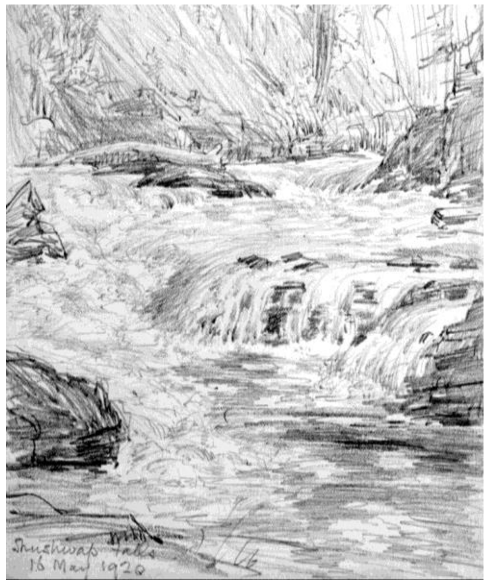
Plan for Fish Passage at Wilsey Dam - FINAL REPORT



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Prepared for:
Wilsey Dam Fish Passage Committee, Whitevalley Community Resource Centre and Fish and Wildlife Compensation Program

Prepared with financial support of the Fish and Wildlife Compensation Program on behalf of its program partners BC Hydro, the Province of BC, Fisheries and Oceans Canada, First Nations and Public stakeholders.

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Executive Summary

Salmon in the Middle Shuswap River have historically played a critical role in sustaining local First Nations and residents. When Wilsey Dam was constructed in 1928 at Shuswap Falls near Lumby, BC, a significant barrier to Chinook, Coho, and Sockeye salmon and Rainbow and Bull trout passage to 32 km of suitable upstream habitat was established. A number of these stocks are currently managed primarily for conservation.

In pursuit of a mutual interest to restore fish passage at Wilsey Dam, representatives from BC Hydro, federal and provincial governments, local First Nations, Whitevalley Community Resource Centre, and other local community organizations and residents (the Wilsey Dam Fish Passage Committee commissioned a series of biological, technical and historical studies to investigate the feasibility of fish passage in this location in accordance with BC Hydro's Fish Passage Decision Framework for Existing Facilities (BC Hydro, 2017). These studies align with the Shuswap Salmonid Action Plan priority 1 action to assess fish passage for Wilsey Dam and to determine if the dam is a limiting factor in salmonid productivity.

The WDFPC has identified the following three goals associated with restoring fish passage at Wilsey Dam:

Goal 1: Increase salmon populations and provide fish access to historical spawning and rearing habitats upstream of Wilsey Dam

Goal 2: Restore historic fisheries and increase fisheries potential

Goal 3: Increase tourism, visitation and educational opportunities

Benefits associated with these goals include the addition of extensive Chinook spawning habitat, and addition of marine nutrients will increase fish production and have positive impacts on the aquatic ecosystem and foodwebs that support fish and wildlife populations (McGrath et al., 2014). Increased Sockeye production may result in increasing abundance and size of Mabel Lake Rainbow Trout as Sockeye fry are an important food source for adult Mabel Lake Rainbow Trout (Jantz, 1986). Substantial cultural, social and economic benefits from re-establishing fish passage have been identified, including revival of First Nations fisheries, additional recreational fishing opportunities, and increased tourism opportunities (McGrath et al., 2014). Socioeconomic benefits of fish passage may increase angling usage of the Middle Shuswap River, which could increase demand for local angling supplies and services and increase visitors to Lumby and the Wilsey Dam area to observe salmon migration. The actual number of fish and resultant economic value would depend on how much the stocks increase as a result of fish passage, and marine survival conditions at the time (McGrath et al., 2014).

This plan outlines the preliminary technical feasibility considerations (Section 6) of fish passage at Wilsey Dam (Step 4 of 7 of the *Fish Passage Decision Framework*) as well as presents the preferred conceptual design option for fish passage at Wilsey Dam to the

Fish and Wildlife Compensation Program for endorsement (Step 5 of 7 of the *Fish Passage Decision Framework*). To support BC Hydro's TBL business case development (Step 6), this plan identifies biological, conservation, cultural and other societal benefits (Section 4), costs (Section 6.1.5), and potential risks and potential mitigation options (Section 6.3) associated with the fish passage plan.

A structured decision making (SDM) approach, using a common set of biological, financial, social, and general evaluation criteria guided the evaluation process for fish passage alternatives. This approach was supported by provision of two workshops, expert opinion, technical literature review, and two focused fish passage engineering feasibility studies. Fish passage alternatives that were evaluated include a vertical slot fish ladder within the spillway, a concrete vertical slot off-channel fish ladder, a *Naturalized By-Pass Channel*, a Whooshh fish cannon transport system, and trap and truck operations. The *Naturalized By-Pass Channel* was selected through consensus as the preferred fish passage alternative at Wilsey Dam because of the many ecological benefits produced through the provision of passage to a wider range of aquatic species, comparatively lower operations and maintenance requirements, comparatively lower public and worker safety risk, and excellent educational and tourism opportunities associated with the close access to migrating salmon in a natural setting.

While beyond its purview as a fish passage committee, the WDFPC recommends that BC Hydro also consider the relative costs and benefits of dam decommissioning as a viable long-term strategy for overcoming the barrier that Wilsey Dam poses to the re-introduction of salmon to the Middle Shuswap River upstream of Shuswap Falls.

Northwest Hydraulic Consultants Ltd. (NHC) was commissioned to provide a conceptual design and a cost estimate for a *Naturalized By-Pass Channel* at Wilsey Dam. The conceptual design comprises of a 750 m long naturalized channel excavated along the right bank (looking downstream and westward) of the headpond. The channel is designed to be operated within normal headpond operating levels of 444.5 m and 447 m at flows ranging from 2-3 m^3/s; however, the channel will remain stable at flows ranging from 1-5 m^3/s. Maximum design velocities allow for passage of adult anadromous and resident salmonids and also provide habitat connectivity for juveniles. Components of the *Naturalized By-Pass Channel* include a fishway inlet, a low gradient upper channel, a 30 m long box culvert, a steeper gradient natural fishway channel, and a fishway outlet. Riffle and run grade controls and boulder complexes are incorporated into the conceptual design to provide hydraulic complexity.

With over 20 existing examples of successful natural fishway designs in the Pacific Northwest (NHC, 2018), the proposed fishway technology is based on demonstrated technically and biologically feasible fish passage technologies; however, due to the preliminary nature of the *Naturalized By-Pass Channel* design and operation specifically at Wilsey Dam, uncertainties surrounding potential biological, engineering, hydraulic, geotechnical, and safety considerations are identified with mitigating factors, monitoring studies and potential contingencies presented, where applicable to address these uncertainties. Many of the potential risks (e.g., attraction flows, passage efficiency, geotechnical considerations, entrainment mortality) can be reduced or eliminated by completing additional works during the detailed design phase. BC Hydro reviewed both the *Naturalized By-Pass Channel* design and Whooshh design and identified concerns. This plan considered concerns and feedback from BC Hydro, the British Columbia Ministry of Forests, Lands, Natural Resource Operations & Rural Development (FLNRORD), Fisheries and Oceans Canada (DFO) and other representatives on the WDFPC, and thus adequately supports the argument that fish passage is biologically and technically feasible at Wilsey Dam (as required in Steps 3 and 4 of the Fish Passage Decision Framework). Through participation in the WDFPC's evaluation of fishway options, BC Hydro agrees that the *Naturalized By-Pass Channel* design is most preferred option given the review to date. This plan can support the biological objectives using technologies and operations that are proven in the specific facility context.

As per Steps 6 and 7 of the Framework, it is anticipated that BC Hydro will use this information to provide a more detailed review of options to define a final fish passage solution.

The WDFPC proposes an adaptive management approach to fish passage at Wilsey Dam that incorporates monitoring data to assess and evaluate the effectiveness of fish passage at achieving its restoration goals and intended benefits. Restoration of fish passage at Wilsey Dam via a Naturalized By-Bass Channel provides a demonstrated biologically and technically feasible concept that is expected to provide substantial benefits to anadromous (Chinook, Coho, and Sockeye salmon) and resident (Rainbow and Bull trout) salmonid populations through restoring connectivity with high quality spawning and rearing habitat above the dam (McGrath et al., 2014). As such, the WFDPC seeks endorsement for this fish passage plan from FWCP in order to proceed to Step 6 of the Fish Passage Decision Framework.

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ACRONYMS

COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CTC	Chinook Technical Committee
CU	Conservation Unit
CWT	Coded-wire-tag
DFO	Fisheries and Oceans Canada
FLNRORD	Ministry of Forests, Lands, Natural Resource Operations & Rural Development
FSC	Food, Social and Ceremonial
FWCP	Fish and Wildlife Compensation Program
NHC	Northwest Hydraulic Consultants
Ltd. PST	Pacific Salmon Commission
SDM	Structured Decision Making
TBL	Triple Bottom Line
WDFPC	Wilsey Dam Fish Passage Committee
WDFSC	Wilsey Dam Fishway Steering Committee
WSP	Wild Salmon Policy

ACKNOWLEDGEMENTS

Work towards restoration of historical fish passage above Wilsey Dam has been an extensive and involved process, requiring feedback and insights from multiple community groups, provincial and federal governments, BC Hydro, and First Nations. This document builds on the efforts of previous and current members of the Wilsey Dam Fish Passage Committee (WDFPC) and the Wilsey Dam Fishway Steering Committee (WDFSC) and acknowledges the significant contribution of time and effort, often volunteered, to further this initiative. The authors would also like to thank Shayla Lawrence for her extensive feedback and edits.

Technical fish passage information in support of this document and process was prepared in consultation with Northwest Hydraulic Consultants Ltd., Whooshh, and BC Hydro, with hydro facility operational information provided by BC Hydro.

Regulatory guidance and fisheries management considerations were provided by Fisheries and Oceans Canada (DFO), as well as through conversations with provincial representatives.

This Project is funded by the Fish and Wildlife Compensation Program (FWCP). The FWCP is a partnership between BC Hydro, the Province of BC, DFO, First Nations, and public stakeholders to conserve and enhance fish and wildlife impacted by the construction of BC Hydro dams. The WDFPC gratefully acknowledges the financial support of the FWCP for its contribution to the Plan for Fish Passage at Wilsey Dam.

FWCP
Fish & Wildlife
COMPENSATION PROGRAM

1. INTRODUCTION

1.1 Background

Middle Shuswap River stretches between Sugar Lake and Mabel Lake in the Southern Interior near Lumby, BC. The river supports populations of anadromous and resident fish species and historically provided for an abundant fishery for local First Nations and residents. Of particular importance was the site of Shuswap Falls, located about half way between Mabel and Sugar lakes. It was a key fishing location for First Nations and an integral part of their seasonal harvesting rounds. Today, this area continues to be frequented by local First Nation members for fishing and other cultural activities.

Wilsey Dam was constructed at Shuswap Falls in 1928, blocking anadromous salmon (Chinook, Coho, Sockeye) and resident fishes (Rainbow and Bull trout) from accessing 32 km of upstream habitat. Even though initial drawings showed a fish ladder leading into the spillway channel, the ladder was never built. The footprint impact of Wilsey Dam is substantial, as former spawning, rearing and overwintering areas were permanently lost or seasonally reduced due in some degree to the barrier, reservoir flooding, flow diversions, or operating flows. What remains today are relatively small runs of anadromous salmon below the dam (compared to historical runs), some of them endangered, and low abundances of resident fish above and below the dam. The historic First Nations fishing site at Shuswap Falls is no longer accessible due to the Shuswap facility and the food fishery was displaced to the river below where access is limited.

Nearly one century later, interest in re-establishing fish passage at Wilsey Dam persists. Starting in the 1970s, numerous biological, technical and historical studies were undertaken to investigate the feasibility of fish passage at Wilsey Dam. The Wilsey Dam Fishway Steering Committee (WDFSC) was formed in 2003 with the goals of advancing fish passage at Wilsey Dam and commissioning studies to fill information gaps. The committee consisted of BC Hydro, federal and provincial government representatives, local First Nations, Whitevalley Community Resource Centre, local fish and game clubs, and residents. The WDFSC was formalized as the Wilsey Dam Fish Passage Committee (WDFPC) in 2013 to conform with requirements of BC Hydro's *"Fish Passage Decision Framework for Existing Facilities*" ("*Fish Passage Framework*"; issued in 2008 and updated in 2017; Appendix A1). The *Fish Passage Framework* guides fish passage efforts at BC Hydro's facilities, including requirements for all proposed physical works that aim to provide adult fish access to historically exploited upstream habitat. It includes the following 7 steps:

1. Preliminary screening (did the facility block passage of a fish stock at the time of construction?)
2. Stakeholder and First Nation engagement and strategic watershed prioritization
3. Environmental feasibility studies
4. **Preliminary technical feasibility consideration**

5. Compensation program endorsement
6. Triple Bottom Line (TBL) business case development (Environmental Assessment, Financial/Technical Assessment, and Social Benefits Assessment)
7. BC Hydro Board of Directors approval

A detailed review and synthesis of the history of the fish passage process at Wilsey Dam and the numerous studies completed in its support is provided in the report *Environmental Feasibility of Establishing Fish Passage at Wilsey Dam* (McGrath et al., 2014). This report formed the basis for demonstrating environmental feasibility and led to the conclusion of Step 3 of the Framework (as indicated by a letter from the Fish and Wildlife Compensation Program (FWCP) board in February 2016, Appendix A2). Thus, the WDFPC is now in Step 4 of the Framework (Preliminary Technical Feasibility Considerations).

1.2 Report Scope and Objectives

This report focuses primarily on providing technical information relevant to fish passage at Wilsey Dam and supplies biological or historical context where needed. Detailed information on the natural and biological setting, the history of the fish passage process, and previously completed studies and reports is provided in McGrath et al. (2014). Technical support from federal and provincial government and BC Hydro was sought through communication with representatives on the WDFPC and via letters in November, 2017 (Appendix D1). The purpose of this report is to:

1. Present technical information developed for Step 4 (Preliminary Technical Feasibility Consideration), including documentation of the decision making process followed to arrive at a recommended conceptual technical design; and
2. Provide a plan for the preferred option for fish passage at Wilsey Dam to FWCP for endorsement (Step 5). This plan identifies potential risks and potential mitigation options, costs, and biological, conservation, cultural and other societal benefits associated with the fish passage plan to support BC Hydro's TBL business case development (Step 6).

Submission of this report marks the end of the proponent-driven stage (Step 1-4) of the fish passage process and the beginning of the FWCP/BC Hydro driven stage (Step 5-7). It is intended to fulfil the information needs of Steps 4 and 5 as outlined in the *Fish Passage Framework*. The intended outcome is to achieve FWCP endorsement of fish passage at Wilsey Dam and complete Step 5 of the *Fish Passage Framework*.

1.3 Overview of Fish Passage Goals

The WDFPC identified three primary goals of fish passage at Wilsey Dam. The goals, their rationale, possible performance measures, expected benefits, and alternative actions to fish passage that were considered to achieve these goals are described in detail in Section 4.

Goal 1: Increase salmon populations and provide fish access to historical spawning and rearing habitats upstream of Wilsey Dam

Goal 2: Restore historic fisheries and increase fisheries potential

Goal 3: Increase tourism, visitation and educational opportunities

2. PHYSICAL SETTING

2.1 Location and Watershed Overview

Wilsey Dam is located approximately 35 km east of Vernon on the Shuswap River (Figure 1). The Shuswap River originates from Joss Pass and flows south into Sugar Lake (Upper Shuswap watershed). It then flows through Peers Dam (known as Sugar Lake Dam) at the outlet of Sugar Lake at the location of Brenda Falls toward Lumby and north before flowing into Mabel Lake (Middle Shuswap watershed). The river then flows out of Mabel Lake northwest toward Mara Lake (Lower Shuswap watershed).

The Middle Shuswap River has several major tributaries. Above Wilsey Dam, Cherry and Ferry creeks join from the east just upstream of Cherryville. The Cherry Creek watershed is almost entirely forested, except for some agricultural activity in the lowest reaches and for the uppermost ridges (elevation 2,570 m), which are above the treeline. Ferry Creek enters the Shuswap River 2 km further downstream and is also almost entirely forested. Its headwaters are a swampy plateau at an elevation of nearly 2,000 m (NHC, 2018). Bessette Creek joins from the south 2 km below Wilsey Dam.

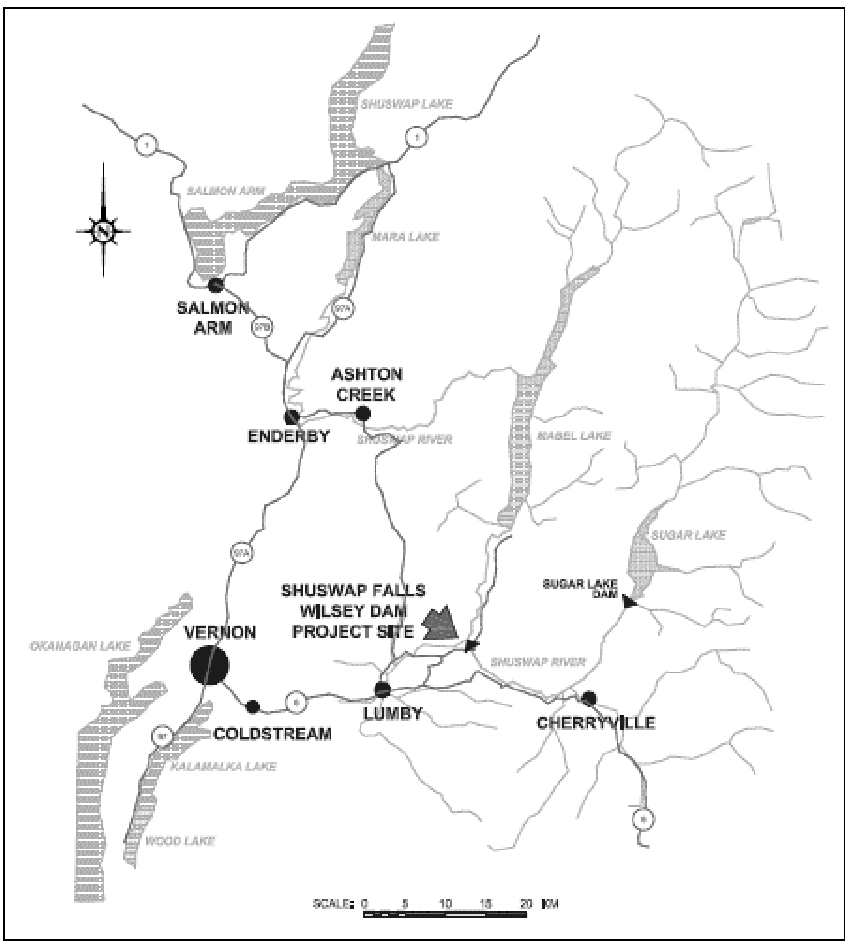

Figure 1: Location of Shuswap River Watershed and Wilsey Dam (NHC 2005).

The Shuswap watershed is affected by both moist maritime air masses and drier continental air masses. Winter snowpacks are relatively deep and small glaciers are located in the eastern headwaters (Golder Associates, 2012). The Middle Shuswap River is a snowmelt-driven system with large freshet flows from May to July and relatively low flows during the remainder of the year (Figure 2). Flows typically peak in June at approximately 163 m^3/s and sometimes a smaller peak occurs in the fall if rainfall is significant. Flows are lowest during the winter months and average monthly minimum flows are approximately 23 m^3/s. Flows typically range from 16 to 222 m^3/s (Table 1).

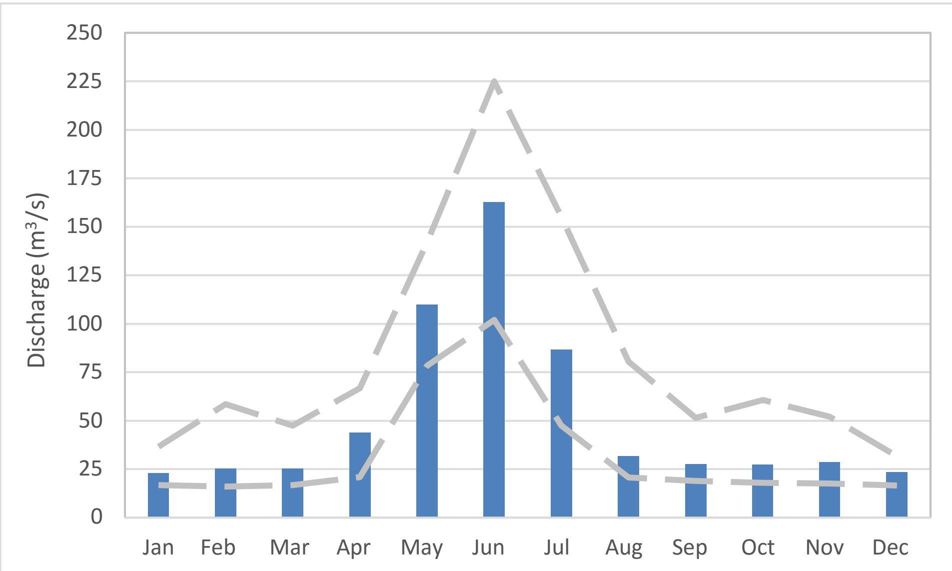

Figure 2: Mean monthly flows (blue bars) and mean monthly peak and minimum flows (grey lines) in the Shuswap River below Wilsey Dam between 1999-2014 (WSC station 08LC003).

Table 1: Annual flow exceedance in the Middle Shuswap River between 1999-2014 (WSC station 08LC003) (Dearden & Garello, 2017).

Percent of Time Exceeded	Flow (m^3/s)
99%	16
95%	18
90%	19
80%	21
75%	22
50%	28
25%	59
10%	131
5%	171
1%	222

2.2 BC Hydro Facilities

Wilsey Dam was constructed by the West Canadian Hydroelectric Corporation on the Middle Shuswap River in 1928. The 30 m high Wilsey Dam is located 22.4 km upstream of Mabel Lake at an elevation of 418 m with a crest elevation of 448.54 m. The facility consists of a concrete arch dam, spillway and two generation units. The dam has two intakes that carry flow through separate penstocks along the left bank to the generating station (Figure 3 and Plate 1). Intake No. 1 is on the left abutment and Intake No. 2 is on the right abutment. Wilsey Dam has a small headpond (~ 7 ha) because most of the water for generation is stored behind Sugar Lake dam approximately 29 km upstream. These two structures make up the Shuswap generating station (BC Hydro, 2003).

Wilsey Dam has a non-gated spillway located on river right, constructed at a crest elevation of 444.5 m (Figure 3 and Plate 2). The spillway can be raised approximately 1 m by adding flashboards. These flashboards are used to create a higher head for power generation during low flows and to prevent the build-up of frazil ice during winter. The spillway was blasted out of bedrock along river right (Plate 3). The water going over the spillway enters the main channel by either going the full length of the spillway channel (~240 m) and entering the original river channel opposite the tail race of the generating station (Plate 4) or through a shorter route (~70 m) across a cut in the rock wall that divides the spillway channel and river channel. Water moving through the shorter spillway route plunges into a pool in the original river channel about halfway between the dam and the tailrace (Plate 5).

The powerhouse consists of two Francis turbine units with a combined capacity of 6 MW, and a hydraulic capacity of 31.6 m^3/s. Maximum withdrawals of 16.4 m^3/s and 15.2 m^3/s from Intake 1 and 2, respectively, carry inflows to two turbine units. Any inflows that exceed the maximum turbine capacities of the generating station are spilled. Due to maintenance and repair requirements at Unit 1, only Unit 2 has been in operation for several years and no flow currently passes through Intake 1. BC Hydro has stated that there are currently no plans to repair Unit 1; therefore, it is unknown when the unit will be taken back into operation (Croxall, pers. comm.). This reduces the generating capacity to approximately 3 MW and maximum withdrawals to 15.2 m^3/s.

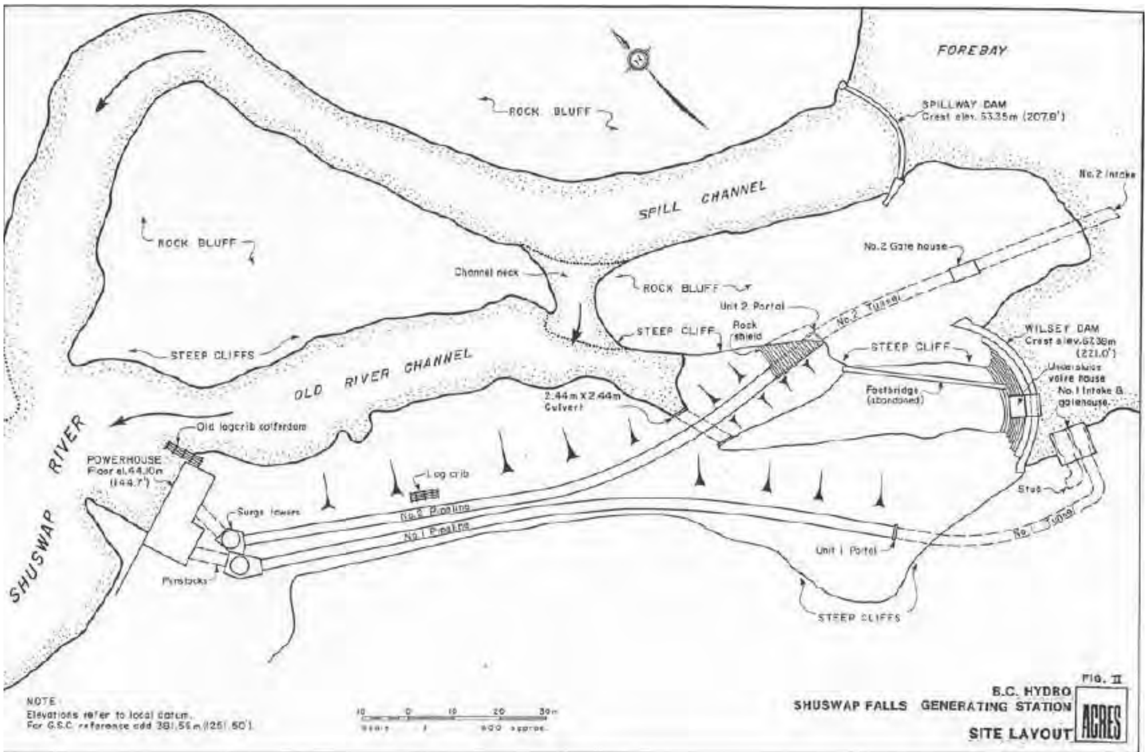

Figure 3: Wilsey Dam facility layout (NHC and Ecofish, 2002).

Plate 1: Wilsey Dam facility layout.

Plate 2: Wilsey Dam spill crest (source: BC Hydro).

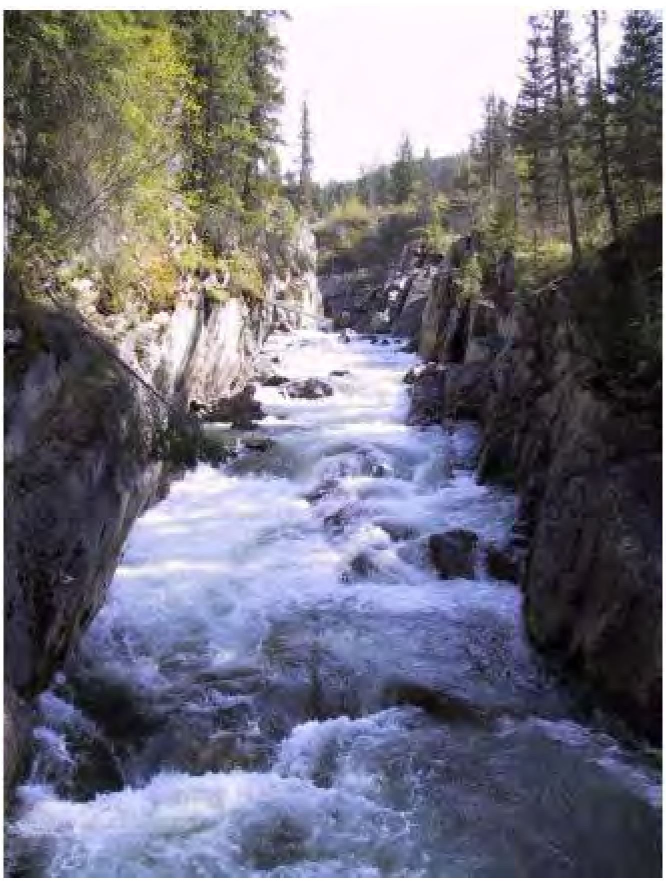

Plate 3: Spillway channel (source: NHC, 2002).

Plate 4: Spillway exit opposite the powerhouse. Powerhouse is located to the right of the photo (source: ONA).

Plate 5: Old channel and spillway saddle upstream of Wilsey Dam is seen on the right of the picture (source: ONA).

3. BIOLOGICAL SETTING AND CONSIDERATIONS

A detailed description of Middle Shuswap River fish populations, their life history, abundance trends, and escapement goals are presented in McGrath et al. (2014). Specific information from that report that is relevant to the fish passage design and technical feasibility are summarized below.

3.1 Middle Shuswap River Fish Populations

The Middle Shuswap River supports several anadromous salmon populations including Chinook Salmon (*Oncorhynchus tshawytscha*), Coho Salmon (*Oncorhynchus kisutch*), Sockeye Salmon (*Oncorhynchus nerka*) as well as resident salmonids such as Rainbow Trout (*Oncorhynchus mykiss)*, Mountain Whitefish (*Prosopium williamsoni)*, Bull Trout (*Salvelinus confluentus)*, Lake Trout (*Salvelinus namaycush)*, and Kokanee Salmon (*Oncorhynchus nerka)*. Coarse fish and minnow species include Longnose Dace (*Rhinichthys cataractae*), Redsided Shiner (*Richardsonius balteatus*), Slimy Sculpin (*Cottus cognatus*), Prickly Sculpin (*Cottus asper*), Leopard Dace (*Rhinichthys falcatus*), Northern Pikeminnow (*Ptychocheilus oregonesis*), Bridgelip Sucker (*Catostomus columbianus*) and Largescale Sucker (*Catostomus macrocheilus*) (McGrath et al., 2014).

3.2 Target Species

The principal target species for restoration of fish passage are Chinook and Coho salmon (Bengeyfield et al., 2001). Abundant returns of Sockeye Salmon have been intermittent downstream of Wilsey Dam during the past decade and are also considered a target species. Provincial interests indicate consideration for Bull Trout and Rainbow Trout stocks that historically accessed habitat upstream of Wilsey Dam (NHC and Ecofish, 2002)

A key principle for local First Nations is that there is connection between all living things and the requirement for respect and protective measures to sustain healthy ecosystems and resources. As such, Kokanee Salmon is also considered to be an important species for its role in supporting other valued food fisheries in the Middle Shuswap River system; however, is not considered a target for re-introduction above Wilsey Dam.

3.2.1 Chinook Salmon

Chinook Salmon are the principal target species for fish passage at Wilsey Dam as the Middle Shuswap River and upstream offers the greatest gain in high quality habitats for this species (McGrath et al., 2014). Two Chinook Salmon populations are currently found below Wilsey Dam: a population that spawns in the mainstem; and a population that spawns in the Bessette Creek tributary system.

The mainstem Middle Shuswap River Chinook Salmon population consists primarily of ocean-type life history (the majority of juveniles migrate to the ocean shortly after emergence from the gravel). This population will be the donor stock for reintroduction above Wilsey Dam and is expected to spawn in the high quality mainstem habitats between Wilsey Dam and Cherryville (Shearing, 2012). Middle Shuswap River Chinook Salmon are part of the Shuswap River-summer timing-age 0.3 Conservation Unit (CU) (CK-15), which also includes spawning populations in the Lower Shuswap River below Mabel Lake and in Wap Creek, a tributary to Mabel Lake (Fisheries and Oceans Canada [DFO], 2013a). This CU was not assessed during a recent Wild Salmon Policy (WSP) status assessment because of hatchery enhancement influences (DFO, 2016).

Adult Chinook Salmon from this population typically return as 4 year old fish. They arrive in the Middle Shuswap River in early July until late September, peaking in mid-August. Spawning occurs from mid-September to late October, peaking in early October (Wolski, pers. comm.; NHC and Ecofish, 2002). Juveniles emerge from the gravel the following spring. Most fry from this population migrate to the ocean between April and June, peaking between April 1 and June 15 (Lister, 1990). Rearing mainly occurs in Mabel Lake during June and July. A proportion of fry (5%-40%) overwinter in freshwater and migrate to the ocean the following April or May (ARC Environmental, 2001a). Those fry may overwinter in Mabel and Shuswap lakes (DFO, 1997), though some offspring of Chinook Salmon spawners transplanted above Wilsey dam in 1993 remained until the following spring, suggesting that a small portion of fry remain to overwinter in the river (Triton, 1994). Offspring from natural spawners above Wilsey Dam may show a greater tendency for extended freshwater rearing than currently exhibited by the Middle Shuswap River Chinook Salmon stocks below the dam, which is thought to have been heavily influenced by hatchery practices (Bailey, pers. comm.).

This Chinook Salmon population has been influenced by hatchery supplementation via fry releases from the Shuswap River hatchery. Releases have averaged 268,796 over the past 12 years but reached above 1 million fry in the late 1980s (Brown et al., 2013). The contribution of hatchery fish to adult escapement has averaged 76% over the past 12 years but has reached as high as 91% (Brown et al., 2013). The primary objective for the hatchery program is the assessment of fishery impacts, and most of the released Chinook Salmon fry are coded-wire-tagged (CWT) for this purpose.

Detailed information on abundance trends and habitat use and availability for Middle Shuswap River Chinook Salmon are provided in McGrath et al. (2014). DFO has since updated the escapement time series and the most recent information is provided in Figure 4. Escapements of Middle Shuswap River Chinook Salmon have ranged from 293 to 7,032 fish since regular escapement surveys were initiated in the late 1970s, with an average of 1,620 spawners over the past 5 years. The general abundance trend of this stock over the past decade has been declining although other spawning populations in this CU with similar life history and marine distribution (e.g., Lower Shuswap) have experienced increased and record high abundances during this timeframe. The escapement target for Middle Shuswap River Chinook Salmon is 10,000 spawners (FWCP, 2011).

Currently, most Chinook Salmon spawning occurs within 3.5 km of Wilsey Dam (ARC Environmental, 2001a). Spawning habitat capacity upstream of the dam is estimated to be approximately 2.3 times greater than below the dam (Shearing, 2012). Most of the suitable spawning habitat above Wilsey Dam is located in a 13.2 km section between Cherryville and the chute immediately upstream of Wilsey Dam (McGrath et al., 2014).

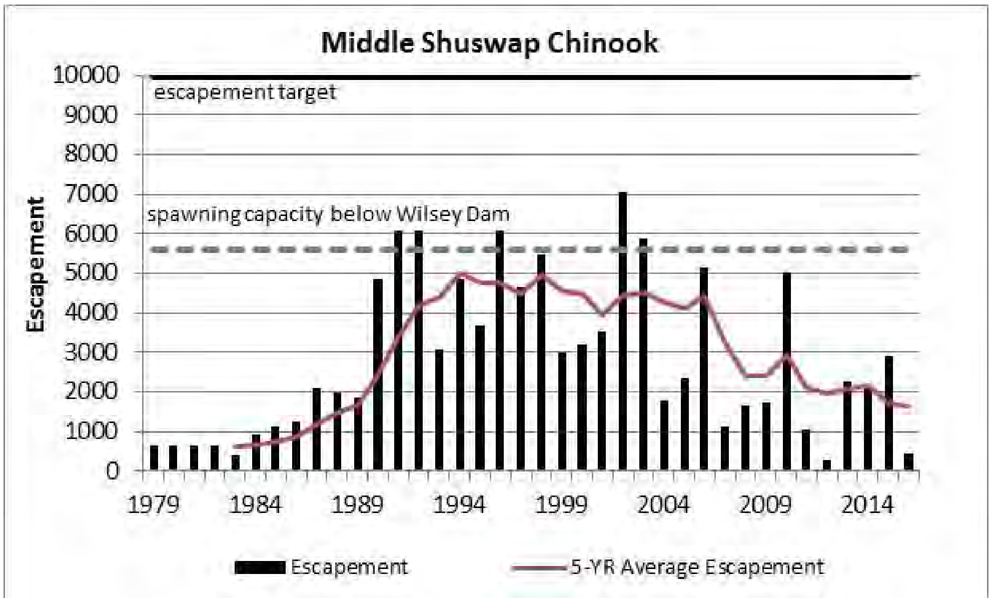

Figure 4: Escapement trends for the Middle Shuswap River Chinook Salmon population 1979-2016 (Source: DFO 2017, Salmon Escapement Data System [nuSEDS]).

The second Chinook Salmon population spawns in the Bessette Creek system, which flows into the Middle Shuswap River approximately 2 km downstream of Wilsey Dam. These are stream-type fish that typically spawn in smaller tributaries. Juveniles spend one full winter in their natal stream or other suitable freshwater habitats along their migration route and enter the ocean in the following spring. They also return as 4 year olds with spawning in Bessette Creek occurring from early to late September.

Bessette Creek Chinook Salmon are part of the South Thompson River-Bessette Creek CU (CK-16) that includes spawning populations in Bessette Creek and its tributaries. This population is not supplemented by hatchery releases and the CU was designated as Red status (poor) under the WSP (DFO, 2016). Escapements for this population are generally lower than the mainstem Middle Shuswap River population and have ranged from 0 to 550, with an average of 91 spawners over the past 5 years (Figure 5).

It is possible that some fish from this population may stray and migrate above Wilsey Dam to spawn in tributary streams such as Cherry or Ferry creeks; however, the Bessette Creek

Chinook Salmon population is very small and has been depressed for several decades, similar to other populations of the same life-history type throughout the Fraser River. Thus, the likelihood of a large stream-type population establishing in tributaries above Wilsey Dam is relatively low in the near future. Nonetheless, it is possible that a stream-type Chinook Salmon population existed in Cherry Creek prior to Wilsey Dam's construction and a new population may establish through colonization via straying from the Bessette Creek population in the long term. This may increase the resiliency of Fraser Chinook Salmon of this life-history type, which is beneficial given their conservation concern.

Like many other Chinook Salmon stocks throughout the south coast of BC, escapements for Bessette Creek and Middle Shuswap River Chinook Salmon stocks have been trending downward over the past decade. It is unclear what is driving this decline; however, changes in marine productivity, harvest, disease, freshwater habitat declines, and hatchery impacts are all thought to play a role (Riddell et al., 2013).

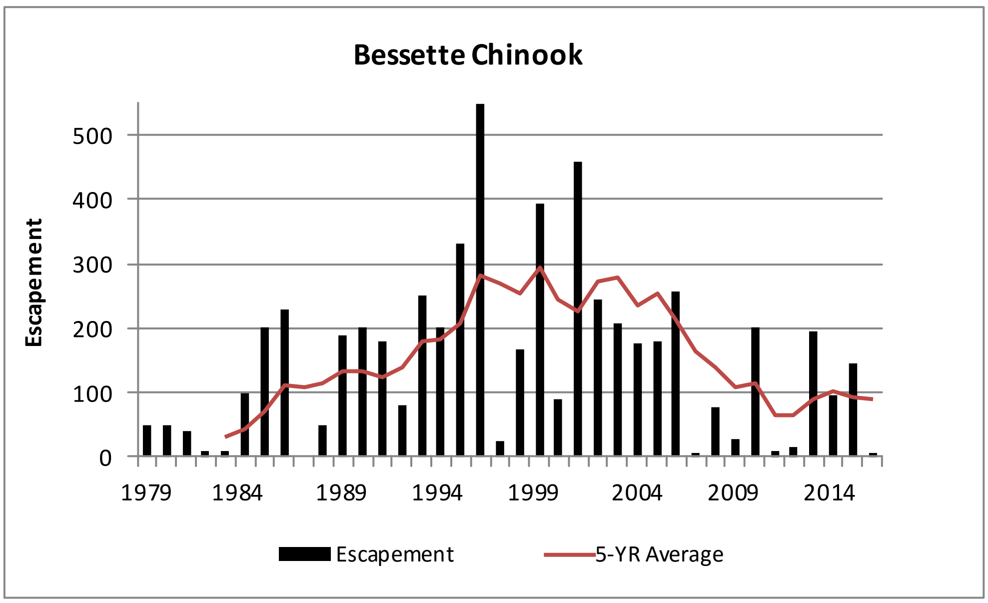

Figure 5: Escapement trends for the Bessette Creek Chinook Salmon population 1979-2016 (Source: DFO 2017, nuSEDS).

3.2.2 Coho Salmon

Two Coho Salmon populations are currently found below Wilsey Dam: a population that spawns in the mainstem; and a population that spawns in the Bessette Creek tributary system. Adult Coho Salmon return from the ocean to the Middle Shuswap River and Bessette Creek to spawn primarily as 3 year olds. They return between late September and the end of November and spawn between late-October and mid-November (Bengeyfield et al., 2001; Wolski, pers. comm.).

Coho Salmon fry emerge from the gravel in early April. Most fry rear for 1 to 2 years in freshwater, where they either remain in their natal stream or migrate downstream where they readily colonize tributaries along their path (Koski, 2009). In the Middle Shuswap River, Coho Salmon smolts generally migrate downstream between mid-April and the end of June (BC Hydro 2002; Wolski, pers. comm.) and approximately 65% of underyearling Coho Salmon from the Middle Shuswap River and Bessette Creek system migrate downstream by the end of May (Bowman and Stewart, 1984).

Coho Salmon escapements in the entire Interior of British Columbia suffered declines in the 1990s. The declines were thought to be caused by excessive fishing mortality combined with reduced marine survival, and prompted a review of the status of Interior Fraser Coho by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The review resulted in a status designation of “Endangered” in 2002, which was downlisted to “Threatened” in 2016 (COSEWIC, 2016). As a result, stringent fisheries management measures were implemented in the early 2000s in marine and freshwater fisheries along the coast to reduce Coho Salmon mortality to a minimum. These measures remain in place today.

Abundance trends for Middle Shuswap River and Bessette Creek Coho Salmon populations are provided in Figure 6 and Figure 7. Escapements for the Middle Shuswap River stock have ranged from 20 to 2,500 fish since the late 1970s, with an average of 809 spawners over the past 5 years. Escapements in the Bessette Creek system have ranged from 27 to 1,442, with an average of 645 spawners over the past 5 years. Escapements for both populations are trending upwards since the early 2000s, though large fluctuations are observed annually.

The escapement target for Middle Shuswap River Coho Salmon is 1000 smolts/km (FWCP, 2011) which translates to 762 spawners below Wilsey Dam (McGrath et al., 2014). Coho Salmon escapement goals for the section upstream of Wilsey Dam have not been determined though habitat exists for approximately 10,898 spawners (McGrath et al., 2014). Coho Salmon will likely migrate past Wilsey Dam following fish passage and may utilize spawning habitat in the mainstem and tributaries.

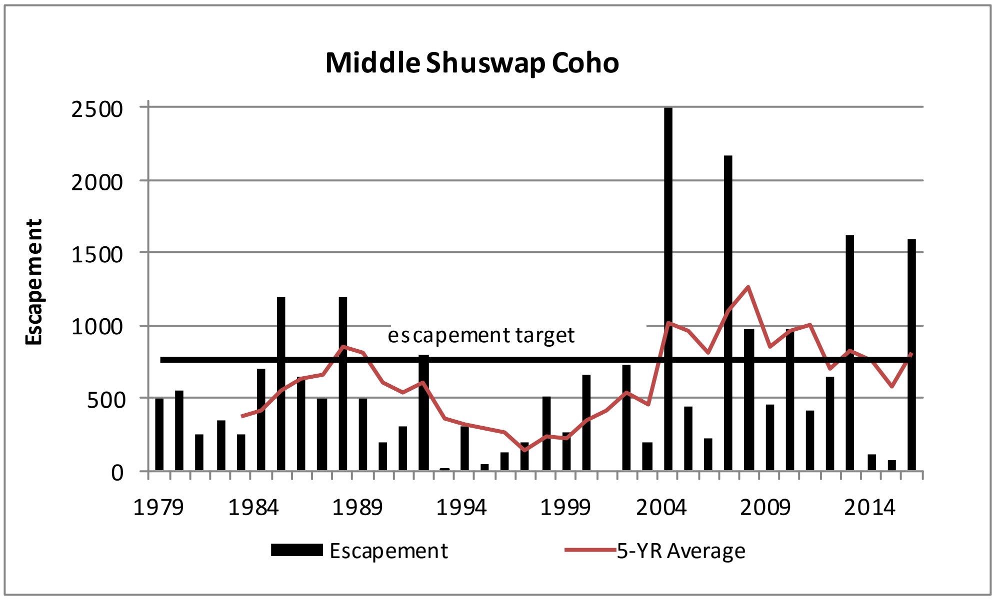

Figure 6: Escapement trends for the Middle Shuswap River Coho Salmon population 1979-2016 (Source: DFO 2017, nuSEDS).

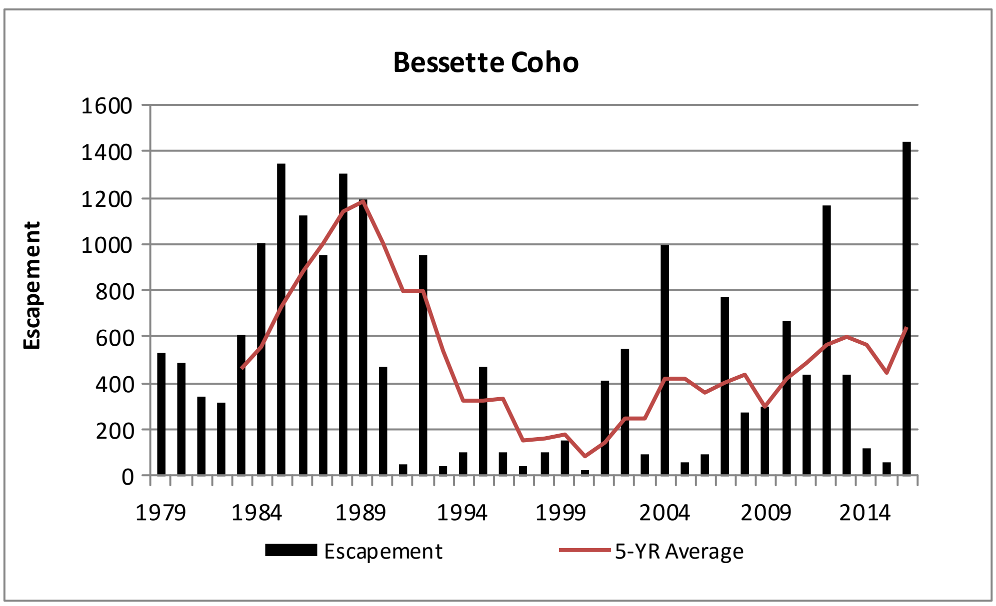

Figure 7: Escapement trends for the Bessette Creek system Coho Salmon population 1979-2016 (Source: DFO 2017, nuSEDS).

3.2.3 Sockeye Salmon

Sockeye Salmon return to the Middle Shuswap River to spawn primarily as 4 year olds. In recent years, Sockeye Salmon have also spawned in increasing numbers in Bessette Creek during dominant cycle years. These fish are part of the late run, which is strongly cyclical with a dominant large run every 4th year, and a subdominant, smaller run in the subsequent year. Returns in the in-between years can be very low. Very low returns of Fraser Sockeye Salmon in 2009 gave rise to the Cohen Commission, which was charged with investigating and reporting on the decline of Fraser Sockeye Salmon. That year was followed by record returns in 2010, indicating how drastically natural productivity of salmon stocks can fluctuate from year to year and cycle to cycle. Middle Shuswap River Sockeye Salmon are part of the Shuswap Complex CU, which has been assigned Amber/Green Status under the most recent WSP Assessment ("Healthy" status; DFO, 2013b).

Middle Shuswap River Sockeye Salmon return in late September, with peak spawn typically between October 10 to 20 (ARC Environmental, 2001a). Fry outmigration begins upon emergence from the gravel and generally occurs between April 1 and May 15, peaking between April 20 and May 10 (Lister, 1990). Fry migrate downstream to Mabel, Mara and Shuswap lakes, where they rear for one year before migrating to the ocean in the following spring (DFO, 1997; ARC Environmental, 2001a).

Middle Shuswap River Sockeye Salmon escapement for the dominant cycle has trended upwards in the past decade, similar to other Fraser Sockeye Salmon stocks of the late run. Returns of Middle Shuswap River Sockeye Salmon were on average 139,638 spawners for the last 5 returns of the dominant cycle year (2014) and 416 for the subdominant cycle year (2015). Returns in the off years are very low (Figure 8). Enumeration of Sockeye Salmon in Bessette Creek commenced in 2005. Returns to Bessette Creek are generally zero during non-dominant/subdominant Late Sockeye Salmon cycle years, but reached 5,900 for the dominant cycle year in 2014 (Figure 9). Returns of Middle Shuswap River Sockeye Salmon, particularly for the dominant cycle year, have been trending upward, reaching the highest number of spawners on record in 2010 (310,754; DFO 2017, nuSEDS).

The interim escapement target for the Middle Shuswap River Sockeye Salmon population is 75,000 spawners (FWCP, 2011). Sockeye Salmon escapement goals for upstream of Wilsey Dam have not been determined though habitat exists for approximately 11,033 spawners (McGrath et al., 2014).

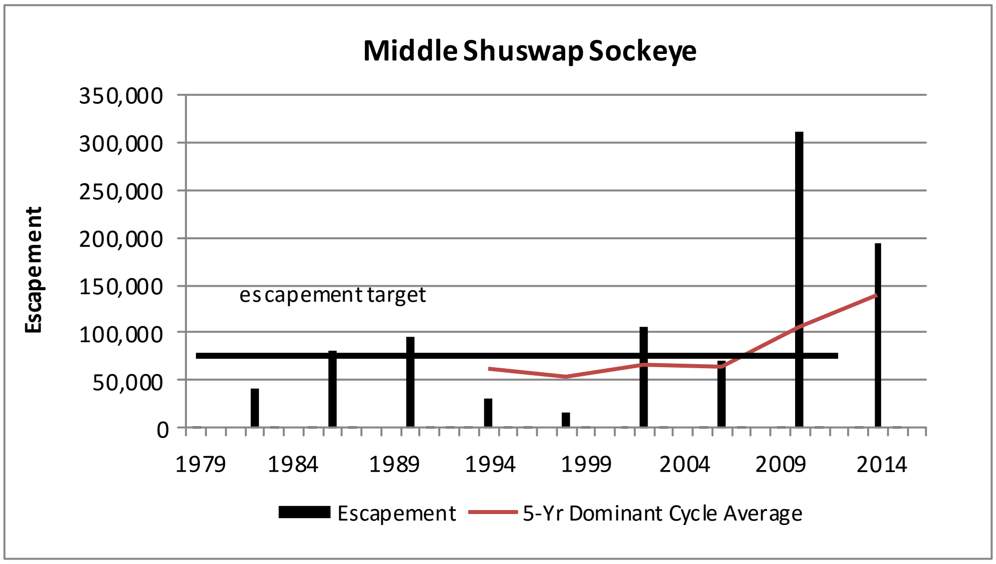

Figure 8: Escapement trends for the Middle Shuswap River Sockeye Salmon population 1979-2016 (Source: DFO 2017, nuSEDS)

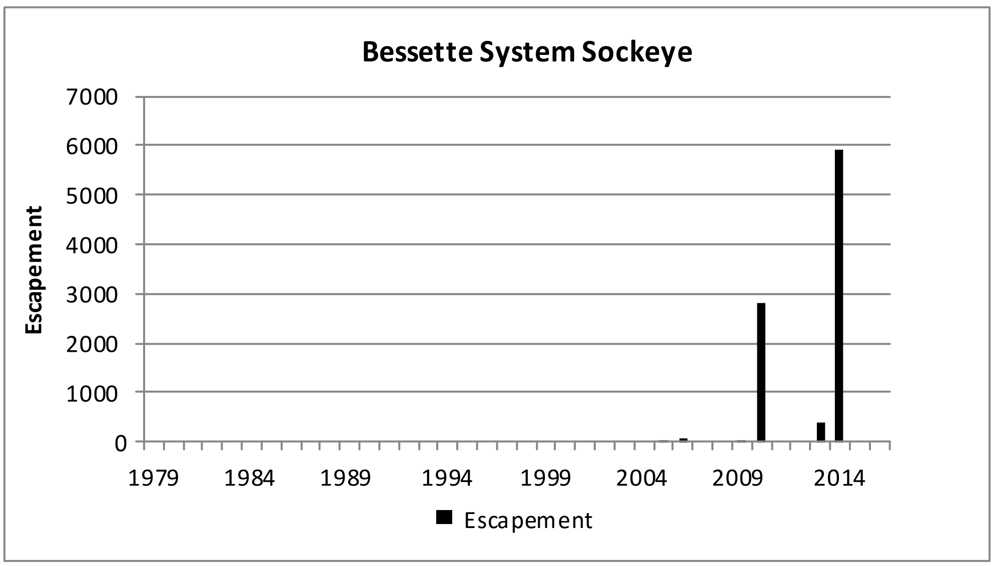

Figure 9: Escapement trends for the Bessette Creek Sockeye Salmon population 1979-2016 (Source: DFO 2017, nuSEDS)

3.2.4 Rainbow Trout

Rainbow Trout are distributed throughout the entire Middle Shuswap River above and below Wilsey Dam, including the Bessette Creek system and most of the tributaries (Golder Associates, 2012). These include small-bodied fluvial and resident populations in the Middle Shuswap River mainstem and tributaries, respectively, and large-bodied adfluvial populations that reside in Mabel Lake but spawn in the tributaries. The Bessette Creek system, (Duteau, Creighton and Harris creeks), is an important production area for this population (Griffith, 1986; Jantz, 1986; Audy et al., 2008; Warman, 2011), with migration to the spawning grounds in mid-March to mid-May, sometimes extending to mid-June (BC Hydro, 2002). Spawning occurs between mid-April and late May (NHC and

Ecofish, 2002) and the eggs and alevin incubate from mid-April to mid-July. Juveniles typically rear from 1 to 2 years in tributaries before moving back into side channels in the Middle Shuswap River mainstem or to Mabel Lake (BC Hydro, 2002; Wilson, pers. comm. 2005).

Spawning surveys are not conducted for Middle Shuswap River Rainbow Trout and numerical information on population trends is not available. Recent work indicates that Mabel Lake Rainbow Trout population abundance follows the 4-year cycle of Sockeye Salmon escapement from the Middle Shuswap River (Askey, 2013), as Sockeye Salmon fry are a preferred food item. Since 2007 there have been large fluctuations in the Rainbow Trout fishery (catch rates and fish size), and this appears to be related to the large fluctuations in Sockeye abundance. Rainbow Trout condition factor (size at age) is closely tied to the abundance of Kokanee and Sockeye pre-smolts, which are the primary forage species for the large bodied piscivorous Mabel Lake Rainbow Trout population. Rainbow Trout size is markedly higher in dominant cycle smolt years (run year + 2 years). Recent work suggests a potential factor limiting Mabel Lake Rainbow Trout growth is in-lake food supply (Askey, 2013).

Streamflow limitations in spawning tributaries downstream of Wilsey Dam have been a key bottleneck to juvenile stock production & survival (Askey, 2013; Epp, 2014; White, pers. comm. 2018). Improved water management strategies have recently been implemented, in attempt to improve Rainbow Trout survival and enhance the rearing habitat availability & quality (White, pers. comm. 2018).

Following implementation of fish passage, Rainbow Trout may begin migrating past Wilsey Dam and access new spawning habitats in the Middle Shuswap River mainstem and its tributaries upstream of Wilsey Dam. Most suitable Rainbow Trout spawning habitat exist in Cherry and Ferry creek tributaries but Middle Shuswap River mainstem spawning is also possible (McGrath et al., 2014). Spawning and migration timing will likely be similar to that observed in Bessette Creek. Upon completion of spawning, these fish return to Mabel Lake and migrate past Wilsey Dam on their return migration in May and June. Their offspring migrate to Mabel Lake following 1 to 2 years of tributary residence. Juvenile migration may occur throughout the year but has been found to occur mainly between March and June in other systems (Downs, 2000).

3.2.5 Bull Trout

Similar to Rainbow Trout, Bull Trout are present throughout the Middle Shuswap River watershed including large-bodied adfluvial populations in Mabel Lake and Sugar Lake, and fluvial and resident populations in the mainstem Middle Shuswap River and above Wilsey Dam in Cherry Creek (Chamberlain et al., 2001). They are not known to occur in the Bessette system and generally prefer colder water temperatures and headwater regions.

The fluvial Bull Trout population between Wilsey and Sugar Lake dams has likely evolved from a migratory population originating in either Sugar or Mabel lakes, prior to dam construction (Chamberlain et. al, 2001), which has likely greatly reduced the number of Bull Trout introduced to this river reach (Morris and Wilson, 2005). This population spawns in Cherry & Ferry Creek and possibly some of its tributaries (ARC Environmental, 2001b). Middle Shuswap River mainstem Bull Trout abundance is generally very low (Chamberlain et al., 2001; Triton, 1995).

The populations in Mabel and Sugar lakes have an adfluvial life history and spawn in tributaries. Suitable spawning substrate for Bull Trout exists in the Middle Shuswap River downstream of Wilsey Dam but high water temperatures likely limit habitat use, as this species has a distinct preference for cold water. These populations are known to spawn in tributaries to Mabel Lake, including Wap Creek (BC Hydro, 2002; White, pers. comm. 2018). They do access the Middle Shuswap River during the fall to feed on salmon carcasses and eggs, and in the spring to feed on emerging salmon fry. Once fish passage is established, spawners from this population may migrate past Wilsey Dam to spawn in Cherry Creek. In the Upper Shuswap River, spawning migrations from Sugar Lake into the Upper Shuswap River tributaries typically commence in early July with spawning occurring in early-mid August. Outmigration of spawners (“kelts”) occurs in mid-September (Morris and Wilson, 2005). Timing of Bull Trout migration through Wilsey Dam would likely be similar, though it may occur earlier in the spring to avoid high water temperatures (NHC and Ecofish, 2002). Local fishermen report catches of large Bull Trout in the canyon immediately below Wilsey Dam in April (Scouras, pers. comm.), which would support this notion.

Bull trout fry tend to stay in tributaries for several years before moving to the lake or mainstem river. Outmigration timing varies but distinct pulses during spring freshet and/or in the summer have been reported from other river systems (Kang & Warnock, 2017). In the Middle Shuswap River, it is expected that juvenile outmigration occurs over a longer time period throughout the year compared to the distinct migration pulse of some of the salmon species (e.g., Sockeye Salmon), though migration likely seizes during cold water temperatures in the winter.

Bull Trout are currently blue-listed in BC (Special Concern) (BC Conservation Data Centre, 2017). Bull Trout in the Middle Shuswap River watershed are part of the Pacific population (Designated Unit [DU] 5), which occurs throughout much of the interior of British Columbia and was designated overall as “Not at Risk” in 2012 (COSEWIC, 2012). However, the Mabel Lake Bull Trout population was designated as “Potential Risk” and Middle Shuswap Bull Trout (between Wilsey and Sugar Lake dams) were designated as “High Risk” of extirpation (COSEWIC, 2012; Hagen and Decker, 2011). The assessment points out this species’ particular need for cold, pristine waters and unimpeded migratory routes joining spawning to adult habitat (COSEWIC, 2012).

3.2.6 Kokanee

Middle Shuswap River Kokanee Salmon migrate from Mabel Lake into the river to spawn as 3 year olds. They are generally small-bodied and average around 200 mm in length. They make extensive use of side channels for spawning (Jantz, 1992) and utilize shallower depth, smaller substrate areas with lower water velocities than the anadromous salmon in the system. Mainstem spawning can be significant during some years but most spawning activity occurs closer to Mabel Lake in the lower gradient section of the river (Jantz, 1992; Chamberlain et al., 2001). A small number spawn in lower Bessette Creek but no regular escapement surveys for Kokanee Salmon are conducted in this system (ARC Environmental, 2001a). Kokanee Salmon are also present in the Upper Shuswap River above Sugar Lake, but not in the Middle Shuswap River between Wilsey Dam and Sugar Lake (Chamberlain et al., 2001).

Kokanee Salmon spawn timing is from mid-September to mid-October. Fry emerge in mid-April and immediately migrate to Mabel Lake, where they are a key forage species for Bull Trout, Rainbow Trout, Lake Trout, and Burbot (*Lota lota*) in Mabel Lake (Chamberlain et al., 2001).

The highest Kokanee Salmon escapement on record for the Middle Shuswap River is 70,594 (2009). Escapement surveys are not undertaken in every year and for that reason it is difficult to determine trends in population abundance. The interim escapement target below Wilsey Dam is 70,000 spawners (FWCP, 2011).

Kokanee Salmon are the primary food source for the Bull Trout & large-bodied piscivorous Rainbow Trout populations which reside in Mabel & Sugar lakes. The nerkid population density (Kokanee/Sockeye) and size structure fluctuates dramatically between years, due to the flux of Sockeye through the system. On non-dominant years, the age-0 nerkid population is primarily Kokanee (Askey, 2013). Recent studies indicate that Kokanee stocks are on the lower end of that required to sustain these piscivorous populations (Askey, 2013).

It is unlikely that substantial numbers of Kokanee Salmon will migrate upstream of Wilsey Dam following implementation of fish passage as they are not known to utilize spawning habitats upstream of Bessette Creek (Jantz, 1992) likely due to unsuitable substrate and velocity conditions.

3.3 Fisheries Management Considerations

Salmon produced in the Middle Shuswap River are caught in First Nations, recreational and commercial fisheries along the entire West Coast of North America, from the Gulf of Alaska through the Fraser and Thompson rivers to the Middle Shuswap River. Fisheries exploitation and management objectives differ for each species and comprise both domestic and international components. Establishment of fish passage would potentially open additional fishing areas for anadromous salmon in the river upstream of the dam and would thus require updating of fishing regulations as we all as an expansion of creel monitoring programs to the newly opened areas.

Middle Shuswap River Chinook Salmon (Section 3.2.1) are managed as an escapement and an exploitation rate indicator stock under Pacific Salmon Treaty Chinook Chapter since 2008. For this purpose, DFO releases approximately 150,000 CWT Chinook Salmon smolts from the Shuswap River hatchery into the Middle Shuswap River below Wilsey Dam annually. Marine survival and exploitation in the fisheries is measured through recovery of tagged fish. High quality escapement estimates are developed annually to monitor abundance and trends, though a formal escapement goal has not yet been developed by the Pacific Salmon Commission (PST) Chinook Technical Committee (CTC). Middle Shuswap River Chinook Salmon total fisheries exploitation rates have averaged 47% between 2011 and 2016. They are primarily caught in the Alaska and northern BC troll fisheries, the southern BC marine recreational fishery and the Fraser River First Nations and sport fisheries (CTC, 2018). Locally, they are important contributors to recreational and First Nations fisheries along the Fraser and Thompson Rivers, and locally in Mabel Lake and the Lower and Middle Shuswap River.

Bessette Creek Chinook Salmon (Section 3.2.1) are part of the Fraser Spring 4_2 Chinook Salmon management unit, which are considered stocks of concern due to low escapements (DFO, 2017). This management unit uses the CWT Nicola River Chinook Salmon indicator stock as a proxy to estimate fisheries exploitation, which has averaged 19% between 2011 and 2016. This indicator stock is mostly caught in southern BC marine recreational and Fraser River fisheries, as well as Fraser River First Nations fisheries. Management actions aimed at reducing fisheries mortality on Spring 4_2 Chinook Salmon stocks are implemented in those fisheries, in addition to size and timing restrictions in Mabel Lake and the Middle Shuswap River to protect Bessette Creek Chinook Salmon. The overall domestic management objective is to conserve these stocks by limiting overall impacts and support rebuilding (DFO, 2017).

Middle Shuswap and Bessette Coho Salmon (Section 3.2.2) are managed primarily for conservation as part of the South Thompson Coho CU. While the status of Interior Fraser Coho is low, the PST Coho Chapter limits Interior Fraser Coho mortality to 10% in US fisheries and Canadian fisheries are managed to achieve less than 3% mortality. Fisheries along the entire coast have been considerably constrained since 1998 to conserve Interior Fraser Coho due to their conservation status (DFO, 2017), and as a result Coho Salmon fishing in the Middle Shuswap River is closed.

Middle Shuswap River Sockeye Salmon (Section 3.2.3) are a part of the late South Thompson Sockeye Salmon aggregate and are managed under the PST by the Fraser River Panel. This aggregate can be important contributors to commercial, First Nations and recreational harvests during the dominant and subdominant cycle years. Annual run size forecasts are developed under the Fraser River Sockeye Spawning Initiative, and fisheries are planned based on predicted abundances (DFO, 2017). There are typically no Sockeye Salmon fisheries in the Middle Shuswap River.

Rainbow Trout (Section 3.2.4) are primarily caught in the recreational fishery in Mabel and Sugar lakes. They may also be caught in the Middle Shuswap River. The fishery is managed as catch and release in the Shuswap River. In Sugar and Mabel lakes, the regional daily quota is 5, but not more than 1 over 50 cm. Provincial management priorities for Rainbow Trout stocks include stock assessment, evaluation of habitat availability and use, identification of escapement targets and factors limiting trout production. Sustainable exploitation rate for these fisheries is 20-30% per year.

Bull Trout (Section 3.2.5) are primarily caught in recreational fisheries in Mabel and Sugar lakes. They are managed as a quality char fishery; however the population is also listed as a regional species at risk (Long, 2003; COSEWIC, 2012). The status of Sugar Lake Bull Trout is currently unknown. Recent anecdotal evidence and limited historical data suggest that the Bull Trout population in Sugar Lake may be at risk of collapse. Current management objectives are to assess the Sugar Lake Bull Trout population, determine factors limiting the growth of the population, and refine fishing regulations (if required) to maintain a sustainable quality char fishery and conserve wild stocks (White, pers. comm. 2018).

The regional daily quota for Bull Trout in Mabel and Sugar lakes is currently 1 fish over 50cm. Bull Trout are protected in the Middle Shuswap River from fishing mortality by non-retention regulations.

Kokanee Salmon (3.2.6) are considered a keystone species and a critical prey fish for the Mabel Lake and Sugar Lake Rainbow Trout and Bull Trout populations. The Kokanee escapement target is set at 70,000 spawners in the Middle Shuswap River (White, pers. comm. 2018). Current management objectives include stock assessment, establishment of long-term escapement monitoring, and identification of factors limiting stock abundance.

Kokanee are primarily targeted in the Sugar and Mabel lakes recreational fisheries. The daily regional quota is set at 5 fish per day.

3.4 Biological Considerations for Fish Passage

This section provides information on key biological considerations for fish passage based on life history characteristics of the target species described in Section 3.2. It further provides information on threats to fish populations and the ecosystem associated with fish passage.

3.4.1 Upstream Passage

Re-establishment of previously excluded fish populations above Wilsey Dam via fish passage is expected to occur through natural dispersal. The preferred approach is to allow all species of fish that reside within the Shuswap River to have unrestricted access to the proposed fishway at Wilsey Dam on a year round basis if possible (Appendix *fish passage framework*), leading to the establishment of self-sustaining populations above the dam. Other interventions, such as seeding with hatchery fish, are not considered at this time. If insufficient numbers of fish are returning within the first cycle, DFO may recommend some seeding of the river above the Wilsey Dam facility to enhance recolonization (Appendix D2). Discussion among DFO, provincial fisheries managers, and First Nations representatives will be undertaken to identify concerns and, with consensus, to develop an acceptable strategy.

Key biological considerations for upstream passage include the migration timing and swimming abilities of target species.

Timing: Spawning migration timing of a composite of anadromous salmon species including Chinook, Coho and Sockeye salmon, and adfluvial Bull Trout and Rainbow Trout, extends from mid-March to early December. Thus, fish passage needs to be operational from early spring to late fall to accommodate the range of migratory species in the system (Figure 10). During this time period, mean monthly stream flows vary widely (16 to 222 m^3/s, Figure 2) and therefore, fish passage needs to accommodate and be operational under a wide range of flows.

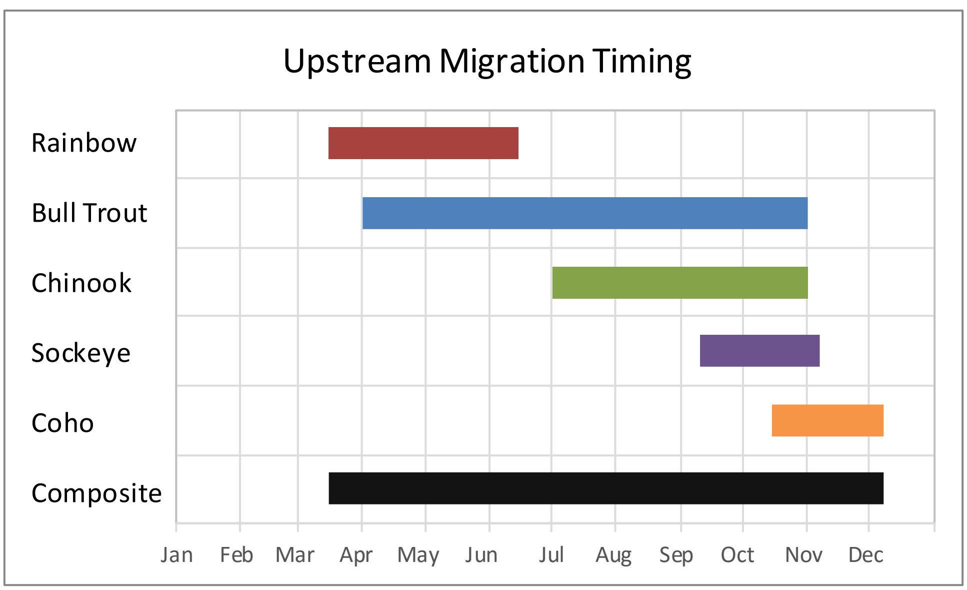

Figure 10: Upstream migration timing of target species for fish passage at Wilsey Dam.

Flow Velocities: Fish passage needs to be designed in a manner that accommodates the swimming ability and energetics of the target species, which generally increases with fish size. A detailed review of swimming abilities was conducted by WDFSC (2005) as part of the vertical slot fish ladder design and updated for the engineering feasibility study of the natural channel fishway (NHC, 2018). In summary, flow velocities in fishway constriction points (e.g., jumps) should be less than burst swimming capabilities, and in resting sections (e.g., glides/pools) should be less than the sustained swimming capabilities of a fish to minimize stress from fatigue (Katopodis, 1991). Excessive fatigue from migration through the fishway may lead to a reduced capability to survive and successfully spawn upstream. Most of the target species are large-bodied (>350 mm in length up to 800 mm; NHC and Ecofish, 2002) with the exception of adult Rainbow Trout, which may be smaller-bodied at lengths > 250 mm and juvenile Rainbow Trout at >100 mm.

3.4.2 Downstream Passage

Following fish passage, there will be two major types of downstream fish migration through Wilsey Dam: juvenile outmigration of anadromous and resident salmonids, and adult outmigration of adfluvial Mabel Lake Rainbow Trout and Bull Trout kelts. Anadromous fish passing Wilsey Dam are semelparous (die after spawning); their downstream movements through Wilsey Dam will thus be limited to those individuals that fall back below the dam after ascending the fishway. Key considerations for downstream passage include migration timing, body size and migration behaviours of emigrating fish.

Timing: Downstream movement of juveniles tends to occur in distinct pulses for some species, particularly for Sockeye Salmon and, to a slightly lesser degree, Chinook Salmon. Other species such as Coho Salmon, Rainbow and Bull trout migrate throughout the year but there is often a pulse during spring freshet (Figure 11). Adult outmigration of adfluvial Rainbow Trout and Bull Trout occurs after spawning is completed in the spring and fall, respectively (Figure 12).

Body size and migration behavior: Juvenile salmonid fry typically show a distinct surface orientation during downstream migration and follow the direction of flow (Coutant & Whitney, 2000). This has been observed at Wilsey Dam during hatchery Chinook Salmon fry releases (Walsh & McGrath, 2015) and Sockeye Salmon fry at Seton Dam (R.L. & L. Environmental Services Ltd, 1999). The body size of juvenile salmon ranges from 30-60 mm for Sockeye, Coho and Chinook salmon fry (spring migration), and from 60-120 mm for Coho and Chinook salmon parr and smolts which migrate over the summer and during subsequent spring (Triton, 1995; Quinn, 2011). Emigrating adfluvial Bull Trout and Rainbow Trout juveniles will likely be of similar length to those observed in the Cherry Creek system, which measured between 80-180 mm in length at age 1+ and 2+ (ARC Environmental, 2001b).

Information on the behavior of migratory adult Bull Trout and Rainbow Trout when passing hydroelectric facilities is relatively limited and likely site-specific. Steelhead (*O. mykiss*) kelts in the Snake River Basin passed through spillway routes in greater proportions and survived at higher rates compared to powerhouse passage (Colotelo et al., 2014). However, Wilsey Dam is different from most other systems studied in the literature due to the lack of a deep reservoir in its forebay.

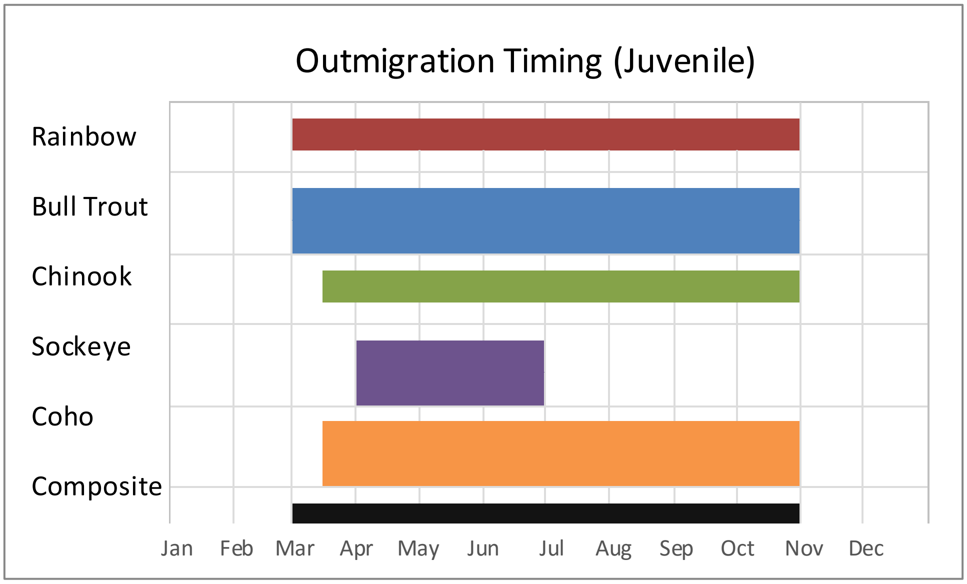

Figure 11: Outmigration timing of juvenile resident and anadromous salmonids in the Middle Shuswap River.

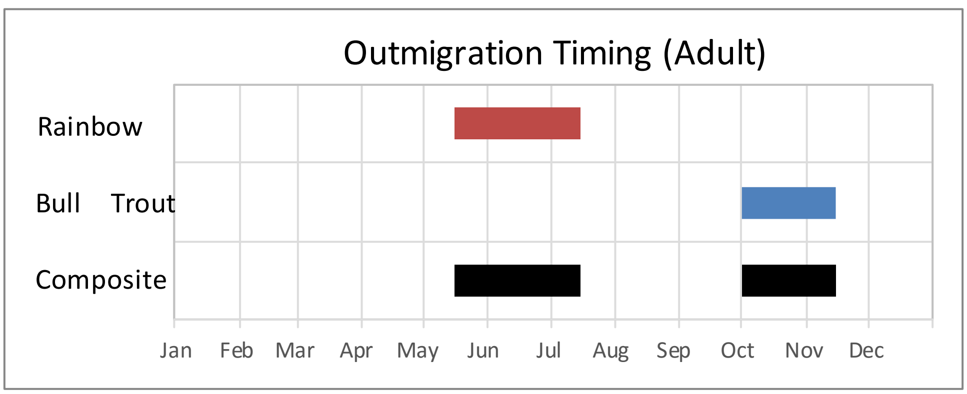

Figure 12: Outmigration timing of adult resident salmonids in the Middle Shuswap River.

4. FISH PASSAGE RESTORATION GOALS AND BENEFITS

The WDFPC has identified three goals that speak to the desired outcomes of restoring fish passage at Wilsey Dam. These goals were chosen under consideration of biological, economic and social drivers in the community and provided overall guidance to the WDFPC during its progression through the fish passage process and technical alternatives assessment (Section 5). The fish passage goals align with FWCP's strategic objectives of Conservation, Sustainable Use and Community Engagement (FWCP, 2017). Each goal statement includes a short description (rationale), suggested performance measures, expected benefits, and alternatives to fish passage considered to achieve the goal.

Goal 1: Increase salmon populations and provide fish access to historical spawning and rearing habitats upstream of Wilsey Dam

Rationale: Increased access to abundant, high-quality spawning habitat upstream of Wilsey Dam will enhance smolt production and accommodate large adult returns when marine conditions are favourable. The long-term objective is to contribute to the rebuilding of Middle Shuswap River salmon stocks consistent with escapement targets outlined in the Shuswap River Salmonid Action Plan (FWCP, 2011) and conservation objectives identified by fisheries managers for stocks of concern. Stream connectivity and habitat diversity are critical components of healthy rivers and reconnection of isolated habitats is one of the most effective restoration approaches (Roni et al., 2002).

Performance measures: Salmon escapement targets for the Middle Shuswap River were determined by DFO in the Middle Shuswap River Salmonid Action Plan (FWCP, 2011):

- 10,000 naturally spawning adult Chinook Salmon
- 1,000 Coho Salmon smolts/km
- 75,000 Sockeye Salmon spawners (this population is strongly cyclical)

While the objective is to achieve escapement targets for the species above, other factors within and outside of the Middle Shuswap River watershed (e.g., effects of hatchery supplementation, fishing mortality, migration and marine survival) and their influence on escapements need to be considered when evaluating the performance of this undertaking.

Expected Benefits:

- **Increased fry and smolt production for Middle Shuswap River salmon stocks.** Areas upstream of Wilsey Dam provide excellent spawning and rearing habitats for Middle Shuswap River Chinook and Coho salmon. Spawning habitats for these species, as well as Sockeye Salmon, are considered to be of higher quality above the dam in comparison to below because there is less fine sediment in the gravel. The coarser bed materials are expected to increase egg-to-fry survival and yield increased fry production. Overall spawning habitat upstream of Wilsey Dam for Chinook Salmon is estimated at 329,088 m^2 (12,956 spawners) versus 141,350 m^2 (5,565 spawners) below Wilsey Dam, and for Coho Salmon, there is an estimated additional 28,117 m^2 (10,898 spawners) of spawning habitat above Wilsey Dam (McGrath et al., 2014). Coho will likely use tributaries for spawning and rearing in addition to the mainstem, therefore, the actual upstream spawning habitat area is likely greater than this estimate (McGrath et al., 2014). Rearing habitats above the dam generally have colder water temperatures and are less impacted by agricultural activities, and this is expected to improve smolt production. Additional rearing habitat located above Wilsey Dam is estimated at 1135,000 m^2 during high flows for Chinook Salmon and 6,100 m^2 during low flows for Chinook and Coho salmon (McGrath et al. 2014). If environmental conditions are favourable, increased smolts will result in increased fishery recruits and ultimately, more adults returning to the Middle Shuswap River to spawn. Increased fry and smolt production will provide a larger prey base for resident fish species in the Middle Shuswap River and in Mabel Lake. The greatest benefits of fish passage in terms of fish production will be achieved during years of large escapements when spawning habitats below the dam are fully seeded, thereby limiting production.

- **Transfer of marine nutrients.** Salmon spawner carcasses will lead to a transfer of marine nutrients to areas upstream of Wilsey Dam where they will be available to the aquatic and terrestrial ecosystems. This is a return to historic conditions in contrast to the current situation where no marine biomass is added to the ecosystem above Wilsey Dam. The transfer of marine nutrients to interior areas via spawning salmon is linked to numerous ecosystem benefits, including healthier resident fish populations that benefit from the increased prey base, abundant food supplies for terrestrial wildlife who rely on salmon as integral parts of their diets (e.g., bears, eagles), as well as healthier riparian forests which in turn provide higher quality habitat for aquatic and terrestrial wildlife species (Gende et al., 2002).

- **Conservation.** The Middle Shuswap River is a spawning location for Interior Fraser Coho, which were listed as Threatened by COSEWIC in 2016. Providing access to a wider range of high-quality habitats with cooler water temperatures above Wilsey Dam may contribute to the recovery of and increase the resiliency of this population. Other fish populations of conservation concern include Middle Shuswap River Bull Trout and Bessette Creek Chinook (Section 3.2).

Alternative Actions to Achieve this Goal: Several alternatives to fish passage for achieving the first component of this goal (enhance salmon populations) were considered, including restoration of habitats below the dam and hatchery supplementation.

Habitat restoration below the dam could increase carrying capacity and salmon production from the restored or enhanced habitats. However, it is highly unlikely that habitat restoration could achieve the same magnitude of enhancement as opening up entirely new, abundant, high quality habitats above the dam for the following reasons:

(1) The ability to enhance mainstem spawning habitats for Chinook Salmon below Wilsey Dam is likely limited to the first ~ 8 km below the dam because the stream gradient further downstream is too low to support the large gravels preferred by this species.

(2) Some of the known habitat issues below the dam are ongoing in nature and will take many years to remedy (e.g., excess sediment deposition from Bessette Creek). Work is underway but adequate funding is often difficult to obtain and projects depend on the collaboration of local landowners on whose property the problem sites are located. Installation of spawning gravels could be used on a small scale as it is impractical on a large scale; however, it is likely that any installed spawning structures would experience deterioration through annual sedimentation similar to the rest of the Middle Shuswap River below the Bessette Creek confluence.

(3) Habitat restoration actions are very cost intensive and it is estimated that restoration actions that would produce habitat gains equivalent to fish passage would be far higher in cost. For example, placing 1,600 m^2 of spawning gravels in the Campbell River cost approximately $690,000 ($430/m^2) in 2008 (NHC, 2008). This translates to a cost of $141,507,840 for installing the equivalent of the 329,088 m^2 of Chinook Salmon spawning gravels that exist upstream of Wilsey Dam, plus annual maintenance. Further, such a large-scale undertaking would be impractical given river conditions and access.

(4) Rearing capacity for salmonids below Wilsey Dam could be increased by the maintenance and improvement of side channel access, and by installation of large woody debris clusters. Substantial work of this nature has been undertaken in the past. However, ongoing maintenance of previously completed works is required and there is no evidence that previous actions have resulted in significant gains in salmonid production. A potential reason is that rearing habitat has not been identified as limiting in the system due to extensive rearing habitats available in Mabel Lake and the general life history plasticity and tendency to use non-natal areas for rearing of juvenile Chinook and Coho salmon (McGrath et al., 2014).

There are no alternatives to fish passage for achieving the second component of this goal (provide fish access to historical spawning and rearing habitats upstream of Wilsey Dam).

Goal 2: Restore historic fisheries and increase fisheries potential

Rationale: Middle Shuswap salmon stocks, particularly Chinook Salmon, are important contributors to First Nations, recreational and commercial fisheries along the entire West Coast of North America. At current exploitation rates for Middle Shuswap River Chinook (47%; Section 3.3), full utilization of spawning habitats above Wilsey Dam would add approximately 11,500 mature Chinook Salmon to fisheries along the coast. Increased adult salmon returns will lead to increased fisheries potential along their entire migration above Wilsey Dam. Shuswap Falls was a key fishing location for local First Nations prior to the building of Wilsey Dam. A Food, Social and Ceremonial (FSC) fishery remains in the area below the dam but FSC needs are rarely met due to low escapements and the conservation status of Interior Fraser Coho. Other Middle Shuswap salmon stocks, such as Coho and Sockeye salmon, are currently less important contributors to local fisheries due to their conservation status and cyclical abundance, respectively.

Performance measures: Increased catch of Middle Shuswap River Chinook Salmon. Of particular interest is an increase in local catch in in-river FSC fisheries and in recreational fisheries in Mabel Lake as measured through catch monitoring data.

Expected Benefits:

- **Restoration of the FSC fishery in the Middle Shuswap River.** Increased abundance of Middle Shuswap River salmon stocks will contribute to local First Nations meeting their FSC needs which are currently often unmet.
- **Restoration of historic First Nations fisheries above Wilsey Dam.** Access to the historic First Nations fishing site at Shuswap Falls has been severely restricted due to the Wilsey Dam facility. Restoration of fish access above the dam will enable First Nations to fish areas upstream of the dam as they did in the past, though access to the facility itself will remain as is.
- **Increased catches of Middle Shuswap River Chinook Salmon in recreational fisheries.** Of particular focus are the recreational fisheries in Mabel Lake and the Middle Shuswap River. Increased recreational catch will result in the area becoming increasingly well known as a fishing destination and lead to increased expenditures by anglers in the area through purchases of gear, food, fuel and lodging. This would add to the local economy and provide additional business opportunities (e.g., guiding).

Alternative Actions to achieve this Goal: An increase in the number of fishery recruits could be achieved by increasing hatchery supplementation of Middle Shuswap River Chinook Salmon. However, the primary objective of the Shuswap River hatchery program is the assessment of fishing mortality and not supplementation of the stock for harvest purposes. The proportion of hatchery Chinook Salmon compared to natural spawners in the escapement of this stock has historically been high (approx. 76%, Section 3.2.1). This poses a conservation concern due to potential impacts associated with genetic effects that result from genetic introgression of hatchery and natural fish, and the effects of ecological interactions that can occur at multiple life stages (Riddell et al., 2013). Further, consistent collection of sufficient broodstock to support additional harvest production is questionable due to current relatively low escapements during some years. Lastly, the Shuswap River hatchery is fully utilized by current production (Bailey, pers. comm.). Thus, increasing hatchery production further to achieve harvest objectives is not considered feasible for this stock.

There are no alternative actions to achieve restoration of historic First Nations fisheries above Wilsey Dam.

Goal 3: Increase tourism, visitation and educational opportunities

Rationale: An observable salmon run above Wilsey Dam would add to the visitor experience of tourists in the area, many of whom are interested in the natural environment and opportunities to observe wildlife. Current salmon viewing opportunities in the Middle Shuswap River are limited to a gravel bar near the hatchery approximately 1 km below Wilsey Dam, with no tourism infrastructure or information to guide visitors (e.g., park facilities, signage, trails, parking, maps, advertisement). Providing up-close salmon viewing in the setting of the existing BC Hydro park and associated facilities would greatly enhance the visitor experience. Further, being able to observe fish passing upstream via ladder or other mechanism would provide ample educational opportunities for regional schools, seniors groups and conservationists.

Performance measure: Increased visitors to Lumby and Shuswap Falls; increased school/educational visits to the facility.

Expected Benefits:

- **Increased visitation:** Depending on the scale of the salmon run and viewing opportunities, increased visitation to the area could be substantial, as witnessed by the Adams River salmon run. Increased visitation will benefit local businesses through expenditures such as fuel, food and lodging.
- **Increased business opportunities:** Improved fisheries and visitation would increase opportunities for businesses such as eco-tourism and fishing guides.
- **Education.** Viewing salmon during their spawning migration presents excellent educational opportunities, which would be beneficial to local schools in educating the next generation(s) about the life cycle of anadromous fish and the importance of healthy and connected ecosystems. Enhanced salmon runs and access to additional fishing locations above the dam would also provide opportunities to teach and conduct indigenous fishing practices and ecological knowledge for local First Nations communities. A revitalization of the FSC fishery would enable First Nations to preserve and maintain the importance of this culturally important fishing area.

Alternative Actions to Achieve this Goal: Options for increasing fish and fishing-related tourism and education in the Middle Shuswap River are fairly limited without fish passage. Being able to get up close and view migrating salmon is an important component of the tourism and educational goal, and the potential is limited without a confined channel, such as a natural bypass channel or fish ladder that the salmon migrate through. Ready access to the mainstem river below the dam is limited to a small section of public land immediately below the dam by the hatchery that would have to be developed into a park with access, trails and viewing platforms. That would be challenging at this location due to topography of the area, limited space and seasonal inundation during spring freshet which would pose significant risks to any installed infrastructure. In addition, viewing conditions for salmon would likely be marginal due to deep water conditions in the mainstem and the lack of a confined “focal point” that salmon have to pass that is readily accessible and viewable. This location is also currently at the upstream end of the accessible range for salmon, meaning that significant spawning occurs downstream in areas surrounded by private land and not accessible by the public for viewing.

Increased access to fish-bearing sections of the river and an increase in the fish stocks to allow a harvestable surplus are key to developing fishing-related business opportunities. Alternative actions to achieve these benefits, including hatchery supplementation and habitat enhancement below the dam are either not feasible or unlikely to achieve the same increases in production, and cannot provide additional access to the river.

5. EVALUATION OF FISH PASSAGE ALTERNATIVES

Step 4 of the *Fish Passage Framework* stipulates the responsibility of the proponent for identifying the fish passage solutions that will best address requirements to meet stated restoration goals. Following confirmation that environmental feasibility of fish passage was met and Step 3 requirements were satisfied, the WDFPC implemented an alternatives assessment process for fish passage technologies in the spring of 2016. This section outlines the evaluation and decision making process followed by the WDFPC and describes key assessment considerations. The evaluation process is described in Section 5.1 and Evaluation Criteria and Considerations are described in Section 5.2. Supporting documents developed for the decision making process are provided in Appendix B.

5.1 Evaluation Process

The evaluation process for fish passage alternatives followed a SDM approach with a common set of evaluation criteria. The process extended over almost 2 years and involved two workshops, provision of expert opinion, technical literature review, and two engineering feasibility studies (Figure 13).

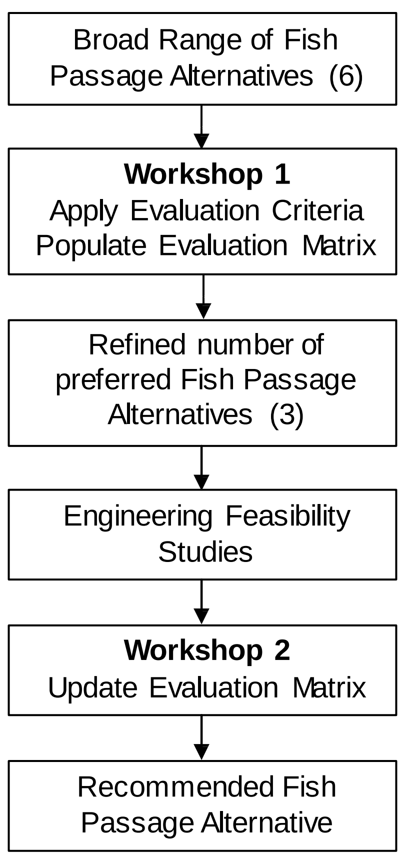

Figure 13: Fish Passage Alternatives Evaluation Process

The WDFPC initially developed a broad list of fish passage alternatives for consideration, including:

- **Fish Ladder in Spillway** – a concrete vertical slot fish ladder that would be constructed within the current spillway of Wilsey Dam and exits upstream through the spill crest. This option was considered and described by NHC (2005).
- **Fish Ladder Off-Channel** – a concrete vertical slot fish ladder that is constructed off-channel along the river right bank through the BC Hydro park. The downstream entry would be located at the outlet of the spillway and the upstream exit would be located approximately 100 m upstream of the spill crest. A detailed design for the ladder with supporting geotechnical studies was prepared by NHC (2005). The cost of the ladder was updated along with some minor updated design recommendations in NHC (2018).
- **Naturalized By-Pass Channel** – a nature-like channel that resembles a natural stream and is constructed of mainly natural materials on the river right bank. A feasibility assessment and preliminary design for this option were completed by NHC (2018). The downstream entry would be located approximately 200 m below the outlet of the spillway in the canyon and the upstream exit would be located approximately 100 m upstream of the spill crest.
- **Whooshh Fish Cannon** – a novel fish transport system that uses flexible tube and a pressure differential to rapidly transport fish upstream of an obstruction. The inside of the tube is kept relatively frictionless through the use of misters. A feasibility assessment and concept evaluation was prepared by (Dearden & Garello, 2017). Whooshh includes a volitional entry system on a floating platform which would be located in the large back eddy pool below the powerhouse. Fish would be enticed to enter the system through the use of attraction flows sourced from penstock #2, and enter a sorting system over a false weir. The system would automatically scan the fish for size and sort it to the appropriate sized tube (larger for fish like Chinook Salmon, smaller for fish like Sockeye and Coho salmon). The tubes would be routed up the old river main channel, up the rock outcrop that separates the main channel and spillway, and exit at the mid-channel gravel bar approximately 100 m upstream of the spill crest directly into the main channel.
- **Trap and Truck** – trap and truck operations are commonly used at fishway passage obstructions due the relatively low infrastructure requirements. This option involves capturing fish below the dam in a trap and moving them upstream in tanks via trucks. Infrastructure typically involves a constructed trap and collection facility, and road access to a suitable release point upstream of the dam.
- **Dam Decommissioning and Removal** – although dam decommissioning was originally considered to be beyond the purview of the WDFPC, this option was nevertheless evaluated during the workshops to determine how it might rank next to the other technical options for fish passage. Thus it provides a bench-mark of

sorts given the apparent biological benefits and widespread precedent at other outdated or obsolete dams that are fish passage barriers in the Pacific Northwest. The WDFPC recognizes that decisions regarding dam decommissioning ultimately rest with BC Hydro.

Initially, the WDFPC convened a one-day SDM workshop in June 2016 to consider and discuss the range of options for fish passage at Wilsey Dam listed above. Prior to the workshop, a reading list of completed studies, technical assessments and PowerPoint presentations was circulated to all participants so that everyone was prepared to consider the advantages and disadvantages of the fish passage options (Appendix B1). The workshop included presentations from experts (DFO, NHC, Whooshh) about each of the technological options, followed by questions and discussions. Subsequently, the WDFPC jointly filled out an Evaluation Matrix of Financial, Biological, Social, and General criteria (Appendix B2), and worked toward consensus on preferred options based on their rankings. Based on the rankings, the list of fish passage alternatives was narrowed down to **three preferred alternatives**. The recommendations resulting from the workshop were two-fold due to uncertainty regarding the future of the ageing Shuswap Falls facility:

(1) install a ladder off channel or *Naturalized By-Pass Channel* if the facility will be maintained fully operational; or

(2) install a Whooshh system in the short term if the facility is to be decommissioned.

The WDFPC also recognized the need for additional detailed engineering feasibility studies for the *Naturalized By-Pass-Channel* and the *Whooshh* and the need for updating a previous cost estimate and design for the *Fish Ladder off-Channel* (NHC, 2005).

In early 2017, the FWCP granted funding to conduct engineering investigations to fill identified knowledge gaps and support the informed selection of a preferred fish passage option. The engineering feasibility investigations were completed in 2017 (Appendix C1 and C2), concurrent with an internal engineering review by BC Hydro. A further WDFPC SDM workshop was convened in October 2017, during which the Evaluation Matrix (Appendix B2) was updated with any newly obtained technical details and cost estimates from the engineering studies and a recommended option was selected by consensus. This recommended option was confirmed as final in February 2018 following completion of the BC Hydro Engineering review of the conceptual design (NHC, 2018). The outcome of the evaluation process resulted in the WDFPC recommendation that the *Naturalized By-Pass Channel* is selected as the preferred option for providing fish passage at Wilsey Dam (Appendix B2).

5.2 Evaluation Criteria and Key Considerations

Evaluation criteria for fish passage alternatives were developed by members of the WDFPC and BC Hydro and included criteria in the following primary categories: Financial, Biological, Social, and General. A brief description of each criterion is provided below. All criteria were compiled in an Evaluation Matrix (Appendix B2) that was used to rank the fish passage alternatives in terms of preference. Each criterion was given a relative weighting (High, Medium, or Low) depending on how important the criterion is judged to be in the overall decision-making process. These relative weights were then applied later in generating summative scores for each fish passage alternative.

1. **Financial Criteria** – include high-level cost estimates for implementing different fish passage alternatives and constitute the most recent estimates of cost available to the WDFPC. Input was sought from experts, consultants, and participants, and general agreement regarding cost estimates was reached at the workshops. For the three preferred alternatives identified during the first workshop (*Naturalized By-Pass-Channel*, *Fish Ladder Off-Channel*, *Whooshh Fish Cannon*), cost estimates were updated following completion of the engineering feasibility studies (Appendix C) and are more accurate than for the remaining alternatives. However, none of these estimates should be interpreted as having contractual precision. All financial criteria were assigned "High" importance as cost is considered an important factor in the decision making process. Entrainment mitigation cost estimates were provided by BC Hydro for operational and physical entrainment mitigation measures, and these costs apply equally to all of the fish passage alternatives, with the exception of Dam Decommissioning, which would not have ongoing costs once the facility is removed.

    a. Capital Costs – include the upfront construction costs for labour and materials as well as a 25% contingency.

    b. Implementation Costs – were estimated for all alternatives relative to construction costs and included: detailed design costs (10%); permitting and planning costs (6%); construction project management and insurance (10.5%); APS procurement (preparation of bid documents) (4%). Further considered were construction environmental monitoring as well as revegetation, though no cost estimates were available and each alternative was assigned qualitative ratings of High, Moderate and Low instead. Implementation costs for the *Naturalized By-Pass Channel* further includes $500,000 contingency for geotechnical investigation and mitigations. Overall project administration costs were estimated at (10%) of the construction and implementation costs combined.

        - Annualized Capital Cost – were estimated as the combined capital and implementation costs divided by the estimated life expectancy of each alternative. Where possible, estimated life expectancy was based on engineering feasibility reports. Life expectancy was assumed to be shorter for alternatives exposed to excess environmental forces (e.g., *Fish Ladder in Spillway*) and those that were technologically complicated (e.g., *Whooshh*).

- Annual Operations, Maintenance and Surveillance Costs – include all costs associated with operating and maintaining the alternative. Operations costs for the *Trap and Truck* alternative and the *Whooshh* were estimated higher than the remaining alternatives. *Trap and Truck* is labour-intensive and requires human intervention on a daily basis for a large period of the year. *Whooshh* is technologically complex and, while designed to operate with little human intervention, would need daily checks to ensure it is operating as planned. *Whooshh* operations and maintenance costs were provided in Dearden and Garello (2017). Maintenance requirements for the *Ladder in Spillway* were considered significantly higher than the other options due to its position in the main water flow and strong current particularly during freshet. *Dam Decommissioning* is associated with the lowest operations and maintenance costs.

c. Annual NET Revenue Loss – was estimated as the cost of foregone energy generation at Wilsey Dam. It is related to the amount of flow used by each alternative that could otherwise be used to generate energy. Based on spill vs. turbine flow data provided by BC Hydro, the dam has spilled sufficiently for providing flows to the various fish passage alternatives since 2014. This will likely continue to be the case because generating capacity is reduced from Unit #1 being out of service with no current plans for repair. Therefore, revenue loss was estimated at $0 for all alternatives except *Dam Decommissioning*. BC Hydro staff provided revenue loss estimates for this alternative with one unit operating (current situation) and two units operating (potential future scenario of lower likelihood).

d. Annual Monitoring Costs – refers to the cost for environmental monitoring during operation, such as enumeration of migrating fish passing upstream, fallback of fish below the dam, condition of fish, habitat use above the dam, and interaction with resident stocks. Some monitoring components will be the same for all options whereas others will differ depending on the passage technology used. *Whooshh* monitoring costs were entered as zero because they were included in a lump operations, maintenance and monitoring estimate in the *Whooshh* feasibility report. Further details on proposed monitoring programs are provided in Section 7.

2. **Biological Criteria** – include those related to the biological performance of each fish passage alternative. Most biological criteria were considered of High importance as they are key in determining whether fish passage will be able to meet the identified restoration goals.

a. Smolt Mortality – mortality of downstreaming smolts. Possible passage routes are through the power house turbines or the spillway, which both have some unknown mortality associated with them. For comparison purposes, the total mortality value was estimated at 10% for options that offer an alternative, safe downstream passage route in form of a ladder or channel (NHC and Ecofish, 2002; Leake, pers. comm.) and slightly higher at 12% for those that do not. Dam decommissioning would lead to zero smolt mortality because passage through turbines or spillway would no longer take place.

b. Juvenile Passage Efficiency – refers to the ability of the fish passage alternative to allow upstream passage of juveniles. Some juvenile fish make extensive upstream migrations to utilize rearing habitats, and the connectivity of habitats is vital to ensuring healthy salmon populations at all life stages (DFO, 2012). Natural channels incorporate areas of lower velocities which better meets the needs of juvenile fish. Thus, juvenile upstream passage would only be possible for the *Naturalized By-Pass Channel* alternative, though it would likely be limited to a small proportion of juveniles and particular times of the year with low flows. Some limited passage would likely also be possible if the dam were to be removed and the river restored to its natural state. This criterion was considered Low importance since the primary goal is restoration of adult upstream passage.

c. Adult Mortality – is mortality of adult fish resulting from fish passage. Excessive delays and abnormal energy expenditure resulting from navigating a fishway can result in elevated stress levels, injury, disease, early mortality, or a reduction in spawning or rearing success (Dane, 1978; Nadeau et al., 2010). Mortality was considered very low for *Dam Decommissioning* and the *Whooshh*, which requires minimal energy expenditure of the fish, no handling and little physical contact with the passage system itself. It was considered slightly higher for the two ladder options and higher yet for the *Naturalized By-Pass Channel*, which is longer (750 m) than the ladders and requires maneuvering nature-like obstacles (e.g., boulders) which may lead to increased abrasions compared to the ladder options, as well as increased predation and/or poaching risks. The highest mortality was estimated for the trap and truck option which requires capture, holding, handling and transporting of the fish.

d. Adult Passage Efficiency (Chinook Salmon) and (Coho Salmon and similar) – refers to the ability of fish to successfully enter and navigate a passage alternative and continue migration in the river above. It encompasses the ease of navigating the structure and its "attractiveness" (i.e., how likely is a fish to enter the structure?). During the workshop discussions it was decided that this does not include attraction flows that would vary between and need to be designed specifically for each alternative, as they have different entry points with different hydraulic conditions. Values were primarily derived from the literature (Casselman et al., 2013; Noonan et al., 2012; Pon et al., 2006) and expert opinion gathered during the workshops.

   Based on expert opinion expressed at the workshops, passage efficiency for Chinook Salmon was rated higher than for Coho Salmon and other species for all passage alternatives, because Coho Salmon tend to be more reluctant to enter man-made passage structures than other species. The *Naturalized By-Pass Channel* was thought to be more appealing to Coho Salmon due to its use of nature-like materials and resemblance to a natural channel, thus it was considered to have the highest passage efficiency for Coho Salmon. It should be noted that while passage efficiency values provided in the Evaluation Matrix are rooted in literature from other facilities, they are intended to facilitate comparison between options and actual passage efficiencies at Wilsey Dam will ultimately be site-specific.

e. Daily Transport Capacity – refers to the number of salmon that can be passed on a daily basis. The intention was to ensure passage alternatives would be able to accommodate large runs to pass as unimpededly as possible without leading to migration delays. All of the fishway-type passage alternatives (including the *Whooshh*) were considered to have approximately equal and sufficient transport capacities. *Trap and Truck* is considered to have substantially lower capacity as it is heavily depended on human intervention, the number of trucks operating, capacity of tanks, etc. *Dam Decommissioning* was considered to provide free and unimpeded passage for all run sizes and was thus ranked the highest.

f. Fallback Risk – refers to the risk of fish falling back below the dam after initial successful passage. It is influenced by the position where fish are released in the river following passage and also by discharge, with higher discharge generally linked to higher fallback (Boggs et al., 2004). Chinook Salmon were used as a proxy due to the wealth of information available for this species; there is also some limited site-specific information from Chinook Salmon transplants above Wilsey Dam in the 1970s (Griffith, 1979). Fallback is a potential problem for all fish passage alternatives except decommissioning because it exposes fish to injury and mortality primarily from passage through the turbines and, to a lesser degree, the spillway. However, it also leads to wasted energy expenditure from repeated fishway ascent, which may ultimately contribute to lower spawning success. Starting values assigned in the Evaluation Matrix (based on Bjornn & Peery 1992; Boggs et al. 2004; Noonan et al. 2012) were adjusted during the June 2016 workshop to reflect advantages and disadvantages of each passage alternative. The *Fish Ladder Off-Channel*, *Naturalized By-Pass Channel*, and *Whoosh Fish Cannon* were considered to have equal fallback risk due to their similar exit positions in the river approximately 100 m upstream of the dam. *Trap and Truck* was considered to have slightly lower fallback risk because fish would likely be released substantially further upstream from the dam where access to the river is possible. The *Fish Ladder in Spillway* would have higher fallback as it exits right at the spillway crest, making it more likely that fish would fall back over the spillway.

3. **Social Criteria** – include those related to the social-economic performance of each fish passage alternative. Most criteria in this category were considered of Moderate importance with the exception of First Nations Traditional Use and Values, which was considered of High importance, and Social License Improvements/Liabilities, which was considered of Low Importance.

a. Enhancement to First Nations Traditional Use and Values – refers to how well each passage alternative facilitates traditional use of the resources and aligns with traditional values related to ecosystem function and integrity. In general, alternatives that allow free and unimpeded passage of fish under conditions as close to natural as possible were ranked highest. Also, alternatives that would return the site closest to pre-dam conditions were ranked highly as the area at the historic Shuswap Falls was a key fishing location with significant subsistence and cultural value. *Dam decommissioning* would facilitate re-establishment of traditional fishing stations and methods that are currently blocked by the Shuswap Falls facility, and was thus ranked highest. *Trap and Truck* requires significant human intervention and was thus ranked lowest. Alternatives that allow passage of the greatest range of species and life stages over the longest duration of the year were ranked higher than others.

b. <u>Opportunities To First Nations Involvement</u> – refers to the potential for First Nations involvement in the planning, construction and operation of each alternative. Alternatives that require a high degree of specialized expertise to construct (e.g. concrete fish ladders, *Dam Decommissioning*) were ranked lower whereas those that required less specialized expertise and/or had greater operations and maintenance labor requirements (e.g., *Trap and Truck*) were ranked higher for the greater potential for local First Nations to participate.

c. <u>Enhanced Fishing Opportunities</u> – refers to fishing opportunities by the public (e.g., recreational fisheries). Alternatives were ranked fairly similarly as all would result in increased access to fishing areas and increased number of fish available for harvest.

d. <u>Enhanced Tourism and Visitation</u> – is related to the appeal of the fish passage alternative to tourists and visitors. Workshop discussions revealed that options that allow visitors to watch migrating salmon up close, in a nature-like setting, would be the most attractive; thus the *Naturalized By-Pass Channel* was ranked highest. The Adams River Sockeye Salmon run, which is a major tourist attraction, was provided as an example. Installation of pathways and interpretive signage in the existing BC Hydro Park would add to the visitor appeal of this alternative. In contrast, alternatives that provide little opportunity for up-close viewing were ranked lower. Visibility and access to the *Fish Ladder in Spillway* would be limited due its proposed position in the relatively inaccessible spillway channel. The *Whoosh* would be mostly blocked from visitors' view in the old river channel, except for the entry and exit in the mainstem. Up-close viewing of migrating fish would not be possible, though workshop participants acknowledged the potential appeal of this alterative for its novel and high-tech nature. *Trap and Truck* was ranked the least attractive to tourists because operations would likely be mostly inaccessible by the public for viewing. *Dam Decommission* was deemed to have relatively limited tourist attraction value although some may be interested in viewing such a major restoration project.

e. <u>Enhanced Public Educational Opportunities</u> – similar to criterion (d) above, alternatives that provided up-close viewing on migrating fish in a nature-like setting were ranked higher than others. *Whooshh* was ranked slightly higher because of its novel and high-tech nature, and *Dam Decommissioning* was ranked slightly higher due to its educational value as a major river restoration project.

f. Social License Improvements/Liabilities – refers to the level of acceptance or approval by local communities and stakeholders. The *Naturalized By-Pass Channel* ranked the highest because a nature-like channel was perceived to be in harmony with natural conditions while also providing outstanding opportunities for public engagement. This would give BC Hydro an opportunity for showing good will within the community and to highlight the environmental conscience of the corporation. *Dam Decommissioning* was also ranked high due to its biological benefits and the high value placed on those benefits by the local community. *Trap and Truck* was ranked lowest with respect to this criterion, due to the lack of harmony with natural migration movements of fish, extensive human intervention required, and lack of public viewing access.

4. **General Criteria** – included those criteria that did not fit under the other categories, such as regulatory considerations, proven effectiveness and health and safety considerations. Regulatory considerations were considered of Moderate importance whereas all others were considered of High importance.

   a. Regulatory/Legislative Hurdles – refers to initial and ongoing regulatory complexity and effort required to overcome possible regulatory hurdles. *Dam Decommissioning* was considered to entail by far the greatest initial regulatory complexity and was thus ranked lowest. *Whooshh* was ranked highest because it requires the least site disturbance and is therefore less complex from a regulatory perspective. Other options that require extensive construction and earth movement activities (e.g. *Naturalized By-Pass Channel*) were ranked slightly lower.

   b. Meet WUP Obligations – refers to the ability of each alternatives to meet operating conditions in the *Shuswap River Water Use Plan* (2005). Operating conditions outline specific water flows in consideration of fisheries, dam safety, flood routing, wildlife, recreation, heritage resources, power and economic development considerations in the system. *Dam Decommissioning* was rated lowest for this criterion because of its implications for the need for a WUP. However, removal of Wilsey Dam itself would likely have relatively little effect on WUP operations due to the limited storage behind Wilsey Dam. Fish passage alternatives that require some flow (all fishway and the *Whooshh* options) were ranked equal and relatively high because while they do require some flow, the impact on WUP operations would be relatively small. *Trap and Truck* was ranked highest because it does not require any modification to WUP operation.

   c. Reduced Regulatory Risk to BC Hydro – relates to fish passage alternatives that reduce regulatory risks to BC Hydro, for example those that mitigates entrainment. *Dam Decommissioning* was ranked far higher than all other passage alternatives because it mitigates most regulatory risks associated with operating Wilsey Dam (e.g., dam safety, fish entrainment). All fishway-type passage options were ranked much lower but equal to each other, as they would slightly reduce entrainment by providing an alternative and safe route for downstream passage for a small proportion of fish. However, entrainment is likely based on flows and most juvenile fish would likely still pass via spillway and turbines. The remaining passage alternatives (*Whooshh, Trap and Truck*) were ranked equal to each other but slightly lower as they do not provide a safe, downstream passage route.

d. Proven Effectiveness for Given Context – describes the degree to which the technology was 'proven' to work in other locations, thereby reducing some of the uncertainty about project success. *Dam Decommissioning, Trap and Truck*, and the *Fish Ladder Off-Channel* are common and well-documented approaches to establishing fish passage and have widespread application throughout North America and the rest of the world. These options were therefore ranked the highest. The *Naturalized By-Pass Channel* was ranked slightly lower as this type of fishway has gained more popularity only in recent years and application and success are therefore less well documented in the literature. The *Whooshh* was ranked lowest as it is the newest technology with relatively limited applications to date and no long-term monitoring of success, though initial applications appear promising.

e. Human Intervention Required for Passage – relates to the need for human intervention to move fish (note: for ranking purposes in the Evaluation Matrix, higher is better for this criterion). Alternatives that require less intervention and allow fish to move freely were preferred and thus, *Dam Decommissioning* was ranked highest. All other alternatives were ranked equal and relatively high as they allow fish to enter at their own will, except *Trap and Truck,* which requires intensive human intervention to allow passage and was thus ranked lowest.

f. Operational Safety and Worker Risk – ranks the level of worker safety during operation and maintenance of fish passage (note: for ranking purposes in the Evaluation Matrix, higher is better for this criterion). *Dam Decommissioning* was ranked highest as it requires virtually no maintenance or operational activities following removal of the dam. Both *Ladder Off-Chann*el and *Naturalized By-Pass Channel* were ranked relatively highly because they require the least amount of maintenance under the safest conditions (off-channel outside of the Shuswap facility in the existing BC Hydro park).

Whooshh was ranked relatively low because of the safety risks associated with frequent maintenance requirements of the *Whooshh* and its position in the old main channel in close proximity the Shuswap facility. The area is dominated by challenging environmental conditions such as steep rock cliffs and deep and turbid water, and is in close proximity to the powerhouse, the emergency bypass valve that may release without warning, and subject to rapid water level fluctuations resulting from dam operations.

Trap and Truck was ranked equally low to the *Whooshh* due to the intense operational labour requirements and inherent worker risks.

The *Ladder in Spillway* was ranked lowest as it was deemed very risky and potentially dangerous to workers both in terms of construction and maintenance due to environmental conditions such as steep rock cliffs, swift flows and **rapid** water level fluctuations in the **spillway.**

6. TECHNICAL APPROACH TO FISH PASSAGE AT WILSEY DAM

6.1 Upstream Passage

Following the evaluation process outlined in Section 5, the *Naturalized By-Pass Channel* was selected through consensus by the WDFPC as the preferred fish passage alternative at Wilsey Dam. *Naturalized By-Pass Channels* simulate natural channels through the use of natural materials and with the objective of providing suitable upstream and downstream passage for a wider variety of fish species than conventional approaches that target specific species only (Katopodis et al., 2001). They provide fish passage over the widest range of flows and for the smallest individuals, can provide year-round habitat, and are ideal for juveniles with shallow water and boulders for cover and lower water velocities (DFO, 2012).

This fish passage option was selected as the preferred option because of the many ecological benefits that can be yielded by providing passage to a wide range of fish species and life stages; comparatively lower operations and maintenance requirements with relatively low public safety and worker risks; and excellent educational and public viewing opportunities provided by offering close access to migrating salmon in a natural setting.

NHC was contracted in 2017 on behalf of the WDFPC to investigate the technical feasibility and provide a preliminary design of a *Naturalized By-Pass Channel* (referred to within the 2018 NHC report as a nature-like fishway or natural channel; Appendix C1, Figure 14). Concurrent with NHC's development of the preliminary design, BC Hydro Engineering conducted an internal technical feasibility review of the design between September 2017 and January 2018. During this time, BC Hydro staff worked closely with NHC to request clarification and adjustments, which were incorporated into the final design. Information in the following subsections is a summary of the information provided in NHC (2018), with supporting information summarized from the detailed design of the Wilsey Dam Fishway (NHC, 2005).

NHC (2018) conclude that the *Naturalized By-Pass Channel* is a technically feasible option for fish passage at Wilsey Dam and refers to over 20 successful natural channel fishway designs in the Pacific Northwest. BC Hydro reviewed both the *Naturalized By-Pass Channel* design and Whooshh design and identified concerns. This plan considered concerns and feedback from BC Hydro, the British Columbia Ministry of Forests, Lands, Natural Resource Operations & Rural Development (FLNRORD), Fisheries and Oceans Canada (DFO) and other representatives on the WDFPC, and thus adequately supports the argument that fish passage is biologically and technically feasible at Wilsey Dam (as required in Steps 3 and 4 of the Fish Passage Decision Framework). Through participation in the WDFPC's evaluation of fishway options, BC Hydro agrees that the *Naturalized By-*

Pass Channel design is most preferred option given the review to date. This plan can support the biological objectives using technologies and operations that are proven in the specific facility context.

As per Steps 6 and 7 of the Framework, it is anticipated that BC Hydro will use this information to provide a more detailed review of options to define a final fish passage solution.

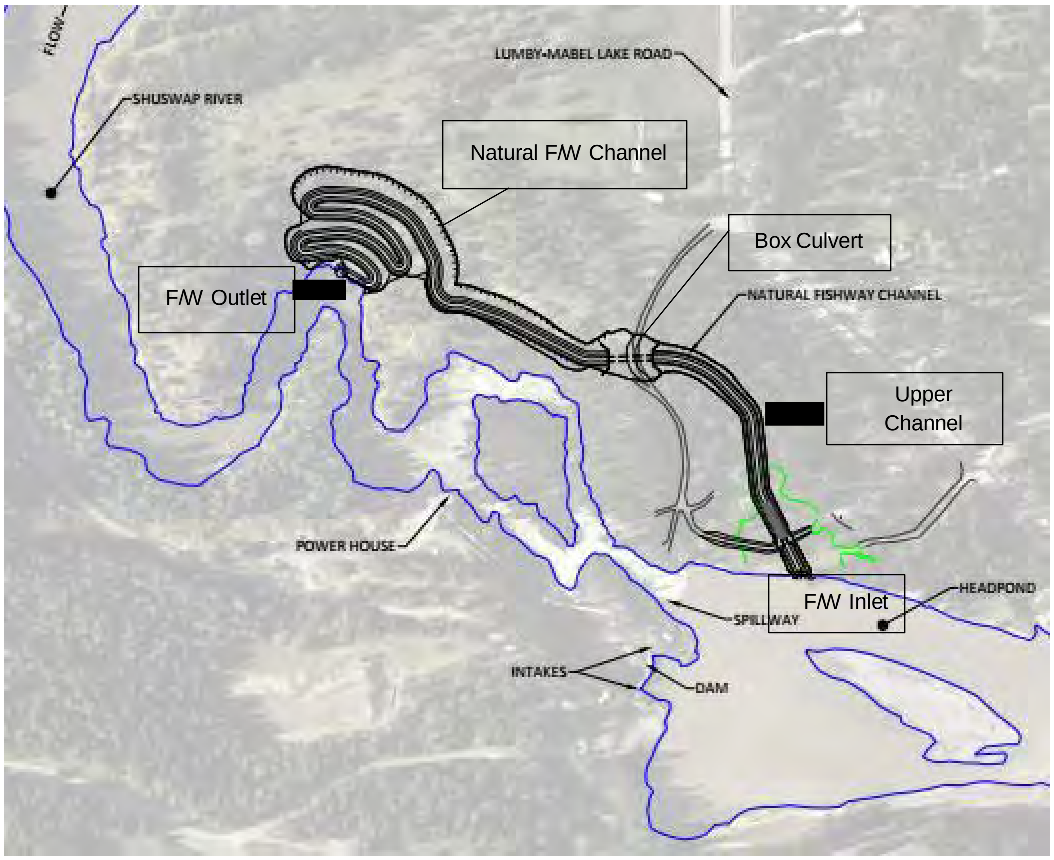

Figure 14. Preliminary Naturalized Bypass Channel Layout (NHC, 2018).

6.1.1 Regulatory Requirements

The following subsection provides an overview of anticipated regulatory requirements for fish passage at Wilsey Dam and is presented herein to inform the development of the business case in Step 6 of the Fish Passage Decision Framework. Application for regulatory approvals is beyond the scope of the WDFPC and of this report. Regulatory requirements for the construction and operation of the *Naturalized By-Pass Channel* include federal, provincial and local legislation and regulations. The main permitting agencies are the DFO, Ministry of Forests, Lands, Natural Resource Operations & Rural Development (FLNRORD), and the Comptroller of Water Rights. DFO has indicated that a review by the Fisheries Protection Program under the *Fisheries Act* may be required. However, as the intention of the project is to reestablish and restore fish and fish habitat access, there is no expectation that this will be a critical decision point for the project proceeding (Appendix D2). Other applicable federal legislation may include the *Navigation Protection Act,* and the *Migratory Birds Convention Act*, and the *Species at Risk Act*.

Applicable provincial legislation includes the *Water Sustainability Act*, the *Heritage Conservation Act,* and the *Forest Act* (NHC, 2018). An approval to make changes in and about a stream (Section 11 of the *Water Sustainability Act)* is likely required, though some components of the works may be covered under existing water licenses. Further, modifications of the Shuswap River Water Use Plan and existing Water Licenses may be required to specify maintenance of certain minimum flows through the fishway and possibly, the spillway to mitigate potential entrainment issues.

Scheduling of instream works should ideally fit within the least risk work timing window for fish for this section of the Shuswap River, which is August 7 to August 15th. However, a request to work outside of this timeline, but in low flow conditions will likely be required. A mitigation plan will also be required to avoid impacts to migrating and resident Kokanee, Chinook and Coho salmon, Rainbow Trout, and Mountain Whitefish.

Additional provincial legislation that may apply primarily during construction includes the *Wildlife Act* because of the large terrestrial project footprint and the sensitive features that are within and adjacent to the project site.

Local building permits and by-laws will apply.

An Introduction and Transfers Committee permit and a provincial *Environmental Assessment Act* Review (potentially viewed as a "shoreline modification project" under the Reviewable Projects Regulation), may also be required by the regulating agencies; but are unlikely based on preliminary FLNRORD and DFO feedback.

6.1.2 Design and Construction

Preliminary design of the *Naturalized By-Pass Channel* at Wilsey Dam involves the construction of a 750 m long naturalized channel excavated along the right bank (looking downstream and westward) from the reservoir. The fishway inlet is located roughly 100 m upstream of the spill crest and the fishway outlet is located approximately 250 m downstream of the powerhouse in the canyon below Wilsey Dam.

The *Naturalized By-Pass Channel* is designed to be operated within normal headpond operating levels of 444.5 m and 447 m at flows from 2-3 m^3/s; however, all *Naturalized By-Pass Channel* components have been designed to withstand expected environmental loadings and the channel will be functional and hydraulically-stable at flows ranging from 1 to 5 m^3/s.

One of the most critical criteria in the *Naturalized By-Pass Channel* design is allowing for suitable water velocities to accommodate the swimming abilities of the target fish species. Swimming velocity and duration were estimated for burst, sustained, and prolonged swim modes over a range of fish size and species and modelled over the full range of operational flows (1 to 5 m^3/s) at maximum and minimum headpond elevations. Adult Sockeye and Coho swim at comparable speeds to Chinook. Rainbow trout swim at a lower speed, so a maximum design velocity of 2.7 m/s was selected to allow for passage of adult Coho, Kokanee, Sockeye, Rainbow and Bull trout species. At the average operating flows (2-3 m^3/s), average velocities in the fishway will range from 0.8 m/s in the run sections to 2.2 m/s at small weirs and constriction points.

Minimum water depth of the channel is based on the 300 mm minimum water depth required for adult Chinook and Sockeye salmon (Bates, 2003), as other resident anadromous salmon's requirements are captured within this level. Additional details about the methodology and results of this analysis are provided in NHC (2018; Appendix C1).

Riffle grade controls installed throughout the Upper Channel and Natural Fishway Channel (described in the sections below) provide the primary hydraulic control, and maintain depth and lower velocities upstream of the installations. Riffles are spaced at 12.5 m from crest to crest, and are 5 m long and approximately 0.4 m in height. They are designed in a shallow v-shape to allow for maximum depth for large fish and greater velocity variation, and consist of rounded to semi-angular riprap materials.

The run sections of the *Naturalized By-Pass Channel* consist of continuous sections of water velocities estimated to be less than 1 m/s, falling well within the sustained and prolonged swimming modes of the targeted fish species. Boulder complexing will add cover and holding habitat for fish and enhance hydraulic complexity.

The *Naturalized By-Pass Channel* components are listed below in upstream to downstream order and described in further detail in subsequent subsections:

- Fishway Inlet (including optional Debris Boom, Trash Rack, Intake Stoplogs, optional Fish Counter and Regulating Fishway);
- Low gradient Upper Channel;
- 30 m length Fishway Box Culvert;
- Steeper gradient Natural Fishway Channel; and
- Fishway Outlet (Fish Entrance below Wilsey Dam).

6.1.2.1 Fishway inlet

Currently, the fishway inlet, where water enters the fishway, is a riprapped bank that can easily be accessed through a grass field in the existing BC Hydro Park on the right bank. This location was selected on the basis that relatively low water velocities in this area will allow migrating fish to rest before proceeding with their upstream migration, thereby reducing the potential for fallback back over the spillway. The fishway inlet design consists of a reinforced cast-in-place concrete structure that is connected to the headpond via a riprapped channel. The inlet includes components that serve to regulate fishway discharge, protect the inlet structure from debris and potential blockage, and isolate the fishway for flood protection and maintenance.

Flow control structures within the inlet structure include a steel metal frame to guide up to ten timber stoplogs, as well as a 26 m long regulating vertical slot fishway. This fishway is a reinforced concrete structure that uses a deep vertical slot within 7 baffle walls to provide hydraulic control between the pools. It is required to overcome the water elevation change between the headpond and the Upper Channel (see below), which can fluctuate by up to 2.5 m. Similar to the rest of the *Naturalized By-Pass Channel*, average flow velocities through the vertical slot openings range from 0.9 to 2.1 m/s under typical operating flows.

A steel trash rack is fixed to the upstream end of the inlet structure with the top edge angled downstream from the bottom edge for easier collection and removal of debris. The trash rack openings are sufficiently wide to allow for fish passage. An optional debris/log boom has been included for consideration though debris issues are anticipated to be minimal. It would provide protection for the inlet from large wood debris over the normal operating elevation range of the headpond.

A pedestrian access bridge located above the trashrack will maintain access to the existing lookout and trail located at the top of the right abutment. The trails from the parking area will require realignment to access the bridge. The inlet structure will extend slightly downstream of the pedestrian bridge to accommodate automated or manual fish enumeration and assessment activities, such as a trap box.

6.1.2.2 Upper Channel

A 144 m long uniform channel connects the inlet structure from the vertical slot fishway to the box culvert road crossing of the existing access road leading to the right bank at the spill crest. The gradient of this trapezoidal channel is low at 0.73%. It will run through a grassy area of the BC Hydro Park and is easily accessible via adjacent level ground. The channel bed will comprise of native sand and gravel materials and be installed to allow for hydraulic connectivity with the headpond in this area, while preventing uplift and destabilization of the channel bed. Rounded, semi-angular rock excavated from the channel construction will be used for the channel bottom and banks. The channel will contain riffle and run structures as described in Section 6.1.2.

Flows are contained within the Upper Channel for reservoir levels up to 446.5 m. Flows of greater than 447.5 m can enter the park from the reservoir over the levee and are contained by the highway embankment and natural topography to the north and east and by the existing access road embankment to the west.

In preparation of the 2005 detailed vertical slot fishway design (NHC, 2005), geotechnical investigations found that there was high hydraulic connectivity between the proposed project area and the reservoir and also identified that dewatering of the upper section of the *Naturalized By-Pass Channel* would be challenging during construction. As such, although this section will be installed in the wet, it should remain isolated from the remainder of the fishway channel to minimize flows during construction of the downstream components. It will also be important to incorporate isolation of the project area to manage water quality considerations.

6.1.2.3 Fishway Box Culvert

A 30 m long, 3.0 m x 2.5 m concrete box culvert is proposed at the crossing of the access road embankment to reduce the amount of spoil as well as to provide an additional highwater barrier to protect the downstream *Naturalized By-Pass Channel*. It maintains the existing access road and also serves as a transition between the lower gradient Upper Channel and the downstream steeper gradient Natural Fishway Channel. The culvert will require a large excavation of substrate materials. A range of natural substrate sizes (including boulders) will line the bottom of the culvert to create localized turbulence and variation in velocities. A riffle at the culvert outlet backwaters the culvert to reduce velocities.

A heavy-duty steel bulkhead gate will be incorporated into the construction of a headwall at the upstream end of the box culvert. This gate should generally be left open during operation and closed during maintenance or when fish passage is not required. It should also be closed when the headpond levels exceed 447 m in elevation and is designed to withstand water elevations in excess of the peak maximum flood reservoir level of ± 452 m.

6.1.2.4 Natural Fishway Channel

Downstream of the proposed box culvert location, the existing landscape consists of a steep-sided bank of rock outcrops and open and dry forest vegetation that slopes down towards the river. To gradually connect the culvert to the river below, a 500 m long trapezoidal shaped channel twists its way down the slope at an average gradient of 5%. The channel will be lined with a geomembrane seepage barrier to seal the channel and prevent loss of water, and then surfaced with gravels and large rocks to form a series of runs and riffle habitat complexity. Bank slopes throughout the open channels are designed at a 1:1 ratio. Riffle grade controls and run sections as described in Section 6.1.2, are located along the length of the Natural Fishway Channel.

Access to this section is provided via a 2 m wide surface for a mini-excavator or ATV. The channel is wide enough to allow for an excavator to travel along its length, with the tracks of the excavator straddling the channel.

6.1.2.5 Fishway Outlet

The proposed *Naturalized By-Pass Channel* outlet discharges to a large back eddy pool suitable for fish holding and located approximately 250 m downstream of the power house. Because of the existing rock formations in this location, it is anticipated that hydraulics in this area will remain similar across a range in water levels. The outlet is to be near channel elevation and will be backwatered once the *Naturalized By-Pass Channel* is built. To keep the proposed channel isolated from flowing water, a berm or other form of approved site isolation methodology will be used during construction.

Successful operation of a fishway passage system is dependent on the ability for fish to be attracted to the channel entrance. In general, higher velocity currents and turbulence attract fish to migrate upstream (Pon et al., 2006). The 20 m section of the channel directly located upstream of the outlet will be deepened and the flow width narrowed using rock materials in order to accelerate flow into the pool. An approximately 25 m long retaining wall is also included in the conceptual design to stabilize rock placed in the outlet and to maintain the concentrated flows into the downstream pool.

There is a small groundwater seep downstream of the proposed outlet and this should undergo geotechnical investigation to further determine additional design requirements.

6.1.3 Operation

The *Naturalized By-Pass Channel* will require an integrated operations and maintenance plan that is linked to the overall Wilsey Dam facility. This information will be developed during the detailed design phase of the *Naturalized By-Pass Channel* and integrated into the Wilsey Dam Operations Manual (NHC, 2018). This will require coordination with and/or implementation by BC Hydro staff. The new natural channel should undergo a testing period or trial operation during the first year to verify proper functioning of the *Naturalized By-Pass Channel* and its components (USFWS, 2017). This testing focuses on final adjustments that will optimize hydraulic conditions to enable fish passage success.

Operational changes to the Shuswap facility will be required to provide sufficient fishway flows at all operating times, and possibly provision of continuous spills and/or other measures such as plant shutdowns to mitigate possible fish entrainment issues (Section 6.2).

The upper fishway will self-regulate flows based on headpond water elevations with nominal flows of 2 m^3/s to 3 m^3/s between headpond elevations of 444.5 m and 447 m. This operating range covers a wide range of flow conditions in the Middle Shuswap River, ensuring that the channel is operational between typical minimum flows (16 m^3/s) and to greater than typical annual peak flows (>222 m^3/s) (Figure 14, Table 1). The channel has to be shut down at flows greater than approximately 265 m^3/s (headpond elevation of 447.0 m), which may lead to short shutdown periods during very high freshet flows.

During normal operation of the *Naturalized By-Pass Channel*, the stoplogs in the upstream intake structure will be removed and the bulkhead gate will be left open. In the event that flood flows are anticipated and headpond levels could exceed the overbank elevations, the bulkhead gate should be closed immediately until reservoir levels drop below an elevation of 446.5 m and continue to drop.

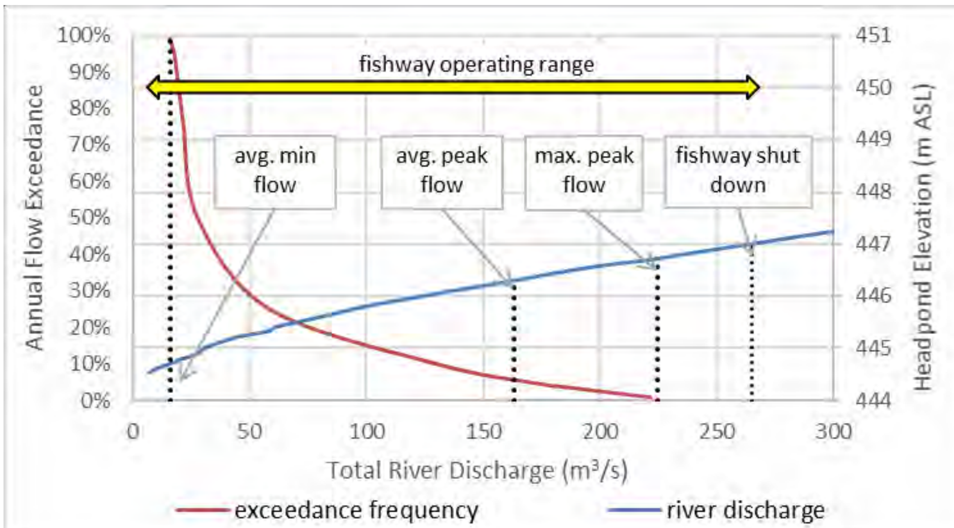

Figure 15: Operating flow range of the *Naturalized By-Pass Channel*.

The natural channel could be operated throughout the entire year or seasonally during the key spawning migration period of target fish species (mid-March – early December, Figure 10, Section 3.4), depending on the availability of flow and the potential for frazil ice (newly formed or slushy ice). Rearing fish within the channel could be sustained by flow over the winter periods. This will require spill at all times through the fishway and while these could present as lost energy generation, with the outage of Unit 1 since 2012, these costs appear to be significantly reduced (NHC, 2018). One benefit of year-round operation would be reduced effort and cost required for fish salvage and monitoring. As such, it is recommended to initially operate the fishway year-round.

Effects of local groundwater influence and channel aspect on the potential ice regime within the fish channel are uncertain. If flows are varied over freeze-up of the channel, there is potential for sheet-like masses of layered ice to form (aufeis) that could cause overbank flows or ice or flow-related damage to the channel. Turbulent flows in the fishway could generate frazil ice which may collect in holding pools reducing pool volumes and affecting flows. If ice flows cause constriction in the channel and erosion, the *Naturalized By-Pass Channel* should be shut down over winter, following the end of the Coho Salmon spawning period (early December). Fish salvage and monitoring activities will be required during seasonal closures. Visual inspections of the channel should occur prior to re-watering in spring to assess for infilling damage and ice blockages. The *Naturalized By-Pass Channel* should be re-watered and operational again for the initiation of Rainbow Trout migration (mid-March) and once the channel is ice-free.

Operational issues such as plant outages and load drops can also cause the headpond to experience considerable fluctuations in water surface elevation. Dewatering of the reservoir may be required during emergencies or maintenance activities. Any dewatering of the channel should be done slowly and would require a fish salvage and monitoring.

Operation of fish counting equipment to enumerate fish species moving up and down the channel has not been described in detail within the preliminary design, but would require additional consideration during the detail design phase and is further discussed in Section 7.

Access to each of the *Naturalized By-Pass Channel* structures will be securely fenced with incorporated walkways to facilitate access without having to enter the bypass channel.

6.1.4 Maintenance

The estimated life of the design is expected to be between 30 to 50 years (NHC 2018). Hydraulic structures and operations incorporated into the preliminary *Naturalized By-Pass Channel* have been designed to largely be self-regulating and require minimal efforts to operate and maintain them; however, some maintenance activities will be required throughout the year and should be documented in an operations and maintenance guide.

NHC developed an Operations and Maintenance Manual for the 2005 Wilsey Dam Vertical Slot Fishway Detail Design and contains information that remains applicable to the *Naturalized By-Pass Channel* preliminary design. Maintenance requirements will vary depending on the components that are integrated into the final design, such as the log boom and the fish counter. It is anticipated that routine and minor maintenance items will be addressed through the daily operations. Larger physical and financial maintenance requirements will be prioritized annually.

Expected routine maintenance activities associated with the preliminary *Naturalized By-Pass Channel* design under normal operations include the following inspection and activities:

- Clearing the trash rack when excessive debris accumulates causing a rise in velocities;
- Pedestrian bridge and railings for paint and/or repair as required;
- Significant movement of riprap materials;
- Rips or tears of the geomembrane seal/liner;
- Flows are free-flowing;
- Bulkhead gate is freely moving;
- Ice-related damage on the channel and its components;
- Management of seepage areas;
- Planting establishment success;
- Fencing integrity and condition;

- Minor sediment removal;
- *Naturalized By-Pass Channel* outlet remains stable and is free of debris.

Should the log boom option be incorporated into the final design, it should be inspected for deteriorated logs, corrosion of the boom chain and boom cable, and ensure that the chain can move freely and that the connection to anchors is sound.

In the event of flooding, more specific maintenance activities and inspection may be required to address any effects on the integrity and/or condition of the downstream and surrounding *Naturalized By-Pass Channel* components and receiving environment.

6.1.5 Costs

The estimated cost of the 2018 NHC preliminary *Naturalized By-Pass Channel* is **$5.9 million**, which includes a $500,000 allowance for geotechnical considerations, a 25% contingency, costs for project and construction management, construction engineering and environmental monitoring, and mitigation during construction. Under the assumption that the *Naturalized By-Pass Channel* will be operated with a flow of 3 m^3/s, it is unlikely that there would be any lost power production due to spilling under the current Wilsey Dam operation conditions (as Unit 1 is not in service and there are currently no plans to bring it back into operation). Table 2 below is taken directly from the 2018 NHC report (Appendix C1) for ease of reference and shows details of the preliminary Wilsey Dam *Naturalized By-Pass Channel* cost estimate.

Table 2: Wilsey Dam *Naturalized By-Pass Channel* cost estimate.

Item	Quantity	Unit	2017 Rate	2017 Cost
Mobilization, Site Clean-up, and Demobilization	1	LS	$50,000	$50,000
Clearing and Grubbing	1	LS	$12,000	$12,000
Erosion Control, De-watering, Planting	1	LS	$25,000	$25,000
Rock Excavation	12,250	m3	$160	$1,960,000
Earth Excavation	24,500	m3	$18	$428,750
Earthworks - Fill				
Type 1	2,000	m3	$50	$100,000
Type 2	1,057	m3	$50	$52,850
Type 3	1,466	m3	$50	$73,300
Type 4	54	m3	$100	$5,400
Reinforced Concrete	150	m3	$2,000	$300,000
Supply and Install Culvert	1	LS	$150,000	$150,000
Supply and Instal Liner	3,000	m2	$100	$300,000
Miscellaneous Metalworks	1	LS	$200,000	$200,000
Supply/Construct/Install Logboom	1	LS	$10,000	$10,000
Construct/Reconstruct Access Road Surface	640	m2	$60	$38,400
Total Construction Costs				$3,705,700
Detailed Design	10%			$370,570
Geotechnical Contigency	report			$500,000
Construction/Project Management	10%			$370,570
Construction Cost Contingency	25%			$926,425
Total Estimated Project Costs				**$5,873,265**

As the cost estimate provided by NHC is preliminary, additional considerations and costs are anticipated as the design phases progress. These include:

- Changes in design are likely to influence the overall construction costs;
- Slight changes in earthwork unit rates and quantities would greatly influence the overall cost of the project as there is a significant amount of these works involved;
- Fish enumeration equipment and costs to operate and maintain equipment;
- Addition of educational and awareness components (e.g, signage, viewing platform);
- Site fencing and security;
- Inclusion of entrainment mitigation. Costs for entrainment mitigation were provided by BC Hydro for consideration in the Evaluation Matrix (Section 5.2; Appendix B2). Physical entrainment prevention measures were estimated to cost approximately $3.7 M (capital cost and 15 year operation) whereas operational entrainment prevention (e.g., seasonal shut-downs) were estimated to cost approximately $2.1 M. The only fish passage alternative not incurring these costs is dam decommissioning as entrainment would no longer occur.
- Offsetting costs for any unforeseen terrestrial and aquatic impacts (e.g., wildlife salvage, Metal Leaching/Acid Rock Drainage results); and
- Operation, maintenance and surveillance costs have been estimated at $40,000 per year by the WDFPC. Ongoing biological monitoring costs were estimated at $50,000 (excluding initial more intensive monitoring programs). An Operations, Maintenance

and Safety Manual and associated budget will be drafted as part of the detailed design phase.

6.2 Considerations for Downstream Passage

Downstream passage of fish through Wilsey Dam during seasonal migrations (Section 3.4.2) can occur one of three ways under the proposed fish passage design: through the *Naturalized By-Pass Channel*, over the spillway, or through the turbines. Entrainment of fish through hydro facilities brings increased risk of mortality or injury from turbine strike, impingement, and latent health impacts. Juvenile fish entrainment may occur during downstream movement of fish past the Shuswap facility (Figure 11, Section 3.4.2). Adult fish may become entrained if they fall back below the dam after successfully ascending the fishway during their upstream spawning migration (Figure 10), or during their return migration to Mabel Lake after completing their spawning activities (Figure 12).

Direct and indirect fish mortality due to entrainment through hydro facilities can result from hydrostatic pressure changes (adjusting from regions of high pressure to regions of low pressure), water quality changes (deficit in oxygen content in the impoundment area), cavitation, shear stresses (exposed to high velocity discharges) and mechanical strikes (e.g., gap grinding, mechanical chop, scraping, abrasions) (BC Hydro, 2006). After crossing through a hydro facility, fish may be damaged, stunned, stressed, disoriented or become trapped in turbulence or recirculating eddies at the base of the dam. All of these situations increase their vulnerability to predators, such as piscivorous birds, otters, and piscivorous fish in the vicinity of the installation. While there are few studies that explore this question (Castro-Santos et al., 2009) predation directly above and below hydroelectric facilities may have a significant impact on overall mortality rates (Larinier & Travade, 2002).

Detailed reviews on entrainment mortality relevant to Wilsey Dam were provided by NHC and Ecofish (2002), Lawrence et al. (2005), and McGrath et al. (2014). Mortality rates from juvenile fish passage through Francis turbines indicate averages of 20.7% (Electrical Power Research Institute, 1992), and range from 1% to 28% for comparable facilities with 30 m head (Eicher Associates Ltd., 1987). However, overall entrainment mortality is likely site specific and depends on specific details of the facility and the proportion of fish that become entrained.

While spillway passage caused injury and mortality is considered to be less than turbine passage at Wilsey Dam (Lawrence et al., 2005), injuries can occur from shear and turbulence that result from different water velocities experienced across the fishes body length when passing through the turbulent rapid-like section of the spillway (Larinier & Travade, 2002; Rytwinski et al., 2017). Further, plunging down the waterfall where the split (saddle) in the spillway is located could also contribute to higher mortality, particularly for adults falling back over the dam. Studies have shown that significant damage to fish occurs when the impact velocity on the surface of the water is greater than 15-16 m/s (critical velocity). A column of water reaches the critical velocity for larger fish (longer than 60 cm) after a drop of 13 m (Larinier & Travade, 2002).

The swimming behavior of juvenile fish is relatively passive due to their low swimming speeds and capabilities, and they typically use shallow water with low velocity habitats associated with physical cover. Smolts are likely to have a slightly more active behavior. Thus, entrainment of outmigrating juvenile fish is typically driven by the distribution of flows between the various passage routes. For example, a 2015 study on entrainment rates of outmigrating Chinook Salmon fry at the Puntledge hydro facility on Vancouver Island found that the proportion of outmigrating fry diverted over the spillway versus through the hydro facility was conservatively proportional to flow (Connors & Parkinson, 2015). Other factors influencing entrainment include the depth of flow withdrawal as well as the location of withdrawal relative to the flows in the river mainstem, as suspected at BC Hydro's Puntledge facility (A. Leake pers. comm.). Mitigating factors at Wilsey Dam include the relatively deep intakes roughly 10 m below the water surface, as well as the somewhat isolated location of the intakes away from the river mainstem (NHC and Ecofish, 2002).

NHC and Ecofish (2002) prepared flow-based entrainment mortality estimates for outmigrating juvenile Chinook Salmon passing through Wilsey Dam based on flow distribution derived from physical modelling. With both turbines operational at the time, overall mortality from turbine entrainment and spillway passage was estimated conservatively at approximately 10% of the population (NHC and Ecofish, 2002). Given that only one turbine is operational now leading to year-round spills, and that the NPBC offers an alternative, safe, downstream passage route, it is reasonable to expect that juvenile mortality would be below 10% following fish passage.

Fish are drawn to a route for downstream passage largely based on attraction flows. The natural bypass channel must generate high enough velocities relative to the ambient flow of the river in order to attract and capture fish without eliciting an avoidance response (some juvenile fish species avoid turbulence). Guidance from the United States Fish and Wildlife Service (2017) states that attraction flows for downstream fish bypass for hydropower sites are based on a fraction of the competing flows (e.g., turbine and spillway discharge) (5 % of powerhouse hydraulic capacity or 0.71 m^3/s, whichever is greater).

Detailed analyses that estimate flow distribution through all paths (spill, gates, nature like channel) under varying hydrologic conditions should be performed to evaluate the magnitude, persistence and location of competing and attraction flows. Other factors to incorporate into the study is the depth of the withdrawal of the power intakes and the location of the intakes as these variables will influence the number of fish that would be diverted through the spillway (A. Leake pers. comm.) It is also imperative to understand the physical environment in the forebay such as flow field dynamics and water temperature in relation to the biology and ecology of the target species (Gutowsky et al., 2016). Kamal and Zhu (2015) conducted velocity measurements in the Wilsey Dam forebay and headpond area during the low flow season (August), where the average river flow was

19.48 m^3/s and Intake Unit 2 withdrawing at a rate of 5.46 m^3/s. This study found that as the water approached the dam, the main channel flow split towards the spillway and the intake. In the forebay, the influence of the turbine withdrawal was observed to be up to 14 m upstream of the turbine intake, with strong directed flows directly into the turbine below water depths of approximately 3.5 m. Flow direction at shallower depths near the surface were primarily perpendicular to the intake and velocities were lower. Outmigrating fry are likely to move along the surface and margins of the main river channel, with those fish on the right bank likely to be drawn to the fishway or spillway, and those fish on the left bank moving into the forebay and then either eventually drawn into the spillway, or through the turbine intakes.

Adult fallback rates can vary from year to year, between locations, and can be affected by factors such as temperature, amount of spill and attraction flows (Liscom et al. 1985). Cumulative thermal exposure and flows are the biggest environmental facts that influence fallback rate and survival. In a study on Chinook Salmon at Bonneville Dam on the Columbia River, high spill was significantly and positively correlated with fall back behaviour (Reischel & Bjornn, 2003). McGrath et al. (2014) summarized fall back rates ranging from as low as 0% up to 40% for Chinook Salmon at Columbia River dams (Bjornn & Peery, 1992), and from 2% (Naughton et al. 2006) up to 40% for Sockeye Salmon (Pon et al., 2006). Crozier et al. (2014) found that fallback rate of adult Snake River Sockeye Salmon was as high as 49% at the Lower Granite Dam. In this same study, water temperature (acute and cumulative) and travel distance were the biggest factors in survival and fallback rate. Siting of the *Naturalized By-Pass Channel* inlet considered the relatively lower water velocities in the area to provide an area for migrating fish to rest before continuing their upstream migration thereby reducing the risk of fallback. Adult fish entrainment is generally less driven by flow distribution than juveniles, as they are stronger swimmers and capable of more active migration behaviour. However, because of their ability and tendency to utilize greater depths, adult fish are more likely to be in closer proximity to the intakes, and may then become entrained (NHC and Ecofish, 2002). Where adult fish become entrained through the turbines, mortality is likely high as mortality is related to fish size (NHC and Ecofish, 2002).

A number of guidance technologies have been developed to direct fish to safe passage and largely relies on the rheotactic response of fish (a fish's behavioural orientation to the water current). Some examples of these include an angled bar screen, louvers, floating guidance systems or booms, and behavioural barriers (acoustic, electric, lights). Recommended strategies and mitigation from a 2005 literature review of juvenile and adult salmon entrainment through hydroelectric dams with Francis turbines suggest the use of physical screens such as inclined plane screens, vertical punched plate screens and cylindrical wedgewire screens (Lawrence et al., 2005). Lighting to attract/repel fish to/from areas of interest has been recently studied at Puntledge Dam on early emergent Chinook Salmon. The results of this study to date suggests that fish are attracted to lights which may provide opportunities to guide outmigrants away from power intakes (the study tested the effectiveness of lights as a repellant and found the opposite effect) (Guimond, Taylor, & Sheng, 2016).

If screens are incorporated into the downstream passage considerations, it is important to ensure that flow velocities match the swimming capabilities of the target species, and that the approach velocity to the screen is uniform (Larinier & Travade, 2002). If the velocity is too high or low, it could influence fish guidance and passage as high velocity areas will cause impingement, while low velocity areas may cause migrating fish to accumulate, increasing the risk of predation.

Operational entrainment mitigation to consider could include nighttime shutdown of power generation, or shutting turbines off during key periods of outmigration; however, there are lost power generation costs associated with these options. Trash racks located at the upstream outlet of the *Naturalized By-Pass Channel* to prevent debris travelling down the channel, may also present as a behavioural barrier to juvenile fish (Perry et al. 2012), although this has been observed to have a greater impact when spacing between the bars is less than 15 cm wide. Lawrence et al. (2005) suggest that the intake trash rack can be modified to minimize fish entrainment by adding angled bar racks and a collection system. NHC and Ecofish (2002) estimated juvenile Chinook Salmon mortality at Wilsey Dam under an alternate operational scenario where hydroelectric generation was curtailed and forced spills were implemented to reduce turbine entrainment to not greater than 25%. This action resulted in a reduction in cumulative overall mortality from 10% to 5%.

Entrainment mitigation to prevent fish from entering areas of high risk for injury or mortality and to guide and concentrate fish to areas where safe passage is available must consider fish attraction and guidance aspects, biological requirements, and hydraulics in order to be effective (Katopodis, 2013). Consideration of changing climate conditions such as warmer river conditions and higher flows can influence the amount of energy use during their migrations and how they approach and behave around fish passage structures and should be included in the fish passage planning process and evaluated by an interdisciplinary team, including engineers and biologists (Gutowsky et al., 2016; Silva et al., 2017).

6.3 Risks and Contingencies

While the preliminary Naturalized By-Pass Channel fish passage option presents the preferred option for fish passage at Wilsey Dam, there remains a number of factors that may require further study and / or have mitigative contingency measures considered during the detailed design phase in order to reduce associated risks. This section provides a summary of potential biological, engineering, hydraulic, geotechnical, and safety risks related to the design, operation and functioning of the fishway, as well as Middle Shuswap River fish populations and the greater ecosystem. For each risk, mitigating factors, monitoring studies and potential contingencies, are identified where applicable to eliminate or lower the risk. Anticipated risks of the preliminary *Naturalized By-Pass*

Channel fish passage at Wilsey Dam and associated mitigation options are summarized below in Table 3 in order of highest to lowest likelihood and consequence of occurrence. Identified risks are manageable in the context of environmental and technical investigations conducted to this stage. Specific performance standards and targets should be established with guidance and direction from fisheries scientists and regulators directly involved with the fisheries populations affected by the proposed fish passage at Wilsey Dam. It is recommended that specific performance criteria could be developed by a Technical Advisory Committee.

Table 3: Risks and mitigation options for the preliminary *Naturalized By-Pass Channel* fish passage at Wilsey Dam.

Fish Passage Risks	Description of Risk and Consequence	Mitigation Measures and Likelihood of Success	Reference Literature
Attraction flows for fishway inlet and outlet (to attract salmonids to enter the fishway)	In general, migrating adult salmon are attracted to higher velocity flows. Natural fishways are reported to experience comparatively lower attraction but highest passage efficiency compared to other fishway designs. The outlet of the Naturalized By-Pass Channel has been designed specifically for optimal attraction flows for salmonids. Refinement of attraction flows may be required in the initial years post construction; however, further minor design changes are expected to address any issues and the resulting risk related to attraction flows is considered low.	• The *Naturalized By-Pass Channel* (NPBC) can discharge the highest flows (up to 5 m3/s) and thus can provide the highest attraction flows compared to river discharge. • The NPBC outlet (fish entrance) has a narrowed design that serves to concentrate and accelerate the flow into the holding pool. The higher velocity directed flow that will result is ideal for salmonid attraction. • Proposed monitoring of attraction efficiencies following fish passage will provide information on fish behaviour and response to variable flow conditions (Section 7.2). • Potential contingency measures to address any attraction flow issues include adjustment to the fish way outlet design to further improve hydraulic conditions, and/or installation of physical (e.g., diversion/guidance systems can be incorporated as well such as behavioural technologies (e.g., lighting), rock placement or broomstick fencing. • Mitigation and contingency measures are described herein based on research of existing successful fishway designs and current fish passage science in the Pacific northwest. As a result, the likelihood that these measures will be successful is considered high.	Roscoe and Hinch, 2010; Calles and Greenberg, 2005; Gutowsky et al., 2016; DFO, 2012; USFWS, 2017; NHC, 2005.
Entrainment Mortality	Entrainment of juvenile fish through the powerhouse and turbines may occur during downstream movement of fish past the Shuswap facility. Adult fish may become entrained if they fall back below the dam after successfully ascending the fishway during their upstream	• Subsequent discussions between DFO and BC Hydro have resulted in the decision to set entrainment assessments aside until after fish passage is completed, and to base entrainment mortality estimates on literature values and modelling during the planning stage (Appendix D2). • Proposed monitoring is discussed in Section 7. These could be supplemented by further studies on hydraulic flow	Guimond et al., 2016; Lawrence et al., 2005; Gutowsky et al., 2016.

Fish Passage Risks	Description of Risk and Consequence	Mitigation Measures and Likelihood of Success	Reference Literature
	spawning migration, or during their return migration to Mabel Lake after completing their spawning activities (Rainbow and Bull Trout). Fish that become entrained may be subjected to injury or mortality. Conservative estimates of entrainment mortality for Wilsey Dam are at 10-15%. There are potential differential effects on different fish species or life history types. For instance, the majority of Middle Shuswap River Chinook Salmon fry are immediate outmigrants (ocean-type; Section 3.2.1; Figure 11) that will migrate through Wilsey Dam during spring peak flow and spill periods when entrainment mortality is likely lowest. Entrainment is likely to happen as fish must pass downstream during their migration; however, mortality of juvenile salmonids is mitigated by outmigration timing that coincides with greatest spill volumes and their general surface orientation which positions them away from the penstock intakes. As a result, entrainment mortality can likely be fully mitigated with implementation of prevention measures outlined under "mitigation measures", if needed.	conditions in the forebay, spatial ecology (where fish are in the water column in relation to the depth of the withdrawal of the turbine intake), and characteristics of the forebay environment, and attraction studies. Potential contingency measures to reduce or prevent entrainment mortality may include forced spills, periodic shut-downs during peak migration periods, as well as behavioural or physical collection or guidance systems (e.g., lighting systems, physical screen barriers). Further details on entrainment prevention measures are provided in Section 6.2. • Monitoring may be required to determine whether differential entrainment mortality results in shifts in the life-history type of the population. • Mitigation and contingency measures are described herein based on research of existing successful fishway designs and current fish passage science in the Pacific northwest. As a result, the likelihood that these measures will be successful is considered high.	

Fish Passage Risks	Description of Risk and Consequence	Mitigation Measures and Likelihood of Success	Reference Literature
Geotechnical considerations	Saturated floodplain deposits are located along the canal alignment and the bedrock shelf which is below the groundwater table but above the fishway invert in the canal section. Blasting potential and drilling activities will depend on subsequent geotechnical site investigations and results. Dewatering of the upper area excavations will be challenging and construction will be in the wet because of the high water table in this area. This may cause the geomembrane liner and the channel base to experience potential hydrostatic uplift. NHC has recommended additional geotechnical works during the detailed design phase and a contingency of $500,000 for potential geotechnical elements (investigations and mitigation) in the 2017 preliminary design and has been added to the projected costs for the detailed design phase of the Naturalized By-Pass Channel. The requirement for a channel liner could be reduced with the additional geotechnical investigation and reduce the risk associated with hydrostatic uplift.	• A specific liner is proposed in the preliminary design to prevent hydrostatic uplift along this section. • A groundwater seep was identified near the fishway outlet. This seep requires further investigation to determine its impact on outlet configuration and stability. A $500,000 geotechnical contingency has been included in the cost estimate to account for any additional investigations or mitigation required to address these geotechnical uncertainties. • Mitigation and contingency measures are described herein based on research of existing successful fishway designs and current fish passage science in the Pacific northwest. As a result, the likelihood that these measures will be successful is considered high.	NHC, 2005; NHC, 2018,

Fish Passage Risks	Description of Risk and Consequence	Mitigation Measures and Likelihood of Success	Reference Literature
Terrestrial sensitivities	The proposed NBPC will disturb the current natural condition of approximately 5600 m^2. The Middle Shuswap River corridor provides habitat for sensitive terrestrial species and also sensitive ecosystems including rock outcrops and dry open forest. Surrounding landscape condition in the area generally remains in a natural state and this provides opportunities for any sensitive species or at-risk species to be relocated if necessary. The risk related to terrestrial sensitivities can likely be fully mitigated with implementation of the measures outlined under “mitigation measures”, if needed.	• Prior to construction, an environmental assessment that incorporates terrestrial sensitive features may be required. Possible design changes may be required if highly sensitive components are identified. • Mitigation measures may be developed and include relocation, restoration, or compensation. • Mitigation and contingency measures are described herein based on research of existing successful fishway designs and current fish passage science in the Pacific northwest. As a result, the likelihood that these measures will be successful is considered high.	Iverson, 2012
Fish stranding	Stranding resulting from sudden flow changes in the *Naturalized By-Pass Channel* has the potential to seriously harm fish. The risk will be greatest during sudden, unexpected changes in flows resulting from emergency operations or outages, or potentially icing during winter operations. The risk associated with fish stranding is considered low with regular inspection during periods of sudden flow changes within the Naturalized By-Pass Channel.	• The intake and flow regulation into the *Naturalized By-Pass Channel* have been designed to accommodate a wide range of forebay water levels (± 2.5 m), somewhat mitigating the stranding risk. • Regular inspections and flow adjustment protocols should be incorporated into the Operations Manual for routine and emergency operations, and fish salvage plans should be prepared to reduce impacts • Mitigation and contingency measures are described herein based on research of existing successful fishway designs and current fish passage science in the Pacific northwest. As a result, the likelihood that these measures will be successful is considered high.	NHC, 2018
Spillway injury	Passage of fish over the spillway can result in injury or mortality due to latent health impacts that include abrasions	• Information collected through entrainment and passage efficiency monitoring (Section 7.2) would assess spillway mortality of juveniles and the risk of adult fish entrainment over the spillway.	Larinier & Travade, 2002)

Fish Passage Risks	Description of Risk and Consequence	Mitigation Measures and Likelihood of Success	Reference Literature
	against the spillway surface, variations in velocity and pressure of the falling fish on the water surface, and physical shock or damage from collisions with downstream hydro facility infrastructure. As adult fish must pass through highly turbulent components (e.g., Hell's Gate) on their way to Wilsey Dam, the risk considered to adult fish as a result of spillway injury is considered low. Outmigration of juvenile fish through the spillway is also considered low and can likely be fully mitigated with implementation of prevention measures outlined under "mitigation measures", if needed.	• The final detailed design of the vertical slot fishway proposed alterations to the spillway as a contingency measure for reducing spillway passage injuries (WDFPC, 2005). These alterations include placement of a low dam in the rock notch of the shorter spillway route (down the saddle). This would keep low volume spills (and fish) in the main spillway channel and also reduce the risk of adults being attracted to the pool area below the dam and the risk of stranding. • Other preventative measures include ensuring that water depths at the base of the spillway are sufficient and at safe velocities. These parameters could potentially be managed through operation of the hydraulic conditions through the hydro facilities. • Mitigation and contingency measures are described herein based on research of existing successful fishway designs and current fish passage science in the Pacific northwest. As a result, the likelihood that these measures will be successful is considered high.	
Passage effectiveness (proportion of fish that successfully navigate the fishway and exit into the river upstream)	Passage effectiveness is influenced by hydraulics in the fishway and its structural components, as well as environmental conditions. Achieving sufficient passage efficiency for the target species is critical to the success of the fishway and achieving the goals of fish passage (Section 4). The channel is relatively steep and may present hydraulic aspects that may influence fish passage effectiveness. Natural fishways tend to have the highest passage efficiencies and thus the risk related to passage efficiency in the Naturalized By-Pass Channel at Wilsey Dam is considered low.	• Proposed monitoring of passage efficiencies following fish passage will provide information on passage rates, as well as passage time and migration delays (Section 7.2). Further possible studies aimed at understanding passage efficiency issues include the influence of environmental factors (e.g., temperature), fishway capacity and impacts of crowding on fish migration behaviour. • Potential contingency measures to address low passage efficiencies include refinement of fishway flows, and adjustments to structural components of the *Naturalized By-Pass Channel* such as boulders and riffle features. • Mitigation and contingency measures are described herein based on research of existing successful fishway designs and current fish passage science in the Pacific northwest. As a result, the likelihood that these measures will be successful is considered high.	Roscoe and Hinch, 2010; Silva et al., 2017; Aarestrup et al., 2003; Bunt et al., 2012.

Fish Passage Risks	Description of Risk and Consequence	Mitigation Measures and Likelihood of Success	Reference Literature
Disease Transfer	The re-establishment of fish passage comes with the potential of introducing or re-introducing bacteria, parasites and fungi to fluvial resident fish populations above the dam. Since fish passage will be provided for both resident and anadromous salmonids, the mix of species above and below the dam would likely be similar after passage. It is therefore likely that current diseases, frequency of occurrence and affected species would be similar. The risk of disease transfer between above and below the dam cannot be readily quantified based on current information (McGrath et al., 2014). However, there are currently no particular disease concerns in fish populations below Wilsey Dam and DFO has indicated that there are no apparent concerns with regards to disease (Appendix D2).	• Mitigation and contingency measures are described herein based on research of existing successful fishway designs and current fish passage science in the Pacific northwest. As a result, the likelihood that these measures will be successful is considered high.	NHC and Ecofish, 2002
Exotic Species Introduction	Distribution of exotic species in the Fraser watershed is extensive; however, there are no known observations in the Lower Shuswap River, Mabel Lake or Middle Shuswap River below Wilsey Dam as confirmed with provincial experts in 2018. The extent to which exotic species would be able to pass Wilsey Dam depends on the fish passage alternative selected and also the species. Many exotic species have smaller	• The recommended monitoring program includes enumeration of fish ascending the fishway by species and would thus be able to detect any exotic species passing the dam (Section 7.2). • Contingency measures to prevent invasive species access could include maintaining flows such that invasive species are unable to ascend the fishway by manipulating the stoplogs at the fishway entry. As many exotic species are smaller bodied than salmonids, it would be possible to limit small species passage as the risk (exotic species are shown to ascend the fishway) outweighs the benefit (habitat connectivity for juvenile and small trout).	Klassen, pers. comm.

Fish Passage Risks	Description of Risk and Consequence	Mitigation Measures and Likelihood of Success	Reference Literature
	body sizes and poorer swimming abilities compared to salmonids, which may limit their ascent through fishways. As a result, the risk of exotic species ascending the fishway is considered low and can likely be fully mitigated with implementation of contingency measures outlined under “mitigation measures”, if needed.	• Mitigation and contingency measures are described herein based on research of existing successful fishway designs and current fish passage science in the Pacific northwest. As a result, the likelihood that these measures will be successful is considered high.	
Competition with resident stocks	Several studies have indicated that the impact of anadromous access above the dam will have little to no negative impact on resident fish species and that fish passage is environmentally feasible. As a result, the risk of competition with resident stocks for habitat capacity, availability and food supply is considered low and can likely be fully mitigated with implementation of contingency measures outlined under “mitigation measures”, if needed	• The proposed monitoring activities include evaluation of the biological implications of fish passage both on salmon populations and resident upstream fish populations. This will enable managers to determine if passage has the intended measurable benefits to fish populations and adaptively manage fish passage operations should any concerns arise. • Potential contingency measures for reducing competition would include limiting the number and/or species of anadromous salmon passing Wilsey Dam by manipulating fishway flows and restricting the operating period. • Mitigation and contingency measures are described herein based on research of existing successful fishway designs and current fish passage science in the Pacific northwest. As a result, the likelihood that these measures will be successful is considered high.	Griffith, 1979; Triton, 1995
Post-passage survival	Once a fish has passed through the fishway, it is not certain that they will continue on their migration to spawn possibly due to predation, loss of fitness and energy use, cumulative thermal exposure, and localized hydraulic conditions. To address the uncertainty of the level of post-passage survival	• Potential monitoring studies should investigate pre-spawn mortality of fish that have ascended the fishway (may be assessed as part of regular DFO stock assessment activities), and the condition of fish after fishway ascent, which will be facilitated by structures (e.g., trap box) that allow for inspection of fish. • Mechanisms of delayed mortality may be explained by enhanced understanding of migrational cues and exposure to thermal extremes prior to reaching the fishway, as well as	Roscoe and Hinch, 2010; Silva et al., 2017.

Fish Passage Risks	Description of Risk and Consequence	Mitigation Measures and Likelihood of Success	Reference Literature
	rates of the Naturalized By-Pass Channel, the implementation of the contingencies described under "mitigation measures", if needed are expected to address any issues and the resulting risk related to post-passage survival is considered low.	identifying energy requirements for successful passage. • Potential contingency measures include ensuring ample cover is available for fish recovering within and adjacent to the fishway, ensuring hydraulic conditions are such that fish are not experiencing excessive abrasion against rocks; and thermal conditions in the fishway are suitable for migrating fish. • Mitigation and contingency measures are described herein based on research of existing successful fishway designs and current fish passage science in the Pacific northwest. As a result, the likelihood that these measures will be successful is considered high.	
Metal Leachate / Acid Rock Drainage potential	Proposed NBPC rock materials are to be sourced in-situ or off-site. Examination of construction material suitability can be determined during the detailed design phase and could eliminate the risk of Metal Leachate and Acid Rock Drainage potential, thereby eliminating the risk of occurrence.	• Any rock materials should be tested for acid rock drainage potential and only used if found to be safe for fish and water. • Mitigation and contingency measures are described herein based on research of existing successful fishway designs and current fish passage science in the Pacific northwest. As a result, the likelihood that these measures will be successful is considered high.	
Ice Formation	Ice formation can be influenced by turbulent flows, as well as variance in flow rates. The consequence of ice formation is that it could potentially reduce pool volumes and affect flows within the Naturalized By-Pass Channel. Ice formation has a risk of occurring but can be reduced by computational fluid dynamics modelling to lower the risk of occurrence, thereby the	• Additional computational fluid dynamics (CFD) modelling can assist with refinement of finer detailed hydraulic aspects such as effects of roughness and momentum and influence of operational flow rates. Results of this modelling can guide small changes (rock placement) within the NBPC to improve efficiencies. • Mitigation and contingency measures are described herein based on research of existing successful fishway designs and current fish passage science in the Pacific northwest. As a result, the likelihood that these measures will be successful is considered high.	NHC, 2018; USFWS 2017

Fish Passage Risks	Description of Risk and Consequence	Mitigation Measures and Likelihood of Success	Reference Literature
	risk is considered to be low.		
Park flooding potential	Park flooding may occur for reservoir elevations greater than 447.5 m, but not as a result of the proposed fish passage structure. Flood level flow may impact the structure at a particular design elevation. Preliminary design of the Naturalized By-Pass Channel considers flooding, and flows can be released through the embankment through the fishway. Additional prevention measures described under the "mitigation measures" if needed and implemented, are expected to address any issues and the resulting risk to park flooding potential is considered low.	• Debris guards and restoration measures may be required. • Mitigation and contingency measures are described herein based on research of existing successful fishway designs and current fish passage science in the Pacific northwest. As a result, the likelihood that these measures will be successful is considered high.	BC Hydro, 2005, NHC, 2018

7. MONITORING PROGRAMS

The WDFPC proposes an adaptive management approach to fish passage at Wilsey Dam that uses monitoring data to understand if passage is meeting its restoration goals and has the intended measurable benefits to fish populations and the ecosystem, while ensuring that objectives of the facility are being met. This approach could be informed by the results of biological and engineering monitoring programs and processes that collect information upon which adaptive management decisions are based. It is recommended that a Technical Advisory Committee be established to advise on the further development and ongoing implementation of the monitoring program.

A comprehensive summary of recommended biological and engineering monitoring programs was developed by DFO in WDFSC (2005) and further information was provided in a letter dated Dec 5, 2017 (Appendix D2). Recent research provides insight on specific issues and monitoring topics affecting fishway success (Castro-Santos, Cotel, & Webb, 2009; Gutowsky et al., 2016; Noonan et al., 2012; Roscoe & Hinch, 2010; Silva et al., 2017) and should also be considered in the evaluation of fish passage effectiveness. The suggested monitoring topics include components assessing the biological consequences, and fishway effectiveness, and are listed in the sections below. Where applicable, specific monitoring components are included to address uncertainties and biological risks identified in Section 6.3.

7.1 Assessment Monitoring

Assessment monitoring includes evaluation of the biological outcomes of fish passage both on salmon populations and resident upstream and downstream fish populations. In some cases, this requires several years of monitoring data collection before fish passage implementation to sufficiently characterize baseline conditions and their natural variability (WDFSC, 2005; Washington Salmon Recovery Funding Board, 2011). Details on potential approaches are provided in a proposal for the collection of initial baseline monitoring data submitted to FWCP in the fall of 2017 (Appendix E). The following components are proposed to address uncertainties associated with the performance of aspects of the fish passage program and for consideration in an Assessment Monitoring Program at Wilsey Dam:

- **Salmon Spawner Distribution and Success** - enumerate spawning salmon species and redd site distribution, as well as spawner success, in the Middle Shuswap River above Wilsey Dam once passage is provided.
- **Adult Resident Salmonid Abundance and Distribution** – monitor adult resident salmonids, including Rainbow Trout and Bull Trout, in the Middle Shuswap mainstem above and below Wilsey Dam, and in Cherry and Ferry creeks. This monitoring component will provide information on resident adult fish abundance, habitat use,

possible competition for spawning habitats between salmon and resident fish following passage, and possibly the use of upstream habitats by adfluvial Rainbow and Bull Trout from Mabel Lake.

- **Juvenile Salmonid Abundance and Distribution** – monitor juvenile fish distribution above and below Wilsey Dam in the mainstem and Cherry and Ferry creeks. This monitoring component will provide information on changes in the resident fish community following fish passage, the utilization of rearing habitats by juvenile salmon above the dam, and any possible competitive interactions between anadromous and resident juvenile fish.
- **Invertebrate Abundance and Composition** – monitor changes in invertebrate prey abundance and composition following fish passage. This monitoring component addresses uncertainties about prey food abundance identified in Section 6.3.

7.2 Effectiveness Monitoring

Monitoring the effectiveness of a fishway involves determining if it is successful at passing target species up- and downstream to meet ecological, management, and conservation goals. It is specifically focused on determining how effective the fishway is at providing safe fish passage. Effectiveness monitoring is relatively limited in spatial scope to the fishway itself, its approach and exit, and the hydroelectric facility it bypasses. It also includes entrainment monitoring to inform the identification and evaluation of entrainment prevention structures or measures to acceptably mitigate entrainment issues.

- **Fish Enumeration** - this includes enumerating fish utilizing the fishway and accessing the Middle Shuswap River above Wilsey Dam. It should include enumeration of up- and down migration.
- **Passage Efficiency** – refers to the proportion of fish that successfully navigate the fishway and exit into the river upstream.
- **Attraction Efficiency** – refers to the proportion of fish above or below the fishway that are attracted to and ultimately enter the fishway. Overall fishway efficiency consists of both passage and attraction efficiency.
- **Fallback** - Assess the effectiveness of the upstream outlet of the fishway channel in directing fish to continue in an upstream migration by identifying any fallback over the dam spillway of adult fish that have recently ascended the fishway
- **Juvenile Entrainment** – enumerate juvenile fish outmigration either through the fishway or through the facility to determine population success and any entrainment issues (Section 6.2).
- **Adult Entrainment** – enumerate adult fish migration through the fishway and spillway vs. the Shuswap facility.

Entrainment Prevention Structures – evaluate the effectiveness of entrainment prevention structures and measures and include an assessment of impacts to fish that may become entrained (Section 6.2).

8. RECOMMENDATIONS AND DECISION POINTS

Following on from the significant and dedicated efforts of regulatory bodies, local stakeholders, and regional Syilx and Secwepemc First Nations, and the collective review of detailed case studies, fish passage at Wilsey Dam has been deemed to be biologically and technically feasible. Submission of this fish passage plan marks the end of the proponent-driven steps of the Fish Passage Decision Framework and moves the process into Step 5 (FWCP Endorsement). As such, the next step for the WDFPC is to seek endorsement for this plan from FWCP in order to proceed to Step 6 of the Fish Passage Decision Framework.

While not required under the Fish Passage Decision Framework to select a preferred option, it is the responsibility of the proponent (the WDFPC) to identify the fish passage solutions that will best address requirements to meet stated restoration goals. Using a SDM approach to evaluate fish passage alternatives against a common set of biological, financial, social, and general evaluation criteria, with support from expert opinion, technical literature review, and two focused fish passage engineering feasibility studies, the *Naturalized By-Pass Channel* is the engineering option that best meets environmental and preliminary technical feasibility of facilitating fish passage past Wilsey Dam in the current context. The *Naturalized By-Pass Channel* was selected through consensus as the preferred fish passage alternative at Wilsey Dam because of the many ecological benefits produced through the provision of passage to a wider range of aquatic species, comparatively lower operations and maintenance requirements, comparatively lower public and worker safety risk, and excellent educational and tourism opportunities associated with the close access to migrating salmon in a natural setting.

The WDFPC encourages BC Hydro to consider Dam Decommissioning as an alternative solution to the goal of re-introducing salmonids to their historic habitat above Shuswap Falls. The WDFPC was unable to consider Dam Decommissioning with the same level of scrutiny as the range of engineering options evaluated for fish passage (given the presence of the dam), but it was evident that there was much to commend to this potential solution. Although there are considerable up-front costs to Dam Decommissioning, the long-term liabilities associated with dam safety, government regulations, and the recurring annual expenses of maintaining and monitoring fish passage structures (e.g., a ladder or by-pass channel) are effectively eliminated.

While there are costs and risks associated with providing fish passage at Wilsey Dam, contingencies to mitigate those risks are available. The substantial anticipated biological, socioeconomic, and cultural benefits, as a result of restoring historical salmonid access to high-quality spawning and rearing habitat above Wilsey Dam, offset the costs and risks identified. The benefit of fish passage and increasing fisheries potential have been long-awaited by many. Ongoing discussions with FWCP are anticipated and encouraged to support the endorsement process and to progress to the remaining steps of the Fish Passage Decision Framework.

The WDFPC proposes an adaptive management approach to fish passage at Wilsey Dam that incorporates monitoring data to assess and evaluate the effectiveness of fish passage at achieving its restoration goals and intended benefits and to address uncertainties, while ensuring that objectives of the Wilsey Dam facility are also being met.

While restoring fish passage remains the focus and mandate of the WDFPC, it is important to acknowledge that restoration of abundant and healthy salmonid populations in the Middle Shuswap River depends on a number of conservation and management actions being implemented concurrently in order to provide the best likelihood of success. Ongoing inclusive efforts to recover salmonid populations in the Middle Shuswap River need to integrate planning and management considerations that recognize the conservation and cultural relevance of these at-risk fish populations.

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Appendix A – BC Hydro Fish Passage Decision Framework

A1 – Fish Passage Decision Framework (2017) – 8 pages pdf

A2 – FWCP letter February 2016

Fish Passage Decision Framework for BC Hydro Facilities

Revision 1 - December 2016

Note: this document was originally created in 2008 and signed off and endorsed by Fish, Wildlife and Hydro Policy Committee representatives. Subsequently in 2016, additional information was added to the document and reviewed and endorsed by the Fish, Wildlife and Hydro Policy Committee representatives in January 2017.

Purpose - To establish a process which will determine how BC Hydro will address fish passage issues at BC Hydro facilities. This document also clarifies the role of the Fish and Wildlife Compensation Program (FWCP) in supporting the development of fish passage proposals for BC Hydro consideration.

Background and Scope - The development of some of the BC Hydro dams in certain watersheds resulted in a blockage to migratory fish. The result often meant the elimination or the reduction of specific migratory fish species or populations in the rivers. Proposals for fish passage have been initiated by public and First Nation groups, with Fisheries Agencies support, at several BC Hydro facilities. The rationale for fish passage is to improve the productivity of affected watersheds through the re-establishment of selected species of fish to the portions of the watershed they historically utilized. This Framework has been endorsed by the FWCP in 2008 for application to facilities where fish passage has been identified as a priority at respective facility watersheds.

BC Hydro Statement of Strategic Intent - BC Hydro's long term goal, stewardship ethic and environmental policy establish the commitment to minimizing our impacts, and where possible, restoring the environment. The *Fish Passage Decision Framework* will ensure that fish passage decisions are based on a structured decision making approach, with sound defensible criteria.

Fish Passage Decision Framework for BC Hydro Facilities

Revision 1 - December 2016

The construction of several of BC Hydro hydro-electric facilities resulted in a barrier to fish that previously utilized areas of the watershed above and below the dam. Fish passage is required to re-establish selected species of fish to portions of the watershed that they historically utilized. There have been several fish passage proposals that promote the construction of fish ladders or other permanent fish passage facilities at hydro-electric facilities.

The Fish and Wildlife Compensation Program (Coastal, Peace and Columbia) was established by BC Hydro in partnership with the Department of Fisheries and Oceans (DFO) and the Province as a mechanism to help address footprint impacts. Each region is managed by a separate Board made up of members from the public, First Nations, DFO, the province and BC Hydro. The Policy Committee made up of senior managers from BC Hydro, the province and DFO sets the overall policy direction for the FWCP including the governance structure, establishes the strategic framework, overseas periodic FWCP evaluations, approves significant changes to the FWCP, and addresses disputes arising from within the FWCP when necessary (FWCP Governance Manual 2014). The FWCP was established to compensate for impacts to fish, wildlife and their supporting habitat resulting from the construction of BC Hydro dams (footprint impacts)." Whereas impacts caused by facility operations (e.g. water level changes and maintenance) are addressed through other programs such as Water Use Plans, the Fish Entrainment Strategy, and fish stranding protocols.

While the blockage of fish passage is defined as a footprint impact, there is insufficient funding in the FWCP to take on the funding of construction projects (e.g. fish passage infrastructure). As a result, the Policy Committee has endorsed a formalized approach to involve the FWCP Boards in the decision making process of analyzing the issue and to ultimately make decisions to address the technical feasibility and likelihood of success of fish passage. The Fish Passage Decision Framework ("the Framework") is divided into two parts:

- The FWCP role: a Proponent-led process whereby the proponent (typically a fish passage committee) seeks funding from the FWCP to evaluate the feasibility of restoring target species above respective BC Hydro facilities through the installation of some form of fish passage infrastructure. This part of the Framework is completed when a proposal is found to be "infeasible" or if the regional FWCP Board endorses the fish passage proposal; and

- The BC Hydro role: Once the regional FWCP Board endorses the fish passage proposal ("Step 5" of the Framework), the Proponent will submit a supported project proposal for fish passage which will then go to BC Hydro for business case and financial approval.

Currently, FWCP Coastal region is the only chapter to consider fish passage initiatives within its Action Plans. If other chapters identify and approve fish passage as a key priority in their watershed Action Plans, the Framework would apply accordingly.

FWCP Role:

The applicable FWCP Board needs to be convinced that the fish passage proponent has met the requirements of each step in the Framework before it endorses a fish passage plan. The FWCP Board can, at any time, utilize the regional FWCP Technical Review Committee within the FWCP proposal review process or an independent consultant (e.g. a fish passage expert) to inform its decisions. In addition, BC Hydro will provide a technical lead to support the proponent, and act as a liaison with the FWCP Board to ensure consistency and support communication between the FWCP Board and the proponent.

Although the Framework is intended to be implemented in as a linear process, studies and activities under Steps 3 and 4 may be implemented in order of priority or complexity in the process, as informed by the target species requirements and the facility context.

Step 1 - Preliminary Screening

To determine whether a fish passage proposal for a specific watershed addresses a footprint impact, the following screening question will be asked:

"Did the facility block passage of a migratory fish stock at the time of construction?"

Each of the of the FWCP regions has developed Watershed Action Plans in partnership with the FWCP Board, Technical Committees, BC Hydro, First Nations, DFO, the province, and other stakeholders through a series of consensus building workshops. The planning process establishes priority conservation, enhancement and restoration opportunities for each watershed.

Fish passage opportunities are prioritized within the Watershed Action Planning process. Within-watershed priorities are based on Provincial and Federal agency species objectives and on preliminary biological and technical feasibility criteria, including whether the facility blocked passage at time of construction. High priority opportunities are integrated into watershed or species specific Action Plans. If fish passage has not been identified as a priority in the Action Plan or by the FWCP Board, it would need further evaluation before the proponent could proceed to Step 2.

Step 2 –First Nations and Stakeholder Engagement

Fish Passage Decision Framework studies and activities outlined in Steps 3 and 4 below are funded through the normal FWCP application process, which requires that proponents demonstrate their applications have the support of regional First Nations, stakeholders and regulatory groups. To ensure that the proponent considers affected interests, it is highly recommended that a fish passage committee be established that includes representatives from local First Nations, community and regulatory groups, and BC Hydro. It is recommended that all participants carry the mandate to represent their interests and the authority to participate in fish passage committee decisions. The fish passage committee should document its fish passage plan objectives, including expected restoration goals, expectations of ongoing support, and consistencies with fish passage committee representative objectives (regulatory requirements, BC Hydro operating requirements, etc.). Based on the objectives, the fish passage committee can then identify its data gaps in developing a fish passage plan that will address Steps 3 and 4 below. The fish passage committee should establish a timeline for addressing its critical gaps, with those uncertainties deemed of most significance to plan success addressed earliest in the timeline. Changes to the plans based on inputs from studies or other sources should also be communicated and reviewed as needed.

Step 3 - Environmental Feasibility Studies

In order to assess the potential for success for a fish passage proposal, initial environmental feasibility studies must be undertaken. Environmental feasibility studies are undertaken to determine whether fish passage plan objectives described by the fish passage committee can be met given biologic inputs collected in the Framework. The environmental feasibility of each fish passage proposal must include the following assessments:

- Target species are available in the watershed in sufficient numbers to support rebuilding a sustainable population. If the target species is not available and a donor stock transplant is proposed, a thorough risk assessment related to suitability of the donor stock and impact on the donor stock must be undertaken;
- Potential genetic, ecological and disease impacts to native species;
- Existence of high quality spawning and rearing habitat below the dam;
- Other physical impediments, such as other adult migration barriers below the dam, or juvenile passage issues at the facility, or different flow regimes that may limit the potential for restoration goals to be achieved;
- Sufficient spawning and rearing habitat above the barrier to support the target fish population numbers established in the Watershed Action Plan, or the known potential to restore sufficient habitat. Feasibility studies must be undertaken to assess this potential; and
- An assessment of the biologic benefits of a fish passage plan, as well as a summary of the risks of biologic impact and regulatory requirements.

Assessments may be based on available literature, modeling, or direct empirical measurement as dictated by the complexity and understanding of the issue. In evaluating an assessment proposal, the FWCP Board will determine if:

(a) an appropriate review of options has been conducted;

(b) the assessment is required to determine feasibility; and

(c) whether the approach has a reasonable chance of addressing the uncertainty.

Depending on the number and complexity of data gaps, this step can take several years to complete. Multi-year study plans will be considered where the criteria above have been accounted for and the proposal represents a priority for funding. Some studies used to establish biological feasibility may require approval from the province or DFO.

Environmental feasibility is established where the fish passage committee and the FWCP Board agree that studies and activities demonstrate that fish passage plan objectives can be sustained under the appropriate technical circumstances. The proponent may request a meeting with the FWCP Board to determine whether Step 3 requirements have been met.

If environmental feasibility has not been adequately demonstrated, or any of the fish passage committee feels that their objective are not adequately considered in the process, the FWCP Board may direct proponents to re-submit to address their concerns, or deny their application.

Step 4 – Preliminary Technical Feasibility Consideration

The proponent is responsible for identifying the fish passage solutions that will best address requirements to meet its stated restoration goals. This includes a review of fish passage options, an analysis of fish passage efficiencies and effectiveness (e.g. survival), a description of operations, conceptual design and an estimate of cost. BC Hydro engineering will provide in-kind support to the proponent in its review and selection of fish passage options, to ensure that dam safety, operating requirements, maintenance standards and crew requirements are appropriately addressed in the final recommendation. The proponent needs to ensure that it responds to any concerns BC Hydro raises in its review.

The review and analysis of options can be based on case studies of technologies applied successfully in similar contexts, or may require more specific evaluation in lieu of relevant examples from the literature. The technical assessment will include a conceptual design and the costs of the preferred option.

Technical feasibility is established once the fish passage committee and the FWCP Board agree that the plan can support its biologic objectives using technologies and operations that are proven within the specific facility context. The proponent may request a meeting with the FWCP Board to determine whether Step 4 requirements have been met.

If technical feasibility has not been adequately demonstrated, the FWCP Board may direct proponents to submit applications that will address identified gaps, or deny their application.

Step 5 – FWCP Endorsement

After completing Steps 3 and 4, the proponent will prepare a fish passage plan and seek technical support with Fisheries and Oceans Canada and the province. The proponent will then present the fish passage plan to the FWCP Board for its endorsement to proceed to Step 6. The summary and presentation will be reviewed by the FWCP Board utilizing any additional technical resources dictated by the complexity of the fish passage plan and the understanding of FWCP Board members.

In addition to demonstrating technical and environmental feasibility, the FWCP Board and proponent must ensure that the information provided in the fish passage plan will adequately inform the development of a business case in Step 6:

- What are the risks associated with the fish passage plan:
    - likelihood of success?
    - Regulatory approvals?
    - Demonstrated success of the proposed technologies?
    - Population, genetic or ecosystem threats?
- What are the costs of the fish passage plan: operations, study costs, construction?
- What are the benefits: biologic (productivity), conservation, First Nations cultural and other societal benefits (tourism, education)?

The FWCP Board is not responsible for conducting the business case evaluation, but will ensure the proponent has provided the values in a meaningful summary to inform the next step in the Framework. Once the FWCP Board is satisfied the proponent has met the requirement in these 5 steps, it will endorse the fish passage plan for BC Hydro consideration.

Where the proponent has NOT met the Framework requirements to this point, the FWCP Board will provide feedback (according to its technical review or directly from the FWCP Board) to the proponent for further work. If the proponent's fish passage plan is deemed NOT feasible based on the weight of evidence provided, the FWCP Board must indicate that it cannot be endorsed and that future requests to support the its evaluation will not be funded.

BC Hydro Role:

Step 6 –Business Case Development

The business case recommendation will follow a structured approach that explicitly integrates environmental, social and financial objectives in evaluating alternatives for fish passage. The process will provide a rating from high to low for fish passage alternatives. The process will evaluate alternatives against objectives provided from the proponent with additional analysis of alternatives, updated costs and any gaps in the original proposal.

(a) **Environmental Assessment:** in consultation with FWCP and the original proponent, BC Hydro will further assess the environmental feasibility if required.

(b) **Financial/Technical Assessment:** options to provide fish passage will be analyzed to ensure technical feasibility for the proposed watershed.

- Dam structure integrity must be maintained; therefore designs for upstream and downstream passage facilities must undergo a BC Hydro engineering review.
- The fish passage proposal must be able to operate within the current Water Use Plan (WUP) operating parameters for the facility. If not, the proposal will be deferred until the scheduled WUP review takes place.
- Designs and costs for additional structures, such as screens to reduce potential juvenile migrant fish mortality, must be considered.

(c) **Social Benefits Assessment –** fish passage at the proposed site will be considered with respect to added societal value. Considerations may include:

- Intrinsic values – there is demonstrated evidence that the intrinsic value of the watershed will be positively impacted by the proposal (i.e. improved ecosystem biodiversity);
- Cultural – First Nation have identified the importance of returning fish providing food, social, ceremonial and spiritual values; and
- Socio-economic – there is demonstrated evidence that there will be an increase in tourism, recreation, jobs and / or a new or enhanced fishery.

The proposal will move to Step 7 if the evaluation of the above indicates it has a high potential for success. This process of developing a business case can take 3 months to 2 years to complete, depending on the level of information provided from Step 5 and the potential for additional options to be considered outside of the original fish passage plan.

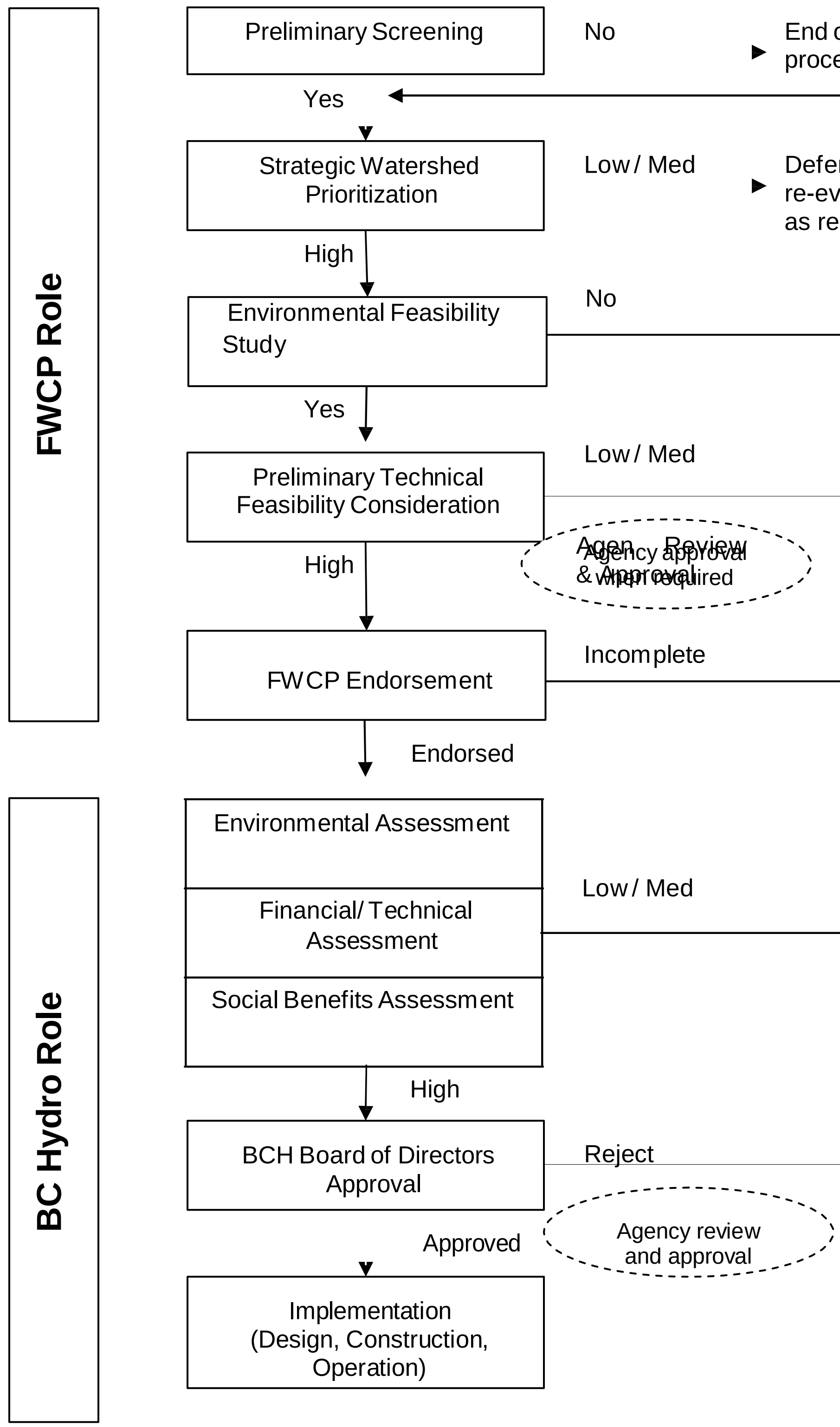
Step 7 –BC Hydro Board of Directors Approval

The proposed fish passage project will need to be evaluated with respect to BC Hydro's economic and business practices to determine whether it fits into BC Hydro's long term capital plan. The business case may include a detailed trade-off analysis and will include a detailed design.

If accepted by the BC Hydro Board of Directors, BC Hydro will be responsible for the management of design and construction of the passage facility. Regulatory Agency review and approval will be required. BC Hydro will be responsible for ongoing operation and maintenance of the passage facility.

Fish Passage Decision Framework for BC Hydro Facilities

Revision 1 - December 2016



February 29, 2016

PO Box 1500, 400 Madsen Road
Nanaimo, British Columbia
V9R5M3

Whitevalley Community Resource Centre Society
c/o Gay Jewitt
PO Box 661
Lumby, BC
V0E2G0

Re: Wilsey Dam Smolt Survival Study (COA-F17-F-1196) - $196,959.84

Dear Gay,

Thank you for submitting an application to the Fish and Wildlife Compensation Program (FWCP) Coastal Region for the (2016-17) grant year. We recognize, and appreciate, the time and effort it takes to develop the project proposal, gain the necessary support, and complete the application.

Sixty-one applications were received during this intake with a total request of over $3.0M from Coastal funding.

Each application went through the review process including: Stage 1 – Program Office review; Stage 2 – Technical Committee review; and Stage 3 – Coastal Board review and final decisions. As a result of this thorough review process, the Program was able to support 38 projects for 2016/17. The review process gives consideration to the following: applicability to the Program mandate, strategic plan alignment (i.e. Action Plans) and priorities, technical merit, cost effectiveness, and partnerships.

Following the completion of the review process, we regret to inform you that your application was **Not Approved** by the Coastal Board. In an effort to report back as much information as possible to applicants, we have added comments from the Program Office, Technical Review Committee, and Coastal Board:

- very well written proposal; and
- excellent First Nations leadership on this project/initiative.

Comments from the Coastal Board:

Upon review of the Wilsey Dam Fish Passage process, the Coastal Board considers that the committee has adequately established the Environmental Feasibility Studies (**Step 3**) of the Fish Passage Decision Framework. **The Coastal Board recommends that the committee proceed to Preliminary Technical Feasibility (Step 4), and therefore not submit further proposals in support of Step 3 feasibility.**

We look forward to continuing the dialogue regarding the Fish Passage Decision Framework process and we anticipate that the committee will be exploring Preliminary Technical Feasibility and submitting a subsequent application to the FWCP. Specifically, I look forward to these continued discussions this spring and would be open to a conference call at your convenience to discuss the Board's project decision and the next steps.

If you would like any further information or clarification, please do not hesitate to contact me at **trevor.oussoren@bchydro.com or 250-755-7152**. Alternatively, you may direct questions to fwcp@bchydro.com - be sure to cite your application number COA-F17-F-1196 in any emails.

Thank you again for your interest in the FWCP and if you have any questions regarding future application submissions, please do not hesitate to contact me. For additional FWCP-related information, please also refer to our website at www.fwcp.ca

Sincerely,

Trevor Oussoren
Coastal Region Manager (250-755-7152)

Appendix B – Fish Passage Alternatives Decision Making Process

B1 – Reading List for June 2016 fish passage Workshop

B2 – Final Evaluation Matrix resulting from January 28, 2018

1. **nhc. and ecofish. 2002. Wilsey Dam Fish Passage Concepts**
2. **nhc. 2005. Wilsey Dam Fishway Design Document**
3. **nhc. 2005. Wilsey Dam Fish Passage Detail Design (excluding Geotechnical assessment)**
4. **WDFSC. 2005. Feasibility Study Phase 2 – Introduction only (up to Appendix A)**
5. **BC Hydro *Fish Passage Framework* and accompanying flowchart (5a and 5b)**
6. Fish Passage Options Presentations (DFO, Whooshh, NHC)
7. McGrath et al. 2013. Environmental Feasibility of Establishing Fish Passage at Wilsey Dam.
8. Bengeyfield et al. 2001. Evaluation of Restoring Historic Passage for Anadromous Fish at BC Hydro Facilities
9. Bocking and Gaboury. 2002. *Fish Passage Framework*.
10. Noonan. 2012. A quantitative Assessment of Fish Passage Efficiency
11. DFO. Fish Passage Guidance for Pacific Salmon.

Bold = must read

	Criterion	Performance Measure (Units)	Desired	Importance - Relative (L, M, H)	Importance Weighting (H=3; M=2; L=1)	*Ladder (in spillway)*	*Ladder (off channel)*	*Naturalized By-Pass Channel*	*Whooshh*	*Trap & Truck*	*Dam De-commissioning (Structure Breach - 2 Units Operating)*	*Dam De-commissioning (Structure Breach - 1 Unit Operating)*	*Dam Operations Management*	*Other - Entrainment Mitigation*
						Technological Option for Fish Passage								
Financial	**Construction Costs** incl. 25% contingency (inc. $500,000 geotech contingency for naturalized by-pass channel only)	NPV ($)	Lower	H	3	$4,000,000	$4,658,600	$5,132,125	$4,103,125	$1,250,000	$4,000,000	$4,000,000	$0	$2,500,000
	Implementation Cost (35% of construction costs incl contingency; based on Whoosh and nhc reports, applied to all options)	NPV ($)	Lower	H	3	$1,393,600	$1,625,362	$1,663,832	$1,429,529	$435,500				
	Estimated Life Expectancy	Years	Higher	M	2	20	25	25	15	20	30	30	30	25
	Annualized Capital Cost (over life expectency)	$/yr	**Lower**	**H**	**3**	**$269,680**	**$251,358**	**$271,838**	**$368,844**	**$84,275**	**$133,333**	**$133,333**	**$0**	**$100,000**
	Annual operations, maintenance and surveillance costs	$/yr	Lower	H	3	$100,000	$50,000	$40,000	$157,000	$225,000	$20,000	$20,000	$10,000	$50,000
	Annual NET revenue loss	$/yr	Lower	H	3	$0	$0	$0	$0	$0	$1,490,314	$597,059	$130,862	$29,853
	Annual monitoring costs	$/yr	Lower	H	3	$50,000	$50,000	$50,000	$15,000	$15,000	$10,000	$10,000	$0	$0
	Total Annualized Cost	$/yr	Lower	H	3	**$419,680**	**$351,358**	**$361,838**	**$540,844**	**$324,275**	**$1,653,647**	**$760,392**	**$140,862**	**$179,853**
	Total Project Cost (Capital Cost + 15 yrs Operation Cost)	NPV ($)	Lower	H	3	**$7,643,600**	**$7,783,962**	**$8,145,957.35**	**$8,112,654**	**$5,285,500**	**$26,804,704**	**$13,405,881**	**$2,112,933**	**$3,697,794**
Biological	Smolt mortality	Mortality (%)	Lower	H	3	10%	10%	10%	12%	12%	0%	0%	5%	0%
	Juvenile passage efficiency (if applicable)	Efficiency (%)	Higher	L	1	0%	0%	10%	0%	0%	5%	5%	0%	0%
	Adult mortality	Mortality (%)	Lower	H	3	2%	3%	7%	1%	9%	1%	1%	N/A	N/A
	Adult passage efficiency - Chinook	Efficiency (%)	Higher	H	3	70%	80%	90%	95%	83%	90%	90%	N/A	N/A
	Adult passage efficiency - Coho (and similar)	Efficiency (%)	Higher	H	3	40%	40%	70%	40%	40%	90%	90%	N/A	N/A
	Daily Transport Capacity	Degree (1-10)	Higher	M	2	60%	60%	60%	60%	20%	100%	100%	N/A	N/A
	Fallback Risk (CH as proxy)	Proportion (%)	Lower	H	3	30%	10%	10%	10%	5%	0%	0%	0%	0%
	Weighted Score	Relative Measure	Higher			**12.2**	**13.1**	**14.3**	**13.6**	**12.3**	**16.4**	**16.4**	**#VALUE!**	**#VALUE!**
Social	Enhancement to First Nations traditional use and value	Degree (1-10)	Higher	H	3	6	8	9	6	3	10	10	N/A	N/A
	Opportunities for First Nations involvement (e.g., empl	Degree (1-10)	Higher	M	2	4	4	6	7	8	2	2	1	1
	Enhanced Fishing Opportunities (Public)	Degree (1-10)	Higher	M	2	8	8	9	8	8	9	9	N/A	N/A
	Enhanced tourism and visitation	Degree (1-10)	Higher	M	2	4	8	10	6	1	3	3	N/A	N/A
	Enhanced public educational opportunities	Degree (1-10)	Higher	M	2	3	9	10	8	4	6	6	N/A	N/A
	Social license improvements/liabilities	Degree (1-10)	Higher	L	1	8	8	10	8	3	10	10	N/A	N/A
	Weighted Score	Relative Measure	Higher			**10.7**	**15.0**	**17.8**	**14.0**	**9.0**	**13.3**	**13.3**	**#VALUE!**	**#VALUE!**
General	Regulatory/legislative hurdles (initial and ongoing)	Degree (1-10)	Higher	M	2	4	6	6	8	7	1	1	9	6
	Meet WUP Obligations	Degree (1-10)	Higher	M	2	8	8	8	8	10	1	1	4	9
	Reduced regulatory risk to BC Hydro (e.g. mitigates ent	Degree (1-10)	Higher	M	2	3	3	3	2	2	10	10	8	10
	Proven effectiveness for given context	Degree (1-10)	Higher	H	3	7	8	7	5	8	8	8	7	5
	Human intervention required for passage (Intense = 1;	Degree (1-10)	Higher	H	3	8	8	8	8	1	10	10	3	N/A
	Operational safety and worker risk	Degree (1-10)	Higher	H	3	1	7	7	3	3	10	10	9	
	Weighted Score	Relative Measure	Higher			**13.0**	**17.2**	**16.7**	**14.0**	**12.3**	**18.0**	**18.0**	**16.5**	**#VALUE!**

RANK ASSESSMENT

Financial	**2**	**3**	**5**	**4**	**1**	**7**	**6**
Biological	**7**	**5**	**3**	**4**	**6**	**1.5**	**1.5**
Social	**6**	**2**	**1**	**3**	**7**	**4.5**	**4.5**
General	**6**	**3**	**4**	**5**	**7**	**1.5**	**1.5**
Average Rank	**5.3**	**3.3**	**3.3**	**4.0**	**5.3**	**3.6**	**3.4**

Appendix C – Engineering Feasibility Studies

C1 – Naturalized By-Pass-Channel Engineering Feasibility Study and Fish Ladder Design Update Memo (NHC 2018)

C2 – Whoosh Engineering Feasibility Study (Dearden and Garello, 2017)

WILSEY DAM FISH PASSAGE
NATURAL CHANNEL FISHWAY
PRELIMINARY DESIGN

Final Report

Prepared for:
Whitevalley Community Resource Center
Lumby, BC

Prepared by:
Northwest Hydraulic Consultants Ltd.
North Vancouver, BC

January 23rd 2018

3001907

Acknowledgements

Northwest Hydraulic Consultants Ltd. (NHC) would like to express appreciation to Whitevalley Community Resource Centre (the Centre) for coordinating this project on behalf of the Wilsey Dam Fish Passage Committee. NHC would also like to thank the all members of the Committee for their input to the project. NHC would also like to acknowledge BC Hydro for providing review comments and facility information.

The NHC project team were:

- Barry Chilibeck, MASc, PEng
- Patricia House, PEng
- Joel Trubilowicz, PhD, EIT
- Pablo Rodriguez, BASc, EIT.

Notification

Document Control

Rev	Description	Date Issued	Prepared by	Reviewed by	Approved by
0	Draft	2017/09/11	PAH	DPM	BMC
1	Draft	2017/10/18	PAH	BMC	BMC
2	Final Draft	2017/12/10	PAH	BMC	BMC
3	Final	2018/01/23	PAH	BMC	BMC

Certification

Report Prepared by:

Original signed by

Patricia House, PEng
Senior Water Resource Engineer

Report Reviewed by:

Original signed by

Barry Chilibeck, MASc, PEng
Principal

Executive Summary

There has been increasing support for re-establishing anadromous fish passage past BC Hydro's Shuswap Falls Facility and Wilsey Dam, on the Shuswap River near Lumby, BC. As a tributary to the Fraser River, the Shuswap River provides spawning and rearing habitat for Chinook, Coho, and Sockeye salmon, and resident freshwater species like Rainbow Trout, Bull Trout, and Kokanee.

The current concrete dam currently prevents upstream migration and movement of all fish. By providing passage past Wilsey Dam, anadromous fish would gain access to habitat in the mainstem river to Peers or Sugar Lake Dam at the outlet of Sugar Lake, as well as several large tributaries. Freshwater fish would be able to move freely within the aquatic environment, and marine-derived nutrients (MDN) would be returned to the upper river providing benefits to the ecosystem as a whole.

The Wilsey Dam Fish Passage Committee (Committee) was formed to facilitate and foster the support of fish passage at Wilsey Dam. This has been an ongoing process, addressing the criteria and structure of the BC Hydro's *Fish Passage Decision Framework* (2017), particularly the environmental and technical feasibility. Several previous studies have been conducted to assess habitat availability, historic use, potential use, and implications of future use (e.g. inter species competition and disease), as well as to identify and evaluate fish passage options.

During 2017 Committee meetings evaluating fish passage alternatives, both the vertical slot and natural fishway were identified as favoured options. Whitevalley Community Resource Centre contracted Northwest Hydraulic Consultants Ltd. (NHC) to further investigate the natural fishway options, to produce a preliminary design with plans, specifications, and cost estimates for a natural fishway that would provide fish passage around Wilsey Dam, and to update the costs and design considerations from previous assessments for the vertical slot fishway for comparison with the natural fishway. A final design would be used in an evaluation of other methods and actions to provide a final fish passage solution.

Biologists and fisheries engineers have observed for years that fish utilize the roughness and hydraulics created in a natural stream channel to pass what appear to be difficult and insurmountable barriers. These observations led to development the analogous natural design in fish passage systems. Nature-like, naturalized or natural fishways all refer to the same concept – a fishway resembling a stream channel – and have been used for several decades, but only recently considered a separate type of fishway distinct from other structural fishways like vertical slot and pool and weir fishways.

In Europe, natural channel fishways have been increasingly used at a multitude of low head barriers and dams. In North America, they are being used increasingly to provide volitional passage for multiple species and multiple life stages, including resident freshwater fish species that make seasonal and life stage movements, and highly migratory fish like Pacific Salmon, that require access to natal spawning areas to complete their cyclic life history.

Nature-like or natural channel fishways are structures that are purposely built to simulate hydraulics of a natural stream. They are constructed using similar morphology, section and materials as natural riffle pool and step pool channels. This is a key difference to structural fishways, like the vertical slot, that are designed with high regulated, consistent hydraulics. Most of the operational natural channels are lower gradient as many have been designed for weaker swimming fish species or a wide range of fish species as found in many of the diverse large river ecosystems where they are common.

NHC reviewed the criteria that the Committee developed for assessment of the natural channel design, and the data that was currently available to undertake the work. NHC noted that there was insufficient spatial data to provide a good basis for the design, so additional LIDAR data was acquired for the area around the dam. BC Hydro also provided updated operational hydrology for the facility to update the hydrological data. The design did not acquire any additional geotechnical data, and if the design is progressed, further geotechnical engineering is warranted including the assessment of slope stability, mapping of rock type and strength, excavation, and slope stabilization design.

Using the site data and natural channel design criteria developed from ecohydraulic data, different channel lay-outs were evaluated. As the design is sensitive to the amount of rock and material excavated to construct the channel, different options were reviewed along the right bank where there is sufficient space. A plan was adopted that would see a 750 m long channel excavated along the right bank from the headpond roughly 75 m upstream of the spillway crest, downstream at a 5 percent slope to the Shuswap River, approximately 180 m downstream of the powerhouse.

The channel width was sized to provide adequate depth of flow and moderate velocities such that all adult fish species and many juvenile fish present in the Shuswap River are likely to occupy and use the channel for movement. All sections of the channel are surfaced with graded rocks to form a step-pool structure. Additional boulder complexing is provided so that channel resembles a typical, moderately steep stream environment. Portions of the excavated channel are lined with a geomembrane to prevent seepage; other sections of the channel have well graded filters to provide bank stability.

Commissioning, operation, maintenance, and surveillance requirements for the new design are expected to be reasonable for a structure of this nature. The fishway has been designed to be stable, require no specialized upkeep, and operate without need for regular flow adjustment, and recommendations for year-round have been provided. There are forgone power benefits from lost energy generation due to the release of flow down the fishway during non-spill periods. However, since 2012 and the outage of Unit No. 1, there appears to be sufficient spill flows that reduce these costs significantly.

NHC used the design drawings and updated project unit costs to prepares a preliminary cost estimate for the construction of the design. The cost estimate for the natural channel fishway is $5.9M and this includes a project cost and geotechnical contingency as detailed in the report. The costs for the vertical slot design were also updated to 2017 rates and total $5.4M, and the difference in cost between the natural and the vertical slot fishway in the updated 2017 estimates is less than the precision of the estimate (-5%/+20%).

A comparison of features and risk elements between the natural fishway and vertical slot design are presented (**Table 9-1**). Overall, the natural fishway design provides key benefits that the vertical slot cannot, and potential deficiencies in the natural fishway can likely be mitigated through operation or further information in the design process. On the basis of this information, NHC recommends that the natural fishway design be promoted as the best possible fishway alternative in the overall assessment of fish passage options at Wilsey Dam.

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1 Introduction

Wilsey Dam was constructed nearly 100 years ago at the Shuswap Falls site on the Shuswap River near Lumby, BC. The dam construction resulted in complete blockage of upstream fish passage for Chinook Salmon, Coho Salmon, Sockeye Salmon, Bull Trout and Rainbow Trout and access to the 29 km of habitat between Wilsey Dam and Sugar Lake Dam (NHC, 2002).

The need for fish passage past the dam has been recognized since the initial application to construct the dam in 1913, with the early designs including plans for a fishway. By providing passage past Wilsey Dam, anadromous fish would gain access to habitat in the mainstem river to Peers or Sugar Lake Dam at the outlet of Sugar Lake, as well as several large tributaries. Freshwater fish would be able to move freely within the aquatic environment, and marine-derived nutrients (MDN) would be returned to the upper river providing benefits to the ecosystem as a whole.

This report documents the preliminary design for a nature-like or natural fishway at Wilsey Dam. This report and the underlying work was prepared to provide information for the assessment of feasibility of such an approach and comparison with other options for providing fish passage at Wilsey Dam. This document presents the background information on the site and project, the basis of design, preliminary design drawings and cost estimate for the project, discussion of the operations and other issues related to furthering the design.

1.1 Background

The Wilsey Dam Fish Passage Committee (the Committee) was established to bring together all parties involved with restoring fish passage past the Wilsey Dam. This Committee was formed in August 2003 and included interested partners: BC Hydro, the Spallumacheen Indian Band, Secwepemc Fisheries Commission, Okanagan Indian Band, Okanagan Nations Fisheries Commission, Fisheries and Oceans Canada, Ministry of Environment (then Ministry of Water, Land, and Air Protection), and Whitevalley Community Resource Centre (the Centre). Members of other community group (e.g. fish and game club), the general public and industry are also invited, regularly attending, and engaging in the committee's meetings.

In 2005, Northwest Hydraulic Consultants Ltd. (NHC) prepared a detailed design of a vertical slot fishway. At the time, this approached was deemed the most effective solution based on target species, cost, and flow requirements. The Committee has compiled and undertaken many studies since its conception to address the criteria that need to be evaluated, particularly the environmental and technical feasibility, as detailed the BC Hydro's *Fish Passage Decision Framework* that was originally approved in 2008 and revised in 2017. These additional studies have included fishway design option evaluations as well as biological studies including habitat availability, inter-species competition, and disease.

On June 29th 2016, a workshop to review the passage options and issues at Wilsey Dam was held by the Committee. One of the key outcomes of the workshop was the development of an evaluation matrix of passage options at Wilsey Dam, reflecting the current thoughts and goals of the Committee. The matrix assessed financial, biological, technical, and social factors and rated the various fish passage options. Of all the structural options assessed, a fish ladder similar to the 2005 design, and a naturalized or nature-like fishway channel were ranked highest of all the options. The Committee further evaluated the two options and ranked both equal.

Based on the outcome of the June 2016 workshop and the Committee's recommendations, the Centre, on behalf of the Committee, engaged NHC to undertake the following work:

1. Update the previous 2005 fishway design and costs to reflect current issues, constructability, and costs.

2. Undertake a preliminary design of a natural fish passage channel, and provide a design report including estimate of construction costs. Differences of the natural fishway compared to the 2005 vertical slot design have also been summarized.

3. These deliverables are to provide an updated comparable assessment of both equally-ranked options and provide the information required to select a preferred option to carry forward to detailed design and implementation. The updated 2005 fishway design review and costs were provided under separate cover as a draft letter report dated October 18th, 2017 to the Centre.

2 Scope

2.1 Natural Fish Passage Channel Preliminary Design

Using the existing and collected topographical information, the channel alignment was determined at the design gradient based on the objectives of avoiding large cut and fills, balancing cut and fill, targeting preferential materials (i.e. earth versus rock cuts), targeting preferential entrance and exit locations, and working within any other identified constraints (i.e. land ownership, stable slopes, existing access routes for BC Hydro and the public, high value terrestrial habitat). Due to the location of the generation facilities, dam and spillway channel, the available alignments are limited to the right bank.

The natural fishway channel design encompasses the following:

1. **Inlet structure**

   The channel inlet design accounts for the upstream water elevation variation within the headpond and accounts for the range in flow within the fishway. An inlet structure, such as a vertical slot fishway, is required to limit the range in fishway flow and stop-log control structure as a shut-off flow to dewater the fishway for inspection and maintenance. Vertical slot fishway to address water levels into the fishway

2. **Channel section and design**

   The design channel shape in terms of width and operational depths would be determined, and the channel units forming the roughness, hydraulic control and holding habitats would also be designed. Natural materials – angular and alluvial rock, gravels and bedrock – are used for the channel features, and reinforced concrete or steel use is minimized.

   The culvert will provide for connectivity from the fishway to the head pond. To provide additional channel control, a bulkhead gate at upstream end of the culvert for on/off hydraulic control at the upstream end of the culvert. Downstream of the culvert the natural fishway will be composed of a series for riffles for hydraulic control

3. **Fishway outlet**

   The fishway outlet provides the entrance for volitional upstream migration of fish, and the location, placement and position are critical in determining the overall effectiveness of the fishway. The design incorporates previous knowledge of fish behaviour in the area to ensure fish rapidly find and enter the fishway.

Following design, infrastructure and material quantities were estimated for Class C (-5%/+20%) costing purposes. Contingencies for detailed design including structural and geotechnical requirements as well as, construction engineering, project management and environmental mitigation are added, and a preliminary cost was developed.

NHC reviewed the 2005 vertical slot design and revised it to reflect current state-of-design and knowledge for fish passage. The construction costs have been updated to reflect current material costs and construction contractor rates.

Components that have been identified but not fully developed or investigated in this scope include:

- Changes in water licensing requirements
- Fish counter specifications or viewing platform details
- Ancillary monitoring and maintenance equipment
- Fencing and site security, and
- Educational and awareness components such as informational signs.

2.2 BC Hydro Fish Passage Decision Framework

The purpose of this Project is to contribute to satisfying the requirements of the BC Hydro Fish Passage Framework (2017). The BC Hydro Fish Passage Decision Framework is a five-step process as follows:

Step 1 - Preliminary Screening

Step 2 –First Nations and Stakeholder Engagement

Step 3 - Environmental Feasibility Studies

Step 4 – Preliminary Technical Feasibility Consideration, and

Step 5 – BC Hydro Fish and Wildlife Compensation Program (FWCP) Endorsement.

This Project falls primarily under Step 4 – Technical Feasibility, as such the following considerations for the natural fishway option are considered within the scope:

- Demonstration of success in similar contexts (NHC, 2002)
- Dam safety (**Sections 5.4** and **8.3**)
- Operating and maintenance requirements (**Section 8**)
- Biological objectives can be met with this passage design (**Section 6.1.1** and **6.1.4**), and
- Any technical limitations (**Section 6.2, 6.3**, and **9**).

3 Project Definition

3.1 Overview

Biologists and fisheries engineers have observed for years that fish utilize the roughness and hydraulics created in a natural stream channel to pass what appear to be difficult and insurmountable barriers. These observations led to development the analogous natural design in fish passage systems. Nature-like, naturalized or natural fishways all refer to the same concept – a fishway resembling a stream channel – and have been used for several decades, but only recently considered a separate type of fishway distinct from other structural fishways like vertical slot and pool and weir fishways.

In Europe, natural channel fishways have been increasingly used at a multitude of low head barriers and dams. In North America, they are being used increasingly to provide volitional passage for multiple species and multiple life stages, including resident freshwater fish species that make seasonal and life stage movements, and highly migratory fish like Pacific Salmon, that require access to natal spawning areas to complete their cyclic life history.

Nature-like or natural channel fishways are structures that are purposely built to simulate hydraulics of a natural stream. They are constructed using similar morphology, section and materials as natural riffle pool and step pool channels. With proper design and construction, natural fishways channels provide volitional passage for a wide range of aquatic species due to their varied hydraulics that provide multiple movement pathways. This is a key difference to structural fishways, like the vertical slot, that are designed with high regulated, consistent hydraulics.

The natural fishways can be formed in excavated earthworks, concrete or bedrock channels, but all tend to utilize a basic pool weir design. Materials are selected for their hydraulic characteristics and stability, and include boulders embedded in cobbles and gravels on stream slopes to approximately 5 percent, with steeper slopes to 10 percent requiring larger founding substrates or anchoring with concrete. Most of the operational natural channels are lower gradient as many have been designed for weaker swimming fish species or a wide range of fish species as found in many of the diverse large river ecosystems where they are common.

3.2 Site Conditions

3.2.1 Existing BC Hydro Facility

Wilsey Dam is located at Shuswap Falls on the Shuswap River near Lumby, B.C. (**Figure 3-1**). The facility consists of a concrete arch dam, spillway, and two generation units. The reservoir upstream of the dam provides very little live storage. The facility is operated in conjunction with Sugar Lake Dam, constructed 29 km upstream in 1942 to provide storage and flow regulation to maximize power production at Wilsey Dam. There is no generation at Sugar Lake Dam.

Wilsey Dam is a 30 m high, 43 m wide concrete arch dam was constructed in 1929. Intake No. 1 is on the left abutment, and Intake No. 2 is on the right abutment. The dam crest is at elevation of 448.54 m. The structure has had several structural and seismic upgrades. In 1991, the existing two low level outlets were permanently closed, and in 1992 the dam plug, added to prevent additional loss of material at the base of the dam when constructed, was stabilized with drilled anchors. **Figure 3-2** shows the existing Wilsey Dam facilities.

To the left of the concrete dam is a fixed un-gated 36.5 m wide concrete arch spillway. The existing spillway was constructed to an elevation of 443.66 m but was raised to El. 444.52 m in 1940-41. Flashboards are used at the spillway to increase the net head on the generators resulting in incremental increase in energy generated. The flashboards increase the head pond elevation from 444.52 m to 445.43 m, and are typically installed from September to March when inflows are controlled by Sugar Lake Dam releases.

The spillway discharges into a blasted rock chute that flows approximately 300 meters into downstream of the dam opposite the tailrace of the generating station. Approximately one third of the way down the chute, a saddle spillway on the left bank of the chute discharges back into the old river channel. The chute is wetted only when flow is going over the spillway, which is typical during freshet conditions.

A schematic of flow through the generation facilities is provided in **Figure 3-3**. The intakes carry flow through separate penstocks along the left bank of the old channel to the generating facility. A 1.22 m diameter hollow cone by-pass valve has been installed on Penstock No. 2 to provide fish flow releases should the generators be shut down. The capacity of the valve is approximately 19 m^3/s at normal operating levels in the headpond. Intake No. 1 withdraws a maximum of 16.4 m^3/s and Intake No. 2 carries 15.2 m^3/s to the two Francis turbine units which operate under a nominal head of 23.8 m.

The first unit with the wood penstock was installed with the original dam in 1921. The second unit was installed in 1941 along with the spillway modifications. Both units are shut down when inflows are less than 8 m^3/s, one unit is run for increasing flows up to 17 m^3/s, two units are used up to flows of 31.6 m^3/s and flows in excess of this are spilled over the spillway.

Since 2012, the Unit No.1 turbine has been shut down and requires repair. However, there are currently no plans to bring the unit back on-line and the project currently runs at a reduced capacity. Flows over 17 m^3/s are currently spilled and the maximum generation is limited to approximately 2.9 MW.

The reservoir upstream of the dam has a wetted area of 4.27 ha at maximum normal water level El. 444.52 m (spillway crest elevation). At this water level the reservoir influences the water elevation upstream of the dam, through backwater affects to 3.2 km upstream of the dam. The total storage is 0.997 Mm^3 behind the structure at normal headpond operating levels, and increases to 1.01 Mm^3 with installation of the flashboards. The headpond has been subject to considerable infilling of fine and coarse sediments from the upper river. Historic sediment removal at the dam consisted of dredging and excavation in the immediate area in front of the two intakes.

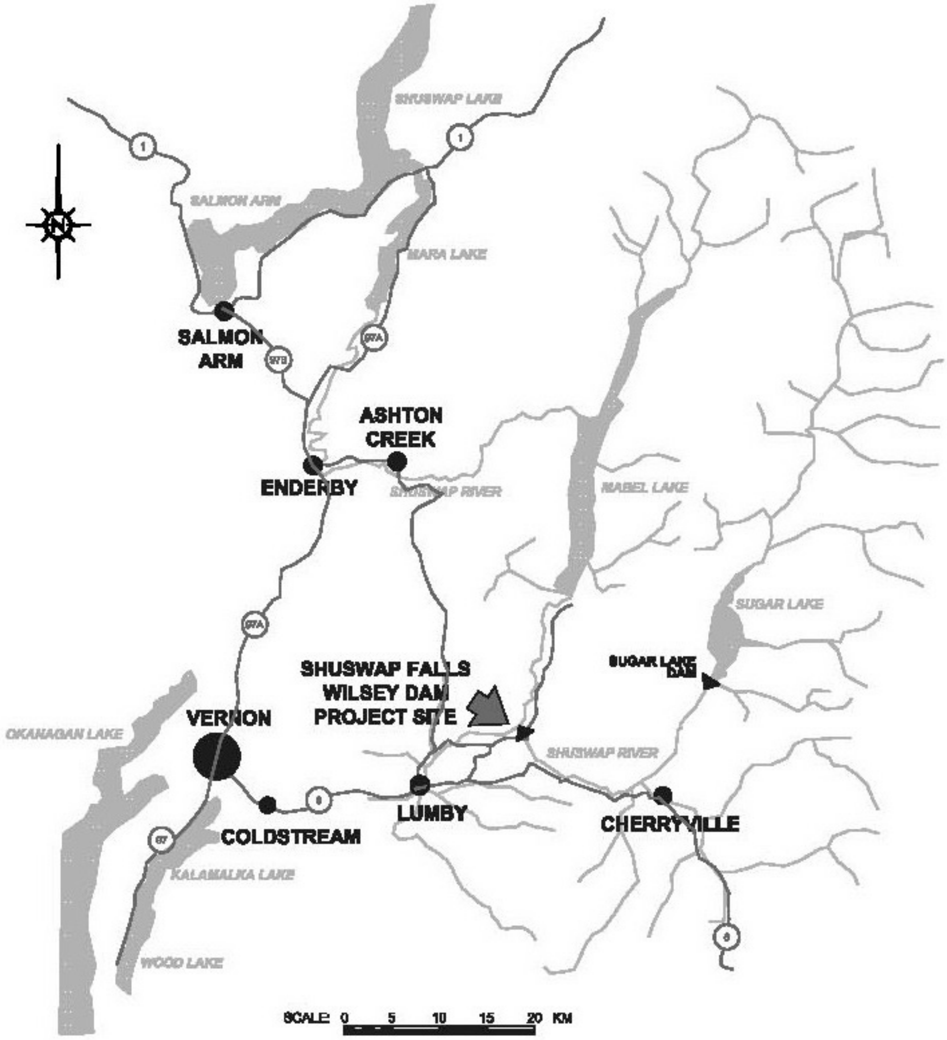

Figure 3-1 Project Location Map (NHC, 2005).

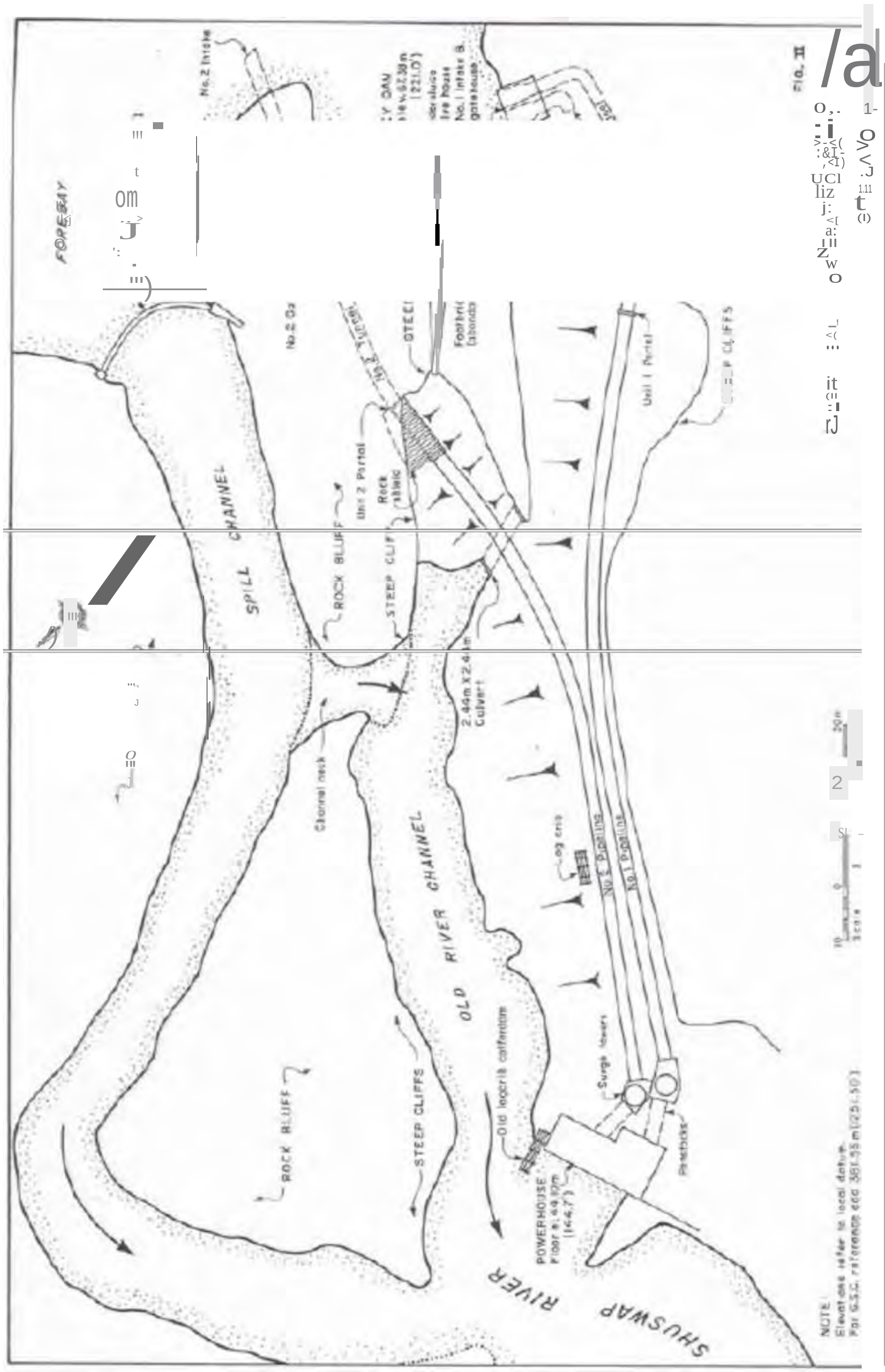

Figure 3-2 Existing Site Layout at Wilsey Dam (BC Hydro, 2000}.

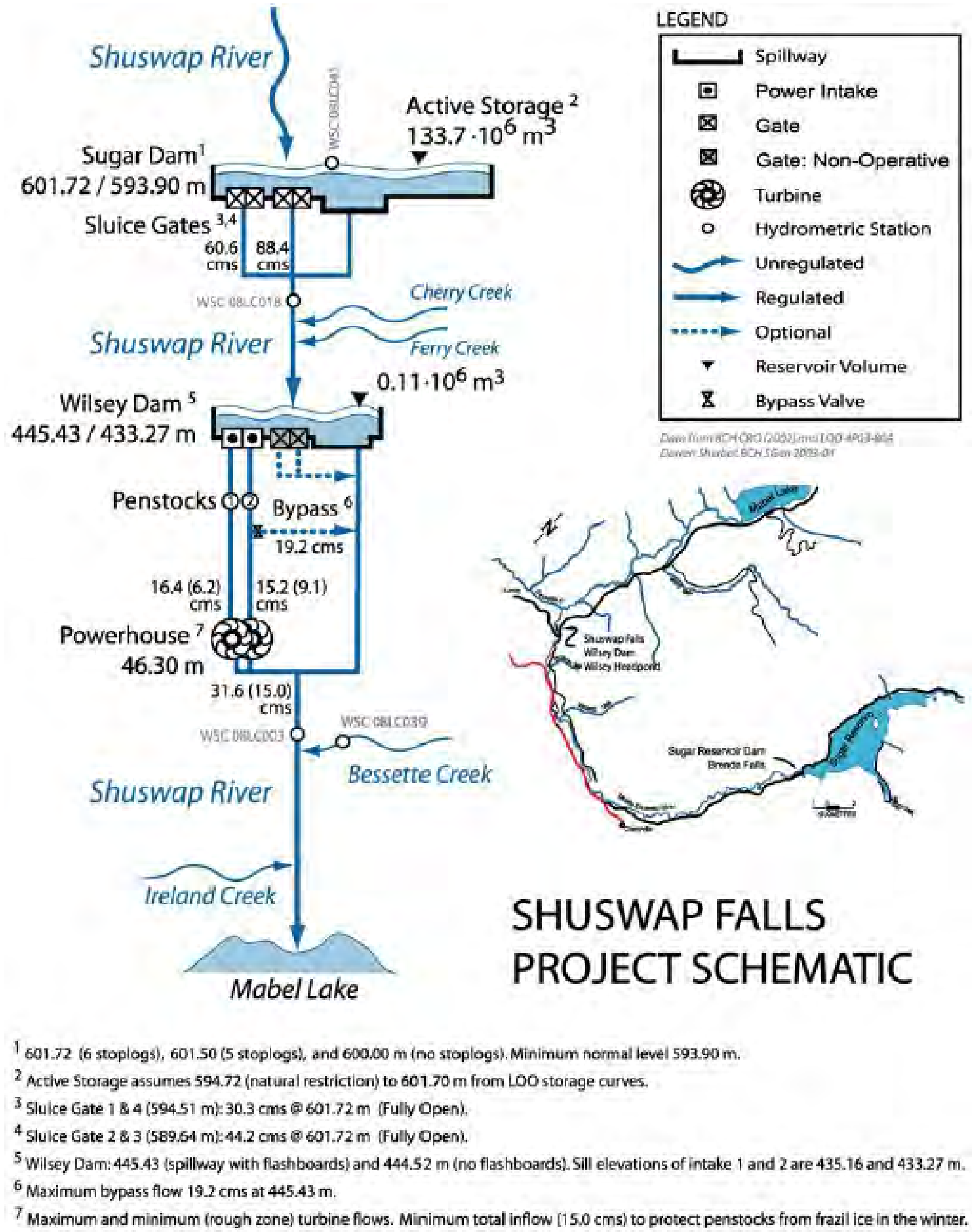

Figure 3-3 Wilsey Dam operations schematic (BC Hydro, 2005).

3.2.2 Site Tenure

The fishway, as proposed, is on BC Hydro controlled properties (PID[1] #18145337, #13591916, #13591894 (**Figure 3-4**). All three of these properties are accessed by the public for recreational use (i.e. picnic, canoeing, hiking) and by BC Hydro for maintenance of the Wilsey facilities. There are no rights-of-ways (ROW) or other encumbrances known through the three BC Hydro properties of interest for the

[1] PID – Parcel Identifier

fishway. Areas that interface with the Upper and Middle Shuswap (I.e. fishway entrance and exit) are crown land.

The main access to the BC Hydro site and park area is from Mabel Lake Road (PID #3819311), northeast of the properties of interest. This is a Ministry of Transportation and Infrastructure (MOTI) maintained road. Immediately to the north of PID #18145337 is private property. This property is used for both residential and agricultural purposes.

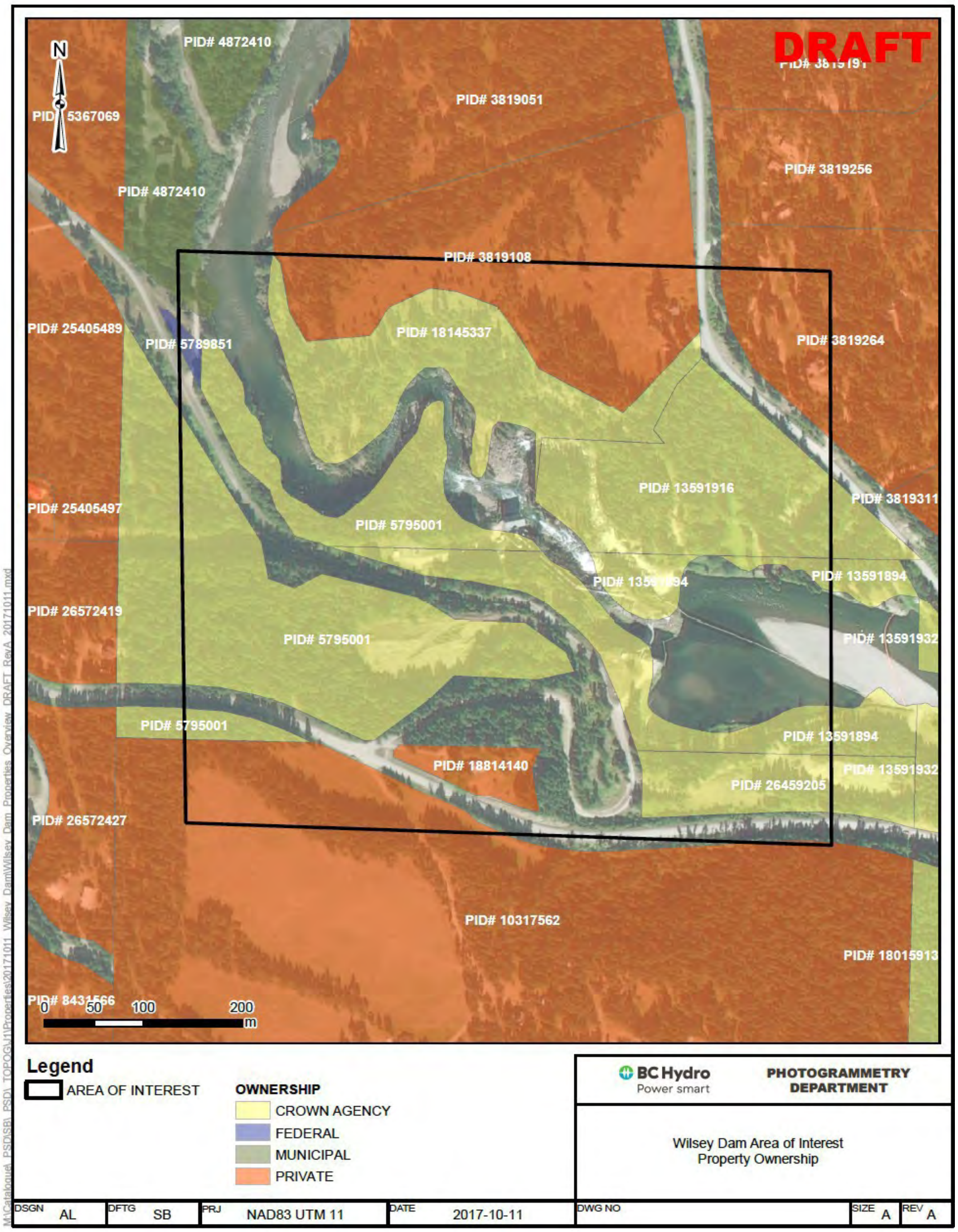

Figure 3-4 Reference property line locations in vicinity of Wilsey Dam (image from BC Hydro, 2017).

3.3 Project Intent

The Committee expressed a strong desire to have a naturalized or natural fishway for fish passage at Wilsey Dam. The natural option was rated highly in the evaluation matrix on the basis of social and biological criteria.

The preliminary design of a natural fishway will provide the required information for the Committee to evaluate all the fish passage options and select a preferred option to carry forward to detailed design and implementation.

3.4 User Requirements

A natural fishway will need to consider several requirements for functional design and differentiation from other fishway designs. These requirements include:

1. **Biological**
   a) Ability to pass anadromous spawning salmon upstream
   b) Improved upstream fish passage for a resident of fish species for a greater range of sizes
   c) Operate ideally year-round, but at a minimum from early April through early December
2. **Physical**
   a) Impacts to existing dam operations and maintenance
   b) 'Hard' infrastructure components (i.e. inlet, culvert rather; the entire fishway);
   c) Public safety considerations (e.g. potential entrapment locations);
   d) Ability to operate over a range of head pond or forebay elevations (El. 444.5 to 447.0 m)
   e) Ability to operate over a wide range of flows (e.g. 1 to 5 m^3/s)
   f) Ability to provide access for fish under a range of tail race elevations (El. 414.5 to 418.0 m)
3. **Social**
   a) Maintain existing park use including canoe portage route and day use area
   b) Educational opportunities
4. **Operations and Maintenance**
   a) Minimize impacts to existing dam operations and maintenance
   b) Minimized operational and maintenance costs
   c) Ability to monitor fish movement
   d) Minimize fish salvage requirements.

4 Design Information

4.1 Studies and Reports

Several studies provide background information related to fish passage and the design of natural fishway at Wilsey Dam, including:

- Evaluation of Chinook and Coho out planting opportunities in the Middle Shuswap River above and below Shuswap Falls. Volumes I and II., 1984
- Historic Review of Anadromous Fish passage above Shuswap Falls, British Columbia, 1995;
- Wilsey Dam Fish Passage Concepts; NHC, 2002
- Wilsey Dam Fish Passage Concepts – Design Options Memo, NHC, 2004
- Wilsey Dam Passage Feasibility Study Phase 2 Project # 04.Sh.01 Final Report; NHC, March 2005
- Wilsey Dam Fishway Operation and Maintenance Manual; NHC March 2005
- Environmental Feasibility of Establishing Fish Passage at Wilsey Dam; Okanagan Nation Alliance, March 2014, and
- Fish Passage Decision Framework for BC Hydro Facilities, BC Hydro, January 2017.

4.1.1 Previous Fishway Designs

NHC completed a conceptual and detailed design of a vertical slot fishway system for Wilsey dam in 2005. A short summary of the 2005 vertical slot design has been provided below for reference.

Vertical slot fishways are essentially large pools connected with deep vertical slots that are used as hydraulic control between pools. As flows increase, pool volumes also increase and provide additional dissipation, and therefore the maximum expected velocities in the system are not as affected by changes in flow as other types of fishways. Vertical slot fishways are typically constructed of cast-in-place reinforced concrete with the slot reinforced with metal plating.

The design is a 190 m long, 12.5 percent grade fishway that would switchback up the right bank of the Shuswap River. It would be formed of 80 pool-units along the right bank of the Shuswap River. Each pool would be 3.5 m deep, 3.0 m wide, and 3.0 m long and connected with the next pool through a 0.5 m wide angled vertical slot. This size of fishway will accommodate flows up to 4.0 m^3/s, and operate nominally at flows of 3 m^3/s. The increased flow decreases the likelihood of requiring additional attraction flows at the fishway entrance, but would increase the water used.

The dimensions of the proposed 2005 vertical slot fishway were designed based on the physical size and swimming capabilities of the design fish, which was a 450 mm Chinook Salmon (*Oncorhynchus tshawytscha*). The maximum velocity in the fishway slots at all flows is expected to be around 2.7 m/s, within the burst speed range of the design fish. Lower velocities found near the bottom of the slot fall below burst speed capabilities of Rainbow Trout (*Oncorhynchus mykiss*) and Bull Trout (*Salvelinus confluentus*). The velocities in the pools are significantly less, allowing the fish to recover during transit up the fishway.

Construction of a vertical slot fishway could be completed in one season without interruption of power generation or operations at the existing Wilsey Dam, and the expected operations and maintenance is minimal. The fishway is designed to operate un-attended and regular and emergency operations could be accommodated within the regular activities of BC Hydro staff at some cost. The largest operation and maintenance cost is expected to be the forgone energy generation values associated with flows required for the fishway, however the fishway can likely be operated only during required migrations periods with significant savings.

In addition to the fishway structure, engineering works would have to be completed at the fishway exit (intake), through a culvert transition and at the fishway entrance (outlet). The vertical slot fishway requires a means of inlet control, a trash rack, a channel gate or stoplogs to control the flow to the fishway for maintenance, and a crossing structure to be used for maintenance. The 2017 cost of the vertical slot fishway is estimated to be $5.4M (**Appendix B**).

4.2 Geomatics

Due to the extended length of the natural fishway compared to the vertical slot fishway, additional survey information was required downstream of Wilsey Dam along the right bank. McElhanney Consulting Services Ltd. was sub-contracted to collect LIDAR (**Figure 4-1**) and orthophotography **(Figure 4-2)** of the site in May 2017.

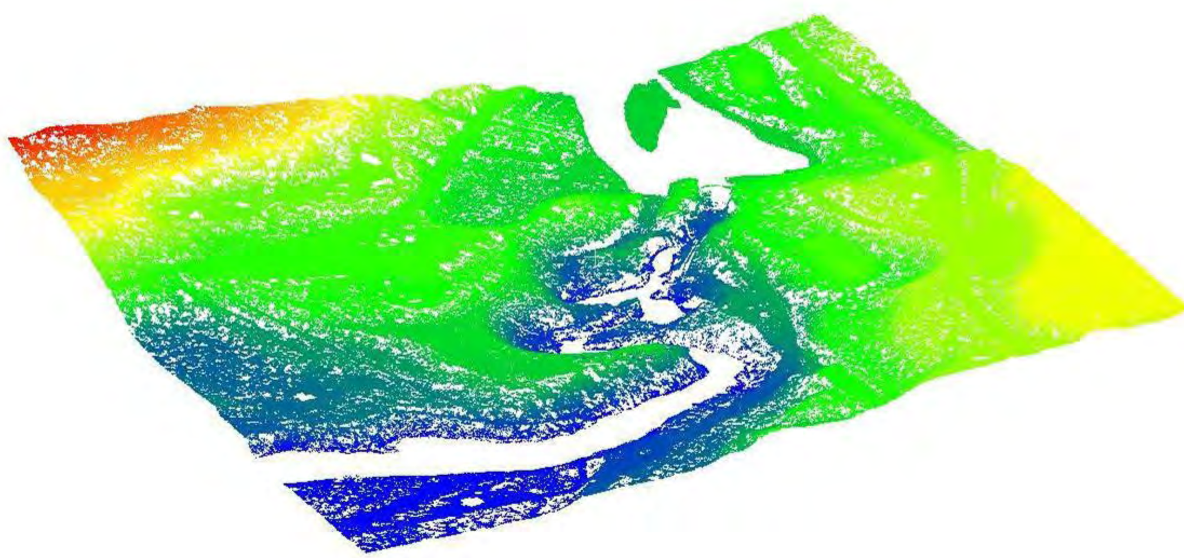

Figure 4-1 Wilsey Dam LIDAR data point cloud image.

Figure 4-2 Orthophoto from 2017 of Wilsey Dam and project area.

4.3 Site Inspections

Patricia House and Pablo Rodriguez (NHC) conducted a site inspection on July 20th 2017 to confirm site topography and the other aspects of the potential fishway configuration and lay-out. A summary of the current condition of the site, based on the inspection, is presented below with accompanying photographs:

The inlet location is a riprapped bank, easily accessed through a grass field (**Photo 4-1**).

From intake to the proposed road crossing is flat and easily accessible from the open grass area. Large trees are located within this area; during detailed design the channel alignment may need tweaking to avoid the trees, however some will need to be removed (**Photo 4-2**).

Crossing of the existing right abutment access road will require a large cut. Use of a culvert, similar to the 2005 design for the vertical slot fishway, will allow continued use of the access road and reduce volume of spoil material (**Photo 4-3**).

The steep rock bank from the access road back down to the river is steep with substantial bedrock exposure and sparsely populated pine trees.

The proposed fishway outlet discharges to a large back eddy pool that is suitable for fish holding (**Photo 4-4**). It is expected, based on the rock formations, that the proposed outlet location hydraulics are similar for a range in water levels. This location is approximately 250 m downstream form the proposed 2005 vertical slot fishway (**Photo 4-5**).

Downstream of the proposed natural fishway outlet, is a small groundwater seep (**Photo 4-6).** This seep was not in the area of the 2005 geotechnical work and should be investigated further to determine any required design mitigation needs.

The type of access currently in the park was noted as well included the type of roadways that would be needed to maintain current access requirements (**Photo 4-7**). A canoe portage route exists along the right bank and will be affected by the proposed fishway alignment.

Photo 4-1 Approximate location on right bank for fishway inlet (looking downstream).

Photo 4-2 Looking down slope from current access road to upstream areas of channel from the inlet to the proposed culvert.

Photo 4-3 Looking downslope towards the river in the area where the natural fishway would be constructed.

Photo 4-4 Looking upstream from river right at proposed fishway outlet area for natural option. Outlet is proposed to be downstream of the rock in the left, middle of the image. This location will allow a year-round holding area for fish in the large eddy.

Photo 4-5 Looking upstream from river right at proposed fishway outlet area for vertical slot option. Outlet is proposed to be to the left of the falls. Outlet conditions may vary depending on water level.

Photo 4-6 Groundwater seep observed near the downstream end of the proposed alignment for the natural fishway.

Photo 4-7 Example of the typical access that will need to be maintained or restored for public use as well a maintenance for the Wilsey facility and proposed fishway.

4.4 Hydrology

The hydrologic analysis of the upper Shuswap basin, including the Shuswap River, Ferry Creek, and Cherry Creek was completed for the initial concept report and summarized in the 2005 vertical slot fishway design documents (NHC 2002, 2005). The work presented here has been updated for 2017 and has been used to confirm the design criteria for the natural fishway.

The Shuswap River watershed upstream of the dam at Sugar Lake is 1,113 km^2, between the dams the watershed area is 856 km^2, for a total area upstream of Wilsey Dam of 1,969 km^2. Between Sugar Lake and Wilsey Dam, the average valley gradient is roughly 1.5 percent.

Two major tributaries within this reach are Cherry Creek and Ferry Creek. Despite a moderate valley slope, around 4.8 percent, the upper watershed of Cherry Creek rises steeply to a maximum elevation of 2,570 m. Cherry Creek joins the Shuswap River at approximately an elevation of 500 m. Its watershed is almost entirely forested, except for the uppermost ridges. Ferry Creek enters the Shuswap River 2 km further downstream. It has an average valley slope of 5.5 percent, and unlike the steep ridges at the head of Cherry Creek, the headwaters of Ferry Creek are a swampy plateau at an elevation of nearly 2,000 m.

The climate in the region is affected by both interior and modified maritime air masses. During the winter, when moist maritime air masses approaching from the coast collide with cold continental air, snowfalls can be heavy. As a result, snow pack in the upper Shuswap basin is relatively deep. Rapidly increasing temperatures in late spring lead to a significant snowmelt freshet which generally peaks in June. As in most watersheds with large winter snow packs, the magnitude and duration of the flood peak depends on the snow pack depth and air temperatures during May and June. In some years, spill flows are insignificant or absent, particularly outside of the peak. Historical spill flows at Wilsey Dam were calculated and presented in **Table 4-1** and mean daily spill flows illustrated in **Figure 4-3.** Spill flows occur more regularly since 2012 through the winter since the Unit No. 1 is not in operation (**Table 4-1**); however, the shape of the release curve remains relatively consistent (**Figure 4-3**).

Reservoir and tailrace levels associated with BC Hydro's increased surveillance level (just under 10-year maximum) (BC Hydro, 2000) and 10-year minimum flows were selected as high and low levels for the design of the fishway. Extreme flows for the Shuswap were calculated from historical gauged data. Maximum 10-year instantaneous floods along the Shuswap River are in the order of 297 m^3/s (WSC 08LC018 Shuswap River at Sugar Lake Outlet) to 366 m^3/s (WSC 08LC003 Shuswap River near Lumby). This corresponds with a tailrace level of El. 418.40 m and an upstream reservoir level of El. 447.3 m (BC Hydro, 2002). At reservoir levels in excess of El. 447.00 m, surveillance of Wilsey Dam is increased (BC Hydro, 2000). Minimum 10-year daily flows for the same two gauges are 14 m^3/s and 16 m^3/s respectively. This approximately corresponds with a tailrace level El. 416.20 m

Reservoir and tailrace levels associated with BC Hydro's increased surveillance level (just under 10-year maximum) and 10-year minimum flows were selected as high and low levels for the design of the Wilsey Dam Fishway. The design reservoir levels are normal operation between 444.50 m El. and 445.50 m El. and maximum peak reservoir level of El. 447.00 m. The design tailrace level for normal operation is between El. 416.20 m and El. 418.40 m (**Table 4-2**).

The PMF for Wilsey Dam site is estimated at ±2,300 m^3/s which corresponds to a water surface elevation in the headpond of El. 452 m (**Table 4-2**).

Based on the flow record since 2012, there appears to be sufficient mean monthly spill flows to support the proposed fishway flow regime without impacting energy generation. This result is dependent on the current non-operational condition of the Unit No. 1.

Table 4-1 Historical mean monthly spill flows at Wilsey Dam.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1974	0	0	1	30	83	140	90	3	0	0	0	10
1975	0	0	0	1	58	125	36	0	0	0	0	0
1976	0	9	26	44	116	108	95	64	36	1	0	0
1977	0	0	0	21	82	75	1	1	0	0	0	0
1978	0	0	11	30	86	119	52	0	39	12	4	0
1979	0	0	0	2	75	82	12	0	0	0	0	0
1980	0	0	0	16	77	61	2	0	0	0	0	1
1981	0	0	0	5	86	102	83	12	1	0	0	1
1982	0	0	5	4	81	144	98	14	5	0	0	0
1983	0	0	12	42	100	109	67	8	0	0	0	0
1984	0	0	1	32	41	122	108	29	29	14	16	15
1985	11	5	0	16	115	145	29	0	0	5	11	2
1986	0	0	3	23	65	130	38	0	0	0	0	0
1987	0	0	0	28	89	25	9	0	0	0	0	0
1988	0	0	0	28	91	80	30	0	0	3	1	0
1989	0	0	0	23	91	79	13	3	0	0	0	0
1990	0	9	1	47	90	169	82	7	0	0	2	0
1991	0	13	6	34	99	122	64	7	1	0	0	0
1992	0	0	19	26	80	53	10	0	0	1	1	0
1993	0	0	0	23	109	63	42	7	0	0	0	0
1994	0	0	3	57	103	89	31	4	0	0	0	0
1995	0	0	3	13	64	75	9	12	0	2	16	15
1996	1	1	4	37	65	130	74	14	4	2	3	0
1997	6	8	4	19	127	198	138	11	4	25	3	2
1998	6	3	1	0	4	3	0	0	0	2	0	0
1999	0	0	2	17	73	171	118	55	22	4	13	1
2000	1	1	0	0	13	44	16	0	0	0	0	0
2001	0	0	1	5	70	79	52	8	1	6	14	0
2002	0	0	2	17	65	160	60	2	1	1	8	0
2003	1	0	0	17	64	121	26	11	13	17	35	8
2004	5	3	2	44	92	98	33	8	26	15	2	2
2005	14	26	21	30	100	73	26	1	1	29	10	6
2006	3	4	1	24	122	121	25	16	8	5	8	3
2007	6	3	15	36	76	112	46	3	3	4	9	2
2008	3	5	4	6	96	146	65	16	15	4	16	7
2009	4	5	1	16	68	108	33	22	17	1	6	6
2010	4	9	14	28	61	104	42	16	25	29	24	19
2011	14	22	24	23	86	185	130	29	16	14	10	13
2012	17	18	10	28	95	211	132	20	13	2	1	2
2013	6	7	9	50	106	164	86	47	31	25	23	22
2014	18	17	12	32	124	161	81	28	23	21	47	28
2015	24	30	49	62	83	91	19	17	31	23	23	19
2016	15	13	25	85	128	91	51	24	18	29	44	31
2017	28	15	9	33	124	156	54	19	20			

Figure 4-3 Mean daily spill flows at Wilsey Dam.

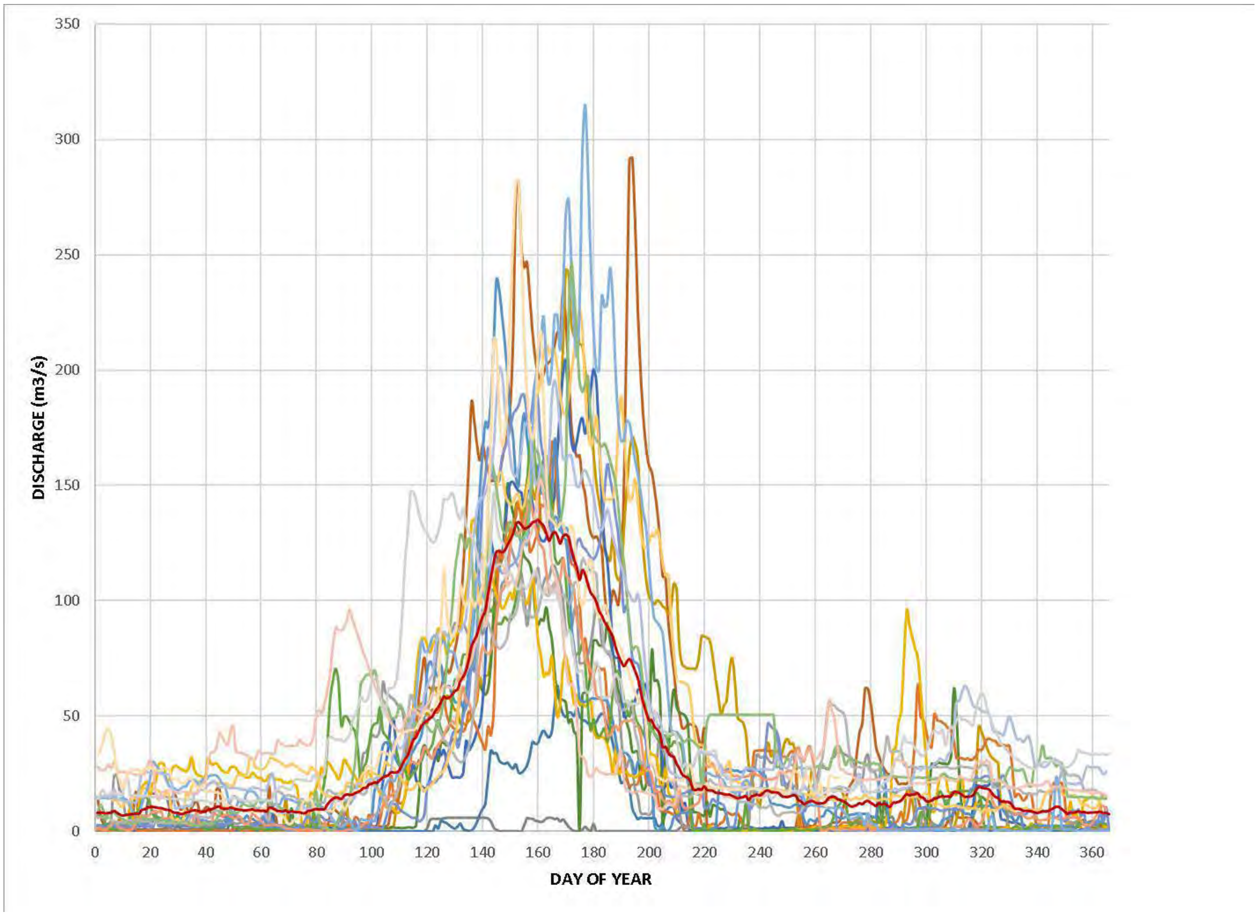

Table 4-2 Summary of hydrological criteria for the Wilsey facility.

Criteria	Flow (m^3/s)	Elevation (m)	
		Headpond	Tailrace
Mean monthly spill less power flows	31.6		
Design reservoir levels at normal operation [1]		444.50 to 445.50	416.20 to 418.40
Maximum peak reservoir level		447.00	
PMF	±2300	452.00	
Maximum 10-year instantaneous flood [1]	297 to 366	447.30	418.40
Minimum discharge below Wilsey Dam [1]	13 to 16		416.20

[1] BC Hydro, 2017.

5 General Criteria

5.1 Codes and Standards

The following lists the key applicable codes and standards that influence the Project. Approvals and/or authorizations may not necessarily be needed to be obtained; however, guidance for the requirements to be met by the design and possible approaches to meet these requirements may be found within them. In addition, discussions may be required with regulators to ensure that amendments to existing operational standards, such as water licencing, are not required with the potential addition of a fishway at Wilsey Dam.

5.1.1 Regulations and Permits

1. Federal Legislation
    - *a) Fisheries Act* (1985, amended 2012)
    - *b) Navigation Protection Act* (1985, amended 2012) (NPA)
    - *c) Migratory Birds Convention Act* (1994)
2. Provincial Legislation
    - a) *Water Sustainability Act* (2014) (WSA)
    - b) *Heritage Act* (1996)
    - c) *Forest Act* (1996)
3. Regional District of North Okanagan (RDNO)
    - a) Building permits and by-laws

5.1.2 Standards of Practice and Operations

1. Current water licences held by BC Hydro for Shuswap Falls and Sugar Lake
    - a) 120948, 120949, 120950 and 120951
2. Shuswap Falls and Sugar Lake Water Use Plan
    - a) Water Use Plan (2005)

5.1.3 Technical Standards

1. APEGBC Guidelines for Geotechnical, Engineering Services for Building Projects (1998)
2. BC Building Code (2012)
3. BC Hydro's Guidelines for Design of Debris Booms (Report No. H2703, March 1994), outlines methods and procedures for debris boom design.
4. DFO Practitioners Guide to Fish Passage (2007).

5.2 Units of Measure

International System of Units (SI) are used for this project.

5.3 Datum and Elevations

Geodetic datum is used for all provided coordinates. Elevations are given relative to mean sea level.

5.4 Safety by Design

5.4.1 Dam Safety and Stability

A primary design objective includes maintaining the structural stability, overall safety and operational flexibility of the existing Wilsey Dam and generation facilities. The addition of the fishway including all construction practices, final facilities, and additional flow paths through the dam are designed not to increase the likelihood of uncontrolled releases of water from the Wilsey Dam reservoir or reduce the stability or safety of the dam and its associated facilities and abutments.

The fishway is also designed to be able to operate independently of the facility operations, such that power generation is unaffected apart from flows that are used by the fishway.

5.4.2 Spill Flows and Uncontrolled Water Releases

Spill flows and uncontrolled water release refers to potential flows that are uncontrolled or under limited control, and directly or indirectly result from the addition of the fishway to Wilsey Dam. Potential modes of spill and uncontrolled flows from Wilsey Dam Fishway are:

1. The inlet structure allows water to freely flow into the park at the right abutment. Flows are contained within the channel for reservoir levels up to El. 446.50 m. Similar to pre-existing conditions, for reservoir flows of greater than El. 447.50 m flow can enter the park from the reservoir over the levee along the right bank of the reservoir. Flow into the park is contained to the north and east by the highway embankment and natural topography and to the west by the pre-existing road embankment. If the fishway bulkhead gate is open, flow can be released through the embankment through the fishway.
2. Water within the park along the right abutment can be discharged through the abutment via the fishway if the fishway bulkhead gate is open. The culvert and its inlet and outlet structures limit the volume of water that can be released through the embankment.
3. During normal operating conditions (i.e. flow < 5 m^3/s), flow is fully contained within the natural fishway from the embankment down to the fishway outlet.

5.4.3 Public Safety

The public safety refers to potential incidents that could result in harm to employees or public persons on the Wilsey Dam site directly or indirectly resulting from the operation of the natural fishway to Wilsey Dam site. Potential hazards associated with the dam are as follows:

1. inlet trapping hazard for people in the channel upstream of the inlet structure trash rack and vertical slot fishway
2. fall hazard at inlet structure and its associated bridge (3 m)

3. water current hazard along the canal between the inlet structure and the road embankment. Water flow in the canal is typically 1 to 3 m deep with velocity less than 1 m/s
4. fall hazard at bulkhead gate headwall (5 m)
5. steep slope hazard along fishway and road embankment (1H:1V)
6. flow hazard for anyone within in the channel and culvert area, and
7. flow hazard for anyone within in the vertical slot fishway area.

5.4.4 Public Access

Existing park use will be impacted by the fishway; however, access within the park site can be re-routed. The existing roads and trails will be re-aligned as needed to maintain park use, portage route, dam operations, and fishway operational access. As there are expected to be steeper slopes in some areas of the natural fishway, railings/guard rails, means of egress and warning signage will be required.

The existing grass field along the right shore of the reservoir will be replaced by the inlet structure and channel. Construction excavation and re-grading will require a wide swath of tree removal which is to be followed by re-vegetation. The final constructed fishway footprint has an area of ±5,600 m^2. Access and facilities can be integrated to potential interpretive displays and viewing areas. A significant portion of the disturbed area may be revegetated; however, vegetation will need to be selected to ensure appropriate to maintain access.

5.4.5 Signage and Visibility

A *Navigable Protection Act* (NPA) approval may have requirements to address safety for navigation. The inlet and the outlet of the fishway are expected to require signage marking their location for all water levels. Additional specific signage would be installed on the fishway itself to identify it as a non-navigable water.

5.4.6 Log Boom

Any log booms that may be installed, will require adequate signage and visibility:

- Signage showing location and layout of the debris boom
- Yellow cautionary buoys along its entire length, and bands of yellow reflective tape on pontoons visible from all aspects
- Flashing yellow lights must be installed to mark each end and the midpoint of the boom, to be operated in conditions of darkness or limited visibility, and
- Signs warning of any construction activity placed 200 m upstream of the shear boom.

5.4.7 Boat Passage

The Middle and Upper Shuswap Rivers are included in the *Schedule of Navigable Waters* in the *Navigation Protection Act* (NPA). It is expected that the fishway will not be required to facilitate vessel traffic, such as canoes or kayaks through it; rather maintain this river reach as it currently is as a portage route around the dam. Related infrastructure, such as trails, will be maintained with modifications as needed to accommodate the fishway infrastructure.

5.5 Design Life

The design life of the proposed design for the natural fishway structure and channel should be similar to other civil water resource project operated in the same operational and climactic conditions. Project components will subject to regular inspection and maintenance, and a design life or 30 to 50 years is expected.

5.6 Environment

Although the project is located within BC Hydro property and is intended as a mitigation works for fish passage, protection of the environment – including protection of water quality, fish and fish habitat – are important factors in the design basis. Features implemented in this design include:

1. mitigation of permanent and temporary fills through design to limit footprint effects on river channel and hydraulic impacts
2. design of channel openings, fills and materials to ensure flow continuity and connectivity
3. the use of temporary bridge crossings and structures that can be removed from the environment prior to commissioning the channel
4. limiting the use of concrete and other materials to key structures, and
5. use of natural, benign materials like rock, gravel, and cobbles in remaining structures.

5.7 Impacts to Licenced Rights and Permitted Uses

There have been no impacts to licenced rights or permitted uses identified in the screening of the preliminary design.

5.7.1 Shuswap River Water Use Plan

The 2005 Water Use Plan (WUP) for the Shuswap Project presents the operating conditions for both Sugar Lake and Wilsey Dams. The operating conditions in the WUP provided more consistent flows throughout the year, with smaller spills during the freshet as compared to historical spills at Wilsey Dam; however, there is no requirement to provide minimum spillway flow. The WUP minimum discharge downstream of Wilsey Dam or the Shuswap Powerhouse is 16 m^3/s (August 15th and December 31st) and 13 m^3/s (January 1st to August 14$^{th)}$ subject to low inflow modifications.

6 Design Basis

Key issues addressed in the preliminary design include:

1. Wilsey Dam is a high dam, with an elevation of around 30 m from the headpond to the tailrace channel, this is a large elevation drop for any fishway or fish passage system.
2. The design must operate independent of the dam and not interfere with issues related to dam safety, seismic risk or safety and operations during extreme floods.
3. Design costs are very sensitive to excavation costs, so designs must minimize large sections and rock cuts.
4. Steep slopes and canyons are geohazards. Simplified rock cut designs and moderate slopes are likely to be less costly than steep slopes requiring rock fall protection and slope stabilization.
5. Fishway design must minimize biological risks to fish by providing energetically-efficient passage with low risk of fall-back and an effective attractive entrance conditions.
6. Lower slope designs have inherently lower velocities and greater flow depths, that translate into a high effectiveness for a wider range of fish. Nature-like or natural fishway designs may not be the most effective for certain fish life stages and species due to those characteristics.
7. The Shuswap River is a mountain river with debris, ice and sediment. The design must be robust enough for relatively unattended operations and low maintenance. The design and operation must accommodate high seasonal sediment loads and ice.
8. The site is in a high use, park area, and public safety is paramount.

6.1 Hydrotechnical Elements

6.1.1 Ecohydraulics

A critical factor in the design of any passage structure is the swimming ability and energetics of fish that may potentially use it. Ecohydraulic criteria are generally based on generic fish features or abilities based around swimming mode (taxonomy/body type) and fish length.

Fish energetics and passage criteria were reviewed as part of the 2005 vertical slot design. The original 2005 design estimated swimming velocity and duration were estimated for burst, sustained, and prolonged swim modes over a range of size and species of fish. Anadromous salmon and rainbow trout were the focus species for the 2005 option. Generally, the increased size of adult fish allowed for faster swimming speeds sustained for shorter durations.

Adult Chinook swim at sustained speeds of between 1.2 m/s and 3.3 m/s, and can burst up to speeds of 6.7 m/s (Bell 1991). Adult Sockeye (*Oncorhynchus nerka*) and Coho (*Oncorhynchus tshawytscha*) salmon swim at comparable speeds to the Chinook. Rainbow Trout (82 to 310 mm FL), a smaller bodied fish, swims at lower speeds, with a sustained speed of between 0.3 m/s and 0.6 m/s (Katopodis and Gervais 1991), and a burst speed of up to approximately 2.7 m/s. For the 2005 design, a maximum design velocity of 2.7 m/s was selected.

For the nature like fish way a wider range of sizes and species are desired to be passed. The two anadromous species of Chinook and Sockeye continue to be important species; however, Rainbow Trout (*Oncorhynchus mykiss*) and other resident species such as Mountain Whitefish (*Prosopium williamsoni*) and Bull Trout (*Salvelinus confluentus*) are also of interest. With the natural fishway the selected life stages for all species has also changed from only upstream adult anadromous passage and downstream juvenile passage, to up and downstream passage for as many life stages as feasible.

The design burst, prolonged swimming speeds and sustained swimming speeds for the fish species and size ranges influenced by the Project were determined and are presented in **Table 6-1**. The swimming speeds were derived from linear regression fatigue curves presented in Katopodis and Gervais (2016), where burst swimming speeds have time < 20 seconds, prolonged swimming speeds have 20 seconds < t < 20 to 30 minutes, and sustained swimming speeds have t > 20 to 30 minutes where t = time of swimming.

The resident species were also selected for evaluation as it is expected that the they will be using the entire watershed during their life history. Sockeye fry would also be expected to move downstream to rear in Mabel Lake rather than upstream through the fishway. Similarly, Chinook juveniles, are expected to only move downstream as smolts. As such, water velocities within the fishway for anadromous species are less of a concern compared to water depth for upstream migrating adults (**Table 6-1**). Velocities are of greater concern for resident fish as they would likely move both upstream and downstream of Wilsey for both rearing and spawning.

The Washington Department of Fish and Wildlife, Fish Passage Design at Road Culverts (Bates, 2003) states that the minimum water depth for an adult trout greater than 150 mm in length is 250 mm and for adult Chinook and Sockeye Salmon if 300 mm. The depth requirements Mountain Whitefish are assumed to be the same for Rainbow Trout.

Fish are able to swim greater distances at sustained swimming speeds versus burst speed where they fatigue quickly. Depending on the lay-out and design of the fish passage structure, the design fish could transit the distance through it at different swimming speeds and rest as needed. **Table 6-2** provides the maximum distance capable of being travelled prior to fatigue based on the data. Note that the data is used to develop regressions based on average values – goodness-of-fit and coefficient of regression are expressed in the original data. Individuals within any population will have swimming performance greater or lesser than these values estimated using the design fish data.

Unlike in culverts where turbulence can become a barrier to small fish, natural channels can have features like riffles and boulder for additional roughness, to create a low enough average velocity to satisfy the needs of juvenile fish for passage. Although a natural fishway will have variable velocities, from the evaluation of the ecohydraulic criteria for the species of interest, the required swimming velocities should not exceed 3.2 m/s for upstream anadromous salmon migration at a minimum depth of 300 mm at operating flows of 2 to 3 m^3/s.

To accommodate resident passage for a species such as Rainbow trout and Mountain Whitefish, the design swimming velocities can vary with in the fishway as outlined in **Table 6-2** depending on the corresponding distance, as determined by fatigue, at a particular water velocity between hydraulic features. Spaced features such as riffles, runs and boulders will improve hydraulic conditions to reduce fatigue.

Table 6-1 Fish Species, Body Sizes, and Generalized Passage Requirements.

					Minimum Water Depth[4] (mm)
Chinook Salmon	>500 [1]	2.45	2.75	4.33	300
Sockeye Salmon	>500 [1]	1.80	2.02	3.18	300
Rainbow Trout	>250 [1]	0.65	0.88	2.91	250
Rainbow Trout	±100 [2]	0.26	0.88	1.16	100
Bull Trout[5]	>250 [1]	0.65	0.95	4.11	250
Mountain Whitefish[6]	>200 [1]	0.34	0.50	2.09	250

[1] Design fork length represents expected minimum fork length of adult fish.
[2] Design fork length represents expected typical fork length of juvenile fish.
[3] Based on a time of one second (approximately 12 FL swimming distance).
[4] Bates, 2003.
[5] Insufficient species-specific data for Bull Trout, so data from all freshwater trout species was used.
[6] Insufficient species-specific data for Mountain Whitefish, so data for the *Coregoninae* taxonomic group was used.

Table 6-2 Maximum Fish Swimming Distances.

Water Velocity (m/s)	Maximum Distance (m)	Swimming Mode
0.25	none	sustained
0.50	824	sustained
0.75	245	prolonged
1.00	103	prolonged
1.25	53	prolonged
1.50	31	prolonged
1.75	19	prolonged
2.00	13	prolonged
2.25	9.1	burst
2.50	6.7	burst
2.75	5.0	burst
3.00	3.9	burst
3.25	3.0	burst
3.50	2.4	burst

6.1.2 Hydraulic Design

Using the LIDAR data, a digital elevation model (DEM) was created in AutoCAD Civil3D to allow creation and comparison of potential alignments for the fishway. Alternative outlet locations and alignments were evaluated based largely on limiting depth of cut and fill, balancing volumes of cut and fill, targeting preferential materials (i.e. earth excavation versus rock cuts), targeting preferential entrance and exit locations, land ownership, slope stability and construction access. Due to the location of the generation facilities, dam and spillway channel, fishway alignments were only considered along the right bank.

Once the grade and channel length was selected, critical hydraulics of the control structures and fishway channel sections were modelled using hydraulic calculators and spreadsheets for preliminary sizing. The flow depths and velocities were compared over a range of design inflows. This process was iterated to select a channel width that allowed some a range of flows that were sufficient for attraction and passage in a natural design (e.g. meeting the ecohydraulic criteria), but were not so large as to require a large channel section – increasing costs.

Once the design was determined, a 1D HEC RAS hydraulic model of the natural fishway was developed using the final geometry. The model is uncalibrated, and was used to develop sectional velocities and depths and check the hydraulic profile. Modelling was conducted for over a range of operational flows (1 to 5 m^3/s) at maximum and minimum headpond elevations. Critical water depths and velocities were evaluated at all hydraulic controls and typical sections of the fishway in the preliminary design.

Nature-like or natural channels utilize varied hydraulics and high form and bed roughness that are associated with natural stream and river morphologies. The channels are also relatively steep. In final design, additional CFD modelling may assist in refinement of some finer detailed hydraulic aspects (e.g. effects of roughness and momentum), but these are relatively minor points and not material to the fundamental design elements and preliminary cost estimate.

6.1.3 Sedimentation

The Shuswap River has a significant suspended load during the freshet period and during high runoff periods associated with precipitation events. The presence of the large bars and sediment deposits in the headpond indicates the quantity of sediment transported through the reach from below Sugar Lake dam. The location of the fishway headworks and design of the fishway will result in the transport of captured suspended sediments through the fishway. At flood flows, some ingestion of wash load or bed load materials (sands and gravels) into the fishway is expected.

Water velocities in the fishway will transport sand, silt and clay particles in suspension These materials should be transported through the fishway. It is possible that some localized settling may occur, though it is expected that this finer material (i.e. silts and clays) will be remobilized during the next higher operational flow and transported out of the fishway. Where sediments do deposit between the interstitial spaces of the channel lining material, the lining may become embedded but this is not likely to affect the hydraulic characteristics for fish passage.

Abrasion wear on any fishway structural components (i.e. inlet, culvert) due to sediment transport is expected to be minimal.

6.1.4 Fish Entrainment

Fish entrainment at the Wilsey Dam was estimated to be approximately 10%, should both turbines be operational and a spill is occurring (NHC, 2002). Based on the type of turbines installed at the facility, the estimated smolt mortality would be significant.

With only one turbine currently in operation and its repair not anticipated, fish entrainment would potentially reduce to ±5%. These estimates are based solely on a volumetric basis, and ignored behavioural avoidance or habitat suitability that would affect the location and movement of fish (e.g. downstream migrating smolts). This is close to the estimated losses that may be expected through entrainment over the spillway alone of ±2% (Lawrence *et al*., 2005).

With the addition of a fishway, entrainment losses to the spillway or the turbine(s) can be expected to be reduced further. There may also be a bias during non-spill periods that result in fish preferentially using the spillway that would further reduce fish injury and mortality at the facility.

6.2 Structural Elements

Structural design will be undertaken on the following components in the detailed design:

- Shear boom
- Channel inlet structure
- Intake debris trash racks, and
- Channel box culvert and head walls.

All structural elements will be designed to withstand expected environmental loadings.

6.3 Geotechnical Elements

In the vertical slot fishway detailed design (NHC, 2005), a geotechnical investigation (FPA, 2005) was undertaken that included drilling and test along the proposed fishway centerline. These locations are similar to the alignment of the upper portion of the 2017 preliminary design. The FPA report findings and recommendations included:

1. Bedrock geology around Wilsey Dam has been studied in detail in and internal BC Hydro report (not referenced)
2. Rock in the spillway area is generally sound
3. The area upstream of the embankment (kame) separating the upper and lower areas consists of sands and gravels with high hydraulic connectivity to the headpond water elevations
4. Dewatering of the upper area excavations will be very difficult
5. Geomembrane liners and the channel base may be subject to potential hydrostatic uplift
6. Any culvert structure through the embankment (kame) will require cut-off or seepage mitigation, and
7. The stability of the embankment during a PMF has not been determined.

The 2017 preliminary design utilizes a longer lay-out that results in more excavation of the rock slope along the right bank downstream of the embankment. The extent of the rock excavation will require further assessment. Geotechnical design is recommended in detailed design on the following components:

1. Geomembrane/geotextile channel liner system
2. Graded seepage liner system to prevent hydrostatic uplift
3. Slope stability assessment, rock-fall and slope stabilization systems
4. Bedrock mapping and strength assessment, rock scaling, blasting design and implementation
5. Sheet pile, reinforced earth or earth retaining wall systems, and
6. Engineered fills, design of slopes and cuts in rock and earth.

The potential mitigation of these geotechnical elements in the 2017 preliminary design are likely to increase the expected costs of the work, and a $500,000 geotechnical contingency is recommended in the preliminary costing in addition to an overall project costing contingency.

7 Channel Design

Drawings for the natural fishway design are presented in **Appendix A**.

The fishway has been designed to operate at flows from 2 to 3 m^3/s to nominally meet all ecohydraulic design criteria and minimize water use, though it is also functional and hydraulically-stable at flows ranging from 1 to 5 m^3/s.

7.1 Fishway Inlet (Fish Exit) STA 0+000 to STA 0+056.52

The fishway inlet is described in plan and profile with details in **Appendix A – Sheet 07.**

The natural fishway inlet design is similar to the 2005 design. It consists of a reinforced cast-in-place concrete structure founded on compacted engineered fill. The fishway exit is located along the right bank of the headpond approximately 100 m upstream of the spillway crest. The water velocities in this area are generally low, allowing migrating fish to rest, re-orient to the flow before continuing their upstream migration, reducing the potential for entrainment back over the spillway.

The fishway exit (water inlet) structure serves to regulate the total fishway discharge, protect the fishway structure from debris and potential blockage, and isolation for flood protection and maintenance. Flow regulation, in addition to fish passage, is provided through a vertical slot fishway, which addresses the water elevation change between the headpond and the fishway channel. The stoplogs will provide additional on/off control for flood protection and maintenance activities.

7.1.1 Debris Boom (Optional)

The debris boom is described in plan and profile **Appendix A – Sheet 07** with details on **Appendix A – Sheet 10**.

Due to the placement of the fishway exit (water inlet), debris issues due to large wood should be minimal; however, a debris boom has been included for consideration. A log boom, designed following BC Hydro's Guidelines for Design of Debris Booms (1994) should be installed roughly parallel with the exiting flow over the spillway and anchored at an elevation and tightness to provide protection for the inlet over a range of headpond levels from El. 444.50 m to El. 447.50 m

7.1.2 Trash Rack

The trash rack is described in plan and profile **Appendix A – Sheet 15**.

The steel trash rack is bolted to the upstream end of the inlet structure. Its openings are 400 mm to allow for fish passage, same width as the vertical slot fishway baffle opening. The trash rack is mounted with the top edge angled downstream from the bottom edge. This provides for easier removal of debris than a vertical installation. When excessive debris accumulates causing a noticeable rise in velocities, the trash rack should be freed of debris. This increase in velocity will not only attract additional debris but also limit fish passage.

7.1.3 Intake Stoplogs

The intake stoplogs are located in plan and profile **Appendix A – Sheet 07** with details on **Appendix A – Sheet 15**.

A steel metal frame consisting of C-channel and embedment will be cast into the inlet structure as guideway for 300 x 300 mm (12” x 12”) wide timber stoplogs. These stoplogs can be installed via a truck-mounted hi-ab or overhead winch to close and dewater the fishway. Dewatering and drawdown of the fishway should be done to mitigate any geotechnical or environmental issues within the channel. A 2.0 m wide steel gangway-style pedestrian access bridge will maintain access from the parking lot to the top of the right abutment and its lookout.

7.1.4 Fish Counter (Optional)

The inlet structure is designed to extend downstream past the pedestrian bridge by 3 m. This additional space is provided for the potential of manual counting or future installation of a fish counter. Fish counters such as VAKI (www.vaki.is) can be obtained through local distributors such as PRAqua Supplies Ltd. Nanaimo, B.C. (www.praqua.co) and Instream Fisheries Research Inc., Vancouver, B.C. (www.instream.net).

7.1.5 Regulating Fishway

The regulating fishway is presented in detail in plan and profile **Appendix A – Sheet 07** with details on **Appendix A – Sheet 15**.

Downstream of intake and trash rack, there will be a short regulating fishway to control inflows into the fishway and address variation in inflow water levels (±2.5 m) at headpond during normal project operations. Plant outages and operational changes can result in rapid increases in headpond water elevation, and if unregulated, these would increase flows in the fishway, overloading the hydraulics of the natural channel design.

The regulating slot/orifice fishway is a reinforced cast-in-place concrete structured constructed on compacted engineered fills. It is approximately 3 m wide and 26 m long with an open top, covered with metal grating for safety and a handrail for access control. The regulating section has been located towards the upstream end of the fishway to improve the hydraulic performance of the fishway through water level control, and safe operations. The inlet bottom elevation is 442.90 m, and it is designed to be operated with reservoir levels between El. 444.50 m and El.447.00 m.

Fishway baffle openings will have a net area of 1.5 to 1.75 m^2, oriented in width and height to ensure passage of larger fish with surface orientation and low velocities for less capable fish. To accommodate the maximum head pond water level elevation (El. 447.00 m), 7 baffles are proposed in the preliminary design. Stoplog guides have been included to provide additional flow manipulation ability within the vertical slot fishway. The average velocity ranges from 0.9 to 2.1 m/s through the slot area for design flows of 1.5 to 3.7 m^3/s. These values are all within the ecohydraulic criteria presented in **Section 6.1.1**.

7.2 Upper Channel STA 0+056.2 to 0+200

Upper channel plan and profile may be found in **Appendix A – Sheet 05**. Typical channel cross sections and profiles may be found in **Appendix A – Sheet 09**.

The upstream channel for the natural fishway constructed from the fishway exit invert to the culvert inlet. A 144 m long, inlet channel for the natural fishway is a trapezoidal channel with an average slope of 0.73 percent. A uniform grade and section was used to ensure the hydraulics are repeatable, reproducible and consistent and varied flow hydraulics are minimized. The channel would be earthworks structure, constructed on native material, with a base layer to prevent deformation.

The channel is to be excavated to the design grade. The channel does not have a geotextile/geomembrane liner installed through this section as groundwater is expected to infiltrate into the channel. As a result, the liner is designed as a filter to prevent uplift and piping though the native sands and gravels.

At the base of the excavation a 0.2 m thick layer of bedding material is to be placed. The bedding material (Type 3 material) is to be rounded material and range in size from 5 to 500 mm diameter. The channel will then be lined with 0.5 m thick layer of semi-angular to angular material ranging in size from 50 to 300 mm diameter (Type 2 material). Type 2 material is to be used for the channel bottom and banks. The material that is more angular is to be used for the banks. The banks are at a 1H:1V slope.

7.3 Fishway Culvert STA 0+200 to 0+230

Culvert plan and profile may be found in **Appendix A – Sheet 08** with details in **Appendix A – Sheet 14**.

The fishway culvert provides a transition between the upper open water channel and regulating fishway, and the lower natural fishway channel section. The fishway culvert will have natural substrate, including select boulders, on the bottom to provide roughness to create localized turbulence and velocity variation. There is a riffle at the channel and grade transition (i.e. change from 0.73 percent to 5.0 percent) that also controls hydraulics in the culvert, increasing the depth to reduce velocities to improve fish passage for smaller fish in the reduced section.

The location of the crossing of the embankment was selected to reduce the amount of spoil as well as to provide an additional high water barrier to protect the natural fishway downstream. In the 2005 design, various methods of crossing the embankment were considered to reduce excavation and minimize cost, including sheet piling, reinforced wall structures and culverts.

The selected culvert is 30 m long culvert, 3,000 mm x 2,500 mm concrete box culvert. The culvert inlet bottom elevation is 441.55 m and is lined with 50 to 300 mm diameter (Type 2) material to a depth of 0.3 m. The first riffle at the fishway grade break (i.e. transition from 0.73 to 5 percent), is 0.3 m in height and backwaters the culvert to reduce velocities.

The culvert was modelled to determine the estimated maximum velocities and depths of flow over the operational flow range of the fishway (**Table 7-1**). Boulders to increase hydraulic variation can be place within the culvert if needed.

The culvert maintains the existing access road, provides a stable hydraulic control under PMF conditions by limiting the flood flows down the fishway under flood conditions even if bulkhead gate is open. If the expected bedrock elevation is at or above the invert of the culvert, the blasted rock will be re-used on side for armouring.

Table 7-1 Maximum channel velocities and depths in vicinity of the culvert.

Flow (m^3/s)	Velocity (m/s)			Depth (m)		
	Upstream of Culvert	Within Culvert	Downstream of Culvert	Upstream of Riffle	Within Culvert	Downstream of Culvert
1	0.97	0.83	0.54	0.29	0.40	0.40
2	1.06	1.15	0.70	0.47	0.58	0.58
3	1.13	1.43	0.83	0.61	0.70	0.70
4	1.18	1.67	0.95	0.72	0.80	0.80
5	1.21	1.92	1.05	0.83	0.87	0.87

A headwall will be constructed at the upstream end of the culvert allowing for a mount for a heavy-duty bottom opening 2,500 mm square steel bulkhead gate. The bulkhead gate will be lowered or raised using a truck-based hi-ab or gantry winch system. The gate will be accessible when headpond levels are below El. 447.50 m, but it is designed to be capable of withstanding water surface elevations in excess of the PMF reservoir level of El. ±452 m.

The bulkhead gate is designed to be opened when head pond levels are between El. 444.50 m and El. 447.00 m It should be closed when the headpond levels exceed El. 447.00 m and not reopened until water levels drop below El. 446.50 m and are continuing to fall.

The gate should generally be fully open during fishway operation and fully closed when fish passage is not required or during maintenance. An inspection and fish salvage will be required when the fishway is dewatered (**Section 8**).

7.4 Natural Fishway Channel STA 0+230 to STA 0+730

Upper channel plan and profile may be found in **Appendix A – Sheet 06**. Typical channel cross sections and profiles may be found in **Appendix A – Sheet 09**.

A 500 m long, natural fishway will be constructed as a trapezoidal channel with an average slope of 5 percent. The total drop from the outlet of the fishway culvert to the tailwater below the dam is approximately 24.9 m. A uniform grade and section was used to ensure the hydraulic are repeatable, reproducible and consistent, and varied flow hydraulics are minimized. The channel would be earthworks structure, constructed on native material with a geomembrane/geotextile liner system within a base layer of granular fill.

The channel would be excavated to the design grades, and a 0.15 m thick layer of Type 3 bedding material is placed. The Type 3 engineered fill is a manufactured crushed rock material from 5 to 50 mm diameter. Above this bedding layer a geotextile-geomembrane-geotextile "sandwich" would be placed and covered by another 150 mm of Type 3 material. The channel will then be lined with a semi-angular to rounded Type 2 material ranging in size from 50 to 300 mm diameter. Type 2 material is to be used for the channel bottom and banks. The banks are at a 1H:1V slope.

7.4.1 Riffle Section Detail

The riffle structures within the fishway provide the primary hydraulic control, maintaining depth and lower velocities upstream and energy loss through the riffle body and turbulent flow. The riffle height, spacing and total number determine the overall elevation drop through the natural fishway.

Riffles are spaced at 12.5 m, and are 5.0 m long and roughly 0.4 m high following the general rule of approximately twice the channel slope. The riffles are to be constructed in a shallow V-shape to provide maximum depth for large fish as well as greater velocity variation across the riffle when compared to a broad-crested weir (**Figure 7-1**).

The riffles will be constructed using 80 to 200 mm diameter rounded to semi angular (Type 1 material) In addition to the riffles, 600 to 1000 mm diameter, rounded to semi angular habitat boulders (Type 4 material) will be placed between the riffles to provide additional velocity variation and cover (**Figure 7-2)**.

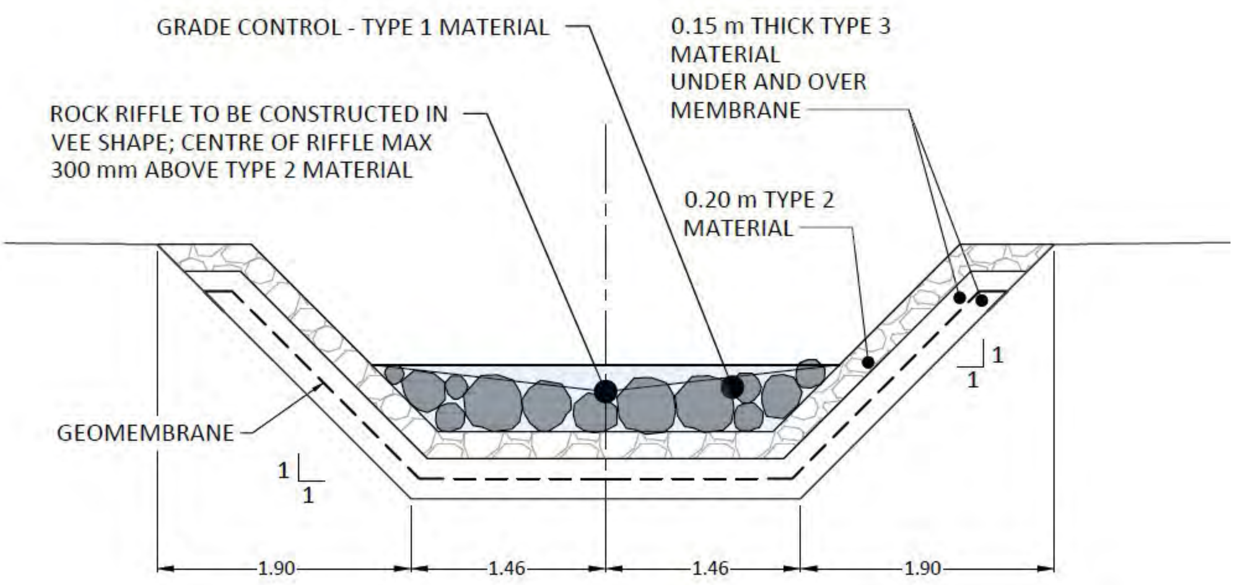

Figure 7-1 Section view of typical riffle arrangement.

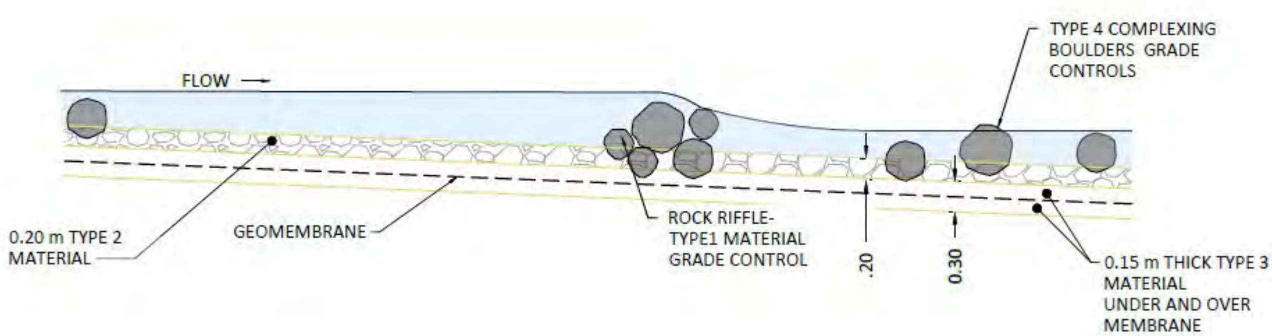

Figure 7-2 Profile view of typical riffle construction.

Hydraulics through the riffles vary with the flow. Preferred passage conditions for the majority of species resulted with modelled flows of 3 m^3/s. At the riffles, with water velocities of 2.2 m/s or less, fish are able to burst for maximum 9.1 m (**Table 6-2**), which is greater than the proposed length of the riffles of ±3 m.

Water depths are suitable at all flows with the exception of very low fishway flows of 1.0 m^3/s where they are slightly less that desirable (±0.2 m) for fish migration. Optimization of the riffle crest and body would be undertaken in detail design. This may include staggering of key rocks at the crest to concentrate flows at lower discharges, and sloping of the riffle body to vary the velocities across the riffle face.

The natural fishway is a relatively long, steep structure. Large, mature salmon will be able to pass multiple riffles continuously, and smaller resident freshwater and juvenile fish will make use of the runs between the riffles for resting and feeding. Based on the average velocities, Mountain Whitefish and other similarly capable fish should be expected to navigate the fishway riffles successfully.

These hydraulic responses are all expected and mimic a natural river system, where the high and low limits of flows generally increase restrictions to fish movement in some manner. Although it is expected that fish will still be able to successfully transit the fishway at flows less that 2 m^3/s, optimal hydraulics are provided at flows between 2 to 3 m^3/s.

7.4.2 Run Section Detail

The run section of the channel extends between the riffles sections, and are general constructed of the simple channels section described earlier. The channel lining provides high relative roughness and the average flow depths range between 0.4 to 0.5 m with velocities between 1.6 to 1.8 m/s for flows between 2 to 3 m^3/s and moderate roughness values (Manning's n = 0.06).

Increased roughness using boulder elements and form roughness will also increase flow depths and reduce velocities. Depths increase and velocities reduce due to the influence of the riffle sections and velocities along the margins of the run section are also expected to be much less.

Areas between the riffles will have continuous regions of water velocities estimated to be less than 1.0 m/s that are within the sustained and prolonged swimming modes of the design fish. Pool volumes were also not limiting in terms of minimum volumes to provide sufficient energy dissipation. Additional complexing with boulders is expected to provide a diverse holding habitat in the run sections of the fishway.

7.5 Fishway Outlet (Fish Entrance) STA 0+730 to STA 0+757

The fishway outlet is presented in detail in plan and profile **Appendix A – Sheet 07** with details in **Appendix A – Sheet 09**.

The fishway outlet (fish entrance) enters the river downstream of the power house on the right bank approximately 250 m downstream of the left bank powerhouse. This location is also downstream from the 2005 vertical slot fishway outlet.

The fishway entrance provides the access for upstream migration of fish, and the location, placement and position are critical in determining the overall effectiveness of the fishway. The design incorporates previous knowledge of fish behaviour in the system to reduce the need for a fish diversion to ensure fish rapidly find and enter the fishway.

The outlet provides a controlled transition from the natural fishway into the pool in the Middle Shuswap River. Additional channel shaping and structuring may be needed in the transition from the fishway to the river as this area is predominately bedrock for the last ±25 m of the channel. The design is expected to deepen the section and narrow the flow width to accelerate the flow into the pool. A low concrete wall has been included to retain the rock placed in the outlet and maintain concentrated fishway outlet flows into the downstream pool.

Fish are expected to hold in this pool and encounter the fishway flow prior to moving upstream into the next smaller pool. This will to improve attraction flow conditions. The channel slope will remain at ±5% but the roughness in the outlet created by the rock will provide stable access for fish at the various water level expected (El. 416.20 to 418.40 m).

8 Operations, Maintenance and Safety

Anticipated operations and maintenance are summarized below. Relevant considerations are included in this design basis documentation.

8.1 Channel Operations

The natural fishway channel may be operated seasonally or year-round, depending on the availability of flow and the effects of ice within the fishway channel that is expected to develop during the winter period.

8.1.1 Year-round Operations

Year-round operations would see flow maintained in the natural fishway channel throughout the year. The upper fishway will self-regulate flows according to headpond water elevations, and will provide nominal flows of 2 m^3/s to 3 m^3/s at headpond levels between El. 444.50 m and El. 447.00 m.

A significant benefit to year-round operation is the reduction of effort and cost related to potential fish salvage and monitoring if the channel is to be closed seasonally. The flow regime during winter periods may be reduced to sustain fish rearing within the channel, and NHC recommends that year-round operations be used initially and assessed.

If near-constant flows are maintained into the fishway during winter freeze-up, the fishway channel may develop relatively secure ice formation along the margins with sufficient open area through the riffle sections to convey flows throughout the mid-winter period. However, if flows are varied during freeze-up, aufeis[2] may develop that could cause overbank flows and either flow or ice-related damage to the channel. The effects of local groundwater and channel aspect on the potential ice regime within the fishway channel are not known, but a gradual thermal melting of ice is expected during spring break-up.

8.1.2 Seasonal Operations

If the fishway is closed and re-opened every year, additional assessment and monitoring will be required. The seasonal operational window for a natural fishway is expected to be opened by April 1st and closed December 1st unless monitoring indicates otherwise.

It is expected that minimal in-river migration during the winter when water temperatures are less than 5°C to 7°C. Generally, by early December, all salmon and trout that may potentially use the fishway should have completed their upstream migration. Larger resident freshwater fish would have moved to discrete overwintering habitats. It is expected that there will be rearing fish constantly utilizing the fishway, so dewatering and closure of the fishway will require inspection and monitoring, and fish salvage will be required to prevent fish stranding and dewatering.

Due to the turbulence in the fishway, the generation of frazil ice could potentially collect in holding pools, reducing pool volumes, and affecting flows. This may lead to additional constriction in the channel and possible erosion.

[2] Sheet-like mass of layered ice that forms from successive flows of water during freezing temperatures.

Groundwater conditions may result in winter seepage flows down the dewatered channel resulting in aufeis. The formation of ice and management of seepage may require additional inspection and maintenance during the winter period.

Before the fishway is re-watered in the spring, it should be visually inspected for infilling damage or ice blockages. It should be opened and operated during all ice-free, open water conditions in early spring to ensure passage is available for spring migrants.

8.2 Site Access

The upper section of the fishway is accessible through level areas adjacent to the channel.

Lower portions of the channel through areas of the bedrock slope have been provided a level 2.0 m wide running surface for an ATV or mini-excavator. The channel width is also sufficiently wide to walk an excavator down the channel – straddling both sides with the tracks. With this access, minor modifications, such as boulder placement or relocation, can be done with a mini-excavator or by hand.

All structures will have secure fencing and walkways to allow access without entering the fishway channel.

8.3 Emergency Operations

8.3.1 Extreme Flooding and PMF

Operation of the fishway would typically consists of removal of the stoplogs in the upstream intake structure with regulation and control of the flows through upstream regulating fishway. The heavy-duty bulkhead gate located at the upstream end of access road embankment culvert system is typically left open during normal operations.

If flood flows are forecast and headpond levels could reach or exceed the overbank elevations or breach the upstream control structure of the fishway channel, the bulkhead gate on the embankment should be closed immediately. The bulkhead gate should not be reopened until reservoir levels drop below El. 446.50 m, water levels are expected to continue receding, and additional flooding is not forecasted. The bulkhead gate controls will be accessible when headpond levels are below El. 447.50 m, but it is designed to be capable of withstanding water surface elevations in excess of the PMF reservoir level of El. ±452 m

Operation of the bulkhead gate should be incorporated with the Wilsey Dam BC Hydro OMS Manual (BC Hydro, 2000).

8.4 Flow Ramping and Fishway Dewatering

Inflow changes and operational issues such as load drops, and plant outages cause the headpond at Wilsey Dam to be subject to considerable short-term fluctuations in water surface elevation. When not spilling, the water surface is typically maintained approximately 0.4 to 0.5 meters below the spillway crest. Dewatering of the headpond may occur during emergencies or maintenance activities. During routine maintenance work, the fishway can be dewatered and isolated from the headpond and upper river by installation of stoplogs at the inlet structure and closure of the bulkhead gate. Fishway flows should be reduced and the fishway channel slowly dewatered. During any flow ramping activities, regardless of the reason, there will be the need to monitor and potentially salvage fish within the fishway.

8.5 Operations and Maintenance Costs

Currently, Unit No. 1 is not operational and there are no current plans to repair it. As a result, spills occur when flows are in excess of 17 m^3/s due to the limited turbine capacity of Unit No. 2. Based on the available mean spill records, there have been no mean spills less than 3 m^3/s since 2012 (**Table 4-1**). Assuming the fishway is operated with a flow of 3 m^3/s, this suggests that there would be no foregone power production due to the spilling under current operating conditions with Unit No. 1 not in service.

The natural fishway will require regular inspections and routine maintenance. Expected tasks included fish salvage, vegetation management, walk-throughs inspections, gate/stoplog operation and fish use monitoring. As part of the detailed design, an Operations, Maintenance and Safety Manual (OMSM) would be drafted and a budget established. For preliminary consideration, the cost of these tasks is estimated in **Table 8-1**.

Table 8-1 Examples of preliminary operations and maintenance tasks and costs.

Maintenance Task	Crew Required [1]	Preliminary Cost	Frequency
Gate/Stoplog Operation	2	$1,500	2 times per year
Typical Inspections [2]	2	$2,500 to $8,000	2 times per year
Vegetation Management	2	$2,500	2 times per year, can potentially be incorporated into park maintenance works
Fish Salvage	2 to 3	$6,000 to $8,000	Once or twice per year when fishway shut-off for winter, high water, or for maintenance activities
Fish Use Monitoring [3]	2	TBD	As determined by regulatory agency or scientific need

[1] In most cases a minimum of 2 crew will be required for safety reasons.
[2] Recommended to involve Engineer(s) in inspection(s).
[3] Fish monitoring costs will vary depending on the type (i.e. cameras, trapping) and intent (i.e. adult anadromous passage, juvenile downstream use) of the monitoring program.

9 Preliminary Design Summary

9.1 Summary

The updated 2005 vertical slot fishway design review and costs were provided under separate cover as a draft letter report dated October 18, 2017 to the Centre and provided in **Appendix B**. Preliminary costing for the 2017 natural fishway design are summarized in **Appendix C**.

The total estimated factored costs of the 2017 preliminary natural channel design are $5.9M[3], including the suggested geotechnical provision. Additional costs have been included for project and construction management, construction engineering and environmental monitoring and mitigation during construction. Factors to consider in the preliminary design and in the costing for the proposed natural fishway include:

1. **Structural Design items outlined in Section 6.2**
   Additional structure design and engineering is required for minor structures associated with the project.

2. **Geotechnical design factors outlined in Section 6.3**
   NHC recommends a separate geotechnical contingency of $0.5M to account for issues that cannot be resolved without detailed design and site investigations.

3. **Detailed Design Issues and Costs**
   Until a detailed design is complete, all the potential design costs issues are not resolved, significant re-design may be required, or value engineering may identify savings through alternate designs. For example, competent rock and controlled blasting may reduce the need for geomembrane liner systems and channel armouring.

4. **Impacts of Earthworks Unit Rate and Quantities**
   The 2017 natural fishway design has a significant amount of earthworks and rock removal that are dependent on unit rate estimates. Slight changes to the rates have a significant bearing on project costing, and these are not typically available until costing is provided by a construction contractor through tendering or invitation to price process.

5. **Contractor Mark-up, Risk and Construction Climate**
   Project cost estimates for works that will be constructed by a general construction contractor are subject to uncertainty due to labour conditions, economic factors, and margins. It is difficult for a preliminary cost estimate to account for uncertainty, risk and profits that are incorporated into costs to construct. As such, project costs estimates tend to increase rather than decrease as additional design information is collected and analyzed.

6. **Unforeseen Factors**
   Although significant effort has been made to identify potential project risks, there may be some future unknown issue, yet to be identified, that invalidates the current design or approach.

[3] Cost estimate is a "Class C" estimate of -5%/+20% costs and does not include additional capital project costs including IDC, public and regulatory consultation and commitment costs, site monitoring or procurement and safety costs.

9.2 Comparison Between Vertical Slot and Natural Fishway Options

The comparison of the vertical slot and natural fishway options has been summarized in the following table. Note that some of the factors are qualitative.

Table 9-1 Summary of Wilsey Dam fishway options.

Factor	Vertical Slot Design	Natural Design
Slope	12.50% [1]	1 to 5%
Length	190 m	750 m
Average Operational Discharge	±3 m^3/s [1]	±3 m^3/s
Average Velocity Range	<3.3 m/s [1]	0.8 to 2.2 m/s
Existing Successful Fishway Designs in PNW [2]	>30	>20
Estimated 2017 Cost	$5.4M [3]	$5.9M [4]
Design Fish Range	≥450 mm	100 mm to >500 mm
Small Fish Passage Risk	Low [1, 5]	Low
Medium Fish Passage Risk	Low [1]	Low
Large Fish Passage Risk	Low [1]	Low
Outlet Condition Risk	Medium [6]	Low
Freshet Flow Attraction Risk	Medium [1]	Low
Normal Flow Attraction Risk	Low [1]	Low
Sedimentation Risk	Low	Medium
Structural Durability	High	Medium
Dam Safety/PMF Risk	Low	Low
Expected operations/maintenance issues	Low	Medium
Stranding Risk During Dewatering	Low	Medium
Icing Concerns	Low	Medium
Effect on fish entrainment	Low	Low

[1] NHC, 2005.
[2] Pacific Northwest (PNW) designs vary in vertical drop, grade, and length.
[3] Appendix B.
[4] Appendix C.
[5] Assumes small fish moving downstream for vertical slot design
[6] Further distance for fish to find entrance and access concerns at different tail race levels.

9.3 Recommendation

In summary, there are several critical factors to consider in the selection of a natural fishway design over the vertical slot design.

1. **Biological requirement for improved passage for a wider range of fish species and life stages**
   If this is biologically critical, then the natural fishway design is better. It will provide the widest range of passage hydraulics and pathways in comparison to the vertical slot design.

2. **Fishway attraction characteristics and influence on overall fishway efficiency**
   Assuming that the tailwater conditions remain unaffected and no additional fish guidance or fencing is provided, the natural fishway is will provide better attraction hydraulics as a result of the ability to discharge higher flows. With the outlet channel design, a higher velocity directed flow will result that is ideal for salmonid attraction.

3. **Period of operations, and effects of dewatering, ice and durability**
   If the fishway can be operated seasonally from a biological perspective and dewatered with minimal issues, winter operations can be avoided and potential ice effects limited. This negates the benefit the vertical slot design had over the natural channel option.

4. **Constructability of the Project**
   As discussed in **Section 9.1**, the natural fishway has larger volumes and a greater area of excavation and costs are sensitive to unit rates and geotechnical issues. With a smaller footprint, the vertical slot design has less inherent risk. There are also geotechnical uncertainties as discussed in **Section 6.3**, but these have been addressed with a provisional amount in the cost estimate and will only be resolved in detailed design.

The difference in cost between the natural and the vertical slot fishway in the updated 2017 estimates is less than the precision of the estimate (-5%/+20%). At this level of design, project costs should be considered in the overall assessment, but not necessarily used as a deciding factor between fishway designs.

On the best available information available at this time, NHC recommends that the natural fishway design be promoted as the best possible fishway alternative in the overall assessment of fish passage options at Wilsey Dam.

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Appendix A Drawings

Appendix B Updated 2005 Vertical Slot Cost Memo

NHC Ref. No. 3001970

October 18th 2017

Whitevalley Community Resource Center
2114 Shuswap Avenue
Lumby, BC
V0E 2G0e

Attention: **Ms. Gay Jewitt**
Executive Director
gjewitt@whitevalley.ca

Re: **2005 Design Review and Cost Update**

Dear Ms. Jewitt:

In 2005, NHC produced a detailed design of a vertical slot fishway along the right bank, as well as detailed design drawings, specifications and costing information. Under this scope of work, NHC reviewed the previous design and was to identify any modifications to reflect current state-of-design and knowledge for fish passage. The construction costs have been updated to reflect current material costs and construction contractor rates.

NHC feels revisions to the design are fairly minor and changes to the design drawings could entail additional costs that are not required at this time.

1 Proposed Fishway Design Modifications

Based on a review of the 2005 vertical slot fishway design, the following modifications should be given consideration:

1. **Embankment culvert**: The selected design is to use a 27.5 long culvert, with the option given to tendered contractors to use either a 2400 mm x 2400 mm concrete box culvert or a 2740 mm diameter CMP (corrugated metal pipe) culvert. The use of a concrete box culvert to facilitate maintenance (i.e. sediment removal if needed) may be beneficial and preferred.
2. **Safety features and maintenance of public access routes**: Railing and guard rails will be necessary for public safety as well as the maintenance of existing trail routes (i.e. canoe portage). Some of these costs are included in the miscellaneous metal work and the contingency should cover any additional costs in this regards.

2 Updated Project Costs

A review of the 2005 budget was undertaken. Unit costs were update to 2017 estimates along with any changes that were recommended in the design modifications. The table below provides a comparison of the 2005 costs to the 2017 cost estimate.

Item	Quantity	Unit	2005		2017	
			Rate	Cost	Rate	Cost
Mobilization, Site Clean-up, and Demobilization	1	LS	$20,000	$20,000	$50,000	$50,000
Clearing and Grubbing	1	LS	$8,000	$8,000	$12,000	$12,000
Erosion Control, De-watering, Planting	1	LS	$15,000	$15,000	$25,000	$25,000
Earthworks - Excavation						
Rock Excavation	4,550	m3	$125	$568,750	$160	$728,000
Earth Excavation	21,850	m3	$10	$218,500	$18	$382,375
Earthworks - Fill						
Heavy Riprap	1,010	m3	$20	$20,200	$100	$101,000
Armour Riprap	200	m3	$20	$4,000	$75	$15,000
Shotrock	3,000	m3	$15	$45,000	$50	$150,000
E1 - Engineered Fill	7,280	m3	$15	$109,200	$25	$182,000
Cast-in-place Reinforced Concrete	841	m3	$800	$672,800	$2,000	$1,682,000
Permanent Drainage (headwall and fishladder)	1	LS	$2,000	$2,000	$3,000	$3,000
Rock-dowell for concrete work	32	m	$140	$4,480	$200	$6,400
Supply and Install Culvert Miscellaneous	1	LS	$20,000	$20,000	$150,000	$150,000
Metalworks Supply/Construct/Install	1	LS	$71,500	$71,500	$200,000	$200,000
Logboom Construct/Reconstruct Access	1	LS	$5,000	$5,000	$7,000	$7,000
Road Surface	640	m2	$40	$25,600	$60	$38,400
Total Construction Costs				$1,810,030		$3,732,175
Detailed Design	10%			$181,003		$373,218
Construction/Project Management	10%			$181,003		$373,218
Construction Cost Contingency	25%			$452,508		$933,044
Total Estimated Project Costs				**$2,624,544**		**$5,411,654**

The costs are significantly higher, increasing from roughly $2.6M to $5.4M. Roughly 35 to 40% can be attributed to inflation and cost-of-living over the 12 years assuming 2.5 to 3.0% annually, however the largest increases in item costs were:

1. Cast-in-placereinforcedconcretecosts: the 2005 costs have increased due to steel costs and the 2017 unit rates reflect real costs.
2. CulvertInstallation: 2017 costs reflect true costs of supplying and installing culvert system to include grouting and water-proofing, and headwall construction.
3. Metalwork: again raw materials costs have changed from roughly $5 kg to over $10/kg for estimating purposes.

3 Closure

We trust this document provides Whitevalley Community Resource Centre with the necessary updated costing information to continue the evaluation process of fish passage at BC Hydro's Wilsey Dam.

If you have any questions, please do not hesitate to contact Patricia House at (250) 851.9262 or Barry Chilibeck at (604) 969-3007.

Sincerely,

Northwest Hydraulic Consultants Ltd.

Report Prepared by:	**Report Reviewed by:**
original signed by	*original signed by*
Patricia House, PEng Senior Water Resource Engineer	Barry Chilibeck, MASc, PEng Principal

Notification
This document has been prepared by **Northwest Hydraulic Consultants Ltd.** for the benefit of **Whitevalley Community Resource Center** for specific application to the **Plan for Fish Passage at Wilsey Dam**. The information and data contained herein represent **Plan for Fish Passage at Wilsey Dam Northwest Hydraulic Consultants Ltd.** best professional judgment in light of the knowledge and information available to **Northwest Hydraulic Consultants Ltd.** at the time of preparation, and was prepared in accordance with generally accepted engineering practices.

Except as required by law, this report and the information and data contained herein are to be treated as confidential and may be used and relied upon only by **Whitevalley Community Resource Center**, its officers and employees. **Northwest Hydraulic Consultants Ltd.** denies any liability whatsoever to other parties who may obtain access to this report for any injury, loss or damage suffered by such parties arising from their use of, or reliance upon, this report or any of its contents.

Appendix C 2017 Natural Channel Fishway Preliminary Costs

Table C-1 Summary of Wilsey Dam natural fishway cost estimate (Class D).

Item	Quantity	Unit	2017 Rate	2017 Cost
Mobilization, Site Clean-up, and Demobilization	1	LS	$50,000	$50,000
Clearing and Grubbing	1	LS	$12,000	$12,000
Erosion Control, De-watering, Planting	1	LS	$25,000	$25,000
Rock Excavation	12,250	m3	$160	$1,960,000
Earth Excavation	24,500	m3	$18	$428,750
Earthworks - Fill				
Type 1	2,000	m3	$50	$100,000
Type 2	1,057	m3	$50	$52,850
Type 3	1,466	m3	$50	$73,300
Type 4	54	m3	$100	$5,400
Reinforced Concrete	150	m3	$2,000	$300,000
Supply and Install Culvert	1	LS	$150,000	$150,000
Supply and Instal Liner	3,000	m2	$100	$300,000
Miscellaneous Metalworks	1	LS	$200,000	$200,000
Supply/Construct/Install Logboom	1	LS	$10,000	$10,000
Construct/Reconstruct Access Road Surface	640	m2	$60	$38,400
Total Construction Costs				$3,705,700
Detailed Design	10%			$370,570
Geotechnical Contigency	report			$500,000
Construction/Project Management	10%			$370,570
Construction Cost Contingency	25%			$926,425
Total Estimated Project Costs				**$5,873,265**

Technical Memorandum

Date:	Wednesday, September 20, 2017
Project:	Wilsey Dam Hydroelectric Project
To:	Elinor McGrath (Whitevalley Community Resource Centre)
From:	Steve Dearden (Fish Transport Systems, LLC) and Mike Garello, PE (HDR)
Subject:	Concept Evaluation of Fish Transport System Implementation at Wilsey Dam

Table 1. Summary of document revisions.

Rev No.	Revision Date	Description
0	July 28, 2017	Initial draft submittal for review.
1	September 20, 2017	Incorporation of comments from BC Hydro and Whitevalley Community Resource Centre

Introduction

HDR was retained by the Whitevalley Community Resource Centre (WCRC) as a subconsultant to Fish Transport Systems LLC to perform professional engineering services related to the evaluation and placement of the Whooshh fish transport tube technology for the purpose of providing fish passage upstream of the Wilsey Dam Hydroelectric Project in British Columbia, Canada. Services performed include reviewing and analyzing salient background information made readily available by the client, performing site reconnaissance and preparing a brief document summarizing findings resulting from completion of the work activities.

The overall objective of this task was to evaluate the use of the fish transport tube technology as an interim and/or long-term solution to providing upstream fish passage at Wilsey Dam for selected target species. The purpose of this document is to document the results of the work activities performed which can be used by WCRC and BC Hydro to make an informed decision relating to future fish passage work at Wilsey Dam.

All information presented herein is conceptual in nature based upon the information available at the time this document was developed. Further investigation and design development is required to improve specific details and refine preliminary construction and implementation costs of the described action.

Scope of Document

The following tasks were performed during preparation of this document:

- Reviewed salient background information relating to fish passage at Wilsey Dam, facility operations, and general factors that characterize the project operating environment

inclusive of reports prepared by others and information made readily available by the client and project owner;
- Attended a one-day site visit at Wilsey Dam;
- Summarized the results of the background review and site investigation; and
- Developed a fish passage concept incorporating the use of the fish transport tube (Whooshh) technology.

Background

The Wilsey Dam Hydroelectric Project (Project) is located on the Shuswap River approximately 22.4 km upstream of the Mabel Lake Inlet, and approximately 35 km east of the City of Vernon on the Shuswap River (McGrath et al. 2014). The Project was constructed in 1928 at a location historically known as Shuswap Falls. It is understood that prior to the construction of the Wilsey Dam project, the Shuswap Falls were passable to multiple fish species. The implementation of the dam and hydroelectric project created an upstream migration barrier to both resident and anadromous species and blocked access to an estimated 30 km of upstream habitat (Wilsey Dam Fishway Steering Community [WDFSC] 2005).

Figure 1 shows the approximate location of Wilsey Dam in relation to the City of Vernon as well as Mabel, Sugar and Shuswap lakes, among other landmarks and locations.

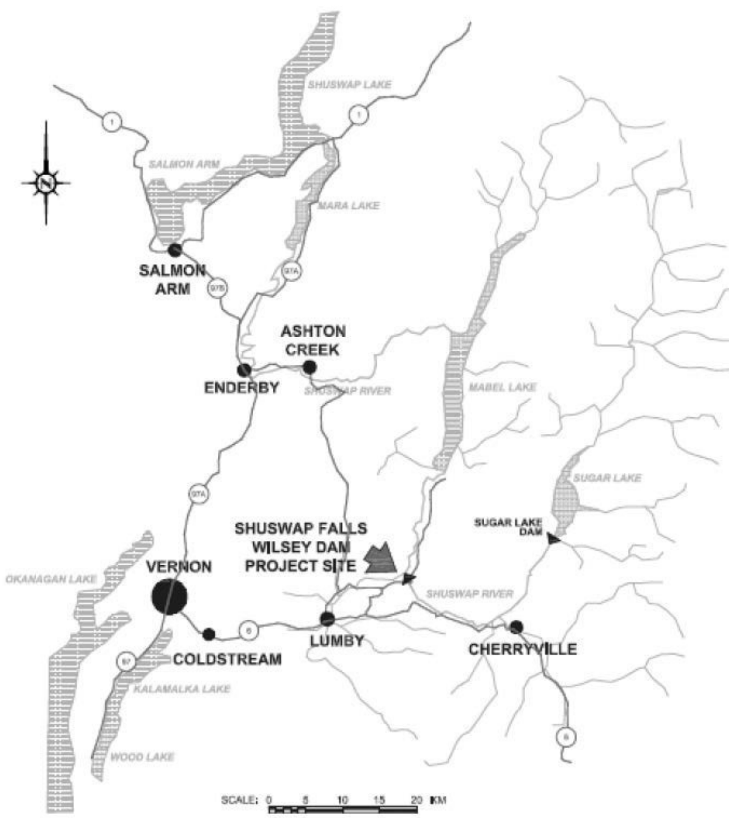

Figure 1. Project Location (McGrath et al. 2014)

Select Wilsey Dam Characteristics

The Project facilities include a concrete arch dam, an ungated spillway, two intakes with penstocks, and a powerhouse, among other ancillary components. Table 1 below provides a list of characteristics of Wilsey Dam and associated features that are useful in development of potential fish passage alternatives.

The powerhouse is located approximately 140 meters downstream of the dam, and holds two Francis turbine units. Each turbine unit is fed from a separate penstock, with intakes located on either side of the dam, on the left and right abutments. During power outages, flow from the second penstock is diverted downstream of the powerhouse to bypass the turbine units (Walsh and McGrath 2015). When inflows are less than 8 cubic meters per second, both units are shut down (Walsh and McGrath 2015). When inflows exceed the maximum turbine capacities of the powerhouse, the water is spilled (Kamal and Zhu 2015). Once spilled, water follows a spill channel that is excavated into competent rock and is conveyed downstream to a point near the powerhouse. Less than half way down the spill channel, a deep saddle in the rock wall of the spillway channel allows a portion of the flow volume to cross over into the old river channel. Flow in the spill channel and the old river channel converge just downstream of the powerhouse.

Flashboards can be installed on the spillway crest during low flows to increase the forebay elevation by approximately one meter. They are typically in-place during the months of September through April – outside the annual freshet. The dam typically spills from April to August, after the flashboards are removed and turbine capacities are exceeded (Walsh and McGrath 2015). In addition to the flashboards, a programmable logic controller, or PLC, is located in the powerhouse. This PLC is programmed to regulate the forebay elevation using two level sensing units near the No. 1 power intake. The controller keeps forebay elevations between 2 cm above and 2 cm below the spillway crest or top of the flashboards (Pattinson 2017). This controller is normally left in service, except in cases where high river flow results in spill (e.g. freshet) (Pattinson 2017). A “save fish” setting is implemented if a spill occurs during a time when spawning fish may swim up past the station and below the falls, which may occur in late July, August, or September. This setting regulates a small spill over the spillway to help reduce the potential for fish stranding in the channel. After visual confirmation by the SGB manager that all fish have left the area below the dam, this setting may be turned off (Pattinson 2017) and spill can be reduced to zero.

A debris control boom is anchored between the No. 2 power intake and the spillway, extending to the upstream end of the reservoir. During spring freshet, the majority of the debris passes over the spillway and continues down the spillway channel (Pattinson 2017).

Table 2. Summary of Select Wilsey Dam Characteristics

Characteristic		Description
Top of arch dam (elevation)[1]		448.54 m
Arch dam crest (length)		43.00 m
Dam height[2]		30.00 m
PMF Flow[3]		1480 m^3/s
Forebay water surface elevation at PMF[3]		451.70 m
Forebay normal minimum elevation[3]		444.50 m
Forebay normal maximum elevation (with flashboards)		445.53 m
Forebay maximum peak elevation[3]		447.00 m
Forebay length[4]		3.2 km
Forebay area (at max. normal elevation)[4]		4.27 ha
Forebay storage at elevation 444.52 m (spillway crest)[5]		99,900 m^3
Forebay storage at elevation 445.53 m (top of flashboards)[5]		170,300 m^3
IDF Flow[5]		740 m^3/s
Spillway crest elevation	With flashboards	445.43 m
	Without flashboards	444.52 m
Spillway crest length		36.50 m
Power intake invert elevations	No. 1 at entrance to tunnel	433.61 m
	No. 1 at sill of gate	434.52 m
	No. 2 at entrance to tunnel	435.16 m
	No. 2 at sill of gate	433.27 m
Sill elevation of low level outlet[5]		427.51 m
Tailwater normal minimum elevation at Powerhouse[3]		416.20 m
Tailwater normal maximum elevation at Powerhouse [3]		418.40 m
Turbine generating capacity[1]	No. 1 (Francis)	16.4 m^3/s
	No. 2 (Francis)	15.2 m^3/s
Minimum generating capacity		8 m^3/s
Powerhouse generation[5]		6 MW
Minimum flows released from Wilsey Dam[5]	January 1 – August 14	13 m^3/s
	August 15 – December 31	16 m^3/s
Bypass valve diameter[5]		1.22 m
Elevation of center of bypass valve[5]		420.46 m
Bypass valve maximum discharge range[5]		18.74 – 19.11 m^3/s

1. BC Hydro 2002
2. Kamal and Zhu 2015
3. WDFSC 2005
4. Walsh and McGrath 2015
5. Pattinson 2017

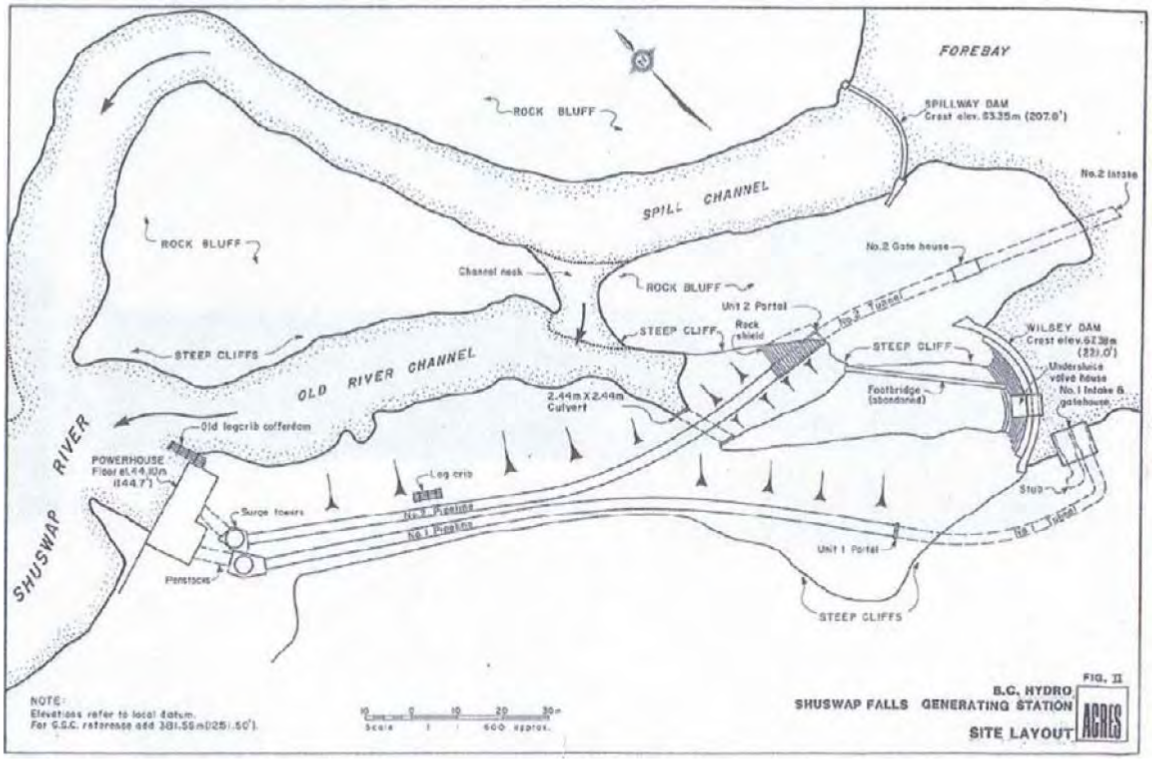

Figure 2. Plan View of Wilsey Dam and Powerhouse (WDFSC 2005)

Target ramp rates were included as part of the Operations Summary for the Shuswap Falls Generating Plant. Values in Table 2 were taken directly from the Local Operating Order (Pattinson 2017).

Table 3. Target Ramp Rates, m^3/s

Time of Year	Fisheries Life History Change	Down Ramp Rate		Up Ramp Rate	
		Night[1]	Day	Night[1]	Day
1 April – 31 July	Fry Emergence	2.5	2.5	5	5
1 August – 1 October	Rearing	5	2.5	5	5
1 October – 31 March	Winter Rearing	5	2.5	5	5

1. Night is defined as dusk, 1 hour before it gets dark and up to sunrise in the morning.

Previous Fish Passage Efforts at Wilsey Dam

Previous studies have been conducted to evaluate the feasibility of fish passage at this site. A summary of these studies is included below.

In March 2005, the second phase of the Wilsey Dam Passage Feasibility Study was released by members of the Wilsey Dam Fishway Steering Committee, reporting that effective passage could likely be achieved at Wilsey Dam. This study included the design of a potential fishway at the project site. Some of the conclusions of this study are: (WDFSC 2005):

- Implementation of the proposed fishway was expected to increase freshwater production of salmon by means of increasing spawning and rearing habitats in the area;
- The proposed fishway design did not include integration of an Auxiliary Water Supply (AWS), which may be necessary to improve overall attraction and passage efficiency at this location;
- Construction of the vertical slot fishway was estimated to cost roughly $1.8M Canadian, without contingency (in 2005 dollars);
- This estimate (without contingency) would correspond to approximately $7.8M Canadian in 2017 dollars using a more recent parametric costs for fish ladders of similar size ($10.4M with a 30% contingency to account for design and construction uncertainty); and
- Entrainment estimates of downstream migrating fish were not possible given the information available at the time of the 2004 – 2005 study. No data was present in the literature at the time that was directly applicable to Wilsey Dam.

In March 2014, an Environmental Feasibility Report was released by Okanagan Nation Alliance. The report lists the following findings (McGrath et al. 2014).

- Fish passage at Wilsey Dam appeared to be feasible and no serious obstacles are identified; and
- Data gaps still remain, the most critical of which being entrainment mortality of juvenile fish in the penstock intakes and hydropower turbines. It is recommended these data gaps are filled.

In April 2015, a third feasibility study was released regarding Assessment of Fish Entrainment at the project location. The report notes (Walsh and McGrath 2015):

- Hydroacoustic technology was shown to be feasible at detecting salmon smolts in all regions upstream of Wilsey Dam, with some limitations due to noise levels, particularly near the spillway;
- Data indicates that considerable numbers of (likely) target fish pass through the spillway and the active turbine intake, but some also remained milling around in the forebay; and
- Further refinement of hydroacoustic transducer configuration and fish sampling methodology are needed to allow estimation of entrainment rates.

In September 2015, individuals at the University of Alberta's Department of Civil and Environmental Engineering submitted a report on velocity measurements at the project site. An ADP was used to measure velocities at various transects in the forebay (Kamal and Zhu 2015). These values were then used to calculate three dimensional velocity and discharge at various locations (Kamal and Zhu 2015). The following conclusions were presented:

- Maximum depth averaged velocities were found to be 0.71 m/s at the main channel, 0.54 m/s near the spillway face and 0.42 m/s near Intake 2;
- Analysis of the velocity field showed the existence of secondary currents in the 30 meters upstream zone of the spillway directing towards Intake 2; and

- The flow pattern near the intake was governed by the flow withdrawal at the turbine.

These studies conclude that upstream passage at the project site appears to be achievable. It was noted, however, that some data gaps exist that are recommended to be filled in order to move forward with an informed design. The studies identified that there is concern over potential for entrainment or fall-back of adult upstream migrating fish into the penstock intakes or spillway after passage upstream into the forebay.

Project Setting

Site Investigation

A one-day site visit was performed at the Wilsey Dam project area on April 13, 2017 and was attended by Elinor McGrath (WDFSC), Steve Dearden (Whooshh), Mike Garello (HDR), and Adam Croxall of BC Hydro. Attendees visited and visually observed Wilsey Dam and the hydropower facilities immediately downstream of the dam structure. Discussion topics focused on the overall operation and layout of the primary dam components as well as specific topics related to areas of fish accumulation during the migration period and operational conditions experienced in the forebay during periods of power generation. Selected photographs taken during the site investigation that represent the various dam components and operational conditions observed are provided as Attachment A.

Biological Setting

Species in Project Area
Species found in this project area include anadromous Chinook and coho salmon, as well as resident bull trout, rainbow trout, and mountain whitefish (WDFSC 2005). A large number of sockeye and kokanee have also been observed downstream of the dam in the past decade (McGrath et al. 2014).

Period of Migration
Each species is known to have unique migration behavior and is believed to pass upstream and downstream within the Shuswap River at specific times of the year for specific durations. The migration timing and duration influence the design and operation of proposed fish passage facilities by defining physical, operational, and environmental conditions expected to occur while upstream passage is required.

The following migration periods were published in the Phase 2 Feasibility Study Report for the species of interest (WDFSC 2005) and the Environmental Feasibility Study from 2014 (McGrath et al. 2014). It is understood that the periodicities established in both the 2005 study and the 2014 study remain applicable.

Table 4. Species Periodicity

Species	Adult Migration	Peak Migration[1]
Chinook[1]	Early July – late September	Mid-August
Coho[1]	Mid October – late November	Early November
Sockeye	Mid-September[1] – late September[2]	Mid-September
Bull Trout[1]	April – June	Mid-May
Rainbow Trout[1]	March – June	Mid-May
Mountain Whitefish[1]	September – October	Early October
Kokanee[2]	Early September – mid-October	Mid-September

[1] WDFSC 2005
[2] McGrath et al. 2014

Population Abundance

The 2014 Environmental Feasibility Study included the abundance values presented in Table 4 for Chinook, coho, and sockeye salmon (McGrath et al. 2014). In general large sockeye runs are only experienced once in every two or three years. Typical years exhibit populations of approximately 500 to 2,500 Chinook, 1,000 coho, and no sockeye (McGrath, personal communication, September 10, 2017).

Table 5. Observed Abundances (5-yr mean)

Species	Below Wilsey Dam	Above Wilsey Dam
Chinook	1,411	-
Coho	696	-
Sockeye	77,982	-

Goals of this project include reintroducing anadromous and fluvial species of fish to the area upstream of Wilsey Dam (WDFSC 2005). Escapement targets upstream of the dam have not been established, but escapement goals in the Middle Shuswap River (downstream of Wilsey Dam) are included in Table 5 (McGrath et al. 2014).

Table 6. Escapement Goals Downstream of Wilsey Dam

Species	Escapement Target
Chinook	10,000
Coho	762
Sockeye	75,000

The 2014 Environmental Feasibility Study also provided spawning habitat estimates upstream and downstream of Wilsey Dam (McGrath et al. 2014). These values are presented in Table 6. Fish populations requiring passage beyond Wilsey Dam are also estimated assuming that fish are distributed upstream based upon the proportion of available spawning habitat in the Shuswap watershed.

Table 7. Spawning Habitat Estimates

Species	Below Wilsey Dam	Above Wilsey Dam	Proportion of Habitat Upstream of Wilsey	Estimate of Population Passing Wilsey
Chinook	141,350	329,088	70%	987
Coho	78,970	28,117	26%	183
Sockeye	Not Available	36,961	100%	77,982

Rates of Migration

The rates of migration for species found in the project area were not included in the information provided.

Physical Setting

Hydrology

Shuswap River hydrology was evaluated to gain an understanding of the historic and current flow conditions in the river, as well as the magnitude, duration, and frequency of Shuswap River streamflow both upstream and downstream of Wilsey Dam. Specific elements analyzed for development of conceptual fish passage alternatives including flood recurrence and exceedance of mean daily flow. Results were used to examine headwater and tailwater conditions for various future operational scenarios at the project site as well as to develop fish passage design flows in accordance with government guidelines.

Releases over the Wilsey Dam Spillway were provided by BC Hydro for a period of record extending from 2008 through 2016, along with a small portion of data available from 2017. Figure 3 compares all years of data. The data shows that releases over Shuswap Falls are greatest in the summer months, from around April to Mid-August, with a lower and relatively steady flow during the rest of the year. By comparing these seasonal flow patterns with the anticipated migration periods provided in the previous section, collection and passage of bull trout and rainbow trout would need to accommodate the highest flows observed throughout the year.

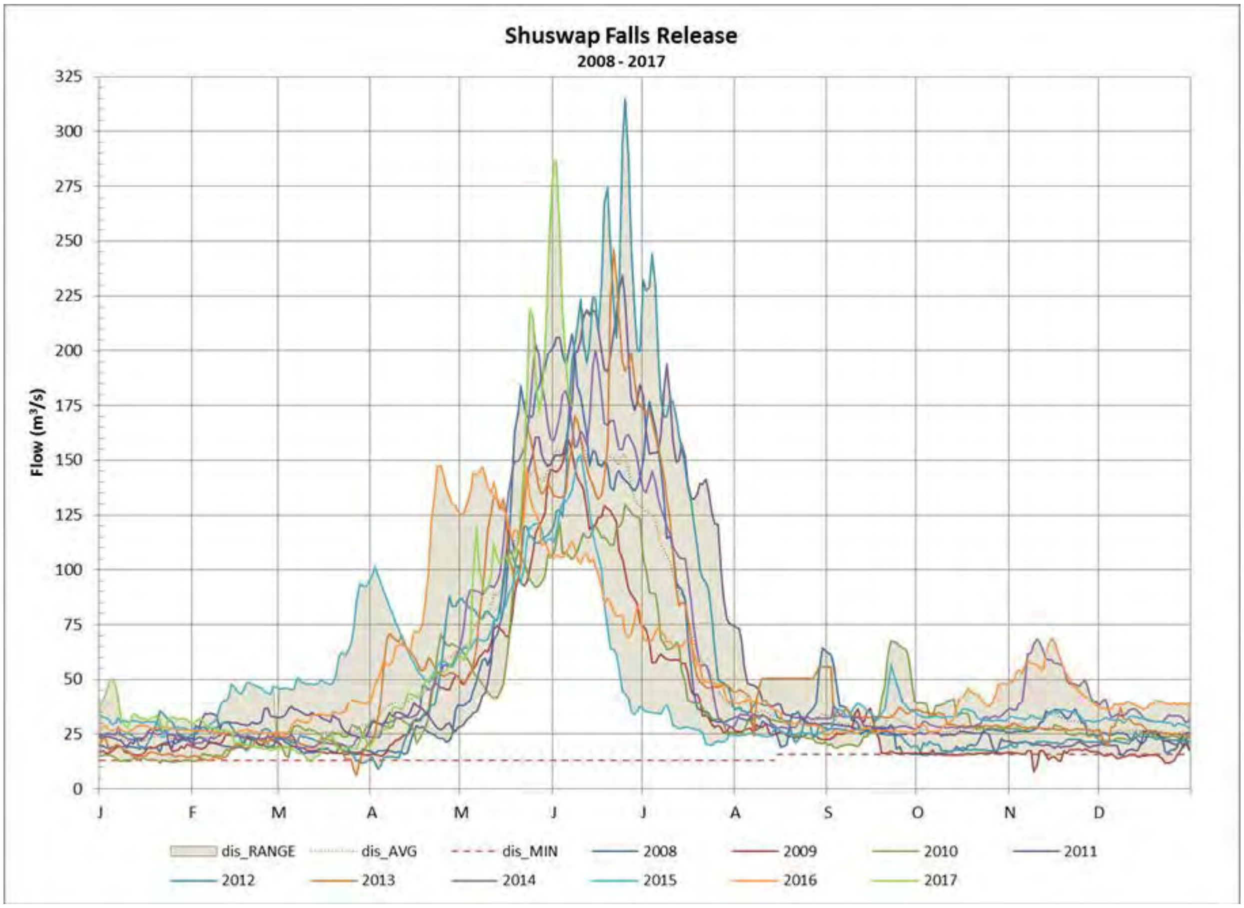

Figure 3. Shuswap River Flows Released Down Wilsey Dam Spillway (BC Hydro 2017 Pers Comm)

Mean daily flow data for water years 1999 through 2014 (n=15) from Canadian gage station 08LC003 on the Shuswap River near Lumby was obtained via the Canadian National Hydrological Service's website (wateroffice.ec.gc.ca). Mean daily data prior to 1999 appeared inconsistent and was not selected for further analysis. An exceedance analysis was then performed on the flows at this site. Annual flow exceedance flows are summarized in Table 7.

Table 8. Annual Flow Exceedance

Percent of Time Exceeded	Flow (m^3/s)
99%	16
95%	18
90%	19
80%	21
75%	22
50%	28
25%	59
10%	131
5%	171
1%	222

Forebay Fluctuation

Forebay fluctuations upstream of Wilsey Dam change based upon seasonal river conditions and operational flows. During low river flow conditions, forebay elevations range from 444.1 to 444.5 meters. During high flow conditions, forebay elevations have been measured to be as high as 448 meters but typically range between 446 and 447 meters. The total forebay fluctuation may range from 444 to 448 meters on an annual basis based upon the information available. A more detailed analysis of forebay fluctuation is not warranted at this stage of development. A detailed analysis will be conducted in future stages of development.

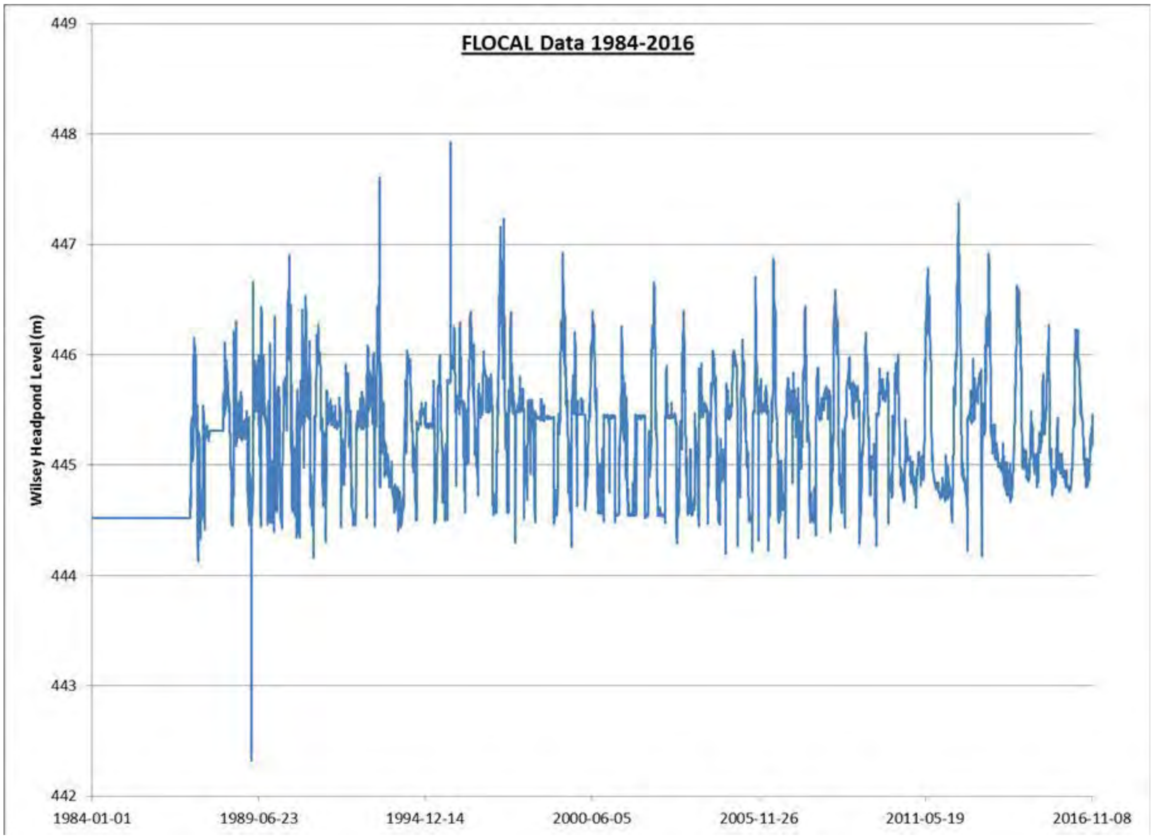

Figure 4. Historical FLOCAL Data for Wilsey Headpond (BC Hydro 2017 Pers Comm)

Tailwater Fluctuation

Tailwater fluctuations at the project location are not readily available with the information provided.

Geology

Key information provided in the Geotechnical Information section of the 2005 Fishway Feasibility and Design document that may be of significance for this passage design effort are included below (WDFSC 2005).

Development of Design Criteria

Performance and fish passage design criteria are developed based upon the known site-specific biological and physical factors that could influence the type, size, and complexity of the potential fish passage project. The following paragraphs summarize the rationale and conclusions associated with specific design criteria developed for the physical and biological conditions unique to the project location.

Biological Design Criteria

Limited data is available regarding the phenology, abundance, habitat requirements, distribution, and migration patterns of fish present in the vicinity of Wilsey Dam. Biological criteria were developed based on the information available. The three primary types of biological design criteria that have the most influence on facility type, size, and configuration relate to the following:

- Selected species and migration timing: Informs the selection of species and life stages targeted for fish passage design as well as their seasonality, anticipated hydrologic conditions, and duration of periods where these target fish species may be expected to migrate upstream of the dam.
- Species abundance: Informs the annual number of fish that require passage as well as the peak daily rate of migration that influences facility size and operation requirements.
- Trapping and Holding Criteria: Informs the requirements for fish trapping and holding, including, but not limited to, holding volume, duration, temperature, and water supply.

Selected Target Species

Adult Chinook, sockeye, and coho salmon are selected as the target species for design. Their behavior, migration patterns, and size characteristics are used to inform specific design elements, features, and dimensions.

Period of Migration

The target fish species are anticipated to migrate upstream between the start of July to the end of November.

Population Abundance

There is limited information available on historic population trends or recovery targets for each target species. Available information suggests that the annual number of adult fish requiring passage above Wilsey Dam is about 80,000 (McGrath et al. 2014). Future reintroduction and recovery efforts may indicate that greater numbers of fish would need to be accommodated should a long-term fish passage facility be considered.

Rates of Migration

There is limited information available on peak rates of migration for each target species. For the purposes of this document, the peak daily count of salmon and steelhead migrating upstream were estimated as 10% of the maximum annual run (WDFW 1992), and peak hourly counts were estimated as 20% of the peak daily count based on Bell (1991), and as cited in NOAA Fisheries (2011). Using this methodology and the values presented in the literature, a peak daily rate of migration could be approximated to be 8,000, with a peak hourly count estimated at 1,600 fish. These values are conceptual in nature and could vary substantially from the actual frequency and occurrence of fish at Wilsey Dam. Future monitoring would need to occur to verify actual rates of migration.

Technical Design Criteria

Technical fish facility design criteria typically fall into two categories – criteria and guidelines. Criteria are specific standards for fish passage design that require an approved variance from the governing state or federal agency before a design can deviate from the established criteria. Deviating from an agency-established criterion requires establishing a site-specific, biological- or physical-based rationale for the deviation. In contrast, guidelines provide a range of values, or in some instances, specific values that the designer should seek to achieve but that can be adjusted in light of project-specific conditions, if needed, to achieve the overall fish passage objectives for a project by supporting better performance or solving site-specific issues. Adjustments to a design may be requested by the governing agencies during development of the design. Ultimately, if two or more agencies provide differing guidance on a specific design criterion, the most conservative guidance from a fish passage and protection standpoint should be followed.

For the purposes of conceptual design, it is assumed that technical design criteria are developed in conformance with the guidance and guidelines presented in the document titled Anadromous Salmonid Passage Facility Design, published by the United States National Marine Fisheries Service (NMFS 2011). For brevity, not all technical design criteria applicable to the proposed system are presented in this document.

Selection of Fish Passage Flows

Fish passage design flow criteria influence several factors associated with fish passage facility size and complexity. NMFS provides guidelines for the selection of high and low flows to be used in the design of fish passage facilities. Guidelines presented by NMFS are based on exceedance calculations of mean daily flows but can be modified to suit site-specific requirements. The exceedance flows statistically represent the flow equaled or exceeded during certain percentages of the time when migrating fish may be present. The established guidelines are used to set instream flow depths, flow velocities, debris and bedload conditions, fish attraction requirements, tailwater fluctuations, and numerous other factors that a facility might experience while target fish species are migrating.

NMFS (2011) requires the high fish passage design flow to be the mean daily stream flow that is exceeded 5 percent of the time during periods when target fish species are migrating. NMFS (2011) requires a low fish passage design flow equal to the mean daily stream flow that is exceeded 95 percent of the time during periods when migrating fish are typically present. A flow range between the 95 percent and 5 percent exceedance flows provides the widest range of flows for which facilities should be capable of passing fish, therefore, this flow range is set as the design criteria for the proposed facilities.

Five percent and 95 percent exceedance flows at the dam site were also calculated for targeted species using their respective upstream migration timing established in the Biological Setting section of this document. The lowest 95 percent exceedance flow and the largest 5 percent exceedance determined the fish passage design flow that this fish passage facility will be designed for. The lowest 95 percent exceedance flow is 18 cubic meters per second, which occurs during the coho migration period. The highest 5 percent exceedance flow is 150 cubic meters per second, which occurs during the Chinook salmon migration period. Therefore, fish passage facilities should be designed to operate from a low fish passage flow of 18 to 150 cubic meters per second.

Table 9. Flow Exceedance during Adult Fish Migration Periods

Species	95% Exceedance (m^3/s)	5% Exceedance (m^3/s)
Chinook	19	150
Coho	18	59
Sockeye	19	60

Selection of Attraction Flow

Determination of an effective attraction flow will vary based upon the location of the proposed fish guidance and/or collection components of the proposed fish passage facility. The total stream flow is split into three separate flow paths as it is conveyed downstream of the hydropower facility. Initially, flow is diverted from the Shuswap River into the penstock intakes at the project forebay. The remainder passes downstream over the spillway channel. As described in previous sections of this document, a portion of the river flow conveyed down the spillway channel overflows into the old river channel. For the purposes of this document, the bypass pool just upstream of the powerhouse is targeted for fish collection into the Whooshh system. Given the above assumptions, the flow conveyed down the old river channel should be used to establish the target design attraction flow. At a minimum, attraction flow should be designed to be at least 5% of the total anticipated 5% exceedance fish passage design flow. At the time this document was prepared, there was no quantitative method of knowing what proportion of flow was conveyed down the spillway channel versus the old river channel. For the purposes of developing a conservative estimate, the maximum intake flow of 15 cubic meters per second was negated and it was assumed that one-third of the flow passed down the old river channel. Therefore, the estimated high mean daily fish passage design flow at the anticipated point of collection is 50 cubic meters per second and the total attraction flow would be on the order of 2.5 cubic meters per second.

Target Forebay Elevations and Potential Fluctuation

From the available information discussed previously and presented in Figure 4, the target forebay fluctuation for the proposed upstream passage system encompasses a 4 meter range of potential water surface elevations from 444 to 448 meters. This occurs during the anticipated period of upstream migration for the identified target species.

Target Tailwater Elevations and Potential Fluctuation

The target tailwater fluctuation for the proposed upstream passage system was not available at the time this document was developed. However, typical tailwater elevations are provided for the powerhouse located at the downstream end of the project. Given the general vicinity of this facility to potential fish collection points, a water surface range of 416.20 to 418.4 meters was assumed (see Table 1) for the purposes of concept development.

Total Anticipated Hydraulic Differential

In consideration of the low tailwater and high forebay elevations presented above, the total hydraulic differential anticipated to occur during the period of upstream fish migration is 30.8 meters.

Concept Formulation and Description

Whooshh is an evolving fish passage technology that has been adapted over the past decade to provide transport of live fish over distances of 510 meters at heights of over 75 meters. The technology is undergoing extensive pilot testing throughout the Pacific Northwest and Northeastern United States on live fish species ranging from salmon and steelhead to shad and sturgeon. Overall, the technology is gaining popularity with some resource agencies as a viable and potentially permittable option for safe and timely passage of fish over low-head and high-head barriers up to 250 meters in height. Data resulting from numerous pilot tests suggest that fish transport through the Whooshh system can be done safely and with faster transit times than other existing fish passage technologies. The technology is already being used successfully on live fish at hatcheries and aquaculture facilities around the world.

In general, the Whooshh system consists of a flexible plastic tube that is connected to an air pump. A pressure differential of about 7 to 14 kilopascals is induced in the tube between the front and the back of the fish, thus pulling and pushing the fish through the tube. Once in the tube, fish travel at a speed of approximately 4.5 to 9 meters per second and exit the tube directly into the desired body of water upstream of a passage barrier. Misters are located within the tube to keep the inside surface of the tube wet and relatively frictionless.

Fish enter the tube through a volitional entry system configured to attract, collect, and route fish into the transport tube entrance without the need for handling by humans. The volitional entry system is modeled from other proven trap and transport type systems which incorporate a short fish ladder section that enables fish to ascend from the river and into the collecting system. An Auxiliary Water System (AWS) is used to create an outflow of water from the entrance pool to attract fish and motivate them to enter into the fish ladder. Once in the fish ladder, the fish ascend to the top of the ladder and over a false weir. After fish ascend over the false weir, they then pass down a transport flume that would convey them into a scanner and diverter gate. As fish are scanned and their size characteristics are identified, the diverter gate changes position to guide the fish to the entrance of the appropriately sized transport tube. It is expected that a system accommodating adult migrating Chinook, coho, and sockeye would require a minimum of two tubes. The transport tubes would extend upstream and be secured to fabricated support stringers along the old river channel and then to an apex support tower located on the rock bar near Intake No. 2. The tower would function to suspend the tubes approximately 5 to 7 meters above the water surface. This would allow the tubes to remain suspended as they descend at a steady slope further into the forebay to a release point 80 to 100 meters upstream of the dam, reducing the potential for fall-back of fish down the spillway or entrainment into one of the intakes. The outlet would likely consist of a small floating platform, anchored in place using a shore-based anchor and cabling system that would accommodate the full range of forebay fluctuation and reduce the maximum drop height from the Whooshh tube to the forebay. The cabling system would remain over the water surface to ensure that it would not accumulate or be impacted by large floating debris conveyed down the river.

The volitional entrance of the transport tube system can be fixed into one position near the river shore or be mounted on a floating platform. For the purposes of this installation, a floating platform was selected so that the collection position could be changed over time. The floating platform gives the owner an opportunity to adaptively test collection performance at different locations. Although the change in location would require some level of effort, the floating entrance could be moved over several years of operation or seasonally to accommodate more effective fish collection locations. The impetus for such experimentation may be based upon the need to move to better hydraulic conditions in the river, to operate at a location favored by migrating fish, or for various other biomechanical, operational, or safety requirements of the project. One option at Wilsey Dam would be to collect fish in the bypass pool which exists just upstream of the powerhouse and adjacent to the existing turbine bypass valve. Another option would be to collect fish at the tailwater pool just downstream of the powerhouse.

Table 9 summarizes the anticipated functional elements that could be the basis of major design features for this concept.

Table 10. Summary of Anticipated Functional Elements

Project Element	Function and Intent
Integration of gravity Auxiliary Water Supply (AWS)	Provides attraction water up to 3 to 4 cubic meters per second at the volitional fish passage entrance to improve attraction under all potential fish passage conditions. It may be possible to tap the existing steel penstock just upstream of the bypass valve to provide this flow using gravity. Provisions for energy dissipation would be required prior to water from the penstock entering the AWS system.
Floating volitional entry platform	Provides a floating platform that integrates several critical elements of the volitional entrance system such as the fish ladder entrance, a short fish ladder, false weir, scanner, accelerator, and Whooshh tube entrance capable of accommodating fluctuations and flow velocities anticipated to occur while in operation at the bypass pool. These elements are described individually below but are integral to the floating platform.
Entrance designed for adult salmonids	Targets collection and use by adult salmonids motivated to migrate upstream and accommodates diffusion of AWS to promote attraction.
Technical fish ladder section	Provides vertical transition from the Shuswap River to a small elevated transition pool and false weir leading to the entrance of the Whooshh system.
Transition pool and false weir	Provides a short navigational corridor at the top of the fish ladder with uniform velocities and promotes attraction to and successful navigation over a false weir at the end of the pool section.
Sorting flume, diverter gates, and tube entrance	Scans for PIT tags, obtains photographs for monitoring purposes, sorts by size, and guides fish to the appropriate size Whooshh tube.

Project Element	Function and Intent
Two Whooshh tubes to the dam crest	Transports collected salmon to the forebay upstream of Wilsey Dam over a 300 to 350 meter distance.
Floating exit to accommodate forebay fluctuation and allow for safe transition from Whooshh tube to the forebay	Transfers fish exiting the transport tube safely to the forebay surface at a desired location and depth. Accommodates anticipated forebay fluctuation anticipated to occur during the period of migration.
Facility shelter and storage building	Allows for seasonal storage and protection of the transport tubes from extreme winter conditions when not in use.
Upgraded electrical service to the bypass pool	Provides the ability to operate more complex mechanical equipment such as instrumentation, control electronics, monitoring systems, motorized valves, and small water pumps.

Figure 5 provides an example concept of the floating volitional entrance platform. Figure 6 provides an example sketch of the overall system layout aerial photo.

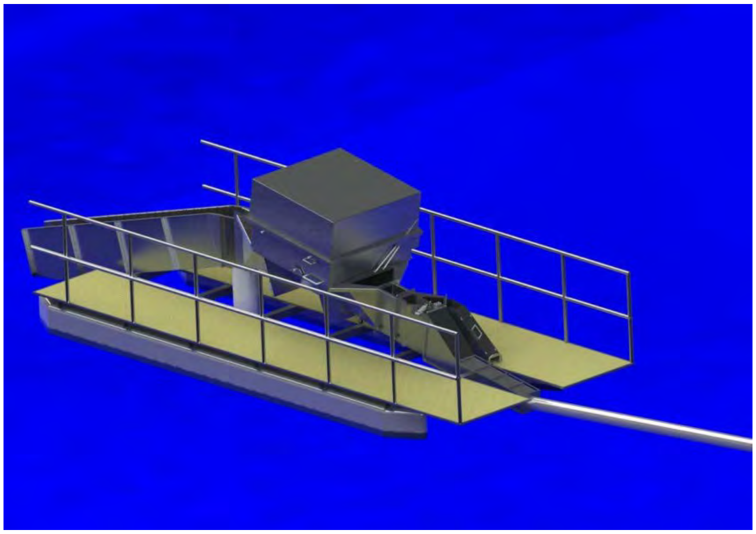

Figure 5. Concept Floating Collection Platform and Volitional Entrance to Transport Tube System

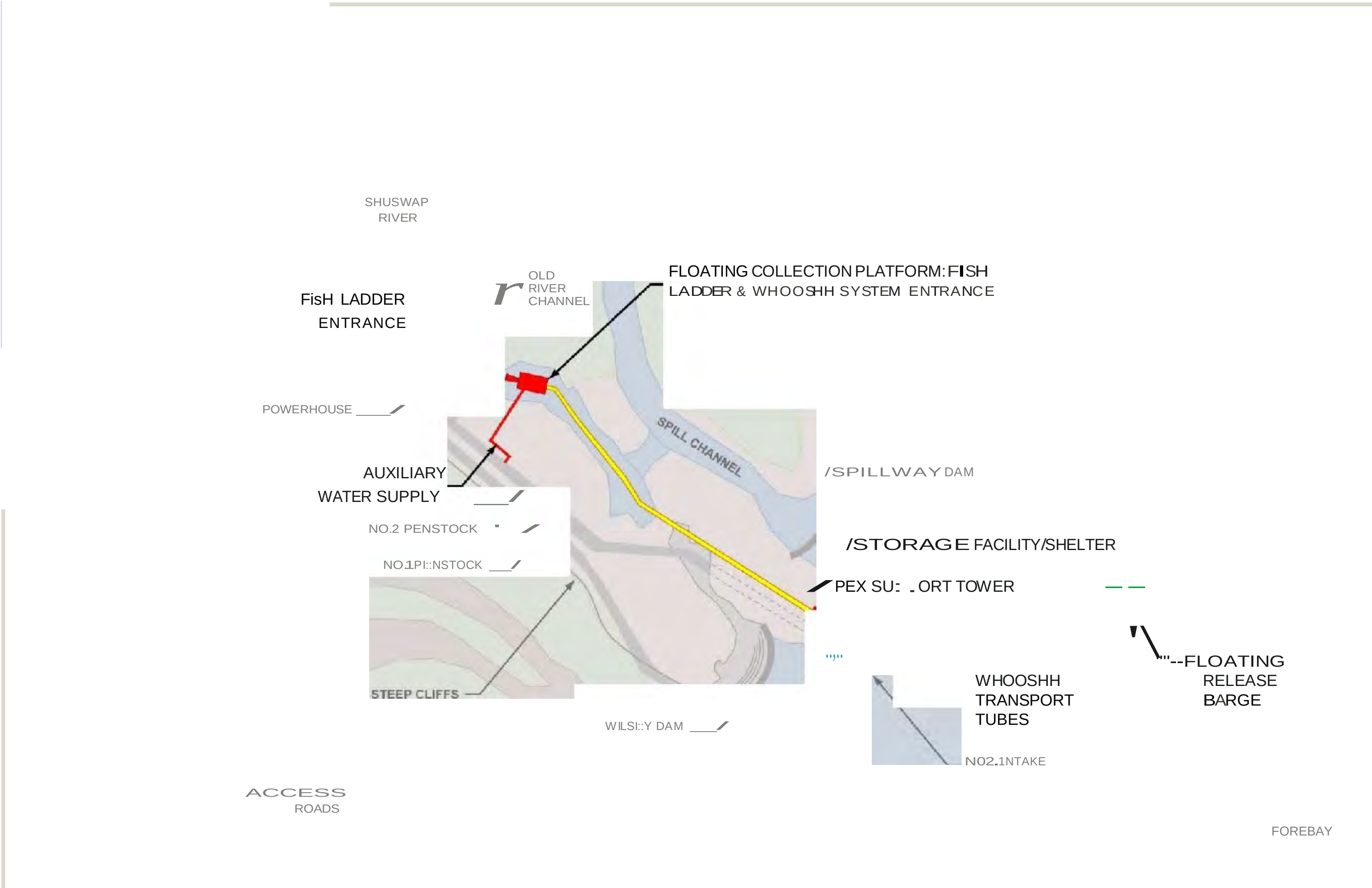

Figure 6.Plan View Sketch of Proposed Whooshh System Concept

Operational Theory

It is assumed that the transport tube system would be operated on a seasonal basis during periods when target species are actively migrating. This operational period is anticipated to occur for a duration of 5 months beginning the first of July and ending near the end of November. Throughout this duration, gravity AWS would supply attraction flow to the fish ladder entrance and false weir systems. A pair of smaller screened submersible pumps would supply water along the length of the tube to the temperature/moisture control misters.

During idle periods within the expected fish migration window, the air system would remain in an idle position and air would not be supplied to the accelerator. As fish actively break the plane of the fish ladder entrance, motion sensing equipment would inititiate a standby sequence and would remain at the ready until fish are sensed in the accelerator. When fish enter the accelorator, air pumps would immediately initiate the transport sequence and send fish through the transport tube to the designated release point. All systems would remain active and at the ready until a specified duraton has passed where no fish have moved into the collection inlet, at such point all air systems return to an idle state of readiness. While idle, attraction flow and temperature control system remain in operation.

While deployed and operating, the facilty would need to be observed on a daily basis and inspections would need to occur to ensure that systems are functioning as intended. Monitoring data can be collected, transmitted, and observed remotely via SCADA, however on-call personel would need to be available to respond to system alarms and other potential issues.

During non-operational periods, the system would be dismantled and stored in a secure location protected from the elements. After disconnection from the AWS, power source, and anchorage, the floating volitional entry platform would be removed from the water surface via crane and mounted on a trailer. While on the trailer, it could be transported to another secure location or left at the powerhouse behind locked gates. The transport tube could be collected, spooled, and kept in a new small storage building located on the rock bar upstream of the dam. This strategy will protect sensitive materials from the harsh winter elements, improve reliability, and is believed to reduce long-term replacement costs of the transport tube elements. This will also alleviate the need for debris management and removal at start-up which is likely needed for other traditional fish passage technologies.

The system is anticipated to be able to pass up to 12 fish per minute given the proposed distance and height of travel which corresponds to approximately 720 fish per hour. Although population estimates suggest peak hourly migrations rates up to 1,600 fish could occur at Wilsey Dam, further monitoring is required to verify actual rates of migration. If at some time additional capacity of the Whooshh system is required to accommodate greater numbers of migrating fish, additional tubes can be added.

Construction Sequencing and Duration

Construction and initial commissioning of the upstream passage system is anticipated to require a seven month construction period with the first four months devoted to off-site fabrication of long-lead items and the last three months devoted to on-site installation and field testing. The following sequencing would be expected as part of project construction:

- Shop drawing preparation and review;
- Fabrication of long-lead items, including:
    - Floating volitional entry system;
    - Tap and branch for penstock connection;
    - Energy dissipation valve;
    - Rock anchors and pedestals;
    - Outlet barge; and
    - Associated mechanical and electronic control equipment.
- Mobilization of equipment, materials, and personnel to the site;
- Installation of service power supply improvements;
- Installation of AWS tap into existing penstock and layout of conveyance piping;
- Installation of energy dissipation system;
- Installation of rock anchors, pedestals, and apex tower;
- Installation of support cable;
- Deployment and anchorage of outlet platform;
- Deployment and anchorage of volitional entry platform;
- Installation of transport tubes;
- Connection of AWS and electrical supply;
- Integration of instrumentation and controls;
- Demonstration period, testing, and commissioning; and
- Demobilization of construction equipment and personnel.

Summary of Costs

Order of magnitude construction, operations & maintenance, and administrative implementation costs were evaluated for implementation of the proposed technology at the Wilsey Dam location. The costs developed for this document is based upon limited information generated as part of concept alternative development and should be considered to be for comparative purposes only. In general, costs presented below are rounded and anticipated to be a high budgetary value. Should this alternative be selected for further consideration, more accurate cost information can be updated as the design development of the alternative progresses. All costs are presented in 2018 Canadian Dollars.

Lifecycle costs amortized over the expected life of the project were not calculated as part of this document.

Anticipated Opinion of Probable Construction Cost

An order of magnitude Opinion of Probable Construction Cost (OPCC) was developed for purposes of comparing the potential cost for this alternative concept to other alternatives previously developed by others. Cost data generated as part this OPCC is based upon bids received from other projects similar in nature, available vendor cost data, details from cost estimates prepared for other projects of similar scope, RS Means Cost data, and professional judgment. The OPCC is based upon the preliminary layout shown in Figure 6 and is developed to a level of detail commensurate with the AACE Class 5 standard. The anticipated base cost value for this project is estimated to be $4.5M and could range from as low as $3.3M (-25%) to as high as $6.2M (+40%) based upon the current level of detail and cost certainty. Cost assumptions and calculation details used to develop the OPCC are provided in Attachment B. Taxes imposed by local agencies or governments are not included as part of the OPCC and should be added onto the total OPCC provided. It is anticipated that an additional transport tube can be added for an approximate order of magnitude cost of $400,000 in the event with the initial volitional entry system design includes the capacity for the third transport tube (i.e. spare diverter gate and accelerator).

Operation and Maintenance Costs

Operation and maintenance costs include those reoccurring or one-time costs that are incurred over the life of the project. Operational costs are costs associated with items such as staffing required to keep the facilities functioning, power costs, regular debris cleaning, and periodic inspection. Labor is based on Full Time Equivalents (FTEs) for necessary resources. Maintenance costs are the costs associated with keeping system components functioning and actions that allow system components to achieve their optimal useful life, such as painting, lubrication of moving parts, repair of damage, replacement of broken or non-functional parts, updating electronic components, and improving PLC and SCADA programming. Expendables as well as equipment and electrical power costs are incorporated to the extent possible given the level of detail formulated as part of preliminary alternative development.

Table 11. Summary of FTEs anticipated for operation and maintenance.

Operations	Biologists	Maintenance	Total
0.38	0.50	0.31	1.19

Estimates of annual operating and maintenance costs are anticipated to be on the order of $156,000 per year inclusive of all labor, materials, expendables, and electrical costs. Allowances for one-time maintenance costs, such as part replacements, are amortized and included in the estimated yearly cost. A more detailed list of calculations and resulting values is provided in Appendix B.

Total Project Costs

At this level of development, the anticipated base Opinion of Probable Construction Cost (OPCC) is estimated to be on the order of $4.5M. Specific cost items are anticipated to include integration of an auxiliary water supply ($0.3M); the whoosh system floating entrance, transport, and floating exit ($2.1M); the facility shelter and storage ($0.2M); and upgrades to electrical service ($0.2M). Other additional anticipated construction costs included in the OPCC are general conditions, mobilization/demobilization, and site work with a design and construction contingency of 30% and are estimated to be $1.0M. For the purposes of this cost assessment, it is assumed that construction would begin in 2018 and would occur over a one year construction period with construction and installation work conducted on-site during the approved in-water work window.

Implementation of the Whooshh concept at the Wilsey Hydroelectric project will also require design, permitting, construction management, and commissioning of various civil, structural, piping, hydraulic, and electrical improvements. In concept, implementation costs are assumed to be 30.5% of the base OPCC and include approximate engineering, permitting, and construction management costs. See Attachment B for a detailed breakdown of cost assumptions. Based upon this assumption, project implementation costs are estimated to be on the order of $1.4M. Project implementation costs are assumed to begin in 2018 and end with construction in 2019.

The total project cost, including construction and implementation, is estimated to be on the order of $5.8M in 2018 Canadian dollars.

Discussion of Tradeoffs

This alternative exhibits the following advantages:

- Eliminates fish transport by truck and reduces the anticipated level of effort and expense of driving fish to or around the reservoir;
- Provides more timely passage than traditional trap and transport methods as fish are passed as they arrive (no holding time);
- Results from pilot testing suggest that injury and stress to fish is equal to or less than that of other conventional, upstream passage technologies;
- Anticipated to have a lower capital cost than fish ladders and similar capital cost to a trap and transport facility;
- Can more easily accommodate the full range of tailwater and reservoir fluctuations;
- Entrance and exit could be modified as needed to operate under a number of future conditions and different collection/release locations;
- Requires significantly less earthwork and potential dam modification than that of other alternatives such as a fish ladder; and
- Operation and maintenance effort is anticipated to be comparable to other trap and transport alternatives.

This alternative exhibits the following disadvantages:

- Potential for mechanical failure or power loss could interrupt fish passage until repaired;
- Anchorage for floating platforms can increase construction and seasonal start-up complexity;
- Transport tubes should be stored in enclosed location and protected from harsh winter elements and accumulation of ice;
- Currently an evolving technology that may require acceptance by regulating agencies.
- No long-term performance data.

Data Gaps, Limitations, and Further Evaluation Needs

The following data gaps and evaluation needs should be considered if this alternative is selected for further evaluation:

- Geology and competence of existing rock;
- Dam operating procedures – emergency and regular; flow release regime;
- Headwater curve and analysis of headwater fluctuation vs. lake inflow and dam outflow;
- Tailwater curve;
- Peak 100-year water surface elevations;
- Existing electrical service and facilities;
- Construction contracting limitations (e.g. – small / disadvantaged / First Nation / etc. contracting percentages; union / prevailing wage requirements);
- Shipping and material acquisition premiums due to site location;
- Coordination and buyoff on design criteria, features, etc. with government (e.g. – Fish and Wildlife Department, provincial and local government agencies, dam safety, etc.) and/or non-governmental agencies (e.g. – First Nations, recreation NGOs, environmental NGOs, etc.); and
- Confirm population targets and peak rates of migration.

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WDFSC (Wilsey Dam Fishway Steering Community). 2005. Wilsey Dam Passage Feasibility Study Phase 2: Project #04.Sh.01, Final Report. Prepared for Whitevalley Community Resource Centre Society.

WDFW (Washington State Department of Fish and Wildlife), 1992. Fishway Design Guidelines for Pacific Salmon.

ATTACHMENT A-PROJECT PHOTOGRAPH LOG

Photo 1. Forebay of Wilsey hydroelectric project looking downstream.

Photo 2. Forebay upstream of spillway crest (downstream to the left). Debris boom in foreground.

Photo 3. Wilsey Dam structure (right) and Intake No. 1 (left).

Photo 4. Wilsey Dam (left) and Intake No. 2 (right).

Photo 5. Spillway crest (downstream to the left).

Photo 6. Spillway with forebay in background.

Photo 7. Downstream face of Wilsey Dam concrete arch.

Photo 8. Looking downstream at existing penstocks and old river channel.

Photo 9. Confluence of spillway flow: spillway channel (left) overflow to old river channel (right).

Photo 10. Existing power generation facility with Wilsey Dam in the background. “Bypass pool,” to left of structure.

Photo 11. Existing power generation facility and point of downstream access.

ATTACHMENT B-OPCC AND O&M COST DATA

WHITEVALLEY COMMUNITY RESOURCE CENTRE
CONCEPT EVALUATION OF FISH TRANSPORT SYSTEM AT WILSEY DAM

SUMMARY OF ANTICIPATED FISH PASSAGE ALTERNATIVE COSTS

Table 1 - Project implementation costs for all alternatives shown as a percentage of the OPCC.

PROJECT IMPLEMENTATION COSTS	PERCENTAGE OF OPCC
CONSTRUCTION MANAGEMENT	8.00%
APS PROCUREMENT	4.00%
ENGINEERING AND DESIGN	10.00%
LOCAL AND ENVIRONMENTAL PERMITTING	6.00%
BOND AND INSURANCE	2.50%
APPLICABLE TAXES (NOT INCLUDED)	0.00%
PROJECT ADMINISTRATIVE (NOT INCLUDED)	0.00%
TOTAL PERCENTAGE OF OPCC	**30.50%**

Table 2 - Summary of concept OPCC (rounded to $10,000).

ALTERNATIVE	BASE OPCC W/ CONT
UPSTREAM FISH PASSAGE: WHOOSHH	$4,460,000

Table 3 - Summary of OPCC, implementation cost, and total project costs for each concept (rounded to $100,000).

ALTERNATIVE	BASE OPCC	IMPLEMENTATION COST	TOTAL PROJECT COST
UPSTREAM FISH PASSAGE: WHOOSHH	$4,460,000	$1,360,300	$5,820,300

Table 4 - Summary of anticipated Operations and Maintenance Costs (rounded to $1,000).

ALTERNATIVE	BASE O&M COST
UPSTREAM FISH PASSAGE: WHOOSHH	$157,000

WHITEVALLEY COMMUNITY RESOURCE CENTRE
CONCEPT EVALUATION OF FISH TRANSPORT SYSTEM AT WILSEY DAM SUMMARY OF

ANTICIPATED FISH PASSAGE ALTERNATIVE COSTS, BY MAJOR COST ITEM

ITEM	TOTAL
MOBILIZATION AND DEMOBILIZATION (10%)	$206,000
GENERAL CONDITIONS (20%)	$147,000
SITEWORK AND ACCESS IMPROVEMENTS	$150,000
INTEGRATION OF AUXILIARY WATER SUPPLY	$302,000
WHOOSHH FLOATING ENTRANCE	$430,000
WHOOSHH TRANSPORT	$1,507,500
FACILITY SHELTER AND STORAGE	$200,000
WHOOSHH FLOATING EXIT	$190,000
UPGRADED ELECTRICAL SERVICE	$150,000
SUBTOTAL CONSTRUCTION COSTS	**$3,282,500**
UNDEFINED DESIGN AND CONSTRUCTION ITEMS (30%)	$984,750
SUBTOTAL W/ CONTINGENCY	**$4,300,000**
ESCALATION (3.5% PER YEAR)	$150,500
TOTAL OPCC	**$4,450,500**

WHITEVALLEY COMMUNITY RESOURCE CENTRE

CONCEPT EVALUATION OF FISH TRANSPORT SYSTEM AT WILSEY DAM

OPINION OF PROBABLE CONSTRUCTION COSTS

ITEM	QUANTITY	UNIT	UNIT COST	AMOUNT	TOTAL
MOBILIZATION AND DEMOBILIZATION (7%)	**1**	**LS**	**$205,065**	**$206,000**	**$206,000**
GENERAL CONDITIONS (5%)	**1**	**LS**	**$146,475**	**$147,000**	**$147,000**
SITEWORK AND ACCESS IMPROVEMENTS	**1**	**LS**	**$150,000**	**$150,000**	**$150,000**
INTEGRATION OF AUXILIARY WATER SUPPLY	**1**	**LS**		**$302,000**	**$302,000**
MODIFICATION TO EXISTING PENSTOCK NO. 2	1	LS	$130,000	$130,000	
WATER SUPPLY PIPE	60	LM	$1,200	$72,000	
ENERGY DISSIPATION & DIFFUSION	1	LS	$100,000	$100,000	
W OOSHH FLOATING ENTRANCE				**$430,000**	**$430,000**
FLOATING PLATFORM	1	LS	$250,000	$250,000	
STEEPASS SECTION	1	LS	$45,000	$45,000	
TRANSITION AND FALSE WEIR	1	LS	$30,000	$30,000	
AWS OUTFALL	1	LS	$30,000	$30,000	
ANCHORAGE AND CABLING	1	LS	$75,000	$75,000	
WHOOSHH TRANSPORT	**1**	**LS**		**$1,507,500**	**$1,507,500**
SORTING FLUME AND DIVERTER GATES	1	LS	$45,000	$45,000	
SCANNER	2	LS	$100,000	$200,000	
ACCELERATOR	2	LS	$100,000	$200,000	
WHOOSHH TUBE AND CABLE	700	LM	$900	$630,000	
TUBE SUPPORTS AND HARDWARE	58	EA	$4,500	$262,500	
TOWER NEAR EXIT	1	LS	$50,000	$50,000	
ELECTRONICS AND CONTROLS	2	LS	$60,000	$120,000	
FACILITY SHELTER AND STORAGE	**200**	**SQ M**	**$1,000**	**$200,000**	**$200,000**
WHOOSHH FLOATING EXIT	**1**	**LS**		**$190,000**	**$190,000**
FLOATATION PLATFORM	1	LS	$40,000	$40,000	
ANCHORAGE AND CABLING	1	LS	$150,000	$150,000	
UPGRADED ELECTRICAL SERVICE	**1**	**LS**	**$150,000**	**$150,000**	**$150,000**
SUBTOTAL CONSTRUCTION COSTS					**$3,282,500**
UNDEFINED DESIGN AND CONSTRUCTION ITEMS (30%)					**$984,750**
SUBTOTAL W/ CONTINGENCY					**$4,300,000**
SUBTOTAL W/ ESCALATION					**$4,300,000**
Escalation to 2018 Dollars	3.50%	LS	$4,300,000	$150,500	
TOTAL OPCC					**$4,450,500**

WHITEVALLEY COMMUNITY RESOURCE CENTRE
CONCEPT EVALUATION OF FISH TRANSPORT SYSTEM AT WILSEY DAM

ANTICIPATED ANNUAL OPERATION AND MAINTENANCE COSTS

Item	Quantity	Unit	Unit Cost	Amount	Total
LABOR	**1**	**LS**		**$149,657**	**$149,657**
Maintenance direct labor cost	0.25	FTE	$71,250	$17,813	
(average 10 hr/week for 12-month operating period)					
Maintenance benefits @1.15 labor cost	0.25	FTE	$81,938	$20,484	
1- Fisheries technician direct labor cost	0.5	FTE	$75,000	$37,500	
(Half time, all year-round)					
Fisheries technician benefits @ 1.15 labor cost	0.5	FTE	$86,250	$43,125	
1 - Seasonal technician direct labor cost	0.38	FTE	$30,000	$11,250	
(average 20 hrs/week for 9-month intensive operating period)					
Seasonal technician benefits @ 0.85 labor cost	0.38	FTE	$25,500	$9,563	
Annual inspections and Maintenance	0.06	FTE	$75,000	$4,615	
(assume 2 people for quarterly (4) 2-day periods)					
Annual inspections and Maintenance	0.06	FTE	$86,250	$5,308	
FTE = Full time equivalent					
EXPENDABLES AND REPLACEMENT COSTS	**1**	**LS**		**$5,500**	**$5,500**
ELECTRICAL	**1**	**LS**		**$1,232**	**$1,232**
General service loads for year-round operation (control gates, monitoring, etc.)	10950	kWh	$0.11	$1,232	
Assume average of 30 kWh/day					
TOTAL ANTICIPATED OPERATIONS AND MAINTENANCE COSTS					**$156,389**

Appendix D – Technical Information Solicitation from Agencies

D1 – Request Letters for technical support to BC Hydro, DFO and FLNRORD

D2 – DFO Letter 2011 (Hwang)
DFO Letter 2016 (Crowe)
DFO Letter 2017 (Crowe)

D3 – BC Hydro Email (Leake)

D4 – FLNRORD Letter

Wilsey Dam Fish Passage Committee

Doug Edwards and Michael Crowe
Fisheries and Oceans Canada

November 23, 2017

Doug Edwards and Michael Crowe

Members of the Wilsey Dam Fish Passage Committee are currently in the process of completing a technical feasibility assessment and drafting a fish passage plan for Wilsey Dam. A draft plan for fish passage at Wilsey Dam will be circulated for review in approximately mid-December. At this time, we would like to solicit input from your agency to better inform contents of the draft plan, as outlined in BC Hydro's Fish Passage Decision Framework for Existing Facilities (2017). There will be further opportunity to review and comment on the plan once it is circulated. Specific topics we would like to solicit input on are listed below but please provide input on any additional topics as you see fit:

1. Please describe current management objectives for anadromous salmon in the Middle Shuswap River (e.g. escapement targets, egg to fry survival, life history types, % hatchery component, hatchery needs/requirements...)
2. What are the regulatory considerations required under the Fisheries Act, or Species at Risk Act to support the fish passage plan? What specific permits and approvals are needed and please describe the process and approximate timelines, if applicable?
3. Please indicate a high level outline of the preferred approach to fish re-introduction above Wilsey Dam for the first years following passage. E.g., allow passage for a smaller proportion of the chinook/coho/sockeye run initially, then increase annually up to x% of the total run? This does not necessarily have to include numbers but can be a brief description of the preferred approach.
4. Please indicate some critical monitoring components for anadromous stocks once fish passage is established (e.g., fallback, spawner enumeration and distribution, passage efficiency, entrainment...). A section on monitoring will be circulated in the draft in mid-December; however, we would like to solicit input up front to expedite the review process.

Sincerely,

Ms. Gay Jewitt, Chair on behalf of the Wilsey Dam Fish Passage Committee

C/O Whitevallcy Community Resource Centre 2114 Shuswap Avenue Box 661 Phone (250) 547·8866 Fax (250) 547-6285
in(o hitevalley.ca www.whitevalley.ca

Wilsey Dam Fish Passage Committee

Tara White and Rich McCleary
Forests, lands, Natural Resource Operations and Rural Development

November 23, 2017

Tara White and Rich McCleary

Members of the Wilsey Dam Fish Passage Committee are currently in the process of completing a technical feasibility assessment and drafting a fish passage plan for Wilsey Dam. A draft plan for fish passage at Wilsey Dam will be circulated for review in approximately mid-December. At this time, we would like to solicit input from your agency to better inform contents of the draft plan, as outlined in BC Hydro's Fish Passage Decision Framework for Existing Facilities (2017). There will be further opportunity to review and comment on the plan once it is circulated. Specific topics we would like to solicit input on are listed below but please provide input on any additional topics as you see fit:

1. Please describe current management objectives for resident fish stocks in the Middle Shuswap River above and below Wilsey Dam (e.g., Rainbow, Bull Trout, Kokanee).
2. Are there any provincial regulatory considerations that we need to acknowledge into our fish passage feasibility plan (e.g., Water Sustainability Act)? What specific permits are needed and please describe the process and approximate timelines, if applicable?
3. Is fish passage of resident salmonids wanted by MFLNRORD? This will require operation of the fishway through the spring period which is planned for in the current feasibility level technical design. We would like to confirm your agency's fish passage preferences and goals for resident stocks at this point.
4. Please indicate some critical monitoring components for resident salmonid stocks once fish passage is established (e.g., fallback, spawner distribution, passage efficiency, entrainment...). A section on monitoring will be circulated in the draft in mid-December; however, we would like to solicit input up front to expedite the review process.

Sincerely,

Ms. Gay Jewitt, Chair on behalf of the Wilsey Dam Fish Passage Committee

C/O Whitevalley Community Resource Centre 2114 Shuswap Avenue Box 661 Phone (250) 547-8866 Fax (250) 547-6285
info@whitevalley.ca www.whitevalley.ca

Wilsey Dam Fish Passage Committee

Alf Leake, Adam Croxall and Katy Jay
BC Hydro

November 23, 2017

Alf Leake, Adam Croxall and Katy Jay

Members of the Wilsey Dam Fish Passage Committee are currently in the process of completing a technical feasibility assessment and drafting a fish passage plan for Wilsey Dam. A draft plan for fish passage at Wilsey Dam will be circulated for review in approximately mid-December. At this time, we would like to solicit input from your agency to better inform contents of the draft plan, as outlined in BC Hydro's Fish Passage Decision Framework for Existing Facilities (2017). There will be further opportunity to review and comment on the plan once it is circulated. Specific topics we would like to solicit input on are listed below but please provide input on any additional topics as you see fit:

1. Does the hydrological modelling presented in the NHC report adequately capture current operational conditions, and if not, is updated modelling available or does it need to be completed?
2. Is there any new or updated information that we should be aware of that can inform the fish passage technical feasibility report (e.g., entrainment rates and mitigation?)
3. Please provide information on entrainment rates at other BC Hydro dams, and entrainment reduction approaches and technologies. Ideally this would include report references and approximate costs.
4. Please provide relevant documents {e.g., implementation plan, goals, biological monitoring program) for other BC Hydro fish passage/dam removal projects that have been or are in the process of being completed (e.g., Illecillewat River, Salmon River, others?).

Sincerely,

Ms. Gay Jewitt, Chair on behalf of the Wilsey Dam Fish Passage Committee

C/0 Whitevalley Community Resource Centre 2114 Shuswap Avenue Box 661 Phone (250) 547-8866 Fax (250) 547-6285
info@whitevalley.ca www.whitevalley.ca

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1+1 Fisheries and Oceans Canada
Peches et Oceans Canada

985 McGiU Place,
Komloops V2C 6X6

Your fil Votr1 rlftrmf:c:

April 14, 2011

Ollr file Noh" rifertiiCI!!
(REF / FILE NO.)

Whitevalley Community Resource Centre
P.O. Box 661
2'14 Shuswap Avenue
Lumby, BC
VOE2GO
Phone: (250) 547-8866
FAX: (250) 547-6285

Dear Gay Jewitt:

Subject: Wilsey Dam Fish Passage Goals, Information Gaps and Considerations for Fisheries and Oceans Canada

Fisheries and Oceans Canada (DFO) is pleased to be a part of the BC Hydro Fish Passage Protocol that is being undertaken under the umbrella group, "Wilsey Dam Fish Passage Committee".

DFO appreciates the energy and support for restoring fish passage at Wilsey Dam from the community at large. Jt is of key importance to DFO that all interested parties are infonned and engaged in the fish passage process in order to achieve consensus as the project evolves within the BC Hydro Fish Passage Protocol.

From a DFO perspective, there are no apparent concerns with regards to disease or competition between anadromous and resident fish stocks within the Middle Shuswap River. All of the stocks which will access the portion of river above Wilsey Dam currently coexist downstream of the dam. DFO acknowledges that while there will be the potential for changes in populations above the dam there should be an overall net benefit to the aquatic resource with the renewed jncrease in ecological connectivity.

With regard to the re-colonization of the inaccessible section of stream above Wilsey Dam, DFO feels it is important not to pursue a 'trap and truck' approach to the recolonization of the river, but would prefer to allow fish to naturally recolonize upstream once passage is achieved. Natural recolonization may allow for the most habitat appropriate stock composition to be established above the dam and which may benefit Chinook salmon in panicular. In the Middle Shuswap River Watershed two distinct life history strategies are present. Within the mainstem of the Middle and Lower Shuswap River's 'ocean type' Chinook, those which migrate to the ocean 90 to 120 days after

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emergence, are dominant. Within the Bessette Creek Watershed, Chinook salmon exhibit a 'stream type' life history, where juveniles rear in fresh water for a year before migrating to the ocean. Life history variations are largely due to the thermal regimes in which the Chinook persist. While it is expected that above Shuswap Falls, the thermal regime in the mainstem would continue to be conducive to the ocean type life history, the tributary of Cherry Creek is likely suitable for 'stream type' Chinook salmon. Allowing for natural re-colonization of upstream habitat may allow for the re-establishment of both life histories populations.

It is important to ensure that fish passage will result in an overall net benefit to the fisheries resource. Although it is understood that there is extensive under utilized habitat upstream of the Wilsey Dam, there are significant unknowns and risks associated with the downstream migration, not only to the Chinook but for all species, including but not limited to timing, fish size and species behavior. As a result of the potential downstream fish loss passage improvements may result in a net loss to the fisheries resource.

To address this, a short and long tenn approach should be taken. In the longer term behavioral migration pattems will need to be looked at from a spatial, species and timing perspective. Within the short tenn, preliminary entrainment studies should be undertaken to determine the direct losses through the turbines and over the spiiJway. It is recommended that studies attempt to assess the immediate and short tenn mortalities associated with downstream migration as well as the long term (smolt to adult) survival of salmon originating above Wilsey Dam.

The ONA proposal that has been developed is part of this process and fits well into the short term information collection. The Committee should use the time between now and the next fall funding submission deadline to collectively review and improve the submission. On a related point, DFO has concerns with availability of fish fat this study as Shuswap Falls Hatchery is currently at capacity with Shuswap Chinook and Okanagan sockeye. Over the short tenn, there may be some limitation in our ability to provide fish for the enttainment study, however, we will do our best to accommodate thjs.

From an operational perspective DFO will be considering several aspects that will impact vatious sectors internally as the protocol process proceeds. These include but are not limited to:

- The ability to enumerate both juveniles and adults migrating through the flshway should be integrated into the operational plan. Fishway design should accommodate automated enumeration devices (i.e. resistivity and/or video), as well as a controlled trap box to allow *fot* the capture and physical assessment of migrating salmonids.
- The development of escapement capacity estimates through habitat capacity models where they exist.
- Consultation with First Nations and other interests with regards to potential future harvest expectations.

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- The habitat referral area of interest would also be increased along with the subsequent workload that goes with it.
- The future demands on the Shuswap Falls Hatchery must also be reviewed from an enhancement/conservation perspective and the hatchery's capacity.

Should you have any questions or comments, please contact Patricia House directly by phone at 250-851-4920, by fax at 250-851-4951, or by e-mail at patricia.house@dfo-mpo.gc.ca.

Yours sincerely,

JJ -

Area Manager, Oceans Habitat & Enhancement
B.C. Interior Area

1+1 Fisheries and Oceans Peches et Oceans

Habitat & Enhancement Branch
Kamloops Office
985 McGill Place
Kamloops, B.C. V2C 6X6

Dec 5th, 2017

Ms. Gay Jewitt
Chair – Wilsey Dam Fish Passage Committee
C/0 Whitevalley Community Resource Centre
2114 Shusway Avenue
Box 661
VOE 2GO

RE: Wilsey Dam Fish Passage Letter Dated November 23,2017

I am writing in response to your November 23rct, 2017 request for information regarding inputs to the technical feasibility assessment draft plan for fish passage through the Wilsey Dam facility. I am excited to see progress on this issue as DFO has been a supporter of the communities (both local and First Nations) promoting fish passage through the Wilsey Dam for many years.

Your letter outlined four specific questions seeking further information and clarification with regards to fish passage, and the effects of fish moving above the dam and potentially back down through the facility or the new fishway. The department has attempted to answer each of these questions for you in a concise manner.

1) Please describe current management objectives for anadromous salmon in the middle Shuswap River (e.g. escapement targets, egg to fry survival, life history types, %hatchery component, hatchery needs/requirements...)

Sockeye, Chinook and Coho are all managed separately, and each has different management objectives. Management for each species has both domestic and international components. Middle Shuswap Chinook are managed to produce a Fraser River 41 indicator stock program, including releases of 150K coded-wire-tagged fry annually. They ae fished from Alaska all the way to the Mid Shuswap in commercial, First nations and recreational fisheries. Coho are managed primarily for conservation as part of the South Thompson Coho Conservation Unit. Fisheries are considerably constrained to conserve those populations. Middle Shuswap Sockeye are a part of the late South Thompson Sockeye aggregate and are managed under the Pacific Salmon Treaty. That aggregate can also be important contributors to commercial, First Nations and recreational harvests.

2) What are the regulatory considerations required under the Fisheries Act or Species at Risk Act to support the fish passage plan? What specific permits and approvals are needed and please describe the process and approximate timelines, if applicable?

Canada

It is DFO's understanding that based on historical archeological records and First Nation testimony that salmon species did exist and were able to access areas ofthe Upper Shuswap River above the current BC Hydro facility location during the time period before construction of the Wilsey Dam facility. Based on this evidence it is DFO's opinion that this is a re-establishment of salmon species to the upper Shuswap River (above Wilsey Dam) and therefore there is no need for a review by the federal-provincial Introductions and Transfers Committee. It is possible that a review and approval by DFO's Fisheries Protection Program (FPP) may be required. But as the intention of the project is to re-establish and restore fish and fish habitat access, there is no expectation that this will be a critical decision point for the project proceeding. DFO's Resource Restoration Unit will be able to work with FPP to address any concerns.

3) Please indicate a high level outline of the preferred approach to fish re-introduction above Wilsey Dam for the first years following passage. E.g., allow passage for a smaller proportion of chinook/coho/sockeye run initially, then increase annually up to x% of the total run? This does not necessarily have to include numbers but can be a brief description of the preferred approach.

DFO would prefer all species of fish that reside within the Shuswap River to have unrestricted access to the proposed fishway at Wilsey Dam, and ideally, on a year round basis. However, as a minimum, we would expect the fishway to operate from the initiation of Chinook migration to the end of the Coho spawning period. DFO feels that self-seeding should be allowed to occur, with monitoring to determine fish use and habitat preferences. Monitoring of fish migration, passage and habitat preferences can be used to determine if further management action would be required to optimize the use of the new available habitats.

4) Please indicate some critical monitoring components for anadromous stocks once fish passage is established (e.g. fallback, spawner enumeration and distribution, passage efficiency, entrainment...) a section on monitoring will be circulated in the draft in mid-December; however, we would like to solicit input up front to expedite the review process.

Monitoring within the proposed fishway and within the upper river will be a critical tool to assessing the efficiency of the fishway design and also the effects of re-introduction to upper river habitats by migrating fish species. Monitoring can take many shapes and forms but the DFO's would like the committee to consider the following concepts for the upcoming draft monitoring plan.

i) Enumerate fish species moving through the fishwaY (both up and down). This may be accomplished with electronic counters and video validation of counts. Additional surveys may be deployed in upstream habitats to assess spawning success and habitat preferences.

ii) Enumerate juvenile fish species outmigration either through the fishway or through the facility to determine population success and any entrainment issues

iii) Monitor fishway efficiency and determine solutions for potential issues that may arise (e.g. fish migrating through the fishway multiply times, fish species having difficulty moving through the structure etc.)

iv) Assess upstream migration impacts on resident upstream fish populations

v) Assess upstream migration effects on existing upstream benthic invertebrate populations

vi) Assess upper river spawning and rearing numbers and locations of chinook and coho. If insufficient numbers of fish are returning within the first cycle, DFO may recommend some seeding of the Upper Shuswap River above the Wilsey Dam facility to enhance recolonization.

trff cerely,

9

Micliael Crowe
Section Head
Salmonid Enhancement Program
Fraser and Interior Area

Fisheries and Oceans Canada | Peches et Oceans Canada

985 McGill Place
Kamloops BC, V2C 6X6

11 May 2016

Gay Jewitt
Whitevalley Community Resource Centre
Box 661
Lumby BC VOE 2GO

Dear Ms. Jewitt

Subject: Wilsey Dam Fish Passage Goals and Entrainment Issues

Fisheries and Oceans Canada (DFO) remains pleased to be a part of the umbrella group, "Wilsey Dam Fish Passage Committee". DFO appreciates the energy and support for restoring fish passage at Wilsey Dam from the stakeholders and community at large. It is of key importance to DFO that all interested parties are informed and engaged in the fish passage process in order to achieve consensus as the project proceeds.

As you may recall, in the letter of 14 April 2011 from DFO to the Whitevalley Community Resource Centre, DFO had expressed concern regarding the potential for fish mortality due to entrainment in the BC-Hydro generator turbines and penstocks. The concern was that a high proportion of out-migrating fish could be killed due to entrainment, with a subsequent net loss of fish to the system. Thus, it was considered that this issue should be studied further, prior to implementation of fish passage, to forecast what the estimated loss would be and whether fish passage would result in a net loss.

Due to recent developments with the BC-Hydro Fish and Wildlife Compensation Program (FWCP), DFO has reconsidered the requirement for entrainment studies prior to implementation of fish passage. Consequently, no further entrainment studies are required, from the DFO perspective, prior to implementation of fish passage.

DFO still has a concern about potential fish mortality due to entrainment. However, it is felt that this concern can be addressed in two ways. Firstly, it is understood that there should be an existing sufficient body of knowledge based on literature and modelling to make an estimate of fish mortality due to entrainment, prior to implementation of fish passage. Secondly, entrainment mortality can also be managed *ex-post* (after the event) by rigorous monitoring of *actual* fish mortality and by mitigation measures such as physical works, management of the dam, and operational methods, once fish passage has been implemented. It is still important that fish passage result in no net loss and, preferably, a net benefit to fish populations.

If you have any questions or concerns, please contact Doug Edwards at 250-318-5711 or by email at Doug.Edwards@dfo-mpo.gc.ca, or myself at 250-851-4963 or by email at Michaei.Crowe@dfo-mpo.gc.ca.

tu? sincerely,

ij L Q

Michael Crowe
Section Head, Salmonid Enhancement Program
BC Interior and Lower Fraser Areas

Robyn Laubman

From:	Leake, Alf <Alf.Leake@bchydro.com>
Sent:	Monday, December 4, 2017 5:01 PM
To:	Leake, Alf; Croxall, Adam; Jay, Katy; Gay Jewitt (gjewitt@whitevalley.ca)
Cc:	Strajt, David; Elinor McGrath; Robyn Laubman; Wendy Gilbert
Subject:	FW: Technical information request
Attachments:	Hydro.pdf; Final_Report Strobe Light Study_Dec8_2016.pdf; 2011-07-05 Final Report.pdf

Gay – my comments below. I've included David Strajt to take a look as well.

David – the attached highlights a few questions from the Wilsey Fish Passage committee to help inform the development of their fish passage plan – can you take a look at #1 in particular?

1. I believe the modeling conducted to date is minimal at best, but is not critical to determining the feasibility of the options reviewed.
2. Entrainment rates described in historic documents from NHC (2005) and re-referenced in more recent reports from ONA provide an adequate representation of the entrainment risks for chinook outmigrants. Work we have done most recently on Puntledge seem to support the hypothesis that juveniles follow flow proportionally. As part of this work, we are looking at the effect of lighting to attract/repel fish to/from areas of interest. The Puntledge work (on early emergent chinook) suggests that fish are attracted to lights which may provide opportunities to guide outmigrants away from power intakes (the study tested the effectiveness of lights as a repellant and found the opposite effect…). A report on this work is attached. More work is planned this February.
3. As above, entrainment rates observed at Puntledge likely reflect proportion of flow (conservatively), but are more likely also defined by the depth of flow withdrawal and location of withdrawal relative to mainstem flows. If your assessment can speak to the likelihood of these two issues (depth of withdrawal of the power intakes, and the location of the intakes) influencing the proportion of fish diverted through the spillway, that would be good context for future assessment of entrainment mitigation needs.
4. Unfortunately, the Shuswap River is leading charge in terms of setting the precedent for how we want the endorsement process with the FWCP Board to proceed. There are some good reports completed so far: Synthesis reporting for Coquitlam and Alouette and the environmental feasibility report done by Burt for Salmon River (attached). Myself and Katy would be keen on helping Elinor with the report.

Hope this helps, thanks for the opportunity to provide input.

Alf.

From: Gay Jewitt [mailto:gjewitt@whitevalley.ca]
Sent: 2017, November 23 12:18 PM
To: Leake, Alf; Croxall, Adam; Jay, Katy
Cc: Elinor McGrath; Robyn Laubman; Wendy Gilbert
Subject: Technical information request

Hello Alf, Adam and Katy,

Members of the Wilsey Dam Fish Passage Committee are currently in the process of completing a technical feasibility assessment and drafting a fish passage plan for Wilsey Dam.

A draft plan for fish passage at Wilsey Dam will be circulated for review in approximately mid-December. At this time, we would like to solicit input from your agency to better inform contents of the draft plan, as outlined in BC Hydro's Fish Passage Decision Framework for Existing Facilities (2017). There will be further opportunity to review and comment on the plan once it is circulated. Specific topics we would like to solicit input on are listed in the attached, but please provide input on any additional topics as you see fit.

Thank you

Gay

Gay Jewitt ~ Executive Director
Whitevalley Community Resource Centre

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May 10, 2018 File: 34560-20-03/Shuswap River

Wilsey Dam fish Passage Committee
C/O Whitevalley Community Resource Centre
2114 Shuswap Avenue
Box 661

Attention: Gay Jewitt, Chair

Re: Response Wilsey Dam Fish Passage Committee – provincial priorities resident stocks.

Thank you for your letter dated November 23, 2017 requesting agency input to better inform the Wilsey Dam Fish Passage Plan. A response to your questions is provided below as well as additional elements the province would like to see should fish passage be implemented.

1. Current Management Objectives for resident fish stocks in the Middle Shuswap river and above Wilsey dam include:

- **Rainbow trout**: population monitoring, monitoring of habitat availability and use, identification of escapement targets, assessment of factors limiting trout production (ie. food supply availability), and ensuring stock conservation targets are met so as to maintain a sustainable recreational fishery in the Upper Shuswap (including Mabel and Sugar lakes) for future generations to come.

- **Bull trout**: assessment of stock status, angler effort and fisheries statistics (ie. fishing mortality), identification of factors limiting the growth of the population refinement of fishing regulations to maintain a sustainable quality char fishery and conserve wild stocks, and collection of habitat information within upstream tributaries to inform fisheries management decisions.

- **Kokanee**: stock assessment monitoring (in-lake juvenile production and adult escapement), identification of factors limiting stock abundance (ie. over fishing), stock conservation and maintenance of sport fishery opportunities on Mabel and Sugar Lakes.

Ministry of
Forests, Lands and
Natural Resource Operations
and Rural Development

Resource Management
Thompson Okanagan Region
102 Industrial Place
Penticton, BC V2A 7C8

Telephone: (250) 490-8200
Facsimile: (250) 490-2231

2. Provincial regulatory considerations for construction of Fish Passage at Wilsey Dam may include, but are not limited to: a Section 11 Water Sustainability Act (WSA) authorization for instream works, Wildlife Act fish salvage permit for removal/salvage of fish within the proposed construction site, a WSA license for water diversion, an ITC permit for introduction/re-establishment of fish stocks upstream of Wilsey Dam. Review and processing timelines for each of these differ and can range from 2 weeks (ie. fish salvage application) up to 3 months (Section 11 approval or ITC review). The contact for permitting and authorizations under the Water Act is Ray Reilly, Senior Authorization Specialist in Penticton. He may be reached at 250.490.2218 or Ray.Reilly@gov.bc.ca. Questions regarding the need for an Introductions and Transfer Committee (ITC) permit may be directed to Vicki Lewis (provincial committee rep/Fish Science Policy Analyst). Vicki may be reached at 778.698.9215 or via email at Vicki.Lewis@gov.bc.ca. Questions regarding fish salvage requirements under the Wildlife Act may be directed to myself.

3. Regional fish passage preferences and goals for resident stocks (ie. in terms of operation of the fishway):

- The Okanagan Fish and Wildlife section is cautiously supportive of the Wilsey Dam Fish Passage project. Potential benefits of fish passage for provincially managed species include access to important upstream rearing and refuge habitat for resident stocks in Ferry and Cherry creeks. It will also permit free access to rainbow and bull trout stocks migrating downstream from Mabel and Sugar lakes, but currently unable to return.
- Our preference is to see free unrestricted fish access at Wilsey Dam, which would mean year round operation of the fishway.

4. Critical monitoring components for resident salmonids once fish passage is established include:

- Use of fish ladder by all species and life-stages (not just salmonids)
    - o Enumeration how many fish travel through the ladder
    - o Evaluation of passage efficiency, fallback, entrainment and survival through the fishway
    - o Monitoring of migration timing, including –travel time through the ladder at various flows
    - o Real-time reporting of results

- If fish do not use the ladder, we need to determine why
    - o Problems with attraction flows
    - o Fish not physically able to traverse the ladder
    - o Fish preference/constraints

- Would also like to understand the changes in ecology as a result of fish passage
    - o How fish passage affects upstream salmonid production?
    - o How does it alter the ecosystem dynamics?

- Is there an on resident stocks – particularly in regards to disease transfer, habitat capacity and availability and food supply

I trust you have received the comments from The Province on the draft plan for fish passage at Wilsey dam, that were sent in April 2018.

If you have any questions regarding the information provided, please feel free to contact me at 250-490-2287.

Yours truly,

Tara C. White, R.P.Bio.
Senior Fisheries Biologist
Thompson-Okanagan Region

TW/cl

Cc: Rich McCleary, Regional Aquatic Ecologist, Kamloops

Appendix E – Monitoring Proposal

Wilsey Dam Fish Passage Baseline Monitoring Program

1. Background and context for the proposed project

Wilsey Dam was constructed on the Middle Shuswap River between Mabel and Sugar lakes in 1928 at which time it blocked anadromous salmon (Chinook, Coho, Sockeye) and resident fluvial and adfluvial fish populations (Rainbow and Bull trout) from accessing 29 km of upstream habitats. The footprint impact of Wilsey Dam is substantial, as former spawning, rearing and overwintering areas were permanently lost or seasonally reduced due to the barrier, reservoir flooding, flow diversions, or operating flows. Even though initial drawings showed a fish ladder leading into the spillway channel, the ladder was never built. However, nearly one century later, interest in re-establishing fish passage at the dam has remained as evidenced by the large number of studies conducted in its support.

The local community, formalized in the Wilsey Dam Fish Passage Committee (WDFPC) since 2011, has been working to achieve fish passage over four decades. The WDFPC is working through BC Hydro's *Fish Passage Decision Framework for Existing Facilities* (BC Hydro, 2017), which lays out information requirements and steps required for all proposed physical works that involve providing fish passage for upstream migrating adult fish at BC Hydro facilities:

1. Preliminary screening (did the facility block passage of a fish stock at the time of construction?)
2. Stakeholder and First Nation engagement and strategic watershed prioritization
3. Environmental feasibility studies
4. **Preliminary technical feasibility consideration**
5. Compensation program endorsement
6. Triple Bottom Line (TBL) business case development (Environmental Assessment, Financial/Technical Assessment, and Social Benefits Assessment)
7. BC Hydro Board of Directors approval

The WDFPC is in the process of completing Step 4 (technical feasibility) during winter 2017/2018. This step will conclude with submission of a Plan for Fish Passage at Wilsey Dam (*in draft*) which will mark the end of the proponent-driven stage (Steps 1-4) and the beginning of the FWCP/BC Hydro-driven stage (Step 5-7). It is anticipated that FWCP will make a decision regarding endorsement of fish passage in the spring of 2018 (Step 5). If endorsed, BC Hydro will undertake a TBL business case development. A decision regarding approval may take up to 2 years (2020) and it has been indicated that if approved, fish passage is approximately 3-5 years away from now (Croxall, pers. comm).

Several studies have indicated that the impact of anadromous access above the dam will have little to no negative impact on resident fish species and that fish passage is environmentally feasible (summarized in McGrath et al., 2014). The WDFPC proposes an adaptive management approach to fish passage at Wilsey Dam that uses monitoring data to understand if passage has the intended measurable benefits to fish populations. This approach requires adequate collection of baseline information on resident and anadromous fish stocks, which should be initiated several years before fish passage is implemented to characterize abundance, distribution and health as well as the natural variability in those factors (Members of the Wilsey Dam Fishway Steering Committee, 2005; Washington Salmon Recovery Funding Board, 2011). Commencing this monitoring program now will ensure that implementation of fish passage can proceed in a timely manner if approval is received in 2020.

This project focuses on the collection of baseline data for a minimum of 3 years before fish passage is implemented; it has been communicated that upon approval of fish passage, BC Hydro will begin covering monitoring costs to evaluate the post-fish passage time period (Croxall, pers. comm), which will include a more extensive anadromous component above the dam. The **goal** of this monitoring program is to provide baseline data on fish stocks that will form the basis for adaptive management following fish passage at Wilsey Dam.

2. Project Area

The Shuswap River originates in the Monashee Mountains and flows through Sugar, Mabel and Mara lakes before entering Shuswap Lake. The Middle Shuswap River refers to a 52 km stretch between Sugar and Mabel lakes, near Lumby, BC (Figure 1). Two BC Hydro-owned dams are located on this river: Sugar Lake (Peers) Dam at the oulet of Sugar Lake and Wilsey Dam at the location of Shuswap Falls (approximately ½ way between Sugar and Mabel lakes). A hydroelectric generating facility is located at Wilsey Dam; however, the headpond at the dam is small and most storage is provided by Sugar Lake Dam approximately 29 km upstream. Two major tributaries within this reach are Cherry Creek and Ferry Creek, which flow into the Middle Shuswap River near Cherryville, BC. The Cherry Creek watershed is almost entirely forested, except for some

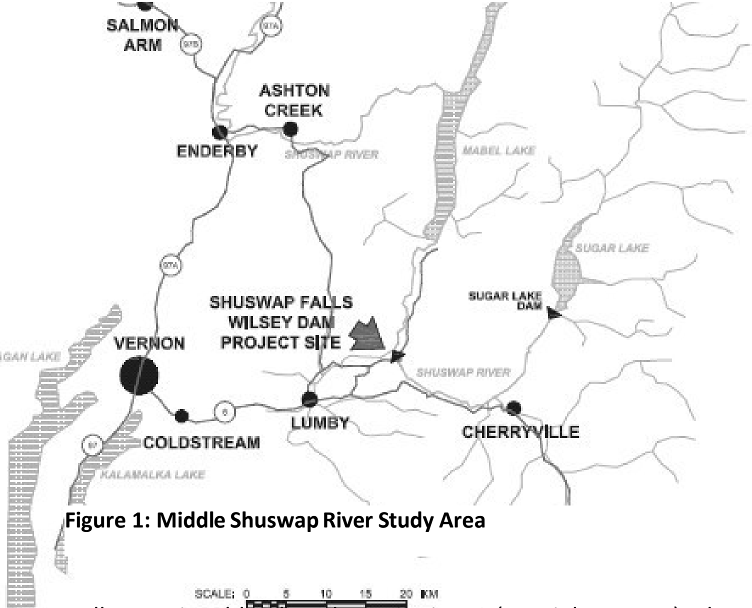

Figure 1: Middle Shuswap River Study Area

ltural activity in the lowest reaches and for the uppermost ·, which are above the treeline. Ferry Creek enters the wap River 2 km further downstream and is also almost ly forested. Its headwaters are a swampy plateau at an ion of nearly 2,000 m. Below Wilsey Dam, the major ary is the Bessette Creek system.

M iddle Shuswap River supports anadromous (Chinook, and Sockeye salmon) and resident (Rainbow and Bull Kokanee) game fish species. Since fish passage above y Dam was blocked in 1928, only resident fish populations n in this section though past reported abundances are low. ple coarse fish and minnow species occur throughout, as a very abundant population of Whitefish (Triton, 1995).

Bull Trout is a blue listed species in BC (special concern). The population between Wilsey and Sugar Lake dams has a fluvial life history (adults rear in the mainstem river and spawn in tributaries, juveniles rear in the tributaries for several years). This population was assessed as High Risk for extirpation (Hagen and Decker, 2011). These fish may have evolved from a migratory population originating in either Sugar or Mabel lakes, prior to dam construction (Chamberlain et. al, 2001), which has likely greatly reduced the number of Bull Trout introduced to this river reach (Morris and Wilson, 2005). In addition, smaller-bodied resident populations may exist in the tributaries of Cherry and Ferry creeks. The only suitable spawning beds in this section of the Middle Shuswap River are thought to be in Cherry Creek, possibly its Monashee Creek tributary, and in Ferry Creek (Arc, 2001; Triton, 1995), though no records of spawning surveys in the systems exist.

Rainbow Trout occur throughout the Middle Shuswap mainstem but production in this reach occurs primarily in Cherry and Ferry creeks as suitable spawning habitat in the mainstem is limited (Triton, 1995). Following fish passage, anadromous salmon will likely use the mainstem rather than the tributaries for spawning consistent with the donor stocks below the dam. However, it is possible that a portion of juvenile salmon will move into the tributaries to rear.

3. Methods

This project will collect baseline data on fish stocks pre- fish passage for 3 years, a timeframe that is recommended as a minimum in recent guidelines for effectiveness monitoring designs (Smokorowski et al., 2015). Data collection will continue following fish passage for at least the same time period. Data will be collected up- and downstream of the dam, where the reach below the dam provides a control for whole system processes (e.g., extremely high or low flows, high temperature events). This is consistent with a Before-After, Control-Impact (BACI) design (Smith 2002; Schwartz, 2015), which is most appropriate for biotic response monitoring (Hatfield et. al, 2007; Smokorowski and Randall, 2017). External statistical review of the sampling design will be sought at the beginning of the project from Dr. Carl Schwartz at Simon Fraser University.

Monitoring of other influencing factors (e.g., stream discharge and temperatures, habitat conditions, harvest, disease occurrence, in- and outmigration from this isolated stretch of river, etc.) would be required to control for all the possible variables affecting stock dynamics. However, such a program would be far beyond the scope of available funding for this work and is not typically included in BACI designs. It is the intention of this project to collect baseline information on the abundance trends and health of fish stocks, and to monitor trends in these variables pre- and post- fish passage. This approach balances information needs with budgetary constraints. Should concerning (i.e., declining) trends be observed following fish passage, fisheries managers will decide jointly the likelihood of these factors being related to fish passage and whether fish passage management actions are warranted to mitigate the observed changes. The primary **management actions** are (1) adjusting the number of fish passed upstream of the dam; and (2) limiting the species that are passed above the dam by adjusting fishway operational timing and/or flows.

The methods chosen for monitoring fish stocks were based on careful consideration of: their distribution and life history; how the life stages may be affected by fish passage; information needs to answer monitoring questions; safety of fish and staff; field logistics and practicality; literature and guideline review; and budgetary constraints. A summary of monitoring components and methods is provided in Table 1. Detailed descriptions of field methods are provided in Section 3.1 - 3.4.

The overall approach chosen establishes index reaches and sites at which annual sampling is conducted according to standard methods. It is understood that this approach will provide indices of fish abundance rather than actual whole system abundance estimates. Abundance indices are sufficient to detect trends over time and answer our monitoring questions (Table 1), and are commonly used in other monitoring programs of a similar nature (e.g., Temple et al., 2009). Developing actual abundance estimates would require a more labor intensive and invasive approach such as mark re-capture studies, resulting in higher cost and handling stress on the fish.

The survey area will include the mainstem of the Middle Shuswap river from Sugar Lake Dam to Wilsey Dam (“above Wilsey Dam”), the mainstem from Wilsey Dam to Mabel Lake (“below Wilsey Dam”), and Cherry and Ferry creeks and major tributaries. The Bessette system below Wilsey Dam will not be sampled. Index reaches and sites will be recorded using GPS and clearly marked in the field (rebar, flagging, detailed description) to remain consistent between years. Sample sites and reaches will be selected randomly where possible but may be stratified/guided by the following factors: reaches/sites surveyed in previous studies (to enable comparisons); access; habitat types; and proportionally representing the length of habitat available from above and below the dam.

Table 1: Monitoring components, locations and methods.

Monitoring Question	Components to be monitored	Method	Sampling Location
What are trends in salmonid abundance?[1]	Bull Trout spawner abundance	Redd surveys	Cherry and Ferry creeks
	Adult Bull Trout and Rainbow abundance	Snorkel surveys	Mainstem above and below Wilsey Dam
	Juvenile Bull Trout and Rainbow abundance, and anadromous stocks below the dam	Snorkel surveys	Mainstem above and below Wilsey Dam
		Electrofishing (juveniles)	Cherry and Ferry creeks Mainstem sidechannels above and below Wilsey Dam
What are trends in species assemblage and distribution of salmonids?	Fish species assemblage and distribution	Snorkel surveys	Mainstem above and below Wilsey Dam
		Electrofishing (juveniles)	Cherry and Ferry creeks Mainstem sidechannels above and below Wilsey Dam
What are trends in body condition of juvenile salmonids?	Condition factor	Electrofishing	Cherry and Ferry creeks Mainstem sidechannels above and below Wilsey Dam
How abundant is the invertebrate food supply; is it limiting the number of salmonids that can be supported; changes after fish passage is implemented?	Benthic invertebrate abundance	Benthic invertebrate kicknet sampling	Cherry and Ferry creeks Mainstem above and below Wilsey

[1] Detailed anadromous spawner surveys are already conducted by DFO below Wilsey Dam annually and are therefore not included in this program. Anadromous spawners will be monitored above Wilsey Dam following fish passage.

3.1 Snorkel Surveys

Snorkel surveys in specified index sections will develop an index of abundance of Rainbow and Bull Trout (and anadromous salmon below the dam). The surveys will provide information on species assemblage, abundance and distribution. Snorkel Surveys will be conducted in late July/early August during low flow conditions in the mainstem of the Middle Shuswap River above and below Wilsey Dam. The timing is considered optimal for reasons of safety, water clarity and temperature and because fish will be actively feeding and rearing which makes them easier to observe. The drawback of this timing is that Bull Trout may begin to enter tributaries for spawning. For this reason, Bull Trout abundance trends will be monitored via redd surveys in addition to the snorkel surveys. Other methods for enumerating adult Rainbow Trout (e.g., spawner surveys, redd surveys, counting fence) were considered but deemed unlikely to succeed due to the generally high flows and poor visibility during Rainbow spawning season (April to June).

During the snorkel surveys, 4-5 staff will snorkel index sections of the river. Each staff will snorkel a specific “lane”. The number of snorklers will be determined by underwater visibility and width of the river. In addition, one staff will be a spotter paddling in a kayak along with the snorklers for safety. This protocol has been applied successfully for over 10 years on the Okanagan River (Rivard-Sirois et al., 2017) and other rivers (Askey, 2009). The snorklers will wear flippers, life jackets, and wet/dry suits as needed and will be swiftwater trained. During the snorkel, all fish will be identified to species and recorded in size classes. The survey will consist of 5 days of snorkeling in a row or as close together as possible. Snorkels will be scheduled annually at approximately the same time of the year but timing may be shifted slightly to avoid high river flows and turbidity events that reduce visibility. Based on other snorkel surveys completed by ONA it is estimated that between 5-8 km can be snorkeled in one day, allowing for approximately 48% - 77% of the entire mainstem length (23 km below and 29 km above the dam = 52 km) to be sampled during each survey. Total survey days may be adjusted downward if appropriate after methods are refined during Year 1.

Fieldwork during Year 1 will be preceded by a 2-day scoping visit during which the river will be paddled, access will be determined, index sections will be marked, and potential hazards identified. Attempts will be made to replicate sections sampled via this method previously (Griffith 1979, Fee and Jong, 1984; Triton, 1995; Chamberlain et. al, 2001).

3.2 Bull Trout Redd Surveys

Redd surveys are a common and relatively inexpensive method for monitoring abundance trends in Bull Trout and are particularly well-suited to monitoring trends in abundance (USFWS, 2008). Surveys will occur in Cherry and Ferry creeks, which are the only suitable spawning areas for Bull Trout between Wilsey and Sugar Lake dams. No surveys will be conducted below the dam because Bull Trout have never been observed in the only suitable spawning tributary below the dam (Bessette system), despite extensive long term salmon spawning enumeration programs. The tributaries are relatively remote and access can be challenging; therefore, fieldwork during Year 1 will be preceded by a 2-day scoping visit during which sampling sections will be identified and marked, access will be determined, and permissions from landowners obtained.

Surveys will be conducted by two crews of 2 staff walking upstream from the mouth. Crews will count all observed redds and record their location with GPS. Redds will be identified as patches of "clean" gravel that do not show coverage of algae (Decker and Hagen, 2007; Lewis et al., 2017). Surveys will be timed to occur shortly after peak spawning has ended in early October (Baxter and McPhail, 1996; Morris and Wilson, 2005). At that time, the majority of redds have already been completed but redds constructed earlier in the spawning period have not yet faded so much that they are undetectable. The river systems are generally clear water systems with good visibility; however, surveys will be timed to avoid high flow events and associated turbidity to ensure good visibility of redds.

By leap-frogging, the teams will be able to cover approximately 8-12 km per day. No detailed information on spawning locations or areas of suitable spawning habitat exist for the creeks and it is therefore anticipated that most of their accessible length will need to be surveyed during Year 1. Surveys in subsequent years can likely be reduced substantially to cover only reaches with suitable spawning habitat and/or where spawning was observed during Year 1, as Bull Trout have a tendency to spawn in concentrated locations (Baxter and McPhail 1996). Surveys will focus on the following creeks in which juvenile Bull Trout have been detected during previous surveys and those reaches with a gradient <3%: Cherry Creek mainstem (34 km) and the lower reaches of its tributary Monashee Creek (21 km) (Trumbley Environmental Consulting, 2002); Ferry Creek mainstem (1.5 km) (Benson, 2006). The total survey length during Year 1 will be approximately 55 km which will take an estimated 5 to 7 days to survey.

3.3 Electrofishing surveys

Electrofishing at index sites will be conducted to monitor juvenile salmonids. It provides information on species abundance, assemblage, age and size structure, condition factors, and distribution of juvenile salmonids and other species, and is used in similar monitoring programs for example on the Yakima River (Temple et al., 2010). All of these are factors that could change in both resident and anadromous stocks following fish passage.

Index survey sites will be established in Cherry and Ferry creeks as well as Middle Shuswap River mainstem side channels above and below Wilsey Dam. The mainstem Shuswap River is typically too deep to electrofish and previous studies surveying mainstem channel margins had very low catches (Fee and Jong, 1984). It is anticipated that 2 sites per day can be fished but the total will depend on the number of fish caught. A total of 10 days of sampling is scheduled per year for a total of 20 sites.

Survey sites will be isolated with stop nets and electro-fished using multiple-pass depletion methods (Carle and Strub, 1978). Captured fish will be collected in buckets and anesthetized with a 5 mg/L solution of Tricaine Methanesulfonate (MS 222). Fish will be identified and counted by species and biosampled for fork length and wetted weight. Following sampling, fish will be placed into a recovery bucket until full consciousness is regained. Fish will then be released back into the stream.

The following parameters will be calculated for each site, by species where applicable:

1. fish densities (fish/m^2) = number of fish / site area (site length * average wetted width)
2. total salmonid biomass (g/m^2) = number of fish * mean fish weight / site area
3. biomass density (g/m^2) = total fish biomass (g) / site area

4. Condition factor K = $(10^X * \text{Weight}) * (\text{Length}^3)^{-1}$ where X=5 (Barnham & Baxter, 1998)
5. Species assemblage = % of each species of total fish count

Calculation of these parameters will allow for comparison with previous studies (Griffith, 1979, Fee and Jong, 1984; Triton, 1995; Benson, 2006) and also between reaches over time pre- and post fish passage using the BACI approach.

3.4 Invertebrate Sampling

We will be collecting 15 benthic macroinvertebrate samples in riffles (5 below the dam in the mainstem, 5 above the dam in the mainstem, and 5 in the tributaries of Cherry and Ferry Creek) in the Middle Shuswap River using the CABIN protocol. A desktop pre-field assessment will be used to determine appropriate access points and the general location of sample sites along the reach. Two staff will float the reach below the dam to Bailey bridge and will stop at randomly selected riffles to collect samples. Sites above the dam will be accessible by vehicle and/or boat. The invertebrate samples will be sieved and preserved, and sent to Cordillera Consulting for sorting and family-level identification.

Post-processing analysis will include calculating the abundance and biomass of invertebrates at each sample site/m of transect and producing averages by reach. Differences in abundance will be compared via ANOVA or t-test and changes post fish passage will be analyzed using a BACI design.

4. Deliverables

The deliverable will be a summary report with detailed descriptions of methods and results of the field surveys as well as mapping of sampling and detection sites.

5. Risks of proceeding with this project

There are no anticipated major negative impacts on the fish, wildlife, habitat or heritage resources associated with the execution of this project. Some safety risks exist associated with the field surveys for this project. A detailed pre-field hazard assessment will identify these risks and appropriate actions to remedy and mitigate them. Further, standard safety procedures will be followed and appropriate training and safety equipment provided. There is a risk that this project will be commenced and fish passage not ultimately be approved, making a fish passage monitoring program futile. However, the data collected for this project is very relevant to other priority actions identified in the Shuswap River Watershed Action Plan (FWCP, 2017) such as SHU.ALL.RI.02.0 (Limiting factors analysis for priority fish species between Wilsey and Sugar Lake Dam and tributaries – Priority 1), SHU.ALL.ME.07 (Develop and implement an integrated monitoring plan for fish and/or wildlife – Priority 1), SHU.RLR.RI.12.01 (Assess current habitat use, distribution and restoration opportunities for Bull Trout – Priority 2). All data obtained through this project will be made available to projects addressing other actions.

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7. How FWCP will be recognized in community engagement / communication activities.

The FWCP will be acknowledged in the final report as well as all project communications such as WDFPC presentations, media releases, and public open houses. The WDFPC includes representatives of the Whitevalley Community Resource Centre, BC Hydro, Secwepemc Fisheries Commission, Okanagan Nation Alliance, Ministry of Forests, Lands and Natural Resource Operations, Fisheries and Oceans Canada, local and regional fish and game clubs, private residents, Okanagan Indian Band, Splatsin, Regional District and Village of Lumby staff as well as regional political representatives, which all communicate results and activities back to their constituents and members. FWCP staff will be invited to attend any project open houses and committee meetings.