable for Northern Pike spawning (Casselman and Lewis, 1996). River temperature and observed condition of female Northern Pike in 2009 indicate Northern Pike spawning season in this area of the Clark Fork River is in April and May (PPL Montana, 2010b).

4.3.5.3 Diet Composition

Gastric lavage was performed on 143 Northern Pike, 84 collected using electrofishing, 50 collected using gillnetting, and nine collected angling. A summary of the number of Northern Pike with stomach content *versus* empty stomachs is presented in Table 4-5 below.

Table 4-5. Summary of gastric lavage performed on 143 Northern Pike. The data are summarized by sampling location and method, and whether the stomach was full or empty.

Sampling Location	Stomach Content	Stomach Empty	Total
Lower Thompson Falls Reservoir	9	22	31
Island Complex	52	60	112
TOTAL	**61**	**82**	**143**

Diet composition included fish, insects, leeches, worms, a frog, a pocket gopher, and grass. Of the 152 items identified in the stomachs, 118 (78%) were classified as fish (Figure 4-11). Fish species observed in the stomach content included Mountain Whitefish, Peamouth, Northern Pikeminnow, Rainbow/Cutthroat Trout, Bull Trout, Largescale Sucker, unknown sucker species, Yellow Perch, unknown *Oncorhynchus* spp., and unknown small fish (Figure 4-12). Unknown fish include small fish and fish parts that were not identified to the species level.

One Bull Trout approximately 150 mm in length was recorded in a Northern Pike captured in the Island Complex via gillnetting on April 30, 2009. The Northern Pike that ate the Bull Trout was a ripe male that measured 480 mm in length and weighed 825 g.

Figure 4-11. Summary of diet composition observed in the 61 Northern Pike stomachs sampled via gillnetting, electrofishing, and angling in the lower Thompson Falls Reservoir and Island Complex from March through July 2009 (PPL Montana, 2010b).

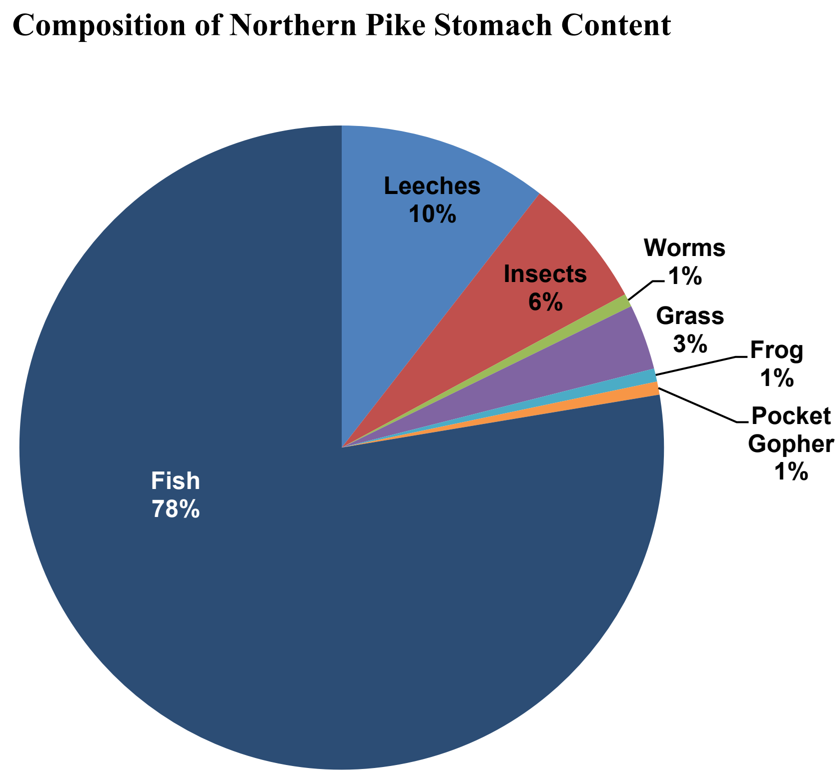
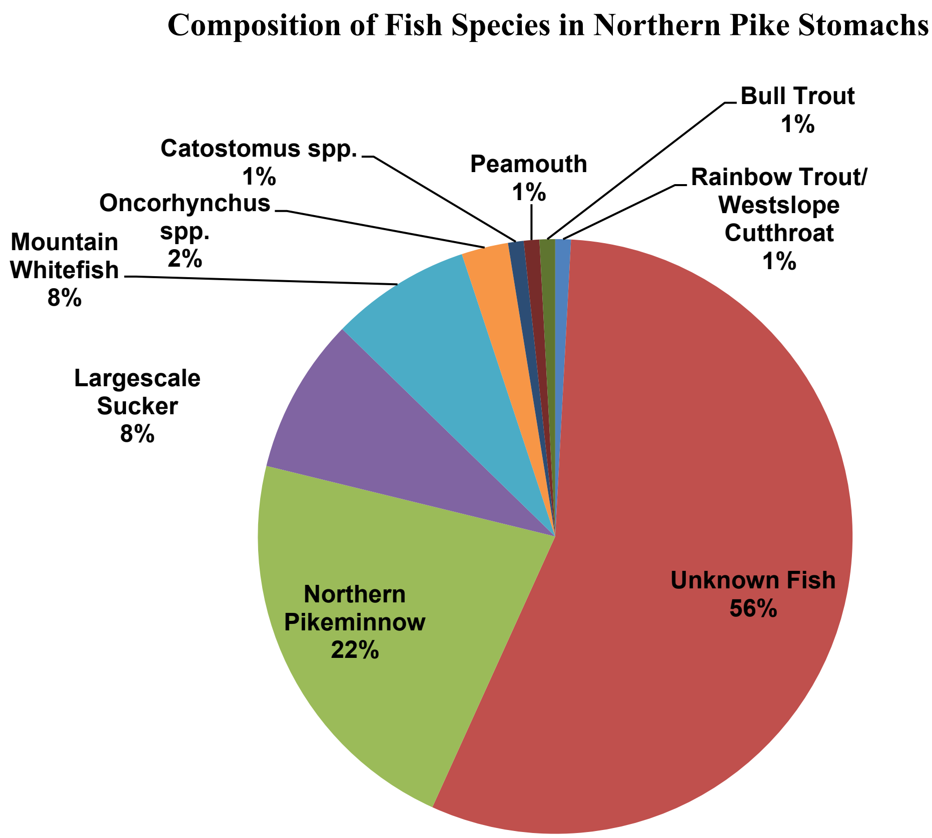


Figure 4-12. Composition (by number) of fish species observed in the 61 Northern Pike stomachs sampled in the lower Thompson Falls Reservoir and Island Complex via electrofishing, gillnetting, and angling (PPL Montana, 2010b).



4.3.5.4 Movement

Northern Pike movements between the Thompson Falls Reservoir and Island Complex were studied through the multiple mark-recapture census between March and July 2009. Movement of Northern Pike was also documented through angler recovery of tagged Northern Pike.

The mark-recapture efforts resulted in a total of 146 Northern Pike tagged with an orange Floy tag, 112 from the Island Complex and 34 from the lower Thompson Falls Reservoir (PPL Montana, 2010b). During this study, a total of 24 Northern Pike were recaptured via gillnetting or electrofishing. All except one of the 24 recaptured Northern Pike had been initially tagged in 2009. One recapture had been marked with a yellow Floy tag in April 2008.

All 23 Northern Pike tagged and recaptured in 2009 were recaptured in the same sampling location. The one Northern Pike that was tagged in 2008 and recaptured 13 months later had moved from the lower Thompson Falls Reservoir upstream to the Island Complex. Two tagged Northern Pike were recaptured twice, and one tagged Northern Pike was recaptured three times (PPL Montana, 2010b).

FWP was contacted by several anglers between May 15 and December 11, 2009 with location information for 20 Northern Pike marked with Floy tags. Angling reports indicate approximately 14 percent of tagged Northern Pike from this study were harvested within 9 months of being tagged.

In three of the 20 angler reports, the location where the Northern Pike were captured was not provided. In 11 reports, the angler caught the Northern Pike in the same general location as it had been initially tagged. In the remaining six reports, the Northern Pike was caught in a new location. Three Northern Pike that were initially tagged in the Island Complex that were later caught in the lower Thompson Falls Reservoir; two Northern Pike tagged in the lower Thompson Falls Reservoir were later caught downstream of the Thompson Falls Dam; and one Northern Pike tagged in the lower Thompson Falls Reservoir was caught upstream, near Plains (approximately 22 miles southeast of Thompson Falls). It is not known if the Northern Pike that passed downstream of the dam were passed over the spillway or through the turbines. However, it is apparent that they survived passage.

Data collected in 2009 indicate Northern Pike are not isolated to the lower Thompson Falls Reservoir or the Island Complex. Northern Pike move between these two locations and migrate up and downstream of these two locations.

4.3.6 *Discussion*

No Bull Trout have been collected in Thompson Falls Reservoir during fall gillnetting (conducted since 2004) and spring electrofishing surveys (conducted since 2009). One Bull Trout was collected via gillnet in the reservoir in May 2009 and a second Bull Trout was identified in the stomach content of a Northern Pike caught gillnetting near the Island complex in April 2009 (PPL Montana, 2010b). Bull Trout presence in the Thompson Reservoir based on recent data collection is rare. However, Bull Trout must be present in Thompson Falls Reservoir at some level during some seasons because adult Bull Trout are collected downstream of Cabinet Gorge Dam that have a genetic profile indicating that the Thompson River is their natal stream. This indicates that a population of migratory, adfluvial Bull Trout persists, and this population must pass through Thompson Falls Reservoir to complete their life history. However, the numbers of adfluvial Bull Trout appear to be very low.

Given their apparent rarity, there is no evidence that Bull Trout reside in Thompson Falls Reservoir for any length of time. The evidence suggests that Thompson Falls Reservoir is used as a migratory corridor.

The 2009 Northern Pike study provided information on population characteristics, spawning, diet composition, and movement of Northern Pike present in two locations in Thompson Falls Reservoir, which is helpful for assessing the risk that this species poses to migratory Bull Trout.

It is apparent that Northern Pike are more abundant in the Island Complex area than they are further downstream in lower Thompson Falls Reservoir. The Island Complex is a wider area of the river with slower water velocity and more backwater habitat of the type that is favored by Northern Pike.

The Island Complex is upstream of the confluence of the Thompson River with the Clark Fork River. Bull Trout migrating to or from the Thompson River to habitats downstream are unlikely to pass through the Island Complex area of the Clark Fork River. However, Bull Trout migrating from other tributaries in the middle Clark Fork River upstream of the Thompson River would pass through the Island Complex.

Specific spawning locations were not determined during this study, however, gravid and spent females were only noted in the Island Complex area. Ripe males were found in both sampling areas.

Northern Pike were found to eat a varied diet, but primarily fish. Northern Pikeminnow, Largescale Sucker, and Mountain Whitefish were the most abundant prey items that could be identified. These finding are consistent with results of a Northern Pike study conducted at the former Milltown Reservoir on the Clark Fork River upstream of Thompson Falls Hydroelectric Project (Schmetterling, 2001). Schmetterling (2001) found Northern Pike in Milltown Reservoir exhibited seasonal shifts in diet, which corresponded to movement of fish through the reservoir. In March, Largescale Sucker, Northern Pikeminnow, and Mountain Whitefish were the most abundant species in the stomachs of Northern Pike in Milltown Reservoir, similar to the findings at Thompson Falls.

However, at Milltown, Bull Trout were the single most abundant species collected from Northern Pike stomachs over a 3-week period in May during high water (Schmetterling, 2001). Schmetterling (2001) did not find Bull Trout in stomachs of Northern Pike during the summer or fall sampling. At Thompson Falls, one Bull Trout was found in a Northern Pike stomach on April 30, 2009.

The evidence indicates that there is predation risk to Bull Trout in the Island Complex area, where Northern Pike densities are the highest, and during the April to May time period when juvenile Bull Trout may be outmigrating from upstream tributaries. Fall outmigrants would also be at risk of predation from Northern Pike, however, the Northern Pike diet study was not conducted in the fall and so such predation has not been documented locally at that time of year. The risks to juvenile Bull Trout outmigrants from the Thompson River may be less, as they do not need to pass through the Island Complex area.

4.4 Thompson River Bull Trout Enhancement and Recovery Plan

4.4.1 *Introduction*

The Thompson Falls TAC has identified the Thompson River as a critical drainage to concentrate Bull Trout conservation measures and allocation of MOU funding.

Bull Trout conservation measures were identified for implementation with the overall goal to, "boost recruitment of juvenile Bull Trout and partially mitigate for incidental take of Bull Trout caused by downstream passage through the turbines and spillways at Thompson Falls Dam" (FWS, 2008).

In 2013, the Licensee completed a Thompson River Bull Trout Enhancement and Recovery Plan (GEI and Steigers, 2013), also referred to as the Thompson River Plan. The objective of the Thompson River Plan was to identify projects that focus on the recovery and enhancement of migratory Bull Trout in the Thompson River drainage.

The Thompson River Plan included an analysis identifying potential Bull Trout habitat patches and critical limiting factors. The results of the analysis were used to:

- Identify and prioritize potential Bull Trout habitat enhancement projects that focus on the recovery of Bull Trout
- Identify subwatersheds that would benefit from additional studies or sampling
- Identify subwatersheds that do not meet the criteria to support Bull Trout and should not be included on the priority list for further Bull Trout sampling or habitat improvement

Identifying potential Bull Trout habitat patches and critical limiting factors facilitates the process of identifying prospective projects to enhance Bull Trout habitat and recovery.

4.4.2 *Methods*

The first objective in the Thompson River Plan was characterization of Bull Trout in the Thompson River drainage. To address this objective, the Licensee coordinated with several agencies and organizations to gather historic information (data and reports) on streams in the Thompson River drainage. Information was provided by Plum Creek Timber Company (now Weyerhaeuser), Avista, USFS, MDEQ, FWS, and FWP. The data were compiled into a database which includes information from 1973 through 2011.

The information gathered was used to identify potential Bull Trout habitat patches, identify limiting factors, and develop recommendations for projects focused on migratory Bull Trout recovery. To evaluate potential Bull Trout habitat in the Thompson River drainage at the subwatershed level, criteria and methodologies presented in Isaak et al. (2009) were utilized to delineate suitable Bull Trout patches or habitat areas. Data used in this analysis included summer stream temperatures, stream width measurements, stream gradient, and presence of known manmade barriers.

Stream temperature is a strong predictor of presence of Bull Trout because of their cold water habitat requirements (Rieman and McIntyre, 1993). Weyerhaeuser provided stream temperature monitoring records for various locations in the Thompson River drainage that had been collected between late June and October from 1999 to 2011 (Weyerhauser, unpublished data). This was the most comprehensive dataset for stream temperature available in the drainage.

In addition, temperature loggers were deployed in the summer of 2012 to monitor stream temperatures in the mainstem Thompson River and several tributary streams. The goal was to have a more comprehensive dataset of summer stream temperatures in the Thompson River drainage, including areas previously monitored and areas with limited data, taken during the same time period.

The mean weekly maximum temperature (MWMT) was separated into three categories based on Bull Trout thermal suitability (Isaak et al., 2009):

- Low thermal suitability (>17.5 °C)
- Medium thermal suitability (>15 and ≤ 17.5 °C)
- High thermal suitability (≤ 15 °C)

Temperature data collected by the USFS and FWP were also used to assess the thermal suitability of the streams in the Thompson River watershed. This data set included single temperature readings collected during fish and habitat surveys. The single temperature readings were often in known Bull Trout areas (e.g., Big Rock Creek, West Fork Thompson River).

Bull Trout are rarely found in streams less than approximately 30 to 6 feet (1 to 2 meters) in width (Rieman and McIntyre, 1993, Isaak et al., 2009). Therefore, streams less than 6 feet (2 meters) in width were screened out as being unsuitable as Bull Trout habitat.

There was a limited data set of stream widths available in the watershed. However, studies have found a relationship between the size of the watershed and stream width (Isaak et al., 2009). Therefore, drainage area was used as a surrogate for stream width for the habitat screening. Using Geographic Information System (GIS), the contributing area upstream of each available stream width measurement was calculated and used to establish a relationship between stream width and subwatershed size/contributing area. This information was used to extrapolate which subwatersheds were likely to support stream widths greater than 2 meters. This analysis found that watersheds less than 2 square miles (mi^2) (5.2 km^2) rarely, if ever, produce streams larger than 6 feet (2 meters) in width. Therefore, watersheds less than 2 mi^2 (5.2 km^2) were screened out as potential Bull Trout habitat.

Streams with steep slopes (exceeding 15–20%) are unlikely to provide primary spawning and rearing habitat and are more likely to consist of geologic barriers to migration (Isaak et al., 2009). Digital elevation models in GIS were used to assess potential stream gradient and exclude areas of the Thompson River drainage where stream gradients exceed 15 percent.

The last criteria used in this analysis included known barriers to upstream fish movement in the drainage. The USFS (Lolo National Forest) provided a GIS layer with these data (unpublished data). The majority of the manmade barriers in the drainage are related to the existing road network. Additional information on barriers was supplied by Weyerhaeuser.

The output of this GIS analysis of temperature, stream width, stream gradient, and fish migration barriers delineated the location of potential Bull Trout patches in the Thompson River drainage. These data were then compared to known Bull Trout locations to verify the process was, at a minimum, including known Bull Trout populations.

Ranking criteria were established to prioritize Bull Trout management activities in the Thompson River drainage. The highest priority will be placed on (in order of importance):

- Preserving the best quality migratory Bull Trout habitat
- Improving, as needed, migratory Bull Trout habitat which is presently used by migratory Bull Trout
- Extending the range of migratory Bull Trout

4.4.3 *Results – Bull Trout in the Thompson River Drainage*

The Thompson River Plan found that Bull Trout are known to be present in the following areas of the Thompson River drainage (GEI and Steigers, 2013):

- Fishtrap Creek and tributaries Beartrap (Fork) Creek, West Fork Fishtrap Creek, Beatrice Creek, and Jungle Creek
- West Fork Thompson River and tributaries Anne Creek, Four Lakes Creek, Big Spruce Creek
- Big Rock Creek
- Mainstem of the Thompson River

One adult Bull Trout was observed in lower section of Murr Creek in the late 1990s, near the confluence with the Thompson River (Plum Creek, 1998). A waterfall barrier prevents upstream movement of fish in that stream.

It does not appear that there is a Bull Trout subpopulation currently present in the Little Thompson River watershed. FWP's data from MFISH Fishing Log in 1977 identified one Bull Trout in the Little Thompson River. There were no other Bull Trout sightings in that stream since 1977 (FWP, 2010).

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). Trapping and telemetry studies completed since 2001 have monitored movement patterns of Bull Trout in the Thompson River drainage. The data indicate West Fork Thompson River and Fishtrap Creek provide important spawning and rearing habitat for Bull Trout. A more recent study (Glaid, 2017) revealed Bull Trout utilized the mainstem Thompson River year-round and not just as a corridor for migration and critical overwintering habitat.

4.4.4 *Results – Habitat Analysis of the Thompson River Drainage*

Suitable Bull Trout habitat areas in the Thompson River were identified based on the analysis of temperature, stream width, and slope thresholds as outlined by Isaak et al. (2009) and are shown in Figure 4-13. Green dots indicate locations where the maximum weekly maximum temperature (MWMT) was found to be 59 ºF (15 °C) or less. A stream with a MWMT in this range is thermally suitable for Bull Trout in the summer months. Yellow dots indicate temperatures greater than 59 ºF (15 °C) but less than or equal to 63.5 ºF (17.5 °C). This temperature range is marginal for Bull Trout summer use. Red dots are the MWMT in excess of 63.5 ºF (17.5 °C), with low thermal suitability for Bull Trout in the summer. The map includes data collected in 2012, as well as data gathered in previous years by other researchers.

The watersheds shaded in green are those that, in general, appear to be thermally suitable for Bull Trout in the summer. It should be noted that the decision to shade a watershed in green was somewhat subjective. Some watersheds have localized areas that may, or may not, be thermally suitable for Bull Trout. In addition, there is variation from year to year. Some locations may have borderline conditions, where water temperatures are suitable in cool years but marginal or unsuitable in warm years. Therefore, the decision to shade a watershed in green was made based on the preponderance of the evidence.

Watersheds smaller than 2 mi^2 (5.2 km^2) were shaded in brown. These are watersheds estimated to be too small to produce a stream of sufficient size to support Bull Trout (Isaak et al., 2009).

Portions of streams which are estimated to be in excess of 15 percent slope are shaded in red (Isaak et al., 2009). The decision about the red shading was also subjective. Many streams have short reaches of steep slope, but are not, overall, steep. Therefore, the determination of which streams were “too steep” was based on the overall character of the stream reach.

The Thompson River has a series of lakes in the headwaters. The large surface area of the lakes results in warm water temperatures. Therefore, water temperature in the headwaters of the Thompson River is relatively warm, and then decreases downstream as cooler tributaries contribute to the river. However, none of the tributaries of the upstream portions of the Thompson River have a large enough cold water volume to cool the mainstem Thompson River to a sufficient extent to bring the MWMT into the suitable or marginal range for Bull Trout in the summer months. Thus, the entire mainstem upstream of Fishtrap Creek is in the unsuitable summer temperature range for Bull Trout.

Temperature monitoring in the mainstem Thompson River in the summer of 2012 found that none of the sites monitored were thermally suitable for Bull Trout in the summer, although the most downstream two sites (at the gaging station and at the mouth) were in the marginal range. The monitoring site below McGregor Creek (the most upstream site) had the highest MWMT recorded in the mainstem, at 77.5 ºF (25.3 ºC). Water temperature downstream of the confluence of Fishtrap Creek, which is located between RM 15 and 16, is much cooler than water temperature upstream of Fishtrap Creek. It should be noted that Bull Trout use the mainstem Thompson River as a migratory corridor and for over wintering, and so thermal exceedances in the summer months do not fully exclude the species.

Water temperature data collected in the West Fork Thompson River indicate that this stream has summer water temperatures that are suitable for Bull Trout. While there are some headwater portions of the West Fork Thompson River that may be too steep or small to support Bull Trout, the majority of the watershed is suitable for Bull Trout.

Summer water temperatures are in the optimal range for all of the tributaries of Fishtrap Creek where temperature has been monitored, and most of the mainstem in many years. Stream temperatures in upper Fishtrap Creek are considerably warmer than stream temperatures measured downstream, potentially as a result of naturally occurring meadows and low-gradient beaver affected streams. While there are some smaller tributaries and headwater areas within the Fishtrap Creek watershed that are either too steep or too small to be suitable Bull Trout habitat, most of the 60,000-acre watershed is suitable Bull Trout habitat in terms of summer water temperature, stream slope, and stream width.

Summer water temperature in the mainstem Little Thompson River is in the unsuitable range for Bull Trout, although there may be some tributary areas of the Little Thompson River (North Fork Little Thompson and Mudd Creek) that are cold enough to support Bull Trout rearing.

The Big Rock Creek Bull Trout population is the most upstream Bull Trout population known to occur in the Thompson River drainage. It is not known if these fish are strictly resident, or if there is migratory Bull Trout use of the watershed. While some of the tributaries to Big Rock Creek are too steep or small to support Bull Trout, the stream as a whole appears to have generally suitable conditions to support Bull Trout.

The Thompson River Plan noted that other tributary streams in the Thompson River drainage with suitable habitat conditions to potentially support Bull Trout include Alder, Murr, Lazier, Twin Lakes, and Indian creeks. Following the recommendations in the Thompson River Plan, FWP, with assistance from PPL Montana, completed fish surveys in Big Rock, Lazier, Indian, and Twin Lakes creeks (in 2013) and Murr Creek (in 2014). Sample locations are shown in Figure 4-14.

Figure 4-13. Results of Bull Trout habitat suitability analysis, Thompson River drainage, Montana.

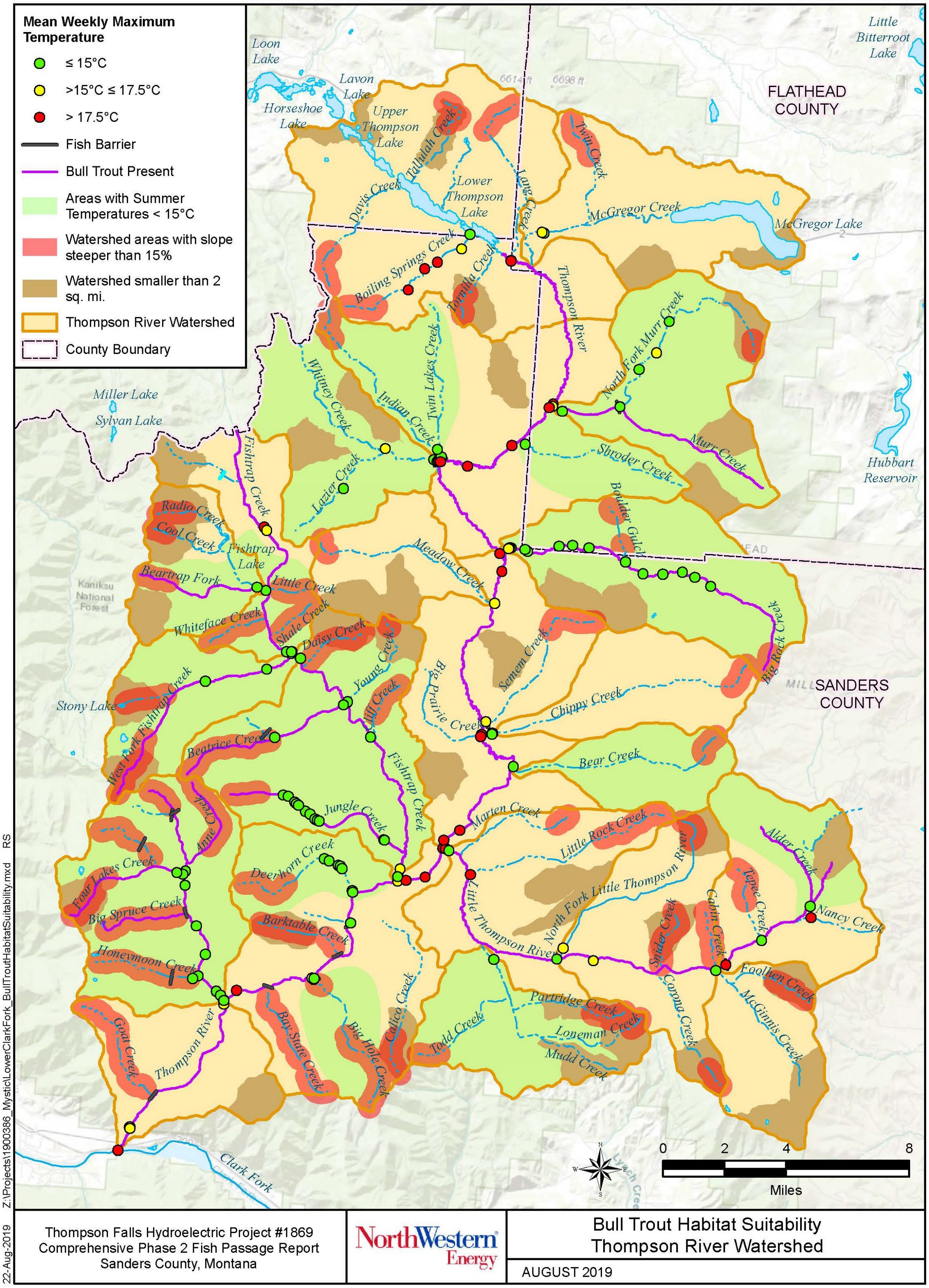
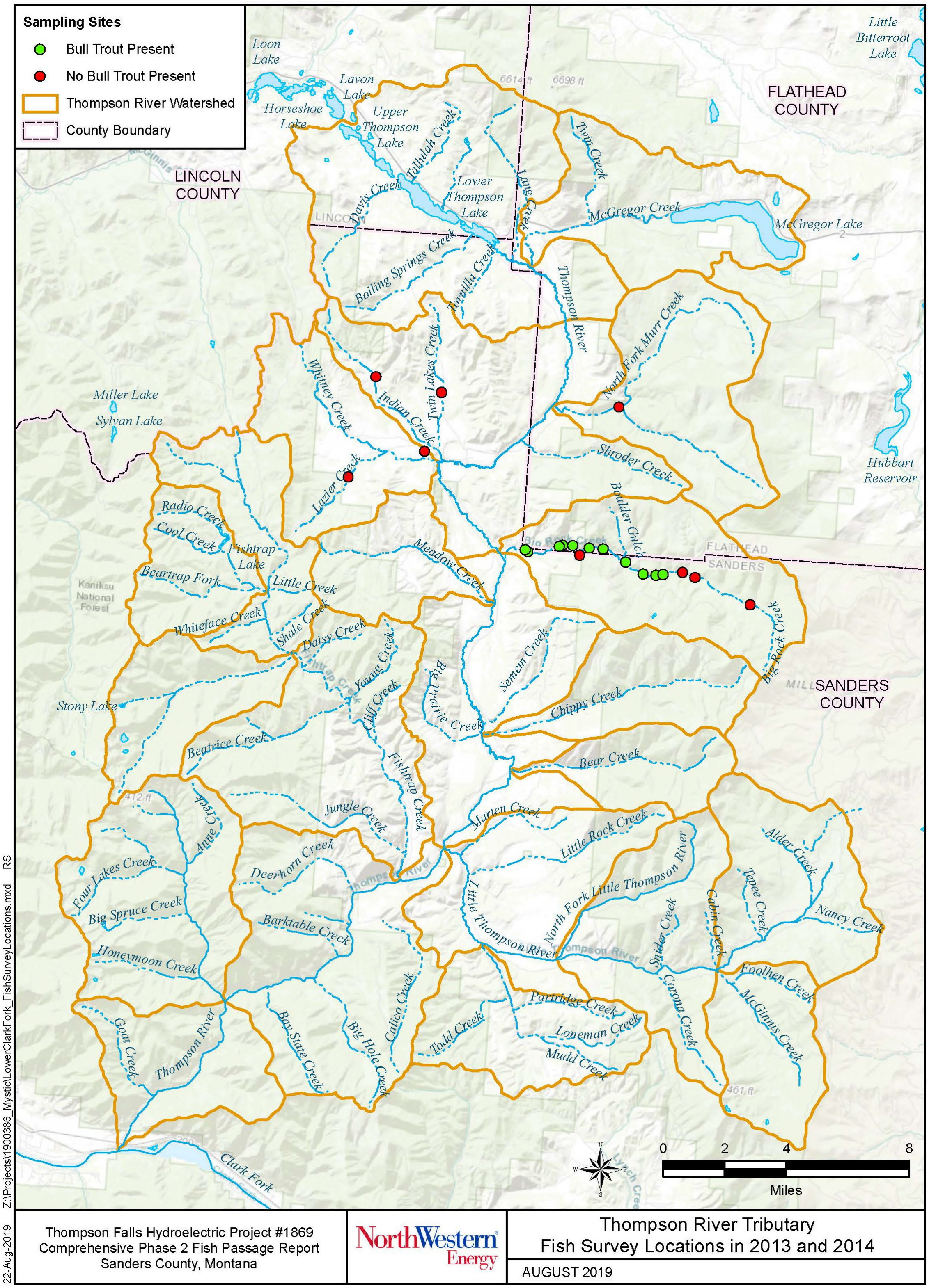


Figure 4-14. Thompson River tributary fish survey locations in 2013 and 2014.



No Bull Trout were observed in Indian, Lazier, Murr, or Twin Lakes creeks. Water from Twin Lakes Creek is diverted for irrigation and the creek is not hydrologically connected to the Thompson River.

In Big Rock Creek, Bull Trout were observed in the three of the five reaches surveyed in 2013. Bull Trout were not detected near the confluence of Big Rock Creek with the Thompson River or in the headwaters. The Bull Trout in Big Rock Creek are thought to be a resident population based on 1) a lack of captures in the mainstem Thompson River near the creek; 2) the observation of resident adult-sized fish at several sections; and 3) lower genetic variation than other nearby populations (DeHaan et al., 2015; Kreiner and Terrazas, 2018).

4.4.5 *Discussion*

Migratory Bull Trout are known to utilize two subwatersheds in the Thompson River drainage, the West Fork Thompson River and Fishtrap Creek. To the extent that there are habitat problems in these two watersheds which can be repaired, or habitat functions that can be enhanced, then those efforts will potentially benefit the migratory life history. For this reason, the Thompson River Plan recommended that these two watersheds have the top priority for any habitat improvement project.

The mainstem Thompson River downstream of Fishtrap Creek is the migratory corridor for Bull Trout. There is also evidence to indicate that this river is used for overwintering by migratory Bull Trout. The Thompson River Plan recommended that habitat improvement projects which would enhance overwintering habitat, and security for adult Bull Trout at all times of the year, would be an additional top priority.

As a second priority, the Thompson River Plan recommended additional research be conducted to determine if the Big Rock Creek Bull Trout population is migratory. However, subsequent data collection indicates that Big Rock Creek likely contains a resident population.

At the time the BiOp was prepared, it was assumed that the Thompson River was likely the most important tributary in the Thompson Falls area. It appears this assumption was correct, as at least 25 percent of the tagged fish (and 27% of the Bull Trout), passed at the ladder were subsequently detected entering the Thompson River. The focus on habitat protection and improvement in this watershed is warranted.

Since the time that the Thompson River Plan was prepared there have been three projects in the Thompson River plus one watershed coordinator position for the Thompson River funded by the Thompson Falls TAC. These projects include 3-years of funding for the graduate work completed by Glaid (2017) studying subadult juvenile outmigration from the Thompson River drainage (*see* Section 4.5 Subadult Bull Trout Out-Migration from the Thompson River Drainage), Thompson River fish surveys in 2013 and 2014, culvert removal in Beartrap Fork Creek (tributary to Fishtrap Creek) in 2018, and a proposed road realignment project in West

Fork Fishtrap Creek in 2019. Before the Thompson River Plan a habitat restoration project to relocate a road was implemented in lower Big Rock Creek.

4.5 Subadult Bull Trout Out-Migration from the Thompson River Drainage

4.5.1 *Introduction*

The Thompson River drainage appears to be the primary spawning and rearing habitat for Bull Trout in the Project area (Thompson Falls Reservoir and the Clark Fork River in the vicinity) (FWS, 2008). As described above, the TAC has identified the Thompson River as a critical drainage to concentrate Bull Trout minimization measures and allocation of MOU funding. Migratory Bull Trout are known to occur in two tributaries of the Thompson River, the West Fork Thompson River and Fishtrap Creek (Liermann, 2003; Liermann et al., 2003; Glaid, 2017).

There is a paucity of information on the outmigration characteristics of juvenile and subadult Bull Trout in general. At Thompson Falls, at the time the BiOp (FWS, 2008) was prepared, there was no site-specific information on the timing of juvenile Bull Trout outmigration through Thompson Falls Reservoir. To address this data gap, the Licensee provided financial and logistical support for a graduate research project to assess subadult Bull Trout outmigration in the Thompson River drainage.

Since the time that the graduate study was conducted, the Licensee has continued to fund monitoring of Bull Trout migration into and out of the Thompson River drainage, with the results described below.

4.5.2 *Methods*

In order to assess the outmigration characteristics of subadult Bull Trout (100 – 300 mm total length) from the Thompson River drainage, Bull Trout were tagged with PIT tags starting with studies conducted in by FWP in 2000 through 2002 (Liermann, 2003). Weir traps were installed in the West Fork Thompson River and in Fishtrap Creek. Bull Trout collected in those traps were tagged with PIT tags and released.

In 2014 and 2015, the Licensee funded a graduate study which looked at juvenile outmigration from the Thompson River drainage (Glaid, 2017). During that study, Bull Trout were collected and tagged with PIT tags (Table 4-6) An additional, 29 Bull Trout were tagged with acoustic transmitters in 2014. FWP tagged additional Bull Trout in the drainage in 2016, 2017, and 2018 (Table 4-6).

Remote PIT tag detector arrays were installed near the mouths of the mainstem Thompson River, West Fork Thompson River, and Fishtrap Creek. The West Fork Thompson River and Fishtrap arrays have been maintained sporadically, with primary downtime occurring in the spring (NorthWestern, 2019). The mainstem array has been more consistently operated

(Kreiner and Terrazas, 2018). Details of collecting, tagging, and detection techniques can be found in Glaid (2017) and Kreiner and Terrazas (2018).

Table 4-6. Numbers and location of Bull Trout tagged with PIT tags during outmigration studies in the Thompson River drainage (*Source*: Glaid, 2017; Kreiner and Terrazas, 2018; FWP unpublished data 2019).

Location	Year					Total
	2014	2015	2016	2017	2018	
Fishtrap Creek Watershed						
WF Fishtrap Ck		137	10	34	3	184
Beatrice Ck		107		1		108
Jungle Ck		39				39
Radio Ck			1			1
Fishtrap Ck		140	6	21	9	176
Fishtrap Creek Watershed Subtotal	**0**	**423**	**17**	**56**	**12**	**507**
West Fork Thompson River Watershed						
WF Thompson R	53	149		36		238
WF Thompson River Watershed Subtotal	**53**	**149**		**36**		**239**
TOTAL	***53***	***572***	***17***	***92***	***12***	***746***

4.5.3 *Results – Sub-adult Bull Trout Outmigration from Thompson River*

Glaid (2017) found few subadult Bull Trout emigrated from the tributaries into the mainstem Thompson River or from the tributaries to Thompson Falls Reservoir. Glaid (2017) tracked 14 radio-tagged Bull Trout for 78 days between September 24 and December 22, 2015. None of the radio-tagged fish were documented leaving the Thompson River drainage and only one was recorded at the remote array station on the mainstem Thompson River near the confluence with the Clark Fork River. Radio-tagged Bull Trout from Fishtrap and West Fork Thompson River did not intermix and four of the radio-tagged fish were casualties of mink predation.

The majority of Bull Trout emigration from the tributaries occurred at night between 2000 and 0800 hrs (Glaid, 2017). Bull Trout movement out of the tributaries peaked in October and out-migration of the Thompson River peaked in December. Size of Bull Trout tagged in the tributaries were not a strong predictor of out-migration and abiotic factors were weakly associated with out-migration.

The study found sub-adult Bull Trout spend prolonged periods in the mainstem Thompson River, and shows the importance of the mainstem Thompson River for overwintering habitat and potentially prolonged residency (Glaid, 2017). The study also identified mink predation as potential risk to Bull Trout. Monitoring data show there was the lack of intermixing between

Fishtrap and West Fork Thompson River sub-adult Bull Trout in the mainstem Thompson River and Glaid (2017) questioned if potential "habitat bottlenecks" are associated with predation and/or human-instigated habitat degradation.

Of the 746 subadult Bull Trout that have been tagged in tributaries to the Thompson River between 2014 and 2018, 51 (6.8%) have been detected at the mainstem Thompson River PIT tag array. A higher percentage of West Fork Thompson River subadult Bull Trout have been detected at the Thompson River PIT tag array (11.3%) than Fishtrap Creek subadult Bull Trout (4.7%) (Table 4-7).

Subadult Bull Trout have been detected at the mainstem Thompson River PIT tag detector array in every calendar month (*see* Figure 2-4). It is generally assumed that a detection at the mainstem PIT tag detector array indicated an out-migrating Bull Trout, however Kreiner and Terrazas (2018) noted that several fish were detected for multiple months at the array and appeared to be inhabiting the lower mainstem Thompson River. *See* Section 2.3.5 Tracking Tag Array Detections – Thompson River for more information on the timing of juvenile Bull Trout outmigration from the Thompson River.

Table 4-7. Bull Trout detected at the mainstem Thompson River PIT tag detector array, 2014 through July 1, 2019, originally tagged as juveniles in the Thompson River drainage.

Stream Fish Tagged	2014-2015	2016	2017	2018	2019*	Total
Fishtrap Creek	12	8	2	1	1	24 (4.7% of tagged fish)
West Fork Thompson River	16	8	1	1	1	27 (11.3% of tagged fish)
Total	**28**	**16**	**3**	**2**	**2**	**51** **(6.8% of tagged fish)**

4.5.4 *Discussion*

The 2008 FWS BiOp for the Thompson Falls Hydroelectric Project estimated that at least 10 percent and perhaps as much as 25 percent of juvenile Bull Trout in the Thompson River drainage outmigrate to the Thompson Falls Reservoir and pass downstream of the project. Based on this estimated percentage of outmigration, the 2008 BiOp estimated that between 234 and 585 juvenile Bull Trout from the Thompson River migrate downstream through Thompson Falls Dam. Recent data collection from 2014 through June 2019 (Glaid, 2017; Kreiner and Terrazas, 2018) indicate that the adfluvial life history form is currently less abundant than expected. To date, based on recent tagging studies, the percentage of juvenile Bull Trout found to outmigrate from the Thompson River drainage is less than 7 percent (*refer to* Table 4-7).

Kreiner and Terrazas (2018) noted in their report that, "The proportions of Bull Trout detected leaving the tributaries and the mainstem indicates that conservation actions intended to benefit reservoir-utilizing Bull Trout (e.g., Northern Pike suppression, trap and transport) would only benefit a small percentage of Bull Trout in the Thompson River. Instead, conservation actions intended to benefit Thompson River Bull Trout should focus first on perceived problems within the Thompson River basin, before actions downstream are considered. An adfluvial form of Bull Trout was perhaps more common prior to dam construction, as migratory life histories can be suppressed due to man-made barrier construction (Nelson et al., 2002, Schmetterling, 2003). However, given the current physical habitat limitations in the Clark Fork River, focus should be placed on conserving populations and improving conditions within vital tributary networks such as the Thompson River."

NorthWestern concurs that conserving populations and improving conditions in vital tributary networks should be a focus of attention. NorthWestern looks forward to continuing to fund projects of this nature in the tributaries upstream of Thompson Falls, and in Prospect Creek. NorthWestern also concurs that project to benefit reservoir-utilizing Bull Trout would only benefit a small percentage of Bull Trout, and we recommend not pursuing non-native species suppression activities.

5. Conclusions

5.1 Bull Trout in the Project area

Bull Trout are rare in the lower Clark Fork River, both upstream and downstream of the Thompson Falls Hydroelectric Project because of a variety of factors. The BiOp for the Project noted dams, forestry management, mining, transportation, urban and rural development, agriculture and grazing, and fisheries management including stocking of non-native fish species as human impacts that are identified as affecting Bull Trout habitat. Although the FWS judged that recovery measures related to connectivity described in the 2002 Draft Recovery Plan (FWS, 2002), were being partially met (FWS, 2006), improving passage has not resulted in large increases in Bull Trout numbers in the drainage.

After 9 years (2011–2019) of upstream fish ladder operations at the Project, Bull Trout ladder ascents varied from zero to five Bull Trout per year, averaging 1.9 Bull Trout per year. The annual number of Bull Trout recorded at the ladder, while very low, appears to be reflective of the very low numbers of Bull Trout present in the Project area.

Evidence for this conclusion comes from sampling conducted over a long period of time the Project area. For example, the numbers of Bull Trout captured downstream of the Project via multiple sampling methods (angling, electrofishing, and fish trapping) over a 7-year period (1999–2006) resulted in one to seven Bull Trout captured per year (an average of 3.3 Bull Trout per year). Additional seasonal sampling via a small scale Denil fish ladder in the Project Main Dam tailrace in 2001 and 2004 also found few Bull Trout in the area. In 2001 (March 21–September 28), three Bull Trout out of 4,259 fish were collected in the Denil trap. In 2004 (March 16–May 10), three Bull Trout out of 195 fish were collected at this trap.

Electrofishing downstream of the Project in the spring of 2011, 2012 and 2014 collectively sampled seven individual Bull Trout out of 2,222 fish handled. Bull Trout represented a small fraction of the fish community sampled each year with three Bull Trout sampled out of 1,109 fish in 2011, one Bull Trout out of 737 fish in 2012, and three Bull Trout out of 376 fish in 2014.

Avista samples fish in Noxon Reservoir downstream of the Project with gillnets in the fall. Between 2013 and 2015, 3,278 fish were collected, including two Bull Trout, for all years and locations combined (Kreiner and Tholl, 2016). However, these authors noted that salmonids tend to be under-represented in the sampling in Noxon Reservoir, so the numbers of Bull Trout present may be higher than reflected in the gillnet catches.

Upstream of the Project, eight Bull Trout have been collected in Thompson Falls Reservoir since the beginning of fish monitoring efforts in 2004 (after 15 years of annual fall gillnetting and 9 years of spring electrofishing surveys in two sections of Thompson Falls Reservoir). Annual fall gillnetting has never collected a Bull Trout. Spring electrofishing has captured six Bull Trout, one in the lower section and five in the upper section close to the Thompson River.

Spring gillnetting conducted over a 15-week period in 2009 in two sections of Thompson Falls Reservoir as part of a study of Northern Pike collected two Bull Trout. One Bull Trout was collected during gillnetting (in May) in the downstream sampling area and one Bull Trout was collected in a Northern Pike stomach (in April) from the Island Complex sampling area.

Upstream of Thompson Falls Reservoir, 9 years of fall electrofishing conducted since 2009 in two separate sections (above the Island complex, and Paradise to Plains) sampled four Bull Trout. One Bull Trout was collected in the above Island complex section. Three Bull Trout have been collected in the Paradise to Plains section. The Paradise to Plains section is located downstream of the confluence with the lower Flathead River and upper boundary of the lower Clark Fork River drainage.

Avista collects Bull Trout upstream of Lake Pend Oreille and downstream of Cabinet Gorge Dam. A fin clip from each Bull Trout is genetically tested to determine their natal stream so they can be transported to (or near) their tributary of origin. In some instances, Bull Trout captured as juveniles in their natal stream are returned to that stream, even if the genetic analysis does not concur. Avista has implemented the adult Bull Trout transport program since 2001. Transport of Bull Trout to Region 4, upstream of Thompson Falls Dam began in 2007. For the last 12 years, Avista has transported an average 37 Bull Trout upstream of Cabinet Gorge Dam with about 21 percent (7 Bull Trout) transported to Region 4 each year.

Lake Pend Oreille was estimated to support a population of approximately 10,000 Bull Trout over 350 mm in length in 2008 (McCubbins et.al., 2016). Based on the numbers of Bull Trout collected below Cabinet Gorge Dam that are estimated to have migrated from Clark Fork River tributaries, it appears that portion of the adfluvial population of Bull Trout originating from the Clark Fork drainage is relatively small. It also appears that an even smaller proportion of adfluvial Bull Trout outmigrating from tributaries upstream of Thompson Falls Dam reside in Noxon Reservoir. Therefore, the numbers of upstream migrating Bull Trout that approach the Project fish ladder at Thompson Falls are very small.

5.2 Fish Ladder Effectiveness

NorthWestern’s upstream adult fish ladder at the Main Dam Spillway became operational in March 2011. From 2011 through July 1, 2019, there were 17 Bull Trout out of 32,130 fish that ascended the ladder (representing 14 species and three hybrids). It is clear that the ladder is passable to a wide variety of fish species, including some weaker swimming species.

Not all fish that enter the ladder and are detected in the lower pools ascend to the top of the ladder. Since 2011, 25 Bull Trout were detected in the lower pools, and 17 of these fish ascended to the top. The number of salmonids ascending the ladder after being detected in the lower pools generally ranged between 70 and 80 percent each year.

In 2018 and 2019, two of five Bull Trout detected via the Prospect Creek PIT-tag array had known natal tributaries located upstream of Thompson Falls Dams. These fish were not detected entering the lower pools of the ladder in either year. These fish were presumably motivated to move upstream past Thompson Falls Dam but did not access the ladder.

Since 2011, experiments were also conducted to assess the optimal fish passage operational scheme. This resulted in years with low total catches compared to others, such as in 2018 when only 227 fish were passed. These experiments have generated valuable information on the impact of ladder operations on fish passage, which should result in improved fish passage numbers in the future.

Because the ladder was a pioneering structure in Bull Trout passage, it was designed with flexibility to allow operations of the ladder in “orifice” or “notch” modes. Raising the central sliding weir gate allows pool-to-pool flow through the bottom orifice (orifice mode). Lowering the weir gate allows pool-to-pool flow through the top weir (notch mode).

Tests of orifice and notch mode found that notch mode appears to select against the weaker swimmers so fewer native fish such as suckers and Northern Pikeminnow ascend the ladder. Although the number of salmonids remain relatively constant during notch and orifice operations, notch mode appeared to select for salmonids capable of ascending the ladder more quickly than observed in orifice mode.

A hydraulic analysis of the ladder was conducted for both notch and orifice mode. The hydraulic analysis showed notch mode results in higher velocities and reduction in areas of slack or calm water compared to orifice mode. The conclusion of both the hydraulic analysis and the empirical tests was that orifice mode provided more suitable upstream fish passage conditions for a broader group of fish species than notch mode. NorthWestern recommendation is to operate the ladder in orifice mode for the remainder of the license, to best meet the TAC agreed goals and objectives of the ladder.

The hydraulics study also concluded that neither weir mode was operating to the optimal design. Potential areas of improvements for orifice mode include experimenting with a smaller orifice between Pools 18 and 19 and/or testing different internal baffle configurations. However, any changes made to an individual pool may affect all downstream pool hydraulics. NorthWestern is considering the use of a computational fluid dynamics model of the ladder to test different weir configurations along one or more segments of the ladder and to evaluate potential downstream effects.

In 2019, NorthWestern experimented with operation of the lower ladder pools in orifice mode, however, operating the lower ladder pools in orifice mode may interfere with the auxiliary water supply system. We recommend that the operation of the lower pools be further evaluated in the upcoming modeling and hydraulic evaluation.

5.3 Fish Movement Patterns in the Thompson Falls Project Area

The challenge of evaluating fish ladder effectiveness in a river with potamodromous species is evident at Thompson Falls. Effectiveness needs to be evaluated based on the 'motivated' population, that proportion of the population motivated to pass a barrier. But as shown at Thompson Falls, assessing the proportion of the population that is 'motivated' is complex and challenging.

Salmonids in general, and Bull Trout in particular, have been found to move upstream, downstream, and into multiple tributaries. The timing of these movements is not strictly tied to spawning seasons. Bull Trout ascend the ladder most frequently in the spring, but the timing is variable, and they have ascended the ladder as late in the season as September, so the 'motivation' is unclear. An example of complex Bull Trout movement is the Bull Trout radio tagged in 2010 and found in both Fishtrap Creek (during spawning season) and then later in the Vermilion River (after spawning season). Adult Bull Trout have been found in multiple tributaries, including tributaries that are not their natal stream even when the natal stream is accessible. For example, a Bull Trout PIT-tagged as a juvenile in Graves Creek was detected in Prospect Creek about a year later. The FWS (FWS, 2015) states that the ability to migrate is important to the persistence of Bull Trout as it allows them to seasonally or temporally occupy habitat that may be advantageous on an intermittent basis. It appears that seasonal and temporal movements are a part of the behavior of Bull Trout in the Project area.

Many fish have made round trips ascending the ladder, and some moving further upstream to the Thompson River, and then back downstream of the dam before ascending the ladder again, some multiple times (some consecutive years and other at varying intervals). Between 2011 and 2018, over 250 fish were documented to ascend the ladder more than once. The record for ascents is held by one Brown Trout that has ascended the ladder six times in 5 years.

For Bull Trout, the genetics database is helpful to assess the likely natal stream of the fish. However, the genetics database is not infallible, as was documented by genetic tests of juveniles collected in tributaries assumed to be their natal stream.

The importance of the Thompson River to salmonids in the Thompson Falls Project has been affirmed by the number of fish that have been found to migrate into the Thompson River after passing the fish ladder. A minimum of 25 percent of the PIT-tagged fish that ascended the ladder between 2014–2018 were later detected in the Thompson River, including a minimum of 27 percent of the Bull Trout that were released upstream after ascending the fish ladder. The travel time for fish to reach the Thompson River from Thompson Falls Dam was often quite rapid, with the majority of fish reaching the Thompson River in 1 day or less.

5.4 Downstream Passage through Thompson Falls Reservoir

The BiOP (TC 5a) required the Licensee to assess the potential impacts of predatory non-native fish species on Bull Trout residing in or passing through the Thompson Falls Reservoir. The 2009 FERC Order expanded on this requirement and included TC 5b requiring the need for the Licensee to evaluate a non-native species control program for Thompson Falls Reservoir. The purpose of such a program would be to reduce predation on juvenile Bull Trout.

Bull Trout appear to use Thompson Falls Reservoir as a migratory corridor, but no specific migratory pathway has been defined due to the lack of data on these rare fish. The number of salmonids found in Thompson Falls Reservoir in general is quite low. The Reservoir is primarily habitat for native non-game species and non-native species including Black Bullhead and Northern Pike.

A juvenile Bull Trout was found in a Northern Pike (captured in the Island Complex area) stomach during a 2009 food habits study indicating that there is some risk of non-native species predation on juvenile Bull Trout (PPL Montana, 2010b). However, a multi-year study in 2014–2015 on out-migration of juvenile Bull Trout out of the Thompson River drainage and into the Thompson Reservoir did not identify non-native predation as a critical limiting factor (Glaid, 2017). Therefore, NorthWestern and the TAC agencies did not identify, develop, or recommend a non-native species suppression program be instituted in Thompson Falls Reservoir because the efficacy of such a program for the purpose of Bull Trout restoration seems unlikely.

6. Recommendations

NorthWestern makes the following recommendations based on the Phase 2 fish passage evaluation studies:

- The fish ladder be operated in orifice mode for the remainder of the current FERC license. This recommendation is consistent with agency goals of passing Bull Trout as first priority, and native species as a second priority.
- Computational fluid dynamics modeling of the fish ladder followed by potential modifications to improve hydraulic conditions in orifice mode.
- Installation of one or more additional PIT tag arrays in the ladder to better evaluate fish movement between the lower pools and the holding pool and identify sections of the ladder that may present less than optimal conditions for upstream fish movement. Flat plate PIT tag detectors may be preferable to reduce impacts to ladder hydraulics.
- If the scientific review panel concludes delay for fish locating the ladder entrance is a concern, then radio telemetry studies could be considered for evaluating fish in the tailrace. However, the risk and stress to fish from handling and tagging should be considered when making this determination.
- Continued testing of new main channel radial gates (operational in 2019 season) timing and influence to fish movement to tailrace and ladder (as well as TDG implications). This testing could include photo documentation of tailrace flow patterns to assess passage conditions at varying discharge and spillway operations.
- Continued monitoring of PIT tags in major tributary streams, Thompson River and Prospect Creek.
- No non-native fish suppression in Thompson Falls Reservoir.

NorthWestern will prepare a revised Fishway Operations Plan for submission with the Final FERC License Application, due December 31, 2023. This Plan will incorporate the results of the studies that will be undertaken during the upcoming relicensing period.

7. Literature Cited

Bernall, S. and K. Duffy. 2019. Upstream Fish Passage Program – Bull Trout. Annual Project Update – 2018. Avista, Noxon, Montana.

Boggs, C., M Keefer, C. Peery, T. Bjornn, and L. Stuehrenberg. 2004. Fallback, reascension, and adjusted fishway escapement for adult chinook salmon and steelhead at Columbia and Snake River dams. Transactions of the American Fisheries Society 133, 932-949.

Brenkman, S., S. Corbett, and E. Volk. 2007. Use of otolith chemistry and radio telemetry to determine age-specific migratory patterns of anadromous Bull Trout in the Hoh River, Washington. Transactions of the American Fisheries Society 136(1):1-11.

Casselman, J.M., and C.A. Lewis. 1996. Habitat Requirements of Northern Pike (*Esox lucius*). Canadian Journal of Fisheries and Aquatic Science 53 (Suppl.1):161-174.

Davie, A., M. Minghetti, and H. Migaud. 2009. Seasonal variations in clock gene-expression in Atlantic salmon (*Salmo salar*). Chronobiology International. Apr, 26(2):379-95

DeHaan, P., B. Adams, and JJ. Von Bargen. 2015. Genetic Analysis of Native Salmonids from the Lake Pend Oreille and Clark Fork River System, Idaho and Montana, Annual Report for Calendar Year 2014. U.S. Fish and Wildlife Service, Abernathy Fish Technology Center, Longview, Washington. Submitted to Avista Corp., Noxon, Montana.

DeHaan, P. and S. Bernall. 2013. Spawning success of Bull Trout transported above main-stem Clark Fork River Dams in Idaho and Montana. North American Journal of Fisheries Management, 33:1269-1282.

Downs, C.C., D. Horan, E. Morgan-Harris, R. Jakubowski. 2006. Spawning Demographics and Juvenile Dispersal of an Adfluvial Bull Trout Population in Trestle Creek, Idaho. North American Journal of Fisheries Management. 26:190–200.

Dunham, J., B. Rieman, and K. Davis. 2001. Sources and magnitude of sampling error in redd counts for Bull Trout. North American Journal of Fisheries Management (21):343-352.

Federal Energy Regulatory Commission. FERC. 2009. Order Approving Construction and Operation of Fish Passage Facility. February 12, 2009. 126 FERC 62,105.

--. 1990. Order Amending License (Major). Thompson Falls Project Number 1869-003, Montana. Montana Power Company. Washington, D.C.

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.

--. 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.

--. 2010. 50 CFR Part 17. Endangered and Threatened Wildlife and Plants; Revised Designation of Critical Habitat for Bull Trout in the Coterminous United States; Final Rule. October 18, 2010. (https://www.govinfo.gov/content/pkg/FR-2010-10-18/pdf/2010-25028.pdf#page=2)

Fraley, J. J. and Shepard, B. B. 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.

Frank, H., M.E. Mather, J.M Smith, R.M. Muth, J.T. Finn, S.D. McCormick. 2009. What is “fallback”?: metrics needed to assess telemetry tag effects on anadromous fish behavior. Hydrobiologia 635:237-249.

FWP (Montana Fish, Wildlife and Parks). 2010. MFISH Data: Fish Distribution Report, Little Thompson River.

FWS (U.S. Fish and Wildlife Service). 2002. Bull Trout (*Salvelinus confluentus*) Draft Recovery Plan (Klamath River, Columbia River, and St. Mary-Belly River Distinct Population Segments). U.S. Fish and Wildlife Service, Portland, Oregon.

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

--. 2008. Biological Opinion for Thompson Falls Hydroelectric Project Bull Trout Consultation. Federal Energy Regulatory Commission Docket No. 1869-048 – Montana. PPL Montana, LLC, Licenses. Prepared by FWS Montana ES Field Office, Helena.

--. 2010. Critical Habitat for Bull Trout (*Salvelinus confluentus*) Unit: 31, Sub-Unit Lower Clark Fork River. Available April 20, 2018: https://www.fws.gov/pacific/bulltrout/finalcrithab/mtnv/Unit_31_Lower_Clark_Fork_River.pdf.

--. 2011. Guiding Principles for Bull Trout Passage Through the Clark Fork River Corridor, Montana and Idaho. U.S. Fish and Wildlife Service Technical Memorandum, Montana ES Field Office, Helena, Montana, March 31, 2011.

--. 2015. Recovery Plan for the Coterminous United States Population of Bull Trout (*Salvelinus confluentus*). Portland, Oregon. xii+179 pages.

--. 2017. Fish Passage Engineering Design Criteria. FWS, Northeast Region R5, Hadley, Massachusetts.

GEI. (GEI Consultants, Inc.). 2003. Biological Evaluation of Thompson Falls Hydroelectric Development, Thompson Falls, Montana. Prepared for PPL Montana, Butte, Montana.

--. 2007. Results of 2006 Fish Telemetry Study Thompson Falls Dam. Submitted to PPL Montana, Butte, Montana.

--. 2007a. Thompson Falls Dam Fish Ladder Preliminary Design Report – DRAFT. Submitted to PPL Montana, 45 Basin Creek Road, Butte, Montana 59701 (don't have a copy of this).

--. 2007b. Upstream Fish Passage Alternatives Evaluation – Final Report. Submitted to PPL Montana, Butte, Montana.

GEI Consultants, Inc. and Steigers Corporation. 2013. Thompson River Bull Trout Enhancement and Recovery Plan. Thompson Falls Project No. 1869, Thompson Falls Montana. Prepared for PPL Montana, Butte, Montana.

Gillin, G. and J. Pizzimenti. 2003. Thompson Falls Dam Fish Passage Study Plan Pre-Design Phase, Thompson Falls, Montana.

Gillin, G. and T. Haddix. 2005. Thompson Falls Fish Passage Studies Annual Report for 2004, Thompson Falls, MT.

Glaid, J.R. 2017. Master Thesis: Subadult Bull Trout Out-Migration in the Thompson River Drainage, Montana. July 2017

Haddix, T. and G. Gillin. 2006. Final Report: Fish Behavior in the Tailrace of Thompson Falls Dam, Results of 2005 Radio Telemetry. Submitted to PPL Montana, Butte, Montana.

Hogen, D.M. and D. L. Scarnecchia. 2006. Distinct fluvial and adfluvial migration patterns of a relict charr, Salvelinus confluentus, stock in a mountainous watershed, Idaho. USA. Ecology and Freshwater Fish 15:376-387.

Holton, G. D. 2003. A Field Guide to Montana Fishes. Montana Department of Fish, Wildlife and Parks, 95 pp.

Homel, K, P. Budy, M. Pfrender, T. Whitesel, and K. Mock. 2008. Evaluating genetic structure among resident and migratory forms of Bull Trout (*Salvelinus confluentus*) in Northeast Oregon. Ecology of Freshwater Fish, Vol 17 (3) 465-474.

Isaak, D., B. Rieman, and D. Horan. 2009. A Watershed-Scale Monitoring Protocol for Bull Trout. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-224. Ft. Collins, Colorado.

Kanda, N., R.F. Leary, and F.W. Allendorf. 1997. Population genetic structure of Bull Trout in the upper Flathead River drainage. Pages 299-308 in: Mackay, W.C., M.K. Brewin, and M. Montia, eds. Friends of the Bull Trout Conference Proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary.

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, Appendix C, and Montana Tributary Habitat Acquisition and Recreational Fishery Enhancement Program, Appendix B. Report to Avista Corporation, Spokane, Washington. Montana Fish, Wildlife and Parks, Thompson Falls, Montana and Avista Corporation, Noxon, Montana.

Kreiner, R. and M. Terrazas. 2018. Thompson River Fisheries Investigations: A Compilation Through 2017. Montana Fish, Wildlife and Parks, Thompson Falls.

Kreiner, R. and T. Tholl. 2016. Noxon Rapids and Cabinet Gorge Reservoirs Fisheries Monitoring Comprehensive Report: 2013–2015. Including Data From:1999–2015. Montana Tributary Habitat Acquisition and Recreational Fishery Enhancement Program Appendix B. Prepared for Avista Corporation, Noxon, Montana.

Lacy, S.D., J.R. Stover, and E.W. Oldenburg. 2016. Tributary Trapping and Downstream Juvenile Bull Trout Transport Program, Annual Progress Report – 2015. Fish Passage/Native Salmonid Restoration Program. Avista Corporation, Noxon, Montana.

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, Montana.

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.

McCubbins, J.L., M. J. Hansen, J.M. DosSantos and A. M. Dux. 2016. Demographic Characteristics of an Adfluvial Bull Trout Population in Lake Pend Oreille, Idaho, North American Journal of Fisheries Management, 36:6, 1269-1277

McLaughlin, R. E. Smyth, T. Castro-Santos, M. Jones, M. Koops, T. Pratt, L. Vélez-Espino. 2013. Unintended consequences and trade-offs of fish passage. Fish and Fisheries, 14:580-604.

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

MOU (Memorandum of Understanding), 2008. Facilitation and Funding of FERC License based Consultation Process and Implementation of Minimization Measures for Bull Trout. PPL Montana, Montana Fish and Wildlife and Parks, U.S. Fish and Wildlife Services, Confederate Salish and Kootenai Tribes. Signed January 15, 2008.

-- . 2013. Facilitation and Funding of FERC License based Consultation Process and Implementation of Minimization Measures for Bull Trout. PPL Montana, Montana Fish and Wildlife and Parks, U.S. Fish and Wildlife Service, Confederate Salish and Kootenai Tribes. Signed September 20, 2013.

MTBRT (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, Helena, Montana.

Muhlfeld, C. and B. Marotz. 2005. Seasonal Movement and Habitat Use by Subadult Bull Trout in the Upper Flathead River System, Montana. North American Journal of Fisheries Management, 25:797-810.

National Marine Fisheries Service (NMFS). 2008. Anadromous Salmonid Passage Facility Design. NMFS, Northwest Region, Portland, Oregon.

NMFS. 2011. Anadromous Salmonid Passage Facility Design. NMFS, Northwest Region, Portland, Oregon.

Naughton, G., C. Caudill, M. Keefer, T. Bjornn, C. Peery, and L. Stuehrenberg. 2006. Fallback by adult sockeye salmon at Columbia River Dams. North American Journal of Fisheries Management 26:380-390.

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.

NorthWestern (NorthWestern Energy). 2018. 2017. Annual Report Fish Passage Project Thompson Falls Hydroelectric Project, FERC Project Number 1869. Submitted to FERC, Washington D.C.

--. 2018a. Fish Ladder Hydraulic Assessment Thompson Falls, Montana. Federal Energy Regulatory Commission Project No. 1869.

--. 2018b. Thompson Falls Hydroelectric Project FERC Project No. 1869. Baseline Environmental Document.

NorthWestern. 2019. 2018. Annual Report Fish Passage Project Thompson Falls Hydroelectric Project, FERC Project Number 1869. Submitted to FERC, Washington D.C.

Noonan, M, J. Grant, C. Jackson. 2012. A quantitative assessment of fish passage efficiency. Fish and Fisheries, 13 450-464.

O'Malley, R. McClelland, K. Naish. 2010. Clock Genes Localize to Quantitative Trait Loci for Stage-Specific Growth in Juvenile Coho Salmon, *Oncorhynchus kisutch*. Journal of Heredity 101(5):628-632.

Pizzimenti, J. and G. Gillin. 2003 Biological Evaluation of the Thompson Falls Hydroelectric Development, Thompson Falls, Montana. Submitted to PPL Montana, Butte, Montana.

Plum Creek Timber Company (Plum Creek). 1998. Thompson River Basin Watershed Analyses: Beatrice Creek, Boiling Springs Creek, Murr Creek.

PPL Montana. 2008. Biological Evaluation for Bull Trout Thompson Falls Project (FERC No. 1869). Submitted to FERC.

--. 2010. PPL Montana. 2010. Thompson Falls Hydropower Project FERC Project Number 1869. 5-Year Reservoir Monitoring Plan, 2011–2015. Public. Submitted to FERC, Washington D.C.

--. 2010a. Thompson Falls Hydropower Project FERC Number 1869, Passage Evaluation Plan, Phase 2 Action Plan, 2011–2020, October 2010. Public. Submitted to FERC, Washington D.C.

--. 2010b. 2009 Annual Report Fish Passage Project Thompson Falls Hydroelectric Project, FERC Project Number 1869. Submitted to FERC, Washington D.C.

--. 2010c. Final Thompson Falls Fish Ladder – Fishway Operations Manual 1.0. Submitted to FERC, Washington D.C.

--. 2010d. Total Dissolved Gas Control Plan. Thompson Falls Hydroelectric Project FERC Project Number 1869. Submitted to Montana Department of Environmental Quality, Helena, Montana.

--. 2011. 2010 Annual Report Fish Passage Project Thompson Falls Hydroelectric Project, FERC Project Number 1869. Submitted to FERC, Washington D.C.

--. 2012. 2011 Annual Report Fish Passage Project Thompson Falls Hydroelectric Project, FERC Project Number 1869. Submitted to FERC, Washington D.C.

--. 2013. 2012. Annual Report Fish Passage Project Thompson Falls Hydroelectric Project, FERC Project Number 1869. Submitted to FERC, Washington D.C.

--. 2014. 2013. Annual Report Fish Passage Project Thompson Falls Hydroelectric Project, FERC Project Number 1869. Submitted to FERC, Washington D.C.

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.

Quinn, T.P. 2005. The Behavior and Ecology of Pacific Salmon and Trout. University of Washington Press, Seattle. p.170.

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.

Rischel, T. and T. Bjornn. 2003. Influence of fishway placement on fallback of adult salmon at the Bonneville Dam on the Columbia River. North American Journal of Fisheries Management 23:1215-1224.

Robichaud, D. and A. Gingerich. 2017. Bull Trout Passage and Take Monitoring At Wells Dam and the Twisp River Weir, Final Report. Prepared for Public Utility District No. 1 of Douglas County, East Wenatchee, Washington. November 8, 2017.

Schmetterling, D.A. 2003. Reconnecting a 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.

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

Schneider, J.C. 1998. Lake fish population estimates by mark-and-recapture methods. Chapter 8 *in* Schneider, J.C. (ed.) 2000. Manual of fisheries survey methods II: with periodic updates. Michigan Department of Natural Resources, Fisheries Special Report 25, Ann Arbor.

Silva, A., M. Lucas, T. Castro-Santos, C. Katopodis, L. Baumgartner, J. Thiem, K. Aaresturp, P. Pompeu, G. O'Brien, D. Braun, N. Burnett, D. Zhu, H. Fjeldstad, T. Forseth, N. Rajaratnam, J. Williams, S. Cooke. 2018. The future of fish passage science, engineering, and practice. Fish and Fisheries, 19:340-362.

Thurow, R. 2016. Chapter 4. Life Histories of Potamodromous Fishes, Pages 29-54. Editors, Pedro Marais and Françoise Daverat in An Introduction of Fish Migration. CRC Press: Boca Raton. 315 pages. (https://www.taylorfrancis.com/books/e/9780429082474)

USGS (U.S. Geological Survey). 2018. National Water Information. USGS 1238900 Clark Fork River Near Plains, Montana. https://waterdata.usgs.gov/mt/nwis/uv?site_no=12389000