Chance Oil and Gas, Eagle Plains Project: Fish and Fish Habitat Studies

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EXECUTIVE SUMMARY

The Eagle Plains Project (the Project) is an oil and gas exploration program in north-central Yukon, approximately 605 km north of Whitehorse along the Dempster Highway. Chance Oil and Gas Ltd. intends to conduct exploratory activities over 10 years to confirm the quality, quantity, and areal extent of hydrocarbons. Project activities will include seismic exploration and exploratory wells supported by an expanded winter road network. The purpose of this study was to collect information to understand better the distribution of fish and fish habitat across the Regional Study Area (RSA) in both summer and winter. This information will be used to assess the Project's potential effects on fisheries values and guide measures to mitigate effects, if warranted.

The RSA is located within the Eagle Plains Ecoregion, which consists of a relatively subdued topography of rolling hills and sloping plains between the Richardson and Ogilvie Mountains. The RSA is centred on a local height of land, with areas to the north and west draining into the Yukon River (Pacific) system via the Porcupine watershed, and areas to the southeast draining into the Mackenzie River (Arctic) system via the Peel watershed. The largest named streams in the RSA include Chance (Porcupine), McParlon (Porcupine), Dalglish (Peel), and Enterprise (Peel) creeks. The RSA encompasses 1,467 streams, most of which are smaller headwater streams; there are 1,142 first-order streams[1], 239 second-order, 68 third-order, 16 fourth-order, and 2 fifth-order streams in the RSA. Few ponds and lakes occur in the RSA, with none greater than 5 ha. Before this study, very little was known about fisheries values in the RSA; Arctic grayling had been detected in a handful of locations across the RSA.

This study aimed to determine fish occurrence patterns across the RSA. This included: (i) a quantitative estimate of the probability of fish occurrence in all streams during summer and (ii) a more qualitative description of fish distribution based on habitat in winter (due to limitations in surveying fish presence during the winter). Due to the large number of streams in the area it was not possible to survey all streams that had the potential to be affected by exploration activities. Instead, a predictive, model-based approach was used, like a recent study conducted by the Yukon Government in the adjacent Peel watershed. The approach consisted of surveying a representative subsample of streams across the RSA and interpolating the probability of fish presence at all streams in the RSA using a statistical model. The environmental variables considered in the model included: stream order, stream slope, terrain slope, elevation, catchment area, and, as measures of potential overwintering habitat, distance to third-, fourth-, and fifth-order streams, as well as the distance to in-line ponds. The relationship between fish presence and environmental conditions was analyzed using logistic regression. Models with different combinations of the environmental variables were compared using corrected Akaike Information Criterion (AIC) scores.

To obtain a representative subsample of streams to support statistical analyses, survey sites were selected using a stratified random design, stratifying by stream order. Summer field surveys included fish sampling, habitat assessment, and water quality sampling. Fish sampling involved electrofishing supplemented with minnow trapping at a subsample of sites. Fish habitat descriptions included a broad suite of stream characteristics, such

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[1] Stream order refers to the relative position of a stream within a watershed and is based on the number of upstream tributaries. The greater the stream order number, the larger the stream and the lower/further downstream it occurs within a watershed.

as stream width and depth, gradient, type and extent of cover, and type of bed material, as well as qualitative assessments of spawning, overwintering and rearing potential. Water sampling included temperature, turbidity, conductivity, and dissolved oxygen. In winter, sampling initially required drilling holes through the ice to determine if water was present. If water was present, the presence of fish was assessed with an underwater camera and water temperature, conductivity, and dissolved oxygen were measured. A total of 118 sites were surveyed in the summer, from July 25 to August 1, 2019, and 49 sites were surveyed in the winter, from March 7 to 13, 2020.

Survey results showed clear fish distribution patterns in summer and habitat availability for fish during winter. In summer, the best model for fish occurrence was based solely on stream order. The probability of fish occurrence was 8% in first-order streams, 45% in second-order, 89% in third-order, 99% in fourth-order, and 100% in fifth-order streams. Fish were detected in almost none of the first-order streams, half of the second-order streams, and almost all third-order and greater streams during summer sampling. The variability of fish presence in second-order streams was partly attributable to differences in site-specific conditions (e.g., different channel widths and stream depths at different streams); however, across many second-order streams the intermediate probability of fish occurrence simply reflects marginal fish habitat conditions. Five fish species were captured during the summer sampling program. Arctic grayling (*Thymallus arcticus*) were the most widespread captured species, accounting for 85% of captured fish. Slimy sculpin (*Cottus cognatus*), longnose sucker (*Catostomus catostomus*), round whitefish (*Prosopium cylindraceum*), and burbot (*Lota lota*) were also captured in limited numbers and locations. No salmon were observed in the RSA, consistent with historical information about salmon distribution within the area. In terms of habitat, most streams (all streams in the Porcupine watershed) consisted of low gradient, slow-moving streams with turbid water and bed materials dominated by fines and organics. Most streams were rated as having low spawning potential and moderate summer rearing potential for most fish species.

Winter field assessments determined that most first-, second- and third-order streams either freeze to bed or dewater during the winter. The presence of water at one second-order stream and four third-order streams all occurred in residual pools in ponds the streams flowed through. The outlet channels of these ponds were all dewatered, indicating that water was limited to residual pools and no stream flow was present. Of the 16 fourth- and fifth-order streams surveyed, 63% of the sites contained water, but the majority also appeared to be residual pools with no flow; only four sites had evidence of flowing water. Of the fifteen sites where water was detected, only one site had dissolved oxygen levels able to support fish. No fish were detected via underwater cameras.

The results of this study indicated a dynamic pattern of fish occurrence in the RSA between summer and winter. Overwintering habitat is very limited in the RSA and most fish likely migrate out of the RSA to find suitable overwintering habitat in larger rivers. The lower reaches of Chance Creek and select sites along McParlon, Dalglish, and Enterprise creeks may offer limited overwintering habitat to a small number of fish (based on water conditions in March 2020 and the presence of non-migratory slimy sculpin at some sites). During summer, transient fish, most notably Arctic grayling, travel tens to greater than 100 km from larger, higher order rivers outside the RSA to use second order and greater streams as seasonal rearing habitat.

ACKNOWLEDGEMENTS

This work was completed within the traditional territories of the Vuntut Gwitchin First Nation (VGFN), First Nation of the Na-Cho Nyäk Dun, and the Tetlit Gwich'in Council (Secondary Use Area). Tyrel Kassi, a VGFN citizen, played an active role in all field components of the project. We thank him for the diligence and perspectives that he shared during the project. During summer fieldwork, crews include Petra Szekeres (EDI crew lead), Pat Tobler (EDI crew lead), Matt Power (EDI), Jonathan Lowey (EDI), and Tyrel Kassi (a VGFN member). Winter fieldwork was conducted by EDI employees Petra Szekeres (lead), Jonathan Lowey, and Tyrel Kassi. Horizon Helicopters provided transportation to sampling sites for both field trips.

AUTHORSHIP

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ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Definition
2D	Two Dimensional
3D	Three Dimensional
AIC	Akaike's Information Criterion
AUC	Area Under the Curve
BC	British Columbia
°C	degrees Celsius
cm	centimetre
DFO	Fisheries and Oceans Canada
FISS	Fisheries Information Summary System
FL	Fork Length
GIS	Geographic Information System
GPS	Global Positioning System
ha	hectares
IMA	Integrated Management Area
km	kilometers
km^2	square kilometers
m	meter
mg/L	milligrams per litre
mm	millimeter
µS/cm	microSiemens per centimetre
NCD	Non-classified Drainages
NND	Na-cho Nyäk Dun
NYLUP	North Yukon Land Use Plan
PWLUP	Peel Watershed Land Use Plan
ROC	Receiver Operating Characteristics
the Project	the Eagle Plains Project (proposed by Chance Oil and Gas Ltd.)
TGC	Tetlit Gwich'in Council
THFN	Tr'ondëk Hwëchin First Nation
TL	Total Length
VGFN	Vuntut Gwitchin First Nation
YESAA	*Yukon Environmental and Socio-Economic Assessment Act*
YESAB	Yukon Environmental and Socio-Economic Assessment Board
YOY	Young-of-the-year

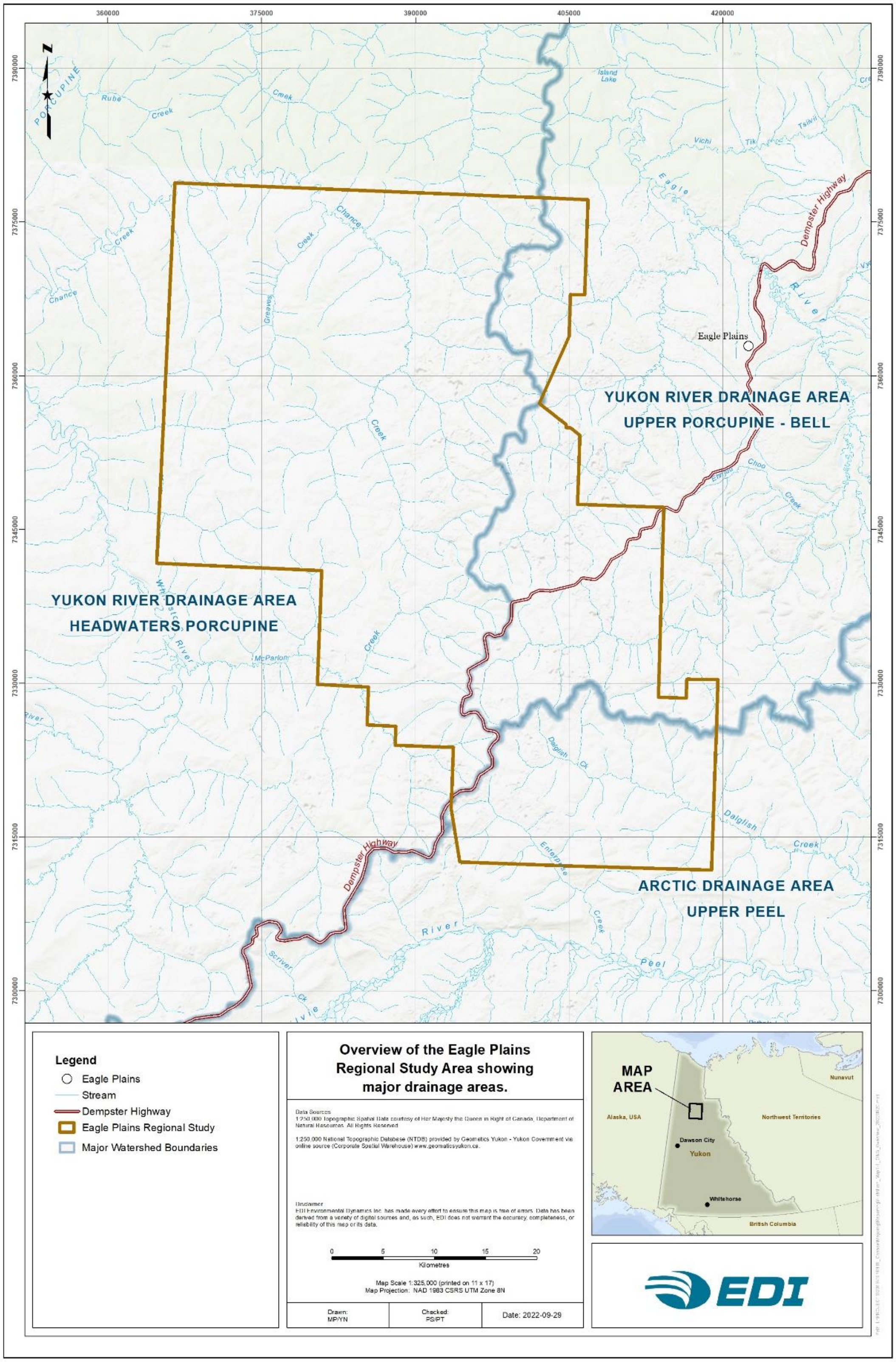
1 INTRODUCTION

1.1 PROJECT DESCRIPTION

The Eagle Plains Project (the Project) encompasses a 2,386 km² area in north-central Yukon, approximately 600 km north of Whitehorse and 40 km south and west of Eagle Plains Hotel, along the Dempster Highway (Map 1-1). The Project occurs within the Eagle Plains petroleum basin, north of the Ogilvie River and west of the Richardson Mountains. The basin contains proven natural gas and oil reserves (Peel Watershed Planning Commission 2019), including 4.6 billion m³ of gas and 3.2 million m³ of oil (Hannigan 2014).

The Regional Study Area (RSA; Map 1-1) has had intermittent periods of oil and gas exploration since the 1950s. That activity has resulted in the development of winter roads, seismic lines, and exploratory wells across parts of the current RSA. Approximately 40 exploration wells have been drilled at Eagle Plains. Eight wells are currently being maintained in suspended status and the remaining wells have been decommissioned. Seismic exploration has included approximately 10,000 km of two-dimensional (2D) lines (mostly before 1985), and about 325 km² of three-dimensional (3D) seismic was conducted in 2013/2014 (Northern Cross (Yukon) Ltd. 2014).

The current exploration program will build on past exploration to better define the extent, amount and quality of oil and gas deposits in the area. Under the current program, Chance Oil and Gas Ltd. Proposes conducting additional seismic exploration over large extents of the RSA and drill up to 30 exploratory wells over 10 years. Depending on the results of the drilling program, extended flow testing may be conducted over several months at a subset of the wells to determine the quantity and quality of the oil and gas deposit. The existing winter road network will be expanded to support the seismic and drilling programs. Most work is expected to be conducted in the winter (e.g., seismic line clearing and drilling); however, seismic recordings and extended flow testing may also occur during summer.



Overview of the Eagle Plains Regional Study Area showing major drainage areas.

Data Sources
1:250,000 Topographic Spatial Data courtesy of Her Majesty the Queen in Right of Canada, Department of Natural Resources. All Rights Reserved.

1:250,000 National Topographic Database (NTDB) provided by Geomatics Yukon - Yukon Government via online source (Corporate Spatial Warehouse) www.geomaticsyukon.ca.

Disclaimer
EDI Environmental Dynamics Inc. has made every effort to ensure this map is free of errors. Data has been derived from a variety of digital sources and, as such, EDI does not warrant the accuracy, completeness, or reliability of this map or its data.

Map Scale 1:325,000 (printed on 11 x 17)
Map Projection: NAD 1983 CSRS UTM Zone 8N

Drawn: MP/YN
Checked: PS/PT
Date: 2022-09-29

Map 1-1. Overview of the Eagle Plains Regional Study Area showing major drainage areas.

1.2 PURPOSE AND OBJECTIVES

Baseline environmental information and data are required for proposed oil and gas projects submitted to the Yukon Environmental and Socio-economic Assessment Board (YESAB) Executive Committee for screening under the *Yukon Environment and Socio-Economic Assessment Act* (YESAA), as well as applications submitted for an Industrial Licence and Type A Water Licence from the Yukon Water Board, among other permits and licences (YESAB 2016).

Aspects of the Project activities (e.g., winter operations using winter roads that avoid soil disturbance) and design (e.g., location of roads to avoid streams and riparian areas) will minimize the potential effects of the Project on fish and fish habitat; however, a small number of streams will need to be crossed. The purpose of this study was to collect baseline information on fish and fish habitat within the RSA. This information can be used to assess the Project's potential effects on fish and fish habitat in the permit proposal to the YESAB and support management measures to mitigate potential effects.

The overall objective of the 2019 and 2020 fisheries and aquatics study was to collect information on fish occurrence across the range of streams within the RSA and use predictive modelling to quantify the probability of fish presence in all streams within the RSA.

The specific objectives of this study were to:

- develop and implement a fish occurrence inventory across the RSA during summer, including:
    - compiling historic fish occurrence data;
    - assembling relevant stream variables to support survey stratification and statistical modelling;
    - developing stream stratification criteria and conducting a stratified random sample to obtain a representative field sample;
    - conducting fish and fish habitat surveys using standardized field survey methods;
    - quantifying relationships between fish presence and environmental variables using statistical models and using the results to predict the probability of fish presence across the remaining streams in the RSA;
- conduct winter water level and quality surveys to determine potential overwintering habitat within the RSA; and,
- provide recommendations for using the results of this study for the YESAB assessment and management measures to mitigate the project's potential effects on fish and fish habitat.

Fish surveys were conducted in July and August when fish distribution is likely most widespread. It was predicted that fish presence was greatly reduced in lower-order streams in winter due to reduced water flow and water quality (i.e., dissolved oxygen). This is due to the lack of permafrost melting as a water source in winter and the general lack of groundwater sources in permafrost-controlled systems (Connon et al. 2014). To address this issue, winter surveys were also conducted to assess water levels and quality across various stream types within the RSA.

1.3 STUDY AREA

The Project encompasses 2,386 km² (238,566 ha), centred in the Eagle Plains Ecoregion in north Yukon. The area consists of subdued topography of rolling hills and sloping plains. The Dempster Highway crosses the southern portion of the RSA (Map 1-1) along a local height of land. From there, the RSA drains into the Porcupine River watershed to the north (via Chance Creek) and west (via McParlon Creek and the Whitestone River) and into the Peel River watershed to the southeast (via Dalglish Creek).

The RSA overlaps four First Nation traditional territories. Most of the RSA is located within the traditional territory of the Vuntut Gwitchin First Nation (VGFN). The southeastern portion is in an area of overlapping traditional territories of VGFN, the Tetlit Gwich'in Council (TGC), the First Nation of Na-cho Nyäk Dun (NND), and Tr'ondëk Hwëchin First Nation (THFN). Although the RSA is located outside any First Nation Settlement Lands, it adjoins VGFN Settlement Lands on parts of its east and southwest borders.

Anthropogenic development in the RSA and the surrounding Eagle Plains is low. The Dempster Highway is the main vehicle access corridor, running from Dawson City, Yukon in the southwest, to Inuvik, Northwest Territories, to the northeast, and transiting the RSA along the way. Several winter access roads also branch off the Dempster Highway. Past oil and gas exploration includes a network of seismic lines, in various stages of regeneration and approximately 40 well sites, all but 8 of which have been decommissioned. The Eagle Plains settlement is located along the Dempster Highway, about 30 km east of the Project boundary and consists of the Eagle Plains Hotel and the Government of Yukon's Highway Maintenance Branch.

The Project is located within the North Yukon Planning Region and Peel Watershed Planning Region and is, therefore, subject to the North Yukon Land Use Plan (NYLUP) and Peel Watershed Land Use Plan (PWLUP) (Vuntut Gwitchin Government and Yukon Government 2009, Peel Watershed Planning Commission 2019). The Project falls within the Integrated Management Area (IMA) Zone IV of both plans, with lower ecological and cultural values and the most permissible development of the four IMA zones. Both Plans describe General Management Directions for fish and fish habitat and identify potential concerns associated with water removal from sensitive and vital overwintering fish habitats, stream crossings, and seismic lines resulting in increased traffic and use of otherwise inaccessible regions and fish stocks.

1.3.1 ECOLOGICAL OVERVIEW

The Eagle Plains Ecoregion is in the Taiga Cordillera Ecozone, characterized by subarctic coniferous forest (90%), and mixed forest and Arctic/alpine tundra (5% each; Yukon Ecoregions Working Group 2004). Black spruce woodlands dominate this Ecoregion, with black spruce-tussock tundra at lower elevations, and shrub-tundra above 800 m (Smith et al. 2004). The Ecoregion is characterized by long winters, generally extending from October to May, with a mean annual temperature of −7.5°C (average −28°C in January and 13°C in July). The Eagle Plains Ecoregion has extensive permafrost, approximately 89 m deep, with the active layer in the top 1 m (i.e., thaws in summer and refreezes in the winter). Permafrost landscapes are prone to dynamic changes in the late spring and summer months due to the thawing of the active layer, resulting in changes to hydrology and overall water quality. Permafrost thaw has been occurring at unprecedented rates in northern latitudes, characterized by elevated discharge rates, elevated silt deposits into waterways, and changes to adjacent riparian zones (e.g., slumping banks, higher sediment loads; Connon et al. 2014).

The major drainages within and adjacent to the RSA include the Porcupine (Yukon Basin) and Peel (Mackenzie Basin) river watersheds, with the subdrainages of the Eagle and Whitestone rivers entering the Porcupine drainage and the Ogilvie River entering the Peel drainage. The largest drainages within the RSA include Chance (Porcupine), McParlon (Porcupine), Dalglish (Peel), and Enterprise (Peel) creeks. The RSA encompasses 1,467 streams, most of which are smaller headwater streams; there are 1,142 first-order streams, 239 second-order, 68 third-order, 16 fourth-order, and 2 fifth-order streams in the RSA (using the Strahler method; Barker et al. 2011). Few ponds and lakes occur in the RSA, with none greater than 5 ha.

Several fish species are found in the major drainages adjacent to the RSA (Table 1-1); however, limited information was available on fisheries values within the RSA, with some available knowledge on fish presence and distribution. The only works conducted in the proximity of the RSA include work conducted by the Yukon Government for the Peel watershed that modelled the likelihood of fish presence based on different environmental variables (Barker et al. 2011), as well as preliminary baseline fish sampling in support of past oil and gas exploration in the area (Anderson Resources Ltd. 2001).

Permafrost and climate strongly affect hydrology and fish presence within the Eagle Plains Ecoregion. Low precipitation occurs in the area, with permafrost largely controlling stream flow. Groundwater flow appears to be very limited across the RSA, as the Eagle Plains Ecoregion is characterized by extensive ground ice (Smith et al. 2004). Peak stream flows are associated with snow and permafrost melt in June, with minimum flows occurring in March. Small streams, and even some intermediate-sized streams, often experience zero flows during the winter months (Smith et al. 2004). Fish presence is expected to be seasonal in response to the variable hydrology throughout the year. Due to the absence of water in lower-order streams during most months of the year, and even intermediate streams experiencing no winter flows, fish are excluded from many streams for much of the year. As a result, little suitable year-round habitat is available for resident fish, with many species instead employing transient, seasonal rearing use of local streams. Arctic grayling is a highly transient fish species and known to travel long distances (e.g., West et al. 1992, EDI 2015).

Conversely, slimy sculpin have high site fidelity and do not travel distances greater than a few hundred metres within their lifetime (Gray et al. 2004, 2018) — as such, they are often used as an indicator species for overwintering potential. Suitable overwintering habitat is often the most limiting factor for seasonal fish presence in northern latitudes and is a requirement for non-transient species. Other habitat requirements include adequate food sources and stream productivity; cover (e.g., vegetation, undercut banks) for rearing, resting, and predator avoidance; and suitable water quality metrics, notably dissolved oxygen levels (CCME 1999).

In the late 1990s, members of the VGFN discussed catching grayling in the spring and whitefish in the summer. They noted that important fishing sites in their territory were where small creeks entered the Peel River and the Ogilvie River. They observed fewer fish than many years before and fewer fish in lakes, although more in rivers (Sherry and Vuntut Gwitchin First Nation 1999, p. 249, 247).

Table 1-1. Fish species known to occur in the Peel and Porcupine watersheds.

Common Name	Vuntut Gwitch'in	Scientific Name	Species Abbreviation	Porcupine River (Yukon Basin)	Peel River (Mackenzie Basin)
Arctic grayling	sriijaa	*Thymallus arcticus*	GR	✓	✓
Slimy sculpin	–	*Cottus cognatus*	CCG	✓	✓
Arctic lamprey	–	*Lethenteron camtschaticum*	AL	✓	✓
Inconnu	shryuh	*Stenodus leucichthys*	IN	✓	✓
Lake whitefish	łuk dagàii	*Coregonus clupeaformis*	LW	✓	✓
Round whitefish	–	*Prosopium cylindraceum*	RW	✓	✓
Broad whitefish	chihshòo	*Coregonus nasus*	BW	✓	✓
Northern pike	atlin	*Esox lucius*	NP	✓	✓
Lake chub	–	*Couesius plumbeus*	LKC	✓	✓
Longnose sucker	daats 'at	*Catostomus catostomus*	LSU	✓	✓
Burbot	chèhlùk	*Lota lota*	BB	✓	✓
Trout perch	–	*Percopsis omiscomaycus*	TP	✓	
Chinook salmon	łuk choo	*Oncorhynchus tshawytscha*	CH	✓	
Chum salmon	shii	*Oncorhynchus keta*	CM	✓	
Coho salmon	nèhdlii	*Oncorhynchus kisutch*	CO	✓	
Least cisco	–	*Coregonus sardinella*	CS	✓	
Pygmy whitefish	–	*Prosopium coulterii*	PW		✓
Lake trout	vit	*Salvelinus namaycush*	LT		✓
Dolly Varden	–	*Salvelinus malma*	DV		✓
Longnose dace	–	*Rhinichthys cataractae*	LNC		✓
Flathead chub	–	*Platygobio gracilis*	FHC		✓
Spoonhead sculpin	–	*Cottus ricei*	CRI		✓

(McPhail and Lindsey 1970, Yukon Native Language Centre 1976, Lindsey et al. 1981, Scott and Crossman 1998, Anderson Resources Ltd. 2001, First Voices 2022)

2 METHODS

2.1 STUDY DESIGN

Limited information regarding fish presence and fisheries values within the RSA is available. Due to the large number of streams within the RSA, it was not feasible to survey all streams. Also, the exact location of Project development, including stream crossings, have not been predetermined. To address these issues, a study design was developed to predict the probability of fish presence across all streams, based on field surveys at a representative subsample of streams. This approach follows a similar study in the adjacent Peel watershed (Barker et al. 2011).

The approach uses the observed relationships between fish presence and environmental variables, such as stream order, gradient, catchment area, and adjacent vegetation, to interpolate the statistical probability of fish presence in non-surveyed streams. The authors of the Peel study indicated the importance and relevance of completing landscape-scale statistical modelling to understand the relationships between fish and their environment. They further highlighted the utility of using predictive modelling in costly or logistically difficult areas to complete comprehensive sampling, as with the Eagle Plains RSA. As such, the current study used the same approach as Barker et al. (2011), conducting a representative field-based study and using those results to support a comprehensive landscape-scale predictive model with GIS-derived environmental data to determine the probabilities of fish presence at all 1,467 streams in the RSA.

The study design included the following steps:

- compile historic fish occurrence data;
- assemble relevant stream variables to support survey stratification and statistical modelling;
- develop stream stratification criteria and conduct a stratified random sample to obtain a representative field sample;
- conduct fish and fish habitat surveys using standardized field survey methods; and,
- quantify relationships between fish presence and stream variables using statistical models and use the results to predict the probability of fish presence across the remaining streams in the RSA.

To obtain a representative subsample of streams to support statistical analyses, summer survey sites were selected using a stratified random design, stratifying by stream order. Stream order refers to the relative position of a stream within a watershed and is based on the number of upstream tributaries. The greater the stream order number, the larger the stream and the lower/farther downstream it occurs within a watershed. Stream order correlates to several different stream characteristics, including stream width and depth, gradient, and channel morphology, which makes it a good metric for stratifying field samples.

2.2 HISTORIC FISH INVENTORY INFORMATION

Before study design and field surveys, existing fisheries information was compiled to guide study design and site selection (e.g., to avoid surveying sites where fish presence was known). The Fisheries Information Summary System (FISS) was examined for fisheries information within the RSA and available grey literature that contained information on streams within or adjacent to the RSA (Anderson Resources Ltd. 2001, Barker et al. 2011). Stream files from Fisheries and Oceans Canada (DFO) were also searched for fisheries information within the RSA.

2.3 GIS-BASED STREAM DATA DERIVATION

The GIS-based environmental data were required to estimate the probability of fish presence at all streams across the RSA (i.e., because it was not feasible to collect field data for all 1,467 streams in the RSA). Nine stream variables were chosen for the analysis: stream order; distance to third, fourth, and fifth-order streams; stream slope; terrain slope; elevation; catchment area; and distance to large inline pools[2]. All these variables are known to affect fish occurrence and fish habitat (e.g., Barker et al. 2011). Stream order is a valuable qualitative proxy for water volume and flow rate metrics. Higher-order streams (i.e., third-order and greater) were initially predicted to have stream conditions sufficient for overwintering habitat, and thus distances to these streams may relate to fish presence. Landscape components such as slope (stream and terrain) and elevation relate to flow, flooding potential, temperature, and productivity, respectively. The total catchment area upstream from a location measures total water quantity, which may also affect the probability of fish presence. Inline pools may also be important during high summer temperatures and low-flow dry seasons or as overwintering habitat for fish. The nine predictors were developed in ArcGIS as unique raster layers at a 100 m × 100 m resolution.

2.4 FIELD SURVEYS

Fish presence, habitat, and water conditions were assessed in the field in July, August 2019, and March 2020. The summer sampling consisted of two crews: one crew of two EDI Environmental Dynamics Inc. (EDI) employees and another of two EDI employees and a VGFN assistant. A helicopter shared by both crews accessed all sites; sites for the day were coordinated to make the most efficient use of sampling and helicopter time. Sampling in March 2020 was limited to fewer variables due to the winter conditions, including the lack of water at many sites. There was one crew of two EDI employees and a VGFN assistant for March fieldwork.

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[2] Large pools or ponds (>0.25 ha) occurring along a stream reach.

2.4.1 SUMMER

Surveys for fish presence and habitat conditions in the RSA occurred between July 25 and August 1, 2019, with two field crews. Field assessments included habitat quality assessments and fish sampling via electrofishing (and occasional minnow trapping) when sufficient water was present. In total, 118 streams in the RSA were assessed for fish presence and had British Columbia (BC) site cards filled out. Stream orders with higher occurrence had higher sampling effort (i.e., more lower-order streams sampled; Table 2-1). Stratified random sampling was used to sample a subset of streams from each order while providing relatively even spatial coverage across the RSA. Site assessment occurred on 52 first-order streams, 42 second-order, 18 third-order, four fourth-order, and two fifth-order sites (Table 2-1; Map 2-1). Sampling occurred in all the watersheds within the RSA — the Bell (upper Porcupine), Whitestone (Porcupine), and Ogilvie (upper Peel). Some larger order streams were visited at two spatially separated sites within the RSA to achieve the appropriate spatial coverage (e.g., Chance Creek). Each site with water had in situ water quality parameters recorded; a YSI ProPlus and YSI ProSOLO were used to collect data on temperature (°C), dissolved oxygen (% and mg/L), specific conductivity (µS), and pH (pH was only recorded on the ProPlus). Where applicable, digital photos and GPS coordinates were taken at the downstream and upstream extents sampled.

A broad suite of stream characteristics were documented in the field, following the BC Ministry of Environment's Fish and Fish Habitat Inventory standards and using the BC site cards (BC Ministry of Environment 2008). The primary metrics of interest included: channel and wetted widths, residual pool depth, gradient, type and total cover, and bed material. Qualitative estimates of habitat quality for spawning, overwintering, and rearing potential was also recorded. The BC Fish and Fish Habitat Inventory definitions were used to classify drainages as either: a stream; no defined channel; or no visible channel drainage. The definition relies on both fluvial material (sediment or substrate) and a stream channel (BC Ministry of Environment 2008). Field results from site cards and electrofishing supported the field-based predictive model.

All streams that contained water at the time of survey were surveyed for fish using standard electrofishing methods. The electrofishers were a Smith-Root LR-24 and a Smith-Root 12B POW. A minimum sampling effort of approximately 100 m and 500 sec was attempted at each site; however, this was not achieved at a small number of first- and second-order streams (n = 11) due to partially dry stream channels. Sampling covered an average of 92 m (± 43 SD; range = 25 – 200 m) and 455 sec (± 89 SD; range = 211 – 693 sec) per site (Attachment A). The electrofisher settings were also variable due to large discrepancies in specific conductivity between sites. Electrofishing was completed by moving upstream. Once a fish was stunned, it was transferred to a bucket with fresh water to be measured and to recover. During fish handling, fish experienced limited air exposure, no contact with abrasive or dry surfaces, and minimal handling; nets were knotless rubberized mesh, and all fish were measured using a soft tape measure with the gills submerged underwater. Captured fish were enumerated, identified to species, and measured to fork length (FL; mm); burbot and slimy sculpin were measured to total length (TL; mm). The species and count were recorded if a fish was not captured and only observed. Fish were released back into the stream once electrofishing had concluded.

Minnow trapping was conducted at six sites, primarily in larger streams or ponds to complement or verify electrofishing data. Minnow traps were placed in areas of good cover and suitable depth and stream velocity. Each site had three small gee-type minnow traps (0.6 cm mesh size) baited with roe in a perforated bag and deployed along stream margins in slow water habitats. In the case of the pond that was sampled, sampling occurred along the pond shore. Water depth, site characteristics, and photos were recorded for each trap and traps were left to soak overnight (Attachment A).

Table 2-1. Summary of sampled stream orders during summer sampling in July and August 2019.

Stream Order	Streams in RSA	Streams Sampled in Summer	Percent Sampled (%)
1	1,142	52	1.9
2	239	42	17.6
3	68	18	26.5
4	16	4	25.0
5	2	2	100.0

2.4.2 WINTER

The RSA was visited again from March 7 to 13, 2020, to assess the presence of water and overwintering fish habitat at a subsample of streams across the RSA. In total, 49 unique sites were visited—1 first-order stream, 14 second-order, 18 third-order, 13 fourth-order, and three fifth-order (Map 2-1). Sites were accessed via helicopter. Only one first-order stream was surveyed because summer surveys found very low fish presence in first-order streams, and because past work adjacent to the RSA in the Peel watershed indicated most first- and second-order systems are dewatered or froze to bed in winter (Barker et al. 2011). Some larger order streams were visited at more than one location of the stream (e.g., Chance Creek) as they extended through the entire RSA, and because those streams were suspected to be the primary overwintering habitats within the RSA.

It is important to highlight the difficulties associated with winter assessments and the nature of random sampling (i.e., uncertainties as to what part of the stream is most likely to contain water). To address these issues, efforts were made to target some sites that had either pools (characterized by widening or a bend in stream) or a visible inline pond, as these sites were more likely to have residual pools at lower winter flows. If sites corresponded to an inline pond or a pool, a site was sampled in the stream channel (i.e., where it appeared to be average channel width), as well as in the inline pond and/or pool, and lastly at the inlet or outlet to determine if there was flowing water (Photo 2-1; Table 2-2). As such, some sites included two or three distinct sampling locations. This situation occurred most frequently at some of the third- and fourth-order sites visited (Table 2-2). While every effort was made to locate survey sites at locations most likely to contain water, it is possible that some survey locations missed the 'best' microsites in the vicinity (i.e., locations with the deepest pool or the part of the channel with the most flow).

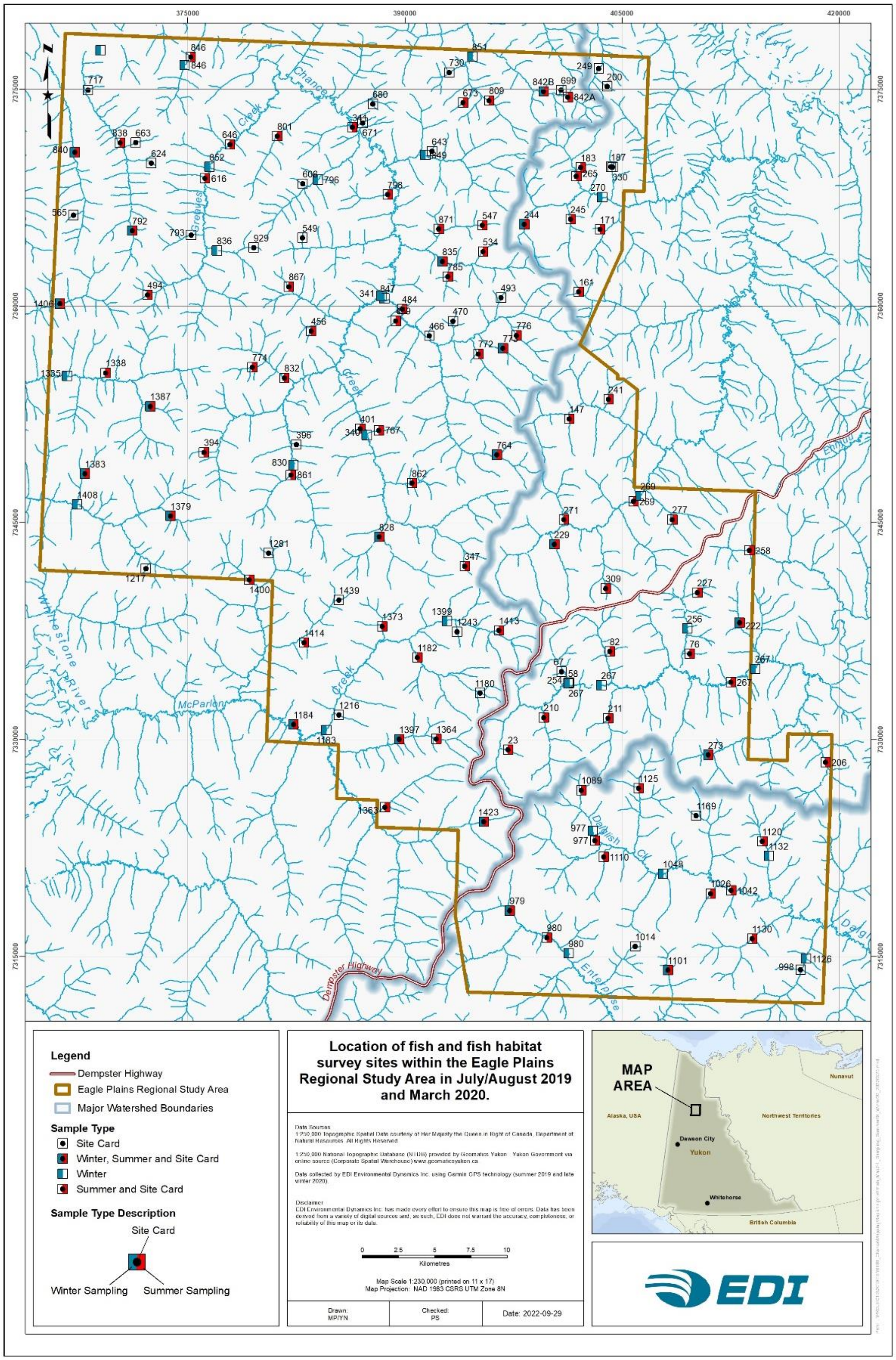
Upon arrival at a site, the stream bed was located under the snow and the snow was removed from the surface of the stream. The ice was initially checked with an ice spud (probe) for thickness. Occasionally an ice spud was sufficient to penetrate the ice; in the event of thicker ice, a power auger was used. The hole was assessed for the presence of water. If no water was found in the first drilled hole, then another spot along the stream was surveyed (though on some occasions, only a single hole was drilled due to concerns of cold exposure). If the bank width of a stream was small enough (<2 m), a trench was chipped across. At channels greater than 2 m wide, one to five holes were drilled across the width of the channel to evaluate for the presence of water. If water was identified at the site, and the water was greater than 10 cm deep, an Aqua-Vu underwater fish viewing camera was submersed and the video feed was viewed for 10 to 20 minutes to check for fish activity. Each site with sufficient water had in situ water quality parameters recorded using a YSI ProSOLO to collect temperature (°C), dissolved oxygen (% and mg/L), and specific conductivity (µS/cm). At all holes drilled or chipped, the overlaying snow depth, ice depth, hollow depth, water depth, and depth from substrate to the top of the ice were recorded (m); hollow depth was measured when a hollow space was present between the ice and water or frozen substrate. Photos and GPS coordinates were recorded for each site visited, as well as notes of the findings from each site.

Table 2-2. Distribution of sampled streams regarding stream order and type of environment sampled in March 2020.

Stream Order	Sampled Stream Channel	Sampled Inline Pond or Pool	Sampled Inline Pond or Pool Inlet/Outlet	Total Sampling Locations[1]
1	1	0	0	1
2	13	1	1	15
3	15	4	4	23
4	10	5	4	19
5	3	0	0	3

[1] Some sites were sampled in more than one distinct location (e.g., the same site was sampled in a stream section, a pool, and the pool outlet).

Photo 2-1. Example sampling locations within the average channel width, the outlet (or inlet), and inline pond (or pool) during sampling in March 2020.



Map 2-1. Location of fish and fish habitat survey sites within the Eagle Plains Regional Study Area in July/August 2019 and March 2020.

2.5 FISH PRESENCE — PREDICTIVE MODELLING

Estimates of fish presence during summer were derived using logistic regression analysis. Logistic regression quantifies the contribution of environmental covariates to fish presence and yields predictions in the form of probabilities. Several candidate models, consisting of different combinations of the nine environmental variables (see Section 2.3), were developed and information-theoretic procedures were used to select the most parsimonious model (Burnham and Anderson 2002). Environmental covariates were chosen based on their relevance to fish ecology and their potential for variation in the RSA. For the analysis, stream order was treated as an ordinal, continuous variable because (1) the limited and unbalanced sample sizes across stream orders and (2) the expectation that the probability of fish presence would increase in consecutively higher-order streams (Table 2-3). All other predictors were treated as continuous, numeric variables: elevation, catchment area, stream and terrain slope, distance to inline ponds, and distance to third-, fourth-, and fifth-order streams. Predictor values were extracted from the 100 m raster layers for each of the 118 sampled locations and corresponded with the presence or absence of fish. Statistical analyses were conducted using R Statistical Software, version 3.6.1 (R Development Core Team 2020).

Before model construction, multicollinearity among variables was evaluated to confirm unbiased estimates of coefficients (and their associated error) for each environmental covariate. A correlation matrix (for variables with high Pearson's correlation coefficients, $r > 0.7$) and variance inflation factor scores (scores >4) were used — neither identified problematic variables. Due to large and differing ranges of values among continuous numeric predictors, these variables were centered and standardized to have a mean of zero and a standard deviation of one.

Analyses began by specifying a 'global model' with all environmental covariates. Diagnostic plots of the global model's residuals to fitted values did not identify any concerns of heterogeneity or outliers. Coefficient estimates associated with each covariate were also evaluated based on logical predictions and removed if contrary to fish biology. For instance, in the global model, "distance to fith-order streams" had a positive coefficient (i.e., increased probability of occurrence associated with distances farther from fifth-order streams). Such an estimate is illogical from an ecological perspective and likely the result of spurious correlation; the expectation is that the probability of occurrence should decrease with distances farther from fifth-order streams because of low water volumes and flow rates. Therefore, this distance covariate was dropped from additional consideration.

Beginning with the global model, model comparisons were conducted via sequential log-likelihood ratio tests in which covariates were removed one at a time depending on their contribution to residual deviance (i.e., analysis of deviance table using a $p < 0.05$ threshold). A series of candidate models were considered during model selection, ranging from the global model to those with single predictors. As per information theoretic procedures, corrected Akaike Information Criterion (AICc) scores, used when the sample size is small (e.g., $n = 118$), were calculated for each model (R package "AICcmodavg", Mazerolle 2019). An AICc score is the amount of information a candidate model loses when compared to the "true", unknown (and unattainable) model, which perfectly describes a natural phenomenon (Burnham and Anderson 2002). In this case, the model with the lowest AICc score (and statistics) yields the best approximation for explaining fish presence, given the data. Significant main effects, as well as AICc weights (w_{AICc}) and corresponding evidence ratios (e.g., $\frac{w_{model\,8}}{w_{model\,7}}$) were considered for model selection.

The final step was model validation. Predictions from the final model were evaluated with observed data using a Receiver Operating Characteristics (ROC) curve (or area under the curve, AUC) in R software (package "pROC", Robin et al. 2011). The ROC curves (or AUC scores) identify the proportion of true positives to false positives based on predictions from the model, using an iteratively variable threshold to convert probabilities to binary responses (1, 0). An AUC value of 1 signifies that the model perfectly distinguishes between presence and absence (1, 0), while 0.5 means it cannot differentiate between them.

An alternative model was developed using field data collected in the RSA to evaluate further the robustness and predictive power of the GIS-based analysis. This additional analysis was also conducted to determine whether field-based covariates could address aspects of fish presence that geospatial data could not (i.e., to improve model accuracy and confidence). Stream order was retained for the analysis, and the following field-based covariates were also included: channel width, wetted width, residual pool depth, overwintering habitat quality, dissolved oxygen, and gradient. During preliminary multicollinearity tests, two variables were removed from further analyses — channel width and wetted width — because of their high correlation with stream order (r = 0.78 and 0.80, respectively) and high variance inflation factor (VIF) scores. The model construction, selection, and evaluation procedures followed were identical to those used for the GIS-based model.

Table 2-3. Contingency table comparing fish presence and absence among stream orders from sampled locations in the Regional Study Area during July and August 2019.

Stream Order	% Fish Present	Total Sites Visited
1	3.8	52
2	54.8	42
3	77.8	18
4	100	4
5	100	2
TOTAL		**118**

3 RESULTS

3.1 HISTORICAL INFORMATION

Very little fisheries information was found during the literature search for historical and baseline information within the RSA. No information was contained in FISS within the RSA. The only fish inventory conducted in the RSA is limited baseline fish sampling supporting past oil and gas exploration in the area (Anderson Resources Ltd. 2001; Attachment B). In the adjacent Peel watershed, the Yukon Government conducted broad inventory work that modelled the likelihood of fish presence based on different environmental variables (Barker et al. 2011).

Anderson (2001) indicated that historical fish surveys in the broader Eagle Plains area primarily focused on larger drainages rather than smaller order streams, with data being somewhat dated in the proximity of the RSA (e.g., mainstem Eagle, Ogilvie, Peel, and Porcupine rivers; Bryan et al. 1973, Steigenberger et al. 1975, Eby and Associates 1977, Lindsey et al. 1981). Anderson (2001) concluded that diversity and habitat use are lower within the headwaters of these mainstem rivers (i.e., within the smaller streams of the RSA) and that overwintering habitat would be limited to areas of groundwater or deeper pools.

Anderson (2001) surveyed the physical stream characteristics and conducted electrofishing, beach seining, minnow trapping, gillnetting, and angling on eight streams and two ponds within and adjacent to the currently proposed RSA during June, August, and September 2001 (Attachment B). Species captured and observed by Anderson (2001) included: Arctic grayling, slimy sculpin, longnose sucker, burbot, round whitefish, and lake whitefish. They electrofished for an average of 350 sec (± 192.4 SD; range = 33 – 795 sec; Attachment B) per site. Regarding habitat, fish cover was primarily in the form of turbidity, large woody debris, and undercut banks. Although turbidity could provide cover, several negatives are associated with excess turbidity (e.g., poor foraging opportunities and increased ventilation/metabolic costs; Henley et al. 2000, Lowe et al. 2015, Alaska Department of Environmental Conservation 2016). Overhanging and instream vegetation was also present in some streams and the occasional pool. Many stream banks were characterized by erosion and slumping banks from melting permafrost, contributing to the turbidity at some sites.

The Yukon Government Peel watershed study by Barker et al. (2011) used GIS-based covariates to develop hypothesis-driven models to predict the presence and abundance of Dolly Varden, Arctic grayling, and slimy sculpin; they also used a model which considered all fish species. Habitat covariates included: elevation, mean slope, upstream extent, distance to ≥5th-order streams, rock proportion and upland vegetation cover. The hypothesis-driven models they developed included different combinations of covariates: flooding (rock proportion + mean slope + upstream extent + distance to ≥5th order streams); freezing (elevation + upstream extent + distance to ≥5th order streams); drying (upstream extent + distance to ≥5th order streams); stream volume (upstream extent); migration (elevation + distance to ≥5th order streams); and productivity (vegetation proportion + elevation + upstream extent). The field findings and predictive model indicated fish were absent from nearly all first-order streams and present in nearly all fourth-order streams; they assumed fish were present at fifth-order streams. The model combining all species found very low probability of fish presence in first-order and upper reaches of second-order streams and had high predicted fish presence in most third- and fourth-order streams. Their predictive hypothesis-driven models indicated that the stream volume model was the best predictor for Dolly Varden and slimy sculpin presence. In contrast, the productivity model best predicted Arctic grayling presence and all fish combined. The stream productivity model also had the most predictive power for fish abundance of Dolly Varden, Arctic grayling, and slimy sculpin (Barker et al. 2011).

3.2 FIELD SURVEYS

3.2.1 SUMMER

3.2.1.1 Fish Sampling

A total of 118 sites were visited across all orders, 81 of which contained enough water to sample for fish (Map 3-1; Attachment C). Twenty-seven first-order and four second-order drainages were considered non-classified (NCD; i.e., not a stream) based on the definition provided in the BC Site Card Field Guide (BC Ministry of Environment 2008). To be an NCD, a drainage lacks evidence of a defined bank or fluvial deposits (i.e., stream bed material; BC Ministry of Environment 2008). Another six first-order streams could not be sampled for fish as they were dry or did not contain enough water for sampling (Map 3-1; BC Ministry of Environment 2008). Field crews supporting the wildlife and vegetation components of the baseline studies noted that water levels were considerably higher in June than in late July and early August when streams were assessed for fish presence (a June peak is common in this region; Yukon Ecoregions Working Group 2004).

Overall, the proportion of sites with fish present increased considerably with increasing stream order (Table 3-1). Few fish were captured in first-order streams, with only 3.8% of sites visited containing fish (Table 3-1). The only fish captured in first-order streams were adult Arctic grayling in one site in the Dalglish Creek watershed (Site 1026) and another in the MacParlon Creek watershed (Site 1423; Table 3-1; Map 3-1; Attachment C). These two Arctic grayling were among the largest captured throughout the RSA (Table 3-2). Both streams had a wetted width of less than 1 m and were considered to have moderate rearing habitat, though both had poor connectivity and the fish were in isolated residual pools at the time of sampling (i.e., the fish had moved into the streams during higher flows and had become stranded).

Second-order streams had the most variable fish presence, with 52.4% of visited sites containing fish (Table 3-1). Four fish species were captured in second-order streams: Arctic grayling, slimy sculpin, longnose sucker, and burbot (Table 3-2). Arctic grayling were captured most frequently in second-order streams. Notably, young-of-the-year (YOY; <50 mm) Arctic grayling were captured at one site in the Chance Creek watershed (Site 861; Map 3-1; Attachment C) and another site in the Eagle River watershed (Site 229; Photo 3-1; Table 3-2; Map 3-1; Attachment C). Slimy sculpin were captured at three second-order streams (Site 210, 211, 273; Map 3-1; Attachment C), all in the Eagle River watershed. Longnose sucker and burbot were captured at two second-order streams (Sites 1387, 1383) in the Whitestone River watershed, and longnose sucker were captured at one other site in the MacParlon Creek watershed (Site 1373; Map 3-1; Attachment C).

Third-order streams had a fish presence at 77.8% of sites, with five fish species captured (Table 3-2). Adult Arctic grayling were captured at all but three sites (Photo 3-2), and YOY Arctic grayling were present at six sites total: three sites in the Chance watershed (Site 828, 832, 835), one in the Dalglish watershed (977), one in the MacParlon watershed (Site 1182), and one site in the Whitestone watershed (Site 1406; Table 3-2; Map 3-1; Attachment C). Slimy sculpin were captured at one site in the Enterprise Creek watershed (Site 980) and one site in the MacParlon watershed (Site 1397; Table 3-2; Map 3-1; Attachment C). Round whitefish were only captured at two sites in the whole RSA, both in the Dalglish Creek watershed (Site 977, 1130; Photo 3-3; Table 3-2; Map 3-1; Attachment C). Lastly, a single longnose sucker was captured (Photo 3-4) and a burbot was observed at the same site in the Chance Creek watershed (Site 840).

Fourth- and fifth-order streams had fish present in 100% of the sites visited, albeit few sites were visited as fish presence was anticipated in these higher-order streams (Barker et al. 2011). Arctic grayling and slimy sculpin were the only species captured in fourth- and fifth-order streams (Table 3-2; Attachment C). Slimy sculpin were captured at two fourth-order streams (Site 267 and 269) and in one fifth-order stream (MacParlon Creek; Site 1184).

Minnow traps were set at six locations within the RSA (Attachment C). Only one site successfully captured fish, with two Arctic grayling caught in the same trap in a third-order stream (fork length = 45 mm each; catch-per-unit-effort = 0.5 fish per 24 hr). Minnow trapping was initially used at a subset of sites to verify the success of electrofishing. As minnow trapping was not gathering any new information, electrofishing became the preferred method for capturing fish.

Table 3-1. Summary of fish sampling sites and corresponding fish presence from July and August 2019.

Stream Order	Sites Visited	Sites Sampled for Fish	Sites with Fish Present	Percent of Sites Visited with Fish Present (%)
1	52	19	2	3.8
2	42	38	22	52.4
3	18	18	14	77.8
4	4	4	4	100
5	2	2	2	100
Total	**118**	**81**	**44**	**54.3**

Table 3-2. Fish species and measurement metrics summary based on stream order from July and August 2019 sampling.

Order	Species	Number of Sites with Fish Present	Number of Fish Observed/Captured	Number Measured	Average Fork Length (mm, ± SE)	Fork Length Range (mm)
1	GR	2	3	3	238.8 ± 13.3	200 – 250
2	GR	19	67	44	171.2 ± 12.0	38 – 350
	CCG	3	16	4	104.3 ± 6.7	90 – 120
	LSU	3	10	5	129.8 ± 13.8	87 – 170
	BB	2	8	3	245.0 ± 24.7	200 – 285
3	GR	15	66	51	117.8 ±12.6	27 – 325
	CCG	2	15	2	68.5 ± 1.5	67 – 70
	LSU	1	8	1	211.0 ± 0.0	–
	BB	1	1	–	–	–
	RW	2	8	2	294.0 ± 4.0	290 – 298
4	GR	4	38	20	49.5 ± 1.7	33 – 65
	CCG	2	5	3	85.7 ± 4.2	81 – 94
5	GR	2	13	9	46.0 ± 6.1	34 – 93
	CCG	1	6	4	71.0 ± 12.1	64 – 89

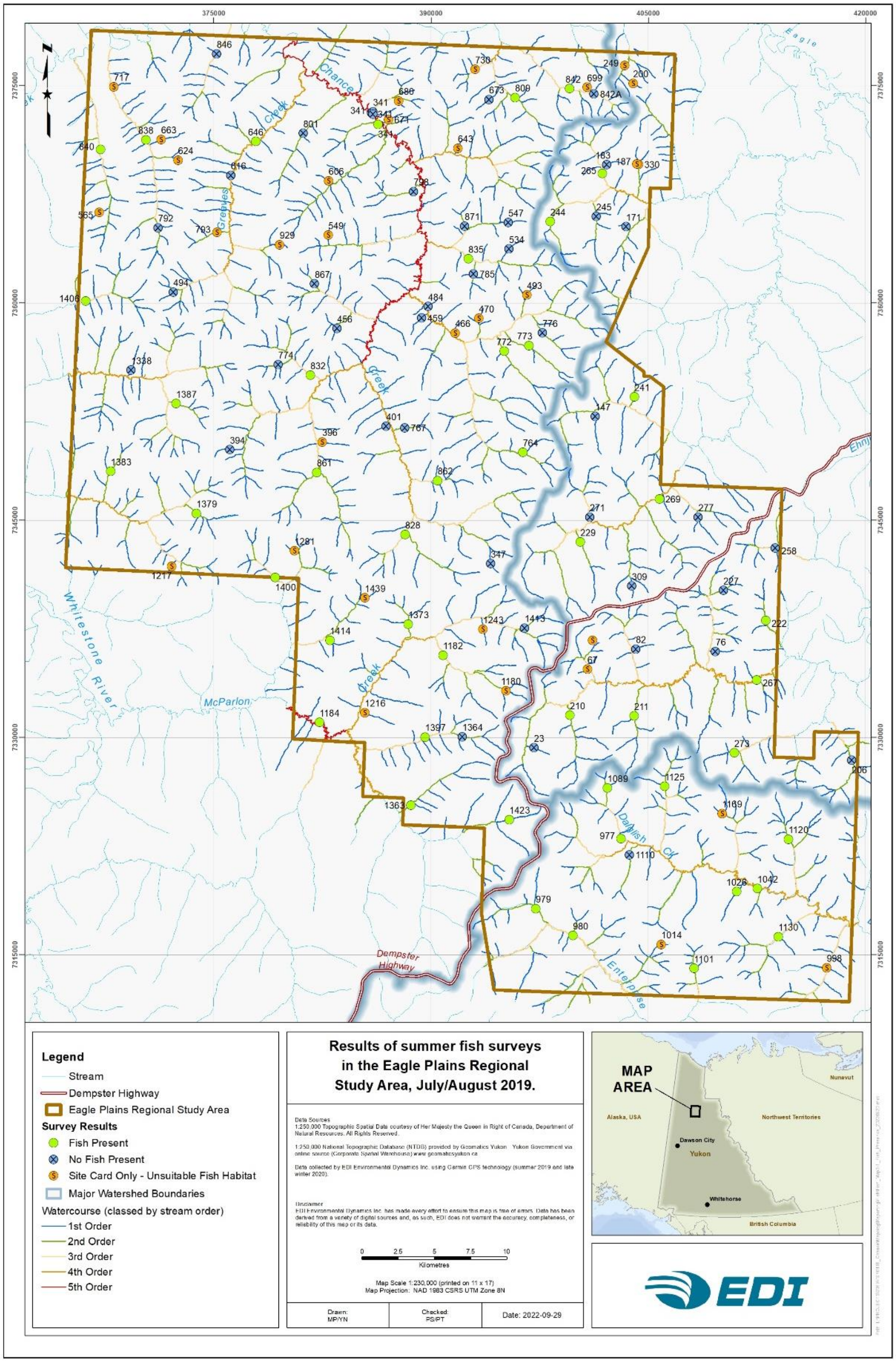
GR = Arctic grayling; CCG = slimy sculpin; LSU = longnose sucker; BB = burbot; RW = round whitefish

Photo 3-1. Young-of-the-year Arctic grayling captured in a second-order stream within the Eagle River watershed on July 29, 2019.

Photo 3-2. Adult Arctic grayling captured in a third-order stream within the Dalglish Creek watershed on July 31, 2019.

Photo 3-3. A round whitefish captured in a third-order stream within the Dalglish Creek watershed on July 31, 2019.

Photo 3-4. A longnose sucker captured in a third-order stream within the Chance Creek watershed on July 27, 2019.



Map 3-1. Results of summer fish surveys in the Eagle Plains Regional Study Area, July/August 2019.

3.2.1.2 Water Quality

First- and smaller second-order streams were frequently characterized by little or no flow, inconsistent connectivity, and isolated residual pools. Many wetted first-order streams did not have consistently flowing water at the time of sampling, and many sites were sampled from isolated residual pools; this was occasionally the case in some smaller second-order streams as well. As such, the fish captured in these streams were at least temporarily stranded and likely travelled upstream into these first and second-order streams during high spring water levels. These low or no flow streams were characterized by low dissolved oxygen (Table 3-3; Attachment D). Water temperatures were lowest in first-order streams due to the greater inputs from the melting of the active layer of the permafrost; in some streams, ice was discovered below the substrate. As stream order increased, water temperature also increased on average (Table 3-3). General guidelines for dissolved oxygen in fish-bearing waters indicate that most fish require dissolved oxygen levels above 6 mg/L, with potentially lethal consequences to prolonged exposure below 2 mg/L (Doudoroff and Shumway 1970, Davis 1975, Leppi et al. 2016). The lowest dissolved oxygen that contained fish was 2.2 mg/L in a first-order stream, where fish were caught in a disconnected residual pool (Table 3-3; Attachment D).

Table 3-3. Water quality parameters at sites that contained fish during July and August 2019 fish sampling.

Stream Order	Sites with Fish Present	Dissolved Oxygen (%)		Dissolved Oxygen (mg/L)		Temperature (°C)	
		Average DO of Sites with Fish Present (± SE)	Range	Average DO of Sites with Fish Present (mg/L ± SE)	Range	Average Temperature of Sites with Fish Present (± SE)	Range
1	2	31.4 ± 17.2	18.2 – 44.5	3.7 ± 2.7	2.2 – 5.3	8.7 ± 1.8	8.4 – 8.7
2	22	65.8 ± 2.9	42.9 – 89.8	7.2 ± 0.3	4.3 – 10.2	11.2 ± 0.5	7.3 – 16.2
3	14	72.7 ± 4.6	6.2 – 15.4	7.8 ± 0.5	7.6 – 14.5	11.6 ± 0.5	7.6 – 14.5
4	3	82.0 ± 6.4	70.6 – 92.8	8.7 ± 0.2	8.4 – 8.9	12.6 ± 2.6	8.1 – 17.1
5	2	99.0 ± 15.7	70.6 – 92.8	10.1 ± 1.5	8.4 – 9.0	14.4 ± 0.4	14.0 – 14.7

3.2.1.3 Habitat

Most first- to third-order streams in the RSA were characterized by fine bed material and overhanging vegetation (Photo 3-5, Photo 3-6, Photo 3-7). Areas of permafrost melting and slumping of stream banks added to the siltation of the stream bottoms and turbidity. The exception was lower order streams in the Peel watershed (e.g., Dalglish and Enterprise creeks and tributaries) that had bed material predominantly comprised of gravels (Photo 3-8). Larger third-, fourth- and fifth-order streams throughout the RSA were still characterized by a large amount of fines and moderate turbidity, although some had sections of gravel present (Photo 3-8, Photo 3-9, Photo 3-10).

Habitat quality in the RSA generally increased with increasing stream order. Generally, first- and second-order streams provided discontinuous habitat at the time of survey due to low water flow. In first- and second-order streams, habitat complexity was low, with most cover restricted to undercut banks, overhanging vegetation, and occasional woody debris (Photo 3-5, Photo 3-6). A few pools occurred, many of which were not substantial in size or residual depth (Table 3-4; Attachment D). However, in all third-order and greater streams, the depths of pools and runs generally offered adequate cover to support fish in many stream sections. Channel widths also generally increased with increasing stream order. Stream gradient generally decreased with increasing stream order; the highest stream gradient was 7.0% at a first-order stream (Table 3-5). However, the gradient is unlikely to play a major role in fish presence in the RSA because fish passage is normally not hindered below 20% gradient. At many sites there was an indiscernible amount of gradient (Table 3-5; Attachment E)—this was particularly true in poorly defined and braided streams.

Table 3-4. Stream measurement metrics summary based on stream order from sampling in July and August 2019.

Stream Order	Sites[1]	Channel Width		Wetted Width		Residual Pool Depth	
		Average (m; ± SE)	Range (m)	Average (m; ± SE)	Range (m)	Average (m; ± SE)	Range (m)
1	2	31.4 ± 17.2	18.2 – 44.5	3.7 ± 2.7	2.2 – 5.3	8.7 ± 1.8	8.4 – 8.7
2	22	65.8 ± 2.9	42.9 – 89.8	7.2 ± 0.3	4.3 – 10.2	11.2 ± 0.5	7.3 – 16.2
3	14	72.7 ± 4.6	6.2 – 15.4	7.8 ± 0.5	7.6 – 14.5	11.6 ± 0.5	7.6 – 14.5
4	3	82.0 ± 6.4	70.6 – 92.8	8.7 ± 0.2	8.4 – 8.9	12.6 ± 2.6	8.1 – 17.1
5	2	99.0 ± 15.7	70.6 – 92.8	10.1 ± 1.5	8.4 – 9.0	14.4 ± 0.4	14.0 – 14.7

[1] Sites that were not considered a stream (i.e., no banks or bed material) were not included in these calculations.

Table 3-5. Stream gradient summary based on stream order from sampling in July and August 2019.

Stream Order	Gradient (%)	
	Average (± SE)	Range
1	2.05 ± 0.31	0.00 – 7.00
2	1.16 ± 0.17	0.00 – 3.50
3	1.06 ± 0.28	0.00 – 3.50
4	0.44 ± 0.21	0.00 – 1.00
5	0.63 ± 0.13	0.50 – 0.75

Photo 3-5. **A wetted first-order drainage in the Chance Creek watershed.**

Photo 3-6. **A second-order stream in the Chance Creek watershed; notice the slumping banks and associated siltation.**

Photo 3-7. A third-order stream in the Porcupine River watershed.

Photo 3-8. A third-order stream in the Enterprise Creek watershed, characterized by gravel and cobble substrate.

Photo 3-9. A fourth-order stream in Chance Creek watershed.

Photo 3-10. McParlon Creek, a fifth-order stream in the McParlon Creek watershed.

3.2.2 WINTER

Forty-nine sites were evaluated for fish presence potential in March 2020 within the RSA (Map 3-2; Table 3-6; Attachment F). Efforts were made to sample a typical stream section with average channel width. Sampling was also conducted at inline ponds or pools along the stream, where they occurred, and at their corresponding inlets/outlets (Table 3-7). If water was detected in one of the holes drilled at a site (e.g., pond/pool/stream) but not in others, the site was still designated as containing water. Fifteen of the 49 sites visited in March contained water (Map 3-2; Table 3-6).

In March 2020, no water was present in the single first-order stream visited, and the only second-order stream with water present was in a small inline pond, although the water was in the form of wet mud and not suitable fish habitat at the time of sampling (Photo 3-11; Table 3-6, Table 3-7). The ice depth was 0.63 m, with 0.32 m between the bottom of the ice at the top of the water—the water measured 0.05 m in depth (Photo 3-12). At all other second-order sites no water was detected during winter sampling (Photo 3-12). In third-order streams, all four inline ponds/pools sampled contained water (Photo 3-13), but with the outlets frozen to bed or as layered ice, indicating water level lowering and draining (Photo 3-14; Table 3-6, Table 3-7). As such, the water in the inline ponds and pool was likely to be standing water, acting as a residual pool as the rest of the stream water level dropped and froze during the fall and winter. The water quality of these sites was unsuitable for long-term fish rearing, with very low dissolved oxygen levels (range = 0.1 – 0.5 mg/L; Table 3-8; Attachment F, Attachment G) and generally dark-coloured water with a strong anoxic smell. Adequate under-ice dissolved oxygen is important for fish overwintering, with potentially lethal effects to prolonged exposure to below 2 mg/L, with preferred levels at or above 6 mg/L (Doudoroff and Shumway 1970, Davis 1975, Leppi et al. 2016). The water was deep enough to use the fish camera at two sites; during 10 to 20 minutes of observation, no indication of fish presence was found at either site.

Eight of 14 fourth-order streams contained water in March 2020. Five of the sites (646, 270, 340, 1408, 267) contained water in a pool or inline pond, and of these, two also contained water in the adjacent stream channel (both sites on stream 267), suggesting flowing water may have been present (Table 3-6, Table 3-7). The other three sites had water present in the stream channel (also used for water quality sites in the EDI Surface Water Quality and Hydrology Baseline Report: NCY-PT19, DALG-003, EAGL-t-004; EDI 2021). Four of the sites had enough water to use the fish camera for 15 to 20 minutes—no fish were detected at any of the sites. Most of the sites containing water did not have suitable water quality parameters for fish presence, with average dissolved oxygen levels ranging from 0.2 to 1.7 mg/L at five of the six sites that had water quality collected (Table 3-11). Only one of the fourth-order streams (Site 267) had low to moderate dissolved oxygen levels in the pool and stream channel sampled (3.97 mg/L and 8.50 mg/L, respectively; Table 3-8; Attachment G); these dissolved oxygen levels are likely sufficient for fish to overwinter (Leppi et al. 2016).

Fifth-order stream sampling included two sites on Chance Creek and one on McParlon Creek. Chance Creek was sampled for fish at the water quality site CHNC-003 and at a site at the farthest downstream extent before leaving the RSA. Five holes were drilled across the channel at site CHNC-003, with four of the five holes frozen to the bed (Photo 3-15). The fifth hole contained very little water (0.17 m) and was a ferrous orange in colour. The downstream site on Chance Creek also had five holes drilled cross-sectionally, with all holes frozen to bed and no detectable water. Water quality site CHNC-001 (located outside of the RSA) did contain water very near to the confluence with the Whitestone River. The site on McParlon Creek contained water but had poor overwintering habitat potential, with a low dissolved oxygen level (1.70 mg/L) and anoxic-smelling water (Table 3-8). Due to the nature of sampling beneath the ice, it is possible that the best overwintering habitat (e.g., areas of flow) could have been missed. However, this issue was minimized by sampling multiple locations at each site and drilling multiple holes across the channels.

Generally, most sites with water had a strong anoxic smell and low dissolved oxygen levels (Table 3-8). No fish were detected using the underwater fish viewer on the nine occasions water depth was sufficient to use it. The temperature did not vary considerably among sites (Table 3-8; Attachment F), with no sites appearing to have groundwater influence (i.e., warmer water inputs) at the sampled locations (Table 3-8; Attachment F, Attachment G).

Table 3-6. Summary of sites visited and those that contained water from the overwintering assessments in March 2020.

Stream Order	Sampled Sites	Sites Containing Water	Percent of Sites Visited that Contained Water (%)	Average Water Depth[1] (± SE; m)	Water Depth Range[1] (m)
1	1	0	0	–	–
2	14	1	7	0.05 ± 0.00	0.05 – 0.05
3	18	4	22	0.64 ± 0.24	0.1 – 1.1
4	13	8	62	0.37 ± 0.11	0.01 – 1.1
5	3	2	67	0.33 ± 0.16	0.17 – 0.48
TOTAL	**49**	**15**			

[1] Average water depth calculations and ranges only used sites that contained water and did not include zeroes.

Table 3-7. Summary of water presence based on stream order and habitat of stream sampled in March 2020.

Stream Order	Sites Containing Water in a Stream Reach	Sites Containing Water in an Inline Pond or Pool	Sites Containing Water in the Outlet/Inlet of an Inline Pond or Pool	Total Sites Containing Water
1	0	0	0	**0**
2	0	1	0	**1**
3	0	4	0	**4**
4	5	5	1	**11**[1]
5	2	0	0	**2**

[1] Two fourth-order streams contained water in the stream and pool, and one contained water in the outlet.

Table 3-8. Summary of in situ water quality parameters from the March 2020 investigations.

Stream Order	Sites with In Situ Water Quality	Dissolved Oxygen (%)		Dissolved Oxygen (mg/L)		Temperature (°C)	
		Average (± SE)	Range	Average (± SE)	Range	Average (± SE)	Range
1	2	31.4 ± 17.2	18.2 – 44.5	3.7 ± 2.7	2.2 – 5.3	8.7 ± 1.8	8.4 – 8.7
2	22	65.8 ± 2.9	42.9 – 89.8	7.2 ± 0.3	4.3 – 10.2	11.2 ± 0.5	7.3 – 16.2
3	14	72.7 ± 4.6	6.2 – 15.4	7.8 ± 0.5	7.6 – 14.5	11.6 ± 0.5	7.6 – 14.5
4	3	82.0 ± 6.4	70.6 – 92.8	8.7 ± 0.2	8.4 – 8.9	12.6 ± 2.6	8.1 – 17.1
5	2	99.0 ± 15.7	70.6 – 92.8	10.1 ± 1.5	8.4 – 9.0	14.4 ± 0.4	14.0 – 14.7

Photo 3-11. The only second order stream (inline pond) containing trace amounts of water (ice thickness 0.63 m), sampled on March 10, 2020.

Photo 3-12. Dry inlet of the inline pond in the second-order stream, characterized by thin layered ice and overhanging vegetation on March 10, 2020.

Photo 3-13. Inline pond in a third-order stream containing water on March 9, 2020.

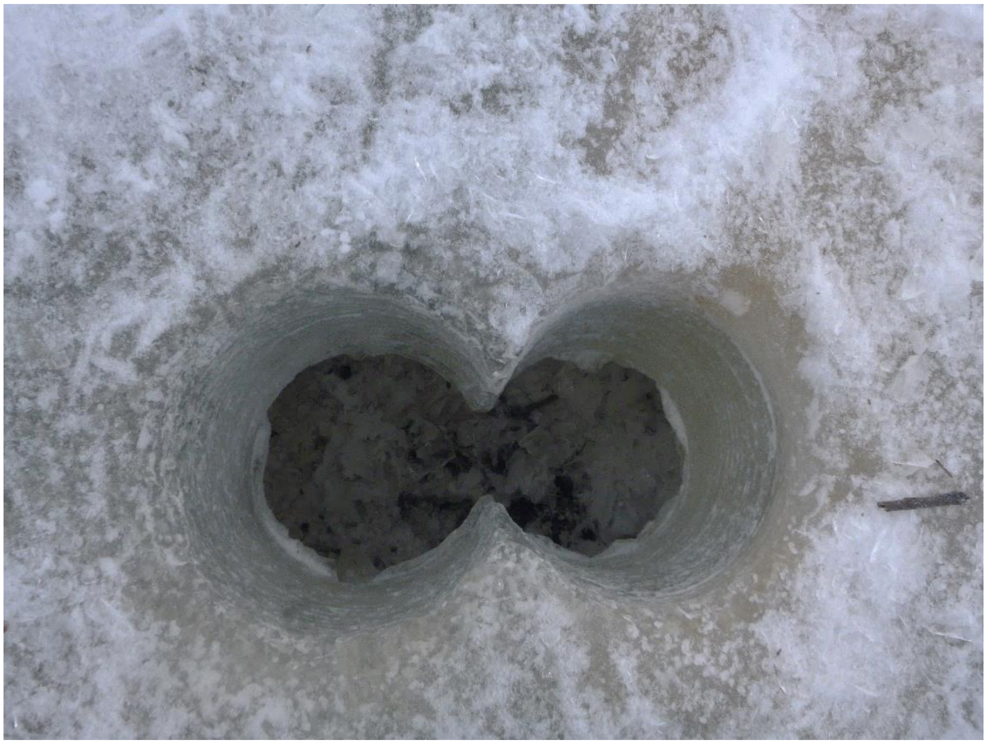
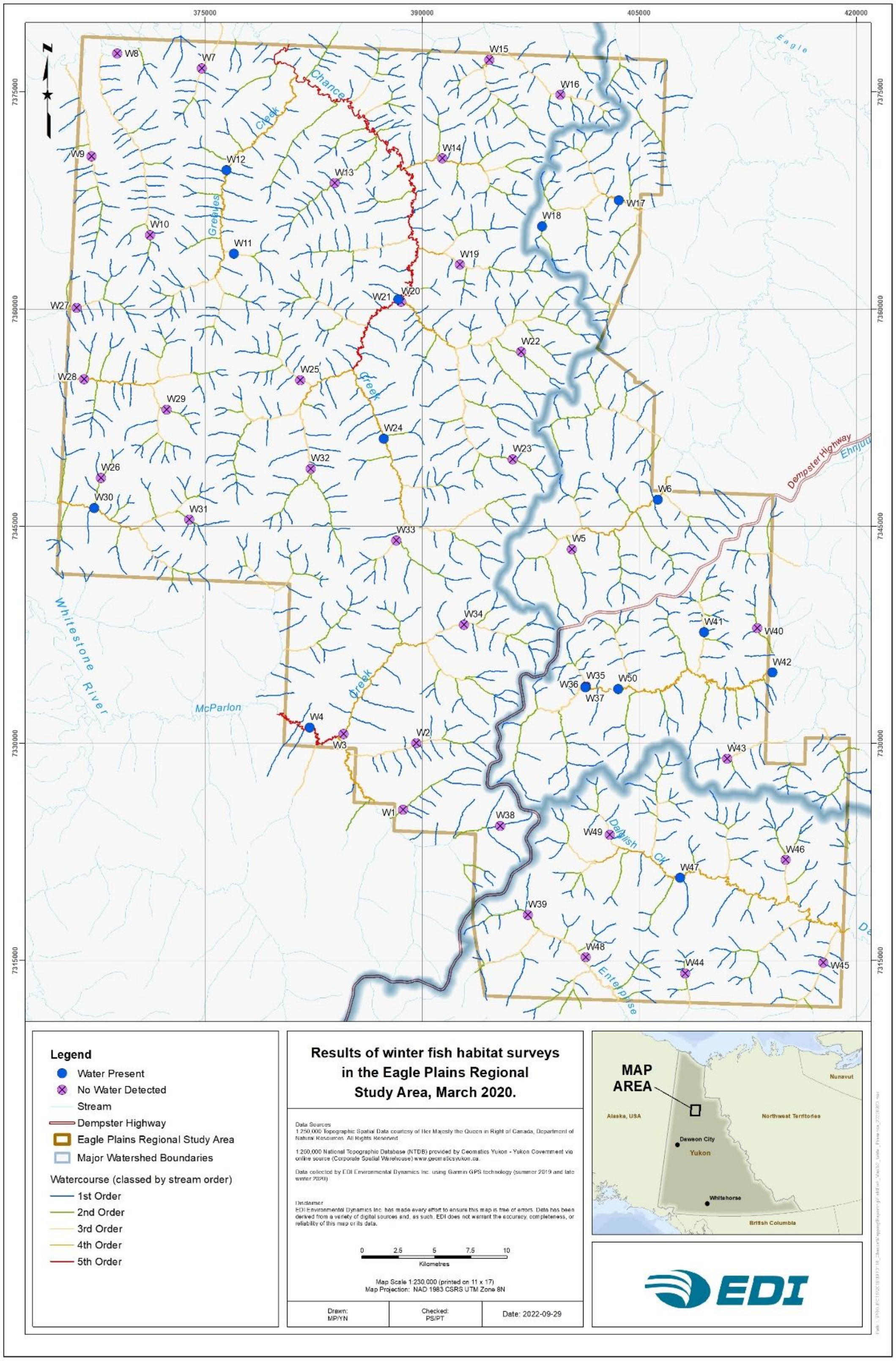


Photo 3-14. Layered ice at a dry pond outlet in a third-order stream (ice thickness 0.62 m) during sampling on March 9, 2020.

Photo 3-15. Holes drilled at Chance Creek water quality site CHNC-003 March 10, 2020.



Results of winter fish habitat surveys in the Eagle Plains Regional Study Area, March 2020.

Data Sources
1:250,000 Topographic Spatial Data courtesy of Her Majesty the Queen in Right of Canada, Department of Natural Resources. All Rights Reserved.

1:250,000 National Topographic Database (NTDB) provided by Geomatics Yukon - Yukon Government via online source (Corporate Spatial Warehouse) www.geomaticsyukon.ca.

Data collected by EDI Environmental Dynamics Inc. using Garmin GPS technology (summer 2019 and late winter 2020)

Disclaimer
EDI Environmental Dynamics Inc. has made every effort to ensure this map is free of errors. Data has been derived from a variety of digital sources and, as such, EDI does not warrant the accuracy, completeness, or reliability of this map or its data.

Map Scale 1:230,000 (printed on 11 x 17)
Map Projection: NAD 1983 CSRS UTM Zone 8N

Drawn: MP/YN
Checked: PS/PT
Date: 2022-09-29

Map 3-2. Results of winter fish habitat surveys in the Eagle Plains Regional Study Area, March 2020.

3.3 FISH PRESENCE — PREDICTIVE MODELLING

Eight models were developed that represented plausible combinations of the nine environmental variables to explain fish presence in the RSA (Table 3-9). The top model for predicting fish presence contained a single variable, stream order (Table 3-9). There was also support for models that included either distance to third--order stream or distance to third-order stream + terrain slope (i.e., Δ AICc <2 relative to the top model). Together, the top three models account for 83% of model weights. Although the 2nd and 3rd ranked models have modest wAICc values, adding those extra variables does little to improve prediction accuracy over the univariate model with stream order (Table 3-10). Based on this, the univariate model of stream order is recommended for management use due to its simplicity and model parsimony. The odds of fish presence increased with stream order (Table 3-10; Map 3-3). Absolute probabilities of occurrence associated with each stream order were as follows: 7.6% in first-order, 45.3% in second-order, 89.3% in third-order, 98.8% in fourth-order, and 99.9% in fifth-order streams. A test of the model's performance using a ROC curve indicated that the model was statistically valid for prediction with an AUC score of 0.87.

For the secondary analysis using field-based data, the top two models had nearly equivalent AICc scores and weights (Table 3-11). The model that included only stream order and pool depth was selected as the best model because it was the most parsimonious[3] and because a post hoc Fisher's exact (contingency table) test revealed that if stream order were used as a categorical variable, it would be highly associated with overwintering habitat ($p = 0.0005$). That model was then evaluated using a ROC curve, resulting in an AUC score of 0.89.

The GIS-based and field-based models performed relatively equivalently, though the latter had slightly higher accuracy in differentiating between the presences and absences of fish. In both models, stream order was the best predictor and explained a substantial proportion of the variation in fish presence. In the field-based model, stream order and pool depth had a relatively similar magnitude of effect on fish occurrence, but the room for error in those estimates were narrower for stream order. In terms of model prediction, including pool depth made a nominal difference in estimates of fish presence over the univariate model with stream order (Table 3-12).

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[3] a simple model with exceptional explanatory predictive power; explains data with minimal number of parameters.

Table 3-9. Candidate logistic regression models predicting fish presence, ranked by AICc raw scores, differences (Δ AICc), and weights (w_{AICc}), in the Eagle Plains Regional Study Area.

Rank	Model Structure	K[1]	AICc	Δ AICc	wAICc[2]
1	stream order	2	102.81	0	0.35
2	stream order + distance to third-order stream	3	103.31	0.50	0.27
3	stream order + distance to third-order stream + terrain slope	4	103.86	1.05	0.21
4	stream order + distance to third-order stream + terrain slope + distance to inline pools	5	105.29	2.48	0.10
5	stream order + distance to third-order stream + terrain slope + distance to inline pools + stream slope	6	106.71	3.89	0.05
6	stream order + distance to third-order stream + terrain slope + distance to inline pools + stream slope + elevation	7	108.88	6.07	0.02
7	stream order + distance to third-order stream + terrain slope + distance to inline pools + stream slope + elevation + catchment area	8	110.66	7.85	0.01
8	stream order + distance to third-order stream + terrain slope + distance to inline pools + stream slope + elevation + catchment area + distance to 4th order stream	9	113.00	10.19	0

[1] *K* parameters = intercept + number of covariates.

[2] Weight of evidence favouring a best model (i.e., 'relative model probabilities'; Burnham and Anderson 2002).

Table 3-10. Predicted probabilities (% and lower–upper confidence intervals) of fish presence across stream order for the top three models using GIS-based covariates.

Stream Order	Model – Predicted Probabilities		
	Stream Order	Stream Order + Distance to Third-Order	Stream Order + Distance to Third-Order + Terrain Slope
1	7.6% (0.6 – 48.9)	7.5% (0.2 – 59.4)	7.4% (0.2 – 59.4)
2	45.3% (2.7 – 96.2)	45.6% (1.4 – 97.7)	45.7% (1.2 – 97.3)
3	89.3% (11.4 – 99.8)	88.8% (8.6 – 99.9)	88.6% (8.1 – 99.9)
4	98.8% (37.8 – 100.0)	99.1% (33.9 – 100.0)	99.0% (34.5 – 100.0)
5	99.9% (74.1 – 100.0)	99.9% (73.7 – 100.0)	99.9% (80.5 – 100.0)

Table 3-11. Candidate logistic regression models constructed with field-based covariates (with *K* parameters) predicting fish presence, ranked by AICc raw scores, differences (Δ AICc), and weights (w_{AICc}) with reference to the best-supported model.

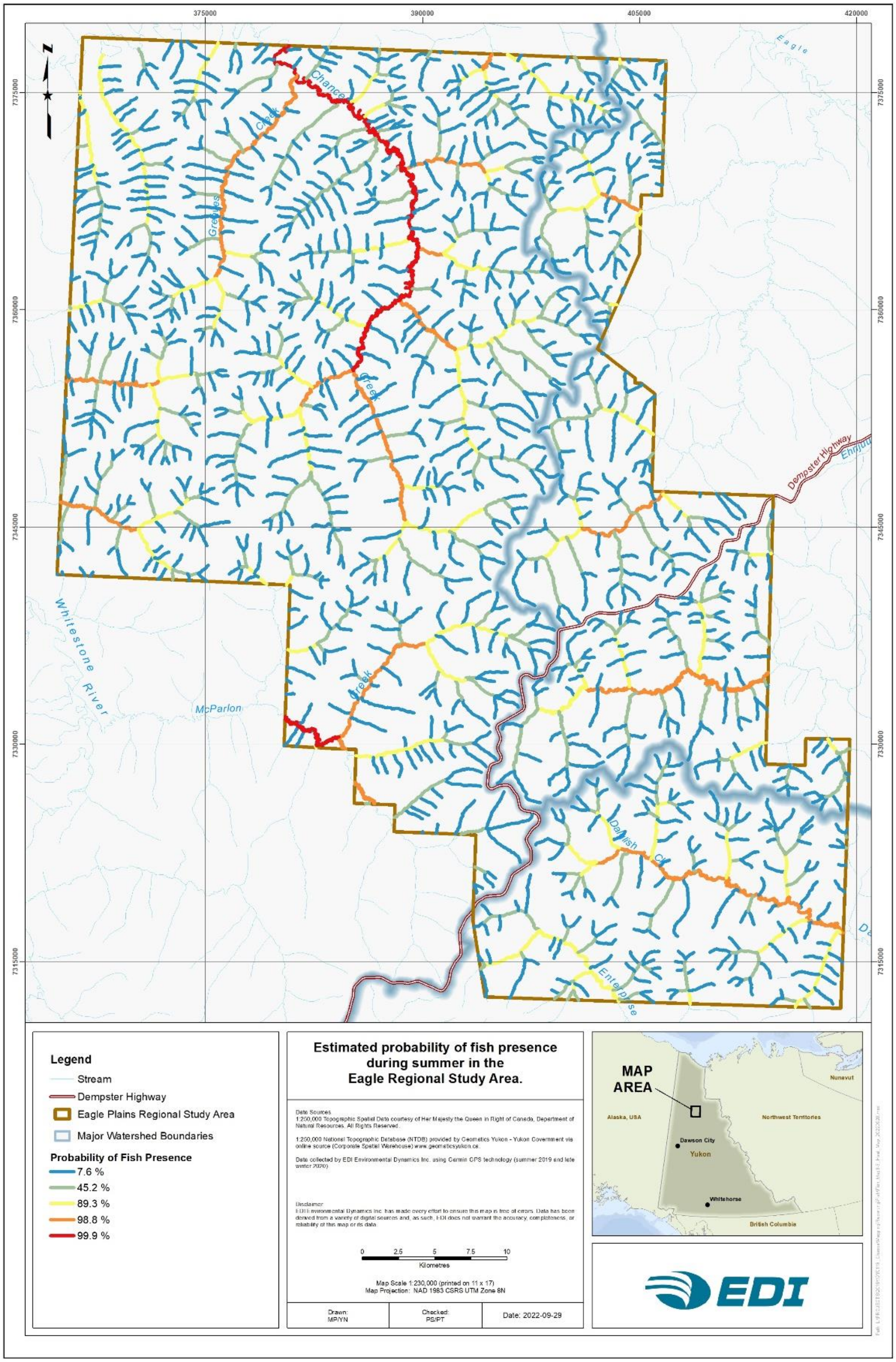
Rank	Model Structure	K[1]	AICc	Δ AICc	wAICc[2]
1	stream order + pool depth + overwintering habitat	6	99.05	0	0.39
2	stream order + pool depth	3	99.06	0.01	0.39
3	stream order + overwintering habitat	5	101.63	2.58	0.11
4	stream order	2	102.81	3.76	0.06
5	stream order + pool depth + dissolved oxygen (%) + temperature + gradient + overwintering habitat	9	102.99	3.94	0.05
6	pool depth + overwintering habitat	5	109.45	10.4	0
7	overwintering habitat	4	116.50	17.45	0
8	pool depth	2	131.61	32.56	0

[1] *K* parameters = intercept + number of covariates. Each level of a categorical variable adds a parameter.

[2] Weight of evidence favouring a best model (i.e., ‘relative model probabilities’; Burnham and Anderson 2002).

Table 3-12. Predicted probabilities (% and lower – upper 95% confidence intervals) of fish presence across stream order comparing the base model with just stream order to the top model where field covariates were also considered (stream order + pool depth).

Stream Order	Model – Predicted Probabilities	
	Stream Order (GIS Based Model)	Stream Order + Pool Depth (Field Based Model)
1	7.6% (0.6 – 48.9)	7.0% (0.4 – 51.6)
2	45.3% (2.7 – 96.2)	46.9% (1.4 – 96.9)
3	89.3% (11.4 – 99.8)	87.3% (4.9 – 99.9)
4	98.8% (37.8 – 100.0)	99.2% (16.8 – 100.0)
5	99.9% (74.1 – 100.0)	99.7% (36.51 – 100.0)



Map 3-3. Estimated probability of fish presence during summer in the Eagle Plains Regional Study Area.

4 DISCUSSION

These baseline investigations on fish and fish habitat in the RSA showed clear patterns of fish distribution in summer and of habitat availability for fish during winter. During the summer, the strong relationship between fish presence and stream order provides a clear and simple pattern of fish distribution that can be used for management to assess and mitigate potential Project effects to fish values in the RSA. Almost no first-order streams contained fish and all third-order or greater streams did contain fish during summer sampling. The variability of fish presence in second-order streams was partly attributable to differences in site-specific conditions (e.g., different channel widths and stream depths at different streams); however, across many second-order streams the intermediate probability of fish occurrence simply reflects marginal fish habitat conditions with low fish densities. Although evidence exists that additional GIS-based covariates (distance to third-order stream and terrain slope), and a field-based covariate (pool depth) may slightly improve model performance, the improvements those variables add to prediction accuracy are nominal. As such, they were not included in the final model, in favour of a simple univariate model's simplicity and ease of use (i.e., stream order only).

Electrofishing was successful at capturing several species within the RSA. Five species were captured: Arctic grayling, slimy sculpin, longnose sucker, round whitefish, and burbot. All but Arctic grayling were captured in low densities throughout the RSA. Six longnose sucker were captured at four sites in the Chance Creek, Whitestone River, and MacParlon Creek watersheds (Porcupine drainage) in second- and third-order streams. Longnose sucker are a generalist species and are the most widespread sucker in the north, commonly found in headwater streams (McPhail 2007). Four burbot were captured at three sites in second- and third-order streams in the Whitestone River and Chance Creek watersheds (Porcupine drainage). Burbot are widely distributed throughout the Northern Hemisphere and are not uncommon in riverine habitats (McPhail 2007). A study in the National Petroleum Reserve in Alaska completed a tagging study and found that burbot commonly travel up to 100 km in a season and were found in small headwater tributaries (Morris 2003). Lastly, two round whitefish were found in a third-order stream in the Dalglish Creek watershed (Peel drainage). While round whitefish are more commonly associated with larger riverine systems, they are still found in smaller streams, barring steep gradients (McPhail 2007).

The results of this study are similar to the findings in the adjacent Peel watershed study (Barker et al. 2011). The Peel study also observed a very low probability of fish in first-order streams and a high probability in third- and fourth-order (authors assumed presence in fifth-order streams; Barker et al. 2011). The Peel study findings also indicated the greatest variability in fish presence and abundance occurred in second-order streams. The Peel study identified ≥50% probability for Arctic grayling to be present in third-order streams (and only in larger, lower reaches), with probabilities 'declining rapidly to nil' in upstream sections (Barker et al. 2011).

A comparison of the AUC scores between the two studies (AUC = 0.87 Eagle Plains model vs. 0.75 Peel model) suggests that the Eagle Plains model provides somewhat better predictive performance than the Peel model in quantifying fish occurrence. This may be due to how environmental variables were assessed between the two studies. The Peel study was designed to test specific ecological hypotheses about fish distribution. In contrast, this study was designed to develop the best model to predict fish occurrence, and the two studies varied their model sets accordingly. Another potential limitation in the Peel study is that they did not use stream order as a variable in the model. Instead, they used 'upstream extent', described as the cumulative length of all stream segments upstream from the sampled location (Barker et al. 2011). In the Peel study the predictor's coefficients were weak in magnitude (e.g., $\beta = 0.0001$ on a logit scale; Barker et al. 2011). By comparison, the coefficient of stream order in the current study was fairly strong (i.e., $\beta = 2.14$ on a logit scale). This demonstrates how a simple variable like stream order captures most of the variation in fish presence. For the GIS-based model, stream order outperformed eight other predictors: distance to third-, fourth-, and fifth-order streams; stream slope; terrain slope; elevation; catchment area; and distance to inline pools.

Higher stream orders are typically associated with higher quality and more diverse fish habitat, and thus greater abundances and species diversity (Gorman and Karr 1978, Harvey and Stewart 1991). Although stream order is a simple metric, it is correlated with several other stream characteristics that, individually and in combination, tend to support more fish. As stream order increases, the metrics involved with stream width, depth, water volume, habitat complexity, and potential for overwintering habitat all increase (Harrel et al. 1967, Gorman and Karr 1978, Reynolds 1997). The results from the current study support this concept, whereby fish presence increased as stream order increased. During the summer field studies, more fish were observed or captured in higher-order streams, with very few (n = 4) fish being captured or observed in the 52 first-order streams sampled. In third-, fourth- and fifth-order streams, the proportions of streams containing fish were approaching or reaching 100%. Habitat assessments also indicated that habitat quality (e.g., pool depths) and complexity increased with increasing stream order, with higher-order streams having higher quality habitat for rearing, spawning, and potential overwintering (Attachment C).

The field studies conducted in the RSA provide a temporal picture of habitat availability and utilization. Between the summer (n = 118) and winter (n = 49) sampling, a total of 167 sites were sampled within the RSA (some sites from the summer were revisited during winter sampling). As such, all the sampling conducted provided updated information on temporal fish distribution within the RSA. Ultimately the findings of the current study illustrated the disproportionate amount of habitat available to fish during the summer compared to winter. While most of the habitat assessed in the summer was considered to have poor or no spawning habitat (with some higher-order streams considered moderate to good), the observed and captured fish indicated that rearing habitat was widespread throughout the RSA. While not many sites were considered to have optimal Arctic grayling spawning habitats, YOY were captured in second- to fifth-order streams, suggesting that spawning does occur in some streams sampled. Young-of-the-year Arctic grayling were captured in two second-order streams; both streams had channel widths of greater than 3 m and had fines for bed material (Attachment D). Young-of-the-year Arctic grayling were present in eight third-order streams, three fourth-order streams, and in both fifth-order streams sampled.

Notwithstanding the gradient of habitat quality across stream orders, the overall diversity and habitat quality in the RSA was relatively low at a regional level. Streams are low gradient, with slow-moving, turbid water. The stream beds and banks are predominantly fines and organics, which reduce water quality, forage diversity and quantity, and spawning potential compared to streams with clearer water and rocky steam beds/banks

(Gorman and Karr 1978). On average, streams in the RSA were rated as moderate quality rearing habitat and low or nil quality spawning habitat for the dominant species, Arctic grayling. Despite the suboptimal conditions, Arctic grayling were the most frequently captured species during summer fieldwork (85%) and were the most widespread regarding being higher upstream in headwater streams.

The ability of Arctic grayling to travel long distances to occupy seasonally available streams is well known. During the open water months, Arctic grayling travel upstream into the feeding areas of headwater streams for more optimal foraging opportunities and less competition (Tack 1980, Hughes 1999, McFarland 2015). This was clearly apparent in the current study, whereby Arctic grayling were found high in the headwaters of different watersheds during the summer. Streams within the RSA are highly influenced by local hydrology (i.e., permafrost, snowmelt, and precipitation events), as illustrated during summer fieldwork (Smith et al. 2004). When terrestrial field crews were in the RSA in June, water levels were considerably higher than during fish sampling in July and August; the peak flow throughout Eagle Plains typically occurs in June (Smith et al. 2004). As a result, more accessible habitat for Arctic grayling was available higher in the watersheds in June, and they occupied habitats that are otherwise inaccessible during much of the year, using headwater streams for feeding opportunities. Foraging success during the short open water season is critical for fish to acquire sufficient energy reserves before winter, when habitats are less productive overall (Morris 2003, Heim et al. 2016). Arctic grayling forage on aquatic and terrestrial invertebrates, and depending on availability, on smaller fish; these feeding behaviours change seasonally (e.g., aquatic invertebrates during the winter months; Armstrong et al. 1986, McFarland 2015). Some Arctic grayling were found isolated in residual pools with no downstream connectivity and were at risk of being stranded in areas that would become anoxic or freeze, unless a heavy rainfall event elevated the water flow and allowed them to travel downstream. Arctic grayling movements in Arctic ecosystems are strongly tied to seasonal changes in discharge and temperature (Heim et al. 2016).

Another finding from this study that is consistent with the literature is of larger Arctic grayling occupying habitats higher in headwater streams (Hughes 1992, Hughes and Reynolds 1994, Heim et al. 2016). Foraging opportunities tend to be higher in smaller, headwater streams (less water volume to cover for drift-feeding) and large grayling often occupy these areas and exclude smaller grayling from them (Vascotto 1970, Hughes 1992, 1999, Hughes and Reynolds 1994, Heim et al. 2016). This size-sorting was evident in the results herein—on average, the largest Arctic grayling were found in first-order streams (238.8 ± 13.3 mm SE), with average fork length decreasing as stream order increased (e.g., third-order average fork length = 117.8 ± 12.6 mm SE; fifth-order average fork length = 46.0 ± 6.1 mm SE).

In the late summer and fall, Arctic grayling seasonally migrate considerable distances (up to 320 km; Tripp and McCart 1974), leaving smaller headwater lakes and streams to overwinter in larger waterbodies, as the small headwater streams they inhabited in the summer often dewater or freeze to bottom during the winter months (Armstrong et al. 1986, West et al. 1992, Stewart et al. 2007, Heim 2014). This pattern appears consistent with our winter field results. Several of the same streams were visited in the summer and winter, and in nearly all cases, the streams were found to be dewatered or frozen to bed. Information on the Eagle Plains Ecoregion supports that small to intermediate streams in the region have no flow during the winter months (Smith et al. 2004).

Although water was detected in 15 of 49 sites during the winter field visit, the water depth and dissolved oxygen levels were insufficient to support overwintering fish at most sites. Adequate under-ice dissolved oxygen is a requirement for overwintering fish, as it affects fish respiration and metabolism, reproduction, growth, and survival (Leppi et al. 2016). General freshwater fish guidelines for dissolved oxygen indicate that most fish require dissolved oxygen levels above 6.0 mg/L, with potentially lethal consequences to prolonged exposure below 2.0 mg/L (Doudoroff and Shumway 1970, Davis 1975, Leppi et al. 2016). In third- and fourth-order streams sampled in the winter, dissolved oxygen levels ranged from 0.1 – 1.2 mg/L in all but one fourth-order stream. This site had dissolved oxygen levels of 4.0 mg/L in a pool, and 8.5 mg/L in the adjacent stream channel (where water was less stagnant). The only fifth-order stream with enough water to take water quality parameters was on McParlon Creek, and had dissolved oxygen levels of 1.7 mg/L. As such, based on the accepted published values of overwintering dissolved oxygen values, only one site sampled contained moderate dissolved oxygen levels for fish to overwinter.

A baseline water and sediment quality report (Golder Associates Ltd. 2018) assessed several of the same sites that were considered for the fish and water quality work completed in this report and the EDI Surface Water Quality and Hydrology Baseline Report (EDI 2021). Overall, the findings from the Golder study, completed between 2014 and 2017, are consistent with this study's water quality parameters and their suitability for fish rearing. Their findings determined that while there was sufficient dissolved oxygen during freshet and the open-water season, the ice-covered seasons had dissolved oxygen levels below the federal guidelines for aquatic life (5.5 – 9.5 mg/L; CCME 1999, Golder Associates Ltd. 2018). The water quality site CHNC-001 (located downstream, outside of the RSA) has been recorded by the Yukon Government from summer 2014 to fall 2017. During the three years of winter sampling (mid-March), the dissolved oxygen levels varied from 0.93 – 5.8 mg/L. As detailed in the EDI Surface Water Quality and Hydrology Baseline Report, CHNC-001 contained water during March 2019 with dissolved oxygen levels of 3.05 mg/L (EDI 2021). Though this site appears to contain water during the winter (potentially due to its proximity to the Whitestone River), the under-ice dissolved oxygen is considered poor to moderate for fish rearing (Doudoroff and Shumway 1970, Davis 1975, Leppi et al. 2016). Several other sites sampled by the Yukon Government were frozen or were characterized by shallow, muddy water (Golder Associates Ltd. 2018).

Slimy sculpin are considered an important indicator species for overwintering habitat, as they have strong site fidelity and only move a few hundred metres during their lifetime (Gray et al. 2004, 2018). Therefore, it is commonly accepted that if a slimy sculpin is captured in the summer, overwintering habitat will occur within several hundred metres of that location. Within this study, all slimy sculpin were captured in a concentrated area in the southern end of the RSA. Individuals were caught in five sites in Eagle River tributaries (Porcupine drainage; second- and fourth-order), two sites in the MacParlon River watershed (Porcupine drainage; third- and fifth-order), and one site in a tributary to Enterprise Creek (Peel drainage; third-order; Attachment C). Slimy sculpin were captured at eight sites during the summer sampling. These sites were revisited, and five winter sites contained water near summer slimy sculpin sites. As discussed above, one of these sites was the only site with sufficient under-ice dissolved oxygen to support overwintering fish (8.5 mg/L, site 267; Attachment G). Two other winter sites downstream of this site contained water, but at the point of sampling, they both had insufficient dissolved oxygen for overwintering fish. With the evidence of summer sampling capturing slimy sculpin in second-order streams upstream of these sites, it is likely pockets of overwintering habitat exist elsewhere and within the range a slimy sculpin would travel.

Despite appropriate sampling methods, no salmon were captured or observed in the RSA. This finding is consistent with past work in the Porcupine River watershed that indicated salmon rearing appears to be limited to natal streams (streams in which they spawn; Anderton 2004). Known salmon spawning areas in the Porcupine drainage downstream of the RSA include the Whitestone (Chinook), Bell (Chinook and chum), and Rock rivers (Chinook and chum; Anderton 2004, EDI 2016), all of which are tens of km downstream from the RSA. From a habitat perspective, the predominance of slow-moving, turbid water, with silty/organic stream beds offers no spawning potential and low-quality juvenile rearing for salmon. Based on the far distances to suitable spawning habitat outside the RSA and the poor quality of rearing habitat within the RSA, salmon are unlikely to use the streams within the RSA.

5 CONCLUSIONS

This study successfully met its objectives of improving the understanding of fish distribution across the RSA in summer and winter. The results of this study indicate a dynamic pattern of fish occurrence in the RSA between summer and winter. Overwintering habitat is very limited in the RSA, and most fish likely migrate out of the RSA to find suitable overwintering habitat in larger rivers. During summer, transient fish, most notably Arctic grayling, travel tens to greater than 100 km from larger, higher order rivers to use second-order and greater streams in the RSA as seasonal rearing habitat.

Overall, the habitat diversity in the RSA was low and dominated by slow-moving, turbid water, with fines and organics bed materials. Despite this habitat not typically being considered quality rearing habitat for Arctic grayling, this fish was the most widespread species in the RSA, accounting for 85% of fish captured in the summer. Burbot, round whitefish, longnose sucker and slimy sculpin made up the other 15% of fish captured during the summer field program. No salmon were captured or observed within the RSA; these findings are consistent with the known extent of salmon use in the Porcupine River watershed. During the summer, fish presence was predominantly explained by stream order—fish were detected in almost none of the first-order streams, approximately half of the second-order streams, and almost all third-order and greater streams. The strong relationship between fish presence and stream order provides a clear and simple pattern of fish distribution that can be used for management to assess and mitigate potential Project effects to fish values in the RSA.

While fish (especially Arctic grayling) were found widely across the RSA during the summer months, nearly all sites assessed in the winter were frozen to bed, dewatered, or had insufficient under-ice dissolved oxygen levels for fish to overwinter. The lower reaches of Chance Creek and select sites along McParlon, Dalglish, and Enterprise creeks may offer limited overwintering habitat to a small number of fish (based on water conditions in March 2020 and the presence of non-migratory slimy sculpin at some summer sites). However, the extent of suitable overwintering habitat appears limited to small pockets capable of supporting only small numbers of fish. Most fish (i.e., all species other than slimy sculpin) likely migrate to higher-order streams outside the RSA with better overwintering conditions and larger stream extents.

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ATTACHMENTS

ATTACHMENT A ELECTROFISHING SETTINGS AND ELECTROFISHING AND MINNOW TRAPPING EFFORT

Table A-1. Electrofisher settings and site sampling details, July and August 2020.

Electrofisher	Stream ID	Time "On" (secs)	Distance (m)	Voltage (V)	Frequency (Hz)	Duty cycle	Pulse width (ms)	Power (w)	Amps (A)
LR-24	773	483	50	350	30	20	4	44	0.1
LR-24	871	419	80	360	30	20	4	-	0.1
LR-24	547	364	90	360	30	20	4	30	0.1
LR-24	244	372	40	300	30	30	5	37	0.1
LR-24	183	420	40	375	30	20	4	26	0.1
LR-24	842A	400	45	300	30	30	4	47	0.2
LR-24	842B	427	45	-	30	20	4	87	0.3
LR-24	809	427	50	450	30	20	4	18	0.3
LR-24	801	483	100	450	30	20	4	90	0.2
LR-24	494	407	70	500	30	20	4	42	0.1
LR-24	846	480	60	500	30	20	4	48	0.1
LR-24	840	496	-	450	30	20	4	41	0.1
LR-24	867	211	70	685	30	12	4	-	0.1
LR-24	456	450	40	500	30	20	4	-	0.1
LR-24	1387	476	70	450	30	20	4	46	0.1
LR-24	1383	492	70	450	30	20	4	49	0.1
LR-24	1379	495	60	500	30	20	4	54	0.1
LR-24	1271	438	65	600	30	20	4	60	0.1
LR-24	767	482	60	500	30	30	5	40	0.1
LR-24	862	461	60	550	30	12	4	40	0.1
LR-24	764	439	80	550	30	20	4	40	0.1
LR-24	271	461	60	550	30	20	4	-	-
LR-24	229	486	-	250	30	20	4	130	0.5-0.8
LR-24	309	427	65	400	30	20	4	40	0-1
LR-24	1182	498	-	250	40	20	5	130	0.7
LR-24	210	441	50	300	40	20	5	130	0.5
LR-24	1364	456	60	250	30	20	4	45	0.1
LR-24	1397	450	60	250	30	20	4	-	0.1
LR-24	1373	499	60	400	30	20	4	55	0.1
LR-24	979	467	60	400	30	20	4	80	0.1
LR-24	980	518	60	400	30	20	4	80	0.2
LR-24	1110	442	40	250	30	12	4	47	0.1
LR-24	1101	445	25	400	40	20	5	65	0.1
LR-24	1130	447	30	400	40	20	5	70	0.1
LR-24	206	439	60	200	30	20	4	70	0.1
12B POW	459	430	125	600	60	36	6	n/a	n/a
12B POW	776	418	150	400	60	36	6	n/a	n/a

Electrofisher	Stream ID	Time "On" (secs)	Distance (m)	Voltage (V)	Frequency (Hz)	Duty cycle	Pulse width (ms)	Power (w)	Amps (A)
12B POW	835	609	200	400	60	36	6	n/a	n/a
12B POW	785	585	-	500	60	36	6	n/a	n/a
12B POW	534	454	200	300	60	36	6	n/a	n/a
12B POW	245	408	150	500	60	36	6	n/a	n/a
12B POW	171	402	150	500	60	36	6	n/a	n/a
12B POW	265	461	150	400	60	36	6	n/a	n/a
12B POW	673	248	-	400	60	36	6	n/a	n/a
12B POW	341	460	-	500	60	36	6	n/a	n/a
12B POW	798	633	100	500	60	36	6	n/a	n/a
12B POW	646	628	80	500	60	36	6	n/a	n/a
12B POW	616	423	70	500	60	36	6	n/a	n/a
12B POW	792	573	-	400	60	36	6	n/a	n/a
12B POW	838	524	80	400	60	36	6	n/a	n/a
12B POW	1406	414	80	400	60	36	6	n/a	n/a
12B POW	861	509	70	400	60	36	6	n/a	n/a
12B POW	1400	503	100	500	60	36	6	n/a	n/a
12B POW	832	430	80	500	60	36	6	n/a	n/a
12B POW	394	463	150	500	60	36	6	n/a	n/a
12B POW	774	449	100	500	60	36	6	n/a	n/a
12B POW	1338	351	65	500	60	36	6	n/a	n/a
12B POW	277	411	160	100	60	36	6	n/a	n/a
12B POW	147	415	100	500	60	36	6	n/a	n/a
12B POW	241	313	120	600	60	36	6	n/a	n/a
12B POW	269	669	150	100	60	36	6	n/a	n/a
12B POW	401	323	-	400	60	36	6	n/a	n/a
12B POW	828	465	60	500	60	36	6	n/a	n/a
12B POW	347	404	100	600	60	36	6	n/a	n/a
12B POW	772	491	80	500	60	36	6	n/a	n/a
12B POW	1184	689	75	300	60	36	6	n/a	n/a
12B POW	1414	299	80	500	60	36	6	n/a	n/a
12B POW	1413	545	-	300	60	36	6	n/a	n/a
12B POW	23	406	100	300	60	36	6	n/a	n/a
12B POW	1423	403	-	300	60	36	6	n/a	n/a
12B POW	1363	276	150	500	60	36	6	n/a	n/a
12B POW	977	567	150	200	60	36	6	n/a	n/a
12B POW	1089	331	150	100	60	36	6	n/a	n/a
12B POW	1125	595	200	100	60	36	6	n/a	n/a
12B POW	1026	453	80	400	60	36	6	n/a	n/a

Electrofisher	Stream ID	Time "On" (secs)	Distance (m)	Voltage (V)	Frequency (Hz)	Duty cycle	Pulse width (ms)	Power (w)	Amps (A)
12B POW	1042	693	150	200	60	36	6	n/a	n/a
12B POW	1120	430	120	100	60	36	6	n/a	n/a
12B POW	211	503	80	200	60	36	6	n/a	n/a
12B POW	273	416	100	200	60	36	6	n/a	n/a
12B POW	267	565	65	100	60	36	6	n/a	n/a
12B POW	222	493	100	100	60	36	6	n/a	n/a
12B POW	76	285	200	200	60	36	6	n/a	n/a
12B POW	82	410	100	300	60	36	6	n/a	n/a
12B POW	227	477	120	100	60	36	6	n/a	n/a
12B POW	258	445	100	300	60	36	6	n/a	n/a

ATTACHMENT B ANDERSON RESOURCES LTD. 2001 PRELIMINARY BASELINE DATA

Table B-1. Access Consulting electrofishing results, June, August, and September 2001. Modified from Anderson (2001).

Sampling Site	River Drainage	Subdrainage	Date	Effort (seconds)	Fish Captured
AXL1	Peel	Ogilvie River	June 20, 2001	458	12 GR, 1 RW, 1 LW
AXL1	Peel	Ogilvie River	August 31, 2001	795	1 GR, 3 CCG, 1 BB, 2 LSU
AXL2 (pond)	Porcupine (Whitestone)	McParlon Creek	June 19, 2001	300	NFC
AXL2 (pond)	Porcupine (Whitestone)	McParlon Creek	September 3, 2001	33	NFC
AXL3	Porcupine (Whitestone)	McParlon Creek	June 19, 2001	190	NFC
AXL3	Porcupine (Whitestone)	McParlon Creek	September 3, 2001	424	1 GR
AXL4	Porcupine (Whitestone)	Chance Creek	June 19, 2001	588	NFC
AXL4	Porcupine (Whitestone)	Chance Creek	September 4, 2001	381	NFC
AXL5	Porcupine (Eagle)	Fly Creek	September 3, 2001	165 (u/s culvert); 126 d/s culvert	NFC both u/s and d/s culvert
AXL6 (pond)	Porcupine (Eagle)	Eagle Creek	June 21, 2001	178	NFC
AXL6 (pond)	Porcupine (Eagle)	Eagle Creek	September 1, 2001	199	NFC
AXL7	Porcupine (Eagle)	Eagle Creek	June 21, 2001	389	1 CCG
AXL7	Porcupine (Eagle)	Eagle Creek	September 1, 2001	277	1 GR
AXL8	Peel	Enterprise Creek	June 20, 2001	495	1 CCG
AXL8	Peel	Enterprise Creek	September 1, 2001	565	1 CCG
AXL9	Peel	Dalglish Creek	June 20, 2001	480	4 GR, 1 CCG, 1 LSU, 1 LW, 1 RW,1 CCG
AXL9	Peel	Dalglish Creek	September 1, 2001	516	1 CCG
AXL10	Porcupine (Eagle)	Eagle River	June 21, 2001	290	NFC
AXL11	Porcupine (Whitestone)	McParlon Creek	September 2, 2001	143	2 GR

Table B-2. Access Consulting angling results from June and September 2001. Modified from Anderson (2001).

Sampling site	River Drainage	Subdrainage	Date	Effort (hours)	Fish captured
AXL8	Peel	Enterprise Creek	September 1, 2001	0.25	1 GR
AXL9	Peel	Dalglish Creek	September 1, 2001	0.25	1 GR
AXL10	Porcupine (Eagle)	Eagle River	June 21, 2001	0.50	NFC

Table B-3. Access Consulting beach seining results from June, August, and September 2001. Modified from Anderson (2001).

Sampling Site	River Drainage	Subdrainage	Date	Effort (m^2)	Fish Captured
AXL1	Peel	Ogilvie River	August 31, 2001	144 (6 seine hauls)	1 GR
AXL1	Peel	Ogilvie River	September 1, 2001	95 (3 seine hauls)	1 GR
AXL6 (pond)	Porcupine (Eagle)	Eagle Creek	September 1, 2001	60 (1 seine haul)	NFC
AXL8	Peel	Enterprise Creek	September 1, 2001	136 (3 seine hauls)	2 GR, 2 CCG, 1 RW
AXL9	Peel	Dalglish Creek	September 1, 2001	416 (4 seine hauls)	3 LSU, 3 CCG, 1 GR
AXL10	Porcupine (Eagle)	Eagle River	June 21, 2001	108 (3 seine hauls)	10 CCG
AXL10	Porcupine (Eagle)	Eagle River	September 2, 2001	810 (6 seine hauls)	10 GR, 5 LSU, 4 CCG, 1 NP

ATTACHMENT C SUMMER SAMPLING FISH METRICS

Table C-1. Summer fish capture data and metrics, July and August 2020.

Date	Stream ID	Lat	Long	Stream Order	Method	Waterbody/Tributary	Species	Fork Length (mm)
25-Jul-19	244	66.39362	-137.27721	2	EF	Eagle River tributaries	GR	250
25-Jul-19	773	66.31628	-137.30335	2	EF	Chance Creek and tributaries	GR	210
25-Jul-19	773	66.31628	-137.30335	2	EF	Chance Creek and tributaries	GR	215
25-Jul-19	835	66.36866	-137.40148	3	EF	Chance Creek and tributaries	GR	32
25-Jul-19	835	66.36866	-137.40148	3	EF	Chance Creek and tributaries	GR	35
25-Jul-19	835	66.36866	-137.40148	3	EF	Chance Creek and tributaries	GR	35
26-Jul-19	265	66.42464	-137.19939	3	EF	Eagle River tributaries	GR	270
26-Jul-19	265	66.42464	-137.19939	3	EF	Eagle River tributaries	GR	180
26-Jul-19	341	66.44963	-137.54914	5	EF	Chance Creek and tributaries	GR	42
26-Jul-19	341	66.44963	-137.54914	5	EF	Chance Creek and tributaries	GR	34
26-Jul-19	341	66.44963	-137.54914	5	EF	Chance Creek and tributaries	GR	42
26-Jul-19	341	66.44963	-137.54914	5	EF	Chance Creek and tributaries	GR	35
26-Jul-19	341	66.44963	-137.54914	5	EF	Chance Creek and tributaries	GR	44
26-Jul-19	341	66.44963	-137.54914	5	EF	Chance Creek and tributaries	GR	38
26-Jul-19	341	66.44963	-137.54914	5	EF	Chance Creek and tributaries	GR	38
26-Jul-19	809	66.46959	-137.33893	2	EF	Porcupine River tributaries	GR	225
26-Jul-19	842B	66.47637	-137.25497	3	EF	Porcupine River tributaries	GR	220
27-Jul-19	646	66.43586	-137.73723	4	EF	Chance Creek and tributaries	GR	42
27-Jul-19	646	66.43586	-137.73723	4	EF	Chance Creek and tributaries	GR	47
27-Jul-19	646	66.43586	-137.73723	4	EF	Chance Creek and tributaries	GR	40
27-Jul-19	646	66.43586	-137.73723	4	EF	Chance Creek and tributaries	GR	42
27-Jul-19	646	66.43586	-137.73723	4	EF	Chance Creek and tributaries	GR	41

Date	Stream ID	Lat	Long	Stream Order	Method	Waterbody/Tributary	Species	Fork Length (mm)
27-Jul-19	646	66.43586	-137.73723	4	EF	Chance Creek and tributaries	GR	45
27-Jul-19	646	66.43586	-137.73723	4	EF	Chance Creek and tributaries	GR	33
27-Jul-19	838	66.43382	-137.90719	3	EF	Chance Creek and tributaries	GR	230
27-Jul-19	840	66.42658	-137.97697	3	EF	Chance Creek and tributaries	BB	-
27-Jul-19	840	66.42658	-137.97697	3	EF	Chance Creek and tributaries	GR	168
27-Jul-19	840	66.42658	-137.97697	3	EF	Chance Creek and tributaries	GR	190
27-Jul-19	840	66.42658	-137.97697	3	EF	Chance Creek and tributaries	GR	170
27-Jul-19	840	66.42658	-137.97697	3	EF	Chance Creek and tributaries	LSU	211
28-Jul-19	832	66.29263	-137.63791	3	EF	Chance Creek and tributaries	GR	325
28-Jul-19	832	66.29263	-137.63791	3	EF	Chance Creek and tributaries	GR	33
28-Jul-19	832	66.29263	-137.63791	3	EF	Chance Creek and tributaries	GR	43
28-Jul-19	832	66.29263	-137.63791	3	EF	Chance Creek and tributaries	GR	43
28-Jul-19	832	66.29263	-137.63791	3	EF	Chance Creek and tributaries	GR	45
28-Jul-19	832	66.29263	-137.63791	3	EF	Chance Creek and tributaries	GR	45
28-Jul-19	861	66.23264	-137.62143	2	EF	Chance Creek and tributaries	GR	200
28-Jul-19	861	66.23264	-137.62143	2	EF	Chance Creek and tributaries	GR	260
28-Jul-19	861	66.23264	-137.62143	2	EF	Chance Creek and tributaries	GR	280
28-Jul-19	861	66.23264	-137.62143	2	EF	Chance Creek and tributaries	GR	200
28-Jul-19	861	66.23264	-137.62143	2	EF	Chance Creek and tributaries	GR	45
28-Jul-19	861	66.23264	-137.62143	2	EF	Chance Creek and tributaries	GR	45
28-Jul-19	861	66.23264	-137.62143	2	EF	Chance Creek and tributaries	GR	250
28-Jul-19	861	66.23264	-137.62143	2	EF	Chance Creek and tributaries	GR	40

Date	Stream ID	Lat	Long	Stream Order	Method	Waterbody/Tributary	Species	Fork Length (mm)
28-Jul-19	861	66.23264	-137.62143	2	EF	Chance Creek and tributaries	GR	45
28-Jul-19	1379	66.20401	-137.80348	2	EF	Whitestone River tributaries	GR	169
28-Jul-19	1379	66.20401	-137.80348	2	EF	Whitestone River tributaries	GR	176
28-Jul-19	1379	66.20401	-137.80348	2	EF	Whitestone River tributaries	GR	175
28-Jul-19	1383	66.22768	-137.93771	2	EF	Whitestone River tributaries	BB	200
28-Jul-19	1383	66.22768	-137.93771	2	EF	Whitestone River tributaries	BB	250
28-Jul-19	1383	66.22768	-137.93771	2	EF	Whitestone River tributaries	LSU	127
28-Jul-19	1383	66.22768	-137.93771	2	EF	Whitestone River tributaries	LSU	145
28-Jul-19	1387	66.27138	-137.84242	2	EF	Whitestone River tributaries	BB	285
28-Jul-19	1387	66.27138	-137.84242	2	EF	Whitestone River tributaries	GR	140
28-Jul-19	1387	66.27138	-137.84242	2	EF	Whitestone River tributaries	GR	190
28-Jul-19	1387	66.27138	-137.84242	2	EF	Whitestone River tributaries	LSU	87
28-Jul-19	1400	66.16558	-137.67757	3	EF	MacParlon Creek and tributaries	GR	45
28-Jul-19	1406	66.33226	-137.98871	3	EF	Whitestone River tributaries	GR	48
28-Jul-19	1406	66.33226	-137.98871	3	EF	Whitestone River tributaries	GR	37
29-Jul-19	229	66.19591	-137.21330	2	EF	Eagle River tributaries	GR	38
29-Jul-19	229	66.19591	-137.21330	2	EF	Eagle River tributaries	GR	45
29-Jul-19	229	66.19591	-137.21330	2	EF	Eagle River tributaries	GR	50
29-Jul-19	229	66.19591	-137.21330	2	EF	Eagle River tributaries	GR	45
29-Jul-19	241	66.28690	-137.13797	2	EF	Eagle River tributaries	GR	200
29-Jul-19	269	66.22424	-137.09426	4	EF	Eagle River tributaries	CCG	94
29-Jul-19	269	66.22424	-137.09426	4	EF	Eagle River tributaries	GR	45
29-Jul-19	764	66.25010	-137.30640	2	EF	Chance Creek and tributaries	GR	260
29-Jul-19	772	66.31227	-137.34092	1	EF	Chance Creek and tributaries	GR	250
29-Jul-19	828	66.19646	-137.48249	3	EF	Chance Creek and tributaries	GR	230

Date	Stream ID	Lat	Long	Stream Order	Method	Waterbody/Tributary	Species	Fork Length (mm)
29-Jul-19	828	66.19646	-137.48249	3	EF	Chance Creek and tributaries	GR	38
29-Jul-19	828	66.19646	-137.48249	3	EF	Chance Creek and tributaries	GR	38
29-Jul-19	828	66.19646	-137.48249	3	EF	Chance Creek and tributaries	GR	46
29-Jul-19	828	66.19646	-137.48249	3	EF	Chance Creek and tributaries	GR	27
29-Jul-19	828	66.19646	-137.48249	3	EF	Chance Creek and tributaries	GR	30
29-Jul-19	828	66.19646	-137.48249	3	EF	Chance Creek and tributaries	GR	51
29-Jul-19	828	66.19646	-137.48249	3	EF	Chance Creek and tributaries	GR	37
29-Jul-19	828	66.19646	-137.48249	3	EF	Chance Creek and tributaries	GR	27
29-Jul-19	828	66.19646	-137.48249	3	EF	Chance Creek and tributaries	GR	32
29-Jul-19	828	66.19646	-137.48249	3	EF	Chance Creek and tributaries	GR	37
29-Jul-19	862	66.23062	-137.43553	2	EF	Chance Creek and tributaries	GR	298
29-Jul-19	862	66.23062	-137.43553	2	EF	Chance Creek and tributaries	GR	265
30-Jul-19	210	66.08836	-137.21996	2	EF	Eagle River tributaries	CCG	97
30-Jul-19	210	66.08836	-137.21996	2	EF	Eagle River tributaries	CCG	110
30-Jul-19	977	66.01317	-137.13562	3	EF	Dalglish Creek and tributaries	GR	210
30-Jul-19	977	66.01317	-137.13562	3	EF	Dalglish Creek and tributaries	GR	260
30-Jul-19	977	66.01317	-137.13562	3	EF	Dalglish Creek and tributaries	GR	40
30-Jul-19	977	66.01317	-137.13562	3	EF	Dalglish Creek and tributaries	WF	290
30-Jul-19	1182	66.12263	-137.41684	3	MT	MacParlon Creek and tributaries	GR	245
30-Jul-19	1182	66.12263	-137.41684	3	MT	MacParlon Creek and tributaries	GR	46
30-Jul-19	1182	66.12263	-137.41684	3	MT	MacParlon Creek and tributaries	GR	45
30-Jul-19	1182	66.12263	-137.41684	3	MT	MacParlon Creek and tributaries	GR	45
30-Jul-19	1182	66.12263	-137.41684	3	EF	MacParlon Creek and tributaries	GR	45

Date	Stream ID	Lat	Long	Stream Order	Method	Waterbody/Tributary	Species	Fork Length (mm)
30-Jul-19	1182	66.12263	-137.41684	3	EF	MacParlon Creek and tributaries	GR	45
30-Jul-19	1182	66.12263	-137.41684	3	EF	MacParlon Creek and tributaries	GR	250
30-Jul-19	1182	66.12263	-137.41684	3	EF	MacParlon Creek and tributaries	GR	200
30-Jul-19	1184	66.07806	-137.60150	5	EF	MacParlon Creek and tributaries	CCG	64
30-Jul-19	1184	66.07806	-137.60150	5	EF	MacParlon Creek and tributaries	CCG	89
30-Jul-19	1184	66.07806	-137.60150	5	EF	MacParlon Creek and tributaries	CCG	67
30-Jul-19	1184	66.07806	-137.60150	5	EF	MacParlon Creek and tributaries	CCG	64
30-Jul-19	1184	66.07806	-137.60150	5	EF	MacParlon Creek and tributaries	GR	48
30-Jul-19	1184	66.07806	-137.60150	5	EF	MacParlon Creek and tributaries	GR	93
30-Jul-19	1363	66.03002	-137.45626	2	EF	MacParlon Creek and tributaries	GR	250
30-Jul-19	1373	66.14102	-137.47226	2	EF	MacParlon Creek and tributaries	LSU	170
30-Jul-19	1373	66.14102	-137.47226	2	EF	MacParlon Creek and tributaries	LSU	120
30-Jul-19	1397	66.07154	-137.43953	3	EF	MacParlon Creek and tributaries	CCG	-
30-Jul-19	1397	66.07154	-137.43953	3	EF	MacParlon Creek and tributaries	GR	195
30-Jul-19	1397	66.07154	-137.43953	3	EF	MacParlon Creek and tributaries	GR	142
30-Jul-19	1397	66.07154	-137.43953	3	EF	MacParlon Creek and tributaries	GR	200
30-Jul-19	1414	66.12903	-137.59081	1	EF	MacParlon Creek and tributaries	GR	260
30-Jul-19	1423	66.02239	-137.30629	1	EF	MacParlon Creek and tributaries	GR	245
31-Jul-19	979	65.96795	-137.26147	2	EF	Enterprise Creek and tributaries	GR	121
31-Jul-19	979	65.96795	-137.26147	2	EF	Enterprise Creek and tributaries	GR	120
31-Jul-19	979	65.96795	-137.26147	2	EF	Enterprise Creek and tributaries	GR	120
31-Jul-19	979	65.96795	-137.26147	2	EF	Enterprise Creek and tributaries	GR	120

Date	Stream ID	Lat	Long	Stream Order	Method	Waterbody/Tributary	Species	Fork Length (mm)
31-Jul-19	979	65.96795	-137.26147	2	EF	Enterprise Creek and tributaries	GR	200
31-Jul-19	979	65.96795	-137.26147	2	EF	Enterprise Creek and tributaries	GR	350
31-Jul-19	980	65.95205	-137.20335	3	EF	Enterprise Creek and tributaries	CCG	70
31-Jul-19	980	65.95205	-137.20335	3	EF	Enterprise Creek and tributaries	CCG	67
31-Jul-19	980	65.95205	-137.20335	3	EF	Enterprise Creek and tributaries	GR	-
31-Jul-19	980	65.95205	-137.20335	3	EF	Enterprise Creek and tributaries	GR	-
31-Jul-19	980	65.95205	-137.20335	3	EF	Enterprise Creek and tributaries	GR	-
31-Jul-19	980	65.95205	-137.20335	3	EF	Enterprise Creek and tributaries	GR	-
31-Jul-19	980	65.95205	-137.20335	3	EF	Enterprise Creek and tributaries	GR	-
31-Jul-19	980	65.95205	-137.20335	3	EF	Enterprise Creek and tributaries	GR	180
31-Jul-19	980	65.95205	-137.20335	3	EF	Enterprise Creek and tributaries	GR	190
31-Jul-19	980	65.95205	-137.20335	3	EF	Enterprise Creek and tributaries	GR	180
31-Jul-19	980	65.95205	-137.20335	3	EF	Enterprise Creek and tributaries	GR	125
31-Jul-19	1026	65.98262	-136.95693	1	EF	Dalglish Creek and tributaries	GR	200
31-Jul-19	1026	65.98262	-136.95693	1	EF	Dalglish Creek and tributaries	GR	250
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	54
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	56
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	53
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	53
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	52
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	52
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	56

Date	Stream ID	Lat	Long	Stream Order	Method	Waterbody/Tributary	Species	Fork Length (mm)
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	57
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	51
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	50
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	65
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	-
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	-
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	-
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	-
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	-
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	-
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	-
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	-
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	-
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	-
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	-
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	-
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	-
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	-
31-Jul-19	1042	65.98499	-136.92573	4	EF	Dalglish Creek and tributaries	GR	-
31-Jul-19	1101	65.93429	-137.01817	2	EF	Enterprise Creek and tributaries	GR	196
31-Jul-19	1101	65.93429	-137.01817	2	EF	Enterprise Creek and tributaries	GR	220
31-Jul-19	1101	65.93429	-137.01817	2	EF	Enterprise Creek and tributaries	GR	128

Date	Stream ID	Lat	Long	Stream Order	Method	Waterbody/Tributary	Species	Fork Length (mm)
31-Jul-19	1101	65.93429	-137.01817	2	EF	Enterprise Creek and tributaries	GR	124
31-Jul-19	1120	66.01606	-136.88086	2	EF	Dalglish Creek and tributaries	GR	185
31-Jul-19	1120	66.01606	-136.88086	2	EF	Dalglish Creek and tributaries	GR	200
31-Jul-19	1125	66.04642	-137.07181	2	EF	Dalglish Creek and tributaries	GR	200
31-Jul-19	1130	65.95552	-136.89151	3	EF	Dalglish Creek and tributaries	GR	275
31-Jul-19	1130	65.95552	-136.89151	3	EF	Dalglish Creek and tributaries	GR	157
31-Jul-19	1130	65.95552	-136.89151	3	EF	Dalglish Creek and tributaries	GR	145
31-Jul-19	1130	65.95552	-136.89151	3	EF	Dalglish Creek and tributaries	RW	298
01-Aug-19	211	66.08931	-137.12180	2	EF	Eagle River tributaries	CCG	120
01-Aug-19	211	66.08931	-137.12180	2	EF	Eagle River tributaries	GR	140
01-Aug-19	211	66.08931	-137.12180	2	EF	Eagle River tributaries	GR	-
01-Aug-19	222	66.15111	-136.92546	2	EF	Eagle River tributaries	GR	117
01-Aug-19	267	66.11403	-136.93640	4	EF	Eagle River tributaries	CCG	81
01-Aug-19	267	66.11403	-136.93640	4	EF	Eagle River tributaries	CCG	82
01-Aug-19	267	66.11403	-136.93640	4	EF	Eagle River tributaries	GR	55
01-Aug-19	273	66.06855	-136.96714	2	EF	Eagle River tributaries	CCG	90
01-Aug-19	273	66.06855	-136.96714	2	EF	Eagle River tributaries	GR	175

ATTACHMENT D SUMMER WATER QUALITY PARAMETERS

Table D-1. Summer site water quality parameters, July and August 2019.

Date	Stream ID	Latitude	Longitude	Stream Order	DO (mg/L)	(DO %)	Temperature (C°)
25-Jul-19	244	66.39362	-137.2772	2	6.87	69.8	16.2
25-Jul-19	245	66.39774	-137.2063	2	6.77	66.2	14.5
25-Jul-19	459	66.33082	-137.4702	1	8.90	73.4	7.4
25-Jul-19	470	66.332	-137.382	1	3.47	31.9	9.1
25-Jul-19	484	66.33816	-137.4609	1	6.02	52.2	9.1
25-Jul-19	493	66.34765	-137.3092	1	2.71	25.2	11.3
25-Jul-19	534	66.37569	-137.3396	1	0.72	6.5	11.9
25-Jul-19	547	66.392	-137.3421	1	8.23	76.1	11.7
25-Jul-19	773	66.31628	-137.3034	2	4.26	42.9	14.3
25-Jul-19	776	66.3245	-137.2833	2	7.36	69.2	12.7
25-Jul-19	785	66.35938	-137.3926	2	9.83	88.0	10.5
25-Jul-19	835	66.36866	-137.4015	3	7.94	75.2	13.0
25-Jul-19	871	66.38873	-137.4091	2	8.72	76.7	9.7
26-Jul-19	171	66.39209	-137.1602	1	16.70	17.0	9.6
26-Jul-19	183	66.43003	-137.1931	1	8.11	72.0	10.3
26-Jul-19	187	66.43113	-137.1464	1	5.54	48.0	8.6
26-Jul-19	200	66.48093	-137.1565	1	1.16	1.1	8.8
26-Jul-19	249	66.4918	-137.1707	2	0.76	6.5	11.8
26-Jul-19	265	66.42464	-137.1994	3	8.82	81.8	12.0
26-Jul-19	341	66.44963	-137.5491	5	11.53	114.7	14.7
26-Jul-19	643	66.43681	-137.4243	1	9.71	97.1	15.4
26-Jul-19	673	66.46764	-137.3792	1	3.54	33.2	11.7
26-Jul-19	809	66.46959	-137.3389	2	7.32	70.8	13.8
26-Jul-19	842A	66.47348	-137.2169	3	9.45	82.5	9.4
26-Jul-19	842B	66.47637	-137.255	3	8.40	78.0	11.6
27-Jul-19	494	66.34035	-137.8542	1	8.36	71.2	8.8
27-Jul-19	565	66.38764	-137.9742	1	7.32	69.4	13.1
27-Jul-19	616	66.41416	-137.7735	2	5.06	45.1	10.6
27-Jul-19	646	66.43586	-137.7372	4	7.31	70.5	13.7
27-Jul-19	663	66.43439	-137.8836	1	1.72	15.0	8.7
27-Jul-19	792	66.37972	-137.8823	2	10.06	85.8	8.4
27-Jul-19	793	66.37863	-137.7911	2	4.07	33.1	9.0
27-Jul-19	798	66.40889	-137.4901	2	9.24	93.1	15.7
27-Jul-19	801	66.44221	-137.6647	2	5.02	49.4	14.7
27-Jul-19	838	66.43382	-137.9072	3	8.94	84.8	13.2
27-Jul-19	840	66.42658	-137.977	3	8.21	77.8	13.0
27-Jul-19	846	66.48896	-137.8039	3	5.61	51.6	10.9

Date	Stream ID	Latitude	Longitude	Stream Order	DO (mg/L)	(DO %)	Temperature (C°)
28-Jul-19	347	66.18079	-137.3507	1	9.08	77.0	8.2
28-Jul-19	394	66.2444	-137.7567	1	1.90	15.6	7.9
28-Jul-19	396	66.2516	-137.6151	1	3.88	35.5	11.9
28-Jul-19	456	66.32227	-137.5995	1	4.86	42.6	9.3
28-Jul-19	774	66.2984	-137.6879	2	10.90	90.2	7.2
28-Jul-19	832	66.29263	-137.6379	3	7.52	72.1	13.4
28-Jul-19	861	66.23264	-137.6214	2	9.05	89.8	14.9
28-Jul-19	867	66.34926	-137.6371	2	8.16	65.8	6.0
28-Jul-19	1217	66.17073	-137.8379	1	10.30	86.9	7.9
28-Jul-19	1338	66.29083	-137.9135	1	5.50	47.7	9.5
28-Jul-19	1379	66.20401	-137.8035	2	7.94	74.0	12.0
28-Jul-19	1383	66.22768	-137.9377	2	8.90	83.4	12.5
28-Jul-19	1387	66.27138	-137.8424	2	8.32	72.8	8.9
28-Jul-19	1400	66.16558	-137.6776	3	7.79	76.0	14.5
28-Jul-19	1406	66.33226	-137.9887	3	9.58	89.3	12.2
29-Jul-19	147	66.27397	-137.1972	1	0.40	4.0	12.0
29-Jul-19	229	66.19591	-137.2133	2	6.92	61.5	9.7
29-Jul-19	241	66.2869	-137.138	2	5.95	53.7	7.3
29-Jul-19	269	66.22424	-137.0943	4	8.74	82.4	12.7
29-Jul-19	271	66.21147	-137.2004	3	8.07	70.8	9.8
29-Jul-19	277	66.2138	-137.0339	2	6.60	61.0	10.9
29-Jul-19	309	66.16972	-137.1325	1	5.64	51.2	11.0
29-Jul-19	401	66.26299	-137.5179	1	8.05	71.9	10.4
29-Jul-19	764	66.2501	-137.3064	2	4.58	45.1	11.5
29-Jul-19	767	66.26252	-137.4892	2	6.73	58.4	9.1
29-Jul-19	772	66.31227	-137.3409	2	7.25	70.6	13.7
29-Jul-19	828	66.19646	-137.4825	3	4.40	40.7	11.2
29-Jul-19	862	66.23062	-137.4355	2	4.91	44.2	9.6
30-Jul-19	23	66.0675	-137.2728	1	4.83	41.7	8.8
30-Jul-19	210	66.08836	-137.22	2	7.58	73.9	13.6
30-Jul-19	977	66.01317	-137.1356	3	10.23	85.7	7.6
30-Jul-19	1089	66.03002	-137.4563	1	9.96	79.9	5.8
30-Jul-19	1180	66.10212	-137.3189	1		6.2	54.4
30-Jul-19	1182	66.12263	-137.4168	3	8.67	80.2	11.8
30-Jul-19	1184	66.07806	-137.6015	5	8.61	83.4	14.0
30-Jul-19	1216	66.08516	-137.5328	1	0.46	3.5	7.0
30-Jul-19	1363	66.03002	-137.4563	2	5.71	49.6	9.2
30-Jul-19	1364	66.0726	-137.3827	2	4.23	35.6	7.9
30-Jul-19	1373	66.14102	-137.4723	2	6.95	65.1	12.2

Date	Stream ID	Latitude	Longitude	Stream Order	DO (mg/L)	(DO %)	Temperature (C°)
30-Jul-19	1397	66.07154	-137.4395	3	7.45	66.5	10.3
30-Jul-19	1413	66.14128	-137.2938	2	5.77	57.8	13.1
30-Jul-19	1414	66.12903	-137.5908	2	6.63	60.1	10.7
30-Jul-19	1423	66.02239	-137.3063	1	2.18	18.2	8.7
30-Jul-19	1439	66.1563	-137.54	1	8.22	73.8	10.6
31-Jul-19	206	66.06615	-136.7881	2	9.11	88.5	13.2
31-Jul-19	979	65.96795	-137.2615	2	9.10	76.1	7.6
31-Jul-19	980	65.95205	-137.2034	3	8.51	77.2	10.5
31-Jul-19	998	65.93714	-136.8167	1	3.32	32.5	14.1
31-Jul-19	1026	65.98262	-136.9569	1	5.28	44.5	8.6
31-Jul-19	1042	65.98499	-136.9257	4	8.95	92.8	17.1
31-Jul-19	1101	65.93429	-137.0182	2	5.63	52.7	12.1
31-Jul-19	1110	66.00323	-137.1217	2	5.16	44.1	7.8
31-Jul-19	1120	66.01606	-136.8809	2	10.20	87.9	8.7
31-Jul-19	1125	66.04642	-137.0718	2	7.58	64.7	8.2
31-Jul-19	1130	65.95552	-136.8915	3	4.02	35.6	8.4
31-Jul-19	1169	66.03066	-136.9827	1	6.61	54.0	6.5
01-Aug-19	67	66.11721	-137.1957	1	4.50	37.5	7.5
01-Aug-19	76	66.13092	-137.0008	1	5.88	50.4	8.9
01-Aug-19	82	66.13076	-137.1228	1	8.31	80.4	13.4
01-Aug-19	211	66.08931	-137.1218	2	6.59	57.0	9.0
01-Aug-19	222	66.15111	-136.9255	2	8.32	76.5	10.8
01-Aug-19	227	66.16889	-136.9918	2	8.17	75.8	11.8
01-Aug-19	258	66.19616	-136.9141	3	2.88	24.4	9.0
01-Aug-19	267	66.11403	-136.9364	4	8.26	79.7	13.5
01-Aug-19	273	66.06855	-136.9671	2	8.35	70.6	8.1

ATTACHMENT E SUMMER BC SITE CARD DATA

Table E-1. Data collected from BC site cards, July and August 2019. [4]

Date	Stream ID	Stream Order	Lat (deg)	Long (deg)	Fish Present[5]	Channel Width (m)	Wetted Width (m)	Residual Pool Depth (m)	Gradient (%)	DO (mg/L)	DO (%)	Temp (C°)	Total Cover[6]	Bed Material[7]	Spawning	Over Wintering	Rearing
25-Jul-19	459	1	66.331	-137.470	N	1.51	1.46	0.25	0.25	8.90	73.40	7.40	L	F	None	Poor	Poor
25-Jul-19	466	1	66.322	-137.418	NS	-	-	-	-	-	-	-	-	-	None	None	None
25-Jul-19	470	1	66.332	-137.382	NS	-	-	-	-	3.47	31.90	9.10	-	O	None	None	None
25-Jul-19	484	1	66.338	-137.461	N	1.67	0.59	0.06	1.75	6.02	52.20	9.10	-	F	None	None	Poor
25-Jul-19	493	1	66.348	-137.309	NS	-	-	-	0.50	2.71	25.20	11.30	H	O	Poor	Poor	Poor
25-Jul-19	534	1	66.376	-137.340	N	0.79	2.27	0.39	0.25	0.72	6.50	11.90	L	F	None	None	Poor
25-Jul-19	547	1	66.392	-137.342	N	3.39	1.88	0.10	1.50	8.23	76.10	11.70	M	F	None	None	None
25-Jul-19	244	2	66.394	-137.277	Y	5.68	2.03	-	1.00	6.87	69.80	16.20	-	F	Poor	Poor	Poor
25-Jul-19	245	2	66.398	-137.206	N	1.82	1.14	0.49	0.25	6.77	66.20	14.50	M	F	None	Poor	Poor
25-Jul-19	773	2	66.316	-137.303	Y	1.84	0.72	0.28	0.50	4.26	42.90	14.30	H	F	Poor	Poor	Mod
25-Jul-19	776	2	66.325	-137.283	N	1.57	0.87	0.50	0.00	7.36	69.20	12.70	M	F	None	Poor	Mod
25-Jul-19	785	2	66.359	-137.393	N	2.06	1.22	0.50	0.75	9.83	88.00	10.50	H	F	Poor	Poor	Mod
25-Jul-19	871	2	66.389	-137.409	N	6.51	1.48	-	1.50	8.72	76.70	9.70	-	F	Poor	Poor	Poor
25-Jul-19	835	3	66.369	-137.401	Y	4.54	2.79	0.69	0.50	7.94	75.20	13.00	H	F	Poor	Good	Good
26-Jul-19	161	1	66.135	-137.189	NS	-	-	-	-	-	-	-	-	-	None	None	None
26-Jul-19	171	1	66.392	-137.160	N	0.91	0.38	0.29	1.50	16.70	17.00	9.60	L	F	None	Poor	Poor
26-Jul-19	183	1	66.430	-137.193	N	3.83	1.26	0.43	0.75	8.11	72.00	10.30	H	F	None	None	Poor
26-Jul-19	187	1	66.431	-137.146	NS	-	-	-	-	5.54	48.00	8.60	-	-	None	None	None
26-Jul-19	200	1	66.481	-137.157	NS	-	-	-	-	1.16	1.08	8.80	-	-	None	None	None
26-Jul-19	330	1	66.431	-137.144	NS	-	-	-	-	-	-	-	-	-	None	None	None
26-Jul-19	643	1	66.437	-137.424	NS	-	-	-	-	9.71	97.10	15.40	-	-	None	None	None

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[4] See (BC Ministry of Environment 2008) for more detailed descriptions.

[5] N=no, Y=yes, NS=not sampled

[6] Total cover = Any structure within the wetted width or within 1 m above the water surface that provides rearing habitat; L=low (≤ 5%), M=moderate (6-20%), H=high (≥21%)

[7] F=fines, O=organics, C=cobble, G=gravel
(-) denotes metrics not taken or not applicable, most often due to insufficient water.

Date	Stream ID	Stream Order	Lat (deg)	Long (deg)	Fish Present[5]	Channel Width (m)	Wetted Width (m)	Residual Pool Depth (m)	Gradient (%)	DO (mg/L)	DO (%)	Temp (C°)	Total Cover[6]	Bed Mater-ial[7]	Spawning	Over Wintering	Rearing
26-Jul-19	671	1	66.453	-137.533	NS	-	-	-	-	-	-	-	-	F	None	None	Poor
26-Jul-19	673	1	66.468	-137.379	N	1.76	0.67	0.15	-	3.54	33.20	11.70	L	F	None	None	Poor
26-Jul-19	680	1	66.465	-137.519	NS	-	-	-	-	-	-	-	-	-	None	None	None
26-Jul-19	699	1	66.478	-137.228	NS	-	-	-	-	-	-	-	-	-	None	None	None
26-Jul-19	730	1	66.486	-137.403	NS	-	-	-	-	-	-	-	-	-	None	None	None
26-Jul-19	249	2	66.492	-137.171	NS	-	-	-	-	0.76	6.50	11.80	-	-	None	None	None
26-Jul-19	809	2	66.470	-137.339	Y	3.03	1.41	0.62	0.50	7.32	70.80	13.80	-	F	None	Mod	Mod
26-Jul-19	265	3	66.425	-137.199	Y	4.03	2.22	0.45	1.00	8.82	81.80	12.00	H	F	Poor	Mod	Mod
26-Jul-19	842A	3	66.473	-137.217	N	3.76	2.45	0.56	0.75	9.45	82.50	9.40	-	F	None	Poor	Good
26-Jul-19	842B	3	66.476	-137.255	Y	3.04	2.43	-	0.25	8.40	78.00	11.60	M	F	Poor	Mod	Good
26-Jul-19	341	5	66.450	-137.549	Y	14.87	9.93	-	0.75	11.53	114.70	14.70	-	F	Mod	Mod	Good
27-Jul-19	494	1	66.340	-137.854	N	3.45	0.60	0.20	-	8.36	71.20	8.80	H	F	None	None	Poor
27-Jul-19	549	1	66.380	-137.619	NS	-	-	-	-	-	-	-	-	-	None	None	None
27-Jul-19	565	1	66.388	-137.974	NS	-	-	-	-	7.32	69.40	13.10	-	-	None	None	None
27-Jul-19	606	1	66.413	-137.622	NS	-	-	-	3.00	-	-	-	-	-	None	None	None
27-Jul-19	624	1	66.422	-137.856	NS	-	-	-	-	-	-	-	-	-	None	None	None
27-Jul-19	663	1	66.434	-137.884	NS	6.00		0.26	2.50	1.72	15.00	8.70	-	F	None	None	None
27-Jul-19	717	1	66.466	-137.961	NS	-	-	-	-	-	-	-	-	F	None	None	None
27-Jul-19	929	1	66.373	-137.694	NS	-	0.58	0.10	3.00	-	-	-	-	F	None	None	Poor
27-Jul-19	616	2	66.414	-137.773	N	1.32	1.08	0.24	0.75	5.06	45.10	10.60	L	F	None	None	Poor
27-Jul-19	792	2	66.380	-137.882	N	2.08	1.06	0.56	1.00	10.06	85.80	8.40	M	F	Poor	Poor	Mod
27-Jul-19	793	2	66.379	-137.791	NS	-	-	-	-	4.07	33.10	9.00	-	F	None	None	None
27-Jul-19	798	2	66.409	-137.490	N	3.18	2.44	0.58	1.00	9.24	93.10	15.70	H	F	Poor	Mod	Mod
27-Jul-19	801	2	66.442	-137.665	N	3.02	1.88	-	-	5.02	49.40	14.70	M	F	None	None	Mod
27-Jul-19	838	3	66.434	-137.907	Y	4.68	3.98	0.45	0.00	8.94	84.80	13.20	H	F	Poor	Mod	Mod
27-Jul-19	840	3	66.427	-137.977	Y	6.33	3.55	0.42	3.50	8.21	77.80	13.00	H	F	Mod	Good	Good
27-Jul-19	846	3	66.489	-137.804	N	0.40	0.32	0.07	2.00	5.61	51.60	10.90	H	F	None	Poor	Mod
27-Jul-19	646	4	66.436	-137.737	Y	9.50	5.25	0.85	0.25	7.31	70.50	13.70	H	F	Poor	Mod	Mod

Date	Stream ID	Stream Order	Lat (deg)	Long (deg)	Fish Present[5]	Channel Width (m)	Wetted Width (m)	Residual Pool Depth (m)	Gradient (%)	DO (mg/L)	DO (%)	Temp (C°)	Total Cover[6]	Bed Material[7]	Spawning	Over Wintering	Rearing
28-Jul-19	347	1	66.181	-137.351	N	1.46	0.95	0.43	1.00	9.08	77.00	8.20	L	F	None	None	Poor
28-Jul-19	394	1	66.244	-137.757	N	2.74	1.53	0.11	2.50	1.90	15.60	7.90	-	F	None	None	Poor
28-Jul-19	396	1	66.252	-137.615	NS	-	-	-	-	3.88	35.50	11.90	-	-	None	None	None
28-Jul-19	456	1	66.322	-137.599	N	2.65	0.58	0.09	3.50	4.86	42.60	9.30	M	F	None	None	Poor
28-Jul-19	1217	1	66.171	-137.838	NS	1.49	0.81	0.15	2.00	10.30	86.90	7.90	-	F	None	None	Poor
28-Jul-19	1281	1	66.184	-137.651	NS	-	-	-	-	-	-	-	-	-	None	None	None
28-Jul-19	1338	1	66.291	-137.914	N	1.07	0.66	0.06	2.00	5.50	47.70	9.50	-	F	None	None	Poor
28-Jul-19	774	2	66.298	-137.688	N	2.60	1.80	0.06	1.00	10.90	90.20	7.20	-	F	None	None	Poor
28-Jul-19	861	2	66.233	-137.621	Y	3.18	1.02	0.45	0.50	9.05	89.80	14.90	H	F	Poor	None	Mod
28-Jul-19	867	2	66.349	-137.637	N	-	-	-	-	8.16	65.80	6.00	-	-	None	None	None
28-Jul-19	1379	2	66.204	-137.803	Y	7.93	3.23	-	2.50	7.94	74.00	12.00	-	F	Good	Mod	Good
28-Jul-19	1383	2	66.228	-137.938	Y	4.04	2.30	0.45	3.00	8.90	83.40	12.50	M	F	None	None	Mod
28-Jul-19	1387	2	66.271	-137.842	Y	6.29	5.00	1.20	1.00	8.32	72.80	8.90	H	F	None	None	Mod
28-Jul-19	832	3	66.293	-137.638	Y	5.26	3.36	0.40	0.00	7.52	72.10	13.40	H	F	Poor	Poor	Mod
28-Jul-19	1400	3	66.166	-137.678	Y	3.07	1.89	0.83	0.00	7.79	76.00	14.50	M	F	Poor	Poor	Mod
28-Jul-19	1406	3	66.332	-137.989	Y	6.57	5.30	0.44	2.75	9.58	89.30	12.20	H	F	None	Mod	Mod
29-Jul-19	147	1	66.274	-137.197	N	1.12	0.82	0.26	0.00	0.40	4.00	12.00	L	F	None	None	Poor
29-Jul-19	309	1	66.170	-137.132	N	2.18	1.03	0.56	3.00	5.64	51.20	11.00	M	F	None	None	Poor
29-Jul-19	401	1	66.263	-137.518	N	1.02	0.59	0.32	1.75	8.05	71.90	10.40	L	F	None	None	Poor
29-Jul-19	229	2	66.196	-137.213	Y	3.41	2.33	-	-	6.92	61.50	9.70	H	F	Poor	None	Mod
29-Jul-19	241	2	66.287	-137.138	Y	1.63	1.04	0.13	0.50	5.95	53.70	7.30	M	F	None	None	Poor
29-Jul-19	277	2	66.214	-137.034	N	1.78	1.00	0.33	0.00	6.60	61.00	10.90	H	F	None	None	Poor
29-Jul-19	764	2	66.250	-137.306	Y	6.93	2.32	-	1.00	4.58	45.10	11.50	M	F	None	None	Poor
29-Jul-19	767	2	66.263	-137.489	N	3.14	1.65	0.43	3.00	6.73	58.40	9.10	H	F	None	Poor	Poor
29-Jul-19	772	2	66.312	-137.341	Y	2.28	1.29	0.75	0.50	7.25	70.60	13.70	H	F	Poor	Poor	Mod
29-Jul-19	862	2	66.231	-137.436	Y	2.77	1.93	-	-	4.91	44.20	9.60	-	F	None	Mod	Mod
29-Jul-19	271	3	66.211	-137.200	N	3.02	1.67	-	1.00	8.07	70.80	9.80	H	F	None	None	None
29-Jul-19	828	3	66.196	-137.482	Y	3.22	1.22	0.50	0.50	4.40	40.70	11.20	H	F	Poor	Poor	Mod

Date	Stream ID	Stream Order	Lat (deg)	Long (deg)	Fish Present[5]	Channel Width (m)	Wetted Width (m)	Residual Pool Depth (m)	Gradient (%)	DO (mg/L)	DO (%)	Temp (C°)	Total Cover[6]	Bed Mater-ial[7]	Spawning	Over Wintering	Rearing
29-Jul-19	269	4	66.224	-137.094	Y	10.30	8.90	1.05	0.00	8.74	82.40	12.70	M	F	Poor	Good	Mod
30-Jul-19	23	1	66.067	-137.273	N	0.84	0.46	0.42	0.50	4.83	41.70	8.80	M	F	Poor	None	Poor
30-Jul-19	1089	1	66.030	-137.456	N	1.52	0.68	0.29	7.00	9.96	79.90	5.80	L	F	None	None	Poor
30-Jul-19	1180	1	66.102	-137.319	NS	-	-	-	-		6.17	54.40	-	-	None	None	None
30-Jul-19	1216	1	66.085	-137.533	NS	-	-	-	-	0.46	3.47	7.00	-	F	None	None	None
30-Jul-19	1243	1	66.140	-137.358	NS	-	-	-	0.50	-	-	-	-	F	None	None	Poor
30-Jul-19	1423	1	66.022	-137.306	Y	1.31	0.93	0.27	4.00	2.18	18.20	8.70	M	F	Poor	Poor	Mod
30-Jul-19	1439	1	66.156	-137.540	NS	-	-	-	3.00	8.22	73.80	10.60	-	-	None	None	None
30-Jul-19	210	2	66.088	-137.220	Y	6.67	5.62	1.60	0.25	7.58	73.90	13.60	A	F	Poor	Good	Good
30-Jul-19	1363	2	66.030	-137.456	Y	2.69	1.61	0.20	1.00	5.71	49.60	9.20	-	F	None	None	Mod
30-Jul-19	1364	2	66.073	-137.383	N	2.81	1.01	0.25	2.00	4.23	35.60	7.90	A	F	None	None	Poor
30-Jul-19	1373	2	66.141	-137.472	Y	3.43	1.61	-	3.00	6.95	65.10	12.20	A	F	Poor	Poor	Mod
30-Jul-19	1413	2	66.141	-137.294	N	1.94	1.21	0.66	0.00	5.77	57.80	13.10	M	F	Poor	Poor	Poor
30-Jul-19	1414	2	66.129	-137.591	Y	-	1.03	0.45	0.00	6.63	60.10	10.70	M	O	Poor	Poor	Poor
30-Jul-19	977	3	66.013	-137.136	Y	4.26	1.97	0.27	3.50	10.23	85.70	7.60	M	F	Poor	Mod	Good
30-Jul-19	1182	3	66.123	-137.417	Y	7.18	3.42	1.25	0.75	8.67	80.20	11.80	A	F	Poor	Mod	Mod
30-Jul-19	1397	3	66.072	-137.440	Y	4.86	2.89	-	-	7.45	66.50	10.30	M	F	Poor	Poor	Mod
30-Jul-19	1184	5	66.078	-137.602	Y	11.60	9.57	0.70	0.50	8.61	83.40	14.00	A	F	Mod	Good	Good
31-Jul-19	998	1	65.937	-136.817	NS	2.32	-	0.08	4.00	3.32	32.50	14.10	A	C	Poor	Poor	Poor
31-Jul-19	1014	1	65.948	-137.069	NS	1.77	-	0.16	3.00	-	-	-	-	F	Poor	Poor	Poor
31-Jul-19	1026	1	65.983	-136.957	Y	1.22	0.82	0.61	1.50	5.28	44.50	8.60	H	F	Poor	Poor	Mod
31-Jul-19	1169	1	66.031	-136.983	NS	-	-	-	-	6.61	54.00	6.50	-	-	None	None	None
31-Jul-19	206	2	66.066	-136.788	N	7.10	6.10	-	0.75	9.11	88.50	13.20	M	F	Poor	Good	Mod
31-Jul-19	979	2	65.968	-137.261	Y	3.53	2.15	0.56	3.50	9.10	76.10	7.60	M	G	Mod	Poor	Good
31-Jul-19	1101	2	65.934	-137.018	Y	5.37	-	1.15	2.50	5.63	52.70	12.10	H	F	Poor	None	Poor
31-Jul-19	1110	2	66.003	-137.122	N	2.68	1.68	0.80	-	5.16	44.10	7.80	-	F	Poor	Poor	Poor
31-Jul-19	1120	2	66.016	-136.881	Y	1.29	1.20	0.41	2.00	10.20	87.90	8.70	A	F	Poor	Poor	Mod
31-Jul-19	1125	2	66.046	-137.072	Y	1.91	1.10	0.13	0.50	7.58	64.70	8.20	-	F	None	Mod	Mod

Date	Stream ID	Stream Order	Lat (deg)	Long (deg)	Fish Present[5]	Channel Width (m)	Wetted Width (m)	Residual Pool Depth (m)	Gradient (%)	DO (mg/L)	DO (%)	Temp (C°)	Total Cover[6]	Bed Material[7]	Spawning	Over Wintering	Rearing
31-Jul-19	980	3	65.952	-137.203	Y	6.93	5.40	0.73	0.75	8.51	77.20	10.50	A	G	Mod	Mod	Good
31-Jul-19	1130	3	65.956	-136.892	Y	3.41	2.32	0.50	0.75	4.02	35.60	8.40	A	F	Poor	Poor	Mod
31-Jul-19	1042	4	65.985	-136.926	Y	10.88	6.56	0.63	0.50	8.95	92.80	17.10	M	C	Good	Mod	Good
1-Aug-19	67	1	66.117	-137.196	NS	-	-	-	3.00	4.50	37.50	7.50	-	-	None	None	None
1-Aug-19	76	1	66.131	-137.001	N	1.40	0.31	0.14	1.00	5.88	50.40	8.90	L	F	None	None	Poor
1-Aug-19	82	1	66.131	-137.123	N	-	-	-	-	8.31	80.40	13.40	-	-	None	None	None
1-Aug-19	211	2	66.089	-137.122	Y	2.73	1.60	0.86	0.00	6.59	57.00	9.00	A	F	None	Good	Mod
1-Aug-19	222	2	66.151	-136.925	Y	4.36	2.35	0.57	1.50	8.32	76.50	10.80	L	F	None	Poor	Poor
1-Aug-19	227	2	66.169	-136.992	N	1.42	0.55	0.23	1.50	8.17	75.80	11.80	L	F	None	None	Poor
1-Aug-19	273	2	66.069	-136.967	Y	1.80	1.19	0.33	2.00	8.35	70.60	8.10	M	F	None	None	Poor
1-Aug-19	258	3	66.196	-136.914	N	2.13	2.01	0.58	0.00	2.88	24.40	9.00	A	F	Poor	Poor	Mod
1-Aug-19	267	4	66.114	-136.936	Y	9.70	8.70	0.90	1.00	8.26	79.70	13.50	A	F	Mod	Mod	Good

ATTACHMENT F WINTER SAMPLING SITE DATA

Table F-1. Winter sampling site data, March 2020 (bold denotes sites with water present).

Date	Site	Order	Water	Type	Hole Number	Snow Depth (m)	Ice Depth (m)	Water Depth (m)	Hollow Depth (m)	Bed to Top of Ice (m)
8-Mar-20	1363	2	N	Stream	H1	1.10	0.35	0.00	0.45	0.80
8-Mar-20	1363	2	N	Stream	H2	0.87	0.23	0.00	0.20	0.43
8-Mar-20	1397	3	N	Stream	H1	0.57	0.15	0.00	0.20	0.35
8-Mar-20	1397	3	N	Stream	H2	0.57	0.20	0.00	0.10	0.35
8-Mar-20	1397	3	N	Stream	H3	0.77	0.45	0.00	0.15	0.58
8-Mar-20	1397	3	N	Stream	H4	0.50	0.56	0.00	0.20	0.75
8-Mar-20	1397	3	N	Stream	H5	0.60	0.48	0.00	0.29	0.76
8-Mar-20	MCPL-002	4	N	Stream	H1	0.68	0.21	0.00	0.00	0.21
8-Mar-20	MCPL-002	4	N	Stream	H2	0.68	0.22	0.00	0.12	0.34
8-Mar-20	MCPL-002	4	N	Stream	H3	0.50	0.40	0.00	0.10	0.45
8-Mar-20	MCPL-002	4	N	Stream	H4	0.50	0.35	0.00	0.07	0.45
8-Mar-20	**1184**	**5**	**Y**	**Stream**	**H1**	**0.65**	**0.40**	**0.48**	**0.00**	**0.44**
8-Mar-20	229	2	N	Stream	H1	0.55	0.45	0.00	0.00	0.45
8-Mar-20	**NCY-PT19**	**4**	**Y**	**Stream**	**H1**	**0.43**	**0.95**	**0.15**	**0.00**	**1.12**
9-Mar-20	846	3	N	Stream	H1	1.30	0.43	0.00	0.00	0.43
9-Mar-20	CHNC-no label	5	N	Stream	H1	0.70	0.10	0.00	0.05	0.15
9-Mar-20	CHNC-no label	5	N	Stream	H2	0.63	0.43	0.00	0.00	0.43
9-Mar-20	CHNC-no label	5	N	Stream	H3	0.63	0.44	0.00	0.00	0.44
9-Mar-20	CHNC-no label	5	N	Stream	H4	0.61	0.48	0.00	0.00	0.48
9-Mar-20	840	3	N	Stream	H1	0.62	0.35	0.00	0.09	0.47
9-Mar-20	840	3	N	Stream	H2	0.62	0.20	0.00	0.35	0.52
9-Mar-20	792	2	N	Stream	H1	0.78	0.20	0.00	0.30	0.47
9-Mar-20	**836**	**3**	**Y**	**Pond**	**H1**	**0.50**	**0.61**	**1.00**	**0.00**	**1.60**
9-Mar-20	836	3	N	Pond outlet	H2	0.70	0.09	0.00	0.80	0.90
9-Mar-20	836	3	N	Stream	H3	0.78	0.27	0.00	0.37	0.62
9-Mar-20	**646**	**4**	**Y**	**Pond**	**H1**	**0.68**	**0.48**	**1.10**	**0.00**	**1.55**
9-Mar-20	646	4	N	Pond outlet	H2	0.65	0.37	0.00	0.00	0.37
9-Mar-20	646	4	N	Pond outlet	H3	0.65	0.44	0.00	0.13	0.61
9-Mar-20	646	4	N	Pond outlet	H4	0.65	0.23	0.00	0.00	0.23
9-Mar-20	796	2	N	Stream	H1	0.95	0.10	0.00	0.50	0.60
9-Mar-20	849	4	N	Stream	H1	0.57	0.46	0.00	0.00	0.46
9-Mar-20	849	4	N	Stream	H2	0.65	0.19	0.00	0.12	0.30
9-Mar-20	851	4	N	Stream	H1	0.83	0.15	0.00	0.25	0.40
9-Mar-20	851	4	N	Stream	H2	0.83	0.16	0.00	0.25	0.37
10-Mar-20	842B	3	N	Stream	H1	0.64	0.25	0.00	0.23	0.50
10-Mar-20	842B	3	N	Stream	H2	0.64	0.25	0.00	0.30	0.60
10-Mar-20	**270**	**3**	**Y**	**Pool**	**H1**	**0.68**	**0.61**	**0.35**	**0.00**	**0.98**
10-Mar-20	270	3	N	Pool outlet	H2	0.68	0.23	0.00	0.30	0.55
10-Mar-20	**244**	**2**	**Y**	**Pool**	**H1**	**0.66**	**0.63**	**0.05**	**0.32**	**0.95**

Date	Site	Order	Water	Type	Hole Number	Snow Depth (m)	Ice Depth (m)	Water Depth (m)	Hollow Depth (m)	Bed to Top of Ice (m)
10-Mar-20	244	2	N	Pool inlet	H2	0.70	0.03	0.00	0.14	0.18
10-Mar-20	835	3	N	Stream	H1	0.72	0.18	0.00	0.33	0.52
10-Mar-20	CHNC-t-002	4	N	Stream	H1	0.58	0.08	0.00	0.20	0.30
10-Mar-20	CHNC-t-002	4	N	Stream	H2	0.58	0.06	0.00	0.20	0.27
10-Mar-20	CHNC-t-002	4	N	Stream	H3	0.63	0.24	0.00	0.33	0.56
10-Mar-20	CHNC-003	5	N	Stream	H1	0.70	0.35	0.00	0.11	0.46
10-Mar-20	CHNC-003	5	N	Stream	H2	0.70	0.29	0.00	0.00	0.29
10-Mar-20	CHNC-003	5	N	Stream	H3	0.70	0.47	0.00	0.00	0.47
10-Mar-20	**CHNC-003**	**5**	**Y**	**Stream**	**H4**	**0.70**	**0.33**	**0.17**	**0.37**	**0.86**
10-Mar-20	773	2	N	Stream	H1	0.63	0.26	0.00	0.00	0.26
10-Mar-20	773	2	N	Stream	H2	0.63	0.33	0.00	0.00	0.33
10-Mar-20	764	2	N	Stream	H1	0.70	0.67	0.00	0.35	0.44
10-Mar-20	**340**	**4**	**Y**	**Pool**	**H1**	**0.70**	**0.60**	**0.80**	**0.00**	**1.40**
10-Mar-20	340	4	N	Pool inlet	H2	0.80	0.10	0.00	0.25	0.35
10-Mar-20	832	3	N	Stream	H1	0.65	0.50	0.00	0.60	1.40
10-Mar-20	1383	2	N	Stream	H1	0.75	0.20	0.00	0.00	0.20
11-Mar-20	1406	3	N	Stream	H1	0.74	0.50	0.00	0.20	0.70
11-Mar-20	1406	3	N	Stream	H2	0.74	0.50	0.00	0.27	0.75
11-Mar-20	1409	4	N	Stream	H1	0.64	0.38	0.00	0.20	0.54
11-Mar-20	1387	2	N	Stream	H1	0.65	0.69	0.00	0.15	0.84
11-Mar-20	**1408**	**4**	**Y**	**Pool**	**H1**	**0.66**	**0.40**	**0.34**	**0.14**	**0.91**
11-Mar-20	1408	4	N	Pool inlet	H2	0.51	0.20	0.00	0.25	0.44
11-Mar-20	1379	2	N	Stream	H1	0.74	0.10	0.00	0.23	0.33
11-Mar-20	830	3	N	Stream	H1	0.76	0.27	0.00	0.10	0.39
11-Mar-20	830	3	N	Stream	H2	0.76	0.05	0.00	0.15	0.20
11-Mar-20	828	3	N	Stream	H1	0.75	0.15	0.00	0.37	0.41
11-Mar-20	828	3	N	Stream	H2	0.75	0.20	0.00	0.49	0.70
11-Mar-20	399	3	N	Stream	H1	0.57	0.40	0.00	0.30	0.70
11-Mar-20	**254**	**3**	**Y**	**Pond**	**H1**	**0.66**	**0.60**	**0.10**	**0.00**	**0.70**
11-Mar-20	254	3	N	Pond outlet	H2	0.66	0.16	0.00	0.00	0.16
11-Mar-20	**267**	**4**	**Y**	**Stream**	**H1**	**0.50**	**0.80**	**0.21**	**0.00**	**1.02**
11-Mar-20	**267**	**4**	**Y**	**Pool**	**H2**	**0.40**	**1.00**	**0.37**	**0.00**	**1.34**
11-Mar-20	1423	1	N	Stream	H1	0.85	0.15	0.00	0.36	0.54
11-Mar-20	979	2	N	Stream	H1	0.62	0.44	0.00	0.26	0.68
12-Mar-20	222	2	N	Stream	H1	0.75	0.11	0.00	0.80	0.91
12-Mar-20	256	3	N	Pond	H1	0.53	0.57	0.00	0.03	0.60
12-Mar-20	**256**	**3**	**Y**	**Pond**	**H2**	**0.45**	**0.55**	**1.10**	**0.00**	**1.13**
12-Mar-20	256	3	N	Pond outlet	H3	0.73	0.08	0.00	0.08	0.16
12-Mar-20	256	3	N	Pond outlet	H4	0.73	0.10	0.00	0.60	0.16
12-Mar-20	256	3	N	Pond outlet	H5	0.73	0.07	0.00	0.90	0.16

Date	Site	Order	Water	Type	Hole Number	Snow Depth (m)	Ice Depth (m)	Water Depth (m)	Hollow Depth (m)	Bed to Top of Ice (m)
12-Mar-20	**EAGL-t-004**	**4**	**Y**	**Stream**	**H1**	**0.70**	**0.41**	**0.01**	**0.00**	**0.54**
12-Mar-20	273	2	N	Stream	H1	0.71	0.20	0.00	0.43	0.66
12-Mar-20	1101	2	N	Stream	H1	0.82	0.13	0.00	0.00	0.13
12-Mar-20	1126	3	N	Stream	H1	0.60	0.47	0.00	0.24	0.73
12-Mar-20	1126	3	N	Stream	H2	0.63	0.57	0.00	0.00	0.57
12-Mar-20	1132	3	N	Stream	H1	0.80	0.32	0.00	0.35	0.67
12-Mar-20	**DALG-003**	**4**	**Y**	**Stream**	**H1**	**0.62**	**0.65**	**0.08**	**0.00**	**0.75**
12-Mar-20	**DALG-003**	**4**	**Y**	**Stream**	**H2**	**0.62**	**0.63**	**0.10**	**0.00**	**0.70**
12-Mar-20	980	3	N	Stream	H1	0.69	0.35	0.00	0.00	0.35
12-Mar-20	977	3	N	Stream	H1	1.03	0.15	0.00	1.05	1.20
12-Mar-20	**267**	**4**	**Y**	**Pond**	**H1**	**0.69**	**0.39**	**0.25**	**0.00**	**0.64**
12-Mar-20	**267**	**4**	**Y**	**Pond outlet**	**H2**	**0.62**	**0.61**	**0.60**	**0.00**	**1.25**
12-Mar-20	**267**	**4**	**Y**	**Stream**	**H3**	**0.60**	**0.65**	**0.48**	**0.00**	**1.10**

ATTACHMENT G WINTER SAMPLING WATER QUALITY PARAMETERS

Table G-1. Winter sampling water quality parameters, March 2020.

Site	Order	Type	Hole Number	DO (%)	DO (mg/L)	Temperature (°C)	SPC (µS/cm)
1184	5	Stream	H1	11.7	1.70	0.1	704
NCY-PT19	4	Stream	H1	8.6	1.19	-0.3	13980
836	3	Pond	H1	2.0	0.28	0.3	102
646	4	Pond	H1	2.5	0.35	0.0	205
270	3	Pool	H1	0.7	0.11	0.1	418
340	4	Pool	H1	1.5	0.21	0.1	269
1408	4	Pool	H1	3.5	0.50	0.2	529
254	3	Pond	H1	3.5	0.49	0.6	279
267	4	Stream	H1	59.6	8.50	-0.1	5641
267	4	Pool	H2	27.7	3.97	-0.1	5098
256	3	Pond	H2	2.7	0.36	0.7	5413
267	4	Pond	H1	1.2	0.17	0.2	2780
267	4	Pond outlet	H2	5.2	0.74	-0.1	2344