Columbia River Project Water Use Plan

Lower Columbia River Fish Stranding Assessment and Ramping Protocol

Implementation Year 8

Reference: CLBMON-42A

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

Study Period: April 1, 2014 to April 1, 2015

Golder Associates Ltd.
201 Columbia Avenue
Castlegar, BC

July 15, 2015

July 15, 2015

ANNUAL SUMMARY REPORT

Lower Columbia River [CLBMON#42(A)] and Kootenay River Fish Stranding Assessments: Annual Summary (April 2014 to April 2015)

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BC Hydro
601 18th Street
Castlegar, BC
V1N 4G7

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REPORT

Cover Photo: Large pool forming at the Lions Head site during a flow reduction (see Appendix A; Figure A1 for location). This site was re-contoured, April 2015.

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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 stranding of native fish species of the lower Columbia and Kootenay rivers. The program assessed fish stranding at pre-determined sites (Appendix A) between HLK and the Canada/USA border. The revised fish stranding protocol, “Canadian Lower Columbia River: Fish Stranding Risk Assessment and Response Strategy” (Golder 2011), was intended to decrease the number of stranding assessments conducted annually. The number of occurrences when stranding crews were deployed due to flow reductions from HLK/ALH has remained constant over the past six years of data collection. The number ranged from 10 to 15 deployments with crews going out on an average of 84% of the reductions. The number of occurrences when stranding crews were deployed due to flow reductions from BRD/X has decreased over the past six years, from an average of nine Reduction Events (REs) to one RE per year. Over time the number of flow reductions requiring assessments may decrease as the continued collection of data will eliminate data gaps in less common discharge levels and will further focus stranding assessment efforts.

This report summarizes the information collected following flow reductions at HLK/ALH on the Columbia River and BRD/X on the Kootenay River. Stranding assessments were conducted for 12 of 16 REs that occurred between April 1, 2014 and April 1, 2015. One assessment was conducted in response to flow reductions from BRD/X and 11 assessments were conducted in response to flow reductions from HLK/ALH. An estimated 4521 isolated or stranded fishes were observed during the 12 REs. The fish numbers reported in the previous four annual summary reports decreased annually. Fish numbers reported by ascending year (starting with the 2010-2011 report period) were; *n*=20 320 *n*=5500, *n*=6700 and *n*=4845 fish. The majority (69%) of stranded fishes were observed during two REs; RE2014-08 on August 9, 2014 and RE2015-04 on March 31 and April 1, 2015. None of the stranding assessments conducted during the sample period were classified as a “Significant Fish Stranding” event (>5000 fishes observed at a site).

Information from the two systems (HLK/ALH and BRD/X) was combined into a single document. Fish stranding in the study area from HLK/ALH to the Canada/USA border, including the Kootenay River below BRD/X, is influenced by both dams and the key variables that affect fish stranding are thought to be similar for both dams. Since each system has unique operation management strategies and operation drivers, distinct information for each system has been identified. [i.e., the Water Use Planning Objectives, Management Questions and Hypotheses specific to CLBMON #42A (Table ES1)].

Table ES1: CLBMON #42A Status of Hugh L. Keenleyside Dam Program Objectives, Management Questions and Hypotheses

Primary Objective	Secondary Objectives	Management Questions	Management Hypotheses	Year 8 (2014/2015) Status
To assess the impact of flow reductions and flow ramping rates from HLK on the native species of the lower Columbia River.	To determine ramping rates for flow reductions which reduce the stranding rate of fish at different times of the year.	Is there a ramping rate (fast vs. slow, day vs. night) for flow reductions from HLK that reduces the number of fish stranded (interstitially and pool) per flow reduction event in the summer and winter?	The number of stranded fish is independent of either the ramping rate or time of day of flow reductions in the summer and winter.	Previous studies suggested that ramping rates were not a statistically significant predictor of fish stranding (Golder/Poisson 2010). Data (2000 to 2015) supports this finding. No ramping studies were conducted during this study period.
	To determine whether the wetted history influences the stranding rate of fish for flow reductions.	Does wetted history (length of time the habitat has been wetted prior to the flow reduction) influence the number of fish stranded (interstitially and pool) per flow reduction event for flow reductions from HLK?	Wetted history does not influence the stranding rate of fish (both interstitially and pool stranding) for flow reductions from HLK.	Wetted history influences the stranding rate of fish. A significant increase in the number of stranded fish was observed after a 10-day wetted history, although the effect size (rate of stranding as a function of days of wetted history) has not been accurately quantified. (Golder/Poisson 2010). No additional analysis of wetted history data collected during this study period was undertaken because of lack of significant variation from previous analysis.
	To determine whether a conditioning flow reduction from HLK reduces the stranding rate of fish.	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 reduce the stranding rate of fish?	A conditioning flow from HLK does not reduce the stranding rate of fish in the lower Columbia River.	Hypothesis cannot be rejected at this time due to the limited data and the preliminary stages of analysis (Golder/Poisson 2010). A conditioning flow would require an experimental manipulation of flows and for a definitive answer, replicates with significant time between tests would be desirable. No additional data were collected during this study period.
	To determine whether physical habitat manipulation will reduce the incidence of fish stranding.	Can physical habitat works (i.e., re-contouring) reduce the incidence of fish stranding in high risk areas?	Physical habitat manipulation does not reduce the stranding rate of fish in the lower Columbia River.	Previous studies demonstrated that physical habitat manipulation reduces incidences of fish stranding. The effect size (rate of stranding per reduction event) has not been adequately quantified.
	Reduce the number of occurrences when a stranding crew would be deployed for a flow reduction.	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?	The number of fish salvage events can be reduced through adaptive adjustments made as a result of ongoing data collection.	Data collected over the previous 6 years does not support this hypothesis. Continued collection of stranding data and upgrading the Columbia River stranding protocol has not decreased the number of stranding events where crews were deployed. The number of occurrences when stranding crews were deployed ranged from 10 to 15 deployments with crews going out on an average of 84% of the reductions. Crews responded to 12 of the 16 flow reductions during this study period.

Key Words

Lower Columbia River

Kootenay River

Water Use Planning

Fish Stranding

Flow Reduction

Discharge Regulation

Re-contouring

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The following employees of **Golder Associates Ltd.** contributed to the collection of data and preparation of this report.

Demitria Burgoon	Project Biologist/Author
Dana Schmidt	Project Director/Senior Fisheries Biologist/Limnologist
Dustin Ford	Senior Biologist/Database Manager
Bob Chapman	Biologist/Editor
David Roscoe	Biologist
Michael Hildebrand	Biologist
Brad Hildebrand	Biologist
Bronwen Lewis	Biologist
Paul Grutter	Biologist
Sima Usvyatsov	Biologist
Kevin Little	Biologist
James Chircoski	Biologist
Carissa Fox-Canning	Environmental Scientist
Chris King	Biological Technician
Blaine Cook	Biological Technician
Geoff Sawatzky	Biological Technician
Natasha Audy	Biological Technician
Ron Giles	Warehouse Technician
Carrie McAllister	Office Administrator

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1.0 INTRODUCTION

1.1 Scope and Objectives

The main objective of the monitoring program was 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. The program assessed fish stranding at pre-determined sites (Appendix A) between Hugh L. Keenleyside Dam (HLK) and the Canada/USA border. Secondary objectives included: 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 fish during flow reductions; 3) determining whether a conditioning flow reduction from HLK reduced the stranding rate of fish; 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 needed to be deployed during flow reductions (BC Hydro 2007).

This report describes the results of fish stranding assessments conducted in the lower Kootenay and Columbia rivers from April 1, 2014 to April 1, 2015. Results are compared with data from previous years of monitoring and are discussed in relation to the objectives, management questions, and hypotheses outlined above and below.

1.2 Management Questions

The key management questions identified under the Columbia Water Use Plan and addressed under the current monitoring program are (BC Hydro 2007):

1) Is there a ramping rate (fast vs. slow, day vs. night) for flow reductions from HLK that reduces the number of fish 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 fish stranded (interstitially and pool) per flow reduction event for flow reductions from HLK?

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 reduce the stranding rate of fish?

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?

1.3 Management Hypotheses

For fish stranding in the lower Columbia River, the following hypotheses (BC Hydro 2007) will be tested:

Ho_1: The number of stranded fish is independent of either the ramping rate or time of day of flow reductions in the summer and winter.

Ho_2: Wetted history does not influence the stranding rate of fish (both interstitially and pool stranding) for flow reductions from HLK.

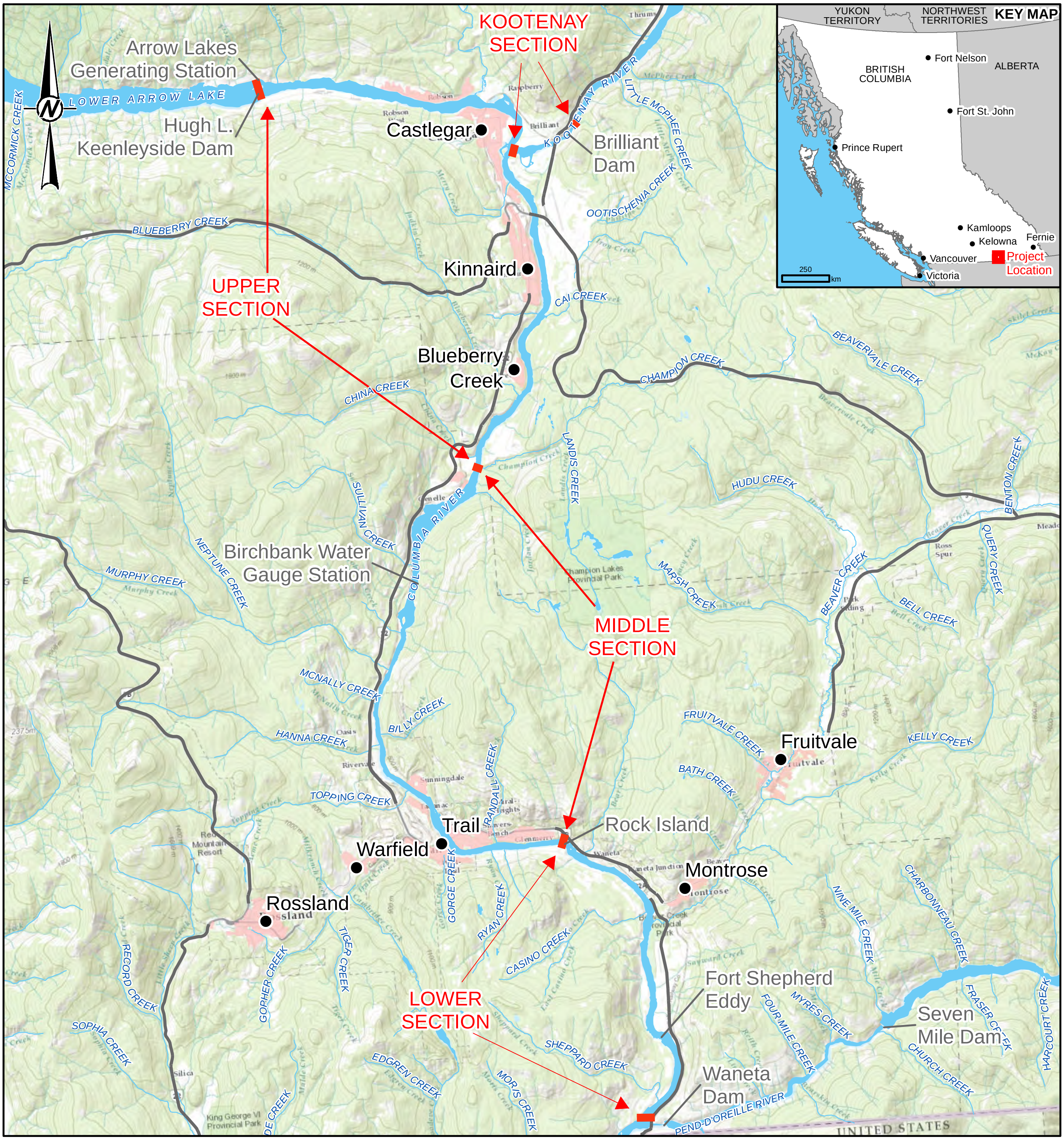
Ho_3: A conditioning flow from HLK does not reduce the stranding rate of fish in the lower Columbia River.

Ho_4: Physical habitat manipulation does not reduce the stranding rate of fish in the lower Columbia River.

Ho_5: The number of fish salvage events can be reduced through adaptive adjustments made as a result of ongoing data collection.

1.4 Study Area

The study area encompasses the approximately 56 km long section of the lower Columbia River from HLK to the Canada/USA border and the lower Kootenay River (approximately 2 km) from below BRD/X to the Columbia River confluence (Figure 1).



LEGEND

- TOWN
- HIGHWAY
- WATERCOURSE
- RESIDENTIAL AREA
- WATERBODY

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BC HYDRO

PROJECT
LOWER COLUMBIA RIVER AND KOOTENAY RIVER FISH STRANDING

TITLE
STUDY AREA OVERVIEW

CONSULTANT

Golder Associates

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2.0 METHODS

2.1 Fish Stranding Risk Assessment

The fish stranding protocol *Canadian Lower Columbia River Fish Stranding Risk Assessment and Response Strategy* (Golder 2011) was implemented preceding each reduction event and during all stranding surveys conducted and included in this summary. Fish stranding protocols were previously developed by BC Hydro, Columbia Power Corporation (CPC) and FortisBC, in collaboration with the Columbia Operations Fish Advisory Committee (COFAC). The protocols were developed to manage fish impacts associated with flow reductions from the Columbia (HLK/ALH) and the Kootenay (BRD/X) systems. Fish stranding risk 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). An evaluation of fish stranding risk was based on the current environmental conditions at the time of the reduction and the results of previous stranding assessments. The risk periods were designated as ‘High Risk’ or ‘Low Risk’ based on the probability of stranding fish and used the criteria below.

Risk periods were defined by:

- **Timing of Reduction**- Day of Year is a proxy for fish use of near-shore habitats which is similar in timing with the previous protocol. The high stranding risk period occurs from June 1 to September 30; the Low Risk period occurs from October 1 to May 31 (Golder and Poisson 2010). Stranding risk is greatest in the summer months because newly emerged juvenile fish occupy shallow near-shore habitats where they are more susceptible to stranding (Golder and Poisson 2010).
- **River Stage**- The probability of fish stranding is typically inversely related to water levels. There are certain river stage elevations that have a high risk for stranding because of the formation of pools and the low slope habitat that is uncovered at that elevation. The low angle river bank and presence of shallow depressions at lower water levels result in greater risk of fish stranding than during higher water levels. During the High Risk period (June 1 to September 30), fish stranding risk is less when discharge is greater than 110 kilo cubic feet per second (kcfs) (based on limited data). During the Low Risk period (October 1 to May 31), stranding risk decreases when discharge is greater than 60 kcfs (Golder and Poisson 2010).

The Lower Columbia River Fish Stranding Database was developed to archive historic flow reduction assessment data (discharge levels, ramping rates, sites, number of pools isolated, number and species of fish/egg stranded either interstitially or within pools, etc.) for use in predicting the potential impacts of a proposed flow reduction. Data from each stranding survey were entered into a MS-Access database. A database operating manual assists with the operation and maintenance of the database (Golder 2005a).

The database is queried to help define fish stranding risk at a particular site based on historical data collected during similar times of the year under similar flow conditions. Data entered into the query include daily discharge from HLK/ALH and BRD/X (current) and proposed resultant daily discharge from HLK/ALH and BRD/X, the Columbia River water temperature from Birchbank Water Station and the date of the proposed reduction. Based on these data, the database provides a prediction of stranding risk at individual sites.

Based on data collected since 2000, a fish stranding event at a site is defined as:

- A **'Minimal Effect'** site is defined as a site that site has a history of stranding less than 200 fish/RE.
- An **'Effect'** site is defined as a site where the maximum number of fish historically stranded at the site is greater than or equal to 200 fish/RE (all species combined), or when species of conservation concern (i.e., species listed under Canada's Species at Risk Act or the British Columbia Conservation Data Centre's red or blue lists) have been recorded as stranded at the site at similar flow levels.
- A **'Reconnaissance'** site is defined as a site that has been visited less than five times and where there are insufficient data to classify the site under one of the other categories.
- A **'No Pools'** site is defined as a site where pools have never been recorded during assessments conducted under similar conditions (river level and reduction amount).
- **'Significant Fish Stranding'** site- Significant fish stranding in the lower Columbia and Kootenay rivers has been defined as fish stranding greater than 5000 fishes of all species identified during a single flow reduction event. It is uncertain if this level of stranding would result in a population level effect for a given species; therefore, stranding of this magnitude requires a thorough assessment and, in some cases may warrant additional management attention (e.g., alterations to the flow reduction strategy), particularly where threatened or endangered species are involved.

The fish stranding risk categories (i.e., Minimal Effect, Effect, or Significant Fish Stranding) are defined based on absolute numbers of fish stranded during previous assessments (Golder 2011) and do not take into account the survey effort in time or area. As it is, the absolute numbers are appropriate guidelines for stranding risk. The assumptions of using the absolute numbers of stranded fishes to define risk are that all the area of isolated pools are searched, and that the relative amount of time spent searching pools (dependent upon size and number of pool in an area) and the resultant efficiency in detecting fish are approximately constant among surveys. These assumptions are likely reasonable, as all the area of pools are typically searched, experienced survey crews attempt to have similar search effort among surveys, and pool habitats are typically simple, which likely results in consistent detection efficiency over time for each site.

However, it is possible that not all stranded fishes are detected during assessments, leading to underestimates of the stranding risk in terms of the number of fishes. As the thresholds for an 'Effect' (>200 fish) or 'Significant Fish Stranding' (>5000 fish) are often based on visual estimates, and these guidelines are used consistently over time, these methods are unlikely to seriously bias the stranding risk categories predicted by using the Lower Columbia River Fish Stranding Database. However, if managers wish to validate assumptions of this method or refine estimates of the number of stranded fishes, then additional studies or modifications to the assessment and survey protocols would be necessary.

During a stranding assessment, sites were selected for fish salvage and surveying in 2014/2015 on a priority basis. The query used projected flow conditions and the stranding history classification in the database to assign designations to each site. Sites where an 'Effect' designation was assigned were assessed first. The next priorities were 'Reconnaissance' sites, and, if time permitted, 'Minimal Effect' or 'No Pools' sites to confirm information in the database. Data are summarized and presented in a report "Stranding Risk Assessment Output", of which an example is provided in Appendix C.

2.2 Salvage Methods

Standard methodologies used during the field component for each fish stranding assessment were outlined in the *Canadian Lower Columbia River Fish Stranding Risk Assessment and Response Strategy* (Golder 2011) and are summarized below. The primary objective was to collect information on effects of flow reduction on fish stranding with fish salvage as a secondary objective. Fish stranding and salvage assessments began at the most upstream site identified for assessment by the Lower Columbia River Fish Stranding Database Fish Stranding Database query and continued downstream following the stage recession. The crew was on site no later than one hour after the initiation of a flow reduction from HLK/ALH or BRD/X.

At each site the crew conducted the following activities:

1) Documented the current conditions (date, time, weather, air and water temperature, approximate vertical drawdown of the water level, etc.) on Stranding Field Forms.
2) Observed and recorded the number of new isolated pools that were created as a result of the flow reduction. Pools isolated during previous reductions were not enumerated.
3) Inspected each pool for fish and attempted to salvage any fish present using dipnets, backpack electrofishers (Smith-Root Model LR 24 or 12-B POW), or beach seines.
4) Transferred the captured fish into a bucket of water where each fish was identified to species and life stage and released into the main channel of the river. Where possible, fish were classed into one of the following life stages; egg, young-of-the-year, juvenile, and adult. If stranded fishes were numerous (>200), subsamples of the catch were captured and identified to species. If field identification to species was not possible, a subsample of up to approximately 30 individuals was preserved for positive laboratory identification. Samples were preserved in *Prefer*™ solution for identification in the laboratory.
5) Visually estimated the number of larvae and alevins present if sample methods were ineffective at capturing these life stages.
6) Inspected interstitial stranding areas and salvaged any fish observed.
7) Photographed representative areas of the site at the time of sampling and photographed representative or unusual fish species where appropriate.
8) Fish length data was collected from up to 20 individuals of each species identified during each reduction event. Total length was measured for sculpin species and fork length was measured for all other species.

The collection of fish fork length data was proposed in the *Columbia River Project Water Use Plan Monitoring Program Terms of Reference - Lower Columbia River Fish Management Plan (CLBMON-42 Lower Columbia River Fish Stranding Assessment and Ramping Protocol, 31 August 2007)*. These data were collected and were used to investigate whether there is a size at which certain species are more susceptible to stranding.

All length data previously collected were combined, in order to increase the sample size available to assess the frequency of stranding of different size-classes. Combining all length data for each species was considered reasonable based on the assumption that the year did not have a statistical effect on fish length. Length-frequency data are presented for seven non sportfish species [Longnose Dace (*Rhinichthys cataractae*), Northern Pikeminnow (*Ptychocheilus oregonensis*), Prickly Sculpin (*Cottus asper*), Redside Shiner (*Richardsonius balteatus*), sucker species (Catostomidae), Torrent Sculpin (*Cottus rhotheus*) and Umatilla Dace (*Rhinichthys umatilla)*] and two sportfish species [Rainbow Trout (*Oncorhynchus mykiss*) and Kokanee (*Oncorhynchus nerka*)].

3.0 RESULTS

3.1 Operations Overview 2014/2015

3.1.1 Columbia River Discharge

Mean daily discharge in the Columbia River at the Birchbank gauging station ranged from 35.8 kcfs to 132.4 kcfs in 2014/2015 (Figure 2).

3.1.2 Hugh L. Keenleyside and Arrow Lakes Generating Station (HLK/ALH)

From April 1, 2014 to April 1, 2015, the Columbia River mean hourly discharge from HLK/ALH ranged from a minimum of 17.1 kcfs on April 1, 2015 to a maximum of 80.1 kcfs on July 25, 2014.

This recorded minimum discharge does not include the low discharge event that occurred during an emergency outage at HLK/ALH on November 29, 2014. During that event, discharge was reduced to less than 1.0 kcfs for approximately an hour. Discharge was restored to approximately 56.0 kcfs on November 30, 2014. A separate memo was produced for this reduction (RE2014-16) and is included in Appendix B.

During the study period, there were 15 operational flow reduction events (REs) from HLK/ALH (Figure 2). Of the 15 REs, six occurred during the High Risk period (June 1 to September 30) and nine occurred during the Low Risk period (October 1 to May 31). The magnitude of flow reductions ranged from 3.0 to 21.0 kcfs, excluding RE2014-16 where the magnitude of flow reduction was approximately 56.0 kcfs (Table 1). In total 11 REs were responded to during the study period. The remaining 4 REs were not responded to due to a decision by BC Hydro.

3.1.3 Brilliant Dam and Brilliant Expansion (BRD/X)

From April 1, 2014 to April 1, 2015, the Kootenay River mean hourly discharge from BRD/X ranged from a minimum of 12.6 kcfs on October 7, 2014 to a maximum of 98.6 kcfs on May 26, 2015. During the study period, there was one operational Base Flow RE from BRD/X (Figure 2). This operational Base Flow (defined as the minimum average hourly discharge from BRD/X that occurred during the previous 48 hrs) RE occurred on September 5, 2014 during the High Risk period. The magnitude of the flow reduction was 4.0 kcfs. Load factoring, which results in shaping average daily inflows into peak discharge during 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 18.0 and 43.0 kcfs. Load factoring occurred during August and throughout the winter months (Figure 2). Flow reductions associated with load factoring were not considered REs.

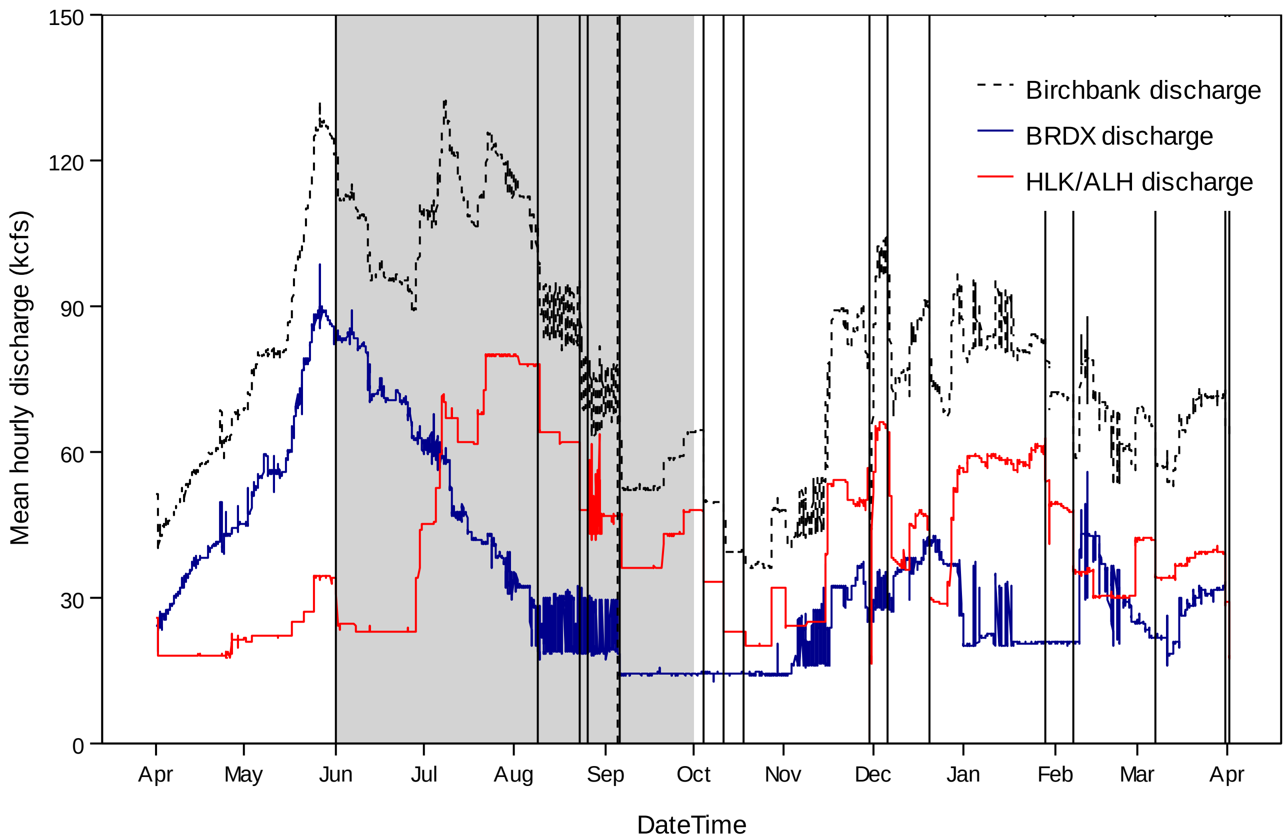

Figure 2: Mean hourly discharge from HLK/ALH (blue line), BRD/X (red line), and at the Water Survey of Canada Gauging Station at Birchbank (dotted black line), April 1, 2014 to April 1, 2015. The solid black vertical lines indicate REs at HLK/ALH and the dashed black vertical lines indicate REs at BRD/X. REs were numbered from RE2014-07 to RE2015-04 (left to right on the figure).Grey rectangle includes period of high risk.

3.2 Fish Stranding Assessments

Fish stranding assessments were conducted for 12 of the 16 REs that occurred between April 1, 2014 and April 1, 2015 (Table 1). The total number of reductions in 2014/2015 (*n* = 16) was lower than the total number of reductions recorded during the previous five study periods (Figure 2). Year 2009/2010 recorded 23 reductions, year 2010/2011 recorded 21 reductions, year 2011/2012 recorded 22 reductions, year 2012/2013 recorded 17 reductions and year 2013/2014 recorded 17 reductions. The numbers of reductions from HLK/ALH have remained fairly consistent, with between 12 and 16 reductions during each reporting period. Reductions from BRD/X and combined reductions from both facilities have generally decreased (from nine reductions to one reduction) over this same time period.

During the last study period stranding assessments were conducted for 75% of the reductions. This was slightly lower than the previous study period where stranding assessments were conducted for 82% of the reductions. The total number of flow reductions has declined over the previous six years, from 23 to 16, reflecting a decline in total assessments that were conducted over time.

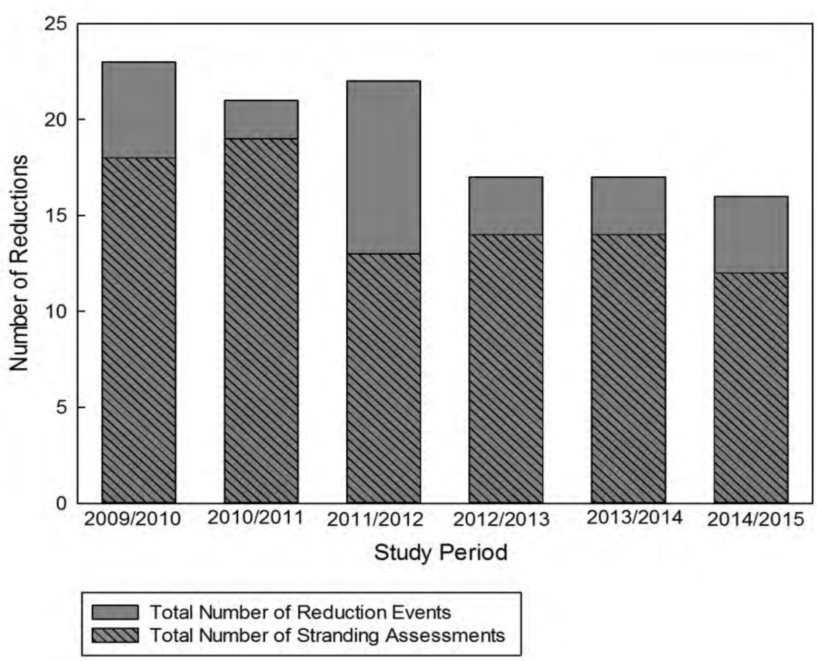

Figure 3: Total number of Reduction Events and Stranding Assessments conducted during each study period.

In total, 22 different sites were assessed at least once during the 2014/2015 stranding assessment period (Table 2). As with previous study years, assessment efforts were concentrated on sites identified as having a high risk of stranding fish defined by a database query and outlined in the *Columbia River Project Water Use Plan Monitoring Program Terms of Reference - Lower Columbia River Fish Management Plan (CLBMON-42 Lower Columbia River Fish Stranding Assessment and Ramping Protocol, 31 August 2007).*

As with previous years, poor site access (e.g., excessive snow) and limited daylight hours during the Low Risk winter season restricted the number of sites that could be assessed, most notably, sites downstream of the Genelle Mainland LUB site on the right upstream bank [Beaver Creek RUB, Trail Bridge RUB, Casino Bridge LUB (upstream), Casino Bridge LUB (downstream), and Bear Creek RUB] and the sites accessed using the Fort Shepherd Conservancy Area access road on the left upstream side of the Columbia River [Beaver Creek LUB and Fort Shepherd Eddy LUB sites (Appendix A, Figures A4 to A7)]. This access road is closed annually, from December 1 until April 1.

3.2.1 Fish Captured or Observed During 2014/2015 Stranding Assessments

Isolated pools and stranded fishes were recorded during all but one RE (2014-18) for which stranding assessments were conducted (Table 1). During the remaining 12 REs, 5,767 stranded fishes were recorded (Table 2). The majority (75.8%) of these fishes were observed during three RE assessments (RE2014-06, RE2014-08, and RE2015-04). The total number of fishes observed or salvaged for each RE ranged from 0 to 1768 (Table 1). None of the stranding assessments conducted during the sample period were classified as a 'Significant Fish Stranding' event (>5000 fishes observed).

The majority (51.8%) of the isolated fishes were recorded in pools located at the Genelle Mainland LUB (28.6%) and Lions Head RUB (23.2%) sites (Table 2). See Appendix A; Figure A1 through A7 for site locations.

Table 1: Summary of Reduction Events (RE) from HLK/ALH and BRD/X 1 June 2014 to 1 April 2015.

				Birchbank				Brilliant Dam/BRX					HLK/ALGS									
Reduction Event No.	Reduction Date	Concern Category	Crew Dispatched?	Mean Daily Water Temp (°C)	Max. Q (kcfs)	Min. Q (kcfs)	Magnitude of Reduction (kcfs)	Prev Q (kcfs)	Resulting Q (kcfs)	Magnitude of Reduction (kcfs)	No. Ramped Flow Reductions	Avg. Ramping Rate (kcfs)	Prev Q (kcfs)	Resulting Q (kcfs)	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 2014-07	June 1, 2014	High	No	8	121.7	111.9	9.8	87.0	87.0	0.0	N/A	N/A	34.0	24.0	10.0	2	5.0	N/A	N/A	N/A	0	Reduction of inflows; Treaty requirements
HLK/ALH 2014-08	August 9, 2014	High	Yes	16.5	105.2	88.2	17.0	28.0	28.0	0.0	N/A	N/A	78.0	63.0	15.0	3	5.0	Yes	Yes	1228	10	Reduction of inflows; Treaty requirements
HLK/ALH 2014-09	August 23, 2014	High	Yes	17.6	90.7	74.3	16.4	20.0	20.0	0.0	N/A	N/A	62.0	48.0	14.0	3	4.7	Yes	Yes	259	9	Reduction of inflows; Treaty requirements
HLK/ALH 2014-10	August 26, 2014	High	No	17.3	78.9	65.5	13.4	29.0	29.0	0.0	N/A	N/A	48.0	43.0	5.0	1	5	N/A	N/A	N/A	0	Reduction of inflows; Treaty requirements
BRD/X 2014-11	September 5, 2014	High	Yes	17.0	72.6	62.6	10.0	18.0	14.0	4.0	1	4.0	47.0	47.0	0.0	3.0	1.3	Yes	No	11	8	Kootenay Canal Dewatering
HLK/ALH 2014-12	September 6, 2014	High	Yes	17.0	62.6	52.3	10.3	14.0	14.0	0.0	N/A	N/A	47.0	36.0	11.0	3	3.6	Yes	No	284	5	Reduction of inflows; Treaty requirements
HLK/ALH 2014-13	October 4, 2014	Low	Yes	14.7	64.3	49.9	14.4	14.0	14.0	0.0	N/A	N/A	48.0	33.0	15.0	3	5.0	Yes	Yes	86	7	Treaty flows and non-treaty storage
HLK/ALH 2014-14	October 11, 2014	Low	Yes	14.5	49.4	39.5	9.9	14.0	14.0	0.0	N/A	N/A	33.0	23.0	10.0	2	5.0	Yes	Yes	188	6	Reduction of inflows: Treaty requirements
HLK/ALH 2014-15	October 18, 2014	Low	Yes	12.4	39.5	36.4	3.1	14.0	14.0	0.0	N/A	N/A	23.0	20.0	3.0	1	3	Yes	Yes	340	7	Reduction of inflows: Treaty requirements
HLK/ALH 2014-16	November 30, 2014	Low	Yes	6.4	78.2	48.3	29.9	25.0	25.0	0.0	N/A	N/A	56.0	0.0	56.0	1	56	Yes	Yes	189	16	Emergency flow reduction for dam safety
HLK/ALH 2014-17	December 6, 2014	Low	No	6.0	99.9	82.0	17.9	30.0	18.0	12.0	N/A*	N/A*	66.0	40.0	26.0	3	4.3	N/A	N/A	N/A	0	Treaty flows and non-treaty storage
HLK/ALH 2014-18	December 20, 2014	Low	Yes	5.4	89.9	73.6	16.3	36.0	36.0	0.0	N/A	N/A	46.0	30.0	16.0	3	5.3	Yes	Yes	0	9	Adjustments to meet Treaty requirements.
HLK/ALH 2015-01	January 29, 2015	Low	Yes	4.0	ND	ND	ND	20.0	20.0	0.0	N/A	N/A	63.0	48.0	15.0	3	5	Yes	Yes	4	6	Emergency flow reduction; temporary reduction
HLK/ALH 2015-02	February 7, 2015	Low	Yes	4.0	71.7	59.6	12.1	20.0	20.0	0.0	N/A	N/A	48.0	35.0	13.0	3	4.7	Yes	Yes	39	8	Treaty flows and non-treaty storage
HLK/ALH 2015-03	March 7, 2015	Low	No	3.8	65.1	57.3	7.8	23.0	23.0	0.0	N/A	N/A	42.0	34.0	8.0	3	2.7	N/A	N/A	N/A	0	Treaty flows and non-treaty storage
HLK/ALH 2015-04	March 31, 2015	Low	Yes	4.7	72.5	64.9	7.6	28.0	28.0	0.0	N/A	N/A	39.0	28.0	11.0	3	3.5	Yes	Yes	324	12	Adjustments to meet Treaty requirements. Establishment of rainbow trout protection flows.
	April 1, 2015	Low	Yes	4.7	ND	ND	ND	28.0	28.0	0.0	N/A	N/A	28.0	17.0	11.0	3	3.5	Yes	Yes	1569	20	

*Brilliant Dam was load factoring at this time.

ND= No Data. Mean or maximum discharge for this period was not recorded because of missing data at Birchbank Water Gauge Satation.

Table 2: Percentage of the Total Number of Fish Stranded during the Reduction Events from April 1, 2014 to April 1, 2015 that were Stranded at each Site.

Site[a]	Total Number of Visits	Total Number of Fish Stranded	Median Number of Fish Stranded per Visit	% of Total Stranded Fish at each Site
Genelle (Mainland) (LUB)	12	1650	28.5	28.6
Lions Head (upstream of Norns Fan) (RUB)	6	1337	7.5	23.2
Gyro Boat Launch	9	1025	8	17.8
Norns Creek Fan (RUB)	10	961	5.5	16.7
Tin Cup Rapids (RUB)	11	274	0	4.8
CPR Island (MID)	7	195	0	3.4
Beaver Creek (RUB)	4	108	23	1.9
Zuckerberg Island (LUB)	4	94	4	1.6
Kootenay River (RUB)	11	51	0	0.9
Millennium Park (Tin Cup LUB)	4	24	0	0.4
Trail Bridge (RUB) (Downstream)	5	23	0	0.4
Fort Shepherd Launch (RUB)	9	9	0	0.2
Fort Shepherd Eddy (LUB)	1	8	8	0.1
Kootenay River (LUB)	10	5	0	0.1
Bear Creek (RUB)	3	2	0	0
Casino Road Bridge, Trail (LUB) (Downstream)	3	1	0	0
Beaver Creek (LUB)	1	0	0	0
Blueberry Creek (LUB)	1	0	0	0
Casino Road Bridge, Trail (LUB) (Upstream)	3	0	0	0
Genelle Lower Cobble Island (MID)	2	0	0	0
Genelle Upper Cobble Island (MID)	2	0	0	0
Kinnaird Rapids (RUB)	2	0	0	0
Total	**120**	**5,767**		**100**

[a]Appendix A; Figures A1 through A7
[b]LUB=left upstream bank; RUB=right upstream bank

Table 3 shows the fish species and numbers stranded during the 2014/2015 study period.

Table 3: Summary of Fish Species Captured or Observed during Fish Stranding Assessments Subsequent to Reductions in Discharge from Hugh L. Keenleyside Dam/Arrow Lakes Generating Station or from Brilliant Dam/Brilliant Expansion, April 1, 2014 to April 1, 2015.

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]
Sportfish	Brook Trout (*Salvelinus fontinalis*)	3	0.1	0	3			
	Kokanee (*Oncorhynchus nerka*)	254	4.4	202	52	N/A	N/A	Yellow
	Mountain Whitefish (*Prosopium williamsoni*)	306	5.3	1	5			
	Rainbow Trout (*Oncorhynchus mykiss*)	147	2.5	15	96	N/A	N/A	Yellow
	Walleye (*Sander vitreus)*	1	<0.1	0	0	N/A	N/A	Yellow
	Whitefish species (*Coregoninae spp.)*	1509	26.2	1000	9	N/A	N/A	Yellow
	Yellow Perch *(Perca flavescens)*	1	<0.1	1	0	N/A	N/A	Exotic
Non-Sportfish	Longnose Dace (*Rhinichthys cataractae*)	488	8.5	201	199	N/A	N/A	Yellow
	Umatilla Dace (*Rhinichthys umatilla*)	31	0.5	5	25	Schedule 3 Special Concern	Threatened	Red
	Northern Pikeminnow (*Ptychocheilus oregonensis*)	77	1.3	4	73	N/A	N/A	Yellow
	Peamouth (*Mylocheilus caurinus*)	61	1.1	1	60	N/A	N/A	Yellow
	Redside Shiner (*Richardsonius balteatus*)	498	8.6	31	451	N/A	N/A	Yellow
	Sculpin species (*Cottus spp.)*	289	5.0	10	66	N/A[d]	N/A[d]	N/A[d]
	Columbia Sculpin (*Cottus hubbsi)*	15	0.3	8	6	Schedule 1 Special Concern	Special Concern	Blue
	Prickly Sculpin (*Cottus asper*)	59	1	30	28	N/A	N/A	Yellow
	Shorthead Sculpin (*Cottus confusus)*	2	<0.1	0	2	Schedule 1 Special Concern	Special Concern	Blue
	Torrent Sculpin (*Cottus rhotheus*)	131	2.3	27	103	N/A	N/A	Yellow
	Tench *(Tinca tinca)*	1	<0.1	0	1	N/A	N/A	Exotic
	Sucker species *(Catostomidae spp.)*	1579	27.4	53	625	N/A[e]	N/A[e]	N/A[e]
	Unidentified[f]	315	5.5	0	0	N/A[d]	N/A[d]	N/A[d]
Totals		**4521**	**100**	**1548**	**1102**			

[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]Conservation Data Centre; Red=ecological communities and indigenous species and subspecies that are extirpated, endangered or threatened in British Columbia; Blue= ecological communities and indigenous species and subspecies of special concern in British Columbia; Yellow= ecological communities and indigenous species and subspecies that are not at risk in British Columbia (BCCDC 2011).
[d]Fish identified to family level or other high level taxa may potentially be species of concern under the classification systems listed.
[e]No species are listed from this region that are found under any of the classification criteria for species of concern.
[f]Not identified to species because they were young-of-the-year life stage or observed but not captured.

3.2.1.1 Fish Species

3.2.1.1.1 Sportfish

All whitefish species (*Coregoninae spp.*) recorded during the 2014/2015 stranding assessments were larval fish associated with RE2015-04 which occurred in early spring to facilitate Rainbow Trout Protection Flows. The small body size and fragility of these fish rendered salvage attempts ineffective. For this reason, the numbers of whitefish observed in isolated pools were estimated and assumed to be mortalities. All whitefish recorded during RE2015-04 were observed at the Lions Head and Norns Creek Fan sites (Appendix A, Figure A1).

The majority (94%) of Rainbow Trout were recorded from the sites upstream of the Kootenay River confluence (i.e. Lions Head, Norns Creek Fan, CPR Island, Tincup Rapids and Millennium Park sites. (Appendix A; Figure A1 and A2). All recorded Rainbow Trout were either young-of-the year or juveniles.

Aside from one adult Kokanee mortality found in a pool that had formed during RE2014-16, all other Kokanee (*n*=251) were recorded from pools that had formed during RE2015-04 at the Lions Head and Norns Creek Fan sites. All were classified as young-of-the-year fish and similar to the whitefish their small body size and fragility rendered salvage attempts ineffective. The majority (80%) of these Kokanee numbers were estimated and assumed to be mortalities.

During RE2014-16 one adult Walleye was observed stranded in a large pool at the Bear Creek RUB site. Flows increased later that same day and re-connected this pool to the mainstem Columbia River; therefore the crew did not attempt to salvage this fish. The crew estimated the fork length to be approximately 400 mm.

3.2.1.1.2 Non-sportfish

The majority of non-sportfish found during the 2014/2015 stranding assessments were young-of-the-year juvenile sucker species (*n* = 1371). Longnose Dace (*n* = 485) was the second most abundant non-sportfish species recorded, followed by Torrent Sculpin (*n* = 118; Table 3).

3.2.1.1.3 Unidentified Fish

During this study period, 300 of the 315 unidentified fish were larval fish recorded at two sites (the Gyro Boat Launch and Beaver Creek RUB sites) during one reduction (RE2014-08) on August 9, 2014. The remaining unidentified fish were observations of fish that either escaped capture or capture was not attempted because the pool was too large.

A large number (*n* = 226) of unidentified sculpin species were recorded during RE2014-12 at the Tincup Rapid RUB site. These fish were not all salvaged because of the conditions (shallow water and algae throughout a large expanse of cobble/boulders) and the difficulty netting sculpin in this type of habitat.

Determining the species of young-of-the-year fish, including dace and sculpin species in the field continues to be a challenge. Collecting, preserving and laboratory identification of subsamples of these fish during subsequent reductions will continue to be a priority. During this study period approximately 60 sculpin (mortalities associated with reduction events) were preserved and identified in the laboratory. These samples were stored and can be used for species verification.

3.2.1.1.4 Listed Fish Species

Currently, four resident fish species in the study area are considered at risk: Columbia Sculpin, Shorthead Sculpin, Umatilla Dace, and White Sturgeon (*Acipenser transmontanus*). Both species of sculpin and Umatilla Dace were documented during the 2014/2015 stranding assessment period (Table 4).

Table 4: Summary of Listed Species Captured or Observed during Stranding Assessments, April 1, 2014 to April 1, 2015.

Site[a]	Risk Period[b]	Total Number of Visits	Number of Visits with Listed Species Present	Number of Listed Fish Stranded
Umatilla Dace				
Beaver Creek (RUB)	Low	2	1	5
Fort Shepherd Eddy (LUB)	Low	1	1	5
Genelle (Mainland) (LUB)	Low	9	1	1
Gyro Boat Launch	Low	8	2	16
Kootenay River (LUB)	Low	7	2	3
Trail Bridge (RUB) (Downstream)	Low	5	1	1
Columbia Sculpin				
CPR Island (MID)	Low	6	1	1
Genelle Mainland LUB	Low	9	2	9
Norns Creek Fan (RUB)	Low	7	2	5
Shorthead Sculpin				
Norns Creek Fan (RUB)	Low	7	1	2
Total				**25**

[a]Appendix A; Figures A1 through A7
[b]High Risk Period = June 1 to September 30 and Low Risk period = October 1 to May 31

Historically, the majority (94%) of listed species recorded in the Standing Database (from 2000 to present) were captured during the Low Risk period. However, it is possible that listed fish were also stranded during the High Risk period, but were not identified to species because of their life stage (i.e., immature). Some of the unidentified fish documented during the study period may have been Umatilla Dace. Umatilla Dace probably spawn in the late spring or early summer similar to closely related species (McPhail 2007). Therefore larval stage dace numbers may be combined in the numbers of unidentified fish collected during REs in late summer.

Columbia Sculpin and Shorthead Sculpin were identified during the 2014/2015 stranding assessments and 289 unidentified sculpin species were captured or observed. All of the listed sculpin species captured or observed during the present study were recorded during the Low Risk period. The majority (77%) of the unidentified sculpin species were observed in isolated pools but not captured; consequently field identification was not possible.

3.2.1.1.5 Exotic Fish Species

Only two exotic fish species were captured during the 2014/2015 study period. One juvenile Tench was recorded at the Kootenay River RUB site and one juvenile Yellow Perch was recorded at the Genelle Mainland site.

Several exotic fish species have been identified and recorded during stranding assessments since 2000 in varying numbers. Species composition has remained constant. The majority (99%) of all of the exotic fish species recorded during stranding assessments were Smallmouth Bass (*Micropterus dolomieu*). The remaining 1% was Common Carp, Brook Trout, Tench and Yellow Perch. Although exotic fish species were found at sites throughout the study area, the majority (99%) were from the Fort Shepherd Launch RUB site. The fish numbers at the Fort Shepherd Launch site were recorded at the site before it was re-contoured. This site is approximately 2.5 km upstream from the Columbia River confluence with the Pend d'Oreille River, which is known to have an established population of Smallmouth Bass and other invasive species (Golder 2005b).

3.2.1.1.6 Sportfish

During 2014/2015, fork length measurements were recorded for 52 Rainbow Trout from seven different stranding assessments. Fork length measurements were recorded for 33 Kokanee during RE2015-04. Five whitefish were measured (fork lengths ranged from 15 mm to 150 mm) during this study period.

Figure 4 shows the length-frequency of stranded Kokanee (*n* = 35) from all reductions where Kokanee were measured. All of the stranded Kokanee were small and classified as Young-of-the-Year fish, with the exception of one adult Kokanee mortality found in a pool that had formed during RE2014-16.

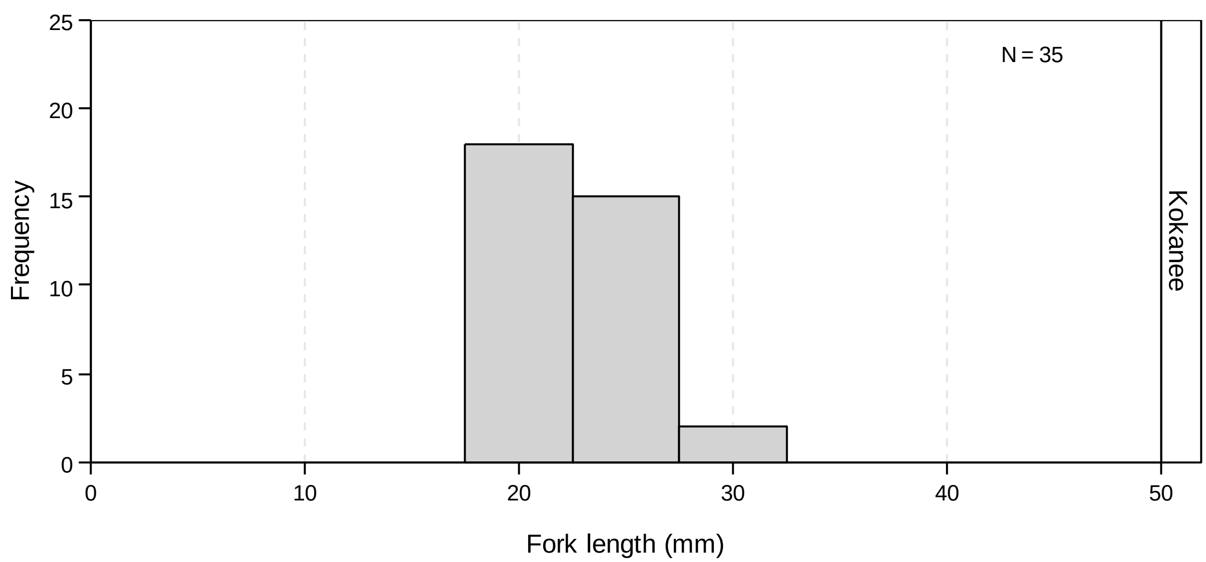

Figure 4: Length-frequency for Kokanee collected during stranding assessments conducted during 2014 to 2015.

Figure 5 shows the length-frequency of stranded Rainbow Trout (*n* = 150) from all years combined. All stranded Rainbow Trout were small and classified as juvenile or Young-of-the-Year fish. The majority (99%) had fork lengths <140mm and 89% had fork lengths <100mm.

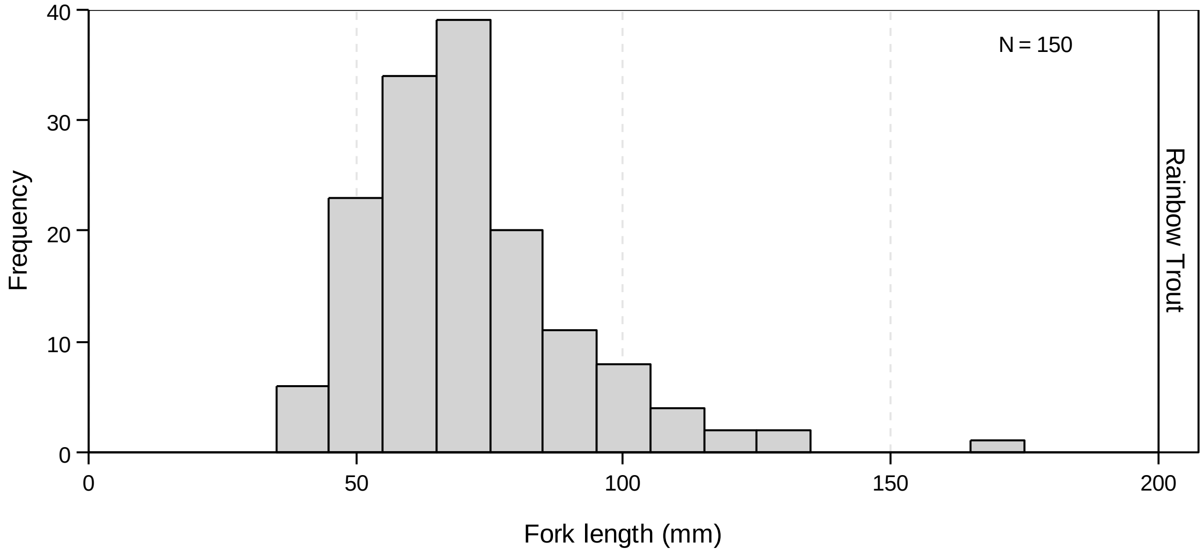

Figure 5: Length-frequency for Rainbow Trout collected during stranding assessments conducted during 2011 to 2015.

3.2.1.1.7 Non-sportfish

A sub-sample of fork length measurements was recorded for all non-sportfish species collected during the 2014/2015 stranding assessments. A total of 436 fork length measurements were collected (97% were from fish captured in isolated pools and 3% were from fish collected from interstitial stranding areas). These measurements were recorded over the course of the reporting period, during all stranding assessments except RE2014-18. The frequency of fish species stranded by fork lengths (all years combined) is provided in Figures 6 and 7, for the following species:

- Longnose Dace (*n* = 84), combined years (*n* = 310);
- Northern Pikeminnow (*n* = 31), combined years (*n* = 139);
- Redside Shiner (*n* = 36), combined years (*n* = 256);
- Peamouth (*n* = 20), combined years (*n* = 59);
- Prickly Sculpin (*n* = 55), combined years (*n* = 100);
- sucker spp.(*n* = 91), combined years (*n* = 461);
- Torrent Sculpin (*n* = 93), combined years (*n* = 195); and
- Umatilla Dace (*n* = 8), combined years (*n* = 155).

All of the Cyprinidae and Catostomidae species stranded were small and classified as juvenile or Young-of-the-Year fish (Figure 6) except for one larger sized (220 mm) Northern Pikeminnow and one 137 mm Largescale Sucker (not shown in figure). The Northern Pikeminnow was captured in an isolated pool at the Zuckerberg Island site during RE2015-04 and appeared unhealthy (external fungus covering half of its body).

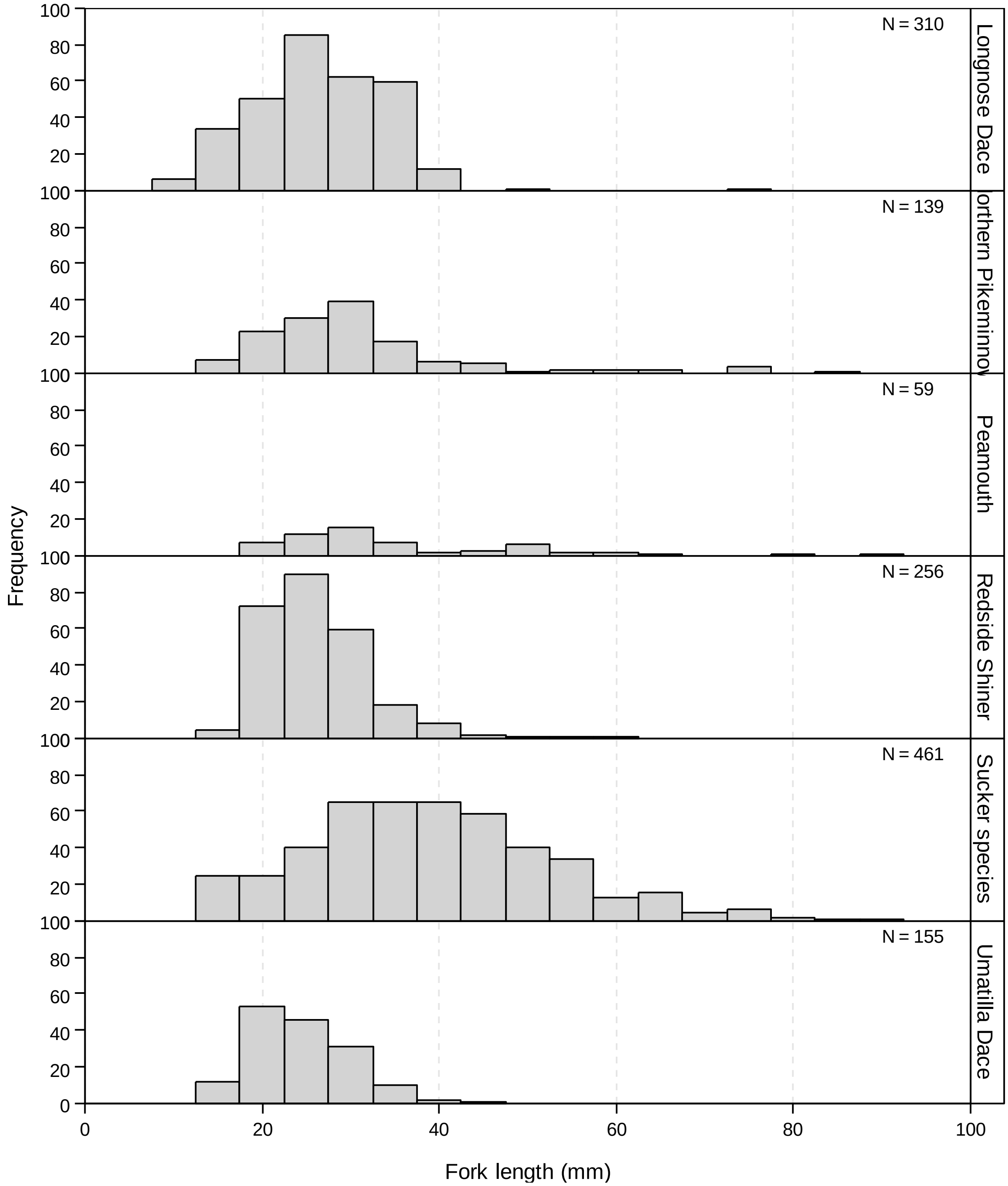

Figure 6: Length-frequencies for Longnose Dace, Northern Pikeminnow, Redside Shiner, Peamouth, sucker spp. and Umatilla Dace collected during stranding assessments conducted during 2011 to 2015. One Northern Pikeminnow and one Largescale Sucker, with fork lengths of 220 mm and 137 mm, respectively, were also captured, but not shown, to improve figure legibility.

Both adult and juvenile sculpin were recorded during the stranding events. Approximately half (53%) of the measured Prickly and Torrent sculpin were considered adults with total lengths >45 mm. The cut-off point between adult and juvenile sculpin was established using the total length. This method was discussed in Year 5 *CLBMON 43-Lower Columbia Sculpin and Dace Life History Assessment (*AMEC 2014). The age class designations were assigned by total length values. The designations took into account the previous CLBMON 43 studies data and available literature for these species.

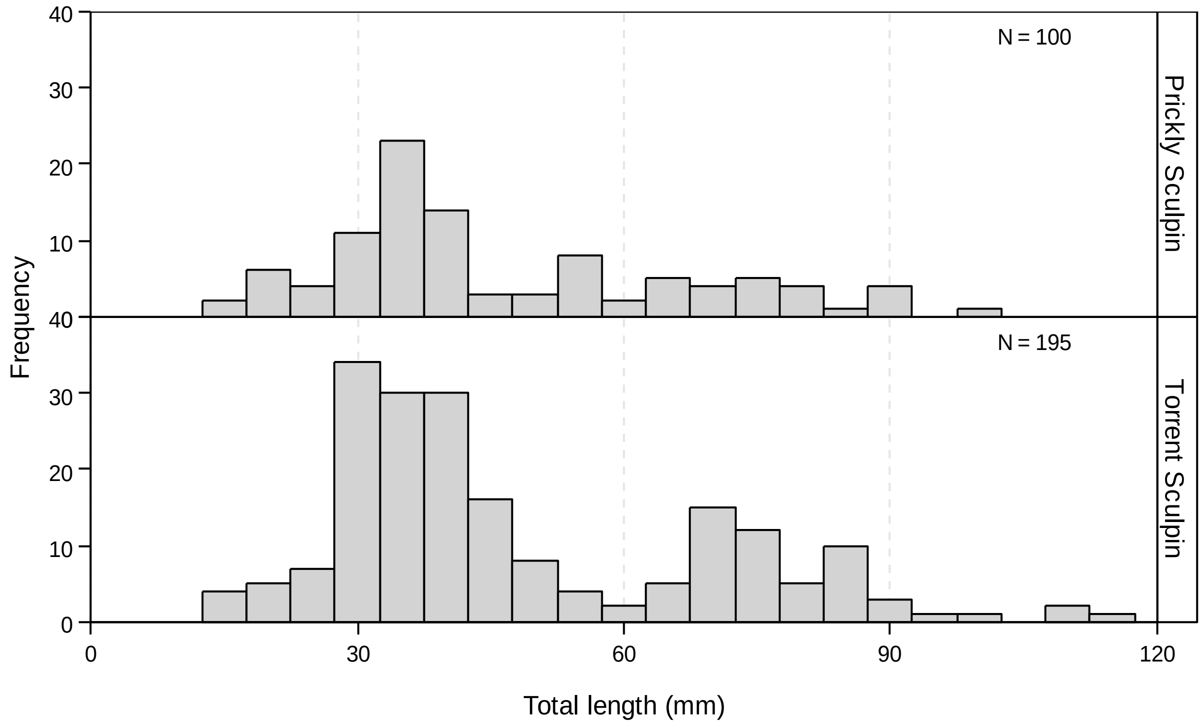

Figure 7: Length-frequencies for Prickly Sculpin and Torrent Sculpin collected during stranding assessments during the previous four years.

3.2.2 Historic Fish Stranding Summary

The results of fish stranding assessments conducted between January 2000 and April 2015 are summarized by site, water elevation and risk period (Table 5). This table can be used as a tool for personnel managing flow reductions to readily identify sites, flows, and seasons of high stranding risk. The classification of sites where listed species have been previously identified is included (yellow highlighted cells). More sites had listed species identified during the Low Risk period than in the High Risk period (28 versus 7 sites). The numbers of fishes are presented as the maximum number of fishes observed stranded at each site during a single assessment. For the majority of sites upstream of Trail, BC higher total fish numbers were recorded during the High Risk period irrespective of resultant discharge levels (Table 5).

In comparison to the Low Risk period, the High Risk period had a larger range of resultant Birchbank discharge (120 kcfs to 30 kcfs) where effects were recorded (Table 5). During the Low Risk period, resultant Birchbank discharge <50 kcfs had the greatest number of stranded fish for all sites (Table 5). Conducting surveys at sites with no previous data or insufficient data (surveyed less than five times) will continue to help identify sites that pose a high risk of fish stranding during flow reductions. Increased numbers of site surveys will lead to more data on REs. Therefore, salvage and assessment efforts will continue to become more focussed and fewer REs will be responded to where there are already data indicating minimal effects. An additional emphasis should be made to visit stranding sites downstream of Trail, BC. The majority of data gaps at all flow levels during both risk periods occur for these sites (Table 5). There was a decrease in the effort spent on sites where lower fish stranding risk was anticipated (sites designated as ‘Minimal Effect’ or ‘No Pools’). Last year, the total number of visits to ‘Effect’ sites was 56 and the total number of visits to ‘Reconnaissance’ sites was 59.Two sites that were designated as ‘Minimal Effect’ were visited and were used to confirm the accuracy of the database query. In both cases, the database query designation proved to be appropriate.

3.2.3 Ramping Rates

To visually explore whether the number of fish stranded was independent of the ramping rate, fish stranding data from 2000 until 2015 were combined and plotted by risk period (Figure 8). All of the data plotted were from reductions that occurred because of flow changes at HLK/ALH. The ramping rates ranged between 1 kcfs/hour and 15 kcfs/hour. There was no indication that a larger ramping interval (e.g., 15 kcfs/hour) stranded more fish than a smaller ramping interval (e.g., 2 kcfs/hour). This was true for both the Low Risk Period and the High Risk Period. More data were available for the smaller ramping intervals because reduction rates of 5 kcfs/hour or less were recommended in the LCR Fish Stranding Risk Assessment and Response Strategy in 2011 and have been followed by BC Hydro since then. There was one reduction of >15 kcfs/hour (BC Hydro has operating restrictions which limit changes to 15 kcfs a day except during flood control or full pool), during an emergency reduction. This reduction was not plotted as it was an extreme outlier, but the number of fish stranded was approximately 300 and the reduction was during the Low Risk Period. In order to determine the ramping rate at which the lowest number of fish are stranded, experimental flow operations will need to be conducted and determination of the proportion of fish present that are stranded should be the metric used. These plots did not take into account the location, the number of times a site has been visited or river level at the time of the reductions and the data collected from monitoring shows high variability and insensitive to determining effects of changes in ramping rates.

Table 5 Summary of effects and corresponding responses for fish stranding on the lower Columbia River from flow reductions at Hugh L. Keenleyside Dam and Brilliant Dam sorted by time of year. (Based on data collected between 2000 and 2015)

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 30 September)	≤30																	No Pools		No Pools								No Pools										No Pools		No Pools					
	30-40							13500	1					0	1	620	1	No Pools		No Pools				No Pools		No Pools								0	1							200	1		
	40-50	6	3	311	4	457	4	76	3	0	1	72	3	81	5							14302	3	No Pools		No Pools		464	2					207	2	No Pools									
	50-60	425	11	215	11			253	10	34	4	2894	7	2700	12	18	6	No Pools		No Pools		2865	13			No Pools		No Pools		0	1	0	1	11	4	0	2	1	1	27	1	0	1		
	60-70	16	6	423	18	0	1	258	9	0	4	492	19	2686	20	55	7	No Pools				37964	20			20	2	500	2	No Pools				0	1	500	5	1	5					2	2
	70-80	42	5	19	9	No Pools		4	5	0	1	1	4	35	7	48	6	No Pools		50	3	6000	9	54	1	0	1	500	2	No Pools		No Pools				0	1	8	2	No Pools		0	1		
	80-90	2	4	88	9	No Pools		34	5	4	7	No Pools		12	3	No Pools		No Pools		0	4	90	6	No Pools		3	5	0	2	No Pools		No Pools		No Pools				0	2	No Pools		380	2		
	90-100	0	1	5	6	No Pools		458	8	26	3	No Pools		No Pools		No Pools						3060	8	No Pools		No Pools		500	7	No Pools		No Pools		No Pools		No Pools		251	3	No Pools		No Pools		0	1
	100-110	No Pools		2	2	2	2	10307	4	7521	3	No Pools		No Pools		0	3	No Pools		0	1	20	3					500	2																
	110-120	0	2	No Pools		No Pools		1500	4	60	1	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		0	1		
	>120	0	1	No Pools		No Pools		0	1	100	1	No Pools		No Pools		No Pools				0	1	No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools							
Low Risk (1 October to 31 May)	≤30	13	3	38	3	93	2	54	3	601	3	0	2	642	2	1	3	No Pools		No Pools		33	2					8	3	8	6	0	4	1	2	2013	2	No Pools		0	2	8	2	5	1
	30-40	717	17	5002	25	82	5	224	12	522	17	210	3	971	23	95	11	No Pools		No Pools		280	16	No Pools		No Pools		1455	11	19	4	0	3	1	3	12	3	38	1	0	1	0	1	0	2
	40-50	1445	30	623	33	147	25	86	27	92	17	450	25	1450	48	298	26	0	2	0	3	1414	28	No Pools		No Pools		755	21	4	5	4	6	4	5	No Pools		44	8	0	3	7	5	2	3
	50-60	176	20	320	23	4	7	59	16	52	18	157	23	332	32	71	17	7	3	No Pools		400	29	0	2	0	2	48	5	0	2	0	10	21	12	0	8	2	3	20	2	2	3	0	2
	60-70	8	10	39	19	5	3	11	12	0	13	103	19	529	25	109	19	No Pools		2	4	520	20	1	4	0	3	4	5	No Pools		1	8	3	8	0	4	4	3	0	2	0	2	0	1
	70-80	0	3	79	10	No Pools		0	2	0	8	0	3	10	5	0	9	No Pools		0	2	7	6			0	1	No Pools		No Pools		No Pools		0	1	3	3	0	2	No Pools					
	80-90					No Pools		0	1	0	2	No Pools				No Pools		No Pools		0	1	1	3	No Pools		0	1			No Pools		No Pools		No Pools		0	1			No Pools					
	90-100	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			
	100-110	No Pools										No Pools		No Pools														No Pools																	
	110-120			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		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; isolated pools were observed; less than 200 fish were recorded during each reduction event under similar conditions (minimum of 5 visits under similar conditions). No Response.
	No Data or Insufficient Data	Site has been previously surveyed less than five times at or near these flows; less than 200 fish were recorded during each reduction event under similar conditions. Reconnaissance Survey.
	Effect	Site has been previously surveyed; isolated pools were observed; more than 200 fish were recorded during a single reduction event under similar 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 2015).
	Listed species were captured or observed.	During at least one of the visits at these sites listed species were captured or observed, during these resultant discharge levels.

Does not include data pre-recontoring.

Includes all visits and fish until 1 April 2015.

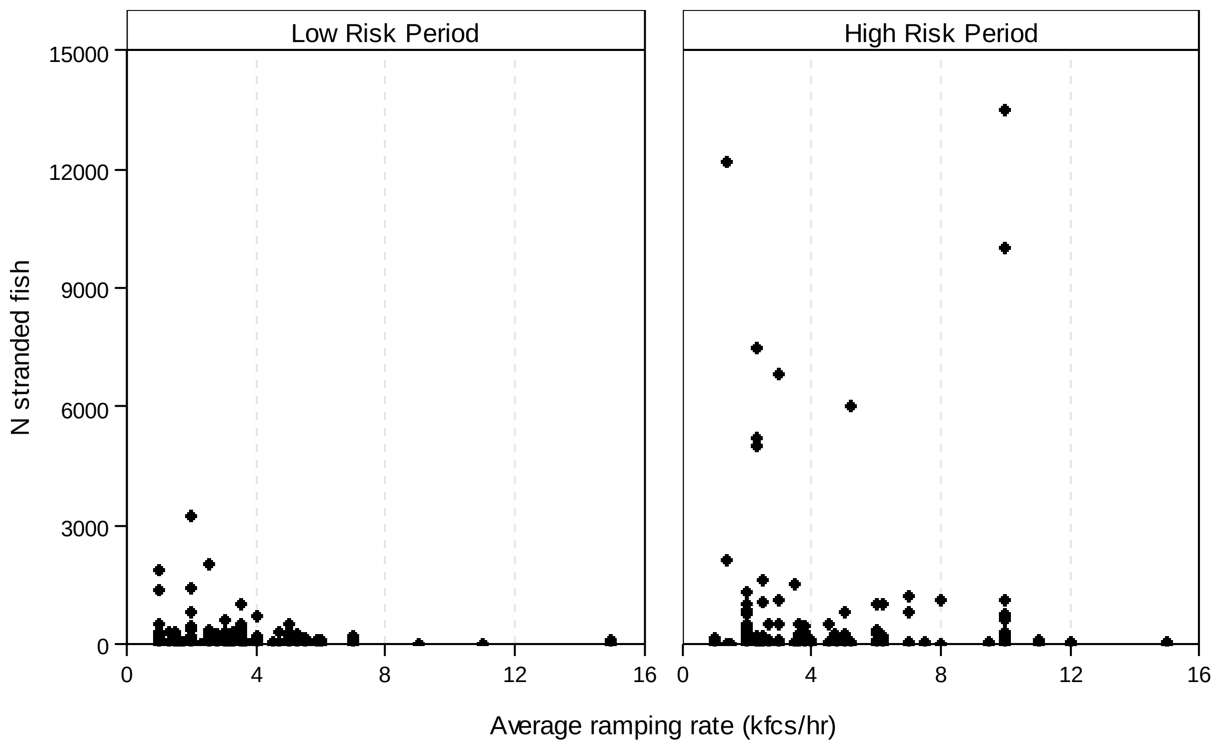

Figure 8: Number of fish stranded versus ramping rate (kcfs/hr) by risk period. Data presented as combined fish numbers for all sites for individual Reduction Events between 2000 and 2015.

4.0 DISCUSSION

4.1 CLBMON-#42(A) Lower Columbia River Fish Standing Assessment and Ramping Protocol Management Questions

Data necessary to address the first four management questions from BC Hydro Water Use Plan terms of reference were not collected during the current study period. These management questions were addressed using data presented in the 2009/2010 and 2010/2011 annual summaries. Since the new protocol was implemented, the program has focused on answering Question #5. Management Questions to be addressed by the program include:

1) *Is there a ramping rate (fast vs. slow, day vs. night) for flow reductions from HLK that reduces the number of fish stranded (interstitially and in pools) per flow reduction event in the summer and winter?*

   Information regarding ramping rates was obtained through a review of the fish stranding database for the lower Columbia and lower Kootenay rivers and presented in the 2010 report- *Columbia and Kootenay River Fish Stranding Protocol Review: Literature Review and Fish Stranding Database Analysis*. This report indicated increased stranding with increased ramping rates during ramping experiments in the Columbia, Kootenay and lower Duncan river systems; however, this trend was not statistically significant. Ramping rates within previously used ranges were not considered a statistically significant predictor for defining fish stranding risk (Golder and Poisson 2010).

2) *Does wetted history (length of time the habitat has been wetted prior to the flow reduction) influence the number of fish stranded (interstitially and in pools) per flow reduction event for flow reductions from HLK?*

   Previous analysis indicated a statistically significant increase in the number of fish stranded during assessments conducted after a wetted history of greater than 10 days versus a wetted history of less than ten days (Poisson 2009). However, there were insufficient data to define the size of the effect (proportion of the population affected and the response to wetted histories of variable lengths greater than 10 days). The determination of a response should be based on factors, in addition to wetted history, particularly for wetted histories less than 10 days.

3) *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 reduce the stranding rate of fish?*

   Currently, conditioning flow reductions from HLK are not being considered as a management tool to reduce fish stranding. The value of implementing conditioning flows is still under consideration and further discussions regarding the operational risk versus biological rational are needed. Two key concerns regarding the assumption that conditioning flow reductions reduce fish stranding were identified in a literature review (Golder and Poisson 2010). The first concern was the limited amount of data collected and preliminary stages of research on the suitability of conditioning flows for use on the Columbia and Kootenay rivers. The second concern was with the actual effectiveness of the method (i.e., some fishes may leave the area but the conditioning reduction may cause significant mortality within a short period of time, which would reduce the practicality of the method; Golder and Poisson 2010). Based on these previous analysis and literature review, abandonment of this strategy should be considered because of the risks of mortality with any intentional conditional stranding, regardless of duration.

4) *Can physical habitat works (i.e., re-contouring) reduce the incidence of fish stranding in high risk areas?*

Over the past 14 years, four previously identified high risk stranding sites have been re-contoured in an attempt to mitigate the occurrence and severity of fish stranding. The Genelle Lower Cobble Island site was re-contoured in 2001, Millennium Park site was re-contoured in September 2001, Norn's Creek Fan site was re-contoured in 2002, and Genelle Mainland site was re-contoured in 2003. Re-contouring reduced the incidence of fish stranding in these areas (Golder and Poisson 2010). However, the effect size (the proportion of the population or the relative number of fish not stranded as a result of the physical habitat works) was not estimated due to limited data. Irvine et al. (2014) indicated significant benefits of recontouring on reduction of the rate of stranding using a data set from this system. This suggests that physical habitat has benefits, particularly at sites that have high stranding potential and have physical conditions suitable for recontouring.

The Fort Shepherd Launch (RUB) site was re-contoured by Columbia Power Corporation (CPC) as a component of the CPC Owner's Commitment #39 [(Revised November 10, 2006) (CPC 2011)]. This commitment included the development of a Shallow-water Habitat Compensation Plan which was designed as the "Fort Shepherd Bar-Shallow-water Habitat Compensation Site" at the Fort Shepherd Launch (RUB) site. Fifteen stranding assessments have been conducted at this site since the re-contouring. Since this site was designated as a new site in the Database it will require visits at most flow changes to populate with data and provide insight as to the effectiveness of this re-contouring. The previous Fort Shepherd Launch (RUB) site was renamed as 'Fort Shepherd Launch (RUB) Before Re-contouring'. CPC is investigating post-project benefits of these physical alterations at this site (Pers. Comm., Teal Moffat, CPC, July 2015).

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?*

The number of occurrences when stranding crews were deployed due to flow reductions from HLK has remained constant over the past five years of data collection. The number ranged from 10 to 15 deployments, with crews going out on an average of 84% of the reductions. The total numbers of reductions from HLK have remained constant, but reductions from BRD/X have decreased in the past six years. The trend in visiting sites continues downward overall, based on reduced reductions requiring salvage work below BRD/X and improved data indicating decreased risks for certain sites at certain times of the year and flow levels.

The continued collection of data and the use of the Columbia River Stranding Protocol has focused stranding assessments to those occurrences where location, season and resultant discharge level posed an elevated risk to fish stranding. Since the majority of the data clusters around resultant Birchbank discharge between 70 kcfs and 30 kcfs (Table 5) the elimination of data gaps in less common discharge levels will further focus stranding assessment efforts.

5.0 RECOMMENDATIONS

- Fish species identification should continue to be a priority during stranding assessments, including young of-the-year fish identification.

  Continued species verification through laboratory examination and external audits by qualified professionals will assist with species identification. When large numbers of fish are encountered, the collection of sub-samples for positive identification is recommended. This is important to determine if the stranding event has a potential to affect a population that is rare or listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) or under the Species at Risk Act (SARA), or the impact has only been on abundant species, such as the catastomids. When a large number of fish are observed in a pool and species identification is not possible due to field conditions and constraints (i.e., too large of pool to effectively sample), a voucher sample should be taken. Tools/methods used to identify young-of-the-year fish also should be improved, as it is currently not possible to identify larval or young-of-the-year fish of most species, which is an important limitation of the stranding assessment methods.

- Continue to collect fish length data for species where insufficient numbers have previously been collected [<510 based on advise of Thompson (1987)]. This would include unusual lengths (i.e., large fish) of fish with previously sufficient numbers (Longnose Dace, Northern Pikeminnow, Rainbow Trout and Redside Shiner). It is recommended that length data continue to be collected for any listed species and for all sculpin species (since sculpin of all age classes have been recorded stranded, the numbers for certain age classes are still insufficient). The relative impact of stranding on any given species population is dependent upon the life history stage impacted, with larval stages of much less important that adult or subadult stages. As the life history stage can only be defined through length measurements, increased sample sizes of length measurements for select species will help achieve this goal.

- Re-contouring is recommended at a number of areas, including sites that have previously been re-contoured because of recent changes in morphology, and sites that were not previously modified. The sites listed below are recommended as candidates for re-contouring because of high stranding risk relative to other sites, and shoreline and substrate features that could be re-contoured or enhanced to reduce stranding risk. 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:

  - Re-contour **Kootenay RUB site** to assist in the draining of Kootenay Oxbow.

    This would help reduce stranding at a public and logistically difficult place to salvage fish (very large, shallow pools with cobble substrate bottoms).

  - Conduct additional re-contouring at the **Genelle Mainland** LUB site to reduce incidence of fish stranding. This site is a good candidate for re-contouring because of large abundance of fishes that are common in this area, a history of significant stranding events, and changes to the shoreline caused by river flow since the previous enhancements were completed. Suggested modifications include:

    a) improve drainage between the access road and the Whispering Pines Trailer Park.

    b) make improvements to previously re-contoured area by removing a depositional berm that has formed since the original re-contouring.

  - Re-contour the **Gyro Park** Launch RUB site to reduce incidence of fish stranding.

    The site has a large artificial depression (potential storm drain exit) that is prone to fish stranding.

- Target sites designated as ‘Reconnaissance’ sites by the database query in order to continue to fill in data gaps.
- Assess the validity of keeping sites that are never visited active in the database, unless there is effort to access these sites over a range of flow reductions. These would include sites that are accessed by boat (i.e., Upper and Lower Cobble Island sites in Genelle), to evaluate stranding risk in these areas.

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.

GOLDER ASSOCIATES LTD.

Demitria Burgoon, B.Sc.
Aquatic Biologist

Dana Schmidt, Ph.D., R.P.Bio.
Associate, Senior Fisheries Biologist/Limnologist

DB/BC/DS/cmc/jlj

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APPENDIX A

Site Maps

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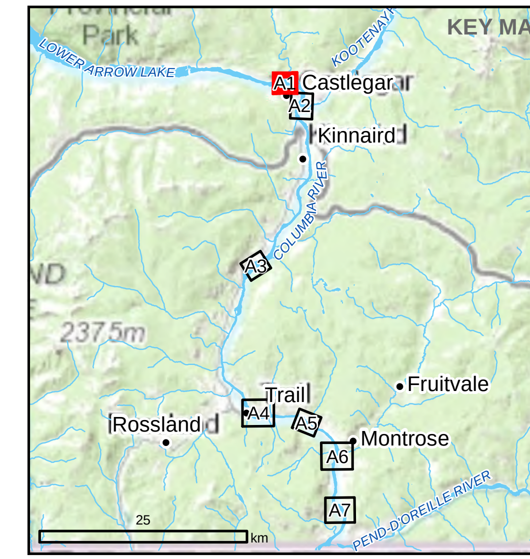

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BC HYDRO

PROJECT
LOWER COLUMBIA RIVER AND
KOOTENAY RIVER FISH STRANDING

TITLE
STRANDING SITES: UPPER SECTION - COLUMBIA RIVER

CONSULTANT

Golder Associates

YYYY-MM-DD	2015-04-30
PREPARED	CD
DESIGN	DB
REVIEW	
APPROVED	

PROJECT No.	CONTROL	Rev.	FIGURE
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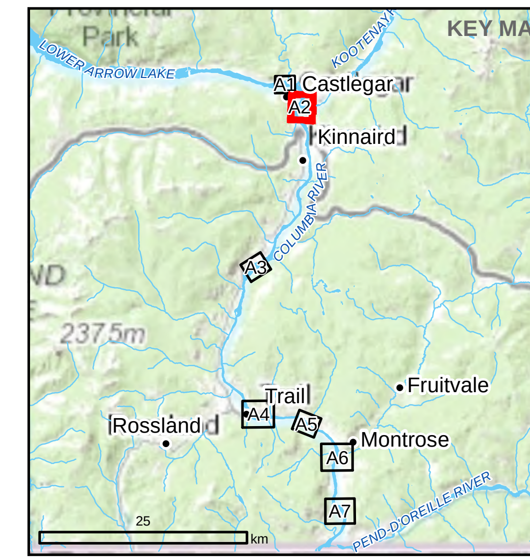

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TITLE
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CONSULTANT
Golder Associates

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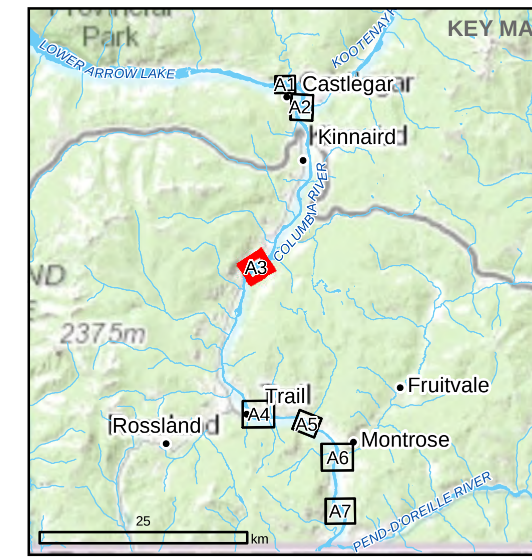

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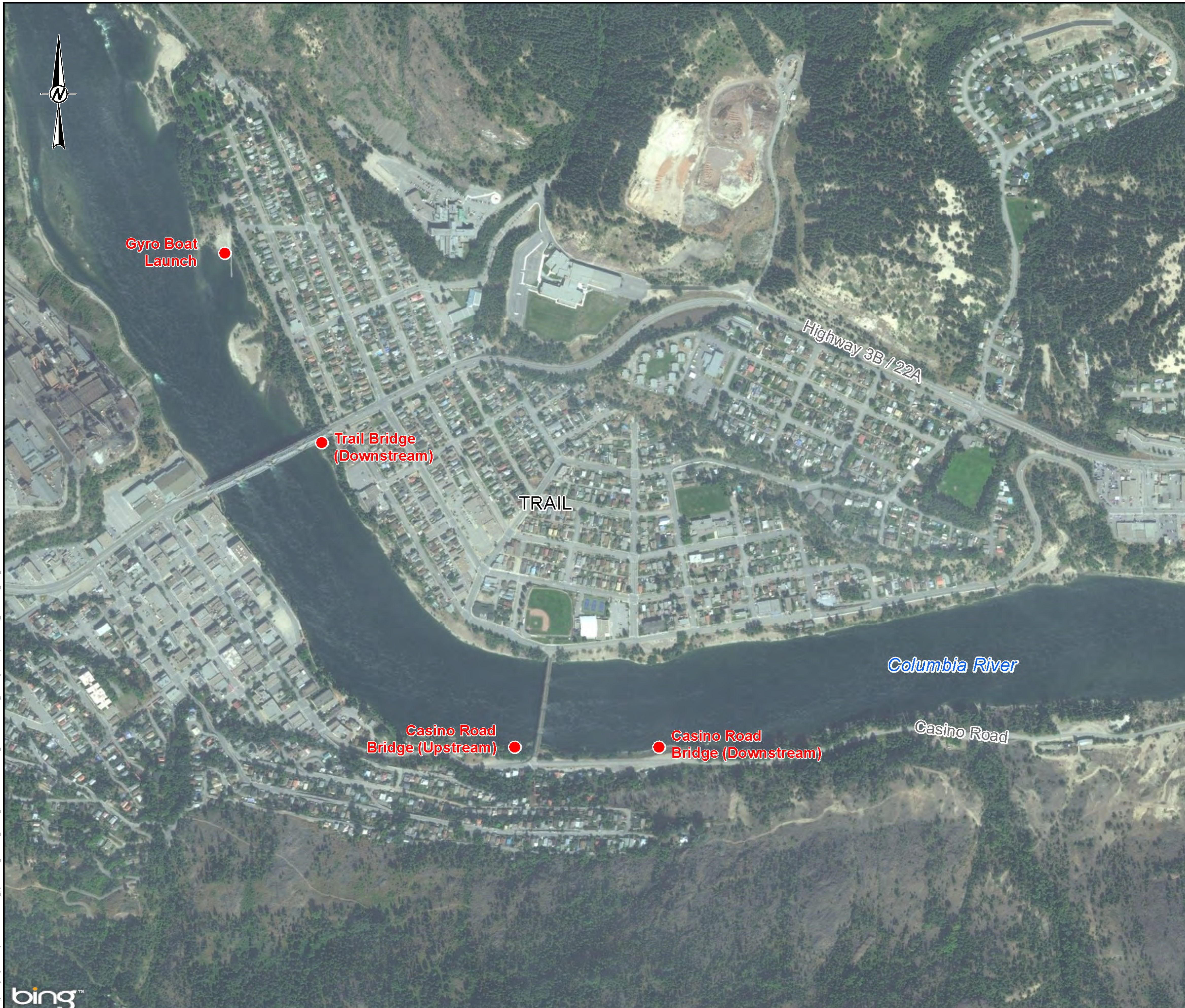

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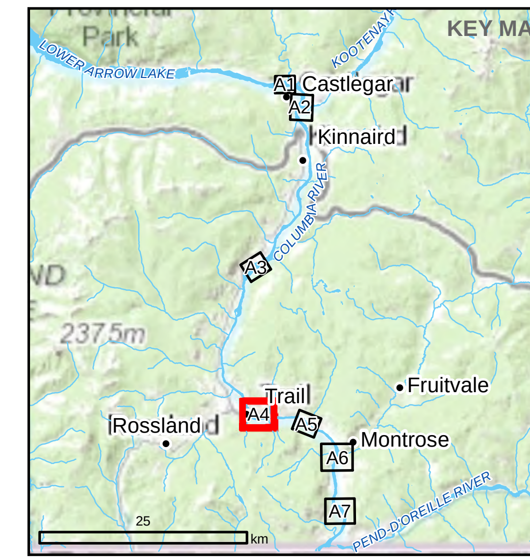

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TITLE
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CONSULTANT
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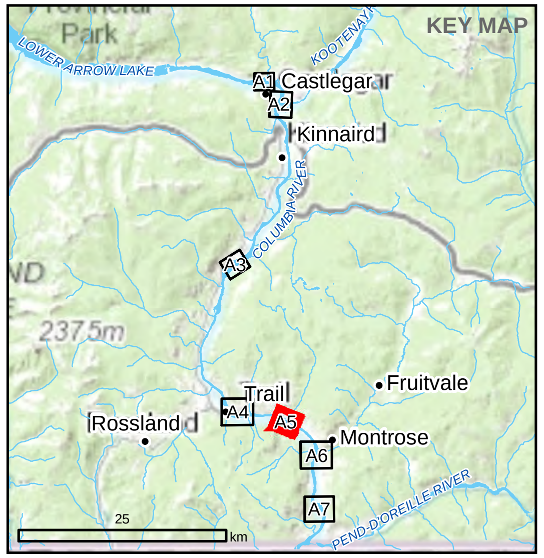

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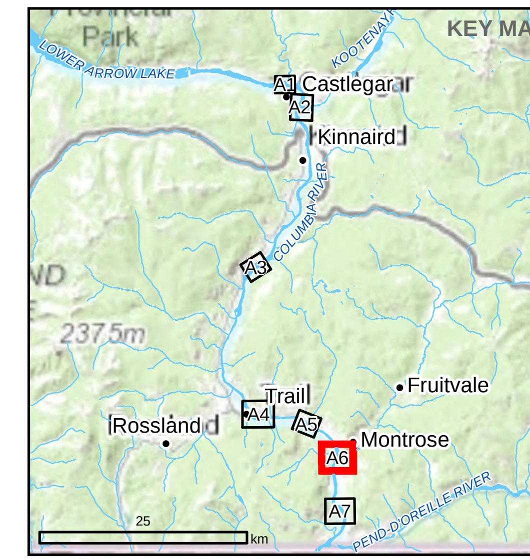

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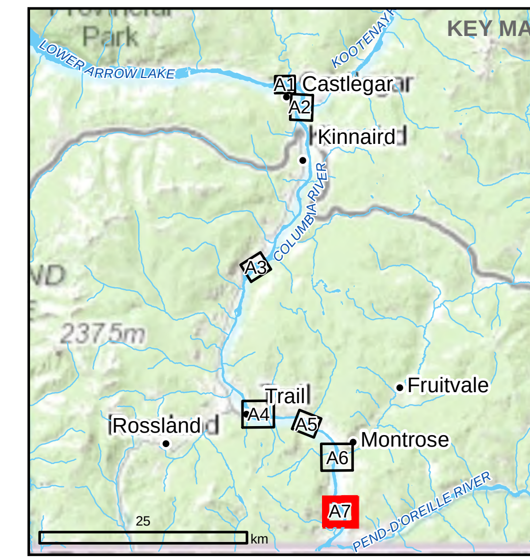
LEGEND

● STRANDING SITE



DRAFT

REFERENCE

1. WATERCOURSE AND WATERBODY DATA OBTAINED FROM IHS ENERGY INC.
2. BASE IMAGERY SOURCE: SOURCES: ESRI, HERE, DELORME, TOMTOM, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, MAPMYINDIA, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY © 2015 DIGITALGLOBE IMAGE COURTESY OF USGS © 2015 GEOEYE © PROVINCE OF BRITISH COLUMBIA EARTHSTAR GEOGRAPHICS SIO © 2015 MICROSOFT CORPORATION

DATUM: NAD83 PROJECTION UTM 11

CLIENT
BC HYDRO

PROJECT
LOWER COLUMBIA RIVER AND KOOTENAY RIVER FISH STRANDING

TITLE
STRANDING SITES: LOWER SECTION - COLUMBIA RIVER

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-04-30
PREPARED	CD
DESIGN	DB
REVIEW	
APPROVED	

PROJECT No.	CONTROL	Rev.	FIGURE
1407618	1000	A	A7

APPENDIX B

Memo

TECHNICAL MEMORANDUM

DATE December 2, 2014 **REFERENCE No.** 1407618-001-TM-Rev0

TO James Baxter
BC Hydro

FROM David Roscoe **EMAIL** droscoe@golder.com

SUMMARY OF NOVEMBER 30, 2014 FISH STRANDING SURVEY

On November 29, 2014, BC Hydro notified Golder Associates Ltd. (Golder) about an emergency reduction of discharge from Hugh L. Keenleyside Dam (HLK) and Arrow Lakes Generating Station. BC Hydro requested that Golder conduct a fish stranding survey on November 30, 2014, as part of the Lower Columbia River and Kootenay River Stranding Assessment study (CLBMON-42a). This memorandum provides a brief summary of the assessment conducted and its findings, as requested by BC Hydro by email on December 1, 2014. The results presented here should be considered preliminary and have not been subjected to QA/QC.

Fish Stranding Assessment Effort

For most discharge reductions, a query of the Lower Columbia Fish Stranding Database is conducted to prioritize sites where the fish stranding risk is the greatest. In this case, a query was not run, but the potential for stranding risk was thought to be high at all sites because of the large magnitude of the reduction. Therefore, the goal of the survey was to assess as many of the sites as possible, with an emphasis on sites where stranding risk is typically greatest. In total, 16 sites were visited (Table 1).

Two crews of two workers conducted the fish stranding assessment, beginning at approximately 0700 h on November 30, 2014. Crews began at sites closest to HLK and worked downstream.

Fish Stranding Assessment Results

Air temperatures during the survey ranged from -10°C to -6°C with mostly clear and windy weather. The estimated reduction in water level observed at the sites closest to HLK ranged from 2.5 m at Norn's Creek Fan RUB to 1.0 m at Fort Sheperd (RUB and LUB). The freezing temperatures and time elapsed since the reduction (flows decreased the previous night) made it very difficult to tell the how much the water level decreased at each site. Therefore, many of the water level reduction estimates in Table 1 are likely not accurate. The estimated reduction of 2.5 m at Norn's Creek Fan RUB seems to roughly agree with the decrease shown at the Water Survey of Canada Birchbank Gauging Station (www.wateroffice.gc.ca), which was approximately 2.2 m. At the time this memorandum was prepared, Golder did not have any information from BC Hydro regarding time of the discharge reduction, magnitude of the reduction, and time of return to previous flows.

Isolated pools were observed at all sites visited. Most of the smaller, shallower pools were completely frozen, whereas many of the larger or deeper pools (>10 cm depth) were frozen on the surface but had water underneath. In total, 202 stranded fish were observed, of which 77 were dead (Table 1). Frozen water in most of the isolated pools made electrofishing impossible and visual surveys difficult. The number of fish stranded was likely greater than those observed. Any of the live fish that were captured were returned to the river but some of the live fish (Table 1) were only observed under the ice and not able to be captured and salvaged. Sculpin were not identified to species level for this memorandum because the frozen and/or damaged condition of many of the sculpin made identification difficult. Dead stranded sculpin were preserved so species identification could be conducted in the future if desired.

Sites that were not surveyed were: Kootenay River RUB, Blueberry Creek, Beaver Creek RUB, Genelle Cobble Islands, and Kinnaird Rapids. Most of these sites were not sampled because of difficult access (e.g. snow, boat access) and/or lower potential risk of stranding based on previous experience. Kootenay River RUB was not sampled because the Golder crew received notification from BC Hydro that flows were going to be increased to the pre-reduction level later that day, and surveying efforts would be better spent downstream before the increased flow reached downstream sites. Of the sites not surveyed, Kootenay RUB likely had the greatest potential for a significant stranding event that was not documented, because of greater stranding risk based on previous surveys, and the presence of Umatilla Dace, which is an at-risk species.

Table 1: Summary of sites visited, approximate water level reduction, and stranded fish observed on November 30, 2014.

Site[a]	Approximate River Stage Reduction[b] (m)	Stranded Fish Observed[c]			
		Species	Life Stage	Live[d]	Dead
LionsHead RUB	1.8	-	-	-	-
Norn's Creek Fan RUB	2.5	Rainbow Trout	Juvenile	-	3
		Sculpin species	All	0	30
CPR Island Mid	2.5	Northern Pikeminnow	Juvenile	10	-
		Rainbow Trout	Juvenile	26	1
		Redside Shiner	All	36	1
		Sucker species	All	34	1
		Sculpin species	All	2	1
Tin Cup Rapids RUB	1.4	-	-	-	-
Kootenay River LUB	1.1	-	-	-	-
Millennium Park LUB	1.8	-	-	-	-
Zuckerberg Island LUB	1.8	-	-	-	-
Genelle Mainland	1.7	Sculpin species	All	1	23
		Sucker species	Juvenile	-	8
		Yellow Perch	Juvenile	-	1
Gyro Boat Launch RUB[b]	1.2	Sculpin species	Adult	2	-
		Unknown species	Juvenile	6	-
Trail Bridge RUB	1.2	-	-	-	-
Casino Road Bridge LUB (upstream)	1.5	-	-	-	-

Site[a]	Approximate River Stage Reduction[b] (m)	Stranded Fish Observed[c]			
		Species	Life Stage	Live[d]	Dead
Casino Road Bridge LUB (downstream)	1.5	Kokanee	Adult	-	1
Bear Creek RUB	1.5	Sculpin species	All	1	-
		Walleye	Adult	1	-
Beaver Creek LUB	1.5	-	-	-	-
Fort Sheperd Launch RUB	1.0	Sculpin species	All	1	-
		Mountain Whitefish	Juvenile	1	-
		Unknown species	Juvenile	3	-
Fort Sheperd LUB	1.0	Rainbow Trout	Juvenile	-	1
		Sculpin species	All	1	1
		Umatilla Dace	All	-	5
Total	-	-	-	**125**	**77**

a. See annual reports for details and locations of stranding sites
b. Freezing temperatures and the time elapsed since the reduction made it very difficult to assess the reduction in water level at many sites. These values are approximate and may not be accurate.
c. Frozen water in most of the isolated pools made electrofishing impossible and visual surveys very difficult. The number of fish stranded was likely greater than those observed.
d. Live fish include fish that were captured and salvaged (returned to river) and fish that were observed but not captured and salvaged.

Closure

We trust that this document meets your requirements to summarize the fish stranding survey on November 2014. Photographs of all sites surveyed will also be provided electronically to BC Hydro. If you have any questions please do not hesitate to contact us.

David Roscoe, M.Sc.
Fisheries Biologist

Bob Chapman, R.P.Bio.
Associate, Aquatics Group Manager

DR/BC/jc

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APPENDIX C

Database Query Example

Fish Stranding Data Query Results

Current Birchbank Discharge =	**62 kcfs**	Current Water Temp =	**14.7 °C**
Resulting Birchbank Discharge =	**47 kcfs**	Proposed Reduction Date =	**04-Oct-14**
		Reduction Location =	**Hugh L. Keenleyside Dam**

Site Name	Reduction Date	Reduction Event #	Max. BB Disch. (kcfs)	Min. BB Disch. (kcfs)	Water Temp. at BB (°C)	Total Number Unlisted Fish Stranded	Total Number of Stranded Listed Fish
Lions Head (upstream of Norns Fan) (RUB)	06-Oct-02	200217	57.3	51.9	14.1	0	
	29-Oct-03	200314	54.7	51.7	6.4	0	
	26-Oct-05	200522	63.2	60.8	10.0	0	
	29-Oct-05	200522	59.5	55.1	6.1	0	
	04-Nov-05	200523	54.5	49.9		0	
	07-Oct-06	200619	54.0	47.0	13.0	0	
	09-Dec-06	200625	62.0	50.9	5.0	3	
	01-Oct-07	200724	55.9	52.0	13.8	0	
	24-Nov-07	200726	66.8	56.3	5.8	1	
	08-Oct-11	201119	56.5	49.3	14.0	0	
Maximum number of fish stranded at this site during a single reduction (based on 10 reductions) =						**3**	
					Concern Category:	**Minimal Effect**	
Norns Creek Fan (RUB)	05-Oct-02	200217	61.9	57.2	12.3	9	
	06-Oct-02	200217	57.3	51.9	14.1	3	
	08-Oct-03	200313	63.3	58.3	13.0	32	
	21-Nov-03	200316	62.9	59.8	2.5	0	
	08-Oct-05	200521	63.7	61.3	10.5	1	
	26-Oct-05	200522	63.2	60.8	9.0	0	
	29-Oct-05	200522	59.5	55.1	4.8	2	
	04-Nov-05	200523	54.5	49.9		3	
	07-Oct-06	200619	54.0	47.0	9.0	0	
	09-Dec-06	200625	62.0	50.9	5.0	0	
	01-Oct-07	200724	55.9	52.0	15.8	0	
	24-Nov-07	200726	66.8	56.3	3.8	0	
	08-Oct-10	201016	54.3	48.9	14.0	19	
	08-Oct-11	201119	56.5	49.3	10.0	4	
Maximum number of fish stranded at this site during a single reduction (based on 14 reductions) =						**32**	
					Concern Category:	**Minimal Effect**	

Site Name	Reduction Date	Reduction Event #	Max. BB Disch. (kcfs)	Min. BB Disch. (kcfs)	Water Temp. at BB (°C)	Total Number Unlisted Fish Stranded	Total Number of Stranded Listed Fish
CPR Island (MID)	06-Oct-02	200217	57.3	51.9	14.1	0	
	07-Oct-06	200619	54.0	47.0	13.0	10	**1**
	08-Oct-10	201016	54.3	48.9	14.0	0	
	08-Oct-11	201119	56.5	49.3	14.0	0	
Maximum number of fish stranded at this site during a single reduction (based on 4 reductions) =						**10**	**1**
					Concern Category:	**Effect**	
Tin Cup Rapids (RUB)	01-Oct-01	200119	62.0	52.8	12.7	86	
	05-Oct-01	200120	52.6	47.8	14.2	19	
	05-Oct-02	200217	61.9	57.2	13.1	0	
	06-Oct-02	200217	57.3	51.9		0	
	28-Oct-03	200314	63.0	54.7	12.0	8	
	29-Oct-03	200314	54.7	51.7	11.0	1	
	26-Oct-05	200522	63.2	60.8	12.0	0	
	29-Oct-05	200522	59.5	55.1	11.4	0	
	04-Nov-05	200523	54.5	49.9		6	
	07-Oct-06	200619	54.0	47.0		0	
	09-Dec-06	200625	62.0	50.9	4.0	0	
	24-Nov-07	200726	66.8	56.3	6.2	0	
	21-Oct-11	201121	53.4	52.0	12.0	0	
Maximum number of fish stranded at this site during a single reduction (based on 13 reductions) =						**86**	
					Concern Category:	**Minimal Effect**	
Millenium Park (Tin Cup LUB)	05-Oct-01	200120	52.6	47.8	14.2	0	
	21-Nov-01	200126	60.1	54.4	8.0	0	
	07-Oct-06	200619	54.0	47.0	13.0	0	
	01-Oct-07	200724	55.9	52.0	13.4	14	
	24-Nov-07	200726	66.8	56.3	6.2	0	
	21-Oct-11	201121	53.4	52.0	12.0	1	
Maximum number of fish stranded at this site during a single reduction (based on 6 reductions) =						**14**	
					Concern Category:	**Minimal Effect**	

Current Water Temperature (°C) = **14.7**

Site Name	Reduction Date	Reduction Event #	Max. BB Disch. (kcfs)	Min. BB Disch. (kcfs)	Water Temp. at BB (°C)	Total Number Unlisted Fish Stranded	Total Number of Stranded Listed Fish
Kootenay River (LUB)	15-Nov-00	200024	63.2	60.2	6.0	0	
	01-Oct-01	200119	62.0	52.8	16.0	3	
	06-Oct-02	200217	57.3	51.9	14.5	0	
	28-Oct-03	200314	63.0	54.7	12.0	97	**50**
	04-Nov-05	200523	54.5	49.9		0	
	07-Oct-06	200619	54.0	47.0	14.0	0	
	01-Oct-07	200724	55.9	52.0	14.4	0	
	04-Dec-08	200820	69.5	55.7	7.0	0	
	02-Oct-09	200916	58.1	53.6	16.0	34	
	08-Oct-11	201119	56.5	49.3	15.0	**208**	**13**
Maximum number of fish stranded at this site during a single reduction (based on 10 reductions) =						**208**	**50**
					Concern Category:	**Effect**	
Kootenay River (RUB)	15-Nov-00	200024	63.2	60.2	6.0	0	
	05-Oct-01	200120	52.6	47.8	15.5	**1450**	
	21-Nov-01	200126	60.1	54.4	8.0	0	
	05-Oct-02	200217	61.9	57.2	13.2	22	
	06-Oct-02	200217	57.3	51.9	15.4	**318**	
	08-Oct-03	200313	63.3	58.3	14.0	0	
	28-Oct-03	200314	63.0	54.7	12.0	**332**	**6**
	08-Oct-05	200521	63.7	61.3	13.0	0	
	29-Oct-05	200522	59.5	55.1	10.4	0	
	04-Nov-05	200523	54.5	49.9		**313**	**5**
	07-Oct-06	200619	54.0	47.0	13.0	124	**1**
	09-Dec-06	200625	62.0	50.9	3.0	0	
	01-Oct-07	200724	55.9	52.0	14.4	5	
	04-Dec-08	200820	69.5	55.7	7.0	0	
	02-Oct-09	200916	58.1	53.6	16.0	62	
	08-Oct-10	201016	54.3	48.9	14.5	**377**	
	08-Oct-11	201119	56.5	49.3	15.0	**460**	**2**
	21-Oct-11	201121	53.4	52.0	9.0	0	
Maximum number of fish stranded at this site during a single reduction (based on 18 reductions) =						**1450**	**6**
					Concern Category:	**Effect**	

Current Water Temperature (°C) = **14.7**

Site Name	Reduction Date	Reduction Event #	Max. BB Disch. (kcfs)	Min. BB Disch. (kcfs)	Water Temp. at BB (°C)	Total Number Unlisted Fish Stranded	Total Number of Stranded Listed Fish
Zuckerberg Island (LUB)	06-Oct-00	200020	58.0	52.8	13.0	0	
	15-Nov-00	200024	63.2	60.2	7.6	0	
	01-Oct-01	200119	62.0	52.8		0	
	05-Oct-01	200120	52.6	47.8	14.3	0	
	21-Nov-01	200126	60.1	54.4	8.0	0	
	05-Oct-02	200217	61.9	57.2	13.3	0	
	21-Nov-03	200316	62.9	59.8	6.7	0	
	08-Oct-05	200521	63.7	61.3	12.0	0	
	01-Oct-07	200724	55.9	52.0	13.4	1	
	24-Nov-07	200726	66.8	56.3	6.2	0	

Maximum number of fish stranded at this site during a single reduction (based on 10 reductions) = 1

Concern Category: **Minimal Effect**

Kinnaird Rapids (RUB)

Maximum number of fish stranded at this site during a single reduction (based on 1 reduction) =

Concern Category: **No Pools**

Blueberry Creek (LUB)	07-Oct-06	200619	54.0	47.0	9.0	0	

Maximum number of fish stranded at this site during a single reduction (based on 1 reduction) = 0

Concern Category: **Reconnaissance Survey**

Current Water Temperature (°C) = **14.7**

Site Name	Reduction Date	Reduction Event #	Max. BB Disch. (kcfs)	Min. BB Disch. (kcfs)	Water Temp. at BB (°C)	Total Number Unlisted Fish Stranded	Total Number of Stranded Listed Fish
Genelle (Mainland) (LUB)	08-Oct-03	200313	63.3	58.3	13.5	2	
	28-Oct-03	200314	63.0	54.7	11.5	2	
	29-Oct-03	200314	54.7	51.7	11.1	0	
	21-Nov-03	200316	62.9	59.8	6.7	0	
	08-Oct-05	200521	63.7	61.3	12.0	**520**	
	26-Oct-05	200522	63.2	60.8	12.0	0	
	29-Oct-05	200522	59.5	55.1	10.5	0	
	04-Nov-05	200523	54.5	49.9		0	
	07-Oct-06	200619	54.0	47.0	14.0	0	
	09-Dec-06	200625	62.0	50.9	4.0	0	
	01-Oct-07	200724	55.9	52.0	14.5	28	
	24-Nov-07	200726	66.8	56.3	4.4	0	
	04-Dec-08	200820	69.5	55.7	7.0	0	
	02-Oct-09	200916	58.1	53.6	16.0	0	
	08-Oct-10	201016	54.3	48.9	15.0	12	
	21-Oct-11	201121	53.4	52.0	12.0	0	
Maximum number of fish stranded at this site during a single reduction (based on 16 reductions) =						**520**	
Concern Category:						**Effect**	
Genelle Upper Cobble Island (MID)	21-Nov-03	200316	62.9	59.8	6.7	0	
Maximum number of fish stranded at this site during a single reduction (based on 1 reduction) =						**0**	
Concern Category:						**Reconnaissance Survey**	
Genelle Lower Cobble Island (MID)							
Maximum number of fish stranded at this site during a single reduction (based on 1 reduction) =						No Data	
Concern Category:						**Reconnaissance Survey**	
Gyro Boat Launch	07-Oct-06	200619	54.0	47.0	13.0	89	**5**
	21-Oct-11	201121	53.4	52.0	12.0	48	
Maximum number of fish stranded at this site during a single reduction (based on 2 reductions) =						**89**	**5**
Concern Category:						**Effect**	
Trail Bridge (RUB) (Downstream)							
Maximum number of fish stranded at this site during a single reduction (based on 1 reduction) =						No Data	
Concern Category:						**Reconnaissance Survey**	

Current Water Temperature (°C) = **14.7**

Site Name	Reduction Date	Reduction Event #	Max. BB Disch. (kcfs)	Min. BB Disch. (kcfs)	Water Temp. at BB (°C)	Total Number Unlisted Fish Stranded	Total Number of Stranded Listed Fish
Casino Road Bridge, Trail (LUB) (Upstream)	28-Oct-03	200314	63.0	54.7	11.6	0	
	29-Oct-05	200522	59.5	55.1	10.7	0	
	09-Dec-06	200625	62.0	50.9	4.0	0	
	01-Oct-07	200724	55.9	52.0	14.0	0	
	24-Nov-07	200726	66.8	56.3	6.9	0	
Maximum number of fish stranded at this site during a single reduction (based on 5 reductions) =						**0**	
					Concern Category:	**Minimal Effect**	
Casino Road Bridge, Trail (LUB) (Downstream)	20-Nov-01	200126	65.4	60.4	8.0	0	
	21-Nov-01	200126	60.1	54.4	8.0	21	
	05-Oct-02	200217	61.9	57.2	13.1	1	
	28-Oct-03	200314	63.0	54.7	11.6	1	
	29-Oct-03	200314	54.7	51.7	10.1	0	
	29-Oct-05	200522	59.5	55.1	10.7	0	
	09-Dec-06	200625	62.0	50.9	4.0	0	
Maximum number of fish stranded at this site during a single reduction (based on 7 reductions) =						**21**	
					Concern Category:	**Minimal Effect**	
Bear Creek (RUB)	28-Oct-03	200314	63.0	54.7	11.5	0	
	29-Oct-03	200314	54.7	51.7	10.0	0	
Maximum number of fish stranded at this site during a single reduction (based on 2 reductions) =						**0**	
					Concern Category:	**Reconnaissance Survey**	
Beaver Creek (RUB)							
Maximum number of fish stranded at this site during a single reduction (based on 1 reduction) =						No Data	
					Concern Category:	**Reconnaissance Survey**	
Beaver Creek (LUB)	29-Oct-03	200314	54.7	51.7	10.1	0	
Maximum number of fish stranded at this site during a single reduction (based on 1 reduction) =						**0**	
					Concern Category:	**Reconnaissance Survey**	
Fort Shepherd Eddy (LUB)	29-Oct-03	200314	54.7	51.7	8.2	0	
Maximum number of fish stranded at this site during a single reduction (based on 1 reduction) =						**0**	
					Concern Category:	**Reconnaissance Survey**	
Fort Shepherd Launch (RUB)							
Maximum number of fish stranded at this site during a single reduction (based on 1 reduction) =						No Data	
					Concern Category:	**Reconnaissance Survey**	

Current Water Temperature (°C) = **14.7**

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For more information, visit golder.com

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 44 1628 851851
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Ltd.
201 Columbia Avenue
Castlegar, British Columbia, V1N 1A8
Canada
T: +1 (250) 365 0344

Golder Associates