Columbia River Project Water Use Plan

Lower Columbia River Fish Management Plan

Lower Columbia River Fish Stranding Assessment and Ramping Protocol

Implementation Year 13

Reference: CLBMON-42A

Annual Monitoring Report

Study Period: April 2019 to April 2020

Golder Associates Ltd
201 Columbia Avenue
Castlegar, BC

June 11, 2020

REPORT

Annual Summary Report

Lower Columbia River (CLBMON42[A]) and Kootenay River Fish Stranding Assessments: Annual Summary (April 2019 to April 2020)

Submitted to:

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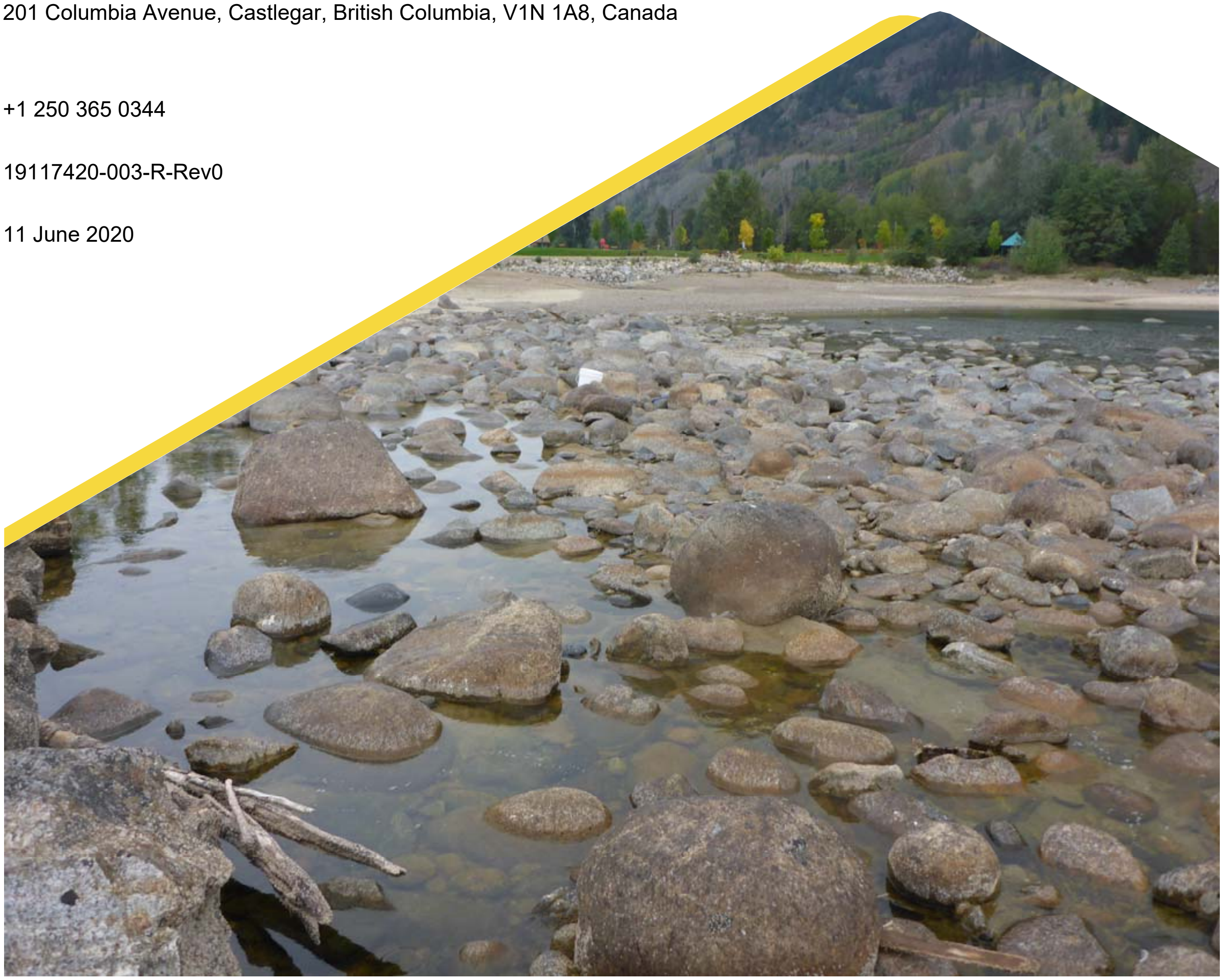
11 June 2020



Cover Photo: Pools formed at Millennium Park (LUB) during flow reduction event RE2019-25 on 29 September 2019 (see Appendix A; Figure A2 for location).

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Executive Summary

Discharge reductions and flow ramping from Hugh L. Keenleyside Dam/Arrow Lakes Generating Station (HLK/ALH) and Brilliant Dam/Expansion (BRD/X) can result in the stranding of fish species of the lower Columbia and Kootenay rivers. The Lower Columbia River Fish Stranding Assessment and Ramping Protocol Monitoring Program (CLBMON#42) has been carried out under the 13-year Columbia River Water Use Plan (BC Hydro 2007). The primary objective of CLMBON#42 is to continue to collect fish stranding data to assess the impact of flow reductions and flow ramping rates from HLK/ALH on the native fish species of the Lower Columbia River and includes two field data collection components: 1) Lower Columbia River and Kootenay River Fish Stranding Assessments (CLMBMON#42[A]), and 2) Lower Columbia River Flow Ramping Studies. The present study is Year 13 of the Lower Columbia River and Kootenay River Fish Stranding Assessments (CLBMON#42[A]), which summarizes the results of stranding assessments collected following flow reductions at HLK/ALH and BRD/X at pre-determined sites (Appendix A) on the Columbia and Kootenay rivers between 1 April 2019 and 1 April 2020.

At total of 28 reduction events (RE) occurred between 1 April 2019 and 1 April 2020 (the present study period). A total of 25 reduction events occurred at HLK/ALH and 3 reduction events occurred at BRD/X. Of those 28 reduction events, 11 occurred during the High Risk period (1 June to 30 September) and 17 occurred during the Low Risk period (1 October to 31 May). Stranding assessments were conducted for 16 of the 28 reduction events. Of those stranding assessments, 9 occurred during the High Risk period and 7 occurred during the Low Risk period.

An estimated 10,281 stranded fishes were observed during the 16 stranding assessments. Approximately 57% of these fishes were salvaged and successfully relocated to the mainstem Columbia or Kootenay rivers. A total of 18 sites were assessed at least once during the study period and the majority (84%) of stranded fishes were found at Genelle Mainland (LUB), Bear Creek (RUB), and Lions Head (RUB). Sportfishes accounted for 18.6% of the total stranded fishes and included Mountain Whitefish (*Prosopium williamsoni*), and Rainbow Trout (*Oncorhynchus mykiss*). Stranded invasive species, not native to the Columbia River included one Brook Trout (*Salvelinus fontinalis*), three Tench (*Tinca tinca*), and one Northern Pike (*Esox Lucius*). The remainder of stranded fishes were non-sportfish; the most abundant being juvenile and young of year (YOY) Sucker species (*Catostomidae spp.*), accounting for 63.8% of the non-sportfishes stranded. Stranded species at risk accounted for 0.6% of total fish stranded and included Umatilla Dace (*Rhinichthys umatilla*) and Shorthead Sculpin (*Cottus confuses*).

In addition to salvaging stranded fishes, the stranding assessments conducted during the present study period provided valuable data for the Lower Columbia River Fish Stranding Database, particularly at discharges where previous stranding data were limited, thereby improving the resolution of future database queries that help predict the effects of flow reductions at HLK/ALH and BRD/X.

Secondary objectives of CLBMON#42 include addressing five key management questions identified under the Columbia River Project Water Use Plan (Table ES1) (BC Hydro 2007). Analyses to address the management questions were not conducted during the present study; however, the current status of the management questions is identified in Table ES1. A subsequent analysis on the Lower Columbia River Fish Stranding Database will be conducted that will include all 13 years of fish stranding assessment data collected under the Columbia River Project Water Use Plan. Results of this database analysis, along with a summary of previous studies pertaining to CLBMON#42 will be presented to BC Hydro in a forthcoming final compendium report (Golder in prep).

Table ES1: CLBMON#42 Status of Lower Columbia River Fish Stranding Assessment and Ramping Protocol Program Objectives, Management Questions and Hypotheses

Primary Objective	Secondary Objectives	Management Questions	Management Hypotheses	Year 13 (2019/2020) Status
To assess the impact of flow reductions and flow ramping rates from HLK/ALH on the native species of the lower Columbia River.	To determine ramping rates for flow reductions which reduce the stranding rate of fishes at different times of the year.	MQ1: Is there a ramping rate (fast vs. slow, day vs. night) for flow reductions from HLK/ALH that reduces the number of fishes stranded (interstitially and pool) per flow reduction event in the summer and winter?	Ho1: The number of stranded fishes is independent of either the ramping rate or time of day of flow reductions in the summer and winter.	The variable of ramping rate and time of day on fish stranding risk has been assessed through analyses from three years of ramping studies on the Columbia and Kootenay rivers (Golder 2007; Irvine et al. 2009) and from a statistical analyses conducted on 10 years of stranding assessment data (1999 to 2009) in the stranding database (Golder and Poisson 2010; Irvine et al. 2014). Based on these previous analyses ramping rate was not found to be a statistically significant predictor of stranding risk; however, there was a noticeable trend of increased fish stranding frequency with increased ramping rates under certain scenarios (i.e. pool stranding in summer) (Irvine et al. 2009). Given these results, the effect of ramping rate on the fish stranding component of the null hypothesis cannot be rejected. An analysis on three years of ramping studies indicate that time of day (day vs night) was not a significant variable for stranding risk (Golder 2007); however when an analysis was conducted on the stranding database, time of day was found to be a significant predictor of stranding risk with the highest risk of stranding occurring in the late afternoon (Golder and Poisson 2010; Irvine et al. 2014). Given these differing results, the effect of time of day on the fish stranding component of the null hypothesis cannot be rejected.
	To determine whether the wetted history influences the stranding rate of fishes for flow reductions.	MQ2: Does wetted history (length of time the habitat has been wetted prior to the flow reduction) influence the number of fishes stranded (interstitially and pool) per flow reduction event for flow reductions from HLK/ALH?	Ho2: Wetted history does not influence the stranding rate of fishes (both interstitially and pool stranding) for flow reductions from HLK/ALH.	An analysis on flow ramping studies in the Columbia and Kootenay river systems indicated that stranding risk has been shown to increase with increased wetted history (Irvine et al. 2009). However, this relationship was not statistically significant (Golder 2007). A previous analysis on the results from the stranding database indicated a statistically significant positive correlation between wetted history and stranding risk (Golder and Poisson 2010; Irvine et al. 2014). Additionally, a significant increase in the number of stranded fishes was observed after a 10-day wetted history (Golder and Poisson 2010). Based on these previous studies, the null hypothesis can be rejected.
	To determine whether a conditioning flow reduction from HLK/ALH reduces the stranding rate of fishes.	MQ3: Can a conditioning flow (temporary, one step, flow reduction of approximately 2 hours to the final target dam discharge that occurs prior to the final flow change) from HLK/ALH reduce the stranding rate of fishes?	Ho3: A conditioning flow from HLK/ALH does not reduce the stranding rate of fishes in the lower Columbia River.	Previous studies have shown that the use of a conditioning flow reduction appears to reduce the incidence of pool stranding on the Columbia River (Golder 2007; Irvine et al. 2009), however this relationship was not statistically significant and the analysis was based on limited results (Golder 2007). Currently, this hypothesis cannot be rejected at this time. For a definitive answer to this management question an experimental conditioning flow study including manipulation of flows with substantial time between replicates would be required.
	To determine whether physical habitat manipulation will reduce the incidence of fish stranding.	MQ4: Can physical habitat works (i.e., re-contouring) reduce the incidence of fish stranding in high risk areas?	Ho4: Physical habitat manipulation does not reduce the stranding rate of fishes in the lower Columbia River.	Since 2000, six high risk stranding sites on the Columbia River have been re-contoured. Previous stranding database analysis have revealed that the efforts of re-contouring sites on the lower Columbia River have been successful in decreasing the incidence of stranding and the number of fishes stranded (Golder and Poisson 2010; Irvine et al. 2014; Golder 2018). Based on these previous analyses, this hypothesis can be rejected.
	Reduce the number of occurrences when a stranding crew would be deployed for a flow reduction.	MQ5: Does the continued collection of stranding data, and upgrading of the lower Columbia River stranding protocol, limit the number of occurrences when stranding crews need to be deployed due to flow reductions from HLK/ALH?	Ho5: The number of fish salvage events can be reduced through adaptive adjustments made as a result of ongoing data collection.	Currently this hypothesis can not be rejected. During the 13 year period of CLBMON#42 the number of annual stranding assessments that have been conducted in response to reduction events from HLK/ALH has not decreased. Over the study, the annual number of stranding assessments conducted due to flow events at HLK/ALH has ranged from 8 to 15 (median = 12; average = 12) with no increasing or decreasing trend.

Key Words

Lower Columbia River

Kootenay River

Water Use Planning

Fish Stranding

Flow Reduction

Flow Ramping

Discharge Regulation

Re-contouring

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1.0 INTRODUCTION

1.1 Scope and Objectives

The Lower Columbia River Fish Stranding Assessment and Ramping Protocol Monitoring Program (CLBMON#42) has been carried out since 2007 under the 13-year Columbia River Project Water Use Plan (BC Hydro 2007). The monitoring program includes two field data collection components:

- Lower Columbia River and Kootenay River Fish Stranding Assessments (CLBMON#42[A])
- Lower Columbia River Flow Ramping Studies

The main objective of the Lower Columbia River Fish Stranding Assessment and Ramping Protocol Monitoring Program is to collect fish stranding data to assess the impact of flow reductions and flow ramping rates from Hugh L. Keenleyside Dam/Arrow Lakes Generating Station (HLK/ALH) and Brilliant Dam/Expansion (BRD/X) on native fish species of the lower Columbia and Kootenay rivers. Secondary objectives include the following: 1) determining ramping rates for flow reductions that reduced incidences of fish stranding at different times of the year; 2) determining whether wetted history influenced the stranding rate of fishes during flow reductions; 3) determining whether a conditioning flow reduction from HLK/ALH reduced the stranding rate of fishes; 4) determining whether physical habitat manipulation (e.g., re-contouring the shoreline) reduced incidences of fish stranding in the lower Columbia River; and 5) reducing (through risk management strategies) the number of occurrences when stranding crews need to be deployed during flow reductions (BC Hydro 2007).

The key management questions to be addressed by the Lower Columbia River Fish Stranding and Ramping Protocol Monitoring Program are as follows:

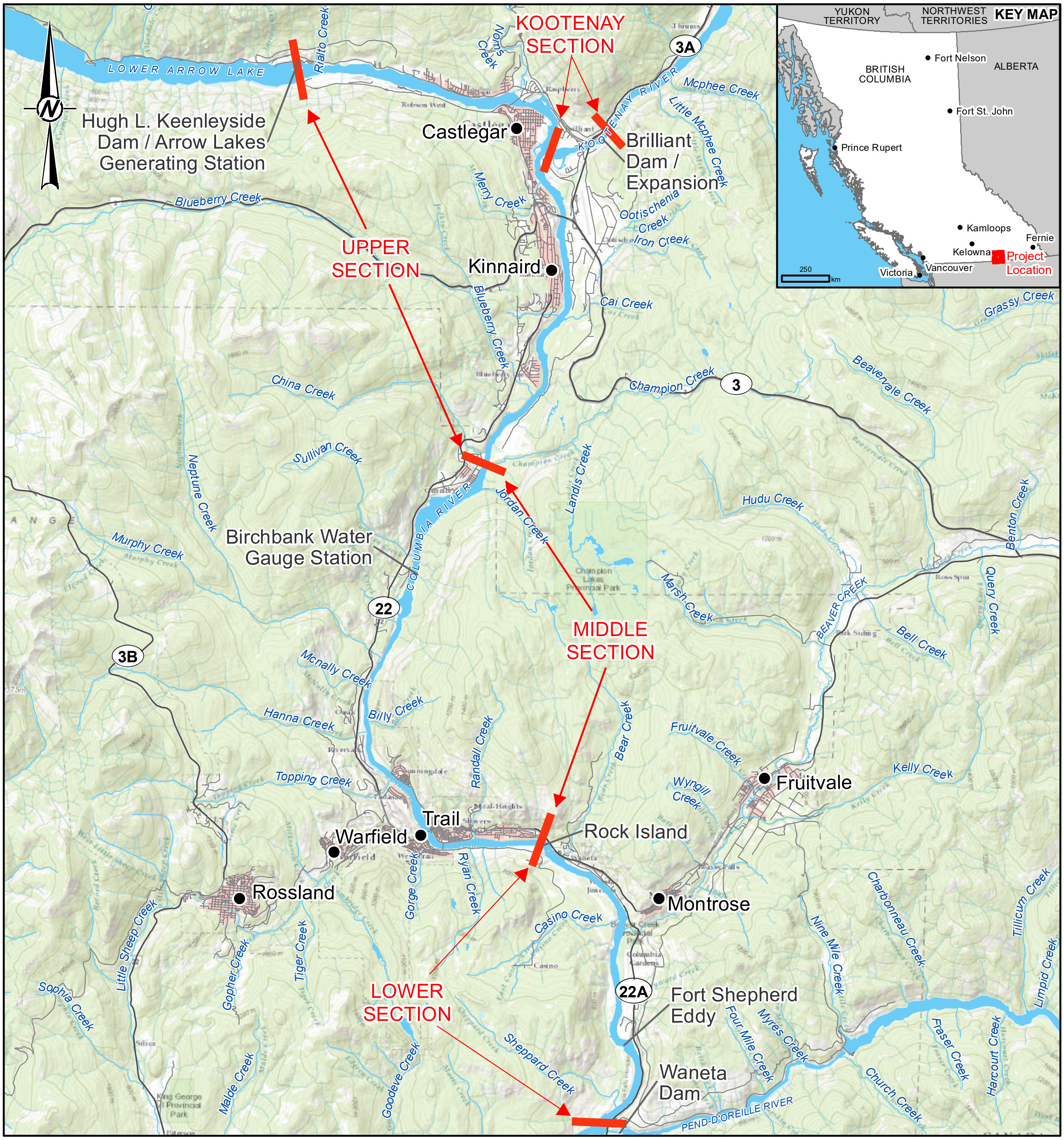
1) Is there a ramping rate (fast vs. slow, day vs. night) for flow reductions from HLK/ALH that reduces the number of fishes stranded (interstitially and pool) per flow reduction event in the summer and winter?
2) Does wetted history (the length of time the habitat has been wetted prior to the flow reduction) influence the number of fishes stranded (interstitially and pool) per flow reduction event for flow reductions from HLK/ALH?
3) Can a conditioning flow (a temporary, one step, flow reduction of approximately 2 hours to the final target dam discharge that occurs prior to the final flow change) from HLK/ALH reduce the stranding rate of fishes?
4) Can physical habitat works (i.e., re-contouring) reduce the incidence of fish stranding in high risk areas?
5) Does the continued collection of stranding data, and upgrading of the lower Columbia River stranding protocol, limit the number of occurrences when stranding crews need to be deployed due to flow reductions from HLK/ALH?

The present study is Year 13 of the Lower Columbia River and Kootenay River Fish Stranding Assessments (CLBMON#42[A]), which summarizes the results of stranding assessments collected following flow reductions at HLK/ALH and BRD/X at pre-determined sites (Appendix A) on the Columbia and Kootenay rivers between 1 April 2019 and 1 April 2020. The primary objective of the fish stranding assessments was to collect fish stranding data associated with hydro-electric dam flow reductions occurring on the lower Columbia and Kootenay Rivers to address fish stranding impact (Golder 2011). Fish stranding assessments were designed to deploy crews to sites where stranding is expected, collect data on the number of fish stranded, and salvage stranded fish by returning them to the mainstem of the Kootenay or Columbia River (BC Hydro 2007).

To address the management questions #1-5 above, a subsequent analysis on the Lower Columbia River Fish Stranding Database will be conducted that will include all 13 years of fish stranding assessment data collected under the Columbia River Project Water Use Plan. Results of this database analysis, along with a summary of previous studies pertaining to CLBMON#42 will be presented to BC Hydro in a forthcoming final compendium report (Golder in prep).

1.2 Study Area

The study area encompassed the approximately 56 km long section of the lower Columbia River from HLK/ALH to the Canada/USA border, and included the lower Kootenay River (approximately 2.8 km) from downstream of BRD/X to the Columbia River confluence (Figure 1).



LEGEND

- TOWN
- HIGHWAY
- ROAD
- WATERCOURSE
- RESIDENTIAL AREA
- WATERBODY

0 5 10

1:200,000 KILOMETERS

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PROJECT
LOWER COLUMBIA RIVER (CLBMON#42[A]) AND KOOTENAY RIVER FISH STRANDING ASSESSMENTS: ANNUAL SUMMARY (APRIL 2019 TO APRIL 2020)

TITLE
STUDY AREA OVERVIEW

CONSULTANT

GOLDER

YYYY-MM-DD	2020-06-11
DESIGNED	KL
PREPARED	CD
REVIEWED	SR
APPROVED	KL

PROJECT NO.	PHASE	REV.	FIGURE
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2.0 METHODS

2.1 Fish Stranding Risk Assessment

Owners and operators (BC Hydro, Columbia Basin Trust/Columbia Power, and FortisBC) of hydroelectric facilities located on the lower Columbia and Kootenay rivers within BC have direct or indirect influences on water levels. The *Canadian Lower Columbia River: Fish Stranding Risk Assessment and Response Strategy* (Golder 2011) was developed to mitigate the effects of flow reductions from HLK/ALH and BRD/X on native fish species through flow reduction planning, and outlines the roles and responsibilities pertaining to flow reductions for owners and operators of hydroelectric facilities on the lower Columbia and Kootenay rivers. The *Canadian Lower Columbia River: Fish Stranding Risk Assessment and Response Strategy* (Golder 2011) also outlines the roles and responsibilities of the Stranding Assessment Supervisor (Golder) and the protocols to be followed while conducting fish stranding assessments.

During the present study, the protocols developed in the *Canadian Lower Columbia River: Fish Stranding Risk Assessment and Response Strategy* (Golder 2011) were implemented prior to each reduction event and during all stranding surveys conducted. Fish stranding risk and response was based on current knowledge of factors known to influence fish stranding in regulated systems and the results of previous stranding assessments (Vonk 2003; BC Hydro 2005; Golder and Poisson 2010).

Once a potential flow reduction requirement was identified for HLK/ALH or BRD/X, the BC Hydro Operations Planning Engineer (OPE) for the facility consulted with the BC Hydro Environmental Discharge Change Coordinator (DCC) regarding the potential flow reduction. The consultation included information on the following:

- The timing and magnitude of the planned discharge change.
- The drivers of the discharge change.
- Flexibility of the system to modify discharge change expectations.
- Benefits of implementing the discharge change vs. consequences of not implementing the change.
- Current operations and/or planned changes at related hydroelectric facilities (HLK/ALH or BRD/X) to assist in deciding the most appropriate implementation/response strategy. It was important to ensure that there was knowledge of system operations for both the Columbia and Kootenay rivers to avoid potential incremental impacts.

Once a flow change decision was made, a fish stranding risk assessment was conducted. The assessment was based on both current environmental conditions at the time, and the results of past stranding assessments. Figure 2 summarizes the five phases of the fish stranding risk assessment process for defining fish stranding risk, as well as guiding assessment/salvage response decisions. Details of each phase are as follows:

- **Phase 1 - Timing of Reduction:** The timing of the proposed reduction is the first factor which is taken into consideration when deciding to initiate a stranding assessment. Stranding risk is greatest in the summer months because newly emerged juvenile fishes occupy shallow near-shore habitats where they are more susceptible to stranding (Golder and Poisson 2010). The stranding High Risk period occurs from 1 June to 30 September; the Low Risk period occurs from 1 October to 31 May as defined in the *Canadian Lower Columbia River: Fish Stranding Risk Assessment and Response Strategy* (Golder 2011).
- **Phase 2 - River Stage:** Defines the current and proposed base flow level at the Water Survey of Canada Birchbank Gauging Station (Station Number 08NE049) as a result of the proposed flow reduction. Previous fish stranding assessment data is used to define risk for the proposed flow reduction change. The probability of fish stranding is typically inversely related to water levels. Low angle river bank and the presence of shallow depressions that are more common at lower water levels result in greater risk of fish stranding when compared to conditions present at higher water levels. During the High Risk period (1 June to 30 September), fish stranding risk decreases when discharge is greater than 110 thousand cubic feet per second (kcfs) (based on limited data). During the Low Risk period (1 October to 31 May), stranding risk decreases when discharge is greater than 60 kcfs (Golder and Poisson 2010).
- **Phase 3 - Info Review:** The DCC considers seasonal conditions and the significance of the planned flow reduction in relation to fish stranding. In performing this evaluation, the DCC relies on forecasted discharge, recent observations from stranding assessments, and on the historic fish stranding results identified in a query of the Lower Columbia River Fish Stranding Database.

  The Lower Columbia River Fish Stranding Database was developed to store and manage historic flow reduction and stranding assessment data (i.e., discharge, ramping rates, stranding sites, number of pools isolated, number and species of fishes/eggs stranded either interstitially or within pools, etc.) for use in predicting the potential impacts of a proposed reduction event. This database is updated with results of recent stranding assessments a minimum of quarterly throughout the year. Prior to a new reduction event, the database is queried to help define fish stranding risk for the proposed reduction. Database query fields include current and expected resulting discharge at Birchbank Gauge station, current water temperature, date of proposed reduction, and facility responsible (HLK/ALH, BRD/X, or both) for the proposed reduction. Based on these fields, the database queries the total number of stranding assessments conducted (year 2000 to current) and provides query results indicating total fishes stranded per assessment (including presence of listed species) and a ranking of predicted stranding risk at 22 identified stranding sites on the lower Columbia and Kootenay rivers. From high to low stranding risk, the site rankings are as follows: ‘**Significant Stranding Event**’ (greater than 5000 fishes stranded during any of the previous reduction events), ‘**Effect**’ (greater than 200 fishes stranded during any of the previous reduction events), ‘**Minimal Effect**’ (less than 200 fishes stranded during any of the previous reduction events), ‘**Reconnaissance**’ (less than five previous stranding assessments conducted), and ‘**No Pools**’ (No pools were recorded at the site during previous assessments conducted).

  In addition to the Lower Columbia River Fish Stranding Database query, the DCC uses the results of fish stranding assessments conducted between January 2000 to the current year summarized by site, resultant Birchbank Discharge, and risk period (See Section 3.3, Table 5). This table provides total number of stranding assessments conducted and the maximum number of fishes stranded at each site during a single reduction event. This table provides a quick reference to determine if a proposed reduction has occurred historically for the time of year and which sites resulted in high numbers of stranded fish.

- **Phase 4 – Management Decision:** After timing, river stage, and results of the database query have been considered (Phases 1 to 3), the DCC develops an appropriate environmental response recommendation for the proposed reduction event. If it is decided that a stranding assessment will be conducted in response to a proposed reduction event, stranding assessments are recommended at sites where results from previous stranding assessments indicate the following:
  - The flow reduction is likely to result in an 'Effect' (greater than 200 fishes stranded at any given site) during a flow reduction under similar conditions based on the database query (year 2000 to current) results.
  - The flow reduction has the potential to strand species at risk (Umatilla Dace [*Rhinichthys umatilla*], Columbia Sculpin [*Cottus hubbsi*], Shorthead Sculpin [*Cottus confusus*] based on the database query (year 2000 to current) results.
  - The range of operations projected are outside those routinely undertaken for the time of year or few assessments have occurred at the flow range in the past two years.
  - No monitoring is required when past survey data indicates operation will be within the range of normal operations, the anticipated stranding effects are minimal, and listed species are not likely to be stranded. Effects are considered to be minimal when results from the Lower Columbia River Fish Stranding Database query indicates either no pools are likely to form, or pools are likely to form but less than 200 fishes have been stranded at any given site during previous surveys and listed species are not likely to be stranded under similar conditions.
  - The hydroelectric utilities undertakes periodic non-mandatory assessments throughout the range of operations and risk levels over time in order to collect data that can be analysed to confirm or alter the state of knowledge about stranding risks. The number and timing of fish stranding assessments undertaken during periods when low numbers of fishes are expected to become stranded will be at the discretion of the DCC.
- **Phase 5 – Assessment Refinement:** The DCC and the Golder Stranding Assessment Supervisor (SAS) define crew requirements for a stranding assessment based on the following:
  - Review of database query results and total number of potential sites ranked as 'Effect" and/or 'Significant Stranding Event'.
  - Results from the most recent stranding assessment conducted, which can help to identify which species may be occupying near-shore habitats, and which sites may form isolated pools.
  - Wetted history, based on water levels recorded at the Birchbank gauging station. Habitat that has a wetted history of greater than 10 days has a greater risk of stranding fishes (Golder and Poisson 2010). During the High Risk period, YOY (young-of-year) fishes typically inhabit near-shore shallow water habitats and wetted history is less relevant to defining stranding risk.
  - Air temperature greater than 25°C or less than 0°C can influence fish survival in isolated habitats by warming/cooling pool habitats and must be considered when fish salvage is anticipated.

Figure 2: Flow Reduction Fish Stranding Assessment Response Procedure

2.2 Fish Stranding Assessment and Salvage Methods

Standard methodology used during the field component for each fish stranding assessment are outlined in the *Canadian Lower Columbia: River Fish Stranding Risk Assessment and Response Strategy* (Golder 2011) and are summarized below. The primary objective of the fish stranding assessments was to collect fish stranding data associated with hydro-electric dam flow reductions occurring on the lower Columbia and Kootenay Rivers to address fish stranding impact (Golder 2011). Fish stranding assessments were designed to deploy crews to sites where stranding is expected, collect data on the number of fish stranded, and salvage stranded fish by returning them to the mainstem of the Kootenay or Columbia River (BC Hydro 2007). Fish stranding is defined as fishes that become stranded as a result of isolation in pools (wetted and de-watered) or stranded interstitially between substrate particles and are cut off from the mainstem river due to receding water levels.

Stranding assessment crews were on site no later than one hour after the final staged reduction from HLK/ALH or BRD/X. All fish stranding assessments were conducted via truck access. Fish stranding and salvage assessments began at the most upstream site identified for assessment by the Lower Columbia River Fish Stranding Database query and assessments continued downstream throughout the day following the stage recession. This standardized order of site assessment ensured that no site would be assessed prior to the effects of the flow reduction reaching each site. Sites were also assessed in order from high to low priority based on the site ranking from the database query. Sites where a ‘Significant Fish Stranding’ or ‘Effect’ ranking was assigned were the highest priority. The next priorities were ‘Reconnaissance’ sites, and, if time permitted, ‘Minimal Effect’ or ‘No Pools’ sites to confirm information in the database.

At each site, the crew conducted the following activities:

1) The current conditions were documented (date, time, weather, air temperature, water temperature, approximate vertical drawdown of the water level, and substrate material) on stranding field forms. The formation of new pools with future flow reductions (next 0.5 m stage decrease) was indicated for each site. Comments were also noted on the stranding field forms and any other pertinent information regarding the stranding assessment.

2) The number of new isolated pools (pools no longer connected to the mainstem of Columbia or Kootenay river) or de-watered pools that were created as a result of the flow reduction was recorded. Pools isolated during previous reduction events were noted in the comments but were not included in the total pools formed from the current reduction event.

3) Each pool was inspected for stranded fishes and crews attempted to salvage any fishes present using dipnets, backpack electrofishers (Smith-Root Model LR 24 or 12-B POW), or beach seines. The effort and number of pools sampled was recorded at each site depending on the method used for fish capture. Salvaged fishes from previously isolated pools (i.e. different reduction event), were recorded but were not included in the total number of fishes stranded during the current reduction event.

4) Captured fishes were transferred to a bucket of water where each fish was identified to species if possible. Fishes were classed into one of the following life stages; egg, YOY, juvenile, and adult. The total number of live fishes, dead fishes, and salvaged fishes were recorded for each species and life stage. Salvaged fishes were returned to the main channel of the Columbia or Kootenay rivers. If stranded fishes were numerous (greater than 200 individuals), a subsample were captured and identified to species and an estimate of total fishes stranded was made.

5) The number of larvae and fry stranded was estimated if sample methods were ineffective at capturing these life stages.

6) Interstitial stranding areas were inspected, and the total area searched was recorded. Any live fishes found during interstitial searches were salvaged.

7) Representative areas of the site at the time of sampling were photographed. Photographs of representative or unusual fish species where also taken as appropriate.

8) Fish length data were collected from up to 20 individuals of each species identified during each stranding assessment. Total length was measured for sculpin species and fork length was measured for all other species.

9) Invasive species (i.e. Brook Trout, Northern Pike, Tench [*Tinca tinca*]) found during stranding assessments were euthanized and removed from the system based on recommendation from the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) (Pers. Comm., Matt Neufeld, FLNRORD, 22 February 2016).

3.0 RESULTS

3.1 Operations Overview 2019/2020

During the present study period, the discharge in the Columbia River at the Birchbank Gauging Station ranged from a low of 25.6 kcfs recorded on 22 October 2019 to a maximum of 96.2 kcfs on 27 July 2019 (Figure 3). Discharge at Birchbank generally increased through April and May and through November and December, and generally decreasing from August to November, and from January to the end of March. The annual trend in discharge at Birchbank in 2019/2020 was typical of previous years.

The mean hourly discharge from HLK/ALH ranged from a low of 10.3 kcfs on 4 June 2019 to a maximum of 71.2 kcfs on 27 July 2019. During the High Risk stranding period, discharge from HLK/ALH was generally increasing through June and July, then generally decreasing through August and September. The majority (70%) of reduction events from HLK/ALH during the High Risk period occurred in August and September (Figure 3).

The mean hourly discharge from BRD/X ranged from a minimum of 9.3 kcfs on 3 October 2019 to a maximum of 65.2 kcfs on 4 June 2019 (Figure 3). During the High Risk stranding period, discharge from BRD/X was generally decreasing through June and July (opposite trend to HLK/ALH) and remained relatively consistent through August and September at a discharge of approximately 18.0 kcfs. Kootenay River system operation can be more dynamic in certain situations due to the need to meet system load requirements. Load factoring at BRD/X, which results in shaping average daily inflows into peak discharge during the high load hours (typically 0600 to 2200 hrs) and minimum discharge during low load hours (typically 2200 to 0600 hrs), can occur when Kootenay River inflows are between 18 and 43 kcfs. Load factoring at BRD/X occurred during the end of April and early May (Figure 3). Flow reductions associated with load factoring were not considered individual reduction events.

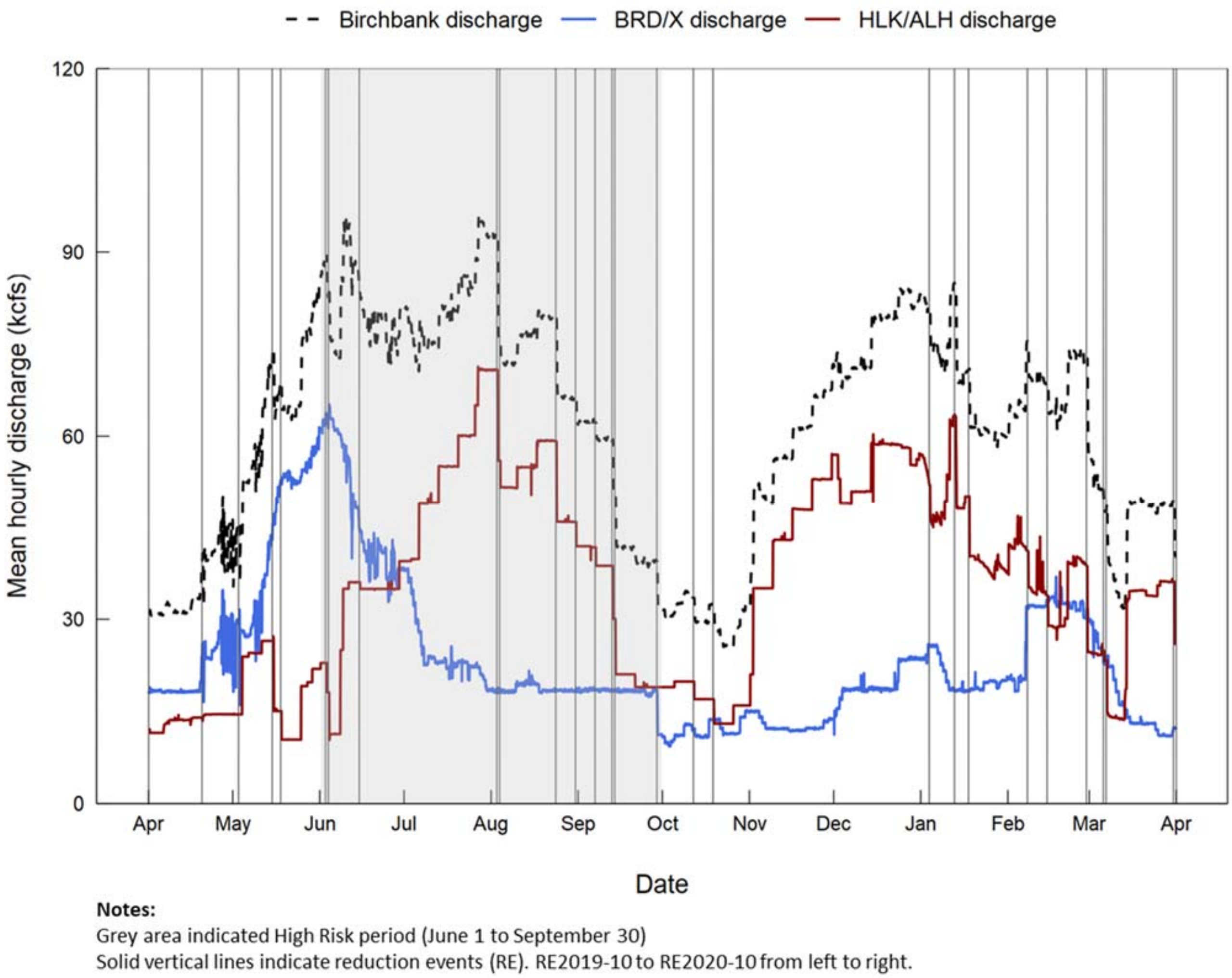

Figure 3: Mean hourly discharge from HLK/ALH, BRD/X, and at the WSC Birchbank Gauging Station 1 April 2019 to 1 April 2020

3.2 Reduction Events and Fish Stranding Assessments

During the present study period there were a total of 28 operational flow reduction events (Figure 3); 25 occurred at HLK/ALH and 3 occurred at BRD/X (Table 1). During the High Risk period, there were 11 reduction events, and the remaining 17 occurred during the Low Risk period.

Each reduction event occurred on a single day. In previous years, reduction events have occasionally been defined as multi-day events, with a stranding assessment conducted on a single day (Golder 2016, 2017, and 2018). Based on discussions with BC Hydro (pers. comm. James Baxter), during the 2018/2019 study period it was decided that each reduction event would be defined as occurring on a single day rather than over multiple days. The rationale for this decision was to simplify the Lower Columbia River Fish Stranding Database to keep fish salvaged during each stranding assessment linked to a specific reduction event occurring on the same day.

During the present study period, the magnitude of flow reduction for each event at HLK/ALH ranged from 0.5 to 15 kcfs. All reduction events from HLK/ALH had a mean ramping rate of 5 kcfs per hour or less. The majority of reduction events at HLK/ALH were required to fulfill Columbia River Treaty Coordination Agreements. RE2020-02 (13 January 2020) was a 15 kcfs reduction from HLK/ALH that was required to relieve stress on a floating guidewall upstream of HLK/ALH that had lost two pontoons due to extreme weather. RE2020-07 (6 March 2020) and RE2020-08 (7 March 2020) were required to support safety requirements for construction work upstream of HLK/ALH for the purpose of repairing the damaged guidewall.

The magnitude of flow reduction for each event at BRD/X ranged from 2.5 to 6.9 kcfs. RE2019-11 (20 April 2019) and RE2019-12 (3 May 2019) were short-term flow reductions at BRD/X that were required to extract a vehicle from the Kootenay River downstream of BRD/X. RE2019-25 (29 September 2019) was required at BRD/X due to limited inflows in the upstream reservoir.

Fish stranding assessments were conducted for 16 of the 28 reduction events (Table 1) that occurred during the present study period, resulting in a response rate (percent of total reduction events that initiated a stranding assessment) of 57%. Between 2009 and 2020, the total number of yearly stranding assessments has ranged from 12 to 19 (median = 15), and has generally followed the same pattern as the number of yearly reduction events (Figure 4). The median response rate since 2009 has been 82%.

Environmental conditions during stranding assessments were generally adequate for fish salvage purposes, except for RE2020-03 (18 January 2020). During this stranding assessment, the field crew experienced heavy snow. The accumulation of snow and slush in isolated pools and dewatered interstitial habitat reduced visibility while conducting assessments and therefore reduced sampling effectiveness.

Table 1: Summary of Reduction Events (RE) from HLK/ALH and BRD/X 1 April 2019 to 1 April 2020.

Reduction Event No.	Reduction Date	Risk Period	Crew Dispatched?	Birchbank Gauge Station: Mean Daily Water Temp (°C)	Birchbank Gauge Station: Max. Q (kcfs)	Birchbank Gauge Station: Min. Q (kcfs)	Birchbank Gauge Station: Magnitude of Reduction (kcfs)	BRD/X: Prev Q (kcfs)[a]	BRD/X: Resulting Q (kcfs)[a]	BRD/X: Magnitude of Reduction (kcfs)	No. Ramped Flow Reductions	Avg. Ramping Rate (kcfs/hr)	HLK/ALH: Prev Q (kcfs)	HLK/ALH: Resulting Q (kcfs)	HLK/ALH: Magnitude of Reduction (kcfs)	No. Ramped Flow Reductions	Avg. Ramping Rate (kcfs/hr)	Pools Formed	Interstitial Stranding	Fish Stranded	Sites Visited	Purpose of Flow Reduction
HLK/ALH 2019-10	1-Apr-19	Low	No	5.1	31.5	30.6	0.9	18.1	18.1	0.0	N/A	N/A	12.0	11.5	0.5	1	0.5	N/A	N/A	N/A	0	Operational Requirement under Treaty due to reduction in Columbia River inflow
BRD/X 2019-11	20-Apr-19	Low	No	6.1	40.8	32.2	8.6	20.5	16.5	4.0	2	2.0	13.5	13.5	0.0	N/A	N/A	N/A	N/A	N/A	0	First attempted recovery of vehicle in Kootenay River
BRD/X 2019-12	3-May-19	Low	No	7.4	45.7	36.0	9.7	18.5	16.0	2.5	1	2.5	14.5	14.5	0.0	N/A	N/A	N/A	N/A	N/A	0	Second attempted recovery of vehicle in Kootenay River
HLK/ALH 2019-13	15-May-19	Low	No	9.1	74.4	63.0	11.4	35.0	35.0	0.0	N/A	N/A	26.0	15.0	11.0	3	3.7	N/A	N/A	N/A	0	Operational Requirement under Treaty. Increased spring run-off and total gas pressure (TGP) issues in USA
HLK/ALH 2019-14	18-May-19	Low	Yes	9	69.1	64.3	4.8	46.0	46.0	0.0	N/A	N/A	15.0	10.0	5.0	1	5.0	Yes	No	477	9	Operational Requirement under Treaty and Non-Treaty Coordination Agreement
HLK/ALH 2019-15	3-Jun-19	High	No	12.2	89.4	82.6	6.8	63.0	63.0	0.0	N/A	N/A	23.0	18.0	5.0	1	5.0	N/A	N/A	N/A	0	Operational Requirement under Treaty due to TGP issues
HLK/ALH 2019-16	4-Jun-19	High	Yes	12.3	84.4	75.5	8.9	63.0	63.0	0.0	N/A	N/A	18.0	10.0	8.0	2	4.0	Yes	Yes	30	10	Operational Requirement under Treaty due to TGP issues
HLK/ALH 2019-17	15-Jun-19	High	No	15.1	84.4	81.1	3.3	44.0	44.0	0.0	N/A	N/A	36.0	35.0	1.0	1	1.0	N/A	N/A	N/A	0	Operational Requirement under Treaty and Non-Treaty Coordination Agreement
HLK/ALH 2019-18	3-Aug-19	High	Yes	15.6	92.5	76.1	16.4	18.5	18.5	0.0	N/A	N/A	70.8	56.0	14.8	3	4.9	Yes	Yes	47	7	Operational Requirement under Treaty and Non-Treaty Coordination Agreement
HLK/ALH 2019-19	4-Aug-19	High	Yes	17.5	76.2	71.6	4.6	18.5	18.5	0.0	N/A	N/A	56.0	51.5	4.5	1	4.5	Yes	No	9	9	Operational Requirement under Treaty and Non-Treaty Coordination Agreement
HLK/ALH 2019-20	24-Aug-19	High	Yes	18.6	79.1	66.5	12.6	18.0	18.0	0.0	N/A	N/A	59.0	46.0	13.0	3	4.3	Yes	No	2487	7	Operational Requirement under Treaty and Non-Treaty Coordination Agreement
HLK/ALH 2019-21	31-Aug-19	High	Yes	17.3	66.3	61.9	4.4	18.4	18.4	0.0	N/A	N/A	46	42.0	4.0	1	4.0	Yes	No	333	7	Operational Requirement under Treaty and Non-Treaty Coordination Agreement
HLK/ALH 2019-22	7-Sep-19	High	Yes	17.6	62.3	59.5	2.8	18.5	18.5	0.0	N/A	N/A	42.0	39.0	3.0	1	3.0	Yes	No	10	8	Operational Requirement under Treaty and Non-Treaty Coordination Agreement
HLK/ALH 2019-23	13-Sep-19	High	Yes	17	59.5	50.8	8.7	18.6	18.6	0.0	N/A	N/A	39.0	30.0	9.0	2	4.5	Yes	No	4463	7	Operational Requirement under Treaty and Non-Treaty Coordination Agreement
HLK/ALH 2019-24	14-Sep-19	High	Yes	17.5	51.0	41.8	9.2	18.6	18.6	0.0	N/A	N/A	30.0	21.0	9.0	2	4.5	Yes	Yes	56	6	Operational Requirement under Treaty and Non-Treaty Coordination Agreement
BRD/X 2019-25	29-Sep-19	High	Yes	15.2	39.5	32.0	7.5	18.4	11.5	6.9	4	1.7	19.0	19.0	0.0	N/A	N/A	Yes	Yes	423	7	Reduction from BRD/X due to limited inflows in reservoir
HLK/ALH 2019-26	12-Oct-19	Low	Yes	12.3	33.5	29.5	4.0	10.9	10.9	0.0	N/A	N/A	20.0	17.0	3.0	1	3.0	Yes	No	13	12	Operational Requirement under Treaty and Non-Treaty Coordination Agreement
HLK/ALH 2019-27	19-Oct-19	Low	No	12	32.4	28.0	4.4	10.7	10.7	0.0	N/A	N/A	17.0	13.0	4.0	4	1.0	N/A	N/A	N/A	0	Operational Requirement under Treaty and Non-Treaty Coordination Agreement
HLK/ALH 2020-01	4-Jan-20	Low	No	5.3	80.5	73.9	6.6	23.3	23.3	0.0	N/A	N/A	54.0	47.0	7.0	3	2.3	N/A	N/A	N/A	0	Operational Requirement under Treaty and Non-Treaty Coordination Agreement
HLK/ALH 2020-02	13-Jan-20	Low	No	4.4	84.9	70.2	14.7	18.4	18.4	0.0	N/A	N/A	63.0	48.0	15.0	3	5.0	N/A	N/A	N/A	0	Flows were dropped from HLK/ALH in an attempt to retrieve the floating guidewall upstream of HLK/ALH that was damaged due to extreme weather.
HLK/ALH 2020-03	18-Jan-20	Low	Yes	3.6	70.9	61.4	9.5	18.2	18.2	0.0	N/A	N/A	48.0	40.0	8.0	2	4.0	Yes	No	0	8	Operational Requirement under Treaty and Non-Treaty Coordination Agreement
HLK/ALH 2020-04	8-Feb-20	Low	No	4.1	75.5	69.5	6.0	18.2	32.8	N/A[c]	N/A	N/A	42.0	35.0	7.0	2	3.5	N/A	N/A	N/A	0	Operational Requirement under Treaty and Non-Treaty Coordination Agreement
HLK/ALH 2020-05	15-Feb-20	Low	No	4.3	68.6	63.6	5.0	33.0	33.0	0.0	N/A	N/A	35.0	28.5	6.5	2	3.3	N/A	N/A	N/A	0	Operational Requirement under Treaty and Non-Treaty Coordination Agreement
HLK/ALH 2020-06	29-Feb-20	Low	Yes	4.3	72.6	56.7	15.9	32.0	32.0	0.0	N/A	N/A	40.0	25.0	15.0	3	5.0	Yes	No	17	6	Operational Requirement under Treaty and Non-Treaty Coordination Agreement
HLK/ALH 2020-07	6-Mar-20	Low	No	4.5	51.2	47.5	3.7	24.0	24.0	0.0	N/A	N/A	25.0	23.0	2.0	1	2.0	N/A	N/A	N/A	0	Operational Requirement under Treaty and Floating Guidewall Repair Project (zero flow through HLK)
HLK/ALH 2020-08	7-Mar-20	Low	Yes	4.6	49.0	39.5	9.5	24.0	24.0	0.0	N/A	N/A	23.0	13.0	10.0	2	5.0	Yes	Yes	325	11	Operational Requirement under Treaty and Floating Guidewall Repair Project (zero flow through HLK)
HLK/ALH 2020-09	31-Mar-20	Low	Yes	4.9	49.7	40.2	9.5	14.1	14.1	0.0	N/A	N/A	36.0	26.0	10.0	2	5.0	Yes	Yes	568	12	Operational Requirement under Treaty and implementation of Rainbow Trout Spawning Protection Flows under non-power use agreement negotiated with US Entity
HLK/ALH 2020-10	1-Apr-20	Low	Yes	4.7	40.3	31.0	9.3	16.1	16.1	0.0	N/A	N/A	26.0	15.0	11.0	3	3.7	Yes	Yes	997	14	Operational Requirement under Treaty and implementation of Rainbow Trout Spawning Protection Flows under non-power use agreement negotiated with US Entity

Notes

[a] Discharge value used for database query prior to RE. Value based on predicted flow forecast on day of RE.

[c] Flows increased

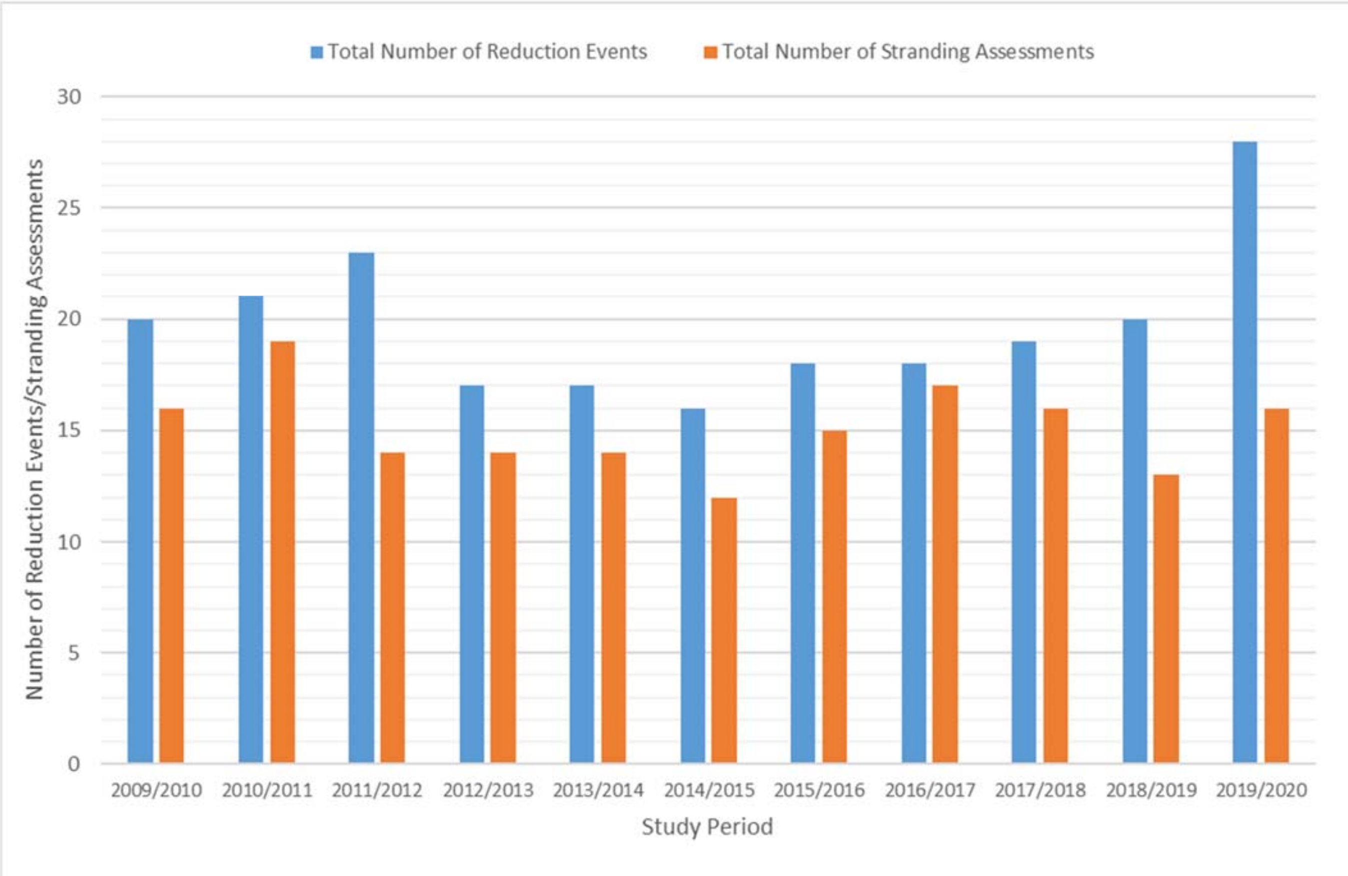

Figure 4: Total number of Reduction Events and Stranding Assessments conducted during each study period from 2009/2010 to 2019/2020

As in previous years, sites ranked as 'Effect' sites in the database queries were prioritized during stranding assessments. Out of a total of 139 individual site assessments conducted during the present study period, 76 were ranked 'Effect' sites, 61 were ranked 'Reconnaissance' sites, one was ranked 'Minimal Effect' site, and one was ranked 'No Pools', based on the database queries. The 'No Pools' site was assessed on 4 August 2019 during RE2019-19 at Bear Creek (LUB). This site was assessed to confirm the database designation. During this assessment, one pool was found and seven YOY fishes (Sucker spp. and unidentified) were captured and successfully salvaged. As a result of this assessment, the site designation of 'No Pools' for Bear Creek (LUB) at a resultant Birchbank discharge of 71.6 kcfs will change to 'Minimal Effect'.

During the present study period, 18 stranding sites were assessed at least once (Table 2). Stranding assessments were not conducted at Genelle Upper Cobble Island, Genelle Lower Cobble Island, Beaver Creek (LUB) and Fort Shepherd (LUB) due to an inability to access these sites with a truck. Genelle Upper Cobble Island and Genelle Lower Cobble Island are islands in the middle of the Columbia River that are surrounded by water year-round and are therefore limited to boat-access only. Access to Beaver Creek (LUB) and Fort Shepherd (LUB) is currently closed due to a permanent motorized vehicle closure of this area by the Fort Shepherd

Conservancy (managed by the Trail Wildlife Association). Despite limited assessments conducted at these sites in recent years, these sites will remain in the Lower Columbia River Fish Stranding Database because previous assessments still provide valuable data to the program.

See Appendix A; Figures A1 through A8 for site locations.

3.2.1 Fishes Captured or Observed During 2019/2020 Stranding Assessments

Isolated pools were observed during all stranding assessments conducted during the present study period. Stranded fishes were found during all stranding assessments conducted except for RE2020-03 (18 January 2020), when weather conditions were unfavourable for conducting a stranding assessment due to heavy snow; these conditions likely had an effect on the lack of fishes found during the stranding assessment. None of the stranding assessments conducted resulted in a 'Significant Fish Stranding Event' (greater than 5,000 fishes observed).

During the 16 fish stranding assessments conducted, an estimated total of 10,281 fishes were stranded (Table 2). The total number of fishes observed or captured during each stranding assessment ranged from 0 to 4,463.

On a temporal scale, the majority (77%) of stranded fishes were observed during the nine stranding assessments conducted during the High Risk period (1 June to 30 September). This temporal trend of higher stranding numbers between June 1 and Sept 30 has been observed in previous years (Golder 2017, 2018 and 2019). During this time period, larval and YOY fishes are known to inhabit near shore habitat, and the risk of stranding is elevated (Golder and Poisson 2010). High stranding numbers were also observed during RE2020-09 (568 fishes) and RE2020-10 (997 fishes), when flows were reduced at HLK/ALH from 36 to 26 kcfs (RE2020-09) and from 26 to 15 kcfs (RE2020-10) at the end of March for the implementation of Rainbow Trout Spawning Protection Flows (Table 1).

On a spatial scale the majority (84%) of stranded fishes were identified from pools and de-watered substrate located at Genelle Mainland (LUB), Bear Creek (RUB), and Lions Head (RUB) (Table 2). Genelle Mainland (LUB) has often been associated with high fish stranding numbers during annual assessments (Golder 2016, 2017, 2018, and 2019).

Table 2: Total Number of Fishes Stranded at each site during Reduction Events from 1 April 2019 to 1 April 2020

Site[a]	Total Number of Assessments	Total Number of Fishes Stranded	Median Number of Fishes Stranded per Assessment	% of Total Stranded Fishes
Genelle (Mainland) (LUB)	15	5185	5	50.4
Bear Creek (RUB)	9	2089	0	20.3
Lions Head (upstream of Norns Fan) (RUB)	8	1369	15	13.3
Norns Creek Fan (RUB)	13	532	22	5.2
Kootenay River (RUB)	12	478	2	4.6
Kootenay River (LUB)	13	148	0	1.4
CPR Island (MID)	7	141	0	1.4
Gyro Boat Launch	11	130	0	1.3
Zuckerberg Island (LUB)	7	55	1	0.5
Tin Cup Rapids (RUB)	11	46	1	0.4
Millennium Park (LUB)	8	41	0.5	0.4
Trail Bridge (RUB) (Downstream)	4	23	1.5	0.2
Blueberry Creek (LUB)	4	21	0	0.2
Casino Road Bridge, Trail (LUB) (Downstream)	4	11	0	0.1
Fort Shepherd Launch (RUB)	5	8	0	<0.1
Casino Road Bridge, Trail (LUB) (Upstream)	4	3	0	<0.1
Kinnaird Rapids (RUB)	1	1	1	<0.1
Beaver Creek (RUB)	3	0	0	0
Total	**139**	**10,281**		**100.0**

[a] Appendix A; Figures A1 through A8.

LUB = left bank as viewed facing upstream; RUB = right bank as viewed facing upstream.

3.2.1.1 *Fish Species*

3.2.1.1.1 Sportfishes

Sportfishes accounted for 18.6% of total fishes stranded during the present study period (Table 3). This catch represents an increase from the 2018/2019 study period, when sportfishes accounted for 3.7% of total fishes stranded. Stranded sportfishes during the present study period were limited to Mountain Whitefish and Rainbow Trout.

The higher percentage of stranded sportfishes during the present study period is attributed to 1,687 Mountain Whitefish that were stranded (Table 3). All Mountain Whitefish were YOY or juvenile age classes and were found during four reduction events that occurred in May/June 2019 and March/April 2020. This trend in timing was also observed during the 2016/2017 study period when nearly 100% of stranded Mountain Whitefish were found on 31 March 2017 (Golder 2017). These results indicate that Mountain Whitefish, likely face the highest risk of stranding during the spring months (March to June), when newly emerged fry are inhabiting near shore habitat. During the present study, the majority (99%) of Mountain Whitefish stranded were found at Lions Head (RUB), and Norns Creek Fan (RUB). Norns Creek is a known Mountain Whitefish spawning area. Once emerged from the egg stage, Mountain Whitefish fry drift downstream to the mouth of the creek which provides favourable rearing habitat (Golder 2014).

All Rainbow Trout were YOY or juveniles, and 89% were stranded during the High Risk period, indicating that the summer months may pose a higher risk of stranding for Rainbow Trout. The highest number of stranded Rainbow Trout (n = 108) occurred at CPR Island (RUB) during RE2019-23 on 13 September 2019. During this stranding assessment, 79 Rainbow Trout were successfully salvaged and returned to the Columbia River. Similar to previous years, Rainbow Trout were commonly found at sites with coarse substrate upstream of the Kootenay River and Columbia River confluence, including Tin Cup Rapids (RUB), CPR Island (MID), Norns Creek Fan (RUB), and Millennium Park (LUB). Juvenile Rainbow Trout tend to prefer areas with coarse substrate including cobble and boulder which provide adequate cover during daylight hours (McPhail 2007).

3.2.1.1.2 Non-sportfishes

As in previous years, non-sportfishes accounted for the majority (81.4%) of total fishes stranded during the present study period (Table 3). Of all non-sportfish species stranded, YOY and juvenile Sucker species were the most abundant. Sucker species commonly represent the highest number of stranded fishes during yearly stranding assessments (Golder 2016, 2017, and 2018). During the present study period, 97% of Sucker species were stranded during the High Risk period and the highest numbers were found at Genelle Mainland (LUB) (n = 3,889) and Bear Creek (RUB) (n = 1,238). During the 2018/2019 study period, Genelle Mainland (LUB) also had the highest number stranded Sucker species (n = 586) compared to other sites. This site is characterized by low angle sloping banks with gravel and sand substrate, and a shallow back channel that runs along the left downstream bank. The shallow, sheltered water within the back channel at Genelle Mainland (LUB) provides rearing habitat for YOY and juvenile Sucker species during the summer months; however this area poses a high stranding risk for YOY and juvenile Sucker species when reduction events occur during between 1 June and 30 September.

Redside Shiner were the second most abundant non-sportfishes stranded (Table 3). The majority (98%) of Redside Shiner were stranded during the High Risk period and the greatest numbers were found at Bear Creek (RUB) (n = 816) and Genelle Mainland (LUB) (n = 191). During RE2019-20 on 24 August 2019 a total of 800 Redside Shiner were stranded in a single large isolated pool at Bear Creek (RUB). This large pool forms when Birchbank discharge drops to approximately 66 kcfs and poses a high stranding risk for YOY and juvenile Sucker species and Redside Shiner during the High Risk period.

A total of 688 YOY and juvenile Northern Pikeminnow (*Ptychocheilus oregonensis*) were stranded during the present study period (Table 3). Of the total, 86.7% Northern Pikeminnow were stranded during the High Risk period and the greatest number (n = 590) were found at Genelle Mainland (LUB) during RE2019-23. During this stranding assessment, the field crew were able to salvage approximately 450 Northern Pikeminnow with a dip net and successfully return them to the Columbia River.

Sculpin species are bottom-dwellers, remaining close to the substrate throughout their life stages, and are commonly observed during stranding assessments in the Columbia River. Torrent Sculpin (*Cottus rhotheus*), Prickly Sculpin (*Cottus asper*), Slimy Sculpin (*Cottus cognatus*), and Shorthead Sculpin (*Cottus confusus*) were stranded during the present study period (Table 3). As in previous years, Torrent Sculpin represented the highest number of all stranded sculpin species (Golder 2016, 2017, 2018, and 2019). In 2019/2020, a total of 123 Torrent Sculpin were stranded, accounting for 74% of all sculpin that were identified to species. Stranded Torrent Sculpin were found nearly equal between the High Risk (44%) and Low Risk Period (56%) periods and were found at most stranding sites.

3.2.1.1.3 Unidentified Fishes

During the present study period, 577 unidentified fishes and 42 sculpin were observed during stranding assessments but were not identified to species. The majority (99%) of fishes listed as unidentified were observed visually during salvage efforts but were not captured either due to time constraints or because they avoided capture (i.e., buried into coarse substrate) during electrofishing efforts. A total of 4 fishes listed as unidentified were captured and salvaged. These fish were larval age class (12 to 14 mm fork length) and were captured during RE2019-19 (4 August 2019) at Bear Creek (RUB) and during RE2019-20 (24 August 2019) at Kootenay River (RUB). Due to the early age class and few distinguishing features of these fishes they were not able to be identified in the field. Based on other fishes captured from nearby sites during the same reduction events, these fish were likely larval Sucker species.

The captured sculpin (n = 41) that were not identified to species were juveniles with total lengths between 17 and 42 mm. Due to the small size of juvenile sculpin and widespread interspecific hybridization is common in the Kootenay region (McPhail 2007), field identification of juvenile sculpin to the species level can be difficult.

3.2.1.1.4 Exotic Fish Species

Exotic species stranded during the present study period were limited to Brook Trout, Northern Pike, and Tench. A single juvenile Brook Trout was found in an isolated pool at Fort Shepherd Launch (RUB) during RE2020-09. A single juvenile Northern Pike was found in a large isolated pool with submergent vegetation at Zuckerberg Island (LUB) during RE2019-25. Three juvenile Tench were found stranded in an isolated pool at Kootenay (RUB) during RE2020-09. All stranded exotic species were measured for fork length and euthanized as requested by the Ministry of Forests, Lands, Natural Resource Operations & Rural Development (FLNRORD) (Pers. Comm., Matt Neufeld, FLNRORD, 22 February 2016).

Exotic fish species have been identified and recorded during stranding assessments since 2000 in varying numbers, although species composition has remained constant. The majority (98%) of all exotic fish species recorded during stranding assessments were Smallmouth Bass (*Micropterus dolomieu*). The remaining 2% in order of abundance were Common Carp (*Cyprinus carpio*), Brook Trout, Yellow Perch (*Perca flavescens*), Northern Pike, Tench, and Walleye (*Sander vitreus*).

Table 3: Summary of Fish Species Captured or Observed during Fish Stranding Assessments Subsequent to Reductions in Discharge from HLK/ALH or from BRD/X, 1 April 2019 to 1 April 2020

Group	Species	Total Stranded and/or Captured	Percent of Total Stranded and/or Captured (%)	Number of Mortalities	Number Salvaged	Species Classification		
						SARA [a]	COSEWIC [b]	CDC [c]
Sportfishes	Mountain Whitefish (*Prosopium williamsoni*)	1687	16.4	260	390	N/A	N/A	Yellow
	Rainbow Trout (*Oncorhynchus mykiss*)	227	2.2	43	148	N/A	N/A	Yellow
Non-Sportfishes	Sucker species (*Catostomidae spp.*)	5336	51.9	23	3150	N/A [d]	N/A [d]	N/A [d]
	Redside Shiner (*Richardsonius balteatus*)	1037	10.1	25	992	N/A	N/A	Yellow
	Northern Pikeminnow (*Ptychocheilus oregonensis*)	688	6.7	5	543	N/A	N/A	Yellow
	Unidentified [e]	577	5.6	1	4	N/A [f]	N/A [f]	N/A [f]
	Longnose Dace (*Rhinichthys cataractae*)	448	4.4	35	388	N/A	N/A	Yellow
	Torrent Sculpin (*Cottus rhotheus*)	123	1.2	11	111	N/A	N/A	Yellow
	Umatilla Dace (*Rhinichthys umatilla*)	58	0.6	2	56	Schedule 3 Special Concern	Threatened	Red
	Sculpin species (*Cottus spp.*)	42	0.4	0	39	N/A [f]	N/A [f]	N/A [f]
	Prickly Sculpin (*Cottus asper*)	33	0.3	7	24	N/A	N/A	Yellow
	Peamouth (*Mylocheilus caurinus*)	10	0.1	1	8	N/A	N/A	Yellow
	Slimy Sculpin (*Cottus cognatus*)	7	< 0.1	0	7	N/A	N/A	Yellow
	Shorthead Sculpin (*Cottus confusus*)	3	< 0.1	0	3	Schedule 1 Special Concern	Special Concern	Blue
Exotic Fishes	Brook Trout (*Salvelinus fontinalis*)	1	< 0.1	1	0	N/A	N/A	Exotic
	Northern Pike (*Esox lucius*)	1	< 0.1	1	0	N/A	N/A	Exotic [g]
	Tench (*Tinca tinca*)	3	< 0.1	1	0	N/A	N/A	Exotic
Total		**10,281**		**416**	**5,863**			

[a] Species at Risk Act; Species that were designated at risk by COSEWIC (the Committee on the Status of Endangered Wildlife in Canada) before the creation of the *Species at Risk Act* must be reassessed according to the new criteria of the Act before they can be added to Schedule 1. These species are listed on Schedules 2 and 3 and are not yet officially protected under SARA (COSEWIC 2010).
[b] Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2010).
[c] BC Conservation Data Centre; Red = any indigenous species or subspecies that have, or are candidates for, Extirpated, Endangered, or Threatened status in British Columbia; Blue = any indigenous species or subspecies considered to be of Special Concern (formerly Vulnerable) in British Columbia. Yellow = species that are apparently secure and not at risk of extinction. Exotic = species that have been moved beyond their natural range as a result of human activity. (B.C. Conservation Data Centre. 2020).
[d] No species are listed from this region that are found under any of the classification criteria for species of concern.
[e] Not identified to species because they were observed during visual surveys but not captured.
[f] Fish identified to family level or other high-level taxa may potentially be species of concern under the classification system listed.
[g] Northern Pike are listed as ‘Yellow’ under the BC Conservation Data Center; however, this species is considered exotic for the Columbia River.

3.2.1.1.5 Listed Fish Species

Umatilla Dace, Columbia Sculpin, Shorthead Sculpin, and White Sturgeon are the four listed resident species in the study area. Umatilla Dace, Columbia Sculpin, and Shorthead Sculpin have been documented during previous study years (Golder 2016, 2017, 2018, and 2019), however White Sturgeon have never been documented during lower Columbia River and Kootenay River fish stranding assessments.

During the present study period, 58 Umatilla Dace, and 3 Shorthead Sculpin were stranded and the majority were stranded during the Low Risk period (Table 4). These findings indicate that Umatilla Dace are not uncommon in the lower Columbia and Kootenay rivers, and that that this species likely does not face a higher stranding risk during the summer months as do other species (i.e., Sucker species, and Redside Shiner).

Of all listed fishes stranded since year 2000, 94% were stranded during the Low Risk period and 96% were Umatilla Dace. The reason Umatilla Dace have been found more commonly during the Low Risk period compared to the High Risk period is unknown. Previous studies have noted opposing trends. In a report by R.L. & L. Environmental Services Ltd. (1995), YOY Umatilla Dace were recorded in the mainstem Columbia River in shallow nearshore areas throughout the year and juveniles (1+) were abundant in nearshore areas in the summer, but then moved to deeper water during the fall (R.L. & L. Environmental Services Ltd. 1995).

During the present study period, the greatest number of stranded Umatilla Dace occurred at Gyro Boat Launch during RE2020-08. During this reduction event, a total of 43 Umatilla Dace were stranded in a large isolated pool with cobble and sand substrate. All Umatilla Dace that were captured at Gyro Boat Launch were successfully salvaged. Since 2000, there have been a total of 263 Umatilla Dace found stranded at Gyro Boat Launch, indicating that this location may provide adequate habitat for this species.

The total number of Shorthead Sculpin found stranded annually is often low. Since 2000, there have been a total of 30 Shorthead Sculpin found stranded during fish stranding assessments on the Lower Columbia River.

Table 4: Summary of Listed Species Captured or Observed during Stranding Assessments, 1 April 2019 to 1 April 2020

Site [a]	Total Number of Assessments	Number of Assessments with Listed Species	Risk Period when Listed Species were Stranded [b]	Number of Listed Fish Stranded
Umatilla Dace (SARA: Schedule 3 Special Concern, COSEWIC: Threatened, CDC: Red)				
Bear Creek (RUB)	9	1	Low	3
Genelle Mainland (LUB)	15	1	High	1
Gyro Boat Launch	11	1	Low	43
Kootenay River (LUB)	12	1	High	5
		1	Low	1
Kootenay River (RUB)	13	3	Low	5
Shorthead Sculpin (SARA: Schedule 1 Special Concern, COSEWIC: Special Concern, CDC: Blue)				
Genelle Mainland (LUB)	15	1	Low	2
Millennium Park (LUB)	8	1	Low	1
Total				**61**

[a] For site locations see Appendix A; Figures A1 through A8.
[b] High Risk period = 1 June to 30 September; Low Risk period = 1 October to 31 May.

3.3 Historic Fish Stranding Summary

The results of fish stranding assessments conducted between January 2000 and 1 April 2020 are summarized by site, resultant Birchbank discharge (classified into 10 kcfs ranges), and risk period (Table 5). This table is used by the DCC to determine if a proposed reduction event has occurred historically for the time of year, and which sites resulted in high stranding risk. The numbers of fishes are presented as the maximum number of fishes stranded at each site during a single reduction event. The classification of sites where listed species have been previously identified is included as yellow highlighted cells.

During the High Risk period, ‘Effect’ sites have been identified at all resultant Birchbank discharge ranges between ≥30 to <40 kcfs and >120 kcfs, with high stranding numbers from previous reduction events occurring between 30 and 60 kcfs (Table 5). Specifically, 37,964 fishes were stranded at Genelle Mainland (LUB) between 29 July and 14 August 2008 when discharge reached 59.3 kcfs due to load factoring operations at BRD/X; 14,302 fishes were stranded at Genelle Mainland (LUB) on 22 July 2004 when discharge reached 48.8 kcfs; and 13,500 fishes were stranded at Tin Cup Rapids (RUB) on 18 July 2001 when discharge reached 30.3 kcfs. Genelle Mainland (LUB) and Tin Cup Rapids (RUB) have been identified as ‘Effect’ sites for most discharge ranges during the High Risk period and are a priority for stranding assessments during this time period. During the present study, nine stranding assessments were conducted during the High Risk period for reduction events with resultant Birchbank discharge values between 32.0 and 75.5 kcfs. As a result of these stranding assessments, there were no new ‘Effect’ sites added to Table 5. During the Low Risk period, ‘Effect’ sites have been identified at all resultant Birchbank discharges ranges between ≤ 30 kcfs and ≥60 to <70 kcfs, with high stranding numbers from previous reduction events occurring between 30 and 40 kcfs (Table 5). The highest stranding event occurred at Norn's Creek Fan, when 5,071 fishes were stranded on 1 April 2005 when discharge reached 38.6 kcfs. Generally, the maximum number of fish per site and overall discharge in the Columbia River are lower during the Low Risk period than in the High Risk period. During the present study, seven stranding assessments were conducted during the Low Risk period for reduction events with resultant Birchbank discharge values between 29.5 and 64.3 kcfs. As a result of these stranding assessments, Lions Head (RUB) changed to an 'Effect' site due to RE2020-09 (201 fishes stranded) and RE2020-10 (953 fishes stranded) (Table 5). RE2020-09 had a resultant Birchbank discharge of 40.2 kcfs, and RE2020-10 had a resultant Birchbank discharge of 31.0 kcfs. During both assessments a large number of small pools were found within fine silt substrate and most fishes that were stranded were YOY Mountain Whitefish. These findings show that Lions Head (RUB) site should be a focus during future stranding assessments when Birchbank discharge reaches near 30 - 40 kcfs, particularly in the spring months when YOY mountain whitefish are likely to be abundant.

Historically, a greater number of listed fishes have been stranded during the Low Risk period compared to the High Risk period. Since 2000, listed fishes have been found at 15 sites during the Low Risk period, compared to only 5 sites during the High Risk period (Table 5).

An analysis of the Lower Columbia River Fish Stranding Database conducted in 2010 identified that stranding risk decreased when Birchbank discharge was greater than 110 kcfs during the High Risk period and when Birchbank discharge was greater than 60 kcfs during the Low Risk period (Golder and Poisson 2010). Based on the patterns observed in Table 5 (with the inclusion of an additional 10 years of stranding data), it would appear that the above relationships between risk period, discharge and stranding risk remain true. However, it should be noted that there have been few stranding assessments conducted at a Birchbank discharge greater than 110 kcfs during the High Risk period and that this level of discharge in the Columbia River is not common. An analysis on the Lower Columbia River Fish Stranding Database will be conducted in 2020 to further investigate whether the time of year a reduction occurs and the minimum discharge reached during reductions (as recorded at Birchbank) have an effect on fish stranding. The findings will be presented in a forthcoming final compendium report (Golder in prep.), and results of this analysis will provide rationale for update to the *Canadian Lower Columbia River: Fish Stranding Risk Assessment and Response Strategy* (Golder 2011).

Table 5: Summary of effects and corresponding responses for fish stranding on the lower Columbia River from flow reductions at HLK/ALH and BRD/BRX sorted by time of year. (Based on data collected between 2000 and 2020).

Risk Period	Resultant Birchbank Discharge (kcfs)	Observed Effect																																									
		Columbia River										Kootenay River				Columbia River																													
		Lions Head		Norn's Creek Fan		CPR Island		Tin Cup Rapids		Millennium Park		Kootenay River (LUB)		Kootenay River (RUB)		Zuckerberg Island		Kinnaird Rapids		Blueberry Creek		Genelle Mainland		Genelle Upper Cobble Island		Genelle Lower Cobble Island		Gyro Boat Launch		Trail Bridge		Casino Road Bridge, Trail (u/s)		Casino Road Bridge, Trail (d/s)		Bear Creek		Beaver Creek (RUB)		Beaver Creek (LUB)		Fort Shepherd Eddy		Fort Shepherd Launch	
		Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits
High Risk (1 June to 30 September)	≤30																			No Pools																		No Pools		No Pools					
	≥30 to <40	8	1	455	2	60	3	13500	3	38	2	129	2	641	4	620	3	No Pools		No Pools		1720	2	No Pools		0	1	152	1					0	1			31	1			7500	2		
	≥40 to <50	0	1	312	6	191	6	76	4	15	2	94	4	81	8	0	1			4505	1	14302	7	No Pools				464	4					207	3	0	1							0	1
	≥50 to <60	17	4	150	14	112	4	253	16	17	8	58	15	3901	21	18	8	No Pools		No Pools		37964	21					0	5	0	3	0	4	11	4	0	5	358	4			0	2	0	2
	≥60 to <70	0	4	423	31	0	5	258	29	34	10	3172	36	5737	35	55	16	0	1	1	4	3118	33	1	1	20	2	0	4	No Pools		3	8	5	8	2030	11	6	8	0	1	0	2	2	4
	≥70 to <80	8	10	56	19	0	2	219	18	0	13	1	12	35	16	48	13	No Pools		1299	11	1503	21	54	2	0	4	0	2	No Pools		No Pools		0	5	34	10	8	10	No Pools		0	2	1	8
	≥80 to <90	No Pools		88	20	No Pools		34	19	24	21	No Pools		12	9	0	13	No Pools		269	9	6000	18	0	8	3	9	500	7	No Pools		No Pools		No Pools		0	4	62	5	No Pools		0	4	134	5
	≥90 to <100	No Pools		5	11	0	4	563	13	26	11	No Pools		No Pools		No Pools		No Pools		No Pools		900	12	No Pools		0	3	500	6	No Pools		No Pools		No Pools		No Pools		251	7	No Pools		0	4	No Pools	
	≥100 to <110			2	3	2	1	10307	4	7521	3	No Pools		No Pools		0	3			No Pools		0	3					500	2																
	≥110 to <120			No Pools		No Pools		1500	5	60	3	No Pools		No Pools		No Pools		No Pools		0	2	No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		0	2		
	≥120			No Pools		No Pools		1200	3	100	1	No Pools		0	3	0	1			0	2	0	2	No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		0	1		
Low Risk (1 October to 31 May)	≤30			29	6	6	3	68	5	601	6	0	3	643	6	5	4	1	3	No Pools		5	4					0	4	8	4	0	4	0	4	2063	5	No Pools		No Pools		0	1		1
	≥30 to <40	953	12	5071	43	110	13	228	29	358	34	286	27	1168	37	95	32	No Pools		No Pools		1414	32	No Pools		0	4	2024	17	20	13	0	11	1	14	18	12	38	9	0	4	80	3	9	10
	≥40 to <50	201	8	623	54	337	41	117	42	526	29	517	52	1450	72	298	42	0	3	0	4	210	47	No Pools		0	6	755	38	14	13	4	12	2	10	2015	15	44	11	0	7	8	7	5	12
	≥50 to <60	33	5	146	30	12	16	86	24	52	22	193	31	340	38	71	31	No Pools		No Pools		400	33	0	6	0	7	48	16	0	10	0	16	21	21	1	12	0	5	20	4	2	4	29	5
	≥60 to <70	177	5	700	32	16	15	11	30	2	23	122	42	529	45	109	30	0	6	1	7	520	36	1	5	0	4	351	18	No Pools		1	20	3	23	0	17	4	6	0	2	0	2	46	7
	≥70 to <80	0	2	79	15	2	4	3	17	2	18	0	14	10	18	0	19	No Pools		0	5	7	11	0	3	0	5	No Pools		No Pools		No Pools		0	8	3	15	0	6	No Pools		0	1	0	1
	≥80 to <90	No Pools		0	2	No Pools		1	3	0	4	No Pools		0	4	0	3	No Pools		0	3	1	4	0	2	0	4	0	3	No Pools		No Pools		No Pools		0	2	0	4	No Pools		0	1	0	1
	≥90 to <100	No Pools		0	1	0	1	0	1	0	1	No Pools		No Pools		No Pools		No Pools		No Pools		0	1	No Pools		0	1			No Pools		No Pools		No Pools		No Pools				No Pools		0	1	No Pools	
	≥100 to <110											No Pools		No Pools						No Pools																									
	≥110 to <120			No Pools		No Pools						No Pools		No Pools		No Pools		No Pools				No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools					
	≥120			No Pools		No Pools		0	1	0	1	No Pools		0	1	0	1					0	1	No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools					

Code	Description	Definition and Response
	No Pools	Site has been previously surveyed; pools have not been recorded at or near these flows. No Response.
	Minimal Effect	Site has been previously surveyed at least five times under similar flow conditions and isolated pools were observed; less than 200 fish were recorded during a single reduction event under similar conditions. No Response.
	No Data or Insufficient Data	Site has been previously surveyed less than five times under similar flow conditions; less than 200 fish were recorded during a single reduction event under similar conditions. Reconnaissance Survey.
	Effect	Site has been previously surveyed under similar flow conditions and isolated pools were observed; greater than 200 fish were recorded during a single reduction event under similar flow conditions. Stranding Survey.
	Unlikely Discharge Range	Birchbank discharge has not been recorded at these levels during the specified time period (based on discharge data collected between 2000 and 2020).
	Listed species were captured or observed.	During at least one stranding assessment under similar flow conditions listed species were captured or observed.

Does not include data pre-recontouring.

Includes all stranding assessments and stranded fish between 1 January 2000 and 1 April 2020.

4.0 SUMMARY

- The present study is a data report summarizing the results of fish stranding assessments conducted following flow reductions at HLK/ALH and BRD/X at pre-determined sites on the Columbia and Kootenay rivers between 1 April 2019 and 1 April 2020. The five management questions of the Lower Columbia River Fish Stranding Assessment and Ramping Protocol (CLBMON#42) will be discussed and addressed in a forthcoming final compendium report (Golder in prep.)
- Discharge in the Columbia River at the Birchbank Gauging Station was typical of previous years and ranged from 25.6 to 96.2 kcfs between 1 April 2019 and 1 April 2020.
- During the present study, there were 28 operational flow reduction events; 25 from HLK/ALH and 3 from BRD/X. Stranding assessments were conducted for 16 of the 28 reduction events, resulting in a response rate of 57%.
- During the 16 fish stranding assessments conducted, an estimated total of 10,281 fishes were stranded, and 57% of stranded fishes were successfully salvaged and returned to the Columbia or Kootenay rivers. Similar to previous years, the majority of stranded fishes (77%) were observed during the High Risk period.
- Sportfishes accounted for 18.6% of all stranded fishes and represented a higher percentage of total fishes stranded compared to the previous study period (2018/2019). The higher percentage of stranded sportfishes during the present study period is attributed to 1,687 YOY and juvenile Mountain Whitefish that were stranded during four reduction events between the months of March and June. This timing corresponds with the emergence of Mountain Whitefish from egg to larval stage. Stranded sportfishes were limited to YOY and juvenile Mountain Whitefish, Rainbow Trout, Brook Trout and Northern Pike, in order of abundance.
- Non-sportfishes accounted for 81.4% of all stranded fishes with YOY and juvenile Sucker species representing the highest abundance. The majority of Sucker species were found at Genelle Mainland (LUB), which continues to be a site with high stranding risk for YOY and juvenile Sucker species.
- Listed species that were stranded during the present study were limited to 43 Umatilla Dace and 3 Shorthead Sculpin. All Umatilla Dace and Shorthead Sculpin were found in isolated pools, and the majority (90%) were found during the Low Risk period.

5.0 RECOMMENDATIONS

- As written in the *Canadian Lower Columbia River: Fish Stranding Risk Assessment and Response Strategy* (Golder 2011) ‘Effect’ sites should remain the focus of stranding assessments, and if time permits, it is recommended that ‘Reconnaissance’ sites be visited in order to fill in data gaps that still exist in Table 5. Additional site assessments will lead to a site designation of ‘No Pools’, ‘Minimal Effect’, ‘Effect’ or ‘Significant Fish Stranding’, thereby increasing the precision of the query. As the dataset becomes more refined, so too will the decision to initiate stranding assessments.

Currently the database queries identify an ‘Effect’ site as any site that has had greater than 200 fishes or any listed species stranded during previous reduction events under similar conditions between year 2000 and the current date. In early 2020 the *Canadian Lower Columbia River: Fish Stranding Risk Assessment and Response Strategy* will be updated, and the update will re-consider when a stranding assessment is recommended. For this update it is recommended that the frequency of a site being an ‘Effect’ site be considered in the decision-making process for initiating a stranding assessment.

- The sites listed below have been previously recommended as candidates for re-contouring because of high stranding risk relative to other sites (Golder and Poisson 2010). Re-contouring at these sites could be conducted using a phased approach, with higher priority sites (based on stranding risk, cost, and other factors) being enhanced first and other sites being re-contoured in subsequent years. Sites recommended for re-contouring are:
  - Kootenay (RUB) - Kootenay (RUB) and the associated Kootenay Oxbow are inundated and dewatered as a result of flow regulation from BRD/X and HLK/ALH. Re-contouring of this site would assist in the draining of Kootenay Oxbow during RE. Kootenay (RUB) is a good candidate for re-contouring because it is a common stranding site. Since 2000, this site has stranded a total of 22,725 fishes (third highest site for total stranded fishes), including 496 listed fishes during 256 reduction events. Listed species have been stranded for 17 of the previous 20 years. Kootenay (RUB) has also been identified as an ‘Effect’ site at common Birchbank discharge ranges (30 to 70 kcfs in High and Low Risk period) (Table 5). Additionally, re-contouring efforts would help reduce stranding at a public and logistically difficult place to salvage fishes (very large, shallow pools with large cobble substrate).
  - Genelle Mainland (LUB) - In 2003, two large pools at the downstream end of Genelle Mainland (LUB) were re-contoured. Since then, years of high flow (in particular 2012) have changed the site topography resulting in the formation of stranding pools at a variety of discharges. This site is a good candidate for re-contouring because of a large abundance of fishes that are common in this area (particularly during the High Risk period) and has a history of significant stranding events. Since 2000, Genelle Mainland (LUB) has had the highest total number of stranded fishes (96,647 fishes including 84 listed species during 227 reduction events). Additionally, Genelle Mainland (LUB) has been designated as an ‘Effect’ site for a large range of discharges (40 to 100 kcfs during the High Risk period, and 30 to 70 kcfs during the Low Risk period) (Table 5). Suggested modifications include improving drainage between the access road and the Whispering Pines Trailer Park and infilling of a large pool that forms at a Birchbank discharge near 60 kcfs.
  - Gyro Boat Launch (RUB) - Since 2000, Gyro Boat Launch (RUB) has stranded a total of 9475 fishes including 301 listed species during 124 reduction events. This site is a good candidate for re-contouring because it would be a logistically easy place to bring equipment in to conduct re-contouring. Re-contouring efforts at Gyro Boat Launch (RUB) should include the removal of a large artificial depression (potential storm drain exit) that is prone to fish stranding.
- 1 April 2019 to 1 April 2020 represents the final year of the Lower Columbia and Kootenay River Fish Stranding Assessments under the 13 year Columbia River Water Use Plan. Golder recommends conducting a statistical analysis on the Lower Columbia River Fish Stranding Database similar to Golder and Poisson (2010). These analyses would include all data collected from stranding assessments between year 2000 and 2020. As in Golder and Poisson (2010), the analyses would be conducted with a focus to answer the CLBMON-42 management questions (BC Hydro 2007). The results of this analysis will be presented to BC Hydro in a forthcoming final compendium report (Golder in prep).

6.0 CLOSURE

We trust that this report meets your current requirements. If you have any further questions, please do not hesitate to contact the undersigned.

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KL/SR/cmc

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https://golderassociates.sharepoint.com/sites/104258/project files/6 deliverables/issued to client_for wp/19117420-003-r-rev0/19117420-003-r-rev0-lcr stranding 2019_2020_annual_summary 11jun_20.docx

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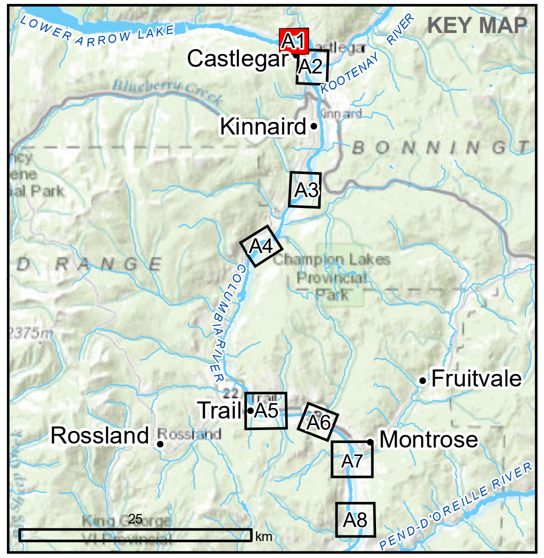
APPENDIX A

Site Maps

LEGEND

● STRANDING SITE



0 130 260

1:5,000 METRES

REFERENCE

1. WATERCOURSE AND WATERBODY DATA OBTAINED FROM IHS ENERGY INC.
2. BASE IMAGERY SOURCE: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY
SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

CLIENT
BC HYDRO

PROJECT
LOWER COLUMBIA RIVER (CLBMON#42[A]) AND KOOTENAY RIVER FISH STRANDING ASSESSMENTS: ANNUAL SUMMARY (APRIL 2019 TO APRIL 2020)

TITLE
STRANDING SITES: UPPER SECTION - COLUMBIA RIVER

CONSULTANT

GOLDER

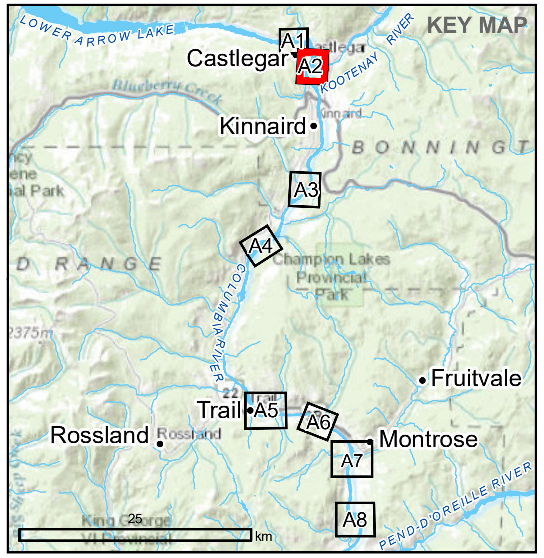
YYYY-MM-DD	2020-06-11
DESIGN	KL
PREPARED	CD
REVIEW	SR
APPROVED	KL

PROJECT No.	CONTROL	Rev.	FIGURE
19117420	2020	0	**A1**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM
25mm

LEGEND

● STRANDING SITE



0 170 340

1:6,500 METRES

REFERENCE

1. WATERCOURSE AND WATERBODY DATA OBTAINED FROM IHS ENERGY INC.
2. BASE IMAGERY SOURCE: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY
SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

CLIENT
BC HYDRO

PROJECT
LOWER COLUMBIA RIVER (CLBMON#42[A]) AND KOOTENAY RIVER FISH STRANDING ASSESSMENTS: ANNUAL SUMMARY (APRIL 2019 TO APRIL 2020)

TITLE
STRANDING SITES: UPPER SECTION - COLUMBIA RIVER

CONSULTANT

GOLDER

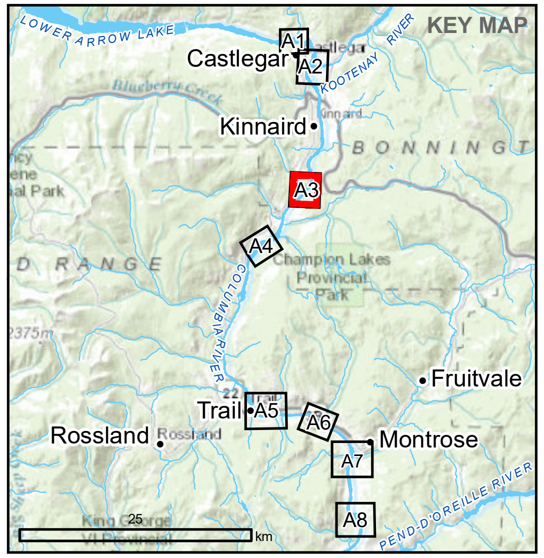
YYYY-MM-DD	2020-06-11
DESIGN	KL
PREPARED	CD
REVIEW	SR
APPROVED	KL

PROJECT No.	CONTROL	Rev.	FIGURE
19117420	2020	0	A2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

LEGEND

STRANDING SITE



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1:6,500 METRES

REFERENCE

1. WATERCOURSE AND WATERBODY DATA OBTAINED FROM IHS ENERGY INC.
2. BASE IMAGERY SOURCE: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY
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CLIENT
BC HYDRO

PROJECT
LOWER COLUMBIA RIVER (CLBMON#42[A]) AND KOOTENAY RIVER FISH STRANDING ASSESSMENTS: ANNUAL SUMMARY (APRIL 2019 TO APRIL 2020)

TITLE
STRANDING SITES: UPPER SECTION - COLUMBIA RIVER

CONSULTANT

GOLDER

YYYY-MM-DD	2020-06-11
DESIGN	KL
PREPARED	CD
REVIEW	SR
APPROVED	KL

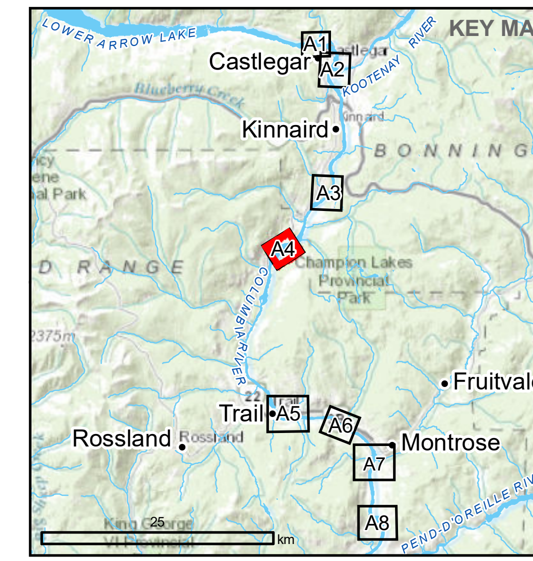
PROJECT No.	CONTROL	Rev.	FIGURE
19117420	2020	0	A3

25mm

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM

LEGEND

● STRANDING SITE



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1:6,000 METRES

REFERENCE

1. WATERCOURSE AND WATERBODY DATA OBTAINED FROM IHS ENERGY INC.
2. BASE IMAGERY SOURCE: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY
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CLIENT
BC HYDRO

PROJECT
LOWER COLUMBIA RIVER (CLBMON#42[A]) AND KOOTENAY RIVER FISH STRANDING ASSESSMENTS: ANNUAL SUMMARY (APRIL 2019 TO APRIL 2020)

TITLE
STRANDING SITES: MIDDLE SECTION - COLUMBIA RIVER

CONSULTANT

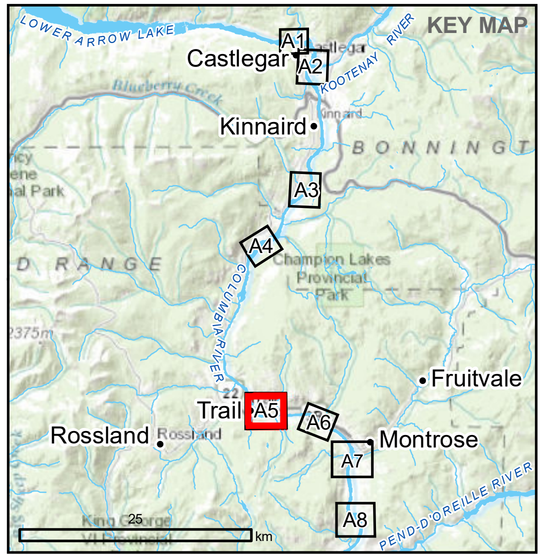
GOLDER

YYYY-MM-DD	2020-06-11
DESIGN	KL
PREPARED	CD
REVIEW	SR
APPROVED	KL

PROJECT No.	CONTROL	Rev.	FIGURE
19117420	2020	0	A4

LEGEND

● STRANDING SITE



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1:8,000 METRES

REFERENCE

1. WATERCOURSE AND WATERBODY DATA OBTAINED FROM IHS ENERGY INC.
2. BASE IMAGERY SOURCE: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY
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CLIENT
BC HYDRO

PROJECT
LOWER COLUMBIA RIVER (CLBMON#42[A]) AND KOOTENAY RIVER FISH STRANDING ASSESSMENTS: ANNUAL SUMMARY (APRIL 2019 TO APRIL 2020)

TITLE
STRANDING SITES: LOWER SECTION - COLUMBIA RIVER

CONSULTANT

GOLDER

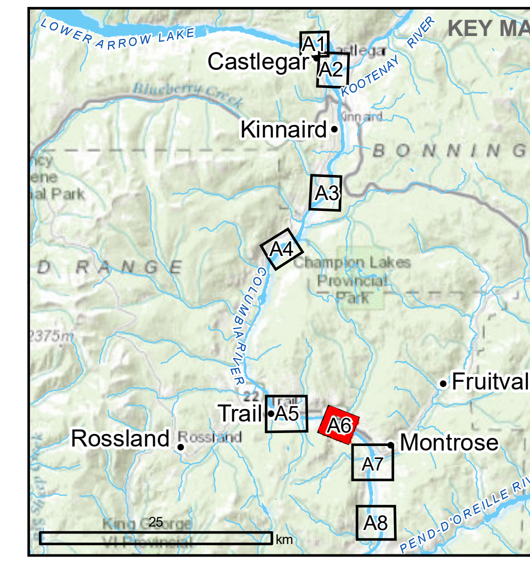
YYYY-MM-DD	2020-06-11
DESIGN	KL
PREPARED	CD
REVIEW	SR
APPROVED	KL

PROJECT No.	CONTROL	Rev.	FIGURE
19117420	2020	0	**A5**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

LEGEND

● STRANDING SITE



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1:6,000 METRES

REFERENCE

1. WATERCOURSE AND WATERBODY DATA OBTAINED FROM IHS ENERGY INC.
2. BASE IMAGERY SOURCE: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY
SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

CLIENT
BC HYDRO

PROJECT
LOWER COLUMBIA RIVER (CLBMON#42[A]) AND KOOTENAY RIVER FISH STRANDING ASSESSMENTS: ANNUAL SUMMARY (APRIL 2019 TO APRIL 2020)

TITLE
STRANDING SITES: LOWER SECTION - COLUMBIA RIVER

CONSULTANT

GOLDER

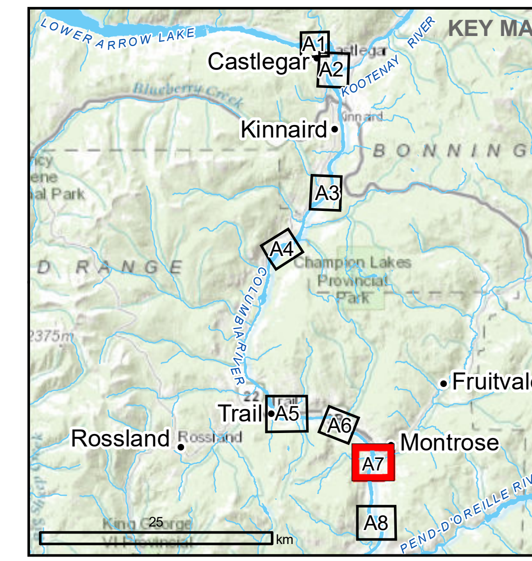
YYYY-MM-DD	2020-06-11
DESIGN	KL
PREPARED	CD
REVIEW	SR
APPROVED	KL

PROJECT No.	CONTROL	Rev.	FIGURE
19117420	2020	0	**A6**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

LEGEND

● STRANDING SITE



0 210 420

1:8,000 METRES

REFERENCE

1. WATERCOURSE AND WATERBODY DATA OBTAINED FROM IHS ENERGY INC.
2. BASE IMAGERY SOURCE: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY
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PROJECT
LOWER COLUMBIA RIVER (CLBMON#42[A]) AND KOOTENAY RIVER FISH STRANDING ASSESSMENTS: ANNUAL SUMMARY (APRIL 2019 TO APRIL 2020)

TITLE
STRANDING SITES: LOWER SECTION - COLUMBIA RIVER

CONSULTANT

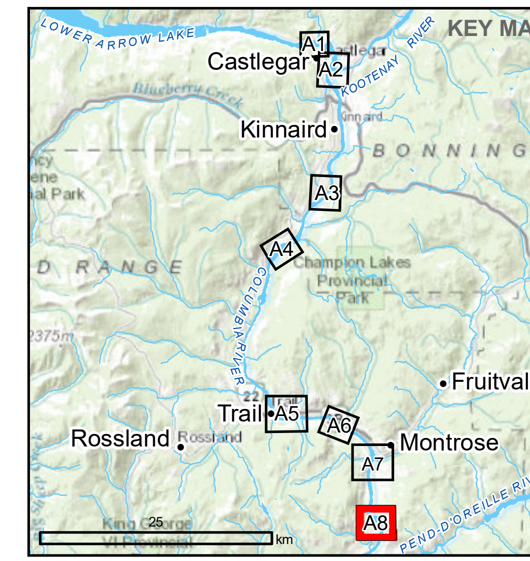
GOLDER

YYYY-MM-DD	2020-06-11
DESIGN	KL
PREPARED	CD
REVIEW	SR
APPROVED	KL

PROJECT No.	CONTROL	Rev.	FIGURE
19117420	2020	0	**A7**

LEGEND

● STRANDING SITE



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1:7,500 METRES

REFERENCE

1. WATERCOURSE AND WATERBODY DATA OBTAINED FROM IHS ENERGY INC.
2. BASE IMAGERY SOURCE: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY
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PROJECT
LOWER COLUMBIA RIVER (CLBMON#42[A]) AND KOOTENAY RIVER FISH STRANDING ASSESSMENTS: ANNUAL SUMMARY (APRIL 2019 TO APRIL 2020)

TITLE
STRANDING SITES: LOWER SECTION - COLUMBIA RIVER

CONSULTANT

GOLDER

YYYY-MM-DD	2020-06-11
DESIGN	KL
PREPARED	CD
REVIEW	SR
APPROVED	KL

PROJECT No.	CONTROL	Rev.	FIGURE
19117420	2020	0	A8

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

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