Subject Matter Expert Report: CHANNEL DEWATERING. Evaluation of Cause – Decline in Upper Fording River Westslope Cutthroat Trout Population

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EXECUTIVE SUMMARY

Abundances of both juvenile and adult life stages of Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*; WCT) in the upper Fording River (UFR) were substantively lower in 2019 than 2017, indicating a large decline during that two-year period (the Westslope Cutthroat Trout Population Decline Window, also referred to as the Decline Window). Teck Coal Limited (Teck Coal) initiated the "Evaluation of Cause" (EoC) to determine whether and to what extent various stressors and conditions played a role in the decline. One of several potential stressors identified is the dewatering of habitat in channels that are operationally influenced and connected to the UFR; such dewatering could cause stranding and potential mortality of fish. This report investigates if, and to what extent, dewatering of channels contributed to the WCT decline. Dewatering of channels could cause, or contribute to, reduced WCT abundance if stranding increased mortality during the Decline Window. Mortality may occur if fish are present in the channel and if habitat in the channel is sensitive to stranding.

The impact hypothesis evaluated was:

- Did dewatering of operationally influenced channels cause or contribute to the observed WCT population decline?

We investigated the potential role of channel dewatering and fish stranding by first identifying channels with the potential for operational influence. Fifteen channels of interest were identified based on the potential for flow changes from water use at Fording River Operations (FRO), Greenhills Operations (GHO), and Line Creek Operations (LCO). An additional four channels were identified that are proximate to FRO facilities, have no surface connection to a settling pond decant but have groundwater feeding the channels that may be influenced by FRO settling ponds. The lower portion of the Fording River Side Channel was also included in the assessment because it is operationally influenced when there is flow in the Kilmarnock Phase 1 Discharge Channel. Twenty channels were evaluated in total.

Using a three-step process, we assessed each of the channels for potential to strand fish. First (Step 1), we assessed fish presence. Based on available reports, habitat data, and client communications, each channel was classified as having fish present (fish could have accessed all or a portion of the channel) or not present (fish barrier prevents fish access). If fish were assessed to be present, we then (Step 2) assessed habitat quality and quantity, and the sensitivity of habitat to stranding. Habitat quality was assessed from fish habitat assessment procedure (FHAP) results and was rated as poor, fair, or good based on channel characteristics and professional judgement. Sensitivity of habitat to stranding was qualitatively rated based on Fisheries and Oceans Canada (DFO) ramping guidelines developed for stranding sensitive habitat and FHAP results, and was ranked as low, moderate, or high. Habitat quantity was also determined from FHAP, existing data, or ortho imagery, and a proportion relative to total habitat in the UFR was calculated. Last (Step 3), the potential for a dewatering event was evaluated for each channel by year by assessing if there was a cessation of flow (determined mostly from spot measurements and sometimes from continuous data from hydrometric gauges).

Classifications of fish presence, habitat quality, sensitivity of habitat to stranding, and potential for a dewatering event were then used to classify the overall potential stranding risk to fish from dewatering (low, moderate, high, or unknown) of each channel by year. After all identified channels had been assessed for stranding risk and dewatering potential, we evaluated requisite conditions (conditions that would need to be true if channel dewatering was responsible for some or all of the observed WCT decline) of Spatial Extent, Duration, Location, Timing, and Intensity of dewatering events.

Of the twenty channels evaluated, fourteen were accessible to fish. Among these, potential stranding risk for fish was assessed as high in three channels (Kilmarnock Phase 1 Discharge Channel, Fording River Side Channel, and Kilmarnock Phase 2 Discharge Channel) in at least one year during the Decline Window based on habitat quality and sensitivity to stranding and evidence of dewatering. However, the proportion of habitat accessible to fish in these three channels was low relative to total habitat available in the UFR (0.91% of the total habitat available). Thus, although some requisite conditions (Intensity, Location, and Timing) were met for three of twenty channels, the requisite condition for Spatial Extent was not met because the proportion of habitat that is accessible to fish in these channels is small. Further, potential stranding risk was also documented as high during the historical period (2011-2016) for some channels, using the same methods and assumptions. Thus, there is no strong evidence that stranding conditions were notably different during the Decline Window than in previous years. We therefore conclude that this pathway is not a primary cause of the decline.

Several uncertainties were identified in relation to this assessment. In particular, limitations of the hydrological data (e.g., spot measurements are less likely to capture short-duration flow events) prevented detailed evaluation of some factors relating to mortality risk to fish, such as duration of dewatering events, rate of flow changes, and wetted history; these limitations also affected our ability to compare some of the dewatering events during the Decline Window to those during the historical period. In addition, data on site-specific habitat characteristics were not available to ascertain the flows required to sustain fish. Assumptions were therefore made that any flow (i.e., > 0 m^3/s) will sustain fish and that a cessation of flow (i.e., 0 m^3/s) would cause stranding of fish; neither assumption is expected to always be true. Differences in stranding risk by fish age class or age classes likely present could also not be considered given available data. Additional uncertainties noted include: potential stranding risk did not consider flow in the UFR, which can affect stranding risk in channels; spatial variability in the sensitivity of habitat to stranding within channels was not captured in the assessment; the spatial distribution of the WCT population within accessible habitat was not considered in the assessment; and some channels classified as not accessible to fish could possibly be accessed by fish at extreme flow levels.

Given that all requisite conditions were not met, the assessment concluded that the channel dewatering stressor did not cause the WCT population decline. However, a high potential stranding risk was identified for a low proportion of the fish-accessible habitat in channels during the Decline Window; thus, requisite conditions for channel dewatering contributing to the WCT population decline were met. This conclusion is supported by knowledge of the 2018 fish stranding event that occurred in the

Kilmarnock Phase 1 Discharge Channel and Fording River Side Channel (a total of 1095 WCT isolated or stranded). The channel dewatering stressor may interact with other stressors in the EoC, such as ramping or stranding in the UFR mainstem.

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ACRONYMNS AND ABBREVIATIONS

DFO - Fisheries and Oceans Canada

EoC – Evaluation of Cause

FHAP - Fish Habitat Assessment Procedure

FRO – Fording River Operations

GHO – Greenhills Operations

HDPE - High Density Polyethylene

SME – Subject Matter Expert

UFR – Upper Fording River

WCT – Westslope Cutthroat Trout

READER'S NOTE

What is the Evaluation of Cause and what is its purpose?

The Evaluation of Cause is the process used to investigate, evaluate and report on the reasons the Westslope Cutthroat Trout population declined in the upper Fording River between fall 2017 and fall 2019.

Background

The Elk Valley is located in the southeast corner of British Columbia (BC), Canada. It contains the main stem of the Elk River (220 km long) and many tributaries, including the Fording River (70 km long). This report focuses on the upper Fording River, which starts 20 km upstream from its confluence with the Elk River at Josephine Falls. The Ktunaxa First Nation has occupied lands in the region for more than 10,000 years. Rivers and streams of the region provide culturally important sources of fish and plants.

The upper Fording River watershed is at a high elevation and is occupied by only one fish species, a genetically pure population of Westslope Cutthroat Trout *(Oncorhynchus clarkii lewisi)* — an iconic fish species that is highly valued in the area. This population is physically isolated because Josephine Falls is a natural barrier to fish movement. The species is protected under the federal Fisheries Act and the Species at Risk Act. In BC, the Conservation Data Center categorized Westslope Cutthroat Trout as "*imperiled or of special concern, vulnerable to extirpation or extinction.*" Finally, it has been identified as a priority sport fish species by the Province of BC.

The upper Fording River watershed is influenced by various human-caused disturbances including roads, a railway, a natural gas pipeline, forest harvesting and coal mining. Teck Coal Limited (Teck Coal) operates the three surface coal mines within the upper Fording River

Evaluation of Cause

Following identification of the decline in the Westslope Cutthroat Trout population, Teck Coal initiated an Evaluation of Cause process. The overall results of this process are reported in a separate document (Evaluation of Cause Team, 2021) and are supported by a series of Subject Matter Expert reports.

The report that follows this Reader's Note is one of those Subject Matter Expert Reports.

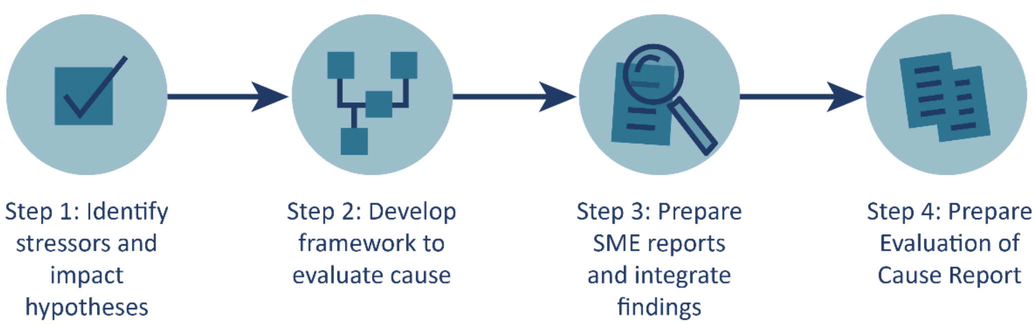
watershed, upstream of Josephine Falls: Fording River Operations, Greenhills Operations and Line Creek Operations.

Monitoring conducted for Teck Coal in the fall of 2019 found that the abundance of Westslope Cutthroat Trout adults and sub-adults in the upper Fording River had declined significantly since previous sampling in fall 2017. In addition, there was evidence that juvenile fish density had decreased. Teck Coal initiated an *Evaluation of Cause* process. The overall results of this process are reported separately (Evaluation of Cause Team, 2021) and are supported by a series of Subject Matter Expert reports such as this one. The full list of SME reports follows at the end of this Reader's Note.

Building on and in addition to the Evaluation of Cause, there are ongoing efforts to support fish population recovery and implement environmental improvements in the upper Fording River.

How the Evaluation of Cause was approached

When the fish decline was identified, Teck Coal established an *Evaluation of Cause Team* (the Team), composed of *Subject Matter Experts* and coordinated by an Evaluation of Cause *Team Lead.* Further details about the Team are provided in the Evaluation of Cause report. The Team developed a systematic and objective approach (see figure below) that included developing a Framework for Subject Matter Experts to apply in their specific work. All work was subjected to rigorous peer review.



Conceptual approach to the Evaluation of Cause for the decline in the upper Fording River Westslope Cutthroat Trout population.

With input from representatives of various regulatory agencies and the Ktunaxa Nation Council, the Team initially identified potential stressors and impact hypotheses that might explain the cause(s) of the population decline. Two overarching hypotheses (essentially, questions for the Team to evaluate) were used:

- Overarching Hypothesis #1: The significant decline in the upper Fording River Westslope Cutthroat Trout population was a result of a single acute stressor[1] or a single chronic stressor[2].
- Overarching Hypothesis #2: The significant decline in the upper Fording River Westslope Cutthroat Trout population was a result of a combination of acute and/or chronic stressors, which individually may not account for reduced fish numbers, but cumulatively caused the decline.

The Evaluation of Cause examined numerous stressors in the UFR to determine if and to what extent those stressors and various conditions played a role in the Westslope Cutthroat Trout's decline. Given that the purpose was to evaluate the cause of the decline in abundance from 2017 to 2019[3], it was important to identify stressors or conditions that changed or were different during that period. It was equally important to identify the potential stressors or conditions that did not change during the decline window but may, nevertheless, have been important constraints on the population with respect to their ability to respond to or recover from the stressors. Finally, interactions between stressors and conditions had to be considered in an integrated fashion. Where an *impact hypothesis* depended on or may have been exacerbated by interactions among stressors or conditions, the interaction mechanisms were also considered.

The Evaluation of Cause process produced two types of deliverables:

1. **Individual Subject Matter Expert (SME) reports** (such as the one that follows this Note): These reports mostly focus on impact hypotheses under Overarching Hypothesis #1 (see list, following). A Framework was used to align SME work for all the potential stressors, and, for consistency, most SME reports have the same overall format. The format covers: (1) rationale for impact hypotheses, (2) methods, (3) analysis and (4) findings, particularly

[1] Implies September 2017 to September 2019.

[2] Implies a chronic, slow change in the stressor (using 2012–2019 timeframe, data dependent).

[3] Abundance estimates for adults/sub-adults are based on surveys in September of each year, while estimates for juveniles are based on surveys in August.

whether the requisite conditions[4] were met for the stressor(s) to be the sole cause of the fish population decline, or a contributor to it. In addition to the report, each SME provided a summary table of findings, generated according to the Framework. These summaries were used to integrate information for the Evaluation of Cause report. Note that some SME reports did not investigate specific stressors; instead, they evaluated other information considered potentially useful for supporting SME reports and the overall Evaluation of Cause, or added context (such as in the SME report that describes climate (Wright et al., 2021).

2. **The Evaluation of Cause report** (prepared by a subset of the Team, with input from SMEs): This overall report summarizes the findings of the SME reports and further considers interactions between stressors (Overarching Hypothesis #2). It describes the reasons that most likely account for the decline in the Westslope Cutthroat Trout population in the upper Fording River.

Participation, Engagement & Transparency

To support transparency, the Team engaged frequently throughout the Evaluation of Cause process. Participants in the Evaluation of Cause process, through various committees, included:

Ktunaxa Nation Council

BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development

BC Ministry Environment & Climate Change Strategy

Ministry of Energy, Mines and Low Carbon Innovation

Environmental Assessment Office

[4] These are the conditions that would need to have occurred for the impact hypothesis to have resulted in the observed decline of Westslope Cutthroat Trout population in the upper Fording River.

Citation for the Evaluation of Cause Report

When citing the Evaluation of Cause Report use:

Evaluation of Cause Team, (2021). *Evaluation of Cause — Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited by Evaluation of Cause Team.

Citations for Subject Matter Expert Reports

Focus	Citation for Subject Matter Expert Reports
Climate, temperature, and streamflow	Wright, N., Greenacre, D., & Hatfield, T. (2021). *Subject Matter Expert Report: Climate, Water Temperature, Streamflow and Water Use Trends. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Ecofish Research Ltd.
Ice	Hatfield, T., & Whelan, C. (2021). *Subject Matter Expert Report: Ice. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Ltd. Report Prepared by Ecofish Research Ltd.
Habitat availability (instream flow)	Healey, K., Little, P., & Hatfield, T. (2021). *Subject Matter Expert Report: Habitat availability. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited by Ecofish Research Ltd.
Stranding – ramping	Faulkner, S., Carter, J., Sparling, M., Hatfield, T., & Nicholl, S. (2021). *Subject Matter Expert Report: Ramping and stranding. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited by Ecofish Research Ltd.

Focus	Citation for Subject Matter Expert Reports
Stranding – channel dewatering	Hatfield, T., Ammerlaan, J., Regehr, H., Carter, J., & Faulkner, S. (2021). *Subject Matter Expert Report: Channel dewatering. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited by Ecofish Research Ltd.
Stranding – mainstem dewatering	Hocking M., Ammerlaan, J., Healey, K., Akaoka, K., & Hatfield T. (2021). *Subject Matter Expert Report: Mainstem dewatering. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Ltd. by Ecofish Research Ltd. and Lotic Environmental Ltd. Zathey, N., & Robinson, M.D. (2021). *Summary of ephemeral conditions in the upper Fording River Watershed. In Hocking et al. (2021). Subject Matter Expert Report: Mainstem dewatering. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Ltd. by Ecofish Research Ltd. and Lotic Environmental Ltd.
Calcite	Hocking, M., Tamminga, A., Arnett, T., Robinson M., Larratt, H., & Hatfield, T. (2021). *Subject Matter Expert Report: Calcite. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Ltd. by Ecofish Research Ltd., Lotic Environmental Ltd., and Larratt Aquatic Consulting Ltd.
Total suspended solids	Durston, D., Greenacre, D., Ganshorn, K & Hatfield, T. (2021). *Subject Matter Expert Report: Total suspended solids. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Ecofish Research Ltd.
Fish passage (habitat connectivity)	Harwood, A., Suzanne, C., Whelan, C., & Hatfield, T. (2021). *Subject Matter Expert Report: Fish passage. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Ltd. by Ecofish Research Ltd. Akaoka, K., & Hatfield, T. (2021). Telemetry Movement Analysis. In Harwood et al. (2021). *Subject Matter Expert Report: Fish passage. Evaluation of Cause – Decline in upper*

Focus	Citation for Subject Matter Expert Reports
	Fording River Westslope Cutthroat Trout population. Report prepared for Teck Coal Ltd. by Ecofish Research Ltd.
Cyanobacteria Algae / macrophytes	Larratt, H., & Self, J. (2021). *Subject Matter Expert Report: Cyanobacteria, periphyton and aquatic macrophytes. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Larratt Aquatic Consulting Ltd.
Water quality (all parameters except water temperature and TSS [Ecofish])	Costa, EJ., & de Bruyn, A. (2021). *Subject Matter Expert Report: Water quality. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Golder Associates Ltd. Healey, K., & Hatfield, T. (2021). *Calculator to assess Potential for cryoconcentration in upper Fording River.* In Costa, EJ., & de Bruyn, A. (2021). *Subject Matter Expert Report: Water quality. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Golder Associates Ltd.
Industrial chemicals, spills and unauthorized releases	Van Geest, J., Hart, V., Costa, EJ., & de Bruyn, A. (2021). *Subject Matter Expert Report: Industrial chemicals, spills and unauthorized releases. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Golder Associates Ltd. Branton, M., & Power, B. (2021). *Stressor Evaluation – Sewage.* In Van Geest et al. (2021). *Industrial chemicals, spills and unauthorized releases. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Golder Associates Ltd.
Wildlife predators	Dean, D. (2021). *Subject Matter Expert Report: Wildlife predation. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by VAST Resource Solutions Inc.

Focus	Citation for Subject Matter Expert Reports
Poaching	Dean, D. (2021). *Subject Matter Expert Report: Poaching. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by VAST Resource Solutions Inc.
Food availability	Orr, P., & Ings, J. (2021). *Subject Matter Expert Report: Food availability. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Minnow Environmental Inc.
Fish handling	Cope, S. (2020). *Subject Matter Expert Report: Fish handling. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Westslope Fisheries Ltd.
	Korman, J., & Branton, M. (2021). *Effects of capture and handling on Westslope Cutthroat Trout in the upper Fording River: A brief review of Cope (2020) and additional calculations.* Report prepared for Teck Coal Limited. Prepared by Ecometric Research and Azimuth Consulting Group.
Infectious disease	Bollinger, T. (2021). *Subject Matter Expert Report: Infectious disease. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by TKB Ecosystem Health Services Ltd.
Pathophysiology	Bollinger, T. (2021). *Subject Matter Expert Report: Pathophysiology of stressors on fish. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by TKB Ecosystem Health Services Ltd.
Coal dust and sediment quality	DiMauro, M., Branton, M., & Franz, E. (2021). *Subject Matter Expert Report: Coal dust and sediment quality. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Azimuth Consulting Group Inc.

Focus	Citation for Subject Matter Expert Reports
Groundwater quality and quantity	Henry, C., & Humphries, S. (2021). *Subject Matter Expert Report: Hydrogeological stressors. Evaluation of Cause - Decline in upper Fording River Westslope Cutthroat Trout population.* Report Prepared for Teck Coal Limited. Prepared by SNC-Lavalin Inc.

1. INTRODUCTION

Abundances of adult and juvenile life stages of Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) (WCT) in the Upper Fording River (UFR) have been estimated since 2012 using high-effort snorkel and electrofishing surveys, supported by radio-telemetry and redd surveys (Cope *et al.* 2016). Annual snorkel and electrofishing surveys were conducted in the autumns of 2012-2014, 2017, and 2019. Abundances of both juvenile and adult life stages were substantively lower in 2019 than 2017, indicating a large decline during the two-year period between September 2017 and September 2019 (Westslope Cutthroat Trout Population Decline Window, hereafter referred to as Decline Window; Cope 2020). The magnitude of the decline as well as refinements in the timing of decline are reviewed in detail by Cope (2020) and Evaluation of Cause Team (2021).

Teck Coal Limited (Teck Coal) initiated the "Evaluation of Cause" (EoC) to assess factors responsible for the population decline. The EoC evaluates numerous impact hypotheses to determine whether and to what extent various stressors and conditions played a role in the decline of WCT. Given that the primary objective is to evaluate the cause of the sudden decline over a short time period (from 2017 to 2019), it is important to identify stressors or conditions that changed or were different during the Decline Window relative to previous years. However, it is equally important to identify all potential stressors or conditions that did not change during the Decline Window but nevertheless may be important constraints on the population. Finally, interactions among stressors are also considered in the EoC. Where an impact hypothesis depends on interactions among stressors or conditions, or where the impact may be exacerbated by particular interactions, the mechanisms of interaction are considered as part of the evaluation of specific impact hypotheses.

A project team is evaluating the cause of WCT decline in abundance and is investigating two "Over-arching" Hypotheses:

- Over-arching Hypothesis #1: The significant decline in the UFR WCT population was a result of a single acute stressor[5] or a single chronic stressor[6].
- Over-arching Hypothesis #2: The significant decline in the UFR WCT population was a result of a combination of acute and/or chronic stressors, which individually may not account for reduced WCT numbers, but cumulatively caused the decline.

This report investigates dewatering of operationally influenced channels that drain into the UFR; dewatering can cause stranding and subsequent mortality of fish, and therefore may have been a stressor on WCT in the UFR during the Decline Window. As described below, other SME reports evaluate potential risk to fish from stranding within the UFR mainstem and side channels.

[5] Implies the single acute stressor acted between September 2017 and September 2019.

[6] Implies a chronic slow change in the stressor (using 2011-2019 timeframe, data dependent).

1.1. Background

1.1.1. Overall Background

This document is one of a series of SME reports that supports the overall EoC of the UFR WCT population decline (Evaluation of Cause Team 2021). For general information, see the preceding Reader's Note.

1.1.2. Report-Specific Background

Dewatering of channels, or rapid changes in water level or flow (ramping), that result in stranding of fish can be caused by natural factors (e.g., changes to inflows) or water withdrawal for mining or other water uses. When flows drop quickly or to a level where connectivity is lost, fish may become stranded in the interstices of exposed gravel or cobble substrate or isolated in pools (Irvine *et al.* 2009, Irvine *et al.* 2014). This can lead to mortality from suffocation, desiccation, freezing, or predation. The likelihood of fish stranding or isolation during rapid changes in water level is dependent on fish life stage, species, wetted history of the habitat, rate of stage change (i.e., ramping rate), magnitude of stage change, substrate characteristics, bank slope, channel morphology, water temperature, time of day, and other biotic and abiotic factors (Nagrodski *et al.* 2012, Irvine *et al.* 2014). Fry are typically more sensitive to stranding than are older age classes due to the poor swimming ability of fry and their preference for shallow and low velocity habitat; however, complete dewatering may affect all age-classes of fish. Generic standard ramping rate criteria that are typically protective of fish are specified in guidelines (Lewis *et al.* 2013).

Many of the channels that drain into the UFR are affected by operational water uses from Fording River Operations (FRO), Greenhills Operations (GHO), or Line Creek Operations (LCO) (i.e., Teck Coal facilities) because they receive discharge or seepage from ponds used for operations or are affected by consumptive water use. Operational water uses may therefore cause ramping within channels by reducing or ceasing discharge to the channels by drawing down water in ponds to a level that reduces flow in the channels. Ramping may also occur in channels not impacted by operations, and water levels may fluctuate naturally in all channels due to weather (e.g., precipitation), climate (e.g., rapid freeze up), and the annual hydrological cycle. Thus, stranding or isolation of fish can occur due to natural or operational flow changes in channels to which fish have access, and if this occurs over large spatial scales or frequently, resultant mortality could lead to population decline. Dewatering causing fish stranding may also occur within the UFR itself, either within the mainstem (e.g., the drying reach), or within side channels that may be seasonally wetted by flow from the mainstem UFR.

In total, three SME reports assess risks to fish from stranding. This report addresses risks to fish from dewatering of channels that are operationally influenced that discharge to the UFR, including a portion of one side channel of the UFR that is at times operationally influenced (see below). The Mainstem Dewatering Report addresses risks to fish from dewatering in the UFR mainstem and side channels, and the Ramping and Stranding Report addresses risks to fish from rapid changes in flow within the UFR.

The channels assessed in this report are relatively distinct from the mainstem UFR and can be assessed independently; however, the Kilmarnock Phase 1 Discharge Channel, which is fully described in Section 3.12, discharges into the Fording River Side Channel rather than into the UFR mainstem. Thus, the lower portion of the Fording River Side Channel (downstream of its confluence with the discharge channel) can be wetted by flow from the discharge channel or from the UFR (or both), and flow changes from either source can affect fish stranding risk. This system is of particular importance to this report because a fish stranding event was documented within both the Kilmarnock Phase 1 Discharge Channel and the lower portion of the Fording River Side Channel in 2018. This event occurred between August 30 and September 7, 2018, when flow changes in the Kilmarnock Phase 1 Discharge Channel and Fording River Side Channel caused isolation and stranding of WCT. Although no flow changes to the discharge water occurred between August 30 and September 5, flows in the Fording River Side Channel were fluctuating during this time. Discharge from Kilmarnock Phase 1 Discharge Channel was maintained during the side-channel dewatering and was ceased on September 5 to support fish salvages in the lower portion of the channel. A total of 881 WCT were salvaged and 216 WCT (ranging from approximately 76 mm to 147 mm) died (Teck 2019a, Teck 2019b; Table 1). Overall, 743 (68%) of the 1095 total fish recorded (salvage plus mortalities) were in the Fording River Side Channel and the remainder were in the Kilmarnock Phase 1 Discharge Channel. Because the lower portion of the Fording River Side Channel is also operationally influenced (through influence on flow within the Kilmarnock Phase 1 Discharge Channel), both the Kilmarnock Phase 1 Discharge Channel and the lower portion of the Fording River Side Channel are included in this report. Other side channels of the UFR are assessed in the Mainstem Dewatering Report, as explained above.

Table 1. Westslope Cutthroat Trout documented during the 2018 stranding event in the Kilmarnock Phase 1 Discharge Channel and the Fording River Side Channel as reported in Teck (2019b).

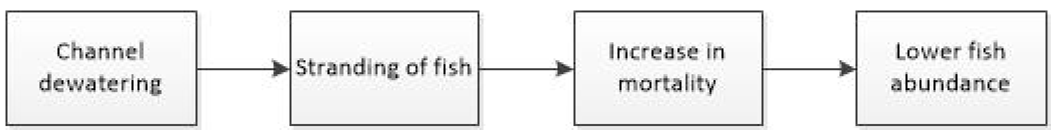
Location	Westslope Cutthroat Trout Recorded		
	Total Number	Number Salvaged	Number Died
Kilmarnock Phase 1 Discharge Channel	352	326	26
Fording River Side Channel	743	555	188
Total (both channels)	*1095*	*881*	*214* [1]

[1] The total number of mortalities reported in Teck (2019a) is 216.

Although stranding and isolation of fish can result when flows drop rapidly (ramping), continuous gauging does not occur at many of the channels that drain into the UFR; thus, most of the available flow data consist of spot measurements (see Section 2.1). Spot measurement data are not adequate for determining or comparing ramping events (rates of flow change). However, the available data identify time periods when there was no flow in channels and can be used to identify dewatering events during the Decline Window and the historical period (see Section 1.3 for the identification of stranding risk in this assessment given data limitations).

Figure 1 provides a pathway of effect conceptual model for the cause-effect linkages between channel dewatering (due to natural or operational causes) and reduced fish abundance considered in this investigation. The potential for impacts on fish abundance due to channel dewatering is related to channel characteristics given that channels differ in the quantity and quality of habitat for fish and in the sensitivity of habitat to stranding due to differences in channel morphology (e.g., confinement, gradient) and substrate characteristics. Thus, the evaluation of the potential adverse effect of channel dewatering on fish abundance must consider all key life stages (spawning, incubation, and rearing).

Figure 1. Pathway of effect relevant to potential effects to fish from rapid changes in water level in channels.



1.1.3. Author Qualifications

Todd Hatfield, Ph.D., R.P.Bio.

This project is being led by Todd Hatfield, Ph.D., a registered Professional Biologist and Principal at Ecofish Research Ltd. Todd has been a practising biological consultant since 1996 and he has focused his professional career on three core areas: environmental impact assessment of aquatic resources, environmental assessment of flow regime changes in regulated rivers, and conservation biology of freshwater fishes. Since 2012, Todd has provided expertise to a wide array of projects for Teck Coal: third party review of reports and studies, instream flow studies, environmental flow needs assessments, aquatic technical input to structured decision making processes and other decision support, environmental impact assessments, water licensing support, fish community baseline studies, calcite effects studies, habitat offsetting review and prioritizations, aquatic habitat management plans, streamflow ramping assessments, development of effectiveness and biological response monitoring programs, population modelling, and environmental incident investigations.

Todd has facilitated technical committees as part of multi-stakeholder structured decision making processes for water allocation in the Lower Athabasca, Campbell, Quinsam, Salmon, Peace, Capilano, Seymour and Fording rivers; he has been involved in detailed studies and evaluation of environmental flows needs and effects of river regulation for Lois River, China Creek, Tamihi Creek, Fording River, Duck Creek, Chemainus River, Sooke River, Nicola valley streams, Okanagan valley streams, and Dry Creek. Todd was the lead author or co-author on guidelines related to water diversion and allocation for the BC provincial government and industry, particularly as related to the determination of instream flow for the protection of valued ecosystem components in BC. He has worked on numerous projects related to water management, fisheries conservation, and impact assessments, and developed management plans and guidelines for industry and government related to many different development types. Todd is currently in his third 4-year term with COSEWIC (Committee on the Status of Endangered Wildlife in Canada) on the Freshwater Fishes Subcommittee.

Sean Faulkner, M.Sc., R.P.Bio., Fisheries Biologist

Sean Faulkner is a fisheries biologist who obtained his Master of Science in Environmental Biology and Ecology at the University of Alberta. He has over twelve years of experience conducting fisheries and aquatic assessments in British Columbia and has worked at Ecofish since 2007, where he has designed and led numerous studies assessing the effects of ramping rates of fish and defining protective ramping rates for hydroelectric facilities.

Mr. Faulkner's experience as a consultant to Teck Coal, specifically in the Upper Fording river watershed, includes leading instream flow assessment and habitat studies on LCO Dry Creek, developing and conducting ramping assessment for the Fording River as part of the operational environmental monitoring program (OEMP), and assessments of potential ramping effects to support development of active water treatment facilities and saturated rock fill treatment locations.

Sean has also developed, implemented and reported on several unique fish salvage and ramping assessments throughout a number of BC streams to support regulatory requirements (e.g., Fisheries Act Authorizations and Conditional Water Licences). Sean has also led ramping workshops and training sessions for ramping assessments for Fisheries and Oceans Canada and other environmental consultants.

1.2. Objective

The objective of this report is to review the available information on fish presence, habitat quality and quantity, and sensitivity of stranding for channels within the UFR watershed that are influenced by operational uses and thereby assess potential risk to fish stranding from channel dewatering and the potential role of stranding within the channels to the documented WCT abundance decline. The potential impacts to fish from channel dewatering are stranding or isolation, which can lead to death, and which can, in turn, lead to population decline if a large proportion of the population is impacted.

Thus, the specific impact hypothesis evaluated was:

- Did dewatering of operationally influenced channels cause or contribute to the observed WCT population decline?

1.3. Approach

The information compiled and reviewed to evaluate the dewatering of channels included fish presence, fish habitat quality and quantity, sensitivity of habitat to stranding, and evidence of dewatering. The findings were used to provide a determination of whether channel dewatering during the Decline Window caused or contributed to the WCT population decline by evaluating the potential for dewatering events to have impacted fish and by comparing the risk to fish between the Decline Window and prior years.

Channels that are tributaries of the UFR mainstem were chosen for assessment based on their potential for operational influence. Fish stranding may occur in channels that have operational influence because they are more likely to exhibit high magnitude or rapid flow changes than channels that are not influenced by operations. However, flows within channels that have operational controls may also be influenced by natural factors.

A total of twenty channels with the potential for operational influence were identified for this assessment (Table 2). Fifteen channels that drain into the UFR were identified based on the potential for flow changes from operational water use (e.g., regulation of water within settling ponds that discharge into the channels) and an additional four channels (Fish Pond Creek, West Exfiltration Ditch, Grassy Creek, and Greenhouse Side Chanel) were identified that are in close proximity to Teck Coal facilities but have no existing surface connection to a settling pond decant. We took the precautionary approach of including the additional four channels assuming that the groundwater feeding the channels may be influenced by FRO facilities; thus, operational influence could directly affect flow in these channels. The lower portion of the Fording River Side Channel was also included in the assessment because it is operationally influenced through flow in the Kilmarnock Phase 1 Discharge Channel (as described in Section 1.1.2). Channels were identified from ortho imagery and were confirmed with Teck Coal. Each of the channels are presented in a conceptual diagram in Figure 2 depicting known surface water and subsurface water transport pathways to provide the context of their location in the watershed and relationship with the UFR. With input from the EoC Team and Teck Coal, Figure 2 was modified for summarizing water connections in a watershed context from those generated by the Regional Aquatic Effects Monitoring Program reporting and prepared by Minnow Environmental Inc. For more information on subsurface flows, see Henry and Humphries (2020) – for example subsurface connections through bedrock from pits are not shown due to (1) long travel times from pits to surface water, and (2) not all pits store water (e.g., Lake Mountain Pit). Hydrology data were obtained from hydrometric gauges and spot sampling conducted by Teck Coal personnel and contractors (Section 2.1).

All channels were evaluated for potential stranding risk to fish using a three-step approach (Section 2.2). First, fish presence was determined (or inferred) for each channel (Step 1). Where fish were assessed to have had the potential to be present, we then assessed habitat quality and quantity in the channel and determined whether stranding sensitive habitat was present (Step 2). Given that data on fish distribution or abundance within channels was not generally available or comparable (see below), habitat quality was used as a proxy for the likely use of accessible habitat by fish. Habitat quantity was compared to the amount of habitat available in the UFR, which addresses the relative importance of the habitat potentially affected in relation to total habitat present for fish (i.e., the potential proportion of the WCT that could be affected by channel dewatering). Finally, we examined the available hydrology data to determine if there was evidence of dewatering in the channel, both during the Decline Window (2017-2019) and during prior years (2011-2016; referred to as the historical period) (Step 3). This three-step approach was used to evaluate the potential stranding of fish to have occurred in each identified channel (potential stranding risk).

Once potential stranding risk was determined for each channel, we evaluated whether stranding within channels as a group could be responsible for the observed WCT decline (Section 2.3). Specifically, we identified requisite conditions that would have to be met to establish a cause-effect relationship between channel dewatering and reduced WCT abundance.

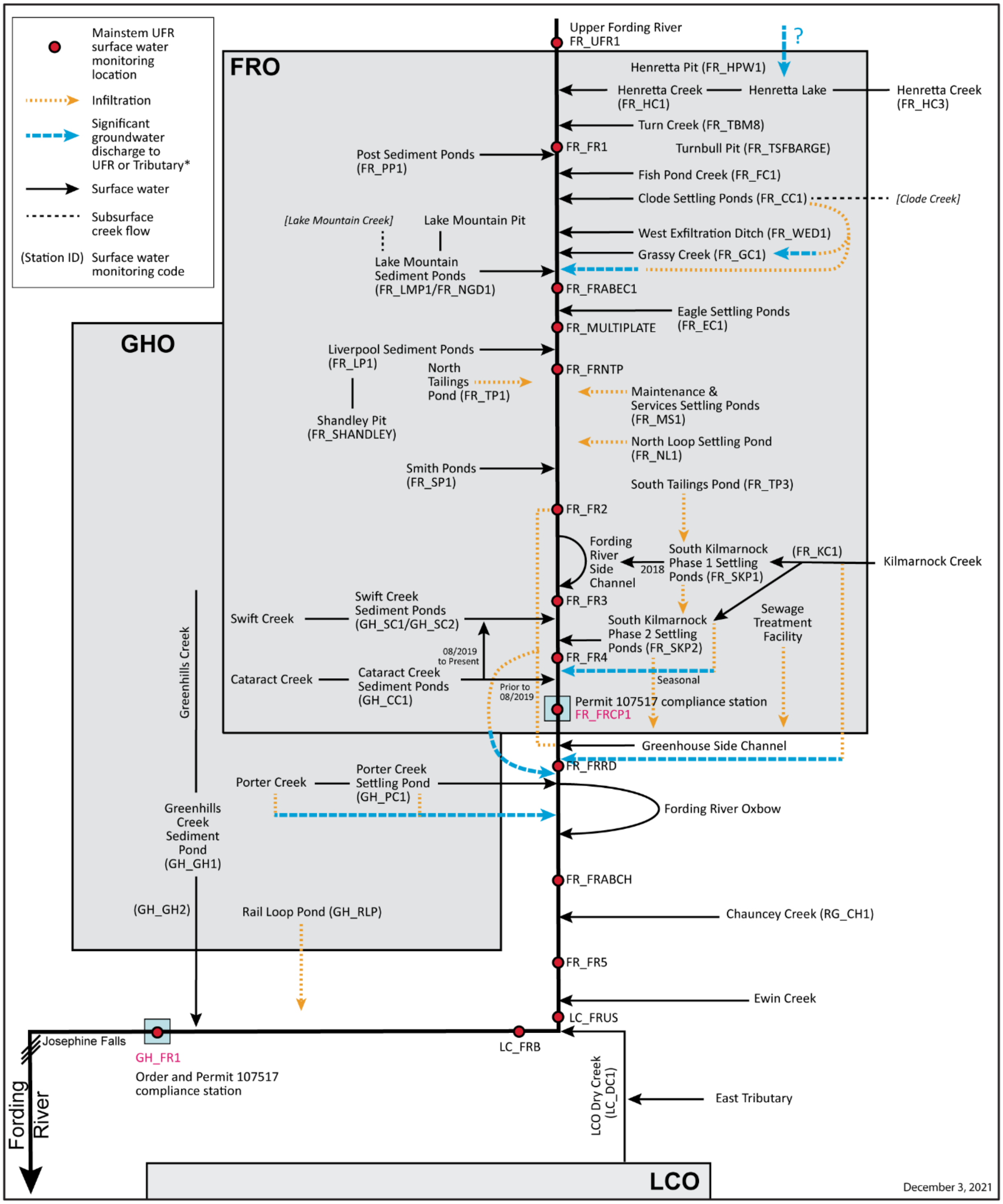
Although some data exist for fish use (distribution and abundance) within the assessed channels (e.g., Cope *et al.* 2016), we did not consider such data within the assessment because data were not adequate to allow comparison among channels. We also did not classify fish habitat by type (e.g., rearing, spawning) within the channels or when comparing habitat potentially affected in the channels to habitat available in the UFR. Habitat data detailed enough to allow classification by type were not available and the comparisons made for the assessment were therefore coarse (see assessment uncertainty in Section 4.3).

We also did not consider fish age classes likely to be present. As explained in Sections 1.1.2 and 2.2.3), zero flow occurrences were used to identify dewatering events with the potential to strand fish, and such events are more likely to affect all age classes than are other types of conditions that can cause stranding (e.g., low flow events, rapid flow changes). In addition, detailed data on channel morphology, substrate, and flow would be required to allow distinction of stranding risk by age class. For the same reasons, potential seasonal differences in fish presence were also not considered. Thus, dewatering events, defined as zero flow occurrences, were assumed to represent stranding risk for fish generally (all age classes, all times of year).

Table 2. Channels identified for this assessment (Appendix A).

Channel
Post Sediment Ponds Channel
Fish Pond Creek
Clode Creek
West Exfiltration Ditch
Grassy Creek
Lake Mountain Creek
Eagle Settling Ponds Channel
Liverpool Sediment Ponds Channel
Maintenance and Service Settling Ponds Channel
North Loop Settling Pond Channel
Smith Ponds Channel
Kilmarnock Phase 1 Discharge Channel
Fording River Side Channel (lower portion)
Kilmarnock Phase 2 Discharge Channel
Swift Creek
Cataract Creek
Greenhouse Side Channel
Porter Creek
Dry Creek
Lower Greenhills Creek

Figure 2. Water network figure for the UFR surface water and subsurface water transport pathways.



* Known or potential zones of significant groundwater discharge to the Fording River or major tributaries are shown. It is noted that there are numerous minor or unknown discharge zones throughout the UFR as well.

2. METHODS

2.1. Hydrological Data

The evaluation of potential stranding risk to fish relies on the ability to assess channel dewatering, which relies on the interpretation of hydrological data. Flow data from hydrometric gauges and spot sampling conducted by Teck Coal personnel and contractors were provided to Ecofish. Sampling methods are specified in Teck Coal's Flow Monitoring Protocol (KWL 2017). Any continuous data available had been recorded at 15-minute intervals. Spot measurements were recorded manually using a Flow Tracker meter during pond inspections either weekly (during freshet; March 15 to July 15) or monthly (not during freshet; July 16 to March 14). All finalized stage and flow data from hydrometric gauges were provided by Kerr Wood Leidel (KWL), Teck Coal's Qualified Professional for the hydrometric program.

Due to hydrological data limitations, several assumptions were required, particularly for non-continuous data:

1. Individual spot measurements are representative of average flow conditions in a given channel for the period of measurement.
2. Measured minimum flows are representative of actual minimum flow in the channel (i.e., flow was not lower than recorded minimum flow).
3. A measurement of zero flow indicates channel dewatering.
4. Recorded flow above zero is sufficient to maintain a wetted channel.

The required assumptions for channel dewatering and maintenance of a wetted channel identify uncertainty in the link between the hydrological data and its assumed consequences. However, by applying assumptions and assessment methods equally to the Decline Window (2017 to 2019) and the historical period (2011-2016; hydrological data prior to 2011 may not all be stored within Teck Coal's database, thus have not been included in this assessment), the hydrological data may nonetheless provide reasonable indications of channel dewatering events and are suitable for comparison between time periods.

2.2. Stranding Risk Assessment

A three-step assessment approach was applied to each channel (Table 2) to evaluate potential stranding risk to fish from dewatering:

Step 1: Assess fish presence;

Step 2: Assess habitat quality and quantity and the sensitivity of habitat to stranding; and

Step 3: Assess evidence for channel dewatering through examination of available hydrology data.

Steps 2 and 3 were followed if fish were assessed to be present in Step 1. The three steps, followed by an overall assessment of potential stranding risk by channel, are described below.

2.2.1. Step 1

In Step 1, fish presence was assessed for each channel. Fish were assessed to be present if fish could have accessed all or a portion of the channel that connects to the UFR; fish were assessed as not present if there was a barrier to fish access under most conditions (i.e., other than extreme high flows). Fish presence was assessed for each channel through review of fish salvage and assessment reports (Cope *et al.* 2016, Crowley and Oliver 2017, Lotic Environmental 2017, Eaton and Eisler 2019, Robinson *et al.* 2019, Smithson 2019, Nupqu Development Corporation 2020), stranding assessment reports, habitat assessment data, and unpublished data (Nicholl *et al.* 2018, Teck Coal unpublished data, Ecofish unpublished data), or client communications (Wilm, pers. comm. 2020). Steps 2 and 3 were followed for channels for which fish were assessed as present.

2.2.2. Step 2

In Step 2, for each channel where fish were assessed to be present, habitat quality, habitat quantity, and the sensitivity of habitat to stranding were determined based on available data. Habitat quality reflects the likely relative fish use of the habitat available. For example, a channel with poor habitat quality is expected to have fewer fish present per unit area than one with high habitat quality; therefore, fewer fish would be affected by a dewatering event. A single habitat quality rating (poor, fair, or good) was assigned to each channel. This single rating was assigned based on channel characteristics documented during a fish habitat assessment procedure (FHAP), the habitat quality classifications developed by Johnston and Slaney (1996) (summarized in Table 3), site photographs, and professional judgement.

Table 3. Habitat quality classifications from Johnson and Slaney (1996).

Use	Habitat Parameter	Gradient or W_b Class	Quality		
			Poor	Fair	Good
Summer/ winter rearing habitat	Percent pool (by area)	<2 %, < 15 m wide	< 40 %	40 - 55%	> 55 %
		2-5 % , < 15 m wide	< 30 %	30 - 40 %	> 40 %
		>5 % , < 15 m wide	< 20 %	20 - 30 %	> 30 %
	Pool frequency (mean pool spacing)	<2 %, < 15 m wide	> 4 channel widths per pool	2 - 4 channel widths per pool	< 2 channel widths per pool
		2-5 % , < 15 m wide	> 4 channel widths per pool	2 - 4 channel widths per pool	< 2 channel widths per pool
		>5 % , < 15 m wide	> 4 channel widths per pool	2 - 4 channel widths per pool	< 2 channel widths per pool
	LWD pieces per bankfull channel width	all	< 1	1-2	> 2
	% wood cover in pools	< 5 %, < 15 m wide	most pools in low category 0 - 5 %	most pools in moderate category 6 - 20 %	most pools in high category > 20 %
	Boulder cover in gravel-cobble riffles	all	< 10 %	10 - 30 %	> 30 %
	Overhead cover	all	< 10 %	10 - 20 %	> 20 %
Winter rearing habitat	Substrate	all	interstices filled: sand or small gravel subdominant in cobble or boulder dominant	interstices reduced: sand subdominant in some units with cobble or boulder dominant	interstices clear: sand or small gravel rarely subdominant in any habitat unit
	Off-channel habitat	< 3 % , all widths	few or no backwaters, no off-channel ponds	some backwaters	backwaters with cover and pond, oxbows and other low energy off-channel areas
Adult migration	Holding pools	all	few pools/km > 1 m deep with good cover, cool	-	adequate pools/km, > 1 m deep with good cover, cool
	Access to spawning areas	all	access blocked by low water, culvert, falls, temperature	-	no blockages

W_b is the mean bankfull channel width in m. SRP is soluble reactive phosphorus.

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Table 3. Continued (2 of 2).

Use	Habitat Parameter	Gradient or W_b Class	Quality		
			Poor	Fair	Good
Spawning and incubation	Gravel quantity	all	absent or little	-	Frequent spawning areas
	Gravel quality	all	sand is dominant substrate at some sites	sand is subdominant substrate at some sites	sand is never dominant or subdominant substrate
	Redd scour	all	evidence of extensive redd scour	some scour or potential for scour	stable with low potential for scour
Summer rearing habitat	Inorganic nutrients	all	spawner numbers depressed and NO_3-N < 20 μg·L-1 and / or SRP < 1 μg·L-1	spawner numbers normal; NO_3-N from 20-40 μg·L-1 and SRP from 1-2 μg·L-1	NO_3-N > 60 μg·L-1 and SRP >3 μg·L-1

W_b is the mean bankfull channel width in m. SRP is soluble reactive phosphorus.

Habitat quantity in each channel was assessed to determine the spatial extent of habitat accessible to fish that could be affected by dewatering relative to the total amount of habitat available in the UFR. Habitat quantity (m^2) was calculated directly for each channel from modified FHAP Level 1 data (Johnston and Slaney 1996), other existing area data (Teck 2020), or from ortho imagery. Habitat quantity in each channel was also assessed relative to (as a percentage of) habitat available in the UFR because this would provide an indication of the potential for impacts to the habitat in this channel to affect the UFR WCT population. To calculate % fish habitat in channels relative to the habitat in the UFR (hereafter referred to as relative % habitat), we divided the area of accessible habitat in each channel by the total accessible habitat area of the UFR using existing area calculations (Teck 2020).

Stranding sensitive habitat is habitat that is vulnerable to stranding due to channel and substrate characteristics. Thus, the sensitivity of habitat to stranding in a channel can be used as a measure of the likelihood that fish would become stranded during a dewatering event. In general, low gradient habitat with medium or large substrate is more sensitive to fish stranding than a channel that is high gradient, confined, and with fine substrate because these characteristics affect the likelihood of fish getting trapped out of water as the water recedes. For example, fish are less likely to become stranded in a channel with fine or no natural substrate (i.e., concrete channel base) that drains evenly because fish are able to swim out of the area as it drains. In contrast, a channel with large substrate and shallow gradient is more likely to strand fish during dewatering because fish can seek cover as flows decline and become trapped in wetted pockets of the substrate that later dry out. Nevertheless, a complete dewatering event may result in fish stranding despite the sensitivity of habitat. The sensitivity of habitat to stranding was qualitatively rated (a single rating for each channel) based on

Fisheries and Oceans Canada (DFO) ramping guidelines developed for stranding sensitive habitat (Lewis *et al.* 2011) using the following classifications:

- Low – Habitats generally contain no features that could trap or isolate fish (i.e., gradient is uniform, sediments are primarily fines or small gravels, cobbles if present are highly embedded).
- Moderate – Habitats are low to medium gradient (e.g., up to 5%) and may have depressions or other features that could trap fish but these features are not distributed throughout (i.e., may contain a small area of higher risk habitat, but majority is lower risk habitat).
- High – Habitats are generally low gradient (e.g., <2%) and are characterized by features that could trap/isolate fish with a small change in water level (i.e., medium to large substrate that is not uniform in size, not embedded, and contains depressions).
- Unknown (marked as n/a) – Not enough data exist to provide a classification; therefore, it was not assessed.

2.2.3. Step 3

In Step 3, the potential for a dewatering event was evaluated from available hydrological data for each channel by assessing if there was a cessation of flow. Dewatering events were defined as events during which flow ceased. Lack of dewatering events was defined as flows that remained above zero or had no flow throughout the period. Flow data (described in Section 2.1) were reviewed to identify evidence of dewatering during the Decline Window (2017-2019) and the historical period (2011 to 2016). Given that one dewatering event has the potential to kill fish, a conservative approach to evaluating dewatering was taken using the following binary classification for each channel by year:

- There was no evidence of dewatering: No cessation of flow was observed in a given year (all flows were greater than zero) or there was no discharge to the channel for a year (i.e., no flow present so that there was no potential for fish occupancy in that year).
- There was evidence of dewatering: At least one dewatering event (flow dropped from above zero to zero) was documented within a given year.

Given that fry are more sensitive to stranding than older age classes, the timing of dewatering events in relation to the fry-present period was noted. For the UFR area, the fry-present period is defined as August 1 to October 31, which extends from earliest emergence to the overwintering period. The fry not-present period includes all other times since juveniles and adults are present year-round (Cope *et al.* 2016). However, adults can also be sensitive to stranding under the conditions defined as dewatering events for this assessment (i.e., cessation of flow).

2.2.4. Potential Stranding Risk

Classifications of fish presence, habitat quality, sensitivity of habitat to stranding, and potential for a dewatering event were used to rank the overall potential stranding risk to fish from dewatering for each channel (Table 4). This ranking scheme thus considers both the probability of a dewatering event occurring and the consequence of such an event to fish (i.e., based on fish presence, habitat quality, and presence of stranding sensitive habitat).

In some cases, although dewatering occurred and habitat may have been of good quality and sensitive to stranding, steps had been taken to preclude fish from specified areas (e.g., dewatering was a planned event and was preceded by fish salvage; or a fish fence prevented fish access). In such cases, potential stranding risk was assessed as low.

Table 4. Potential stranding risk ranking scheme based on classification of fish presence, habitat quality, sensitivity of habitat to stranding, and evidence of dewatering.

Fish Presence	Habitat Quality	Stranding Sensitive Habitat	Evidence of Dewatering	Potential Stranding Risk
N				n/a
Y	Poor/Good	Low	No	Low
Y	Poor/Good	Moderate/High	No	Low
Y	Poor	Low/Moderate	Yes	Moderate
Y	Good	Moderate	Yes	High
Y	Poor/Good	High	Yes	High

2.3. Evaluation of Requisite Conditions

Requisite conditions are defined as the circumstances that would need to be met for dewatering of habitat to cause or contribute to the WCT population decline. The three-step approach described above was used to evaluate stranding of fish in natural and constructed channels and to determine whether requisite conditions were met. Requisite conditions (Table 5) were based on spatial (extent and location) and temporal (timing and duration) aspects of dewatering events and on the intensity (magnitude) of the events in relation to stranding risk for fish. It should be noted that hydrological data were not adequate for determining the duration of dewatering events (Section 2.1) and habitat data were not adequate to determine the relationship between duration of dewatering and stranding risk to fish, which is dependent on multiple factors including channel, mesohabitat, and substrate characteristics (e.g., presence of pools that may temporarily sustain fish when flows cease), as well as fish age class.

Table 5. Requisite conditions that need to be met for dewatering of operationally influenced channels to have caused or contributed to the WCT population decline.

Spatial extent	The dewatering event affected a relatively large portion of accessible fish habitat relative to that available in the UFR (therefore assumed to affect a large portion of the population)
Duration	The dewatering event was of a duration great enough to cause fish mortality
Location	The dewatering event occurred in the channel in a location where fish are present (accessible to fish and suitable for fish) and where habitat is sensitive to stranding
Timing	The dewatering event occurred during the Decline Window when fish were present (adults are present throughout the year, fry are present from August through October)
Intensity	Flow during the dewatering event was reduced sufficiently to isolate or strand fish

Requisite conditions for causing the WCT population decline are met if dewatering events during the Decline Window had the potential for stranding a large portion of the UFR fish population as inferred by stranding potential and spatial extent. **Requisite conditions for contributing** to the WCT population decline are met if dewatering events during the Decline Window had the potential for stranding a low to moderate portion of the UFR fish population as inferred by stranding potential and spatial extent. However, because stranding risk may have also occurred in the years prior to the Decline Window, and the difference in stranding risk between the two time periods (Decline Window and historical period) would affect the validity of stranding as an explanation for reduced fish abundance during the Decline Window, the comparison of potential stranding risk between the two time periods was also an important consideration. Thus, the greater the proportion of habitat and the higher the stranding risk during the Decline Window relative to the historical period, the more likely it is that dewatering events caused or contributed to the observed WCT population decline.

3. RESULTS

3.1. Post Sediment Ponds Channel

The Post Sediment Ponds and channel (Map 1 of Appendix A) were constructed in 2018 and flow commenced in spring 2019. Water decants through a hung high-density polyethylene (HDPE) pipe 1.6 m above a rip rap energy dissipator (Figure 3). From there, water flows through or over approximately 18 m of rip rap to the bank of the UFR, then drops about 1 m into the river.

3.1.1. Fish Presence

It was assumed for this assessment that the diffuse discharge through rip rap followed by the 1 m drop into the UFR provides a barrier to fish upstream movement into the Post Sediment Ponds Channel except under extreme flood events (Wilm, pers. comm. 2020). Post Sediment Ponds channel was considered non-fish bearing and therefore potential stranding risk to fish was not assessed (not applicable).

Figure 3 Discharge from Post Ponds Channel on June 17, 2020.

3.2. Fish Pond Creek

Fish Pond Creek (Map 2 of Appendix A) is a constructed channel that connects with the Fording River approximately 250 m upstream of Clode Creek (Figure 4, Figure 5). There are no settling ponds that decant into Fish Pond Creek and the creek is fed by shallow groundwater (Wilm, pers. comm. 2020).

3.2.1. Fish Presence

Fish presence has been documented in Fish Pond Creek (Cope *et al.* 2016). There are no known barriers to fish access and all life stages of WCT are assumed to be present.

3.2.2. Habitat Quality, Quantity, and Stranding Sensitive Habitat

Fish habitat quality and stranding sensitive habitat were evaluated for Fish Pond Creek from a modified FHAP Level 1 (Johnston and Slaney 1996) conducted on June 28, 2018 (Hocking *et al.* 2019). Fish habitat quality in Fish Pond Creek was classified as good. The habitat is comprised primarily of pond and glide mesohabitat, although riffle and run pool mesohabitats are also present

(Hocking *et al*. 2019). The habitat in Fish Pond Creek was classified as having low sensitivity to stranding because the channel banks are mostly steep and channelized (Ecofish unpublished data). Habitat area accessible to fish was determined to be 3,100 m^2 through area-estimate calculations (Teck 2020). The relative % habitat was calculated as 0.34%.

3.2.3. Dewatering Potential

There are no hydrometric gauges in Fish Pond Creek; thus, no flow measurements have been recorded and the potential for dewatering is unknown. However, Fish Pond Creek is fed by groundwater (Wilm, pers. comm. 2020), and thus was considered to have a stable, continuous flow. We therefore assumed that dewatering did not occur.

3.2.4. Potential Stranding Risk

The potential stranding risk for Fish Pond Creek was assessed as low for years 2011 to 2019 because it was assumed that dewatering did not occur (Table 4).

Figure 4. Fish Pond Creek and Fording River confluence on June 28, 2018.

Figure 5. Fish Pond Creek on June 28, 2018.

3.3. Clode Creek

Clode Creek was diverted to the Clode Settling Pond in the early 1970s (Wilm, pers. comm. 2020). Since that time, the Clode Settling Ponds have been the operational control of Clode Creek because surface water is decanted from the settling ponds to lower Clode Creek, which flows into the UFR (Map 3 of Appendix A).

3.3.1. Fish Presence

The Clode Settling Ponds outlet consists of seven corrugated steel pipe culverts with fish screens (Nupqu Development Corporation 2020) (Figure 7), which act as a partial fish barrier (i.e., only to larger, older life stages) between Clode Creek and the Clode Creek Settling Ponds (Map 3 of Appendix A). Fish have access from the Fording River to the 172 m of Clode Creek downstream of the pond outlet culverts (Nicholl *et al.* 2018) (Figure 8, Figure 9).

Fish presence has been documented in Clode Creek: 5, 293, and 16 WCT were recorded during fish salvages conducted in Clode Creek in 2013, 2016, and 2019, respectively (Lotic Environmental 2017, Teck Coal file data). Of the 314 total fish salvaged, 309 were classified as fry or juvenile fish. Redds have been observed in Clode Creek in multiple years, indicating repeated use as spawning habitat (Cope *et al.* 2016, Hocking 2019).

3.3.2. Habitat Quality, Quantity, and Stranding Sensitive Habitat

Fish habitat quality and stranding sensitive habitat were evaluated for Clode Creek from a modified FHAP Level 1 (Johnston and Slaney 1996) conducted on June 28, 2018 (Nicholl *et al.* 2018). Fish habitat quality in Clode Creek was classified as good. The habitat is comprised primarily of glide mesohabitat, although riffle, run, and pool mesohabitats are also present (Nicholl *et al.* 2018). All eight mesohabitat units within Clode Creek were classified as having low sensitivity to stranding due to channel morphology (i.e., confined channel, steep bank slope gradient) and substrate characteristics (i.e., primarily small gravels and fines) (Nicholl *et al.* 2018). Habitat area was calculated to be 688 m^2 (Nicholl *et al.* 2018). The relative % habitat was calculated as 0.08%.

3.3.3. Dewatering Potential

Spot measurements of flow were recorded from 2011 to 2019 and continuous flow data were recorded from 2017 to 2019 (Figure 6) at hydrometric gauge FR_CC1 (Map 3 of Appendix A). Spot measurements were recorded from one to five times a month, generally weekly from March to July and monthly from August to March. There were few data gaps in the continuous record for years 2017 (3 days) and 2019 (35 days), but there were 237 days of missing data in 2018 (see Figure 6). The 2017 FRO Hydrometric report notes that in September 2017 the logger data became noisy and is considered less reliable (KWL 2017). KWL also indicated a Grade E (estimate) for the continuous data in 2018 at FR_CC1 and notes the inaccuracy of the stage-discharge rating curve during the open water season due to rapid growth of vegetation in the channel (KWL 2018). Highest flows occurred from April to August, except in 2017 when flows peaked again in October. The comparison of continuous and spot flow data shown in Figure 6 illustrates limitations of spot data for recording variability in flow. For example, flow variability such as that documented by the continuous data record in 2017 would likely not have been captured by spot data, and peaks or drops in flow could therefore occur undetected by spot measurements. However, assumptions associated with continuous hydrological data (see sections 2.1 and 4.3) must also be considered when evaluating flow data.

Records from hydrometric gauges indicated that flow was more variable during the historical period (2011-2016) than the Decline Window (2017-2019) (Figure 6). Flow recorded during spot measurements ranged from 0.01 m^3/s to 0.84 m^3/s and 0.02 m^3/s to 0.28 m^3/s for the historical and Decline Window, respectively. Continuous flow data indicated particularly low flows early in 2018 (flows from continuous data record ranged from 0.002 m^3/s to 0.23 m^3/s). Because low flows may lead to fish stranding depending on duration and habitat type, the minimum recorded flow of 0.002 m^3/s was further evaluated to determine accuracy. It was determined that on January 31, 2018, the mean continuous flow was 0.003 m^3/s and the range of flows was 0.002 m^3/s to 0.005 m^3/s; thus, the low minimum flow recorded on that day appears to be accurate (not an isolated recording error). However, no spot measurements were taken on the date to confirm the continuous data. The nearest date on which both types of data exist was February 6, 2018, at which time average spot measurements indicated a flow of 0.26 m^3/s and average continuous flow was recorded as 0.008 m^3/s. This may suggest that flows were higher than indicated by the continuous data record (Figure 6). When both types of data exist, flows recorded by spot measurements are preferred over the continuous record and the hydrometric gauges may be unreliable during the winter due to ice effects.

No zero flows were recorded by either data method; thus, available data provide no evidence of dewatering at Clode Creek for both the historical record (2011-2016) and the Decline Window

(2017-2019). However, uncertainties remain as to whether dewatering events may have occurred due to data gaps and because spot measurements are less likely to capture short-duration events. In addition, flows appeared to change rapidly in some years, sometimes during the fry present period, which could have led to stranding or isolation of fish even if flows did not cease completely; however, ramping rates could not be determined.

3.3.4. Potential Stranding Risk

The potential stranding risk for Clode Creek was assessed as low for years 2011 to 2019 because there was no evidence of dewatering (Table 4), although, as described in Section 3.3.3, uncertainties remain due to data limitations.

Figure 6. Flow at Clode Creek (FR_CC1) from 2011 to 2019. Shading identifies the fry present period (August through October).

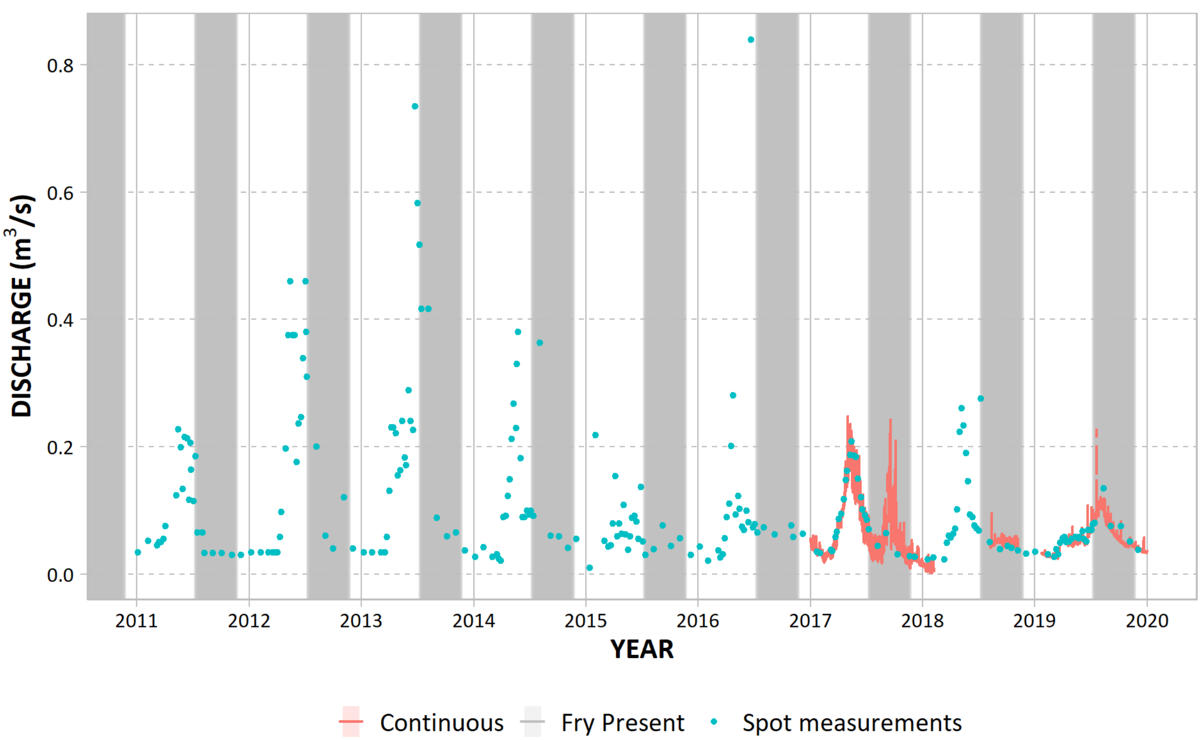


Figure 7. Discharge culverts on Clode Creek on April 28, 2020.

Figure 8 Downstream of discharge culverts on Clode Creek on May 5, 2020.

Figure 9 Clode Creek and Fording River confluence on May 12, 2020.

3.4. West Exfiltration Ditch

Based on current understanding, the West Exfiltration Ditch does not have an operational control (i.e., flow is not directly regulated by operations) and is fed by groundwater from the UFR and/or Clode Settling Ponds (Map 4 of Appendix A). We have included this channel in our assessment because water levels are potentially affected by water withdrawals from nearby settling ponds. Confirmation of source waters for West Exfiltration Ditch is currently being investigated by Golder Associates (Nicholl *et al.* 2020).

3.4.1. Fish Presence

No barriers to fish passage have been identified at West Exfiltration Ditch; the entire length (284 m) of the watercourse is accessible to fish (Nicholl *et al.* 2018) (Figure 10). Fish presence has been documented in West Exfiltration Ditch: four WCT juvenile fish were recorded during a fish community survey completed in 2019 (Smithson 2019).

3.4.2. Habitat Quality, Quantity, and Stranding Sensitive Habitat

Fish habitat quality and stranding sensitive habitat were evaluated for West Exfiltration Ditch from a modified FHAP Level 1 (Johnston and Slaney 1996) conducted on June 28, 2018 (Nicholl *et al.* 2018), and accessible fish habitat area was calculated from the same FHAP survey data. Fish habitat quality in West Exfiltration Ditch was classified as good. Riffle, pool, and glide mesohabitats were identified in the primary channel of the West Exfiltration Ditch (Nicholl *et al.* 2018). Most of the mesohabitat units in the West Exfiltration Ditch were classified as having low sensitivity to stranding due to channel morphology (e.g., confined channel, steep bank slope) and substrate characteristics (dominated by fines and gravels; Nicholl *et al.* 2018). Habitat area was calculated to be 1,136 m^2 (Nicholl *et al.* 2018) and the relative % habitat was calculated as 0.12%.

3.4.3. Dewatering Potential

There have been no flow measurements taken at West Exfiltration Ditch; however, it is not subject to operational dewatering and is known to have a stable, continuous flow because it is fed by groundwater (Wilm, pers. comm. 2020, Nicholl *et al.* 2018).We therefore assumed that dewatering did not occur .

3.4.4. Potential Stranding Risk

The potential stranding risk for West Exfiltration Ditch was assessed as low for years 2011 to 2019 because it was assumed that dewatering did not occur (Table 4).

Figure 10. West Exfiltration Ditch on April 16, 2020.

3.5. Grassy Creek

Grassy Creek does not have an operational control (i.e., flow is not directly regulated by operations) and is assumed to be fed by groundwater seepage from nearby settling ponds. We have included this channel in our assessment because water levels are potentially affected by water levels in nearby settling ponds. Confirmation of source waters for this stream is currently being investigated by Golder Associates (Nicholl *et al.* 2020).

3.5.1. Fish Presence

Grassy Creek may be wetted throughout the year and no barrier to fish passage has been identified; the entire length (236 m) of the watercourse was assessed as accessible to fish (Nicholl *et al.* 2018) (Figure 11). Fish presence has been documented in Grassy Creek: 21 juvenile WCT were recorded during a fish community survey completed in 2019 (Smithson 2019).

3.5.2. Habitat Quality, Quantity, and Stranding Sensitive Habitat

Fish habitat quality and stranding sensitive habitat were evaluated for Grassy Creek from a modified FHAP Level 1 (Johnston and Slaney 1996) conducted on October 12, 2018 (Nicholl *et al.* 2018) and habitat quantity was calculated from the same FHAP survey data. Fish habitat quality in Grassy Creek was classified as poor. Mesohabitat was primarily run, although glide, riffle, and cascade mesohabitats were also identified (Nicholl *et al.* 2018). All six mesohabitat units were classified as having low stranding sensitivity due to the prevalence of fine sediments and the confined nature of the channel (Nicholl *et al.* 2018). Habitat quantity was calculated to be 1,180 m^2 (Nicholl *et al.* 2018). The relative % habitat was calculated as 0.13%.

3.5.3. Dewatering Potential

There have been no flow measurements taken at Grassy Creek and it is unknown whether this channel stays consistently wetted year-round (Wilm, pers. comm. 2020). However, Grassy Creek is fed by groundwater, and thus was considered to have a stable, continuous flow. We therefore assumed that dewatering did not occur.

3.5.4. Potential Stranding Risk

The potential stranding risk for Grassy Creek was assessed as low for years 2011 to 2019 because it was assumed that dewatering did not occur (Table 4).

Figure 11. Grassy Creek on March 12, 2020.

3.6. Lake Mountain Creek

Lake Mountain Creek discharges from Lake Mountain Ponds into the UFR (Map 6 of Appendix A). A concrete fish exclusion structure, located 23 m upstream of the UFR confluence (Map 6 of Appendix A), was constructed in 2017 as part of the Lake Mountain Reach 1 Bypass construction and the channel downstream was infilled with rip rap. Lake Mountain Ponds provide the operational control for Lake Mountain Creek.

3.6.1. Fish Presence

Lake Mountain Creek is fish bearing downstream of the concrete fish exclusion structure, which has a 2.4 m vertical drop and a 0.10 m deep plunge pool (Figure 12, Figure 13) (Nicholl *et al.* 2018). The fish exclusion structure was placed as close to the UFR as feasible to meet permit requirements, and the rip rap channel (Figure 14) was designed to prevent fish from accessing the channel although this may not be effective at high flows. It is likely that fish can access the 23 m section of channel below the exclusion structure when flows are high in Lake Mountain Creek or the UFR (Nicholl *et al.* 2018), although such high flows may also affect habitat availability for fish.

Fish were documented in Lake Mountain Creek before the exclusion structure was constructed: 125, 86, and 5 WCT were recorded during fish salvages conducted in 2016, 2017, and 2018 (Nupqu Development Corporation 2020, Eaton and Eisler 2019, Crowley and Oliver 2017, Teck Coal file data). No fish were recorded during a salvage in 2019 after the exclusion structure was constructed (Nupqu 2020).

3.6.2. Habitat Quality, Quantity, and Stranding Sensitive Habitat

Fish habitat quality and stranding sensitive habitat were evaluated for Lake Mountain Creek from a modified FHAP Level 1 (Johnston and Slaney 1996) conducted on October 9, 2018 (Nicholl *et al.* 2018), and habitat quantity was calculated using the same FHAP survey data. Fish habitat quality in the lower reaches of Lake Mountain Creek (within the rip rap channel) was classified as poor. Mesohabitat is riffle (20 m total length) and there is a small cascade (3 m total length) (Nicholl *et al.* 2018). The two mesohabitats were classified as having high stranding sensitivity due to shallow bank slope and the extensive depressions within the channel formed by the rip rap (Nicholl *et al.* 2018). Fish habitat quantity was calculated to be 207 m^2 (Nicholl *et al.* 2018) and relative % habitat was calculated as 0.02%.

3.6.3. Dewatering Potential

Both spot and continuous flow measurements, taken at FR_LMP1 (Map 6 of Appendix A), were available for Lake Mountain Creek at (Figure 15). With a few exceptions, spot measurements were recorded at least once per month (more frequently in spring and summer) from 2011 to 2019 and continuous flow data were recorded in 2019. Spot measurements were taken at two locations owing to changes in permits and the construction of the Lake Mountain Sediment Ponds (Map 6 of Appendix A): FR_NGD1 prior to November 7, 2016, and at FR_LMP1 after this date. There are no water inputs between the two locations; thus, data from both locations are comparable for the evaluation of dewatering events. There were 35 days of missing data from the 2019 continuous flow record (Figure 15).

Flow recorded during spot measurements ranged from 0.024 m^3/s to 1.71 m^3/s in 2011 through 2016, from 0 m^3/s to 1.0 m^3/s in 2017, and from 0.01 m^3/s to 0.3 m^3/s in 2018-2019 (Figure 15). Continuous flow measurements in 2019 ranged from 0.003 m^3/s to 0.40 m^3/s. Thus, the only evidence of dewatering (0 m^3/s flow) was for 2017. However, the dewatering that occurred in October 2017 (Figure 15) was implemented to allow maintenance of the ponds (cleaning) and to complete the construction of the Lake Mountain Reach 1 Bypass. Lake Mountain Ponds underwent cleaning from September 19 to November 17 in 2017, and during this time the ponds were bypassed to Shandley Pit (from which there is no discharge, and negligible groundwater influence, on the UFR; O'Neill (2020)). Fish surveys and salvage were conducted as water was diverted from the discharge channel (see above). Discharge from the Lake Mountain Ponds through Lake Mountain Creek resumed at the end of November through the new fish exclusion structure.

Although there was no evidence for dewatering in years other than 2017, extreme low flows were recorded during spot measurements in 2018 (0.005 m^3/s) and during continuous measurements in 2019 (0.003 m^3/s). Such low flows could also lead to stranding depending on duration of the event and habitat type. The minimum flow of 0.003 m^3/s recorded during continuous measurements in 2019 was further evaluated to determine accuracy. It was determined that the mean continuous flow recorded on November 7, 2019 was 0.01 m^3/s, with flows increasing from 0.003 m^3/s to 0.03 m^3/s throughout the day; thus, the low minimum flow recorded on that day appears to be correct. Although no spot measurements were taken on the date to confirm the continuous data, on November 14, 2019, which is the nearest date to the date in question when both types of data exist, both spot and mean continuous flow recorded was 0.03 m^3/s. Thus, on average, spot measurements were only 1% higher than continuous measurements in 2019, confirming accuracy of the continuous flow data. Nevertheless, uncertainty remains regarding whether a flow of 0.003 m^3/s will maintain wetted habitat (flows remained below 0.005 m^3/s for approximately 24 hours from November 6 at 15:00 to November 7 at 14:30); however, we assumed no dewatering occurred in 2019.

3.6.4. Potential Stranding Risk

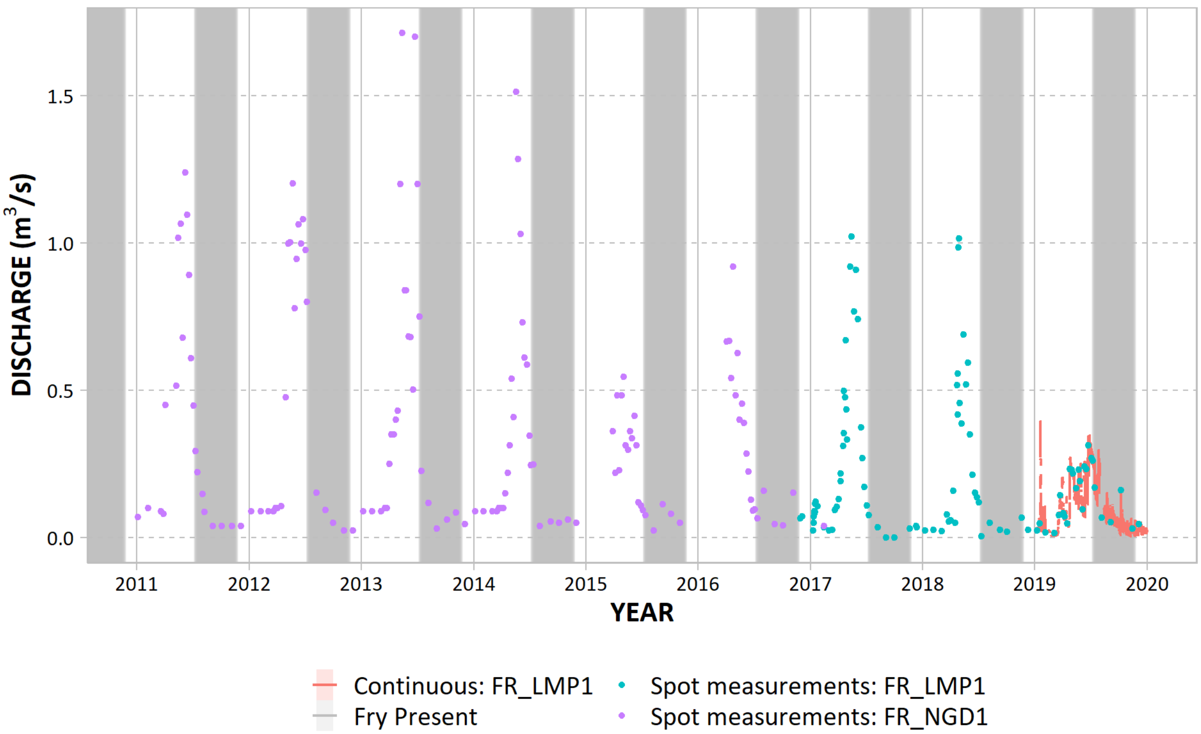
The potential stranding risk for Lake Mountain Creek was assessed as low for 2017 because the dewatering event that occurred was a planned maintenance event and was preceded by fish salvage (Table 4). Potential stranding risk for 2011-2016 and 2018-2019 was assessed as low because the evidence of dewatering occurred at a time in which fish salvage was implemented as mitigation.

Figure 12. Looking upstream from the UFR (foreground) at Lake Mountain Creek and the fish exclusion structure on October 9, 2018.

Figure 13. Plunge pool at base of fish exclusion structure at Lake Mountain Creek on October 9, 2018.

Figure 14. Looking downstream from the fish exclusion structure in Lake Mountain Creek through the rip rap channel towards the UFR on October 9, 2018.

Figure 15. Flow at Lake Mountain Creek (FR_NGD1 prior to November 7, 2016; FR_LMP1 after this date) from 2011 to 2019. Shading identifies the fry present period (August through October).



3.7. Eagle Settling Ponds Channel

The Eagle Settling Ponds, which discharge to the UFR (Map 7 of Appendix A), are located within the original alignment of Clode Creek. Clode Creek was diverted to the Clode Settling Pond in the early 1970s. Since that time, the Eagle Settling Ponds collect water from the remnant Clode Creek catchment (the Clode Creek channel was buried by waste rock in the 1970s) and from localized drainage around the ponds (Wilm, pers. comm. 2020). Water discharges from the Eagle Settling Ponds through four hanging culverts (fish barrier shown in Map 7 of Appendix A) onto a flat, elevated benched area, which flows for approximately 15 m prior to flowing through rip rap along the bank of the UFR (Figure 16).

3.7.1. Fish Presence

It was assumed for the the purposes of this assessment there is no fish access to the Eagle Settling Pond Channel except under extreme flood events; it was assumed that the elevated bench at the bank of the UFR, along with the rip rap section below that diffuses flow, provide a barrier to fish upstream movement (Wilm, pers. comm. 2020). Thus, potential stranding risk to fish was not assessed (not applicable).

Figure 16 Discharge culverts in Eagle Settling Ponds Channel on May 12, 2020.

3.8. Liverpool Sediment Ponds Channel

Water from the Liverpool Sediment Ponds flows into the UFR through a constructed channel (Map 8 of Appendix A). This channel has two elevated culverts near the confluence of the channel with the UFR (Nicholl *et al.* 2018) (Figure 17) and a fish exclusion structure upstream from the culverts.

3.8.1. Fish Presence

A concrete fish exclusion structure with a 2 m vertical drop (Figure 17) is located ~75 m upstream of the confluence with the UFR (Map 8 of Appendix A). In addition to the fish exclusion structure, two hanging culverts, located on the bank of the UFR, are also barriers to fish. The hanging culverts are about 3.0 m above the water surface elevation of the UFR and water flowing through the culverts drops 0.65 m onto a steep rip rap bank. The culverts, which are located at the downstream end of the channel, are believed to prevent upstream fish passage at all flows except under extreme flood events (Nicholl *et al.* 2018); thus, potential stranding risk to fish was not assessed (not applicable).

Figure 17. Discharge culverts in Liverpool Sediment Ponds Channel on June 22, 2020.

Figure 18. The concrete lip of the fish exclusion structure in Liverpool Sediment Ponds Channel on October 9, 2018.

3.9. Maintenance and Service Settling Ponds Channel

The Maintenance and Service (MS) Settling Ponds collect localized drainage and are not associated with a stream. The ponds see infrequent discharge and did not discharge from 2017 through 2019. In the event that discharge occurs, water decants through two hanging pipes onto an elevated bench and from there through rip rap onto the bank of the UFR (Wilm, pers. comm. 2020) (Figure 19) (Map 9 of Appendix A).

3.9.1. Fish Presence

Fish are unable to access the MS Settling Ponds Channel except under extreme flood events (Wilm, pers. comm. 2020). MS Settling Ponds Channel is considered non-fish bearing and therefore potential stranding risk to fish was not assessed (not applicable).

Figure 19. Discharge culverts in MS Settling Ponds Channel on June 22, 2020.

3.10. North Loop Settling Pond Channel

The North Loop Settling Pond collects localized drainage and is not associated with a stream. The pond sees infrequent discharge and when water does discharge, it is carried through an underground pipe first into a ditch, then into a sump, and from there it runs through a set of culverts into a wooded area where the water infiltrates into the ground (Wilm, pers. comm. 2020; Map 10 of Appendix A).

3.10.1. Fish Presence

Fish are unable to access the North Loop Settling Pond channel because there is no surface connection to the UFR (Wilm, pers. comm. 2020). North Loop Settling Pond channel is considered non-fish bearing; thus, potential stranding risk to fish was not assessed (not applicable).

3.11. Smith Ponds Channel

The Smith Ponds collect localized drainage and are not associated with a stream. Water collects in a series of small ponds on a bench elevated about 20 m above the UFR floodplain. The ponds discharge through two hanging culverts from which water drops approximately 3 m onto a steep slope and then cascades another 15 m directly onto the floodplain and into the former UFR mainstem (Figure 20). Following the flood of 2013, the UFR moved east; thus, the Smith Ponds no longer discharge into the UFR mainstem. Since then, water from Smith Ponds flows for approximately 200 m through the former mainstem channel (referred to here as Smith Ponds Channel) to its intersection with the current UFR mainstem (Figure 21, Figure 22) (Map 11 of Appendix A).

3.11.1. Fish Presence

The two hanging culverts that discharge water from the Smith Ponds prevent fish passage into the ponds (Figure 20), but fish have access from the confluence of the UFR into the open channel below these culverts (i.e., the former UFR mainstem channel). In September 2018 and 2019, a temporary fish exclusion net was installed (shown as fish fence on Map 11 of Appendix A) to prevent fish access during the winter months because it was uncertain if water would decant from Smith Ponds during the winter months, and a salvage was completed to support relocating fish from above the temporary fish fence. A total of 786 and 995 juvenile WCT were salvaged in 2018 and 2019, respectively (Nupqu Development Corporation 2020, Eaton and Eisler 2019, Teck Coal file data). This fish fence was removed in spring of each of these years (2019 and 2020) and fish were again able to access the open channel below the culverts during summer (Wilm, pers. comm. 2020).

3.11.2. Habitat Quality, Quantity, and Stranding Sensitive Habitat

There were no available data to evaluate habitat quality or sensitivity of habitat to stranding for Smith Ponds Channel; however, based on numbers of fish documented during 2018 and 2019 salvages (see above), habitat quality was assumed good and stranding risk was assumed high. Habitat quantity (1,427 m^2) was estimated based on GIS calculation and an assumed length of 253 m and an average wetted width of 5.64 m, and relative % habitat was calculated as 0.16%.

3.11.3. Dewatering Potential

Spot measurements of flow, taken at FR_SP1 (Map 11 of Appendix A), were available from 2011 to 2019 (generally collected from one to five times a month: weekly from March to July and monthly from August to March). According to spot measurements, highest flows generally occurred from April to August.

Flow recorded during spot measurements ranged from 0 m^3/s to 0.46 m^3/s in 2011-2017 and 0.01 m^3/s to 0.05 m^3/s in 2018-2019 (Figure 23). There is evidence of dewatering (flows of 0 m^3/s) for 2014 and 2015, and no evidence for dewatering for 2011-2013 and 2016-2019. Although 0 m^3/s flows were not recorded in 2011, flow was low when measured in October (0.002 m^3/s). Available data are insufficient to determine if flows this low would prevent fish stranding; however, we assumed no dewatering occurred in 2011 given that no cessation of flow (0 m^3/s) was recorded. Dewatering events occurred during the fry present period in 2014 and outside of it in 2015.

3.11.4. Potential Stranding Risk

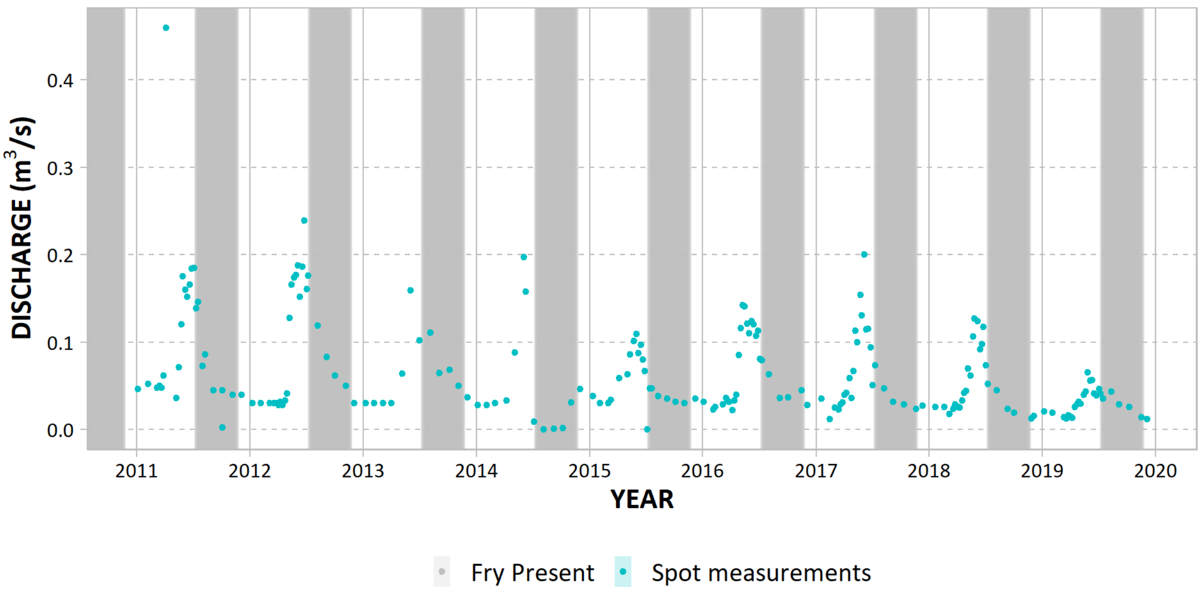
The potential stranding risk for Smith Ponds Channel was assessed as high for 2014 and 2015 when dewatering occurred based on assumed good habitat quality and high stranding risk (Table 4). Potential stranding risk for 2011-2013 and 2016-2019 was assessed as low because there was no evidence of dewatering for these years. Low stranding risk in 2018 and 2019 was also supported by the implementation of fish salvages in those years and prior to the 2013 flood (i.e., 2011–2013), the ponds discharged directly to the UFR mainstem.

Figure 20. Discharge culvert on Smith Ponds Channel on May 13, 2020.

Figure 21. Smith Ponds Channel downstream of culverts on May 13, 2020.

Figure 22. Smith Ponds Channel and UFR confluence on May 13, 2020.

Figure 23. Flow at Smith Ponds Channel (FR_SP1) from 2011 to 2019. Shading identifies the fry present period (August through October).



3.12. Kilmarnock Phase 1 Discharge Channel and the Fording River Side Channel

Kilmarnock Phase 1 Discharge Channel is a constructed channel that conveys discharge from the Kilmarnock Phase 1 Settling Ponds if they decant. Water decants from the ponds through a hanging culvert (Figure 24) and then flows through 204 m of open channel (Figure 25) to the confluence with the Fording River Side Channel (Figure 26). From this point, water runs through the lower portion of the Fording River Side Channel for approximately 375 m to its confluence with the UFR mainstem (Map 12 of Appendix A).

Flow from the Kilmarnock Phase 1 Settling Ponds is largely driven by the natural flow regime of Kilmarnock Creek. During high flow periods, the surface water inflow to the pond can be greater than the ground infiltration rate from the pond and water may decant from the pond and into the Fording River Side Channel through the Kilmarnock Phase 1 Discharge Channel (Wilm, pers. comm. 2020). Thus, the lower portion of the Fording River Side Channel may receive flow from the Kilmarnock Phase 1 Discharge Channel and/or from UFR mainstem. Water discharging from the Kilmarnock Phase 1 Settling Ponds may become sub-surface within the Kilmarnock Phase 1 Discharge Channel or within the Fording River Side Channel, or can reach the UFR mainstem as surface water if it also flows on the surface through the Fording River Side Channel. Based on anecdotal and periodic photographic evidence, the Fording River Side Channel has generally conveyed seasonal surface flows annually during higher water table/freshet periods (Wilm, pers. comm. 2020). Assessment for both the 204 m Kilmarnock Phase 1 Discharge Channel and the lower portion of the Fording River Side Channel, which conveys water from the Kilmarnock Phase 1 Discharge Channel to the UFR mainstem, are presented here (explained in Section 1.1.2). The fish stranding documented in 2018 (Teck 2019a, 2019b) (described in Section 1.1.2) occurred in both the Fording River Side Channel and the Kilmarnock Phase 1 Discharge Channel.

3.12.1. Fish Presence

Kilmarnock Phase 1 Discharge Channel

At the upstream end of the Kilmarnock Phase 1 Discharge Channel, a hanging culvert prevents fish from entering the Kilmarnock Phase 1 Secondary Pond (Wilm, pers. comm. 2020) (Map 12 of Appendix A). Water flowing through this culvert drops 0.8 m onto a 1.5 m rip rap landing (Figure 24). Prior to September 2018, the entire Kilmarnock Phase 1 Discharge Channel was accessible to fish, from its confluence with the Fording River Side Channel to this culvert, whenever flow was present in the channel (Nicholl *et al.* 2018). In September 2018, a fish fence was installed within the Kilmarnock Phase 1 Discharge Channel upstream of the confluence with the Fording River Side Channel and fish no longer had access to the Kilmarnock Phase 1 Discharge Channel (Teck Coal Ltd. 2019a, Wilm, pers. comm. 2020).

Fording River Side Channel

Fish have access to the Fording River Side Channel from the mainstem of the UFR when there is a flow connection between the side channel and the UFR.

3.12.2. Habitat Quality, Quantity, and Stranding Sensitive Habitat

Fish habitat quality and stranding sensitive habitat were evaluated in the Kilmarnock Phase 1 Discharge Channel and the lower portion of the Fording River Side Channel from a modified FHAP Level 1 (Johnston and Slaney 1996) conducted on June 6, 2018 (Ecofish file data, Ecofish Research Ltd. 2019), and accessible habitat area was calculated from the same FHAP survey data.

Kilmarnock Phase 1 Discharge Channel

Fish habitat quality in Kilmarnock Phase 1 Discharge Channel was classified as poor to moderate. Mesohabitat was primarily riffle, and there was also some run and pool mesohabitat identified (habitat of moderate quality was documented in the pool mesohabitat). Stranding sensitivity was not evaluated during the FHAP; however, isolation/stranding of 352 WCT occurred during the 2018 dewatering event (as described in Section 1.1.2); thus, high stranding risk was assumed. Although a portion of fish habitat was restricted in September 2018, a conservative measure of relative % habitat was calculated for the Kilmarnock Phase 1 Discharge Channel using the entire channel accessible prior to installation of the fish fence. Accessible fish habitat area was determined to be 1,938 m^2 (Ecofish file data) and relative % habitat was calculated as 0.21%.

Fording River Side Channel

Fish habitat quality in the lower portion of the Fording River Side Channel was classified as good. Mesohabitat was primarily riffle and glide, although pool and run habitats were also identified.

Classification of stranding sensitivity of the habitat varied; moderate and high risk were identified in riffle and glide sections near the middle of the channel (188 to 301 m from the confluence with the Fording River mainstem) where gradients were shallow (< 1.5%). In addition, isolation/stranding of 743 WCT occurred during the 2018 dewatering event (as described in Section 1.1.2); thus, stranding risk for this channel was classified as high. Accessible fish habitat area was determined to be 5,295 m^2 (Ecofish file data) and relative % habitat was calculated as 0.58%.

3.12.3. Dewatering Potential

Kilmarnock Phase 1 Discharge Channel

Spot measurements of flow were generally recorded weekly from March to July and monthly from August to March at FR_SKP1 (Figure 28, Map 12 of Appendix A). Data were collected one to six times per month, except in 2012, when up to eight measurements were taken in some months. However, no spot flow data were available from January to March 2011.

Available data show high flow events followed by long periods, sometimes greater than a year, of no flow. Flow recorded during spot measurements ranged from 0 m^3/s to 1.34 m^3/s from 2011-2016 and from 0 m^3/s to 0.92 m^3/s from 2017-2019, and there was evidence of dewatering in Kilmarnock Phase 1 Discharge Channel from 2011-2014 and 2018. Dewatering events may have been associated with rapid changes in flow (ramping rates could not be determined) and in all years except 2012, they occurred during the fry present period. Between 2015-2017 and in 2019 there was no discharge to the channel; thus, there was no evidence of dewatering in those years.

Fording River Side Channel

No gauge exists in the Fording River Side Channel, so dewatering events for the channel could not be evaluated. However, a dewatering event occurred in 2018 (during the fry present period) when stranding of fish was documented (Section 1.1.2).

3.12.4. Potential Stranding Risk

Kilmarnock Phase 1 Discharge Channel

The potential stranding risk for Kilmarnock Phase 1 Discharge Channel was assessed as high for years 2011 to 2014 and 2018 as there was evidence of dewatering, habitat quality was rated as poor to moderate, and sensitivity of habitat to stranding was classified as high (Table 4). In addition, stranding and fish mortality was documented in 2018 (Teck 2019a, 2019b) providing direct evidence of stranding risk. The potential stranding risk for Kilmarnock Phase 1 Discharge Channel was assessed as n/a for 2015-2017 and 2019 as no flow was released into the channel; thus, no fish habitat would have been available.

Fording River Side Channel

Potential stranding risk could not be assessed for the Fording River Side Channel for any year other than 2018 because evidence for dewatering could not be assessed. Potential stranding risk was assessed as high for 2018 based on dewatering occurrence, habitat quality and high stranding risk (Table 4).

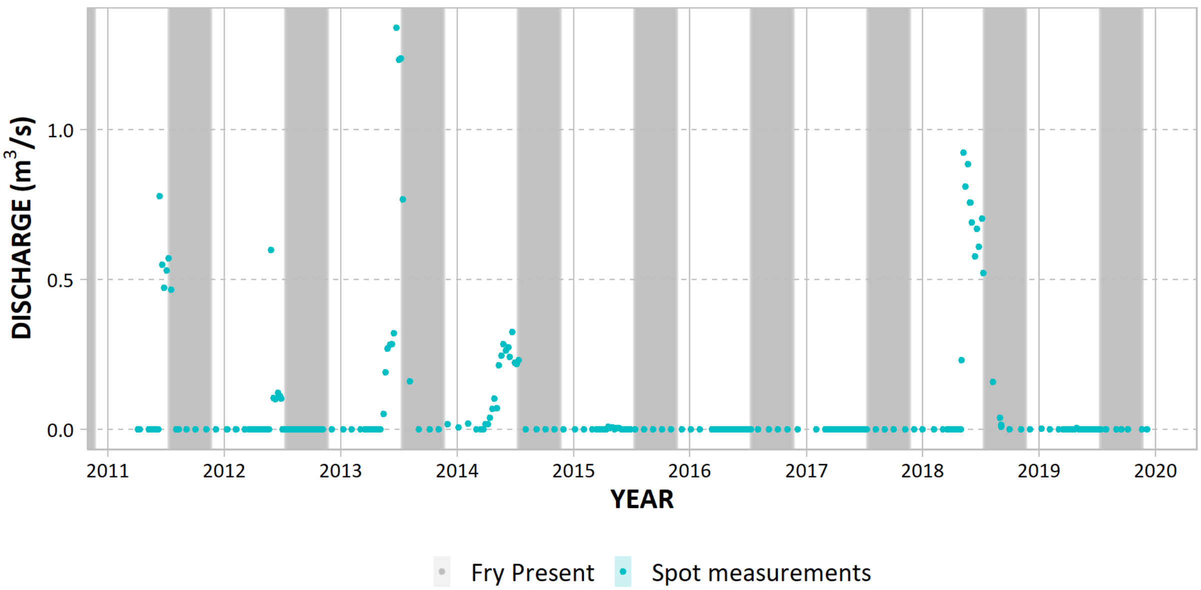
Figure 24. Discharge culvert on Kilmarnock Phase 1 Discharge Channel, June 6, 2018.

Figure 25. Kilmarnock Phase 1 Discharge Channel on June 14, 2020.

Figure 26. Kilmarnock Phase 1 Discharge Channel and Fording River Side Channel confluence on June 14, 2020.

Figure 27. Looking upstream at riffle mesohabitat unit (FHAP unit #12) in the Kilmarnock Phase 1 Discharge Channel on June 6, 2018.

Figure 28. Discharge from the Kilmarnock Creek Phase 1 Discharge Channel (FR_SKP1) from 2011 to 2019. Shading identifies the fry present period (August through October).



3.13. Kilmarnock Phase 2 Discharge Channel

The Kilmarnock Phase 2 Discharge Channel receives discharge and seepage from the Kilmarnock Phase 2 Secondary Pond as well as surface water and groundwater seepage from the UFR. Kilmarnock Creek flows into Kilmarnock Phase 2 Secondary Pond and may at times flow out of the pond and through the channel (Map 13 of Appendix A). The channel has a fish exclusion structure near its upstream end (Map 13 of Appendix A) and immediately downstream of this exclusion structure is a rip rap section approximately 30 m in length (Figure 29). The Kilmarnock Phase 2 Discharge Channel discharged into the mainstem of the UFR immediately downstream of the rip rap section prior to the fish habitat offsetting work within this area in 2018 that realigned the UFR mainstem further to the west. Following the offsetting work, the Kilmarnock Phase 2 Discharge channel extends for 175 m below the rip rap to the UFR (Figure 30, Figure 31).

3.13.1. Fish Presence

The Kilmarnock Phase 2 Discharge Channel has a fish exclusion structure, 15 m length × 10 m width × 1.0 m height, near its upstream end that is designed to carry water from the Kilmarnock Phase 2 Secondary Pond over a 1 m vertical drop onto a concrete pad 3 m in length and from there through 30 m of rip rap (Figure 29). Fish have access to the channel from the confluence with the UFR mainstem to the exclusion structure (Ecofish unpublished data, 2019) (Figure 30, Figure 31).

3.13.2. Habitat Quality, Quantity, and Stranding Sensitive Habitat

Fish habitat quality and stranding sensitive habitat were evaluated on Kilmarnock Phase 2 Discharge Channel from a modified FHAP Level 1 (Johnston and Slaney 1996) conducted on June 6, 2018 (Ecofish file data, Ecofish Research Ltd. 2019), and accessible habitat area was calculated from the same FHAP survey data. The FHAP, which was conducted prior to the offsetting work, was primarily based on the backwatered portion of the channel. Fish habitat quality was composed primarily of riffle and pool mesohabitat and was classified as poor (Ecofish file data). Sensitivity of habitat to stranding was assessed as low within the backwatered portion of the channel because the substrate was relatively uniform and bank slope gradients were moderately steep (between ~2% and 100%; Ecofish Research Ltd. 2019). However, the 30 m section of rip rap at the upstream end of the channel likely has high stranding sensitivity (apparent from Figure 29) and the remainder of the channel (between the rip rap section and the backwatered section) was evaluated to have moderate stranding risk based on slope gradient (shown in Figure 30). Thus, overall habitat stranding sensitivity was classified as moderate. Habitat area was determined to be 1,099 m^2 (Ecofish Research Ltd. 2019) and relative % habitat was calculated as 0.12%. Although the habitat assessment was conducted prior to offsetting work, the dewatering events identified also occurred prior to the offsetting work (see below); thus, the stranding risk identified was appropriate to the habitat accessible to fish during dewatering events.

3.13.3. Dewatering Potential

Spot measurements of flow were generally recorded weekly from March to July and monthly from August to March at FR_SKP2 (Figure 32, Map 12 of Appendix A). Data were collected one to six times per month, except in 2012, when up to eight measurements were taken in some months. No flow measurements were taken from January to March 2011.

Available data show high flow events followed by long periods of no flow (Figure 32). Flow recorded during spot measurements ranged from 0 m^3/s to 1.74 m^3/s from 2011-2016 and 0 m^3/s to 0.81 m^3/s from 2017-2019. In 2016 and 2019, there was no discharge to the channel; thus, there was no evidence of dewatering in those years. There was, however, evidence of dewatering in Kilmarnock Phase 2 Discharge Channel from 2011-2015 and 2017-2018 (all of which occurred prior to the offsetting work). These dewatering events occurred outside, although sometimes immediately prior to, the fry present period in all years and may have been associated with rapid changes in flow (ramping rates could not be determined).

3.13.4. Potential Stranding Risk

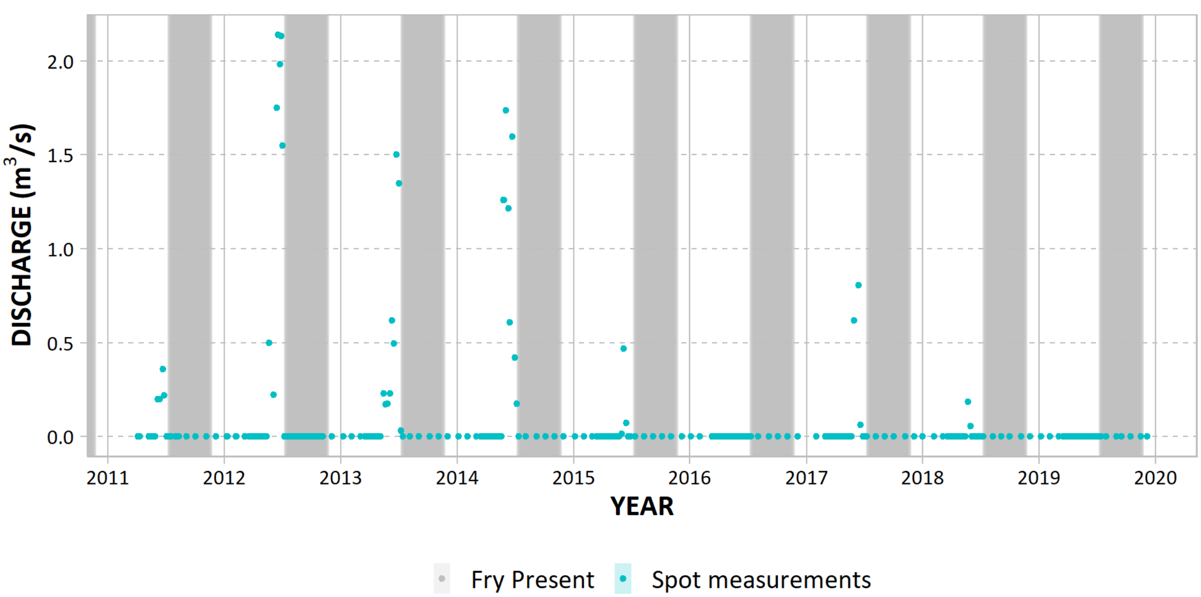
The potential stranding risk for the Kilmarnock Creek Phase 2 Discharge Channel is considered high for 2011-2015 and 2017-2018 because although habitat quality was rated as poor, there was evidence of dewatering and sensitivity of habitat to stranding was classified as moderate (Table 4). The potential stranding risk for Kilmarnock Phase 2 Discharge Channel was assessed as low for 2016 and 2019 as no flow was released into the channel; thus, there was no evidence of dewatering and no fish habitat would have been available.

Figure 29. Kilmarnock Creek Phase 2 fish exclusion structure on May 26, 2020.

Figure 30. Looking downstream from the Kilmarnock Creek Phase 2 fish exclusion structure on May 26, 2020.

Figure 31. Kilmarnock Creek Phase 2 Discharge Channel on May 26, 2020.

Figure 32. Flow in the Kilmarnock Creek Phase 2 Discharge Channel (FR_SKP2) from 2011 to 2019. Shading identifies the fry present period (August through October).



3.14. Swift Creek

Swift Creek is a second order tributary of the UFR that originates in the east slopes of the Greenhills Range and flows in a southeasterly direction before entering the UFR (Teck 2019c) (Map 14 of Appendix A).

3.14.1. Fish Presence

A cascading falls is located on Swift Creek upstream from the confluence with the UFR that is 2.6 m in height, 2.8 m wide, and 2.1 m long (Figure 33, Map 14 of Appendix A) (Ecofish Research Ltd. 2019); this feature is considered to be a fish barrier (Teck 2019c). The channel downstream (and South) of the cascading falls was accessible to fish between 2017 and 2019.

Changes to the fish-bearing sections of Swift Creek occurred between 2013 and 2019 (Map 14 of Appendix A). The channel downstream of the waterfall changed course after a flood event in 2013, which shortened the main part of the channel that entered the UFR to 22 m (orange line on Map 14 of Appendix A) and created a side channel (325 m) where Swift Creek used to flow prior to the 2013 flood. In 2017, water continued to flow through the main part of the channel (22 m; from the cascade waterfall into the UFR) and also may have flowed through the side channel (325 m) into the UFR when water levels were high. As part of a habitat enhancement project in October 2018, a fish exclusion fence was installed, fish were removed, and the main channel (22 m channel) was diverted into the side channel. The fish fence was removed from spring 2019 until September 2019 allowing fish to access the 325 m side channel. Fish fences were installed, and all fish were removed from the 325 m side channel in September 2019 when the channel was dewatered as part of the Fording River Operations Active Water Treatment Facility – South construction. Fish were documented present in Swift Creek during salvages conducted for channel dewatering: a large number of juvenile WCT were salvaged in both 2018 (786 juveniles) and 2019 (995 juveniles) (Nupqu Development Corporation 2020, Eaton and Eisler 2019, Teck Coal file data). Currently, no water from Swift Creek enters the channels downstream of the waterfall and the water flows directly to the UFR through the Fording River Operations Active Water Treatment Facility – South infrastructure (Teck 2019c).

3.14.2. Habitat Quality, Quantity, and Stranding Sensitive Habitat

Fish habitat quality and stranding sensitive habitat were evaluated on the Swift Creek side channel from a modified FHAP Level 1 (Johnston and Slaney 1996) conducted on June 7, 2018 (Ecofish Research Ltd. 2019) and habitat quantity was calculated from the same FHAP survey data. Fish habitat quality in the lower ~220 m of the channel was classified as good; the channel is wide and meandering and has gravel substrates (Ecofish Research Ltd. 2019). The lower 100 m of the channel was classified as having high stranding sensitivity due to a relatively low gradient bank slope (approximately 3%), relatively shallow banks (0.05 m to 0.38 m), and substrate comprised of fines and gravel with low compaction and moderate embeddedness (Ecofish Research Ltd. 2019).

Habitat area differed among years owing to changes to the channel from 2017 to 2019, ranging from 0 m^2 (when there was no fish access) to 2,808 m^2 (when fish could access both the 22 m long main part of the channel and the 325 m side channel). A conservative measure of relative % habitat was calculated for Swift Creek using the greatest amount of habitat quantity available in 2017-2019 (2,808 m^2) and this resulted in a relative % habitat of 0.31%.

3.14.3. Dewatering Potential

Spot measurements of flow taken at GH_SC1 and GH_SC2 (Map 14 of Appendix A) were available from 2011 to 2019 (collected weekly from March to July and monthly from August to March; from one to six times per month) (Figure 34). We have combined flow datasets from both gauges to assess dewatering potential because permit requirements historically implemented a pond bypass (GH_SC2) during periods of lower flow. Water was either sent through the Swift Sediment Ponds (GH_SC1) to Swift Creek or bypassed around the ponds (GH_SC2) to Swift Creek. Therefore, when there was little to no flow recorded at gauge GH_SC1, higher flows were generally recorded at gauge GH_SC2. Highest flows generally occurred from April to August.

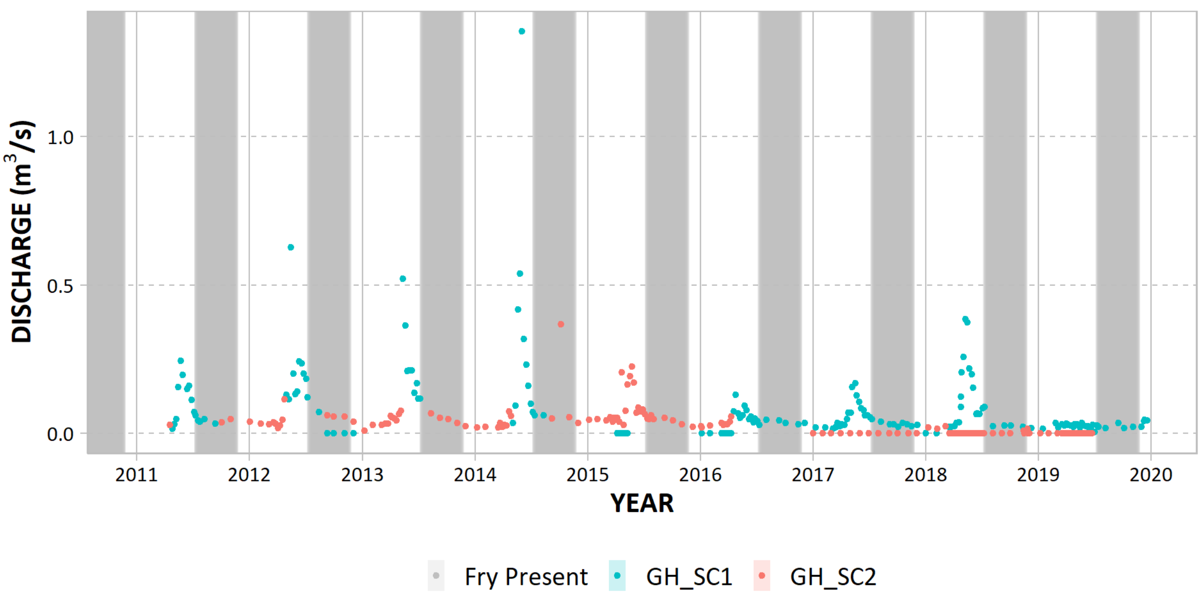
Based on the available data, flow was more variable between 2011 and 2016 (ranging between 0.02 m^3/s to 1.4 m^3/s) than during the Decline Window (ranging between 0 to 0.4 m^3/s) (Figure 34). There was no evidence for dewatering from 2011-2016 (whenever flow of 0 m^3/s was recorded at GH_SC1, flow > 0 m^3/s was measured at GH_SC2). Zero flows at GH_SC1 occurred on two occasions during the Decline Window, November 16 and November 29, 2018, which was after fish fence installation (October 2018). Flow was bypassed on November 14, 2018, to assist the construction of the new Swift Ponds and prior to the bypass a salvage was completed in Swift Creek upstream of the fish fence enclosure (Wilm 2020, Nupqu Development Corporation 2020). The dewatering events (when flow was 0 m^3/s at either gauge) occurred outside the fry present period in 2018.

3.14.4. Potential Stranding Risk

The potential stranding risk for Swift Creek was assessed as low for years 2017-2019. Although a dewatering event occurred in 2018, the event was preceded by the fish salvage described in Section 3.14.1 and a fish fence installed in October, prior to the event, prevented fish access into Swift Creek. The potential stranding risk for Swift Creek was assessed as low for 2011-2016 because there was no evidence of dewatering in these years.

Figure 33. Cascade barrier on Swift Creek on June 7, 2018.

Figure 34. Flow at Swift Creek (GH_SC1 and GH_SC2) from 2011 to 2019 as determined from spot measurements. Shading identifies the fry present period (August through October).



3.15. Cataract Creek

Cataract Creek is a third order tributary of the UFR that originates on the east slopes of the Greenhills Range. Prior to August 2019, the lower 800 m of the creek flowed through a sediment pond system that decanted to the UFR over a 15 m waterfall/cascade at its confluence with the UFR (Figure 35) (Teck 2019c) (Map 15 of Appendix A). This waterfall was present historically. In August 2019, Cataract Creek was diverted to the Swift Sediment Ponds.

3.15.1. Fish Presence

The 15 m waterfall/cascade at the UFR confluence has historically prevented upstream migration of fish into Cataract Creek and the creek did not become accessible after diversion in August 2019; therefore, there was no fish access at any time (Teck 2019c). Cataract Creek is considered non-fish bearing; thus, potential stranding risk to fish was not assessed (not applicable).

Figure 35. Discharge over waterfall/cascade on Cataract Creek on August 23, 2017.

3.16. Greenhouse Side Channel

The Greenhouse Side Channel is a groundwater-fed tributary of the UFR. Water in the Greenhouse Side Channel is presumed to originate from seepages in or near Kilmarnock Creek. SNC Lavalin is currently undertaking a flow accretion study, which is expected to be completed in 2021. Preliminary findings from the study indicate that water quality signatures from the Greenhouse Side Channel are inferred to be from a mine impacted water source; thus, the channel has been included in this report as having the potential for operational influence.

3.16.1. Fish Presence

There are no known fish barriers in the Greenhouse Side Channel, and fish are assumed to be present at all times of the year.

3.16.2. Habitat Quality, Quantity, and Stranding Sensitive Habitat

No habitat quality or stranding sensitive information is available for the Greenhouse Side Channel. However, photos provided by Lotic Environmental Ltd. show a confined channel with fine-grained substrate and large amounts of large woody debris cover. Habitat area was determined to be 14,700 m^2 through area-estimate calculations (Teck 2020) and relative % habitat was calculated as 1.61%.

3.16.3. Dewatering Potential

There have been no flow measurements taken in the Greenhouse Side Channel; however, it is known to have a stable, continuous flow because it is fed by groundwater. We therefore assumed that dewatering did not occur.

3.16.4. Potential Stranding Risk

The potential stranding risk for the Greenhouse Side Channel was assessed as low for years 2011 to 2019 because it was assumed that dewatering did not occur (Table 4).

Figure 36. Photo of the Greenhouse Side Channel from Lotic Environmental Ltd. taken on July 24, 2020.

3.17. Porter Creek

Porter Creek receives discharge from Porter Creek Pond and water flows from the pond to the UFR through an approximately 260 m channel (Map 16 of Appendix A; Figure 37).

3.17.1. Fish Presence

There are no fish barriers between the outlet of Porter Creek Pond and the confluence with the UFR (Ecofish file data) and the status of Porter Creek has been classified as fish-bearing (Robinson *et al.* 2019).

3.17.2. Habitat Quality, Quantity, and Stranding Sensitive Habitat

Fish habitat quality and stranding sensitive habitat were evaluated on Porter Creek from a modified FHAP Level 1 (Johnston and Slaney 1996) conducted on May 13, 2019 (Ecofish file data). Fish habitat quality in Porter Creek was classified as good. It is comprised primarily of cascade, riffle, and run mesohabitat, although glide and pool mesohabitats were also identified (Ecofish file data). Sensitivity of the habitat in Porter Creek to stranding was classified as low because the channel is mostly confined and has a substrate of predominantly fines and gravel (Ecofish file data). Habitat area was determined to be 670 m^2 through area-estimate calculations (Ecofish file data) and relative % habitat was calculated as 0.07%.

3.17.3. Dewatering Potential

Spot measurements of flow, taken at GH_PC1 (Map 16 of Appendix A), were available from 2011 to 2019 (generally collected from one to five times a month: weekly from March to July and monthly from August to March). According to spot measurements (Figure 38), highest flows generally occurred from April to August.

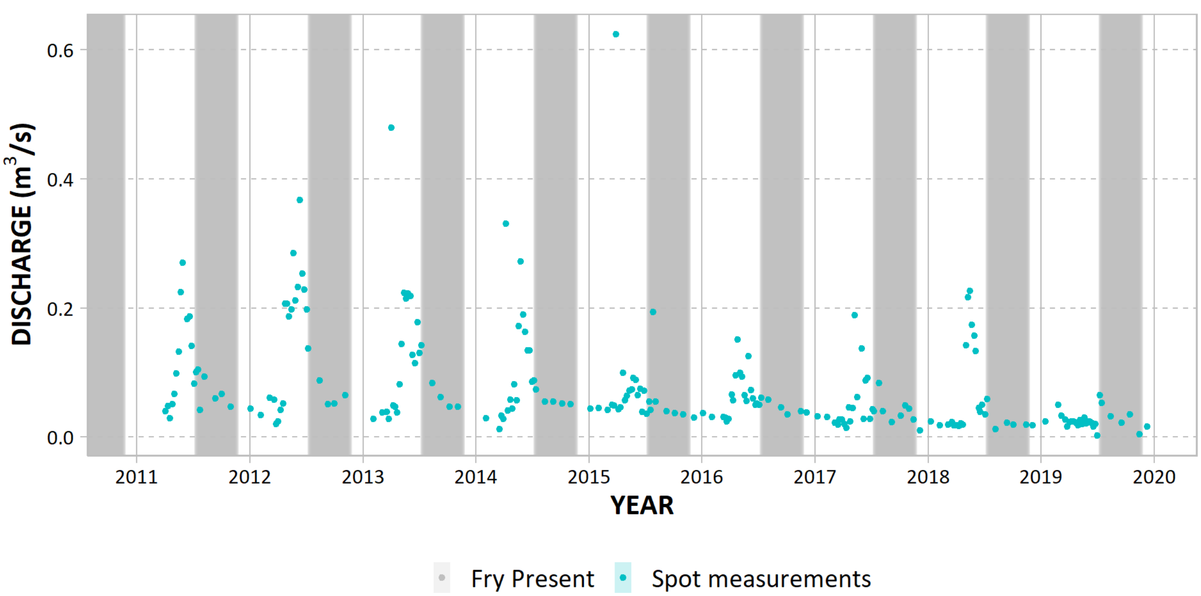
Flow was more variable between 2011 and 2016 (ranging from 0.01 m^3/s to 0.6 m^3/s, including high flows associated with the 2013 flood) than during the Decline Window (2017-2019) when it ranged from 0.002 m^3/s to 0.23 m^3/s (Figure 38). There is no evidence of dewatering between 2011 and 2019 (no zero flows recorded). However, uncertainties remain in whether fluctuations in flow led to ramping or dewatering events and whether flows as low as 0.002 m^3/s would maintain a wetted channel. We assumed no dewatering occurred for these years given that no cessation of flow (0 m^3/s) was recorded.

3.17.4. Potential Stranding Risk

The potential stranding risk for Porter Creek was assessed as low for years 2011 to 2019 because there was no evidence of dewatering (Table 4).

Figure 37. Porter Creek on May 13, 2019.

Figure 38. Flow at Porter Creek (GH_PC1) from 2011 to 2019. Shading identifies the fry present period (August through October).



3.18. Dry Creek

Dry Creek is a 9 km, 3rd order stream that discharges into the Fording River ~7 km east of Elkford BC (Teck 2011). Mining occurs in the watershed upstream of the East Tributary (~1/3 of the watershed), and all flow in Dry Creek upstream of the East Tributary confluence is diverted to the Dry Creek Water Management System, consisting of a headpond and two sediment ponds, where suspended matter is allowed to settle prior to release into Dry Creek. The settling ponds decant through a pipe into a constructed channel ~7 km upstream of the highway bridge culverts (Figure 39).

3.18.1. Fish Presence

WCT are present within Dry Creek (Cope *et al.* 2016); however, there are two culverts located at the highway bridge (Figure 40) located 1.7 km upstream of the UFR confluence that are considered a barrier to WCT upstream migration from the Fording River mainstem (Map 17 of Appendix A). Fish upstream of the highway bridge culverts are considered a fragmented population of WCT separated from the UFR population. As such, only the section of Dry Creek downstream of the highway bridge culverts has been assessed here, since it is only fish in this portion of Dry Creek that are relevant to the EoC (Figure 41).

3.18.2. Habitat Quality, Quantity, and Stranding Sensitive Habitat

Fish habitat quality was evaluated on Dry Creek from a modified FHAP Level 1 (Johnston and Slaney 1996) conducted during June 6 – 12, 2016, July 5 – 7, 2016, and September 6, 2016 (Buchanan *et al.* 2017). Accessible habitat area was calculated from the same FHAP survey data. Fish habitat quality in Dry Creek was classified as good. It is comprised primarily of riffle, run, and glide mesohabitat. Stranding sensitive habitat has been classified as moderate for Dry Creek based on results and photos from the FHAP survey. Accessible habitat area was determined to be 6,848 m^2 and relative % habitat was calculated as 0.75%.

3.18.3. Dewatering Potential

Spot measurements of flow were recorded in 2016 to 2019, and continuous flow data were recorded from 2012 to 2019 at hydrometric gauge LC_DC1 (Figure 42) (Map 17 of Appendix A). Spot measurements were recorded from 10 to 31 times a month from July to November in 2014 and one to six times a month from 2016 to 2019. Spot measurements were generally taken weekly from April to October and monthly from November to March. However, in 2016 spot measurements were only taken from February to March.

Records indicated that flow was more variable during the historical period (2011-2016) than in the Decline Window (2017-2019) (Figure 42). Continuous flow data ranged from 0.02 m^3/s to 9.0 m^3/s and 0.03 m^3/s to 3.2 m^3/s for the historical period and Decline Window, respectively. Flow recorded during spot measurements ranged from 0.01 m^3/s to 2.0 m^3/s in the Decline Window.

No zero flows were recorded by either measurement method; thus, available data provide no evidence of dewatering in Dry Creek for both the historical period (2011-2016) and the Decline Window (2017-2019).

3.18.4. Potential Stranding Risk

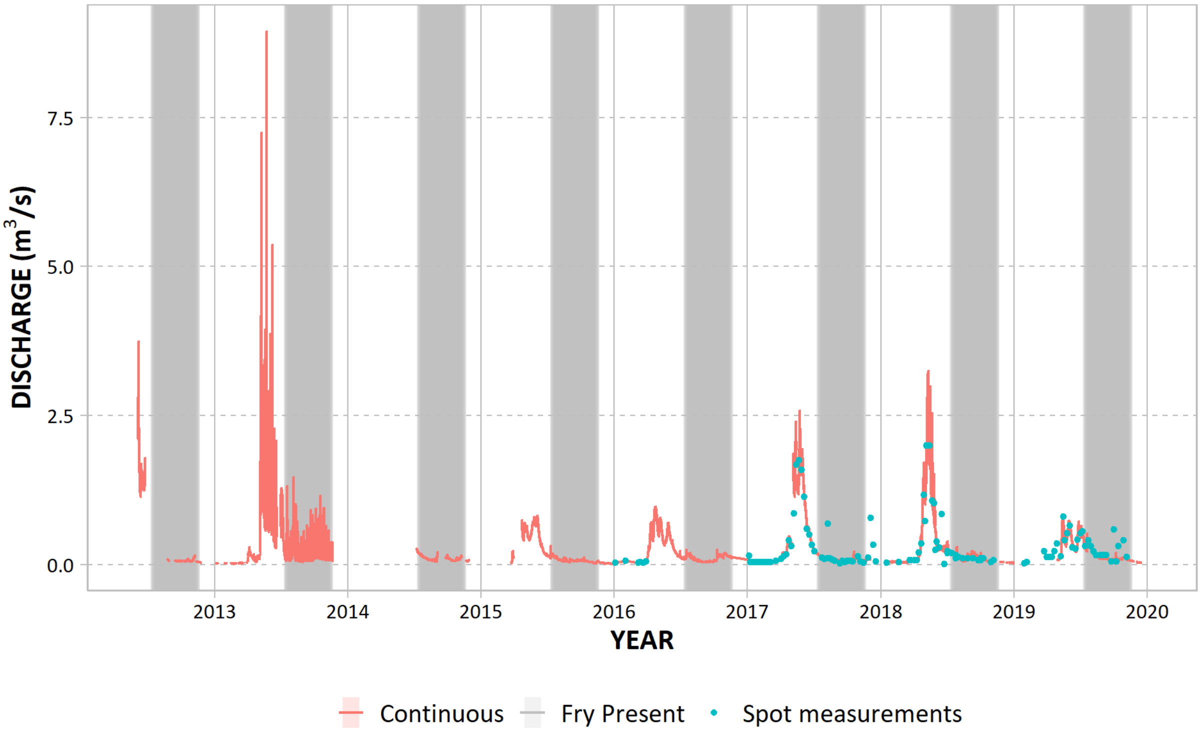
The potential stranding risk for Dry Creek was assessed as low for years 2011 to 2019 because there was no evidence of dewatering (Table 4).

Figure 39. Dry Creek settling pond outlet channel on October 28, 2017.

Figure 40. Looking upstream in Dry Creek at the outlet of the two culverts at the highway crossing on September 7, 2016.

Figure 41. The section of Dry Creek downstream of the two culverts that are considered a fish barrier on June 7, 2016.

Figure 42. Flow at Dry Creek (LC_DC1) from 2012 to 2019. Shading identifies the fry present period (August through October).



3.19. <u>Lower Greenhills Creek</u>

Greenhills Creek is located entirely within Greenhills Operations (GHO) mine property. Greenhills Creek can be divided into three stream segments (Wright *et al.* 2018): 1) the lowermost reaches downstream of the settling pond that has fish connectivity to the UFR; 2) Greenhills settling pond which is isolated from the UFR by a fish barrier; and 3) reaches upstream of the settling pond. This report assesses the lowermost reaches that connect to the mainstem UFR (referred to here as Lower Greenhills Creek).

Lower Greenhills Creek decants from the sediment pond through a fish exclusion structure (concrete flume approximately 12 m high and 5.5 m wide) (Figure 43) into a pool and through a culvert under the Fording River Road. Flow then meanders through a channel for approximately 736 m to the UFR (Hocking *et al.* 2019, Enns, pers. comm. 2020) (Figure 44, Appendix A).

3.19.1. Fish Presence

A hanging culvert on the Fording River Road is a barrier to WCT upstream movements within Greehhills Creek (Cope *et al.* 2016, Beswick 2007). WCT from the UFR have access to 736 m of Lower Greenhills Creek (Figure 44), i.e., from the UFR to the culvert. Lower Greenhills Creek is used for WCT spawning and fry and juvenile rearing (Cope *et al.* 2016, Beswick 2007).

3.19.2. Habitat Quality, Quantity, and Stranding Sensitive Habitat

Fish habitat quality and stranding sensitive habitat were evaluated in Lower Greenhills Creek from a modified FHAP Level 1 (Johnston and Slaney 1996) conducted on August 26, 2017 (Hocking *et al.* 2019). Accessible habitat area was calculated from the same FHAP survey data. Fish habitat quality in Lower Greenhills Creek was classified as good. It is comprised primarily of pool, glide, and riffle mesohabitat. Sensitive stranding habitat was classified as moderate. Accessible habitat area was determined to be 2,208 m^2 and relative habitat was calculated as 0.24%.

3.19.3. Dewatering Potential

Spot measurements of flow were recorded from 2012 to 2018, and continuous flow data were recorded from 2018 to 2019 at hydrometric gauge GH_GH1 (Figure 45) (Map 18 of Appendix A). Spot measurements were recorded from one to five times a month, generally weekly from April to June and monthly from July to March. Spot measurements ranged from 0 m^3/s to 0.43 m^3/s and 0.14 m^3/s to 0.21 m^3/s for the historical period and Decline Window, respectively. Continuous flow data ranged from 0.14 m^3/s to 0.15 m^3/s for the Decline Window.

There is evidence of dewatering (flows of 0 m^3/s) for 2012, and no evidence of dewatering for 2013-2019. In 2016, flow was extremely low when measured in February (0.006 m^3/s). Available data are insufficient to determine if flows this low would prevent fish stranding. However, we assumed no dewatering occurred in 2016 given that no cessation of flow (0 m^3/s) was recorded. Dewatering events occurred during the fry present period in 2012.

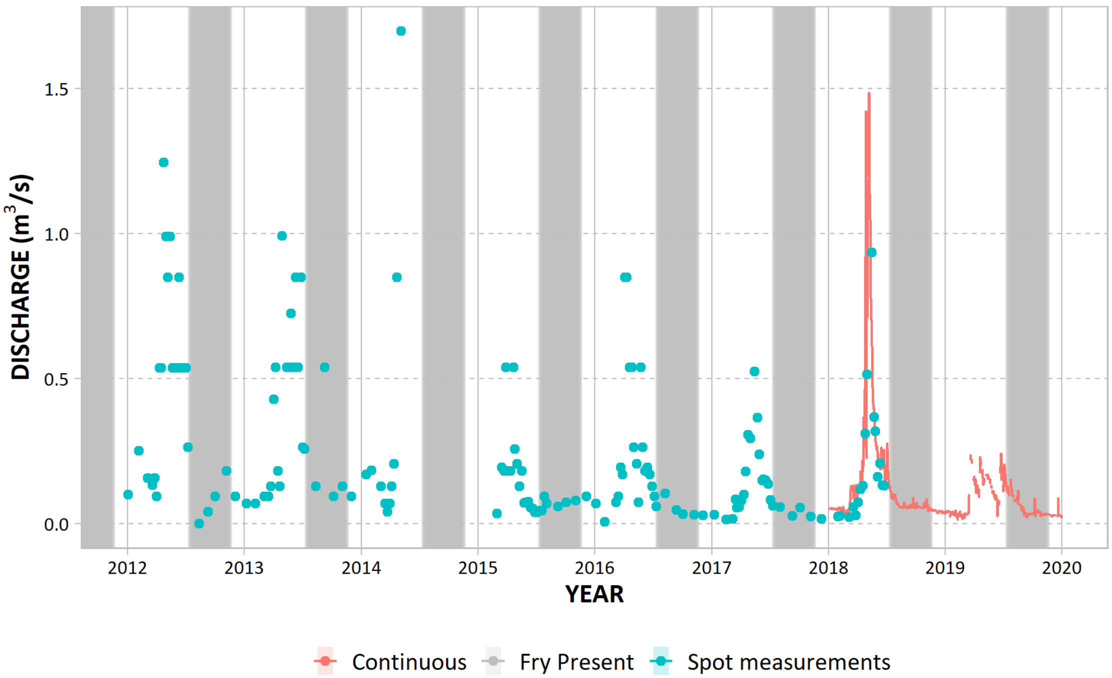
3.19.4. Potential Stranding Risk

The potential stranding risk for Lower Greenhills Creek was assessed as high for 2012 because there was evidence of dewatering, and the habitat quality was rated as good. The potential stranding risk for Lower Greenhills Creek was assessed as low for 2011 and 2013-2019 because there was no evidence of dewatering in these years.

Figure 43. Looking upstream at the fish exclusion structure on Lower Greenhills Creek on August 13, 2019.

Figure 44. Lower Greenhills Creek on June 26, 2019.

Figure 45. Flow in Lower Greenhills Creek (GH_GH1) from 2012 to 201. Shading identifies the fry present period (August through October).



4. DISCUSSION

4.1. Evaluation of Requisite Conditions

The summary of accessible habitat for fish and potential stranding risk used to evaluate requisite conditions (see Table 5 in Section 2.3) is provided in Table 6. Dewatering events during the Decline Window (2017-2019) were documented in four channels where fish were assessed to be present: Kilmarnock Phase 1 Discharge Channel (in 2018), Fording River Side Channel (in 2018), Kilmarnock Phase 2 Discharge Channel (in 2017 and 2018), and Swift Creek (in 2018). The potential stranding risk for these dewatering events was rated as high in these channels based on habitat quality and the sensitivity of habitat to stranding, except for Swift Creek whereby a fish salvage and fish fence mitigated the risk of stranding. Further, stranding was known to have occurred in the Kilmarnock Phase 1 Discharge Channel in 2018 (as described in Section 1.1.2; Teck 2019a, 2019b). Thus, the requisite conditions for Intensity, Location, and Timing (see Table 5 in Section 2.3) were met for three of these four channels because complete dewatering events (flow reduction to zero) occurred during the Decline Window where habitat was accessible to fish, suitable for fish, and sensitive to stranding, and when fish could have been present. Hydrological data were not adequate to determine the duration of dewatering events. Whether the requisite conditions for Duration were met could not be formally evaluated; however, we have assumed that mortality was associated with the recorded dewatering events.

Although some requisite conditions were met for the three channels with high potential stranding risk during the Decline Window, the total proportion of habitat that is accessible to fish and where there is stranding risk is small; thus, the requisite condition for Spatial Extent was not met. The accessible habitat contained within Kilmarnock Phase 1 Discharge Channel, the lower portion of the Fording River Side Channel, and Kilmarnock Phase 2 Discharge Channel, was calculated to represent 0.91% of the habitat available within the UFR. In general, accessible fish habitat in all channels represents only a relatively small proportion (5.26%) of total available fish habitat in the UFR (Table 6). Note that this report only addresses the channels that are operationally influenced, and two other reports consider stranding risk potential for the UFR due to ramping or dewatering (see Section 1.1.2).

Requisite conditions for channel dewatering contributing to the WCT population decline were met because there was moderate to high potential stranding risk identified for a low portion of the UFR fish population during the Decline Window. Requisite conditions for channel dewatering causing the WCT population decline were not met because a low proportion of habitat (0.91%) relative to habitat in the UFR was assessed to have had a high potential stranding risk and because dewatering events similar to those documented for the Decline Window were also documented during the historical period (see below).

4.2. Comparison Between Periods

The likelihood that dewatering events in the channels caused the observed WCT population decline must be evaluated not only based on the occurrence of dewatering events and their likely consequences during the Decline Window, but also in relation to the dewatering events in prior years. Potential stranding risk during the Decline Window was assessed to have been high for at least one year at three channels (Kilmarnock Phase 1 Discharge Channel, Fording River Side Channel, and Kilmarnock Phase 2 Discharge Channel) during the Decline Window. However, potential stranding risk was also high in at least one year during the historical period (2011-2016) where data were available for two of these channels (Table 6). For Swift Creek, there was no evidence of dewatering in the historical period. In contrast, for two channels, Smith Ponds Channel and Lower Greenhills Creek, there was evidence for dewatering during the historical period (2014 and 2015 for Smith Ponds Channel and 2012 for Lower Greenhills Creek) and during no years during the Decline Window. Comparison among periods was not possible for the Fording River Side Channel due to lack of hydrological data.

Where the comparison is possible (i.e., data exist for both periods), there also appeared to be little difference in the occurrence of dewatering events during the fry present period. For Kilmarnock Phase 1 Discharge Channel, dewatering events occurred during the fry present period in all years except one (2012), for Kilmarnock Phase 2 Discharge Channel, dewatering events occurred outside of the fry present period in all years.

Available data suggest that dewatering and stranding risk during the Decline Window was similar during the historical period. This further supports evaluation that the requisite conditions for causing the WCT decline were not met.

4.3. Assumptions and Uncertainty

Key uncertainties that limit confidence in this assessment are:

- The assessment of the occurrence of dewatering events was based mostly on weekly or monthly hydrological spot measurements, which may miss short-duration extreme low flow events (each data point represents a snapshot in time; for example, see Section 3.3.3). In addition, some data gaps were identified for some channels and time periods.
- Hydrological data were not available to evaluate dewatering events for Fish Pond Creek, West Exfiltration Ditch, Grassy Creek, and the Greenhouse Side Channel and potential stranding risk for these channels was assessed based in part on assumptions about stable groundwater supply. Hydrological data were also not available to evaluate dewatering events for Fording River Side Channel. Assumptions for habitat quality and stranding sensitivity were required for some channels.
- Where hydrological data were available, the data record was not adequate or was limited for determining some important factors that affect mortality risk to fish, including:
    - The rate of flow change - Although there is high risk of fish stranding and isolation when flows cease completely, stranding and isolation can also occur when flows drop rapidly (i.e., ramping). The hydrological data were insufficient to determine or compare rates of flow changes (ramping events) among years; thus, complete dewatering events were used as indicators of moderate or high stranding risk (Table 4) even though stranding may occur if flows do not drop completely, provided that habitat is sensitive to stranding and fish are present. This approach also allowed comparisons between the Decline Window and the historical period.
    - The duration of dewatering events – Stranding likelihood is affected by the duration of dewatering events because there is a time lag between loss of flow and loss of wetted habitat. For this assessment, we assumed that any duration of dewatering was sufficient to cause mortality.
    - Fine-scale wetted history of the channel - Stranding likelihood is typically evaluated from magnitude and duration of flow changes in relation to the wetted history of the channel because wetted history provides information on the likelihood of fish presence within stranding sensitive habitats.
- It was assumed that any flow > 0 m^3/s will sustain fish and that a cessation of flow (i.e., 0 m^3/s) would cause stranding of fish. However, data on site-specific habitat characteristics were not available to evaluate flows that would be required to sustain fish. For example, the extreme low flows documented in some channels (e.g., Clode Creek, Lake Mountain Creek, Smith Ponds Channel, and Porter Creek) were assumed to not cause fish stranding risk because no flows of 0 m^3/s were recorded. Conversely, even the complete loss of flow may not cause

mortality of all fish because residual pools may exist that retain water for some time and therefore may sustain fish for a period of time, and fish may move to avoid stranding as flows subside. Differences in stranding risk by age class at low flows, along with age classes likely present, could not be considered with current data.

- Fish presence data were not available for some channels, so fish presence was inferred from habitat accessibility and habitat quality.
- Although the same methods and assumptions were used for the two time periods (historical period and Decline Window), confident comparison between the two time periods is limited by the quality of the hydrological data (described above). For example, although the same stranding risk assessment may have resulted for a particular channel for both time periods, differences in hydrological factors, such duration of dewatering events, rate of flow changes, and wetted history, could result in different outcomes for fish.
- Stranding sensitivity of habitat is generally variable within channels and in some cases varied substantially (e.g., in Kilmarnock Phase 2 Discharge Channel), in which cases the overall evaluation of stranding sensitivity was an estimate of typical or general conditions.
- The spatial distribution of the WCT population within accessible habitat was not considered in the assessment; thus, proportion of the total population potentially affected could not be directly evaluated. Rather the proportion of the population affected was estimated as proportional to the habitat affected by dewatering in relation to the total habitat available in the UFR.
- Habitat type (e.g., rearing, spawning) was not considered when habitat area in the channels was related to total habitat available in the UFR. The assessment therefore provides a rough comparison of habitat potentially affected to that available.
- Potential stranding risk did not consider flow in UFR, which can impact stranding of fish in channels: high UFR flows may reduce stranding risk when there is backwatering of the channels (in which case dewatering of channels would be precluded in spite of zero inflows) or could increase stranding risk if they are sufficient to allow fish access to areas where they can be stranded when flows drop.
- Fish were assessed as not present in a channel (and an assessment for stranding potential was not conducted) if there was a barrier to fish access (including a partial life stage barrier) under most conditions (e.g., Post Sediment Ponds Channel, Eagle Settling Ponds Channel, Liverpool Sediment Ponds Channel, MS Settling Ponds Channel); however, some of these channels, or portions thereof, may be accessible at extreme flood events, in which case stranding could occur when flows recede, or to small fish.

Table 6. Summary of accessible habitat area and potential stranding risk to fish by channel.

Channel Location	Accessible Habitat Area (m²)			% Habitat Relative to UFR	Fish Presence	Habitat Quality	Stranding Sensitive Habitat	Evidence of Dewatering[1] 2011	2012	2013	2014	2015	2016	2017	2018	2019
Post Sediment Ponds Channel	-	N	n/a	n/a	N	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Eagle Settling Ponds Channel	-	N	n/a	n/a	N	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Liverpool Sediment Ponds Channel	Y	Y	n/a	n/a	N	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
MS Ponds Channel			n/a	n/a	N	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
North Loop Settling Pond Channel			n/a	n/a	N	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Cataract Creek	Y	N	n/a	n/a	N	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Fish Pond Creek	900	4	3,100	0.34%	Y	Good	Low	No[2]	No[2]	No[2]	No[2]	No[2]	No[2]	No[2]	No[2]	No[2]
Clode Creek	172	4	688	0.08%	Y	Good	Low	No	No	No	No	No	No	No	No	No
West Exfiltration Ditch	284	4	1,136	0.12%	Y	Good	Low	No[2]	No[2]	No[2]	No[2]	No[2]	No[2]	No[2]	No[2]	No[2]
Grassy Creek	236	5	1,180	0.13%	Y	Poor	Low	No[2]	No[2]	No[2]	No[2]	No[2]	No[2]	No[2]	No[2]	No[2]
Lake Mountain Creek	23	9	207	0.02%	Y	Poor	High	No	No	No	No	No	No	Yes[3]	No	No
Smith Ponds Channel	253	6	1,427	0.16%	Y	Good[4]	High[4]	No	No	No	Yes	Yes	No	No	No	No
Kilmarnock Phase 1 Discharge Channel	204	10	1,938	0.21%	Y	Poor	High[5]	Yes	Yes	Yes	Yes	No	No	No	Yes	No
Fording River Side Channel	427	12	5,295	0.58%	Y	Good	High	–	–	–	–	–	–	–	Yes	–
Kilmarnock Phase 2 Discharge Channel	82	13	1,099	0.12%	Y	Poor	Moderate	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No
Swift Creek	0-468	0-7	2,808	0.31%	Y	Good	High	No	No	No	No	No	No	No	Yes[6]	No
Greenhouse Side Channel	1,513	9	14,700	1.61%	Y	-	-	No[2]	No[2]	No[2]	No[2]	No[2]	No[2]	No[2]	No[2]	No[2]
Porter Creek	335	2	670	0.07%	Y	Good	Low	No	No	No	No	No	No	No	No	No
LCO Dry Creek	1,712	4	6,848	0.75%	Y	Good	Moderate	No	No	No	No	No	No	No	No	No
Lower Greenhills Creek	736	3	2,208	0.24%	Y	Good	Moderate	No	Yes	No	No	No	No	No	No	No
Total Habitat	**-**	**-**	**48,008**	**5.26%**												
Relative Area Stranding Risk Summary[7]	Potential Stranding Risk: Low				% Low Rating			3.8%	3.6%	3.8%	3.7%	3.9%	4.2%	3.7%	3.5%	3.9%
	Potential Stranding Risk: High				% High Rating			0.3%	0.3%	0.3%	0.5%	0.3%	0.0%	0.4%	0.9%	0.3%

[1] Colours correspond to potential stranding risk ratings: pink indicates that there was evidence for dewatering and potential stranding risk was assessed as high; blue indicates that there was no evidence of dewatering, or any dewatering was preceded by fish salvage, and potential stranding risk was therefore assessed as low. Grey (n/a) indicates that the channel is non-fish bearing. Dashes indicate that hydrological data were not available and assumptions about dewatering could not be made. Vertical line between 2016 and 2017 delineates the historical period from the decline window.

[2] Relative habitat for Fish Pond Creek was not included in total habitat due to insufficient flow data

[2] Assumed to have a stable flow due to groundwater influence, but no flow data were available to confirm that dewatering did not occur.

[3] A dewatering event occurred due to planned maintenance, but it was preceded by fish salvage; thus stranding risk to fish was low.

[4] No habitat quality or stranding sensitive habitat data available; however, habitat quality assumed good and stranding risk assumed high based on fish presence during salvage in 2018 and 2019.

[5] No stranding sensitive habitat data available; however, stranding risk assumed high based on documented stranding in 2018.

6 The risk of stranding was mitigated through a fish salvage and fish fence. Stranding risk was therefore low during the dewatering events in 2018.

[7] Relative % habitat indicated for channels and years where there was evidence for dewatering and potential stranding risk was assessed as high (pink) or moderate (yellow), and where there was no evidence of dewatering and potential stranding risk was therefore assessed as low (blue).

5. CONCLUSION

This assessment evaluated the potential for channel dewatering to have caused or contributed to the observed decline of WCT. Twenty channels were identified, 15 of which drain into the UFR and have potential for flow changes from operational water use from Teck Coal facilities, four of which may be hydrologically linked to Teck Coal operations, and one of which is an operationally influenced side channel of the UFR. The channels were assessed for fish presence, habitat quality and quantity, sensitivity of habitat to stranding, and hydrology, which allowed requisite conditions to be evaluated with the aim of determining whether dewatering events may have caused or contributed to reduced WCT abundance.

Although some requisite conditions (Intensity, Location, and Timing) for channel dewatering causing or contributing to the WCT population decline were met for three of 16 channels, the requisite condition for Spatial Extent was not met because the proportion of habitat that is accessible to fish in these channels is small. Dewatering events were also determined to be similar between the Decline Window and the historical period. Thus, the assessment concluded that the channel dewatering stressor did not cause the WCT population decline. Uncertainties were identified (Section 4.3), especially in relation to limitations of hydrological data used to characterize dewatering events and assess the potential for fish stranding.

Some requisite conditions for channel dewatering contributing to the WCT population decline were met because there was enough evidence to infer fish stranding in the Decline Window. This conclusion is further supported by the 2018 Kilmarnock Phase 1 and Fording River Side Channel stranding event (see sections 1.1.2 and 3.12). The channel dewatering stressor may also interact with other stressors in the EoC. Particularly, ramping or sudden flow changes in the UFR mainstem and dewatering in the UFR mainstem (i.e., in the drying reach) and its side channels could cause fish stranding that would contribute to total WCT stranding.

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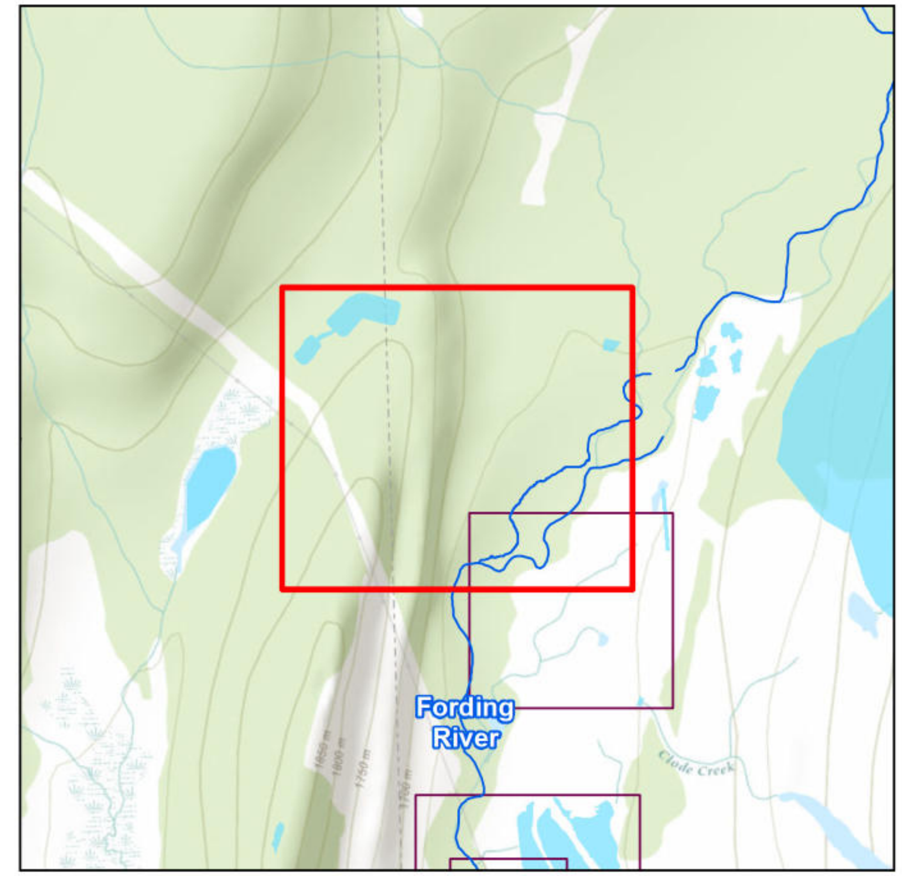
APPENDICES

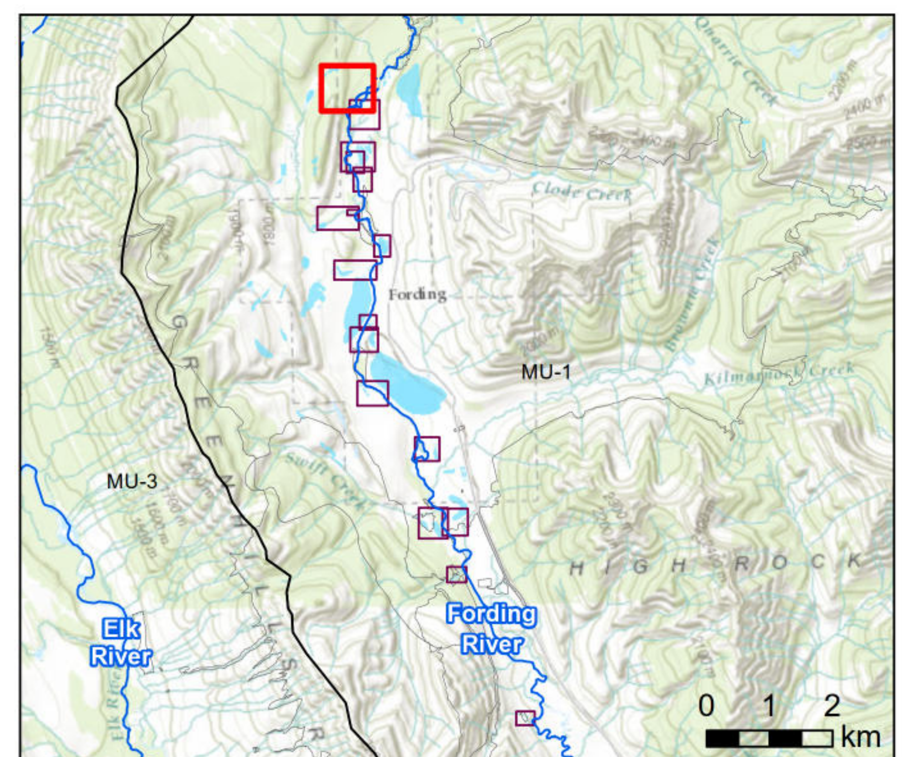
Appendix A. Upper Fording River Evaluation of Cause: Channel Dewatering - Mapbook.

Post Sediment Ponds Channel

Fish Bearing
No

Primary Gauge
FR_PP1





TECK COAL LTD.

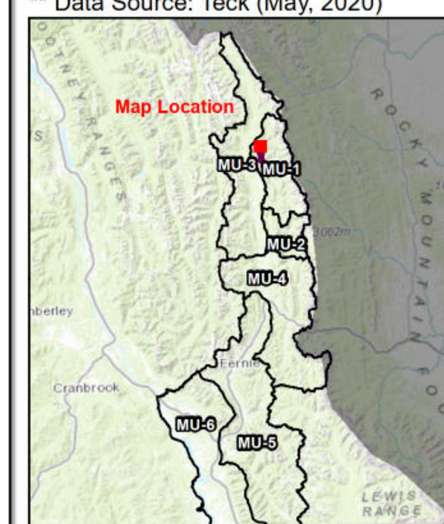
Post Sediment Ponds Channel

Legend

Water Features
- Stream*
- Intermittent Stream*
- Subsurface*
- Water Management Lines**
- Water Management Polygons*
- Channel

Point Features
- Fish Barrier
- Hydrology Stations

* Data Source: Teck (Jan, 2020)
** Data Source: Teck (May, 2020)



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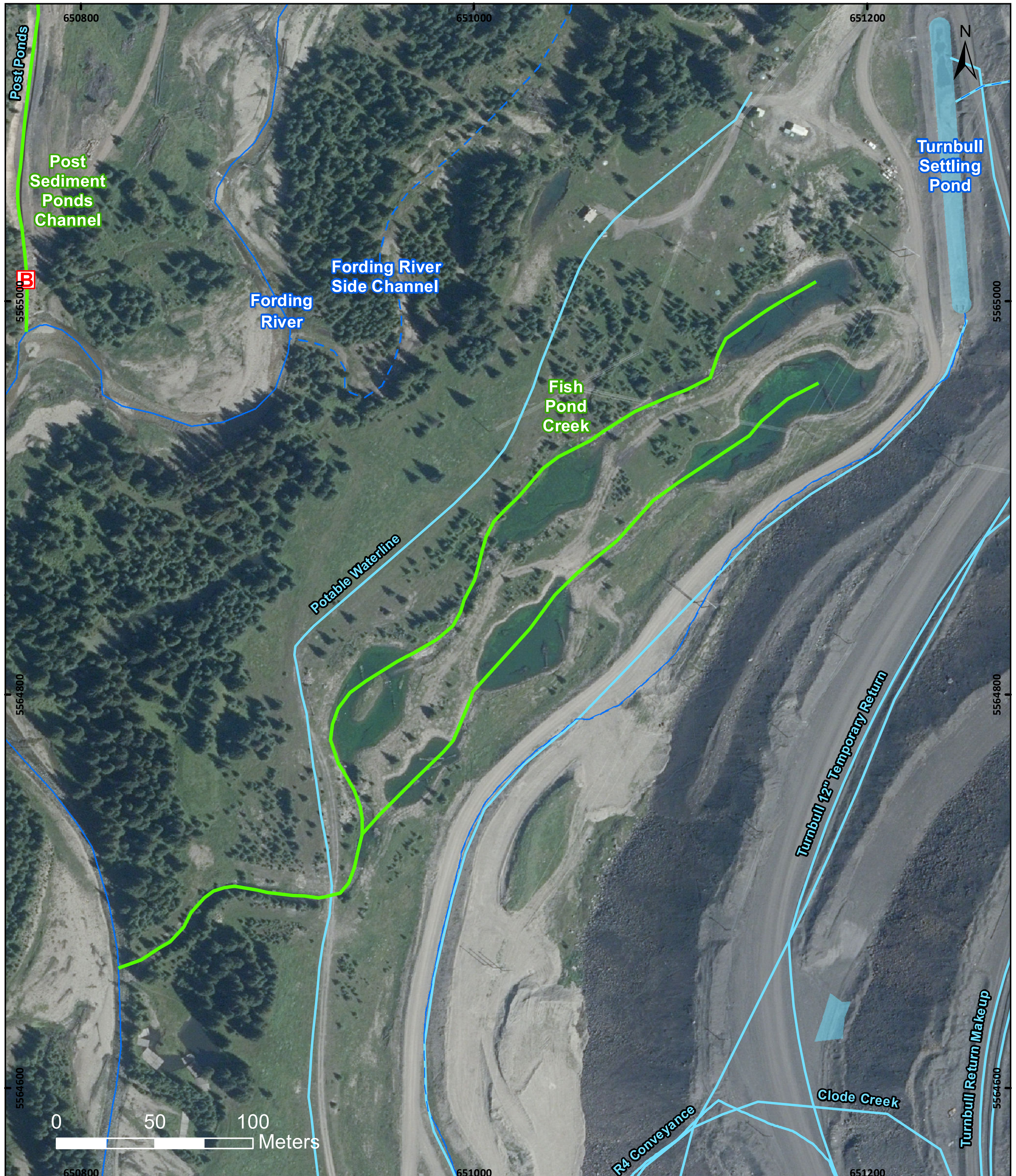
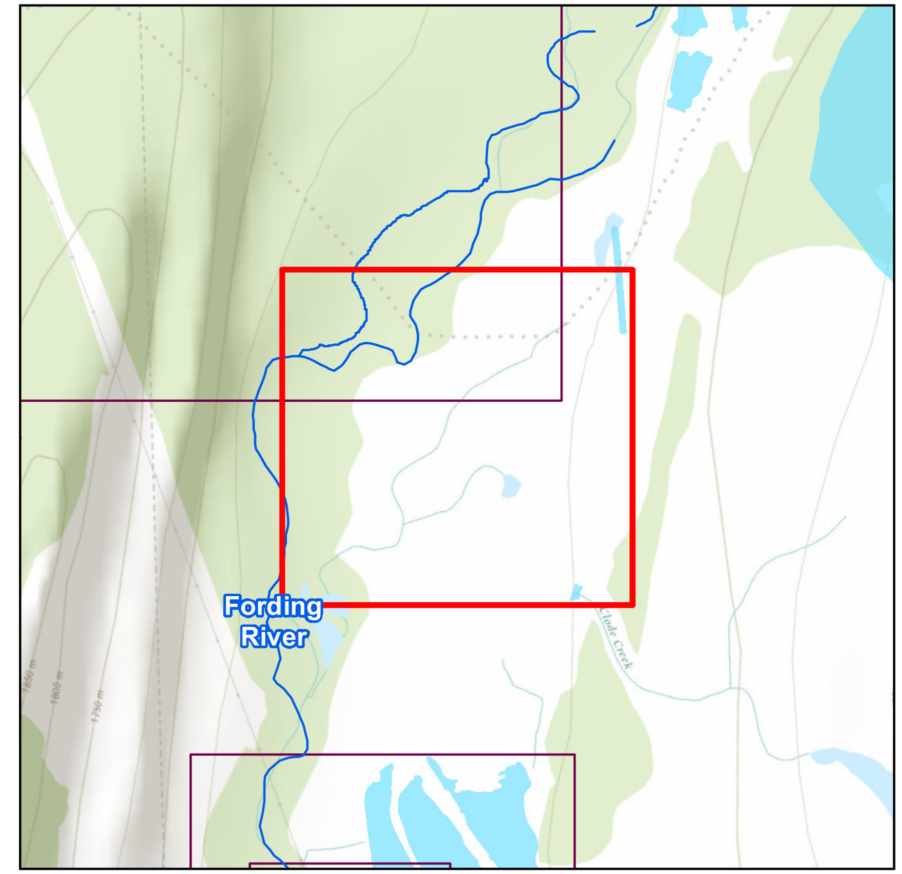
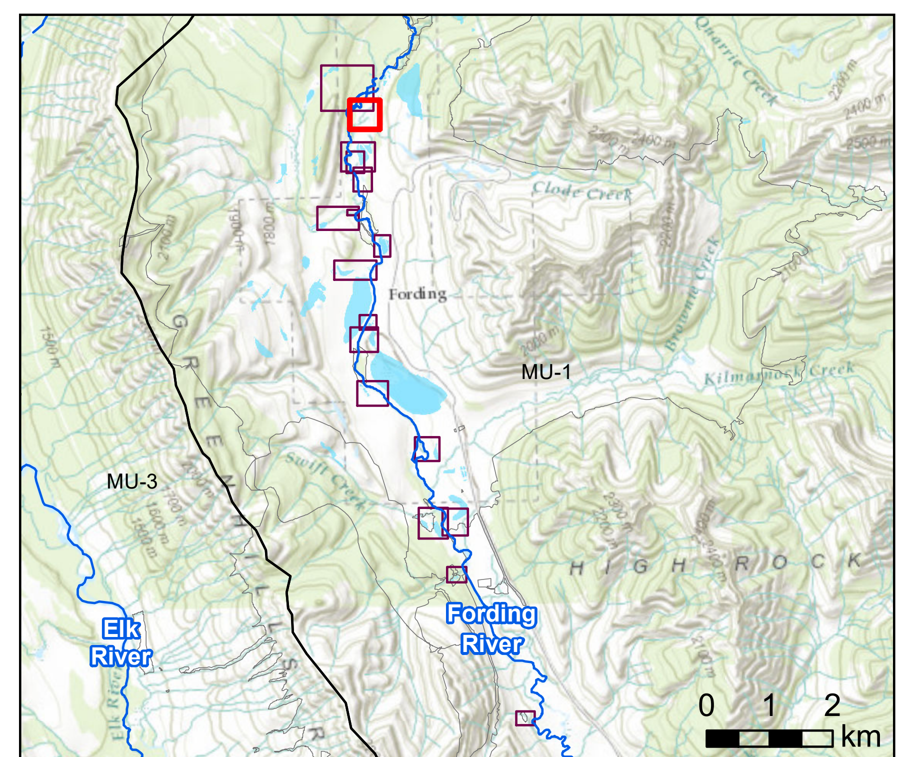


Fish Pond Creek

Fish Bearing Yes

Primary Gauge NA





TECK COAL LTD.

Fish Pond Creek

Legend

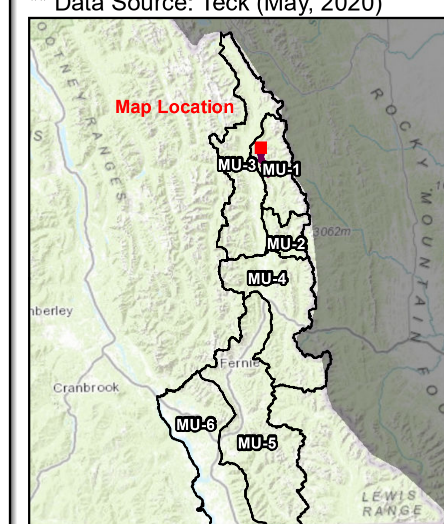
Water Features

- Stream*
- Intermittent Stream*
- Water Management Lines**
- Water Management Polygons*
- Channel

Point Features

- Fish Barrier
- Hydrology Stations

* Data Source: Teck (Jan, 2020)
** Data Source: Teck (May, 2020)



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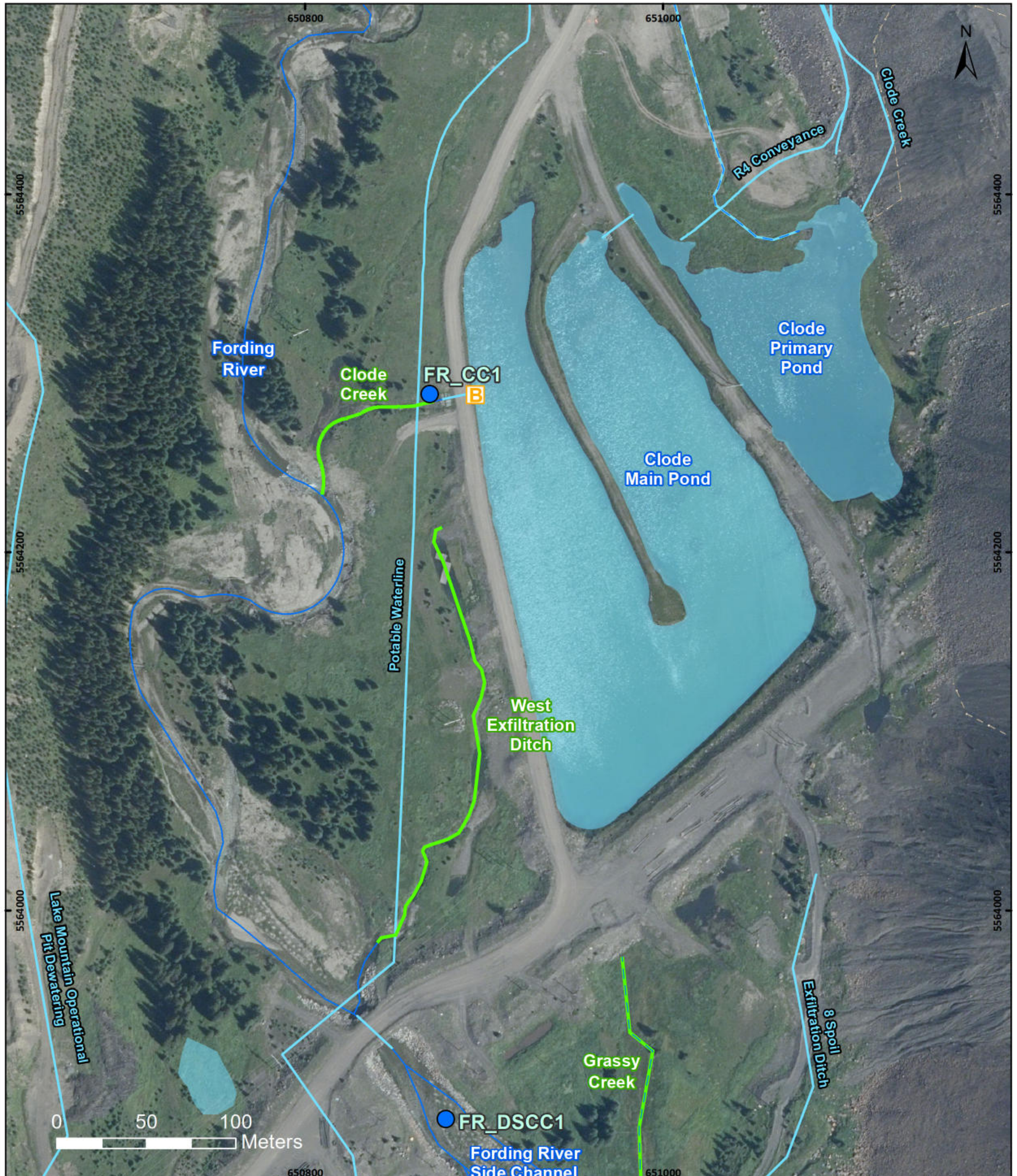
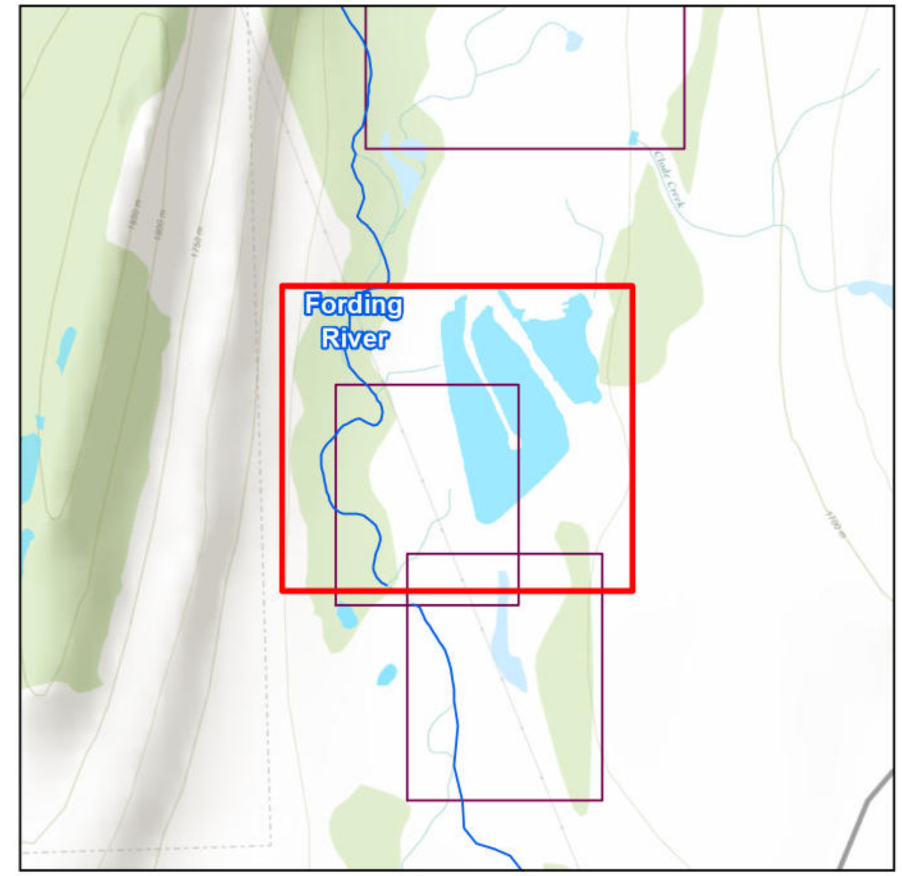
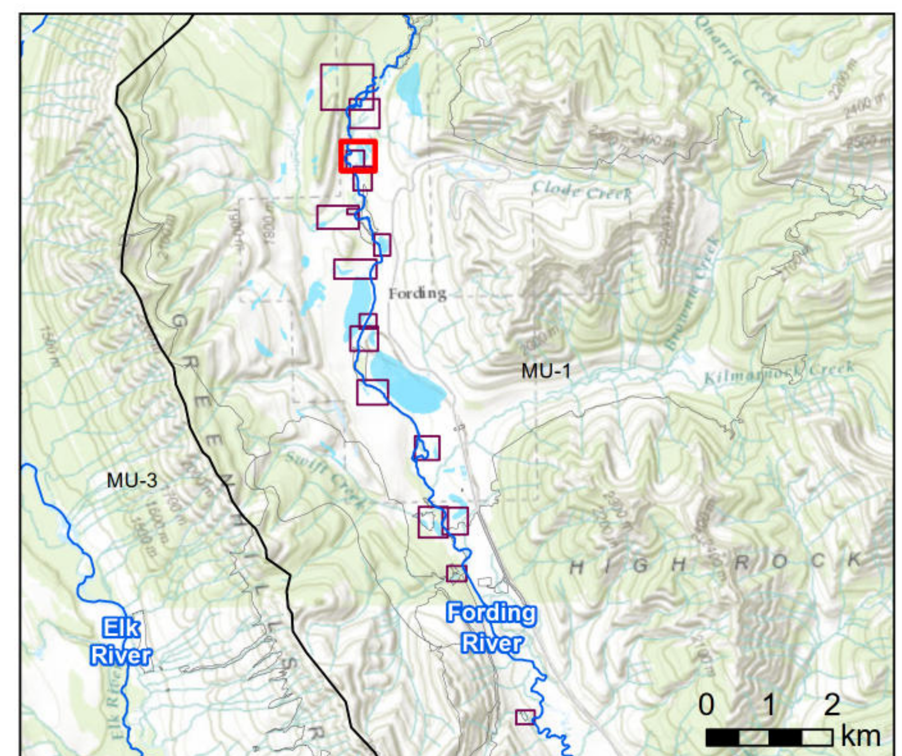


Clode Creek

Fish Bearing	**Primary Gauge**
Yes	FR_DSCC1 / FR_CC1





TECK COAL LTD.

Clode Creek

Legend

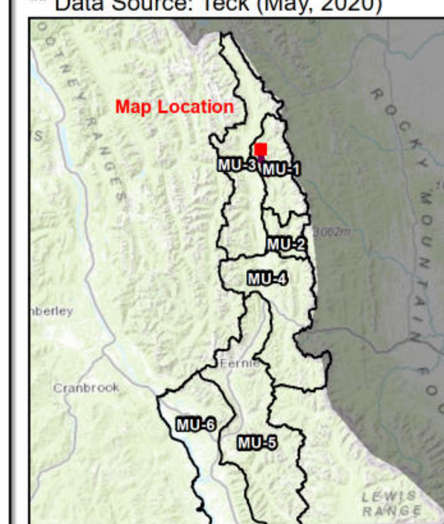
Water Features

- Stream*
- Intermittent Stream*
- Subsurface*
- Water Management Lines**
- Water Management Polygons*
- Channel

Point Features

- B Partial Fish Barrier
- Hydrology Stations

* Data Source: Teck (Jan, 2020)
** Data Source: Teck (May, 2020)



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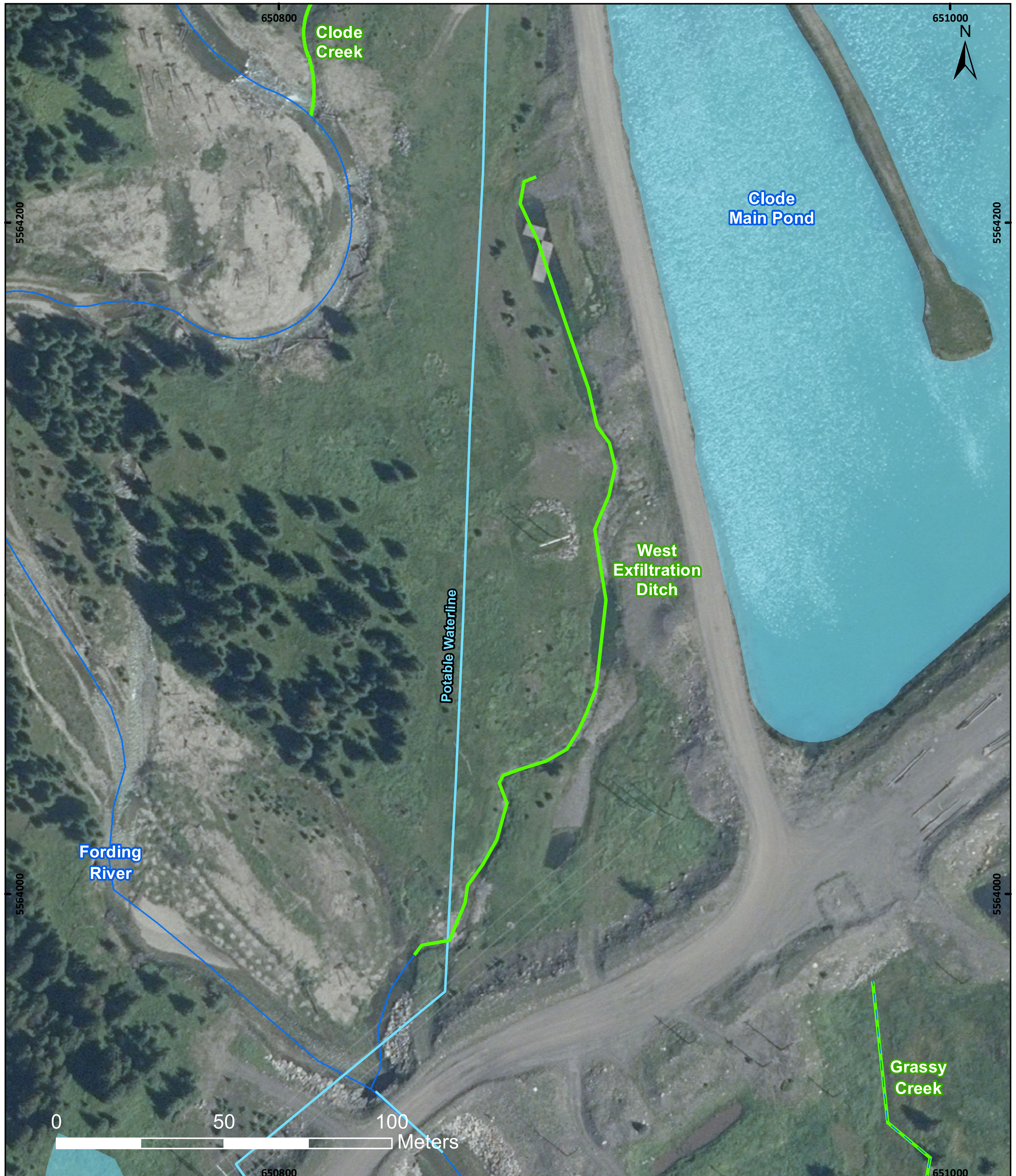
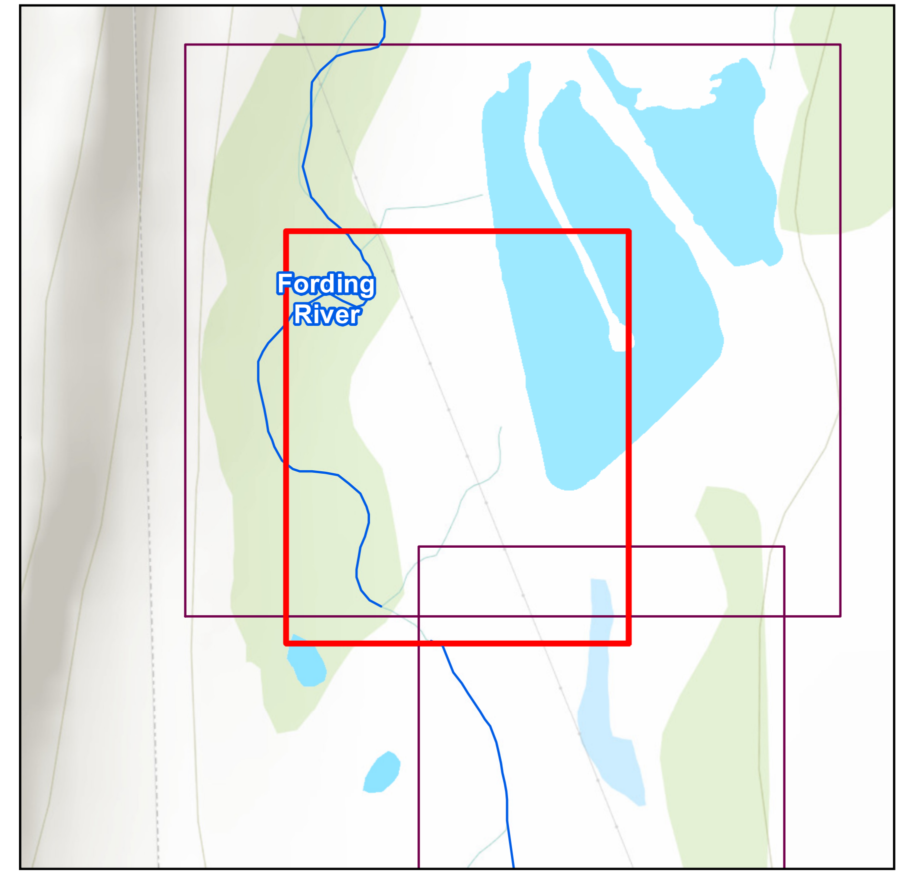
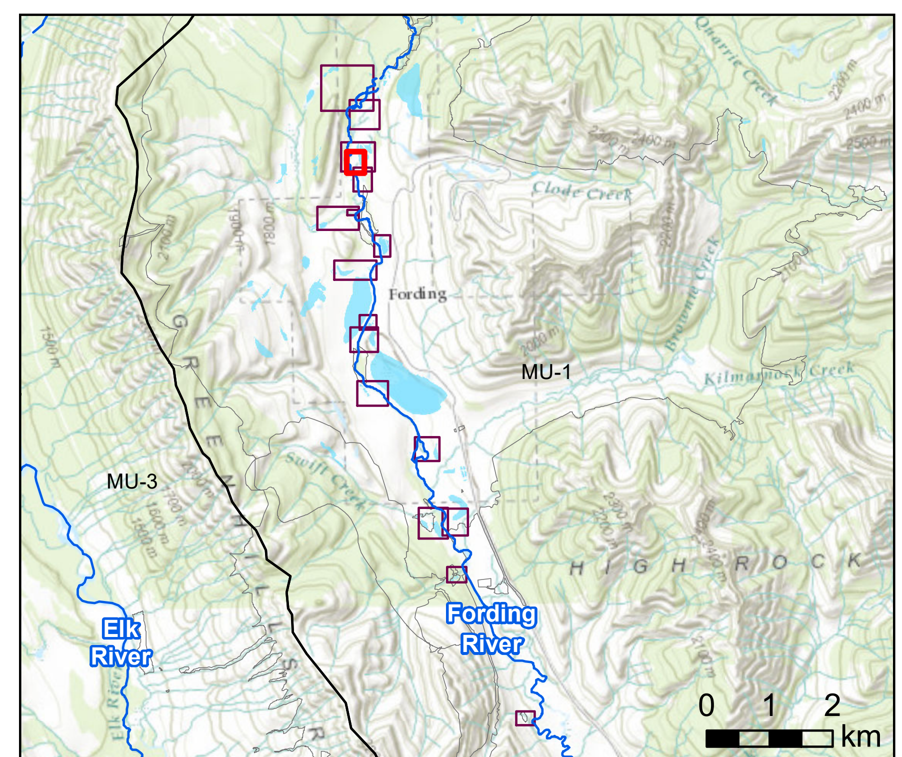
West Exfiltration Ditch

Fish Bearing
Yes

Primary Gauge
NA







TECK COAL LTD.

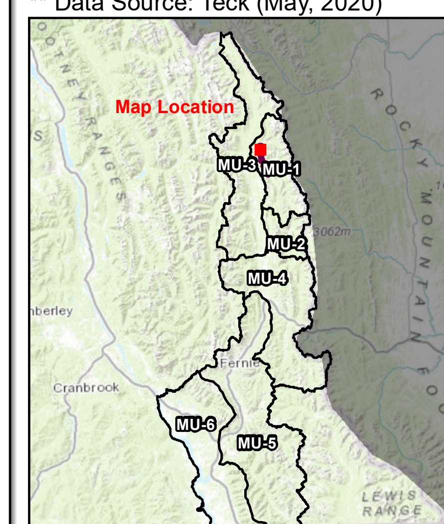
West Exfiltration Ditch

Legend

Water Features

- Stream*
- Intermittent Stream*
- Water Management Lines**
- Water Management Polygons*
- Channel
- Hydrology Stations

* Data Source: Teck (Jan, 2020)
** Data Source: Teck (May, 2020)



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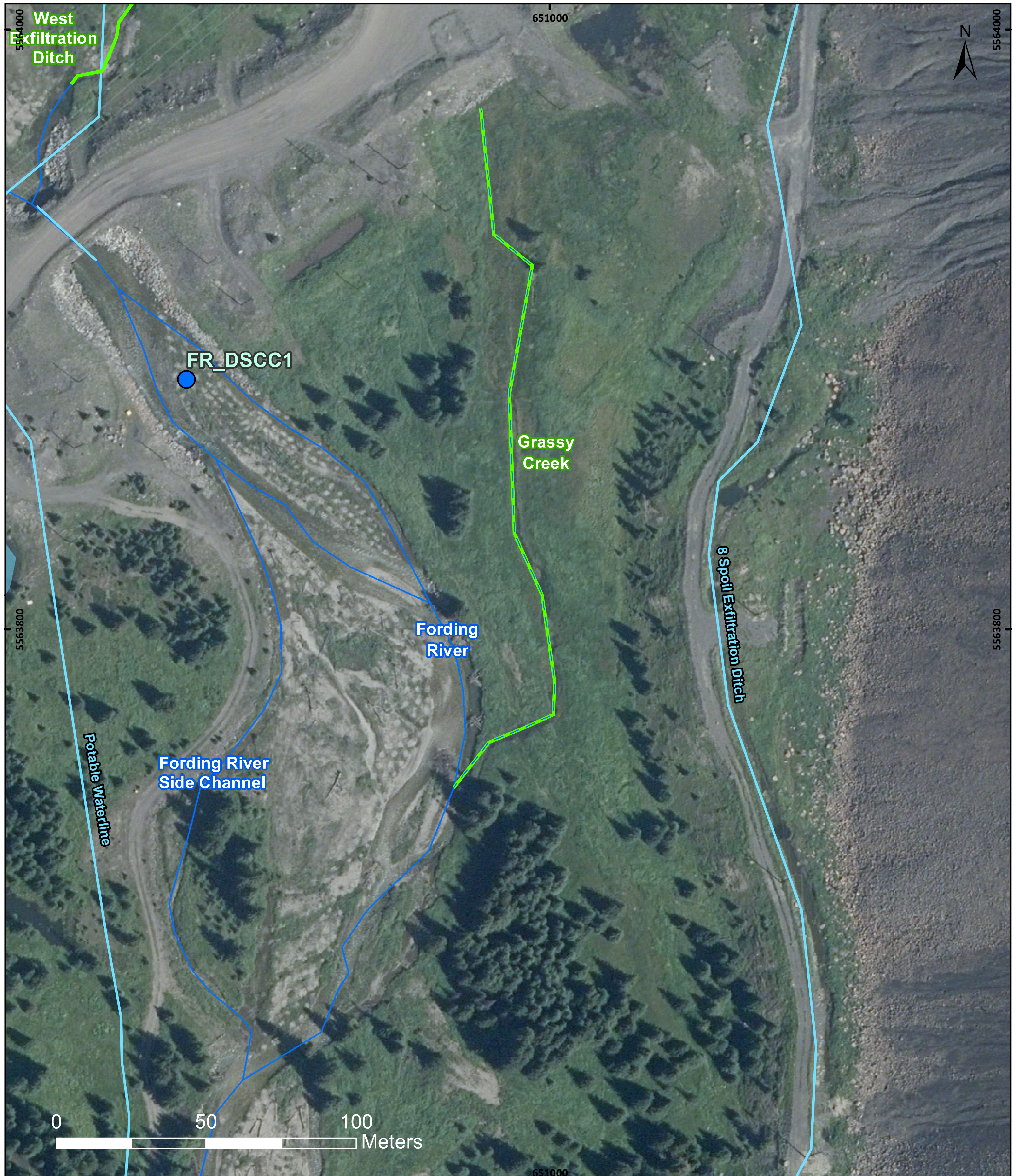
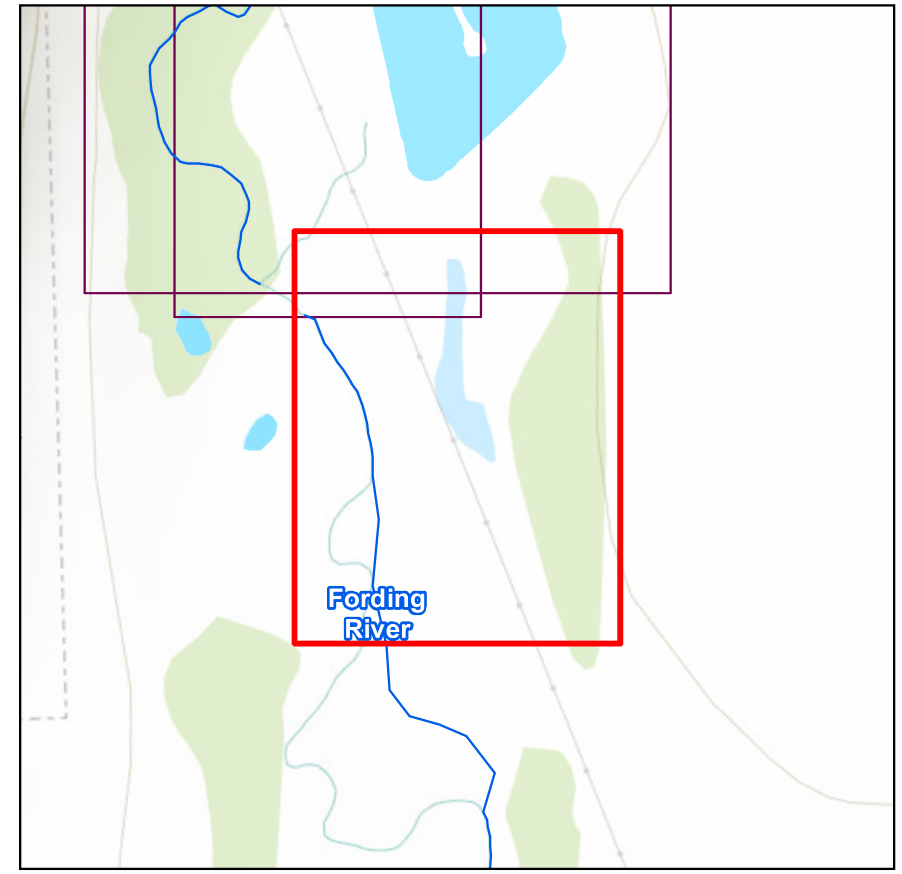
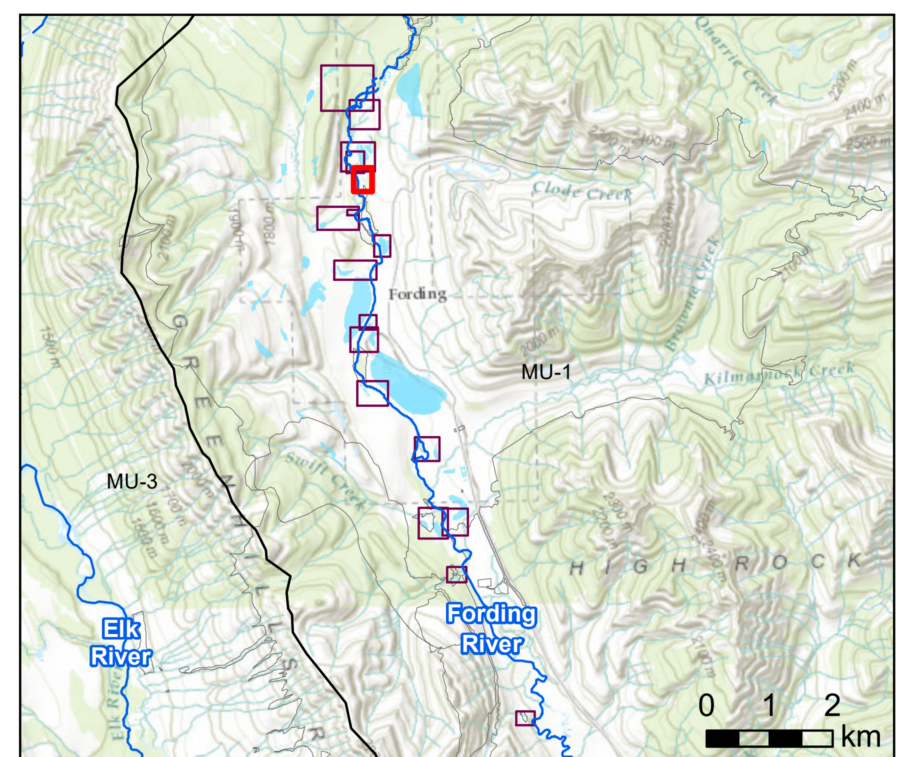


Grassy Creek

Fish Bearing
Yes

Primary Gauge
NA





TECK COAL LTD.

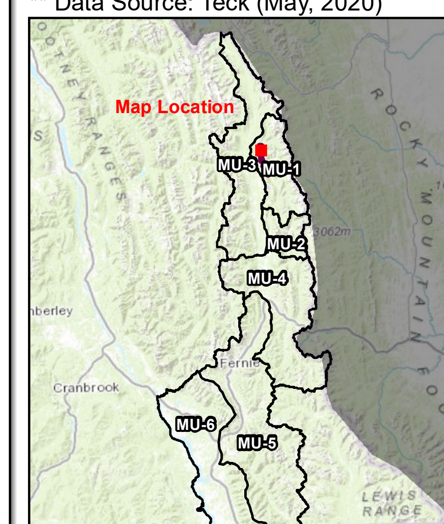
Grassy Creek

Legend

Water Features

- Stream*
- Intermittent Stream*
- Water Management Lines**
- Water Management Polygons*
- Channel
- Hydrology Stations

* Data Source: Teck (Jan, 2020)
** Data Source: Teck (May, 2020)



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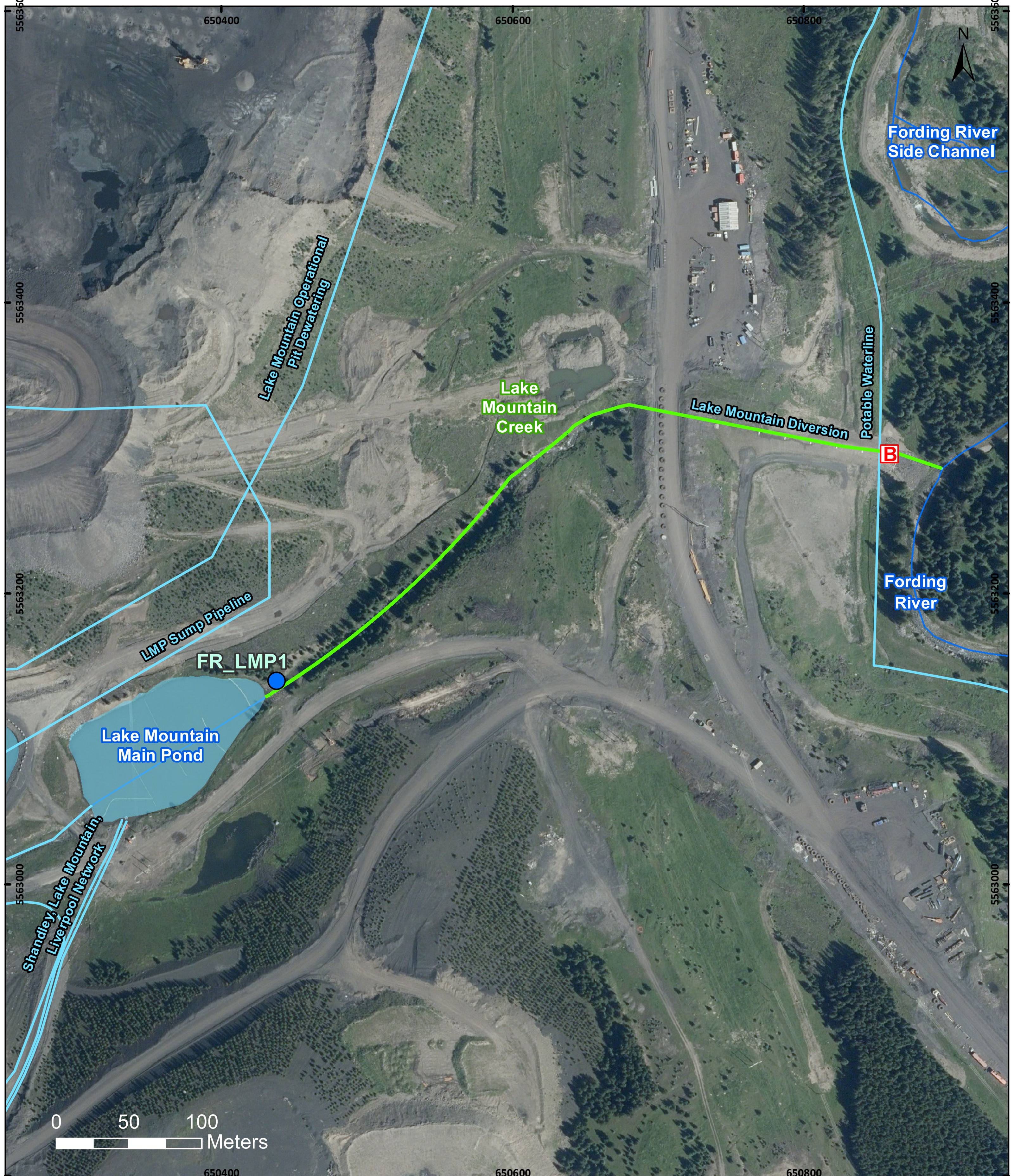
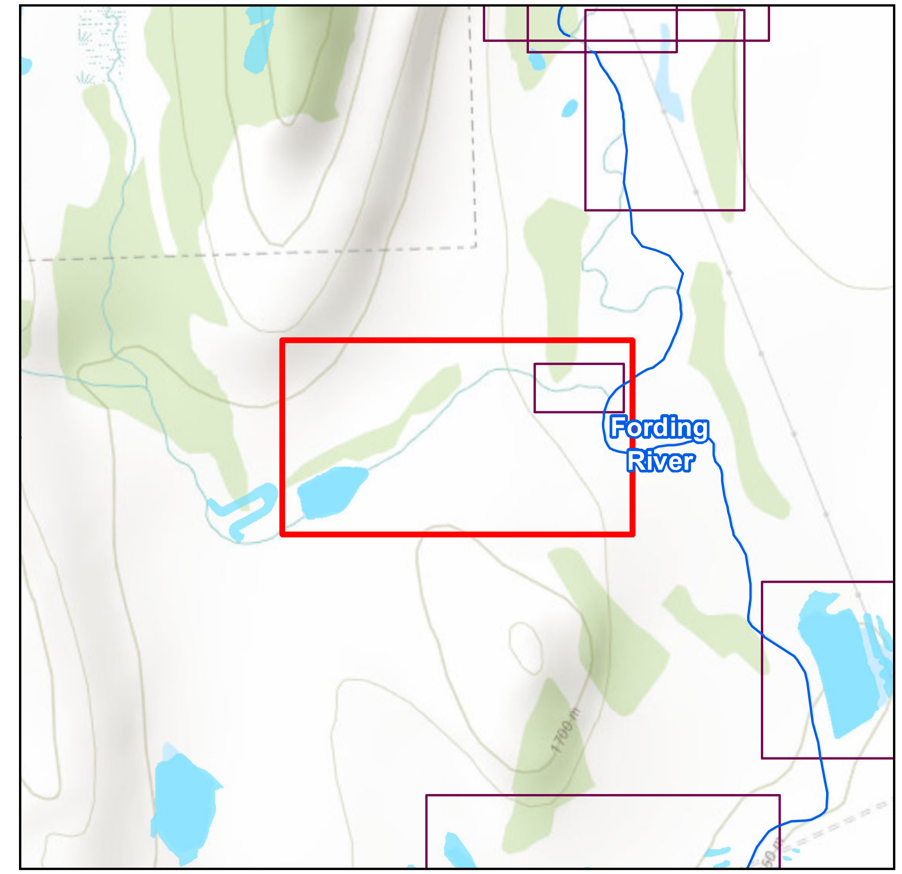
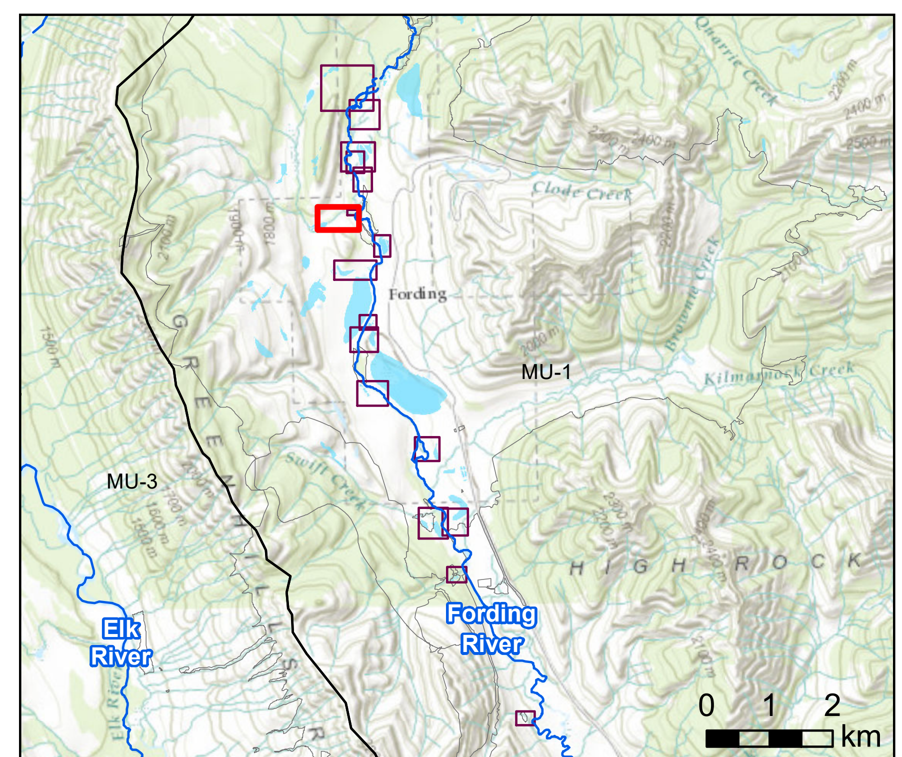
Lake Mountain Creek

Fish Bearing	Primary Gauge
No	FR_LMP1







TECK COAL LTD.

Lake Mountain Creek

Legend

Water Features

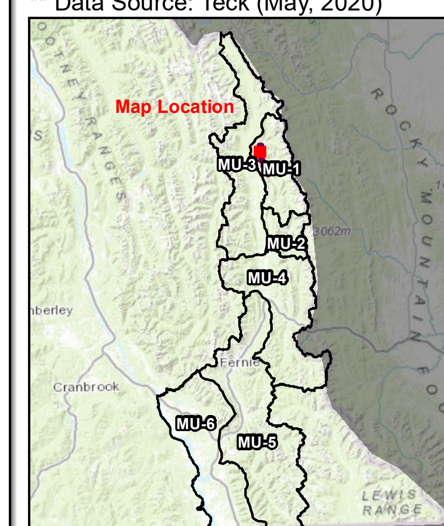
- Stream*
- Water Management Lines**
- Water Management Polygons*
- Channel

Point Features

- Fish Barrier
- Hydrology Stations

* Data Source: Teck (Jan, 2020)

** Data Source: Teck (May, 2020)



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Date Saved: 2020-06-15

Coordinate System: NAD 1983 UTM Zone 11N

ECOFISH RESEARCH

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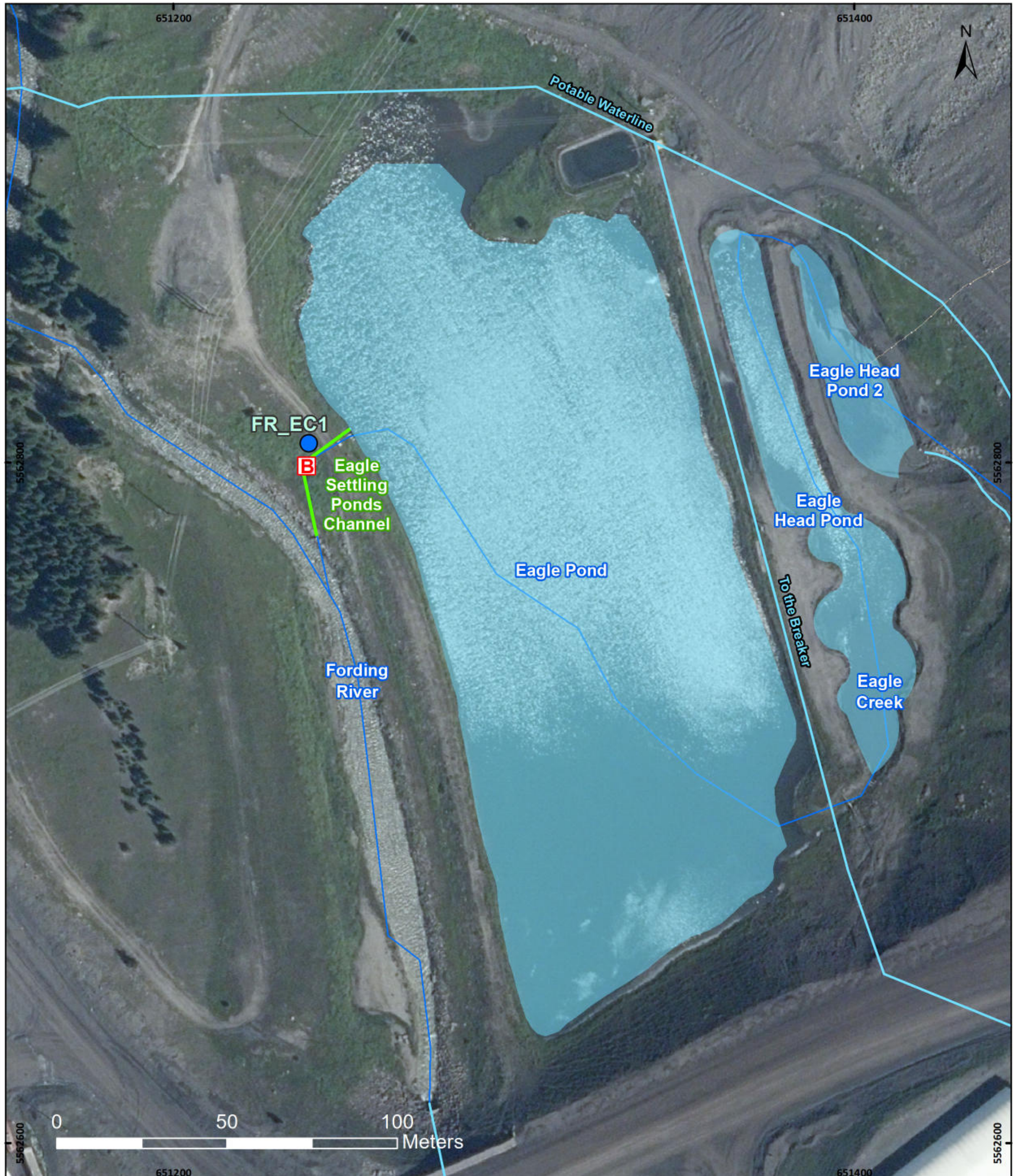
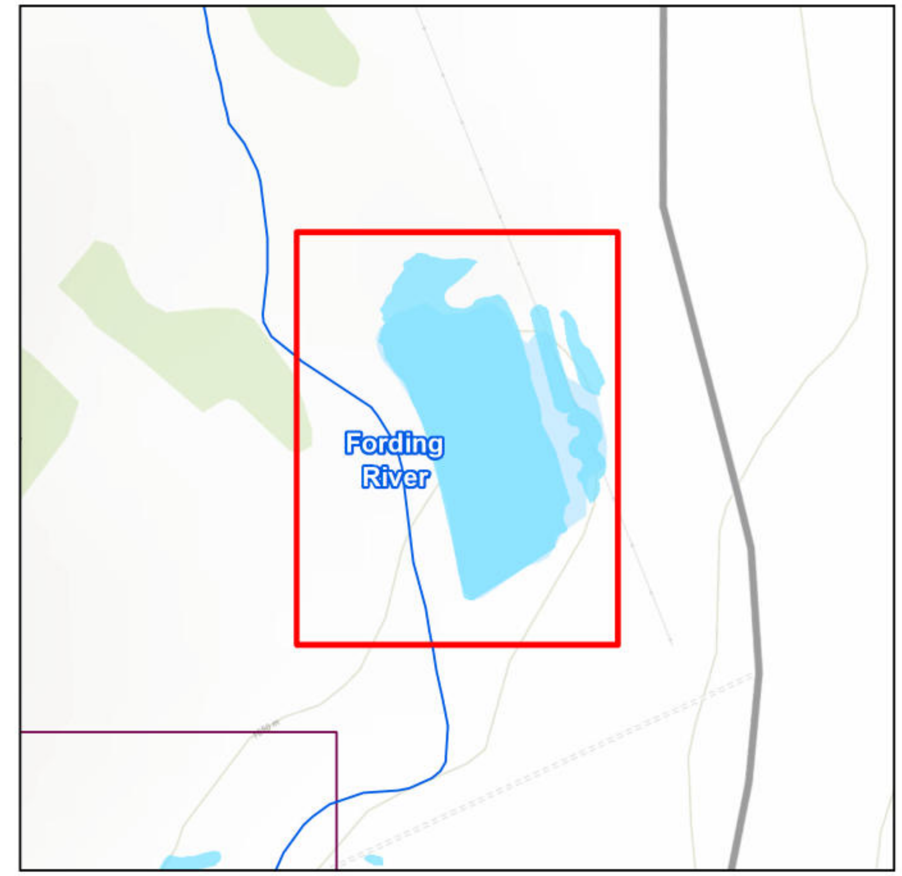
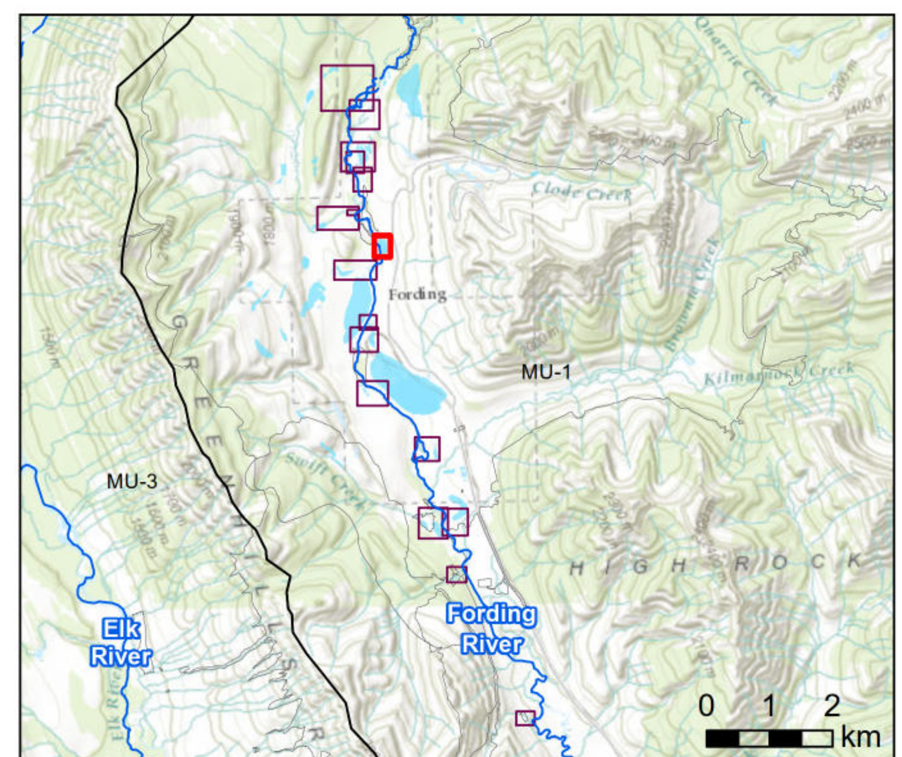


Eagle Settling Ponds Channel

Fish Bearing
No

Primary Gauge
FR_EC1





TECK COAL LTD.

Eagle Settling Ponds Channel

Legend

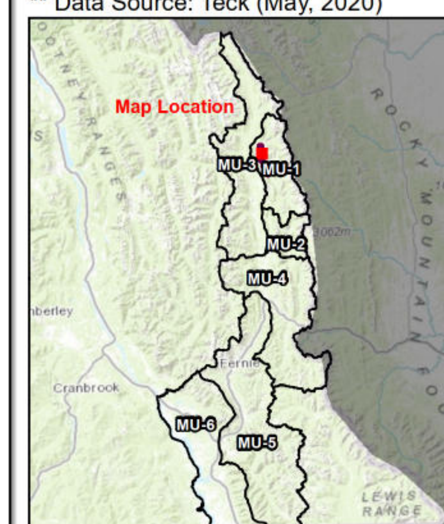
Water Features

- Stream*
- Subsurface*
- Water Management Lines**
- Water Management Polygons*
- Channel

Point Features

- B Fish Barrier
- Hydrology Stations

* Data Source: Teck (Jan, 2020)
** Data Source: Teck (May, 2020)



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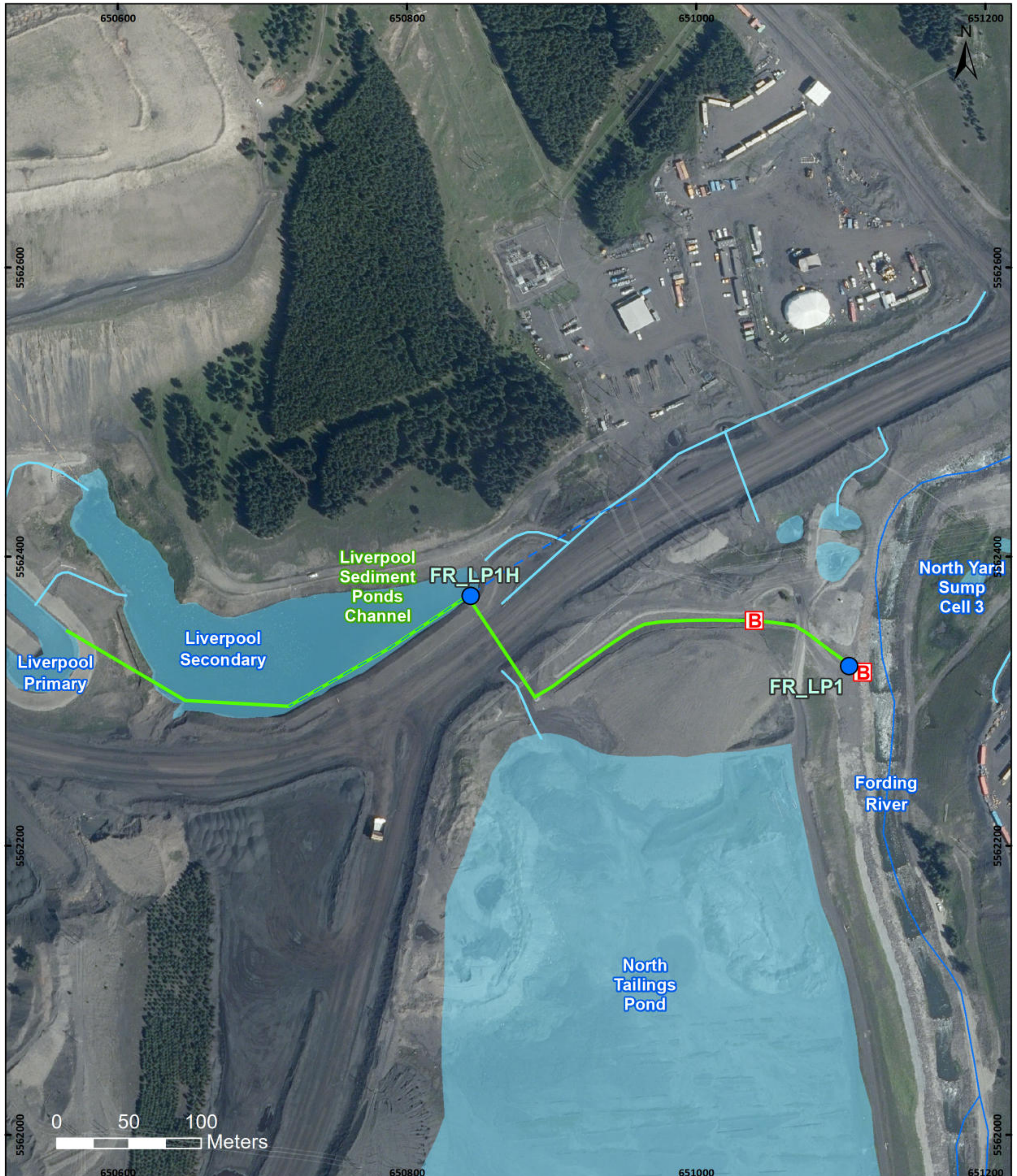
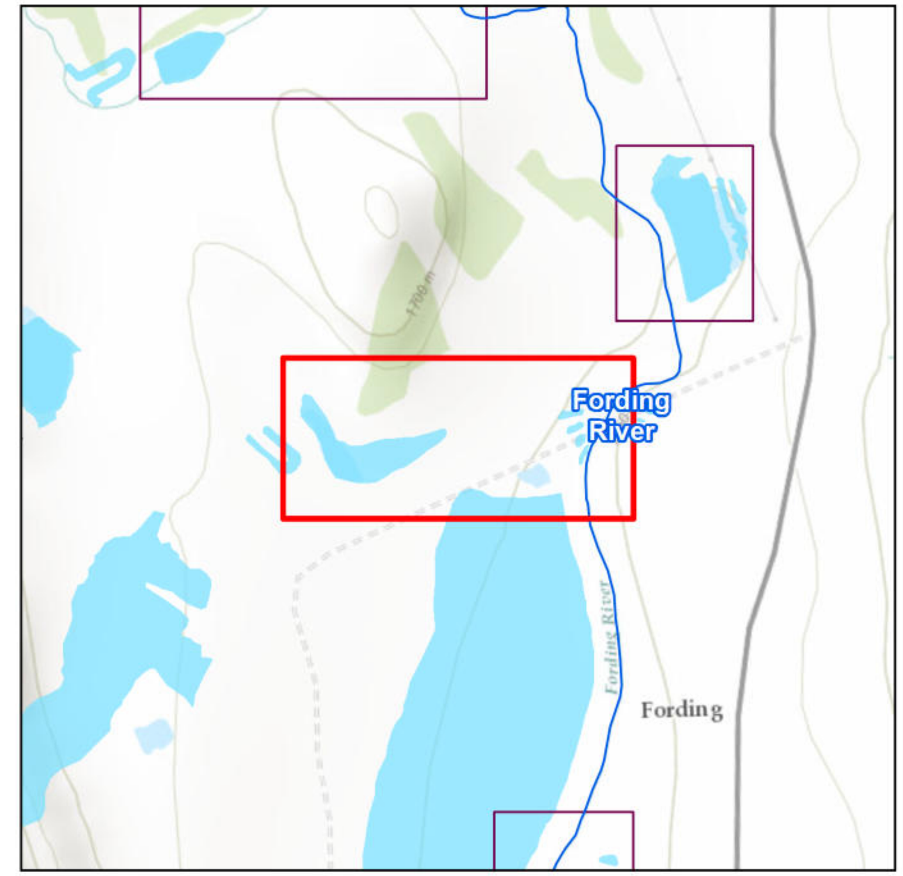
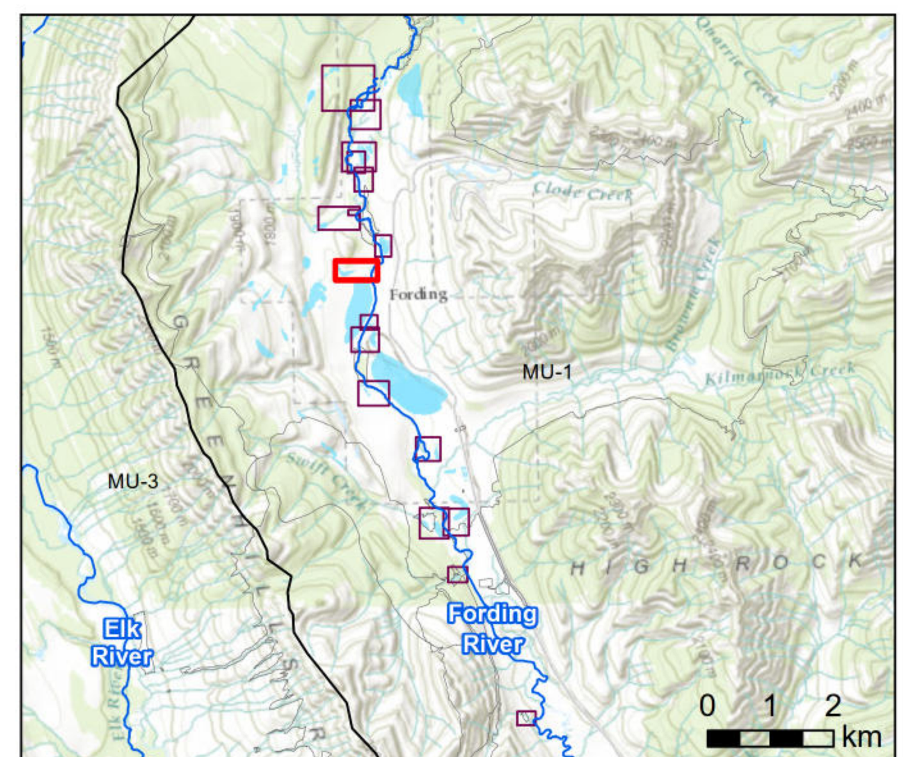


Liverpool Sediment Ponds Channel

Fish Bearing
No

Primary Gauge
FR_LP1





TECK COAL LTD.

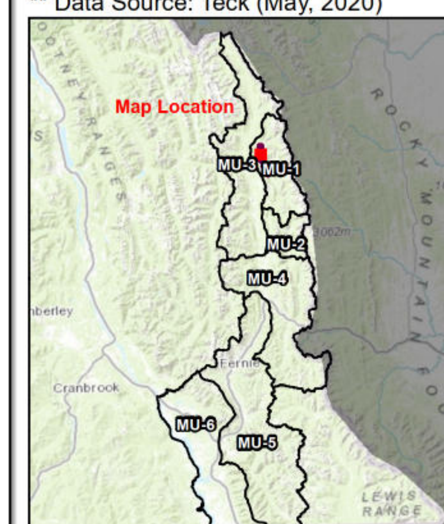
Liverpool Sediment Ponds Channel

Legend

Water Features
- Stream*
- Intermittent Stream*
- Subsurface*
- Water Management Lines**
- Water Management Polygons*
- Channel

Point Features
- Fish Barrier
- Hydrology Stations

* Data Source: Teck (Jan, 2020)
** Data Source: Teck (May, 2020)



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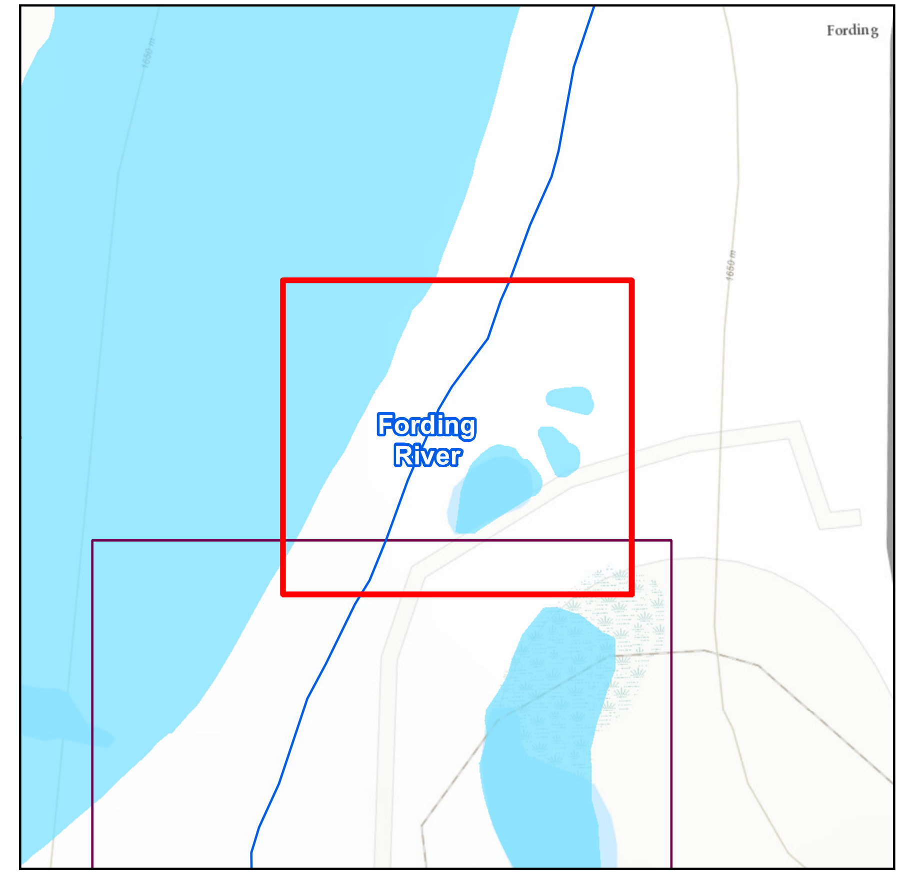
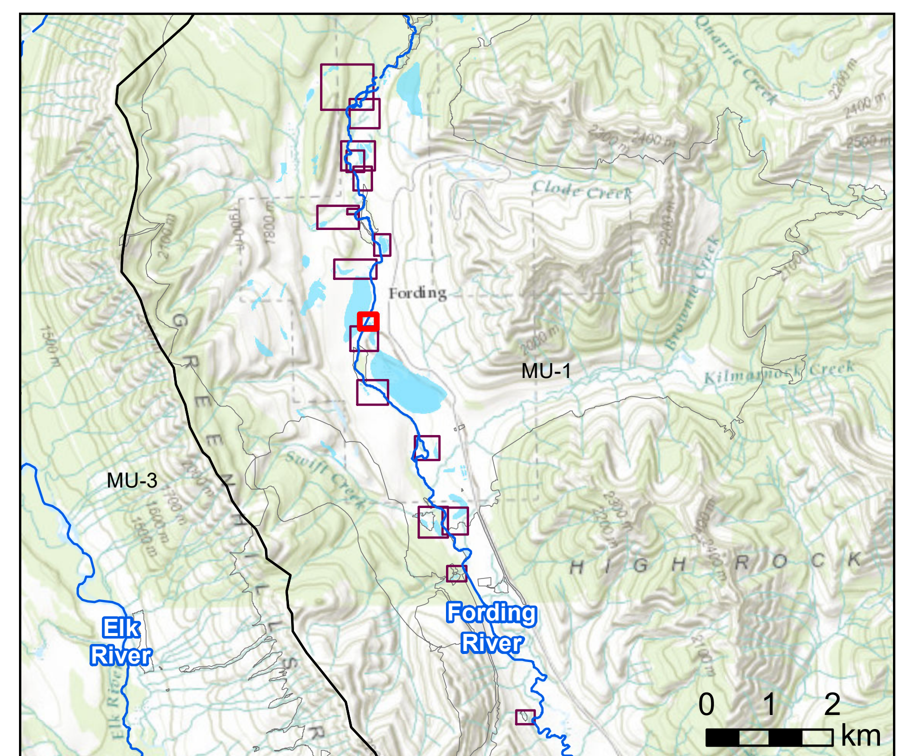
Maintenance and Service Settling Ponds Channel

Fish Bearing
No

Primary Gauge
FR_MS1





TECK COAL LTD.

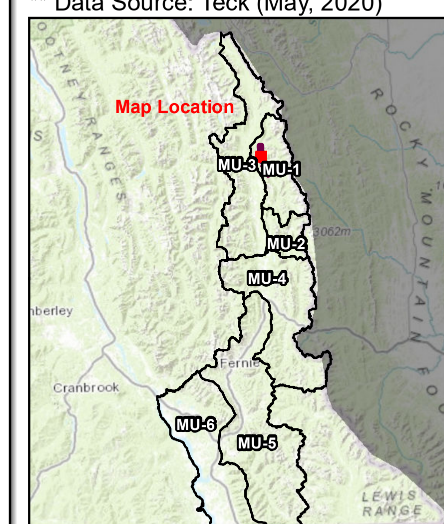
Maintenance and Service Settling Ponds Channel

Legend

Water Features
- Stream*
- Water Management Lines**
- Water Management Polygons*
- Channel

Point Features
- Fish Barrier
- Hydrology Stations

* Data Source: Teck (Jan, 2020)
** Data Source: Teck (May, 2020)



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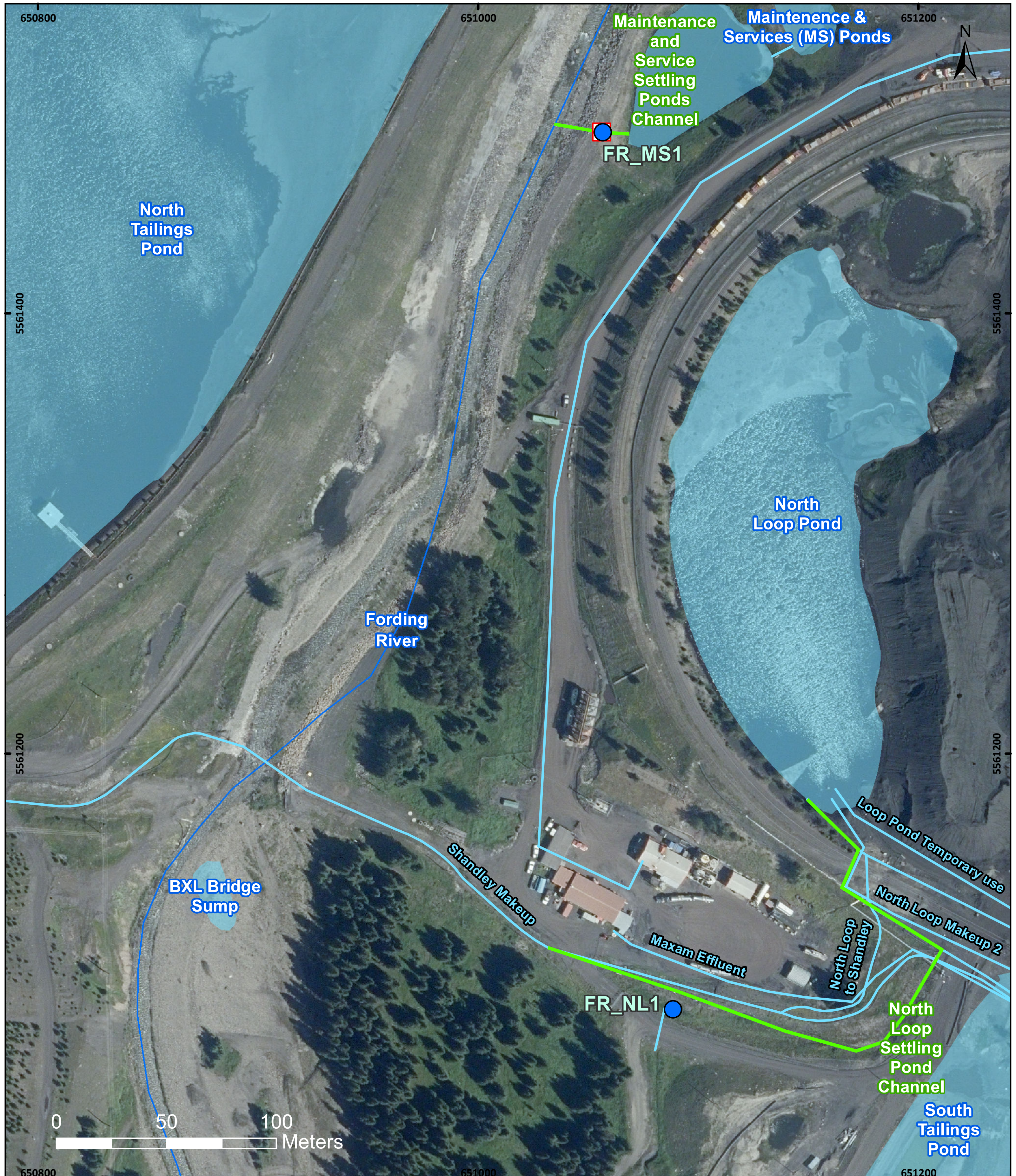
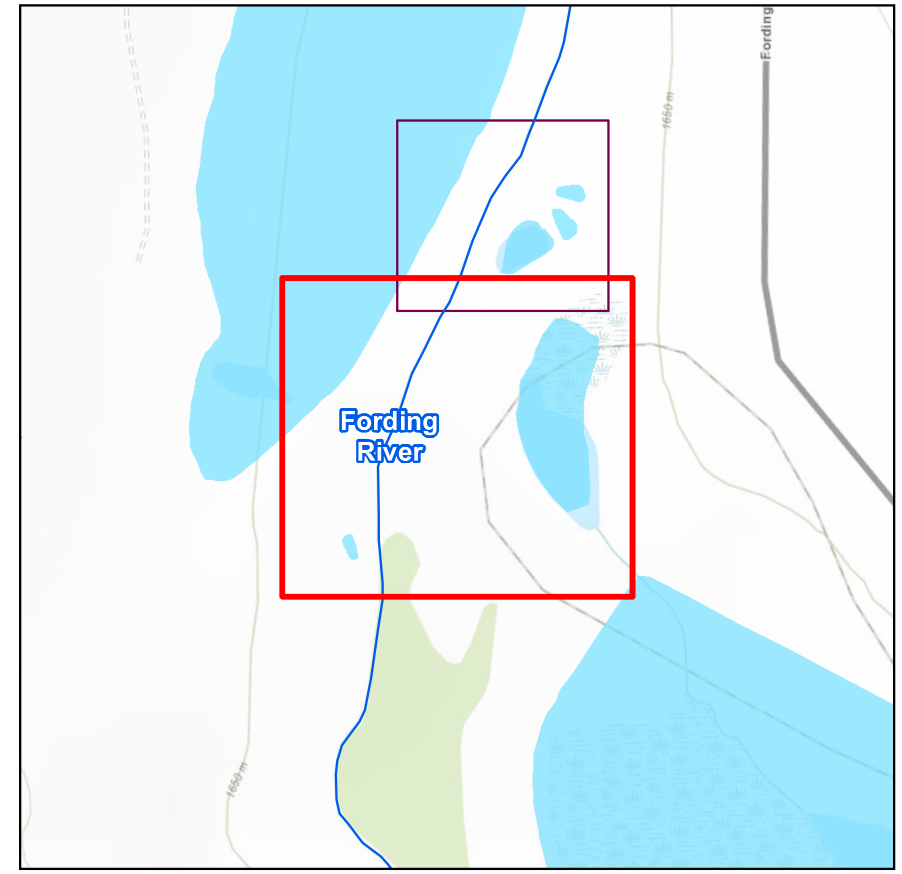
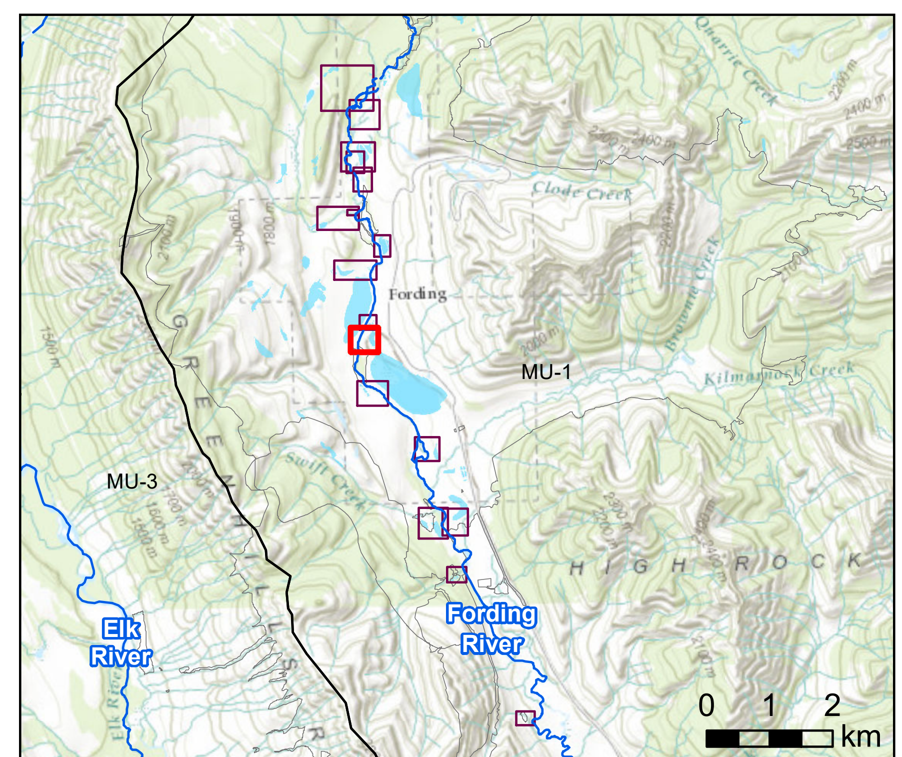


North Loop Settling Pond Channel

Fish Bearing	Primary Gauge
No	FR_NL1





TECK COAL LTD.

North Loop Settling Pond Channel

Legend

Water Features

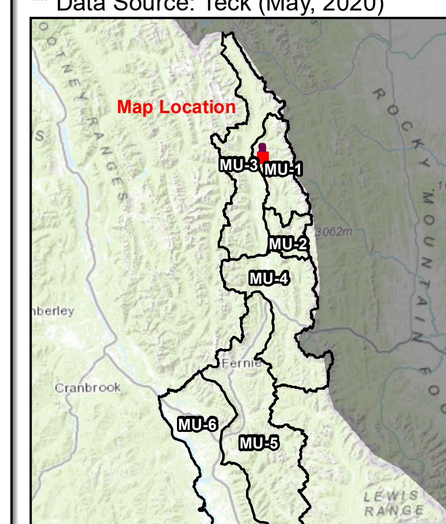
- Stream*
- Water Management Lines**
- Water Management Polygons*
- Channel

Point Features

- B Fish Barrier
- Hydrology Stations

* Data Source: Teck (Jan, 2020)

** Data Source: Teck (May, 2020)



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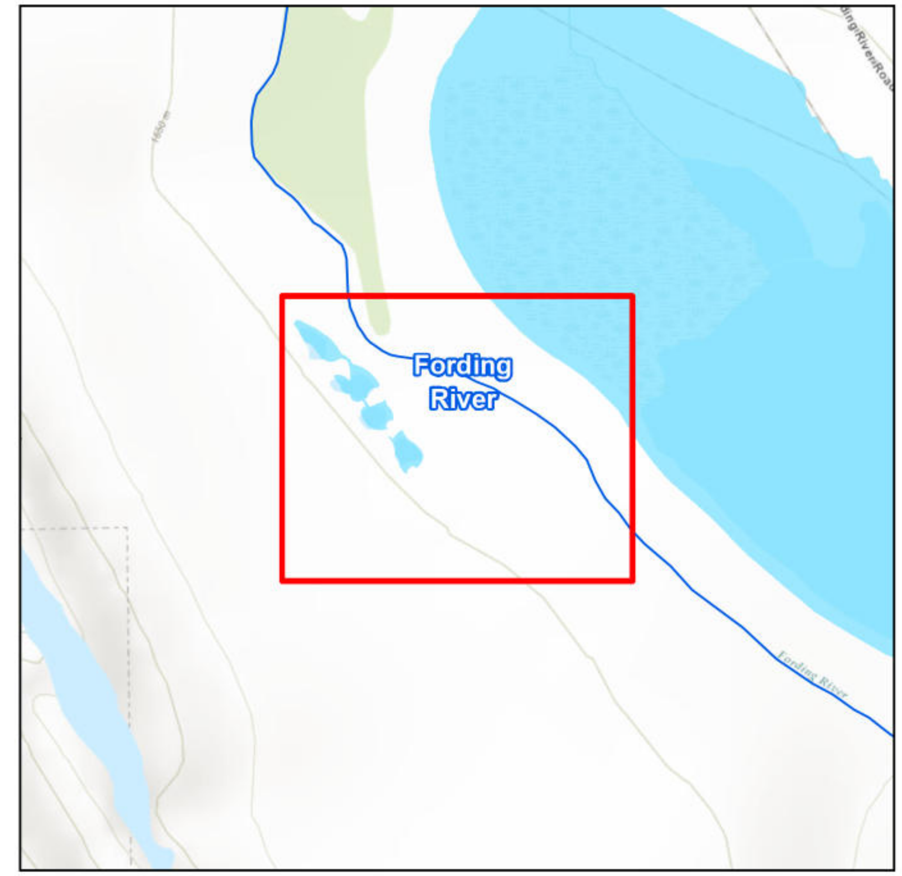
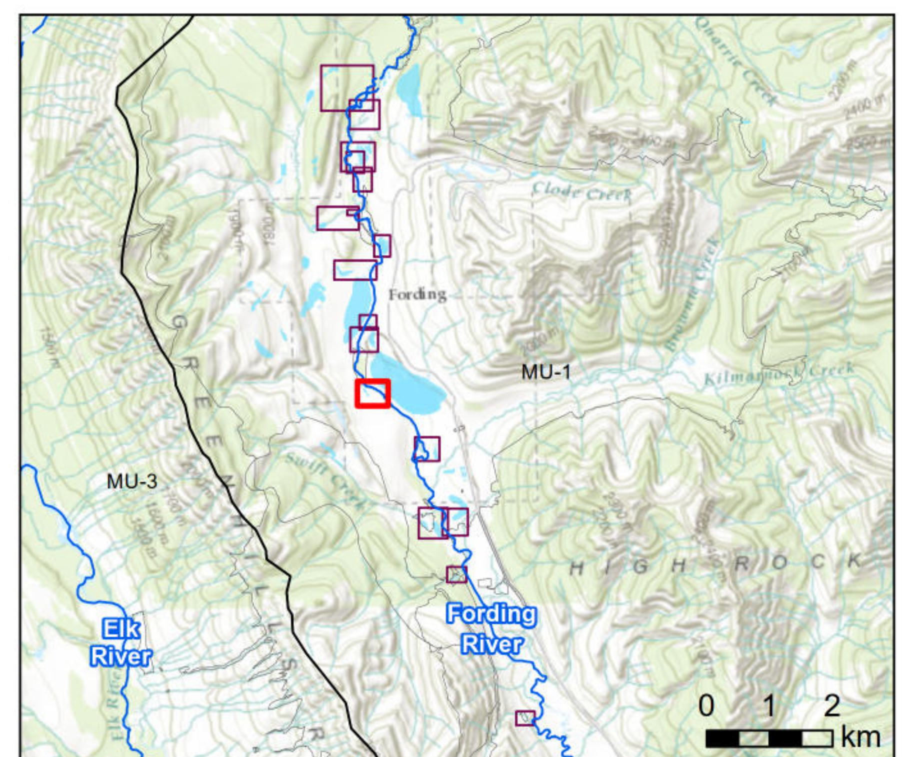
Smith Ponds Channel

Fish Bearing
Yes

Primary Gauge
FR_SP1





TECK COAL LTD.

Smith Ponds Channel

Legend

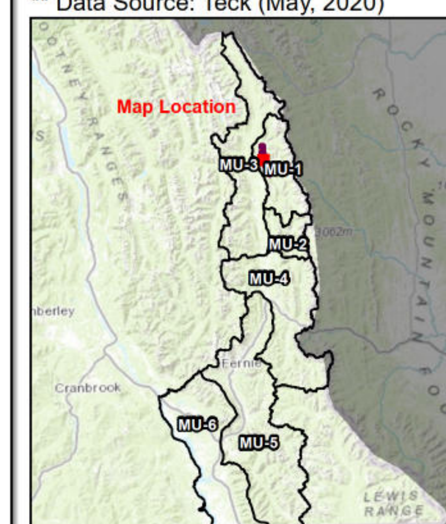
Water Features

- Stream*
- Subsurface*
- Water Management Lines**
- Water Management Polygons*
- Channel

Point Features

- Fish Barrier
- Temporary Fish Fence
- Hydrology Stations

* Data Source: Teck (Jan, 2020)
** Data Source: Teck (May, 2020)



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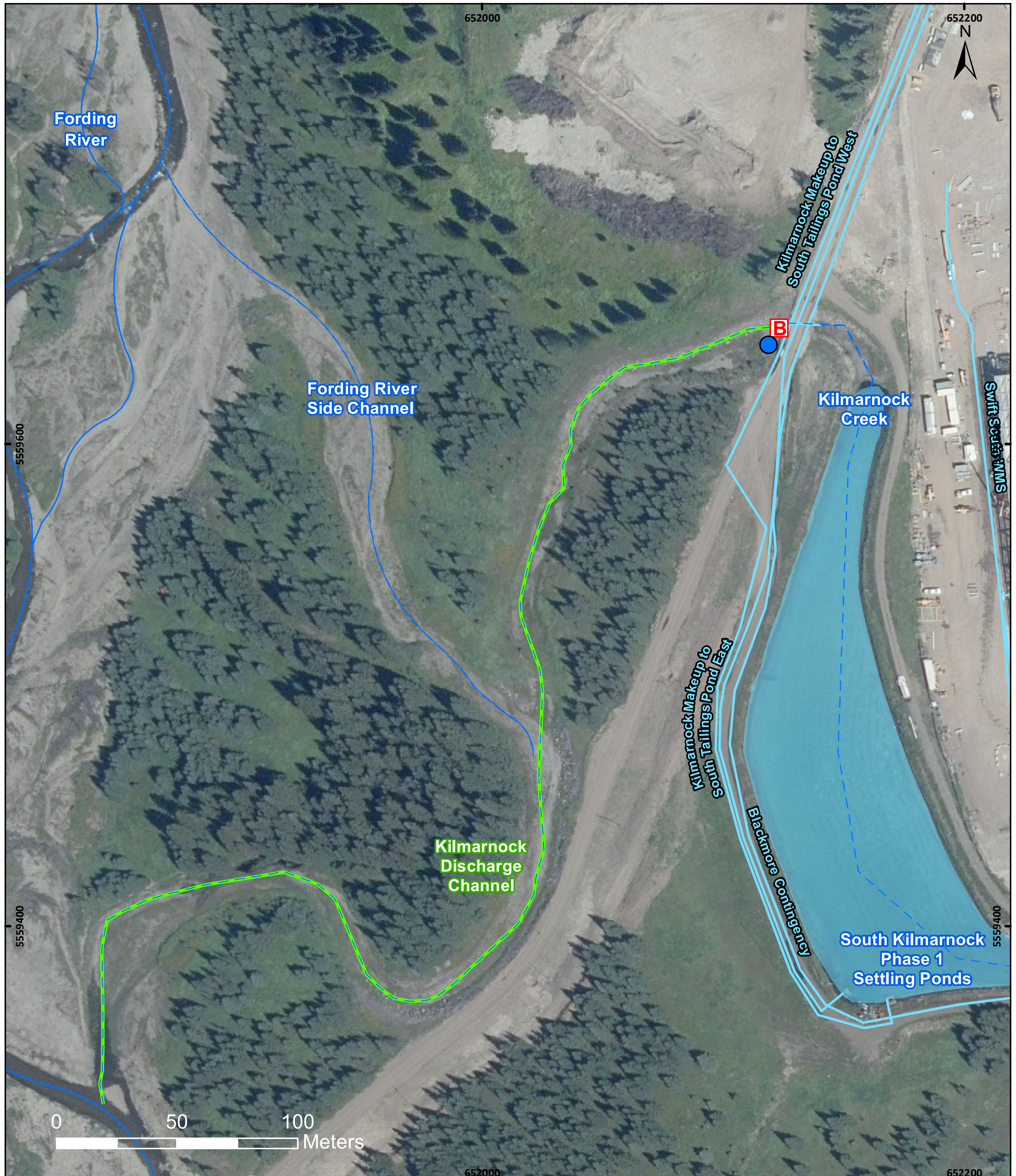
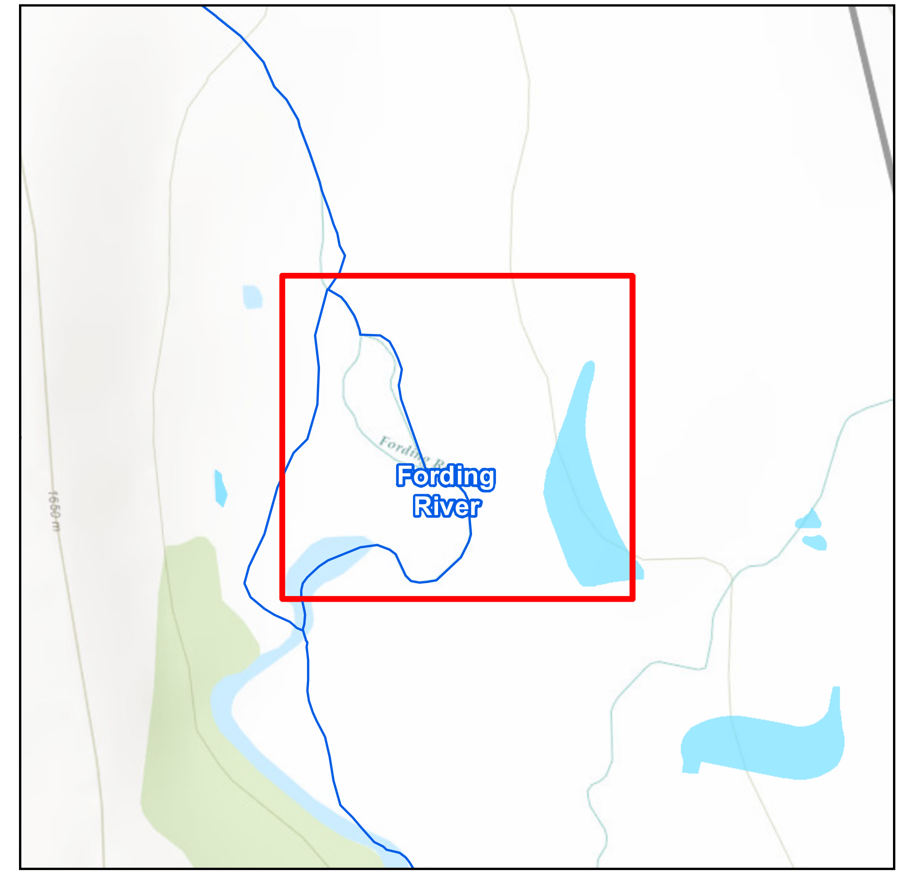
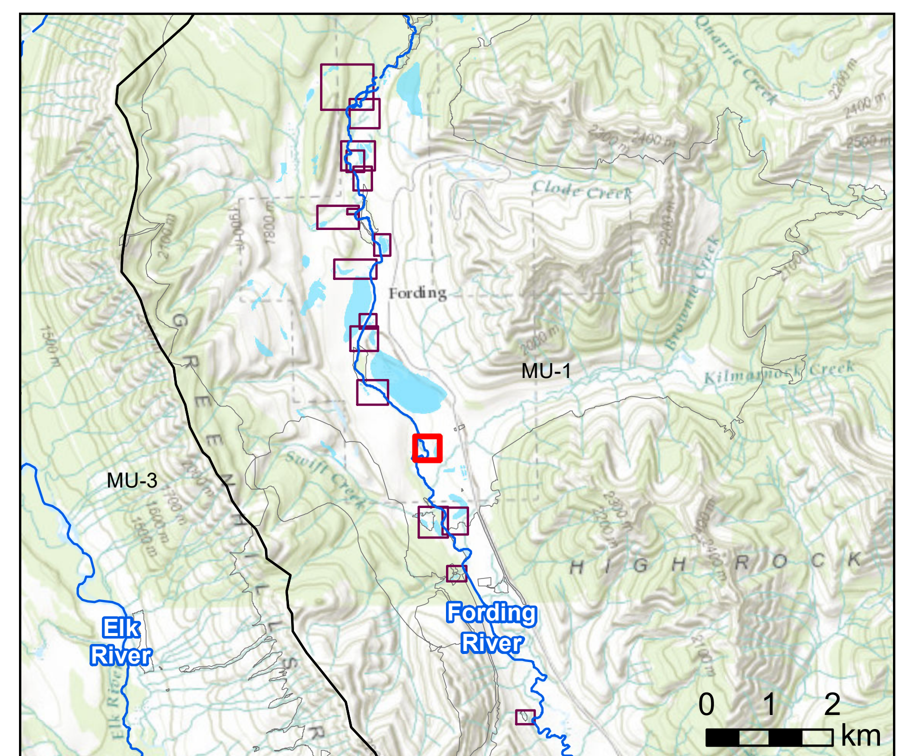


Kilmarnock Creek Phase 1 Channel

Fish Bearing
Yes

Primary Gauge
FR_SKP1





TECK COAL LTD.

Kilmarnock Creek Phase 1 Channel

Legend

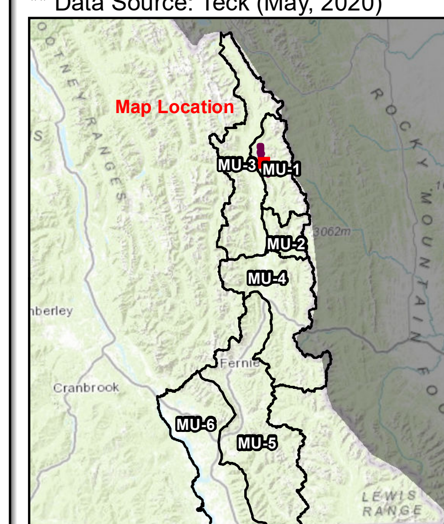
Water Features

- Stream*
- Intermittent Stream*
- Water Management Lines**
- Water Management Polygons*
- Channel

Point Features

- B Fish Barrier
- Hydrology Stations

* Data Source: Teck (Jan, 2020)
** Data Source: Teck (May, 2020)



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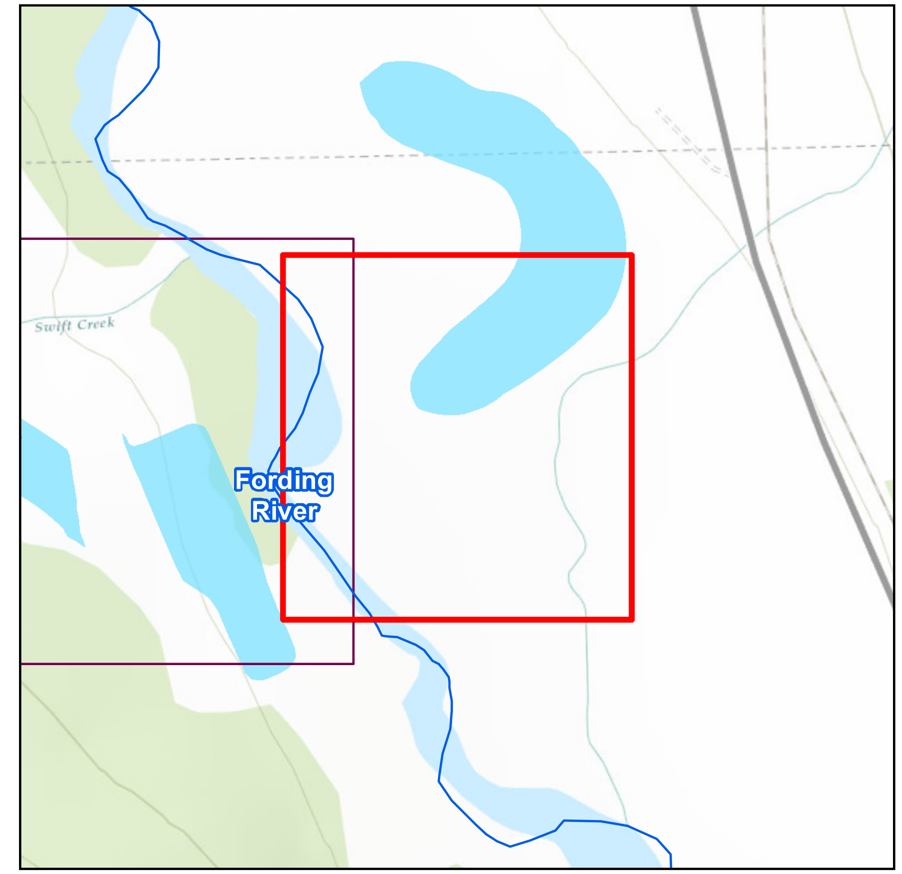
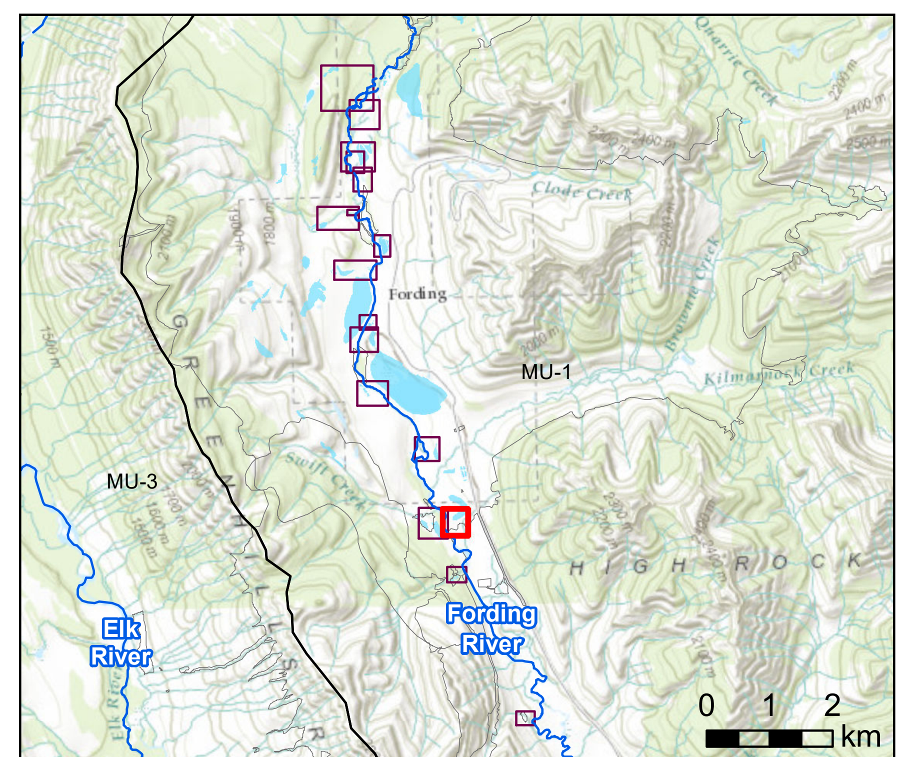
Kilmarnock Creek Phase 2 Channel

Fish Bearing
Yes

Primary Gauge
FR_SKP2





TECK COAL LTD.

Kilmarnock Creek Phase 2 Channel

Legend

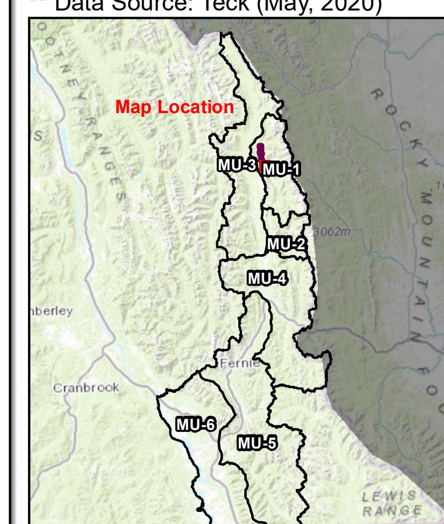
Water Features

- Stream*
- Intermittent Stream*
- Water Management Lines**
- Water Management Polygons*
- Channel

Point Features

- Fish Barrier
- Hydrology Stations

* Data Source: Teck (Jan, 2020)
** Data Source: Teck (May, 2020)



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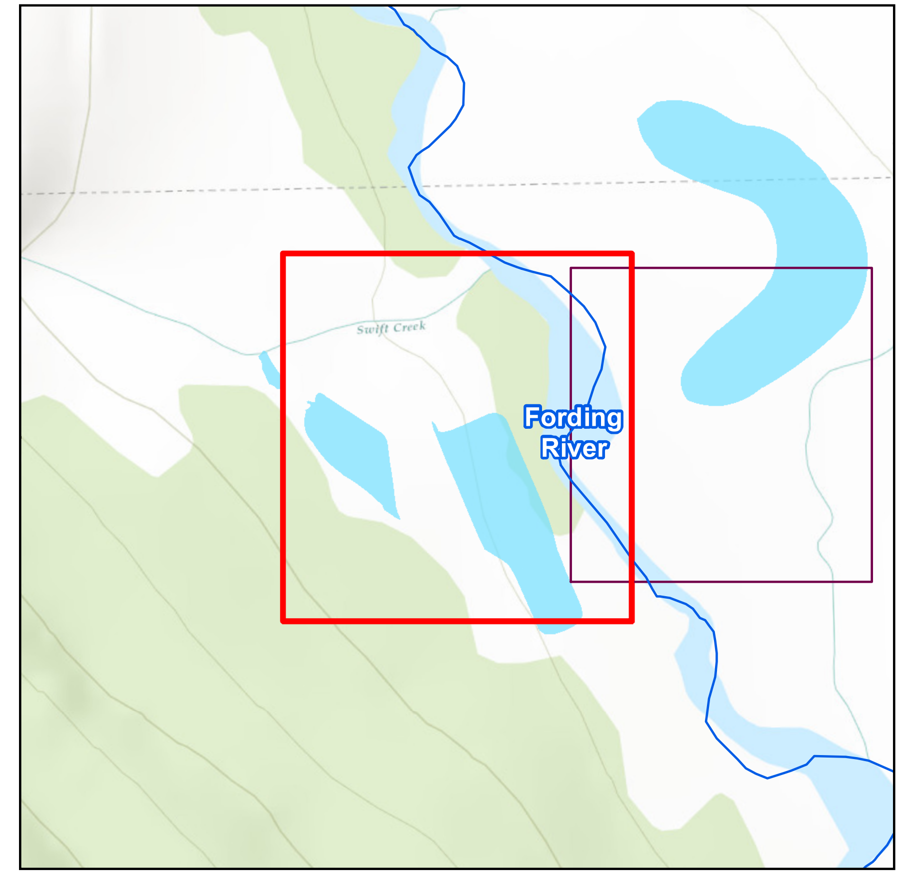
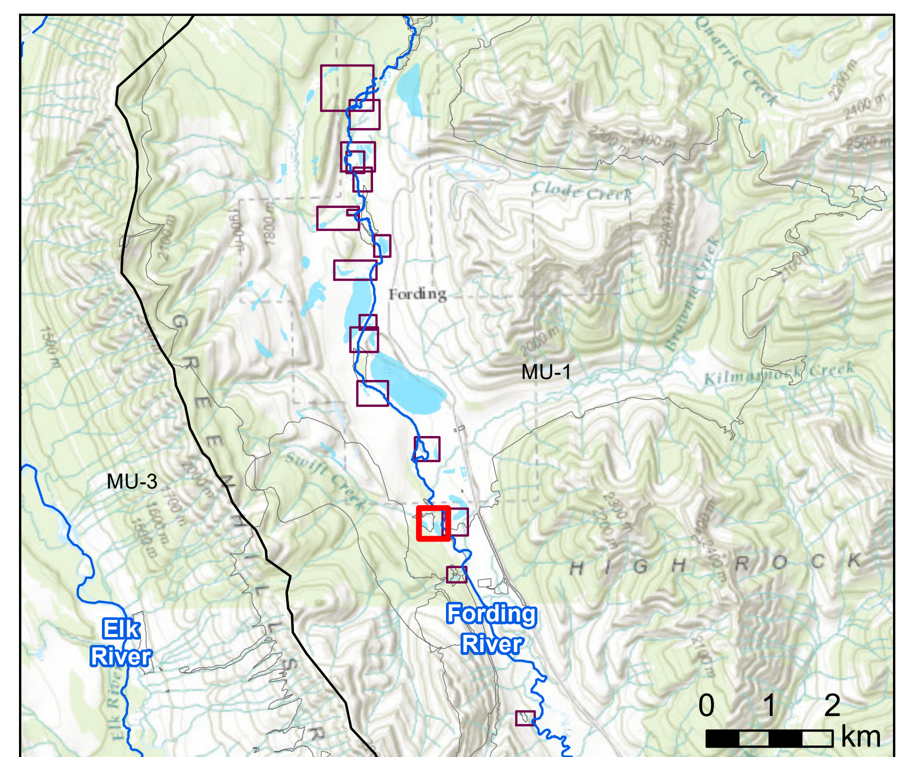
Swift Creek

Fish Bearing
Yes

Primary Gauge
FR_Swift; FR_SC1





TECK COAL LTD.

Swift Creek

Legend

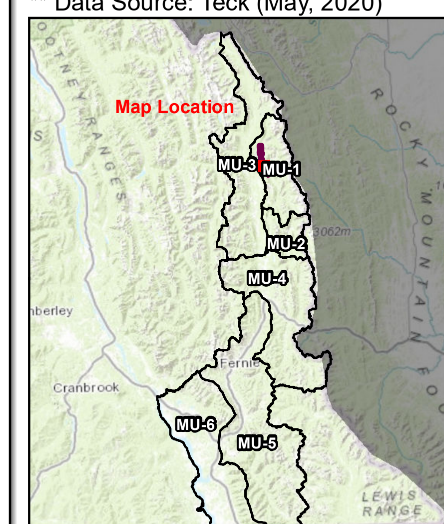
Water Features

- Stream*
- Intermittent Stream*
- Water Management Lines**
- Water Management Polygons*
- Channel
- Channel (2013-Oct 2018)

Point Features

- B Fish Barrier
- FF Temporary Fish Fence
- Hydrology Stations

* Data Source: Teck (Jan, 2020)
** Data Source: Teck (May, 2020)



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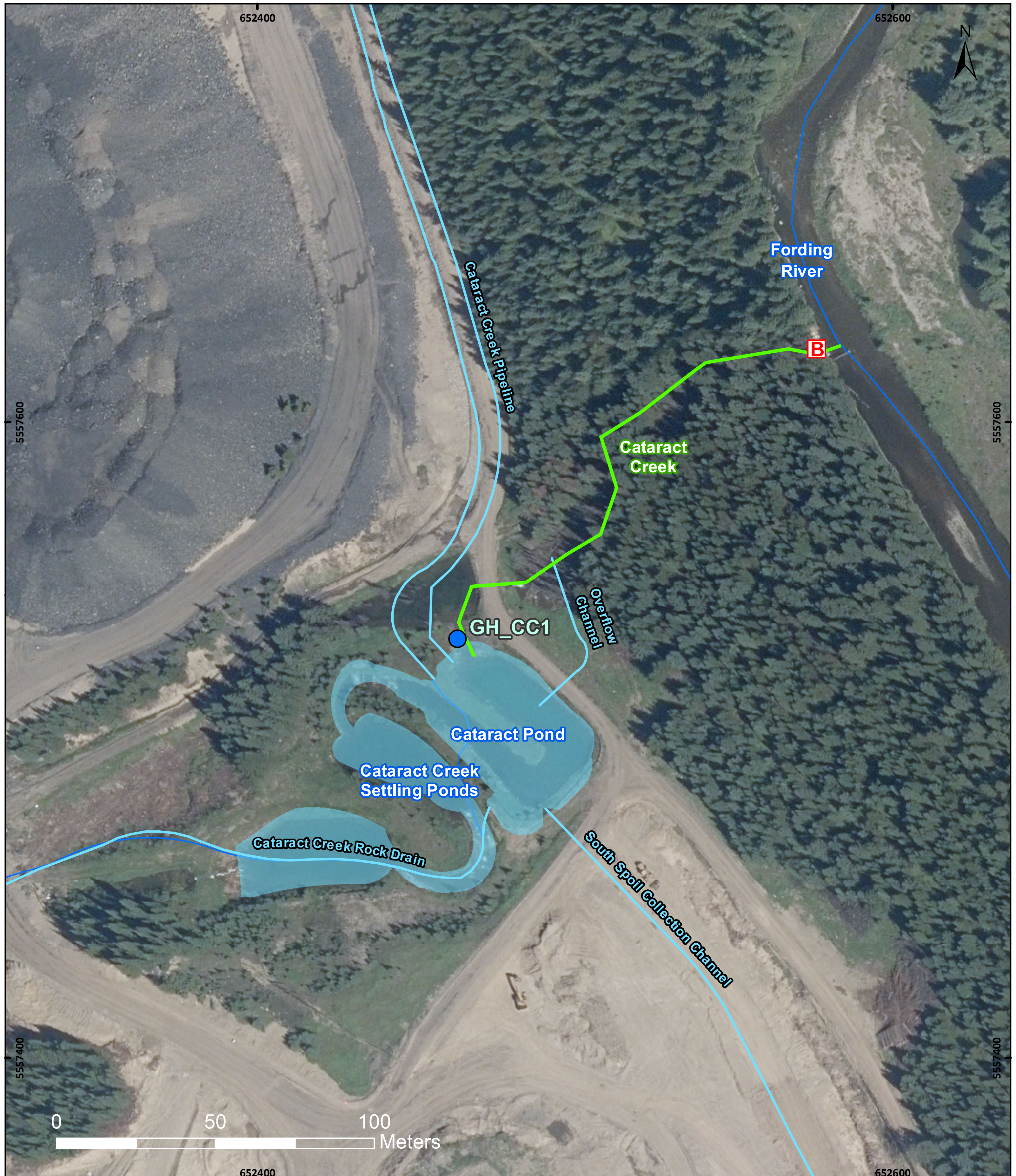
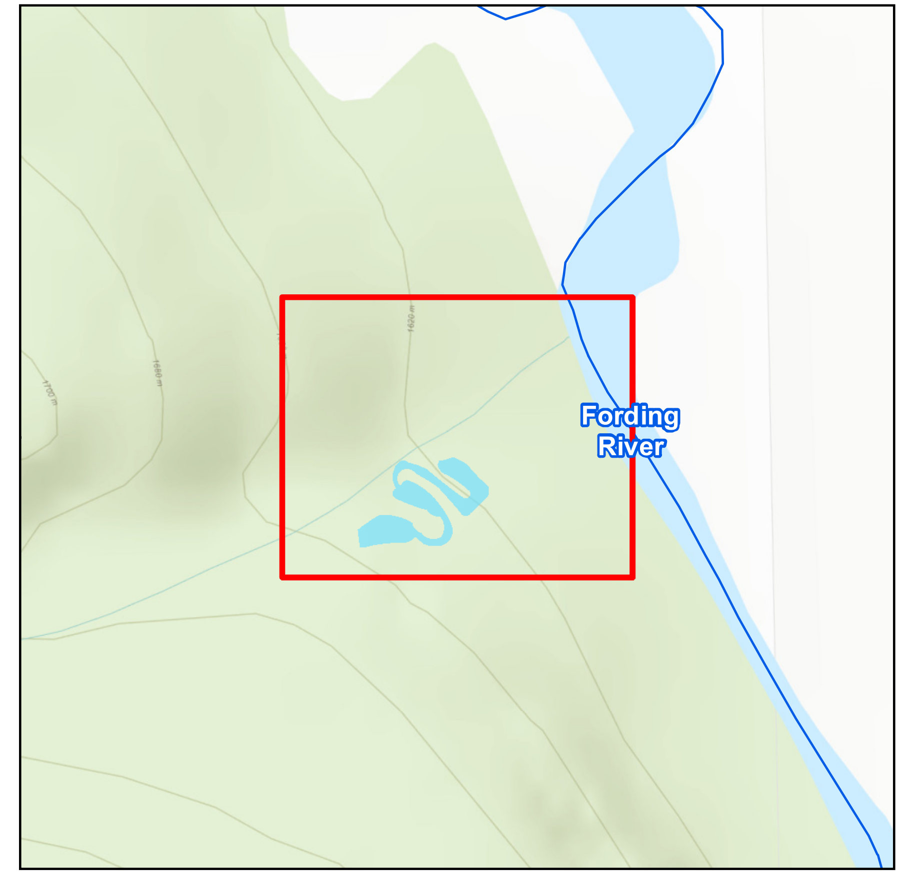
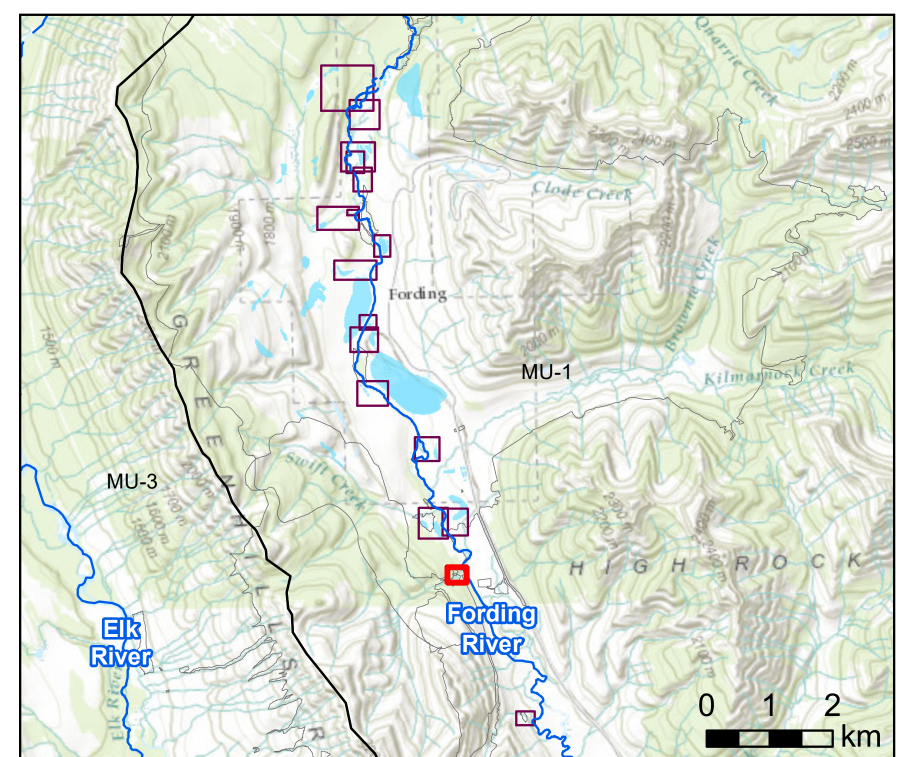


Cataract Creek

Fish Bearing	Primary Gauge
No	GH_CC1





TECK COAL LTD.

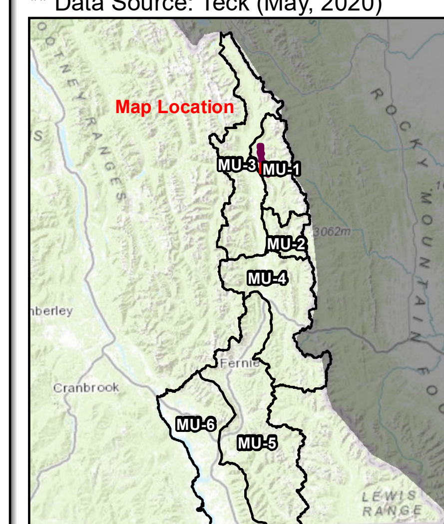
Cataract Creek

Legend

Water Features
- Stream*
- Water Management Lines**
- Water Management Polygons*
- Channel

Point Features
- Fish Barrier
- Hydrology Stations

* Data Source: Teck (Jan, 2020)
** Data Source: Teck (May, 2020)



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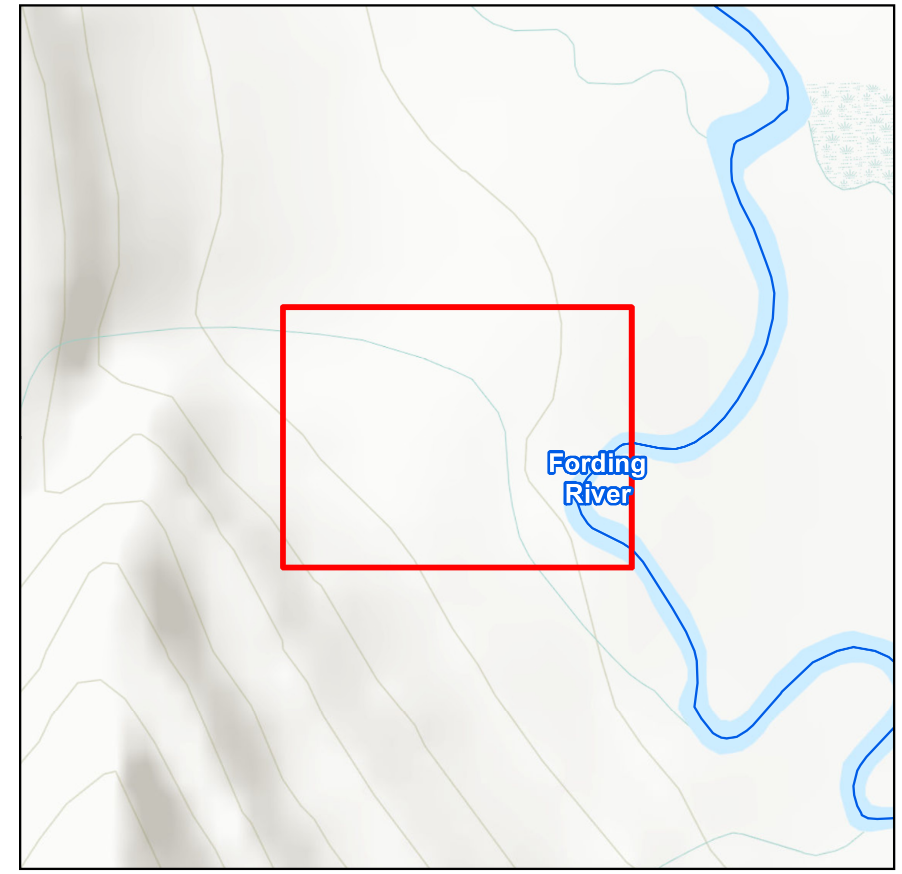
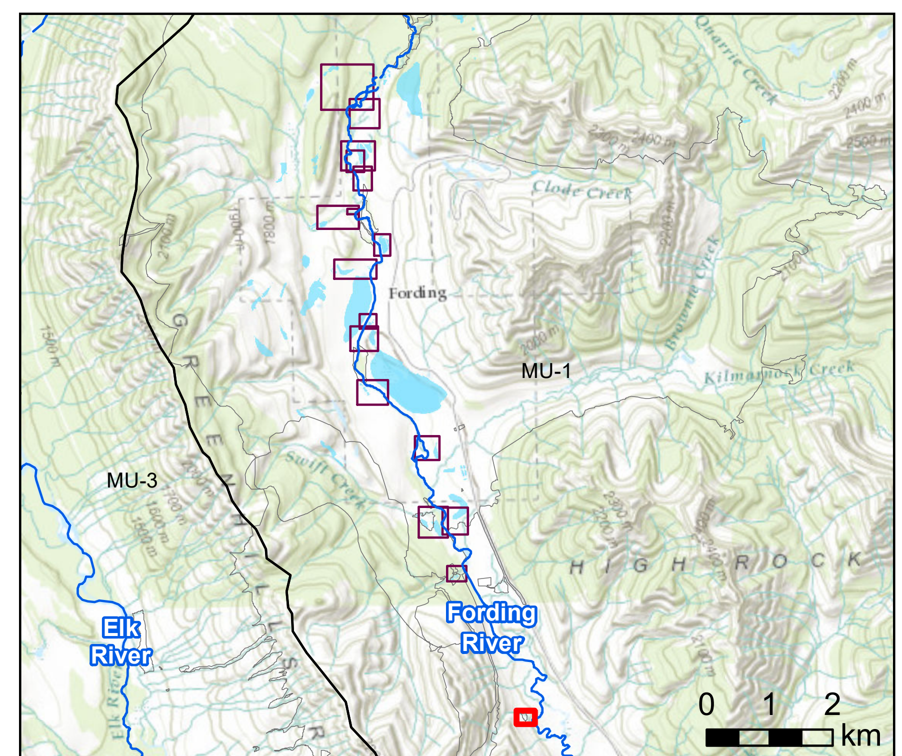
Porter Creek

Fish Bearing
Yes

Primary Gauge
GH_PC2





TECK COAL LTD.

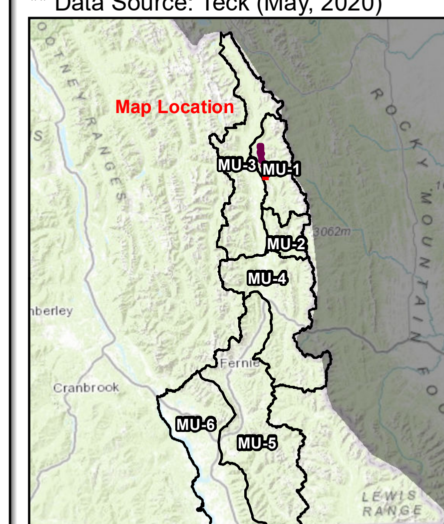
Porter Creek

Legend

Water Features

- Stream*
- Water Management Lines**
- Water Management Polygons*
- Channel
- Hydrology Stations

* Data Source: Teck (Jan, 2020)
** Data Source: Teck (May, 2020)



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