Site C Clean Energy Project

Offset Effectiveness Monitoring for River Road Rock Spurs and Upper Site 109L – 2018

Peace River Fish Community Monitoring Program (Mon-2, Task 2d)
Peace River Physical Habitat Monitoring Program (Mon-3, Task 2c)

Construction Year 4 (2018)

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27 February 2019

REPORT

Site C Clean Energy Project
Offset Effectiveness Monitoring

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Peace River Physical Habitat Monitoring Program (Mon-3, Task 2c)

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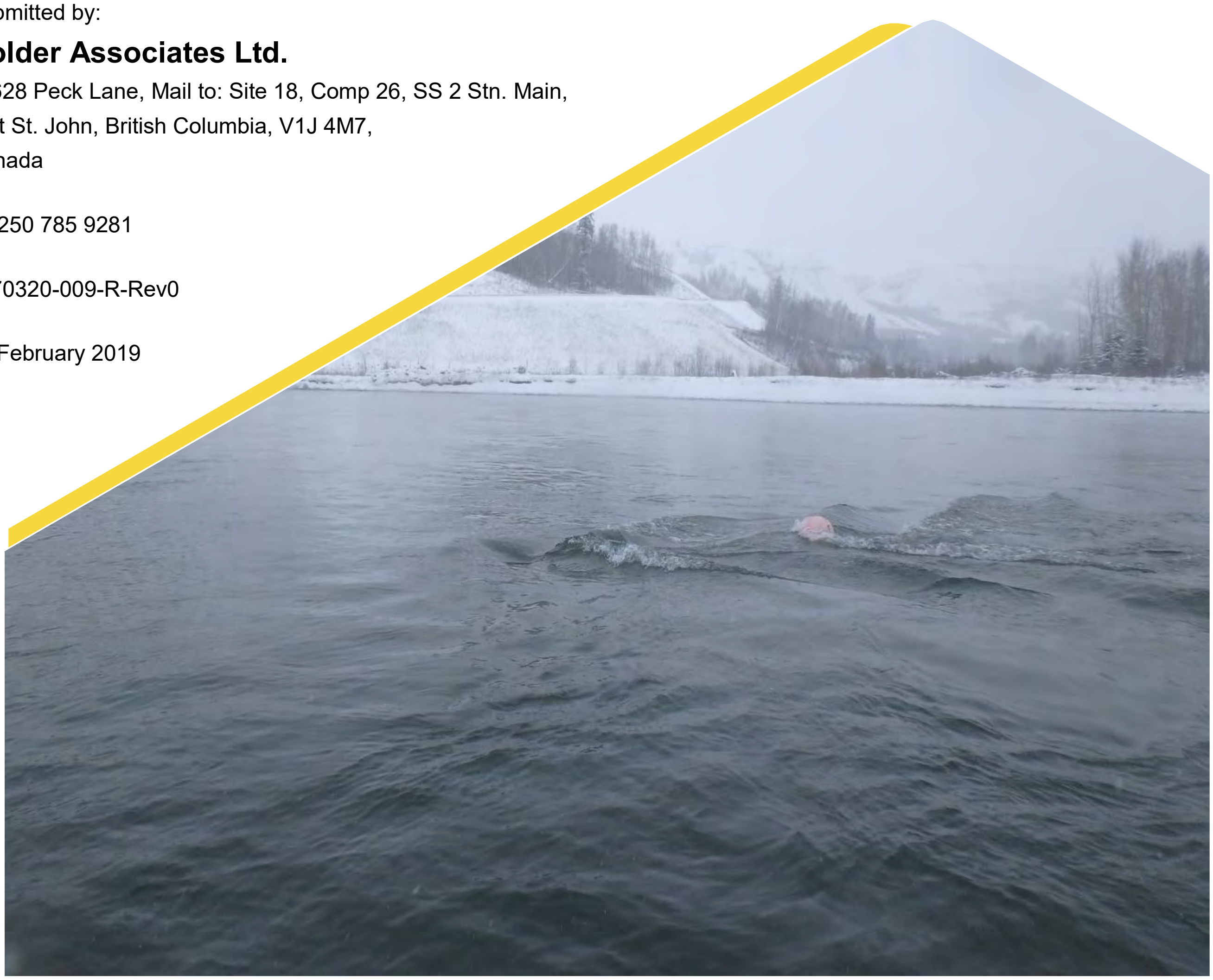

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Executive Summary

Fish and fish habitat are valued components of the Peace River that are considered important by BC Hydro, Aboriginal groups, the public, the scientific community, and government agencies. The Site C Clean Energy Project (the Project), including Project construction, reservoir filling, and operation, could affect fish and fish habitat via three key pathways: changes to fish habitat (including nutrient concentrations and lower trophic biota), changes to fish health and fish survival, and changes to fish movement.

BC Hydro submitted an application to Fisheries and Oceans Canada (DFO) for an authorization under Section 35(2)b of the *Fisheries Act* for several components of the Project associated with Site Preparation. The application included an Offsetting Plan, which proposed the creation of rock spurs along River Road, channel modifications at Upper Site 109L, and channel modifications at Side Channel Site 108R, which were designed to offset unavoidable serious harm to fish as a result of Site Preparation by providing the following (as detailed in the application; BC Hydro 2015):

- increase the quantity and quality of available, permanently wetted habitat to support primary and secondary production as food production for fish and provide rearing, feeding, overwintering, and potential spawning habitats for fish
- reduce fish stranding risk
- increase the complexity and variability of fish habitat to support a variety of life stages for local fish populations

DFO approved the Offsetting Plan and issued a *Fisheries Act* Authorization (FAA; No. 15-HPAC-00170) for site preparation works on 30 September 2015. The FAA requires BC Hydro undertake monitoring and reporting of the implementation of offsetting measures. The objectives of Site C Offset Effectiveness Monitoring are to identify the following (as detailed in the application; BC Hydro 2015):

- that the offsets have been implemented as designed and approved
- that the offsets maintain their design and purpose over time
- that the offsets are biologically effective (i.e., support ongoing productivity)

Construction of two habitat offset areas, the River Road rock spurs and channel modifications at Upper Site 109L, began in 2015 and were completed in 2016. Construction of the third habitat offset area (channel modifications at Side Channel Site 108R) began in October 2018 and construction is scheduled to continue in 2019.

Monitoring the effectiveness of the two constructed habitat offset areas began in 2017. In 2018, the second year of monitoring was completed. This report presents the results of the second of three years of proposed offset effectiveness monitoring for these two offsets.

In 2018, effectiveness monitoring of offset areas focused on the same three components as the 2017 effectiveness monitoring; physical habitat, general fish use, and Mountain Whitefish (*Prosopium williamsoni*) spawning.

Physical habitat was visually assessed to confirm that the rock spurs provided a diversity of hydraulic conditions that were unique to that reach of the Peace River. Water velocity patterns were also assessed using an Acoustic Doppler Current Profiler (ADCP). Where possible, water depth data collected during boat-based and ground-based ADCP surveys were compared to data that were similarly collected in 2015 and 2017. ADCP surveys were conducted on 29 and 30 October 2018 at eight previously established transect locations (Golder 2018). Five transects were previously assessed as part of BC Hydro's Site C Fisheries and Aquatic Habitat Monitoring and Follow-up Program (FAHMFP; Golder 2015), and three new transects were established in 2017 for the purposes of this study.

A visual assessment of the rock spur structures and associated bank armouring along River Road indicated that the near-channel area provides more turbulent and variable flow patterns with slower mean water column velocities when compared to the more laminar flows observed towards the mid-channel and along adjacent Peace River shorelines. Water vector assessments showed that flow directions were affected by the rock spurs, with velocity vectors pointing in different directions. At Upper Site 109L, ADCP mean water column velocity data generally indicate higher velocities near the upstream and downstream ends of Upper Site 109L and lower velocities near the middle of the site. Water velocities were also higher along the mid-channel side (i.e., south side) of Upper Site 109L when compared to the north side. Locations of individual excavated depressions were visible in the ADCP data and indicated variability in water depths and velocities throughout Upper Site 109L. The variability in water depths and velocities created by the excavated channel depressions is likely to increase habitat complexity and habitat suitability for the indicator species (i.e., Arctic Grayling [*Thymallus arcticus*], Bull Trout [*Salvelinus confluentus*], Mountain Whitefish, Rainbow Trout [*Oncorhynchus mykiss*], and Walleye [*Sander vitreus*]). In addition, the excavation of Upper Site 109L to an elevation of less than 407 metres above sea level (masl) ensures that the area remains permanently wetted even under minimum operating flows for the Project (409 masl), increasing the quantity of permanently wetted habitat available for primary and secondary productivity while reducing fish stranding risk. Upper Site 109L remained wetted under all water levels observed over the duration of the 2018 field program. Substrate data collected in 2018 showed variable riverbed material throughout Upper Site 109L. The majority of the material surveyed was relatively clean (no collection of fines evident) gravel and cobble with suitable interstitial spaces for Mountain Whitefish egg incubation.

General fish use was assessed by conducting boat electroshocking sampling in each offset area. Sampling was conducted at three previously established sites that are also assessed as part of the Site C FAHMFP. Two additional sites were established in 2017 and sampled within Upper Site 109L for the purposes of this study. An additional site was established and sampled in 2018 within Upper Site 109L. Boat electroshocking was conducted between 7 September and 10 October 2018. These data were combined with data collected in 2016 and 2017 (i.e., a 3-year block of post offset construction data) and compared to data collected from 2013 to 2015 (i.e., a 3-year block of pre offset construction data).

Fish use data collected in 2018 showed similar trends to those identified in 2017. There was increased use of the area by Arctic Grayling, Bull Trout, and Rainbow Trout, and decreased use of the area by Walleye, Northern Pike (*Esox lucius*), and the three sucker species (Largescale Sucker [*Catostomus macrocheilus*], Longnose Sucker [*Catostomus catostomus*], and White Sucker [*Catostomus commersonii*]). The number of Mountain Whitefish recorded in the rock spur area declined in the first two years after the construction of the offsets; however, Mountain Whitefish catches were lower throughout the Peace River during this same period. In 2018, Mountain

Whitefish catches increased 50% from 2017 and 70% from 2016 catches. A total of four Burbot (*Lota lota*) were recorded in 2017 and 2018 combined along the rock spurs. One of the Burbot captured in 2018 was classified as a young-of-the-year fish with a total length of 82 mm. The 2017 occurrences (both classified as adult fish) were the first two recorded for this species along these two sites of the Peace River in 16 years of systematic sampling conducted by BC Hydro. Sparse data for all other species during all study years limit analysis and interpretation for these species.

Fish use data collected during the three years prior to the construction of Upper Site 109L and data collected during the three years after construction of Upper Site 109L indicated a change in use by Mountain Whitefish. Approximately 40% fewer Mountain Whitefish were captured after the construction of the offset. There was no indication of substantial changes in use of this area for any other fish species or life stages after the construction of the offsets.

The use of Upper Site 109L for spawning by Mountain Whitefish was monitored using artificial substrate mats that rested on the river bottom to trap eggs that drifted downstream. These samplers were deployed continuously between 20 October 2018 and 14 January 2019 and were checked approximately once per week.

Approximately 23,000 mat-hours were expended during a 12-week long Mountain Whitefish spawn monitoring survey within Upper Site 109L. The sampling period covered a range of water temperatures from a high of 6.3°C to a low of 0.4°C, as well as a range of daily average discharge levels (424 m^3/s to 1650 m^3/s).
Mountain Whitefish eggs were not recorded during this period.

Overall, the survey documented the effectiveness of the offsets relative to monitoring objectives. First, the River Road rock spurs and channel modifications at Upper Site 109L were constructed as described in Section 6.2.1 (Mitigation Measures Downstream of Site C Dam Site) of the Project's Fisheries and Aquatic Habitat Management Plan[1] and the offsets maintained their design and function over the monitoring period. Second, physical habitat data collected in 2017 and 2018 showed that the offsets provide a variety of habitats unique to that reach of the Peace River that are suitable for use by a variety of fish species and life stages, while reducing stranding risk. Lastly, a variety of fish species and life stages were recorded in the offset areas after their construction.

[1] Available for download at: https://www.sitecproject.com/sites/default/files/Fisheries_and_Aquatic_Habitat_Management_Plan.pdf.

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1.0 INTRODUCTION AND BACKGROUND

Fish and fish habitat are valued components of the Peace River that are considered important by BC Hydro, Aboriginal groups, the public, the scientific community, and government agencies. The Site C Clean Energy Project (the Project), including Project construction, reservoir filling, and operation, could affect fish and fish habitat via three key pathways: changes to fish habitat (including nutrient concentrations and lower trophic biota), changes to fish health and fish survival, and changes to fish movement. These paths are examined in Volume 2 of the Project's Environmental Impact Statement (EIS)[2].

BC Hydro submitted an application to Fisheries and Oceans Canada (DFO) for an authorization under Section 35(2)b of the *Fisheries Act* for several components of the Project associated with Site Preparation (BC Hydro 2015). The application included an Offsetting Plan, which proposed the creation of rock spurs along the River Road, channel modifications at Upper Site 109L, and channel modifications at Side Channel Site 108R, which were designed to offset unavoidable serious harm to fish as a result of Site Preparation by providing the following (BC Hydro 2015):

- increasing the quantity and quality of available, permanently wetted habitat to support primary and secondary production as food production for fish and provide rearing, feeding, overwintering, and potential spawning habitats for fish
- reducing fish stranding risk
- increasing the complexity and variability of fish habitat to support a variety of life stages for local fish populations

The design of the offsets is described in the Project's Fisheries and Aquatic Habitat Management Plan[3]. BC Hydro's *Fisheries Act* Authorization Application for Site Preparation (BC Hydro 2015) provides the following summary with regards to the construction of the River Road rock spurs:

> *Twenty rock spurs will be constructed along a 2.4 km length of River Road that extend from River Road into the river to enhance fish habitat by providing a diversity of water velocities, depths, and predation refuges. These spurs were proposed in the EIS for the Project and are a common enhancement method to induce eddies or shear zones, which are frequently used as resting and feeding areas by fish (Slaney and Zaldokas 1997). The rock spurs will be constructed either entirely of riprap from Wuthrich Quarry or a combination of river cobble/gravels and armoured with Wuthrich riprap as River Road construction progresses. The rock spurs will be 15 m long and 4 m wide at the crest. The spacing between the spurs will be 60 m, four times their length. The rock spurs will alter 0.19 ha of instream area beyond the River Road footprint. In addition to the rock spurs, this portion of River Road will be stabilized with large riprap and boulders, which will also provide more substrate variability and interstitial cover for rearing fish when compared to existing conditions.*
>
> *Flow conditions associated with the rock spurs (i.e., flow streamlines, water levels, and depth averaged velocities) were modelled using River 2D. Modelling predicted that the spurs would be effective at moving the higher velocities away from the bank, and therefore provide a range of velocities between them that is more*

[2] Available for download at: http://www.ceaa-acee.gc.ca/050/document-eng.cfm?document=85328.

[3] Available for download at: https://www.sitecproject.com/sites/default/files/Fisheries_and_Aquatic_Habitat_Management_Plan.pdf

suitable for fish use. Substrata between the spurs will initially consist of gravel and cobble that is suitable for supporting benthos. At discharges below 1000 m^3/s, the modelling predicted low velocity depositional areas will form between the spurs that will result in some sediment deposition. At higher flows, recirculation between the spurs is predicted, which will limit fine sediment deposition and potentially scour out previously deposited fines…

The rock spurs are expected to enhance fish productivity by diversifying water velocities and depths in the area, as well as providing predation refugia for juvenile large-bodied fish and all life stages of small-bodied fish. Current hydraulic conditions along this section of the river bank are homogenous due to a lack of physical habitat (such as log jams or depositional fans), limited undulations in the shoreline, and a consistent bank slope. The eddies that will form behind each rock spur will benefit most life stages of the cold-water target fish species. Migrating Bull Trout (Salvelinus confluentus) will use the slack water within the eddies for resting. Adult Arctic Grayling (Thymallus arcticus), Bull Trout, Mountain Whitefish (Prosopium williamsoni), and Rainbow Trout (Oncorhynchus mykiss) can hold in the eddies, dart into the adjacent main current to capture prey items drifting downstream, and quickly return to the eddy. Juvenile Rainbow Trout are known to prefer the interstitial areas created within the large riprap substrate (Tabor and Wurtsbaugh 1991; ONA et al. 2014).

Riprap substrate was placed between the rock spurs and adjacent to River Road to armour the newly constructed bank (BC Hydro 2015). The riprap substrate was larger than the substrate found in the area prior to construction (Golder 2016) and is expected to provide additional interstitial cover for small fish. Throughout this report, assessments of fish use consider the combined influence of the River Road rock spurs themselves and the associated bank armouring along the length of River Road.

With regards to Upper Site 109L, BC Hydro (2015) provides the following summary:

The approach is to use a 'cut and fill' excavation and deposition approach in shallow water habitats that are dewatered during Project operations. Areas will be excavated to below low flow levels, and this material will be used to 'fill' adjacent shallow areas to an elevation above high water. Alternatively, at some locations, excavated material from shallow water habitats can be moved and used as Project construction material. The area proposed for excavation during Site Preparation comprises 15.43 ha of instream area and 0.04 ha of riparian area…

The works are expected to increase the potential use of the area for Mountain Whitefish spawning by providing suitable depth and velocity characteristics. The excavation should provide clean gravels and cobbles that will increase interstitial spaces, thereby providing additional cover for eggs and larvae that in turn, may benefit survival of these life stages. The increased wetted surface area and wetted duration of the habitat at Upper Site 109L is also expected to result in an overall increase in primary and secondary productivity…

In addition, channel depressions will be excavated within Upper Site 109L. These depressions and their associated monitoring form part of BC Hydro's adaptive management strategy, and monitoring results on the physical and biological effectiveness of these depressions will guide future channel enhancements. There is substantial biological precedent for the use of structures that alter depth and velocity to increase habitat suitability in rivers, and this approach will be used to increase fish use at this site. These depressions will include both longitudinal (parallel to flow) and transverse (perpendicular to flow) types to create a variety of hydraulic conditions. The depressions proposed are 5 to 25 m in length and width (at the top), and vary in depth from 1 m to 2 m deeper than the adjacent bed. The depressions will be spaced to maintain uniform *hydraulics across the area. The depressions will be located and spaced across the area to optimize fish habitat features.*

These depressions will provide areas of greater depth (up to 3 m at minimum flows) and increase the habitat suitability and complexity in the area by providing more appropriate depths and velocities, as well as complex flow patterns and velocity refugia, while not interfering with the overall flow-through of the main current. The additional habitat complexity provided by the proposed depressions is expected to increase the number of fish that use the area for feeding and holding functions. Hydraulic modelling of 109L shows the velocities of up to [sic] *exceed preferences of Mountain Whitefish during peak operating flows over most of the 109L area. Under these conditions the proposed depressions will provide lower velocities across 109L, increasing habitat suitability over a range of flows for Mountain Whitefish. The depressions are also expected to provide shear zones at higher flows and deeper pool areas for cover and holding at lower flows. These features will provide additional habitat for species such as Walleye (Sander vitreus), Mountain Whitefish and Bull Trout, which make use of deeper habitats.*

Construction of the third offset area (i.e., Side Channel Site 108R) began in October 2018 and is scheduled to continue in 2019.

DFO approved the Offsetting Plan and issued a *Fisheries Act* Authorization (FAA; No. 15-HPAC-00170) for site preparation works[4]. Condition 6.3 of the FAA states that the Proponent shall provide an annual effectiveness monitoring report to DFO. This report documents the results of monitoring in accordance with this condition.

During 2015 and 2016, the construction of the River Road rock spurs and the channel modifications at Upper Site 109L were completed. Monitoring the effectiveness of these two offset areas began in 2017 (Golder 2018), the first year following the construction of the offsets, as described in the monitoring plan. Offset effectiveness monitoring includes data collection that supplements existing monitoring of fish and fish habitat that has been ongoing. This report presents the results of the second year of three years of proposed offset effectiveness monitoring.

1.1 Objectives

The Site C Fisheries and Aquatic Habitat Monitoring and Follow-up Program (FAHMFP) states that the objective of Offset Effectiveness Monitoring is to determine the biological effectiveness of the offsets (i.e., to support ongoing productivity) by monitoring fish abundance and community composition at both a site- (i.e., 100’s m) and reach-scale (i.e., 10’s km). Data were specifically collected as part of this study to summarize the effectiveness of the offset areas at a site-scale. Reach-scale monitoring will be encompassed within the entirety of the Site C FAHMFP. The offset areas were not expected to have an immediate reach-scale effect; therefore, summaries of the reach-scale effectiveness of the offset areas will be provided during future study years.

Site-scale offset effectiveness monitoring as detailed in this report represents a summary of activities conducted under two different components of the Site C FAHMFP: the Peace River Physical Habitat Monitoring Program (Mon-3) and the Peace River Fish Community Monitoring Program (Mon-2).

[4] Available at: https://www.sitecproject.com/sites/default/files/authorization-site-preparation-15-HPAC-00170_0.pdf

The objective of Offset Effectiveness Monitoring (Task 2c) under Mon-3 is to determine if offset areas maintain their structure and function over time and to evaluate the suitability of habitat for fish. One of the uncertainties listed within Mon-3 is if the effectiveness of the offset components in terms of potential rates of sediment deposition and changes in physical configuration will change over time.

The application for authorizations states that there is relatively high confidence (low uncertainty) that the offset measures are likely to be effective. However, uncertainties remain regarding the effectiveness of these offsets in terms of fish use. As a result, fish use of offset areas by indicator species and Mountain Whitefish spawning at the offset areas will be monitored under Task 2d (Offset Effectiveness Monitoring) of Mon-2.

Monitoring techniques, as detailed in Section 2.0, were adapted based on the results of the 2017 survey (Golder 2018) while following the methods and requirements detailed in the FAA. Monitoring is intended to meet the following objectives that are listed in the application:

- are the offsets implemented as designed and approved
- do the offsets maintain their design and purpose over time
- are the offsets biologically effective (i.e., support ongoing productivity)

The offsets were constructed as described in Section 6.2.1 (Mitigation Measures Downstream of Site C Dam Site) of the Project's Fisheries and Aquatic Habitat Management Plan[5].

Determining whether the offsets maintain their design and purpose over time will be tested by Hypothesis #3 of Mon-3, which is stated as follows:

H_3: Site C offset habitat areas in the Peace River maintain their design and purpose over time.

The biological effectiveness of the offsets will be tested by Hypothesis #6 of Mon-2, which is stated as follows:

H_6: Indicator fish species will use the Site C offset habitat areas in the Peace River between the Project and the Many Islands area in Alberta for rearing, feeding, and/or spawning as shown in Table [1].

The indicator fish species referenced in the Site C FAHMFP are Arctic Grayling, Bull Trout, Burbot (*Lota lota*), Goldeye (*Hiodon alosoides*), Mountain Whitefish, Rainbow Trout, and Walleye (BC Government 2011); however, the offset areas were not predicted to yield measurable improvements to habitats preferred by Burbot and Goldeye. As such, these two species are not presented in Table 1. Table 1 has been modified relative to the one presented in the Site C FAHMFP to only include offset areas that are applicable to the Project's Site Preparation FAA.

[5] Available for download at: https://www.sitecproject.com/sites/default/files/Fisheries_and_Aquatic_Habitat_Management_Plan.pdf#page=27.

Table 1: Expected use of proposed habitat offsets located in the Peace River between the Project and the Many Islands area in Alberta by indicator fish species. Modified from Table 2 of the Peace River Fish Community Monitoring Program (Mon-2) of the Site C FAHMFP.

Location	Species				
	Arctic	Bull Trout	Mountain Whitefish	Rainbow Trout	Walleye
River Road Rock	R[a], F	F	R, F	R, F	
Upper Site 109L	R	F	R, F, S	R, F	F
Side Channel Site	R, F		R, F	R, F	

[a] R = rearing; F = feeding; and S = habitat suitable for spawning.

Throughout this report, indicator species are classified as being members of either the coldwater or coolwater fish groups. Information regarding these classifications are summarized in the Project's EIS[6]. Arctic Grayling, Bull Trout, Mountain Whitefish, and Rainbow Trout belong to the coldwater fish group and Burbot, Goldeye, and Walleye belong to the coolwater fish group.

[6] Site C Clean Energy Project Environmental Impact Statement, Volume 2, Section 12.3.2.1.

2.0 METHODS

Peace River discharge data presented in this report are from the Water Survey of Canada's Peace River at Pine River station (Station Number 07FA004)[7], which is located approximately 3 km downstream of Upper Site 109L. Unless stated otherwise, discharge values are daily average values presented in cubic metres per second (m^3/s).

Effectiveness monitoring of offset areas at the site-scale has three components; physical habitat, general fish use, and Mountain Whitefish spawning. A site-scale overview map of the study area is provided in Appendix A, Figure A1.

2.1 Physical Habitat

The study design for physical habitat at the River Road rock spurs and Upper Site 109L included assessing water depths and velocities using an Acoustic Doppler Current Profiler (ADCP) at channel cross section transects and visual assessments of the offsets and the hydraulic features around the offsets. ADCP measurements were obtained by boat or foot depending on water depths (see below). Physical habitat was visually assessed at the rock spurs to determine if they provide a diversity of hydraulic conditions that are less common in that reach of the Peace River. Additional ADCP surveys were conducted around two separate “typical” rock spurs to collect additional measurements of flows around individual rock spurs. The physical habitat survey was conducted on 29 and 30 October 2018.

ADCP surveys were conducted at the same nine previously established transect locations surveyed in 2017 (Golder 2018). Five transects were assessed as part of the Site C FAHMFP's Peace River Physical Habitat Monitoring Program (Mon-3), three transects were established for the purposes of offset effectiveness monitoring (Task 2c; Mon-3) (Table 2; Appendix A Figure A2). The ninth transect (DS08) was situated downstream of both offset areas and was surveyed to collect additional baseline data for the area prior to the development of other proposed offsets associated with the Project (i.e., Lower Site 109L). Although surveyed, cross section data for DS08 are not presented in this report. Where possible, water depth data from 2018 were compared to data collected in 2015 (Golder 2016) and 2017 (Golder 2018).

Table 2: Physical habitat transect locations surveyed on 29-30 October 2018 as part of Site C Offset Effectiveness Monitoring. All transects are located within UTM Zone 10.

Transect Identifier	Offset Location	Left Bank[a] (Transect Start)		Right Bank[a] (Transect End)	
		Easting (m)	Northing (m)	Easting (m)	Northing (m)
DS03	Rock Spurs	630856	6229716	630577	6228620
DS04	Rock Spurs	631314	6229624	631318	6228389
DS05	Rock Spurs	631894	6229580	632071	6228420
DS06a	Upper Site 109L	632275	6229669	632676	6228529
DS06	Upper Site 109L	632409	6229718	632843	6228578
DS06b	Upper Site 109L	632544	6229773	632996	6228659
DS07	Upper Site 109L	632669	6229861	633151	6228740
DS07b	Upper Site 109L	632830	6229854	633283	6228819

[a] As viewed facing downstream.

[7] https://wateroffice.ec.gc.ca/search/real_time_e.html.

ADCP data were collected using two methods:

1) **GPS Total Station Surveys.** A Trimble R10 (GPS RTK; Trimble Inc., Sunnyvale, CA) system and benchmark system were used to measure ground elevations on the banks and elevations in shallow areas of the Peace River near the shorelines that could be accessed safely by field staff wearing chest waders. Water surface elevations were also collected. Topographic elevations were measured along the established cross sections and extended away from the wetted channel to the top of the bank as allowed by terrain access. Large floods (i.e., discharges greater than approximately 2500 m^3/s) were not recorded on the Peace River between surveys conducted in July 2015 and October 2018[8]; therefore, the shoreline above the bankfull elevation was assumed to have remained unchanged between these two surveys and were not recorded in 2018. The maximum wadeable depth during the 2018 survey was approximately 0.6 m.

2) **River Depth Surveys.** A SonTek RiverSurveyor® M9 dual-beam ADCP system (SonTek / Xylem Inc., San Diego, CA) was used to perform depth surveys and to measure riverbed bathymetry. The transducer of the ADCP was mounted 0.20 m below the water surface with a minimum measurable depth of 0.14 m below the transducer. Thus, the minimum measurable water depth was 0.34 m during surveys. Both water depth and water velocity data were collected.

During river depth surveys, the Trimble R10 (GPS RTK) system was attached to the ADCP system and the local coordinates were transmitted to the ADCP unit and incorporated into the raw data by the ADCP data collection software. The two survey methods were referenced to the same datum and had overlap where possible so they could be spliced together to produce a single dataset. For Upper Site 109L, water velocity and water depth figures were created using a 'natural neighbour' interpolation method using a benchmark water surface elevation of 409.26 metres above sea level (masl).

Cross section data from 2018, 2017 (Golder 2018), and 2015[9] (Golder 2016) were available for all transects except DS06a, DS06b, and DS07b (these three transects were not surveyed prior to 2017). Transect data were plotted, overlain, and visually assessed to identify changes in elevations over time.

In addition to the ADCP data collected at established transects (Table 2), additional ADCP data were also collected within the Upper Site 109L area to garner more information on water velocities and water depths in this area. These data were collected by conducting longitudinal transects (surveyed from upstream to downstream) across the area.

2.1.1 Substrate Characteristics

On 30 November, substrate characteristics for Upper Site 109L were assessed through the collection of substrate grab samples. Field crews attempted to collect grab samples within Upper Site 109L using a Wildco petite PONAR® substrate sampler (Wildco, Yulee, FL) and the methods outlined by Cavanagh *et al.* 1994. The petite PONAR® sampler consists of a trigger mechanism that holds two opposing semi-circular jaws open while the device is lowered through the water column. When the sampler contacts the river bottom the trigger mechanism causes the jaws to close around a substrate sample, which is then brought to the surface. Material is kept inside

[8] The highest daily average discharge for the Peace River at Water Survey of Canada gauging station 07FA004 between the two survey periods was 2010 m^3/s on 4 September 2015.

[9] For some transects, data were available for years prior to 2015; however, these data were not analyzed as part of the current study. See Church (2015) for a summary of these data.

the sampler by a 500 µm copper screen which covers the top of the petite PONAR® sampler so the sample is not lost during retrieval. The petite PONAR® substrate sampler proved ineffective at Upper Site 109L due to high water velocities. The sampler was deployed at 10 different locations within Upper Site 109L; samples were not collected during any of these attempts. Use of the sampler as an assessment method was abandoned in favour of alternative methods (underwater video surveys). Results from the petite PONAR® substrate sampler are not discussed further in this report.

Imagery collected by underwater video surveys was used to collect substrate characteristic data (i.e., particle size and embeddedness) at select locations within Upper Site 109L where water depths were less than 2.0 m. The video survey was conducted on 19 December during a period of low water discharge and low water turbidity. Seven video transects were conducted within Upper Site 109L starting at the upstream end of the site (Table 3). Underwater video footage was collected using an Olympus Stylus Tough TG-870 waterproof digital camera (Olympus Canada Inc., Richmond Hill, ON) recording in HD 1080p video. The camera was attached to an aluminium survey rod that was marked in 10 cm increments. The underwater camera was lowered on the survey rod off the port side of the boat, approximately 0.2 m off the river bottom. The initial starting depth was measured using the depth sounder on the boat. Video footage was collected as the boat drifted downstream with the current until water depths exceeded the depth of view of the camera, which typically occurred at water depths greater than 2.0 m. Substrate sizes were not expressly measured but were compared to adjacent substrates. In addition to the substrate imagery, anecdotal observations of water clarity and the amount/type of substrate material collected on the mats were recorded throughout the Mountain Whitefish spawning monitoring survey (Section 2.3).

Table 3: Substrate characteristic underwater video locations surveyed on 19 December 2018 as part of Site C Offset Effectiveness Monitoring. All video sites are located within UTM Zone 10.

Video Sites	Offset Location	Easting (m)	Northing (m)	Comments
Video-01	Upper Site 109L	632403	6229544	Near substrate mat M3
Video-02		632376	6229555	Near substrate mat M3
Video-03		632521	6229515	Near substrate mat M6
Video-04		632827	6229698	Near substrate mat M12
Video-05		632710	6229667	Near substrate mat M7
Video-06		632480	6229589	Near substrate mat M4
Video-07		632142	6229511	Near substrate mat M1

2.2 General Fish Use

The study design for fish use consisted of monitoring each of the two offset areas (i.e., River Road rock spurs and Upper Site 109L) between early September and early October. This timing corresponded with the timing of historical surveys conducted by BC Hydro (e.g., Mainstream 2010, 2011, 2013, Mainstream and Gazey 2004-2014; Golder and Gazey 2015-2018). A more accurate comparison between the two datasets was possible by aligning the study period with historical datasets. The sampling conditions in the Peace River during the late summer to early fall period were the most suitable in terms of water clarity, water temperature, and discharge. In addition, the fish species and life stages that are expected to use the offset areas were expected to be present at this time. During the first year of monitoring (2017), sampling during other seasons was considered, but ultimately abandoned due to expected inefficiencies, largely associated with ice formation and cold weather in the winter and high water levels and high turbidity during the spring and early summer.

During the 2018 survey, boat electroshocking was the exclusive fish capture technique conducted for assessing general fish use of the River Road rock spurs and Upper Site 109L. Other capture and observation methods, including gillnets, minnow traps, backpack electrofishing, beach seining, visual surveys (both snorkel-based and boat-based), and sonar surveys, were considered or attempted during the 2017 survey period but were considered ineffective and were not employed in 2018. Most of these methods were considered unsafe or impractical due to the physical characteristics of the offset areas (i.e., high water depths, water velocities, and turbidity).

Boat electroshocking techniques were consistent with techniques used during baseline studies (e.g., Golder and Gazey 2015-2017) and the 2017 survey (Golder 2018), and followed industry standard methods (e.g., Nielsen and Johnson 1992). Sampling consisted of a three-person crew operating a Smith-Root Inc. (Vancouver, WA) high-output Generator Powered Pulsator (GPP 5.0) electroshocker from a 5.5 m outboard jet-drive riverboat. The electroshocking procedure generally consisted of manoeuvring the boat downstream along the shoreline of each sample site; however, Sites 109OSA and 109OSB (Appendix A, Figure A3) were located further from the shoreline to ensure adequate coverage of Upper Site 109L. Two crew members, positioned on a netting platform at the bow of the boat, netted stunned fish, while the third individual operated the boat and electroshocking unit. The two netters attempted to capture all fish that were stunned by the electrical field. Captured fish were immediately placed into a 175 L onboard live-well equipped with a freshwater pump. To prevent electroshocking-induced injuries, fish were netted one at a time (i.e., fish were not double-netted). Fish that were positively identified but avoided capture were enumerated and recorded as “observed”. The electroshocking unit was operated at a frequency of 30 Hz with pulsed direct current. Amperage was adjusted as needed to achieve the desired effect on fishes, which was the minimum level of immobilization that allowed efficient capture and did not cause undesired outcomes such as immediate tetany or visible haemorrhaging (Martinez and Kolz 2009). An amperage of 3.2 A typically produced the desired effect on fishes; however, the amperage was set as low as 2.1 A and as high as 4.0 A at some sites based on local water conditions. Electroshocker settings were based on information provided by Golder (2004, 2005) that resulted in less electroshocking-induced injuries on large-bodied Rainbow Trout in the Columbia River. These settings also align with recommendations by Snyder (2003) for pulsed direct current and low frequencies for adult salmonids.

Habitat variables recorded at each site (Table 4) included variables recorded during baseline studies (e.g., Golder and Gazey 2015–2017) and the 2017 survey (Golder 2018). These data were collected to provide a means of detecting changes in habitat availability or suitability in sample sites over time and were not intended to quantify habitat availability or imply habitat preferences.

Where water depths were sufficient, water clarity was estimated using a “Secchi Bar” that was manufactured based on the description provided by Mainstream and Gazey (2014). Mean and maximum sample depths were estimated by the boat operator based on the boat’s sonar depth display.

Table 4: Habitat variables and boat electroshocker settings recorded at each site during each sample session in 2018.

Variable	Description
Date	The date the site was sampled
Time	The time the site was sampled
Air Temp	Air temperature at the time of sampling (to the nearest 1°C)
Water Temp	Water temperature at the time of sampling (to the nearest 0.1°C)
Conductivity	Water conductivity at the time of sampling (to the nearest 10 µS/cm)
Secchi Bar Depth	The Secchi Bar depth recorded at the time of sampling (to the nearest 0.1 m)
Cloud Cover	A categorical ranking of cloud cover (Clear = 0-10% cloud cover; Partly Cloudy = 10-50% cloud cover; Mostly Cloudy = 50-90% cloud cover; Overcast = 90-100% cloud cover)
Boat Model	The model of boat used during sampling
Range	The range of voltage used during sampling (high or low)
Percent	The estimated duty cycle (as a percent) used during sampling
Amperes	The average amperes used during sampling
Mode	The mode (AC or DC) and frequency (in Hz) of current used during sampling
Length Sampled	The length of shoreline sampled (to the nearest 1 m)
Time Sampled	The duration of electroshocker operation (to the nearest 1 second)
Mean Depth	The mean water depth sampled (to the nearest 0.1 m)
Maximum Depth	The maximum water depth sampled (to the nearest 0.1 m)

2.2.1 River Road Rock Spurs

Data from two boat electroshocking sites (Site 0505 and 0506; Appendix B, Figure B3) situated along River Road and sampled as part of the Site C Peace River Large Fish Indexing Survey (Mon-2, Task 2a) were assessed to determine general fish use of the rock spurs. These two sites were previously surveyed each year between 2007 and 2017 under various BC Hydro projects and provide a baseline dataset for the River Road area. Under Mon-2, Task 2a, each of these two sites were sampled five times in 2018, approximately once per week, between 7 September and 10 October. No additional sampling was conducted for the River Road area as part of Offset Effectiveness Monitoring.

2.2.2 Upper Site 109L

Data from four boat electroshocking sites (Site 0509, 109OSA, 109OSB and 109OSC) were situated within Upper Site 109L (Appendix A, Figure A3). Site 109OSC was created in 2018 and was located along the shoreline between the downstream end of Site 0506 and the upstream end of Site 0509. Site 0509 was sampled as part of Mon-2, Task 2a. Site 0509 was sampled each year between 2007 and 2017 under various BC Hydro projects (e.g., Golder and Gazey 2018). Sites 109OSA, 109OSB and 109OSC were sampled four times in 2018 (14, 20, and 27 September and 10 October). These sites are not index sites that are sampled as part of Mon-2, Task 2a, but were sampled specifically in 2018 to gather additional information on fish use of Upper Site 109L as part of offset effectiveness monitoring. Sites 109OSA and 109OSB were sampled once in 2017. Sites 0509, 109OSA, 109OSB and 109OSC were situated within Upper Site 109L, but Sites 109OSA and 109OSB were located further offshore when compared to Sites 109OSC and 0509 (Appendix A, Figure A3).

Portions of Site 0509 are located outside of Upper Site 109L. As such, fish captured within Site 0509 in 2018 were further delineated into Site 0509a (located within the boundaries of Upper Site 109L) and Site 0509b (located outside the boundaries of Upper Site 109L) for some analyses.

2.2.3 Data Analysis

Diversity profile analyses developed by Golder and Gazey (2018) for the Peace River were modified and limited to only include data from the offset areas to monitor changes to the fish community's composition in response to the construction of the two offsets. A diversity profile plots the relationship between diversity and the degree to which relative abundance is represented (Leinster and Cobbold 2012). The response variable in a diversity profile is the "effective number of species", which is the number of equally common species required to get a particular value of an index (Jost 2006). Effective numbers are recommended for comparisons of diversity because they allow intuitive and straightforward comparison of the number of species, instead of individual indices, which are more difficult to interpret and can be misleading due to non-linearity (Jost 2006; Chao et al. 2014).

Diversity profiles were calculated using the following equation:

1) $$^{q}D^{\mathbf{Z}}(\mathbf{p}) = \left(\sum p_i \,(\mathbf{Zp})_i^{q-1}\right)^{\frac{1}{1-q}}$$

where D is the effective number of species, p is the relative abundance of the species present, q is the parameter representing the relative contribution of relative abundance data, and Z is the similarity matrix among species (Leinster and Cobbold 2012). A value of $q = 0$ represents no importance of relative abundance and is equivalent to a count of the number of species, often referred to as species richness. A value of $q = 1$ is equivalent to the Shannon index. Values less than 1 result in rare species being over-represented, and values greater than 1 result in common species being over-represented. Values on the right of a diversity profile (highest values of q) are insensitive to changes in rare species and values on the left are sensitive to rare species. The shape of diversity profiles can be used to interpret the community composition and compare composition between datasets. For instance, a flat profile indicates near equal abundance among species, whereas a steeper profile indicates more unequal abundance among species. Diversity profiles allow comparison of the number of effective species across the entire range of importance of rare/common species, instead of requiring the assumptions of a single diversity index. Diversity profiles have previously been used in a power analysis to assess the likelihood of detecting significant differences in community composition in the Peace River before and after Project construction (Ma et al. 2015).

Diversity profiles were calculated separately for each year, combining the catch data from all sample sessions and sites within the offset area. To assess differences in community composition, the mean values with 95% confidence intervals were calculated from the three years before offset construction (2013-2015) and the three years after offset construction (2016-2018) from the annual diversity profiles. The analysis used captured fish of all species but excluded fish not identified to the species level (e.g., fish recorded as sculpin species or sucker species). For the species similarity matrix (Z), values were set to 1 for all "small fish" species and for all sucker species, which treated each of these groups as one species. These settings were consistent with Ma et al. (2015) and based on groupings established in the Site C EIS[10]. Diversity was not statistically compared between each section (e.g., t-test). Instead, the effective number of species are shown graphically to allow the reader to decide what magnitude of difference is biologically meaningful.

2.3 Mountain Whitefish Spawning

The study design for Mountain Whitefish spawning consisted of deploying artificial substrate mats throughout Upper Site 109L and adjacent areas (Appendix A, Figure A4) to collect eggs that were deposited in the area over the expected Mountain Whitefish spawning season. The spawning season was expected to be between late October to mid-December, based on data from other systems (e.g., Golder 2014) and water temperatures. Northcote and Ennis (1994) found that Mountain Whitefish initiate spawning in the fall when water temperatures decline below 6°C. Water temperature at the start of sampling averaged 6.3°C and declined to a low 0.4°C during the monitoring period. Any eggs collected would be considered as evidence that Mountain Whitefish used the area for spawning. Habitat near the River Road rock spurs was not predicted to provide potential Mountain Whitefish spawning habitats (Table 1); therefore, this area was not surveyed, per the monitoring plan (BC Hydro 2015). Mountain Whitefish spawning monitoring was conducted between 20 October and 14 January (Table 5), approximately 1 month longer than monitoring conducted in 2017.

Table 5: Summary of Mountain Whitefish spawning monitoring conducted as part of Site C Offset Effectiveness Monitoring, 2018.

Date(s)	Activity
20 and 21 October	Deployment of egg collection mats
25 and 31 October; 8, 22 and 30 November; 3, 11, and 19 December; 4 January	Retrieval, inspection, and redeployment of egg collection mats
14 January 2019	Retrieval, inspection, and removal of egg collection mats

Mountain Whitefish spawning monitoring followed industry-accepted methods (e.g., Golder 2014, 2017) and was consistent with 2017 methods (Golder 2018). Artificial substrate mats consisted of a 0.76 by 0.76 m iron frame that enclosed two layers of filter material (latex-coated animal hair). When deployed, the mats rested on the river bottom to trap eggs that drift downstream. All sets deployed in 2018 were mid-channel sets which consisted of an anchor system and a 10 m long steel cable that connected the anchor system to the egg collection mat. A float line with approximately 15 m of rope was attached to the mat to enable retrieval by boat. Another float line with approximately 15 m of rope was also attached to the anchor system to allow for removal of the anchor system at the end of the survey. A total of 12 mid-channel sets were used during the 2018 survey. During the 2017 survey, shore-based sets were deployed at some locations; however, they frequently became dewatered and pushed up onto shore during water level fluctuations. Shore-based sets were not deployed in 2018. Mats were positioned throughout Upper Site 109L and adjacent areas and were repositioned periodically over the study period to ensure adequate coverage of the offset. The egg collection mats were retrieved by the float line. Carabiners were used at all float line attachment points to allow quick removal of the mats. The mats were then pulled off the river

[10] Site C Clean Energy Project Environmental Impact Statement, Volume 2, Section 12.3.2.2.

bottom by an electric winch mounted on the starboard side of the boat and brought on board the boat. Once the one mat was detached, the float line was attached to a new mat on the anchor cable and the set was redeployed.

Each egg collection mat was inspected by two different people, and if eggs were collected, they were to be removed using forceps and placed in preservative for later staging. During the collection process, the number of eggs collected on each mat, set time and date, retrieval time and date, water temperature, depth (determined by the boat-mounted echo sounder) and location (UTMs) were recorded on standardized field forms.

A total of 12 egg collection mats were deployed each week until 11 December when one of the egg collection mat sets was too damaged to replace. The remainder of the Mountain Whitefish spawning study was conducted with 11 egg collection mats. Mats were not always deployed at the same locations and not all locations were sampled continuously over the study period. Over the 2018 study period, 15 different locations were surveyed (Table 6; Appendix A, Figure A4). Egg mats within the study area were retrieved, checked, cleaned, and redeployed generally on a weekly basis. Occasionally during this survey period, mats were left unchecked for two weeks due to poor weather conditions or scheduling logistics. Prior to each deployment, mats were inspected and the filter material was replaced as required.

Table 6: Locations sampled as part of the Mountain Whitefish spawning survey for Site C Offset Effectiveness Monitoring, 2018. All sites are located within UTM Zone 10.

Site Name	UTM Easting	UTM Northing
M01	632004	6229509
M02	632180	6229554
M03	632205	6229501
M04	632418	6229614
M05	632434	6229547
M06	632434	6229496
M07	632614	6229649
M08	632617	6229590
M09	632605	6229499
M10	632849	6229674
M11	632825	6229573
M12	630002	6229657
M13	632468	6229606
M14	632929	6229678
M15	632853	6229720

3.0 RESULTS

3.1 Physical Habitat

River cross section profiles were measured at eight transects in 2018 to provide channel profile data. Survey transect locations are provided in Appendix A, Figure A2, and cross section profiles are presented in Appendix B, Figures B1 to B8. Six of the channel cross sections were previously surveyed in July 2015 (Golder 2016) and eight of these transects were previously surveyed in 2017 (Golder 2018). Where possible, data from 2015 and 2017 were compared to results from the current survey. Water velocity data and water depth data for Upper Site 109L are presented in Appendix B, Figures B17 and B18, respectively.

3.1.1 River Road Rock Spurs

Transects DS03, DS04, and DS05 are located along the length of the Peace River where River Road and associated bank armouring, as well as the rock spurs, were constructed between 2015 and 2016. As noted during the 2017 study year, the activities associated with the construction of River Road resulted in the left bank (i.e., north shore) shifting south towards the river compared to 2015 data (Appendix B, Figures B1 to B3). No additional lateral movement was noted in 2018.

At Transect DS03, an approximate 0.5 m decrease in elevation of the riverbed approximately 300 m from the north bank (Appendix B, Figures B1) was noted between 2017 and 2018. The remaining two transects (DS04 and DS05) showed minimal change to the riverbed elevation (as erosion or deposition) between 2017 and 2018 (Appendix B, Figures B2 to B3).

Water direction and velocity data were collected at Transects DS03, DS04, and DS05 and are presented in Appendix B, Figures B9, B10, and B11, respectively. Similar to 2017, the transects surveyed in 2018 portrayed the same general water velocity patterns. For approximately 20 m from the shoreline, the rock spurs created a more turbulent flow pattern (i.e., variable water velocities and flow direction), when compared to the more laminar flows observed towards the mid-channel, consistent with River 2D model predictions (BC Hydro 2015). These results are supported by additional ADCP data collected around two individual rock spurs in 2018 (Appendix B, Figures B13 and B14), which show variable water velocities that generally increase in speed with distance from the shoreline. The rock spurs created areas of variable water depths in and around the individual structures. Depths around one individual rock spur surveyed ranged between 0.8 m and 6.4 m (Figure B15) and between 1.5 m and 4.0 m around the second rock spur surveyed (Figure B16). The deepest water relative to the rocks spurs was located directly adjacent to the southern end of each rock spur as well as downstream of the rock spurs and shallower water was measured directly over the top of the rock spurs (Figure B15 and B16).

Similar to 2017 results, in 2018, the majority of water velocities around the rock spurs were measured at 0.4 m/s or less (average velocities over the entire water column), which was approximately 1.6 m/s slower than the average water velocities recorded at these transects in the mid-channel area (approximately 2.0 m/s). Velocity vectors show that flow directions were affected by the rock spurs, with velocity vectors pointing randomly in different directions (towards the river bank, upstream, downstream, and towards the mid channel). The 2018 transect data showed a similar range and pattern of water velocities measured around the rock spurs.

Measured water velocities increased as the transect continued further south (i.e., towards mid-channel and away from the influence of the rock spurs) until the south side of the thalweg, where measured water velocities started to decrease toward the south shore. Most of the flow measured away from the rock spurs was laminar with the water vector directions pointed downstream.

3.1.2 Upper Site 109L

Upper Site 109L was recontoured to have a riverbed elevation of less than 407 masl, ensuring that the area remains permanently wetted, even under the minimum operating flows for the Project (409 masl; BC Hydro 2015). This permanently wetted area increases the quantity of habitat available for primary and secondary production, increases the area available for fish eggs to incubate without risk of dewatering, and eliminates fish stranding risk under expected operations.

Five transverse transects were located within Upper Site 109L (Transects DS06a, DS06, DS06b, DS07, and DS07b) (Appendix A, Figure A2). Water direction and velocity data collected at these transects are presented in Appendix B, Figure B12. Results from Transects DS06a and DS06 (the two most upstream transects in Upper Site 109L) indicated that profile changes were the result of the deposition of material and occurred mainly along the north bank at Transect DS06a and near mid-river at Transect DS06. Data from Transect DS06a showed an approximate 1.0 m increase in elevation of the riverbed approximately 100 m from the north bank (Appendix B, Figure B4), while data from Transect DS06 showed an approximate 2.0 m increase in elevation approximately 200 m from the north bank (Appendix B, Figure B5). In late April 2018, field crews working in the area noted a large root wad impinged in the substrate in the vicinity of Transect DS06 and near the area where the riverbed change was recorded. The root wad was observed several times in the spring of 2018, but was not observed later in the year during boat electroshocking, ADCP, or Mountain Whitefish spawning monitoring surveys. The root wad was not observed prior to the spring of 2018.

Transects DS06b, DS07, and DS07b (Appendix B, Figures B6 to B8) indicated minimal deposition or aggregation between 2017 and 2018.

ADCP mean water column velocity data (Appendix B, Figure B17) generally indicate higher velocities near the upstream and downstream ends of Upper Site 109L and lower velocities near the middle of the site. Water velocities were also higher along the mid-channel side (i.e., south side) of Upper Site 109L when compared to the north side.

In 2018, data from the original five transects combined with the data from the additional longitudinal transects allowed for better resolution when compared to data collected in 2017. In 2018, the locations of individual excavated depressions were visible in the data. The excavated contours provided areas of lower water velocities (0 to 1.5 m/s) relative to adjacent areas (2.0 to 2.5 m/s) (Appendix B, Figure B17). ADCP mean water column depth data (Appendix B, Figure B18) indicate variations in water depths associated with the transverse depressions. The variability in water depths and velocities created by the excavated channel depressions is likely to increase habitat complexity and habitat suitability for the indicator species.

3.1.2.1 Substrate Characteristics

Underwater video imagery was collected on December 19 when water levels and turbidity were low. The average Secchi depth recorded at the time of the survey was 1.65 m, while water depths recorded on the same day ranged between 1.0 m and 3.1 m. Video footage indicated variable riverbed substrate in Upper Site 109L. Areas dominated by clean gravel and small cobbles, with no visible accumulations of fines, were common (Plate 1).

Substrate surveyed during Video-03 (i.e., the area between substrate mat M06 and M09; Appendix A, Figure A4) consisted mainly of sands and fines (Plate 2).

Table 7: Substrate characteristics at Upper Site 109L surveyed as part of Site C Offset Effectiveness Monitoring on 19 December 2018.

Video Site Name	Start Time	Depth (m)	Dominant Substrate	Sub-dominant Substrate
Video-01	12:00	1.7	Gravel	Cobble
Video-02	12:04	1.5	Gravel	Cobble
Video-03	12:08	1.0	Sand	Gravel
Video-04	12:11	1.2	Gravel	Cobble
Video-05	12:14	1.6	Cobble	Gravel
Video-06	12:16	1.7	Gravel	Cobble
Video-07	12:18	1.5	Gravel	Cobble

During the Mountain Whitefish spawning period (Section 3.3), field crews noted that substrate mats at M06 and M09 had substantial volumes of sand and small gravel embedded in the mat material (Plate 3). During one retrieval, the downstream anchor and chain of M06 were completely covered with sand and fine substrate and was not visible to the crew.

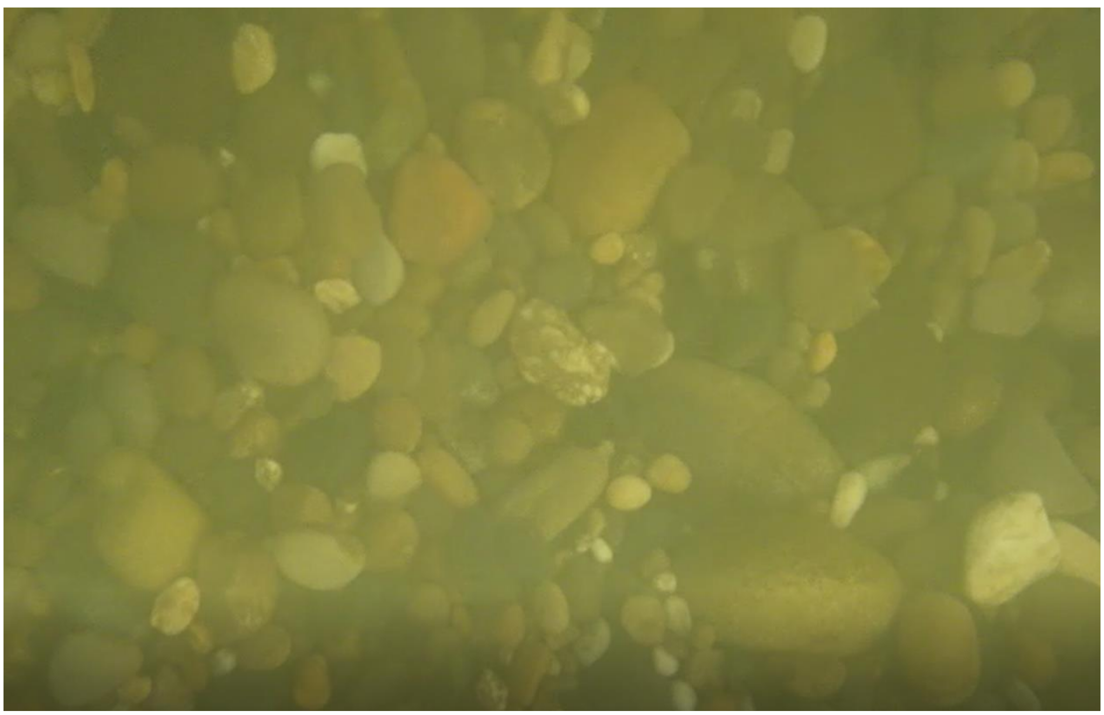

Plate 1 Riverbed substrate material image captured at the Video-01 site located upstream of substrate mat M05 (Appendix A, Figure A4), 19 December 2018.

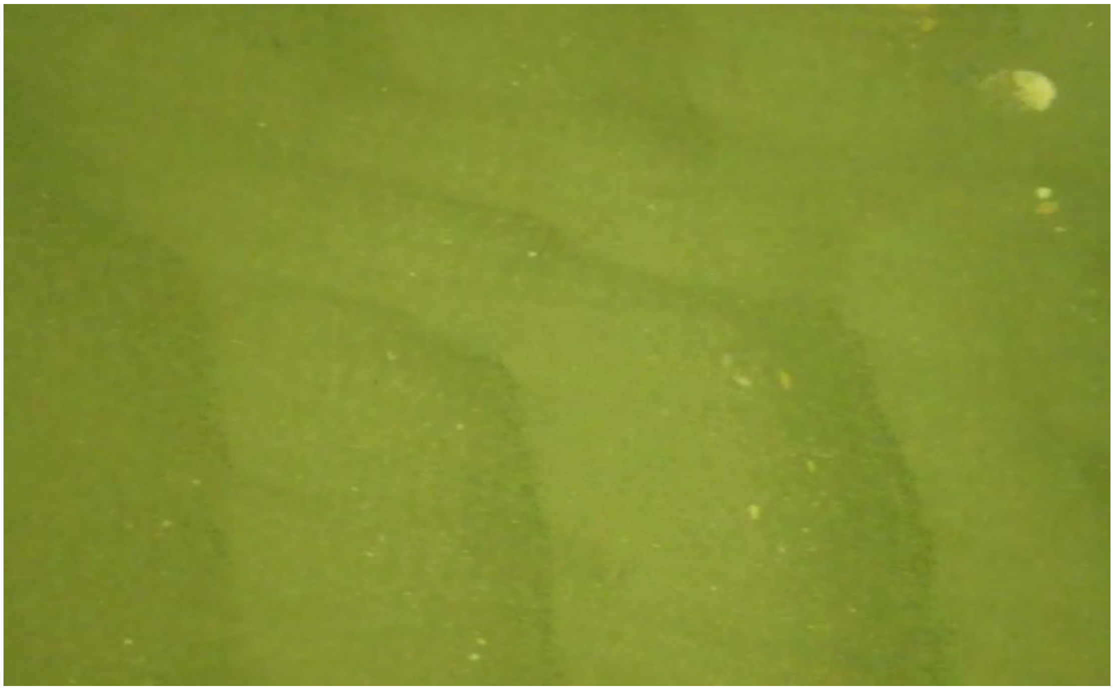

Plate 2 Riverbed substrate material image captured at the Video-03 site located between substrate mat M06 and M09 (Appendix A, Figure A4), 19 December 2018.

Plate 3 Sand and fines deposited onto substrate mat M09 on 4 January 2019.

Currently, the range of water depths (0.7 to 4.2 m), velocities (0.13 to 1.8 m/s), and substrates (dominantly gravels with cobbles subdominant; Golder 2016) within Upper Site 109L are similar to criteria preferred by the indicator species and life stages (e.g., CEMA 2009; Golder 2014). Fish were not observed by crew members during the substrate characteristics survey.

3.2 General Fish Use

Sites 0505, 0506, and 0509 were sampled in 2005 (Mainstream and Gazey 2006) and 2006 (Mainstream and Gazey 2007) and from 2008 to 2018 inclusive (Mainstream and Gazey 2008-2014; Golder and Gazey 2015-2018; Golder and Gazey in prep.) as part of various BC Hydro studies. These studies include the Large River Fish Indexing Program (2001 to 2007), the Peace Project Water Use Plan (2008 to 2014), and Mon-2, Task 2a (2015 to 2018). While sample collection methods employed each year were relatively consistent between 2005 and 2013, a few changes were implemented in 2014 and 2015 that should be considered when drawing conclusions across study years.

In 2014, electroshocker settings were modified to reduce the likelihood of electroshocker-induced injuries to large-bodied fish. As a result of this change, catchability (i.e., the fraction of the population that is caught in a given unit of effort) was lower from 2014-2018 when compared to 2005-2013. A summary of these electroshocker setting changes is provided in Golder and Gazey (2015).

In 2015, the objectives of sampling were modified to ensure collected data met the needs of the Project. One of these changes included the size of fish targeted by the netters. Prior to 2015, netters focused effort on fish that had fork lengths (FL) greater than approximately 150 mm. From 2015 onward, netters targeted all size classes of fish. As a result of this change to the methods, small-bodied fish species (e.g., Redside Shiner [*Richardsonius balteatus*]) and younger age-classes of large-bodied fish species were less consistently recorded prior to 2015.

To more readily allow comparisons across study years, before-after comparisons in the following sections were limited to data collected during the three years prior to offset construction (i.e., 2013, 2014, and 2015; before) and data collected during the three years after offset construction (i.e., 2016, 2017, and 2018; after). Data collected prior to 2015 were collected before the area was physically affected by the construction of the Project, while data collected during and after 2016 were collected after construction of the Project had commenced. The River Road rock spurs and Upper Site 109L were completed prior to the initiation of sampling in 2016; however, the amount of time required for fish to effectively move back into these areas after construction ended is unknown. Site 109OSA was added to the program in 2017 to better characterize fish use of this area. Sites 109OSB and 109OSC were added in 2018 in response to the limited fish use data that were collected in Upper Site 109L in 2017 (Golder 2018). Changes in sample methods between 2013 and 2014 (e.g., altered boat electroshocker settings) and changes in study objectives between 2014 and 2015 (e.g., targeted fish species and size classes) confound interannual comparisons of the data. These changes are discussed in detail in Golder and Gazey (2016).

Activities associated with the construction of the Project were ongoing during the 2018 field season. These activities were largely limited to locations upstream of the two offset areas and may have altered water quality, and therefore fish use of the offset areas at the time of sampling. Instream construction work associated with the site preparation for Side Channel Site 108R offset area started in September 2018 and continued through the Mountain Whitefish spawning period. This instream work was located on the right bank (i.e., south shore) of the river near the downstream end of Upper Site 109L.

Habitat conditions recorded during boat electroshocking are provided in Appendix C, Table C1.

3.2.1 River Road Rock Spurs

Similar to 2017, the efficiency of sampling in the River Road area was negatively impacted by the construction of the rock spurs themselves. Variable water depths, velocities, and flow directions around the rock spurs made it difficult to manoeuvre the boat and resulted in an inconsistent electrical field. These changes caused less predictable responses by fish, making them more difficult to capture by the netters.

During the three years after construction of the rock spurs, a total of 451 fish were captured at Sites 0505 and 0506 combined (Table 8; Appendix C, Table C2). These numbers do not include fish that were observed but avoided capture. The total number of fish captured after the construction of the offsets (*n* = 451) was substantially lower than the total number of fish captured during the three years before offset construction (*n* = 1092). The largest change in composition before and after the construction of the rock spurs was attributed to the three sucker species (Largescale Sucker [*Catostomus macrocheilus*], Longnose Sucker [*Catostomus catostomus*], and White Sucker [*Catostomus commersonii*]). Combined, these three species represented 55% of the total catch before the construction of the rock spurs and 29% of the total catch after the construction of the rock spurs. The portion of coldwater indicator species (i.e., Arctic Grayling, Bull Trout, Mountain Whitefish, and Rainbow Trout) in the catch increased from 41% prior to offset construction to 61% after offset construction. For these species, Bull Trout and Rainbow Trout showed the largest increases, at 7.5% and 6.8%, respectively.

Burbot have only been captured at these sites in the last two years of sampling (post construction of the rock spurs). A single Trout-perch (*Percopsis omiscomaycus*) was recorded in 2018, representing the first time this species was recorded in Sites 0505 or 0506 during 16 years of systematic sampling.

Data collected before the construction of the offset and data collected after construction of the offset suggest increased use of the area for most coldwater indicator species (i.e., Arctic Grayling, Bull Trout, and Rainbow Trout) and decreased use by coolwater indicator species (i.e., Walleye) and sucker species. The number of Mountain Whitefish (a coldwater indicator species) recorded in the study area declined in the first two years after the construction of the offsets but catches for this species were lower throughout the Peace River in 2016 and 2017 (Golder and Gazey 2017–2018). There was an increase in Mountain Whitefish captures in 2018 relative to 2016 and 2017. Sparse data for all other species during all study years limit analysis and interpretation for these species.

In the diversity profiles, the effective number of species is used to indicate the diversity of fish species, while varying the value of q, which represents the relative contribution of rare species to the diversity metric. The steep decline in the effective number of species with increasing values of q reflects the community composition in the offset area, with a few species dominating the catch and low numbers of rare species (Figure 1). Species richness ($q = 0$) was approximately 2 effective species higher after the offset was constructed; however, confidence intervals overlapped for these two estimates. Based on a Shannon Index ($q = 1$), community composition was substantially different after construction of the offset, indicating increased diversity (approximately two effective species) after offset construction with no overlap in confidence intervals.

Table 8: Number of fish caught by boat electroshocking and their frequency of occurrence in Sites 0505 and 0506 of the Peace River, 2013 to 2018.

Species	Year															
	Before								After							
	2013		2014		2015		Combined Before		2016		2017		2018		Combined After	
	n[a]	%[b]	n[a]	%[b]	n[a]	%[b]	n[a]	%[b]	n[a]	%[b]	n[a]	%[b]	n[a]	%[b]	n[a]	%[b]
Indicator Species																
Arctic Grayling			1	<1	1	<1	2	<1	3	2	1	1			4	<1
Bull Trout	3	1	4	1	6	1	13	1	12	9	14	11	13	7	39	9
Burbot											2	2	2	1	4	<1
Mountain Whitefish	164	66	170	50	90	18	424	39	33	26	57	43	109	57	199	44
Rainbow Trout	3	1			3	1	6	<1	9	7	10	8	14	7	33	7
Walleye	14	6	11	3	3	1	28	3	2	2	1	1	8	4	11	2
Indicator Spp. Subtotal	**184**	**74**	**186**	**55**	**103**	**20**	**473**	**43**	**59**	**46**	**85**	**65**	**146**	**77**	**290**	**64**
Non-Indicator Species																
Lake Trout	1	<1					1	<1								
Kokanee											1	1			1	<1
Lake Chub											1	1			1	<1
Largescale Sucker	11	4	20	6	61	12	92	8	4	3	3	2	8	4	15	3
Longnose Sucker	50	20	117	35	288	57	455	42	46	36	31	23	27	14	104	23
Northern Pike			2	1			2	<1					2	1	2	<1
Northern Pikeminnow			2	1	10	2	12	1	4	3	7	5	3	2	14	3
Redside Shiner					2	<1	2	<1	5	4	3	2			8	2
Slimy Sculpin					1	<1	1	<1					1	<1	1	<1
Trout-Perch													1	<1	1	<1
White Sucker	2	<1	9	3	42	8	53	5	10	8	2	2	2	1	14	3
Sucker spp.[c] (Catostomidae)			1	<1			1	<1								
Non-Indicator Spp. Subtotal	**64**	**26**	**151**	**45**	**404**	**80**	**619**	**57**	**69**	**54**	**48**	**35**	**44**	**23**	**161**	**36**
All species	**248**	**100**	**337**	**100**	**507**	**100**	**1092**	**100**	**128**	**100**	**133**	**100**	**190**	**100**	**451**	**100**

[a] Includes fish captured and identified to species; does not include fish that were positively identified but avoided capture.

[b] Percent composition of the total catch.

[c] Not identified to species.

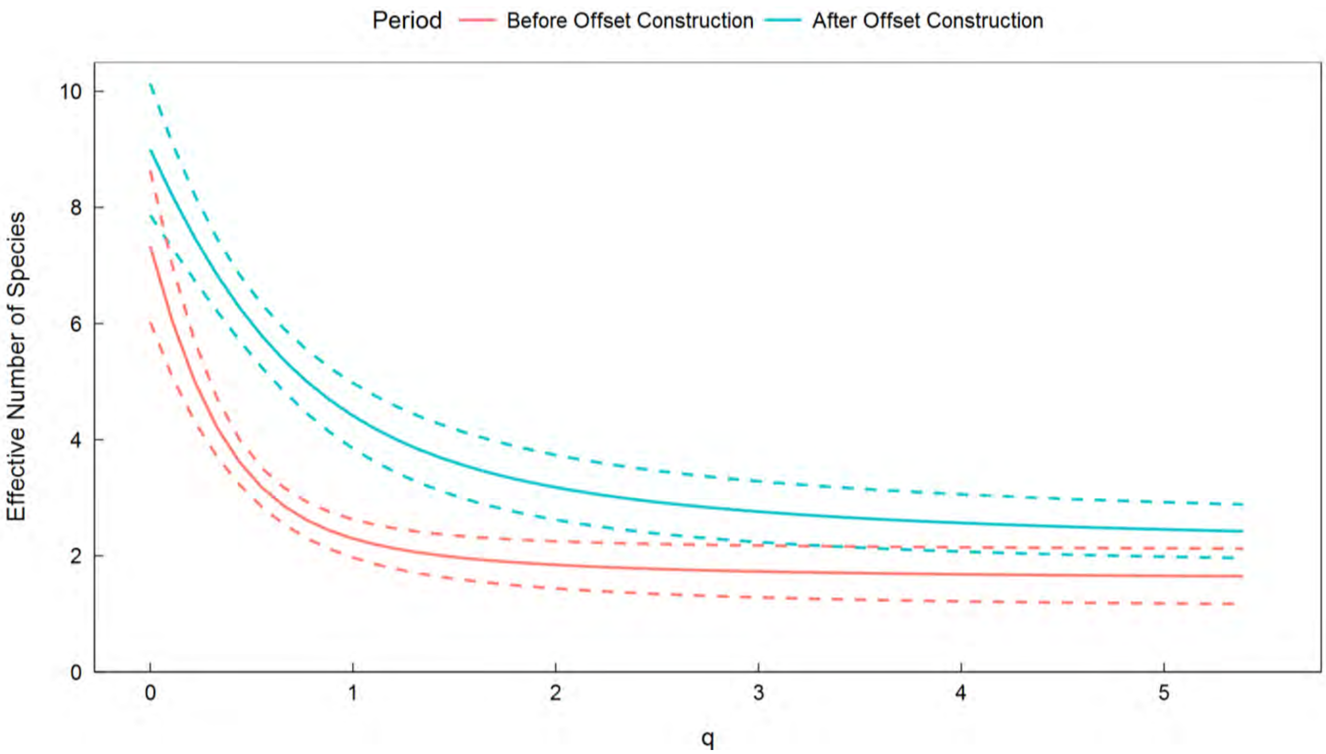

Figure 1: Diversity profiles for the River Road rock spurs area showing effective number of species versus the parameter (q) representing the importance of rare/common species in the calculation. Values are means (solid lines) with 95% confidence intervals (dashed lines) from annual diversity profiles from 2013 to 2015 combined (before offset construction) and 2016 to 2018 combined (after offset construction). A value of q = 0 corresponds to species richness while a value of q = 1 corresponds to the Shannon index.

The River Road rock spurs are intended to provide additional rearing habitat for immature Arctic Grayling, Mountain Whitefish, and Rainbow Trout (Table 1). Both immature Mountain Whitefish and immature Rainbow Trout were recorded within Sites 0505 and 0506 after the construction of the offset (Appendix C, Table C3). Overall, Arctic Grayling numbers have decreased at these two sites since 2007 (n = 46) to 2018 (n = 0) with approximately two Arctic Grayling captured annually over the last eight years. Immature Arctic Grayling were not recorded within Sites 0505 or 0506 after the construction of the offset but were also rare in these sites before offset construction (1 immature Arctic Grayling in 2014 and 1 immature Arctic Grayling in 2015).

Overall, data suggest increased use of the River Road rock spur area by the indicator species and that this area may provide more preferable habitats for some species that had not previously been captured at these sites (e.g., Burbot, Lake Chub and Trout-perch).

Length-frequency histograms were generated for all species for all years between 2013 and 2018 but were uninformative for all species except Mountain Whitefish due to the low number of individuals measured within each year. For all of these species, the range of fork lengths recorded after the construction of the rock spurs (Appendix C, Table C3) were similar to the ranges recorded before the construction of Upper Site 109L (Golder and Gazey 2018).

Length-frequency data for Mountain Whitefish (Figure 2) indicate that fewer small (i.e., less than approximately 220 mm FL) Mountain Whitefish were captured in the River Road rock spur area after the construction of the rock spurs. Fish less than approximately 220 mm FL correspond to the age-0 and age-1 cohorts (Golder and Gazey 2018).

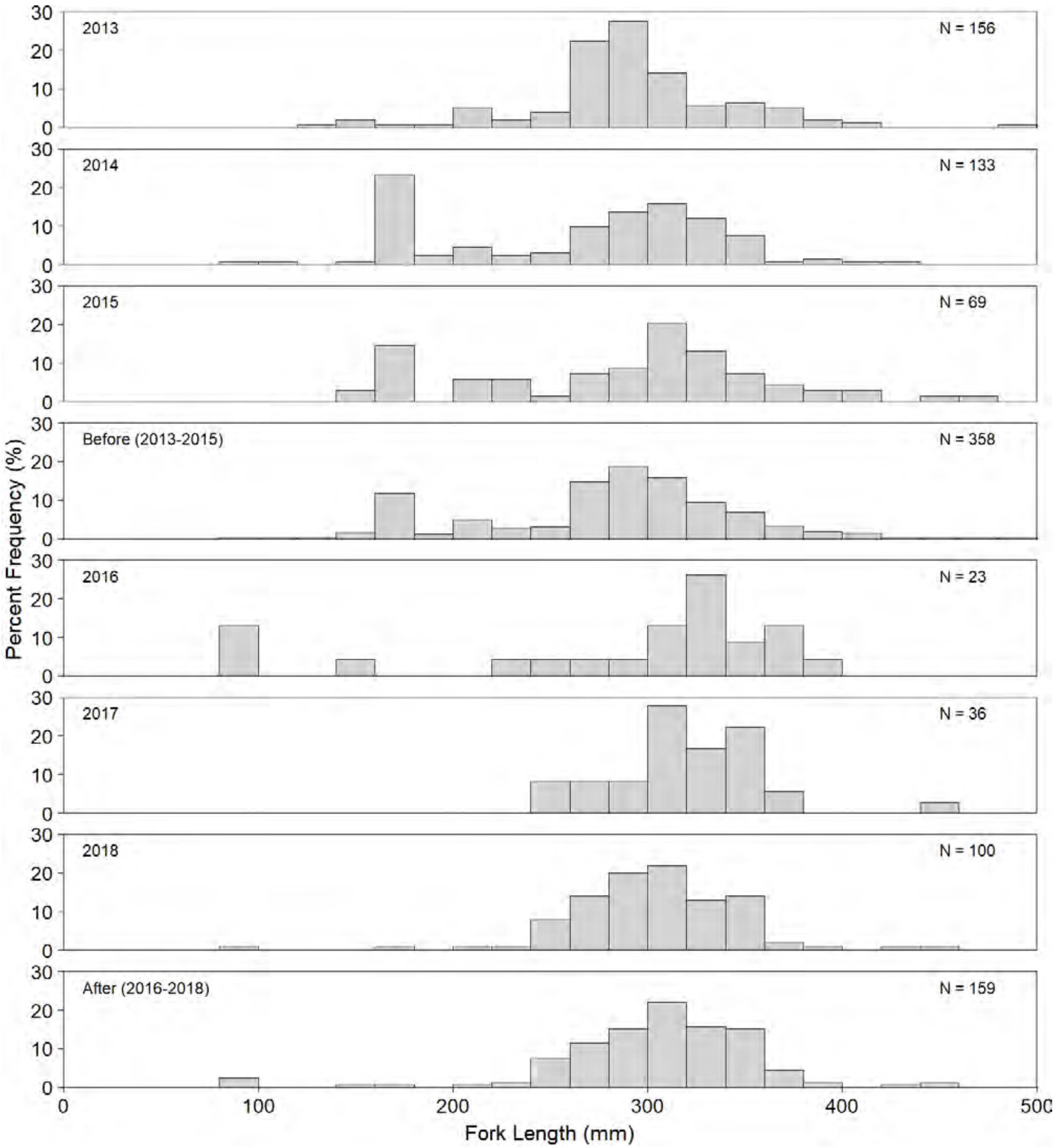

Figure 2: Length-frequency distributions for Mountain Whitefish captured by boat electroshocking in Sites 0505 and 0506 of the Peace River as part of the Peace River Large Fish Indexing Survey (Site C FAHMFP Mon-2, Task 2a), 2013, 2014 and 2015, both separate and combined, and 2016, 2017 and 2018, both separate and combined.

Body condition values recorded at Sites 0505 and 0506 in 2016, 2017, and 2018 were similar to values recorded at these sites in 2013, 2014, and 2015 for all species. A summary of body condition values for Mountain Whitefish, the most abundant species recorded, is provided in Figure 3. Raw body condition data for all species encountered in 2018 are provided in Appendix C, Table C3; data for all other years is provided in Golder and Gazey (2018).

Figure 3: Mean body condition with 95% confidence intervals (CIs) for Mountain Whitefish captured by boat electroshocking in Sites 0505 and 0506 of the Peace River as part of the Peace River Large Fish Indexing Survey (Site C FAHMFP Mon 2, Task 2a), 2013 to 2018.

3.2.2 Upper Site 109L

During 2016, 2017, and 2018 surveys, a total of 593 fish were captured at Sites 0509, 109OSA, 109OSB and 109OSC combined (Table 8; Appendix C, Table C2); only Site 0509 was sampled in 2016 and sites 0509, 109OSA and 109OSB were sampled in 2017. Site 109OSC was added in 2018. These numbers do not include fish that were observed but avoided capture. The total number of fish captured after the construction of the offset (n = 593) was approximately 30% lower when compared to the total number of fish captured during the three years prior to offset construction (n = 844). This decline was almost entirely due to a decline in the Mountain Whitefish catch (approximately 40% lower when compared to Mountain Whitefish captured in the three years prior to construction of the offset). Arctic Grayling have not been recorded in Upper Site 109L since its construction, but this species was rarely encountered prior to Upper Site 109L’s development. There were no other substantial changes in the composition of the catch before and after the construction of this offset.

Similar to the results from the River Road rock spur area, diversity profiles for Upper Site 109L indicate a steep decline in the effective number of species with increasing values of q, indicating that a few fish species dominate the catch with low numbers of rare species (Figure 1). Differences in the effective number of species before and after construction of the offset were not apparent at any values of q.

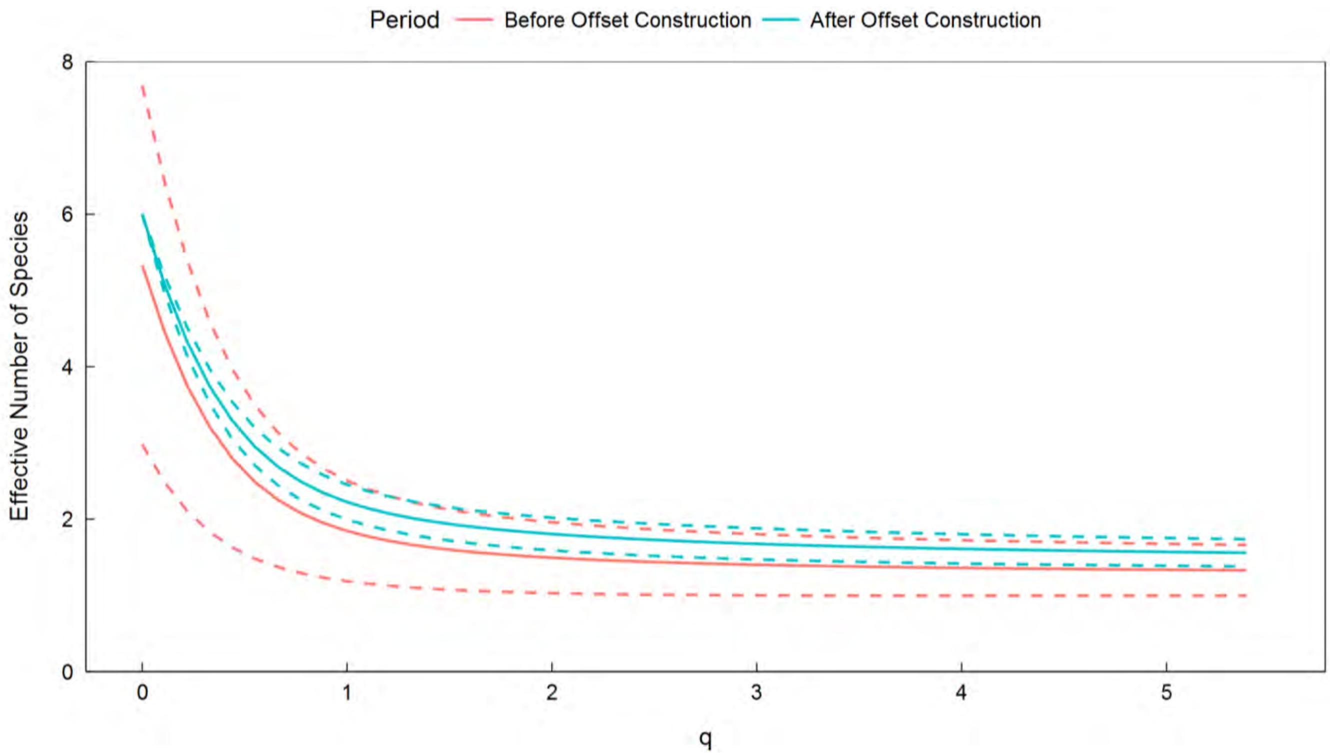

Figure 4: Diversity profiles for Upper Site 109L showing effective number of species versus the parameter (q) representing the importance of rare/common species in the calculation. Values are means (solid lines) with 95% confidence intervals (dashed lines) from annual diversity profiles from 2013 to 2015 combined (before offset construction) and 2016 to 2018 combined (after offset construction). A value of q = 0 corresponds to species richness while a value of q = 1 corresponds to the Shannon index.

Upper Site 109L was predicted to provide additional rearing habitat for immature Arctic Grayling, Mountain Whitefish, and Rainbow Trout, and additional feeding habitat for adult Bull Trout, Mountain Whitefish, Rainbow Trout, and Walleye (Table 1). Immature Mountain Whitefish were common at these sites after construction of the offset and represented approximately 22% of the combined 2016–2018 Mountain Whitefish catch. These data are consistent with previous study years. Three immature Rainbow Trout were recorded after the construction of Upper Site 109L. All three were recorded in 2016 (Golder and Gazey 2017). Immature Arctic Grayling were not recorded within Upper Site 109L after construction; this species was rarely encountered in this area prior to construction. The adult Bull Trout and Walleye catch was low in Upper Site 109L post-construction and similar to pre-construction results.

Length-frequency histograms were generated for all species for all years between 2013 and 2018 but were uninformative for all species except Mountain Whitefish due to the low number of individuals measured within each year. For all of these species, the range of fork lengths recorded after the construction of Upper Site 109L (Appendix C, Table C3) were similar to the ranges recorded before the construction of Upper Site 109L (Golder and Gazey 2018).

Length-frequency data for Mountain Whitefish (Figure 6) indicate that the Upper Site 109L area is used by all life stages of Mountain Whitefish. One difference noted between the fork lengths of Mountain Whitefish captured before construction and the Mountain Whitefish captured after construction was a decrease in age-2 fish caught with fork lengths recorded between 170 mm and 180 mm. The change was due to a larger number of these size fish captured in 2014 compared to other study years. Based on Golder and Gazey (2018) these fish correspond to the age-1 cohort. The Mountain Whitefish length-frequency distribution for all other fork lengths recorded was similar before and after construction of Upper Site 109L (Figure 6).

Body condition values recorded in the Upper Site 109L area after offset construction were similar to values recorded in these sites before offset construction for all species. A summary of body condition values for Mountain Whitefish, the most abundant species recorded, is provided in Figure 3. Raw body condition data for all species encountered in 2018 are provided in Appendix C, Table C3; data for all other years is provided in Golder and Gazey (2018).

Figure 5: Mean body condition with 95% confidence intervals (CIs) for Mountain Whitefish captured by boat electroshocking in Sites 0509, 109OSA, 109OSB and 109OSC of the Peace River as part of the Peace River Large Fish Indexing Survey (Site C FAHMFP Mon 2, Task 2a), 2013 to 2018.

Table 9: Number of fish caught by boat electroshocking and their frequency of occurrence in Sites 0509, 109OSA, 109OSB and 109OSC of the Peace River, 2013 to 2018. Data courtesy of BC Hydro's Peace River Large Fish Indexing Survey (Mon-2, Task 2a).

Species	Year															
	Before								After							
	2013[a]		2014[a]		2015[a]		Combined Before		2016[a]		2017[b]		2018		Combined After	
	n[c]	%[d]	n[c]	%[d]	n[c]	%[d]	n[c]	%[d]	n[c]	%[d]	n[c]	%[d]	n[c]	%[d]	n[c]	%[d]
Indicator Species																
Arctic Grayling	2	<1			2	1	4	<1								
Bull Trout	4	1			5	2	9	1	2	2	3	2	3	1	8	1
Mountain Whitefish	305	87	223	91	162	66	690	82	87	65	133	66	202	77	423	71
Rainbow Trout	3	<1			6	2	9	1	3	2					3	<1
Walleye			1	<1			1	<1			1	<1	2	<1	3	<1
Indicator Spp. Subtotal	**314**	**89**	**224**	**91**	**175**	**71**	**713**	**84**	**92**	**69**	**137**	**69**	**207**	**79**	**436**	**74**
Non-Indicator Species																
Largescale Sucker	4	1	5	2	2	1	11	1	7	5	13	7	14	5	34	6
Longnose Sucker	33	9	16	7	64	26	113	13	31	23	43	22	35	13	109	18
Northern Pike	1	<1					1	<1					1	<1	1	<1
Northern Pikeminnow					2	1	2	<1	1	<1	1	<1			2	<1
Prickly Sculpin													1	<1	1	<1
Redside Shiner									2	2	3	2	1	<1	6	1
Slimy Sculpin					2	1	2	<1					2	<1	2	<1
Trout-Perch													1	<1	1	<1
White Sucker			1	<1	1	<1	2	<1					1	<1	1	<1
Non-Indicator Spp. Subtotal	**38**	**11**	**22**	**9**	**71**	**29**	**131**	**16**	**41**	**31**	**60**	**31**	**56**	**21**	**157**	**26**
All species	**352**	**100**	**246**	**100**	**246**	**100**	**844**	**100**	**133**	**100**	**197**	**100**	**263**	**100**	**593**	**100**

[a] Only includes data from Site 0509; Sites 109OSA, 109OSB, and 109OSC were not sampled during this study year.

[b] Includes data from Site 0509, Sites 109OSA and 109OSB; Site 109OSC was not sampled during this study year.

[c] Includes fish captured and identified to species; does not include fish that were positively identified but avoided capture.

[d] Percent composition of the total catch.

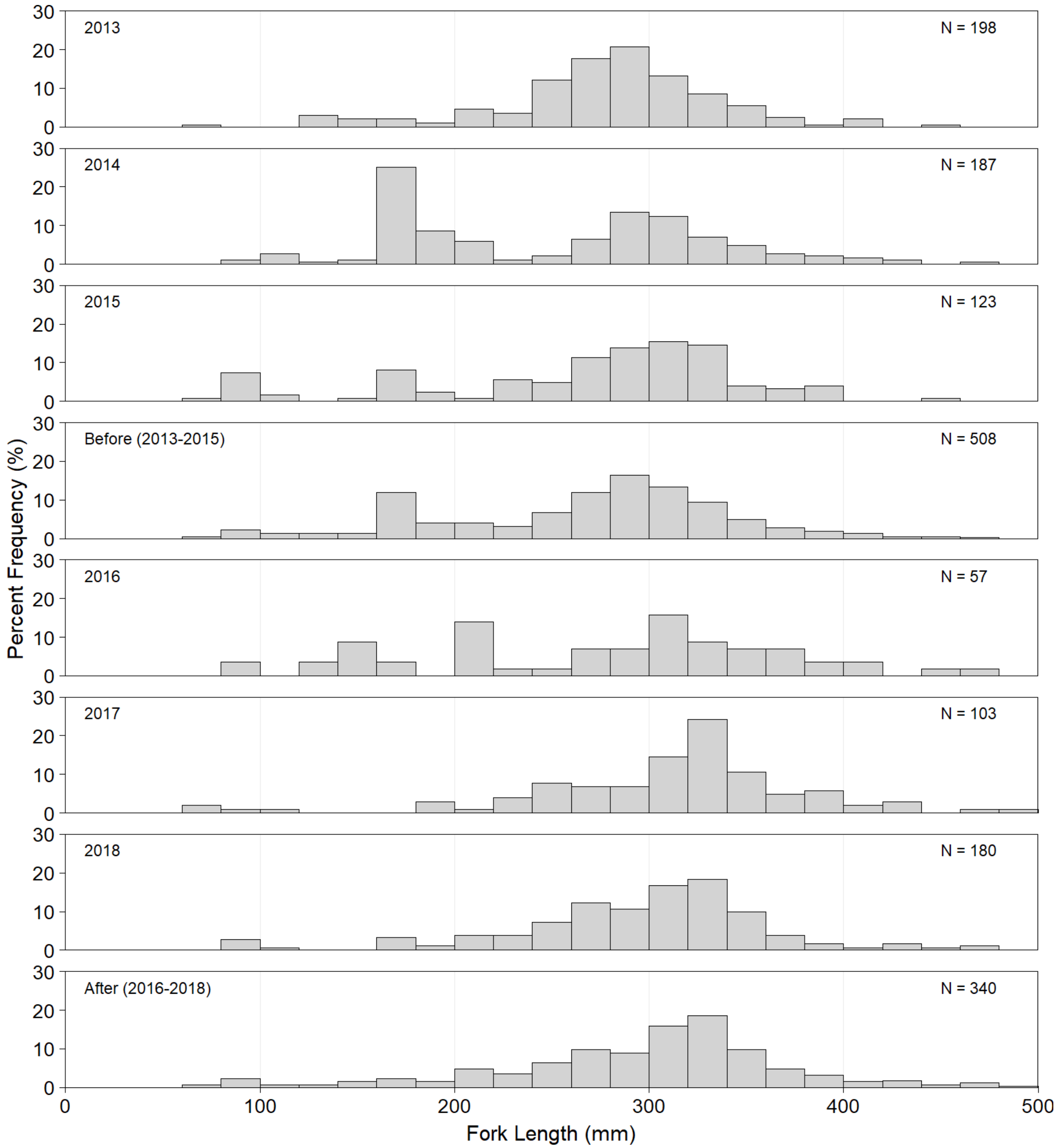

Figure 6: Length-frequency distributions for Mountain Whitefish captured by boat electroshocking in Sites 0509, 109OSA, 109OSB and 109OSC of the Peace River as part of the Peace River Large Fish Indexing Survey (Site C FAHMFP Mon-2, Task 2a), 2013, 2014 and 2015, both separate and combined, and 2016, 2017 and 2018, both separate and combined.

3.3 Mountain Whitefish Spawning

Artificial substrate mat sampling in Upper Site 109L occurred from 20 October 2018 to 14 January 2019 (Table 5). Over this time period, mats were deployed on the river bottom at 15 different locations at water depths that ranged between 0.7 and 4.1 m (average = 2.5 m). Water temperature declined from a high of 6.3°C to a low of 0.4°C over the monitoring period. In total, 22,941 mat-hours were expended during the 2018 survey (Appendix D, Table D1). Mountain Whitefish eggs were not recorded.

Over the 2018 study period, daily average Peace River discharges ranged between 471 and 1577 m^3/s (average = 1175 m^3/s; WaterOffice 2019). The minimum instantaneous discharge recorded over the study period was 424 m^3/s (recorded on 4 November; not presented). Based on the lowest water level observed by the crew while on site (765 m^3/s on 19 December), it is unlikely that any of Upper Site 109L dewatered over the course of the study period as mean water depths at that time were greater than 2.2 m.

4.0 DISCUSSION

This report summarizes results collected during the second of three years of proposed offset effectiveness monitoring for the River Road rock spurs and Upper Site 109L and the effectiveness of the offset areas at a site-scale. This monitoring is in addition to other ongoing monitoring components in this portion of the Peace River. Results from 2018 were compared to data from 2017 and baseline conditions, when possible, and will be used as benchmark data for comparisons during future study years.

A summary of the effectiveness of the offsets at a reach-scale was not conducted in 2018 because the offsets were not anticipated to have an immediate impact on Peace River fish populations over a short time period (i.e., 3 years is not long enough for a reach-level change to be detected). The effectiveness of the offset areas at a reach-scale, as outlined in the FAA, will be preliminarily explored under Offset Effectiveness Monitoring following sampling in 2019; however, monitoring over a longer timeframe will likely be required to identify reach-level effects of the offsets. Long-term monitoring planned under other components of the Site C FAHMFP, most notably the Peace River Physical Habitat Monitoring Program (Mon-3) and the Peace River Fish Community Monitoring Program (Mon-2), will likely be required.

4.1 Physical Habitat

4.1.1 River Road Rock Spurs

The River Road rock spurs were designed to provide variability in water depths, water velocities, and substrate sizes (through the use of riprap and boulders), as well as lower nearshore water velocities, resulting in more suitable rearing and feeding habitat for most coldwater fish species. ADCP data collected in 2018 indicate substantial variability in water velocities and flow directions immediately upstream, downstream, and above the rock spurs. In addition, increased flow variability was observed in the areas immediately adjacent to the rock spurs (i.e., towards mid-channel). Flow and depth variability surrounding the rock spurs contrasts with adjacent Peace River shorelines, which typically consist of few bank irregularities and more laminar flows. Nearshore velocities along River Road were lower adjacent to rock spurs when compared to nearshore areas along River Road away from rock spurs (e.g., Transect DS06a).

Visual observations of the rock spurs and armoured rip-rap bank during different water levels indicated these features had maintained their structure. As these substrates are substantially larger than the substrate sizes present in the area prior to the construction of the rock spurs (dominantly fines to cobbles; Golder 2016), they provide increased interstitial areas and predation refugia for juvenile large-bodied fish and all life stages of small-bodied fish.

Overall, the construction of the rock spurs and associated bank armouring provide physical habitat that is consistent with predictions made by BC Hydro (2015), which has resulted in lower, and more variable water velocities, and lower water depths compared to adjacent areas. In addition, the offset provides velocity and interstitial refugia for small fish. The habitat present along River Road is suitable for feeding and rearing for coldwater species like Arctic Grayling, Bull Trout, Mountain Whitefish, and Rainbow Trout.

4.1.2 Upper Site 109L

Upper Site 109L was designed and constructed to meet certain objectives, including increasing the quantity and quality of permanently wetted habitat available to support primary and secondary productivity, providing rearing, feeding, overwintering, and potential spawning habitats for fish, reducing fish stranding risk, and increasing the complexity and variability of fish habitat to support a variety of life stages for local fish populations.

ADCP data collected in the first two monitoring years (2017 and 2018) indicate variability in water velocities, flow directions, and water depths associated with the constructed channel depressions. This variability results in increased habitat complexity when compared to pre-Project conditions.

Upper Site 109L was recontoured with an elevation of less than 407 masl, with the intent of ensuring that the area remains permanently wetted under the minimum operating flows for the Project (409 masl; BC Hydro 2015). Recontouring aimed to increase the quantity of permanently wetted habitat available for primary and secondary production, an area where eggs could incubate without risk of dewatering, and reduce fish stranding risk. The area was observed to remain wetted over a range of discharges in 2018 (i.e., a low of 765 m^3/s on 19 December). Some minimal changes (erosion and deposition) in riverbed elevations were noted along the surveyed transects which could indicate changes to the structure and function of the offset features in Upper Site 109L over time. It is possible that a root wad impinged in the substrate near the upstream end of the site increased aggradation in its immediate vicinity. This root wad was visible in the spring of 2018, but it was not observed by field crews while they were working in the area in December 2017 or August 2018. High water levels may have submerged the root wad during some site visits. The aggraded area was visible in aerial photographs taken of the area on 18 September 2018 (Underhill Geomatics Ltd. unpublished data); the root wad was not visible in these same photographs.

4.1.2.1 Substrate Characteristics

Although no riverbed substrate samples were collected, and the underwater video footage was limited to areas where the water depth was less than 2.0 m, interpretation of the images indicated a variety of riverbed substrate sizes. The majority of the substrate observed in Upper Site 109L was gravel and cobble with very little accumulation of fines. Evidence of interstitial spaces for potential fish egg incubation was observed. The substrate at some locations near the south edge of the recontoured area was dominated by fines. This area was on the outside edge of the recontoured area riverbed where riverbed material settled out on the downstream side of a shallow gravel/cobble bar.

4.2 General Fish Use

During the 2018 field program, the only assessment method employed was boat electroshocking. Based on methods employed in 2017, this method was the most effective for the local conditions (i.e., high water velocities, high water depths, and high turbidity).

Successful boat electroshocking surveys were conducted in both offset areas, providing a reliable index of fish use for the sample period (September-October); however, smaller life stages of fish are typically underrepresented in boat electroshocking catches. Both offset areas are intended to increase the amount of rearing habitat available for Arctic Grayling, Mountain Whitefish, and Rainbow Trout. Direct observations of these smaller life stages using boat electroshocking is difficult.

4.2.1 River Road Rock Spurs

Boat electroshocking was less efficient along River Road after the construction of the rock spurs. The eddies formed by the rock spurs resulted in less effective netting and made manoeuvring the boat more onerous when compared to the straight shoreline and laminar flows that were present in the area prior to the construction of the rock spurs. This decline in efficiency likely contributed to lower catch rates in Sites 0505 and 0506 after the rock spurs were constructed; however, this decline was likely consistent across species and size classes.

An increase in species diversity compared to historical studies since the construction of the River Road and the associated habitat structures is likely due to the increased habitat complexity associated with the rock spurs; however, additional data are required to confirm this finding. The four Burbot captured in the last two years of sampling along the River Road rock spurs were the first encounters of this species in this portion of the Peace River in 16 years of systematic sampling. One of the Burbot captured in 2018 was classified as a young-of-the-year (82 mm total length). Burbot were frequently associated with similarly constructed rock spurs during boat electroshocking surveys conducted on the Columbia River (Golder 2005, 2006) and McPhail (2007) notes that juvenile Burbot strongly associate with riprap jetties and natural boulder areas. Based on these data, Burbot use of this area of the Peace River may increase as a result of the construction of the rock spurs. Lake Chub and Kokanee were also recorded along the River Road for the first time during 2017 sampling and Trout-perch were recorded for the first time in 2018; however, these species have been recorded in immediately adjacent areas in recent study years (e.g., Golder and Gazey 2015, 2016).

Catch data suggest increased use of the River Road and rock spur area for most coldwater indicator species (i.e., Arctic Grayling, Bull Trout, and Rainbow Trout) and decreased use by coolwater indicator species (i.e., Walleye and Northern Pike) and sucker species (Largescale Sucker, Longnose Sucker, and White Sucker). Use of the area by Mountain Whitefish declined in the first two years after construction (2016 and 2017), but this decline was consistent with an overall decline in Mountain Whitefish catch throughout the Peace River (Golder and Gazey 2018). In 2018, Mountain Whitefish represented a larger portion of the overall catch (57%) than they did in 2016 (26%) and 2017 (43%). Overall, Mountain Whitefish represented a larger portion of the overall catch in the 3 years after construction (44%) than the 3 years prior to construction (39%). Additional years of data will further inform the use of the rock spurs area by indicator fish species.

The River Road rock spurs are intended to provide additional rearing habitat for immature Arctic Grayling, Mountain Whitefish, and Rainbow Trout (Table 1). Both immature Mountain Whitefish and immature Rainbow Trout were recorded within Sites 0505 and 0506 since the construction of the offset (Appendix C, Table C3). Immature Arctic Grayling were not recorded within Sites 0505 or 0506 after the construction of the offset, but were also rare in these sites before offset construction (1 immature Arctic Grayling in 2014 and 1 immature Arctic Grayling in 2015).

Overall, data collected since the construction of the River Road rock spurs suggest increased use of the area by the indicator species and that this area may provide more preferable habitats for some species that had not previously been captured at these sites (e.g., Burbot and Lake Chub).

4.2.2 Upper Site 109L

Data suggest similar uses of Upper Site 109L in 2018 when compared to previous study years, with no apparent changes in use by fish species or life stage. Apparent changes in use based on percent composition and length-frequency histograms are likely an artefact of low sample sizes or reflect changes in the overall Peace River fish population. Additional years of data are required to adequately determine use of the offset area by the indicator fish species.

4.3 Mountain Whitefish Spawning

Collected data did not indicate that Mountain Whitefish spawned immediately upstream or within Upper Site 109L in 2018. Samplers were deployed for the duration of what was expected to be the bulk of the Mountain Whitefish spawning season (i.e., late October to mid-January when water temperatures declined from a high of 6.3°C to a low of 0.4°C). This sampling period encompassed a larger period (one month longer) of potential spawning season over a larger range of water temperatures than the 2017 study. In other systems, water temperatures at the onset of Mountain Whitefish spawning range between 6.0°C and 10°C (Golder 2014; Northcote and Ennis 1994 cited in Mainstream and Gazey 2014; McPhail 2007). Samplers were deployed at a variety of water depths and locations within Upper Site 109L; adequate spatial and temporal coverage of the area was assumed with the study design. The intensity of sampling was expected to capture eggs, if spawning occurred.

Between 7 September and 10 October 2018, Upper Site 109L was repeatedly sampled for fish as part of the Peace River Large Fish Indexing Survey (Mon-2, Task 2a). During this time, captured Mountain Whitefish were frequently observed with tubercles; however, none of the Mountain Whitefish recorded in the area were gravid or ripe. It is unlikely that this species spawned in the area during the approximately 10-day long period between the end of the Mon-2, Task 2a sampling period and the beginning of Mountain Whitefish spawning monitoring under the current program.

The site provided a potential area for egg incubation, as the area did not dewater over the range of discharges observed and the riverbed substrate provided adequate material and interstitial spaces to protect eggs during development. Additional years of data are required to determine use of the area for spawning by Mountain Whitefish.

5.0 CONCLUSION

The FAA lists three offset effectiveness criteria. Offset Effectiveness Monitoring's progress towards addressing each of these three criteria are briefly addressed below.

1) Offsets will be constructed according to designs. Information gathered during implementation monitoring will inform this assumption.

The offsets were constructed as described in Section 6.2.1 (Mitigation Measures Downstream of Site C Dam Site) of the Project's Fisheries and Aquatic Habitat Management Plan[11].

2) Offsets maintain their structure and function. For example, the depressions maintain their structure and function (i.e., infilling does not reduce physical function) and substrate at Upper Site 109L is suitable for spawning by Mountain Whitefish. This will be assessed in the physical component of the Offset Effectiveness Monitoring.

Physical habitat data, as well as visual assessment of the offset in 2018, indicate that the offsets have generally maintained their structure since their construction. Two of the channel profiles in Upper Site 109L showed evidence of deposition in areas along the north bank. The physical characteristics of water depths and water velocities occurred as predicted (BC Hydro 2015). The construction of the rock spurs and associated bank armouring along River Road has increased habitat complexity and provides habitats that are uncommon in this reach of the Peace River. Upper Site 109L effectively increases the amount of permanently wetted habitat available to support primary and secondary productivity, while eliminating stranding risk, and increasing the complexity of habitat available to fish. Based on interpretation of video images collected throughout the area, the riverbed substrate at Upper Site 109L consisted of gravel and cobble with limited fines and was considered suitable to support Mountain Whitefish spawning and egg incubation. Overall, the two offset areas increase the quantity and quality of rearing, feeding, overwintering, and potential spawning habitats available to fish and are capable of supporting a variety of life stages.

Physical habitat data collected in 2018 were compared to data collected in 2017 and used to monitor physical changes at the River Road rock spurs and Upper Sites 109L. Habitat characteristics measured at Upper Site 109L in 2018 were similar to habitat characteristics measured in 2017 (e.g., Golder 2018).

3) Fish will use the offset areas. Information collected on fish use will inform this assumption.

The River Road rock spurs were designed to provide additional rearing habitat for Arctic Grayling, Mountain Whitefish, and Rainbow Trout. Young Mountain Whitefish and Rainbow Trout were recorded along River Road after the rock spurs were constructed. However, young Arctic Grayling were not recorded in this area after the rock spurs were constructed, but were also rarely recorded before the rock spurs were constructed.

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[11] Available for download at: https://www.sitecproject.com/sites/default/files/Fisheries_and_Aquatic_Habitat_Management_Plan.pdf#page=27.

The River Road rock spurs were also designed to provide additional feeding habitat for Arctic Grayling, Bull Trout, Mountain Whitefish, and Rainbow Trout. The adult life stages of these species represented a larger portion of the total catch after the rocks spurs were constructed, indicating that the area provides suitable feeding habitat for these species. The largest increase in catch was seen in Bull Trout and Rainbow Trout.

Upper Site 109L was designed to provide additional rearing habitat for Arctic Grayling, Mountain Whitefish, and Rainbow Trout; both immature Mountain Whitefish and immature Rainbow Trout were recorded in the area in 2018. Young Arctic Grayling were not recorded in this area after Upper Site 109L was constructed, but they were also rarely recorded before Upper Site 109L was constructed.

Upper Site 109L was designed to provide additional feeding habitat for Bull Trout, Mountain Whitefish, Rainbow Trout, and Walleye. The adult life stages of these species were recorded after Upper Site 109L's construction at numbers that were similar to those recorded before Upper Site 109L's construction.

After its construction, Upper Site 109L provided habitat conditions that were similar to habitats known to successfully incubate Mountain Whitefish eggs in other systems (e.g., Golder 2014). Riverbed substrate that was suitable to support Mountain Whitefish spawning and egg incubation was recorded in 2018. Mountain Whitefish eggs were not recorded in the area in 2018.

Additional years of data will further inform the assessment of the effectiveness of the constructed offsets.

6.0 CLOSURE

We trust the information contained in this report is sufficiently detailed for your review purposes. Please do not hesitate to contact us should you have any questions or require clarification.

Golder Associates Ltd.

Demitria Burgoon, BSc, RPBio
Aquatic Biologist

Dustin Ford, BSc, RPBio
Associate, Senior Aquatic Biologist

DB/DF/lih

https://golderassociates.sharepoint.com/sites/12150g/deliverables/issued to client_for wp/1670320-009-r-rev0/1670320-009-r-rev0-2018 oem annual report 127feb_19.docx

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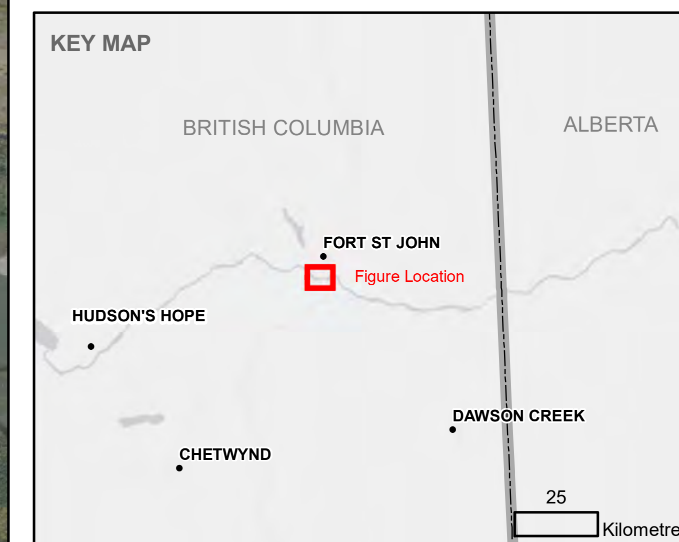
APPENDIX A

Maps and UTM Locations

LEGEND

- APPROXIMATE LOCATION OF ROCK SPUR
- RIVER KILOMETRE AS MEASURED DOWNSTREAM FROM W.A.C. BENNETT DAM
- ROAD
- OUTLINE OF SITE C PERMANENT COMPONENTS
- UPPER SITE 109L
- FLOW DIRECTION



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REFERENCES

1. RIVER KILOMETER MARKERS OBTAINED FROM BC HYDRO.
2. IMAGERY PROVIDED BY CLIENT 2017-05-10. IMAGE DATE: 2016-11-10.
3. INSET MAP OBTAINED BY ESRI, HERE, DELORME, MAPMYINDIA, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

DATUM: NAD83 PROJECTION UTM10

CLIENT
BC HYDRO

PROJECT
SITE C OFFSET EFFECTIVENESS MONITORING PROGRAM - 2018

TITLE
OVERVIEW OF STUDY AREA

CONSULTANT
GOLDER

YYYY-MM-DD	2019-02-22
DESIGNED	DB
PREPARED	JP / CD
REVIEWED	DF
APPROVED	SR

PROJECT NO.	PHASE	REV.	FIGURE
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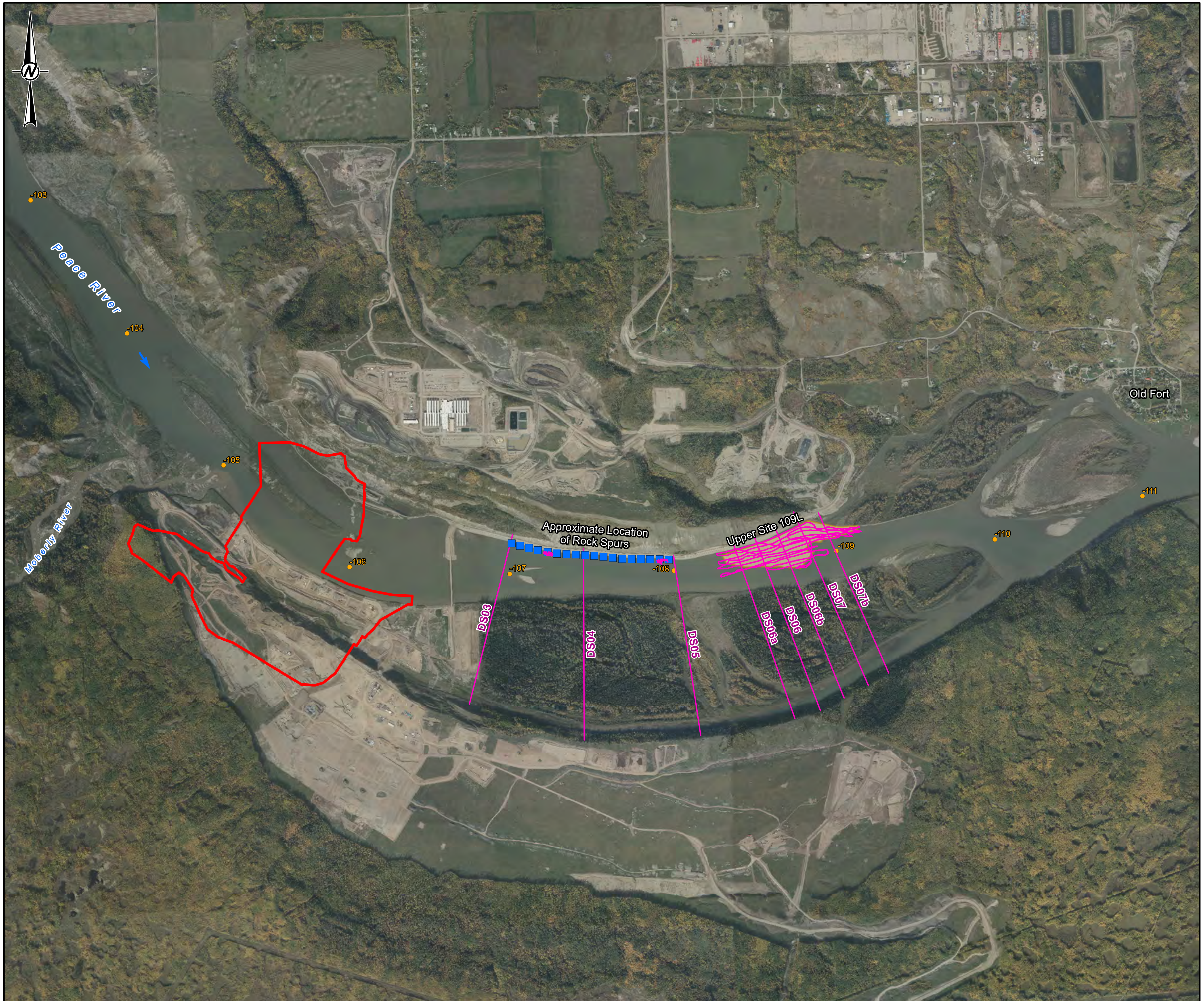

LEGEND

- APPROXIMATE LOCATION OF ROCK SPUR
- RIVER KILOMETRE AS MEASURED DOWNSTREAM FROM W.A.C. BENNETT DAM
- ADCP HABITAT TRANSECT LOCATION
- ROAD
- OUTLINE OF SITE C PERMANENT COMPONENTS
- UPPER SITE 109L
- FLOW DIRECTION

0 250 500 750 1,000 m

1:25,000

REFERENCES

1. RIVER KILOMETER MARKERS OBTAINED FROM BC HYDRO.
2. IMAGERY PROVIDED BY CLIENT 2017-05-10. IMAGE DATE: 2016-11-10.

DATUM: NAD83 PROJECTION UTM10

CLIENT
BC HYDRO

PROJECT
SITE C OFFSET EFFECTIVENESS MONITORING PROGRAM - 2018

TITLE
OVERVIEW OF PHYSICAL HABITAT SAMPLE LOCATIONS

CONSULTANT

GOLDER

YYYY-MM-DD	2019-02-22
DESIGNED	DB
PREPARED	JP / CD
REVIEWED	DF
APPROVED	SR

PROJECT NO.	PHASE	REV.	FIGURE
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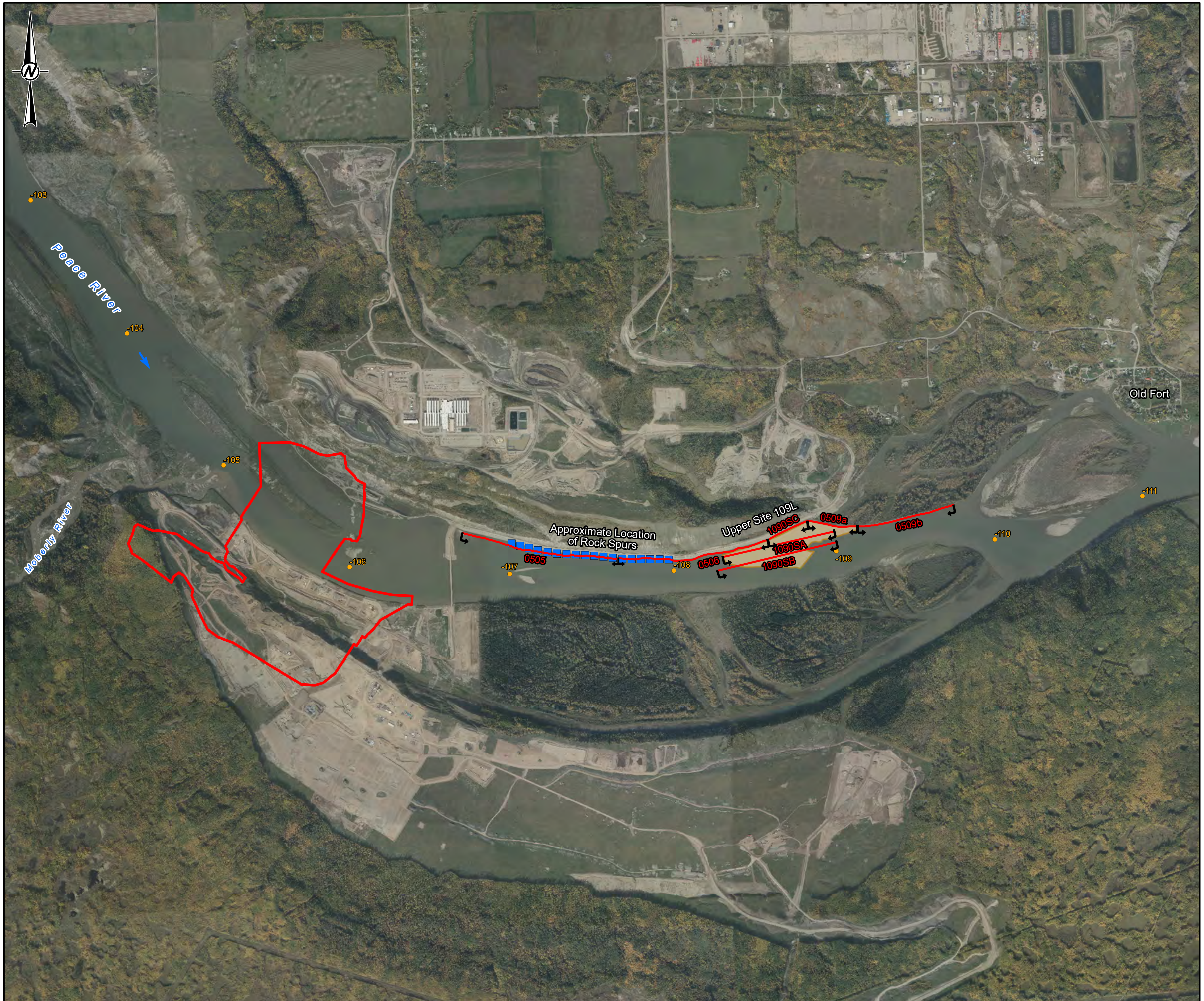

LEGEND

- APPROXIMATE LOCATION OF ROCK SPUR
- RIVER KILOMETRE AS MEASURED DOWNSTREAM FROM W.A.C. BENNETT DAM
- ROAD
- OUTLINE OF SITE C PERMANENT COMPONENTS
- UPPER SITE 109L
- 0110 BOAT ELECTROSHOCKING SITE
- FLOW DIRECTION

0 250 500 750 1,000 m

1:25,000

REFERENCES

1. RIVER KILOMETER MARKERS OBTAINED FROM BC HYDRO.
2. IMAGERY PROVIDED BY CLIENT 2017-05-10. IMAGE DATE: 2016-11-10.

DATUM: NAD83 PROJECTION UTM10

CLIENT
BC HYDRO

PROJECT
SITE C OFFSET EFFECTIVENESS MONITORING PROGRAM - 2018

TITLE
OVERVIEW OF GENERAL FISH USE SAMPLE LOCATIONS

CONSULTANT
GOLDER

YYYY-MM-DD	2019-02-22
DESIGNED	DB
PREPARED	JP / CD
REVIEWED	DF
APPROVED	SR

PROJECT NO.	PHASE	REV.	FIGURE
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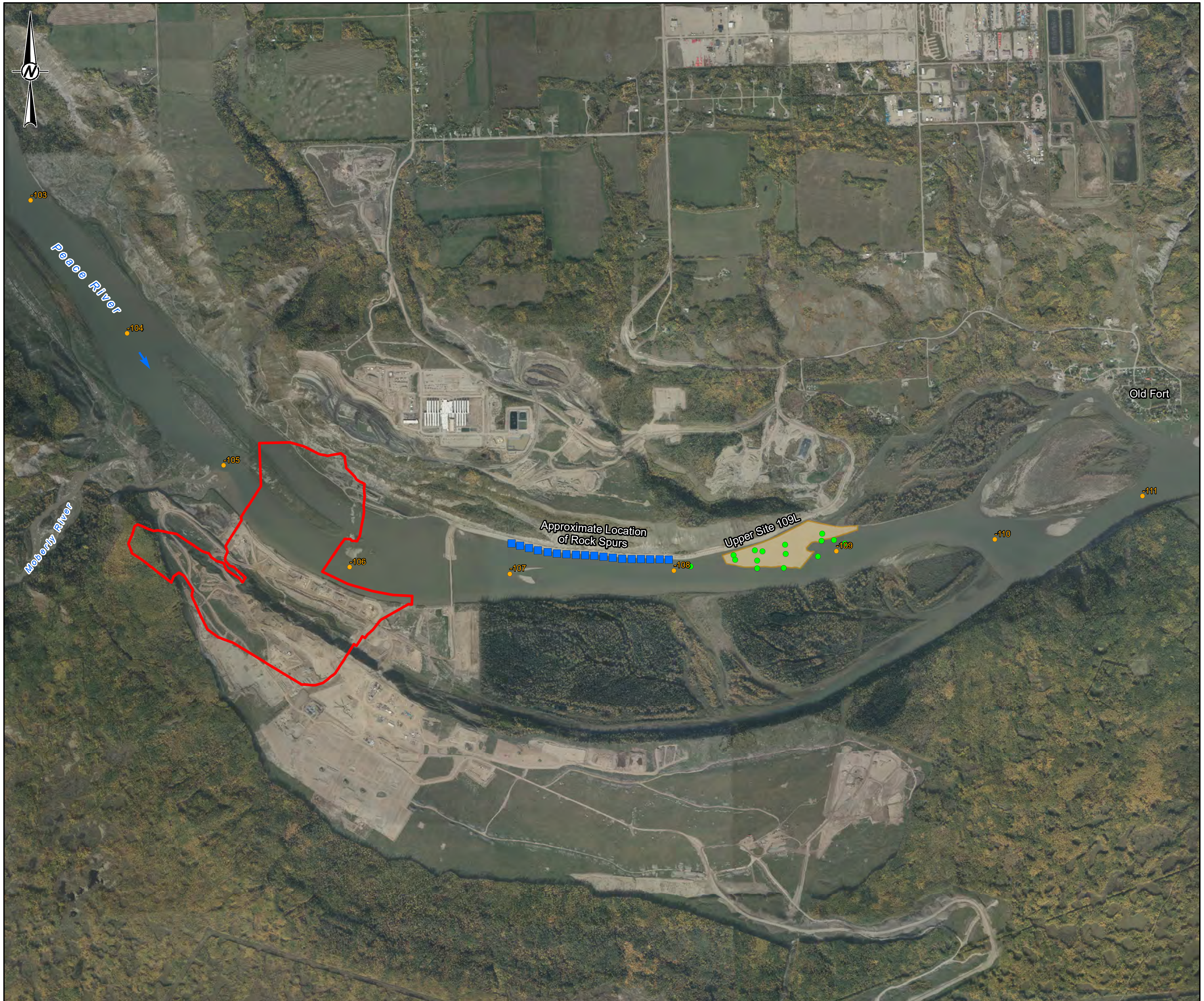

LEGEND

- MOUNTAIN WHITEFISH SPAWN MONITORING LOCATION
- APPROXIMATE LOCATION OF ROCK SPUR
- RIVER KILOMETRE AS MEASURED DOWNSTREAM FROM W.A.C. BENNETT DAM
- ROAD
- OUTLINE OF SITE C PERMANENT COMPONENTS
- UPPER SITE 109L
- FLOW DIRECTION

0 250 500 750 1,000 m
1:25,000

REFERENCES
1. RIVER KILOMETER MARKERS OBTAINED FROM BC HYDRO.
2. IMAGERY PROVIDED BY CLIENT 2017-05-10. IMAGE DATE: 2016-11-10.

DATUM: NAD83 PROJECTION UTM10

CLIENT
BC HYDRO

PROJECT
SITE C OFFSET EFFECTIVENESS MONITORING PROGRAM - 2018

TITLE
OVERVIEW OF MOUNTAIN WHITEFISH SPAWN MONITORING LOCATIONS

CONSULTANT
GOLDER

YYYY-MM-DD	2019-02-22
DESIGNED	DB
PREPARED	JP / CD
REVIEWED	DF
APPROVED	SR

PROJECT NO.	PHASE	REV.	FIGURE
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APPENDIX B

Physical Habitat Data

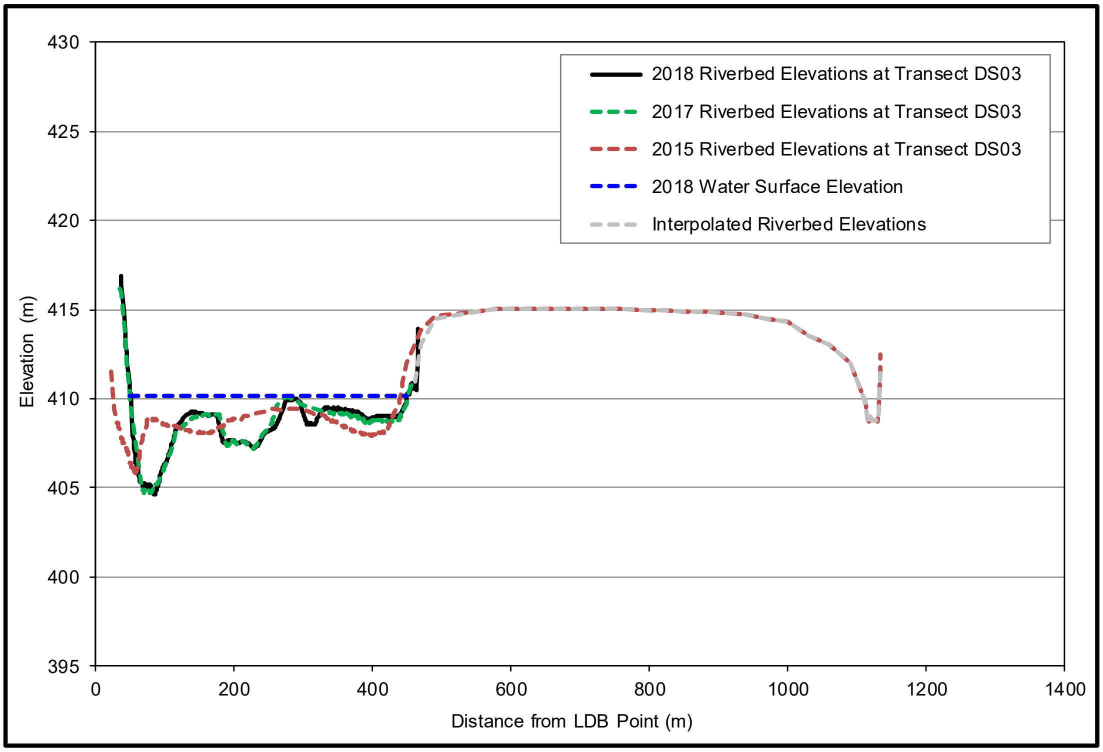


Figure B1: Cross section results for Transect DS03. Transect was surveyed as part of BC Hydro's Site C Offset Effectiveness Monitoring Program, 29-30 October 2018.

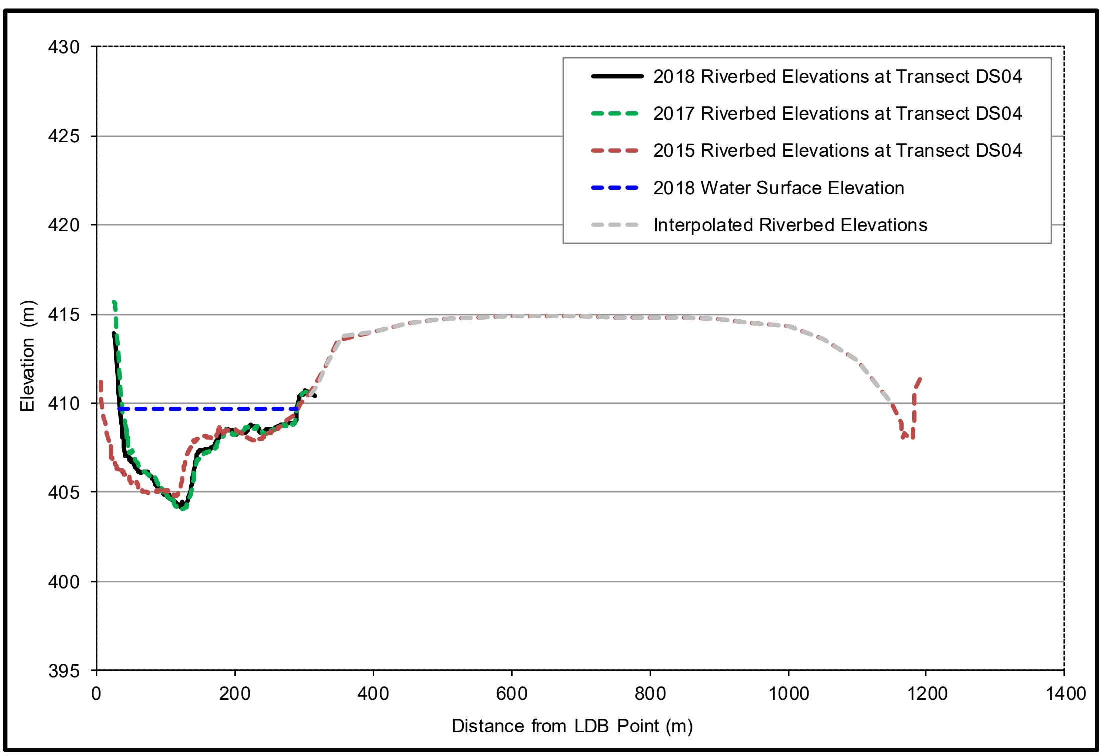


Figure B2: Cross-section results for Transect DS04. Transect was surveyed as part of BC Hydro's Site C Offset Effectiveness Monitoring Program, 29-30 October 2018.

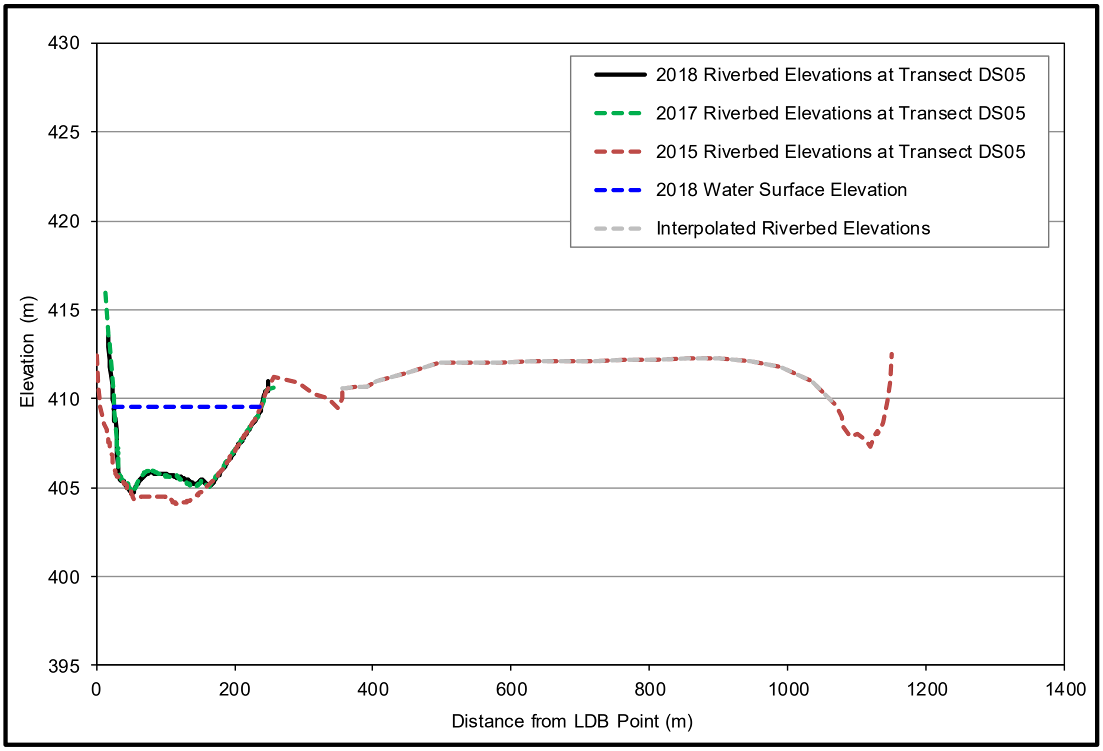


Figure B3: Cross-section results for Transect DS05. Transect was surveyed as part of BC Hydro's Site C Offset Effectiveness Monitoring Program, 29-30 October 2018.

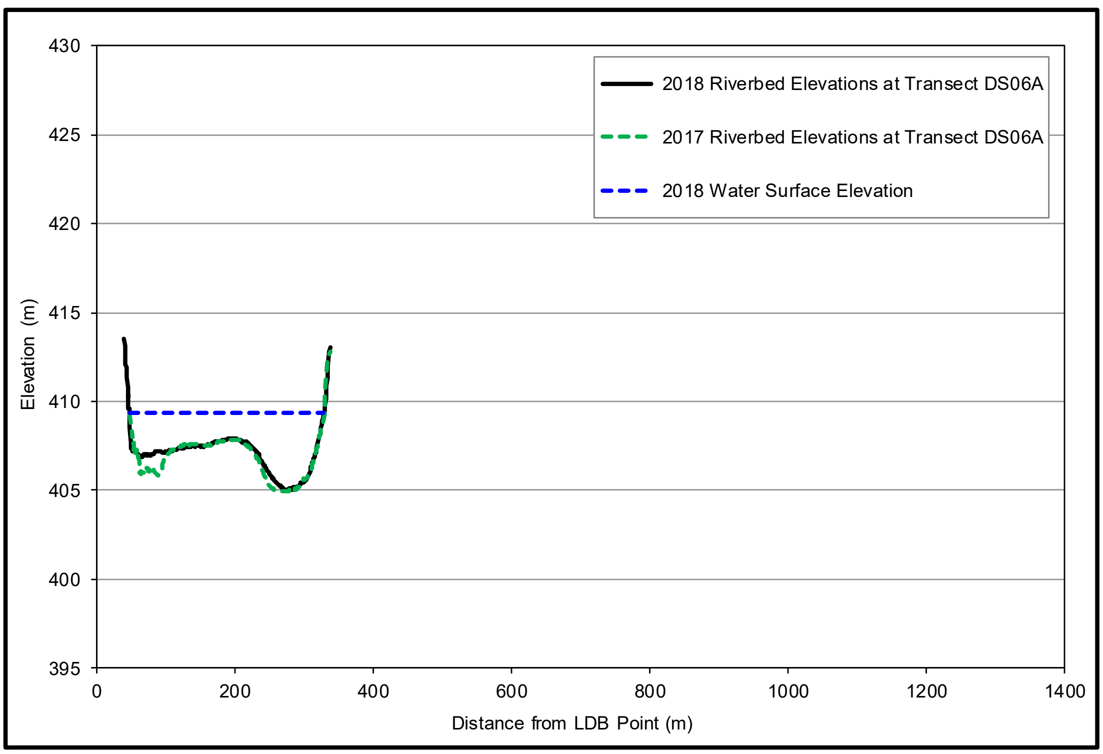


Figure B4: Cross-section results for Transect DS06a. Transect was surveyed as part of BC Hydro's Site C Offset Effectiveness Monitoring Program, 29-30 October 2018.

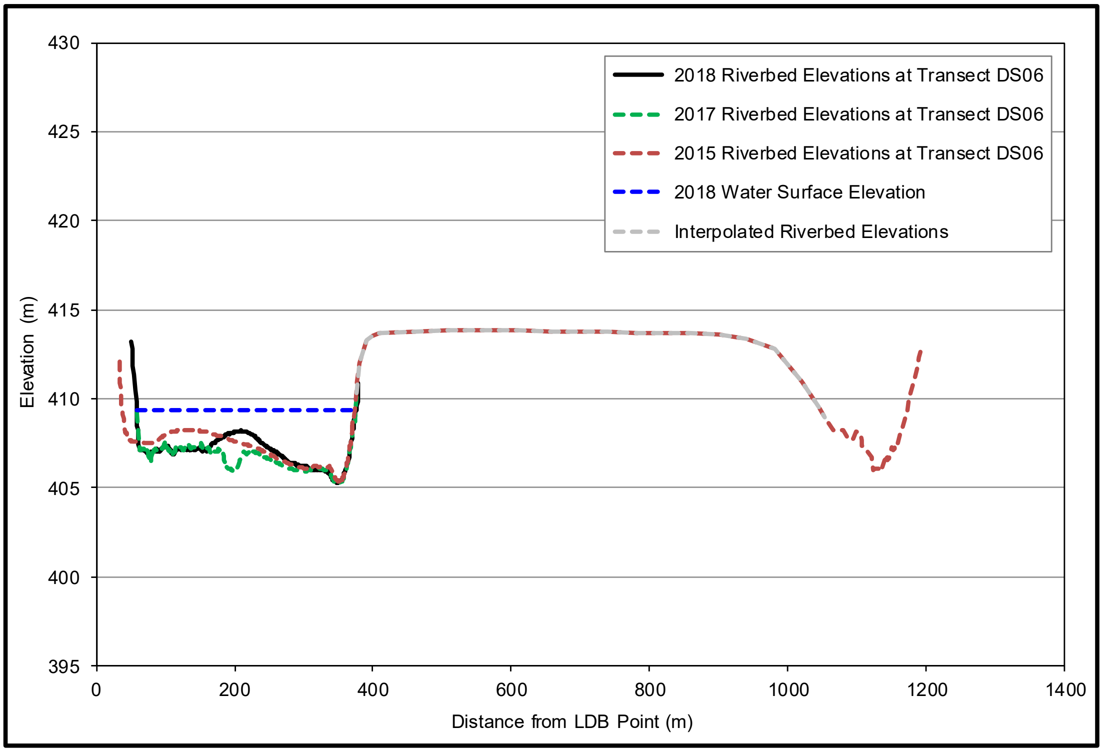


Figure B5: Cross-section results for Transect DS06. Transect was surveyed as part of BC Hydro's Site C Offset Effectiveness Monitoring Program, 29-30 October 2018.

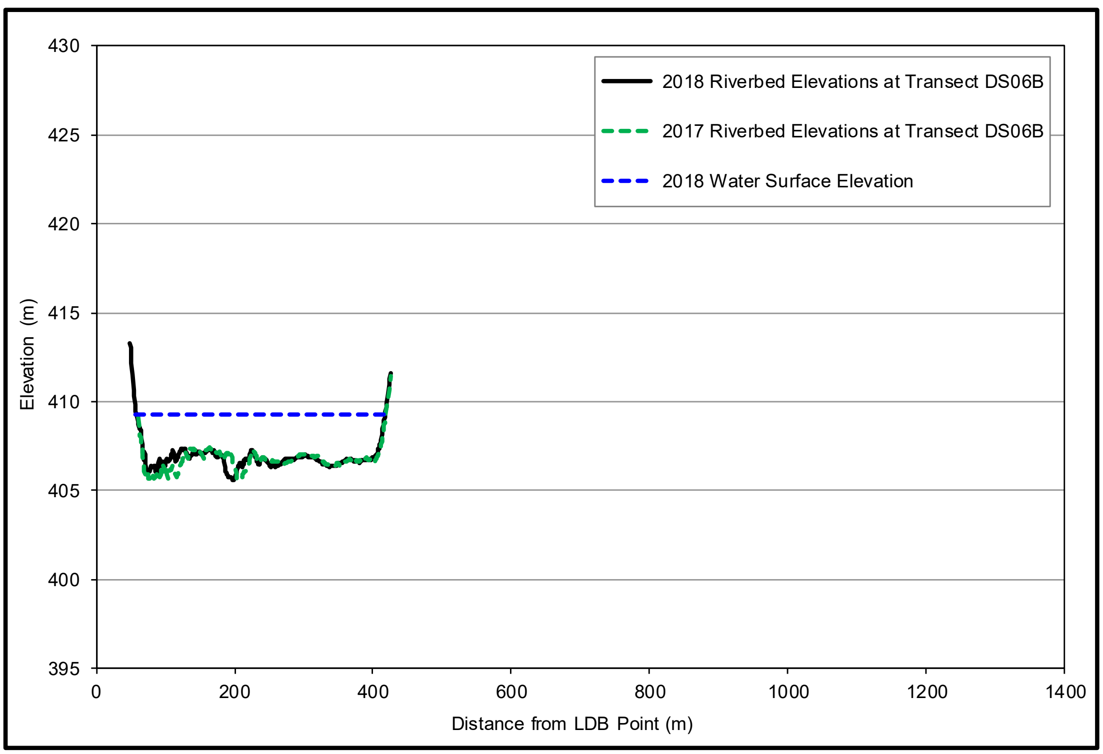


Figure B6: Cross-section results for Transect DS06b. Transect was surveyed as part of BC Hydro's Site C Offset Effectiveness Monitoring Program, 29-30 October 2018.

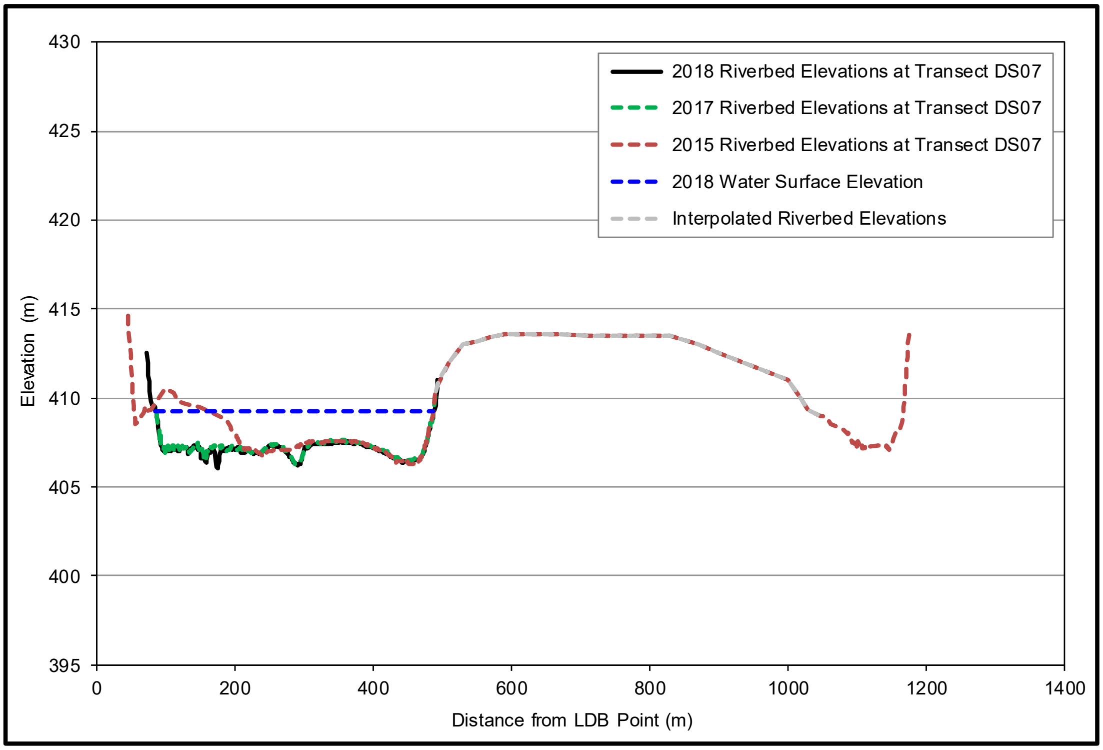


Figure B7: Cross-section results for Transect DS07. Transect was surveyed as part of BC Hydro's Site C Offset Effectiveness Monitoring Program, 29-30 October 2018.

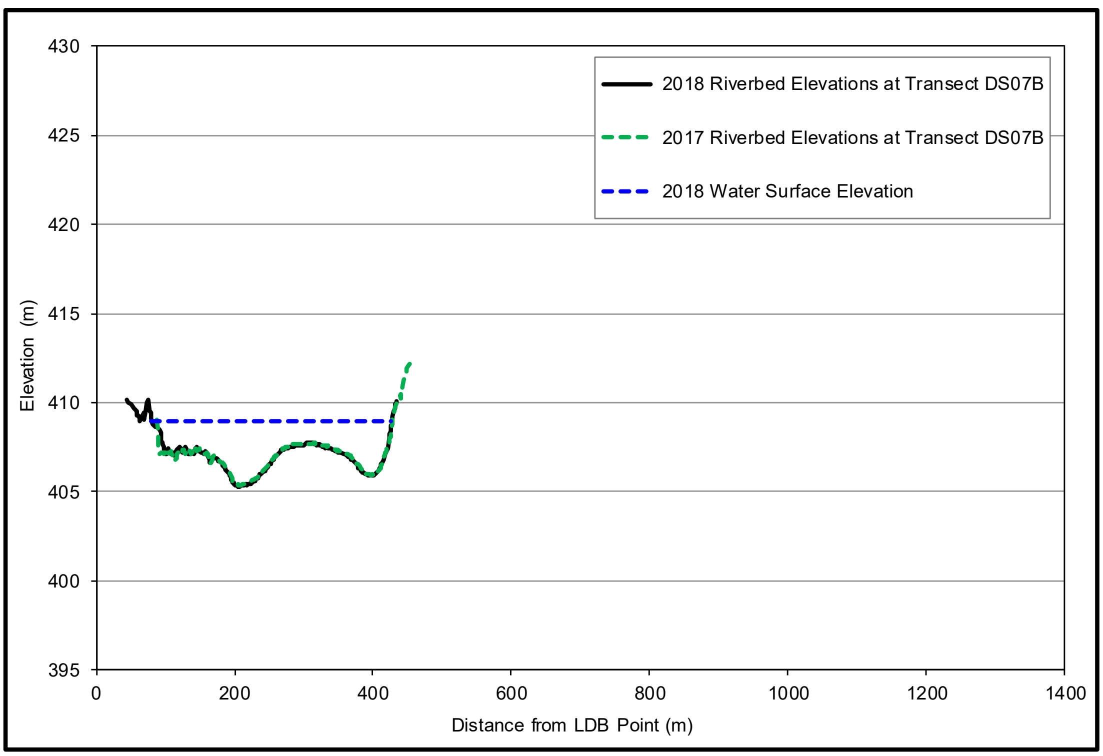
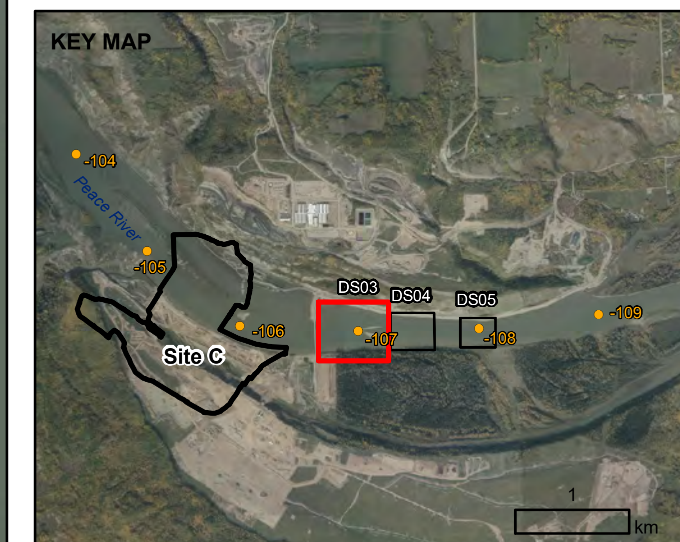


Figure B8: Cross-section results for Transect DS07b. Transect was surveyed as part of BC Hydro's Site C Offset Effectiveness Monitoring Program, 29-30 October 2018.

LEGEND

WATER SPEED AND DIRECTION VECTOR

- <= 0.4 m/s
- 0.4 - 0.8 m/s
- 0.8 - 1.2 m/s
- 1.2 - 1.6 m/s
- 1.6 - 2.9 m/s
- SPUR STRUCTURE



0 20 40 60 80

1:2,000 METRES

REFERENCES

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2. IMAGERY PROVIDED BY CLIENT 2017-05-10. IMAGE DATE: 2016-11-10.
3. TRANSECT SURVEY DATA OBTAINED BY GOLDER ASSOCIATES LTD. 27 MAY 2017.

DATUM: NAD83 PROJECTION UTM10

CLIENT
BC HYDRO

PROJECT
SITE C OFFSET EFFECTIVENESS MONITORING PROGRAM - 2018

TITLE
WATER VELOCITY VECTORS FOR TRANSECT DS03

CONSULTANT
GOLDER

YYYY-MM-DD	2019-02-22
DESIGNED	DF
PREPARED	CD
REVIEWED	DF
APPROVED	SR

PROJECT NO.	PHASE	REV.	FIGURE
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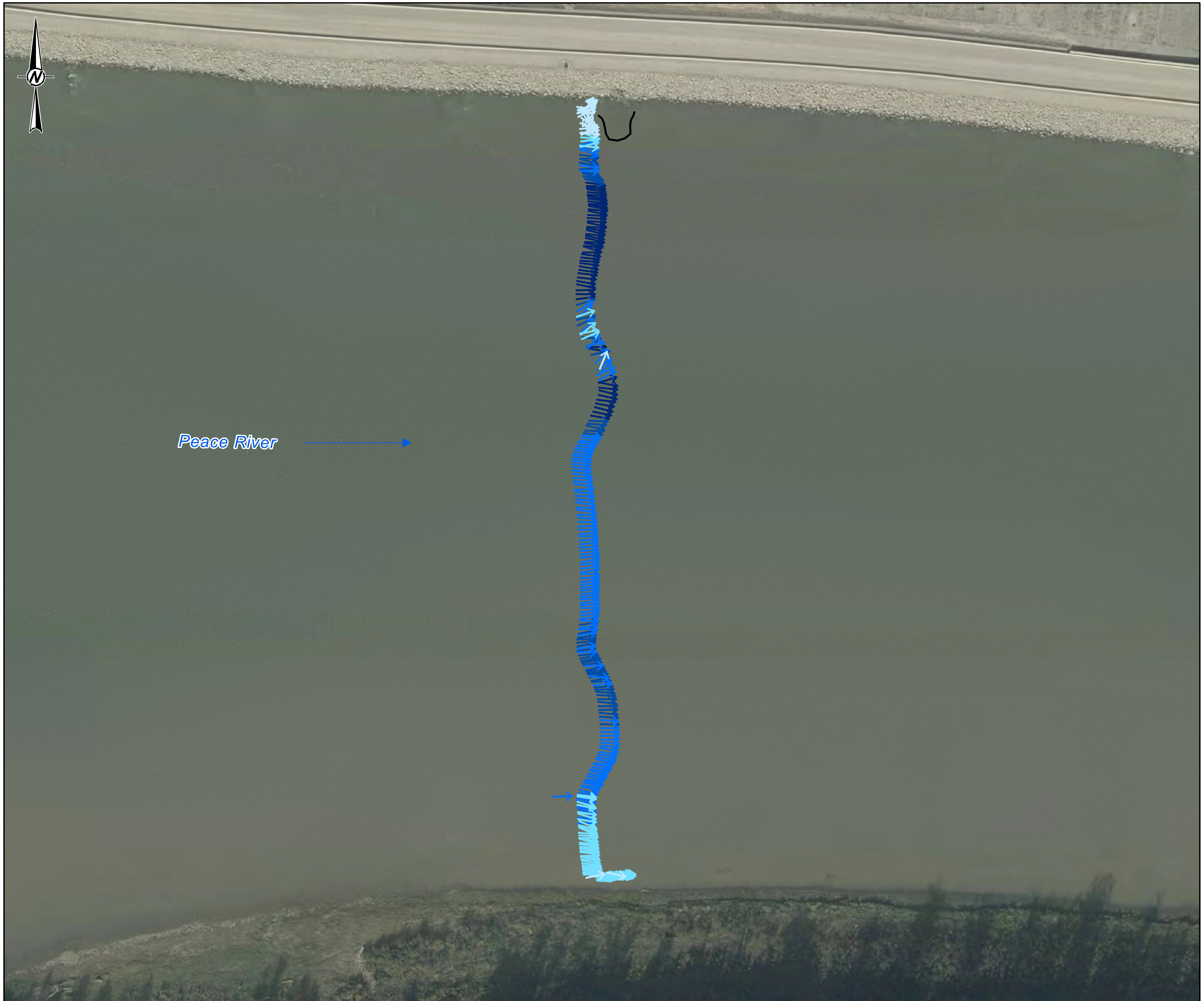

LEGEND

WATER SPEED AND DIRECTION VECTOR

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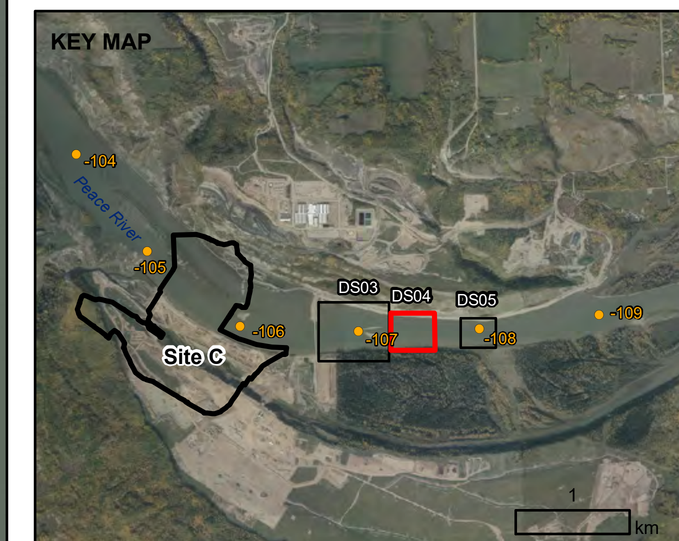
- 0.4 - 0.8 m/s
- 0.8 - 1.2 m/s
- 1.2 - 1.6 m/s
- 1.6 - 2.9 m/s
- SPUR STRUCTURE



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REFERENCES

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3. TRANSECT SURVEY DATA OBTAINED BY GOLDER ASSOCIATES LTD. 27 MAY 2017.

DATUM: NAD83 PROJECTION UTM10

CLIENT
BC HYDRO

PROJECT
SITE C OFFSET EFFECTIVENESS MONITORING PROGRAM - 2018

TITLE
WATER VELOCITY VECTORS FOR TRANSECT DS04

CONSULTANT

GOLDER

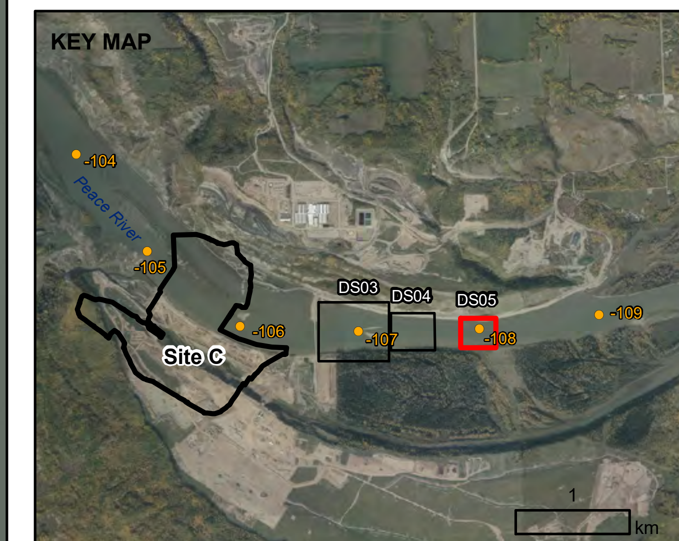
YYYY-MM-DD	2019-02-22
DESIGNED	DF
PREPARED	CD
REVIEWED	DF
APPROVED	SR

PROJECT NO.	PHASE	REV.	FIGURE
1670320	3010	0	B10

LEGEND

WATER SPEED AND DIRECTION VECTOR

- <= 0.4 m/s
- 0.4 - 0.8 m/s
- 0.8 - 1.2 m/s
- 1.2 - 1.6 m/s
- 1.6 - 2.9 m/s
- SPUR STRUCTURE



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1:1,000 METRES

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DATUM: NAD83 PROJECTION UTM10

CLIENT
BC HYDRO

PROJECT
SITE C OFFSET EFFECTIVENESS MONITORING PROGRAM - 2018

TITLE
WATER VELOCITY VECTORS FOR TRANSECT DS05

CONSULTANT

GOLDER

YYYY-MM-DD	2019-02-22
DESIGNED	DF
PREPARED	CD
REVIEWED	DF
APPROVED	SR

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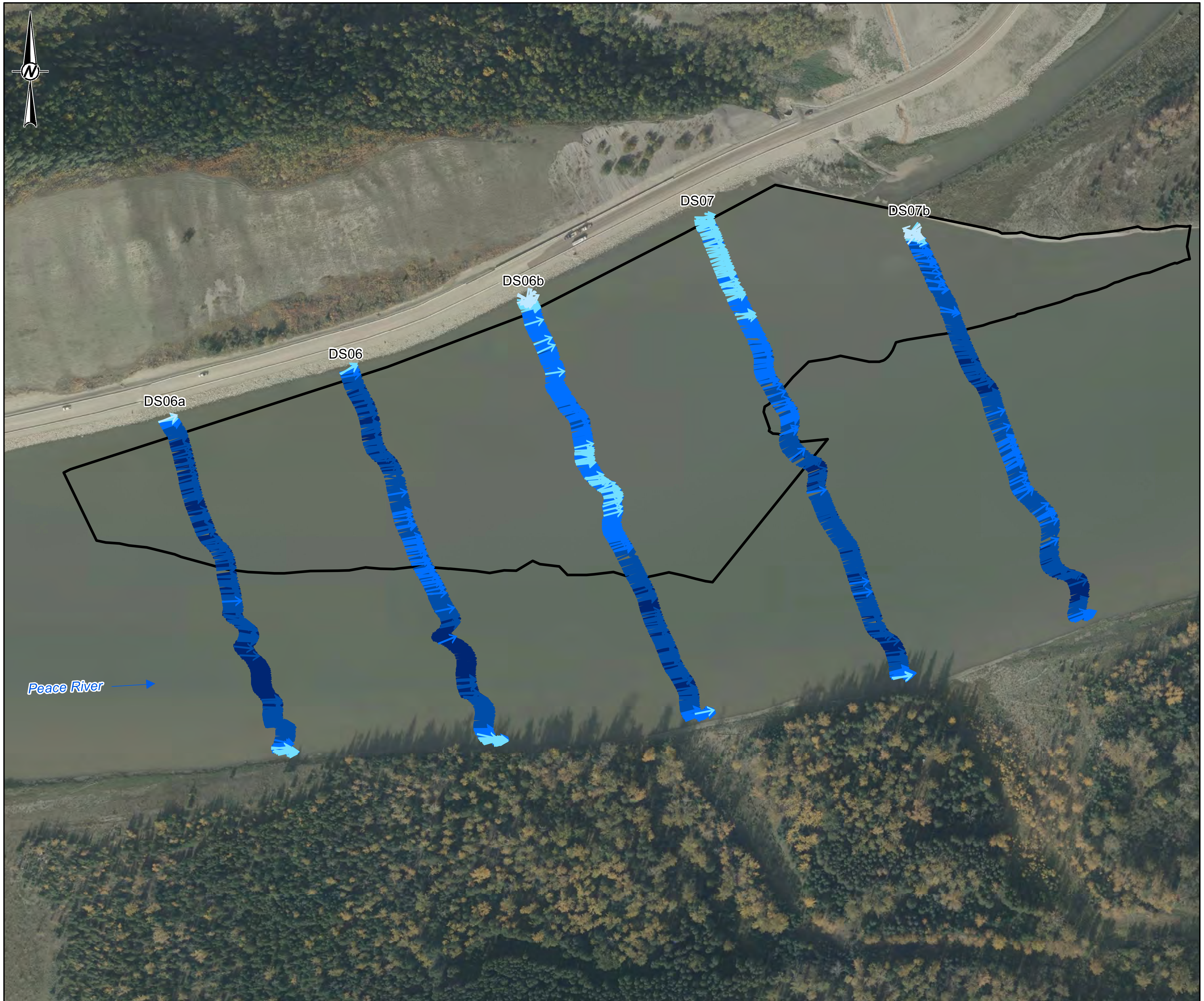

LEGEND

UPPER109L

WATER SPEED AND DIRECTION VECTOR

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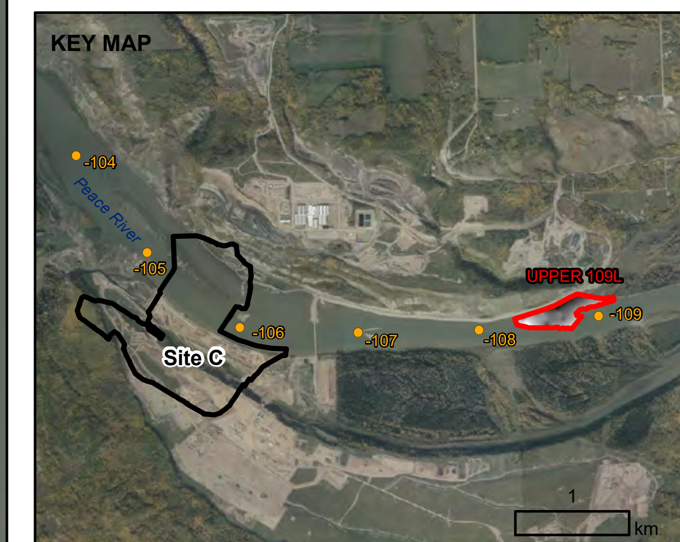
- 0.4 - 0.8 m/s
- 0.8 - 1.2 m/s
- 1.2 - 1.6 m/s
- 1.6 - 2.9 m/s



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REFERENCES

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DATUM: NAD83 PROJECTION UTM10

CLIENT
BC HYDRO

PROJECT
SITE C OFFSET EFFECTIVENESS MONITORING PROGRAM - 2018

TITLE
WATER VELOCITY VECTORS FOR UPPER SITE 109L

CONSULTANT
GOLDER

YYYY-MM-DD	2019-02-22
DESIGNED	DF
PREPARED	CD
REVIEWED	DF
APPROVED	SR

PROJECT NO.	PHASE	REV.	FIGURE
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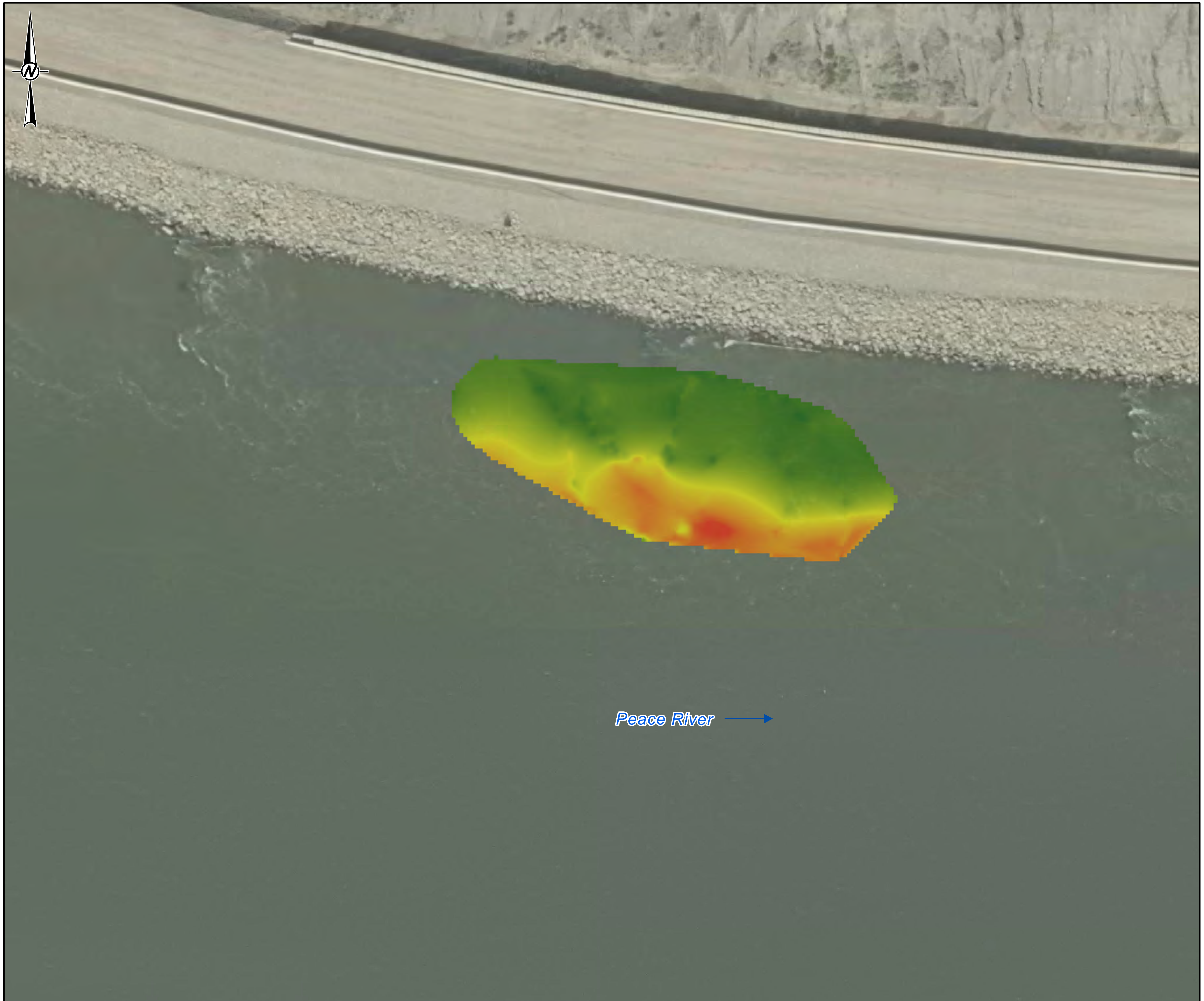
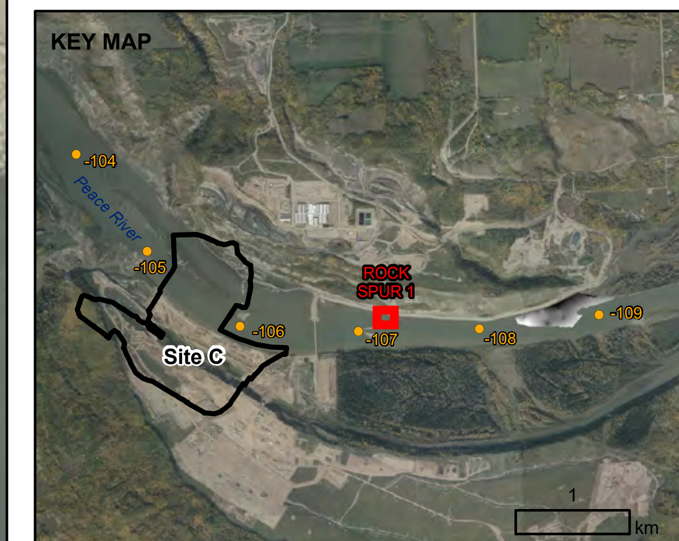


LEGEND

WATER VELOCITY

HIGH (2.5m/s)

LOW (0m/s)



0 5 10 15 20 m

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REFERENCES

1. SPUR STRUCTURE DIGITISED FROM BING IMAGERY.
2. IMAGERY PROVIDED BY CLIENT 2017-05-10. IMAGE DATE: 2016-11-10.
3. TRANSECT SURVEY DATA OBTAINED BY GOLDER ASSOCIATES LTD. 27 MAY 2017.

DATUM: NAD83 PROJECTION UTM10

CLIENT
BC HYDRO

PROJECT
SITE C OFFSET EFFECTIVENESS MONITORING PROGRAM - 2018

TITLE
WATER VELOCITY VECTORS FOR ROCK SPUR 1

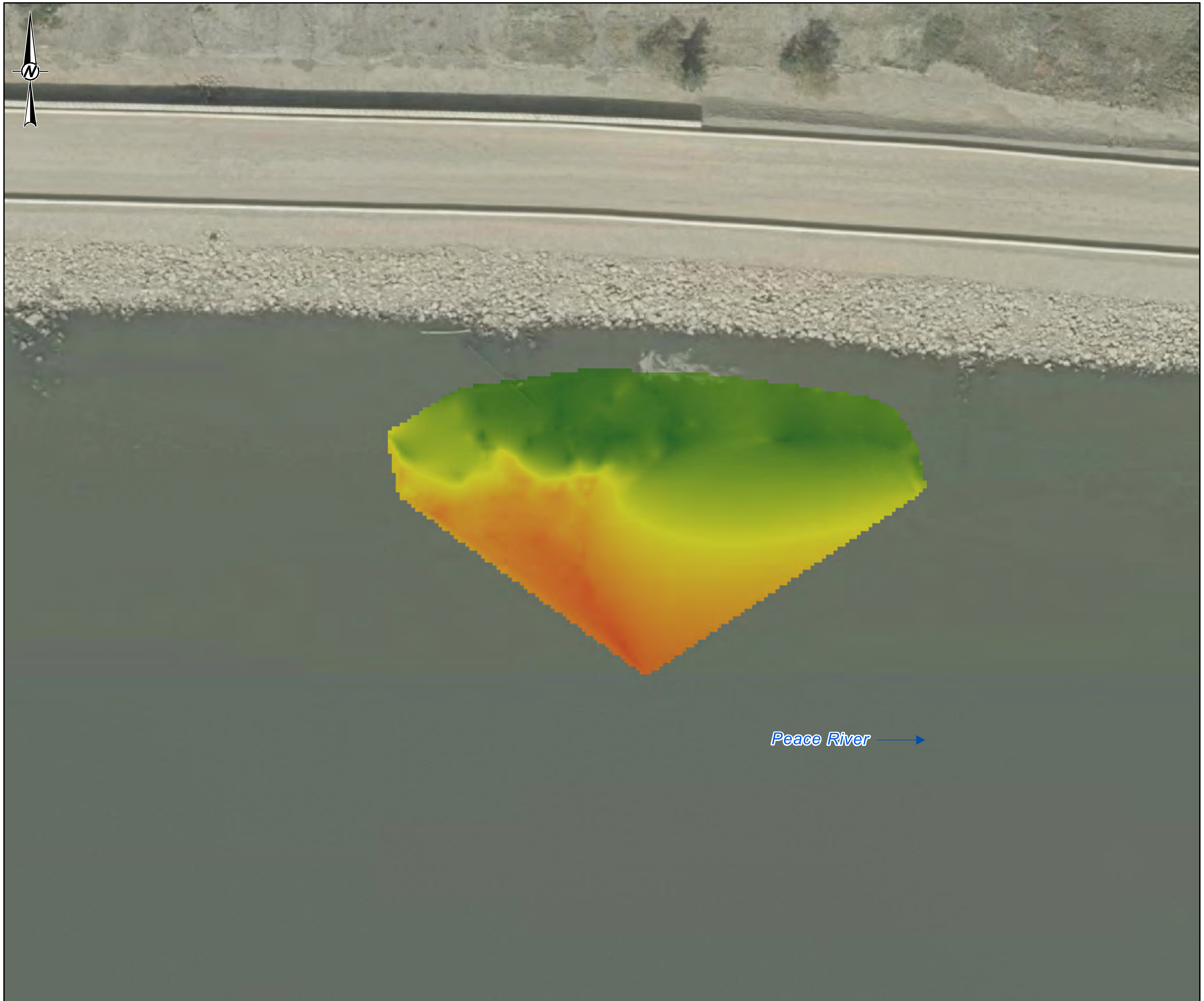
CONSULTANT

GOLDER

YYYY-MM-DD	2019-02-22
DESIGNED	DF
PREPARED	CD
REVIEWED	DF
APPROVED	SR

PROJECT NO.	PHASE	REV.	FIGURE
1670320	3010	0	**B13**

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

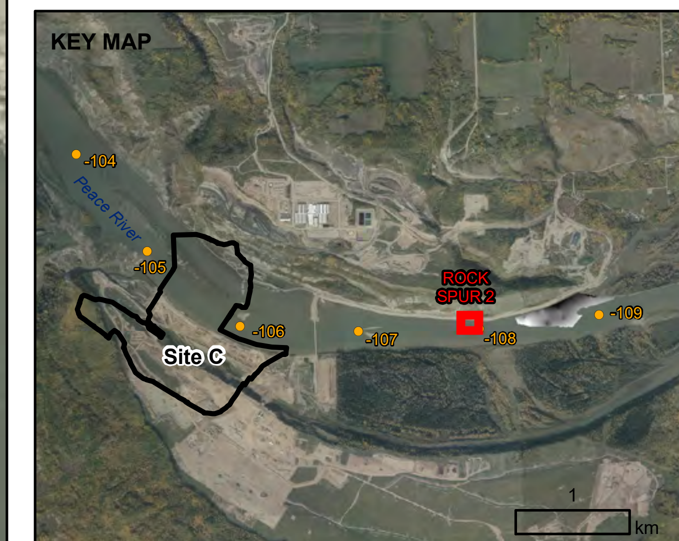


LEGEND

WATER VELOCITY

HIGH (1.4m/s)

LOW (0m/s)



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REFERENCES

1. SPUR STRUCTURE DIGITISED FROM BING IMAGERY.
2. IMAGERY PROVIDED BY CLIENT 2017-05-10. IMAGE DATE: 2016-11-10.
3. TRANSECT SURVEY DATA OBTAINED BY GOLDER ASSOCIATES LTD. 27 MAY 2017.

DATUM: NAD83 PROJECTION UTM10

CLIENT
BC HYDRO

PROJECT
SITE C OFFSET EFFECTIVENESS MONITORING PROGRAM - 2018

TITLE
WATER VELOCITY VECTORS FOR ROCK SPUR 2

CONSULTANT

GOLDER

YYYY-MM-DD	2019-02-22
DESIGNED	DF
PREPARED	CD
REVIEWED	DF
APPROVED	SR

PROJECT NO.	PHASE	REV.	FIGURE
1670320	3010	0	**B14**

PATH: \\golder.gds\gal\burnaby\CAD-GIS\Client\BC_Hydro\Peace_River_GMS\99_PROJECTS\1670320_PeaceRiver_GMS\02_PRODUCTION\2018\MXD\Report\1670320_FIG_B14_VELOCITY_VECTORS_ROCK_SPUR_2_2018.mxd

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

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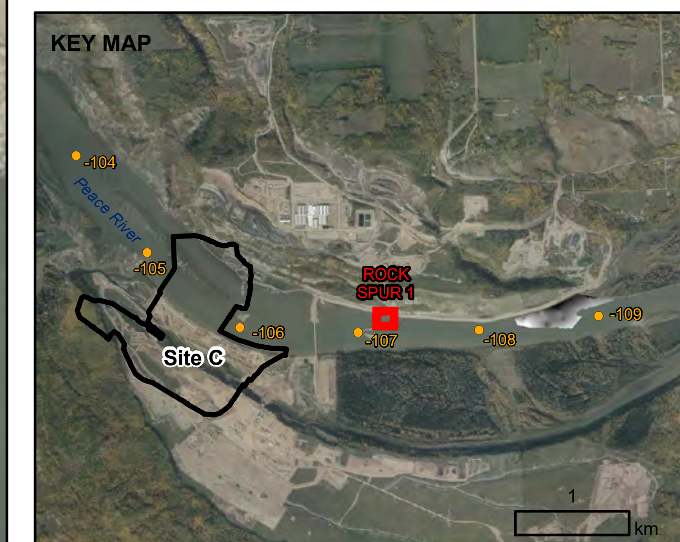
LEGEND

WATER DEPTH

HIGH (6.4m)

LOW (0.8m)



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REFERENCES

1. SPUR STRUCTURE DIGITISED FROM BING IMAGERY.
2. IMAGERY PROVIDED BY CLIENT 2017-05-10. IMAGE DATE: 2016-11-10.
3. TRANSECT SURVEY DATA OBTAINED BY GOLDER ASSOCIATES LTD. 27 MAY 2017.

DATUM: NAD83 PROJECTION UTM10

CLIENT
BC HYDRO

PROJECT
SITE C OFFSET EFFECTIVENESS MONITORING PROGRAM - 2018

TITLE
WATER DEPTH FOR ROCK SPUR 1

CONSULTANT

GOLDER

YYYY-MM-DD	2019-02-22
DESIGNED	DF
PREPARED	CD
REVIEWED	DF
APPROVED	SR

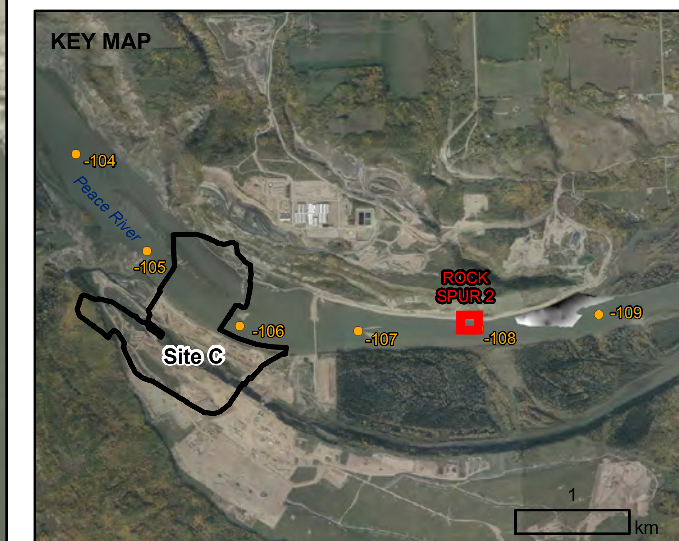
PROJECT NO.	PHASE	REV.	FIGURE
1670320	3010	0	**B15**

LEGEND

WATER DEPTH

HIGH (4m)

LOW (1.5m)



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REFERENCES

1. SPUR STRUCTURE DIGITISED FROM BING IMAGERY.
2. IMAGERY PROVIDED BY CLIENT 2017-05-10. IMAGE DATE: 2016-11-10.
3. TRANSECT SURVEY DATA OBTAINED BY GOLDER ASSOCIATES LTD. 27 MAY 2017.

DATUM: NAD83 PROJECTION UTM10

CLIENT

BC HYDRO

PROJECT

SITE C OFFSET EFFECTIVENESS MONITORING PROGRAM - 2018

TITLE

WATER DEPTH FOR ROCK SPUR 2

CONSULTANT

GOLDER

YYYY-MM-DD	2019-02-22
DESIGNED	DF
PREPARED	CD
REVIEWED	DF
APPROVED	SR

PROJECT NO.	PHASE	REV.	FIGURE
1670320	3010	0	**B16**

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

25mm

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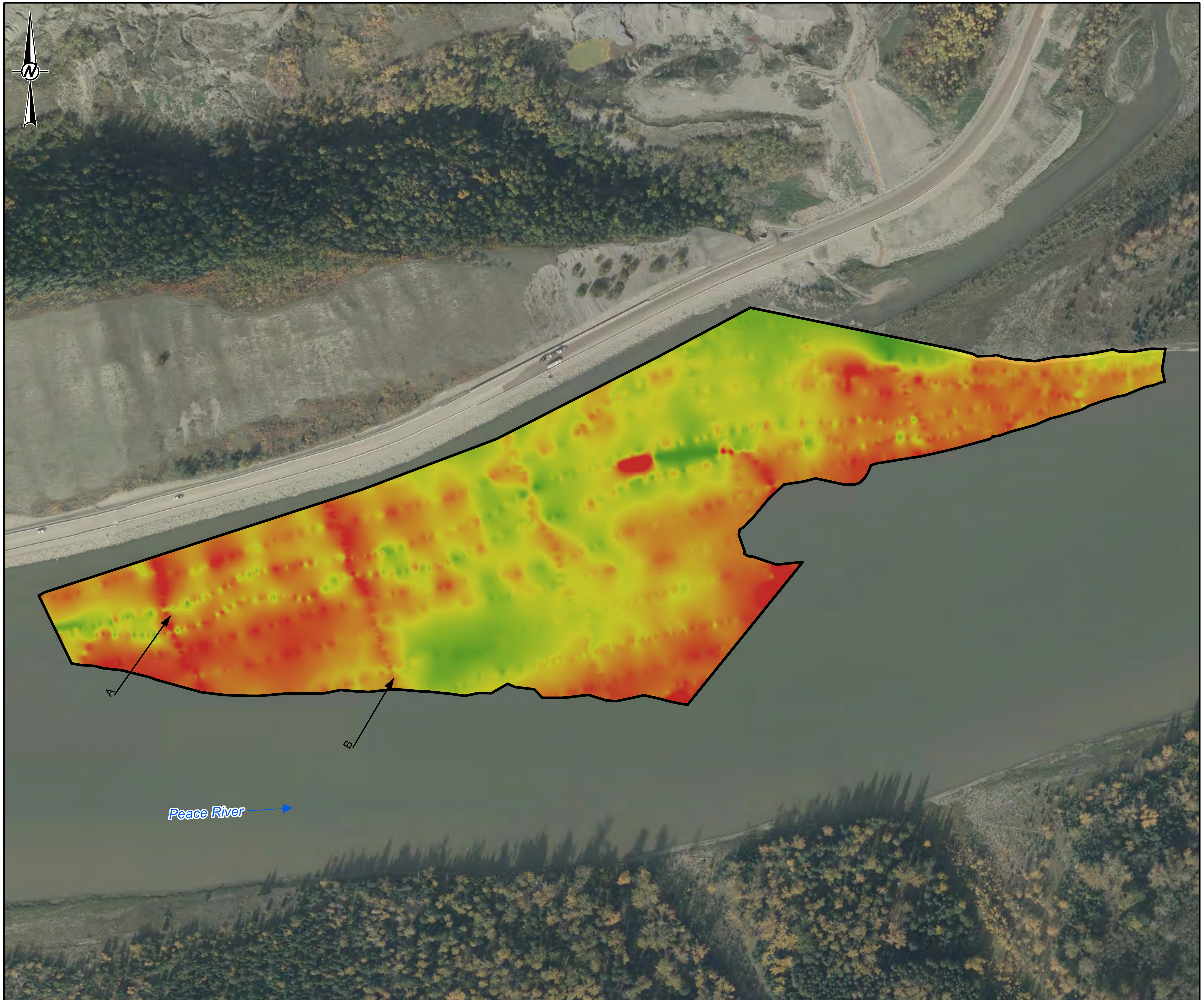


LEGEND

UPPER109L

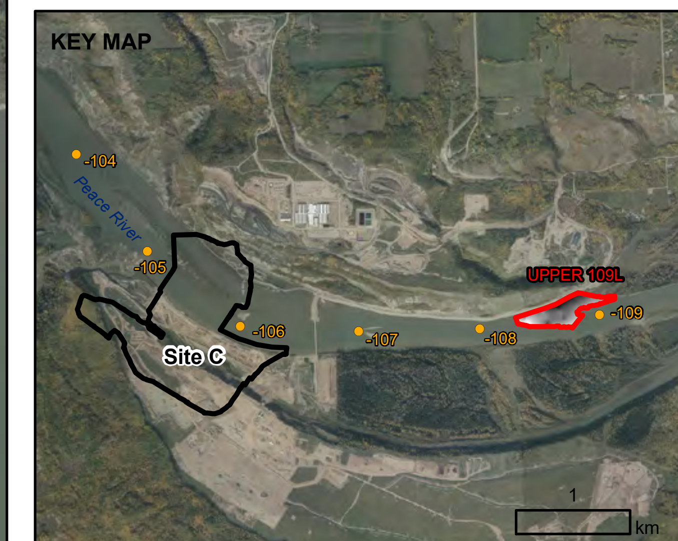
WATER VELOCITY

HIGH (2.5m/s)

LOW (0m/s)

A – APPROXIMATE LOCATION OF AGGRADATION AREA NOTED ALONG TRANSECT DS06A

B – APPROXIMATE LOCATION OF AGGRADATION AREA NOTED ALONG TRANSECT DS06



0 25 50 75 100 m

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REFERENCES

1. SPUR STRUCTURE DIGITISED FROM BING IMAGERY.
2. IMAGERY PROVIDED BY CLIENT 2017-05-10. IMAGE DATE: 2016-11-10.
3. TRANSECT SURVEY DATA OBTAINED BY GOLDER ASSOCIATES LTD. 27 MAY 2017.

DATUM: NAD83 PROJECTION UTM10

CLIENT
BC HYDRO

PROJECT
SITE C OFFSET EFFECTIVENESS MONITORING PROGRAM - 2018

TITLE
WATER VELOCITY FOR UPPER SITE 109L

CONSULTANT

GOLDER

YYYY-MM-DD	2019-02-22
DESIGNED	DF
PREPARED	CD
REVIEWED	DF
APPROVED	SR

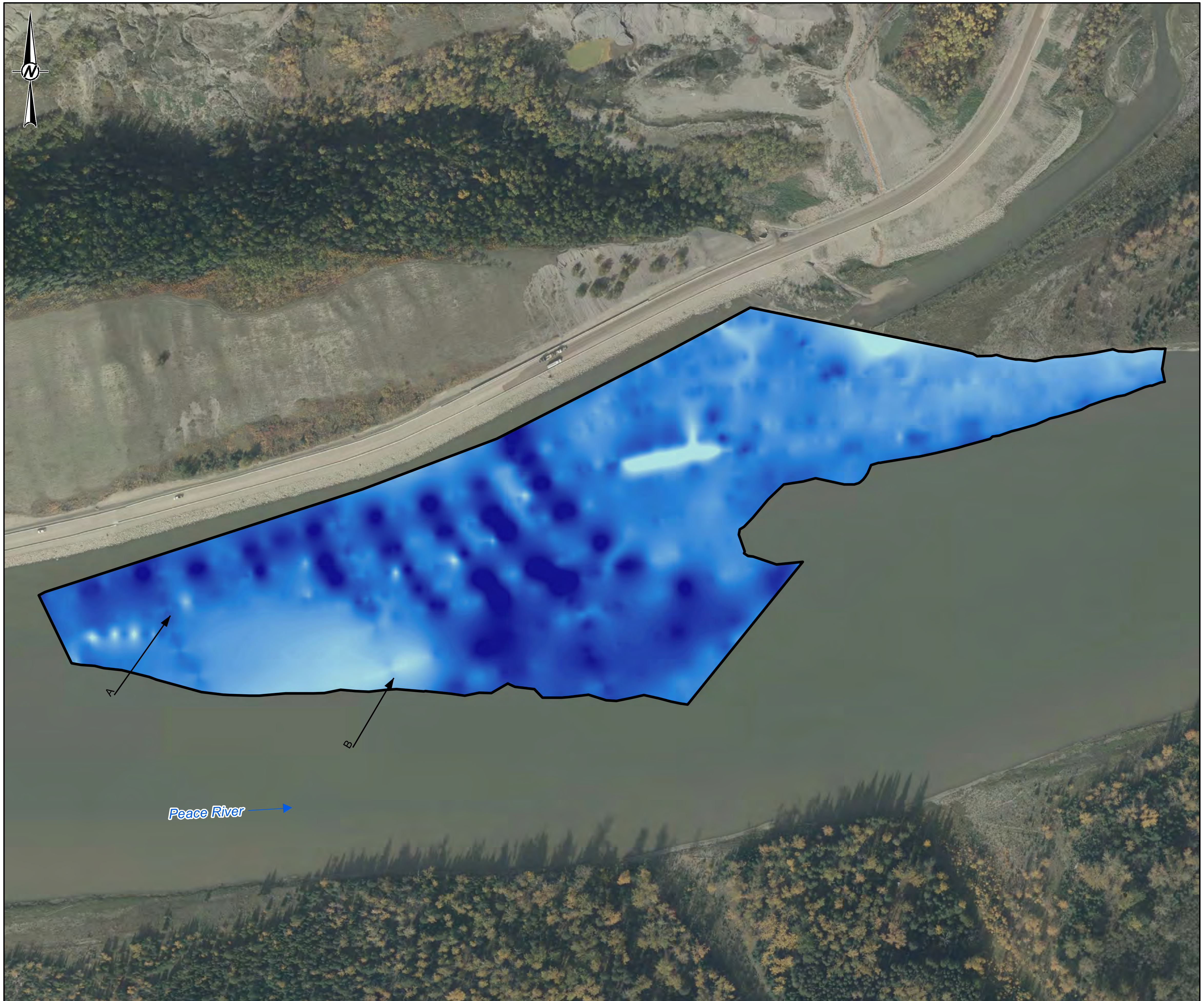
PROJECT NO.	PHASE	REV.	FIGURE
1670320	3010	0	**B17**

PATH: \\golder.gds\gal\burnaby\CAD-GIS\Client\BC_Hydro\Peace_River_GMS\99_PROJECTS\1670320_PeaceRiver_GMS\02_PRODUCTION\2018\MXD\Report\1670320_FIG_B17_VELOCITY_UPPER_109L_2018.mxd

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

25mm

0



LEGEND

UPPER109L

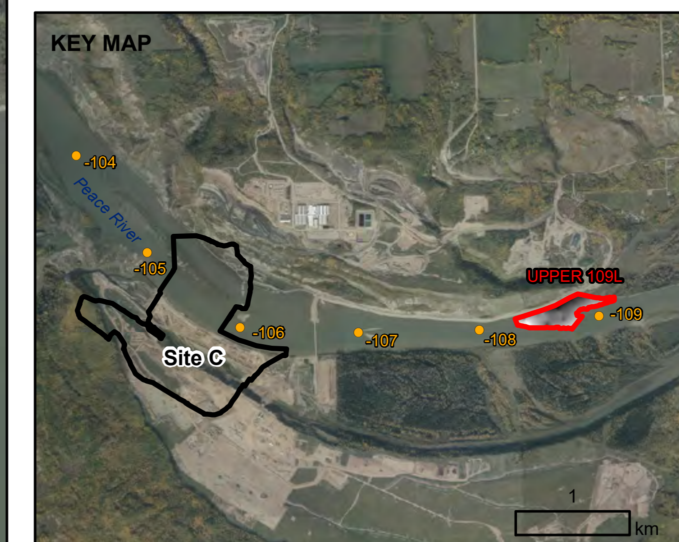
WATER DEPTH

HIGH (4.3m)

LOW (0m)

A – APPROXIMATE LOCATION OF AGGRADATION AREA NOTED ALONG TRANSECT DS06A

B – APPROXIMATE LOCATION OF AGGRADATION AREA NOTED ALONG TRANSECT DS06



0 25 50 75 100 m

1:3,000

REFERENCES

1. SPUR STRUCTURE DIGITISED FROM BING IMAGERY.
2. IMAGERY PROVIDED BY CLIENT 2017-05-10. IMAGE DATE: 2016-11-10.
3. TRANSECT SURVEY DATA OBTAINED BY GOLDER ASSOCIATES LTD. 27 MAY 2017.

DATUM: NAD83 PROJECTION UTM10

CLIENT

BC HYDRO

PROJECT

SITE C OFFSET EFFECTIVENESS MONITORING PROGRAM - 2018

TITLE

WATER DEPTH FOR UPPER SITE 109L

CONSULTANT

GOLDER

YYYY-MM-DD	2019-02-22
DESIGNED	DF
PREPARED	CD
REVIEWED	DF
APPROVED	SR

PROJECT NO.	PHASE	REV.	FIGURE
1670320	3010	0	B18

PATH: \\golder.gds\gal\burnaby\CAD-GIS\Client\BC_Hydro\Peace_River\Peace_River_GMS\99_PROJECTS\1670320_PeaceRiver_GMS\02_PRODUCTION\2018\MXD\Report\1670320_FIG_B18_WATER_DEPTHS_UPPER_109L_2018.mxd

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

25mm

APPENDIX C

General Fish Use Data

Table C1 Summary of habitat variables recorded at boat electroshocking sites surveyed during Site C Offset Effectiveness Monitoring, 2018.

Offset Area	Site Name[a]	Sample Date	Sample Time	Sample Session	Air Temp. (°C)	Water Temp. (°C)	Water Cond. (µs/cm)	Sechi Depth (m)	Cloud Cover[b]	Boat Model	Electroshocker Settings				Length Sampled (m)	Time Sampled (s)	Mean Depth (m)	Max Depth (m)
											Range	Percent	Amperes	Mode				
Rock Spurs	0505	7-Sep-2018	11:35	1	10.0	11.4	200	2.20	Overcast	18H (Cal)	High	37	2.2	30DC	1000	1450	1.8	4.3
Rock Spurs	0506	7-Sep-2018	12:39	1	10.0	11.4	200	2.00	Overcast	18H (Cal)	High	37	2.1	30DC	1000	1521	1.5	2.9
Upper Site 109L	0509	7-Sep-2018	14:30	1	12.0	11.6			Mostly cloudy	18H (Cal)	High	38	2.2	30DC	945	669	1.0	3.0
Rock Spurs	0505	13-Sep-2018	10:15	2	1.0	8.9	190	1.20	Overcast	18H (Cas)	High	19	4.0	30DC	1000	1143	1.6	3.0
Rock Spurs	0506	13-Sep-2018	11:38	2	1.0	8.9	190	1.20	Overcast	18H (Cas)	High	19	4.0	30DC	1000	955	1.4	3.5
Upper Site 109L	0509	13-Sep-2018	14:09	2	2.0	9.2	190	1.20	Mostly cloudy	18H (Cas)	High	18	4.0	30DC	975	775	0.9	1.7
Upper Site 109L	109OSA	14-Sep-2018	12:06	2	1.0	9.1	230	1.70	Clear	18H (Cas)	High	16	4.0	30DC	700	337	2.5	3.8
Upper Site 109L	109OSB	14-Sep-2018	12:18	2	1.0	9.1	230	1.90	Clear	18H (Cas)	High	15	4.0	30DC	775	231	2.0	2.6
Upper Site 109L	109OSC	14-Sep-2018	12:46	2	1.0	9.1	220	1.75	Clear	18H (Cas)	High	17	4.0	30DC	300	235	1.2	3.0
Rock Spurs	0505	20-Sep-2018	10:25	3	0.0	7.9	250	1.55	Overcast	18H (Cas)	High	18	4.0	30DC	1000	1110	1.6	2.8
Rock Spurs	0506	20-Sep-2018	12:08	3	0.0	8.0	250	1.60	Overcast	18H (Cas)	High	18	3.9	30DC	1000	1103	1.5	3.0
Upper Site 109L	0509	20-Sep-2018	17:36	3	2.0	7.9	250	1.60	Mostly cloudy	18H (Cas)	High	18	4.0	30DC	975	816	1.0	3.0
Upper Site 109L	109OSA	20-Sep-2018	14:56	3	3.0	8.1	250	1.60	Partly cloudy	18H (Cas)	High	19	4.0	30DC	700	527	0.7	2.8
Upper Site 109L	109OSB	20-Sep-2018	15:34	3	5.0	8.1	250	1.60	Partly cloudy	18H (Cas)	High	19	4.0	30DC	745	312	1.1	1.9
Upper Site 109L	109OSC	20-Sep-2018	14:23	3	2.0	8.0	250	1.60	Overcast	18H (Cas)	High	18	4.0	30DC	300	220	0.7	1.3
Rock Spurs	0505	27-Sep-2018	10:05	4	3.0	8.1	240	2.00	Mostly cloudy	18H (Cas)	High	15	4.0	30DC	1000	1058	1.3	2.9
Rock Spurs	0506	27-Sep-2018	10:54	4	5.0	8.1	240	2.00	Overcast	18H (Cas)	High	17	3.8	30DC	1000	981	1.0	1.6
Upper Site 109L	0509	27-Sep-2018	14:07	4	10.0	8.6	240	2.00	Partly cloudy	18H (Cas)	High	15	4.0	30DC	975	732	0.9	2.9
Upper Site 109L	109OSA	27-Sep-2018	11:13	4	5.0	8.1	240	2.00	Overcast	18H (Cas)	High	15	3.8	30DC	700	464	1.0	2.5
Upper Site 109L	109OSB	27-Sep-2018	12:15	4	5.0	8.1	240	2.00	Clear	18H (Cas)	High	15	4.0	30DC	575	192	0.7	1.1
Upper Site 109L	109OSC	27-Sep-2018	12:23	4	5.0	8.1	240	2.00	Clear	18H (Cal)	High	15	4.0	30DC	300	180	0.8	1.4
Rock Spurs	0505	10-Oct-2018	9:54	5	1.0	5.0	220	1.75	Overcast	Type VI[c]	336	3.5	5.0	30DC	1000	1190	2.0	3.8
Rock Spurs	0506	10-Oct-2018	10:41	5	1.0	5.0	220	1.75	Overcast	Type VI[c]	336	3.5	5.0	30DC	1000	664	1.4	3.1
Upper Site 109L	0509	10-Oct-2018	11:46	5	1.0	5.0	220	1.75	Overcast	Type VI[c]	336	3.5	5.0	30DC	975	552	1.2	
Upper Site 109L	109OSA	10-Oct-2018	11:14	5	1.0	5.0	220	1.75	Overcast	Type VI[c]	336	3.5	5.0	30DC	700	315	2.0	4.3
Upper Site 109L	109OSB	10-Oct-2018	11:33	5	1.0	5.0	220	1.75	Overcast	Type VI[c]	336	3.5	5.0	30DC	775	179	2.0	4.0
Upper Site 109L	109OSC	10-Oct-2018	11:05	5	1.0	5.0	220	1.75	Overcast	Type VI[c]	336	3.5	5.0	30DC	300	232	1.6	2.6

[a] See Appendix A, Figure A3 for sample site locations.

[b] Clear = <10%; Partly Cloudy = 10-50%; Mostly Cloudy = 50-90%; Overcast = >90%.

[c] During Session 5 the Type VI electrofisher unit was used with the 18H (Cal) boat. The setting are slightly different than the GPP 5.0 on the 18H (Cal). The output is measured in volts and milliseconds (pulse width), as well as amperes.

Table C2 Summary of boat electroshockinging catch recorded during Site C Offset Effectiveness Monitoring, 2018.

Offset Area	Site Name[a]	Sample Date	Sample Session	Species Name	Size Class	Total Number Caught
Rock Spurs	0505	7-Sep-2018	1	Burbot	<150	1
				Largescale Sucker	200-299	1
				Largescale Sucker	>300	3
				Longnose Sucker	>300	7
				Mountain Whitefish	<150	1
				Mountain Whitefish	200-299	3
				Mountain Whitefish	>300	1
				Rainbow Trout	>300	1
				Slimy Sculpin	-	1
				Walleye	>300	2
				White Sucker	>300	1
		Session Total				**22**
		13-Sep-2018	2	Burbot	>300	1
				Bull Trout	>300	1
				Longnose Sucker	150-199	1
				Longnose Sucker	>300	2
				Mountain Whitefish	>300	6
				Rainbow Trout	>300	3
				Walleye	>300	1
		Session Total				**15**
		20-Sep-2018	3	Bull Trout	200-299	1
				Bull Trout	>300	2
				Longnose Sucker	<150	1
				Longnose Sucker	>300	1
				Mountain Whitefish	150-199	1
				Mountain Whitefish	200-299	3
				Mountain Whitefish	>300	3
				Northern Pikeminnow	>300	1
				Rainbow Trout	150-199	1
				Rainbow Trout	>300	3
				Walleye	>300	2
		Session Total				**19**
		27-Sep-2018	4	Bull Trout	>300	1
				Mountain Whitefish	200-299	4
				Mountain Whitefish	>300	4
				Rainbow Trout	>300	2
				Trout-Perch	-	1
		Session Total				**12**
		10-Oct-2018	5	Bull Trout	200-299	1
				Bull Trout	>300	1
				Mountain Whitefish	200-299	1
				Mountain Whitefish	>300	3
				Rainbow Trout	>300	1
		Session Total				**7**
	Site Total					**75**
	0506	7-Sep-2018	1	Bull Trout	>300	1
				Largescale Sucker	>300	1
				Longnose Sucker	200-299	2
				Longnose Sucker	>300	5
				Mountain Whitefish	200-299	3
				Mountain Whitefish	>300	2
				Northern Pike	<150	1
				Northern Pike	>300	1
				Walleye	>300	2
		Session Total				**18**
		13-Sep-2018	2	Bull Trout	200-299	1
				Bull Trout	>300	2
				Longnose Sucker	200-299	1
				Longnose Sucker	>300	1
				Mountain Whitefish	200-299	7
				Mountain Whitefish	>300	13
				Northern Pikeminnow	>300	1
				Rainbow Trout	>300	1
				White Sucker	>300	1
		Session Total				**28**

…continued.

Table C2 Continued.

Offset Area	Site Name[a]	Sample Date	Sample Session	Species Name	Size Class	Total Number Caught
Rock Spurs	0506	20-Sep-2018	3	Bull Trout	>300	1
				Largescale Sucker	>300	1
				Longnose Sucker	150-199	1
				Longnose Sucker	200-299	2
				Longnose Sucker	>300	3
				Mountain Whitefish	200-299	15
				Mountain Whitefish	>300	14
				Northern Pikeminnow	>300	1
				Walleye	>300	1
		Session Total				**39**
		27-Sep-2018	4	Bull Trout	>300	1
				Largescale Sucker	150-199	1
				Largescale Sucker	>300	1
				Mountain Whitefish	200-299	9
				Mountain Whitefish	>300	11
				Rainbow Trout	>300	1
		Session Total				**24**
		10-Oct-2018	5	Mountain Whitefish	200-299	3
				Mountain Whitefish	>300	2
				Rainbow Trout	>300	1
		Session Total				**6**
	Site Total					**115**
Rock Spurs Total						**190**
Upper Site 109L	0509	7-Sep-2018	1	Largescale Sucker	>300	3
				Longnose Sucker	<150	2
				Longnose Sucker	200-299	1
				Longnose Sucker	>300	5
				Mountain Whitefish	150-199	2
				Mountain Whitefish	200-299	3
				Mountain Whitefish	>300	3
		Session Total				**19**
		13-Sep-2018	2	Bull Trout	>300	2
				Largescale Sucker	>300	4
				Longnose Sucker	<150	2
				Longnose Sucker	>300	4
				Mountain Whitefish	200-299	10
				Mountain Whitefish	>300	13
				Prickly Sculpin	-	1
				Redside Shiner	-	1
				Slimy Sculpin	-	2
				Trout-Perch	-	1
				Walleye	>300	1
		Session Total				**41**
		20-Sep-2018	3	Largescale Sucker	>300	3
				Longnose Sucker	>300	6
				Mountain Whitefish	<150	2
				Mountain Whitefish	150-199	1
				Mountain Whitefish	200-299	8
				Mountain Whitefish	>300	10
		Session Total				**30**
		27-Sep-2018	4	Largescale Sucker	>300	1
				Longnose Sucker	>300	1
				Mountain Whitefish	<150	2
				Mountain Whitefish	150-199	2
				Mountain Whitefish	200-299	17
				Mountain Whitefish	>300	13
				Northern Pike	>300	1
				White Sucker	>300	1
		Session Total				**38**
		10-Oct-2018	5	Largescale Sucker	>300	1
				Mountain Whitefish	150-199	2
				Mountain Whitefish	200-299	7
				Mountain Whitefish	>300	12
		Session Total				**22**
	Site Total					**150**

...continued.

Table C2 Continued.

Offset Area	Site Name[a]	Sample Date	Sample Session	Species Name	Size Class	Total Number Caught
Upper Site 109L	109OSA	14-Sep-2018	2	Mountain Whitefish	200-299	2
				Mountain Whitefish	>300	9
		Session Total				**11**
		20-Sep-2018	3	Mountain Whitefish	<150	2
				Mountain Whitefish	150-199	2
				Mountain Whitefish	200-299	4
				Mountain Whitefish	>300	8
		Session Total				**16**
		27-Sep-2018	4	Mountain Whitefish	150-199	1
				Mountain Whitefish	200-299	8
				Mountain Whitefish	>300	16
		Session Total				**25**
		10-Oct-2018	5	No Fish Caught	-	0
		Session Total				**0**
	Site Total					**52**
Upper Site 109L	109OSB	14-Sep-2018	2	Mountain Whitefish	>300	1
		Session Total				**1**
		20-Sep-2018	3	Largescale Sucker	>300	1
				Longnose Sucker	>300	1
				Mountain Whitefish	200-299	3
				Walleye	>300	1
		Session Total				**6**
		27-Sep-2018	4	Longnose Sucker	>300	1
				Mountain Whitefish	200-299	1
				Mountain Whitefish	>300	1
		Session Total				**3**
		10-Oct-2018	5	No Fish Caught	-	0
		Session Total				**0**
	Site Total					**10**
Upper Site 109L	109OSC	14-Sep-2018	2	Largescale Sucker	>300	1
				Longnose Sucker	>300	1
				Mountain Whitefish	200-299	4
				Mountain Whitefish	>300	8
		Session Total				**14**
		20-Sep-2018	3	Longnose Sucker	200-299	1
				Longnose Sucker	>300	6
				Mountain Whitefish	200-299	5
				Mountain Whitefish	>300	9
		Session Total				**21**
		27-Sep-2018	4	Longnose Sucker	200-299	1
				Longnose Sucker	>300	2
				Mountain Whitefish	>300	4
		Session Total				**7**
		10-Oct-2018	5	Bull Trout	>300	1
				Longnose Sucker	>300	1
				Mountain Whitefish	150-199	1
				Mountain Whitefish	200-299	2
				Mountain Whitefish	>300	4
		Session Total				**9**
	Site Total					**51**
Upper Site 109L Total						**263**
Survey Total						**453**

Table C3 Summary of life history data collected in the Peace River during boat electroshocking surveys conducted as part of BC Hydro's Site C Offset Effectiveness Monitoring Program, 2018.

Site Name	Date	Sample Number	Species	Length (mm)	Weight (g)	Condition (K)	Tag 1 Number	Tag 2 Number	Preserve Code[a]
0505	07-Sep-18	769	Mountain Whitefish	212	109	1.144	900228000586684		
		770	Mountain Whitefish	243	172	1.199	900228000587285		
		771	Mountain Whitefish	229	144	1.199	900228000591611		
		772	Largescale Sucker	402	678	1.044	900230000079955		
		773	Longnose Sucker	390	778	1.312	900230000079961		
		774	Longnose Sucker	402	864	1.33	900230000074274		
		775	Longnose Sucker	464	1007	1.008	900230000079913		
		776	Longnose Sucker	399	778	1.225	900230000079859		
		777	Longnose Sucker	334	462	1.24	900230000079686		
		778	Largescale Sucker	229	130	1.083	900228000348003		
		779	Largescale Sucker	362	584	1.231	900230000079797		
		780	Mountain Whitefish	352	440	1.009	900230000078211		
		781	Largescale Sucker	334	460	1.235	900230000079891		
		782	Longnose Sucker	409	792	1.158	900230000079867		
		783	White Sucker	318	434	1.35	900230000079924		
		784	Longnose Sucker	440	1125	1.321	900230000079728		
		785	Burbot	82	4	0.725			
		786	Rainbow Trout	434	1144	1.399	900230000078021		3
		787	Walleye	452	1012	1.096	900230000079762		
		788	Walleye	600	2381	1.102	900230000033767		
		789	Mountain Whitefish	90	10	1.372			
		790	Slimy Sculpin	76	7	1.595			3
	13-Sep-18	1829	Mountain Whitefish	314	337	1.089	900230000076185		
		1830	Mountain Whitefish	315	344	1.101	900230000076805		
		1831	Mountain Whitefish	302	324	1.176	981098104934785	900230000077077	
		1832	Mountain Whitefish	309	324	1.098	900230000076042		
		1833	Mountain Whitefish	307	304	1.051	900230000077036		
		1834	Mountain Whitefish	356	379	0.84	900230000076890		
		1835	Longnose Sucker	405	856	1.289	900230000077080		

[a] 1 = Stomach contents (gastric lavage); 3 = DNA Sample; 5 = Mercury and SIA (biopsy)

Table C3 Continued.

Site Name	Date	Sample Number	Species	Length (mm)	Weight (g)	Condition (K)	Tag 1 Number	Tag 2 Number	Preserve Code[a]
0505	13-Sep-18	1836	Longnose Sucker	436	1068	1.289	900230000077987		
		1837	Longnose Sucker	162	45	1.058			
		1838	Walleye	373	659	1.27	900230000076212		5
		1839	Rainbow Trout	391	726	1.215	900228000587516		1, 3
		1840	Rainbow Trout	379	755	1.387	900230000076186		1, 3
		1841	Rainbow Trout	412	939	1.343	900230000076728		1, 3
		1842	Bull Trout	435	789	0.959	900228000349614		3, 5
		1843	Burbot	454	485	0.518	900230000076665		5
	20-Sep-18	3569	Longnose Sucker	69	5	1.522			
		3570	Northern Pikeminnow	504	1433	1.119			
		3571	Mountain Whitefish	161	40	0.958			
		3572	Mountain Whitefish	240	174	1.259	900228000591445		
		3573	Mountain Whitefish	274	254	1.235	900228000591338		
		3574	Walleye	506	1455	1.123	900230000080322		
		3575	Mountain Whitefish	318	340	1.057	900230000080920		
		3576	Mountain Whitefish	314	340	1.098	900230000076852		
		3577	Mountain Whitefish	313	290	0.946	900230000081267		
		3578	Walleye	454	1130	1.208	900230000080082		
		3579	Longnose Sucker	394	733	1.198	900230000080497		
		3580	Rainbow Trout	178	64	1.135	900226000255515		1, 3
		3581	Mountain Whitefish	263	231	1.27	900228000591902		1
		3582	Rainbow Trout	378	719	1.331	900230000080638		1, 3
		3583	Rainbow Trout	344			900230000077403		
		3584	Rainbow Trout	412	936	1.338	900230000076728		
		3585	Bull Trout	262	188	1.045	900228000591039		3, 5
		3586	Bull Trout	475	1115	1.04	900230000080431		3, 5
		3587	Bull Trout	450	951	1.044	900230000057450		3
	27-Sep-18	5839	Mountain Whitefish	310	267	0.896	965000000281522	900230000076366	
		5840	Mountain Whitefish	258	204	1.188	900228000369628		
		5841	Troutperch	57	2	1.08			

[a] 1 = Stomach contents (gastric lavage); 3 = DNA Sample; 5 = Mercury and SIA (biopsy)

Table C3 Continued.

Site Name	Date	Sample Number	Species	Length (mm)	Weight (g)	Condition (K)	Tag 1 Number	Tag 2 Number	Preserve Code[a]
0505	27-Sep-18	5842	Mountain Whitefish	293	277	1.101	900228000348109		
		5843	Mountain Whitefish	256	184	1.097	900228000369622		
		5844	Mountain Whitefish	317	345	1.083	900230000076852		
		5845	Mountain Whitefish	284	322	1.406	900230000076513		
		5846	Mountain Whitefish	351	382	0.883	900230000076890		
		5847	Mountain Whitefish	325	392	1.142	900026000186921	900230000080403	
		5848	Bull Trout	442	816	0.945	900228000349219		
		5849	Rainbow Trout	408	900	1.325	900230000076728		
		5850	Rainbow Trout	318	390	1.213	900230000080368		1, 3
	10-Oct-18	6974	Bull Trout	431	818	1.022	900228000349219		3
		6975	Bull Trout	291	269	1.092	900228000635661		3
		6976	Rainbow Trout	376	623	1.172	900230000084318		1, 3
0506	07-Sep-18	792	Mountain Whitefish	264	208	1.13	900228000586312		
		793	Mountain Whitefish	284	284	1.24	900228000591293		
		794	Longnose Sucker	272	243	1.208	900228000591114		
		795	Mountain Whitefish	338	381	0.987	900230000078155		
		796	Longnose Sucker	419	815	1.108			
		797	Longnose Sucker	400	710	1.109	900230000078141		
		798	Largescale Sucker	534	1883	1.237	900230000079691		
		799	Longnose Sucker	392	742	1.232		900230000079788	
		800	Longnose Sucker	384	683	1.206	900230000079998		
		801	Mountain Whitefish	420	815	1.1	900230000078129		
		802	Longnose Sucker	292	288	1.157	900228000348209		
		803	Longnose Sucker	422	1034	1.376	900230000079971		
		804	Northern Pike	132	16	0.696			
		805	Walleye	420	868	1.172	900230000079946		
		806	Walleye	640	2888	1.102	900230000075148		
		807	Mountain Whitefish	252	184	1.15	900228000587754		
		808	Northern Pike	372	374	0.727	900230000078106		5
		809	Bull Trout	430	771	0.97	900230000079893		3, 5

[a] 1 = Stomach contents (gastric lavage); 3 = DNA Sample; 5 = Mercury and SIA (biopsy)

Table C3 Continued.

Site Name	Date	Sample Number	Species	Length (mm)	Weight (g)	Condition (K)	Tag 1 Number	Tag 2 Number	Preserve Code[a]
0506	13-Sep-18	1845	Mountain Whitefish	323	363	1.077	900230000127717		
		1846	Mountain Whitefish	327	362	1.035	900230000076733		
		1847	Mountain Whitefish	290	280	1.148	900228000591946		
		1848	Mountain Whitefish	292	308	1.237	900228000368646		
		1849	Mountain Whitefish	321	354	1.07	900230000076229		
		1850	Mountain Whitefish	447	798	0.893	900230000076988		
		1851	Mountain Whitefish	327	344	0.984	900230000077132		
		1852	Mountain Whitefish	319	338	1.041	900230000077112		
		1853	Mountain Whitefish	330	386	1.074	900230000056979		
		1854	Mountain Whitefish	289	243	1.007	900228000368573		
		1855	Mountain Whitefish	340	448	1.14	900230000076952		
		1856	Mountain Whitefish	294	269	1.059	900228000368769		
		1857	Mountain Whitefish	310	346	1.161	900230000076014		
		1858	Mountain Whitefish	306	286	0.998	981098104791125	900230000076134	
		1859	Mountain Whitefish	275	167	0.803	900228000368632		
		1860	Mountain Whitefish	305	341	1.202	900230000077252		
		1861	Mountain Whitefish	308	320	1.095	900230000076942		
		1862	Mountain Whitefish	351	449	1.038	900230000076237		
		1863	Mountain Whitefish	276	217	1.032	900228000368705		
		1864	Northern Pikeminnow	446	1099	1.239			
		1865	Longnose Sucker	419	848	1.153	900230000076943		
		1866	Mountain Whitefish	295	280	1.091	900228000368502		
		1867	White Sucker	387	729	1.258	900230000076311		
		1868	Longnose Sucker	245	162	1.102	900228000368714		
		1869	Rainbow Trout	366	726	1.481	900230000077403		1, 3
		1870	Bull Trout	257	187	1.102	900228000369169		3, 5
		1871	Bull Trout	470	997	0.96	900230000076230		3, 5
		1872	Bull Trout	480	1031	0.932	900230000076467		3, 5
	20-Sep-18	3589	Mountain Whitefish	335	370	0.984	900026000056129	900230000080298	
		3590	Northern Pikeminnow	376	599	1.127			

[a] 1 = Stomach contents (gastric lavage); 3 = DNA Sample; 5 = Mercury and SIA (biopsy)

Table C3 Continued.

Site Name	Date	Sample Number	Species	Length (mm)	Weight (g)	Condition (K)	Tag 1 Number	Tag 2 Number	Preserve Code[a]
0506	20-Sep-18	3591	Mountain Whitefish	351	407	0.941	900230000080149		
		3592	Mountain Whitefish	290	295	1.21	900230000080242		
		3593	Mountain Whitefish	344	491	1.206	900230000080210		
		3594	Mountain Whitefish	319	317	0.977	900230000076926		
		3595	Mountain Whitefish	283	236	1.041	900228000591878		
		3596	Mountain Whitefish	321	418	1.264	900230000079693		
		3597	Mountain Whitefish	352	345	0.791	900230000077929		
		3598	Mountain Whitefish	284	274	1.196	900228000369032		
		3599	Mountain Whitefish	293	254	1.01	900228000591431		
		3600	Mountain Whitefish	379	616	1.132	900230000080338		
		3601	Mountain Whitefish	362	531	1.119	900230000080447		
		3602	Mountain Whitefish	296	240	0.925	900228000591907		
		3603	Mountain Whitefish	255	222	1.339	900228000591852		
		3604	Mountain Whitefish	256	190	1.132	981098104937937	900228000591228	
		3605	Mountain Whitefish	262	210	1.168	900228000586312		
		3606	Mountain Whitefish	293	269	1.069	900228000369241		
		3607	Mountain Whitefish	308	323	1.105	900230000080275		
		3608	Mountain Whitefish	314	366	1.182	900230000080728		
		3609	Mountain Whitefish	264	248	1.348	900228000591661		
		3610	Mountain Whitefish	346	448	1.082	900230000076952		
		3611	Mountain Whitefish	336	426	1.123	900230000076700		
		3612	Mountain Whitefish	297	287	1.096	900228000591394		
		3613	Mountain Whitefish	288	292	1.222	981098104933917	900228000591524	
		3614	Mountain Whitefish	280	261	1.189	900228000591005		
		3615	Mountain Whitefish	315	262	0.838	900230000080096		
		3616	Mountain Whitefish	287	215	0.909	900228000368596		
		3617	Mountain Whitefish	381	519	0.938	900230000080142		
		3618	Mountain Whitefish	271	276	1.387	900228000591892		
		3619	Longnose Sucker	430	949	1.194	900230000080196		
		3620	Walleye	471	1259	1.205	900230000080038		

[a] 1 = Stomach contents (gastric lavage); 3 = DNA Sample; 5 = Mercury and SIA (biopsy)

Table C3 Continued.

Site Name	Date	Sample Number	Species	Length (mm)	Weight (g)	Condition (K)	Tag 1 Number	Tag 2 Number	Preserve Code[a]
0506	20-Sep-18	3621	Longnose Sucker	360	531	1.138	900228000585943		
		3622	Longnose Sucker	215			900228000591363		
		3623	Largescale Sucker	450	1192	1.308	900230000081143		
		3624	Longnose Sucker	266	223	1.185	900228000591339		
		3625	Longnose Sucker	409	840	1.228	900230000080056		
		3626	Longnose Sucker	175					
		3627	Bull Trout	473	995	0.94	900230000080725		3
	27-Sep-18	5852	Mountain Whitefish	345	452	1.101	900230000077226		
		5853	Mountain Whitefish	345	383	0.933	900230000080747		
		5854	Mountain Whitefish	300	299	1.107	900228000369848		
		5855	Mountain Whitefish	263	236	1.297	900228000369462		
		5856	Mountain Whitefish	269	230	1.182	900228000591728		
		5857	Mountain Whitefish	333	430	1.164	900230000080721		
		5858	Mountain Whitefish	278	285	1.327	900228000591747		
		5859	Mountain Whitefish	309	353	1.196	900230000076605		
		5860	Mountain Whitefish	252	192	1.2	900228000369360		
		5861	Mountain Whitefish	342	446	1.115	900230000080770		
		5862	Mountain Whitefish	324	370	1.088	900230000081295		
		5863	Mountain Whitefish	344	450	1.105	900230000076041		
		5864	Mountain Whitefish	338	462	1.196	900230000080924		
		5865	Mountain Whitefish	282	285	1.271	900228000369521		
		5866	Mountain Whitefish	266	264	1.403	900228000369083		
		5867	Mountain Whitefish	278	242	1.126	900228000369305		
		5868	Mountain Whitefish	313	349	1.138	900230000080539		
		5869	Mountain Whitefish	275	258	1.241	900228000348043		
		5870	Mountain Whitefish	287	234	0.99	900228000368988		
		5871	Mountain Whitefish	353	488	1.109	900230000080722		
		5872	Largescale Sucker	408	859	1.265	900230000080621		
		5873	Largescale Sucker	171	55	1.1			
		5874	Bull Trout	438	770	0.916	900228000349614		

[a] 1 = Stomach contents (gastric lavage); 3 = DNA Sample; 5 = Mercury and SIA (biopsy)

Table C3 Continued.

Site Name	Date	Sample Number	Species	Length (mm)	Weight (g)	Condition (K)	Tag 1 Number	Tag 2 Number	Preserve Code[a]
0506	27-Sep-18	5875	Rainbow Trout	361	568	1.207	900230000056991		1, 3
	10-Oct-18	6978	Rainbow Trout	366	746	1.522	900230000077403		
0509	07-Sep-18	861	Mountain Whitefish	170	40	0.814			
		862	Mountain Whitefish	164	41	0.93			
		863	Mountain Whitefish	246	192	1.29	900228000348181		
		864	Mountain Whitefish	248	173	1.134	900228000592072		
		865	Mountain Whitefish	230	136	1.118	900228000591668		
		866	Mountain Whitefish	338	352	0.912	900230000079921		
		867	Mountain Whitefish	312	299	0.984	900230000078213		
		868	Mountain Whitefish	330	372	1.035	900230000079828		
		870	Largescale Sucker	480	1261	1.14	900230000079820		
		871	Longnose Sucker	440	974	1.143	900230000126103		
		872	Largescale Sucker	430	895	1.126	900230000079792		
		873	Longnose Sucker	300	345	1.278	900230000079713		
		874	Longnose Sucker	430	924	1.162	900230000079896		
		875	Largescale Sucker	530	1755	1.179	981098104943479	900230000078224	
		876	Longnose Sucker	406	801	1.197	900230000127186		
		877	Longnose Sucker	464	1091	1.092	900230000079731		
		878	Longnose Sucker	252	179	1.119	900228000591591		
		879	Longnose Sucker	148	36	1.11			
		880	Longnose Sucker	95					
	13-Sep-18	1920	Mountain Whitefish	469	1210	1.173	900230000077367		
		1921	Mountain Whitefish	338	386	1	900230000077812		
		1922	Mountain Whitefish	207	96	1.082	900228000368575		
		1923	Mountain Whitefish	245	160	1.088	900228000369053		
		1924	Mountain Whitefish	290	274	1.123	900026000185959	900228000368696	
		1925	Mountain Whitefish	204	81	0.954	900228000368526		
		1926	Mountain Whitefish	324	389	1.144	900230000076578		
		1927	Mountain Whitefish	300	320	1.185	900230000056812		
		1928	Mountain Whitefish	358	428	0.933	900230000077172		

[a] 1 = Stomach contents (gastric lavage); 3 = DNA Sample; 5 = Mercury and SIA (biopsy)

Table C3 Continued.

Site Name	Date	Sample Number	Species	Length (mm)	Weight (g)	Condition (K)	Tag 1 Number	Tag 2 Number	Preserve Code[a]
0509	13-Sep-18	1929	Mountain Whitefish	335	428	1.138	900230000077226		
		1930	Mountain Whitefish	262	192	1.068	900228000541522		
		1931	Mountain Whitefish	316	352	1.116	900230000057512		
		1932	Mountain Whitefish	206	93	1.064	900228000368993		
		1933	Mountain Whitefish	290	330	1.353	900228000368543		
		1934	Mountain Whitefish	377	535	0.998	900230000077363		
		1935	Mountain Whitefish	236	178	1.354	900228000591867		
		1936	Mountain Whitefish	372	534	1.037	900230000077498		
		1937	Mountain Whitefish	319	371	1.143	900230000076219		
		1938	Mountain Whitefish	346	488	1.178	900230000076959		
		1939	Mountain Whitefish	251	180	1.138	900228000369086		
		1940	Mountain Whitefish	423	951	1.256	900230000077399		
		1941	Longnose Sucker	395	739	1.199	900230000077370		
		1942	Longnose Sucker	429	952	1.206	981098104939047	900230000077074	
		1943	Largescale Sucker	535	1630	1.064	900230000076238		
		1944	Mountain Whitefish	374	529	1.011	981098104934658	900230000077336	
		1945	Largescale Sucker	495	1688	1.392	900230000076885		
		1946	Longnose Sucker	430	959	1.206	900230000076555		
		1947	Largescale Sucker	493	1411	1.178	900230000076224		
		1948	Longnose Sucker	374	588	1.124	900230000076113		
		1949	Troutperch	70	6	1.749			
		1950	Longnose Sucker	76					
		1951	Redside Shiner	60	1	0.463			3
		1952	Largescale Sucker	499	1512	1.217	900230000076116		
		1953	Bull Trout	430	765	0.962	900230000079893		
		1954	Mountain Whitefish	296	320	1.234	900228000368694		
		1955	Longnose Sucker	65					
		1956	Walleye	403	686	1.048	900230000076459		
		1957	Prickly Sculpin	76	3	0.683			3
		1958	Slimy Sculpin	71	4	1.118			3

[a] 1 = Stomach contents (gastric lavage); 3 = DNA Sample; 5 = Mercury and SIA (biopsy)

Table C3 Continued.

Site Name	Date	Sample Number	Species	Length (mm)	Weight (g)	Condition (K)	Tag 1 Number	Tag 2 Number	Preserve Code[a]
0509	13-Sep-18	1959	Slimy Sculpin	80	5	0.977			3
		1960	Bull Trout	720	4381	1.174	900230000077335		3, 5
109OSA	14-Sep-18	2138	Mountain Whitefish	337	359	0.938	900026000147092	900026000147092	
		2139	Mountain Whitefish	367	479	0.969	900230000076964		
		2140	Mountain Whitefish	338	417	1.08	900230000076100		
		2141	Mountain Whitefish	471	1189	1.138	900230000076199		
		2142	Mountain Whitefish	320	328	1.001	900230000076321		
		2143	Mountain Whitefish	318	366	1.138	900230000076706		
		2144	Mountain Whitefish	310	321	1.078	900230000076811		
		2145	Mountain Whitefish	292	283	1.137	900228000348312		
		2146	Mountain Whitefish	342	385	0.962	900230000076570		
		2147	Mountain Whitefish	251	180	1.138	900228000368687		
		2148	Mountain Whitefish	323	326	0.967	900230000076958		
	20-Sep-18	3649	Mountain Whitefish	344	406	0.997	900230000080233		
		3651	Mountain Whitefish	355	365	0.816	900230000080973		
		3652	Mountain Whitefish	279	253	1.165	900228000368795		
		3653	Mountain Whitefish	305	336	1.184	900230000080159		
		3654	Mountain Whitefish	99	10	1.031			
		3655	Mountain Whitefish	278	268	1.247	900228000591183		
		3656	Mountain Whitefish	280	278	1.266	900228000591692		
		3657	Mountain Whitefish	440	1049	1.231	900010000178135	900230000080953	
		3658	Mountain Whitefish	381	646	1.168	900230000080330		
		3659	Mountain Whitefish	262	167	0.929	900228000587754		
		3660	Mountain Whitefish	315	262	0.838	900026000155063	900230000080104	
		3661	Mountain Whitefish	175	63	1.176			
		3662	Mountain Whitefish	325	417	1.215	900230000080985		
		3663	Mountain Whitefish	173	50	0.966			
		3664	Mountain Whitefish	103	12	1.098			
		3667	Mountain Whitefish	330	446	1.241	900230000125602		
	27-Sep-18	5877	Mountain Whitefish	237	139	1.044	900228000369550		

[a] 1 = Stomach contents (gastric lavage); 3 = DNA Sample; 5 = Mercury and SIA (biopsy)

Table C3 Continued.

Site Name	Date	Sample Number	Species	Length (mm)	Weight (g)	Condition (K)	Tag 1 Number	Tag 2 Number	Preserve Code[a]
109OSA	27-Sep-18	5878	Mountain Whitefish	198	91	1.172			
		5879	Mountain Whitefish	307	335	1.158	900230000080649		
		5880	Mountain Whitefish	431	834	1.042	900230000080389		
		5881	Mountain Whitefish	349	474	1.115	900026000147721	900230000080267	
		5882	Mountain Whitefish	318	421	1.309	900230000123381		
		5883	Mountain Whitefish	321	386	1.167	900230000080220		
		5884	Mountain Whitefish	327	378	1.081	900026000148812	900230000080478	
		5885	Mountain Whitefish	339	386	0.991	900230000080072		
		5886	Mountain Whitefish	317	333	1.045	900026000146094	900230000077288	
		5887	Mountain Whitefish	257	225	1.326	900228000591608		
		5888	Mountain Whitefish	259	180	1.036			
		5889	Mountain Whitefish	301	277	1.016	900230000080840		
		5890	Mountain Whitefish	335	410	1.091	900230000080541		
		5891	Mountain Whitefish	344	402	0.988	900230000080357		
		5892	Mountain Whitefish	328	411	1.165	900230000080629		
		5893	Mountain Whitefish	361	536	1.139	900230000076949		
		5894	Mountain Whitefish	413	780	1.107	900230000076416		
		5895	Mountain Whitefish	238	161	1.194	900228000591635		
		5896	Mountain Whitefish	277	292	1.374	900228000591699		
		5897	Mountain Whitefish	261	243	1.367	900228000369331		
		5898	Mountain Whitefish	282	260	1.159	900228000591882		
		5899	Mountain Whitefish	273	245	1.204	900228000369033		
		5900	Mountain Whitefish	309	354	1.2	900230000076848		
		5901	Mountain Whitefish	306	381	1.33	900230000076143		
109OSB	14-Sep-18	2136	Mountain Whitefish	317	376	1.18	900230000076973		
	20-Sep-18	3666	Mountain Whitefish	289	278	1.152	900228000591462		
		3668	Mountain Whitefish	253	202	1.247	900228000368515		
		3669	Mountain Whitefish	284	286	1.249	900228000591192		
		3670	Largescale Sucker	396	777	1.251	900230000080009		
		3671	Longnose Sucker	334	580	1.557	900230000081092		

[a] 1 = Stomach contents (gastric lavage); 3 = DNA Sample; 5 = Mercury and SIA (biopsy)

Table C3 Continued.

Site Name	Date	Sample Number	Species	Length (mm)	Weight (g)	Condition (K)	Tag 1 Number	Tag 2 Number	Preserve Code[a]
109OSB	20-Sep-18	3672	Walleye	462	1183	1.2	900230000076974		
	27-Sep-18	5911	Mountain Whitefish	317	392	1.231	900230000081053		
		5912	Mountain Whitefish	215	100	1.006	900228000369119		
		5913	Longnose Sucker	453	1130	1.216	900230000080595		
109OSC	14-Sep-18	2150	Mountain Whitefish	352	459	1.052	900230000076430		
		2151	Mountain Whitefish	387	591	1.02	900230000076365		
		2152	Mountain Whitefish	309	321	1.088	900230000077846		
		2153	Mountain Whitefish	281	274	1.235	900228000591231		
		2154	Mountain Whitefish	332	457	1.249	981098104933826	900230000076358	
		2155	Mountain Whitefish	290	252	1.033	900228000368787		
		2156	Mountain Whitefish	263	214	1.176	900228000586312		
		2157	Mountain Whitefish	312	306	1.008	900228000591188		
		2158	Mountain Whitefish	322	364	1.09	900230000076122		
		2159	Mountain Whitefish	321	333	1.007	900230000077165		
		2160	Mountain Whitefish	325	440	1.282	900230000076536		
		2161	Mountain Whitefish	253	194	1.198	900228000368877		
		2162	Largescale Sucker	485	1400	1.227	900230000076437		
		2163	Longnose Sucker	362	639	1.347	900230000127080		
	20-Sep-18	3628	Mountain Whitefish	305	305	1.075	900230000080059		
		3629	Mountain Whitefish	367	399	0.807	900230000080090		
		3630	Mountain Whitefish	324	411	1.208	965000000090542	900230000080944	
		3631	Mountain Whitefish	296	309	1.191	900228000591622		
		3632	Mountain Whitefish	260	176	1.001	900228000591903		
		3633	Mountain Whitefish	348	455	1.08	900230000081223		
		3634	Mountain Whitefish	301	275	1.008	900230000081228		
		3635	Mountain Whitefish	319	333	1.026	900230000076156		
		3636	Mountain Whitefish	275	227	1.092	900228000591534		
		3637	Mountain Whitefish	267	202	1.061	900228000591295		
		3638	Mountain Whitefish	331	427	1.177	900230000080006		
		3639	Mountain Whitefish	325	357	1.04	900230000080263		

[a] 1 = Stomach contents (gastric lavage); 3 = DNA Sample; 5 = Mercury and SIA (biopsy)

Table C3 Continued.

Site Name	Date	Sample Number	Species	Length (mm)	Weight (g)	Condition (K)	Tag 1 Number	Tag 2 Number	Preserve Code[a]
109OSC	20-Sep-18	3640	Mountain Whitefish	281	269	1.212	900228000591231		
		3641	Longnose Sucker	436	1051	1.268	900230000077575		
		3642	Longnose Sucker	399	776	1.222	900230000076729		
		3643	Longnose Sucker	274	251	1.22	900228000591520		
		3644	Longnose Sucker	385	697	1.221	981098104939696	900230000080050	
		3645	Longnose Sucker	388	616	1.055	900230000080331		
		3646	Longnose Sucker	408	850	1.252	900230000056841		
		3647	Longnose Sucker	364	540	1.12	900230000076251		
		3650	Mountain Whitefish	340	491	1.249	900230000080085		
	27-Sep-18	5903	Mountain Whitefish	350	458	1.068	900230000076393		
		5904	Mountain Whitefish	311	344	1.144	900230000080020		
		5905	Mountain Whitefish	363	491	1.027	900230000076508		
		5906	Mountain Whitefish	316	354	1.122	900230000080179		
		5907	Longnose Sucker	406	858	1.282	900230000080146		
		5908	Longnose Sucker	391	677	1.133	900230000080698		
		5909	Longnose Sucker	294	329	1.295	900228000369595		
	10-Oct-18	6984	Bull Trout	683	3835	1.204	900230000080483		
		6985	Mountain Whitefish	270	268	1.362	900228000370104		
		6986	Mountain Whitefish	312	307	1.011	965000000086451	900230000084319	
		6987	Longnose Sucker	401	766	1.188	981098104942495	900230000084189	

[a] 1 = Stomach contents (gastric lavage); 3 = DNA Sample; 5 = Mercury and SIA (biopsy)

APPENDIX D

Mountain Whitefish Spawn Monitoring Data

Table D1 Summary of egg collection mat data collected during Mountain Whitefish spawning monitoring under Site C Offset Effectiveness Monitoring, 2018.

Station Name[a]	Number of Samplers Deployed	Set		Pull		Effort (h)	Water Temperature (°C)		Water Depth (m)	Number of Mountain Whitefish Eggs
		Date	Time	Date	Time		Set	Pull		
M01	1	20-Oct-18	12:20	25-Oct-18	12:24	120.07	6.3	5.4	4.2	0
M02	1	20-Oct-18	13:45	25-Oct-18	12:31	118.77	6.3	5.4	2.1	0
M03	1	20-Oct-18	13:03	25-Oct-18	13:35	120.53	6.3	5.4	2.6	0
M04	1	20-Oct-18	15:12	25-Oct-18	12:36	117.40	6.3	5.4	3.4	0
M05	1	20-Oct-18	14:40	25-Oct-18	12:41	118.02	6.3	5.4	1.4	0
M06	1	20-Oct-18	14:10	25-Oct-18	12:48	118.63	6.3	5.4	1.0	0
M07	1	21-Oct-18	10:41	25-Oct-18	12:58	98.28	5.8	5.4	3.1	0
M08	1	21-Oct-18	11:11	25-Oct-18	13:02	97.85	5.8	5.4	2.8	0
M09	1	21-Oct-18	11:42	25-Oct-18	13:09	97.45	5.8	5.4	2.4	0
M10	1	21-Oct-18	12:24	25-Oct-18	13:14	96.83	5.8	5.4	2.3	0
M11	1	21-Oct-18	13:08	25-Oct-18	13:21	96.22	5.8	5.4	1.5	0
M12	1	21-Oct-18	13:42	25-Oct-18	13:28	95.77	5.8	5.4	3.9	0
M01	1	25-Oct-18	12:25	31-Oct-18	10:13	141.80	5.4	5.1	4.0	0
M02	1	25-Oct-18	12:32	31-Oct-18	10:19	141.78	5.4	5.1	2.0	0
M03	1	25-Oct-18	14:19	31-Oct-18	10:23	140.07	5.4	5.1	2.1	0
M04	1	25-Oct-18	12:37	31-Oct-18	10:27	141.83	5.4	5.1	3.6	0
M05	1	25-Oct-18	12:42	31-Oct-18	10:31	141.82	5.4	5.1	1.2	0
M06	1	25-Oct-18	12:49	31-Oct-18	10:35	141.77	5.4	5.1	0.9	0
M07	1	25-Oct-18	12:59	31-Oct-18	10:41	141.70	5.4	5.1	3.1	0
M08	1	25-Oct-18	13:03	31-Oct-18	10:46	141.72	5.4	5.1	2.5	0
M09	1	25-Oct-18	13:10	31-Oct-18	10:51	141.68	5.4	5.1	2.3	0
M10	1	25-Oct-18	13:15	31-Oct-18	10:55	141.67	5.4	5.1	2.2	0
M11	1	25-Oct-18	13:22	31-Oct-18	11:01	141.65	5.4	5.1	1.5	0
M12	1	25-Oct-18	13:29	31-Oct-18	11:05	141.60	5.4	5.1	3.6	0
M01	1	31-Oct-18	10:14	08-Nov-18	12:27	194.22	5.1	3.1	4.0	0
M02	1	31-Oct-18	10:20	08-Nov-18	12:33	194.22	5.1	3.1	1.8	0
M03	1	31-Oct-18	10:24	08-Nov-18	12:37	194.22	5.1	3.1	2.0	0
M04	1	31-Oct-18	10:28	08-Nov-18	12:45	194.28	5.1	3.1	3.0	0
M05	1	31-Oct-18	10:32	08-Nov-18	12:48	194.27	5.1	3.1	1.1	0
M06	1	31-Oct-18	10:36	08-Nov-18	12:52	194.27	5.1	3.1	0.7	0
M07	1	31-Oct-18	10:42	08-Nov-18	12:58	194.27	5.1	3.1	3.1	0
M08	1	31-Oct-18	10:47	08-Nov-18	13:03	194.27	5.1	3.1	2.8	0
M09	1	31-Oct-18	10:52	08-Nov-18	13:07	194.25	5.1	3.1	2.1	0
M10	1	31-Oct-18	10:56	08-Nov-18	13:12	194.27	5.1	3.1	2.0	0
M11	1	31-Oct-18	11:02	08-Nov-18	13:17	194.25	5.1	3.1	1.1	0
M12	1	31-Oct-18	11:06	08-Nov-18	13:22	194.27	5.1	3.1	3.6	0
M01	1	08-Nov-18	12:28	22-Nov-18	11:24	334.93	3.1	3.7	4.0	0
M02	1	08-Nov-18	12:34	22-Nov-18	11:55	N/A[b]	3.1	3.7	1.9	0
M03	1	08-Nov-18	12:38	22-Nov-18	11:44	335.10	3.1	3.7	2.8	0
M04	1	08-Nov-18	12:46	22-Nov-18	11:59	335.22	3.1	3.7	3.3	0
M05	1	08-Nov-18	12:49	22-Nov-18	12:03	335.23	3.1	3.7	1.2	0

[a]See Appendix A, Figure A4 for sample site locations. …continued.

[b]Mat was missing at retrieval time.

Table D1 Continued.

Station Name[a]	Number of Samplers Deployed	Set		Pull		Effort (h)	Water Temperature (°C)		Water Depth (m)	Number of Mountain Whitefish Eggs
		Date	Time	Date	Time		Set	Pull		
M06	1	08-Nov-18	12:53	22-Nov-18	12:07	335.23	3.1	3.7	0.8	0
M07	1	08-Nov-18	12:59	22-Nov-18	12:11	335.20	3.1	3.7	3.2	0
M08	1	08-Nov-18	13:04	22-Nov-18	12:15	335.18	3.1	3.7	2.6	0
M09	1	08-Nov-18	13:08	22-Nov-18	12:21	335.22	3.1	3.7	2.2	0
M10	1	08-Nov-18	13:14	22-Nov-18	12:38	335.40	3.1	3.7	2.2	0
M11	1	08-Nov-18	13:18	22-Nov-18	12:25	335.12	3.1	3.7	1.3	0
M12	1	08-Nov-18	13:23	22-Nov-18	10:40	333.28	3.1	3.7	3.8	0
M01	1	22-Nov-18	11:41	30-Nov-18	12:35	192.90	3.7	3.5	4.1	0
M02	1	22-Nov-18	11:56	30-Nov-18	10:58	191.03	3.7	3.5	2.7	0
M03	1	22-Nov-18	11:44	30-Nov-18	10:52	191.13	3.7	3.5	1.9	0
M04	1	22-Nov-18	12:30	30-Nov-18	11:03	190.55	3.7	3.5	2.6	0
M05	1	22-Nov-18	12:04	30-Nov-18	11:10	191.10	3.7	3.5	2.1	0
M06	1	22-Nov-18	12:08	30-Nov-18	11:15	191.12	3.7	3.5	2.6	0
M07	1	22-Nov-18	12:12	30-Nov-18	11:21	191.15	3.7	3.5	3.1	0
M08	1	22-Nov-18	12:16	30-Nov-18	11:27	191.18	3.7	3.5	3.0	0
M09	1	22-Nov-18	12:22	30-Nov-18	11:33	191.18	3.7	3.5	2.6	0
M10	1	22-Nov-18	12:53	30-Nov-18	11:41	190.80	3.7	3.5	3.0	0
M11	1	22-Nov-18	12:26	30-Nov-18	11:48	191.37	3.7	3.5	1.6	0
M12	1	22-Nov-18	11:15	30-Nov-18	11:54	192.65	3.7	3.5	4.0	0
M01	1	30-Nov-18	12:42	11-Dec-18	12:25	263.72	3.5	2.2	3.1	0
M13	1	30-Nov-18	10:59	11-Dec-18	10:53	263.90	3.5	2.2	2.7	0
M03	1	30-Nov-18	10:53	11-Dec-18	10:40	263.78	3.5	2.2	2.4	0
M04	1	30-Nov-18	11:04	11-Dec-18	13:30	N/A[b]	3.5	2.2	3.6	0
M05	1	30-Nov-18	11:11	11-Dec-18	10:57	263.77	3.5	2.2	2.6	0
M06	1	30-Nov-18	11:16	11-Dec-18	10:02	262.77	3.5	2.2	3.2	0
M07	1	30-Nov-18	11:22	11-Dec-18	12:05	264.72	3.5	2.2	4.0	0
M08	1	30-Nov-18	11:28	11-Dec-18	11:08	263.67	3.5	2.2	3.1	0
M09	1	30-Nov-18	11:34	11-Dec-18	11:12	263.63	3.5	2.2	3.1	0
M10	1	30-Nov-18	11:42	11-Dec-18	11:11	263.48	3.5	2.2	3.8	0
M11	1	30-Nov-18	11:49	11-Dec-18	11:24	263.58	3.5	2.2	2.1	0
M12	1	30-Nov-18	12:29	11-Dec-18	11:33	263.07	3.5	2.2	3.8	0
M01	1	11-Dec-18	12:31	19-Dec-18	10:44	190.22	2.2	1.3	2.8	0
M13	1	11-Dec-18	10:54	19-Dec-18	10:54	192.00	2.2	1.3	2.3	0
M03	1	11-Dec-18	10:49	19-Dec-18	10:49	192.00	2.2	1.3	2.1	0
M04	1	11-Dec-18	Mat and one anchor was missing; did not replace.							
M05	1	11-Dec-18	10:58	19-Dec-18	10:58	192.00	2.2	1.3	2.4	0
M06	1	11-Dec-18	11:03	19-Dec-18	11:04	192.02	2.2	1.3	2.2	0
M07	1	11-Dec-18	12:20	19-Dec-18	11:09	190.82	2.2	1.3	2.5	
M08	1	11-Dec-18	11:09	19-Dec-18	11:15	192.10	2.2	1.3	3.3	0

[a]See Appendix A, Figure A4 for sample site locations.

…continued.

[b]Mat was missing at retrieval time.

Table D1 Concluded.

Station Name[a]	Number of Samplers Deployed	Set		Pull		Effort (h)	Water		Water Depth (m)	Number of Mountain Whitefish Eggs
		Date	Time	Date	Time		Set	Pull		
M09	1	11-Dec-18	11:13	19-Dec-18	11:20	192.12	2.2	1.3	2.9	0
M10	1	11-Dec-18	11:19	19-Dec-18	11:24	192.08	2.2	1.3	3.1	0
M11	1	11-Dec-18	11:27	19-Dec-18	11:28	192.02	2.2	1.3	1.9	0
M14	1	11-Dec-18	11:53	19-Dec-18	11:33	191.67	2.2	1.3	1.8	0
M01	1	19-Dec-18	10:45	04-Jan-19	11:11	384.43	1.3	0.4	2.9	0
M13	1	19-Dec-18	10:55	04-Jan-19	11:22	384.45	1.3	0.4	2.0	0
M03	1	19-Dec-18	10:50	04-Jan-19	11:16	384.43	1.3	0.4	1.7	0
M05	1	19-Dec-18	10:59	04-Jan-19	11:27	384.47	1.3	0.4	2.0	0
M06	1	19-Dec-18	11:05	04-Jan-19	11:30	384.42	1.3	0.4	2.6	0
M07	1	19-Dec-18	11:10	04-Jan-19	11:45	384.58	1.3	0.4	2.2	0
M08	1	19-Dec-18	11:16	04-Jan-19	11:49	384.55	1.3	0.4	2.5	0
M09	1	19-Dec-18	11:21	04-Jan-19	11:55	384.57	1.3	0.4	2.5	0
M10	1	19-Dec-18	11:25	04-Jan-19	12:02	384.62	1.3	0.4	3.1	0
M11	1	19-Dec-18	11:29	04-Jan-19	12:22	384.88	1.3	0.4	1.4	0
M15	1	19-Dec-18	11:34	04-Jan-19	12:29	384.92	1.3	0.4	1.5	0
M01	1	04-Jan-19	11:12	14-Jan-19	10:42	239.50	0.4	0.4	2.0	0
M13	1	04-Jan-19	11:23	14-Jan-19	10:52	239.48	0.4	0.4	1.6	0
M03	1	04-Jan-19	11:17	14-Jan-19	10:48	239.52	0.4	0.4	1.4	0
M05	1	04-Jan-19	11:28	14-Jan-19	10:56	239.47	0.4	0.4	1.5	0
M06	1	04-Jan-19	12:50	14-Jan-19	11:00	238.17	0.4	0.4	0.7	0
M07	1	04-Jan-19	11:46	14-Jan-19	11:03	239.28	0.4	0.4	1.8	0
M08	1	04-Jan-19	11:50	14-Jan-19	11:06	239.27	0.4	0.4	2.3	0
M09	1	04-Jan-19	11:56	14-Jan-19	11:10	239.23	0.4	0.4	2.0	0
M10	1	04-Jan-19	12:20	14-Jan-19	13:28	N/A[b]	0.4	0.4	3.4	0
M11	1	04-Jan-19	12:23	14-Jan-19	13:40	241.28	0.4	0.4	1.1	0
M15	1	04-Jan-19	12:30	14-Jan-19	11:18	238.80	0.4	0.4	1.2	0
Total						**22941**				**0**

[a]See Appendix A, Figure A4 for sample site locations.

[b]Mat was missing at retrieval time.

Concluded.

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