SOCIETY FOR ECOSYSTEM RESTORATION IN NORTHERN BRITISH COLUMBIA

Skeena Watershed Fish Passage Restoration Planning 2023

Prepared for
Habitat Conservation Trust Foundation - CAT23-6-288
BC Fish Passage Remediation Program
Ministry of Transportation and Infrastructure

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on behalf of
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Research & Consulting

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Acknowledgement

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

The Society for Ecosystem Restoration in Northern British Columbia recognizes the Habitat Conservation Trust Foundation, BC Fish Passage Remediation Program and Ministry of Transportation and Infrastructure for making a significant financial contributions to supporting Skeena Watershed Fish Passage Restoration Planning. Partnerships are key to conserving BC's wildlife, fish, and their habitats.

Executive Summary

This report is available as both a pdf and as an online interactive report at https://newgraphenvironment.github.io/fish_passage_skeena_2023_reporting/. We recommend viewing online as the web-hosted version contains more features and is more easily navigable. Please reference the website for the latest version number and download the latest pdf from https://github.com/NewGraphEnvironment/fish_passage_skeena_2023_reporting/raw/main/docs/fish_passage_skeena_2023.pdf

Since 2020, the Society for Ecosystem Restoration Northern British Columbia (SERNbc) has been actively involved in planning, coordinating, and conducting fish passage restoration efforts within the Bulkley River and Morice River watershed groups, which are sub-basins of the Skeena River watershed. In 2022, the study area was expanded to include the Zymoetz Watershed Group and the Kispiox River watershed groups, followed by an extension in 2023 to encompass sections of the Kitsumkalum River watershed group, particularly where Highway 16 intersects the watershed.

The primary objective of this project is to identify and prioritize fish passage barriers within these study areas, develop comprehensive restoration plans to address these barriers, and foster momentum for broader ecosystem restoration initiatives. While the primary focus is on fish passage, this work also serves as a lens through which to view the broader ecosystems, leveraging efforts to build capacity for ecosystem restoration and improving our understanding of watershed health. We recognize that the health of life - such as our own - and the health of our surroundings are interconnected, with our overall well-being dependent on the health of our environment.

Although the main purpose of this report is to document 2023 field work data and results, it also builds on reporting from field activities conducted from 2020 to 2022. In addition to the numerous assessments at sites undocumented in past years of the project, field activities were also conducted at 10 sites where habitat confirmations were previously documented. When this occurred, past reports for these sites edited and updated with 2023 data.

- Bulkley River and Morice River Watershed Groups Fish Passage Restoration Planning (2020)
- Bulkley River and Morice River Watershed Groups Fish Passage Restoration Planning 2021
- Bulkley River Watershed Fish Passage Restoration Planning 2022
- Skeena Watershed Fish Passage Restoration Planning 2022

Please note that at the time of reporting, this report was a living document - changing over time. Version numbers are logged for each release with modifications, enhancements and other changes tracked with the "Changelog" section. Additionally, issues and planned enhancements are tracked here.

Fish Passage Assessments were completed at 53 sites in 2023. Although the focus of Fish Passage Assessment sites in 2023 was within areas adjacent to the Skeena River from Hazelton to Terrace (Kispiox River and Kitsumkalum River watershed groups), numerous sites were also assessed throughout other areas of the Kispiox, Zymoetz, Bulkley and Morice River watershed groups.

During 2023 field assessments, habitat confirmation assessments were conducted at seven sites in the Morice River and Zymoetz River watershed groups. A total of approximately 9km of stream was assessed, fish sampling utilizing electrofishing surveys were conducted at four of the subject habitat confirmation streams. Fish sampling was conducted at 49 sites within 10 streams a total of 416 fish captured. At all electrofishing sites, salmonids with fork lengths >60mm were tagged with PIT tags to facitate the tracking of health and movement over time.

Culverts previously located on a tributary to Skeena River - PSCIS 198217 - Sik-E-Dakh Water Tower Road were replaced with the crossing with a clear-span bridge in 2024 with funding acquired by and remediation work led by the Gitskan Watershed Authorities in partnership with the Skeena Fisheries Commission.

Ten sites where habitat confirmations were conducted in the first three years of this program (2020 - 2022) were revisited in 2023 to gather data to further inform prioritization and/or to provide data for effectiveness monitoring. Additional work primarily included fish sampling, PIT tagging and aquisition of aerial imagery using remotely piloted aircraft.

Recommendations for potential incorporation into collaborative watershed connectivity planning include:

- Continue to work with Gitskan Watershed Authorities (GWA) to prioritize and implement another fish passage restoration project in 2025. Learnings from the successful replacement of crossing 198217 on a tributary to the Skeena River on Sik-e-dakh Water Tower Road adjacent to the community of Glen Vowell can now be applied to the Zymoetz River watershed group leveraging further funding acquired by GWA for replacement of a crossing in 2025. At the time of reporting several crossings have been identified as potential candidates for replacement with funding for engineering design earmarked from this year's fiscal dollars.

- Refine climate change risk collection metrics with GIS and remote sensing to provide more quantitative metrics of risk, leveraging advancements from other Ministry of Transportation and Infrastructure team efforts and incorporating outputs (ex. discharge) from modelling using climate change scenarios such as those available through the Pacific Climate Impacts Consortium.

- Integrate fish passage restoration planning with other restoration and enhancement initiatives in the region to maximize benefits to fish populations as well as for communities within the Skeena River watershed. This includes working with the Gitskan Watershed Authorities (GWA), Skeena Fisheries Commission, Skeena Wild, Office of Wet’suwet’en, Morice Watershed Monitoring Trust, Fisheries and Oceans Canada, Provincial Regulators, Bulkley Valley Research Centre, Gitxsan Environmental Services, the Environmental Stewardship Initiative (Skeena Sustainability Assessment Forum) and others to leverage funding, knowledge and resources for fish passage restoration towards programs related to watershed health in the region.

1 Introduction

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- Bulkley River and Morice River Watershed Groups Fish Passage Restoration Planning 2021
- Bulkley River Watershed Fish Passage Restoration Planning 2022
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The health and viability of freshwater fish populations can depend on access to tributary and off channel areas which provide refuge during high flows, opportunities for foraging, overwintering habitat, spawning habitat and summer rearing habitat (Bramblett et al. 2002; Swales and Levings 1989; Diebel et al. 2015). Culverts can present barriers to fish migration due to low water depth, increased water velocity, turbulence, a vertical drop at the culvert outlet and/or maintenance issues (Slaney, Zaldokas, and Watershed Restoration Program (B.C.) 1997; Cote et al. 2005). As road crossing structures are commonly upgraded or removed there are numerous opportunities to restore connectivity by ensuring that fish passage considerations are incorporated into repair, replacement, relocation and deactivation designs.

Although remediation and replacement of stream crossing structures can have benefits to local fish populations, the costs of remedial works can be significant and the impacts of the work often complex to evaluate and quantify. Additionally, allocation of ecosystem restoration funding towards infrastructure upgrades on transportation right of ways are not always considered ethical under all circumstances from all perspectives. When funds are finite and invested groups are engaged in fund raising, cost benefits and the ethics of crossing replacements should be explored collaboratively alongside the cost benefits and ethics of alternative investment activities including transportation corridor relocation/deactivation, land procurement/covenant, cattle exclusion, riparian/floodplain restoration, habitat complexing, water conservation, commercial/recreational fishing management, salt water interventions and research.

2 Background

The study area includes the Bulkley River, Zymoetz River, Kispiox River, Morice River and Kitsumkalum River watershed groups (Figure 2.1) and is within the traditional territories of the Wet’suwet’en, Gitxsan and Tsimshian.

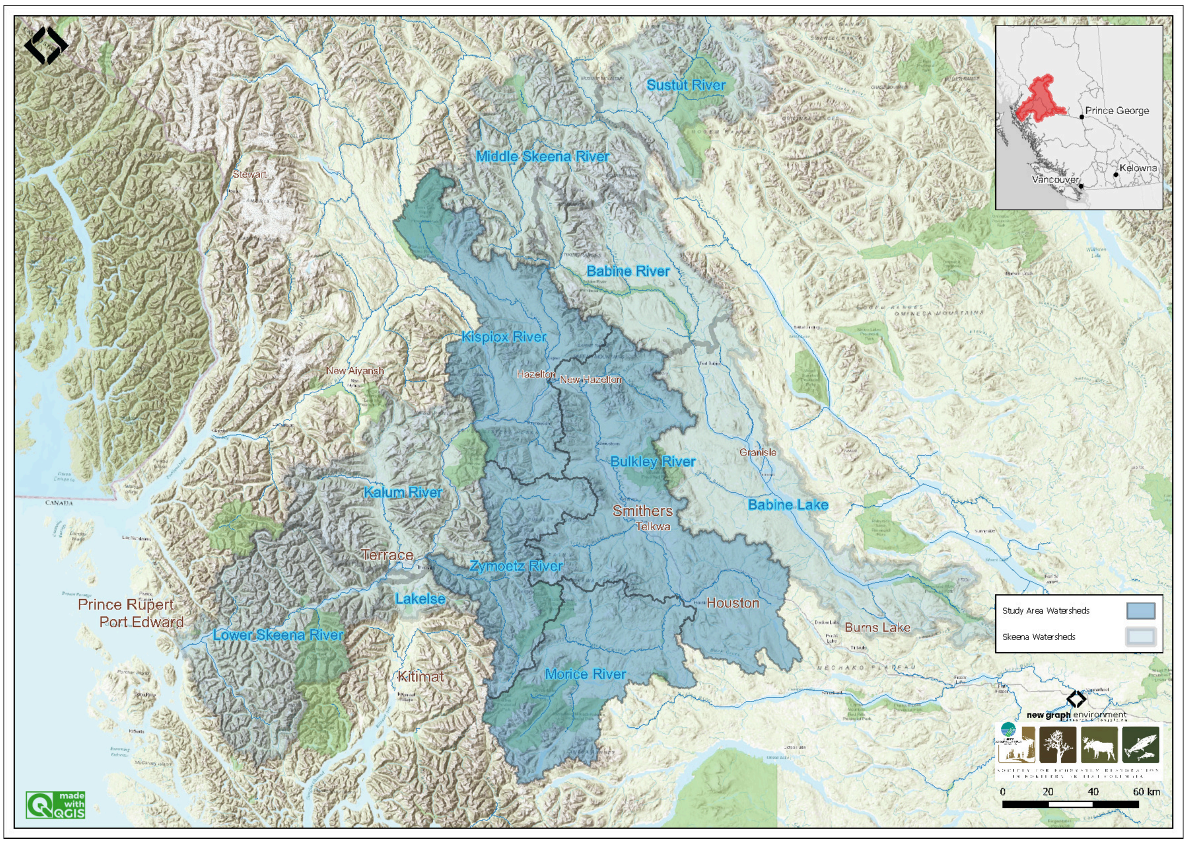

Figure 2.1: Overview map of Study Areas

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

Gitxsan means "People of the River Mist". 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" n.d.). Many band members live in Hazelton, Kispiox and Glen Vowell (the Eastern Gitxsan) as well as within Kitwanga, Kitwankool and Kitsegukla (the Western Gitxsan) (Powell, Jensen, and Pedersen 2018).

2.3 Tsimshian

The Kitsumkalum community, part of the Tsimshian Nation, maintains a rich cultural heritage rooted in ancient traditions and values. Their society, governed by Tsimshian Law (ayaawx), emphasizes strong connections through marriages, adoptions, and resource sharing with other Tsimshian tribes. The community upholds its cultural and spiritual practices, including fishing, harvesting, and land stewardship, despite the impacts of colonization (Kitsumkalum Band n.d.).

Kitsumkalum's social structure is based on matrilineal kinship, with significant emphasis on family ties through the mother's lineage. Their cultural identity is expressed through crest groups (pteex), lineage houses (waap), and the importance of landed property (laxyuup), which ties them to their ancestral territories. The community combines traditional governance with modern administrative functions, reflecting their resilience and commitment to preserving their heritage (Kitsumkalum Band n.d.).

The Kitsumkalum River salmon populations have been an important part of their culture and economy (A. Gottesfeld and Rabnett 2007).

2.4 Bulkley River

The Bukley River is an 8th order stream that drains an area of 7,762km^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 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 (Calvin et al. 2023; 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).

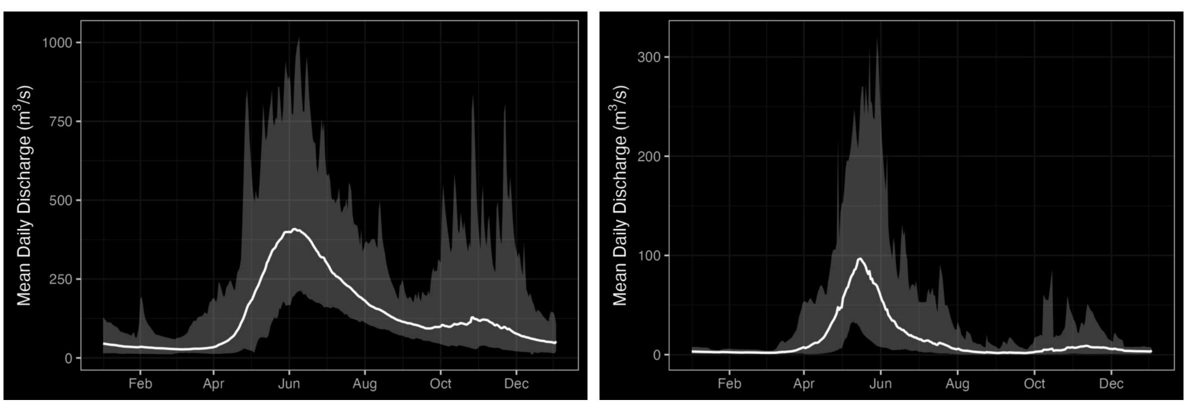

Figure 2.2: Hydrograph for Bulkley River at Quick (Station #08EE004) and near Houston (Station #08EE003).

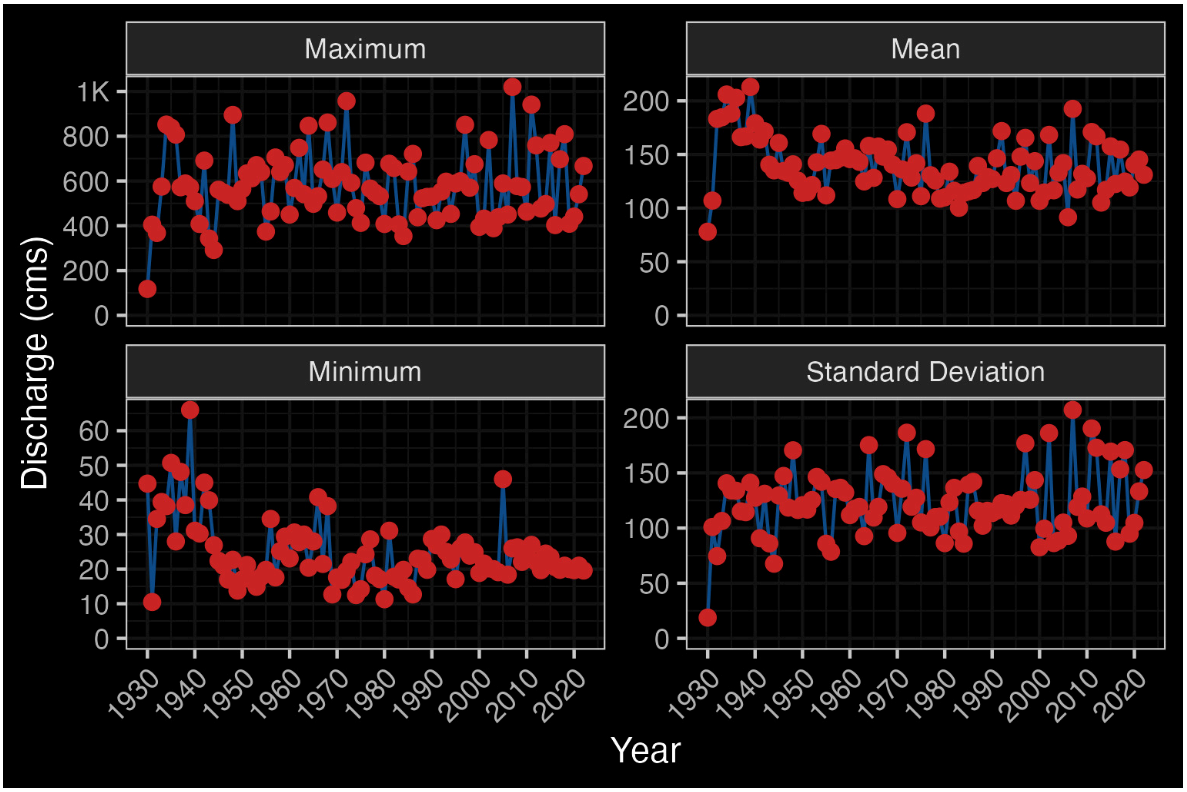

Figure 2.3: Bulkley River At Quick (Station #08EE004 - Lat 54.61861 Lon -126.89997). Available daily discharge data from 1930 to 2022.

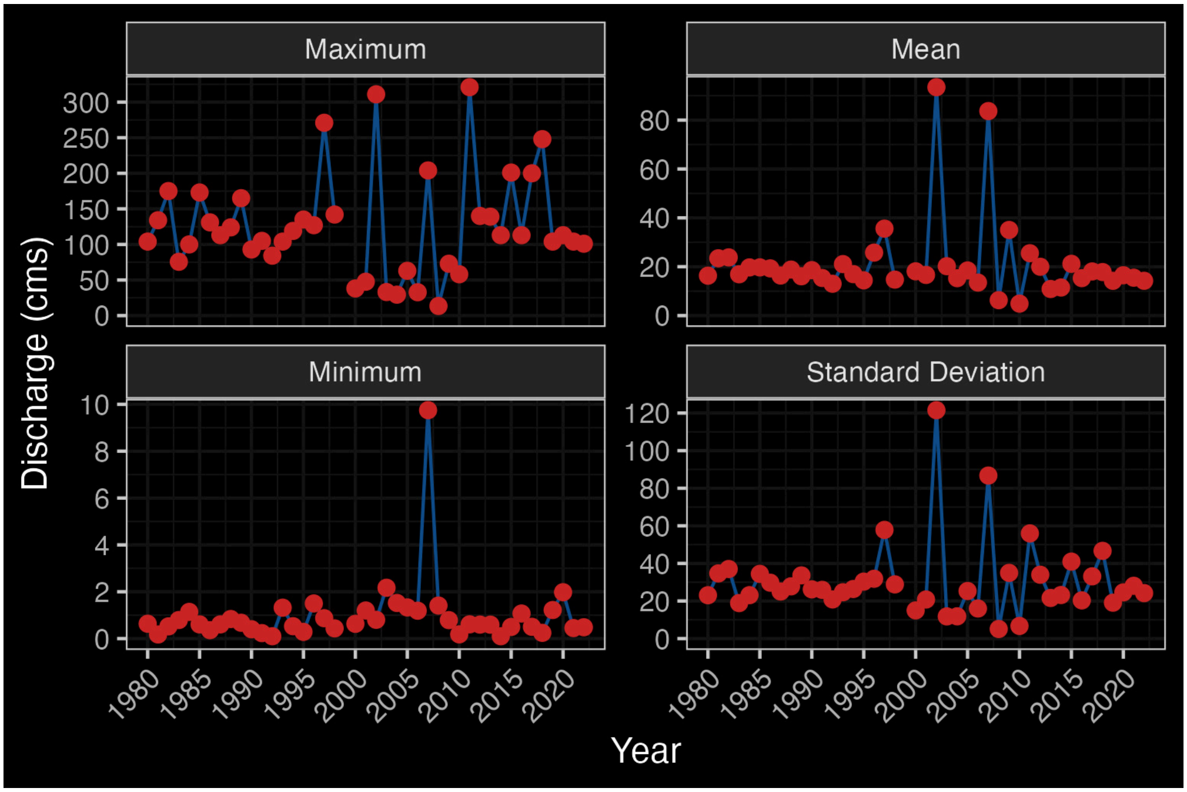

Figure 2.4: Bulkley River Near Houston (Station #08EE003 - Lat 54.39938 Lon -126.71941). Available daily discharge data from 1980 to 2022.

2.5 Morice River

The Morice River watershed drains 4,379km^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 (Canada 2024). 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 m^3/s. Mean annual discharge is estimated at 75 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).

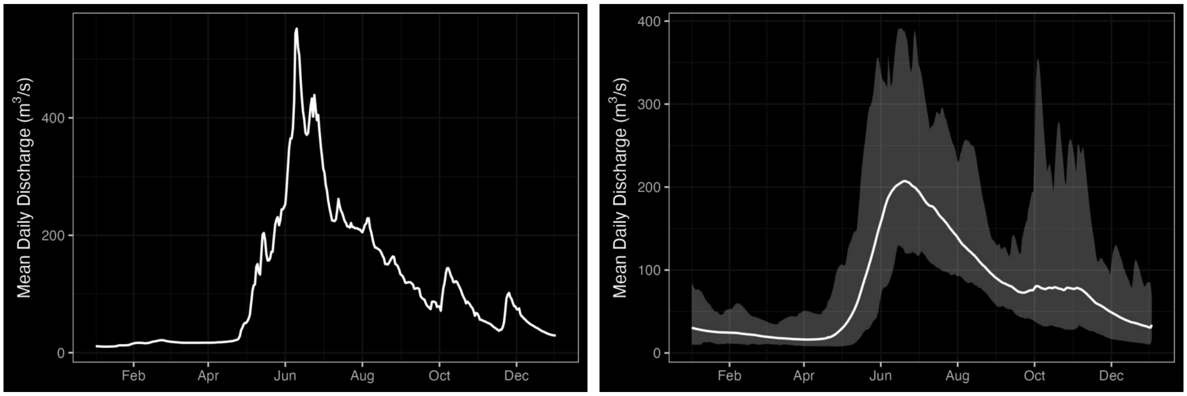

Figure 2.5: Left: Hydrograph for Morice River near Houston (Station #08ED003 - 1971 data only). Right: Hydrograph for Morice River near outlet of Morice Lake (Station #08ED002).

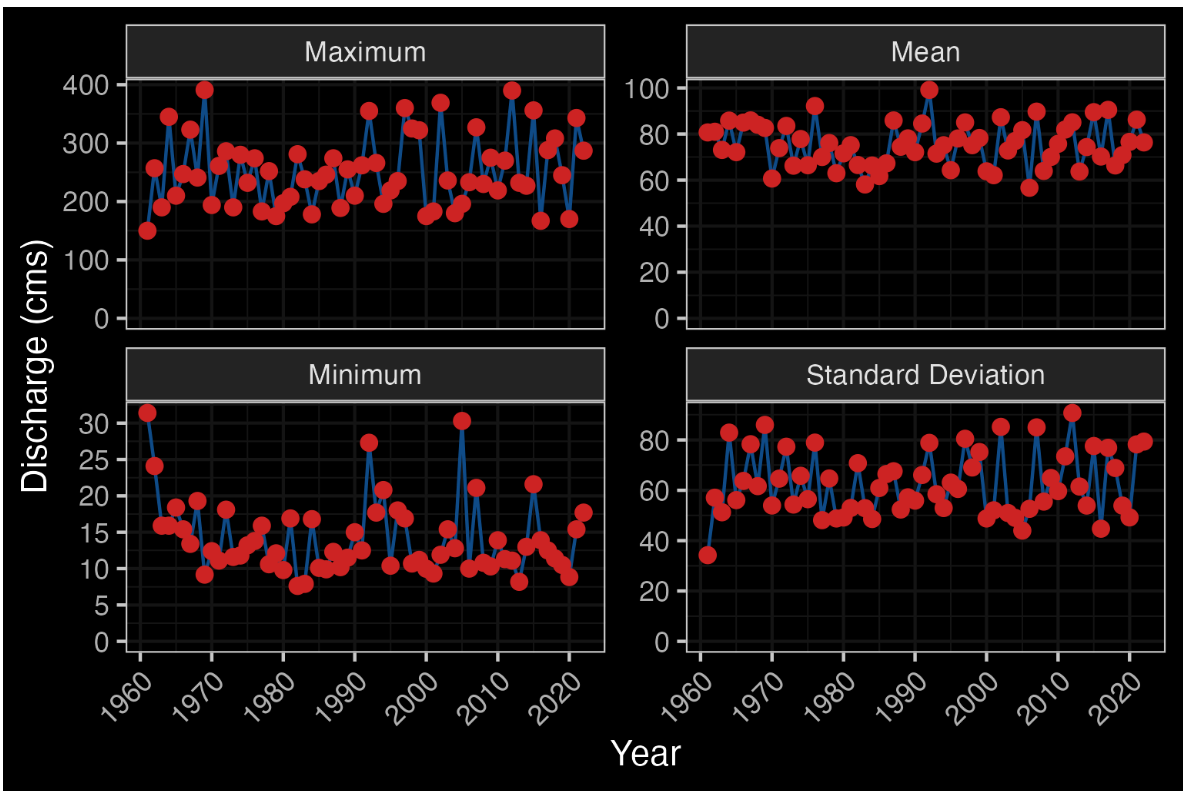

Figure 2.6: Summary of hydrology statistics for Morice River near outlet of Morice Lake (Station #08ED002 - Lat 54.116829 Lon -127.426582). Available daily discharge data from 1961 to 2022.

2.6 Zymoetz River

The Zymoetz River (known locally as the Copper River) watershed is an eighth order stream that drains an area of 3026km^2 in a generally westerly direction. It is considered a major tributary of the

Skeena River, as it contributes approximately 10% of the flow. The headwater lakes are located approximately 20km southwest of Smithers, and they include Aldrich, Dennis and McDonell Lakes. The upper and lower portions of the watershed are accessed via logging roads off of Highway 16 from Smithers and Terrace, respectively. Access to the middle watershed is difficult due to road wash out. The Zymoetz River flows roughly 120km, starting just west of Hudson Bay mountain near Smithers and ending at the confluence of the Skeena River, approximately 8km north-east of Terrace. Elevations in the watershed range from 120m at the confluence, to 2740m in the Howson Range. The Duthie mine operated on the south-west slope of Hudson Bay Mountain during the 1930's and 1950's, and reports have documented contaminated streams and lakes in the surrounding area (Allen Gottesfeld, Rabnett, and Hall 2002). The lower end of the Zymoetz watershed has seen a significant reduction in riparian habitat due to fires, forest development practices, pipe line and road construction (Allen Gottesfeld, Rabnett, and Hall 2002). Snowmelt plays a big role in controlling the stream hydrology, with a mean annual discharge estimated at 106 m^3/s at station 08EF005 located near Smithers. Peak discharge happens in May to early June, which is typical of a high elevation watershed like this (Figures 2.7 - 2.8).

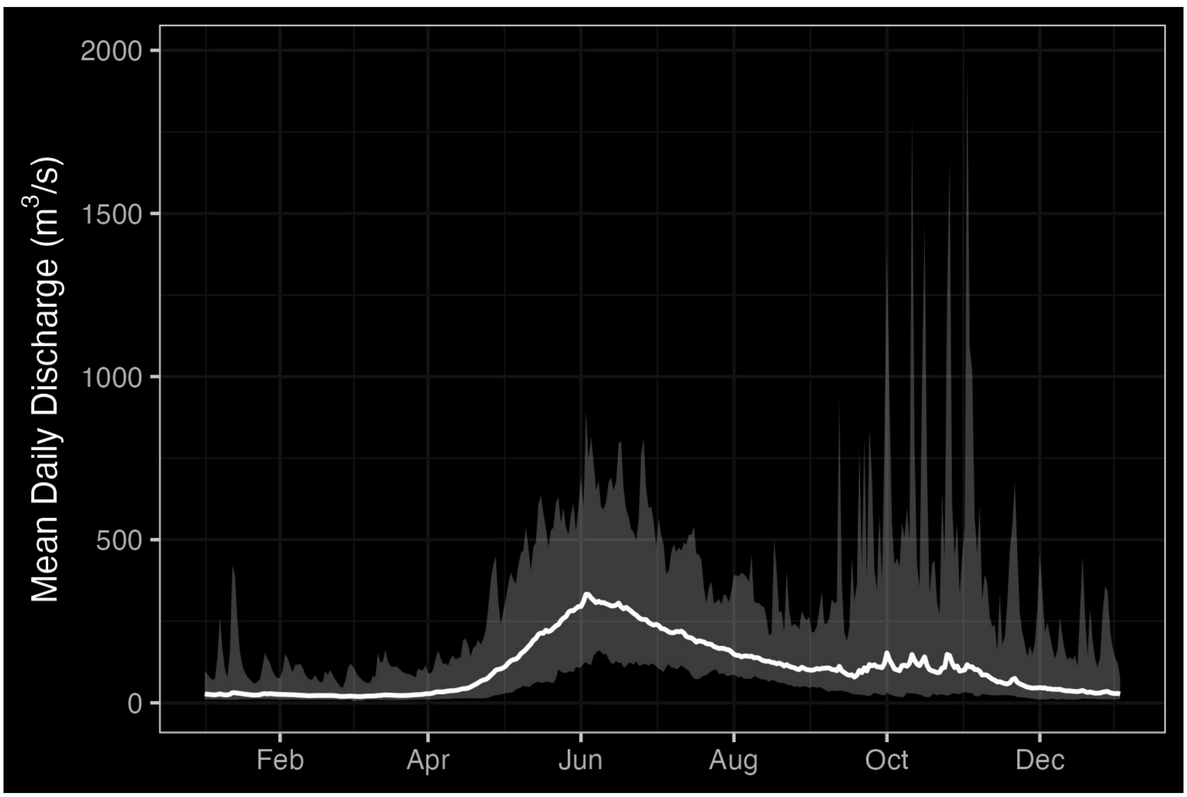

Figure 2.7: Zymoetz River Above O.k. Creek (Station #08EF005 - Lat 54.49363 Lon -128.32466). Available mean daily discharge data from 1963 to 2021.

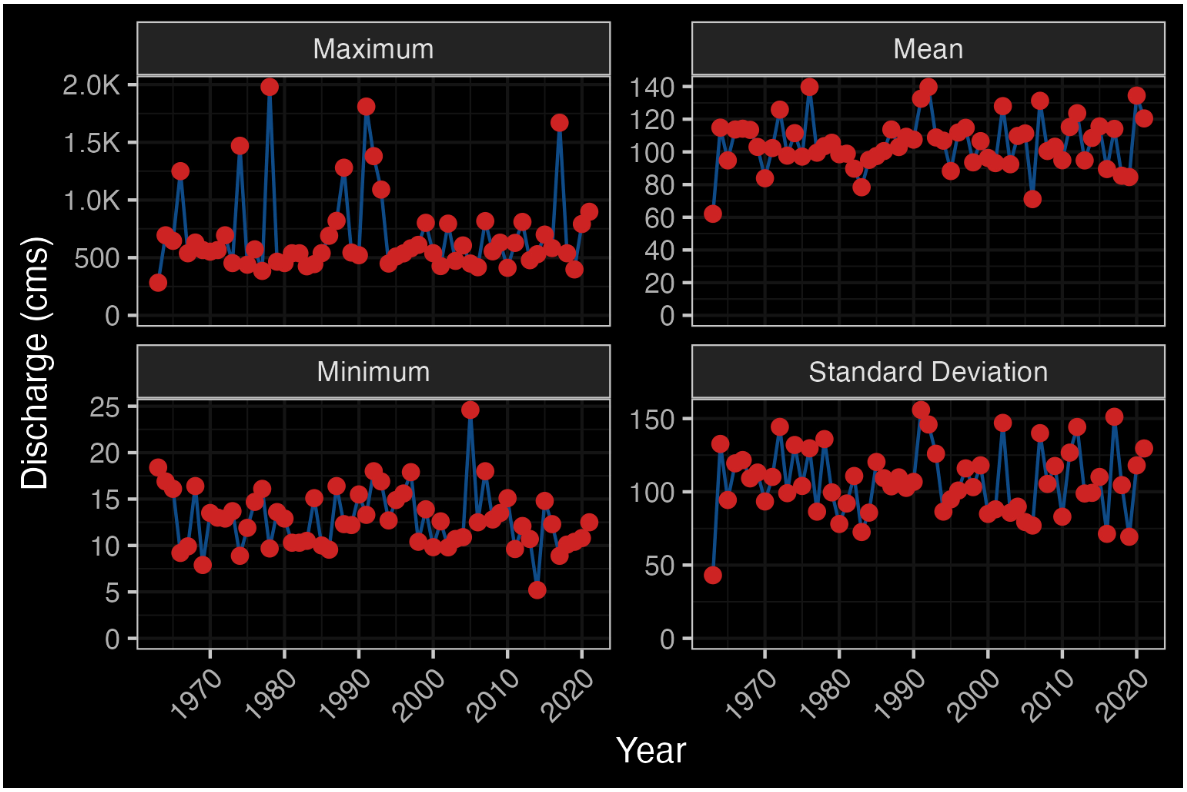

Figure 2.8: Zymoetz River Above O.k. Creek (Station #08EF005 - Lat 54.49363 Lon -128.32466). Available daily discharge data from 1963 to 2021.

2.6.1 Kispiox River

The Kispiox River watershed is a seventh order stream that drains an area of 2100km^2 in a south east direction. It is a large tributary of the Skeena River, contributing approximately 9% of its flow. It flows 140km to the confluence of the Skeena River, near Kispiox Village. Elevations in the watershed range from 200m at the mouth to as high as 2090m on Kispiox Mountain. The mainstream of the Kispiox is fed mainly by glacier melt and high elevation snow melt. Swan and Stephens Lakes (located in the upper watershed) are important sockeye systems. Swan Lake drains via Club Lake into Stephens Lake which in turn flows via Stephens Creek into the mainstem of the Kispiox River. Some of the biggest threats to aquatic ecosystems in the Kispiox valley are reported as erosion, obstructions, sedimentation, and altered water yield. The upper third of the Kispiox watershed (upstream of the Nangeese River) is well protected from development by the Swan Lake Kispiox River Provincial Park and because it contains few roads with little forestry development (Allen Gottesfeld, Rabnett, and Hall 2002). The Kispiox River has a mean annual discharge estimated at 45 m^3/s at station 08EB004 located near Hazelton. Peak discharge happens in May and June as a result of the spring snowmelt (Figures 2.9 - 2.10).

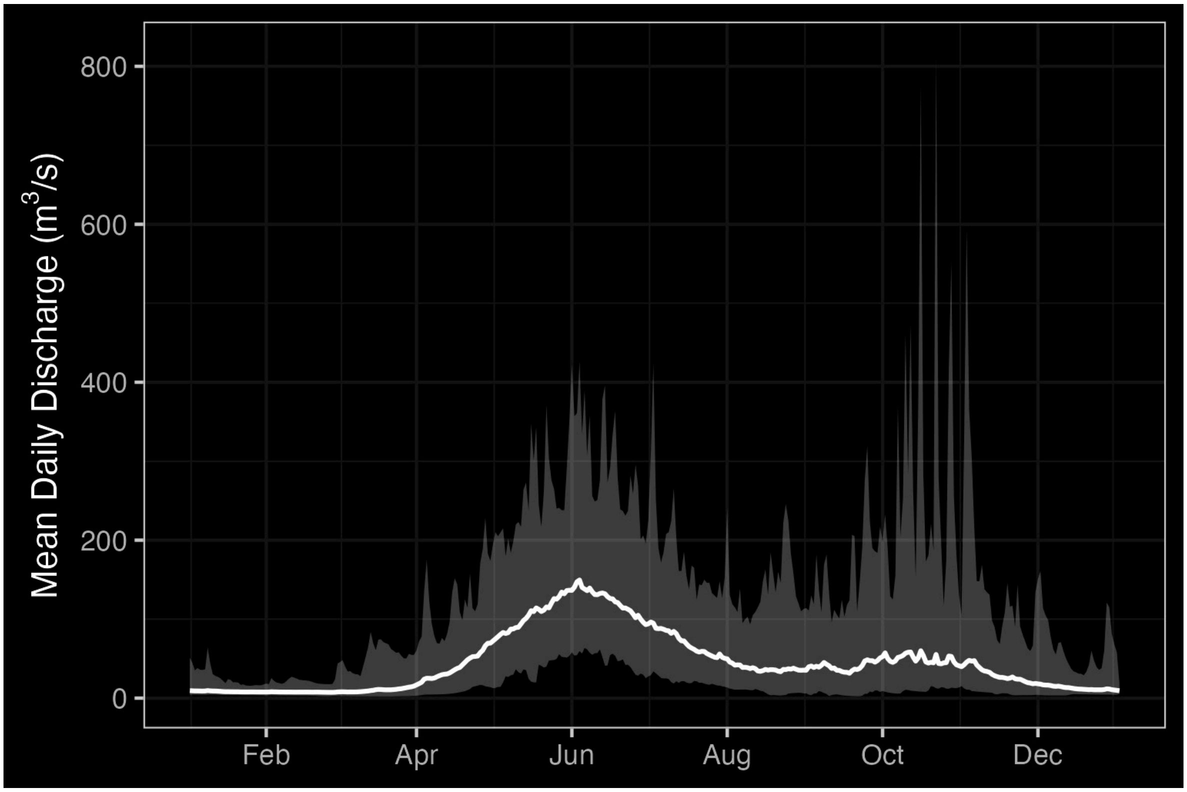

Figure 2.9: Kispiox River Near Hazelton (Station #08EB004 - Lat 55.43385 Lon -127.71616). Available mean daily discharge data from 1963 to 2022.

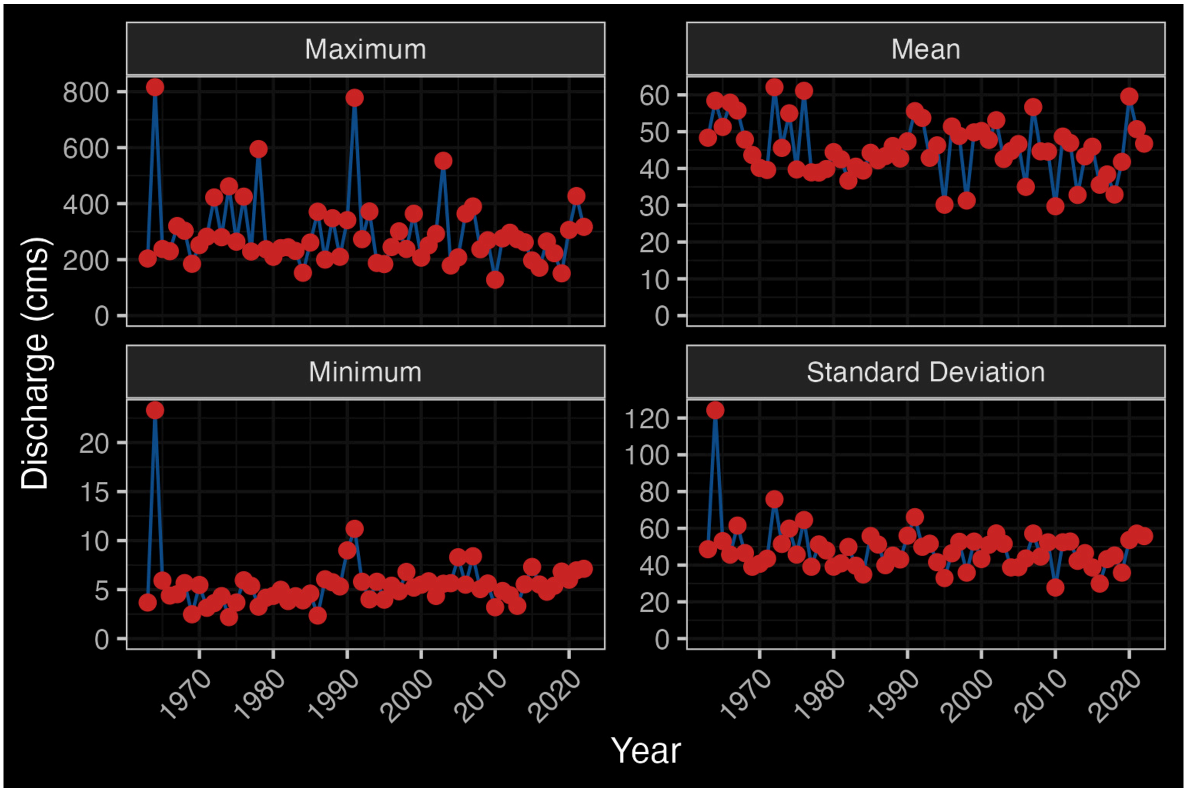

Figure 2.10: Kispiox River Near Hazelton (Station #08EB004 - Lat 55.43385 Lon -127.71616). Available daily discharge data from 1963 to 2022.

2.7 Kitsumkalum River

The Kitsumkalum River is a sixth order stream that flows east from the Coast Mountains to Kitsumkalum lake then south to Terrace where it joins the Skeena River, draining an area of 2289km^2. Major tributaries to the Kitsumkalum River include the Cedar River, Nelson River, Mayo Creek, Goat Creek, Lean-To Creek and Deep Creek (McElhanney 2022). Peak flows occur in May-June from snow melt with subsequent peaks the fall from rain events (McElhanney 2022). There is one hydrometric station below Kitsumkalum lake which has been active since 2018, and has a mean annual discharge of `round(fasstr::calc_longterm_mean(station_number = "08EG019")$LTMAD,0)`m^3/s (Figures 2.11 - 2.12. From 1929-1954, there was a hydrometric station near Terrace, which estimated the mean annual discharge to be 138m^3/s.

The Kitsumkalum River watershed has been highly impacted by logging. Many of the tributaries to the Kitsumkalum River have altered channel morphology, increased bedload movement, bank failures, sediment loading, and debris accumulation (A. Gottesfeld and Rabnett 2007).

several tributaries to the Kitsumkalum River, including Willow Creek, Spring Creek, Lean-To Creek, and Deep Creek (Healthy Watersheds Initiative 2021). The Deep Creek Hatchery, operated by the Terrace Salmonid Enhancement Society, has been supporting Kitsumkalum River chinook populations since 1984 (A. Gottesfeld and Rabnett 2007). Additionally, there is a small groundwater facility for the incubation and rearing coho and chum, run by the Kitsumkalum First Nation (A. Gottesfeld and Rabnett 2007). In 2000 The Clear Creek Eastern Side Channel was constructed to enhance juvenile rearing habitat and adult spawning habitat for coho salmon on Clear Creek, a tributary to the Kitsumkalum River, however the site has not been maintained and beaver activity has obstructed fish accessibility to much of the channel (Elmer 2021).

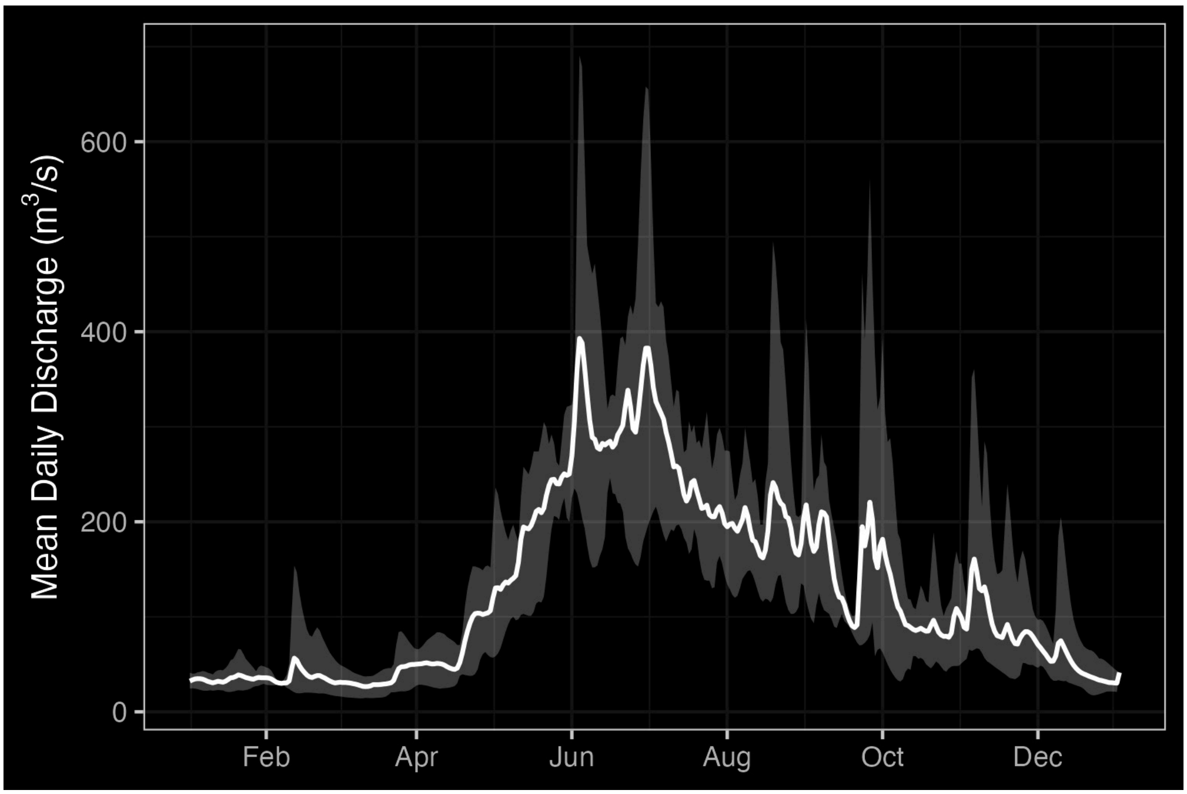

Figure 2.11: Kitsumkalum River Below Alice Creek (Station #08EG019 - Lat 54.6793 Lon -128.74396). Available mean daily discharge data from 2018 to 2022.

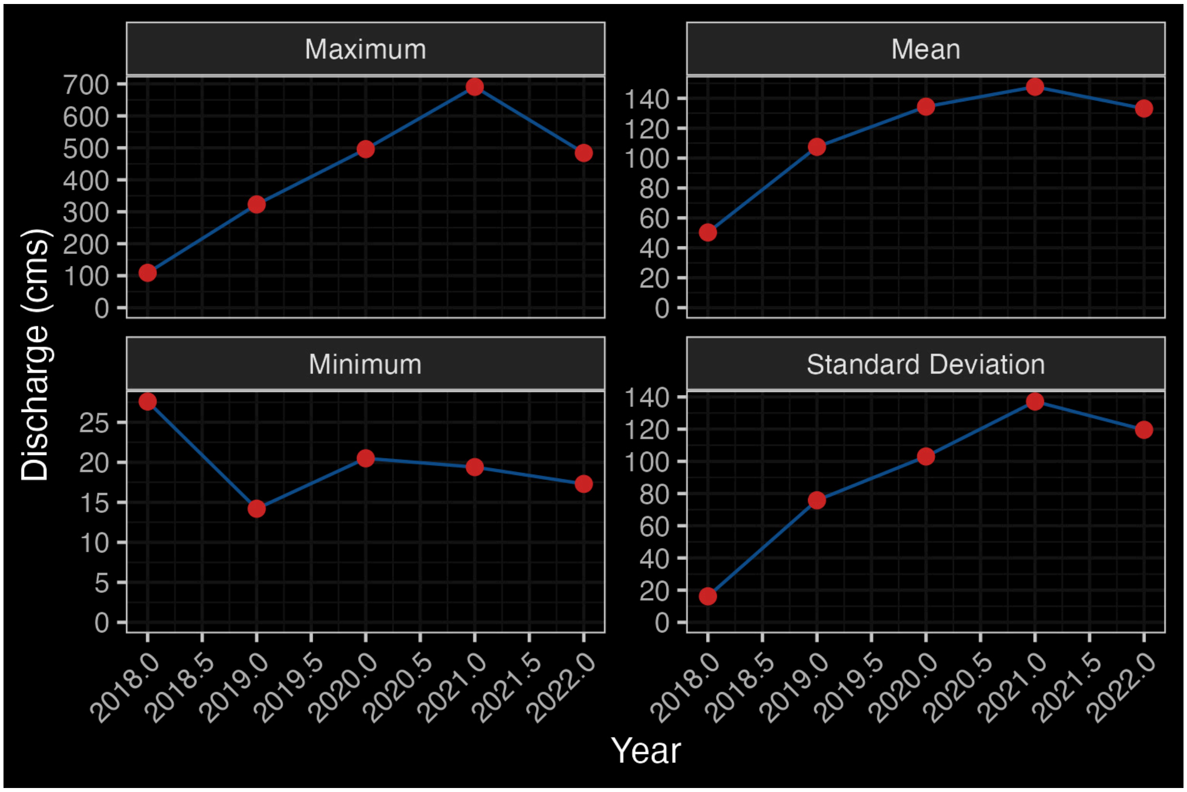

Figure 2.12: Kitsumkalum River Below Alice Creek (Station #08EG019 - Lat 54.6793 Lon -128.74396). Available daily discharge data from 2018 to 2022.

2.8 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).

2.8.1 Bulkley River

Traditionally, the salmon stocks passing through and spawning in the greater Bulkley River were the principal food source for the Gitxsan and Wet'suwet'en people living there (Wilson and Rabnett 2007). Anadromous lamprey passing through and spawning in the upper Bulkley River were traditionally also an important food source for the Wet'suwet'en (A. Gottesfeld and Rabnett (2007); pers comm. Mike Ridsdale, Environmental Assessment Coordinator, Office of the Wet'suwet'en). A. Gottesfeld and Rabnett (2007) report sourceing information from Department of Fisheries and Oceans (1991) that principal spawning areas for chinook in the Neexdzii Kwah include the mainstem above and below Buck and McQuarrie Creeks, between Cesford and Watson Creeks, and the reaches upstream and downstream of Bulkley Falls.

Renowned as a world class recreational steelhead and coho fishery, the greater 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 Neexdzii Kwah is considered Class II water and there is no fshing permitted upstream of the Morice/Bulkley River Confluence (FLNRO 2013a, 2013b; FLNRORD 2019).

2.8.1.1 Upper Bulkley Falls

A detailed field assessment and write up regarding the upper Bulkley falls was conducted as part of fish passage restoration in the watershed - is presented in Irvine (2021) with a condensed summary here. 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. 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 (Irvine 2021).

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 Neexdzii Kwah from the outlet of Bulkley Lake.

Wilson and Rabnett (2007) reported that 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 Neexdzii Kwah, 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. Wilson and Rabnett (2007) also reported that coho have not been observed beyond the falls since 1972.

2.8.2 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.

2.8.3 Zymoetz River

Within the Zymoetz Watershed, there are many areas with high fishery values. Steelhead are the most extensively documented fish species in the Zymoetz River watershed. Adults enter the river from July to November and then go on to spawn the following year in late spring to early summer. The Zymoetz River is a relatively steep system. Two canyons are located 6.4 and 19.6 kilometers upstream of the Skeena River confluence. These canyons make access to the Zymoetz difficult for pink and chum salmon (Allen Gottesfeld, Rabnett, and Hall 2002). The Zymoetz River is renowned for its aggressive steelhead that have been known to take flies or lures. There is a 50km stretch upstream of Limonite Creek that's very remote and offers high quality fishing opportunities for anglers (FLNRORD 2013).

Traditional First Nations use of the upper Zymoetz River watershed by the Gitxsan and Wet'suwet'en people differed between community sites, residences, and fish houses, and was large and diverse. From the upper to lower Zymoetz River and to the Skeena River, a significant ancient grease trail connected, with a branch track forking through Limonite Creek and flowing down the Telkwa River. The fishery used a weir at the mouth of McDonell Lake and spears at Six Mile Flats, near Dennis Lake. There is no information on native fisheries on the lower Zymoetz River. The Zymoetz is considered to be one of the top ten steelhead rivers in BC (Allen Gottesfeld, Rabnett, and Hall 2002).

2.8.4 Kispiox River

Kispiox River salmon are a important food source and cultural symbol for the Gitxsan people with sockeye and coho historically the two most significant species. Gitangwalk and Lax Didax, two significant villages that were both abandoned in the early 1900s, were situated on the Kispiox in such a way as to block the sockeye and coho salmon's upstream migration to the Upper Kispiox River spawning grounds providing opportunities to gather and preserve a significant amount of high-quality food over relatively short time periods (Allen Gottesfeld, Rabnett, and Hall 2002). The 100 km of mainstem and 300km of tributary streams in the Kispiox River Watershed are considering high value fish habitat supporting migration, spawning and rearing for many fish species. The Kispiox fisheries supports both recreational and commercial fishing while also enhancing the ecology, nutrient regime, and structural diversity of the drainage. Since 1992, sockeye and coho escapements from the Kispiox Watershed have been documented by the Gitxsan Watershed

Authorities as they creates strong cultural, economic, and symbolic ties for the local communities (Allen Gottesfeld, Rabnett, and Hall 2002).

2.8.5 Kitsumkalum River

The Kitsumkalum River is an important waterway for all species of salmon. It is one of the three main chinook producing rivers in the Skeena watershed and supports all five species of pacific salmon, steelhead, and other resident trout and char species (McElhanney 2022). Most notably, the Kitsumkalum River has consistently produced the largest-bodied chinook in the Skeena Watershed, as well as on most of the Pacific coast (A. Gottesfeld and Rabnett 2007). The watershed supports strong recreational coho, steelhead, and chinook fishing. Kitsumkalum salmon also play an important role in the culture and economy of the Kitsumkalum Band (A. Gottesfeld and Rabnett 2007).

2.8.6 Salmon Stock Assessment Data

Fisheries and Oceans Canada stock assessment data was accessed via the NuSEDS-New Salmon Escapement Database System through the Open Government Portal with results presented here. A brief memo on the data extraction process is available here.

2.8.7 Fish Species

Fish species recorded in the Morice, Bulkley, Zymoetz, Kispiox, and Kitsumkalum Rivers watershed groups are detailed in Table 2.1 (MoE 2019a). Coastal cutthrout trout and bull trout are considered of special concern (blue-listed) provincially. Summaries of some of the Skeena 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 2.13. 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 2.14 - 2.15.

Table 2.1: Fish species recorded in the Morice River, Bulkley River, Zymoetz River, Kispiox River, and Kitsumkalum River watershed groups.

Scientific Name	Species Name	BC List	COSEWIC	Bulkley	Kispiox	Kalum	Morice	Zymoetz
Catostomus catostomus	Longnose Sucker	Yellow	–	Yes	Yes	–	Yes	Yes
Catostomus commersonii	White Sucker	Yellow	–	Yes	Yes	Yes	Yes	–
Catostomus macrocheilus	Largescale Sucker	Yellow	–	Yes	Yes	Yes	Yes	Yes
Chrosomus eos	Northern Redbelly Dace	Yellow	–	Yes	–	–	–	–
Coregonus clupeaformis	Lake Whitefish	Yellow	–	Yes	Yes	–	Yes	–
Coregonus sardinella	Least Cisco	Blue	–	–	–	Yes	–	–
Cottus aleuticus	Coastrange Sculpin (formerly Aleutian Sculpin)	Yellow	–	Yes	Yes	Yes	Yes	–
Cottus asper	Prickly Sculpin	Yellow	–	Yes	Yes	Yes	Yes	Yes
Cottus cognatus	Slimy Sculpin	Yellow	–	–	Yes	Yes	–	–
Couesius plumbeus	Lake Chub	Yellow	DD	Yes	Yes	Yes	Yes	–
Entosphenus tridentatus	Pacific Lamprey	Yellow	–	Yes	–	Yes	Yes	–
Gasterosteus aculeatus	Threespine Stickleback	Yellow	–	–	Yes	Yes	–	–
Hybognathus hankinsoni	Brassy Minnow	No Status	–	Yes	–	–	–	–
Lampetra ayresii	River Lamprey	Yellow	–	–	–	Yes	–	–
Lota lota	Burbot	Yellow	–	Yes	Yes	Yes	Yes	Yes

2.8 Fisheries

Scientific Name	Species Name	BC List	COSEWIC	Bulkley	Kispiox	Kalum	Morice	Zymoetz
Mylocheilus caurinus	Peamouth Chub	Yellow	–	Yes	Yes	Yes	Yes	Yes
Oncorhynchus clarkii	Cutthroat Trout	No Status	–	Yes	Yes	Yes	Yes	Yes
Oncorhynchus clarkii	Cutthroat Trout (Anadromous)	No Status	–	Yes	Yes	–	–	Yes
Oncorhynchus clarkii clarkii	Coastal Cutthroat Trout	Blue	–	Yes	Yes	Yes	Yes	Yes
Oncorhynchus clarkii lewisi	Westslope (Yellowstone) Cutthroat Trout	Blue	SC (Nov 2016)	–	Yes	Yes	–	–
Oncorhynchus gorbuscha	Pink Salmon	Yellow	–	Yes	Yes	Yes	Yes	Yes
Oncorhynchus keta	Chum Salmon	Yellow	–	Yes	Yes	Yes	Yes	Yes
Oncorhynchus kisutch	Coho Salmon	Yellow	–	Yes	Yes	Yes	Yes	Yes
Oncorhynchus mykiss	Rainbow Trout	Yellow	–	Yes	Yes	Yes	Yes	Yes
Oncorhynchus mykiss	Steelhead	Yellow	–	Yes	Yes	Yes	Yes	Yes
Oncorhynchus mykiss	Steelhead (Summer-run)	Yellow	–	Yes	–	–	Yes	–
Oncorhynchus mykiss	Steelhead (Winter-run)	Yellow	–	–	Yes	–	–	Yes
Oncorhynchus nerka	Kokanee	Yellow	–	Yes	Yes	Yes	Yes	Yes
Oncorhynchus nerka	Sockeye Salmon	Yellow	–	Yes	Yes	Yes	Yes	Yes
Oncorhynchus tshawytscha	Chinook Salmon	Yellow	E/T/SC (Dec 2018)	Yes	Yes	Yes	Yes	Yes
Prosopium coulterii	Pygmy Whitefish	Yellow	NAR (Nov 2016)	Yes	Yes	–	Yes	–
Prosopium coulterii pop. 3	Giant Pygmy Whitefish	Yellow	–	Yes	–	–	–	–
Prosopium cylindraceum	Round Whitefish	Yellow	–	–	–	Yes	–	–
Prosopium williamsoni	Mountain Whitefish	Yellow	–	Yes	Yes	Yes	Yes	Yes
Ptychocheilus oregonensis	Northern Pikeminnow	Yellow	–	Yes	Yes	–	Yes	Yes
Pungitius pungitius	Ninespine Stickleback	Unknown	–	Yes	–	–	–	–
Rhinichthys cataractae	Longnose Dace	Yellow	–	Yes	Yes	Yes	Yes	Yes
Rhinichthys falcatus	Leopard Dace	Yellow	NAR (May 1990)	–	–	–	Yes	–
Richardsonius balteatus	Redside Shiner	Yellow	–	Yes	Yes	Yes	Yes	Yes
Salvelinus confluentus	Bull Trout	Blue	SC (Nov 2012)	Yes	Yes	Yes	Yes	Yes
Salvelinus fontinalis	Brook Trout	Exotic	–	Yes	–	–	Yes	–
Salvelinus malma	Dolly Varden	Yellow	–	Yes	Yes	Yes	Yes	Yes
Salvelinus namaycush	Lake Trout	Yellow	–	Yes	Yes	–	Yes	–

Scientific Name	Species Name	BC List	COSEWIC	Bulkley	Kispiox	Kalum	Morice	Zymoetz
–	Arctic Char	–	–	–	–	–	Yes	–
–	Chub (General)	–	–	–	Yes	–	–	–
–	Cutthroat/Rainbow cross	–	–	Yes	Yes	Yes	–	–
–	Dace (General)	–	–	–	–	–	Yes	–
–	Lamprey (General)	–	–	Yes	Yes	Yes	Yes	–
–	Minnow (General)	–	–	Yes	Yes	–	Yes	–
–	Mottled Sculpin	–	–	Yes	–	–	–	–
–	Salmon (General)	–	–	Yes	Yes	–	Yes	Yes
–	Sculpin (General)	–	–	Yes	Yes	Yes	Yes	Yes
–	Squanga	–	–	–	Yes	–	–	–
–	Stickleback (General)	–	–	–	Yes	Yes	–	–
–	Sucker (General)	–	–	Yes	Yes	Yes	Yes	Yes
–	Verified DV BT hybrid	–	–	–	–	Yes	–	–
–	Whitefish (General)	–	–	Yes	Yes	Yes	Yes	Yes

* COSEWIC abbreviations :
SC - Special concern
DD - Data deficient
NAR - Not at risk
E - Endangered
T - Threatened

BC List definitions :
Yellow - Species that is apparently secure
Blue - Species that is of special concern
Exotic - Species that have been moved beyond their natural range as a result of human activity

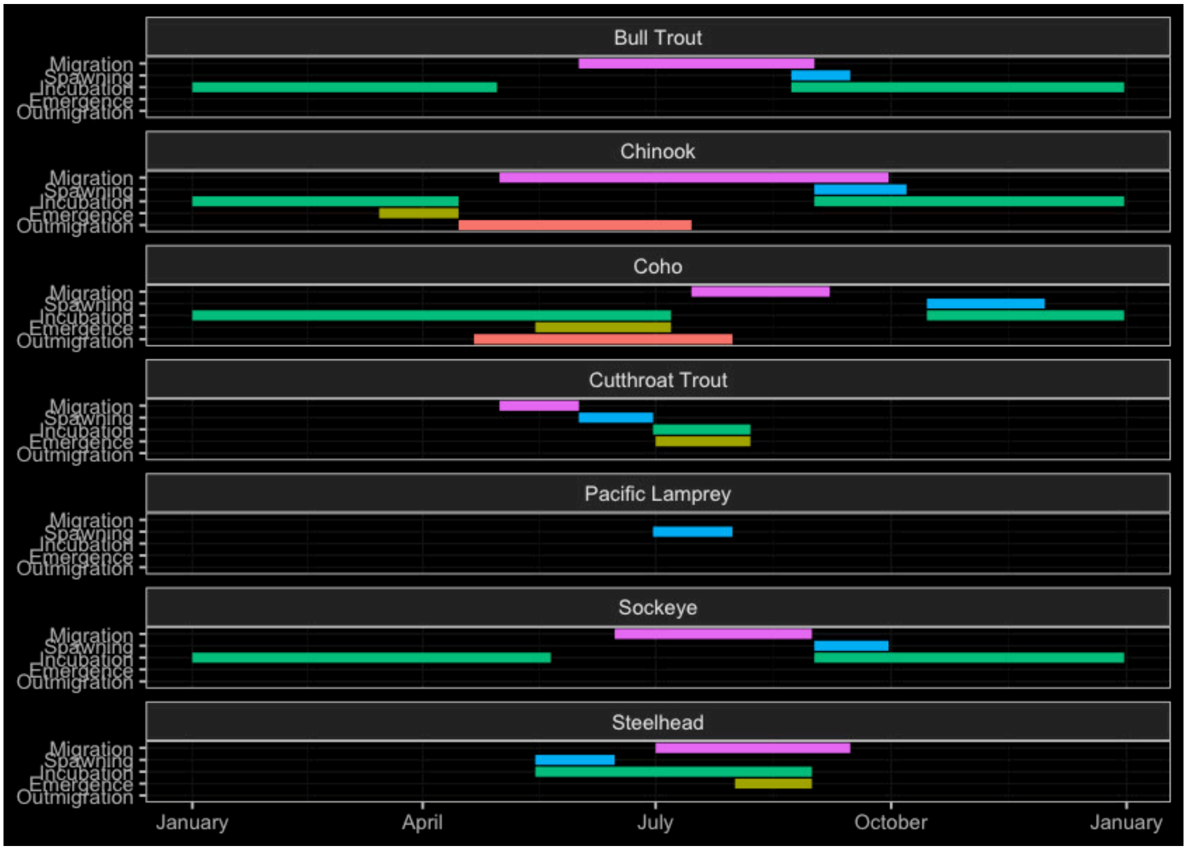

Figure 2.13: Gantt chart for select species in the Morice River and Bulkley River watersheds. To be updated in consultation with local fisheries techicians and knowledge holders.

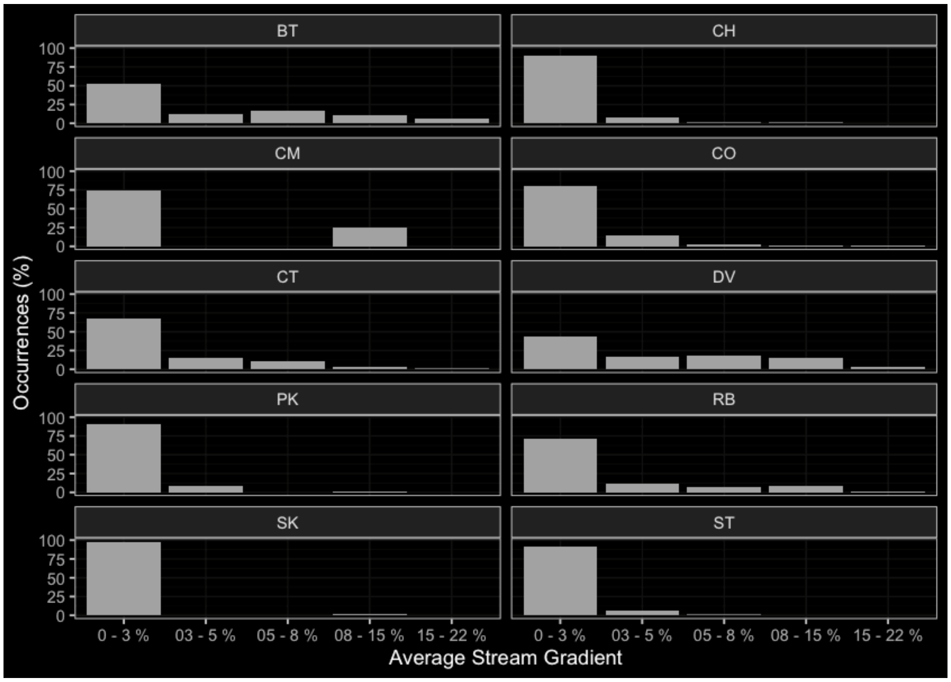

Figure 2.14: Summary of historic salmonid observations vs. stream gradient category for the Bulkley River watershed group.

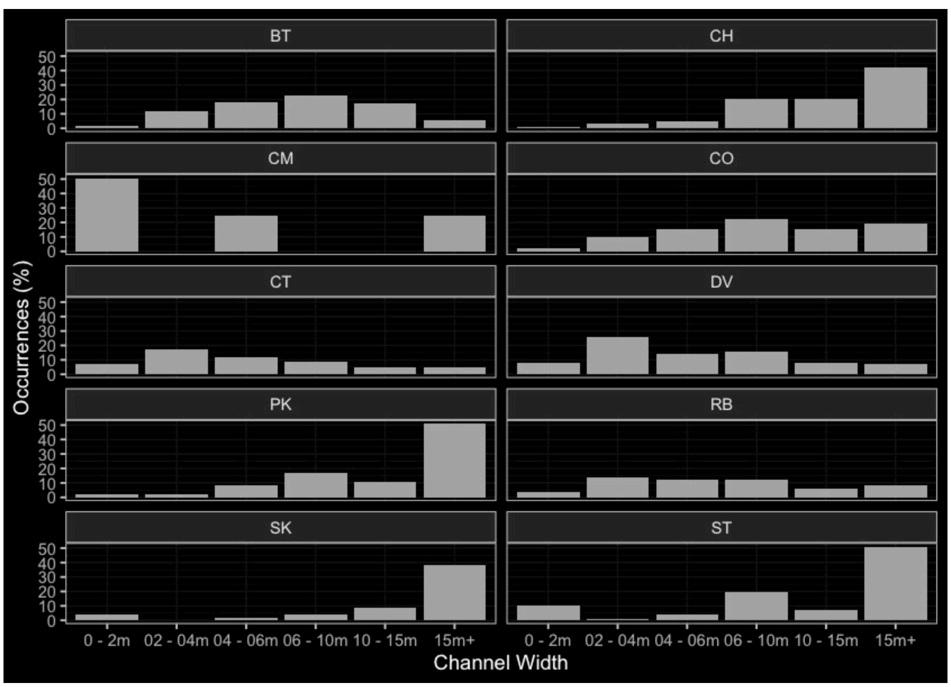

Figure 2.15: Summary of historic salmonid observations vs. channel width category for the Bulkley River watershed group.

2.8 Fisheries

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 Collaborative GIS Environment

Geographical Information Systems are essential for developing and communicating restoration plans as well as the reasons they are required and how they are developed. Without the ability to visualize the landscape and the data that is used to make decisions it is difficult to conduct and communicate the need for restoration, the details of past and future plans as well as and the potential results of physical works.

To facilitate the planning and implementation of restoration activities a collaborative GIS environment has been established using QGIS served on the cloud using source code kept stored here. This environment is intended to be a space where project team members can access and view and contribute to the amalgamation of background spatial data and the development of restoration as well as monitoring for the project. The collaborative GIS environment allows users to view, edit, and analyze shared up to date spatial data on personal computers in an office setting as well as phones and tablets in the field. At the time of reporting, the environment was being used to develop and share maps, conduct spatial analyses, communicate restoration plans to stakeholders as well as to provide a central place to store methodologies and tools for conducting field assessments on standardized pre-developed digital forms. The platform can also be used to track the progress of restoration activities and monitor changes in the landscape over time helping encourage the record keeping of past and future restoration activities in a coordinated manner.

The shared QGIS project was created using scripts currently kept in `dff-2022` with the precise calls to project creation scripts tracked in the `project_creation_and_permissions.txt` document kept in the main QGIS project directory. Information about how GIS project creation and update scripts function can be viewed here with outcomes of their use summarized below: - download and clip user specified layers from the BC Data Catalougue as well as data layers stored in custom Amazon Web Services buckets for an area of interest defined by a list of watershed groups and load to a geopackage called `background_layers.gpkg` stored in the main directory of the project.
- A project directory is created to hold the spatial data and `QGIS` project information (ie. layer symbology and naming conventions, metadata, etc.). - Metadata for individual project spatial layers is kept in the `rfp_tracking` table within the `background_layers.gpkg` along with tables related to user supplied stream width/gradient inputs to `bcfishpass` to model potentially high value habitat that is accessible to fish species of interest.

3.1.1 Issue Tracking

"Issues" logged on the online github platform are effective ways to track tasks, enhancements, and bugs related to project components. They can be referenced with the scripts, text and actions used to address them by linking documentation to the issues with text comments or programatically through `git` commit messages. Issues for this project are kept here as well as past years repositories which can be found by searches including the keywords "Skeena" and "Bulkley" here.

3.1.2 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 by the Canadian Wildlife Federation (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 ([2020] 2021) using sql and python based shell script libraries to generate a simple model of aquatic habitat connectivity. The model identifies natural barriers (ex. steep gradients for extended distances) and hydroelectric dams to classifying the accessibility upstream by fish (Norris [2020] 2021). 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 2019b) or PSCIS assessment data (MoE 2021) 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 Skeena Watershed 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 2019b). 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 Skeena watershed 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.

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

Variable	Chinook Salmon	Chum Salmon	Coho Salmon	Pink Salmon	Sockeye Salmon	Steelhead
Spawning Gradient Max (%)	4.5	6.5	5.5	6.5	2.5	4.5
Spawning Width Min (m)	4.0	2.1	2.0	2.1	2.0	4.0
Rearing Gradient Max (%)	5.5	–	5.5	–	–	8.5
Rearing Width Min (m)	1.5	–	1.5	–	1.5	1.5

Variable	Bull Trout	Chinook Salmon	Coho Salmon	Steelhead
Spawning Gradient Max (%)	5.5	4.5	5.5	4.5
Spawning Width Min (m)	2	4	2	4
Rearing Gradient Max (%)	10.5	5.5	5.5	8.5

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

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

3.2 Fish Passage Assessments

In the field, crossings prioritized for follow-up were first assessed for fish passage following the procedures outlined in “Field Assessment for Determining Fish Passage Status of Closed Bottomed Structures” (BC Ministry of Environment 2011). 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 34)), a culvert fix and recommended diameter/span was proposed.

Table 3.4: Table 3.5: 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 BC Ministry of Environment (2011). 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 3.6, Table 3.7. 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 3.6: 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 3.7: 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 3.6), 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 (2020) 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 BC Ministry of Environment (2011) and included:

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

Cost estimates for structure replacement with bridges and embedded culverts were generated based on the channel width, slope of the culvert, depth of fill, road class and road surface type. Road details were sourced from FLNRORD (2020b) and FLNRORD (2020a) through `bcfishpass`. Interviews with Phil MacDonald, Engineering Specialist FLNR - Kootenay, Steve Page, Area Engineer - FLNR - Northern Engineering Group and Matt Hawkins - MoTi - Design Supervisor for Highway Design and Survey - Nelson were utilized to helped refine estimates.

Base costs for installation of bridges on forest service roads and permit roads with surfaces specified in provincial GIS road layers as rough and loose was estimated at $25000/linear m and assumed that the road could be closed during construction and a minimum bridge span of 15m. For streams with channel widths <2m, embedded culverts were reported as an effective solution with total installation costs estimated at $50k/crossing (pers. comm. Phil MacDonald, Steve Page) adjusted for inflation. 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 3.8) should be considered very approximate with refinement recommended for future projects.

Table 3.8: Cost multiplier table based on road class and surface type.

Class	Surface	Class Multiplier	Surface Multiplier	Bridge $K/10m	Streambed Simulation $K
FSR	Rough	1	1	300	100
FSR	Loose	1	1	300	100
Resource	Loose	1	1	300	100
Permit	Unknown	1	1	300	100
Permit	Loose	1	1	300	100
Unclassified	Loose	1	1	300	100
Unclassified	Rough	1	1	300	100
Unclassified	Paved	1	2	500	150
Unclassified	Unknown	1	2	500	150
Local	Loose	4	1	1000	200
Local	Paved	4	2	2000	400
Arterial	Paved	15	2	7500	1500
Highway	Paved	15	2	7500	1500
Rail	Rail	15	2	7500	1500

3.3 Climate Change Risk Assessment

In collaboration with the Ministry of Transportation and Infrastructure (MoTi), a new climate change replacement program aims to prioritize vulnerable culverts for replacement (pers. comm Sean Wong, 2022) based on data collected and ranked related to three categories - culvert condition, vulnerability and priority. Within the "condition" risk category - data was collected and crossings were ranked based on erosion, embankment and blockage issues. The "climate" risk category included ranked assessments of the likelihood of both a flood event affecting the culvert as well as the consequence of a flood event affecting the culvert. Within the "priority" category the following factors were ranked - traffic volume, community access, cost, constructability, fish bearing status and environmental impacts (Table 3.9). This project is still in its early stages with methodology changes likely going forward.

Table 3.9: Climate change data collected at MoTi culvert sites

Parameter	Description
erosion_issues	Erosion (scale 1 low - 5 high)
embankment_fill_issues	Embankment fill issues 1 (low) 2 (medium) 3 (high)
blockage_issues	Blockage Issues 1 (0-30%) 2 (>30-75%) 3 (>75%)
condition_rank	Condition Rank = embankment + blockage + erosion
condition_notes	Describe details and rational for condition rankings
likelihood_flood_event_affecting_culvert	Likelihood Flood Event Affecting Culvert (scale 1 low - 5 high)
consequence_flood_event_affecting_culvert	Consequence Flood Event Affecting Culvert (scale 1 low - 5 high)
climate_change_flood_risk	Climate Change Flood Risk (likelihood x consequence) 1-6 (low) 6-12 (medium) 10-25 (high)
vulnerability_rank	Vulnerability Rank = Condition Rank + Climate Rank
climate_notes	Describe details and rational for climate risk rankings
traffic_volume	Traffic Volume 1 (low) 5 (medium) 10 (high)
community_access	Community Access - Scale - 1 (high - multiple road access) 5 (medium - some road access) 10 (low - one road access)
cost	Cost (scale: 1 high - 10 low)
constructability	Constructibility (scale: 1 difficult -10 easy)
fish_bearing	Fish Bearing 10 (Yes) 0 (No) - see maps for fish points
environmental_impacts	Environmental Impacts (scale: 1 high -10 low)
priority_rank	Priority Rank = traffic volume + community access + cost + constructability + fish bearing + environmental impacts
overall_rank	Overall Rank = Vulnerability Rank + Priority Rank

3.4 Habitat Confirmation Assessments

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

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

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

3.5 Reporting

Reporting was generated with `bookdown` (Yihui [2015] 2024) from `Rmarkdown` (Allaire et al. [2014] 2023) with primarily `R` (R Core Team 2022) and `SQL` scripts. The `R` package `fpr` contains many specialized custom functions related to the work (Allan Irvine [2022] 2022). In addition to numerous spatial layers sourced through the BC Data Catalogue then stored and queried in a local `postgresql` and `sqlite` databases data inputs for this project include:

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

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

3.6 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 Collaborative GIS Environment

In addition to numerous layers documenting fieldwork activities since 2020, a summary of background information spatial layers and tables loaded to the collaborative GIS project (sern_skeena_2023) at the time of writing (2024-06-27) are included online here

4.2 Phase 1 - Fish Passage Assessemnts

Field assessments were conducted between September 12, 2023 and September 27, 2023 by Allan Irvine, R.P.Bio. and Mateo Winterscheidt, B.Sc., Tieasha Pierre, Vern Joseph and Jesse Olson. A total of 43 Fish Passage Assessments were completed at 53 sites. Although the focus of Fish Passage Assessment sites in 2023 was within areas adjacent to the Skeena River from Hazelton to Terrace (Kispiox River and Kitsumkalum River watershed groups), numerous sites were also assessed throughout other areas of the Kispiox, Zymoetz, Bulkley and Morice River watershed groups.

Of the 53 sites where fish passage assessments were completed, `r 43 were not yet inventoried in the PSCIS system. This included 2 crossings considered "passable", 5 crossings considered "potential" barriers and 34 crossings considered "barriers" according to threshold values based on culvert embedment, outlet drop, slope, diameter (relative to channel size) and length (BC Ministry of Environment 2011). Additionally, although all were considered fully passable, 2 crossings assessed were fords and ranked as "unknown" according to the provincial protocol.

Reassessments were completed at 10 sites where PSICS data required updating.

A summary of crossings assessed, a rough cost estimate for remediation and a priority ranking for follow up for Phase 1 sites is presented in Table 4.1. Detailed data with photos are presented in [Attachment 2](https://www.newgraphenvironment.com/fish_passage_skeena_2023_reporting/appendix---phase-1-fish-passage-assessment-data-and-photos.html.

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

Shaw et al. 2016; Mahlum et al. 2014; Kemp and O'Hanley 2010). Washington Department of Fish & Wildlife (2009) present criteria for assigning passability scores to culverts that have already been assessed as barriers in coarser level assessments. These passability scores provide additional information to feed into decision making processes related to the prioritization of remediation site candidates and have potential for application in British Columbia.

Table 4.1: Upstream habitat estimates and cost benefit analysis for Phase 1 assessments conducted on sites not yet inventoried in PSCIS. Steelhead network model (total length stream network <20% gradient).

PSCIS ID	External ID	Stream	Road	Result	Habitat value	Stream Width (m)	Priority	Fix	Cost Est ($K)
58067	–	Gramophone Creek	Telkwa High Rd	Barrier	High	6.1	high	OBS	–
123377	–	Thompson Creek	Walcott Rd	Barrier	High	4.1	high	OBS	–
124500	–	Helps Creek	Lawson Rd	Barrier	Medium	3.2	mod	OBS	–
197365	–	Tributary to Owen Creek	Morice-Owen FSR	Barrier	Low	1.5	low	SS-CBS	100
197640	–	Tributary to Buck Creek	Buck Flats Rd	Barrier	High	4.2	high	OBS	–
198215	–	Dale Creek	Date Creek FSR	Barrier	High	4.2	high	OBS	1800
198217	–	Tributary to Skeena River	Sik-e-dakh Water Tower Rd	Barrier	High	4.5	high	OBS	–
198225	–	Sterritt Creek	Babine Slide FSR	Barrier	Medium	4.1	mod	OBS	450
198906	8300003	Chicago Creek	Highway 16	Barrier	High	3.9	high	OBS	13500
198907	8300013	Gershwin Creek	Braucher Rd	Barrier	Low	2.1	low	OBS	1500
198908	8300091	Tributary to Skeena River	Aldous St	Barrier	Medium	3.1	mod	OBS	–
198909	8300094	Comeau Creek	Highway 16	Barrier	Low	0.9	low	SS-CBS	1500
198910	8300157	Shandilla Creek	Highway 16	Barrier	High	5.8	high	OBS	13500
198911	8300756	Tributary to Skeena River	Highway 16	Barrier	Medium	2.4	mod	SS-CBS	1500
198912	8300759	Tributary to Chicago Creek	Highway 16	Potential	Medium	2.3	low	OBS	11250
198913	8300872	Tributary to Gershwin Creek	Highway 16	Barrier	High	4.1	high	OBS	11250

PSCIS ID	External ID	Stream	Road	Result	Habitat value	Stream Width (m)	Priority	Fix	Cost Est ($K)
198915	8302868	Chicago Creek	Railway	Barrier	High	5.0	high	OBS	26625
198916	8302869	Gershwin Creek	Railway	Barrier	High	4.5	high	OBS	26625
198917	8800020	Tributary to Skeena River	Cedarvale Rd	Potential	Low	1.0	low	SS-CBS	400
198918	8800026	Singlehurst Creek	Highway 16	Barrier	High	5.7	high	OBS	18000
198919	8800047	Singlehurst Creek	Singlehurst Rd	Barrier	High	4.6	high	OBS	1500
198920	8800056	Noble Five Creek	Highway 16	Barrier	Medium	2.1	mod	OBS	15750
198921	8800070	Fall Creek	Highway 16	Barrier	High	5.6	high	OBS	11250
198922	8800072	Tributary to Skeena River	Highway 16	Barrier	Medium	6.4	mod	OBS	11250
198923	8800076	Flint Creek	Highway 16	Barrier	High	6.8	high	OBS	22500
198924	8800130	Tributary to Skeena River	Highway 16	Barrier	Low	1.6	low	SS-CBS	1500
198925	8800140	Tributary to Skeena River	Highway 16	Potential	Low	8.0	low	OBS	11250
198926	8800144	Tributary to Skeena River	Highway 16	Barrier	Low	0.6	low	SS-CBS	1500
198927	8800149	Tributary to Skeena River	Highway 16	Barrier	Medium	10.0	mod	OBS	13500
198928	8801343	Tributary to Skeena River	Highway 16	Potential	Low	1.7	low	SS-CBS	1500
198930	8801379	Tributary to Skeena River	Highway 16	Barrier	Low	6.8	low	OBS	13500
198931	8801406	Tributary to Skeena River	Highway 16	Barrier	Medium	1.5	mod	SS-CBS	1500
198932	8801409	Tributary to Skeena River	Highway 16	Barrier	Medium	2.7	mod	OBS	11250
198934	14000571	Tributary to Houston Tommy Creek	Spur	Barrier	High	2.8	high	SS-CBS	100
198935	14000575	Tributary to Knapper Creek	Gold Creek FSR	Barrier	High	2.2	high	OBS	–
198936	14000637	Tributary to Morice River	Gold Creek FSR	Barrier	Medium	2.0	mod	OBS	630
198937	14000638	Tributary to Morice River	Gold Creek FSR	Barrier	Medium	1.7	mod	SS-CBS	100
198938	14000707	Wrinch Creek	Morice-Owen FSR	Barrier	Medium	1.5	mod	SS-CBS	100
198939	14000708	Emil Creek	Morice-Owen FSR	Potential	High	2.5	mod	OBS	450
198940	14000855	Tributary to Knapper Creek	Knapper Rd	Barrier	High	1.9	high	SS-CBS	100
198941	14001105	Tributary to Houston Tommy Creek	Holland Rd	Barrier	Low	0.8	low	SS-CBS	100

PSCIS ID	External ID	Stream	Road	Result	Habitat value	Stream Width (m)	Priority	Fix	Cost Est ($K)
198944	24601268	Tributary to Zymoetz River	Dennis West FSR	Barrier	Low	1.1	low	SS-CBS	100
198946	24601279	Tributary to McDonell Lake	Dennis West FSR	Barrier	Low	0.8	low	SS-CBS	100
198947	24601280	Tributary to Zymoetz River	Dennis West FSR	Barrier	Medium	1.8	mod	SS-CBS	100
198948	2023092701	Tributary to Tagit Creek	9946-27 Rd	Barrier	Low	1.2	low	SS-CBS	–

4.3 Phase 2 - Habitat Confirmation Assessments

During 2023 field assessments, habitat confirmation assessments were conducted at seven sites in the Morice River and Zymoetz River watershed groups. A total of approximately 9km of stream was assessed, fish sampling utilizing electrofishing surveys were conducted at four of the subject habitat confirmation streams. 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. Results are summarized in Tables 4.2 - 4.3 with raw habitat and fish sampling data included in digital format here. A summary of preliminary modelling results illustrating the estimated 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 4.1. Detailed information for each site assessed with Phase 2 assessments (including maps) are presented within site specific appendices to this document.

Table 4.2: Overview of habitat confirmation sites. Steelhead rearing model used for habitat estimates (total length of stream segments <7.5% gradient)

PSCIS ID	Stream	Road	UTM (9U)	Fish Species	Habitat Gain (km)	Habitat Value	Priority	Comments
8478	Tributary to McDonell Lake	Dennis West FSR	590065 6069867	DV	0.0	Medium	moderate	Steep system with high flow and periodic cascades (<1m in height). Few deep pools and areas with suitable spawning gravels. Approximately 400m upstream of FSR steam gradients increase to 20%

PSCIS ID	Stream	Road	UTM (9U)	Fish Species	Habitat Gain (km)	Habitat Value	Priority	Comments
Dolly varden captured with some fish showing deteriorating purple gill plates and unusual round black spots. 14:25:27								
8525	Tributary to Coal Creek	McDonell FSR	580998 6074681	DV	0.9	Medium	moderate	Moderate value habitat. Abundant gravel throughout. Isolated pools are consistent every 30 to 50 m and up to 55 cm in depth. This is a wetland type fern and alder dominated gully with mature spruce riparian. Dolly Varden captured. 12:49:28
8543	Tributary to McDonell Lake	McDonell Lake FSR	592142 6072357	DV;RB	0.0	Low	low	Moderate to low value habitat. Stream is mostly dewatered but with isolated pools to 60 cm deep spaced every 30 to 40 m. Stream is entrenched in the valley with large amounts of mobile angular cobbled substrate throughout. Fish observed in multiple isolated pools up to 300 m upstream of the crossing. No permanent Natural barriers observed. 10:35:09
8547	Tributary to McDonell Lake	McDonell Lake FSR	589988 6072657	–	0.0	Medium	moderate	Small channel. with moderate flows. Very few areas with gravels suitable for resident salmonid spawning. Few deep pools. Frequent functional woody debris creating complexity. Electrofishing conducted. 10:41:30
197949	Tributary to Tagit Creek	Spur	614404 6010346	CT	1.1	Medium	moderate	Riparian vegetation consists of mostly deciduous young saplings. Some older vegetation (alder) present as well creating abundant overhanging cover. Small channel with low flows and occasional dewatered patches. Fish spotted approximately 500m upstream of culvert (~80mm length). Some gravels present suitable for spawning. Occasional undercut banks. Very few deep pools at time of survey. 11:21:38
198022	Tributary to Tagit Creek	9946-27 Rd	614703 6009976	CT	1.6	Medium	moderate	Moderate value habitat. Site surveyed from upper crossing down to lower crossing. Stream is dewatered approximately 75 m

PSCIS ID	Stream	Road	UTM (9U)	Fish Species	Habitat Gain (km)	Habitat Value	Priority	Comments
downstream of upstream crossing. Approximately 50m upstream of the road is wetland type area, dominated by willow and sedge. Several fish, approximately 70 mm long, were observed in the outlet pool of the upper crossing. Although primarily dry, the upper part of the site beyond the wetland area contained abundant gravels. Residual pools were dry except some shallow ones near the top end of the site when gradients were greater. 10:54:14								
198934	Tributary to Houston Tommy Creek	Spur	631703 6017418	DV;RB	4.6	Medium	moderate	Medium value habitat. Surveyed to raod upsteram and PSCIS crossing 198942. Approximately 30 m high and 30 m long landslide at edge of clear cut on left bank 300m downstream of top road. Below the landslide sediments have led to sub surface flows with isolated deep pools for a section approximately 300m long. Abundant gravels throughout. Sparse pools but likely deep enough for overwintering. Fish observed at culvert outlet at top end of site. 10:47:07
198942	Tributary to Houston Tommy Creek	Holland Rd	631508 6018096	RB	3.7	Medium	moderate	Small channel with moderate flow. Fish sampling conducted in outlet pool of culvert. Medium habitat value. Abundant gravels suitable for spawning. Few deep pools for resident overwintering. Stream forks ~200m upstream of the culvert but the channel size remained similiar. West fork of stream assessed. Large cutblock 50m north of stream, and a quad bridge (no modelled crossing) present at cut block. Undercut banks are present in most sections of stream. Rainbow trout point upstream of fork ~1.1km. 10:44:37
198947	Tributary to Zymoetz River	Dennis West FSR	597637 6070211	–	0.0	Medium	moderate	Moderate value habitat. Upon a gravel is present suitable for dolly Varden spawning. Occasional pools to 0.3 and 0.35m deep. Good flow on dry year. Fish observed downstream in outlet pool. No card filled out.17:33:59

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
8478	No	0.20	1.9	1.3	4	12	31	Barrier
8525	No	0.50	0.9	2.1	1	28	34	Barrier
8543	No	0.50	1.2	1.5	3	14	36	Barrier
8547	No	0.70	0.9	2.1	3	20	39	Barrier
197949	No	0.50	1.2	1.9	2	14	31	Barrier
198022	No	0.00	1.0	2.4	2	14	21	Barrier
198934	No	0.70	1.6	2.1	4	18	39	Barrier
198942	No	0.10	1.2	1.6	1	14	21	Barrier
198947	No	0.18	0.6	3.2	5	18	34	Barrier

Table 4.4: Cost benefit analysis for Phase 2 assessments. Steelhead rearing model used (total length of stream segments <7.5% gradient)

PSCIS ID	Stream	Road	Result	Habitat value	Stream Width (m)	Fix	Cost Est (in $K)	Habitat Upstream (m)	Cost Benefit (m / $K)	Cost Benefit (m2 / $K)
8478	Tributary to McDonell Lake	Dennis West FSR	Barrier	Medium	2.5	OBS	450	0	0.0	0.0
8525	Tributary to Coal Creek	McDonell FSR	Barrier	Medium	1.9	SS-CBS	100	866	8660.0	8227.0
8543	Tributary to McDonell Lake	McDonell Lake FSR	Barrier	Low	3.2	SS-CBS	100	0	0.0	0.0
8547	Tributary to McDonell Lake	McDonell Lake FSR	Barrier	Medium	1.9	SS-CBS	100	0	0.0	0.0
197949	Tributary to Tagit Creek	Spur	Barrier	Medium	2.3	OBS	450	1083	2406.7	2767.7
198022	Tributary to Tagit Creek	9946-27 Rd	Barrier	Medium	2.5	OBS	450	1590	3533.3	4240.0
198934	Tributary to Houston Tommy Creek	Spur	Barrier	Medium	3.3	SS-CBS	100	4557	45570.0	75190.5
198942	Tributary to Houston Tommy Creek	Holland Rd	Barrier	Medium	1.9	SS-CBS	100	3694	36940.0	35093.0
198947	Tributary to Zymoetz River	Dennis West FSR	Barrier	Medium	1.8	SS-CBS	100	0	0.0	0.0

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
8478	400	2.5	1.8	0.5	10.0	moderate	Medium
8525	600	1.9	1.7	0.4	1.4	moderate	Medium
8525	105	2.0	1.5	0.2	2.5	moderate	Medium
8543	450	3.2	1.2	0.4	5.9	trace	Low
8547	500	1.9	1.2	0.4	5.6	moderate	Medium
197949	550	2.3	1.0	0.4	6.8	abundant	Medium
198022	500	2.5	0.3	0.2	3.8	moderate	Medium
198934	850	3.3	1.7	0.5	5.5	moderate	Medium
198942	650	1.9	1.5	0.4	3.8	abundant	Medium
198947	300	1.8	1.2	0.3	7.0	moderate	Medium

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

Site	Area Km	Elev Site	Elev Max	Elev Median	Elev P60	Aspect
197949	4.0	834	1379	1083	1034	S
198022	4.0	815	1379	1083	1034	S
198934	11.7	826	1336	1012	976	S
198942	11.7	870	1336	1012	976	S
198947	1.6	884	1240	1109	1075	ESE
8478	2.8	940	1710	1269	1233	WSW
8525	1.6	850	1177	1052	1028	SSW
8543	4.6	844	1189	1067	1048	S
8547	2.2	937	1177	1086	1069	SW

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

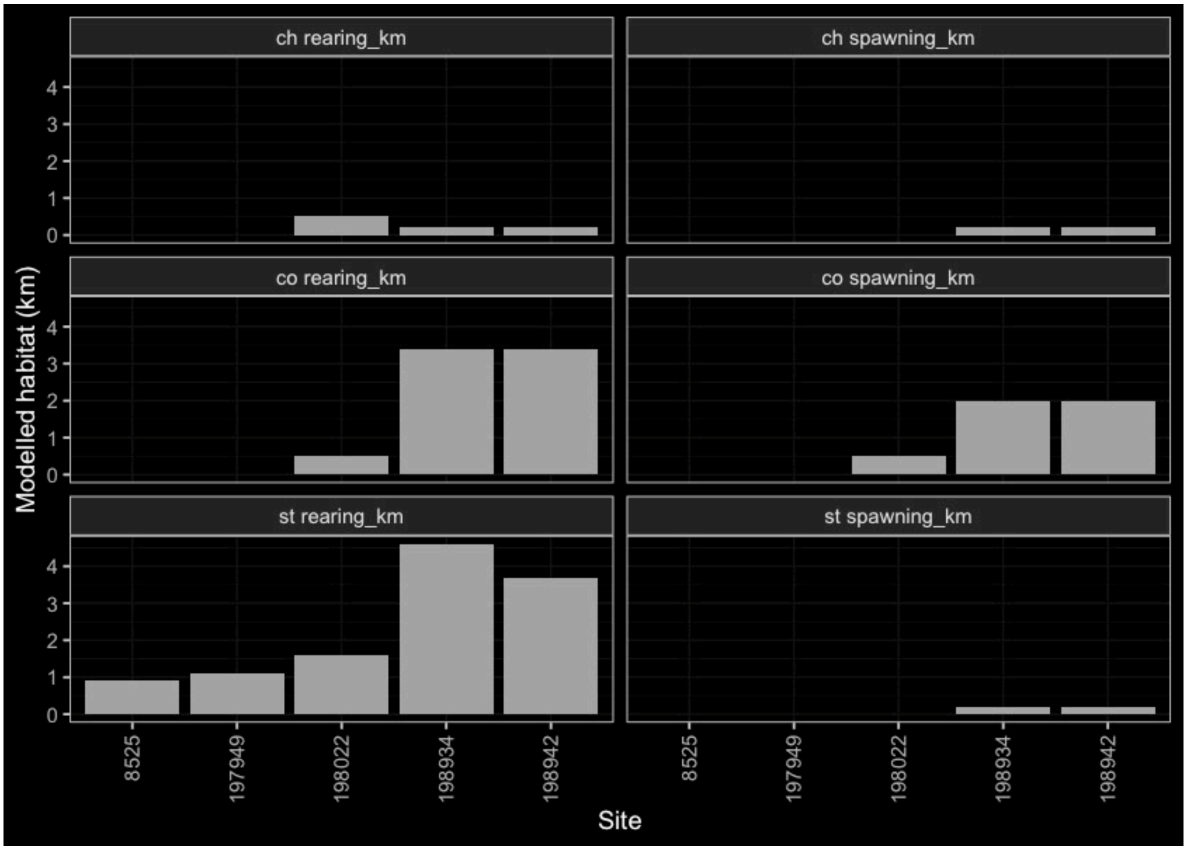

Figure 4.1: Summary of potential habitat upstream of habitat confirmation assessment sites estimated based on modelled channel width and upstream channel length.

4.3.1 Fish Sampling

Fish sampling was conducted at 49 sites within 10 streams a total of 416 fish captured. At all electrofishing sitesm, salmonids with fork lengths >60mm were tagged with PIT tags to facitate the tracking of health and movement over time. 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 4.2. 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 4.3. Results are presented in greater detail within individual habitat confirmation site appendices.

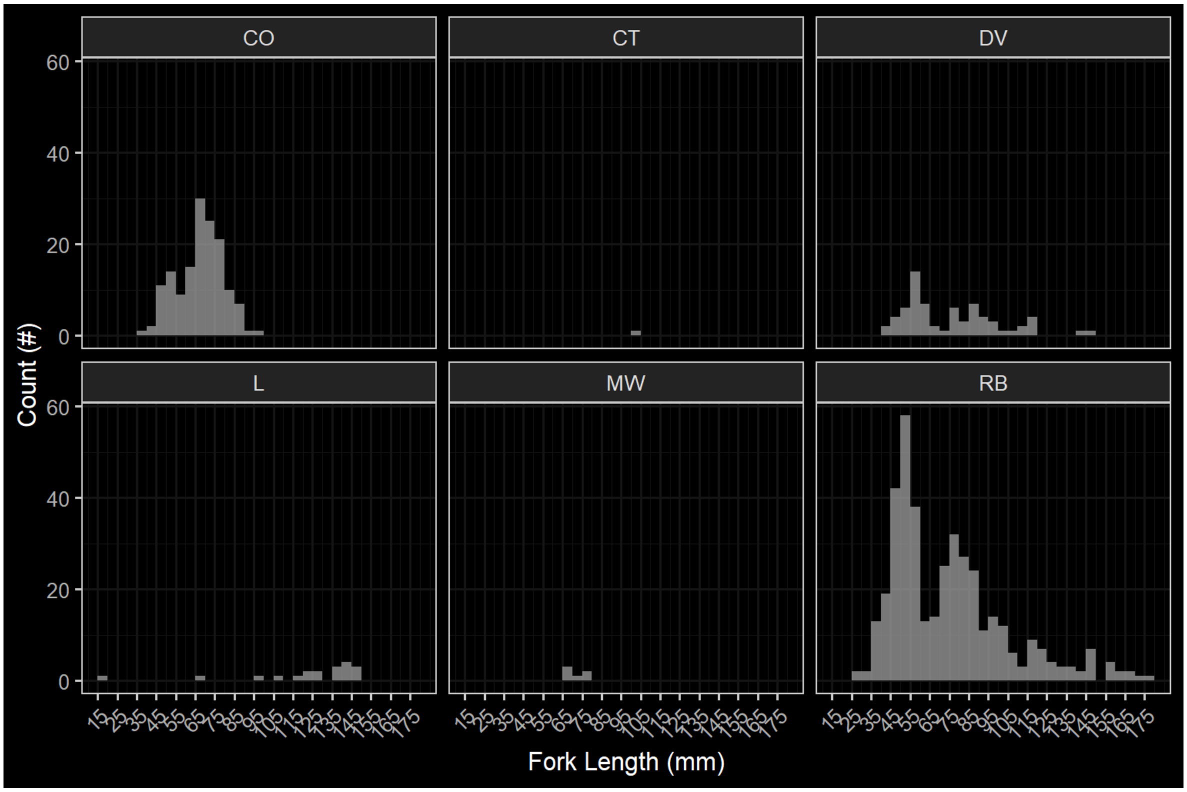

Figure 4.2: Histograms of fish lengths by species. Fish captured by electrofishing during habitat confirmation assessments.

Table 4.7: Summary of electrofishing sites.

site	passes	ef_length_m	ef_width_m	area_m2	enclosure
123377_ds_ef1	1	9	2.35	21.2	Closed
123377_ds_ef2	1	8	2.47	19.8	Closed
123377_ds_ef3	1	8	2.80	22.4	Closed
123377_ds_ef4	1	9	2.35	21.2	Closed
123377_ds_ef5	1	8	2.47	19.8	Closed
123377_ds_ef6	1	8	2.80	22.4	Closed
123377_us_ef1	1	4	4.40	17.6	Open
123377_us_ef2	1	15	3.20	48.0	Open
123377_us_ef3	1	8	2.35	18.8	Open
124500_ds_ef1	1	12	2.70	32.4	Open
124500_ds_ef2	1	13	2.53	32.9	Open
124500_ds_ef3	1	16	1.98	31.7	Open
124500_us_ef1	1	7	2.87	20.1	Open
124500_us_ef2	1	3	4.23	12.7	Open
124500_us_ef3	1	11	2.00	22.0	Open
197360_ds_ef1	1	4	3.38	13.5	Open
197360_us_ef1	1	12	1.45	17.4	Open
197378_ds_ef1	1	7	3.00	21.0	Open

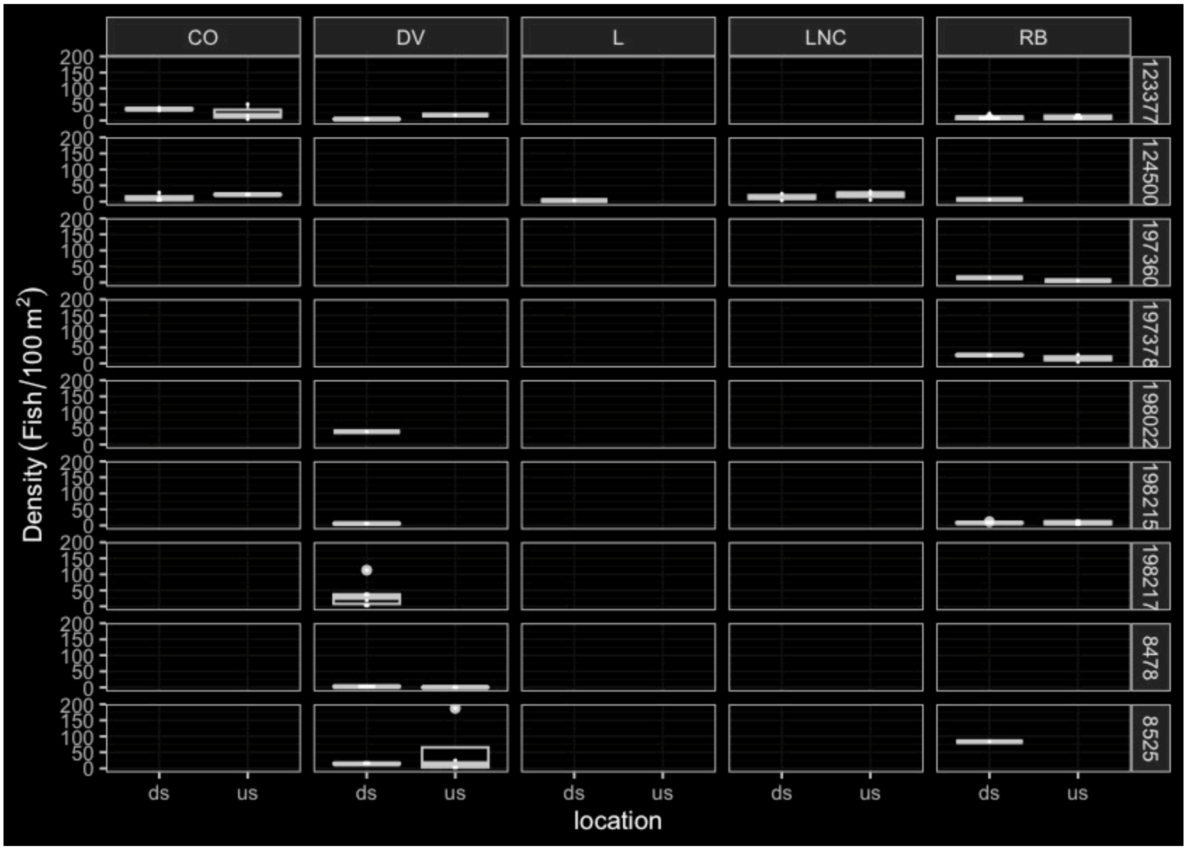

Figure 4.3: Boxplots of densities (fish/100m2) of fish captured by electrofishing during habitat confirmation assessments.

4.4 Phase 3 - Design

At the time of reporting, designs for remediation of fish passage had been completed for the following sites listed by watershed group:

4.4.1 Bulkley River

- McDowell Creek - PSCIS 58159 - Private Road. Design for clear-span bridge completed in 2021 Onsite Engineering with funding provided through this program. Background presented here.
- Tyhee Creek - PSCIS 123445 - Highway 16. Preliminary design commissioned from Pacific North Coast Consulting by Canadian Wildlife Federation. Background presented here.
- Helps Creek - PSCIS 124500 - Lawson Road. Background presented here.
- Thompson Creek - 123377 - Walcott Road. At the time of reporting, geotechnical assessments were underway from consultants under contract to the Ministry of Transportation and Infrastructure to inform the design of the replacement structure. Background presented here.
- Tributary to Buck Creek - PSCIS 197640 - Buck Flats Road. Preliminary design commisioned from Pacific North Coast Consulting by Canadian Wildlife Federation. Background presented here.

- Station Creek (also know as Mission Creek) - PSCIS 124420. Preliminary design commisioned from Pacific North Coast Consulting by Canadian Wildlife Federation. Background presented here.
- Tributary to Skeena River - PSCIS 198217 - Sik-E-Dakh Water Tower Road. Design for clear-span bridge completed in 2023 by Onsite Engineering with funding provided through this program. Background information here

4.4.2 Morice River

- Riddeck Creek - PSCIS 197360 - Morice-Owen FSR. Design developed by consultants under contract to the Ministry of Water, Lands and Resource Stewardship. Some materials have been purchased for construction and the site has been incorporated into the Bii Wenii Kwa Restoration/Recovery Plan lead by the Office of the Wet'suwet'en. Background presented here.
- Alvin Creek - PSCIS 197379 - Morice-Owen FSR (km 29.8). Design developed by Mark Dewitt from the Ministry of Forests. Background presented here. the site has been incorporated into the Bii Wenii Kwa Restoration/Recovery Plan lead by the Office of the Wet'suwet'en.

4.4.3 Kispiox River

- Tributary to Skeena River - PSCIS 198217 - Sik-E-Dakh Water Tower Road. Background information here

4.5 Phase 4 - Remediations

Remediation of fish passage has been completed at the following sites (listed by watershed group):

4.5.1 Bulkley River

- McDowell Creek - 58159 - Private Road. Replaced with a clear-span bridge in 2022 with remediation work led by the Canadian Wildlife Federation. Background presented here.
- Robert Hatch Creek - 197912 - Unnamed Road. Removal of the collapsed bridge in 2022 with remediation work led by the Canadian Wildlife Federation. Background presented here.

4.5.2 Kispiox River

- Tributary to Skeena River - 198217 - Sik-E-Dakh Water Tower Road. Replacement of the crossing with a clear-span bridge in 2024 with remediation work led by the Gitskan Watershed Authorities. Background information - updated in 2024 - here

4.6 Monitoring

Ten sites where habitat confirmations were conducted in the past were revisited in 2023 to gather data to further inform prioritization and or to provide data for effectiveness monitoring. Below are sites visited (listed by watershed group) with details of data collected and links to reporting provided.

4.6.1 Bulkley River

- Tributary to Buck Creek - PSCIS 197640 - Buck Flats Road. Revisited with the intention to conduct fish sampling however the stream was primarily dry with water present only within a small culvert outlet pool. The culvert was reassessed for fish passage with results presented here.

- Helps Creek - PSCIS 124500 - Lawson Road. Electrofishing was conducted above and below the crossing and fish over 60mm were tagged with PIT tags so that their movement and health can be tracked over time. Aerial imagery was also collected utilizing an unmanned aerial vehicle. Results are presented here.

- Thompson Creek - PSCIS 123377 - Walcott Road. Electrofishing was conducted above and below the crossing and fish over 60mm were tagged with PIT tags so that their movement and health can be tracked over time. Aerial imagery was also collected utilizing an unmanned aerial vehicle. Results are presented here.

- Gramophone Creek - PSCIS 58067 - Telkwa High Road. The site was revisited to scope for downstream barriers with the entire length of stream between Telkwa High Road and the Bulkley River surveyed. A canyon was discovered approximately 600m from the Bulkley River and dip nettting was conducted below. Results are presented here.

4.6.2 Morice River

All sites below have been incorporated into the Bii Wenii Kwa Restoration/Recovery Plan lead by the Office of the Wet'suwet'en.

- Riddeck Creek - PSCIS 197360 - Morice-Owen FSR. Electrofishing was conducted above and below the crossing and fish over 60mm were tagged with PIT tags so that their movement and health can be tracked over time. Results are presented here.

- Alvin Creek - PSCIS 197379 - Morice-Owen FSR (km 29.8). Revisited with the intention to conduct fish sampling however the stream was primarily dry with water present only within a small culvert outlet pool. Areas electrofished in 2022 were surveyed with PIT tag reader to scope for tags from potential mortalities related to the dewatering. Results are presented here.

- Tributary to Owen Creek - PSCIS 197378 - Klate lake Road. Electrofishing was conducted above and below the crossing and fish over 60mm were tagged with PIT tags so that their movement and health can be tracked over time. Aerial imagery was also collected utilizing an unmanned aerial vehicle. Results are presented here

4.6.3 Kispiox River

- Tributary to Skeena River - PSCIS 198217 - Sik-E-Dakh Water Tower Road. Prior to replacement of the crosssing in the spring of 2024, electrofishing was conducted above and below the crossing and fish over 60mm were tagged with PIT tags so that their movement and health can be tracked over time. Additionally, lidar imagery was also collected utilizing an unmanned aerial vehicle. Aerial imagery and lidar data were collected with a drone. Results are presented here.

- Dale Creek - PSCIS 198215 - Kispiox Westside Road. Electrofishing was conducted above and below the crossing and fish over 60mm were tagged with PIT tags so that their movement and health can be tracked as part of effectiveness monitoring at the site. Results are presented here.
- Sterritt creek - 198225 - Babine Slide FSR. Revisited with the intention to conduct fish sampling however, before sampling was conducted surveyors observed a 2 - 3m high near vertical cascade flowing over bedrock into the small culvert outlet pool immediately below the FSR. It was decided to not proceed with electrofishing as replacement of the culvert with a bridge would not facilitate upstream fish migration. Results are presented here.

5 Recommendations

Recommendations for potential incorporation into collaborative watershed connectivity planning include:

- Continue to work with Gitskan Watershed Authorities (GWA) to prioritize and implement another fish passage restoration project in 2025. Learnings from the successful replacement of crossing 198217 on a tributary to the Skeena River on Sik-e-dakh Water Tower Road adjacent to the community of Glen Vowell can now be applied to the Zymoetz River watershed group leveraging further funding acquired by GWA for replacement of a crossing in 2025. At the time of reporting several crossings have been identified as potential candidates for replacement with funding for engineering design earmarked from this year's fiscal dollars. At the time of reporting several crossings have been identified as potential candidates for replacement including Sandstone Creek as well as the tributaries to Coal Creek and McDonell Lake detailed in the results of this year's reporting.

- Refine climate change risk collection metrics with GIS and remote sensing to provide more quantitative metrics of risk, leveraging advancements from other Ministry of Transportation and Infrastructure team efforts and incorporating outputs (ex. discharge) from modelling using climate change scenarios such as those available through the Pacific Climate Impacts Consortium.

- Integrate fish passage restoration planning with other restoration and enhancement initiatives in the region to maximize benefits to fish populations as well as for communities within the Skeena River watershed. This includes working with the Gitskan Watershed Authorities (GWA), Skeena Fisheries Commission, Skeena Wild, Office of Wet'suwet'en, Morice Watershed Monitoring Trust, Fisheries and Oceans Canada, Provincial Regulators, Bulkley Valley Research Centre, Gitxsan Environmental Services, the Environmental Stewardship Initiative (Skeena Sustainability Assessment Forum) and others to leverage funding, knowledge and resources for fish passage restoration towards other projects related to watershed health in the region. Examples of where this is already taking place is leveraging of Morice River watershed group fish passage sites into the Bii Wenii Kwa Restoration/Recovery Plan lead by the Office of the Wet'suwet'en and incorporation of Upper Bulkley River sites into the Neexdzii Kwah Restoration Planning.

- Continue to acquire background information and leverage ongoing research initiatives in the region to collaboratively clarify current conditions and identify limiting factors to inform prioritization and effectiveness monitoring programs.

- Develop strategies to explore cost and fisheries production benefits of stream crossing structure upgrades alongside alternative/additional restoration and enhancement investments such as land conservation/procurement/covenant, cattle exclusion, riparian restoration, habitat complexing, water conservation, commercial/recreational fishing management, water treatment and research. Ideentify and pursue opportunities to collaborate and leverage initiatives together in study area watersheds (ex. fish passage rehabilitation, riparian restoration and cattle exclusion) for maximum likely restoration benefits.

- Refine barrier thresholds for road-stream crossing structures to explore metrics specific to life stage and life history types of species of interest. This will further focus efforts of potential remediation actions based on biological attributes (ex. timing of migration, size/direction of fish migrating, population dynamics, etc.) and could result in the consideration of interim “stop-gap” physical works to alter crossing characteristics that can address key connectivity issues yet be significantly less costly than structure replacements (ex. building up of downstream area with rock riffles to decrease the outlet drop size and/or increasing water depth within pipe with baffles and substrate additions).

- Model fish densities (fish/m^2) vs. habitat/water quality characteristics (i.e. gradient, discharge, alkalinity, elevation, riparian health, distance from high order streams, etc.) using historically gathered electrofishing and remotely sensed geodata to inform crossing prioritization, future data acquisition needs and the monitoring of restoration actions.

- Continue to develop `bcfishpass`,`bcfishobs`, `fwapg`, `bcdata`, `fpr`, `dff-2022` and `rfp` 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.

- As fish density by area can fluctuate greatly with different flow levels we plan to shift towards linear accounting in future years of the study (ie. fish/m vs fish/m2).

Appendix - Climate Change Risk Assessment

Climate change risk assessment data is presented below. Work to date is considered a pilot project with data collected considered preliminary. Data collected are presented online here

Tributary to Tagit Creek - 198022 & 197949 - Appendix

Site Location

PSCIS crossing 198022 and 197949 are located on Tributary to Tagit Creek, which flows in a southeast direction to Tagit Creek, approximately 45km west of Houston, BC within the Morice River watershed group. Crossing 198022 is located 0.2km upstream of Tagit Creek, and crossing 197949 a further 0.5km upstream. Downstream of the crossings, Tagit Creek flows southeast to Chisholm Lake then southwest to the Morice River approximately 5km downstream. Crossing 198022 is located on 9946-27 Rd with road tenure granted to West Fraser Mills Ltd. Crossing 197949 is located on a Spur of 9946-27 Rd and is the responsibility of the Ministry of Forest.

Background

Tributary to Tagit Creek is a second order stream with an upstream watershed area of approximately 4km^2. The elevation of the watershed ranges from a maximum of 1379m to 815m near the lower crossing (Table 5.1).

In 2021, crossings 198022 and 197949 were assessed with fish passage assessments and prioritized for follow up with habitat confirmation assessments (Irvine 2021). Upstream of the crossing 198022, cutthroat trout have been documented in the past (Norris [2018] 2024; MoE 2024b).

Table 5.1: Summary of derived upstream watershed statistics for PSCIS crossing 198022.

Site	Area Km	Elev Site	Elev Max	Elev Median	Elev P60	Aspect
198022	4	815	1379	1083	1034	S

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

A summary of habitat modelling outputs is presented in Table 5.2. A map of the watershed is provided in map attachment 093L.107.

Table 5.2: Summary of fish habitat modelling for PSCIS crossing 198022.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	6.7	0.5	7
ST Lake Reservoir (ha)	0.0	0.0	–

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Slopeclass03 Waterbodies (km)	0.2	0.0	0
ST Slopeclass03 (km)	0.4	0.0	0
ST Slopeclass05 (km)	0.6	0.5	83
ST Slopeclass08 (km)	2.2	0.0	0
ST Spawning (km)	0.0	0.0	–
ST Rearing (km)	1.6	0.5	31
CH Spawning (km)	0.0	0.0	–
CH Rearing (km)	0.5	0.5	100
CO Spawning (km)	0.5	0.5	100
CO Rearing (km)	0.5	0.5	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	0.0	–

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing 198022 and 197949

During the 2023 survey, both crossings were un-embedded, non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Tables 5.3 - 5.4). Crossing 197949 had a 0.5m outlet drop with fish observed in the outlet pool. Water temperature was 6.5°C, pH was 6.9 and conductivity was 267uS/cm.

Table 5.3: Summary of fish passage assessment for PSCIS crossing 198022.

Location and Stream Data	•	Crossing Characteristics	–
Date	2023-09-27	Crossing Sub Type	Round Culvert
PSCIS ID	198022	Diameter (m)	1
External ID	–	Length (m)	14
Crew	AI	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	614703	Resemble Channel	No
Northing	6009976	Backwatered	No
Stream	Tributary to Tagit Creek	Percent Backwatered	–

Stream Characteristics at Crossing 19…

Location and Stream Data	•	Crossing Characteristics	–
Road Tenure	West Fraser Mills Ltd.	Outlet Drop (m)	0
Channel Width (m)	2.4	Outlet Pool Depth (m)	0
Stream Slope (%)	2	Inlet Drop	No
Beaver Activity	Yes	Slope (%)	2
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	21	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	15

Location and Stream Data	Crossing Characteristics	–

Comments: Moderate value habitat. Habitat confirmation conducted on stream, walked from upstream crossing down through wetland type area to culvert. Mostly dewatered besides small section above this crossing and below the upper crossing. Surveyed from upstream to down and ended up on road approximately 40 m to the north. Stream seems to merge with wetland type area just upstream of the road. Fish sampling conducted with dolly varden captured in small (2.5m2) outlet pool. Cutthroat are known to be upstream of crossing.. 12:12:45

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

Table 5.4: Summary of fish passage assessment for PSCIS crossing 197949.

Location and Stream Data	•	**Crossing Characteristics**	**–**
Date	2023-09-27	Crossing Sub Type	Round Culvert
PSCIS ID	197949	Diameter (m)	1.2
External ID	–	Length (m)	14
Crew	MW	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	614404	Resemble Channel	No
Northing	6010346	Backwatered	No
Stream	Tributary to Tagit Creek	Percent Backwatered	–
Road	Spur	Fill Depth (m)	1.2
Road Tenure	MOF 9946	Outlet Drop (m)	0.5
Channel Width (m)	2.3	Outlet Pool Depth (m)	0.6
Stream Slope (%)	2	Inlet Drop	No
Beaver Activity	No	Slope (%)	2
Habitat Value	High	Valley Fill	Deep Fill
Final score	31	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	15

Location and Stream Data	**Crossing Characteristics**

Comments: Numerous fish spotted in outlet pool. Low flow but water present upstream and downstream.. 11:10:01

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

Stream Characteristics at Crossing 19…

Approximately 175m east on , crossing 198948 was also assessed. The crossing was located within the same network of stream channels and wetlands as the other two subject culverts but was not mapped within the Freshwater Atlas. The culvert was noted as rusting through with some blockage of the culvert inlet caused by a beaver dam. Photos and data are presented in Appendix - Phase 1 Fish Passage Assessments.

Stream Characteristics Downstream of Crossing 198022

The stream was surveyed downstream from crossing 198022 for 250m to the confluence with Tagit Creek. The first 100m of stream was noted as contained sporadic pools with a dewatered below. The stream flowed through a steep confined valley to Tagit Creek, where there was a large log jam at the confluence (Figures @ref(fig:photo-198022-d01 - 5.3). Total cover amount was rated as moderate with large woody debris dominant. Cover was also present as small woody debris and overhanging vegetation.The dominant substrate was cobbles with gravels sub-dominant.The average channel width was 1.8m, the average wetted width was 0.2m, and the average gradient was 3%. The habitat was rated as medium value for salmonid rearing and spawning.

Stream Characteristics Upstream of Crossing 198022 and Downstream of Crossing 197949

The stream was surveyed for approximately 500m from the upper crossing 197949 to the lower crossing 198022 (Figure 5.3). Surveyors observed several fish in the outlet pool of the upper crossing. At the top end of the site there were occasional shallow pools and partial dewatering. At a location approximately 75m downstream of crossing 197949 (Spur), the stream dewatered. The dominant substrate was gravels with fines sub-dominant.Total cover amount was rated as moderate with overhanging vegetation dominant. Cover was also present as small woody debris and undercut banks.The average channel width was 2.5m, the average wetted width was 0.3m, and the average gradient was 3.8%. There were abundant gravels present suitable for spawning. Approximatley 300m from the lower crossing, the stream converged with a primarily dry, willow and sedge dominated wetland type area. The habitat was rated as medium for salmonid rearing and spawning.

Stream Characteristics Upstream of Crossing 197949

The stream was surveyed upstream from crossing 197949 for 550m . Flow levels were noted as low with occasional dewatered patches (Figure 5.3). There were few deep pools with fish observed throughout the areas surveyed. Total cover amount was rated as abundant with overhanging vegetation dominant. Cover was also present as small woody debris and large woody debris.The average channel width was 2.3m, the average wetted width was 1m, and the average gradient was 6.8%.The dominant substrate was cobbles with gravels sub-dominant. The habitat was rated as medium value for salmonid rearing and spawning.

Fish Sampling

Electrofishing was conducted above and below crossing 198022 with the upstream site located just below 197949. The results are summarised in Tables 5.6 - 5.7 and Figure 5.1. A total of 17 cutthroat were captured upstream, and 1 dolly varden was captured downstream (Figures 5.4). All fish captured with a fork length greater than 60mm were tagged with Passive Integrated Transponders (PIT tags) with data stored here.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, it is recommended that the crossings are replaced with 15m span bridges. The preliminary cost estimate for each bridge is $450,000.

Conclusion

There was 1.6km of steelhead rearing habitat modelled upstream of crossing 198022 with approximately 500m less modelled upstream of 197949. Electrofishing confirmed the stream provides habitat to cutthroat trout and dolly varden with habitat value rated as medium. The sites were ranked as moderate priorities for replacement.

Table 5.5: Summary of habitat details for PSCIS crossing198022and 197949.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
197949	Upstream	550	2.3	1.0	0.4	6.8	abundant	Medium
198022	Downstream	250	1.8	0.2	–	3.0	moderate	Medium
198022	Upstream	500	2.5	0.3	0.2	3.8	moderate	Medium

Table 5.6: Fish sampling site summary for 198022.

site	passes	ef_length_m	ef_width_m	area_m2	enclosure
198022_ds_ef1	1	2	1.25	2.5	Open
198022_us_ef1	1	4	4.05	16.2	Open

Table 5.7: Fish sampling density results summary for 198022.

local_name	species_code	life_stage	catch	density_100m2	nfc_pass
198022_ds_ef1	DV	juvenile	1	40.0	FALSE
198022_us_ef1	CT	parr	15	92.6	FALSE
198022_us_ef1	CT	juvenile	1	6.2	FALSE
198022_us_ef1	CT	adult	1	6.2	FALSE

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

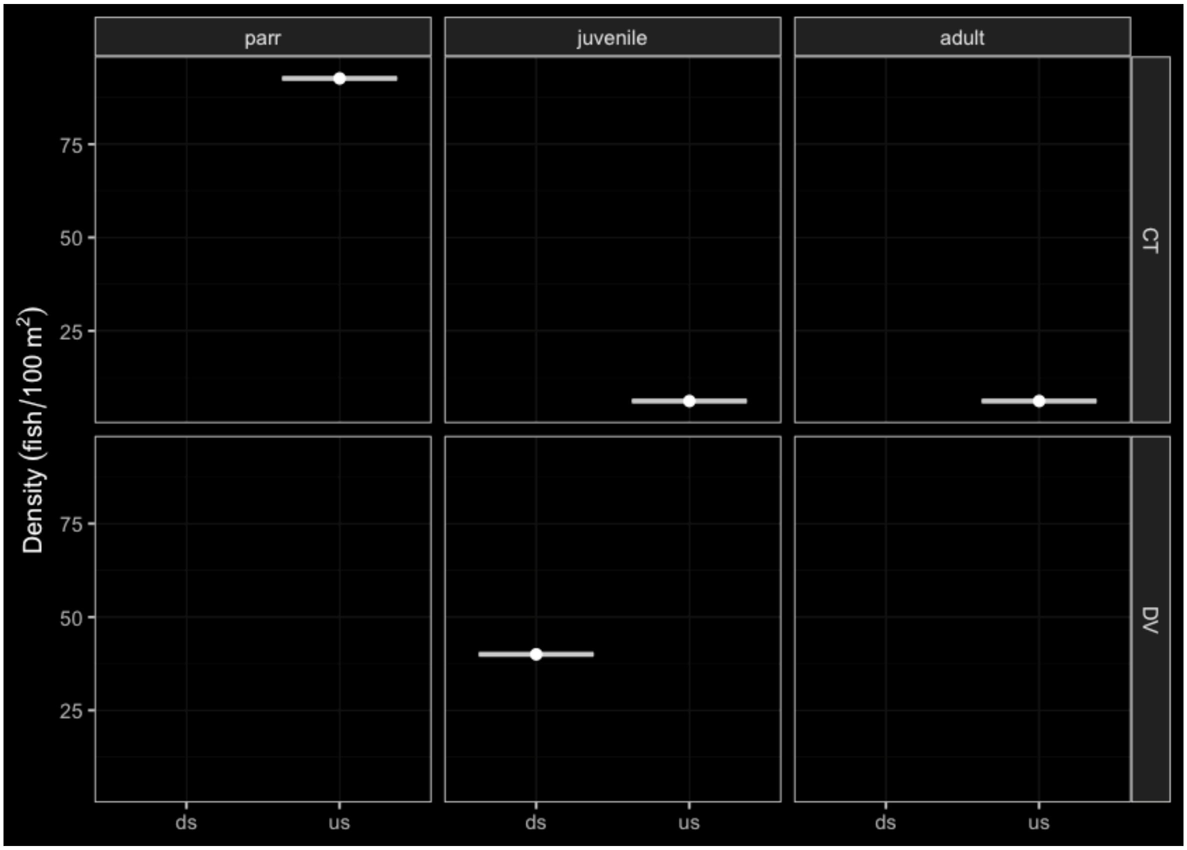

Figure 5.1: Densites of fish (fish/100m2) captured upstream and downstream of PSCIS crossing 198022.

Figure 5.2: Left: Typical habitat downstream of PSCIS crossing 198022. Right: Log jam at the confluence with Tagit Creek.

Figure 5.3: Left: Typical habitat upstream of PSCIS crossing 198022 and downstream of crossing 197949. Right: Typical habitat upstream of PSCIS crossing 197949.

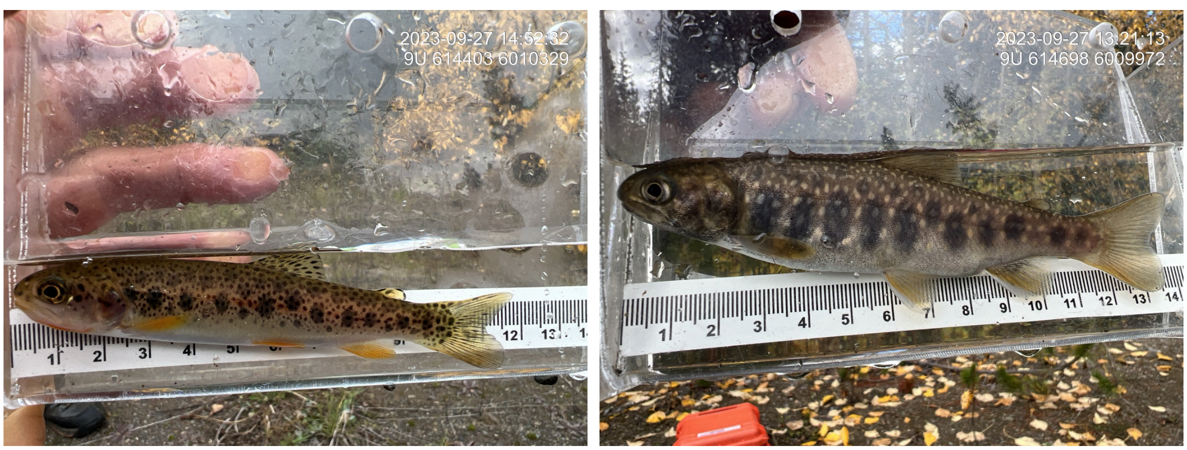

Figure 5.4: Left: Cutthroat trout captured upstream of crossing 198022. Right: Dolly varden captured downstream of crossing 198022.

Tributary to Houston Tommy Creek - 198934 & 198942 - Appendix

Site Location

Crossings 198934 and 198942 are located on a Tributary to Houston Tommy Creek, approximately 2.1km and 3km upstream of Houston Tommy Creek. The stream flows southeast to Houston Tommy Creek, which then flows roughly 9km west to its confluence with the Morice River. The sites are located approximately 30km southwest of Houston, BC.

The upper crossing (PSCIS 198942) is located on Holland Rd and crossing 198934 on a spur of Holland Rd. Both roads are documented as the responsibility of Canfor R07549 within the Forest Tenure Road Section Lines spatial layer distributed by BC Data Catalogue (MoE 2024a).

Background

At crossings 198934 and 198942, Tributary to Houston Tommy Creek is a third order stream with an upstream watershed area of approximately 11.7km^2. The elevation of the watershed ranges from a maximum of 1336m to 826m at the lower crossing 198934 (Table 5.8).

Review of MoE (2024d) indicates that in 2002 upstream of the Holland Road spur and crossing 198934 stream sample sites were assessed in by Triton Environmental Consultants with fish captured and some detail on fish distribution in the watershed provided within submitted site card notes.

Crossing 198934 was ranked as a moderate priority for field assessment during planning activities conducted in 2022 due to significant quantities of modelled habitat upstream. Following a fish passage assessment in 2023, surveyors conducted habitat confirmation assessments for both 198934 and 198942 as the crossings ranked as barriers to fish passage and because habitat quality and stream flow levels appeared above average when compared to other small culverted streams in the area. In the past, rainbow trout and dolly varden have been documented upstream of crossing 198934 (Norris [2018] 2024; MoE 2024b).

Table 5.8: Summary of derived upstream watershed statistics for PSCIS crossing 198934.

Site	Area Km	Elev Site	Elev Max	Elev Median	Elev P60	Aspect
198934	11.7	826	1336	1012	976	S

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

A summary of habitat modelling outputs are presented in Table 5.9. A map of the watershed is provided in map attachment 093L.108.

Table 5.9: Summary of fish habitat modelling for PSCIS crossing 198934.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	16.5	0.9	5
ST Lake Reservoir (ha)	1.2	0.0	0
ST Wetland (ha)	22.0	0.0	0
ST Slopeclass03 Waterbodies (km)	2.5	0.0	0
ST Slopeclass03 (km)	1.4	0.0	0
ST Slopeclass05 (km)	5.0	0.0	0
ST Slopeclass08 (km)	6.0	0.9	15
ST Spawning (km)	0.2	0.0	0
ST Rearing (km)	4.6	0.9	20
CH Spawning (km)	0.2	0.0	0
CH Rearing (km)	0.2	0.0	0
CO Spawning (km)	2.0	0.0	0
CO Rearing (km)	3.4	0.0	0
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	0.0	–

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossings 198934 and 198942

During the 2023 survey, PSCIS crossing 198934 was found to be un-embedded, non-backwatered, and classified as a barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table 5.10). The culvert was bent in the middle and had a significant outlet drop of 0.7m. Water temperature was 6°C, pH was 8.7 and conductivity was 147uS/cm. Of note, the crossing had an estimated 8m of road fill above the culvert.

PSCIS crossing 198934 was un-embedded, non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table 5.10). The culvert was noted as in good condition with a deep outlet pool, suggesting the pipe was undersized.

Table 5.10: Summary of fish passage assessment for PSCIS crossing 198934.

Location and Stream Data	•	**Crossing Characteristics**	**–**
Date	2023-09-12	Crossing Sub Type	Round Culvert
PSCIS ID	198934	Diameter (m)	1.6
External ID	–	Length (m)	18
Crew	MW	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	631703	Resemble Channel	No
Northing	6017418	Backwatered	No
Stream	Tributary to Houston Tommy Creek	Percent Backwatered	–
Road	Spur	Fill Depth (m)	8
Road Tenure	Canfor R07549	Outlet Drop (m)	0.7
Channel Width (m)	3.3	Outlet Pool Depth (m)	0.5
Stream Slope (%)	3	Inlet Drop	No
Beaver Activity	No	Slope (%)	4
Habitat Value	High	Valley Fill	Deep Fill
Final score	39	Barrier Result	Barrier
Fix type	Replace Structure with Streambed Simulation CBS	Fix Span / Diameter	4.5

Tributary to Houston Tommy Creek - 1…

Location and Stream Data	Crossing Characteristics	–

Comments: Very good habitat upstream and downstream. Culvert is a little bent in the middle. Big outlet drop, fish spotted in outlet pool. Moderate flowing stream.. 14:35:45

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

Table 5.11: Summary of fish passage assessment for PSCIS crossing 198942.

Location and Stream Data	•	Crossing Characteristics	–
Date	2023-09-12	Crossing Sub Type	Round Culvert
PSCIS ID	198942	Diameter (m)	1.2
External ID	–	Length (m)	14
Crew	MW	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	631508	Resemble Channel	No
Northing	6018096	Backwatered	No
Stream	Tributary to Houston Tommy Creek	Percent Backwatered	–
Road	Holland Rd	Fill Depth (m)	0.7
Road Tenure	Canfor R07549	Outlet Drop (m)	0.1
Channel Width (m)	1.9	Outlet Pool Depth (m)	0.7
Stream Slope (%)	2	Inlet Drop	No
Beaver Activity	No	Slope (%)	1
Habitat Value	High	Valley Fill	Deep Fill
Final score	21	Barrier Result	Barrier
Fix type	Replace Structure with Streambed Simulation CBS	Fix Span / Diameter	3

Location and Stream Data	•	**Crossing Characteristics**	–

Comments: Deep outlet pool, culvert may be undersized. Relatively wide stream with good habitat, dolly varden confirmed downstream in the past.. 15:05:09

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

Stream Characteristics Downstream of 198934

The stream was surveyed downstream from crossing 198934 for 275m (Figure 5.5). Total cover amount was rated as moderate with large woody debris dominant. Cover was also present as small woody debris, undercut banks, and overhanging vegetation.The average channel width was 3.2m, the average wetted width was 2.1m, and the average gradient was 2.7%.The dominant substrate was cobbles with gravels sub-dominant. Surveyor notes indicate pockets of gravel suitable for resident salmonid spawning and occasional deep pools for overwintering. Fish (<150mm - species unconfirmed) were observed in the outlet pool of the culvert. Overall, habitat was rated as medium value for salmonid rearing and spawning.

Stream Characteristics Upstream of 198934 and Downstream of 198942

The stream was surveyed the entire distance from crossing 198934 to crossing 198942 on Holland Rd(~850m) (Figure 5.5). Total cover amount was rated as moderate with deep pools dominant. Cover was also present as small woody debris, large woody debris, boulders, and overhanging vegetation.The dominant substrate was cobbles with gravels sub-dominant.The average channel width was 3.3m, the average wetted width was 1.7m, and the average gradient was 5.5%. In the area surveyed, the stream contained abundant gravels suitable for spawning and occasional pools. Approximately 300m downstream of Holland Rd, on the left bank, there was a landslide roughly 30m high and 30m long (Figure 5.6). Below the landslide, it was noted that aggraded sediments had caused the stream to go sub-surface for a distance of approximately 300m with only occasional pools containing water. Fish were observed in the outlet pool of crossing 198942. The habitat was rated as medium value for salmonid rearing and spawning.

Stream Characteristics Upstream of 198942

The stream was surveyed upstream from crossing 198942 for 650m (Figure 5.6). The average channel width was 1.9m, the average wetted width was 1.5m, and the average gradient was 3.8%.The dominant substrate was gravels with fines sub-dominant.Total cover amount was rated as abundant with large woody debris dominant. Cover was also present as small woody debris, undercut banks, and overhanging vegetation. Flow levels were noted as moderate with occasional deep pools present suitable for resident fish overwintering.

The stream forked at a location approximately 200 meters upstream of Holland Rd, and the west fork was assessed for a further 650m. Roughly 1.1km upstream on the east fork, rainbow trout have been documented in the past with survey notes indicating a falls present near the location of fish capture that likely limits the upstream distribution of fish (Norris [2018] 2024; MoE 2024b). Although MoE (2024c) indicates that the falls noted is not documented in provincial databases, the 300m long site in which the falls is noted begins at a point on the eastern most fork of the stream approximately 1.3km upstream of Holland Rd. The habitat in the area surveyed was rated as medium value for salmonid rearing and spawning.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, it is recommended to replace crossings 198934 and 198942 with embedded culverts (streambed simulation), with spans of 4.5m and 3m, respectively. While these estimates are preliminary, the rough cost of the work for each crossing is estimated at $100,000. However, 8m of road fill was noted as above crossing 198934, which will likely significantly increase the cost of replacement.

Conclusion

`bcfishpass` modelling indicates over 3km of potential steelhead rearing habitat upstream of crossing 198942 with habitat rated as medium value. Conducting fish sampling at the site site may provide data useful for further guiding prioritization particularly if genetic analysis could determine if somw of the fish utilizing the stream are progeny of anadromous steelhead.

Table 5.12: Summary of habitat details for PSCIS crossing 198934.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
198934	Downstream	275	3.2	2.1	0.4	2.7	moderate	Medium
198934	Upstream	850	3.3	1.7	0.5	5.5	moderate	Medium
198942	Upstream	650	1.9	1.5	0.4	3.8	abundant	Medium

Figure 5.5: Left: Typical habitat downstream of PSCIS crossing 198934. Right: Typical habitat upstream of PSCIS crossing 198934 and downstream of PSCIS crossing 198942.

Figure 5.6: Left: Landslide located 300m downstream of crossing 198942. Right: Typical habitat upstream of PSCIS crossing 198942.

Tributary to McDonell Lake - 8478 - Appendix

Site Location

PSCIS crossing 8478 is a located on a Tributary to McDonell Lake within the Zymoetz River watershed. The culvert is located on the Dennis West FSR at a point 1.9km upstream of where the stream flows north-west into the western end of McDonell Lake. The Forest Tenure Layer indicates that BC Timber Sales is responsible for the road at the crossing location.

Background

At crossing 8478, Tributary to McDonell Lake is a second order stream with an upstream watershed area of approximately 2.8km^2. This stream drains a steep cold water system, where the elevation ranges from a maximum of 1710m to 940m near the crossing (Table 5.13).

The crossing was previously assessed with a fish passage assessment by Viveiros (2011) in 2010, with fish sampling and replacement with a streambed simulation recommneded. Approximately 1.5km downstream of crossing 8478 there is a documented sockeye spawning location in the FISS database, and upstream of the FSR dolly varden have been documented in the past (Norris [2018] 2024; MoE 2024b). Revisited in 2023, surveyors conducted a habitat confirmation assessment and electrofishing with results included in this memo.

Table 5.13: Summary of derived upstream watershed statistics for PSCIS crossing 8478.

Site	Area Km	Elev Site	Elev Max	Elev Median	Elev P60	Aspect
8478	2.8	940	1710	1269	1233	WSW

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

Habitat modelling outputs form `bcfishpass` indicated only 400m of habitat accessible to steelhead or coho (stream gradients <20% and 15%) and no habitat of high intrinsic potential for either species (gradients <8.5% for steelhead and <5.5% for coho). Outputs are presented in Table 5.14. A map of the watershed is provided in map attachment 093L.117.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	0.4	0.4	100
ST Lake Reservoir (ha)	0.0	0.0	–
ST Wetland (ha)	0.0	0.0	–
ST Slopeclass03 Waterbodies (km)	0.0	0.0	–
ST Slopeclass03 (km)	0.0	0.0	–
ST Slopeclass05 (km)	0.0	0.0	–
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)	0.0	0.0	–
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	0.0	–

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing 8478

At the time of the survey in 2023, PSCIS crossing 8478 was un-embedded, non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table 5.15). The culvert was slightly undersized for the size of the stream with an outlet drop measured at 0.2m high. Water temperature was 5.6°C, pH was 7.4 and conductivity was 153uS/cm.

Table 5.15: Summary of fish passage assessment for PSCIS crossing 8478.

Location and Stream Data	•	Crossing Characteristics	–
Date	2023-09-19	Crossing Sub Type	Round Culvert
PSCIS ID	8478	Diameter (m)	1.9
External ID	–	Length (m)	12
Crew	AI	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	590065	Resemble Channel	No
Northing	6069867	Backwatered	No
Stream	Tributary to McDonell Lake	Percent Backwatered	–
Road	Dennis West FSR	Fill Depth (m)	1.5
Road Tenure	BCTS R22433	Outlet Drop (m)	0.2
Channel Width (m)	2.5	Outlet Pool Depth (m)	0.25
Stream Slope (%)	8	Inlet Drop	Yes
Beaver Activity	No	Slope (%)	4
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	31	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	15

Location and Stream Data	• **Crossing Characteristics**	–

Comments: Pipe is in good condition. Nice habitat upstream and downstream. Very good flow for time of year. Dolly Varden captured upstream and downstream of crossing.. 13:30:02

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

Stream Characteristics Downstream

The stream was surveyed downstream from crossing 8478 for 200m . Total cover amount was rated as moderate with large woody debris dominant. Cover was also present as small woody debris, undercut banks, and overhanging vegetation.The average channel width was 3m, the average wetted width was 2.2m, and the average gradient was 8.3%.The dominant substrate was gravels with cobbles sub-dominant. The stream was noted as having good flow and containing pockets of gravel suitable for spawning (Figure 5.8). Deep pools were infrequent and the morphology was step-pool cobble. The habitat was rated as medium value suitable for salmonid rearing and spawning.

Stream Characteristics Upstream

The stream was surveyed upstream from crossing 8478 for 400m to a point where gradients increased to 20% (Figure 5.8). Total cover amount was rated as moderate with large woody debris dominant. Cover was also present as small woody debris and boulders.The average channel width was 2.5m, the average wetted width was 1.8m, and the average gradient was 10%.The dominant substrate was cobbles with gravels sub-dominant. There was good flow volume in the area surveyed and step-pool cascades (<1m high) created by large woody debris present throughout and pockets of gravel present suitable for spawning. The habitat was rated as medium value with moderate rearing potential for dolly varden.

Fish Sampling

Electrofishing was conducted at three sites below and one site above the FSR with results summarised in Tables 5.17 - 5.18 and Figure 5.7. A total of 12 dolly varden were captured downstream, and 5 dolly varden were captured upstream. Multiple fish captured had deteriorating purple gill plates and unusual round black spots (Figures 5.10). All fish captured with a fork length greater than 60mm were tagged with Passive Integrated Transponders (PIT tags) with data stored here.

Structure Remediation and Cost Estimate

Although replacement of PSCIS crossing 8478 with a streambed simulation may be feasible and a potentially more economical option, replacement with a bridge (15m span) is roughly estimated to cost $450,000. Deactivation of the Dennis West FSR beyond the culvert and removal of the crossing could also be explored as a cost-effective option.

Conclusion

PSCIS crossing 8478 is located on a steeper, colder water stream providing medium value habitat for dolly varden in the areas surveyed. Habitat modelling and ground measurements of gradient upstream of the Dennis West FSR were slightly above the selected threshold for high intrinsic potential for steelhead rearing (>8.5%) with averaged values at 10%. As these relatively steep gradients drain a relatively high elevation watershed it may be most suitable for dolly varden. The site was rated as a moderate priority for replacement containing medium value for salmonid rearing and spawning. As noted earlier, multiple fish captured had deteriorating purple gill plates and unusual round black spots potentially indicating some sort of natural or anthropogenic contaminants draining into the watershed.

Table 5.16: Summary of habitat details for PSCIS crossing 8478.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
8478	Downstream	200	3.0	2.2	0.3	8.3	moderate	Medium
8478	Upstream	400	2.5	1.8	0.5	10.0	moderate	Medium

Table 5.17: Fish sampling site summary for 8478.

site	passes	ef_length_m	ef_width_m	area_m2	enclosure
8478_ds_ef1	1	24	2.22	53.3	Open
8478_ds_ef2	1	45	1.77	79.7	Open
8478_ds_ef3	1	25	1.83	45.8	Open
8478_us	1	400	1.83	732.0	Open

Table 5.18: Fish sampling density results summary for 8478.

local_name	species_code	life_stage	catch	density_100m2	nfc_pass
8478_ds_ef1	DV	fry	2	3.8	FALSE
8478_ds_ef1	DV	parr	2	3.8	FALSE
8478_ds_ef2	DV	fry	1	1.3	FALSE
8478_ds_ef2	DV	parr	1	1.3	FALSE
8478_ds_ef2	DV	juvenile	2	2.5	FALSE
8478_ds_ef3	DV	fry	1	2.2	FALSE
8478_ds_ef3	DV	parr	2	4.4	FALSE
8478_ds_ef3	DV	adult	1	2.2	FALSE
8478_us	DV	fry	3	0.4	FALSE
8478_us	DV	parr	2	0.3	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.

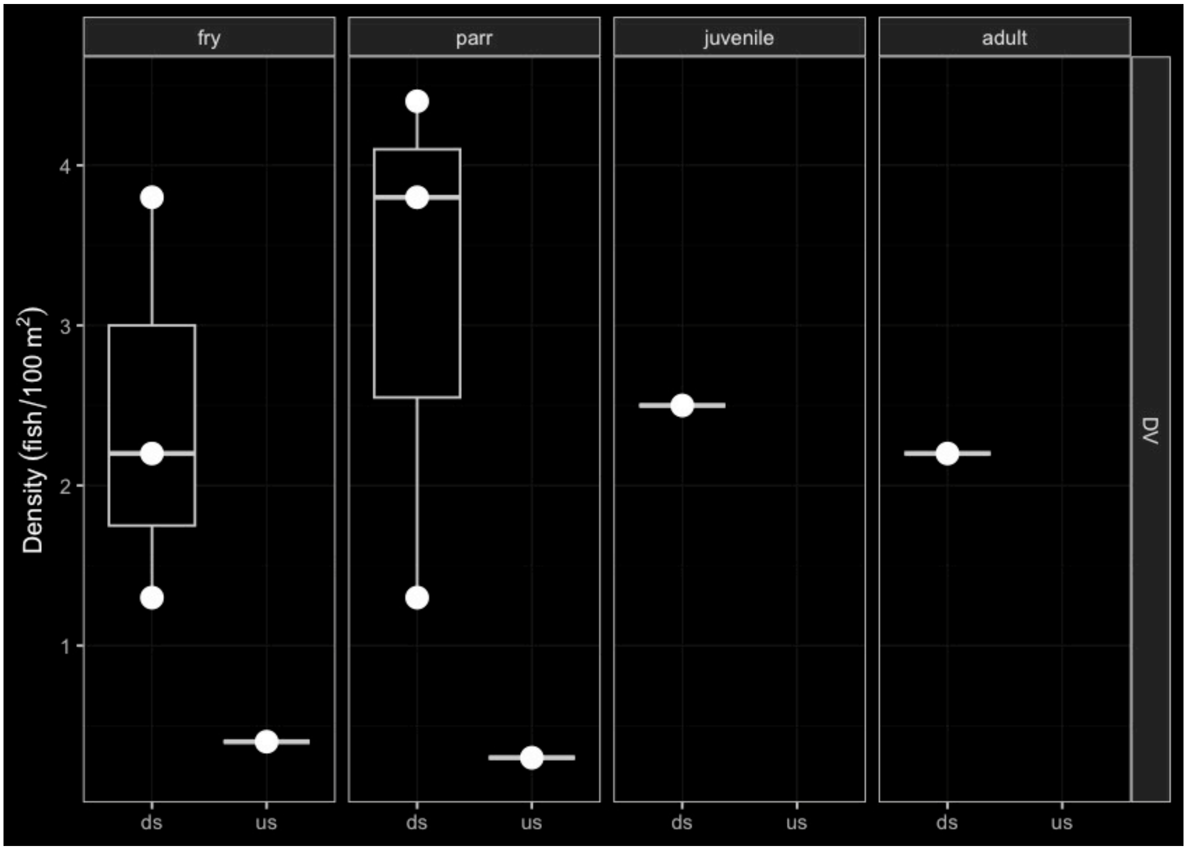

Figure 5.7: Densites of fish (fish/100m2) captured upstream and downstream of PSCIS crossing 8478.

Figure 5.8: Left: Typical habitat downstream of PSCIS crossing 8478. Right: Typical habitat upstream of PSCIS crossing 8478.

Figure 5.9: Dolly varden with deteriorating purple gill plates and unusual black spots captured upstream of crossing 8478.

Figure 5.10: Left: Dolly varden with deteriorating purple gill plates and unusual black spots captured downstream of crossing 8478. Right: Dolly varden with deteriorating purple gill plates and unusual black spots captured upstream of crossing 8478.

Tributary to Coal Creek - 8525 - Appendix

Site Location

PSCIS crossing 8525 on a Tributary to Coal Creek is located on McDonell FSR approximately 7.5km west of the downstream end of McDonnell Lake. The road at the crossing location is the responsibility of the Ministry of Forests.

Background

At crossing 8525, Tributary to Coal Creek is a second order stream with an upstream watershed area of approximately 1.6km^2. The elevation of the watershed ranges from a maximum of 1177m to 850m near the crossing (Table 5.19). The stream flows in a south-west direction into Coal Creek approximately 0.8km downstream of McDonell FSR.

The crossing was originally assessed with a fish passage assessment by Viveiros (2011) in 2010. The site was re-assessed in 2022 and ranked as a moderate priority for follow up in A. Irvine and Wintersheidt (2023) due to relatively low mapped gradients, the crossing's proximity to Coal Creek, and relatively good flow volumes. Upstream of the crossing, dolly varden have been documented in the past (Norris [2018] 2024; MoE 2024b). In 2022, minnow traps were set at crossing 8525 to scope for coho presence with only dolly varden captured. Revisited in 2023, surveyors conducted a habitat confirmation assessment and electrofishing with results included in this memo.

Table 5.19: Summary of derived upstream watershed statistics for PSCIS crossing 8525.

Site	Area Km	Elev Site	Elev Max	Elev Median	Elev P60	Aspect
8525	1.6	850	1177	1052	1028	SSW

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

A summary of habitat modelling outputs is presented in Table 5.20. A map of the watershed is provided in map attachment 093L.121.

Table 5.20: Summary of fish habitat modelling for PSCIS crossing 8525.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	5.0	5.0	100

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Lake Reservoir (ha)	1.2	1.2	100
ST Wetland (ha)	0.0	0.0	–
ST Slopeclass03 Waterbodies (km)	0.0	0.0	–
ST Slopeclass03 (km)	1.2	1.2	100
ST Slopeclass05 (km)	1.4	1.4	100
ST Slopeclass08 (km)	1.1	1.1	100
ST Spawning (km)	0.0	0.0	–
ST Rearing (km)	0.9	0.9	100
CH Spawning (km)	0.0	0.0	–
CH Rearing (km)	0.0	0.0	–
CO Spawning (km)	0.0	0.0	–
CO Rearing (km)	0.0	0.0	–
CO Rearing (ha)	0.0	0.0	–
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	0.0	0.0	–

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing 8525

At the time of the survey in 2023, PSCIS crossing 8525 was un-embedded, non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table 5.21). There was a small blockage at the inlet and a 0.5m outlet drop. Water temperature was 6.7° C, pH was 7.7 and conductivity was 133uS/cm.

Table 5.21: Summary of fish passage assessment for PSCIS crossing 8525.

Location and Stream Data	•	**Crossing Characteristics**	**–**
Date	2023-09-18	Crossing Sub Type	Round Culvert
PSCIS ID	8525	Diameter (m)	0.9
External ID	–	Length (m)	28
Crew	MW TP VJ	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	580998	Resemble Channel	No
Northing	6074681	Backwatered	No
Stream	Tributary to Coal Creek	Percent Backwatered	–
Road	McDonell FSR	Fill Depth (m)	2
Road Tenure	MOF 7552	Outlet Drop (m)	0.5
Channel Width (m)	1.9	Outlet Pool Depth (m)	0.2
Stream Slope (%)	4	Inlet Drop	No
Beaver Activity	No	Slope (%)	1
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	34	Barrier Result	Barrier
Fix type	Replace Structure with Streambed Simulation CBS	Fix Span / Diameter	3

Location and Stream Data	•	Crossing Characteristics	–

Comments: Small flowing stream. Fish captured in minnow traps in 2022.. 09:57:03

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

Stream Characteristics Downstream

The stream was surveyed downstream from crossing 8525 for 400m . The stream was noted to have intermittent dewatering, but good flow relative to other streams in the area given it was a very dry year. Water was noted as relatively turbid (Figure 5.12). There were few deep pools and abundant small gravels present throughout the area surveyed. The dominant substrate was gravels with cobbles sub-dominant.The average channel width was 1.8m, the average wetted width was 1.5m, and the average gradient was 6.2%.Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris, large woody debris, and overhanging vegetation. The habitat was rated as medium value for salmonid rearing and spawning.

Stream Characteristics Upstream

The stream was surveyed upstream from crossing 8525 for 600m (Figure 5.12). The dominant substrate was gravels with fines sub-dominant.The average channel width was 1.9m, the average wetted width was 1.7m, and the average gradient was 1.4%.Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris, large woody debris, and overhanging vegetation. There were isolated pools every 30 to 50m that were up to 55cm in depth, and abundant gravel throughout. The habitat was wetland in character dominated by fern, alder and mature spruce. The habitat was rated as medium for salmonid rearing and spawning.

Approximately 1.7km upstream of crossing 8525, PSCIS crossing 8529 was previously documented as a wooden box culvert. This site was reassessed in 2023 and the habitat adjacent to the structure assessed. The wooden box culvert had recently been replaced with a bridge. The stream was surveyed upstream from crossing 8529 for approximately 100m and was noted as having good flow for a small system on a dry year. The average channel width was 2m, the average wetted width was 1.5m, and the average gradient was 2.5%.The dominant substrate was gravels with cobbles sub-dominant.Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris and overhanging vegetation. (Figure 5.13). The average channel width was 2m, the average wetted width was 1.5m, and the average gradient was 2.5%.Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris and overhanging vegetation.The dominant substrate was gravels with cobbles sub-dominant. The habitat was rated as medium value for salmonid rearing and spawning.

Fish Sampling

As noted, in 2022, minnow traps were set at 8525 to scope for coho presence. Dolly varden were captured both above and below the crossing, with fish sampling data here

During the 2023 survey, electrofishing was conducted at three sites above and three sites below crossing 8525, with results summarised in Tables 5.23 - 5.24 and Figure 5.11. A total of 9 dolly varden were captured upstream, and 19 fish were captured downstream, including dolly varden and rainbow trout (Figures 5.14). All fish captured with a fork length greater than 60mm were tagged with Passive Integrated Transponders (PIT tags) with data stored here.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 8525 with a streambed simulation (embedded culvert) recommended (3m span). Although preliminary - a rough cost of the work is estimated at $100,000.

Conclusion

There was 0.9km of steelhead rearing habitat modelled upstream of crossing 8525. Electrofishing surveys in 2023 captured dolly varden upstream of the FSR and rainbow trout and dolly varden downstream. Although no coho were captured during assessments in 2022 or 2023, these species may have populated the system in the past as it is connected to Coal Creek ~800m downstream, where historic presence of coho has been confirmed [Norris ([2018] 2024); ; MoE (2024b)]. Electrofishing results from the site indicate the stream is a productive for dolly varden providing flows suitable for rearing and spawning. The site was rated as a moderate priority for replacement containing medium value for salmonid rearing and spawning.

Table 5.22: Summary of habitat details for PSCIS crossing 8525.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
8525	Downstream	400	1.8	1.5	0.2	6.2	moderate	Medium
8525	Upstream	600	1.9	1.7	0.4	1.4	moderate	Medium
8525	Upstream2	105	2.0	1.5	0.2	2.5	moderate	Medium

Table 5.23: Fish sampling site summary for 8525.

site	passes	ef_length_m	ef_width_m	area_m2	enclosure
8525_ds_ef1	1	8	1.80	14.4	Open
8525_ds_ef2	1	11	1.47	16.2	Open
8525_ds_ef3	1	13	1.13	14.7	Open
8525_us_ef1	1	8	1.50	12.0	Open
8525_us_ef2	1	40	1.35	54.0	Open
8525_us_ef3	1	1	1.63	1.6	Open

Table 5.24: Fish sampling density results summary for 8525.

local_name	species_code	life_stage	catch	density_100m2	nfc_pass
8525_ds_ef1	DV	parr	2	13.9	FALSE
8525_ds_ef1	RB	fry	12	83.3	FALSE
8525_ds_ef2	DV	parr	3	18.5	FALSE
8525_ds_ef3	DV	parr	2	13.6	FALSE
8525_us_ef1	DV	parr	3	25.0	FALSE
8525_us_ef2	DV	parr	2	3.7	FALSE
8525_us_ef2	DV	juvenile	1	1.9	FALSE
8525_us_ef3	DV	parr	3	187.5	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.

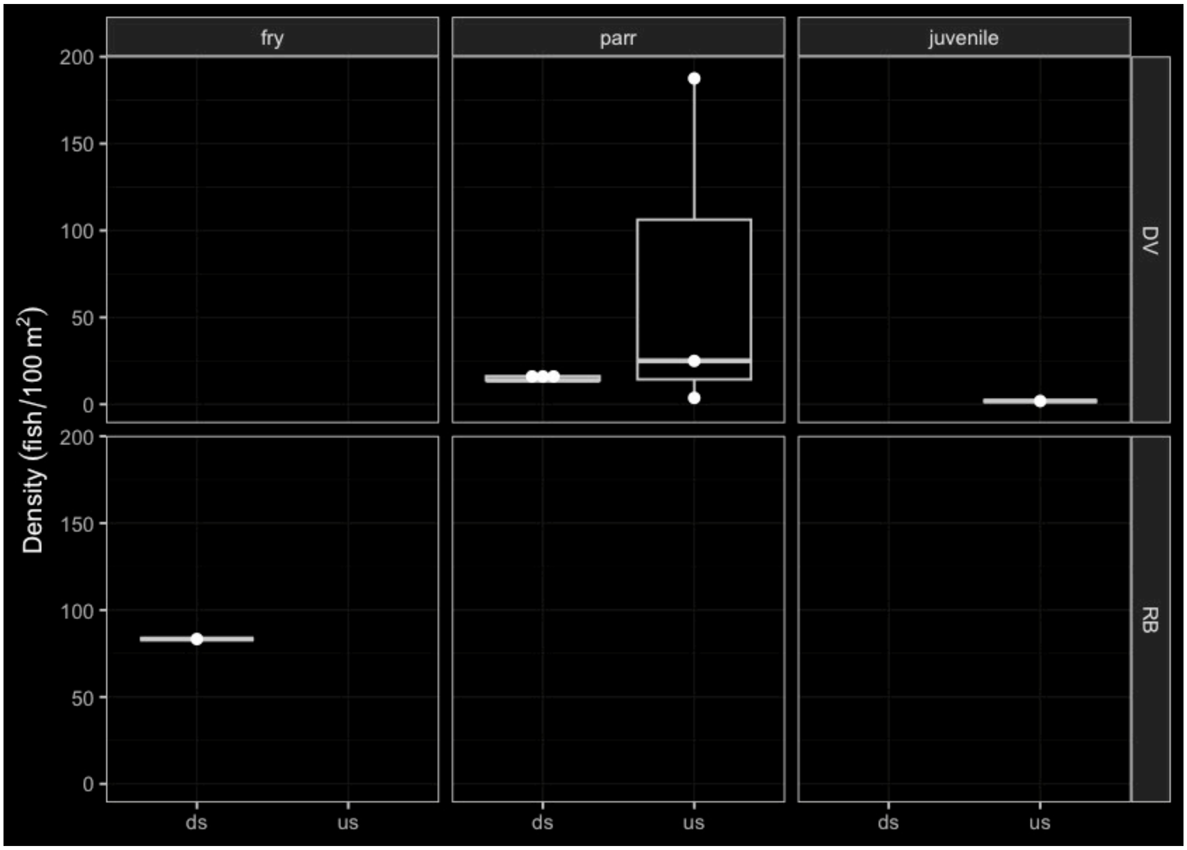

Figure 5.11: Densites of fish (fish/100m2) captured upstream and downstream of PSCIS crossing 8525.

Figure 5.12: Left: Typical habitat downstream of PSCIS crossing 8525. Right: Typical habitat upstream of PSCIS crossing 8525.

Figure 5.13: Left: Typical habitat upstream of PSCIS crossing 8529. Right: Typical pool habitat at PSCIS crossing 8529.

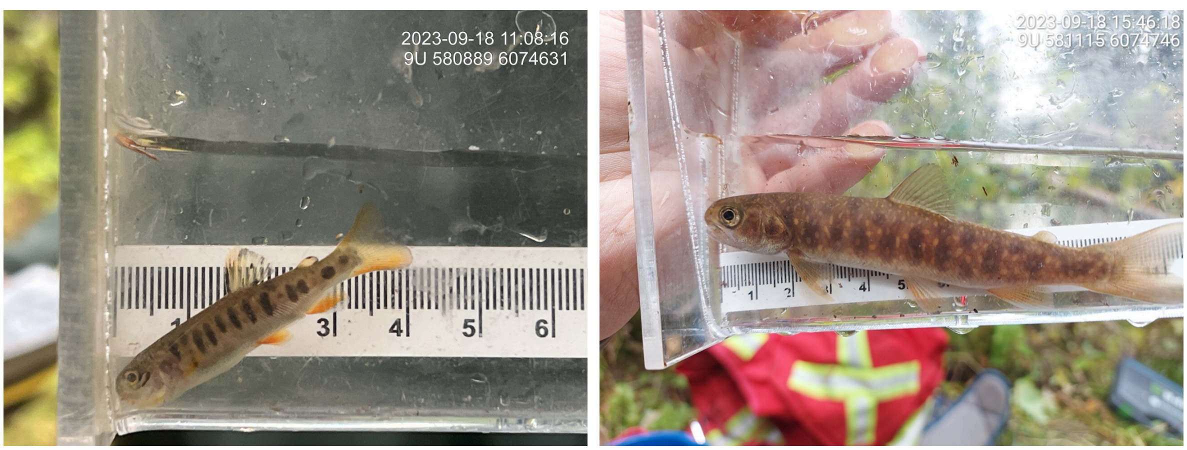

Figure 5.14: Left: Rainbow trout captured downstream of crossing 8525. Right: Dolly varden captured upstream of crossing 8525.

Tributary to McDonell Lake - 8543 - Appendix

Site Location

PSCIS crossing 8543 on Tributary to McDonell Lake is located approximately 0.5km upstream of the McDonell Lake, on the most eastern side of the lake. The site is located at kilometer 23 of McDonell Lake FSR, which at the crossing location is the responsibility of the Wetzinkwa Community Forest Corporation.

Background

At crossing 8543, Tributary to McDonell Lake is a second order stream with an upstream watershed area of approximately 4.6km^2. The elevation of the watershed ranges from a maximum of 1189m to 844m at the crossing (Table 5.25).

The crossing was originally assessed with a fish passage assessment by Timber Sales Manager Skeena in 2010 with a recommendation for fish sampling and replacement with an open bottomed structure. Upstream of the crossing, rainbow trout and dolly varden have been documented in the past (Norris [2018] 2024; MoE 2024b).

Table 5.25: Summary of derived upstream watershed statistics for PSCIS crossing 8543.

Site	Area Km	Elev Site	Elev Max	Elev Median	Elev P60	Aspect
8543	4.6	844	1189	1067	1048	S

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

A summary of habitat modelling outputs is presented in Table 5.26. A map of the watershed is provided in map attachment 093L.117.

Table 5.26: Summary of fish habitat modelling for PSCIS crossing 8543.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	5.5	5.2	95
ST Lake Reservoir (ha)	0.0	0.0	–
ST Wetland (ha)	0.0	0.0	–

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Slopeclass03 Waterbodies (km)	0.0	0.0	–
ST Slopeclass03 (km)	0.0	0.0	–
ST Slopeclass05 (km)	0.0	0.0	–
ST Slopeclass08 (km)	3.5	3.5	100
ST Spawning (km)	0.0	0.0	–
ST Rearing (km)	0.0	0.0	–
CH Spawning (km)	0.0	0.0	–
CH Rearing (km)	0.0	0.0	–
CO Spawning (km)	0.0	0.0	–
CO Rearing (km)	0.0	0.0	–
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	0.0	–

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing

At the time of the survey in 2023, PSCIS crossing 8543 was un-embedded, non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table 5.27). The culvert was in poor condition with holes in the bottom and had a 0.5m outlet drop.

Table 5.27: Summary of fish passage assessment for PSCIS crossing 8543.

Location and Stream Data	•	Crossing Characteristics	–
Date	2023-09-20	Crossing Sub Type	Round Culvert
PSCIS ID	8543	Diameter (m)	1.2
External ID	–	Length (m)	14
Crew	MW JO RB	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	592142	Resemble Channel	No
Northing	6072357	Backwatered	No
Stream	Tributary to McDonell Lake	Percent Backwatered	–
Road	McDonell Lake FSR	Fill Depth (m)	1
Road Tenure	Wetzinkwa Community Forest Corporation	Outlet Drop (m)	0.5
Channel Width (m)	1.8	Outlet Pool Depth (m)	0.8
Stream Slope (%)	5	Inlet Drop	No
Beaver Activity	No	Slope (%)	3
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	36	Barrier Result	Barrier
Fix type	Replace Structure with Streambed Simulation CBS	Fix Span / Diameter	3

•

Location and Stream Data	**Crossing Characteristics**	–

Comments: Small trickle in stream, very little flowing water. Stream runs halfway down culvert from inlet and then flows through holes underneath culvert. Stream gets wider upstream of crossing. Fish caught in the past above and below culvert. Deep outlet pool.. 09:49:51

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

Stream Characteristics Downstream

The stream was surveyed downstream from crossing 8543 for 160m (Figure 5.15). The stream was dry at the time of the survey. Total cover amount was rated as moderate with overhanging vegetation dominant. Cover was also present as small woody debris, large woody debris, undercut banks, and deep pools.The dominant substrate was cobbles with gravels sub-dominant.The average channel width was 2.4m, the average wetted width was 0.7m, and the average gradient was 2.8%. There are historic dolly varden and rainbow trout observations just downstream of the crossing in the FISS database. The habitat was rated as low value for salmonid rearing and spawning.

Stream Characteristics Upstream

The stream was surveyed upstream from crossing 8543 for 450m (Figure 5.15). Total cover amount was rated as trace with deep pools dominant. Cover was also present as small woody debris, large woody debris, undercut banks, and overhanging vegetation.The average channel width was 3.2m, the average wetted width was 1.2m, and the average gradient was 5.9%.The dominant substrate was cobbles with gravels sub-dominant. The stream had intermittent dewatering with isolated pools to 60 cm deep spaced every 30 to 40 m. The stream channel was entrenched in the valley with large amounts of mobile angular cobbled substrate throughout. Fish were observed in multiple isolated pools up to 300m upstream of the crossing, and there is a historic dolly varden observation just upstream of the crossing in the FISS database. The habitat was rated as low for salmonid rearing and spawning. There is a FISS obstacle noted as a cascade just upstream of crossing 8543 but no permanent natural barriers were observed during the survey.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 8543 with an embedded culvert (streambed simulation) (3m span) is recommended. Although preliminary - a rough cost of the work is estimated at $100,000.

Conclusion

The culvert at crossing 8543 was in bad condition with holes in the bottom and had a significant 0.5m outlet drop. The crossing ranked as a barrier to fish passage. There are historic fish observations both upstream and downstream of the crossing in the FISS database and surveyors observed fish upstream of the crossing during the assessment, suggesting this stream provides habitat suitable for rearing and spawning. Therefore, we recommendation electrofishing above and below the crossing to provide insight into fish community composition and density to help further inform prioritization.

Although there is a FISS obstacle noted as a cascade just upstream of crossing 8543, no permanent natural barriers were observed during the survey.

Table 5.28: Summary of habitat details for PSCIS crossing 8543.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
8543	Downstream	160	2.4	0.7	0.6	2.8	moderate	Low
8543	Upstream	450	3.2	1.2	0.4	5.9	trace	Low

Figure 5.15: Left: Typical habitat downstream of PSCIS crossing 8543. Right: Typical habitat upstream of PSCIS crossing 8543.

Tributary to McDonell Lake - 8547 - Appendix

Site Location

PSCIS crossing 8547 on Tributary to McDonell Lake is located on the south side of the Zymoetz River approximately 1.6km upstream of McDonell Lake, on the McDonell Lake FSR. The road at the crossing location is the responsibility of the Wetzinkwa Community Forest Corporation.

Background

At crossing 8547, Tributary to McDonell Lake is a second order stream with an upstream watershed area of approximately 2.2km^2. The elevation of the watershed ranges from a maximum of 1177m to 937m at the crossing (Table 5.29). The stream drains a small lake area estimated at 8.8ha in a south-east direction entering McDonell Lake approximately 1km west of the lake inlet.

The crossing was originally assessed with a fish passage assessment by Viveiros (2011) in 2010 with fish sampling and replacement with an open bottomed structure recommended. The site was visited by our field crews in 2022 and prioritized for follow up with a habitat confirmation in 2024 because relatively good flow volumes were observed along with a significant outlet drop. Upstream of the crossing, no past fish information was available (Norris [2018] 2024; MoE 2024b) however a sockeye spawning location was noted as present within the stream approximately 150m upstream from McDonell Lake and ~1200m downstream of the FSR. A modelled crossing was noted as present within `bcfishpass` modelling outputs near the historic sockeye observation.

Table 5.29: Summary of derived upstream watershed statistics for PSCIS crossing 8547.

Site	Area Km	Elev Site	Elev Max	Elev Median	Elev P60	Aspect
8547	2.2	937	1177	1086	1069	SW

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

A summary of habitat modelling outputs is presented in Table 5.30. A map of the watershed is provided in map attachment 093L.116.

Table 5.30: Summary of fish habitat modelling for PSCIS crossing 8547.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	0.7	0.7	100

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Wetland (ha)	0.0	0.0	–
ST Slopeclass03 Waterbodies (km)	0.0	0.0	–
ST Slopeclass03 (km)	0.0	0.0	–
ST Slopeclass05 (km)	0.7	0.7	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)	0.0	0.0	–
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	0.0	–

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing

At the time of the survey in 2023, PSCIS crossing 8547 was un-embedded, non-backwatered, had an oulet drop of 0.7m and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table 5.31). Water temperature was 5.9°C, pH was 7.9 and conductivity was 113uS/cm.

Table 5.31: Summary of fish passage assessment for PSCIS crossing 8547.

Location and Stream Data	•	Crossing Characteristics	–
Date	2023-11-01	Crossing Sub Type	Round Culvert
PSCIS ID	8547	Diameter (m)	0.9
External ID	–	Length (m)	20
Crew	AR AF	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	589988	Resemble Channel	No
Northing	6072657	Backwatered	No
Stream	Tributary to McDonell Lake	Percent Backwatered	–
Road	McDonell Lake FSR	Fill Depth (m)	3
Road Tenure	Wetzinkwa Community Forest Corporation	Outlet Drop (m)	0.7
Channel Width (m)	1.9	Outlet Pool Depth (m)	0.5
Stream Slope (%)	3	Inlet Drop	No
Beaver Activity	No	Slope (%)	3
Habitat Value	High	Valley Fill	Deep Fill
Final score	39	Barrier Result	Barrier
Fix type	Replace Structure with Streambed Simulation CBS	Fix Span / Diameter	3

Location and Stream Data	Crossing Characteristics	–

Comments: 2 round culverts, one is not functional and was installed higher above stream channel. Culvert slope was estimated.CT observed in stream and historic CT FISS downstream.. 13:34:15

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

Stream Characteristics Downstream

The stream was surveyed downstream from crossing 8547 for 220m . This section of stream was shallow with slow moving water and had some shallow pools with large rocks for fish shelter. (Figure 5.17). Total cover amount was rated as moderate with large woody debris dominant. Cover was also present as small woody debris, boulders, undercut banks, and overhanging vegetation.The dominant substrate was boulders with cobbles sub-dominant.The average channel width was 2m, the average wetted width was 0.7m, and the average gradient was 11%. The habitat was rated as Medium value for salmonid rearing and spawning.

Approximately 1.2km downstream of the FSR, the location of PSCIS crossing 24600461 was also assessed. The crossing had been removed. The stream was surveyed upstream the mapped location of crossing 24600461 for 100m. Total cover amount was rated as moderate with large woody debris dominant. Cover was also present as small woody debris, undercut banks, and overhanging vegetation.The dominant substrate was gravels with cobbles sub-dominant.The average channel width was 2.3m, the average wetted width was 1.3m, and the average gradient was 4.8%. There were abundant gravels, few deep pools, and multiple shallow pools up to 20-25cm deep (Figure 5.17).
Surveyors observed numerous fry and parr and noted the stream had good flow considering the time of year and low flows observed elsewhere in the watershed. The habitat was rated as high value for salmonid rearing and spawning.

Stream Characteristics Upstream

The stream was surveyed upstream from crossing 8547 for 500m (Figure 5.18). The dominant substrate was cobbles with gravels sub-dominant.The average channel width was 1.9m, the average wetted width was 1.2m, and the average gradient was 5.6%.Total cover amount was rated as moderate with small woody debris dominant. Cover was also present as large woody debris, undercut banks, and overhanging vegetation. The stream channel was small and moderately steep, with modest flow. There were very few areas with gravels suitable for spawning and not many deep pools. Other than the culvert no natural or anthroprogenic barriers were observed. The habitat was rated as medium for salmonid rearing and spawning.

Fish Sampling

Electrofishing was conducted at three sites above and three sites below the FSR crossing, with results summarised in Tables 5.33 - 5.34 and Figure 5.16. A total of 19 fish were captured upstream and 15 fish were captured downstream, all of which were cutthroat trout (Figures 5.18). All fish captured with a fork length greater than 60mm were tagged with Passive Integrated Transponders (PIT tags) with data stored here.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 8547 with an embedded culvert (streambed simulation) (3m span) is recommended. A preliminary cost of the work is estimated at $100,000.

Conclusion

Electrofishing surveys in 2023 captured cutthrout trout upstream and downstream of the FSR with densities of fish captured indicating the stream is productive and provides habitat suitable for rearing and spawning. The small lake at the headwaters of the stream likely moderates water temperature and flows in the system providing a suitable environment for salmonids. Habitat upstream of the crossing was rated as medium value for salmonid rearing and spawning with the site rated as a moderate priority for replacement. As the stream is relatively small, it may be possible to replace the crossing with a streambed simulation culvert (embedded 3m pipe) to provide fish passage and maintain the natural stream channel while providing a cost effective solution.

Table 5.32: Summary of habitat details for PSCIS crossing 8547.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
8547	Downstream	220	2.0	0.7	0.2	11.0	moderate	Medium
8547	Downstream2	100	2.3	1.3	0.2	4.8	moderate	High
8547	Upstream	500	1.9	1.2	0.4	5.6	moderate	Medium

Table 5.33: Fish sampling site summary for 8547.

site	passes	ef_length_m	ef_width_m	area_m2	enclosure
8547_ds_ef1	1	50	1.57	78.5	Open
8547_ds_ef2	1	18	1.35	24.3	Open
8547_ds_ef3	1	3	1.90	5.7	Open
8547_us_ef1	1	15	1.07	16.0	Open
8547_us_ef2	1	12	1.10	13.2	Open
8547_us_ef3	1	12	1.60	19.2	Open

Table 5.34: Fish sampling density results summary for 8547.

local_name	species_code	life_stage	catch	density_100m2	nfc_pass
8547_ds_ef1	CT	fry	3	3.8	FALSE
8547_ds_ef1	CT	parr	1	1.3	FALSE
8547_ds_ef2	CT	fry	5	20.6	FALSE
8547_ds_ef2	CT	parr	4	16.5	FALSE
8547_ds_ef3	CT	parr	1	17.5	FALSE
8547_ds_ef3	CT	juvenile	1	17.5	FALSE
8547_us_ef1	CT	fry	4	25.0	FALSE
8547_us_ef2	CT	fry	5	37.9	FALSE
8547_us_ef2	CT	parr	3	22.7	FALSE
8547_us_ef3	CT	fry	4	20.8	FALSE
8547_us_ef3	CT	parr	3	15.6	FALSE

local_name	species_code	life_stage	catch	density_100m2	nfc_pass

* 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.

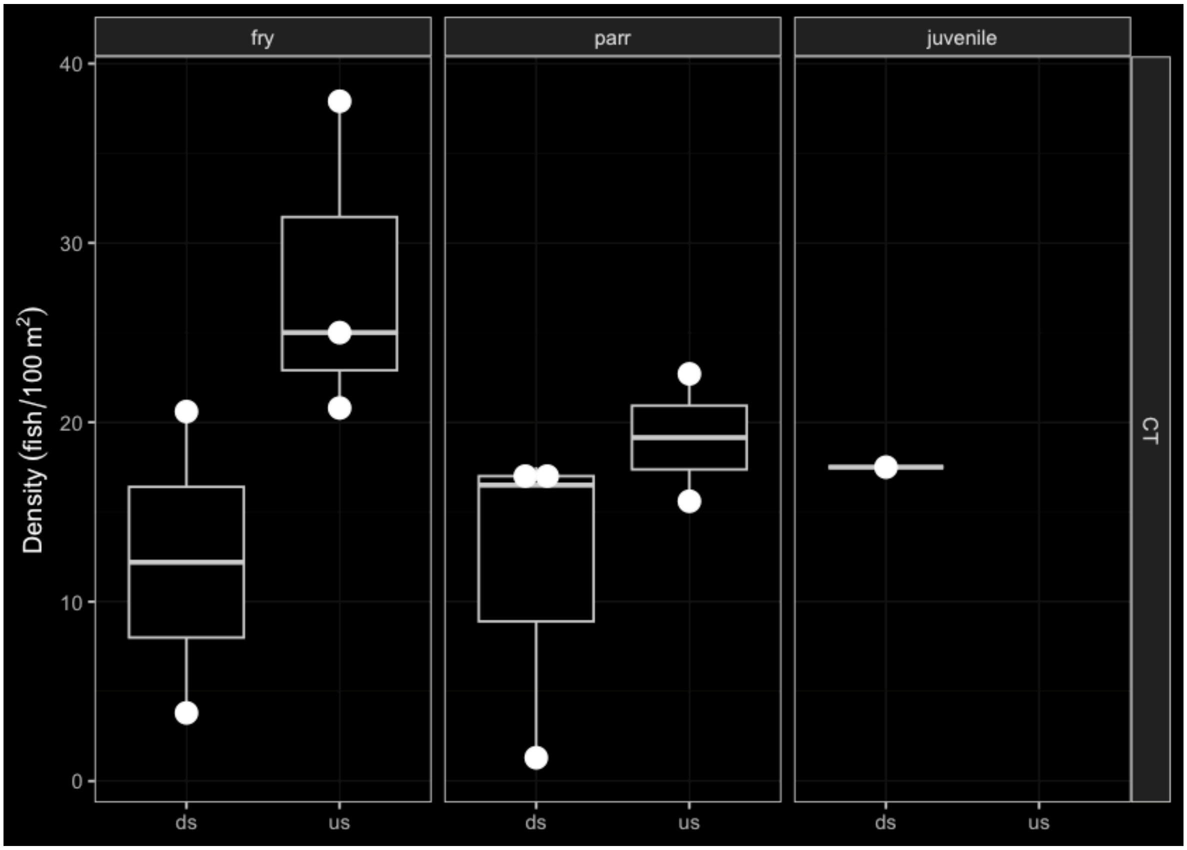

Figure 5.16: Densites of fish (fish/100m2) captured upstream and downstream of PSCIS crossing 8547.

Figure 5.17: Left: Typical habitat downstream of PSCIS crossing 8547. Right: Typical habitat downstream of PSCIS crossing 24600461.

Figure 5.18: Left: Typical habitat upstream of PSCIS crossing 8547. Right: Cutthroat trout captured upstream of crossing 8547.

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Changelog

fish_passage_skeena_2023_reporting 0.0.3 (20240627)

- don't filter dfo table by total return to river so that we get info after 1997. Remove some columns and increase visibility of buttons. Improve caption text to inform reader of table functionality
- correct link error in exec and intro
- skinny down packages ` put kableExtra call before fpr to deal with black caption issues

fish_passage_skeena_2023_reporting 0.0.2 (20240617)

- add executive summary
- include section for GIS project
- provide links to reports where 2023 data has been added
- Numerous memo updates
- Include filterable DT table for DFO stock assessment data

fish_passage_skeena_2023_reporting 0.0.1 (20240415)

- Initial draft

Session Info

Information about the computing environment is important for reproducibility. A summary of the computing environment is saved to `session_info.csv` that can be viewed and downloaded from https://github.com/NewGraphEnvironment/fish_passage_skeena_2023_reporting/blob/main/data/session_info.csv.

```
## ─ Session info
```

```
—
## setting  value
## version  R version 4.4.0 (2024-04-24)
## os       macOS Monterey 12.7.4
## system   aarch64, darwin20
## ui       RStudio
## language (EN)
## collate  en_US.UTF-8
## ctype    en_US.UTF-8
## tz       America/Vancouver
## date     2024-06-27
## rstudio  2024.04.1+748 Chocolate Cosmos (desktop)
## pandoc   3.1.11 @
/Applications/RStudio.app/Contents/Resources/app/quarto/bin/tools/aarch6-
```

```
4/ (via rmarkdown)
##
## ─ Packages
```

```
## package * version date (UTC) lib source
## askpass 1.2.0 2023-09-03 [1] CRAN (R 4.4.0)
## base64enc 0.1-3 2015-07-28 [1] CRAN (R 4.4.0)
## bcdata * 0.4.1 2023-03-18 [1] CRAN (R 4.4.0)
## bit 4.0.5 2022-11-15 [1] CRAN (R 4.4.0)
## bit64 4.0.5 2020-08-30 [1] CRAN (R 4.4.0)
## bitops 1.0-7 2021-04-24 [1] CRAN (R 4.4.0)
## blob 1.2.4 2023-03-17 [1] CRAN (R 4.4.0)
## bookdown * 0.39 2024-04-15 [1] CRAN (R 4.4.0)
## brew 1.0-10 2023-12-16 [1] CRAN (R 4.4.0)
## bslib 0.7.0 2024-03-29 [1] CRAN (R 4.4.0)
## cachem 1.0.8 2023-05-01 [1] CRAN (R 4.4.0)
## cellranger 1.1.0 2016-07-27 [1] CRAN (R 4.4.0)
## chk 0.9.1.9001 2024-06-16 [1] Github
(poissonconsulting/chk@ea59f9c)
## chron * 2.3-61 2023-05-02 [1] CRAN (R 4.4.0)
## class 7.3-22 2023-05-03 [1] CRAN (R 4.4.0)
## classInt 0.4-10 2023-09-05 [1] CRAN (R 4.4.0)
## cli 3.6.2 2023-12-11 [1] CRAN (R 4.4.0)
## codetools 0.2-20 2024-03-31 [1] CRAN (R 4.4.0)
## colorspace 2.1-0 2023-01-23 [1] CRAN (R 4.4.0)
## crayon 1.5.2 2022-09-29 [1] CRAN (R 4.4.0)
## crosstalk 1.2.1 2023-11-23 [1] CRAN (R 4.4.0)
## crul 1.4.2 2024-04-09 [1] CRAN (R 4.4.0)
## curl 5.2.1 2024-03-01 [1] CRAN (R 4.4.0)
## data.table * 1.15.4 2024-03-30 [1] CRAN (R 4.4.0)
## datapasta * 3.1.0 2020-01-17 [1] CRAN (R 4.4.0)
## DBI * 1.2.3 2024-06-02 [1] CRAN (R 4.4.0)
## dbplyr 2.5.0 2024-03-19 [1] CRAN (R 4.4.0)
## devtools * 2.4.5 2022-10-11 [1] CRAN (R 4.4.0)
## digest 0.6.35 2024-03-11 [1] CRAN (R 4.4.0)
## dplyr * 1.1.4 2023-11-17 [1] CRAN (R 4.4.0)
## e1071 1.7-14 2023-12-06 [1] CRAN (R 4.4.0)
## elevatr * 0.99.0 2023-09-12 [1] CRAN (R 4.4.0)
## ellipsis 0.3.2 2021-04-29 [1] CRAN (R 4.4.0)
## english * 1.2-6 2021-08-21 [1] CRAN (R 4.4.0)
## evaluate 0.23 2023-11-01 [1] CRAN (R 4.4.0)
## exifr * 0.3.2 2021-03-20 [1] CRAN (R 4.4.0)
## fansi 1.0.6 2023-12-08 [1] CRAN (R 4.4.0)
## farver 2.1.2 2024-05-13 [1] CRAN (R 4.4.0)
## fasstr * 0.5.2 2024-03-28 [1] CRAN (R 4.4.0)
## fastmap 1.1.1 2023-02-24 [1] CRAN (R 4.4.0)
## fishbc * 0.2.1 2021-05-12 [1] CRAN (R 4.4.0)
## forcats * 1.0.0 2023-01-29 [1] CRAN (R 4.4.0)
## fpr * 1.1.0 2024-06-18 [1] Github
(newgraphenvironment/fpr@22436b6)
```

```
##  fs              * 1.6.4      2024-04-25 [1] CRAN (R 4.4.0)
##  fwapgr          * 0.1.0.9015 2024-05-14 [1] Github
(poissonconsulting/fwapgr@a81de3d)
##  generics          0.1.3      2022-07-05 [1] CRAN (R 4.4.0)
##  geojson           0.3.5      2023-08-08 [1] CRAN (R 4.4.0)
##  geojsonio       * 0.11.3     2023-09-06 [1] CRAN (R 4.4.0)
##  geojsonsf         2.0.3      2022-05-30 [1] CRAN (R 4.4.0)
##  ggdark          * 0.2.1      2019-01-11 [1] CRAN (R 4.4.0)
##  ggmap             4.0.0.900  2024-05-14 [1] Github
(dkahle/ggmap@8b12beb)
##  ggplot2         * 3.5.1      2024-04-23 [1] CRAN (R 4.4.0)
##  glue              1.7.0      2024-01-09 [1] CRAN (R 4.4.0)
##  googleway         2.7.8      2023-08-22 [1] CRAN (R 4.4.0)
##  gtable            0.3.5      2024-04-22 [1] CRAN (R 4.4.0)
##  highr             0.11       2024-05-26 [1] CRAN (R 4.4.0)
##  hms               1.1.3      2023-03-21 [1] CRAN (R 4.4.0)
##  htmltools         0.5.8.1    2024-04-04 [1] CRAN (R 4.4.0)
##  htmlwidgets       1.6.4      2023-12-06 [1] CRAN (R 4.4.0)
##  httpcode          0.3.0      2020-04-10 [1] CRAN (R 4.4.0)
##  httpuv            1.6.15     2024-03-26 [1] CRAN (R 4.4.0)
##  httr            * 1.4.7      2023-08-15 [1] CRAN (R 4.4.0)
##  janitor         * 2.2.0      2023-02-02 [1] CRAN (R 4.4.0)
##  jpeg            * 0.1-10     2022-11-29 [1] CRAN (R 4.4.0)
##  jqr               1.3.3      2023-12-04 [1] CRAN (R 4.4.0)
##  jquerylib         0.1.4      2021-04-26 [1] CRAN (R 4.4.0)
##  jsonlite          1.8.8      2023-12-04 [1] CRAN (R 4.4.0)
##  kableExtra        1.4.0.3    2024-06-14 [1] Github
(haozhu233/kableExtra@a9c509a)
##  KernSmooth        2.23-22    2023-07-10 [1] CRAN (R 4.4.0)
##  knitr           * 1.47       2024-05-29 [1] CRAN (R 4.4.0)
##  labeling          0.4.3      2023-08-29 [1] CRAN (R 4.4.0)
##  later             1.3.2      2023-12-06 [1] CRAN (R 4.4.0)
##  lattice           0.22-6     2024-03-20 [1] CRAN (R 4.4.0)
##  lazyeval          0.2.2      2019-03-15 [1] CRAN (R 4.4.0)
##  leafem          * 0.2.3      2023-09-17 [1] CRAN (R 4.4.0)
##  leaflet         * 2.2.2      2024-03-26 [1] CRAN (R 4.4.0)
##  leaflet.extras  * 2.0.0      2024-06-10 [1] CRAN (R 4.4.0)
##  leafpop         * 0.1.0      2021-05-22 [1] CRAN (R 4.4.0)
##  lifecycle         1.0.4      2023-11-07 [1] CRAN (R 4.4.0)
##  lubridate       * 1.9.3      2023-09-27 [1] CRAN (R 4.4.0)
##  magick          * 2.8.3      2024-02-18 [1] CRAN (R 4.4.0)
##  magrittr          2.0.3      2022-03-30 [1] CRAN (R 4.4.0)
##  memoise           2.0.1      2021-11-26 [1] CRAN (R 4.4.0)
##  mime              0.12       2021-09-28 [1] CRAN (R 4.4.0)
##  miniUI            0.1.1.1    2018-05-18 [1] CRAN (R 4.4.0)
##  munsell           0.5.1      2024-04-01 [1] CRAN (R 4.4.0)
##  pagedown        * 0.20       2022-12-13 [1] CRAN (R 4.4.0)
```

```
## pak                 0.7.2      2024-03-17 [1] CRAN (R 4.4.0)
## pdftools          * 3.4.0      2023-09-25 [1] CRAN (R 4.4.0)
## pillar              1.9.0      2023-03-22 [1] CRAN (R 4.4.0)
## pkgbuild            1.4.4      2024-03-17 [1] CRAN (R 4.4.0)
## pkgconfig           2.0.3      2019-09-22 [1] CRAN (R 4.4.0)
## pkgload             1.3.4      2024-01-16 [1] CRAN (R 4.4.0)
## plyr                1.8.9      2023-10-02 [1] CRAN (R 4.4.0)
## png                 0.1-8      2022-11-29 [1] CRAN (R 4.4.0)
## poisspatial       * 0.1.0.9000 2024-05-14 [1] Github
(poissonconsulting/poisspatial@39f7e18)
## poisutils           0.0.0.9010 2024-05-14 [1] Github
(poissonconsulting/poisutils@8310dc4)
## profvis             0.3.8      2023-05-02 [1] CRAN (R 4.4.0)
## progressr           0.14.0     2023-08-10 [1] CRAN (R 4.4.0)
## promises            1.3.0      2024-04-05 [1] CRAN (R 4.4.0)
## proxy               0.4-27     2022-06-09 [1] CRAN (R 4.4.0)
## purrr             * 1.0.2      2023-08-10 [1] CRAN (R 4.4.0)
## qpdf                1.3.3      2024-03-25 [1] CRAN (R 4.4.0)
## R6                  2.5.1      2021-08-19 [1] CRAN (R 4.4.0)
## rappdirs            0.3.3      2021-01-31 [1] CRAN (R 4.4.0)
## raster            * 3.6-26     2023-10-14 [1] CRAN (R 4.4.0)
## rbbt                0.0.0.9000 2024-06-26 [1] local
## Rcpp                1.0.12     2024-01-09 [1] CRAN (R 4.4.0)
## RcppRoll            0.3.0      2018-06-05 [1] CRAN (R 4.4.0)
## readr             * 2.1.5      2024-01-10 [1] CRAN (R 4.4.0)
## readwritesqlite   * 0.2.0      2022-10-16 [1] CRAN (R 4.4.0)
## readxl            * 1.4.3      2023-07-06 [1] CRAN (R 4.4.0)
## remotes             2.5.0      2024-03-17 [1] CRAN (R 4.4.0)
## rfp               * 0.0.0.9000 2024-06-18 [1] Github
(newgraphenvironment/rfp@be1d720)
## rlang               1.1.3      2024-01-10 [1] CRAN (R 4.4.0)
## rmarkdown         * 2.27       2024-05-17 [1] CRAN (R 4.4.0)
## roxygen2            7.3.1      2024-01-22 [1] CRAN (R 4.4.0)
## RPostgres         * 1.4.7      2024-05-27 [1] CRAN (R 4.4.0)
## RSQLite             2.3.6      2024-03-31 [1] CRAN (R 4.4.0)
## rstudioapi          0.16.0     2024-03-24 [1] CRAN (R 4.4.0)
## s2                  1.1.6      2023-12-19 [1] CRAN (R 4.4.0)
## sass                0.4.9      2024-03-15 [1] CRAN (R 4.4.0)
## scales              1.3.0      2023-11-28 [1] CRAN (R 4.4.0)
## sessioninfo         1.2.2      2021-12-06 [1] CRAN (R 4.4.0)
## sf                * 1.0-16     2024-03-24 [1] CRAN (R 4.4.0)
## shiny               1.8.1.1    2024-04-02 [1] CRAN (R 4.4.0)
## shrtcts             0.1.2      2024-05-14 [1] Github
(gadenbuie/shrtcts@41051cf)
## snakecase           0.11.1     2023-08-27 [1] CRAN (R 4.4.0)
## sp                * 2.1-4      2024-04-30 [1] CRAN (R 4.4.0)
## stringi             1.8.4      2024-05-06 [1] CRAN (R 4.4.0)
```

```
##  stringr        * 1.5.1      2023-11-14 [1] CRAN (R 4.4.0)
##  svglite          2.1.3      2023-12-08 [1] CRAN (R 4.4.0)
##  systemfonts      1.0.6      2024-03-07 [1] CRAN (R 4.4.0)
##  terra            1.7-71     2024-01-31 [1] CRAN (R 4.4.0)
##  tibble         * 3.2.1      2023-03-20 [1] CRAN (R 4.4.0)
##  tidyhydat      * 0.6.1      2024-01-11 [1] CRAN (R 4.4.0)
##  tidyr          * 1.3.1      2024-01-24 [1] CRAN (R 4.4.0)
##  tidyselect       1.2.1      2024-03-11 [1] CRAN (R 4.4.0)
##  tidyverse      * 2.0.0      2023-02-22 [1] CRAN (R 4.4.0)
##  timechange       0.3.0      2024-01-18 [1] CRAN (R 4.4.0)
##  tzdb             0.4.0      2023-05-12 [1] CRAN (R 4.4.0)
##  units            0.8-5      2023-11-28 [1] CRAN (R 4.4.0)
##  urlchecker       1.0.1      2021-11-30 [1] CRAN (R 4.4.0)
##  usethis        * 2.2.3      2024-02-19 [1] CRAN (R 4.4.0)
##  utf8             1.2.4      2023-10-22 [1] CRAN (R 4.4.0)
##  uuid             1.2-0      2024-01-14 [1] CRAN (R 4.4.0)
##  V8               4.4.2      2024-02-15 [1] CRAN (R 4.4.0)
##  vctrs            0.6.5      2023-12-01 [1] CRAN (R 4.4.0)
##  viridisLite      0.4.2      2023-05-02 [1] CRAN (R 4.4.0)
##  vroom            1.6.5      2023-12-05 [1] CRAN (R 4.4.0)
##  withr            3.0.0      2024-01-16 [1] CRAN (R 4.4.0)
##  wk               0.9.1      2023-11-29 [1] CRAN (R 4.4.0)
##  xfun             0.44       2024-05-15 [1] CRAN (R 4.4.0)
##  xml2             1.3.6      2023-12-04 [1] CRAN (R 4.4.0)
##  xtable           1.8-4      2019-04-21 [1] CRAN (R 4.4.0)
##  yaml             2.3.8      2023-12-11 [1] CRAN (R 4.4.0)
##  yesno            0.1.2      2020-07-10 [1] CRAN (R 4.4.0)
##
##  [1] /Library/Frameworks/R.framework/Versions/4.4-
arm64/Resources/library
##
##
```

Attachment 1 - Maps

All georeferenced field maps are presented at:

- ’https://hillcrestgeo.ca/outgoing/fishpassage/projects/bulk/archive/2022-09-06/
- ’https://hillcrestgeo.ca/outgoing/fishpassage/projects/morr/archive/2022-09-06/
- https://hillcrestgeo.ca/outgoing/fishpassage/projects/zymo/archive/2022-09-06/
- https://hillcrestgeo.ca/outgoing/fishpassage/projects/kisp/archive/2022-09-06/

Maps are also available zipped for bulk download at:

- https://hillcrestgeo.ca/outgoing/fishpassage/projects/bulk/archive/2022-09-06/2022-09-06.zip
- https://hillcrestgeo.ca/outgoing/fishpassage/projects/morr/archive/2022-09-06/2022-09-06.zip
- https://hillcrestgeo.ca/outgoing/fishpassage/projects/zymo/archive/2022-09-06/2022-09-06.zip
- https://hillcrestgeo.ca/outgoing/fishpassage/projects/kisp/archive/2022-09-06/2022-09-06.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_skeena_2023_reporting/raw/main/docs/Attachment_2.pdf

Attachment 3 - Habitat Assessment Data

Raw habitat assessment data is included in digital format at https://github.com/NewGraphEnvironment/fish_passage_skeena_2023_reporting//blob/main/data/habitat_confirmations.xls. The file can be downloaded with the download button top right of the page at the URL above or by clicking https://github.com/NewGraphEnvironment/fish_passage_skeena_2023_reporting//raw/main/data/habitat_confirmations.xls

Attachment 4 - Bayesian analysis to map stream discharge and temperature causal effects pathways

We are working with Poisson Consulting to map stream discharge and temperature causal effects pathways with the intent of focusing aquatic restoration actions in areas of highest potential for positive impacts on fisheries values at https://github.com/poissonconsulting/fish-passage-22/issues