SOCIETY FOR ECOSYSTEM RESTORATION
IN NORTHERN BRITISH COLUMBIA

Bulkley Watershed Fish Passage Restoration Planning 2022

Prepared for
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Research & Consulting

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Acknowledgement

Modern civilization has a long journey ahead to acknowledge and address the historic and ongoing impacts of colonialism that have resulted in harm to the cultures and livelihoods living interconnected with our ecosystems for many thousands of years.

1 Introduction

This report is available as both a pdf and as an online interactive report at https://newgraphenvironment.github.io/fish_passage_bulkley_2022_reporting/. We recommend viewing online as the web-hosted version contains more features and is more easily navigable. Please reference the website for the latest version number and download the latest pdf from https://github.com/NewGraphEnvironment/fish_passage_bulkley_2022_reporting/raw/master/docs/bulkley2022.pdf

This report is part of a larger effort by the Society for Ecosystem Restoration Northern British Columbia (SERNbc) in the Skeena River watershed which began in 2020. Although this document discusses crossings in the the Bulkey River watershed group only (as defined by the Freshwater Atlas of BC), project activities since 2020 have also included sites in the Morice River watershed group with expansion of the study area in 2022 to include the Zymoetz Watershed Group and the Kispiox River watershed group. At the time of reporting, additional reporting related to 2022 fieldwork planning and results interpretation for these other watershed groups was underway and available here. Work in 2022 builds on planning which began in 2018 by Irvine (2018), documentation in Mazany-Wright et al. (2021) and reporting from field activities conducted in 2020 (Irvine 2021) and 2021 (Irvine 2022). Past years of SERNbc reporting can be viewed interactively here and here.

Please note that at the time of reporting, this document was in draft format and changing over time. Version numbers are logged for each release with modifications, enhancements and other changes tracked here with issues tracked here.

The health and viability of freshwater fish populations can depend on access to tributary and off channel areas which provide refuge during high flows, opportunities for foraging, overwintering habitat, spawning habitat and summer rearing habitat (Bramblett et al. 2002; Swales and Levings 1989; Diebel et al. 2015). Culverts can present barriers to fish migration due to low water depth, increased water velocity, turbulence, a vertical drop at the culvert outlet and/or maintenance issues (Slaney, Zaldokas, and Watershed Restoration Program (B.C.) 1997; Cote et al. 2005). As road crossing structures are commonly upgraded or removed there are numerous opportunities to restore connectivity by ensuring that fish passage considerations are incorporated into repair, replacement, relocation and deactivation designs.

Although remediation and replacement of stream crossing structures can have benefits to local fish populations, the costs of remedial works can be significant and the impacts of the work often complex to evaluate and quantify. Additionally, allocation of ecosystem restoration funding towards infrastructure upgrades on transportation right of ways are not always considered ethical under all circumstances from all perspectives. When funds are finite and invested groups are engaged in fund raising, cost benefits and the ethics of crossing replacements should be explored

collaboratively alongside the cost benefits and ethics of alternative investment activities including transportation corridor relocation/deactivation, land procurement/covenant, cattle exclusion, riparian/floodplain restoration, habitat complexing, water conservation, commercial/recreational fishing management, salt water interventions and research.

2 Background

The study area includes the Bulkley River watershed group (Figure 2.1) and is within the traditional territories of the Wet'suwet'en and Gitsxan First Nations.

2.1 Wet'suwet'en

Wet'suwet'en hereditary territory covers an area of 22,000km^2 including the Bulkley River watershed, Zymoetz River watershed, Morice River watershed and portions of the Nechako River watershed. The Wet'suwet'en people are a matrilineal society organized into the Gilseyhu (Big Frog), Laksilyu (Small Frog), Tsayu (Beaver clan), Gitdumden (Wolf/Bear) and Laksamshu (Fireweed) clans. Within each of the clans there are are a number of kin-based groups known as Yikhs or House groups. The Yikh is a partnership between the people and the territory. Thirteen Yikhs with Hereditary Chiefs manage a total of 38 distinct territories upon which they have jurisdiction. Within a clan, the head Chief is entrusted with the stewardship of the House territory to ensure the Land is managed in a sustainable manner. Inuk Nu'at'en (Wet'suwet'en law) governing the harvesting of fish within their lands are based on values founded on thousands of years of social, subsistence and environmental dynamics. The Yintahk (Land) is the centre of life as well as culture and it's management is intended to provide security for sustaining salmon, wildlife, and natural foods to ensure the health and well-being of the Wet'suwet'en (Office of the Wet'suwet'en 2013; "Office of the Wet'suwet'en" 2021; FLNRORD 2017).

2.2 Gitxsan

The Gitxsan Laxyip (traditional territories) covers an area of 33,000km^2 within the Skeena River and Nass River watersheds. The Laxyip is governed by 60 Simgiigyet (Hereditary Chiefs), within the traditional hereditary system made up of Wilps (House groups). Anaat are fisheries tenures found throughout the Laxyip. Traditional governance within a matrilineal society operates under the principles of Ayookw (Gitxsan law) ("Gitxsan Huwilp Government" 2021).

2.3 Project Location

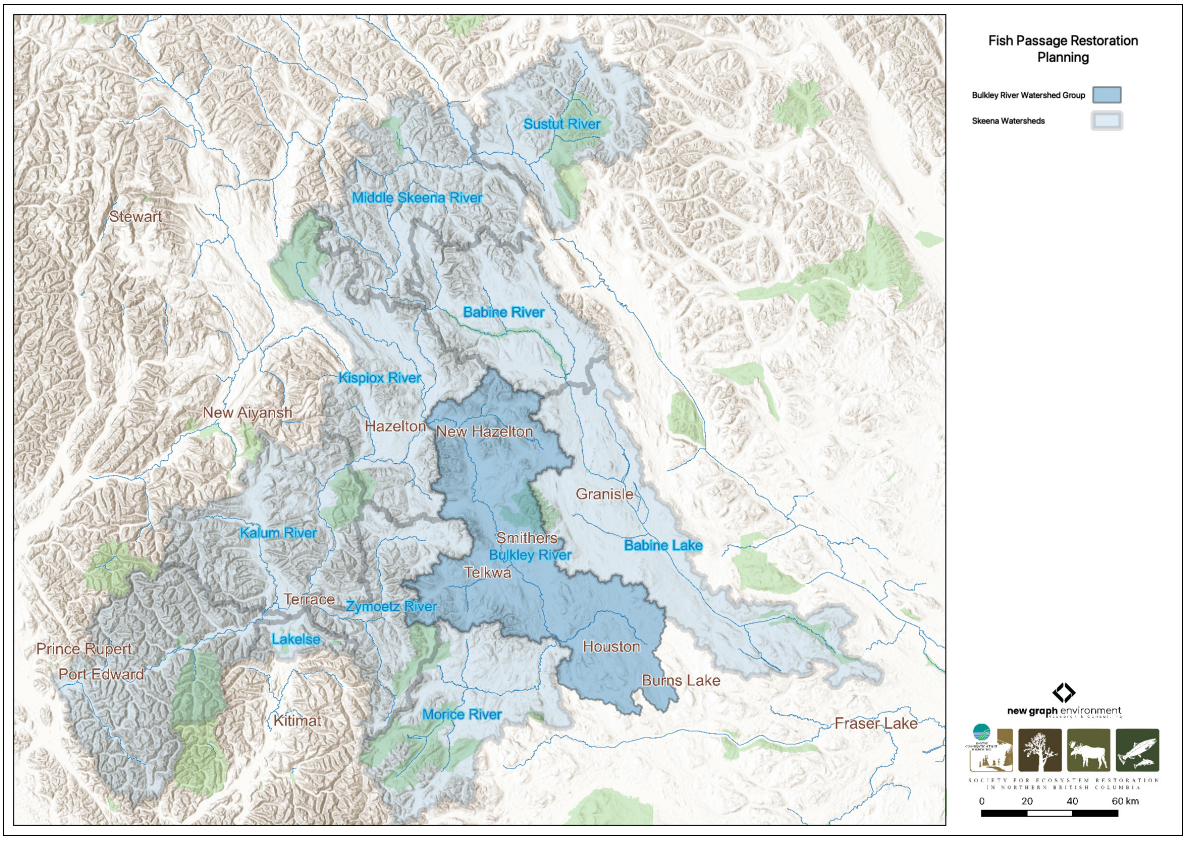

Figure 2.1: Overview map of Study Areas

The Bukley River is an 8th order stream that drains an area of 7,762 km^2 in a generally northerly direction from Bulkley Lake on the Nechako Plateau to its confluence with the Skeena River at Hazleton. It has a mean annual discharge of 139.2 m^3/s at station 08EE004 located near Quick (~27km south of Telkwa) and 19.4 m^3/s at station 08EE003 located upstream near Houston. Flow patterns at Quick are heavily influenced by inflows from the Morice River (enters just downstream of Houston) resulting in flow patterns typical of high elevation watersheds which receive large amounts of precipitation as snow leading to peak levels of discharge during snowmelt, typically from May to July (Figures 2.2 - 2.3). The hydrograph peaks faster and generally earlier (May - June) for the Bulkley River upstream of Houston where the topography is of lower lower elevation (Figures 2.2 and 2.4).

Changes to the climate systems are causing impacts to natural and human systems on all continents with alterations to hydrological systems caused by changing precipitation or melting snow and ice increasing the frequency and magnitude of extreme events such as floods and droughts (IPCC 2014; ECCC 2016). These changes are resulting in modifications to the quantity and quality of water resources throughout British Columbia and are likely to compound issues

related to drought and flooding in the Bulkley River watershed where numerous water licenses are held with a potential over-allocation of flows identified during low flow periods (ILMB 2007).

The valley bottom has seen extensive settlement over the past hundred years with major population centers including the Village of Hazelton, the Town of Smithers, the Village of Telkwa and the District Municipality of Houston. As a major access corridor to northwestern British Columbia, Highway 16 and the Canadian National Railway are major linear developments that run along the Bulkley River within and adjacent to the floodplain with numerous crossing structures impeding fish access into and potentially out from important fish habitats. Additionally, as the valley bottom contains some of the most productive land in the area, there has been extensive conversion of riparian ecosystems to hayfields and pastures leading to alterations in flow regimes, increases in water temperatures, reduced streambank stability, loss of overstream cover and channelization (ILMB 2007; Wilson and Rabnett 2007).

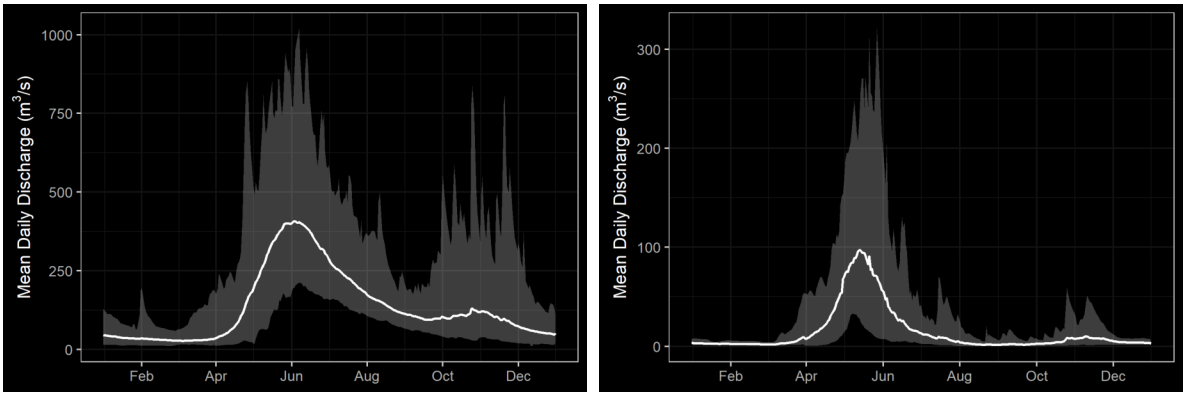

Figure 2.2: Hydrograph for Bulkley River at Quick (Station #08EE004) and near Houston (Station #08EE003).

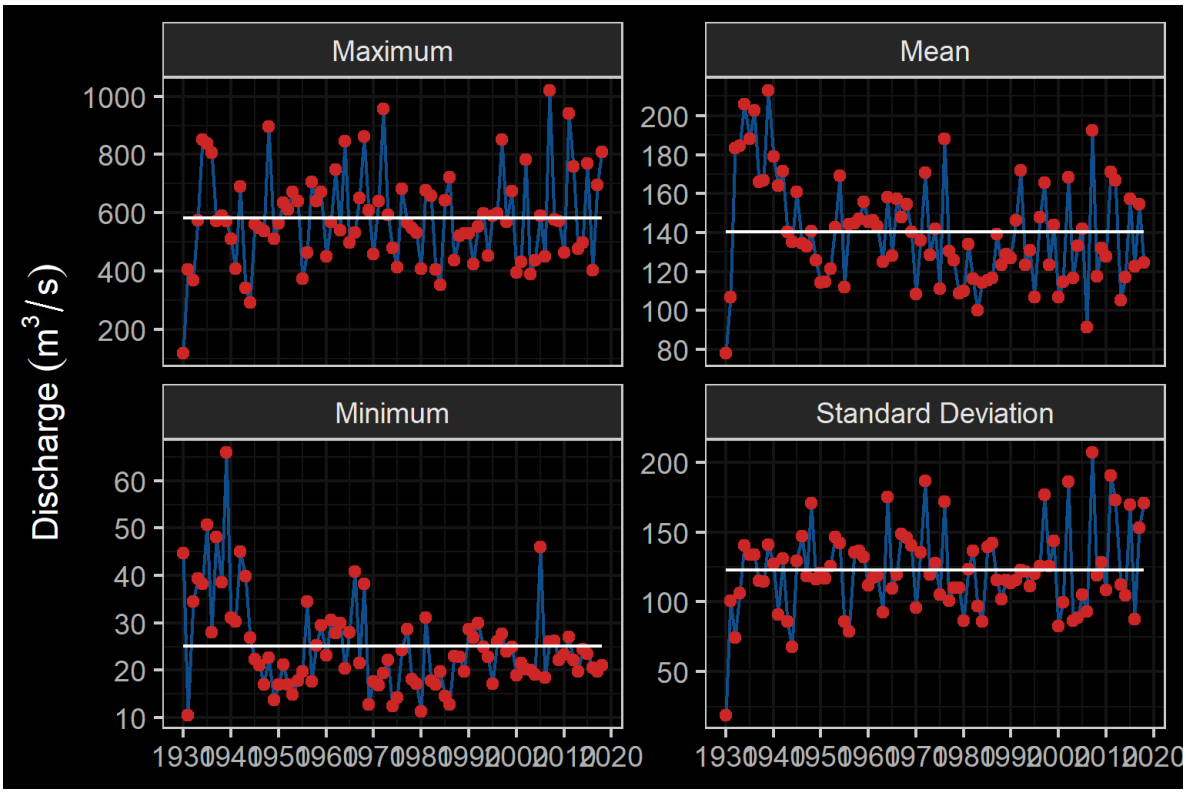

Figure 2.3: Summary of hydrology statistics for Bulkley River at Quick (Station #08EE004 - daily discharge data from 1930 to 2018).

Figure 2.4: Summary of hydrology statistics for Bulkley River near Houston (Station #08EE003 - daily discharge data from 1980 to 2018).

2.4 Fisheries

In 2004, IBM Business Consulting Services (2006) estimated the value of Skeena Fisheries at an annual average of $110 million dollars. The Bulkley-Morice watershed is an integral part of the salmon production in the Skeena drainage and supports an internationally renown steelhead, chinook and coho sport fishery (Tamblyn 2005).

Traditionally, the salmon stocks passing through and spawning in Bulkley River were the principal food source for the Gitxsan and Wet'suwet'en people living there (Wilson and Rabnett 2007). Wilson and Rabnett (2007) detail numerous fishing areas located within the lower Bulkley drainage (from the confluence of the Skeena to the confluence with the Telkwa River) and the upper Bulkley drainage which includes the mainstem Bulkley River and tributaries upstream of the Telkwa River confluence. Anadromous lamprey passing through and spawning in the upper Bulkley River were traditionally also an important food source for the Wet'suwet'en (Wilson and Rabnett 2007; pers comm. Mike Ridsdale, Environmental Assessment Coordinator, Office of the Wet'suwet'en).

Approximately 11.3 km downstream of the Bulkley Lake outlet and just upstream of Watson Creek, the upper Bulkley falls is an approximately 4m high narrow rock sill that crosses the Bulkley River,

producing a steep cascade section. This obstacle to fish passage is recorded as an almost complete barrier to fish passage for salmon during low water flows. Coho have not been observed beyond the falls since 1972 (Wilson and Rabnett 2007).

Renowned as a world class recreational steelhead and coho fishery, the Bulkley River receives some of the heaviest angling pressure in the province. In response to longstanding angler concerns with respect to overcrowding, quality of experience and conflict amongst anglers, an Angling Management Plan was drafted for the river following the initiation of the Skeena Quality Waters Strategy process in 2006 and an extensive multi-year consultation process. The plan introduces a number of regulatory measures with the intent to provide Canadian resident anglers with quality steelhead fishing opportunities. Regulatory measures introduced with the Angling Management Plan include prohibited angling for non-guided non-resident aliens on Saturdays and Sundays, Sept 1 - Oct 31 within the Bulkley River, angling prohibited for non-guided non-resident aliens on Saturdays and Sundays, all year within the Suskwa River and angling prohibited for non-guided non-resident aliens Sept 1 - Oct 31 in the Telkwa River. The Bukley River is considered Class II waterand there is no fshing permitted upstream of the Morice/Bulkley River Confluence (FLNRO 2013a, 2013b; FLNRORD 2019).

2.4.0.1 Fish Species

Fish species recorded in the Bulkley River watershed group are detailed in Table 2.1 (MoE 2020a). Coastal cutthrout trout and bull trout are considered of special concern (blue-listed) provincially. Summaries of some of the Skeena and Bulkley River fish species life history, biology, stock status, and traditional use are documented in Schell (2003), Wilson and Rabnett (2007), Gottesfeld, Rabnett, and Hall (2002) and Office of the Wet'suwet'en (2013). Wilson and Rabnett (2007) discuss chinook, pink, sockeye, coho, steelhead and indigenous freshwater Bulkley River fish stocks within the context of key lower and upper Bulkley River habitats such as the Suskwa River, Station Creek, Harold Price Creek, Telkwa River and Buck Creek. Key areas within the upper Bulkley River watershed with high fishery values, documented in Schell (2003), are the upper Bulkley mainstem, Buck Creek, Dungate Creek, Barren Creek, McQuarrie Creek, Byman Creek, Richfield Creek, Johnny David Creek, Aitken Creek and Emerson Creek.

A draft gantt chart for select species in the Bulkley River watershed was derived from reviews of the aforementioned references and is included as Figure 2.5. The data is considered in draft form and will be refined over the spring and summer of 2021 with local fisheries technicians and knowledge holders during the collaboratory assessment planning and fieldwork activities planned.

Summaries of historical fish observations in the Bulkley River and Morice River watershed groups (n=4033), graphed by remotely sensed average gradient as well as measured or modelled channel

width categories for their associated stream segments where calculated with `bcfishpass` and `bcfishobs` and are provided in Figures 2.6 - 2.7.

Table 2.1: Fish species recorded in the Bulkley River watershed group.

Scientific Name	Species Name	Species Code	BC List	Provincial FRPA	COSEWIC	SARA
Catostomus catostomus	Longnose Sucker	LSU	Yellow	–	–	–
Catostomus commersonii	White Sucker	WSU	Yellow	–	–	–
Catostomus macrocheilus	Largescale Sucker	CSU	Yellow	–	–	–
Chrosomus eos	Northern Redbelly Dace	RDC	Yellow	–	–	–
Coregonus clupeaformis	Lake Whitefish	LW	Yellow	–	–	–
Cottus aleuticus	Coastrange Sculpin (formerly Aleutian Sculpin)	CAL	Yellow	–	–	–
Cottus asper	Prickly Sculpin	CAS	Yellow	–	–	–
Couesius plumbeus	Lake Chub	LKC	Yellow	–	DD	–
Entosphenus tridentatus	Pacific Lamprey	PL	Yellow	–	–	–
Hybognathus hankinsoni	Brassy Minnow	BMC	No Status	–	–	–
Lota lota	Burbot	BB	Yellow	–	–	–
Mylocheilus caurinus	Peamouth Chub	PCC	Yellow	–	–	–
Oncorhynchus clarkii	Cutthroat Trout	CT	No Status	–	–	–
Oncorhynchus clarkii	Cutthroat Trout (Anadromous)	ACT	No Status	–	–	–
Oncorhynchus clarkii clarkii	Coastal Cutthroat Trout	CCT	Blue	–	–	–
Oncorhynchus gorbuscha	Pink Salmon	PK	Yellow	–	–	–
Oncorhynchus keta	Chum Salmon	CM	Yellow	–	–	–
Oncorhynchus kisutch	Coho Salmon	CO	Yellow	–	–	–
Oncorhynchus mykiss	Rainbow Trout	RB	Yellow	–	–	–
Oncorhynchus mykiss	Steelhead	ST	Yellow	–	–	–
Oncorhynchus mykiss	Steelhead (Summer-run)	SST	Yellow	–	–	–
Oncorhynchus nerka	Kokanee	KO	Yellow	–	–	–
Oncorhynchus nerka	Sockeye Salmon	SK	Yellow	–	–	–
Oncorhynchus tshawytscha	Chinook Salmon	CH	Yellow	–	–	–
Prosopium coulterii	Pygmy Whitefish	PW	Yellow	–	NAR (Nov 2016)	–
Prosopium coulterii pop. 3	Giant Pygmy Whitefish	GPW	Yellow	–	–	–
Prosopium williamsoni	Mountain Whitefish	MW	Yellow	–	–	–
Ptychocheilus oregonensis	Northern Pikeminnow	NSC	Yellow	–	–	–
Pungitius pungitius	Ninespine Stickleback	NSB	Unknown	–	–	–
Rhinichthys cataractae	Longnose Dace	LNC	Yellow	–	–	–
Richardsonius balteatus	Redside Shiner	RSC	Yellow	–	–	–
Salvelinus confluentus pop. 26	Bull Trout	BT	Blue	–	–	–
Salvelinus fontinalis	Brook Trout	EB	Exotic	–	–	–
Salvelinus malma	Dolly Varden	DV	Yellow	–	–	–
Salvelinus namaycush	Lake Trout	LT	Yellow	–	–	–
–	Cutthroat/Rainbow cross	CRS	–	–	–	–

Scientific Name	Species Name	Species Code	BC List	Provincial FRPA	COSEWIC	SARA
–	Minnow (General)	C	–	–	–	–
–	Salmon (General)	SA	–	–	–	–
–	Sculpin (General)	CC	–	–	–	–
–	Sucker (General)	SU	–	–	–	–
–	Whitefish (General)	WF	–	–	–	–

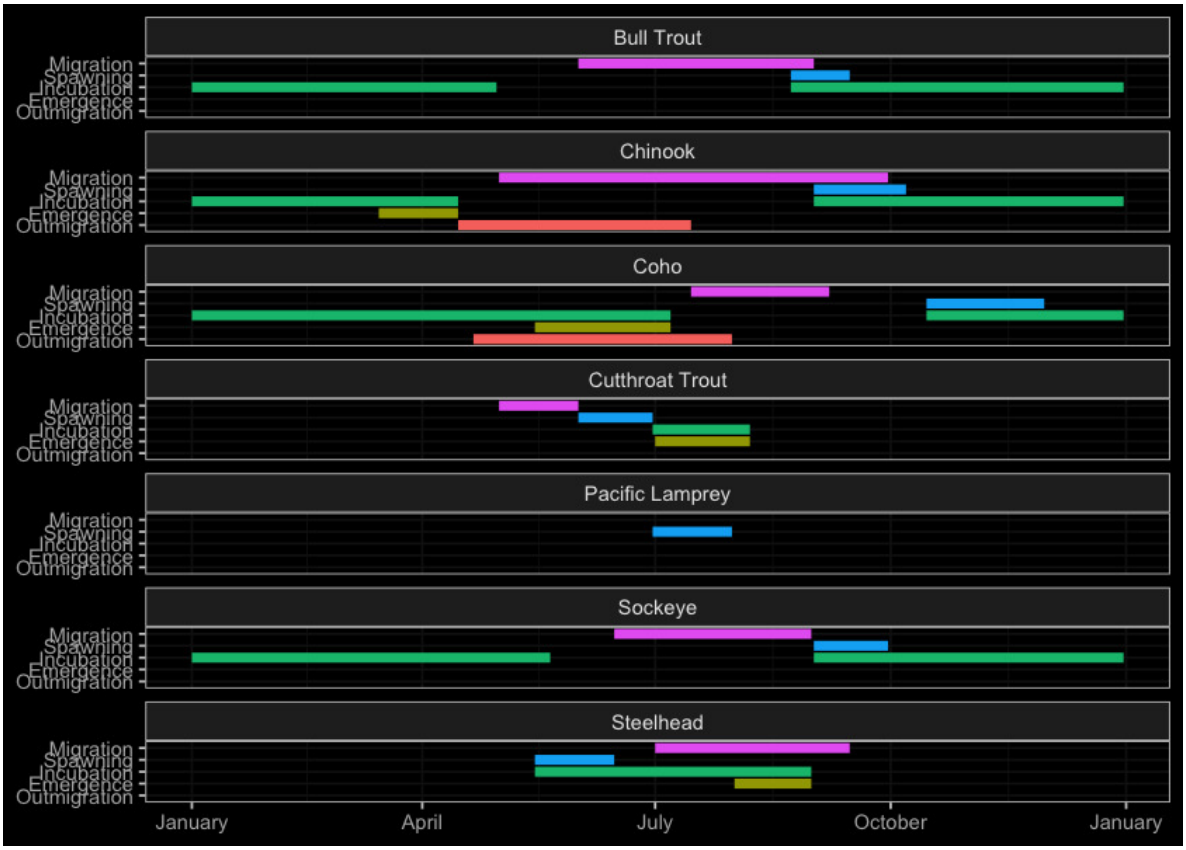

Figure 2.5: Gantt chart for select species in the Bulkley River watersheds. To be updated in consultation with local fisheries techicians and knowledge holders.

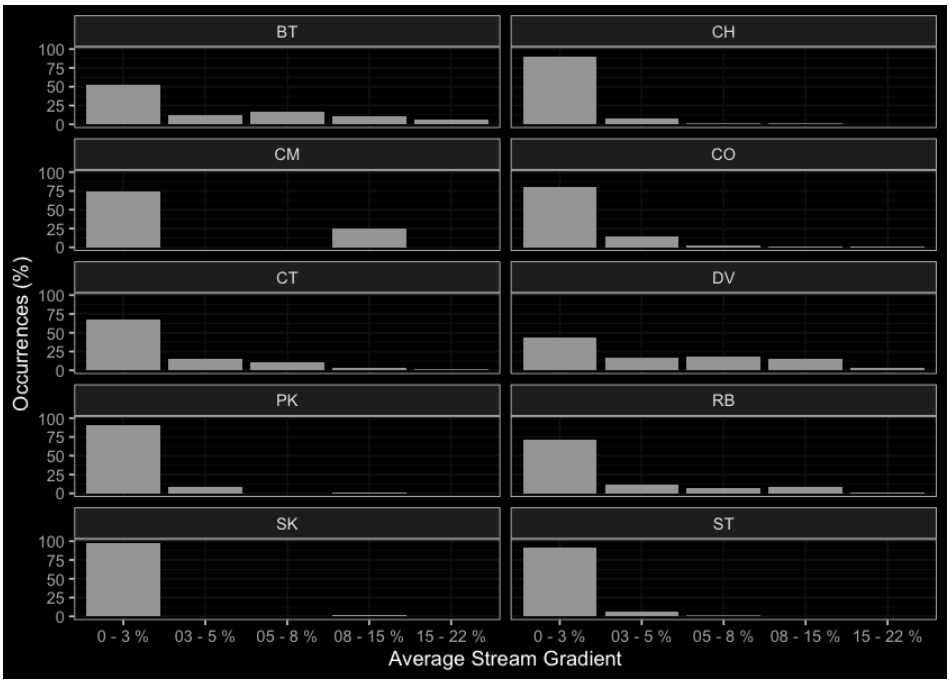

Figure 2.6: Summary of historic salmonid observations vs. stream gradient category for the Bulkley River watershed group.

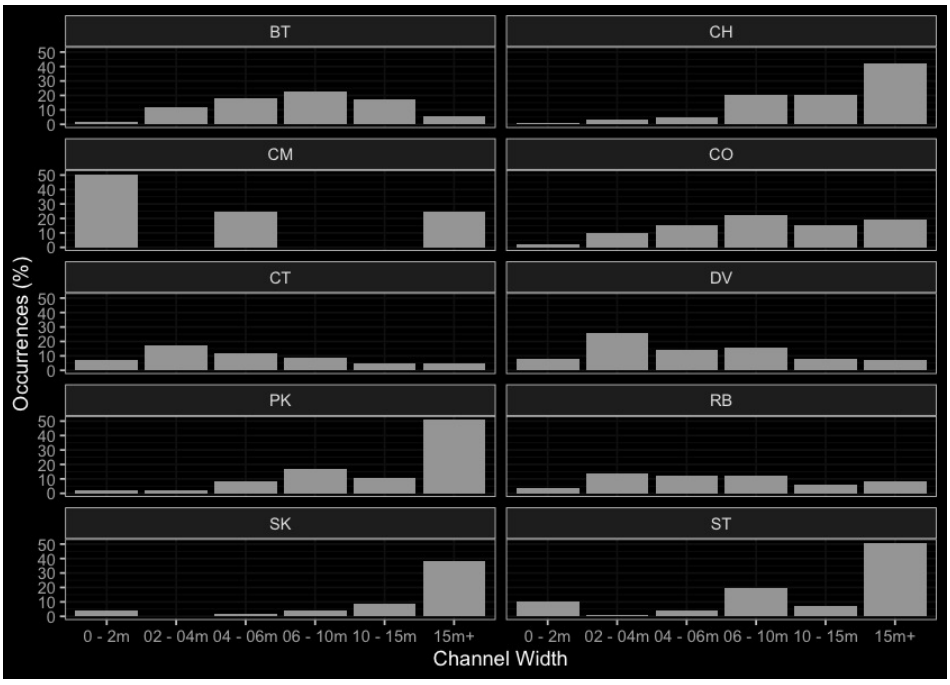

Figure 2.7: Summary of historic salmonid observations vs. channel width category for the Bulkley River watershed group.

2.5 Fish Passage Restoration Planning and Implementation

As a result of high-level direction from the provincial government, a Fish Passage Strategic Approach protocol has been developed for British Columbia to ensure that the greatest opportunities for restoration of fish passage are pursued. A Fish Passage Technical Working Group has been formed to coordinate the protocol and data is continuously amalgamated within the Provincial Steam Crossing Inventory System (PSCIS). The strategic approach protocol involves a four-phase process as described in Fish Passage Technical Working Group (2014) :

- Phase 1: Fish Passage Assessment – Fish stream crossings within watersheds with high fish values are assessed to determine barrier status of structures and document a general assessment of adjacent habitat quality and quantity.
- Phase 2: Habitat Confirmation – Assessments of crossings prioritized for follow up in Phase 1 studies are conducted to confirm quality and quantity of habitat upstream and down as well as to scope for other potential nearby barriers that could affect the practicality of remediation.
- Phase 3: Design – Site plans and designs are drawn for priority crossings where high value fish habitat has been confirmed.
- Phase 4: Remediation – Re-connection of isolated habitats through replacement, rehabilitation or removal of prioritized crossing structure barriers.

There is a rich history of fish passage restoration planning in the Bulkley River watershed group with not all the work documented in the PSCIS system. A non-exhaustive list of historic fish passage reports for the watershed includes Wilson and Rabnett (2007), McCarthy and Fernando (2015),Smith (2018) Casselman and Stanley (2010), Irvine (2018), Irvine (2021), Mazany-Wright et al. (2021) and Irvine (2022).

Review of the PSCIS database indicated that prior to 2022, 1720 assessments for fish passage (Phase 1) and 38 habitat confirmations were recorded at crossing structures within the Bulkley River watershed MoE (2023b). Within the Bulkley River watershed group, a number of remediation projects have been completed over the years with backwatering works conducted on Toboggan Creek, Coffin Creek, Moan Creek, Johnny David Creek and potentially others. Three culvert replacements (with open bottom structures) in the watershed group have been tracked in PSCIS and include works on Barren Creek as well as two tributaries to Harold Prince Creek (MoE 2021b). McDowell Creek at Highway 16 was replaced with a horizontally drilled baffled structure in 2017 and the Highway 16 crossing over Taman Creek was replaced in 2022. Canadian Wildlife Federation led the removal of a collapsed bridge located on Robert Hatch Creek following assessment work completed by Irvine (2022).

3 Methods

Workflows for the project have been classified into planning, fish passage assessments, habitat confirmation assessments, reporting and mapping. All components leveraged `R`, `SQL` or `Python` programming languages to facilitate workflow tracking, collaboration, transparency and continually improving research. Project workflows utilized local and remote `postgreSQL` databases as well as a "snapshot" of select datasets contained within a local `sqlite` database. A data and script repository to facilitate this reporting is located on Github.

3.1 Planning

To identify priorities for crossing structure rehabilitation, background literature, fisheries information, PSCIS, and `bcfishpass` (Norris 2021d) outputs were reviewed. `bcfishpass` is an updated open-source code repository comprised of tools ported over from the `Fish Habitat Model` (Norris and Mount 2016) developed by the BC Ministry of Environment along with a number of significant upgrades and new features. Scripts within `bcfishpass` also pull and analyze data using other open-source tools such as `bcdata` (Norris 2021b), `bcfishobs` (Norris 2021c), and `fwapg` (Norris 2021a) which serve numerous functions related to open-data access as well as the analysis of the BC Freshwater Atlas, roads, fish and fish habitat in British Columbia.

3.1.1 Habitat Modelling

`bcfishpass` calculates the average gradient of BC Freshwater Atlas stream network lines at minimum 100m long intervals starting from the downstream end of the streamline segment and working upstream. The network lines are broken into max gradient categories with new segments created if and when the average slope of the stream line segment exceeds user provided thresholds. For this project, the user provided gradient thresholds used to delineate "potentially accessible habitat" were based on estimated max gradients that salmon (15% - coho and chinook) and steelhead (20%) are likely to be capable of ascending.

Through this initiative and other SERN/New Graph led initiatives, the Provincial Fish Passage Remediation Program and connectivity restoration planning (Mazany-Wright et al. 2021), `bcfishpass` has been designed to prioritize potential fish passage barriers for assessment or remediation. The software is under continual development and has been designed and constructed by Norris (2021d) using sql and python based shell script libraries to generate a simple model of aquatic habitat connectivity. The model identifies natural barriers (ex. steep gradients for extended distances) and hydroelectric dams to classifying the accessibility upstream by fish (Norris 2021d). On potentially accessible streams, scripts identify known barriers (ex. waterfalls >5m high) and additional anthropogenic features which are primarily road/railway stream crossings (i.e. culverts) that are potentially barriers. To prioritize these features for assessment or remediation, scripts report on how much modelled potentially accessible aquatic habitat the barriers may obstruct. The model can be refined with known fish observations upstream of identified barriers and for each crossing location, the area of lake and wetland habitat upstream, species documented

upstream/downstream, an estimate of watershed area (on 2nd order and higher streams), mean annual precipitation weighted to upstream watershed area and channel width can be collated using `bcfishpass`, `fwapg` and `bcfishobs`. This, information, can be used to provides an indication of the potential quantity and quality of habitat potentially gained should fish passage be restored by comparing to user defined thresholds for the aforementioned parameters. A discussion of the methodology to derive channel width is below.

Gradient, channel size and stream discharge are key determinants of channel morphology and subsequently fish distribution. High value rearing, overwintering and spawning habitat preferred by numerous species/life stages of fish are often located within channel types that have relatively low gradients and large channel widths (also quantified by the amount of flow in the stream). Following delineation of “potentially accessible habitat”, the average gradient of each stream segment within habitat classified as below the 15% and 20% thresholds was calculated and summed within species and life stage specific gradient categories. Average gradient of stream line segments can be calculated from elevations contained in the provincial freshwater atlas streamline dataset. To obtain estimates of channel width upstream of crossing locations, Where available, `bcfishpass` was utilized to pull average channel gradients from Fisheries Information Summary System (FISS) site assessment data (MoE 2020d) or PSCIS assessment data (MoE 2021a) and associate with stream segment lines. When both FISS and PSCIS values were associated with a particular stream segment, FISS channel width was used. When multiple FISS sites were associated with a particular stream segment a mean of the average channel widths was taken. To model channel width for 2nd order and above stream segments without associated FISS or PSCIS sites, first `fwapg` was used to estimate the drainage area upstream of the segment. Then, rasters from ClimateBC (Wang et al. 2012) were sampled for each stream segments and a mean annual precipitation weighted by upstream watershed area was calculated. Mean annual precipitation was then combined with the channel widths and BEC zone information (gathered through a spatial query tied to the bottom of the stream segment) into a dataset (n = 22990) for analysis fo the relationship between these variables. The details of this analysis and resulting formula used to estimate channel width on stream segments in the Bulkley River is included as a technical appendix at https://www.poissonconsulting.ca/f/859859031.

`bcfishpass` and associated tools have been designed to be flexible in analysis, accepting user defined gradient, channel width and stream discharge categories (MoE 2020d). Although currently in draft form, and subject to development revisions, gradient and channel width thresholds for habitat with the highest intrinsic value for a number of fish species in the Bulkley River watershed group have been specified and applied to model habitat upstream of stream crossing locations with the highest intrinsic value (Table 3.1). Thresholds were derived based on a literature review with references provided in Table 3.2. Output parameters for modelling are presented in Table 3.3.

Table 3.1: Stream gradient and channel width thresholds used to model potentially highest value fish habitat.

Variable	Chinook Salmon	Coho Salmon	Steelhead	Sockeye Salmon
Spawning Gradient Max (%)	4	5	4	2
Spawning Width Min (m)	4	2	4	2
Rearing Gradient Max (%)	5.0	5.0	7.4	–
Rearing Width Min (m)	1.5	1.5	1.5	1.5

Table 3.2: References for stream gradient and channel width thresholds used to model potentially highest value fish habitat. Preliminary and subject to revisions.

Variable	Chinook Salmon	Coho Salmon	Steelhead	Sockeye Salmon
Spawning Gradient Max (%)	0.03 (Kirsch et al. 2004, Busch et al. 2011, Cooney and Holzer 2006)	0.05 (Roberge et al. 2002, Sloat et al. 2017)	0.04 (Scheer and Steel 2006, Cooney and Holzer 2006)	0.02 (Lake 1999, Hoopes 1972)
Spawning Width Min (m)	3.7 (Busch et al. 2011, Cooney and Holzer 2006)	2 (Sloat et. al 2017)	3.8 (Cooney and Holzer 2006)	2 (Woll et al. 2017)
Rearing Gradient Max (%)	0.05 (Woll et al. 2017, Porter et al. 2008)	0.05 (Kirsch et al. 2004, Porter et al. 2008, Rosenfeld et al. 2000)	0.074 (Porter et al. 2008)	–

Table 3.3: bcfishpass outputs and associated definitions

Attribute	Definition
ST Network (km)	Steelhead model, total length of stream network potentially accessible upstream of point
ST Lake Reservoir (ha)	Steelhead model, total area lakes and reservoirs potentially accessible upstream of point
ST Wetland (ha)	Steelhead model, total area wetlands potentially accessible upstream of point
ST Slopeclass03 Waterbodies (km)	Steelhead model, length of stream connectors (in waterbodies) potentially accessible upstream of point with slope 0-3%
ST Slopeclass03 (km)	Steelhead model, length of stream potentially accessible upstream of point with slope 0-3%
ST Slopeclass05 (km)	Steelhead model, length of stream potentially accessible upstream of point with slope 3-5%
ST Slopeclass08 (km)	Steelhead model, length of stream potentially accessible upstream of point with slope 5-8%
ST Spawning (km)	Length of stream upstream of point modelled as potential Steelhead spawning habitat
ST Rearing (km)	Length of stream upstream of point modelled as potential Steelhead rearing habitat
CH Spawning (km)	Length of stream upstream of point modelled as potential Chinook spawning habitat
CH Rearing (km)	Length of stream upstream of point modelled as potential Chinook rearing habitat
CO Spawning (km)	Length of stream upstream of point modelled as potential Coho spawning habitat
CO Rearing (km)	Length of stream upstream of point modelled as potential Coho rearing habitat
CO Rearing (ha)	Area of wetlands upstream of point modelled as potential Coho rearing habitat
SK Spawning (km)	Length of stream upstream of point modelled as potential Sockeye spawning habitat
SK Rearing (km)	Length of stream upstream of point modelled as potential Sockeye rearing habitat
SK Rearing (ha)	Area of lakes upstream of point modelled as potential Sockeye rearing habitat
All Spawning (km)	Length of stream upstream of point modelled as potential spawning habitat (all CH,CO,SK,ST,WCT)
All Rearing (km)	Length of stream upstream of point and below any additional upstream barriers, modelled as potential spawning habitat (all CH,CO,SK,ST,WCT)
All Spawning Rearing (km)	Length of all spawning and rearing habitat upstream of point

* Steelhead model uses a gradient threshold of maximum 20% to determine if access if likely possible

3.2 Fish Passage Assessments

In the field, crossings prioritized for follow-up were first assessed for fish passage following the procedures outlined in “Field Assessment for Determining Fish Passage Status of Closed Bottomed Structures” (MoE 2011a). Crossings surveyed included closed bottom structures (CBS), open bottom structures (OBS) and crossings considered “other” (i.e. fords). Photos were taken at surveyed crossings and when possible included images of the road, crossing inlet, crossing outlet, crossing barrel, channel downstream and channel upstream of the crossing and any other relevant features. The following information was recorded for all surveyed crossings: date of inspection, crossing reference, crew member initials, Universal Transverse Mercator (UTM) coordinates, stream name, road name and kilometer, road tenure information, crossing type, crossing subtype, culvert diameter or span for OBS, culvert length or width for OBS. A more detailed “full assessment” was completed for all closed bottom structures and included the following parameters: presence/absence of continuous culvert embedment (yes/no), average depth of embedment, whether or not the culvert bed resembled the native stream bed, presence of and percentage backwatering, fill depth, outlet drop, outlet pool depth, inlet drop, culvert slope, average downstream channel width, stream slope, presence/absence of beaver activity, presence/absence of fish at time of survey, type of valley fill, and a habitat value rating. Habitat value ratings were based on channel morphology, flow characteristics (perennial, intermittent, ephemeral), fish migration patterns, the presence/absence of deep pools, un-embedded boulders, substrate, woody debris, undercut banks, aquatic vegetation and overhanging riparian vegetation (Table 3.4). For crossings determined to be potential barriers or barriers based on the data (see Barrier Scoring (page 17)), a culvert fix and recommended diameter/span was proposed.

Table 3.4: Habitat value criteria (Fish Passage Technical Working Group, 2011).

Habitat Value	Fish Habitat Criteria
High	The presence of high value spawning or rearing habitat (e.g., locations with abundance of suitably sized gravels, deep pools, undercut banks, or stable debris) which are critical to the fish population.
Medium	Important migration corridor. Presence of suitable spawning habitat. Habitat with moderate rearing potential for the fish species present.
Low	No suitable spawning habitat, and habitat with low rearing potential (e.g., locations without deep pools, undercut banks, or stable debris, and with little or no suitably sized spawning gravels for the fish species present).

3.2.1 Barrier Scoring

Fish passage potential was determined for each stream crossing identified as a closed bottom structure as per MoE (2011a). The combined scores from five criteria: depth and degree to which the structure is embedded, outlet drop, stream width ratio, culvert slope, and culvert length were used to screen whether each culvert was a likely barrier to some fish species and life stages (Table 3.5, Table 3.6. These criteria were developed based on data obtained from various studies and reflect an estimation for the passage of a juvenile salmon or small resident rainbow trout (Clarkin et al. 2005 ; Bell 1991; Thompson 2013).

Table 3.5: Fish Barrier Risk Assessment (MoE 2011).

Risk	LOW	MOD	HIGH
Embedded	>30cm or >20% of diameter and continuous	<30cm or 20% of diameter but continuous	No embedment or discontinuous
Value	0	5	10
Outlet Drop (cm)	<15	15-30	>30
Value	0	5	10
SWR	<1.0	1.0-1.3	>1.3
Value	0	3	6
Slope (%)	<1	1-3	>3
Value	0	5	10
Length (m)	<15	15-30	>30
Value	0	3	6

Table 3.6: Fish Barrier Scoring Results (MoE 2011).

Cumlative Score	Result
0-14	passable
15-19	potential barrier
>20	barrier

3.2.2 Cost Benefit Analysis

A cost benefit analysis was conducted for each crossing determined to be a barrier based on an estimate of cost associated with remediation or replacement of the crossing with a structure that facilitates fish passage and the amount of potential habitat that would be made available by remediating fish passage at the site (habitat gain index).

3.2.2.1 Habitat Gain Index

The habitat gain index is the quantity of modelled habitat upstream of the subject crossing and represents an estimate of habitat gained with remediation of fish passage at the crossing. For this project, a gradient threshold between accessible and non-accessible habitat was set at 20% (for a minimimum length of 100m) intended to represent the maximum gradient of which the strongest swimmers of anadromous species (steelhead) are likely to be able to migrate upstream.

For reporting of Phase 1 - fish passage assessments within the body of this report (Table 3.5), a "total" value of habitat <20% output from `bcfishpass` was used to estimate the amount of habitat upstream of each crossing less than 20% gradient before a falls of height >5m - as recorded in MoE (2020c) or documented in other `bcfishpass` online documentation. For Phase 2 - habitat confirmation sites, conservative estimates of the linear quantity of habitat to be potentially gained by fish passage restoration, steelhead rearing maximum gradient threshold (7.4%) was used. To generate areas of habitat upstream, the estimated linear length was multiplied by half the downstream channel width measured (overall triangular channel shape) as part of the fish passage assessment protocol. Although these estimates are not generally conservative, have low accuracy and do not account for upstream stream crossing structures they allow a rough idea of the best candidates for follow up.

Potential options to remediate fish passage were selected from MoE (2011a) and included:

- Removal (RM) - Complete removal of the structure and deactivation of the road.
- Open Bottom Structure (OBS) - Replacement of the culvert with a bridge or other open bottom structure. Based on consultation with FLNR road crossing engineering experts, for this project we considered bridges as the only viable option for OBS type .
- Streambed Simulation (SS) - Replacement of the structure with a streambed simulation design culvert. Often achieved by embedding the culvert by 40% or more. Based on consultation with FLNR engineering experts, we considered crossings on streams with a channel width of <2m and a stream gradient of <8% as candidates for replacement with streambed simulations.
- Additional Substrate Material (EM) - Add additional substrate to the culvert and/or downstream weir to embed culvert and reduce overall velocity/turbulence. This option was considered only when outlet drop = 0, culvert slope <1.0% and stream width ratio < 1.0.
- Backwater (BW) - Backwatering of the structure to reduce velocity and turbulence. This option was considered only when outlet drop < 0.3m, culvert slope <2.0%, stream width ratio < 1.2 and stream profiling indicates it would be effective..

Cost estimates for structure replacement with bridges and embedded culverts were generated based on the channel width, slope of the culvert, depth of fill, road class and road surface type. Road details were sourced from FLNRORD (2020b) and FLNRORD (2020a) through `bcfishpass`.

Interviews with Phil MacDonald, Engineering Specialist FLNR - Kootenay, Steve Page, Area Engineer - FLNR - Northern Engineering Group and Matt Hawkins - MoTi - Design Supervisor for Highway Design and Survey - Nelson were utilized to helped refine estimates.

Base costs for installation of bridges on forest service roads and permit roads with surfaces specified in provincial GIS road layers as rough and loose was estimated at $12500/linear m and assumed that the road could be closed during construction and a minimum bridge span of 10m. For streams with channel widths <2m, embedded culverts were reported as an effective solution with total installation costs estimated at $25k/crossing (pers. comm. Phil MacDonald, Steve Page). For larger streams (>6m), span width increased proportionally to the size of the stream (ex. for an 8m wide stream a 12m wide span was prescribed). For crossings with large amounts of fill (>3m), the replacement bridge span was increased by an additional 3m for each 1m of fill >3m to account for cutslopes to the stream at a 1.5:1 ratio. To account for road type, a multiplier table was also generated to estimate incremental cost increases with costs estimated for structure replacement on paved surfaces, railways and arterial/highways costing up to 20 times more than forest service roads due to expenses associate with design/engineering requirements, traffic control and paving. The cost multiplier table (Table 3.7) should be considered very approximate with refinement recommended for future projects.

Table 3.7: Cost multiplier table based on road class and surface type.

Class	Surface	Class Multiplier	Surface Multiplier	Bridge $K/10m	Streambed Simulation $K
Forest Service Road	Loose	1	1	250	50
Resource	Loose	1	1	250	50
Road Permit	Loose	1	1	250	50
Unclassified	Loose	1	1	250	50
Unclassified	Rough	1	1	250	50
Unclassified	Paved	1	2	500	100
Unclassified	Unknown	1	2	500	100
Local	Loose	4	1	1000	200
Local	Paved	4	2	2000	400
Arterial	Paved	15	2	7500	1500
Highway	Paved	15	2	7500	1500
Rail	Rail	15	2	7500	1500

3.3 Habitat Confirmation Assessments

Following fish passage assessments, habitat confirmations were completed in accordance with procedures outlined in the document “A Checklist for Fish Habitat Confirmation Prior to the Rehabilitation of a Stream Crossing” (Fish Passage Technical Working Group 2011). The main objective of the field surveys was to document upstream habitat quantity and quality and to determine if any other obstructions exist above or below the crossing. Habitat value was assessed based on channel morphology, flow characteristics (perennial, intermittent, ephemeral), the presence/absence of deep pools, un-embedded boulders, substrate, woody debris, undercut banks, aquatic vegetation and overhanging riparian vegetation. Criteria used to rank habitat value was based on guidelines in Fish Passage Technical Working Group (2011) (Table 3.4).

During habitat confirmations, to standardize data collected and facilitate submission of the data to provincial databases, information was collected on “Site Cards”. Habitat characteristics recorded included channel widths, wetted widths, residual pool depths, gradients, bankfull depths, stage, temperature, conductivity, pH, cover by type, substrate and channel morphology (among others). When possible, the crew surveyed downstream of the crossing to the point where fish presence had been previously confirmed and upstream to a minimum distance of 600m. Any potential obstacles to fish passage were inventoried with photos, physical descriptions and locations recorded on site cards. Surveyed routes were recorded with time-signatures on handheld GPS units.

Fish sampling was conducted on a subset of sites when biological data was considered to add significant value to the physical habitat assessment information. When possible, electrofishing was utilized within discrete site units both upstream and downstream of the subject crossing with electrofisher settings, water quality parameters (i.e. conductivity, temperature and ph), start location, length of site and wetted widths (average of a minimum of three) recorded. For each fish captured, fork length and species was recorded, with results included within the fish data submission spreadsheet. Fish information and habitat data will be submitted to the province under scientific fish collection permit CB20-611971.

3.4 Reporting

Reporting was generated with `bookdown` (Xie 2016) from `Rmarkdown` (Allaire et al. 2022) with primarily `R` (R Core Team 2022) and `SQL` scripts. The `R` package `fpr` contains many specialized custom functions related to the work (Irvine [2022] 2022). In addition to numerous spatial layers sourced through the BC Data Catalogue then stored and queried in a local `postgresql` and `sqlite` databases data inputs for this project include:

- Populated Fish Data Submission Spreadsheet Template - V 2.0, January 20, 2020
- Populated pscis_assessment_template_v24.xls
- `bcfishpass` outputs.
- Custom CSV file detailing Phase 2 site:
    - priority level for proceeding to design for replacement
    - length of survey upstream and downstream
    - a conservative estimate of the linear length of mainstem habitat potentially available upstream of the crossing
    - fish species confirmed as present upstream of the crossing
- GPS tracks from field surveys.
- Photos and photo metadata

Version changes are tracked here and issues/planned enhancements tracked here.

3.5 Mapping

Mapping was completed by Hillcrest Geographics. `pdf` maps were generated using `QGIS` with data supplied via a `postgreSQL` database. A QGIS layer file defining and symbolizing all layers required for general fish passage mapping was developed and at the time of reporting was kept under version control within `bcfishpass`.

4 Results and Discussion

4.1 Dam Assessment

One dam on Coffin Creek - Canadian Aquatic Barrier Database and `bcfishpass dam_id` 1f365462-063c-491e-9fb3-bfac004d9183 - was assessed for fish passage (Canadian Wildlife Federation 2023). The Coffin Creek watershed has been selected as a focus area for Environmental Stewardship Initiative (ESI) sampling research critical flow monitoring, benthic invertebrate sampling and fisheries assessments (pers. comm Don Morgan, Ministry of Environment and Climate Change Strategy). Irvine (2021) assessed crossings located at the downstream end of the stream on Lawson Road and under the CN Railway in 2020 with results presented here.

Coffin Lake is a shallow lake (max depth 2m) located approximately 4.5km upstream of Lawson Road. In the late 1980s, Ducks Unlimited raised water levels in Coffin Lake and a downstream wetland area by installing a 63m long by 2.3m high earthen dam incorporating a variable crest weir capable of a 1.0m drawdown. Additionally excavated level ditching (1800m) within the sedge willow meadow was planned.The intent of the works was to provide a more secure and stable water regime, improve water/cover interspersion and provide territorial, loafing and nesting sites for waterfowl (Hatlevik 1985; Simpson 1986; MoE 2020c). Documentation detailing specifics of the final design of the dam was not obtained with a search of available literature.

Upstream of dam, longnose sucker, largescale sucker, redside shiner, cutthroat trout, rainbow trout, mountain whitefish, and dolly varden have previously been recorded upstream (Knowledge Management 2022; Norris [2018] 2022). A summary of habitat modelling outputs is presented in Table 4.2.

The site was assessed on August 31, 2022 with results summarized in Table 4.1. Photos are presented in Figures \(**ref?**)(fig:photo-dams-01). Surveys were conducted with a remotely piloted aircraft upstream and downstream of the dam with resulting images stitched into an orthomosaic and 3-dimensional model presented here and here. Wetland habitat was present upstream and downstream of the dam with habitat rated as high value for juvenile coho and lamprey rearing. A map of the watershed is provided in map attachment 093L.113.

Table 4.1: Results from fish passability assessments at dam 1f365462-063c-491e-9fb3-bfac004d9183.

Site	Stream	Easting	Northing	Mapsheet	Barrier	Notes
1f365462-063c-491e-9fb3-bfac004d9183	Coffin Creek	634763	6051171	093L.113	T	Aerial imagery aquired. Complete barrier. 1.2m high steel structure within wetland complex downstream of Coffin Lake. Extremely difficult access via all terrain vehicle due to muddy conditions

* UTM Zone 9

Table 4.2: Summary of fish habitat modelling for PSCIS crossing 1f365462-063c-491e-9fb3-bfac004d9183.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	30.9	30.7	99
ST Lake Reservoir (ha)	73.2	73.2	100
ST Wetland (ha)	117.8	117.8	100
ST Slopeclass03 Waterbodies (km)	5.7	0.0	0
ST Slopeclass03 (km)	7.8	7.8	100
ST Slopeclass05 (km)	1.4	1.4	100
ST Slopeclass08 (km)	7.5	7.5	100
ST Spawning (km)	0.0	0.0	–
ST Rearing (km)	0.0	0.0	–
CH Spawning (km)	0.0	0.0	–
CH Rearing (km)	0.0	0.0	–
CO Spawning (km)	0.9	0.9	100
CO Rearing (km)	8.3	8.3	100
CO Rearing (ha)	103.9	0.0	0
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	–	0.0	–
All Spawning (km)	10.5	10.5	100
All Rearing (km)	8.3	8.3	100
All Spawning Rearing (km)	14.3	14.3	100

* Model data is preliminary and subject to adjustments.

Figure 4.1: Photos of Dam 1f365462-063c-491e-9fb3-bfac004d9183 on Coffin Creek

4.2 Phase 1

Field assessments were conducted between August 29 2022 and September 10 2022 by Allan Irvine, R.P.Bio. and Mateo Winterscheidt, B.Sc., Tieasha Pierre, Vern Joseph, Dallas Nikal, Alexandria Nikal, Jesse Olson and Colin Morrison. A total of 9 Phase 1 assessments at sites not yet inventoried into the PSCIS system included 3 crossings considered “passable”, 0 crossings considered “potential” barriers and 3 crossings considered “barriers” according to threshold values based on culvert embedment, outlet drop, slope, diameter (relative to channel size) and length (MoE 2011a). Additionally, although all were considered fully passable, 3 crossings assessed were fords and ranked as “unknown” according to the provincial protocol. Georeferenced field maps are presented in Attachment 1. A summary of crossings assessed, a cost estimate for remediation and a priority ranking for follow up for Phase 1 sites is presented in Table 4.3. Detailed data with photos are presented in [Attachment 2](https://www.newgraphenvironment.com/fish_passage_bulkley_2022_reporting/appendix---phase-1-fish-passage-assessment-data-and-photos.html.

“Barrier” and “Potential Barrier” rankings used in this project followed MoE (2011a) and reflect an assessment of passability for juvenile salmon or small resident rainbow trout at any flows potentially present throughout the year (Clarkin et al. 2005 ; Bell 1991; Thompson 2013). As noted in Bourne et al. (2011), with a detailed review of different criteria in Kemp and O’Hanley (2010), passability of barriers can be quantified in many different ways. Fish physiology (i.e. species, length, swim speeds) can make defining passability complex but with important implications for evaluating connectivity and prioritizing remediation candidates (Bourne et al. 2011; Shaw et al. 2016; Mahlum

et al. 2014; Kemp and O'Hanley 2010). Washington Department of Fish & Wildlife (2009) present criteria for assigning passability scores to culverts that have already been assessed as barriers in coarser level assessments. These passability scores provide additional information to feed into decision making processes related to the prioritization of remediation site candidates and have potential for application in British Columbia.

Table 4.3: Upstream habitat estimates and cost benefit analysis for Phase 1 assessments conducted on sites not yet inventoried in PSCIS. Steelhead network model (total length stream network <20% gradient).

PSCIS ID	External ID	Stream	Road	Result	Habitat value	Stream Width (m)	Priority	Fix	Cost Est ($K)
198115	2022091001	Tributary to Waterfall Creek	13 Avenue	Barrier	High	2.8	high	OBS	2000
198116	2022091002	Tributary to Waterfall Creek	Highway 16	Barrier	High	3.9	high	OBS	7500
198117	2022091003	Tributary to Waterfall Creek	9th Avenue	Barrier	High	2.6	high	OBS	2000

4.3 Phase 2

During 2022 field assessments, habitat confirmation assessments were conducted at 8 sites in the Bulkley River watershed. A total of approximately 7km of stream was assessed, fish sampling utilizing electrofishing surveys were conducted at one stream. Georeferenced field maps are presented in Attachment 1.

As collaborative decision making was ongoing at the time of reporting, site prioritization can be considered preliminary. In total, Three crossings were rated as high priorities for proceeding to design for replacement, 4 crossings were rated as moderate priorities, and 0 crossings were rated as low priorities. Results are summarized in Tables 4.4 - 4.4 with raw habitat and fish sampling data included in digital format as Attachment 3. A summary of preliminary modelling results illustrating the quantity of chinook, coho and steelhead spawning and rearing habitat potentially available upstream of each crossing as estimated by measured/modelled channel width and upstream accessible stream length are presented in Figure 4.2. Detailed information for each site assessed with Phase 2 assessments (including maps) are presented within site specific appendices to this document.

Table 4.4: Overview of habitat confirmation sites. Steelhead rearing model used for habitat estimates (total length of stream segments <7.5% gradient)

PSCIS ID	Stream	Road	UTM (11U)	Fish Species	Habitat Gain (km)	Habitat Value	Priority	Comments
57793	Vallee Creek	Walcott Road	641460 6044049	CAL,CT,LSU,RB	3.4	High	moderate	High value habitat with abundant undercut banks providing cover for resident fish. Some pockets of gravel present suitable for spawning. Large and small woody debris found throughout stream. 10:15:45
58067	Gramophone Creek	Telkwa high road	609736 6092880	RB,ST	3.4	High	high	Small beaver dam ~500m upstream. Abundant cover. Approx. 50m of open residential area on right bank. Gravels suitable for spawning. 11:18
195943	Stock Creek	Barrett Station Road	645434 6035035	–	7.9	Medium	high	Good flow volume and complexity. Pockets of gravel suitable for resident rainbow spawning and potential coho. Channel constricted due to agricultural development on both sides of the stream.
195944	Stock Creek	Highway 16	646015 6035570	–	7.2	Medium	moderate	Heavily impacted by cattle. Occasional pockets of gravel. Small rock drop of 65cm is located 365m upstream of the top end of the culvert. Massive culvert (170m long under 35m of fill).
197653	Perow Creek	Perow Loop Road	665520 6044200	–	7.4	Low	moderate	No water until ~350m upstream, then abundant gravels and cobbles suitable for spawning with some deep pools and undercut banks.
197974	Watson Creek	Highway 16	680379 6040073	CO, RB	13.9	Medium	moderate	Abundant gravels present for spawning. Lower 150-200m of stream heavily impacted by cattle. Beaver present in lower section. Numerous fry throughout. Some deep pools. Cattle impacts throughout.
198116	Tributary to Waterfall Creek	Highway 16	590233 6123183	CO, CT, RB, DV	1.2	High	high	Stream not mapped in freshwater atlas. Runs right through Hazelton. Watershed restoration plan in place by Skeena Conservation Coalition. Trap and truck coho operation. Station Creek downstream.

Table 4.5: Summary of Phase 2 fish passage reassessments.

PSCIS ID	Embedded	Outlet Drop (m)	Diameter (m)	SWR	Slope (%)	Length (m)	Final score	Barrier Result
57793	No	0.10	3.0	1.6	2.0	20	24	Barrier
58067	No	0.49	2.2	3.0	0.3	16	29	Barrier
195943	No	1.10	2.0	1.5	1.5	14	31	Barrier
195944	No	1.50	1.8	1.4	3.5	99	42	Barrier
197653	No	0.30	2.3	1.9	1.5	28	34	Barrier
197974	No	1.00	0.9	3.8	3.5	26	39	Barrier
198116	No	0.00	1.5	2.6	2.5	27	24	Barrier

Table 4.6: Cost benefit analysis for Phase 2 assessments. Steelhead rearing model used (total length of stream segments <7.5% gradient)

PSCIS ID	Stream	Road	Result	Habitat value	Stream Width (m)	Fix	Cost Est (in $K)	Habitat Upstream (m)	Cost Benefit (m / $K)	Cost Benefit (m2 / $K)
57793	Vallee Creek	Walcott Road	Barrier	High	4.1	OBS	2000	3440	8.0	18.8
58067	Gramophone Creek	Telkwa high road	Barrier	High	5.7	OBS	1150	3430	12.2	40.2
195943	Stock Creek	Barrett Station Road	Barrier	Medium	3.1	OBS	2000	7920	0.4	0.6
195944	Stock Creek	Highway 16	Barrier	Medium	4.2	SS-CBS	1500	7180	0.1	0.1
197653	Perow Creek	Perow Loop Road	Barrier	Low	3.2	SS-CBS	400	7390	0.8	1.8
197974	Watson Creek	Highway 16	Barrier	Medium	3.4	SS-CBS	1500	13950	1.6	2.8
198116	Tributary to Waterfall Creek	Highway 16	Barrier	High	3.7	OBS	7500	1200	–	–

Table 4.7: Summary of Phase 2 habitat confirmation details.

PSCIS ID	Length surveyed upstream (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
57793	600	4.1	2.0	–	2.0	abundant	high
58067	600	5.7	4.0	0.3	3.0	moderate	high
195943	330	3.1	1.8	0.3	2.1	abundant	medium
195944	640	4.2	1.8	0.3	2.0	moderate	medium
197653	500	3.2	1.9	0.4	3.0	moderate	medium
197653	150	4.7	2.4	0.6	3.7	moderate	medium
197974	600	3.4	1.8	0.5	1.8	moderate	medium
198066	–	5.2	2.8	0.4	2.5	moderate	high
198116	1200	3.7	3.5	0.3	1.5	abundant	high

Table 4.8: Summary of watershed area statistics upstream of Phase 2 crossings.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
57793	21.7	617	646	1370	847	828	SW
58067	33.3	459	–	1480	1043	951	WSW
195943	14.3	636	681	1274	923	892	SW
195944	14.3	689	681	1274	923	892	SW
197653	16.4	649	810	1412	991	970	SSE
197974	17.9	731	771	1415	950	922	SSW

* Elev P60 = Elevation at which 60% of the watershed area is above

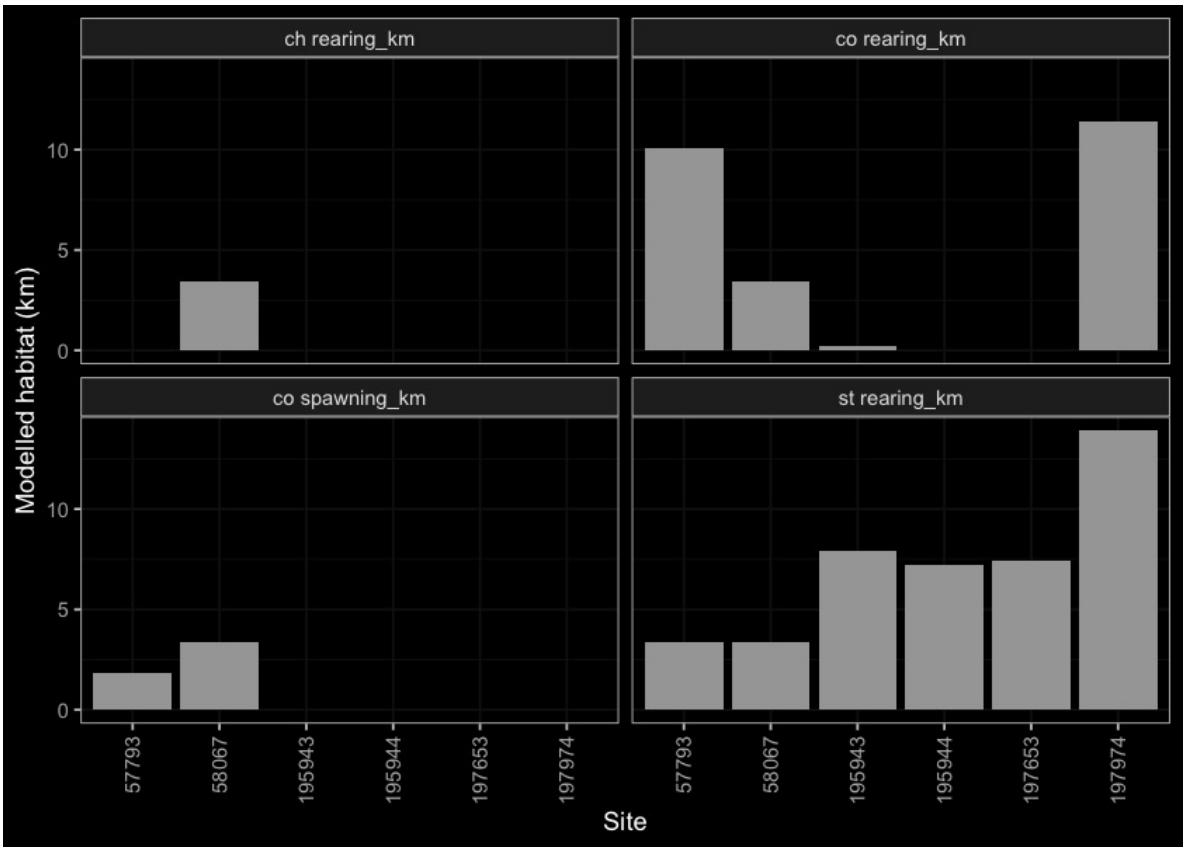

Figure 4.2: Summary of potential habitat upstream of habitat confirmation assessment sites estimated based on modelled channel width and upstream channel length.

4.3.1 Fish Sampling

Fish sampling was conducted at 12 sites with a total of 50 fish captured. Of these, 50 were rainbow trout, 0 coho, 0 were dolly varden and 0 were lamprey. Fork length data was used to delineate

salmonids based on life stages: fry (0 to 65mm), parr (>65 to 110mm), juvenile (>110mm to 140mm) and adult (>140mm) by visually assessing the histograms presented in Figure 4.3. A summary of sites assessed are included in Table 4.9 and raw data is provided in Attachment 3. A summary of density results for all life stages combined of select species is also presented in Figure 4.4. Results are presented in greater detail within individual habitat confirmation site appendices.

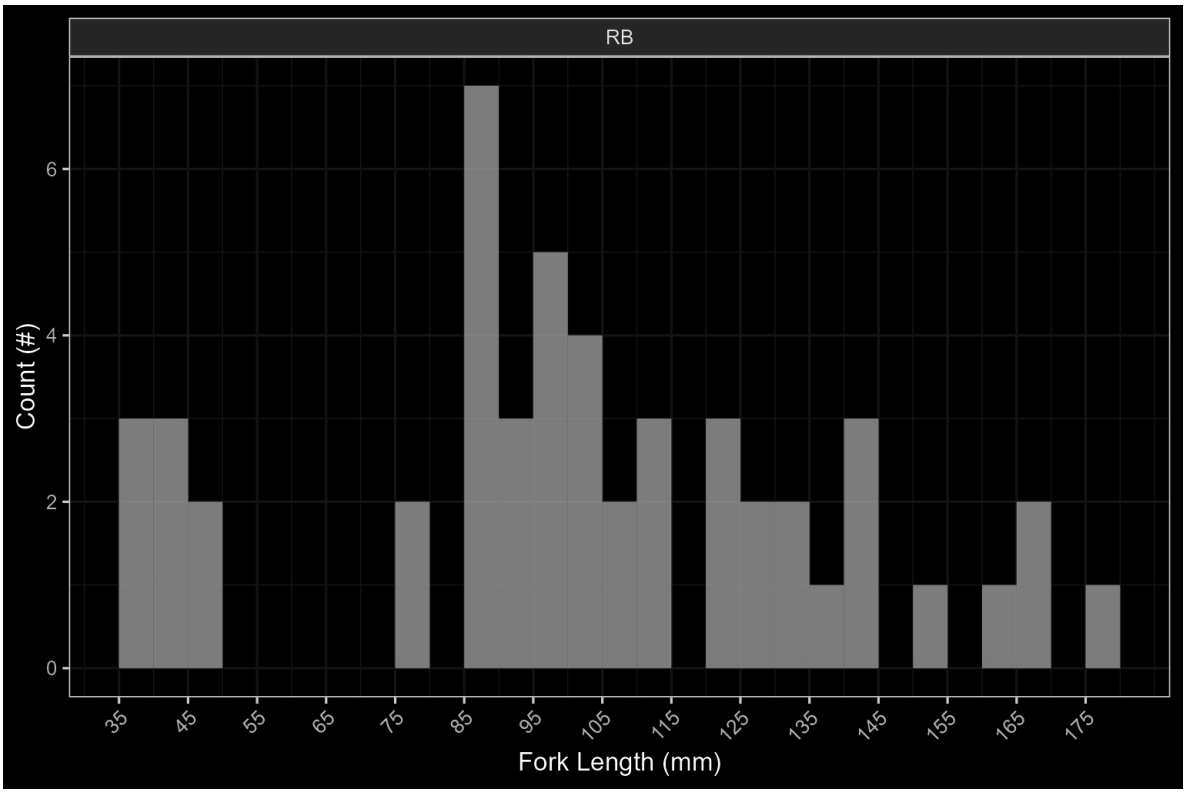

Figure 4.3: Histograms of fish lengths by species. Fish captured by electrofishing during habitat confirmation assessments.

Table 4.9: Summary of electrofishing sites.

site	passes	ef_length_m	ef_width_m	area_m2	enclosure
53067_ds_ef6	1	7.7	5.6	43.1	open
58067_ds_ef1	1	15.9	3.3	52.5	open
58067_ds_ef2	1	24.0	3.6	86.4	open
58067_ds_ef3	1	25.2	3.5	88.2	open
58067_ds_ef4	1	32.2	3.4	109.5	open
58067_ds_ef5	1	13.0	2.6	33.8	open
58067_us_ef1	1	8.6	3.4	29.2	open
58067_us_ef2	1	19.8	2.8	55.4	open
58067_us_ef3	1	25.2	3.5	88.2	open
58067_us_ef4	1	32.2	2.8	90.2	open
58067_us_ef5	1	13.0	3.1	40.3	open
58067_us_ef6	1	6.0	4.0	24.0	open

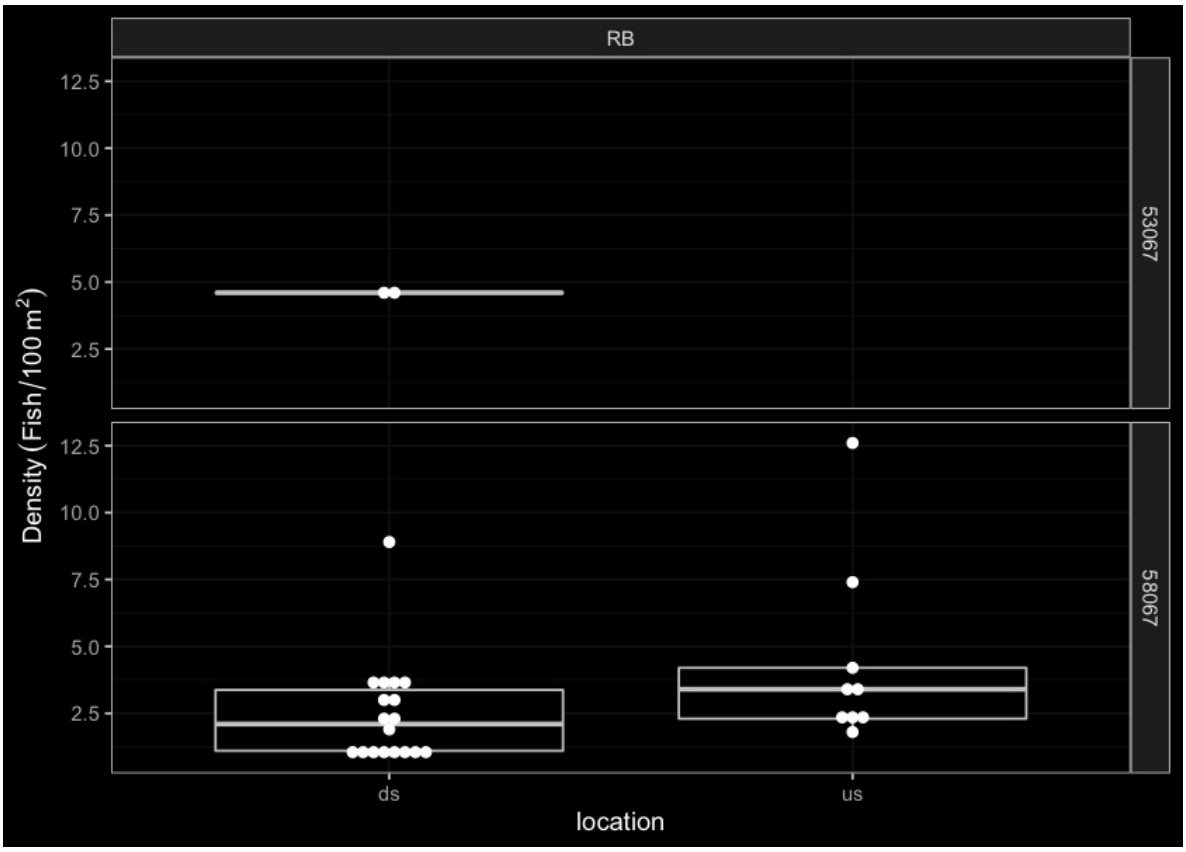

Figure 4.4: Boxplots of densities (fish/100m2) of fish captured by electrofishing during habitat confirmation assessments.

4.4 Phase 3

Engineering designs have been completed for replacement of PSCIS crossing 58159 on McDowell Creek (Irvine 2021) with a clear-span bridge and for removal of the collapsed bridge (PSCIS crossing 197912) on Robert Hatch Creek. Designs for McDowell and Robert Hatch were procured by SERNbc and Canadian Wildlife Federation respectively. At the time of reporting, the Ministry of Transportation and Infrastructure, in collaboration with Canadian Wildlife Federation was in the process of procuring designs for remediation of fish passage at three sites documented in Irvine (2021) including PSCIS 123445 on Tyhee Creek, PSCIS 124500 on Helps Creek and PSCIS 197640 on a tributary to Buck Creek. Additionally, the Ministry of Transportation and Infrastructure were procuring a design for PSCIS crossing 124420 on Station Creek (also know as Mission Creek) near New Hazleton (pers. comm. Sean Wong, Environmental Programs, MoTi).

5 Recommendations

Recommendations for potential incorporation into collaborative watershed connectivity planning include:

- Continue to acquire background information and leverage ongoing research initiatives in the region to collaboratively clarify current conditions and identify limiting factors to inform prioritization and effectiveness monitoring programs.
- Develop strategies to explore cost and fisheries production benefits of stream crossing structure upgrades alongside alternative/additional restoration and enhancement investments such as land conservation/procurement/covenant, cattle exclusion, riparian restoration, habitat complexing, water conservation, commercial/recreational fishing management, water treatment and research. Ideentify and pursue opportunities to collaborate and leverage initiatives together in study area watersheds (ex. fish passage rehabilitation, riparian restoration and cattle exclusion) for maximum likely restoration benefits.
- Refine barrier thresholds for road-stream crossing structures to explore metrics specific to life stage and life history types of species of interest. This will further focus efforts of potential remediation actions based on biological attributes (ex. timing of migration, size/direction of fish migrating, population dynamics, etc.) and could result in the consideration of interim "stop-gap" physical works to alter crossing characteristics that can address key connectivity issues yet be significantly less costly than structure replacements (ex. building up of downstream area with rock riffles to decrease the outlet drop size and/or increasing water depth within pipe with baffles and substrate additions).
- Model fish densities (fish/m^2) vs. habitat/water quality characteristics (i.e. gradient, discharge, alkalinity, elevation, riparian health, distance from high order streams, etc.) using historically gathered electrofishing and remotely sensed geodata to inform crossing prioritization, future data acquisition needs and the monitoring of restoration actions.
- Continue to develop `bcfishpass`,`bcfishobs`, `fwapg`, `bcdata` and `fpr` as well as to share open source data analysis and presentation tools that are scaleable and facilitate continual improvement. Tools should continue to be flexible and well documented to allow the future incorporation of alternative fragmentation indicators, habitat gain/value metrics and watershed sensitivity indicators.
- Continue to collaborate with potential partners to build relationships, explore perspectives and develop "road maps" for aquatic restoration in different situations (MoT roads, rail lines, permit roads of different usages, FSRs, etc.) – documenting the people involved, discussions and processes that are undertaken, funding options, synergies, measures of success, etc.

Stock Creek - 195943 - Appendix

Site Location

PSCIS crossing 195943 is located approximately 12km north west of Houston, BC. The site is located on Barrett Station Road, approximately 2.5km upstream from the confluence with the Bulkley River. PSCIS crossing 195944 is located on Highway 16, approximately 850m upstream of crossing 195943. Both crossings are the responsibility of the Ministry of Transportation and Infrastructure.

Background

At crossing 195943, Stock Creek is a third order stream with a watershed area upstream of the crossing of approximately 14.3km^2. The elevation of the watershed ranges from a maximum of 1274m to 636m at the crossing (Table 5.1). Although coho and chinook salmon have been observed just downstream of the railway crossing in the past, there is no fisheries information within provincial databases for the areas upstream of crossings 195943 and 195944 (Knowledge Management 2022; Norris [2018] 2022). At the time of reporting, Harry Bell owned the land adjacent to the creek downstream and upstream of the highway crossing. He reported historical sightings of adult coho and steelhead in Stock Creek. Approximately 2km downstream of crossing 195943, there is a railway crossing (PSCIS 198112) that was assessed and found to be fully passable.

Table 5.1: Summary of derived upstream watershed statistics for PSCIS crossing 195943.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
195943	14.3	636	681	1274	923	892	SW

* Elev P60 = Elevation at which 60% of the upstream watershed area is above

At the time of reporting, Dogwood Environmental Consulting (Dogwood) were working on a grazing/fuel reduction pilot project in collaboration with BC Wildfire, the Ministry of Agriculture and BC Cattleman's Association. The purpose of the work is to reduce fuel load on crown/agricultural land interface and enhance grazing land through targeted grazing and/or through the manual removal of dead standing timber and coarse woody debris. At the time of reporting, Stock Creek, upstream of the assessed Highway 16 crossing, was included within the project area. Dogwood hopes to help range holders mitigate some of the potential impacts related to opening up access to streams by exploring opportunities to prevent cattle from accessing riparian buffers (pers. comm Jenn Atkins, 2022).

PSCIS stream crossings 195943 and 195944 were ranked as a high priority for follow up by Canadian Wildlife Federation due to significant amounts of habitat modelled as upstream of the crossing. Following a review of PSCIS database and modelling outputs Irvine (2018) ranked both crossings as moderate priorities for follow up with habitat confirmations with notes that the stream appeared to be dewatered at both locations in the PSCIS database photos and because the watershed was relatively low in elevation. A total of 11ha of lake and 21ha of wetland is modelled upstream and a summary of habitat modelling outputs is presented in Table 5.2. A map of the watershed is provided in map attachment 093L.114.

Table 5.2: Summary of fish habitat modelling for PSCIS crossing 195943.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	23.1	0.7	3
ST Lake Reservoir (ha)	10.6	0.0	0
ST Wetland (ha)	20.6	0.0	0
ST Slopeclass03 Waterbodies (km)	2.0	0.0	0
ST Slopeclass03 (km)	3.3	0.0	0
ST Slopeclass05 (km)	7.5	0.2	3
ST Slopeclass08 (km)	5.7	0.5	9
ST Spawning (km)	0.0	0.0	–
ST Rearing (km)	7.9	0.7	9
CH Spawning (km)	0.0	0.0	–
CH Rearing (km)	0.0	0.0	–
CO Spawning (km)	0.0	0.0	–
CO Rearing (km)	0.2	0.2	100
CO Rearing (ha)	–	0.0	–
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	–	0.0	–
All Spawning (km)	12.0	0.7	6
All Rearing (km)	7.9	0.7	9
All Spawning Rearing (km)	12.0	0.7	6

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossings

At the time of the survey, PSCIS crossing 195943 was un-embedded, non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.3). The culvert outlet drop was significant at 1.1m. Water temperature was 14°C, pH was 8.1 and conductivity was 343uS/cm. A beaver dam was noted just upstream of the culvert inlet (~1.5m high).

PSCIS crossing 195944 was un-embedded, non-backwatered and ranked as a barrier to upstream fish passage. The culvert length and fill depth were estimated at 167m and 35m, respectively (Table 5.4).

Table 5.3: Summary of fish passage assessment for PSCIS crossing 195943.

Location and Stream Data	•	**Crossing Characteristics**	–
Date	2022-08-30	Crossing Sub Type	Oval Culvert
PSCIS ID	195943	Diameter (m)	2
External ID	–	Length (m)	14
Crew	MW, TP, AI, VJ, AN, DN	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	645434	Resemble Channel	No
Northing	6035035	Backwatered	No
Stream	Stock Creek	Percent Backwatered	–
Road	Barrett Station Road	Fill Depth (m)	0.6
Road Tenure	MoTi	Outlet Drop (m)	1.1
Channel Width (m)	3	Outlet Pool Depth (m)	0.71
Stream Slope (%)	3	Inlet Drop	No
Beaver Activity	No	Slope (%)	1.5
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	31	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	10

Location and Stream Data	•	Crossing Characteristics	–

Comments: Very large outlet drop, but creates nice pool for fish. Erosion on LB/RB on outlet side. Agricultural fields, minimal municipality population ds. Road is paved, detour available. 10:25

Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.

Table 5.4: Summary of fish passage assessment for PSCIS crossing 195944.

Location and Stream Data	•	**Crossing Characteristics**	–
Location and Stream Data	•	**Crossing Characteristics**	–
Date	2022-08-30	Crossing Sub Type	Round Culvert
PSCIS ID	195944	Diameter (m)	1.8
External ID	–	Length (m)	99
Crew	MW, TP, AI, VJ, AN, DN	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	646015.2	Resemble Channel	No
Northing	6035570	Backwatered	No
Stream	Stock Creek	Percent Backwatered	–
Road	Highway 16	Fill Depth (m)	9.99
Road Tenure	MoTi	Outlet Drop (m)	1.5
Channel Width (m)	2.6	Outlet Pool Depth (m)	0.25
Stream Slope (%)	2	Inlet Drop	No
Beaver Activity	No	Slope (%)	3.5
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	42	Barrier Result	Barrier
Fix type	Replace Structure with Streambed Simulation CBS	Fix Span / Diameter	4.5

Location and Stream Data	•	Crossing Characteristics	–

Comments: Length 167 m. Fill depth estimated at approximately 35 m. 14:35

Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.

Stream Characteristics Downstream of 195943

The stream was surveyed downstream from crossing 195943 for 300m . (Figure 5.1). Total cover amount was rated as moderate with small woody debris dominant. Cover was also present as .The dominant substrate was gravels with cobbles sub-dominant.The average channel width was 3.8m, the average wetted width was 1.8m, and the average gradient was 2.7%. There was a pool approximately 180m downstream of the crossing where multiple fish up to 10cm in length were spotted. A footbridge was found 20m past this pool. Concrete slabs were located on both banks upstream of the bridge. The stream had minimal overhanging and riparian vegetation due to farmland. Some areas had built up dams that formed pools. These are likely being used as livestock waterholes. Some garbage and debris was found in and around the stream. The habitat was rated as medium value for salmonid rearing and spawning. There is potential for higher value habitat but there is limited complexity due to adjacent agricultural activities.

PSCIS crossing 198112 located further downstream on the CN Railway was assessed and ranked as passable to all species and life stages at the time of survey. The crossing was embedded and fully backwatered (Table 5.5).

Table 5.5: Summary of fish passage assessment for PSCIS crossing 198112.

Location and Stream Data	•	**Crossing Characteristics**	–
Date	2022-08-30	Crossing Sub Type	Concrete Box
PSCIS ID	198112	Diameter (m)	2.5
External ID	1805507	Length (m)	14
Crew	AI, DN, AN	Embedded	Yes
UTM Zone	9	Depth Embedded (m)	0.4
Easting	645034	Resemble Channel	Yes
Northing	6033148	Backwatered	Yes
Stream	Stock Creek	Percent Backwatered	100
Road	CN Railway	Fill Depth (m)	0.5
Road Tenure	CN Rail	Outlet Drop (m)	0
Channel Width (m)	2.5	Outlet Pool Depth (m)	0.2
Stream Slope (%)	0	Inlet Drop	No
Beaver Activity	Yes	Slope (%)	0
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	8	Barrier Result	Passable
Fix type	–	Fix Span / Diameter	–

Location and Stream Data	•	Crossing Characteristics	–

Comments: Fully backwatered and embedded concrete box structure on the Railway. Not a fish passage issue at this time. 13:37

Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.

Stream Characteristics Upstream of 195943 and Downstream of 195944

The stream was surveyed upstream from crossing 195943 for 330m (Figure 5.2).
Total cover amount was rated as abundant with boulders dominant. Cover was also present as undercut banks.The dominant substrate was cobbles with boulders sub-dominant.The average channel width was 3.1m, the average wetted width was 1.8m, and the average gradient was 2.1%. There was good flow volume and a decent amount of complexity due to boulders and undercut banks. There were small pockets of gravel suitable for resident rainbow as well as coho and steelhead spawning. Occasional shallow pools and traces of large water debris were sighted. The channel appeared to be constricted due to agricultural development on both sides of the stream. Water withdrawal is occurring as well. More agricultural development was encroaching on the riparian farther upstream. The habitat was rated as medium value as an important migration corridor containing suitable spawning habitat and having moderate rearing potential.

The stream was surveyed downstream from crossing 195944 for 300m (Figure 5.2).
The average channel width was 3.1m, the average wetted width was 1.8m, and the average gradient was 2.1%.Total cover amount was rated as abundant with boulders dominant. Cover was also present as undercut banks.The dominant substrate was cobbles with boulders sub-dominant. There were many undercut banks throughout, with fish up tp 20cm long sighted throughout covered areas. There was a cattle trail next to length of creek, with some areas that showed obvious signs of erosion and an associated risk of sediment falling into stream. There were not many gravel patches suitable for spawning. The habitat was rated as medium value as an important migration corridor containing some suitable spawning habitat and having moderate rearing potential.

Stream Characteristics Upstream of 195944

The stream was surveyed upstream from crossing 195944 for 640m (Figure **??**). The average channel width was 4.2m, the average wetted width was 1.8m, and the average gradient was 2%.The dominant substrate was boulders with cobbles sub-dominant.Total cover amount was rated as moderate with boulders dominant. Cover was also present as small woody debris and undercut banks. This section of the stream is likely an important migration corridor, however the stream is heavily impacted by cattle activity. There were significant amounts of cattle manure in the stream, which likely affected water quality levels. There were occasional pockets of gravel suitable for resident rainbow spawning. Boulders were the significant cover however there were occasional pools with depths suitable for overwintering. Decent amount of rearing habitat for juveniles though. There was a small rock drop of 65cm located 365m upstream of the top end of the culvert.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 195943 with a bridge (10m span) is recommended. The cost of the work is estimated at $2,000,000 for a cost benefit of 0.4 linear m/$1000 and 0.6 m^2/$1000.

Conclusion

There was 7.9km of habitat modelled upstream of crossing 195943 rated as medium value for salmonid rearing and spawning. Crossing 195943 was ranked as a high priority for proceeding to design for replacement. Replacement with a new open bottom structure is recommended.

This stream is heavily impacted by adjacent land use and cattle activity. However, the habitat is still moderate to high value and suitable for rearing and overwintering. Resident fish were spotted at the time of survey. It is advised that individuals continue to work with adjacent landowners and tenure holders to carry out stream restoration activities and keep livestock out of the riparian region and streambed.

Table 5.6: Summary of habitat details for PSCIS crossing 195943 and 195944.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
195943	Downstream	300	3.8	1.8	0.4	2.7	moderate	medium
195943	Upstream	330	3.1	1.8	0.3	2.1	abundant	medium
195944	Downstream	300	4.1	1.5	0.3	3.2	trace	medium
195944	Upstream	640	4.2	1.8	0.3	2.0	moderate	medium

Figure 5.1: Left: Habitat downstream of PSCIS crossing 195943. Right: Habitat downstream of PSCIS crossing 195943.

Figure 5.2: Left: Habitat upstream of PSCIS crossing 195943. Right: Habitat upstream of PSCIS crossing 195943.

Figure 5.3: Left: Habitat upstream of PSCIS crossing 195944. Right: Habitat upstream of PSCIS crossing 195944.

Perow Creek - 197653 - Appendix

Site Location

PSCIS crossing 197653 is located on Perow Creek approximately 10km west of Topley, BC within a small subdivision of residential properties. The site is located on Perow Loop Road, 0.5km upstream from the confluence with Byman Creek and approximately 50m upstream of Highway 16. Byman Creek habitat and road stream crossing structures were assessed in 2020 with background and results presented in Irvine (2021). Three stream crossing structures are located downstream of Perow Loop road and are discussed below. Although modelling indicates seven crossings are located upstream of crossing 197653, review of GIS data indicates six of those crossings are located on small tributary streams over 7km upstream and very unlikely to provide high value habitat. The upstream crossing on the transmission line ~350m from Perow Loop road was assessed and is discussed below. Crossing 197653 is the responsibility of the Ministry of Transportation and Infrastructure.

Background

At crossing 197653, Perow Creek is a fourth order stream with a watershed area upstream of the crossing of approximately 16.4km^2. The elevation of the watershed ranges from a maximum of 1412m to 810m near the crossing (Table 5.7). Although chinook, coho and steelhead have been observed downstream in Byman Creek within ~100m of the crossing, at the time of reporting, there was no fisheries information available for the area upstream of crossing 197653 (MoE 2020b; Norris 2020).

Table 5.7: Summary of derived upstream watershed statistics for PSCIS crossing 197653.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
197653	16.4	649	810	1412	991	970	SSE

* Elev P60 = Elevation at which 60% of the upstream watershed area is above

PSCIS stream crossing 197653 was ranked as a high priority for follow up by the Canadian Wildlife Federation and a moderate priority for follow up by Irvine (2021) due to significant quantities of habitat upstream modelled by `bcfishpass` as likely suitable for salmon rearing. A total of 5ha of lake and 12ha of wetland is modelled upstream and a summary of habitat modelling outputs is presented in Table 5.8. A map of the watershed is provided in map attachment 093L.114.

Table 5.8: Summary of fish habitat modelling for PSCIS crossing 197653.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	34.2	0.3	1
ST Lake Reservoir (ha)	4.6	0.0	0
ST Wetland (ha)	12.2	0.0	0
ST Slopeclass03 Waterbodies (km)	1.8	0.0	0
ST Slopeclass03 (km)	6.6	0.3	5
ST Slopeclass05 (km)	3.8	0.0	0
ST Slopeclass08 (km)	15.1	0.0	0
ST Spawning (km)	0.0	0.0	–
ST Rearing (km)	7.4	0.3	4
CH Spawning (km)	0.0	0.0	–
CH Rearing (km)	0.0	0.0	–
CO Spawning (km)	0.0	0.0	–
CO Rearing (km)	0.0	0.0	–
CO Rearing (ha)	–	0.0	–
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	–	0.0	–
All Spawning (km)	19.1	0.3	2
All Rearing (km)	7.4	0.3	4
All Spawning Rearing (km)	19.1	0.3	2

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 197653 was un-embedded, non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.9). The culvert outlet drop measured at 0.3m high. There were large chunks of concrete just downstream of the outlet armouring the banks. There was no water at the time of survey. Water temperature was 13°C, pH was 8.1 and conductivity was 230uS/cm.

Table 5.9: Summary of fish passage assessment for PSCIS crossing 197653.

Location and Stream Data	•	**Crossing Characteristics**	–
Date	2022-08-29	Crossing Sub Type	Round Culvert
PSCIS ID	197653	Diameter (m)	2.3
External ID	–	Length (m)	28
Crew	MW, TP	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	665520	Resemble Channel	No
Northing	6044200	Backwatered	No
Stream	Perow Creek	Percent Backwatered	–
Road	Perow Loop Road	Fill Depth (m)	0.5
Road Tenure	MoTi	Outlet Drop (m)	0.3
Channel Width (m)	4.3	Outlet Pool Depth (m)	0
Stream Slope (%)	4	Inlet Drop	No
Beaver Activity	No	Slope (%)	1.5
Habitat Value	Low	Valley Fill	Deep Fill
Final score	34	Barrier Result	Barrier
Fix type	Replace Structure with Streambed Simulation CBS	Fix Span / Diameter	3

Location and Stream Data	•	Crossing Characteristics	–

Comments: Stream is dry. Private yards u/s and d/s. Rip rap and cement in channel. 10:48

Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.

Stream Characteristics Downstream

The stream was surveyed downstream from crossing 197653 for 100m to the culvert (PSCIS 197657) located on Highway 16, then an additional 25m downstream from the highway. The entire

area assessed downstream of the crossing was dry at the time of the survey (Figure 5.4). Total cover amount was rated as moderate with boulders dominant. Cover was also present as overhanging vegetation.The average channel width was 4.3m, the average wetted width was NAm, and the average gradient was 2%.The dominant substrate was boulders with cobbles sub-dominant. PSCIS crossing 197657 on the highway, approximately 50m downstream from crossing 197653 was reassessed and ranked as passable as it was low gradient, fully embedded and with no outlet drop. It appeared passable to all species and life stages at the time of assessment (Table 5.10). This crossing was previously assessed in 2020 by Irvine (2021), but it was mistakenly input as modelled crossing ID 1800064, when it should have been 1800067. The stream from Perow Loop Road to the highway flowed through private property and appeared to be channelized and confined with concrete slabs used as stream bank armoring just downstream of the outlet. Downstream of the highway crossing two bridges are documented in the PSCIS database (197660 and 197659). Although habitat downstream had limited complexity resulting from impacts related to the adjacent road infrastructure and residential properties, the habitat was rated as medium value as it was considered an important migration corridor.

Table 5.10: Summary of fish passage assessment for PSCIS crossing 197657.

Location and Stream Data	•	**Crossing Characteristics**	–
Date	2022-08-29	Crossing Sub Type	Oval Culvert
PSCIS ID	197657	Diameter (m)	2.3
External ID	–	Length (m)	18
Crew	AI, TP	Embedded	Yes
UTM Zone	9	Depth Embedded (m)	1
Easting	665525.1	Resemble Channel	Yes
Northing	6044126	Backwatered	No
Stream	Perow Creek	Percent Backwatered	–
Road	Highway 16	Fill Depth (m)	0.5
Road Tenure	–	Outlet Drop (m)	0
Channel Width (m)	4.6	Outlet Pool Depth (m)	0
Stream Slope (%)	3	Inlet Drop	No
Beaver Activity	No	Slope (%)	1.5
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	14	Barrier Result	Passable
Fix type	–	Fix Span / Diameter	–

Location and Stream Data	•	Crossing Characteristics	–

Comments: Stream was dry at time of survey but had water last year during extremely dry ear. Culvert appears passable for all life stages. There is private land residential development impacting the stream with the constricted channel with a large chunks of coffee just as rip rap throughout. 10:45

Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.

Stream Characteristics Upstream

The stream was surveyed upstream from crossing 197653 for 500m (Figure 5.5). Two sections of stream upstream of the crossing were assessed. As residential buildings and yards were situated immediately adjacent to the stream upstream of the crossing, the stream was accessed from a ford located on the transmission line ~325m upstream of Perow Loop Road. The first section surveyed included ~350m of channel upstream of the ford and was dewatered at the time of survey. The dominant substrate was cobbles with gravels sub-dominant.The average channel width was 3.2m, the average wetted width was 1.9m, and the average gradient was 3%.Total cover amount was rated as moderate with overhanging vegetation dominant. Cover was also present as small woody debris.

Habitat quality improved significantly within the second section of stream surveyed where flows were significant. Total cover amount was rated as moderate with overhanging vegetation dominant. Cover was also present as small woody debris, large woody debris, undercut banks, and deep pools.The dominant substrate was cobbles with gravels sub-dominant.The average channel width was 4.7m, the average wetted width was 2.4m, and the average gradient was 3.7%.Total cover amount was rated as moderate with boulders dominant. Cover was also present as small woody debris, large woody debris, undercut banks, and deep pools. There were gravels present throughout the area surveyed that were suitable for resident and anadromous salmonid spawning. Infrequent deep pools for salmonids rearing and overwintering were also present. Overall, the habitat was rated as medium value as an important migration corridor containing pockets of habitat suitable for spawning with moderate potential for juvenile salmonid rearing.

Table 5.11: Summary of fish passage assessment for PSCIS crossing 1801071.

Location and Stream Data	•	**Crossing Characteristics**	–
Date	2022-08-29	Crossing Sub Type	Ford
PSCIS ID	198109	Diameter (m)	–
External ID	1801071	Length (m)	–
Crew	MW, TP	Embedded	–
UTM Zone	9	Depth Embedded (m)	–
Easting	665432	Resemble Channel	–
Northing	6044495	Backwatered	–
Stream	Perow Creek	Percent Backwatered	–
Road	Transmission Line	Fill Depth (m)	–
Road Tenure	Hydro	Outlet Drop (m)	–
Channel Width (m)	–	Outlet Pool Depth (m)	–
Stream Slope (%)	–	Inlet Drop	–
Beaver Activity	No	Slope (%)	–
Habitat Value	–	Valley Fill	–

Location and Stream Data	•	Crossing Characteristics	–
Fix type	–	Fix Span / Diameter	–
Comments: No crossing. Transmission line. 12:49			
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 197653 with a streambed simulation (3m span) is recommended. The cost of the work is estimated at $400,000 for a cost benefit of 0.8 linear m/$1000 and 1.8 m^2/$1000.

Conclusion

There was 7.4km of habitat modelled upstream of crossing 197653 with areas surveyed rated as medium value for salmonid rearing and spawning. Crossing 197653 was ranked as a moderate priority for proceeding to design for replacement. Perow Creek near crossing 197653 has been negatively impacted by adjacent land use related to landscaping of private residences. Impacts include riparian vegetation removal, channelization, and streambank armouring. As there is no historic information on fish presence upstream of the highway fish sampling is recommended. Regardless of whether structure replacement proceeds, local residents should be engaged to explore options for riparian and channel rehabilitation on private lands within the lower reaches.

Table 5.12: Summary of habitat details for PSCIS crossing 197653.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
197653	Downstream	100	4.3	–	–	2.0	moderate	medium
197653	Upstream	500	3.2	1.9	0.4	3.0	moderate	medium
197653	Upstream2	150	4.7	2.4	0.6	3.7	moderate	medium

Figure 5.4: Left: Habitat downstream of PSCIS crossing 197653. Right: Habitat downstream of PSCIS crossing 197653.

Figure 5.5: Left: Habitat upstream of PSCIS crossing 197653. Right: Habitat upstream of PSCIS crossing 197653.

Figure 5.6: Left: Habitat upstream of PSCIS crossing 197653. Right: Habitat upstream of PSCIS crossing 197653.

Watson Creek - 197974 - Appendix

Site Location

PSCIS crossing 197974 is located under Highway 16 on Watson Creek, approximately 7km southeast of Topley, BC. The highway is 0.4km upstream from the confluence with the Bulkley River and the crossing is the responsibility of the Ministry of Transportation and Infrastructure.

Background

At crossing 197974, Watson Creek is a third order stream with a watershed area upstream of the crossing of approximately 17.9km^2. The elevation of the watershed ranges from a maximum of 1415m to 771m near the crossing (Table 5.13). Upstream of the highway coho salmon and rainbow trout have previously been recorded with the coho observation date documented as September 2000 (MoE 2020b; Norris 2020). PSCIS crossing 198065 is located ~2.5km upstream of the highway on Montgomery Road. The site was assessed in 2021 and was ranked as a barrier to fish passage according to the provincial protocol. Farther upstream, there are two addition site where GIS modelling indicates road stream crossings may be present (modelled crossing IDs 1801123 and 1801115). Watson Creek flows through Buckrow Angus farm immediately upstream of the highway then into Ailport Creek approximately 350m downstream. Stream crossing structures within Ailport Creek upstream of the confluence with Watson Creek were assessed in 2021 with results presented in Irvine (2022).

Table 5.13: Summary of derived upstream watershed statistics for PSCIS crossing 197974.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
197974	17.9	731	771	1415	950	922	SSW

* Elev P60 = Elevation at which 60% of the watershed area is above

PSCIS stream crossing 197974 was ranked as a high priority for follow up by the Canadian Wildlife Federation and Irvine (2021) due to significant quantities of habitat upstream modelled by `bcfishpass` as likely suitable for salmon rearing. A summary of habitat modelling outputs is presented in Table 5.14 and a map of the watershed is provided in map attachment 093L.115.

Table 5.14: Summary of fish habitat modelling for PSCIS crossing 197974.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	21.2	2.5	12
ST Lake Reservoir (ha)	0.0	0.0	–
ST Wetland (ha)	3.7	0.0	0
ST Slopeclass03 Waterbodies (km)	0.3	0.0	0
ST Slopeclass03 (km)	2.1	0.5	24
ST Slopeclass05 (km)	10.7	1.5	14
ST Slopeclass08 (km)	6.9	0.5	7
ST Spawning (km)	0.0	0.0	–
ST Rearing (km)	13.9	2.0	14
CH Spawning (km)	0.0	0.0	–
CH Rearing (km)	0.0	0.0	–
CO Spawning (km)	0.0	0.0	–
CO Rearing (km)	11.4	2.0	18
CO Rearing (ha)	3.7	0.0	0
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	–	0.0	–
All Spawning (km)	16.1	2.0	12
All Rearing (km)	14.2	2.0	14
All Spawning Rearing (km)	16.6	2.0	12

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 197974 was un-embedded, non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.15). The culvert was considered a complete barrier to all species and all life stages at all flows due to an outlet drop measured at 1m high. The deep and large outlet pool indicated that the culvert was significantly undersized. Condition of the pipe was noted as poor with extensive corrosion present and some collapsing in the middle of the pipe. Water temperature was 13°C, pH was 7.8 and conductivity was 199uS/cm.

Table 5.15: Summary of fish passage assessment for PSCIS crossing 197974.

Location and Stream Data	•	**Crossing Characteristics**	–
Date	2022-08-28	Crossing Sub Type	Round Culvert
PSCIS ID	197974	Diameter (m)	0.9
External ID	–	Length (m)	26
Crew	MW, AI	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	680379	Resemble Channel	No
Northing	6040073	Backwatered	No
Stream	Watson Creek	Percent Backwatered	–
Road	Highway 16	Fill Depth (m)	3
Road Tenure	MoTi	Outlet Drop (m)	1
Channel Width (m)	3.4	Outlet Pool Depth (m)	1.2
Stream Slope (%)	2	Inlet Drop	No
Beaver Activity	No	Slope (%)	3.5
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	39	Barrier Result	Barrier
Fix type	Replace Structure with Streambed Simulation CBS	Fix Span / Diameter	3

Location and Stream Data	•	Crossing Characteristics	–

Comments: Deep and large outlet pool indicate culvert is significantly undersized. Condition of the pipe is poor with corrosion and some collapsing in the middle of the pipe. 0.6m diameter overflow pipe located adjacent to the main culvert. Some decent gravels downstream. 15:52

Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.

Stream Characteristics Downstream

The stream was surveyed downstream from crossing 197974 for 350m to the confluence with Ailport Creek (Figure 5.7). Total cover amount was rated as trace with small woody debris dominant. Cover was also present as undercut banks and deep pools.The dominant substrate was gravels with cobbles sub-dominant.The average channel width was 3.5m, the average wetted width was 1.4m, and the average gradient was 2.2%. Immediately downstream of the culvert stream flows were noted as very minimal however, at approximately 50m downstream the volume of water increased substantially. There were occasional deep pools and undercut banks but cover and complexity was notably lacking in most areas. At approximately 100m downstream of the highway riparian forests have been removed to accommodate pasture with notably less cover present and a channel confined by steep banks. Abundant gravels suitable for resident and anadromous salmonid spawning were present throughout the area surveyed. The habitat was rated as medium value for salmonid rearing and spawning.

Stream Characteristics Upstream

The stream was surveyed upstream from crossing 197974 for 600m (Figure 5.8). Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris, large woody debris, deep pools, and overhanging vegetation.The dominant substrate was gravels with fines sub-dominant.The average channel width was 3.4m, the average wetted width was 1.8m, and the average gradient was 1.8%. Numerous salmonid fry were noted throughout the area surveyed along with abundant gravels suitable for resident and anadromous salmonid spawning. Immediately upstream of the crossing for approximately 150-200m stream banks and riparian areas were heavily impacted by cattle with beaver activity also noted in this area. Some deep pools to 0.7m for rearing and overwintering. Survey notes indicate that at the time of the survey cattle appeared to be accessing the stream intermittently throughout the entire area surveyed.T Overall, the habitat surveyed upstream of the crossing rated as medium value as an important migration corridor containing habitat suitable for spawning with moderate rearing potential.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 197974 with a streambed simulation (3m span) is recommended. The cost of the work is estimated at $1,500,000 for a cost benefit of 1.6 linear m/$1000 and 2.8 m^2/$1000.

Conclusion

Modelling indicates 13.9km of habitat upstream of crossing 197974 suitable for steelhead rearing with areas surveyed rated as medium value for rearing and spawning. Crossing 197974 was ranked as a moderate priority for proceeding to design for replacement. Capture of coho upstream of the highway in 2000 is an indication that the watershed has provided habitat for anadromous species in the past. Although the culvert under the highway appears to be a complete barrier to all species and

life stages of fish at all flows, fish sampling in this area would help confirm that anadromous fish are no longer able to ascend the culvert. This seems likely so it would be necessary to replace the highway crossing for anadromous fish to populate the watershed upstream. Subsequently the highway crossing should be replaced first, before pursueing remedial works at the culvert located 2.5km upstream on Montgomery Road.

Table 5.16: Summary of habitat details for PSCIS crossing 197974.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
197974	Downstream	350	3.5	1.4	0.4	2.2	trace	medium
197974	Upstream	600	3.4	1.8	0.5	1.8	moderate	medium

Figure 5.7: Left: Typical habitat downstream of PSCIS crossing 197974. Right: Typical habitat downstream of PSCIS crossing 197974.

Figure 5.8: Left: Typical habitat upstream of PSCIS crossing 197974. Right: Typical habitat upstream of PSCIS crossing 197974.

Figure 5.9: Left: Typical habitat upstream of PSCIS crossing 197974. Right: Typical habitat upstream of PSCIS crossing 197974.

Tributary to Waterfall Creek - 198116 - Appendix

Site Location

PSCIS crossing 198116 is located on Tributary to Waterfall Creek, in the town of New Hazelton, BC. on Highway 16. Tributary to Waterfall Creek is a tributary to Waterfall Creek which is in turn a tributary to Station Creek (a.k.a Mission Creek) with the Waterfall/Station confluence located approximately 4km downstream of the 10th avenue/Highway 16 crossing. The stream was labelled in Donas (2022b) as North Waterfall Creek however this name has not been assigned in the freshwater atlas. The subject stream is mapped incorrectly in the BC freshwater atlas which documents it as a small drainage originating on the north side of Highway 16. In reality, the stream flows from an area south of town, through New Hazelton in a northern direction crossing under numerous road crossings and two CN railway crossings before joining with Waterfall Creek approximately 1.6km above where it joins Station Creek (Figure 5.10). Due to the large size of the stream in the areas surveyed and the small stream size of Waterfall Creek documented in PSCIS at crossing 124456 we suspect that our subject stream should potentially have been labelled Waterfall Creek in the freshwater atlas as it appears to contain the bulk of the flow in the watershed.

During 2022 field surveys, three previously un-assessed stream crossings located upstream of the upper most railway culverts (PSCIS 124423) were surveyed for fish passage (PSCIS 198117 on 9th avenue, 198116 on Highway 16/10th avenue and 198115 on 13th avenue). Downstream of these three crossings the stream flows through six more road/rail crossings before it's confluence with Station Creek. A small bridge (modelled crossing 24704553 - a.k.a Mile 48) is located under the CN Railway approximately 875m upstream of the highway and at the time of reporting, there was an un-assessed crossing (1803294) on the subject tributary just upstream of it's confluence with Waterfall Creek. Site surveys downstream in Waterfall Creek in 2021 along with review of aerial imagery indicate that modelled crossing 1803294 likely does not exist as the stream appears to run adjacent to the railway at this location and not cross the road. The location of modeled crossing 1803294 would need to be accessed from the west by crossing the CN Railway or from the east via a private road located behind gates to the New Hazelton sewage treatment facility.

Although the habitat confirmation assessment in this memo is detailed as for crossing 198116, the assessment conducted also covered areas downstream of 198117 and upstream of crossing 198115 so has significance for informing remediation of those culverts as well. The crossing locations were prioritized for follow up after field reconnaissance indicated that Tributary to Waterfall Creek was mapped incorrectly in the BC Freshwater Atlas stream network and likely contained significant quantities of high value habitat for coho spawning and rearing.

As the subject tributary to Waterfall Creek was not mapped in the freshwater atlas at the location of these crossings at the time of reporting, there were no road stream crossings modeled as present in `bcfishpass`. As there were no crossings modeled, the software generated no estimates of fish habitat quantity. PSCIS crossing 198117 is located on , just downstream of 198116. PSCIS crossing

198115 is located on , approximately 370m upstream of 198116. Crossing 198116 on Hiighway 16/10th avenue is the responsibility of the Ministry of Transportation and Infrastructure while crossings 198117 and 198115 are the responsibility of the District of New Hazelton.

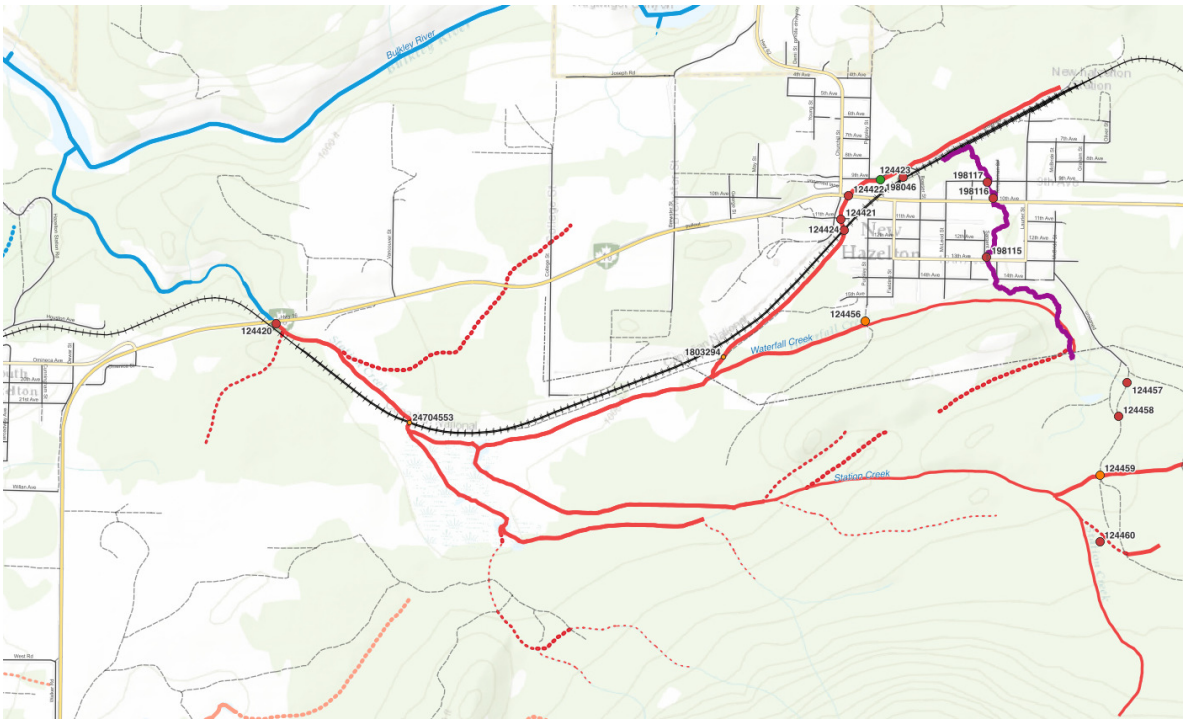

Figure 5.10: Map of Station Creek and Watershed Creek watersheds. Pink line indicates sections of tributary to Waterfall Creek that were surveyed and that at the time of reporting were not mapped correctly in the freshwater atlas.

Background

In 2021, fish passage and habitat confirmation assessments were conducted on Waterfall Creek downstream of the upper railway crossing (PSCIS 124423) as well as on Station Creek at Highway 16 (PSCIS 124420). Details of these assessments can be referenced in Irvine (2022). Wilson and Rabnett (2007) report that the crossing structure located on Highway 16 and Station Creek (PSCIS 124420) has been the subject of numerous assessments and designs with respect to the rehabilitation of fish passage, and they rated this crossing as the highest priority for rehabilitation in the Bulkley River watershed. Gitxsan Watershed Authority reports that Xsan Xsagiibil was a fishing site located at the mouth of Station Creek (Xsi Gwin Sagiiblax) (Wilson and Rabnett 2007). Identified as a high priority for additional assessments by Rabnett and Williams (2004), SKR Consultants Ltd. (2006) conducted a detailed inspection, offered rehabilitation design options and identified the natural limits of potential fish distribution to support rehabilitation efforts. At the time of reporting, a design for remediation utilizing a retrofit of the existing structure to backwater the pipe was being drafted (Sean Wong, Environmental Programs Manager - Ministry of Transportation and Infrastructure pers. comm.).

A trap and truck operation led by the Chicago Creek Community Environmental Enhancement Society moves coho from a fence set up near the confluence with the Bulkley River to upstream of Highway 16 on Waterfall Creek annually. Houlden, Houlden, and Donas (2001) report that the coho stocks in the system were wiped out in the late 1970s by the improper installation of PSCIS crossing 124420 located on Highway 16 west of New Hazelton. The Waterfall Creek Stream Rehabilitation Project began in 1990 to reintroduce coho to the stream with surplus stocks transplanted from Toboggan Creek near Smithers. In 1993 the Hazelton Elementary Streamkeepers program was developed to assist with the project and in 1995 the Chicago Creek Community Environmental Enhancement Society was incorporated to develop a hatchery nearby. The hatchery no longer operates but operations were considered successful with coho runs between 65 to over 1800 fish documented between 1998 - 2020 Donas (2022a).

There is a rich history of past assessment and restoration work in the watershed that is summarized in Donas (2022a). Work has included stream/habitat surveys, construction of spawning pads, riparian planting, construction of walkways/bridges and juvenile assessments (Donas 2022a; Nortec Consulting 2000). Donas (2022a) is a watershed recovery plan for the greater Station Creek watershed that was submitted to Fisheries and Oceans Canada in March of 2022. The report details coho escapement information for 2002 - 2021 gathered from the “Mission Creek” fence noting numbers have fallen below the target of 400 in 10 out of 20 years. They summarize juvenile overwintering study results indicate a decline in catch per unit effort over the last 10 years with condition of juveniles noted as declining. The document lays out a list of threats affecting coho recovery in the system which among others include connectivity, habitat degradation, loss of riparian cover, beaver dam removals and potential water quality issues. Finally, the recovery plan lays out goals, objectives and recommended activities to stop and reverse the decline of coho in the watershed.

At crossing 198116, Tributary to Waterfall Creek is a second order stream. Upstream of crossing 198116, coho, cutthroat trout, rainbow trout and dolly varden have previously been recorded (Donas 2022a; MoE 2020b; Norris 2020). A map of the watershed is provided in map attachment .

Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 198116 was un-embedded, non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.17). Water temperature was 8°C, pH was 8.1 and conductivity was 52uS/cm.

Table 5.17: Summary of fish passage assessment for PSCIS crossing 198116.

Location and Stream Data	•	**Crossing Characteristics**	–
Date	2022-09-10	Crossing Sub Type	Round Culvert
PSCIS ID	198116	Diameter (m)	1.5
External ID	–	Length (m)	27
Crew	AI	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	590233.2	Resemble Channel	No
Northing	6123183	Backwatered	No
Stream	Tributary to Waterfall Creek	Percent Backwatered	–
Road	Highway 16	Fill Depth (m)	1
Road Tenure	MoTi	Outlet Drop (m)	0
Channel Width (m)	3.9	Outlet Pool Depth (m)	0.2
Stream Slope (%)	2.5	Inlet Drop	Yes
Beaver Activity	No	Slope (%)	2.5
Habitat Value	High	Valley Fill	Deep Fill
Final score	24	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	10

Location and Stream Data	•	Crossing Characteristics	–

Comments: Stream is not mapped correctly in the freshwater atlas as it actually flows in a north direction through town. Great flow, patches of gravel suitable for cohost Bonnie. Right within the town of New Hazelton. Trap and truck coho operation occurring with spawners transplanted upstream of the railway and 14th avenue. 16:34

Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.

Stream Characteristics Downstream

The stream was surveyed downstream from crossing 198116 for 450m past PSCIS crossing 198177 to adjacent to the CN railway approximately 220m upstream of PSCIS crossing 124423 (Figure 5.11). Total cover amount was rated as abundant with overhanging vegetation dominant. Cover was also present as instream vegetation.The dominant substrate was fines with gravels sub-dominant.The average channel width was 3m, the average wetted width was 2.8m, and the average gradient was 1%. There is a culvert approximately 100m downstream (PSCIS crossing 198117) that was also assessed. At the time of survey, this crossing was un-embedded, non-backwatered, and ranked as a barrier to upstream fish passage (Table 5.18).The stream flows through the town of New Hazelton. There was low flow at the time of survey and the stream contained a lot of waste and debris. There was a lot of cover from vegetation. The stream hits the railway and is drained into a tributary that flows west until it joins Station Creek. The habitat was rated as high value for salmonid rearing and spawning.

Table 5.18: Summary of fish passage assessment for PSCIS crossing 198117.

Location and Stream Data	•	**Crossing Characteristics**	–
Date	2022-09-10	Crossing Sub Type	Round Culvert
PSCIS ID	198117	Diameter (m)	1.8
External ID	2022091003	Length (m)	19
Crew	AI	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	590200.9	Resemble Channel	No
Northing	6123262	Backwatered	No
Stream	Tributary to Waterfall Creek	Percent Backwatered	–
Road	9th Avenue	Fill Depth (m)	1
Road Tenure	New Hazelton	Outlet Drop (m)	0.2
Channel Width (m)	2.6	Outlet Pool Depth (m)	0.1
Stream Slope (%)	1	Inlet Drop	Yes
Beaver Activity	No	Slope (%)	1
Habitat Value	High	Valley Fill	Deep Fill
Final score	29	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	10

Location and Stream Data	•	Crossing Characteristics	–

Comments: Two 0.9 pipe added together for width. Left pipe has significant blockage 1/3 of the way through the pipe. Right Bank of the stream has an empty lot with only grass and invasive weed riparian. 16:52

Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.

Stream Characteristics Upstream

The stream was surveyed upstream from crossing 198116 for 1200m to the location of a waterfall that blocks upstream migration for all life stages and species (Figure 5.12). The average channel width was 3.7m, the average wetted width was 3.5m, and the average gradient was 1.5%.Total cover amount was rated as abundant with overhanging vegetation dominant. Cover was also present as undercut banks.The dominant substrate was fines with gravels sub-dominant.Total cover amount was rated as abundant with small woody debris dominant. Cover was also present as undercut banks. There was a culvert approximately 400m upstream of PSCIS crossing 198116 that was also assessed. At the time of survey, this crossing was un-embedded, non-backwatered, and ranked as a barrier to upstream fish passage (Table 5.19). The habitat quality was excellent. The stream flow was moderate and there were fish spotted all the way up to the waterfall where the survey ended. An adult coho was seen upstream of crossing 198115. Cover from vegetation and undercut banks was noted as abundant. The habitat was rated as high value as an important migration corridor containing suitable spawning habitat and having high rearing potential for juvenile coho, rainbow trout, cuthtout trout and dolly varden.

Table 5.19: Summary of fish passage assessment for PSCIS crossing 198115.

Location and Stream Data	•	**Crossing Characteristics**	–
Date	2022-09-10	Crossing Sub Type	Round Culvert
PSCIS ID	198115	Diameter (m)	1.25
External ID	2022091001	Length (m)	22
Crew	AI	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	590210.7	Resemble Channel	No
Northing	6122882	Backwatered	No
Stream	Tributary to Waterfall Creek	Percent Backwatered	–
Road	13 Avenue	Fill Depth (m)	1.5
Road Tenure	New Hazelton	Outlet Drop (m)	0
Channel Width (m)	2.8	Outlet Pool Depth (m)	0.4
Stream Slope (%)	3	Inlet Drop	Yes
Beaver Activity	No	Slope (%)	1
Habitat Value	High	Valley Fill	Deep Fill
Final score	24	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	10

Location and Stream Data	•	Crossing Characteristics	–

Comments: This is waterfall Creek. It does not show up in the freshwater atlas as here, however this is the main flow. Numerous fry and parr observed upstream of the crossing. No paper card for site. 16:03

Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 198116 with a bridge (10m span) is recommended. The cost of the work is estimated at $7,500,000 for a cost benefit of NA linear m/$1000 and NA m^2/$1000.

Conclusion

The Waterfall Creek system is part of the greater Station/Mission Creek watershed and located directly in the community of New Hazelton. Although heavily impacted by urban and industrial development, this watershed provides valuable opportunities for public interaction with aquatic values and high potential for meaningful ecosystem function improvements. There is a long history of community led research, restoration and rehabilitation projects within the community which is likley to continue into the future through initiatives described in Donas (2022a). Although upstream migration of adult coho is unlikely to be hindered by the three crossings surveyed, conditions could degrade over time and passage through the structures by younger lifestages salmonids is likley already be prevented at some flows. Ongoing research, monitoring and advocy efforts by groups such as the Chicago Cr Community Environmental Enhancement Society, Skeena Watershed Conservation Coalition and the Gitskan Watershed Authorities indicate that biological conditions in the stream have been worsening overtime. There was 1.2km of habitat upstream of crossing 198116 rated ashighvalue for salmonid rearing and spawning with all three crossings considered high priorities for proceeding to design for replacement. A further recommendation is that infrastructure upgrade dollars for the efforts also be leveraged towards alternative restoration activities such as riparian restoration, public education and research.

Table 5.20: Summary of habitat details for PSCIS crossing 198116.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
198116	Downstream	450	3.0	2.8	0.2	1.0	abundant	high
198116	Upstream	1200	3.7	3.5	0.3	1.5	abundant	high

Figure 5.11: Left: Typical habitat downstream of PSCIS crossing 198116. Right: Typical habitat downstream of PSCIS crossing 198116.

Figure 5.12: Left: Gravel and cobble substrate immediately upstream of PSCIS crossing 198116. Right: Footbridge located upstream of PSCIS crossing 198116.

Figure 5.13: Left: Typical habitat upstream of PSCIS crossing 198116. Right: Typical habitat upstream of PSCIS crossing 198116.

Figure 5.14: Left: Typical habitat upstream of PSCIS crossing 198116. Right: Gravel and cobble substrate immediately downstream of waterfall, upstream of PSCIS crossing 198115.

Vallee Creek - 57793 - Appendix

Site Location

PSCIS crossing 57793 is located on Vallee Creek, approximately 30km north west of Houston, BC. The site is located on Walcott Road. Crossing 57793 was located 1.9km upstream from the confluence with the Bulkley River. Crossing 57793 is the responsibility of the Ministry of Transportation and Infrastructure.

Background

At crossing 57793, Vallee Creek is a third order stream with a watershed area upstream of the crossing of approximately 21.7km^2. The elevation of the watershed ranges from a maximum of 1370m to 646m near the crossing (Table 5.21). Upstream of crossing 57793, longnose sucker, cutthroat trout, rainbow trout, and coastrange sculpin (formerly aleutian sculpin) have previously been recorded (MoE 2020b; Norris 2020).

Table 5.21: Summary of derived upstream watershed statistics for PSCIS crossing 57793.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
57793	21.7	617	646	1370	847	828	SW

* Elev P60 = Elevation at which 60% of the watershed area is above

Vallee Lake is 29ha in size and modelling indicates an additional 59ha of wetland upstream of the highway. Large lakes within watersheds can throttle high freshet and storm flows, increasing stability downstream for egg incubation and juvenile rearing.

PSCIS stream crossing 57793 was ranked as a high priority for follow up by the Canadian Wildlife Federation due to significant amounts of habitat modeled upstream. Irvine (2018) ranked the site as a moderate priority for follow up after review of PSCIS data/photos because the site appeared to have low flows, be partially backwatered and have no outlet drop indicating it was likely passable to most species and life stages at the time the initial fish passage assessment was conducted (2012). A summary of habitat modelling outputs is presented in Table 5.22. A map of the watershed is provided in map attachment 093L.113.

Table 5.22: Summary of fish habitat modelling for PSCIS crossing 57793.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	31.8	16.0	50
ST Lake Reservoir (ha)	29.1	2.3	8
ST Wetland (ha)	59.1	10.0	17
ST Slopeclass03 Waterbodies (km)	4.5	0.0	0
ST Slopeclass03 (km)	9.4	4.8	51
ST Slopeclass05 (km)	7.3	4.8	66
ST Slopeclass08 (km)	9.9	5.3	54
ST Spawning (km)	0.0	0.0	–
ST Rearing (km)	3.4	3.4	100
CH Spawning (km)	0.0	0.0	–
CH Rearing (km)	0.0	0.0	–
CO Spawning (km)	1.8	1.8	100
CO Rearing (km)	10.1	5.6	55
CO Rearing (ha)	27.5	0.0	0
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	–	0.0	–
All Spawning (km)	23.2	13.1	56
All Rearing (km)	10.1	5.6	55
All Spawning Rearing (km)	25.3	13.5	53

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 57793 was un-embedded, non-backwatered and ranked as a barrier barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.23). There was low flow through the culvert at the time of survey. However, a deep outlet pool was present indicating high flows do occur and that the culvert may be undersized. Water temperature was 12°C, pH was 8 and conductivity was 204uS/cm.

Table 5.23: Summary of fish passage assessment for PSCIS crossing 57793.

Location and Stream Data	•	**Crossing Characteristics**	–
Date	2022-08-31	Crossing Sub Type	Round Culvert
PSCIS ID	57793	Diameter (m)	3
External ID	–	Length (m)	20
Crew	MW, DN, TP, AN	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	641460	Resemble Channel	No
Northing	6044049	Backwatered	No
Stream	Vallee Creek	Percent Backwatered	–
Road	Walcott Road	Fill Depth (m)	1
Road Tenure	MoTi	Outlet Drop (m)	0.1
Channel Width (m)	4.7	Outlet Pool Depth (m)	0.5
Stream Slope (%)	3	Inlet Drop	No
Beaver Activity	No	Slope (%)	2
Habitat Value	High	Valley Fill	Deep Fill
Final score	24	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	10

Location and Stream Data	•	Crossing Characteristics	–

Comments: Slight outlet drop, low water levels would be a fish passage issue. Little amount of water running through culvert. Deep pool at outlet of culvert, good for fish. Boulders in culvert, which are obstacles to fish. 9:34

Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.

Stream Characteristics Downstream

The stream was surveyed downstream from crossing 57793 for 300m to the confluence with the Bulkley River (Figure 5.15). The dominant substrate was gravels with cobbles sub-dominant.The average channel width was 4.1m, the average wetted width was 2.4m, and the average gradient was 2%.Total cover amount was rated as abundant with undercut banks dominant. Cover was also present as small woody debris, large woody debris, and overhanging vegetation. There were undercut banks and abundant riparian vegetation throughout providing good cover for fish. Some gravels were present that could be suitable for spawning. Functional large woody debris was present throughout the stream.The habitat was rated as high value for salmonid rearing and spawning.

Stream Characteristics Upstream

The stream was surveyed upstream from crossing 57793 for 600m (Figure 5.16). Total cover amount was rated as abundant with large woody debris dominant. Cover was also present as small woody debris, undercut banks, and overhanging vegetation.The average channel width was 4.1m, the average wetted width was 2m, and the average gradient was 2%.The dominant substrate was cobbles with gravels sub-dominant. Stream measurements were obtained by using ground estimates. The habitat quality was excellent. There were abundant undercut banks and healthy mixed riparian vegetation throughout. The stream is wide and contained some pockets of gravel suitable for spawning resident species. The habitat was rated as high value as an important migration corridor containing suitable spawning habitat and having moderate rearing potential.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 57793 with a bridge (10m span) is recommended. The cost of the work is estimated at $2,000,000 for a cost benefit of 8 linear m/$1000 and 18.8 m^2/$1000.

Conclusion

There was 3.4km of habitat modelled upstream of crossing 57793 with areas surveyed rated as high value for salmonid rearing and spawning. Crossing 57793 was ranked as a moderate priority for proceeding to design for replacement.

Table 5.24: Summary of habitat details for PSCIS crossing 57793.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
57793	Downstream	300	4.1	2.4	0.5	2	abundant	high
57793	Upstream	600	4.1	2.0	–	2	abundant	high

Figure 5.15: Left: Typical habitat downstream of PSCIS crossing 57793. Right: Typical habitat downstream of PSCIS crossing 57793.

Figure 5.16: Left: Typical habitat upstream of PSCIS crossing 57793. Right: Typical habitat upstream of PSCIS crossing 57793.

Figure 5.17: Left: Typical habitat upstream of PSCIS crossing 57793. Right: Typical habitat upstream of PSCIS crossing 57793.

Figure 5.18: Left: Typical habitat upstream of PSCIS crossing 57793. Right: Habitat upstream of PSCIS crossing 57793.

Gramophone Creek - 58067 - Appendix

Site Location

PSCIS crossing 58067 is located on Gramophone Creek approximately 9km south of the community of Witset, BC on Telkwa high road. Crossing 58067 was located 2.6km upstream from the confluence with the Bulkley River and is the responsibility of the Ministry of Transportation and Infrastructure.

Background

At crossing 58067, Gramophone Creek is a fourth order stream with a watershed area upstream of the crossing of approximately 33.3km^2. The elevation of the watershed ranges from a maximum of 1480m to 459m at the crossing (Table 5.25). Upstream of crossing 58067, rainbow trout and steelhead have previously been recorded (MoE 2020b; Norris 2020).

Table 5.25: Summary of derived upstream watershed statistics for PSCIS crossing 58067.

Site	Area Km	Elev Site	Elev Max	Elev Median	Elev P60	Aspect
58067	33.3	459	1480	1043	951	WSW

* Elev P60 = Elevation at which 60% of the watershed area is above

The Gramophone Creek watershed is designated as a Fisheries Sensitive Watershed under British Columbia's Forest and Range Practices Act Government Actions Regulation, and the Oil and Gas Activities Act Environmental Management and Protection Regulation. Fisheries Sensitive Watersheds have significant fish values and are sensitive to changes in habitat (M. Porter et al. 2015).

The Trout Creek/Moricetown watershed project was an integrated restoration plan designed for 14 watersheds found on either side of the Bulkley River. Gramophone Creek was included in the study area. A level I sediment source assessment was conducted on the watershed. This provided an overview and a risk assessment of sedimentation in pre defined study blocks, which was then used to recommend further restoration strategies. The risk assessment was used to determine if the roads were on low, moderate, or high-risk terrain; and the consequence that sedimentation could have on the road's associated fisheries stream. Gramophone Creek scored lower than average overall on the risk assessment but had some study blocks that required a level II assessment (Sterling Wood Group Inc. 1997).

In a study conducted by (M. Porter et al. 2015), the Gramophone Creek stream network was analysed using GIS methods to assess the risk status related to fish habitat impact. Risk status was determined by measuring nine habitat indicators. These included: road density for the entire watershed, road density above the H_{60} line (the elevation above which 60% of the watershed area lies), road density less than 100m from a stream, stream crossing density, proportion of stream logged, proportion of fish-bearing stream logged, density of stream banks logged on slopes greater than 60%, peak flow index, and road density on unstable slopes. Measured values were compared to a baseline to classify risk as low, moderate, or high. Of the 71 watersheds included in the analysis, Gramophone Creek was notable for having all nine indicators rated as high risk.

PSCIS stream crossing 58067 was ranked as a high priority for follow up by the Canadian Wildlife Federation because of significant amounts of habitat modelled upstream of the crossing. Upon review of an assessment done on this crossing in 2012 by Gollner, Cain, and Russell (2013), Irvine (2018) ranked it as a high priority for follow up due to its high habitat value. A summary of habitat modelling outputs is presented in Table 5.26. A map of the watershed is provided in map attachment 093L.122.

Table 5.26: Summary of fish habitat modelling for PSCIS crossing 58067.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	23.9	14.0	59
ST Lake Reservoir (ha)	0.1	0.0	0
ST Wetland (ha)	3.3	0.0	0
ST Slopeclass03 Waterbodies (km)	0.3	0.0	0
ST Slopeclass03 (km)	1.9	1.4	74
ST Slopeclass05 (km)	3.3	3.2	97
ST Slopeclass08 (km)	5.1	3.0	59
ST Spawning (km)	0.0	0.0	–
ST Rearing (km)	3.4	3.4	100
CH Spawning (km)	0.0	0.0	–
CH Rearing (km)	3.4	3.4	100
CO Spawning (km)	3.4	3.4	100
CO Rearing (km)	3.4	3.4	100
CO Rearing (ha)	–	0.0	–
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	–	0.0	–
All Spawning (km)	5.4	5.0	93
All Rearing (km)	3.4	3.4	100
All Spawning Rearing (km)	5.4	5.0	93

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 58067 was un-embedded, non-backwatered, had an outlet drop of 0.49m and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.27). The crossing consisted of two pipes, with a very big outlet pool indicating the crossing was undersized. The pipes were notes as in poor condition due to corrosion and the road prism at the site had indications of significant erosion adjacent to the crossing. Water temperature was 12°C, pH was 8.2 and conductivity was 93uS/cm.

Table 5.27: Summary of fish passage assessment for PSCIS crossing 58067.

Location and Stream Data	•	Crossing Characteristics	–
Date	2022-09-01	Crossing Sub Type	Oval Culvert
PSCIS ID	58067	Diameter (m)	2.2
External ID	–	Length (m)	16
Crew	AI, CM, JO	Embedded	No

Location and Stream Data	•	Crossing Characteristics	–
Easting	609735.8	Resemble Channel	No
Northing	6092880	Backwatered	No
Stream	Gramophone Creek	Percent Backwatered	–
Road	Telkwa high road	Fill Depth (m)	1.8
Road Tenure	MoTi	Outlet Drop (m)	0.49
Channel Width (m)	6.6	Outlet Pool Depth (m)	1.46
Stream Slope (%)	4	Inlet Drop	Yes
Beaver Activity	No	Slope (%)	0.3
Habitat Value	High	Valley Fill	Deep Fill
Final score	29	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	11.5

Location and Stream Data	•	Crossing Characteristics	–

Comments: Gradient of culvert shot with laser level. Inside of pipe is bent downward at the outlet. Upstream side of the road is eroding. Enormous outlet pool indicates pricing is undersized. Water flowing under overflow. Just outside of Whitsett community. Seems like a really good candidate for replacement. 10:26

Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.

Stream Characteristics Downstream

The stream was surveyed downstream from crossing 58067 for 300m to the confluence with the Bulkley River (Figure 5.20). Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris, boulders, deep pools, and overhanging vegetation.The average channel width was 5.1m, the average wetted width was 3m, and the average gradient was 3%.The dominant substrate was cobbles with boulders sub-dominant. There were abundant undercut banks available for cover. Some patches of gravel were present that would be suitable for rainbow, steelhead and coho spawning. Occasional deep pools were present that would serve as good habitat suitable for fish rearing and overwintering. Riparian vegetation was mixed decidous and conifer old growth forest. The habitat was rated as high value for salmonid rearing and spawning.

Stream Characteristics Upstream

The stream was surveyed upstream from crossing 58067 for 600m (Figure 5.21). The dominant substrate was cobbles with gravels sub-dominant.Total cover amount was rated as moderate with boulders dominant. Cover was also present as small woody debris and undercut banks.The average channel width was 5.7m, the average wetted width was 4m, and the average gradient was 3%. There is a small beaver dam ~500m upstream from the crossing. The stream is wide throughout with abundant cover and some areas with gravels suitable for spawning. There is approximately 50m of open residential area on the right bank. The habitat was rated as high value as an important migration corridor containing suitable spawning habitat and having moderate rearing potential.

Fish Sampling

Electrofishing was conducted with results summarised in Tables 5.29 - 5.30 and Figure 5.19.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 58067 with a bridge (11.5m span) is recommended. The cost of the work is estimated at $1,150,000 for a cost benefit of 12.2 linear m/$1000 and 40.2 m^2/$1000.

Conclusion

There was 3.4km of habitat modelled upstream of crossing 58067 with areas surveyed rated as high value for salmonid rearing and spawning. Gramophone Creek is a large system with habitat suitable for numerous species including coho salmon and steelhead. The crossings location adjacent to the community of Witset, BC is ideal for community involvement in the project. Additionally, because Telkwa high road is a non-paved road with a crossing location that can be accessed from either side, the costs of the work are low when compared to paved road and

highway options. Crossing 58067 was ranked as a high priority for proceeding to design for replacement. Elecrofishing results at the site indicated that the stream is productive in terms of rainbow trout however the lack of coho presence was surprising. It is recommended that the stream be surveyed all the way down to the Bulkley River to confirm that there are no barriers to migration downstream of the crossing before remedial works are planned.

Table 5.28: Summary of habitat details for PSCIS crossing 58067.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
58067	Downstream	300	5.1	3	0.4	3	moderate	high
58067	Upstream	600	5.7	4	0.3	3	moderate	high

Table 5.29: Fish sampling site summary for 58067.

site	passes	ef_length_m	ef_width_m	area_m2	enclosure
58067_ds_ef1	1	15.9	3.3	52.5	open
58067_ds_ef2	1	24.0	3.6	86.4	open
58067_ds_ef3	1	25.2	3.5	88.2	open
58067_ds_ef4	1	32.2	3.4	109.5	open
58067_ds_ef5	1	13.0	2.6	33.8	open
58067_us_ef1	1	8.6	3.4	29.2	open
58067_us_ef2	1	19.8	2.8	55.4	open
58067_us_ef3	1	25.2	3.5	88.2	open
58067_us_ef4	1	32.2	2.8	90.2	open
58067_us_ef5	1	13.0	3.1	40.3	open
58067_us_ef6	1	6.0	4.0	24.0	open

Table 5.30: Fish sampling density results summary for 58067.

local_name	species_code	life_stage	catch	density_100m2	nfc_pass
58067_ds_ef1	RB	fry	1	1.9	FALSE
58067_ds_ef1	RB	parr	2	3.8	FALSE
58067_ds_ef1	RB	juvenile	2	3.8	FALSE
58067_ds_ef1	RB	adult	2	3.8	FALSE
58067_ds_ef2	RB	parr	3	3.5	FALSE
58067_ds_ef2	RB	juvenile	1	1.2	FALSE
58067_ds_ef2	RB	adult	2	2.3	FALSE
58067_ds_ef3	RB	fry	1	1.1	FALSE
58067_ds_ef3	RB	parr	1	1.1	FALSE
58067_ds_ef3	RB	juvenile	2	2.3	FALSE
58067_ds_ef3	RB	adult	1	1.1	FALSE
58067_ds_ef4	RB	fry	1	0.9	FALSE
58067_ds_ef4	RB	parr	1	0.9	FALSE
58067_ds_ef4	RB	juvenile	1	0.9	FALSE
58067_ds_ef4	RB	adult	1	0.9	FALSE
58067_ds_ef5	RB	fry	3	8.9	FALSE
58067_ds_ef5	RB	parr	1	3.0	FALSE
58067_ds_ef5	RB	juvenile	1	3.0	FALSE
58067_us_ef1	RB	parr	1	3.4	FALSE
58067_us_ef1	RB	juvenile	1	3.4	FALSE
58067_us_ef2	RB	parr	7	12.6	FALSE

local_name	species_code	life_stage	catch	density_100m2	nfc_pass
58067_us_ef2	RB	adult	1	1.8	FALSE
58067_us_ef3	RB	parr	2	2.3	FALSE
58067_us_ef4	RB	parr	2	2.2	FALSE
58067_us_ef5	RB	parr	3	7.4	FALSE
58067_us_ef5	RB	juvenile	1	2.5	FALSE
58067_us_ef6	RB	adult	1	4.2	FALSE

* nfc_pass FALSE means fish were captured in final pass indicating more fish of this species/lifestage may have remained in site. Mark-recaptured required to reduce uncertainties.

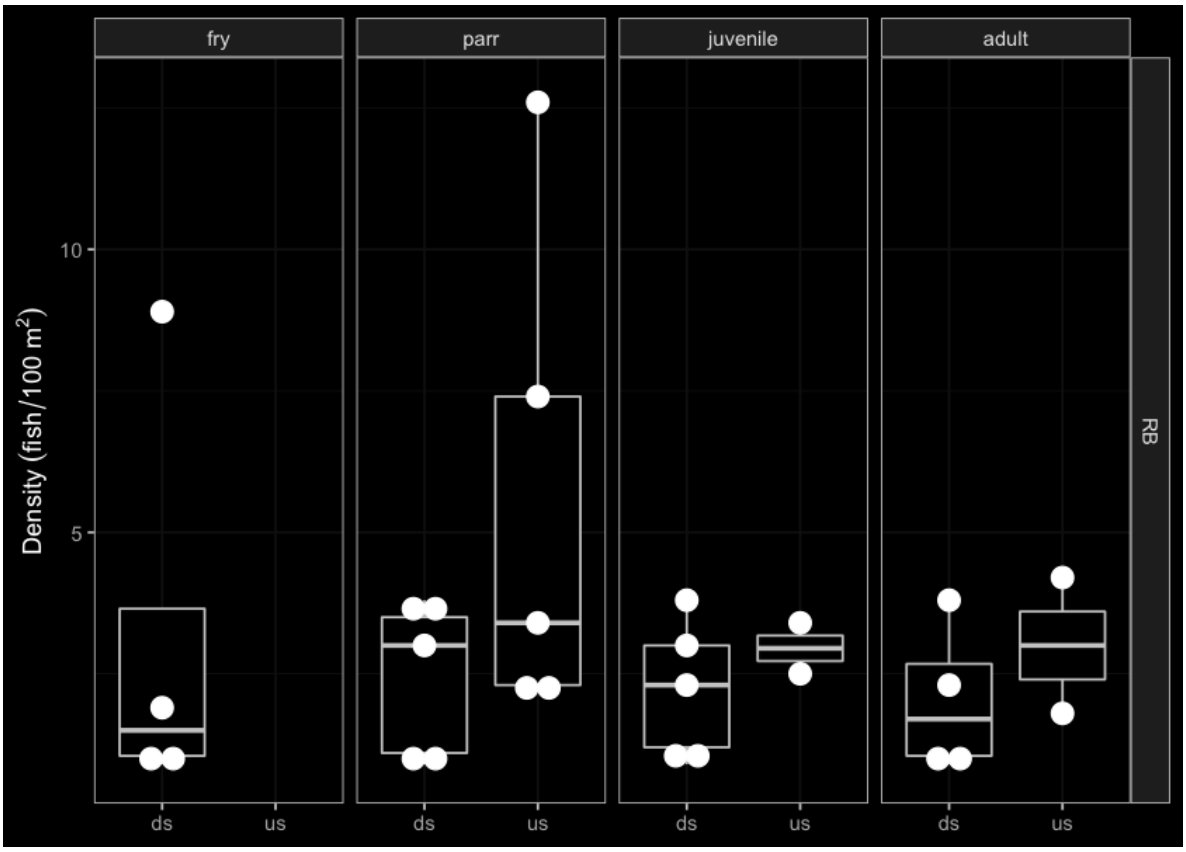

Figure 5.19: Densites of fish (fish/100m2) captured upstream of PSCIS crossing 58067.

Figure 5.20: Left: Typical habitat downstream of PSCIS crossing 58067. Right: Typical habitat downstream of PSCIS crossing 58067.

Figure 5.21: Left: Typical habitat upstream of PSCIS crossing 58067. Right: Typical habitat upstream of PSCIS crossing 58067.

Figure 5.22: Left: Typical habitat upstream of PSCIS crossing 58067. Right: Typical habitat upstream of PSCIS crossing 58067.

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Session Info

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Running under: , RStudio 2022.12.0.353

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