Upper Elk River and Flathead River Fish Passage Restoration Planning

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Version 1.2

2021-01-30

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Executive Summary

New Graph Environment and Nupqu Limited Partnership were retained by the Canadian Wildlife Federation in the fall of 2020 to plan and conduct fish passage and habitat confirmation assessments at road-stream crossings as part of connectivity restoration planning targeting westslope cutthrout trout. Although some planning was conducted for both the Elk River watershed upstream of the Elko Dam near Elko, BC and the Flathead River, on the ground surveys in 2020 focused on the Elk River and tributaries located upstream of the Elko Dam. This report is available as pdf and as an html document online interactive report at https://newgraphenvironment.github.io/fish_passage_elk_2020_reporting_cwf/. We recommend viewing online as the web-hosted html version contains more features and is more easily navigable.

A total of 72 Phase 1 assessments were conducted with 17 crossings considered “passable”, 8 crossings considered “potential” barriers and 43 crossings considered “barriers” according to threshold values based on culvert embedment, outlet drop, slope, diameter (relative to channel size) and length. Cost benefit analysis were conducted for each crossing determined to be a barrier based on estimates of the costs associated with fish passage remediation and the amount of habitat (linear and area) that would potentially be made available by remedial works.

Habitat confirmation assessments were conducted at 15 sites with a total of approximately 15 km of stream assessed. Six crossings were rated as high priorities for proceeding to design for replacement, 8 crossings were rated as moderate priorities for proceeding to design for replacement, 0 crossings were rated as a low priority and 1 crossing was rated as “no fix”. Cost benefit analysis were again conducted for each crossing assessed.

1 Introduction

New Graph Environment and Nupqu Limited Partnership were retained by the Canadian Wildlife Federation in the fall of 2020 to plan and conduct fish passage and habitat confirmation assessments at road-stream crossings as part of connectivity restoration planning targeting westslope cutthrout trout. Although some planning was conducted for both the Elk River watershed upstream of the Elko Dam near Elko, BC and the Flathead River, on the ground surveys in 2020 focused on the Elk River and tributaries located upstream of the Elko Dam. This report is available as pdf and as an html document online interactive report at https://newgraphenvironment.github.io/fish_passage_elk_2020_reporting_cwf/. We recommend viewing online as the web-hosted html version contains more features and is more easily navigable.

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 upstream and downstream 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). Reconnecting fragmented habitats by culvert removal or replacement is a management action that can generate high ecological returns relative to other habitat restoration techniques (Saldi-Caromile et al. 2004; Roni, Hanson, and Beechie 2008). As road and rail systems are commonly upgraded there are numerous opportunities to restore connectivity by ensuring that fish passage considerations are incorporated into repair, replacement and relocation/decommisioning designs.

2 Background

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

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

The Canadian Wildlife Federation has been working on a watershed connectivity remediation plan for the Elk River watershed that incorporates the provincial Strategic Approach and local knowledge of the watershed to prioritize barriers for remediation, to restore connectivity for westslope cutthroat trout and other species in a strategic manner. New Graph Environment was retained to conduct fish passage assessments and habitat confirmations to fill data gaps in support of this work.

2.1 Project Location

To focus the project area on habitat with high value for conservation of westslope cutthrout trout, the project included the upper Elk River watershed upstream of the Elko Dam with planning also conducted for the Flathead River watershed (Figure 2.1).

The Elk River has a mean annual discharge of 47.3 m^3/s with flow patterns typical of high elevation watersheds on the west side of the Rocky Mountains which receive large amounts of precipitation as snow leading to peak levels of discharge during snowmelt, typically from May to July (Figures 2.2 - 2.3) (Environment and Canada 2020).

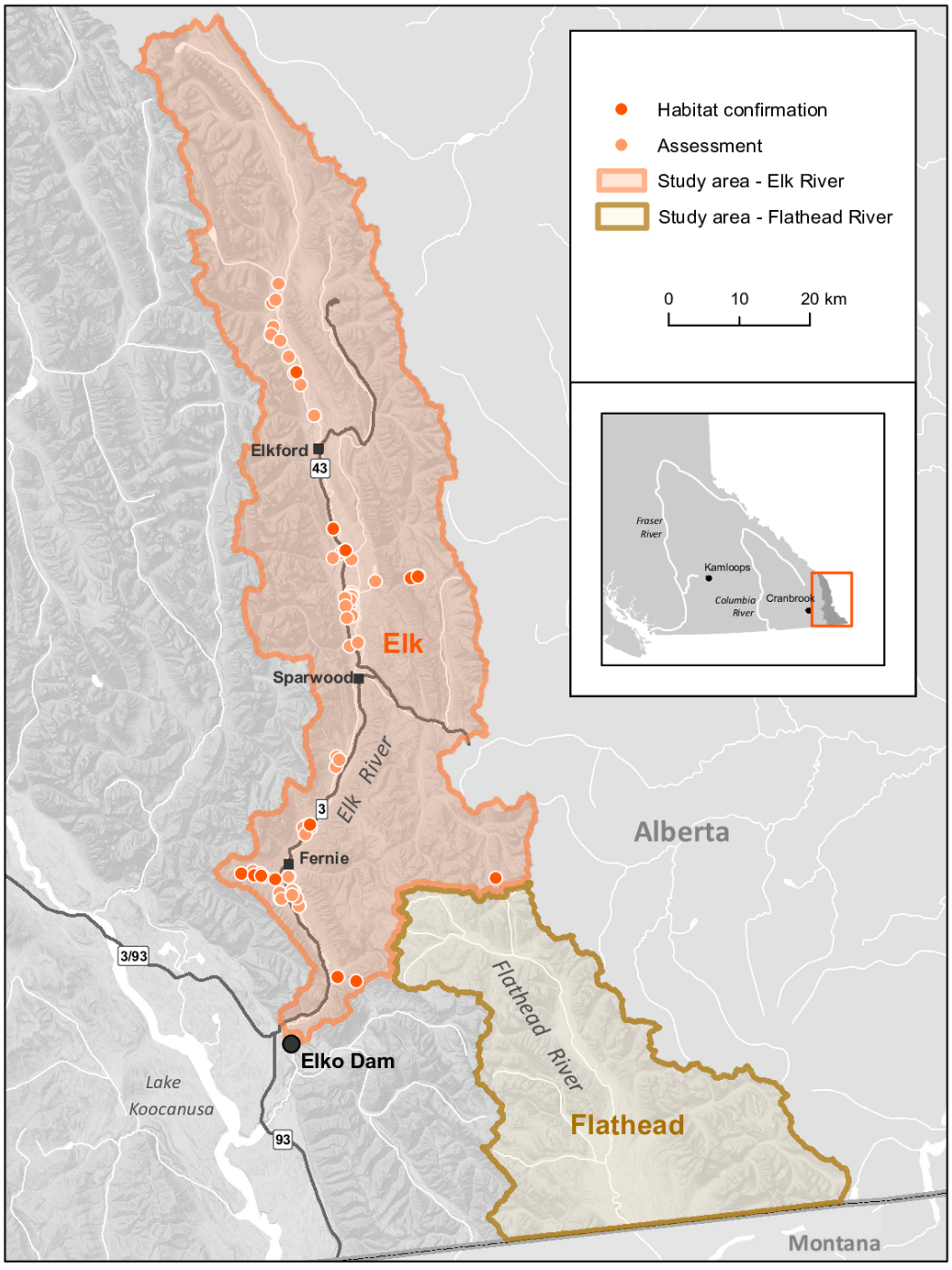


Figure 2.1: Overview map of Study Areas.

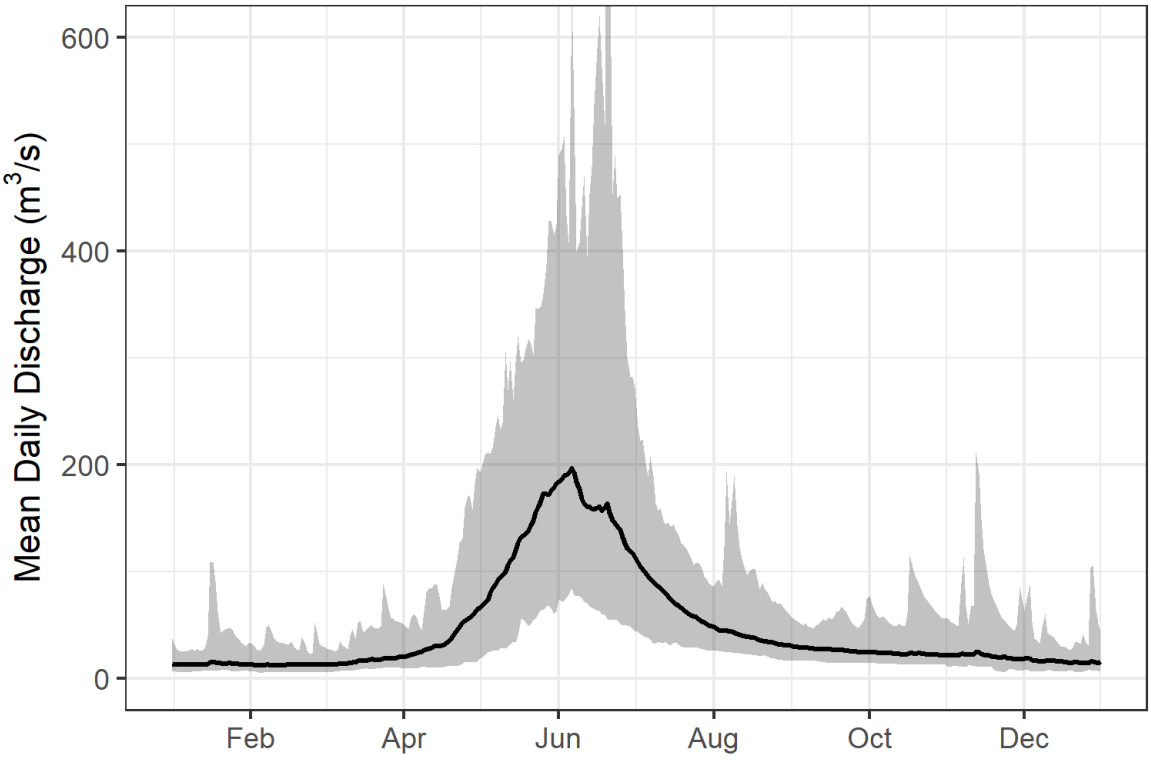


Figure 2.2: Hydrograph for Elk River at Fernie (Station #08NK002). Available daily discharge data from 1970 to 2018 with black line and shaded ribbon representing mean and maximum/minimum flows respectively.

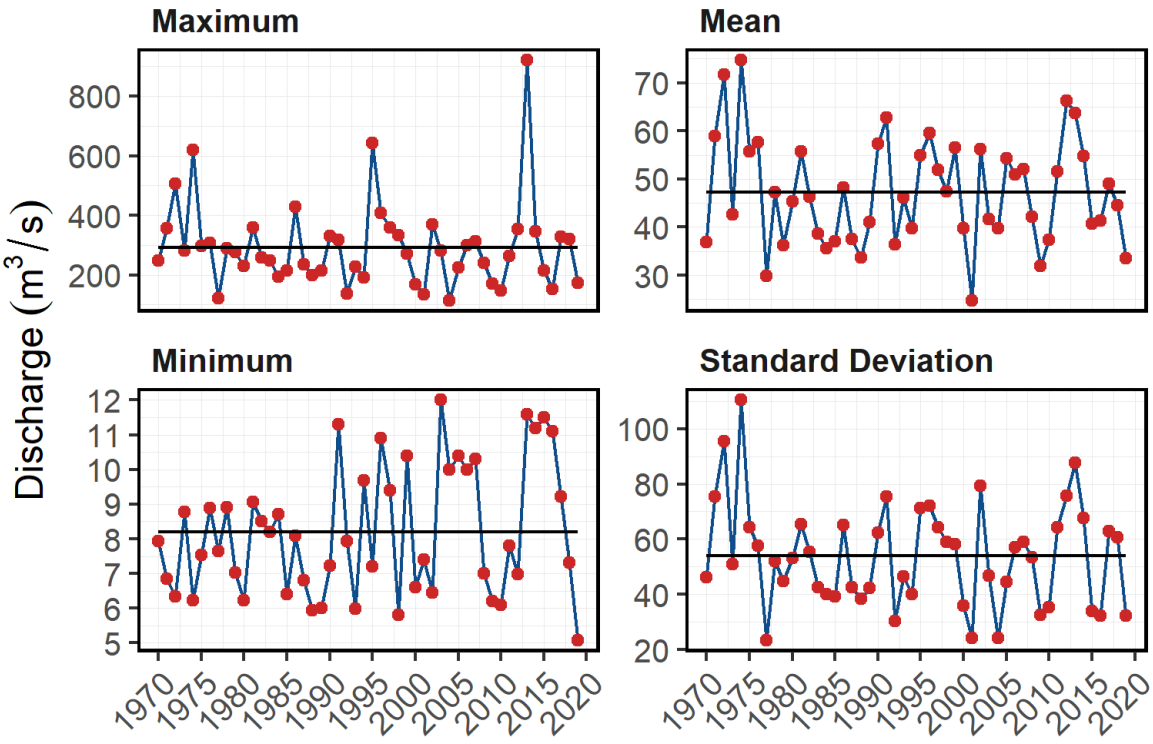


Figure 2.3: Summary of hydrology statistics in Elk River at Fernie (Station #08NK002)

2.1.1 Ktunaxa Nation

The project location is within the traditional territory of the Ktunaxa Nation ("Ktunaxa Nation" 2020) with Elk River components within an area known as Qukin ʔamakʔis, or Raven's Land (Ministry of Forests 2020). When Europeans settled in the Kootenay Region around 200 hundred years ago, the Indian Reserves were created which lead to the seven Indian Bands:

- ʔakisq̓nuk- Columbia Lake Band (Windermere, BC);
- ʔaq̓am- St. Mary's Band (Cranbrook, BC);
- ʔakink̓um‡asnuq‡iʔit- Tobacco Plains Band (Grasmere, BC);
- yaqan nuʔkiy- Lower Kootenay Band (Creston, BC);
- kyaknuq‡iʔit- Shuswap Band (Invermere, BC);
- ʔaq̓anqmi- Kootenai Tribe of Idaho (Bonners Ferry, Idaho);
- k̓upawiȼq̓nuk- Ksanka Band (Elmo, Montana)

("Ktunaxa Nation" 2020) report the vision statement of the Ktunaxa as:

“Kɸmaǩqa ksukłuła·k kuǩqani ɸ ǩitqakiɬ haqa ksiʔɬ ɸxa ʔa·kłukqaʔis ksukiɬq̓ukaʔmi·k kiʔin Ktunaxa naʔs ʔamaǩʔis. Qus piǩaksɸ naʔs ɸxaɬ yaqanakiɬ haqaʔki. Ḱitqawiɸmu kakiɬwiɸkiɬ ʔamakʔis ǩisnikɸik kɸxaɬ qa kiɬkǩaxuxami·k ǩitqakiɬ haqa ɸ ǩisʔin ʔaknumuɸtiɬʔis.”

The vision statement has been translated to english as:

“Strong, healthy citizens and communities, speaking our languages and celebrating who we are and our history in our ancestral homelands, working together, managing our lands and resources, within a self-sufficient, self-governing Nation.”

2.1.2 Elk Valley Cumulative Effects Management Framework

First Nations, stakeholders, proponents and provincial and municipal governments have recognized that the region has been impacted by historic and current coal operations as well as other stresses such as forestry operations, wildfire, residential development, recreational activities and transportation. To assess the historic, current and potential future conditions of valued ecosystem components and to support resource management decisions within the region, the Provincial Cumulative Effects Framework and the Elk Valley Cumulative Effects Management Framework (EV-CEMF) have been formed under joint management between the Ktunaxa Nation Council and the B.C. Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD). A working group consisting of the Ktunaxa Nation Council, industry, community, organizations, and provincial government ministries has been formed to provide guidance and oversight for EV-CEMF activities. Valued component technical reports for Grizzly Bear, Riparian and westslope cutthroat trout (Davidson et al. 2018), bighorn sheep, and old and mature forest have been drafted, integrated into an overarching Cumulative Effects Assessment and Management Report (Elk Valley Cumulative Effects Management Framework Working Group 2018) and endorsed by the Working Group. These reports describe the historical, current, and future assessment of cumulative effects in the Elk Valley and provide management and mitigation recommendations. Next steps for the framework include the development of an Implementation Plan to identify priority actions and spatial locations to focus management and mitigation of cumulative effects in the valley which may include actions to address aquatic habitat connectivity issues (Ministry of Forests 2020).

2.2 Fisheries

Fish species recorded in the Elk River watershed group are detailed in Table 2.1 (MoE 2020b). Bull trout and westslope cutthrout trout are considered of special concern (blue-listed) provincially and westslope cutthrout trout (Pacific populations) are are listed under the *Species at Risk Act* by the Committee on the Status of Endangered Wildlife in Canada as a species of special concern (BC Species & Ecosystem Explorer 2020b, 2020a; Schweigert et al. 2017). The focus of 2020 field work was to assess potential impacts of road-stream crossings on habitat connectivity for westslope cutthrout trout.

Table 2.1: Fish species recorded in the study areas (FISS 2020).

Scientific Name	Species Name	Species Code	BC List	Provincial FRPA	COSEWIC	SARA	Upper Elk	Flathead
Catostomus catostomus	Longnose Sucker	LSU	Yellow	–	–	–	Yes	Yes
Catostomus columbianus	Bridgelip Sucker	BSU	Yellow	–	–	–	Yes	–
Catostomus commersonii	White Sucker	WSU	Yellow	–	–	–	Yes	–
Catostomus macrocheilus	Largescale Sucker	CSU	Yellow	–	–	–	–	Yes
Cottus cognatus	Slimy Sculpin	CCG	Yellow	–	–	–	–	Yes
Cottus confusus	Shorthead Sculpin	CCN	Blue	–	SC (Nov 2010)	1-SC	–	Yes
Cottus hubbsi	Mottled Sculpin	CBA	Blue	–	SC (Nov 2010)	1-SC (Jun 2003)	–	Yes
Cottus sp. 9	Rocky Mountain Sculpin	CRM	Red	–	SC (Apr 2010)	1-SC (May 2017)	–	Yes
Oncorhynchus clarkii	Cutthroat Trout	CT	No Status	–	–	–	Yes	Yes
Oncorhynchus clarkii lewisi	Westslope Cutthroat Trout	WCT	Blue	Y (Jun 2006)	SC (Nov 2016)	1-SC (Feb 2010)	Yes	Yes
Oncorhynchus mykiss	Rainbow Trout	RB	Yellow	–	–	–	Yes	Yes
Oncorhynchus nerka	Kokanee	KO	Yellow	–	–	–	Yes	Yes
Prosopium williamsoni	Mountain Whitefish	MW	Yellow	–	–	–	Yes	Yes
Rhinichthys cataractae	Longnose Dace	LNC	Yellow	–	–	–	Yes	Yes
Richardsonius balteatus	Redside Shiner	RSC	Yellow	–	–	–	Yes	–
Salvelinus confluentus pop. 26	Bull Trout	BT	Blue	–	–	–	Yes	Yes
Salvelinus fontinalis	Brook Trout	EB	Exotic	–	–	–	Yes	–
–	Cutthroat/Rainbow cross	CRS	–	–	–	–	Yes	–
–	Sculpin (General)	CC	–	–	–	–	–	Yes
–	Sucker (General)	SU	–	–	–	–	Yes	Yes

2.2.1 Westslope Cutthrout Trout

There are multiple life history strategies for westslope cutthrout trout including stream-resident, fluvial and adfluvial. All have habitat requirements during life history stages that include cold clean water and varied forms of cover (undercut banks, pool-riffle habitat and riparian vegetation). Stream-resident fish inhabitat headwater streams above barriers, complete their life cycle within a relatively small range and typically remain relatively small (i.e. <200mm in length). Fluvial fish are migratory subpopulations that migrate between small spawning/rearing tributaries and larger adult rearing rivers. Lengths of fluvial fish generally reach more than 400mm. Finally, adfluvial subpopulations rear in lakes and migrate to spawning/rearing tributaries with lengths often exceeding 500mm (Schweigert et al. 2017).

Spawning habitat for resident and fluvial subpopulations are documented as within the tailouts of deep pools at moderate to high-flow events within small, low-gradient streams with cold well-oxygenated water and clean unsilted gravels (Schmetterling 2001). Proximity to large woody debris, boulder or bedrock cover is important for spawning fish while residing in spawning tributaries as

high mortality may result when suitable cover is lacking. The dominant substrate used for spawning is gravel (1.8 - 3.3cm diameter) with spawning occurring in late May and June towards the end of the spring freshet with rising water temperatures between 7-11°C. Nine of 11 westslope cutthrout trout radio-tagged in the Blackfoot River drainage, Montana by Schmetterling (2001) made movements to tributaries presumable for spawning. While in tributaries, fish movements to spawning sites averaged 12.5km where they stayed within an approximately 100m reach during the spawning period for between 15 and 63 days.

Small perennial streams with a diversity of cover are important for juvenile rearing with young-of-year fish inhabiting low energy lateral habitats (i.e. shallow riffle or backwatered areas) with cover available. Larger juveniles move into pools with social dominance behaviors prevalent and based on fish size. Availability of pool habitat is important and limiting for parr which have large territories (Schweigert et al. 2017; Schmetterling 2001).

The suitability of overwintering habitat is determined by groundwater influx and the absence of anchor ice with fluvial adults congregating in slow deep pools in the winter. Boulders and other large in-stream structures or off-channel habitat (beaver bonds and sloughs) provide cover for juveniles with adfluvial fish overwintering in lakes (Schweigert et al. 2017; Brown and Mackay 1995; Cope, Schwarz, and Prince 2017).

In a swimming performance study conducted in an open-channel flume Blank et al. (2020) estimated the overall average swim speeds of westlope cutthrout trout (150mm - 290mm in length) at 0.84m/s with a maximum observed swim speed of 3.55m/s.

The greatest threats to westslope cutthrout trout are hybridization with non-native rainbow trout and degradation of the environment due to forestry, hydroelectric development, mining, urbanization and agriculture (Schweigert et al. 2017). Lamson (2020) sampled over 2000 trout in the Upper Kootenay watershed from 2014 to 2019 with results of genotyping indicating consistently high levels of westslope cutthrout trout allele purity (i.e. very low levels of rainbow trout, yellowstone cutthrout trout or coastal cutthrout trout genetic introgression) throughout the Elk River watershed areas upstream of the Elko Dam. Boyer, Muhlfeld, and Allendorf (2008) sampled 31 sites in the upper Flathead River system within the United States (27 sites) and Canada (4 sites). Genetic introgression declined with latitude with no evidence of rainbow trout allelles within any westslope cutthrout trout sampled within the Canadian portion of the upper Flathead River.

A summary of historical westslope cutthrout trout observations in the Elk River watershed group by average gradient category of associated stream segment is provided in Figure 2.4. Of 4003 observations, 93% were within stream segments with average gradients ranging from 0 - 8%. A total of 73% of historic observations were within stream segments with gradients between 0 - 3%,

12% were within stream segments with gradients ranging from 3 - 5% and 8% were within stream segments with gradients between 5 - 8% (MoE 2020b; Norris 2020a).

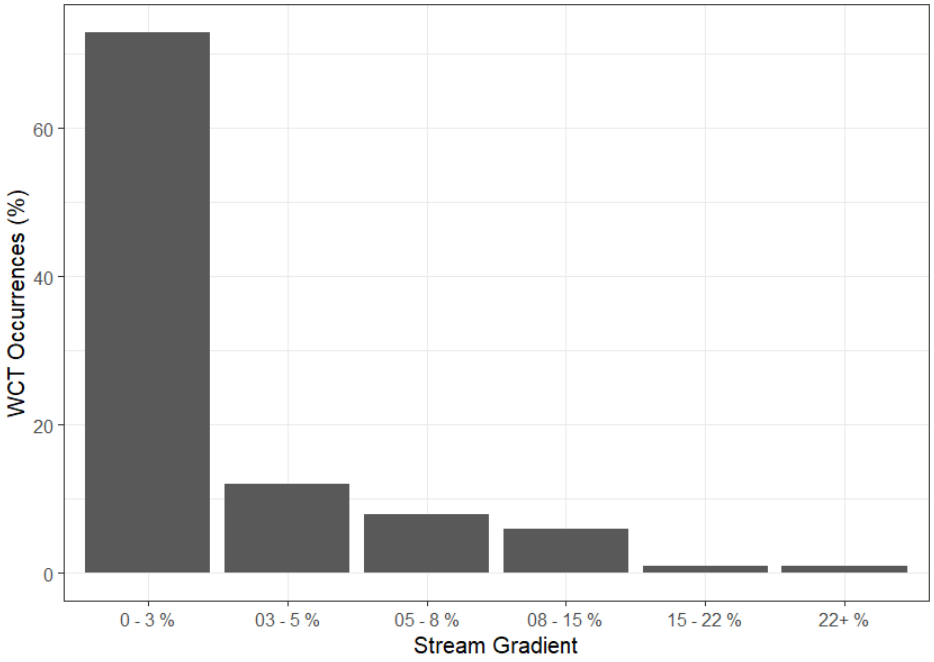


Figure 2.4: Summary of historic westslope cutthrout trout observations vs. stream gradient category.

3 Methods

Workflows for the project are categorized into planning, fish passage assessments, habitat confirmation assessments and reporting. All components leveraged the R programming language and environment for statistical computing to facilitate workflow tracking and reproducibility (R Core Team 2020).

3.1 Planning

To identify priorities for crossing structure rehabilitation, background literature, fisheries information, PSCIS, `Fish Habitat Model` outputs modified from Norris and Mount (2016) and `bcfishpass` (Norris 2020b) outputs were reviewed. The `Fish Habitat Model` was developed by the BC Ministry of Environment to provide estimates of the amount of fish habitat potentially accessible to fish upstream of crossing locations. The model 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 when the average gradient of the stream lines exceeds user provided gradient thresholds.

`bcfishpass` is comprised of sql and python based shell script libraries that "generate a simple model of aquatic habitat connectivity by identifying natural barriers to fish passage (plus hydro dams that are not feasible to remediate) and classifying all streams not upstream of these barriers as 'potentially accessible'" (Norris 2020b). On potentially accessible streams, `bcfishpass` scripts "identify known barriers and additional anthropogenic features (primarily road/railway stream crossings, i.e. culverts) that are potentially barriers. To prioritize these features for assessment or remediation," the scripts "report on how much modelled potentially accessible aquatic habitat the barriers may obstruct. The model can be refined with known fish observations. Depending on the modelling scenario, all aquatic habitat downstream of a given fish observation can be classified as 'observed accessible', overriding any downstream barriers."

Following delineation of "non-fish habitat" with the `Fish Habitat Model`, the *average* gradient of each stream segment within habitat classified as below the 20% threshold was calculated and summed using `bcfishpass` to quantify upstream habitat potentially available for westslope cutthrout trout and facilitate stream line symbology based on stream morphology. `bcfishpass` summed average gradients of stream network line segments within six categories (0 - 3%, 3 - 5%, 5 - 8%, 8 - 15%, 15 - 20% and >20%) with these outputs further amalgamated to summarize and symbolize potentially accessible upstream habitat in five categories: riffle/cascade (0 - 3%), step-pool (5 - 8%), step-pool very steep (8-15%) and extremely steep (15 - 20%) (Table 3.1). For each crossing location, the area of lake and wetland habitat upstream, species documented upstream and an estimate of watershed area was also collated using `bcfishpass` (Norris 2020b), `fwapg` (Norris 2020c) and `bcfishobs` (Norris 2020a) to provide an indication of the potential quantity and quality of habitat potentially gained should fish passage be restored.

Table 3.1: Stream gradient categories (threshold and average) and associated channel type.

Gradient	Channel Type
0 - 3%	Riffle and cascade pool
5 - 8%	Step pool
8 - 15%	Step pool - very steep
15 - 20%	Step pool - extremely steep
>20%	WCT Unaccessible

To prepare for Phase 1 and 2 assessments in the study area, past fish passage assessment reports for the Elk River watershed group were first reviewed to identify crossing structures not yet assessed or previously ranked as priorities for rehabilitation in Irvine (2016); VAST Resource Solutions Inc. (2013) and Grainger (2011). To determine which of those crossings had not yet been assessed with Phase 1 and Phase 2 assessments we cross-referenced these reports with the Phase 2 report previously completed in the study area (Masse Environmental Consultants Ltd. 2015; Vast Resource Solutions Inc. 2013) and reviewed outputs from PSCIS as well as the `Fish Habitat Model` and `bcfishpass`. Outputs for modelled and PSCIS crossings (barriers and potential barriers) that met the following criteria underwent a detailed review to facilitate prioritization for Phase1 - Fish Passage Assessments and Phase 2 - Habitat Confirmations.

- Confirmed fish presence upstream of the PSCIS or modelled structure.
- Stream width documented as > 2.0m in PSCIS.
- Habitat value rated as “medium” or “high” in PSCIS.
- For PSCIS crossings: linear lengths of modelled upstream habitat <20% gradient for ≥1km
- For modelled crossings crossings: linear lengths of modelled upstream habitat <20% gradient for ≥2km and no anthropogenic barriers (including modelled potential stream crossing structures) documented downstream.
- Crossings located on streams classified as 3rd order or higher.

3.2 Fish Passage Assessments

In the field, crossings prioritized for follow-up were first assessed for fish passage following the procedures outlined in “Field Assessment for Determining Fish Passage Status of Closed Bottom Structures” (MoE 2011). Crossings surveyed included closed bottom structures (CBS), open bottom structures (OBS) and crossings considered “other” (i.e. fords). Photos were taken at surveyed crossings and when possible included images of the road, crossing inlet, crossing outlet, crossing barrel, channel downstream and channel upstream of the crossing and any other relevant features. The following information was recorded for all surveyed crossings: date of inspection, crossing reference, crew member initials, Universal Transverse Mercator (UTM) coordinates, stream name, road name and kilometer, road tenure information, crossing type, crossing subtype, culvert diameter or span for OBS, culvert length or width for OBS. A more detailed “full assessment” was completed for all closed bottom structures and included the following parameters: presence/absence of continuous culvert embedment (yes/no), average depth of embedment, whether or not the culvert bed resembled the native stream bed, presence of and percentage backwatering, fill depth, outlet drop, outlet pool depth, inlet drop, culvert slope, average downstream channel width, stream slope, presence/absence of beaver activity, presence/absence of fish at time of survey, type of valley fill,

and a habitat value rating. Habitat value ratings were based on channel morphology, flow characteristics (perennial, intermittent, ephemeral), fish migration patterns, the presence/absence of deep pools, un-embedded boulders, substrate, woody debris, undercut banks, aquatic vegetation and overhanging riparian vegetation (Table 3.2). For crossings determined to be potential barriers or barriers based on the data, a culvert fix and recommended diameter/span was proposed.

Table 3.2: Habitat value criteria (Fish Passage Technical Working Group, 2011).

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

3.2.1 Barrier Scoring

Fish passage potential was determined for each stream crossing identified as a closed bottom structure as per MoE (2011). The combined scores from five criteria: depth and degree to which the structure is embedded, outlet drop, stream width ratio, culvert slope, and culvert length were used to screen whether each culvert was a likely barrier to some fish species and life stages (Table 3.3, Table 3.4. These criteria were developed based on data obtained from various studies and reflect an estimation for the passage of a juvenile salmon or small resident rainbow trout (Clarkin et al. 2005 ; Bell 1991; Thompson 2013).

Table 3.3: 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 3.4: Fish Barrier Scoring Results (MoE 2011).

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

3.2.2 Cost Benefit Analysis

Cost benefit analysis were conducted for each crossing determined to be a barrier based on estimates of the costs associated with fish passage remediation and the amount of habitat (linear length and area) that would potentially be made available by remedial works (habitat gain index).

3.2.2.1 Habitat Gain Index

The habitat gain index is the quantity of modelled habitat upstream of the subject crossing and represents an estimate of habitat gained with remediation of fish passage at the crossing. For this project, a gradient threshold between accessible and non-accessible habitat was set at 20% (for a minimum length of 100m) intended to represent the maximum gradient of which westslope cutthrout trout are likely to be able to migrate upstream. For Phase 1 assessments a “gross” value of habitat quantity output from `bcfishpass` was used to estimate the amount of habitat upstream of each crossing less than 20% gradient before either a falls of height >5m - as recorded in MoE (2020c) or a section of stream with an average gradient >20% for >100m. This methodology gives a best case scenario of potential habitat gain that does not consider road stream structures upstream that may be barriers to migration. To determine area of habitat potentially gained the downstream channel width from the Phase 1 assessment was multiplied by the linear amount of habitat. For Phase 2 assessments, to provide a conservative estimate of habitat to be potentially gained by fish passage restoration, the amount of habitat upstream of each crossing was measured using the measure tool within QGIS (QGIS Development Team 2009) to estimate the amount of mainstem and stream segments > 1st order upstream of the crossing before any natural migration barriers or stream crossing structures that are located upstream and confirmed or potential barriers. To determine area of habitat potentially gained for Phase 2 assessments, the average upstream channel width (from the habitat confirmation assessment) was multiplied by the linear amount of habitat.

3.2.2.2 Cost Estimates

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. For this project we considered bridges as the only viable option for OBS type based on consultation with FLNR road crossing engineering experts who reported a consistent history of footing scour and eventual failure on arch culvert structures both in the Kootenay and Skeena regions.
- Streambed Simulation (SS) - Replacement of the structure with a streambed simulation design culvert. Often achieved by embedding a culvert pipe or box 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 to limit the risk of erosion of embedding substrates.
- Additional Substrate Material (EM) - Add additional substrate to the culvert and/or downstream weir to embed culvert and reduce overall velocity/turbulence. Based on MoE (2011), 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. Based on MoE (2011), this option was considered only when outlet drop < 0.3m, culvert slope <2.0%, stream width ratio < 1.2 and stream profiling indicates it would be effective.

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

Base costs for installation of bridges on forest service roads and permit roads with surfaces specified in provincial GIS road layers as rough and loose was estimated at $12500/linear m and assumed that the road could be closed during construction. For streams with channel widths <2m, embedded culverts were reported as an effective solution with total installation costs estimated at $25k/crossing (pers. comm. Phil MacDonald, Steve Page). For larger streams, an additional 2m was added to the replacement structure's estimated span width for each 1m of channel width >5m. For crossings with large amounts of fill, the size of replacement structure was increase by 3m for each 1m of fill >3m to account for cutslopes to the stream at a 1.5:1 ratio. To account for road type, a multiplier table was also generated to estimate incremental cost increases with costs estimated for structure replacement on paved surfaces, railways and arterial/highways costing up to 40 times more than forest service roads due to expenses associate with design/engineering requirements, traffic control and paving. The cost multiplier table (Table 3.5) should be considered very approximate with refinement recommended for future projects.

Table 3.5: Cost multiplier table based on road class and surface type.

Class	Surface	Class Multiplier	Surface Multiplier	Bridge $K/10m	Streambed Simulation $K
Forest Service Road	Loose	1	1	125	25
Road Permit	Loose	1	1	125	25
Unclassified	Rough	1	1	125	25
Unclassified	Loose	1	1	125	25
Local	Loose	4	1	500	100
Collector	Paved	4	2	1000	200
Local	Paved	4	2	1000	200
Arterial	Paved	20	2	5000	1000
Highway	Paved	20	2	5000	1000
Rail	Rail	20	2	5000	1000

3.3 Habitat Confirmation Assessments

Following fish passage assessments, habitat confirmations were completed in accordance with procedures outlined in the document “A Checklist for Fish Habitat Confirmation Prior to the Rehabilitation of a Stream Crossing” (Fish Passage Technical Working Group 2011). The main objective of the field surveys was to document upstream habitat quantity and quality and to determine if any other obstructions exist above or below the crossing. Habitat value was assessed based on channel morphology, flow characteristics (perennial, intermittent, ephemeral), the presence/absence of deep pools, un-embedded boulders, substrate, woody debris, undercut banks, aquatic vegetation and overhanging riparian vegetation. Criteria used to rank habitat value was based on guidelines in Fish Passage Technical Working Group (2011) (Table 3.2).

During habitat confirmations, to standardize data collected and facilitate submission of the data to provincial databases, information was collated on “Site Cards” (Resources Inventory Committee 2001). Habitat characteristics recorded included channel widths, wetted widths, residual pool depths, gradients, bankfull depths, stage, temperature, conductivity, pH, cover by type, substrate and channel morphology (among others). When possible, the crew surveyed downstream of the crossing to the point where fish presence had been previously confirmed and upstream to a minimum distance of 600m. Any potential obstacles to fish passage were inventoried with photos, physical descriptions and locations recorded on site cards. Surveyed routes were recorded with time-signatures on handheld GPS units.

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

3.3 Habitat Confirmation Assessments

3.4 Reporting

This pdf report and an online interactive report were generated with `bookdown` (Xie 2016) from `Rmarkdown` (Allaire et al. 2020) documents processing raw data available at the New Graph Environment Github Site. In addition to numerous spatial layers sourced through the BC Data Catalogue, data inputs for this project can be sourced here and include:

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

4 Results and Discussion

Field assessments were conducted between September 16 2020 and October 17 2020 by Allan Irvine, R.P.Bio, Mark Fjeld, BiT, Kyle Prince, P,Biol, and Chad Hughes, Ecologist. Mapping was completed by Hillcrest Geographics.

4.1 Planning

Review of the PSCIS database indicated that prior to 2020, 480 assessments for fish passage (Phase 1) and 11 habitat confirmations (Phase 2) had been conducted at crossing structures within the Upper Elk River. Within the Flathead River watershed, 126 fish passage assessments and 3 habitat confirmations had been conducted.

Following review of background literature, fisheries information, PSCIS and `bcfishpass` outputs, 241 modelled and PSCIS crossings were reviewed to select sites for follow up with Phase 1 and 2 assessments. In total, 160 crossings were reviewed in the Upper Elk River watershed and 81 crossings were reviewed in the Flathead River watershed. Not including sites surveyed in the field in 2020, 17 crossings ranked as high priority for future follow up with Phase 1 and/or Phase 2 assessments, 39 crossings ranked as moderate priorities, 90 crossings ranked as low priorities and 23 crossings ranked as “no fix”. Results are included as a zipped Google Earth kml file (Attachment 1).

4.2 Phase 1

During 2020 field surveys, a total of 72 Phase 1 assessments were conducted with 17 crossings considered “passable”, 8 crossings considered “potential” barriers and 43 crossings considered “barriers” according to threshold values based on culvert embedment, outlet drop, slope, diameter (relative to channel size) and length (MoE 2011). Site maps are presented in Attachment 2 with a summary of crossings assessed, a cost benefit analysis and priority ranking for follow up for Phase 1 sites presented in Table 4.1. Detailed data with photos are presented in Attachment 3.

Barrier passability criteria used in this project follows MoE (2011), and reflects an estimation for the passage of a juvenile salmon or small resident rainbow trout (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) as well as the temporal variation of physical characteristics (ex. due to flow volumes/velocities a particular culvert is passable 50% of the time to fish with a defined physiological capacity) make defining passability difficult with important implications for watershed connectivity modelling (Bourne et al. 2011; Shaw et al. 2016; Mahlum et al. 2014; Kemp and O’Hanley 2010).

Table 4.1: Upstream habitat estimates and cost benefit analysis for Phase 1 assessments. See Appendix - Phase 1 Fish Passage Assessments for details. IDs are PSCIS idenfifiers with exception of those with * which are interim references.

ID	Stream	Road	Habitat Value (priority)	Result (Score)	Stream Width (m)	Fix	Cost Est ($K)	Habitat Upstream (km)	Cost Benefit (m / $K)	Cost Benefit (m2 / $K)
197520	Tributary to Elk River	Elk River FSR	Medium (low)	Barrier (26)	2.5	OBS	125	2.49	19.9	49.8
197521	Tributary to Elk River	Elk River FSR	Medium (low)	Barrier (21)	2	OBS	125	3.86	30.9	61.8
197522	Tributary to Elk River	Elk River FSR	Low (low)	Barrier (34)	1	SS-CBS	–	–	–	–
197523	Tributary to Lowe Creek	Elk River FSR	Low (low)	Potential (16)	1.1	SS-CBS	25	1.43	57.2	62.9
197524	Tributary to Elk River	Spur	Low (low)	Barrier (31)	1	SS-CBS	25	1.77	70.8	70.8
197525	Tributary to Elk River	Spur	Low (low)	Barrier (21)	1	RM	–	1.8	–	–
197526	Tributary to Elk River	Elk River FSR	Low (low)	Barrier (31)	3.1	OBS	125	6.6	52.8	163.7
197527	Crossing Creek	Elk River FSR	Low (low)	Barrier (26)	2.5	OBS	125	12.34	98.7	246.8
197528	Tributary to Whiting Creek	Lower Elk Valley Rd	Low (low)	Potential (15)	0.5	SS-CBS	1000	2.32	2.3	1.2
197529	Littlemoor Creek	Lower Elk Valley Rd	Low (low)	Barrier (34)	1	SS-CBS	1000	4.95	5	5
197530	Dalzell Creek	Airport Road	–	Passable (14)	5	–	–	2.51	–	–
197531	Dalzell Creek	Driveway	Medium (low)	Potential (16)	2.5	OBS	5000	2.03	0.4	1
197532	Dalzell Creek	Driveway	Medium (low)	Potential (16)	1.2	SS-CBS	1000	1.76	1.8	2.1
197533	Brule Creek	Busato Road	High (high)	Barrier (39)	7.1	OBS	710	36.95	52	369.5
197534	Weigart Creek	Highway 43	High (high)	Barrier (34)	4.3	OBS	5000	20.38	4.1	17.5
197535	Brule Creek	Private	–	Unknown (0)	–	–	–	36.06	–	–
197536	Brule Creek	Spur	–	Unknown (0)	–	–	–	34.66	–	–
197537	North Littlemoor Creek	Highway 43	Medium (mod)	Barrier (42)	1.6	SS-CBS	1000	3.77	3.8	6
197538	Littlemoor Creek	Highway 43	Medium (mod)	Barrier (42)	1.2	SS-CBS	1000	4.37	4.4	5.2
197539	McCool Creek	Hadner FSR	–	Passable (3)	–	–	–	12.04	–	–
197540	McCool Creek	–	–	Passable (3)	–	–	–	3.41	–	–
197541	Tributary to Elk River	Hadner FSR	Medium (low)	Barrier (36)	2.9	OBS	162	0	0	0
197542	Hartley Creek	Dicken Road	High (high)	Barrier (34)	3.5	OBS	1000	13.07	13.1	45.7
197543	Tributary to Lizard Creek	Lazy Lizard Lower	–	Passable (0)	–	–	–	–	–	–
197544	Tributary to Lizard Creek	Trail	–	Passable (0)	–	–	–	–	–	–
197545	Tributary to Elk River	Mt Mclean Road	–	Passable (14)	2.7	–	–	0.86	–	–
197546	Tributary to Elk River	McGiverin Road	Low (low)	Barrier (21)	0.5	SS-CBS	100	0.5	5	2.5
197547	Tributary to Elk River	Railway	–	Passable (10)	0.5	–	–	0.54	–	–

Table 4.1:

ID	Stream	Road	Habitat Value (priority)	Result (Score)	Stream Width (m)	Fix	Cost Est ($K)	Habitat Upstream (km)	Cost Benefit (m / $K)	Cost Benefit (m2 / $K)
197548	Tributary to Elk River	Robinson Road	–	Passable (11)	1.2	–	–	0.98	–	–
197549	Tributary to Elk River	Hill Road	–	Passable (11)	1.5	–	–	–	–	–
197550	Tributary to Elk River	Driveway	Low (low)	Potential (19)	1.5	SS-CBS	–	–	–	–
197551	Tributary to Elk River	Elk River FSR	–	Passable (0)	–	–	–	1.09	–	–
197552	Tributary to Elk River	Elk River FSR	Low (low)	Barrier (21)	2.3	OBS	125	1.33	10.6	24.5
197553	Lowe Creek	Elk River FSR	High (mod)	Potential (19)	2.5	OBS	125	6.45	51.6	129
197554	Tributary to Elk River	Elk River FSR	Medium (low)	Potential (16)	1	SS-CBS	25	1.5	60	60
197555	Tributary to Elk River	Elk River FSR	High (high)	Barrier (42)	3.5	OBS	312	5.99	19.2	67.2
197556	Tributary to Elk River	Lower Elk Valley Rd	Low (low)	Potential (18)	0	SS-CBS	1000	1.13	1.1	0
197557	North Littlemoor Creek	Lower Elk Valley Rd	Low (low)	Barrier (29)	1.5	SS-CBS	1000	4.6	4.6	6.9
197558	Dalzell Creek	Lower Elk Valley Rd	Medium (low)	Barrier (24)	3.8	OBS	5000	2.23	0.4	1.7
197559	Brule Creek	Highway 43	Medium (high)	Barrier (22)	6.1	OBS	6100	36.82	6	36.8
197560	Tributary to Elk River	Line Creek Mine Rd	Low (low)	Barrier (21)	0.5	SS-CBS	200	2.49	12.4	6.2
197561	Hollow Creek	Highway 43	Low (low)	Barrier (39)	1.1	SS-CBS	1000	0.25	0.2	0.3
197562	Whiting Creek	Highway 43	Low (low)	Barrier (23)	0.6	SS-CBS	1000	0.96	1	0.6
197563	Grave Creek	–	–	Unknown (0)	–	–	–	5.84	–	–
197564	Grave Creek	–	Low (low)	Barrier (20)	0.1	SS-CBS	25	5.73	229.2	22.9
197565	Tributary to Grave Creek	–	Low (low)	Barrier (26)	1.5	SS-CBS	25	5.45	218	327
197566	Tributary to Lizard Creek	Lazy Lizard Lower	–	Passable (0)	–	–	–	–	–	–
197567	Tributary to Elk River	Cokato Road	Low (low)	Barrier (23)	0.65	SS-CBS	200	0.69	3.5	2.2
197568	Tributary to Elk River	Railway	–	Passable (13)	1.5	–	–	0.78	–	–
197569	Tributary to Elk River	Cokato Road	Low (low)	Barrier (32)	2.1	OBS	1000	1.28	1.3	2.7
197570	Cokato Creek	Cokato Road	Low (low)	Barrier (26)	4.5	OBS	1000	1.76	1.8	7.9
197571	Tributary to Elk River	Cokato Road	Low (low)	Barrier (21)	4.1	OBS	1000	1.9	1.9	7.8
197572	Tributary to Elk River	Railway	Low (low)	Barrier (24)	2.7	OBS	500	1.93	3.9	10.4
197573	Tributary to Elk River	Highline Drive	Medium (mod)	Barrier (37)	2.3	OBS	1900	0.63	0.3	0.8
197574	Tributary to Elk River	Fernie ski hill	Low (low)	Barrier (32)	1.4	SS-CBS	25	0.29	11.6	16.2
197575	Tributary to Elk River	Fernie ski hill	Low (low)	Barrier (34)	1.5	SS-CBS	25	0.29	11.6	17.4
197576	Tributary to Elk River	Fernie ski hill	Low (low)	Barrier (39)	1.5	SS-CBS	25	0.29	11.6	17.4
197577	Tributary to Elk River	Fernie ski hill	Low (low)	Barrier (26)	1.3	SS-CBS	25	0.23	9.2	12

Table 4.1:

ID	Stream	Road	Habitat Value (priority)	Result (Score)	Stream Width (m)	Fix	Cost Est ($K)	Habitat Upstream (km)	Cost Benefit (m / $K)	Cost Benefit (m2 / $K)
197578	Tributary to Elk River	Fernie Nordic Trail	Medium (mod)	Barrier (26)	2	OBS	125	2.24	17.9	35.8
197579	Tributary to Elk River	Highway 3	Medium (mod)	Barrier (24)	3.3	OBS	5000	5.27	1.1	3.5
197580	Tributary to Elk River	Dicken Rd	Low (low)	Barrier (34)	2.2	OBS	1000	1.38	1.4	3
197581	Bean Creek	Dicken Rd	High (mod)	Barrier (36)	2	OBS	1000	0.63	0.6	1.3
197582	Hartley Creek	Highway 3	–	Passable (6)	–	–	–	13.46	–	–
197583	Bean Creek	Highway 3	Medium (mod)	Barrier (29)	3.2	OBS	5000	3.78	0.8	2.4
*4600005	Tributary to Elk R	Hwy 3	Low (low)	Barrier (39)	2.7	OBS	5000	1.81	0.4	1
*4603294	Tributary to Hartley Creek	Hartley Lake Rd	Low (low)	Barrier (36)	1.8	SS-CBS	25	1.83	73.2	131.8
*4606006	Weigert Creek	Weigert FSR	–	Unknown (0)	–	–	–	19.17	–	–
*4606515	Tributary to Hartley Creek	Hartley Lake Rd	Low (low)	Barrier (26)	6.7	OBS	168	1.5	8.9	59.8
*4606518	Tributary to Hartley Creek	Hartley Lake Rd	–	Passable (0)	–	–	–	–	–	–
*2020101410	Tributary to Hartley Creek	Hartley Lake Rd	–	Passable (0)	–	–	–	–	–	–
*2020101610	Stove Creek	Trail	–	Passable (0)	–	–	–	–	–	–
*2020101611	Stove Creek	Trail	–	Passable (0)	–	–	–	–	–	–

4.3 Phase 2

Habitat confirmation assessments were conducted at 15 sites with a total of approximately 15 km of stream assessed. Six crossings were rated as high priorities for proceeding to design for replacement, Eight crossings were rated as moderate priorities for proceeding to design for replacement, 0 crossings were rated as a low priority and 1 rated as “no fix”. Results are summarized in Tables 4.2 - 4.5 with raw habitat and fish sampling data included in digital format as Attachment 3. Detailed information for each site assessed with Phase 2 assessments is included within site specific reports included as appendices to this document with maps included as Attachment 2.

Table 4.2: Overview of habitat confirmation sites.

PSCIS ID	Stream	Road	UTM (11U)	Fish Species	Habitat Gain (km)	Habitat Value	Priority	Comments
50152	Tributary to Lizard Creek	Mt.Fernie Park Rd	637987 5483407	(WCT)	2.7	High	high	Newly installed culvert with large outlet drop. Cover as undercut banks, small woody debris, large woody debris and overhanging vegetation. Numerous fry observed throughout the area surveyed and abundant gravels suitable for salmonid spawning. Highest value habitat of 4 Lizard Creek tributary streams surveyed.
50155	Tributary to Lizard Creek	Island Lake Lodge Road	635113 5484261	EB, WCT	1.8	Medium	moderate	Frequent areas of gravels suitable for resident westslope cutthrout trout spawning and pools to 40cm deep associated with small and large woody debris. Fish sampling indicates westslope cutthrout trout fry densities lower upstream than downstream.
50159	Tributary to Lizard Creek	Island Lake Lodge Road	633320 5484601	–	0.3	Medium	moderate	Abundant gravels suitable for resident and fluvial westslope cutthrout trout spawning. Frequent pools to 40cm deep associated with woody debris. Within old growth cedar forest and not mapped in the freshwater atlas stream layer. Flows potentially diverted as part of a micro-hydro facilty for Island Lake Lodge.
50181	Tributary to Morrissey Creek	Lodgepole FSR	648276 5468176	WCT	0.5	Medium	high	Boulders, small woody debris, large woody debris, undercut banks, overhanging vegetation and gravels suitable for spawning. Electrofished upstream and downstream of the crossing with westslope cutthrout trout fry, juvenile and adult fish captured downstream and only parr captured upstream. Density of parr (fish/area) lower in the steeper habitat located upstream.
50185	Tributary to Morrisey Creek	River Rd	645683 5469025	EB, WCT	4.5	High	high	Good flows, pools to 0.6m deep and pockets of gravel suitable for salmonid spawning throughout. Infrequent large woody debris jams to 0.5m high. Electrofishing indicated generally higher densities of fry, parr and juvenile westslope cutthrout trout downstream when compared to upstream.
50261	Tributary to Michel Creek	Flathead FSR	669027 5481115	–	0.0	Low	no fix	A 4.4m high chute was located 200m downstream of crossing (UTM: 11U 668858 5481210) and is considered a permanent impassable barrier to upstream migration.
62423	Harriet Lake Creek	Grave Creek FSR	660508 5524239	WCT	2.3	Low	moderate	Crossing dry at time of survey. Incorrectly mapped as Grave Creek. Steep gradients in Harriet Lake Creek approximatlely 1km upstream.
62425	Grave Creek	Spur	661486 5524426	WCT	0.2	Medium	moderate	Deep pools, large woody debris and boulders present. Stream is Grave Creek mainstem that has redirected from historic channel. Higher value habitat in adjacent valley channel. Crossing is 170m downstream of 62426. Westslope cutthrout density study underway within watershed by Lotic Environmental Ltd.
62426	Grave Creek	Spur	661611 5524460	WCT	1.8	Medium	moderate	Deep pools, large woody debris and boulders present. Habitat quality decreases with distance upstream. Upstream tributary too steep at 250m upstream. Channel is Grave Creek mainstem that has redirected from historic channel. Located 170m usptream of 62425.
62516	Tributary to Lizard Creek	Island Lake Lodge Road	636123 5484087	(WCT)	0.5	Medium	moderate	Undercut banks throughout with small woody debris, large woody debris, deep pools, and overhanging vegetation also present. Abundant gravels suitable for resident westslope cutthrout trout spawning. Fry observed upstream and downstream.

Table 4.2:

PSCIS ID	Stream	Road	Tenure	UTM (11U)	Fish Species	Habitat Gain (km)	Habitat Value	Priority	Comments
197533	Brule Creek	Busato Rd	MoTi local	651626 5528888	RB, WCT, BT	0.1	High	high	Recommend exploring deactivation as a potential remediatory action. Culvert is located 125m below crossing 197559.
197534	Weigert Creek	Highway 43	MoTi highway	650144 5532055	–	11.6	High	high	Undercut banks, small woody debris, large woody debris, boulders, deep pools, and overhanging vegetation present. Abundant gravels present. Habitat increasingly complex upstream. Watershed is a habitat protection area with motor vehicle restrictions. Elk Valley Park recreation site is located downstream of the crossing. Water too cold to sample. Recommend fish sampling upstream and down.
197542	Hartley Creek	Dicken Road	MoTi collector	643534 5490723	WCT, BT, EB	7.2	High	high	Frequent pools formed by small and large woody debris ranging from 0.3 - 0.7m in depth. Pockets of gravels suitable for resident and fluvial salmonids. Downstream crossing on Hwy 3 is passable but requires dredging to keep clear. Historic fish density information available on Ecocat for 3 upstream sites.
197555	Tributary to Elk River	Elk River FSR	FLNR 0103	646735 5554534	BT	6.0	High	moderate	Good flows, pools to 0.6m deep and pockets of gravel suitable for spawning. Infrequent large woody debris jams to 0.5m high. Sites electrofished upstream and downstream with one bull trout captured downstream within 315m site.
197559	Brule Creek	Highway 43	MoTi highway	651516 5528829	RB, WCT	23.0	Medium	moderate	Deep pools, boulders and undercut banks within wetted channel upstream. Adult westslope cutthout trout in outlet pool below hwy. Section of stream (670m) immediately upstream of Highway 43 subsurface during survey. Electrofished upstream only with no fish captured.

Table 4.3: Summary of Phase 2 fish passage reassessments.

PSCIS ID	Embedded	Outlet Drop (m)	Diameter (m)	SWR	Slope (%)	Length (m)	Score	Result
50152	No	0.90	0.9	2.9	1.5	30	37	Barrier
50155	No	0.22	0.9	2.5	2.6	11	26	Barrier
50159	No	1.60	0.8	3.1	8.0	12	36	Barrier
50181	No	0.95	1.2	2.2	7.0	30	42	Barrier
50185	No	0.00	2.2	2.0	3.4	17	29	Barrier
50261	No	1.80	2.7	1.7	12.0	19	39	Barrier
62423	No	0.18	0.9	1.6	0.5	12	21	Barrier
62425	No	0.47	1.2	3.1	7.5	12	36	Barrier
62426	No	0.25	1.2	2.9	5.0	12	31	Barrier
62516	No	0.49	1.2	2.1	5.0	11	36	Barrier
197533	No	0.70	3.3	2.2	4.0	20	39	Barrier
197534	No	0.15	3.2	1.3	3.4	18	34	Barrier
197542	No	0.40	2.6	1.3	2.0	20	34	Barrier
197555	No	1.48	1.5	2.3	3.5	49	42	Barrier
197559	Yes	0.00	2.5	2.4	2.5	35	22	Barrier

Table 4.4: Cost benefit analysis for Phase 2 assessments.

PSCIS ID	Stream	Road	Result	Habitat value	Stream Width (m)	Fix	Cost Est (in $K)	Habitat Upstream (m)	Cost Benefit (m / $K)	Cost Benefit (m2 / $K)
50152	Tributary to Lizard Creek	Mt.Fernie Park Rd	Barrier	High	2.6	OBS	438	2700	6.2	16
50155	Tributary to Lizard Creek	Island Lake Lodge Road	Barrier	Medium	2.2	OBS	125	1800	14.4	31.7
50159	Tributary to Lizard Creek	Island Lake Lodge Road	Barrier	Medium	3	OBS	125	350	2.8	8.4
50181	Tributary to Morrissey Creek	Lodgepole FSR	Barrier	Medium	2.9	OBS	125	515	4.1	11.9
50185	Tributary to Morrisey Creek	River Rd	Barrier	High	4	OBS	125	4500	36	144
50261	Tributary to Michel Creek	Flathead FSR	Barrier	Low	5.2	OBS	125	0	0	0
62423	Harriet Lake Creek	Grave Creek FSR	Barrier	Low	1.2	SS-CBS	25	2300	92	110.4
62425	Grave Creek	Spur	Barrier	Medium	3.5	OBS	125	170	1.4	4.8
62426	Grave Creek	Spur	Barrier	Medium	3.9	OBS	125	1800	14.4	56.2
62516	Tributary to Lizard Creek	Island Lake Lodge Road	Barrier	Medium	2	OBS	125	540	4.3	8.6
197533	Brule Creek	Busato Rd	Barrier	High	5.5	OBS	710	125	0.2	1
197534	Weigert Creek	Highway 43	Barrier	High	6.6	OBS	5000	11600	2.3	15.3
197542	Hartley Creek	Dicken Road	Barrier	High	6.1	OBS	1000	7200	7.2	43.9
197555	Tributary to Elk River	Elk River FSR	Barrier	High	5.9	OBS	312	6000	19.2	113.5
197559	Brule Creek	Highway 43	Barrier	Medium	7.7	OBS	6100	23000	3.8	29

Table 4.5: Summary of Phase 2 habitat confirmation details.

PSCIS ID	Length surveyed upstream (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
50152	675	2.6	2	0.3	3.0	moderate	high
50155	700	2.2	1.6	0.3	10.5	abundant	high
50159	400	3.0	2.6	0.4	11.2	moderate	high
50181	515	2.9	2.2	0.3	12.4	moderate	medium
50185	740	4.0	2.8	0.4	6.2	moderate	high
50261	220	5.2	3.6	0.6	12.0	moderate	medium
62423	725	1.2	0.8	0.2	4.4	moderate	medium
62425	170	3.5	2.1	0.3	5.0	moderate	high
62426	650	3.9	1.6	0.4	11.9	moderate	medium
62516	730	2.0	1.3	0.3	7.6	moderate	high
197533	125	5.5	3.8	–	1.5	moderate	high
197534	1100	6.6	4.6	0.5	4.5	moderate	high
197542	725	6.1	3.8	0.5	3.5	moderate	high
197555	675	5.9	3.8	0.4	5.9	abundant	high
197559	1600	7.7	2.3	0.6	3.5	moderate	high

4.4 Fish Sampling

Fish sampling was conducted at five sites with a total of 154 westslope cutthout trout, 31 eastern brook trout and 1 bull trout captured. Westslope cutthrout trout were captured at three of the sites sampled with fork length data delineated into life stages: fry (≤60mm), parr (>60 to 110mm), juvenile (>110mm to 140mm) and adult (>140mm) by visually assessing the histogram presented in Figure 4.1. Fish sampling results are presented in detail within individual habitat confirmation site memos within the appendices of this document with westslope cutthrout trout density results also presented in Figure 4.2.

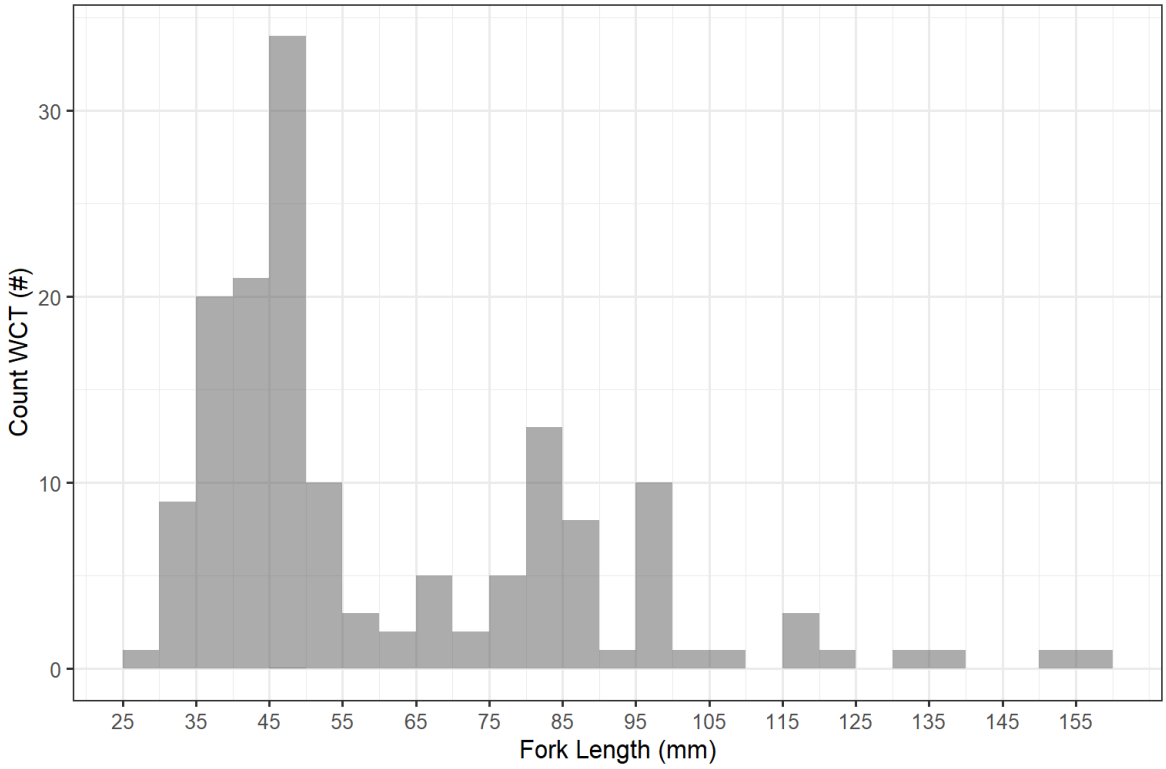


Figure 4.1: Histogram of westslope cutthrout trout captured during electrofishing surveys.

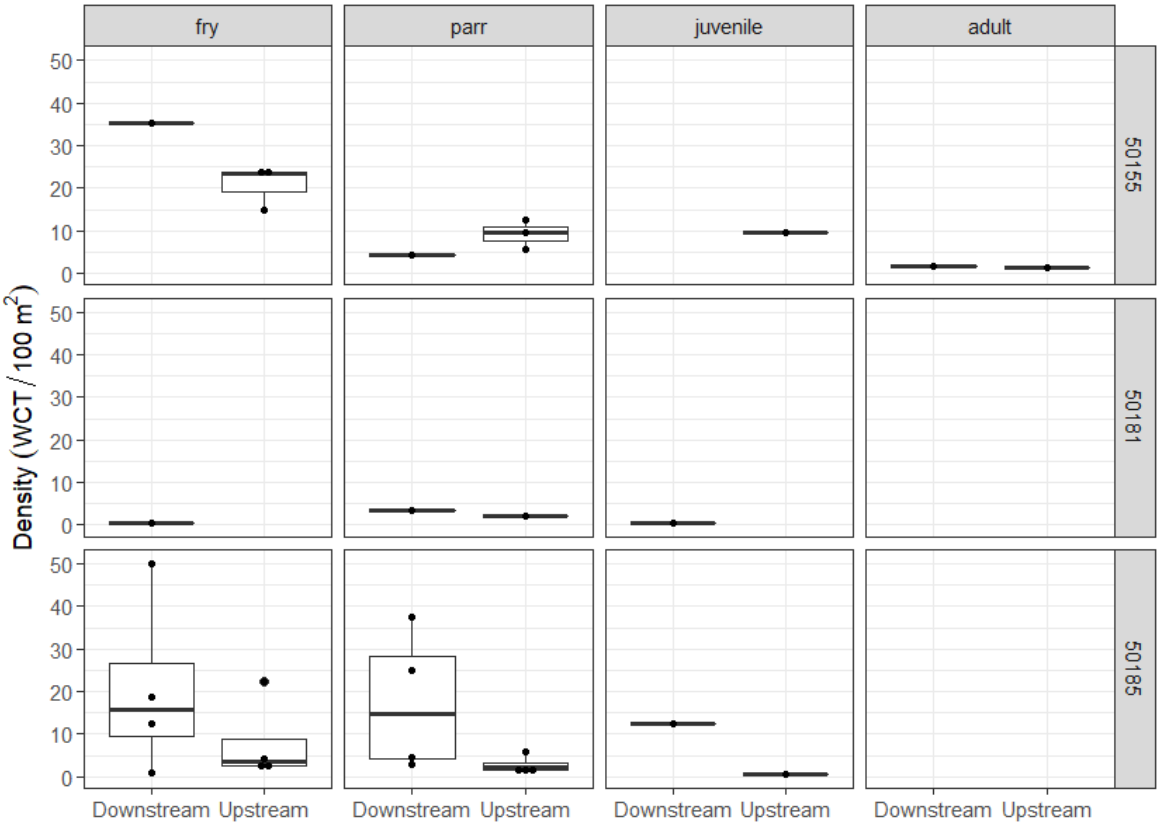


Figure 4.2: Boxplots of densities (fish/100m2) of westslope cutthrout trout captured by life stage and site for data collected during habitat confirmation assessments.

5 Recommendations

Recommendations for potential incorporation into watershed connectivity planning for the Upper Elk River and the Flathead River watersheds led by Canadian Wildlife Federation include:

- 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, etc.) and could result in the consideration of physical works to alter crossing characteristics that can be significantly less costly than structure replacements (i.e. build up downstream area with rock riffles to decrease the outlet drop size).

- Model fish densities (fish/m^2) vs. habitat/water quality characteristics (i.e. gradient, watershed size, channel size, alkalinity, elevation, etc.) using historically gathered electrofishing data to inform crossing prioritization and the monitoring of subsequent restoration actions.

- Continue to develop `bcfishpass` and other open source tools that are scalable, facilitate reproducible analysis and can be adapted to incorporate alternative fragmentation indicators and habitat gain/value metrics.

- Continue to conduct fish passage and habitat confirmation assessments at road and rail stream crossings at sites in the upper Elk River and Flathead River study areas prioritized through this project and future connectivity modelling.

- Continue to acquire funding to procure site plans and replacement designs for structures identified as high priorities for restoration.

- Continue to collaborate with potential partners to build relationships, explore perspectives and develop “road maps” for fish passage 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. Through this collaboration, continue to draft and implement a plan to prioritize fish passage restoration investments as well as to monitor the impacts of those investments on fish populations.

Appendix - 50152 - Tributary to Lizard Creek

Site Location

Crossing 50152 is located on a tributary to Lizard Creek, approximately 140m upstream from the confluence with Lizard Creek and within Mt.Fernie provincial Park. This culvert has also been recorded in PSCIS as crossing 62521. The culvert is located on a paved section of Mt.Fernie Park Road (0.3km mark) and is accessed from Highway 3 within Fernie city limits. The Mt.Fernie Provincial Park is a popular recreational destination for hikers, sightseers and mountain bikers. Island Lake Lodge is located at 1400m of elevation near Island Lake and is a year round tourist destination providing accommodations, guided hiking and backcountry catskiing in the Lizard Creek watershed.

Background

The subject culvert appears to have been recently replaced with a new structure. No fisheries information was available for the stream although Lizard Creek supports westslope cutthroat trout, bull trout, mountain whitefish, brook trout, longnose sucker and longnose dace downstream (MoE 2020d, 2020b). Elk River Alliance (2020) conducted redd surveys in Lizard Creek in 2019 along with Morrissey Creek, Coal Creek and Forsyth Creek. A total of 55 redds were observed within a 2.4km section of Lizard Creek comprising the largest densities of redds of the four tributaries surveyed (22.9 redds/km).

PSCIS stream crossing 50152 was ranked as a high priority for follow up with habitat confirmation due to the large size of the stream recorded in PSCIS (channel width = 2.4m) relative to other tributary streams in the Lizard Creek watershed and because it was rated as containing high value habitat by VAST Resource Solutions Inc. (2013) and Grainger (2011). There is a bridge located on the Lazy Lizard recreation trail approximately 150m upstream of the crossing and an unassessed modelled crossing (ID 4600926) approximately 2100m upstream which could not be accessed due to a road closure. The habitat confirmation was completed on October 16, 2020. A map of the watershed including areas surveyed is provided in Attachment 1 – Map 082G.113.

Stream Characteristics at Crossing

As noted, the culvert located at PSCIS 50152 appeared to have been replaced in 2020 with fresh rock, road fill and pavement present. At the time of the survey, the un-embedded and non-backwatered 0.9m diameter crossing was considered a barrier to upstream fish passage with a pipe length of 30m, a culvert slope of 1.5%, a stream width ratio of 2.9 and an outlet drop of 0.9m (Table 5.1). Water temperature was 5°C, pH was 8.5 and conductivity was 286uS/cm.

Stream Characteristics Downstream

The stream was surveyed downstream from the culvert for 140m to Lizard Creek. Overall, 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 (Table 5.2, Figure 5.1). The average channel width was 2.7m, the average wetted width was 2.1m and the average gradient was 4%. The dominant substrate was cobbles with gravels subdominant. Downstream of the crossing, numerous fry were observed, there were frequent sections of gravels suitable for salmonid spawning and there were no barriers or obstacles to fish passage. Habitat was rated as high value for fry/juvenile salmonid rearing.

Stream Characteristics Upstream

The stream was surveyed upstream from the culvert for 675m. Overall, 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 (Table 5.2, Figure 5.2). The average channel width was 2.6m, the average wetted width was 2m and the average gradient was 3%. There were numerous fry observed throughout the area surveyed and abundant gravels suitable for resident westslope cutthrout trout spawning were noted. Habitat value was rated as high for salmonid rearing and spawning.

Structure Remediation and Cost Estimate

Structure replacement with a bridge is recommended to provide access to the habitat located upstream of PSCIS crossing 50152. The cost of the work is estimated at $438,000 for a cost benefit of 6.2 linear m/$1000 and 16$m^2$/$1000.

Conclusion

There is 2.7km of mainstem habitat in Stove Creek upstream of crossing 50152 with habitat rated as high value for fry and juvenile salmonid rearing. Of the four streams surveyed with habitat confirmations in the Lizard Creek drainage during this project, Stove Creek contained the highest value habitat. The large outlet drop (0.9m) on the newly installed culvert prevents upstream migration by all species and life stages. This paved section of road is within Mt.Fernie Provincial Park. The crossing was ranked as a high priority for proceeding to design for replacement.

Table 5.1: Summary of fish passage reassessment for PSCIS crossing 50152.

Location and Stream Data	•	Crossing Characteristics	–
Date	2020-10-16	Crossing Sub Type	Round Culvert
PSCIS ID	50152	Diameter (m)	0.9
External ID	–	Length (m)	30
Crew	AI, MF	Embedded	No
UTM Zone	11	Depth Embedded (m)	–
Easting	637987	Resemble Channel	No
Northing	5483407	Backwatered	No
Stream	Tributary to Lizard Creek	Percent Backwatered	–
Road	Mt.Fernie Park Rd	Fill Depth (m)	5.5
Road Tenure	–	Outlet Drop (m)	0.9
Channel Width (m)	2.6	Outlet Pool Depth (m)	0.4
Stream Slope (%)	3	Inlet Drop	No
Beaver Activity	No	Slope (%)	1.5
Habitat Value	High	Valley Fill	Deep Fill
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Table 5.2: Summary of habitat details for PSCIS crossing 50152.

Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
Upstream	675	2.6	2	0.3	3	moderate	high
Downstream	140	2.7	2.1	0.3	4	moderate	high

Stream Characteristics Downstream

Figure 5.1: Typical habitat downstream of PSCIS crossing 50152.

Figure 5.2: Typical habitat upstream of PSCIS crossing 50152.

Appendix - 50155 - Tributary to Lizard Creek

Site Location

Crossing 50155 is located on a tributary to Lizard Creek, approximately 75m upstream from the confluence with Lizard Creek. The stream is located approximately 100m east of the location where it is mapped on the freshwater atlas stream layer. The culvert is located at km 3.6 of Island Lake Lodge Road which is an extension of Mt.Fernie Park Road with access from Highway 3 located within Fernie city limits. The area is a popular recreational destination for hikers and mountain bikers. Island Lake Lodge is a year round tourist destination in the Lizard Creek watershed providing accommodations, guided hiking and backcountry catskiing for clients.

Background

At the crossing location, the stream is 2nd order with a watershed area upstream of the road of approximately 1.8km^2. The elevation of the watershed ranges from a maximum of 1945m to 1080m at the culvert. One 12m long bridge (PSCIS 197543) is located upstream of the subject crossing approximately 575m on the Lazy Lizard bike trail and another 7m long bridge structure is located downstream also on a recreational trail. A search of provincial records yielded no fisheries information for the stream (MoE 2020d). Downstream, Lizard Creek supports westslope cutthroat trout, bull trout, mountain whitefish, brook trout, longnose sucker and longnose dace (MoE 2020b). Elk River Alliance (2020) conducted redd surveys in Lizard Creek in 2019 along with Morrissey Creek, Coal Creek and Forsyth Creek. A total of 55 redds were observed within a 2.4km section of Lizard Creek comprising the largest densities of redds of the four tributaries surveyed (22.9 redds/km).

PSCIS stream crossing 50155 was ranked as a high priority for follow up with habitat confirmation due to the large size of the stream relative to other tributary streams in the watershed, the previously rated high value habitat and because it was prioritized for follow up by VAST Resource Solutions Inc. (2013). The habitat confirmation was completed on September 22, 2020. A map of the watershed including areas surveyed is provided in Attachment 1 – Map 082G.113.

Stream Characteristics at Crossing

At the time of the survey, the un-embedded and non-backwatered 0.9m diameter crossing was considered a barrier to upstream fish passage with a pipe length of 11m, a culvert slope of 2.6%, a stream width ratio of 2.5 an outlet drop of 0.22m (Table 5.3). Water temperature was 9°C, pH was 7.7 and conductivity was 480uS/cm.

Stream Characteristics Downstream

The stream was surveyed downstream from the culvert for 100m to Lizard Creek. Overall, 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 (Table 5.8, Figure 5.4). The average channel width was 2.2m, the average wetted width was 1.9m and the average gradient was 4.3%. Habitat value was rated as medium with good potential for fry/juvenile salmonid rearing but a lack of deep pools for adult overwintering and rearing.

Stream Characteristics Upstream

The stream was surveyed upstream from the culvert for 700m. Overall, total cover amount was rated as abundant with deep pools dominant. Cover was also present as small woody debris, large woody debris, boulders, undercut banks, and overhanging vegetation (Table 5.8, Figure 5.5). The average channel width was 2.2m, the average wetted width was 1.6m and the average gradient was 10.5%. Frequent areas of gravels suitable for resident westslope cutthrout trout spawning and pools to 40cm deep associated with small and large woody debris were present throughout areas surveyed. Habitat value was rated as high for fry and juvenile westslope cutthrout rearing.

Fish Sampling

To assess potential impacts of the culvert on fish densities in the stream we electrofished upstream and downstream of the crossing. Three sites were sampled upstream and one site was sampled downstream. A total of 42 westslope cutthrout trout and 4 eastern brook trout were captured upstream with 28 westslope cutthrout trout and 2 eastern brook trout captured downstream. Raw results are included in digital format as Attachment 2 and summarized in Tables 5.5 - 5.6 and Figure 5.3.

Structure Remediation and Cost Estimate

Structure replacement with a bridge is recommended to provide unconstained access to the habitat located upstream of PSCIS crossing 50155. The cost of the work is estimated at $125,000 for a cost benefit of 14.4 linear m/$1000 and 31.7$m^2$/$1000.

Conclusion

There is an estimated 1.8km of mainstem habitat upstream of crossing 50155 with habitat in the areas surveyed rated as high value for fry and juvenile salmonid rearing. Although potentially attributable to lower gradient habitat and closer proximity to the Lizard Creek mainstem, fish sampling results demonstrated that westslope cutthrout trout fry densities were lower upstream of the crossing than below. The road may be permitted to Island Lake Lodge or solely the responsibility of the Ministry of Forests, Lands, Natural Resource Operations & Rural Development.

The crossing was ranked as a moderate priority for proceeding to design for replacement with an open bottomed structure.

Table 5.3: Summary of fish passage reassessment for PSCIS crossing 50155.

Location and Stream Data	•	**Crossing Characteristics**	–
Date	2020-09-22	Crossing Sub Type	Round Culvert
PSCIS ID	50155	Diameter (m)	0.9
External ID	–	Length (m)	11
Crew	KP, AI	Embedded	No
UTM Zone	11	Depth Embedded (m)	–
Easting	635113	Resemble Channel	No
Northing	5484261	Backwatered	No
Stream	Tributary to Lizard Creek	Percent Backwatered	–
Road	Island Lake Lodge Road	Fill Depth (m)	0.3
Road Tenure	MoTi recreation	Outlet Drop (m)	0.22
Channel Width (m)	2.25	Outlet Pool Depth (m)	0.45
Stream Slope (%)	4.3	Inlet Drop	Yes
Beaver Activity	No	Slope (%)	2.6
Habitat Value	Medium	Valley Fill	Deep Fill
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Stream Characteristics Downstream

Table 5.4: Summary of habitat details for PSCIS crossing 50155.

Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
Upstream	700	2.2	1.6	0.3	10.5	abundant	high
Downstream	100	2.2	1.9	–	4.3	moderate	medium

Table 5.5: Electrofishing sites for PSCIS crossing 50155.

Site	Location	Width (m)	Length (m)	Area (m2)	Effort (s)	Effort (s/m2)
19	Downstream	1.7	40	68	200	2.9
18	Upstream	1.6	25	40	117	2.9
33	Upstream	1.6	13	21	61	2.9
34	Upstream	1.6	45	72	154	2.1

Table 5.6: Westslope cuthrout trout densities (fish/100m2) for PSCIS crossing 50155.

Site	Location	Fry	Parr	Adult	Juvenile
19	Downstream	35.3	4.4	1.5	0
18	Upstream	15	12.5	0	0
33	Upstream	23.8	9.5	0	9.5
34	Upstream	23.6	5.6	1.4	0

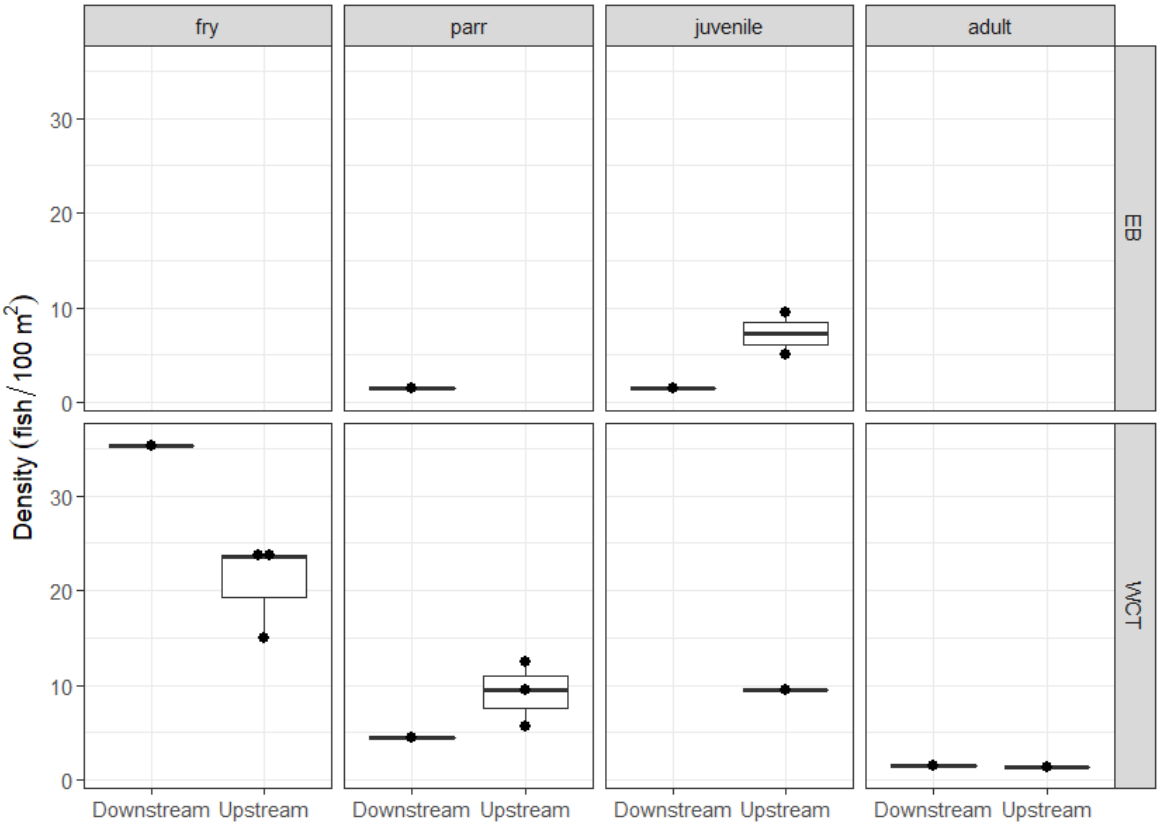


Figure 5.3: Fish densities (fish/100m2) for PSCIS crossing 50155.

Figure 5.4: Typical habitat downstream of PSCIS crossing 50155.

Figure 5.5: Typical habitat upstream of PSCIS crossing 50155.

Appendix - 50159 - Tributary to Lizard Creek

Site Location

Crossing 50159 is located on a tributary to Lizard Creek, approximately 150m upstream from the confluence with Lizard Creek. This crossing has also been recorded in PSCIS as crossing 62510. The culvert is located at approximately 5.5km up Island Lake Lodge Road which is an extension of Mt.Fernie Park Road. The area is accessed off of Highway 3 within Fernie city limits and is a popular recreational destination for hikers, skiers and mountain bikers. Island Lake Lodge is located at 1400m of elevation near Island Lake and is a year round tourist destination providing accommodations, guided hiking and backcountry catskiing for clients. The subject stream is not mapped in the freshwater atlas stream layer and may have been diverted as part of a micro-hydro facilty for Island Lake Lodge. A small building that may be a generating station was observed on aerial imagery approximately 1500m upstream of the road.

Background

At the crossing location, the stream had good flow and is located within an area of old growth cedar adjacent to a recreation trail. At the time of the survey the stream was the highest volume tributary to Lizard Creek located on the east side of the valley. No fisheries information was available for the stream (MoE 2020d), however, Lizard Creek supports westslope cutthroat trout, bull trout, mountain whitefish, brook trout, longnose sucker and longnose dace (MoE 2020b). Elk River Alliance (2020) conducted redd surveys in Lizard Creek in 2019 along with Morrissey Creek, Coal Creek and Forsyth Creek. A total of 55 redds were observed within a 2.4km section of Lizard Creek comprising the largest densities of redds of the four tributaries surveyed (22.9 redds/km).

PSCIS stream crossing 50159 was ranked as a high priority for follow up with habitat confirmation due to the relatively large size of the stream recorded in PSCIS (channel width = 3.5m) relative to other tributary streams in the Lizard Creek watershed and because it was rated as containing high value habitat by VAST Resource Solutions Inc. (2013) and Grainger (2011). The habitat confirmation was completed on September 22, 2020. A map of the watershed including areas surveyed is provided in Attachment 1 – Map 082G.113.

Stream Characteristics at Crossing

At the time of the survey, the un-embedded and non-backwatered 0.8m diameter crossing was considered a barrier to upstream fish passage with a pipe length of 12m, a culvert slope of 8%, a stream width ratio of 3.1 and an outlet drop of 1.6m (Table 5.7). Water temperature was 10°C, pH was 7.6 and conductivity was 729uS/cm.

Stream Characteristics Downstream

The stream was surveyed downstream from the culvert for 150m to Lizard Creek. Overall, total cover amount was rated as moderate with large woody debris dominant. Cover was also present as small woody debris, deep pools, and overhanging vegetation (Table 5.4, Figure 5.4). The average channel width was 2.5m, the average wetted width was 2.3m and the average gradient was 8.8%. The dominant substrate was gravels with cobbles subdominant. Some small pools and steps of 0.2 - 0.6m in height were present throughout the area surveyed. Large woody debris steps ranging from 0.4 - 0.8m high were spaced sporadically throughout area surveyed. Habitat value was rated as moderate for salmonid fry/juvenile rearing and high value habitat for spawning.

Stream Characteristics Upstream

The stream was surveyed upstream from the culvert for 400m. Overall, total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris, large woody debris, and deep pools (Table 5.4, Figure 5.5). The average channel width was 3m, the average wetted width was 2.6m and the average gradient was 11.2%. There were abundant gravels suitable for resident and fluvial westslope cutthrout trout spawning. Frequent pools to 40cm deep were present and associated with small and large woody debris. The stream contained relatively flatter sections from 3 - 8% and steeper sections of 15 - 18% for first 350m above culvert where the stream becomes too steep for upstream salmonid passage (35% - UTM: 11 U 632810 5484842). Habitat was rated as high value for salmonid rearing and spawning.

Structure Remediation and Cost Estimate

Structure replacement with a bridge is recommended to provide access to the habitat located upstream of PSCIS crossing 50159. The cost of the work is estimated at $125,000 for a cost benefit of 2.8 linear m/$1000 and 8.4$m^2$/$1000.

Conclusion

There is 0.35km of habitat upstream of crossing 50159 within old growth cedar riparian forest before the stream becomes too steep for upstream fish migration (>22%). The habitat upstream of the crossing was rated as high value for salmonid rearing and spawning with good flows, large woody debris throughout and abundant gravels suitable for spawning. The subject stream is not mapped in the freshwater atlas stream layer and may have been diverted from upstream flows as part of a micro-hydro facilty for Island Lake Lodge. The road may be permitted to Island Lake Lodge or solely the responsibility of the Ministry of Forests, Lands, Natural Resource Operations & Rural Development. The crossing was ranked as a moderate priority for proceeding to design for replacement with an open bottomed structure. Elecrofishing upstream and downstream of the crossing is recommended to determine utilization of habitat before and after restorative measures.

Table 5.7: Summary of fish passage reassessment for PSCIS crossing 50159.

Location and Stream Data	•	Crossing Characteristics	–
Date	2020-09-22	Crossing Sub Type	Round Culvert
PSCIS ID	50159	Diameter (m)	0.8
External ID	–	Length (m)	12
Crew	KP, AI	Embedded	No
UTM Zone	11	Depth Embedded (m)	–
Easting	633320	Resemble Channel	No
Northing	5484601	Backwatered	No
Stream	Tributary to Lizard Creek	Percent Backwatered	–
Road	Island Lake Lodge Road	Fill Depth (m)	1
Road Tenure	MoTi recreation	Outlet Drop (m)	1.6
Channel Width (m)	2.45	Outlet Pool Depth (m)	0
Stream Slope (%)	9	Inlet Drop	Yes
Beaver Activity	No	Slope (%)	8
Habitat Value	Medium	Valley Fill	Deep Fill
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			


2020-09-22, 11:59
11U 633357 5484612
2020-09-22, 12:00
11U 633310 5484613
2020-09-22, 12:00
11U 633310 5484613
2020-09-22, 12:02
11U 633314 5484613
2020-09-22, 12:00
11U 633310 5484613
2020-09-22, 12:07
11U 633324 5484607

Table 5.8: Summary of habitat details for PSCIS crossing 50159.

Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
Upstream	400	3.0	2.6	0.4	11.2	moderate	high
Downstream	150	2.5	2.3	0.2	8.8	moderate	high

Figure 5.6: Typical habitat downstream of PSCIS crossing 50159.

Figure 5.7: Typical habitat upstream of PSCIS crossing 50159.

Appendix - 50181 - Tributary to Morrissey Creek

Site Location

Crossing 50181 is located on a tributary to Morrissey Creek, approximately 200m upstream from the confluence with a tributary to Morrissey Creek. The crossing is located on Lodgepole FSR just south of Morrissey approximately 15km south of Fernie. Lodgepole FSR is a gravel forest tenure road with active log hauling at the time of the survey. This crossing is on a stream that flows into the Morrissey Creek tributary approximately 2.7km upstream of where PSCIS crossing 50185 on River Road was also surveyed with a habitat confirmation assessment.

Background

At the crossing location, the stream is third order with a watershed area upstream of the road of approximately 3.4 km^2. The elevation of the watershed ranges from a maximum of 2100 to 1200m at the culvert. Upstream of the crossing, although there are four fords documented in PSCIS there are no other road-stream crossing barriers. No fisheries information was available for the stream (MoE 2020d) however westslope cutthroat trout, bull trout, mountain whitefish, brook trout, longnose sucker and longnose dace have been recorded downstream in Morrissey Creek (MoE 2020b). Elk River Alliance (2020) conducted redd surveys in Morrissey Creek in 2019 with a total of 7 redds observed within a 3.6km of stream surveyed.

PSCIS stream crossing 50181 was ranked as a high priority for follow up with habitat confirmation due to the relatively large channel width (3.7m) and the previously rated high value habitat reported in PSCIS from Grainger (2011). The habitat confirmation was completed on October 15, 2020. A map of the watershed including areas surveyed is provided in Attachment 1 – Map 082G.108.

Stream Characteristics at Crossing

At the time of the survey, the un-embedded and non-backwatered 1.2m diameter crossing was considered a barrier to upstream fish passage with a pipe length of 30m, a culvert slope of 7%, a stream width ratio of 2.2 and an outlet drop of 0.95m (Table 5.9). Water temperature was 4°C, pH was 8.4 and conductivity was 292uS/cm.

Stream Characteristics Downstream

The stream was surveyed downstream from the culvert for 200m to the confluence with the downstream channel. The mouth of the stream is located approximately 100m east of where it is mapped on the freshwater atlas stream layer. Overall, total cover amount was rated as moderate with large woody debris dominant. Cover was also present as small woody debris, boulders, undercut banks, deep pools, and overhanging vegetation (Table 5.10, Figure 5.9). The average channel width was 4m, the average wetted width was 2.2m and the average gradient was 8%. The

dominant substrate was boulders with cobbles subdominant. Intermittent smaller pools and pockets of gravels suitably sized for resident salmonid spawning were present. Habitat was rated as medium value for fry/juvenile salmonid rearing.

Stream Characteristics Upstream

The stream was surveyed upstream from the culvert for 515m. Overall, total cover amount was rated as moderate with boulders dominant. Cover was also present as small woody debris, large woody debris, undercut banks, and overhanging vegetation (Table 5.10, Figure 5.10). The average channel width was 2.9m, the average wetted width was 2.2m and the average gradient was 12.4%. The dominant substrate was cobbles with boulders subdominant. Good flows were present and some pockets of gravels suitable for spawning were observed throughout. There were steps ranging from 0.5 - 0.8m due to large woody debris jams but no permanent migration barriers were observed until a cascade at the top end of the survey area (24% for >50m). Habitat was rated as medium value for fry and juvenile westslope cutthrout trout rearing.

Fish Sampling

To confirm fish presence and assess potential impacts of the culvert on fish densities in the stream, electrofishing was conducted upstream and downstream of the crossing. One site was sampled downstream and one site was sampled upstream. A total of 6 westslope cutthrout trout were captured upstream and 15 were captured downstream (Figure 5.11). Raw results are included in digital format as Attachment 2 and summarized in Tables 5.11 - 5.12 and Figure 5.8.

Structure Remediation and Cost Estimate

Structure replacement with a bridge is recommended to provide access to the habitat located upstream of PSCIS crossing 50181. The cost of the work is estimated at $125,000 for a cost benefit of 4.1 linear m/$1000 and 11.9$m^2$/$1000.

Conclusion

There is an estimated 0.52km of mainstem habitat upstream of crossing 50181 with habitat in the areas surveyed upstream of the crossing rated as medium value for fry and juvenile salmonid rearing. Density of westslope cutthrout trout parr was higher in the site sampled downstream of the crossing when compared to the upstream site with fry, juvenile and adult fish captured downstream only. The Lodgepole FSR is under tenure of the Ministry of Forests, Lands, Natural Resource Operations & Rural Development. The crossing was ranked as a high priority for proceeding to design for replacement with an open bottomed structure and consideration of remediation of PSCIS 50185 should be considered at the same time for maximum potential benefits.

Table 5.9: Summary of fish passage reassessment for PSCIS crossing 50181.

Location and Stream Data	•	Crossing Characteristics	–
Date	2020-10-15	Crossing Sub Type	Round Culvert
PSCIS ID	50181	Diameter (m)	1.2
External ID	–	Length (m)	30
Crew	MF, AI	Embedded	No
UTM Zone	11	Depth Embedded (m)	–
Easting	648276	Resemble Channel	No
Northing	5468176	Backwatered	No
Stream	Tributary to Morrissey Creek	Percent Backwatered	–
Road	Lodgepole FSR	Fill Depth (m)	3
Road Tenure	–	Outlet Drop (m)	0.95
Channel Width (m)	2.6	Outlet Pool Depth (m)	0.18
Stream Slope (%)	7	Inlet Drop	No
Beaver Activity	No	Slope (%)	7
Habitat Value	Medium	Valley Fill	Deep Fill
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			


Date & Time: Thu. Oct 15. 2020. 10:15:32 MDT
Position: 11 N 648266 5468167 (±11.8m)
Altitude: 1165m (±13.4m)
Datum: WGS-84
Azimuth/Bearing: 225° S45W 4000mils True (±13°)
Elevation Grade: -043%
Horizon Grade: -001%
Zoom: 1.0X
Nupqu Limited Partnership
50181
2020-10-15 10:17 AM
11U 648276 5468273
2020-10-15 10:18 AM
11U 648296 5468184
undercut
Nupqu Limited Partnership

Table 5.10: Summary of habitat details for PSCIS crossing 50181.

Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
Upstream	515	2.9	2.2	0.3	12.4	moderate	medium
Downstream	200	4.0	2.2	0.3	8.0	moderate	medium

Table 5.11: Electrofishing sites for PSCIS crossing 50181.

Site	Location	Width (m)	Length (m)	Area (m2)	Effort (s)	Effort (s/m2)
47	Downstream	2.2	150	330	840	2.5
46	Upstream	2.2	130	286	651	2.3

Table 5.12: Westslope cuthrout trout densities (fish/100m2) for PSCIS crossing 50181.

Site	Location	Fry	Parr	Juvenile
47	Downstream	0.6	3.3	0.6
46	Upstream	0	2.1	0

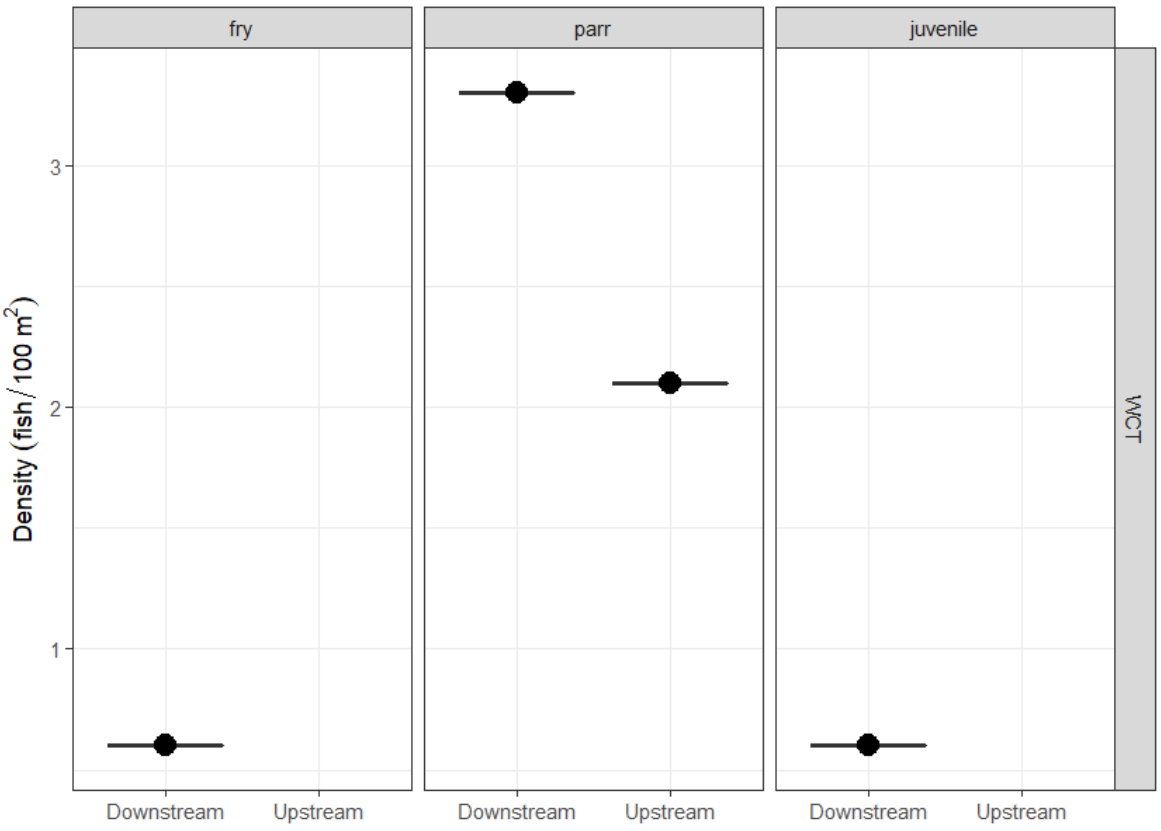


Figure 5.8: Fish densities (fish/100m2) for PSCIS crossing 50181.

Figure 5.9: Typical habitat downstream of PSCIS crossing 50181.

Figure 5.10: Typical habitat upstream of PSCIS crossing 50181.

Figure 5.11: Westslope cutthrout trout captured upstream of PSCIS crossing 50181.

Appendix - 50185 - Tributary to Morrisey Creek

Site Location

Crossing 50185 is located on a tributary to Morrisey Creek, approximately 255m upstream from the confluence with Morrisey Creek. The crossing is located at km 14.5 on River Road just south of Morrissey approximately 15km south of Fernie. The road is accessed off of Lodgepole FSR via the Morrissey Bridge over the Elk River adjacent to Highway 3. River Road is a gravel forest tenure road (forest file id 5466 with active log hauling at the time of the survey. PSCIS crossing 50181 on an upstream tributary located approximately 2.7km upstream was also surveyed with a habitat confirmation assessment.

Background

At the crossing location, the stream is 4th order with a watershed area upstream of the road of approximately 12km^2. The elevation of the watershed ranges from a maximum of 2000 to 970m at the culvert. Upstream of the crossing, there are no anthropogenic barriers on the mainstem however PSCIS crossing 50181 (also recorded as PSCIS 103033) is documented as a barrier located on a significantly sized tributary entering the stream from the north-east approximately 2.8km upstream of River Road. A wetland type area is mapped at the top of the watershed. No fisheries information was available for the stream (MoE 2020d) however westslope cutthroat trout, bull trout, mountain whitefish, brook trout, longnose sucker and longnose dace have been recorded downstream in Morrissey Creek (MoE 2020b). Elk River Alliance (2020) conducted redd surveys in Morrissey Creek in 2019 with a total of 7 redds observed within a 3.6km of stream surveyed.

PSCIS stream crossing 50185 was ranked as a high priority for follow up with habitat confirmation due to the large size of the stream relative to other tributary streams in the watershed, the moderate value habitat rating by VAST Resource Solutions Inc. (2013) and because VAST Resource Solutions Inc. (2013) noted that the culvert was a good candidate for RPBio assessment. The habitat confirmation was completed on September 21, 2020. A map of the watershed including areas surveyed is provided in Attachment 1 – Map 082G.108.

Stream Characteristics at Crossing

At the time of the survey, the un-embedded and non-backwatered 2.2m diameter crossing was considered a barrier to upstream fish passage with a pipe length of 17m, a culvert slope of 3.4%, a stream width ratio of 2 and an outlet drop of 0m (Table 5.13). Water temperature was 9°C, pH was 7.6 and conductivity was 378uS/cm. It appeared as though fish passage restoration works had taken place at the site historically as there were what appeared to be boulder riffle structures installed downstream of the crossing. The structures appeared to be effective at reducing the outlet drop size but had created a rock drop (0.4m) and were not resulting in backwatering of the culvert.

Stream Characteristics Downstream

The stream was surveyed downstream from the culvert for 255m to the confluence with Morrisey Creek. The mouth of the stream is located approximately 500m upstream from the confluence of Morrissey Creek and the Elk River. Overall, total cover amount was rated as moderate with small woody debris dominant. Cover was also present as large woody debris, undercut banks, deep pools, and overhanging vegetation (Table 5.14, Figure 5.13). The average channel width was 4.3m, the average wetted width was 2.7m and the average gradient was 4.2%. The dominant substrate was cobbles with gravels subdominant. There were frequent pools formed by small and large woody debris ranging from 0.3 - 0.75m in depth (average residual depth = 0.4m). Pockets of small gravels suitable for resident salmonid spawning were also present. Habitat value was rated as high with good potential for fry/juvenile salmonid rearing.

Stream Characteristics Upstream

The stream was surveyed upstream from the culvert for 740m. Overall, total cover amount was rated as moderate with small woody debris dominant. Cover was also present as large woody debris, undercut banks, deep pools, and overhanging vegetation (Table 5.14, Figure 5.14). The average channel width was 4m, the average wetted width was 2.8m and the average gradient was 6.2%. The dominant substrate was cobbles with gravels subdominant. The stream had good flows with fry observed throughout the area surveyed. Pools to 0.6m deep were present with pockets of gravel suitable for salmonid spawning throughout. Infrequent large woody debris jams to 0.5m high were also observed. Habitat value was rated as high for fry and juvenile westslope cutthrout trout rearing.

Fish Sampling

To assess potential impacts of the culvert on fish densities in the stream electrofishing was conducted upstream and downstream of the crossing. Five sites were sampled downstream and five sites were sampled upstream. A total of 37 westslope cutthrout trout and 22 eastern brook trout were captured upstream with 26 westslope cutthrout trout and 3 eastern brook trout captured downstream (Figure 5.15). Raw results are included in digital format as Attachment 2 and summarized in Tables 5.15 - 5.16 and Figure 5.12.

Structure Remediation and Cost Estimate

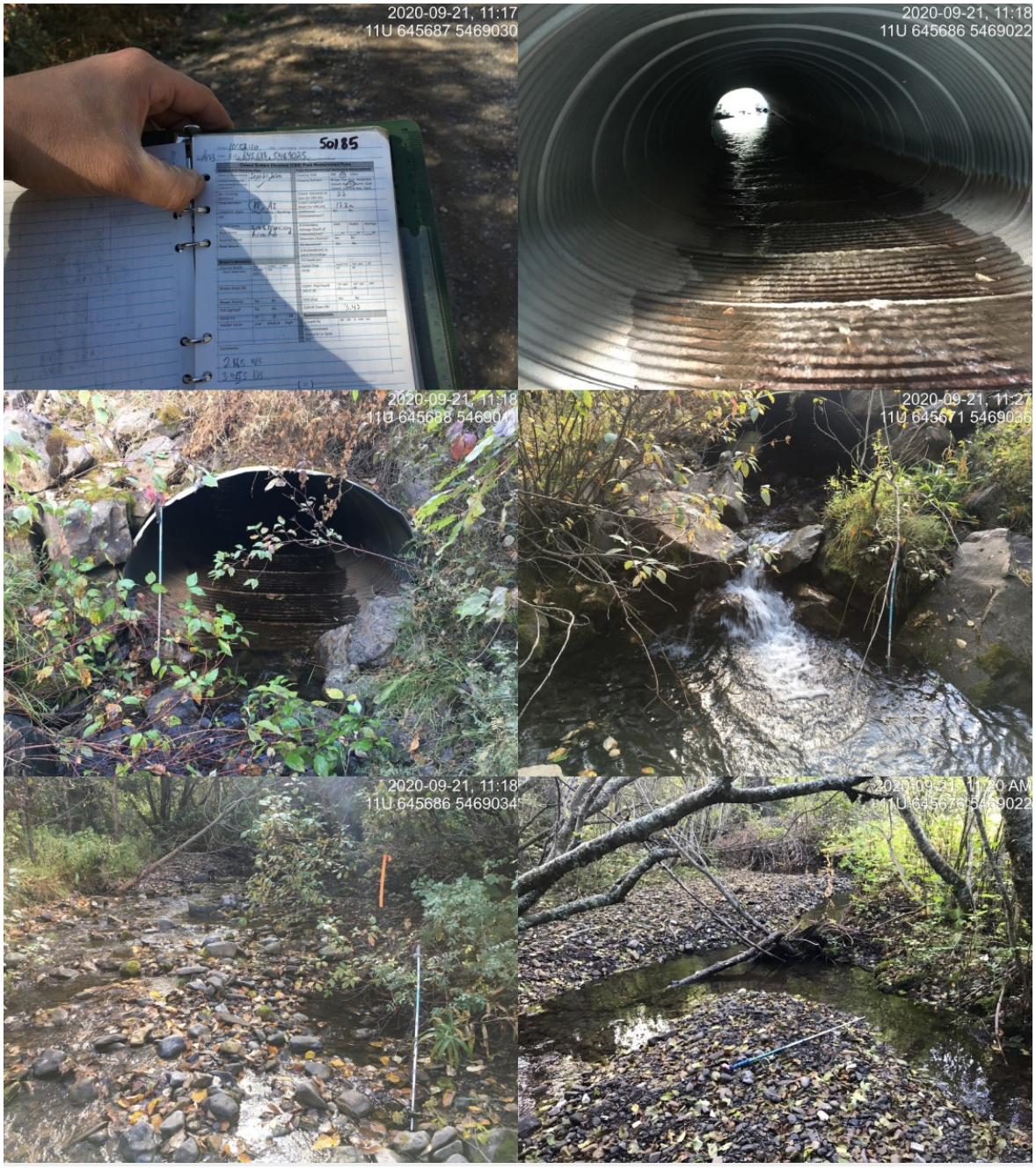
Structure replacement with a bridge is recommended to provide access to the habitat located upstream of PSCIS crossing 50185. The cost of the work is estimated at $125,000 for a cost benefit of 36 linear m/$1000 and 144$m^2$/$1000.

Conclusion

There is an estimated 4.5km of mainstem habitat upstream of crossing 50185 with habitat in the areas surveyed upstream of the crossing rated as high value for fry and juvenile salmonid rearing. Fish sampling indicated generally higher densities of fry, parr and juvenile westslope cutthrout trout downstream when compared to upstream. River Road is under tenure of the Ministry of Forests, Lands, Natural Resource Operations & Rural Development. The crossing was ranked as a high priority for proceeding to design for replacement with an open bottomed structure.

Table 5.13: Summary of fish passage reassessment for PSCIS crossing 50185.

Location and Stream Data	•	**Crossing Characteristics**	–
Date	2020-09-21	Crossing Sub Type	Round Culvert
PSCIS ID	50185	Diameter (m)	2.2
External ID	–	Length (m)	17
Crew	KP, AI	Embedded	No
UTM Zone	11	Depth Embedded (m)	–
Easting	645683	Resemble Channel	No
Northing	5469025	Backwatered	No
Stream	Tributary to Morrisey Creek	Percent Backwatered	–
Road	River Rd	Fill Depth (m)	1.4
Road Tenure	FLNR 5466	Outlet Drop (m)	0
Channel Width (m)	4.3	Outlet Pool Depth (m)	0
Stream Slope (%)	4.3	Inlet Drop	No
Beaver Activity	No	Slope (%)	3.4
Habitat Value	High	Valley Fill	Deep Fill
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			


2020-09-21, 11:17
11U 645687 5469030
2020-09-21, 11:18
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2020-09-21, 11:18
11U 645688 5469041
2020-09-21, 11:27
11U 645671 5469026
2020-09-21, 11:18
11U 645686 5469034
2020-09-21, 11:20 AM
11U 645676 5469022

Table 5.14: Summary of habitat details for PSCIS crossing 50185.

Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
Upstream	740	4.0	2.8	0.4	6.2	moderate	high
Downstream	255	4.3	2.7	0.4	4.2	moderate	high

Table 5.15: Electrofishing sites for PSCIS crossing 50185.

Site	Location	Width (m)	Length (m)	Area (m2)	Effort (s)	Effort (s/m2)
24	Downstream	2.7	40	108	361	3.3
25	Downstream	2.25	7	16	70	4.4
26	Downstream	2.6	3	8	36	4.5
27	Downstream	2.6	3	8	57	7.1
28	Downstream	3.1	7	22	170	7.7
29	Upstream	2.9	40	116	361	3.1
30	Upstream	2.67	13	35	123	3.5
31	Upstream	2.8	13	36	63	1.8
32	Upstream	4.47	18	80	223	2.8
48	Upstream	2.8	60	168	521	3.1

Table 5.16: Westslope cuthrout trout densities (fish/100m2) for PSCIS crossing 50185.

Site	Location	Fry	Parr	Juvenile
24	Downstream	0.9	2.8	0
25	Downstream	18.8	0	0
26	Downstream	12.5	37.5	0
27	Downstream	0	25	12.5
28	Downstream	50	4.5	0
29	Upstream	4.3	0.9	0
30	Upstream	0	5.7	0
31	Upstream	2.8	0	0
32	Upstream	22.5	2.5	0
48	Upstream	2.4	1.8	0.6

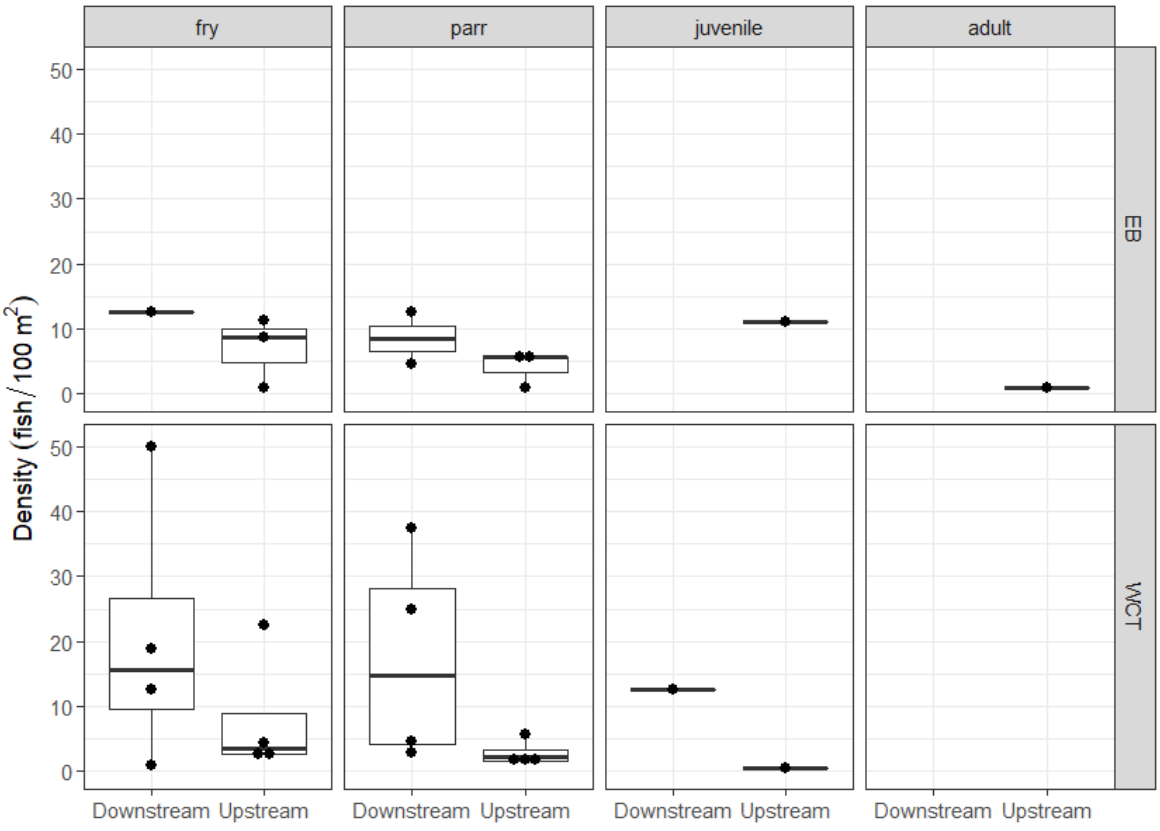

Figure 5.12: Fish densities (fish/100m2) for PSCIS crossing 50185.

Figure 5.13: Typical habitat downstream of PSCIS crossing 50185.

Figure 5.14: Typical habitat upstream of PSCIS crossing 50185.

Figure 5.15: Westslope cutthrout trout captured upstream of PSCIS crossing 50185.

Appendix - 50261 - Tributary to Michel Creek

Site Location

Crossing 50261 is located on a tributary to Michel Creek, approximately 210m upstream from the confluence with the Michel Creek. The crossing is located at 7.6km on the Flathead FSR accessed from Coal Mountain.

Background

At the crossing location, the stream is third order with a watershed area upstream of the road of approximately 5.4 km^2. The elevation of the watershed ranges from a maximum of 2600 to 1700m at the culvert. There is one crossing modelled downstream of PCSIS 50261 (4600837) and one modelled above (4602097). There was no fisheries information available for the watershed (MoE 2020d, 2020b).

PSCIS stream crossing 50261 was ranked as a moderate priority for follow up with habitat confirmation due to the relatively large amount of potential habitat modelled as suitable for westslope cutthrout trout occupancy (<20% for ~3km) located upstream and a medium habitat value ranking by Grainger (2011). The habitat confirmation was completed on October 17, 2020. A map of the watershed including areas surveyed is provided in Attachment 1 – Map 082G.114.

Stream Characteristics at Crossing

At the time of the survey, the three un-embedded and non-backwatered 2.7m diameter crossings were considered a barrier to upstream fish passage with a pipe lengths of 19m, culvert slopes of 12%, a stream width ratio of 1.7 and outlet drops of 1.8m (Table 5.17). Water temperature was 1°C, pH was 8.5 and conductivity was 320uS/cm.

Stream Characteristics Downstream

The stream was surveyed downstream from the culvert for 210m. Overall total cover amount was rated as moderate with boulders dominant. Cover was also present as large woody debris, undercut banks, deep pools, and overhanging vegetation (Table 5.18, Figure 5.16). The average channel width was 4.4m, the average wetted width was 2.5m and the average gradient was 15%. The dominant substrate was boulders with cobbles subdominant. Some intermittent pools were present with occasional pockets of gravel suitable for spawning. A 4.4m high chute was located 200m downstream of crossing (UTM: 11U 668858 5481210) and is considered a permanent impassable barrier to upstream migration (Figure 5.17.

Stream Characteristics Upstream

The stream was surveyed immediately upstream from the culvert for 210m. Overall, total cover amount was rated as moderate with deep pools dominant. Cover was also present as small woody debris, large woody debris, boulders, undercut banks, and overhanging vegetation (Table 5.18, Figure 5.18). The average channel width was 5.2m, the average wetted width was 3.6m and the average gradient was 12%. The dominant substrate was large rock/bedrock with boulders subdominant. Overall, habitat was rated as medium value. There were multiple natural barriers to upstream fish passage within the area surveyed that were considered too steep for upstream migration by any species.

Conclusion

The chute located 200m downstream of PSCIS 50261 is an impassable barrier to upstream migration and negates the value in restoring passage at the crossing. It is recommended that the crossing not proceed to design for remediation of fish passage.

Table 5.17: Summary of fish passage reassessment for PSCIS crossing 50261.

Location and Stream Data	•	Crossing Characteristics	–
Date	2020-10-17	Crossing Sub Type	Round Culvert
PSCIS ID	50261	Diameter (m)	2.7
External ID	–	Length (m)	19
Crew	AI, MF	Embedded	No
UTM Zone	11	Depth Embedded (m)	–
Easting	669027	Resemble Channel	No
Northing	5481115	Backwatered	No
Stream	Tributary to Michel Creek	Percent Backwatered	–
Road	Flathead FSR	Fill Depth (m)	3
Road Tenure	–	Outlet Drop (m)	1.8
Channel Width (m)	4.6	Outlet Pool Depth (m)	0
Stream Slope (%)	12	Inlet Drop	Yes
Beaver Activity	No	Slope (%)	12
Habitat Value	Low	Valley Fill	Deep Fill
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			


2020-10-17, 3:24 PM
11U 669024 5481110
50261
2020-10-17, 3:27 PM
11U 669037 5481116
2020-10-17, 3:24 PM
11U 669032 5481118
2020-10-17, 3:25 PM
11U 669028 5481140
2020-10-17, 3:24 PM
11U 669024 5481110
2020-10-17, 3:25 PM
11U 669035 5481129

Table 5.18: Summary of habitat details for PSCIS crossing 50261.

Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
Upstream	220	5.2	3.6	0.6	12	moderate	medium
Downstream	210	4.4	2.5	0.2	15	moderate	medium

Figure 5.16: Habitat downstream of PSCIS crossing 50261.

Figure 5.17: Chute barrier located 200 downstream of PSCIS crossing 50261.

Figure 5.18: Habitat upstream of PSCIS crossing 50261.

Appendix - 62423 - Harriet Lake Creek

Site Location

Crossing 62423 is located on Harriet Lake Creek, approximately 30m upstream from the confluence with Grave Creek and accessed from Grave Creek Forest Service Road. Although the freshwater atlas stream layer mapping incorrectly indicates the subject stream is the mainstem of Grave Creek it is actually a small drainage that joins Harriet Lake Creek which flows primarily from the 6ha Harriet Lake located to the north at an elevation of 2100m approximately 4km upstream of the crossing.

Background

Harriet Lake was stocked with “wild” westslope cutthrout trout five times between 1985 and 2002 (MoE 2020a). Downstream, Grave Creek is known to contain westslope cutthrout trout, rainbow trout and bull trout (MoE 2020b). Two habitat confirmation assessments were conducted downstream on the mainstem of Grave Creek in 2014 at PSCIS crossings 62421 and 62422 (Masse Environmental Consultants Ltd. 2015). Although Heather Lamson - MoE Fisheries Biologist recommended the culverts not be removed to prevent potential hybridization of westslope cutthrout trout with stocked rainbow trout downstream (Masse Environmental Consultants Ltd. 2015), both structures had been replaced with bridges at the time of the surveys. Designs and remediations of these crossings were not recorded in PSCIS. Reassessments of these crossings were conducted by our team in 2020 and results will be loaded to PSCIS. In the field, Lotic Environmental Ltd. field teams were observed conducting two-pass closed site electrofishing in Grave Creek as part of a westslope cutthrout trout population assessment and aquatic monitoring program. Data from the program is uploaded to the Fisheries Information Summary System annually and is made available through the BC Data Catalog (MoE 2020b, 2020d).

Although the modelling of potential habitat upstream of this crossing was considered not accurate due to the incorrect mapping of Grave Creek, during field work planning, PSCIS stream crossing 62423 was ranked as a high priority for follow up with habitat confirmation due to the large size of the modelled stream network upstream (20km) and because it was located on a stream with habitat rated as moderate value by VAST Resource Solutions Inc. (2013). A bridge (PSCIS 62413) is located approximately 1km upstream of the crossing. The habitat confirmation was completed on September 20, 2020. A map of the watershed including areas surveyed is provided in Attachment 1 – Map 082G.124.

Stream Characteristics at Crossing

At the time of the survey, the un-embedded and non-backwatered 0.9m diameter crossing was considered a barrier to upstream fish passage with a pipe length of 12m, a culvert slope of 0.5%, a stream width ratio of 1.6 and an outlet drop of 0.18m (Table 5.19). The stream was dry at the crossing location at the time of the survey.

Stream Characteristics Downstream

The stream was surveyed downstream from the culvert for 30m to Grave Creek. Overall, total cover amount was rated as moderate with overhanging vegetation dominant. Cover was also present as small woody debris and boulders (Table 5.20, Figure 5.20). The average channel width was 1.3m, and the average gradient was 4%. The dominant substrate was cobbles with boulders subdominant. Habitat value was rated as low value due to a lack of flow.

Stream Characteristics Upstream

The stream was surveyed upstream from the culvert in the general location of the mapped Grave Creek streamline for 725m. As Harriet Lake Creek was the primary source of flow for the area and enters the surveyed tributary 150m upstream of the crossing location, flows were very minimal and substrate was primarily fines above its confluence. There was however, a visible channel in this location with a ford (PSCIS 197563) located approximately 600m upstream of PSCIS 62423. Overall, total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris, large woody debris, and boulders (Table 5.20, Figure 5.19). The average channel width was 1.2m, the average wetted width was 0.8m and the average gradient was 4.4%. Harriet Lake Creek gradients modelled at 19% just upstream of the bridge located 1km upstream and too steep for upstream westslope cutthrout passage (>20%) at 2.2km. Habitat value was rated as medium for fry and juvenile westslope cutthrout rearing in Harriet Creek and low in the unnamed tributary mapped as Grave Creek due to a lack of flow.

Structure Remediation and Cost Estimate

Structure replacement with an embedded culvert is recommended to provide access to the habitat located upstream of PSCIS crossing 62423. The cost of the work is estimated at $25,000 for a cost benefit of 92 linear m/$1000 and 110.4$m^2$/$1000.

Conclusion

There is 2.3km of mainstem habitat upstream of crossing 62423 with habitat in the areas surveyed upstream of the crossing rated as medium value. Although the provincial forest tenure road layer does not include Grave Creek FSR, it is likely that it is a tenure road under the responsibility of the Ministry of Forests, Lands, Natural Resource Operations and Rural Development. The crossing was ranked as a moderate priority for proceeding to design for replacement with an open bottomed structure due to the low water conditions and steep gradients upstream in Harriet Lake Creek.

Table 5.19: Summary of fish passage reassessment for PSCIS crossing 62423.

Location and Stream Data	•	Crossing Characteristics	–
Date	2020-09-20	Crossing Sub Type	Round Culvert
PSCIS ID	62423	Diameter (m)	0.9
External ID	–	Length (m)	12
Crew	KP, AI	Embedded	No
UTM Zone	11	Depth Embedded (m)	–
Easting	660508	Resemble Channel	No
Northing	5524239	Backwatered	No
Stream	Harriet Lake Creek	Percent Backwatered	–
Road	Grave Creek FSR	Fill Depth (m)	0.3
Road Tenure	Unknown	Outlet Drop (m)	0.18
Channel Width (m)	1.44	Outlet Pool Depth (m)	0.6
Stream Slope (%)	4	Inlet Drop	Yes
Beaver Activity	No	Slope (%)	0.5
Habitat Value	Low	Valley Fill	Deep Fill
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Table 5.20: Summary of habitat details for PSCIS crossing 62423.

Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
Downstream	30	1.3	–	–	4.0	moderate	low
Upstream	725	1.2	0.8	0.2	4.4	moderate	medium

Figure 5.19: Typical habitat downstream of PSCIS crossing 62423.

Figure 5.20: Typical habitat upstream of PSCIS crossing 62423.

Appendix - 62425 & 62426 - Grave Creek

Site Location

PSCIS crossings 62425 and 62426 are located on Grave Creek, approximately 75m and 185m upstream from where Grave Creek splits into two channels with the majority of flow originating from the other channel flowing from the south. Of note, the confluence of Grave Creek and the other channel is located approximately 175m to the west of where the confluence is mapped - likely due to a channel redirection approximately 375m upstream that appears to have occurred due to a large woody debris jam. Three PSCIS crossings (62427, 62428 and 62429) and one un-assessed modelled crossing (modelled ID 4601159) are located upstream of 62426 however, there are very minimal quantities of potential habitat upstream of their locations. Although mapped within the digital road atlas it is suspected that the road on which both culverts are located is a forest tenure road (Canfor Forest Products Ltd. tenure) as it is located immediately adjacent to another forest tenure road and within an area utilized for forestry.

Background

Grave Creek is known to contain westslope cutthrout trout, rainbow trout and bull trout downstream of the subject culverts and westslope cutthrout trout above (MoE 2020b). Two habitat confirmation assessments were conducted downstream on the mainstem of Grave Creek in 2014 at PSCIS crossings 62421 and 62422 (Masse Environmental Consultants Ltd. 2015). Although Heather Lamson - MoE Fisheries Biologist recommended the culverts not be removed to prevent potential hybridization of westslope cutthrout trout with stocked rainbow trout downstream (Masse Environmental Consultants Ltd. 2015), both structures had been replaced with bridges at the time of the surveys. Designs and remediations of these crossings were not recorded in PSCIS. Reassessments of these crossings were conducted by our team in 2020 and results will be loaded to PSCIS. In the field, Lotic Environmental Ltd. field teams were observed conducting two-pass closed site electrofishing in Grave Creek as part of a westslope cutthrout trout population assessment and aquatic monitoring program. Data from the program is uploaded to the Fisheries Information Summary System annually and is made available through the BC Data Catalog (MoE 2020b, 2020d).

PSCIS stream crossings 62425 and 62426 were ranked as moderate priorities for follow up with habitat confirmation due to the relatively large size of the stream network upstream (3.5km) and because they contained habitat rated as moderate value by VAST Resource Solutions Inc. (2013). The habitat confirmation was completed on September 20, 2020. A map of the watershed including areas surveyed is provided in Attachment 1 – Map 082G.124.

Stream Characteristics at Crossing

At the time of the survey, both culverts were un-embedded, non-backwatered and considered barriers to upstream fish passage. PSCIS crossing 62425 was 1.2m in diameter with a pipe length

of 12m, a culvert slope of 7.5%, a stream width ratio of 3.1 and an outlet drop of 0.47m (Table 5.21). PSCIS crossing 62426 was 1.2m in diameter with a pipe length of 12m, a culvert slope of 5%, a stream width ratio of 2.9 and an outlet drop of 0.25m (Table 5.22). Water temperature was 8°C, pH was 7.8 and conductivity was 370uS/cm.

Stream Characteristics Downstream of 62425

The stream was surveyed downstream from the culvert for 75m to where the stream joins the flow entering the valley from the south. Overall, total cover amount was rated as moderate with deep pools dominant. Cover was also present as small woody debris, large woody debris, boulders, undercut banks, and overhanging vegetation (Table 5.23, Figure 5.21). The average channel width was 3.7m, the average wetted width was 1.8m and the average gradient was 7.5%. The dominant substrate was cobbles with boulders subdominant. Downstream of the crossing there were frequent sections of gravels suitable for salmonid spawning and no barriers or obstacles to fish passage. Habitat was rated as high value for fry/juvenile salmonid rearing.

Stream Characteristics Upstream of 62425 and Downstream of 62426

The stream was surveyed upstream from 62425 for 170m to 62426. Overall, total cover amount was rated as moderate with deep pools dominant. Cover was also present as large woody debris and boulders (Table 5.23, Figure 5.22). The average channel width was 3.5m, the average wetted width was 2.1m and the average gradient was 5%. There were abundant gravels suitable for resident westslope cutthrout trout spawning throughout (Figure 5.23). Some debris jam steps to 0.8m in height were observed and there were approximately 15 westslope cutthrout trout (approximately 170mm long) in the outlet pool for crossing 62426. Habitat value was rated as high for fry/juvenile salmonid rearing.

Stream Characteristics Upstream of 62426

The stream was surveyed upstream from 62426 for 650m. Overall, total cover amount was rated as moderate with deep pools dominant. Cover was also present as boulders (Table 5.23, Figure 5.22). The average channel width was 3.5m, the average wetted width was 1.6m and the average gradient was 11.9%. This stream channel showed evidence of recent disturbance with eroding banks, multiple channels and aggraded sections throughout. Steps (0.6 - 0.9m in height) due to large woody debris debris jams were frequent throughout surveyed area and at a point approximately 200 m upstream of the road-stream crossing to the top end of the area surveyed, cover was limited to sporadic pools up to 0.3m deep. As mentioned previously, the historic channel was abandoned at 175m upstream of 62426 (UTM: 11 U 661748 5524558, Figure 5.23) with no flow observed within its banks. One of the tributaries that enters Grave Creek approximately 250m upstream of 62426 was accessed off of an adjacent spur road with a rapid assessment conducted 250m upstream from the confluence with Grave Creek (UTM: 11U 662083 5524708). The average channel width at this location was 1.9m and the average gradient was 9%. Immediately upstream, the gradient in this tributary was 20% representing grades not likely passable for westslope cutthroat trout migrating

upstream. Overall, habitat value upstream of 62426 within the mainstem of Grave Creek was rated as medium with moderate rearing potential for fry/juvenile westslope cutthrout trout.

Structure Remediation and Cost Estimate

Replacing PSCIS crossings 62425 and 62426 with bridges is recommended to provide access to the habitat located upstream. The costs are estimated at $125,000 and $125,000 respectively for a combined cost benefit of 15800 linear m/$1000 and 61000$m^2$/$1000.

Conclusion

There is 0.17km of habitat upstream of crossing 62425 with habitat rated as high value for fry and juvenile salmonid rearing and another 1.8km upstream of 62426 rated as medium value. Although mapped only within the digital road atlas, it is suspected that the road on which both culverts are located is a forest tenure road (Canfor Forest Products Ltd. permit) as it is located immediately adjacent to another forest tenure road under permit to Canfor and within an area utilized for forestry. The crossings were ranked as moderate priorities for proceeding to design for replacement.

Table 5.21: Summary of fish passage reassessment for PSCIS crossing 62425.

Location and Stream Data	•	**Crossing Characteristics**	–
Date	2020-09-20	Crossing Sub Type	Round Culvert
PSCIS ID	62425	Diameter (m)	1.2
External ID	–	Length (m)	12
Crew	KP, AI	Embedded	No
UTM Zone	11	Depth Embedded (m)	–
Easting	661486	Resemble Channel	No
Northing	5524426	Backwatered	No
Stream	Grave Creek	Percent Backwatered	–
Road	Spur	Fill Depth (m)	1
Road Tenure	Canfor R08362	Outlet Drop (m)	0.47
Channel Width (m)	3.7	Outlet Pool Depth (m)	0.38
Stream Slope (%)	7.5	Inlet Drop	Yes
Beaver Activity	No	Slope (%)	7.5
Habitat Value	Medium	Valley Fill	Deep Fill
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Table 5.22: Summary of fish passage reassessment for PSCIS crossing 62426.

Location and Stream Data	•	Crossing Characteristics	–
Date	2020-09-20	Crossing Sub Type	Round Culvert
PSCIS ID	62426	Diameter (m)	1.2

External ID	–	Length (m)	12
Crew	KP, AI	Embedded	No
UTM Zone	11	Depth Embedded (m)	–
Easting	661611	Resemble Channel	No
Northing	5524460	Backwatered	No
Stream	Grave Creek	Percent Backwatered	–
Road	Spur	Fill Depth (m)	1
Road Tenure	Canfor R08362	Outlet Drop (m)	0.25
Channel Width (m)	3.5	Outlet Pool Depth (m)	0.65
Stream Slope (%)	6	Inlet Drop	Yes
Beaver Activity	No	Slope (%)	5
Habitat Value	Medium	Valley Fill	Deep Fill
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Table 5.23: Summary of habitat details for PSCIS crossings 62425 and 62426.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
62425	Upstream	170	3.5	2.1	0.3	5.0	moderate	high
62425	Downstream	75	3.7	1.8	0.3	7.5	moderate	high
62426	Upstream	650	3.9	1.6	0.4	11.9	moderate	medium

Figure 5.21: Typical habitat downstream of PSCIS crossing 62425.

Figure 5.22: Typical habitat upstream of PSCIS crossing 62425 and downstream of PSCIS crossing 62426.

Figure 5.23: Grave Creek redirection out of historic channel located upstream of PSCIS crossing 62426.

Appendix - 62516 - Tributary to Lizard Creek

Site Location

Crossing 62516 is located on a tributary to Lizard Creek, approximately 630m upstream from the confluence with Lizard Creek. This culvert has also been recorded in PSCIS as crossing 50153. The culvert is located at 2.5km on Island Lake Lodge Road which is an extension of Mt.Fernie Park Road accessed from Highway 3 within Fernie city limits. The Mt.Fernie Provincial Park is a popular recreational destination for hikers, sightseers and mountain bikers. Island Lake Lodge is located at 1400m of elevation near Island Lake and is a year round tourist destination providing accommodations, guided hiking and backcountry catskiing. The stream has been diverted from its historic channel and runs adjacent to a historic road to Lizard Creek approximately 500m downstream of the location of the confluence in the freshwater atlas.

Background

At the crossing location, the stream had good flow and is located within an area of old growth cedar adjacent to a recreation trail. At the time of the survey the stream was the highest volume tributary to Lizard Creek located on the east side of the valley. No fisheries information was available for the stream (MoE 2020d). Downstream however, Lizard Creek supports westslope cutthroat trout, bull trout, mountain whitefish, brook trout, longnose sucker and longnose dace (MoE 2020b). Elk River Alliance (2020) conducted redd surveys in Lizard Creek in 2019 with a total of 55 redds observed within a 2.4km of stream surveyed comprising the largest densities of redds of the four tributaries surveyed (22.9 redds/km).

PSCIS stream crossing 62516 was ranked as a high priority for follow up with habitat confirmation due to the relatively large size of the stream recorded in PSCIS (channel width = 3.5m) relative to other tributary streams in the Lizard Creek watershed and because it was rated as containing high value habitat by VAST Resource Solutions Inc. (2013) and Grainger (2011). There is a bridge (PSCIS 197566) located on the Lazy Lizard recreation trail approximately 350m upstream of the crossing and an unassessed modelled crossing (modelled ID 4600929) approximately 950m upstream. Downstream approximately 400m there is a foot bridge (PSCIS 197544) on a recreational hiking/biking trail. The habitat confirmation was completed on September 23, 2020. A map of the watershed including areas surveyed is provided in Attachment 1 – Map 082G.113.

Stream Characteristics at Crossing

Th culvert located at PSCIS 62516 appeared to have been replaced in 2020 with fresh rock and road fill present. At the time of the survey, the un-embedded and non-backwatered 1.2m diameter crossing was considered a barrier to upstream fish passage with a pipe length of 11m, a culvert slope of 5%, a stream width ratio of 2.1 and an outlet drop of 0.49m (Table 5.24). Water temperature was 9°C, pH was 7.9 and conductivity was 333uS/cm.

Stream Characteristics Downstream

The stream was surveyed downstream from the culvert for 630m to Lizard Creek. Overall, 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 (Table 5.25, Figure 5.24). The average channel width was 2.5m, the average wetted width was 1.4m and the average gradient was 2.7%. The dominant substrate was gravels with cobbles subdominant. Adjacent to the historic road, on the right bank of stream, there was very limited shrub and tree riparian vegetation. Downstream of the crossing there were frequent sections of gravels suitable for salmonid spawning and no barriers or obstacles to fish passage. Habitat was rated as high value for fry/juvenile salmonid rearing.

Stream Characteristics Upstream

The stream was surveyed upstream from the culvert for 730m. Overall, 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 (Table 5.25, Figure 5.24). The average channel width was 2m, the average wetted width was 1.3m and the average gradient was 7.6%. There were abundant gravels suitable for resident westslope cutthrout trout spawning throughout (Figure 5.24). Fry were observed within the area surveyed to 540m upstream of the culvert where gradients increased to >20% for a distance of approximately 15m. Although no sampling was conducted, no fish were observed above this high gradient section. Habitat value was rated as high for fry/juvenile salmonid rearing.

Structure Remediation and Cost Estimate

Structure replacement with a bridge is recommended to provide access to the habitat located upstream of PSCIS crossing 62516. The cost of the work is estimated at $125,000 for a cost benefit of 4.3 linear m/$1000 and 8.6$m^2$/$1000.

Conclusion

There is 0.54km of mainstem habitat upstream of crossing 62516 with habitat rated as high value for fry and juvenile salmonid rearing. The road may be part of the Island Lake Recreational tenure or solely the responsiblity of the Ministry of Forests, Lands, Natural Resource Operations & Rural Development. The crossing was ranked as a moderate priority for proceeding to design for replacement.

Table 5.24: Summary of fish passage reassessment for PSCIS crossing 62516.

Location and Stream Data	•	Crossing Characteristics	–
Date	2020-09-23	Crossing Sub Type	Round Culvert
PSCIS ID	62516	Diameter (m)	1.2
External ID	–	Length (m)	11
Crew	KP, AI	Embedded	No
UTM Zone	11	Depth Embedded (m)	–
Easting	636123	Resemble Channel	No
Northing	5484087	Backwatered	No
Stream	Tributary to Lizard Creek	Percent Backwatered	–
Road	Island Lake Lodge Road	Fill Depth (m)	1.3
Road Tenure	MoTi recreation	Outlet Drop (m)	0.49
Channel Width (m)	2.47	Outlet Pool Depth (m)	0.8
Stream Slope (%)	2.67	Inlet Drop	No
Beaver Activity	No	Slope (%)	5
Habitat Value	Medium	Valley Fill	Deep Fill
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Table 5.25: Summary of habitat details for PSCIS crossing 62516.

Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
Upstream	730	2.0	1.3	0.3	7.6	moderate	high
Downstream	630	2.5	1.4	0.4	2.7	moderate	high

Figure 5.24: Typical habitat downstream of PSCIS crossing 62516.

Figure 5.25: Typical habitat upstream of PSCIS crossing 62516.

Figure 5.26: Gravels suitable for spawning upstream of PSCIS crossing 62516.

Appendix - 197533 & 197559 - Brule Creek

Site Location

PSCIS crossings 197533 and 197559 are located north of Sparwood, BC on Brule Creek, approximately 600m and 725m upstream from the Elk River. During 2020 surveys, two fords (PSCIS 197535 and 197536) were documented 700m and 2km upstream of crossing 197559 respectively. Although several un-assessed crossings are modelled upstream of PSCIS 197536 (ford), review of aerial imagery indicates that the sole crossing upstream on the mainstem of Brule Creek is a bridge (modelled crossing 24706664) and the remaining upstream crossings are on small and/or very steep tributaries and unlikely to be blocking access to significant amounts of important habitat. Both Busato Road and Highway 43 are the responsibility of the Ministry of Transportation and Infrastructure.

Background

At the crossing locations, Brule Creek is a 5th order stream with a watershed area upstream of the highway of approximately 87km^2. The elevation of the watershed ranges from a maximum of 2800 to 1200m at PSCIS crossing 197533. Brule Creek is known to contain westslope cutthrout trout, rainbow trout and bull trout downstream of the subject culverts and westslope cutthrout trout and rainbow trout above (MoE 2020b). On the south side of the upper watershed, at an elevation of 2000m, is the 5ha Josephine Lake (also known as Big Lake). The lake was stocked with westslope cutthrout trout from 1983 - 2000 (MoE 2020b; “Fish Inventories Data Queries” 2020).

PSCIS stream crossings 197533 and 197559 were ranked as high priorities for follow up with fish passage assessments and habitat confirmations due to the large size of the stream network upstream (37km) of the highway and because Brule Creek is a 5th order stream. The habitat confirmation was completed on September 17, 2020. A map of the watershed including areas surveyed is provided in Attachment 1 – Map 082G.123.

Stream Characteristics at Crossing

At the time of the survey, both culverts were un-embedded, non-backwatered and considered barriers to upstream fish passage. PSCIS crossing 197533 was 3.3m in diameter with a pipe length of 20m, a culvert slope of 4%, a stream width ratio of 2.2 and an outlet drop of 0.7m (Table 5.26). PSCIS crossing 197559 was 2.5m in diameter with a pipe length of 35m, a culvert slope of 2.5%, a stream width ratio of 2.4 and an outlet drop of 0m (Table 5.27). Water temperature was 6°C, pH was 7.5 and conductivity was 337uS/cm.

Stream Characteristics Downstream of 197533

The stream was surveyed downstream from the culvert for 400m. Overall, total cover amount was rated as moderate with small woody debris dominant. Cover was also present as large woody debris and overhanging vegetation (Table 5.28, Figure 5.27). The average channel width was 7.4m, the average wetted width was 4.1m and the average gradient was 1.9%. The dominant substrate was cobbles with boulders subdominant. In the area surveyed, the stream channel appeared to be anthropogenically channelized and straightened with influence of adjacent livestock grazing/access negatively impacting stream banks due to loss of riparian vegetation and erosion. Habitat was rated as medium as it was considered an important migration corridor with moderate value habitat for fry/juvenile salmonid rearing.

Stream Characteristics Upstream of 197533 and Downstream of 197559

The stream was surveyed upstream from 197533 for 125m to 197559. Overall, total cover amount was rated as moderate with small woody debris dominant. Cover was also present as large woody debris and overhanging vegetation (Table 5.28, Figure 5.28). The average channel width was 5.5m, the average wetted width was 3.8m and the average gradient was 1.5%. There was a large pool at the outlet of crossing 197559 containing approximately nine westslope cutthrout trout with lengths of five of the fish estimated at 200mm and four at 300mm (Figure 5.29). The outlet pool depth was >1m with gravels suitable for spawning at the tailout. Habitat value was rated as high for resident and fluvial salmonid rearing and spawning.

Stream Characteristics Upstream of 197559

The stream was surveyed immediately upstream from 197559 for 1200m and then another 600m beginning at the ford (PSCIS 197536) 2km upstream for a total of 1600m. The channel was dewatered immediately upstream of Highway 43 with intermittent pools only to a distance approximately 670 m upstream (Figure 5.30). Upstream of the dewatered area, stream flows increased with increasing upstream distance. Overall, total cover amount was rated as moderate with deep pools dominant. Cover was also present as boulders and undercut banks (Table 5.28, Figure 5.31). The average channel width was 5.5m, the average wetted width was 2.3m and the average gradient was 3.5%. Overall, habitat upstream of 197559 was rated as high value habitat present suitable for resident and fluvial salmonid rearing and spawning.

Fish Sampling

To assess potential impacts of the culvert on fisheries values in the stream, electrofishing was conducted upstream of the crossing. Sampling was not conducted downstream of crossing 197559 as bull trout presence was suspected and it was determined that spawners and/or eggs may have been present. One site was sampled upstream with no fish captured (Figure 5.15). Raw results are included in digital format as Attachment 2 and summarized in Table 5.29.

Structure Remediation and Cost Estimate

As properties on Busato Road could be accessed from either side of the road, removal of PSCIS 197533 could be explored as an option for providing access to the 125m of habitat located upstream and below PSCIS 197533. However, to facilitate an estimate of “worst case scenario”, costs for replacement of both crossing 197533 and 197559 with bridges are estimated at $710,000 and $6,100,000 respectively. The combined cost benefit of replacements are estimated at $4000 linear m/$1000 and and $30000m^2/$1000.

Conclusion

There is 0.12km of habitat upstream of crossing 197533 and another 23km upstream of 197559 rated as high value for resident and fluvial salmonid rearing/spawning. The lack of fish captured upstream of the crossing is not necessarily an indication of a lack of fish presence but may be indicative of low population densities and/or restricted access due to downstream culverts and dewatering. Although an interim ranking for remediation at the crossings was assessed as high priority to proceeding to designs for both crossings, follow up to determine the extent of dewatering during higher flow periods is recommended. Although unconfirmed at the time of reporting, the 670m section of stream located immediately upstream of Highway 43 that was flowing subsurface at the time of the survey, very likely flows above ground during high and peak flows when adult westslope cutthrout trout display a general pattern of upstream movement to spawning areas (Schweigert et al. 2017).

Table 5.26: Summary of fish passage reassessment for PSCIS crossing 197533.

Location and Stream Data	•	**Crossing Characteristics**	–
Date	2020-09-17	Crossing Sub Type	Oval Culvert
PSCIS ID	197533	Diameter (m)	3.3
External ID	–	Length (m)	20
Crew	AI, KP	Embedded	No
UTM Zone	11	Depth Embedded (m)	–
Easting	651626	Resemble Channel	No
Northing	5528888	Backwatered	No
Stream	Brule Creek	Percent Backwatered	–
Road	Busato Rd	Fill Depth (m)	1
Road Tenure	MoTi local	Outlet Drop (m)	0.7
Channel Width (m)	7.1	Outlet Pool Depth (m)	1.5
Stream Slope (%)	2	Inlet Drop	Yes
Beaver Activity	No	Slope (%)	4
Habitat Value	High	Valley Fill	Deep Fill
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Table 5.27: Summary of fish passage reassessment for PSCIS crossing 197559.

Location and Stream Data	•	**Crossing Characteristics**	–
Date	2020-09-17	Crossing Sub Type	Round Culvert
PSCIS ID	197559	Diameter (m)	2.5

External ID	–	Length (m)	35
Crew	KP, AI	Embedded	Yes
UTM Zone	11	Depth Embedded (m)	0.05
Easting	651516	Resemble Channel	Yes
Northing	5528829	Backwatered	No
Stream	Brule Creek	Percent Backwatered	–
Road	Highway 43	Fill Depth (m)	3
Road Tenure	MoTi highway	Outlet Drop (m)	0
Channel Width (m)	6.1	Outlet Pool Depth (m)	1.7
Stream Slope (%)	1.5	Inlet Drop	No
Beaver Activity	No	Slope (%)	2.5
Habitat Value	Medium	Valley Fill	Deep Fill
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Table 5.28: Summary of habitat details for PSCIS crossings 197533 and 197559.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
197533	Upstream	125	5.5	3.8	–	1.5	moderate	high
197533	Downstream	400	7.4	4.1	–	1.9	moderate	medium
197559	Upstream	1600	7.7	2.3	0.6	3.5	moderate	high

Table 5.29: Electrofishing site upstream of PSCIS crossing 197559.

Site	Location	Width (m)	Length (m)	Area (m2)	Effort (s)	Effort (s/m2)
6	Upstream	5.1	200	1020	233	0.2

Figure 5.27: Typical habitat downstream of PSCIS crossing 197533.

Figure 5.28: Typical habitat upstream of PSCIS crossing 197533 and downstream of PSCIS crossing 197533.

Figure 5.29: Westlope cutthrout trout in outlet pool downstream of PSCIS crossing 197559.

Figure 5.30: Subsurface flow area upstream of PSCIS crossing 197559.

Figure 5.31: Typical habitat above dewatered area upstream of PSCIS crossing 197533.

Figure 5.32: Habitat within electrofishing site upstream of PSCIS crossing 197533.

Appendix - 197534 - Weigert Creek

Site Location

Crossing 197534 is located on a Weigert Creek, approximately 675m upstream from the confluence with the Elk River. The crossing is located on Highway 43 approximately 20km north of Sparwood. Elk Valley Park recreation site is located downstream of the crossing adjacent to the right bank of the river and the watershed upstream of the crossing is a habitat protection area with motor vehicle restrictions.

Background

At the crossing location, the stream is fourth order with a watershed area upstream of the road of approximately 43.3 km^2 situated between Phillips Peak and Mount VanBuskirk. The elevation of the watershed ranges from a maximum of 2950 to 1250m at the culvert. Although, there are several modelled crossings on the mainstem of Hartley Creek upstream of the crossing, 2020 surveys indicated they were either fords or bridges. Modelled crossing 4606006 is a ford located approximately 1.2km upstream of the highway. There are several additional crossings modelled further upstream on the mainstem, however it is suspected that these crossings have been removed to facilitate the motor vehicle restrictions in place in the watershed. Westslope cutthroat trout and bull trout have been recorded in Weigert Creek downstream of PCSIS 197534. Although multiple upstream survey sites are recorded within provincial databases, there have been no fish recorded upstream (MoE 2020d, 2020b).

PSCIS stream crossing 197534 was ranked as a high priority for follow up with habitat confirmation due to the large amount of potential habitat modelled upstream (20km). The habitat confirmation was completed on September 17, 2020. A map of the watershed including areas surveyed is provided in Attachment 1 – Map 082G.123.

Stream Characteristics at Crossing

At the time of the survey, the un-embedded and non-backwatered 3.2m diameter crossing was considered a barrier to upstream fish passage with a pipe length of 18m, a culvert slope of 3.4%, a stream width ratio of 1.3 and an outlet drop of 0.15m (Table 5.30). Water temperature was 3°C, pH was 8.5 and conductivity was 422uS/cm.

Stream Characteristics Downstream

The stream was surveyed downstream from the culvert for 675m. Overall total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris, large woody debris, boulders, deep pools, and overhanging vegetation (Table 5.31, Figure 5.33). The average channel width was 4.7m, the average wetted width was 3.6m and the average gradient

was 3.7%. The dominant substrate was cobbles with gravels subdominant. Pools were present to 0.8m deep and gravels/cobbles suitable for resident and fluvial spawning were present. A ford crosses the stream at the Fortis gasline located approximately 115m downstream of the highway. Overall, habitat was rated as medium value providing an important migration corridor and habitat suitable for resident and fluvial salmonid rearing and spawning.

Stream Characteristics Upstream

The stream was surveyed immediately upstream from the culvert for 675m. Overall, total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris, large woody debris, boulders, deep pools, and overhanging vegetation (Table 5.31, Figure 5.34). The average channel width was 6.6m, the average wetted width was 4.6m and the average gradient was 4.5%. The dominant substrate was cobbles with boulders subdominant. Habitat became increasingly complex with increased distance upstream. Throughout the area surveyed there were occasional pools available with depths suitable for juvenile/adult salmonid overwintering and rearing and frequent sections of gravels available for resident and fluvial salmonid spawning. Overall, habitat was rated as medium value.

Structure Remediation and Cost Estimate

Structure replacement with a bridge is recommended to provide access to the habitat located upstream of PSCIS crossing 197534. The cost of the work is estimated at $5,000,000 for a cost benefit of 2.3 linear m/$1000 and 15.3$m^2$/$1000.

Conclusion

There is an estimated 11.6km of mainstem Weigert Creek habitat available upstream of PSCIS 197534 with habitat rated as high value, representing an important migration corridor with high rearing and spawning potential for resident and fluvial salmonids. Highway 43 is the responsibility of the Ministry of Transportation and Infrastructure. The crossing was ranked as a high priority for proceeding to design for replacement with an open bottomed structure.

Table 5.30: Summary of fish passage reassessment for PSCIS crossing 197534.

Location and Stream Data	•	Crossing Characteristics	–
Date	2020-09-17	Crossing Sub Type	Round Culvert
PSCIS ID	197534	Diameter (m)	3.2
External ID	–	Length (m)	18
Crew	AI, KP	Embedded	No
UTM Zone	11	Depth Embedded (m)	–
Easting	650144	Resemble Channel	No
Northing	5532055	Backwatered	No
Stream	Weigert Creek	Percent Backwatered	–
Road	Highway 43	Fill Depth (m)	1.3
Road Tenure	MoTi highway	Outlet Drop (m)	0.15
Channel Width (m)	4.3	Outlet Pool Depth (m)	0.6
Stream Slope (%)	2	Inlet Drop	Yes
Beaver Activity	No	Slope (%)	3.4
Habitat Value	High	Valley Fill	Deep Fill
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			


2020-09-17, 11:27 AM
11U 650127 5532061
2020-09-17, 11:25 AM
11U 650157 5532067
2020-09-17, 11:29 AM

Table 5.31: Summary of habitat details for PSCIS crossing 197534.

Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
Upstream	1100	6.6	4.6	0.5	4.5	moderate	high
Downstream	675	4.7	3.6	0.5	3.7	moderate	medium

Figure 5.33: Habitat downstream of PSCIS crossing 197534.

Figure 5.34: Habitat upstream of PSCIS crossing 197534.

Appendix - 197542 - Hartley Creek

Site Location

Crossing 197542 is located on a Hartley Creek, approximately 400m upstream from the confluence with the Elk River. The crossing is located on Dicken Road just north of Fernie. Dicken Road is a paved Ministry of Transportation and Infrastructure collector road accessing semi-rural residential and recreational areas.

Background

At the crossing location, the stream is fourth order with a watershed area upstream of the road of approximately 17.1 km^2. The elevation of the watershed ranges from a maximum of 2350 to 1030m at the culvert. The system is headed by the 1.6ha Hartley Lake. Although, there are several modelled crossings on the mainstem of Hartley Creek upstream of the crossing, 2020 surveys indicated they were either not present (4603296, 24732660) or bridges (4606518). PSCIS crossing 197582 is an open bottomed structure located under Highway 3 approximately 400m downstream of Dicken Road and was considered passable.

During surveys, we spoke with the owner of lands adjacent to crossing 197542 and they noted that the properties both upstream and downstream of the crossing were located within an area used historically as a log sort and that Hartley Creek was used to transport logs at that time. The landowner also reported that within the last ten years there was a dam failure upstream near Hartley Lake that resulted in significant debris flows throughout the lower reaches of the stream. Aggradation of the channel adjacent to this crossing, reported by Robinson (2008) as likely a result of a low width/depth ratio and unstable banks, has been an ongoing issue requiring repeated dredging to reduce disruptions to traffic flow and high water damage to highway infrastructure. Interior Reforestation Co. Ltd. designed and installed remediation measures in 2006 and 2007 (vortex weir installation, channel armouring, rootwad installation and riparian planting) with the intent to restore the hydraulic conditions necessary to carry transported gravel further downstream and improve fish habitat immediately below the crossing (Robinson 2008). The works were not completely successful in preventing aggradation, as dredging was reported in 2019 (Marlim Ecological Consulting 2019) with only approximately 30cm of headboard observed within the highway stream crossing structure during 2020 surveys.

Westslope cutthroat trout, bull trout and brook trout have been recorded in Hartley Creek upstream of PCSIS 197542 with westslope cutthroat trout, bull trout and mountain whitefish recorded below (MoE 2020b). A radio-tagging study conducted in 2001–2002, identified Hartley Creek as a spawning location of westslope cutthrout trout captured and tagged in the Elk River (Schweigert et al. 2017). In 2012, three pass closed site electrofishing data, including individual fish collection information, sampling effort and site measurements were collected for three sites located within the first 100m upstream of Dicken Road as part of work completed by Lotic Environmental Ltd. (2012)

to produce habitat suitability for westslope cutthrout trout in the Upper Elk River. Westslope cutthrout trout were captured at all sites.

PSCIS stream crossing 197542 was ranked as a high priority for follow up with habitat confirmation due to the large amount of potential habitat modelled upstream (13km) including the 1.6ha Hartley Lake. The habitat confirmation was completed on September 18, 2020. A map of the watershed including areas surveyed is provided in Attachment 1 – Map 082G.113.

Stream Characteristics at Crossing

At the time of the survey, the un-embedded and non-backwatered 2.6m diameter oval crossing structure was considered a barrier to upstream fish passage with a pipe length of 20m, a culvert slope of 2%, a stream width ratio of 1.3 and an outlet drop of 0.4m (Table 5.32). Water temperature was 5°C, pH was 8.6 and conductivity was 526uS/cm.

Stream Characteristics Downstream

The stream was surveyed downstream from the culvert for 940m to the confluence with the Elk River including the 500m below PSCIS crossing 197582. Within the 400m section between Dicken Road and Highway 3, total cover amount was rated as moderate with deep pools dominant. Cover was also present as small woody debris and undercut banks (Table 5.33, Figure 5.35). The average channel width was 3.6m, the average wetted width was 2.8m and the average gradient was 1.7%. The dominant substrate was gravels with cobbles subdominant. Although abundant gravels suitable for spawning were present, the Hartley Creek channel appeared anthropogenically straightened in the area surveyed with a notable lack of deep pools and undercut banks. Overall, habitat was rated as medium value providing suitable habitat for resident and fluvial westlope cutthrout trout spawning.

Within the 500m below PSCIS crossing 197582, the first 175m of channel downstream of the culvert was primarily composed of an aggrading gravel channel with widths between 12-15m. Downstream of this initial section was a marsh area impounded by multiple beaver dams containing run sections to 1m deep and fine substrates. Much of the channel surveyed within the lower sections was within the Elk River floodplain. Total cover amount was rated as moderate with overhanging vegetation dominant. Cover was also present as small woody debris, large woody debris, and instream vegetation (Table 5.33, Figures 5.36 - 5.37). The average channel width was 8.1m, the average wetted width was 6.3m and the average gradient was 1.8%. The dominant substrate was gravels with fines subdominant. Young of the year salmonids were observed upstream of upper most beaver dam. Habitat was rated as medium representing an important migration corridor containing habitat with moderate rearing potential for resident and fluvial salmonids.

Stream Characteristics Upstream

The stream was surveyed immediately upstream from the culvert for 650m with an addition 75m section surveyed upstram approximatley 2.5km upstream. A small dam (0.3m) high is located approximately 5m upstream of Dicken Road and may present an obstruction to upstream fish passage for fry and juvenile salmonids at some flows. Overall, total cover amount was rated as moderate with deep pools dominant. Cover was also present as small woody debris, undercut banks, and overhanging vegetation (Table 5.33, Figure 5.38). The average channel width was 6.1m, the average wetted width was 3.8m and the average gradient was 3.5%. The dominant substrate was cobbles with gravels subdominant. There were frequent pools formed by small and large woody debris ranging from 0.3 - 0.7m in depth with a debris jam near top of site (11U 643668 5491243) measured at 1.2m in height. Pockets of gravels suitable for resident and fluvial salmonids were present and there were areas of erosion notable on the right bank of the stream.

Within the 75m section of stream surveyed 2.5km upstream of Dicken Road, stream conditions were similiar to those observed downstream with an average channel width of 4.6m and gravel dominated substrate (Figure 5.39). Overall, upstream of PSCIS 197542 was rated as high habitat value, containing habitat with moderate rearing and spawning potential for resident and fluvial salmonids.

Structure Remediation and Cost Estimate

Structure replacement with an open bottomed structure is recommended to provide access to the habitat located upstream of PSCIS crossing 197542. The cost of the work is estimated at $1,000,000 for a cost benefit of 7.2 linear m/$1000 and 43.9$m^2$/$1000.

Conclusion

There is an estimated 7.2km of mainstem habitat available upstream of crossing 197542 with habitat rated as high value, representing an important migration corridor with moderate rearing and spawning potential for resident and fluvial salmonids. Dicken Road is the responsiblity of the Ministry of Transportation and Infrastructure. We recommend fish collection data from Lotic Environmental Ltd. (2012) be analyzed to calculate baseline fish densities upstream of the crossing in 2012. The crossing was ranked as a high priority for proceeding to design for replacement with an open bottomed structure. The private land adjacent to Hartley Creek in the vicinity of Dicken Road and Highway 3 may represent valuable opportunities for channel and riparian restoration activities as it is located within an area of intensive fish habitat impacts resulting from dredging to protect highway infrastructure as well as other historic land use activities (i.e. log transport and processing).

Table 5.32: Summary of fish passage reassessment for PSCIS crossing 197542.

Location and Stream Data	•	Crossing Characteristics	–
Date	2020-09-18	Crossing Sub Type	Oval Culvert
PSCIS ID	197542	Diameter (m)	2.6
External ID	–	Length (m)	20
Crew	AI, KP	Embedded	No
UTM Zone	11	Depth Embedded (m)	–
Easting	643534	Resemble Channel	No
Northing	5490723	Backwatered	No
Stream	Hartley Creek	Percent Backwatered	–
Road	Dicken Road	Fill Depth (m)	0.4
Road Tenure	MoTi collector	Outlet Drop (m)	0.4
Channel Width (m)	3.5	Outlet Pool Depth (m)	0.8
Stream Slope (%)	1	Inlet Drop	No
Beaver Activity	No	Slope (%)	2
Habitat Value	High	Valley Fill	Deep Fill
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Stream Characteristics Upstream

Table 5.33: Summary of habitat details for PSCIS crossing 197542.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
197542	Upstream	725	6.1	3.8	0.5	3.5	moderate	high
197542	Downstream	400	3.6	2.8	0.2	1.7	moderate	medium
197582	Downstream	540	8.1	6.3	0.5	1.8	moderate	medium

Figure 5.35: Typical habitat downstream of PSCIS crossing 197542.

Figure 5.36: Typical habitat downstream of PSCIS crossing 197582.

Figure 5.37: PSCIS crossing 197582.

Figure 5.38: Typical habitat upstream of PSCIS crossing 197542.

Figure 5.39: Habitat upstream of PSCIS crossing 197542 approximatley 2.5km.

Appendix - 197555 - Tributary to Elk River

Site Location

Crossing 197555 is located on a tributary to Elk River, approximately 900m upstream from the confluence with the Elk River. The crossing is located on the Elk River FSR approximately 10km north of Elkford, BC. The Elk River FSR is a gravel forest tenure road (forest file id 0103) with active log hauling at the time of the survey.

Background

At the crossing location, the stream is 4th order with a watershed area upstream of the road of approximately 17km^2. The elevation of the watershed ranges from a maximum of 2900 to 1400m at the culvert. Upstream of the crossing, there are no anthropogenic barriers on the mainstem. Although there are two modelled crossings on small tributaries that enter the stream approximately 1.5km upstream of the road, machinery operators encountered onsite indicated that they had been removed during road deactivation. No fisheries information was available for the stream (MoE 2020d) however westslope cutthroat trout, bull trout, mountain whitefish, brook trout, longnose sucker and longnose dace (among other species) have been recorded downstream in the Elk River (MoE 2020b).

PSCIS stream crossing 197555 was ranked as a high priority for follow up with habitat confirmation due to the large amount of habitat modelled upstream of the crossing. The habitat confirmation was completed on September 16, 2020. A map of the watershed including areas surveyed is provided in Attachment 1 – Map 082J.103.

Stream Characteristics at Crossing

At the time of the survey, the un-embedded and non-backwatered 1.5m diameter crossing was considered a barrier to upstream fish passage with a pipe length of 49m, a culvert slope of 3.5%, a stream width ratio of 2.3 and an outlet drop of 1.48m (Table 5.34). Water temperature was 6°C, pH was 7.2 and conductivity was 378uS/cm.

Stream Characteristics Downstream

The stream was surveyed downstream from the culvert for 700m. Overall, total cover amount was rated as moderate with deep pools dominant. Cover was also present as small woody debris, large woody debris, boulders, and overhanging vegetation (Table 5.35, Figure 5.40). The average channel width was 4.4m, the average wetted width was 3.1m and the average gradient was 3.6%. The dominant substrate was cobbles with gravels subdominant . There were frequent pools formed by small and large woody debris ranging from 0.3 - 0.75m in depth (average residual depth = 0.4m).

Frequent pockets of gravels suitably sized for resident and fluvial salmonid spawning were also present. Habitat value was rated as high with good potential for fry/juvenile salmonid rearing.

Stream Characteristics Upstream

The stream was surveyed upstream from the culvert for 675m. Overall, total cover amount was rated as abundant with boulders as the dominant type. Cover was also present as small woody debris, large woody debris, undercut banks, deep pools, and overhanging vegetation (Table 5.35, Figure 5.41). The average channel width was 5.9m, the average wetted width was 3.8m and the average gradient was 5.9%. The dominant substrate was cobbles with boulders subdominant. The stream had good flows, pools to 0.6m deep (average residual depth = 0.4m) were present and pockets of gravel suitable for spawning were observed throughout. Infrequent large woody debris jams to 0.5m high were also noted. Habitat value was rated as high for fry and juvenile westslope cutthrout trout and bull trout rearing.

Fish Sampling

To assess potential impacts of the culvert on fish communities in the stream, electrofishing was conducted upstream and downstream of the crossing. One 150m site was sampled upstream and one 315m site was sampled downstream. One bull trout was captured downstream and no fish were captured upstream (Figure 5.42). Raw results are included in digital format as Attachment 2 and summarized in Table 5.36.

Structure Remediation and Cost Estimate

Structure replacement with an open bottomed culvert is recommended to provide access to the habitat located upstream of PSCIS crossing 197555. Due to the large amount of fill on the road (8m) the size of a replacement bridge was estimated at 25m. The cost for work is estimated at $312,000 for a cost benefit of 19200linear m/$1000 and 113500$m^2$/$1000.

Conclusion

There is an estimated 6km of mainstem habitat upstream of crossing 197555 with habitat in the areas surveyed upstream of the crossing rated as high value for fry and juvenile salmonid rearing. However, fish sampling results indicate that westslope cutthrout trout are not currently utilizing the stream and densities of bull trout are very low. This could be the result of the cold water conditions due to the positioning of the watershed at high elevation in the generally cold Rocky Mountain setting. Elk River FSR is a forest tenure liscensee road of the Ministry of Forests, Lands, Natural Resource Operations & Rural Development. The crossing was ranked as a moderate priority for proceeding to design for replacement with an open bottomed structure.

Table 5.34: Summary of fish passage reassessment for PSCIS crossing 197555.

Location and Stream Data	•	Crossing Characteristics	–
Date	2020-09-16	Crossing Sub Type	Round Culvert
PSCIS ID	197555	Diameter (m)	1.5
External ID	–	Length (m)	49
Crew	KP, AI	Embedded	No
UTM Zone	11	Depth Embedded (m)	–
Easting	646735	Resemble Channel	No
Northing	5554534	Backwatered	No
Stream	Tributary to Elk River	Percent Backwatered	–
Road	Elk River FSR	Fill Depth (m)	8
Road Tenure	FLNR 0103	Outlet Drop (m)	1.48
Channel Width (m)	3.5	Outlet Pool Depth (m)	1.3
Stream Slope (%)	1.5	Inlet Drop	Yes
Beaver Activity	No	Slope (%)	3.5
Habitat Value	High	Valley Fill	Deep Fill
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Table 5.35: Summary of habitat details for PSCIS crossing 197555.

Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
Upstream	675	5.9	3.8	0.4	5.9	abundant	high
Downstream	700	4.4	3.1	0.4	3.6	moderate	high

Table 5.36: Electrofishing sites for PSCIS crossing 197555.

Site	Location	Width (m)	Length (m)	Area (m2)	Effort (s)	Effort (s/m2)
4	Downstream	3.1	315	976	550	0.6
3	Upstream	3.8	150	570	177	0.3

Figure 5.40: Typical habitat downstream of PSCIS crossing 197555.

Figure 5.41: Typical habitat upstream of PSCIS crossing 197555.

Figure 5.42: Bull trout captured downstream of PSCIS crossing 197555.

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