



S O C I E T Y F O R E C O S Y S T E M R E S T O R A T I O N
I N N O R T H E R N B R I T I S H C O L U M B I A

Skeena Watershed Fish Passage Restoration Planning 2024

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

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Society for Ecosystem Restoration in Northern British Columbia

Version 0.0.1 2025-03-28



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Acknowledgement

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

1 Introduction

This report is available as a PDF and as an online interactive report at https://newgraphenvironment.github.io/fish_passage_skeena_2024_reporting. We recommend viewing online as the web-hosted HTML version contains more features and is more easily navigable. Please reference the website for the latest PDF from [fish_passage_skeena_2024.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 River watershed group and the Kispiox River watershed group, 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 2024 field work data and results, it also builds on reporting from field activities conducted from 2020 to 2023. In addition to the numerous assessments at sites undocumented in past years of the project, field activities were also conducted at 3 sites where habitat confirmations were previously documented as per the report links below. The reports for these sites were edited and updated with 2024 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](#)
- [Skeena Watershed Fish Passage Restoration Planning 2023](#)

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

1 Introduction

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.

Please note that at the time of reporting this document can be considered a living document. Version numbers are logged for each release with modifications, enhancements, and other changes tracked in the [Changelog \(page 107\)](#) with issues and proposed/planned enhancements tracked [here](#).

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.

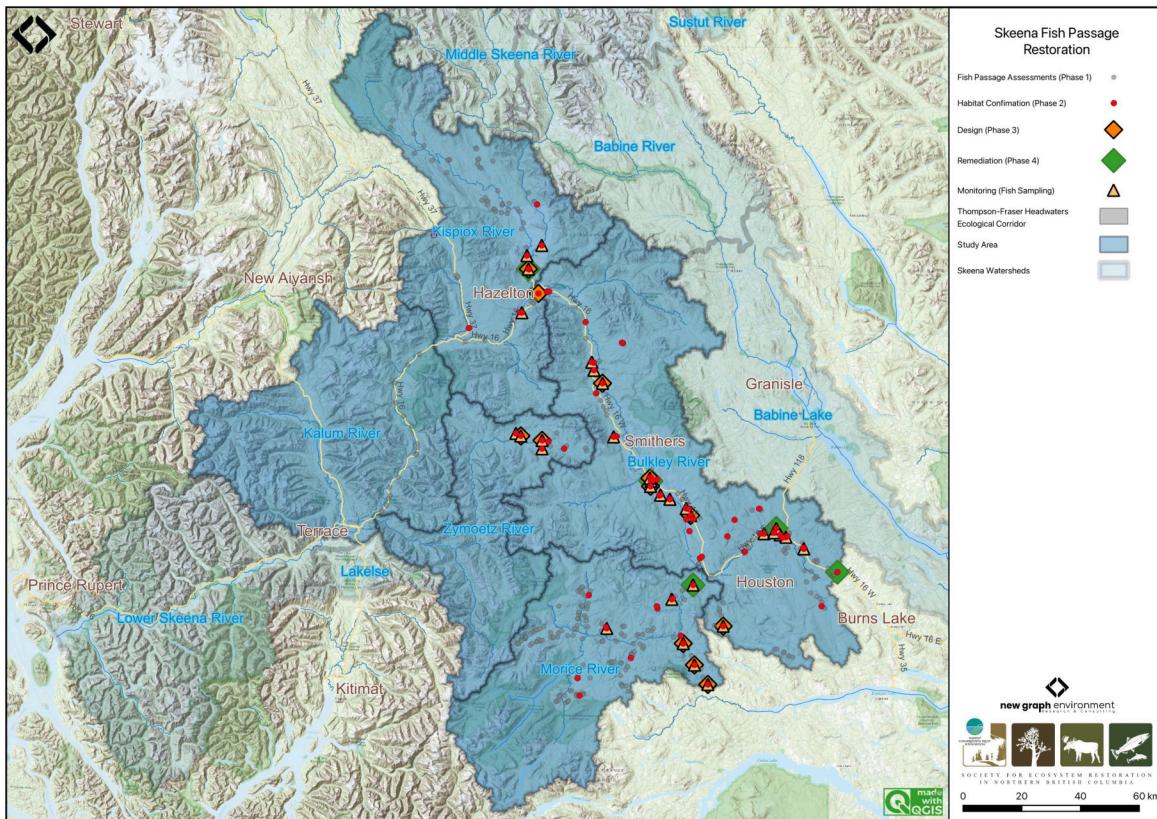


Figure 2.1: Overview map of Study Areas

2.1 Wet'suwet'en

Wet'suwet'en hereditary territory covers an area of 22,000km² 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 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

2 Background

dynamics. The Yintahk (Land) is the centre of life as well as culture and its 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 33,000km² 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 Bulkley River is an 8th order stream that drains an area of 7,762km² 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 138.7 m³/s at station 08EE004 located near Quick

2.4 Bulkley River

(~27km south of Telkwa) and 19 m³/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 (Figure 2.2). The hydrograph peaks faster and generally earlier (May - June) for the Bulkley River upstream of Houston where the topography is of lower lower elevation (Figure 2.2).

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).

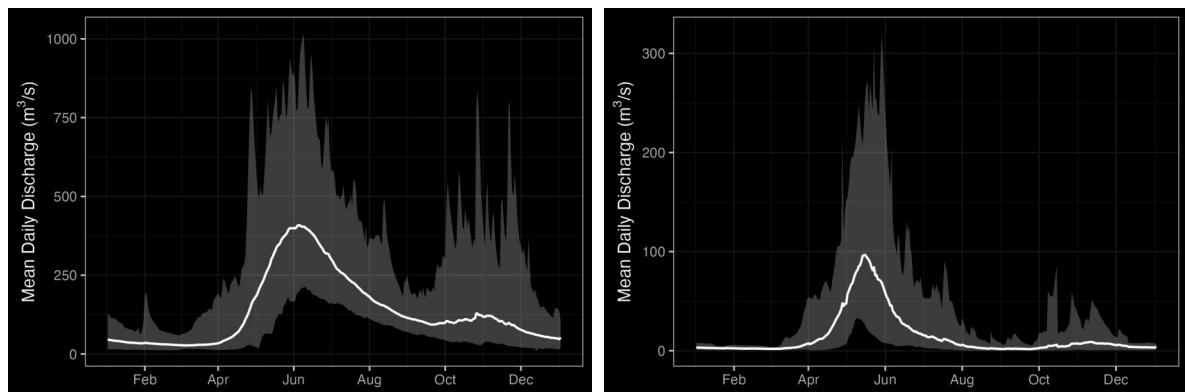


Figure 2.2: Hydrograph for Bulkley River at Quick (Station #08EE004) and near Houston (Station #08EE003).

2.5 Morice River

The Morice River watershed drains 4,379km² of Coast Mountains and Interior Plateau in a generally south-eastern direction. The Morice River is an 8th order stream that flows approximately 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 are 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 its confluence with the Bulkley River is 113 m³/s. Mean annual discharge is estimated at 75 m³/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 (Figure 2.3).

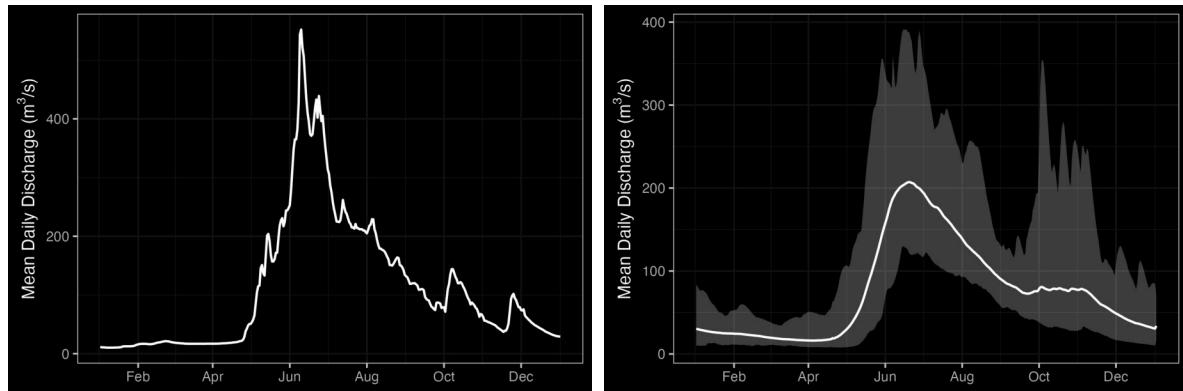


Figure 2.3: Left: Hydrograph for Morice River near Houston (Station #08ED003 - 1971 data only). Right: Hydrograph for Morice River near outlet of Morice Lake (Station #08ED002).

2.6 Zymoetz River

The Zymoetz River (known locally as the Copper River) watershed is an eighth order stream that drains an area of 3026km² 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

2.6 Zymoetz River

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 m³/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 (Figure 2.4).

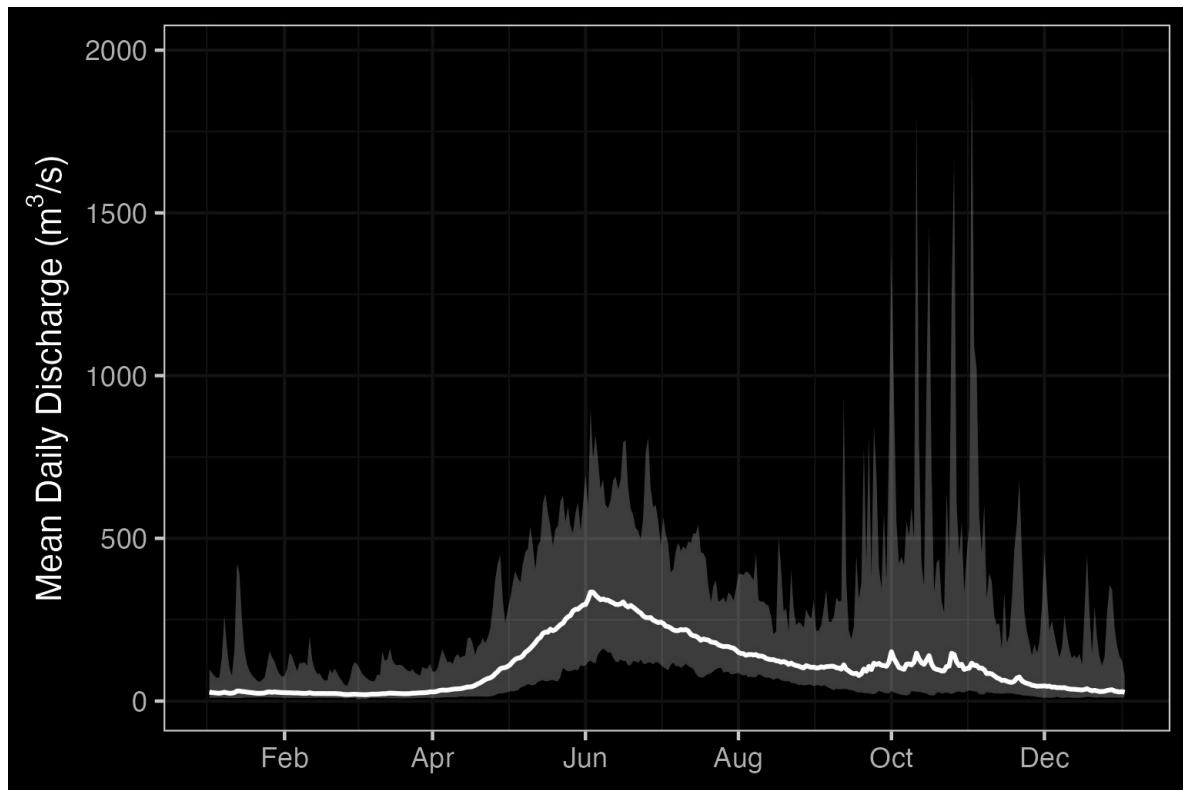


Figure 2.4: Zymoetz River Above O.k. Creek (Station #08EF005 - Lat 54.49363 Lon -128.32466). Available mean daily discharge data from 1963 to 2021.

2.6.1 Kispiox River

The Kispiox River watershed is a seventh order stream that drains an area of 2100km² 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

2 Background

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 Nangese 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 $45 \text{ m}^3/\text{s}$ at station 08EB004 located near Hazelton. Peak discharge happens in May and June as a result of the spring snowmelt (Figure 2.5).

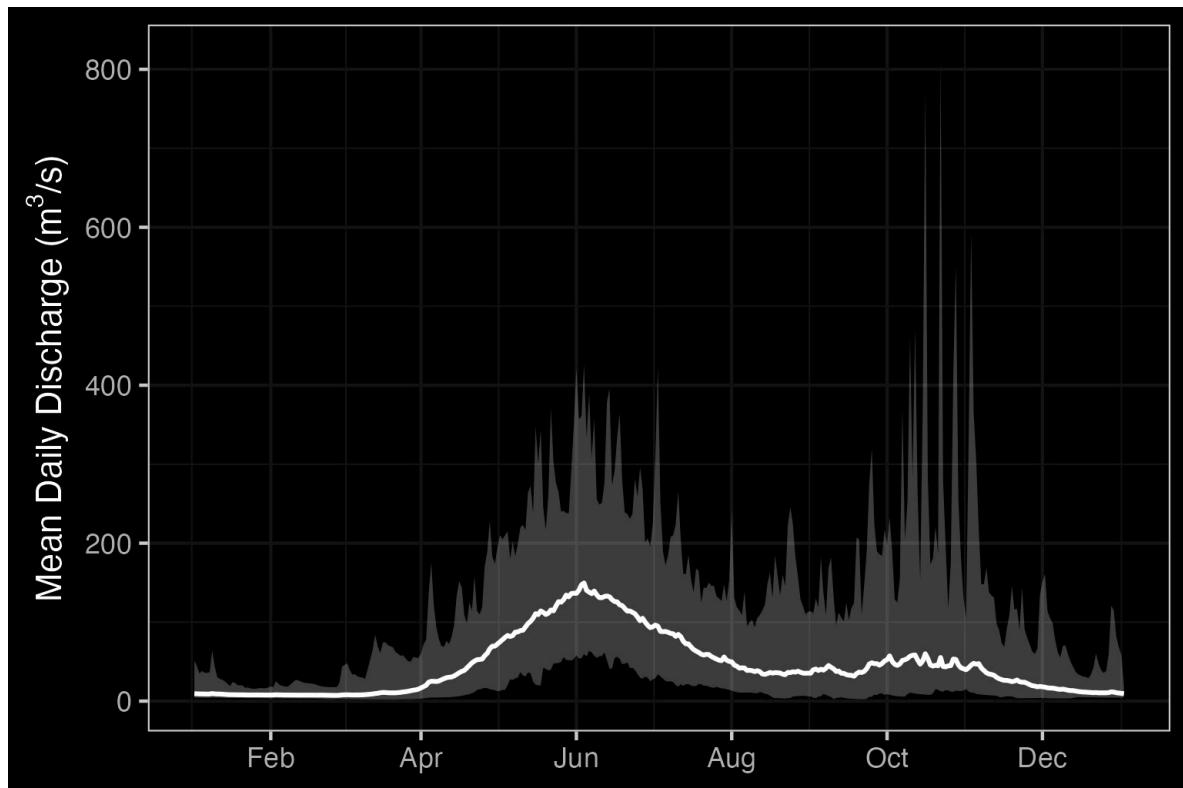


Figure 2.5: Kispiox River Near Hazelton (Station #08EB004 - Lat 55.43385 Lon -127.71616). Available mean daily discharge data from 1963 to 2022.

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

2.7 Kitsumkalum River

one hydrometric station below Kitsumkalum lake which has been active since 2018, and has a mean annual discharge of 123 m³/s (Figure [2.6](#)). From 1929-1954, there was a hydrometric station near Terrace, which estimated the mean annual discharge to be 138m³/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).

There has been a significant amount of work done to enhance salmon populations within the watershed. The SkeenaWild Conservation Trust is conducting riparian restoration surveys on 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).

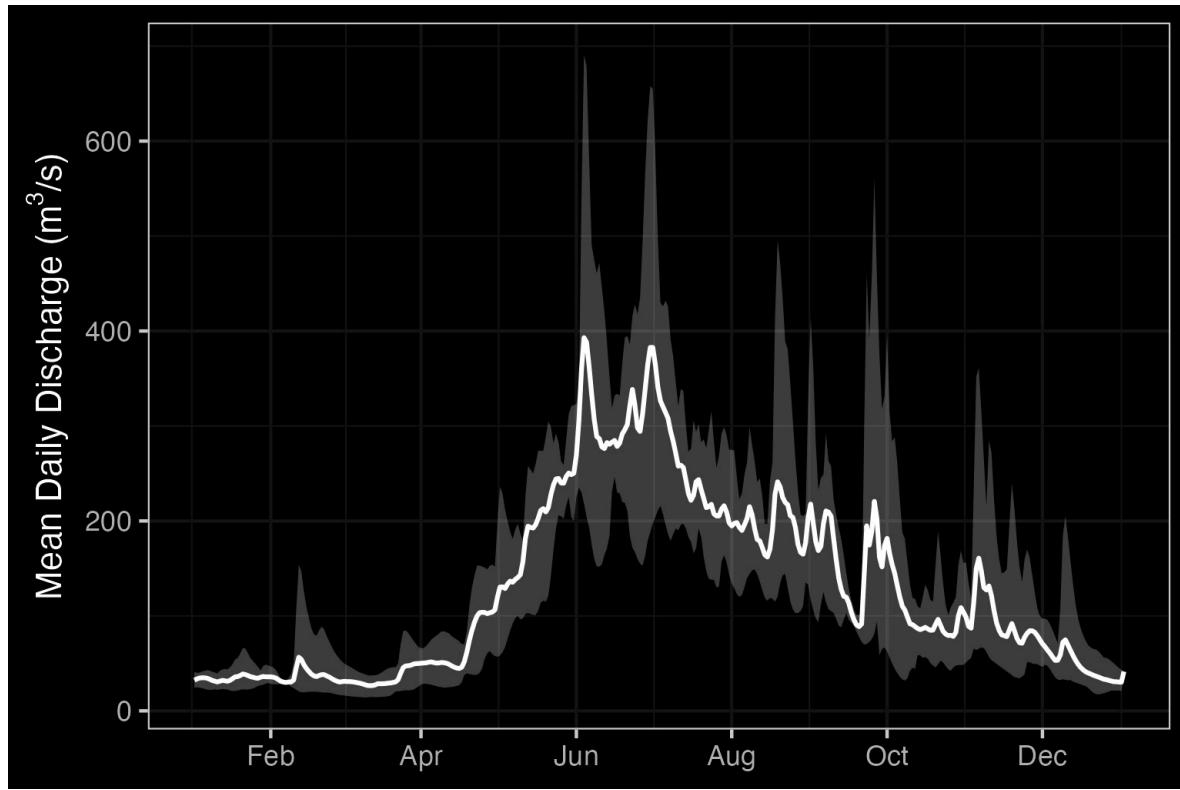


Figure 2.6: Kitsumkalum River Below Alice Creek (Station #08EG019 - Lat 54.6793 Lon -128.74396). Available mean daily discharge data from 2018 to 2022.

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 sourcing 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.

2.8 Fisheries

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 fishing 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 Airport Creek. Within the Bulkley River immediately below the 12 - 15m high bedrock falls, the 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

2 Background

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 an 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

2.8 Fisheries

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](#). 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 cutthroat 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.

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Some key areas of high fisheries values for chinook, sockeye and coho are noted in Bustard and Schell (2002) as McBride Lake, Nanika Lake, and Morice Lake watersheds. A draft gantt chart for select species in the Morice River and Bulkley River watersheds was derived from reviews of the aforementioned references and is included as Figure [2.7](#). The data is considered in draft form and will be refined over the spring and summer of 2021 with local fisheries technicians and knowledge holders during the collaborative assessment planning and fieldwork activities planned.

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

Summaries of historical fish observations in the Bulkley River and Morice River watershed groups (n=4033), graphed by remotely sensed average gradient as well as measured or modelled channel width categories for their associated stream segments where calculated with bcfishpass and bcfishobs and are provided in Figures [2.8](#) - [2.9](#).

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

Scientific Name	Species Name	BC List	COSEWIC	Bulkley	Kispiox	Kalam	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	-

2.8 Fisheries

Scientific Name	Species Name	BC List	COSEWIC	Bulkley	Kispiox	Kalum	Morice	Zymoetz
<i>Cottus asper</i>	Prickly Sculpin	Yellow	—	Yes	Yes	Yes	Yes	Yes
<i>Cottus cognatus</i>	Slimy Sculpin	Yellow	—	—	Yes	Yes	—	—
<i>Couesius plumbeus</i>	Lake Chub	Yellow	DD	Yes	Yes	Yes	Yes	—
<i>Entosphenus tridentatus</i>	Pacific Lamprey	Yellow	—	Yes	—	Yes	Yes	—
<i>Gasterosteus aculeatus</i>	Threespine Stickleback	Yellow	—	—	Yes	Yes	—	—
<i>Hybognathus hankinsoni</i>	Brassy Minnow	No Status	—	Yes	—	—	—	—
<i>Lampetra ayresii</i>	River Lamprey	Yellow	—	—	—	Yes	—	—
<i>Lota lota</i>	Burbot	Yellow	—	Yes	Yes	Yes	Yes	Yes
<i>Mylocheilus caurinus</i>	Peamouth Chub	Yellow	—	Yes	Yes	Yes	Yes	Yes
<i>Oncorhynchus clarkii</i>	Cutthroat Trout	No Status	—	Yes	Yes	Yes	Yes	Yes
<i>Oncorhynchus clarkii</i>	Cutthroat Trout (Anadromous)	No Status	—	Yes	Yes	—	—	Yes
<i>Oncorhynchus clarkii</i>	Coastal Cutthroat Trout	Blue	—	Yes	Yes	Yes	Yes	Yes
<i>Oncorhynchus clarkii lewisi</i>	Westslope (Yellowstone) Cutthroat Trout	Blue	SC (Nov 2016)	—	Yes	Yes	—	—
<i>Oncorhynchus gorbuscha</i>	Pink Salmon	Not Reviewed	—	Yes	Yes	Yes	Yes	Yes
<i>Oncorhynchus keta</i>	Chum Salmon	Not Reviewed	—	Yes	Yes	Yes	Yes	Yes
<i>Oncorhynchus kisutch</i>	Coho Salmon	Not Reviewed	—	Yes	Yes	Yes	Yes	Yes
<i>Oncorhynchus mykiss</i>	Rainbow Trout	Yellow	—	Yes	Yes	Yes	Yes	Yes
<i>Oncorhynchus mykiss</i>	Steelhead	Yellow	—	Yes	Yes	Yes	Yes	Yes
<i>Oncorhynchus mykiss</i>	Steelhead (Summer-run)	Yellow	—	Yes	—	—	Yes	—
<i>Oncorhynchus mykiss</i>	Steelhead (Winter-run)	Yellow	—	—	Yes	—	—	Yes
<i>Oncorhynchus nerka</i>	Kokane	Not Reviewed	—	Yes	Yes	Yes	Yes	Yes
<i>Oncorhynchus nerka</i>	Sockeye Salmon	Not Reviewed	—	Yes	Yes	Yes	Yes	Yes
<i>Oncorhynchus tshawytscha</i>	Chinook Salmon	Not Reviewed	E/T/SC/DD/NAR (Nov 2020)	Yes	Yes	Yes	Yes	Yes
<i>Prosopium coulterii</i>	Pygmy Whitefish	Yellow	NAR (Nov 2016)	Yes	Yes	—	Yes	—

2 Background

Scientific Name	Species Name	BC List	COSEWIC	Bulkley	Kispiox	Kalum	Morice	Zymoetz
<i>Prosopium cylindraceum</i>	Round Whitefish	Yellow	—	—	—	Yes	—	—
<i>Prosopium williamsoni</i>	Mountain Whitefish	Yellow	—	Yes	Yes	Yes	Yes	Yes
<i>Ptychocheilus oregonensis</i>	Northern Pikeminnow	Yellow	—	Yes	Yes	—	Yes	Yes
<i>Pungitius pungitius</i>	Ninespine Stickleback	Unknown	—	Yes	—	—	—	—
<i>Rhinichthys cataractae</i>	Longnose Dace	Yellow	—	Yes	Yes	Yes	Yes	Yes
<i>Rhinichthys falcatus</i>	Leopard Dace	Yellow	NAR (May 1990)	—	—	—	Yes	—
<i>Richardsonius balteatus</i>	Redside Shiner	Yellow	—	Yes	Yes	Yes	Yes	Yes
<i>Salvelinus confluentus</i>	Bull Trout	Blue	SC (Nov 2012)	Yes	Yes	Yes	Yes	Yes
<i>Salvelinus fontinalis</i>	Brook Trout	Exotic	—	Yes	—	—	Yes	—
<i>Salvelinus malma</i>	Dolly Varden	Yellow	—	Yes	Yes	Yes	Yes	Yes
<i>Salvelinus namaycush</i>	Lake Trout	Yellow	—	Yes	Yes	—	Yes	—
—	All Salmon	—	—	—	Yes	Yes	—	—
—	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

2.8 Fisheries

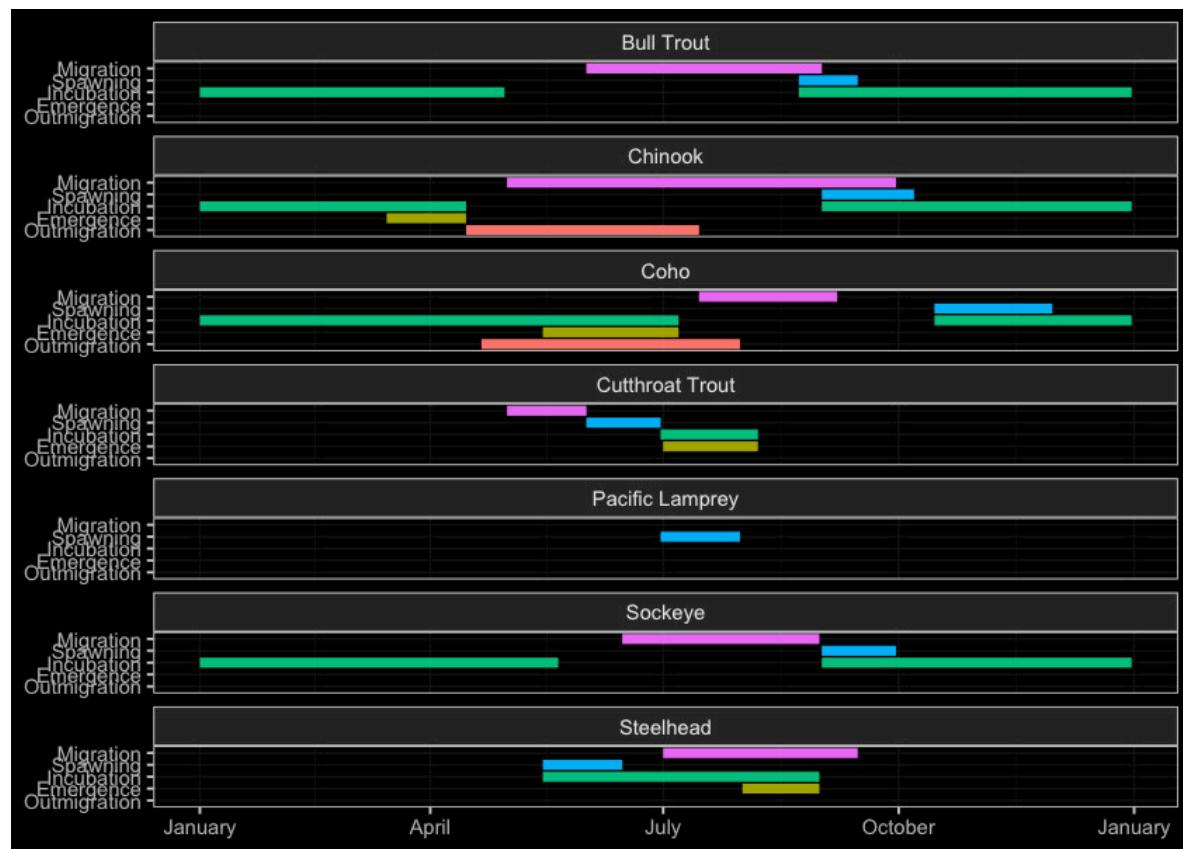


Figure 2.7: Gantt chart for select species in the Morice River and Bulkley River watersheds. To be updated in consultation with local fisheries technicians and knowledge holders.

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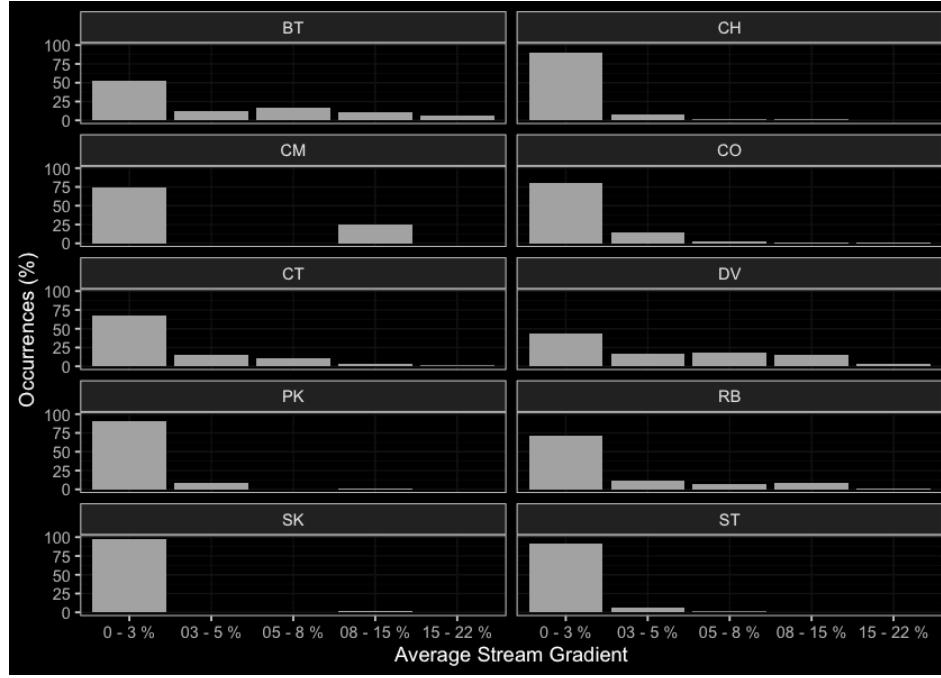


Figure 2.8: Summary of historic salmonid observations vs. stream gradient category for the Bulkley River watershed group.

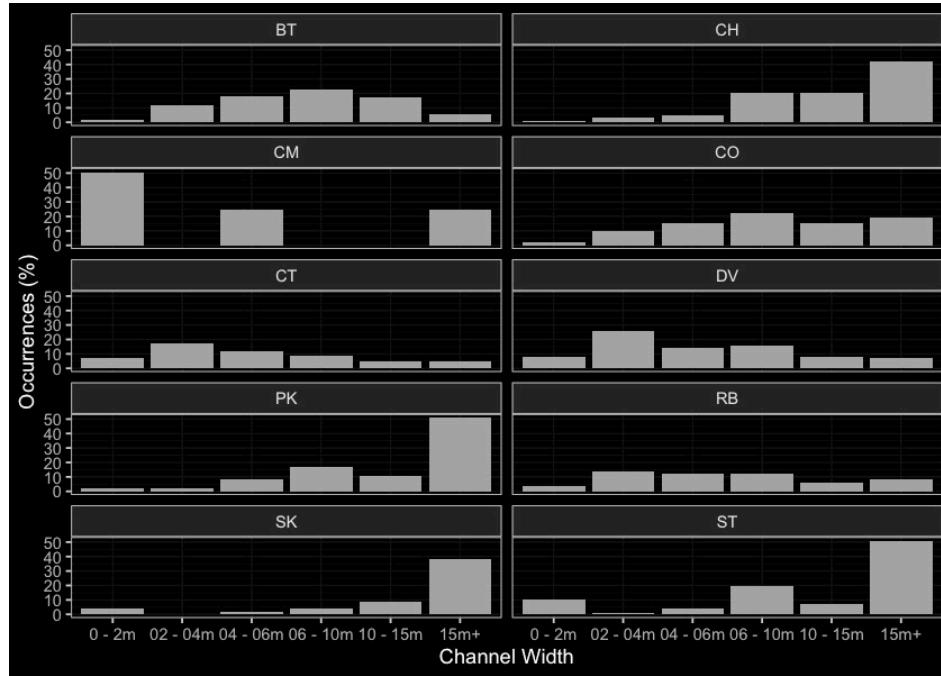


Figure 2.9: Summary of historic salmonid observations vs. channel width category for the Bulkley River watershed group.

2.8 Fisheries

3 Methods

3.1 Communicate Connectivity Issues

3.1.1 Engage Partners

Engaging partners for ecosystem restoration initiatives is critical as it allows us to utilize available resources, tap into different areas of expertise, and benefit from diverse perspectives through collaboration that leads to successful outcomes. Engagement actions have included video conference calls, meetings, emails, presentations and phone calls.

3.1.2 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](#) and is served on the cloud using source code stored [here](#). This environment is intended to be a space where project team members can access, 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 on 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 the scripts used for GIS project creation and updates can be viewed [here](#) with outcomes of their use summarized below:

- Download and clip user specified layers from the [BC Data Catalogue](#) 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.).

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- 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.

3.1.3 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 programmatically through git commit messages. Issues for this project are kept [here](#).

3.1.4 Mapping

The workflows to produce the georeferenced pdf maps include using a QGIS layer file defining and symbolizing all layers required and are continuously evolving. At the time of reporting - mapping scripts and associated layer file were kept under version control within `bcfishpass` [here](#). Loading the QGIS layer file within a QGIS project, allows load and representation of all map component layers provided the user points to a postgresql database populated via `bcfishpass` outputs.

3.2 Planning

3.2.1 Habitat Modelling

Habitat modelling used to help guide planning for field assessments is generated by `bcfishpass` (Norris [2020] 2024) which has been designed to prioritize potential fish passage barriers for assessment or remediation by generating a simple model of aquatic habitat connectivity. We utilize the `bcfishpass` access model and linear spawning/rearing habitat model for planning purposes. These models provide a valuable starting point, but their results are not definitive and should always be considered with professional judgment. Detailed information regarding model parameters and limitations can be found at the following links:

- [bcfishpass background information](#)
- [Access model](#)
- [Linear spawning/rearing habitat model](#)

The access model identifies natural barriers (ex. steep gradients for extended distances) and hydroelectric dams to classify the accessibility of streams for 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 numerous parameters including known fish observations upstream of identified barriers and for each crossing location, the area of lake and wetland habitat upstream, species documented upstream/downstream, and an estimate of watershed area (on 2nd order and higher streams). Furthermore, mean annual precipitation weighted to upstream watershed area, stream discharge, and channel width can be collated using `bcfishpass`, `fwapg` and `bcfishobs`. This

3.2 Planning

information can be used to provide 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.

The linear spawning and rearing habitat model uses species-specific thresholds for stream gradient (Table [3.1](#)), channel width or discharge, network connectivity, and habitat type to assess the intrinsic potential of streams to support spawning and rearing. It also incorporates documented spawning locations and literature-derived parameters to refine habitat suitability estimates. This model helps guide field assessments and prioritize locations for fish passage restoration.

Regarding gradients, `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 phase of the project, the user provided gradient thresholds used to delineate “potentially accessible habitat” were based on estimated max gradients that rainbow trout (20%) and bull trout (25%) are likely to be capable of ascending.

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 20% and 25% 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, or multiple FISS channel widths are available a mean of the average channel widths was used. 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 downloaded to a `postgis` database, sampled for upstream watershed areas associated with each stream segment and a mean annual precipitation weighted by upstream watershed area was calculated. In early 2021, Bayesian statistical methods were developed to predict channel width in all provincial freshwater atlas stream

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segments where width measurements had not previously been measured in the field. The model was based on the relationship between watershed area and mean annual precipitation weighted by upstream watershed area (Thorley and Irvine 2021). In December of 2021, Thorley and Irvine (2021) methods were updated using a power model derived by Finnegan et al. (2005) which relates stream discharge to watershed area and mean annual precipitation. Data ($n = 24849$) on watershed size, mean annual precipitation and measured channel width was extracted from the provincial freshwater atlas (FLNRORD 2021; GeoBC 2022), the BC Data Catalogue fisheries datasets (MoE 2024c, 2021) and Wang et al. (2012) utilizing bcfishpass(Norris [2020] 2021) and fwapg(Norris [2019] 2021).

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. Details of this analysis and subsequent outputs can be reviewed in [Attachment 3 \(page 123\)](#).

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 Width Min (m)	1.5	–	1.5	–	1.5	1.5
Rearing Gradient Max (%)	5.5	–	5.5	–	–	8.5
*						

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

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

* The maximum gradient for steelhead rearing has been adjusted to 8.5% based on professional judgment, although references indicate 7.49%

3.2 Planning

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 uses a maximum gradient threshold of 25% to determine whether access is likely possible

Table 3.4: Stream gradient categories (threshold and average) and associated channel type.

Gradient	Channel Type
0 - 5%	Riffle and cascade pool
5 - 15%	Step pool
15 - 20%	Step pool - very steep
>20%	Non fish habitat

3.3 Fish Passage Assessments

In the field, crossings prioritized for follow-up were first assessed for fish passage following the procedures outlined in “Field Assessment for Determining Fish Passage Status of Closed Bottomed Structures” (MoE 2011). The reader is referred to (MoE 2011) for detailed methodology. 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, road 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 3.5).

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).

3.3 Fish Passage Assessments

Fish passage potential was determined for each stream crossing identified as a closed bottom structure as per MoE (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 (Tables [3.6](#) - [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). For crossings determined to be potential barriers or barriers based on the data, a culvert fix and recommended diameter/span was proposed.

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).

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

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 minimum 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.

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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 (8.5%) was used. To generate estimates for area of habitat upstream (m^2), the estimated linear length was multiplied by half the downstream channel width measured (overall triangular channel shape) as part of the fish passage assessment protocol. Although these estimates are not generally conservative, have low accuracy and do not account for upstream stream crossing structures they allow a rough idea of the best candidates for follow up.

Potential options to remediate fish passage were selected from MoE (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..

3.3.1 Cost Estimates

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 help refine estimates which have since been adjusted for inflation in 2020 and based on past experience.

3.3 Fish Passage Assessments

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 \$30000/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 \$100k/crossing (pers. comm. Phil MacDonald, Steve Page then adjusted for inflation in 2020). For larger streams (>6m), estimated span width increased proportionally to the size of the stream. 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 generated to estimate incremental cost increases with costs estimated for structure replacement on paved surfaces, railways and arterial/highways costing up to 15 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 \$/15m	Streambed Simulation \$
FSR	Rough	1		1 450,000	100,000
FSR	Loose	1		1 450,000	100,000
Resource	Loose	1		1 450,000	100,000
Resource	Rough	1		1 450,000	100,000
Permit	Unknown	1		1 450,000	100,000
Permit	Loose	1		1 450,000	100,000
Permit	Rough	1		1 450,000	100,000
Unclassified	Loose	1		1 450,000	100,000
Unclassified	Rough	1		1 450,000	100,000
Unclassified	Paved	1		2 750,000	150,000
Unclassified	Unknown	1		2 750,000	150,000
Local	Loose	4		1 1,500,000	200,000
Local	Paved	4		2 3,000,000	400,000
Collector	Paved	4		2 3,000,000	400,000
Arterial	Paved	15		2 11,250,000	1,500,000
Highway	Paved	15		2 11,250,000	1,500,000
Rail	Rail	15		2 11,250,000	1,500,000

3.4 Designs

Engineering designs were conducted by consultants hired by forest licensees with tenure over the roads and/or timber harvest planned on the roads where work was conducted. Completed designs are loaded to the PSCIS data portal.

3.5 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 3.5](#)).

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 a minimum distance 300m and upstream to a minimum distance of 500 - 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.

3.6 Fish Sampling

3.6.1 Electrofishing

Fish sampling was conducted on a subset of sites when biological data was considered to add significant value to the physical habitat assessment information. Electrofishing was utilized for fish sampling according to stream inventory standards and procedures found in the Reconnaissance (1:20 000) Fish and Fish Habitat Inventory Manual (Resources Inventory Committee 2001). A Haltech 2000 backpack electrofisher was used within discrete site units both upstream and downstream of the subject crossing with electrofisher settings and seconds, water quality parameters (i.e. conductivity, temperature and ph), start and end locations, length of site and wetted widths (average of a minimum of three) recorded.

3.7 Remediations

3.6.2 Fish Handling and Processing

Captured fish were held in buckets with sufficient water to minimize stress until processing, and multiple buckets were used when catch numbers were high. For each fish captured, fork length, weight and species was recorded with results documented in the fish data submission spreadsheet.

3.6.3 Pit Tagging

Fish with a fork length greater than 60 mm and belonging to species approved under the scientific fish collection permit SM24-882238 were tagged with Passive Integrated Transponders (PIT tags) using the [Abdominal Cavity](#) method outlined by Biomark. To anesthetize fish prior to pit tagging, we used a solution of approximately 0.1 mL of clove oil per 1 L of water (1:10,000). This concentration was selected for its efficiency in providing effective sedation with minimal residual effects, making it ideal for studies in which fish are released back into their natural habitats (Fernandes et al. 2017). The clove oil solution was prepared in advance by dissolving pure clove oil in ethyl alcohol in a 1:9 ratio (clove oil: ethyl alcohol) to enhance solubility, then mixed into the water bucket (Fernandes et al. 2017). Fish were immersed in this solution until they reached an appropriate level of anesthesia for handling and then were tagged. To maintain needle sharpness and minimize injury risk, needles were replaced approximately every 10 fish. Each tagged fish was scanned with the PIT reader, and both the PIT tag ID and row ID were recorded. Once tagged, fish were placed into a bucket of fresh water and allowed to recover before being released back into the stream. Fish information and habitat data will be submitted to the province under scientific fish collection permit SM24-882238.

3.7 Remediations

Structure replacement was conducted by project specific contractors. As-built drawings were completed and loaded to the PSCIS data portal.

3.8 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 going forward.

3 Methods

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	Constructability (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
priority_notes	Describe details and rational for priority rankings

3.9 Aerial Imagery

Scripted processing and serving of UAV imagery collected during the project is available at https://github.com/NewGraphEnvironment/stac_uav_bc/ (Irvine [2025] 2025). [OpenDroneMap](#) was utilized to produce orthomosaics, digital surface models (DSMs), and digital terrain models (DTMs) (OpenDroneMap Authors [2014] 2025). To support efficient web-based access - imagery products were converted to cloud-optimized GeoTIFFs (COGs) using `rio-cogeo`, then collated according to the [SpatioTemporal Asset Catalog \(STAC\)](#) specification with `pystac` and uploaded to S3 storage Amazon Web Services (2025). A `titiler` tile server was set up to facilitate interactive viewing of the orthoimagery and an Application Program Interface (API) leveraging `stac-fastapi-pgstac` is served at <https://images.a11s.one> to enable linking of collection images through QGIS as well as remote spatial and temporal querying using open source software such as `rstac` (Development Seed [2019] 2025; `stac-utils` 2025; Simoes et al. 2021).

4 Results and Discussion

4.1 Site Assessment Data Since 2020

Fish passage assessment procedures conducted through SERNbc in the Skeena River Watershed since 2020 are amalgamated online within the Results and Discussion section of the report found [here](#).

4.2 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 (2025-03-28) are included online [here](#).

4.3 Buck Creek Falls

Buck falls are located just downstream of the Buck Flats Road bridge on the Buck Creek mainstem approximately 30 km upstream of its confluence with the Bulkley River. The falls have not yet been documented in the FISS database (MoE 2024b) but have been previously noted in A. Gottesfeld and Rabnett (2007), the World Waterfall Database (“Buck Falls, British Columbia, Canada - World Waterfall Database” n.d.), and on the Houston Hikers website (“Buck Falls | Adventures” n.d.).

Although rainbow trout, mountain whitefish, kokanee and other non-salmonid resident species have been documented upstream of the falls in the FISS database - no salmon species are documented upstream (MoE 2024a). An assessment was conducted on September 19, 2024 to assess the feasibility of upstream migration of the falls.

The falls consist of a series of three separate vertical and cascade sections over an approximately 200m section of stream. The upper falls consisted of a ~4 m high vertical drop, presenting a substantial barrier to fish passage (Figure [4.1](#)). Approximately 25 m downstream, the second falls was a ~3.5 m high sheer drop to bedrock, with minimal pool depth available to facilitate fish passage (Figure [4.1](#)). Further downstream ~100 m, the third step comprised a ~1.5 m vertical drop with an overlying cascade, exhibiting a ~15% gradient over a 1.0 m height (Figure [4.2](#)). An additional cascade, located a further ~25 m downstream, featured a ~2 m high drop with a ~30% gradient extending over a 5 m length (Figure [4.2](#)).

4 Results and Discussion



Figure 4.1: Left: Buck Falls – The upper falls featured a ~4m high vertical drop. A 2m tall net is included for scale. Right: Buck Falls – The second falls consisted of a ~3.5m high sheer drop to bedrock.



Figure 4.2: Left: Buck Falls – The third step consisted of a ~1.5 m vertical drop with an overlying cascade, exhibiting a ~15% gradient over a 1.0m height. Right: Buck Falls – An additional cascade featured a ~2m high drop with a ~30% gradient extending over a 5 m length. A 2m tall net is included for scale.

4.4 Phase 1 - Fish Passage Assessments

Field assessments were conducted between September 17, 2024 and October 03, 2024 by Allan Irvine, R.P.Bio. and Lucy Schick, B.Sc., Tieasha Pierre, Vern Joseph, Jesse Olson, and Jessica Doyon. A total of 16 Fish Passage Assessments were completed, including 9 Phase 1 assessments and 7 reassessments. In 2024, field efforts prioritized revisiting previously assessed sites for

4.4 Phase 1 - Fish Passage Assesse...

monitoring rather than evaluating new Fish Passage Assessment locations. As this was the fifth year of the study, a substantial number of sites had already been assessed, allowing the focus to shift toward monitoring and informing restoration activities at key locations.

Of the 16 sites where fish passage assessments were completed, 9 were not yet inventoried in the PSCIS system. This included 4 crossings considered “passable”, 1 crossings considered a “potential” barrier, and 4 crossings were considered “barriers” according to threshold values based on culvert embedment, outlet drop, slope, diameter (relative to channel size) and length (MoE 2011).

Reassessments were completed at 7 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 [Appendix](#).

The “Barrier” and “Potential Barrier” rankings used in this project followed MoE (2011) and represent an assessment of passability for juvenile salmon or small resident rainbow trout under any flow conditions that may occur 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.

4 Results and Discussion

PSCIS ID	External ID	Stream	Road	Barrier Result	Habitat value	Habitat Upstream (km)	Stream Width (m)	Priority	Fix	Cost Est (\$K)
8530	–	Sandstone Creek	McDonnell FSR	Barrier	High	24.0	3.90	high	OBS	990
195934	–	Dunalter Creek	Barret Station Road	Barrier	Medium	15.9	1.60	low	SS-CBS	200
195935	–	Dunalter Creek	Houston Airport Road	Barrier	Medium	15.9	1.70	mod	SS-CBS	400
195943	–	Stock Creek	Barrett Station Road	Barrier	Medium	23.1	2.60	mod	OBS	3000
197967	–	Taman Creek	Highway 16	Potential	Medium	150.7	5.50	–	OBS	20250
203122	1805555	Simpson Creek	Railway	Barrier	High	4.1	5.00	low	OBS	11250
203123	8300088	Tributary to Gershwin Creek	Comeau Road	Potential	Low	1.8	0.50	low	SS-CBS	200
203124	8300015	Tributary to Gershwin Creek	Comeau Road	Barrier	Medium	3.2	0.95	low	SS-CBS	200
203125	2024092550	Gershwin Creek	Private property	Barrier	High	6.0	6.00	mod	OBS	–
203126	2024092003	Simpson Creek	Private driveway	Barrier	High	5.4	7.00	low	OBS	–

4.5 Phase 2 - Habitat Confirmation Assessments

During the 2024 field assessments, habitat confirmation assessments were conducted at three sites within the Morice River, Kispiox River, and Bulkley River watershed groups. A total of approximately 6 km of stream was assessed. Electrofishing surveys were conducted at all habitat confirmation sites. Georeferenced field maps are provided 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](#) - [4.4](#) with raw habitat and fish sampling data included in [Attachment 2](#). A summary of preliminary modeling results illustrates the estimated Chinook, coho, and steelhead spawning and rearing habitat potentially available upstream of each crossing, based on measured/modelled channel width and upstream accessible stream length, as presented in Figure [4.3](#). Detailed information for each site assessed with Phase 2 assessments (including maps) are presented within site specific appendices to this document.

4.5 Phase 2 - Habitat Confirmation As...

Table 4.2: Overview of habitat confirmation sites. Steelhead rearing model used for habitat estimates (total length of stream network)

PSCIS ID	Stream	Road	Tenure	UTM	UTM zone	Fish Species	Habitat			Priority	Comments
							Gain (km)	Habitat Value			
198935	Tributary to Knapper Creek	Gold Creek FSR	Canfor R07549 6	636440 6020756	9	CT	0.9	Medium	High		The stream was surveyed upstream for ~700 m. The stream exhibited medium-value habitat with a good flow and abundant gravels throughout. A mature mixed forest, including cottonwood, provided excellent bank stabilization, resulting in deeply undercut banks and intermittent pools up to 60 cm deep within the surveyed area. Electrofishing conducted downstream of the crossing captured rainbow trout, cutthroat trout, and Dolly Varden. Upstream sampling captured rainbow trout, cutthroat trout, and cutthroat trout/rainbow trout hybrids. The low-gradient habitat is suitable for cutthroat trout, rainbow trout, and coho juvenile rearing, as well as adfluvial and anadromous spawning. A sizeable beaver dam complex was present at the upper end of the surveyed area, coinciding with the confluence of a tributary mapped in the Freshwater Atlas. There is suspected interconnection between wetlands in this watershed and adjacent watersheds, suggesting the current mapping may misrepresent the watershed's size. This remains unconfirmed, but LiDAR analysis could be used to verify these connections.
198940	Tributary to Knapper Creek	HM7504	Canfor R07549 16	636706 6020960	9	CT;RB	1.2	Medium	High		The stream was surveyed in th-

4 Results and Discussion

PSCIS ID	Stream	Road	Tenure	UTM	UTM zone	Fish Species	Habitat			
							Gain (km)	Habitat Value	Priority	Comments
<p>e downstream direction, starting at the upstream crossing on Gold Creek FSR, down to this crossing on road/spur HM7504, approximately 340 m. This section of stream provided medium-value habitat, with good flow, abundant gravels for spawning, and suitable rearing areas within undercut banks and occasional deep pools. Evidence of historic beaver activity is present throughout the area surveyed, including one large breached dam near the upstream end of the site. The riparian zone consists of a healthy shrub and herbaceous flood-tolerant plant community. The stream corridor is approximately 40–50 m wide, bordered by mature coniferous forest on both sides.</p> <p>Electrofishing conducted at the upstream crossing on Gold Creek FSR captured rainbow trout, cutthroat trout, cutthroat trout/rainbow trout hybrids, and Dolly Varden.</p>										
58245	Simpson Creek	Lake Kathlyn Road	MoTi	615383 6075125	9	CO;CT;DV;MW;RB;SA;ST	2.0	High	Low	The s-

4.5 Phase 2 - Habitat Confirmation As...

PSCIS ID	Stream	Road	Tenure	UTM	Habitat				
					UTM zone	Fish Species	Gain (km)	Value	Habitat Priority
<p>stream was surveyed from the railway downstream to Lake Kathlyn Road, covering approximately 1 km. The upper 750 m of the stream is in relatively good condition, with mostly intact riparian vegetation, abundant gravels, deep pools, and large woody debris throughout. The lower 250–500 m is heavily impacted by adjacent private lands, with riparian vegetation removal, stream channelization, and bank armouring. Extensive beaver activity was observed within the lower ~300 m, with dams ranging from 0.4 to 1 m in height. An additional crossing was noted on private land just upstream of Lake Kathlyn Road on a driveway. This stream is a major contributor to the greater Kathlyn Creek watershed, with flow volumes during the assessment slightly less than the Kathlyn Creek mainstem. The stream provides high-value habitat upstream, particularly in the upper sections, within this known steelhead, coho, and historically Chinook spawning system.</p> <p>Electrofishing upstream of Nielsen Road captured rainbow trout, while downstream sampling confirmed the presence of Dolly Varden, rainbow trout, cutthroat trout/rainbow trout hybrids, and coho. The coho were captured approximately 350 m downstream of Nielsen Road.</p>									
198916	Gershwin Creek	Railway	CN Rail	580463 6115769	9 –	0.0	Medium	High	This survey cover-

4 Results and Discussion

PSCIS ID	Stream	Road	Tenure	UTM	Habitat						
					UTM zone	Fish Species	Gain (km)	Habitat Value	Priority	Comments	
<p>s the area from the railway culvert (crossing 198916, ~100m long and from the 1920s) upstream to the crossing on Highway 16 (crossing 198913), spanning approximately 900 m. A separate habitat confirmation was conducted upstream of Highway 16. Therefore, this site encompasses both 198916_us and 198913_ds. A large woody debris jam was observed approximately 250 m upstream of the culvert, creating a 17% gradient over a 9 m section due to a fallen tree. The stream had good flow in this steeper section, supported by a healthy, mature mixed riparian forest that stabilized the banks. Occasional pockets of gravels suitable for coho, Dolly Varden, and cutthroat trout spawning were present. Electrofishing was conducted and Dolly Varden and cutthroat trout were captured above and below the highway crossing. WP79 marks the confluence with a steel bridge on private land.</p>											
198913	Gershwin Creek	Highway 16	MOTi	581250 6115660	9 –		0.0	Medium	Moderate	The stream has frequent pools suitable for overwintering fish, with spawning gravel present despite a significant amount of fines. It has a low gradient near the culvert and flows through agricultural fields, but maintains sufficient riparian cover with large cottonwoods throughout the 600 m survey. A landowner-constructed bridge with two culverts is located ~250 m upstream of the highway crossing. Two ~1 m high logjams are present but remain passable for fish. Electrofishing was conducted and Dolly Varden and cutthroat trout were captured above and below the highway crossing.	
58264	Simpson Creek	Nielson Road	MoTi	614280 6074951	9 –		0.4	High	High	The stream wa-	

4.5 Phase 2 - Habitat Confirmation As...

PSCIS ID	Stream	Road	Tenure	UTM	UTM zone	Fish Species	Habitat		
							Gain (km)	Habitat Value	Priority
<p>s surveyed from Nielsen Road upstream for approximately 650 m, to roughly 200 m upstream of the powerlines. The stream had a steeper gradient with predominantly boulder cover and pockets of gravels suitable for coho, steelhead, and Dolly Varden spawning. Pools were infrequent. The upper end of the site was located just upstream of a short cascade with a 20% gradient. The riparian zone consisted of a healthy, mature mixed forest. This stream is a major contributor to the greater Kathlyn Creek watershed, with flow volumes during the assessment slightly less than the Kathlyn Creek mainstem. The stream provides high-value habitat, particularly below Nielsen Road, as this is a known steelhead, coho, and historically Chinook spawning system. The culvert on Nielsen Road has a significant outlet drop and likely limits fish passage. Electrofishing upstream of Nielsen Road captured rainbow trout, while downstream sampling confirmed the presence of Dolly Varden, rainbow trout, cutthroat trout/rainbow trout hybrids, and coho. The coho were captured approximately 350 m downstream of Nielsen Road.</p>									

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
58245	No	0.00	2.50	2.80	2.0	20	24	Barrier
58264	No	1.00	2.40	2.33	5.0	23	39	Barrier
198913	No	0.35	1.50	3.33	3.0	40	42	Barrier
198916	No	0.45	1.50	2.93	6.0	100	42	Barrier
198935	No	0.15	1.20	2.25	1.5	20	29	Barrier
198940	No	0.00	0.95	4.53	2.0	25	24	Barrier
203122	No	0.05	3.00	1.67	2.0	25	24	Barrier

4 Results and Discussion

Table 4.4: Cost benefit analysis for Phase 2 assessments. Steelhead rearing model used for habitat estimates (total length of stream network)

PSCIS ID	Stream	Road	Barrier Result	Habitat value	Stream Width (m)	Fix	Cost Est (\$K)	Habitat Upstream (m)	Cost Benefit (m / \$K)	Cost Benefit (m ² / \$K)
58245	Simpson Creek	Lake Kathlyn Road	Barrier	High	6.0	OBS	3000	2014	671.3	2349.7
58264	Simpson Creek	Nielson Road	Barrier	High	8.9	OBS	3000	401	133.7	374.3
198913	Gershwin Creek	Highway 16	Barrier	Medium	6.0	OBS	11250	0	0.0	0.0
198916	Gershwin Creek	Railway	Barrier	Medium	4.4	OBS	26625	0	0.0	0.0
198935	Tributary to Knapper Creek	Gold creek fsr	Barrier	Medium	2.5	OBS	540	897	1661.1	2242.5
198940	Tributary to Knapper Creek	HM7504	Barrier	Medium	2.8	OBS	450	1236	2746.7	5905.3
203122	Simpson Creek	Railway	Barrier	High	6.2	OBS	11250	1582	140.6	351.6

4.5 Phase 2 - Habitat Confirmation As...

Table 4.5: Summary of Phase 2 habitat confirmation details.

PSCIS ID	Length surveyed upstream (m)	Average Channel Width (m)	Average Wetted Width (m)	Average Pool Depth (m)	Average Gradient (%)	Total Cover	Habitat Value
58245	1000	6.0	4.3	0.7	1.1	moderate	high
58264	615	8.9	4.7	0.3	7.3	moderate	medium
198106	475	4.3	3.3	0.3	1.9	moderate	high
198913	600	6.0	4.0	0.6	2.8	abundant	high
198916	900	4.4	3.3	0.4	4.4	moderate	medium
198935	700	2.5	1.9	0.4	2.2	moderate	medium
198940	340	2.8	1.2	0.3	2.7	moderate	medium
203122	950	6.2	3.5	0.6	4.1	moderate	high

4 Results and Discussion

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

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
198913	5.7	296	277	1996	700	505	W
198916	12.9	264	201	2019	575	411	W
198935	4.1	797	799	1131	923	903	SE
198940	4.1	785	799	1131	923	903	SE
58245	13.1	503	495	2477	1311	1068	E
58264	6.8	533	931	2478	1757	1696	SE

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

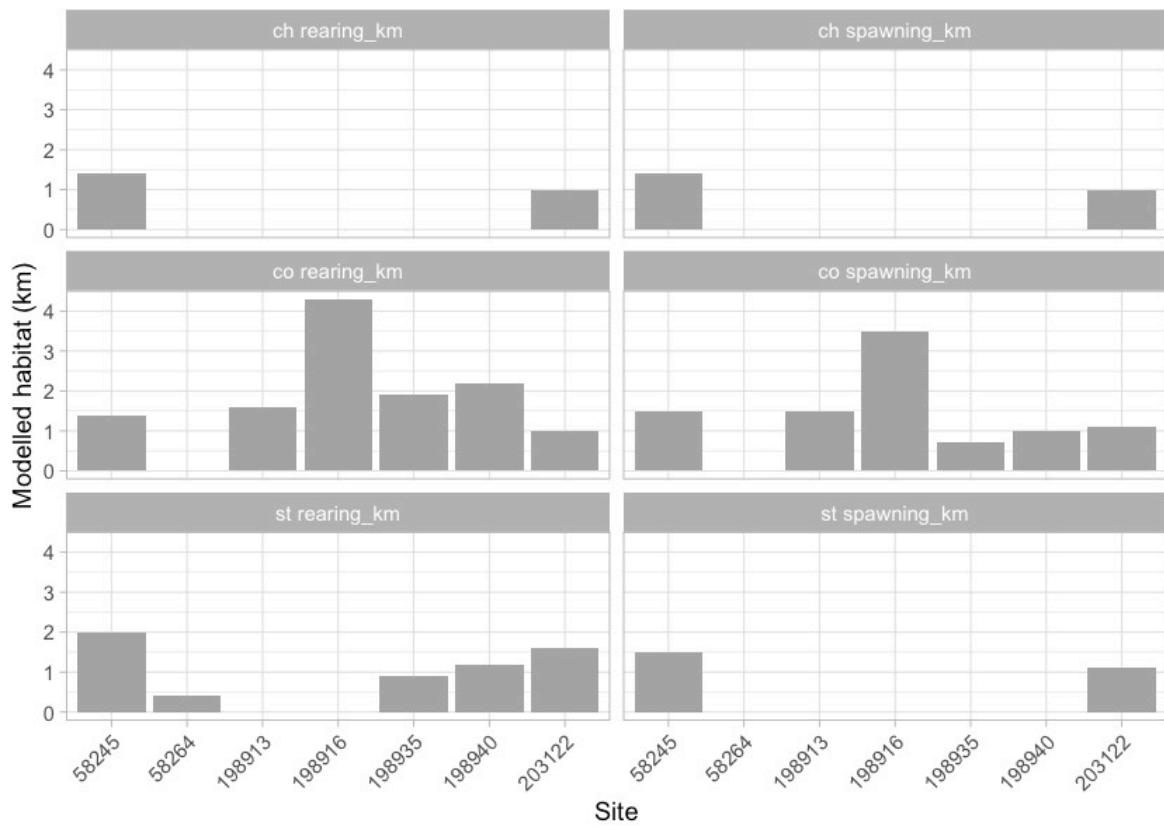


Figure 4.3: Summary of potential rearing and spawning habitat upstream of habitat confirmation assessment sites. See Table 3.1 for modelling thresholds.

4.5.1 Fish Sampling

Fish sampling was conducted at 15 sites within 5 streams, with a total of 314 fish captured. Fork length, weight, and species were documented for each fish.

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 [4.5](#). A summary of sites assessed are included in Table [4.7](#) and raw data is provided in [Attachment 2](#). A summary of density results for all life stages combined of select species is also presented in Figure [4.4](#).

Results are presented in greater detail within individual habitat confirmation site appendices, and for Sandstone Creek [here](#).

4 Results and Discussion

Table 4.7: Summary of electrofishing sites.

site	stream	passes	ef_length_m	ef_width_m	area_m2	enclosure
8530_ds_ef1	Sandstone Creek	1	30	2.8	84.0	partial enclosure
8530_us_ef1	Sandstone Creek	1	35	1.8	63.0	partial enclosure
198935_ds_ef1	Tributary To Knapper Creek	1	8	1.1	8.8	partial enclosure
198935_us_ef1	Tributary To Knapper Creek	1	30	1.6	48.0	partial enclosure
195943_ds_ef1	Stock Creek	1	30	2.1	63.0	partial enclosure
195943_us_ef1	Stock Creek	1	40	1.4	56.0	partial enclosure
58264_ds_ef1	Simpson Creek	1	25	3.3	82.5	partial enclosure
58264_ds_ef2	Simpson Creek	1	30	2.7	81.0	partial enclosure
58264_us_ef1	Simpson Creek	1	32	3.5	112.0	partial enclosure
198916_ds_ef1	Gershwin Creek	1	34	3.1	105.4	partial enclosure
198916_ds_ef2	Gershwin Creek	1	7	5.8	40.6	partial enclosure
198916_us_ef1	Gershwin Creek	1	43	3.4	146.2	partial enclosure
198913_ds_ef1	Gershwin Creek	1	7	6.0	42.0	partial enclosure
198913_ds_ef2	Gershwin Creek	1	20	3.3	66.0	open
198913_us_ef1	Gershwin Creek	1	30	3.0	90.0	partial enclosure

4.5 Phase 2 - Habitat Confirmation As...

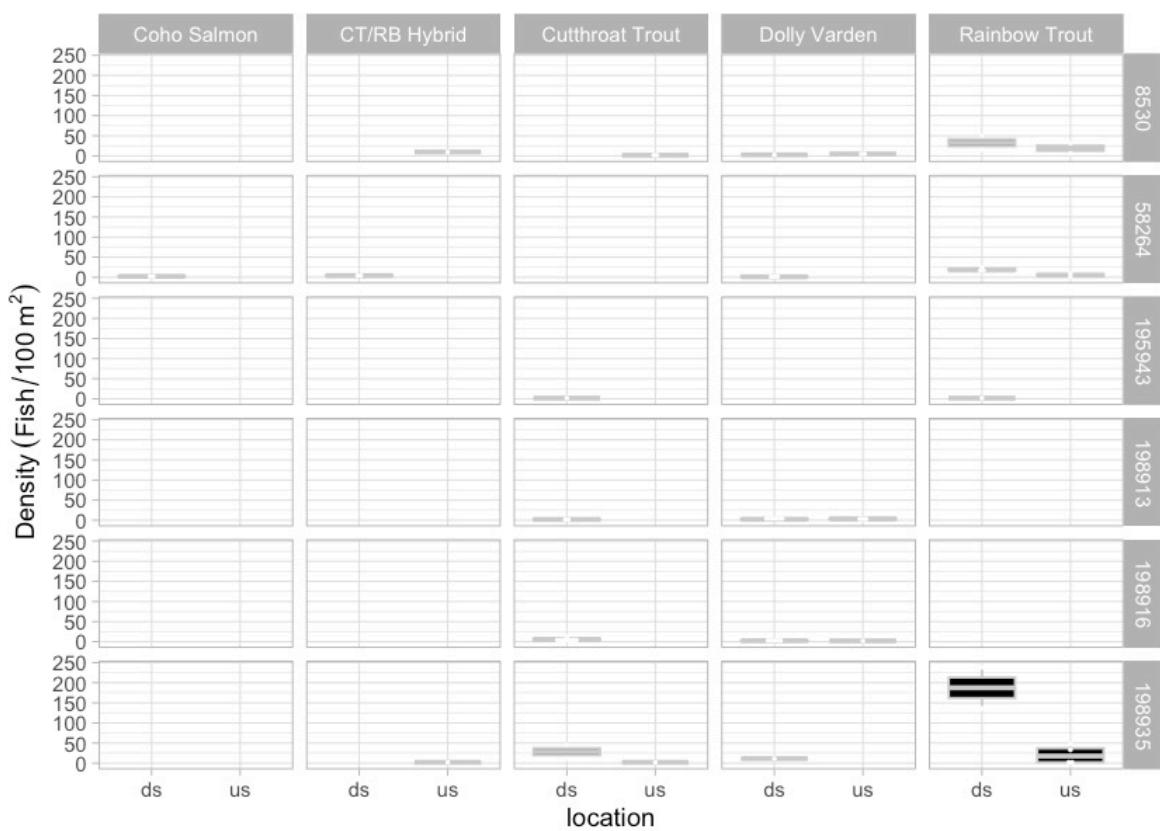


Figure 4.4: Boxplots of densities (fish/100m²) of fish captured downstream (ds) and upstream (us) by electrofishing during habitat confirmation assessments.

4 Results and Discussion

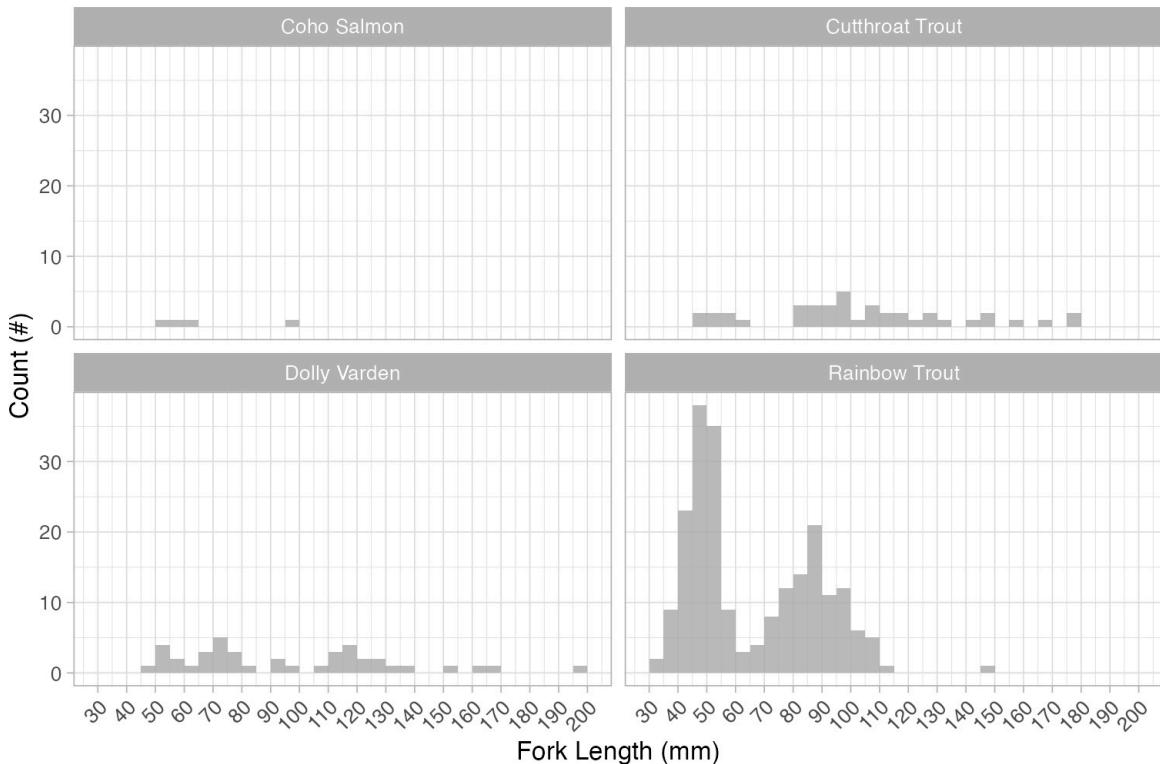


Figure 4.5: Histograms of fish lengths by species. Fish captured by electrofishing during habitat confirmation assessments.

4.6 Phase 3 - Design

All sites with a design for remediation of fish passage can be found online within the Results and Discussion section of the report found [here](#). In 2024, designs for remediation of fish passage were completed for the following sites:

- Waterfall Creek – PSCIS crossing 124421 is a Hazelton municipal crossing on 11th Avenue. Waterfall Creek flows into Station Creek downstream of this site. Remediation efforts, led by Gitksan Watershed Authorities, in collaboration with SERNbc, Skeena Fisheries Commission, the Department of Fisheries and Oceans, Gitsxan House representatives and the Chicago Creek Community Environmental Enhancement Society, are tentatively planned for summer 2025. Through this year's project - SERNbc funded the engineering design for a bridge to replace the open bottom culverts - drafted by Pacific North Coast Consulting Services. In 2024 a field visit was conducted which included a habitat survey from the waterfall located above town to Highway 16. Additionally an aerial survey was conducted with a drone to map the historic Waterfall Creek wetland areas located north of Highway 16/10th avenue (east of Churchill Street) to support restoration planning (orthomosaics available [here](#)). Reporting updated with 2024 data along with background information for the Station Creek and Waterfall Creek watersheds are presented [here](#) and [here](#).

4.7 Phase 4 - Remediations

- Tributary to Owen Creek – PSCIS crossing 197378 is located on Klate Lake Road. Through 2024/25 project activities SERNbc funded an engineering design completed by Pacific North Coast Consulting Services. Proposed works include the replacement of the existing 1.0m wide round culvert with a 12m free span bridge. This site has been earmarked for replacement through the Bii Wenii Kwa Restoration/Recovery Plan which is a collaboration between the Wet'suwet'en Treaty Society, Fisheries and Oceans Canada, BC Ministry of Forests, and Water, Land and Resource Stewardship, Morice Water Monitoring Trust, and Northwest Research and Monitoring (Morgan and Reese-Hansen 2024). Klate Lake Road provides access to forestry areas under the tenure of Yinka Dene Economic Development Limited Partnership (YLP) which is the corporate business arm of the Wet'suwet'en First Nation. Additionally this road provides access to the [Nadina Mountain Provincial Park](#), which features the [Nadina Mountain Trail](#) (BC Parks 2025). Background information updated in 2025 and also including habitat confirmation reporting and fish sampling conducted in 2021 and 2023 is presented in Irvine and Schick (2023) [here](#). Design drawings for the proposed bridge installation are available [here](#).

4.7 Phase 4 - Remediations

All sites where remediation of fish passage has been completed can be found online within the Results and Discussion section of the report found [here](#). In 2024, remediation of fish passage was completed at the following site:

- In 2024, PSCIS crossing 198217 on Tributary to Skeena River, located on the Sik-E-Dakh Water Tower Road was replaced with a clear-span bridge with remediation work led by the Gitskan Watershed Authorities. This project serves as a great example to follow in future installations, demonstrating thoughtful erosion control and re-vegetation, a wide, stable channel with minimal riprap, and strategic riprap placement that was effectively buried to maintain natural channel morphology. Background information - updated in 2025 - can be found [here](#).

4.8 Monitoring

Electrofishing was conducted at Sandstone Creek to build on previous data. Salmonids with fork lengths >60mm were PIT-tagged to facilitate long-term tracking of health and movement with data amalgamated into past reporting [here](#).

Following replacement of Taman Creek (PSCIS crossing 197967) on Highway 16, effectiveness monitoring was conducted in 2024. Background information can be reviewed [here](#) with results of the 2024 monitoring presented in [Taman Creek - 197967 - Appendix \(page 51\)](#).

4 Results and Discussion

4.9 Aerial Imagery

Orthoimagery and elevation model rasters are presented

[at https://newgraphenvironment.github.io/fish_passage_skeena_2024_reporting/results-and-discussion.html](https://newgraphenvironment.github.io/fish_passage_skeena_2024_reporting/results-and-discussion.html).

Taman Creek - 197967 - Appendix

Site Location

PSCIS crossing 197967 is located on the Bulkley River approximately 22.5km east of Topley, BC within the Bulkley River watershed group. The site is situated on Highway 16, approximately 2.5km upstream from Bulkley Lake. Although the stream is named the Bulkley River in the BC Freshwater Atlas, the stream at the highway is commonly referred to as Taman Creek (including on highway signage) as Taman Creek flows into this stream approximately 750m upstream of the highway. The culvert is the responsibility of the Ministry of Transportation and Infrastructure (chris_hwy_structure_road_id 33227).

Background

Detailed background for this site is available in Irvine ([2021] 2022) related to the habitat confirmation conducted in 2021 which can be found [here](#). A map of the watershed is provided in map attachment [093L.115](#).

Between 2022 and 2024, the Ministry of Transportation and Infrastructure contracted Enviro-Ex Contracting Ltd. to replace the crossing with an extensive streambed simulation structure at a cost of \$16,000,000 (Link 2023). The 3m wide un-embedded round culvert was replaced with a 5.6m wide fully embedded round streambed simulation culvert.

Monitoring

In 2024, crews revisited the site for monitoring purposes, with results summarised in Tables @ref(tab:tab-monitoring-197967 - [4.9](#)). The structure was well-constructed, with nearly 2m of embedded material within the new structure consisting of large boulders, cobbles, and gravels. Upstream, woody debris and boulder structures were cabled together within the reconstructed stream channel to provide habitat complexity and bank stabilization Figure [4.6](#). This large-scale construction project involved substantial fill, extending for approximately 60m downstream and over 200m upstream.

Photos showing a comparison of the culvert assessment conducted in 2021 versus the completed replacement structure in 2024 are presented in Figure [4.6](#).

Taman Creek - 197967 - Appendix

variable	value
Pscis Crossing Id	197967
Stream Name	Taman Creek
Road Name	Highway 16
Crossing Subtype	ROUND
Span	5.6
Width	40
Assessment Comment	This is a brand-new replacement structure, extremely well built with extensive embedment that includes numerous large boulders, cobbles, and gravel. The multiplate round structure is embedded nearly 2 m. Upstream, woody debris and boulder structures are cabled together for added stability. This massive construction project involved a substantial amount of fill extending 60 m downstream and over 200 m upstream. The site now offers migration conditions significantly better than before.
Dewatering Notes	No dewatering
Velocity Notes	Velocity appeared reasonable, with a low gradient effectively connecting upstream and downstream sections. The boulders placed in the culvert, along with cabled woody debris and boulder structures upstream, would help reduce velocity and enhance habitat complexity over time.
Constriction Notes	The culvert diameter was wide (5.6m) and did not appear to be constricting the channel.
Substrate Notes	The culvert had extensive embedment of natural substrate materials, including large boulders, cobbles, and gravels. The substrates within the culvert closely matched those observed upstream and downstream.
Riparian Notes	Some riparian vegetation was removed, but it appeared to have been replanted with grasses. The riparian area upstream on the right bank remained the most intact and similar to its natural state. The channelized banks directly upstream and downstream of the culvert, for approximately 50m, were reinforced with riprap, with no apparent riparian planting or fill covering the riprap. If future work is considered at this site, additional re-vegetation is recommended, including planting willow whips into the riprap and increasing vegetation on the stream banks to improve overhead cover for fish.
Flow Depth Notes	Flow depths were adequate, and at higher flows, deeper sections would likely form behind the boulders and chained logs. NULL
Stability Notes	The structure was well built, with the road column extensively reinforced with fill. Road runoff areas along the embankment were armored with rock for added stability.
Revegetation Notes	There did not appear to be significant re-vegetation efforts, as much of the riprap remained exposed and only grasses seemed to have been planted. More effort could have been directed toward re-vegetation; however, the overall condition of the riparian area was adequate. If future work is considered at this site, additional re-vegetation is recommended, including planting willow whips into the riprap and increasing vegetation on the stream banks to improve overhead cover for fish.
Cover Notes	The boulders placed in the culvert, along with the woody debris and boulder structures cabled together upstream, will provide cover over time. However, overhead cover was sparse within the construction footprint, with no signs of vegetative planting to enhance cover. If future work is considered at this site, additional re-vegetation is recommended, including planting willow whips into the riprap and increasing vegetation on the stream banks to improve overhead cover for fish.
Maintenance Notes	No maintenance required.

Monitoring

Location and Stream Data		Crossing Characteristics	
Date	2024-10-03	Crossing Sub Type	Round Culvert
PSCIS ID	197967	Diameter (m)	5.6
External ID	–	Length (m)	40
Crew	AI	Embedded	Yes
UTM Zone	9	Depth Embedded (m)	2
Easting	692426	Resemble Channel	Yes
Northing	6032341	Backwatered	No
Stream	Taman Creek	Percent Backwatered	–
Road	Highway 16	Fill Depth (m)	7
Road Tenure	MoTi	Outlet Drop (m)	0
Channel Width (m)	5.5	Outlet Pool Depth (m)	0
Stream Slope (%)	2	Inlet Drop	No
Beaver Activity	Yes	Slope (%)	3
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	16	Barrier Result	Potential
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	27
Comments:			
This is a brand-new replacement structure, extremely well built with extensive embedment that includes numerous large boulders, cobbles, and gravel. The multiplate round structure is embedded nearly 2 m. Upstream, woody debris and boulder structures are cabled together for added stability. This massive construction project involved a substantial amount of fill extending 60 m downstream and over 200 m upstream. The site now offers migration conditions for fish that are equal to or better than previous conditions. MoTi chris_culvert_id: 2076452			
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			



Conclusion

Conclusion

In 2024, conditions for upstream fish passage through the highway crossing at Taman Creek was greatly improved through installation of a streambed simulation structure featuring a large culvert width, embedded natural streambed substrates, and the addition of well designed habitat features within the reconstructed channel. Future monitoring of the site could repeat monitoring metrics conducted in 2024, track morphological changes to the channel in the years following construction and include fish sampling and/or eDNA presence surveys to understand fish use upstream and downstream of the crossing.

Taman Creek - 197967 - Appendix



Figure 4.6: Left: Woody debris and boulder structures located upstream of 197967 in 2024. Right: Photos of crossing 197967 in 2021.

Gershwin Creek - 198916 & 198913 - Appendix

Site Location

PSCIS crossings 198916 and 198913 are located on Gershwin Creek. This stream flows from an unnamed lake, first southwest and then northwest, before entering the Skeena River approximately 12.5km southwest of the town of New Hazelton. PSCIS crossing 198916 is located 1.8km upstream of the confluence of Gershwin Creek and the Skeena River, on the CN Railway. Approximately 900m upstream, crossing 198913 is located on Highway 16, and is the responsibility of the Ministry of Transportation and Infrastructure. Both crossings are within the Kispiox River watershed group.

Background

Gershwin Creek is a fourth order stream with an upstream watershed area of approximately 12.9km². The watershed ranges in elevation from a maximum of 2019m to 264m near the lower crossing (Table [4.10](#)).

In 2023, crossings 198916 and 198913 were assessed with fish passage assessments (Irvine and Schick 2023). These sites were prioritized for follow-up with habitat confirmation assessments due to the presence of high-value habitat observed upstream and fish documented immediately downstream of the Highway 16 crossing during the 2023 assessment (Irvine and Schick 2023). Previously, have been documented in the lake upstream of the Highway 16 crossing (198913) (Norris [2018] 2024; MoE 2024a).

During the 2024 survey, two additional crossings were assessed. Approximately 1.3km upstream of the Highway 16 crossing (198913) on Gershwin Creek, a crossing was assessed on Comeau Road (PSCIS crossing 203123). At this location, the stream had no visible channel and was determined to be unlikely to provide fish habitat. The road is the responsibility of the Ministry of Transportation and Infrastructure.

Approximately 680 m upstream of the railway crossing, a small tributary flows into Gershwin Creek from the north. In 2023, PSCIS crossing 198907 was assessed where this tributary intersects Braucher Road. At this location, the stream had moderate flow downstream with a well-defined channel, while the upstream channel was heavily overgrown and led to a wetland. In 2024, a second crossing on this tributary was assessed approximately 900 m further upstream on Comeau Road (PSCIS crossing 203124). Downstream of this crossing, the stream was described as a very small drainage. The road is the responsibility of the Ministry of Transportation and Infrastructure.

Table 4.10: Summary of derived upstream watershed statistics for PSCIS crossing 198916.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
198916	12.9	264	201	2019	575	411	W

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

Bcfishpass modelling outputs are presented in Table 4.11). A map of the watershed is provided in map attachment [093M.101](#).

Table 4.11: Summary of fish habitat modelling for PSCIS crossing 198916.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	16.5	1.2	7
ST Lake Reservoir (ha)	9.5	0.0	0
ST Wetland (ha)	6.1	0.0	0
ST Slopeclass03 Waterbodies (km)	1.8	0.0	0
ST Slopeclass03 (km)	7.0	0.0	0
ST Slopeclass05 (km)	4.0	0.5	12
ST Slopeclass08 (km)	3.5	0.7	20
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)	3.5	0.5	14
CO Rearing (km)	4.3	0.5	12
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 198916 and 198913

At the time of assessment, PSCIS crossing 198916 was un-embedded, non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table [4.12](#)). Constructed in the 1920s, this crossing is a concrete box culvert approximately 100 m in length, located beneath the CN railway with approximately 30–40 m of fill above it. It features a moderate 0.45 m outlet drop that adult fish could likely overcome but is presumed to act as a barrier to juvenile fish. The culvert's relatively steep 6% slope, minimal flow depths, and swift currents further impede fish passage. Installing baffles within the culvert would likely improve fish passage conditions.

PSCIS crossing 198913 was un-embedded, non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table [4.13](#)). Located on Highway 16, this crossing had a 0.35 m outlet drop and a significant 0.85 m deep outlet pool, suggesting the culvert is undersized for the stream.

At both crossings, the water temperature was 7.6°C, pH was 8.1 and conductivity was 305 uS/cm.

Table 4.12: Summary of fish passage assessment for PSCIS crossing 198916.

Location and Stream Data		Crossing Characteristics	
Date	2024-09-25	Crossing Sub Type	Concrete Box
PSCIS ID	198916	Diameter (m)	1.5
External ID	–	Length (m)	100
Crew	LS JD	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	580463	Resemble Channel	–
Northing	6115769	Backwatered	No
Stream	Gershwin Creek	Percent Backwatered	–
Road	Railway	Fill Depth (m)	9.9
Road Tenure	CN Rail	Outlet Drop (m)	0.45
Channel Width (m)	4.4	Outlet Pool Depth (m)	0.35
Stream Slope (%)	4.4	Inlet Drop	No
Beaver Activity	No	Slope (%)	6
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	42	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	35.5

Comments: The concrete box culvert is approximately 100 m long beneath a railway crossing, with about 30 to 40 m of fill above it. A swift current flows through the culvert, and installing baffles could improve fish passage. Fish sampling captured cutthroat trout and Dolly Varden. There is a moderate outlet drop, but adult fish could likely move upstream. The habitat upstream features good flow through a steeper section with a healthy, mature mixed riparian forest, stable banks, and gravel pockets suitable for spawning coho, Dolly Varden, and cutthroat trout. Downstream, abundant boulders create step pools alongside frequent large woody debris, though high flows limited suitable fish habitat during the survey.

Although construction would be expensive and challenging, this site is a high priority for restoration follow-up. Culvert length 100 m but changed to 99.9 m to meet submission requirements. Fill depth 30 m but changed to 9.9 m to meet submission requirements.

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

Stream Characteristics at Crossings 1...



Gershwin Creek - 198916 & 198913 - ...

Location and Stream Data		Crossing Characteristics	
Date	2024-09-25	Crossing Sub Type	Round Culvert
PSCIS ID	198913	Diameter (m)	1.5
External ID	-	Length (m)	40
Crew	AI JO	Embedded	No
UTM Zone	9	Depth Embedded (m)	-
Easting	581250	Resemble Channel	-
Northing	6115660	Backwatered	No
Stream	Gershwin Creek	Percent Backwatered	-
Road	Highway 16	Fill Depth (m)	2.5
Road Tenure	MOTi	Outlet Drop (m)	0.35
Channel Width (m)	5	Outlet Pool Depth (m)	0.85
Stream Slope (%)	3	Inlet Drop	No
Beaver Activity	No	Slope (%)	3
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	42	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	15

Comments:

There is a deep outlet pool, suggesting the culvert is undersized for the stream. High-quality gravels were present at the pool's outlet, and upstream of the crossing, there was high-value habitat with frequent overwintering pools, spawning gravels, and adequate riparian cover with large cottonwoods throughout. This site was part of a habitat confirmation assessment, with the stream surveyed from the downstream railway crossing up to this location and an additional 600 m upstream. Downstream, crossing 198916 consists of a large, long box culvert beneath the railway with minimal flow depth and a swift current, making it unlikely that fish from the mainstem of the Skeena River can access this site until the railway barrier is addressed. Fish sampling at this site captured cutthroat trout and Dolly Varden. MoTi chris_culvert_id: 8300872

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

Stream Characteristics at Crossings 1...



Stream Characteristics Downstream of Crossing 198916

The stream was surveyed downstream from crossing 198916 for 300m . The stream contained numerous boulders forming step pools; however, moderate flows at the time of assessment limited the availability of pools suitable for fish. The first pool suitable for overwintering fish, with adequately reduced flow, was located approximately 250 m downstream of the culvert. There were occasional gravels suitable for spawning and frequent large woody debris, which contributed to the formation of additional steps. (Figure [4.9](#)). Total cover amount was rated as moderate with boulders dominant. Cover was also present as small woody debris, large woody debris, and overhanging vegetation. The dominant substrate was cobbles with gravels sub-dominant. The average channel width was 5.9m, the average wetted width was 3.7m, and the average gradient was 5.1%. The habitat was rated as medium value suitable for salmonid rearing and spawning.

Stream Characteristics Upstream of Crossing 198916 and Downstream of Crossing 198913

The stream was surveyed from the railway crossing (198916) upstream to the Highway 16 crossing (198913), a distance of approximately 900 m (Figures [4.9](#)- [4.10](#)). A large woody debris jam was observed approximately 250 m upstream of the railway crossing, creating a 17% gradient over a 9 m section due to a fallen tree. The stream maintained good flow through this steeper section, supported by a healthy, mature mixed riparian forest that stabilized the banks. Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris, boulders, and overhanging vegetation. The dominant substrate was cobbles with boulders sub-dominant. The average channel width was 4.4m, the average wetted width was 3.3m, and the average gradient was 4.4%. The habitat was rated as medium value and contained occasional pockets of gravels suitable for spawning by coho salmon, Dolly Varden, and cutthroat trout.

Stream Characteristics Upstream of Crossing 198913

The stream was surveyed upstream from crossing 198913 for 600m . The stream had frequent pools suitable for overwintering fish, with spawning gravels present despite a significant amount of fines. In the ~200 m section just upstream of the crossing, the stream maintains a low gradient and flows through agricultural fields, however, there were large cottonwoods providing sufficient riparian cover observed throughout the entire 600 m surveyed. Two logjams, each approximately 1 m in height, were observed but remain passable for fish (Figure [4.10](#)). The dominant substrate was gravels with fines sub-dominant. The average channel width was 6.0m, the average wetted width was 4m, and the average gradient was 2.8%. Total cover amount was rated as abundant with large woody debris dominant. Cover was also present as small woody debris, boulders, deep pools, and overhanging vegetation. The habitat was rated as high value for salmonid rearing and spawning.

Fish Sampling

Fish Sampling

Electrofishing was conducted below and above the railway crossing (198916) with results summarised in Tables [4.15 - 4.17](#) and Figure [4.7](#). A total of 35 fish were captured downstream including Dolly Varden and cutthroat trout, and 3 Dolly Varden were captured upstream (Figures [4.12](#)).

Electrofishing was also conducted upstream and downstream of the crossing on Highway 16 (198913) with results summarised in Tables [4.16 - 4.18](#) and Figure [4.8](#). A total of 12 fish were captured downstream including Dolly Varden and cutthroat trout, and 9 Dolly Varden were captured upstream (Figures [4.12](#)).

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of the railway crossing (198916) with a bridge or open bottom structure is recommended. At the time of reporting in 2025, the cost of the work is estimated at \$ 26,625,000. It is unlikely that fish from the mainstem of the Skeena River can access Gershwin Creek upstream of this railway crossing, and although construction would be expensive and challenging, this crossing is a high priority for restoration follow-up.

Until the downstream railway crossing is upgraded, replacement of the upstream crossing on Highway 16 (198913) is not recommended. If the downstream crossing is upgraded, the Highway 16 crossing should be replaced with a bridge spanning 15 m. At the time of reporting in 2025, the estimated cost for the replacement is \$ 11,250,000.

Conclusion

PSCIS crossings 198916 and 198913 are located on Gershwin Creek which provides medium to high-value habitat for salmonids, including coho salmon, Dolly Varden, and cutthroat trout. Conservative estimates indicate approximately 2.3km of coho rearing habitat upstream of the railway crossing and 1.3km upstream of the Highway 16 crossing.

Crossing 198916 on the CN Railway is a historic, exceptionally long concrete box culvert with approximately 30–40 m of fill above it. It has been identified as a barrier to juvenile fish passage due to its 0.45 m outlet drop, steep slope, and swift currents. This culvert likely inhibits fish from the mainstem of the Skeena River from accessing upstream habitats beyond this crossing. The site was rated as a high priority for replacement, however, given the significant cost and scale of such a project, the installation of baffles is recommended as a more practical interim solution to improve fish passage conditions.

Replacement of the upstream Highway 16 crossing (198913) is recommended only if the downstream CN Railway crossing is first upgraded, as fish passage is otherwise restricted at the railway culvert. Collectively, these crossings form a passage for salmonid movement within the watershed. Restoration efforts should prioritize the downstream CN Railway crossing, as its improvement would unlock access to high-value rearing and spawning habitats further upstream.

Conclusion

Table 4.14: Summary of habitat details for PSCIS crossings 198916 and 198913.

Site	Location	Length Surveyed (m)	Average		Average Pool Depth (m)	Average Gradient (%)	Total Cover	Habitat Value
			Channel Width (m)	Average Wetted Width (m)				
198913	Upstream	600	6.0	4.0	0.6	2.8	abundant	high
198916	Downstream	300	5.9	3.7	0.3	5.1	moderate	medium
198916	Upstream	900	4.4	3.3	0.4	4.4	moderate	medium

Table 4.15: Fish sampling site summary for 198916.

site	passes	ef_length_m	ef_width_m	area_m2	enclosure
198916_ds_ef1	1	34	3.1	105.4	partial enclosure
198916_ds_ef2	1	7	5.8	40.6	partial enclosure
198916_us_ef1	1	43	3.4	146.2	partial enclosure

Table 4.16: Fish sampling site summary for 198913.

site	passes	ef_length_m	ef_width_m	area_m2	enclosure
198913_ds_ef1	1	7	6.0	42	partial enclosure
198913_ds_ef2	1	20	3.3	66	open
198913_us_ef1	1	30	3.0	90	partial enclosure

Table 4.17: Fish sampling density results summary for 198916.

local_name	species_code	life_stage	catch	density_100m2	nfc_pass
198916_ds_ef1	Cutthroat Trout	adult	1	0.9	FALSE
198916_ds_ef1	Cutthroat Trout	fry	4	3.8	FALSE
198916_ds_ef1	Cutthroat Trout	juvenile	4	3.8	FALSE
198916_ds_ef1	Cutthroat Trout	parr	8	7.6	FALSE
198916_ds_ef1	Dolly Varden	adult	1	0.9	FALSE
198916_ds_ef1	Dolly Varden	juvenile	1	0.9	FALSE

Gershwin Creek - 198916 & 198913 - ...

local_name	species_code	life_stage	catch	density_100m2	nfc_pass
198916_ds_ef2	Cutthroat Trout	adult	1	2.5	FALSE
198916_ds_ef2	Cutthroat Trout	fry	3	7.4	FALSE
198916_ds_ef2	Cutthroat Trout	juvenile	3	7.4	FALSE
198916_ds_ef2	Cutthroat Trout	parr	5	12.3	FALSE
198916_ds_ef2	Dolly Varden	adult	2	4.9	FALSE
198916_ds_ef2	Dolly Varden	fry	1	2.5	FALSE
198916_ds_ef2	Dolly Varden	juvenile	1	2.5	FALSE
198916_us_ef1	Dolly Varden	parr	3	2.1	FALSE

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

Table 4.18: Fish sampling density results summary for 198913.

local_name	species_code	life_stage	catch	density_100m2	nfc_pass
198913_ds_ef1	Cutthroat Trout	adult	1	2.4	FALSE
198913_ds_ef1	Dolly Varden	adult	1	2.4	FALSE
198913_ds_ef1	Dolly Varden	fry	1	2.4	FALSE
198913_ds_ef1	Dolly Varden	juvenile	3	7.1	FALSE
198913_ds_ef2	Cutthroat Trout	adult	1	1.5	FALSE
198913_ds_ef2	Dolly Varden	fry	1	1.5	FALSE
198913_ds_ef2	Dolly Varden	juvenile	3	4.5	FALSE
198913_ds_ef2	Dolly Varden	parr	1	1.5	FALSE
198913_us_ef1	Dolly Varden	fry	1	1.1	FALSE
198913_us_ef1	Dolly Varden	juvenile	3	3.3	FALSE
198913_us_ef1	Dolly Varden	parr	5	5.6	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.

Conclusion

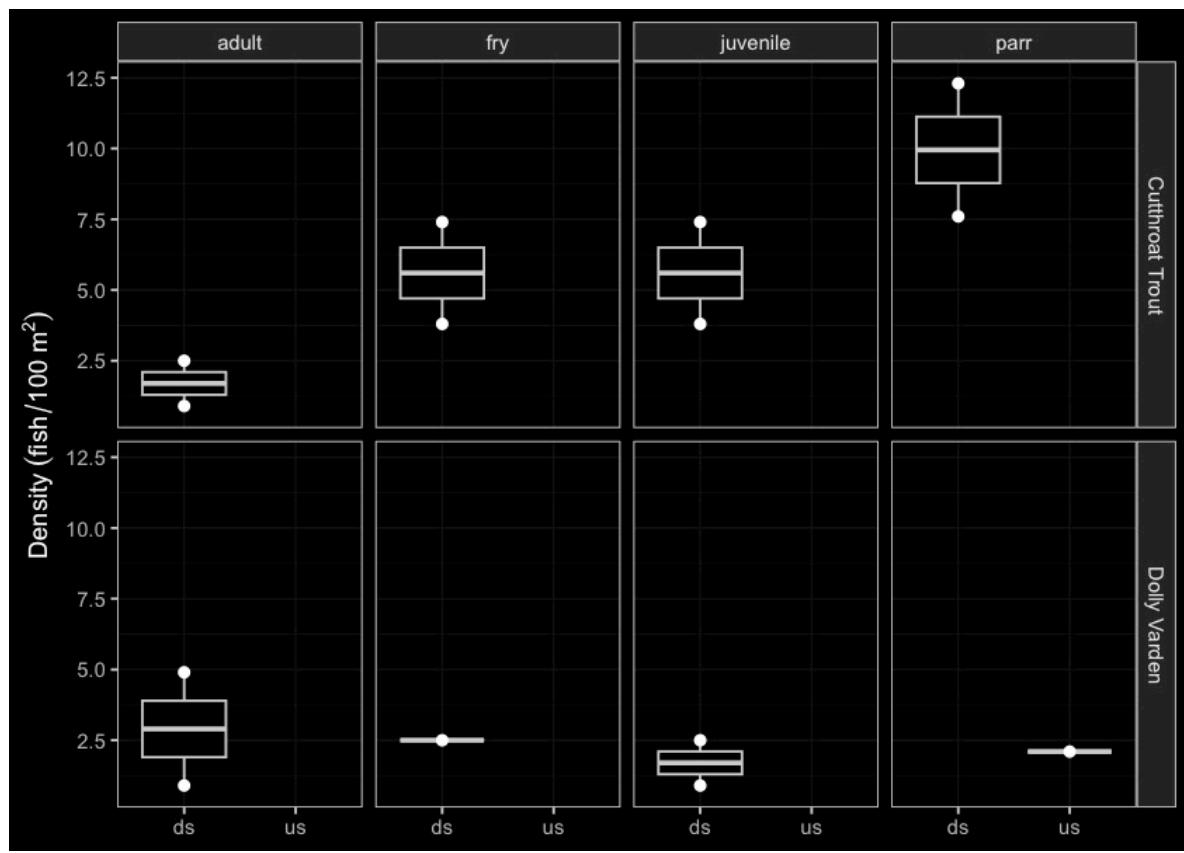


Figure 4.7: Densities of fish (fish/100m²) captured upstream and downstream of PSCIS crossing 198916.

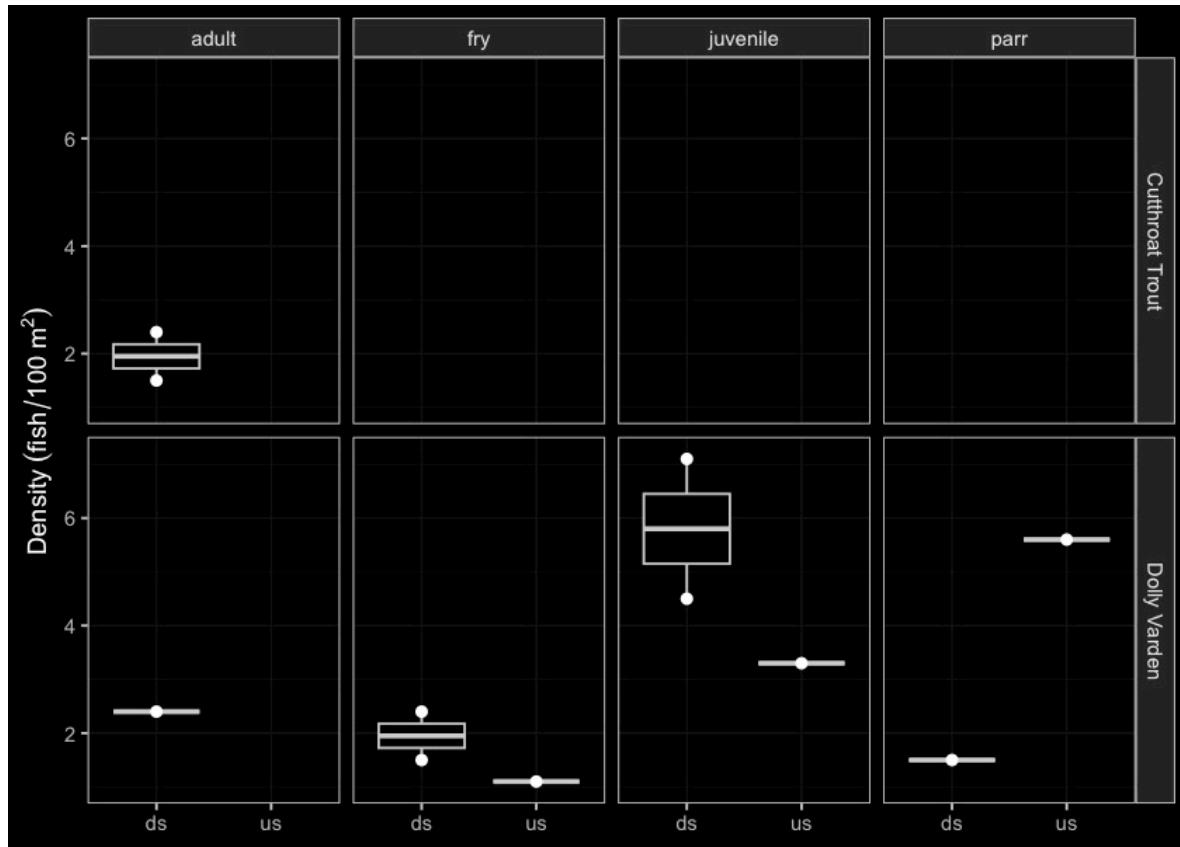


Figure 4.8: Densities of fish (fish/100m²) captured upstream and downstream of PSCIS crossing 198913.

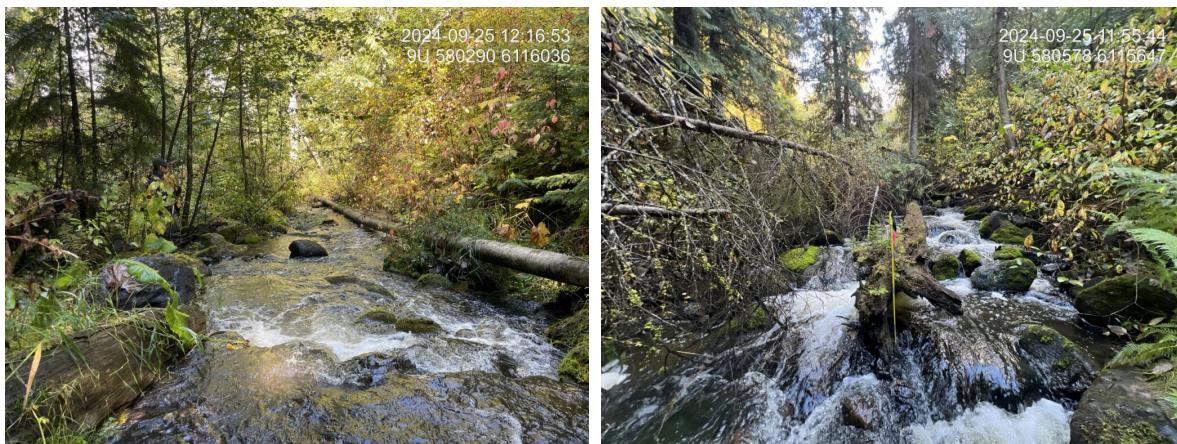


Figure 4.9: Left: Typical habitat downstream of PSCIS crossing 198916. Right: Typical habitat upstream of PSCIS crossing 198916.

Conclusion



Figure 4.10: Left: Typical habitat downstream of PSCIS crossing 198913. Right: Typical habitat upstream of PSCIS crossing 198913.

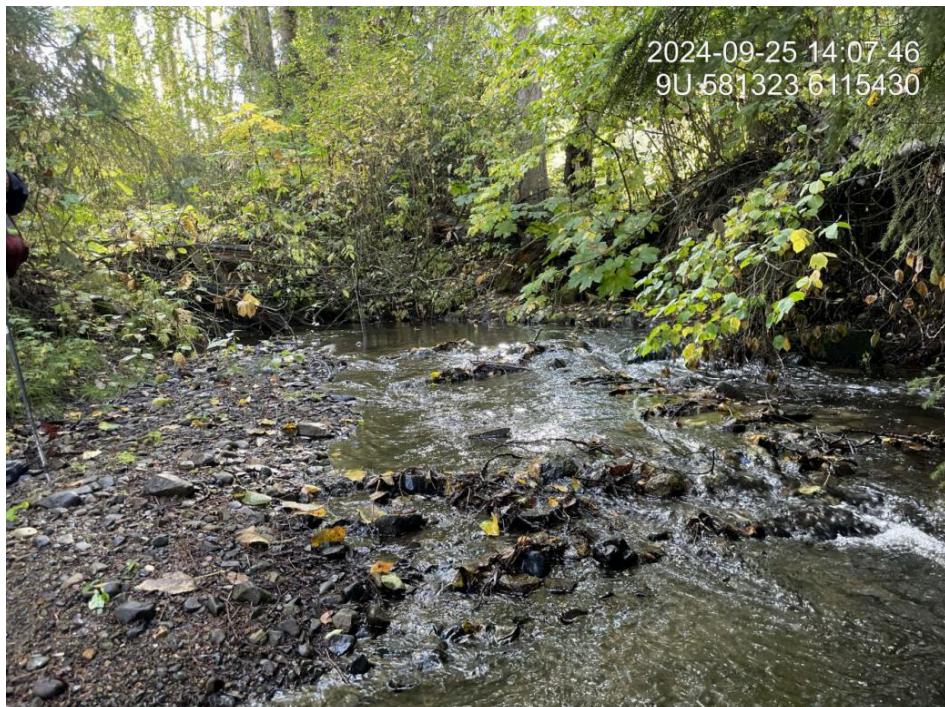


Figure 4.11: Typical habitat upstream of PSCIS crossing 198913.



Figure 4.12: Left: Cutthroat trout captured downstream of crossing 198916. Right: Typical habitat upstream of PSCIS crossing 198913.

Tributary to Knapper Creek - 198940 & 198935 - Appendix

Site Location

PSCIS crossings 198940 and 198935 are located on Tributary to Knapper Creek, approximately 22km southwest of Houston, BC within the Morice River watershed group. Tributary to Knapper Creek flows into Knapper Creek, which joins the Morice River approximalety 2km downstream. PSCIS crossing 198940 is located 1.3km upstream of the confluence of the subject tributary and Knapper Creek, on spur HM7504 which is the responsibility of Canfor R07549 16. Approximately 350 m upstream, crossing 198935 is located on Gold creek fsr which is the responsibility of Canfor R07549 6.

Background

At this location, Tributary to Knapper Creek is a second order stream and drains a watershed of approximately 4.1km². The watershed ranges in elevation from a maximum of 1131m to 785m near the lower crossing (Table 4.19). There is suspected interconnection between wetlands in this watershed and adjacent watersheds, suggesting the current estimates may under-represent the watershed's size.

In 2023, crossings 198940 and 198935 were assessed with fish passage assessments (Irvine and Schick 2023). These sites were prioritized for follow-up with habitat confirmation assessments due to the presence of high-value habitat observed upstream and fish observed during the 2023 assessment (Irvine and Schick 2023). Previously, cutthroat trout and rainbow trout have been documented upstream of crossing 198940 (Norris [2018] 2024; MoE 2024a).

Table 4.19: Summary of derived upstream watershed statistics for PSCIS crossing 198940.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
198940	4.1	785	799	1131	923	903	SE

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

Outputs are presented in Table 4.20). A map of the watershed is provided in map attachment [093L.108](#).

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	7.7	0.3	4
ST Lake Reservoir (ha)	0.1	0.0	0
ST Wetland (ha)	2.0	0.0	0
ST Slopeclass03 Waterbodies (km)	0.2	0.0	0
ST Slopeclass03 (km)	1.2	0.3	25
ST Slopeclass05 (km)	3.3	0.0	0
ST Slopeclass08 (km)	2.1	0.0	0
ST Spawning (km)	0.0	0.0	—
ST Rearing (km)	1.2	0.3	25
CH Spawning (km)	0.0	0.0	—
CH Rearing (km)	0.0	0.0	—
CO Spawning (km)	1.0	0.3	30
CO Rearing (km)	2.2	0.3	14
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 198940 and 198935

At the time of the 2024 assessment, PSCIS crossing 198940 on spur HM7504 was un-embedded, and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table [4.21](#)). However, the culvert was backwatered to 30%, making it unlikely to be a barrier to fish passage. The pipe was significantly undersized for the stream, and the road appeared to be failing, likely due to a partially clogged inlet and spring freshet impacts.

PSCIS crossing 198935 on Gold creek fsr was un-embedded, non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table [4.22](#)). This culvert had a significant 0.8 m deep outlet pool, and was deteriorating at the inlet.

At all crossings, the water temperature was 4.9°C, pH was 8.2 and conductivity was 236 uS/cm.

Stream Characteristics at Crossings 1...

Table 4.21: Summary of fish passage assessment for PSCIS crossing 198940.

Location and Stream Data		Crossing Characteristics	
Date	2024-09-18	Crossing Sub Type	Round Culvert
PSCIS ID	198940	Diameter (m)	0.95
External ID	–	Length (m)	25
Crew	AI	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	636706	Resemble Channel	–
Northing	6020960	Backwatered	Yes
Stream	Tributary to Knapper Creek	Percent Backwatered	30
Road	HM7504	Fill Depth (m)	1.75
Road Tenure	Canfor R07549 16	Outlet Drop (m)	0
Channel Width (m)	4.3	Outlet Pool Depth (m)	0.9
Stream Slope (%)	3	Inlet Drop	Yes
Beaver Activity	Yes	Slope (%)	2
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	24	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	15

Location and Stream Data	Crossing Characteristics
<p>Comments: Very nice stream with good flow, abundant gravels for spawning, and undercut banks and occasional deep pools for rearing. Confirmed populations of cutthroat trout, rainbow trout, and Dolly Varden. The culvert is significantly undersized for the stream, and the road appears to be failing, likely due to a partially clogged inlet and spring freshet. Habitat confirmations were completed for this crossing and the next upstream crossing (198935) on the Gold FSR.</p>	
<p>Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.</p>	
 A photograph of a yellow rectangular site card standing on a gravel road. The card has "198940" handwritten on it. The background shows a dense forest of coniferous trees under a cloudy sky.	 A photograph looking down the interior of a large, corrugated metal culvert. The walls are ribbed and show signs of water damage and rust. A small amount of water is visible at the bottom.
 A photograph of a dark-colored barrel or drum lying on its side on a grassy bank next to a small stream. The ground is rocky and uneven.	 A photograph of a large, white PVC pipe lying horizontally across a shallow stream. The water is brownish and flows around the pipe.
 A photograph of a rocky, overgrown embankment next to a stream. A small orange pipe is visible protruding from the ground. The surrounding vegetation is tall grass and low shrubs.	 A photograph of a shallow stream flowing through a forest. The water is brown and reflects the surrounding green trees. Some fallen branches are visible in the water.

Stream Characteristics at Crossings 1...

Table 4.22: Summary of fish passage assessment for PSCIS crossing 198935.

Location and Stream Data		Crossing Characteristics	
Date	2024-09-18	Crossing Sub Type	Round Culvert
PSCIS ID	198935	Diameter (m)	1.2
External ID	–	Length (m)	20
Crew	LS	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	636440	Resemble Channel	–
Northing	6020756	Backwatered	No
Stream	Tributary to Knapper Creek	Percent Backwatered	–
Road	Gold creek fsr	Fill Depth (m)	4
Road Tenure	Canfor R07549 6	Outlet Drop (m)	0.15
Channel Width (m)	2.7	Outlet Pool Depth (m)	0.8
Stream Slope (%)	2.2	Inlet Drop	No
Beaver Activity	Yes	Slope (%)	1.5
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	29	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	18

Location and Stream Data	Crossing Characteristics
<p>Comments: The culvert is deteriorating at the inlet. Large outlet pool where fish were captured during sampling. The stream flows from the outlet pool along the left-hand side into a well-defined channel with gravels suitable for spawning and several pools, providing good habitat. A moderate amount of road fill is present.</p>	
<p>Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.</p>	
 2024-09-18 14:51:33 9U 636440 6020759	 2024-09-18 14:52:50 9U 636429 6020759
 2024-09-18 14:52:46 9U 636428 6020759	 2024-09-18 14:55:39 9U 636450 6020755
 2024-09-18 14:53:01 9U 636425 6020749	 2024-09-18 15:04:36 9U 636459 6020752

Stream Characteristics Downstream of Crossing 198940

The stream was surveyed downstream from crossing 198940 for 300m (Figure [4.14](#)).. The habitat was rated as medium, with good flow, abundant gravels, overhanging banks, and healthy riparian vegetation, providing good rearing and spawning habitat for coho, rainbow trout, Dolly Varden, and cutthroat trout. 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, large woody debris, and overhanging vegetation.The average channel width was 3.3m, the average wetted width was 1.5m, and the average gradient was 3.3%..

Stream Characteristics Upstream of Crossing 198940 and Downstream of Crossing 198935

The stream was surveyed in the downstream direction, starting at the upstream crossing on Gold Creek FSR (198935), down to the crossing on road/spur HM7504 (198940), a distance of approximately 340 m (Figure [4.14](#) Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris, large woody debris, deep pools, and overhanging vegetation.The average channel width was 2.8m, the average wetted width was 1.2m, and the average gradient was 2.7%.The dominant substrate was gravels with fines sub-dominant. The habitat was rated as medium value with good flow, abundant spawning gravels, and suitable rearing habitat in undercut banks and occasional deep pools. Historic beaver activity was evident, including a large breached dam near the upstream end of the site. The riparian zone consisted of a healthy shrub and herbaceous flood-tolerant plant community. The stream corridor, approximately 40–50 m wide, was bordered by mature coniferous forest on both sides.

Stream Characteristics Upstream of Crossing 198935

The stream was surveyed upstream from crossing 198935 for 700m . (Figure [4.15](#)). The habitat was rated as medium value with a good flow and abundant gravels throughout. A mature mixed forest, including cottonwood, provided excellent bank stabilization, resulting in deeply undercut banks and intermittent pools up to 60 cm deep within the surveyed area. The dominant substrate was gravels with fines sub-dominant.Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris, large woody debris, deep pools, and overhanging vegetation.The average channel width was 2.5m, the average wetted width was 1.9m, and the average gradient was 2.2%.

Fish Sampling

Electrofishing was conducted upstream and downstream of crossing (198935) with results summarised in Tables [4.24 - 4.25](#) and Figure [4.13](#). A total of 39 fish were captured downstream including rainbow trout, cutthroat trout, and Dolly Varden. Upstream of the crossing 43 fish were

captured including rainbow trout, cutthroat trout, and cutthroat trout/rainbow trout hybrid (Figure [4.15](#)). .

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of the Gold Creek FSR crossing (198935) with a bridge (18 m span) is recommended. At the time of reporting in 2025, the cost of the work is estimated at \$ 450,000.

At the time of assessment, the downstream crossing on road/spur HM7504 was unlikely a barrier to fish passage, and restoration efforts should prioritize the upstream crossing on Gold Creek FSR. However, should restoration activities proceed at crossing 198940, replacement with a bridge spanning 15 m is recommended. At the time of reporting in 2025, the estimated cost for the replacement is \$ 540,000.

Conclusion

Tributary to Knapper Creek contains moderate-value rearing and spawning habitat for coho, rainbow trout, Dolly Varden, and cutthroat trout. Electrofishing at the time of assessment confirmed the presence of rainbow trout, cutthroat trout, cutthroat/rainbow trout hybrids, and Dolly Varden. Habitat modelling identified 1.2km of steelhead rearing habitat upstream of crossing 198940, with approximately 300m less upstream of 198935. There is suspected interconnection between wetlands in this watershed and adjacent watersheds, suggesting the current modelling may under-represent the watershed's size.

Should restoration activities proceed, efforts should focus on PSCIS crossing [as.character\(my_site2\)](#) on Gold Creek FSR, which had a small outlet drop and a deep outlet pool. PSCIS crossing 198940 on Road/Spur HM7504 was backwatered and not presumed to be a barrier to fish passage. Both crossings were noted as undersized for the stream.

Conclusion

Table 4.23: Summary of habitat details for PSCIS crossings 198940 and 198935.

Site	Location	Length Surveyed (m)	Average		Average Pool Depth (m)	Average Gradient (%)	Total Cover	Habitat Value
			Channel Width (m)	Average Wetted Width (m)				
198935	Upstream	700	2.5	1.9	0.4	2.2	moderate	medium
198940	Downstream	300	3.3	1.5	0.4	3.3	moderate	medium
198940	Upstream	340	2.8	1.2	0.3	2.7	moderate	medium

Table 4.24: Fish sampling site summary for 198935.

site	passes	ef_length_m	ef_width_m	area_m2	enclosure
198935_ds_ef1	1	8	1.1	8.8	partial enclosure
198935_us_ef1	1	30	1.6	48.0	partial enclosure

Table 4.25: Fish sampling density results summary for 198935.

local_name	species_code	life_stage	catch	density_100m2	nfc_pass
198935_ds_ef1	Cutthroat Trout	adult	1	11.4	FALSE
198935_ds_ef1	Cutthroat Trout	parr	4	45.5	FALSE
198935_ds_ef1	Dolly Varden	parr	1	11.4	FALSE
198935_ds_ef1	Rainbow Trout	fry	12	136.4	FALSE
198935_ds_ef1	Rainbow Trout	parr	21	238.6	FALSE
198935_us_ef1	Cutthroat Trout	adult	1	2.1	FALSE
198935_us_ef1	Cutthroat Trout /Rainbow Trout hybrid	fry	1	2.1	FALSE
198935_us_ef1	Rainbow Trout	adult	1	2.1	FALSE
198935_us_ef1	Rainbow Trout	fry	23	47.9	FALSE
198935_us_ef1	Rainbow Trout	juvenile	1	2.1	FALSE
198935_us_ef1	Rainbow Trout	parr	16	33.3	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.

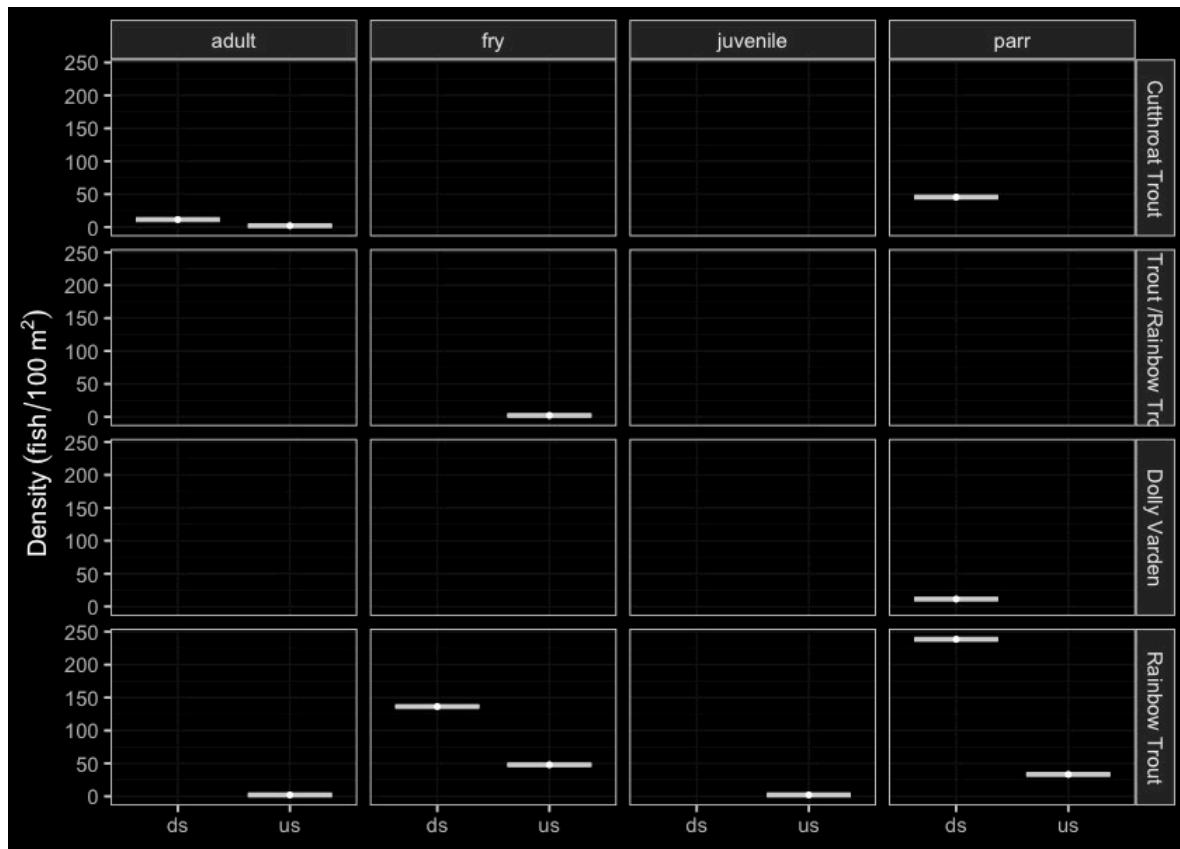


Figure 4.13: Densities of fish (fish/100m²) captured upstream and downstream of PSCIS crossing 198935.



Figure 4.14: Left: Typical habitat downstream of PSCIS crossing 198940. Right: Typical habitat upstream of PSCIS crossing 198940.

Conclusion



Figure 4.15: Left: Typical habitat upstream of PSCIS crossing 198935. Right: Rainbow trout captured downstream of crossing 198935.

Simpson Creek - 58245 & 203122 & 58264 - Appendix

Site Location

PSCIS crossings 58245, 203122, and 58264 are located on Simpson Creek, approximately 3km northwest of Smithers, BC. The stream is incorrectly mapped in the BC Freshwater Atlas, and is located south of the mapped channel. Simpson Creek flows into Kathlyn Creek, which joins the Bulkley River approximalety 4km downstream. PSCIS crossing 58245 is located 70m upstream of the confluence of Simpson Creek and Kathlyn Creek, on Lake Kathlyn Road. Approximately 530 m upstream, crossing 203122 is located on and is the responsibility of the Canadian National Railway. A further 950m upstream, crossing 58264 is located on Nielson Road. The Lake Kathlyn Road and Nielson Road crossings are the responsibility of the Ministry of Transportation and Infrastructure and all crossing are within the Bulkley River watershed group.

Background

At this location, Simpson Creek is a third order stream and drains a high elevation watershed of approximately 13.1km². The watershed ranges in elevation from a maximum of 2477m to 503m near the lower crossing (Table [4.26](#)). Simpson Creek is a major contributor to the greater Kathlyn Creek watershed, with flow volumes during the 2024 assessment slightly less than the Kathlyn Creek mainstem.

In 2012, PSCIS crossings 58245 and 58264 were assessed with fish passage assessments by Marlim Ecological Consulting Ltd. and both were ranked as barriers (MarLim Ecological Consulting Ltd. 2013).

Historically, Simpson Creek has been a spawning location for coho salmon. Since 1986, coho have been transplanted into the Kathlyn Creek system from the Toboggan Creek Hatchery (A. Gottesfeld and Rabnett 2007). Kathlyn Creek also supports a small population of pink salmon, and steelhead are known to inhabit Kathlyn Lake and spawn upstream of the Chicken Creek confluence, which would include areas near the Simpson Creek confluence (A. Gottesfeld and Rabnett 2007). Adjacent to the crossing on Nielson Road (58264), coho salmon and other salmonids have been documented in the past, along with cutthroat trout, rainbow trout, steelhead, mountain whitefish, and Dolly Varden (Norris [2018] 2024; MoE 2024a). Approximately 360 m downstream of Nielson Road, the adjacent landowner has observed recent steelhead and coho spawning and historically chinook spawning.

According to a nearby landowner, the crossing on Nielson Road (58264) was originally a bridge but was replaced with the current culvert during an emergency flood event in the 1990s. Materials from the flood were used to construct dikes upstream and downstream of the crossing, which remained in place at the time of the 2024 assessment. Upstream of the Nielson Road crossing, a trail runs

parallel to the stream for 400m up to the power line, offering an excellent opportunity for community engagement. By connecting people to the land, the trail can foster stewardship and advocacy for the stream, potentially leading to future restoration efforts.

Table 4.26: Summary of derived upstream watershed statistics for PSCIS crossing 58245.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
58245	13.1	503	495	2477	1311	1068	E

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

Habitat modelling outputs from `bcfishpass` indicated 1.6km of steelhead and 1.4km of coho rearing habitat upstream of crossing 58245 on Lake Kathlyn Road (gradients <8.5% for steelhead and <5.5% for coho). Upstream of the crossing on Nielson Road, only 100m of habitat is modelled for steelhead and coho rearing due to a steeper stream gradient exceeding 8.5%. Outputs are presented in Table [4.27](#)). A map of the watershed is provided in map attachment [093L.122](#).

Table 4.27: Summary of fish habitat modelling for PSCIS crossing 58245.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	5.4	0	0
ST Lake Reservoir (ha)	0.6	0	0
ST Wetland (ha)	0.0	0	-
ST Slopeclass03 Waterbodies (km)	0.1	0	0
ST Slopeclass03 (km)	2.5	0	0
ST Slopeclass05 (km)	0.4	0	0
ST Slopeclass08 (km)	0.8	0	0
ST Spawning (km)	1.5	0	0
ST Rearing (km)	2.0	0	0
CH Spawning (km)	1.4	0	0
CH Rearing (km)	1.4	0	0
CO Spawning (km)	1.5	0	0
CO Rearing (km)	1.4	0	0
CO Rearing (ha)	0.0	0	-
SK Spawning (km)	0.0	0	-

Stream Characteristics at Crossings 5...

Habitat	Potential	Remediation Gain	Remediation Gain (%)
SK Rearing (km)	0.0	0	-
SK Rearing (ha)	0.0	0	-

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossings 58245, 203122, and 58264

At the time of the 2024 assessment, PSCIS crossing 58245 on Lake Kathlyn Road was un-embedded, non-backwatered and although it ranked as a barrier to upstream fish passage according to the provincial protocol, neither of the two culverts at this location had an outlet drop, therefore it is unlikely a barrier to fish passage (MoE 2011) (Table [4.28](#)).

Approximately 530 m upstream of Lake Kathlyn Road, PSCIS crossing 203122 on the CN Railway was un-embedded, non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table [4.29](#)). The two culverts were roughly 30 m apart, the southern pipe was dry and fully embedded, while the northern pipe was currently conveying the main flow of Simpson Creek.

A further 950m upstream, PSCIS crossing 58264 on Nielson Road was un-embedded, non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table [4.30](#)). This concrete oval culvert had a significant 1 m outlet drop and 1.2 m deep outlet pool.

At all crossings, the water temperature was 6.1°C, pH was 7.7 and conductivity was 107 uS/cm.

Table 4.28: Summary of fish passage assessment for PSCIS crossing 58245.

Location and Stream Data		Crossing Characteristics	
Date	2024-09-20	Crossing Sub Type	Round Culvert
PSCIS ID	58245	Diameter (m)	2.5
External ID	–	Length (m)	20
Crew	AI	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	615383	Resemble Channel	–
Northing	6075125	Backwatered	No
Stream	Simpson Creek	Percent Backwatered	–
Road	Lake Kathlyn Road	Fill Depth (m)	2.2
Road Tenure	MoTi	Outlet Drop (m)	0
Channel Width (m)	7	Outlet Pool Depth (m)	0.3
Stream Slope (%)	1.5	Inlet Drop	No
Beaver Activity	Yes	Slope (%)	2
Habitat Value	High	Valley Fill	Deep Fill
Final score	24	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	15

Stream Characteristics at Crossings 5...

Location and Stream Data	Crossing Characteristics
Comments: Two 1.25 m pipes are present and are heavily corroded. Upstream and downstream, the streambanks are heavily modified adjacent to private land, including riparian vegetation removal, stream channelization, and bank armouring. High-value steelhead, coho, and chinook spawning habitat is documented further upstream above the railway crossing. MoTi chris_culvert_id: 1514706, 1514705	-
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.	-
 A photograph of a yellow rectangular site card with the number "5845" and "MoTi" printed on it, lying on the ground next to a paved road. The road has a double yellow line and is surrounded by green vegetation and utility poles under a cloudy sky.	 A photograph looking down the interior of a large, corrugated metal culvert pipe. The pipe is dark and shows signs of water damage and debris. The timestamp in the top right corner is 2024-09-20 15:32:17 and the MoTi ID is 9U 615371 6075127.
 A photograph showing two large black pipes discharging water into a stream. The water is brownish and turbulent. The timestamp in the top right corner is 2024-09-20 15:32:10 and the MoTi ID is 9U 615371 6075127.	 A photograph of the same two pipes from a different angle, showing more of the surrounding green vegetation and the flow of water downstream. The timestamp in the top right corner is 2024-09-20 15:35:03 and the MoTi ID is 9U 615371 6075112.
 A photograph of a small stream flowing through dense green vegetation. A single black pipe is visible on the left bank. The water is clear and reflects the surrounding trees. The timestamp in the top right corner is 2024-09-20 15:32:27 and the MoTi ID is 9U 615371 6075127.	 A photograph of a larger stream flowing through dense green vegetation. Two black pipes are visible on the left bank, with water flowing out into the stream. The water is brownish and turbulent. The timestamp in the top right corner is 2024-09-20 15:35:11 and the MoTi ID is 9U 615391 6075120.

Table 4.29: Summary of fish passage assessment for PSCIS crossing 203122.

Location and Stream Data		Crossing Characteristics	
Date	2024-09-20	Crossing Sub Type	Round Culvert
PSCIS ID	203122	Diameter (m)	3
External ID	–	Length (m)	25
Crew	AI	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	614941	Resemble Channel	Yes
Northing	6075232	Backwatered	No
Stream	Simpson Creek	Percent Backwatered	–
Road	Railway	Fill Depth (m)	1
Road Tenure	CN Rail	Outlet Drop (m)	0.05
Channel Width (m)	5	Outlet Pool Depth (m)	0.9
Stream Slope (%)	1	Inlet Drop	Yes
Beaver Activity	Yes	Slope (%)	2
Habitat Value	High	Valley Fill	Deep Fill
Final score	24	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	15
Comments: Although this culvert is on Simpson Creek, it is not currently conveying the main flow and remains mostly dry. Two 1.5 m diameter pipes run under the railway, approximately 30 m apart. The southern pipe is fully embedded with an average embedment depth of 25 cm, while the northern pipe is currently passing all stream flow. This is a high-value stream with extensive gravel areas suitable for steelhead, coho, and chinook salmon spawning upstream. The adjacent landowner has reported recent observations of steelhead spawning and has historical knowledge of chinook spawning approximately 300 m downstream from Nielsen Road.			
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Stream Characteristics at Crossings 5...



Location and Stream Data		Crossing Characteristics	
Date	2024-09-20	Crossing Sub Type	Oval Culvert
PSCIS ID	58264	Diameter (m)	2.4
External ID	-	Length (m)	23
Crew	LS TP	Embedded	No
UTM Zone	9	Depth Embedded (m)	-
Easting	614280	Resemble Channel	-
Northing	6074951	Backwatered	No
Stream	Simpson Creek	Percent Backwatered	-
Road	Nielson Road	Fill Depth (m)	0.4
Road Tenure	MoTi	Outlet Drop (m)	1
Channel Width (m)	5.6	Outlet Pool Depth (m)	1.2
Stream Slope (%)	13	Inlet Drop	No
Beaver Activity	No	Slope (%)	5
Habitat Value	High	Valley Fill	Deep Fill
Final score	39	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	15

Comments: This concrete oval culvert has a significant 1 m outlet drop, likely inhibiting fish passage. The stream is incorrectly mapped in the Freshwater Atlas, located south of the mapped channel. Upstream habitat includes boulder cover, gravel pockets suitable for coho, steelhead, and Dolly Varden spawning, and a healthy mature mixed forest riparian zone. Downstream habitat transitions to lower-gradient, high-value conditions with extensive gravels, deep pools (up to 90 cm), large woody debris, and abundant cover, supporting recent steelhead and historically chinook spawning, as reported by the adjacent landowner. Habitat confirmations were completed at this site and all downstream crossings to the confluence with Kathlyn Creek. The stream is a major contributor to the greater Kathlyn Creek watershed, with flow volumes during the assessment slightly less than the Kathlyn Creek mainstem. Electrofishing upstream of Nielsen Road captured rainbow trout, while downstream sampling confirmed the presence of Dolly Varden, rainbow trout, cutthroat trout/rainbow trout hybrids, and coho. The coho were captured approximately 350 m downstream of Nielsen Road. According to the landowner, this crossing was originally a bridge but was replaced with the current culvert during an emergency flood event in the 1990s.

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

Stream Characteristics at Crossings 5...



Stream Characteristics Downstream of Crossing 58245

The stream was surveyed downstream from crossing 58245 for 70m , to the confluence with Kathlyn Creek. The stream ran adjacent to the road along one bank, which had limited riparian vegetation consisting primarily of shrubs. The opposite bank, bordered by private property, had minimal vegetation and no significant riparian cover. Multiple sections of bank armouring and channelization were observed near the private property, and only small pockets of gravels suitable for spawning were observed (Figure [4.17](#)). The average channel width was 6.2m, the average wetted width was 3.9m, and the average gradient was 2%. Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris, deep pools, and overhanging vegetation. The dominant substrate was fines with cobbles sub-dominant. The habitat was rated as medium value for salmonid rearing and spawning.

Stream Characteristics Upstream of Crossing 58245 and Downstream of Crossing 203122

The stream was surveyed from Lake Kathlyn Road (crossing 58245) to the CN railway (crossing 203122), a distance of approximately 650m. Above Lake Kathlyn Road, the stream was heavily impacted by adjacent private lands, with riparian vegetation removed, the stream channelized, and banks armoured (Figure [4.17](#)). Extensive beaver activity was observed in the lower stream, with dams ranging in height from 0.4 to 1 m. Nearing the railway crossing, the stream consisted of mostly intact riparian vegetation, abundant gravels, deep pools, and large woody debris. Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris, large woody debris, deep pools, and overhanging vegetation. The average channel width was 6m, the average wetted width was 4.3m, and the average gradient was 1.1%. The dominant substrate was fines with gravels sub-dominant. The habitat was rated as high value for salmonid spawning and rearing.

PSCIS crossing 203126, situated approximately 70m upstream of Lake Kathlyn Road, was also assessed during the survey, with the culvert assessment provided in [Appendix 1 \(page 0\)](#). The crossing consisted of three 0.95m pipes running beneath a private driveway, with two pipes appearing fully embedded. The crossing was non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011). Evidence of beaver activity was observed including debris accumulation at the inlet, and the landowner reported previous blockages caused by beavers, which required periodic inlet clearing and the removal of significant accumulated material through dredging.

Stream Characteristics Upstream of Crossing 203122 and Downstream of Crossing 58264

The stream was surveyed from the CN railway (crossing 203122) to Nielson Road (crossing 58264), a distance of approximately 950m (Figure [4.18](#)). From the railway crossing upstream, the gradient

was low (2–3%), with high-quality habitat characterized by abundant gravels, deep pools up to 90cm, large woody debris, and diverse cover. In this section, the adjacent landowner reported recent steelhead and coho spawning, as well as historical Chinook spawning. Approximately 300m downstream of Nielson Road, the gradient increased (5–6%), transitioning into straight riffle-cascade sections with confined, channelized, dyke-like banks. The dominant substrate was gravels with cobbles sub-dominant. Total cover amount was rated as moderate with deep pools dominant. Cover was also present as small woody debris, large woody debris, undercut banks, and overhanging vegetation. The average channel width was 6.2m, the average wetted width was 3.5m, and the average gradient was 4.1%. The habitat was rated as high value for salmonid spawning and rearing.

Stream Characteristics Upstream of Crossing 58264

The stream was surveyed upstream from crossing 58264 for 615m . This section of the stream featured a steeper gradient, predominantly characterized by boulder cover with occasional pockets of gravels suitable for coho, steelhead, and Dolly Varden spawning (Figure 4.18). Pools were infrequent throughout. The riparian zone was composed of a healthy, mature mixed forest, providing stability and shading. The upper end of the site was situated just upstream of a short cascade with a 20% gradient. The habitat was rated as medium value for salmonid rearing and spawning. The average channel width was 8.9m, the average wetted width was 4.7m, and the average gradient was 7.3%. The dominant substrate was cobbles with boulders sub-dominant. Total cover amount was rated as moderate with boulders dominant. Cover was also present as large woody debris.

Fish Sampling

Electrofishing was conducted upstream and downstream of crossing (58264) with results summarised in Tables 4.32 - 4.33 and Figure 4.16. A total of 20 fish were captured downstream including rainbow trout, cutthroat trout/rainbow trout hybrid, and Dolly Varden. Upstream of the crossing 12 rainbow trout were captured (Figure 4.19) .

Electrofishing was conducted at one site approximately 360 m downstream of Nielsen Road, with results summarised in Tables 4.32 - 4.33 and Figure 4.16. At this location, the adjacent landowner had reported recent steelhead and coho spawning and historically Chinook spawning. A total of 43 fish were captured including coho salmon, cutthroat trout/rainbow trout hybrid, and Dolly Varden (Figure 4.19).

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of the Nielson Road crossing (58264) with a bridge (15 m span) is recommended. The significant 1 m outlet drop at this crossing, combined with the presence of salmonids in the system, makes it a top priority for remediation. At the time of reporting in 2025, the cost of the work is estimated at \$ 3,000,000.

PSCIS crossing 203122 on the CN Railway presented a minimal barrier to fish passage and is considered a low priority for replacement. However, if restoration activities are undertaken, replacing the existing structure with a bridge spanning 15 m is recommended. As of 2025, the estimated replacement cost is \$ 11,250,000, with the high cost attributed to the complexities of working within a railway corridor.

At the time of assessment, the downstream crossing on Lake Kathlyn Road was unlikely a barrier to fish passage. However, should restoration activities proceed, replacement with a bridge spanning 15 m is recommended. At the time of reporting in 2025, the estimated cost for the replacement is \$ 3,000,000.

Conclusion

Simpson Creek is a significant contributor to the Kathlyn Creek watershed, with flow volumes during the 2024 assessment slightly less than those observed in the Kathlyn Creek mainstem. The habitat was rated as value for salmonid spawning and rearing. Simpson Creek has historically supported a variety of salmonids, and coho captured during electrofishing at the time of assessment further confirm the stream's continued importance as salmonid habitat. PSCIS crossing 58264 on Nielsen Road is a strong candidate for remediation, given its large outlet drop (1m) and low traffic volume, it is a high priority for replacement. Upstream of this crossing, a trail runs alongside the stream offering opportunities for community engagement and education, which could foster stewardship and advocacy for the stream. PSCIS crossing 203122 on the CN Railway presented a minimal barrier at the time of assessment and was considered a low priority for replacement. However, if restoration activities proceed at the upstream crossing on Nielsen Road, this crossing should be reassessed. PSCIS crossing 58245 on Lake Kathlyn Road is not presumed to be a significant barrier to fish passage and was rated as a low priority for replacement. However, the culverts were heavily corroded and located in an area impacted by riparian vegetation removal, stream channelization, and bank armouring, which presents a valuable opportunity for community-led restoration efforts and education. The proximity of these sites to Smithers, BC, enhances opportunities for public involvement and education, further supporting long-term restoration goals for Simpson Creek.

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Table 4.31: Summary of habitat details for PSCIS crossings 58245 and 58264.

Site	Location	Length Surveyed (m)	Average Channel Width (m)	Average Wetted Width (m)	Average Pool Depth (m)	Average Gradient (%)	Total Cover	Habitat Value
58245	Downstream	70	6.2	3.9	0.3	2.0	moderate	medium
58245	Upstream	1000	6.0	4.3	0.7	1.1	moderate	high
58264	Upstream	615	8.9	4.7	0.3	7.3	moderate	medium

Table 4.32: Fish sampling site summary for 58264.

site	passes	ef_length_m	ef_width_m	area_m2	enclosure
58264_ds_ef1	1	25	3.3	82.5	partial enclosure
58264_ds_ef2	1	30	2.7	81.0	partial enclosure
58264_us_ef1	1	32	3.5	112.0	partial enclosure

Table 4.33: Fish sampling density results summary for 58264.

local_name	species_code	life_stage	catch	density_100m2	nfc_pass
58264_ds_ef1	Cutthroat Trout /Rainbow Trout hybrid	parr	2	2.4	FALSE
58264_ds_ef1	Dolly Varden	juvenile	2	2.4	FALSE
58264_ds_ef1	Dolly Varden	parr	1	1.2	FALSE
58264_ds_ef1	Rainbow Trout	parr	15	18.2	FALSE
58264_ds_ef2	Coho Salmon	fry	3	3.7	FALSE
58264_ds_ef2	Coho Salmon	parr	1	1.2	FALSE
58264_ds_ef2	Cutthroat Trout /Rainbow Trout hybrid	parr	5	6.2	FALSE
58264_ds_ef2	Dolly Varden	fry	1	1.2	FALSE
58264_ds_ef2	Rainbow Trout	fry	20	24.7	FALSE
58264_ds_ef2	Rainbow Trout	parr	13	16.0	FALSE
58264_us_ef1	Rainbow Trout	fry	1	0.9	FALSE
58264_us_ef1	Rainbow Trout	parr	11	9.8	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.

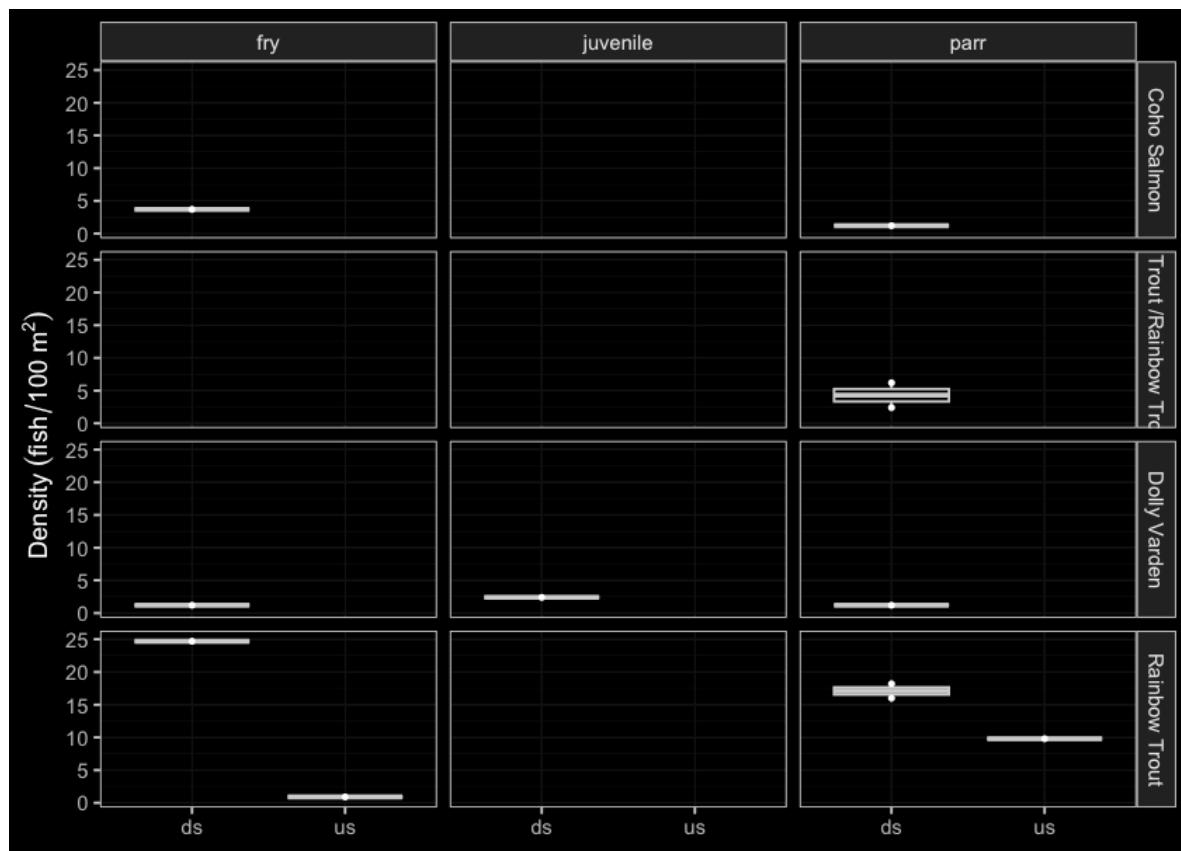


Figure 4.16: Densites of fish (fish/100m²) captured upstream and downstream of PSCIS crossing 58264.

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Figure 4.17: Left: Typical habitat downstream of PSCIS crossing 58245. Right: Typical habitat upstream of PSCIS crossing 58245 and downstream of PSCIS crossing 203122, with signs of bank armouring and channelization.



Figure 4.18: Left: Steelhead spawning location upstream of PSCIS crossing 203122 and downstream of PSCIS crossing 58264, as reported by the adjacent landowner. Right: Typical habitat upstream of PSCIS crossing 58264.



Figure 4.19: Left: Rainbow trout captured downstream of crossing 58264. Right: Coho salmon captured approximately 360 m downstream of crossing 58264.

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Note that this reference was not actually cited in the body of the report but rather in the index.Rmd file yaml headerj under the no_cite key.

Changelog

Skeena Watershed Fish Passage Restoration Planning 2024 - 0.0.1 {-}

- *2025-02-04*
 - Initial draft of the 2024 report.

Session Info

Information about the computing environment is important for reproducibility. A summary of the computing environment is saved to `session_info.csv`, which can be viewed and downloaded from [here](#).

```
## – Session info
```

Session Info

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## setting value
## version R version 4.4.2 (2024-10-31)
## os      macOS Sequoia 15.3.2
## system aarch64, darwin20
## ui     RStudio
## language (EN)
## collate en_US.UTF-8
## ctype   en_US.UTF-8
## tz      America/Vancouver
## date    2025-03-28
## rstudio 2024.12.0+467 Kousa Dogwood (desktop)
## pandoc  3.2 @
/Applications/RStudio.app/Contents/Resources/app/quarto/bin/tools/aarch6-
```

Session Info

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

Session Info

## package	* version	date (UTC)	lib	source
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## base64enc	0.1-3	2015-07-28	[1]	CRAN (R 4.4.1)
## bit	4.5.0.1	2024-12-03	[1]	CRAN (R 4.4.1)
## bit64	4.6.0-1	2025-01-16	[1]	CRAN (R 4.4.1)
## blob	1.2.4	2023-03-17	[1]	CRAN (R 4.4.0)
## bookdown	* 0.42	2025-01-07	[1]	CRAN (R 4.4.1)
## brew	1.0-10	2023-12-16	[1]	CRAN (R 4.4.1)
## bslib	0.9.0	2025-01-30	[1]	CRAN (R 4.4.1)
## cachem	1.1.0	2024-05-16	[1]	CRAN (R 4.4.1)
## cellranger	1.1.0	2016-07-27	[1]	CRAN (R 4.4.0)
## chk	0.10.0	2025-01-24	[1]	CRAN (R 4.4.1)
## chromote	0.4.0	2025-01-25	[1]	CRAN (R 4.4.1)
## class	7.3-22	2023-05-03	[2]	CRAN (R 4.4.2)
## classInt	0.4-11	2025-01-08	[1]	CRAN (R 4.4.1)
## cli	3.6.3	2024-06-21	[1]	CRAN (R 4.4.1)
## codetools	0.2-20	2024-03-31	[2]	CRAN (R 4.4.2)
## colorspace	2.1-1	2024-07-26	[1]	CRAN (R 4.4.1)
## crayon	1.5.3	2024-06-20	[1]	CRAN (R 4.4.1)
## crosstalk	1.2.1	2023-11-23	[1]	CRAN (R 4.4.0)
## curl	6.2.0	2025-01-23	[1]	CRAN (R 4.4.1)
## DBI	1.2.3	2024-06-02	[1]	CRAN (R 4.4.1)
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## devtools	2.4.5	2022-10-11	[2]	CRAN (R 4.4.0)
## digest	0.6.37	2024-08-19	[1]	CRAN (R 4.4.1)
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## DT	0.33	2024-04-04	[1]	CRAN (R 4.4.0)
## e1071	1.7-16	2024-09-16	[1]	CRAN (R 4.4.1)
## ellipsis	0.3.2	2021-04-29	[2]	CRAN (R 4.4.0)
## english	1.2-6	2021-08-21	[2]	CRAN (R 4.4.0)
## evaluate	1.0.3	2025-01-10	[1]	CRAN (R 4.4.1)
## farver	2.1.2	2024-05-13	[1]	CRAN (R 4.4.1)
## fasstr	0.5.3	2024-09-27	[1]	CRAN (R 4.4.1)
## fastmap	1.2.0	2024-05-15	[1]	CRAN (R 4.4.1)
## 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)
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(newgraphenvironment/fpr@7943230)				
## fs	1.6.5	2024-10-30	[1]	CRAN (R 4.4.1)
## generics	0.1.3	2022-07-05	[1]	CRAN (R 4.4.1)
## ggdark	* 0.2.1	2019-01-11	[1]	CRAN (R 4.4.0)
## ggplot2	* 3.5.1	2024-04-23	[1]	CRAN (R 4.4.0)
## glue	1.8.0	2024-09-30	[1]	CRAN (R 4.4.1)
## gtable	0.3.6	2024-10-25	[1]	CRAN (R 4.4.1)
## here	1.0.1	2020-12-13	[1]	CRAN (R 4.4.1)
## hms	1.1.3	2023-03-21	[1]	CRAN (R 4.4.0)

```

## htmltools           0.5.8.1    2024-04-04 [1] CRAN (R 4.4.1)
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## 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            2.2.1      2024-12-22 [1] CRAN (R 4.4.1)
## jquerylib          0.1.4      2021-04-26 [1] CRAN (R 4.4.0)
## jsonlite            1.8.9      2024-09-20 [1] CRAN (R 4.4.1)
## kableExtra          1.4.0.3    2025-03-04 [1] Github
(haozhu233/kableExtra@a9c509a)
## KernSmooth         2.23-24   2024-05-17 [2] CRAN (R 4.4.2)
## knitr              * 1.49     2024-11-08 [1] CRAN (R 4.4.1)
## labeling            0.4.3      2023-08-29 [1] CRAN (R 4.4.1)
## later               1.4.1      2024-11-27 [1] CRAN (R 4.4.1)
## leaflet             2.2.2      2024-03-26 [1] CRAN (R 4.4.0)
## leaflet.extras      2.0.1      2024-08-19 [1] CRAN (R 4.4.1)
## leaflet.providers   2.0.0      2023-10-17 [1] CRAN (R 4.4.0)
## leafpop              0.1.0      2021-05-22 [1] CRAN (R 4.4.0)
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## lubridate            * 1.9.4     2024-12-08 [1] CRAN (R 4.4.1)
## magick               2.8.5      2024-09-20 [1] CRAN (R 4.4.1)
## magrittr             2.0.3      2022-03-30 [1] CRAN (R 4.4.1)
## memoise              2.0.1      2021-11-26 [1] CRAN (R 4.4.0)
## mime                 0.12       2021-09-28 [1] CRAN (R 4.4.1)
## miniUI              0.1.1.1    2018-05-18 [2] CRAN (R 4.4.0)
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## ngr                  * 0.0.0.9002  2025-03-12 [1] local
## pagedown             * 0.22     2025-01-07 [1] CRAN (R 4.4.1)
## pillar               1.10.1     2025-01-07 [1] CRAN (R 4.4.1)
## pkgbuild              1.4.6     2025-01-16 [1] CRAN (R 4.4.1)
## pkgconfig             2.0.3     2019-09-22 [1] CRAN (R 4.4.1)
## pkgload               1.4.0     2024-06-28 [1] CRAN (R 4.4.0)
## poisutils            0.0.0.9010  2024-05-14 [2] Github
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## processx             3.8.5      2025-01-08 [1] CRAN (R 4.4.1)
## profvis              0.3.8      2023-05-02 [2] CRAN (R 4.4.0)
## promises             1.3.2      2024-11-28 [1] CRAN (R 4.4.1)
## proxy                 0.4-27    2022-06-09 [1] CRAN (R 4.4.1)
## ps                     1.8.1      2024-10-28 [1] CRAN (R 4.4.1)
## purrr                * 1.0.4     2025-02-05 [1] CRAN (R 4.4.1)
## R6                     2.5.1     2021-08-19 [1] CRAN (R 4.4.1)
## rappdirs              0.3.3     2021-01-31 [1] CRAN (R 4.4.1)
## rbbt                  0.0.0.9000  2024-06-26 [2] local
## Rcpp                  1.0.14    2025-01-12 [1] CRAN (R 4.4.1)
## RcppRoll              0.3.1      2024-07-07 [1] CRAN (R 4.4.1)
## readr                 * 2.1.5     2024-01-10 [1] CRAN (R 4.4.0)
## readwritesqlite       * 0.2.0.9006  2025-02-21 [1] Github
(poissonconsulting/readwritesqlite@d178ad5)

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Session Info

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##  rlang        1.1.5     2025-01-17 [1] CRAN (R 4.4.1)
##  rmarkdown    * 2.29     2024-11-04 [1] CRAN (R 4.4.1)
##  roxygen2    7.3.1     2024-01-22 [2] CRAN (R 4.4.0)
##  RPostgres   * 1.4.7     2024-05-27 [1] CRAN (R 4.4.0)
##  rprojroot   2.0.4     2023-11-05 [1] CRAN (R 4.4.1)
##  rsconnect    1.3.4     2025-01-22 [2] CRAN (R 4.4.1)
##  RSQLite      2.3.9     2024-12-03 [1] CRAN (R 4.4.1)
##  rstudioapi   0.17.1    2024-10-22 [1] CRAN (R 4.4.1)
##  rvest        1.0.4     2024-02-12 [1] CRAN (R 4.4.0)
##  s2           1.1.7     2024-07-17 [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 [2] CRAN (R 4.4.0)
##  sf            * 1.0-19    2024-11-05 [1] CRAN (R 4.4.1)
##  shiny         1.10.0    2024-12-14 [1] CRAN (R 4.4.1)
##  shrtcts     0.1.2     2024-05-14 [2] Github
(gadenbuie/shrtcts@41051cf)
##  snakecase    0.11.1    2023-08-27 [1] CRAN (R 4.4.0)
##  staticimports 0.0.0.9001 2025-02-14 [1] local
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##  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  1.2.1     2025-01-20 [1] CRAN (R 4.4.1)
##  terra         1.8-21    2025-02-10 [1] CRAN (R 4.4.1)
##  tibble        * 3.2.1     2023-03-20 [1] CRAN (R 4.4.0)
##  tidyhydat    0.7.0     2024-10-04 [1] CRAN (R 4.4.1)
##  tidyverse     * 1.3.1     2024-01-24 [1] CRAN (R 4.4.1)
##  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)
##  tidyxl        1.0.10    2025-03-04 [1] Github
(nacnudus/tidyxl@7e2fbe7)
##  timechange   0.3.0     2024-01-18 [1] CRAN (R 4.4.1)
##  tzdb          0.4.0     2023-05-12 [1] CRAN (R 4.4.0)
##  units         0.8-5     2023-11-28 [1] CRAN (R 4.4.1)
##  urlchecker   1.0.1     2021-11-30 [2] CRAN (R 4.4.0)
##  usethis       2.2.3     2024-02-19 [2] CRAN (R 4.4.0)
##  uuid          1.2-1     2024-07-29 [1] CRAN (R 4.4.1)
##  vctrs          0.6.5     2023-12-01 [1] CRAN (R 4.4.0)
##  viridisLite  0.4.2     2023-05-02 [1] CRAN (R 4.4.1)
##  vroom          1.6.5     2023-12-05 [1] CRAN (R 4.4.0)
##  websocket    1.4.2     2024-07-22 [1] CRAN (R 4.4.1)
##  withr          3.0.2     2024-10-28 [1] CRAN (R 4.4.1)
##  wk             0.9.4     2024-10-11 [1] CRAN (R 4.4.1)
##  xfun           0.50      2025-01-07 [1] CRAN (R 4.4.1)
##  xml2          1.3.6     2023-12-04 [1] CRAN (R 4.4.1)
```

```
## xtable      1.8-4      2019-04-21 [1] CRAN (R 4.4.1)
## yaml        2.3.10     2024-07-26 [1] CRAN (R 4.4.1)
## yesno       0.1.3      2024-07-26 [1] CRAN (R 4.4.1)
##
## [1] /Users/airvine/Library/R/arm64/4.4/library
## [2] /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 - Habitat Assessment and Fish Sampling Data

All field data collected is available [here](#).

Habitat assessment data (including fish sampling and PIT tagging information) is available for download [here](#).

Raw fish data is available for download [here](#).

Attachment 3 - 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. Details of this analysis and subsequent outputs can be reviewed in the report [Spatial Stream Network Analysis of Nechako Watershed Stream Temperatures 2022b](#) (Hill, Thorley, and Irvine 2024). Ongoing work regarding the project are tracked [here](#) and [here](#).

The project began with a custom mechanistic model (visually represented [here](#)), but the model struggled to converge. The project then shifted to the air2stream model, which offers a middle ground between fully mechanistic models—often data-intensive and reliant on quantities that are difficult to measure or estimate—and purely statistical models, which lack physical justification and perform poorly when extrapolated to new conditions (Toffolon and Piccolroaz (2015)). After several adaptations, the expected stream temperatures were best modeled using the four-parameter version of the air2stream model, with added random effects by site for each of the four parameters (Hill, Thorley, and Irvine (2024)).

The data used for the model were sourced from the following locations, for years 2019-2021:

- Water temperature data collected in the Nechako Watershed were downloaded from [Zenodo](#) (Gilbert et al. 2022).
- Hourly air temperature data were obtained from the ERA-5-Land dataset via the Copernicus Climate Change Service (Muñoz Sabater (2019))
- Daily baseflow and surface runoff data were sourced from the [Pacific Climate Impacts Consortium's Gridded Hydrologic Model Output](#) using the ACCESS1-0_rcp85 scenario (Victoria Pacific Climate Impacts Consortium (n.d.)).