SOCIETY FOR ECOSYSTEM RESTORATION
IN NORTHERN BRITISH COLUMBIA

Bulkley River and Morice River Watershed Groups Fish Passage Restoration Planning 2021 - DRAFT

Prepared for
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BC Fish Passage Remediation Program
Canadian Wildlife Federation

Prepared by
Al Irvine, B.Sc., R.P.Bio.
New Graph Environment Ltd.
on behalf of
Society for Ecosytem Restoration in Northern British Columbia

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new graph environment
Research & Consulting

Table of Contents

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 pdf and as an online interactive report at https://newgraphenvironment.github.io/fish_passage_skeena_2021_reporting/. We recommend viewing online as the web-hosted html version contains more features and is more easily navigable.

This report builds on reporting from the spring of 2021 which can be referenced here. The work presented is currently in draft form for partner and stakeholder engagement purposes, contains errors and will change over time.

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.

2 Background

The study area includes the Bulkley River and Morice River watershed groups (Figure 2.1) and is within the traditional territories of the Gitxsan and Wet'suwet'en.

2.1 Wet'suwet'en

Wet'suwet'en hereditary territory covers an area of 22,000km^2 including the Bulkley River and Morice River watersheds 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

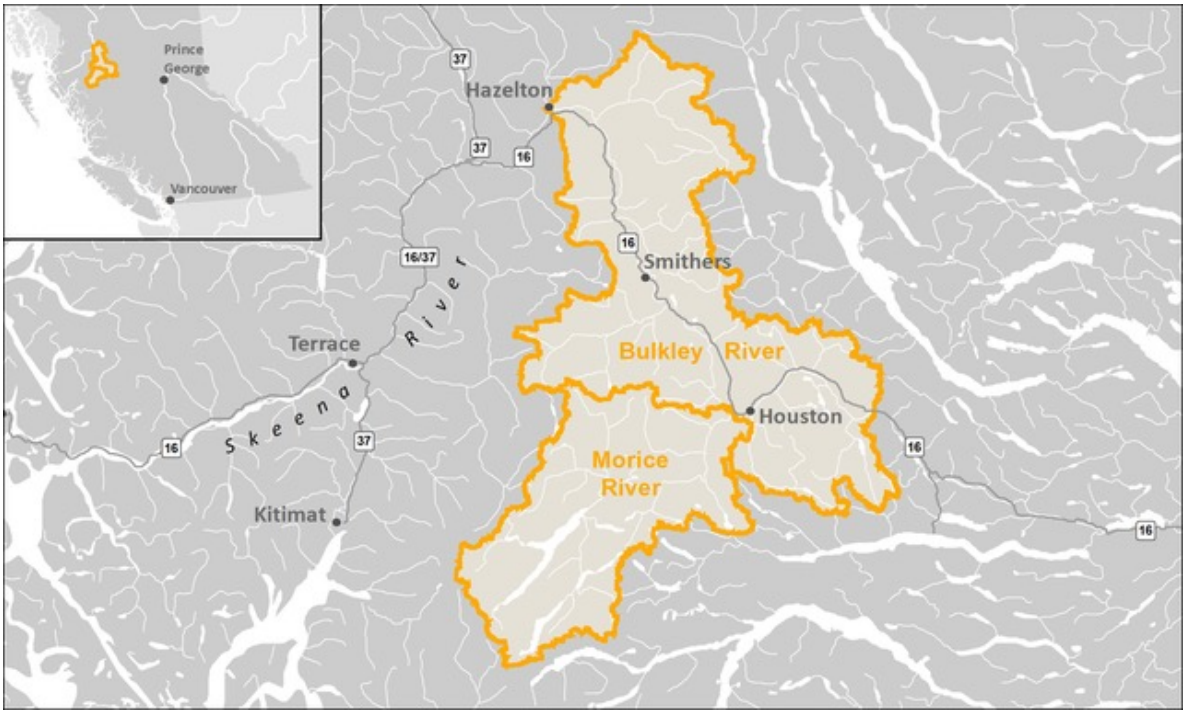


Figure 2.1: Overview map of Study Areas

2.3.1 Bulkley River

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 139.1 m^3/s at station 08EE004 located near Quick (~27km south of Telkwa) and 19.5 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).

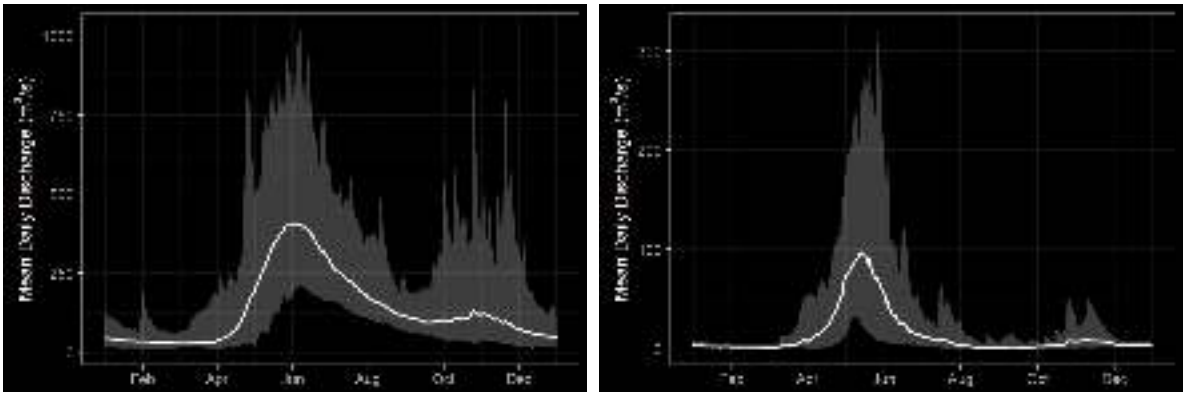


Figure 2.2: Hydrograph for Bulkley River at Quick (Station #08EE004) and near Houston (Station #08EE003).

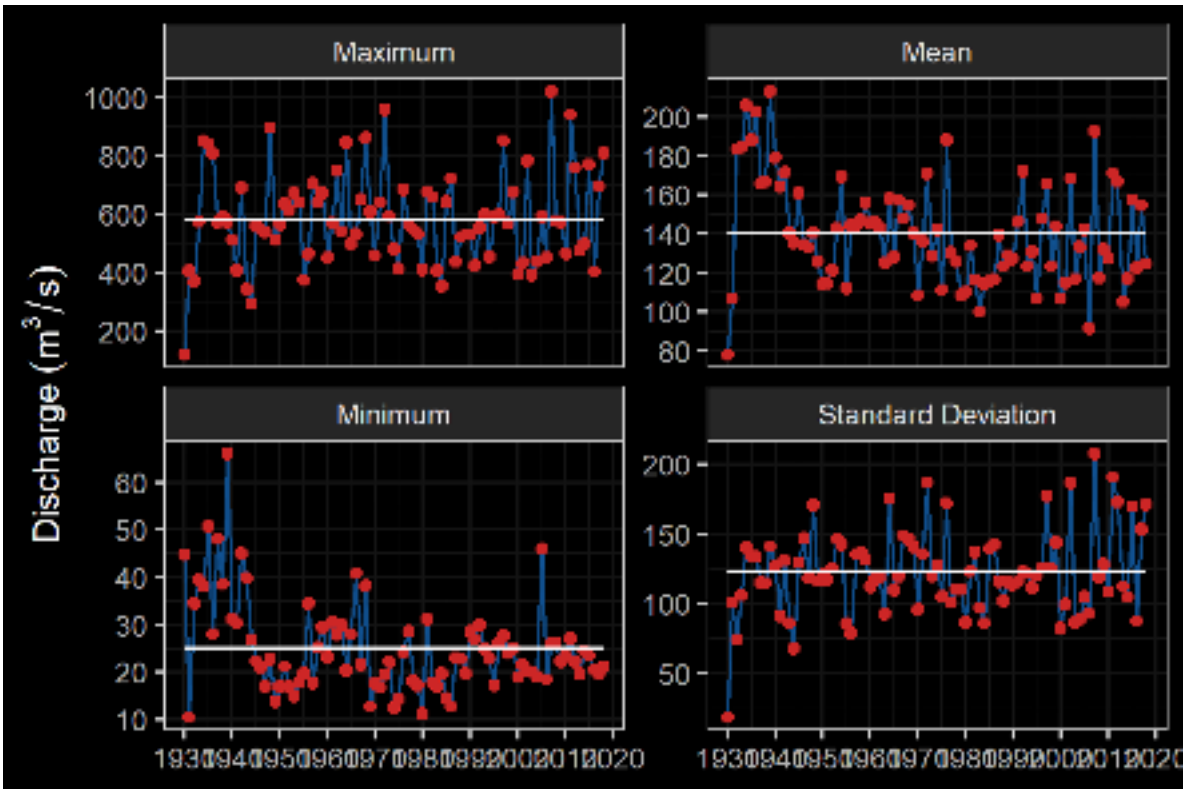


Figure 2.3: Summary of hydrology statistics for Bulkley River at Quick (Station #08EE004 - daily discharge data from 1930 to 2018).

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

2.3.2 Morice River

The Morice River watershed drains 4,379 km^2 of Coast Mountains and Interior Plateau in a generally south-eastern direction. The Morice River is an 8th order stream that flows approximatley 80km from Morice Lake to the confluence with the upper Bulkley River just north of Houston. Major tributaries include the Nanika River, the Atna River, Gosnell Creek and the Thautil River. There area numerous large lakes situated on the south side of the watershed including Morice Lake, McBride Lake, Stepp Lake, Nanika Lake, Kid Price Lake, Owen Lake and others. There is one active hydrometric station on the mainstem of the Morice River near the outlet of Morice Lake and one historic station that was located at the mouth of the river near Houston that gathered data in 1971 only (Environment and limate Change Canada 2021). An estimate of mean annual discharge for the one year of data available for the Morice near it's confluence with the Bulkley River is 113.3 m^3/s. Mean annual discharge is estimated at 75.3 m^3/s at station 08ED002 located near the outlet of Morice Lake. Flow patterns are typical of high elevation watersheds influenced by coastal weather patterns which receive large amounts of winter precipitation as snow in the winter and large precipitation events in the fall. This leads to peak levels of discharge during snowmelt, typically from May to July with isolated high flows related to rain and rain on snow events common in the fall (Figures 2.5 - 2.6).

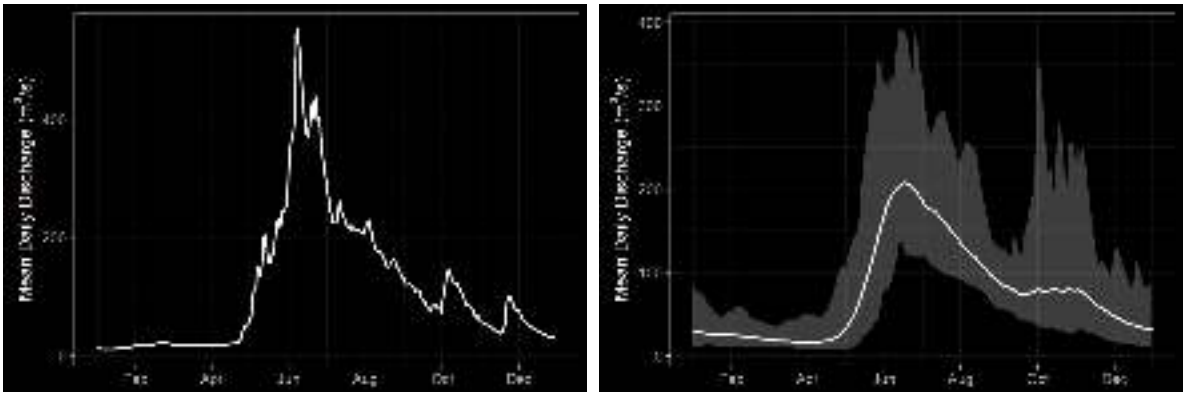


Figure 2.5: Left: Hydrograph for Morice River near Houston (Station #08ED003 - 1971 data only). Right: Hydrograph for Morice River near outlet of Morice Lake (Station #08ED002).

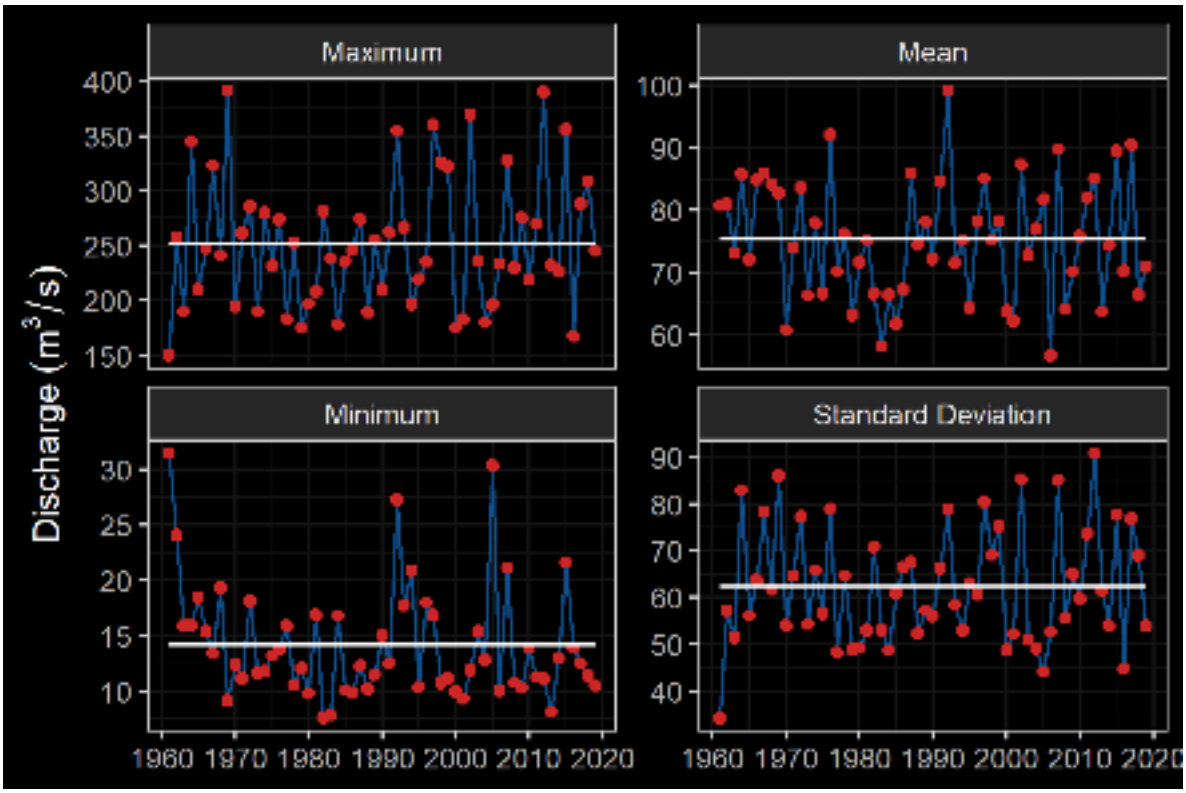


Figure 2.6: Summary of hydrology statistics for Morice River near outlet of Morice Lake (Station #08ED002 - Lat 54.116829 Lon -127.426582). Available daily discharge data from 1961 to 2018.

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).

2.4.1 Bulkley River

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).

2.4.2 Morice River

Detailed reviews of Morice River watershed fisheries can be found in Bustard and Schell (2002), Allen Gottesfeld, Rabnett, and Hall (2002), Schell (2003), A. Gottesfeld and Rabnett (2007), and

ILMB (2007) with a comprehensive review of water quality by Oliver (2018). Overall, the Morice watershed contains high fisheries values as a major producer of chinook, pink, sockeye, coho and steelhead.

2.4.2.1 Fish Species

Fish species recorded in the Bulkley River and Morice River watershed groups 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), Allen 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.

Some key areas of high fisheries values for chinook, sockeye and coho are noted in Bustard and Schell (2002) as McBride Lake, Nanika Lake, and Morice Lake watersheds. A draft gantt chart for select species in the Morice River and Bulkley River watersheds was derived from reviews of the aforementioned references and is included as Figure 2.7. 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.

In the 1990's the Morice River watershed, A. Gottesfeld and Rabnett (2007) estimated that chinook comprised 30% of the total Skeena system chinook escapements. It is estimated that Morice River coho comprise approximatley 4% of the Skeena escapement with a declining trend noted since the 1950 in A. Gottesfeld and Rabnett (2007). Coho spawn in major tributaries and small streams ideally at locations where downstream dispersal can result in seeding of prime off channel habitats including warm productive sloughs and side channels. Of all the salmon species, coho rely on small tributaries the most (Bustard and Schell 2002). Bustard and Schell (2002) report that much of the distribution of coho into non-natal tributaries occurs during high flow periods of May - early July with road culverts blocking migration into these habitats.

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 2.8 - 2.9.

Table 2.1: Fish species recorded in the Bulkley River and Morice River watershed groups.

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

Scientific Name	Species Name	Species Code	BC List	Provincial FRPA	COSEWIC	SARA	Bulkley	Morice
1990)	–	–	Yes					
Richardsonius balteatus	Redside Shiner	RSC	Yellow	–	–	–	Yes	Yes
Salvelinus confluentus pop. 26	Bull Trout	BT	Blue	–	–	–	Yes	Yes
Salvelinus fontinalis	Brook Trout	EB	Exotic	–	–	–	Yes	Yes
Salvelinus malma	Dolly Varden	DV	Yellow	–	–	–	Yes	Yes
Salvelinus namaycush	Lake Trout	LT	Yellow	–	–	–	Yes	Yes
–	Arctic Char	AC	–	–	–	–	–	Yes
–	Cutthroat/Rainbow cross	CRS	–	–	–	–	Yes	–
–	Dace (General)	DC	–	–	–	–	–	Yes
–	Lamprey (General)	L	–	–	–	–	Yes	Yes
–	Minnow (General)	C	–	–	–	–	Yes	Yes
–	Salmon (General)	SA	–	–	–	–	Yes	Yes
–	Sculpin (General)	CC	–	–	–	–	Yes	Yes
–	Sucker (General)	SU	–	–	–	–	Yes	Yes
–	Whitefish (General)	WF	–	–	–	–	Yes	Yes

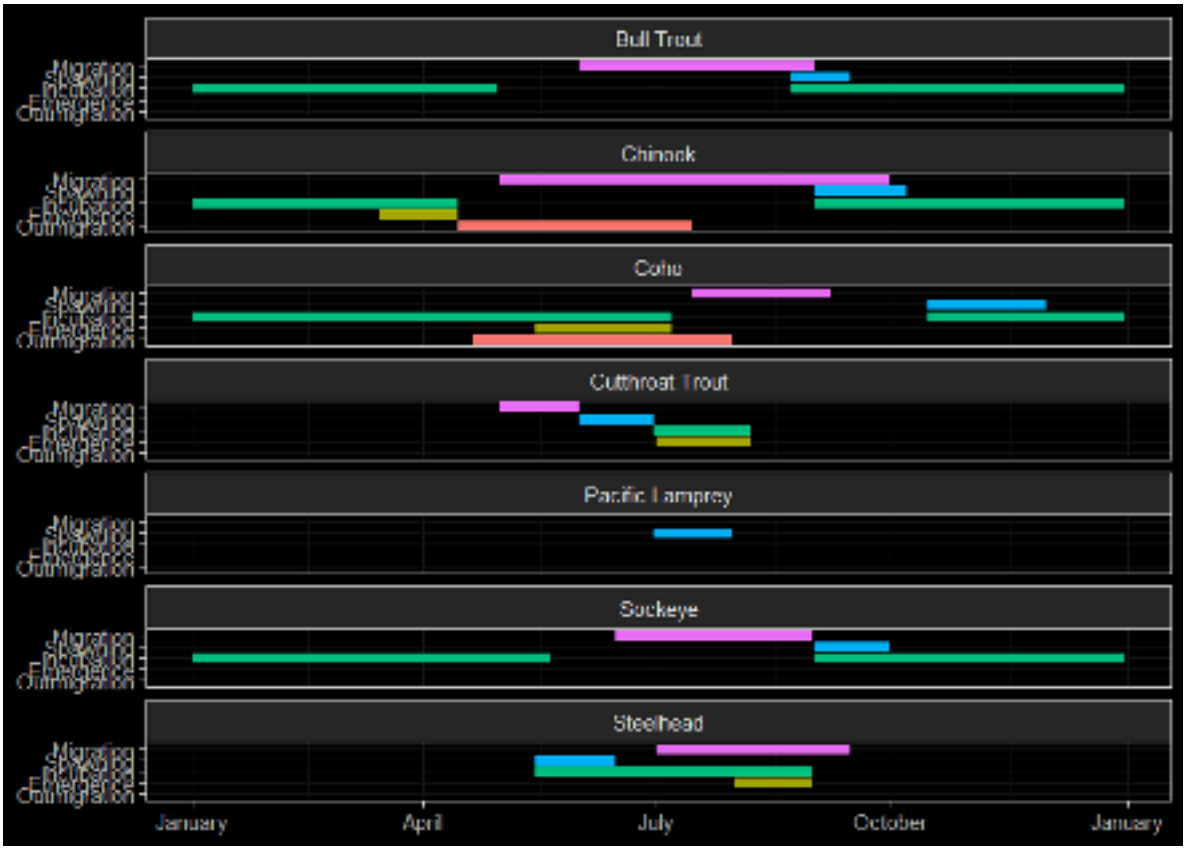


Figure 2.7: Gantt chart for select species in the Morice River and Bulkley River watersheds. To be updated in consultation with local fisheries techicians and knowledge holders.

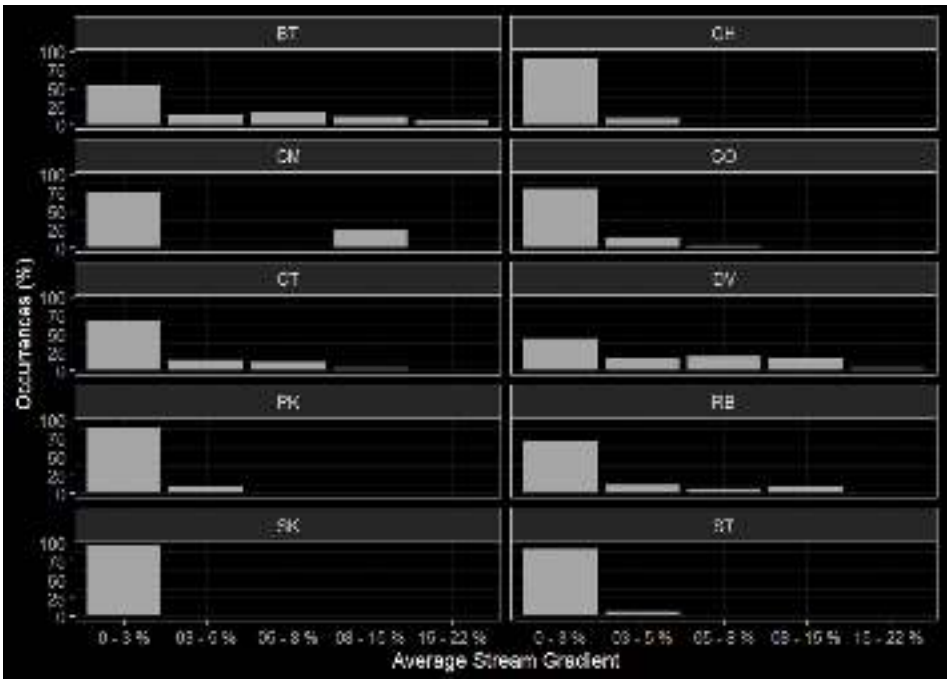


Figure 2.8: Summary of historic salmonid observations vs. stream gradient category for the Bulkley River watershed group.

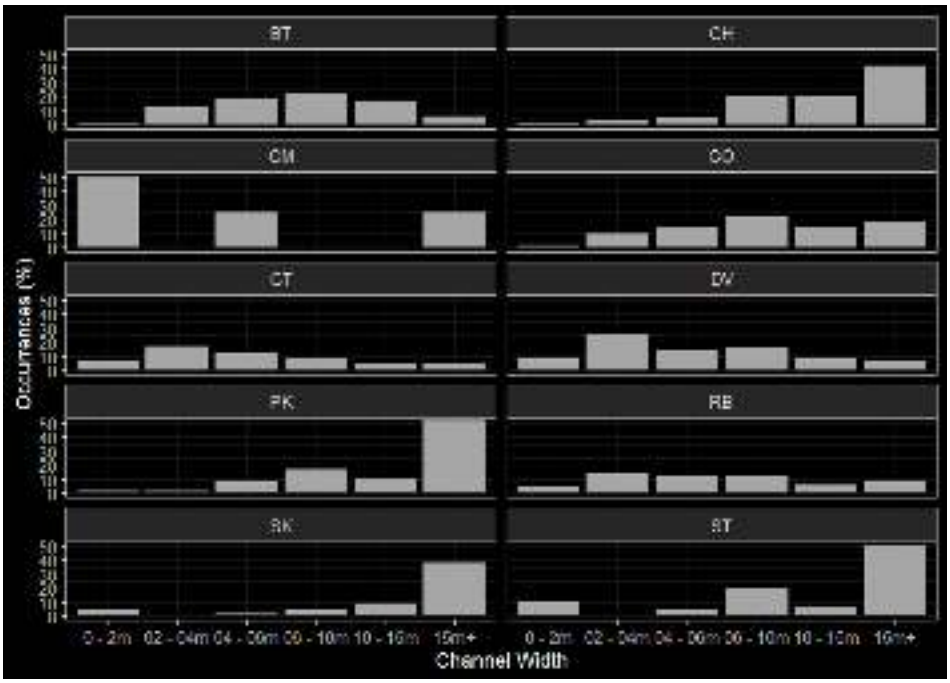


Figure 2.9: Summary of historic salmonid observations vs. channel width category for the Bulkley River watershed group.

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.

2.5.1 Bulkley River

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) and Irvine (2018).

Review of the PSCIS database indicated that prior to 2020, XXXXXXXXXXXXXXXXXXXX assessments for fish passage (Phase 1) at crossing structures within the Bulkley River watershed group have been recorded in the PSCIS database (MoE 2021a). No habitat confirmations are recorded in the PSCIS database (MoE 2021b). 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 2021c). McDowell Creek at Highway 16 was replaced with a horizontally drilled baffled structure in 2017 and a design is currently being drafted for the Highway 16 crossing over Taman Creek (pers. comm. Kathryn Graham, Regional Manager Environmental Services - Ministry of Transportation and Infrastructure).

2.6 Morice river

Within the Morice River watershed group prior to 2020, XXXXXXXXXXXXXXXXX fish passage assessments (Phase 1) had been recorded in the PSCIS database (MoE 2021a). At the time of reporting, no habitat confirmations had been recorded (MoE 2021b). Two culvert replacements (with open bottom structures) in the watershed group have been tracked in PSCIS in the and include works on a tributary to the Morice River located at km 39.2 of the Morice River FSR and on bridge installation at km 4 of McBride Road on a tributary to McBride Lake (MoE 2021c).

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 of sql and python based shell script libraries to generate a simple model of aquatic habitat connectivity. The model identifes 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 2020e) 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 Bukley River and Morice River watersheds 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 2020e). 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 and Morice River watersheds groups 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.

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

Variable	Chinook Salmon	Coho Salmon	Steelhead	Sockeye Salmon
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	–

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

3.1.2 PSCIS and Modelled Stream Crossing Review

To prepare for Phase 1 and 2 assessments in the study area, past fish passage assessment reports for the Bulkley River and Morice River watershed groups were first reviewed to identify crossing structures not yet assessed or previously ranked as priorities for rehabilitation (Casselman and Stanley 2010; Irvine 2018; McCarthy and Fernando 2015; Smith 2018; Wilson and Rabnett 2007). To determine which of those crossings had not yet been assessed with Phase 1 and Phase 2 assessments we cross-referenced these reports with the PSCIS database, available background info and viewed sites within the output of `bcfishpass`. Outputs for modelled and PSCIS crossings (barriers and potential barriers) that met the following criteria underwent a detailed review to facilitate prioritization for Phase1 - Fish Passage Assessments and Phase 2 - Habitat Confirmations.

- Confirmed fish presence upstream of the structure.
- Stream width documented as > 2.0m in PSCIS.
- Linear lengths of modelled upstream habitat <8% gradient for ≥1km.

- Crossings located on streams classified as 3rd order or higher.
- Crossings located on streams with >5 ha of modeled wetland and/or lake habitat upstream.
- Habitat value rated as “medium” or “high” in PSCIS.

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 22)), 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. For this project we considered bridges as the only viable option for OBS type based on consultation with FLNR road crossing engineering experts. It should be noted however, that box culverts could be considered a viable and economical option as they have been observed as successfully facilitating fish passage on the west coast of the province (Betty Rebellato, Canadian Wildlife Federation - Project Biologist).
- 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	200	40
Resource	Loose	1	1	200	40
Road Permit	Loose	1	1	200	40
Unclassified	Loose	1	1	200	40
Unclassified	Rough	1	1	200	40
Unclassified	Paved	1	2	400	80
Unclassified	Unknown	1	2	400	80
Local	Loose	4	1	800	160
Local	Paved	4	2	1600	320
Arterial	Paved	15	2	6000	1200
Highway	Paved	15	2	6000	1200
Rail	Rail	15	2	6000	1200

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 collated 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 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

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 Phase 1

Field assessments were conducted between August 09 2021 and September 16 2021 by Allan Irvine, R.P.Bio. and Kyle Prince, P.Biol., Tieasha Pierre, Vern Joseph, Dallas Nikal, Alexandria Nikal, Chad Lewis, Tim Wilson, Adam Wrench, Lars Reese-Hanson and Don Morgan. A total of 191 Phase 1 assessments were conducted with 77 crossings considered “passable,” 10 crossings considered “potential” barriers and 84 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, 20 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 benefit analysis and priority ranking for follow up for Phase 1 sites presented in Table 4.1. Detailed data with photos are presented in Attachment 2.

“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.

benefit analysis for Phase 1 assessments. 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)	Habitat Upstream (km)	Cost Benefit (m / $K)	Cost Benefit (m2 / $K)
PSCIS ID	External ID	Stream	Road	Result	Habitat value	Stream Width (m)	Priority	Fix	Cost Est ($K)	Habitat Upstream (km)	Cost Benefit (m / $K)	Cost Benefit (m2 / $K)
123375	–	Tributary to Thompson Creek	Highway 16	Barrier	Low	1.00	low	SS-CBS	1200	30.11	25.1	12.5
198048	1800048	Cesford Creek	Highway 16	Barrier	High	5.48	high	OBS	6000	54.43	9.1	24.9
197967	1800050	Taman Creek	Highway 16	Barrier	Medium	5.30	mod	OBS	18600	142.42	7.7	20.3
197903	1800180	Tributary to Bulkley River	Rose Lake Cuttoff Road	Barrier	Low	1.50	low	SS-CBS	160	3.67	22.9	17.2
198065	1800191	Watson Creek	Montgomery Road	Barrier	Medium	3.00	mod	OBS	800	18.77	23.5	35.2
198049	1800193	Cesford Creek	Highway 118	Barrier	High	4.90	high	OBS	6000	50.46	8.4	20.6
197976	1800355	Ailport Creek	Highway 16	Barrier	High	7.50	high	OBS	7500	53.15	7.1	26.6
197974	1800356	Watson Creek	Highway 16	Barrier	Low	2.20	low	OBS	6000	21.24	3.5	3.9
197902	1800360	Tributary to Bulkley River	Rose Lake Cuttoff Road	Barrier	Low	1.50	low	SS-CBS	160	4.75	29.7	22.3
197904	1800372	Tributary to Bulkley River	Crow Creek Road	Barrier	Low	2.00	low	OBS	200	3.03	15.2	15.2
197975	1801122	Ailport Creek	Private Driveway	Barrier	Medium	6.50	mod	OBS	230	52.76	229.4	745.5
197972	1802040	Tributary to Broman Lake	Powerline	Barrier	Low	0.80	low	SS-CBS	40	7.78	194.5	77.8
198066	1802488	Thompson Creek	Private Road	Potential	High	2.77	mod	OBS	200	35.88	179.4	248.5
197907	1802611	Tributary to Maxan Creek	Maxan Creek FSR	Barrier	Low	1.30	low	SS-CBS	40	8.97	224.2	145.8
197908	1803697	Tributary to Maxan Creek	Maxan Creek FSR	Barrier	Low	1.00	low	SS-CBS	40	4.03	100.8	50.4
197906	1803706	Tributary to Maxan Creek	Maxan Creek FSR	Barrier	Low	1.20	low	SS-CBS	40	7.84	196.0	117.6
197970	1803813	Tributary to Broman Lake	Broman Lake FSR	Barrier	Low	0.70	low	SS-CBS	40	2.84	71.0	24.8
197909	1804693	Tributary to Maxan Creek	Maxan Creek FSR	Barrier	Medium	0.90	mod	SS-CBS	40	0.68	17.0	7.7
197964	1805529	Bulkley River	Railway	Potential	High	9.00	mod	OBS	8400	144.22	17.2	77.3
197963	1805531	Tributary to Bulkley River	Railway	Barrier	Low	4.00	low	OBS	6000	1.52	0.3	0.5
198044	1805573	Tributary to Toboggan Creek	Railway	Barrier	Low	2.00	low	SS-CBS	1200	10.09	8.4	8.4
198071	14000022	Tributary to Collins Lake	spur Morice Nado	Barrier	Medium	2.00	mod	SS-CBS	40	4.63	115.8	115.8
198069	14000256	Tributary to Collins Lake	Morice Nado	Barrier	Medium	2.50	mod	OBS	200	6.08	30.4	38.0
198037	14000375	Tributary to Thautil River	Thautil FSR	Potential	Low	0.65	low	SS-CBS	40	1.14	28.5	9.3
198036	14000377	Tributary to Thaultil River	Thautil FSR	Barrier	Medium	1.90	mod	SS-CBS	40	2.39	59.8	56.8
198039	14000379	Tributary to Thautil River	Thautil FSR	Barrier	Low	1.10	low	SS-CBS	40	6.01	150.2	82.6
198055	14000381	Tributary to Thautil River	Thautil FSR	Barrier	Low	1.10	low	SS-CBS	40	0.09	2.2	1.2
198038	14000382	Tributary to Thautil River	Thautil FSR	Barrier	Low	0.70	low	SS-CBS	40	1.27	31.8	11.1
198057	14000383	Tributary to Gabriel Creek	Thautil FSR	Barrier	Medium	3.00	mod	OBS	200	1.69	8.4	12.7

PSCIS ID	External ID	Stream	Road	Result	Habitat value	Stream Width (m)	Priority	Fix	Cost Est ($K)	Habitat Upstream (km)	Cost Benefit (m / $K)	Cost Benefit (m2 / $K)
198056	14000389	Tributary to Thautil River	Thautil FSR	Barrier	Low	1.80	low	SS-CBS	40	2.09	52.2	47.0
198058	14000390	Tributary to Gabriel Creek	Thautil FSR	Barrier	Low	1.50	low	SS-CBS	40	1.13	28.2	21.2
198059	14000392	Tributary to Gabriel Creek	Thautil FSR	Barrier	Medium	1.50	mod	SS-CBS	40	2.85	71.2	53.4
198050	14000394	Tributary to Thautil River	Thautil FSR	Barrier	Low	0.90	low	SS-CBS	40	1.79	44.8	20.1
198033	14000395	Tributary to Gabriel Creek	Thautil FSR	Barrier	Low	0.67	low	SS-CBS	40	1.11	27.8	9.3
198035	14000398	Tributary to Gabriel Creek	Thautil FSR	Barrier	Low	1.17	low	SS-CBS	40	1.21	30.2	17.7
198011	14000443	Tributary to Nanika River	4 Road	Barrier	Low	2.20	low	OBS	200	0.42	2.1	2.3
198087	14000453	Tributary to Nanika River	Cutthroat 1	Barrier	Low	1.90	low	SS-CBS	1200	3.96	3.3	3.1
197994	14000481	Tributary to Gosnell Creek	6 Road	Barrier	Medium	1.10	mod	SS-CBS	40	0.94	23.5	12.9
197991	14000506	Tributary to Gosnell Creek	6 Road	Barrier	Medium	0.80	mod	SS-CBS	40	0.00	0.0	0.0
197998	14000507	Tributary to Gosnell Creek	6 Road	Barrier	Medium	1.80	mod	SS-CBS	40	1.15	28.8	25.9
198009	14000535	Tributary to Nanika River	1 Road	Barrier	Low	1.00	low	SS-CBS	40	0.49	12.2	6.1
197937	14000536	Tributary to Nanika River	Spur	Barrier	Low	0.80	low	SS-CBS	40	1.49	37.2	14.9
198016	14000562	Tributary to Thautil River	Chisholm FSR	Barrier	Medium	1.30	mod	SS-CBS	40	0.74	18.5	12.0
198003	14000582	Tributary to Nanika River	Nanika FSR	Barrier	Low	0.50	low	SS-CBS	40	1.14	28.5	7.1
198081	14000592	Tributary to Lamprey Creek	07 Road	Barrier	Low	1.60	low	SS-CBS	40	3.65	91.2	73.0
198019	14000669	Tributary to Thautil River	Chisholm FSR	Barrier	Medium	1.60	mod	SS-CBS	40	5.40	135.0	108.0
198028	14000683	Tributary to Thautil River	Chisholm FSR	Barrier	Low	1.10	low	SS-CBS	40	5.12	128.0	70.4
197945	14000684	Tributary to Thaulit River	Chisholm FSR	Barrier	Low	1.00	low	SS-CBS	40	2.34	58.5	29.2
198020	14000688	Tributary to Thautil River	Chisholm FSR	Barrier	Low	0.00	low	SS-CBS	40	5.70	142.5	0.0
197952	14000690	Tributary to Morice River	Chisholm FSR	Barrier	Low	2.10	low	OBS	200	6.19	31.0	32.5
198029	14000694	Tributary to Thautil River	Chisholm FSR	Barrier	Low	0.90	low	SS-CBS	40	4.94	123.5	55.6
197944	14000695	Tributary to Thaulit River	Chisholm FSR	Barrier	Medium	2.20	mod	OBS	200	0.00	0.0	0.0
197954	14000696	Tributary to Morice River	Chisholm FSR	Barrier	Medium	1.70	mod	OBS	200	7.86	39.3	33.4
198026	14000697	Tributary to Thautil River	Chisholm FSR	Barrier	Low	0.70	low	SS-CBS	40	1.97	49.2	17.2
198060	14000718	Tributary to Owen Creek	Morice-Owen FSR	Potential	Medium	2.00	low	OBS	200	7.01	35.0	35.0
197962	14000798	Peacock Creek	Morice FSR	Barrier	High	9.30	high	OBS	316	6.14	19.4	90.4
198085	14000799	Tributary to Lamprey Creek	Morice FSR	Barrier	Medium	1.40	mod	SS-CBS	40	0.68	17.0	11.9
197989	14000801	Tributary to Morice River	Morice FSR	Barrier	Medium	2.20	mod	OBS	200	2.68	13.4	14.7

PSCIS ID	External ID	Stream	Road	Result	Habitat value	Stream Width (m)	Priority	Fix	Cost Est ($K)	Habitat Upstream (km)	Cost Benefit (m / $K)	Cost Benefit (m2 / $K)
198067	14000804	Tributary to Lamprey Creek	Morice R FSR	Barrier	Low	2.20	low	OBS	200	6.77	33.9	37.2
198068	14000815	Tributary to Lamprey Creek	Morice R FSR	Barrier	Low	0.80	low	SS-CBS	40	1.03	25.8	10.3
197965	14000820	Tributary to Collins Lake	Morice R FSR	Barrier	Medium	0.35	mod	SS-CBS	40	7.77	194.2	34.0
198030	14000823	Tributary to Lamprey Creek	Morice FSR	Barrier	Low	1.00	low	SS-CBS	40	0.90	22.5	11.2
198008	14000865	Tributary to Nanika River	Spur	Barrier	Medium	1.80	mod	SS-CBS	40	0.60	15.0	13.5
198040	14000882	Tributary to Morice River	Spur	Potential	Medium	0.90	low	SS-CBS	40	0.34	8.5	3.8
198079	14000890	Tributary to Lamprey Creek	Spur	Barrier	Medium	0.90	mod	SS-CBS	40	1.23	30.8	13.8
198072	14000892	Tributary to Lamprey Creek	Spur	Potential	Low	1.00	low	SS-CBS	40	3.61	90.2	45.1
198080	14000894	Tributary to Lamprey Creek	Spur	Barrier	Medium	0.60	mod	SS-CBS	40	1.01	25.2	7.6
197931	14000932	Tributary to Nanika River	Spur	Barrier	Low	0.40	low	SS-CBS	40	1.19	29.8	6.0
197982	14000941	Tributary to Gosnell Creek	Crystal Creek FSR	Barrier	Medium	2.20	mod	OBS	200	5.75	28.8	31.6
197923	14000949	Tributary to Gosnell Creek	Crystal Creek FSR	Barrier	Low	0.90	low	SS-CBS	40	0.28	7.0	3.1
197924	14000954	Tributary to Gosnell Creek	Crystal Creek FSR	Barrier	Low	1.30	low	SS-CBS	40	1.46	36.5	23.7
198084	14000968	Tributary to Lamprey Creek	Spur	Barrier	Medium	0.90	mod	SS-CBS	40	1.48	37.0	16.6
198062	14000991	Tributary to Morice River	Morice-West FSR	Barrier	Medium	10.00	mod	OBS	300	2.61	8.7	43.5
198034	14000994	Tributary to Thautil River	Thautil FSR	Barrier	Medium	0.60	mod	SS-CBS	40	3.15	78.8	23.6
197928	14000997	Tributary to Morice River	Morice West FSR	Barrier	Low	1.20	low	SS-CBS	40	0.63	15.8	9.4
197926	14001002	Tributary to Morice River	Morice West FSR	Barrier	Medium	2.00	mod	OBS	200	8.98	44.9	44.9
198002	14001009	Tributary to Nanika River	9 Road	Barrier	Low	0.50	low	SS-CBS	40	1.37	34.2	8.6
198082	14001062	Tributary to Lamprey Creek	Bill Nye	Barrier	Medium	0.60	mod	SS-CBS	40	1.81	45.2	13.6
198007	14001077	Tributary to Nanika River	Spur	Barrier	Low	1.00	low	SS-CBS	40	2.13	53.2	26.6
198005	14001078	Tributary to Nanika River	Spur	Barrier	Low	0.80	low	SS-CBS	40	2.09	52.2	20.9
198064	14001094	Tributary to Lamprey Creek	Spur	Barrier	Medium	2.56	mod	OBS	200	5.05	25.2	32.3
198000	14001161	McBride Creek	Nanika FSR	Potential	High	9.00	mod	OBS	280	84.07	300.2	1351.1
198086	14001170	Tributary to Lamprey Creek	spur (overgrown)	Barrier	Low	2.00	low	OBS	200	6.12	30.6	30.6
197951	14001177	Tributatry to Morice River	False Tagit FSR	Barrier	Medium	3.00	mod	OBS	200	11.06	55.3	83.0
198051	14001409	Tributary to Thautil River	Spur	Barrier	Low	1.30	low	SS-CBS	40	2.07	51.8	33.6
197934	14001414	Tributary to Nanika River	Spur	Potential	Low	1.00	low	SS-CBS	40	3.10	77.5	38.8
198052	14001468	Tributary to Thautil River	Spur	Barrier	Low	0.50	low	SS-CBS	80	1.60	20.0	5.0
198075	14001624	Tributary to										

PSCIS ID	External ID	Stream	Road	Result	Habitat value	Stream Width (m)	Priority	Fix	Cost Est ($K)	Habitat Upstream (km)	Cost Benefit (m / $K)	Cost Benefit (m2 / $K)
Collins Lake	Spur	Potential	Low	0.65	low	SS-CBS	40	0.70	17.5	5.7		
198022	14001769	Tributary to Tagit Creek	5 Road	Barrier	Medium	1.40	mod	SS-CBS	40	6.67	166.8	116.7
197960	24704566	Corya Creek	Railway	Barrier	High	18.00	high	OBS	1800	27.01	15.0	135.1
197938	2021083150	Bulkley River Side Channel	Railway	Potential	Medium	3.00	low	SS-CBS	1200	1.01	0.8	1.3
197992	2021090161	Tributary to Gosnell Creek	6 Road	Barrier	Low	0.50	low	SS-CBS	40	–	–	–
197936	2021090299	–	Spur	Barrier	Low	0.90	low	SS-CBS	40	1.62	40.5	18.2
197949	2021090303	Tributary to Tagit Creek	11 Rd	Barrier	Medium	2.00	mod	OBS	200	6.16	30.8	30.8
198090	2021090551	Cesford Creek	Railway	Barrier	High	5.00	high	OBS	200	0.00	0.0	0.0

4.2 Bulkley Falls Assessment

Bulkley Falls is located near Topley, BC on the mainstem of the Bulkley River. Information on the crossing was scarce so an assessment was prioritized by Canadian Wildlife Federation. The site was assessed on October 28, 2021 by Nallas Nikal, B.i.T, and Chad Lewis, Environmental Technician. The top of the falls is located at 11U.678269.6038266 at an elevation of 697m approximatley 11.3km downstream of Bulkley Lake and upstream of Ailport Creek (Figure **??**).. Water temperature was 3.0°C, pH was 7.75 and conductivity was 159uS/cm. Within the Bulkley River immediately below the 12 - 15m high bedrock falls, channel width was 17.4m and the wetted width was 15.6m. Two channels comprised the falls. The primary channel was 20m long, had a channel/wetted width of 8.5m, a 16% grade and water depths ranging from 35 - 63cm. The secondary channel was 25m long, with channel/wetted widths of 7.5m, a grade of 12% and water depths ranging from 3 - 13cm.

Dyson (1949) and Stokes (1956) report substantial use of habitat above Bulkley Falls by steelhead, chinook, coho and sockeye utilization in the past (pre-1950) based on spawning reports. Both authors concluded that the Bulkley Falls pose a partial obstruction to migrating fish based on flow levels. Chinook, which migrate early in the summer when water levels are high, have been noted as able to ascend the falls in normal to high water years and in high water years it was thought that coho and steelhead could ascend. A. Gottesfeld and Rabnett (2007) report that the falls are almost completely impassable to all salmon during low water flows. Stokes (1956) reports that there was high value spawning habitat located within the first 3km of the Bulkley River from the outlet of Bulkley Lake.

Figure 4.1: Left: Bulkley Falls main channel. Right: Bulkley Falls side channel.

4.3 Phase 2

During 2021 field assessments, habitat confirmation assessments were conducted at 29 sites in the Bulkley River and Morice River watershed groups. A total of approximately 16km of stream was assessed, fish sampling utilizing electrofishing was conducted at five sites, and five sites were mapped using remotely piloted aircraft. 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, Twelve crossings were rated as high priorities for proceeding to design for replacement, 10 crossings were rated as moderate priorities, and 5 crossings were rated as low priorities. Results are summarized in Tables 4.2 - 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.

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
PSCIS ID	Stream	Road	UTM (11U)	Fish Species	Habitat Gain (km)	Habitat Value	Priority	Comments
57944	Toboggan Creek	Highway 16	607729 6089383	CC,CH,CO,CT,DV,KO,L,LSU,PK,RB,SK,ST	5.2	High	high	Water quite turbid due to rain event. Armoured banks due to adjacent properties. Not very complex in area surveyed from highway up. Hatchery located upstream. Extremely high value spawning and rearing habitat upstream of Owen Creek bridge with spawning salmon noted throughout.
58151	McDowell Creek	Woodmere Road	629753 6061126	RB	4.3	Medium	low	Channel dry. Close to house so very short dry survey. Lots of fines and sediment likely from cleared yard, roads, and agriculture use. Channel well defined.
123377	Thompson Creek	Walcott Road	641633 6049398	CT,DV,RB	12.3	High	high	High value habitat, frequent deep pools to 80cm and abundant large woody debris and gravels. Narrow but meaningful mature cottonwoood riparian. Majority of flow comes from open bottom structure under highway (PSCIS 123376) vs channel mapped as mainstem.
123544	McDowell Creek	Private Road	628287 6060648	RB	6.1	Medium	low	Dry at time of survey. Culvert inlet is perched aprox. 5m above channel. Road appears to be historic pipeline or powerline. Creates impassably steep gradients immediately downstream of crossing due to fill placement.
123770	John Brown	Highway 16	606627 6097185	BT,CH,CT,DV,RB	11.7	Medium	high	Frequent sections of gravels suitable for spawning salmon. Occasional very deep pools formed by large woody debris. Large eroding bank near mill. Mealthy mature mixed riparian vegetation. Six electrofishing sites.
123775	Witset Creek	Highway 16	606445 6099726	–	–	Low	low	No flow. Beaver activity present. Stream channel overgrown. Witset Lake outflow disconnected from stream. Witset mainenance actively traps beavers to prevent flood events as of 2017.
124420	Mission Creek	Highway 16	586632 6122395	BT,CO,CT,DV,PK,RB,SP	9.3	Medium	high	Frequent pockets of gravels suitable for spawning throughout. High value spawning habitat in upper end of survey area. Refer to DFO report for habitat details.
124421	Tributary to Waterfall Creek	11th Ave	589467 6123042	CO,DV	1.3	Medium	moderate	Slow moving wetland type stream. Deep glides throughout with instream vegetation, overhanging vegetation, and undercut banks. Near top of survey, gradient increased slightly and substrate goes from fines/organics to small gravel.
124422	Tributary to Waterfall Creek	Highway 16	589500 6123162	CO,DV	1.2	Medium	low	Appears to be restoration site with logs embedded in stream and gravels added. Upstream of footbridge stream flows from wetland type habitat. Low priority as 100% backwatered and likely passable for parr and adult salmon.
197370	Owen Creek	Morice West FSR	639980 6008557	–	1.9	High	high	Aerial survey conducted. Wetland and glide type habitat. Bii Wenii C'eek historic fishing site located near confluence of this stream and Morice River. Office of Wet'suwet'en contact (Mike Risdale) reports that this stream historically carrier flows from mainstem of Owen Creek which has now been redirected to Morice River at bridge site upstream. Mesohabitat mapping conducted in this area in the fall of 2021 by Jeff Anderson.
197378	Tributary to Owen							

PSCIS ID	Stream	Road	UTM (11U)	Fish Species	Habitat Gain (km)	Habitat Value	Priority	Comments
Creek	Klate Lake	645085 5998822	DV,LNC,MW,RB	0.6	Medium	moderate	Several pockets of gravel suitable for resident rainbow spawning. Good flow with run habitat.	
197379	Tributary to Owen Creek	Morice-Owen FSR	640961 6005930	CO,RB	0.1	High	high	Abundant undercut banks with some pools. Healthy riparian vegetation providing cover and woody debris to habitat. Good flow.
197662	Richfield Creek	Highway 16	672405 6044146	CH,CO,LKC,LNC,LSU,RB,ST	12.8	High	high	Three closed multipass electrofishing sites upstream and downstream. Habitat confirmation conducted in 2020 with results in 2021 report. Mesohabitat mapping conducted with Office of Wet'suwet'en field crew and Jeff Anderson in 2021.
197909	Tributary to Maxan Creek	Maxan Creek FSR	687557 6020572	–	0.2	Medium	–	Small stream with beaver pond upstream. Downstream channel confined.
197912	Robert Hatch Creek	Private	670963 6046221	LSU,RB	27.7	–	moderate	High value habitat. Abundant gravels, deep pools, undercut banks, and small woody debris. Areas of algal growth. Cattle impacts extreme throughout.
197960	Corya Creek	CN Railway	605786 6099884	DV,RB	10.0	High	high	High energy glaciated system. Substrate quite embedded. Three electrofishing sites upstream and three sites downstream.
197962	Peacock Creek	Morice FSR	643460 6025890	–	4.8	Medium	high	Culvert has been replaced with a bridge. Complex habitat with undercut banks, large and small woody debris and some nice pools. Three closed site multi-pass electrofishing sites upstream and three downstream.
197967	Taman Creek	Highway 16	692435 6032331	BMC,CSU,LKC,LNC,LSU,NSC,RB,RBG	30.9	Medium	moderate	First 250m above crossing was beaver influenced area with dry channel. Frequent pockets of gravels and small cobbles suitable for rainbow trout and coho salmon spawning further upstream. Canyon section has deep bedrock pools with small fish present.
197975	Ailport Creek	Private Driveway	680832 6040045	CO,CT,RB	24.7	Medium	high	Cattle and dredgeing damage in first sections of survey with dredges in first 80m removing all habitat. Heavy grazing continuous for another few hundred meters. Deep pools, undercut banks, and overhanging vegetation occurs throughout. Fence across stream halfway up. Some areas have large piles of substrate deposited within extent of channel (perhaps from flooding). Two electrofishing sites upstream and two sites downstream.
197976	Ailport Creek	Highway 16	680645 6039756	CO,CT,RB	25.1	High	moderate	Fish sighted throug-

PSCIS ID	Stream	Road	UTM (11U)	Fish Species	Habitat Gain (km)	Habitat Value	Priority	Comments
hout. Extensive algae growth seen during entire survey. Fences accrosss creek near highway including electric fence. Riparian / bank damage from livestock quite minimal and only seen in a few places as trails, perhaps watering sites. 150mm long fish observed swimming upstream through culvert during survey.								
198000	McBride Creek	Nanika FSR	605511 5992667	BB,CAS,CO,CSU,CT,DV,LD,LSU,RB,RSC,WSU	20.1	High	moderate	Abundant instream vegetation including vascular plants. Large woody debris accumulated at outflow of McBride Lake.
198008	Tributary to Nanika River	Spur	606426 5986782	–	0.0	Medium	moderate	Multiple channels. Surveyed non-dominant channel. Site should be reassessed to confirm habitat upstream of 100m. Bottom 100m before split is low gradient gravels with good flow for time of year.
198016	Tributary to Thautil River	Chisholm FSR	608138 6020911	–	0.0	Medium	moderate	Sporadic pools and abundant deeply undercut banks. Abundant gravels present suitable for spawning. Very occasional large and small woody debris steps to 70cm. Good flow with mature spruce riparian.
198048	Cesford Creek	Highway 16	674397 6043433	–	10.7	High	moderate	Stream appears to have been dredged for near entire length between highways. Left side of stream is powerline and highway for first 200m. Riparian area is very sparse below due to agricultural land clearing. Fish are concentrated in pool habitat which is sporatic. Frequent pockets of gravel throughout. Good flow. Eroded bank at near highway 118.
198049	Cesford Creek	Highway 118	674875 6043782	–	10.0	High	–	Good flow and decent complexity due to mature cottonwood riparian / large woody debris. Occossional pools and frequent gravel sections.
198064	Tributary to Lamprey Creek	Spur	623369 6000283	DV	0.0	Medium	moderate	Comparitively good flow for the greater Lamprey Creek watershed. Abundant gravel suitable for coho spawning at higher flows. Abundant undercut banks for cover but pools observed as shallow.
198066	Thompson Creek	Private Road	640244 6048061	CO,CRS,CT,DV,RB,SP	14.7	High	high	Important migration corridor. Fully channelized through agricultural area. Fine sediments, pool and glide habitat up to 80 cm deep. Canary reed grass riparian. Landowner reports stream was redirected in 60s and used to flow from the valley to the Bulkley in a low lying area in a north west direction.
198090	Cesford Creek	CN Railway	673235 6043218	–	–	High	high	No connection to Bulkley

	PSCIS ID	Stream	Road	UTM (11U)	Fish Species	Habitat Gain (km)	Habitat Value	Priority	Comments
River under railway found and landowner reports there is not one present. Large ditch runs north-south and may be impacting water level in oxbow type habitat comprising lower end of stream. Primarily dry to just before Highway 16. Important migration corridor. Coho would likely be present upstream if connected to the Bulkley River.									

Table 4.3: Summary of Phase 2 fish passage reassessments.

PSCIS ID	Embedded	Outlet Drop (m)	Diameter (m)	SWR	Slope (%)	Length (m)	Final score	Barrier Result
57944	No	0.00	7.00	1.2	3.0	30	29	Barrier
58151	No	0.25	1.00	1.8	5.0	14	31	Barrier
123377	No	0.25	1.05	4.6	3.0	29	34	Barrier
123544	No	0.00	1.50	1.8	18.5	14	26	Barrier
123770	No	0.64	4.00	3.1	2.0	36	37	Barrier
123775	No	0.00	1.22	0.4	0.5	32	16	Potential
124420	No	0.80	1.60	3.5	3.5	90	42	Barrier
124421	No	0.30	1.00	2.6	1.0	15	34	Barrier
124422	No	0.00	1.20	4.3	1.5	45	27	Barrier
197370	No	0.00	0.90	7.6	1.0	18	24	Barrier
197378	No	0.10	1.00	2.4	1.0	15	24	Barrier
197379	No	0.47	1.50	4.3	1.5	26	34	Barrier
197662	No	0.20	4.20	3.0	2.0	24	29	Barrier
197909	No	0.00	0.60	1.5	3.0	16	29	Barrier
197912	–	–	12.00	0.0	–	7	0	Passable
197960	No	0.65	3.40	5.3	2.5	24	34	Barrier
197962	No	0.50	3.60	2.6	3.5	15	39	Barrier
197967	No	0.00	3.00	1.8	2.5	30	27	Barrier
197975	No	0.30	3.00	2.2	4.0	10	36	Barrier
197976	No	–	3.50	2.1	2.0	23	24	Barrier
198000	No	0.05	3.90	2.3	0.5	16	19	Potential
198008	No	0.18	0.90	2.0	6.0	11	31	Barrier
198016	No	0.19	1.20	1.1	5.0	25	31	Barrier
198048	No	0.00	2.50	2.2	1.5	25	24	Barrier
198049	No	0.50	3.70	1.3	1.5	21	34	Barrier
198064	No	0.54	1.60	1.6	5.0	14	36	Barrier
198066	No	0.00	1.30	2.1	0.4	6	16	Potential
198090	No	0.00	0.10	50.0	3.0	15	29	Barrier

Table 4.4: Cost benefit analysis for Phase 2 assessments. Coho 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)
57944	Toboggan Creek	Highway 16	Barrier	High	8.5	OBS	8100	52355	6.5	54.9
58151	McDowell Creek	Woodmere Road	Barrier	Medium	1.7	SS-CBS	160	4300	26.9	45.7
123377	Thompson Creek	Walcott Road	Barrier	High	4.8	OBS	1600	12315	7.7	36.9
123544	McDowell Creek	Private Road	Barrier	Medium	–	OBS	200	6070	30.4	–
123770	John Brown	Highway 16	Barrier	Medium	12.2	OBS	11400	11710	1.0	12.5
123775	Witset Creek	Highway 16	Potential	Low	2.4	SS-CBS	1200	–	–	–
124420	Mission Creek	Highway 16	Barrier	Medium	5.7	OBS	18000	9255	0.5	2.9
124421	Tributary to Waterfall Creek	11th Ave	Barrier	Medium	2.6	OBS	800	1340	1.7	4.4
124422	Tributary to Waterfall Creek	Highway 16	Barrier	Medium	6.7	OBS	11400	1210	0.1	0.7
197370	Owen Creek	Morice West FSR	Barrier	High	–	OBS	240	1870	7.8	–
197378	Tributary to Owen Creek	Klate Lake	Barrier	Medium	1.8	OBS	200	560	2.8	5.0
197379	Tributary to Owen Creek	Morice-Owen FSR	Barrier	High	6.4	OBS	320	120	0.4	2.4
197662	Richfield Creek	Highway 16	Barrier	High	13.2	OBS	9900	32780	3.3	43.7
197909	Tributary to Maxan Creek	Maxan Creek FSR	Barrier	Medium	1.3	SS-CBS	40	225	5.6	7.3
197912	Robert Hatch Creek	Private	Passable	–	4.3	–	30	27720	924.0	3973.2
197960	Corya Creek	Railway	Barrier	High	18.0	OBS	13800	9960	0.7	13.0
197962	Peacock Creek	Morice FSR	Barrier	Medium	6.9	OBS	320	4810	15.0	103.7
197967	Taman Creek	Highway 16	Barrier	Medium	5.3	OBS	18600	51905	2.8	14.8
197975	Ailport Creek	Private Driveway	Barrier	Medium	7.7	OBS	230	24690	107.3	826.6
197976	Ailport Creek	Highway 16	Barrier	High	8.1	OBS	7500	25090	3.3	27.1
198000	McBride Creek	Nanika FSR	Potential	High	5.5	OBS	280	20095	71.8	394.7
198008	Tributary to Nanika River	Spur	Barrier	Medium	2.0	SS-CBS	40	0	0.0	0.0
198016	Tributary to Thautil River	Chisholm FSR	Barrier	Medium	1.9	SS-CBS	40	0	0.0	0.0
198048	Cesford Creek	Highway 16	Barrier	High	5.1	OBS	6000	10700	1.8	9.1
198049	Cesford Creek	Highway 118	Barrier	High	5.0	OBS	6000	10030	1.7	8.4
198064	Tributary to Lamprey Creek	Spur	Barrier	Medium	2.8	OBS	200	0	0.0	0.0
198066	Thompson Creek	Private Road	Potential	High	2.8	OBS	200	14705	73.5	205.9
198090	Cesford Creek	Railway	Barrier	High	–	OBS	200	–	–	–

Table 4.5: 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
57944	880	8.5	6.7	0.5	2.1	moderate	high
57944	150	12.6	10.5	2.0	0.5	abundant	high
58151	70	1.7	–	–	0.8	abundant	low
123375	100	1.7	1.9	–	0.8	–	low
123377	450	4.8	3.4	0.7	2.7	abundant	high
123544	25	–	–	–	–	–	low
123770	1000	12.2	8.3	0.8	2.9	moderate	high
123770	350	11.2	9.1	0.3	3.0	moderate	high
123775	200	2.4	0.9	–	1.2	moderate	low
124420	370	5.7	4.7	0.5	2.0	abundant	high
124420	430	6.2	5.5	–	0.5	abundant	high
124421	120	2.6	2.5	0.3	1.0	abundant	moderate
124422	350	6.7	6.6	–	1.0	abundant	moderate
197370	1500	–	–	–	–	–	high
197378	–	1.8	1.5	–	3.0	abundant	medium
197379	800	6.4	3.1	0.7	4.8	moderate	high
197662	100	13.2	–	–	2.1	–	high
197909	–	1.3	–	–	–	moderate	–
197912	340	4.3	2.5	0.6	1.5	abundant	high
197960	1000	18.0	8.9	0.7	2.8	moderate	medium
197962	750	6.9	3.6	0.4	2.8	moderate	high
197967	–	5.3	2.3	0.7	1.7	moderate	medium
197967	375	3.8	2.2	0.5	1.5	moderate	–
197975	550	7.7	3.5	0.3	3.0	moderate	medium
197976	345	8.1	4.2	0.3	2.2	moderate	medium
198000	135	5.5	4.4	–	1.0	moderate	high
198008	–	2.0	0.9	0.2	7.5	–	medium
198016	625	1.9	1.5	0.3	7.0	moderate	medium
198042	–	11.5	11.0	–	0.2	moderate	–
198048	–	5.1	3.3	0.3	2.8	moderate	medium
198049	600	5.0	2.8	0.5	2.1	moderate	medium
198049	–	4.3	1.9	0.5	4.2	moderate	medium
198064	500	2.8	1.9	–	4.2	moderate	medium
198066	–	2.8	2.1	–	0.5	–	medium
198090	–	–	–	–	–	–	moderate

Table 4.6: Summary of watershed area statistics upstream of Phase 2 crossings.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
57944	119.9	413	412	2586	629	547	SE
58151	15.9	610	576	1038	850	810	SSW
123377	43.1	613	596	1623	832	802	WSW
123544	15.9	553	576	1038	850	810	SSW
123770	80.6	385	375	2050	1201	1087	SE
123775	4.1	406	478	1248	762	697	E
124420	28.6	301	211	2171	521	425	NNE
124422	3.3	320	224	430	331	326	SSW
197370	3.9	650	644	953	739	717	WSW
197378	7.9	758	743	2073	920	885	ENE
197379	32.9	676	688	1418	931	909	SSW
197662	161.3	676	650	1753	1096	1039	SSW
197909	2.1	835	788	956	851	847	E
197912	31.5	720	715	1070	1004	983	S
197960	65.7	415	410	2502	1260	1106	ESE
197962	36.3	631	654	1822	1166	1119	E
197967	93.8	736	699	1373	900	870	S
197975	66.9	735	736	1445	1186	1093	SSW
197976	66.9	729	736	1445	1186	1093	SSW
198000	83.5	799	-1270	1597	908	887	SSW
198008	1.6	912	-1114	1605	1221	1150	NW
198016	0.1	917	889	1019	953	944	W
198048	36.6	679	659	1543	935	914	SSW
198049	34.0	698	675	1543	951	929	SSW
198064	4.8	740	763	1221	1061	967	WSW
198066	43.1	548	596	1623	832	802	WSW

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

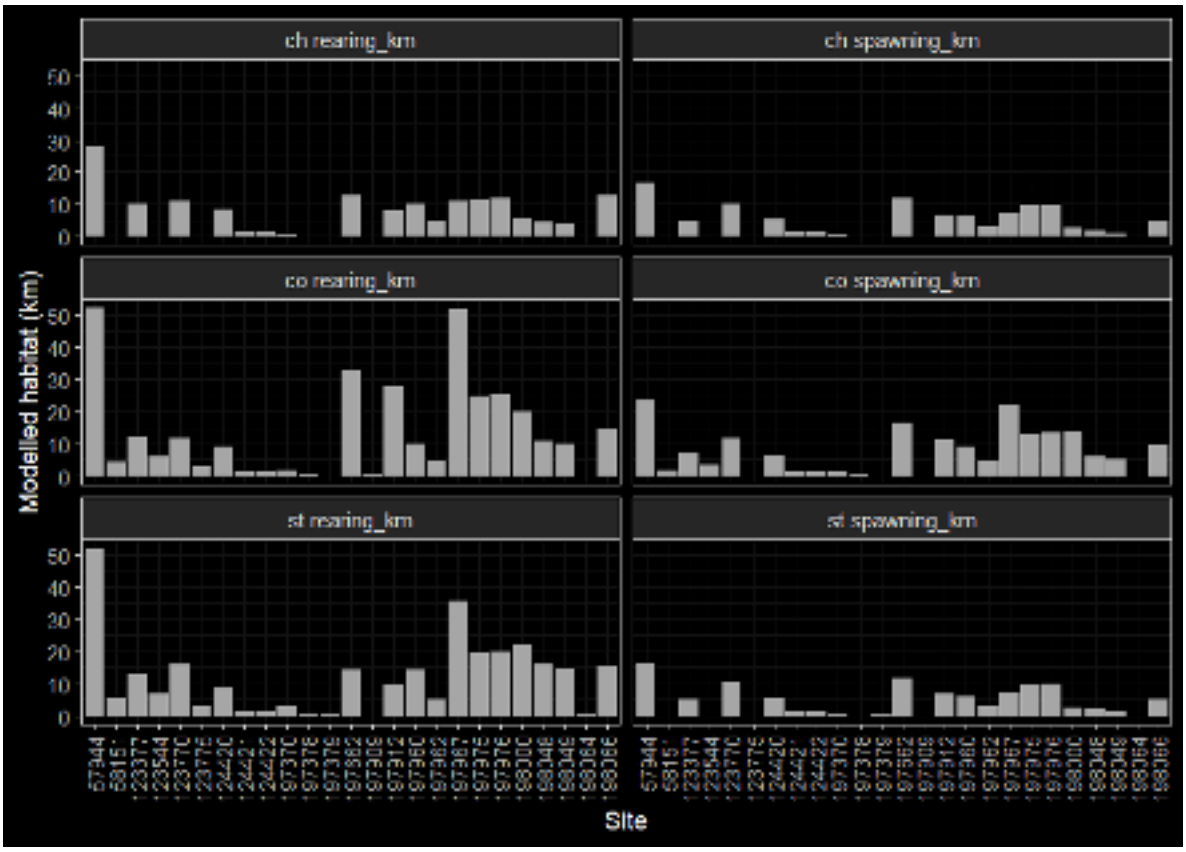


Figure 4.2: Summary of potential habitat upstream of habitat confirmation assessment sites estimated based on modelled channel width and upstream channel length.

4.3.1 Fish Sampling

Fish sampling was conducted at 31 sites with a total of 663 fish captured. Of these, 400 were rainbow trout, 147 coho, 69 were dolly varden and 19 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 4.7 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.

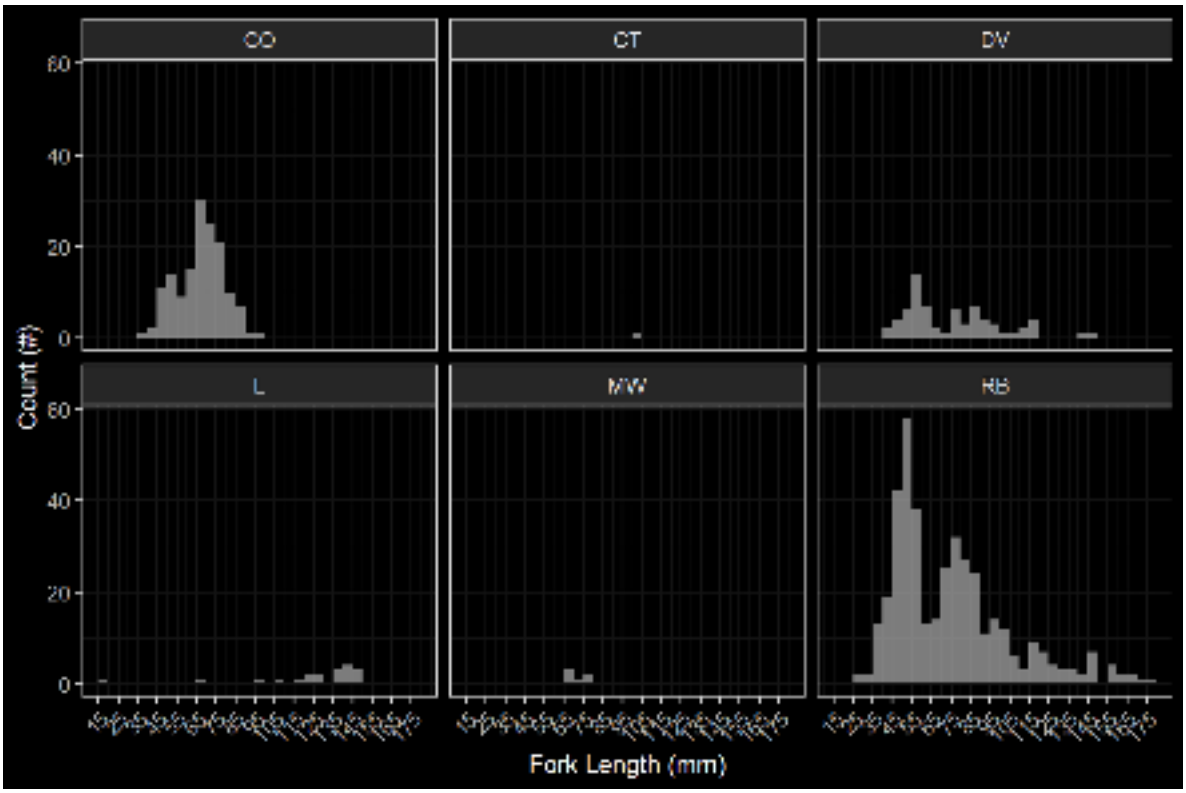


Figure 4.3: Histograms of fish lengths by species. Fish captured by electrofishing during habitat confirmation assessments.

Table 4.7: Summary of electrofishing sites.

site	passes	ef_length_m	ef_width_m	area_m2	enclosure
123770_us_ef1	1	15.7	1.65	25.9	Open
123770_us_ef2	1	3.3	3.23	10.7	Open
123770_us_ef3	1	1.8	2.83	5.1	Open
123770_us_ef4	1	6.4	3.57	22.8	Open
123770_us_ef5	1	4.8	3.03	14.5	Open
123770_us_ef6	1	2.9	2.00	5.8	Open
197662_ds_ef1	6	21.4	6.10	130.5	Closed
197662_ds_ef2	4	5.8	5.60	32.5	Closed
197662_ds_ef3	3	4.2	6.05	25.4	Closed
197662_us_ef1	4	6.4	7.00	44.8	Closed
197662_us_ef2	3	5.1	4.83	24.6	Closed
197662_us_ef3	3	5.6	2.73	15.3	Closed
197912_ds_ef1	3	8.6	4.80	41.3	Closed
197912_ds_ef2	1	28.0	1.96	54.9	Open
197912_ds_ef3	1	14.0	2.87	40.2	Open
197960_ds_ef1	1	9.6	1.28	12.3	Open
197960_ds_ef2	1	5.0	1.83	9.2	Open
197960_ds_ef3	1	10.1	1.67	16.9	Open
197960_us_ef1	1	4.7	1.65	7.8	Open
197960_us_ef2	1	19.0	1.86	35.3	Open
197960_us_ef3	1	3.3	3.27	10.8	Open
197962_ds_ef1	3	14.2	4.83	68.6	Closed
197962_ds_ef2	3	6.8	4.63	31.5	Closed
197962_ds_ef3	3	7.1	2.90	20.6	Closed
197962_us_ef1	3	7.2	3.87	27.9	Closed
197962_us_ef2	3	5.7	4.97	28.3	Closed
197962_us_ef3	3	7.0	5.27	36.9	Closed
197975_ds_ef1	1	3.8	4.27	16.2	Open
197975_ds_ef2	1	3.9	3.60	14.0	Open

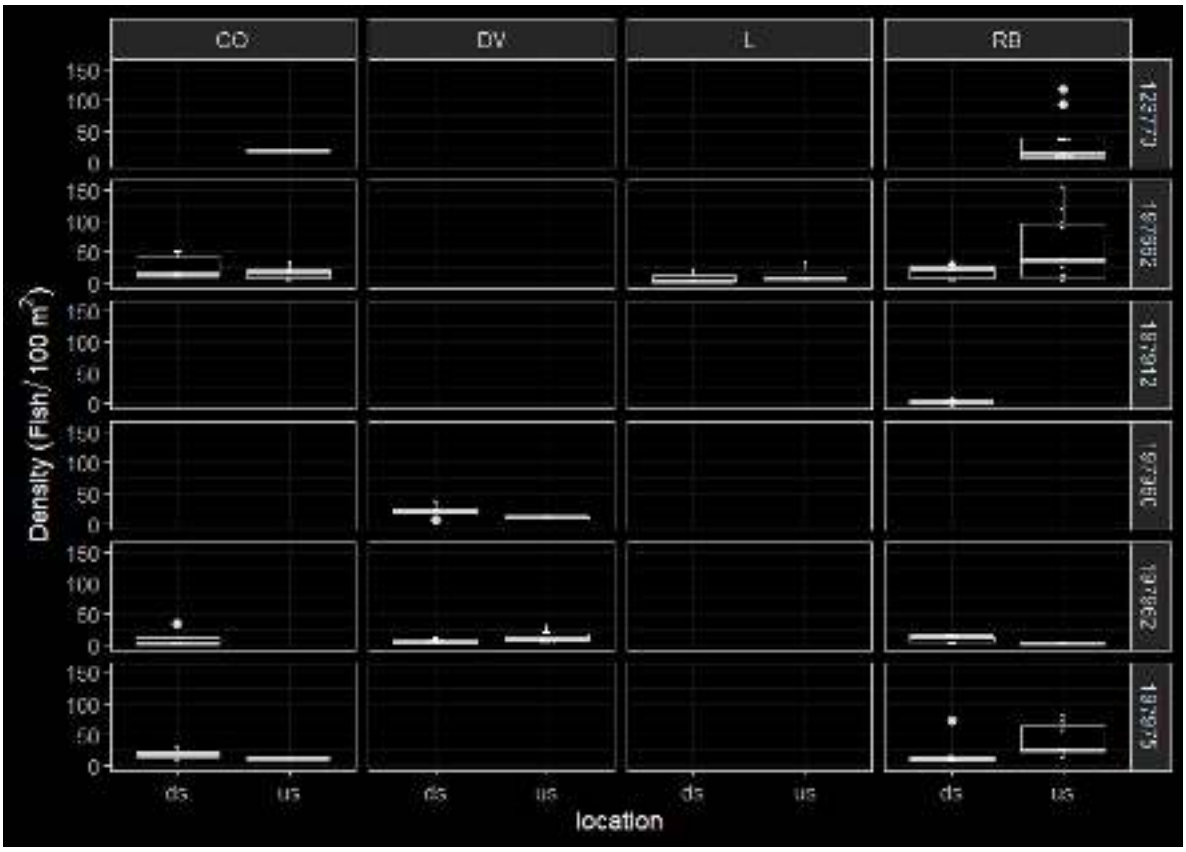


Figure 4.4: Boxplots of densities (fish/100m2) of fish captured by electrofishing during habitat confirmation assessments.

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. At the time of reporting, the Ministry of Transportation and Infrastructure 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 Mission Creek (a.k.a Station Creek) in Hazleton (pers. comm. Sean Wong, Environmental Programs, MoTi). Details for the habitat confirmation of Mission Creek are included in the associated appendix of this report.

4.5 Phase 4

Ministry of Forest engineers collaborated with Canfor and Coastal Gaslink to replace crossing 197962 on Peacock Creek located on the Morice FSR within the Morice River watershed group. As detailed in the associated attachment within this report, baseline effectiveness monitoring including multipass electrofishing at three closed sites both upstream and downstream of the FSR in the fall of 2021 before the bridge install occurred.

5 Recommendations

Recommendations for potential incorporation into collaborative watershed connectivity planning for the Elk River watershed group 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. Look for opportunities to collaborate and leverage initiatives together for maximum likley 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.

Toboggan Creek - 57944 - Appendix

Site Location

PSCIS crossing 57944 is located on Toboggan Creek within the Coryatsaqua 2 (Moricetown) Indian Reserve at Moricetown, BC. PSCIS crossing 57944 is located on Highway 16. Crossing 57944 was located 0.2km upstream from the confluence with the Bulkley River. Crossing 57944 is the responsibility of the Ministry of Transportation and Infrastructure.

Background

At crossing 57944, Toboggan Creek is a fifth order stream with a watershed area upstream of the crossing of approximately 119.9km^2. The elevation of the watershed ranges from a maximum of 2586m to 412m near the crossing (Table 5.1). Upstream of crossing 57944, longnose sucker, cutthroat trout, pink salmon, coho salmon, rainbow trout, steelhead, kokanee, sockeye salmon, chinook salmon, mountain whitefish, dolly varden, sculpin (general), and lamprey (general) have previously been recorded (MoE 2020b; Norris 2020). There is a wealth of information available for Toboggan Creek with numerous references available through the Skeena Salmon Data Centre.

Table 5.1: Summary of derived upstream watershed statistics for PSCIS crossing 57944.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
57944	119.9	413	412	2586	629	547	SE

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

The Toboggan Creek Hatchery facility is located on the stream approximately 8.7km upstream of Highway 16. The hatchery has been operated by the Toboggan Creek Salmon & Steelhead Enhancement Society since 1985. The hatchery serves to enhance coho and chinook stocks in the watershed as well as help assess coho stock with coded wire tag hatchery releases (Smithers District Chamber of Commerce 2022; Wilson and Rabnett 2007). Office of Wet'suwet'en (2016) report that Toboggan hatchery fish have been used to enhance the Bulkley mainstem, Maxan Creek and Buck Creek with chinook fry and smolt.

Office of Wet'suwet'en (2016) note that Wet'suwet'en Knowledge documents Toboggan Lake as a sockey nursery lake. Additionally, as cited in Office of Wet'suwet'en (2016), K. Rabnett, Holland, and Gottesfeld (2017) report a historic fishery at the outlet of Toboggan Lake where an extirpated stock of sockeye stock existed.

Toboggan Lake is 25ha in size and modelling indicates an additional 256ha of wetland upstream of the highway. Significantly sized lakes within watersheds can throttle high freshet and storm flows often resulting in increased stability downstream and conditions conducive to egg incubation and juvenile rearing.

Works to remediate fish passage issues at PSCIS stream crossing 57944 were conducted in 2015 with backwatering completed through installation of boulders downstream of the crossing (McCarthy and Fernando 2015). Comparison of historic PSCIS photos and data between 2021 and 2012 indicate that the historical recorded outlet drop of 90cm has been reduced to 0cm as a result of the works. Sandra Devcic, DFO Restoration Engineer (pers. comm.) has noted that developing a design to replace the crossing with an open bottom structure presents challenges due to the stream crossing location at the bottom of a hill and on a corner of the highway.

In 2021 at the time of the assessment, pink salmon spawners were noted as present at the enumeration fences near the hatchery indicating that the highway structure was passable to these relatively weak swimmers in 2021.

PSCIS stream crossing 57944 was ranked as a high priority for follow up by Wilson and Rabnett (2007), Irvine (2018), Irvine (2021) and Mazany-Wright et al. (2021) because of significant amounts of habitat modelled as upstream of the crossing. A summary of habitat modelling outputs is presented in Table 5.2. A map of the watershed is provided in map attachment 093L.122.

Table 5.2: Summary of fish habitat modelling for PSCIS crossing 57944.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	96.3	33.0	34
ST Lake Reservoir (ha)	16.9	15.7	93
ST Wetland (ha)	256.1	93.5	37
ST Slopeclass03 Waterbodies (km)	13.6	0.0	0
ST Slopeclass03 (km)	38.5	18.1	47
ST Slopeclass05 (km)	18.1	2.8	15
ST Slopeclass08 (km)	11.3	1.1	10
ST Spawning (km)	16.6	13.8	83
ST Rearing (km)	51.7	19.7	38
CH Spawning (km)	16.6	13.8	83
CH Rearing (km)	28.2	15.9	56
CO Spawning (km)	23.5	16.2	69
CO Rearing (km)	52.4	25.6	49
CO Rearing (ha)	122.8	0.0	0
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–

Habitat	Potential	Remediation Gain	Remediation Gain (%)
SK Rearing (ha)	–	0.0	–
All Spawning (km)	23.5	16.2	69
All Rearing (km)	63.5	26.6	42
All Spawning Rearing (km)	63.5	26.6	42

* Model data is preliminary and subject to adjustments.

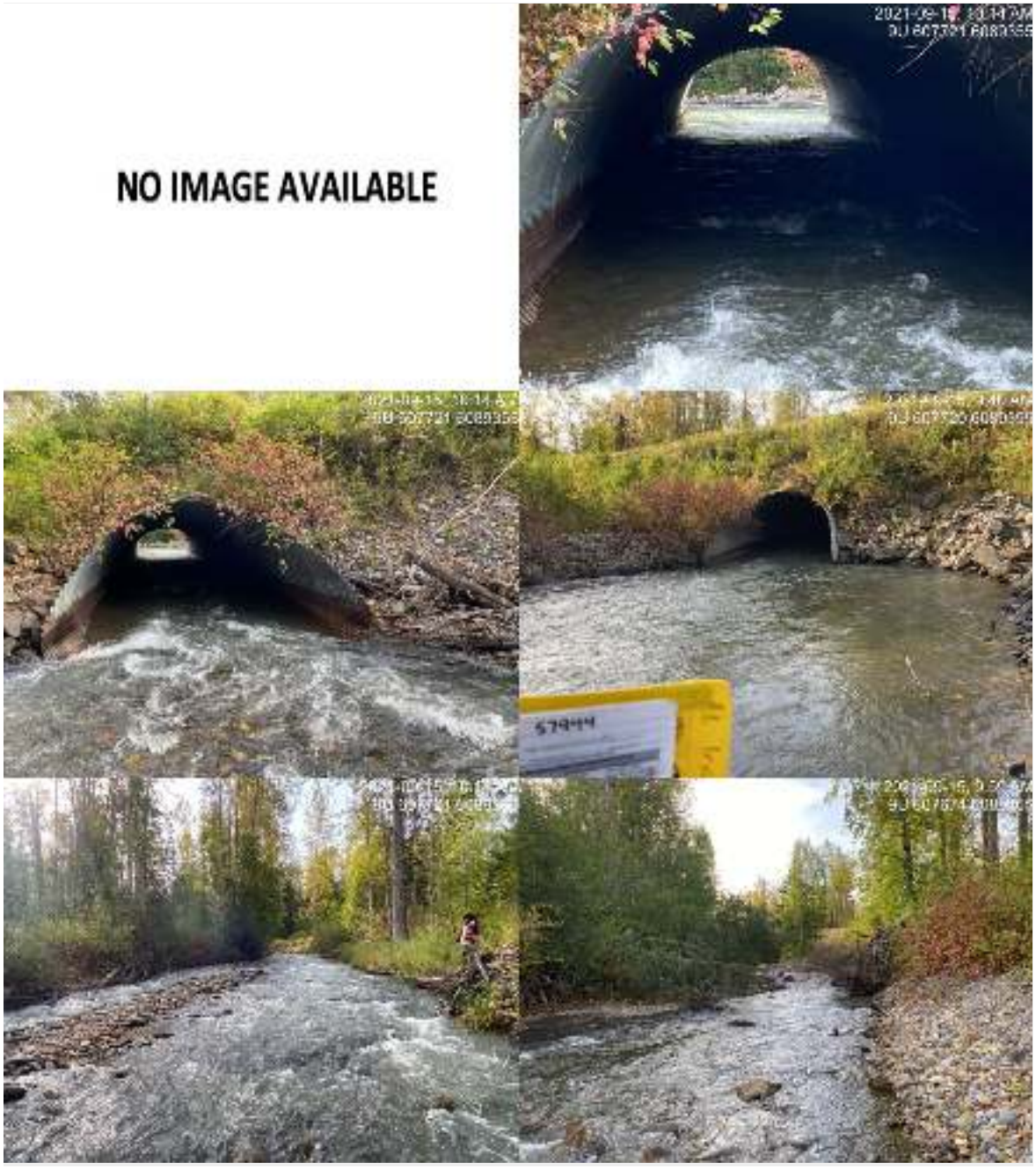
Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 57944 was un-embedded, non-backwatered and ranked as a barrier barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.3). Water temperature was 8°C, pH was 8.2 and conductivity was 74uS/cm.

Table 5.3: Summary of fish passage assessment for PSCIS crossing 57944.

Location and Stream Data	•	**Crossing Characteristics**	–
Date	2021-09-15	Crossing Sub Type	Oval Culvert
PSCIS ID	57944	Diameter (m)	7
External ID	–	Length (m)	30
Crew	AI	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	607729	Resemble Channel	No
Northing	6089383	Backwatered	No
Stream	Toboggan Creek	Percent Backwatered	–
Road	Highway 16	Fill Depth (m)	2
Road Tenure	Highway	Outlet Drop (m)	0
Channel Width (m)	8.5	Outlet Pool Depth (m)	2
Stream Slope (%)	2.1	Inlet Drop	No
Beaver Activity	No	Slope (%)	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	13.5
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Location and Stream Data	•	Crossing Characteristics	–



Stream Characteristics Downstream

The stream was surveyed downstream from crossing 57944 for 140m to the conflence with the Bulkley River (Figure 5.1). Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris, large woody debris, boulders, and overhanging vegetation. The average channel width was 13.9m, the average wetted width was

6.7m and the average gradient was 5.5%. The dominant substrate was cobbles with boulders subdominant. Although rated as an important migration corridor, the habitat was rated as medium value for salmonid rearing and spawning.

Stream Characteristics Upstream

The stream was surveyed upstream from crossing 57944 for 880m (Figure 5.2). Total cover amount was rated as moderate with large woody debris dominant. Cover was also present as small woody debris and boulders., Total cover amount was rated as moderate with overhanging vegetation dominant. Cover was also present as small woody debris and boulders. The average channel width was 8.5m, the average wetted width was 6.7m and the average gradient was 2.1%. The dominant substrate was cobbles with gravels subdominant. The first 50 - 100m upstream of crossing channel and banks were noted as armoured with riprap. Abundant gravels suitable for resident and anadromous salmonids were noted throughout. The habitat was rated as high value as an important migration corridor containing suitable spawning habitat and having moderate rearing potential.

The stream was also surveyed at a second location upstream of the hatchery adjacent to the Owen Road bridge for 150m (Figure 5.3). Total cover amount was rated as abundant with deep pools dominant. Cover was also present as small woody debris, undercut banks, and overhanging vegetation. The average channel width was 12.6m, the average wetted width was 10.5m and the average gradient was 0.5%. The dominant substrate was gravels with fines subdominant. The habitat was rated as high value for salmon rearing and spawning.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 57944 with a bridge (13.5m span) is recommended. The cost of the work is estimated at $8,100,000 for a cost benefit of 6.5 linear m/$1000 and 54.9 m^2/$1000.

Conclusion

There was 52.4km of habitat modelled upstream of crossing 57944 with areas survyed rated as high value for salmonid rearing and spawning. Crossing 57944 was ranked as a high priority for proceeding to design for replacement. Toboggan Creek represents an extremely important system for the Bulkley River system in terms of fisheries values, it’s function for outreach within the community as well as it’s contribution to stock enhancement and assessment. Development of a plan to replace the crossing with a bridge may be considered as a prudent step to mitigating risks of a blow out of the backwatering works currently in place downstream and a return to conditions similiar to those observed historically when a significant outlet drop was present (Figure 5.4).

Table 5.4: Summary of habitat details for PSCIS crossing 57944.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
57944	Downstream	140	13.9	10.1	0.3	5.5	moderate	medium
57944	Upstream	880	8.5	6.7	0.5	2.1	moderate	high
57944	Upstream2	150	12.6	10.5	2.0	0.5	abundant	high

Figure 5.1: Left: Typical habitat downstream of PSCIS crossing 57944. Right: Typical habitat downstream of PSCIS crossing 57944.

Figure 5.2: Left: Typical habitat upstream of PSCIS crossing 57944. Right: Typical habitat upstream of PSCIS crossing 57944.

Figure 5.3: Left: Typical habitat upstream of PSCIS crossing 57944. Right: Typical habitat upstream of PSCIS crossing 57944.

Figure 5.4: Left: Outlet of PSCIS crossing 57944 in 2012. Photo from PSCIS. Right: Inlet of PSCIS crossing 57944 in 2012. Photo from PSCIS.

McDowell Creek - 123544 & 58151 - Appendix

Site Location

PSCIS crossing 123544 and 58151 are located on McDowell Creek approximately 3.5km south-east of Telkwa, BC. PSCIS crossing 123544 is located on a private road and 58151 is located on Woodmere Road. Crossing 123544 was located 0.9km upstream from the confluence with the Bulkley River and crossing 58151 was located a further 1773m upstream. Crossing 123544 is located on private land so likely the responsibility of the landowner. Crossing 58151 is the responsibility of the Ministry of Transportation and Infrastructure.

Background

McDowell Creek drains McDowell Lake (35ha), Dorsay Lake (4ha) and one other unnamed lake (9ha) flowing from McDowell Lake in a south then west direction for approximately 9km to the confluence with the Bulkley River adjacent to the Woodmere Nursery. At crossing 123544, McDowell Creek is a third order stream with a watershed area upstream of the crossing of approximately 15.9km^2. The elevation of the watershed ranges from a maximum of 1038m to 576m near the crossing (Table 5.5).

Upstream of crossing 123544, rainbow trout have previously been recorded (MoE 2020b; Norris 2020). An adjacent landowner reports that historic high flow events in the watershed were likely related to beaver dam failures in the upper reaches of the stream network.

A habitat confirmation assessment downstream of 123544 PSCIS stream crossing 58159 (Woodmere Nursery private road) was assessed with by Irvine (2021) in 2020 and the reader is directed there for detailed background, habitat assessment and fish sampling information from 2020 surveys. 58151 was ranked as a moderate priority for follow up by Irvine (2018) due to significant quantities of upstream habitat suitable for salmonid rearing. A total of 54ha of lake and 18ha of wetland is modelled upstream with a summary of additional habitat modelling outputs presented in Table 5.6. A map of the watershed is provided in map attachment 093L.118.

crossing 123544.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
123544	15.9	553	576	1038	850	810	SSW

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

Table 5.6: Summary of fish habitat modelling for PSCIS crossing 123544.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	9.6	1.8	19
ST Lake Reservoir (ha)	4.4	0.0	0
ST Wetland (ha)	0.0	0.0	–
ST Slopeclass03 Waterbodies (km)	0.3	0.0	0
ST Slopeclass03 (km)	3.1	0.0	0
ST Slopeclass05 (km)	3.0	1.8	60
ST Slopeclass08 (km)	1.7	0.0	0
ST Spawning (km)	0.0	0.0	–
ST Rearing (km)	7.0	1.8	26
CH Spawning (km)	0.0	0.0	–
CH Rearing (km)	0.0	0.0	–
CO Spawning (km)	3.5	1.8	51
CO Rearing (km)	6.1	1.8	30
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)	3.5	1.8	51
All Rearing (km)	7.4	1.8	24
All Spawning Rearing (km)	7.4	1.8	24

* Model data is preliminary and subject to adjustments.

Table 5.7: Summary of fish habitat modelling for PSCIS crossing 123544.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	7.8	2.2	28
ST Lake Reservoir (ha)	4.4	0.0	0
ST Wetland (ha)	0.0	0.0	–
ST Slopeclass03 Waterbodies (km)	0.3	0.0	0
ST Slopeclass03 (km)	3.1	2.2	71
ST Slopeclass05 (km)	1.2	0.0	0
ST Slopeclass08 (km)	1.7	0.0	0
ST Spawning (km)	0.0	0.0	–
ST Rearing (km)	5.3	2.2	42
CH Spawning (km)	0.0	0.0	–
CH Rearing (km)	0.0	0.0	–
CO Spawning (km)	1.8	0.6	33
CO Rearing (km)	4.3	2.2	51
CO Rearing (ha)	–	0.0	–
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	–	0.0	–

Habitat	Potential	Remediation Gain	Remediation Gain (%)
All Spawning (km)	1.8	0.6	33
All Rearing (km)	5.6	2.2	39
All Spawning Rearing (km)	5.6	2.2	39

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing

McDowell Creek was dewatered at both culverts at the time of the surveys. Additionally, the stream was dry at Highway 16 and the Woodmere Nursery private road. PSCIS crossing 123544 was not backwatered, un-embedded and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.8). The culvert was perched above the stream at the inlet approximately 2m and road fill had caused a steep slope (>25%) just below the culvert for 5 - 10m.

PSCIS crossing 58151 was not backwatered, not embedded and ranked as a barrier to upstream fish passage according to the provincial protocol (Table 5.9).

Table 5.8: Summary of fish passage assessment for PSCIS crossing 123544.

Location and Stream Data	•	Crossing Characteristics	–
Date	2021-09-13	Crossing Sub Type	Round Culvert
PSCIS ID	123544	Diameter (m)	1.5
External ID	–	Length (m)	14
Crew	AI	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	628286.7	Resemble Channel	No
Northing	6060648	Backwatered	No
Stream	McDowell Creek	Percent Backwatered	–
Road	Private Road	Fill Depth (m)	1.5
Road Tenure	Unclassified	Outlet Drop (m)	0
Channel Width (m)	2.7	Outlet Pool Depth (m)	0
Stream Slope (%)	1	Inlet Drop	No
Beaver Activity	No	Slope (%)	18.5
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	26	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	10
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Location and Stream Data	•	Crossing Characteristics	–

Location and Stream Data	•	Crossing Characteristics	–
Date	2021-09-15	Crossing Sub Type	Round Culvert
PSCIS ID	58151	Diameter (m)	1
External ID	–	Length (m)	14
Crew	KP	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	629753.3	Resemble Channel	No
Northing	6061126	Backwatered	No
Stream	McDowell Creek	Percent Backwatered	–
Road	Woodmere Road	Fill Depth (m)	0.5
Road Tenure	MoTi Local	Outlet Drop (m)	0.25
Channel Width (m)	1.8	Outlet Pool Depth (m)	0.64
Stream Slope (%)	1.5	Inlet Drop	No
Beaver Activity	No	Slope (%)	5
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	31	Barrier Result	Barrier
Fix type	Replace Structure with Streambed Simulation CBS	Fix Span / Diameter	3
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Location and Stream Data	•	Crossing Characteristics	–

Stream Characteristics Downstream of 123544

The stream was surveyed downstream from crossing 123544 for NAm (Figure 5.5). The dominant substrate was gravels with fines sub-dominant., The average channel width was 2.6m, the average wetted width was NAm, 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, boulders, deep pools, and overhanging vegetation. Although dry, the channel was well defined with frequent gravels throughout. The undercut banks were deeply cut an riparian vegetation was comprised of thick red-osier dogwood understory and open mature cottonwood forest. Habitat was rated as low value for salmonid rearing and spawning.

At the time of the survey, PSCIS culvert 58158 on Highway 16 located approximately had been recently replaced with a baffled structure embedded with a natural cobble and gravel substrates. Although ranked as a barrier to upstream fish passage using the provincial metric the crossing is likely not a barrier during most flows for adult anadromous salmon and fluvial salmonids migrating upstream from the Bulkley River.

Stream Characteristics Upstream of 123544 and downstream of 58151

The stream was surveyed upstream of crossing 123544 for 25m and downstream from crossing 58151 for 120m (Figure 5.6). Total cover amount was rated as NA with dominant. Cover was also present as ., The dominant substrate was NA with NA sub-dominant., The average channel width was NAm, the average wetted width was NAm, and the average gradient was 2%. Fish were observed throughout the area surveyed and extensive algae growth was present on stream substrates. Large woody debris was rare and riparian/bank damage due to livestock was minimal and located at what appeared to be watering sites. Fencing was located across the stream in multiple locations. Patches of gravels suitable for spawning were present. Habitat value was rated as low as the surveyed area was considered an important migration corridor containing suitable spawning habitat and having moderate rearing potential.

5.1 Stream Characteristics Upstream of 58151

The stream was surveyed upstream from crossing 58151 for 70m (Figure 5.7). The average channel width was 1.7m, the average wetted width was NAm, and the average gradient was 2%., The dominant substrate was fines with gravels sub-dominant., Total cover amount was rated as abundant with overhanging vegetation dominant. Cover was also present as small woody debris and undercut banks. Immediately upstream of the crossing for ~80m, extensive anthropogenic damage was noted due to dredging of the channel. Heavy cattle grazing was also observed on the left bank. Juvenile salmonids were observed occasionally throughout the area surveyed. Fencing was located across the stream approximately 250m upstream of the culvert. Patches of gravels suitable for spawning were present. Habitat value was rated as low as the surveyed area was considered 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 123544 with a bridge (10m span) is recommended. The cost of the work is estimated at $200,000 for a cost benefit of 30.4 linear m/$1000 and NA m^2/$1000.

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 123544 with a bridge (10m span) is recommended. The cost of the work is estimated at $200,000 for a cost benefit of 30.4 linear m/$1000 and NA m^2/$1000.

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 58151 with a bridge (3m span) is recommended. The cost of the work is estimated at $160,000 for a cost benefit of 26.9 linear m/$1000 and 45.7 m^2/$1000. Relocation of the driveway accessing the private land from the other side of the stream and removal of the crossing could also be considered.

Conclusion

There was 6.1km of habitat modelled upstream of crossing 58151 with areas surveyed rated as low value for salmonid rearing and spawning. Crossing 123544 was ranked as a low priority for proceeding to design due to low flows and highly impacted habitats upstream. Crossing 58151 was ranked as a low priority for proceeding to design for replacement. In the upper reaches of McDowell Creek, impacts are apparent due to adjacent land use (cattle trampled banks and grazed/removed riparian vegetation). It is recommended that a plan be developed to work with adjacent landowners and tenure holders to exclude cattle from the riparian area, implement stream restoration actions and explore possibilities related to progressive beaver management in the watershed.

Table 5.10: Summary of habitat details for PSCIS crossing 123544.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
58151	Downstream	120	1.8	–	–	1.2	abundant	low
58151	Upstream	70	1.7	–	–	0.8	abundant	low
123544	Downstream	–	2.6	–	–	2.0	abundant	low
123544	Upstream	25	–	–	–	–	–	low

Figure 5.5: Left: Habitat downstream of PSCIS crossing 123544. Right: Habitat downstream of PSCIS crossing 123544.

Figure 5.6: Left: Habitat downstream of PSCIS crossing 58151. Right: Typical habitat upstream of PSCIS crossing 123544.

Figure 5.7: Left: Typical habitat upstream of PSCIS crossing 58151. Right: Typical habitat upstream of PSCIS crossing 58151.

John Brown - 123770 - Appendix

Site Location

PSCIS crossing 123770 is located on John Brown approximately 650m south of the Moricetown canyon at Moricetown, BC. PSCIS crossing 123770 is located on Highway 16. Crossing 123770 was located 0.3km upstream from the confluence with the Bulkley River and is the responsibility of the Ministry of Transportation and Infrastructure.

Background

At crossing 123770, John Brown is a fifth order stream with a watershed area upstream of the crossing of approximately 80.6km^2. The elevation of the watershed ranges from a maximum of 2050m to 375m near the crossing (Table 5.11). Upstream of crossing 123770, coho salmon, cutthroat trout, rainbow trout, chinook salmon, bull trout, and dolly varden have previously been recorded (MoE 2020b; Norris 2020). A. Gottesfeld and Rabnett (2007) report that although spawner abundance and location are unknown, chinook have been observed with John Brown Creek at 0.4km.

Table 5.11: Summary of derived upstream watershed statistics for PSCIS crossing 123770.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
123770	80.6	385	375	2050	1201	1087	SE

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

Wilson and Rabnett (2007) and McCarthy and Fernando (2015) report that the culvert on John Brown at Highway 16 has received efforts to facilitate backwatering including rock lines to establish backwater pools downstream of the culvert.

PSCIS stream crossing 123770 was ranked as a high priority for follow up by Irvine (2018), Irvine (2021) and Mazany-Wright et al. (2021) because of significant amounts of habitat modelled as upstream of the crossing. A summary of habitat modelling outputs is presented in Table 5.12. A map of the watershed is provided in map attachment 093M.102.

Table 5.12: Summary of fish habitat modelling for PSCIS crossing 123770.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	39.6	39.3	99
ST Lake Reservoir (ha)	0.0	0.0	–
ST Wetland (ha)	11.4	11.4	100
ST Slopeclass03 Waterbodies (km)	0.7	0.0	0
ST Slopeclass03 (km)	5.0	5.0	100
ST Slopeclass05 (km)	8.1	8.0	99
ST Slopeclass08 (km)	8.2	7.9	96
ST Spawning (km)	10.3	10.3	100
ST Rearing (km)	15.9	15.9	100
CH Spawning (km)	10.3	10.3	100
CH Rearing (km)	11.2	11.2	100
CO Spawning (km)	11.7	11.7	100
CO Rearing (km)	11.7	11.7	100
CO Rearing (ha)	0.0	0.0	–
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	–	0.0	–
All Spawning (km)	11.7	11.7	100
All Rearing (km)	15.9	15.9	100
All Spawning Rearing (km)	15.9	15.9	100

* Model data is preliminary and subject to adjustments.

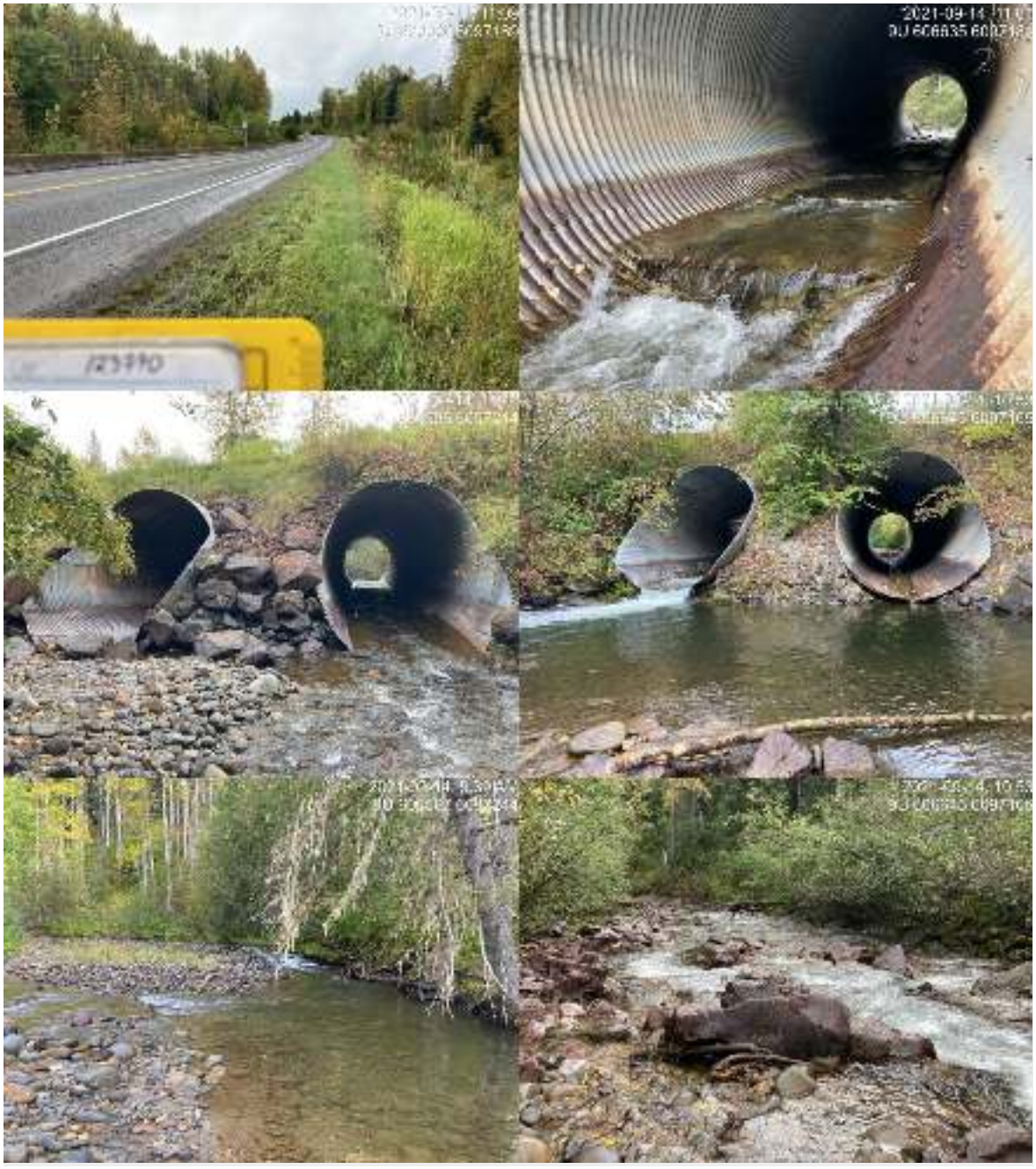
Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 123770 was non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.13). The crossing consisted on two pipes with baffles installed within the lower elevation pipe. There was a significant outlet drop and the baffled pipe was not embedded for its entire length. Water temperature was 10° C, pH was 7.2 and conductivity was 94uS/cm. The stream was also assessed at the location of a modelled crossing 1418m upstream from the confluence with the Bulkley River (PSCIS 198043) where a ford was located.

crossing 123770.

Location and Stream Data	•	**Crossing Characteristics**	–
Location and Stream Data	•	**Crossing Characteristics**	–
Date	2021-09-07	Crossing Sub Type	Round Culvert
PSCIS ID	123770	Diameter (m)	4
External ID	–	Length (m)	36
Crew	KP AN	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	606626.5	Resemble Channel	No
Northing	6097185	Backwatered	No
Stream	John Brown	Percent Backwatered	–
Road	Highway 16	Fill Depth (m)	3.5
Road Tenure	MoTi Arterial	Outlet Drop (m)	0.64
Channel Width (m)	12.3	Outlet Pool Depth (m)	1.5
Stream Slope (%)	2.9	Inlet Drop	Yes
Beaver Activity	No	Slope (%)	2
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	37	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	19
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Location and Stream Data	•	Crossing Characteristics	–



Stream Characteristics Downstream

The stream was surveyed downstream from crossing 123770 for 230m to the conflence with the Bulkley River (Figure 5.9). Total cover amount was rated as moderate with boulders dominant. Cover was also present as deep pools and overhanging vegetation. The average channel width was 13.6m, the average wetted width was 8.3m and the average gradient was 4.1%. The dominant

substrate was large rock/bedrock with cobbles subdominant. Although rated as an important migration corridor, the habitat was rated as medium value for salmonid rearing and spawning with high flows and limited complexity. Several dead pink salmon were noted on the fan at the confluence with the Bulkley River.

Stream Characteristics Upstream

The stream was surveyed upstream from crossing 123770 for 1000m (Figure 5.10). Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris, large woody debris, boulders, deep pools, and overhanging vegetation. The average channel width was 12.2m, the average wetted width was 8.3m and the average gradient was 2.9%. The dominant substrate was cobbles with gravels subdominant. The first 50 - 100m upstream of crossing channel and banks were noted as armoured with riprap. Abundant gravels suitable for resident and anadromous salmonids were noted throughout. The habitat was rated as high value as an important migration corridor containing suitable spawning habitat and having moderate rearing potential.

The stream was also surveyed immediately upstream of PSCIS ford 198043 for 350m (Figure 5.11). Total cover amount was rated as moderate with boulders dominant. Cover was also present as small woody debris and overhanging vegetation.. The average channel width was 11.2m, the average wetted width was 9.1m and the average gradient was 3%. The dominant substrate was cobbles with boulders subdominant. The habitat was rated as high value for salmon rearing and spawning.

Fish Sampling

Electrofishing was conducted with results summarised in Tables 5.15 - 5.16 and Figure 5.8.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 123770 with a bridge (19m span) is recommended. The cost of the work is estimated at $11,400,000 for a cost benefit of 1 linear m/$1000 and 12.5 m^2/$1000.

Conclusion

There was 11.7km of habitat modelled upstream of crossing 123770 with areas surveyed rated as high value for salmonid rearing and spawning. Crossing 123770 was ranked as a high priority for proceeding to design for replacement. John Brown Creek is a large system with habitat suitable for numerous species includeing coho, steelhead and chinook salmon. Development of a plan to replace the crossing with a bridge may be considered as a prudent step to eliminating an outlet

drop, reducing flow velocities at the highway crossing and mitigating risks of a blow out to the baffle induced partial embedding currently in place in the south pipe of the crossing.

Table 5.14: Summary of habitat details for PSCIS crossing 123770.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
123770	Downstream	230	13.6	7.4	1.0	4.1	moderate	medium
123770	Upstream	1000	12.2	8.3	0.8	2.9	moderate	high
123770	Upstream2	350	11.2	9.1	0.3	3.0	moderate	high

Table 5.15: Fish sampling site summary for 123770.

site	passes	ef_length_m	ef_width_m	area_m2	enclosure
123770_us_ef1	1	15.7	1.65	25.9	Open
123770_us_ef2	1	3.3	3.23	10.7	Open
123770_us_ef3	1	1.8	2.83	5.1	Open
123770_us_ef4	1	6.4	3.57	22.8	Open
123770_us_ef5	1	4.8	3.03	14.5	Open
123770_us_ef6	1	2.9	2.00	5.8	Open

Table 5.16: Fish sampling density results summary for 123770.

local_name	species_code	life_stage	catch	density_100m2	nfc_pass
123770_us_ef1	RB	fry	2	7.7	FALSE
123770_us_ef1	RB	parr	4	15.4	FALSE
123770_us_ef2	CO	fry	2	18.7	FALSE
123770_us_ef2	RB	fry	10	93.5	FALSE
123770_us_ef2	RB	parr	4	37.4	FALSE
123770_us_ef3	RB	fry	6	117.6	FALSE
123770_us_ef3	RB	parr	2	39.2	FALSE
123770_us_ef3	RB	juvenile	2	39.2	FALSE
123770_us_ef4	RB	fry	1	4.4	FALSE
123770_us_ef4	RB	parr	8	35.1	FALSE
123770_us_ef4	RB	juvenile	2	8.8	FALSE
123770_us_ef4	RB	adult	1	4.4	FALSE
123770_us_ef5	RB	fry	1	6.9	FALSE
123770_us_ef5	RB	parr	1	6.9	FALSE
123770_us_ef6	NFC	–	0	0.0	TRUE

* 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.

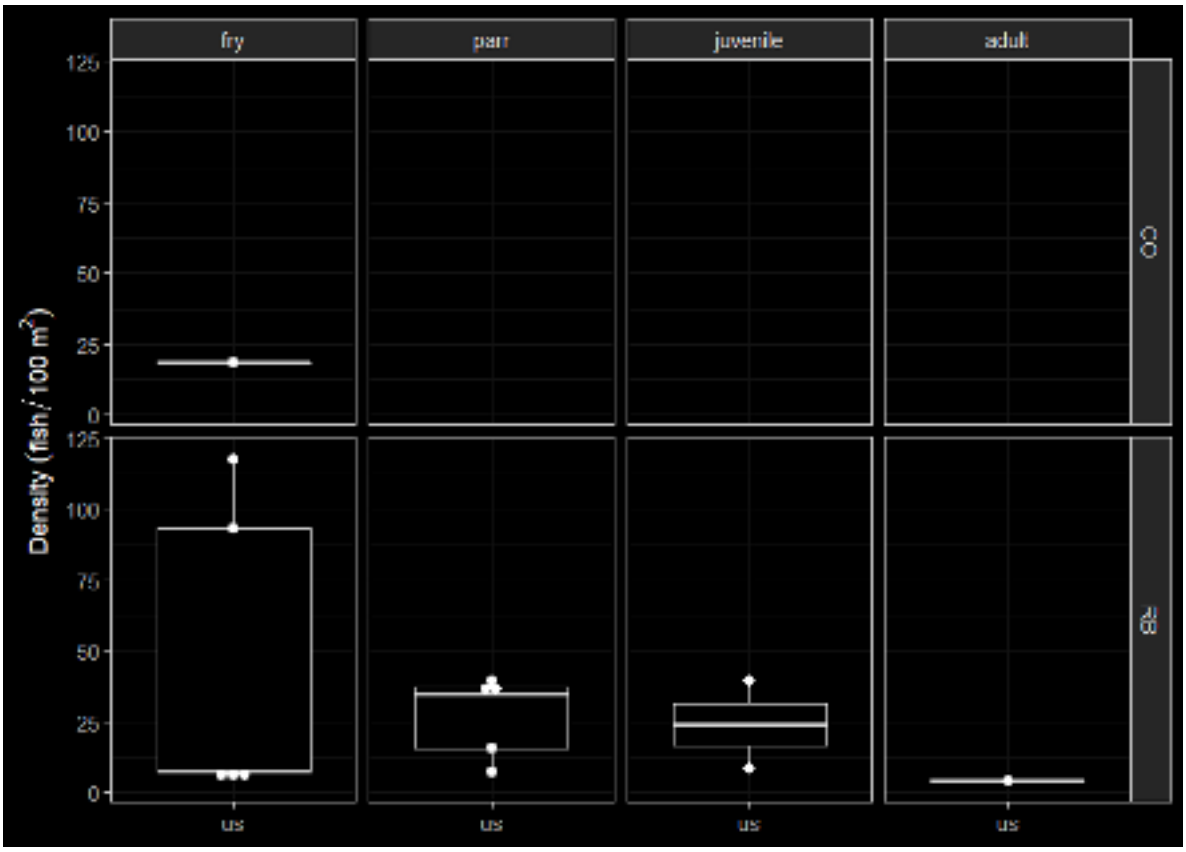


Figure 5.8: Densites of fish (fish/100m2) captured upstream of PSCIS crossing 123770.

Figure 5.9: Left: Typical habitat downstream of PSCIS crossing 123770. Right: Typical habitat downstream of PSCIS crossing 123770.

Figure 5.10: Left: Typical habitat upstream of PSCIS crossing 123770. Right: Typical habitat upstream of PSCIS crossing 123770.

Figure 5.11: Left: Typical habitat upstream of PSCIS crossing 123770. Right: Typical habitat upstream of PSCIS crossing 123770.

Mission Creek - 124420 - Appendix

Site Location

PSCIS crossing 124420 is located on Mission Creek at Hazleton, BC. PSCIS crossing 124420 is located on Highway 16. Crossing 124420 was located 1.8km upstream from the confluence with the Bulkley River. Crossing 124420 is the responsibility of the Ministry of Transportation and Infrastructure.

Background

At crossing 124420, Mission Creek is a fourth order stream with a watershed area upstream of the crossing of approximately 28.6km^2. The elevation of the watershed ranges from a maximum of 2171m to 211m near the crossing (Table 5.17). Upstream of crossing 124420, cutthroat trout, pink salmon, coho salmon, rainbow trout, bull trout, and dolly varden have previously been recorded (MoE 2020b; Norris 2020).

Wilson and Rabnett (2007) report that the crossing structure located on Highway 16 and Station Creek 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 K. 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 Restoration Society moves spawning coho upstream of the crossing annually. Following stream morphology changes which occurred during a fall 2017 flood event causing the release and distribution of sediment loads, Newman and England (2018) conducted a fish habitat assessment from the confluence of Mission Creek with the Bulkley River upstream to the Mile 48 Canadian National railway crossing to determine stream diversity, spawning gravel catchment areas, beaver dam activity and negative impacts present in or along the stream. Beaver control activities on Mission and Waterfall Creeks by CN Rail upstream of crossing 124420 may have been the cause of the 2017 flood event (pers comm. Brenda Donas, Chicago Creek Restoration Society).

5.17: Summary of derived upstream watershed statistics for PSCIS crossing 124420.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
124420	28.6	301	211	2171	521	425	NNE

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

PSCIS stream crossing 124420 was ranked as a high priority for follow up by Wilson and Rabnett (2007), McCarthy and Fernando (2015) and Irvine (2018) because of known high value spawning and rearing habitat upstream of the crossing. A summary of habitat modelling outputs is presented in Table 5.18. A map of the watershed is provided in map attachment 093M.106.

Table 5.18: Summary of fish habitat modelling for PSCIS crossing 124420.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	26.3	14.2	54
ST Lake Reservoir (ha)	6.5	2.0	31
ST Wetland (ha)	73.9	56.5	76
ST Slopeclass03 Waterbodies (km)	3.4	0.0	0
ST Slopeclass03 (km)	11.1	6.5	59
ST Slopeclass05 (km)	5.2	1.0	19
ST Slopeclass08 (km)	4.1	3.0	73
ST Spawning (km)	5.3	3.0	57
ST Rearing (km)	8.5	5.0	59
CH Spawning (km)	5.3	3.0	57
CH Rearing (km)	8.4	5.0	60
CO Spawning (km)	6.5	4.2	65
CO Rearing (km)	9.3	5.8	62
CO Rearing (ha)	28.3	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)	6.5	4.2	65
All Rearing (km)	9.3	5.8	62
All Spawning Rearing (km)	9.3	5.8	62

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 124420 was un-embedded, non-backwatered and ranked as a barrier barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.19). Water temperature was 8°C, pH was 7.9 and conductivity was 89uS/cm. Surveys were conducted with a remotely piloted aircraft upstream of the crossing with resulting images stitched into an orthomosaic and 3-dimensional model presented here and here.

Table 5.19: Summary of fish passage assessment for PSCIS crossing 124420.

Location and Stream Data	•	Crossing Characteristics	–
Date	2021-09-16	Crossing Sub Type	Round Culvert
PSCIS ID	124420	Diameter (m)	1.6
External ID	–	Length (m)	90
Crew	KP DN	Embedded	No
UTM Zone	9	Depth Embedded (m)	–

Location and Stream Data	•	Crossing Characteristics	–
Easting	586632.3	Resemble Channel	No
Northing	6122395	Backwatered	No
Stream	Mission Creek	Percent Backwatered	–
Road	Highway 16	Fill Depth (m)	9.99
Road Tenure	New Hazelton Highway	Outlet Drop (m)	0.8
Channel Width (m)	5.6	Outlet Pool Depth (m)	1.6
Stream Slope (%)	2	Inlet Drop	Yes
Beaver Activity	No	Slope (%)	3.5
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	42	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	30
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Location and Stream Data	•	Crossing Characteristics	–

Location and Stream Data	•	**Crossing Characteristics**	–
Date	2021-09-16	Crossing Sub Type	Round Culvert
PSCIS ID	124421	Diameter (m)	1
External ID	–	Length (m)	15
Crew	KP	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	589466.5	Resemble Channel	No
Northing	6123042	Backwatered	No
Stream	Tributary to Waterfall Creek	Percent Backwatered	–
Road	11th Ave	Fill Depth (m)	1.5
Road Tenure	New Hazelton Local	Outlet Drop (m)	0.3
Channel Width (m)	2.6	Outlet Pool Depth (m)	0.27
Stream Slope (%)	1	Inlet Drop	Yes
Beaver Activity	No	Slope (%)	1
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	34	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	10
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Location and Stream Data	•	Crossing Characteristics	–

Location and Stream Data	•	Crossing Characteristics	–
Date	2021-09-16	Crossing Sub Type	Round Culvert
PSCIS ID	124422	Diameter (m)	1.2
External ID	–	Length (m)	45
Crew	KP	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	589499.9	Resemble Channel	No
Northing	6123162	Backwatered	Yes
Stream	Tributary to Waterfall Creek	Percent Backwatered	100
Road	Highway 16	Fill Depth (m)	6
Road Tenure	New Hazelton Arterial	Outlet Drop (m)	0
Channel Width (m)	5.2	Outlet Pool Depth (m)	0
Stream Slope (%)	5.2	Inlet Drop	Yes
Beaver Activity	Yes	Slope (%)	1.5
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	27	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	19
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Location and Stream Data	•	Crossing Characteristics	–

Stream Characteristics Downstream of 124420

The stream was surveyed downstream from the culvert for 375m (Figure 5.12). Total cover amount was rated as with large woody debris dominant. Cover was also present as small woody debris, boulders, and overhanging vegetation (Table 5.22). The average channel width was 6.1m, the average wetted width was 4.6m and the average gradient was 2.1%. The dominant substrate was gravels with cobbles subdominant. The habitat was rated as high value for salmonid rearing and spawning.

Stream Characteristics Upstream of 124420 and downstream of 124421

The stream was surveyed immediately upstream from 124420 for approximately 370m (Figure 5.13). Within the area surveyed, total cover amount was rated as with large woody debris dominant. Cover was also present as small woody debris, undercut banks, deep pools, and overhanging vegetation (Table 5.22). The average channel width was 5.7m, the average wetted width was 4.7m and the average gradient was 2%. The dominant substrate was cobbles with gravels subdominant. Habitat value was rated as high value for resident salmonid rearing and spawning.

Stream Characteristics Upstream of 124421 and downstream of 124422

Stream Characteristics Upstream of 124422

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 124420 with a bridge (30m span) is recommended. The cost of the work is estimated at $18,000,000 for a cost benefit of 0.5 linear m/$1000 and 2.9 m^2/$1000. These cost benefit estimates assume that adult coho spawner passage through 124420 will result in passage through upstream crossings which rank as barriers according to the provincial metric but are likely to be passable to adult coho.

Conclusion

There was 124420 is 9.3km of habitat modelled upstream of the crossing with areas surveyed rated as high value for salmonid rearing and spawning. Crossing 124420 was ranked as a high priority for proceeding to design for replacement. At the time of reporting, the Ministry of Transportation and Infrastructure was in the process of developing a design to retrofit the existing structure at 124420 with some sort of backwatering mechanism so that it could pass adult coho spawners. Although, backwatering can be considered an interim solution, replacement of this crossing with an open bottom structure is recommended in the long term.

Table 5.22: Summary of habitat details for PSCIS crossing 124420, 124421 and 124422.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
124420	Downstream	375	6.1	4.6	0.5	2.1	abundant	high
124420	Upstream	370	5.7	4.7	0.5	2.0	abundant	high
124420	Upstream2	430	6.2	5.5	–	0.5	abundant	high
124421	Downstream	50	1.6	1.5	–	1.0	–	moderate
124421	Upstream	120	2.6	2.5	0.3	1.0	abundant	moderate
124422	Upstream	350	6.7	6.6	–	1.0	abundant	moderate

Figure 5.12: Left: Typical habitat downstream of PSCIS crossing 124420. Right: Typical habitat downstream of PSCIS crossing 124420.

Figure 5.13: Left: Typical habitat upstream of PSCIS crossing 124420. Right: Typical habitat upstream of PSCIS crossing 124420.

Richfield Creek - 197662 - Appendix

Site Location

PSCIS crossing 197662 is located on Richfield Creek approximately 30km east of Houston, BC with the highway located approximately 1.2km upstream upstream from the confluence with the Bulkley River. Highway 16 is the responsibility of the Ministry of Transportation and Infrastructure.

Background

At crossing 197662, Richfield Creek is a fifth order stream with a watershed area upstream of the crossing of approximately 161.3km^2. The elevation of the watershed ranges from a maximum of 1753m to 650m near the crossing (Table 5.23). Upstream of crossing 197662, longnose sucker, lake chub, longnose dace, coho salmon, rainbow trout, steelhead, and chinook salmon have previously been recorded upstream (MoE 2020b; Norris 2020). Habitat modelling outputs are presented in Table 5.24. A map of the watershed is provided in map attachment 093L.115.

Table 5.23: Summary of derived upstream watershed statistics for PSCIS crossing 197662.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
197662	161.3	676	650	1753	1096	1039	SSW

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

A habitat confirmation assessment was conducted by Irvine (2021) in 2020 and the reader is directed there for detailed background, habitat assessment and fish sampling information from 2020 surveys. Acquisition of high resolution aerial imagery and fish sampling was conducted at the site in 2021 to provide context for crossing prioritization. Additionally, Society for Ecosystem Restoration BC, Fisheries and Oceans Canada and the Morice Watershed Monitoring Trust were able to collaborate in 2021 to provide funding for the installation of barbed wire fenceing adjacent to a buffer on the west bank of Richfield Creek below the highway as a restorative action to exclude cattle from the riparian area. Details of these three activities are provided below.

Table 5.24: Summary of fish habitat modelling for PSCIS crossing 197662.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	70.8	50.9	72
ST Lake Reservoir (ha)	2.5	2.0	80
ST Wetland (ha)	198.5	65.8	33
ST Slopeclass03 Waterbodies (km)	8.7	0.0	0
ST Slopeclass03 (km)	31.9	23.8	75
ST Slopeclass05 (km)	20.6	16.4	80
ST Slopeclass08 (km)	7.2	3.3	46
ST Spawning (km)	11.8	11.8	100
ST Rearing (km)	14.4	14.4	100
CH Spawning (km)	11.8	11.8	100
CH Rearing (km)	12.8	12.8	100
CO Spawning (km)	16.4	16.4	100
CO Rearing (km)	32.8	26.0	79
CO Rearing (ha)	104.4	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)	16.4	16.4	100
All Rearing (km)	33.2	26.5	80
All Spawning Rearing (km)	33.2	26.5	80

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing

Although, culvert measurement data was recycled from 2020, crossing photos were retaken (Table 5.25).

Table 5.25: Summary of fish passage assessment for PSCIS crossing 197662.

Location and Stream Data	•	Crossing Characteristics	–
Date	2021-09-10	Crossing Sub Type	Round Culvert
PSCIS ID	197662	Diameter (m)	4.2
External ID	–	Length (m)	24
Crew	AI	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	672404.7	Resemble Channel	No
Northing	6044146	Backwatered	No
Stream	Richfield Creek	Percent Backwatered	–

Stream Characteristics at Crossing

Location and Stream Data	•	Crossing Characteristics	–
Road	Highway 16	Fill Depth (m)	1
Road Tenure	MoTi highway	Outlet Drop (m)	0.2
Channel Width (m)	12.5	Outlet Pool Depth (m)	1
Stream Slope (%)	1.5	Inlet Drop	No
Beaver Activity	No	Slope (%)	2
Habitat Value	High	Valley Fill	Deep Fill
Final score	29	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	16.5
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Location and Stream Data	•	Crossing Characteristics	–

5.2 Aerial Imagery

Surveys were conducted with a remotely piloted aircraft upstream of the crossing with resulting images stitched into an orthomosaic and 3-dimensional model presented here and here.

5.3 Fish Sampling

Multipass electrofishing was conducted at three sites upstream of the highway and three sites downstream. Water temperature was 10°C, pH was 8.1 and conductivity was 234uS/cm. results are summarised in Tables 5.26 - 5.27 and Figure 5.14. Photos are provided in (Figures 5.15) - 5.16).

Table 5.26: Fish sampling site summary for 197662.

site	passes	ef_length_m	ef_width_m	area_m2	enclosure
197662_ds_ef1	6	21.4	6.10	130.5	Closed
197662_ds_ef2	4	5.8	5.60	32.5	Closed
197662_ds_ef3	3	4.2	6.05	25.4	Closed
197662_us_ef1	4	6.4	7.00	44.8	Closed
197662_us_ef2	3	5.1	4.83	24.6	Closed
197662_us_ef3	3	5.6	2.73	15.3	Closed

Table 5.27: Fish sampling density results summary for 197662.

local_name	species_code	life_stage	catch	density_100m2	nfc_pass
197662_ds_ef1	CO	fry	12	9.2	TRUE
197662_ds_ef1	CO	parr	65	49.8	FALSE
197662_ds_ef1	L	–	3	2.3	FALSE
197662_ds_ef1	LSU	–	1	0.8	TRUE
197662_ds_ef1	MW	parr	6	4.6	TRUE
197662_ds_ef1	RB	fry	29	22.2	FALSE
197662_ds_ef1	RB	parr	42	32.2	FALSE
197662_ds_ef1	RB	juvenile	9	6.9	TRUE
197662_ds_ef1	RB	adult	4	3.1	TRUE
197662_ds_ef1	SU	–	14	10.7	FALSE
197662_ds_ef2	CO	fry	17	52.3	FALSE
197662_ds_ef2	CO	parr	5	15.4	TRUE
197662_ds_ef2	L	–	6	18.5	FALSE
197662_ds_ef2	RB	fry	11	33.8	FALSE
197662_ds_ef2	RB	parr	7	21.5	TRUE
197662_ds_ef2	RB	adult	2	6.2	TRUE
197662_ds_ef2	SU	–	3	9.2	TRUE
197662_ds_ef3	CO	fry	2	7.9	TRUE
197662_ds_ef3	CO	parr	3	11.8	FALSE
197662_ds_ef3	L	–	1	3.9	TRUE
197662_ds_ef3	RB	fry	7	27.6	FALSE
197662_ds_ef3	RB	parr	7	27.6	TRUE
197662_ds_ef3	SU	–	3	11.8	TRUE
197662_us_ef1	CO	fry	6	13.4	FALSE
197662_us_ef1	CO	parr	2	4.5	TRUE
197662_us_ef1	L	–	3	6.7	TRUE

local_name	species_code	life_stage	catch	density_100m2	nfc_pass
197662_us_ef1	RB	fry	43	96.0	FALSE
197662_us_ef1	RB	parr	16	35.7	TRUE
197662_us_ef1	RB	juvenile	4	8.9	TRUE
197662_us_ef1	RB	adult	1	2.2	FALSE
197662_us_ef2	CO	fry	5	20.3	TRUE
197662_us_ef2	CO	parr	5	20.3	FALSE
197662_us_ef2	L	–	1	4.1	FALSE
197662_us_ef2	RB	fry	38	154.5	FALSE
197662_us_ef2	RB	parr	22	89.4	FALSE
197662_us_ef2	RB	juvenile	2	8.1	TRUE
197662_us_ef3	CO	fry	5	32.7	FALSE
197662_us_ef3	CO	parr	1	6.5	TRUE
197662_us_ef3	L	–	5	32.7	FALSE
197662_us_ef3	RB	fry	18	117.6	TRUE
197662_us_ef3	RB	parr	4	26.1	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.

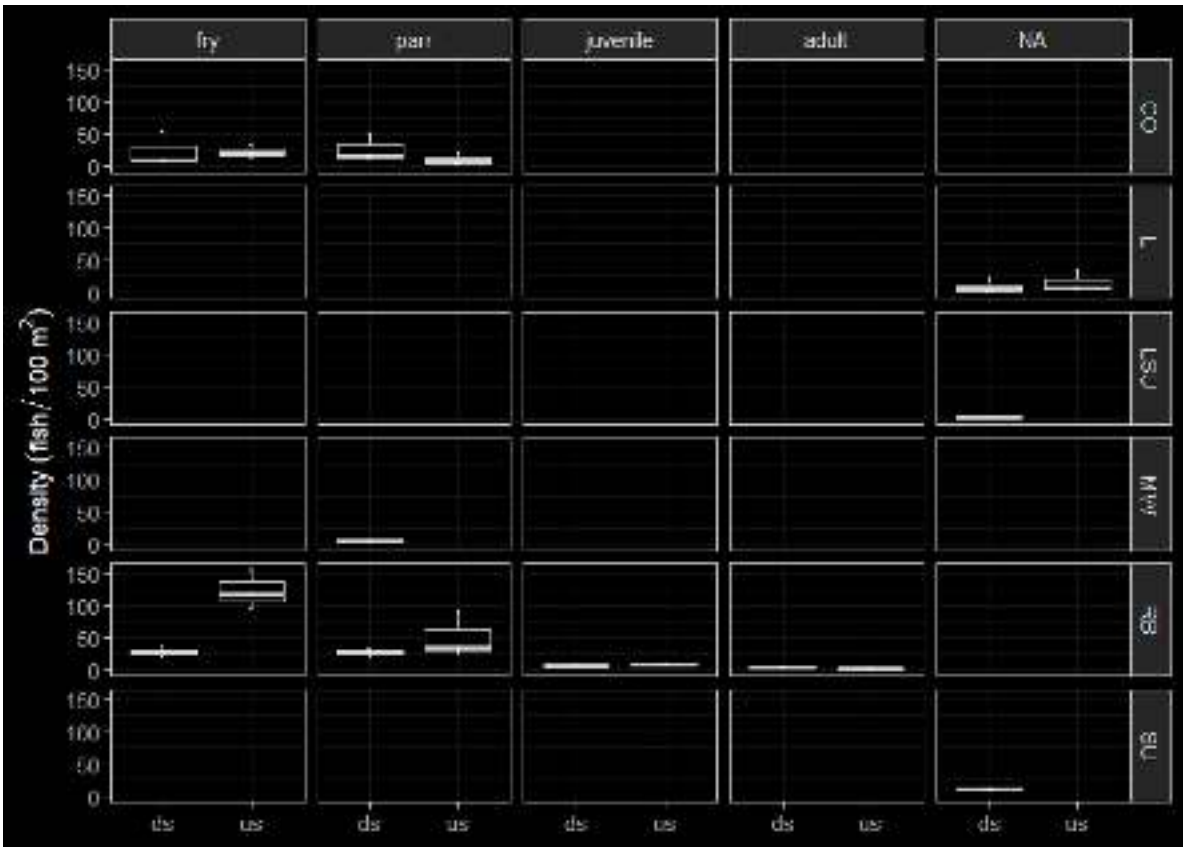


Figure 5.14: Densites of fish (fish/100m2) captured upstream and downstream of PSCIS crossing 197662.

Figure 5.15: Left: Habitat downstream of PSCIS crossing 197662. Right: Lamprey captured downstream of PSCIS crossing 197662.

Figure 5.16: Left: Habitat upstream of PSCIS crossing 197662. Right: Habitat upstream of PSCIS crossing 197662.

5.4 Riparian Fenceing

Approximately 1100 m of new four strand barbed wire fencing was installed to the west of Richfield Creek between November 26 and December 14, 2021. Fencing of the area complemented significant restoration work completed in by the Morice Watershed Monitoring Trust project which included bank stabilization, installation of vertical posts for bank stability, live stakeing of willow/cottonwood and planting of rooted willow plugs. Details of the work conducted is documented in Wrench (2022) and included as Attachment 4.

Conclusion

There was 197662 is 32.8km of habitat modelled upstream of the crossing with areas surveyed in 2020 rated as high value for salmonid rearing and spawning (Irvine 2021). There is extensive background information on this system summarized in Irvine (2021) and in development at the time of reporting. Crossing 197662 was ranked as a high priority for proceeding to design for replacement. As Richfield Creek is a high value fish stream with cold water inputs and significant historic and ongoing impacts due to adjacent land use (linear development, residential development, cattle trampled banks and grazed/removed riparian vegetation) it is recommended that individuals, organizations and regulators continue to work with adjacent landowners and tenure holders to implement stream restoration actions, exclude cattle from the riparian area, and explore possibilities related to progressive beaver management in the watershed.

Tributary to Maxan Creek - 197909 - Appendix

Site Location

PSCIS crossing 197909 is located on Tributary to Maxan Creek adjacent to the west side of Maxan Lake located south of Topley, BC. PSCIS crossing 197909 is located on Maxan Creek FSR. Crossing 197909 was located 1.8km upstream from the confluence with Maxan Lake. Crossing 198043 is the responsibility of the Ministry of Forests.

Background

At crossing 197909, Tributary to Maxan Creek is a first order stream with a watershed area upstream of the crossing of approximately 2.1km^2. The elevation of the watershed ranges from a maximum of 956m to 788m near the crossing (Table 5.28). No fish have previously been recorded at the site (MoE 2020b; Norris 2020).

Table 5.28: Summary of derived upstream watershed statistics for PSCIS crossing 197909.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
197909	2.1	835	788	956	851	847	E

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

PSCIS stream crossing 198043 was ranked as a moderate priority for follow up during field assessments because of the presence of modelled habitat upstream and relatively good flows in t he stream when compared to the rest of the culverted streams surveyed in the greater Maxan Creek watershed (Table 5.29. A map of the watershed is provided in map attachment 093L.110.

Table 5.29: Summary of fish habitat modelling for PSCIS crossing 197909.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	0.7	0.7	100
ST Lake Reservoir (ha)	5.7	5.7	100
ST Wetland (ha)	27.7	27.7	100
ST Slopeclass03 Waterbodies (km)	0.6	0.0	0
ST Slopeclass03 (km)	0.0	0.0	–
ST Slopeclass05 (km)	0.1	0.1	100
ST Slopeclass08 (km)	0.0	0.0	–
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)	0.0	0.0	–
CO Rearing (km)	0.2	0.2	100
CO Rearing (ha)	13.8	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)	0.0	0.0	–
All Rearing (km)	0.2	0.2	100
All Spawning Rearing (km)	0.2	0.2	100

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 197909 was comprised of an un-embedded and non-backwatered round culvert (Table 5.30). Water temperature was 12°C, pH was 7.2 and conductivity was 106uS/cm.

Table 5.30: Summary of fish passage assessment for PSCIS crossing 197909.

Location and Stream Data	•	**Crossing Characteristics**	–
Date	2021-08-30	Crossing Sub Type	Round Culvert
PSCIS ID	197909	Diameter (m)	0.6
External ID	–	Length (m)	16
Crew	AI KP	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	687557	Resemble Channel	No
Northing	6020572	Backwatered	No
Stream	Tributary to Maxan Creek	Percent Backwatered	–
Road	Maxan Creek FSR	Fill Depth (m)	2.5
Road Tenure	FLNR DND 7735	Outlet Drop (m)	0
Channel Width (m)	0.9	Outlet Pool Depth (m)	0.65
Stream Slope (%)	4	Inlet Drop	Yes
Beaver Activity	Yes	Slope (%)	3
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	29	Barrier Result	Barrier
Fix type	Replace Structure with Streambed Simulation CBS	Fix Span / Diameter	3
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Location and Stream Data	•	Crossing Characteristics	–

Stream Characteristics Downstream

The stream was surveyed downstream from the culvert for NAm

Stream Characteristics Upstream of 197909

The stream was surveyed immediately upstream from 197909 for approximately NAm to the location of a large beaver dam.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed at the site, removal of PSCIS crossing 197909 is recommended. In addition to removal of the collapsed bridge, resloping of banks and the installation of live cuttings/pegboarding is recommended in three areas downstream where cattle trampling is resulting in significant erosion. A map of the erosion areas and associated prescriptions for rehabilitation of the downstream corners is provided as Figure **??**. The cost of the work is estimated at $40,000 for a cost benefit of 5.6 linear m/$1000 and 7.3 m^2/$1000.

Conclusion

There was 197909 is 0.2km of habitat modelled upstream of crossing with areas surveyed rated as NA value for salmonid rearing and spawning. Crossing 197909 was ranked as a NA priority for proceeding to design for removal.

Table 5.31: Summary of habitat details for PSCIS crossing 197909.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
197909	Downstream	–	1.3	1.3	0.5	3.2	abundant	low
197909	Upstream	–	1.3	–	–	–	moderate	–

Robert Hatch Creek - 197912 - Appendix

Site Location

PSCIS crossing 197912 is located on Robert Hatch Creek near Topley, BC. PSCIS crossing 197912 is located on a small private road and the Hatch Creek Ranch. Crossing 197912 was located 2.6km upstream from the confluence with Richfield Creek. Crossing 198043 is the responsibility of the range tenure holder (Hatch Creek Ranch Ltd. - forest file id RAN074136 and Groot Bros. Contracting Ltd. - forest file id RANM01180) where the road is located.

Background

At crossing 197912, Robert Hatch Creek is a fourth order stream with a watershed area upstream of the crossing of approximately 31.5km^2. The elevation of the watershed ranges from a maximum of 1070m to 715m near the crossing (Table 5.32). No fish have previously been recorded at the site (MoE 2020b; Norris 2020).

Table 5.32: Summary of derived upstream watershed statistics for PSCIS crossing 197912.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
197912	31.5	720	715	1070	1004	983	S

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

Extensive background on Richfield Creek is presented in Irvine (2021) with fish sampling and orthoimagery available within the “Richfield Creek - 197662 - Appendix” within this document.

PSCIS stream crossing 198043 was ranked as a high priority for follow up by Canadian Wildlife Federation because of the relatively large size of the stream and habitat rated as high value in PSCIS (Table 5.33. A map of the watershed is provided in map attachment 093L.115.

Table 5.33: Summary of fish habitat modelling for PSCIS crossing 197912.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	63.7	55.6	87
ST Lake Reservoir (ha)	2.5	2.4	96
ST Wetland (ha)	198.5	198.5	100
ST Slopeclass03 Waterbodies (km)	8.7	0.0	0
ST Slopeclass03 (km)	26.8	26.8	100
ST Slopeclass05 (km)	18.8	15.1	80
ST Slopeclass08 (km)	7.0	3.1	44
ST Spawning (km)	6.7	6.7	100
ST Rearing (km)	9.3	9.3	100
CH Spawning (km)	6.7	6.7	100
CH Rearing (km)	7.8	7.8	100
CO Spawning (km)	11.3	11.3	100
CO Rearing (km)	27.7	27.7	100
CO Rearing (ha)	104.4	104.4	100
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	–	0.0	–
All Spawning (km)	11.3	11.3	100
All Rearing (km)	28.2	28.2	100
All Spawning Rearing (km)	28.2	28.2	100

* Model data is preliminary and subject to adjustments.

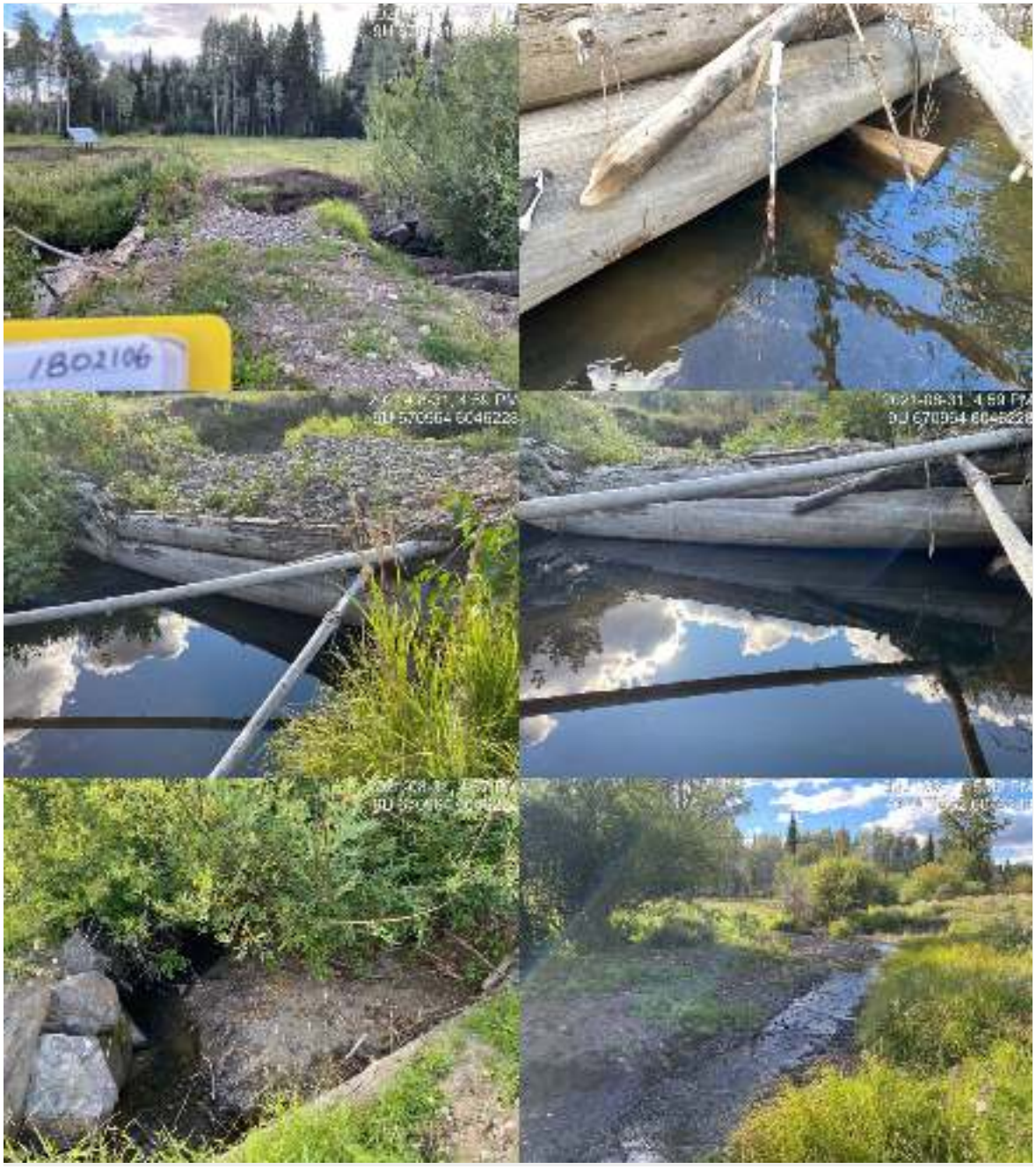
Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 197912 was comprised of a collapsing bridge (Table 5.34). The structure may have been presenting an impediment to upstream fish passage for adult fish and the bridge debris in the channel was resulting in erosion of the banks adjacent to the historic structure. Water temperature was 12°C, pH was 8 and conductivity was 283uS/cm. Surveys were conducted with a remotely piloted aircraft immediately upstream and downstream of the crossing with resulting images stitched into an orthomosaic and 3-dimensional model presented here and here.

Table 5.34: Summary of fish passage assessment for PSCIS crossing 197912.

Location and Stream Data	•	Crossing Characteristics	–
Date	2021-08-31	Crossing Sub Type	Bridge
PSCIS ID	197912	Diameter (m)	12
External ID	–	Length (m)	7
Crew	AI	Embedded	–
UTM Zone	9	Depth Embedded (m)	–
Easting	670963	Resemble Channel	–
Northing	6046221	Backwatered	–
Stream	Robert Hatch Creek	Percent Backwatered	–
Road	Private	Fill Depth (m)	–
Road Tenure	Unclassified	Outlet Drop (m)	–
Channel Width (m)	–	Outlet Pool Depth (m)	–
Stream Slope (%)	–	Inlet Drop	–
Beaver Activity	–	Slope (%)	–
Habitat Value	–	Valley Fill	–
Final score	0	Barrier Result	Passable
Fix type	–	Fix Span / Diameter	–
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Location and Stream Data	•	Crossing Characteristics	–



Stream Characteristics Downstream

The stream was surveyed downstream from the culvert for 300m (Figure 5.18). Total cover amount was rated as with deep pools dominant. Cover was also present as small woody debris, large woody debris, undercut banks, and overhanging vegetation (Table 5.35). The average channel width was 4.7m, the average wetted width was 3.2m and the average gradient was 1.2%. The dominant substrate was gravels with fines subdominant. The habitat was rated as medium value for salmonid rearing and spawning.

Stream Characteristics Upstream of 197912

The stream was surveyed immediately upstream from 197912 for approximately 340m to the location of a large beaver dam (Figure 5.19). Within the area surveyed, total cover amount was rated as with deep pools dominant. Cover was also present as small woody debris, large woody debris, undercut banks, overhanging vegetation, and instream vegetation (Table 5.35). The average channel width was 4.3m, the average wetted width was 2.5m and the average gradient was 1.5%. The dominant substrate was gravels with fines subdominant. Habitat value was rated as high value for resident salmonid rearing and spawning.

Fish Sampling

Electrofishing was conducted downstream of the collapsed bridge with results summarised in Tables 5.36 - 5.37 and Figure 5.17.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed at the site, removal of PSCIS crossing 197912 is recommended. In addition to removal of the collapsed bridge, resloping of banks and the installation of live cuttings/pegboarding is recommended in three areas downstream where cattle trampling is resulting in significant erosion. A map of the erosion areas and associated prescriptions for rehabilitation of the downstream corners is provided as Figure **??**. The cost of the work is estimated at $30,000 for a cost benefit of 924 linear m/$1000 and 3973.2 m^2/$1000.

Conclusion

There was 197912 is 27.7km of habitat modelled upstream of crossing with areas surveyed rated as high value for salmonid rearing and spawning. Crossing 197912 was ranked as a moderate priority for proceeding to design for removal. As Robert Hatch Creek appears to be a high value fish stream with significant impacts due to adjacent land use (cattle trampled banks and grazed/removed riparian vegetation), it is recommended that a plan be developed to work with adjacent landowners and tenure holders to exclude cattle from the riparian area, implement stream restoration actions and explore possibilities related to progressive beaver management in the watershed.

Table 5.35: Summary of habitat details for PSCIS crossing 197912.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
197912	Downstream	300	4.7	3.2	0.5	1.2	–	medium
197912	Upstream	340	4.3	2.5	0.6	1.5	abundant	high

Table 5.36: Fish sampling site summary for 197912.

site	passes	ef_length_m	ef_width_m	area_m2	enclosure
197912_ds_ef1	3	8.6	4.80	41.3	Closed
197912_ds_ef2	1	28.0	1.96	54.9	Open
197912_ds_ef3	1	14.0	2.87	40.2	Open

Table 5.37: Fish sampling density results summary for 197912.

local_name	species_code	life_stage	catch	density_100m2	nfc_pass
197912_ds_ef1	NFC	–	0	0.0	TRUE
197912_ds_ef1	RB	adult	1	2.4	TRUE
197912_ds_ef2	RB	fry	1	1.8	FALSE
197912_ds_ef3	RB	fry	1	2.5	FALSE
197912_ds_ef3	RB	adult	1	2.5	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.

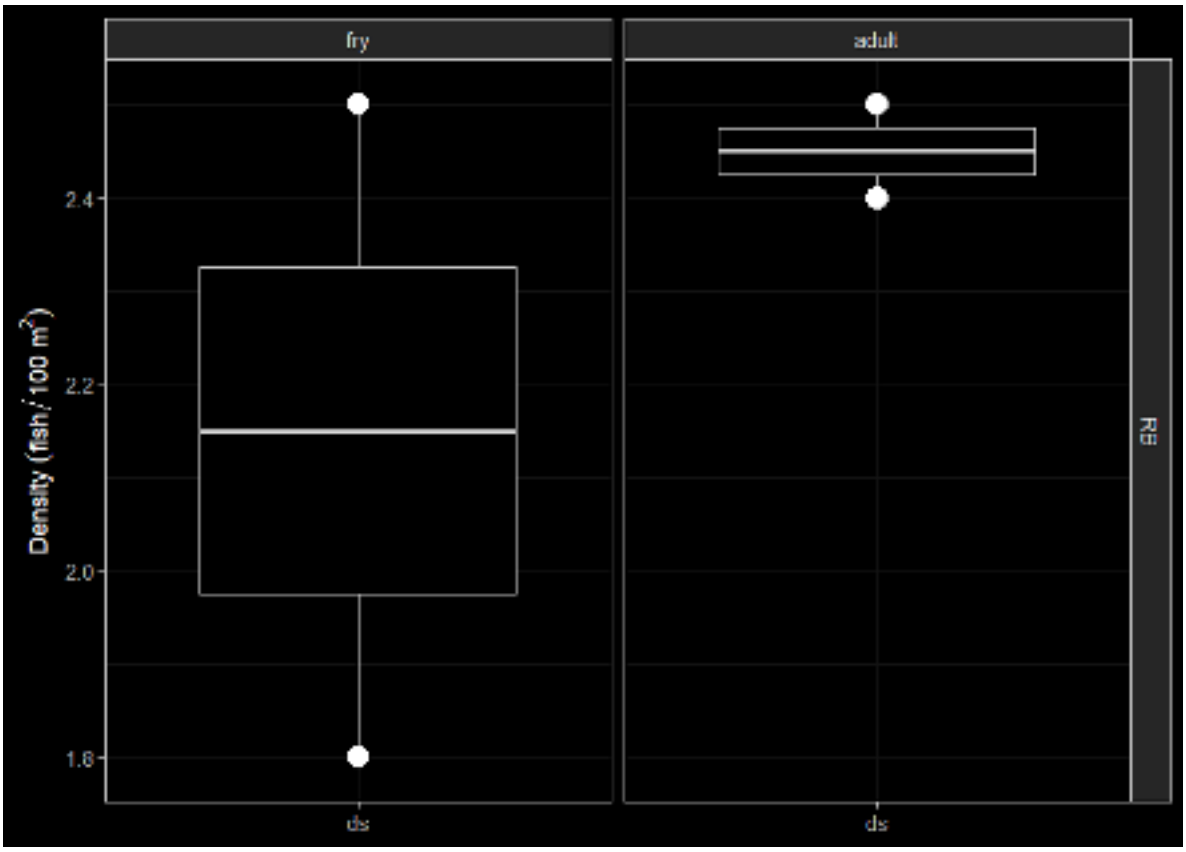


Figure 5.17: Densites of fish (fish/100m2) captured downstream of PSCIS crossing 197912.

Figure 5.18: Left: Typical habitat downstream of PSCIS crossing 197912. Right: Typical habitat downstream of PSCIS crossing 197912.

Figure 5.19: Left: Typical habitat upstream of PSCIS crossing 197912. Right: Typical habitat upstream of PSCIS crossing 197912.

Corya Creek - 197960 - Appendix

Site Location

PSCIS crossing 197960 is located on Corya Creek within the Coryatsaqua 2 (Moricetown) Indian Reserve at Moricetown, BC. PSCIS crossing 197960 is located on CN Railway. Crossing 197960 was located 2.7km upstream from the confluence with the Bulkley River. Crossing 197960 is the responsibility of the Canadian National Railway.

Background

At crossing 197960, Corya Creek is a fourth order stream with a watershed area upstream of the crossing of approximately 65.7km^2. The elevation of the watershed ranges from a maximum of 2502m to 410m near the crossing (Table 5.38). Upstream of crossing 197960, rainbow trout and dolly varden have previously been recorded (MoE 2020b; Norris 2020). PSCIS crossing 124612 is a bridge located 800m upstream at the powerline crossing and PSCIS crossing 123776 is a newly installed bridge downstream on Highway 16. Witset Creek drains Witset Lake and is a tributary to Corya Creek that flows in immediately downstream of the Highway 16 bridge. Witset Lake is 41ha in size with an associated 12ha of wetland. The upper Corya Creek watershed is glaciated and may provide habitat conditions most suitable for bull trout and cutthroat due to cold water and turbid conditions due to glacial flour. Although only rainbow trout and dolly varden have previously been recorded upstream of the railway, the historic culvert under Highway 16 and the current culvert under the railway may have hindered passage by other species including anadromous salmon.

In spring of 2017 a flood event caused by beaver dam failure forced the evacuation of homes in the Two Mile subdivision of Moricetown (Smithers Interior News 2017). Since this time beaver control activities have taken place in both the Corya and Witset watersheds to reduce the risk of flooding (pers comm. Dallas Nikal, Nico Ridge Consulting).

Table 5.38: Summary of derived upstream watershed statistics for PSCIS crossing 197960and PSCIS crossing 123775.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
123775	4.1	406	478	1248	762	697	E
197960	65.7	415	410	2502	1260	1106	ESE

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

Corya Creek was ranked as a high priority for follow up by Irvine (2018) and Mazany-Wright et al. (2021) because of significant amounts of habitat modelled as upstream of the crossing. A summary of habitat modelling outputs is presented in Table 5.39. In the field, PSCIS stream crossing 123775 was also assessed as Witset Lake is located upstream. A map of the watershed is provided in map attachment 093M.102.

Table 5.39: Summary of fish habitat modelling for PSCIS crossing 197960.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	27.0	24.4	90
ST Lake Reservoir (ha)	0.0	0.0	–
ST Wetland (ha)	0.0	0.0	–
ST Slopeclass03 Waterbodies (km)	1.4	0.0	0
ST Slopeclass03 (km)	4.7	3.8	81
ST Slopeclass05 (km)	6.8	6.6	97
ST Slopeclass08 (km)	7.6	6.6	87
ST Spawning (km)	6.1	6.1	100
ST Rearing (km)	14.1	13.9	99
CH Spawning (km)	6.1	6.1	100
CH Rearing (km)	10.0	9.8	98
CO Spawning (km)	9.1	9.1	100
CO Rearing (km)	10.0	9.8	98
CO Rearing (ha)	0.0	0.0	–
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	–	0.0	–
All Spawning (km)	9.1	9.1	100
All Rearing (km)	14.1	13.9	99
All Spawning Rearing (km)	14.1	13.9	99

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 197960 was un-embedded, non-backwatered and ranked as a barrier barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.40). Water temperature was 8°C, pH was 8.6 and conductivity was 138uS/cm.

At the time of the survey, PSCIS crossing 123775 was un-embedded, non-backwatered and ranked as a potential barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table **??**).

Table 5.40: Summary of fish passage assessment for PSCIS crossing 197960.

Location and Stream Data	•	Crossing Characteristics	–
Date	2021-09-13	Crossing Sub Type	Round Culvert
PSCIS ID	197960	Diameter (m)	3.4
External ID	–	Length (m)	24
Crew	AI KP	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	605785.6	Resemble Channel	No
Northing	6099884	Backwatered	No
Stream	Corya Creek	Percent Backwatered	–
Road	CN Railway	Fill Depth (m)	1.5
Road Tenure	Canadian National	Outlet Drop (m)	0.65
Channel Width (m)	18	Outlet Pool Depth (m)	3
Stream Slope (%)	2.8	Inlet Drop	No
Beaver Activity	Yes	Slope (%)	2.5
Habitat Value	High	Valley Fill	Deep Fill
Final score	34	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	23
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Location and Stream Data	•	Crossing Characteristics	–

Location and Stream Data	•	Crossing Characteristics	–
Date	2021-09-15	Crossing Sub Type	Round Culvert
PSCIS ID	123775	Diameter (m)	1.22
External ID	–	Length (m)	32
Crew	DN AN	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	606445.5	Resemble Channel	No
Northing	6099726	Backwatered	No
Stream	Witset Creek	Percent Backwatered	–
Road	Highway 16	Fill Depth (m)	0.3
Road Tenure	MoTi Arterial	Outlet Drop (m)	0
Channel Width (m)	0.5	Outlet Pool Depth (m)	0
Stream Slope (%)	1	Inlet Drop	No
Beaver Activity	No	Slope (%)	0.5
Habitat Value	Low	Valley Fill	Deep Fill
Final score	16	Barrier Result	Potential
Fix type	Replace Structure with Streambed Simulation CBS	Fix Span / Diameter	3
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Location and Stream Data	•	Crossing Characteristics	–

Stream Characteristics Downstream of 197960

The stream was surveyed downstream from crossing 197960 for 450m (Figure 5.21). 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 average channel width was 25.4m, the average wetted width was 8.9m and the average gradient was 1.7%. The

dominant substrate was cobbles with gravels subdominant. The stream was moderately turbid due to glacial flour with abundant quantities of gravels suitably sized for trout and salmon species present. The stream channel was noted as riffle dominated with a lack of complexity due to adjacent riparian clearing and dyke installation. The habitat was rated as medium value for salmonid rearing and spawning.

Stream Characteristics Upstream of 197960

The stream was surveyed upstream from crossing 197960 for 1000m (Figure 5.22). Total cover amount was rated as moderate with overhanging vegetation dominant. Cover was also present as small woody debris, large woody debris, boulders, and undercut banks. The average channel width was 18m, the average wetted width was 8.9m and the average gradient was 2.8%. The dominant substrate was cobbles with gravels subdominant. The first 50 - 100m upstream of crossing channel and banks were noted as armoured with riprap. Abundant gravels suitable for resident and anadromous salmonids were noted throughout. The habitat was rated as medium value as an important migration corridor containing suitable spawning habitat and having moderate rearing potential.

Fish Sampling

To assess potential impacts of the culvert on fisheries values in the stream, electrofishing was conducted with results summarised in Tables 5.43 - 5.44 and Figure 5.20.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 197960 with a bridge (23m span) is recommended. The cost of the work is estimated at $13,800,000 for a cost benefit of 0.7 linear m/$1000 and 13 m^2/$1000.

Conclusion

There was 10km of habitat upstream of crossing 197960 rated as medium value for salmonid rearing and spawning. Crossing 197960 was ranked as a high priority for proceeding to design for replacement. The stream is a cold water glaciated system and may currently provide habitat conditions most suitable for dolly varden and cutthrout trout.

Crossing 197960 was ranked as a low priority for remediation at the time of reporting due to low habitat value within the channel connecting Witset Lake to Corya Creek. Beaver control activities within the watershed to reduce the risk of flooding in the Moricetown likely impacts flow patterns (shorter freshet and flashier flows following precipitation) and the subsequent habitat quality in Witset Creek. A watershed level plan to hold more water on the landscape upstream of the highway and increase the capacity of PSCIS crossing 197960 to pass higher flow events could be considered in the long term to increase the overall health of the watershed and improve the potential for connectivity between Corya Creek and Witset Lake.

Table 5.42: Summary of habitat details for PSCIS crossing 197960 and 123775.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
123775	Downstream	100	0.5	–	–	1.0	abundant	low
123775	Upstream	200	2.4	0.9	–	1.2	moderate	low
197960	Downstream	450	25.4	10.8	0.5	1.7	moderate	medium
197960	Upstream	1000	18.0	8.9	0.7	2.8	moderate	medium

Table 5.43: Fish sampling site summary for 197960.

site	passes	ef_length_m	ef_width_m	area_m2	enclosure
197960_ds_ef1	1	9.6	1.28	12.3	Open
197960_ds_ef2	1	5.0	1.83	9.2	Open
197960_ds_ef3	1	10.1	1.67	16.9	Open
197960_us_ef1	1	4.7	1.65	7.8	Open
197960_us_ef2	1	19.0	1.86	35.3	Open
197960_us_ef3	1	3.3	3.27	10.8	Open

Table 5.44: Fish sampling density results summary for 197960.

local_name	species_code	life_stage	catch	density_100m2	nfc_pass
197960_ds_ef1	NFC	–	0	0.0	TRUE
197960_ds_ef2	DV	fry	2	21.7	FALSE
197960_ds_ef2	DV	parr	2	21.7	FALSE
197960_ds_ef3	DV	fry	6	35.5	FALSE
197960_ds_ef3	DV	parr	1	5.9	FALSE
197960_us_ef1	DV	parr	1	12.8	FALSE
197960_us_ef2	NFC	–	0	0.0	TRUE
197960_us_ef3	DV	parr	1	9.3	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.

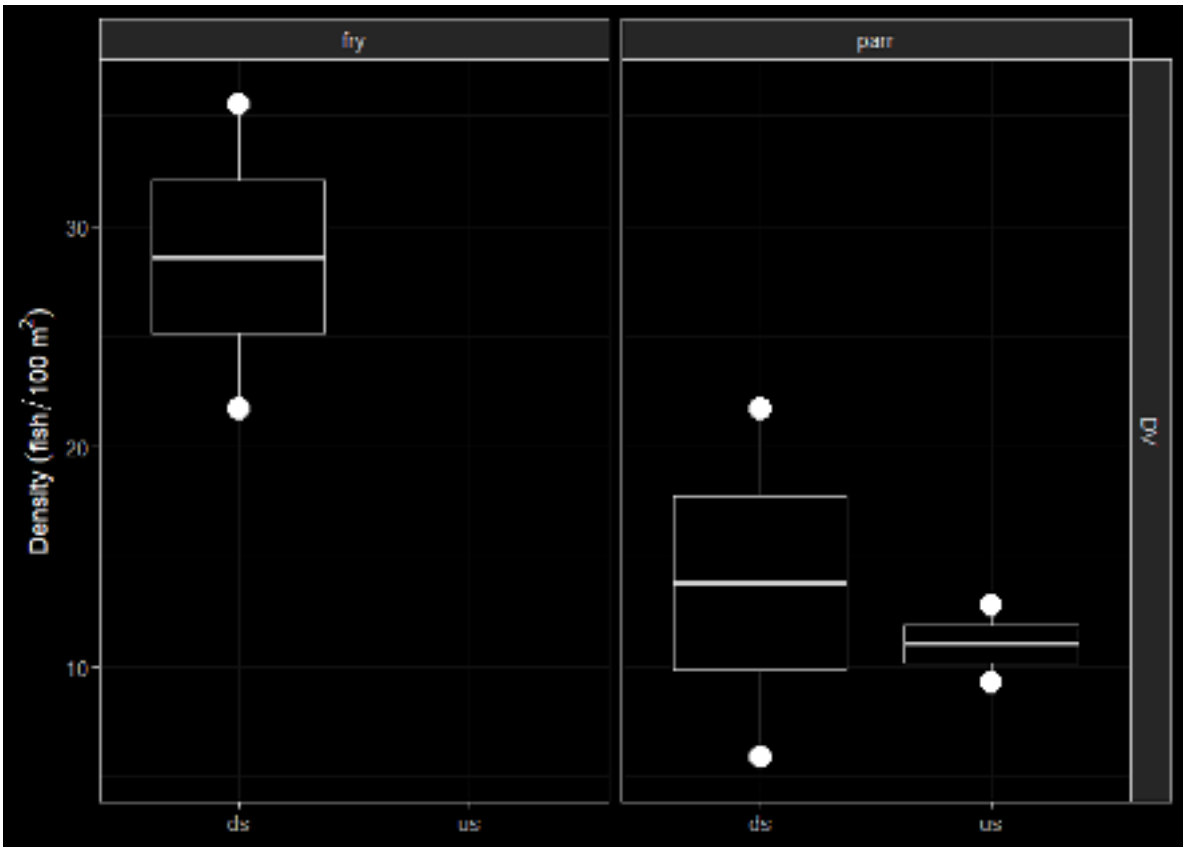


Figure 5.20: Densites of fish (fish/100m2) capture upstream and downstream of PSCIS crossing 197960.

Figure 5.21: Left: Typical habitat downstream of PSCIS crossing 197960. Right: Typical habitat downstream of PSCIS crossing 197960.

Figure 5.22: Left: Typical habitat upstream of PSCIS crossing 197960. Right: Typical habitat upstream of PSCIS crossing 197960.

Taman Creek - 197967 - Appendix

Site Location

PSCIS crossing 197967 is located on the Upper Bulkley River approximately 22.5km east of Topley, BC. PSCIS crossing 197967 is located on Highway 16, approximately 2.5km upstream from Bulkley Lake. Although Taman Creek flows into this stream approximately 750m upstream of the highway, the stream at the highway is commonly referred to as Taman Creek including on highway signage. The culvert is the responsibility of the Ministry of Transportation and Infrastructure.

Background

At crossing 197967, the Upper Bulkey River is a fifth order stream with a watershed area upstream of the crossing of approximately 93.8km^2. The elevation of the watershed ranges from a maximum of 1373m to 375m near the crossing (Table 5.45). Upstream of crossing 197967, longnose sucker, largescale sucker, lake chub, brassy minnow, northern pikeminnow, longnose dace, redside shiner, and rainbow trout have previously been recorded upstream (MoE 2020b; Norris 2020).

Table 5.45: Summary of derived upstream watershed statistics for PSCIS crossing 197967.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
197967	93.8	736	699	1373	900	870	S

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

although no records of the falls have yet been recorded in MoE (2020d), Redden and Jedrzejczyk (1997) report that a 15m high rock falls is located at 7.8km upstream from the confluence with the upper Bulkley River and represents the upstream limit of fish distribution in the watershed. They also report excellent and good rearing potential in upper reaches of the stream located from 5.1km to 7.8km upstream of the confluence.

McCarthy and Fernando (2015) report that the culvert has received past efforts to facilitate backwatering including rock lines to establish backwater pools downstream of the culvert. They also report that the works were not functioning correctly. Smith (2018) visited the site in 2017, subjectively rated the crossing as a potential barrier and ranked the crossing as a low priority for follow up. Irvine (2021) noted that a design was being drafted for the Highway 16 crossing by Ministry of Transportation and Infrastructure in 2021.

PSCIS stream crossing 197967 was ranked as a high priority for follow up by Mazany-Wright et al. (2021) because of significant amounts of habitat modelled as upstream of the crossing and because gathering of habitat confirmation information was considered as potentially beneficial for informing prioritization of the site should remediation plans stall. A total of 172ha of lake and 695ha of wetland is modelled upstream and a summary of habitat modelling outputs is presented in Table 5.46. A map of the watershed is provided in map attachment 093L.115.

Table 5.46: Summary of fish habitat modelling for PSCIS crossing 197967.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	142.4	20.0	14
ST Lake Reservoir (ha)	172.4	98.7	57
ST Wetland (ha)	631.7	208.8	33
ST Slopeclass03 Waterbodies (km)	34.5	0.0	0
ST Slopeclass03 (km)	30.7	7.2	23
ST Slopeclass05 (km)	36.9	2.1	6
ST Slopeclass08 (km)	26.2	0.0	0
ST Spawning (km)	7.2	6.0	83
ST Rearing (km)	35.8	7.9	22
CH Spawning (km)	7.2	6.0	83
CH Rearing (km)	10.9	6.0	55
CO Spawning (km)	22.2	7.4	33
CO Rearing (km)	51.9	14.6	28
CO Rearing (ha)	285.7	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)	22.2	7.4	33
All Rearing (km)	58.0	14.6	25
All Spawning Rearing (km)	58.0	14.6	25

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 197967 was non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.47). Water temperature was 12°C, pH was 7.2 and conductivity was 359uS/cm. A beaver dam was noted just upstream of the culvert inlet (~1.5m high).

Table 5.47: Summary of fish passage assessment for PSCIS crossing 197967.

Location and Stream Data	•	Crossing Characteristics	–
Date	2021-08-31	Crossing Sub Type	Round Culvert
PSCIS ID	197967	Diameter (m)	3
External ID	–	Length (m)	30
Crew	KP AI	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	692434.6	Resemble Channel	No
Northing	6032331	Backwatered	No
Stream	Taman Creek	Percent Backwatered	–
Road	Highway 16	Fill Depth (m)	9.99
Road Tenure	Highway	Outlet Drop (m)	0
Channel Width (m)	5.3	Outlet Pool Depth (m)	0.4
Stream Slope (%)	1.7	Inlet Drop	Yes
Beaver Activity	Yes	Slope (%)	2.5
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	27	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	31
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Location and Stream Data	•	Crossing Characteristics	–

Stream Characteristics Downstream

The stream was surveyed downstream from crossing 197967 for NAm to the bridge (PSCIS 197966) located on Ross Lake Cutoff Rd (Figure 5.23). The dominant substrate was cobbles with fines sub-dominant., Total cover amount was rated as trace with overhanging vegetation dominant. Cover was also present as deep pools and instream vegetation., The average channel width was

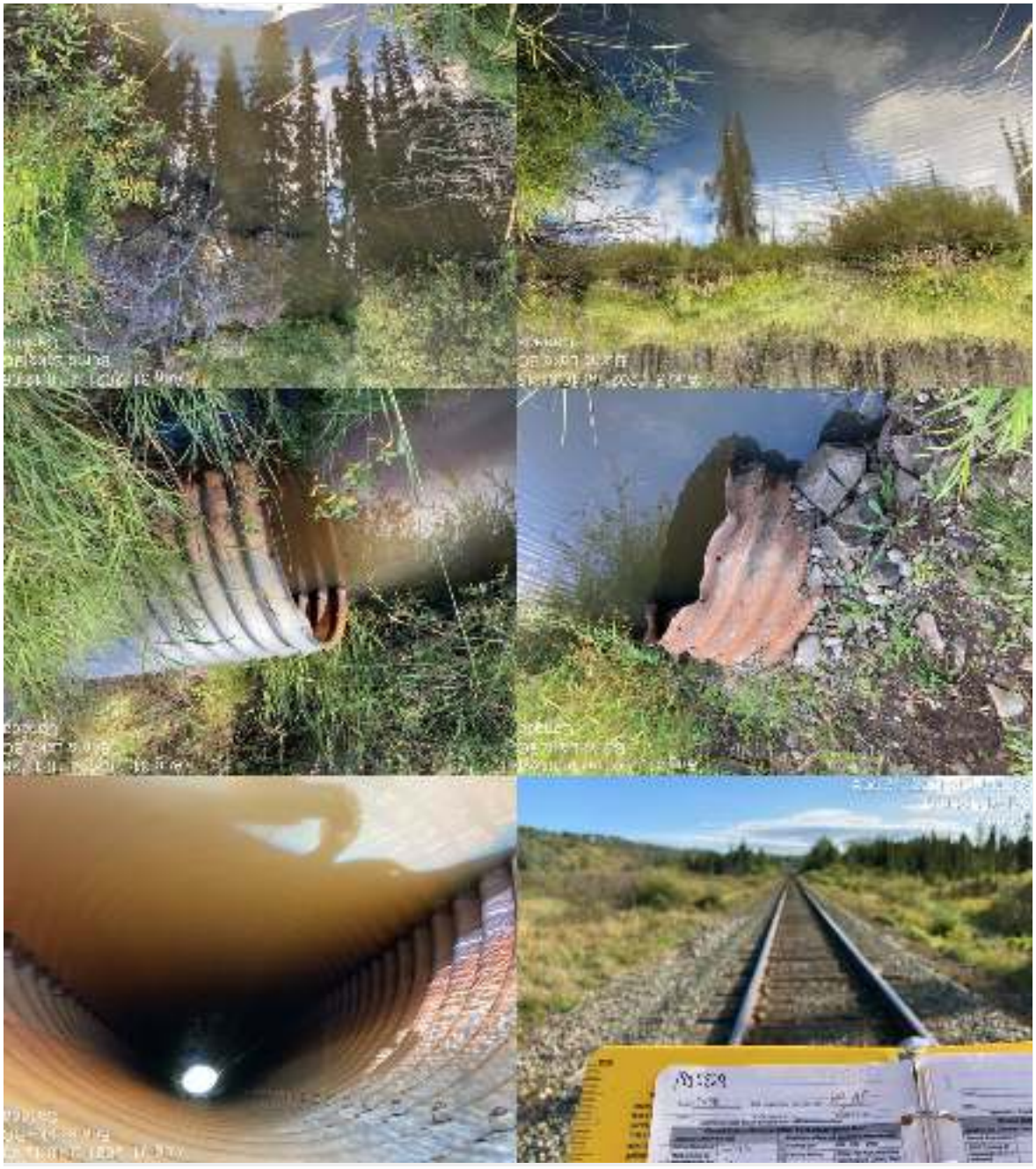
5.7m, the average wetted width was 3.1m, and the average gradient was 2.5%. The site was noted as having significant amounts of thick red colored algae for the majority of survey. Flow was very low with uncommon pools. Fence material was noted in or across channel in two locations and and riparian vegetation had been removed where an agricultural field and fence line were close. Although considered an important migration corridor, the habitat was rated as medium value for salmonid rearing and spawning due to limited complexity resulting from adjacent agricultural activities.

PSCIS crossing 197964 is located on the CN Railway approximately 1.7km downstream of the highway. Although the crossing was assessed as a potential barrier according to the provincial protocol it was 100% backwatered at the time of the assessment and appeared passable to all species and life stages at the time of assessment (Table 5.48).

Table 5.48: Summary of fish passage assessment for PSCIS crossing 1805529.

Location and Stream Data	•	**Crossing Characteristics**	–
Date	2021-08-31	Crossing Sub Type	Round Culvert
PSCIS ID	–	Diameter (m)	1.5
External ID	1805529	Length (m)	21
Crew	KP AI	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	691218.3	Resemble Channel	No
Northing	6031478	Backwatered	Yes
Stream	Bulkley River	Percent Backwatered	100
Road	Railway	Fill Depth (m)	3
Road Tenure	Canadian National	Outlet Drop (m)	0
Channel Width (m)	9	Outlet Pool Depth (m)	0.8
Stream Slope (%)	0	Inlet Drop	No
Beaver Activity	No	Slope (%)	0.7
Habitat Value	High	Valley Fill	Deep Fill
Final score	19	Barrier Result	Potential
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	14
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Location and Stream Data	•	Crossing Characteristics	–



Stream Characteristics Upstream

The stream was surveyed upstream from crossing 197967 for NAm (Figure 5.24). The dominant substrate was gravels with cobbles sub-dominant., Total cover amount was rated as moderate with deep pools dominant. Cover was also present as large woody debris and overhanging vegetation., The average channel width was 5.3m, the average wetted width was 2.3m, and the average

gradient was 2.5%. The first ~250m of channel upstream of the highway were noted as beaver influenced wetland with extensive dry sections at the time of the survey. Frequent pockets of gravels and small cobbles suitable for rainbow trout and coho salmon spawning were noted throughout the area surveyed. A canyon section of stream was located upstream of the crossing approximately 300m contained deep bedrock pools with small fish present and no large woody debris. One deep pool upstream of the canyon section contained likely 2-3 year old juveniles (coloring indicated rainbow trout, unverified). The habitat was rated as medium value as an important migration corridor containing suitable spawning habitat and having moderate rearing potential.

Taman Creek was surveyed for 375m above where it joins the Bulkley River mainstem upstream of PSCIS crossing 197967 (Figure 5.25). The average channel width was 3.8m, the average wetted width was 2.2m, and the average gradient was 2.5%., The dominant substrate was gravels with cobbles sub-dominant., Total cover amount was rated as moderate with deep pools dominant. Cover was also present as small woody debris, large woody debris, undercut banks, and overhanging vegetation. The water in Taman Creek during the survey was noted as turbid with numerous samlonid fry present at the downstream end of the site. Algae was abundant throughout the system and eroding banks were common. Abundant gravels suitable for resident rainbow trout and coho salmon spawning were present and habitat was rated as NA value for salmon rearing and spawning.

The upper Bulkley River was surveyed at numerous crossings upstream of the highway with bridges noted at PSCIS crossings 197968, 197969, 197973 and 197971. Survey crews were not able to access crossing 1802047 from Highway 16 due to a gate and private land postings. This crossing is located between Broman Lake and Old Woman Lake with public access potentially possible by ATV from the powerline to the north. Modelled crossing 1802663 is located on the mainstem of Taman Creek 1.8km upstream of the confluence with the upper Bulkley River. Although this site was not assessed it was considered likely to be a ford due to its location on the powerline. Numerous other unassessed crossings are modelled as located upstream within the system on Taman Creek as well as the upper Bulkley River and their tributaries. As the effort required to assess all these crossings was likely significant with the majority of higher value gains most likely present in the lower reaches, field time was allocated elsewhere in the greater Bulkley River watershed.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 197967 with a bridge (31m span) is recommended. The cost of the work is estimated at $18,600,000 for a cost benefit of 2.8 linear m/$1000 and 14.8 m^2/$1000.

Conclusion

There was 51.9km of habitat modelled upstream of crossing 197967 rated as medium value for salmonid rearing and spawning. Crossing 197967 was ranked as a moderate priority for proceeding

to design for replacement. At the time of reporting, the Ministry of transportation and Infrastructure were in the process of planning for crossing replacement. Of note, due to budgetary constraints, survey plans for the site call for horizontal drilling of a closed bottom structure under the highway with costs likley lower than those estimated for replacement with a clear span bridge. Should structure replacement proceed follow up monitoring is recomended to assess passability and utilization of the crossing by downstream fish populations including coho who have been recorded in the upper Bulkley River within 100m downstream of crossing 197967.

Table 5.49: Summary of habitat details for PSCIS crossing 197967.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
197967	Downstream	–	5.7	3.1	0.5	2.5	trace	medium
197967	Upstream	–	5.3	2.3	0.7	1.7	moderate	medium
197967	Upstream2	375	3.8	2.2	0.5	1.5	moderate	–

Figure 5.23: Left: Habitat downstream of PSCIS crossing 197967. Right: Habitat downstream of PSCIS crossing 197967.

Figure 5.24: Left: Habitat upstream of PSCIS crossing 197967. Right: Habitat upstream of PSCIS crossing 197967.

Figure 5.25: Left: Habitat upstream of PSCIS crossing 197967. Right: Habitat upstream of PSCIS crossing 197967.

Ailport Creek - 197976 & 197975 - Appendix

Site Location

PSCIS crossing 197976 and 197975 are located on Ailport Creek approximately 7km south-west of Topley, BC. PSCIS crossing 197976 is located on Highway 16 and 197975 is located on a private driveway. Crossing 197976 was located 4.2km upstream from the confluence with the Bulkley River and crossing 197975 was located 393m upstream fo Highway 16. Crossing 197976 is the responsibility of the Ministry of Transportation and Infrastructure and crossing 197976 is the responsibility of the private land owner.

Background

At crossing 197976, Ailport Creek is a fifth order stream with a watershed area upstream of the crossing of approximately 66.9km^2. The elevation of the watershed ranges from a maximum of 1445m to 375m near the crossing (Table 5.50).

Upstream of crossing 197976, cutthroat trout, coho salmon, and rainbow trout have previously been recorded (MoE 2020b; Norris 2020). A. Gottesfeld and Rabnett (2007) report that upper Bulkley coho and steelhead spawn and rear in Ailport Creek. An adjacent landowner noted that in the past, during a high flow event, an adult steelhead was stranded in a pond at the side of the field adjacent to the stream upstream of crossing 197975. Another adjacent landowner reports that historic high flow events in the watershed were likely related to beaver dam failures in the upper reaches of the stream network.

DFO (1998), (as cited in McCarthy and Fernando (2015)) reported that crossing 197976 was a barrier at low flows. Following site visits in 2007 and 2017, Wilson and Rabnett (2007) and Smith (2018) reported that the culvert was not an issue for passage. There were no records found of crossing 197975 being assessed for fish passage in the past.

Government of British Columbia (2022) records indicate that downstream of 197976 a range tenure is held by 102039220 Saskatchewan Ltd. and that tenure for the first 210m of stream immediately upstream of the highway is registered to Danny Staudt. Additionally, there are multiple other range tenures overlapping Ailport Creek and tributaries further up in the watershed.

There are numerous modelled stream crossing locations upstream of 197975 however all crossings on the mainstem appear to be bridges in aerial imagery.

PSCIS stream crossings on Ailport Creek were ranked as high priorities for follow up by Irvine (2021) and Mazany-Wright et al. (2021) because of significant amounts of habitat modelled as upstream of the crossing. A total of 42ha of lake and 374ha of wetland is modelled upstream with a summary of additional habitat modelling outputs presented in Tables 5.51 - 5.52. A map of the watershed is provided in map attachment 093L.115.

Table 5.50: Summary of derived upstream watershed statistics for PSCIS crossing 197976.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
197976	66.9	729	736	1445	1186	1093	SSW

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

Table 5.51: Summary of fish habitat modelling for PSCIS crossing 197976.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	53.1	0.4	1
ST Lake Reservoir (ha)	29.8	0.0	0
ST Wetland (ha)	211.0	0.0	0
ST Slopeclass03 Waterbodies (km)	10.7	0.0	0
ST Slopeclass03 (km)	17.6	0.4	2
ST Slopeclass05 (km)	9.8	0.0	0
ST Slopeclass08 (km)	7.6	0.0	0
ST Spawning (km)	9.9	0.4	4
ST Rearing (km)	19.8	0.4	2
CH Spawning (km)	9.9	0.4	4
CH Rearing (km)	11.9	0.4	3
CO Spawning (km)	13.5	0.4	3
CO Rearing (km)	25.1	0.4	2
CO Rearing (ha)	96.1	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)	13.5	0.4	3
All Rearing (km)	28.2	0.4	1
All Spawning Rearing (km)	28.2	0.4	1

* Model data is preliminary and subject to adjustments.

Table 5.52: Summary of fish habitat modelling for PSCIS crossing 197976.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	52.8	38.4	73
ST Lake Reservoir (ha)	29.8	28.9	97
ST Wetland (ha)	211.0	149.7	71
ST Slopeclass03 Waterbodies (km)	10.7	0.0	0
ST Slopeclass03 (km)	17.2	14.5	84
ST Slopeclass05 (km)	9.8	5.6	57
ST Slopeclass08 (km)	7.6	6.6	87
ST Spawning (km)	9.6	9.3	97
ST Rearing (km)	19.4	16.7	86
CH Spawning (km)	9.6	9.3	97
CH Rearing (km)	11.5	10.8	94
CO Spawning (km)	13.1	11.4	87
CO Rearing (km)	24.7	21.8	88
CO Rearing (ha)	96.1	0.0	0
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	–	0.0	–

Habitat	Potential	Remediation Gain	Remediation Gain (%)
All Spawning (km)	13.1	11.4	87
All Rearing (km)	27.8	24.5	88
All Spawning Rearing (km)	27.8	24.5	88

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 197976 was 50% backwatered, un-embedded and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.53). A juvenile fish (~140 cm) was noted as easily swimming upstream through the culvert during the survey. PSCIS crossing 197976 was not backwatered, not embedded and ranked as a barrier to upstream fish passage according to the provincial protocol (Table 5.54). Water temperature was 11° C, pH was 7 and conductivity was 248uS/cm.

Table 5.53: Summary of fish passage assessment for PSCIS crossing 197976.

Location and Stream Data	•	Crossing Characteristics	–
Date	2021-08-31	Crossing Sub Type	Oval Culvert
PSCIS ID	197976	Diameter (m)	3.5
External ID	–	Length (m)	23
Crew	KP	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	680644.8	Resemble Channel	No
Northing	6039756	Backwatered	Yes
Stream	Ailport Creek	Percent Backwatered	50
Road	Highway 16	Fill Depth (m)	3
Road Tenure	Highway	Outlet Drop (m)	–
Channel Width (m)	7.5	Outlet Pool Depth (m)	0.55
Stream Slope (%)	4	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	12.5
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Location and Stream Data	•	Crossing Characteristics	–

Location and Stream Data	•	Crossing Characteristics	–
Date	2021-08-31	Crossing Sub Type	Round Culvert
PSCIS ID	197975	Diameter (m)	3
External ID	–	Length (m)	10
Crew	KP	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	680832	Resemble Channel	No
Northing	6040045	Backwatered	No
Stream	Ailport Creek	Percent Backwatered	–
Road	Private Driveway	Fill Depth (m)	0.5
Road Tenure	Unclassified	Outlet Drop (m)	0.3
Channel Width (m)	6.5	Outlet Pool Depth (m)	1.45
Stream Slope (%)	3	Inlet Drop	No
Beaver Activity	No	Slope (%)	4
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	36	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	11.5
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Location and Stream Data	•	Crossing Characteristics	–

Stream Characteristics Downstream of 197976

The stream was surveyed downstream from crossing 197976 for 575m (Figure 5.27). The dominant substrate was cobbles with gravels sub-dominant., Total cover amount was rated as moderate with deep pools dominant. Cover was also present as small woody debris, undercut banks, overhanging vegetation, and instream vegetation., The average channel width was 7.7m, the average wetted

width was 3.4m, and the average gradient was 1%. Although side channels continued to flow throughout the area surveyed, approximately 160m downstream of the crossing the main channel was dewatered below the location of a beaver dam. Areas of riparian and bank degradation from cattle trampling were noted throughout the area surveyed and there was fencing spanning the channel. Large deposits of substrate and clumped large woody debris piles were observed within widened channel areas indicating disturbance and high flow events. There were abundant gravels presetn suitable for spawning resident and anadromous salmonids. Habitat was rated as high value for salmonid rearing and spawning with numerous fish observed and numerous deep pools to 0.95m deep.

Stream Characteristics Upstream of 197976 and downstream of 197975

The stream was surveyed upstream from crossing 197976 for 345m (Figure 5.28). Total cover amount was rated as moderate with deep pools dominant. Cover was also present as small woody debris, undercut banks, and overhanging vegetation., The dominant substrate was cobbles with gravels sub-dominant., The average channel width was 8.1m, the average wetted width was 4.2m, and the average gradient was 1%. Fish were observed throughout the area surveyed and extensive algae growth was present on stream substrates. Large woody debris was rare and riparian/bank damage due to livestock was minimal and located at what appeared to be watering sites. Fencing was located across the stream in multiple locations. Patches of gravels suitable for spawning were present. Habitat value was rated as medium as the surveyed area was considered an important migration corridor containing suitable spawning habitat and having moderate rearing potential.

5.5 Stream Characteristics Upstream of 197975

The stream was surveyed upstream from crossing 197975 for 550m (Figure 5.29). The average channel width was 7.7m, the average wetted width was 3.5m, and the average gradient was 1%., Total cover amount was rated as moderate with deep pools dominant. Cover was also present as small woody debris, boulders, undercut banks, and overhanging vegetation., The dominant substrate was cobbles with gravels sub-dominant. Immediately upstream of the crossing for ~80m, extensive anthropogenic damage was noted due to dredging of the channel. Heavy cattle grazing was also observed on the left bank. Juvenile salmonids were observed occasionally throughout the area surveyed. Fencing was located across the stream approximately 250m upstream of the culvert. Patches of gravels suitable for spawning were present. Habitat value was rated as medium as the surveyed area was considered an important migration corridor containing suitable spawning habitat and having moderate rearing potential.

Fish Sampling

Electrofishing was conducted with results summarised in Tables 5.56 - 5.57 and Figure 5.26.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 197976 with a bridge (12.5m span) is recommended. The cost of the work is estimated at $7,500,000 for a cost benefit of 3.3 linear m/$1000 and 27.1 m^2/$1000. As the crossing partially backwaters naturally, a plan to backwater the crossing could also be of consideration in the short term with a rough cost estimate to complete of $25,000.

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 197975 with a bridge (11.5m span) is recommended. The cost of the work is estimated at $230,000 for a cost benefit of 107.3 linear m/$1000 and 826.6 m^2/$1000. Relocation of the driveway accessing the private land from the other side of the stream and removal of the crossing could also be considered.

Conclusion

There was 24.7km of habitat modelled upstream of crossing 197975 rated as medium value for salmonid rearing and spawning. Crossing 197976 was ranked as a moderate priority for proceeding to design for replacement as it appears to pass fish during most flows. Crossing 197975 was ranked as a moderate priority for proceeding to design for replacement as it appears to likely present a more serious impediment to upstream passage and because implementation of the works can be considered cost effective and logistically less complicated than works on a major highway. As Ailport Creek appears to be a high value fish stream with significant impacts due to culvert maintenance (dredging), adjacent land use (cattle trampled banks and grazed/removed riparian vegetation) and high flow events (potentially beaver dam failure related), it is recommended that a plan be developed to work with adjacent landowners and tenure holders to exclude cattle from the riparian area, implement stream restoration actions and explore possibilities related to progressive beaver management in the watershed.

Table 5.55: Summary of habitat details for PSCIS crossing 197976.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
197975	Upstream	550	7.7	3.5	0.3	3.0	moderate	medium
197976	Downstream	575	7.7	3.4	0.5	1.0	moderate	high
197976	Upstream	345	8.1	4.2	0.3	2.2	moderate	medium

Table 5.56: Fish sampling site summary for 197975.

site	passes	ef_length_m	ef_width_m	area_m2	enclosure
197975_ds_ef1	1	3.8	4.27	16.2	Open
197975_ds_ef2	1	3.9	3.60	14.0	Open
197975_us_ef1	1	6.0	3.30	19.8	Open
197975_us_ef2	1	3.0	2.97	8.9	Open

Table 5.57: Fish sampling density results summary for 197975.

local_name	species_code	life_stage	catch	density_100m2	nfc_pass
197975_ds_ef1	RB	fry	2	12.3	FALSE
197975_ds_ef1	RB	parr	1	6.2	FALSE
197975_ds_ef2	CO	fry	1	7.1	FALSE
197975_ds_ef2	CO	parr	4	28.6	FALSE
197975_ds_ef2	RB	fry	1	7.1	FALSE
197975_ds_ef2	RB	parr	10	71.4	FALSE
197975_ds_ef2	RB	juvenile	2	14.3	FALSE
197975_ds_ef2	RB	adult	1	7.1	FALSE
197975_us_ef1	CO	parr	2	10.1	FALSE
197975_us_ef1	RB	fry	2	10.1	FALSE
197975_us_ef1	RB	parr	14	70.7	FALSE
197975_us_ef1	RB	juvenile	5	25.3	FALSE
197975_us_ef1	RB	adult	5	25.3	FALSE
197975_us_ef2	RB	fry	5	56.2	FALSE
197975_us_ef2	RB	parr	7	78.7	FALSE
197975_us_ef2	RB	adult	2	22.5	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.

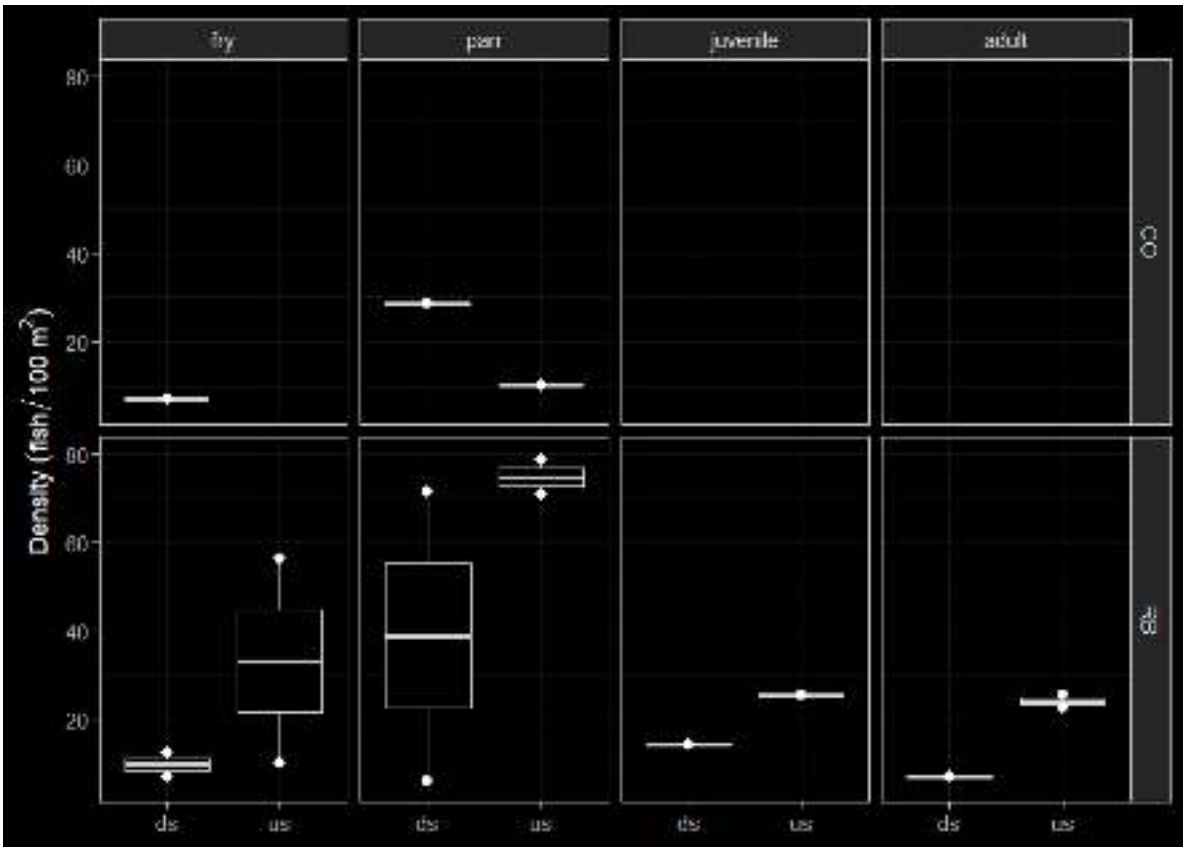


Figure 5.26: Densites of fish (fish/100m2) capture upstream and downstream of PSCIS crossing 197975.

Figure 5.27: Left: Typical habitat downstream of PSCIS crossing 197976. Right: Typical habitat downstream of PSCIS crossing 197976.

Figure 5.28: Left: Typical habitat upstream of PSCIS crossing 197976. Right: Typical habitat upstream of PSCIS crossing 197976.

Figure 5.29: Left: Typical habitat upstream of PSCIS crossing 197975. Right: Typical habitat upstream of PSCIS crossing 197975.

Cesford Creek - 198048 & 198049 - Appendix

Site Location

PSCIS crossing 198048 and 198049 are located on Cesford Creek near Topley, BC. PSCIS crossing 198048 is located on Highway 16 and 198049 is located on Highway 118. Crossing 198048 was located 0.6km upstream from the confluence with the Bulkley River and 198049 was located 1.3km upstream of the confluence. Crossings 198048 and 198049 are the responsibility of the Ministry of Transportation and Infrastructure. PSCIS crossing 198090 makes reference to a potential crossing location under the CN Railway. The survey team was not able to locate a crossing in the field which coincides with personal communications with the adjacent landowner (Figure 5.30).

Background

At crossing 198048, Cesford Creek is a fourth order stream with a watershed area upstream of the crossing of approximately 36.6km^2. The elevation of the watershed ranges from a maximum of 1543m to 659m near the crossing (Table 5.58). Upstream of crossing 198048, have previously been recorded (MoE 2020b; Norris 2020).

Figure 5.30: Location of potential location of crossing 198090 which was not present in the field.

Table 5.58: Summary of derived upstream watershed statistics for PSCIS crossing 198048.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
198048	36.6	679	659	1543	935	914	SSW

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

PSCIS stream crossing 198048 was ranked as a priority for follow up by Irvine (2021) because of the relatively large size of the stream and the potential for large amounts of habitat gains through fish passage remediation (Table 5.59. Although Wilson and Rabnett (2007) recommended establishing a downstream weir and excavating adequate outfall drop pools to facilitate fish passage at crossing 198048, they ranked the site as a moderate priority for remediation due to dewatering below Highway 16. Smith (2018) assessed teh site in 2017 and noted that a comparison of photos taken in 2006 and 2017 indicates that a significant amount of gravel has been deposited in the channel below the culvert outlets. A map of the watershed is provided in map attachment 093L.115.

Table 5.59: Summary of fish habitat modelling for PSCIS crossing 198048.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	54.4	1.0	2
ST Lake Reservoir (ha)	26.4	0.0	0
ST Wetland (ha)	24.0	0.0	0
ST Slopeclass03 Waterbodies (km)	3.4	0.0	0
ST Slopeclass03 (km)	4.9	0.7	14
ST Slopeclass05 (km)	20.8	0.0	0
ST Slopeclass08 (km)	14.0	0.3	2
ST Spawning (km)	1.8	0.7	39
ST Rearing (km)	15.9	1.0	6
CH Spawning (km)	1.7	0.7	41
CH Rearing (km)	4.5	0.7	16
CO Spawning (km)	6.1	0.7	11
CO Rearing (km)	10.7	0.7	7
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)	6.2	0.7	11
All Rearing (km)	15.9	1.0	6
All Spawning Rearing (km)	15.9	1.0	6

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 198048 was un-embedded, non-backwatered and ranked as a barrier barrier to upstream fish passage according to the provincial protocol (MoE 2011b)(Table 5.60). Water temperature was 11°C, pH was 8.2 and conductivity was 263uS/cm.

Table 5.60: Summary of fish passage assessment for PSCIS crossing 198048.

Location and Stream Data	•	Crossing Characteristics	–
Date	2021-09-05	Crossing Sub Type	Round Culvert
PSCIS ID	198048	Diameter (m)	2.5
External ID	–	Length (m)	25
Crew	AI	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	674397.1	Resemble Channel	No
Northing	6043433	Backwatered	Yes

Location and Stream Data	•	Crossing Characteristics	–
Stream	Cesford Creek	Percent Backwatered	30
Road	Highway 16	Fill Depth (m)	1
Road Tenure	MoTi Arterial	Outlet Drop (m)	0
Channel Width (m)	5.48	Outlet Pool Depth (m)	0.09
Stream Slope (%)	3.5	Inlet Drop	Yes
Beaver Activity	No	Slope (%)	1.5
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
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Location and Stream Data	•	Crossing Characteristics	–

Location and Stream Data	•	Crossing Characteristics	–
Date	2021-09-05	Crossing Sub Type	Round Culvert
PSCIS ID	198049	Diameter (m)	3.7
External ID	–	Length (m)	21
Crew	AI	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	674875.4	Resemble Channel	No
Northing	6043782	Backwatered	No
Stream	Cesford Creek	Percent Backwatered	–
Road	Highway 118	Fill Depth (m)	1
Road Tenure	MoTi Arterial	Outlet Drop (m)	0.5
Channel Width (m)	4.9	Outlet Pool Depth (m)	0.25
Stream Slope (%)	2.83	Inlet Drop	No
Beaver Activity	No	Slope (%)	1.5
Habitat Value	High	Valley Fill	Deep Fill
Final score	34	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	10
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Location and Stream Data	•	Crossing Characteristics	–

Location and Stream Data	•	Crossing Characteristics	–
Date	2021-09-05	Crossing Sub Type	Round Culvert
PSCIS ID	198090	Diameter (m)	0.1
External ID	–	Length (m)	15
Crew	KP	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	673235	Resemble Channel	No
Northing	6043218	Backwatered	No
Stream	Cesford Creek	Percent Backwatered	–
Road	CN Railway	Fill Depth (m)	2
Road Tenure	Canadian National	Outlet Drop (m)	0
Channel Width (m)	5	Outlet Pool Depth (m)	0
Stream Slope (%)	1	Inlet Drop	No
Beaver Activity	No	Slope (%)	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	10
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Location and Stream Data	•	Crossing Characteristics	–

NO IMAGE AVAILABLE

NO IMAGE AVAILABLE

NO IMAGE AVAILABLE

Stream Characteristics Downstream

The stream was surveyed downstream from the culvert for NAm (Figure 5.31). Total cover amount was rated as with overhanging vegetation dominant. Cover was also present as small woody debris and undercut banks (Table 5.63). The average channel width was 5.5m, the average wetted width

was 1.5m and the average gradient was 3.5%. The dominant substrate was cobbles with gravels subdominant. The habitat was rated as medium value for salmonid rearing and spawning.

Stream Characteristics Upstream of 198048 and downstream of 198049

The stream was surveyed immediately upstream from 198048 for approximately NAm (Figure 5.32). Within the area surveyed, total cover amount was rated as with deep pools dominant. Cover was also present as small woody debris, large woody debris, and overhanging vegetation (Table 5.63). The average channel width was 5.1m, the average wetted width was 3.3m and the average gradient was 2.8%. The dominant substrate was cobbles with gravels subdominant. Habitat value was rated as medium value for resident salmonid rearing and spawning.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed at the site, replacement of PSCIS crossing 198048 with a bridge (10m span) is recommended.

Conclusion

There was 198048 is 10.7km of habitat upstream of crossing rated as medium value for salmonid rearing and spawning. Crossing 198048 was ranked as a moderate priority for proceeding to design for replacement.

Table 5.63: Summary of habitat details for PSCIS crossing 198048 and 198049.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
198048	Downstream	–	5.5	1.5	0.3	3.5	moderate	medium
198048	Upstream	–	5.1	3.3	0.3	2.8	moderate	medium
198049	Upstream	600	5.0	2.8	0.5	2.1	moderate	medium
198049	Upstream2	–	4.3	1.9	0.5	4.2	moderate	medium

Figure 5.31: Left: Typical habitat downstream of PSCIS crossing 198048. Right: Typical habitat downstream of PSCIS crossing 198048.

Figure 5.32: Left: Typical habitat upstream of PSCIS crossing 198048. Right: Typical habitat upstream of PSCIS crossing 198048.

Thompson Creek - 198066 & 123377 - Appendix

Site Location

PSCIS crossing 198066 and 123377 are located on Thompson Creek midway between Telkwa and Houston. PSCIS crossing 198066 is located on a small private road and 123377 is located on Walcott Road. Crossing 198066 was located 0.1km upstream from the confluence with a side channel of the Bulkley River and 123377 was located 2.4km upstream of the confluence. Crossing 198066 was on private land owned by Jeremy Rouw and hay fields as well as other infrastructure that was part of Udder View Dairy were located upstream of the crossing. Crossing 123377 is the responsibility of the Ministry of Transportation and Infrastructure.

Background

At crossing 198066, Thompson Creek is a fourth order stream with a watershed area upstream of the crossing of approximately 43.1km^2. The elevation of the watershed ranges from a maximum of 1623m to 596m near the crossing (Table 5.64). Upstream of crossing 198066, cutthroat trout, coastal cutthroat trout, coho salmon, rainbow trout, and dolly varden have previously been recorded (MoE 2020b; Norris 2020).

Landowners adjacent to the stream at both crossings as well as regional DFO staff report that Thompson Creek was historically redirected from its original channel on the height of land near the Bulkley River in the 1960s. The historic channel is visible in aerial imagery and would have directed flows in a north-eastern direction from where the agricultural fields meet the Thompson creek valley. The redirection diverts the channel into two seperate channels that flow south-east. The main flow of the channel was flowing in an excavated trench through the hay field at the time of the survey. The distance from the current confluence with the Bulkley River side channel to the historic valley is approximately 370m. The distance the stream would have traveled historically in a north-eastern direction is estimated at 1300m. The landowner reported that conceptually they would like to see the stream redirected to its historic channel. They noted that stranding has been observed within the excavated channel and a realignment would help prevent the loss of hay production caused by the high water table adjacent to the excavated channel. A map of the current man made channels and the historic channel is provided in Figure **??**. Adjacent landowners also report that the crossing at Walcott Road had nearly washed out at the road due to high flows related to beaver dam failures. Crossing 123378 is a bridge on Thompson Creek on the BC Hydro powerline between 198066 and 123377. Landowners report this bridge washed out at the time of the beaver dam failure and was replaced in 2020.

upstream watershed statistics for PSCIS crossing 198066.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
198066	43.1	548	596	1623	832	802	WSW

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

PSCIS stream crossing 123377 was ranked as a high priority for follow up by Irvine (2018) and Smith (2018) because of the relatively large size of the stream and habitat rated as high value in PSCIS (Table 5.65. A map of the watershed is provided in map attachment 093L.113.

Table 5.65: Summary of fish habitat modelling for PSCIS crossing 198066.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	35.9	2.4	7
ST Lake Reservoir (ha)	12.6	0.0	0
ST Wetland (ha)	24.6	0.0	0
ST Slopeclass03 Waterbodies (km)	1.9	0.0	0
ST Slopeclass03 (km)	12.1	1.6	13
ST Slopeclass05 (km)	4.8	0.8	17
ST Slopeclass08 (km)	7.6	0.0	0
ST Spawning (km)	4.9	0.0	0
ST Rearing (km)	15.4	2.4	16
CH Spawning (km)	4.9	0.0	0
CH Rearing (km)	12.7	2.4	19
CO Spawning (km)	9.7	2.4	25
CO Rearing (km)	14.7	2.4	16
CO Rearing (ha)	12.3	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)	9.7	2.4	25
All Rearing (km)	16.7	2.4	14
All Spawning Rearing (km)	16.7	2.4	14

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 198066 was un-embedded, non-backwatered and ranked as a potential barrier to upstream fish passage according to the provincial protocol (MoE 2011b). There was rip rap placed around the culvert inlets and outlets (Table 5.66). Water temperature was NA°C, pH was NA and conductivity was NAuS/cm.

Table 5.66: Summary of fish passage assessment for PSCIS crossing 198066.

Location and Stream Data	•	Crossing Characteristics	–
Date	2021-09-12	Crossing Sub Type	Round Culvert
PSCIS ID	198066	Diameter (m)	1.3
External ID	–	Length (m)	6
Crew	AI	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	640243.9	Resemble Channel	No

Location and Stream Data	•	Crossing Characteristics	–
Northing	6048061	Backwatered	Yes
Stream	Thompson Creek	Percent Backwatered	95
Road	Private Road	Fill Depth (m)	0.2
Road Tenure	Unclassified	Outlet Drop (m)	0
Channel Width (m)	2.77	Outlet Pool Depth (m)	0.1
Stream Slope (%)	0.5	Inlet Drop	No
Beaver Activity	No	Slope (%)	0.4
Habitat Value	High	Valley Fill	Deep Fill
Final score	16	Barrier Result	Potential
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	10
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Location and Stream Data	•	Crossing Characteristics	–

Location and Stream Data	•	Crossing Characteristics	–
Date	2021-09-05	Crossing Sub Type	Round Culvert
PSCIS ID	123377	Diameter (m)	1.05
External ID	–	Length (m)	29
Crew	AI	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	641632.6	Resemble Channel	No
Northing	6049398	Backwatered	No
Stream	Thompson Creek	Percent Backwatered	–
Road	Walcott Road	Fill Depth (m)	1.5
Road Tenure	MoTi Local	Outlet Drop (m)	0.25
Channel Width (m)	4.8	Outlet Pool Depth (m)	0.3
Stream Slope (%)	2.7	Inlet Drop	No
Beaver Activity	No	Slope (%)	3
Habitat Value	High	Valley Fill	Deep Fill
Final score	34	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	10
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Location and Stream Data	•	Crossing Characteristics	–

Stream Characteristics Downstream

The stream was surveyed downstream from the culvert for NAm (Figure 5.33). Total cover amount was rated as with overhanging vegetation dominant. Cover was also present as (Table 5.68). The average channel width was 3.3m, the average wetted width was 2.5m and the average gradient

was 1.8%. The dominant substrate was gravels with fines subdominant. The habitat was rated as medium value for salmonid rearing and spawning.

Stream Characteristics Upstream of 198066 and downstream of 123377

The stream was surveyed immediately upstream from 198066 for approximately NAm (Figure 5.34). Within the area surveyed, total cover amount was rated as with undercut banks dominant. Cover was also present as deep pools and overhanging vegetation (Table 5.68). The average channel width was 2.8m, the average wetted width was 2.1m and the average gradient was 0.5%. The dominant substrate was NA with NA subdominant. Habitat value was rated as medium value for resident salmonid rearing and spawning.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed at the site, replacement of PSCIS crossing 198066 with a bridge (10m span) is recommended.

Conclusion

There was 198066 is 14.7km of habitat upstream of crossing rated as medium value for salmonid rearing and spawning. Crossing 198066 was ranked as a high priority for proceeding to design for replacement.

Table 5.68: Summary of habitat details for PSCIS crossing 198066 and 123377.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
123377	Downstream	–	4.3	2.7	0.3	2.9	abundant	high
123377	Upstream	450	4.8	3.4	0.7	2.7	abundant	high
198066	Downstream	–	3.3	2.5	–	1.8	moderate	medium
198066	Upstream	–	2.8	2.1	–	0.5	–	medium

Figure 5.33: Left: Typical habitat downstream of PSCIS crossing 198066. Right: Habitat on side channel of Bulkley River downstream of crossing 198066.

Figure 5.34: Left: Small drop (50cm high) located ~20m upstream of PSCIS crossing 198066. Right: Habitat immediately upstream of PSCIS crossing 198066 that flows through a hay field within an excavated trench for approximately 350m.

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Session Info

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Attachment 1 - Maps

All georeferenced field maps are presented at https://hillcrestgeo.ca/outgoing/fishpassage/projects/elk/archive/2022-03-17 and available for bulk download as Attachment 1 - https://hillcrestgeo.ca/outgoing/fishpassage/projects/bulkley/archive/2021-04-21/bulkley_2021-04-21.zip.

Attachment 2 - Phase 1 Data and Photos

Data and photos for all Phase 1 (fish passage assessments) are provided in Attachment 2 - https://github.com/NewGraphEnvironment/fish_passage_elk_2021_reporting/raw/master/docs/Attachment_2.pdf

Attachment 3 - Habitat Assessment Data

Raw habitat assessment data included in digital format as Attachment 3 - https://github.com/NewGraphEnvironment/fish_passage_skeena_2021_reporting/raw/master/data/habitat_confirmations