SOCIETY FOR ECOSYSTEM RESTORATION IN NORTHERN BRITISH COLUMBIA

PEA-F22-F-3577-DCA Restoring Fish Passage in the Peace Region

Prepared for
Fish and Wildlife Compensation Program
and
Fish Passage Technical Working Group

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on behalf of
Society for Ecosystem Restoration in Northern British Columbia

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new graph environment
Research & Consulting

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Acknowledgement

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

Mussi cho to the McLeod Lake members of council that took the time to meet and discuss big picture goals for this collaboration. Mussi to Nathan Prince for guidance, viewing sites in the field, liaising with numerous players and tying this work together with the numerous other initiatives the Nation is advising and steering.

Mussi to John DeGagne from SERNbc for helping wrangle cash together to expedite project actions in 2021/2022 and for providing guidance for multiple aspects of the project. Thank you Chelsea Cody and Jen Walker-Larsen from FWCP for connecting our team and facilitating collaboration. Much gratitude to Simon Norris and Joe Thorley for leveraging decades of hard work towards the GIS, modeling, mapping and statistical analysis that are key to the utlity of this work.

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Mussi cho!

Executive Summary

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. As road crossing structures are commonly upgraded or removed there are numerous opportunities to restore connectivity by ensuring that fish passage considerations are incorporated into repair, replacement, relocation and deactivation designs.

The Society for Ecosystem Restoration in Northern BC (SERNbc) is working together with the McLeod Lake Indian Band, the Peace Region Fish and Wildlife Compensation Program (FWCP), the Provincial Fish Passage Technical Working Group (FPTWG), road/rail tenure holders and other FWCP stakeholders/partners to prioritize, plan and fund the restoration of fish passage at Parsnip River watershed road crossing structure barriers.

This project builds on Society for Ecosystem Restoration Northern BC (SERNbc) work in 2019 - 2020 which can be referenced here (Irvine 2020). In 2019, following a literature review, analysis of fish habitat modelling data, the Provincial Stream Crossing Inventory System (PSCIS) and a community scoping exercise within the McLeod Lake Indian Band habitat confirmation assessments were conducted at 17 sites throughout the Parsnip River watershed with 10 crossings rated as high priorities for rehabilitation and three crossings rated as moderate priorities for restoration.

In 2021/2022, through support from FWCP for this collaborative project, and leveraging numerous other connectivity restoration initiatives underway throughout the province, we were able to source funding and in-kind efforts from the Ministry of Forests, Lands and Natural Resource Operations and Rural Development, the Fish Passage Technical Working Group and forest road tenure holders to catalyze fish passage restoration actions in the Parsnip River watershed group.

In 2021/2022 actions were initiated to facilitate replacement of high priority PSCIS crossing 125179 on the Chuchinka-Missinka FSR with a clearspan bridge in the summer of 2022. The bridge structure and associated materials were purchased and environmental permitting/management planning has been initiated. Through financial support from FWCP and the Fish Passage Technical Working Group, as well as in-kind and monetary support from Sinclar Group Forest Products, remediation of fish passage at this site will be completed in 2022.

Engineering design, project permitting, environmental management planning as well as the purchase/mobilization of the bridge structure, abutment riprap and materials is planned for 2022/2023 at high priority PSCIS crossing 125000 on the Chuchinka-Arctic FSR. Installation of the clearspan structure has been scheduled for 2023.

Executive Summary

British Columbia Timber Sales is planning to deactivate the Chuchinka-Colbourne FSR between the location of high priority crossing PSCIS 125345 on a tributary to the Parsnip River and the Chuchinka-Anzac FSR. The work is schedule for July and August of 2022.

Through the ongoing development of open source analysis and data presentation tools we are identifying and communicating connectivity issues while planning on the ground works to assess opportunities, build capacity and provide the data necessary to implement and monitor restoration actions. Planning, field assessments and follow up reporting will continue to include engagement with road/rail/forest tenure holders, build awareness for connectivity issues in the wider community and build capacity for ecosystem restoration in the Peace Region.

We are leveraging this project together with numerous others to contributing to the open source development of database building, habitat/connectivity modeling and data presentation tools to conduct reproducible analysis/presentation of fish passage restoration opportunities in the Peace Region. This work facilitates outreach, prioritizes sites and provides the background information necessary to communicate restoration plans/actions effectively.

Field surveys planned for 2022 and beyond will contribute to McLeod Lake Indian Band capacity building programs, helping facilitate indigenous partnerships in natural resource management and stewardship within traditional territories. On the ground research and monitoring is an essential part of any restoration program and is necessary to ensure the best and most efficient opportunities for fish passage restoration are realized while incorporating adaptive management informed by traditional knowledge and defensible planning/monitoring data.

Updated maps for the Parsnip River, Carp River and Crooked River watershed groups incorporating the newly developed sa'ba (bull trout) spawning and rearing habitat model have been produced and are available here.

An online connectivity mapping portal for the Peace Region has been launched and is located here. At the time of reporting the site was undergoing development with the interface expected to evolve significantly over the coming months.

Although remediation and replacement of stream crossing structures can have significant 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/complimentary investments including transportation corridor relocation/deactivation, land procurement/covenant, cattle exclusion, riparian/floodplain restoration, habitat complexing, water conservation, commercial/recreational fishing management and research.

Introduction

This report is available as pdf and as an online interactive report at https://newgraphenvironment.github.io/fish_passage_parsnip_2021_reporting/. We recommend viewing online as the web-hosted version contains more features and is more easily navigable. Please reference the website for the latest version number and download the most up to date pdf from https://github.com/NewGraphEnvironment/fish_passage_parsnip_2021_reporting/raw/master/docs/parsnip2021.pdf

This document can be considered a living document. Version numbers are logged for each release with modifications, enhancements and other changes tracked here with issues and proposed/planned enhancements tracked here.

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

The Society for Ecosystem Restoration in Northern BC (SERNbc) is working together with the McLeod Lake Indian Band, the Peace Region Fish and Wildlife Compensation Program (FWCP), the Provincial Fish Passage Technical Working Group (FPTWG), road/rail tenure holders and other FWCP stakeholders/partners to prioritize, plan and fund the restoration of fish passage at Parsnip River watershed road crossing structure barriers.

This project builds on Society for Ecosystem Restoration Northern BC (SERNbc) work in 2019 - 2020 which can be referenced here (Irvine 2020). In 2019, following a literature review, analysis of fish habitat modelling data, the Provincial Stream Crossing Inventory System (PSCIS) and a community scoping exercise within the McLeod Lake Indian Band habitat confirmation assessments were conducted throughout the Parsnip River watershed. At 17 sites where habitat confirmation assessments were conducted, crossings were rated for fish passage remediation priority. During the habitat confirmations a total of approximately 15 km of stream was assessed with 10 crossings rated as high priorities for rehabilitation, three crossings rated as moderate priorities and four crossings rated as low priorities.

In 2021/2022, through this collaborative project, and leveraging numerous other connectivity restoration initiatives underway throughout the province, we engaged numerous project partners and were able to source funding to catalyze fish passage restoration activities at multiple sites identified as high priorities in 2019/2020.

Through the ongoing development of open source analysis and data presentation tools (including pdf and web-hosted mapping tools) we are identifying new restoration opportunities, clarifying restoration benefits, communicating with the broader community and planning on the ground works. Partner engagement, planning, field assessments and reporting planned for 2022/2023 will continue to include relationship building with road/rail/forest tenure holders, build awareness for connectivity issues in the wider community, assess opportunities, build capacity for ecosystem restoration and provide the data necessary to implement and monitor restoration actions.

Goal and Objectives

The project engages FWCP partners and stakeholders to clearly communicate fish passage issues in the Parsnip River watershed while collaboratively planning and executing the steps necessary to realize fish passage restorations. Work completed and ongoing aligns with the Fish and Wildlife Compensation Program Rivers, Lakes and Reservoirs Action Plan (Fish and ildlife Compensation Program 2020) sub objective 6 of addressing fish passage issues in streams to enhance productivity of priority species. Project activities undertaken coincide with the following actions:

- PEA.RLR.S06.RI.20 - Conducting engagement to prioritize options for fish passage improvement-P1
- PEA.RLR.S06.RI.19 - Conducting research to prioritize fish passage actions-P1
- PEA.RLR.S06.HB.21 - Restoring fish access to streams-P1

Study Area and Background

Tse'khene

The Parsnip River watershed is located within the south-eastern portion of the 108,000 km^2 traditional territory of the Tse'khene from the McLeod Lake Indian Band. The Tse'khene *"People of the Rocks"* are a south westerly extension of the Athabascan speaking people of northern Canada. They were nomadic hunters whose language belongs to the Beaver-Sarcee-Tse'khene branch of Athapaskan ("History - Who We Are" n.d.). Extensive work is underway to preserve the language with resources such as First Voices available online and in app form for iphone and ipad devices (First People Cultural Council 2022; Language and Council 2022).

The continental divide separates watersheds flowing north into the Arctic Ocean via the Mackenzie River and south and west into the Pacific Ocean via the Fraser River (Figure 1). The Parsnip River is a 6th order stream with a watershed that drains an area of 5597km^2. The mainstem of the river flows within the Rocky Mountain Trench in a north direction into Williston Reservoir starting from the continental divide adjacent to Arctic Lakes. Major tributaries include the Misinchinka, Colbourne, Reynolds, Anzac, Table, Hominka and Missinka sub-basins which drain the western slopes of the Hart Ranges of the Rocky Mountains. The Parsnip River has a mean annual discharge of 147.3 m^3/s with flow patterns typical of high elevation watersheds on the west side of the northern Rocky Mountains which receive large amounts of precipitation as snow leading to peak levels of discharge during snowmelt, typically from May to July (Figures 2 - 3).

Construction of the 183 m high and 2134 m long W.A.C. Bennett Dam was completed in 1967 at Hudson's Hope, BC, creating the Williston Reservoir (Hirst 1991). Filling of the 375km^2 reservoir was complete in 1972 and flooded a substantial portion of the Parsnip River and major tributary valleys forming what is now known as the Peace and Parsnip reaches. The replacement of riverine habitat with an inundated reservoir environment resulted in profound changes to the ecology, resource use and human settlement patterns in these systems (Hagen et al. 2015a; Pearce 2019; Stamford, Hagen, and Williamson 2017a). Prior to the filling of the reservoir, the Pack River, into which McLeod Lake flows, was a major tributary to the Parsnip River. The Pack River currently enters the Williston Reservoir directly as the historic location of the confluence of the two rivers lies within the reservoir's footprint.

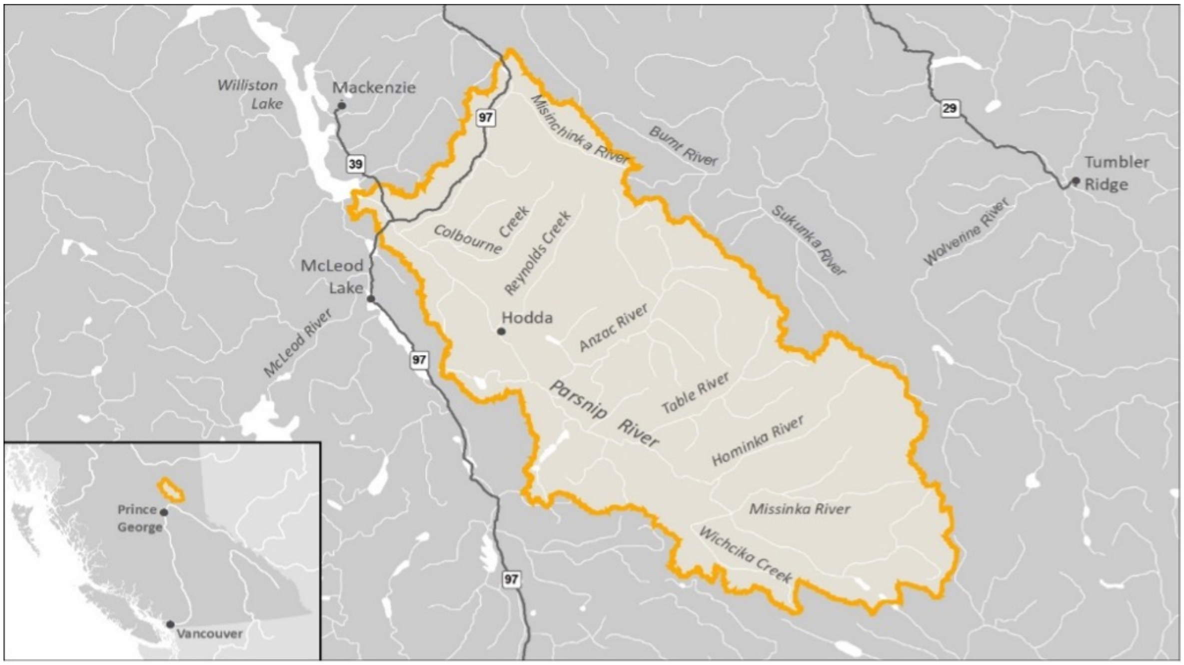

Figure 1: Overview map of study area

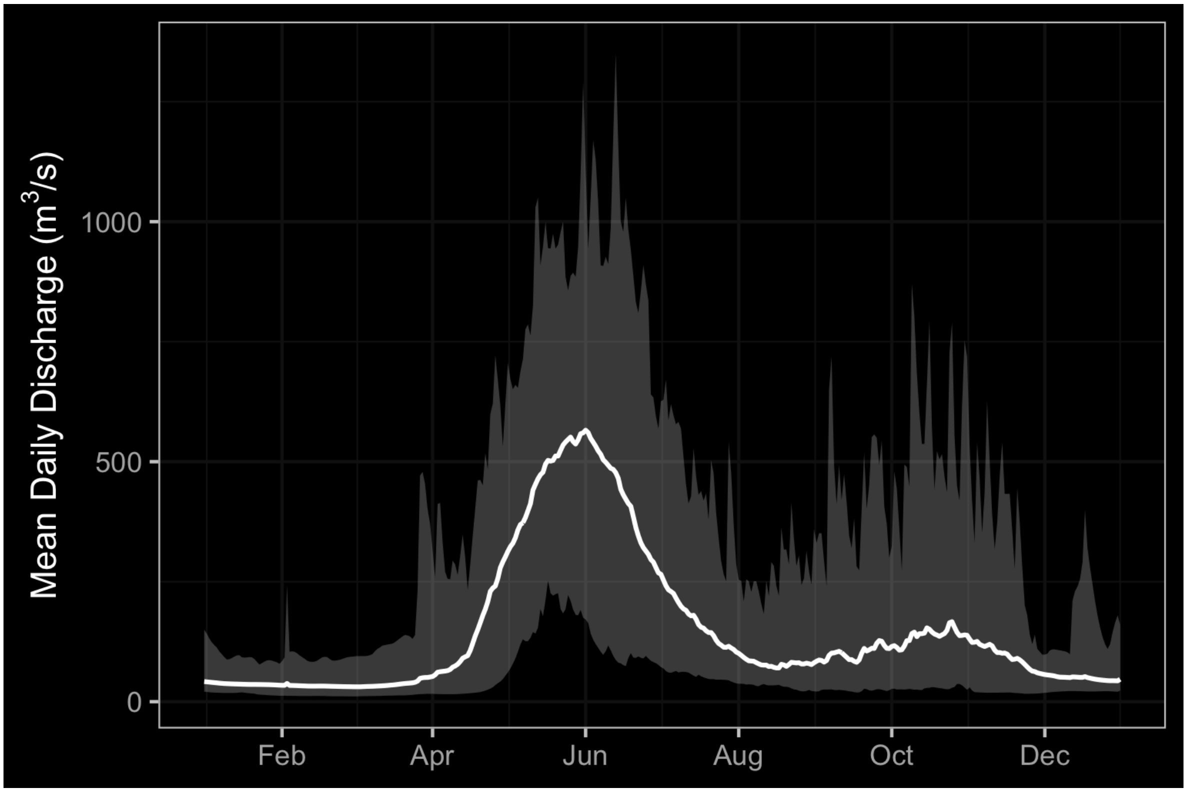

Figure 2: Parsnip River Above Misinchinka River (Station #07EE007 - Lat 55.08194 Lon -122.913063). Available daily discharge data from 1967 to 2019.

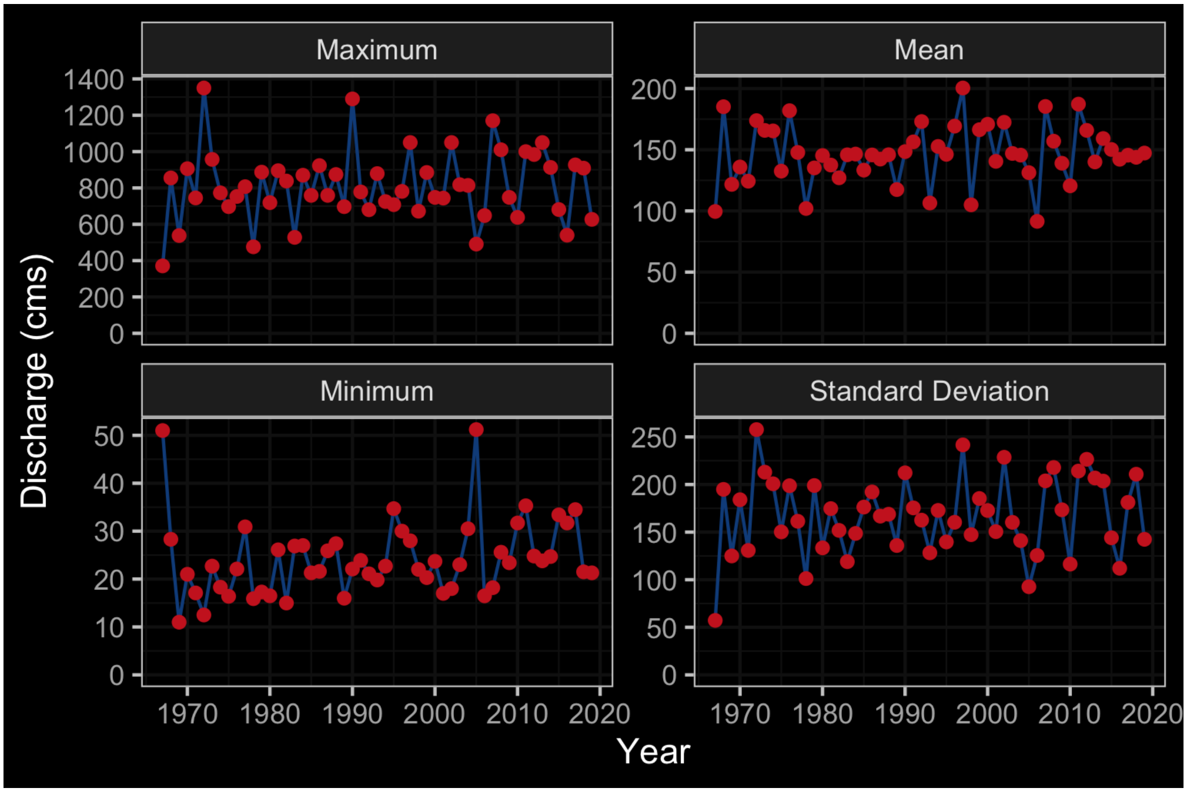

Figure 3: Summary discharge statistics (annual maximum, minimum, mean and standard deviation) for Parsnip River at hydrometric station #07EE007.

Fisheries

Fish species recorded in the Parsnip River watershed are detailed in Table ?? (MoE 2019a). In addition to flooding related to the formation of the Williston Reservoir, transmission lines, gas pipelines, rail, road networks, forestry, elevated water temperatures, interrupted connectivity, invasion from non-native species and insect infestations affecting forested areas pose threats to fisheries values in the Parsnip River watershed (Hagen et al. 2015b; Stamford, Hagen, and Williamson 2017b; Hagen and Weber 2019a; Comittee on the Status of Endangered Wildlife in Canada 2012). A brief summary of trends and knowledge status related to Arctic grayling, bull trout, kokanee, mountain whitefish and rainbow trout in Williston Watershed streams is provided in Fish and ildlife Compensation Program (2020) with a more detailed review of the state of knowledge for Parsnip River watershed populations of Arctic grayling and bull trout provided below.

Table 1: Fish species recorded in the Parsnip River watershed group.

Scientific Name	Species Name	Species Code	BC List	Provincial FRPA	COSEWIC	SARA
Catostomus catostomus	Longnose Sucker	LSU	Yellow	–	–	–
Catostomus commersonii	White Sucker	WSU	Yellow	–	–	–
Catostomus macrocheilus	Largescale Sucker	CSU	Yellow	–	–	–

Scientific Name	Species Name	Species Code	BC List	Provincial FRPA	COSEWIC	SARA
Coregonus clupeaformis	Lake Whitefish	LW	Yellow	–	–	–
Cottus aleuticus	Coastrange Sculpin (formerly Aleutian Sculpin)	CAL	Yellow	–	–	–
Cottus asper	Prickly Sculpin	CAS	Yellow	–	–	–
Cottus cognatus	Slimy Sculpin	CCG	Yellow	–	–	–
Couesius plumbeus	Lake Chub	LKC	Yellow	–	DD	–
Lota lota	Burbot	BB	Yellow	–	–	–
Mylocheilus caurinus	Peamouth Chub	PCC	Yellow	–	–	–
Oncorhynchus mykiss	Rainbow Trout	RB	Yellow	–	–	–
Oncorhynchus nerka	Kokanee	KO	Yellow	–	–	–
Osmerus dentex	Rainbow Smelt	RSM	Unknown	–	–	–
Prosopium coulterii	Pygmy Whitefish	PW	Yellow	–	NAR (Nov 2016)	–
Prosopium cylindraceum	Round Whitefish	RW	Yellow	–	–	–
Prosopium williamsoni	Mountain Whitefish	MW	Yellow	–	–	–
Ptychocheilus oregonensis	Northern Pikeminnow	NSC	Yellow	–	–	–
Rhinichthys cataractae	Longnose Dace	LNC	Yellow	–	–	–
Richardsonius balteatus	Redside Shiner	RSC	Yellow	–	–	–
Salvelinus confluentus	Bull Trout	BT	Blue	Y (Jun 2006)	SC (Nov 2012)	–
Salvelinus fontinalis	Brook Trout	EB	Exotic	–	–	–
Salvelinus malma	Dolly Varden	DV	Yellow	–	–	–
Salvelinus namaycush	Lake Trout	LT	Yellow	–	–	–
Thymallus arcticus	Arctic Grayling	GR	Yellow	–	–	–

Bull Trout - sa’ba

Bull Trout populations of the Williston Reservoir watershed are included within the Western Arctic population ‘Designatable Unit 10’, which, in 2012, received a ranking of ‘Special Concern’ by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2012). They were added to Schedule 1 under the Species of Risk Act in 2019 (Species Registry Canada 2020) and are also considered of special concern (blue-listed) provincially (BC Species & Ecosystem Explorer 2020). Some or all of the long-term foot survey index sections of four Williston Reservoir spawning tributaries (Davis Creek, Misinchinka River, Point Creek, and Scott Creek), have been surveyed within 16 of the 19 years between 2001 and 2019 (16 of 19 in Davis River, 10 years over a 13-year period in the Misinchinka River, 11 years over a 14-year period for Point Creek, and 9 years over an 11-year period for Scott Creek (Hagen, Spendlow, and Pillipow 2020).

A study of sa’ba critical habitats in the Parsnip River was conducted in 2014 with the Misinchinka and Anzac systems identified as the most important systems for large bodied bull trout spawners accounting for a combined total of 65% of spawners counted. The Table River was also highlighted as an important spawning destination accounting for an estimated 15% of the spawners. Other watersheds identified as containing runs of large bodied bull troutspawners included the Colbourne, Reynolds, Hominka and Missinka River with potentially less than 50 spawners utilizing each sub-basin (Hagen et al. 2015a). Hagen and Weber (2019b) have synthesized a large body of information regarding limiting factors, enhancement potential, critical habitats and conservation status for bull trout of the Williston Reservoir and the reader is encouraged to review this work for context. They have recommended experimental enhancements within a monitoring framework for Williston Reservoir bull trout (some spawning and rearing in Parsnip River mainstem and tributaries) which include stream fertilization, side channel development, riparian restoration and fish access improvement.

In 2018, sub-basins of the Anzac River watershed, Homininka River, Missinka River and Table River watersheds were designated as fisheries sensitive watersheds under the authority of the *Forest and Range Practices Act* due to significant downstream fisheries values and significant watershed sensitivity (Beaudry 2013a, 2014a, 2014b, 2013c). Special management is required in these watersheds to protect habitat for fish species including bull trout and Arctic grayling including measures (among others) to limit equivalent clearcut area, reduce impacts to natural stream channel morphology, retain old growth attributes and maintain fish habitat/movement (Forest and Range Practices Act 2018).

Tse'khene Elders from the McLeod Lake Indian Band report that sa'ba (bull trout) size and abundance has decreased in all rivers and tributaries from the reservoir with more injured and diseased fish captured in recent history than was common in the past (Pearce 2019).

Arctic Grayling - dusk'ihje

A detailed review of dusk'ihje life history can be referenced in Stamford, Hagen, and Williamson (2017b). Since impoundment of the Williston Reservoir, it appears that physical habitat and ecological changes have been the most significant factors limiting Arctic grayling productivity. Although these changes are not well understood they have likely resulted in the inundation of key low gradient juvenile rearing and overwintering habitats, isolation of previously connected populations and increases in abundance of predators such as bull trout (Shrimpton, Roberts, and Clarke 2012; Hagen, Pillipow, and Gantner 2018).

Migration of mature adult dusk'ihje (Arctic grayling) occurs in the spring with arrival at known spawning locations coinciding with water temperatures of 4°C. Spawning in the Parsnip watershed appears to occur between late-May and late-June within sites located primarily within the lower reaches of the Anzac and Table rivers as well as within the Parsnip River mainstem. Side-channel and multiple-channel locations containing small gravels appear to be selected for spawning. Currently, the primary distribution of Williston Arctic grayling appears to be among fourth order and larger streams (Williamson and Zimmerman 2005; Stamford, Hagen, and Williamson 2017b). Stewart et al. (2007) report that Arctic grayling spawn in large and small tributaries to rivers and lakes, intermittent streams, within mainstem rivers as well as lakes, most commonly at tributary mouths. Although past study results indicate that 0+ grayling appeared to overwinter in lower reaches of larger tributaries (i.e. Table, Anzac rivers) as well as the Parsnip River and that few age-1+ grayling have been sampled in tributaries, habitat use in small tributaries and the extent they are connected with the mainstem habitats of all core areas is not well understood. Between 1995 and 2019, Arctic grayling population monitoring has been conducted in the Table River in nine out of 25 years (8 years for the Anzac) using snorkel surveys. Results from 2018 are 2019 are intended to contribute to the assessment of the conservation status of the species in the Parsnip Core area (Hagen, Pillipow, and Gantner 2018).

Tse'khene Elders from the McLeod Lake Indian Band report that Arctic grayling numbers have declined dramatically since the flooding of the reservoir and that few dusk'ihje (Arctic Grayling) have been caught in the territory in the past 30 years (Pearce 2019).

Areview of available fisheries data for the Parsnip River watershed stratified by different habitat characteristics can provide insight into which habitats may provide the highest intrinsic value for fish species based on the number of fish captured in those habitats in past assessment work (Figures 4 - 6). It should be noted however that it should not be assumed that all habitat types have been sampled in a non-biased fashion or that particular sites selected do not have a disproportionate influence on the overall dataset composition (ie. fish salvage sites are often located adjacent to construction sites which are more commonly located near lower gradient stream reaches).

Table 2: Summary of historic salmonid observations vs. stream gradient category for the Parsnip River watershed group.

species_code	Gradient	Count	total_spp	Percent
BT	0 - 3 %	160	236	68
BT	03 - 5 %	29	236	12
BT	05 - 8 %	21	236	9
BT	08 - 15 %	20	236	8
BT	15 - 22 %	6	236	3
GR	0 - 3 %	224	230	97
GR	03 - 5 %	2	230	1
GR	05 - 8 %	2	230	1
GR	08 - 15 %	2	230	1
KO	0 - 3 %	17	17	100
RB	0 - 3 %	327	415	79
RB	03 - 5 %	32	415	8
RB	05 - 8 %	22	415	5
RB	08 - 15 %	27	415	7
RB	15 - 22 %	7	415	2

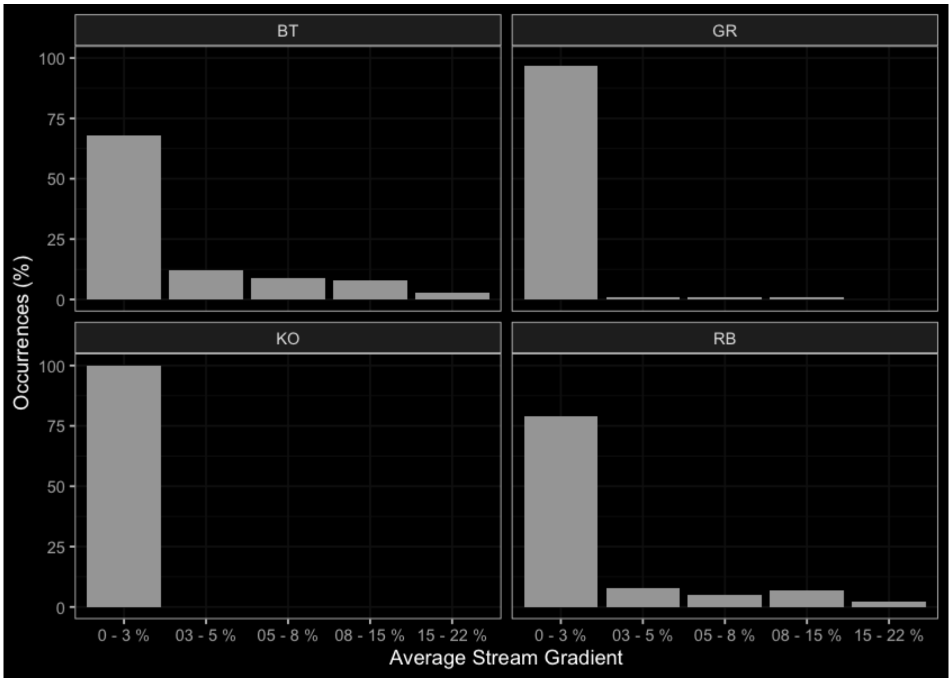

Figure 4: Summary of historic salmonid observations vs. stream gradient category for the Parsnip River watershed group.

Table 3: Summary of historic salmonid observations vs. channel width category for the Parsnip River watershed group.

species_code	Width	Count	total_spp	Percent
BT	0 - 2m	11	236	5
BT	02 - 04m	25	236	11
BT	04 - 06m	29	236	12
BT	06 - 10m	35	236	15
BT	10 - 15m	30	236	13
BT	15m+	103	236	44
BT	–	3	236	1
GR	04 - 06m	5	230	2
GR	06 - 10m	7	230	3
GR	10 - 15m	14	230	6
GR	15m+	200	230	87
GR	–	4	230	2
KO	0 - 2m	1	17	6
KO	06 - 10m	3	17	18
KO	15m+	1	17	6
KO	–	12	17	71
RB	0 - 2m	23	415	6

species_code	Width	Count	total_spp	Percent
RB	02 - 04m	51	415	12
RB	04 - 06m	37	415	9
RB	06 - 10m	36	415	9
RB	10 - 15m	34	415	8
RB	15m+	141	415	34
RB	–	93	415	22

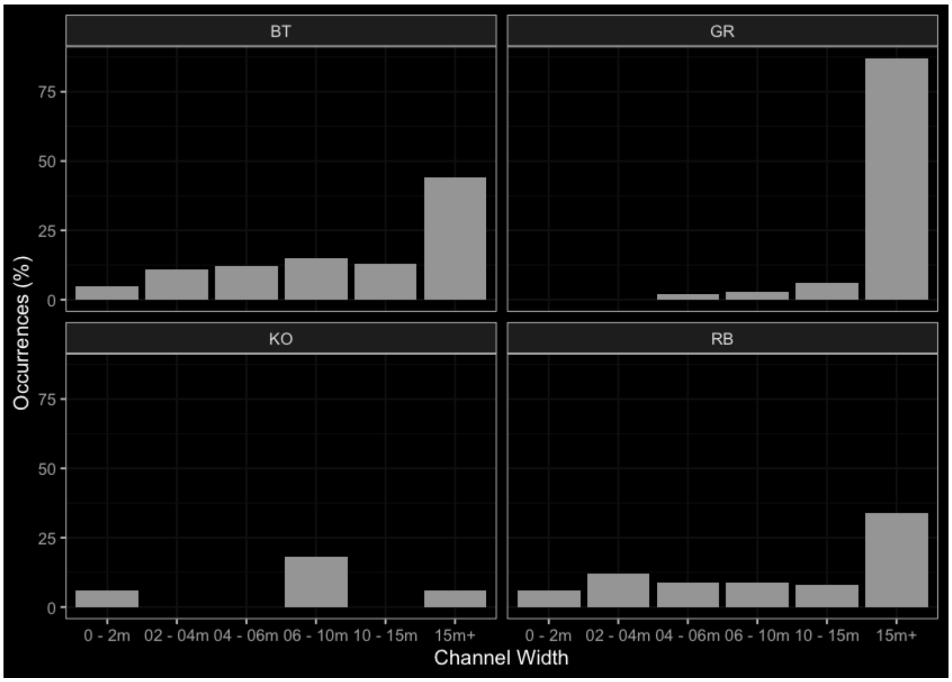

Figure 5: Summary of historic salmonid observations vs. channel width category for the Parsnip River watershed group.

Table 4: Summary of historic salmonid observations vs. watershed size category for the Parsnip River watershed group.

species_code	Watershed	count_wshd	total_spp	Percent
BT	0 - 25km2	89	236	38
BT	25 - 50km2	27	236	11
BT	50 - 75km2	12	236	5
BT	75 - 100km2	9	236	4
BT	100km2+	99	236	42
GR	0 - 25km2	7	230	3
GR	25 - 50km2	5	230	2
GR	50 - 75km2	9	230	4

species_code	Watershed	count_wshd	total_spp	Percent
GR	75 - 100km2	6	230	3
GR	100km2+	203	230	88
KO	0 - 25km2	11	17	65
KO	25 - 50km2	1	17	6
KO	50 - 75km2	2	17	12
KO	75 - 100km2	2	17	12
KO	100km2+	1	17	6
RB	0 - 25km2	210	415	51
RB	25 - 50km2	22	415	5
RB	50 - 75km2	26	415	6
RB	75 - 100km2	17	415	4
RB	100km2+	140	415	34

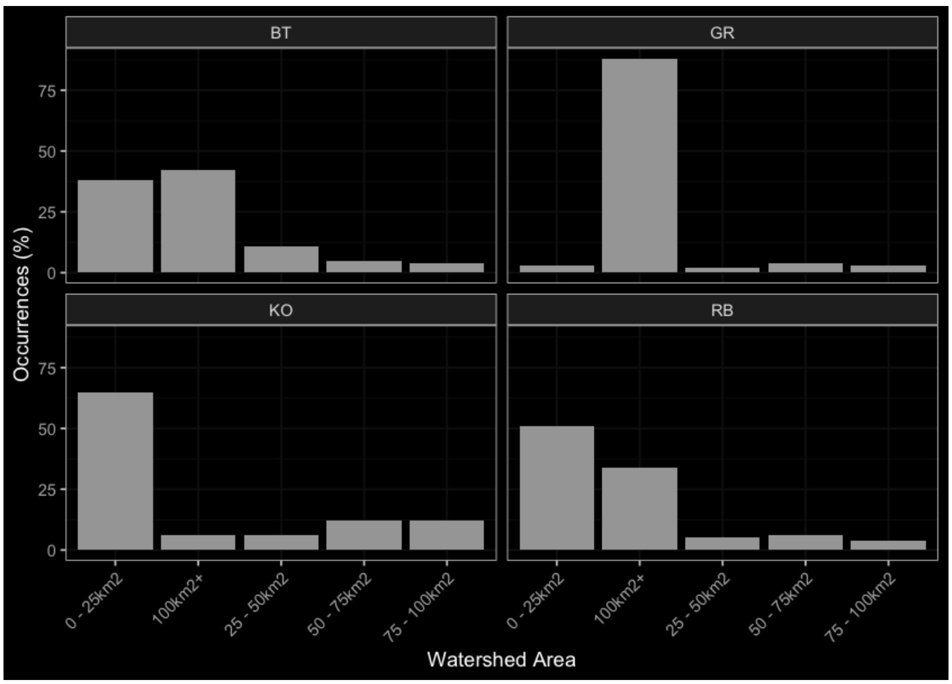

Figure 6: Summary of historic salmonid observations vs. watershed size category for the Parsnip River watershed group.

Methods

Engage Partners

From May 2021 to the time of reporting SERNbc and McLeod Lake staff have been actively engaging with the following groups to discuss the project, solicit input, prioritize sites, raise partnership funding and plan fish passage remediations. Engagement actions have included video conference calls, meetings, emails, presentations and phone calls.

- McLeod Lake Indian Band members of council
- BCTS Engineering
- CN Rail
- Canadian Forest Products (Canfor)
- Sinclar Forest Projects Ltd. (Sinclar)
- Northern Engineering - Forests, Lands, Natural Resource Operations and Rural Development (FLNR)
- BC Ministry of Transportation and Infrastructure
- Fish Passage Technical Working Group
- Coastal Gasliink
- Planning foresters and biologists Ministry of Forests, Lands, Natural Resource Operations and Rural Development (restructured into Ministry of Forests and Ministry of Land, Water and Resource Stewardship)
- Fisheries experts

The Environmental Stewardship Initiative(ESI) is a collaborative partnership between the Province and First Nations with projects designed to focus on ecosystem assessment, restoration, enhancement, research and education. To date, four regional environmental stewardship projects have been developed throughout northern British Columbia. A governance working group with representatives from all four stewardship forums provides governance oversight and guidance for the ESI. The Parsnip River watershed group is within the Regional Strategic Environmental Assessment Forum (RSEA) area. Indigenous partners for RSEA include McLeod lake, Blueberry River, Halfway River, Doig River, West Moberly, Prophet River and Sauteau. Forum values of focus to date include old forest/forest biodiversity, water, moose, peaceful enjoyment and environmental livelihoods.

Working together with McLeod Lake Indian Band we are leveraging RSEA initiatives by overlaying Parsnip River watershed group fish passage planning data with the Recreational Opportunity Spectrum Inventory data to facilitate discussions with partners and stakeholders about how long term landscape stewardship goals of McLeod Lake Indian Band relate to stream crossing infrastructure upgrades/removals within their traditional territory. The inventory data summarizes recreation opportunities as combinations of settings and probable human experience opportunities organized along a spectrum of classes. The spectrum is set out in terms of seven classes as follows: Primitive (P), Semi-primitive Non-motorized (SPNM), Semi-primitive Motorized (SPM), Roaded Natural (RN), Roaded Modified (RM), Rural (R), Urban (U). The general idea is that areas towards the primitive end of the spectrum provide more opportunities for First Nations groups such as the McLeod Lake Indian Band to exercise their rights as indigenous people in pristine areas within their traditional territory (United Nations General Assembly 2007).

Identify and Communicate Connectivity Issues

Habitat Modelling

Through this initiative, other SERNbc led initiatives (Irvine 2021, [2021] 2022), multi-decade direction from the Provincial Fish Passage Remediation Program and connectivity restoration planning conducted by Canadian Wildlife Federation and others (Mazany-Wright et al. 2021; Irvine 2022), `bcfishpass` has been designed to prioritize potential fish passage barriers for assessment or remediation. The software is under continual development and has been designed and constructed by Norris ([2020] 2021) using sql and python based shell script libraries to generate a simple model of aquatic habitat connectivity. The model identifies natural barriers (ex. steep gradients for extended distances) and hydroelectric dams to classifying the accessibility upstream by fish (Norris [2020] 2021). On potentially accessible streams, scripts identify known barriers (ex. waterfalls >5m high) and additional anthropogenic features which are primarily road/railway stream crossings (i.e. culverts) that are potentially barriers. To prioritize these features for assessment or remediation, scripts report on how much modelled potentially accessible aquatic habitat the barriers may obstruct. The model can be refined with 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, 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.

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, FISS channel width was used. When multiple FISS sites were associated with a particular stream segment a mean of the average channel widths was taken. To model channel width for 2nd order and above stream segments without associated FISS or PSCIS sites, first `fwapg` was used to estimate the drainage area upstream of the segment. Then, rasters from ClimateBC (Wang et al. 2012) were downloaded to a `postgresql` database, sampled for upstream watershed areas associated with each stream segment and a mean annual precipitation weighted by upstream watershed area was calculated.

In April of 2021, Bayesian statistical methods were used to model channel width in all provincial freshwater atlas stream segments where width measurements had not previously been taken, based on the relationship between watershed area and mean annual precipitation weighted by upstream watershed area (Thorley and Irvine 2021). Details of this analysis and subsequent outputs can be reviewed here.

In December of 2021, Bayesian statistical methods were used to update results from Thorley and Irvine (2021) using on 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 Catalouge fisheries datasets (MoE 2020, 2021) and Wang et al. (2012) utilizing `bcfishpass` (Norris [2020] 2021) and `fwapg` (Norris [2019] 2021). Using Bayesian statistical methods, the relationship between the input variables was analyzed to update a predictive model of channel width.

`bcfishpass` and associated tools have been designed to be flexible in analysis, accepting user defined gradient, channel width and stream discharge categories (MoE 2019b). Although currently in draft form, and subject to development revisions, gradient and channel width thresholds for habitat with the highest intrinsic value for a number of fish species in the Parsnip River watershed group have been specified and applied to model habitat upstream of stream crossing locations with the highest potential intrinsic value (Table 5). Definitions of modelling outputs for bull trout are presented in Table 6. Modelling of habitat for Arctic grayling, kokannee and rainbow trout in the Peace region are planned for 2022/2023 wtih the work leveraging multiple other initiatives underway by SERNbc and others throughout British Columbia.

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

Variable	Bull Trout	Rainbow Trout	Arctic Grayling	Kokanee
Variable	Bull Trout	Rainbow Trout	Arctic Grayling	Kokanee
Spawning Gradient Max (%)	5	5	2	2
Spawning Width Min (m)	2	2	4	2
Rearing Width Min (m)	1.5	1.5	1.5	1.5
Rearing Gradient Max (%)	7.4	7.4	3.4	–

[*] Models for RB, GR and KO are under a process of development and have not yet been released. All models parameters are preliminary and subject to collaborative development.

Table 6: bcfishpass outputs and associated definitions

Attribute	Definition
BT Rearing (km)	Length of stream upstream of point modelled as potential Bull Trout rearing habitat
BT Spawning (km)	Length of stream upstream of point modelled as potential Bull Trout spawning habitat
BT Network (km)	Bull Trout model, total length of stream network potentially accessible upstream of point
BT Stream (km)	Bull Trout model, total length of streams and rivers potentially accessible upstream of point (does not include network connectors in lakes etc)
BT Lake Reservoir (ha)	Bull Trout model, total area lakes and reservoirs potentially accessible upstream of point
BT Wetland (ha)	Bull Trout model, total area wetlands potentially accessible upstream of point
BT Slopeclass03 (km)	Bull Trout model, length of stream potentially accessible upstream of point with slope 0-3%
BT Slopeclass05 (km)	Bull Trout model, length of stream potentially accessible upstream of point with slope 3-5%
BT Slopeclass08 (km)	Bull Trout model, length of stream potentially accessible upstream of point with slope 5-8%
BT Slopeclass15 (km)	Bull Trout model, length of stream potentially accessible upstream of point with slope 8-15%

[*] Bull trout model uses a gradient threshold of maximum 25% to determine if access if likely possible

Field Planning

As there have been significant advancements in our ability to scope for restoration opportunities since the 2019 habitat confirmations were conducted in the Parsnip River watershed (ie. `bcfishpass` outputs such as the bull trout spawning and rearing model) we built an interactive map/table widget tool to facilitate planning for future field surveys in the Peace Region. The widget was built using R packages `crosstalk` (Cheng and Sievert [2015] 2022), `DT` (Xie, Cheng, and Tan [2014] 2022) and `Leaflet` (Cheng, Karambelkar, and Xie [2014] 2022). The interactive interface allows screening of previously inventoried as well as modelled stream crossing locations based on PSCIS information as well as the likely amount and type of habitat modelled upstream. Users can download csv results from those screening processes as well as associated georeferenced field maps to facilitate field surveys. The 2022 field surveys will contribute to McLeod Lake Indian Band capacity building programs, helping facilitate the continued evolution back to indigenous led natural resource management and stewardship within their traditional territory. On the ground research and monitoring is an essential part of any restoration program and is necessary to ensure that we identify the best and most efficient opportunities for fish passage restoration while incorporating adaptive management informed by traditional knowledge and real-time planning/monitoring data.

Mapping

QGIS

Updated mapping incorporating the newly developed sa'ba (bull trout) spawning and rearing habitat model was developed by Hillcrest Geographics. `pdf` maps were generated using `QGIS` with data supplied via a `postgresql` database. A QGIS layer file defining and symbolizing all layers required for general fish passage mapping has been developed through this initiative and numerous others, is continuously evolving and at the time of reporting was kept under version control within [`bcfishpass`](). Use of the QGIS layer file allows load and representation all map component layers provided the user points to a postgresql database containing the necessary data which can be loaded and built with `bcfishpass`.

Web Mapping

An open source online mapping portal has been developed for engagement and planning purposes. The [template]() for the repository was developed within `bcfishpass` by Simon Norris of Hillcrest Geographics based on a basic mapbox gl style using vector tiles served from `pg_tileserve` and `pg_featureserve` software (CrunchyData [2019a] 2022, [2019b] 2022). At the time of reporting, the web mapping app was under active development with the interface expected to evolve significantly throughout 2022/2023. The interface provides "thin" interactive feature layers providing data representations as vector tiles served directly from underlying `postgresql` databases. This facilitates slippy map representation of large data sets as well as ongoing changes in the underlying `postgresql` databases including alteration and addition of features such as the fish habitat model layers, PSICS crossings, modelled crossings, fish observation points, road layers, forest inventory polygons, etc.

Results and Discussion

Engage Partners

Partnership Funding

Through partnership engagement SERN was able to aquire $105,000 of partnership funding from FLNR ($80,000) and the Provincial Fish Passage Technical Working Group ($25,000) towards the 2021/2022 program. Additionally, we have obtained a commitment for $25,000 of funding from the the Provincial Fish Passage Technical Working Group towards the 2022/2023 program.

Planned Remediations

PSCIS Crossing 125179 - Tributary to Missinka River

We are working together with McLeod Lake and Sinclar to advance crossing [125179 (Tributary to Missinka River)]() on the Chuchinka-Missinka FSR. Works to replace the crossing are planned for summer of 2022. A map of the watershed is provided in map attachment 093I.116. Outputs of `bcfihspass` modelling are presented in (Table 7)

Although this crossing is used to access an area of significant cultural value to McLeod Lake due to high recreational values (unmotorized primitive), and is located within a watershed where expansion of "unmotorized primitive" values will occur in the future through deactivation of roads and reforestation, this site was selected as appropriate for restoration for the following reasons:

- At the time of reporting there was significant harvesting and silviculture obligations in areas accessed by the FSR.
- The Missinka River watershed is designated as a fisheries sensitive watershed under the *Forest and Range Practices Act* (Beaudry 2013b)
- Hagen et al. (2015a) have identified the Missinka River watershed as containing critical spawning and juvenile rearing habitat for large body adult sa'ba (bull trout) with potentially less than 50 spawners utilizing the watershed.
- The Missinka River watershed is utilized by a possibly genetically distinct, self-sustaining dusk'ihje (Arctic grayling) population with the mainstem of the river providing critical habitat for fry and adult fish
- The subject tributary is documented as containing sa'ba.
- A bridge design was commissioned for the site in 2020 through funding from FWCP (project PEA-F20-F-2967) so preparations for replacement could be made in a timely fashion.
- Portions of artnership funding acquired by SERNbc was used to implement key steps towards fish passage restoration at the site in 2022. Following the design acquired for the site in 2019/2020 (Irvine 2020), Sinclar Forest Projects Ltd. has begun delivery of the bridge installation with the following measures completed at the time of reporting:
    - Submission of a Water Sustainability Act Permit Application
    - Development of an Environmental Management Plan

- Source, purchase and mobilization of steel girders, modular timber deck and lock block abutment as per site design

Sinclar has sent out a request for proposals for the structure replacement to three qualified contractors. Project coordination expertise by Sinclar are being provided in-kind. Leveraging support from SERNbc and FWCP, Sinclar will obtain portions of funding for this work through the forestry appraisal system. Bridge installation has been scheduled for the summer of 2022.

Table 7: Summary of fish habitat modelling for PSCIS crossing 125179.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
BT Rearing (km)	0.0	0.0	–
BT Spawning (km)	0.0	0.0	–
BT Network (km)	2.6	2.6	100
BT Stream (km)	2.6	2.6	100
BT Lake Reservoir (ha)	0.0	0.0	–
BT Wetland (ha)	0.0	0.0	–
BT Slopeclass03 (km)	0.0	0.0	–
BT Slopeclass05 (km)	0.0	0.0	–
BT Slopeclass08 (km)	0.1	0.1	100
BT Slopeclass15 (km)	2.0	2.0	100

* Model data is preliminary and subject to adjustments.

PSCIS 125000 - Tributary to Parsnip River

Working together with McLeod Lake and Sinclar, we are advanceing the replacement of crossing 125000 (Tributary to Parsnip River) on the Chuchinka-Arctic FSR. A map of the watershed is provided in map attachment 093I.111 and video from an unmanned aerial vehicle taken in 2019 is available here. The crossing was prioritized for restoration for the following reasons:

- At the time of reporting there was significant harvesting and silviculture obligations in areas accessed by the FSR.
- With an outlet drop of 40cm the culvert in place is a complete barrier to upstream fish passage with very low likelihood of any fish movement upstream.
- The culvert is likely over 30 years old, is undersized and is at risk of washout. A washout event would result in significant deposition of material downstream of the road (including the mainstem of the Parnip River) and negative impacts on local fisheries values.
- The FSR accesses McLeod Lake reservation lands (ID: Arctic Lake 10) located near the outlet of Arctic Lake.
- This site is in the general vicinity of the outlet of Arctic Lake which has been identified as a high priority area for taloo’azi (kokanee) and sa’ba (bull trout) by participants in FWCP supported information gathering work (Pearce 2019).
- The Chuchinka-Arctic FSR accesses the Arctic Lake Provincial Park which has significant historic and recreational values. A canoe launch area for the Parsnip River is also located at

the upper Parsnip River Bridge.
- There are no other stream crossing structures on the mainstem of this tributary that impede fish passage.
- The stream has a large channel width at the crossing location (4.4m) and has an estimated 3.5km of mainstem habitat less than 5% gradient available upstream of the crossing with rainbow Trout and sculpin confirmed as present immediately below the crossing (Table 8). Habitat was rated as high value for salmonid rearing and spawning in surveys conducted in 2019.

Table 8: Summary of fish habitat modelling for PSCIS crossing 125000.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
BT Rearing (km)	4.1	3.3	80
BT Spawning (km)	2.3	2.3	100
BT Network (km)	13.4	13.4	100
BT Stream (km)	12.7	12.7	100
BT Lake Reservoir (ha)	0.0	0.0	–
BT Wetland (ha)	0.0	0.0	–
BT Slopeclass03 (km)	2.0	2.0	100
BT Slopeclass05 (km)	1.9	1.9	100
BT Slopeclass08 (km)	4.7	4.7	100
BT Slopeclass15 (km)	2.8	2.8	100

* Model data is preliminary and subject to adjustments.

PSCIS 125345 - Tributary to Parsnip River

British Columbia Timber Sales is planning to deactivate the Chuchinka-Colbourne FSR between the location of 125345 (Tributary to Parsnip River) and the Chuckhinka-Anzac FSR (Table 9) (pers comm. Stephanie Sundquist, BCTS Planning Forester). The work is schedule for July and August of 2022. BCTS was able to obtain funding for the work through the Forest Carbon Initiative and the work will include a full road rehabilitation as well as decompaction and replanting. This full scale rehabilitation approach provides more intensity towards re-vegetation and access management than traditional deactivation practices. Working with BCTS and McLeod Lake we have been in contact with CN Rail to advocate for the removal of crossing 57687 under the railway immediately upstream of the PSCIS crossing 125345 and the Chuchinka-Colbourne FSR. Discussions are ongoing to advocate that action will be taken by CN this summer to remediate crossing 57687 before the access road from the south is deactivated.

for PSCIS crossing 125345.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
Habitat	Potential	Remediation Gain	Remediation Gain (%)
BT Rearing (km)	10.7	0.0	0
BT Spawning (km)	5.0	0.0	0
BT Network (km)	36.4	36.4	100
BT Stream (km)	29.6	29.6	100
BT Lake Reservoir (ha)	0.0	0.0	–
BT Wetland (ha)	0.0	0.0	–
BT Slopeclass03 (km)	13.1	13.1	100
BT Slopeclass05 (km)	10.9	10.9	100
BT Slopeclass08 (km)	4.3	4.3	100
BT Slopeclass15 (km)	1.6	1.6	100

* Model data is preliminary and subject to adjustments.

PSCIS 125231 - Tributary to Table River

We are working together with McLeod Lake and Canfor to explore opportunities to advance crossing 125231 (Tributary to Table River) on the Chuchinka-Table FSR for the following reasons:

- Table River watershed is designated as a fisheries sensitive watershed under the authority of the *Forest and Range Practices Act* due to significant downstream fisheries values and watershed sensitivity (Beaudry 2014c). Special management is required in the crossing's watershed to protect habitat for sa'ba (bull trout) and dusk'ihje (Arctic grayling) and includes measures (among others) to limit equivalent clearcut area, reduce impacts to natural stream channel morphology, retain old growth attributes and maintain fish habitat/movement.
- Hagen et al. (2015a) have identified the Table River watershed and several tributaries as containing critical spawning and juvenile rearing habitat for large body sa'ba with an estimated minimum spawner abundance of 100 fish.
- The Table River (along with the Anzac River) is identified as the primary core of post-Williston dusk'ihje distribution in the Parsnip River watershed with life history, migration behaviours and critical habitats summarized in Hagen et al. (2015a). The mainstem of the Table River contains critical habitats for all life stages of dusk'ihje with adults observed moving among mainstem locations and tributaries during summer.
- The culvert in place is likely over 30 years old, is undersized and is at risk of washout. A washout event would result in significant deposition of material downstream of the road and negative impacts on local fisheries values.
- The subject tributary is documented as containing rainbow trout with habitat present also suitable for sa'ba rearing and spawning.
- At the time of reporting there was significant harvesting planned and silviculture obligations outstanding in areas accessed by the FSR.
- With an outlet drop of 60cm, the culvert in place is a complete barrier to upstream fish passage with very low likelihood of any upstream fish migration.
- There are no other stream crossing structures on the mainstem of this tributary that impede fish passage. There is a newly installed bridge upstream and the culvert under the CN railway downstream was considered passable according to the provincial protocol (MoE 2011).

- Although, relatively steep, with gradients falling just outside the currently specified thresholds for highest value bull trout rearing, the stream is capable of supporting bull trout, has a large channel width at the crossing location (4.0m) and has an estimated 2.7km habitat available upstream with average gradients mapped at less than 15% (Table 10). Habitat was rated as high value for salmonid rearing and spawning in surveys conducted in 2019.

Table 10: Summary of fish habitat modelling for PSCIS crossing 125231.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
BT Rearing (km)	0.0	0.0	–
BT Spawning (km)	0.0	0.0	–
BT Network (km)	3.4	3.4	100
BT Stream (km)	3.4	3.4	100
BT Lake Reservoir (ha)	0.0	0.0	–
BT Wetland (ha)	0.0	0.0	–
BT Slopeclass03 (km)	0.0	0.0	–
BT Slopeclass05 (km)	0.0	0.0	–
BT Slopeclass08 (km)	0.4	0.4	100
BT Slopeclass15 (km)	2.3	2.3	100

* Model data is preliminary and subject to adjustments.

Identify and Communicate Connectivity Issues

Habitat Modelling

We are leveraging this project together with numerous others to contributing to the open source development of `bcfishpass`, `fwapg`, `bcdata`, bcfishobs and `fpr`. We are using these database building, habitat/connectivity modeling and data presentation tools to conduct reproducible analysis/presentation of fish passage restoration opportunities in the Parsnip River watershed in order to facilitate outreach, prioritize sites and provide the background information necessary to communicate restoration plans/actions effectively.

Results from the Bayesian analysis using on a power model derived by Finnegan et al. (2005) which relates stream discharge to watershed area and mean annual precipitation are documented in Thorley, Norris, and Irvine (2021). We used this predictor of channel width to model stream segments in the Parsnip River watershed with potentially high intrinsic fisheries habitat value. Analysis details and resulting predictive formula are included as Attachment 2 (Thorley, Norris, and Irvine 2021).

Working with Ministry of Environment and Climate Change Strategy we have accessed historic electrofishing data for the entire province from British Columbia databases to begin developing evidence based approaches to modelling the highest value habitat for individual fish species. This work is an important step to increasing our state of knowledge, informing our field data collection and data management protocols provincially as well as for informing fish passage restoration investment decisions and monitoring outcomes. This work leverages many initiatives throughout the province and is briefly detailed here with preliminary results presented as Attachment 3(Amies-Galonski et al. 2022).

Utilizing modelled channel widths, a summary of select `bcfishpass` outputs for the 17 sites surveyed with habitat confirmation assessments in 2019 are presented in Table 11. Complete modelling outputs for the entire watershed group (n = 3911) are included in an sqlite database available for download here.

Table 11: Summary of updated fish habitat modelling outputs (bull trout model) for habitat confirmation sites surveyed in 2019.

id	stream	road	map	spawning_km	rearing_km	network_km	slopeclass03_km	slopeclass05_km	slopeclass08_km	slopeclass15_km
57681	trib to Parsnip R	Chuchinka-Colbourne FSR and CN Railway	093J.119	5.28	13.95	63.78	8.14	3.39	15.80	20.87
57687	trib to Parsnip R	CN Railway	093J.124	4.99	10.70	36.39	13.13	10.93	4.33	1.59
57690	trib to Wichcika Ck	Chuchinka FSR	093J.115	3.76	6.76	18.22	2.92	2.83	4.36	6.17
57695	trib to Wichcika Ck	Chuchinka-Wichcika FSR	093J.115	0.00	0.00	1.53	0.00	0.00	0.00	0.96
57696	Unnamed trib to Wichcika Ck	Chuchinka-Wichcika FSR	093J.115	0.00	0.00	2.92	0.00	0.00	0.00	1.79
125000	trib to Parsnip R	Chuchinka-Arctic FSR	093I.111	2.31	4.09	13.36	2.05	1.93	4.67	2.76
125098	trib to Parsnip R	Unnamed	093I.111	0.00	1.02	1.02	0.00	1.02	0.00	0.00
125128	trib to Missinka R	Unnamed	093I.116	0.09	0.09	3.69	1.01	0.06	1.04	0.02
125175	Unnamed trib to Missinka R	Chuchinka-Missinka FSR	093I.116	0.00	0.38	2.38	0.00	0.12	0.92	1.07
125179	Unnamed trib to Missinka R	Chuchinka-Missinka FSR	093I.116	0.00	0.00	2.59	0.00	0.00	0.13	2.02
125180	trib to Missinka R	Chuchinka-Missinka FSR	093I.116	0.00	0.00	3.80	0.00	0.00	0.09	2.32
125186	trib to Missinka R	Chuchinka-Missinka FSR	093I.116	0.00	0.45	1.87	0.00	0.00	0.45	1.19
125231	trib to Table R	Chuchinka-Table FSR	093J.120	0.00	0.02	3.36	0.00	0.00	0.36	2.26
125247	trib to Parsnip R	Chuchinka-Table FSR and CN Railway	093J.120	6.27	7.81	19.57	7.44	4.25	1.23	2.93
125253	trib to Parsnip R	Chuchinka-Table FSR	093J.119	4.56	5.60	12.28	5.27	2.69	2.00	0.98
125345	trib to Parsnip R	Chuchinka-Colbourne FSR	093J.124	5.01	10.72	36.41	13.14	10.93	4.33	1.59
125403	trib to Parsnip R	Hodda Lake FSR	093J.124	0.00	1.42	7.98	1.24	0.35	4.06	1.87

Field Planning

Planning for potential 2022 field survey sites is presented in Table 12. Please not that an interactive fieldwork planning widget prototype has been developed for the project and is located within the online interactive version of the report located here. Georeferenced field maps containing updated modelling outputs are presented in Attachment 1.

Table 12: Field planning results to facilitate selection of restoration opportunities for 2022 field surveys.

id	stream_name	habitat_value	outlet_drop	bt_spawning_km	bt_rearing_km	utm_easting	utm_northing	assessment_comment
6731	UNN trib of Anzac R.	–	0.20	0.21	7.18	532823	6072543	Failed - drop is too high - Beaver blockage in culvert - water flowing over the road
6745	UNN trib of Anzac R.	–	0.00	0.00	1.23	533992	6076165	Fails due to slope, embedment, however width is okay, don’t think this is a high priority for fixing –– downstream too bushy to photograph, lots of overhanging osier. Upstream has high banks (60cm to water surface). Culvert has scattered rocks and some silt in it.
6746	UNN trib of Anzac R.	–	0.00	0.34	2.48	536670	6076366	Failed - on constriction - baffled culvert - Fish at culvert - inlet pool depth 8cm - some introduced materials downstream natural weir
6824	–	–	0.00	0.31	2.45	536665	6076345	Fail due to stream constriction, slope, embedment –– downstream has lots of blockages (trees down) upstream very thick/ deep silt/muck
6828	–	–	0.03	12.93	15.52	548810	6084301	Fail, SCW –– think these culverts are only here to prevent the road from washing out when river is high, appears to be a side channel from the river. Completely dry at the moment but looks like high flows come through. Is it really necessary to establish fish passage here?? 20 m upstream creek comes in and flows opposite direction back to river.
57606	Tributary to Parsnip River	HIGH	0.23	0.00	1.43	520148	6084917	Road slumping at inlet, and outlet is a barrier
57621	Creek from Fishhook Lake to Tacheeda Lakes	LOW	0.00	11.10	22.44	526546	6057751	3 culverts.
57701	Tributary to Parsnip River	MEDIUM	0.17	0.02	1.04	559948	6046841	Channel is mainly fines, with lots of pools and

id	stream_name	habitat_value	outlet_drop	bt_spawning_km	bt_rearing_km	utm_easting	utm_northing	assessment_comment
debris for shelter								
57718	Tacheeda Creek	HIGH	0.35	14.15	45.66	532021	6065509	Wide creek upstream and downstream. Fry spotted at outlet. Beaved damn inside left pipe should be removed. Backwatering and/or baffle placement recommended.
124963	Tributary to Parsnip River	MEDIUM	0.23	0.00	1.03	559940	6046827	–
124998	Tributary to Parsnip River	MEDIUM	0.35	2.36	4.14	577502	6038240	Two culverts.
125149	Tributary to the Missinka River	MEDIUM	0.00	3.35	5.37	572048	6050308	–
125194	Tributary to the Missinka River	HIGH	0.80	2.00	2.00	563293	6050578	High rearing habitat, moderate spawning.
125206	Tributary to Table River	LOW	0.40	1.77	1.91	557237	6068504	Dry bed.
125207	Tributary to Table River	LOW	0.25	0.00	1.11	557042	6068959	–
125208	Tributary to Table River	LOW	0.00	1.27	1.41	557268	6068983	2 culverts w/ one flowing.
125243	Tributary to Table River	LOW	0.20	0.33	1.13	547236	6063534	–
125252	Tributary to Parsnip River	LOW	0.00	1.05	2.02	538484	6063864	Dry bed. Erosion above culvert.
125254	Tributary to Parsnip River	LOW	0.00	0.72	1.09	537225	6065150	Culvert completely submerged.
125261	Fern Creek	LOW	0.20	4.31	14.26	534600	6067770	Two additional culverts at 0.9m diameter.
125345	tributary to Parsnip River	HIGH	0.00	5.01	10.72	522556	6083663	High priority candidate for restoration. Good habitat. Surveyed upstream for 680 m. Culvert is under the Chuchinka-Colbourne FSR but CN railway located 10 m upstream also has barrier crossing (PSCIS 57687). Abundant gravels throughout with deep pools suitable for overwintering. No barriers. Small beaver dam located 180 m upstream of crossing.
125353	Tributary to Parsnip River	LOW	0.60	5.31	13.97	533241	6067630	2 culverts.
125428	Tributary to Wichcika Creek	LOW	0.00	3.78	10.54	554092	6042229	NCD.
125431	Tributary to Fishhook Lake	LOW	0.05	5.29	11.13	527694	6055196	–
197482	Unnamed tributary to Parsnip River	MEDIUM	0.00	6.08	7.62	542873	6062983	Good habitat. Surveyed downstream for 250 m to beaver dammed area on floodplain of Parsnip River.
197486	Tributary to							

id	stream_name	habitat_value	outlet_drop	bt_spawning_km	bt_rearing_km	utm_easting	utm_northing	assessment_comment
Parsnip River	LOW	0.00	0.00	2.05	517742	6090303	Small stream. A few gravels present. Abundant small woody debris and overhanging vegetation for cover. Frog in outlet pool.	
197492	Tributary to Parsnip River	HIGH	0.00	4.61	5.65	537693	6064700	Habitat confirmation completed for upstream PSCIS crossing 125253. See https://newgraphenvironment.github.io/Parsnip_Fish_Passage/03_Parsnip_report_125253.html
197497	Trib to Tacheeda Lk	LOW	0.70	0.45	3.42	529545	6062716	Dry stream with no visible channel.

Mapping

QGIS

Updated map for the Parsnip River, Carp River and Crooked River watershed groups incorporating the newly developed sa'ba (bull trout) spawning and rearing habitat model are available here.

Web Mapping

An online connectivity mapping portal for the Peace Region is located here. At the time of reporting the site was undergoing development with the interface expected to evolve significantly over the coming months. Future layers to be added to map include fisheries observations, the Recreational Opportunity Spectrum Inventory data, hydrometric station locations, historic fish sampling sites, wetlands, etc.

Recomendations

A multi-year plan with one to two structure replacements (or removals) each year with works at each site phased over two years each is recommended. This approach will facilitate progress at a minimum of one site per year and allows ample time for planning, coordination and funding acquisition related to each restoration. Multi-year planning allows an inclusive environment to solicit funding collaboration with the numerous potential partners and stakeholders in the watershed (i.e. Sinclar, Canfor, CN Rail, Coastal Gas Link, FLNR, fish passage technical working group, Ministry of Transportation and Infrastructure, McLeod Lake, Treaty 8 Nations, etc.).

- In 2023/2024 we propose replacement of crossings where preparations were made in 2022/2023 in partnership with Sinclar. Sinclar has committed to obtaining portions of the funding for this work through the forestry appraisal system and we will actively engage with partners and stakeholders to obtain other funding contributions. Additionally, we propose preparations for structure replacement at addition sites that can be completed in the upcoming years.

- In 2022/2023 we will work together with BCTS and other interested parties to rehabilitate and monitor the Chuchinka-Colbourne FSR where 125345 (Tributary to Parsnip River) will be removed and the road deactivated/decompacted and planted in 2022. We will continue to engage with CN to advance remediation of passage at crossing 57687 located under the railway immediately upstream of this site.

- We recommend continuing to engage FWCP partners and stakeholders to explore and clearly communicate fish passage issues in the Parsnip River watershed, build relationships and obtain partnership funding commitments while collaboratively prioritizing, planning and delivering fish passage restorations.

- We recommend continuing to implement capacity building programs that will provide resources and skills for watershed stakeholders and partners to engage in watershed restoration planning activities and on the ground works as well as to monitor outcomes of project initiatives.

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

- Continue to develop `bcfishpass`,`bcfishobs`, `fwapg`, `bcdata`, `fpr` and the web mapping portal to share open source data analysis and presentation tools that are scaleable, leverage forward years of investments from numerous contributors and facilitate continual improvement. Tools should continue to be flexible and well documented to allow the future incorporation of alternative fragmentation indicators, habitat gain/value metrics and watershed sensitivity indicators. We recommend continuing to work with Ministry of

Environment and First Nations governments to develop an evidenced based approach to the quantification of potential habitat gains through fish passage remediation and update data collection/storage protocols to ensure data collected can be utilized as effectively as possible to inform natural resource management.

- Continue to increase awareness of the Provincial Stream Crossing Inventory Summary System and `bcfishpass` and the need to commit to the use of standardized tools by all parties and collaborators to ensure that the installation and repair of new and historic infrastructure incorporate known data and defensible fisheries science into prioritization/design/implementation/monitoring.

- Continue to collaborate with potential partners to build relationships, explore perspectives and develop “road maps” for aquatic restoration in different situations (MoT roads, rail lines, permit roads of different usages, FSRs, etc.) – documenting the people involved, discussions and processes that are undertaken, funding options, synergies, measures of success, etc.

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Session Info

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Attachment 1 - Maps

All georeferenced field maps are presented at https://hillcrestgeo.ca/outgoing/fishpassage/projects/parsnip/archive/2022-05-27/ and available for bulk download as Attachment 1 - https://hillcrestgeo.ca/outgoing/fishpassage/projects/parsnip/archive/2022-05-27/parsnip_2022-05-27.zip.

Attachment 2 - Bayesian analysis of how stream channel width is influenced by watershed area and precipitation

Attachment 2

Attachment 3 - Bayesian analysis of how lineal fish density varies with stream gradient and/or channel width

Attachment 3