Site C Clean Energy Project

Site C Fish Stranding Monitoring Program (Mon-12)

Construction Year 4 (2018)

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Site C Fish Stranding Monitoring Program (Mon-12) 2018 Data Report

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Executive Summary

BC Hydro is constructing the Site C Clean Energy Project (the Project), including dam and generating station, on the Peace River near Fort St. John. The Project will be the third dam and generating station on the Peace River providing an additional 1,100 megawatts of capacity. Dam construction includes backwatering of an estimated 18 km Diversion Headpond, immediately upstream of the new dam and formation of an 83-km reservoir in 2024. The Site C Fish Stranding Monitoring Program (Mon-12) is intended to determine the magnitude of baseline fish stranding along the Peace River, from the Diversion Headpond (upstream of Site C) to the Many Islands area in Alberta, and to compare these baseline conditions to construction and operations phases of the Project. The program methods are based upon the “Canadian Lower Columbia River: Fish Stranding Risk Assessment and Response Strategy” (Golder 2011) and adaptations from fish stranding programs along the Columbia (CLBMON) and Duncan Rivers (DDMON). The primary management questions of Mon-12 are:

1. What is the magnitude of fish stranding in the Diversion Headpond relative to baseline conditions?
2. Which species and life stages of fish are most affected by stranding in the Diversion Headpond relative to baseline conditions?
3. During Project operation, what is the magnitude of fish stranding by species and life stage in the Peace River downstream of the Project relative to baseline conditions?
4. Do mitigation strategies (i.e., fish salvage and habitat enhancement) reduce fish stranding rates relative to baseline conditions?

Field surveys for Year 3 (2018) of Mon-12 were completed between August and October 2018. Ten sampling days were conducted within two reaches of the study area: the Diversion Headpond and Reach 1 (between Site C and the Taylor Bridge). Two days of sampling were conducted on each of the five trips. Each trip was coordinated with BC Hydro operations to ensure sampling occurred following a planned reduction in discharge (i.e., ramping) at the Peace Canyon Dam and to account for flow change delays between the Peace Canyon Dam and the study area. A total of 180 sampling events were completed using interstitial sampling of dewatered substrates (122 surveys) and pool sampling using backpack electrofishing methods in isolated pools (58 surveys) at both targeted and randomly selected sites.

Of the 180 sampling events completed in 2018, 44 resulted in observations of isolated or stranded fish and a total of 212 individual fish were collected and processed. Of these, 185 fish were considered isolated (i.e., fish collected during sampling in pools or in shallow surface water) and 27 fish were considered stranded (i.e., fish found out of water and either dead or at imminent risk of mortality). The most commonly observed fish species were sucker species (89 fish observed), which represent 42% of the total number of fish collected. The next most common fish observed were sculpin (62 fish observed) and minnows (52 fish observed), representing 29% and 25% of total fish observations, respectively. Together, these three groups represent 96% of all fish observations. Approximately 90% of all fish collected were identified in the Young-of-the-Year and juvenile life history stages.

Data collected in 2018 will be combined with the previous two years of baseline data collection for analysis by Ecofish Research Ltd. with the intention of testing the management hypotheses summarized in Table ES.1 below.

Table ES.1 Summary of Mon-12 Management Hypotheses and Year 3 Results

Objective	Management Hypotheses	Year 3 (2018) Results
To monitor the effects of flow fluctuations associated with the construction and operation of the Project on fish communities.	During Project construction, fish stranding in the Diversion Headpond increases relative to baseline conditions.	Year 3 sampling represents the third year of baseline data collection for the Diversion Headpond.
	During Project operation, fish stranding in the Peace River between the Project and the Pine River confluence increases relative to baseline conditions.	Year 3 sampling represents the third year of baseline data collection for the area between the Project and the Pine River confluence (Reach 1).
	During Project operation, fish stranding in the Peace River between the Pine River confluence and the Many Islands area in Alberta is similar to baseline conditions.	Year 3 did not include sampling downstream of the Pine River confluence. To date, two years of baseline data collection has been completed for Reach 2 and one year of baseline data collection has been completed for Reach 3.
	Proposed mitigation measures in the Headpond during the river diversion phase of Project construction and side channel enhancement and contouring in the Peace River downstream of the Project during operations are effective in reducing fish stranding rates.	Year 3 results contribute to the previous two years of baseline data for the Diversion Headpond and Reach 1.

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D&M Madison Holdings Ltd.
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Appendices

1. Introduction

Ecora Engineering & Resource Group Ltd. (Ecora) was retained by BC Hydro (BCH) to implement the Site C Fish Stranding Monitoring Program (Mon-12) included as Appendix M of the Fisheries and Aquatic Habitat Monitoring and Follow-up Program, FAHMFP (BCH 2015). The scope of Mon-12 includes a field data collection program and data summary report supporting the assessment of effects of flow fluctuations associated with the construction and operation of the Site C Clean Energy Project (the Project) on stranding and isolation of fish communities (BCH 2016). Mon-12 was initiated in 2016 to compare the pre-construction (baseline) conditions to construction and operation conditions associated with the Project, including the creation of the Diversion Headpond. The methodology described for the program follows the methods developed for similar projects in other regulated rivers in BC, including the Columbia and Duncan rivers in the Kootenay region. Ecora partnered with Halfway River Ventures Ltd. (HRVL) to conduct the field component of the program. Ecofish Research Ltd. (Ecofish) was independently retained by BCH to provide technical oversight, including support in the development of field methodologies and completion of the statistical data analyses to test the Mon-12 management hypotheses outlined in Section 1.3.

This report provides a summary of results from sampling conducted in 2018. The results are provided as a data summary and discussed in relation to the Mon-12 program objectives, management questions, and hypotheses defined by BCH (2016). Data analysis and testing of the management hypotheses will be addressed in a separate report prepared by Ecofish. The main objectives of the monitoring program are to collect baseline fish stranding data to quantify the magnitude of fish stranding throughout the study area and to determine the species and life stages most commonly affected for comparison with future conditions during the construction and operation phases of the Project. The results will be used to develop strategies to mitigate the potential effects of stranding on identified species and/or life stages of concern. Following the schedule provided in the monitoring plan, which outlines the sequence of reaches to be assessed each year, the 2018 study area included the Diversion Headpond and Reach 1.

1.1 Background

Fish stranding generally occurs when fish habitat becomes isolated from the main stream channel during flow reductions associated with ramping events (Golder 2014). The magnitude of stranding is usually closely associated with the magnitude and rate of ramping (Irvine et al. 2014). Fish are considered stranded when they are found dead or are at imminent risk of death from the dewatering of aquatic habitats, including within interstitial areas of coarse substrates (Golder 2014). Isolation is another form of stranding that occurs when fish become trapped in waterbodies that have become separated from the main stream flow (i.e., fish are unable to leave the waterbody). Isolated fish may not be at imminent risk of death, but depending on the physical characteristics of the waterbody, may be at higher risk of predation and subjected to adverse effects of increased water temperatures, reduced dissolved oxygen, and other factors that increase the likelihood of mortality (Nicholl and Lewis 2016). The relative level of risk for isolated fish typically depends on physical characteristics of the waterbody (size, depth, substrates, and presence of cover), weather conditions (effects of evaporation, temperature, and dissolved oxygen), and the length of time the pool remains isolated (i.e., until mainstem flows rise and reconnect the isolated waterbody).

Isolation and stranding of fish may occur during natural river level fluctuations, but effects are typically exacerbated by hydroelectric activity due to increases in frequency, rate, and magnitude of water level fluctuations (Irvine et al. 2014). Young-of-the-Year (YOY) and juvenile fish are generally more likely to be stranded by flow reductions due to their preference for shallow waters and near-shore habitats (Triton 2009). The risk of fish stranding is affected by several factors including proximity to the dam, the extent and duration of water level reduction, duration of inundation prior to water level reduction (i.e., wetted history), the rate at which reductions occur (i.e., ramping), and a site's physical characteristics, including slope, substrates, and the presence of depressions or other areas that may collect water during water level reduction events (Golder 2010a, Golder 2010b). The potential effects of isolation and stranding on fish include reduced growth rates, increased stress, and mortality (Irvine et al. 2014; Nagrodski et al. 2012). During the initial three years of baseline sampling, the flow regime within the study area was directly influenced by operation of the Peace Canyon Dam (PCN), located approximately 85 km upstream of the Project near Hudson's Hope, BC.

1.2 Program Objectives

The Mon-12 objectives and management questions were outlined in the Site C Fish Stranding Monitoring Program (BCH 2016). The main objective of the program is to collect data that address four primary fisheries management questions:

1. What is the magnitude of fish stranding in the Diversion Headpond relative to baseline conditions?
2. Which species and life stages of fish are most affected by stranding in the Diversion Headpond relative to baseline conditions?
3. During Project operation, what is the magnitude of fish stranding by species and life stage in the Peace River downstream of the Project relative to baseline conditions?
4. Do mitigation strategies (i.e., fish salvage and habitat enhancement) reduce fish stranding rates relative to baseline conditions?

1.3 Management Hypotheses

To address the management questions, the program will test the following hypotheses (BCH 2016):

H1: During Project construction, fish stranding in the Diversion Headpond increases relative to baseline conditions.

H2: During Project operation, fish stranding in the Peace River between the Project and the Pine River confluence increases relative to baseline conditions.

H3: During Project operation, fish stranding in the Peace River between the Pine River confluence and the Many Islands area in Alberta is similar to baseline conditions.

H4: Proposed mitigation measures in the Diversion Headpond during the river diversion phase of Project construction and side channel enhancement and contouring in the Peace River downstream of the Project during operations are effective in reducing fish stranding rates.

Data from 2018 represents the third consecutive year of four years of planned baseline data collection. Results from 2018 will be compiled with previous program years to contribute to the baseline data collected and improve the statistical power of future analyses.

2. Methods

2.1 Study Area

The 139-kilometre Mon-12 study area is comprised of the Peace River, from the Wilder Creek confluence, downstream to the Many Islands area in Alberta (Figure 2.1). The study area is broadly divided into two sections, as defined in the Mon-12 monitoring plan (BCH 2016):

1. The Site C Diversion Headpond, which is expected to extend 18 km from the dam site upstream to the Wilder Creek confluence. Throughout the report, this area is referred to as the Headpond.
2. The Peace River, from the dam site downstream to the Many Islands area in Alberta (approximately 121 km).

The portion of the Peace River downstream of the dam site is further divided into three reaches:

1. Reach 1 – Site C dam site downstream to the Pine River confluence (approximately 16 km).
2. Reach 2 – Pine River confluence downstream to the Alces River confluence (approximately 42 km).
3. Reach 3 – Alces River confluence to the Many Islands area in Alberta (approximately 63 km).

The total length of each reach is summarized in Table 2.1. The results of 2D modelling provided by BCH (2013) covers portions of Reaches 2 and 3, including areas expected to be the highest risk for stranding. Reach 2 includes three modelled areas, referred to as Upper (Taylor Bridge), Mid (Pallings Flat), and Lower (Raspberry Island). The Reach 3 modelled area is at Many Islands, at the downstream end of the reach. As per the Mon-12 plan, sampling in 2018 focused on the Headpond and Reach 1, which comprised approximately 34 km of river length.

Table 2.1 Summary of Study Area Reach Breaks

Site Strata	Reach Description	Reach Length (km)
1	Headpond	18
2	Reach 1	16
3	Reach 2	42
4	Reach 3	63
Total Length		139

An approximately 7-km portion of the study area surrounding the dam construction site is unavailable for sampling due to active construction and subsequent health, safety, and security-related concerns. The unavailable area occurs between kilometre markers (KM) 103 to 109, as measured downstream of the Gordon M. Shrum Generating Station (GMS), at the WAC Bennett Dam. Of this, approximately 3 km is within the Headpond and 5 km is within Reach 1.

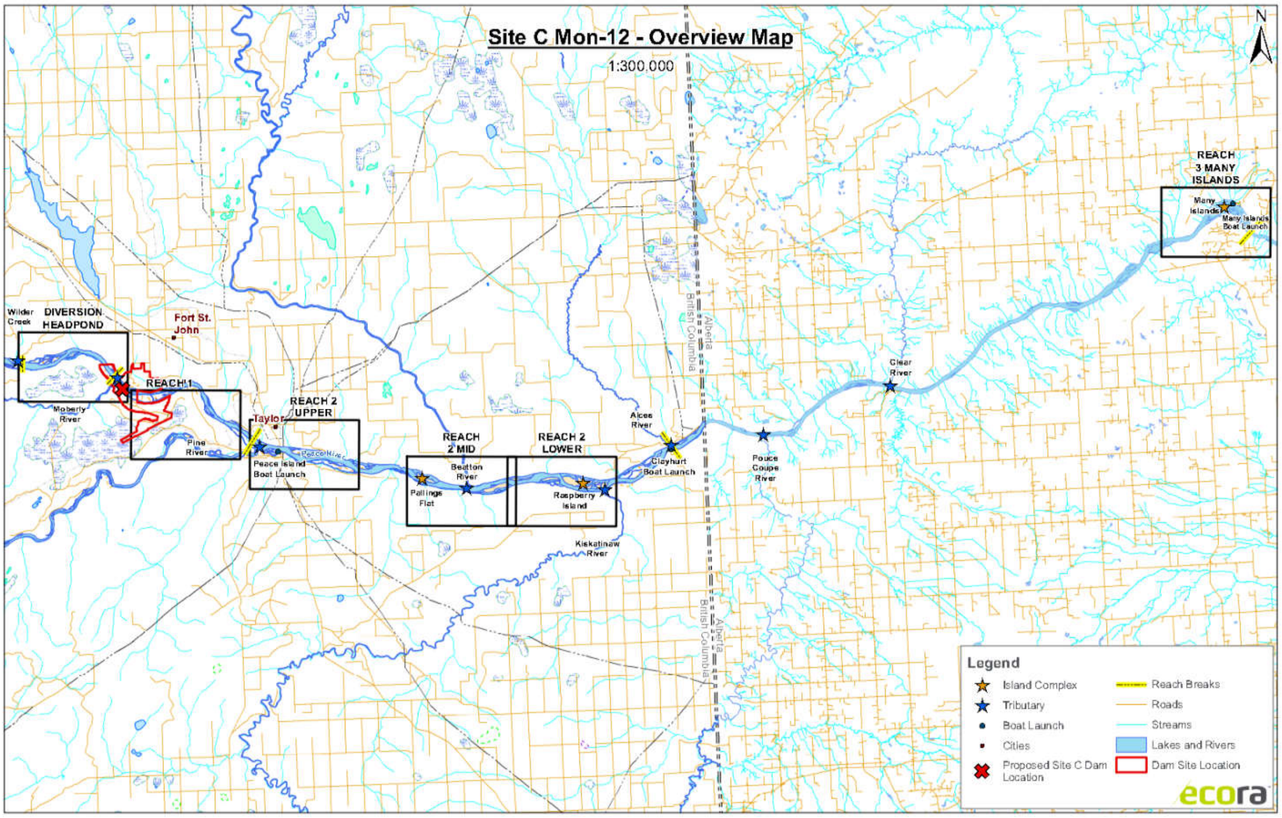


Figure 2.1 Overview Map

2.2 Site Selection

The initial site selection completed in 2016 was based on reviews of other studies of fish stranding in regulated river systems and the results of stranding assessments along the Lower Columbia River downstream of the Hugh Keenleyside Dam (Golder 2014) and the Duncan River downstream of the Duncan Dam (Golder 2013), which are based on adaptations to the Canadian Lower Columbia River Fish Stranding Risk Assessment and Response Strategy (Golder 2011). Sites were selected using physical habitat characteristics that increase stranding and/or isolation risk, as identified in the monitoring plan, which are consistent with other BCH fish stranding monitoring programs. High risk site selection characteristics were defined as areas with:

- Shorelines with gradient of < 4%.
- Large relative area (large areas increase risk of fish stranding).
- Presence of physical cover (woody debris and/or large substrates such as cobble and boulder, with low embeddedness).
- Side Channel or Main Channel habitats.

In the first year of data collection for Mon-12 (2016), the focus on high risk sites had the potential to bias the data, and when extrapolated across the entire study area, may suggest that stranding risk is higher than it actually is. As such, it was agreed through discussions with BCH and Ecofish prior to monitoring in 2017 that sampling efforts would be undertaken in both high and low risk sites to provide a better estimate of total stranding from extrapolation of sampling data. To achieve this, BCH requested that Ecofish provide recommendations for site selection and stranding assessment planning for 2017. The recommendations included a combination of targeted sites (from experience gained during the 2016 surveys and knowledge of the study area) and random sites (generated from Ecofish modelling), which include both high and low risk sites.

2.3 Site Stratification

Prior to the 2017 field season, Ecofish provided linear mapping to Ecora that categorized the modelled shoreline areas as Multi-thread or Single-thread channel type and High Risk or Low Risk. A third category called Negligible Risk was deemed unsuitable for sampling. The delineation of channel type and risk category was completed using the inventory of side channels (NHC 2013), downstream modelled data (Knight-Piésold 2011), and Headpond modelling (Mainstream Aquatics 2012). The methodology used to determine the channel type and risk category was completed by Ecofish. In general, risk categories were defined using gradient between the modelled minimum and maximum wetted shorelines:

- High Risk (≤ 5% gradient);
- Low Risk (> 5% to 20% gradient); and
- Negligible Risk (> 20% gradient).

Random sites were generated by Ecofish along the modelled shoreline, with sampling order determined using a random number generator. Ecofish provided Ecora with the randomly generated sampling points on July 20, 2017 to incorporate into the field sampling planning and mapping. As per the protocol provided by Ecofish, the sampling strategy was approached as follows:

- Targeted high risk – consistent with sampling in 2016, focus of sampling effort to remain on areas with the highest risk of stranding. Focus on previously sampled sites from 2016 and new targeted sites, selected based on judgment of the field crew and knowledge of the study area.
- Random high risk (Multi-thread channels) – randomly select one waypoint per day in habitat designated high risk based on slope analysis.
- Random high risk (Single-thread channels) – randomly select one waypoint per day in habitat designated high risk based on slope analysis.
- Random low risk (Multi-thread channels) – randomly select one waypoint per day in habitat designated low risk based on slope analysis.
- Random low risk (Single-thread channels) – randomly select one waypoint per day in habitat designated low risk based on slope analysis.
- Negligible risk – no sampling unless potential stranding is suspected or observed.

This approach was maintained in 2018 and Ecofish provided a new dataset of random point locations in a randomized order. To address the recommendations of Ecofish and BCH, Ecora undertook a mapping exercise to create polygons from the linear mapping provided by Ecofish. The polygons were intended to quantify discrete habitat areas of similar channel and risk types and to give a measurable spatial area to distinct ‘sites’ throughout each of the study area reaches, as was done for the DDMON program. This mapping was completed for both the Headpond and Reach 1, as these were the focus for the sampling in 2018.

The mapping process adapted the existing risk classification lines, closing them to form discrete polygons (typically at the level of an entire gravel bar) that retained the risk classification from the parent risk modelling lines. Mapping was conducted initially in Google Earth, with line work subsequently cleaned and finalized in ArcGIS. Each polygon was applied a unique identifier (based upon Reach - Channel Type – Risk Type – Numeric

ID) to allow consistent reference to a common site in the field and to enable a linkage between multiple field sites within the same bar. The identifier is recorded on every field form.

Each risk type was verified in the field during sampling events based upon the slopes and habitat characteristics (e.g., substrates, vegetation) observed in the field. To avoid confusion with the Ecofish analysis, changes to the modeled channel type and/or risk category were not made to the mapping. Instead, field-verified risk was recorded to identify sites where the risk of stranding based on habitat conditions (e.g., substrates, vegetation, topography) appeared low and there were limited opportunities to conduct sampling.

2.4 Trip Planning

Trips were scheduled to sample flow reductions during the summer and fall seasons (generally July to October), as this is the period when energy demands result in PCN ramping. The overall approach was to coordinate the sampling trips to align with the ramping forecast provided by PCN Operations. Trips were specifically timed to capture ramping events that best enable the program objectives to be met. This approach is in contrast to other sampling approaches (e.g., DDMON, CLBMON) which have crews ready to be deployed following a ramping event that may not be forecasted to occur.

Recommendations from Ecofish and BCH were to target ramping events with a relatively long ‘wetted history’, which includes a period of high rates of discharge (i.e., >1,000 cubic metres per second or cms) for at least a one day and one night cycle or 48 hours minimum prior to the initiation of a ramping event. The targeted magnitude of each sampled ramping event was a reduction to 500 cms (or less) to allow sampling during a period of maximized exposed habitats. Two-day sampling trips were planned to allow comparison between sampling following a long wetted history (day 1 sampling, immediately following the initial ramping event) and sampling following a short period of wetted history (day 2, following a rebound in flows for a short duration).

Each sampling trip was coordinated with the BCH Operations Planning Engineers at PCN using operations forecasts at different time scales. Longer range operating forecasts (i.e., several months) were reviewed to determine when suitable ramping events might occur. The operating forecasts for 2018 indicated that discharge from PCN would be maintained at low levels between May and July. As a result, field surveys were planned to start in August, when anticipated ramping conditions would enable the sampling objectives to be met.

At a shorter time-scale (hours to days), each trip in 2018 was coordinated with BCH’s Operations Planning Engineers at PCN to ensure sampling occurred following a reduction in discharge at PCN and to account for the lag time between PCN and the study area. For each ramping event, BCH advised Ecora of the planned timing, magnitude, and duration of the event. In some cases, BCH adjusted the timing of the ramping initiation by a few hours to optimize the coordination of the sampling time or the pattern of the ramping (i.e., ramping in two ‘pulses’ to allow back to back days of sampling). However, Ecora avoided influencing the overall timing, duration, or magnitude of each ramping event to prevent introducing bias associated with increasing or decreasing the risk of stranding.

To help coordinate the timing of crew arrival at each reach, BCH provided Ecora with a Peace River flow report via email every six hours which showed discharge rates over the previous four days and a twelve-hour forecast. An example of a typical report is provided in Figure 2.2.

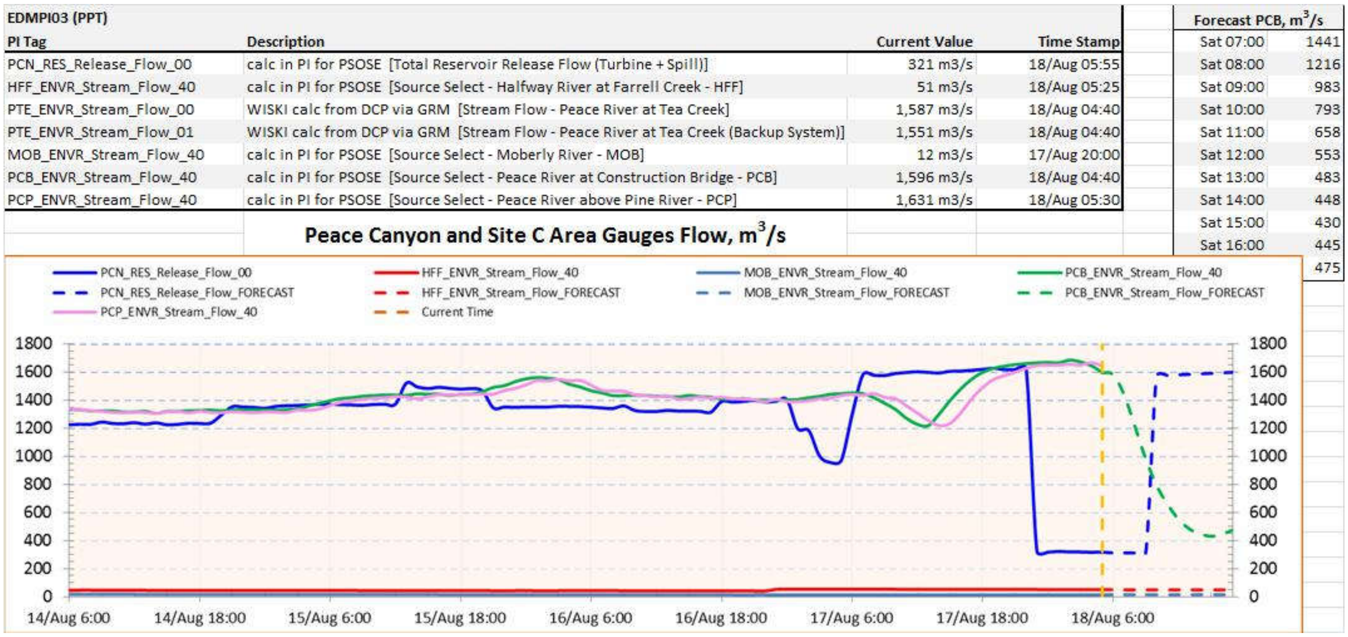


Figure 2.2 Example of typical flow report provided by BCH showing the forecasted reduction event (dashed lines) at PCN prior to Trip 2 on August 18, 2018.

The Peace River above Pine River Water Survey of Canada hydrometric station (07FA004) data were used to determine discharge rates within the 2018 study area as it occurs within Reach 1 (between the Moberly River and Pine River confluences) and represents water level conditions in both the Headpond and Reach 1.

Targeted reductions for planned sampling trips were based on the ramping down of discharge volume from a peak level (typically between 1,200 and 1,600 cms) to a low level (typically 300 to 400 cms). Depending on operational constraints and power demands, the low level discharge rate was held for a period of time or ramped back up and followed by a second reduction event. This ramping regime enabled crews to conduct sampling during low water levels over a two-day sampling period.

2.5 Field Sampling

Ten days of fish stranding surveys were completed over five separate trips (i.e., two sampling days per trip) between August 11 and October 3, 2018. A summary of the sampling completed during each trip is provided in Table 2.2. Maps of sampling locations within each reach are provided in Appendix A.

Table 2.2 Summary of 2018 Sampling Dates, Methods, and Total Sampling Events

Trip	Sampling Day	Date (2018)	Sampling Methods		Total Sampling Events
			Pool Sampling (EF[1])	Interstitial Sampling	
Trip 1	Day 1	August 11	6	10	16
	Day 2	August 12	10	10	20
Trip 2	Day 3	August 18	3	7	10
	Day 4	August 19	4	6	10
Trip 3	Day 5	September 8	**	13	13
	Day 6	September 9	7	11	18
Trip 4	Day 7	September 15	7	15	22
	Day 8	September 16	3	15	18

Trip	Sampling Day	Date (2018)	Sampling Methods		Total Sampling Events
			Pool Sampling (EF[1])	Interstitial Sampling	
Trip 5	Day 9	October 2	9	17	26
	Day 10	October 3	9	18	27
Total			**58**	**122**	**180**

[1] EF: electrofishing

**unable to safely conduct electrofishing due to heavy rain

Surveys were generally conducted between 7:00 am and 7:00 pm by four crews of two to four people (two electrofishing crews and two interstitial survey crews). Sampling locations were accessed using two jet boats (two crews per boat) launched from Peace Island Park, near Taylor, BC. Field navigation was completed through PDF-enabled mapping software on iPad minis. Upon arrival at each site, the crews decided whether to initiate sampling based on availability of recently dewatered substrates and/or formation of isolated pools.

Once a site was deemed suitable for sampling, the spatial coordinates were recorded (waypoint) using the iPad. Location data was obtained by dropping a virtual pin on the PDF map using the GPS-enabled iPad (consumer model A1490 with GPS accuracy of approximately 3 to 5 m). At each site, the following information recorded on previously-prepared waterproof data forms:

- Date and time arrived;
- Reach (Headpond or Reach 1);
- Sampling Event ID: Year-Crew-Survey Day-Site Number (sequential from first sample);
- Site ID (as per the stratified mapping);
- Crew names;
- Method of sampling;
- Weather; and
- Air temperature.

Representative site photos were taken using the iPads and referenced with the GPS waypoint. Based on the site conditions and habitat availability, either interstitial sampling or pool sampling (using electrofishing equipment) was completed, as described below.

2.6 Interstitial Sampling

Interstitial transect sampling methods for 2018 were consistent with the methods developed by Ecofish in 2017. The methodology is described below:

- At each selected site, the crew leader recorded sampling location, start time, site conditions, etc. using the iPad and data sheet. Location data was obtained by dropping a virtual pin on the PDF map using the GPS-enabled iPad. A pin was dropped at the start location and another pin dropped at the end locations for each of the sampling transects.
- An overview (‘Broad-based’) search was completed by the crew over a portion of the site to search for obvious fish presence (i.e., readily observable without overturning substrates). The crew searched at least 100 m length (i.e., transect) along the shoreline in an upstream direction or as the available sampling area allowed. Crews completed the overview sampling by walking side by side over the entire area (Plate 1).
- During the Broad-based search, areas believed to have the highest likelihood of fish stranding (i.e., ‘Hot-spots’) were identified. These generally included shallow depressions, small pools of residual water, and/or areas with habitat cover (e.g., coarse cobble substrates, woody debris, or

vegetation). If fish were found during the overview search, procedures were followed as described below (see ‘Fish Processing’).

- Once the Broad-based search was complete, five Hot-spot locations were selected for detailed sampling. Hot-spot locations were selected using professional judgement and included areas where fish were anticipated to be at highest risk of stranding, such as depressions and recently dewatered pools.
- At each Hot-spot, a measuring tape was laid out to delineate two sides of a sampling area, typically 4-m by 5-m or 10-m by 2-m for a total of 20 m^2 of sampling area per Hot-spot (with a target of 100 m^2 of total Hot-spot sampling per site). Within each Hot-spot, crews overturned all rock substrates and other cover (e.g., vegetation, woody debris) to search for fish (Plate 2).
- Photos were taken of each Hot-spot using the iPad, and showing the tape measure for reference and scale. Sketches were included on the data forms to show the Hot-spot locations within the overall sampling area.
- Quality assurance/quality control (QA/QC) reviews were conducted by having a different crew periodically re-assess a Hot-spot immediately following the initial sampling to confirm that fish were not overlooked and to calibrate crew effort.
- Collected fish were placed in buckets with river water and processed as described in Section 2.8.

2.7 Pool Sampling

Pool sampling was conducted by two crews of two to three people using backpack electrofisher units (Smith-Root LR-24) within waterbodies that became isolated from the main river during the reduction event. A variety of pool sizes were sampled to address the assumption that fish isolated in pools, while not necessarily at imminent risk of mortality, are at elevated risk from predation and from extreme temperatures (high and low) and low dissolved oxygen. Isolated fish may also become stranded if the isolated pool dries prior to river levels rising and inundating the pool. To address these unknown variables, trail cameras were utilized to monitor sites where pools form during ramping events and where fish were collected or expected to be collected based on previous experience. The cameras were set to record time-lapse photos for a subset of pools at ten sites (targeting five in the Headpond and five in Reach 1), as described in Section 2.9.

The general approach to pool sampling was based on the assumption that although some isolated pools may not be at imminent risk of drying out or heating during that particular sampling trip (depending on weather or flow fluctuations), under other circumstances, the isolation may lead to fish stranding and/or mortality (e.g., if flows remained low for an extended period of time or flow increases do not raise water levels sufficient to inundate the pool). As such, sampling was completed at sites where pools form during ramping events to determine what species and life history stages became isolated. The pool sampling methodology is summarized below:

- Upon arrival at each selected site, a brief reconnaissance was completed to determine presence of isolated pools and suitability for sampling, based on relative size, depth, and complexity.
- Pools selected for sampling were required to have no clear fish passage to the mainstem or other adjacent waterbodies (i.e., isolated) and no evidence of a constant water source (from upstream surface water or subsurface upwelling). Targeted sites with pools generally occurred along mid-stream or side-channel bars, were larger than 1 m in width, and deeper than 5 cm (Plate 3). Cover was generally limited to coarse substrates (i.e., cobble and boulder) with occasional vegetation or woody debris present.

- The crew leader recorded sampling location, start time, and site conditions using the iPad and data sheet. The map pin represents the approximate location of the pools being sampled within the site.
- If one to three pools were observed at a site, each pool was sampled. At sites where more than three pools suitable for sampling had formed, a subset of three pools was selected for sampling (Plate 4). Pools with the greatest likelihood of containing fish were selected for sampling, based on habitat suitability, including relative size and depth, coarse substrates, and low embeddedness.
- Sampled pools were searched visually and backpack electrofishing was used to confirm fish presence and collect fish, where possible (Plate 5). Multi-pass electrofishing techniques (i.e., minimum two passes per pool; typically, three were conducted) were used to collect all fish present within each pool. The LR-24 quick setup was used to determine initial settings with manual changes made to optimize capture success.
- Pool characteristics, including approximate size (length and width) of the wetted area. The 'bankfull' area of the pool was also estimated, which was intended to represent the total amount of each pool area that forms at the moment of isolation (i.e., as the water level lowers and pools initially form, thereby isolating fish within the bankfull area of the pool). Other characteristics such as average depth, temperature, conductivity, and substrates (using Modified Wentworth Scale) were recorded at each sampled pool.
- Electrofishing settings and seconds were recorded to measure time spent actively electrofishing.
- Photos were taken of each pool sampling site and all sampled pools using the iPad. Sketches were included on the data forms to show the approximate pool locations within the site.
- Collected fish were placed in buckets with river water and processed as described in Section 2.8.

2.8 Fish Processing

Fish were placed in buckets of river water until processing and each fish was identified to species, where possible. All fish were classified as stranded or isolated at the time of collection. Fish that were immersed in water at the time of collection were considered 'isolated'. Fish that were completely out of water were considered 'stranded'. Fish condition (live or dead) was recorded and, for dead fish, a descriptor was added to identify whether the fish was found dead or if mortality resulted from sampling or handling.

Fish fork length was recorded to the nearest millimeter using a measuring board and/or fish viewer and the life history stage (adult, juvenile, YOY) was determined based on relative size compared to average adult and/or juvenile sizes determined from reference material (McPhail 2007; McPhail and Carveth 1993) and professional judgment (McAllister pers. comm.). Table 2.3 summarizes the life history stage for species observed in 2018.

Table 2.3 Summary of Life History Stage Categories for Fish Observed in 2018

Group	Species	YOY	Juvenile	Adult
Sportfish (Cold)	Arctic Grayling	<70	70-200	>200
	Mountain Whitefish	<100	100-200	>200
Sportfish (Cool)	Burbot	<120	120-400	>400
Sucker	Sucker spp.	<50	50-300	>300
Sculpin	Slimy Sculpin	<40	40-60	>60
Minnow	Lake Chub	<30	30-80	>80
	Longnose Dace	<30	30-60	>60
	Reside Shiner	<40	40-70	>70

All fish (live or dead) were released into the mainstem of the Peace River following the sampling event. Photos were taken of representative fish at each site using a fish viewer (Plate 6). Voucher specimens were not collected.

2.9 Remote Monitoring

To further our understanding about the risk of fish isolated in pools becoming stranded, time-lapse cameras (Browning Command Ops Model BTC-4) were set up at ten sites throughout the 2018 study area (Plate 7). The intended use of the images from the remote cameras was to address uncertainty associated with the time fish remain isolated in pools and the risk of isolated fish becoming stranded (as pools dry out). Where possible, each sampling event where isolated fish were observed during pool sampling at a camera location was cross-referenced to estimate the time the pool became isolated until the time the pool became inundated (i.e., until the river level ramped up and re-connected the pool to the mainstem) or the time until the pool dried out.

Camera locations were selected based on known formation of pools during ramping events and presence of stranded and/or isolated fish observed during previous surveys. Cameras were generally installed on trees, root wads, or on temporary posts and oriented towards the subject pools (Plate 8). Each camera was given a unique ID and programmed to take high-resolution time-lapse images on a 10-minute interval during daylight hours. During the night the cameras only took motion-triggered photos.

During the reconnaissance trip on July 9, 2018, two cameras were set up, one in the Headpond and one in Reach 1 (Appendix A). During Trip 1 on August 11 and 12, the remaining eight cameras were set up, for a total of six cameras in the Headpond and four cameras in Reach 1. One camera was later moved from the Headpond to Reach 1 to provide five cameras in each reach. Cameras were checked on each trip for battery life, condition, and orientation. At each inspection, the SD card was removed and replaced with a blank SD card. The removed SD card was returned to the Ecora office in Kelowna after each trip to download the photos onto the Ecora server. The cameras were retrieved on October 4, following Trip 5.

2.10 Safe Work Procedures and Permits

The Site C Fish Stranding Monitoring Program Safe Work Procedures (SWP) document was updated and submitted to BCH in July 2018. The document outlines the SWP to be followed during work on boats and around flowing water, electrofishing equipment, dangerous wildlife, and operating vehicles. Prior to each day of sampling, Ecora contacted Peace River Hydro Partners (PRHP) to ensure the crew's plans, especially for travel through the active construction zone, was communicated. The crews (Ecora and HRVL) and boat operators met each sampling day at the Peace Island Park boat launch and completed a tailboard safety meeting to review potential hazards, emergency procedures, and other health and safety related concerns. All members participated and signed the daily meeting form. HRVL staff also discussed and signed their own forms to accommodate requirements under their internal safety program.

Cellular phone and data service are available although patchy throughout the Headpond and Reach 1. HRVL provided each crew with a handheld radio for communication. Boat operators kept SPOT and/or Garmin in Reach GPS devices for emergency communication. Boats generally travelled together, and crews maintained line of sight and/or radio contact during the day. Ecora conducted check-in and check-out procedures with Ecora personnel in Kelowna, as well as safety personnel with the BCH dam site construction contractor, PRHP. Digital and hardcopies of fish collection permits were kept in the boats at all times and Ecora provided 48 hours' notice of fish collection activities prior to each sampling trip.

2.11 Data Management

Field data were entered on waterproof data sheets and spatial data were recorded using the GPS-enabled iPads. Upon completion of each trip, data from the field forms were entered into Microsoft Excel, saved on Ecora's network server, and checked for gaps, errors, and other inconsistencies. Data forms were reviewed and cross-referenced with the database during data entry to ensure consistency and identify potential sources of error. All hardcopy field data was scanned and saved as PDF files on the Ecora server, with the original field forms saved in a project binder at the Kelowna office. Calculations in the database were limited to unit area for Broad-based search areas and bankfull area estimates to provide a measure of relative sampling effort.

Broad-based search area was calculated using the assumption that each person walking the transect search a 3 m wide band. Therefore, each Broad-based sampling area was determined using the calculation [(transect length) x (number of persons walking transect x 3)].

Bankfull area (length and width) was estimated in the field surrounding each sampled pool (i.e., the estimated area that would define the pool at the moment of isolation from the mainstem of the river). For consistency, the bankfull estimates from the first sampling event were used for subsequent sampling events at pools that were sampled multiple times. Although pools vary in shape and complexity, the majority of the pools sampled are oval in shape. As such, the estimate of pool size (both wetted and bankfull) utilized the formula for the area of an oval ($A = \pi(\mathrm{R} \quad \mathrm{r})$, where R is the major radius and r is the minor radius). This estimate does not account for pool depth, substrates, or complexity.

GPS data and digital photos were downloaded to the Ecora server and organized using ESRI ArcGIS version 10.2.2. Raw, preliminary hydrometric data (discharge and primary water level) for this report was provided by BCH Operations at PCN for the following stations:

- PCN Total Reservoir Release Flow;
- Peace River at Hudson Hope (Water Survey Canada Hydrometric Station 07EF001);
- Peace River at Site C Construction Bridge; and
- Peace River above Pine River (Water Survey Canada Hydrometric Station 07FA004).

2.12 Quality Assurance

The Ecora and HRVL crews spent the first survey of the first day of each trip working together as a group to review project background and objectives, calibrate surveyor techniques and level of effort, and to train new crew members. Data forms were reviewed by crew leaders following each day of surveying and all sheets were transported to the Kelowna Ecora office at the end of each trip for QA/QC review and data entry. Data from hardcopy forms were entered manually into an Excel database and reviewed. Corrections to errors and omissions were addressed. During the review of the data collected following each trip, inconsistent and/or missing field data was noted and addressed using review of photos, notes, and discussions with field crew members.

3. Results

3.1 Hydrometric Operations

The Peace River above Pine River [07FA004] Water Survey of Canada hydrometric station (PRPR) data shows that maximum discharge of 1,749 cms occurred on August 10, prior to Trip 1. Minimum discharge of 392 cms occurred on September 19 (Figure 3.1). Sampling days are shown in Figure 3.1 as vertical blue lines.

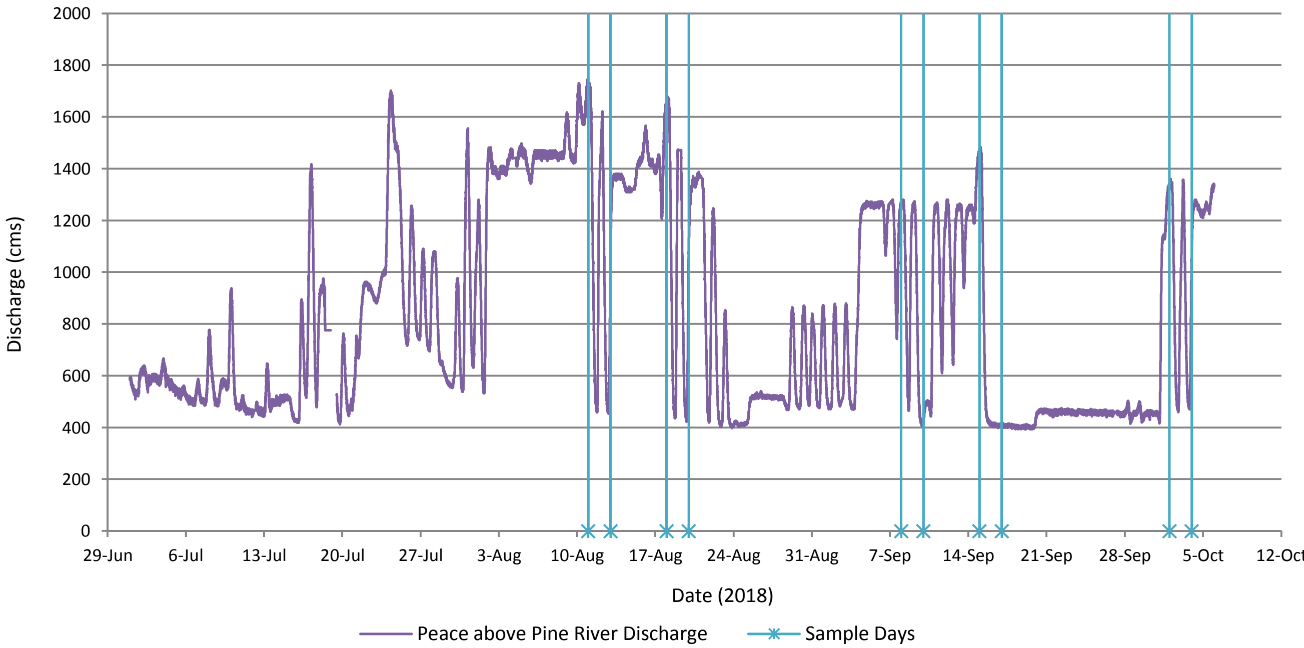


Figure 3.1 Summary of discharge recorded at the Peace River above Pine River (07FA004) Water Survey of Canada Hydrometric Station (purple) and sampling days (blue) between June 29 and October 7, 2018

Sampling was not planned in June or July as PCN discharge was kept low, near the water licence minimum, and there were no ramping events planned. The site reconnaissance trip completed by Ecora and Ecofish was on July 9, 2018 during a period of low flow. Freshet flows and rainfall attenuated the effects of ramping from PCN in July and peak discharge rates (e.g., July 16 and 24) associated with rain events were relatively short in duration (i.e., preceded by low flows and therefore short period of wetted history which reduces the risk of stranding).

The initial sampling trip occurred during the first planned ramping event following a period of extended high discharge rates on August 11. PCN informed Ecora that discharge rates were planned to be kept consistently high (>1,000 cms) following the October trip and there were no further ramping events planned for the fall or winter. Appendix C includes discharge data from PRPR during the two day period for each of the five sampling trips. The figures show the approximate timing of the arrival at the upstream end of each reach in relation to the discharge recorded at PRPR.

3.2 Ramping Rates

Table 3.1 summarizes the ramping events recorded at PRPR during each sampling day. Water level and discharge data for the beginning and end of each ramping event were interpreted from the discharge data. Table 3.1 shows data for the period between the peak water level prior to ramping and the low water level observed following the ramping event.

Table 3.1 Summary of ramping conditions during each sampling day as recorded at the Peace River above Pine River (07FA004) hydrometric station

Trip	Date	Start Time	Water Level (m)	Discharge (cms)	End Time	Water Level (m)	Discharge (cms)	Ramping Period (hr)*	Stage Change (m)	Discharge Change (cms)	Stage Change Rate (cm/hr)	Ramping Rate (cms/hr)
1	11-Aug	4:05	408.04	1716	18:50	405.99	458	14:45	2.05	1258	14	85
	12-Aug	6:15	407.92	1621	19:30	405.98	454	13:15	1.94	1167	15	88
2	18-Aug	4:05	407.99	1672	18:50	405.9	437	14:45	2.05	1235	14	84
	19-Aug	7:15	407.74	1472	18:25	405.93	431	11:10	1.81	1041	16	93
3	8-Sep	4:50	407.46	1280	15:55	406.01	465	11:05	1.45	815	13	74
	9-Sep	5:40	407.44	1260	20:05	405.87	409	14:25	1.57	851	11	59
4	15-Sep	4:00	407.72	1461	16:55	405.91	425	12:55	1.81	1036	14	80
	16-Sep**	-	405.88	410	-	-	-	-	-	-	-	-
5	2-Oct	5:35	407.56	1348	17:40	406.02	469	12:05	1.54	879	13	73
	3-Oct	5:40	407.57	1357	16:30	406.06	486	10:50	1.51	871	14	80

*time between peak flow and low water level during the ramping event

**ramping did not occur on this day; flows remained low

The greatest overall stage changes occurred on August 11 and August 18 (Sampling Days 1 and 3, Table 3.1), when water level (stage) decreased by 2.05 m over a period of approximately 14 hours and 45 minutes. The greatest discharge reductions were also observed on August 11 and August 18, when flows were reduced by 1258 cms and 1235 cms, respectively, over a period of approximately 14hours and 45 minutes.

The rate of reduction during ramping events was relatively consistent in 2018, with stage change rates ramping between 11 and 16 cm/hr. The greatest average ramping rate was on August 19 (Sampling Day 4) when the water level (stage) decreased by 1.81 m and the discharge reduced by 1041 cms over a period of 11 hours and 10 minutes for an average ramping rate of approximately 93 cms/hour (16 cm/hour).

3.3 Fish Stranding Monitoring Surveys

A total of 180 sampling events were completed during ten trips between August 11 and October 3, 2018. These included 122 interstitial surveys and 58 pool surveys using electrofishing methods. The number of each type of survey is summarized by reach, channel type, and risk type in Table 3.2. The number of targeted and random sample events for each survey type is also shown in Table 3.2.

Table 3.2 Summary of Targeted and Random Sampling by Reach, Channel Type, and Risk Type

Reach	Channel Type	Risk Type	Interstitial Sample		Pool Sample		Total
			Targeted	Random	Targeted	Random	
Headpond	Multi-thread	High Risk	46	3	31	0	80
		Low Risk	0	3	1	0	4
		Negligible	0	0	0	0	0
	Single-thread	High Risk	0	3	0	0	3
		Low Risk	0	4	0	0	4
		Negligible	0	0	0	0	0
Reach 1	Multi-thread	High Risk	35	4	15	0	54
		Low Risk	4	4	3	0	11
		Negligible	0	0	0	0	0
	Single-thread	High Risk	6	2	6	0	14
		Low Risk	2	6	1	1	10
		Negligible	0	0	0	0	0
Total			93	29	57	1	180

Of the 122 interstitial surveys, 93 were targeted and 29 were randomly selected (approximately 24%) (Table 3.2). Of the 58 pool surveys, 57 were targeted and 1 was randomly selected (approximately 2%). The low number of randomly sampled pool sites is associated with the low likelihood that pools form at random site locations.

The majority of surveys were completed in the modelled Multi-thread High (134) or Low (15) Risk sites, which represent 83% of the total samples. The remaining samples were completed in modelled Single-thread High (17) or Low (14) Risk sites, which represented 17% of the total samples. This is roughly proportionate to the availability of those habitat types throughout the study area. There were no surveys (targeted or random) completed at sites classified by the modelling as negligible risk.

3.4 Fish Collection

Information for fish observations included condition (live/dead) and whether the fish was considered ‘stranded’ or ‘isolated’ at the time of collection. Isolated fish include all fish that were collected during sampling in pools or were found alive in residual pools or small pockets of water during interstitial sampling. Only fish collected out of water were recorded as stranded (Table 3.3).

Table 3.3 Summary of Sampling Events and Fish Observations in 2018

Method	Number of Sample Events	Samples with Fish Collected	Isolated Fish (Live/Dead)	Stranded Fish (Live/Dead)	Total Fish Collected (Live/Dead)
Interstitial Sampling	122	21	62 (62/0)	27 (5/22)	89 (67/22)
Pool Sampling	58	23	123 (91/32)	0	123 (91/32)
Total	180	44	185 (153/32)	27 (5/22)	212 (158/54)

A total of 212 fish were observed during the 180 sampling events. There were 89 fish collected during interstitial surveys, of which 27 were stranded (i.e., dead or at imminent risk of mortality). There were 123 fish collected during pool sampling, all of which were defined as isolated (i.e., confined within an isolated pool of water but not at imminent risk of mortality).

Approximately 13% of the total fish collected were considered stranded. The majority of fish collected during interstitial sampling (62 fish or 70%) were isolated (i.e., were immersed in water at the time of collection). The remaining 27 fish (30%) were considered stranded, and of these, 22 fish (81% of stranded fish) were found dead at the time of sampling. All of the fish collected during pool sampling were considered isolated and 32 were dead at the time of sampling. There were 23 dead fish collected overall, which represents 11% of all fish collected.

3.5 Fish Observations

Table 3.4 shows the number of species and life history classes for isolated fish collected during both interstitial and pool sampling. Table 3.5 shows the same information for stranded fish collected during interstitial sampling. YOY and/or dead fish in various states of decomposition were identified to species or group (i.e., Family), where possible. Sportfish species were divided into coldwater and coolwater species, as defined in the Environmental Impact Statement Volume 2 Appendix O (Fish and Fish Habitat Technical Data Report).

Table 3.4 Isolated Fish Species and Life History Classes Recorded in 2018

<table>
<tr><th>Group</th><th>Species</th><th>YOY*</th><th>Juvenile</th><th>Adult</th><th>Unknown</th><th>Totals</th><th>Group Total</th><th>Percent of Total</th></tr>
<tr><td rowspan="2">Sportfish (Cold)**</td><td>Arctic Grayling</td><td>0</td><td>1</td><td>0</td><td>0</td><td>1</td><td rowspan="2">3</td><td rowspan="2">1</td></tr>
<tr><td>Mountain Whitefish</td><td>2</td><td>0</td><td>0</td><td>0</td><td>2</td></tr>
<tr><td rowspan="3">Sucker</td><td>Longnose Sucker</td><td>0</td><td>1</td><td>0</td><td>0</td><td>1</td><td rowspan="3">83</td><td rowspan="3">45</td></tr>
<tr><td>White Sucker</td><td>0</td><td>1</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td>Sucker spp.</td><td>61</td><td>20</td><td>0</td><td>0</td><td>81</td></tr>
<tr><td>Sculpin</td><td>Slimy Sculpin</td><td>21</td><td>23</td><td>13</td><td>0</td><td>57</td><td>57</td><td>31</td></tr>
<tr><td rowspan="3">Minnow</td><td>Lake Chub</td><td>0</td><td>5</td><td>0</td><td>0</td><td>5</td><td rowspan="3">37</td><td rowspan="3">20</td></tr>
<tr><td>Longnose Dace</td><td>4</td><td>25</td><td>2</td><td>0</td><td>31</td></tr>
<tr><td>Reside Shiner</td><td>0</td><td>1</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td>Unknown</td><td>Unidentified</td><td>3</td><td>0</td><td>0</td><td>2</td><td>5</td><td>5</td><td>3</td></tr>
<tr><td colspan="2">Totals</td><td>91</td><td>77</td><td>15</td><td>2</td><td rowspan="2">185</td><td rowspan="2">185</td><td rowspan="2">100</td></tr>
<tr><td colspan="2">Percent of Total</td><td>49</td><td>42</td><td>8</td><td>1</td></tr>
</table>

There were 185 isolated fish which were comprised of eight identified species. Three groups (Suckers, Sculpins and Minnows) represented 96% of all isolated fish collected. The majority of fish collected were YOY and juvenile, together representing 92% of isolated fish. There were 32 dead isolated fish observed. Of these, 31 were YOY or juvenile Suckers and one was a YOY Sculpin.

Table 3.5 Stranded Fish Species and Life History Classes Recorded in 2018

<table>
<tr><th>Group</th><th>Species</th><th>YOY*</th><th>Juvenile</th><th>Adult</th><th>Unknown</th><th>Totals</th><th>Group Total</th><th>Percent of Total</th></tr>
<tr><td>Sportfish (Cool)**</td><td>Burbot</td><td>1</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td><td>4</td></tr>
<tr><td rowspan="2">Sucker</td><td>Longnose Sucker</td><td>1</td><td>0</td><td>0</td><td>0</td><td>1</td><td rowspan="2">6</td><td rowspan="2">22</td></tr>
<tr><td>Unknown Sucker</td><td>2</td><td>3</td><td>0</td><td>0</td><td>5</td></tr>
<tr><td>Sculpin</td><td>Slimy Sculpin</td><td>4</td><td>0</td><td>1</td><td>0</td><td>5</td><td>5</td><td>19</td></tr>
<tr><td rowspan="3">Minnow</td><td>Lake Chub</td><td>0</td><td>3</td><td>0</td><td>0</td><td>3</td><td rowspan="3">15</td><td rowspan="3">55</td></tr>
<tr><td>Longnose Dace</td><td>8</td><td>1</td><td>2</td><td>0</td><td>11</td></tr>
<tr><td>Redside Shiner</td><td>0</td><td>0</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td colspan="2">Totals</td><td>16</td><td>7</td><td>4</td><td>0</td><td rowspan="2">27</td><td rowspan="2">27</td><td rowspan="2">100</td></tr>
<tr><td colspan="2">Percent of Total</td><td>59</td><td>26</td><td>15</td><td>0</td></tr>
</table>

There was a total of 27 stranded fish, comprised of six confirmed species. Minnows were most often observed stranded (n=15), representing 55% of the total number of stranded fish observed. The next most common were Sucker (n=6) and Sculpin (n=5), representing 22% and 19%, respectively. The majority of stranded fish are represented by the YOY or juvenile life stages, which represented 85% of the total stranded fish observations. There were 22 dead stranded fish observed, including 15 Minnows, six Suckers, and one Burbot.

3.6 Fork Length Frequency

Fork length was measured for fish collected during the sampling events. A summary of the fork length frequency data for the three most commonly observed species or species groups (suckers, slimy sculpin, and longnose dace) is provided in Figure 3.2.

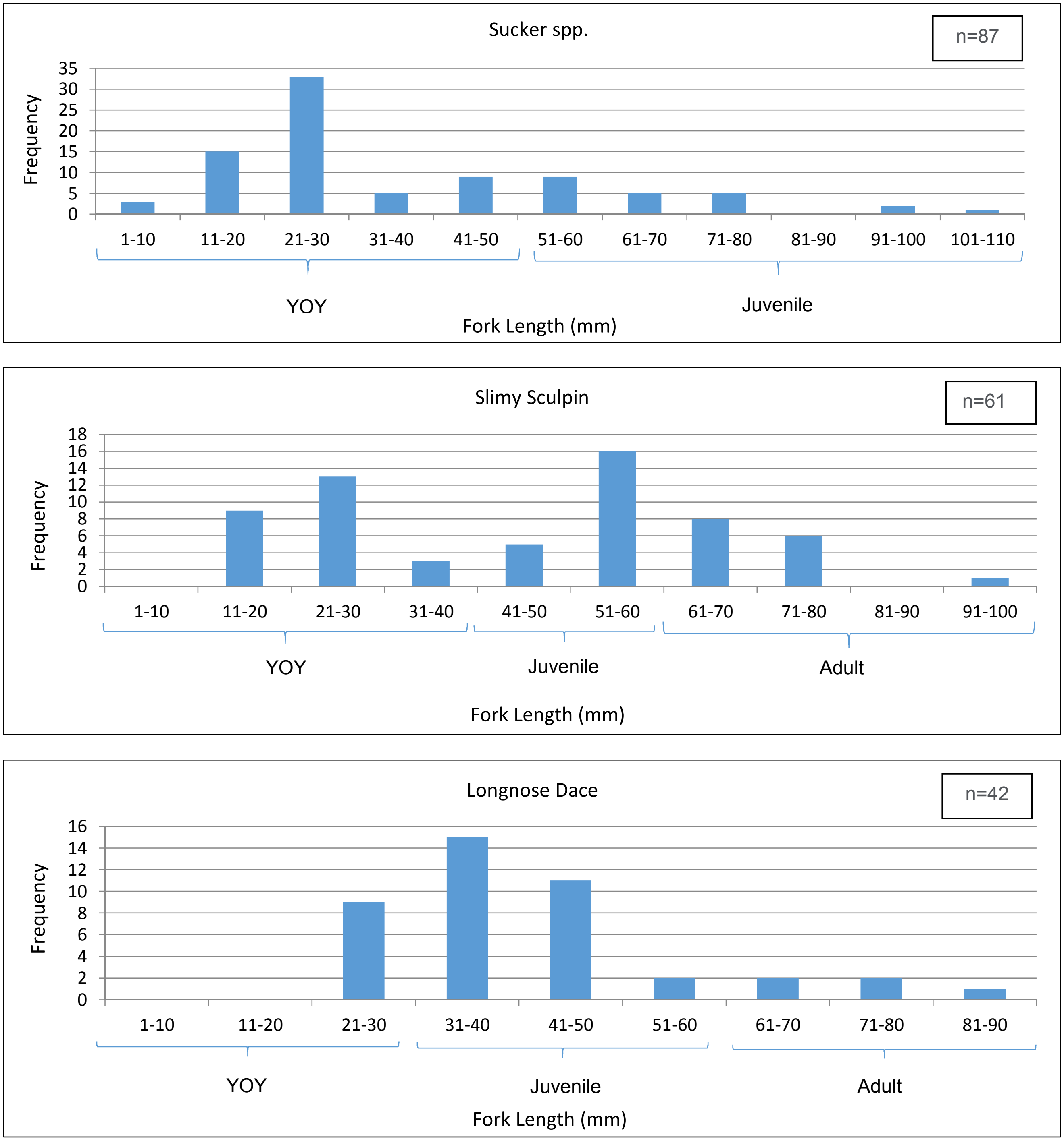


Figure 3.2 Fork length frequency distribution for Sucker spp., Slimy Sculpin, and Longnose Dace, collected from stranding surveys in 2018.

Figure 3.2 includes data from both isolated and stranded fish collected during the 2018 sampling. Life stages are indicated below the horizontal axis. Sucker species life stages are dominated by YOY and juvenile, while Slimy Sculpin and Longnose Dace also include adult life stages. These species and life stages are generally associated with the shallow and near-shore habitats that are most affected by the sampled ramping events.

3.7 Fish Stranding by Reach

Sampling in 2018 was completed in the Headpond and Reach 1. The 212 fish collected were split between 107 (51 %) fish collected in the Headpond and 105 (49 %) fish collected in Reach 1.

Table 3.6 Summary of Interstitial Sampling Fish Observations by Reach

Reach	Stranded Fish	Isolated Fish	Total Fish Observed	No. Surveys	No. Fish Observed per Survey
Headpond	2	45	47	58	0.81
Reach 1	25	17	42	63	0.67
Total	27	62	89	121	0.74

Interstitial sampling resulted in the collection of 89 fish during 121 surveys. Approximately 30% of the fish collected during the interstitial sampling were considered stranded. The total number of fish observations during interstitial sampling was split between the Headpond (47 fish) and Reach 1 (41 fish), although the number of fish observed per survey was greater in the Headpond (0.81 fish per survey). Only two of the 27 stranded fish (approximately 7%) were observed in the Headpond and the remaining 25 (93%) were collected in Reach 1.

Table 3.7 Summary of Pool Sampling Fish Observations by Reach

Reach	Stranded Fish	Isolated Fish	Total Fish Observed	No. Surveys	No. Fish Observed per Survey
Headpond	0	60	60	31	1.94
Reach 1	0	63	63	26	2.42
Total	0	123	123	57	2.16

All of the fish observed during pool sampling were considered isolated. Pool sampling resulted in 123 fish collected during 57 surveys. The total number of fish observations was split between the Headpond (60 fish) and Reach 1 (63 fish), although the number of fish observed per survey was greater in Reach 1 (2.42 fish per survey).

3.8 Fish Distribution

Estimation of stranding rates, including extrapolation of data to the reach scale, will be completed in a separate report by Ecofish. The section below provides a summary of the 2018 study area channel and risk types, the amount of area sampled, and the distribution of fish observations, based on the polygon mapping completed by Ecora.

3.8.1 Risk Type Summary

A summary of the refined extents of polygons representing areas of each defined Channel/Risk Types for the Headpond and Reach 1 is summarized in Table 3.8. The total area of each Channel/Risk Type is expressed in m^2 and is intended to represent the relative amount of dewatered habitat during periods of low water levels (i.e., based on the spatial extents of the modeled high-low water elevation).

Table 3.8 Summary of Channel and Risk Types within each Reach

Reach	Channel Type	Risk Type	Total Area (m^2)	Percent of Reach Total
Headpond	Multi-thread	High Risk	695,897	61
		Low Risk	285,259	25
		Negligible Risk	130,376	12
	Single-thread	High Risk	9,192	1
		Low Risk	12,311	1
		Negligible Risk	2,204	0
		Headpond Total	**1,135,238**	**100**
Reach 1	Multi-thread	High Risk	644,466	54
		Low Risk	214,375	18
		Negligible Risk	149,616	13
	Single-thread	High Risk	55,861	5
		Low Risk	76,898	6
		Negligible Risk	42,575	4
		Reach 1 Total	**1,183,791**	**100**
		Grand Total	**2,319,029**	

The study area in 2018 (Headpond and Reach 1) was dominated by Multi-thread habitat (91%), the majority of which is considered High Risk for stranding (63% of all Multi-thread Channel Type). The relatively small spatial extents of Single-thread Channel Type have resulted in clustered random sites and reduced availability of suitable locations for targeted sampling.

3.8.2 Stranded Fish Distribution

A summary of the sampling results describing the distribution of fish collected during the Broad-based and Hot-spot sampling is provided in Table 3.9 and Table 3.10, respectively. The Channel Type and Risk Type were used to stratify the data and allow comparison among sites with similar characteristics. The spatial area sampled in each Channel and Risk Type is also provided to show the relative sampling effort in each habitat type.

Table 3.9 Summary of Fish Collected During Broad-based Sampling in 2018

Reach	Channel Type	Risk Type	Area Sampled (m^2)	No. Stranded Fish	No. Isolated Fish
Headpond	Multi-thread	High Risk	58,351	2	10
		Low Risk	1,122	0	0
		Negligible	0	0	0
	Single-thread	High Risk	3,090	0	0
		Low Risk	2,309	0	0
		Negligible	0	0	0
Reach 1	Multi-thread	High Risk	43,685	24	5
		Low Risk	6,765	0	2
		Negligible	0	0	0
	Single-thread	High Risk	10,346	0	0
		Low Risk	8,574	0	0
		Negligible	0	0	0
Totals			134,242	26	17

The majority of Broad-based sampling occurred in Multi-thread, High Risk sites, representing 76% of the total area sampled. Almost all of the fish collected (41 out of 43) were within Multi-thread, High Risk sites. There were no fish collected during Broad-based sampling in Single-thread, High Risk sites.

Table 3.10 Summary of Fish Collected During Hot-spot Sampling in 2018

Reach	Channel Type	Risk Type	Area Sampled (m²)	No. Stranded Fish	No. Isolated Fish
Headpond	Multi-thread	High Risk	3,301	0	35
		Low Risk	100	0	0
		Negligible	0	0	0
	Single-thread	High Risk	100	0	0
		Low Risk	0	0	0
		Negligible	0	0	0
Reach 1	Multi-thread	High Risk	3,000	1	9
		Low Risk	500	0	0
		Negligible	0	0	0
	Single-thread	High Risk	800	0	1
		Low Risk	200	0	0
		Negligible	0	0	0
Totals			8,001	1	45

The majority of the sampling occurred within Multi-thread, High Risk sites (79% of the total sampled area) and almost all fish collected during Hot-spot sampling (45 out of 46) were within Multi-thread, High Risk sites. Hot-spot sampling was not completed at all sampling events, such as randomly selected sites where a Broad-based search was completed but the substrate was unsuitable for further surveying (e.g., fines or muddy substrates).

3.8.3 Isolated Fish Distribution

A summary of the distribution of isolated fish collected during pool sampling is provided in Table 3.11. Since pools do not typically form in a uniform manner within each site, the total approximate bankfull area was used to represent the total amount of pool area that forms within a site. The Channel and Risk Type were used to stratify the data and allow for comparison among sites with similar characteristics.

Table 3.11 Summary of Fish Collected During Pool Sampling in 2018

Reach	Channel Type	Risk Type	Bankfull Area (m²)	No. Isolated Fish
Headpond	Multi-thread	High Risk	15,257	60
		Low Risk	175	0
		Negligible	0	0
	Single-thread	High Risk	0	0
		Low Risk	0	0
		Negligible	0	0
Reach 1	Multi-thread	High Risk	6,666	41
		Low Risk	1,349	0
		Negligible	0	0
	Single-thread	High Risk	3,397	22
		Low Risk	723	0
		Negligible	0	0
Totals			27,566	123

The majority of the sampling occurred within Multi-thread, High Risk sites (80% of the total sampled area) and 101 of 123 fish were within Multi-thread, High Risk sites (82%). The remainder of the fish collected (22) were at sample event 18-08-02-05 at a Single-thread, High Risk site (1-S-H-253) on August 12 (Trip 1, Day 2).

During the second day of sampling on Trip 4 (i.e., Day 8), flows had not been increased following the previous reduction. As such, many of the sites that typically have pools form following a reduction event were dry (only two pool samples were conducted on this day). Interstitial sampling therefore also focused on pools that had dried out.

Fish were only collected at a single site on Day 8 during sample event 18-01-08-04, which was at site 1-M-H-251. This site usually includes a relatively large wetted pool (bankfull length of approximately 150 m and bankfull width of approximately 8 m) that had dried out. During this sampling event, 21 stranded fish were collected during a Broad-based search, 17 of which were dead at the time of sampling. The four fish that were alive were all sculpin.

3.9 Pool Monitoring

There were 13 instances where isolated fish were observed in pools that were monitored by the trail cameras. Fish were collected at ten of these sites (Table 3.12). There were four instances where it was assumed that fish isolated in pools either became stranded or were at increased risk of mortality. These are summarized below:

1. Sample Event 18-08-01-02 – Evidence of potential predation from diving piscivorous bird (see Plate 9);
2. Sample Event 18-08-02-01 – Pools dried out after four hours;
3. Sample Event 18-08-02-02 – Pools dried out after four hours (second sampling event at same site as above); and
4. Sample Event 18-01-06-05 – Pools appear to dry out after approximately 12 hours and remain dry for another approximately 18 hours.

In all other instances the condition of the pool between the period of isolation and inundation could not be confidently determined due to changes occurring overnight. In almost all cases, pools remained isolated for less than 24 hours. The exception was on September 9 when the pool remained isolated for approximately 30 hours. Flows remained low following the reduction event on September 15 (Trip 4) until October 1 (16 days later).

On Trip 4, flows were held low after the first day of sampling (Day 7, September 15) and pools were observed dried out on the second day of sampling (Day 8, September 16). As such, it is assumed that fish isolated in pools observed on Day 7 became stranded on Day 8. For example, sampling event 18-01-07-01 at site HP-M-H-238 resulted in the collection of one fish, which would likely have become stranded on Day 8.

Interstitial sampling event 18-01-08-04 was conducted at a site that usually contains a large pool following a reduction event but had dried out on Day 8 and 21 stranded fish were observed, 17 of which were dead (Plate 12). The sites where fish were collected on Day 7 were not monitored by cameras so the imagery cannot be used to confirm. Similarly, sample events at sites monitored by cameras did not result in fish collection so an estimate of stranding cannot be made.

Table 3.12 Summary of Results from Remote Camera Monitoring of Sampled Pools in 2018.

Trip	Day	Date (2018)	Site ID	Sample Event	Camera ID	Time of Pool Formation	Time of Sampling	Period of Isolation (hours)	No. Fish	Description
Trip 1	Day 1	Aug. 11	HP-M-H-230	18-01-01-04	3	08:00*	13:30	<21	3	Last photo taken at 06:10 pm (air temperature is 21C) Pools appear to dry out but cannot be confirmed First image on August 12 at 05:44 am shows site completely inundated
Trip 1	Day 1	Aug. 11	HP-M-H-411	18-08-01-02	7	08:00*	12:00	<21	1	Last photo taken at 18:15 (air temperature is 27C) Pool appears to dry out but cannot be confirmed First image on August 12 at 05:44 shows site completely inundated Belted Kingfisher observed diving into pool at 17:45 pm (see Plate 9)
Trip 1	Day 2	Aug. 12	HP-M-H-82	18-08-02-01	4	08:00*	09:45	4	1	Pools appear to dry out at 12:00 pm (air temperature is 27C) See Plate 10
Trip 1	Day 2	Aug.12	HP-M-H-82	18-08-02-02	4	08:00*	09:45	4	1	Second sample conducted on different pools at same site Pools appear to dry out at 12:00 pm (air temperature is 27C)
Trip 1	Day 2	Aug. 12	HP-M-H-411	18-08-02-03	7	08:00	11:20	12	1	Pool becomes reconnected to mainstem at 20:30 (air temperature is 20C)
Trip 1	Day 2	Aug. 12	1-S-H-253	18-08-02-05	6	12:00*	13:45	<17	22	Last photo taken at 18:14 (air temperature is 31C) First image on August 13 at 05:44 shows site completely inundated
Trip 1	Day 2	Aug. 12	HP-M-H-230	18-01-02-02	3	10:15	11:55	10	1	Pools appear to dry out at 20:15 (air temperature is 17C) Pool almost immediately becomes reconnected to mainstem at 20:24
Trip 2	Day 3	Aug. 18	HP-M-H-411	18-08-03-01	7	08:00	10:00	11	3	Pool becomes reconnected to mainstem at 19:10 pm (air temperature is 22C)
Trip 2	Day 3	Aug. 18	1-M-H-251	18-08-03-03	9	12:00*	13:45	<17	14	Last photo taken at 18:13 (air temperature is 21C) Pools appear to be drying out but cannot be confirmed First image on August 19 at 05:44 shows site completely inundated
Trip 2	Day 4	Aug. 19	HP-M-H-230	18-08-04-03	3	10:00	10:30	10	4	Pools appear to dry out at 19:52 (air temperature is 16C) Pool almost immediately becomes reconnected to mainstem at 20:12
Trip 2	Day 4	Aug. 19	1-M-H-251	18-08-04-05	9	09:00	12:45	<20	22	Pools appear to be drying out in last photo at 21:04 (air temperature is 12C) Pool wetted at 05:00 on August 20
Trip 3	Day 6	Sept. 9	HP-M-H-230	18-01-06-05	3	09:15	13:15	30	3	Pools appear to dry out at 19:52 (air temperature is 6C) Pools become reconnected to mainstem at 16:27 on September 10 (20 hours after drying out) See Plate 11
Trip 4	Day 8	Sept. 16	1-M-H-251	18-01-08-04	9	07:00	12:30 (Sept. 16)	387 (inundated on Oct. 1)	21 (17 dead)	Pool appears to dry out in the last photo at 19:42 (air temperature is 3C) Pool is dry in first photo on September 16 at 06:22 Dried pool sampled using interstitial methods on September 16 at 12:30
Trip 5	Day 9	Oct. 2	HP-M-H-411	18-01-09-01	7	07:30	10:15	<24	1	Pools appear to d out in last photo at 19:07 (air temperature is -2C) Pool wetted at 07:00 on October 3

*Inferred from hydrometric data or other camera data (no direct evidence from camera at site)

References

BC Hydro. 2013. Inter-Office Memo Entitled Site C Clean Energy Project – Downstream Flow Modelling (2D) for High Operations Scenario Wetted Area Analysis. File: STC13MIS YM80003-3281. July 19, 2013.

BC Hydro. 2013. Peace River Project Water Use Plan. Peace Spill Protocol. Reference GMSMON-3. Peace River Fish Stranding Survey Summary Report. Generation, Water License Requirements, Hudson's Hope, BC. vi + 24 pp. + Appendices

BC Hydro. 2015. Fisheries and Aquatic Habitat Monitoring and Follow-up Program. Appendix M. Site C Mon-12 Site C Fish Stranding Monitoring Program.

BC Hydro. 2016. Site C Mon-12 – Site C Fish Stranding Monitoring Program. 11 p.

Golder Associates Ltd. 2011. Canadian Lower Columbia River: Fish Stranding Risk Assessment and Response Strategy, Report prepared for BC Hydro, Columbia Power Corporation, Fortis BC, Columbia operations Fish Advisory Committee (COFAC) and Canal Plant Agreement Operating Committee, Golder Report No. 09-1480-0055F: 31 p. + 4 appendices.

Golder Associates Ltd. 2013. DDMMON-16 Lower Duncan River fish stranding impact monitoring: Year 5 data report (April 2012 to April 2013). Report prepared for BC Hydro, Castlegar, BC. Golder Report No. 12- 1492-0117F: 25 p. + 3 app.

Golder Associates Ltd. 2014. Lower Columbia River [CLBMON #42(A)] and Kootenay River Fish Stranding Assessments: Annual summary (April 2013 to April 2014). Report prepared for BC Hydro, Columbia Power Corporation, and FortisBC, Castlegar, BC. Golder Report No. 10-1492-0042 and 10-1492-0100: 25p. + 1 app.

Golder Associates Ltd. and Poisson Consulting Ltd. 2010a. Columbia and Kootenay River Fish Stranding Protocol Review: Literature Review and Fish Stranding Database Analysis. 34 p + appendices.

Golder Associates Ltd. and Poisson Consulting Ltd. 2010b. Duncan Dam Project Water Use Plan. Lower Duncan River. Implementation Year 2. Reference: DDMMON#15. Lower Duncan River Stranding Protocol Development and Finalization. Study Period: 2010. 47 p.

Golder Associates Ltd. and Poisson Consulting Ltd. 2012. DDMMON-16 Lower Duncan River fish stranding impact monitoring: Year 4 summary report (April 2011 to January 2012). Report prepared for BC Hydro, Castlegar, BC. Golder Report No. 10-1492-0110D: 39 p. + 2 app.

Golder Associates Ltd. and Poisson Consulting Ltd. 2014. DDMMON-15 Lower Duncan River Stranding Protocol Development and Finalization: Year 5 (2012 to 2013). Report prepared for BC Hydro, Castlegar, BC. Golder Report No. 09-1492-5010F: 75 p. + 2 app.

Irvine, R.L., J.L. Thorley, R. Westcott, D. Schmidt, and D. DeRosa. 2014. Why do fish strand? An analysis of ten years of flow reduction monitoring data from the Columbia and Kootenay Rivers, Canada. River Research and Applications. 31: 1242-1250.

Lewis, F.J.A., A.J. Harwood, C. Zyla, K.D. Ganshorn, and T. Hatfield. 2013. Long term Aquatic Monitoring Protocols for New and Upgraded Hydroelectric Projects. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/166. ix + 88 p.

MacInnis, A.M. 2013. GMSMON-3: Peace River Fish Stranding Survey Summary Report. Unpublished report by Cooper Beauchesne and Associates Ltd., Errington, BC, for BC Hydro.

Mainstream Aquatics Ltd. 2012. Mainstream Aquatics Ltd. 2012. Site C Clean Energy Project – Fish and Fish Habitat Technical Data Report. Prepared for BC Hydro Site C Project, Corporate Affairs Report No. 12002F: 239 p.

McPhail, J.D. 2007. The Freshwater Fishes of British Columbia. University of Alberta Press.

McPhail, J.D. and R. Carveth. 1993. Field Key to the Freshwater Fishes of British Columbia. Resources Inventory Committee (Canada).

Nagrodski, A., G.D. Raby, C.T. Hasler, M.K. Taylor, S.J. Cooke. 2012. Fish stranding in freshwater systems: Sources, consequences, and mitigation. Journal of Environmental Management 103 (2012) 133-141

Nicholl, S. and A. Lewis. 2016. Memorandum RE: Site C Fish Stranding Monitoring Protocols. File No. 1200-03. October 27, 2016. 7 p.

Nicholl, S. and A. Lewis. 2017. Memorandum RE: Site C Fish Stranding Monitoring Methods. File No. 1200-03. April 21, 2017. 6 p.

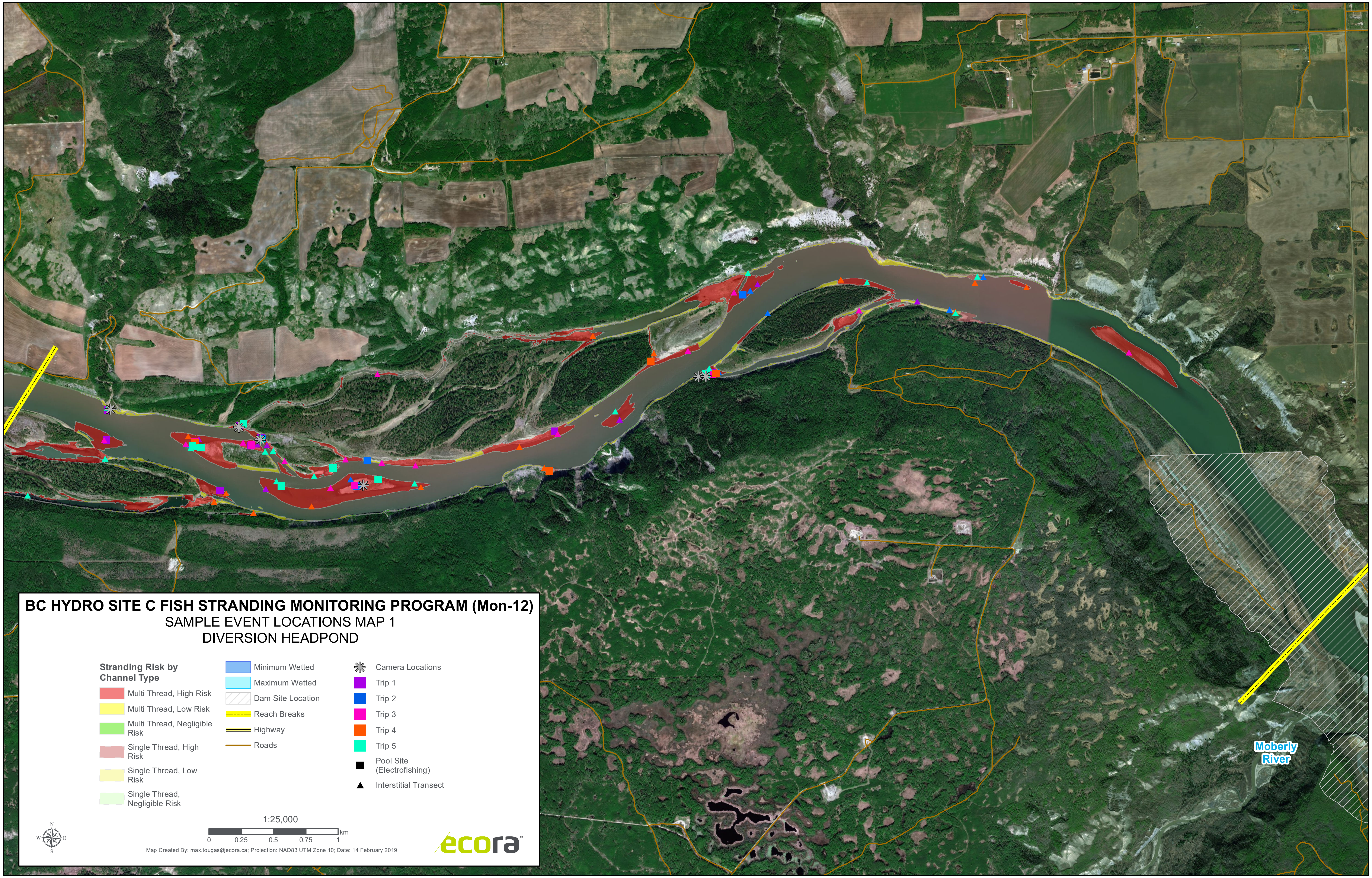
Site C Clean Energy Project - Downstream Flow Modelling (2D) for High Operations Scenario Wetted Area Analysis.

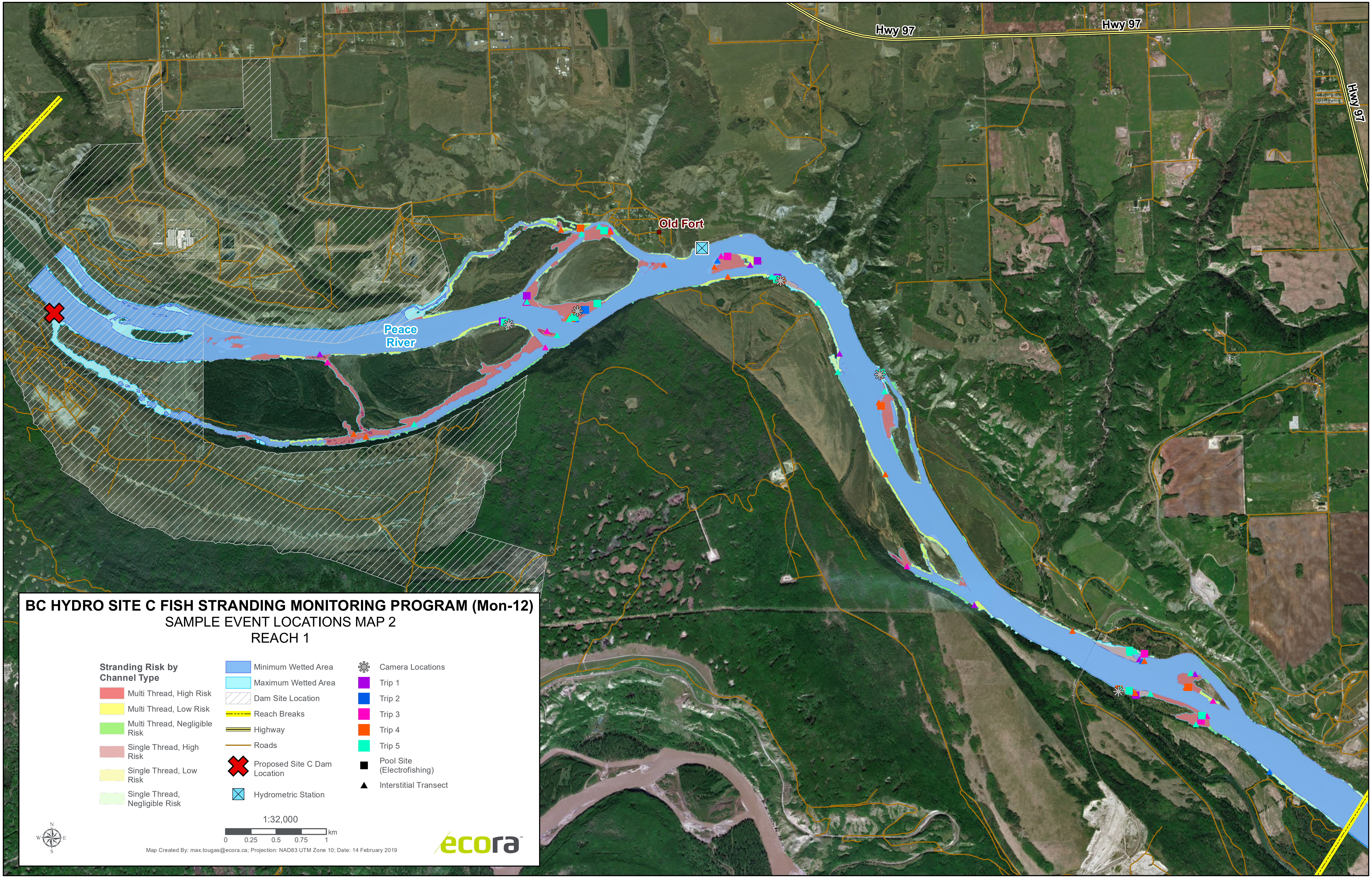
Triton Environmental Consultants Ltd. 2009. Middle Columbia River Juvenile Fish Stranding Assessment (Year 2009) Reference: CLBMON#53 Columbia River Water Use Plan Monitoring Program: Middle Columbia River Juvenile Fish Stranding Assessment Study Period: 2009-2010. 44 p. + appendices.

Triton Environmental Consultants Ltd. 2014. Columbia River Project Water Use Plan Middle Columbia River Juvenile Fish Stranding Assessment (Year 4 of 4). Reference: CLBMON#53 Columbia River Water Use Plan Monitoring Program: Middle Columbia River Juvenile Fish Stranding Assessment Study Period: 2013-2014. 55 p. + appendices.

Appendix A

Study Area Maps and Field Sampling Locations


BC HYDRO SITE C FISH STRANDING MONITORING PROGRAM (Mon-12)
SAMPLE EVENT LOCATIONS MAP 1
DIVERSION HEADPOND
Stranding Risk by Channel Type
Multi Thread, High Risk
Multi Thread, Low Risk
Multi Thread, Negligible Risk
Single Thread, High Risk
Single Thread, Low Risk
Single Thread, Negligible Risk
Minimum Wetted
Maximum Wetted
Dam Site Location
Reach Breaks
Highway
Roads
Camera Locations
Trip 1
Trip 2
Trip 3
Trip 4
Trip 5
Pool Site (Electrofishing)
Interstitial Transect
1:25,000
0 0.25 0.5 0.75 1 km
N S W E
Map Created By: max.tougas@ecora.ca; Projection: NAD83 UTM Zone 10; Date: 14 February 2019
Moberly River



BC HYDRO SITE C FISH STRANDING MONITORING PROGRAM (Mon-12)
SAMPLE EVENT LOCATIONS MAP 2
REACH 1
Stranding Risk by Channel Type
Multi Thread, High Risk
Multi Thread, Low Risk
Multi Thread, Negligible Risk
Single Thread, High Risk
Single Thread, Low Risk
Single Thread, Negligible Risk
Minimum Wetted Area
Maximum Wetted Area
Dam Site Location
Reach Breaks
Highway
Roads
Proposed Site C Dam Location
Hydrometric Station
Camera Locations
Trip 1
Trip 2
Trip 3
Trip 4
Trip 5
Pool Site (Electrofishing)
Interstitial Transect
1:32,000
0 0.25 0.5 0.75 1 km
Map Created By: max.tougas@ecora.ca; Projection: NAD83 UTM Zone 10; Date: 14 February 2019
ecora
Hwy 97
Hwy 97
Hwy 97
Old Fort
Peace River

Appendix B

Photo Plates

Plate 1 View of interstitial sampling crew conducting Broad-based survey at site HP-M-H-238 on Trip 3 – Day 6 (September 9, 2018)

Plate 2 View of crew conducting Hot-spot interstitial sample at site 1-S-H-399 on Trip 4 – Day 8 (September 16, 2018)

Plate 3 View of typical pool sampling location at site HP-M-H-411 on Trip 1 – Day 1 (August 11, 2018)

Plate 4 View of pool sampling site 1-M-H-251 on Trip 5 – Day 9 with multiple small pools occurring throughout (October 2, 2018).

Plate 5 View of electrofishing sampling at an isolated pool at site HP-M-H-67 on Trip 2 – Day 4 (August 19, 2018)

Plate 6 Fish viewer used to measure and photograph Arctic Grayling collected from a pool at site 1-M-H-251 on Trip 2 – Day 4 (August 19, 2018)

Plate 7 **View of Camera 07 (indicated by red arrow) attached to the root wad of a piece of large woody debris at site HP-M-H-411 on Trip 1 – Day 1 (August 11, 2018)**

Plate 8 **View of Camera 04 (indicated by red arrow) attached to a log propped up amongst large woody debris at site HP-M-H-82 on Trip 1 – Day 2 (August 12, 2018)**

Plate 9 **Time-lapse image from Camera 07 showing a Belted Kingfisher (indicated by red arrow) diving into Pool 1 at site HP-M-H-411 on Trip 1 – Day 1 (August 11, 2018)**

Plate 10 **Time-lapse images from Camera 04 showing (upper photo) pools at time of sampling (09:45) and (lower photo) pools dried out (11:00) at site HP-M-H-82 on Trip 1 – Day 2 (August 12, 2018).**

Plate 11 **Time-lapse images from Camera 03 showing (upper photo) pools at time of isolation (09:00), (middle photo) pools at time of sampling (13:15), and (lower photo) pools dried out (19:52) at site HP-M-H-230 on Trip 3 – Day 6 (September 9, 2018).**

Plate 12 Time-lapse images from Camera 09 at site 1-M-H-251 showing (upper photo) pool at time of isolation (September 15 08:12), (middle photo) pool at time of drying out (September 15 19:32), and (lower photo) crew conducting interstitial sample event 18-01-08-04 on Trip 4 – Day 8 (September 16 12:32). There were 21 stranded fish collected, 17 of which were dead.

Appendix C

Hydrometric Graphs

Summary of discharge recorded at the Peace River above Pine River (07FA004) Water Survey of Canada Hydrometric Station during each of the five sampling trips between August 11 and October 3, 2018 and the approximate survey start time at the Diversion Headpond (HP) and the survey start/finish time at Reach 1 (hydrometric data provided by operations staff at Peace Canyon Dam on October 9, 2018).

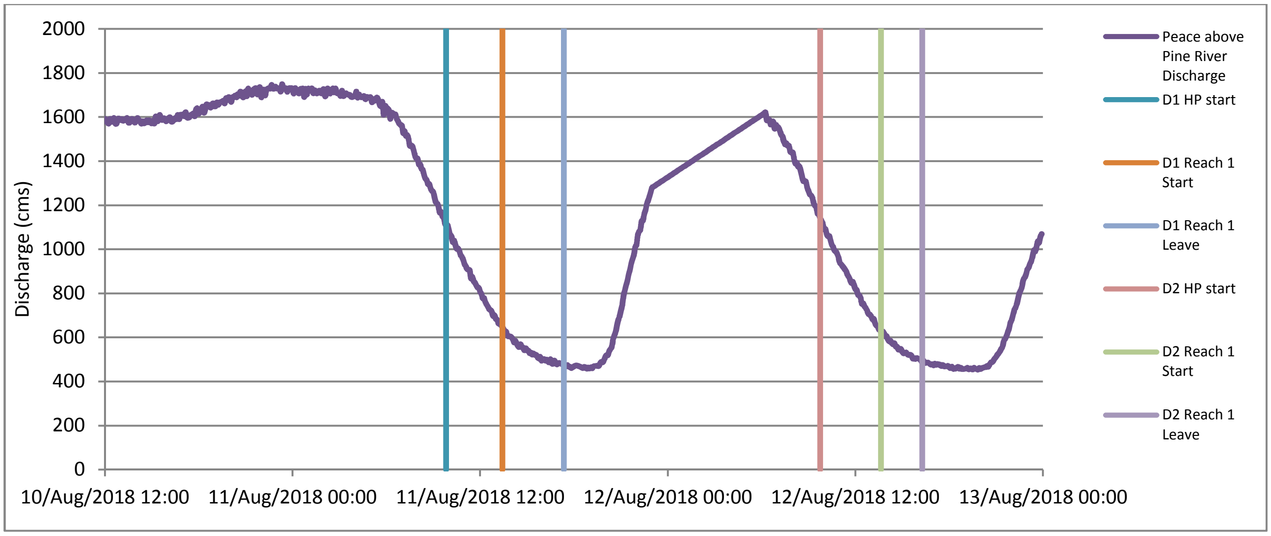


Figure C-1. Trip 1 (Day 1 and 2) on August 11 and 12, 2018.

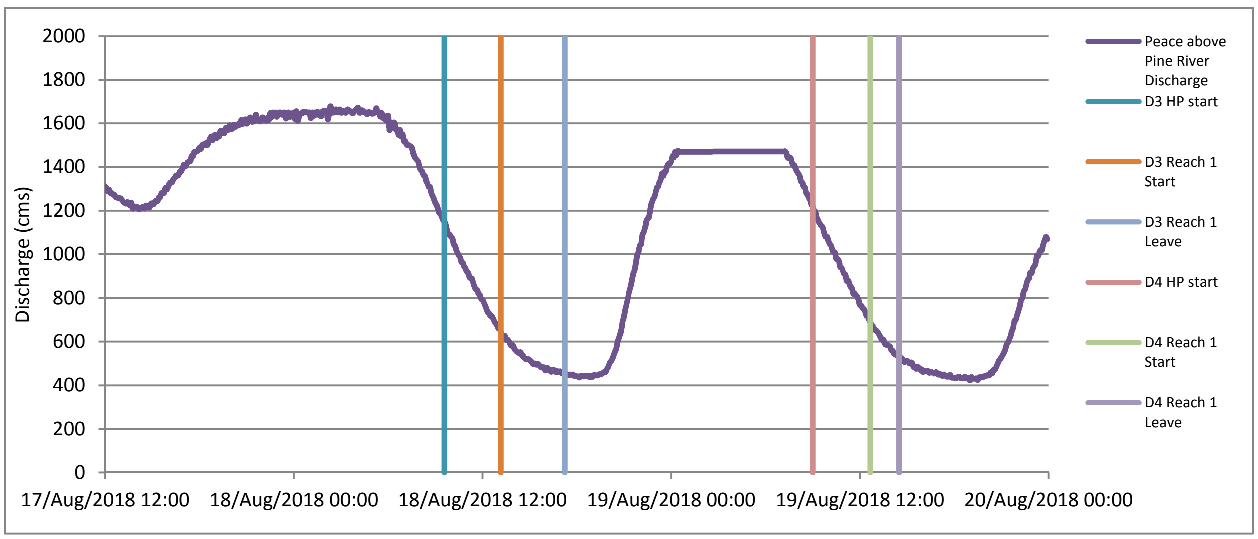


Figure C-2. Trip 2 (Day 3 and 4) on August 18 and 19, 2018

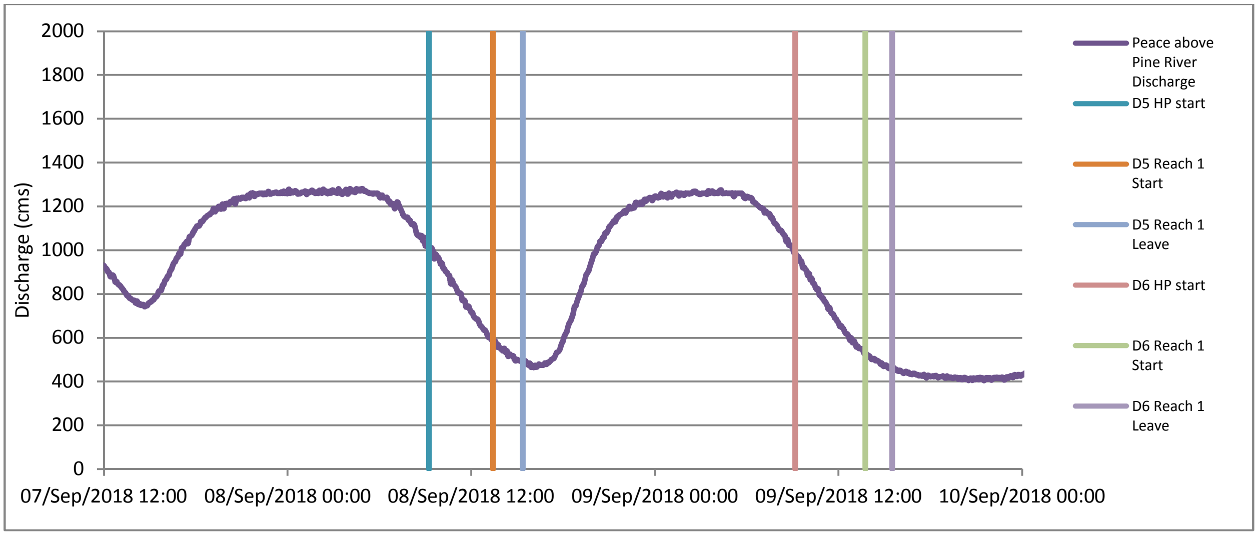


Figure C-3. Trip 3 (Day 5 and 6) on September 8 and 9, 2018

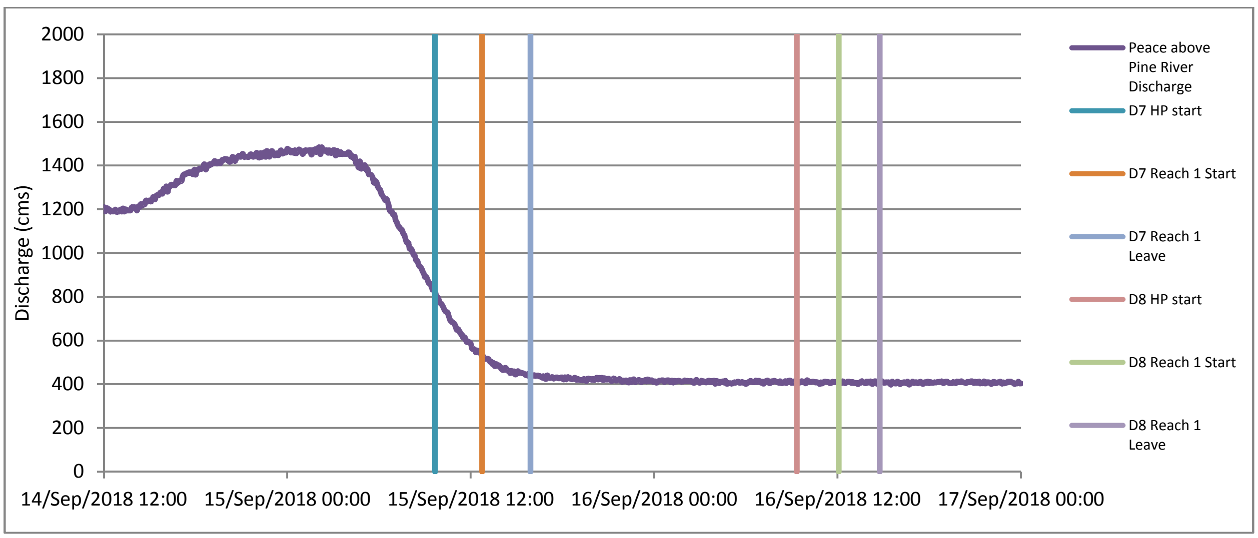


Figure C-4. Trip 4 (Day 7 and 8) on September 15 and 16, 2018

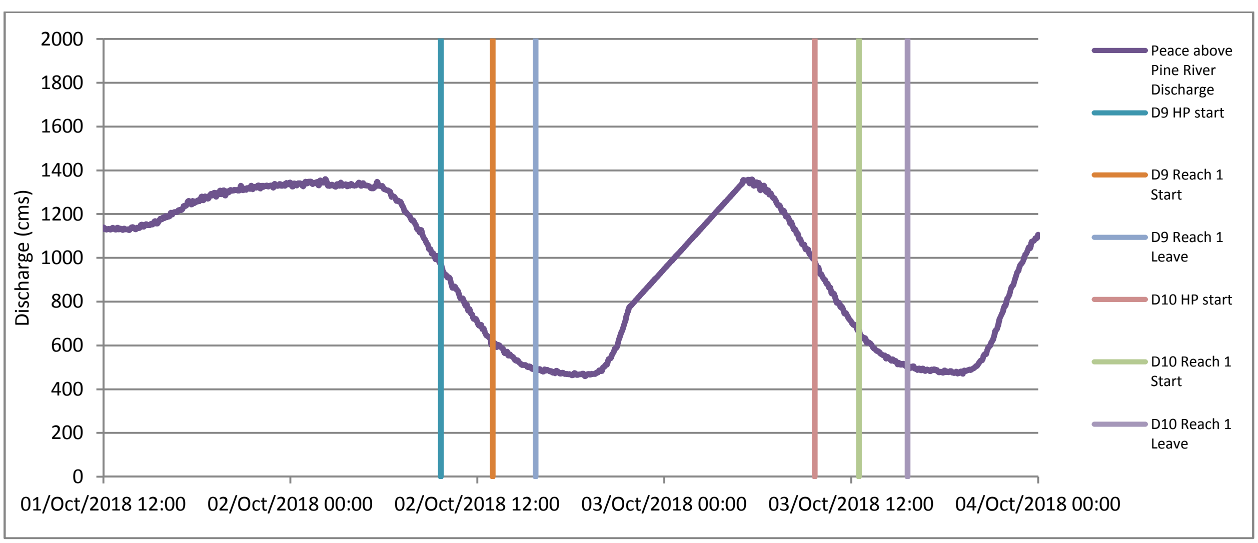


Figure C-5. Trip 5 (Day 9 and 10) on October 2 and 3, 2018