Site C Clean Energy Project

Peace River Physical Habitat Monitoring Program (Mon-3)

Construction Year 7 (2021)

Dan Ciobotaru, PGeo
Golder Associates Ltd.

Kathryn DeRego Semiao, PhD
Golder Associates Ltd.

Phil Osborne, PhD, PGeo
Golder Associates Ltd.

Dustin Ford, RPBio
Golder Associates Ltd.

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GOLDER
MEMBER OF WSP

REPORT

Peace River Physical Habitat Monitoring Program

2021 Investigations (Mon-3)

Submitted to:

Nich Burnett
BC Hydro
1111 West Georgia Street, 9th Floor
Vancouver, BC V6E 4G2

Submitted by:

Golder Associates Ltd.
201 Columbia Avenue, Castlegar, British Columbia, V1N 1A8, Canada

+1 250 365 0344

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Executive Summary

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; BC Hydro 2013).

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 dam construction, reservoir preparation, and reservoir filling (BC Hydro 2015a). In accordance with Provincial Environmental Assessment Certificate (EAC) Condition No. 7 and Federal Decision Statement Condition Nos. 8.4.3 and 8.4.4 for the Project, BC Hydro developed the Site C Fisheries and Aquatic Habitat Monitoring and Follow-up Program (FAHMFP; BC Hydro 2015b). The Peace River Physical Habitat Monitoring Program (Mon-3) represents one component of the FAHMFP that will monitor the effect of the Project on physical habitat in the Peace River.

Once complete, the Project will shift the point of regulation on the Peace River to approximately 85 km downstream of Peace Canyon Dam (PCD), which will influence physical processes driving river geomorphology, such as water velocities and sediment transport capacities (BC Hydro 2015b). Downstream of the Project, the daily range of water levels is predicted to increase, with the magnitude of these increases expected to be greatest closest to the Project. Associated changes to river flows will affect the types and distributions of aquatic habitats available to fish both upstream and downstream of the Project (BC Hydro 2015b).

The focus of Mon-3 is to monitor changes in physical habitat within the diversion headpond during construction of the Project (2015 to 2023), and to monitor changes in physical habitat within the Peace River between the Project and the Many Islands area in Alberta during construction of the Project (2015 to 2023) and the first 30 years of operation (2023 to 2053; BC Hydro 2015b). Data collected in 2021 represent baseline data that will be used in conjunction with Mon-3 survey data collected in 2015 (Golder 2016) and 2019 (Golder 2020) in before-after comparisons in future study years to monitor changes in physical habitat in the Peace River over time. Those changes will be used to help diagnose causes of observed changes in indicator fish species (i.e., Arctic Grayling [*Thymallus arcticus*], Burbot [*Lota lota*], Bull Trout [*Salvelinus confluentus*], Goldeye [*Hiodon alosoides*], Mountain Whitefish [*Prosopium williamsoni*], Rainbow Trout [*Oncorhynchus mykiss*], and Walleye [*Sander vitreus*]) in the study area as monitored through other components of the FAHMFP.

When possible, the baseline dataset was supplemented with physical habitat data collected in 2017 (Golder 2018), 2018 (Golder 2019), and 2019 (Golder 2020b) as part of offset effectiveness monitoring conducted in the study area. Data collected as part of these offset effectiveness surveys are spatially limited and do not cover the entire Mon-3 study area.

In 2021, river cross-section surveys were conducted at 53 previously established transects on the Peace River (Golder 2015) to identify riverbed elevations. Bathymetry data were collected using an acoustic doppler profiler (ADP), and topographic data were collected using a real-time kinematic (RTK) GPS unit. Elevation data for portions of the river cross-sections that could not be surveyed by the ADP or RTK were extracted from LiDAR data collected and provided by BC Hydro. The above data were spliced together to produce a single dataset detailing the riverbed elevation at each transect location.

Grain size measurements were collected in 2021 using a pebble count sampling procedure, with the field crew measuring the medial dimension (e.g., the b-axis) of 100 stones in a grid pattern laid out with a measuring tape at each sample location. The results from pebble counts were then used to calculate the D16, D35, D50, D84, and D90 percentiles (the particle size for which 16%, 35%, 50%, 84%, and 90% of the sample is finer than that size, respectively) at each location.

Overall, results from the 2021 survey indicated a mix of static riverbed and degrading sections within the footprint of the diversion headpond, a dynamic riverbed in the upstream portion of the in-stream works area of the Project (between RKm 105.5 and RKm 109 as measured downstream from WAC Bennett Dam) and a static riverbed in the downstream portion of the in-stream works area of the Project (between RKm 109 and RKm 110), and a relatively static riverbed with localized sections of channel aggradation and degradation downstream of the Project between RKm 110 and RKm 225.

Key results from the 2021 survey, which was conducted between 9 August and 24 September, as well as key trends observed between the 2015 and 2019 surveys are summarized as follows:

- Between 2019 and 2021, the riverbed changes identified a mixture of degrading and static channels within the diversion headpond. The majority of the degrading occurred in the upstream-most 5 km of the diversion headpond (i.e., Transects #US12 to #US08). The channel degradation in 2021 however was at similar elevations as the 2015 surveys. Further downstream (i.e., Transects #US08 to #US06) the riverbed elevations were mostly static between 2019 and 2021.
- Between 2019 and 2021, the riverbed degraded immediately downstream of the Project. This degradation is likely associated with Project construction (e.g., the main channel bar excavation at RKm 107.5). Aggrading was observed for the mid-channel area until RKm 109.5.
- The bed elevation within Upper Site 109L was lowered approximately 2 m during instream excavations in 2015 and 2016 to increase the amount of permanently wetted habitat available to fish and to reduce stranding risk. Since then, the channel has aggraded as much as 3 m. As of 2021, some portions of the riverbed have aggraded to elevations higher than those recorded prior to the development of this offset area.
- With the exception of minor variations in riverbed elevation near either the left or right downstream banks (as viewed facing downstream), the active channel at all 10 transects monitored between the downstream end of the in-stream works area and the Pine River's confluence with the Peace River were similar in both channel shape and riverbed elevations between the 2019 and 2021 surveys.
- Nineteen river cross-section surveys were conducted between the Pine River confluence and the Many Islands area in Alberta. When compared to the 2019 transects, the riverbed elevations show a relatively stable channel, with only minor (typically up 0.4 m) aggradation and degradation sections at some transects.
- Grain size measurements were completed in 2021 at 35 locations, from the upstream end of the diversion headpond (approximately RKm 86) downstream to the Many Islands area (RKm 225). The D50 and D90 values calculated from 2021 pebble count data were similar to historic D50 and D90 values recorded at locations between the Halfway River confluence and the BC-Alberta border where the surveys overlapped (Church 2015), and with gravel size sediment as the main river substrate. Downstream of the BC-Alberta border, the D50 and D90 values were greater compared to the upstream area, and larger sized sediment (i.e., cobble) constituted a larger fraction of the sample compared to samples from sites further upstream.

- Based on the cross-section surveys and grain size measurements, the overall changes to fish habitat as it relates to changes in physical habitat were minimal between 2019 and 2021.

Since the commencement of river diversion, changes to fish habitat due to changes in physical habitat have been minimal within the diversion headpond. The little changes that were observed in the diversion headpond were considered part of the natural variability of the Peace River channel and unlikely to have a noticeable influence on fish use within this area. Overall, data collected since 2015 suggest little change in the physical habitat present in the Peace River with the exception of areas directly affected by the development of the Project. As a result, overall changes observed in physical habitat over this time period are not likely to have a noticeable influence on the Peace River fish community.

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BC Hydro

Nich Burnett	Vancouver, BC
Dave Hunter	Vancouver, BC
Mike McArthur	Vancouver, BC
Brent Mossop	Vancouver, BC

The following employees of ***GOLDER ASSOCIATES LTD.*** contributed to the collection of data and preparation of this report:

Dustin Ford, RPBio	Project Manager, Senior Fisheries Biologist, Associate
Shawn Redden, RPBio	Project Director, Senior Fisheries Biologist, Associate
Dan Ciobotaru, PGeo	Intermediate Hydrologist, Coauthor
Kathryn De Rego Semiao, PhD	Geomorphology Specialist, Coauthor
Phil Osborne, PGeo, PhD	Principal, Senior Geomorphologist
Demitria Burgoon, RPBio	Fisheries Biologist
Paul Grutter, RPBio	Fisheries Biologist
Kevin Little	Fisheries Biology Specialist
Winston Wade	Water Resources Engineer
Corby Shurgot	Fisheries Technician
Natasha Audy	Fisheries Technician
Carmen Orosz	Survey Technician
Carter McNaught	Junior Water Resources Engineer
Jonathan Pokotylo	GIS Specialist
Carrie McAllister	Project Coordinator
Devin Dickson	Warehouse Technician

List of Acronyms and Abbreviations

Acronym	Description
ADP	Acoustic Doppler Profiler
DFO	Fisheries and Oceans Canada
EAC	Environmental Assessment Certificate
EIS	Environmental Impact Statement
FAHMFP	Fisheries and Aquatic Habitat Monitoring and Follow-up Program
FDS	Federal Decision Statement
FLNRO	BC Ministry of Forests, Lands and Natural Resource Operations
LAA	Local Assessment Area
LB	Left bank as viewed facing downstream
LiDAR	Light Detecting and Ranging
Mon-3	Peace River Habitat Monitoring Program
PCD	Peace Canyon Dam
Project	Site C Clean Energy Project
QEP	Qualified Environmental Professional
RB	Right bank as viewed facing downstream
RKm	River Kilometre as measured downstream from WAC Bennett Dam
YOY	Young-of-the-Year

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1.0 INTRODUCTION

Potential effects of the Site C Clean Energy Project (the Project) on fish[1] and fish habitat[2] are described in Volume 2 of the Project's Environmental Impact Statement (EIS, BC Hydro 2012) as follows[3]:

> The Project has the potential to affect fish habitat in two ways. The Project may destroy fish habitat by placing a permanent physical structure on that habitat, or the Project may alter fish habitat by changing the physical or chemical characteristics of that habitat in such a way as to make it unusable by fish. Destruction or alteration of important habitats may be critical to the sustainability of a species population.
>
> The Project may affect fish health and survival. It may cause direct mortality of fish or indirect mortality of fish by changing system productivity, food resource type and abundance, and environmental conditions on which fish depend (e.g., water temperature).
>
> The Project may affect fish movement by physically blocking upstream and downstream migration of fish or by causing water velocities that exceed the swimming capabilities of fish, which results in hindered or blocked upstream migration of fish. Blocked or hindered fish movement has consequences to the species population. Fish may not be able to access important habitats in a timely manner or not at all (e.g., spawning habitats). Blocked fish movement may result in genetic fragmentation of the population.

Condition No. 7 of the Project's Provincial Environmental Assessment Certificate (EAC), Schedule B states the following:

> The EAC Holder must develop a Fisheries and Aquatic Habitat Monitoring and Follow-up Program [FAHMFP] to assess the effectiveness of measures to mitigate Project effects on healthy fish populations in the Peace River and tributaries, and, if recommended by a QEP [Qualified Environmental Professional] or FLNRO [BC Ministry of Forests, Lands and Natural Resource Operations], to assess the need to adjust those measures to adequately mitigate the Project's effects.

Furthermore, the Project's Federal Decision Statement (FDS) states that a plan should be developed that addresses the following:

> Condition No. 8.4.3: an approach to monitor changes to fish and fish habitat baseline conditions in the Local Assessment Area (LAA); and
>
> Condition No. 8.4.4: an approach to monitor and evaluate the effectiveness of mitigation or offsetting measures and to verify the accuracy of the predictions made during the environmental assessment on fish and fish habitat.

The Peace River Physical Habitat Monitoring Program (Mon-3) is designed to provide supporting data to address the EAC and FDS conditions described above. Specifically, Mon-3 represents one component of the FAHMFP (BC Hydro 2015b) that aims to "monitor physical habitat within the [diversion] headpond (the Peace River from Site C upstream to near the Wilder Creek confluence) during Construction Years 5 to 8 [2019 to 2022] and within the Peace River downstream of the Project to the Many Islands area in Alberta during Construction Years 1 to 9 [2015 to 2023] and during Operation Years 1 to 30 [2023 to 2053]" (BC Hydro 2015b). As summarized in Beaudrie et al. (2017), Mon-3 will assist in detecting and diagnosing causes of observed changes in indicator fish species (i.e., Arctic Grayling [*Thymallus arcticus*], Burbot [*Lota lota*], Bull Trout [*Salvelinus confluentus*], Goldeye [*Hiodon alosoides*], Mountain Whitefish [*Prosopium williamsoni*], Rainbow Trout [*Oncorhynchus mykiss*], and Walleye [*Sander vitreus*]) that are monitored under other components of the FAHMFP. Monitoring physical habitat in the diversion headpond and downstream of the Project will provide diagnostic observations, should there be changes to the fish community that are beyond those predicted in the EIS. The observations from Mon-3 can be assessed to identify if observed changes in the fish community may be related to changes in physical habitat.

[1] Fish includes fish abundance, biomass, composition, health, and survival.
[2] Fish habitat includes water quality, sediment quality, lower trophic levels (periphyton and benthic invertebrates), and physical habitat.
[3] Site C EIS, Volume 2, Section 12.1.2.

The potential effects of the Project on physical habitat in the diversion headpond and in the Peace River downstream of the Project are described in Volume 2 of the Site C EIS[4]. These effects are briefly summarized below.

The Project will shift the point of regulation on the Peace River approximately 85 km downstream of Peace Canyon Dam (PCD; the current point of regulation). The diversion headpond will extend approximately 18 km upstream of the Project, influencing physical processes driving river geomorphology, including increasing water depths and decreasing water velocities (BC Hydro 2015a). Water levels in the diversion headpond immediately upstream of the Project will be approximately 5.5 m higher than existing conditions (at the 90th percentile water level) and will be approximately 1.0 m higher than existing conditions near the Wilder Creek confluence (approximately 13 km upstream of the Project; KCB and SNC 2015). Changes in physical habitat within the diversion headpond are expected to be greatest closest to the Project. The higher water levels in the diversion headpond are expected to result in increased sediment inputs from the erosion of newly inundated areas, altering existing clean riverbed materials[5].

Downstream of the Project, changes to the flow regime will affect the temporal and spatial availability of aquatic habitat, with the Project's influence being greatest in the approximately 16 km long portion of the Peace River between the Project and the Pine River's confluence with the Peace River[6]. Following construction of the Project, the mean annual sediment transport load in the Peace River is expected to reduce by 54% immediately downstream of the Project and reduce by 21% at the Pine River confluence due to sediment (mainly sands) settling in the upstream reservoir (BC Hydro 2015a). Downstream of the Pine River confluence, the Project is not expected to result in substantial changes to sediment depositional patterns and any changes observed are expected to be due to natural processes (e.g., valley wall erosion and landslides along the river) or driven by the ongoing response of the river channel to upstream flow regulations that started in 1967[7].

Fish species in the Peace River have the potential to be affected by changes in physical habitat in a variety of ways. For example, spawning habitat may be altered by changes in water depths or substrate sizes, or substrate interstitial spaces may be filled in with finer materials. Furthermore, aggradation or degradation within near-shore areas may create or reduce shallow-water rearing habitats for Young of-the-Year (YOY) and immature life stages. Increased deposition and scouring also have the potential to create new gravel bars or depressions which may result in the creation of habitat or increase fish stranding risk.

The current fluvial geomorphology and sediment transport regime in the Peace River have been in a state of adjustment to the regulated flow conditions created in 1967 by the development of WAC Bennett Dam. The fluvial geomorphology baseline conditions in the Peace River are both naturally variable and are undergoing a long-term response to regulation. Downstream of Peace Canyon Dam to the Project, the Peace River flows mainly within a valley that is incised approximately 200 m below the Alberta Plateau surface. The river channel flows within a nearly continuous alluvial valley-bottom fill, but the river channel impinges against the valley walls in many locations. The river channel has a wandering to low-order braided planform with abundant gravel bars and wooded islands. The bed material in this reach is predominantly gravel and cobble. This reach of the river has been most influenced by upstream river regulation due to its location immediately downstream from the two existing dams, and in most places along this reach of the Peace River, the bed material has rarely been mobilized since the onset of regulation (BC Hydro 2012). Downstream of the Project to the BC-Alberta border, the Peace

[4] Site C EIS, Volume 2, Section 12.
[5] Site C EIS, Volume 2, Section 12.4.1.2.
[6] Site C EIS, Volume 2, Section 12.4.2.2.
[7] Site C EIS, Volume 2, Section 12.4.2.2.

River flows within similar morphological conditions (see above) and has also been influenced by upstream river regulation. Similar fluvial geomorphology characteristics were also observed in the channel where the bed material has rarely been mobilized since the onset of regulation (BC Hydro 2012).

From the BC-Alberta border downstream to the Many Islands area, the Peace River flows within a similar valley type, incised approximately 200 m below the surface of the Alberta Plateau. The river valley becomes narrower and the channel more continuously confined by the valley walls. The river channel has a dominantly single-thread planform. The bed material in this reach is dominantly fine gravel (Church 2011). The historical changes in geomorphology and sediment transport caused by river regulation are moderated in this reach of the river due to tributary inflows and the lower abundance of alluvial channel features.

Mon-3 is designed to address uncertainties presented in the Site C EIS (BC Hydro 2012). Existing physical habitat was described by BC Hydro (2012) using a combination of methods, including channel morphology, bed surface grain size, and physical habitat mapping. In 2021, surveys were conducted under Mon-3 to collect hydrographic and topographic data at monitored cross-sections using an acoustic doppler profiler (ADP) (hereafter the river cross-section surveys) and grain size measurements (i.e., pebble count surveys).

In addition to assisting in diagnosing causes of observed changes in indicator fish species (Beaudrie et al. 2017), the findings of Mon-3 will provide valuable context to offset effectiveness monitoring (e.g., Golder 2020b), and the Site C Fish Stranding Monitoring Program (Mon-12; e.g., Ecora 2020).

1.1 Key Management Questions

The overarching management questions for Mon-3 reflect that the Project can affect physical habitat in different ways:

1) “How does the construction of the Project affect physical habitat in the Site C Construction Headpond?”

2) “How does the construction and operation of the Project affect physical habitat in the Peace River between the Project and the Many Islands area in Alberta?”

1.2 Management Hypotheses

Mon-3’s management questions will be addressed by testing a series of management hypotheses:

H_1: “The Site C Construction Headpond will not affect channel morphology or bed sediment composition within the extent of the headpond.”

H_2: “The construction and operation of the Project will not affect channel morphology, bed surface grain size composition, or wetted area in the Peace River between the Project and the Many Islands area in Alberta.”

1.3 Study Objectives

In 2021, Mon-3 included a bathymetric and topographic survey to generate river cross-section profiles at historical monitoring locations (Golder 2015) located between the upstream limit of the diversion headpond and Many Islands in Alberta. For the portions of the river that could not be surveyed by the ADP or RTK, LiDAR data provided by BC Hydro (BC Hydro 2020) were used to extend the transects to above the bankfull elevations. At each river cross-section (i.e., transect) location, pebble counts were conducted at representative sites to obtain grain size data for analysis. When possible, results of the 2021 survey were compared to data collected in 2015 (Golder 2016) and 2019 (Golder 2020a) as part of Mon-3 and to historical river cross-section and grain size data collected from 1968 to 2005 (Church 2015). Data collected as part of offset effectiveness monitoring from 2017 to 2019 (Golder 2018, 2019, 2020b) were used when applicable but are spatially confined and do not cover the entire study area.

1.4 Study Area and Study Period

The study area for Mon-3 includes an approximately 138 km long section of the Peace River from near the outlet of Cache Creek (RKm 87 as measured downstream from WAC Bennett Dam) downstream to the Many Islands area (RKm 225). Within this area, 53 river transects were surveyed, and included 13 transects upstream of the Project within the footprint of the diversion headpond (Transect #US06 to #US13; RKm 101.9 to RKm 105.5), and 40 transects downstream of the Project (Transect #DS01 to #DS37; RKm 105.5 to RKm 225) (Appendix A, Figures A1 to A15). For analyses herein, transects situated downstream of the Project were grouped as follows: transects between the Project and the downstream extent of in-stream works associated with the Project's development (Transect #DS01 to #DS08; RKm 110); transects from the downstream extent of the in-stream works area to downstream of the Pine River's confluence with the Peace River (Transect #DS09 to #DS18; RKm 122); and transects from the Pine River's confluence downstream to the Many Islands area (Transect #DS19 to #DS37; RKm 225). UTM coordinates of the left and right banks of each transect (as viewed facing downstream) are provided in Appendix A, Table A1.

Grain size data was assessed at 48 sites. Of those 48 sites, 13 were located upstream of the Project and 35 sites were located downstream of the Project (Appendix A, Figures A1 to A15). The locations of the 48 sites were selected to be both close to a river transect (either upstream or downstream of it) and to sample different river morphology features (mid-channel bars, side bars, or point bars). UTM coordinates of grain size measurement locations are provided in Appendix A, Table A2.

In 2021, field work for Mon-3 was conducted in the summer and fall. The river cross-sections were surveyed from 9 to 14 August (Table 1). Grain size measurements were conducted from 21 to 24 September (Table 1). Field work was scheduled to coincide with anticipated high (August) and low (September) water levels in the Peace River. The river cross-section surveys were conducted to coincide with anticipated higher water levels in the summer to facilitate the integration of 2019 LiDAR data (BC Hydro 2020). Grain size data were collected in the fall to coincide with anticipated lower Peace River water levels to ensure larger areas of the active river channel were exposed and accessible for assessment.

Table 1: Summary of field activities conducted in 2021 in support of BC Hydro's Peace River Physical Habitat Monitoring Program (Mon-3).

Sample Activity	Sample Dates
River Cross-Section Surveys	9–14 August 2021
Grain Size Assessment	21–24 September 2021

2.0 METHODS

2.1 River Cross-Section Surveys

River cross-section surveys included areas of the active channel that were within the bankfull flow at the time of survey. Riverbanks located beyond the bankfull flow limits at the time of survey were not surveyed and were obtained from LiDAR survey data collected in May 2019 (BC Hydro 2020). At each of the 53 transects, three different methods were used to collect coordinates (Easting, Northing, and Elevations) of surveyed elevations:

- Bathymetry surveys: A RiverSurveyor® M9 dual beam acoustic doppler profiler (ADP) system (SonTek/Xylem Inc., San Diego, CA, USA) was used to measure the river depth from a boat. These measurements of water depth were used to establish the riverbed surface elevation. The ADP transducer was mounted 0.15 m below the water surface with a minimum measurable river depth of 0.35 m. Water velocity data were collected during the survey and provided to BC Hydro but are not presented in this report.
- Topographic surveys: A Trimble® R8 GPS RTK system (Trimble Inc., Sunnyvale, CA, USA) was used to measure topography in select wadable areas of the Peace River and on shoreline areas above the water surface at the time of the survey. Topographic elevations were measured along the established transects and included areas of the active channel below the bankfull elevation. Survey data of the riverbanks upslope of the bankfull elevation were not collected along any of the river cross-sections.
- Elevation data for portions of the river cross-sections that were not surveyed by the ADP or RTK were extracted from LiDAR data provided by BC Hydro (BC Hydro 2020).

During bathymetric surveys, the Trimble GPS system was attached to the ADP system and the local position coordinates (latitude and longitude) were transmitted to the ADP unit, which were incorporated into the raw data file collected by the ADP data software to provide UTM coordinates for surveyed locations. The survey methods were referenced to the same datum, and at the end of the survey, these data were spliced together to produce a single dataset.

The 2021 river cross-section data were compared to data collected in 2015 (Golder 2016), 2017 (Golder 2018), 2018 (Golder 2019), and 2019 (Golder 2020a, 2020b) when possible. Summary statistics (i.e., mean, median, standard deviation, quartiles, and range) were calculated for each transect completed in 2021 and were qualitatively compared to historical data where river cross-section data overlapped. Only the portions of the active channel, as assessed by the ADP and RTK, were included in summary statistics (i.e., LiDAR data were not included in these summaries).

With the commencement of river diversion in the fall of 2020, boat access to the approximately 2 km long portion of the Peace River between the debris boom upstream of the Project and the Project itself was restricted. This restriction prevented field crews from accessing the 5 most downstream transects situated within the diversion headpond (i.e., Transect #US05 to #US01). These transects were replaced with newly established transects within the upstream portion of the diversion headpond.

2.2 Grain Size Measurements

Grain size distribution was assessed at 48 locations on the Peace River (Appendix A, Figures A1 to A15) using pebble count methodology. Pebble count sample locations were situated near river cross-section survey locations where there was a suitable amount of sub-aerial (i.e., unwetted) exposures of appropriate geomorphic features, which included point or mid-channel bar heads (i.e., the location where the bar meets the underwater riffle crest) and bank deposits. Where possible, sites that were sampled for grain size distribution during the 2015 and 2019 field programs (Golder 2016, 2020a) were reassessed. Reassessing the same locations in 2021 as in 2015 and 2019 was not possible in some cases as some of the sites assessed in 2015 or 2019 were submerged at the time of the 2021 survey, (i.e., the water was too deep and/or too fast to wade safely) while other sites were situated within active construction areas associated with the Project and could not be safely accessed by field staff. For the locations found submerged at the time of survey, the closest location with the same channel feature (e.g., point bar) was surveyed where available.

The pebble count sampling procedure followed the guidelines outlined in Bundt and Abt (2001). The field crew measured the medial dimension (e.g., the b-axis, where the a-axis and c-axis represent the longest and shortest axes in a stone, respectively) of at least 100 stones in a grid pattern laid out with a measuring tape. The spacing of the grid was determined separately for each sample location and was set at approximately twice the diameter of the largest stone in the sample area. Stones were measured with a ruler and then classified by phi size. Phi size classes are defined as the negative base-2 logarithms of sediment sizes on the Wentworth sediment size scale (Wentworth 1922). Half phi sizes were used in the cobble range. Material class size definitions used in the field are presented in Appendix C, Table C1. The results from pebble counts were then used to calculate the D16, D35, D50, D84, and D90 percentiles (the particle size for which 16%, 35%, 50%, 84%, and 95% of the sample is finer than that size, respectively) at each sample location.

3.0 RESULTS

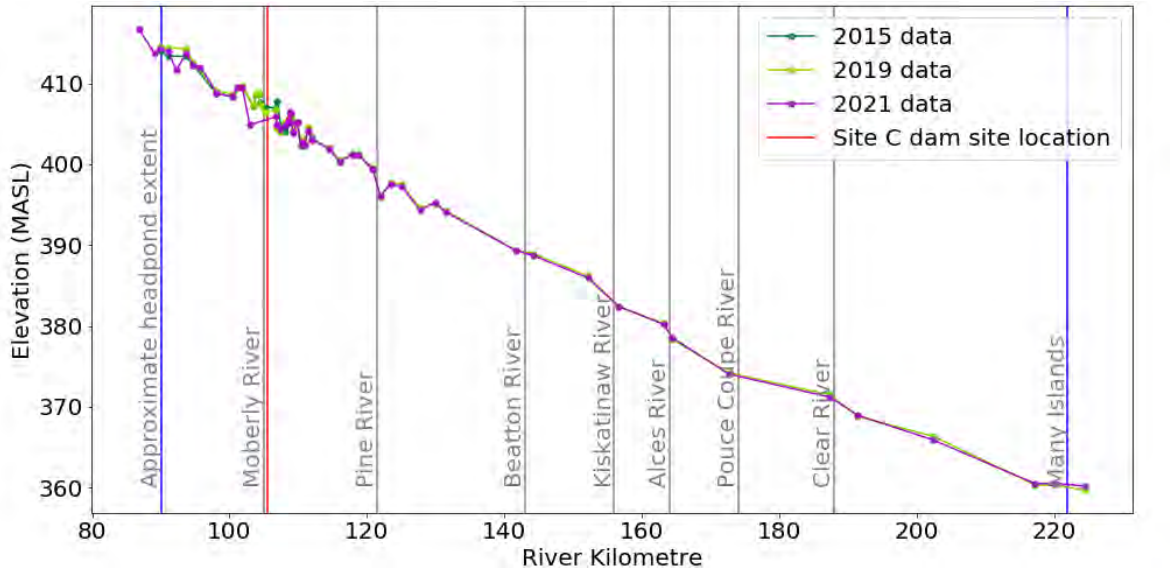
3.1 River Cross-Section Surveys

River cross-sections were measured at 53 transects in 2021 to obtain channel profile data (Appendix B, Figures B1 through B53). The UTM coordinates of each river cross-section are provided in Appendix A, Table A1.

River cross-sections downstream of the Pine River's confluence with the Peace River were not assessed in 2015 and thalweg elevations from 2017 and 2018 were not plotted due to the spatial coverage being limited to the Upper Site 109L offset area.

When compared to the previous surveys from 2015 and 2019, the 2021 thalweg elevation in the headpond showed small changes, typically up to 0.2 m (Figure 1); however, two locations are of note:

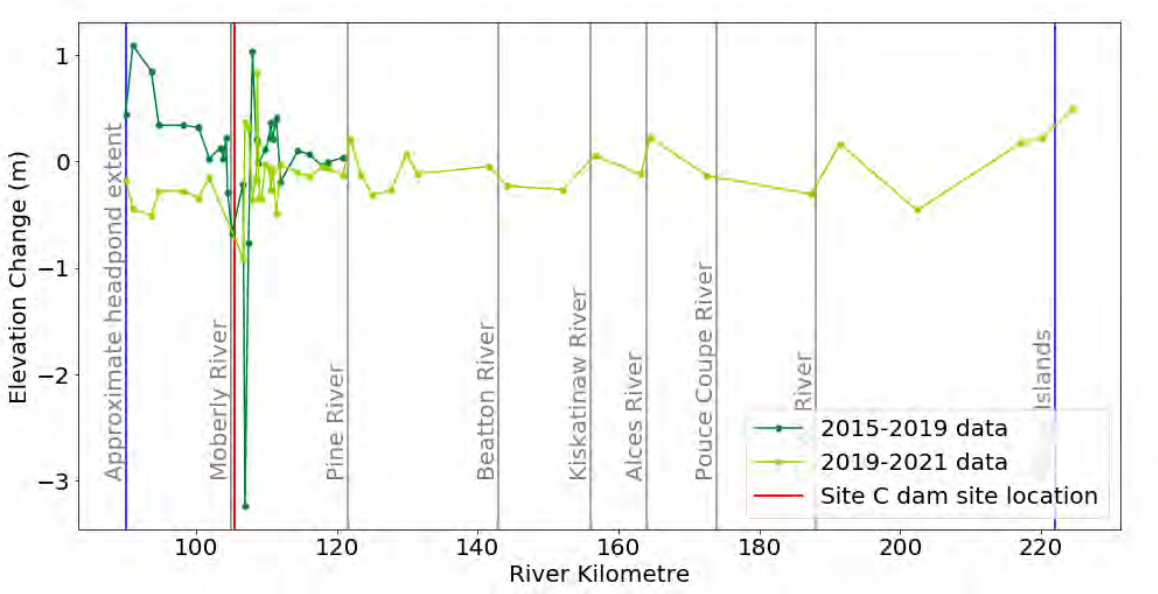
- Transect #US11A – this transect was surveyed for the first time in 2021 and was established in 2021 to replace one of the five most downstream transects within the diversion headpond that were no longer accessible. Prior to 2021, the elevation of the channel at this location was extrapolated based on the data from adjacent transects, which were higher in elevation. The lower elevation of the thalweg at US11A can be attributed to a narrower active channel that would result in a higher mean channel depth (i.e., a deeper channel with a more pronounced "U" shape).
- Transect #US06A – this transect was surveyed for the first time in 2021 and was established in 2021 to replace one of the five most downstream transects within the diversion headpond that were no longer accessible. The lower elevation of the thalweg can be attributed to a narrower active channel that would result in a higher mean channel depth (deeper channel with a more pronounced "U" shape). Transect #US06A is located near the historical monitoring Section 108 (Church 2015) and the thalweg elevation measured in 2021 is at an elevation similar to the 1975 surveys (the first year with surveys at this location).



Note: The locations of the confluences of major tributaries (grey lines), the Project (red line), and the Study Area (blue lines) are noted for reference. In 2015, cross-section profiles were only conducted downstream to the Pine River confluence.

Figure 1: Peace River thalweg elevations (in metres above sea level; MASL) by river kilometre as measured downstream from WAC Bennett Dam.

Between 2019 and 2021, the elevation of the thalweg remained relatively stable throughout the entire survey area, with the exception of the section of the mid-channel island dredged area between Transect #DS01 and #DS03 (Figure 2), which decreased in elevation by approximately 3 m between 2015 and 2019.



Note: Positive change represents accretion, and negative change represents erosion. The locations of the confluences of major tributaries (grey lines) and the Project (red line) are noted for reference.

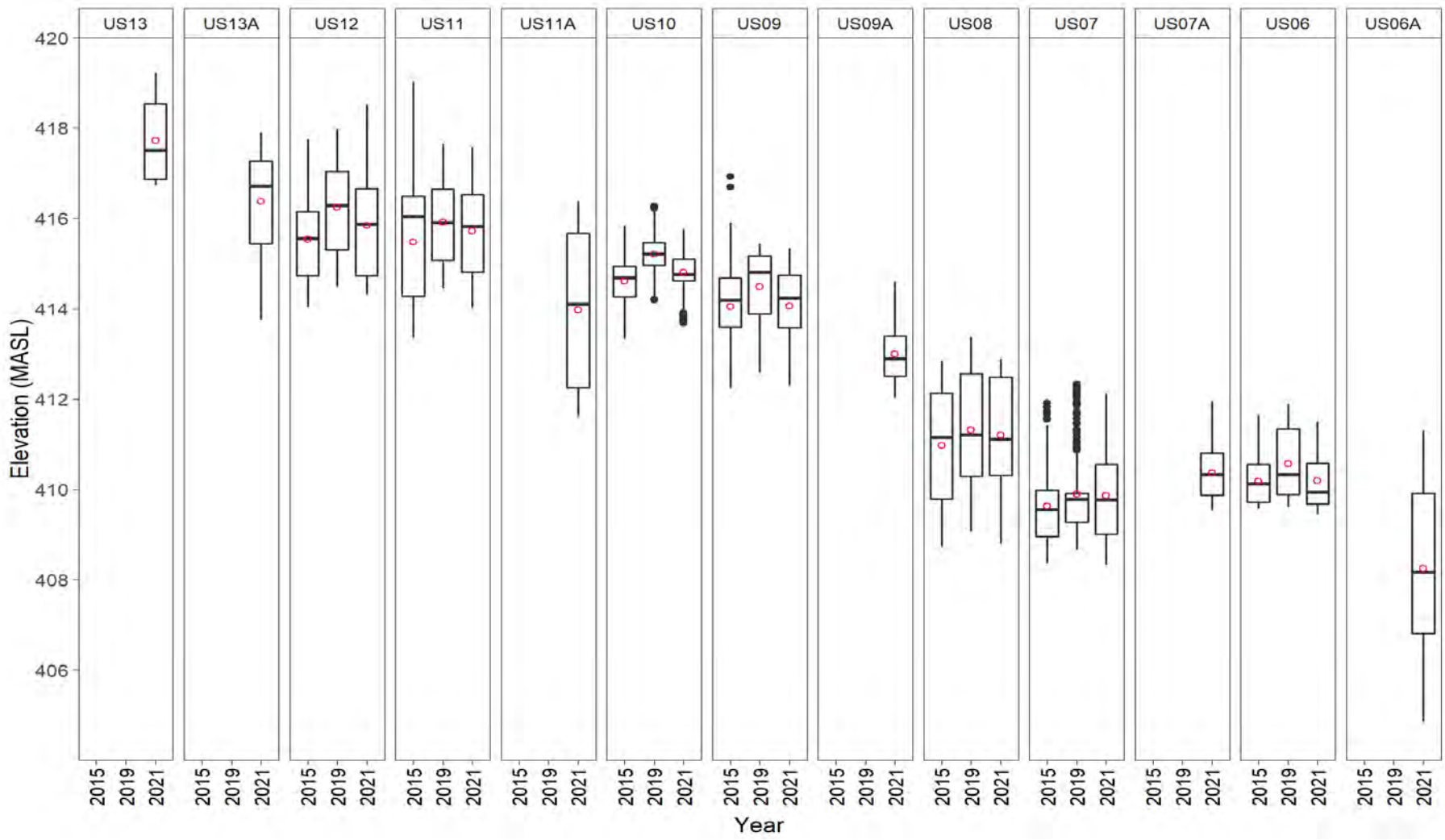
Figure 2: Change in Peace River thalweg elevations (in metres) by river kilometre as measured downstream from WAC Bennett Dam.

3.1.1 Diversion Headpond

In 2021, river cross-sections were measured at 13 transects situated upstream of the Project and within the footprint of the diversion headpond (Transect #US06 to #US13). Transects located downstream of transect #US06 (i.e., from Transect #US05 to #US01) were not measured for the reasons provided in Section 2.1. For all 13 transects, the mean channel elevation in 2021 was similar to the 2019 surveys, and slightly higher than values recorded in 2015 (Table 2 and Figure 3). The elevations presented in Figure 3 are limited to the portions of the active channel that were measured using ADP and RTK.

Table 2: Summary of changes observed during river cross-section surveys conducted in 2015 and 2021 within the footprint of the diversion headpond (Transect #US06 to #US13). Transects are presented in upstream to downstream order.

Transect #	Description of observations and changes noted over the study period
Transect #US13	A single main channel against the right bank and with a smaller side channel against the left bank that has flows during above average flow conditions. This transect was established in 2021 to replace one of Transects #US05 to #US01.
Transect #US13A	A single main channel against the left bank with a smaller side channel against the right bank that has flows during above average flow conditions. This transect was established in 2021 to replace one of Transects #US05 to #US01.
Transect #US12	The active channel maintained a larger main channel on the right bank and a smaller secondary channel on the left bank. In 2021, mean riverbed elevations were slightly lower than in 2019 and slightly higher than in 2015.
Transect #US11	The active channel maintained a larger main channel on the right bank and a smaller secondary channel on the left bank. In 2021, riverbed elevations were similar to the 2019 survey throughout the entire channel length.
Transect #US11A	A single main channel relatively in the middle of the river valley and with a smaller side channel on the right bank that has flows during above average flow conditions. This transect was established in 2021 to replace one of Transects #US05 to #US01.
Transect #US10	The active channel is a single channel. In 2021, the riverbed elevations were slightly lower than in 2019 and similar to the elevations recorded during the 2015 survey.
Transect #US09	The active channel maintained a larger main channel on the right bank. In 2021, riverbed elevations appeared slightly lower than in 2019 and similar to the 2015 survey.
Transect #US09A	The active channel is a single channel with a shallow area in the middle that forms an island during below average flows. This transect was established in 2021 to replace one of Transects #US05 to #US01.
Transect #US08	The active channel maintained a larger main channel on the right bank and a smaller secondary channel on the left bank. In 2021, the secondary channel was not accessible by boat due to low water levels; it was not surveyed. In 2021, riverbed elevations were similar to the 2019 surveys.
Transect #US07	The active channel is a single channel. In 2021, the riverbed elevations were similar to the 2019 surveys.
Transect #US07A	The active channel is a single channel with uniform riverbed elevations. This transect was established in 2021 to replace one of Transects #US05 to #US01.
Transect #US06	The active channel is a single channel with a shallow area in the middle (appearing as an island during low flows). In 2021, riverbed elevations were slightly higher than in 2019 and similar to the 2015 surveys.
Transect #US06A	The active channel is a single channel in a narrow section of the river valley with greater mean river depths. This transect was established in 2021 to replace one of Transects #US05 to #US01.



Note: Whiskers (vertical line) extend from the upper/lower quartiles to the maximum/minimum value within 1.5 times the interquartile range. Data outside of 1.5 times the interquartile range ("outlying" values) are shown individually as points. Data are from Transects #US13 (most upstream transect surveyed in 2021) through #US06A (most downstream transect surveyed in 2021) within the diversion headpond as recorded during 2015 and 2021 river cross-section bathymetry profile surveys.

Figure 3: Transects mean elevation (red circle), median (heavy horizontal line), and upper and lower quartiles (i.e., 25th and 75th percentiles; lower and upper bounds of rectangle).

3.1.2 Peace River Downstream of the Project

3.1.2.1 In-Stream Works Area

River cross-sections were measured at 12 transects from Transect #DS01 to #DS08 in 2021. These transects encompass the portion of the Peace River between the Project (RKm 105.5) and the downstream extent of in-stream works associated with the Project (RKm 110). The mean elevation for these transects was typically lower in 2021 when compared to the 2019 surveys, with the exception of Transects #DS07 and #DS08 (Table 3 and Figure 4). The elevations presented in Figure 4 are limited to the portions of the active channel that were measured using ADP and RTK.

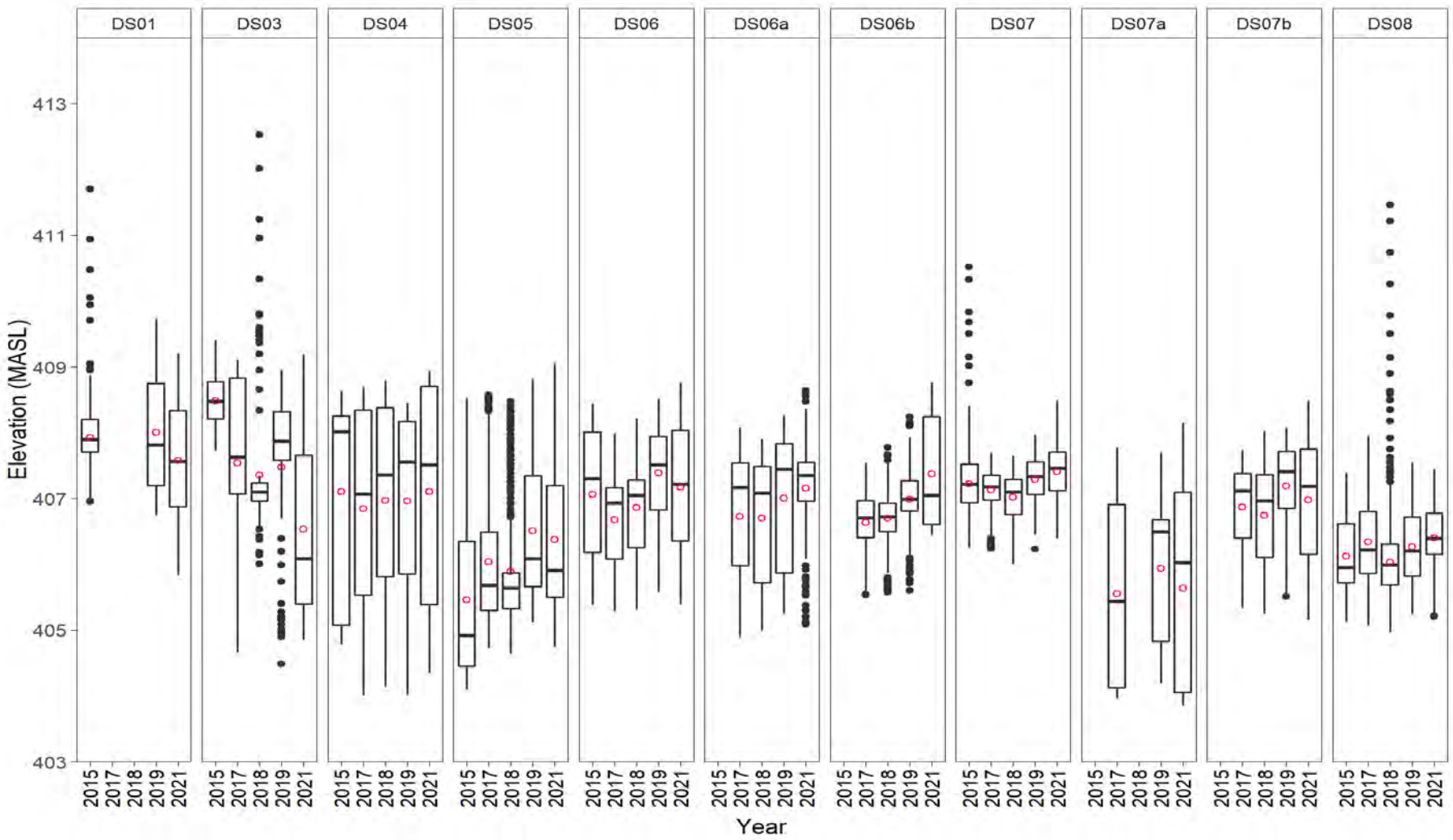
Table 3: Summary of changes observed in river cross-sections between 2019 and 2021 in the Project's downstream in-stream works area of the Peace River (Transect #DS01 to #DS08). Transects are presented in upstream to downstream order.

Transect #	Description of observations and changes noted over the study period
Transect #DS01	The active channel is a single channel with riverbed elevations that were similar in 2019 and 2021, except for the middle of the channel where construction activities associated with the Project occurred (i.e., dredging completed in early 2021). Construction activities along both banks modified the shape and location of each bank when compared to the 2015 and 2019 surveys. The Peace River construction bridge is situated within this transect.
Transect #DS03	This transect was surveyed in 2015, 2017, 2018, 2019, and 2021. River Road construction on the left bank, altered the location of the active channel. The active channel maintained a similar shape and similar riverbed elevations in 2017, 2018 and 2019. Dredging activities associated with the Project began in early 2020 and resulted in riverbed elevations in 2021 that were up to 4 m lower when compared to the 2019 surveys for most of the active channel.
Transect #DS04	This transect was surveyed in 2015, 2017, 2018, 2019, and 2021. River Road construction on the left bank altered the location of the active channel. When compared to the 2019 surveys, the active channel showed an enlargement/widening of approximately 30 m along the thalweg alignment in 2021. This change was associated with the dredging activities for the Project that occurred in early 2020.
Transect #DS05	This transect was surveyed in 2015, 2017, 2018, 2019, and 2021. River Road construction on the left bank altered the location of the active channel. The active channel on the left bank maintained a similar shape and similar riverbed elevations between 2019, and 2021.
Transect #DS06A	This transect was surveyed in 2017, 2018, 2019, and 2021. River Road construction and the development of habitat offset area Upper Site 109L along the left bank altered the location of the active channel. Between 2019 and 2021, the middle of the active channel has decreased in elevations and the deeper channel along the right bank narrowed slightly.
Transect #DS06	This transect was surveyed in 2015, 2017, 2018, 2019, and 2021. River Road construction and the development of habitat offset area Upper Site 109L along the left bank altered the location of the active channel between the 2017 and 2021 surveys. Since completion of the construction activities in 2016, the active channel has maintained a similar shape but increased slightly in elevation between 2019 and 2021 in the middle of the channel.

Transect #	Description of observations and changes noted over the study period
Transect #DS06B	This transect was surveyed in 2017, 2018, 2019, and 2021. River Road construction and the development of habitat offset area Upper Site 109L along the left bank altered the location of the active channel. The active channel riverbed elevations increased by approximately 2 m between 2019 and 2021 in the middle of the channel, which forms a mid-channel island at below average flows. The remainder of the 2021 profile shows a slight decrease of riverbed elevations along the left bank, and similar riverbed elevations along the right bank.
Transect #DS07	This transect was surveyed in 2015, 2017, 2018, 2019, and 2021. River Road construction and the development of habitat offset area Upper Site 109L along the left bank altered the location of the active channel and riverbed elevations in that section. The riverbed elevations for most of the channel remained similar between 2019 and 2021, except for a small increase in elevation in the middle of the channel.
Transect #DS07B	This transect was surveyed in 2017, 2018, 2019, and 2021. River Road construction and the development of habitat offset area Upper Site 109L along the left bank altered the portions of the active channel. In 2021, the active channel showed a similar channel shape with an increase in riverbed elevations of approximately 0.5 m when compared to 2019.
Transect #DS07A	When compared to the 2019 survey, the 2021 survey showed a similar channel shape and slightly lower riverbed elevations for the active channel along the left bank. The channel along the right bank shows the riverbed elevations with an increase in the middle of the channel and a small decrease near the bank, where construction associated with the development of habitat offset area Side Channel Site 108R modified the bank.
Transect #DS08	This transect was surveyed in 2015, 2017, 2018, 2019, and 2021. The active channel showed a similar channel shape and similar riverbed elevations between 2019 and 2021, with the exception of a small portion near the left bank that showed a slight increase in riverbed elevations.

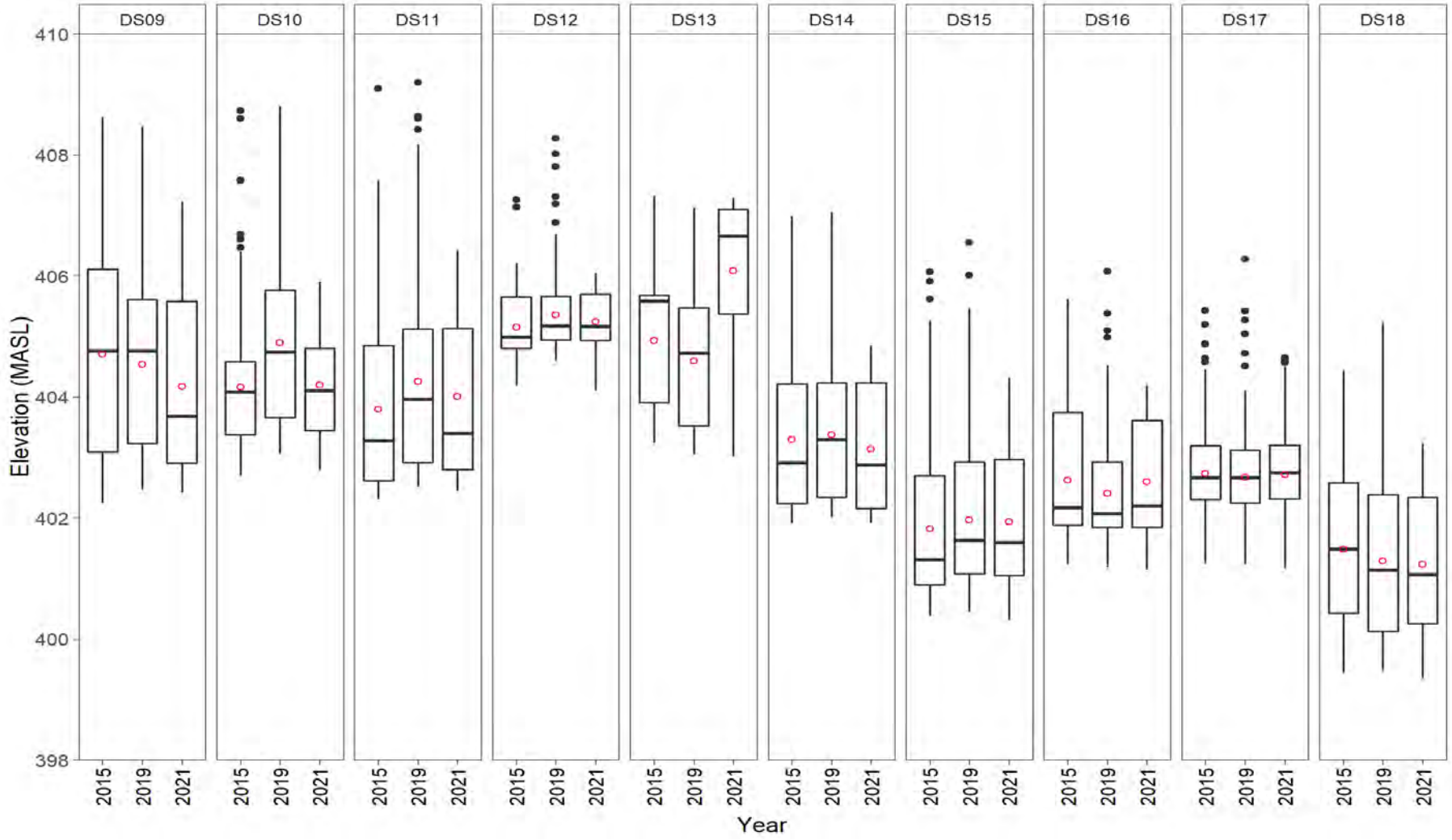
3.1.2.2 In-Stream Works Area to Pine River Confluence

River cross-sections were measured at 10 transects from Transect #DS09 to #DS18 in 2015, 2019, and 2021. These transects encompass the portion of the Peace River from the downstream extent of in-stream works associated with the Project to the Pine River's confluence with the Peace River. With the exception of minor variations in riverbed elevation near either the left or right banks, the active channel at all transects were similar in both channel shape and riverbed elevations during the 2019 and 2021 surveys (Figure 5). The elevations presented in Figure 5 are limited to the portions of the active channel that were measured using ADP and RTK.



Note: Whiskers (vertical line) extend from the upper/lower quartiles to the maximum/minimum value within 1.5 times the interquartile range. Data outside of 1.5 times the interquartile range ("outlying" values) are shown individually as points. Data are from Transects #DS01 (most upstream) through #DS08 (most downstream) of the Peace River as recorded during 2015 to 2021 river cross-section bathymetry profile surveys.

Figure 4: Transects mean elevation (red circle), median (heavy horizontal line), and upper and lower quartiles (i.e., 25th and 75th percentiles; lower and upper bounds of rectangle).



Note: Whiskers (vertical line) extend from the upper/lower quartiles to the maximum/minimum value within 1.5 times the interquartile range. Data outside of 1.5 times the interquartile range ("outlying" values) are shown individually as points. Data are from Transects #DS09 (most upstream) through #DS18 (most downstream) of the Peace River as recorded between 2015 and 2021 river cross-section bathymetry profile surveys.

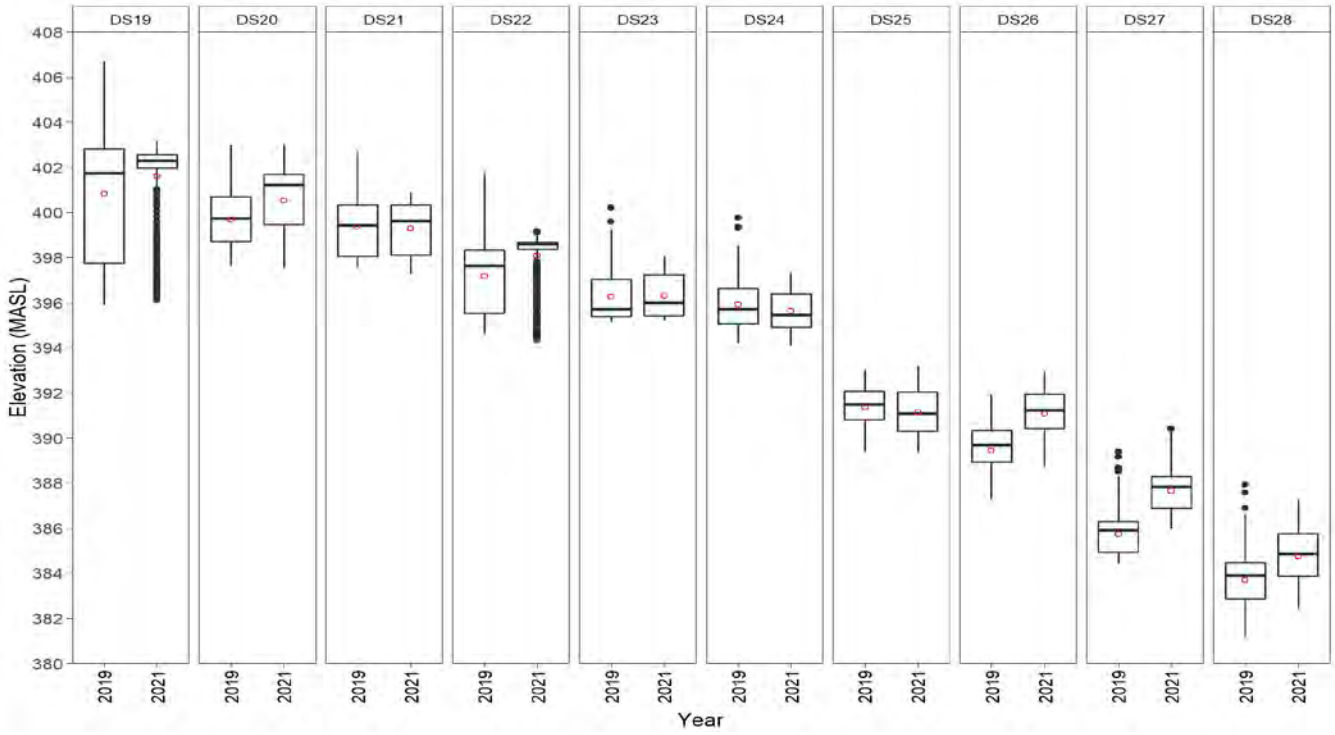
Figure 5: Transects mean elevation (red circle), median (heavy horizontal line), and upper and lower quartiles (i.e., 25th and 75th percentiles; lower and upper bounds of rectangle).

3.1.2.3 Pine River Confluence to Many Islands

River cross-sections were measured at 19 transects from Transect #DS19 to #DS37 in 2021. These transects encompass the portion of the Peace River from the Pine River's confluence downstream to the Many Islands area. Prior to 2021, these transects were surveyed only once, in 2019. The elevations at these transects are presented in Figure 6 and Figure 7 are limited to the portions of the active channel that were measured using ADP and RTK.

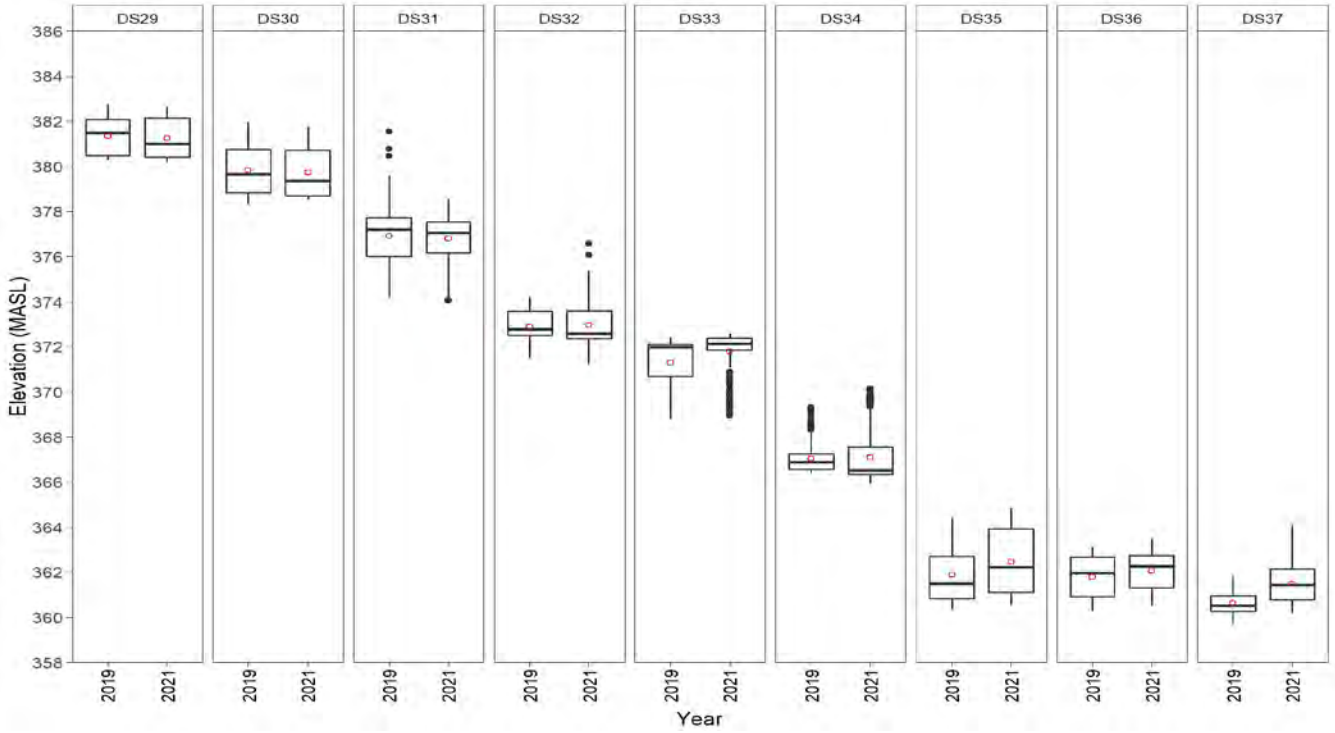
In 2021, the largest change was observed at Transect #DS19, which is located at the Pine River confluence. At this location, the Pine River channel migrated laterally towards its right bank and downstream, for approximately 30 m when compared to the 2019 surveys, and for approximately 150 m when compared with available imagery from 2015 surveys (no surveys were completed in 2015). The lateral migration resulted in the Transect #DS19 alignment being crossed by the active channel of the Pine River in 2021, which is evident in Appendix A, Figure A6, and thus the transect is now sampling a portion of the Pine River channel. This can be observed in Figure 6 below, where the lower and upper quartiles have a reduced elevation range that matches a longer and shallower transect profile.

A similar situation was observed at Transect #DS22, where the shallow portion of the right bank was surveyed for a longer distance (approximately extra 200 m) because the survey was conducted at slightly higher water levels.



Note: Whiskers (vertical line) extend from the upper/lower quartiles to the maximum/minimum value within 1.5 times the interquartile range. Data outside of 1.5 times the interquartile range ("outlying" values) are shown individually as points. Data are from Transects #DS19 (most upstream) through #DS28 (most downstream) of the Peace River as recorded during river cross-section bathymetry profile surveys in 2019 and 2021.

Figure 6: The mean elevation (red circle), median (heavy horizontal line), and upper and lower quartiles (i.e., 25th and 75th percentiles; lower and upper bounds of rectangle).



Note: Whiskers (vertical line) extend from the upper/lower quartiles to the maximum/minimum value within 1.5 times the interquartile range. Data outside of 1.5 times the interquartile range ("outlying" values) are shown individually as points. Data are from Transects #DS29 (most upstream) through #DS37 (most downstream) of the Peace River as recorded during river cross-section bathymetry profile surveys in 2019 and 2021.

Figure 7: Transects mean elevation (red circle), median (heavy horizontal line), and upper and lower quartiles (i.e., 25th and 75th percentiles; lower and upper bounds of rectangle).

3.2 Historical River Cross-Section Comparison

River cross-sections were surveyed between 1968 and 2005 at 15 locations along the Peace River (BC Hydro 2012). These cross-sections extend from approximately RKm 101 to RKm 128 (the Project is located at RKm 105.5). The locations of some of these historical cross-sections are at different river kilometres when compared to cross-sections assessed as part of Mon-3. As such, a direct comparison of all surveyed cross-section profiles was not possible. Instead, thalweg elevations for each year with surveys at historical and Mon-3 cross-sections were plotted in a longitudinal profile to show natural variations in thalweg elevations (Figure 8). The longitudinal profile shows that the largest thalweg elevation variations were located downstream of the Pine River confluence, from Transect #DS19 to #DS21, with variations of up to 3.8 m over the period from 1975 and 2021.

The river cross-sections surveys from between 1968 and 2005 are presented in Appendix B.

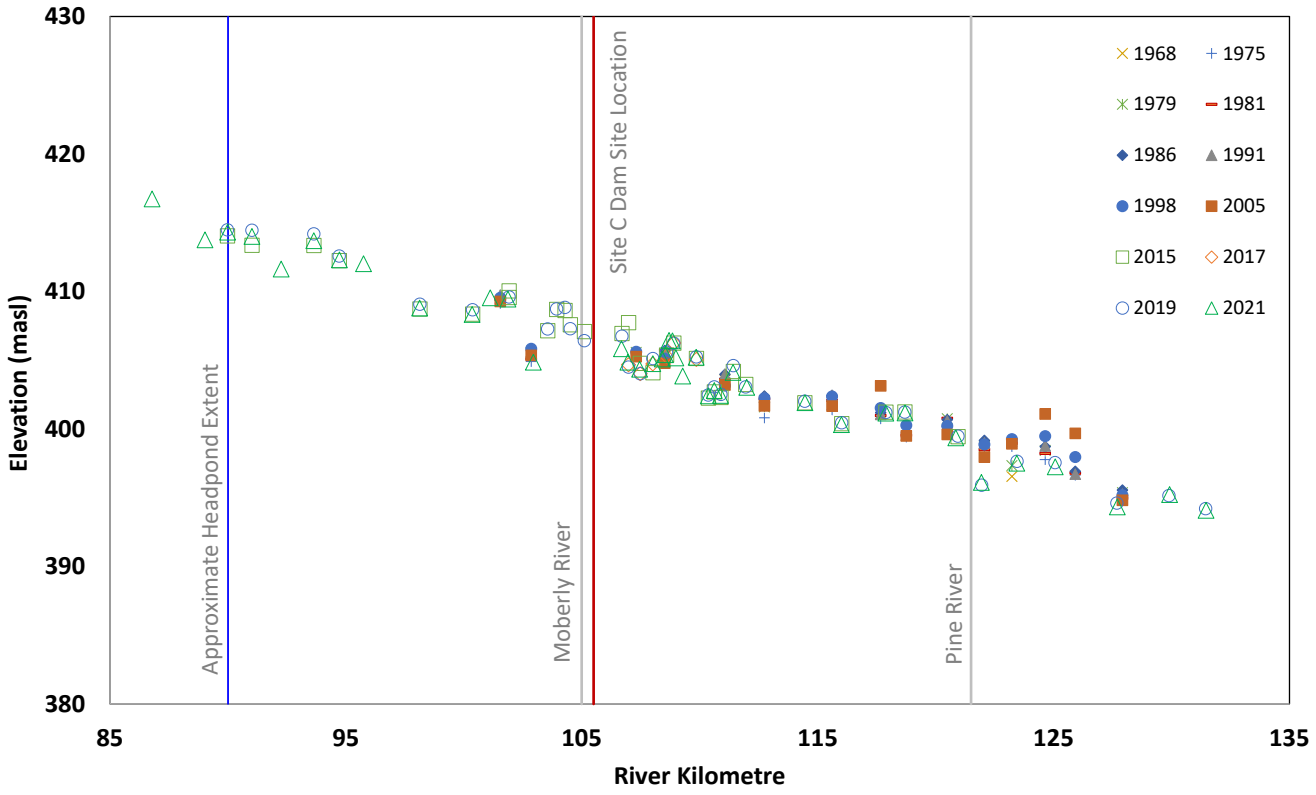


Figure 8: Thalweg profile from historical (BC Hydro 2012) and Mon-3 cross-sections surveys (1968 – 2021).

3.3 Grain Size Measurements

In 2021, the grain size distribution of riverbed materials was estimated using the pebble count method at 35 locations. A number of sites with surveys in the previous years (2015 and 2019) were not surveyed in 2021 for the reasons detailed below:

- Six sites were located downstream of the Peace River debris boom and were not accessible.
- Two sites were located in the area around the Transects #DS02 and #DS03 that was dredged in early 2021.
- Three sites were located in areas that were disturbed by construction activities (near Transects #DS01 and #DS07).
- Ten sites were inundated at the time of the survey.

During the field surveys (September 2021) high water levels were observed at some locations and adjustments were made at each site to allow sampling to cover the available portions of exposed channel features. The survey followed a transect line (typically aligned upstream to downstream) with a constant 0.4 m spacing between the sampling points, similar to the 2019 program. A comparison of D50 between 2019 and 2021 surveys was completed for the sites with common measurements.

Overall, the distribution of D16, D35, D50, D84, and D90 percentiles in 2021 followed similar patterns throughout the study area (Figure 9 to Figure 13). The dominant substrate materials for the surveyed area were gravel (66% averaged over the study area) and cobble (33% averaged over the study area) in channel bar head and bank surfaces (Figure 14). While variability among sites was high, in general, the substrate of Peace River bars and banks over the study area became finer with distance downstream from RKm 90 to RKm 180. Over this distance, the percentage of gravel increased, while the percentage of cobble decreased. The channel coarsened at approximately RKm 190. The percentage of sand size and finer material in the substrate was similar throughout the study area.

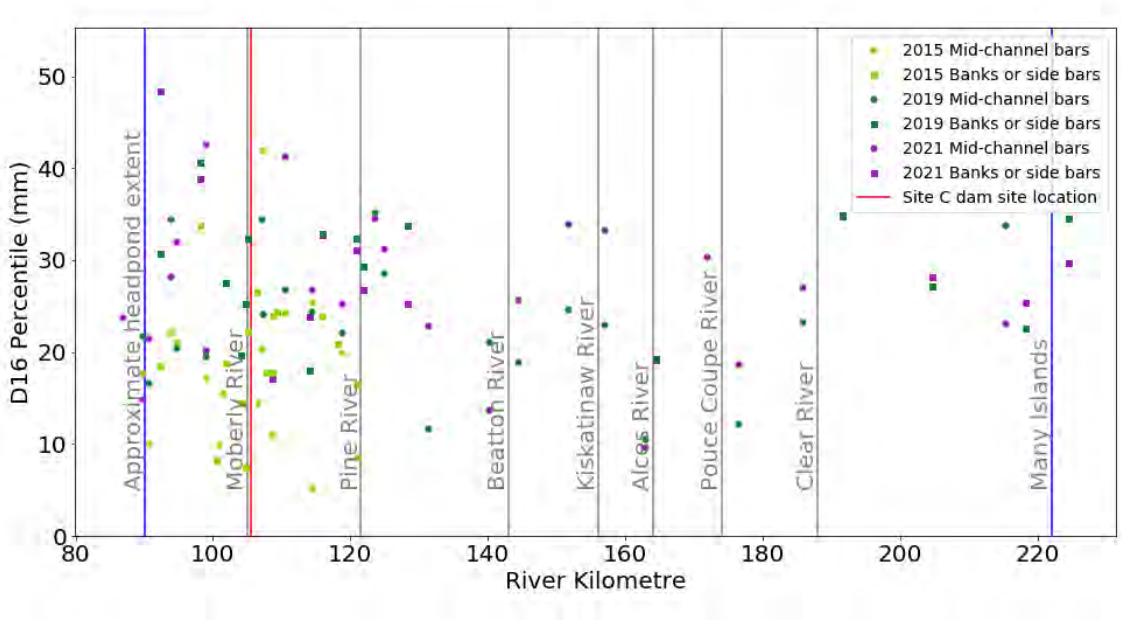


Figure 9: Summary of D16 percentile values (in mm) by sample type (mid-channel bars or bank/side bars) and RKm as measured downstream from WAC Bennett Dam, 2021. The locations of the confluences of major tributaries (grey lines) and the Project (red line) are noted for reference.

The range of grain sizes were similar in 2019 and 2021 for most of the study area (Figure 11), except for the portion of the river between the Beatton River confluence (RKm 143) and downstream of the Pouce Coupe River confluence (RKm 176.5), where grain size was consistently larger.

Complete grain size distributions for 2021 are presented in Figure 15 through Figure 23. Results from multiple sites are compiled together in these figures to reduce the total number of plots presented. Additional figures presenting the D16 to D90 analyses and percentages by substrate type can be found in Appendix C.

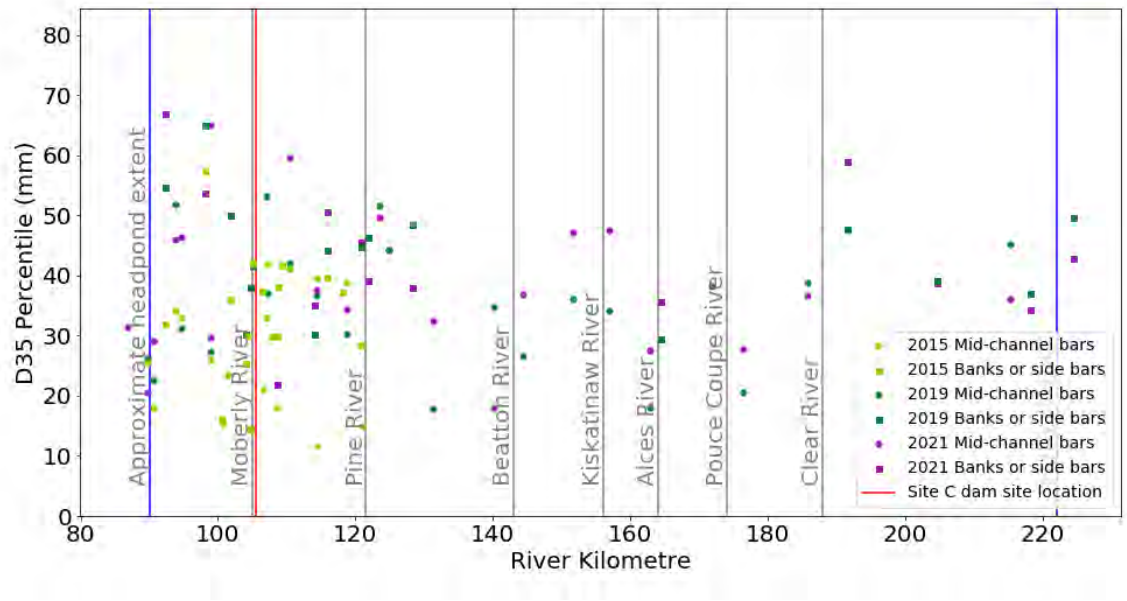


Figure 10: Summary of D35 percentile values (in mm) by sample type (mid-channel bars or bank/side bars) and RKm as measured downstream from WAC Bennett Dam, 2021. The locations of the confluences of major tributaries (grey lines) and the Project (red line) are noted for reference.

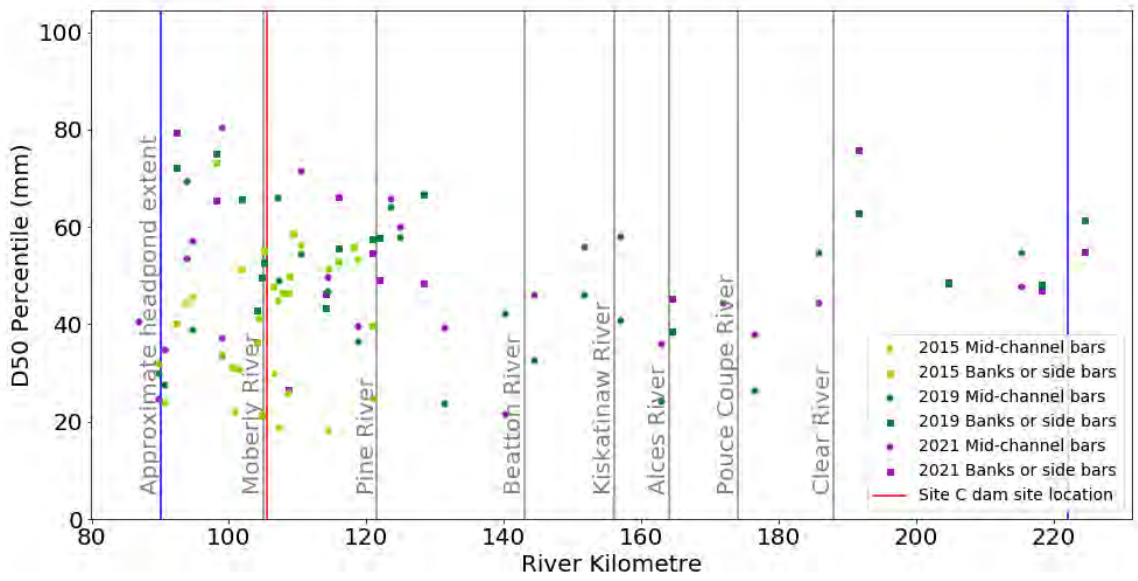


Figure 11: Summary of D50 percentile values (in mm) by sample type (mid-channel bars or bank/side bars) and RKm as measured downstream from WAC Bennett Dam, 2021. The locations of the confluences of major tributaries (grey lines) and the Project (red line) are noted for reference.

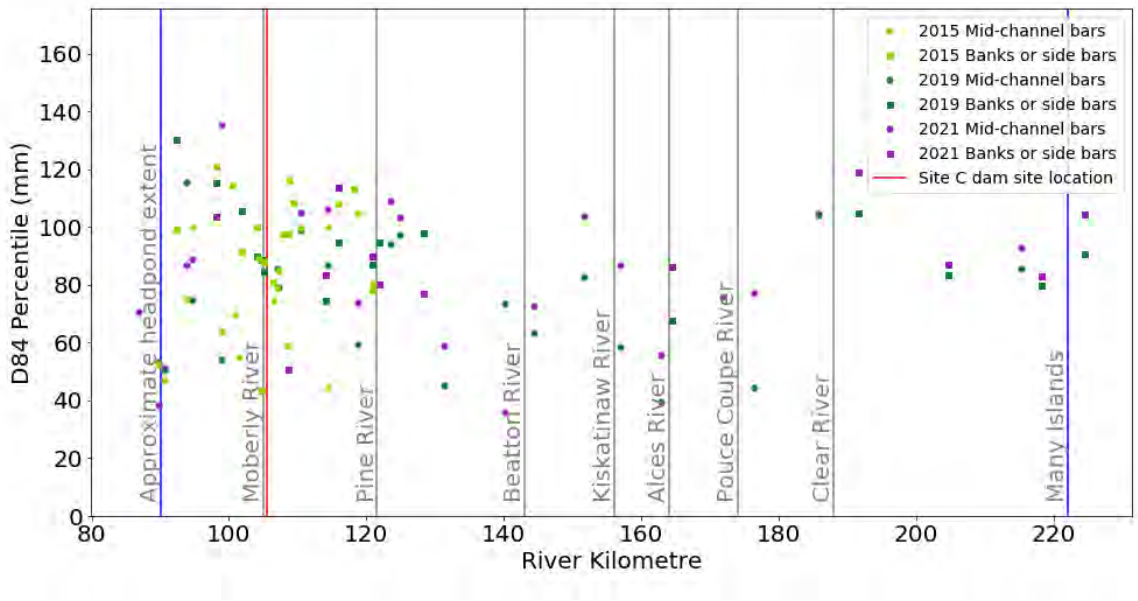


Figure 12: Summary of D84 percentile values (in mm) by sample type (mid-channel bars or bank/side bars) and RKm as measured downstream from WAC Bennett Dam, 2021. The locations of the confluences of major tributaries (grey lines) and the Project (red line) are noted for reference.

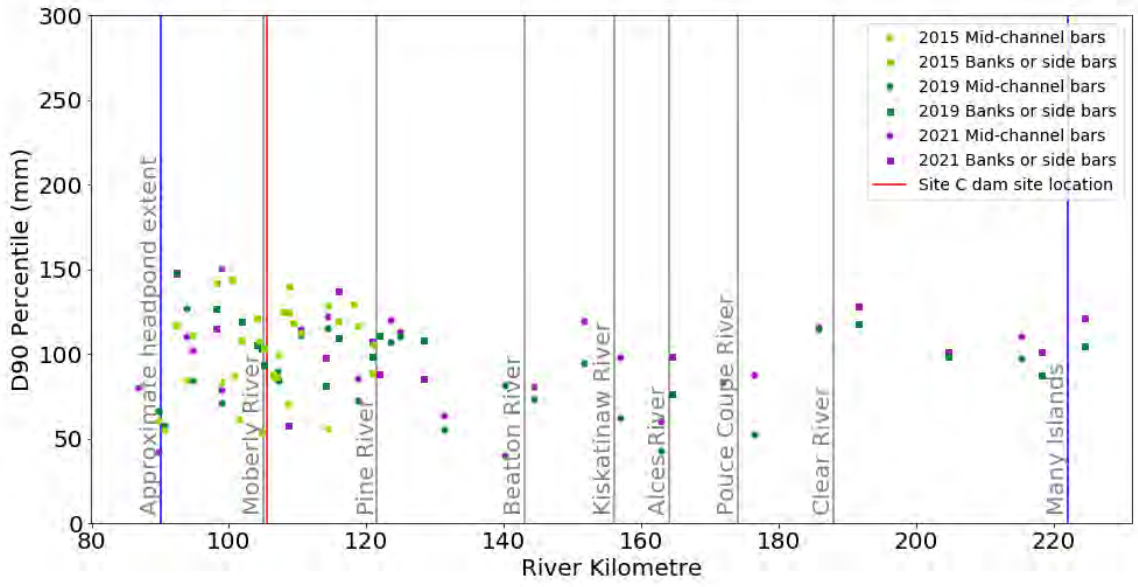


Figure 13: Summary of D90 percentile values (in mm) by sample type (mid-channel bars or bank/side bars) and RKm as measured downstream from WAC Bennett Dam, 2021. The locations of the confluences of major tributaries (grey lines) and the Project (red line) are noted for reference.

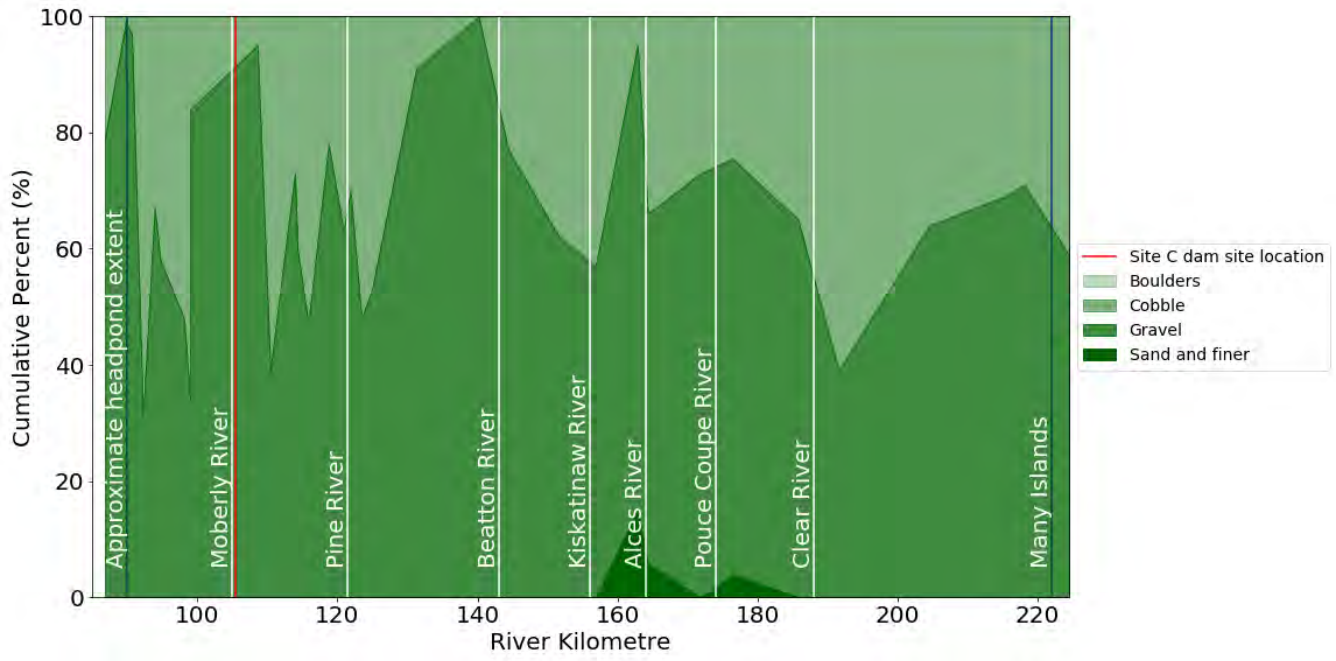


Figure 14: Summary of percent material by substrate type by RKm as measured downstream from WAC Bennett Dam, 2021. The locations of the confluences of major tributaries (grey lines) and the Project (red line) are noted for reference.

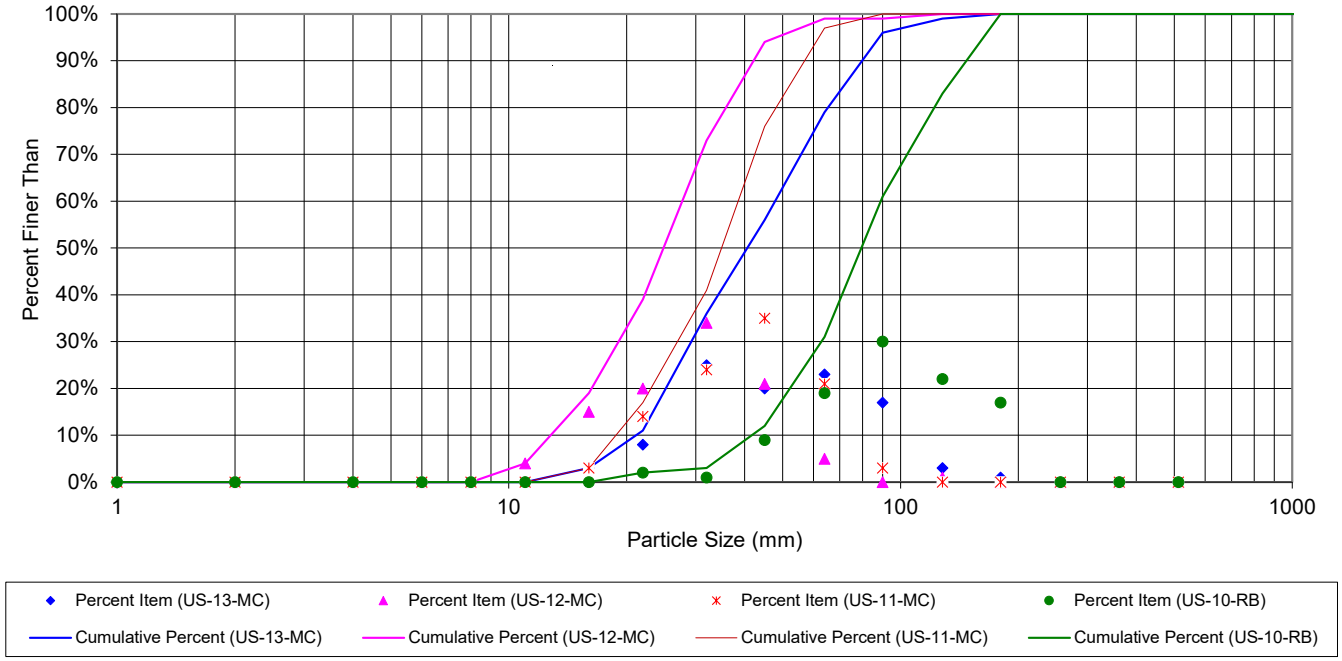


Figure 15: Grain size distributions (points) and cumulative percentages (lines) near Transects #US13, #US12, #US11, and #US10, along the Peace River, 2021.

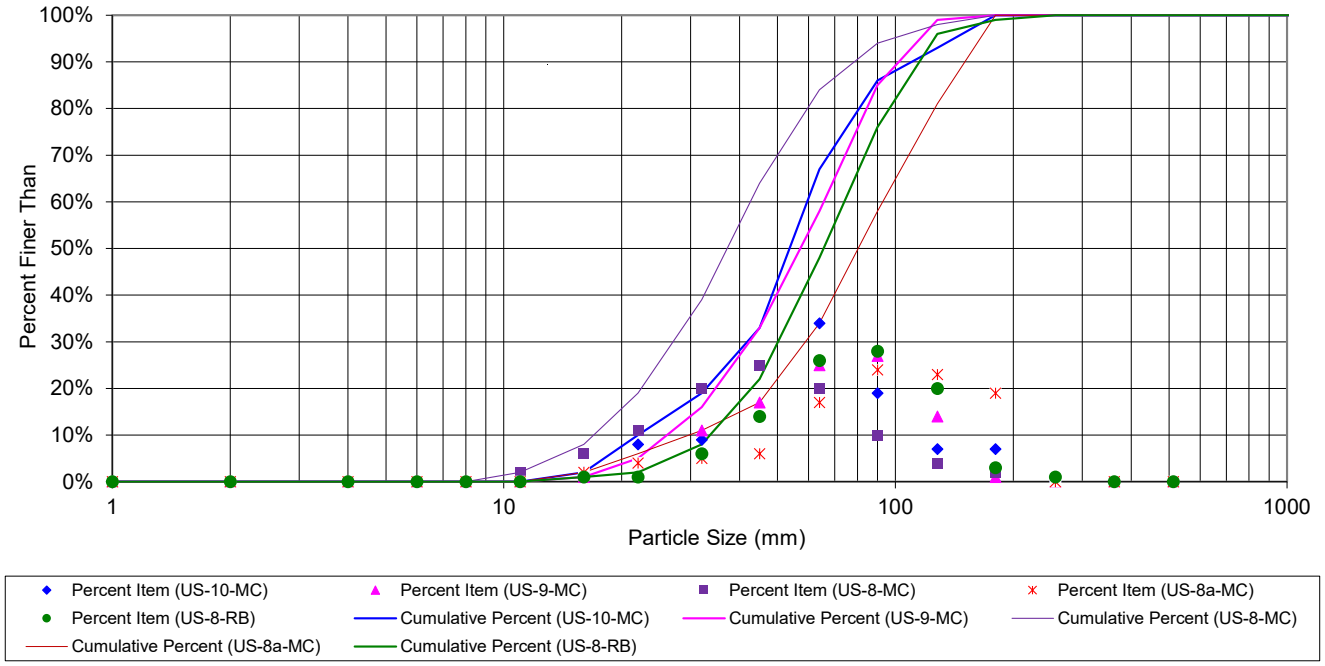


Figure 16: Grain size distributions (points) and cumulative percentages (lines) near Transects #US10, #US09, and #US08, along the Peace River, 2021.

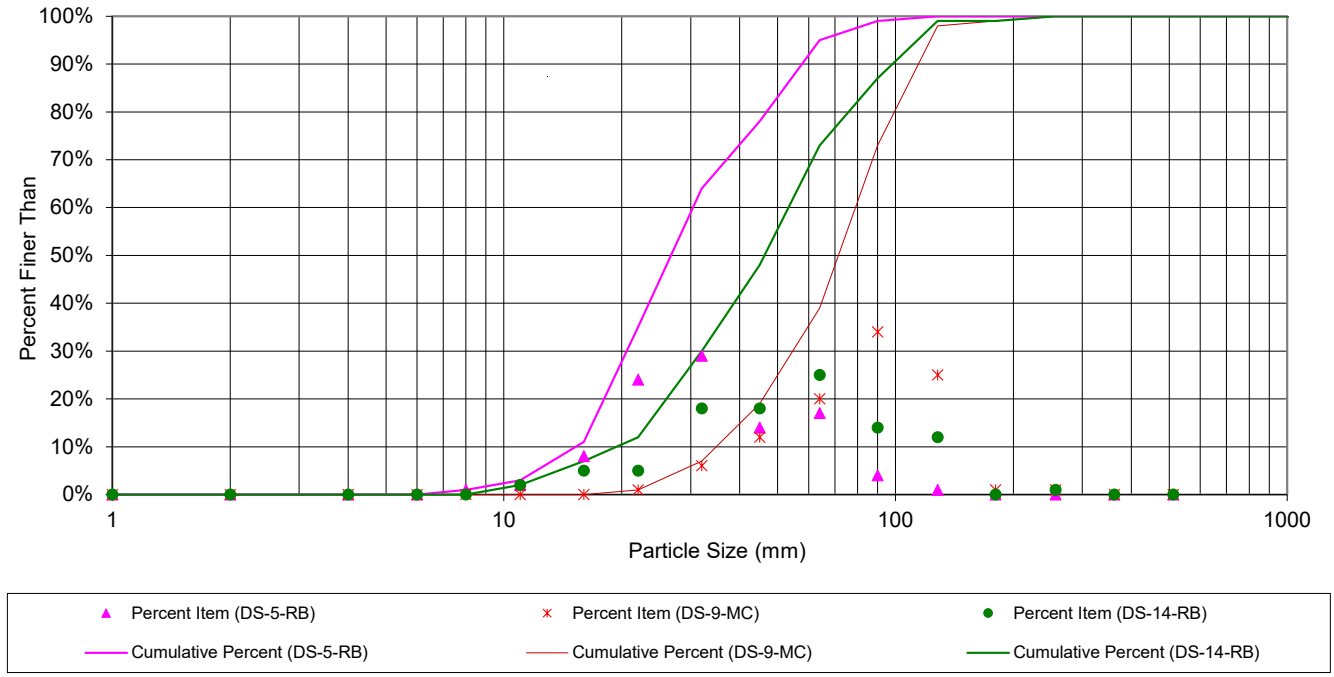


Figure 17: Grain size distributions (points) and cumulative percentages (lines) near Transects #US08, #DS05, #DS09, and #DS14, along the Peace River, 2021.

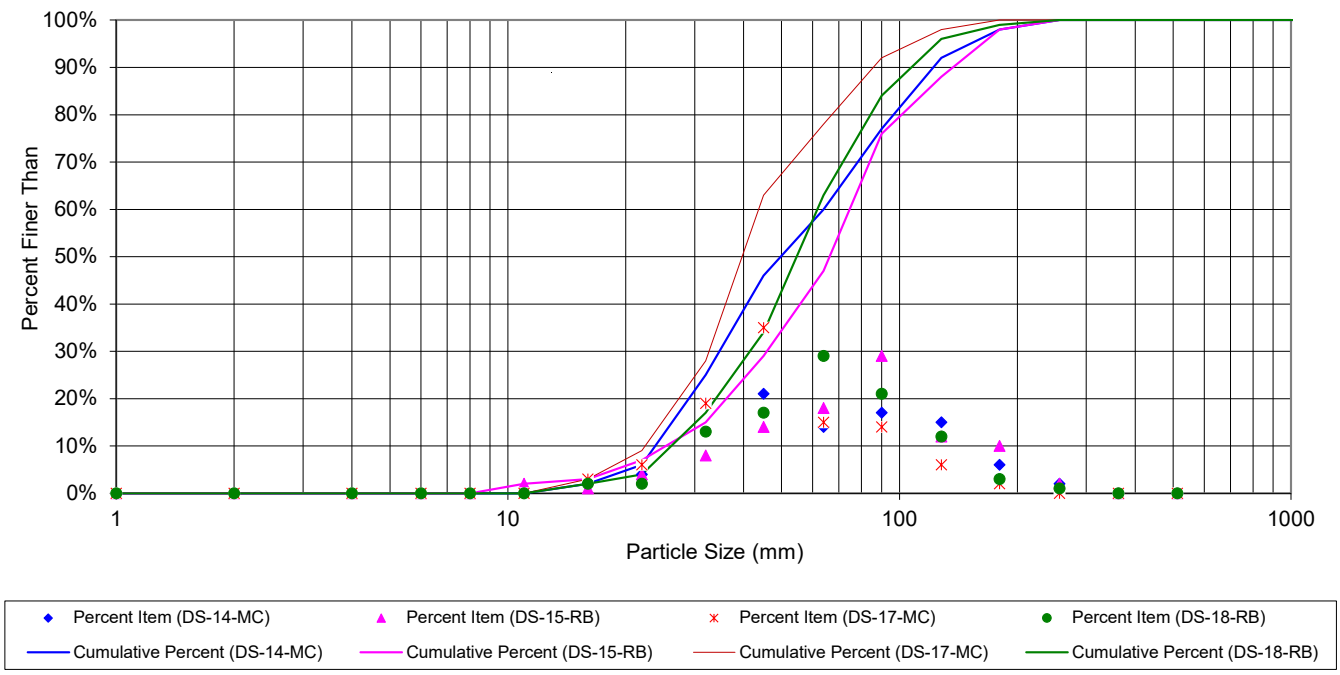


Figure 18: Grain size distributions (points) and cumulative percentages (lines) near Transects #DS14, #DS15, #DS17, and #DS18, along the Peace River, 2021.

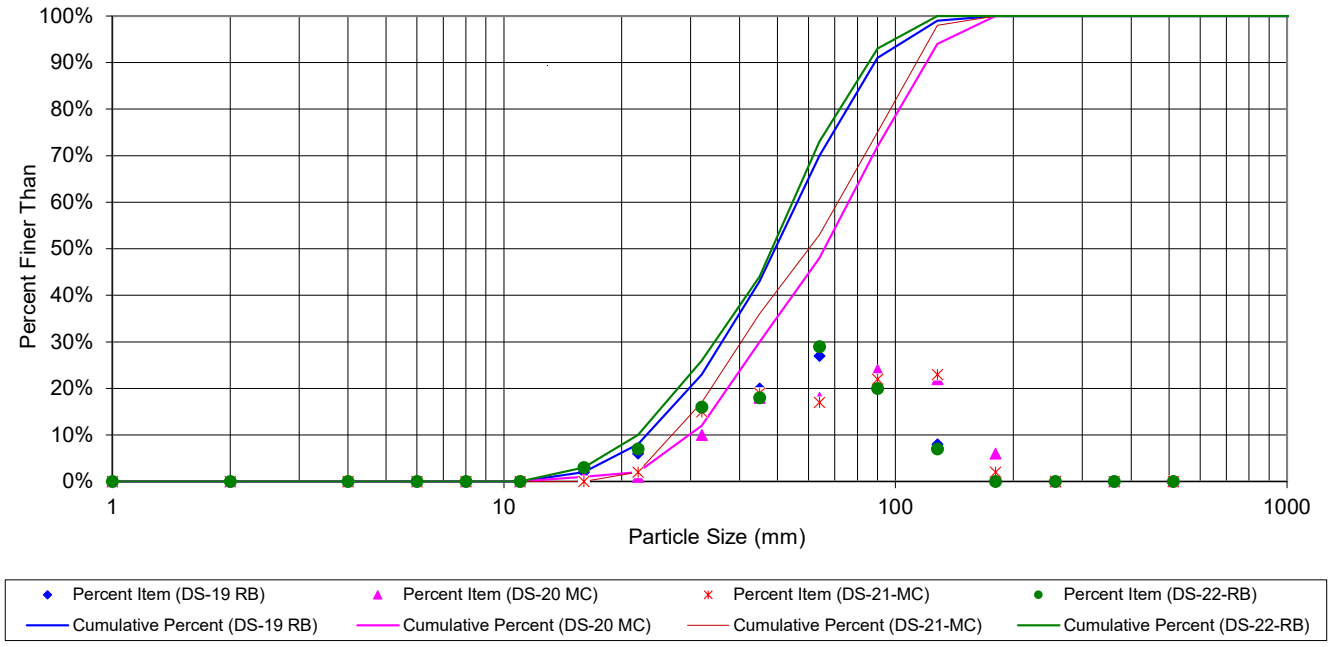


Figure 19: Grain size distributions (points) and cumulative percentages (lines) near Transects #DS19, #DS20, #DS21, and #DS22, along the Peace River, 2021.

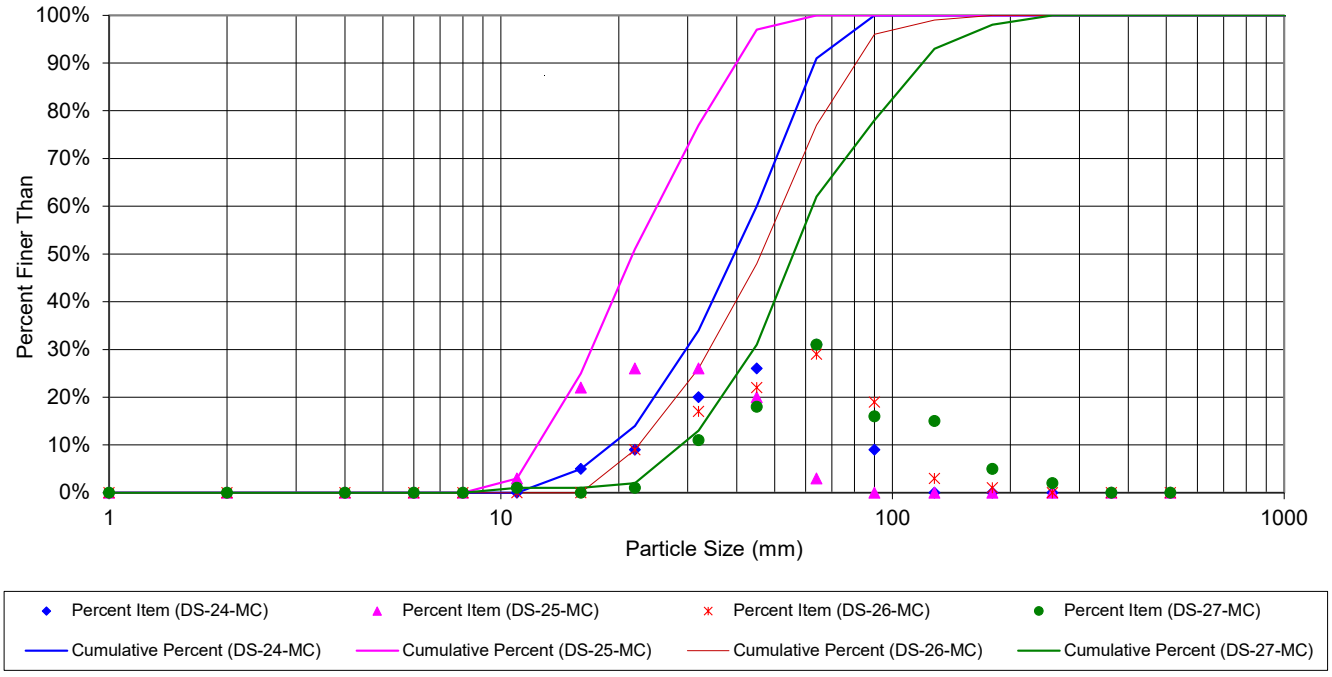


Figure 20: Grain size distributions (points) and cumulative percentages (lines) near Transects #DS24, #DS25, #DS26, and #DS27, along the Peace River, 2021.

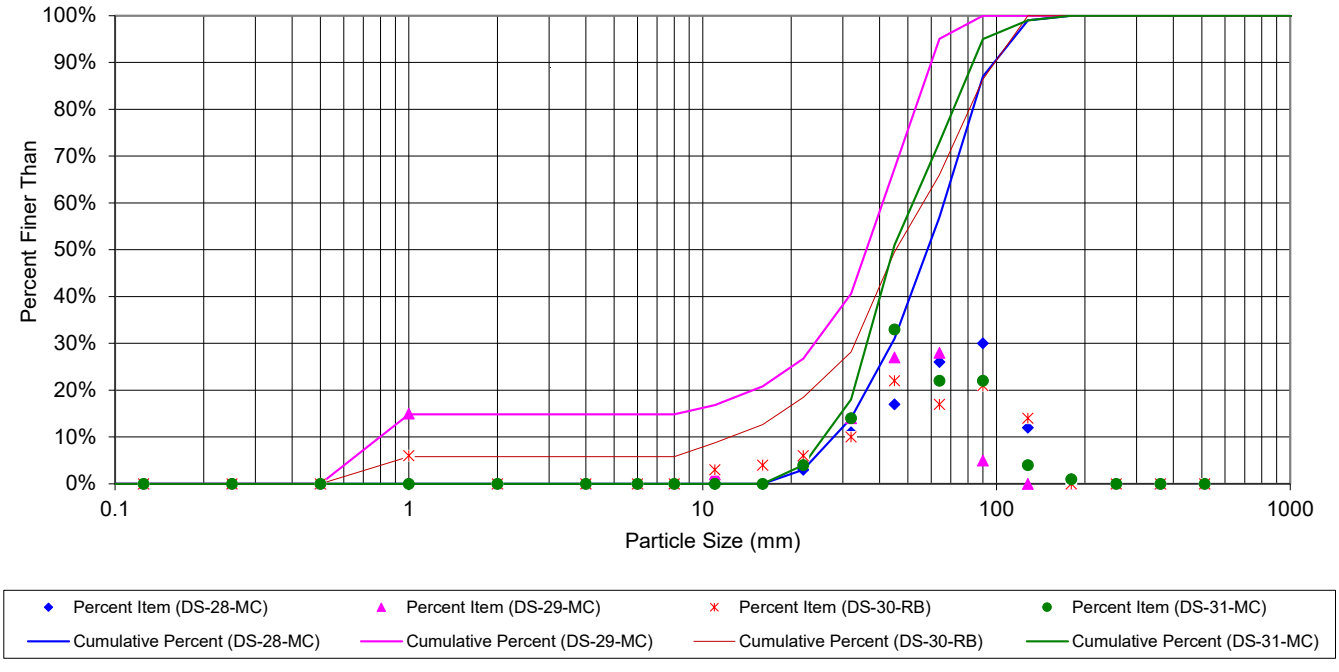


Figure 21: Grain size distributions (points) and cumulative percentages (lines) near Transects #DS28, #DS29, #DS30, and #DS31, along the Peace River, 2021.

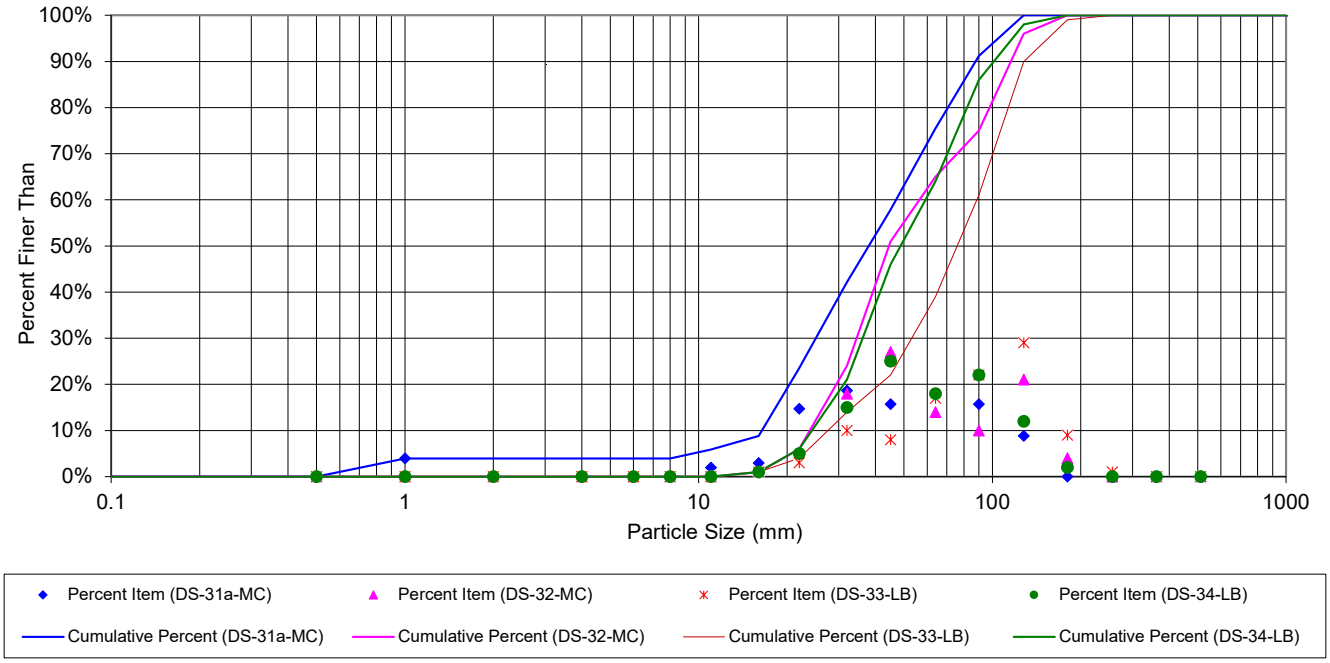


Figure 22: Grain size distributions (points) and cumulative percentages (lines) near Transects #DS31, #DS32, #DS33, and #DS34, along the Peace River, 2021.

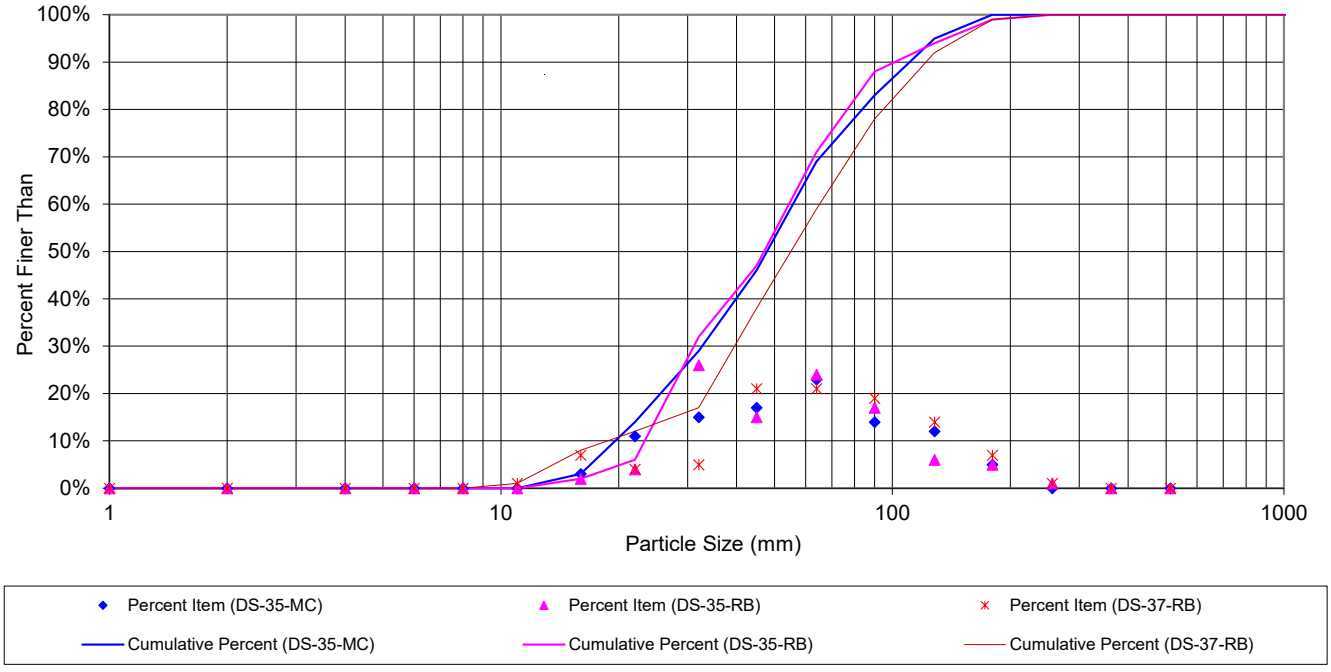


Figure 23: Grain size distributions (points) and cumulative percentages (lines) near Transects #DS35 and #DS37, along the Peace River, 2021.

3.3.1 Historical Grain Size Measurements

Historical grain size measurement data were available for select years between 1968 and 2005 at multiple locations along the Peace River (BC Hydro 2012). The measurements were collected at locations from downstream of Peace Canyon Dam to upstream of the Alces River's confluence with the Peace River (near the BC-Alberta border).

The D50 percentile is presented in a longitudinal profile in Figure 24 and shows larger variations in the D50 percentile upstream of the Halfway River confluence, and smaller variations downstream of the Halfway River confluence.

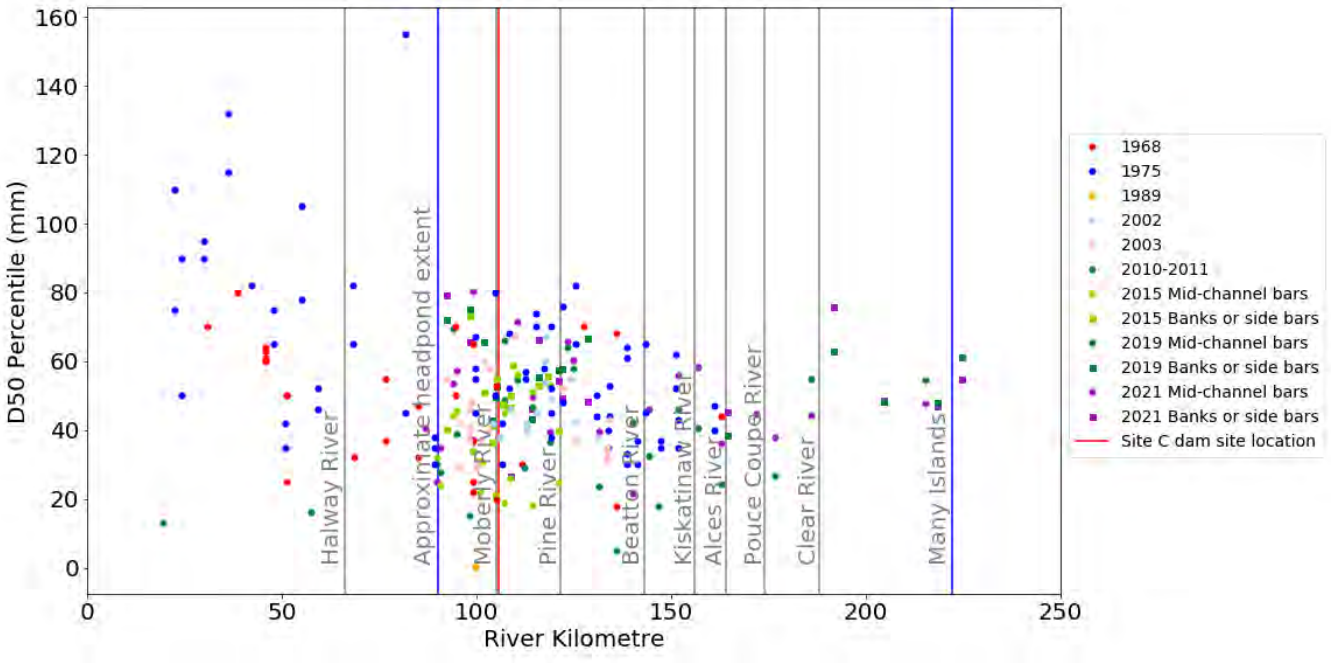


Figure 24: Summary of D50 percentile (in mm) at river cross-sections surveyed between 1968 and 2021, by year and RKm, as measured downstream from WAC Bennett Dam. The locations of the confluences of major tributaries (grey lines) and the Project (red line) are noted for reference.

The D90 percentile is presented in a longitudinal profile in Figure 25 and shows larger variations in the D90 percentile upstream of the Halfway River confluence and smaller variations downstream of the Halfway River confluence.

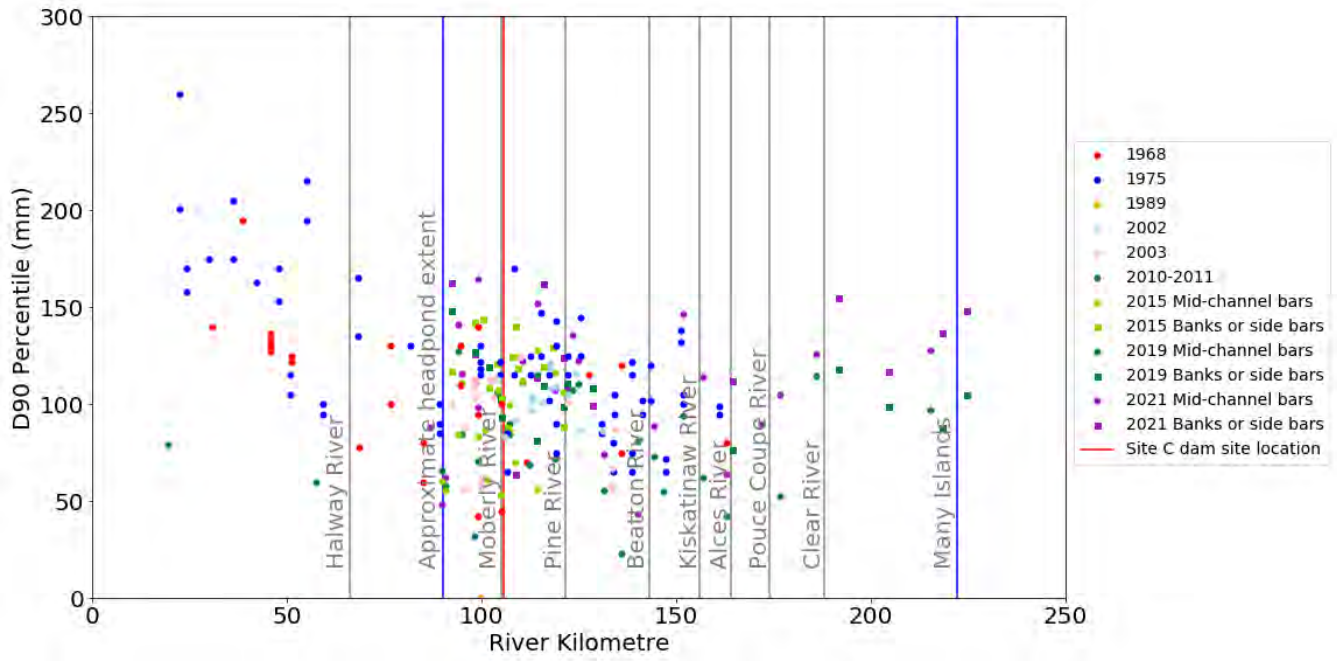


Figure 25: Summary of D90 percentile (in mm) at river cross-sections surveyed between 1968 and 2021, by year and RKm, as measured downstream from WAC Bennett Dam. The locations of the confluences of major tributaries (grey lines) and the Project (red line) are noted for reference.

4.0 DISCUSSION

Mon-3 will use physical habitat monitoring data to validate predictions and address uncertainties identified in the Site C EIS (BC Hydro 2012) and will assist in detecting and diagnosing causes of observed changes in indicator fish species that are monitored under other components of the FAHMFP. Monitoring physical habitat in the diversion headpond and downstream of the Project will provide diagnostic observations, should there be changes to the fish community that are beyond those predicted in the EIS. In 2021, river cross-section surveys and pebble counts were conducted within the footprint of the diversion headpond and in the Peace River downstream of the Project to collect additional baseline data on riverbed elevations and substrate conditions in the Peace River after river diversion, which occurred on 3 October 2020.

Data from the 2021 survey represents conditions in the study area soon after river diversion. These data will be compared to data collected during future study years (i.e., during operation of the Project) to test the program's hypotheses. Not all of Mon-3's established transects (Golder 2015) were surveyed in 2021 as some transect locations were inaccessible due to nearby construction activities or were situated between the Peace River debris boom and the Project. Grain size data were collected in 2015, 2019 and 2021. Field crews attempted to sample the same locations during each study year; however, higher water levels in 2021 relative to previous surveys limited access to some locations. Further, in 2021, constructions activities near the Project prevented access to some of the locations that were sampled in 2019.

Where possible, the relative change in riverbed elevation at each transect was assessed to determine if the channel had aggraded, degraded, or remained unchanged over the six-year study period (2015 to 2021). An increase in riverbed elevation indicates aggradation due to the accumulation of substrate and sediment. A decrease in riverbed elevation indicates degradation and a loss of substrate and sediment. Alternatively, little or no change in riverbed elevation indicated static conditions where gain and loss were approximately equal, and that any mobilized bedload was in transit through the site.

4.1 Diversion Headpond

H_1 of Mon-3 states that diversion headpond construction will not affect channel morphology or bed sediment composition within the extent of the headpond. River diversion occurred on 3 October 2020, after which, the diversion headpond started forming and will operate until reservoir filling, which is scheduled to begin in 2023. Data collected in 2021 represents the first data collected after the start of the river diversion. The bathymetry assessments completed between 2015 and 2021 for the reach of the Peace River between the Halfway River confluence and the Moberly River confluence, which includes a large portion of the diversion headpond footprint, show that the changes in riverbed elevations were relatively small:

- Before river diversion, between 2015 and 2019, a mixture of aggrading and static channels were observed. The majority of the aggrading occurred in the upstream-most 5 km of the diversion headpond (i.e., Transects #US12 to #US09). This was attributed to upstream alluvial deposits from the Halfway River, the largest contributor of sediment into the Peace River downstream of PCN (BC Hydro 2012; Golder 2020a). Downstream of Transect #US09 the riverbed elevations were mostly static.

- After river diversion, between 2019 and 2021, a mixture of degrading and static channels were observed. The majority of the degrading occurred in the upstream-most 5 km of the diversion headpond (i.e., Transects #US12 to #US08). The channel degradation however was at similar elevations as the 2015 surveys. Further downstream (i.e., Transects #US08 to #US06) the riverbed elevations were identified as mostly static. It is likely that the sediments from the accretion that occurred in 2019 have travelled downstream of the diversion headpond. No surveys were completed from Transect #US05 to Transect #US01 because of the Peace River debris boom located between Transect #US06 and #US05.

The D50 and D90 values calculated from 2021 pebble count data were similar to historic D50 and D90 data recorded at locations between the Halfway River confluence and the Moberly River confluence where the surveys overlapped (Church 2015). This was interpreted as an indication that no measurable change was observed in the 2021 surveys (after river diversion) when compared to the 2019 surveys (before river diversion).

Overall, the observed differences between the 2019 and 2021 surveys were expected for this reach of the Peace River and were within the expected natural variability of the river. Also, the changes observed are an indicator of fluvial geomorphology processes happening in the tributaries upstream of the diversion headpond and downstream of Peace Canyon Dam. These can be considered part of the natural variability of the Peace River channel when compared with historical baseline surveys (BC Hydro 2012).

4.2 Peace River Downstream of the Project

H_2 of Mon-3 states that the construction and operation of the Project will not affect channel morphology, bed surface grain size composition, or wetted area in the Peace River between the Project and the Many Islands area in Alberta. Data collected in 2021 represents the first data collected after the onset of river diversion.
The bathymetry assessments completed between 2015 and 2021 for the Peace River downstream of the Project show that the natural changes in riverbed elevations were relatively small.

The D50 and D90 values calculated from 2019 pebble count data were similar to historic D50 and D90 values recorded at locations between the Moberly River and the BC-Alberta border where the two surveys overlapped (Church 2015). This was interpreted as an indication that no measurable change was observed in the 2021 surveys (after river diversion) when compared to the 2019 surveys (before river diversion).

4.2.1 In-Stream Works Area

Transects #DS01 to #DS08 are situated immediately downstream of the Project and encompass the footprint of downstream in-stream works associated with the Project. In-stream works completed between 2015 and 2021 resulted in changes in the channel profile at most transect locations. These changes are summarized below:

- With the exception of the two most downstream transects (i.e., Transect #DS07a and #DS08), the channel profiles at all transects within the downstream in-stream works area were influenced by the construction of River Road along the left bank. Construction of River Road narrowed the active channel and moved the bank approximately 20 m south relative to years prior to the road's construction.

- Substantial changes to the channel profiles in 2021 were noted mid-channel along Transect #DS03. These changes are related to mid-stream main channel bar excavation works associated with the Project (BC Hydro 2015a, 2015c).
- River cross-section surveys conducted along Transect #DS01 and #DS04 between 2019 and 2021 noted a channel widening of approximately 30 m along the thalweg alignment. This widening is associated with the mid-stream main channel bar excavation near the Transect #DS03.
- At Transect #DS06b the channel profile has undergone substantial change since 2019, with the riverbed elevation increasing by approximately 2 m. Reasons for this aggradation are not known but could be related to upstream construction activities, particularly the channel bar excavation approximately 700 m upstream. Similar channel aggradations but at a much lower scale (up to 0.7 m) were observed at the next downstream transects: #DS07, #DS07b, and #DS07a.
- Within the in-stream works area, significant changes were not observed downstream of Transect #DS07a.

The observed changes between the 2019 and 2021 surveys were as expected for this part of the Peace River.

4.2.2 In-Stream Works Area to Pine River Confluence

At Transects #DS09 to #DS19, the river cross-section surveys conducted in 2021 were similar to the 2015 and 2019 surveys, with the exception of Transect #DS19, which is located at the Pine River's confluence with the Peace River. At this location, the Pine River channel migrated laterally towards its right bank and downstream (within the Peace River valley), for approximately 30 m when compared to the 2019 surveys, and for approximately 150 m when compared to the 2019 surveys. The lateral migration resulted in the Transect #DS19 alignment being crossed by the active channel of the Pine River in 2021, which is visible in the cross-section profile for this transect.

The observed changes between the 2019 and 2021 surveys were as expected for this area, and they are within the natural variability of the Peace River channel when compared with historical baseline surveys (BC Hydro 2012).

4.2.3 Pine River Confluence to Many Islands

Historical bathymetry surveys in the Peace River between the Pine and Beatton River confluences found alternating sections of aggrading and degrading habitat; downstream of the Beatton River confluence, the channel gradient decreases and aggrading depositional habitats are more common (Church 2015). Data comparison between the 2019 and 2021 survey at Transects #DS19 to #DS37 indicate the following:

- The Peace River active channel was relatively stable between the Pine and Clear rivers (Transects #DS20 to #DS32), with only small and local riverbed elevation changes observed.

- At Transect #DS34, channel degradation was observed along the thalweg alignment of approximately 0.6 m, and sediment deposition was observed along the right bank that increased the riverbed elevations by approximately 2 m, for a length of approximately 20 m. This was attributed to a small unnamed tributary confluence located immediately upstream of the transect alignment which has formed an alluvial fan at its junction with the Peace River, which would favour sediment deposition downstream.
- At Transects #DS35 to #DS37, the 2021 survey shows minimum changes in riverbed elevations, with small alternating sections of channel aggradation and degradation.

The observed changes between the 2019 and 2021 surveys were as expected for this area, and they are within the natural variability of the Peace River channel when compared with historical baseline surveys (BC Hydro 2012).

4.3 Fish Habitat

The cross-section surveys and grain size measurements conducted in 2021 provide further details regarding changes to overall fish habitat and fish habitat quality in the Peace River upstream and downstream of the Project.

Since implementation of Mon-3 in 2015, overall changes to fish habitat due to changes in physical habitat have been minimal within the diversion headpond. The general aggradation between 2015 and 2019, and the general degradation between 2019 and 2021 identified within the upstream-most 5 km of the diversion headpond, are considered part of the natural variability of the Peace River channel and are therefore unlikely to have a noticeable influence on fish use within this area. The most likely change in fish habitat within the diversion headpond is expected to occur immediately upstream of the Project. The Moberly River is a primary source of sediments for the Peace River and it flows into the Peace River along the right downstream bank immediately upstream of the Project's upstream cofferdam. The formation of the diversion headpond will decrease water velocities in this area, which may result in some build up of sediments in this area. Transects #US01 to #US05 (near the mouth of the Moberly River) could not be sampled in 2021 because they were located downstream of the Peace River debris boom and were not safely accessible by boat. The extent of change in this area of the diversion headpond is unknown.

The most apparent changes to fish habitat between 2015 and 2021 occurred within the in-stream works area. Between 2015 and 2019, fish habitat was reduced along the left bank within this area by the construction of the River Road; however, the habitat loss along the left bank due to the construction of the River Road coincided with the construction of habitat offset areas (i.e., rock spurs along River Road and channel modifications at Upper Site 109L; BC Hydro 2015c) in 2016 (Golder 2018). These areas were constructed with the intent to increase the quantity and quality of available, permanently wetted habitat to support primary and secondary production for fish and provide rearing, feeding, overwintering, and potential spawning habitat for fish (BC Hydro 2015c). In addition, the offset areas were constructed to reduce fish stranding risk and increase the complexity and variability of fish habitat to support a variety of life stages for local fish populations. Effectiveness monitoring of the habitat offsetting areas in 2017 (Golder 2018), 2018 (Golder 2019), and 2019 (Golder 2020b) identified that they provide a variety of suitable habitats for a variety of fish species and life stages.

Between 2019 and 2021 changes to fish habitat were identified within the in-stream works area. At the upstream extent of the in-stream works area (i.e., Transect #DS01 to #DS03), dredging activities in early 2021 resulted in an overall deeper channel, and a widening of the thalweg. The change was most apparent at Transect #DS03, where two mid-channel gravel bars were excavated, resulting in a decrease in mean riverbed surface elevation of over 1.0 m between 2019 and 2021 (Figure 4). The riverbed elevation change at this location results in less shallow water habitat with the potential to strand fish during period of low water, and an increase in deep water habitat, which may provide refuge and/or overwintering habitat for large-bodied fish. This change is likely to have an overall positive impact on fish due to an increase in total wetted habitat at this location.

Between 2019 and 2021, mid-channel sediment deposition occurred at Transect #DS06b, resulting in active channel riverbed elevations increasing approximately 2 m (Appendix A; Figure A-4). Although less substantial, increases in riverbed elevations were also observed at Transect #DS07, #DS07b, and #DS07a. These increases in riverbed surface elevation may have been caused by the mobilization of sediments from the upstream excavation area (i.e., near Transect #DS03). As a result of the riverbed elevation increase, when the river level in the Peace River reaches a surface elevation of approximately 409 m, the river becomes channelized into a left and right channel at Transect #DS06a, thereby reducing overall fish habitat at this location and increasing fish stranding potential at the newly formed mid-channel gravel bar.

The minimal changes in cross-section surveys and grain size measurements between 2015 and 2021 in the remainder of the Mon-3 study areas downstream of the in-stream works area suggests that there has been little overall change to fish habitat over this time period at these locations.

4.4 Summary

Major tributaries are the primary sources of sediment to the mainstem Peace River, with the largest contribution coming from the Moberly River (37,000 tonnes per year), followed by the Kiskatinaw River (14,000 tonnes per year), Pine River (8,600 tonnes per year), and Halfway River (6,900 tonnes per year; Church 2015).
The development of the Project is expected to alter the sediment transport and substrate composition in the Peace River downstream of the Project; however, the extent that these alterations will influence the quality or quantity of downstream aquatic habitat remains unclear. Data collected in 2015, 2017, 2018, 2019, and 2021 suggest little change in the physical habitat present in the Peace River with the exception of areas directly affected by the construction of the Project. As a result, overall changes observed in physical habitat over this period are not likely to have a noticeable influence on the Peace River fish community. During future study years, these data will serve as a baseline dataset for evaluating Mon-3's hypotheses and categorizing the potential effects that the construction and operation of the Project have on physical habitat in the Peace River.

5.0 CLOSURE

We trust that this report provides the information required. If there are any questions or require further detail, please contact the undersigned.

Golder Associates Ltd.

Kathryn DeRego Semiao, PhD
Geomorphology Specialist

Phil Osborne, PhD, PGeo
Principal, Senior Geomorphologist

Dan Ciobotaru, PGeo
Hydrologist

Dustin Ford, RPBio
Associate, Project Manager

DC/DF/cmc

https://golderassociates.sharepoint.com/sites/107993/project files/6 deliverables/issued to the client_for wp/19121767-021-r-rev0/19121767-021-r-rev0-mon-3 2021 peace river physical habitat monitoring 11jul_22.docx

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APPENDIX A

Maps and UTM Coordinates

Table A1: UTM Coordinates of transects located in the Peace River and surveyed as part of BC Hydro's Peace River Physical Habitat Monitoring Program, 2021. Transects are sorted from upstream to downstream with Transects #US13 to #DS30 situated in UTM Zone 10N and Transects #DS31 to #DS37 situated in UTM Zone 11N.

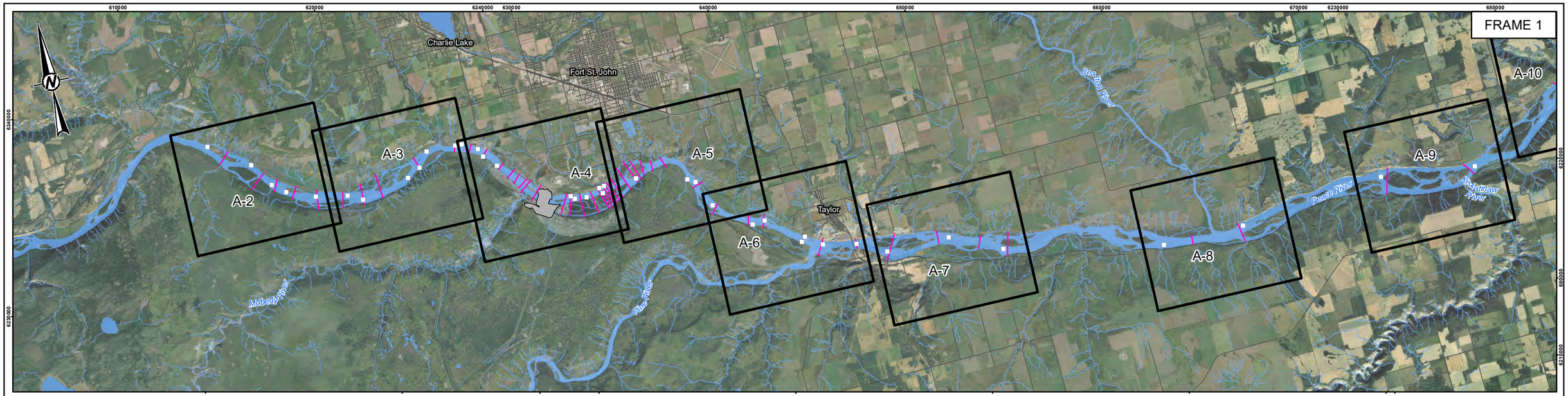
Transect Number	Left Downstream Bank		Right Downstream Bank	
	Easting	Northing	Easting	Northing
US13a	615519	6234376	614713	6233647
US13	613952	6235887	613405	6235327
US12	616127	6233874	615838	6233291
US11	617001	6233312	616652	6232717
US11a	617994	6232900	617856	6231861
US10	619308	6232508	619141	6231654
US9	620268	6232665	620260	6231565
US9a	621160	6233019	621279	6231689
US8	623284	6233361	623539	6232731
US7	625547	6233588	625449	6233190
US7a	626401	6233404	626164	6232976
US6	627148	6232966	626836	6232628
US6a	627809	6232045	627489	6231793
DS1	630670	6229758	630134	6228786
DS3	630856	6229716	630577	6228621
DS4	631314	6229624	631318	6228394
DS5	631894	6229580	632070	6228423
DS6a	632275	6229668	632673	6228536
DS6	632409	6229718	632839	6228587
DS6b	632544	6229773	632995	6228661
DS7	632669	6229861	633150	6228740
DS7b	632829	6229854	633279	6228828
DS7a	633063	6230053	633501	6228947
DS8	633504	6230441	633974	6229272
DS9	633901	6230725	634430	6229527
DS10	634272	6230691	634615	6229678
DS11	634801	6230531	634809	6229801

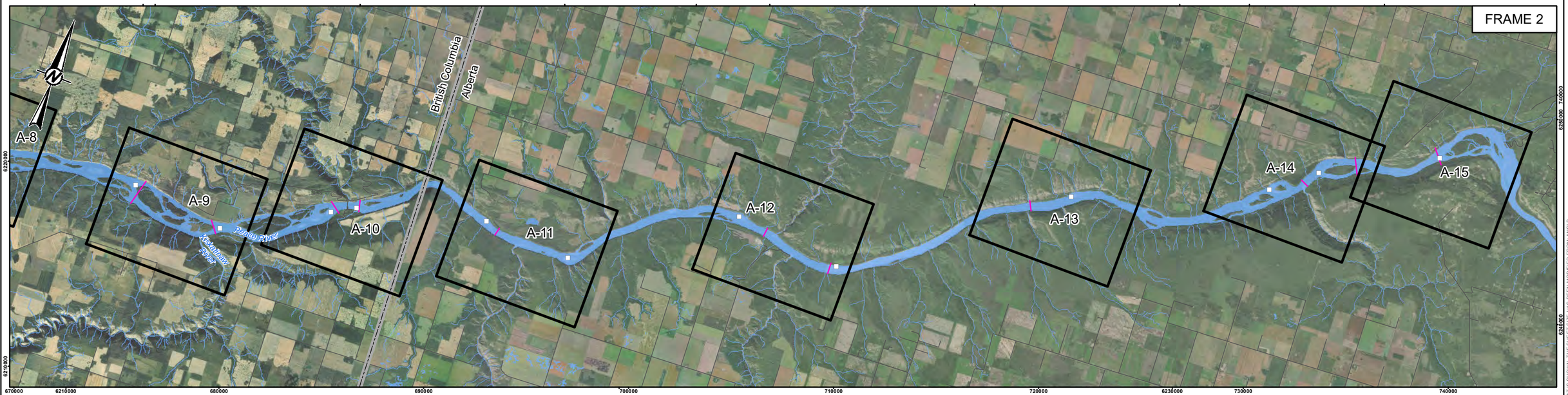
Transect Number	Left Downstream Bank		Right Downstream Bank	
	Easting	Northing	Easting	Northing
DS12	635315	6230462	635323	6229902
DS13	635823	6230523	636045	6229944
DS14	637680	6228779	637153	6228588
DS15	638221	6227477	637864	6227045
DS16	639668	6226526	639517	6226049
DS17	640442	6226405	640278	6225735
DS18	642362	6224867	642035	6224572
DS19	643284	6224430	642963	6223388
DS20	644806	6224091	644808	6223601
DS21	646872	6223891	646172	6222576
DS22	649155	6223494	649069	6222859
DS23	651210	6222776	650967	6222129
DS24	652640	6222601	652364	6221443
DS25	661944	6220369	661935	6219859
DS26	664448	6220395	664621	6219400
DS27	672708	6221474	672357	6220150
DS28	676599	6220779	677055	6220184
DS29	682132	6223850	682703	6223427
DS30	683510	6224430	683643	6223855
DS31	317999	6225195	317864	6224796
DS32	331457	6228902	331353	6228425
DS33	335112	6228020	335104	6227449
DS34	344245	6233889	344452	6233386
DS35	357593	6238661	357983	6238442
DS36	359971	6240553	360361	6239576
DS37	363863	6242126	364389	6241350

Table A2: UTM Coordinates of grain size measurement locations on the Peace River and surveyed as part of BC Hydro's Peace River Physical Habitat Monitoring Program, 2021. Sites are sorted from upstream to downstream with Sites #US-13 MC to #DS-30 RB situated in UTM Zone 10N and Sites #DS-31 MC-1 to #DS-37 MC situated in UTM Zone 11N.

Site Identifier	2021 Survey Date	UTM		Survey Year			Survey 2021 Notes
		Easting	Northing	2015	2019	2021	
US-13 MC	22-Sep-2021	612950	6236335	No	No	Yes	
US-12a MC		614967	6234891	No	No	No	Site submerged in 2021; not assessed.
US-12 MC	22-Sep-2021	615742	6233749	Yes	Yes	Yes	
US-11 MC	22-Sep-2021	616406	6233138	Yes	Yes	Yes	
US-10 RB	22-Sep-2021	617828	6232536	Yes	Yes	Yes	
US-10 MC	22-Sep-2021	619471	6232255	Yes	Yes	Yes	
US-9 MC	22-Sep-2021	620089	6231937	Yes	Yes	Yes	
US-8a MC	22-Sep-2021	622794	6232410	No	No	Yes	
US-8 RB	22-Sep-2021	623493	6232798	Yes	Yes	Yes	
US-8b MC	22-Sep-2021	624098	6233588	Yes	Yes	Yes	
US-7 LB		625560	6233531	Yes	No	No	Site submerged in 2021; not assessed.
US-7 MC		625902	6233497	Yes	No	No	Site submerged in 2021; not assessed.
US-6 MC		626675	6233060	Yes	No	No	Site submerged in 2021; not assessed.
US-6 RB		626861	6232628	Yes	Yes	No	Site submerged in 2021; not assessed.
US-5 RB-2		627448	6231992	Yes	No	No	Site downstream of the debris boom; not visited.
US-5 RB-1		627949	6231359	Yes	No	No	Site downstream of the debris boom; not visited.
US-4 RB		628164	6230987	Yes	Yes	No	Site downstream of the debris boom; not visited.
US-3 MC		628598	6230850	Yes	No	No	Site downstream of the debris boom; not visited.
US-2 RB		628641	6230430	Yes	Yes	No	Site downstream of the debris boom; not visited.
US-1 RB		628933	6230041	Yes	Yes	No	Site downstream of the debris boom; not visited.
DS-1 RB		630266	6229609	Yes	No	No	Site with construction works; not visited.
DS-1 MC		630377	6229640	Yes	No	No	Site dredged; not assessed in 2021.
DS-2 MC		630695	6229502	Yes	Yes	No	Site dredged; not assessed in 2021.
DS-3 MC		631039	6229416	Yes	Yes	No	Site dredged; not assessed in 2021.
DS-4 RB		631647	6229342	Yes	No	No	Site submerged in 2021; not assessed.
DS-5 LB		632406	6229676	Yes	No	No	Site submerged in 2021; not assessed.
DS-5 RB	22-Sep-2021	632514	6229368	Yes	No	Yes	

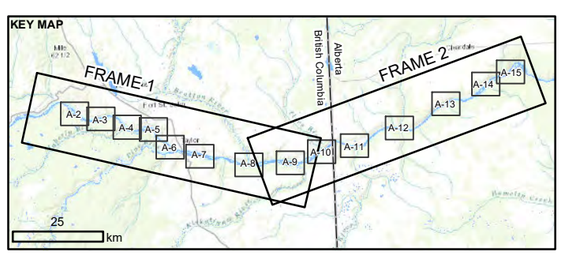
Site Identifier	2021 Survey Date	UTM		Survey Year			Survey 2021 Notes
		Easting	Northing	2015	2019	2021	
DS-6 LB		632644	6229700	Yes	No	No	Site submerged in 2021; not assessed.
DS-7 RB		633193	6229534	Yes	No	No	Site with construction works; not visited.
DS-9 MC	22-Sep-2021	634188	6229962	Yes	Yes	Yes	
DS-14 RB	21-Sep-2021	636960	6229322	Yes	Yes	Yes	
DS-14 MC	21-Sep-2021	637361	6228850	Yes	Yes	Yes	
DS-15 RB	21-Sep-2021	637884	6227501	Yes	Yes	Yes	
DS-16 RB		639760	6226007	Yes	No	No	Site submerged in 2021; not assessed.
DS-17 MC	21-Sep-2021	640359	6226073	Yes	Yes	Yes	
DS-18 RB	21-Sep-2021	642038	6224570	Yes	Yes	Yes	
DS-18 MC		642273	6224794	Yes	No	No	Site submerged in 2021; not assessed.
DS-19 RB	21-Sep-2021	643107	6224188	No	Yes	Yes	
DS-20 MC	21-Sep-2021	644797	6223871	No	Yes	Yes	
DS-21 MC	21-Sep-2021	646298	6223120	No	Yes	Yes	
DS-22 RB	21-Sep-2021	649002	6222888	No	Yes	Yes	
DS-24 MC	21-Sep-2021	652334	6221740	No	Yes	Yes	
DS-25 MC	21-Sep-2021	661938	6220289	No	Yes	Yes	
DS-26 MC	23-Sep-2021	664359	6219807	No	Yes	Yes	
DS-27 MC	23-Sep-2021	672348	6221253	No	Yes	Yes	
DS-28 MC	23-Sep-2021	677081	6220458	No	Yes	Yes	
DS-29 MC	23-Sep-2021	682180	6223269	No	Yes	Yes	
DS-30 RB	23-Sep-2021	683544	6223981	No	Yes	Yes	
DS-31 MC	23-Sep-2021	317241	6225358	No	Yes	Yes	
DS-31a MC	23-Sep-2021	321830	6224649	No	Yes	Yes	
DS-32 MC	23-Sep-2021	329883	6229073	No	Yes	Yes	
DS-33 LB	23-Sep-2021	335436	6227913	No	Yes	Yes	
DS-34 LB	24-Sep-2021	346266	6234648	No	Yes	Yes	
DS-35 MC	24-Sep-2021	356117	6237741	No	Yes	Yes	
DS-35 RB	24-Sep-2021	358371	6239260	No	Yes	Yes	
DS-37 MC	24-Sep-2021	364237	6241655	No	Yes	Yes	





LEGEND

- GRAIN SIZE PLOT LOCATION
- RIVER CROSS-SECTION LOCATION
- PROVINCIAL BORDER
- ROAD
- WATERCOURSE
- OUTLINE OF SITE C PERMANENT COMPONENTS
- FIGURE FRAME
- WATERBODY



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1. IMAGERY AND BASEMAP: SOURCE: ESRI, MAXAR, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
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DATUM/PROJECTION: NAD83/UTM ZONE 10N

CLIENT
BC HYDRO

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-12-16
DESIGNED	KDR
PREPARED	JP
REVIEWED	DF
APPROVED	DC

PROJECT
PEACE RIVER PHYSICAL HABITAT MONITORING PROGRAM – MON-3

TITLE
OVERVIEW OF THE PEACE RIVER PHYSICAL HABITAT MONITORING PROGRAM STUDY AREA, 2021

PROJECT NO.	PHASE	REV.	FIGURE
19121767	10/10.3	0	A-1

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

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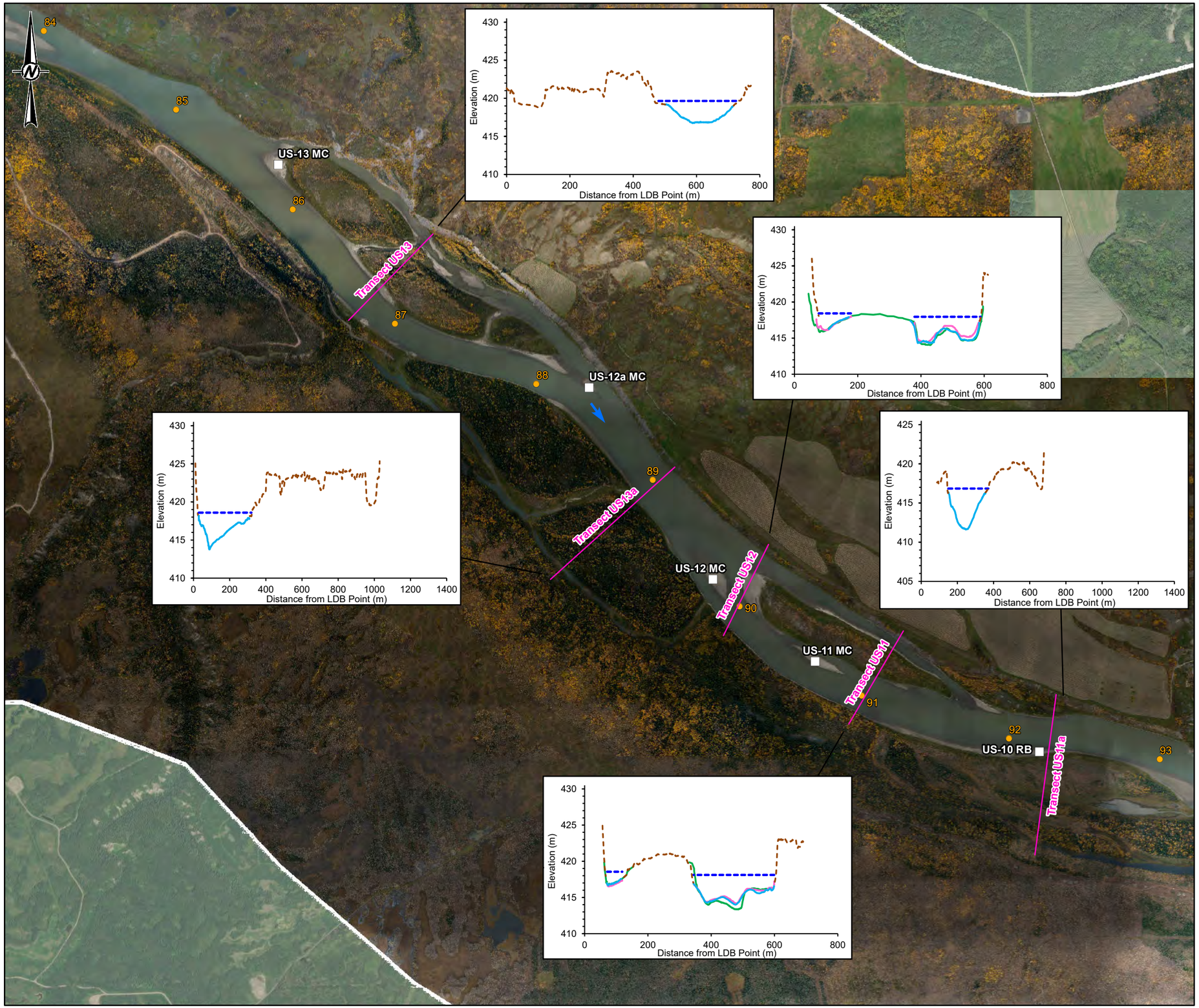
PATH: Y:\Journeyky\CAD-GIS\Client\BC_Hydro\Peace_River_GMS\99_PROJECTS\19121767_PeaceRiver_GMS\02_PRODUCTION\MXD\Report\2021_Overall_Report\19121767_FIG_A-1_PHYSICAL_HABITAT_SAMPLE_LOCATION_OVERVIEW_2021.mxd PRINTED ON: 2021-12-16 AT: 9:29:50 AM

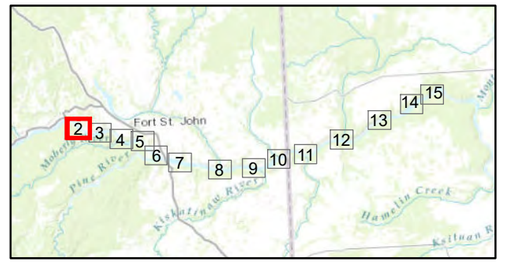


LEGEND

- GRAIN SIZE PLOT LOCATION
- RIVER KILOMETRE AS MEASURED DOWNSTREAM FROM WAC BENNETT DAM
- RIVER CROSS-SECTION LOCATION
- ROAD
- OUTLINE OF SITE C PERMANENT COMPONENTS
- UPPER SITE 109L
- FLOW DIRECTION

INSET PLOT LEGEND

- 2015 RIVERBED ELEVATION
- 2019 RIVERBED ELEVATION
- 2021 RIVERBED ELEVATION
- 2019 LIDAR SURFACE ELEVATION
- 2021 WATER SURFACE ELEVATION



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NOTES

1. LDB: LEFT DOWNSTREAM BANK

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CLIENT
BC HYDRO

PROJECT
PEACE RIVER PHYSICAL HABITAT MONITORING PROGRAM – MON-3

TITLE
PEACE RIVER PHYSICAL HABITAT MONITORING PROGRAM STUDY AREA, 2021

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-02-10
DESIGNED	DC
PREPARED	JP
REVIEWED	
APPROVED	

PROJECT NO.	PHASE	REV.	FIGURE
19121767	10/10.3	A	**A-2**

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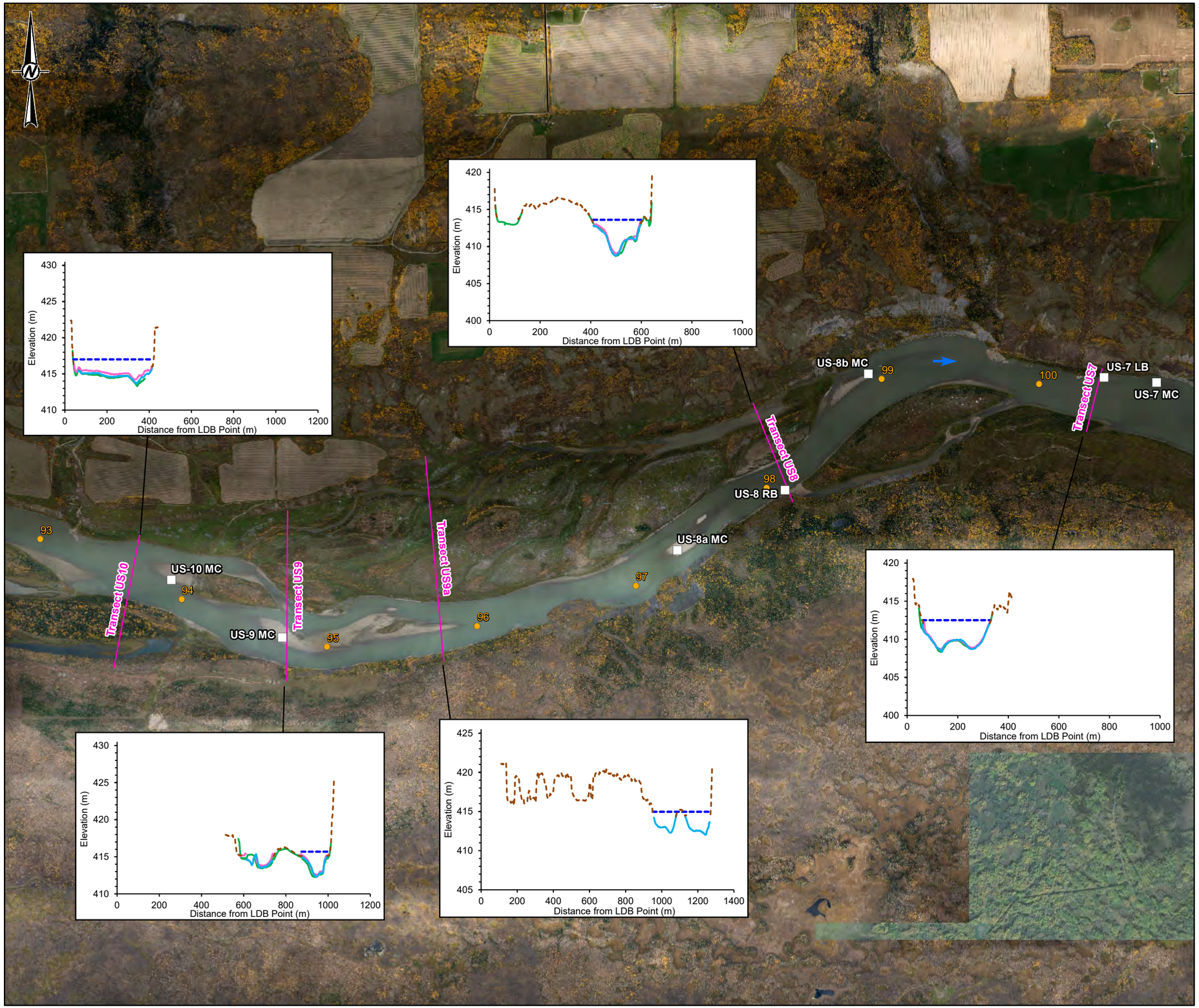
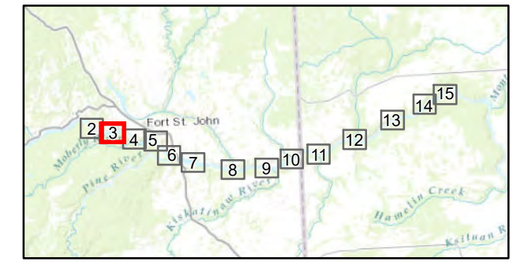


LEGEND

- GRAIN SIZE PLOT LOCATION
- RIVER KILOMETRE AS MEASURED DOWNSTREAM FROM WAC BENNETT DAM
- RIVER CROSS-SECTION LOCATION
- ROAD
- OUTLINE OF SITE C PERMANENT COMPONENTS
- UPPER SITE 109L
- FLOW DIRECTION

INSET PLOT LEGEND

- 2015 RIVERBED ELEVATION
- 2019 RIVERBED ELEVATION
- 2021 RIVERBED ELEVATION
- 2019 LIDAR SURFACE ELEVATION
- 2021 WATER SURFACE ELEVATION



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NOTES

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CLIENT
BC HYDRO

PROJECT
PEACE RIVER PHYSICAL HABITAT MONITORING PROGRAM – MON-3

TITLE
PEACE RIVER PHYSICAL HABITAT MONITORING PROGRAM STUDY AREA, 2021

CONSULTANT
GOLDER

YYYY-MM-DD	2022-02-10
DESIGNED	DC
PREPARED	JP
REVIEWED	DF
APPROVED	DC

PROJECT NO.	PHASE	REV.	FIGURE
19121767	10/10.3	0	**A-3**

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

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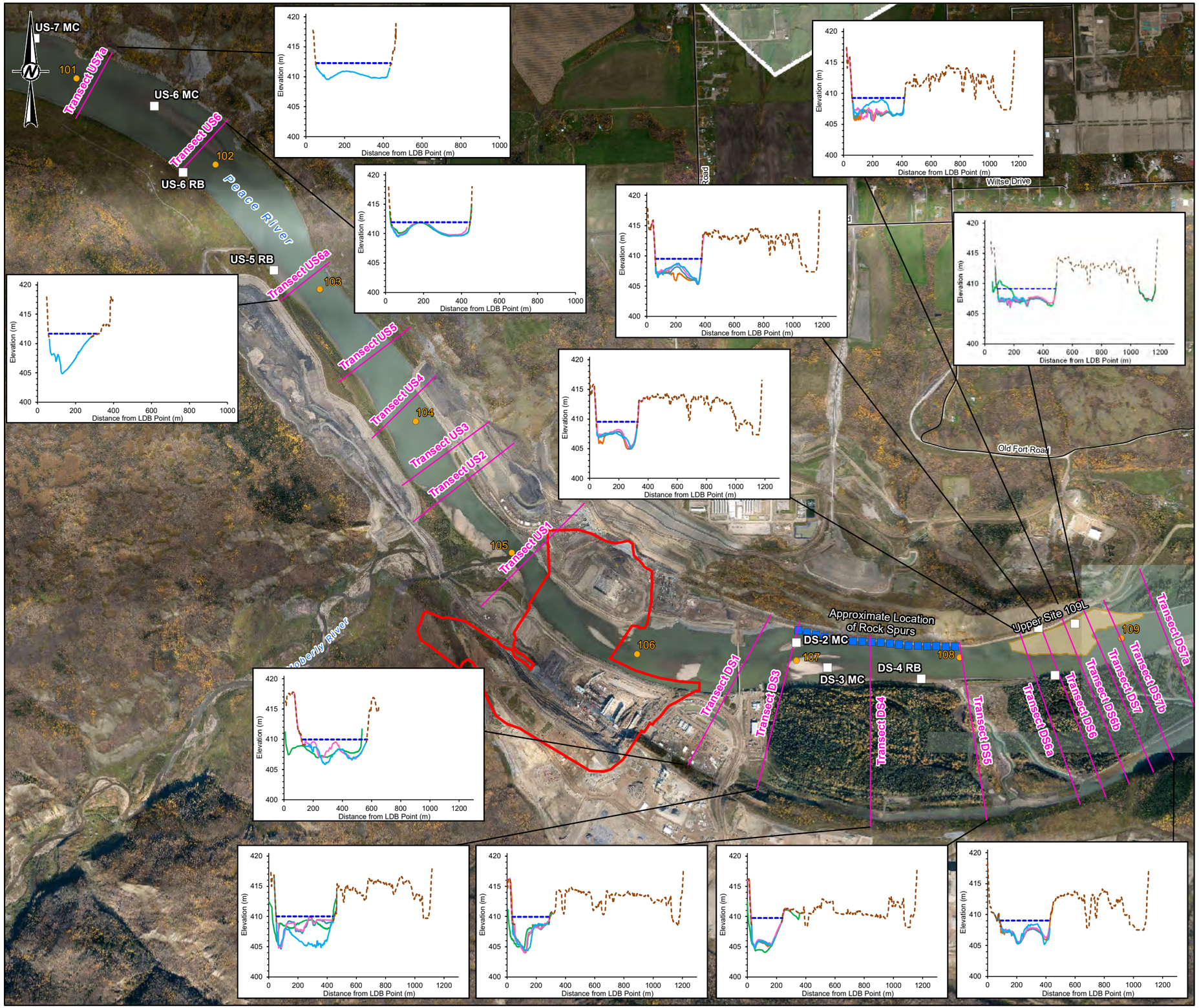
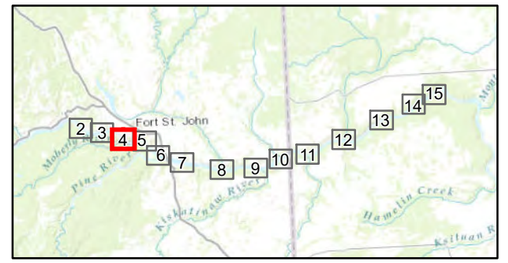


LEGEND

- GRAIN SIZE PLOT LOCATION
- RIVER KILOMETRE AS MEASURED DOWNSTREAM FROM WAC BENNETT DAM
- RIVER CROSS-SECTION LOCATION
- ROAD
- OUTLINE OF SITE C PERMANENT COMPONENTS
- UPPER SITE 109L
- FLOW DIRECTION

INSET PLOT LEGEND

- 2015 RIVERBED ELEVATION
- 2017 RIVERBED ELEVATION
- 2018 RIVERBED ELEVATION
- 2019 RIVERBED ELEVATION
- 2021 RIVERBED ELEVATION
- 2019 LIDAR SURFACE ELEVATION
- 2021 WATER SURFACE ELEVATION



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NOTES
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CLIENT
BC HYDRO

PROJECT
PEACE RIVER PHYSICAL HABITAT MONITORING PROGRAM – MON-3

TITLE
PEACE RIVER PHYSICAL HABITAT MONITORING PROGRAM STUDY AREA, 2021

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-02-10
DESIGNED	DC
PREPARED	JP
REVIEWED	DF
APPROVED	DC

PROJECT NO.	PHASE	REV.	FIGURE
19121767	10/10.3	0	**A-4**

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

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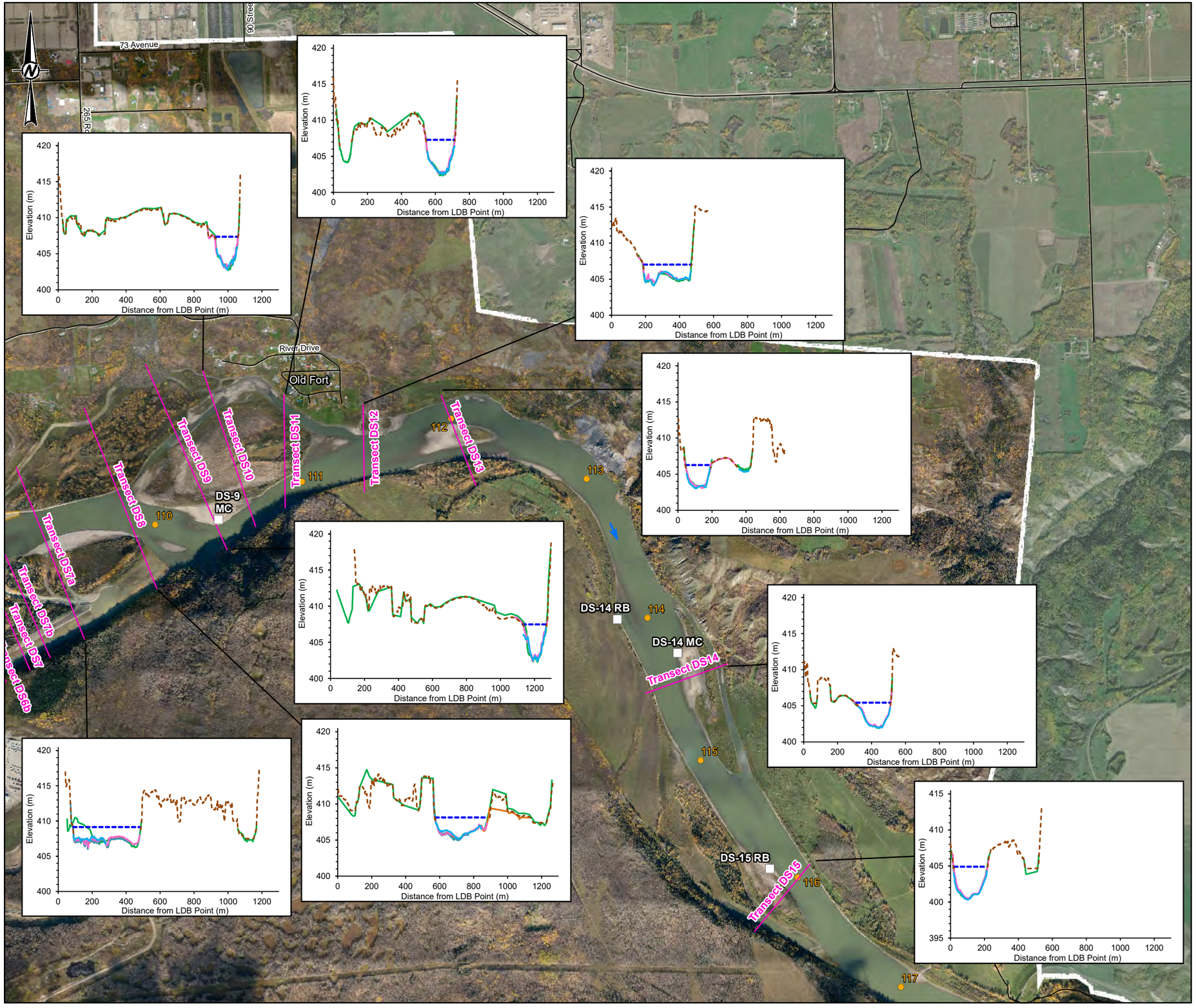
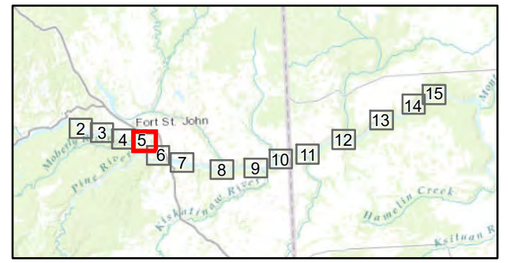


LEGEND

- GRAIN SIZE PLOT LOCATION
- RIVER KILOMETRE AS MEASURED DOWNSTREAM FROM WAC BENNETT DAM
- ROAD
- OUTLINE OF SITE C PERMANENT COMPONENTS
- UPPER SITE 109L
- FLOW DIRECTION

INSET PLOT LEGEND

- 2015 RIVERBED ELEVATION
- 2017 RIVERBED ELEVATION
- 2018 RIVERBED ELEVATION
- 2019 RIVERBED ELEVATION
- 2021 RIVERBED ELEVATION
- 2019 LIDAR SURFACE ELEVATION
- 2021 WATER SURFACE ELEVATION



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NOTES

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CLIENT
BC HYDRO

PROJECT
PEACE RIVER PHYSICAL HABITAT MONITORING PROGRAM – MON-3

TITLE
PEACE RIVER PHYSICAL HABITAT MONITORING PROGRAM STUDY AREA, 2021

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-02-10
DESIGNED	DC
PREPARED	JP
REVIEWED	DF
APPROVED	DC

PROJECT NO.	PHASE	REV.	FIGURE
19121767	10/10.3	0	**A-5**

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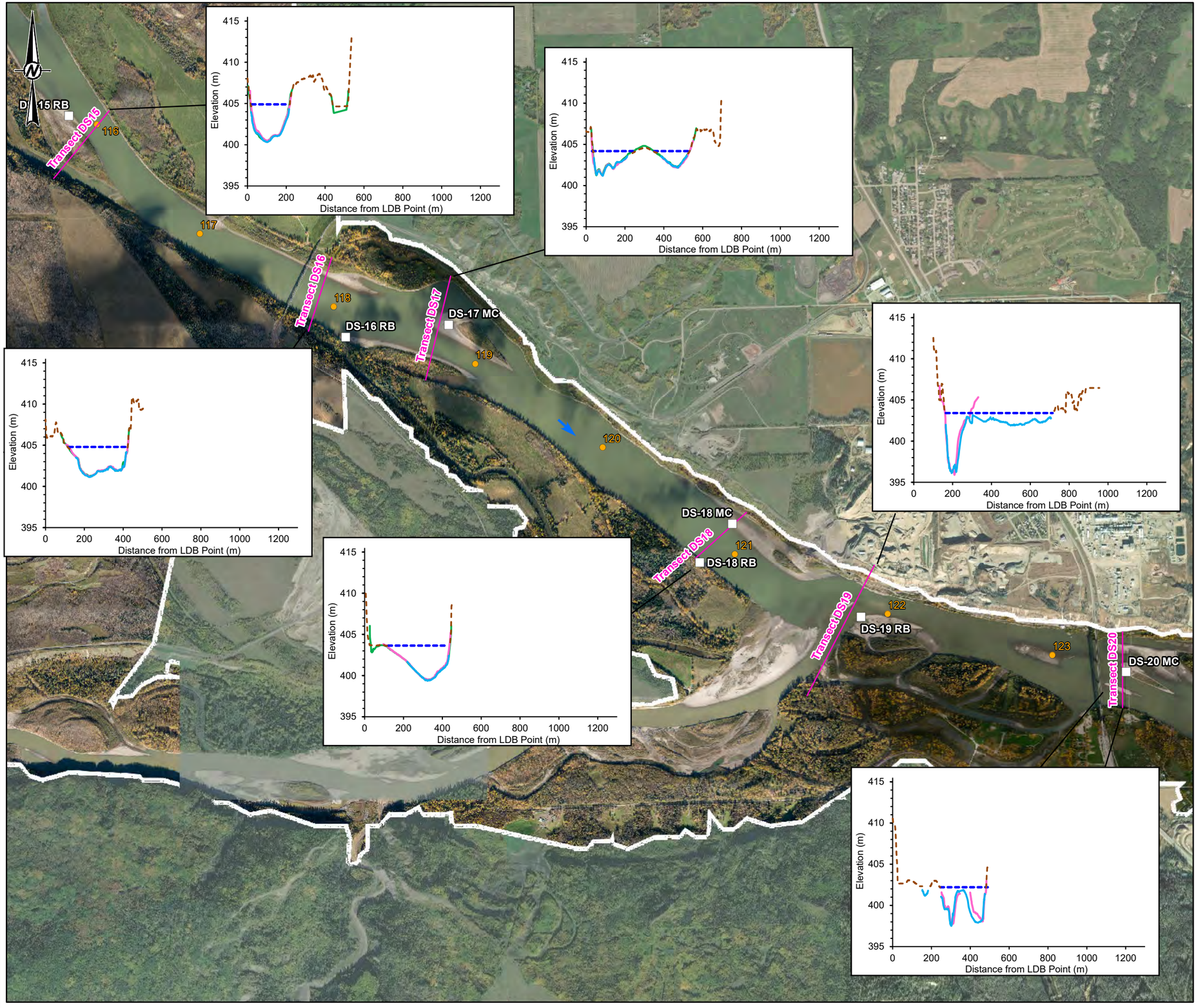
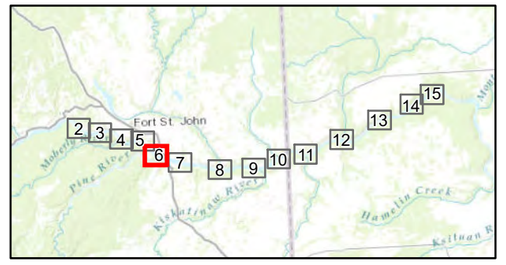


LEGEND

- GRAIN SIZE PLOT LOCATION
- RIVER KILOMETRE AS MEASURED DOWNSTREAM FROM WAC BENNETT DAM
- RIVER CROSS-SECTION LOCATION
- OUTLINE OF SITE C PERMANENT COMPONENTS
- UPPER SITE 109L
- FLOW DIRECTION

INSET PLOT LEGEND

- 2015 RIVERBED ELEVATION
- 2019 RIVERBED ELEVATION
- 2021 RIVERBED ELEVATION
- 2019 LIDAR SURFACE ELEVATION
- 2021 WATER SURFACE ELEVATION



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NOTES

1. LDB: LEFT DOWNSTREAM BANK

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CLIENT
BC HYDRO

PROJECT
PEACE RIVER PHYSICAL HABITAT MONITORING PROGRAM – MON-3

TITLE
PEACE RIVER PHYSICAL HABITAT MONITORING PROGRAM STUDY AREA, 2021

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-02-10
DESIGNED	DC
PREPARED	JP
REVIEWED	DF
APPROVED	DC

PROJECT NO.	PHASE	REV.	FIGURE
19121767	10/10.3	0	**A-6**

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

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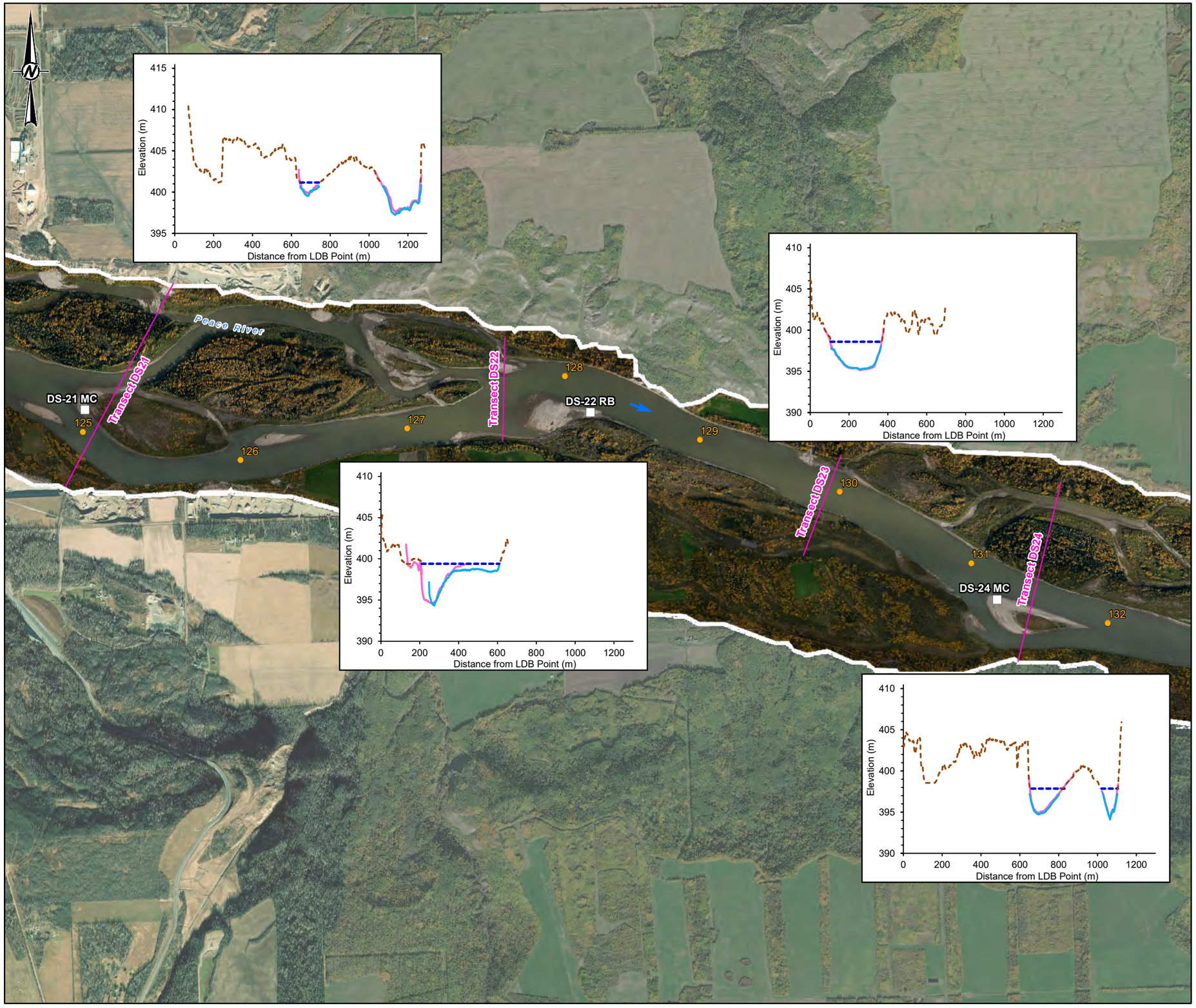
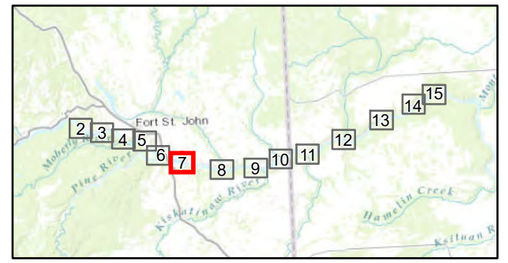


LEGEND

- GRAIN SIZE PLOT LOCATION
- RIVER KILOMETRE AS MEASURED DOWNSTREAM FROM WAC BENNETT DAM
- RIVER CROSS-SECTION LOCATION
- OUTLINE OF SITE C PERMANENT COMPONENTS
- UPPER SITE 109L
- FLOW DIRECTION

INSET PLOT LEGEND

- 2019 RIVERBED ELEVATION
- 2021 RIVERBED ELEVATION
- 2019 LIDAR SURFACE ELEVATION
- 2021 WATER SURFACE ELEVATION



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CLIENT
BC HYDRO

PROJECT
PEACE RIVER PHYSICAL HABITAT MONITORING PROGRAM – MON-3

TITLE
PEACE RIVER PHYSICAL HABITAT MONITORING PROGRAM STUDY AREA, 2021

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-02-10
DESIGNED	DC
PREPARED	JP
REVIEWED	DF
APPROVED	DC

PROJECT NO.	PHASE	REV.	FIGURE
19121767	10/10.3	0	**A-7**

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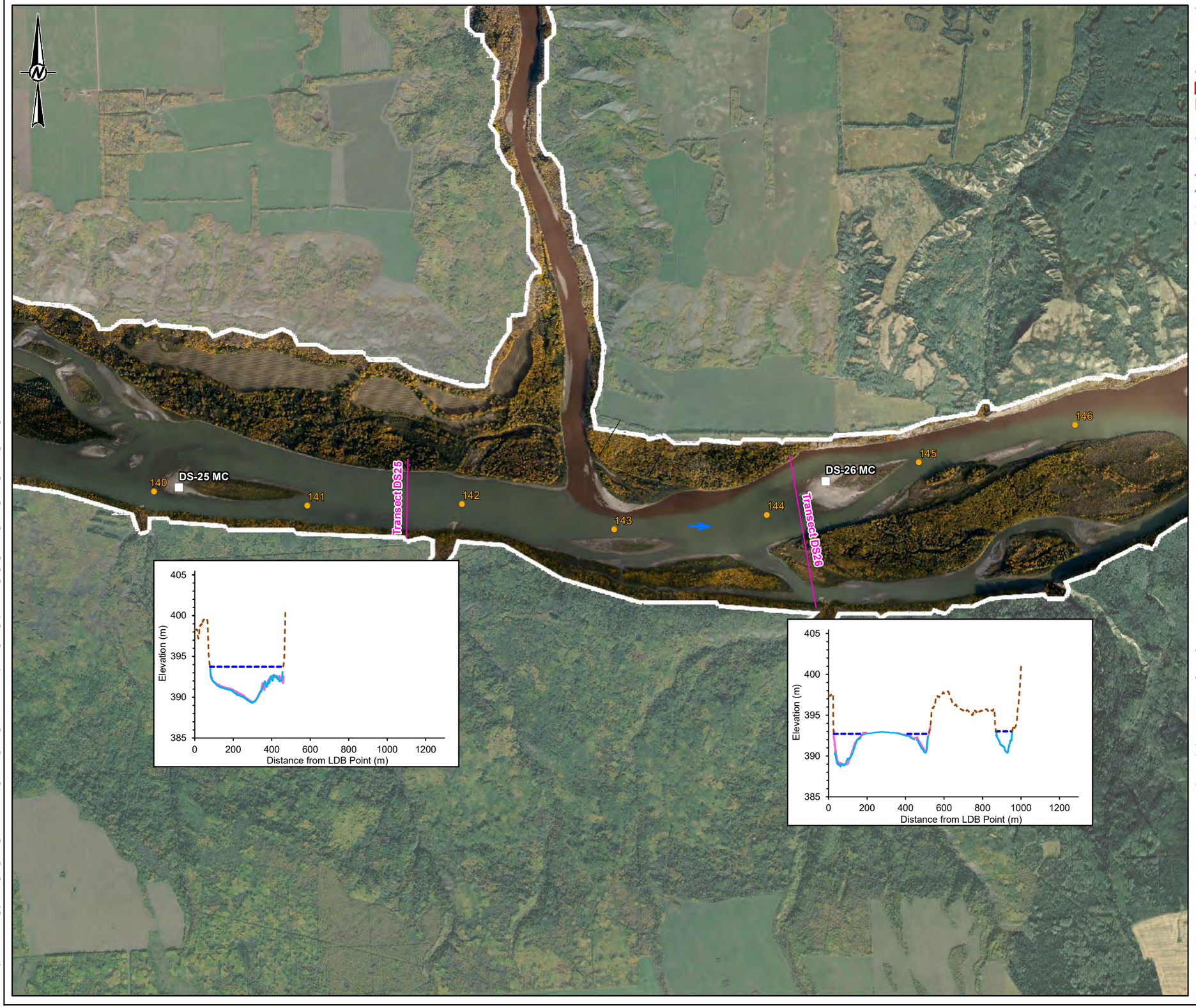
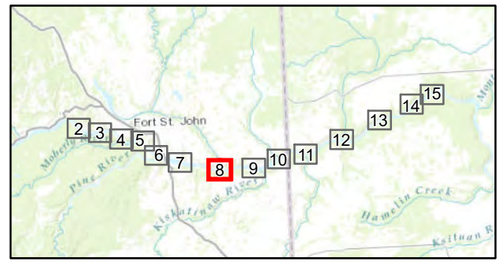


LEGEND

- GRAIN SIZE PLOT LOCATION
- RIVER KILOMETRE AS MEASURED DOWNSTREAM FROM WAC BENNETT DAM
- RIVER CROSS-SECTION LOCATION
- OUTLINE OF SITE C PERMANENT COMPONENTS
- UPPER SITE 109L
- FLOW DIRECTION

INSET PLOT LEGEND

- 2019 RIVERBED ELEVATION
- 2021 RIVERBED ELEVATION
- 2019 LIDAR SURFACE ELEVATION
- 2021 WATER SURFACE ELEVATION



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CLIENT
BC HYDRO

PROJECT
PEACE RIVER PHYSICAL HABITAT MONITORING PROGRAM – MON-3

TITLE
PEACE RIVER PHYSICAL HABITAT MONITORING PROGRAM STUDY AREA, 2021

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-02-10
DESIGNED	DC
PREPARED	JP
REVIEWED	DF
APPROVED	DC

PROJECT NO.	PHASE	REV.	FIGURE
19121767	10/10.3	0	**A-8**

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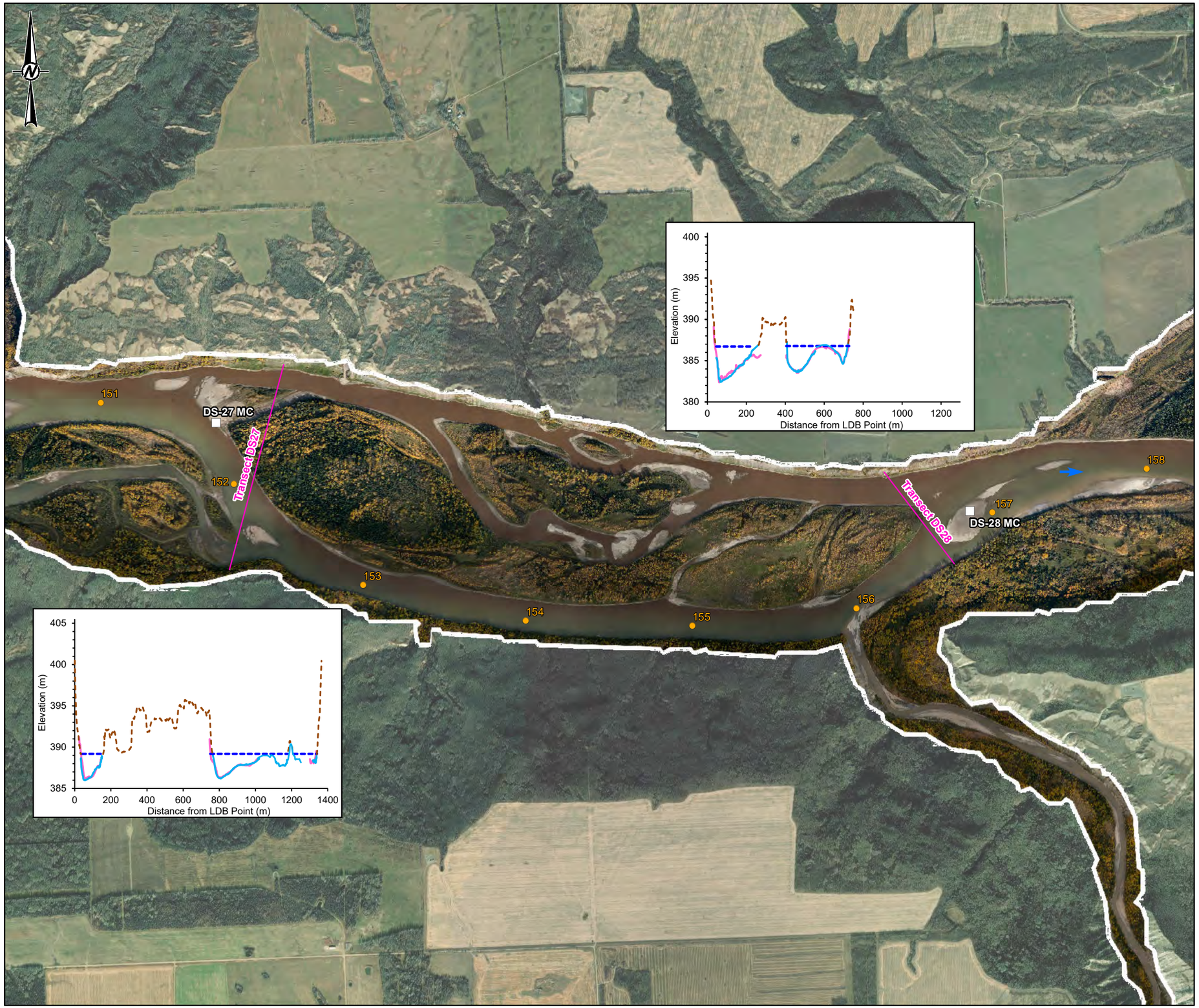
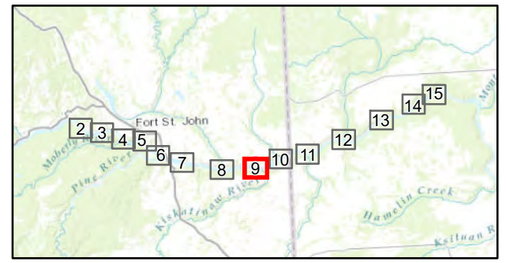


LEGEND

- GRAIN SIZE PLOT LOCATION
- RIVER KILOMETRE AS MEASURED DOWNSTREAM FROM WAC BENNETT DAM
- RIVER CROSS-SECTION LOCATION
- OUTLINE OF SITE C PERMANENT COMPONENTS
- UPPER SITE 109L
- FLOW DIRECTION

INSET PLOT LEGEND

- 2019 RIVERBED ELEVATION
- 2021 RIVERBED ELEVATION
- 2019 LIDAR SURFACE ELEVATION
- 2021 WATER SURFACE ELEVATION



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1:25,000 METRES

NOTES

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CLIENT
BC HYDRO

PROJECT
PEACE RIVER PHYSICAL HABITAT MONITORING PROGRAM – MON-3

TITLE
PEACE RIVER PHYSICAL HABITAT MONITORING PROGRAM STUDY AREA, 2021

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-02-10
DESIGNED	DC
PREPARED	JP
REVIEWED	DF
APPROVED	DC

PROJECT NO.	PHASE	REV.	FIGURE
19121767	10/10.3	0	A-9

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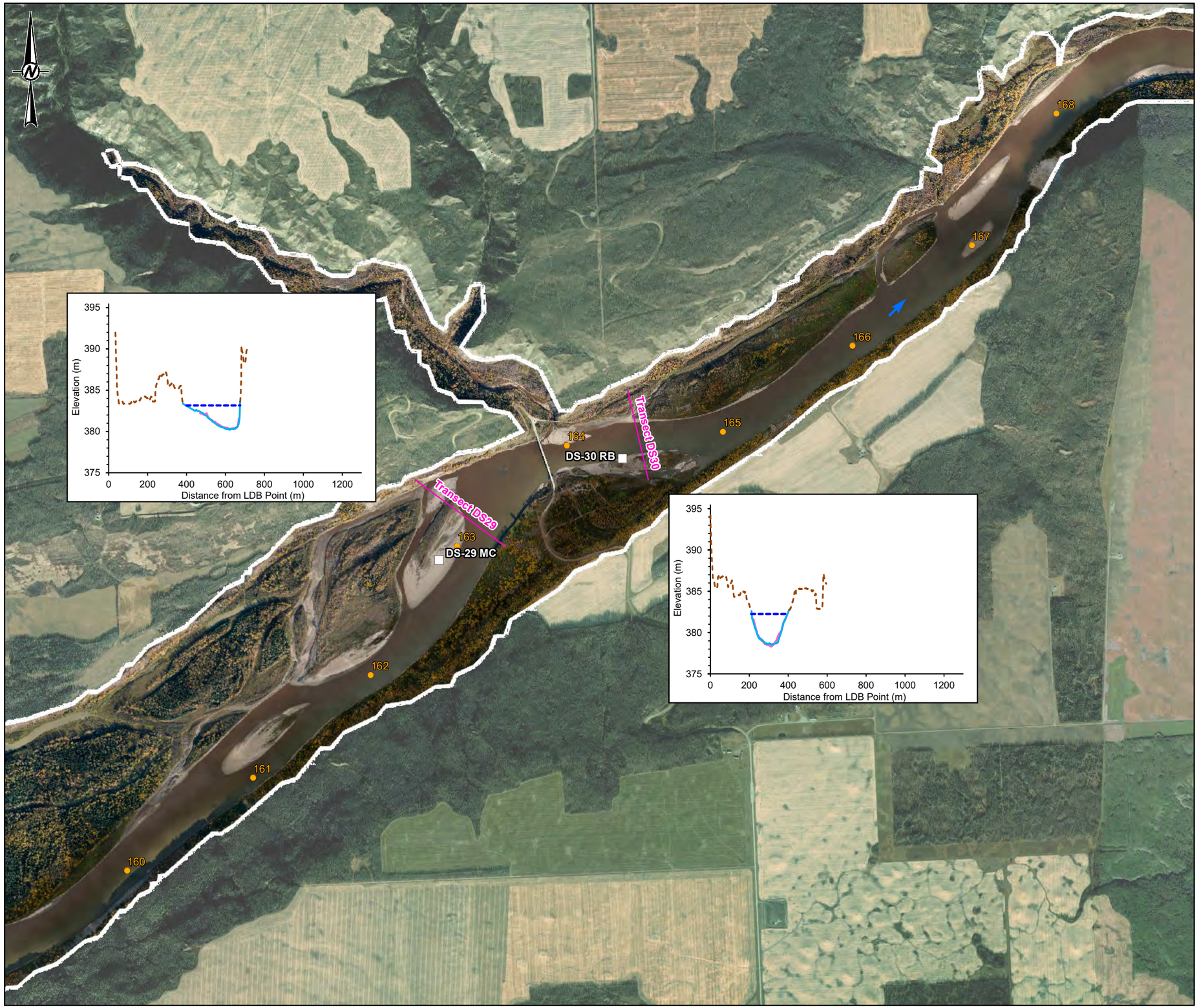

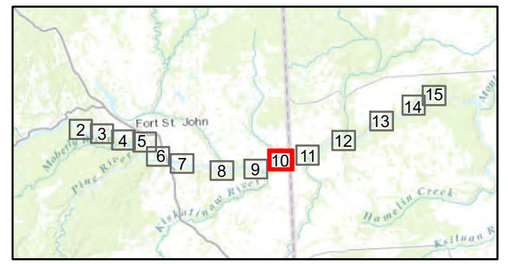

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LEGEND

- GRAIN SIZE PLOT LOCATION
- RIVER KILOMETRE AS MEASURED DOWNSTREAM FROM WAC BENNETT DAM
- RIVER CROSS-SECTION LOCATION
- OUTLINE OF SITE C PERMANENT COMPONENTS
- UPPER SITE 109L
- FLOW DIRECTION

INSET PLOT LEGEND

- 2019 RIVERBED ELEVATION
- 2021 RIVERBED ELEVATION
- 2019 LIDAR SURFACE ELEVATION
- 2021 WATER SURFACE ELEVATION

NOTES

1. LDB: LEFT DOWNSTREAM BANK

REFERENCES

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PROJECT
PEACE RIVER PHYSICAL HABITAT MONITORING PROGRAM – MON-3

TITLE
PEACE RIVER PHYSICAL HABITAT MONITORING PROGRAM STUDY AREA, 2021

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-02-10
DESIGNED	DC
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PROJECT NO.	PHASE	REV.	FIGURE
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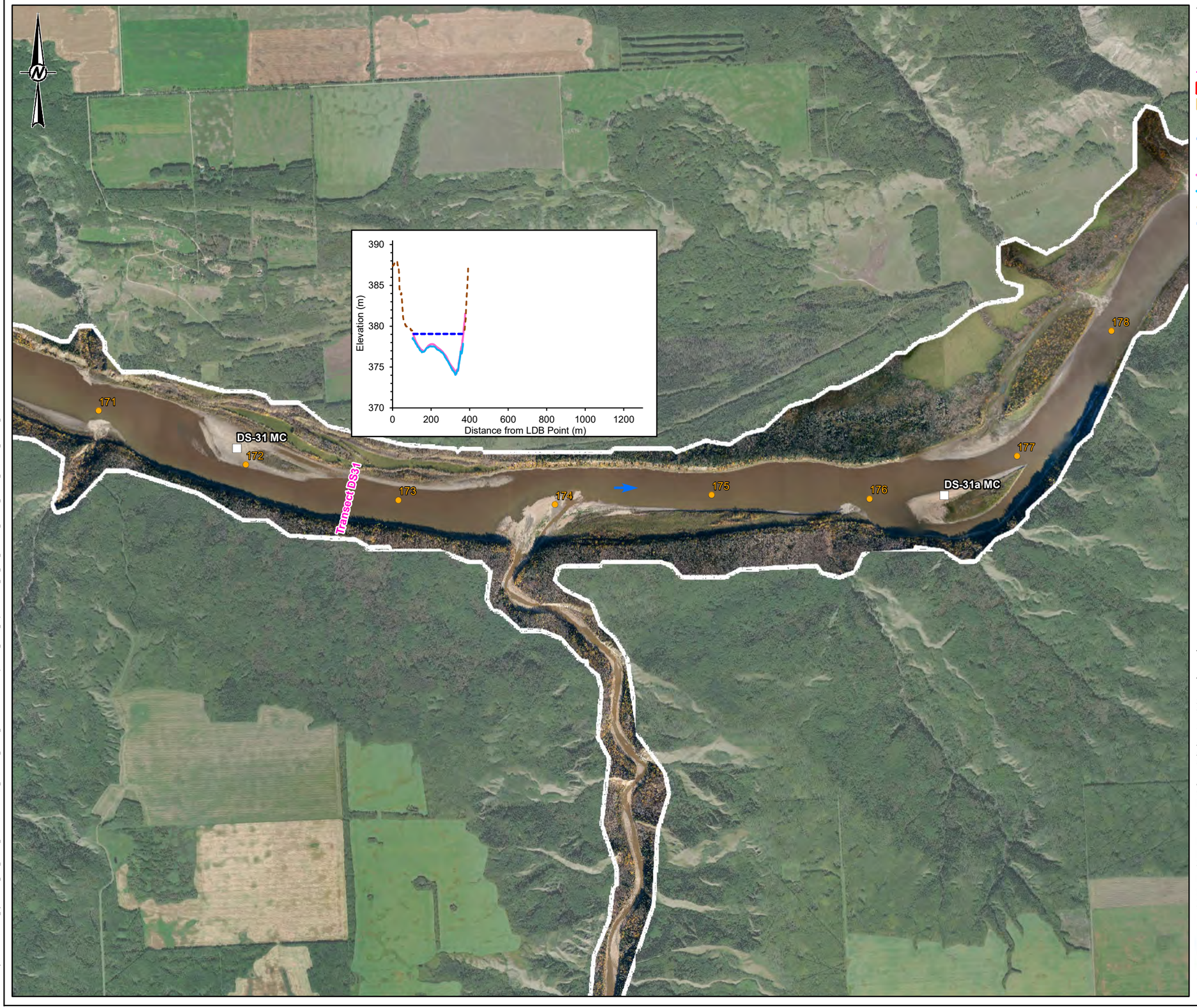
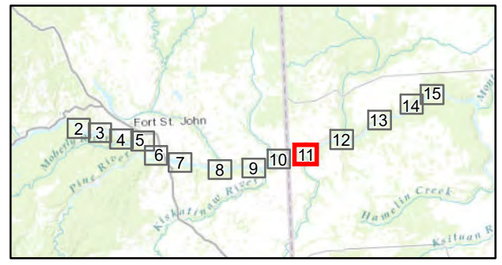


LEGEND

- GRAIN SIZE PLOT LOCATION
- RIVER KILOMETRE AS MEASURED DOWNSTREAM FROM WAC BENNETT DAM
- RIVER CROSS-SECTION LOCATION
- OUTLINE OF SITE C PERMANENT COMPONENTS
- UPPER SITE 109L
- FLOW DIRECTION

INSET PLOT LEGEND

- 2019 RIVERBED ELEVATION
- 2021 RIVERBED ELEVATION
- 2019 LIDAR SURFACE ELEVATION
- 2021 WATER SURFACE ELEVATION



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1. LDB: LEFT DOWNSTREAM BANK

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1. RIVER KILOMETER MARKERS OBTAINED FROM BC HYDRO.
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PROJECT NO.	PHASE	REV.	FIGURE
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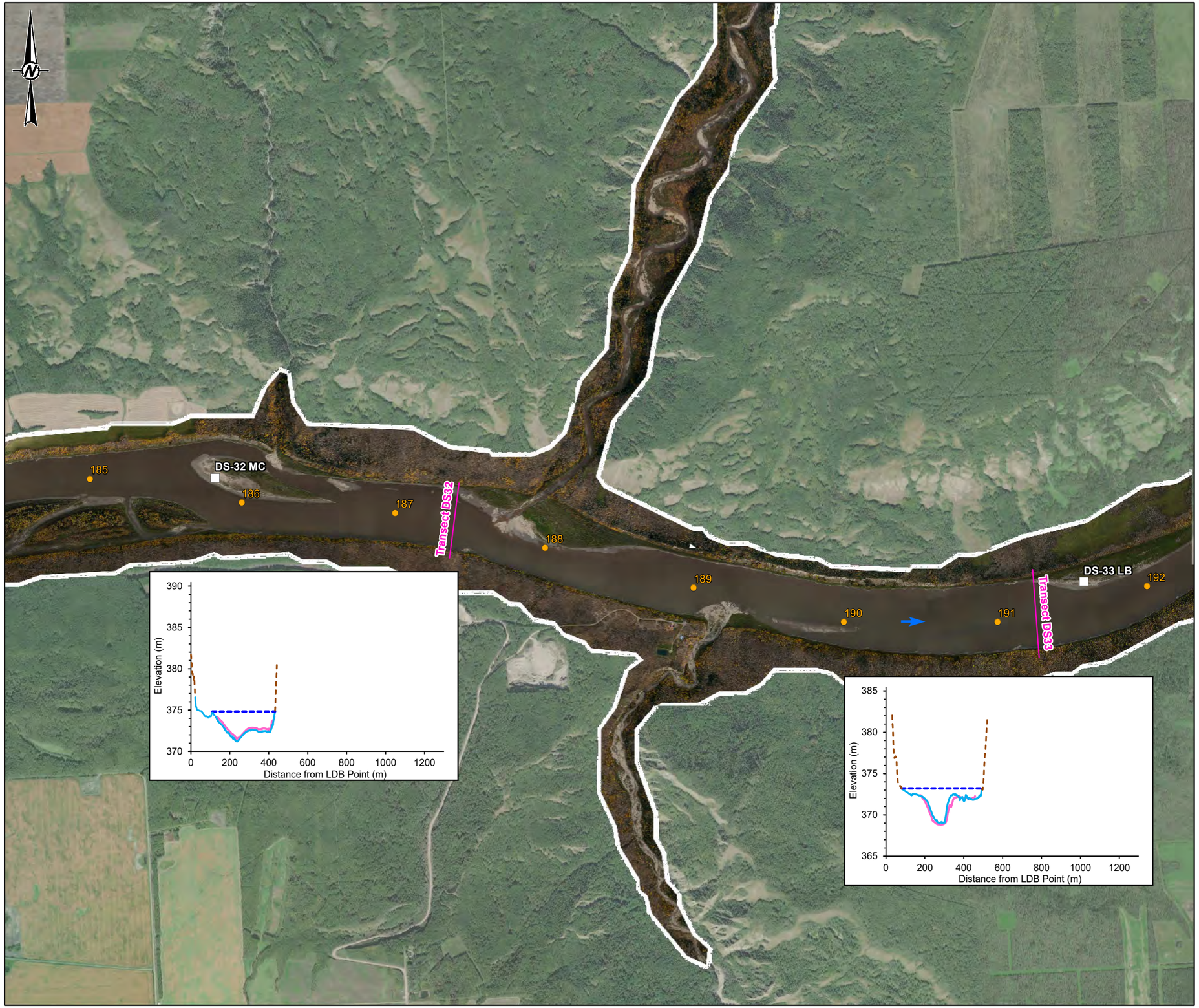
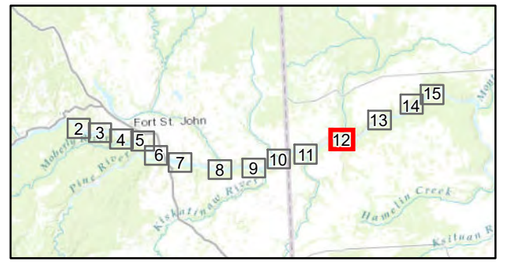


LEGEND

- GRAIN SIZE PLOT LOCATION
- RIVER KILOMETRE AS MEASURED DOWNSTREAM FROM WAC BENNETT DAM
- RIVER CROSS-SECTION LOCATION
- OUTLINE OF SITE C PERMANENT COMPONENTS
- UPPER SITE 109L
- FLOW DIRECTION

INSET PLOT LEGEND

- 2019 RIVERBED ELEVATION
- 2021 RIVERBED ELEVATION
- 2019 LIDAR SURFACE ELEVATION
- 2021 WATER SURFACE ELEVATION



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PROJECT NO.	PHASE	REV.	FIGURE
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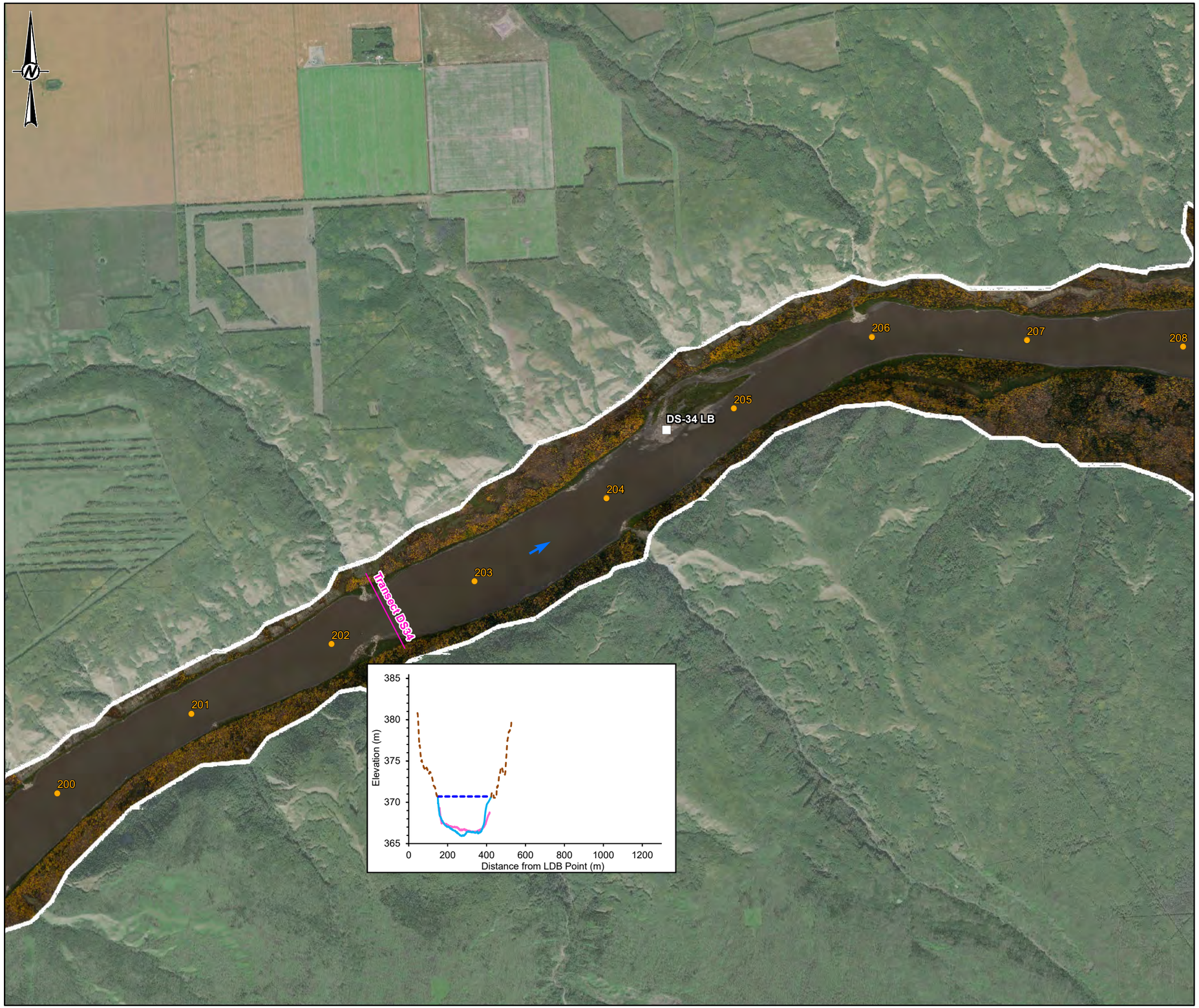
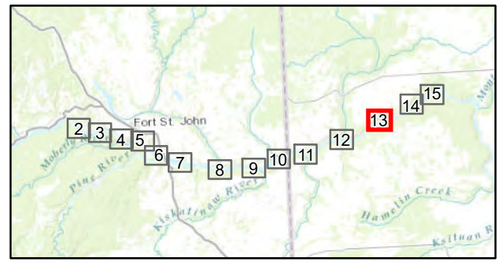


LEGEND

- GRAIN SIZE PLOT LOCATION
- RIVER KILOMETRE AS MEASURED DOWNSTREAM FROM WAC BENNETT DAM
- RIVER CROSS-SECTION LOCATION
- OUTLINE OF SITE C PERMANENT COMPONENTS
- UPPER SITE 109L
- FLOW DIRECTION

INSET PLOT LEGEND

- 2019 RIVERBED ELEVATION
- 2021 RIVERBED ELEVATION
- 2019 LIDAR SURFACE ELEVATION
- 2021 WATER SURFACE ELEVATION



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PROJECT NO.	PHASE	REV.	FIGURE
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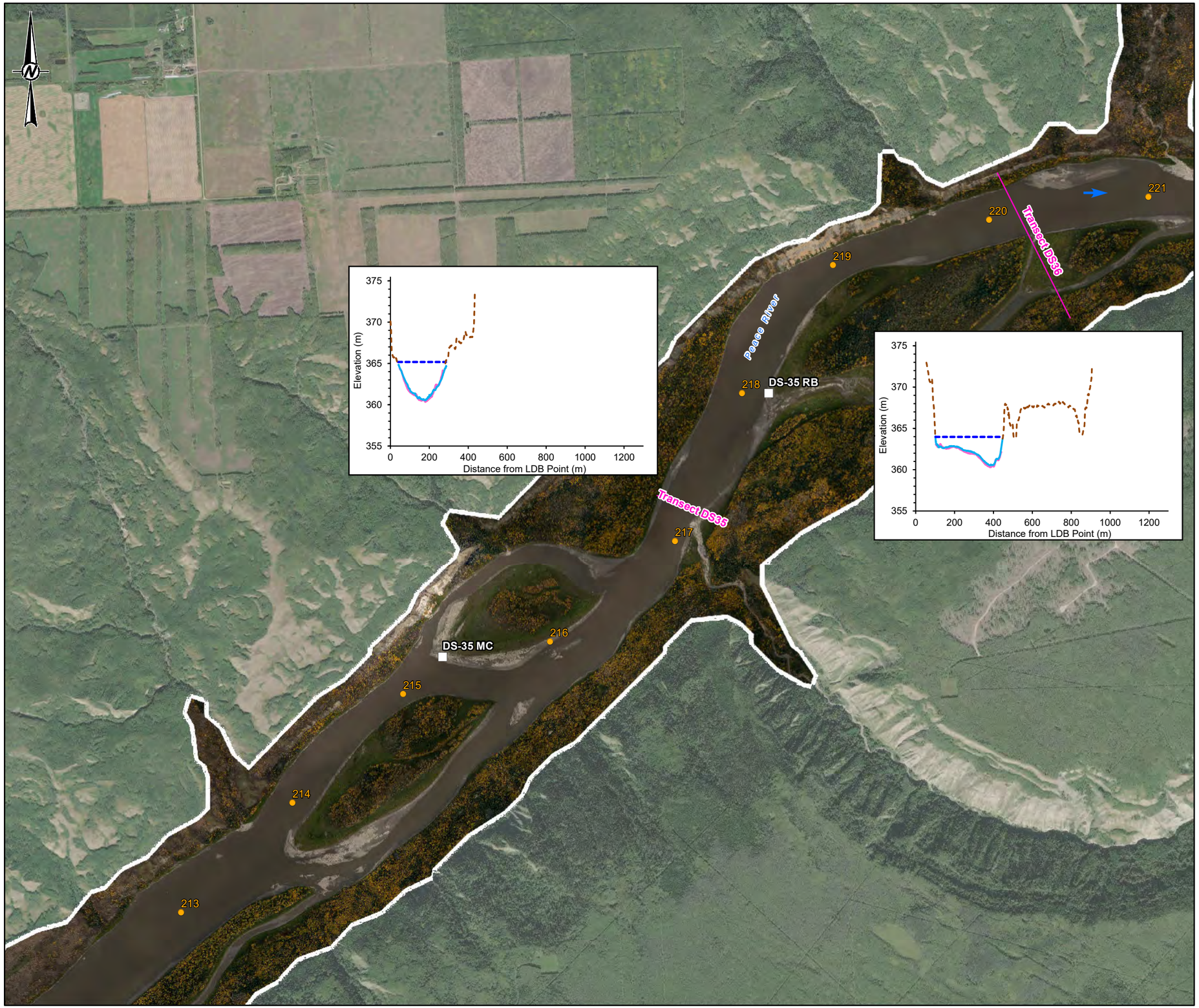
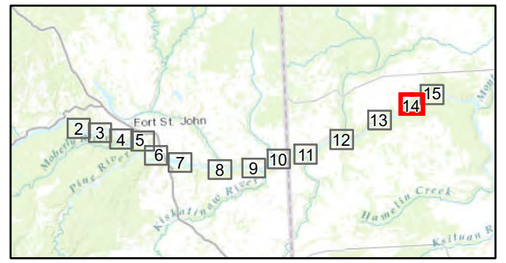


LEGEND

- GRAIN SIZE PLOT LOCATION
- RIVER KILOMETRE AS MEASURED DOWNSTREAM FROM WAC BENNETT DAM
- RIVER CROSS-SECTION LOCATION
- OUTLINE OF SITE C PERMANENT COMPONENTS
- UPPER SITE 109L
- FLOW DIRECTION

INSET PLOT LEGEND

- 2019 RIVERBED ELEVATION
- 2021 RIVERBED ELEVATION
- 2019 LIDAR SURFACE ELEVATION
- 2021 WATER SURFACE ELEVATION



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NOTES

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PROJECT NO.	PHASE	REV.	FIGURE
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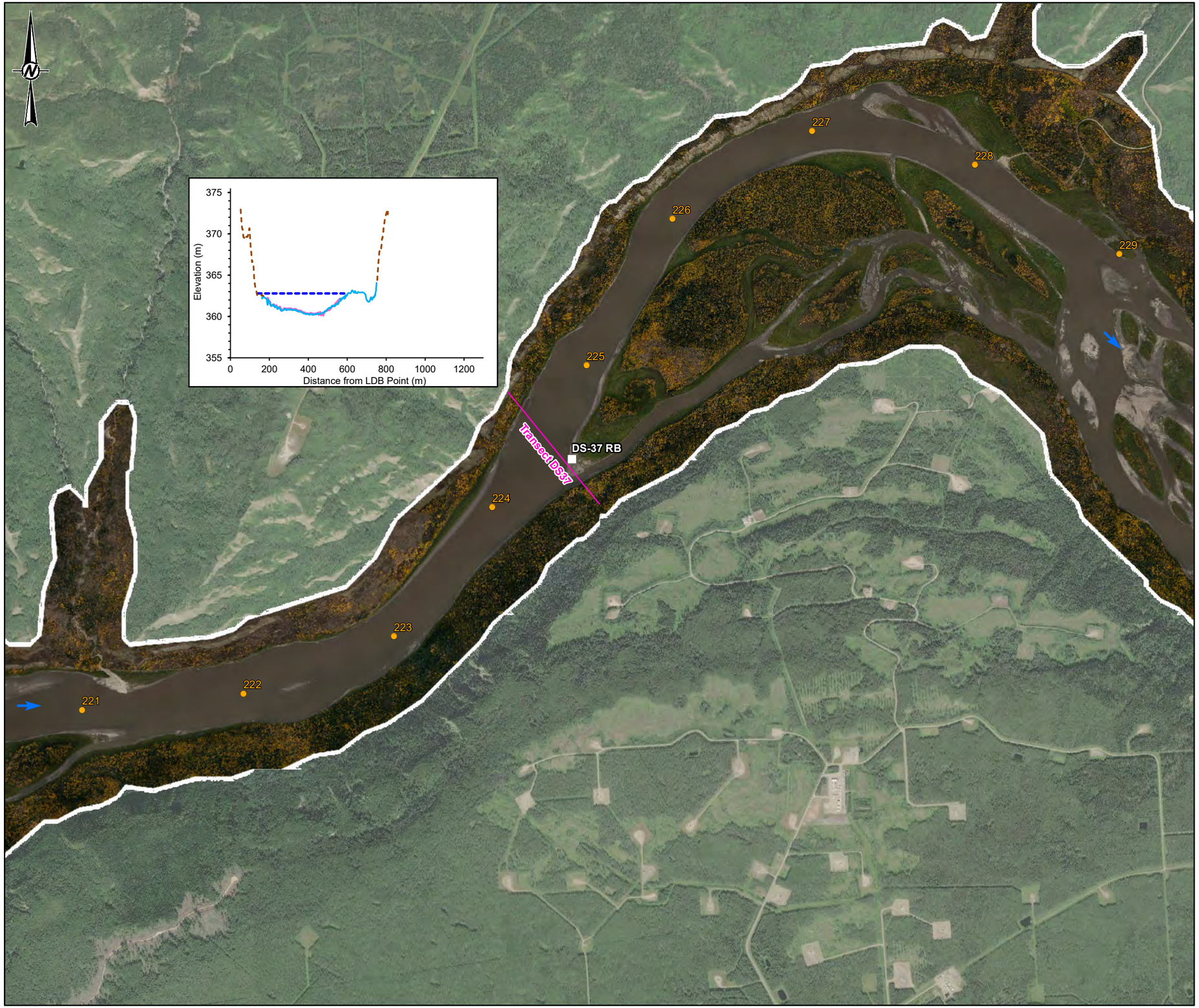
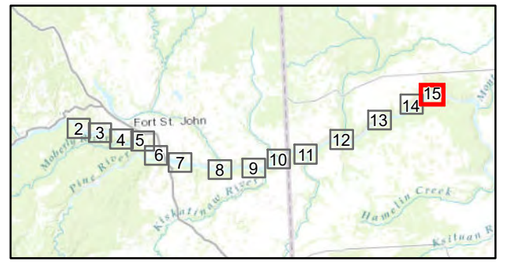


LEGEND

- GRAIN SIZE PLOT LOCATION
- RIVER KILOMETRE AS MEASURED DOWNSTREAM FROM WAC BENNETT DAM
- RIVER CROSS-SECTION LOCATION
- OUTLINE OF SITE C PERMANENT COMPONENTS
- UPPER SITE 109L
- FLOW DIRECTION

INSET PLOT LEGEND

- 2019 RIVERBED ELEVATION
- 2021 RIVERBED ELEVATION
- 2019 LIDAR SURFACE ELEVATION
- 2021 WATER SURFACE ELEVATION



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NOTES

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PROJECT NO.	PHASE	REV.	FIGURE
19121767	10/10.3	0	**A-15**

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APPENDIX B

River Cross-Section Data (2015 to 2021)

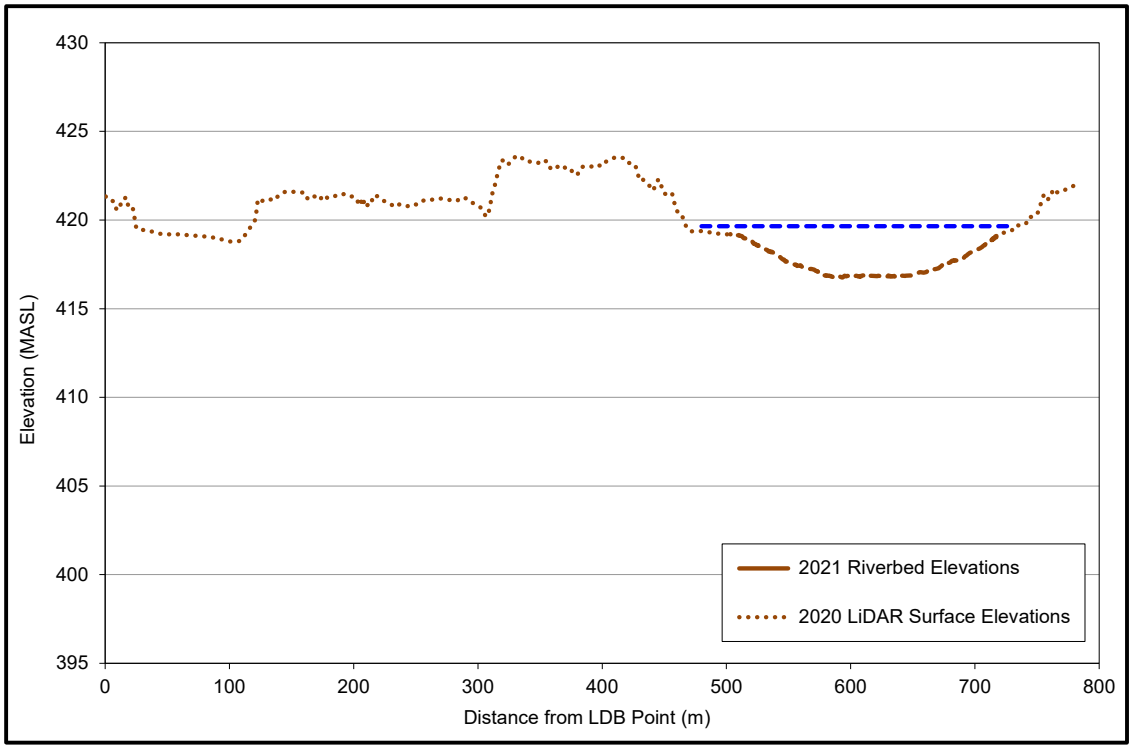


Figure B1: River cross-section at Transect #US13, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

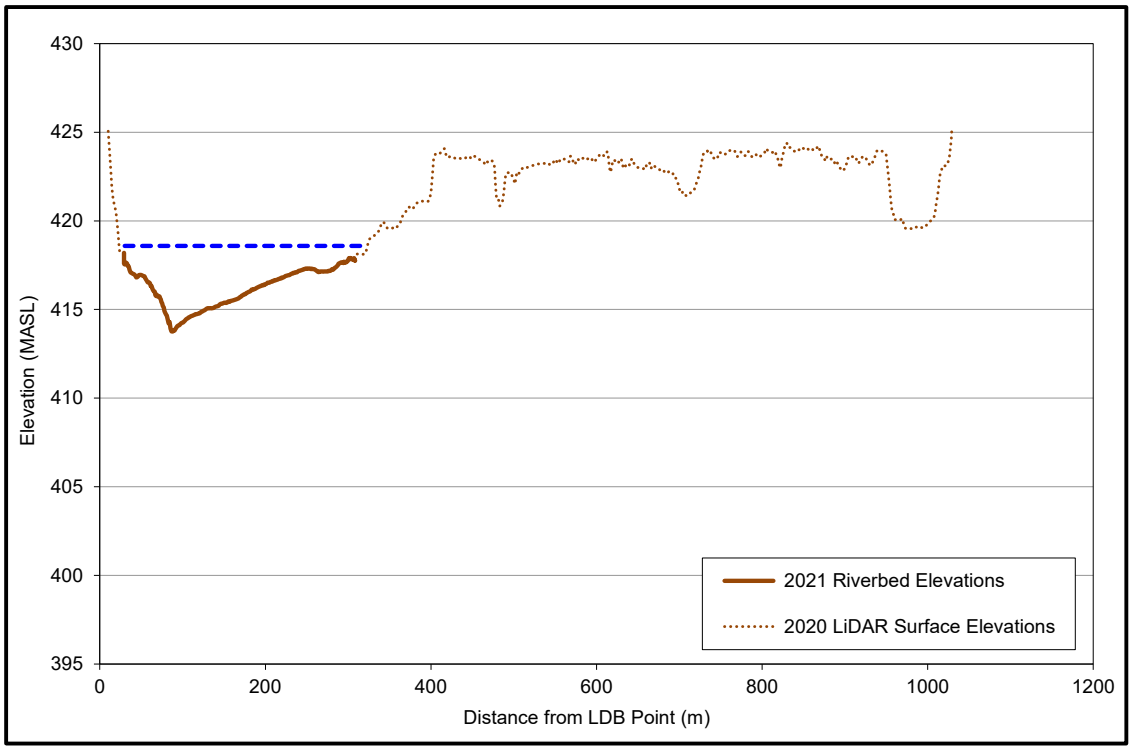


Figure B2: River cross-section at Transect #US13a, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

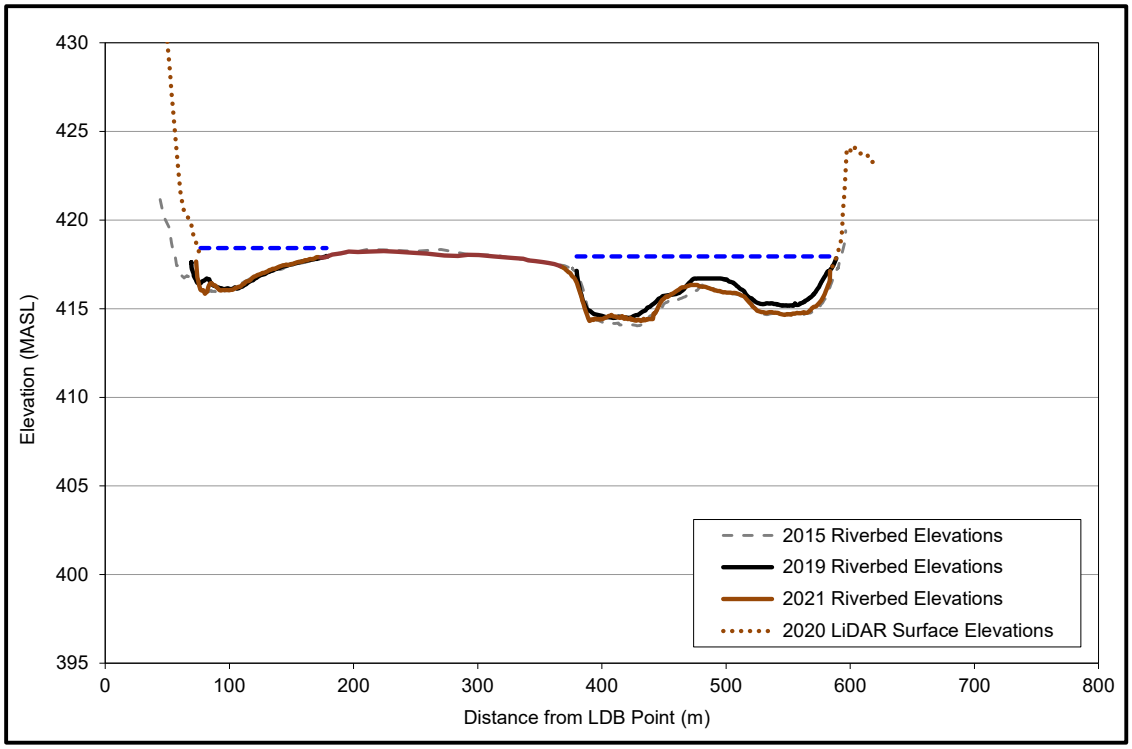


Figure B3: River cross-section at Transect #US12, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

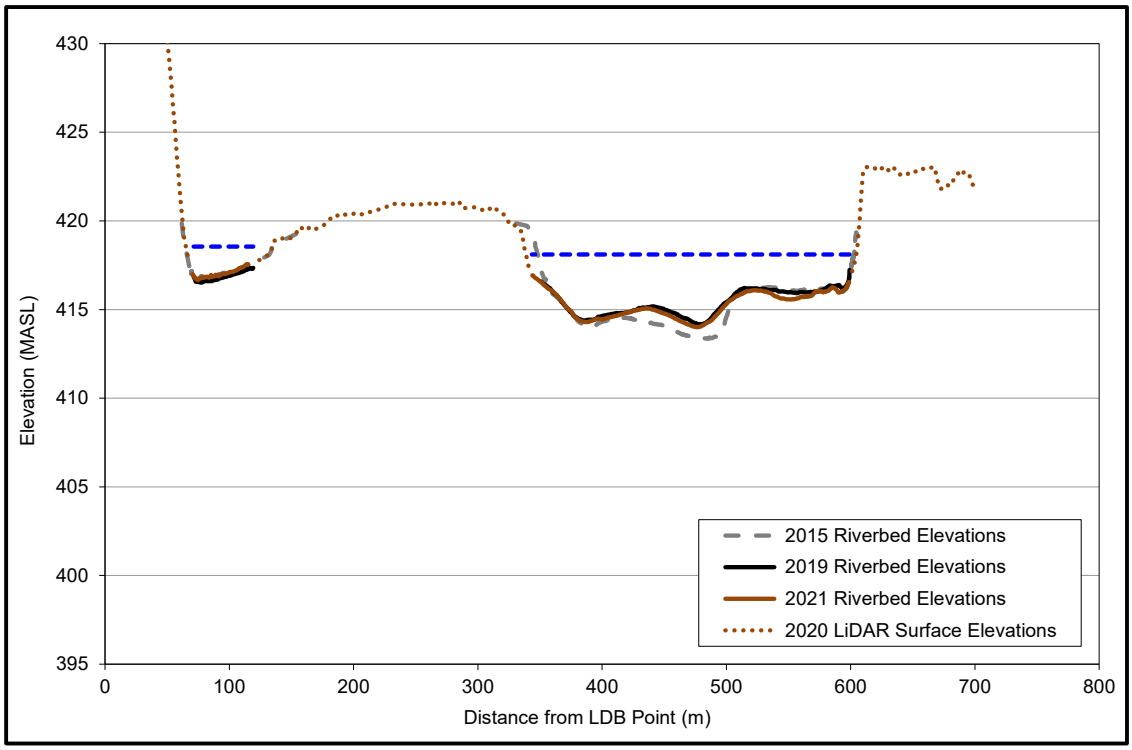


Figure B4: River cross-section at Transect #US11, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

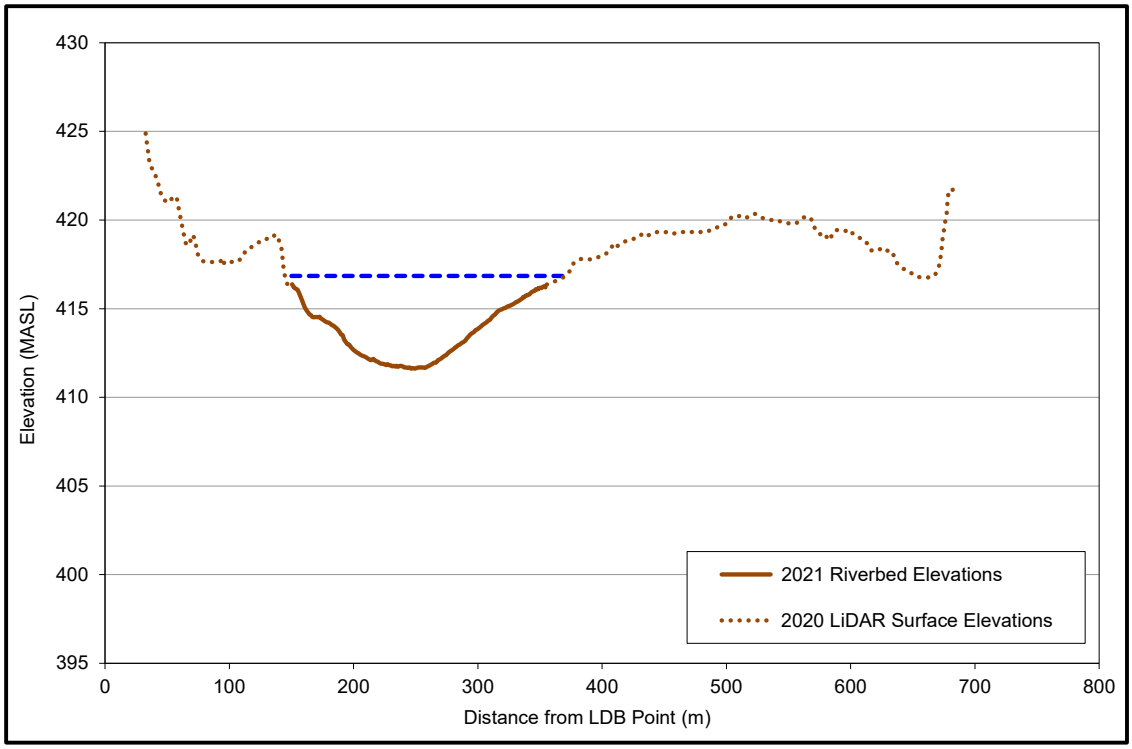


Figure B5: River cross-section at Transect #US11a, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

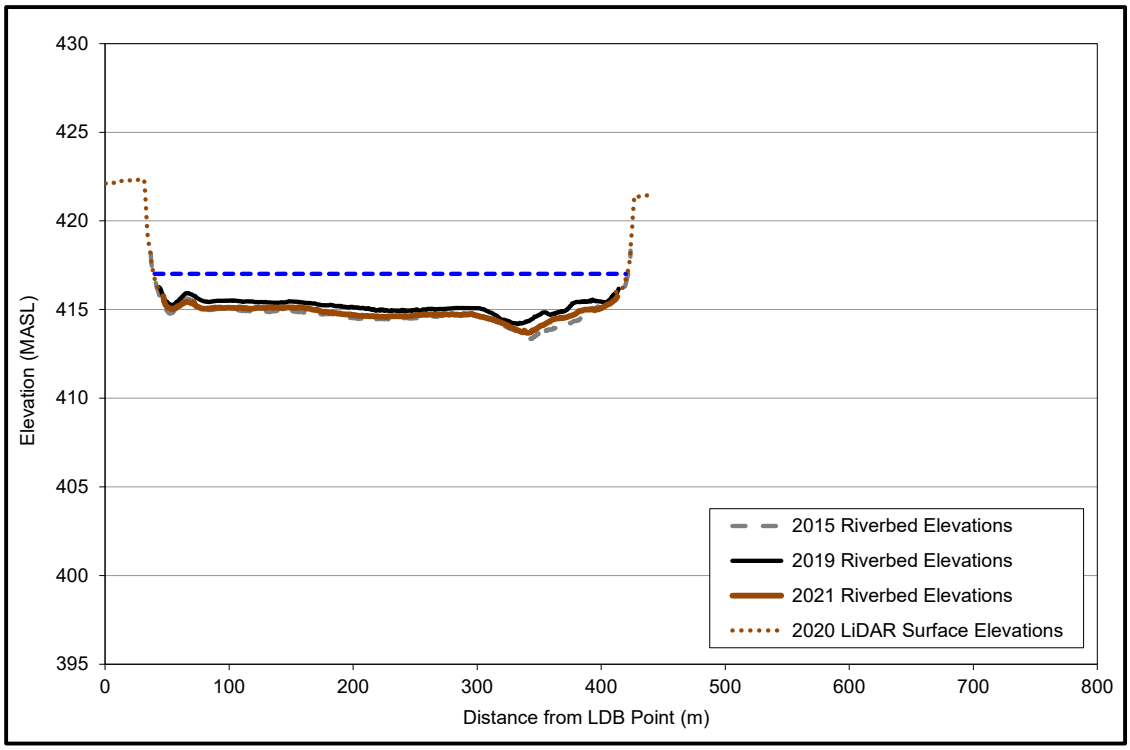


Figure B6: River cross-section at Transect #US10, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

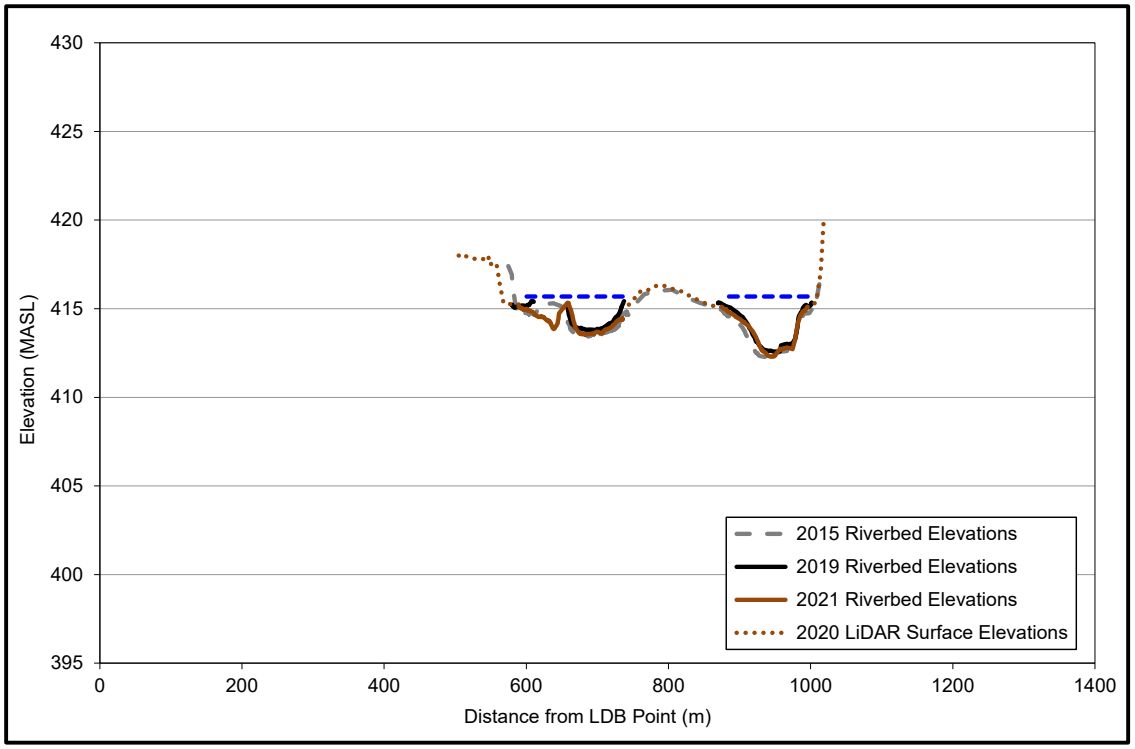


Figure B7: River cross-section at Transect #US09, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

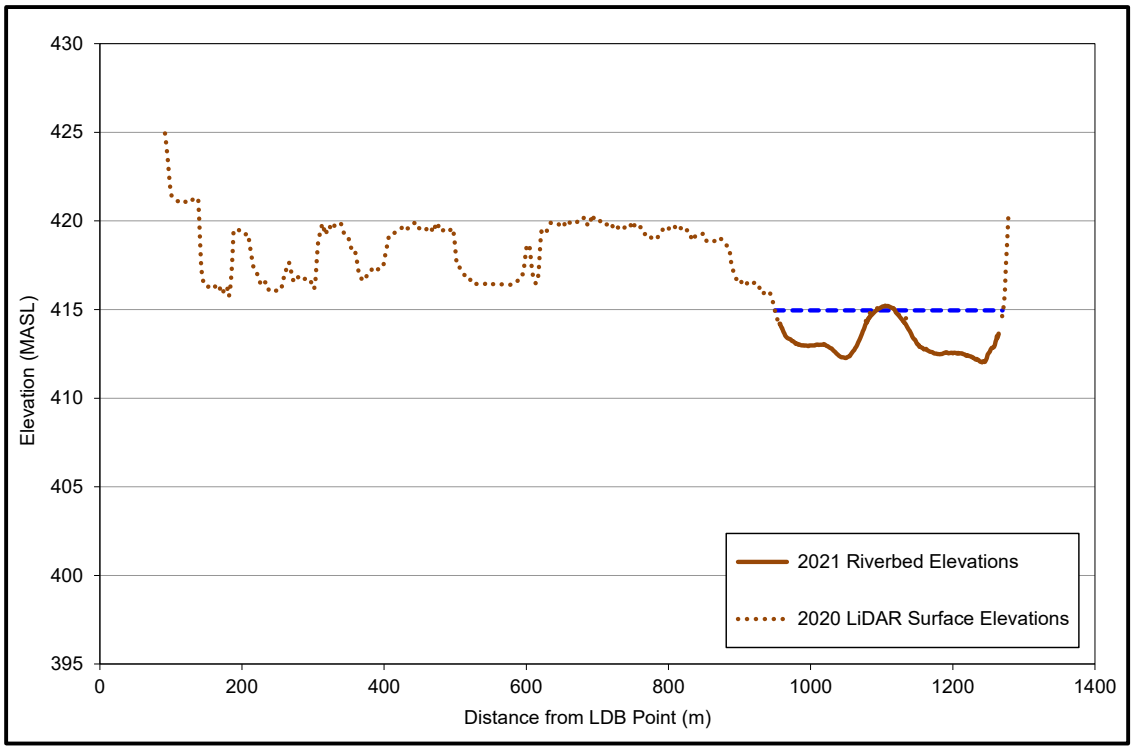


Figure B8: River cross-section at Transect #US09a, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

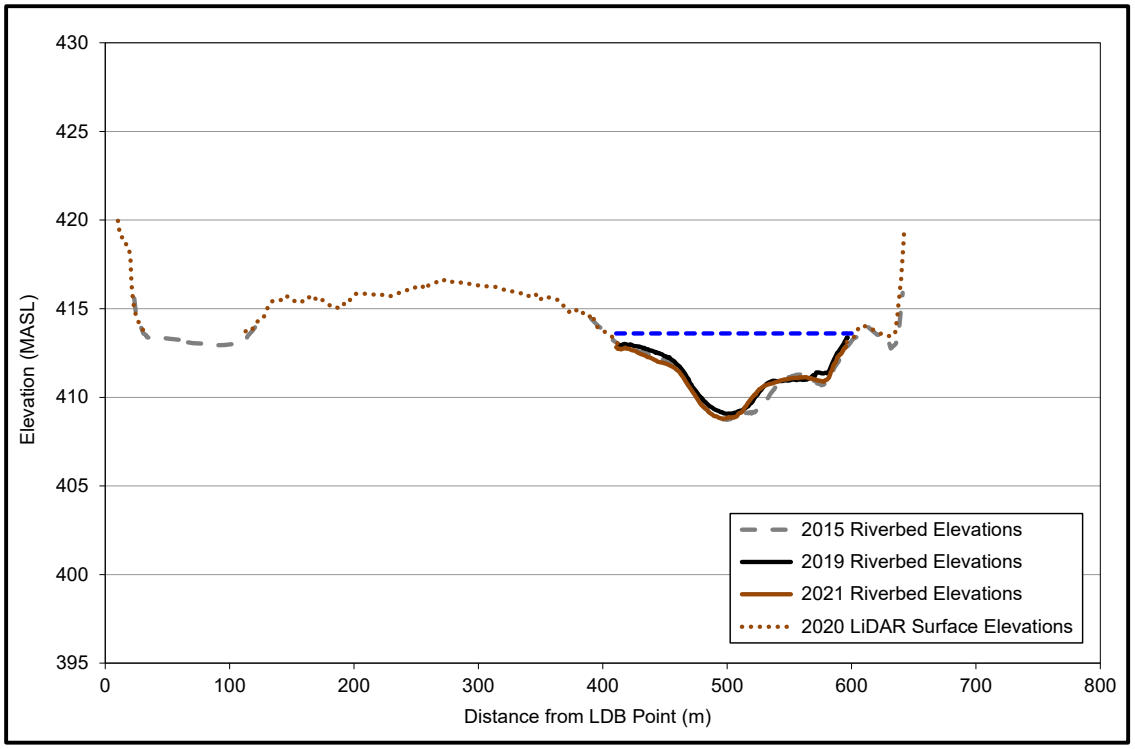


Figure B9: River cross-section at Transect #US08, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

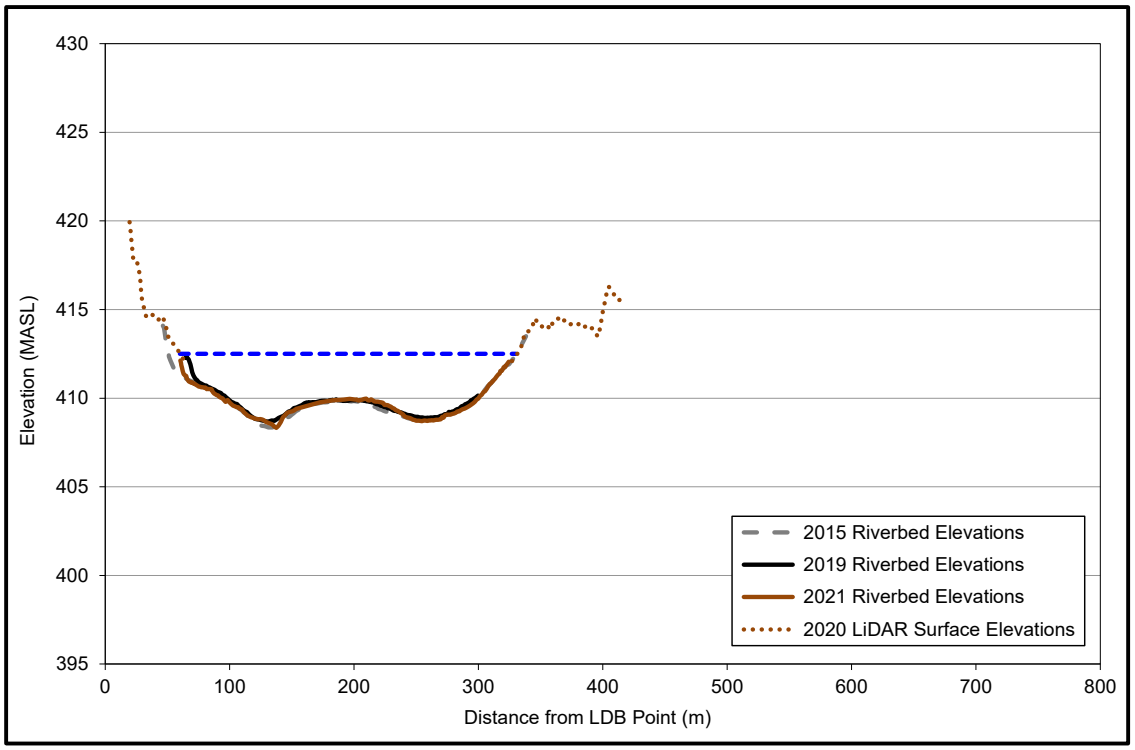


Figure B10: River cross-section at Transect #US07, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

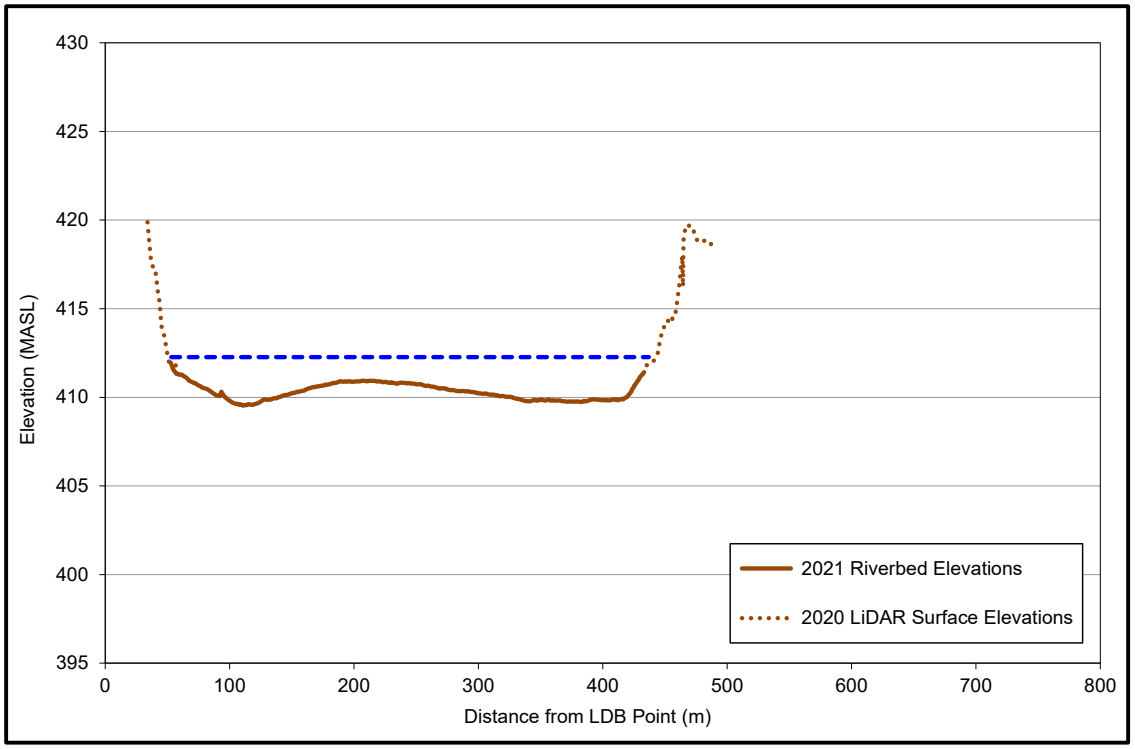


Figure B11: River cross-section at Transect #US07a, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

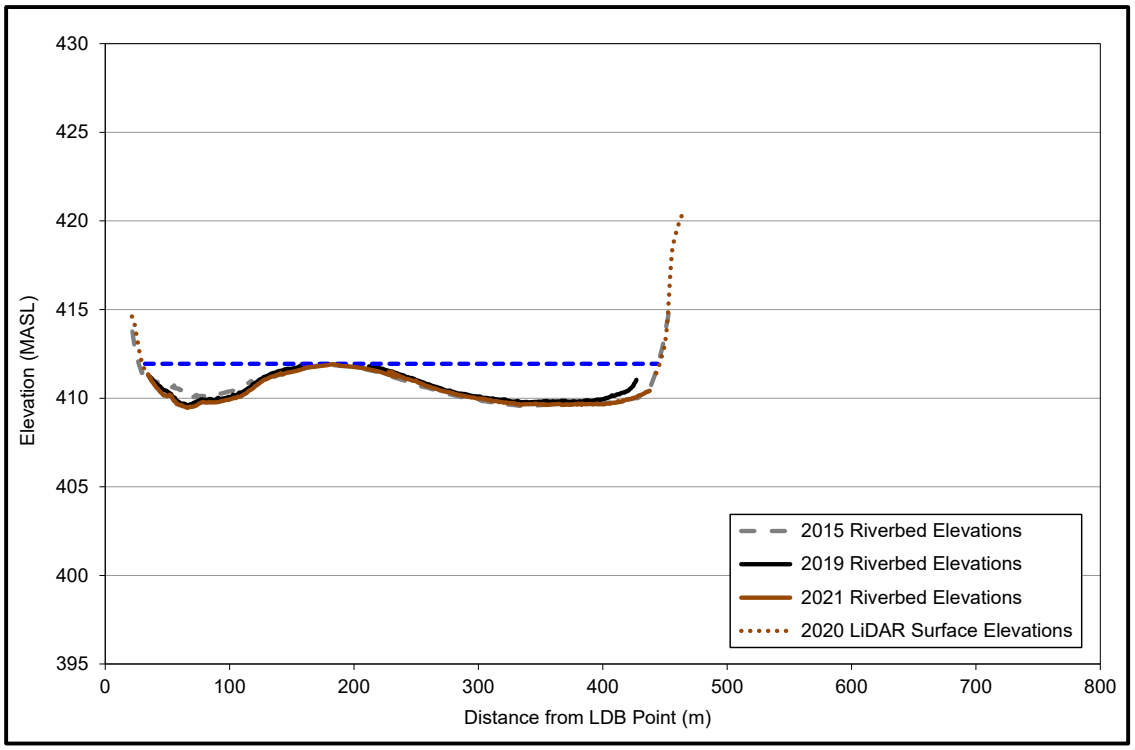


Figure B12: River cross-section at Transect #US06, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

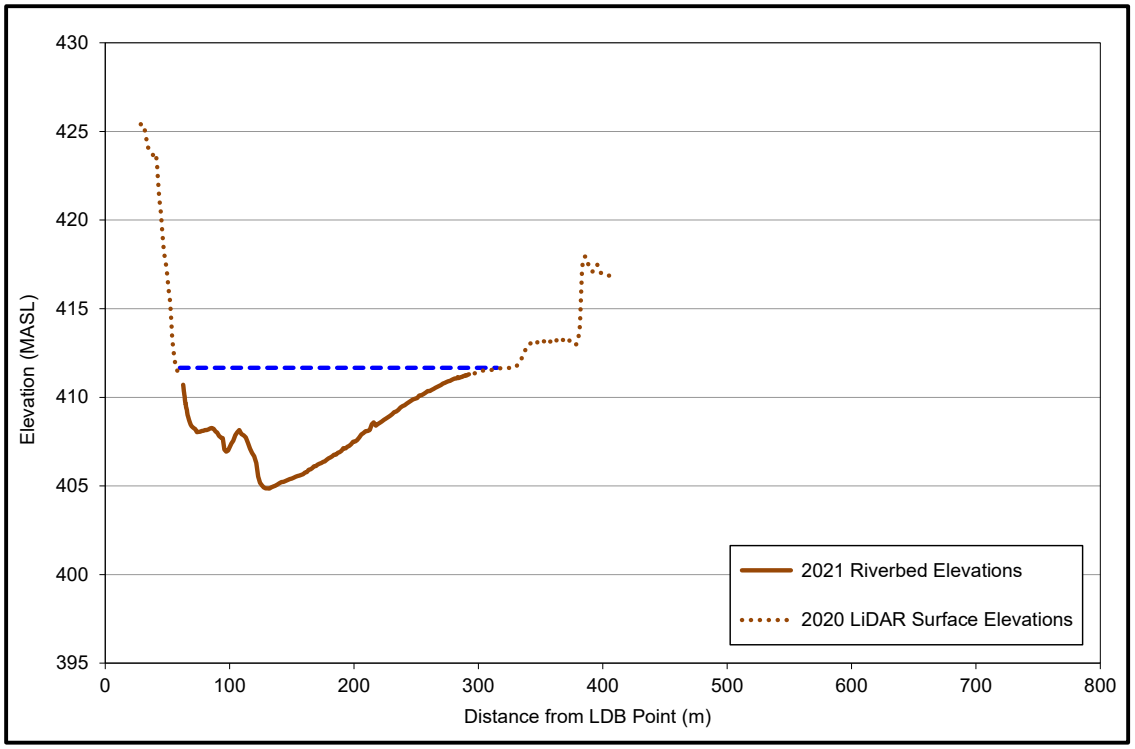


Figure B13: River cross-section at Transect #US06a, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

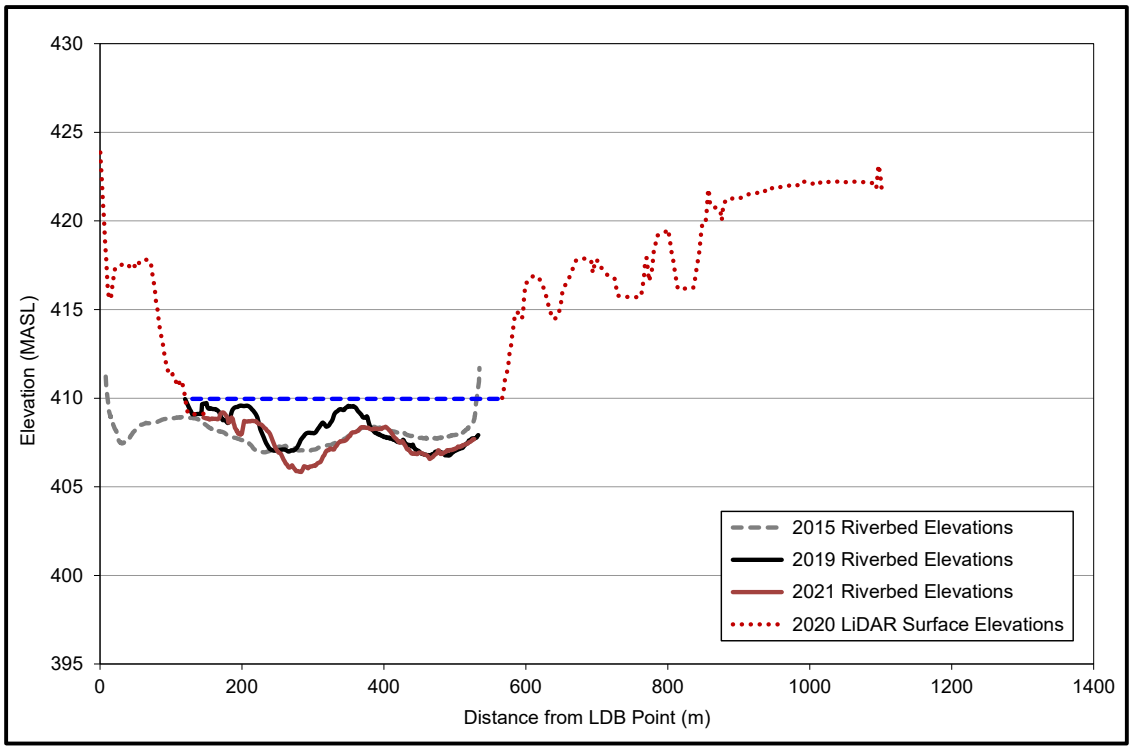


Figure B14: River cross-section at Transect #DS01, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

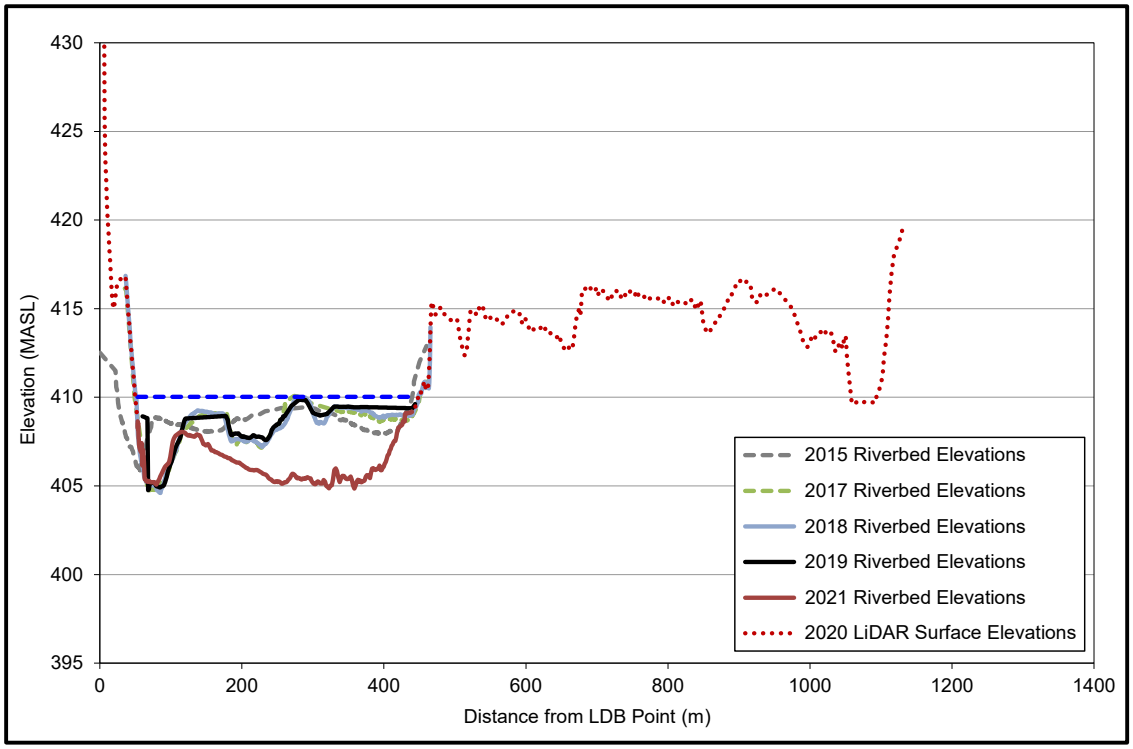


Figure B15: River cross-section at Transect #DS03, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

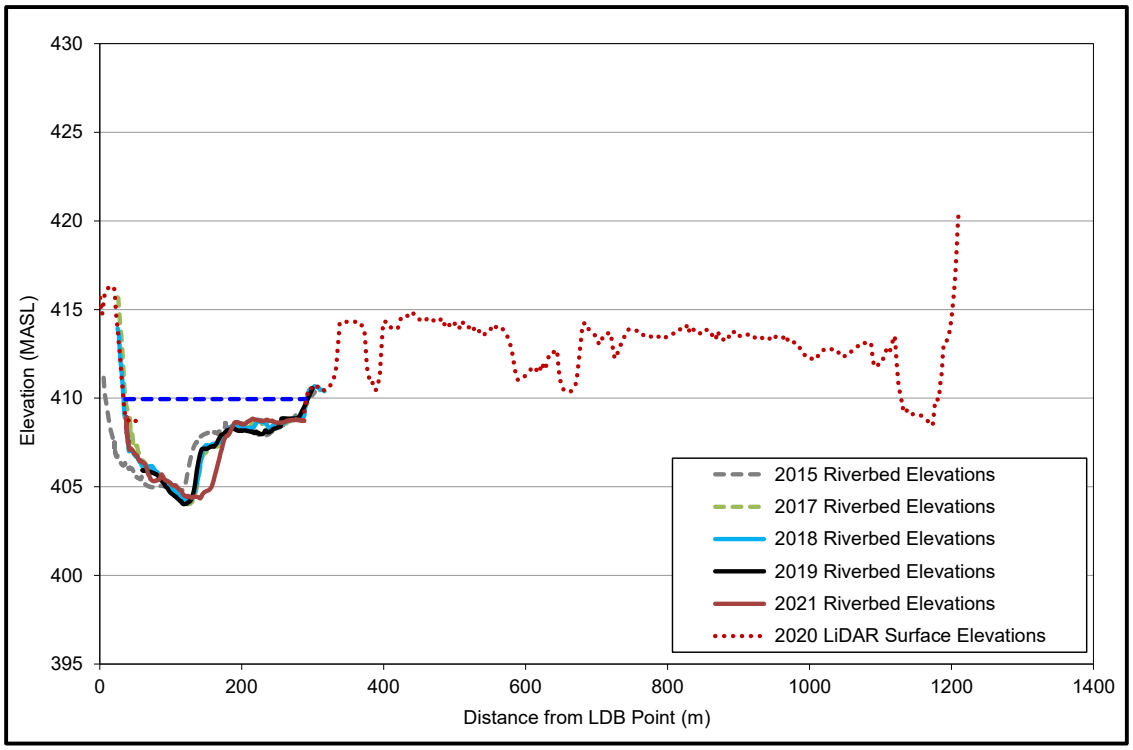


Figure B16: River cross-section at Transect #DS04, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

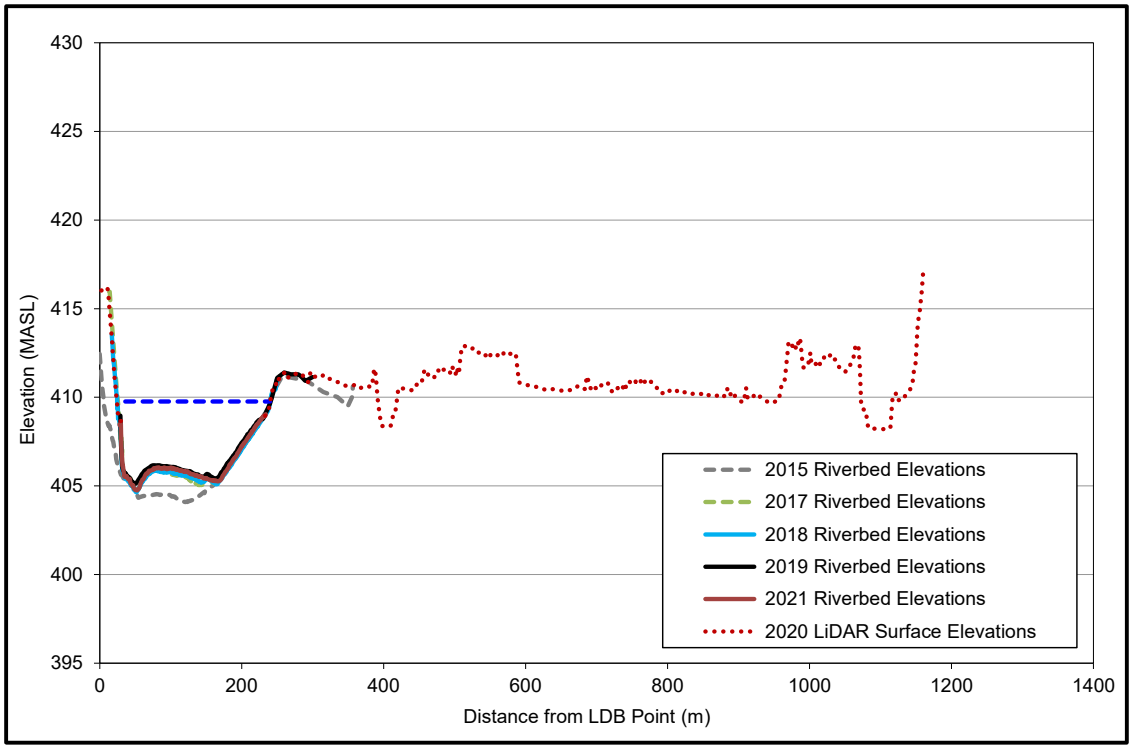


Figure B17: River cross-section at Transect #DS05, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

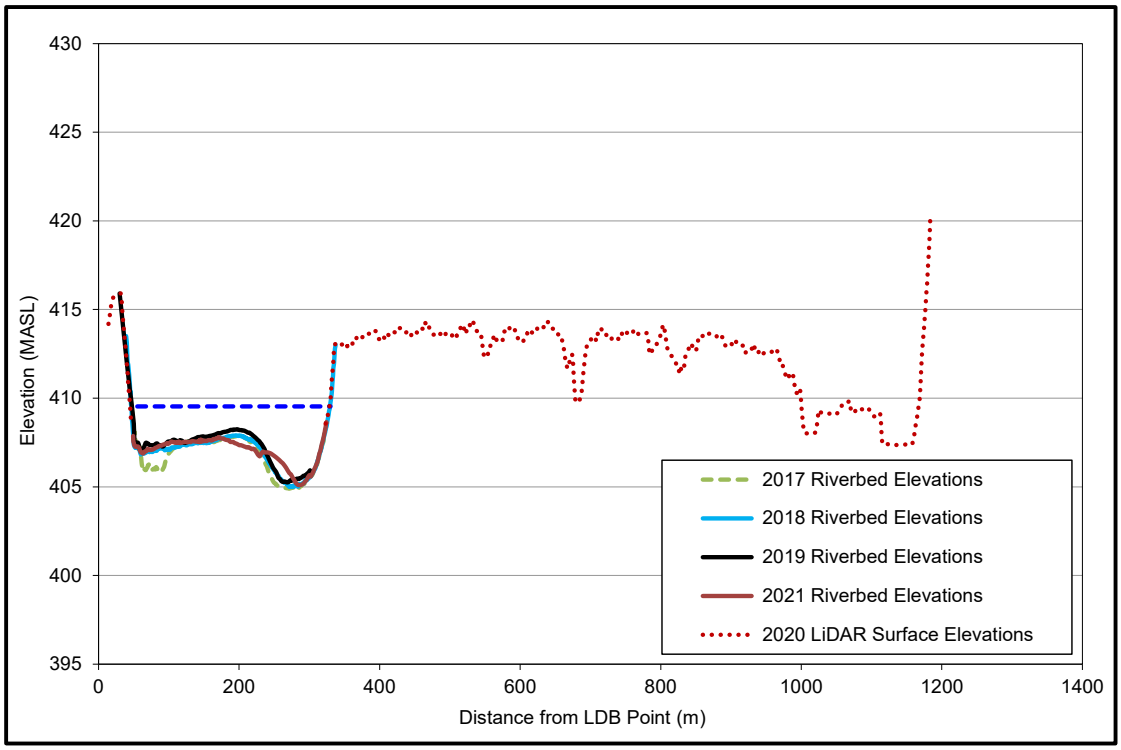


Figure B18: River cross-section at Transect #DS06a, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

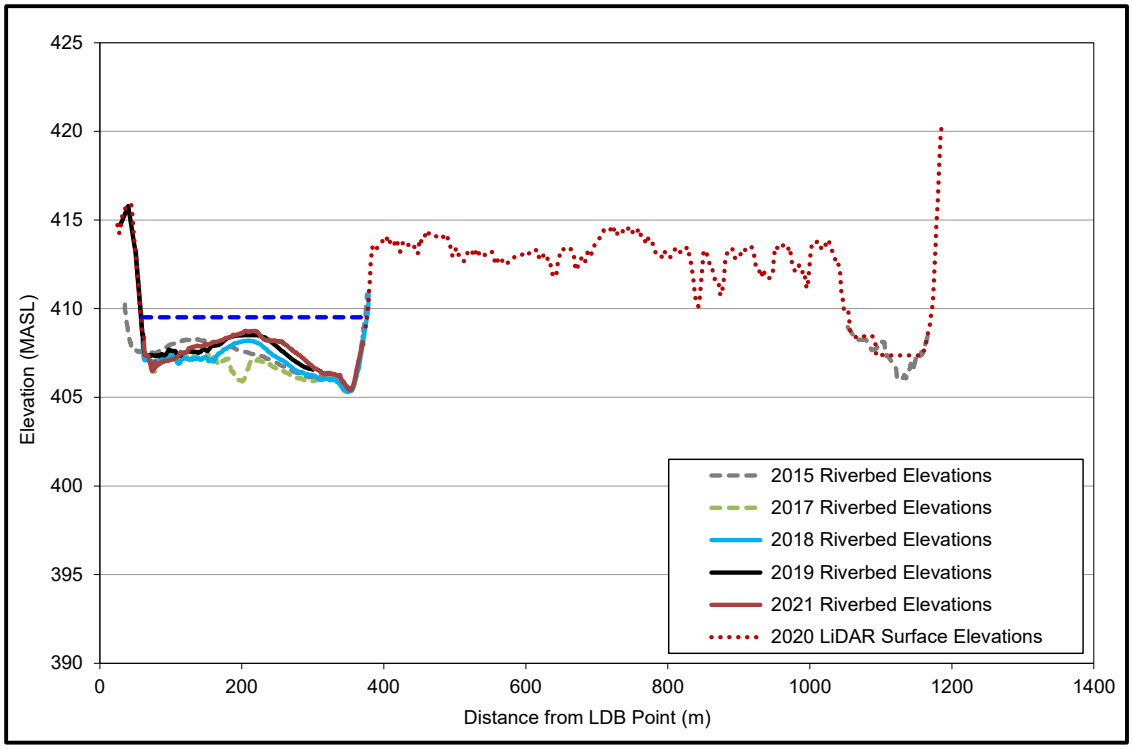


Figure B19: River cross-section at Transect #DS06, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

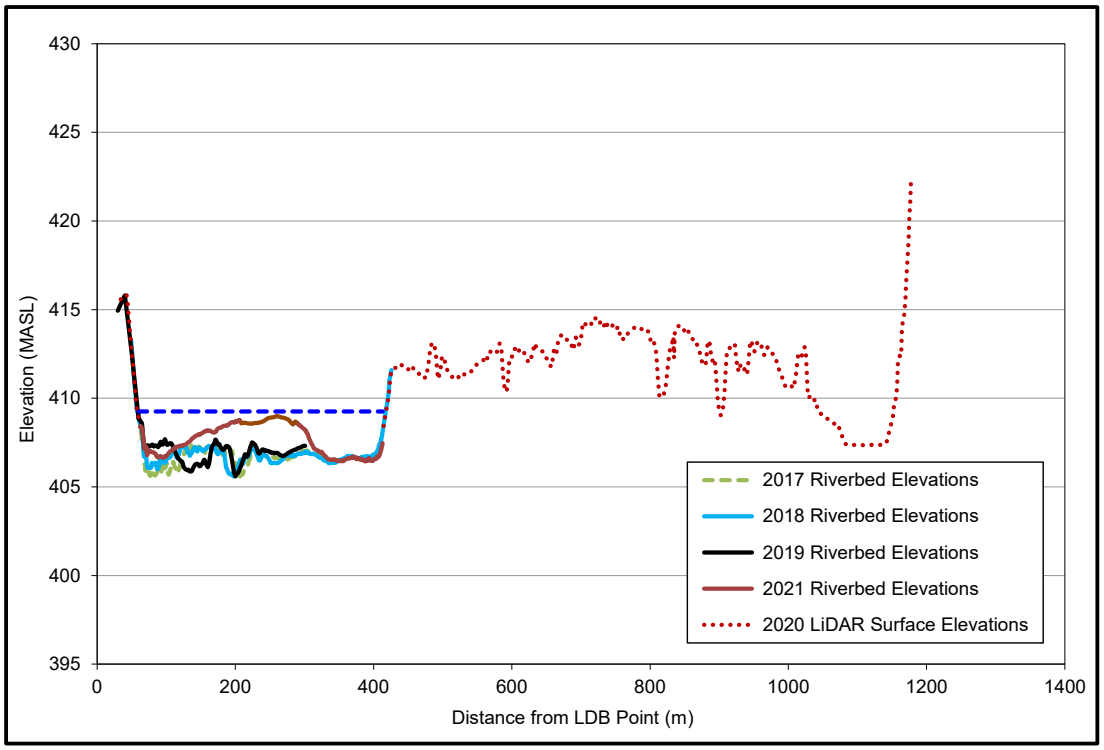


Figure B20: River cross-section at Transect #DS06b, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

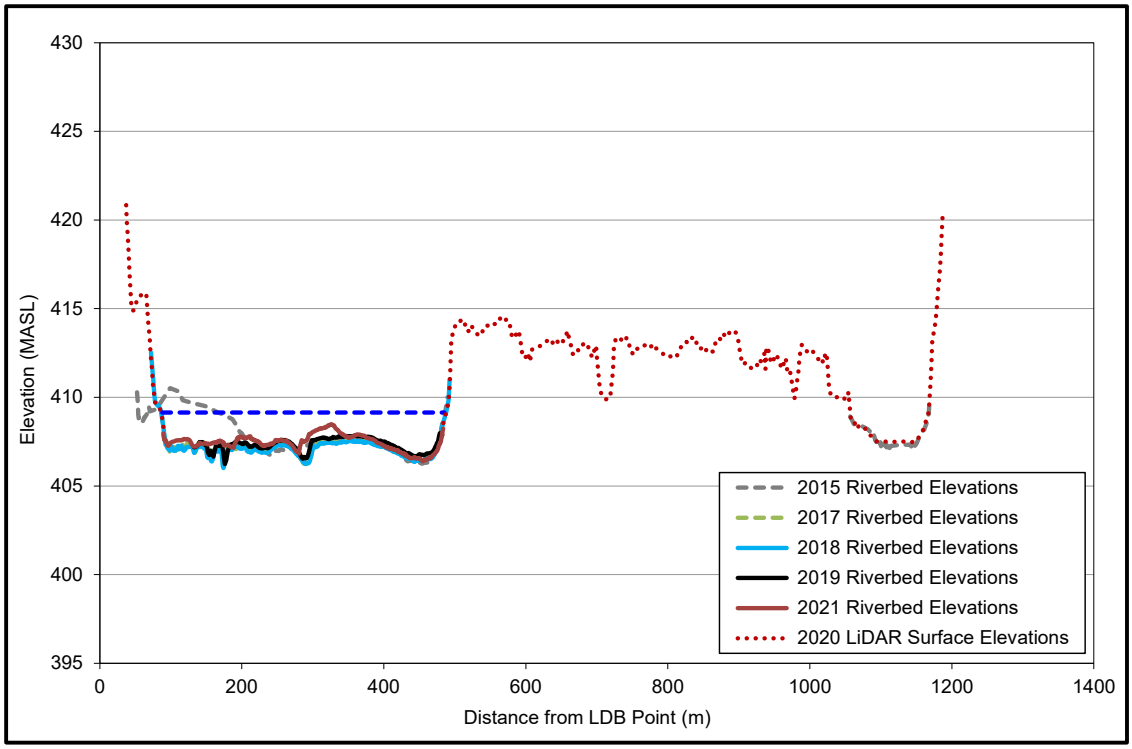


Figure B21: River cross-section at Transect #DS07, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

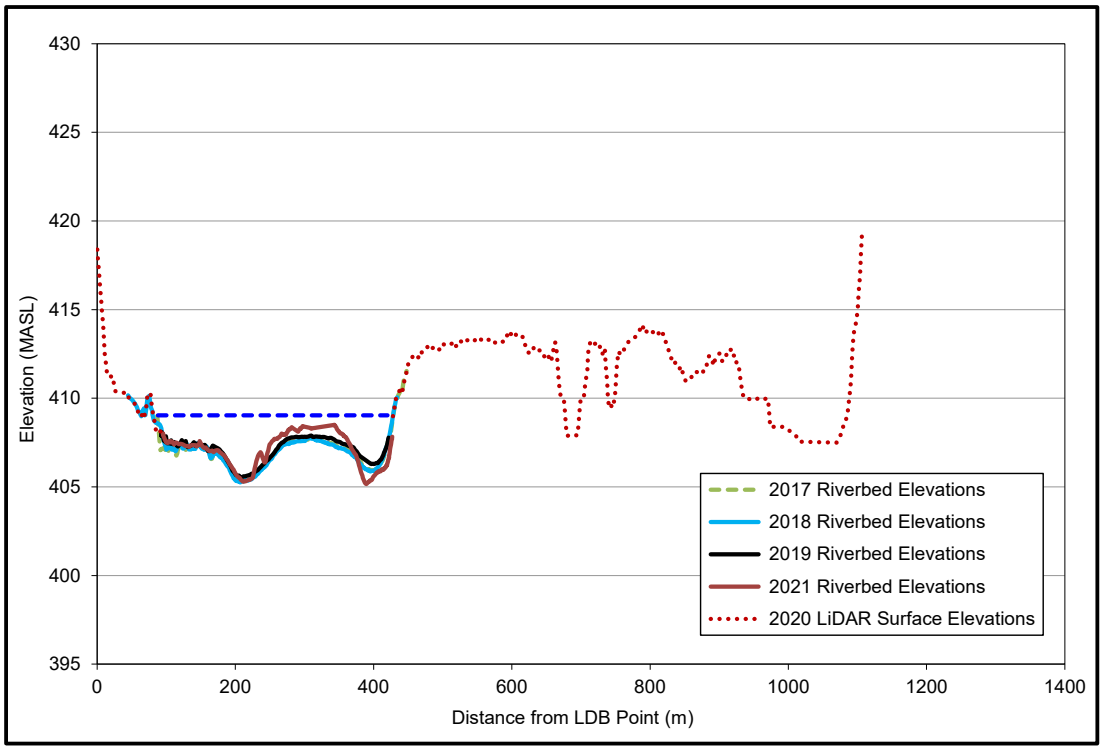


Figure B22: River cross-section at Transect #DS07b, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

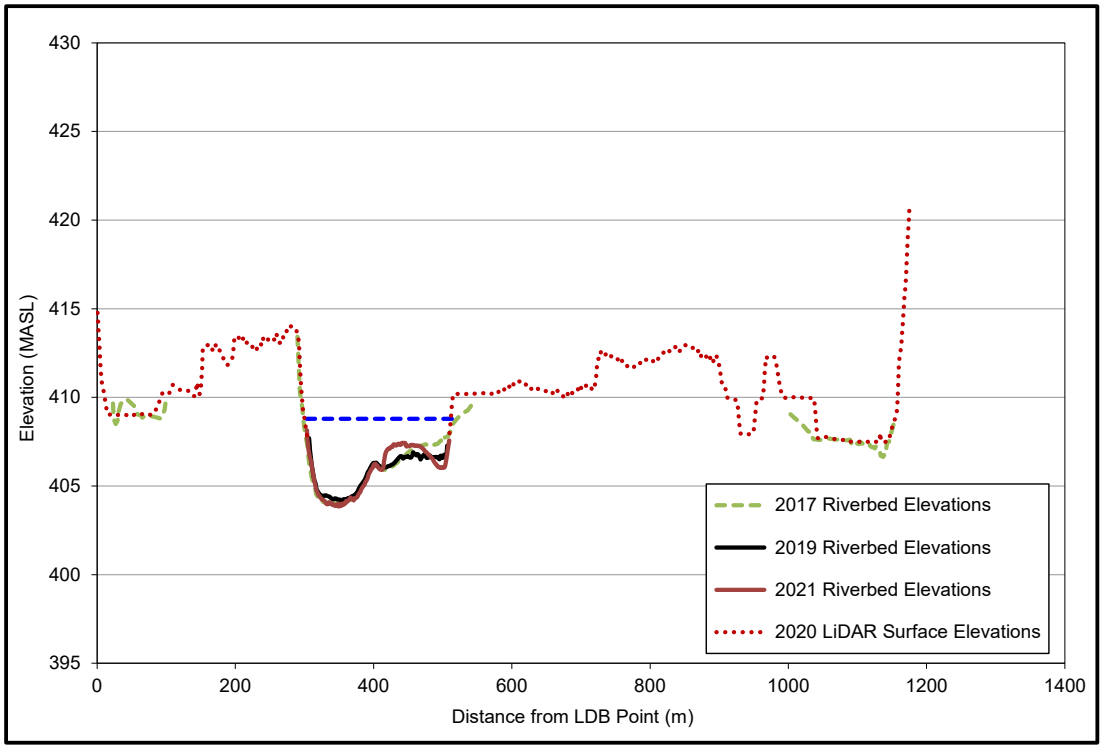


Figure B23: River cross-section at Transect #DS07a, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

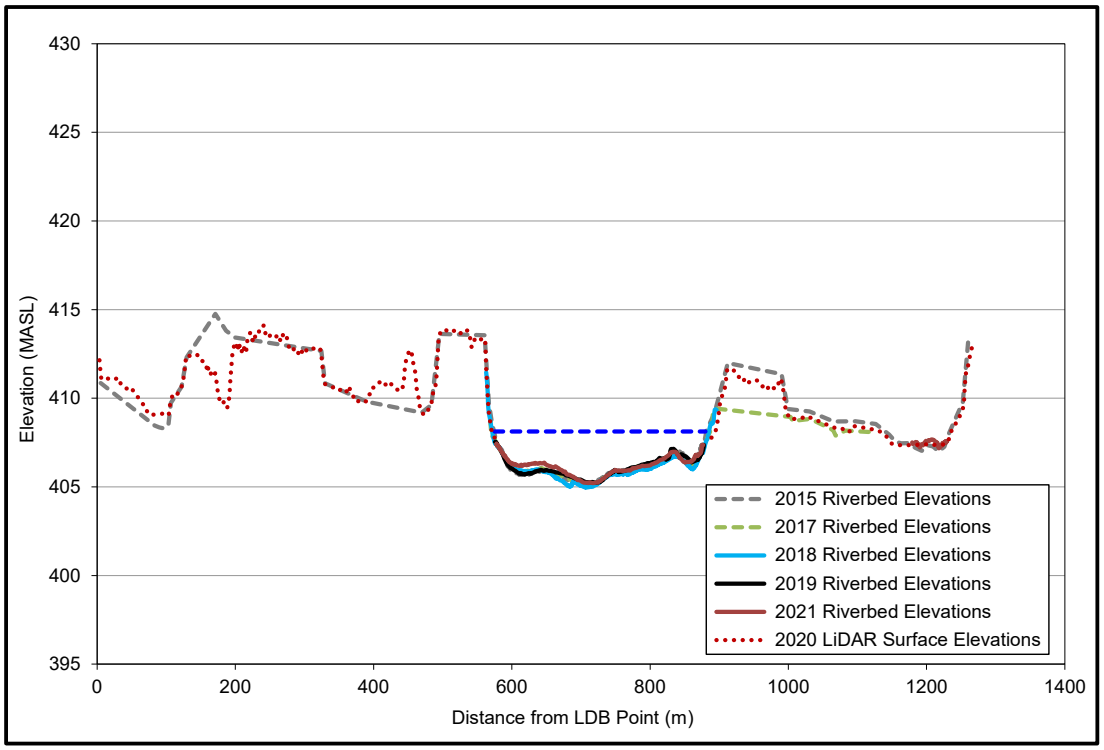


Figure B24: River cross-section at Transect #DS08, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

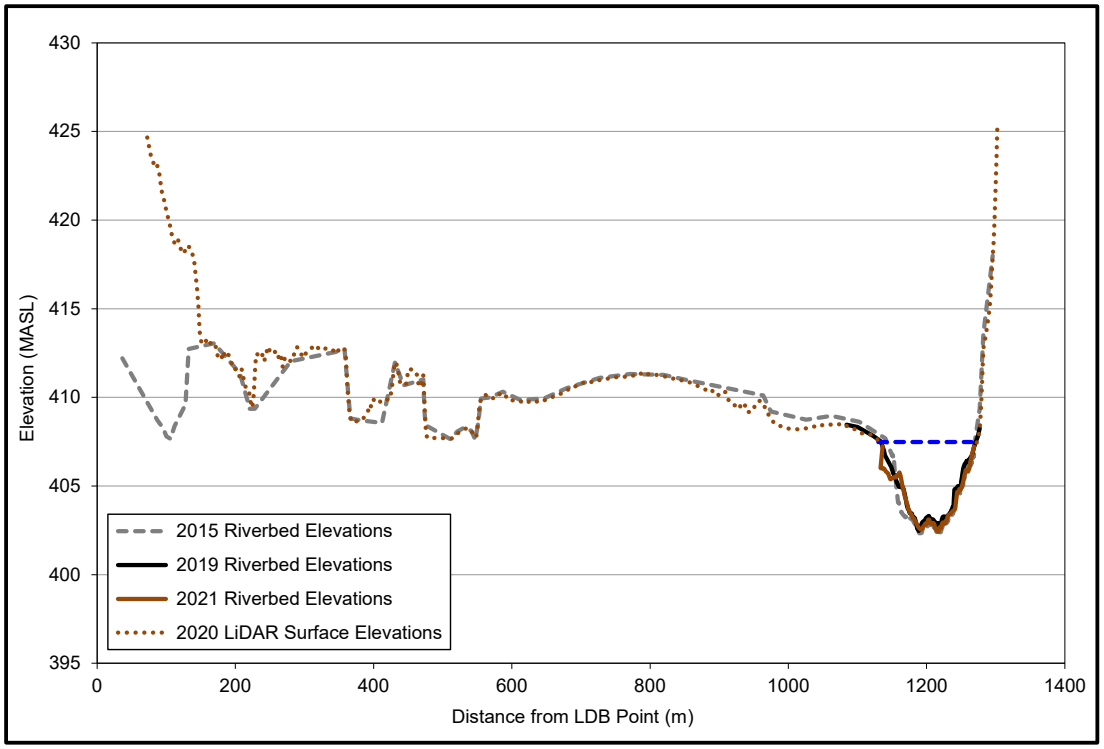


Figure B25: River cross-section at Transect #DS09, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

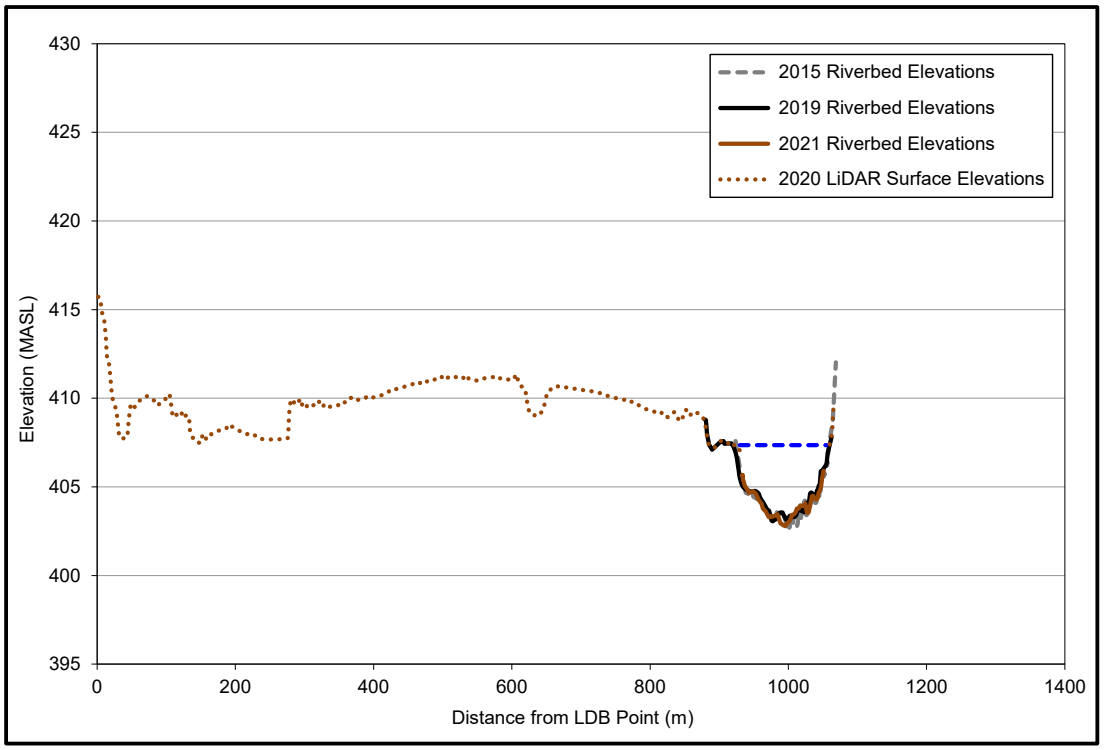


Figure B26: River cross-section at Transect #DS10, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

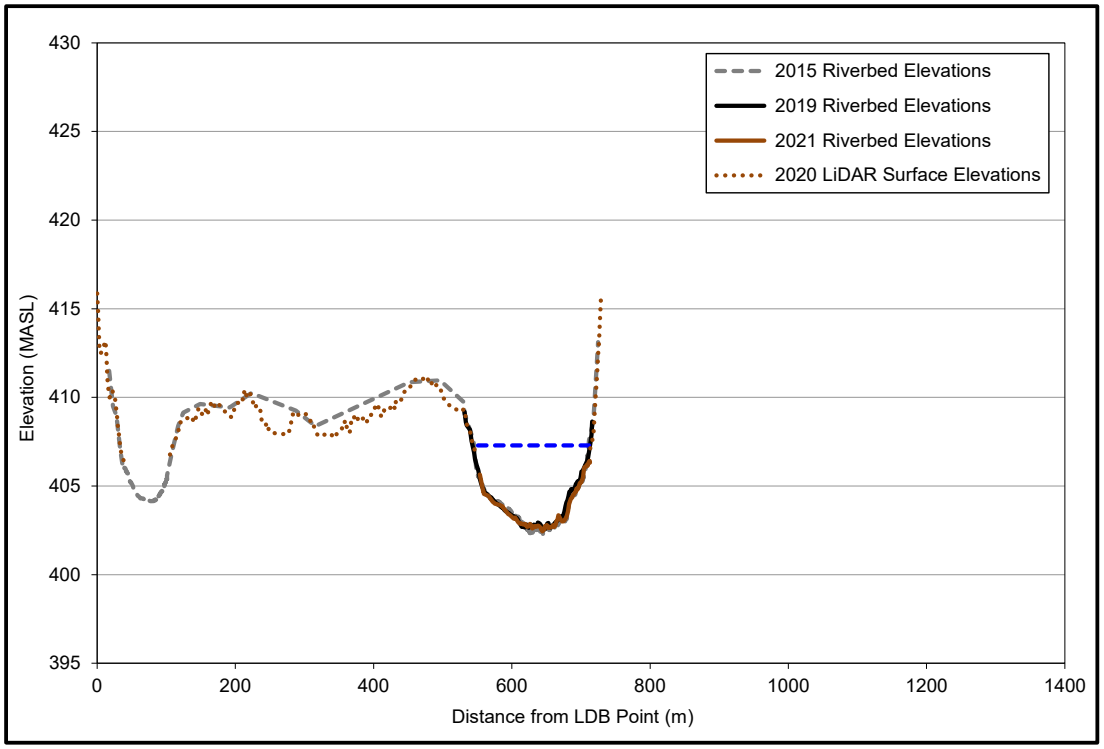


Figure B27: River cross-section at Transect #DS11, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

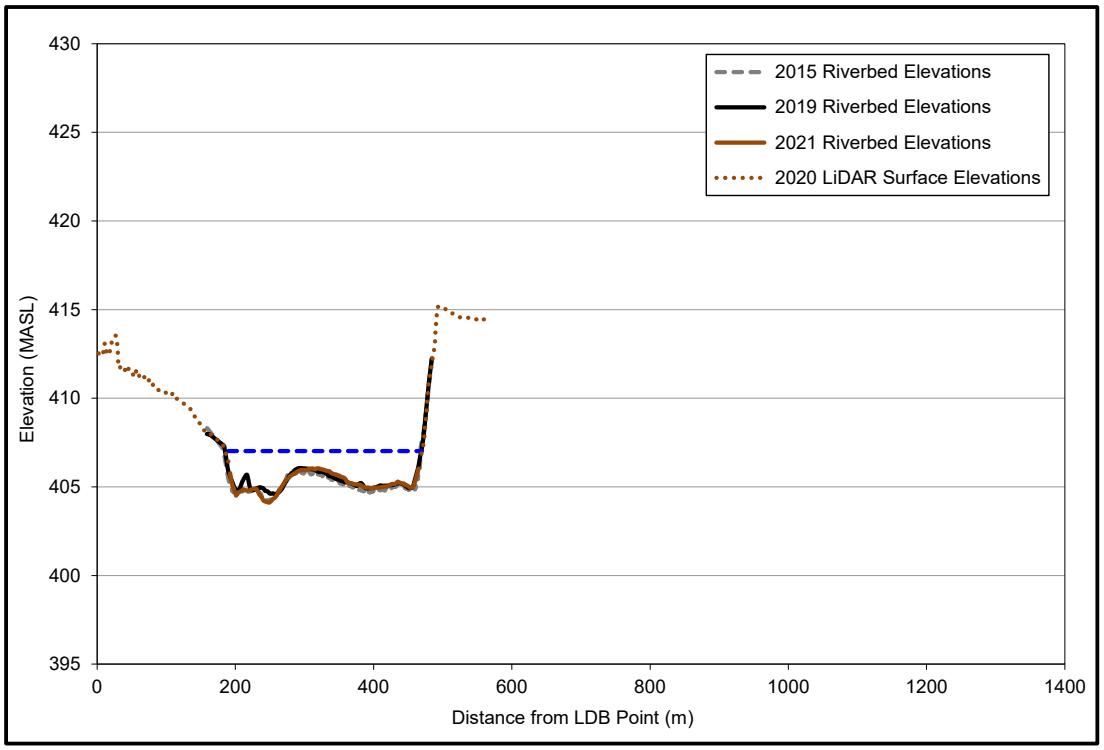


Figure B28: River cross-section at Transect #DS12, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

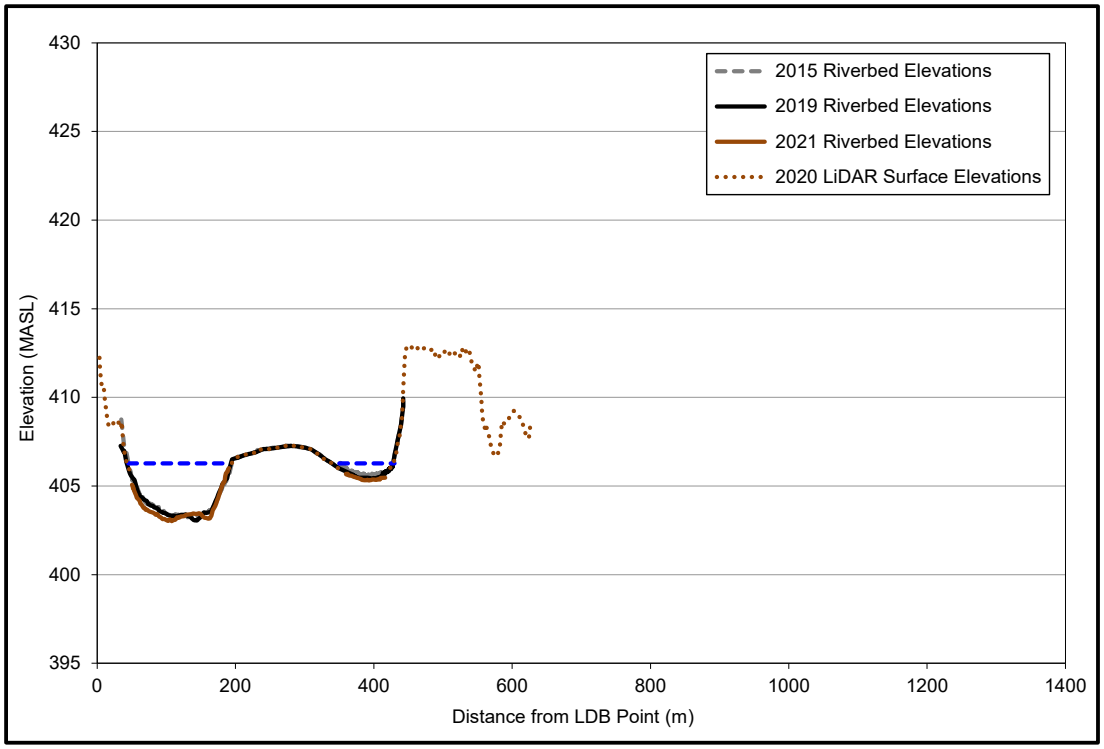


Figure B29: River cross-section at Transect #DS13, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

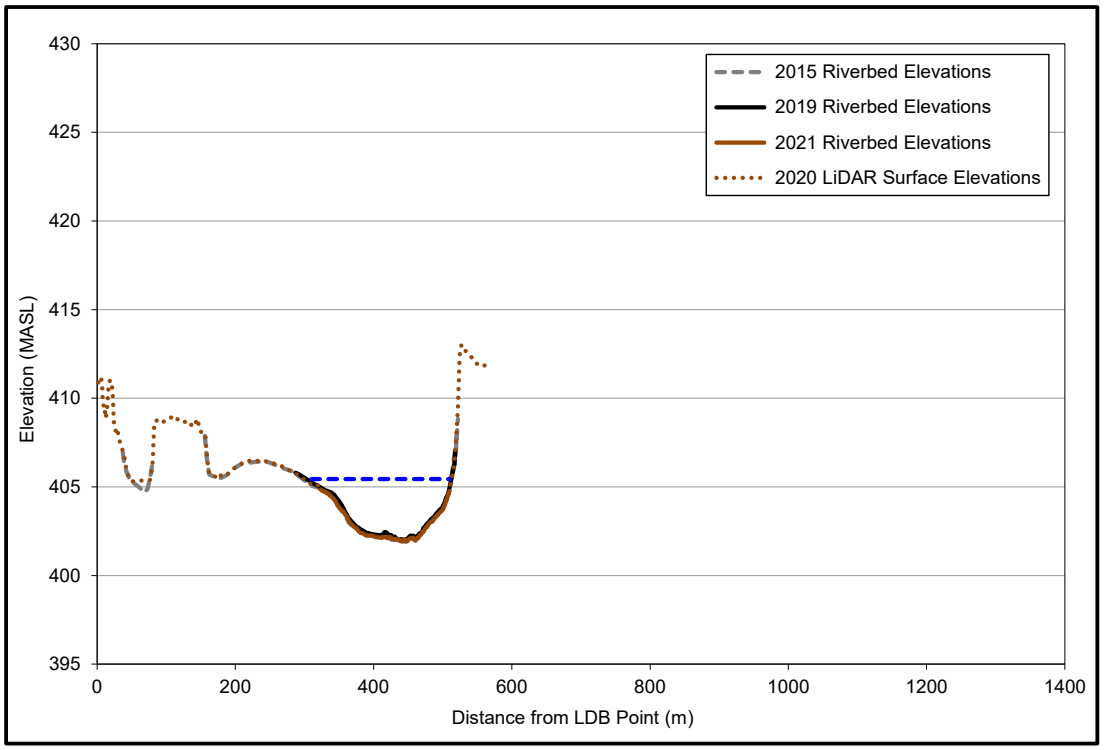


Figure B30: River cross-section at Transect #DS14, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

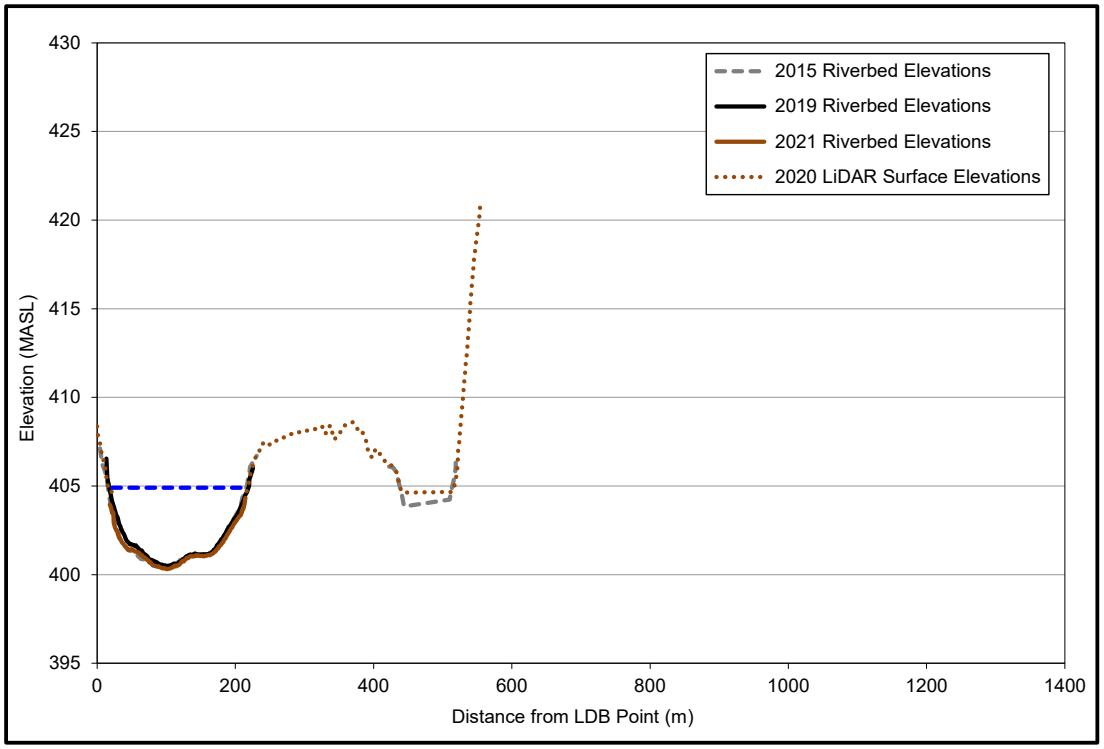


Figure B31: River cross-section at Transect #DS15, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

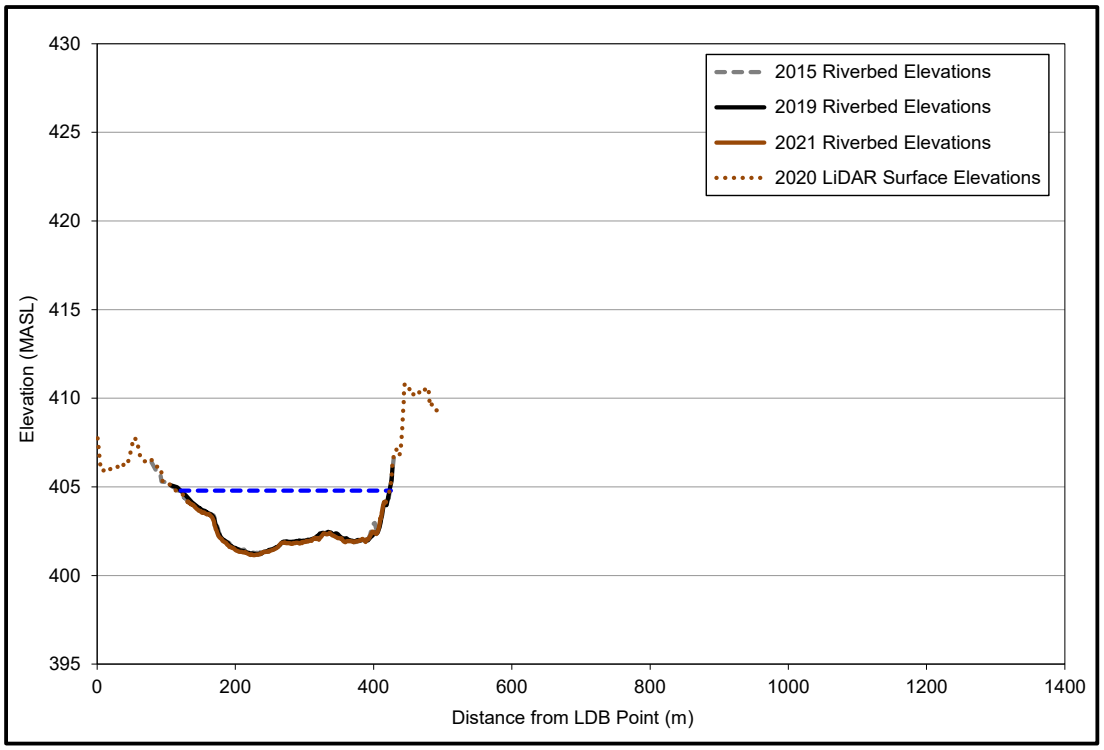


Figure B32: River cross-section at Transect #DS16, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

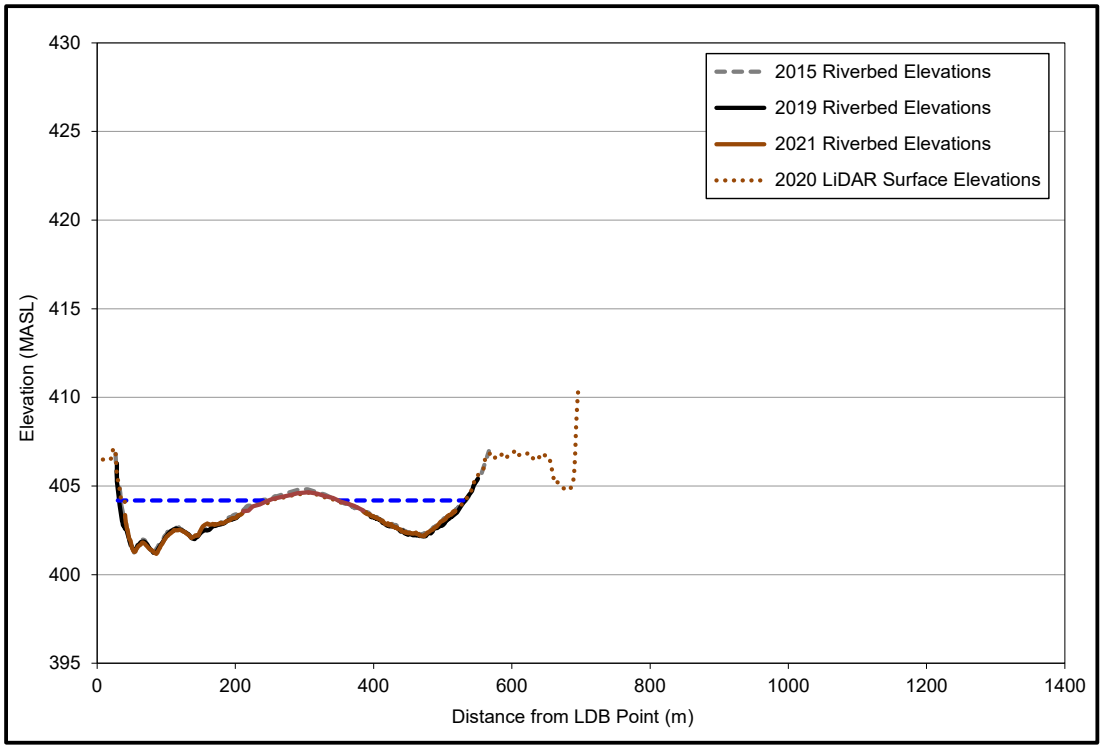


Figure B33: River cross-section at Transect #DS17, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

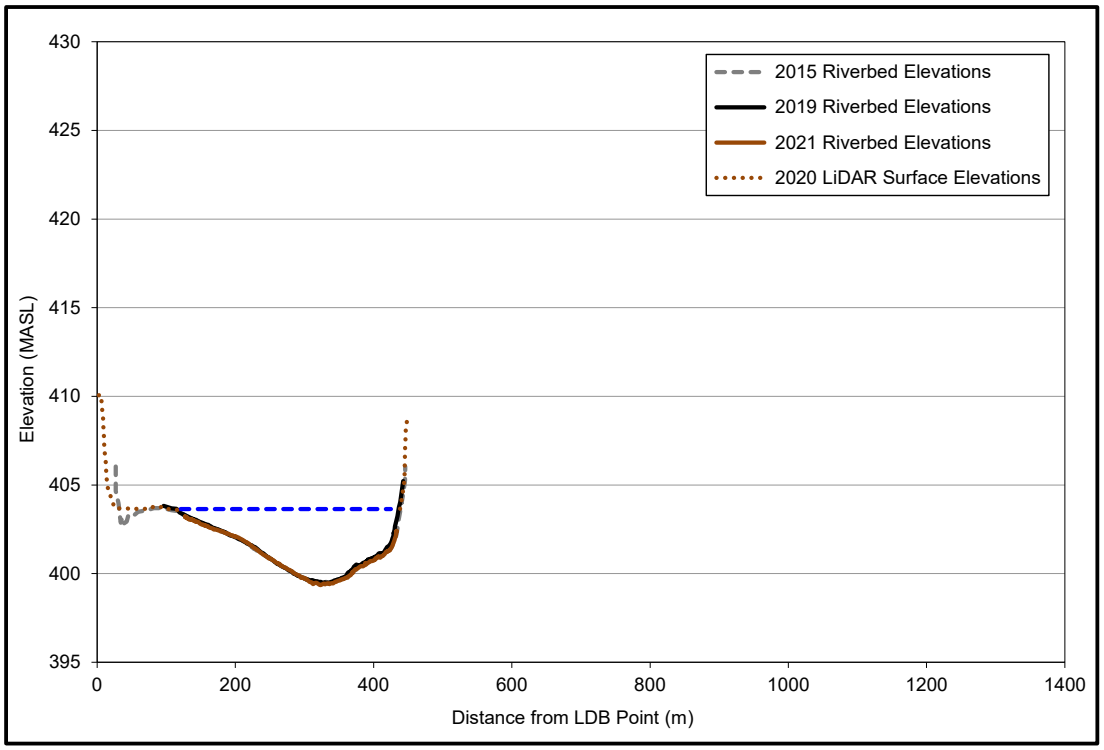


Figure B34: River cross-section at Transect #DS18, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

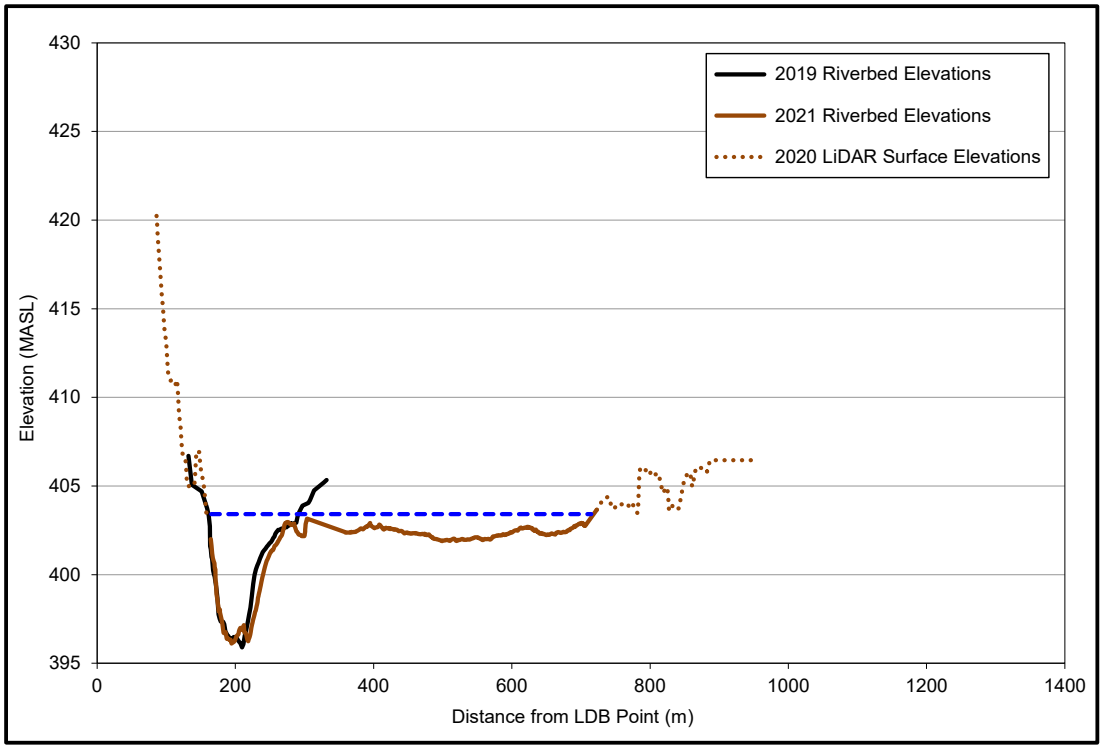


Figure B35: River cross-section at Transect #DS19, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

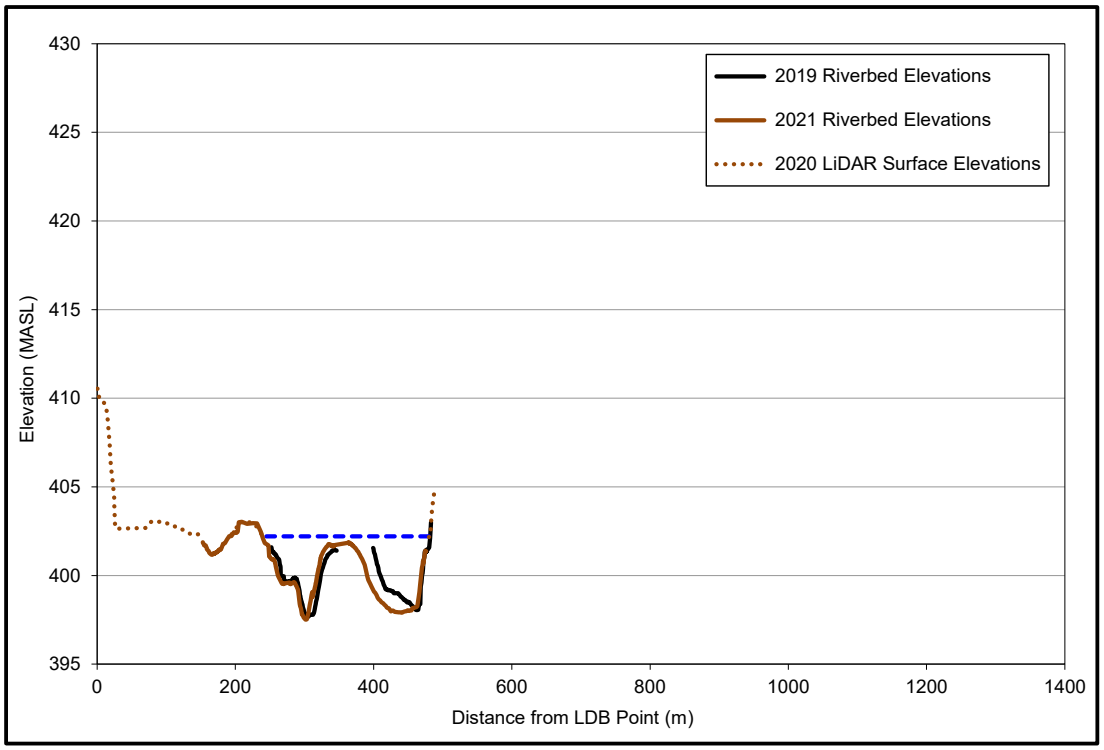


Figure B36: River cross-section at Transect #DS20, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

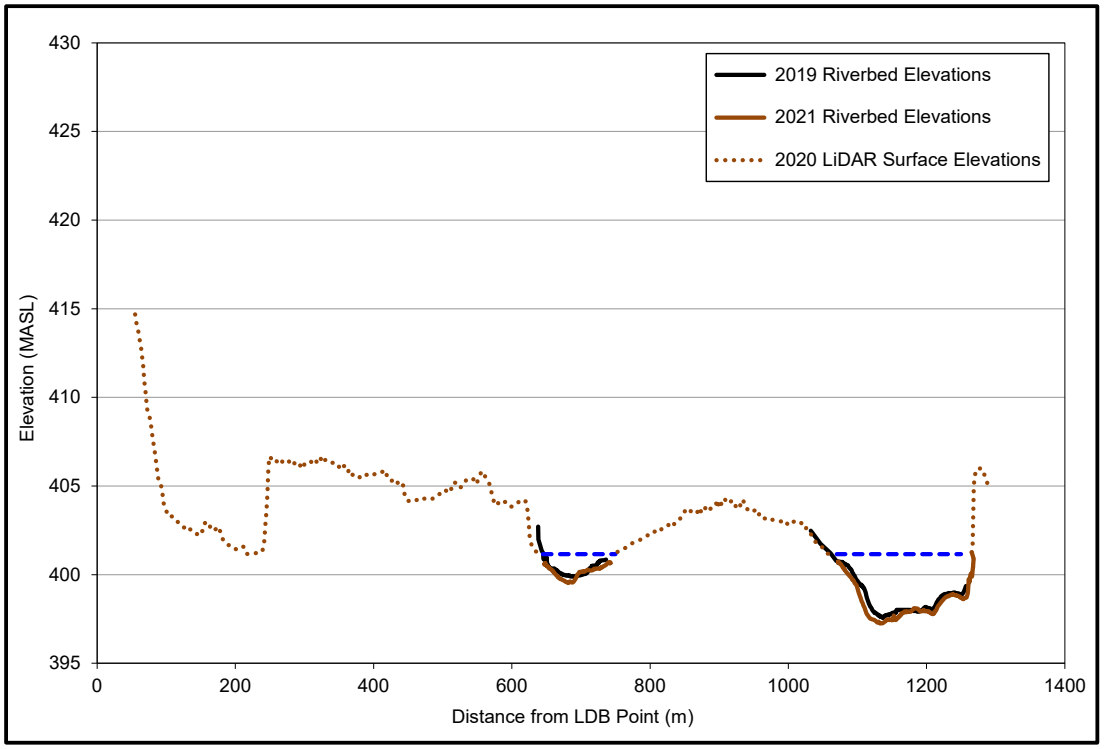


Figure B37: River cross-section at Transect #DS21, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

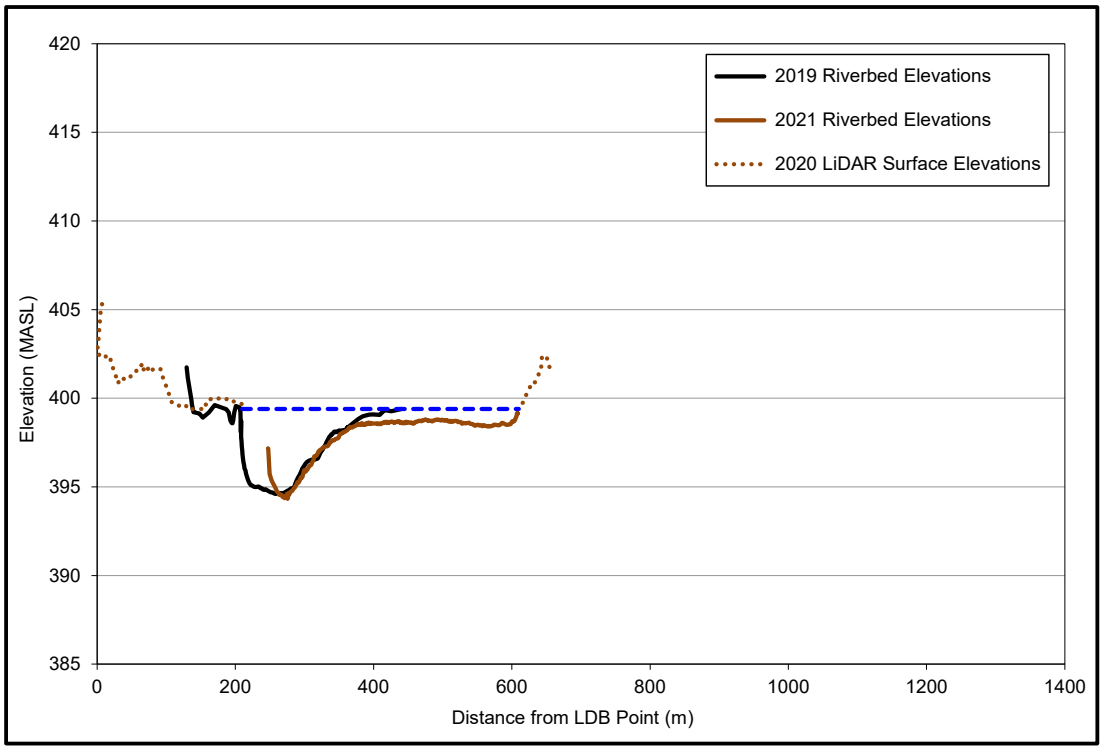


Figure B38: River cross-section at Transect #DS22, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey. The channel differences are attributed to a survey misalignment in the field in 2019.

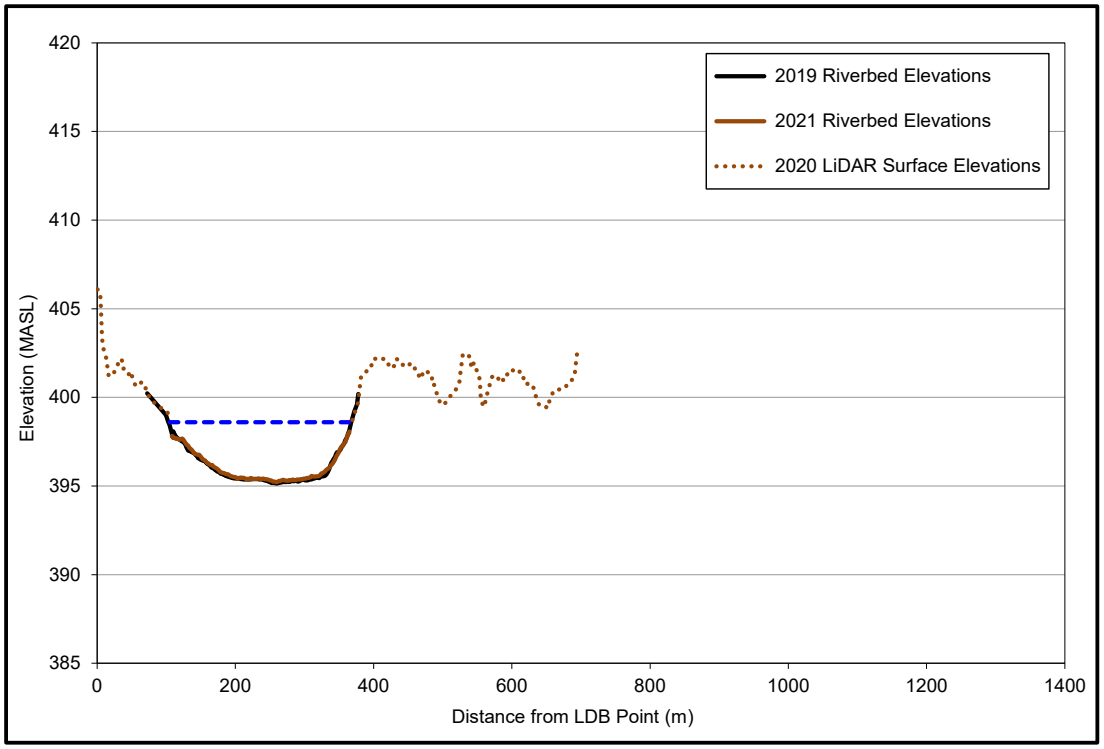


Figure B39: River cross-section at Transect #DS23, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

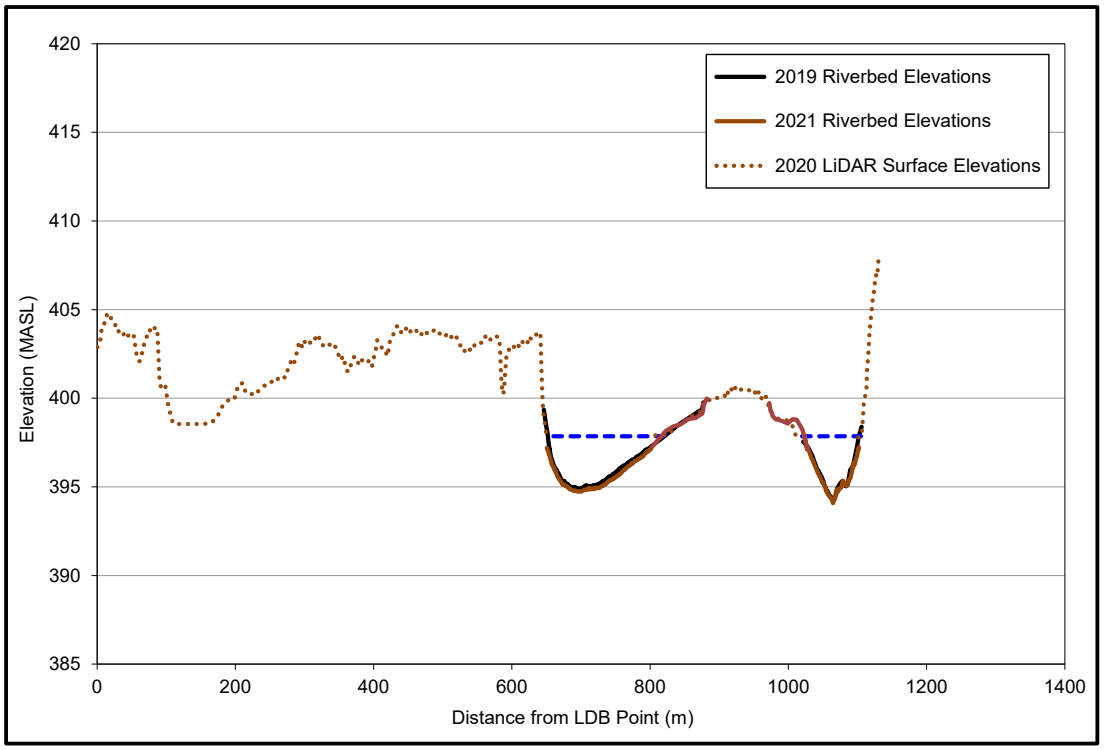


Figure B40: River cross-section at Transect #DS24, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

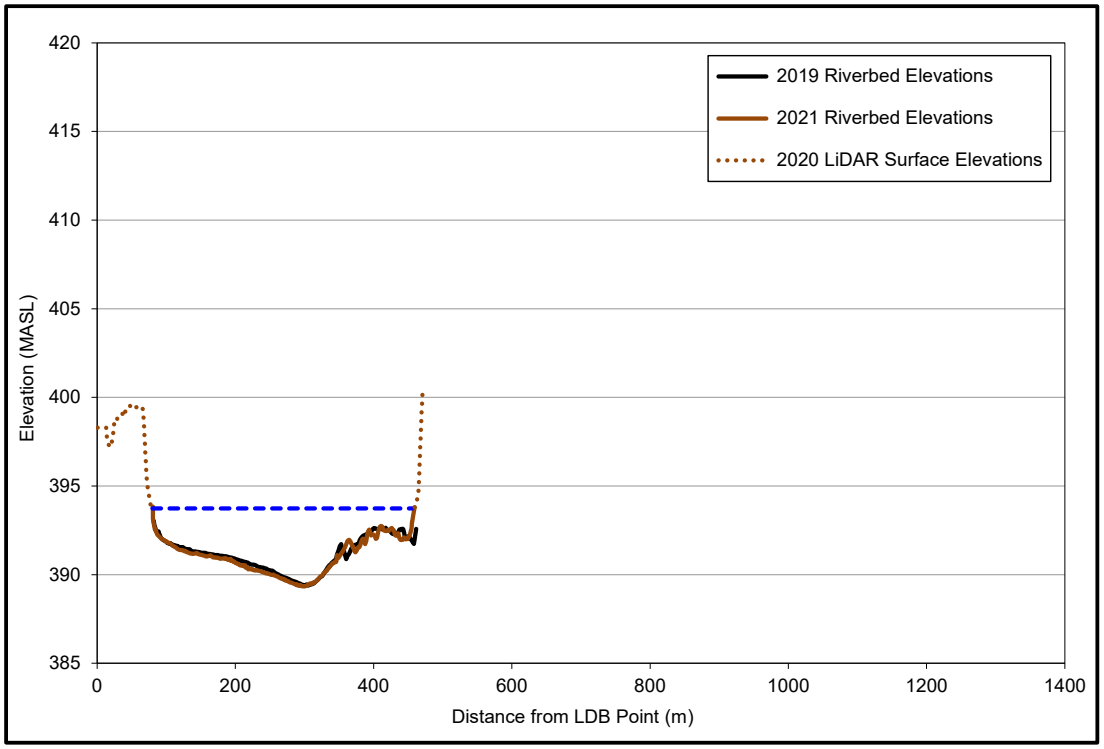


Figure B41: River cross-section at Transect #DS25, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

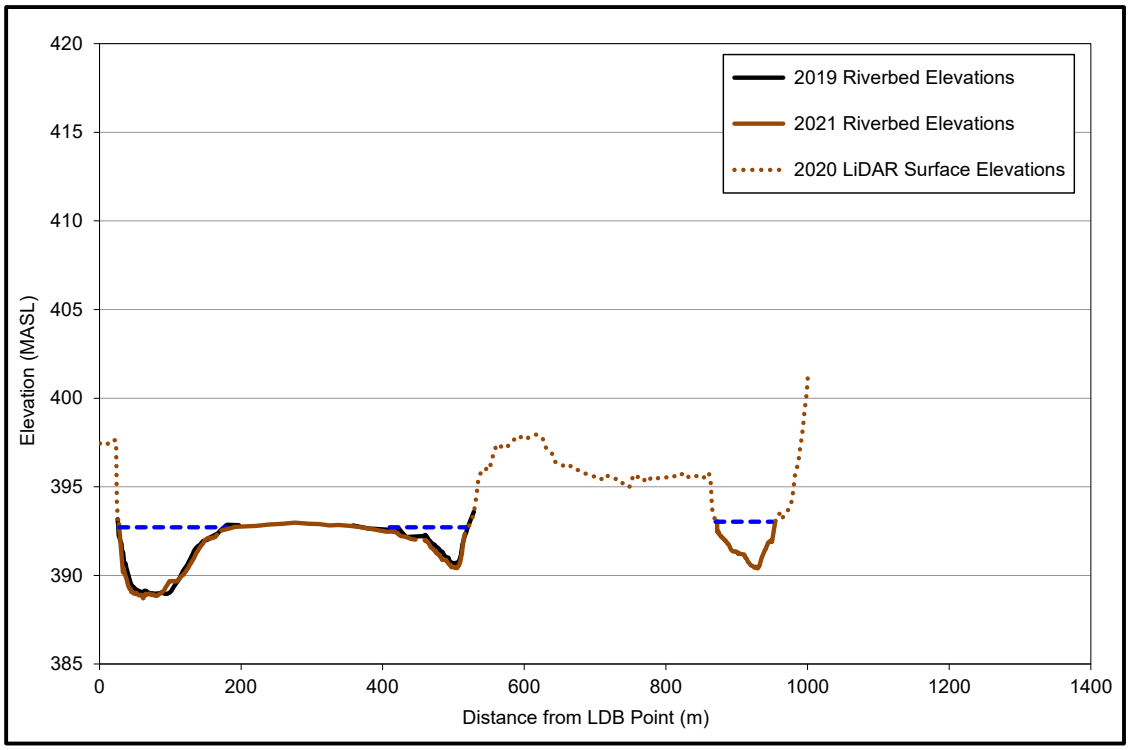


Figure B42: River cross-section at Transect #DS26, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

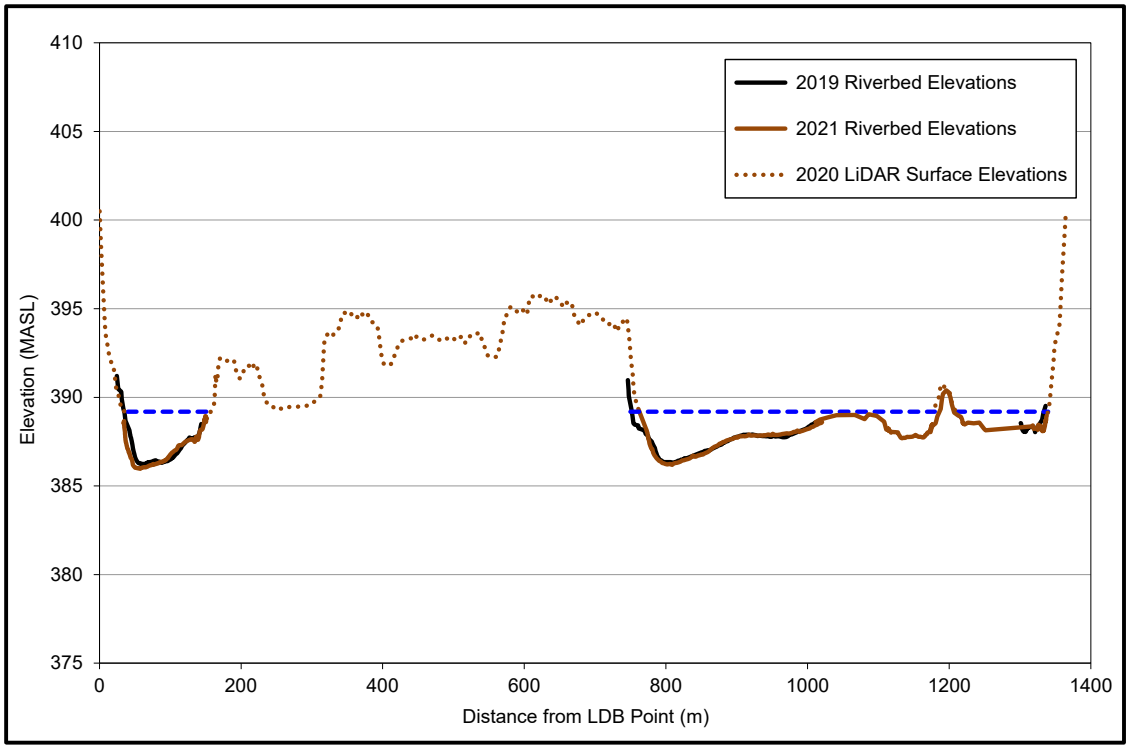


Figure B43: River cross-section at Transect #DS27, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

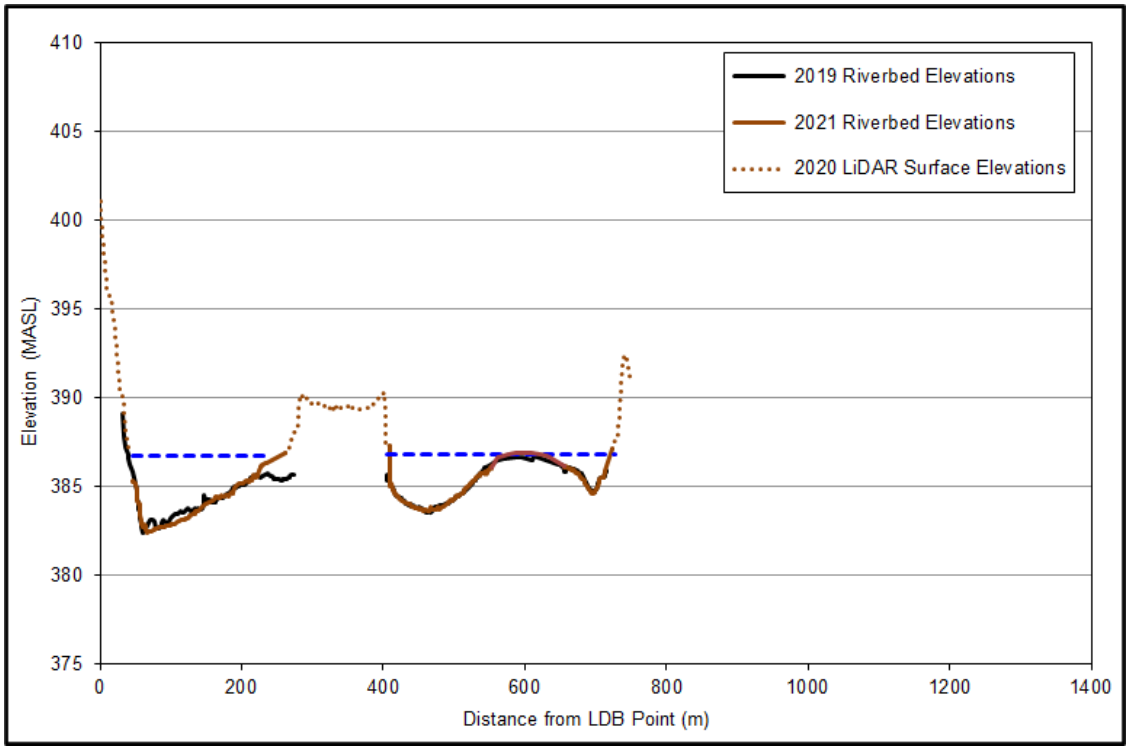


Figure B44: River cross-section at Transect #DS28, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

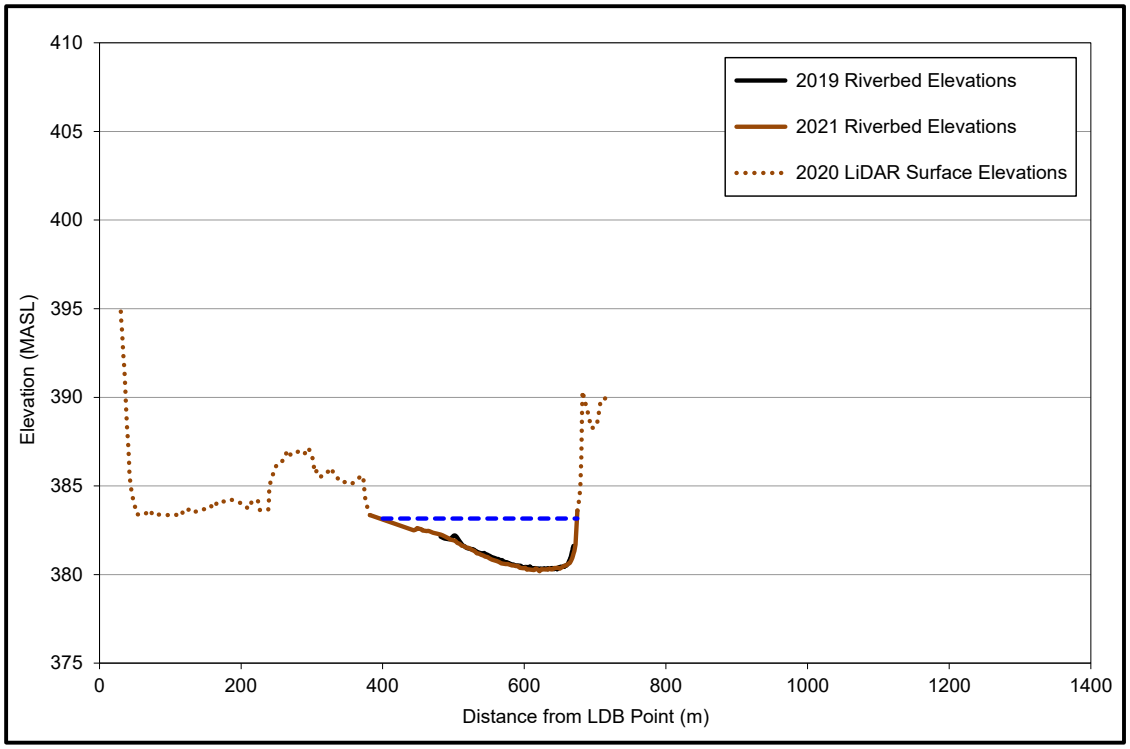


Figure B45: River cross-section at Transect #DS29, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

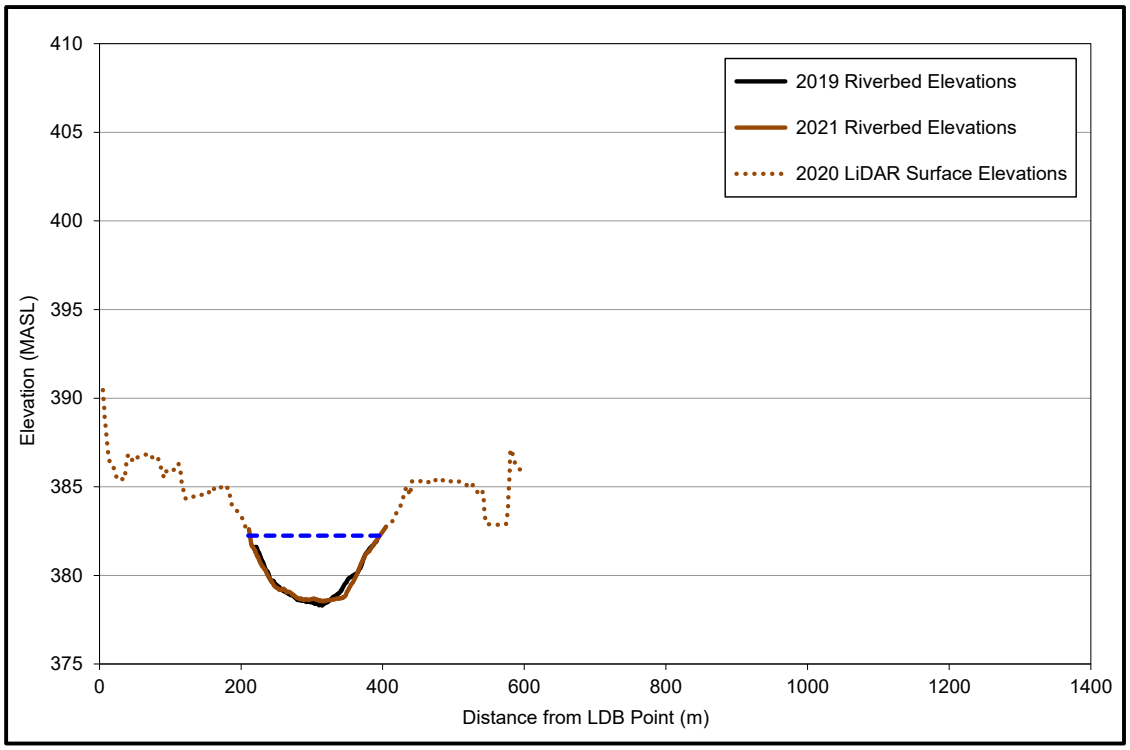


Figure B46: River cross-section at Transect #DS30, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

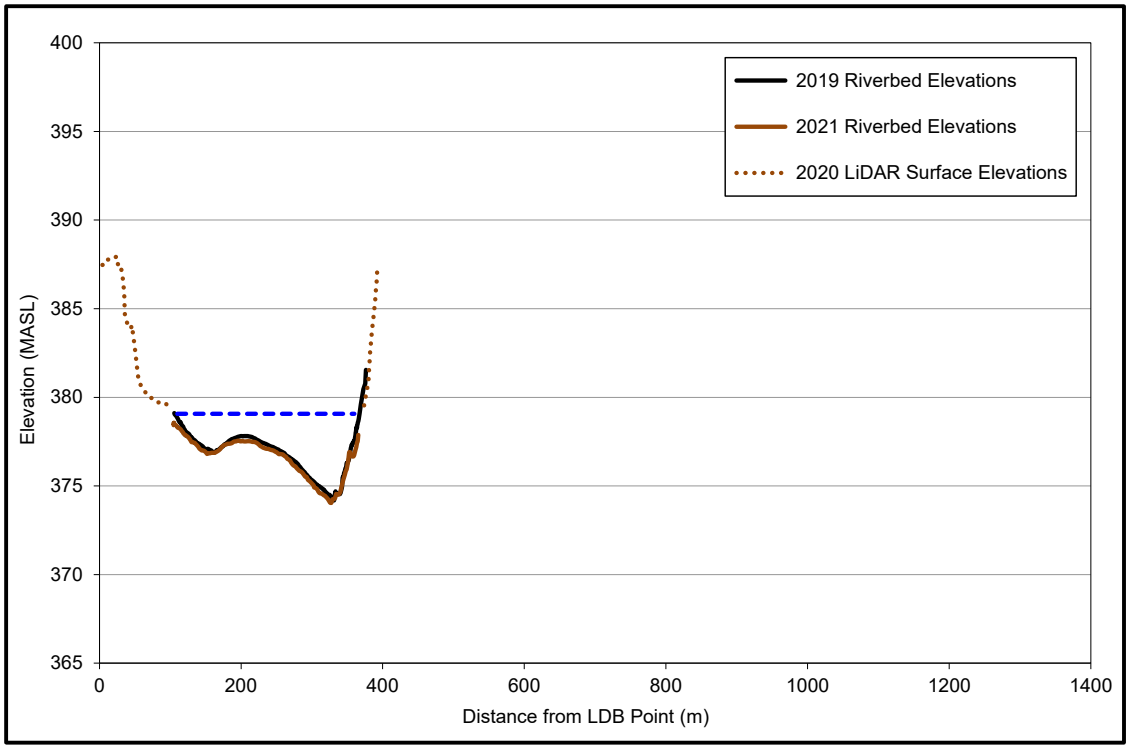


Figure B47: River cross-section at Transect #DS31, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

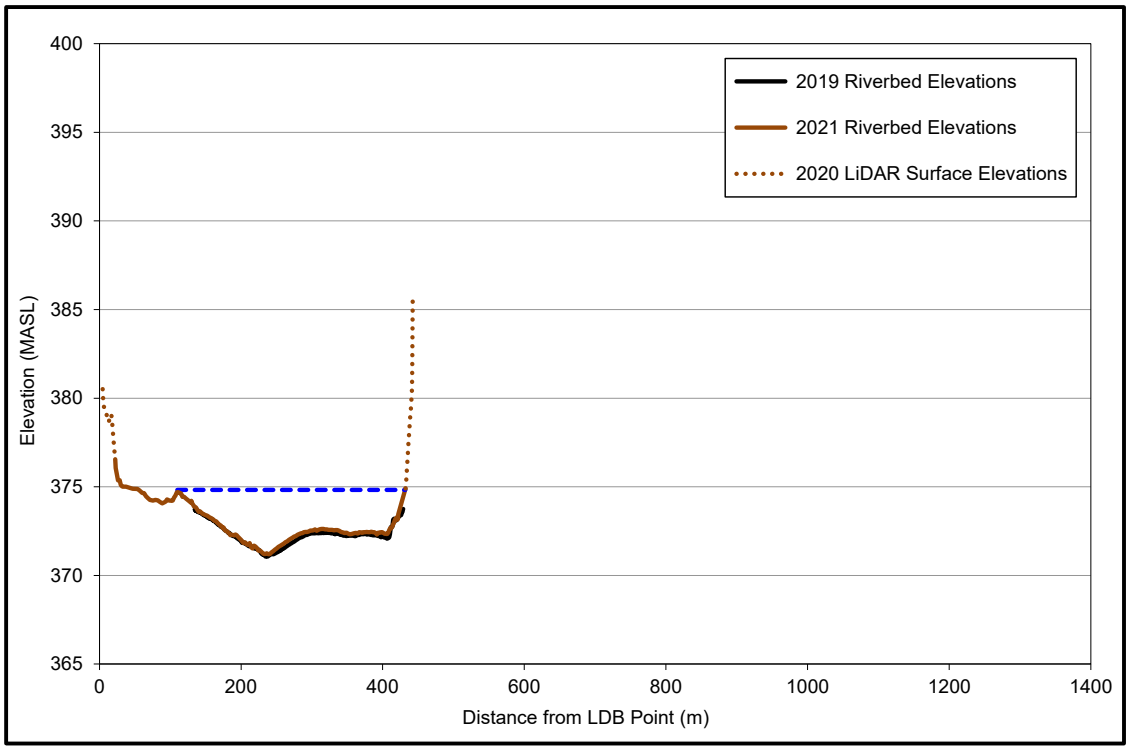


Figure B48: River cross-section at Transect #DS32, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

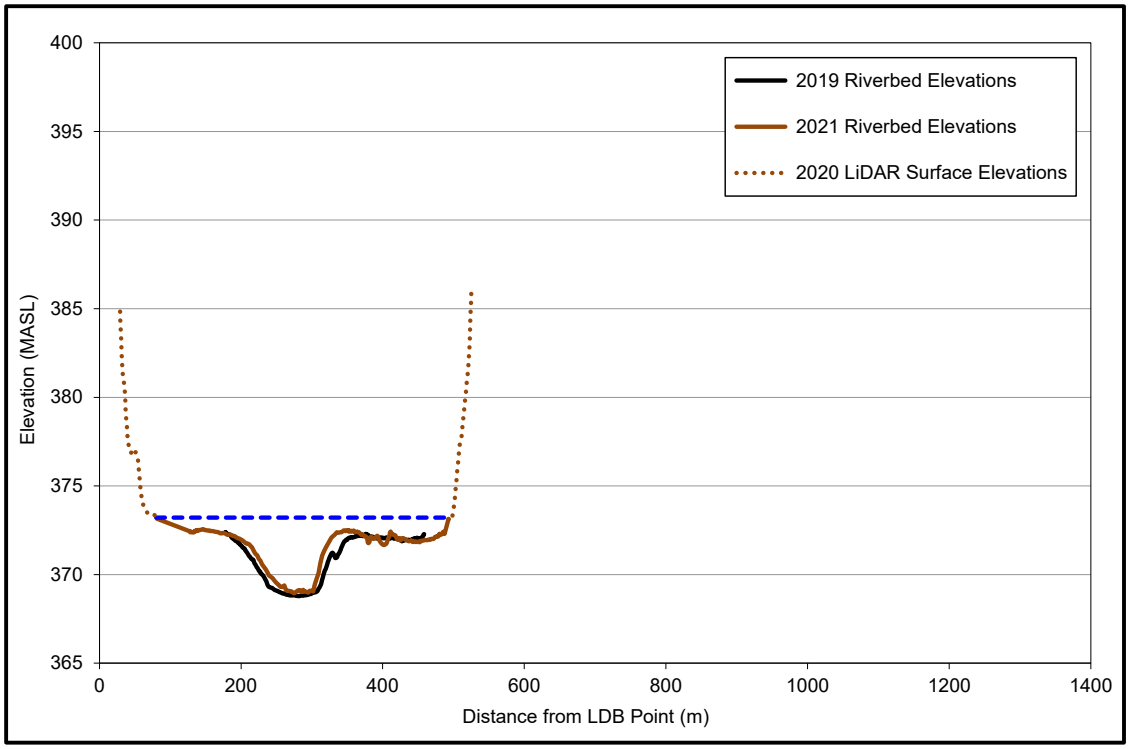


Figure B49: River cross-section at Transect #DS33, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey. The channel differences are attributed to a survey misalignment in the field in 2019.

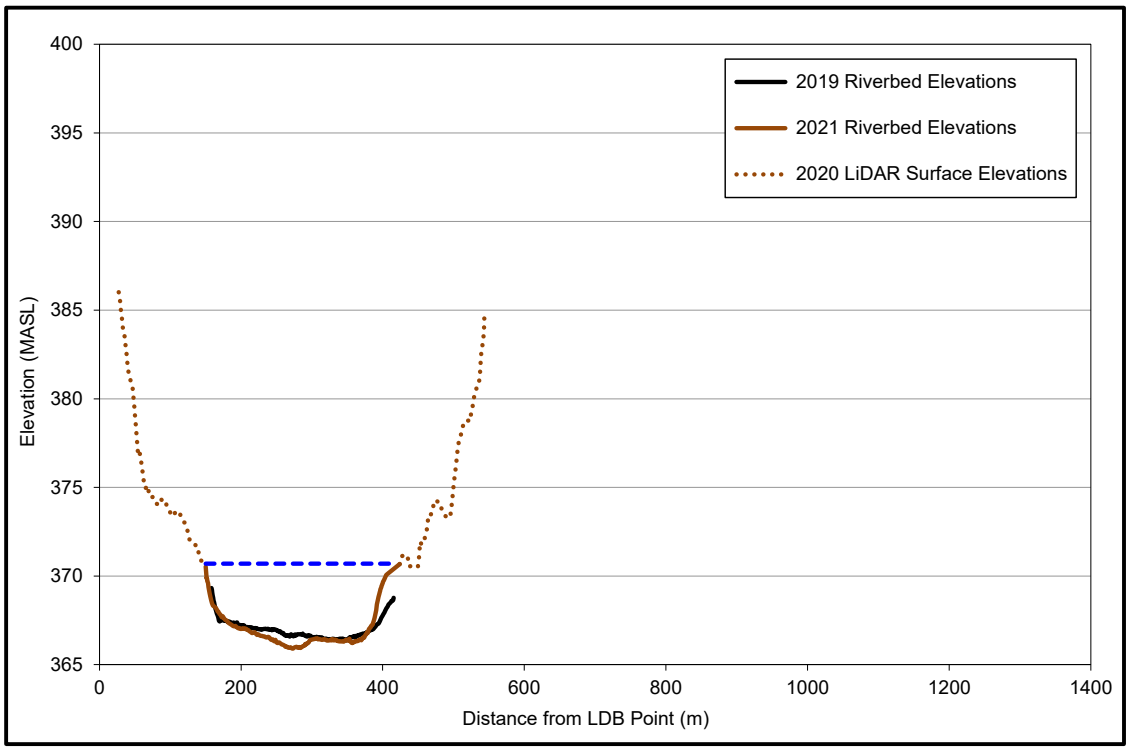


Figure B50: River cross-section at Transect #DS34, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

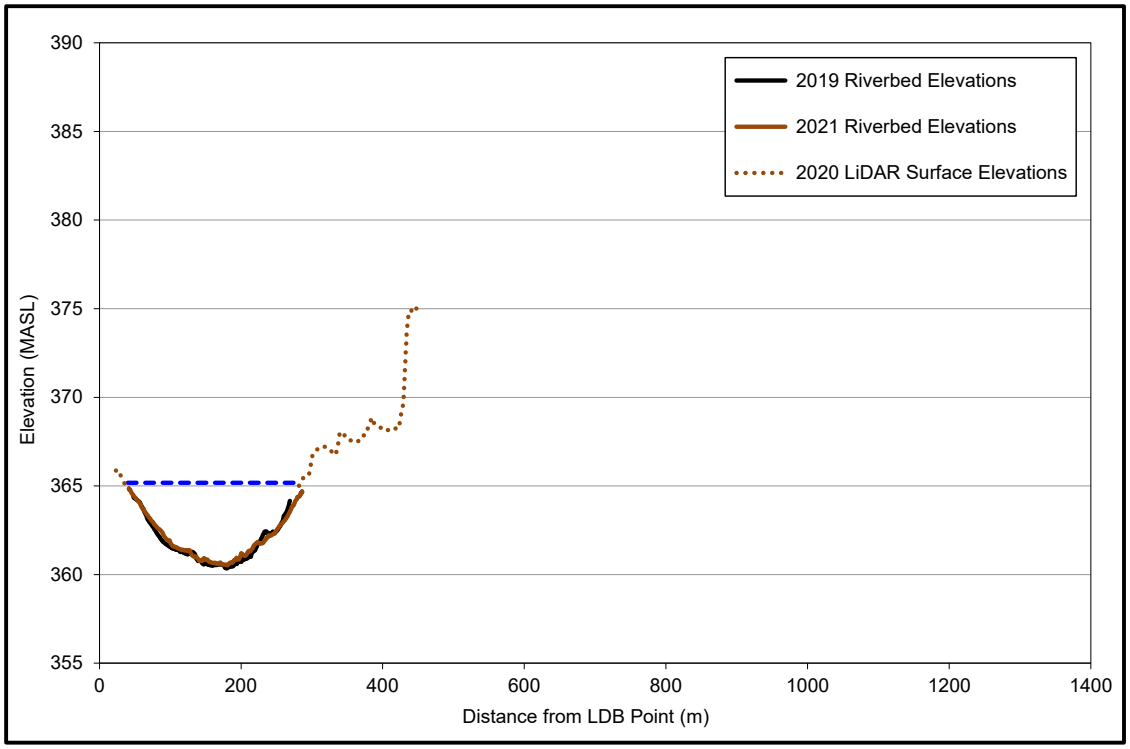


Figure B51: River cross-section at Transect #DS35, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

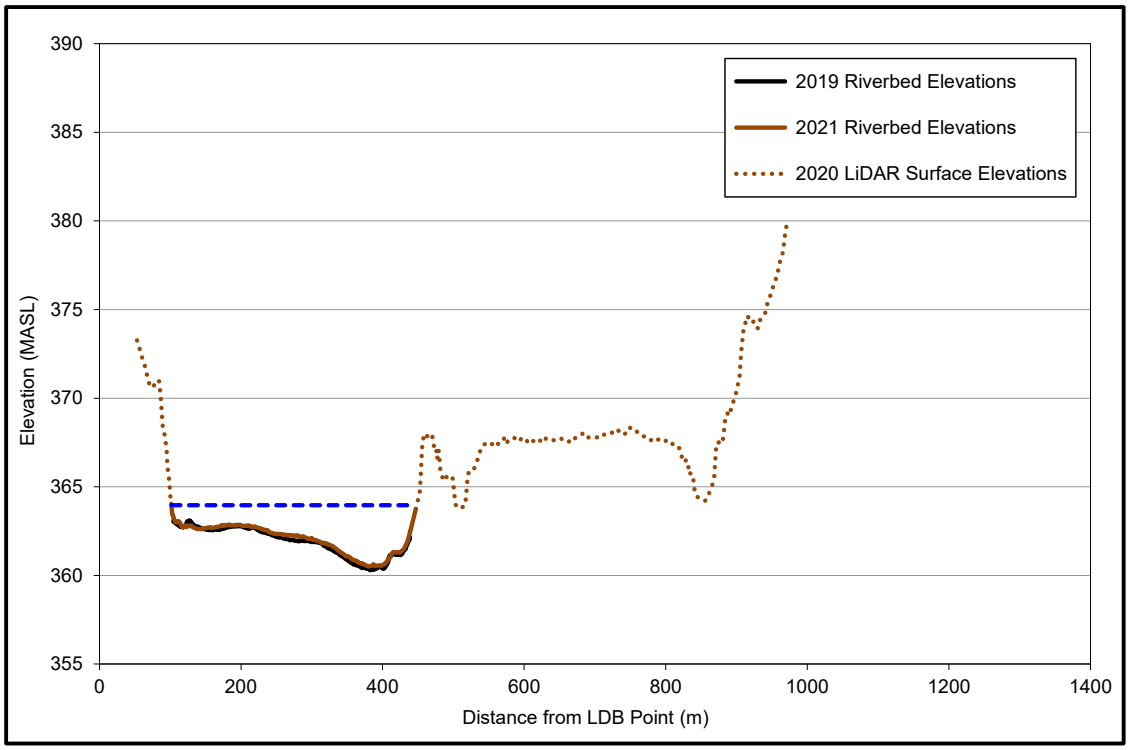


Figure B52: River cross-section at Transect #DS36, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

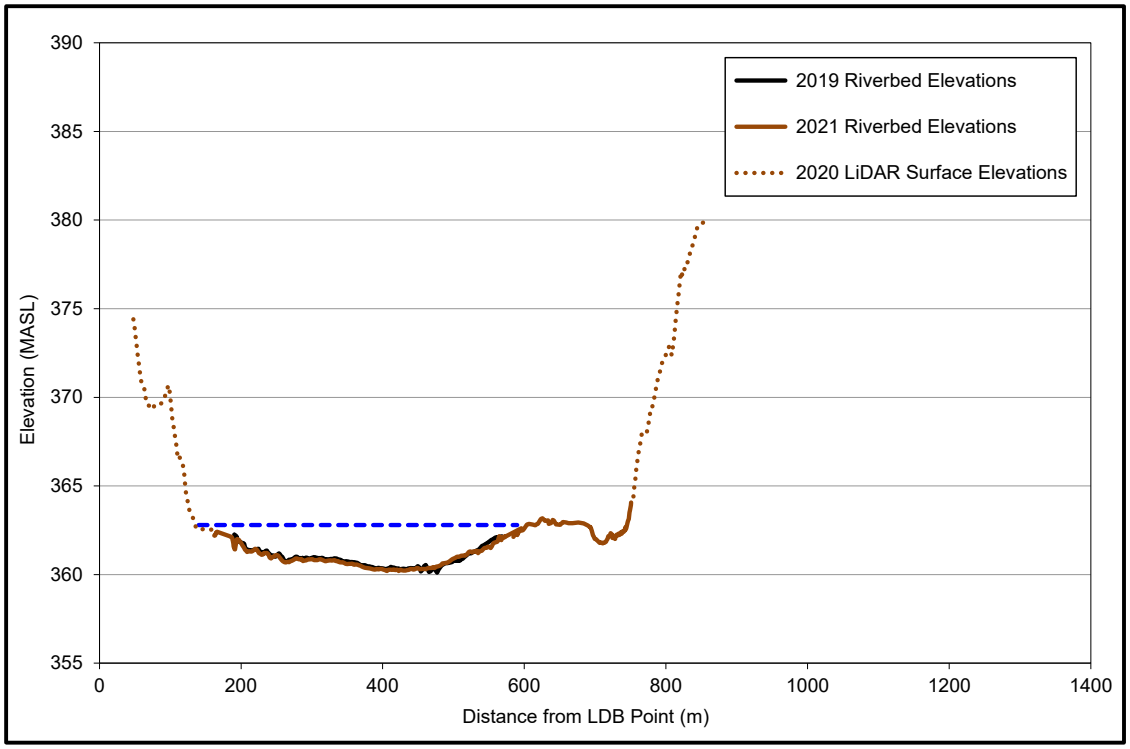


Figure B53: River cross-section at Transect #DS37, Peace River Physical Habitat Monitoring Program (Mon-3), 2021. The blue dotted line denotes water levels at the time of the 2021 survey.

HISTORICAL CROSS-SECTIONS

This section presents the historical cross-sections surveyed on Peace River between 1968 and 2005. The cross-section locations are shown in Figure 54.

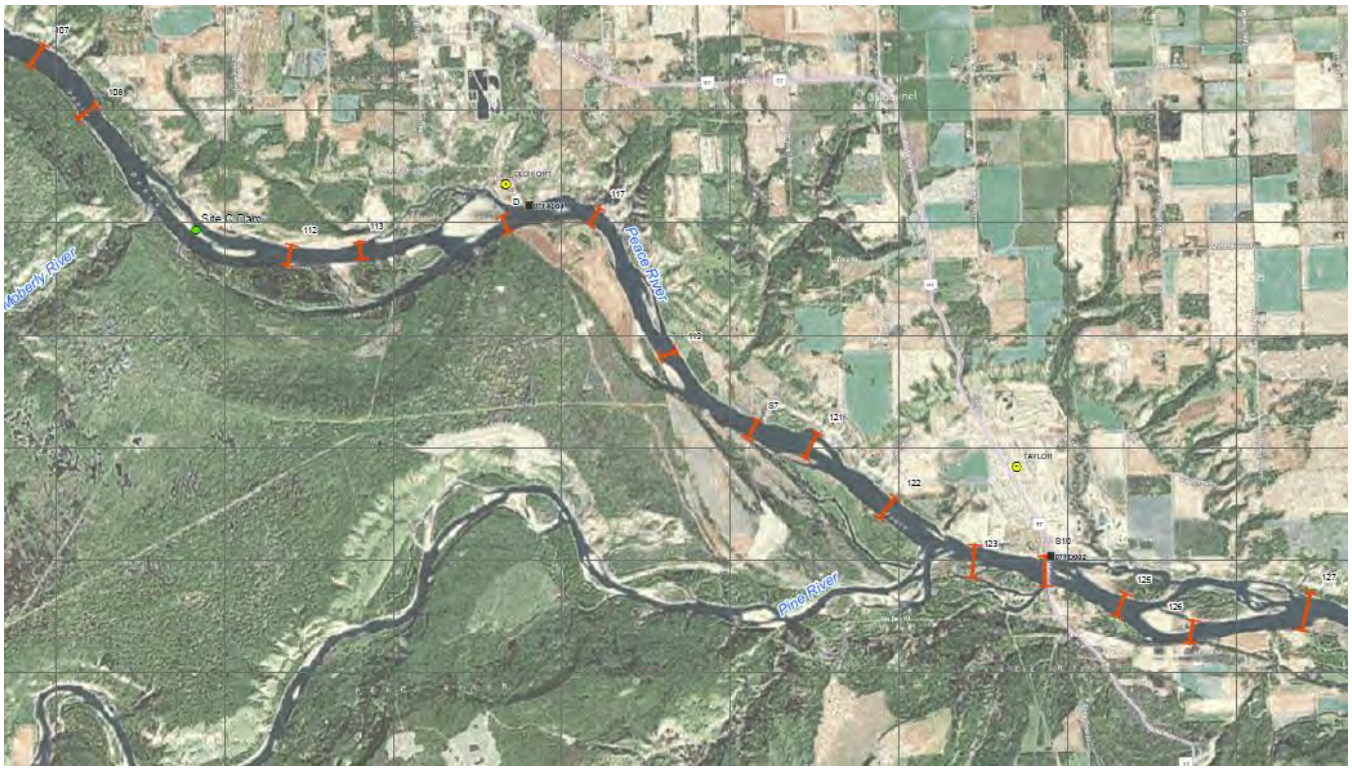
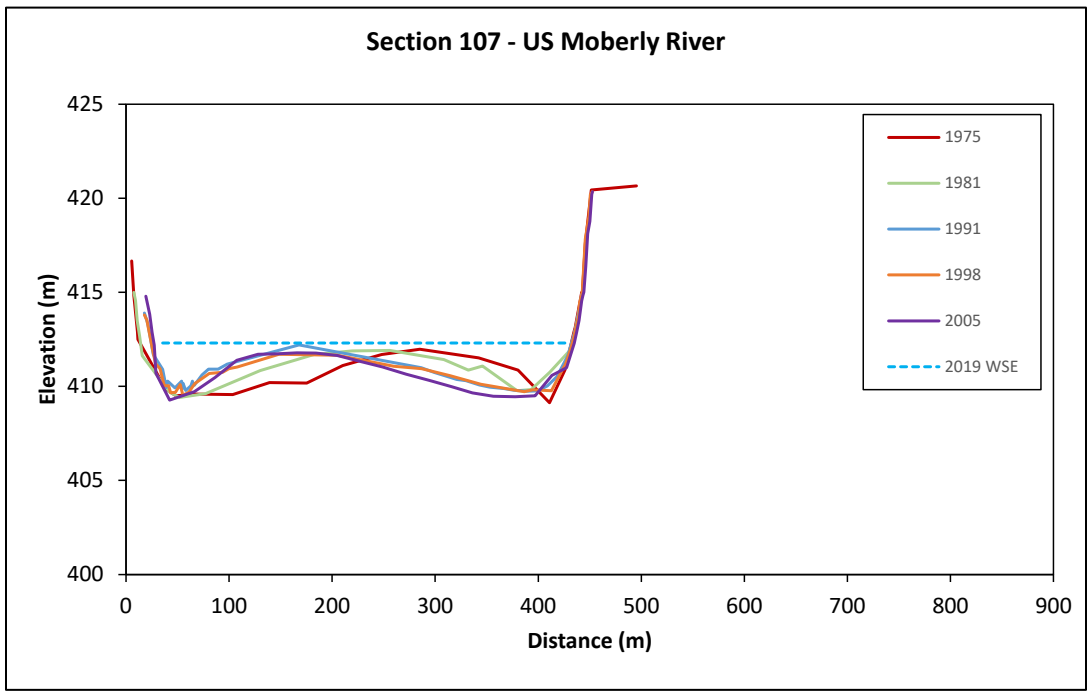
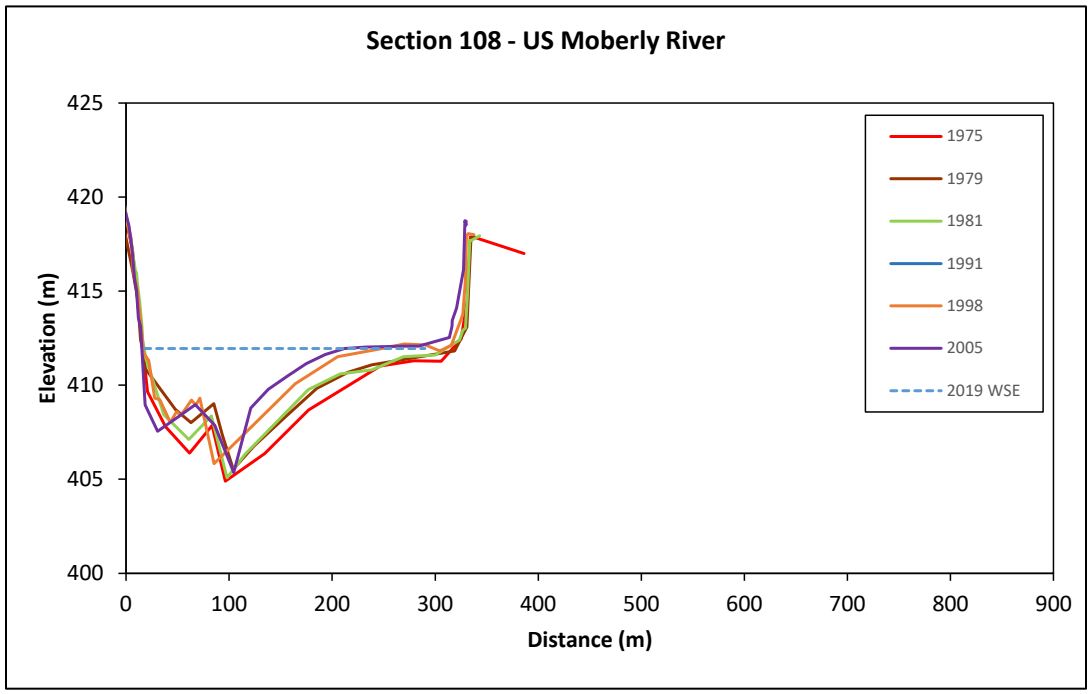
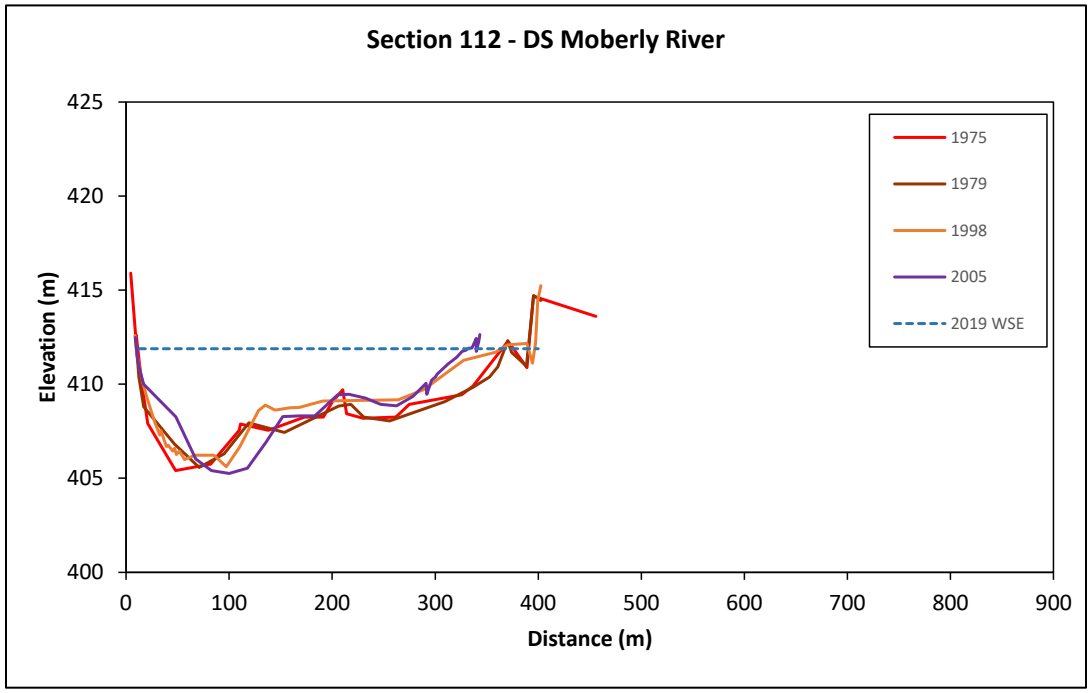
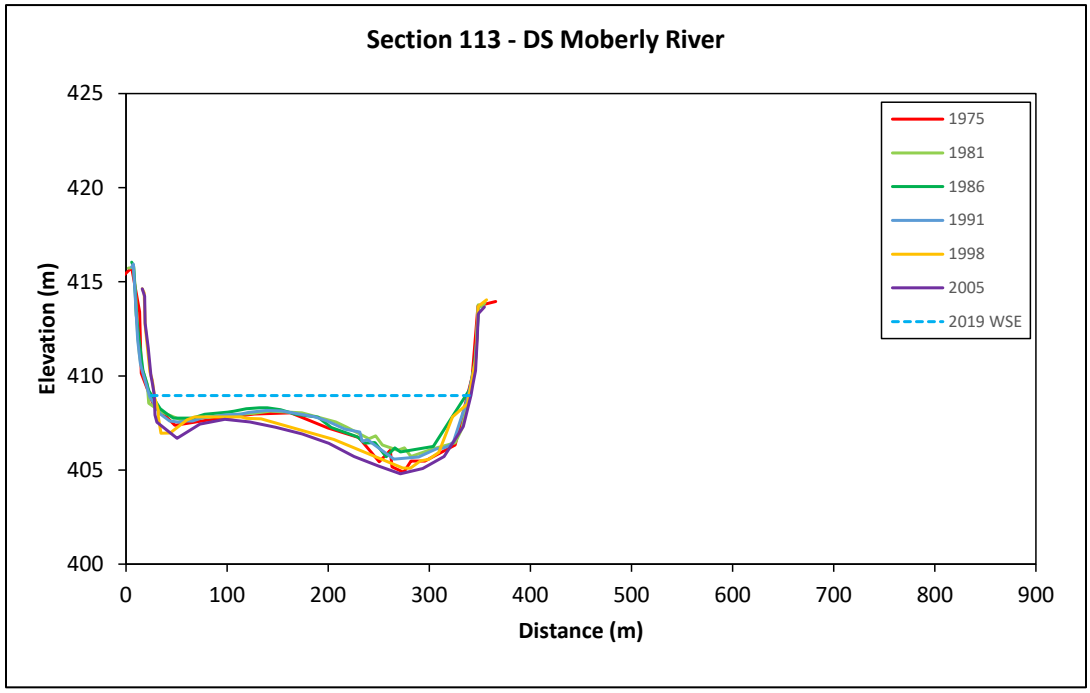


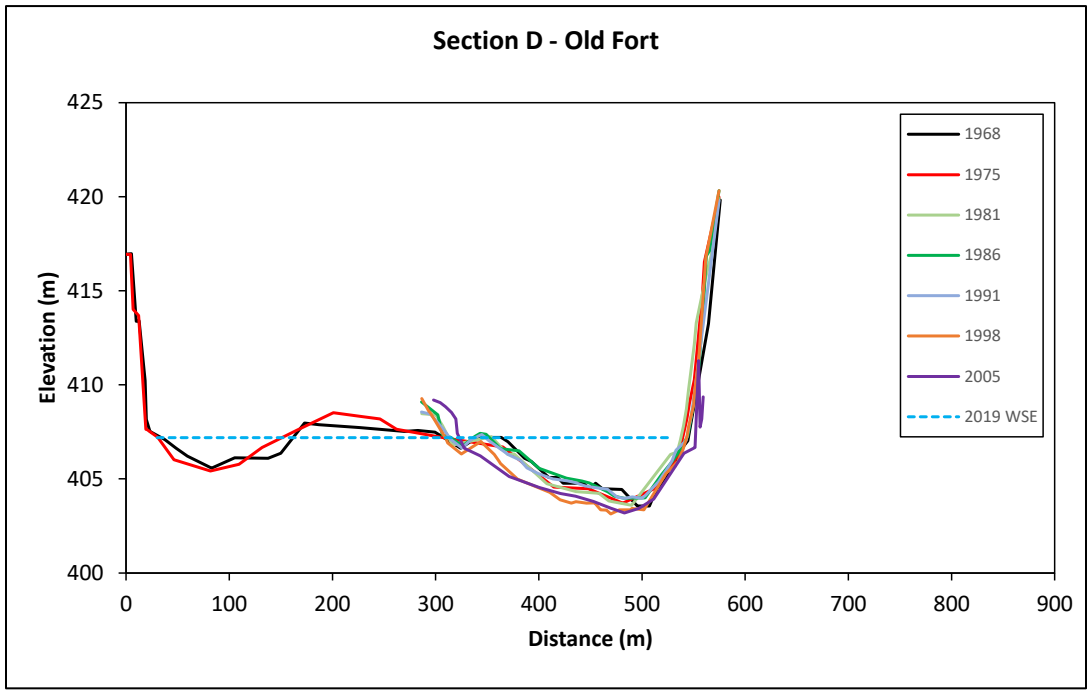
Figure 54: Historical Cross-Section Locations (1968 to 2005)

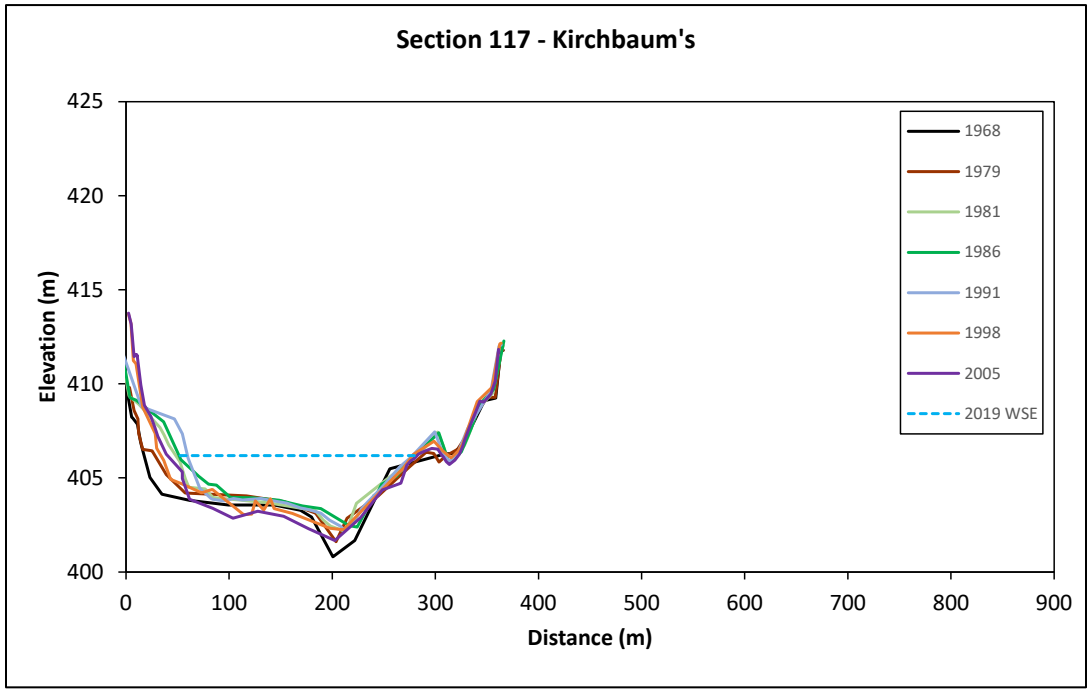


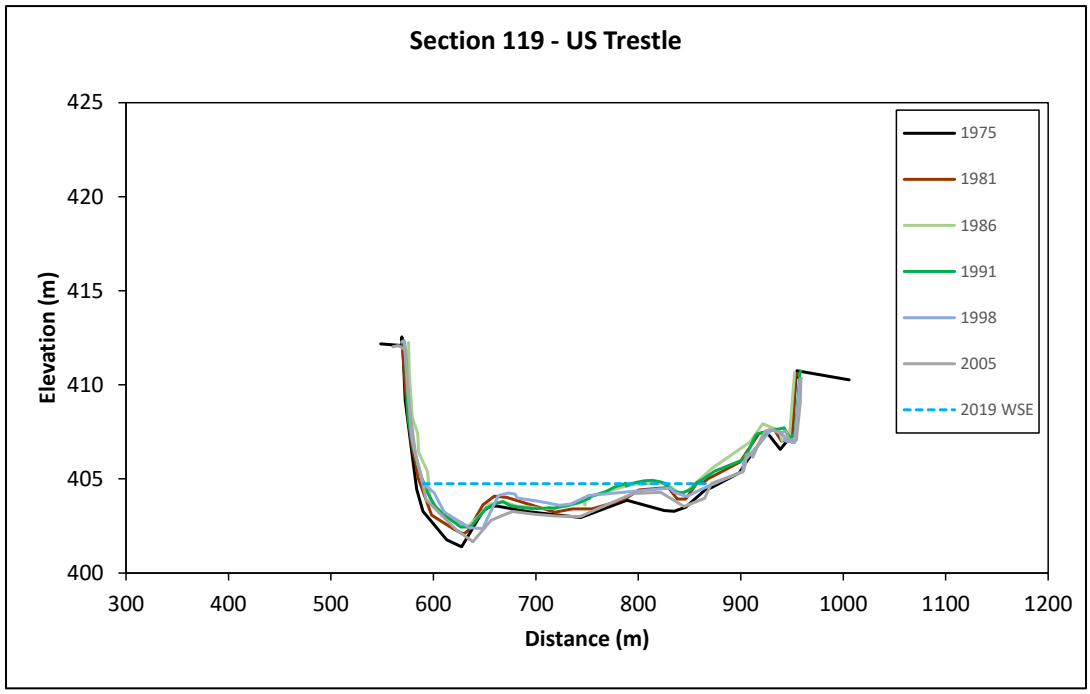

Section 108 - US Moberly River
Elevation (m)
425
420
415
410
405
400
0
100
200
300
400
500
600
700
800
900
Distance (m)
1975
1979
1981
1991
1998
2005
2019 WSE

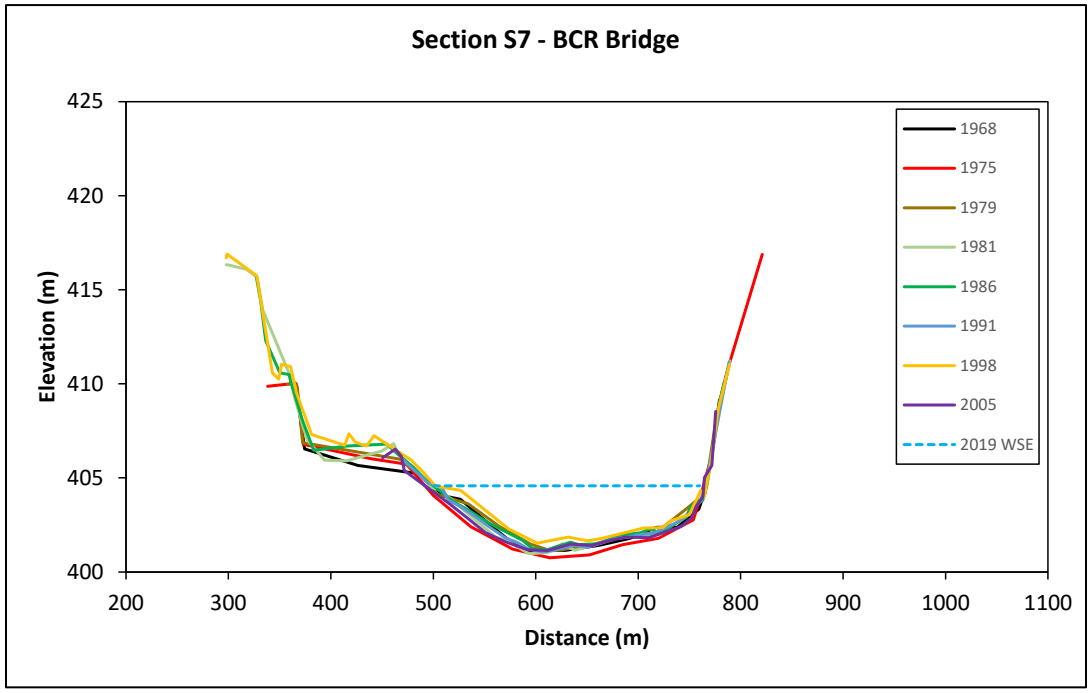

Section 112 - DS Moberly River
Elevation (m)
425
420
415
410
405
400
0
100
200
300
400
500
600
700
800
900
Distance (m)
1975
1979
1998
2005
2019 WSE

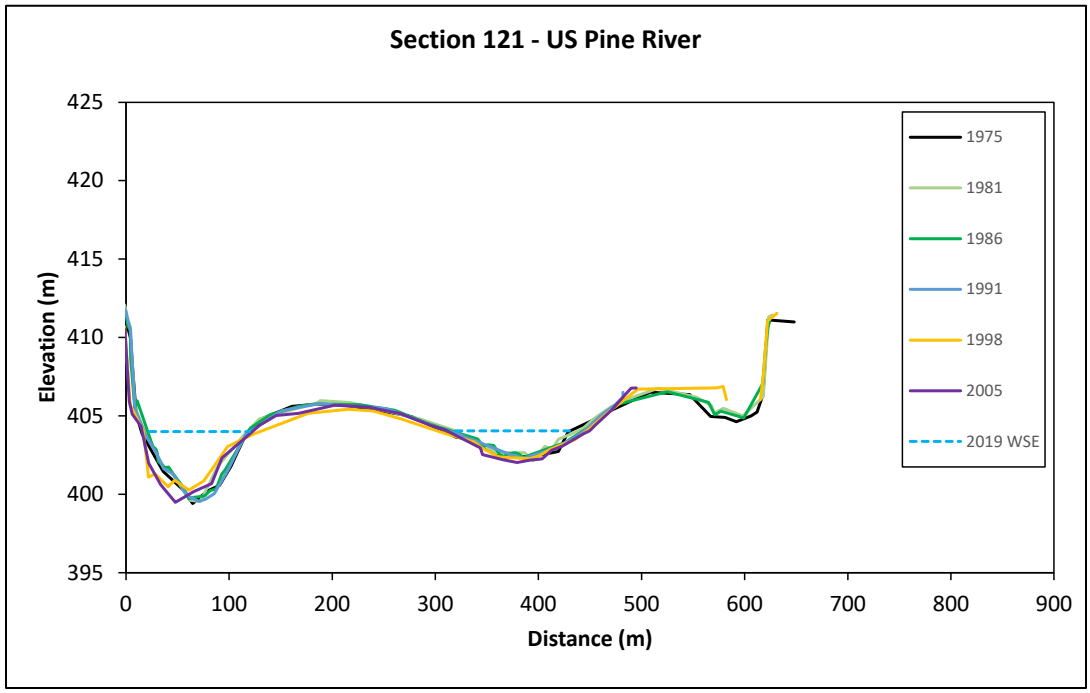

Section 113 - DS Moberly River
Elevation (m)
425
420
415
410
405
400
0
100
200
300
400
500
600
700
800
900
Distance (m)
1975
1981
1986
1991
1998
2005
2019 WSE

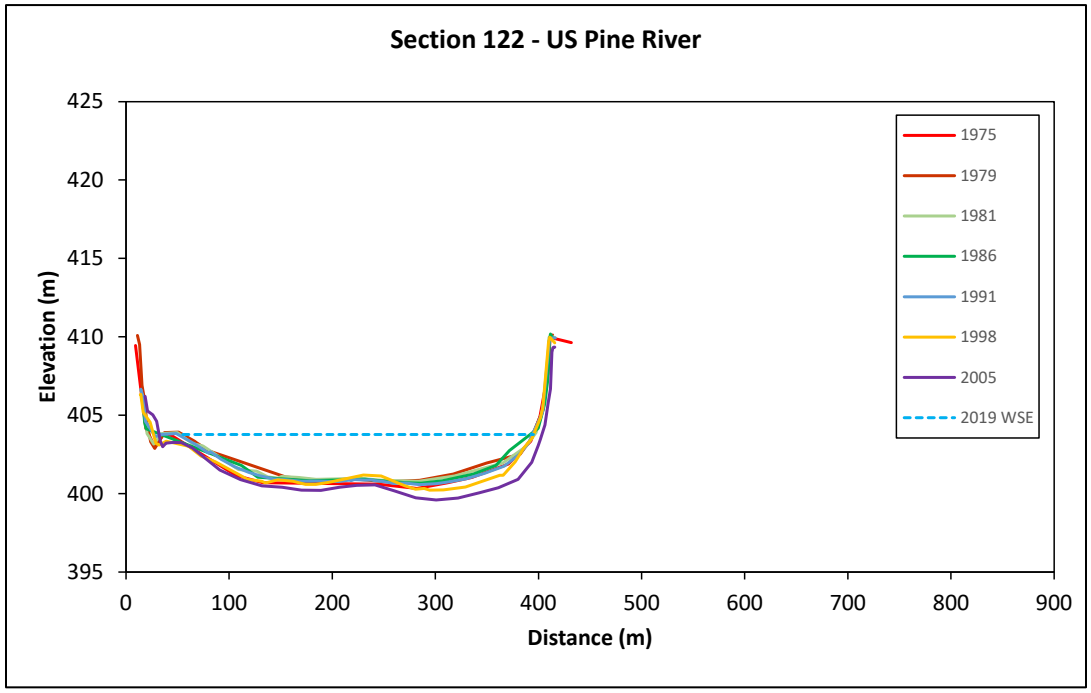

Section D - Old Fort
Elevation (m)
425
420
415
410
405
400
0
100
200
300
400
500
600
700
800
900
Distance (m)
1968
1975
1981
1986
1991
1998
2005
2019 WSE

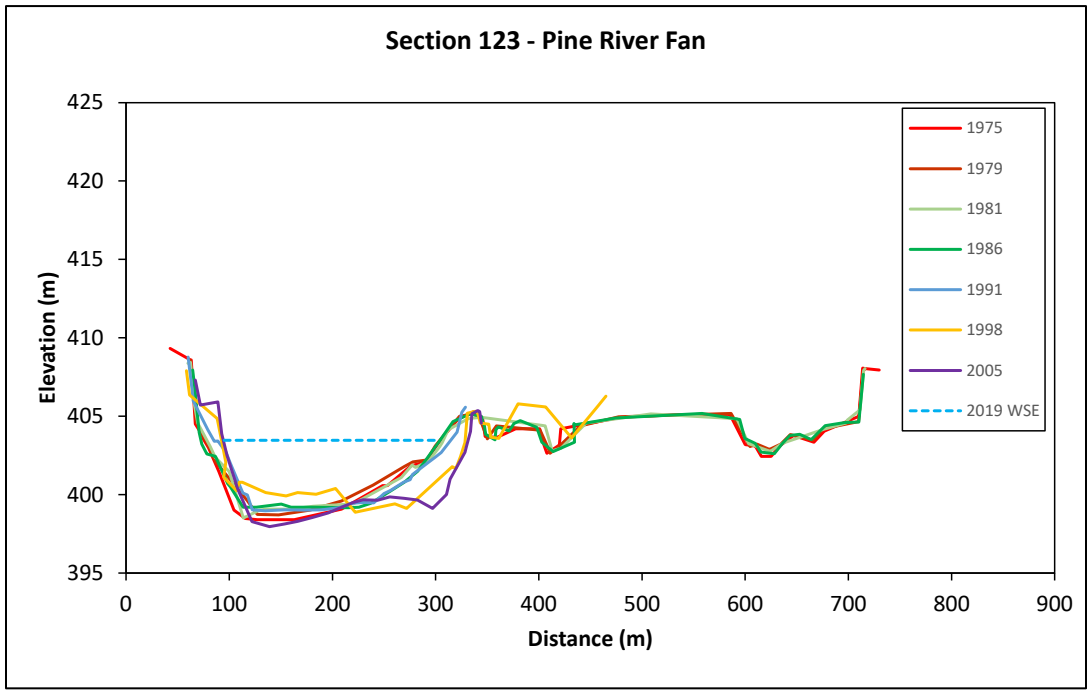

Section 117 - Kirchbaum's
Elevation (m)
425
420
415
410
405
400
0
100
200
300
400
500
600
700
800
900
Distance (m)
1968
1979
1981
1986
1991
1998
2005
2019 WSE

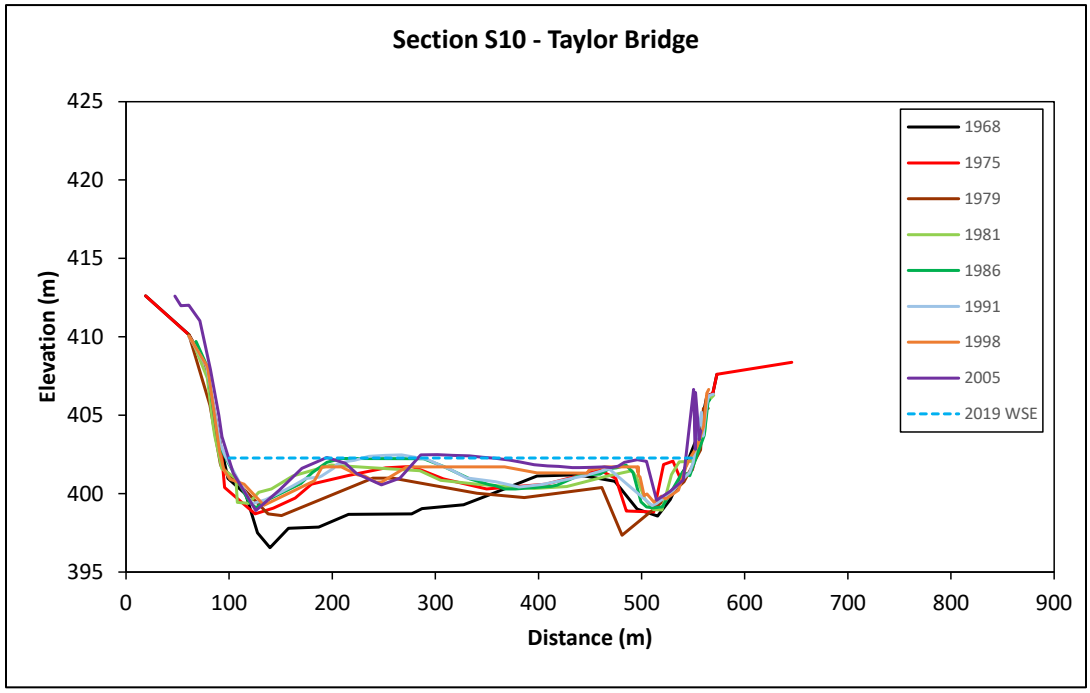

Section 119 - US Trestle
Elevation (m)
425
420
415
410
405
400
300
400
500
600
700
800
900
1000
1100
1200
Distance (m)
1975
1981
1986
1991
1998
2005
2019 WSE

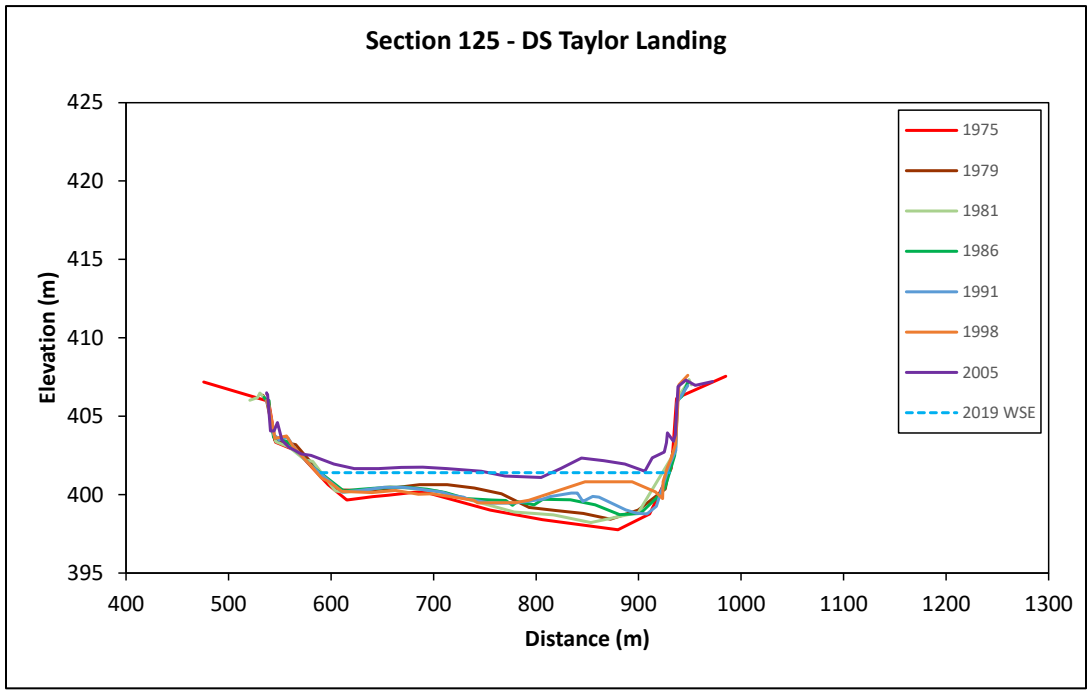

Section S7 - BCR Bridge
Elevation (m)
425
420
415
410
405
400
200
300
400
500
600
700
800
900
1000
1100
Distance (m)
1968
1975
1979
1981
1986
1991
1998
2005
2019 WSE

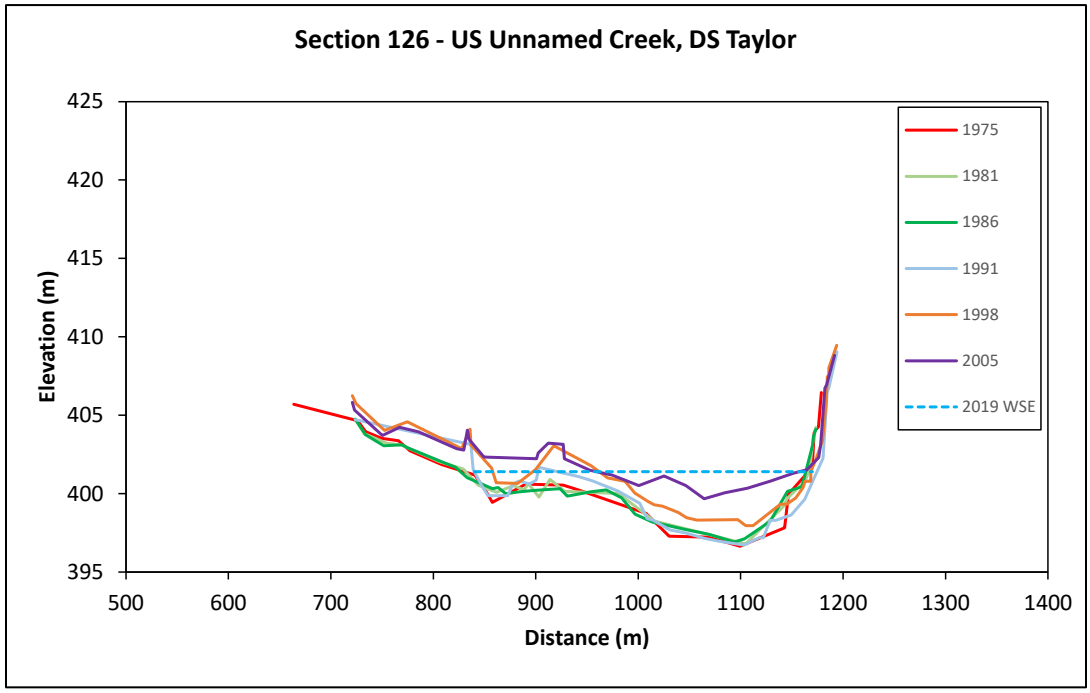

Section 121 - US Pine River
Elevation (m)
425
420
415
410
405
400
395
0
100
200
300
400
500
600
700
800
900
Distance (m)
1975
1981
1986
1991
1998
2005
2019 WSE

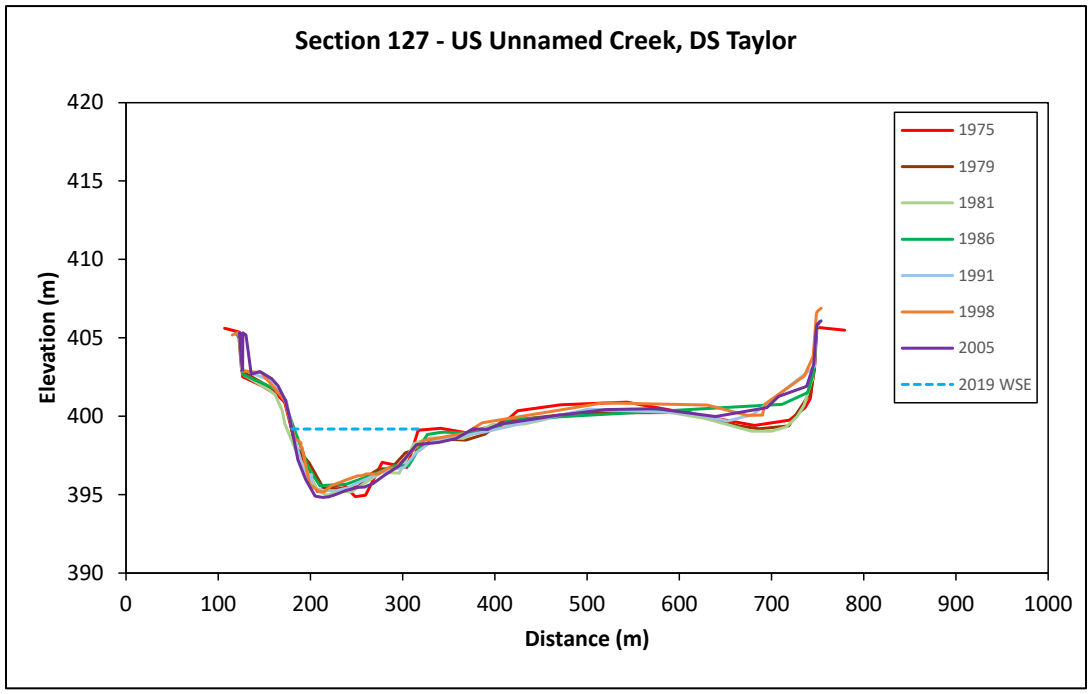

Section 122 - US Pine River
Elevation (m)
425
420
415
410
405
400
395
0
100
200
300
400
500
600
700
800
900
Distance (m)
1975
1979
1981
1986
1991
1998
2005
2019 WSE


Section 123 - Pine River Fan
Elevation (m)
425
420
415
410
405
400
395
0
100
200
300
400
500
600
700
800
900
Distance (m)
1975
1979
1981
1986
1991
1998
2005
2019 WSE


Section S10 - Taylor Bridge
Elevation (m)
425
420
415
410
405
400
395
0
100
200
300
400
500
600
700
800
900
Distance (m)
1968
1975
1979
1981
1986
1991
1998
2005
2019 WSE


Section 125 - DS Taylor Landing
Elevation (m)
425
420
415
410
405
400
395
400
500
600
700
800
900
1000
1100
1200
1300
Distance (m)
1975
1979
1981
1986
1991
1998
2005
2019 WSE


Section 126 - US Unnamed Creek, DS Taylor
Elevation (m)
425
420
415
410
405
400
395
500
600
700
800
900
1000
1100
1200
1300
1400
Distance (m)
1975
1981
1986
1991
1998
2005
2019 WSE


Section 127 - US Unnamed Creek, DS Taylor
Elevation (m)
420
415
410
405
400
395
390
0
100
200
300
400
500
600
700
800
900
1000
Distance (m)
1975
1979
1981
1986
1991
1998
2005
2019 WSE

APPENDIX C

Grain Size Data

Table C1: Size classes used for the grain size analysis during BC Hydro's Peace River Physical Habitat Monitoring Program (Mon-3), 2021 (Wentworth 1922).

Material	Size range (mm)
silt/clay	0 - 0.062
very fine sand	0.062 - 0.125
fine sand	0.125 - 0.25
medium sand	0.25 - 0.5
coarse sand	0.5 - 1
very coarse sand	1 - 2
very fine gravel	2 - 4
fine gravel	4 - 8
medium gravel	8 - 16
coarse gravel	16 - 32
very coarse gravel	32 - 64
small cobble	64 - 90
medium cobble	90 - 128
large cobble	128 - 180
very large cobble	180 - 256
small boulder	256 - 512
medium boulder	512 - 1024
large boulder	1,024 – 2,048
very large boulder	2,048 – 4,096

Table C2: Grain size data (in mm) collected during BC Hydro's Peace River Physical Habitat Monitoring Program (Mon-3), 2021.

Count	US-13-MC		US-12-MC		US-11-MC		US-10-RB		US-10-MC		US-09-MC		US-8a-MC		US-08-RB		US-08-MC	
1	60	44	25	29	62	60	75	126	70	16	42	48	88	145	64	72	18	31
2	54	30	31	30	49	19	140	45	51	30	53	32	125	51	240	107	19	23
3	21	50	28	18	27	55	39	94	29	18	34	24	46	125	50	90	19	10
4	116	35	15	50	49	47	45	110	67	106	110	48	28	130	109	26	70	32
5	92	31	27	32	59	56	152	60	90	78	130	70	117	52	50	100	33	135
6	58	62	14	29	34	27	80	120	55	50	48	22	100	127	96	49	23	168
7	62	27	14	40	32	23	88	111	36	85	34	94	136	130	65	107	30	36
8	78	25	30	43	42	38	54	72	25	52	85	44	97	49	69	80	23	35
9	32	76	26	20	69	57	99	130	18	37	39	21	145	35	35	38	37	42
10	36	36	22	22	51	38	120	70	54	32	38	31	130	34	102	57	31	103
11	34	15	22	48	37	42	85	45	46	150	90	60	56	21	70	57	35	37
12	77	57	18	38	54	37	86	47	45	57	64	110	65	131	59	62	40	47
13	30	87	39	38	36	22	125	20	21	57	114	107	41	106	140	65	33	89
14	30	30	31	18	20	35	140	140	30	132	47	71	83	93	45	45	79	21
15	65	22	15	27	47	32	60	57	46	136	62	52	60	55	85	57	27	19
16	29	55	11	33	30	29	59	105	150	50	88	57	122	26	40	39	20	55
17	42	14	18	41	35	27	96	65	48	54	47	72	47	18	54	57	37	28
18	54	25	35	49	32	21	94	123	48	52	88	29	145	80	68	85	85	20
19	26	26	12	30	31	16	110	72	22	90	38	53	150	89	41	114	52	13
20	32	60	37	14	45	34	70	65	58	47	82	52	145	90	75	54	63	60
21	31	16	26	30	28	24	90	64	22	57	110	70	83	144	89	132	58	15
22	72	36	19	10	19	22	100	114	71	65	90	90	134	33	31	51	12	110
23	68	42	22	19	42	37	40	75	53	73	52	75	67	47	62	60	43	108
24	22	80	27	37	18	26	60	48	40	18	22	71	80	35	66	58	43	30
25	64	55	22	52	45	25	30	105	57	74	46	60	65	70	68	95	47	43
26	30	32	10	28	12	52	82	48	64	137	43	80	124	70	25	23	25	48
27	54	17	16	25	37	23	62	160	36	48	39	105	78	121	39	90	30	13
28	32	20	18	104	36	26	150	95	41	155	32	42	28	120	72	42	35	113
29	36	31	25	25	54	22	41	65	33	128	80	105	106	118	70	40	50	11
30	65	32	30	12	23	33	77	75	78	103	60	52	77	78	60	58	42	68
31	71	72	27	28	25	25	47	165	25	78	109	74	150	22	42	16	58	69
32	106	36	24	36	42	22	135	47	48	103	126	31	82	96	112	64	32	42
33	26	60	16	49	49	18	36	84	16	52	42	52	53	90	82	92	24	57
34	76	59	29	20	22	31	74	82	54	86	37	45	82	120	40	52	15	40
35	57	65	11	16	36	19	129	165	32	19	87	27	51	41	22	95	30	23
36	54	46	31	21	33	68	83	71	37	77	60	95	50	160	57	45	60	33
37	50	40	29	31	40	49	105	52	35	132	79	70	14	130	55	75	22	72
38	19	27	33	18	25	45	47	68	34	47	25	52	83	84	100	105	45	34
39	42	57	30	38	48	42	145	75	53	71	55	60	180	122	69	141	28	50
40	24	44	40	41	35	40	21	131	86	52	27	85	70	92	50	116	17	53
41	20	18	22	14	49	14	98	48	22	67	16	85	18	55	110	109	73	65
42	40	42	16	22	52	55	37	68	48	118	27	87	147	61	90	79	70	64
43	66	72	25	14	41	25	130	170	67	63	25	80	46	125	75	112	26	58
44	37	32	12	20	55	34	40	58	85	62	20	84	106	115	65	30	12	40
45	43	49	34	34	45	40	75	125	40	100	103	48	95	140	28	78	18	50
46	38	54	30	35	32	20	80	116	27	52	70	39	25	88	86	91	48	28
47	34	32	16	42	39	44	155	114	63	40	40	43	145	117	58	54	35	35
48	75	55	29	40	29	66	147	57	38	50	95	69	32	88	45	96	24	57
49	78	155	25	37	40	20	90	80	39	107	36	72	50	60	97	76	52	34
50	26	42	20	27	42	36	47	80	28	52	93	57	15	83	64	65	21	45

Table C2: Continued.

Count	DS-05-RB		DS-09-MC		DS-14-RB		DS-14-MC		DS-15-RB		DS-17-MC		DS-18-RB		DS-19-RB		DS-20-MC	
1	23	54	48	66	79	66	135	20	20	165	26	40	46	50	45	27	34	100
2	36	24	91	105	32	41	20	110	157	84	45	38	30	48	40	34	50	21
3	21	36	93	47	29	14	75	32	152	75	35	34	201	35	65	64	27	76
4	17	50	115	85	22	61	65	170	69	66	34	54	51	82	80	112	37	24
5	29	42	104	73	29	28	40	110	42	80	20	25	56	48	85	122	50	55
6	42	59	91	63	31	38	105	28	38	114	34	40	50	103	48	49	50	49
7	41	32	30	78	102	15	80	42	95	78	106	70	44	68	40	47	70	110
8	35	40	120	118	24	64	95	27	116	78	20	45	38	150	62	29	42	90
9	56	63	60	40	16	28	125	25	70	10	24	37	36	70	45	30	108	32
10	36	20	62	77	52	124	200	62	80	55	30	52	12	60	105	22	47	26
11	14	23	74	62	52	55	49	51	100	200	106	80	30	65	54	60	88	82
12	46	25	118	48	28	17	55	30	83	90	14	70	57	30	42	50	47	42
13	48	19	93	40	31	51	65	61	17	86	16	82	78	94	40	60	64	65
14	17	105	71	33	195	14	35	31	90	34	46	35	85	62	20	27	27	110
15	11	22	95	70	94	45	42	39	94	68	87	45	55	33	45	100	95	115
16	11	22	26	19	57	46	89	90	55	26	37	25	30	42	105	70	62	65
17	32	40	41	31	70	31	44	90	54	29	33	54	101	92	60	53	38	35
18	74	20	65	135	42	104	25	31	60	36	70	65	33	56	50	45	27	75
19	68	17	30	39	35	33	28	130	46	140	26	125	16	54	24	20	100	70
20	55	86	65	50	17	43	34	25	33	44	28	45	60	81	26	35	79	115
21	22	24	102	65	80	75	42	44	35	165	36	79	26	20	24	47	36	14
22	22	23	92	70	34	40	88	117	52	84	80	36	87	80	25	120	122	33
23	28	15	59	102	85	66	46	45	31	75	42	27	35	92	84	85	110	47
24	17	29	88	53	114	85	125	25	70	66	26	34	110	80	26	29	32	115
25	18	29	53	68	110	48	85	46	30	80	112	27	57	77	64	14	37	35
26	29	32	59	73	35	124	125	25	37	114	42	15	78	87	85	74	150	150
27	21	31	84	94	88	95	15	61	20	78	88	180	32	56	27	102	108	140
28	27	55	56	44	57	66	140	215	34	78	39	44	106	58	30	88	96	32
29	8	20	60	99	51	100	71	72	33	10	75	19	36	111	72	37	68	85
30	76	21	115	92	58	70	100	29	46	55	44	35	98	40	56	42	93	106
31	19	39	36	105	36	48	36	107	32	55	64	20	48	40	73	84	57	94
32	15	31	48	33	104	50	40	125	133	105	57	29	90	23	32	46	62	37
33	34	25	88	80	41	16	105	39	34	165	140	28	28	75	90	61	105	64
34	22	48	68	113	54	36	98	35	132	74	48	70	25	75	50	44	80	25
35	14	46	45	118	69	48	68	30	21	55	32	28	27	75	34	39	138	76
36	21	14	61	112	48	41	160	28	105	116	28	62	47	63	78	14	90	31
37	22	25	85	32	10	50	45	98	51	125	52	40	24	23	60	64	87	90
38	16	21	52	80	114	44	50	22	52	65	37	20	69	24	75	65	68	60
39	19	31	76	105	48	53	23	39	93	14	27	60	46	144	55	52	56	67
40	25	26	83	86	52	71	137	65	50	70	37	55	43	103	59	76	54	85
41	16	28	59	68	34	40	90	41	200	107	36	50	54	130	20	40	44	37
42	51	45	73	68	27	30	37	70	90	138	37	25	34	62	35	44	39	77
43	19	38	85	29	55	73	58	110	86	73	22	80	102	35	42	60	47	146
44	60	59	75	83	9	32	46	31	34	51	34	50	33	60	21	53	111	120
45	46	25	33	40	17	118	50	75	68	57	44	45	96	80	20	65	54	35
46	56	14	88	91	28	32	40	40	26	70	28	60	39	52	24	42	80	36
47	26	44	93	76	26	61	31	15	29	31	105	35	37	82	32	130	110	35
48	27	19	40	85	28	20	25	45	36	49	102	40	47	54	60	89	130	85
49	30	29	46	55	48	37	70	49	140	54	60	30	47	22	71	101	95	120
50	52	28	200	71	27	48	20	49	44	63	80	40	70	55	74	50	37	65

Table C2: Continued.

Count	DS-21-MC		DS-22-RB		DS-24-MC		DS-25-MC		DS-26-MC		DS-27-MC		DS-28-MC		DS-29-MC		DS-30-RB	
1	112	38	68	64	50	42	17	43	102	45	54	62	40	79	61	1	111	28
2	38	34	78	34	45	23	32	22	86	52	25	31	46	76	51	15	66	54
3	127	52	57	55	30	35	12	25	58	66	65	60	60	66	45	56	40	14
4	32	48	27	30	33	53	27	23	46	60	45	105	75	48	44	20	73	85
5	45	85	54	22	21	46	18	14	21	22	58	132	44	42	56	25	42	38
6	65	76	75	53	25	70	18	32	41	59	124	43	40	109	65	19	24	40
7	90	130	90	54	52	30	36	21	35	20	82	55	70	42	27	1	20	52
8	40	90	23	39	26	63	16	41	145	29	58	61	92	42	18	1	102	21
9	29	92	58	65	35	36	14	44	38	60	43	18	65	83	42	10	36	53
10	110	72	73	33	16	62	26	28	48	25	112	38	79	29	43	1	24	64
11	57	84	52	114	55	69	32	24	44	31	70	61	51	51	62	60	60	35
12	100	32	65	23	26	19	34	22	44	24	33	64	44	23	1	25	24	92
13	57	72	36	34	65	60	15	25	30	38	45	53	68	51	1	42	31	19
14	35	92	41	38	26	35	24	22	79	40	78	30	27	45	42	46	14	57
15	41	40	44	67	41	28	37	35	46	38	33	75	56	70	33	71	43	1
16	32	96	48	42	65	78	24	51	21	57	58	47	38	27	52	57	62	10
17	39	50	49	35	35	55	26	18	61	62	118	93	56	75	59	61	75	41
18	51	45	15	58	17	45	46	18	31	46	28	55	74	90	49	1	128	82
19	60	35	83	23	19	43	39	14	85	22	30	115	77	91	18	44	10	32
20	30	102	92	23	22	48	37	49	77	33	46	82	85	40	16	22	45	23
21	66	41	62	52	15	21	32	24	75	27	27	34	20	59	64	31	97	28
22	24	26	43	19	35	37	20	35	26	21	125	93	85	90	26	36	93	10
23	100	72	30	63	53	54	21	15	72	55	97	35	56	121	43	39	112	90
24	91	76	20	12	25	41	15	35	77	50	82	90	82	57	25	1	37	1
25	36	52	14	75	13	50	16	15	54	45	31	10	60	50	25	33	82	77
26	26	49	21	38	42	50	45	34	42	57	118	55	30	78	76	37	68	45
27	104	38	45	52	62	31	11	24	32	19	113	53	122	44	31	27	38	49
28	50	72	46	30	50	55	42	16	28	50	33	24	41	93	34	28	39	21
29	24	45	55	75	60	50	31	29	60	25	35	24	52	34	14	52	14	77
30	74	62	43	34	75	35	16	30	35	35	25	43	49	32	41	75	69	44
31	30	112	31	22	50	49	25	9	59	39	47	60	75	100	37	66	37	115
32	145	91	53	32	19	25	14	24	29	44	108	132	88	70	1	42	27	93
33	20	46	56	28	45	35	21	17	41	44	58	92	81	37	55	1	80	75
34	52	71	21	34	75	60	37	20	80	35	75	83	130	26	49	50	41	74
35	30	72	28	32	24	57	16	12	50	75	50	40	47	64	40	36	65	88
36	29	69	22	71	57	57	20	19	27	60	52	62	70	43	54	35	75	49
37	19	54	42	47	45	44	36	16	105	63	70	65	35	21	40	17	66	37
38	51	33	26	77	71	65	24	19	18	75	72	25	101	73	29	32	49	33
39	35	92	53	88	36	46	15	15	84	59	33	56	45	60	56	54	50	62
40	29	39	51	93	18	30	20	16	28	70	38	130	71	22	38	1	94	89
41	30	111	32	98	28	16	35	11	80	59	46	181	94	85	48	1	100	15
42	75	90	76	110	24	42	15	17	25	42	48	54	98	49	50	54	60	33
43	39	95	47	59	57	24	16	15	45	55	57	60	67	31	46	1	62	54
44	100	91	48	124	58	29	27	30	65	74	41	39	31	78	32	57	22	42
45	100	89	102	80	49	19	18	17	20	52	112	138	85	47	31	62	94	69
46	26	88	86	35	35	42	21	17	50	63	67	51	104	25	1	16	17	92
47	91	89	59	27	27	48	43	27	39	94	53	104	48	124	41	42	90	33
48	95	60	59	83	28	13	31	34	29	89	41	185	25	47	50	45	23	49
49	115	79	74	59	49	45	19	19	80	32	70	150	47	57	11	37	1	33
50	97	60	75	49	29	42	34	20	75	46	79	58	47	57	64	38	96	49

Table C2: Continued.

Count	DS-31-MC		DS 31A-MC		DS-32-MC		DS-33-LB		DS-34-LB		DS-35-MC		DS-35-RB		DS-37-RB	
1	84	72	19	31	30	38	32	50	115	16	92	115	66	60	87	57
2	94	45	12	86	120	34	85	43	33	80	132	70	57	49	67	213
3	17	70	19	65	82	28	23	116	65	34	71	22	85	78	59	56
4	35	35	18	1	54	69	103	45	33	30	82	84	66	16	105	62
5	81	80	25	76	125	105	124	80	29	36	102	102	61	50	78	40
6	30	45	18	50	29	84	125	145	25	45	20	22	85	62	52	122
7	82	66	30	82	106	35	127	26	26	105	33	36	65	41	55	20
8	34	32	20	47	40	114	88	70	45	72	54	33	30	31	30	67
9	36	40	42	51	20	142	45	120	68	27	28	56	92	25	16	78
10	22	44	14	23	49	83	93	83	90	131	24	115	34	25	105	66
11	39	62	24	24	31	40	70	117	35	55	28	34	24	55	38	14
12	32	82	20	33	41	113	50	58	41	44	46	28	73	61	32	36
13	58	48	20	18	65	105	56	36	70	41	20	47	47	25	14	45
14	39	68	41	27	115	45	33	135	67	54	14	18	50	20	60	12
15	57	70	50	70	35	24	131	59	84	82	115	24	40	18	44	127
16	42	76	40	25	41	22	76	150	36	74	20	64	49	47	48	109
17	48	70	21	30	46	29	20	112	46	39	31	26	51	129	60	35
18	38	94	36	62	40	70	130	72	32	40	77	22	141	24	18	35
19	40	39	46	44	125	26	46	82	25	25	102	25	62	29	152	55
20	76	68	93	22	115	47	60	190	62	70	25	38	30	30	70	130
21	39	29	24	23	115	105	25	85	40	88	15	27	210	62	38	85
22	56	60	46	43	30	32	117	72	52	18	60	34	125	35	34	40
23	26	43	30	53	35	52	100	104	25	33	36	52	23	105	61	16
24	20	64	10	24	30	70	22	94	105	44	35	68	36	39	62	31
25	30	89	35	16	54	92	65	77	102	59	41	64	75	30	68	37
26	39	59	30	47	120	31	16	115	99	45	55	95	57	22	13	92
27	36	115	19	36	60	58	138	130	59	101	46	44	142	27	25	75
28	95	34	80	41	30	25	57	92	57	59	98	79	61	23	56	105
29	55	42	30	1	35	28	80	43	64	26	140	48	85	30	53	20
30	32	70	77	40	22	94	125	56	70	51	21	25	27	57	36	175
31	45	42	53	75	30	35	81	102	30	118	36	28	26	25	70	100
32	49	36	114	93	55	52	100	80	40	100	31	40	120	39	40	37
33	50	85	30	54	35	120	52	71	130	29	115	92	36	100	92	47
34	41	39	40	22	39	115	35	23	110	89	158	40	135	45	78	90
35	32	52	36	118	25	130	32	96	98	46	86	60	24	37	15	125
36	36	17	79	10	42	35	123	122	40	24	22	21	87	70	123	165
37	25	34	101	94	106	32	107	100	55	41	84	41	95	79	23	36
38	160	70	120	40	20	15	27	135	53	22	14	65	62	38	152	95
39	28	39	108	21	58	72	20	99	38	40	52	46	22	36	63	66
40	63	67	76	30	40	63	83	70	82	20	62	46	31	55	11	80
41	58	43	65	22	40	60	48	93	35	29	25	44	46	28	21	66
42	70	36	52	69	25	122	32	53	20	112	63	66	75	81	44	86
43	72	25	45	62	33	65	128	54	35	32	60	56	76	72	56	70
44	54	56	62	83	140	58	45	130	21	58	55	71	28	45	159	56
45	45	26	65	58	45	103	76	105	98	72	40	62	59	25	134	40
46	53	53	56	34	44	67	110	102	74	55	64	40	28	24	42	55
47	32	49	92	26	38	120	60	52	41	80	80	154	170	35	33	116
48	25	90	47	69	21	35	32	78	50	69	127	178	15	41	33	61
49	56	36	82	30	140	36	50	24	71	68	17	24	60	24	88	92
50	62	45	22	57	40	45	48	78	74	51	65	46	87	47	43	57

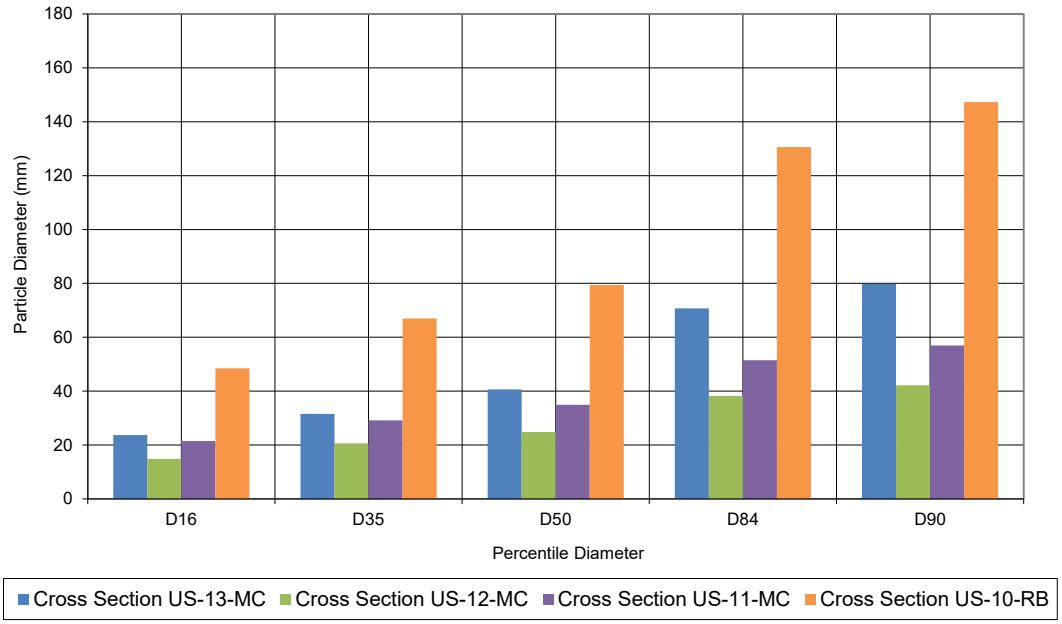


Figure C1: Sample percentile diameter, Cross Sections US-13 MC, US-12 MC, US-11 MC, and US-10 RB, Peace River Physical Habitat Monitoring Program (Mon-3), 2021.

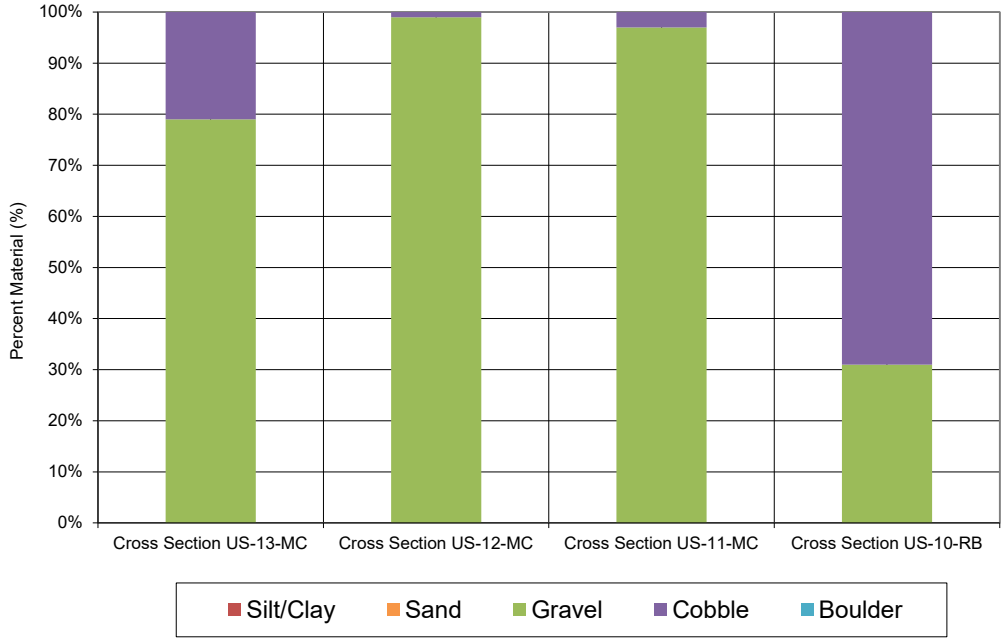


Figure C2: Percent material by substrate type, Cross Sections US-13 MC, US-12 MC, US-11 MC, and US-10 RB, Peace River Physical Habitat Monitoring Program (Mon-3), 2021.

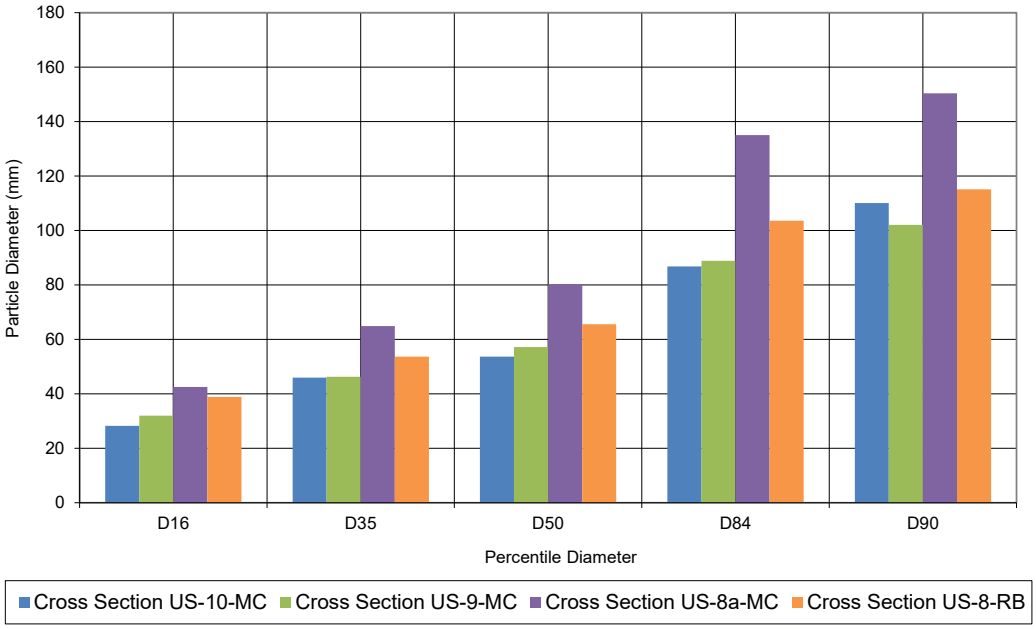


Figure C3: Sample percentile diameter, Cross Sections US-10 MC, US-09 MC, US-08a MC and US-08 RB, Peace River Physical Habitat Monitoring Program (Mon-3), 2021.

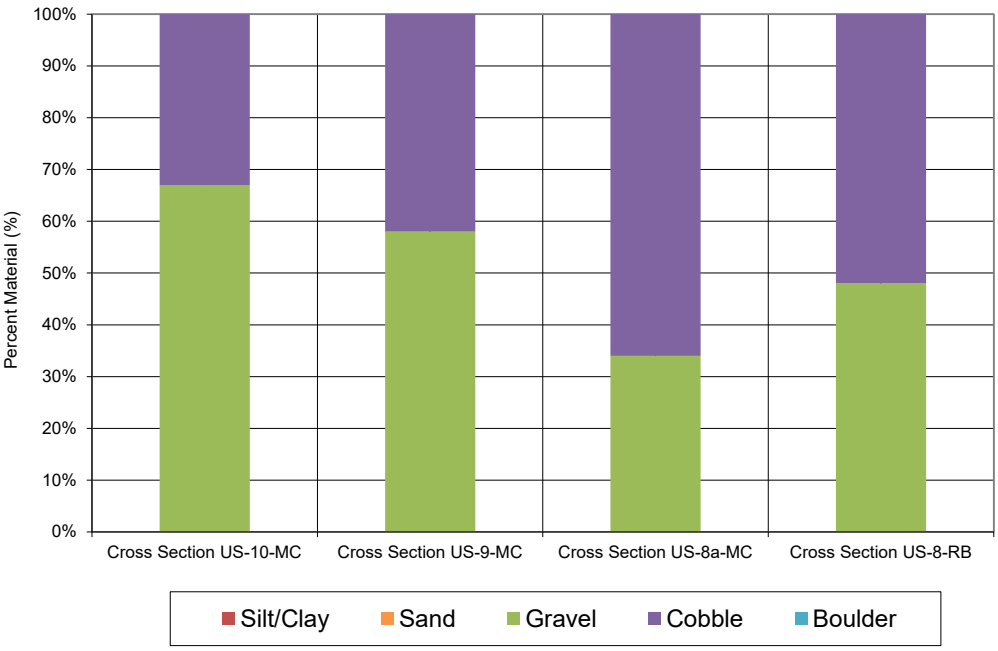


Figure C4: Percent material by substrate type, Cross Sections US-10 MC, US-09 MC, US-08a MC and US-08 RB, Peace River Physical Habitat Monitoring Program (Mon-3), 2021.

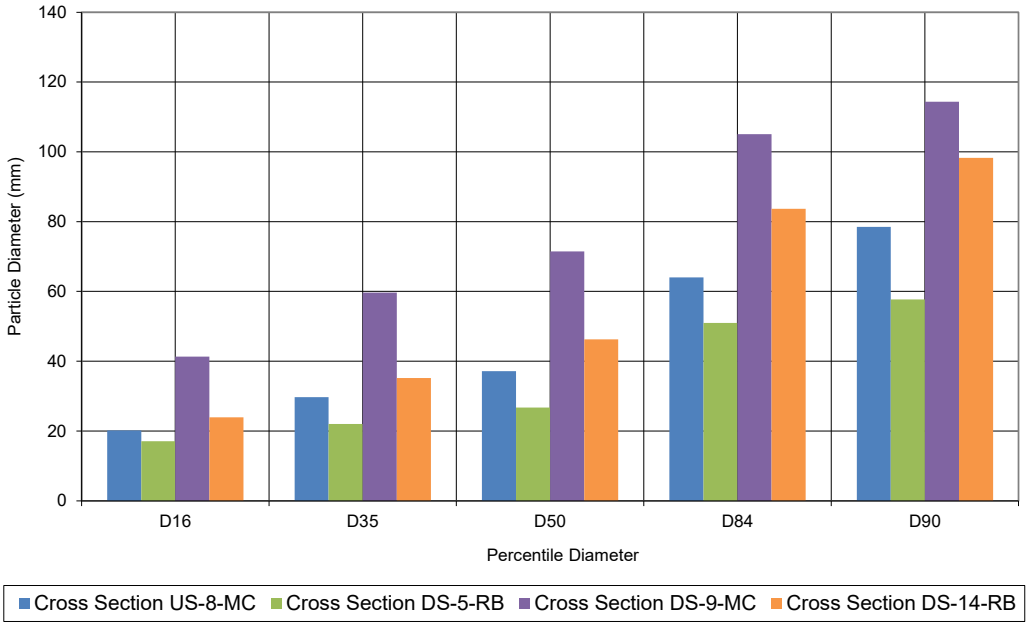


Figure C5: Sample percentile diameter, Cross Sections US-08 MC, DS-05 RB, DS-09 MC, and DS-14 RB, Peace River Physical Habitat Monitoring Program (Mon-3), 2021.

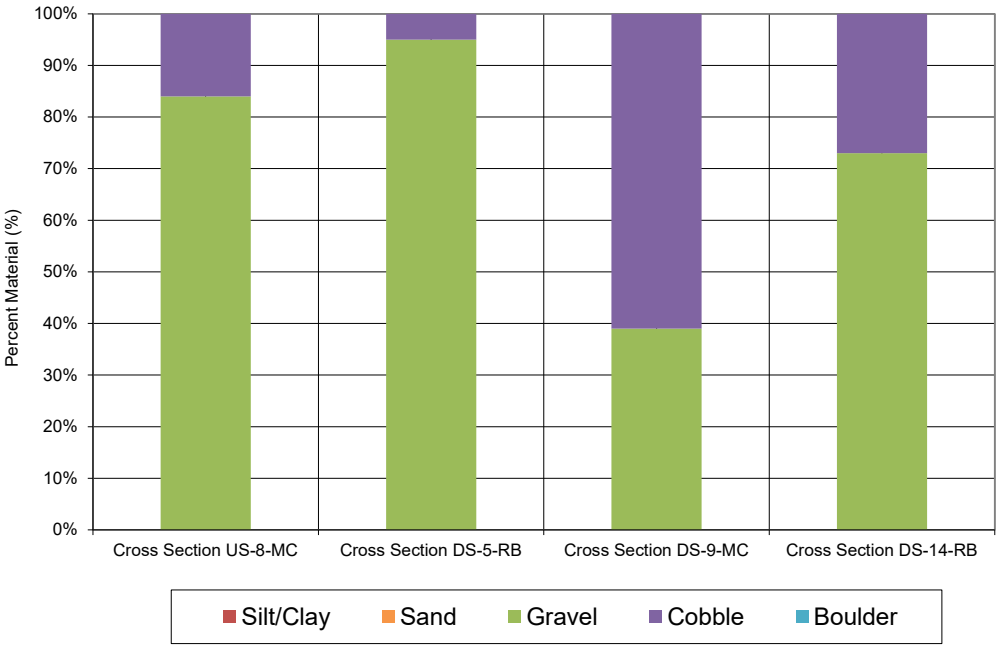


Figure C6: Percent material by substrate type, Cross Sections US-08 MC, DS-05 RB, DS-09 MC, and DS-14 RB, Peace River Physical Habitat Monitoring Program (Mon-3), 2021.

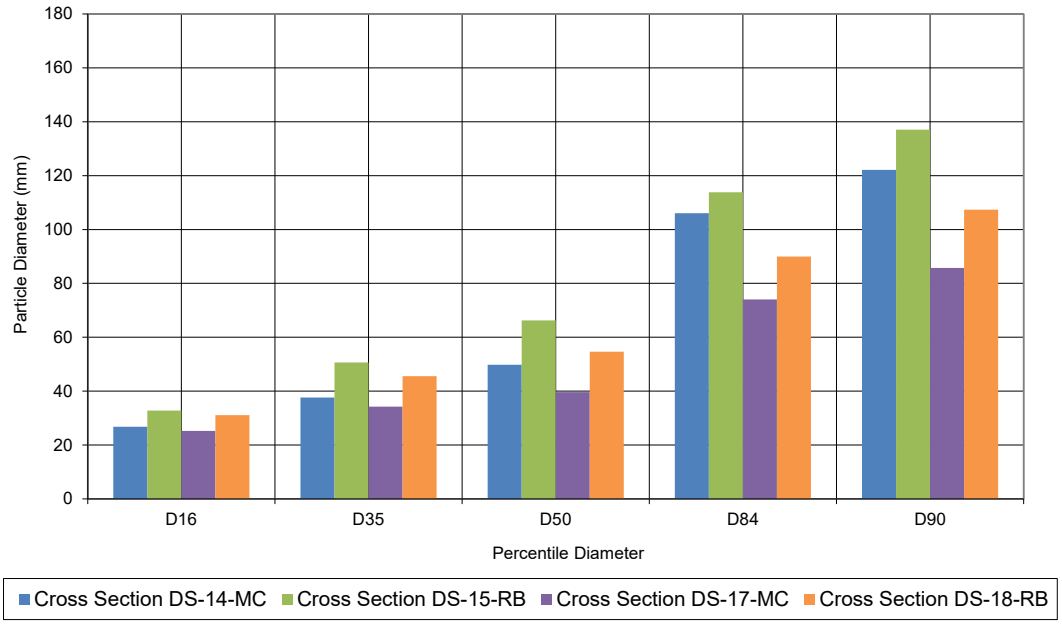


Figure C7: Sample percentile diameter, Cross Sections DS-14 MC, DS-15 RB, DS-17 MC, and DS-18 RB, Peace River Physical Habitat Monitoring Program (Mon-3), 2021.

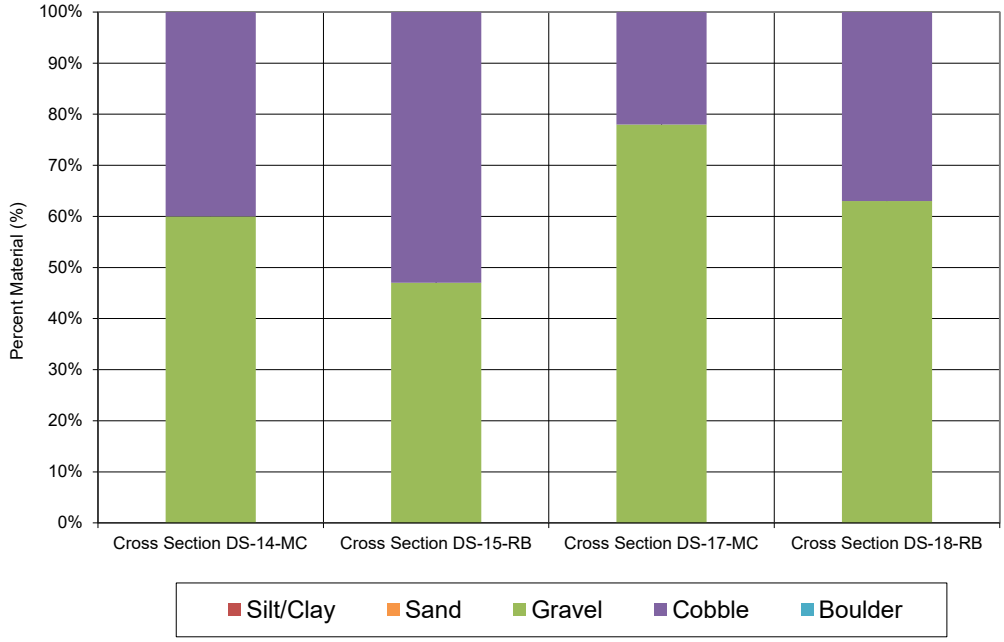


Figure C8: Percent material by substrate type, Cross Sections DS-14 MC, DS-15 RB, DS-17 MC, and DS-18 RB, Peace River Physical Habitat Monitoring Program (Mon-3), 2021.

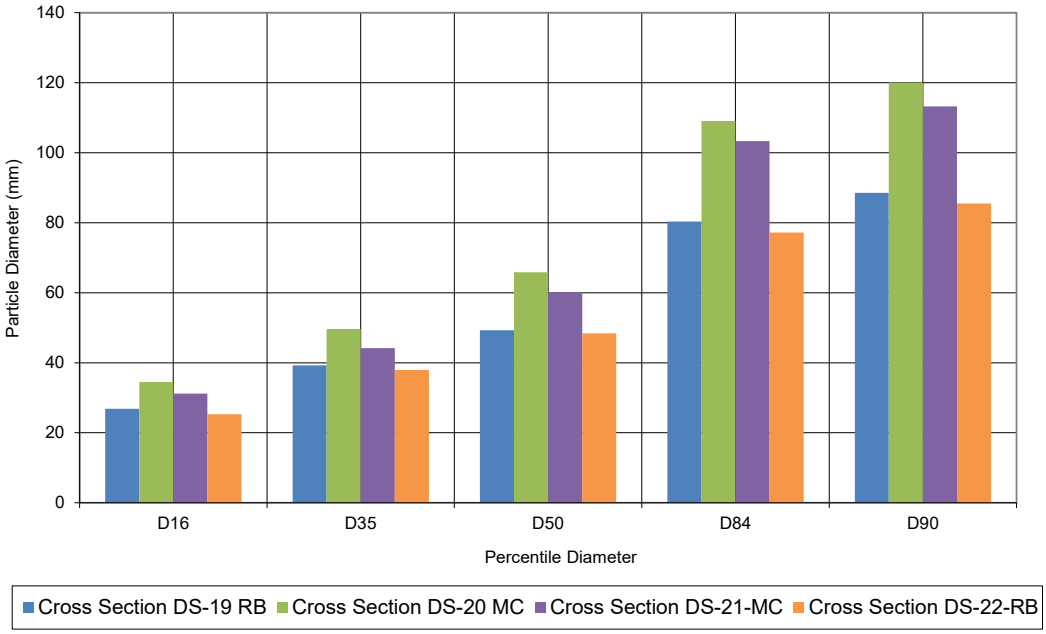


Figure C9: Sample percentile diameter, Cross Sections DS-19 RB, DS-20 MC, DS-21 MC, and DS-22 RB, Peace River Physical Habitat Monitoring Program (Mon-3), 2021.

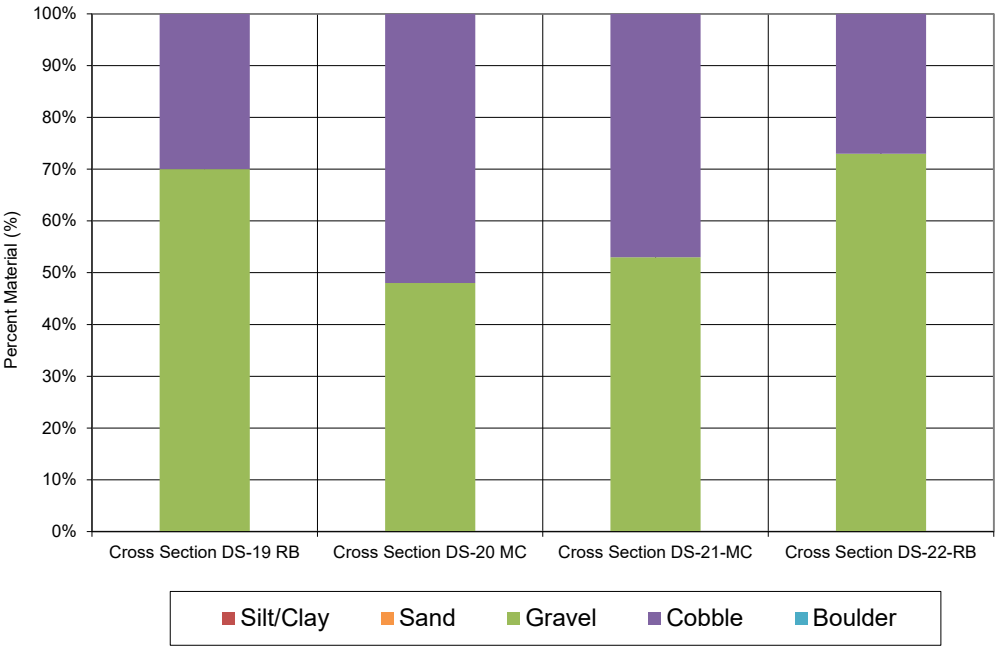


Figure C10: Percent material by substrate type, Cross Sections DS-19 RB, DS-20 MC, DS-21 MC, and DS-22 RB, Peace River Physical Habitat Monitoring Program (Mon-3), 2021.

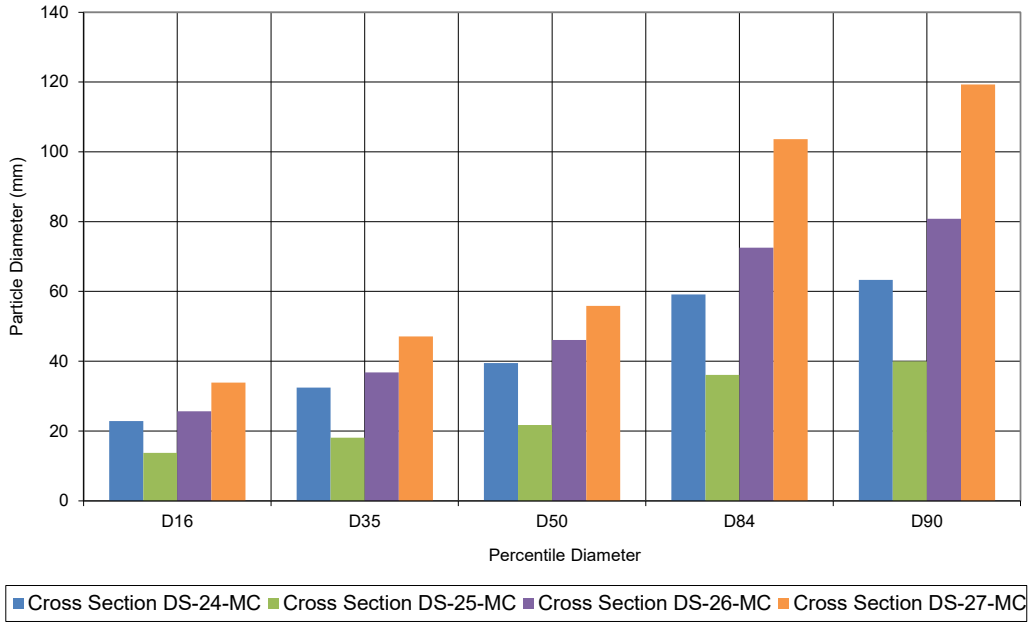


Figure C11: Sample percentile diameter, Cross Sections DS-24 MC, DS-25 MC, DS-26 MC, and DS-27 MC, Peace River Physical Habitat Monitoring Program (Mon-3), 2021.

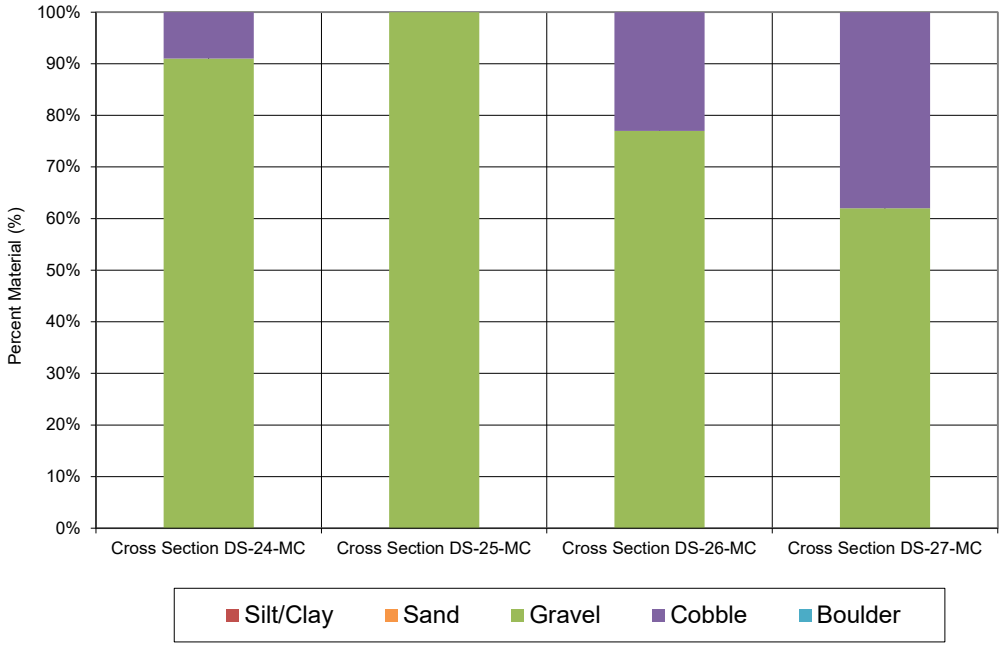


Figure C12: Percent material by substrate type, Cross Sections DS-24 MC, DS-25 MC, DS-26 MC, and DS-27 MC, Peace River Physical Habitat Monitoring Program (Mon-3), 2021.

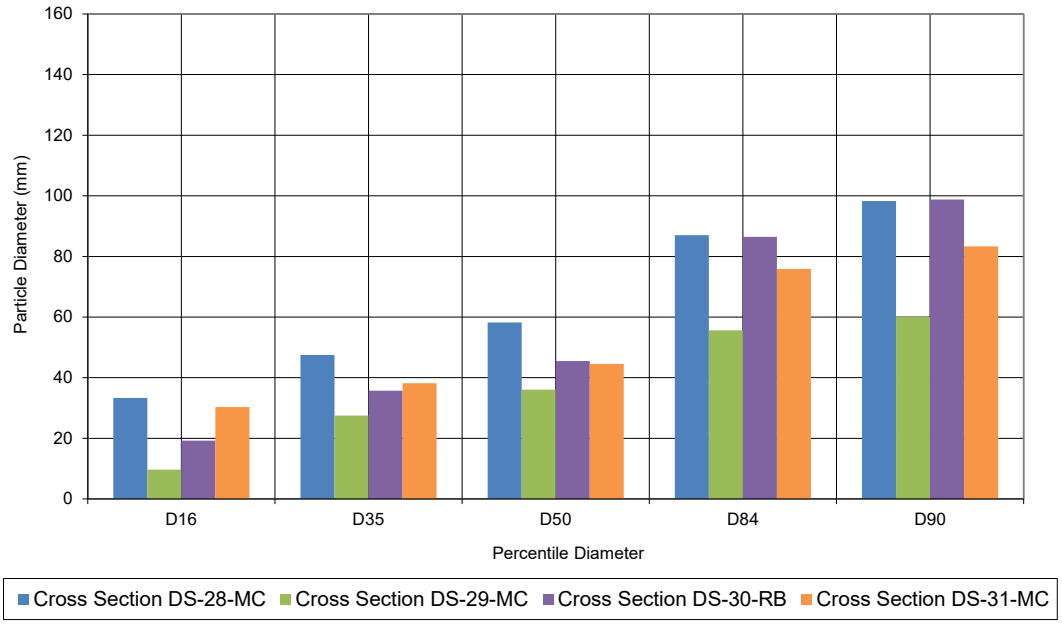


Figure C13: Sample percentile diameter, Cross Sections DS-28 MC, DS-29 MC, DS-30 RB, and DS-31 MC, Peace River Physical Habitat Monitoring Program (Mon-3), 2021.

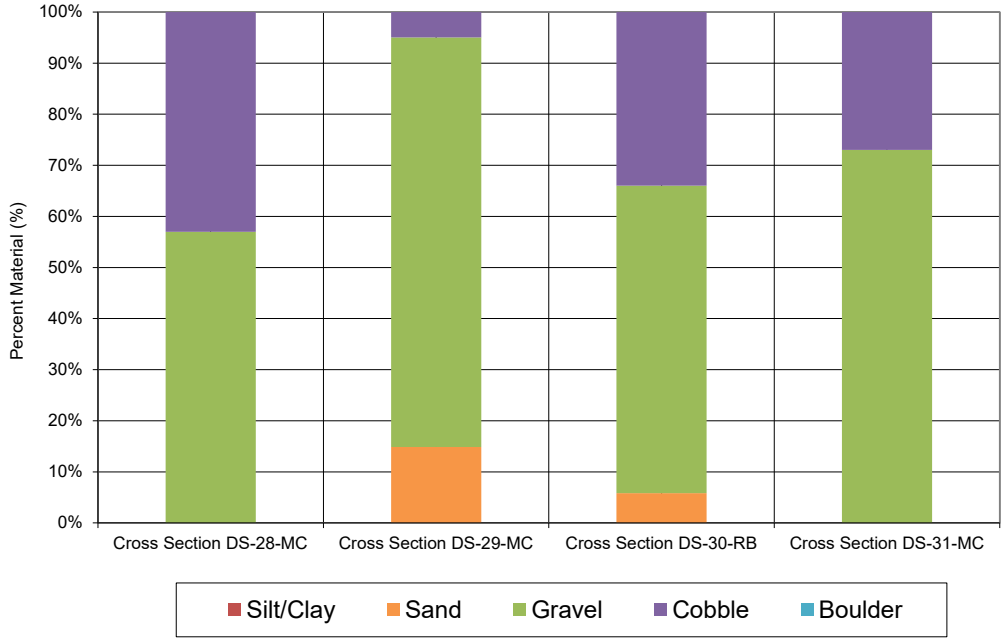


Figure C14: Percent material by substrate type, Cross Sections DS-28 MC, DS-29 MC, DS-30 RB, and DS-31 MC, Peace River Physical Habitat Monitoring Program (Mon-3), 2021.

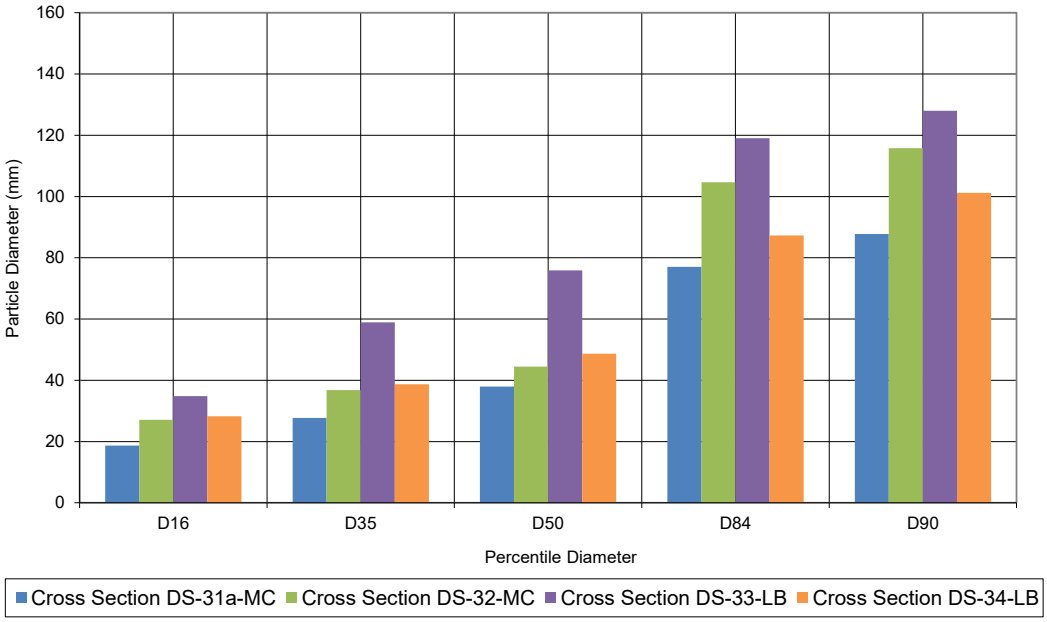


Figure C15: Sample percentile diameter, Cross Sections DS-31a MC, DS-32 MC, DS-33 LB, and DS-34 LB, Peace River Physical Habitat Monitoring Program (Mon-3), 2021.

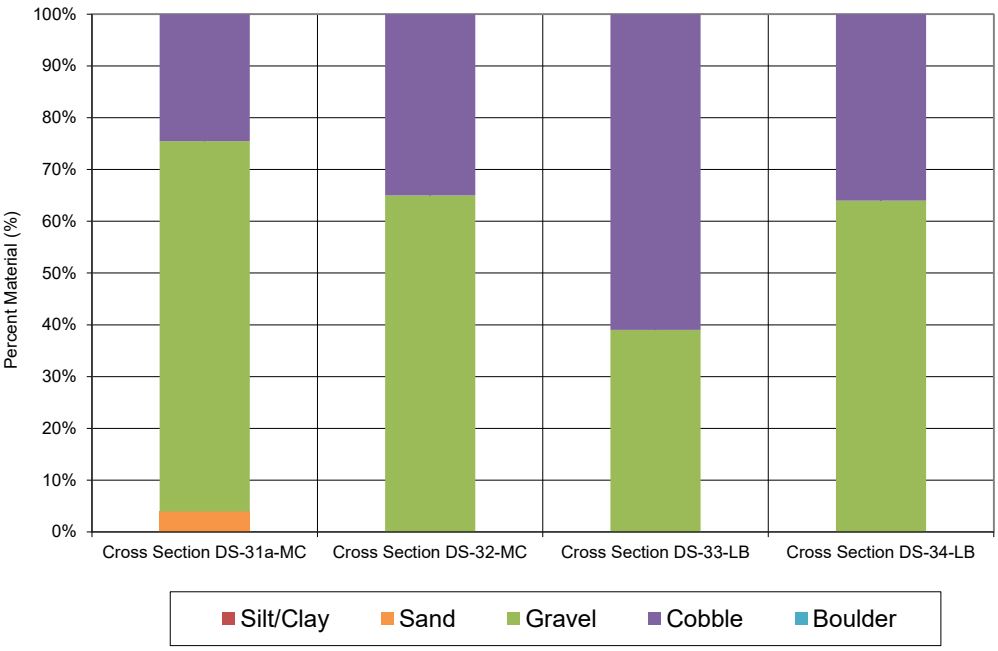


Figure C16: Percent material by substrate type, Cross Sections DS-31a MC, DS-32 MC, DS-33 LB, and DS-34 LB, Peace River Physical Habitat Monitoring Program (Mon-3), 2021.

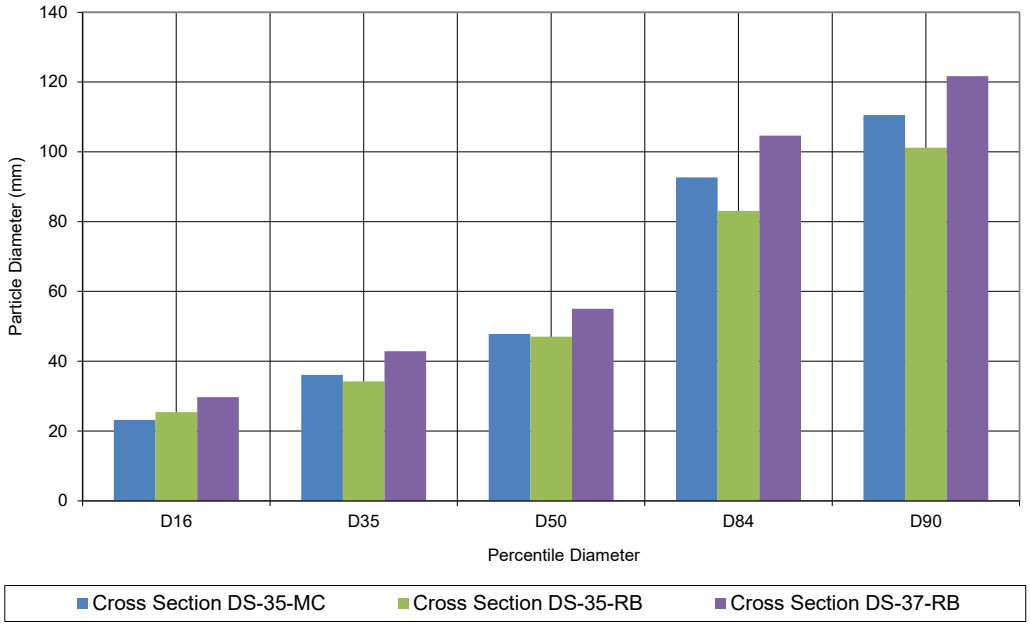


Figure C17: Sample percentile diameter, Cross Sections DS-35 MC, DS-35 RB, and DS-37 RB, Peace River Physical Habitat Monitoring Program (Mon-3), 2021.

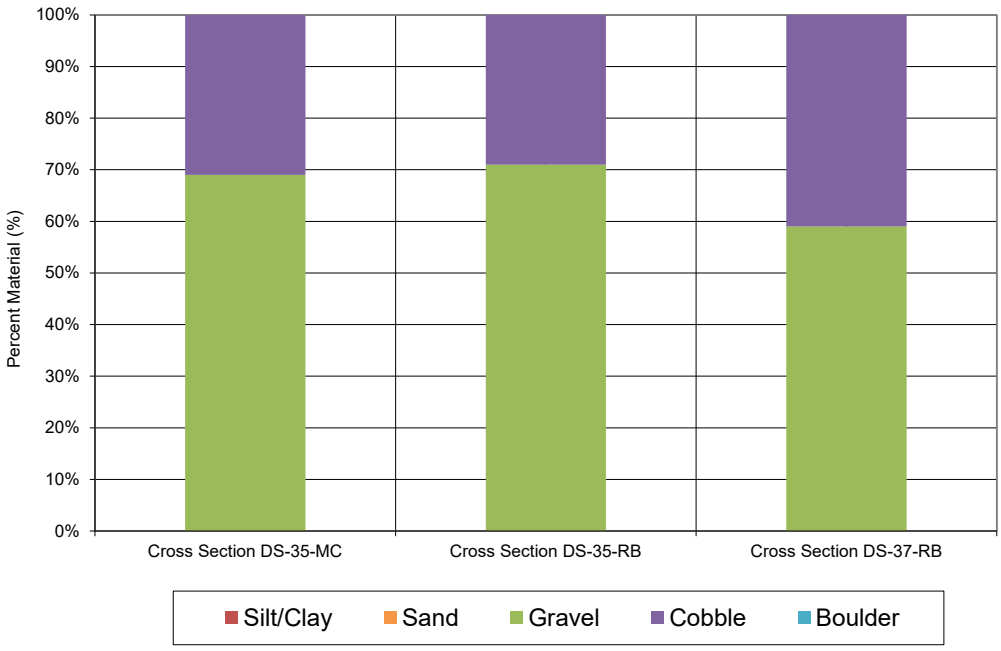


Figure C18: Percent material by substrate type, Cross Sections DS-35 MC, DS-35 RB, and DS-37 RB, Peace River Physical Habitat Monitoring Program (Mon-3), 2021.

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