BC Hydro
Power smart

Site C Clean Energy Project

Fisheries and Aquatic Habitat Monitoring and Follow-up Program

Peace River Fish Stranding Monitoring Programs (Mon-12)

Construction Year 2 (2016)

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May 10, 2017

a resourceful company

Site C Fish Stranding Monitoring Program (Mon-12) FINAL REPORT V.0

Presented To: **BC Hydro and Power Authority**
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Attention: Dave Hunter, Senior Environmental Coordinator – Site C

Dated: May 2017

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OQM | Organizational Quality Management Program

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Executive Summary

The BC Hydro and Power Authority Site C Clean Energy Project (the Project) will result in a new dam structure on the Peace River near Fort St. John, downstream of the Peace Canyon Dam. Dam construction includes backwatering of an estimated 18 km Diversion Headpond, immediately upstream of the new dam location, formation of an 83-km reservoir, and commencement of operations in late 2022. 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 adopted methods from the "Canadian Lower Columbia River: Fish Stranding Risk Assessment and Response Strategy" (Golder 2011) and adaptations from previous fish stranding programs along the Columbia and Duncan Rivers.

Ten days of sampling were undertaken in Year 1 (2016), each of which was coordinated with BC Hydro to ensure suitable flow reductions occurred at the Peace Canyon Dam. A total of 150 sampling events were completed using a combination of electrofishing and dip nets in isolated pools and interstitial transects along suitable dewatered areas. Of those, 72 events had isolated and/or stranded fish present at the time of sampling which resulted in a total of 813 fish captured. The most commonly observed species were longnose sucker (60%), slimy sculpin (13%), and longnose dace (13%). Together, these three species represented 86% of all fish observations in 2016. There were 80 dead fish, representing approximately 10% of all fish captured. The baseline data collected in Year 1 (2016) will be used to help measure the magnitude of fish stranding, determine species and life stages most frequently observed, and to make comparisons between baseline conditions and the conditions observed during the Project's construction and operations phases The four primary management questions associated with the Mon-12 program, as developed by BCH, are identified below:

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 1 (2016) Results.

Objective	Management Hypotheses	Year 1 (2016) 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 1 sampling provides baseline results 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 1 sampling provides baseline results for the area between the Project location and the Pine River confluence.
	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 1 sampling provides baseline results for the Diversion Headpond and Reaches 1 and 2. Reach 3 will be sampled in 2017.
	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 1 results provide baseline data for the Diversion Headpond and Reaches 1 and 2. Preliminary findings suggest there is an area suitable for future mitigation measures within Reach 2.

Year 1 (2016) sampling was conducted between July 31 and October 14, 2016, within the Diversion Headpond Reach (18 km), Reach 1 (16 km), and Reach 2 (42 km), which comprise approximately 76 km (55%) of the total study area. Reach 3, which represents another 63 km distance downstream, will be sampled during the 2017 field monitoring program.

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BC Hydro
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Double Odd Ventures Ltd.
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Appendix Sections

1. Introduction

Ecora Engineering & Resource Group Ltd. (Ecora) was retained by BC Hydro and Power Authority (BCH) to monitor the effects of flow fluctuations associated with the construction and operation of the Site C dam (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 during the completion of 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.

This report provides a summary of the Year 1 (2016) results for fish stranding assessments conducted within the Peace River study area from July 30 to October 14. Results are discussed in relation to addressing the objectives, management questions, and hypotheses defined by BCH and summarized below. The main objective of Site C Mon-12 is to collect fish stranding data to determine baseline conditions within the study area of the Peace River which will be compared to future construction and operation phase conditions. Year 1 (2016) assessed fish stranding at pre-determined sites within the Diversion Headpond Reach, Reach 1, and Reach 2, as defined in Section 2.1. Reach 3 was not within the scope of sampling for Year 1 (2016).

Fish stranding generally occurs when fish habitat becomes isolated from the main stream channel during flow reductions (Golder 2014). As per the Columbia River studies, fish are considered stranded when they are found dead or are at risk of imminent death from the dewatering of pools or interstitial areas (Golder 2014). Isolation is a form of stranding that occurs when fish in pools 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 risk of mortality (Nicholl and Lewis 2016).

Isolation and stranding of fish may occur due to natural river level fluctuations but effects are typically exacerbated by hydroelectric activity due to alterations in frequency and magnitude of water level fluctuations (Irvine et al. 2014). The risk of fish stranding is affected by factors including 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 channel 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). Currently, the flow regime within the study area is directly influenced by operation of the Peace Canyon Dam (PCN), located upstream of the Project near Hudson's Hope, BC.

1.1 Program Objectives

The management questions and hypotheses for the Site C Mon-12 program were outlined in the BC Hydro Peace River Fish Stranding Monitoring Program (BCH 2016). The main objective of the program is to collect data to draw inferences that address the 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?

The overall objective of Site C Mon-12 is to address the management questions using field survey protocols developed to collect information on the incidence of fish stranding and to analyze extent and magnitude of fish stranding resulting from the project construction and operation, relative to baseline conditions.

1.2 Management Hypotheses

To address the management questions, the program will test the following hypotheses, as provided in the program description (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 field survey component included an identification of monitoring sites using available data and a reconnaissance of the study area to identify sites at risk of stranding during periods of reduced water levels, described further below. The outcomes of Site C Mon-12 are expected to help inform decision makers on future management procedures and habitat enhancement to mitigate risks associated with stranding fish within the subject reaches of the Peace River.

2. Methods

2.1 Study Area

The study area occurs within a 139-km section of the Peace River, between PCN downstream to the Many Islands area in Alberta (Figure 2.1). In general, the study area can be divided into two sections, defined in the 2016 Monitoring Program (BCH 2016):

1. The Site C Diversion Headpond that is expected to extend 18 km from the dam site upstream to near the Wilder Creek confluence during river diversion (Construction Years 5 to 8).
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 below. An approximately eight-km portion of the study area was unavailable for sampling due to safety concerns within proximity to the Project's construction area. The unavailable area occurs between kilometre markers (KM) 103 to 109 (distance downstream from GM Shrum Dam (GMS). Of this, approximately three km is within the Diversion Headpond Reach and five km is within Reach 1.

Table 2.1 Summary of Study Area Reach Breaks

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

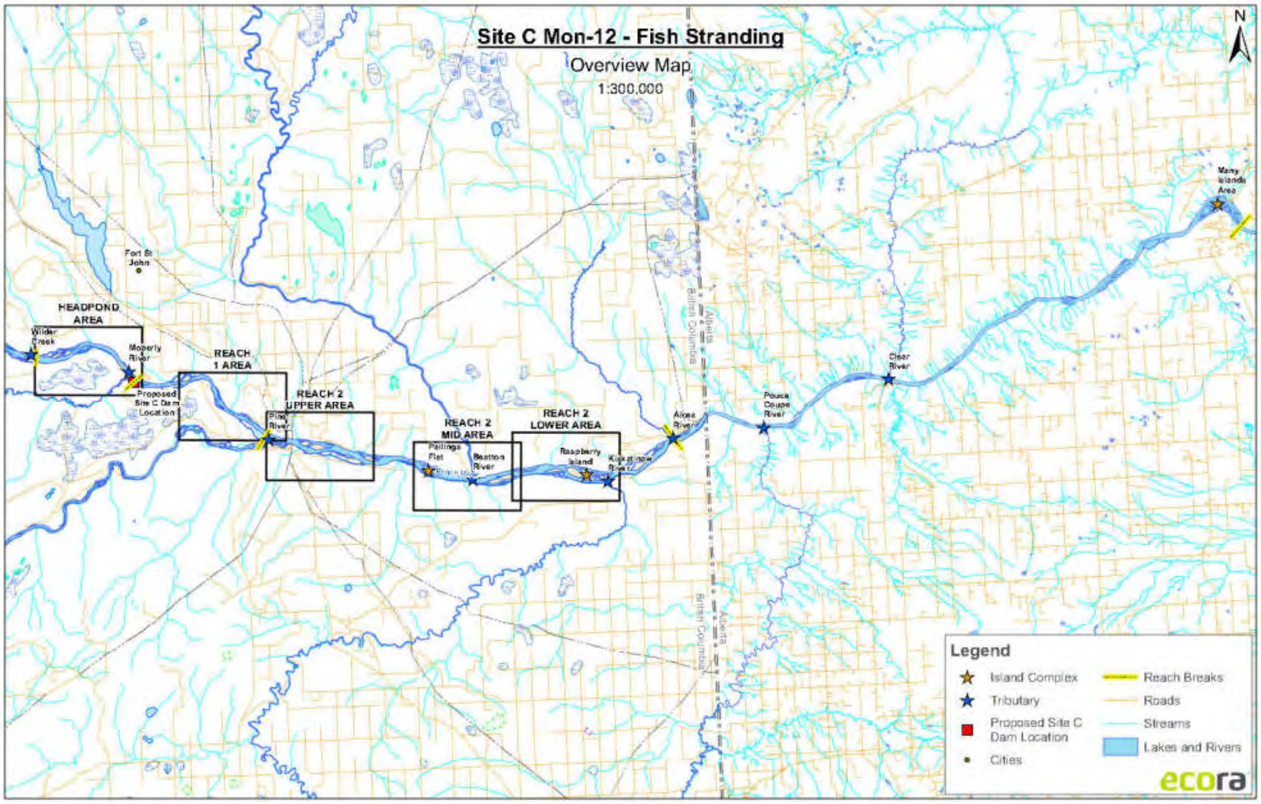


Figure 2.1 Overview Map

2.2 Site Selection

Site selection for Year 1 (2016) of the program was completed following a review of available data (e.g., aerial imagery, hydraulic modelling data, literature review, etc.) and a reconnaissance survey of the study area to identify monitoring sites that have potential to isolate or strand fish. Determination of high risk sites was based on previous studies of fish stranding in regulated river systems and the results of previous stranding assessments, particularly those conducted 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 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. 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.

Ecora and HRFN, with BCH and Ecofish Research, completed a reconnaissance of the study area between July 14 and July 17, 2016 to help refine the site selection process. During that assessment, it was determined that monitoring efforts should be focused on areas with high stranding risk. Suitable sampling sites include areas with a high likelihood of being dewatered on a regular basis (i.e., during normal operation at PCN), areas that form isolated pools that are unlikely to support fish during the period of isolation (i.e., due to harmful changes in water quality conditions such as temperature and dissolved oxygen), and/or areas that are small enough to be effectively searched or sampled using the defined methods (e.g., interstitial transects, seine netting, and electrofishing). Large isolated pools within side channels or mid-stream islands were predicted to be difficult to sample effectively and to potentially provide suitable habitat for fish during the period of isolation or stranding (Nicholl and Lewis 2016).

Sites identified as candidates for stranding monitoring surveys are typically relatively large, low gradient areas along mid-stream or shoreline bars with gravel and cobble substrates (Golder 2011). As per the BCH Monitoring Program (BCH 2016), two different assessment types were included:

- Annual Index Fish Stranding Assessment: The Annual Index Fish Stranding Assessment will focus on portions of the study area that are expected to have the highest risk of stranding fish. This assessment will include the Diversion Headpond Reach during construction and Reach 1 of the Peace River downstream of the Project during operation. They will be conducted up to 10 times during each study year to assess stranding risk during planned and unplanned water level reductions. Reach 1 and Reach 2 were both sampled in 2016 and will be sampled again in 2017.

- Expanded Fish Stranding Assessment: The Expanded Fish Stranding Assessment will focus on the study area Reaches that are expected to have a lower risk of stranding fish and will include assessments of monitoring sites located in Reach 2 and Reach 3. Reach 2 will be monitored during Construction Year 2 and every other year beginning in Construction Year 3. Reach 3 was not sampled during the 2016 surveys but will be monitored in 2017 and every third year after that.

Year 1 (2016) of this program , which included Annual Index Fish Stranding Assessment (Diversion Headpond Reach and Reach 1) and Expanded Fish Stranding Assessment (Reach 2), coincides with Project Construction Year 2.

2.3 Fish Stranding Risk Assessment

The fish stranding sampling protocol was provided by BCH and includes adaptations of the protocol developed for the Lower Columbia River (Golder 2014) and Lower Duncan River (Golder 2013). The Year 1 (2016) surveys began in late July and surveys were not completed in September due to difficulties coordinating timing with planned PCN flow reductions. Originally, all surveys were planned to occur on weekends when PCN flows are typically reduced and a greater dewatering effect is observed downstream. However, this changed during the onset of the fall season due to changes in electricity demands.

Fish stranding risk typically increases during periods of reduced water levels (Golder 2013). As such, attempts were made to ensure sampling occurred following a reduction event at PCN. The Water Survey of Canada (WSC) real-time hydrometric station data were used from Peace River at Hudson Hope (07EF001), Peace River above Pine River (07FA004), and Peace River Near Taylor (07FD002) water monitoring stations to determine timing and effort of surveys. Flow reductions from PCN are typically observed at the upstream end of the Diversion Headpond Reach approximately eight to nine hours following the reduction. Therefore, monitoring efforts were initiated at the upstream end of the Diversion Headpond Reach and continued downstream into Reach 1 and Reach 2 as the observed flow reduction effect continued downstream.

2.4 Field Sampling

Sampling was completed over ten days of surveys during five trips to the study area (i.e., two sampling days per trip) between July 30 and October 14, 2016. A summary of the trips, survey days, and sampling events during each trip is provided in Table 2.2. Maps showing sampling event locations within each Reach are provided in Appendix A.

Table 2.2 Summary of 2016 Sampling Days and Methods Used

Trip	Survey Day	Date (2016)	Sampling Methods			Total Sampling Events
			Pool Sites (EF)	Pool Sites (Net)	Interstitial Transects	
Trip 1	Day 1	July 30	4	3	7	14
	Day 2	July 31	10	2	7	19
Trip 2	Day 3	August 13	10	4	10	24
	Day 4	August 14	7	2	8	17
Trip 3	Day 5	August 27*	0	0	0	0
	Day 6	August 28	8	0	9	17
Trip 4	Day 7	October 3	5	1	12	18
	Day 8	October 4	3	0	11	14
Trip 5	Day 9	October 13	7	0	10	17
	Day 10	October 14	4	0	6	10
Total			58	12	80	150

*Heavy rain event made sampling ineffective

Surveys were generally conducted between 8:00 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 or three jet boats launched at the Peace Island Park boat launch, near Taylor, BC. In some cases interstitial sampling was conducted near identified pools but sampling sites did not overlap. Sites were navigated to using PDF Maps software that was uploaded to iPads, each of which was pre-loaded with geo-referenced maps showing preferred site locations. Upon arrival at each site, the following information was recorded on waterproof data forms:

- Date and time arrived
- Weather
- Reach location (Diversion Headpond Reach, Reach 1, Reach 2)
- Site ID, using Year-Crew-Survey Day-Site Number (sequential from first site visit of the day)
- Crew members
- Method of sampling used
- Location coordinates (from handheld GPS)
- Temperatures of ambient air, pool sampled, and mainstem Peace River
- Substrates (using Modified Wentworth Scale)
- Percent vegetation cover
- Time left and total sampling time

Site photos and GPS location information were also collected using the iPads. Surveys were completed in two general methods (Sections 2.5 and 2.6), depending on the local site conditions.

2.5 Interstitial Transect Sampling

Interstitial transect sampling was conducted by two crews of two to three people in areas that had been recently dewatered but where no pools had formed. Transects were established at suitable sites, generally parallel with the shoreline of the river using a 30-m tape (Appendix B, Plate 2). At each site, a single transect was sampled, although the total length and width of the transect varied depending on availability of suitable sampling area. Transects were walked and presence of stranded fish was assessed through a visual assessment and by turning over rocks. Small residual pools (i.e., puddles) were searched, where encountered, and fish were captured using small dip nets. Puddles were considered distinct from pools, as they were too small and/or shallow to sample using electrofishing techniques or seine nets. Puddles are generally characterized as small (i.e., less than 1 m in width) and shallow (i.e., less than 10 cm depth) pockets of waters between the substrate that were left from recent dewatering and were at risk of drying out in the immediate future (i.e., fish potentially occurring within puddles were considered 'stranded' as opposed to 'isolated'). The spatial coordinates of the start point of each transect were recorded.

Once laid out, surveyors traversed the length of the tape searching a pre-determined buffer along each side of the transect (generally 0.5 to 1.5 m on each side of the tape, depending on availability of suitable dewatered substrates). Within this buffer, surveyors would search visually and overturn large substrates (gravel and cobble) to determine if fish were stranded within the interstices between rocks or in small puddles of water. Additional lengths of tape were laid out if suitable area was available and the total area sampled was calculated by multiplying the total transect length by its width. All fish observed were collected in buckets with river water and data recorded as described below.

2.6 Pool Sampling

Pool sampling was conducted by two crews of two to three people using two backpack electrofisher units (Smith-Root LR-24) in areas where standing water formed in depressions and became isolated from the main river flows. Pools selected for sampling were deemed to be unsuitable in terms of size, depth, or complexity to support fish for the duration of the reduction event based on professional judgment (i.e., isolated pools with high risk of fish mortality). Sampled pools generally occurred along mid-stream or side channel bars, were larger than 1 m in width, and deeper than 10 cm. Cover was generally limited to large substrate (i.e., cobble and boulder) with occasional vegetation or woody debris present.

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. Sampling was focused on pools that were predicted to drain or dry out during a reduction event or not support fish due to increased risk of mortality from predation or poor water quality conditions (i.e., temperature, dissolved oxygen). Pools selected for sampling were required to have no clear fish passage and no evidence of a constant water source (from upstream or groundwater spring) (Appendix B, Plate 1).

Sampling pools were searched visually and backpack electrofishing units were used to confirm fish presence and collect fish, where possible. Multi-pass electrofishing techniques (i.e., 1 to 3 passes per pool) were used in an attempt to collect all fish present within each pool; however, depletion estimates were not completed during the 2016 sampling. If during the first pass, there were no fish collected or observed, additional passes were not conducted. Pool characteristics, including total area (m^2), depth, temperature, and substrates (using Modified Wentworth Scale) were recorded and the spatial coordinates of the pool was recorded. Electrofishing seconds were recorded to measure time spent actively sampling (i.e., effort). Pools deemed unsuitable for electrofishing due to temperature, clarity, conductivity, or other inadequate conditions but which had potential to contain stranded fish were sampled using nets. Depending on the size, depth, and nature of the pool, seine nets or dip nets were used to search for and capture fish. Fish processing methods are described below.

2.7 Fish Processing

Captured fish were held in buckets of river water until processing and each fish was identified to species, where possible. The life stage (adult, juvenile, young-of-year), and condition (live or dead) were recorded using professional judgment. Fish fork length was recorded using a measuring board. All captured fish (live or dead) were released into the mainstem of the Peace River following the sampling event. Where large numbers were captured, data were collected for the first 20 fish of each species collected at the site and the remainder of each species was tallied.

Each crew had an aerator readily available when sampling in hot weather. Each crew was equipped with fish species keys and a hand lens to help with identification. In cases where fish identification was impossible, photos were taken of the fish in hand or in a clear container.

2.8 Data Entry and Analysis

Upon completion of each trip, data from the field forms was entered into a Microsoft Excel database, saved on Ecora's network server, and checked for accuracy. All hardcopy field data was scanned and saved as PDF files on Ecora's server. The GPS data and photos collected with the iPads were also uploaded to Ecora's server. Site location figures were created using ESRI's ArcGIS version 10.2.2, using the spatial coordinates from the field. The data was used to quantify the magnitude of stranding using the number of observed fish stranded/ isolated per unit area of dewatered habitat sampled (e.g., fish per m^2) and/or catch per unit effort (CPUE).

Hydrometric data (discharge and primary water level) for this report was obtained from Environment and Climate Change Canada Real-time Hydrometric Data web site (https://wateroffice.ec.gc.ca/mainmenu/real_time_data_index_e.html). Data was collected for the following stations on November 24, 2016:

- Peace River at Hudson Hope (07EF001)
- Peace River above Pine River (07FA004)
- Peace River near Taylor (07FD002)
- Peace River above Alces River (07FD010)

2.9 Quality Assurance

The raw data went through multiple iterations of review and organization. Corrections to the data were made and errors and omissions were addressed. During the review of the data collected, it was noted that some sources of error were associated with inconsistent field data collection (e.g., electrofishing seconds, time spent completing interstitial transects, and total area sampled). This was discussed with the crews as an area for improvement to ensure complete and accurate data is recorded on all field data forms and handheld devices.

3. Results

3.1 Hydrometric Operations

Mean daily discharge at the Peace River at Hudson's Hope (07EF001) hydrometric station between July 30 and October 14, 2016 ranged from 1,180 cubic metres per second (cms) on July 30 to 859 cms on September 3. The maximum discharge over that time period peaked on September 2 at 1910 cms and again on October 12 at 1913 cms. The minimum discharge was recorded as 299 cms on September 6.

At the Peace River above Pine River (07FA004) hydrometric station between July 30 and October 14, 2016, the mean daily discharge ranged from 1,257 cms on October 14 to 942 cms on August 20. The maximum discharge over that time period peaked on September 3 at 2,191 cms. The minimum discharge was recorded as 423 cms on October 14. The data for each station is shown on Figure 3.1 below.

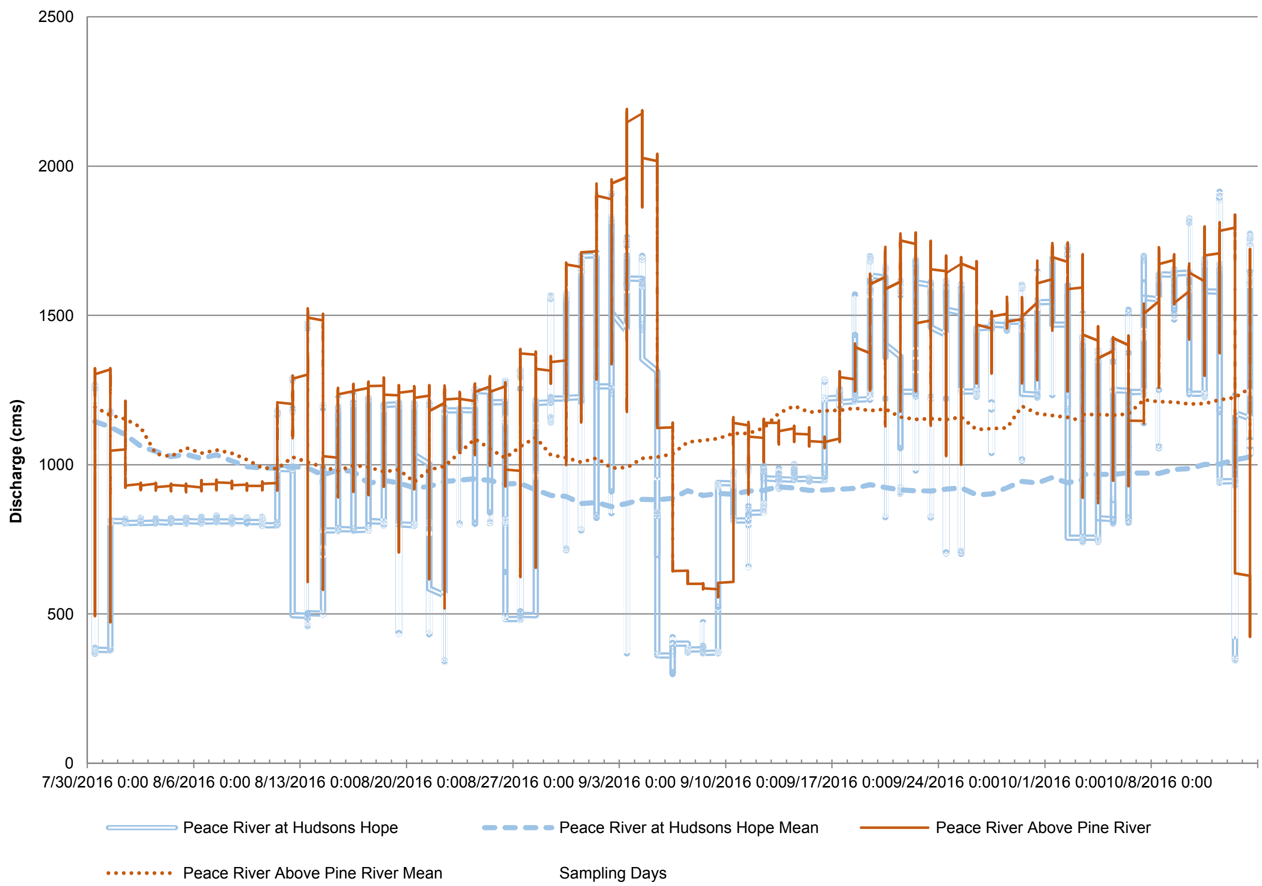


Figure 3.1 **Mean hourly discharge recorded at the Peace River at Hudson's Hope (07EF001) and Peace River above Pine River (07FA004) Water Survey of Canada Hydrometric Stations, July 30 to October 14, 2016. The solid vertical lines represent the sampling days.**

Attempts were made to conduct surveys beginning at the upstream end of the Diversion Headpond Reach approximately eight to nine hours following the initiation of a flow reduction at PCN. Monitoring surveys were completed in a downstream direction to follow the reduction event, which is typically observed at the downstream end of Reach 2 approximately 16 to 17 hours following the reduction at PCN. Selection of sites and level of effort conducting surveys of pools and transects was dependent on the wetted level at the time of the survey. In some cases, pools had neither formed nor become isolated from the main channel flow at the time of the survey.

Table 3.1 and Table 3.2 summarize the reduction events observed on each sampling day at the Peace River above Pine River (07FA004) and Peace River above Alces River (07FD010) hydrometric stations, as these represent conditions at the downstream end of Reach 1 and Reach 2, respectively. Data is shown for the period of time each sampling day between a peak and a low water level (m) and discharge (cms) amount.

Table 3.1 Summary of Reduction Events for each Sampling Day as recorded at the Peace River above Pine River Station (Reach 1)

Trip	Day	Date (2016)	Start Time Reduction	Primary Water Level (m)	Discharge (cms)	End Time Reduction	Primary Water Level (m)	Discharge (cms)	Duration (hours)	Stage Change (m)	Stage Change Rate (m/hour)	Discharge Reduction (cms)	Ramping Rate (cms/hour)
1	1	30-Jul	2:15	1.528	1170	14:20	0.288	492	12.0	1.24	0.10	678.00	56.50
	2	31-Jul	0:30	1.736	1320	12:50	0.24	472	12.5	1.50	0.12	848.00	67.84
2	3	13-Aug	4:05	1.797	1360	14:05	0.555	608	10.0	1.24	0.12	752.00	75.20
	4	14-Aug	*22:40	2.009	1520	11:05	0.495	581	12.5	1.51	0.12	939.00	75.12
3	5	27-Aug	4:55	1.657	1260	13:15	0.59	624	8.5	1.07	0.13	636.00	74.82
	6	28-Aug	0:05	1.825	1380	9:15	0.657	654	9.0	1.17	0.13	726.00	80.67
4	7	3-Oct	3:55	2.228	1720	13:25	1.089	899	9.5	1.14	0.12	821.00	86.42
	8	4-Oct	4:40	1.932	1480	13:15	1.059	883	8.5	0.87	0.10	597.00	70.24
5	9	13-Oct	0:55	2.384	1870	23:55	0.617	648	23.0	1.77	0.08	1222.00	53.13
	10	14-Oct	0:00	0.598	639	5:20	0.116	421	5.5	0.48	0.09	218.00	39.64

*the night before

As indicated in the table, the greatest stage change and discharge reduction at the Peace River above Pine River (i.e., downstream end of Reach 1) was observed on Day 9 (October 13, 2016), which included a stage reduction of 1.77 m and a discharge reduction of 1,222 cms. The stage change rate was very similar for Days 2 through 7 (0.12 to 0.13 m/hour), with Days 5 and 6 being the highest (0.13 m/hour). The ramping rate was greatest on Day 7 (October 3, 2016), which was recorded at 86.42 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 (2016)	Start Time Reduction	Primary Water Level (m)	Discharge (cms)	End Time Reduction	Primary Water Level (m)	Discharge (cms)	Duration (hours)	Stage Change	Stage Change Rate (m/hour)	Discharge Reduction	Ramping Rate (cms/hour)
1	1	30-Jul	9:45	2.904	1230	21:10	1.841	638	12.5	1.06	0.09	592	47.36
	2	31-Jul	6:50	3.151	1410	19:55	1.724	586	13.0	1.43	0.11	824	63.38
2	3	13-Aug	9:55	3.282	1500	21:00	2.209	820	11.0	1.07	0.10	680	61.82
	4	14-Aug	6:55	3.424	1610	6:40	2.031	729	12.0	1.39	0.12	881	73.42
3	5	27-Aug	*12:55	3.137	1400	5:10	2.616	1050	16.0	0.52	0.03	350	21.88
	6	28-Aug	*11:10	3.067	1350	20:25	2.221	826	9.0	0.85	0.09	524	58.22
4	7	3-Oct	9:45	3.849	1960	20:40	2.806	1170	11.0	1.04	0.09	790	71.82
	8	4-Oct	9:35	3.572	1730	20:15	2.794	1160	11.0	0.78	0.07	570	51.82
5	9	13-Oct	6:05	3.952	2010	12:15	1.753	580	23.0	2.20	0.10	1430	62.17
	10	14-Oct	0:00	2.814	1150	12:15	1.753	580	12.0	1.06	0.09	570	47.50

*the night before

As indicated in the table, the greatest stage change and discharge reduction at the Peace River above Alces River (i.e., within Reach 2) was also observed on Day 9 (October 13, 2016), which included a stage reduction of 2.2 m and a discharge reduction of 1,430 cms. The stage change rate and ramping rate was highest on Day 4 (August 14, 2016), which were recorded at 0.12 m/hour and 73.42 cms/hour, respectively.

3.2 Fish Stranding Monitoring Surveys

A total of 150 fish stranding assessments were conducted during ten trips conducted between July 30 and October 14, 2016. Of these, survey effort included 80 interstitial transect sites, 58 electrofishing pool sites, and 12 sites where nets were used to salvage fish from pools (due to inadequate conditions for electrofishing). A total of 813 fish were captured, 80 of which were dead. Of these, 23 were stranded fish observed during interstitial sampling. The remaining 57 were mortalities resulting from the electrofishing collection method. The survey results are summarized in Table 3.3.

Table 3.3 Summary of Sampling Methods and Fish Observations

Method	Number of Sites Sampled	No. Sites with Fish Present	Total Area of Sites Sampled (m^2)	Total Number of Fish Captured	Total Number of Dead Fish
Transect	80	25	35,819	139	23
Pool (Electrofish)	58	38	7,982	640	57
Pool (Net)	12	9	2,409	34	0
Total	150	72	46,210	813	80

3.3 Fish Observations

Fish species and age classes observed during the 2016 monitoring surveys are summarized in Table 3.4.

Table 3.4 Summary of Fish Observations and Life History Classes Recorded in Year 1 (2016)

Group	Species	Young-of-the-Year	Juvenile	Adult	N/A*	Totals	Percent of Total
Sportfish (Cool)**	Burbot	0	1	0	0	1	0.12%
Sportfish (Cold)**	Kokanee	0	1	0	0	1	0.12%
	Mountain Whitefish	7	11	0	0	18	2.21%
Sucker	Largescale Sucker	1	1	0	0	2	0.25%
	Longnose Sucker	166	16	1	310	493	60.64%
	White Sucker	3	0	0	0	3	0.37%
Sculpin	Prickly Sculpin	0	1	0	0	1	0.12%
	Slimy Sculpin	16	6	80	6	108	13.28%
	Spoonhead Sculpin	0	0	1	0	1	0.12%
	Unknown Sculpin	0	0	2	0	2	0.25%
Minnow	Lake Chub	0	5	18	2	25	3.07%
	Longnose Dace	66	21	2	16	105	12.92%
	Northern Pikeminnow	3	2	0	0	5	0.62%
	Pearl Dace	0	1	0	0	1	0.12%
	Reside Shiner	8	18	2	3	31	3.81%
	Spottail Shiner	0	0	6	0	6	0.74%

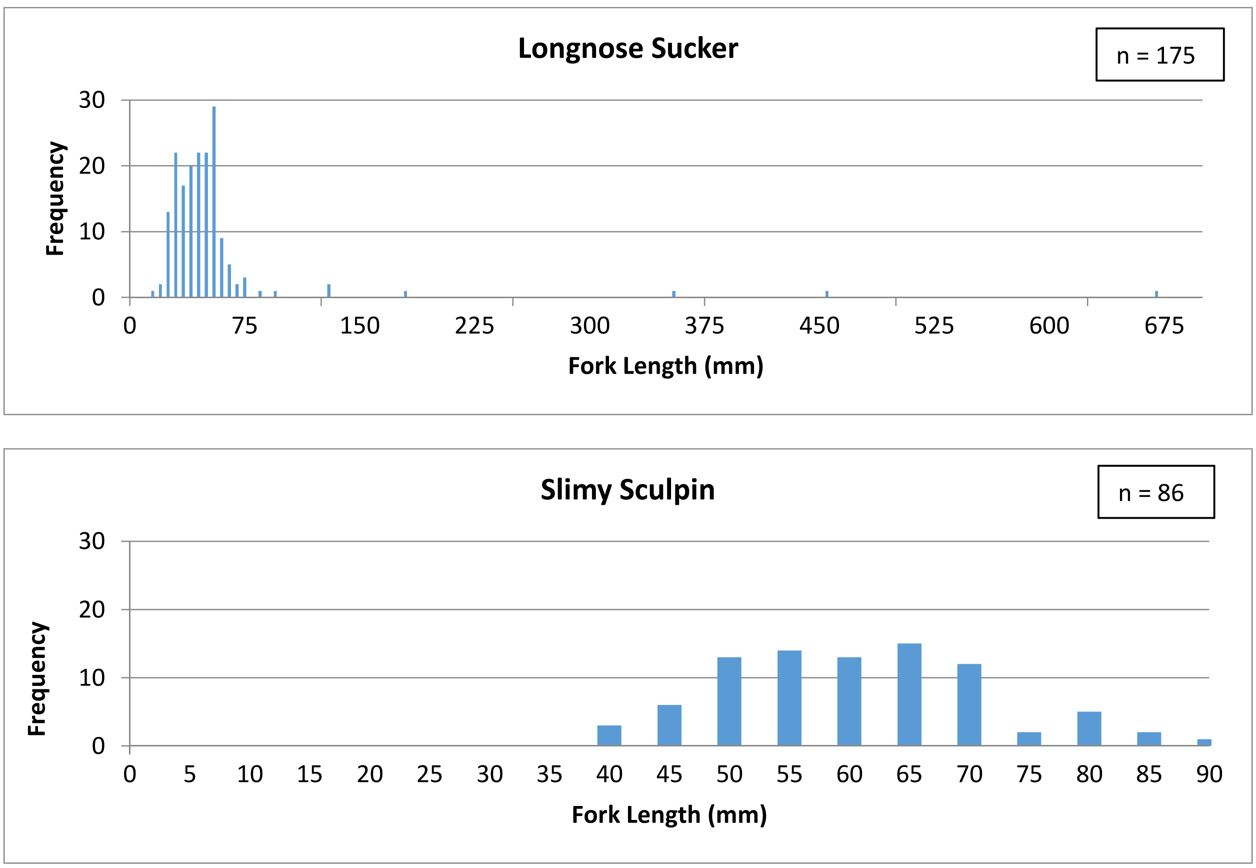
Group	Species	Young-of-the-Year	Juvenile	Adult	N/A*	Totals	Percent of Total
	Unknown Minnow	0	2	0	0	2	0.25%
Other	Trout-perch	0	0	3	0	3	0.37%
Unknown	Unidentified	5	0	0	0	5	0.62%
Totals		275	86	115	337	813	100.00%
Percent of Total		33.83%	10.58%	14.15%	41.45%		

* Not categorized by life stage due to the 20 fish limit per species for life stage and fork length sampling.
** As defined in the Environmental Impact Statement Volume 2 Appendix O (Fish and Fish Habitat Technical Data Report).

The fish species most often observed during the stranding surveys was the longnose sucker (n=493), which represents 60% of the total number observed. The next most common are the slimy sculpin (n=108) and the longnose dace (n=105), each representing approximately 13% of total observations. Together, these three species represented 86% of all fish observations. The life history class distribution (for the 476 fish that were recorded to life history class) included 58% young-of-the-year, 18% juvenile, and 24% adult.

3.4 Fork Length Frequency

For all fish captured at each site during each sampling session, a subset of 20 fish from each species was measured for fork length. The remaining fish (over and above 20) were identified to species, tallied, and released without measurement. A summary of the fork length-frequency data for the three most commonly observed species (longnose sucker, slimy sculpin, and longnose dace) is provided in Figure 3.2.



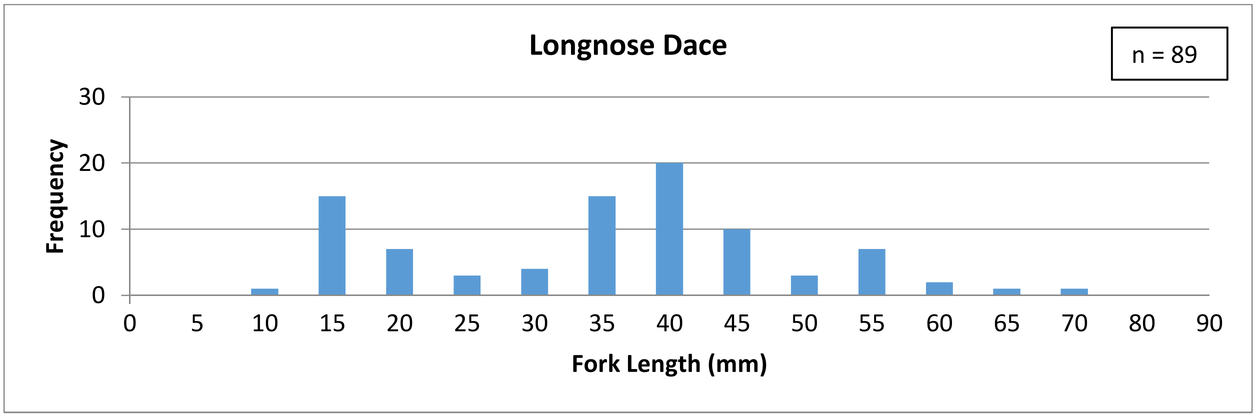


Figure 3.2 Fork length-frequency results for longnose sucker, slimy sculpin, and longnose dace, observed during Year 1 (2016) stranding surveys.

3.5 Fish Stranding by Reach

The fish observations were recorded for the three Reaches surveyed in 2016 (Table 3.5). Of the total 813 fish observed, 569 (70%) were observed in Reach 2 during 73 site surveys. There were 135 observations (16.6%) within Reach 1 during 45 site surveys, and the remaining 109 observations (13.4%) were within the Diversion Headpond Reach during 32 site surveys.

Table 3.5 Summary of Fish Observations and Sampling Sites by Reach

Reach	No. Fish Observed	No. Site Surveys	No. Fish Observed per Survey
Diversion Headpond Reach	109	32	3.41
Reach 1	133	45	2.96
Reach 2	571	73	7.82
Total	813	150	5.42

A relatively large proportion of the total fish observations occurred at one site during surveys on Trip 1 and Trip 2. The site occurs along the left (i.e., north) bank within the upstream end of Reach 2, across from the Pine River confluence. A total of 132 and 171 fish were observed during Trips 1 and 2, respectively, representing 37% of all fish observations for Year 1 (2016).

3.6 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) will also be used where appropriate to estimate potential stranding rates. The analytical methods are in development and will be implemented in future years of the program.

3.6.1 Interstitial Sites

A summary of the interstitial transect sampling results describing magnitude of stranding expressed as fish per m² is provided in Table 3.6 (Diversion Headpond Reach), Table 3.7 (Reach 1) and Table 3.8 (Reach 2).

Table 3.6 Estimated Stranding Rate from 2016 Interstitial Sampling Results within the Diversion Headpond Reach

Trip	Day	Date (2016)	No. Fish Caught	Total Area Sampled (m²)	Estimated Stranding Rate (fish/m²)
1	Day 1	July 30	0	750	0
	Day 2	July 31	41	1,050	0.039
2	Day 3	August 13	4	1,900	0.002
	Day 4	August 14	0	800	0
3	Day 5	August 27	0	0	0
	Day 6	August 28	0	0	0
4	Day 7	October 3	0	570	0
	Day 8	October 4	0	700	0
5	Day 9	October 13	0	420	0
	Day 10	October 14	0	0	0
Total			45	6,190	n/a

Using the results from the seven sampling days (sampling not conducted on Days 5, 6, or 10), the average estimated stranding rate from interstitial transect surveys within the Diversion Headpond Reach is 0.006 fish/m^2.

Table 3.7 Estimated Stranding Rate from 2016 Interstitial Sampling Results within Reach 1

Trip	Day	Date (2016)	No. Fish Caught	Total Area Sampled (m²)	Estimated Stranding Rate (fish/m²)
1	Day 1	July 30	13	600	0.022
	Day 2	July 31	1	486	0.002
2	Day 3	August 13	18	2,900	0.006
	Day 4	August 14	45	3,930	0.012
3	Day 5	August 27	0	0	0
	Day 6	August 28	0	1,330	0
4	Day 7	October 3	3	1,230	0.002
	Day 8	October 4	2	1,540	0.001
5	Day 9	October 13	0	1,060	0
	Day 10	October 14	1	660	0.002
Total			83	13,736	n/a

Using the results from the nine sampling days (sampling not conducted on Day 5 in Reach 1), the average estimated stranding rate from interstitial transect surveys within Reach 1 is 0.005 fish/m^2.

Table 3.8 Estimated Stranding Rate from 2016 Interstitial Sampling Results within Reach 2

Trip	Day	Date (2016)	No. Fish Caught	Total Area Sampled (m²)	Estimated Stranding Rate (fish/m²)
1	Day 1	July 30	8	1,332	0.006
	Day 2	July 31	0	420	0
2	Day 3	August 13	0	3,264	0
	Day 4	August 14	0	5,250	0
3	Day 5	August 27	0	0	0
	Day 6	August 28	0	503	0
4	Day 7	October 3	0	1,260	0
	Day 8	October 4	1	1,220	0.001

Trip	Day	Date (2016)	No. Fish Caught	Total Area Sampled (m^2)	Estimated Stranding Rate (fish/m^2)
5	Day 9	October 13	2	1,345	0.002
	Day 10	October 14	0	1,300	0
Total			11	15,894	n/a

Using the results from the nine sampling days (sampling not conducted on Day 5 in Reach 2), the average estimated stranding rate is 0.001 fish/m^2.

3.6.2 Pool Sites

The estimated stranding rate was determined as measured in terms of CPUE within the Diversion Headpond Reach. There were 51 fish caught during 896 electrofishing (EF) seconds, representing a CPUE of 0.06. Within Reaches 1 and 2 there were 312 fish caught during 10,448 EF seconds for a CPUE of 0.03. Electrofishing seconds were not recorded for each sampling site so the data represents a subset of the total electrofishing results. The fate of isolated fish, had they not been salvaged, is unknown. There is potential for mortality in isolated locations prior to them being re-watered, based on incidental observations of birds at and near pool sites and of water quality conditions (i.e., temperature, dissolved oxygen).

4. Discussion

Data collected during the Year 1 (2016) of the fish stranding program (Construction Year 2) provide baseline information for future comparison to construction and operational phases of the Project. Data collection during Construction Years 2 through 5 will contribute to the baseline information until formation of the Diversion Headpond. A synthesis review will be undertaken following the completion of baseline assessment in Construction Year 5 (2019).

As described in the program monitoring plan, the initial study years (2016 to 2019) will be used to develop and refine the identification of monitoring sites through a combination of model predictions and field verification. Data related to ramping rates will also help improve the baseline data collection. The species and life stages most observed during the 2016 surveys include sucker and minnow species. Few sportfish have been observed or captured in stranding pools or interstitial transects. Year 1 (2016) results relevant to the primary management questions are summarized below.

4.1 What is the magnitude of fish stranding in the Diversion Headpond relative to baseline conditions

The Year 1 (2016) results contribute to the baseline data and will be used to compare to future conditions during construction and operations phases of project. The stranding results within the Diversion Headpond Reach are summarized in Section 3.5, with a focus on measures of magnitude (e.g., observations per unit area surveyed) for each sampling method provided in Table 4.1.

Table 4.1 Summary of Year 1 (2016) data describing the magnitude of fish stranding observed within the Diversion Headpond Reach

Method	No. Sites Sampled	Total No. Fish Observed	Total No. Dead Fish	Total Fish per Sampling Event	Total Area Sampled (m^2)	Fish Density (fish per m^2)
Pool (EF)	14	64	8	4.57	2,319	0.028
Pool (Net)*	0	0	0	0	0	0
Transect	18	45	12	2.50	6,190	0.007
Totals	32	109	20	3.41	8,509	0.013

*The net sampling method was not used within the Diversion Headpond Reach in Year 1 (2016).

As shown in Table 4.1, there were 64 fish captured using electrofishing techniques within the Diversion Headpond Reach, 8 of which were dead (13%). There were 45 fish captured using interstitial transect methods, 12 of which were dead (27%). Overall, there were 109 fish captured within the Diversion Headpond Reach, 20 of which were dead (18%). There was one dead mountain whitefish observed during the transect surveys. The remaining 19 dead fish were all coarse fish.

The number of fish collected within the Diversion Headpond Reach using electrofishing methods per square meter of pool sampled is estimated at 0.028 fish/m^2. Using interstitial sampling methods per square meter of dewatered substrate, there were 0.007 fish/m^2 observed.

4.2 Which species and life stages of fish are most affected by stranding in the Diversion Headpond relative to baseline conditions?

The Year 1 (2016) species and life stage data collected within the Diversion Headpond Reach are summarized in Table 4.2.

Table 4.2 Summary of Year 1 (2016) data describing species and life stages of fish observed within the Diversion Headpond Reach

Group	Species	Life Stage				Total	Totals (excluding N/A)	Percent of Total
		Young-of-the-Year	Juvenile	Adult	N/A*			
Sportfish (Cold)	Mountain Whitefish	0	1	0	0	1	1	1.03%
Sucker	Largescale Sucker	0	1	0	0	1	1	1.03%
	Longnose Sucker	19	6	0	9	34	25	25.77%
Sculpin	Prickly Sculpin	0	1	0	0	1	1	1.03%
	Slimy Sculpin	10	1	14	0	25	25	25.77%
Minnow	Lake Chub	0	5	6	0	11	11	11.34%
	Longnose Dace	1	0	0	0	1	1	1.03%
	Redside Shiner	8	18	0	3	29	26	26.80%
	Spottail Shiner	0	0	3	0	3	3	3.09%
Unknown	Unidentified	3	0	0	0	3	3	3.09%
Totals		41	33	23	12	109	97	100%
Percent of Total		37.61%	30.28%	21.10%	11.00%	100%		

*Not categorized by life stage due to the 20 fish limit for life stage and fork length sampling.

Longnose sucker (31%), redside shiner (27%), and slimy sculpin (23%) make up the majority of the fish observations within the Diversion Headpond Reach. Together, these species comprise over 80% of the fish observations within the Diversion Headpond Reach. Approximately 38% of fish observations were young-of-the-year.

4.3 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?

The Year 1 (2016) species and life stages observed downstream of the Project (i.e., within Reaches 1 and 2) are summarized in Table 4.3.

Table 4.3 Summary of Year 1 (2016) data describing species and life stages of fish observed downstream of the Project (i.e., within Reach 1 and Reach 2)

Group	Species	Life Stage				Total	Totals (excluding N/A)	Percent of Total
		Young-of-the-Year	Juvenile	Adult	N/A*			
Sportfish (Cool)	Burbot	0	1	0	0	1	1	0.27%
Sportfish (Cold)	Kokanee	0	1	0	0	1	1	0.27%
	Mountain Whitefish	7	10	0	0	17	17	4.52%
Sucker	Largescale Sucker	1	0	0	0	1	1	0.27%
	Longnose Sucker	138	10	1	310	459	149	39.63%
	White Sucker	3	0	0	0	3	3	0.80%
Sculpin	Slimy Sculpin	6	8	69	0	83	83	22.07%
	Spoonhead Sculpin	0	0	1	0	1	1	0.27%
	Unknown Sculpin	0	0	2	0	2	2	0.53%
Minnow	Lake Chub	0	0	12	2	14	12	3.19%
	Longnose Dace	65	21	2	16	104	88	23.40%
	Northern Pikeminnow	3	2	0	0	5	5	1.33%
	Pearl Dace	0	1	0	0	1	1	0.27%
	Redside Shiner	0	0	2	0	2	2	0.53%
	Spottail Shiner	0	0	3	0	3	3	0.80%
	Unknown Minnow	0	2	0	0	2	2	0.53%
Other	Trout-perch	0	0	3	0	3	3	0.80%
Unknown	Unidentified	2	0	0	0	2	2	0.53%
Totals		225	56	95	328	704	376	100%
Percent of Total		31.96%	7.95%	13.49%	46.59%	100%		

*Not categorized by life stage due to the 20 fish limit for life stage and fork length sampling.

The fish species most commonly observed downstream of the Project (i.e., within Reaches 1 and 2) include longnose sucker (65%), longnose dace (15%), and slimy sculpin (12%). Together, these species represent 92% of the total fish observations within Reaches 1 and 2. The majority of the observations (62% of all measured fish) were young-of-the-year, although 48% of the fish captured were not categorized by age class (N/A column) as their numbers exceeded the threshold of 20 fish for measurement at each site.

The Year 1 (2016) data collected within Reaches 1 and 2 are summarized in Table 4.4, with a focus on measures of magnitude (e.g., fish observations per unit area surveyed) for each sampling method.

Table 4.4 Summary of Year 1 (2016) data describing the magnitude of fish stranding observed downstream of the Project (Reach 1 and 2)

Method	No. Sites Sampled	Total No. Fish Observed	Total No. Dead Fish	Total Fish per Site	Total Area Sampled (m²)	Fish Density (fish per m²)
Pool (EF)	44	576	49	13.10	5,663	0.102
Pool (Net)*	12	34	0	2.83	2,409	0.014
Transect	62	94	11	1.52	29,629	0.003
Totals	118	704	60	5.97	37,701	0.019

*The net sampling method was not used within the Diversion Headpond Reach in Year 1 (2016).

There were 576 fish captured using electrofishing techniques within Reaches 1 and 2. Of these, there were 49 dead fish (9%). There were 94 fish captured using interstitial transect methods, 11 of which were dead (12%). Overall there were 704 fish captured within Reaches 1 and 2, 60 of which were dead (9%).

The number of fish captured using electrofishing methods per square meter of pool sampled is estimated at 0.102 fish/m^2 within Reach 1 and 2. Using interstitial sampling methods, there were 0.003 fish/m^2 observed and using nets to sample pools, there were 0.014 fish/m^2 observed. As noted previously, a large number of fish observations occurred at one site within Reach 2. There were 303 fish observed at this site during two sampling events, representing 43% of total fish observations downstream of the Project (within Reaches 1 and 2) and 37% of all fish observations in Year 1 (2016).

4.4 Do mitigation strategies (i.e., fish salvage and habitat enhancement) reduce fish stranding rates relative to baseline conditions?

Mitigation by fish salvage and habitat enhancement is expected to reduce fish stranding rates relative to baseline conditions. However, as the program is in the baseline data collection phase, it is premature to evaluate mitigation efficacy. A large proportion of the total fish observations occurred at one site within Reach 2. At this site, 303 fish were observed during two trips, representing 37% of all Year 1 (2016) observations. The feasibility of mitigating stranding at this site by re-contouring could be evaluated during future sampling and evaluation of this site, and others, for mitigation.

Baseline data collection in subsequent years will help further identify specific sites that pose the highest risk for stranding and/or have been observed to have high rates or magnitude of stranding. These sites will be assessed and characterized to determine the physical characteristics that contribute to their higher risk and to help inform development of effective mitigation or enhancement strategies to reduce stranding risk.

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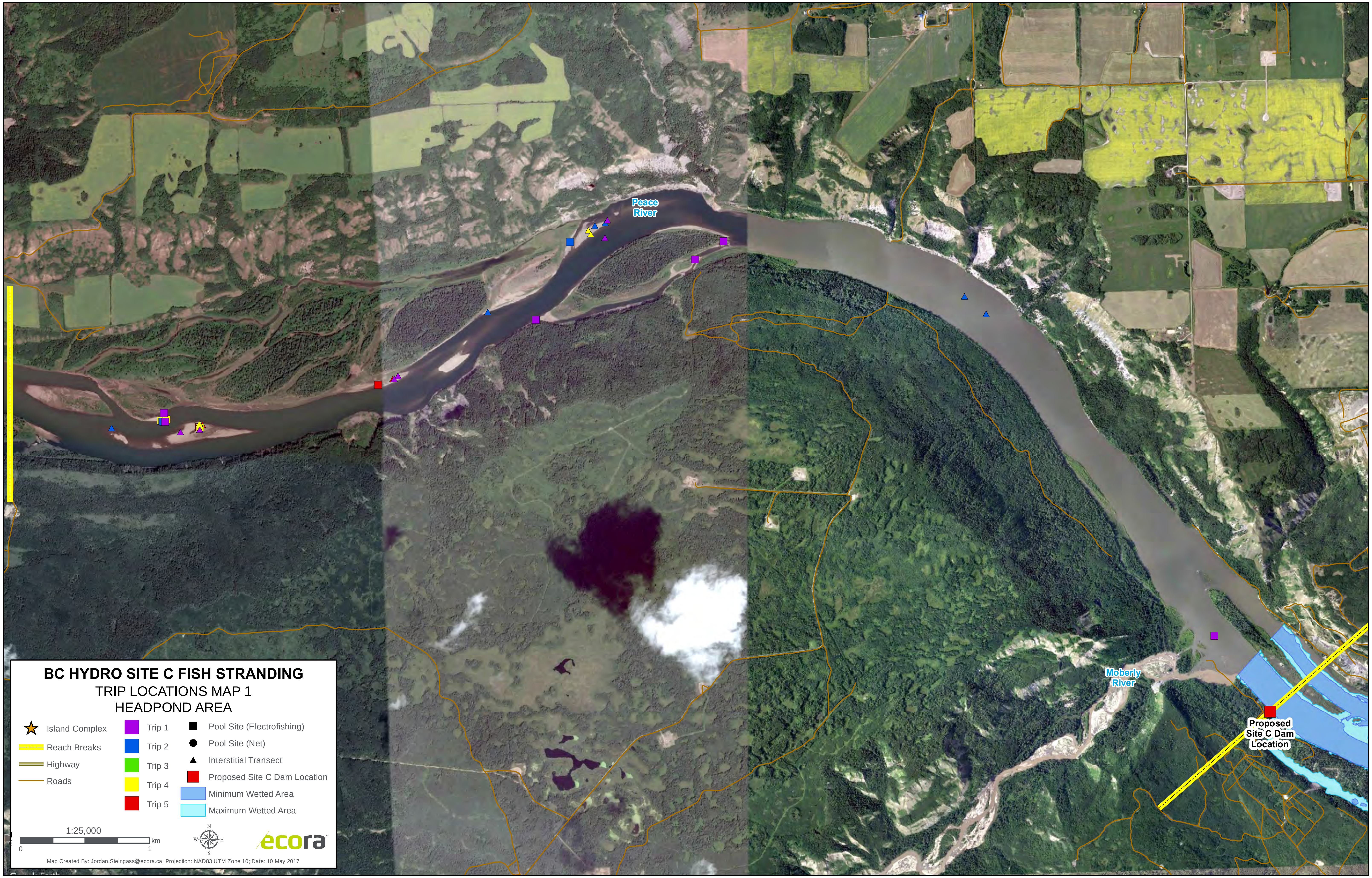
Appendix A

Study Area Maps and Field Sampling Locations


Peace River
Moberly River
Proposed Site C Dam Location
BC HYDRO SITE C FISH STRANDING
TRIP LOCATIONS MAP 1
HEADPOND AREA
Island Complex
Reach Breaks
Highway
Roads
Trip 1
Trip 2
Trip 3
Trip 4
Trip 5
Pool Site (Electrofishing)
Pool Site (Net)
Interstitial Transect
Proposed Site C Dam Location
Minimum Wetted Area
Maximum Wetted Area
1:25,000
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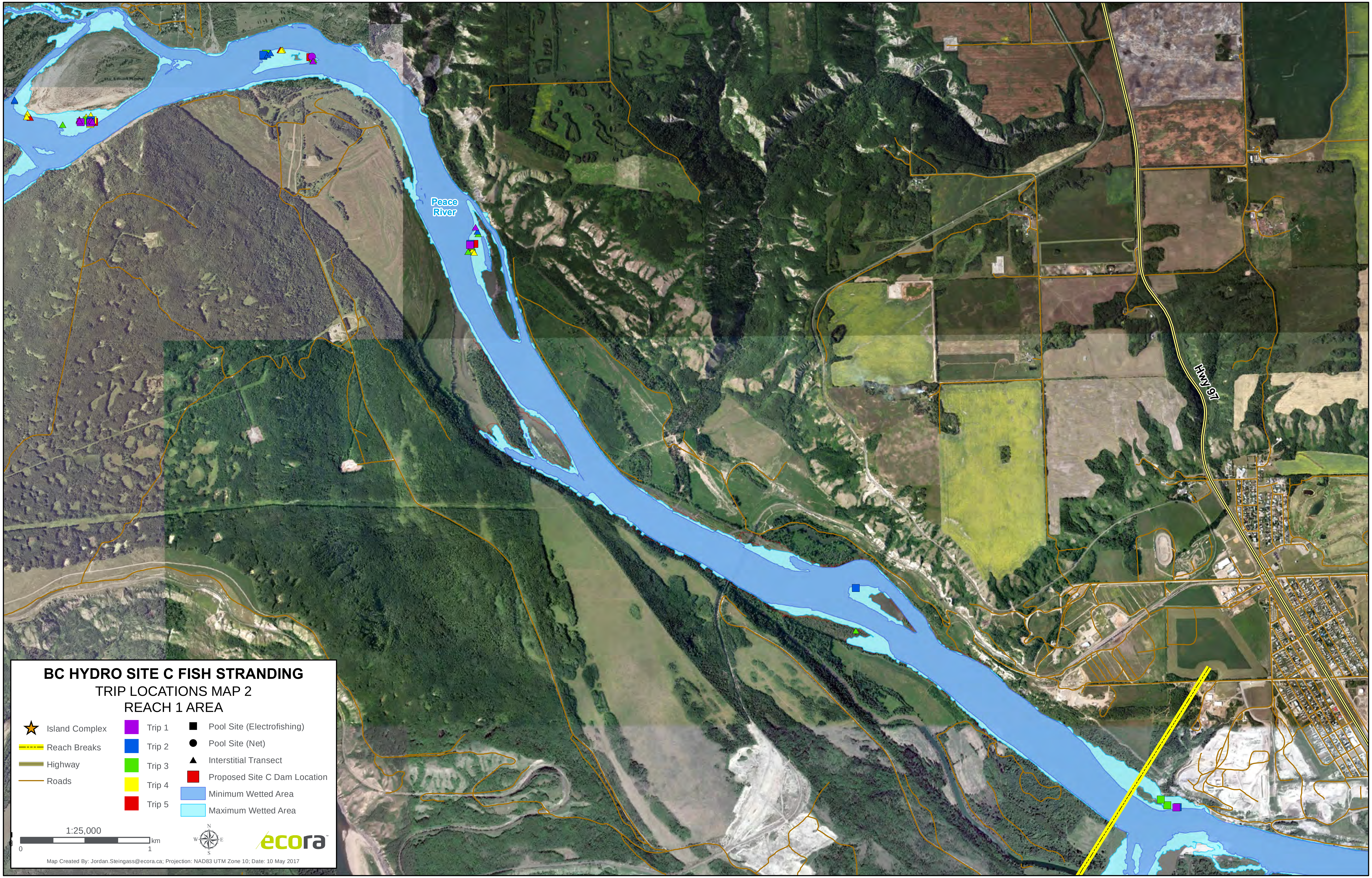
Map Created By: Jordan.Steingass@ecora.ca; Projection: NAD83 UTM Zone 10; Date: 10 May 2017


Peace River
Hwy 97
BC HYDRO SITE C FISH STRANDING
TRIP LOCATIONS MAP 2
REACH 1 AREA
Island Complex
Reach Breaks
Highway
Roads
Trip 1
Trip 2
Trip 3
Trip 4
Trip 5
Pool Site (Electrofishing)
Pool Site (Net)
Interstitial Transect
Proposed Site C Dam Location
Minimum Wetted Area
Maximum Wetted Area
1:25,000
0
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km
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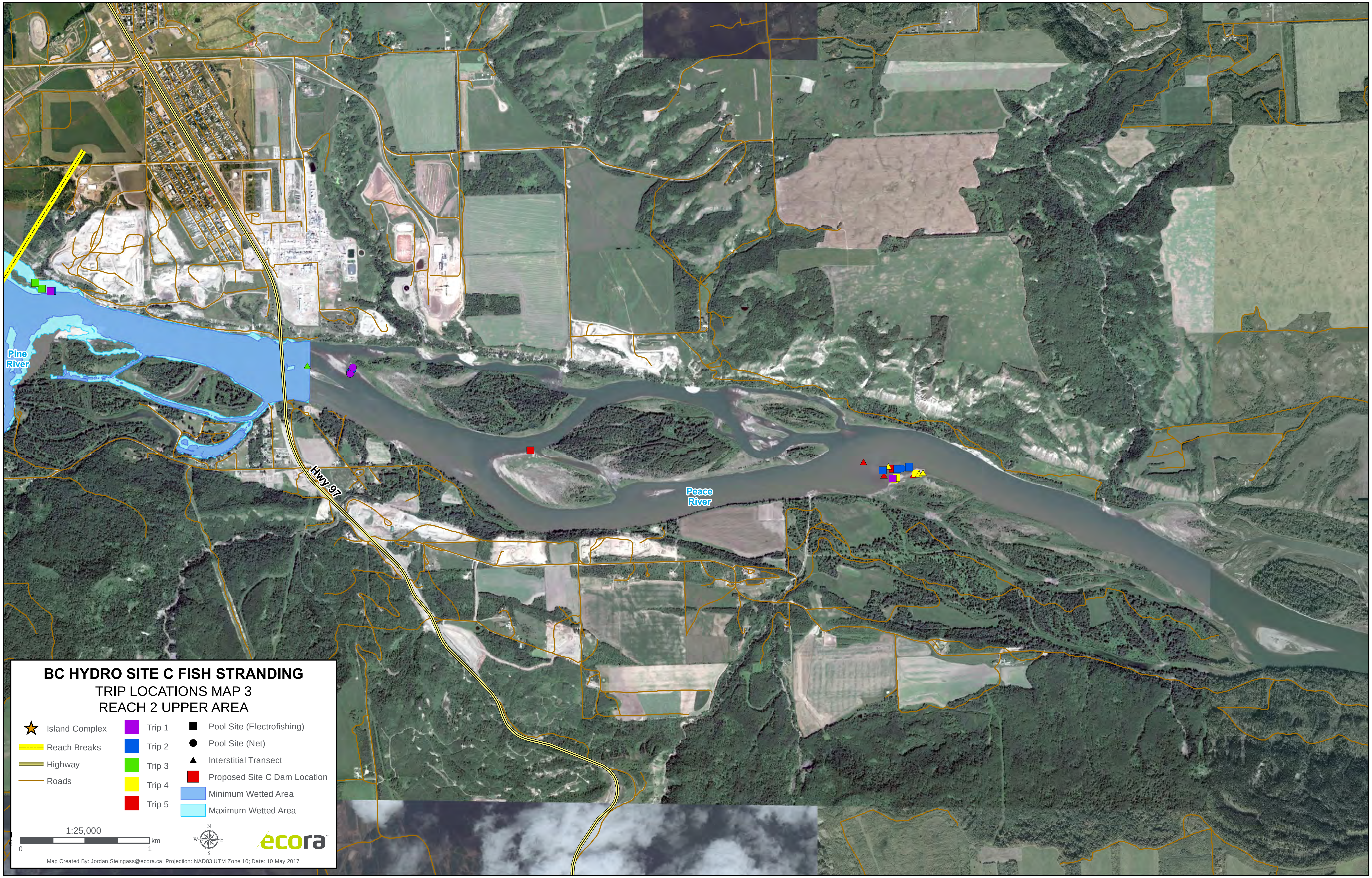
Map Created By: Jordan.Steingass@ecora.ca; Projection: NAD83 UTM Zone 10; Date: 10 May 2017


Pine River
Peace River
Hwy 97
BC HYDRO SITE C FISH STRANDING
TRIP LOCATIONS MAP 3
REACH 2 UPPER AREA
Island Complex
Reach Breaks
Highway
Roads
Trip 1
Trip 2
Trip 3
Trip 4
Trip 5
Pool Site (Electrofishing)
Pool Site (Net)
Interstitial Transect
Proposed Site C Dam Location
Minimum Wetted Area
Maximum Wetted Area
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Beatton River
Pallings Flat
Peace River
BC HYDRO SITE C FISH STRANDING
TRIP LOCATIONS MAP 4
REACH 2 MID AREA
Island Complex
Reach Breaks
Highway
Roads
Trip 1
Trip 2
Trip 3
Trip 4
Trip 5
Pool Site (Electrofishing)
Pool Site (Net)
Interstitial Transect
Proposed Site C Dam Location
Minimum Wetted Area
Maximum Wetted Area
1:25,000
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Peace River
Raspberry Island
Kiskatinaw River
BC HYDRO SITE C FISH STRANDING
TRIP LOCATIONS MAP 5
REACH 2 LOWER AREA
Island Complex
Reach Breaks
Highway
Roads
Trip 1
Trip 2
Trip 3
Trip 4
Trip 5
Pool Site (Electrofishing)
Pool Site (Net)
Interstitial Transect
Proposed Site C Dam Location
Minimum Wetted Area
Maximum Wetted Area
1:25,000
0
1
km
ecora
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Appendix B

Photo Plates

Plate 1 **Downstream view of suitable stranding pool along the right bank within the Diversion Headpond Reach (July 30, 2016).**

Plate 2 **View downstream of interstitial transect sampling along a recently dewatered portion of a gravel bar within Reach 1 (October 14, 2016).**

Plate 3 View of stranding pools formed in the Diversion Headpond Reach.

Plate 4 View of pool formed within mid-stream bar in Reach 1 (sample site 16-02-01-02).

Plate 5 **View of live stranded longnose sucker adult observed within Reach 2 during interstitial sampling (at sample site 16-02-06-03).**

Plate 6 **View of live juvenile burbot observed within Reach 1 during electrofishing sampling (at sample site 16-02-01-02).**