Site C Clean Energy Project

Site C Fish Stranding Monitoring Program (Mon-12)

Construction Year 3 (2017)

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Site C Fish Stranding Monitoring Program (Mon-12) Year 2 (2017) 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 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 late 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 the 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).

Ten days of sampling were undertaken in Year 2 (2017), between July 29 and September 24, throughout the entire study area, including the Diversion Headpond, Reach 1, Reach 2, and Reach 3. Each trip was coordinated with BCH operations to ensure sampling occurred following a reduction in discharge at the upstream BCH Peace Canyon Dam and to account for flow change delays between the Peace Canyon Dam and the downstream study area. A total of 140 sampling events were completed using a combination of interstitial sampling of dewatered substrates (77 samples) and backpack electrofishing in isolated pools (63 samples) within a combination of targeted and randomly selected sampling sites.

Of the 140 sampling events, 59 resulted in observation of isolated and/or stranded fish present at the time of sampling and a total of 259 fish were collected. The most commonly observed fish were sucker species (23 Longnose Sucker and 85 unknown Sucker for a total of 108 observations) which represent 41.7% of the total number of fish observed. The next most common fish observed are sculpin (78 slimy sculpin) and minnows (25 Longnose Dace, 21 Lake Chub, and 1 Redside Shiner for a total of 47), representing 30.1% and 18.1% of total observations, respectively. Together, these three groups of fish represent 90.0% of all fish observations from the Year 2 (2017) sampling.

The data collected in Year 2 (2017), combined with Year 1 (2016) data, provides baseline information which will be used to quantify the magnitude of fish stranding throughout the study area, determine species and life stages most frequently observed, and to make future comparisons between pre-construction and post-construction and operations phases of the Project. The primary management questions of the Mon-12 program 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?

The results of the Mon-12 sampling will focus on addressing the management hypotheses summarized in Table ES.1 below.

Table ES.1 Summary of Mon-12 Management Hypotheses and Year 2 (2017) Results

Objective	Management Hypotheses	Year 2 (2017) 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 2 sampling represents the second 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 2 sampling represents the second 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 2 represents the second year of baseline data collection for the Reach 2 and the first year of baseline data collection 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 2 results contribute to the Year 1 baseline data for the Diversion Headpond and Reaches 1 and 2. Year 2 results provide initial baseline data for Reach 3.

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Double Odd Ventures Ltd.
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1. Introduction

Ecora Engineering & Resource Group Ltd. (Ecora) was retained by BC Hydro (BCH) to implement the field program and provide a 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, as described by the Site C Fish Stranding Monitoring Program included as Appendix N of the Fisheries and Aquatic Habitat Monitoring and Follow-up Program (BCH 2016). The Monitoring Program (Site C Mon-12) was initiated to compare baseline conditions to construction and operation conditions associated with the Site C Dam, including the Diversion Headpond. The methodology described for the program follows the methods developed for similar projects in other hydroelectric regulated rivers in BC, including the Columbia and Duncan rivers in the Kootenay region of BC. Ecora partnered with Halfway River Ventures Ltd. (HRVL) to conduct the field component of the program. Ecofish Research Ltd. (Ecofish) was retained by BCH to provide technical oversight, including the development of field methodologies as well as to undertake final study reporting in consideration of study specific management questions and hypothesis

This report provides a summary of the Year 2 (2017) results for fish stranding assessments conducted within the Site C Mon-12 study area. Results are provided as a data summary and discussed in relation to the program objectives, management questions, and hypotheses defined by BCH and summarized below. The main objectives of the Site C Mon-12 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 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. Year 1 (2016) included sampling within the Diversion Headpond, Reach 1, and Reach 2. Year 2 (2017) sampling was conducted within the entire study area, including the Many Islands region of Alberta (Reach 3).

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 risk of imminent death from the dewatering of aquatic habitats, including pools and interstitial areas of coarse substrates (Golder 2014). Isolation is another form of stranding that occurs when fish become trapped in pools that have become separated from the main stream flow (i.e., fish are unable to leave the pool). Isolated fish may not be at imminent risk of death but are at higher risk of predation and the effects of extreme 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 pool characteristics (size, depth, substrates, and presence of cover), weather conditions (effect on pool evaporation, temperature, and dissolved oxygen), and the length of time the pool remains isolated (i.e., until mainstem flows inundate the pool).

Isolation and stranding of fish may occur during natural river level fluctuations but effects are typically exacerbated by hydroelectric activity due to alterations 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 physical conditions, including slope, substrates, and presence of depressions or other areas that may collect water during water level reduction events (Golder 2010a, Golder 2010b). The potential effects on fish include reduced growth rates, increased stress, and mortality (Irvine et al.

2014; Nagrodski et al. 2012). Currently, the flow regime within the study area is directly influenced by operation of the Peace Canyon Dam (PCN), located approximately 82 km upstream of the Project near Hudson's Hope, BC.

1.2 Program Objectives

The Site C Mon-12 program objectives and management questions were outlined in the BC Hydro Peace River 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.

The Year 2 (2017) data represents the second year of four years of baseline data collection (2016 to 2020). The results of the Year 2 (2017) program will be compared to Year 1 (2016) and combined to contribute to the baseline data collected to date.

2. Methods

2.1 Study Area

The 139-kilometre 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 can be divided into two sections, as defined in the Site C Mon-12 program (BCH 2016):

1. The Site C Diversion Headpond that 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. Due to the lengths of Reaches 2 and 3, it was agreed that sampling would focus on the areas of 2D modelling provided by BCH (2013), which represent the areas of greatest concern for stranding potential based on channel characteristics (i.e., multi-thread channel with mid-channel bars and island complexes considered high risk for stranding). Reach 2 includes three modelled areas, referred to as Upper (Taylor Bridge), Mid (Palings Flat), and Lower (Raspberry Island). The Reach 3 modelled area is at Many Islands, at the downstream end of the Reach.

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 8-km portion of the study area, in close proximity to the dam site, is unavailable for sampling due to construction-related safety 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.

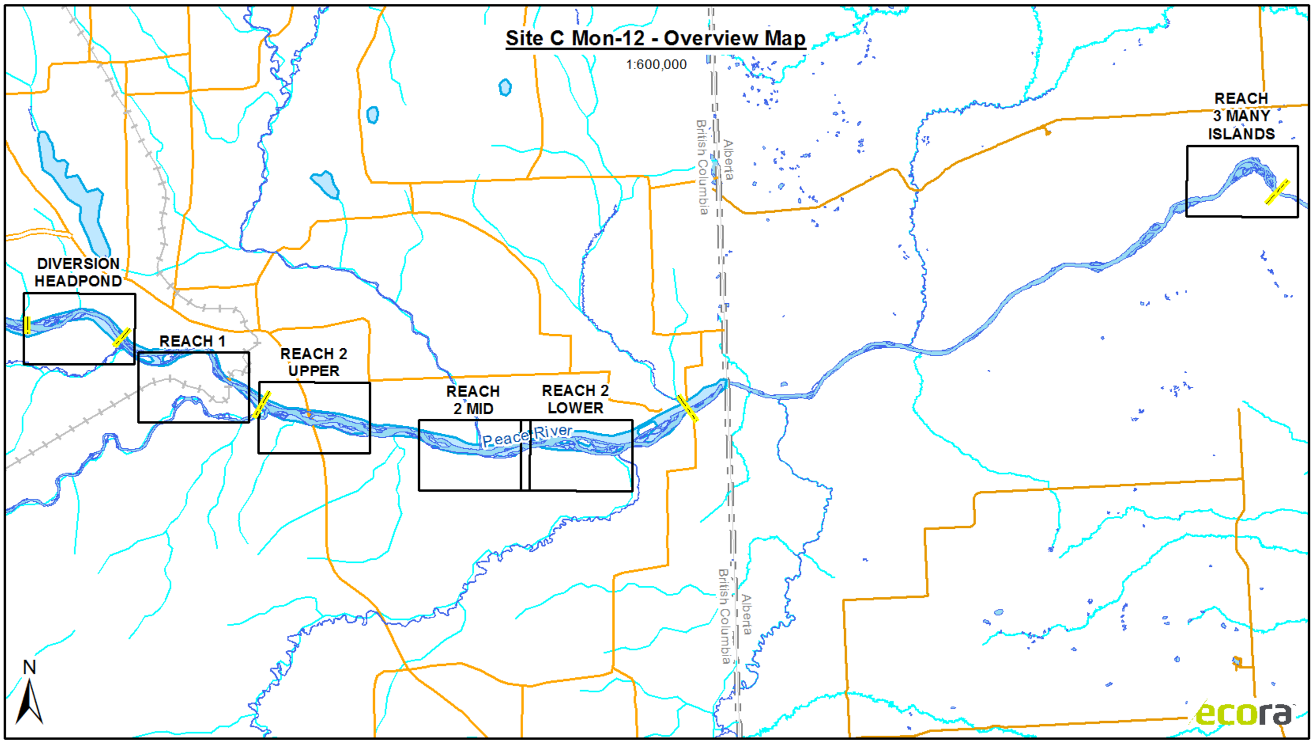

Figure 2.1 Overview Map

2.2 Site Selection

The Year 1 (2016) site selection 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). The sites in 2016 were selected using physical habitat characteristics that increase stranding and/or isolation risk, as identified in the project description, which are consistent with other BCH fish stranding monitoring programs. High risk site selection characteristics include:

- 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.

Year 1 (2016) data collection focused on high risk sites, which has 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 described in the October, 2016 memo (File No. 1200-03) provided by Ecofish, it was determined that monitoring efforts should be undertaken in both high and low risk sites to provide a more accurate estimate of total stranding from extrapolation of sampling data. As such, it was determined that low risk sites should be included in Year 2 (2017) to confirm the assumption that fish stranding is not a concern within areas defined as low risk.

To achieve this, BCH requested that Ecofish provide recommendations for Year 2 (2017) site selection and stranding assessment planning. The recommendations are summarized in an April 2017 memo (Site C Fish Stranding Monitoring Methods File No. 1200-03). As indicated in the memo, a combination of targeted sites (from experience gained during the 2016 surveys and knowledge of the study area) and random sites (generated from Ecofish mapping and modelling), which include both high and low risk sites, were included in Year 2 (2017). Random sites were generated along the modelled shoreline, with sampling order determined using a random number generator.

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

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

Ecofish provided 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 Year 1 (2016) sampling, focus of sampling effort to remain on areas with the highest risk of stranding. Focus on previously sampled sites from Year 1 (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 stranding is observed in low risk sites.

A summary of the mapped Channel and Risk Types within each reach is summarized in Table 2.2 below. The total amount of each Channel/Risk Type is expressed in terms of linear distance, as the delineation of sites is based on the modelled high and low water levels. While this number does not represent the total area of each Channel/Risk Type, it does give an approximation of the relative amount of each type throughout the study area (i.e., a total linear length of high and low water level).

Table 2.2 Summary of Channel and Risk Types within each Reach

Reach	Channel Type	Risk Type	Length (km)
Diversion Headpond	Multi-thread	High Risk	68.48
		Low Risk	39.55
		Negligible Risk	14.26
	Single-thread	High Risk	1.02
		Low Risk	1.24
		Negligible Risk	0.68
Reach 1	Multi-thread	High Risk	49.51
		Low Risk	52.71
		Negligible Risk	40.93
	Single-thread	High Risk	2.43
		Low Risk	9.06
		Negligible Risk	9.85
Reach 2	Multi-thread	High Risk	94.22
		Low Risk	72.92
		Negligible Risk	57.68
		Unclassified	125.61
	Single-thread	High Risk	4.80
		Low Risk	7.14
		Negligible Risk	6.11
		Unclassified	6.35
Reach 3	Multi-thread	High Risk	29.29
		Low Risk	42.72
		Negligible Risk	11.68
	Single-thread	High Risk	0.56
		Low Risk	3.67
		Negligible Risk	2.65

Of the approximately 755 km of mapped shoreline (i.e., high and low water) throughout the study area, 700 km has been classified as Multi-thread. The remaining 55 km is classified as Single-thread. There is approximately 250 km of High Risk Type throughout the study area, largely associated with the Multi-thread Channel Type (241 km). There is approximately 229 km of Low Risk Type, 207 km of which is within the Multi-thread Channel Type. The Unclassified segments are associated with portions of the study area where Risk Type (based on gradient) could not be determined due to the lack of existing Digital Elevation Model (DEM) or LiDAR data. These gaps occur within Reach 2 and Reach 3, between the modelled areas of the island complexes (Palings Flat, Raspberry Island, and Many Islands).

2.3 Trip Planning

Each trip in Year 2 (2017) was coordinated with BCH's Operations Planning Engineers to ensure sampling occurred following a reduction in discharge at PCN and to account for the flow lag time between PCN and the study area. The approach, given that the entire study area was to be sampled, was to initiate a flow reduction (ramp down) prior to the first day of each two-day sampling trip. BCH provided Ecora with a Peace River flow report via email every 6 hours which showed discharge rates over the previous 4 days and a 12-hour forecast. An example of a typical report is provided in Figure 2.2. The flow report helped coordinate timing of crew arrival at each reach.

EDMPI03 (PPT)

PI Tag	Description	Current Value	Time Stamp
PCN_RES_Release_Flow_00	calc in PI for PSOSE [Total Reservoir Release Flow (Turbine + Spill)]	1,322 m3/s	23/Sep 20:55
HFF_ENVR_Stream_Flow_40	calc in PI for PSOSE [Source Select - Halfway River at Farrell Creek - HFF]	40 m3/s	23/Sep 20:55
PTE_ENVR_Stream_Flow_00	WISKI calc from DCP via GRM [Stream Flow - Peace River at Tea Creek]	1,264 m3/s	23/Sep 20:40
PTE_ENVR_Stream_Flow_01	WISKI calc from DCP via GRM [Stream Flow - Peace River at Tea Creek (Backup System)]	1,252 m3/s	23/Sep 20:40
MOB_ENVR_Stream_Flow_40	calc in PI for PSOSE [Source Select - Moberly River - MOB]	1 m3/s	23/Sep 20:55
PCB_ENVR_Stream_Flow_40	calc in PI for PSOSE [Source Select - Peace River at Construction Bridge - PCB]	1,331 m3/s	23/Sep 20:56
PCP_ENVR_Stream_Flow_40	calc in PI for PSOSE [Source Select - Peace River above Pine River - PCP]	1,256 m3/s	23/Sep 20:55

Forecast PCB, m^3/s	
Sat 22:00	1570
Sat 23:00	1601
Sun 00:00	1528
Sun 01:00	1528
Sun 02:00	1528
Sun 03:00	1528
Sun 04:00	1528
Sun 05:00	1528
Sun 06:00	1528
Sun 07:00	1527
	1527

Peace Canyon and Site C Area Gauges Flow, m^3/s

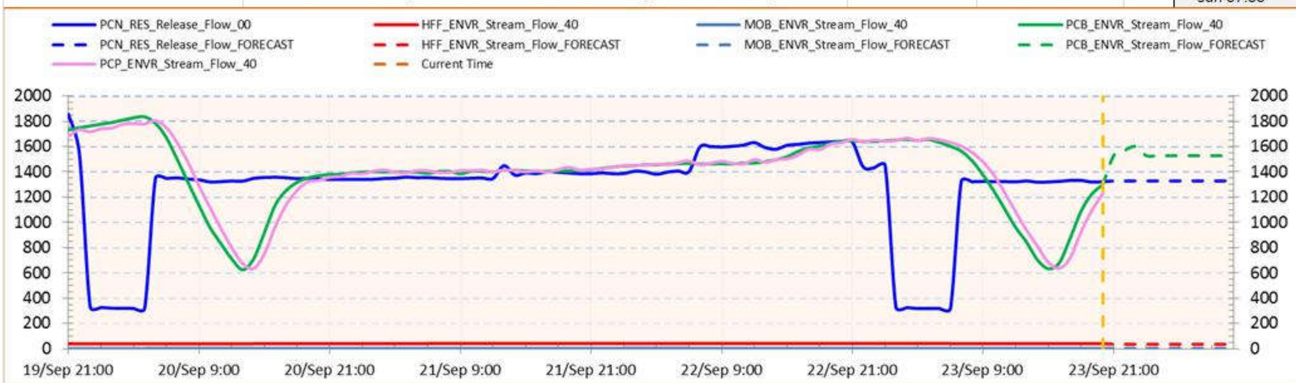

Figure 2.2 Example of flow report provided by BCH to help coordinate crew timing and effort

Figure 2.2 example above shows the reduction event at PCN prior to Trip 5 on September 23 and 24, 2017.

Reductions generally involved the ramping down of discharge rates from a peak level (typically between 1,000 and 1,600 cubic metres per second, or cms) to a low level (typically 300 to 400 cms). The low level discharge rate was held for approximately 4 to 5 hours, given other operational constraints. The intention of this timing was to ensure that the reduction event would be observed at each of the study area reaches at predictable times, based on known approximate lag times (determined from hydrometric data and experience gained in 2016), as summarized below.

- Diversion Headpond Reach: 9 to 10 hours
- Reach 1: 11 to 12 hours
- Reach 2 (Upper): 13 to 14 hours
- Reach 2 (Lower): 17 to 18 hours
- Reach 3 (Many Islands): 28 to 29 hours

As such, a reduction initiated at PCN at 2:00 am on Day 1 of sampling was observed at the following approximate times within each reach:

- Diversion Headpond: 11:00 am to 12:00 pm on Day 1
- Reach 1: 1:00 pm to 2:00 pm on Day 1
- Reach 2 (Upper): 3:00 pm to 4:00 pm on Day 1
- Reach 2 (Lower): 5:00 pm to 6:00 pm on Day 1
- Reach 3 (Many Islands): 6:00 am to 7:00 am on Day 2

This schedule enabled crews to effectively sample the entire study area following a single reduction event, thus eliminating concerns associated with insufficient wetted history between two separate reduction events. Attempts were made to ensure that flows remained high (i.e., above 1,200 cms) for at least 24 to 48 hours prior to the reduction to reduce the bias expected from a wetted history of less than 24 hours prior to the sampling period (insufficient time for fish to colonize).

2.4 Field Sampling

Ten survey days were completed during five separate trips (i.e., two sampling days per trip) between July 29 and September 24, 2017. A summary of the sampling during each trip is provided in Table 2.3. Maps of sampling locations within each Reach are provided in Appendix A.

Table 2.3 Summary of 2017 Sampling Days, Methods, and Total Sampling Events

Trip	Survey Day	Date (2016)	Sampling Methods		Total Sampling Events
			Pool Sampling (EF[1])	Interstitial Sampling	
Trip 1	Day 1	July 29	1	7	8
	Day 2	July 30	5	5	10
Trip 2	Day 3	August 12	10	10	20
	Day 4	August 13	7	7	14
Trip 3	Day 5	August 26	9	9	18
	Day 6	August 27	6	5	11
Trip 4	Day 7	September 9	7	9	16
	Day 8	September 10	4	8	12
Trip 5	Day 9	September 23	9	10	19
	Day 10	September 24	5	7	12
Total			**63**	**77**	**140**

[1] EF: electrofishing

Surveys were generally conducted between 7:00 am and 7:00 pm by four crews of two to three people (two electrofishing crews and two interstitial survey crews). Sample sites 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 field iPads, each of which displayed sampling locations (targeted and random). 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 location was recorded (waypoint) using the iPad GPS and the following information was recorded on both the iPad and waterproof data forms:

- Date and time arrived
- Weather
- Reach (Headpond, Reach 1, Reach 2, Reach 3)
- Site ID, using Year-Crew-Survey Day-Site Number (sequential from first site visit of the day)
- Crew names
- Method of sampling
- Location coordinates
- Air temperature
- Time left and total sampling time

Representative site photos were collected using the iPads. Based on the site conditions, either interstitial sampling or pool sampling (using electrofishing equipment) was completed, as described below.

2.5 Interstitial Sampling

Interstitial transect sampling methods were revised for Year 2 (2017) to provide a more accurate measure of total area sampled and to ensure consistent effort across crews and among different crew members. The revised method included the use of rigid, rectangular PVC pipe frames (1 m by 0.5 m) to provide a measure of total area of substrate searched, as was used in the Lower Duncan River Fish Stranding Impact Monitoring (DDMON-16). Upon arrival at a site, a field transect was established using a nylon measuring tape along the recently dewatered substrate, generally parallel to the wetted shoreline. Surveyors placed the sampling frames at regular intervals along the transect and all substrates within the frame were overturned to search for stranded fish (Photo Plate 1 – Appendix B). This method was used on Trip 1 and Trip 2. The general method is described below:

- Sampling areas were selected and navigated to, as described above.
- Each crew disembarked the boat with necessary sampling equipment, including iPad, clipboard with data sheets, handheld radio, buckets, small dip nets, measuring tape, knee pads, polarized glasses, gloves, and other safety related equipment (bear spray).
- The transect start point was recorded on the iPad and represented one end of the transect. Sampling was conducted along a 100-m transect in an either upstream or downstream direction from the start point, depending on the availability of recently dewatered substrate and other site characteristics.
- The crew leader recorded the sampling start time and site information.
- Each surveyor placed a sampling frame along the transect (typically one person on one side, two persons on the other side of the transect tape).
- Within each frame, all substrates (cobble, gravel, woody debris, vegetation) were searched around and under by flipping rocks, and excavating gently into the interstitial spaces using gloved hands to determine if small bodied fish were present within the frame. Fish observed outside of the frame along the transect or in the vicinity of the transect (i.e., within the sampling area) were recorded, although were noted to be outside of the frames.
- The crew leader recorded the number of frames searched by each observer and the total number of frames searched. The intention was to search at least 20 frames per person per site, for a total of 30 m^2 of sampling area per site. The total area searched varied as it depended on substrate availability and time constraints.
- The crew leader recorded the sampling end time and estimated total sampling time.
- The crew leader recorded detailed notes and took photos of the site and any fish observed.

This method was intended to reduce surveyor bias and provide an accurate measure of total area searched. However, the method resulted in low numbers of fish observations. On Trip 3, a representative from Ecofish provided a revised protocol for interstitial sampling, as described below. A detailed methodology was provided by Ecofish on September 1, 2017. This methodology was adopted for the remaining Trips 3, 4, and 5.

- Stranding sites were selected and navigated to, as described above.
- The crew leader recorded start time, location, site conditions, etc. using the iPad and data sheet.
- An overview search (‘broad-based search’) was completed by the crew over the entire sampling area (i.e., all dewatered substrate considered to be within a distinct sampling area) to search for obvious fish present (i.e., readily observable without overturning substrates). The crew attempted to search at least 100 m length 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 2).
- 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.

- Once the broad-based search was complete, five hot-spot locations were selected for detailed sampling. 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 rocks and other cover to search for fish (Plate 3).

- Photos were taken of each hot-spot, 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 reviews were conducted by having crews re-assess each other's hot-spot to confirm that fish were not being overlooked and to calibrate crew effort.

- All fish observed were collected in buckets with river water and processed as described in Section 2.7.

2.6 Pool Sampling

Pool sampling was conducted by two crews of two to three people using backpack electrofisher units (Smith-Root LR-24) in areas where standing water formed in depressions and became isolated from the main river. A variety of pool sizes were sampled during Year 2 (2017), as it was believed that fish isolated in pools, while not necessarily at imminent risk of mortality from drying out, were at elevated risk from predation and poor water quality (i.e., high temperatures and low dissolved oxygen). This assumption was addressed with a pilot project in 2017 to monitor pools and confirm the fate of fish within them by recording time-lapse photos and temperature data for a subset of pools at three different sites within Reach 1 and Upper Reach 2 (described in Section 2.8).

The general approach was based on the assumption that although isolated pools may not be at imminent risk of drying out or heating during that particular sampling trip (based on weather or flow fluctuations), under other circumstances, the pool may lead to fish mortality (e.g., if flows remained low or flow increases did not raise water levels sufficient to inundate pool, etc.). As such, sampling occurred in pools that form during a typical reduction event to determine if fish are present and if so, what species and life history stages are present. This information was collected to determine which pools and which sites represent the greatest risk to fish mortality from stranding during the highest risk conditions (i.e., pools subject to rapid heating and/or dewatering).

Upon arrival at each identified site, a brief reconnaissance was completed to determine presence of isolated pools and suitability for sampling, based on size, depth, complexity, water clarity, and temperature. Pools selected for sampling were required to have no clear fish passage and no evidence of a constant water source (from upstream surface water or subsurface upwelling). Sampled pools generally occurred along mid-stream or side-channel bars, were larger than 1 m in width, and deeper than 10 cm (Plates 4 and 5). Cover was generally limited to coarse substrates (i.e., cobble and boulder) with occasional vegetation or woody debris present.

If one to three pools were observed at a site, each pool was sampled. At sites where greater than three pools suitable for sampling had formed, a subset of three pools was selected for sampling. Sampling pools were searched visually and backpack electrofishing was used to confirm fish presence and collect fish, where possible (Plate 6 – Appendix B). Multi-pass electrofishing techniques (i.e., minimum 2 passes per pool) were used to collect all fish present within each pool. Pool characteristics, including approximate surface area (m^2), approximate average depth, temperature, conductivity, and substrates (using Modified Wentworth Scale) were recorded at each pool. Electrofishing seconds were recorded to measure time spent actively sampling (i.e., effort).

2.7 Fish Processing

All captured fish were held in buckets of river water until processing and each fish was identified to species, where possible. Fish fork length was recorded using a measuring board and the life history stage (adult, juvenile, young-of-the-year) was determined using professional judgment and based on relative size compared to known average adult and/or juvenile sizes. 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 EF sampling.

All captured fish (live or dead) were released into the mainstem of the Peace River following the sampling event. Crews were equipped with fish species keys and a hand lens for identification. In cases where fish identification was difficult or there were time constraints, photos were taken of the fish on the measuring board or in hand for confirmation of identification (Plate 7). As per previous Project discussions, collection of voucher specimens is not within the scope.

2.8 Remote Monitoring

One of the key information gaps identified following the analysis of Year 1 (2016) data and during the Year 2 (2017) monitoring assessments is the need to determine the fate of fish isolated in pools and the risk of mortality of isolated fish. During the Year 1 (2016) surveys, it was assumed that fish isolated in pools were at elevated risk of mortality and therefore sampled as stranded fish. However, this assumption requires testing to confirm the condition of isolated pools and the fate of fish within them, which largely depends on PCN operations (i.e., the amount of time before the isolated pool becomes re-connected to the mainstem flows following the ramping event), as well as weather, predation, and other confounding factors (e.g., infiltration rates associated with porosity of substrates and other subsurface conditions).

To address this gap, additional effort in the monitoring of pools was undertaken during the last two stranding assessment trips of Year 2 (2017; Trips 4 and 5). These efforts included the establishment of remote cameras to record time-lapse photographs of sites that are known to form isolated pools during ramping events and the installation of temperature data loggers to record pool temperature during the period of isolation.

During Trip 4, two remote cameras (Browning Command Ops Model BTC-4) were set up within upper Reach 2 (see figure in Appendix A). Sites were selected based on known formation of pools during dewatering events and presence of stranded and/or isolated fish observed during previous surveys. Camera 1 was installed on a mid-channel island bar, immediately downstream of the Taylor Bridge (Plate 8). Camera 2 was installed along the Peace River left bank opposite the Pine River fan and oriented towards a side channel bar where large numbers of isolated fish were observed during Year 1 (2016) sampling (Plate 9). The cameras were programed to take high-resolution time-lapse images on a 10-minute interval. Each camera was secured to a solid object and oriented towards the area of the bar where pools were known to form. The cameras were installed on September 9, 2017 (Trip 4, Day 7) and retrieved on September 24, 2017 (Trip 5, Day 10) for a total of 16 recording days.

Six temperature data loggers (Onset HOBO Pendant Temperature Logger, Model No UA-001-64) were installed at two different sampling areas on Trip 5; three within Upper Reach 2 (at same location as Camera 1) and three at another sampling area in Reach 1 (Plate 10). Each logger was installed within an isolated pool by hammering a two-foot piece of rebar into the substrate and using a zip tie to fasten the logger onto the rebar, along the channel bottom. The loggers were launched using Onset HOBO software on September 22, 2017 and the loggers were deployed in the field on September 23, 2017. The loggers were retrieved at the end of the day on September 24, 2017.

2.9 Safe Work Procedures

A Safe Work Procedures (SWP) document was submitted to BCH in May, 2017. The document outlines the SWP to be followed during work on boats and around flowing water, electrofishing, dangerous wildlife, and operating vehicles. Prior to each day of sampling, the crews (Ecora and HRVL) and boat operators met 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 provided each crew with a handheld radio set to a common channel for communication with the boat operators. Cellular phone and data service is patchy throughout the upper reaches and generally unavailable within Reach 3 (although some cell service occurs at the Many Islands area). Boat operators kept SPOT and/or Garmin InReach GPS devices for emergency communication. Boats generally travelled together and crews maintained line of sight and/or radio contact during sampling work. 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, Peace River Hydro Partners (PRHP). Digital and hardcopies of fish collection permits (BC and Alberta) were retained in the boats at all times and Ecora provided 48 hours' notice of fish collection activities to both permit issuers prior to each sampling trip.

2.10 Data Management

Field data was entered on waterproof data sheets and digitally, on the field iPads. Upon completion of each trip, data from the field forms was entered into Microsoft Excel, saved on Ecora's network server, and checked for accuracy. 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. GPS data and digital photos were downloaded to the Ecora server. Site location figures, using the spatial coordinates from the field, were created using ESRI's ArcGIS version 10.2.2. Hydrometric data (discharge and primary water level) for this report was obtained from Environment and Climate Change Canada Real-time Hydrometric Data web site (wateroffice.ec.gc.ca/mainmenu/real_time_data_index_e.) and provided by BCH Operations at PCN. Data was collected for the following stations on November 24, 2017:

- PCN Discharge
- Peace River at Hudson Hope (07EF001)
- Peace River above Pine River (07FA004)
- Peace River above Alces River (07FD010)

2.11 Quality Assurance

During field sampling, the Ecora and HRFN crews spent the first survey of the first day of each trip working together as larger crew to coordinate and calibrate surveyor techniques and level of effort, and to train new crew members. Ecofish was present on Trip 1 (Day 1) and Trip 3 (Days 5 and 6) to refine the sampling protocol, calibrate surveyor efforts, and provide other insight and recommendations. A representative from BCH was present on Trip 5 (Days 9 and 10).

Data forms were reviewed by crew members following each day of surveying and all sheets were collected and returned to Kelowna at the end of each trip. A library of fish photos was compiled and subsets of known and unknown species were sent to Ecofish for review and to confirm the identification of species. Data from the hardcopy forms was entered manually into an Excel database and reviewed for efforts and inconsistencies. Corrections to the data were made and errors and omissions were addressed. During the review of the data collected, inconsistent field data collection was noted. These issues were addressed using review of photos, notes, discussions with field crew, and using online resources to improve data accuracy.

3. Results

3.1 Hydrometric Operations

Mean daily discharge at the Peace River at Hudson's Hope (07EF001) hydrometric station between July 29 and September 24, 2017 ranged from 1,180 cms on July 29 to 864 cms on September 3. The maximum discharge over that time period peaked on September 19 at 1,836.00 cms and again on August 24 at 1,833.00 cms. The minimum discharge (330.90 cms) was observed at the lowest point on both August 12 and 16.

At the Peace River above Pine River (07FA004) hydrometric station, the mean daily discharge ranged from 1,210 cms on July 29 to 947 cms on August 21. The maximum discharge over that time period peaked on August 25 at 1,836.60 cms. The minimum discharge was recorded on July 16, 2017 at 399.35 cms. At the Peace River above Alces River (07FD010) hydrometric station, the mean daily discharge ranged from 1,640 cms on July 29 to 1,070 cms on August 31. The maximum discharge over that time period peaked on August 25 at 2,031.10 cms. The minimum discharge was recorded as 469.79 cms on August 13. The data for each station is shown on Figure 3.1.

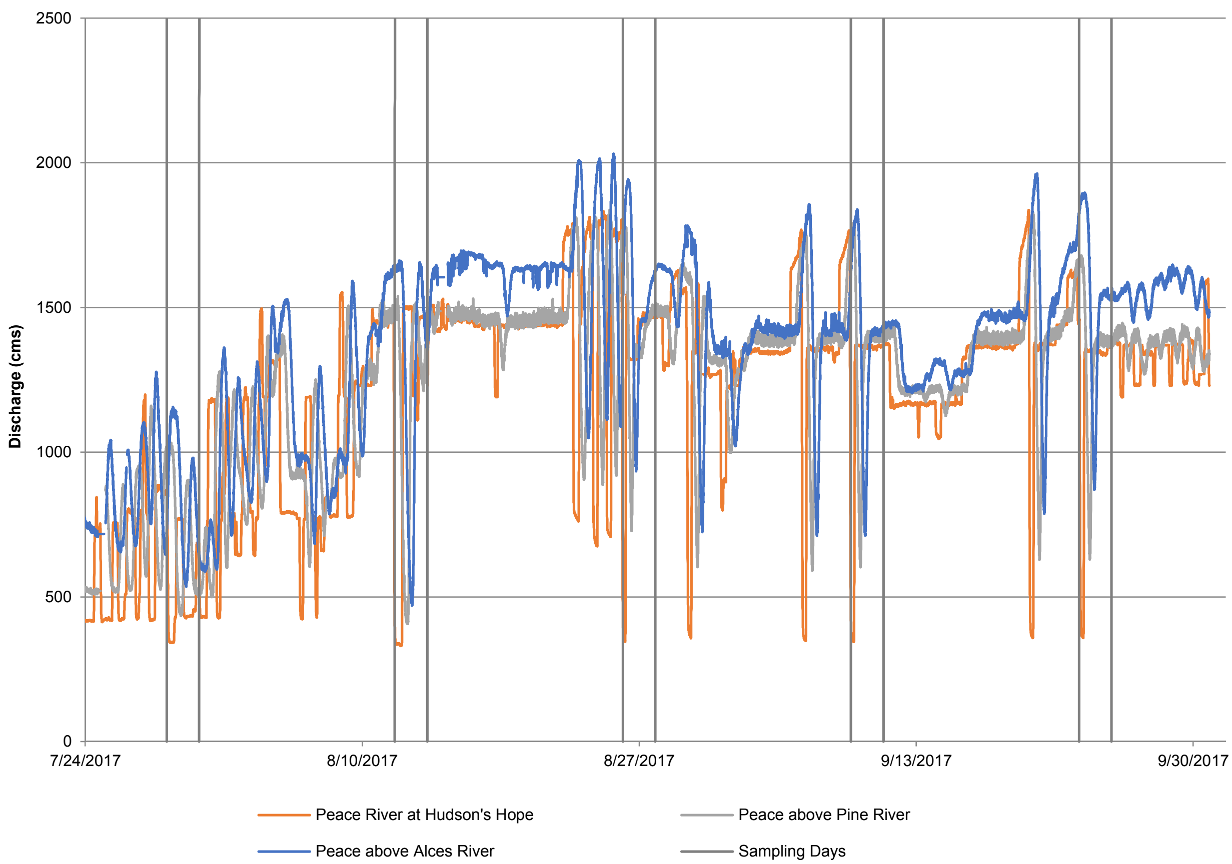

Figure 3.1 Summary of discharge recorded at the Peace River at Hudson's Hope (07EF001), Peace River above Pine River (07FA004), and Peace River above Alces River (07FD010) Water Survey of Canada Hydrometric Stations and sampling days between July 24 and September 30, 2017

Surveys were conducted beginning at the upstream end of the Headpond and completed in a downstream direction to follow the reduction event. Sampling at Reach 3 was completed on the second day of each sampling trip. Appendix C shows hydrometric station data from Peace River at Hudson's Hope (07EF001), Peace River above Pine River (07FA004) (Reach 1), and Peace River above Alces River (07FD010) (Reach 2) hydrometric stations during each of the five sampling trips. Only the first day of each two day trip is shown, as the second day of each trip was spent in Reach 3 (Many Islands).

3.2 Ramping Rates

Table 3.1 and Table 3.2 summarize the reduction events observed on each trip at the Peace River above Pine River (07FA004) and Peace River above Alces River (07FD010) hydrometric stations, as these represent conditions within Reach 1 and Reach 2, respectively. Data is not shown for the second day of sampling on each trip as the next closest hydrometric station is at the Peace River at Dunvegan Bridge Station (07FD003) in Alberta, approximately 62 km downstream of the Many Islands area and the Dunvegan Station does not provide discharge data (only primary water level). As such, the Alces River station was used as a representative station for Reach 3.

Water level and discharge data is shown for the first sampling day of each trip (i.e., during sampling between the Diversion Headpond and the lower end of Reach 2). The initiation and end of each reduction event was inferred from the available hydrometric data. Data is shown for the period between the peak water level prior to the reduction event and the lowest water level observed during the reduction event.

Table 3.1 Summary of Reduction Events observed during the first sampling day of each trip as recorded at the Peace River above Pine River Station (Reach 1)

Trip	Day	Date (2017)	Start Time Reduction	Primary Water Level (m)	Discharge (cms)	End Time Reduction	Primary Water Level (m)	Discharge (cms)	Reduction Time (hours)*	Stage Change (m)	Stage Change Rate (m/hour)	Discharge Reduction (cms)	Ramping Rate (cms/hour)
1	1	29-Jul	08:55	406.97	1008.40	19:25	405.91	462.59	10.50	1.06	0.10	545.81	51.98
2	3	12-Aug	05:50	407.61	1444.70	18:00	405.78	410.41	12.25	1.83	0.15	1034.29	84.43
3	5	26-Aug	05:45	407.92	1690.80	12:55	406.48	728.15	7.25	1.44	0.20	962.65	132.78
4	7	9-Sep	05:35	407.96	1723.60	13:55	406.23	602.21	8.75	1.73	0.20	1121.39	128.16
5	9	23-Sep	08:50	407.65	1481.00	15:55	406.28	629.12	7.25	1.37	0.19	851.88	117.50

*number of hours between peak flow and low water level during the reduction event

As indicated in the table, the greatest stage change at the Peace River above Pine River (i.e., downstream end of Reach 1) was observed on August 12, 2017 (Sampling Day 3), where flows were reduced from 407.61 m to 405.78 m for a total reduction of 1.83 m over a period of approximately 12.25 hours. The greatest discharge reduction was observed on September 9, 2017 (Sampling Day 7) where flows were reduced from a discharge of 1723.60 cms to 602.21 cms over a period of approximately 8.75 hours. Overall, the greatest ramping rate observed was on August 26, 2017 (Sampling Day 5) where the water stage lowered by 1.44 m and the discharge reduced from 1690.80 cms to 728.15 cms over a period of 7.25 hours for a ramping rate of 132.78 cms/hour.

Table 3.2 Summary of Reduction Events for each Sampling Day as recorded at the Peace River above Alces River Station (Reach 2)

Trip	Day	Date (2017)	Start Time Reduction	Primary Water Level (m)	Discharge (cms)	End Time Reduction	Primary Water Level (m)	Discharge (cms)	Reduction Time (hours)*	Stage Change (m)	Stage Change Rate (m/hour)	Discharge Reduction (cms)	Ramping Rate (cms/hour)
1	1	29-Jul	16:05	2.65	1086.08	2:30**	1.67	558.82	10.50	0.98	0.09	527.26	50.22
2	3	12-Aug	11:00	3.39	1621.89	0:35**	1.48	479.74	13.50	1.91	0.14	1142.15	84.60
3	5	26-Aug	10:15	3.73	1910.26	19:30	2.40	934.4	9.50	1.33	0.14	975.86	102.72
4	7	9-Sep	10:30	3.61	1802.60	21:00	1.99	712.62	10.50	1.62	0.15	1089.98	103.81
5	9	23-Sep	11:50	3.66	1847.32	22:25	2.29	869.92	10.50	1.37	0.13	977.4	93.09

*number of hours between peak flow and low water level during the reduction event
**the following day

The greatest stage change and discharge reduction at the Peace River above Alces River (i.e., downstream end of Reach 2) was observed on August 12, 2017, where the observed stage change was 1.91 m and the discharge reduction was 1142.15 over a period of approximately 13.50 hours. The greatest ramping rate was observed on September 9, 2017, where the stage change was 1.62 m and the discharge reduction was 1089.98 cms over a period of approximately 10.50 hours for a ramping rate of 103.81 cms/hour.

3.3 Fish Stranding Monitoring Surveys

A total of 140 fish stranding surveys were conducted during ten trips between July 29 and September 24, 2017. These included 77 interstitial surveys and 63 pool surveys using electrofishing methods. A total of 289 fish were observed, including ten incidental observations, defined as any fish observed that was not associated with the sampling event (e.g., observed while walking to or from the sampling event). During the first two trips, some fish were observed outside of the transect sampling frames and were recorded as ‘incidental’. However, it was later determined that these fish were still associated with the overall sampling area (i.e., broad-based area) and were not considered incidental to the sampling event.

Of the fish observed, there were 252 fish collected during sampling events, including 115 collected during interstitial sampling and 137 collected during pool sampling. Information for collected fish 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 EF 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. The sampling results are summarized in Table 3.3 .

Table 3.3 Summary of Sampling Events and Fish Observations from Year 2 (2017)

Method	Number of Sample Events	Samples with Fish Collected	Isolated Fish (Live/Dead)	Stranded Fish (Live/Dead)	Total Fish Collected (Live/Dead)
Interstitial Sampling	77	22	63 (63/0)	52 (17/35)	115 (80/35)
Pool Sampling	63	33	137 (135/2)	0	137 (135/2)
Total	140	55	200 (198/2)	52 (17/35)	252 (215/37)

As shown in the table, there were 52 stranded fish that were collected during interstitial sampling and, of these, 35 were dead at the time of sampling.

Sampling events are summarized below by reach, channel type, and risk type. The number of each type of survey (interstitial and pool) completed in each reach type is summarized below in Table 3.4. The surveys are also distinguished on the basis of targeted or random surveys.

Table 3.4 Summary of Sampling by Reach, Channel Type, and Risk (Gradient)

Reach	Channel Type	Risk Type (Gradient)	Interstitial Sample		Pool Sample		Total
			Targeted	Random	Targeted	Random	
Diversion Headpond	Multi-thread	High Risk	9		12		21
		Low Risk		4			4
		Negligible	1				1
	Single-thread	High Risk		2	1		3
		Low Risk		1			1
		Negligible					
Reach 1	Multi-thread	High Risk	5	1	4		10
		Low Risk	1				1
		Negligible					
	Single-thread	High Risk	4		3		7
		Low Risk			1		1
		Negligible					
Reach 2	Multi-thread	High Risk	7		7		14
		Low Risk		2			2
		Negligible	4		1		5
		Unclassified	4		7		11
	Single-thread	High Risk					
		Low Risk					
		Negligible					
Reach 3	Multi-thread	High Risk	18	1	16	1	36
		Low Risk	5	2	9	1	17
		Negligible		1			1
	Single-thread	High Risk	1	2			3
		Low Risk		2			2
		Negligible					
Total			59	18	61	2	140

As shown in the table, of the 77 total interstitial samples, 59 were targeted and 18 were randomly selected (approximately 23%). Of the total 63 pool samples, 61 were targeted and 2 were randomly selected (about 3%). The low number of random pool sites is indicative of the low occurrence of pools at randomly selected sites.

The interstitial samples include 41 sites in Multi-thread/High Risk sites and 14 in Multi-thread/Low Risk sites. Interstitial sampling was also conducted in 9 Single-thread/High Risk sites and 3 Single-thread/Low Risk sites. There were 4 samples that were conducted in areas not classified for Risk (all within Multi-thread areas within Reach 2). These sites were not classified as a result of being outside of the modelled area but would all be considered High Risk sites, based on physical characteristics (gradient, substrates, presence of pools). There was also one sampling event conducted with a Negligible Risk sites that would be considered High Risk based on the physical characteristics. The classifications of these sites will be changed based on the field verification prior to Year 3 (2018) sampling.

The pool samples include 40 sites in Multi-thread/High Risk sites and 10 in Multi-thread/Low Risk sites. Interstitial sampling was also conducted in 4 Single-thread/High Risk sites and 1 Single-thread/Low Risk sites. There was 1 sample conducted in a Negligible Risk site and 7 samples that were conducted in areas not classified for Risk (Reach 2).

3.4 Fish Observations

The fish species and life history classes collected during the Year 2 (2017) sampling events are summarized in the tables below. Table 3.5 shows the number of species and life history classes for isolated fish and Table 3.6 shows the same information for stranded fish. Young-of-the-year (YOY) and/or dead fish in various states of decomposition were identified to species or group (i.e., Family), where possible.

Table 3.5 Isolated Fish Species and Life History Classes Recorded in Year 2 (2017)

Group	Species	YOY*	Juvenile	Adult	Unknown	Totals	Percent of Total
Sportfish (Cool)**	Northern Pike	0	0	1	0	1	0.5
Sportfish (Cold)**	Mountain Whitefish	1	2	0	0	3	1.0
Sucker	Longnose Sucker	19	3	1	0	23	11.5
	Unknown Sucker	51	3	0	0	54	27.0
Sculpin	Slimy Sculpin	15	23	19	0	57	28.5
Minnow	Lake Chub	9	3	6	0	18	9.0
	Longnose Dace	17	8	0	0	25	12.5
	Reside Shiner	0	0	1	0	1	0.5
Other	Trout-perch	0	1	0	0	1	0.5
Unknown	Unidentified	14	0	0	3	17	9.0
Totals		126	43	28	3	200	100.0
Percent of Total		63.0	21.5	14.0	1.5		

* Young-of-the-Year

** As defined in the Environmental Impact Statement Volume 2 Appendix O (Fish and Fish Habitat Technical Data Report).

There were a total of 200 isolated fish, comprised of eight confirmed species. Suckers were most often observed during the stranding surveys (n=77), representing 38.5% of the total number of isolated fish observed. The next most common are Sculpin (n=57) and Minnows (n=44), representing 28.5% and 22.0% of total observations, respectively. Together, these three groups of fish represent 89.0% of all isolated fish collected. The majority of the isolated fish collected were YOY or juvenile, representing 84.5% of the total.

Table 3.6 Stranded Fish Species and Life History Classes Recorded in Year 2 (2017)

Group	Species	YOY*	Juvenile	Adult	Unknown	Totals	Percent of Total
Sucker	Unknown Sucker	30	1	0	0	31	59.6
Sculpin	Slimy Sculpin	1	6	10	1	18	34.6
Minnow	Lake Chub	1	0	0	0	1	1.9
Unknown	Unidentified	2	0	0	0	2	3.9
Totals		34	7	10	1	52	100.0
Percent of Total		65.4	13.5	19.2	1.9		

There were a total of 52 stranded fish, comprised of three confirmed species or groups. Suckers were most often observed stranded (n=31), representing 59.6% of the total number of stranded fish observed. The next most common are Sculpin (n=18), representing 34.6%. Sucker and sculpin represent 94.2% of all stranded fish collected. YOY and juvenile life classes represent 78.9% of the total stranded fish.

3.5 Fork Length Frequency

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

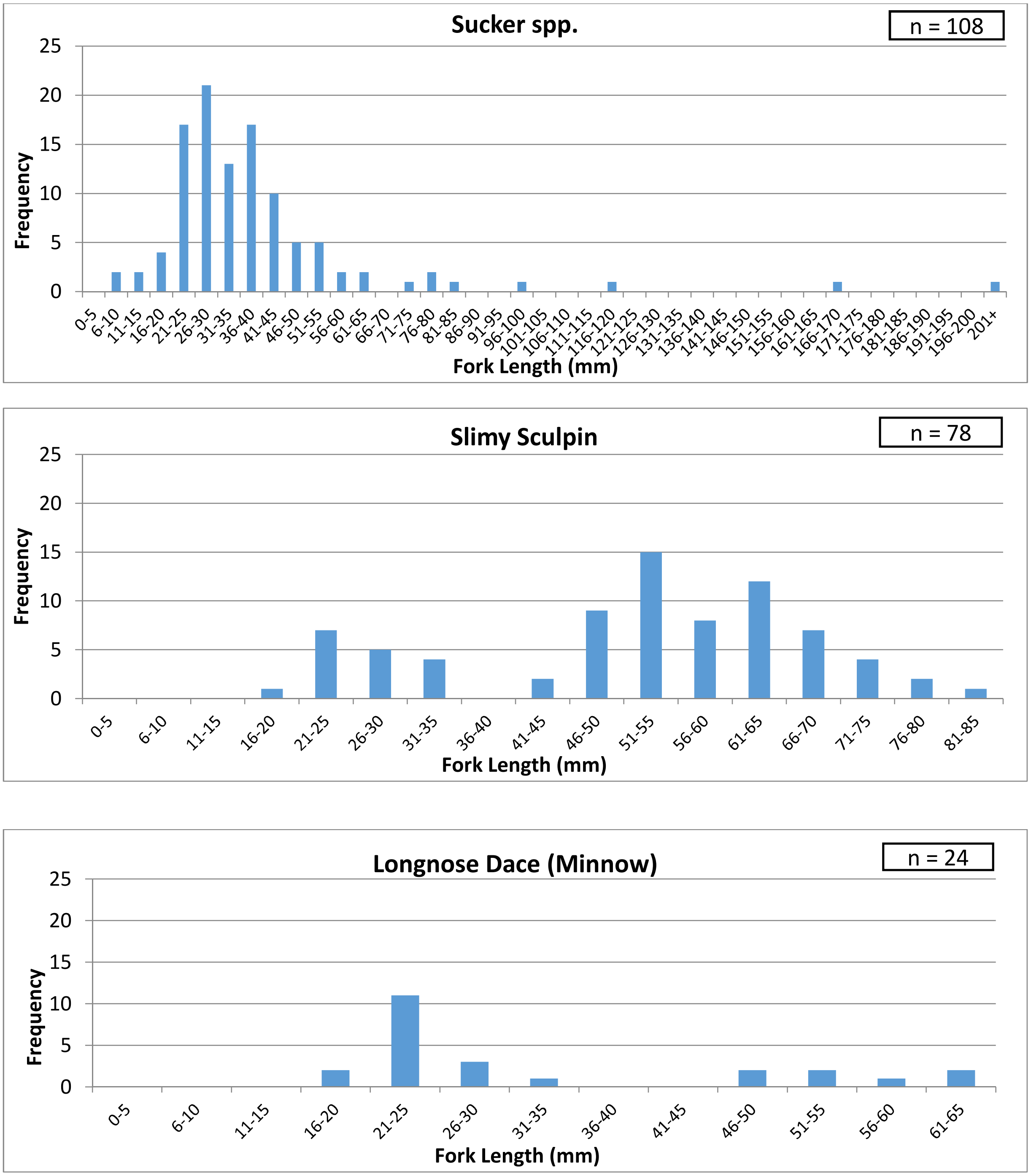

Figure 3.2 **Fork length frequency results for Sucker spp., Slimy Sculpin, and Longnose Dace, collected during Year 2 (2017) stranding surveys**

3.6 Fish Stranding by Reach

Sampling during Year 2 (2017) was completed in all four of the study area reaches (Table 3.7 and Table 3.8). Of the 289 fish observed, including interstitial and pool sampling, 49 (17.0%) were in the Diversion Headpond, 54 (18.7%) were in Reach 1, 26 (9.0%) were in Reach 2, and 160 (55.3%) were in Reach 3. Table 3.7 summarizes the interstitial fish observations and Table 3.8 summarizes the pool observations.

Table 3.7 Summary of Interstitial (Stranded) Fish Observations by Reach

Reach	No. Fish Observed	No. Surveys	No. Fish Observed per Survey
Diversion Headpond	29	17	1.7
Reach 1	12	11	1.1
Reach 2	7	17	0.4
Reach 3	84	32	2.6
Total	132	77	1.7

Fish stranding during interstitial sampling resulted in approximately 1.7 fish per survey overall. The greatest number of fish observed per survey was in Reach 3 (2.6 fish per survey) and the fewest fish per survey was in Reach 2 (0.4 fish per survey).

Table 3.8 Summary of Pool Sampling (Isolated) Fish Observations by Reach

Reach	No. Fish Observed	No. Surveys	No. Fish Observed per Survey
Diversion Headpond	20	13	1.5
Reach 1	42	8	5.3
Reach 2	19	15	1.3
Reach 3	76	27	2.8
Total	157	63	2.5

Fish stranding during pool sampling resulted in approximately 2.5 fish per survey. The greatest number of fish observed per survey was in Reach 1 (5.3 fish per survey). The fewest number of fish per survey was in Reach 2 (1.3 fish per survey).

3.7 Stranding Rates

As described in the BCH monitoring plan, total fish stranding will be calculated by extrapolating observed fish stranding densities (e.g., fish per m²) over the entire dewatered area within each reach. Catch per unit effort (CPUE) was used to estimate the rate of fish within isolated pools.

3.7.1 Interstitial Stranding Rate

A summary of the interstitial sampling results describing magnitude of stranding expressed as fish per m² is provided in Table 3.9. The Channel Type and Risk Type were used to stratify the data and allow comparison between sites with similar characteristics. The results are not shown for Trips 1 and 2, as the number of fish observed per unit area searched was very low. Using the sampling frame method, there were two fish collected from approximately 740 m^2 of substrate searched over 19 sampling events. There were 15 other fish observed outside of the transect frames during those sampling events, but there was no broad-based area estimated to determine a rate per unit area.

The Risk Type column has been updated and refined based on the results of the sampling events and field verification. In cases where the modelling was unavailable (i.e., Unclassified Risk Type), the Risk Type was updated to High Risk (as these were generally targeted sites based on availability of suitable pools and substrates for sampling). Areas described as Negligible Risk were updated to reflect the actual onsite conditions observed during sampling (generally changed to High Risk). In some cases, the modelled Risk Type was lowered (e.g., from High to Low or Low to Negligible) based on the lack of suitable substrates and/or available pools, or steep gradients.

Table 3.9 and Table 3.10, respectively, summarize the results of the broad-based searches and hot-spot searches conducted on Trips 3, 4, and 5, following the revision of the interstitial sampling methods. The tables include all fish collected or observed during sampling events, except for fish observed within the main river channel during sampling (i.e., neither isolated or stranded). Incidental fish (i.e., fish not associated with a defined sampling event) have been omitted from the tables.

Table 3.9 Estimated Stranding Rate from Broad-based Interstitial Sampling on Trips 3, 4, and 5

Reach	Channel Type	Risk Type (Gradient)	No. Samples	Area Sampled (m²)	No. Fish Collected	Estimated Stranding Rate (fish/m²)
Diversion Headpond	Multi-thread	High Risk	6	6,780	12	0.0018
		Low Risk	2	1,200	7	0.0058
		Negligible	0	-	-	-
	Single-thread	High Risk	0	-	-	-
		Low Risk	0	-	-	-
		Negligible	2	700	0	0.0000
Reach 1	Multi-thread	High Risk	5	2,230	5	0.0022
		Low Risk	1	800	-	-
		Negligible			-	-
	Single-thread	High Risk	1	1,150	1	0.0009
		Low Risk	0	0	-	-
		Negligible	0	0	-	-
Reach 2	Multi-thread	High Risk	9	6,690	6	0.0009
		Low Risk	2	280	0	0.0000
		Negligible	0	-	-	-
		Unclassified	0	-	-	-
	Single-thread	High Risk	0	-	-	-
		Low Risk	0	-	-	-
		Negligible	0	-	-	-
		Unclassified	0	-	-	-
Reach 3	Multi-thread	High Risk	15	9,485	79	0.0083
		Low Risk	3	1,760	3	0.0017
		Negligible	0	-	-	-
	Single-thread	High Risk	0	-	-	-
		Low Risk	1	200	0	0.0000
		Negligible	1	400	0	0.0000
Totals			48	31,675	113	0.0036

The highest rate of stranding during broad-based interstitial sampling was observed at Multi-thread High Risk sites within Reach 3 (0.0083 fish/m^2), followed by Multi-thread Low Risk sites within the Diversion Headpond (0.0058 fish/m^2). Overall the stranding rate observed during broad-based interstitial sampling was 0.0036 fish/m^2.

Table 3.10 Estimated Stranding Rate from Hot-Spot Interstitial Sampling on Trips 3, 4, and 5

Reach	Channel Type	Risk Type (Gradient)	No. Samples	Area Sampled (m²)	No. Fish Collected	Estimated Stranding Rate (fish/m²)
Diversion Headpond	Multi-thread	High Risk	6	600	12	0.0200
		Low Risk	2	20	0	0.0000
		Negligible	0	-	-	-
	Single-thread	High Risk	0	-	-	-
		Low Risk	0	-	-	-
		Negligible	2	700	0	0.0000
Reach 1	Multi-thread	High Risk	4	1,430	5	0.0035
		Low Risk	1	800	-	-
		Negligible			-	-
	Single-thread	High Risk	2	1,150	1	0.0009
		Low Risk	0	-	-	-
		Negligible	0	-	-	-
Reach 2	Multi-thread	High Risk	9	820	6	0.0073
		Low Risk	2	200	0	0.0000
		Negligible	0	-	-	-
		Unclassified	0	-	-	-
	Single-thread	High Risk	0	-	-	-
		Low Risk	0	-	-	-
		Negligible	0	-	-	-
		Unclassified	0	-	-	-
Reach 3	Multi-thread	High Risk	15	1,220	79	0.0648
		Low Risk	3	1,760	3	0.0017
		Negligible	0	-	-	-
	Single-thread	High Risk	0	-	-	-
		Low Risk	1	200	0	0.0000
		Negligible	1	0	0	0.0000
Totals			48	8,900	106	0.0119

The highest rate of stranding during hot-spot interstitial sampling was observed at Multi-thread High Risk sites within Reach 3 (0.0648 fish/m^2), followed by Multi-thread High Risk sites within the Diversion Headpond (0.0200 fish /m^2). Overall the stranding rate observed during hot-spot interstitial sampling was 0.0119 fish/m^2.

3.7.2 Pool Stranding Rates

A summary of the pool sampling results describing magnitude of stranding expressed as fish per unit time electrofishing (EF seconds) or Catch Per Unit Effort (CPUE) is provided in Table 3.11. The channel and risk type were used to stratify the data and allow comparison between sites with similar characteristics. Updates to the Risk Type were made as described above.

Table 3.11 Estimated Stranding Rate from Pool Sampling on all Trips

Reach	Channel Type	Risk Type (Gradient)	No. Samples	Electrofishing Seconds (EF)	No. Fish Collected	Estimated Stranding Rate (CPUE)
Diversion Headpond	Multi-thread	High Risk	12	6,614	20	0.0030
		Low Risk	0	-	-	-
		Negligible	0	-	-	-
	Single-thread	High Risk	1	515	0	0
		Low Risk	0	-	-	-
		Negligible	0	-	-	-
Reach 1	Multi-thread	High Risk	4	1,757	27	0.0154
		Low Risk	0	-	-	-
		Negligible	0	-	-	-
	Single-thread	High Risk	3	1,822	14	0.0077
		Low Risk	1	831	1	0.0012
		Negligible	0	-	-	-
Reach 2	Multi-thread	High Risk	7	1,860	1	0.0005
		Low Risk	0	-	-	-
		Negligible	1	424	2	0.0047
		Unclassified	7	3,960	15	0.0038
	Single-thread	High Risk	0	-	-	-
		Low Risk	0	-	-	-
		Negligible	0	-	-	-
		Unclassified	0	-	-	-
Reach 3	Multi-thread	High Risk	17	7,937	19	0.0024
		Low Risk	10	4,531	39	0.0086
		Negligible	0	-	-	-
	Single-thread	High Risk	0	-	-	-
		Low Risk	0	-	-	-
		Negligible	0	-	-	-
Totals			63	30,251	138	0.0046

The estimated stranding rate was determined as measured in terms of CPUE and expressed as fish per second of EF sampling. A total of 138 fish were collected during 63 sampling events and 30,251 electrofishing seconds, representing an overall CPUE of 0.0046 fish/EF second. The highest rate of stranding during pool sampling was observed at Multi-thread High Risk sites within Reach 1 (0.0154 fish/m²), followed by Multi-thread Low Risk sites within Reach 3 (0.0086 fish /m²).

3.8 Remote Monitoring

The following sections describe the results of the remote monitoring of pools using time-lapse camera and temperature data loggers, which was undertaken to determine the fate of pools and the likelihood of fish mortality. The two remote cameras recorded time-lapse images on 10-minute intervals for 16 days (Sep 9 to 24, 2017). During that time, ramping activities were observed on September 11, 13, 14, 16, 19, 20, 21, and 23.

3.8.1 Time Lapse Cameras

Camera 1 recorded conditions on a mid-stream (island) gravel bar, immediately downstream of the Taylor Bridge. The camera was secured to the root wad of a piece of large woody debris within a larger pile of debris. During the high water period of the ramping event on September 19, the woody debris shifted and the angle of the camera was altered. As such, the imagery from September 20 onward does not show the subject gravel bar. However, the rising and lowering of the river level is apparent throughout the recording period and shows the formation of pool during reduction events. The camera was re-positioned during a sampling event on September 23, where two fish were collected during the electrofishing of three pools (17-04-09-03). Following the sampling event, the images show one of the pools continue to dewater, although the camera stops recording images prior to the complete dewatering due to low light. A series of the time-lapse images is shown on Plate 11.

Camera 2 recorded conditions along a side channel bar across from the Pine River fan. The camera was secured to the base of a tree on the left bank and oriented towards the river channel. This camera shows the same ramping activities and the formation of pools along the side channel. In some cases, the pools appear to dewater completely prior to becoming re-connected the mainstem flows (see images on Plate 12).

The results of the camera imagery provide useful information regarding the timing of the reduction events and ramping activities and provide confirmation of the condition of pools following the reduction event. Using cameras in a similar manner during future years of the program will help address assumptions associated with risk of mortality to isolated fish. The imagery will also allow the determination of important factors such as the timing of the pool becoming isolated, the period of time it remains isolated, and whether or not the pool dewaters prior to flows rising and re-connecting the pool to the mainstem river flows.

3.8.2 Temperature Data Loggers

Three (3) temperature data loggers were installed at two locations during Trip 5 (i.e., 6 data loggers overall). One set of three data loggers was installed within the same three pools sampled at the Camera 1 site in Reach 2 (Site 1). The other set of three was installed at a location in Reach 1, referred to as Site 2. The loggers were set on September 23 and retrieved on September 24. Both sites had become inundated as a result of rising river water levels at the time of retrieval.

The results from the data loggers indicate that do not at Site 1 were compared to the time lapse imagery and hydrometric data. The data loggers were deployed in the pools between 16:30 and 17:30. At that time, the pool temperatures were generally 11 to 14°C. Temperatures remain relatively stable, likely due to the low overnight ambient air temperature (11°C at sunset to 5°C at sunrise). As such, there were no sudden increases or decreases in pool temperature observed at the time of isolation or re-connection with the mainstem flows. However, this may change under different weather conditions or timing of ramping and further use of temperature loggers in coordination with remote cameras will help confirm the likelihood of isolated fish mortality.

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.

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.

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

Appendix B

Photo Plates

Plate 1 **Interstitial sampling on Trip 1, Day 1 using 0.5 m^2 frames. This method was used on Trip 1 and Trip 2 only.**

Plate 2 **Crew conducting broad-based interstitial sample, with a group of four walking together along the recently de-watered substrate within the Diversion Headpond on Day 5 (August 26, 2017).**

Plate 3 **View of hot-spot interstitial sampling within a Multi-thread Unclassified Risk site within Reach 2 (17-02-07-04) on Trip 4, Day 7 (September 9, 2017).**

Plate 4 **View of isolated pools within a Multi-thread Low Risk site within Reach 3 (17-04-06-02) on Trip 3, Day 6 (August 27, 2017).**

Plate 5 **View of isolated pool on a mid-stream gravel bar (island) within a Multi-thread High Risk site within the Diversion Headpond (17-04-07-02) on Trip 4, Day 7 (September 9, 2017).**

Plate 6 **View of electrofishing sampling of isolated pools within a Multi-thread Unclassified Risk site within Reach 2 (17-08-03-04) on Trip 2, Day 3 (August 12, 2017).**

Plate 7 View of juvenile Mountain Whitefish collected during interstitial sampling within a Multi-thread High Risk site within Reach 3 (17-08-06-01) on Trip 3, Day 6 (August 27, 2017).

Plate 8 View of Camera 1 setup (indicated by red arrow) on a mid-island bar (island) downstream from the Taylor Bridge within a Multi-thread High Risk site at the upper end of Reach 2 associated with sampling site 17-07-07-05 conducted on Trip 4, Day 7 (September 9, 2017).

Plate 9 **View of Camera 2 setup (indicated by red arrow) along the left bank of the Peace River within a Multi-thread High Risk site at the upper end of Reach 2 associated with sampling site 17-08-07-04 conducted on Trip 4, Day 7 (September 9, 2017).**

Plate 10 **View of electrofishing sampling of isolated pools where temperature data loggers were installed at a Single-thread High Risk site within Reach 1 (17-04-09-02) on Trip 5, Day 9 (September 23, 2017).**

Image 01: Taken prior to sampling (16:19).

Image 02: Taken approximately one hour following sampling (17:42)

Image 03: Taken at 19:12

Plate 11 View of time lapse images from Camera 1 at Site 1, within Reach 2 during the sampling event 17-04-09-03 on September 23, 2017. The sampled pool in the foreground can be seen shrinking prior to sunset at which point it is no longer visible.

Image 01: High water level prior to the initiation of the reduction event (10:02)

Image 02: Low water level prior to flows rising (17:02). Pools can be seen forming along the dewatered substrates.

Image 03: Mainstem flows rising and pools have mostly dewatered. One pool is visible although the low light prevents the confirmation of whether it dried out completely prior to becoming reconnected to the mainstem.

Plate 12 View of time lapse images from Camera 2, within Reach 1 on September 23, 2017. Images show the reduction event from high water to low water levels and the drying out of residual pools.

Appendix C

Hydrometric Graphs