Appendix 12-C

Alexander Creek Westslope Cutthroat Trout Population Study

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Final Report

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Prepared by

Lotic Environmental Ltd.
101 Kootenay Street N
Cranbrook, BC
V1C 3T5

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We trust that this document provides adequate information to describe the population movements and associated habitat use of Westslope Cutthroat Trout in Alexander and West Alexander Creeks. Please do not hesitate to contact us with any inquiries about this document.

<Original signed by>	<Original signed by>	<Original signed by>
Michael Hildebrand, BSc, RPBio Senior Fisheries Bioloist michael.hildebrand@lotic.co	Mike Robinson, MSc, RPBio Senior Aquatic Ecologist mike.robinson@lotic.co	Mia Otto, PhD, RPBio Senior Aquatic Biologist Mia.otto@lotic.co

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1 Introduction

NWP Coal Canada Ltd. (NWP Coal) is proposing the development of the Crown Mountain Coking Coal Project (the Project), an open pit metallurgical coal mine in the East Kootenay Region of southeastern British Columbia. The Project footprint is situated on the height-of-land between the Grave Creek and Alexander Creek watersheds. The footprint is located approximately 12 km northeast of Sparwood, BC with an approximate total area of 1300 ha.

The Project is subject to review under the British Columbia Environmental Assessment Act (2002) and the Canadian Environmental Assessment Act (2012), and as such requires a series of baseline assessments to describe the existing environment. As part of the Fish and Fish Habitat Baseline assessment, the need for a better understanding on the habitat use in West Alexander was highlighted. The Project is anticipated to remove West Alexander aquatic habitat, and little was known or understood about the Westslope Cutthroat Trout (WCT; *Oncorhynchus clarkii lewisi*) population inhabiting these waters. Three Project fish Value Components (VCs) were confirmed to occur in the LSA; WCT, Bull Trout (BT; *Salvelinus confluentus*) and Mountain Whitefish (MW; *Prosopium williamsoni*) (Table 1). BT were confirmed to occur at the lower sections of West Alexander Creek (WAL1) but in very low numbers (one caught during baseline sampling). MW only occurs in the lower sections of Alexander Creek upstream of the confluence with Michel Creek (ALE1 and ALE2). The Fish and Fish Habitat Baseline Assessment found that West Alexander Creek is primarily used by WCT. The purpose of the Fish and Fish Habitat baseline report was to characterize the environment using existing data and new data collected to fill information gaps. As a complimentary addendum study to the Project's Fish and Fish Baseline Assessment the WCT Population Study was initiated in 2020 to fill the information gap that existed on WCT habitat use in West Alexander Creek.

Table 1: Common Name, Scientific Name, and Species Code for Project Fish VCs found in the LSA.

Species name	Scientific name	Species code
Westslope Cutthroat Trout	*Oncorhynchus clarkii lewisi*	WCT
Bull Trout	*Salvelinus confluentus*	BT
Mountain Whitefish	*Prosopium williamsoni*	MW

1.1 Purpose and Objectives

Baseline information suggested that West Alexander Creek is primarily used by WCT. As such, the study objectives were limited to that species. The purpose of this study was to assess the importance of West Alexander Creek habitat to the overall WCT population within the Alexander Creek watershed. To do this, the study objective was to document fish use and life history activity, throughout the Alexander Creek watershed and track fish movements over a full cycle of all life history activities (approximately a one-year period) to gain a better understanding on how WCT use different parts of the watershed. As noted, this study had particular interest in West Alexander Creek as it is anticipated to be impacted by direct and indirect habitat loss due to the Project, resulting in the near total removal of West Alexander Creek.

1.2 WCT Overview and Management Importance

Two designable units (DUs) of Westslope Cutthroat Trout (WCT) occur in Canada: the Saskatchewan-Nelson Rivers population in Alberta; and the Pacific population in B.C., both of which are federally listed under Schedule 1 of the *Species at Risk Act* (2002). The Alberta population is listed as Threatened under Schedule 1 of SARA, whereas the Pacific population is listed as Special Concern. The Project is located in the native range of the Pacific population, which is federally listed as Special Concern and Blue-listed (Special Concern) in B.C. (B.C. Conservation Data Centre [B.C. CDC], 2020).

WCT inhabit most major tributaries, smaller creeks, and lakes in the Kootenay, Flathead, and Pend d'Oreille systems (Committee on the Status of Endangered Wildlife in Canada [COSEWIC], 2016). Resident and migratory sub-populations are both present in these systems. Upstream movement to spawning areas generally occurs during peak spring flows, while spawning occurs as peak flows diminish in May to July (COSEWIC, 2016). Egg incubation rate is dependent on water temperature, but incubation in spawning gravels generally lasts six to seven weeks. Fry emerge from streambeds in early July to late August and migrate to low energy, lateral habitats (COSEWIC, 2016). Although WCT are iteroparous, meaning that they reproduce multiple times throughout their lifetime, spawning typically occur every year or every other year. WCT feed primarily on invertebrates from both aquatic and riparian inputs (COSEWIC, 2016; Liknes and Graham, 1988; Shepard et al., 1984).

WCT play an important ecological role, are valued as a traditionally important fish species by several Indigenous communities including the Ktunaxa Nation, and are a recreationally important sportfish in western Canada (COSEWIC, 2016). As a result of often being the only native trout species in much of their Canadian range, WCT contribute nutrients to riparian vegetation and forests, thereby playing an important role in structuring many northern temperate aquatic ecosystems (COSEWIC, 2016; McPhail and Carveth, 1992). The species' unique adaptations to colder, less productive ecosystems and smaller size allow WCT to inhabit smaller streams than most other salmonids (COSEWIC. 2016; Rasmussen et al., 2012). Due to its specific habitat requirements, WCT is considered an indicator species of general ecosystem health (COSEWIC, 2016).

WCT were identified as a VC for which potential effects resulting from the Project will be assessed due to its regulatory status, value to recreational and traditional fisheries, and sensitivity to fish habitat degradation and water quality. WCT were also identified as a VC assessed by the Elk Valley Cumulative Effects Management Framework (2018 and 2020). How WCT use the habitat in West Alexander and Alexander Creeks are therefore of high importance to understanding and quantifying the Project's potential impact on WCT.

1.3 WCT Distribution

Westslope Cutthroat Trout distribution in Canada is restricted to southeastern British Columbia and southwestern Alberta. Globally, their range has become highly fragmented with the upper Kootenay River, Elk River, Flathead River and Kootenay Lake and its tributaries' population groups becoming increasingly important for the survival of the species (COSEWIC 2016, Fisheries and Oceans Canada 2016). Westslope Cutthroat Trout have strict habitat requirements during various life history phases/stages. These include cool, clean, and well-oxygenated waters and connected habitats for different life stages with various natural habitat attributes. This makes them an indicator of ecosystem health and environmental quality indicator across the landscape.

Population sizes are usually small but have a well-developed population structure. Habitat degradation makes populations more susceptible to displacement and hybridization with introduced species (Fisheries and Oceans Canada 2016). The biggest threats to Westslope Cutthroat Trout are anthropogenic disturbances and the degradation of their habitat. Forestry and mining pose threats to native populations in the Elk Valley watershed. As such, populations in degraded habitats are more likely to decline, and their high degree of demographic independence suggests that losses are not likely to be offset by immigration from nearby sources over the short term (COSEWIC 2016).

Westslope Cutthroat Trout are primarily insectivorous, feeding on drifting invertebrates, nymphs in streams, winged insects and zooplankton while in lakes and large rivers (McPhail 2007). Their ecological success therefore relies closely on benthic invertebrate community structure and trophic dynamics of the habitats they inhabit. Westslope Cutthroat Trout are one of the few large native fish species adapted to cold, nutrient-poor streams within their native range in British Columbia. Eggs, juveniles, and adults are preyed upon by other fish (such as bull trout), mammals (river otters and bears), and birds (raptors, ducks).

1.3.1 Westslope Cutthroat Trout Habitat Requirements

For spawning, Westslope Cutthroat Trout prefer small, low-gradient streams with cold, well-oxygenated water and clean unembedded gravels. Spawning often occurs in the tailouts of large deep pools in moderate to high-flow events (Schmetterling 2000). The location and availability of cover provided by large woody debris, boulders and bedrock is very important to spawners as these structures create the necessary pool habitats that catch the spawning gravels and provide protection from predation.

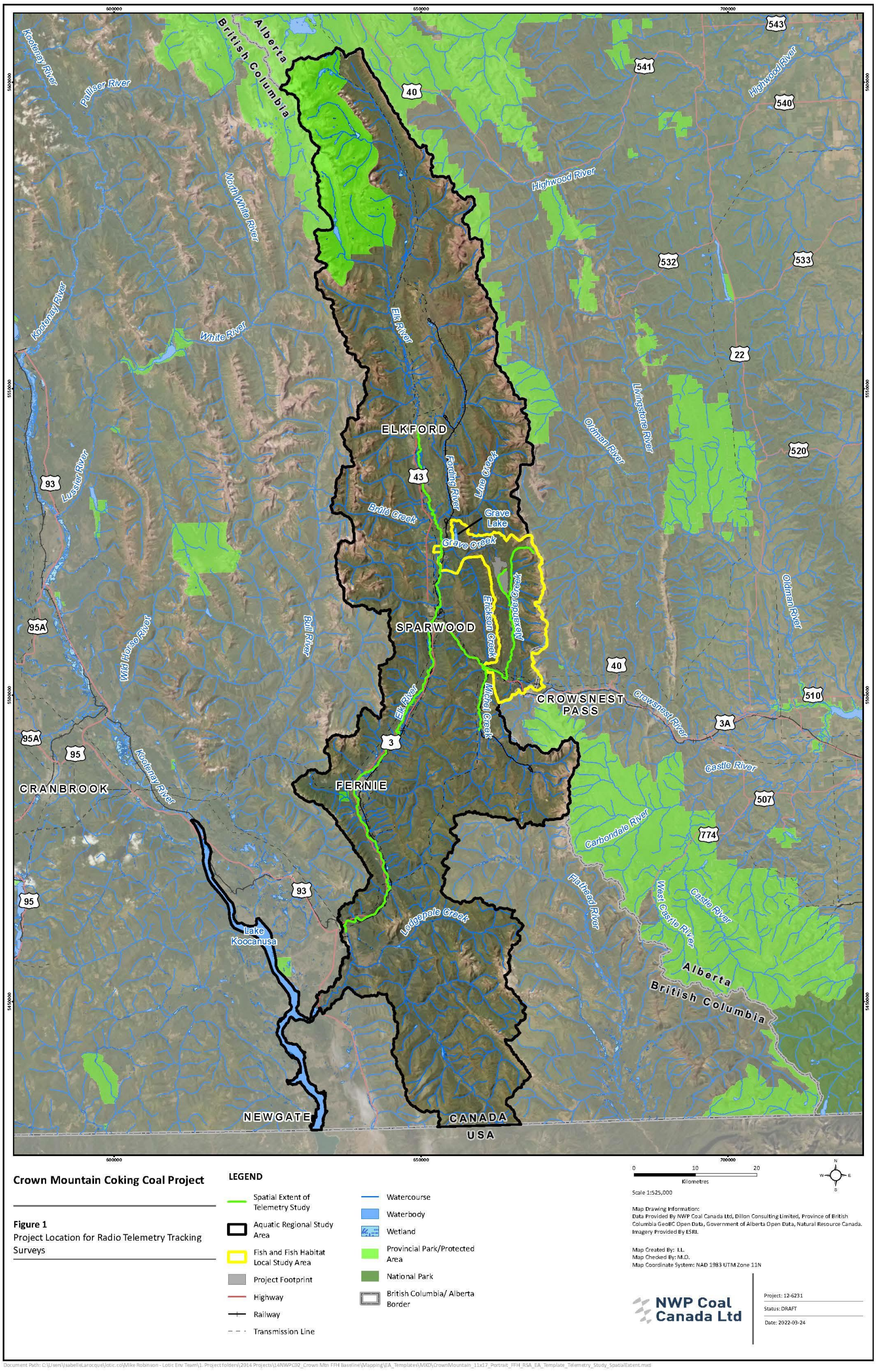
Westslope Cutthroat Trout prefer small streams that remain permanently wetted during low flow periods for rearing. Diverse cover is also required for juvenile rearing habitat to be suitable for rearing as young-of-year fry migrate to lower flow lateral zones with abundant cover for protection from predation. Larger juveniles often move into pools where they establish social dominance according to size. Limited pool habitats could limit a population's productivity and reproductive success even if it is a high productivity stream (Schmetterling 2000).

For overwintering habitat to be suitable for Westslope Cutthroat Trout the habitat needs to be free of anchor ice during colder periods and is often determined by groundwater influx. Fluvial adults will congregate in slow deep pools sheltered from high flows during winter months (Brown and Mackay 1995). Juveniles will utilize the cover provided by large woody debris, boulders and other large instream structures, such as beaver dams, to survive the winter months and maintain their numbers.

2 Methods

2.1 Study Area

The WCT population study area fell within both the Project's Fish and Fish Habitat Regional Study Area (RSA) and Local Study Area (LSA) (Figure 1). Population abundance work remained within the LSA, and specifically in the Alexander Creek watershed (the main study area). Radio telemetry work expanded into the RSA ultimately including the Alexander Creek watershed, Michel Creek from Leach Creek down to the Elk River, and the Elk River from Elko Dam to Elkford (Figure 1).



Crown Mountain Coking Coal Project

Figure 1
Project Location for Radio Telemetry Tracking Surveys

LEGEND

- Spatial Extent of Telemetry Study
- Aquatic Regional Study Area
- Fish and Fish Habitat Local Study Area
- Project Footprint
- Highway
- Railway
- Transmission Line
- Watercourse
- Waterbody
- Wetland
- Provincial Park/Protected Area
- National Park
- British Columbia/ Alberta Border

0 10 20
Kilometres

Scale 1:525,000

Map Drawing Information:
Data Provided By NWP Coal Canada Ltd, Dillon Consulting Limited, Province of British Columbia GeoBC Open Data, Government of Alberta Open Data, Natural Resource Canada.
Imagery Provided By ESRI.

Map Created By: I.L.
Map Checked By: M.O.
Map Coordinate System: NAD 1983 UTM Zone 11N

NWP Coal Canada Ltd

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Figure 1. Project location for radio telemetry tracking surveys.

The main study area consisted of fish bearing reaches on West Alexander Creek (WAL1 and WAL2) and Alexander Creek (ALE 9 down to the confluence with Michel Creek at ALE1) (

Figure 2). The main study area was subdivided into four general capture/release areas (Table 2).

Table 2: Summary of main study areas for fish capture and release with corresponding stream length and description.

Main study area ID	Description	Corresponding FFH baseline reaches	Stream length km
West Alexander Creek	West Alexander Creek upstream of the confluence with Alexander Creek	WAL1, WAL2	5.72
Upper Alexander Creek	Alexander Creek upstream of the confluence with West Alexander Creek	ALE8, ALE9	6.74
Middle Alexander Creek	Alexander Creek from downstream of the confluence with West Alexander Creek to the canyon section upstream of the gun range	ALE4, ALE5, ALE6, ALE7	17.93
Lower Alexander Creek	Alexander Creek from upstream of the gun range to the confluence with Michel Creek	ALE1, ALE2, ALE3	5.48

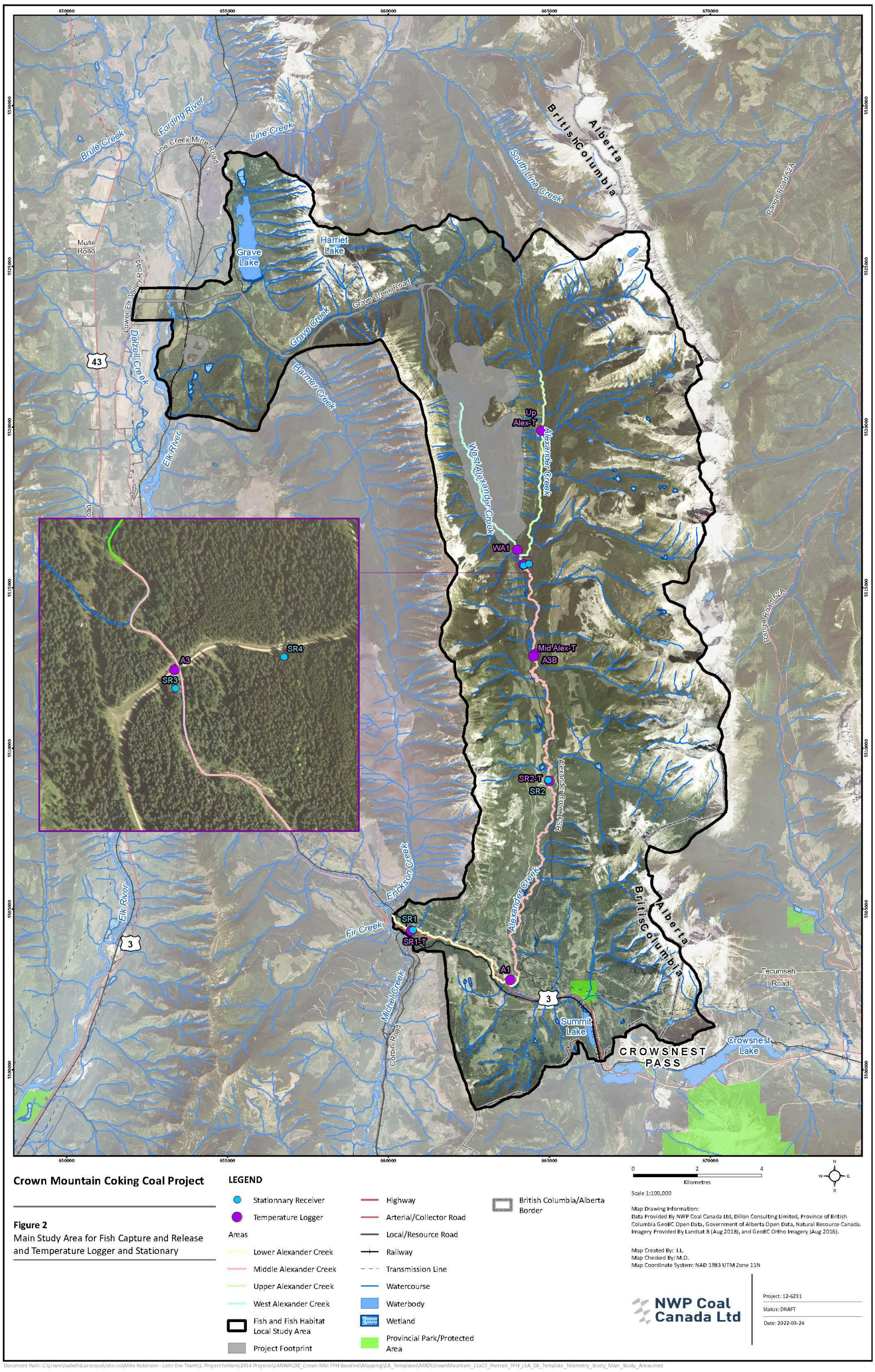

Figure 2: Main study area for fish capture and release and temperature logger and stationary receiver locations.

2.2 Study Period

The study period was one year, from July 2020 to July 2021. Study components within this period were:

- Fish capture and tagging: August 5 to October 7, 2020.
- Snorkel surveys: August 30 to September 3, 2020.
- Spawning surveys: June 26 and July 9, 2021.
- Telemetry tracking: July 2020 to July 2021.

2.3 Temperature Monitoring

In total, six temperature loggers (Onset Tidbit v2 Temp Logger) were deployed; one in West Alexander Creek, two in upper Alexander Creek, two in middle Alexander Creek, and one in lower Alexander Creek (Table 3 and Figure 2). SR3-T and SR4-T were manipulated with by public during the study period. Seeing as one of these loggers were on West Alexander baseline long term stream temperature data was utilized in characterizing the temperatures for WAL1 instead.

Table 3: Location and description of temperature loggers deployed

Logger ID	Location	Easting	Northing
SR1-T	Lower Alexander Creek (ALE1)	660701	5504322
SR2-T	Middle Alexander Creek	664992	5508994
Mid Alex-T	Middle Alexander Creek (Old Bridge)	664493	5512873
SR3-T	West Alexander Creek	664200	5515678
SR4-T	Upper Alexander Creek	664364	5515741
Up Alex-T	Upper Alexander Creek (near ALE9)	664754	5519886

Baseline temperature data collected between 2012 and 2018 as part of the hydrological baseline assessment of the Project (Dillon Consulting Limited. 2020) were also used to characterize mean weekly stream temperatures for locations within the Alexander Creek watershed (

Figure 2 and Table 4). Mid Alex-T and A3B are located in roughly the same spot.

Table 4. Summary of baseline hydrological assessment stream temperature logger data used.

Logger ID	Location	Easting	Northing
A1	Situated in lower Alexander Creek	663787	5502797
A3	Alexander Creek near confluence with West Alexander Creek	664187	5515723
A3B	Middle Alexander Creek at old bridge	664564	5512938
WA1	West Alexander Creek (WAL1)	664001	5516179

Of the 30 WCT that were implanted with radio tags during this study, 20 received larger, 4 g Lotek Wireless radio tags of frequency 150.340 MHz equipped with temperature sensors. Temperatures of the environment the fish was in were obtained each time these fish were located. The remaining ten fish (seven released in West Alexander Creek, and three in Upper Alexander Creek) received

smaller, 2 g Lotek Wireless radio tags of frequency 150.600 MHz that could not be equipped with temperature sensors.

2.4 Fish Capture and Tagging

Fly fishing by experienced personnel was the only method used to capture fish during the present study. In total, 212 angler-hours of effort were expended over 17 days in August, 2 days in September, and 3 days in October (Appendix A, Table A1).

Tagging procedures varied by fish and objective. Radio tags were required for movement tracking and floy tags were required for abundance estimates. A target of 30 radio tags deployed was set for the study area. Radio tagging procedures are discussed in the following paragraphs. All fish captured were measured (FL) and weighed. WCT not selected for radio tagging were >200 mm FL and affixed with a yellow Floy tag and PIT tag. WCT between 120-200 mm FL were PIT tagged; fish under 120 mm FL were not tagged by any method. The Floy tags were used by snorkelers to identify WCT that had been captured and whether they were radio tagged (see Section 2.6). PIT tags were installed in the event that this study was to proceed over multiple years. This did not become the case and as such, PIT tags are not discussed further in this report. Radio tags used for the study were of two types (manufactured by Lotek Wireless):

1. MST-930-T: frequency 150.340 MHz, weight of 4 g, equipped with temperature sensors.
2. MST-820: frequency 150.600 MHz, weight of 2 g.

The larger tags were implanted in fish with a minimum weight of 200 g (tag 2% or less of the body weight of the fish) and smaller tags were implanted in fish with a minimum weight of 100 g. The smaller MST-820 tags were obtained after difficulty capturing fish of sufficient size for the larger tags in West Alexander Creek and upper Alexander Creek (reaches 8-10). Radio tags were programmed with a 10 second burst rate to extend tag life to approximately 1 year.

Captured WCT of sufficient size to radio tag were allowed to rest for a minimum of 0.5 hours prior to work up and surgery for tag implantation. This allowed for the fish to recover their oxygen deficit caused by the capture procedure (Cope et. al. 2016). Fish were anesthetized in a 20 L creek water bath containing 1 mL of clove oil. To improve mixing, the clove oil was mixed with 5 mL of 95% ethanol prior to be added to the bath. Fish were monitored after being placed in the bath (time in and out recorded) and allowed to remain in the bath until they reached a sufficient level of anesthesia to allow for surgical tag implantation. This level of anesthesia involved the loss of gross body or “swimming” movements along with continued opercular movements. Fish were not allowed to remain in the bath past this point, to ensure that they did not succumb to the procedure.

Anesthetized fish were measured for fork length (FL) in mm and weighed (grams, g), examined externally for abnormalities, affixed with a red Floy tag, then placed on their back in a V-shaped trough with the gills submerged in a water bath. Priority was given to complete the procedure in a timely manner and as such an otoscope was not used to internally assess the sex and maturity of the fish. Radio tagged fish were photographed to provide a visual record (Figure 3).

An approximately two-centimeter incision was made just off the mid-ventral line ahead of the pelvic fins. A catheter needle was inserted through the incision to a point behind the pelvic fins. The tag antenna wire was then inserted through the catheter and used to gently pull the tag into the body cavity (Figure 3). The catheter was removed and the antenna used to gently pull the tag back to the pelvic girdle, to avoid complications associated with the tag resting over the incision. The incision was closed using independent, permanent monofilament nylon sutures (5-0

Monosof), then Vetbond™. Fish were then placed in a recovery tub in the stream with fresh water flowing through it, for a minimum of 0.5 hours, until fully recovered from the procedure and released back into the stream (Figure 4).

Figure 3. WCT being fitted with a Floy tag.

Figure 4: WCT released after being fitted with a Floy tag indicating radio tag implemented.

2.5 Telemetry

Radio telemetry is an effective method to monitor WCT movement patterns, seasonal distribution, and habitat use (Cope et al. 2016, Schoby and Keeley 2011). To adequately assess the study area, WCT from four general areas within the study area were radio tagged and subsequently monitored (i.e., West Alexander Creek, and Lower, Middle, and Upper Alexander Creek).

Movements of radio tagged WCT were monitored by stationary receiver (Figure 5), mobile ground tracking, and mobile helicopter tracking. Four stationary receivers were set up to act as "gateways" (i.e., to monitor movements into and out of particular areas (Figure 2). These areas, and the rationale behind them, were:

1. SR1 (installed July 31, 2020; Zone 11U, 660753E, 5504348N)
    a. Near the mouth of Alexander Creek, to monitor movements into and out of Alexander Creek.
2. SR2 (installed August 10, 2020; Zone 11U, 664963E, 5509009N)
    a. Middle Alexander Creek, to monitor migrations from lower Alexander Creek to upper Alexander Creek, and vice versa.
3. SR3 (installed July 30, 2020; Zone 11U, 664189E, 5515695N)
    a. West Alexander Creek, upstream of the confluence with Alexander Creek, to monitor movements into and out of West Alexander Creek.
4. SR4 (installed July 30, 2020, Zone 11U, 664358E, 5515744N)
    a. Upper Alexander Creek, upstream of the confluence with West Alexander Creek, to monitor movements into and out of Upper Alexander Creek.

Stationary receiver stations consisted of a job box cabled and locked to a tree, a Lotek Wireless SRX800-D receiver, two heavy duty 12 V gel cell batteries connected in parallel to power the system, two directional antennas, and associated cables (Figure 5). The antennas were affixed to a tree, with one pointed upstream and the other downstream. Receivers were downloaded and batteries swapped out every three weeks, to ensure they were continuously powered. This ensured that movements of tagged fish into and out of the areas monitored were not missed.

Ground based mobile tracking was conducted using a SRX1200-M receiver and handheld directional antenna. The stream was walked, and triangulation was used to determine the location of tagged fish. Tag ID, UTM coordinates and habitat notes were recorded at locations fish were detected. Because of the size of the expanded study area (i.e., large sections of Michel Creek and the Elk River) and the time that would have been required to cover it using ground-based tracking, this method was used opportunistically if fine scale locations were required.

Helicopter based mobile tracking was conducted on a similar schedule to stationary receiver download and maintenance (i.e., every three weeks). Because of the large area that needed to be covered, this was the main tracking method. The helicopter was equipped with two directional antennas (one aimed forward and one aft), which were connected to the SRX1200-M receiver. The time and location (UTM Coordinates) of detections were recorded.

Figure 5: SR3 setup on West Alexander Creek to monitor WCT movement between West Alexander and Alexander Creeks.

The total distance moved and the home range were calculated for each radio tagged fish. The total distance moved was the total distance in stream km that a fish moved as indicated by the distance between locations that the fish was detected (both mobile tracking and by stationary receivers). The home range represented the distance in stream km within which the fish was detected (i.e., the distance between the most upstream and downstream locations the fish was detected). Note that for most radio tagged fish captured and released in lower and middle Alexander Creek, their home range included sections of Michel Creek and the Elk River, as well as portions of Alexander Creek.

Figure 6: Helicopter based mobile tracking in February 2021 over the Elk River (left) and West Alexander Creek (right).

2.6 Snorkel Surveys

Snorkel surveys were used to collect WCT abundance and density data from Alexander and West Alexander Creeks between August 1-September 3, 2020. Snorkel surveys were conducted by one snorkeler to observe fish and relay information to a shore-based crew member who recorded data to unique, individual GPS locations. During surveys the snorkeler enumerated and sized (in 10 cm increments) fish and noted whether the fish were Floy tagged (Figure 7). In shallower sections of the headwaters, snorkel observations were limited to discrete pools with adequate depth and supplemented with shore-based observations of fish. Tags were found to be visible from both techniques.

A final count of marked and unmarked fish was summed for each reach. Fish abundance was calculated using the Lincoln-Petersen equation by Chapman (1951) (Equation 1) to produce section-specific abundance estimates. Fish abundance was also divided by site length to report fish density as fish per kilometre for comparison to regional studies (e.g., Cope et al 2016).

Equation 1.

$$N = \frac{(M+1)(n+1)}{(m+1)}$$

Where: N=population size; M=number captured and marked during mark run; n=number captured in recapture run; and, m=number of marked fish in recapture run.

Figure 7: A snorkeler during snorkeling surveys in 2020 recording Floy tagged and non-tagged fish on Alexander Creek.

2.7 Spawning Surveys

Spawning surveys were completed in West Alexander Creek on June 26 and July 9, 2021. These were conducted by two crew members walking the banks of the creek with polarized sunglasses and searching for WCT redds. When redds were observed, they were photographed, and the following were recorded: UTM coordinates, length of redd, habitat type the redd was present in, distance of the redd from the left bank, any fish associated with the redd, and general observations regarding the redd and surrounding habitat.

3 Results

3.1 Fish Capture and Tagging

During 212 angler-hours, 83 fish were captured, comprised of 72 Westslope Cutthroat Trout, 6 Bull Trout, 4 Mountain Whitefish, and 1 Rainbow Trout (Appendix A, Table A1). In total, 30 WCT were surgically implanted with radio tags (Appendix A, Table A2). The length and weight, and capture/release locations of these radio-tagged fish are provided in Table 1.

Of the 30 Westslope Cutthroat Trout (WCT) that were implanted with radio tags:

- 7 were captured and released in West Alexander Creek,
- 6 in upper Alexander Creek,
- 5 in middle Alexander Creek, and;
- 12 in lower Alexander Creek.

Table 5: Length and weight of radio tagged WCT by capture/release location and tag type.

Area/ Frequency	*n*	Mean FL (mm)	Min FL (mm)	Max FL (mm)	Mean Wt (g)	Min Wt (g)	Max Wt (g)
West Alex.	7	220	200	248	132	100	183
Upper Alex.	6	246	204	299	216	111	379
Middle Alex.	5	321	268	467	449	227	1162
Lower Alex.	12	416	365	478	905	594	1262
West/Upper	13	232	200	299	171	100	379
Middle/Lower	17	388	268	478	771	227	1262
150.600 MHz	10	218	200	248	131	100	183
150.340 MHz	20	372	254	478	701	227	1262

3.2 Life history timing and water temperature

Life history activities identified in this study were: overwintering, migration (spring and fall), spawning, and summer rearing. These were shown on a periodicity table (Table 6) to provide a means of visualizing fish activity over the course of a year. Activities were defined through a combination of tracking results, water temperature, spawning surveys, and literature of salmonid ecology. Overwintering is a period where WCT tend to be less active, concentrating in specific habitat. It is defined as the opposite of the more active summer rearing period. Summer rearing was defined following Coleman and Fausch (2007), who more or less defined this as the time when water temperature was above 5°C in the spring to when it cooled to below 4°C in the fall (as noted, overwintering was the opposite). Overwintering and rearing periods were estimated from the 2012-2019 baseline data. Telemetry tracking form 2020-2021 were used to corroborate this estimate. Through both movement and temperature monitoring, a distinction was noted between the headwater and lower elevation reaches. West Alexander Creek and upper Alexander Creek both had summer rearing periods that were approximately five weeks shorter than that of the lower reaches.

As discussed below, some of the fish tracked, showed migrations between winter and summer. A spring migration occurred when fish moved out of overwintering areas to move either towards spawning or rearing habitat. This was typically moving from a more concentrated state to a more widely dispersed state. A migration was also observed at the end of the summer rearing when fish moved to overwintering areas. Spawning was identified as a period when hydrologic conditions were appropriate (descending limb of the hydrograph), when some fish had made an apparent migration, and corroborated by spawning surveys. Being spring spawners, WCT spawning occurs on the descending limb of the hydrograph following spring freshet. The life history periods identified for Alexander Creek are provided in Table 6.

Table 6. Alexander Creek WCT Periodicity table.

Life History Activity	Jan				Feb				Mar				Apr				May				Jun				Jul				Aug				Sep				Oct				Nov				Dec			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Overwintering[1]																																															
Spring Migration[2]																																															
Spawning[3]																																															
Incubation[4]																																															
Summer Rearing[5]																																															
Fall Migration[6]																																															

[1] Opposite summer rearing. Hashed cells indicate extended overwintering in headwater reaches.
[2] Documented through telemetry tracking.
[3] Spawning confirmed through redd surveys.
[4] Beginning on the start of spawning until 600 accumulated thermal units reached; a cumulative temperature value required to incubate eggs (Kootenay Trout Hatchery pers com).
[5] Coleman and Fausch (2007). Hashed cells indicate extended rearing in lower reaches.
[6] Documented through telemetry tracking.

Temperature data obtained from the 20 fish with radio tags that had temperature sensors built in are presented by release areas are presented in Table 7. No fish large enough for these tags were captured in West Alexander Creek. Fish were found in water temperature between 0.5°C – 9.9°C over the entire year and in all areas. Overwintering water temperatures remained above 0°C (0.5°C minimum) and 3.2°C. The range in summer rearing temperature was between 3.5-9.9°C. Due to a lack of temperature data in Michel Creek and the Elk River, it was not possible to determine a water temperature range of when fish began a spring migration.

Table 7. Summary of mean fish temperature by main study area and month. Data are in °C.

Release Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower Alexander Creek	0.6	0.5	2.0	-	6.0	7.4	-	9.9	6.2	5.3	2.6	0.7
Middle Alexander Creek	0.7	1.5	0.8	-	4.8	6.0	6.9	-	7.9	6.1	-	1.2
Upper Alexander Creek	2.7	2.0	3.2	-	2.8	3.5	-	-	-	2.8	2.9	2.8

3.3 Telemetry tracking

3.3.1 West Alexander Creek

All of the seven fish implanted with radio tags in West Alexander Creek remained there for the life of the tags. These fish were only detected in West Alexander Creek, from their time of capture during summer rearing, through overwintering, and into the spring spawning period. These fish are suspected to have overwintered in areas with groundwater influence, a behaviour that has been observed in other areas/populations (Cope et al. 2016) and one inferred in this study based on water temperatures obtained through radio tags. These fish were all detected periodically until June, when the tags began dying. Tracking for over an 11-month period showed that these fish complete all life history activities in this tributary. Spawning use was confirmed with direct redd observations.

These fish were smaller than WCT captured in Middle and Lower Alexander Creek (Appendix IV). They exhibited the smallest movements, in terms of mean total distance moved[1] and home range[2], of any of the four sub-groups identified in this study. Their behaviour is indicative of a fluvial-resident life history strategy.

3.3.2 Upper Alexander Creek

Of the six radio-tagged WCT from this area, five remained upstream of the confluence with West Alexander Creek for the life of the tags. The remaining fish moved downstream into middle Alexander Creek where it was detected until June before moving upstream. Five of these fish were last detected in June, and one in February.

The fish in upper Alexander Creek exhibited behaviour similar to fish in West Alexander Creek; remaining in a small area from summer rearing, through overwintering, and to the time of spawning. Spawning surveys were not completed for this portion of the Alexander Creek watershed based on the proposed mine design (low to no impact anticipated). Fish caught in upper Alexander Creek were similar in size to those caught in West Alexander Creek, being smaller bodied than fish captured in middle and lower Alexander Creek. Fish in upper Alexander Creek had the second smallest mean total distance travelled and home range; both similar to West Alexander. These fish would therefore also be considered to have a fluvial-resident life history strategy.

3.3.3 Middle Alexander Creek

Of the five radio-tagged fish in this area, three moved out of Alexander Creek into the Elk River during September/October, one was last detected in Lower Alexander Creek in October, and one remained in Middle Alexander Creek until last detected in June. Therefore, three of these fish overwintered in the Elk River and one in Middle Alexander Creek (the fate of the fifth tag is unknown). Of the three fish that moved into the Elk River, one moved back into Lower Alexander Creek in May and Middle Alexander Creek in June, one was last detected in Michel Creek downstream of Alexander Creek in June (presumably migrating back into Alexander Creek), and one (ID 45) was last detected in the Elk River upstream of Sparwood in June.

[1] Total distance is the full distance travel during the tag life.
[2] Home range is the distance between the upper and lower limits between which the fish was always located.

Fish in middle Alexander had notably larger movements than fish of the upper sections (Appendix IV). They were also larger on average than fish upstream and comparable to fish in lower Alexander. The fish in middle Alexander Creek are considered to be fluvial migratory.

The fish with ID 45 may have been caught by an angler or bird prior to June 18. This fish was detected on June 18 and June 25 during helicopter surveys, but the temperatures indicated by the sensor tag were 25°C and 26°C, respectively, substantially higher than water temperatures. It is also possible that the higher temperature readings were related to tag failure (the tag was nearing the end of its life).

3.3.4 Lower Alexander Creek

Of the 12 WCT implanted with radio tags in this area, 10 moved into the Elk River in the fall, one remained in lower Alexander Creek (exhibited little movement, but was observed alive during snorkel surveys), and one was never detected after release (suspected to have been harvested by an angler or preyed on). Of the 10 fish that moved into the Elk River to overwinter, 8 returned to lower Alexander Creek in June, one was last detected in Michel Creek upstream of the mouth of Alexander Creek at the mouth of Leach Creek in June, and one was last detected in the Elk River in February.

Fish in lower Alexander were similar to middle Alexander in that they exhibited much larger movements than fish of the upper sections and they were larger on average than fish upstream (Appendix IV). The fish in middle Alexander Creek are considered to be fluvial migratory.

3.3.5 Movement and Home Range

Substantial variations in total distance traveled and home ranges were evident between radio tagged fish in the four capture/release areas (Table 8). Fish captured and released in lower Alexander Creek exhibited the greatest total movement and largest home range, followed by fish captured and released in middle Alexander Creek, upper Alexander Creek, and West Alexander Creek. Based on these movement data, the four sub-groups differentiated on logistical basis can be described as two sub-groups based on behavior. These data show smaller fluvial-resident fish inhabit the upper portions of the watershed and larger, fluvial-migratory fish inhabit the lower portions of the watershed (Figure 8). Furthermore, these results suggest that homing and drift between streams is relatively plastic in the fluvial-resident life history forms. Note that one fish released in lower Alexander Creek (ID19) was not detected after release, and therefor is not included in Table 8.

Table 8: Total distance moved, and home range of radio tagged WCT by release group.

Release Area	*n*	Total Distance Moved (km)			Home Range (km)		
		Mean	Min.	Max.	Mean	Min.	Max.
West Alex.	7	1.9	0.9	3.9	1.1	0.3	3.5
Upper Alex.	6	2.8	0.7	7.4	1.9	0.5	7.2
Middle Alex.	5	38.8	4.6	91.5	24.9	3.1	45.8
Lower Alex.	11	53.3	1.7	82.8	28.5	0.8	42.9
All	29	28.0	0.7	91.5	15.8	0.3	45.8

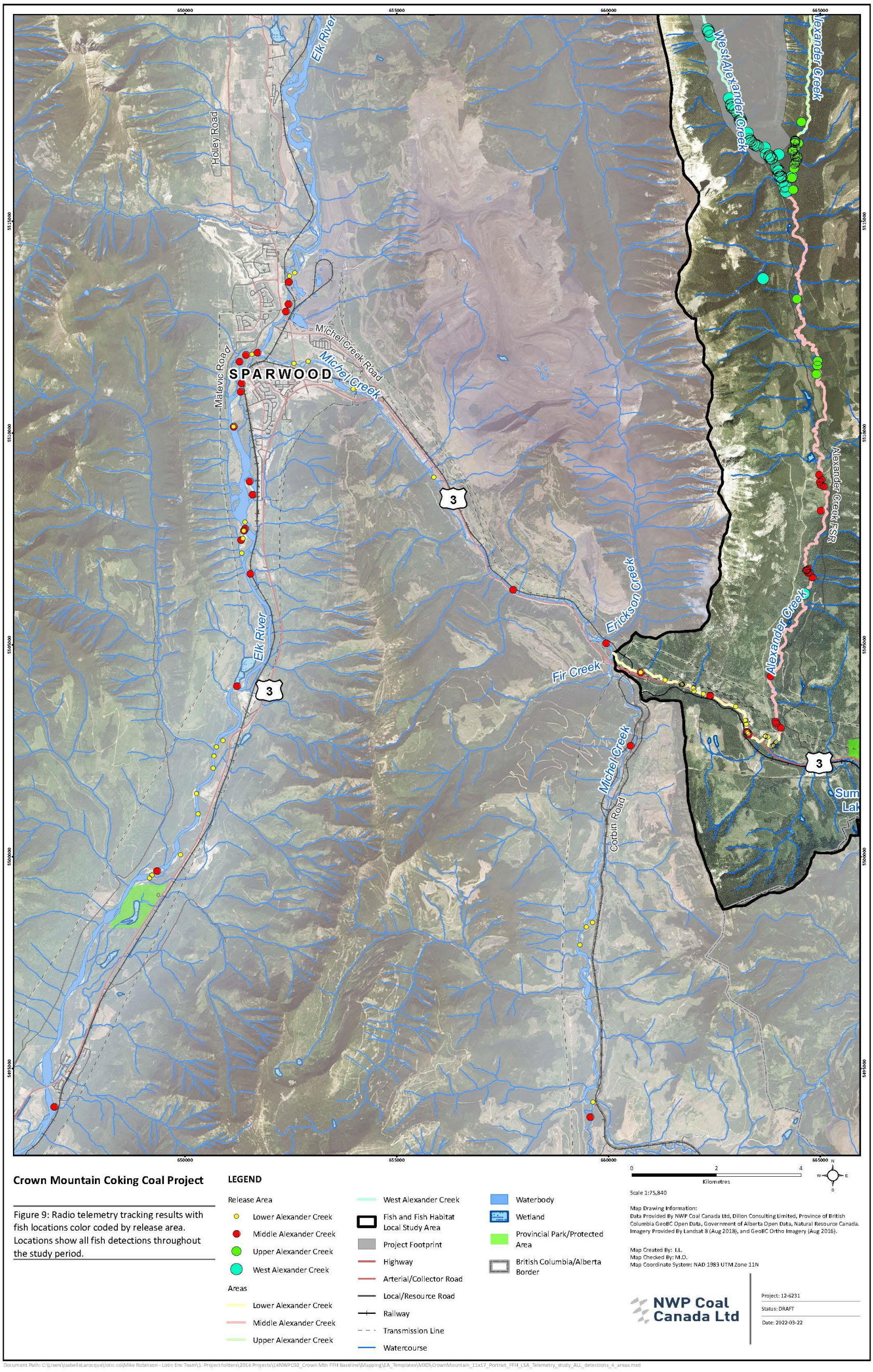

Figure 9: Radio telemetry tracking results with fish locations color coded by release area. Locations show all fish detections throughout the study period.

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Figure 8: Radio telemetry tracking results with fish locations colour coded by release area. Locations show all fish detections throughout the study period.

3.4 Snorkel Surveys and Population Abundance

In total, 21.1 km of stream were snorkel surveyed during the study; comprised of 4.8 km of upper Alexander Creek, 2.9 km of West Alexander Creek, 10 km of middle Alexander Creek, and 3.4 km of lower Alexander Creek (Table 9). Fish were observed in each of the release areas at densities ranging from 1.9 – 14.1 fish/km. Observer efficiency (i.e., percentage of floy tags observed) was 22%. The total population abundance estimated for the Alexander Creek watershed was 641 fish >100 mm fork length.

Table 9. Snorkel survey data from West Alexander and Alexander creeks, August 30 to September 3, 2020.

Stream Section	Floy tags deployed	Km sampled	Count of fish observed (total/marked) by fork length (cm) category							
			< 10	10-20	20-30	30-40	40-50	Total observed	Total observed w/mark	Observed/km
Upper Alex.	23	4.8	-	4/0	5/0	-	-	9	0	1.9
West Alex.	12	2.9	3	25/5	7/1	-	-	35	6	14.1
Middle Alex.	6	10	1	19	35	7	2	63	0	6.4
Lower Alex.	17	3.4	-	-	17	13/6	1/1	31	7	11.2
All Sections	58	21.1	4	53	65	26	4	139	13	-

3.5 Spawning Surveys

Spawning surveys were conducted in West Alexander Creek on June 26 and July 9. On June 26, a WCT was observed holding over a potential redd, but was spooked by the observer's approach and did not return to the area while the surveyors remained. On July 9, seven redds were observed within Reach 1 of West Alexander Creek (Figure 9, Table 10).

Table 10. WCT spawning redd data recorded in West Alexander Creek on July 9, 2021.

Redd #	UTM Location (Zone 11U)		Redd Length (m)	Habitat Type	Distance from Left Bank (m)	Fading Score/Description
	Easting	Northing				
1	663972	5516239	0.6	Glide	1.0	1. Fresh, clean gravel, sorted and defined pit and mound.
2	662882	5517813	0.6	Glide	3.5	1. Fresh, clean gravel, sorted and defined pit and mound.
3	662701	5518345	0.4	Glide	1.8	1. Fresh, clean gravel, sorted and defined pit and mound.
4	662702	5518351	0.45	Glide	2.0	2. Faded, but visible (algae or silt present, but can be distinguished).
5	662640	5518525	0.4	Glide	2.8	1. Fresh, clean gravel, sorted and defined pit and mound.
6	662628	5518699	0.5	Glide	0.25	1. Fresh, clean gravel, sorted and defined pit and mound.
7	662492	5519260	0.4	Glide	1.9	2. Faded, but visible (algae or silt present, but can be distinguished).

Figure 9: A WCT redd observed during spawning surveys on West Alexander Creek.

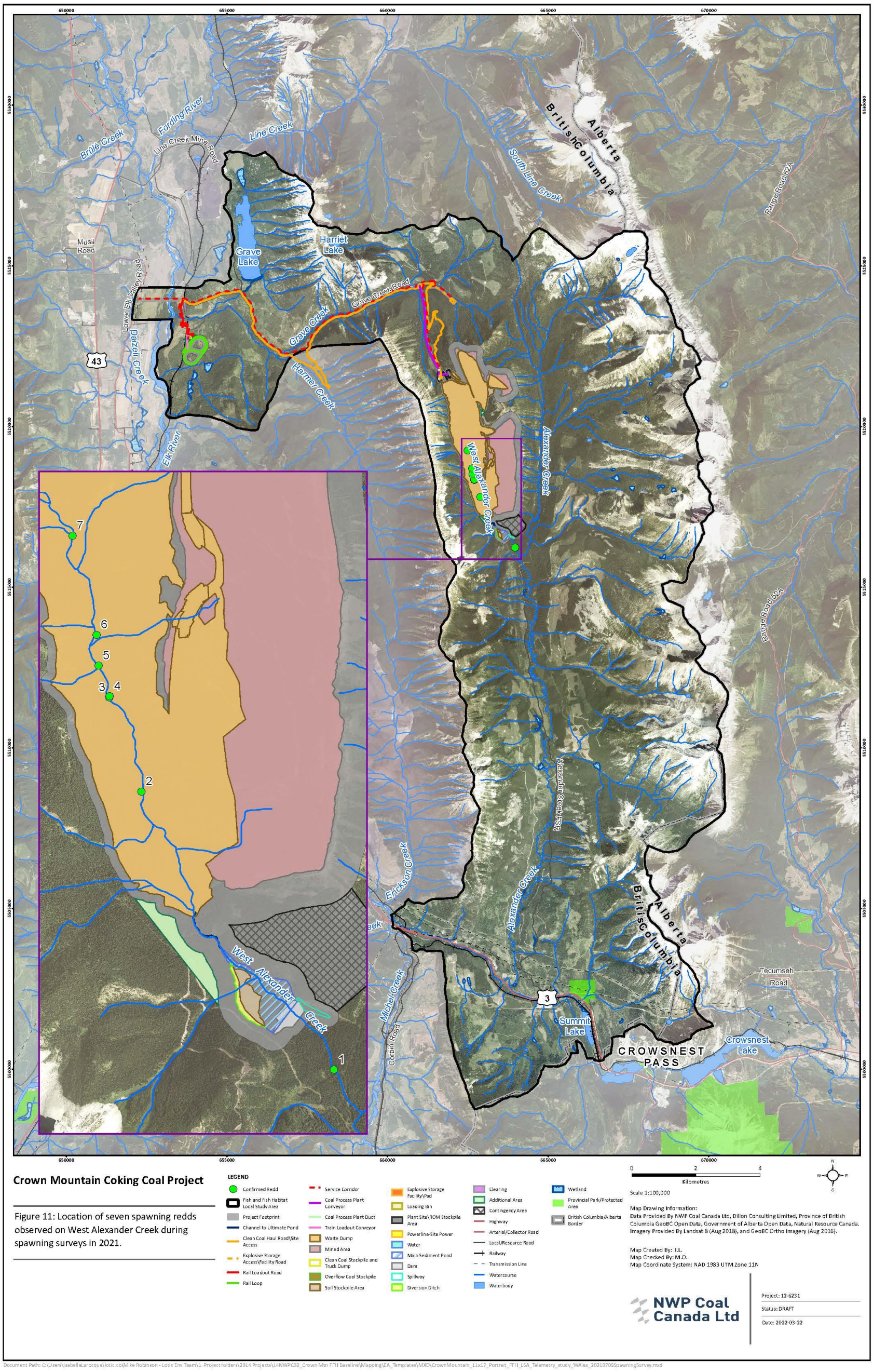

Figure 10: Location of seven spawning redds observed on West Alexander Creek during spawning surveys in 2021.

4 Discussion

This study was completed with that caveat that used just one year of telemetry and abundance estimate results. However, confidence in this assessment is high when considering that similar studies that show how consistent WCT populations in the Elk River are over time in terms of general life history behaviour (e.g., Cope et al. 2019, Cope and Cope 2020). The Alexander Creek Westslope Cutthroat Trout Population Study had the overall purpose to assess the importance of West Alexander Creek habitat to the overall WCT population within the Alexander Creek watershed. The period of study is considered adequate to meet this purpose.

Results of this study indicate that Alexander Creek contains two distinct phenotypes of Westslope Cutthroat Trout. One group inhabits the headwaters with the highest densities in West Alexander Creek. These are smaller fish exhibiting a fluvial-resident life history strategy with a small home range and total distance moved annually (Table 5). WCT in West Alexander Creek and upper Alexander Creek appear to be fluvial resident populations that hold, feed, overwinter, and spawn in these locations. Movements of WCT between West Alexander Creek and Alexander Creek were not recorded, however additional study is required to determine if there is mixing or movement between these groups. A portion of these fish are believed to over-winter in interstitial spaces fed by groundwater, but additional data is needed to prove this. Spawning was recorded in West Alexander Creek, but additional study is required to prove that spawning also occurs in upper Alexander Creek. Radio tagged WCT in West Alexander Creek and upper Alexander Creek were smaller bodied (mean fork lengths of 220 mm and 246 mm; mean weights of 132 g and 216 g, respectively), exhibited much lower total distances moved (1.9 km and 2.8 km, respectively), and smaller home ranges (1.1 km and 1.9 km, respectively).

The second phenotype was a larger fish found in middle and lower Alexander Creek. This sub-population exhibited a fluvial-migratory strategy that would leave Alexander Creek in the fall (September/October) to overwinter in the Elk River, then return to Alexander Creek in the spring (May/June), likely to spawn. Additional study is required to prove that these fish spawn in middle and lower Alexander Creek. WCT from middle and lower Alexander Creek were larger bodied (mean fork lengths of 321 mm and 416 mm; mean weights of 449 g and 905 g, respectively), exhibited much greater total distances moved (38.8 km and 53.3 km, respectively), and larger home ranges (24.9 km and 28.5 km, respectively).

The co-existence of these distinct life history strategies is particularly interesting in that it occurs without a physical barrier. The fish in the upper portions of Alexander Creek have selected a strategy that required them to carry out their entire life cycle within a few kilometers despite having no physical restriction to the alternative approach, which is to migrate downstream to larger habitat to overwinter. From this, it appears that West Alexander Creek contains a distinct phenotype that is unlikely to frequently range outside of the area it was tracked in during this study. This study has found that while as Biologists we tend to classify populations to one life history strategy, it is possible, and in fact more likely, that in open systems life history selection exists as a range of options and perhaps may even be plastic within an individual over its life. When a larger population has the ability to employ a range of strategies, it adds resiliency as it opens up opportunity to inhabit different and diverse habitat at the same time of year. It also allows for beneficial local adaptations to evolve providing diversity in the genetic make up of the larger population, which again improves resiliency.

Table 11: Mean fork length, weight, total distance moved, and home range of radio tagged Westslope Cutthroat Trout in West Alexander Creek and Alexander Creek.

Release area	*n*	Mean FL (mm)	Mean Weight (g)	Mean Total Distance Moved (km)	Mean Home Range (km)
West Alex.	7	220	132	1.9	1.1
Upper Alex.	6	246	216	2.8	1.9
Middle Alex.	5	321	449	38.8	24.9
Lower Alex.	12	416	905	53.3	28.5

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5 Literature Cited

Chapman, D.G. 1951. Some Properties of the Hypergeometric Distribution with Applications to Zoological Sample Censuses. University of California Publications in Statistics. Berkeley and Los Angeles, CA: University of California Press. 1(7)131-160.

Cope, S., C.J. Schwarz, A. Prince and J. Bisset. 2016. Upper Fording River Westslope Cutthroat Trout Population Assessment and Telemetry Project: Final Report. Report prepared for Teck Coal Limited, Sparwood, BC. Report prepared by Westslope Fisheries Ltd., Cranbrook, BC. 266 p.

Schoby, G.P. and E.R. Keeley. 2011. Home Range Size and Foraging Ecology of Bull Trout and Westslope Cutthroat Trout in the Upper Salmon River Basin, Idaho, Transactions of the American Fisheries Society, 140:3, 636-645.

British Columbia Conservation Data Centre. (2020). *B.C. Species and Ecosystems Explorer*. B.C. Minist. of Environ. Victoria, B.C. http://a100.gov.bc.ca/pub/eswp/ (accessed November 27, 2021).

Committee on the Status of Endangered Wildlife in Canada. (2016). *COSEWIC assessment and status report on the Westslope Cutthroat Trout Oncorhynchus clarkii lewisi, Saskatchewan-Nelson River populations and Pacific populations, in Canada*. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xvi + 83 pp. http://www.registrelep-sararegistry.gc.ca/default.asp?lang=en&n=24F7211B-1

Dillon Consulting Limited. (2020). Hydrology Baseline Report – Crown Mountain Coking Coal Project.

Liknes, G., and Graham, P. (1988). Westslope Cutthroat Trout in Montana: Life history, status and management. *American Fisheries Society Symposium, 4*: 53-60.

Shepard, B., Pratt, K., and Graham, P. (1984). *Life histories of westslope cutthroat trout and bull trout in the upper Flathead River Basin, Montana*. Environmental Protection Agency. Reg. VIII. Water Division. Denver, CO. 85 pp.

McPhail, J. D., and Carveth, R. (1992). *A Foundation for Conservation: The Nature and Origin of the Freshwater Fish Fauna of British Columbia*. University of British Columbia Fish Museum, Department of Zoology, Vancouver, B.C. 39pp.

Rasmussen, J. B., Robinson, M. D., Hontela, A., and Heath, D. D. (2012). Metabolic traits of Westslope Cutthroat Trout, introduced rainbow trout and their hybrids in an ecotonal hybrid zone along an elevation gradient. *Biological Journal of the Linnean Society*, *105*: 56-72.

Elk Valley Cumulative Effects Management Framework Working Group (EV CEMF). 2018. Elk Valley Cumulative Effects Assessment and Management Report. *Elk Valley Operations Summary Report*. Prepared by Lotic Environmental Ltd. 12 pp + appendices.

McPhail, J. D. (2007). *The Freshwater fishes of British Columbia*. The University of Alberta Press, Edmonton. 696pp.

SARA Species Registry. 2019. Species at risk public registry: Species search. Government of Canada. Retrieved from: https://species-registry.canada.ca/index-en.html#/species?ranges=1&sortBy=taxonomySort&sortDirection=asc&pageSize=10

Schmetterling, D.A. 2000. Management Briefs: Redd characteristics of fluvial Westslope Cutthroat Trout in four tributaries to the Blackfoot River, Montana. *North American Journal of Fisheries Management*. 20: 776-783.

Brown, R.S. and W.C. Mackay. 1995. Fall and winter movements of and habitat use by cutthroat trout in the Ram River, Alberta. Trans. Amer. *Fisheries Society* 124: 873–885.

Appendix I - Angling Effort

Table A1: Angling effort and catch, Alexander and West Alexander Creeks, August to October, 2020.

Date	General Location	Hook-Hours	Captured[a]						Observed			
			WCT	RB	MW	CB	BT	Total	WCT	WCT fry	BT	Total
5-Aug-20	Lower Alexander	25.00	1	1				**2**	1			**1**
6-Aug-20	Lower Alexander	22.75	7		2			**9**				**0**
7-Aug-20	Lower Alexander	12.00	8		2			**10**				**0**
12-Aug-20	Lower Alexander	0.60	2			1		**3**	10			**10**
17-Aug-20	Lower Alexander	15.00	5					**5**				**0**
25-Aug-20	Lower Alexander	7.00	3					**3**	5	1		**6**
Subtotal:		**82.35**	**26**	**1**	**4**	**1**	**0**	**32**	**16**	**1**	**0**	**17**
CPUE[b] (No./hook-hour):			**0.32**					**0.39**				
10-Aug-20	Middle Alexander	3.00						**0**				**0**
14-Aug-20	Middle Alexander	4.50						**0**				**0**
18-Aug-20	Middle Alexander	6.00						**0**	1			**1**
20-Aug-20	Middle Alexander	12.50					1	**1**				**0**
21-Aug-20	Middle Alexander	10.00						**0**	3			**3**
2-Sep-20	Middle Alexander	2.00	3					**3**				**0**
3-Sep-20	Middle Alexander	2.50	8					**8**	2			**2**
Subtotal:		**40.50**	**11**	**0**	**0**	**0**	**1**	**12**	**6**	**0**	**0**	**6**
CPUE[b] (No./hook-hour):			**0.27**					**0.30**				
27-Aug-20	Upper Alexander	13.00						**0**				**0**
7-Oct-20	Upper Alexander	5.00	9				3	**12**	4			**4**
Subtotal:		**18.00**	**9**	**0**	**0**	**0**	**3**	**12**	**4**	**0**	**0**	**4**
CPUE[b] (No./hook-hour):			**0.50**					**0.67**				
13-Aug-20	West Alexander	6.00	3					**3**	2			**2**
19-Aug-20	West Alexander	18.50	4				2	**6**	16		1	**17**
26-Aug-20	West Alexander	10.00	1					**1**	6			**6**
27-Aug-20	West Alexander	14.25	3					**3**	7			**7**
28-Aug-20	West Alexander	8.00	5					**5**	6			**6**
30-Aug-20	West Alexander	4.75	2					**2**	4			**4**
5-Oct-20	West Alexander	5.00	3					**3**	1			**1**
6-Oct-20	West Alexander	5.00	4					**4**	2			**2**
Subtotal:		**71.50**	**25**	**0**	**0**	**0**	**2**	**27**	**44**	**0**	**1**	**45**
CPUE[b] (No./hook-hour):			**0.35**					**0.38**				
Total, all areas:		**212.35**	**71**	**1**	**4**	**1**	**6**	**83**	**70**	**1**	**1**	**72**
CPUE[b] (No./hook-hour):			**0.33**					**0.39**				

Appendix II - Fish Tagging Data

Table A2: Life history and tagging information for fish captured in Alexander and West Alexander creeks, August to October, 2020.

Fish No.	Date	Species[a]	Capture Loc.	Capture UTMs (11U)		Length	Weight	Floy Tag		PIT Applied	Radio Tag		Scales	Fin Ray
				Easting	Northing	(mm)	(g)	Colour	No.		ID	Freq. (MHz)		
1	5-Aug-20	RB	Lower Alex	660499	5504438	297	322							
2	5-Aug-20	WCT	Lower Alex	661961	5503929	230	161	yellow	163	989001006084660				
3	6-Aug-20	WCT	Lower Alex	661721	5504064	407	744	red	496		15	150.340		
4	6-Aug-20	WCT	Lower Alex	662998	5503542	410	907	yellow	161	989001006084___				
5	6-Aug-20	WCT	Lower Alex	663005	5503518	285	252	yellow	160	989001006084637				
6	6-Aug-20	MW	Lower Alex	663005	5503518	305	322							
7	6-Aug-20	MW	Lower Alex	663005	5503518	330	350							
8	6-Aug-20	WCT	Lower Alex	663937	5502684	410	752	red	495		27	150.340		
9	6-Aug-20	WCT	Lower Alex	663937	5502684	404	873	red	494		26	150.340		
10	6-Aug-20	WCT	Lower Alex	662998	5503542	465	1262	red	493		25	150.340		
11	6-Aug-20	WCT	Lower Alex	663855	5502607	407	800	red	491		23	150.340		
12	7-Aug-20	WCT	Lower Alex	663484	5502714	403	759	yellow	159	989001006084600			Y	
13	7-Aug-20	WCT	Lower Alex	663515	5502777	300	758	yellow	158	989001006084691			Y	
14	7-Aug-20	WCT	Lower Alex	663340	5502857	190	101							
15	7-Aug-20	WCT	Lower Alex	663340	5502857	215	115							
16	7-Aug-20	WCT	Lower Alex	663340	5502857	283	287	yellow	155	989001006084668			Y	
17	7-Aug-20	WCT	Lower Alex	663262	5502900	430	905	yellow	153	989001006084639			Y	
18	7-Aug-20	MW	Lower Alex	663262	5502900	290	302						Y	
19	7-Aug-20	WCT	Lower Alex	663262	5502900	340	509	yellow	152	989001006084604			Y	
20	7-Aug-20	WCT	Lower Alex	663262	5502900	367	648	yellow	151	989001006084618			Y	
21	7-Aug-20	MW	Lower Alex	663262	5502900	350	698						Y	
22	12-Aug-20	WCT	Lower Alex	663702	5502841	365	594	red	490		24	150.340		
23	12-Aug-20	WCT	Lower Alex	663761	5502828	402	727	red	489		28	150.340		
24	12-Aug-20	Cutbow	Lower Alex	663763	5502827	231	164			989001006084692				
25	13-Aug-20	WCT	West Alex	664065	5516017	214	167	yellow	101	989001006084656			Y	
26	13-Aug-20	WCT	West Alex	664349	5515526	246	155	yellow	104	989001006084622			Y	
27	13-Aug-20	WCT	West Alex	664349	5515526	212	130	yellow	103	989001006084609			Y	
28	17-Aug-20	WCT	Lower Alex	663958	5502704	442	1067	red	488		21	150.340		
29	17-Aug-20	WCT	Lower Alex	664057	5503044	478	1260	red	451		19	150.340		
30	17-Aug-20	WCT	Lower Alex	663958	5502704	354	547	yellow	106	989001006084643				
31	17-Aug-20	WCT	Lower Alex	663933	5503189	409	980	red	452		17	150.340		
32	17-Aug-20	WCT	Lower Alex	663958	5502704	427	1229	yellow	125	989001006084650				
33	19-Aug-20	WCT	West Alex	663688	5516638	194	95			989001006084684			Y	
34	19-Aug-20	WCT	West Alex	663573	5516708	194	88			989001006084663			Y	

[a] RB = Rainbow Trout, WCT = Westslope Cutthroat Trout, MW = Mountain Whitefish, BT = Bull Trout.

Continued…

Table A2: Continued.

Fish No.	Date	Species[a]	Capture Loc.	Capture UTMs (11U) Easting	Capture UTMs (11U) Northing	Length (mm)	Weight (g)	Floy Tag Colour	Floy Tag No.	PIT Applied	Radio Tag ID	Radio Tag Freq. (MHz)	Scales	Fin Ray
35	19-Aug-20	WCT	West Alex	663524	5516765	145	46			989001006084633			Y	
36	19-Aug-20	WCT	West Alex	663510	5516794	159	54			989001006084632			Y	
37	19-Aug-20	BT	West Alex	663254	5517000	205	97	yellow	107	989001006084672				Y
38	19-Aug-20	BT	West Alex	663190	5517128	188	53			989001006084620				Y
39	20-Aug-20	BT	Middle Alex	664491	5512884	650		yellow	108	989001006084638				
40	25-Aug-20	WCT	Lower Alex	663824	5504258	380	735	red	476		16	150.340		
41	25-Aug-20	WCT	Lower Alex	663824	5504258	420	1069	red	477		18	150.340		
42	25-Aug-20	WCT	Lower Alex	663824	5504258	165	55			989001006084671				
43	26-Aug-20	WCT	West Alex	663804	5516497	190	100	red	478					
44	27-Aug-20	WCT	West Alex	663192	5517234	184	92							
45	27-Aug-20	WCT	West Alex	663098	5517430	235	151	red	479				Y	Y
46	27-Aug-20	WCT	West Alex	663098	5517430	195	129	red	480					
47	28-Aug-20	WCT	West Alex	663006	5517601	205	119	red	453					
48	28-Aug-20	WCT	West Alex	662895	5517855	275	257	red	482	989001006084607			Y	Y
49	28-Aug-20	WCT	West Alex	663006	5517601	156	52			989001006084667			Y	Y
50	28-Aug-20	WCT	West Alex	662887	5517753	165	55			989001006084617			Y	Y
51	28-Aug-20	WCT	West Alex	662848	5517971	181	74	yellow	174	989001006084680			Y	Y
52	30-Aug-20	WCT	West Alex	663388	5516863	161	46			989001006084652			Y	Y
53	30-Aug-20	WCT	West Alex	663388	5516863	116	14						Y	Y
54	2-Sep-20	WCT	Middle Alex	665022	5508902	210		yellow	172	989001006084676			Y	Y
55	2-Sep-20	WCT	Middle Alex	665022	5508902	280	270	red	454		7	150.340	Y	Y
56	2-Sep-20	WCT	Middle Alex	665022	5508902	284	275	red	455		14	150.340	Y	Y
57	3-Sep-20	WCT	Middle Alex	664987	5508844	467	1162	red	457		13	150.340	Y	Y
58	3-Sep-20	WCT	Middle Alex	665004	5508169	268	227	red	458		22	150.340	Y	Y
59	3-Sep-20	WCT	Middle Alex	665004	5508769	203	128	yellow	1				Y	Y
60	3-Sep-20	WCT	Middle Alex	665004	5508769	214	142	yellow	3				Y	Y
61	3-Sep-20	WCT	Middle Alex	665077	5508732	245	198	yellow	4				Y	Y
62	3-Sep-20	WCT	Middle Alex	665077	5508732	306	312	red	459		45	150.340	Y	Y
63	3-Sep-20	WCT	Middle Alex	665077	5508732	232	145	yellow	5				Y	Y
64	3-Sep-20	WCT	Middle Alex	665077	5508732	183	85	yellow	6				Y	Y
65	5-Oct-20	WCT	West Alex	664055	5516054	212	139	red	475		102	150.600	Y	Y
66	5-Oct-20	WCT	West Alex	663841	5516473	206	100	red	472		106	150.600	Y	Y
67	5-Oct-20	WCT	West Alex	663841	5516473	200	101	red	471		96	150.600	Y	Y
68	6-Oct-20	WCT	West Alex	663344	5516899	248	183	red	470		100	150.600	Y	Y

[a] RB = Rainbow Trout, WCT = Westslope Cutthroat Trout, MW = Mountain Whitefish, BT = Bull Trout.

Continued…

Table A2: Concluded.

Fish No.	Date	Species[a]	Capture Loc.	Capture UTMs (11U)		Length (mm)	Weight (g)	Floy Tag		PIT Applied	Radio Tag		Scales	Fin Ray
				Easting	Northing			Colour	No.		ID	Freq. (MHz)		
69	6-Oct-20	WCT	West Alex	663344	5516899	233	140	red	469		99	150.600	Y	Y
70	6-Oct-20	WCT	West Alex	663036	5517553	217	117	red	468		105	150.600	Y	Y
71	6-Oct-20	WCT	West Alex	663036	5517553	223	142	red	467		101	150.600	Y	Y
72	7-Oct-20	WCT	Upper Alex	664363	5516675	188	79			989001006084792			Y	Y
73	7-Oct-20	WCT	Upper Alex	664363	5516675	204	111	red	466		98	150.600	Y	Y
74	7-Oct-20	BT	Upper Alex	664406	5516813	203	84			989001006084773				Y
75	7-Oct-20	BT	Upper Alex	664397	5516854	205	83			989001006084720				Y
76	7-Oct-20	BT	Upper Alex	664397	5516854	206	89			989001006084707				Y
77	7-Oct-20	WCT	Upper Alex	664410	5516910	181	67			989001006084708			Y	Y
78	7-Oct-20	WCT	Upper Alex	664410	5516910	178	67			989001006084740			Y	Y
79	7-Oct-20	WCT	Upper Alex	664397	5516854	299	379	red	465		1	150.340	Y	Y
80	7-Oct-20	WCT	Upper Alex	664397	5516854	214	125	red	464		97	150.600	Y	Y
81	7-Oct-20	WCT	Upper Alex	664410	5516910	287	293	red	463		20	150.340	Y	Y
82	7-Oct-20	WCT	Upper Alex	664410	5516910	254	237	red	462		8	150.340	Y	Y
83	7-Oct-20	WCT	Upper Alex	664410	5516910	218	150	red	461		92	150.600	Y	Y

[a] RB = Rainbow Trout, WCT = Westslope Cutthroat Trout, MW = Mountain Whitefish, BT = Bull Trout.

Appendix III - Snorkeling Survey Data

Table A3: **Fish observed (in 10 cm fork length bins) during snorkel surveys in Alexander and West Alexander creeks, August 30 to September 3, 2020.**

Date	Time	UTMs (Zone 11U)		Number of WCT Observed[a]						Comments/Notes[a]
		Easting	Northing	< 10	10-20	20-30	30-40	40-50	w/ Floy	
Upper Alexander Creek:										
30-Aug-20	10:36	664757	5519867							U/S End Of Snorkel
30-Aug-20	10:55	664778	5519702							Eroded Bank And Alluvial Aggraded Lens
30-Aug-20	11:05	664785	5519661							LWD Jam
30-Aug-20	11:13	664793	5519609							Cascade With Wide Wbf
30-Aug-20	11:40	664793	5519375							
30-Aug-20	11:59	664773	5519249							
30-Aug-20	12:23	664761	5518888							BT 20-30
30-Aug-20	12:30	664764	5518802							LWD Jam
30-Aug-20	12:47	664711	5518607							Old Road Crossing
30-Aug-20	12:54	664735	5518627							
30-Aug-20	12:55	664743	5518567		1					
30-Aug-20	13:43	664686	5517828		1					
30-Aug-20	13:48	664675	5517782							BT 10-20
30-Aug-20	14:00	664699	5517683			1				
30-Aug-20	14:09	664698	5517524		1					
30-Aug-20	14:51	664675	5517202							Massive Groundwater Source
30-Aug-20	15:12	664632	5517177							Aug 30 15:20 End
30-Aug-20	15:14	664548	5517086							Groundwater Input
31-Aug-20	09:30	664380	5516727							Start 31 August 2020
31-Aug-20	09:49	664357	5516679							Snorkeling photos
31-Aug-20	09:53	664357	5516662							BT 10-20
31-Aug-20	10:07	664369	5516628			1				
31-Aug-20	10:16	664382	5516602		1					
31-Aug-20	10:19	664372	5516592			1				
31-Aug-20	10:43	664382	5516587			1				
31-Aug-20	11:44	664367	5516191							BT 10-20
31-Aug-20	11:57	664369	5516169							Nice pool
31-Aug-20	12:59	664392	5515600			1				
			Upper Alexander Subtotal	**0**	**4**	**5**	**0**	**0**	**0**	**Section length: 4.8 km**
West Alexander Creek:										
31-Aug-20	10:40	663664	5516757							GW Well
31-Aug-20	11:12	663031	5517573		1					
31-Aug-20	11:21	662882	5517751		2					
31-Aug-20	11:25	662843	5518126							Snorkel Start
31-Aug-20	11:25	662879	5517719		1				1	
31-Aug-20	11:31	662879	5517719		1					
31-Aug-20	11:36	662965	5517628	2	2					

31-Aug-20	11:47	662975	5517621							
31-Aug-20	11:48	662980	5517624							Radio tag heard but fish not observed
31-Aug-20	12:07	663093	5517447		1				1	radio tagged WCT observed
31-Aug-20	12:09	663094	5517448		2				1	
31-Aug-20	12:17	663140	5517296		1	1				
31-Aug-20	12:24	663194	5517132		2					
31-Aug-20	12:25	663284	5517262							Seepage
31-Aug-20	12:26	663174	5517132			1				
31-Aug-20	12:33	663334	5516940		1	1				
31-Aug-20	12:35	663334	5516909		1					
31-Aug-20	12:37	663346	5516890		3	2			1	
3-Sep-20	11:48	663571	5516718		1					
3-Sep-20	11:53	663610	5516637		1					
3-Sep-20	11:57	663653	5516672		1	1			1	
3-Sep-20	12:08	663776	5516524		2				1	
3-Sep-20	12:15	663860	5516441	1						
3-Sep-20	12:18	663883	5516437		1	1				
3-Sep-20	12:21	663959	5516445		1					
3-Sep-20	12:23	663935	5516413		1					
3-Sep-20	12:27	663951	5516339		1					
3-Sep-20	12:37	663996	5516192			1				
3-Sep-20	12:38	664016	5516183							Staff gauge 0.235
3-Sep-20	12:48	664091	5515934		1					
3-Sep-20	12:53	664141	5515777		2					
			West Alexander Subtotal	**3**	**30**	**8**	**0**	**0**	**6**	**Section length: 2.9 km**

[a] WCT = Westslope Cutthroat Trout, BT = Bull Trout, EB = Eastern Brook Trout.

Continued…

Table A3: Continued.

Date	Time	UTMs (Zone 11U)		Number of WCT Observed[a]						Comments/Notes[a]
		Easting	Northing	< 10	10-20	20-30	30-40	40-50	w/ Floy	
Middle Alexander Creek:										
31-Aug-20	13:54	664384	5514768							Habitat example (photo)
31-Aug-20	14:37	664599	5514111							BT 10-20
31-Aug-20	15:25	664518	5513281							Possible spawning gravel
31-Aug-20	15:27	664526	5513280							Possible spawning gravel
31-Aug-20	15:37	664473	5513023							Nice pool
31-Aug-20	15:45	664441	5513010			1				WCT 20-30
31-Aug-20	15:49	664464	5512965							End 31 August 2020
1-Sep-20	08:54	664474	5512932							1 September 2020 start
1-Sep-20	11:01	664837	5512047							BT 80-100 (male), BT 60-80 (female), spawning pair
1-Sep-20	11:58	664912	5511439			2				2 WCT 20-30

1-Sep-20	12:04	664910	5511409							BT 10-20
1-Sep-20	12:21	664965	5511152			1				WCT 20-30
1-Sep-20	13:01	664908	5510191							BT 60-70 Developing spawning colours
1-Sep-20	13:12	664895	5510103							BT 40-50
1-Sep-20	13:24	664874	5509916							BT 50-60
1-Sep-20	13:29	664889	5509874			1				WCT 20-30
1-Sep-20	13:36	664949	5509761							EB 10-20
1-Sep-20	13:43	664942	5509737							EB 10-20, EB 20-30
1-Sep-20	13:53	664918	5509651			1				WCT 10-20
1-Sep-20	14:22	665010	5509437							BT 50-60
1-Sep-20	14:26	665006	5509407							BT 60-70
1-Sep-20	14:30	664995	5509418							BT 60-70
1-Sep-20	14:35	664965	5509392							Possible spawning gravel
1-Sep-20	14:48	664991	5509335		4	2				4 WCT 10-20 2 WCT 20-30
1-Sep-20	14:58	664969	5508977							1 September 2020 end
1-Sep-20	10:03	665024	5508920			1				
1-Sep-20	10:07	665018	5508906		1	1				
1-Sep-20	10:13	664996	5508891				1			2 BT 40-50, spawning pair
1-Sep-20	10:22	665010	5508775		1	1				
1-Sep-20	10:28	665050	5508775			2				
1-Sep-20	10:35	665063	5508774		2	3	2			
1-Sep-20	10:41	665086	5508679		1					
1-Sep-20	10:47	665091	5508664		1					
1-Sep-20	10:50	665090	5508660			1				
1-Sep-20	10:51	665097	5508622			1				
1-Sep-20	10:51	665097	5508623			1				
1-Sep-20	10:58	665113	5508618		1	1				EB 10-20
1-Sep-20	11:06	665183	5508536		1					
1-Sep-20	11:09	665179	5508498			1				EB 10-20
1-Sep-20	11:12	665165	5508516			1				EB 10-20
1-Sep-20	11:32	665153	5508434		1					
1-Sep-20	11:44	665160	5508351		1	1				
1-Sep-20	11:47	665160	5508351		1					
1-Sep-20	11:52	665180	5508084				1			
1-Sep-20	11:57	665152	5508090			1	1			
1-Sep-20	11:58	665106	5508020			1	1			
1-Sep-20	12:11	665104	5508023			1				
1-Sep-20	12:15	665072	5507703		1					
1-Sep-20	12:18	665017	5507674							Game trail
1-Sep-20	12:23	665017	5507674							Concretion
1-Sep-20	12:25	664930	5507581			1				
1-Sep-20	12:28	664927	5507541			1				
1-Sep-20	12:56	664640	5507259					1		
1-Sep-20	12:59	664678	5507256			1	1			
1-Sep-20	13:08	664672	5507135							EB 10-20
1-Sep-20	13:08	664661	5507138							EB 10-20
1-Sep-20	13:27	664652	5506759			1				
1-Sep-20	13:35	664816	5506595			1				

1-Sep-20	13:47	664815	5506517			1				
1-Sep-20	14:02	664707	5506333			1				
1-Sep-20	14:22	664657	5505859			1		1		4 EB 10-20, EB 20-30
1-Sep-20	14:30	664551	5505789	1	2	1				
1-Sep-20	14:42	664433	5505645		1					3 EB 10-20
			Middle Alexander Subtotal	**1**	**19**	**35**	**7**	**2**	**0**	**Section length: 10 km**

[a] WCT = Westslope Cutthroat Trout, BT = Bull Trout, EB = Eastern Brook Trout.

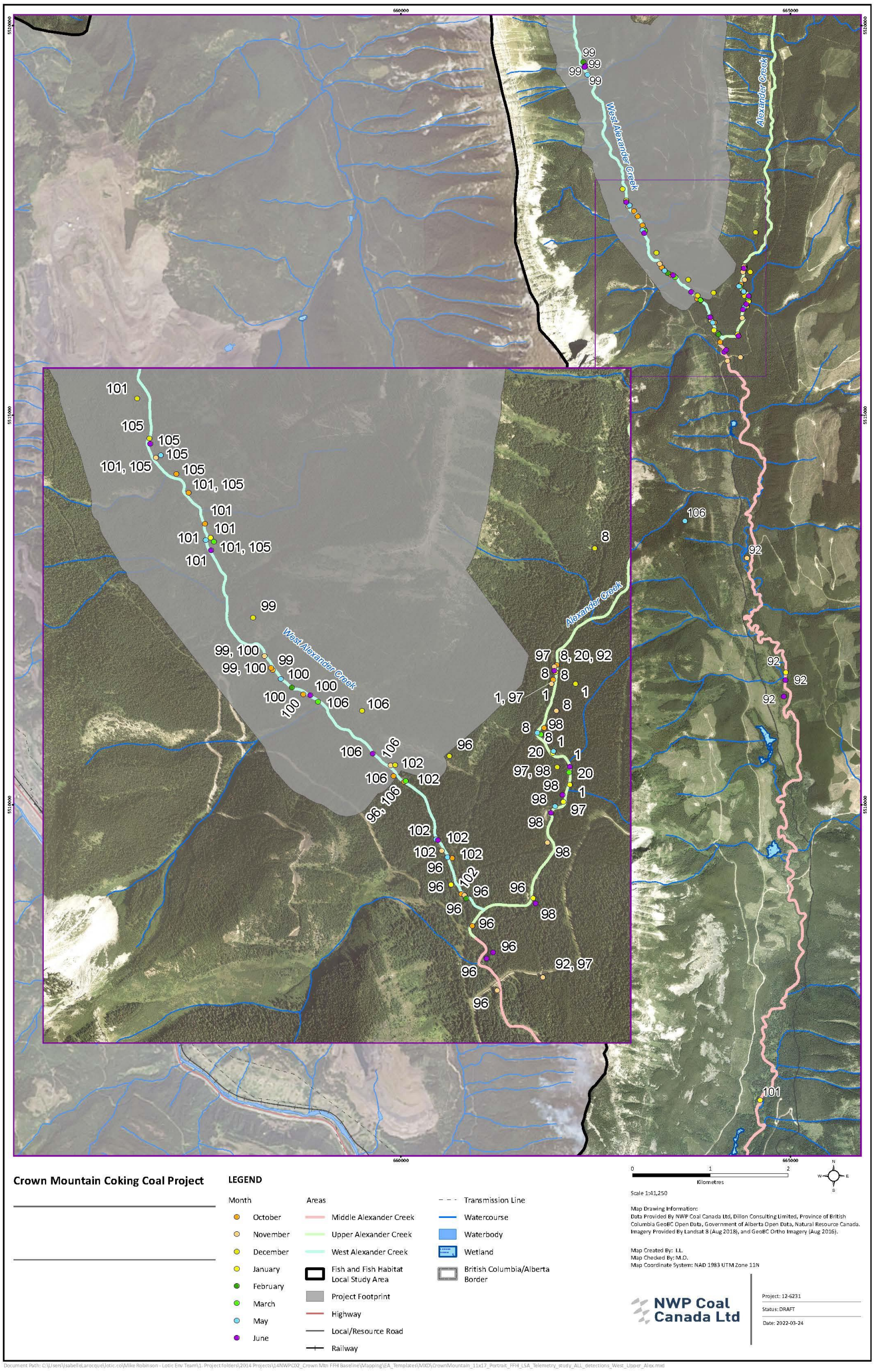
Continued…

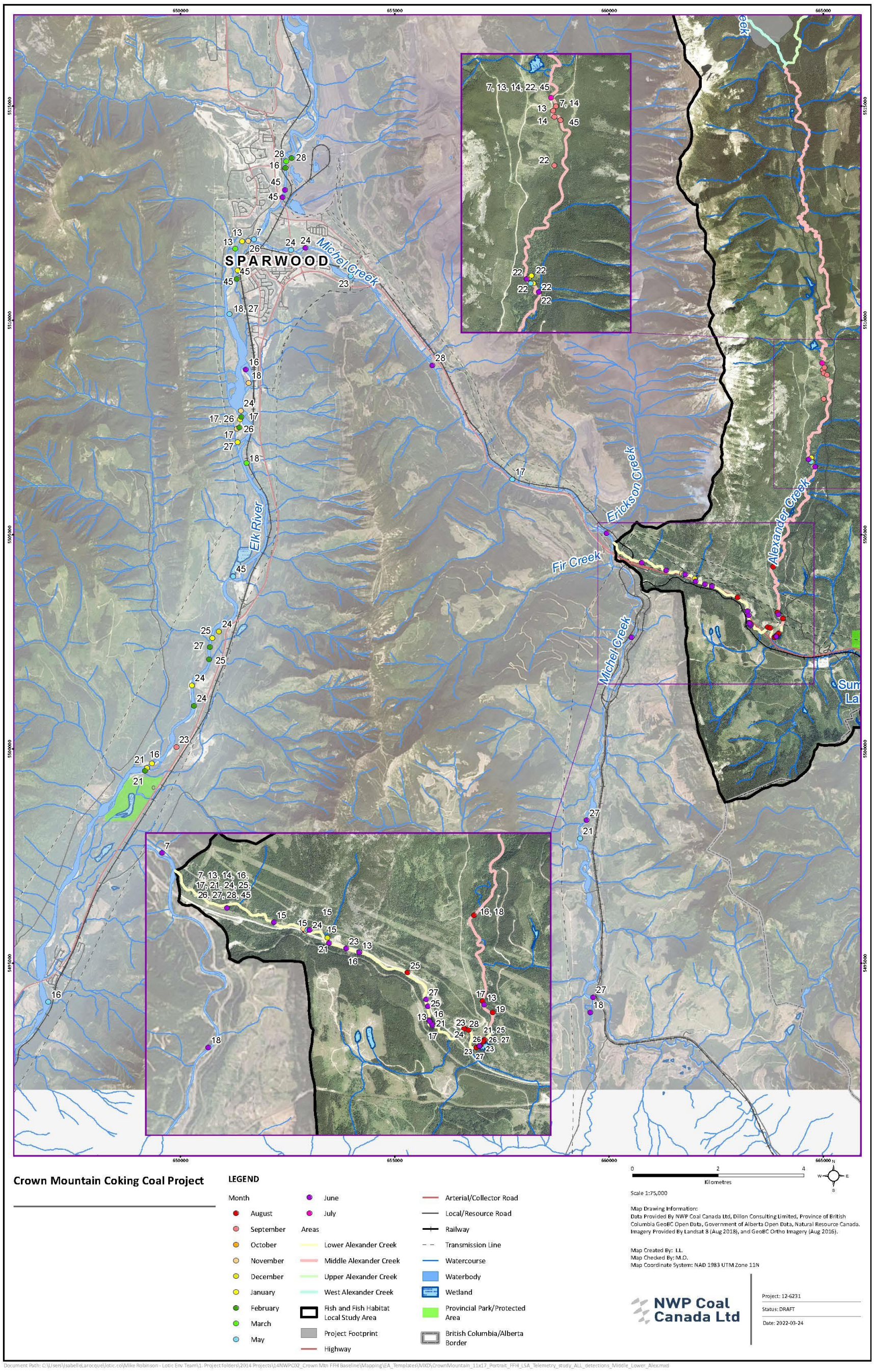
Table A3: Concluded.

Date	Time	UTMs (Zone 11U)		Number of WCT Observed[a]						Comments/Notes[a]
		Easting	Northing	< 10	10-20	20-30	30-40	40-50	w/ Floy	
Lower Alexander Creek:										
2-Sep-20	09:32	664203	5505387							Start
2-Sep-20	09:41	664143	5505202			1				
2-Sep-20	09:46	664180	5505122			1				
2-Sep-20	09:49	664180	5505020			1				
2-Sep-20	10:04	664030	5504820				1			
2-Sep-20	10:07	663646	5504767			8	5		1	
2-Sep-20	10:11	664006	5504803							Blue pin should be here
2-Sep-20	10:52	663951	5503907				1			Bedrock pool
2-Sep-20	10:59	663890	5503820				1			
2-Sep-20	11:03	663848	5503734							Power lines lots of noise on 150.340
2-Sep-20	11:16	663936	5503614			1				
2-Sep-20	11:36	663944	5503444				1			
2-Sep-20	11:36	663943	5503440				1			
2-Sep-20	14:27	663932	5503173			2	2		1	
2-Sep-20	14:35	664012	5503080			1				
2-Sep-20	14:37	664068	5503021				2	1	2	
2-Sep-20	14:47	664011	5502807				1		1	
2-Sep-20	14:48	664015	5502803			1				
2-Sep-20	14:50	664019	5502795				1			
2-Sep-20	14:51	664023	5502751			1				
2-Sep-20	14:55	663951	5502709				1	1	1	
2-Sep-20	14:58	663926	5502672				1			
2-Sep-20	15:05	663834	5502612				1		1	
			Lower Alexander Subtotal	**0**	**0**	**17**	**19**	**2**	**7**	**Section length: 3.4 km**
			All Sections Total	**4**	**53**	**65**	**26**	**4**	**13**	**Total length surveyed: 21.1 km**

[a] WCT = Westslope Cutthroat Trout, BT = Bull Trout, EB = Eastern Brook Trout.

Appendix IV – Fish tracking Maps




650000
655000
660000
665000
5515000
5510000
5505000
5500000
5495000
SPARWOOD
Michel Creek
Elk River
Erickson Creek
Fir Creek
Alexander Creek
Michel Creek
Crown Mountain Coking Coal Project
LEGEND
Month
August
September
October
November
December
January
February
March
May
June
July
Areas
Lower Alexander Creek
Middle Alexander Creek
Upper Alexander Creek
West Alexander Creek
Fish and Fish Habitat Local Study Area
Project Footprint
Highway
Arterial/Collector Road
Local/Resource Road
Railway
Transmission Line
Watercourse
Waterbody
Wetland
Provincial Park/Protected Area
British Columbia/Alberta Border
0
2
4
Kilometres
Scale 1:75,000
Map Drawing Information:
Data Provided By NWP Coal Canada Ltd, Dillon Consulting Limited, Province of British Columbia GeoBC Open Data, Government of Alberta Open Data, Natural Resource Canada.
Imagery Provided By Landsat 8 (Aug 2018), and GeoBC Ortho Imagery (Aug 2016).
Map Created By: I.L.
Map Checked By: M.O.
Map Coordinate System: NAD 1983 UTM Zone 11N
NWP Coal Canada Ltd
Project: 12-6231
Status: DRAFT
Date: 2022-03-24
Document Path: C:\Users\IsabelleLarocque\lotic.co\Mike Robinson - Lotic Env Team\1. Project folders\2014 Projects\14NWPC02_Crown Mtn FFH Baseline\Mapping\EA_Templates\MXD\CrownMountain_11x17_Portrait_FFH_LSA_Telemetry_study_ALL_detections_Middle_Lower_Alex.mxd