Vegetation and Wildlife Mitigation and Monitoring Plan 2022 Annual Report

Site C Clean Energy Project

30 March 2023

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1.0 Introduction

The Vegetation and Wildlife Mitigation and Monitoring Plan (VWMMP) describes the measures that will be used to mitigate the adverse effects of the Site C Clean Energy Project (the Project) on vegetation and ecological communities and wildlife resources during the construction and operation of the Project. The Plan was developed in accordance with the conditions of the Project's provincial Environmental Assessment Certificate (EAC #E14-02, or 'the EAC') and Federal Decision Statement (FDS) issued for the Project in 2014. The draft and first revisions of the VWMMP were submitted to regulatory agencies and Aboriginal Groups for review and feedback on 17 October 2014, and 7 April 2015, respectively. The final VWMMP was submitted to the same recipients on 5 June 2015, and is posted on the Site C Project website at https://www.sitecproject.com/sites/default/files/Veg_and_Wildlife_Mit_and_Mon_Plan.pdf.

The purpose of this annual report is to describe the mitigation and monitoring measures that are described in the VWMMP and were implemented in 2022.

2.0 Objective and Scope

The objective of this VWMMP Annual Report (the Report) is to describe the mitigation and monitoring measures implemented in 2022 to meet the requirements of FDS conditions 9, 10, 11, 16 and 18 and EAC conditions 9 to 12, 14 to 16, 19, 21, 23, and 24. These conditions, and where they are addressed in current or past VWMMP Annual Reports are listed in Tables 1 and 2 below.

The requirements of EAC conditions 8 and 13 (for Vegetation and Ecological Communities), and conditions 17, 18, 20, and 22 (for Wildlife Resources) are addressed in the Construction Environmental Management Plan (CEMP) and/or the Vegetation Clearing and Debris Management Plan (VCDMP). Therefore, those conditions are not addressed in this report.

Table 1. Federal Decision Statement conditions and associated annual report sections

FDS Condition	Condition	Report Section
9	Disturbance and destruction of migratory birds	Section 6.1
9.1	The Proponent shall ensure that the Designated Project is carried out in a manner that avoids mortality and disturbance of migratory birds and their nests.	Section 6.1.1
9.2	The Proponent shall prepare and submit to the Agency an annual schedule, describing the location and timing for construction and reservoir filling activities, 90 days prior to initiating any of these activities.	Section 6.1.2
9.3	The Proponent shall develop, in consultation with Environment Canada, a plan to monitor and mitigate potential disturbance of breeding migratory birds in and adjacent to the Project Activity Zone, including the area immediately downstream of the dam where risks to migratory bird nests could occur, during construction, reservoir filling and	Section 6.1.3

FDS Condition	Condition	Report Section
	operation.	
9.9	The Proponent shall address potential risks of bird collisions with the transmission line, in consultation with Environment Canada, by:	
9.9.1	conducting a risk assessment for bird collisions under the current transmission line design;	2016 Annual Report (Section 6.1.3)
9.9.2	determining if additional mitigation measures could be implemented to reduce the risk of bird collisions;	Section 6.1.4
10	Non-wetland migratory bird habitat	Section 6.2
10.2	The Proponent shall develop, in consultation with Environment Canada, a plan that addresses potential effects of the Designated Project on non-wetland migratory bird habitat.	
10.3	The plan shall include:	
10.3.1	non-wetland migratory bird habitat baseline conditions for habitat that would be permanently lost, habitat that would be fragmented and habitat that would remain intact;	Section 6.2.1
10.3.2	migratory bird abundance, distribution and use of non-wetland habitat;	Section 6.2.2
10.3.3	measures to mitigate the changes in aquatic and riparian-related food resources and other habitat features associated with a change from a fluvial to a reservoir system;	Section 6.2.3
10.3.4	compensation measures to address the unavoidable loss of non-wetland migratory bird habitat, including habitat associated with the Canada Warbler, the Cape May Warbler and the Bay-Breasted Warbler;	Section 6.2.4
10.3.5	an analysis of the effects of any compensation measures identified in condition 10.3.4 on the current use of lands and resources for traditional purposes by Aboriginal peoples; and	Section 6.2.5
10.3.6	an approach to monitor and evaluate the effectiveness of the mitigation or compensation measures to be implemented and to verify the accuracy of the predictions made during the environmental assessment on non-wetland migratory bird habitat, including migratory bird use of that habitat.	Section 6.2.6
11	Wetlands used by migratory birds and for current use of lands and resources for traditional purposes	Section 6.3
11.1	The Proponent shall mitigate the potential effects of the Designated Project on wetland habitat used by migratory birds, species at risk and for current use of lands and resources for traditional purposes by Aboriginal people.	Section 6.3.1
11.2	The Proponent shall develop, in consultation with Environment Canada, Reservoir Area Aboriginal groups and Immediate Downstream	Section 6.3.2

FDS Condition	Condition	Report Section
	Aboriginal groups, a plan that addresses potential effects of the Designated Project on wetland habitat used by migratory birds, species at risk and for current use of lands and resources for traditional purposes.	
11.3	The Proponent shall, in developing the plan, describe how the mitigation hierarchy and the objective of no net loss of wetland functions were considered.	Section 6.3.3
11.4	The plan shall include:	
11.4.1	baseline data on the biogeochemical, hydrological and ecological functioning of the wetlands and associated riparian habitat in the area affected by the Designated Project, including: ground and surface water quality and quantity; vegetation cover; biotic structure and diversity; migratory bird abundance, density, diversity and use; species at risk abundance, density, diversity and use; and current use of the wetlands for traditional purposes by Aboriginal people, including the plant and wildlife species that support that use	Section 6.3.4
11.4.2	mitigation measures to maintain baseline wetland functions for those wetlands that will not be permanently lost;	Section 6.3.5
11.4.3	an approach to monitor and evaluate any changes to baseline conditions, as defined in condition 11.4.1 and identify improvements based on monitoring data;	Section 6.3.6
11.4.4	compensation measures to address the unavoidable loss of wetland areas and functions supporting migratory birds, species at risk, and the current use of lands and resources by Aboriginal people in support of the objective of full replacement of wetlands in terms of area and function	Section 6.3.7
11.8	The Proponent shall commence the implementation of the compensation measures specified in condition 11.4.4 no later than five years from the initiation of construction.	Section 6.3.8
11.9	The Proponent shall implement each component of the plan and provide to the Agency an analysis and summary of the implementation of the plan, as well as any amendments made to the plan in response to the results, on an annual basis during construction and at the end of year 1, 2, 3, 5, 10, 15, 20 and 30 of operation.	Section 6.3.9
16	Species at risk, at-risk and sensitive ecological communities and rare plants	
16.1	The Proponent shall ensure that potential effects of the Designated Project on species at risk, at-risk and sensitive ecological communities and rare plants are addressed and monitored.	Section 6.4
16.2	The Proponent shall develop, in consultation with Environment Canada, a plan setting out measures to address potential effects of the Designated Project on species at risk, at-risk and sensitive ecological communities and rare plants.	Section 6.4

FDS Condition	Condition	Report Section
16.3	The plan shall include:	
16.3.1	field work to verify the modeled results for surveyed species at risk and determine the habitat that would be permanently lost, habitat that would be fragmented and habitat that would remain intact for those species, including the Short-eared Owl, the Western Toad and the Myotis Bat species	2015 Annual Report (Section 6.4.1)
16.3.2	surveys to determine whether the rare plant species potentially facing extirpation in the Project Activity Zone are found elsewhere in the region	2017 Annual Report (Section 6.4.1; Section 7.2.1; Appendix 9)
16.3.3	measures to mitigate environmental effects on species at risk and at-risk and sensitive ecological communities and rare plants;	Section 6.4.1
16.3.4	conservation measures to ensure the viability of rare plants, such as seed recovery and plant relocation;	Section 6.4.2
16.3.5	an approach to avoiding or minimizing the use of herbicides and pesticides in areas that could impact species at risk, at-risk and sensitive ecological communities and rare plants;	2017 Annual Report (Section 6.4.4)
16.3.6	an approach to monitor and evaluate the effectiveness of mitigation measures and to verify the accuracy of the predictions made during the environmental assessment on species at risk, at-risk and sensitive ecological communities and rare plants; and	Section 6.4.3
16.3.7	an approach for tracking updates to the status of listed species identified by the Government of British Columbia, Committee on the Status of Endangered Wildlife in Canada, and the Species at Risk Act, and implementation of additional measures, in accordance with species recovery plans, to mitigate effects of the Designated Project on the affected species should the status of a listed species change during the life of the Designated Project.	Section 6.4.4

Table 2. Environmental Assessment Certificate conditions and associated annual report sections

EAC Condition	Condition	Report Section
Vegetation and Ecological Communities		
9	The EAC Holder must develop a Vegetation and Invasive Plant Management Plan to protect ecosystems, plant habitats, plant communities, and vegetation with components applicable to the construction phase.	Section 7.1
	The Vegetation and Invasive Plant Management Plan must include at least the following:	

EAC Condition	Condition	Report Section
	Invasive Species	
	• Surveys of existing invasive species populations prior to construction.	2015 Annual Report (Section 7.1.1)
	• Invasive plant control measures to manage established invasive species populations and to prevent invasive species establishment.	Section 7.1.1
	Rare Plants and Sensitive Ecosystems	
	• The EAC Holder must expand its modelling, including completing field work, to improve identification of rare and sensitive plant communities and aid in delineation of habitats that may require extra care, 90 days prior to any Project activities that may affect these rare or sensitive plant communities	2015 Annual Report (Section 7.1.3)
	• The EAC Holder must, with the use of a QEP, complete an inventory in areas not already surveyed and use rare plant location information as inputs to final design of access roads and transmission lines. These pre- construction surveys must target rare plants as defined in Section 13.2.2 of the EIS —including vascular plants, mosses, and lichens.	Section 7.1.2
	• The EAC Holder must create and maintain a spatial database of known rare plant occurrences in the vicinity of Project components that must be searched to avoid effects to rare plants during construction activities. The database must be updated as new information becomes available and any findings of new rare plant species occurrences must be submitted to Environment Canada and MOE using provincial data collection standards.	Section 7.1.3
	• The EAC Holder must implement construction methods to reduce the impact to rare plants, maximize use of existing access corridors, and construct transmission towers and temporary roads away from wetlands and known rare plant occurrences.	Section 7.1.4
	• Protect known occurrences of Tufa seeps, wetlands and rare plants located adjacent to construction areas. Install signage and flagging where necessary, as determined by the QEP, to indicate the boundaries of the exclusion area.	Section 7.1.5
	• The EAC Holder will engage the services of a Rare Plant Botanist during construction to design and	Section 7.1.6

EAC Condition	Condition	Report Section
	implement an experimental rare plant translocation program in consultation with MOE using the BC MOE's Guidelines for Translocation of Plant Species at Risk in BC (Maslovat, 2009).	
10	The EAC Holder must fund or undertake directly with the use of a Rare Plant Botanist the following, during construction:	2017 Annual Report (Section 7.2)
	• Targeted surveys in the RAA (as defined in the amended EIS) to identify occurrences of the 18 directly affected rare plant species (as defined in the amended EIS), and rare plant species identified by the MOEs Conservation Framework requiring additional inventories	2017 Annual Report (Section 7.2.1 and Appendix 9)
	• A study focused on clarifying the taxonomy of Ochroleucus bladderwort (*Utricularia ochroleuca*), including field, herbaria, and genetic work in consultation with FLNR and the MOE (BC Conservation Data Centre).	2017 Annual Report (Section 7.2.2 and Appendix 10)
11	EAC Holder must compensate for the loss of rare and sensitive habitats and protect occurrences of rare plants by developing, or funding the development and implementation of a compensation program, during construction, that includes:	Section 7.3
	• Assistance (financial or in-kind) to the managing organization of suitable habitat enhancement projects in the RAA (RAA as defined in the amended EIS).	Section 7.3.1
	• Direct purchase of lands in the RAA and manage these lands and suitable existing properties owned by the EAC Holder to enhance or retain rare plant values where opportunities exist.	Section 7.3.2
	The EAC Holder must engage with FLNR, MOE and Aboriginal Groups with regard to the development of the compensation program.	Section 7.3.3
12	The EAC Holder must develop a Wetland Mitigation and Compensation Plan.	Section 7.4
	The Wetland Mitigation and Compensation Plan must include an assessment of wetland function lost as a result of the Project that is important to migratory birds and species at risk (wildlife and plants). The Wetland Mitigation and Compensation Plan must be developed by a QEP with experience in wetland enhancement, maintenance and development.	Section 7.4.1
	The Wetland Mitigation and Compensation Plan must	

EAC Condition	Condition	Report Section
	include at least the following:	
	• Information on location, size and type of wetlands affected by the Project	Section 7.4.1.1
	• If roads cannot avoid wetlands, culverts will be installed under access roads to maintain hydrological balance, and sedimentation barriers will be installed;	2017 Annual Report (Section 7.3.1.2)
	• Stormwater management will be designed to control runoff and direct it away from work areas where excavation, spoil placement, and staging activities occur.	2017 Annual Report (Section 7.3.1.3)
	• Develop, with the assistance of a hydrologist, site-specific measures prior to construction to reduce changes to the existing hydrologic balance and wetland function during construction of the Jackfish Lake Road and Project access roads and transmission line.	2017 Annual Report (Section 7.3.1.4)
	• All activities that involve potentially harmful or toxic substances, such as oil, fuel, antifreeze, and concrete, must follow approved work practices and consider the provincial BMP guidebook Develop with Care (BC Ministry of Environment 2012 or as amended from time to time).	2017 Annual Report (Section 7.3.1.5)
14	The EAC Holder must develop a Vegetation and Ecological Communities Monitoring and Follow-up Program for the construction phase and first 10 years of the operations phase. The Vegetation and Ecological Communities Monitoring and Follow-up Program must be developed by a QEP. The Vegetation and Ecological Communities Monitoring and Follow-up Program must include at least the following:	Section 7.5
	• Definition of the study design for the rare plant translocation program (see condition 9).	7.5.1
	• Plan for following-up monitoring of any translocation sites to assess the survival and health of translocated rare plant species, under the supervision of a Rare Plant Botanist.	7.5.2
	• Measurement criteria, including vegetation growth, persistence of rare plants and establishment / spread of invasive plant species, and associated monitoring to document the effectiveness of habitat	7.5.3

EAC Condition	Condition	Report Section
	enhancement and possible compensation programs.	
Wildlife Resources		
15	The Wildlife Management Plan must be developed by a QEP.	Section 4.0
	The Wildlife Management Plan must include at least the following:	
	• Field work, conducted by a QEP, to verify the modelled results for surveyed species at risk and determine, with specificity and by ecosystem, the habitat lost or fragmented for those species. The EAC Holder must use these resulting data to inform final Project design and to develop additional mitigation measures, as needed, as part of the Wildlife Management Plan, in consultation with Environment Canada and FLNR.	2015 Annual Report (Section 7.3.1)
	• Measures to avoid, if feasible, constructing in sensitive wildlife habitats. If avoiding sensitive wildlife habitats is not feasible, condition 16 applies.	Section 7.6.1
	• If sensitive habitats, such as wetlands, are located immediately adjacent to any work site, buffer zones must be established by a QEP to avoid direct disturbance to these sites.	Section 7.6.2
	• Protocol for the application of construction methods, equipment, material and timing of activities to mitigate adverse effects to wildlife and wildlife habitat.	Section 7.6.3
	• Protocol to ensure that lighting is focused on work sites and away from surrounding areas to manage light pollution and disturbance to wildlife. If lighting cannot be directed away from surrounding areas, the EAC Holder must ensure additional mitigation measures are implemented to reduce light pollution, including light shielding.	Section 7.6.4
	• A mandatory environmental training program for all workers so that they are informed that hunting in the vicinity of any work site/Project housing site is strictly prohibited for all workers. The EAC Holder must ensure that all workers are familiar with the Wildlife Management Plan.	Section 7.6.5
16	If loss of sensitive wildlife habitat or important wildlife areas cannot be avoided through Project design or otherwise mitigated, the EAC Holder must implement	Section 7.7

EAC Condition	Condition	Report Section
	the following measures, which must be described in the Vegetation and Wildlife Mitigation and Monitoring Plan.	
	The Vegetation and Wildlife Mitigation and Monitoring Plan must include the following compensation measures:	
	• Compensation options for wetlands must include fish-free areas to manage the effects of fish predation on invertebrate and amphibian eggs and larvae and young birds.	Section 7.7.1
	• Mitigation for the loss of snake hibernacula, artificial dens must be included during habitat compensation.	Section 7.7.2
	• Management of EAC Holder-owned lands adjacent to the Peace River suitable as breeding habitat for Northern Harrier and Short-eared Owl.	2017 Annual Report (Section 7.6.1)
	• Establishment of nest boxes for cavity-nesting waterfowl developed as part of wetland mitigation and compensation plan, and established within riparian vegetation zones established along the reservoir on BC Hydro-owned properties.	Section 7.7.3
	• A design for bat roosting habitat in HWY 29 bridges to BC Ministry of Transportation and Infrastructure (MOTI) for consideration into new bridge designs located within the Peace River valley.	Section 7.7.4
	• Following rock extraction at Portage Mountain, creation of hibernating and roosting sites for bats.	Section 7.7.5 VWMMP Section 8.7.6
	• Creation of natural or artificial piles of coarse woody debris dispersed throughout the disturbed landscape to maintain foraging areas and cold-weather rest sites, and arboreal resting sites, for the fisher population south of the Peace River.	Section 7.7.6
19	The EAC Holder must use reasonable efforts to avoid and reduce injury and mortality to amphibians and snakes on roads adjacent to wetlands and other areas where amphibians or snakes are known to migrate across roads including locations with structures designed for wildlife passage	Section 7.8
21	The EAC Holder must ensure that measures implemented to manage harmful Project effects on wildlife resources are effective by implementing monitoring measures detailed in a Vegetation and Wildlife Mitigation and Monitoring Plan.	Section 7.9
	The Vegetation and Wildlife Mitigation and Monitoring	Section 4.0

EAC Condition	Condition	Report Section
	Plan must be developed by a QEP.	
	The Vegetation and Wildlife Mitigation and Monitoring Plan must include at least the following:	
	• Monitor Bald Eagle nesting populations adjacent to the reservoir, including their use of artificial nest structures.	Section 7.9.1
	• Monitor waterfowl and shorebird populations and their use of natural wetlands, created wetlands, and artificial wetland features.	Section 7.9.2
	• Monitor amphibian use of migration crossing structures installed along Project roads.	Section 7.9.3
	• Survey songbird and ground-nesting raptor populations during construction and operations	Section 7.9.4
	• Require annual reporting during the construction phase and during the first 10 years of operations to EAO, beginning 180 days following commencement of construction.	Section 7.9.5
23	The EAC Holder must maintain current knowledge of Project effects on the status of listed species by tracking updates for species identified by the Province, the Committee on the Status of Endangered Wildlife in Canada, and the *Species at Risk Act.*	Section 7.10
24	The EAC Holder must identify suitable lands for ungulate winter range by the end of the first year of construction, on BC Hydro-owned lands, or Crown lands, in the vicinity of the Project in consultation with FLNR. If FLNR determines that identified winter range is required, the EAC Holder must identify and maintain suitable BC Hydro- owned lands for ungulate winter range to the satisfaction of FLNR and for the length of time determined by FLNR.	Section 7.11

3.0 Consultation

Consultation regarding the development and implementation of individual programs conducted in 2022 is provided below.

3.1 Canadian Wildlife Services

In 2022 BC Hydro continued to consult with the Canadian Wildlife Service (CWS) during plan development and implementation. Consultation occurred primarily through the Vegetation and Wildlife Mitigation and Monitoring Technical Committee (VWTC), to which CWS, BC Hydro, and provincial agencies belong. The VWTC was established by the Comptroller of Water Rights under Conditional Water Licences 132990 and 132991 (see Section 3.2).

3.2 Consultation with the Province

The VWTC was established by the Comptroller of Water Rights under Conditional Water Licences 132990 and 132991 to provide ongoing engagement between BC Hydro, Ministry of Environment and Climate Change Strategy (MOECCS) and Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) with respect to the implementation of vegetation and wildlife mitigation and monitoring programs. The province requested that the VWTC be formed as a sub-committee of the existing BC and BC Hydro joint Fish / Hydro Management Committee. The Canadian Wildlife Service of Environment and Climate Change Canada (ECCC) joined the VWTC in July 2016.

The VWTC met in person or via conference call eight times in 2022 to address the Program Areas listed in Schedule A of Conditional Water Licenses 132990 and 132991. Table 3 summarizes the status of the Schedule A Program Areas as of 31 December 2022.

Table 3. Status of Schedule A Program Area Plans as of 31 December 2022.

Program Area Plans	Status
Completed	
1. Ungulates	Complete
2.1. Wetlands and Riparian Habitat: Wetland Function Assessment	Complete
2.2. Wetlands and Riparian Habitat: Downstream Vegetation Monitoring	Complete
	Complete
5.1. Snakes – Downstream Monitoring	Complete
5.2. Snakes – Hibernacula Mitigation and Monitoring	Complete
6.1. Amphibians – Downstream Monitoring	Complete
6.2. Amphibians – Migration Mitigation	Complete
7. Eagles	Complete
8.3. Breeding and Migratory Birds – Common Nighthawk	Complete
8.4. Breeding and Migratory Birds – Woodpeckers	Complete
8.5. Breeding and Migratory Birds – Nest Monitoring	Complete
9. Ground Nesting Raptors	Complete

Program Area Plans	Status
11.1. Rare Plants - Translocation	Complete
11.2. Rare Plants – Regional Surveys	Complete
12. Sharp-tailed Grouse	Complete
13. Lighting Effects	Complete
14. Carnivore Den Sites	Complete
15. Other Raptors	Complete
16. Other Species at Risk	Complete
17. Furbearers	Complete
18. Ungulate calving habitat	Complete
19. Mineral licks	Complete
20. Bear and carnivore habitats	Complete
In Progress	
3. Fisher	In progress
4. Bats	In progress
8.1. Breeding and Migratory Birds - Songbirds	In progress
8.2. Breeding and Migratory Birds – Waterbirds	In progress
10. Cavity Nesting Species	In progress

4.0 Qualified professionals

The Qualified Professionals involved in the development and implementation of vegetation and wildlife mitigation and monitoring programs in 2022 are listed in Table 4.

Table 4. Qualified Professionals involved in development and implementation of programs in 2022

Qualified Professional	Area of Work
Brock Simons, M.Sc., R.P.Bio., BC Hydro	Vegetation and Wildlife
Natasha Bush, M.Sc. P.Ag., EcoLogic Consultants Ltd.	Experimental Rare Plant Translocation, Wetland Monitoring Program
Claudia Houwers, B.Sc., R.P.Bio., P.Biol., Terrestrial Ecologist	Downstream Vegetation Monitoring Program
Dan McAllister, M.Sc., P.Ag., EcoLogic	Experimental Rare Plant Translocation
Jamie Fenneman, Ph.D. R.P.Bio., EcoLogic	Experimental Rare Plant Translocation
Ryan Durand, M.Sc. R.P.Bio., EcoLogic	Experimental Rare Plant Translocation, Wetland Monitoring Program
Jason Jones, Ph.D. R. P. Bio., P. Biol., EcoLogic	Experimental Rare Plant Translocation, Wetland Monitoring, Downstream Vegetation Monitoring
Katherine Garrah, M.Sc. A.Ag. EcoLogic	Experimental Rare Plant Translocation

Qualified Professional	Area of Work
Holly Buehler, MSc. EcoLogic	Experimental Rare Plant Translocation
Randy Krichbaum, M.Sc., P.Biol., R.P.Bio., Eagle Cap Consulting Ltd.	Pre-construction Rare Plant Surveys and Experimental Rare Plant Translocation
Margaret Krichbaum, B.Sc., Eagle Cap Consulting Ltd.	Pre-construction Rare Plant Surveys and Experimental Rare Plant Translocation
Jeff Matheson M.Sc., R.P.Bio., P.Biol., Tetra Tech Canada Inc.	Breeding bird and raptor monitoring
Elyse Hofs, B.Sc., Dipl.T., Tetra Tech Canada Inc.	Breeding bird and raptor monitoring
Heather Bianchini, R.T. Biol., Tetra Tech Canada Inc.	Breeding bird and raptor monitoring
Charlie Palmer, M.Sc., P.Biol., R.P.Bio, Ausenco Sustainability	Strategic advisor, cavity nesting bird mitigation, waterbird monitoring, Portage Mountain bat monitoring, bald eagle monitoring, migratory bird nest monitoring
Jay Brogan M.Sc., R.P.Bio., Ausenco Sustainability	Project manager, cavity nesting bird mitigation, waterbird monitoring, Portage Mountain bat monitoring, bald eagle monitoring, migratory bird nest monitoring
Toby St. Clair, M.Sc., Ausenco Sustainability	Waterbird monitoring, Migratory bird nest monitoring
Felix Martinez-Nunez, M.Sc., R.P.Bio, Ausenco Sustainability	Portage Mountain bat monitoring, cavity nesting bird monitoring
Catherine Craig, M.Sc., R.P.Bio., Ausenco Sustainability	Migratory bird nest monitoring, waterbird monitoring,
Lorraine Andrusiak, M.Sc., R.P.Bio., Ausenco Sustainability	Portage Mountain bat monitoring, cavity nesting bird mitigation, bald eagle monitoring, migratory bird nest monitoring, waterbird monitoring
Iain Jones, M.Sc., Dipl. Tech., RPBio WSP Senior Wildlife Biologist,	Wildlife mitigation structure monitoring program director, technical review and environmental compliance QEP
Tanya Seebacher, MSc, R.P.Bio WSP	Snake artificial den monitoring
Mitch Firman, B.Sc. WSP	Bat box monitoring
Mike Sarell, R.P.Bio. Ophiuchus Consulting	Snake artificial den monitoring, bat artificial hibernacula design consultant
Larry Davis, MSc, R.P.Bio. Davis Environmental Ltd.	Fisher den monitoring

5.0 Structure and Content

The mitigation and monitoring measures discussed in this report are organized into two parts: Section 6.0 describes those mitigation and monitoring measures that were implemented to meet the requirements of the FDS conditions; Section 7.0 describes those measures that were implemented to meet the requirements of the EAC conditions. Cross-references are provided in Section 7.0 where information provided to meet the EAC conditions is the same as that provided for the FDS conditions.

Of the programs outlined in the Vegetation and Wildlife Mitigation Plan, only riparian plantings, which are required by FDS 10.3.3, was not implemented in 2022. Those plantings will be implemented as part of site reclamation, after reservoir filling.

6.0 Implementation of Mitigation and Monitoring Measures – Federal Decision Statement Conditions

Conditions 9, 10, 11, and 16 of the FDS, respectively, set out the mitigation and monitoring requirements for the disturbance and destruction of migratory birds, non-wetland migratory bird habitat, wetlands used by migratory birds and for current use of lands and resources for traditional purposes, and species at risk, at-risk and sensitive ecological communities and rare plants (Table 1).

6.1 Federal Decision Statement Condition 9: Migratory Bird Mitigation and Monitoring

This section of the annual report summarizes the programs conducted in 2022 in accordance with the requirements of FDS condition 9, shown below.

9. Disturbance and destruction of migratory birds

9.1. The Proponent shall ensure that the Designated Project is carried out in a manner that avoids mortality and disturbance of migratory birds and their nests.

9.2. The Proponent shall prepare and submit to the Agency an annual schedule, describing the location and timing for construction and reservoir filling activities, 90 days prior to initiating any of these activities.

9.3. The Proponent shall develop, in consultation with Environment Canada, a plan to monitor and mitigate potential disturbance of breeding migratory birds in and adjacent to the Project Activity Zone, including the area immediately downstream of the dam where risks to migratory bird nests could occur, during construction, reservoir filling and operation.

9.4. The plan shall include measures to undertake construction, reservoir filling and operation in a manner that avoids or minimizes the risk of disturbance and mortality to migratory birds and their nests.

9.5. The Proponent shall, in preparing the plan, consult:

9.5.1. Environment Canada’s policy on Incidental Take of Migratory Birds in Canada; and

9.5.2. Environment Canada’s avoidance guidelines on General Nesting Periods of Migratory Birds in Canada.

9.6. The Proponent shall submit to the Agency and Environment Canada a draft copy of the plan for review 90 days prior to initiating construction.

9.7. The Proponent shall submit to the Agency the final plan a minimum of 30 days prior to initiating construction. When submitting the final plan, the Proponent shall provide to the Agency an analysis that demonstrates how it has appropriately considered the input, views or information received from Environment Canada.

9.8. The Proponent shall implement the plan and provide to the Agency an analysis and summary of the implementation of the plan, as well as any amendments made to the plan in response to the results, on an annual basis during construction and for the first five years of operation.

9.9. The Proponent shall address potential risks of bird collisions with the transmission line, in consultation with Environment Canada, by:

9.9.1. conducting a risk assessment for bird collisions under the current transmission line design;

9.9.2. determining if additional mitigation measures could be implemented to reduce the risk of bird collisions; and

9.9.3. implementing any additional mitigation measures (e.g. line marking and diversions), to minimize impacts.

6.1.1 Condition 9.1

This section summarizes actions taken in accordance with the following requirement of Condition 9.1: *The Proponent shall ensure that the Designated Project is carried out in a manner that avoids mortality and disturbance of migratory birds and their nests.*

In accordance with Condition 9.1, BC Hydro has, where feasible, given Project requirements and constraints, scheduled vegetation clearing outside of the migratory bird nesting period. The Project occurs within Zone B5, for which Environment and Climate Change Canada describes a general nesting period for migratory birds of 19 April to 29 August[1]. BC Hydro developed Section 4.17 of the CEMP to address the requirements of Condition 9.1 and EAC Condition 17, and provided an outline of the nest survey protocol in Section 3.5.1 of the Vegetation Clearing and Debris Management Plan.

BC Hydro developed a pre-clearing nesting activity survey methodology, which outlines specific field procedures to be followed to determine the likelihood that migratory bird nests are present in areas scheduled to be disturbed. The protocol also describes the approach for determining appropriate situation- and species-specific disturbance setback buffers to be applied around locations where nests are likely to be present. That document was broadly distributed to contractors starting when it was first developed in 2015 and 2016. The document was revised in 2018 and 2019 and inserted as Appendix N of the CEMP, starting with rev.6.1 in 2019.

In 2022, pre-clearing nesting activity surveys were completed between April and August wherever small-scale clearing within the migratory bird nesting period could not be avoided. If active or suspected nest areas were identified, protective buffers were established around active nests, as determined by a Qualified Environmental Professional (QEP). Contractor compliance with appropriate steps for mitigating the risk of incidental take of migratory birds, nests and eggs was monitored by BC Hydro environmental monitors and the Independent Environmental Monitor (IEM).

6.1.2 Condition 9.2

This section summarizes actions taken in accordance with the following requirement of Condition 9.2: *The Proponent shall prepare and submit to the Agency an annual schedule, describing the location and timing for construction and reservoir filling activities, 90 days prior to initiating any of these activities.*

An initial construction schedule was submitted to CEAA on 17 October 2014. The most recently revised construction schedule, updated in March 2023 can be found in Appendix 1.

6.1.3 Condition 9.3

This section summarizes actions taken in accordance with the following requirement of Condition 9.3: *The Proponent shall develop, in consultation with Environment Canada, a plan to monitor and mitigate potential disturbance of breeding migratory birds in and adjacent to the*

[1] https://www.canada.ca/en/environment-climate-change/services/avoiding-harm-migratory-birds/general-nesting-periods/nesting-periods.html#_zoneB_calendar

Project Activity Zone, including the area immediately downstream of the dam where risks to migratory bird nests could occur, during construction, reservoir filling and operation.

6.1.3.1 Songbird surveys

The songbird monitoring program is focussed on passerines (songbird perching birds), hummingbirds, swifts, doves, kingfisher, and pigeons (all members of the orders Passeriformes, Apodiformes, Columbiformes, and Coraciiformes), which are collectively referred to as songbirds. Songbird baseline surveys were conducted in 2006, 2008, 2011 and 2012 in support of the EIS. Surveys were again conducted annually 2016 through 2022 as part of the monitoring program. The Breeding Bird Follow-up Monitoring – Songbirds 2022 Annual Report can be found in Appendix 2.

6.1.3.2 Common nighthawk surveys

Common Nighthawk is designated as Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), Threatened under Schedule 1 of the Species at Risk Act (SARA), and listed as Yellow (secure) in British Columbia. Common nighthawk surveys were conducted in 2010 and 2012 in support of the EIS. Surveys again occurred over two years, with approximately half occurring in 2018 and half in 2019 as part of the monitoring program. The Common Nighthawk Follow-up Monitoring 2018 and 2019 annual reports were provided in the 2018 and 2019 VWMMP annual reports.

6.1.3.3 Woodpecker surveys

Woodpecker surveys were conducted in 2010 in support of the EIS. Woodpecker surveys are being completed in the project footprint within the Peace River Valley and in the BC Hydro proposed mitigation properties over a two-year period (2018 and 2019) as part of the monitoring program. The Breeding Bird Follow-up Monitoring – Woodpeckers 2019 Annual Report was provided in the 2019 VWMMP annual report.

6.1.3.4 Waterbird surveys

The waterbirds survey program is focussed on shorebirds, marsh birds, waterfowl, and other birds associated with aquatic and wetland habitats (collectively known as ‘waterbirds’). Waterbird surveys were conducted in the Peace River and adjacent wetlands in 2006 and 2008 and 2012 through 2014. Those waterbird surveys were conducted using fixed-wing aircraft and twin-engine helicopter surveys and, to a lesser extent, ground and boat surveys. No shorebirds were documented during helicopter and fixed-wing aircraft surveys between 2012 and 2014 because of the difficulty detecting small birds using aerial surveys. As a result, methods were adapted in 2017 to continue the use of fixed-wing aircraft for aerial surveys, and to add ground, river boat, unmanned aerial vehicle and autonomous recording unit survey methods. However, aerial surveys make identifying most waterbirds to the species level difficult, and therefore the aerial component of waterbird surveys was discontinued and not applied after 2017. In discussion with CWS, unmanned aerial vehicles were discontinued in 2020 because they were not shown to be efficient for waterbird data collection. The Waterbirds Follow-up Monitoring 2022 Annual Report can be found in Appendix 3.

6.1.3.4 Migratory bird nest monitoring

A migratory bird nest monitoring program was developed and first implemented in 2021 to monitor the potential disturbance to breeding migratory birds from fluctuating water levels caused by construction and operations activities. In 2022, 39 days of nest searching and monitoring surveys were conducted from June 2 to July 11, 2022. The Migratory Bird Nest Monitoring Program 2022 Annual Report can be found in Appendix 4.

6.1.4 Condition 9.9.2

This section summarizes actions taken in accordance with the following requirement of Condition 9.9.2: *The Proponent shall address potential risks of bird collisions with the transmission line, in consultation with Environment Canada, by determining if additional mitigation measures could be implemented to reduce the risk of bird collisions.*

A risk assessment for bird collisions with the transmission line was included in Section 6.1.3 of the 2016 VWMMP Annual Report. Since that time, changes have been incorporated in the transmission line design and implemented in construction that further reduce the risk of bird collisions:

- Phase to phase spacing is more than 12 meters, preventing any electrocution hazard that exists on distribution lines;
- Conductor size is approximately 1.25” diameter, therefore easier for birds to see. Each phase of the conductor will be configured in a square-shaped bundle of four, with spacing of 0.5 meters between each conductor, thus further increasing visibility for birds.
- There are no shield wires on most of the line. Shield wires are smaller in diameter and harder for birds to see and will only be installed in the last kilometer of each end of the line.
- Water crossings of the Peace and Moberly rivers will have marker spheres on them, which will increase visibility for birds.
- Guy wires on the structures are relatively low to the ground, as they connect to the tower at 2/3 the height of the tower. The lower height of the guy wires will reduce risk to birds. The bottoms of the guy wires are marked with bright yellow plastic guards, which will increase their visibility, and further reduce risk to birds.

6.2 Federal Decision Statement Condition 10: Non-Wetland Migratory Bird Habitat Mitigation and Monitoring

This section of the annual report summarizes the applicable components of the VWMMP implemented to fulfill FDS condition 10 in 2022 in accordance with the requirements of FDS condition 10.8. For context, the complete requirements of FDS condition 10 are shown below.

10. Non-wetland migratory bird habitat

10.1. The Proponent shall mitigate the potential effects of the Designated Project on non- wetland migratory bird habitat.

10.2. The Proponent shall develop, in consultation with Environment Canada, a plan that addresses potential effects of the Designated Project on non-wetland migratory bird habitat.

10.3. The plan shall include:

10.3.1. non-wetland migratory bird habitat baseline conditions for habitat that would be permanently lost, habitat that would be fragmented and habitat that would remain intact;

10.3.2. migratory bird abundance, distribution and use of non-wetland habitat;

10.3.3. measures to mitigate the changes in aquatic and riparian-related food resources and other habitat features associated with a change from a fluvial to a reservoir system;

10.3.4. compensation measures to address the unavoidable loss of non-wetland migratory bird habitat, including habitat associated with the Canada Warbler, the Cape May Warbler and the Bay-Breasted Warbler;

10.3.5. an analysis of the effects of any compensation measures identified in condition

10.3.4 on the current use of lands and resources for traditional purposes by Aboriginal peoples; and

10.3.6. an approach to monitor and evaluate the effectiveness of the mitigation or compensation measures to be implemented and to verify the accuracy of the predictions made during the environmental assessment on non-wetland migratory bird habitat, including migratory bird use of that habitat.

10.4. The Proponent shall submit to the Agency and Environment Canada a draft copy of the plan for review:

10.4.1. for conditions 10.3.1, 10.3.2, 10.3.3 and 10.3.6, 90 days prior to initiating construction; and

10.4.2. for conditions 10.3.4 and 10.3.5, 90 days prior to implementing any component of the compensation plan.

10.5. The Proponent shall submit to the Agency the final plan:

10.5.1. for conditions 10.3.1, 10.3.2, 10.3.3 and 10.3.6, a minimum of 30 days prior to initiating construction; and

10.5.2. for conditions 10.3.4 and 10.3.5, a minimum of 30 days prior to implementing any component of the compensation plan.

10.6. When submitting each component of the final plan, the Proponent shall provide to the Agency an analysis that demonstrates how it has appropriately considered the input, views or information received from Environment Canada.

10.7. The Proponent shall commence the implementation of the compensation measures specified in condition 10.3.4 no later than five years from the initiation of construction.

10.8. The Proponent shall implement each component of the plan and provide to the Agency an analysis and summary of the implementation of the applicable component of the plan, as well as any amendments made to the plan in response to the results, on an annual basis during construction and at the end of year 1, 2, 3, 5, 10, 15, 20 and 30 of operation.

6.2.1 Condition 10.3.1

This section summarizes actions taken in accordance with the following requirement of Condition 10.3.1: *The plan shall include non-wetland migratory bird habitat baseline conditions for habitat that would be permanently lost, habitat that would be fragmented and habitat that would remain intact.*

The collection of data on non-wetland migratory bird habitat baseline conditions is done through implementation of the migratory bird monitoring plans, of which the 2022 surveys are discussed in Section 6.1.3 in relation to FDS Condition 9.3 (monitor and mitigate potential disturbance of breeding migratory birds).

6.2.2 Condition 10.3.2

This section summarizes actions taken in accordance with the following requirement of Condition 10.3.2: *The plan shall include migratory bird abundance, distribution and use of non-wetland habitat.*

The collection of data on non-wetland migratory bird abundance, distribution and use of non-wetland habitat is done through implementation of the migratory bird monitoring plans, of which the 2022 surveys are discussed in Section 6.1.3 in relation to FDS Condition 9.3 (monitor and mitigate potential disturbance of breeding migratory birds).

6.2.3 Condition 10.3.3

This section summarizes actions that are being taken in accordance with the following requirement of Condition 10.3.3: *The plan shall include measures to mitigate the changes in aquatic and riparian-related food resources and other habitat features associated with a change from a fluvial to a reservoir system*.

Mitigation measures have been developed to reduce potential adverse impacts associated with a change from a fluvial to a reservoir system by increasing the area of shallow water habitat at along the reservoir shoreline. These measures are expected to enhance fish habitat and also benefit migratory birds by increasing the abundance and availability of aquatic plants, aquatic invertebrates, and fish.

In 2022, construction work ocurred for the following reservoir littoral zone enhancements that are expected to benefit migratory birds:

- About 20.8 ha of littoral habitat was created using rock clusters at about Km 26.
- About 9.0 ha of shallow bench was created along the northern shoreline of the reservoir immediately east of Dry Creek between Km 42-44.
- About 5 ha of littoral habitat was created on the northern shoreline of the reservoir, at the Peaceview Borrow area at Km 78.
- About 1.3 ha of shallow water habitat was created through shoreline protection enhancement at Hudson's Hope.

In addition to the 40.4 ha previously created at sites 108R and 109L, about 15 ha of littoral zone enhancements are expected to be constructed in 2023 through Peace River channel contouring and side channel enhancements at Site 107R. On the northern shoreline of the future reservoir at Wilder Creek at Km 91, construction of littoral habitat planned for early 2023 is expected to provide an additional 19 ha of littoral habitat after reservoir filling. Also, about 3.5 ha of littoral habitat is being created in early 2023 at a rock outcrop at about Km 21 on the south bank of the Peace River.

The fish habitat offset projects are described in the Fisheries and Aquatic Habitat Management Plan[2] (FAHMP). Annual reports describing the status of implementation of these projects are available on the Site C Project website[3].

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[2] BC Hydro. 2015. Fisheries and Aquatic Habitat Management Plan. Site C Clean Energy Project. Revision 1: June 1, 2015. Available at: https://www.sitecproject.com/sites/default/files/Fisheries_and_Aquatic_Habitat_Management_Plan.pdf.

[3] Available at: https://www.sitecproject.com/document-library/environmental-management

6.2.4 Condition 10.3.4

This section summarizes actions taken in accordance with the following requirement of Condition 10.3.4: *The plan shall include compensation measures to address the unavoidable loss of non-wetland migratory bird habitat, including habitat associated with the Canada Warbler, the Cape May Warbler and the Bay-Breasted Warbler.*

BC Hydro continues to manage three properties (i.e., Marl Fen, Rutledge and Wilder Creek) that were retained partly to provide habitat for non-wetland migratory birds. Management plans for those properties were included in the 2015 annual report. In 2019, Ducks Unlimited Canada conducted the physical works necessary at Golata Canyon Ranch to create approximately 50 ha of sedge wetland (see Section 6.3.2). Vegetation developing on the periphery of this wetland is expected to also help support non-wetland migratory birds. No new properties were added to the program in 2022.

6.2.5 Condition 10.3.5

This section summarizes actions taken in accordance with the following requirement of Condition 10.3.4: *The plan shall include an analysis of the effects of any compensation measures identified in condition 10.3.4 on the current use of lands and resources for traditional purposes by Aboriginal peoples.*

To date, compensation measures to address the unavoidable loss of non-wetland migratory bird habitat have been restricted to fee simple lands. Compensation actions enacted on fee simple lands are not expected to affect current use of lands and resources for traditional purposes by Indigenous peoples. Access to fee simple lands is controlled by the owner, or, in the case of BC Hydro, the leaseholder of lands leased by BC Hydro.

6.2.6 Condition 10.3.6

This section summarizes actions taken in accordance with the following requirement of Condition 10.3.6: *The plan shall include an approach to monitor and evaluate the effectiveness of the mitigation or compensation measures to be implemented and to verify the accuracy of the predictions made during the environmental assessment on non-wetland migratory bird habitat, including migratory bird use.*

An approach to monitor the effectiveness of mitigation and compensation measures and to verify the accuracy of the predictions made during the environmental assessment on non-wetland migratory birds is done within the migratory bird monitoring plans. The migratory bird monitoring surveys conducted in 2022 are discussed in Section 6.1.3 in relation to FDS Condition 9.3 (monitor and mitigate potential disturbance of breeding migratory birds).

6.3 Federal Decision Statement Condition 11: Wetland Mitigation and Monitoring

This section of the annual report summarizes the components of the VWMMP implemented to fulfill FDS condition 11 in 2022 in accordance with the requirements of FDS condition 11.9. For context, the complete requirements of FDS condition 11 are listed below.

11.	**Wetlands used by migratory birds and for current use of lands and resources for traditional purposes**
11.1	The Proponent shall mitigate the potential effects of the Designated Project on wetland habitat

used by migratory birds, species at risk and for current use of lands and resources for traditional purposes by Aboriginal people.

11.2. The Proponent shall develop, in consultation with Environment Canada, Reservoir Area Aboriginal groups and Immediate Downstream Aboriginal groups, a plan that addresses potential effects of the Designated Project on wetland habitat used by migratory birds, species at risk and for current use of lands and resources for traditional purposes.

11.3. The Proponent shall, in developing the plan, describe how the mitigation hierarchy and the objective of no net loss of wetland functions were considered.

11.4. The plan shall include:

11.4.1. baseline data on the biogeochemical, hydrological and ecological functioning of the wetlands and associated riparian habitat in the area affected by the Designated Project, including: ground and surface water quality and quantity; vegetation cover; biotic structure and diversity; migratory bird abundance, density, diversity and use; species at risk abundance, density, diversity and use; and current use of the wetlands for traditional purposes by Aboriginal people, including the plant and wildlife species that support that use;

11.4.2. mitigation measures to maintain baseline wetland functions for those wetlands that will not be permanently lost;

11.4.3. an approach to monitor and evaluate any changes to baseline conditions, as defined in condition 11.4.1 and identify improvements based on monitoring data;

11.4.4. compensation measures to address the unavoidable loss of wetland areas and functions supporting migratory birds, species at risk, and the current use of lands and resources by Aboriginal people in support of the objective of full replacement of wetlands in terms of area and function; and

11.4.5. an analysis of the effects of any compensation measures identified in condition 11.4.4 on the current use of lands and resources for traditional purposes by Aboriginal peoples.

11.5. The Proponent shall submit to the Agency, Environment Canada, Reservoir Area Aboriginal groups and Immediate Downstream Aboriginal groups a draft copy of the plan for review:

11.5.1. for conditions 11.4.1, 11.4.2 and 11.4.3, 90 days prior to initiating construction; and

11.5.2. for conditions 11.4.4 and 11.4.5, 90 days prior to implementing any component of the compensation plan.

11.6. The Proponent shall submit to the Agency the final plan:

11.6.1. for conditions 11.4.1, 11.4.2 and 11.4.3, a minimum of 30 days prior to initiating construction; and

11.6.2. for conditions 11.4.4 and 11.4.5, a minimum of 30 days prior to implementing any component of the compensation plan.

11.7. When submitting each component of the final plan, the Proponent shall provide to the Agency an analysis that demonstrates how it has appropriately considered the input, views or information received from Environment Canada, Reservoir Area Aboriginal groups and Immediate Downstream Aboriginal groups.

11.8. The Proponent shall commence the implementation of the compensation measures specified in condition 11.4.4 no later than five years from the initiation of construction.

11.9. The Proponent shall implement each component of the plan and provide to the Agency an analysis and summary of the implementation of the plan, as well as any amendments made to the plan in response to the results, on an annual basis during construction and at the end of year 1, 2, 3, 5, 10, 15, 20 and 30 of operation.

6.3.1 Condition 11.1

This section summarizes actions taken in accordance with the following requirement of Condition 11.1: *The Proponent shall mitigate the potential effects of the Designated Project on wetland habitat used by migratory birds, species at risk and for current use of lands and resources for traditional purposes by Aboriginal people.*

The CEMP (Section 4.5) states that riparian habitat is to be protected by retaining "a 15 m machine-free riparian buffer from the Ordinary High Water Mark of watercourses and waterbodies during clearing, except where worker safety prohibits manual tree falling and vegetation removal methods, and as addressed in a site specific prescription prepared and endorsed by a QEP". The CEMP (Section 4.5) also requires that lay-down and material storage areas be located "at least 15 m from the Ordinary High Water Mark".

The location and boundaries of wetland habitats near construction areas are field-truthed, their boundaries flagged and coordinates recorded using GPS. This information was also used when determining the location of access roads that are being used to construct the transmission line. Mitigation for loss of wetland habitat is discussed in Section 6.3.2.

6.3.2 Condition 11.2

This section summarizes actions taken in accordance with the following requirement of Condition 11.2: *The Proponent shall develop, in consultation with Environment Canada, Reservoir Area Aboriginal groups and Immediate Downstream Aboriginal groups, a plan that addresses potential effects of the Designated Project on wetland habitat used by migratory birds, species at risk and for current use of lands and resources for traditional purposes.*

Potential effects of Site C on wetland habitat are being addressed within a wetland compensation plan, which has the objective of no net loss of wetland functions, as per FDS condition 11.3.

BC Hydro continues to manage the Marl Fen property, which was retained (in part) to protect the marl fen that makes up part of the property. The management plan for that property was included in the 2015 annual report. In 2019, Ducks Unlimited Canada conducted the physical works necessary at Golata Canyon Ranch to create approximately 50 ha of sedge wetland. The development of this wetland area, as vegetation establishes and wetland functions increase, will be monitored over time.

DUC does not have the funding to rebuild aging water control infrastructure, and as a result has been required by their respective water licenses to decommission infrastructure at 13 wetlands in BC since 2009, returning those wetlands to approximately pre-construction conditions and losing functional wetland area. Providing funding to DUC to rebuild aging water control infrastructure saves wetland area from being lost, and therefore meets international best practice standards for biodiversity offsets. DUC has identified seven historically constructed wetlands that are nearing the end of the 30-year lifespan of their water control infrastructure, all in the Peace Region within about 100 km of Site C. Water control infrastructure at three of the seven wetlands was rebuilt in 2022, which represents about 175 ha of wetland area that would otherwise be lost. Aging water control infrastructure is planned to be rebuilt at the other four wetlands in 2023 and 2024, which will preserve another 102 ha. In total, rebuilding the infrastructure at those seven wetlands is estimated to result in preserving 277 ha of wetland area that would otherwise be lost.

BC Hydro estimates that a further 86 ha of wetland will be created during reclamation of Area A. In total, the wetland compensation opportunities that have been constructed or identified for Site C total an estimated 412 ha of wetland. Additional wetland compensation is required beyond what has been constructed or identified, and BC Hydro is working with DUC and local Indigenous Groups to identify further wetland compensation opportunities. The total area that will be required as compensation has yet to be determined due in part to uncertainty regarding total wetland impacts, which is being addressed through wetland monitoring. Wetland compensation opportunities identified so far are primarily sedge wetlands, but BC Hydro is working with DUC to explore options to integrate other wetland types into compensation planning.

A wetland monitoring program has been developed through consultation with and review by MOECCS, FLNRORD, and CWS through the VWTC. Based on the requirements for wetland monitoring described in FDS Condition 11, the monitoring program was developed to comprise the following:

- collection of baseline data on the biogeochemical, hydrological and ecological functioning of the wetlands and associated riparian habitat in the area affected by the Designated Project;
- an evaluation of change to baseline wetland conditions due to the Project;
- selection of compensation measures for loss of wetland areas and functions, including reclamation, improvement, creation and protection; and
- flexibility in the monitoring program to allow for further refinement in the characterization of baseline and affected wetlands, as data become available.

The monitoring program includes direct measures of groundwater quality and quantity, surface water quality and quantity, vegetation cover, structure and diversity, and rare plant occurrence. Wetland monitoring also includes wetland delineation to help evaluate and improve wetland mapping. Further data on biotic structure and diversity, and migratory bird and species at risk abundance, density, diversity and use will be gathered through focussed monitoring plans (e.g., see Section 6.1.3 for details on waterbird surveys). Baseline data regarding current use of wetlands for traditional purposes by Aboriginal people have been gathered by the BC Hydro Indigenous Relations team through groundtruthing with FN groups, who will also gather and compile data regarding changes to use of wetlands for traditional purposes.

The 2022 field program was focused on monitoring wetlands that were sampled in 2020 and 2021. The wetland monitoring program annual report for 2022 is Appendix 5.

Through consultation with and review by MOECCS, FLNRORD and CWS through the VWTC, BC Hydro developed the Wetland Function Assessment (WFA) tool to measure progress towards the objective of no net loss of wetland functions. The WFA assesses the unavoidable loss of wetland area and function that supports migratory birds, amphibians, bats, species at risk, and species important to Indigenous land use due to Project activities. In assessing the loss of wetland area and function, the WFA process informs compensation measures for full replacement of wetland area and function. Wetland function is defined as the natural processes that are associated with wetlands but does not refer to the benefits of those processes to humans.

6.3.3 Condition 11.3

This section summarizes actions taken in accordance with the following requirement of Condition 11.3: *The Proponent shall, in developing the plan, describe how the mitigation hierarchy and the objective of no net loss of wetland functions were considered.*

The mitigation framework has three main steps, as outlined in the Environment Canada's Operational Framework for Use of Conservation Allowances (2012):

- Avoid proposed impacts;
- Minimize proposed impacts; and
- Address any residual environmental effects that cannot be avoided or sufficiently minimized with the use of conservation allowances.

Measures to avoid where feasible, and to minimize impacts to wetlands where avoidance is not feasible, are described in the CEMP and the Site C Vegetation Clearing and Debris Management Plan. For residual impacts to wetlands, BC Hydro is working to create, restore and enhance wetlands with the objective of no net loss of wetland functions. Determining the residual impacts to wetland functions, and the appropriate amount and type of wetlands to develop as conservation allowances, will be done through application of the Wetland Function Assessment, combined with application of the associated wetland monitoring program (see Section 6.3.2 above). The wetland monitoring program is designed to measure residual impacts to wetlands due to Site C, as well as to measure positive changes to wetland functions because of BC Hydro's efforts to create, restore and enhance wetlands.

6.3.4 Condition 11.4.1

This section summarizes actions taken in accordance with the following requirement of Condition 11.4.1: *The plan shall include baseline data on the biogeochemical, hydrological and ecological functioning of the wetlands and associated riparian habitat in the area affected by the Designated Project, including: ground and surface water quality and quantity; vegetation cover; biotic structure and diversity; migratory bird abundance, density, diversity and use; species at risk abundance, density, diversity and use; and current use of the wetlands for traditional purposes by Aboriginal people, including the plant and wildlife species that support that use.*

Baseline data on the biogeochemical, hydrological and ecological functioning of wetlands and associated riparian habitat were collected during baseline surveys in support of the EIS, and subsequent surveys of wetlands, including those likely to be impacted by the transmission line RoW. See Section 6.3.2 for a description of the wetland monitoring program. The wetland monitoring program annual report for 2022 is Appendix 5.

6.3.5 Condition 11.4.2

This section summarizes actions taken in accordance with the following requirement of Condition 11.4.2: *The plan shall include mitigation measures to maintain baseline wetland functions for those wetlands that will not be permanently lost*.

For wetlands that will not be permanently lost, wetland function will be maintained through the timing of works (e.g. winter to minimize ground disturbance), maintenance of hydrology through the installation of culverts during road construction as a matter of practice, and approaches to minimize impacts to wetlands through careful construction practices (see Section 6.3.1). The Wetland Function Assessment tool and the associated wetland monitoring program were designed together to identify impacts to wetlands and wetland functions, which will then inform quantitative wetland compensation objectives (see Section 6.3.2).

6.3.6 Condition 11.4.3

This section summarizes actions taken in accordance with the following requirement of Condition 11.4.3: *The plan shall include an approach to monitor and evaluate any changes to baseline conditions, as defined in condition 11.4.1 and identify improvements based on monitoring data*.

See section 6.3.2 for discussion of the plan for monitoring and evaluating changes to baseline wetland conditions, as defined in condition 11.4.1, and for identifying improvements based on monitoring data.

6.3.7 Condition 11.4.4

This section summarizes actions taken in accordance with the following requirement of Condition 11.4.4: *The plan shall include compensation measures to address the unavoidable loss of wetland areas and functions supporting migratory birds, species at risk, and the current use of lands and resources by Aboriginal people in support of the objective of full replacement of wetlands in terms of area and function*.

Please see Section 6.3.2 for details on the wetland mitigation program and the Wetland Function Assessment tool.

6.3.8 Condition 11.8

This section summarizes actions taken in accordance with the following requirement of Condition 11.8: *The Proponent shall commence the implementation of the compensation measures specified in condition 11.4.4 no later than five years from the initiation of construction.*

Please refer to Section 6.3.2 for details on implementation of wetland compensation measures in 2015, the first year of construction, and ongoing implementation.

6.3.9 Condition 11.9

This section summarizes actions taken in accordance with the following requirement of Condition 11.9: *The Proponent shall implement each component of the plan and provide to the Agency an analysis and summary of the implementation of the plan, as well as any amendments made to the plan in response to the results, on an annual basis during construction and at the end of year 1, 2, 3, 5, 10, 15, 20 and 30 of operation*.

This annual report represents an analysis and summary of the implementation of the plan, as well as amendments made to the plan through the ongoing development of component mitigation and monitoring plans based on survey results and consultation with CWS, FLNRORD and MOECCS.

6.4 Federal Decision Statement Condition 16: Species at Risk Mitigation and Monitoring

This section of the annual report summarizes the programs as implemented in 2022 in accordance with the requirements of FDS condition 16.6.

For context, the complete requirements of FDS condition 16 are listed below.

16.	**Species at risk, at-risk and sensitive ecological communities and rare plants**
16.1.	The Proponent shall ensure that potential effects of the Designated Project on species at risk, at-risk and sensitive ecological communities and rare plants are addressed and monitored.
16.2.	The Proponent shall develop, in consultation with Environment Canada, a plan setting out measures to address potential effects of the Designated Project on species at risk, at-risk and sensitive ecological communities and rare plants.
16.3.	The plan shall include: 16.3.1. field work to verify the modeled results for surveyed species at risk and determine the habitat that would be permanently lost, habitat that would be fragmented and habitat that would remain intact for those species, including the Short-eared Owl, the Western Toad and the Myotis Bat species; 16.3.2. surveys to determine whether the rare plant species potentially facing extirpation in the Project Activity Zone are found elsewhere in the region; 16.3.3. measures to mitigate environmental effects on species at risk and at-risk and sensitive ecological communities and rare plants; 16.3.4. conservation measures to ensure the viability of rare plants, such as seed recovery and plant relocation; 16.3.5. an approach to avoiding or minimizing the use of herbicides and pesticides in areas that could impact species at risk, at-risk and sensitive ecological communities and rare plants; 16.3.6. an approach to monitor and evaluate the effectiveness of mitigation measures and to verify the accuracy of the predictions made during the environmental assessment on species at risk, at-risk and sensitive ecological communities and rare plants; and 16.3.7. an approach for tracking updates to the status of listed species identified by the Government of British Columbia, Committee on the Status of Endangered Wildlife in Canada, and the Species at Risk Act, and implementation of additional measures, in accordance with species recovery plans, to mitigate effects of the Designated Project on the affected species should the status of a listed species change during the life of the Designated Project.
16.4.	The Proponent shall submit to the Agency and Environment Canada a draft copy of the plan for review 90 days prior to initiating construction.
16.5.	The Proponent shall submit to the Agency the final plan a minimum of 30 days prior to initiating construction. When submitting the final plan, the Proponent shall provide to the Agency, an analysis that demonstrates how it has appropriately considered the input, views or information received from Environment Canada.

The requirements of Condition 16.1 and Condition 16.2 are addressed through Condition 16.3. Mitigation and monitoring plans are developed in consultation with the Canadian Wildlife Service of ECCC through the VWTC (Section 3.1).

6.4.1 Condition 16.3.3

This section summarizes actions taken in accordance with the following requirement of Condition 16.3.3: *The plan shall include measures to mitigate environmental effects on species at risk and at-risk and sensitive ecological communities and rare plants.*

In 2022 the following measures were implemented to mitigate effects on species at risk and at-risk and sensitive ecological communities and rare plants:

- Pre-construction rare plant surveys focussed on the remaining segments of Highway 29 realignment corridors on the north side of the Peace River, access roads on the south side of the Peace River, and on the Del Rio proposed aggregate extraction site.

(Section 6.4.1.1);

- Amphibian mitigation through salvages and dispersal translocation (Section 6.4.1.2);
- Implementation of protection measures for wetland and riparian areas, in which rare plant occurrences are generally concentrated, as required by the CEMP (See Section 6.3.1);
- The Environmental Features Map was updated with 2022 rare plant data on 10 February 2023, when it was available to contractors for use in planning;
- Further development and implementation of the Experimental Rare Plant Translocation program in consultation with MOECCS, FLNRORD and CWS (Sections 7.1.6, 7.5.1 and 7.5.2); and
- Avoidance of bat hibernacula and maternity roosts at Portage Mountain, and the construction and installation of bat boxes on the north side of the Peace River. The 2017 VWMMP Annual Report described how impacts to hibernacula at Portage Mountain are being avoided. Monitoring of bat activity at Portage Mountain began in 2017 for evaluating the effectiveness of mitigation. Ongoing monitoring of bat activity at Portage Mountain at installed bat boxes is described in Section 6.4.3.3.

6.4.1.1 Pre-construction rare plant surveys

Pre-construction rare plant surveys were conducted in 2022 in areas of the planned Project footprint not previously surveyed. The resultant data serve as inputs to the final design of access roads, help inform mitigation to avoid or minimize impacts to rare plant occurrences near construction sites, and identify potential propagule sources for the Experimental Rare Plant Translocation Program (see Sections 7.1.6, 7.5.1 and 7.5.2). The first season of pre-construction surveys was completed in the summer and fall of 2015, and those surveys have been ongoing in each year since. The 2022 pre-construction rare plant survey report, which includes methods and results from surveys conducted in 2015 through 2022, is Appendix 6.

6.4.1.2 Amphibian dispersal mitigation and salvage

Mitigation for minimizing the impacts of the Project on amphibians and amphibian habitat is required of contractors and specified in part in Section 4.17 and Appendix L of the CEMP. Those mitigations include the following:

- Limit vegetation clearing and avoid road construction in identified amphibian breeding and migration areas, where feasible;
- If construction is required adjacent to any identified amphibian breeding and migration areas, implement appropriate barriers and set-back buffers around the sites in accordance with aquatic and riparian protection measures (i.e., retain a 15 m machine-free riparian buffer from the Ordinary High Water Mark of watercourses and waterbodies during clearing, except where worker safety prohibits manual tree falling and vegetation removal methods, and as addressed in a site specific prescription prepared and endorsed by a QEP [see Section 4.5 of the CEMP]; and avoid where feasible, including through the use of disturbance setback buffers);
- Install crossing structures for amphibians and snakes to avoid and reduce injury and mortality to amphibians on roads that cross or are immediately beside wetland or other areas where amphibians or snakes are known to migrate across roads in accordance

with Section 8.8 of the VWMMP. Notify BC Hydro of such installations within 5 days of installation; and

- Implement amphibian salvage and translocation procedures as required. Amphibian salvages could be required when avoidance of areas containing metamorphosing tadpoles cannot be avoided, or prior to the destruction of wetlands supporting amphibians (Wildlife Act Permit FJ16-226024, expires December 31, 2023). Amphibian translocation may be required when mass migration events cross access roads and work sites.

It is necessary for each contractor's QEP to conduct amphibian breeding and migration area surveys in advance of ground disturbing activities and alongside active construction roads, where and when appropriate, to determine appropriate mitigation. Revision 5 of the CEMP includes an explicit requirement for each Contractor and its QEP to follow the Western Toad Management Procedure wherever western toads may exist. The Western Toad Management Procedure was developed through extensive consultation with FLNRORD, MOECCS and CWS through the VWTC, and can be found in Appendix 6 of the 2017 Annual Report and is Appendix L of the CEMP. This procedure was finalized June 26, 2017, and since that time has been required for inclusion in all contractors' Environmental Protection Plans (EPPs) for works that could impact amphibians. Appropriate amphibian mitigation is monitored by BC Hydro site Environmental Monitors and the Independent Environmental Monitor (IEM) against commitments within EPPs and CEMP requirements to determine and enforce compliance.

The Western Toad Management Procedure is applicable during construction on access roads, the transmission line, and areas within 250 m of wetlands. It requires daily surveys of all access roads and work sites during the 'core dispersal period' of June 1 to August 15. During the 'caution dispersal periods' of April 1 to May 31 and August 16 to September 30, the protocol requires a minimum of weekly surveys, as well as surveys before travelling to site and before any work commences. The protocol includes a stop work procedure at access roads or construction sites if dispersing toads are confirmed within 20 m of those areas, as well as a requirement for installing temporary barrier fences to prevent toads from being exposed to an increased mortality risk. Trapped toads are then to be translocated safely across work areas in the direction of their dispersal.

6.4.2 Condition 16.3.4

This section summarizes actions taken in accordance with the following requirement of Condition 16.3.4: *The plan shall include conservation measures to ensure the viability of rare plants, such as seed recovery and plant relocation*.

The Experimental Rare Plant Translocation program was developed in consultation with MOECCS, FLNRORD and CWS through the VWTC (see Section 7.5.1 and 7.5.2). Collection of seeds began in 2017. Work to collect seeds and salvage rare plants under this program continued in 2022, along with translocation and monitoring (see Section 7.1.6).

6.4.3 Condition 16.3.6

This section summarizes actions taken in accordance with the following requirement of Condition 16.3.6: *The plan shall include an approach to monitor and evaluate the effectiveness of mitigation measures and to verify the accuracy of the predictions made during the environmental assessment on species at risk, at-risk and sensitive ecological communities and rare plants.*

6.4.3.1 Migratory Bird Monitoring

Please see Section 6.1.3 for a summary of migratory bird surveys conducted in 2022. These monitoring programs are designed to meet a number of objectives, including to monitor and evaluate the effectiveness of mitigation measures and to verify the accuracy of predictions made during the environmental assessment regarding migratory bird species at risk. Numerous migratory species that have been observed in those surveys are provincially and / or federally listed.

6.4.3.2 Ground-nesting Raptor Surveys

Ground-nesting raptor surveys were conducted in 2022 to monitor and evaluate the effectiveness of mitigation measures and to verify the accuracy of predictions made during the environmental assessment on ground nesting raptors, such as short-eared owl (see Section 7.9.4.2). Short-eared owl is a ground-nesting raptor that is provincially Blue-listed, is listed as Threatened by COSEWIC, and listed as Special Concern on Schedule 1 of the federal SARA.

6.4.3.3 Bat Mitigation and Monitoring

To avoid destroying hibernacula at Portage Mountain that may be used by little brown myotis and northern myotis (both of which are federally listed as Endangered on Schedule 1 of SARA), BC Hydro redesigned the Portage Mountain Quarry to the eastern edge of the License of Occupation area. This relocation achieved a 300 m no activity/no access buffer around the 16 documented potential hibernacula. To avoid disturbance to hibernating bats, BC Hydro has also prohibited blasting at Portage Mountain between September 15 and May 15 (see Section 4.2 of the CEMP); this window was established based on data collected at the hibernacula in 2013 and in consultation with bat biologists. This mitigation is summarized in Section 7.7.3 of this annual report and is described in detail in Appendix 8 of the 2016 Annual Report.

To prevent damaging rock structures associated with the hibernacula, MOE[4] recommends noise levels during blasting be kept below certain thresholds at the hibernacula (see Section 7.7.3). BC Hydro conducted noise modelling for blasting at Portage Mountain, which predicted that noise levels at the hibernacula would be below those thresholds.

BC Hydro monitored the noise and vibration caused by activity at Portage Mountain Quarry in 2018 through 2021, which included blasting for haul road construction and aggregate production. Noise monitoring conducted at the site determined that in 2018, 2019 and 2021, noise and vibration caused by blasting did not exceed thresholds at hibernacula locations, as defined in BC MOE Best Management Practices (BMP) Guidelines for Bats in British Columbia (i.e., air overpressure of less than 150 decibels, shock wave less than 15 p.s.i., and peak particle velocity [PPV] less than 15 mm/second; BC MOE 2016). In 2020, noise monitoring was conducted monthly, and so modelling was used to supplement available data. That modelling of noise and vibration showed that also in 2020 blasting was unlikely to have exceeded the BC BMP thresholds for noise or vibration at important bat habitat. No blasting occurred at Portage Mountain in 2022.

BC Hydro is also conducting year-round monitoring of bat activity at Portage Mountain, with the following objectives:

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[4] BC MoE. 2016. Best Management Practices Guidelines for Bats in British Columbia. Chapter 2: Mine Developments and Inactive Mine Habitats. 68 pp.

- confirm that the bat species previously recorded at Portage Mountain remain present during quarry operations;
- evaluate any changes in the use of hibernacula at Portage Mountain through bat activity recorded during the winter and spring-emergence periods;
- evaluate and changes in the use of Portage Mountain by bats by comparing bat activity to previously recorded spring to fall bat activity; and
- emergence counts with bioacoustic surveys to help determine whether maternity roosts are present, and to evaluate the efficacy of spatial setback mitigation from suspected maternity roosts.

Analysis of bat activity data from acoustic detectors and bat emergence counts is challenging due to the high variability inherent in bat activity data, which can make it difficult to confidently identify trends or causal relationships. In addition, relatively few baseline bat activity data were collected before quarry development and operation began.

An analysis of the bat activity data collected at Portage Mountain suggests that quarry construction and operation may have had some limited impacts on bat activity (see Section 6.4.3.3 of the 2021 annual report). Further bat activity monitoring at Portage Mountain is planned to help determine whether any persistent changes in bat activity can be identified now that quarry construction and operation are concluded. The report describing the results of bat activity monitoring at Portage Mountain in 2022 is Appendix 7.

BC Hydro has constructed and installed 120 bat roost boxes and one large bat house in suitable habitat near the future reservoir and dam site. Monitoring of bat activity at the bat box installation locations is planned to occur annually through construction and the first 10 years of operations of Site C. In 2022 there was evidence of bat occupancy at 81% of surveyed boxes and 95% of surveyed sites in July, and at 84% of surveyed boxes (97) and 94% of surveyed sites in September.

6.4.3.4. Western Toad and Gartersnake Monitoring

The Western Toad and Gartersnake Monitoring Program was developed to identify and describe impacts to western toad and gartersnake in wetlands downstream of Site C, and implemented in 2018 through 2020. Western toad is federally listed as Special Concern under COSEWIC, SARA Schedule 1 – Special Concern, but is considered not at risk in BC. Pre-operations data collection was completed in 2020, and operations data collection is scheduled to begin in 2025.

6.4.3.4. Wetland Function Assessment and Wetland Monitoring

The Wetland Function Assessment has been developed to characterize the impacts of the Project on wetlands in general, and specifically the ecological functions that wetlands provide. A wetland monitoring program was implemented in 2018 and continued in 2022 to monitor and evaluate the effectiveness of wetland mitigation measures and to verify the accuracy of the predictions made during the environmental assessment (see Section 6.3.2).

6.4.3.5. Downstream Vegetation Monitoring

The Downstream Vegetation Monitoring program was developed to document the response of downstream vegetation, at-risk and sensitive ecosystems, and rare plant occurrences between the dam and the Pine River to changes in the surface water regime during construction and operations. The program was implemented in 2019 and continued in 2020 to complete pre-river diversion (i.e., baseline) data collection. Data collection occurred in 2022 to capture the river diversion period, and the Downstream Vegetation Monitoring 2022 annual report is Appendix 8.

6.4.4 Condition 16.3.7

This section summarizes actions taken in accordance with the following requirement of Condition 16.3.7: *The plan shall include an approach for tracking updates to the status of listed species identified by the Government of British Columbia, Committee on the Status of Endangered Wildlife in Canada, and the Species at Risk Act, and implementation of additional measures, in accordance with species recovery plans, to mitigate effects of the Designated Project on the affected species should the status of a listed species change during the life of the Designated Project.*

The Conservation Data Center revised its ranking of species at risk in 2022. The following documents were reviewed to identify changes to rankings of species documented in the LAA during baseline surveys[5]:

- 2022 BC Conservation Status Rank Review and Changes, vascular and non-Vascular Plants; and
- 2022 BC Conservation Status Rank Review and Changes, animals summary.

Species listed on Schedules 1, 2 and 3 of the federal Species at Risk Act (SARA) were reviewed to determine if any species occurring in the Project area had been added or had their rankings changed.

Provincially species are assigned to lists based on their Provincial conservation status. Species on the Red and Blue-lists are considered species at risk. Species on the yellow and unknown lists are not considered species at risk. A summary of the lists is provided below and can be accessed at http://www.env.gov.bc.ca/atrisk/help/list.htm:

- **Red-list:** Includes any indigenous species or subspecies that have, or are candidates for, Extirpated, Endangered, or Threatened status in British Columbia. Extirpated taxa no longer exist in the wild in British Columbia but do occur elsewhere. Endangered taxa are facing imminent extirpation or extinction. Threatened taxa are likely to become endangered if limiting factors are not reversed. Not all Red-listed taxa will necessarily become formally designated. Placing taxa on these lists flags them as being at risk and requiring investigation.
- **Blue-list:** Includes any indigenous species or subspecies considered to be of Special Concern (formerly Vulnerable) in British Columbia. Taxa of Special Concern have characteristics that make them particularly sensitive or vulnerable to human activities or natural events. Blue-listed taxa are at risk, but are not Extirpated, Endangered or Threatened.
- **Yellow-list:** Includes species that are apparently secure and not at risk of extinction. Yellow-listed species may have red- or blue-listed subspecies.
- **Unknown**: Includes species or subspecies for which the Provincial Conservation Status is unknown due to extreme uncertainty (e.g., S1S4). It will also be 'Unknown' if it is uncertain whether the entity is native (Red,

[5] Government of British Columbia. 2022. Recent Data Changes. https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/conservation-data-centre/explore-cdc-data/conservation-data-centre-updates. Accessed: 7 February 2022.

Blue or Yellow), introduced (Exotic) or accidental in B.C. This designation highlights species where more inventory and/or data gathering is needed

6.4.4.1 Rare Plants

In 2022, *Oxytropis campestris davisii* (Davis' locoweed) was downlisted to Yellow (apparently secure or secure) in BC. Also, *Drymocallis arguta* (tall wood beauty) was recognized as BC flora in 2022 and Blue-listed. There were no other changes to the conservation status of plants with potential to occur in the Site C Project area.

6.4.4.2 Wildlife

The SARA status listings for wildlife species likely to occur within the Site C Project area did not change in 2022. Of the federally listed species likely to occur within the Site C Project Area, the final recovery strategy for bank swallow (*Riparia riparia*) was released in 2022. That recovery strategy included the identification of Critical Habitat within the Site C Project construction footprint. Critical Habitat for bank swallow is defined as steep, erodible banks within 5 km of historically identified nesting sites and waterbodies or open habitat producing insects within 500 m of those banks[6]. However, based on bank swallow habitat mapping combined with erosion modelling, it is expected that increased erosion due to creation of the Site C reservoir will result in a net increase in suitable bank swallow nesting habitat. Ongoing monitoring data will be used to evaluate the accuracy of this prediction and determine whether any further mitigation for bank swallow would be appropriate.

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) classifications did not change for wildlife species likely to occur within the Site C Project area.

In 2022, the BC Conservation Data Centre (CDC) listing changed for the wildlife species with potential to occur in the Site C Project area listed in Table 5.

Table 5. BC CDC Status Changes in 2022 for Wildlife Likely to Occur in the Site C Project Area

Common Name	Scientific Name	2021 BC Status	2022 BC Status
Broad-winged hawk	*Buteo platypterus*	Blue	Yellow
Olive-sided flycatcher	*Contopus cooperi*	Blue	Yellow
Barn swallow	*Hirundo rustica*	Blue	Yellow
Ruby-throated hummingbird	*Archilochus colubris*	Blue	Red
Killdeer	*Charadrius vociferus*	Yellow	Blue
Common nighthawk	*Chordeiles minor*	Yellow	Blue
Lesser yellowlegs	*Tringa flavipes*	Yellow	Blue

[6] Environment and Climate Change Canada. 2022. Recovery Strategy for the Bank Swallow (Riparia riparia) in Canada. Species at Risk Act Recovery Strategy Series. Environment and Climate Change Canada, Ottawa. ix+ 125pp. Available online: https://wildlife-species.canada.ca/species-risk-registry/virtual_sara/files/plans/rs-HirondelleRivageBankSwallow-v00-2022Apr-eng.pdf.

7.0 Mitigation and Monitoring Measures-Environmental Assessment Certificate Conditions

Conditions 9 to 12, 14 to 16, 19, 21, 23, and 24 of the Environmental Assessment Certificate, respectively, set out the mitigation and monitoring requirements for the Project's effects on vegetation and ecological communities and wildlife resources.

7.1 EAC Condition 9

This section of the annual report summarizes the programs implemented in 2022 in accordance with the requirements of Condition 9. For context, the complete requirements of Condition 9 are shown below.

EAC Condition 9

The EAC Holder must develop a Vegetation and Invasive Plant Management Plan to protect ecosystems, plant habitats, plant communities, and vegetation with components applicable to the construction phase.

The Vegetation and Invasive Plant Management Plan must be developed by a QEP.

The Vegetation and Invasive Plant Management Plan must include at least the following:

Invasive Species

- Surveys of existing invasive species populations prior to construction.
- Invasive plant control measures to manage established invasive species populations and to prevent invasive species establishment.

Rare Plants and Sensitive Ecosystems

- The EAC Holder must expand its modelling, including completing field work, to improve identification of rare and sensitive plant communities and aid in delineation of habitats that may require extra care, 90 days prior to any Project activities that may affect these rare or sensitive plant communities
- The EAC Holder must, with the use of a QEP, complete an inventory in areas not already surveyed and use rare plant location information as inputs to final design of access roads and transmission lines. These pre- construction surveys must target rare plants as defined in Section 13.2.2 of the EIS —including vascular plants, mosses, and lichens.
- The EAC Holder must create and maintain a spatial database of known rare plant occurrences in the vicinity of Project components that must be searched to avoid effects to rare plants during construction activities. The database must be updated as new information becomes available and any findings of new rare plant species occurrences must be submitted to Environment Canada and MOE using provincial data collection standards.
- The EAC Holder must implement construction methods to reduce the impact to rare plants, maximize use of existing access corridors, and construct transmission towers and temporary roads away from wetlands and known rare plant occurrences.
- The EAC Holder must implement construction methods to reduce the impact to rare plants, maximize use of existing access corridors, and construct transmission towers and temporary roads away from wetlands and known rare plant occurrences.
- Protect known occurrences of Tufa seeps, wetlands and rare plants located adjacent to construction areas. Install signage and flagging where necessary, as determined by the QEP, to indicate the boundaries of the exclusion area.
- The EAC Holder will engage the services of a Rare Plant Botanist during construction to design and implement an experimental rare plant translocation program in consultation with MOE using the BC MOE's Guidelines for Translocation of Plant Species at Risk in BC (Maslovat, 2009).

The EAC Holder must provide this draft Vegetation and Invasive Plant Management Plan to Environment Canada, FLNR, MOE, and Aboriginal Groups for review a minimum of 90 days prior to construction and operation phases.

The EAC Holder must file the final Vegetation and Invasive Plant Management Plan with EAO, Environment Canada, FLNR, MOE, and Aboriginal Groups, a minimum of 30 days prior to construction and operation phases.

The EAC Holder must develop, implement and adhere to the final Vegetation and Invasive Plant Management Plan, and any amendments, to the satisfaction of EAO.

7.1.1 Invasive Plant Control

BC Hydro and its contractors adhered to the invasive plant mitigation measures described in Section 4.15 of CEMP and in the Invasive Weed Mitigation and Adaptive Management Plan (IWMAMP). Numerous invasive plant control measures for the Project continued in 2022:

- invasive plant removal through hand pulling;
- biocontrol implementation for toadflax along river road
- on-going inventories of invasive plant locations;
- hydroseeding of exposed slopes across the Project area;
- regular vehicle inspections and cleaning through various methods so that vehicles are clean and free of dirt and invasive plants when transitioning between sites and into the Project area;
- BC Hydro and contractors utilise an operational wash station on site during non-frozen conditions;
- An Invasive Species Management Contractor was sourced by BC Hydro in 2018. That contractor will provide specialized support invasive species management support on the dam site, transmission line, reservoir, Hwy 29 realignment and other off-site locations through 2024

7.1.2 Inventory areas not already surveyed

This section summarizes actions taken in accordance with the following requirement of Condition 9*: The EAC Holder must, with the use of a QEP, complete an inventory in areas not already surveyed and use rare plant location information as inputs to final design of access roads and transmission lines. These pre- construction surveys must target rare plants as defined in Section 13.2.2 of the EIS —including vascular plants, mosses, and lichens.*

Please see Section 6.4.1.1 for pre-construction rare plant surveys conducted in areas not already surveyed. Rare plant location data collected in 2022 was used to update the Environmental Features Map for contractors to access in their planning so that impacts to rare plants could be mitigated.

7.1.3 Spatial database of known rare plant occurrences

This section summarizes actions taken in accordance with the following requirement of Condition 9*: The EAC Holder must create and maintain a spatial database of known rare plant occurrences in the vicinity of Project components that must be searched to avoid effects to rare plants during construction activities. The database must be updated as new information becomes available and any findings of new rare plant species occurrences must be submitted to Environment Canada and MOE using provincial data collection standards.*

The Site C Environmental Features Database and Environmental Features Map was updated with the 2022 rare plant data on 10 February 2023, when it was available to contractors for use in planning.

The 2022 rare plant data were submitted to the Program Botanist at the BC Conservation Data Center, MOECCS on 18 January 2023.

Voucher specimens were collected in 2022 and submitted to the UBC herbarium on 18 October 2022.

7.1.4 Rare plant avoidance

This section summarizes actions taken in accordance with the following requirement of Condition 9*: The EAC Holder must implement construction methods to reduce the impact to rare plants, maximize use of existing access corridors, and construct transmission towers and temporary roads away from wetlands and known rare plant occurrences.*

General mitigation to minimize impacts to wetlands, where rare plants are often concentrated is described in Section 6.3.1.

Rare plant location data collected in 2022 were used to update the Environmental Features Map for BC Hydro and contractors to access in their planning so that impacts to known occurrences of rare plants could be mitigated.

The way that BC Hydro fulfilled this part of Condition 9 during the transmission line design phase was described in the 2015 annual report. Tower types selected are capable of supporting longer spans of conductor than those originally planned, which will reduce the overall number of towers required. Tower pad placement has been adjusted to minimize impacts to wetlands within engineering constraints. As a result, the total number of towers was reduced from 433 in the conceptual design down to 409 in the current design. The number of wetlands impacted was 102 in the conceptual design and is 64 in the current design. Occurrences of rare plants have been avoided through transmission line design and tower placement to the degree feasible.

Further practices for avoidance of rare plant occurrences are described in Section 4.15 of the CEMP. All known rare plant occurrences are stored in the Site C Environmental Features Database and displayed on the Environmental Features Map (see Section 7.1.3). Contractors are required to avoid impacting rare plant occurrences, where feasible. Where complete avoidance is not feasible, contractors are required to employ measures to reduce adverse effects, such as by timing construction activities in winter months and frozen ground conditions, placing ramps or matts over occurrences to reduce soil compaction, using rubber-tired equipment, and implementing designated travel routes to and from work sites. Additional mitigation for rare plant occurrences that cannot be avoided is through the Experimental Rare Plant Translocation program, in which rare plant propagules are being collected, propagated, out-planted and monitored (see Sections 7.1.6, 7.5.1 and 7.5.2).

7.1.5 Protect tufa seeps, wetlands and rare plants located adjacent to construction areas

This section summarizes actions taken in accordance with the following requirement of Condition 9*: Protect known occurrences of Tufa seeps, wetlands and rare plants located adjacent to construction areas. Install signage and flagging where necessary, as determined by the QEP, to indicate the boundaries of the exclusion area.*

Mitigation to minimize impacts to wetlands and rare plants adjacent to construction areas is described in the CEMP, and further described in detail in Sections 6.3.1 and 6.3.3 of this report for tufa seeps and wetlands, and Section 7.1.4 for rare plants.

Tufa seeps are present on the south bank of the eastern reservoir, where clearing occurred in 2019. Mitigation to minimize impacts on the tufa seep consisted of no ground equipment within the feature, and trees were directionally felled away from the tufa seep to the degree feasible.

A tufa seep will be partially impacted due to the construction of the Hudson's Hope shoreline protection berm, which began in 2021 and is planned to continue in 2022. Impacts are being reduced through design and fencing is planned to protect areas of the tufa seep that can be avoided. Prior to filter placement, rock hammer usage on the tufa was limited to overhangs and other inconsistent gradients as opposed to a full excavation. Also, one of the larger seep’s flows was diverted, minimizing impacts necessary for construction of that section of the berm.

A tufa seep was present on the north bank pf the Peace River at Bear Flat/Cache creek. Clearing occurred in the vicinity of the tufa seep in 2020. Impacts to the seep itself were avoided during construction, although a drainage channel was constructed at the west/rear edge of the Pier 1 berm for the Cache Creek Bridge so that the seep could run off the North and South edges of the berm. Unfortunately a slope failure in spring 2022 resulted in the complete loss of the surface of that tufa seep.

7.1.6 Experimental Rare Plant Translocation Program

This section summarizes actions taken in accordance with the following requirement of Condition 9: *The EAC Holder will engage the services of a Rare Plant Botanist during construction to design and implement an experimental rare plant translocation program in consultation with MOE using the BC MOE’s Guidelines for Translocation of Plant Species at Risk in BC (Maslovat, 2009).*

The Experimental Rare Plant Translocation program was developed in consultation with MOECCS, FLNRORD and CWS through the VWTC, and is described in detail in Section 7.5.1. Collection of seeds began in 2017. Work to collect seeds and salvage rare plants under this program continued in 2022, along with translocation and monitoring. A technical memorandum summarizing the results of the 2022 field program is Appendix 9.

7.3 EAC Condition 11

This section of the annual report summarizes the programs implemented in 2022 in accordance with the requirements of Condition 11.

For context, the complete requirements of Condition 11 are shown below.

EAC Condition 11
EAC Holder must compensate for the loss of rare and sensitive habitats and protect occurrences of rare plants by developing, or funding the development and implementation of a compensation program, during construction, that includes: • Assistance (financial or in-kind) to the managing organization of suitable habitat enhancement projects in the RAA (RAA as defined in the amended EIS). • Direct purchase of lands in the RAA and manage these lands and suitable existing properties owned by the EAC Holder to enhance or retain rare plant values where opportunities exist. The EAC Holder must engage with FLNR, MOE and Aboriginal Groups with regard to the development

of the compensation program.

7.3.1 Habitat Enhancement Projects in the RAA

This section summarizes actions taken in accordance with the following requirement of Condition 11: *EAC Holder must compensate for the loss of rare and sensitive habitats and protect occurrences of rare plants by developing, or funding the development and implementation of a compensation program, during construction, that includes assistance (financial or in-kind) to the managing organization of suitable habitat enhancement projects in the RAA (RAA as defined in the amended EIS).*

Habitat enhancement activities to compensate for the loss of rare and sensitive habitats and for protecting occurrences of rare plants are being conducted through Ducks Unlimited Canada for wetland compensation activities (Section 6.3.2), and Ecologic Consultants through the Saulteau-EBA Environmental Services Joint Venture for the Experimental Rare Plant Translocation Program (Section 7.1.6).

7.3.2 Direct purchase of lands in the RAA to enhance or retain rare plant values

This section summarizes actions taken in accordance with the following requirement of Condition 11: *EAC Holder must compensate for the loss of rare and sensitive habitats and protect occurrences of rare plants by developing, or funding the development and implementation of a compensation program, during construction, that includes direct purchase of lands in the RAA and manage these lands and suitable existing properties owned by the EAC Holder to enhance or retain rare plant values where opportunities exist.*

In 2014 BC Hydro purchased the Marl Fen property, located outside Hudson's Hope. This property supports several rare plant species. This property is being managed to maintain rare plants along with other wildlife and vegetation values. Results of surveys documenting species that occur within the property are provided in the 2015 Annual Report for the VWWMP.

7.3.3 Engaging with FLNRORD, MOECCS and Indigenous Groups

This section summarizes actions taken in accordance with the following requirement of Condition 11: *The EAC Holder must engage with FLNR, MOE and Aboriginal Groups with regard to the development of the compensation program.*

BC Hydro continues to engage with FLNRORD and MOECCS through the VWTC regarding the development of the compensation program for the loss of rare and sensitive habitats and to protect occurrences of rare plants. BC Hydro continues to engage with Indigenous Groups through ongoing communications, such as direct requests for assistance in identifying appropriate wetland compensation opportunities. In addition, BC Hydro engages with Indigenous Groups through regularly scheduled permitting and environmental forums. Those forums cover subjects that included rare plants, plants of traditional importance, wetlands, and expected Site C construction impacts on beavers.

7.4 EAC Condition 12

This section of the annual report summarizes the programs implemented in 2022 in accordance with the requirements of Condition 12.

Details regarding the Wetland Mitigation and Compensation Plan and wetland mapping are described in Section 7.4.1 and 7.4.1.1, respectively. Additional details regarding maintaining hydrological balance at wetlands, sedimentation barriers, stormwater management, implementation of approved work practices and Develop with Care are presented in Section 7.3 of the 2017 VWMMP Annual Report.

For context, the complete requirements of Condition 12 are shown below.

EAC Condition 12

The EAC Holder must develop a Wetland Mitigation and Compensation Plan. The Wetland Mitigation and Compensation Plan must include an assessment of wetland function lost as a result of the Project that is important to migratory birds and species at risk (wildlife and plants). The Wetland Mitigation and Compensation Plan must be developed by a QEP with experience in wetland enhancement, maintenance and development.

The Wetland Mitigation and Compensation Plan must include at least the following:

- Information on location, size and type of wetlands affected by the Project;
- If roads cannot avoid wetlands, culverts will be installed under access roads to maintain hydrological balance, and sedimentation barriers will be installed;
- Stormwater management will be designed to control runoff and direct it away from work areas where excavation, spoil placement, and staging activities occur.

Develop, with the assistance of a hydrologist, site-specific measures prior to construction to reduce changes to the existing hydrologic balance and wetland function during construction of the Jackfish Lake Road and Project access roads and transmission line.

- All activities that involve potentially harmful or toxic substances, such as oil, fuel, antifreeze, and concrete, must follow approved work practices and consider the provincial BMP guidebook Develop with Care (BC Ministry of Environment 2012 or as amended from time to time).
- A defined mitigation hierarchy that prioritizes mitigation actions to be undertaken, including but not limited to:
    - Avoid direct effects where feasible;
    - Minimize direct effects where avoidance is not feasible;
    - Maintain or improve hydrology where avoidance is not feasible;
    - Replace like for like where wetlands will be lost, in terms of functions and compensation in terms of area;
    - Improve the function of existing wetland habitats; and
    - Create new wetland habitat

The EAC Holder must monitor construction and operation activities that could cause changes in wetland functions.

The EAC Holder must provide this draft Wetland Mitigation and Compensation Plan to Environment Canada, FLNR, MOE, Aboriginal Groups, Peace River Regional District and District of Hudson's Hope for review a minimum of 90 days prior to any activity affecting the wetlands.

The EAC Holder must file the final Wetland Mitigation and Compensation Plan with EAO, Environment Canada, FLNR, MOE, Peace River Regional District, District of Hudson's Hope and Aboriginal Groups, a minimum of 30 days prior to any activity affecting the wetlands.

The EAC Holder must develop, implement and adhere to the final Wetland Mitigation and Compensation Plan, and any amendments, to the satisfaction of EAO.

7.4.1 Wetland Mitigation and Compensation Plan

Condition 12 requires: *The EAC Holder must develop a Wetland Mitigation and Compensation Plan. The Wetland Mitigation and Compensation Plan must include an assessment of wetland function lost as a result of the Project that is important to migratory birds and species at risk (wildlife and plants). The Wetland Mitigation and Compensation Plan must be developed by a QEP with experience in wetland enhancement, maintenance and development.*

Please see Section 6.3 for a description of the components of the Wetland Mitigation and Compensation Plan:

- Section 6.3.1, 6.3.3 and 6.3.5 describe mitigation to avoid or minimize impacts to wetlands to the degree feasible.
- Section 6.3.2 describes the status of wetland compensation plan development, the wetland monitoring program and the Wetland Function Assessment Tool, which combined represent the measurement and compensation of wetland impacts.

7.4.1.1 Information on location, size and type of wetlands affected by the Project

This section summarizes actions taken in accordance with the following requirement of Condition 12: *Information on location, size and type of wetlands affected by the Project.*

Three spatial datasets are available that describe the location, size and type of wetlands that may be affected by the Project: TEM habitat mapping; detailed wetland mapping; and a dataset produced by Maple Leaf Forestry. The TEM was generated in and around the Project Activity Zone (PAZ) to encompass the Peace River, the transmission line, and other sites within the PAZ. Polygons in the TEM were produced at a 1:20,000 scale, delineated using aerial photography, characterized with aerial photography combined with Vegetation Resources Inventory (VRI) forest cover mapping, and ground-truthed using field sampling. The TEM was used to generate estimates of wetland area to be affected by construction in the PAZ in the EIS, and is being updated based on the results of wetland monitoring.

Detailed wetland mapping was created by BC Hydro to be finer scale wetland mapping than the TEM data. Within a TEM polygon, wetland boundaries were delineated using aerial photos that were either at a 1:5,000 or 1:15,000 scale. This allowed for greater detail to delineate the wetland edge. The detailed wetland mapping was completed along the transmission line corridor and the Peace River. It was delineated by first identifying all TEM polygons classified as wetland habitat. Using large scale aerial photographs, the boundaries of any wetland that fell within a TEM wetland polygon were then delineated and the habitat type of the TEM wetland polygon was assigned to the newly delineated wetland(s). In some cases the TEM wetland was divided up into several smaller wetlands while in others the edge of the TEM wetland was only modified based on the higher detail aerial photographs used. Also, in some cases, wetlands have been delineated outside of TEM wetland polygons. A Field Truthing Required (FTR) label was assigned to any wetland where wetland classification needed refining. Because the detailed wetland mapping polygons follow wetland edge, this GIS dataset is useful for characterizing wetlands that may be affected.

In October 2017, Maple Leaf Forestry Ltd. conducted an assessment and classification of wetlands impacted by the transmission line RoW. This consisted of field visits to identify all the wetlands in the RoW, categorize them into a wetland type, and delineate the boundaries of the wetland. Wetlands were categorized into the same wetland types as in the TEM while also classified into a Wetland Riparian Class of the Forest Practices and Planning Regulation (FPPR) under the Forest and Range Practices Act (FRPA). All wetlands in the transmission line were classified as W1, W3, W5, or a non-classified wetland. The Wetland Riparian Class was used to identify the minimum riparian management area width, riparian reserve zone width and riparian management zone width for the wetland. Because the Maple Leaf Forestry dataset has field-verified wetland edges and type, there is a greater level of accuracy associated with this dataset; however, wetland mapping and characterization was only conducted along the transmission line RoW, and therefore its usefulness for characterizing wetlands that may be affected by the Project is limited.

Although each dataset has its limitations, the TEM, detailed and Maple Leaf wetland habitat mapping can be used in association with each other. Additional wetland delineation is being done through the ongoing wetland monitoring program (Section 6.3.2).

7.5 EAC Condition 14

This section of the annual report summarizes the programs as implemented in 2022 in accordance with the requirements of Condition 14.

For context, the complete requirements of Condition 14 are shown below.

EAC Condition 14

The EAC Holder must develop a Vegetation and Ecological Communities Monitoring and Follow-up Program for the construction phase and first 10 years of the operations phase. The Vegetation and Ecological Communities Monitoring and Follow-up Program must be developed by a QEP.

The Vegetation and Ecological Communities Monitoring and Follow-up Program must include at least the following:

- Definition of the study design for the rare plant translocation program (see condition 9).
- Plan for following-up monitoring of any translocation sites to assess the survival and health of translocated rare plant species, under the supervision of a Rare Plant Botanist.
- Measurement criteria, including vegetation growth, persistence of rare plants and establishment / spread of invasive plant species, and associated monitoring to document the effectiveness of habitat enhancement and possible compensation programs.

The Vegetation and Ecological Communities Monitoring and Follow-up Program reporting must occur annually during construction and the first 10 years of operations, beginning 180 days following commencement of construction.

7.5.1 Definition of the study design for the Experimental Rare Plant Translocation Program

As outlined in the VWMPP, the study design for the Experimental Rare Plant Translocation program will follow a five-step approach, as outlined in Maslovat (2009)[7]. The goals of the experimental rare plant translocation program are to contribute to the following:

- the viability of target rare plant species through propagule collection, propagation and translocation; and
- the field of plant translocation based on the findings from the seeding, propagation, translocation, management, and monitoring measures.

The primary objective of the ERPT is to establish new populations or augment extant populations of target rare plant species using established and, where necessary, experimental techniques.

The ERPT program also has the following secondary objectives:

- support the conservation of the target species by promoting a self-sustaining population;
- maintain local genetic diversity of target species;
- re-establish individuals of target species in high-risk areas into secure, analogous habitat; and
- produce a secondary supply of viable plant stock in the case that supplementing translocated populations is required.

There are four strategies that will be employed in achieving the goals and objectives of the program:

1. Translocate rare plant species through plant salvage, collection of vegetative propagules, and/or seeds from populations that will or may be lost (e.g., lost due to clearing activities or creation of the reservoir).
2. Document the survival of the translocated rare plants through population monitoring at re-location sites through the Site C construction period and up to the first 10 years of the operations phase.
3. Manage translocated populations as needed depending on the results of monitoring.
4. Improve the theory and practice of rare plant translocation and increase knowledge of the biology and ecology of targeted rare plant species.

The results of the study will be made publicly available as part of the annual Vegetation and Wildlife Mitigation and Monitoring Program report so that learnings are accessible to others, thereby adding to the relevant knowledge base and improving the theory/practice of rare plant translocation. A summary of the Experimental Rare Plant Translocation program activities in 2022 is presented in Appendix 9.

The program at its current state of development consists of four main phases over seven years of study (2016 to 2022):

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[7] Maslovat, C. 2009. Guidelines for translocation of plant species at risk in British Columbia. British Columbia Ministry of Environment, Victoria, BC.

1. **Literature review and program development (2016-2022).** The literature review and program development is underway and will continue throughout the duration of the ERPT program. A review of existing guidance, methodologies, and results of previous rare plant translocation projects worldwide is ongoing. The lessons learned through these studies and analyses are being used to inform the structure and methods of the ERPT program.
2. **Propagule collection (2017 to 2022).** The standards for collecting and storing propagules for ex-situ conservation (e.g., timing, sampling, labelling, cleaning, processing, stratification, sowing, and provenance) incorporate guidance outlined in Maslovat (2009) and by the European Native Seed Conservation Network (2009)[8]. The program is designed to collect seeds and cuttings or whole plants and to characterize the site conditions at the source locations. The level of risk to each plant population is being used to prioritize sites for the collection program and will be used for future collection activities, as appropriate. The level of risk is determined based on the expected clearing date, rarity of the plant, and predicted propagule collection timing.

   Propagule collection is occurring throughout the growing season and takes into consideration local plant phenology and propagation. Field teams are conducting multiple site visits to collect seeds on a number of occasions as appropriate based on seed availability and readiness.
3. **Ex-situ propagation (2017 to 2023).** This phase of the ERPT Program involves the evaluation of methods and implementation of seed cleaning, drying, storage, stratification, and ex-situ propagation for each individual taxon. Depending on the species and seed type, seeds are either being dried or cleaned following collection to ensure maximum viability. Cleaning includes the removal of waste material from the seed itself and involves the use of sieves, hand separation, and water baths and drying, as appropriate. Stratification is conducted as needed, whereby seeds are treated with cold or moist heat to simulate natural germination conditions. Stratification is the term for the series of controlled external conditions a seed is exposed to in order to break dormancy, and is designed to emulate the environmental conditions that a seed would be exposed to in nature. Many (but not all) seeds require stratification to break seed dormancy and permit germination. Some seeds also require a pre-treatment, such as mechanical or acid scarification, to weaken the seed coat prior to stratification. Seeds that do not require stratification are stored until spring. Propagation methods for asexual and sexual propagation for each species are being investigated in the context of the ecological conditions observed at the source populations.
4. **Translocation implementation (2018 to 2024).** The detailed methods for translocation implementation are being refined based on data collected during field activities. Translocation implementation involves site selection, site preparation and seeding and/or planting at recipient sites. Efforts will be made to determine if any site preparation (for intact habitats) or site engineering (for restoration sites) is required before translocation and to identify if habitat manipulation after the translocation will be required. Recipient sites will be prepared as necessary prior to the translocation, including invasive plant species removal (and implementation of steps to minimize introduction during the translocation process), soil amendment, and sculpting microcatchments. Specific planting techniques for founder plants (i.e., those plants

[8] ENSCONET. 2009a. Seed Collecting Manual for Wild Species. Main editors: Royal Botanic Gardens (UK) & Universidad Politécnica de Madrid (Spain). Edition 1: 17 March 2009.

initially transplanted at a recipient site) are being developed for each species. The specific timing windows for planting will be determined based on the plant phenology, the development stage of the propagated plants, and the local weather and soil moisture conditions. Initial translocation occurred in September 2018. Additional planting was completed annually from 2019 through 2022. Planting efforts are incorporating the key findings from previous planting efforts. Some stock is being withheld from planting as insurance should inclement conditions negatively affect the initial out-planting stock.

5. **Post-translocation care, maintenance and monitoring (2018 to 2035).** Post-translocation care, maintenance, and monitoring commences immediately after each translocation event is completed. Post-translocation plant care and site management assesses the survival of translocated populations and addresses factors affecting the survival or health of the translocated plants. The first two to three years of follow-up site visits and data collection (i.e., short-term monitoring) will inform the frequency and level of effort required for post-translocation care and additional monitoring in subsequent years (i.e. long-term monitoring). Translocated populations that are achieving identified targets will still require long-term monitoring, but may require less frequent follow-up visits than populations that are not achieving key metrics and require more active management. Monitoring the success or failure of the methods will assist in identifying opportunities for improvement within an adaptive management framework. This information can also help to inform other translocation projects, thereby improving the overall success of rare plant translocation as a tool for biodiversity conservation.

7.5.2 Plan for monitoring translocations

Experimental Rare Plant Translocation Program monitoring will document a suite of parameters designed to evaluate the efficacy of translocation methods in relation to the stated objectives of the program. All actions associated with the translocation (see Section 7.5.1) will be fully documented to retain as much information as possible on the pathway of a given plant (e.g., from seed collection to planting) to facilitate post-hoc assessments of success. Specifically, the monitoring program will measure, document, and evaluate the following:

1. the efficacy of the methods used to a) characterize donor and recipient sites, b) collect and store plant propagules, c) conduct ex-situ propagation; and d) translocate the rare plant species from the host site to the recipient sites;
2. the efficacy of the techniques used for managing the translocated plant propagules (e.g. site preparation, watering, weeding, fertilizing);
3. the survival of the translocated rare plant species through monitoring of population size, extent, threats, resilience, and persistence; and
4. the success of follow up procedures applied to address any declines in survival or fitness of the translocated plants.

7.5.3 Measurement criteria for effectiveness monitoring of habitat enhancement and compensation programs

Please see Section 7.5.2 for how the effectiveness of the rare plant translocation program will be measured.

7.6 EAC Condition 15

This section of the annual report summarizes the programs implemented in 2022 in accordance with the requirements of Condition 15.

For context, the complete requirements of Condition 15 are shown below.

EAC Condition 15
The EAC Holder must develop a Wildlife Management Plan. The Wildlife Management Plan must be developed by a QEP. The Wildlife Management Plan must include at least the following: • Field work, conducted by a QEP, to verify the modelled results for surveyed species at risk and determine, with specificity and by ecosystem, the habitat lost or fragmented for those species. The EAC Holder must use these resulting data to inform final Project design and to develop additional mitigation measures, as needed, as part of the Wildlife Management Plan, in consultation with Environment Canada and FLNR. • Measures to avoid, if feasible, constructing in sensitive wildlife habitats. If avoiding sensitive wildlife habitats is not feasible, condition 16 applies. • If sensitive habitats, such as wetlands, are located immediately adjacent to any work site, buffer zones must be established by a QEP to avoid direct disturbance to these sites. • Protocol for the application of construction methods, equipment, material and timing of activities to mitigate adverse effects to wildlife and wildlife habitat. • Protocol to ensure that lighting is focused on work sites and away from surrounding areas to manage light pollution and disturbance to wildlife. If lighting cannot be directed away from surrounding areas, the EAC Holder must ensure additional mitigation measures are implemented to reduce light pollution, including light shielding. • A mandatory environmental training program for all workers so that they are informed that hunting in the vicinity of any work site/Project housing site is strictly prohibited for all workers. The EAC Holder must ensure that all workers are familiar with the Wildlife Management Plan. The EAC Holder must submit this draft Wildlife Management Plan to Environment Canada, FLNR, MOE and Aboriginal Groups for review a minimum of 90 days prior to the commencement of construction. The EAC Holder must file the final Wildlife Management Plan with EAO, Environment Canada, FLN, MOE and Aboriginal Groups, a minimum of 30 days prior to commencement of construction. The EAC Holder must develop, implement and adhere to the final Wildlife Management Plan, and any amendments, to the satisfaction of EAO.

7.6.1 Measures to avoid, if feasible constructing in sensitive wildlife habitats

This section summarizes actions taken in accordance with the following requirement of Condition 15: *Measures to avoid, if feasible, constructing in sensitive wildlife habitats. If avoiding sensitive wildlife habitats is not feasible, condition 16 applies.*

Measures to avoid impacts to sensitive wildlife habitats are described in Section 4.17 of Revision 5 of the CEMP:

- Avoid construction activity within Important Wildlife Areas, including designated setback buffers determined by a QEP, where feasible. Important Wildlife Areas are defined in the

CEMP as habitat areas that animals use around the same time each year, such as the following:
  - wetlands;
  - snake hibernacula;
  - bat hibernacula;
  - sharp-tailed grouse leks;
  - beaver lodges, dams and food caches;
  - active furbearer and large carnivore den sites;
  - active bird nests;
  - mineral licks;
  - habitat used by ungulates for winter range; and
  - amphibian breeding sites and migration routes.
- Except within the dam site area, on designated access roads and during clearing, construction activities are prohibited within 15 m of the Ordinary High Water Mark of streams or wetlands, unless the activity was described in the EIS and is accepted by BC Hydro (CEMP Section 4.5);
- Guidance to minimize impacts to raptor nests;
- Protocol for conducing sharp-tailed grouse lek monitoring and a decision tree for various lek activity scenarios to minimize impacts to sharp-tailed grouse leks (see also Appendix 7 of the 2016 Annual Report); and
- Measures for minimizing impacts to amphibian breeding and migration areas (see also Section 6.4.1.2).

7.6.2 Setback buffers to avoid direct impacts to sensitive habitats

This section summarizes actions taken in accordance with the following requirement of Condition 15*: If sensitive habitats, such as wetlands, are located immediately adjacent to any work site, buffer zones must be established by a QEP to avoid direct disturbance to these sites*

As specified above in Section 7.6.1, Revision 5 of the CEMP (Section 4.17), construction activity is to be avoided within Important Wildlife Areas, including in designated setback buffers as determined by a QEP, where feasible. Wetland avoidance measures are discussed further in Section 6.3.1.

Procedures for determining appropriate situation- and species-specific disturbance setback buffers to be applied around locations where bird nests are present are discussed in Section 6.1.1 (migratory birds).

7.6.3 Mitigation of adverse effects to wildlife and wildlife habitat

This section summarizes actions taken in accordance with the following requirement of Condition 15*: Protocol for the application of construction methods, equipment, material and timing of activities to mitigate adverse effects to wildlife and wildlife habitat.*

Mitigation of adverse effects to wildlife is discussed in Sections 7.6.1 and 7.6.2. Section 6.4.1.2 provides a summary of mitigation applied to minimize adverse impacts to amphibians. Revisions 5 and 6 of the CEMP (Section 4.17) specify that, where feasible, vegetation clearing will take place during Peace Region terrestrial wildlife least-risk windows. Least risk timing windows for wildlife are described in Table 5 of the CEMP.

Where clearing outside of least-risk timing windows cannot be avoided, pre-clearing surveys are required, with disturbance setback buffers determined by a QEP.

7.6.4 Protocol to ensure that lighting is focused on work sites

This section summarizes actions taken in accordance with the following requirement of Condition 15*: Protocol to ensure that lighting is focused on work sites and away from surrounding areas to manage light pollution and disturbance to wildlife. If lighting cannot be directed away from surrounding areas, the EAC Holder must ensure additional mitigation measures are implemented to reduce light pollution, including light shielding.*

Section 4.17 of the CEMP requires contractors to focus lighting on work sites and away from surrounding areas to minimize light. CEMP requirements are audited by site Environmental Monitors and the Independent Environmental Monitor to determine and enforce compliance.

7.6.5 Environmental training of workers

This section summarizes actions taken in accordance with the following requirement of Condition 15*: A mandatory environmental training program for all workers so that they are informed that hunting in the vicinity of any work site/Project housing site is strictly prohibited for all workers. The EAC Holder must ensure that all workers are familiar with the Wildlife Management Plan.*

All workers are required to attend both a BCH orientation and a contractor specific orientation prior to starting work on-site. A component of these training sessions is environmental training for workers. Completion of these sessions is required prior to the issuance of site access cards for BC Hydro employees and contractors.

7.7 EAC Condition 16

This section of the annual report summarizes the programs implemented in 2022 in accordance with the requirements of Condition 16.

For context, the complete requirements of Condition 16 are shown below.

EAC Condition 16

If loss of sensitive wildlife habitat or important wildlife areas cannot be avoided through Project design or otherwise mitigated, the EAC Holder must implement the following measures, which must be described in the Vegetation and Wildlife Mitigation and Monitoring Plan.

The Vegetation and Wildlife Mitigation and Monitoring Plan must include the following compensation measures:

- Compensation options for wetlands must include fish-free areas to manage the effects of fish predation on invertebrate and amphibian eggs and larvae and young birds.
- Mitigation for the loss of snake hibernacula, artificial dens must be included during habitat compensation.
- Management of EAC Holder-owned lands adjacent to the Peace River suitable as breeding habitat for Northern Harrier and Short-eared Owl.
- Establishment of nest boxes for cavity-nesting waterfowl developed as part of wetland mitigation and compensation plan, and established within riparian vegetation zones established along the reservoir on BC Hydro-owned properties.
- A design for bat roosting habitat in HWY 29 bridges to BC Ministry of Transportation and Infrastructure (MOTI) for consideration into new bridge designs located within the Peace River valley.

- Following rock extraction at Portage Mountain, creation of hibernating and roosting sites for bats.
- Creation of natural or artificial piles of coarse woody debris dispersed throughout the disturbed landscape to maintain foraging areas and cold-weather rest sites, and arboreal resting sites, for the fisher population south of the Peace River.

The EAC Holder must provide this draft Vegetation and Wildlife Mitigation and Monitoring Plan to Environment Canada, FLNR, MOE, and Aboriginal Groups for review a minimum of 90 days prior to the commencement of construction.

The EAC Holder must file the final Vegetation and Wildlife Mitigation and Monitoring Plan with EAO, Environment Canada, FLNR MOE, and Aboriginal Groups, a minimum of 30 days prior to commencement of construction.

The EAC Holder must develop, implement and adhere to the final Vegetation and Wildlife Mitigation and Monitoring Plan, and any amendments, to the satisfaction of EAO.

7.7.1 Wetland compensation that includes fish-free areas

As of the end of 2022, BC Hydro has purchased one property for wetland compensation (i.e., the Marl Fen property) and has constructed or saved from imminent loss 224 ha across four wetlands that are all fish-free. Further wetland compensation opportunities are being explored for development and will include additional fish-free areas.

7.7.2 Mitigation for the loss of snake hibernacula

Six artificial hibernacula for gartersnake overwintering were constructed in 2020 on the north side of the Peace River. One additional snake den is planned to be constructed near Cache Creek in 2023. Occupancy monitoring of constructed snake hibernacula occurred in 2021 and 2022, and is planned for 2023. Two hibernacula were considered to be occupied in 2022: Snake 21.4 (Dam View), and Snake 48 (Wilder Creek). A shed snakeskin was found beneath a patio stone within 10 m of the entrance to Snake 21.4, while a terrestrial gartersnake was observed beneath a rock during the second round of monitoring. At Snake 48, a terrestrial gartersnake was uncovered beneath a patio stone immediately outside the den during the survey, and an unidentified gartersnake was seen darting into the den entrance during an opportunistic visit to the site. This represents the first evidence of potential gartersnake use of the installed hibernacula to date.

7.7.3 Nest boxes for cavity-nesting waterfowl

Thirteen different nest box designs were constructed to accommodate 21 species of cavity nesting birds, with some box designs intended to support multiple species. Between 2017 and 2022, 277 nest boxes were installed on trees and structures on BC Hydro owned and managed lands, and on private lands where permission was granted. Nest boxes were strategically placed along the reservoir shoreline in areas determined to be most beneficial to each species group, while also considering availability of land and suitable access for installation and future mitigation effectiveness monitoring.

Monitoring of nest boxes began in the breeding season of 2020 and continued in 2022. The Cavity Nesting Mitigation and Monitoring Program 2022 Annual Report is Appendix 10 to this report.

7.7.4 A design for bat roosting habitat in HWY 29 bridges

This section summarizes actions taken in accordance with the following requirement of Condition 16: *A design for bat roosting habitat in HWY 29 bridges to BC Ministry of Transportation and Infrastructure (MOTI) for consideration into new bridge designs located within the Peace River valley.*

During baseline surveys bats were documented using the Farrell Creek, Halfway River and Cache Creek bridges as night roosts. These three (3) bridges and the bridge at Lynx Creek will be inundated by the reservoir. New bridges will be constructed at these locations.

BC Hydro had previously reached an agreement with the Ministry of Transportation and Infrastructure to install bat roost structures on newly constructed bridges along re-aligned sections of Highway 29 to offset the losses of night roosts on existing bridges. However, on 25 October 2018, BC Hydro received notification from the Regional Manager of Environmental Services, MOTI, that MOTI no longer supports the placement of bat roosting boxes on bridges. Therefore, bat boxes are no longer planned to be integrated into the designs of any new bridges, including the planned Farrell Creek, Halfway River, Cache Creek and Lynx Creek bridges.

7.7.5 Creation of hibernating and roosting sites for bats

This section summarizes actions taken in accordance with the following requirement of Condition 16: *Following rock extraction at Portage Mountain, creation of hibernating and roosting sites for bats.*

In February of 2016 the BC Ministry of Environment released Best Management Practices Guidelines for Bats in British Columbia "Bat BMPs"[9]. These guidelines recommend that a 100 m buffer be established around the core area of bat habitat, which for Portage Mountain is defined as all the suspected hibernacula entrances that had been documented. Within this 100 m, no activities that modify the above or below ground habitat are allowed. The guidelines also recommend a 1 km special management zone, within which blasting activities are permitted if the following can be achieved:

- No blasting to occur between October and May;
- Blasting must be conducted within the following parameters (to avoid damage to the rock structures associated with the hibernacula):
  - the sound concussion is less than 150 dB;
  - the shock wave is less than 15 p.s.i; and
  - the peak particle velocity is less than 15 mm/s.

To avoid impacting the hibernacula at Portage Mountain that are being used by little brown myotis and northern myotis, BC Hydro moved the quarry to the eastern edge of the License of Occupation area prior to the commencement of construction activities. This relocation achieved a 300 m buffer around 16 documented hibernacula, where no activities or access were permitted. This mitigation is described in detail in Appendix 8 of the 2016 Annual Report.

To avoid disturbance to hibernating bats, BC Hydro has also prohibited blasting at Portage Mountain between September 15 and May 15 (see Section 4.2 of the CEMP); this window was based on data collected at the hibernacula in 2013 and in consultation with bat biologists (see the 2016 Annual Report).

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[9] BC MoE. 2016. Best Management Practices Guidelines for Bats in British Columbia. Chapter 2: Mine Developments and Inactive Mine Habitats. 68 pp.

For planned activities at Portage Mountain Quarry, noise modelling was conducted, from which it was determined that at 300m:

- the sound concussion would be 120 dB (below BMP limit of 150 dB);
- the shock wave would be 0.002 p.s.i (1 kPa) and (below BMP limit of 15 p.s.i (104 kPa); and
- the peak particle velocity would be 2.84 mm/s (below BMP limit of 15 mm/s).

As described in Section 6.4.3.3, BC Hydro monitored the noise and vibration caused by activity at Portage Mountain Quarry in 2018, 2019 and 2021, and found that blasting within the re-designed quarry boundaries did not exceed the thresholds for noise and vibration defined within the BC MOE Best Management Practices Guidelines for Bats in British Columbia (i.e., air overpressure of less than 150 decibels, shock wave less than 15 p.s.i., and peak particle velocity (PPV) less than 15 mm/second). Noise and vibration modelling were used to supplement available data to determine that also in 2020 blasting likely did not exceed the BC BMP thresholds for noise or vibration at important bat habitat. No blasting occurred at Portage Mountain in 2022. As described in Section 6.4.3.3, BC Hydro is also conducting year-round monitoring of bat use at Portage Mountain.

Through the broader Site C bat mitigation and monitoring program, BC Hydro has constructed and installed 120 bat roost boxes and one large bat house in suitable habitat near the future reservoir and dam site.

7.7.6 Resting sites for fisher

This section summarizes actions taken in accordance with the following requirement of Condition 16: *Creation of natural or artificial piles of coarse woody debris dispersed throughout the disturbed landscape to maintain foraging areas and cold-weather rest sites, and arboreal resting sites, for the fisher population south of the Peace River.*

A total of 98 coarse woody debris (CWD) piles to maintain foraging areas and cold-weather rest sites for fisher have been created within the dam site area, along the transmission line, and along the cleared edge of Ice Bridge Road towards Area E. Signs were installed at CWD piles to indicate that they were designated fisher habitat and to prevent their inadvertent disturbance by construction activities.

In addition to CWD piles, BC Hydro constructed and installed 88 fisher den boxes between 2018 and 2020 to help mitigate the loss of denning habitat due to reservoir clearing. Those den boxes have the potential of being used as arboreal rest sites by fisher.

7.8 EAC Condition 19

This section of the annual report summarizes the programs implemented in 2022 in accordance with the requirements of Condition 19.

For context, the complete requirements of Condition 19 are shown below.

EAC Condition 19
The EAC Holder must use reasonable efforts to avoid and reduce injury and mortality to amphibians and snakes on roads adjacent to wetlands and other areas where amphibians or snakes are known to migrate across roads including locations with structures designed for wildlife passage

The EAC Holder must consult with Environment Canada, FLNR and MOE with regard to the size and number of the proposed structures prior to construction.

Appropriate amphibian mitigation is monitored by BC Hydro site Environmental Monitors and the Independent Environmental Monitor against commitments within EPPs to determine and enforce compliance. Amphibian mitigation activities are summarized in Section 6.4.1.2. Work sites are being regularly monitored during the spring and summer for western toad migration and dispersal, as per the Western Toad Management Procedure. Western toad movement patterns have not yet resulted in mass movements across access roads such that specific structures designed for amphibian passage have been required. However, due to specific concerns regarding western toad mitigation at Portage Mountain Quarry during a BC Environmental Assessment Office (EAO) inspection in 2016, a suitable location for installation of an amphibian crossing structure was identified based on a habitat assessment and observations of western toad movement patterns. A 15 m long 1,000 mm diameter culvert was installed along the access road to Portage Mountain, following guidance described in Best Management Practices for Amphibians and Reptiles in Urban and Rural Environments in British Columbia (BC MWLAP 2004[10]).

7.9 EAC Condition 21

This section of the annual report summarizes the programs implemented in 2022 in accordance with the requirements of Condition 21.

For context, the complete requirements of Condition 21 are shown below.

EAC Condition 21

The EAC Holder must ensure that measures implemented to manage harmful Project effects on wildlife resources are effective by implementing monitoring measures detailed in a Vegetation and Wildlife Mitigation and Monitoring Plan. The Vegetation and Wildlife Mitigation and Monitoring Plan must be developed by a QEP.

The Vegetation and Wildlife Mitigation and Monitoring Plan must include at least the following:

- Monitor Bald Eagle nesting populations adjacent to the reservoir, including their use of artificial nest structures.
- Monitor waterfowl and shorebird populations and their use of natural wetlands, created wetlands, and artificial wetland features.
- Monitor amphibian use of migration crossing structures installed along Project roads.
- Survey songbird and ground-nesting raptor populations during construction and operations.
- Survey the distribution of western toad and garter snake populations downstream of the Site C dam to the Pine River.
- Require annual reporting during the construction phase and during the first 10 years of operations to EAO, beginning 180 days following commencement of construction.

The EAC Holder must provide this draft Vegetation and Wildlife Mitigation and Monitoring Plan to FLNR, MOE, Environment Canada and Aboriginal Groups for review a minimum of 90 days prior to the commencement of construction.

The EAC Holder must file the final Vegetation and Wildlife Mitigation and Monitoring Plan must with EAO, FLNR, MOE, Environment Canada and Aboriginal Groups a minimum 30 days prior to the

[10] BC Ministry of Water, Land and Air Protection. 2004. Best Management Practices for Amphibians and Reptiles in Urban and Rural Environments in British Columbia. 159 pp.

commencement of construction. The EAC Holder must develop, implement and adhere to the final Vegetation and Wildlife Mitigation and Monitoring Plan, and any amendments, to the satisfaction of EAO.

7.9.1 Monitoring of Bald Eagle nesting populations

Known bald eagle nest locations along the Peace River and at natural wetlands adjacent to the Site C transmission line right-of-way were surveyed by helicopter over three days in May and June 2022. A summary of the methods and results of bald eagle nest aerial monitoring in 2022 is presented in Appendix 11.

7.9.2 Monitoring waterfowl and shorebird populations

This section summarizes actions taken in accordance with the following requirement of Condition 21: *Monitor waterfowl and shorebird populations and their use of natural wetlands, created wetlands, and artificial wetland features.*

A summary of the waterbird survey program is presented in Section 6.1.3.4 and Waterbirds Follow-up Monitoring 2022 Annual Report can be found in Appendix 3.

7.9.3 Monitor amphibian use of migration crossing structures installed along Project roads

This section summarizes actions taken in accordance with the following requirement of Condition 21: *Monitor amphibian use of migration crossing structures installed along Project roads*.

A 15 m long 1,000 mm diameter culvert has been installed along the access road to Portage Mountain, following guidance described in Best Management Practices for Amphibians and Reptiles in Urban and Rural Environments in British Columbia (BC MWLAP 2004). Monitoring of amphibian use of the crossing structure was conducted following the requirements of the Site C Western Toad Management Procedure. Western toad activity along the area around the access road in general has been low, and no western toad use of the crossing structure has yet been documented.

7.9.4 Survey songbird and ground-nesting raptor populations during construction and operations

This section summarizes actions taken in accordance with the following requirement of Condition 21: *Survey songbird and ground-nesting raptor populations during construction and operations.*

7.9.4.1 Songbirds

A summary of the songbird monitoring program is presented in Section 6.1.3.1 and the Breeding Bird Follow-up Monitoring – Songbirds 2022 Annual Report can be found in Appendix 2.

7.9.4.2 Ground-nesting raptors

Ground nesting raptor surveys in 2022 were conducted at cleared portions of the Site C reservoir. Ground nesting raptor surveys were completed up to four times per site over May and June 2022 to capture early, middle, and late stages of their breeding season. The ground-nesting raptor monitoring 2022 annual report can be found in Appendix 12.

7.9.5 Annual reporting beginning 180 days following commencement of construction

This section summarizes actions taken in accordance with the following requirement of Condition 21: *Require annual reporting during the construction phase and during the first 10 years of operations to EAO, beginning 180 days following commencement of construction.*

Submission of this report satisfies the requirement this portion of Condition 21 for 2022 during the construction phase of the Site C Clean Energy Project.

7.10 Status of listed species

This section of the annual report summarizes the programs implemented in 2022 in accordance with the requirements of Condition 23. For context, the complete requirements of Condition 23 are shown below.

EAC Condition 23
The EAC Holder must maintain current knowledge of Project effects on the status of listed species by tracking updates for species identified by the Province, the Committee on the Status of Endangered Wildlife in Canada, and the Species at Risk Act.
Should the status of a listed species change for the worse during the course of the construction of the Project due to Project activities, the EAC Holder, must work with Environment Canada FLNR and MOE to determine if any changes to the associated management plans or monitoring programs are required to mitigate effects of the Project on affected listed species.

7.10.1 Rare Plants

Please see Section 6.4.4.1 for a summary of ranking changes to rare plants.

7.10.2 Wildlife

Please see Section 6.4.4.2 for a summary of ranking changes to wildlife.

7.11 Ungulate Winter Range

The complete requirements of Condition 23 are shown below.

EAC Condition 24

The EAC Holder must identify suitable lands for ungulate winter range by the end of the first year of construction, on BC Hydro-owned lands, or Crown lands, in the vicinity of the Project in consultation with FLNR. If FLNR determines that identified winter range is required, the EAC Holder must identify and maintain suitable BC Hydro- owned lands for ungulate winter range to the satisfaction of FLNR and for the length of time determined by FLNR.

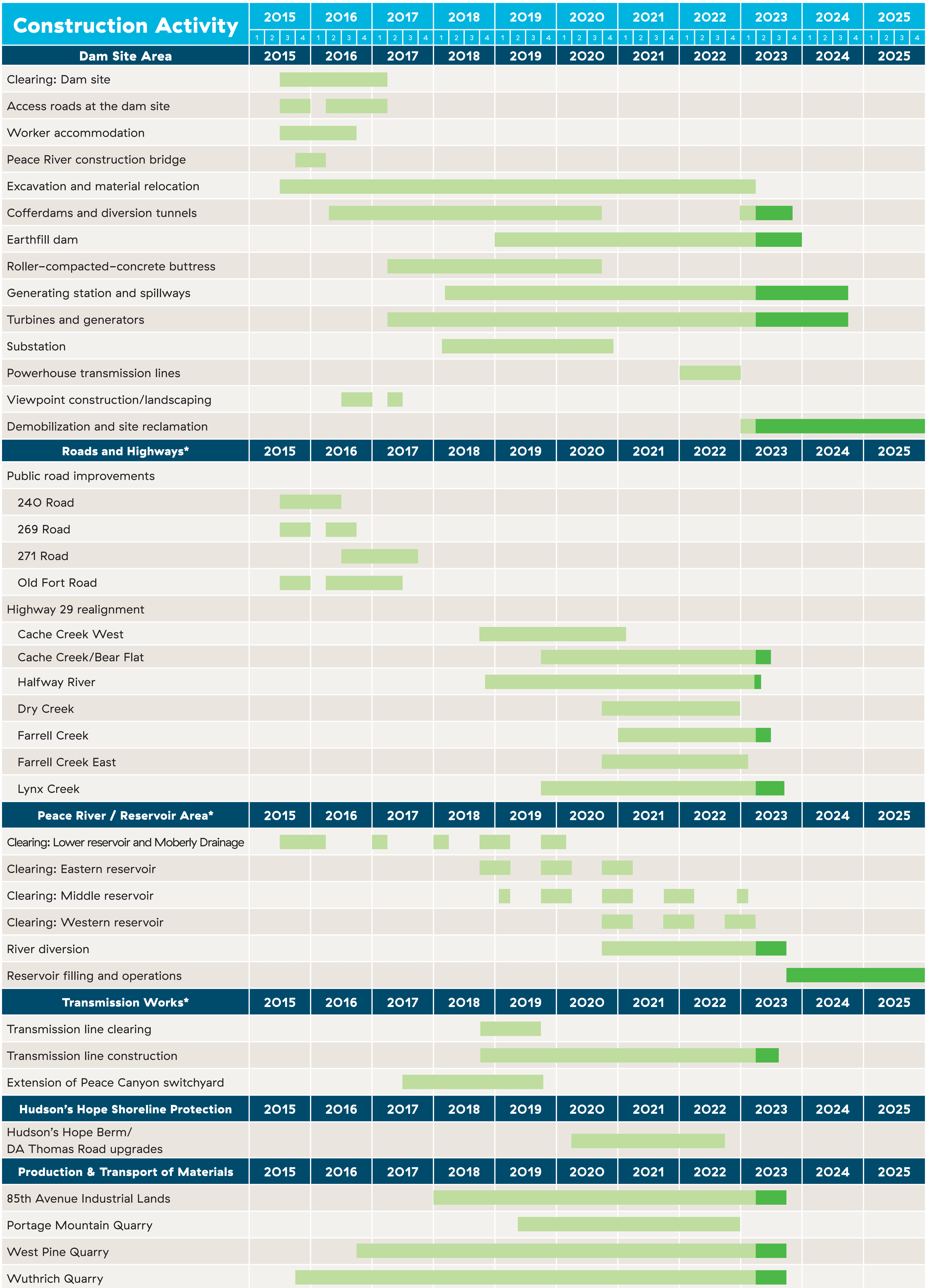
The plan for the identification, retention and maintenance of ungulate winter range was developed through the VWTC and determined to be complete by the Comptroller of Water Resources in 2016. After reservoir filling, it is anticipated that lands identified by BC Hydro as ungulate winter range for elk and deer will total about 515 ha at commencement of operation. A summary of these lands and maps and their locations were provided in the June 5, 2015 VWMMP. These lands are on the north bank of the Peace River between the Halfway River to the west and the dam site to the east.

FLNRORD is in the process of identifying appropriate lands for moose winter range as mitigation for expected Project impacts on moose habitat. BC Hydro has provided $10,000 to FLNRORD to support the Indigenous consultation necessary to identify and protect appropriate moose winter range.

Appendix 1. Site C Clean Energy Project Construction Schedule

Site C Construction Schedule

March 2023
CS-3092



The construction schedule is indicative only and subject to change. The purpose of the schedule is to illustrate the general sequence of construction activities, but the dates and schedule may change.

* Timelines do not include site preparation or wood disposal.

BC Hydro
Power smart

Appendix 2. Breeding Bird Follow-up Monitoring - Songbirds 2022 Annual Report

Site C Clean Energy Project
Breeding Bird Follow-up Monitoring – Songbirds
2022 Annual Report

PRESENTED TO
BC Hydro and Power Authority

NOVEMBER 30, 2022
ISSUED FOR USE
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Saulteau EBA Environmental Services Joint Venture
Suite 1000 – 10th Floor, 885 Dunsmuir Street
Vancouver, BC V6C 1N5 CANADA
Tel 604.685.0275 Fax 604.684.6241

Site C Clean Energy Project Breeding Bird Follow-Up Monitoring - Songbirds
2022 Annual Report

FILE: 704-ENW.PENW03042-02.SONG.REG
November 30, 2022

PRESENTED TO

Site C Clean Energy Project
BC Hydro and Power Authority
P.O. Box 49260
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Prepared by:

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Elyse Hofs, B.Sc., B.I.T.
Junior Biologist

Reviewed by:

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Jeff Matheson, M.Sc., R.P.Bio.
Senior Biologist

EXECUTIVE SUMMARY

Saulteau EBA Environmental Services Joint Venture (SEES JV) completed breeding bird point count surveys in the area of BC Hydro and Power Authority's (BC Hydro) Site C Clean Energy Project ("Site C", the Project) in spring and summer 2022. The surveys were part of BC Hydro's Breeding Bird Follow-up Monitoring Program for songbirds[1]. Songbirds are passerines, hummingbirds, swifts, doves, kingfisher, and pigeons (i.e., all members of the orders *Passeriformes*, *Apodiformes*, *Columbiformes*, and *Coraciiformes*). Songbird baseline surveys were conducted in 2006, 2008, 2011 and 2012. Surveys were again conducted in 2016 through 2022 as part of the follow-up monitoring program. This report describes the methods used to conduct the 2022 surveys and a summary of the results.

Surveys were conducted June 1-25, 2022 at 103 stations in the Peace River Valley and around the Project footprint. Each station was surveyed two times to maximize the detection of early and late breeders. Birds were surveyed using unlimited-radius point counts.

A total of 87 bird species were detected, of which 76 were songbirds. Seven species listed under the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), the *Species at Risk Act* (SARA) and/or British Columbia's Red and Blue lists were observed during the surveys. The median number of songbird species detected per point count survey was 9 (range 4 to 18).

Surveys conducted in 2022 represent a continuation in monitoring of semi-permanent monitoring stations that will be monitored through to 10 years post-construction.

[1] Woodpecker and Common Nighthawk surveys are also included under BC Hydro's Breeding Bird Follow-up Monitoring Program.

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1.0 INTRODUCTION

Saulteau EBA Environmental Services Joint Venture (SEES JV) completed breeding bird point count surveys in the area of BC Hydro and Power Authority's (BC Hydro) Site C Clean Energy Project ("Site C", the Project) in spring and summer 2022. The surveys were part of BC Hydro's Breeding Bird Follow-up Monitoring Program for songbirds[2]. Songbirds are passerines, hummingbirds, swifts, doves, kingfisher, and pigeons (i.e., all members of the orders *Passeriformes*, *Apodiformes*, *Columbiformes*, and *Coraciiformes*). Songbird baseline surveys were conducted in 2006, 2008, 2011 and 2012. Surveys were again conducted in 2016, 2017, 2018, 2019, 2020, 2021 and 2022 as part of the follow-up monitoring program.

The objectives of the Breeding Bird Follow-up Monitoring Program for songbirds are to:

1. Determine the distribution and abundance of songbirds within habitat lost or otherwise affected by the Project to verify the predictions made in the Environmental Impact Statement (EIS).
2. Identify species-habitat relationships to help identify areas for offsetting impacts.
3. Conduct effectiveness monitoring to determine the degree to which mitigation areas offset impacts to songbirds and their habitat and determine further songbird mitigation requirements.
4. Determine changes to the songbird community in the Peace River valley (to 10 years post-construction).

The annual report prepared in 2019 (SEES JV 2019) provided an analysis of the data collected 2006-2019 in support of objectives 1 and 2. Mitigation areas (currently the Marl Fen, Rutledge and Wilder Creek properties) were comprehensively surveyed in 2016 and 2017. BC Hydro intends to conduct the next comprehensive surveys of the mitigation properties when the reservoir has been inundated or when there are land-use changes or habitat modification in the mitigation properties, whichever occur first. The point count data obtained from surveys in 2022 were primarily in support of objective 4 and will form part of the long-term monitoring data to assess changes in the songbird community over time (baseline to 10 years post-construction).

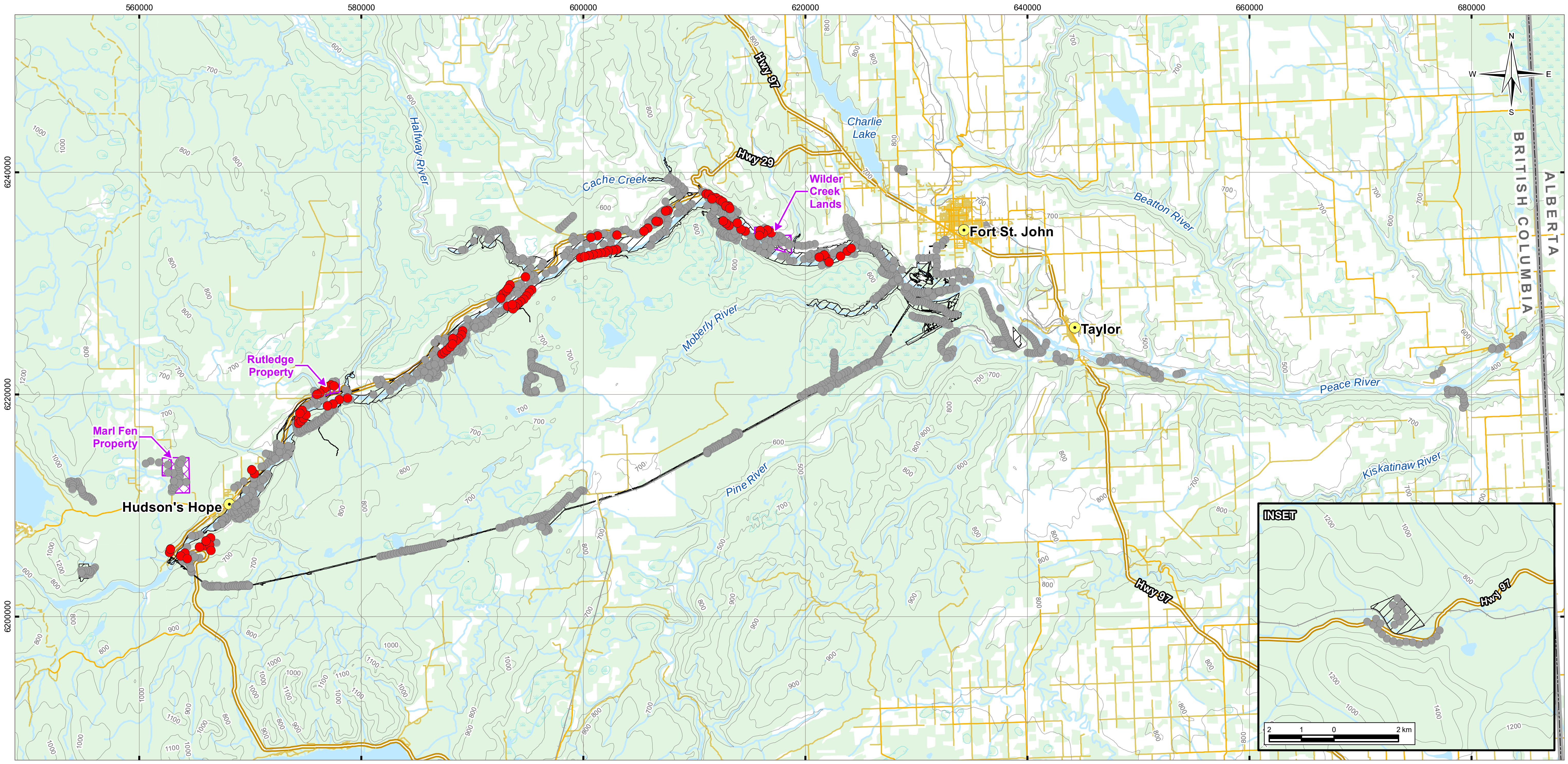
2.0 METHODS

2.1 Survey Locations

Point counts for the baseline and the follow-up monitoring programs have been conducted throughout the Peace River valley (and its tributaries) and in the adjacent plateau areas, both inside and outside the Project footprint (Figure 1). Clearing of the dam site area was completed in 2016. Clearing of the reservoir commenced in 2017 and has incrementally progressed westward from the dam site in each year. By May 2021, most portions of the reservoir footprint along the Peace River from the dam site to the mouth of the Halfway River, including the Moberly River and Cache Creek reservoir footprints, and some islands west of the Halfway River had been cleared [3]. Point counts in 2022 were predominantly located outside the reservoir footprint, though a small number were in cleared portions of the footprint and in the uncleared Watson Slough area.

[2] Woodpecker and Common Nighthawk surveys are also included under BC Hydro's Breeding Bird Follow-up Monitoring Program.

[3] The Watson Slough area along Highway 29 remains largely uncleared, with clearing planned the winter of 2022/2023.

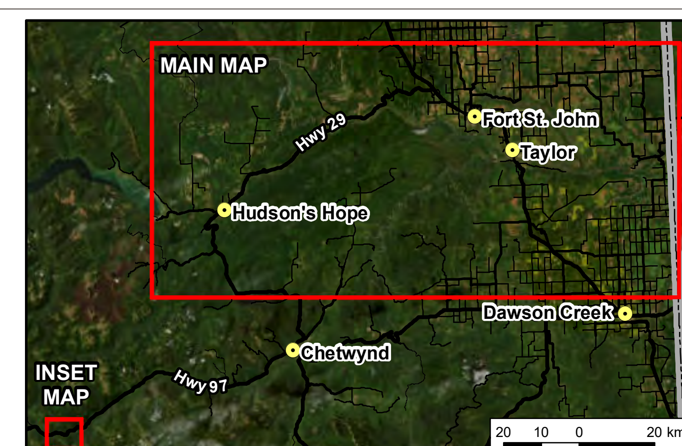


LEGEND

Songbird Survey Locations

Survey Year

- 2022
- 2006 to 2021
- Project Footprint
- Potential Mitigation Property
- Populated Place
- Highway
- Main Road
- Local Road
- Resource/Recreational Road
- Railway
- Residential Area
- Contour (100 m)
- Watercourse
- Waterbody
- Wetland
- Wooded Area
- Provincial Boundary



NOTES
Base data source: CanVec 1:250,000.

STATUS
ISSUED FOR USE

SITE C SONGBIRD 2022 ANNUAL REPORT

Songbird Survey Locations

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	BC Hydro Power smart

Scale: 1:350,000
5 2.5 0 5
Kilometres

FILE NO.
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TETRA TECH

OFFICE	DWN	CKD	APVD	REV
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DATE	PROJECT NO.
November 29, 2022	ENW.PENW03042-02

Figure 1

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Surveys conducted in 2022 represent a continuation of monitoring at the semi-permanent monitoring stations established in 2020. In 2020, 97 semi-permanent monitoring stations were established at randomly located points within the Peace River valley. Each station was located outside the reservoir footprint in accessible areas (slopes that can be traversed on foot) and stratified by bird habitat class in proportion to the mapped area of each class in the Peace River valley (see Section 3.0 for classes). Some survey stations were located within the Rutledge and Wilder Creek mitigation properties as these two properties are within the Peace River valley (the Marl Fen property is located outside the Peace River valley). Candidate locations were then manually adjusted to be 100 m from a habitat edge (e.g. forest-wetland transition) where possible and some locations were linked to form a sequence of survey locations that can be visited on foot. To allow for sampling of all bird habitat classes, some stations were located within uncleared portions of the footprint west of the Halfway River for bird habitat classes that do not exist outside the footprint (e.g., riparian forest that currently only exists in the valley bottom footprint).

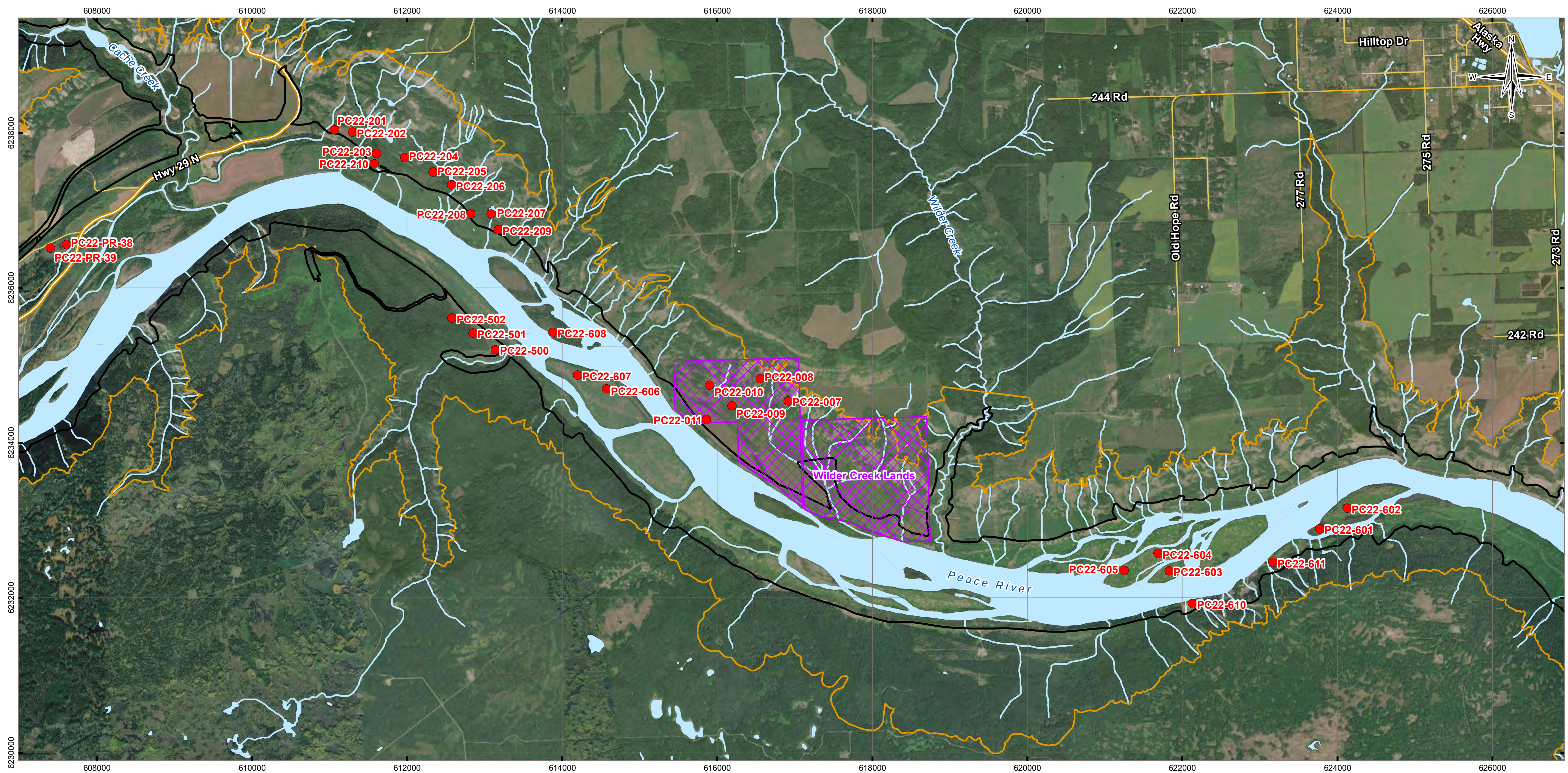
Due to accessibility issues, 4 of the 103 stations surveyed in 2021 required relocation for the 2022 surveys. PC22 D2-1, and PC22 D2-2 were shifted from their previous locations and renamed as PC22 D2-1B and PC22 D2-2B. PC21-004 and PC21-005 were removed completely and replaced with PC22-610 and PC22-611 which were established in a similar area nearby. In total, 103 stations were surveyed in 2022 (Figures 2a to 2d; Appendix A). Each station was surveyed twice, except for PC22-D2-2 and PC22-D2-2B which were each surveyed once.

2.2 Point Count Surveys

Point counts were conducted on June 1-25, 2022 by two teams. Each team was composed of a biologist with songbird survey experience and an assistant (Appendix B). Each station was surveyed (visited) two times, with at least two weeks between visits, to maximize the detection of early and late breeders.

Point count surveys were conducted as unlimited-radius point counts with distance-to-detection intervals set at 0-50 m, 51-100 m and >100 m. Each point count survey was conducted over ten minutes and bird detections were recorded in three intervals: 0-3 minutes, 3-5 minutes and 5-10 minutes. Point counts took place from sunrise to approximately four hours after sunrise. After arriving at each station, the surveyor waited one minute, then commenced the 10-minute survey period and recorded all birds seen and/or heard. Data were recorded on a standardized data form.

Incidental observations were recorded when non-songbird species were observed during surveys, or when any bird species listed under the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) or *Species at Risk Act* (SARA) were observed outside of survey stations (e.g., when surveyors were traveling between stations) or survey periods (e.g. before or after daily observations have started/finished). For each incidental observation, date, time, GPS location, gender, behavior and habitat were recorded.



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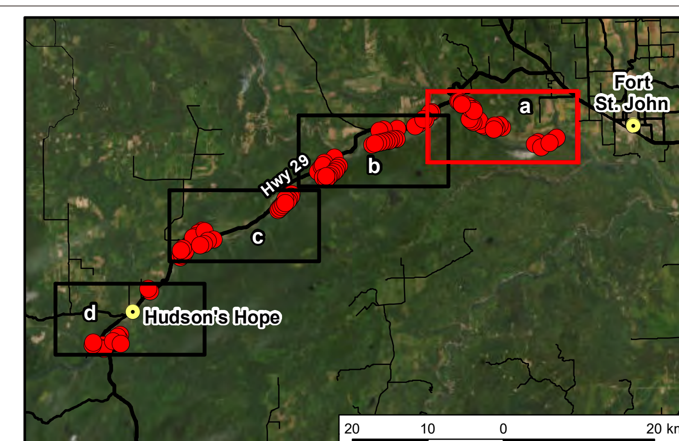
LEGEND

- 2022 Songbird Survey Location
- Project Footprint
- Potential Mitigation Property
- Peace River Valley
- Highway
- Main Road
- Local Road
- Watercourse
- Waterbody



NOTES
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Imagery from ESRI; Maxar

STATUS
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SITE C SONGBIRD 2022 ANNUAL REPORT

2022 Songbird Survey Locations

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	BC Hydro Power smart

Scale: 1:50,000
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Kilometres

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TETRA TECH

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DATE	PROJECT NO.
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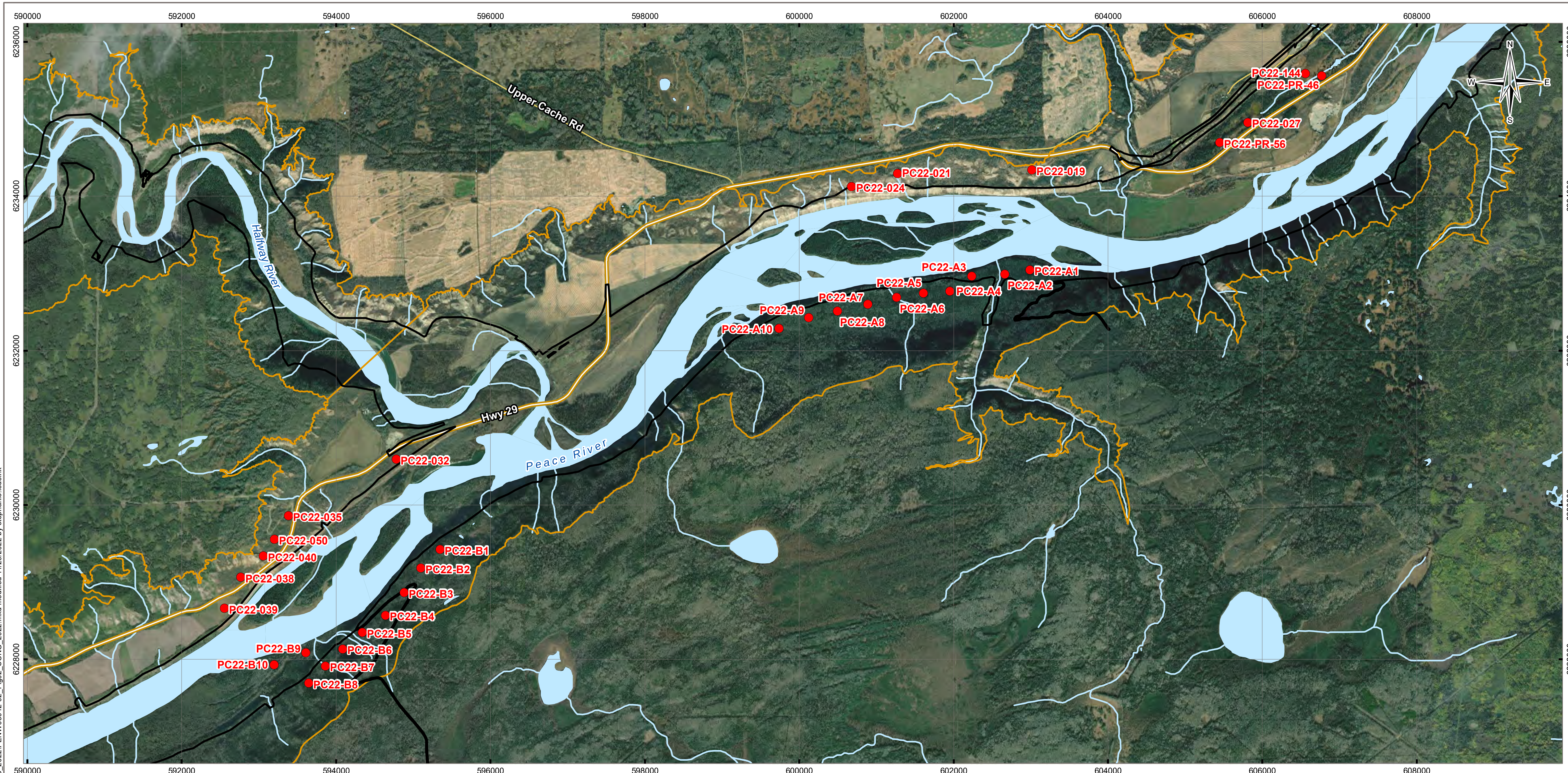
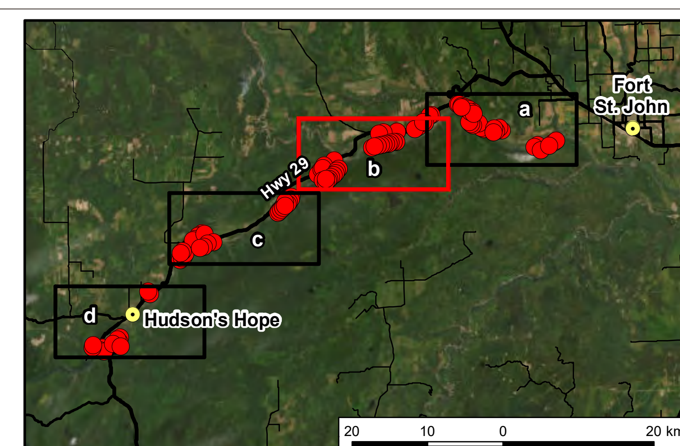
Figure 2a





LEGEND

- 2022 Songbird Survey Location
- Project Footprint
- Potential Mitigation Property
- Peace River Valley
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- Waterbody

NOTES
Base data source:
CanVec 1:50,000 (2019)
Imagery from ESRI; Maxar

STATUS
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SITE C SONGBIRD
2022 ANNUAL REPORT

2022 Songbird Survey Locations

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	BC Hydro Power smart

Scale: 1:50,000
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Kilometres

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DATE
November 29, 2022

PROJECT NO.
ENW.PENW03042-02

Figure 2b

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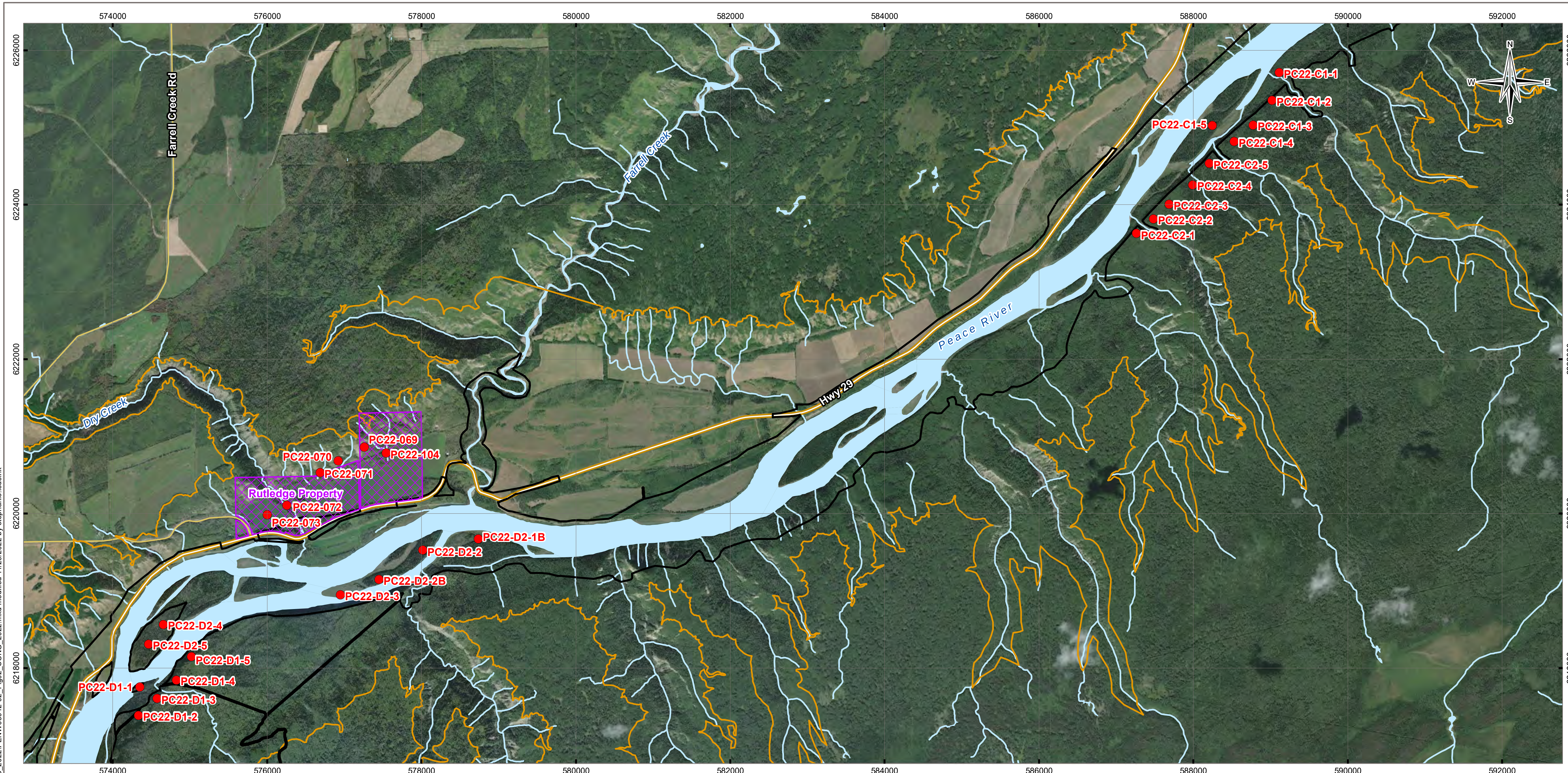

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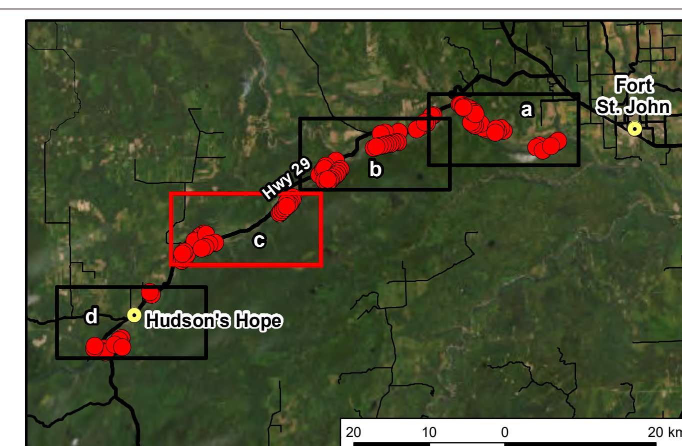
LEGEND

- 2022 Songbird Survey Location
- Project Footprint
- Potential Mitigation Property
- Peace River Valley
- Highway
- Local Road
- Watercourse
- Waterbody



NOTES
Base data source:
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Imagery from ESRI; Maxar

STATUS
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SITE C SONGBIRD 2022 ANNUAL REPORT

2022 Songbird Survey Locations

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	BC Hydro Power smart

Scale: 1:50,000
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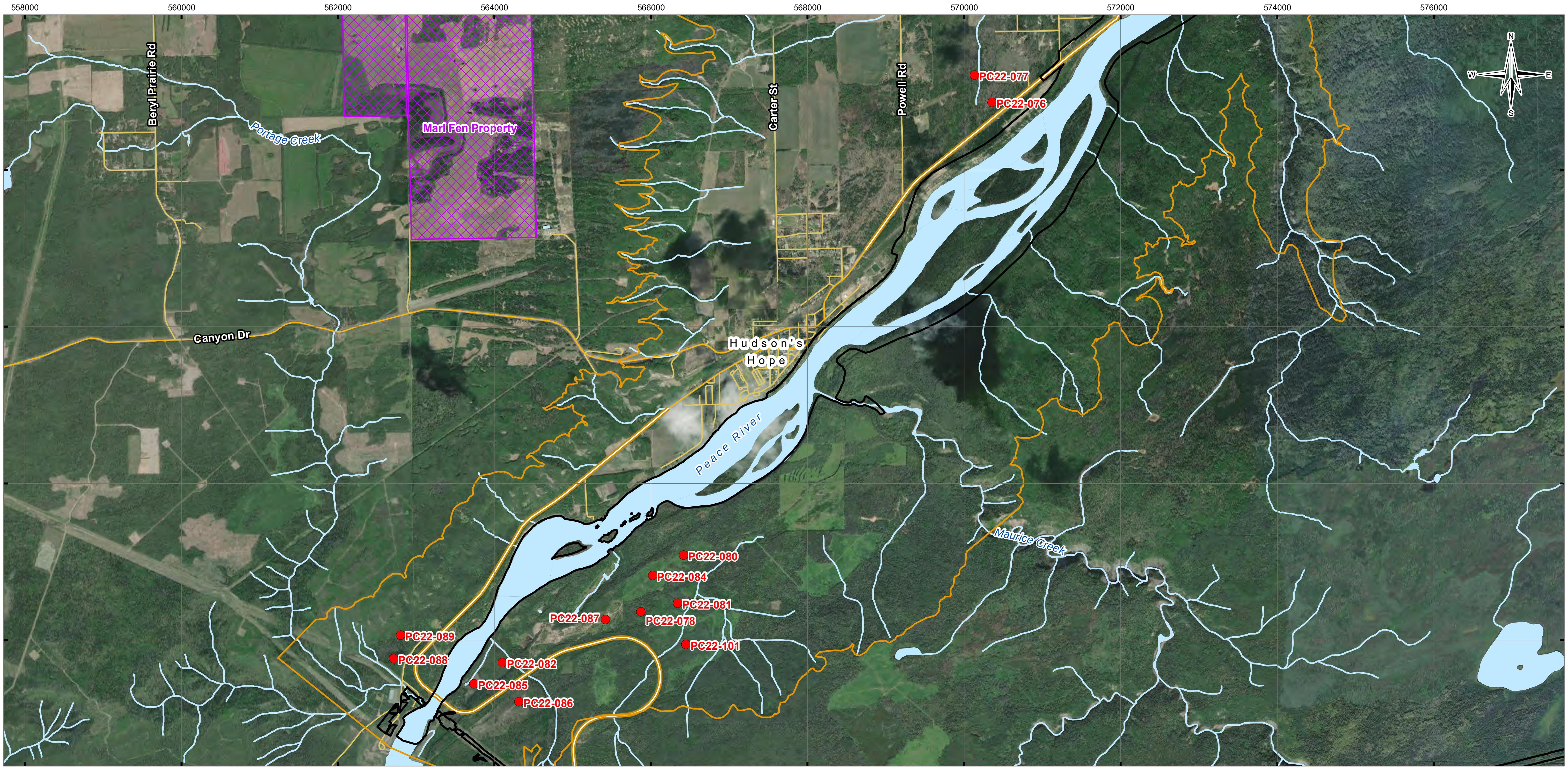
November 29, 2022	ENW.PENW03042-02

Figure 2c



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LEGEND

- 2022 Songbird Survey Location
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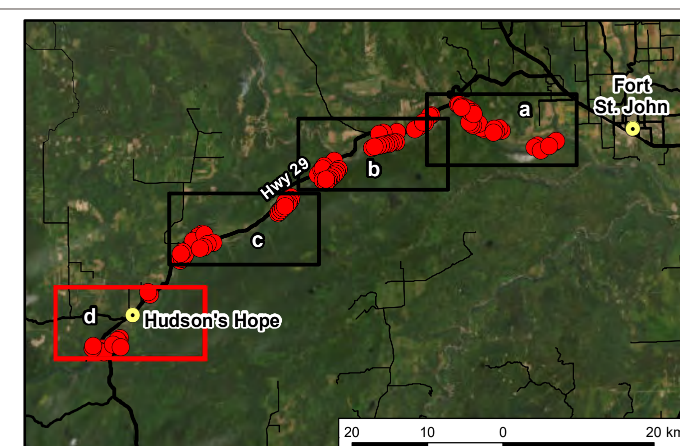

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Imagery from ESRI; Maxar

STATUS
ISSUED FOR USE

SITE C SONGBIRD 2022 ANNUAL REPORT

2022 Songbird Survey Locations

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	BC Hydro Power smart

Scale: 1:50,000
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Kilometres

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TETRA TECH

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DATE	PROJECT NO.
November 29, 2022	ENW.PENW03042-02

Figure 2d

3.0 RESULTS AND DISCUSSION

Surveys were conducted at 103 point count stations within 15 bird habitat classes (Table 1). Each of the point count stations were surveyed twice in June 2022 except for PC22 D2-2 and PC22 D2-2B which were each surveyed once. A total of 204 surveys were conducted in 2022.

Table 1: Number of Songbird Point Count Stations and Surveys Conducted in 2022 by Bird Habitat Class

Bird Habitat Class	Stations	Surveys
Coniferous-shrub	5	9
Coniferous-young forest	8	16
Coniferous-mature forest	17	33
Deciduous-shrub	13	26
Deciduous-young forest	13	26
Deciduous-mature forest	12	24
Riparian-mixed shrub	7	14
Riparian-mixed young forest	3	6
Riparian-mixed mature forest	1	2
Fen/bog-shrub	2	4
Wetland-graminoid	3	6
Wetland-shrub	5	10
Dry slopes-grassland	2	4
Dry slopes-shrubland	8	16
Cultivated	4	8
Total	**103**	**204**

A total of 87 bird species were detected, of which 76 were songbirds (Table 2). Seven species listed under COSEWIC, SARA and/or British Columbia's Red and Blue lists were observed during the surveys. The median number of songbird species detected per point count survey was 9 (ranging from 4 to 18). Other bird species not classified as songbirds were recorded as incidental observations and are listed in Appendix C.

Surveys conducted in 2022 represent a continuation in monitoring of semi-permanent monitoring stations that will be monitored through to 10 years post-construction. In each future year, some stations may be lost to land use changes or access, and others will be added as needed to address the objective to characterize changes in the bird community of the Peace River Valley over time.

Table 2: Songbird Species Observed During the 2022 Point Count Surveys

English Name	Scientific Name	BC List	COSEWIC	SARA Status	Survey Detections
Northern Flicker*	*Colaptes auratus*	Yellow	-	-	3
Downy Woodpecker*	*Dryobates pubescens*	Yellow	-	-	3
Hairy Woodpecker*	*Dryobates villosus*	Yellow	-	-	3
Pileated Woodpecker*	*Dryocopus pileatus*	Yellow	-	-	1
American Three-toed Woodpecker*	*Picoides dorsalis*	Yellow	-	-	2
Yellow-bellied Sapsucker*	*Sphyrapicus varius*	Yellow	-	-	12
Olive-sided Flycatcher	*Contopus cooperi*	Yellow	Special Concern	Threatened	3
Western Wood-Pewee	*Contopus sordidulus*	Yellow	-	-	26
Alder Flycatcher	*Empidonax alnorum*	Yellow	-	-	54
Pacific-slope Flycatcher	*Empidonax difficilis*	Yellow	-	-	7
Yellow-bellied Flycatcher	*Empidonax flaviventris*	Yellow	-	-	1
Least Flycatcher	*Empidonax minimus*	Yellow	-	-	108
Dusky Flycatcher	*Empidonax oberholseri*	Yellow	-	-	1
Eastern Phoebe	*Sayornis phoebe*	Yellow	-	-	2
Eastern Kingbird	*Tyrannus tyrannus*	Yellow	-	-	8
Warbling Vireo	*Vireo gilvus*	Yellow	-	-	38
Red-eyed Vireo	*Vireo olivaceus*	Yellow	-	-	183
Philadelphia Vireo	*Vireo philadelphicus*	Yellow	-	-	4
Blue-headed Vireo	*Vireo solitarius*	Yellow	-	-	10
American Crow	*Corvus brachyrhynchos*	Yellow	-	-	28
Common Raven	*Corvus corax*	Yellow	-	-	14
Canada Jay	*Perisoreus canadensis*	Yellow	-	-	9
Black-billed Magpie	*Pica hudsonia*	Yellow	-	-	7
Cedar Waxwing	*Bombycilla cedrorum*	Yellow	-	-	30
Black-capped Chickadee	*Poecile atricapillus*	Yellow	-	-	8
Boreal Chickadee	*Poecile hudsonicus*	Yellow	-	-	3
Cliff Swallow	*Petrochelidon pyrrhonota*	Yellow	-	-	10
Bank Swallow	*Riparia riparia*	Yellow	Threatened	Threatened	7
Tree Swallow	*Tachycineta bicolor*	Yellow	-	-	1
Violet-green Swallow	*Tachycineta thalassina*	Yellow	-	-	25
Ruby-crowned Kinglet	*Corthylio calendula*	Yellow	-	-	16
Golden-crowned Kinglet	*Regulus satrapa*	Yellow	-	-	2
Marsh Wren	*Cistothorus palustris*	Yellow	-	-	8
Red-breasted Nuthatch	*Sitta canadensis*	Yellow	-	-	18

English Name	Scientific Name	BC List	COSEWIC	SARA Status	Survey Detections
House Wren	*Troglodytes aedon*	Yellow	-	-	5
Gray Catbird	*Dumetella carolinensis*	Yellow	-	-	8
Hermit Thrush	*Catharus guttatus*	Yellow	-	-	20
Swainson's Thrush	*Catharus ustulatus*	Yellow	-	-	91
Townsend's Solitaire	*Myadestes townsendi*	Yellow	-	-	1
American Robin	*Turdus migratorius*	Yellow	-	-	88
Purple Finch	*Haemorhous purpureus*	Yellow	-	-	19
White-winged Crossbill	*Loxia leucoptera*	Yellow	-	-	1
Pine Siskin	*Spinus pinus*	Yellow	-	-	27
Canada Warbler	*Cardellina canadensis*	Blue	Special Concern	Threatened	17
Mourning Warbler	*Geothlypis philadelphia*	Yellow	-	-	4
Common Yellowthroat	*Geothlypis trichas*	Yellow	-	-	57
Orange-crowned Warbler	*Leiothlypis celata*	Yellow	-	-	42
Tennessee Warbler	*Leiothlypis peregrina*	Yellow	-	-	66
Black-and-white Warbler	*Mniotilta varia*	Yellow	-	-	36
Northern Waterthrush	*Parkesia noveboracensis*	Yellow	-	-	12
Ovenbird	*Seiurus aurocapilla*	Yellow	-	-	136
Bay-breasted Warbler	*Setophaga castanea*	Red	-	-	1
Yellow-rumped Warbler	*Setophaga coronata*	Yellow	-	-	131
Magnolia Warbler	*Setophaga magnolia*	Yellow	-	-	20
Yellow Warbler	*Setophaga petechia*	Yellow	-	-	123
American Redstart	*Setophaga ruticilla*	Yellow	-	-	29
Blackpoll Warbler	*Setophaga striata*	Yellow	-	-	3
Cape May Warbler	*Setophaga tigrina*	Blue	-	-	1
Black-throated Green Warbler	*Setophaga virens*	Blue	-	-	12
Red-winged Blackbird	*Agelaius phoeniceus*	Yellow	-	-	106
Brewer's Blackbird	*Euphagus cyanocephalus*	Yellow	-	-	2
Baltimore Oriole	*Icterus galbula*	Blue	-	-	18
Brown-headed Cowbird	*Molothrus ater*	Yellow	-	-	8
Dark-eyed Junco	*Junco hyemalis*	Yellow	-	-	48
Swamp Sparrow	*Melospiza georgiana*	Yellow	-	-	21
Lincoln's Sparrow	*Melospiza lincolnii*	Yellow	-	-	45
Song Sparrow	*Melospiza melodia*	Yellow	-	-	50
Savannah Sparrow	*Passerculus sandwichensis*	Yellow	-	-	2

English Name	Scientific Name	BC List	COSEWIC	SARA Status	Survey Detections
Fox Sparrow	*Passerella iliaca*	Yellow	-	-	3
Vesper Sparrow	*Pooecetes gramineus*	Yellow	-	-	12
Clay-colored Sparrow	*Spizella pallida*	Yellow	-	-	81
Chipping Sparrow	*Spizella passerina*	Yellow	-	-	22
White-throated Sparrow	*Zonotrichia albicollis*	Yellow	-	-	315
White-crowned Sparrow	*Zonotrichia leucophrys*	Yellow	-	-	3
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Yellow	-	-	46
Western Tanager	*Piranga ludoviciana*	Yellow	-	-	43

* Includes woodpeckers. Though not songbirds, woodpeckers are also part of the Breeding Bird Follow-up Monitoring Program (surveyed separately from songbirds) and are regularly detected during points counts.

4.0 REFERENCES

Saulteau EBA Environmental Services Joint Venture (SEEJ JV) 2019. Site C Clean Energy Project Breeding Bird Follow-up Monitoring – Songbirds. 2020 Annual Report. Prepared by Tetra Tech Canada Inc. for BC Hydro and Power Authority.

APPENDIX A

2022 POINT COUNT STATIONS

Table A1: Songbird Point Count Stations Surveyed in 2022

Station	UTM Zone	UTM Easting	UTM Northing	Survey 1 Date	Survey 1 Time	Survey 2 Date	Survey 2 Time	Bird Habitat Class
PC22-601	10	623773	6232892	6/1/2022	4:23	6/19/2022	4:30	Riparian-mixed young forest
PC22-602	10	624125	6233158	6/1/2022	4:24	6/19/2022	4:30	Riparian-mixed shrub
PC22-603	10	621827	6232349	6/1/2022	4:53	6/19/2022	5:02	Riparian-mixed shrub
PC22-604	10	621685	6232571	6/1/2022	5:13	6/19/2022	5:24	Riparian-mixed shrub
PC22-605	10	621248	6232354	6/1/2022	5:37	6/19/2022	5:48	Riparian-mixed shrub
PC22-606	10	614571	6234696	6/1/2022	6:40	6/19/2022	6:47	Coniferous-shrub
PC22-607	10	614201	6234874	6/1/2022	7:04	6/19/2022	7:14	Riparian-mixed shrub
PC22-608	10	613880	6235428	6/1/2022	7:32	6/19/2022	7:40	Riparian-mixed shrub
PC22-610	10	622131	6231923	6/1/2022	5:20	6/19/2022	6:02	Deciduous-young forest
PC22-611	10	623167	6232457	6/1/2022	5:54	6/19/2022	5:04	Deciduous-shrub
PC22-500	10	613140	6235203	6/1/2022	8:20	6/19/2022	9:16	Deciduous-young forest
PC22-501	10	612849	6235419	6/1/2022	8:53	6/19/2022	9:40	Deciduous-mature forest
PC22-502	10	612581	6235611	6/1/2022	9:24	6/19/2022	10:03	Deciduous-mature forest
PC22-007	10	616913	6234543	6/1/2022	8:09	6/19/2022	8:03	Dry slopes-grassland
PC22-008	10	616553	6234827	6/1/2022	7:38	6/19/2022	7:33	Dry slopes-shrubland
PC22-009	10	616192	6234479	6/1/2022	8:39	6/19/2022	8:28	Cultivated
PC22-010	10	615902	6234745	6/1/2022	7:06	6/19/2022	7:04	Dry slopes-shrubland
PC22-011	10	615862	6234301	6/1/2022	6:44	6/19/2022	6:45	Cultivated
PC22-019	10	603014	6234339	6/5/2022	4:13	6/25/2022	4:10	Dry slopes-grassland
PC22-021	10	601274	6234292	6/5/2022	4:47	6/20/2022	6:51	Deciduous-shrub
PC22-024	10	600679	6234123	6/5/2022	5:26	6/20/2022	6:15	Deciduous-shrub

Station	UTM Zone	UTM Easting	UTM Northing	Survey 1 Date	Survey 1 Time	Survey 2 Date	Survey 2 Time	Bird Habitat Class
PC22-027	10	605811	6234955	6/6/2022	6:17	6/20/2022	8:55	Fen/bog-shrub
PC22-032	10	594779	6230591	6/5/2022	6:02	6/25/2022	4:42	Coniferous-shrub
PC22-035	10	593385	6229860	6/5/2022	6:47	6/25/2022	5:06	Deciduous-shrub
PC22-038	10	592767	6229065	6/5/2022	8:01	6/25/2022	6:20	Dry slopes-shrubland
PC22-PR-38	10	607605	6236561	6/6/2022	4:45	6/20/2022	7:37	Wetland-graminoid
PC22-PR-39	10	607396	6236515	6/6/2022	5:05	6/20/2022	7:57	Wetland-shrub
PC22-039	10	592553	6228662	6/5/2022	8:30	6/25/2022	6:48	Cultivated
PC22-040	10	593058	6229341	6/5/2022	7:34	6/25/2022	5:55	Dry slopes-shrubland
PC22-PR-46	10	606770	6235559	6/6/2022	5:50	6/20/2022	8:26	Wetland-graminoid
PC22-050	10	593202	6229554	6/5/2022	7:13	6/25/2022	5:30	Dry slopes-shrubland
PC22-PR-56	10	605447	6234696	6/6/2022	6:45	6/20/2022	9:26	Coniferous-mature forest
PC22-069	10	577259	6220860	6/4/2022	8:17	6/23/2022	8:36	Dry slopes-shrubland
PC22-070	10	576921	6220683	6/4/2022	7:50	6/23/2022	8:01	Dry slopes-shrubland
PC22-071	10	576686	6220531	6/4/2022	7:29	6/23/2022	7:48	Deciduous-shrub
PC22-072	10	576256	6220108	6/4/2022	6:55	6/23/2022	7:14	Riparian-mixed young forest
PC22-073	10	576001	6219985	6/4/2022	6:33	6/23/2022	6:56	Cultivated
PC22-076	10	570355	6212864	6/4/2022	5:34	6/23/2022	5:45	Coniferous-young forest
PC22-077	10	570134	6213209	6/4/2022	5:53	6/23/2022	6:11	Coniferous-young forest
PC22-078	10	565870	6206360	6/4/2022	6:36	6/24/2022	6:35	Deciduous-mature forest
PC22-080	10	566416	6207084	6/4/2022	4:22	6/24/2022	4:30	Deciduous-shrub
PC22-081	10	566341	6206470	6/4/2022	5:19	6/24/2022	4:53	Wetland-shrub
PC22-082	10	564101	6205711	6/4/2022	7:34	6/24/2022	7:36	Deciduous-mature forest

Station	UTM Zone	UTM Easting	UTM Northing	Survey 1 Date	Survey 1 Time	Survey 2 Date	Survey 2 Time	Bird Habitat Class
PC22-084	10	566021	6206826	6/4/2022	4:55	6/24/2022	6:03	Deciduous-shrub
PC22-085	10	563734	6205440	6/4/2022	8:54	6/24/2022	8:50	Fen/bog-shrub
PC22-086	10	564312	6205213	6/4/2022	8:19	6/24/2022	8:15	Deciduous-shrub
PC22-087	10	565416	6206263	6/4/2022	7:00	6/24/2022	7:02	Deciduous-shrub
PC22-088	10	562713	6205763	6/4/2022	4:15	6/23/2022	4:23	Deciduous-mature forest
PC22-089	10	562800	6206063	6/4/2022	4:46	6/23/2022	5:02	Deciduous-mature forest
PC22-101	10	566447	6205946	6/4/2022	5:50	6/24/2022	5:24	Coniferous-young forest
PC22-104	10	577541	6220783	6/4/2022	8:42	6/23/2022	8:59	Deciduous-young forest
PC22-144	10	606558	6235589	6/6/2022	7:30	6/25/2022	8:34	Wetland-graminoid
PC22-201	10	611065	6238042	6/5/2022	4:15	6/23/2022	4:10	Dry slopes-shrubland
PC22-202	10	611295	6238013	6/5/2022	4:33	6/23/2022	4:24	Deciduous-young forest
PC22-203	10	611606	6237736	6/5/2022	5:24	6/23/2022	5:08	Deciduous-mature forest
PC22-204	10	611968	6237681	6/5/2022	5:58	6/23/2022	5:42	Deciduous-young forest
PC22-205	10	612332	6237495	6/5/2022	6:40	6/23/2022	6:15	Deciduous-mature forest
PC22-206	10	612573	6237329	6/5/2022	7:12	6/23/2022	6:44	Wetland-shrub
PC22-207	10	613084	6236953	6/5/2022	8:48	6/23/2022	8:00	Wetland-shrub
PC22-208	10	612820	6236955	6/5/2022	7:45	6/23/2022	7:13	Deciduous-shrub
PC22-209	10	613174	6236752	6/5/2022	8:08	6/23/2022	7:35	Deciduous-young forest
PC22-210	10	611575	6237602	6/5/2022	4:59	6/23/2022	4:46	Wetland-shrub
PC22-A1	10	602990	6233046	6/2/2022	4:40	6/24/2022	4:16	Deciduous-mature forest
PC22-A10	10	599738	6232286	6/2/2022	6:50	6/24/2022	8:10	Coniferous-mature forest
PC22-A2	10	602661	6232990	6/2/2022	4:20	6/24/2022	4:37	Deciduous-shrub

Station	UTM Zone	UTM Easting	UTM Northing	Survey 1 Date	Survey 1 Time	Survey 2 Date	Survey 2 Time	Bird Habitat Class
PC22-A3	10	602233	6232962	6/2/2022	9:23	6/24/2022	5:08	Deciduous-shrub
PC22-A4	10	601952	6232770	6/2/2022	8:52	6/24/2022	5:29	Coniferous-mature forest
PC22-A5	10	601607	6232742	6/2/2022	8:25	6/24/2022	5:52	Coniferous-mature forest
PC22-A6	10	601260	6232688	6/2/2022	7:59	6/24/2022	6:19	Coniferous-mature forest
PC22-A7	10	600890	6232601	6/2/2022	7:35	6/24/2022	6:47	Coniferous-mature forest
PC22-A8	10	600496	6232512	6/2/2022	5:55	6/24/2022	7:16	Coniferous-mature forest
PC22-A9	10	600121	6232427	6/2/2022	6:20	6/24/2022	7:45	Coniferous-mature forest
PC22-B1	10	595349	6229423	6/2/2022	4:42	6/21/2022	4:33	Coniferous-young forest
PC22-B10	10	593197	6227928	6/2/2022	8:50	6/21/2022	8:43	Coniferous-shrub
PC22-B2	10	595098	6229182	6/2/2022	5:09	6/21/2022	4:53	Coniferous-mature forest
PC22-B3	10	594882	6228865	6/2/2022	5:41	6/21/2022	5:18	Coniferous-young forest
PC22-B4	10	594639	6228571	6/2/2022	6:11	6/21/2022	5:48	Coniferous-young forest
PC22-B5	10	594340	6228348	6/2/2022	6:42	6/21/2022	6:18	Deciduous-young forest
PC22-B6	10	594087	6228135	6/2/2022	7:13	6/21/2022	6:48	Deciduous-young forest
PC22-B7	10	593863	6227915	6/2/2022	7:42	6/21/2022	7:16	Deciduous-young forest
PC22-B8	10	593646	6227692	6/2/2022	8:09	6/21/2022	7:47	Coniferous-young forest
PC22-B9	10	593609	6228086	6/2/2022	9:16	6/21/2022	8:19	Coniferous-shrub
PC22-C1-1	10	589114	6225713	6/3/2022	8:15	6/22/2022	7:48	Deciduous-shrub
PC22-C1-2	10	589021	6225353	6/3/2022	8:40	6/22/2022	8:13	Coniferous-mature forest
PC22-C1-3	10	588775	6225032	6/3/2022	9:10	6/22/2022	8:41	Coniferous-mature forest
PC22-C1-4	10	588528	6224817	6/3/2022	9:36	6/22/2022	9:06	Coniferous-mature forest
PC22-C1-5	10	588244	6225026	6/3/2022	10:08	6/22/2022	9:36	Riparian-mixed mature forest

Station	UTM Zone	UTM Easting	UTM Northing	Survey 1 Date	Survey 1 Time	Survey 2 Date	Survey 2 Time	Bird Habitat Class
PC22-C2-1	10	587264	6223631	6/3/2022	8:12	6/22/2022	7:46	Deciduous-young forest
PC22-C2-2	10	587483	6223815	6/3/2022	8:52	6/22/2022	8:17	Deciduous-young forest
PC22-C2-3	10	587687	6224007	6/3/2022	9:10	6/22/2022	8:41	Deciduous-young forest
PC22-C2-4	10	587990	6224257	6/3/2022	9:34	6/22/2022	9:12	Coniferous-young forest
PC22-C2-5	10	588205	6224535	6/3/2022	10:03	6/22/2022	9:43	Coniferous-mature forest
PC22-D1-1	10	574352	6217752	6/3/2022	4:26	6/22/2022	4:22	Riparian-mixed young forest
PC22-D1-2	10	574335	6217385	6/3/2022	4:53	6/22/2022	4:55	Coniferous-mature forest
PC22-D1-3	10	574574	6217605	6/3/2022	5:18	6/22/2022	5:17	Coniferous-mature forest
PC22-D1-4	10	574823	6217844	6/3/2022	5:52	6/22/2022	5:44	Deciduous-mature forest
PC22-D1-5	10	575018	6218149	6/3/2022	6:20	6/22/2022	6:06	Coniferous-mature forest
PC22-D2-1B	10	578738	6219672	6/3/2022	7:27	6/22/2022	7:00	Deciduous-young forest
PC22-D2-2	10	578018	6219525	6/3/2022	6:48	NA	NA	Coniferous-mature forest
PC22-D2-2B	10	577450	6219145	NA	NA	6/22/2022	6:16	Coniferous-shrub
PC22-D2-3	10	576950	6218948	6/3/2022	6:10	6/22/2022	5:44	Riparian-mixed shrub
PC22-D2-4	10	574657	6218563	6/3/2022	5:10	6/22/2022	5:02	Deciduous-mature forest
PC22-D2-5	10	574463	6218308	6/3/2022	4:42	6/22/2022	4:38	Deciduous-mature forest

APPENDIX B
PROJECT QUALIFIED ENVIRONMENTAL PROFESSIONALS

Name and Affiliation	Project Role
Jeff Matheson, M.Sc., R.P.Bio. Tetra Tech Canada Inc.	Project manager, report author
Elyse Hofs, B.Sc., Dipl.T., B.I.T. Tetra Tech Canada Inc.	Field data collection, data entry, report author
Heather Gauthier, R.T.Biol. Tetra Tech Canada Inc.	Field data collection

APPENDIX C
INCIDENTAL BIRD OBSERVATIONS

Table C.1: Incidental observations of birds recorded outside of point count surveys and birds recorded during point counts that are not songbirds

English Name	Scientific Name	BC List	COSEWIC	SARA Status	Detections
Spotted Sandpiper	*Actitis macularius*	Yellow	-	-	1
Cedar Waxwing	*Bombycilla cedrorum*	Yellow	-	-	1
Ruffed Grouse	*Bonasa umbellus*	Yellow	-	-	7
Canada Goose	*Branta canadensis*	Yellow	-	-	5
Great Horned Owl	*Bubo virginianus*	Yellow	-	-	1
Bufflehead	*Bucephala albeola*	Yellow	-	-	2
Red-tailed Hawk	*Buteo jamaicensis*	Yellow	Not at Risk	-	1
Canada Warbler	*Cardellina canadensis*	Blue	Special Concern	Threatened	1
Northern Harrier	*Circus hudsonius*	Yellow	Not at Risk	-	3
American Crow	*Corvus brachyrhynchos*	Yellow	-	-	9
Common Raven	*Corvus corax*	Yellow	-	-	1
Yellow Rail	*Coturnicops noveboracensis*	Red	Special Concern	Special Concern	1
Pileated Woodpecker	*Dryocopus pileatus*	Yellow	-	-	1
Merlin	*Falco columbarius*	Yellow	Not at Risk	-	1
Wilson's Snipe	*Gallinago delicata*	Yellow	-	-	13
Common Loon	*Gavia immer*	Yellow	Not at Risk	-	1
Bald Eagle	*Haliaeetus leucocephalus*	Yellow	Not at Risk	-	10
American Wigeon	*Mareca americana*	Yellow	-	-	1
Belted Kingfisher	*Megaceryle alcyon*	Yellow	-	-	1
Brown-headed Cowbird	*Molothrus ater*	Yellow	-	-	1
Horned Grebe	*Podiceps auritus*	Yellow	Special Concern	Special Concern	4
Sora	*Porzana carolina*	Yellow	-	-	8
Pine Siskin	*Spinus pinus*	Yellow	-	-	3
Violet-green Swallow	*Tachycineta thalassina*	Yellow	-	-	3
Pacific Wren	*Troglodytes pacificus*	Yellow	-	-	1

APPENDIX D
LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

NATURAL SCIENCES

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During the performance of the work and the preparation of this Professional Document, SEES JV may have relied on information provided by third parties other than the Client.

While SEES JV endeavours to verify the accuracy of such information, SEES JV accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

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This Professional Document is based solely on the conditions presented and the data available to SEES JV at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

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1.7 ENVIRONMENTAL ISSUES

The ability to rely upon and generalize from environmental baseline data is dependent on data collection activities occurring within biologically relevant survey windows.

It is incumbent upon the Client and any Authorized Party, to be knowledgeable of the level of risk that has been incorporated into the project design or scope, in consideration of the level of the environmental baseline information that was reasonably acquired to facilitate completion of the scope.

1.8 NOTIFICATION OF AUTHORITIES

SEES JV professionals are bound by their ethical commitments to act within the bounds of all pertinent regulations. In certain instances, observations by SEES JV of regulatory contravention may require that regulatory agencies and other persons be informed. The client agrees that notification to such bodies or persons as required may be done by SEES JV in its reasonably exercised discretion.

Appendix 3. Waterbird Migration Follow-up Monitoring Program 2022 Annual Report

Ausenco

Site C Vegetation and Wildlife Waterbird Migration Follow-up Monitoring Program – 2022 Annual Report

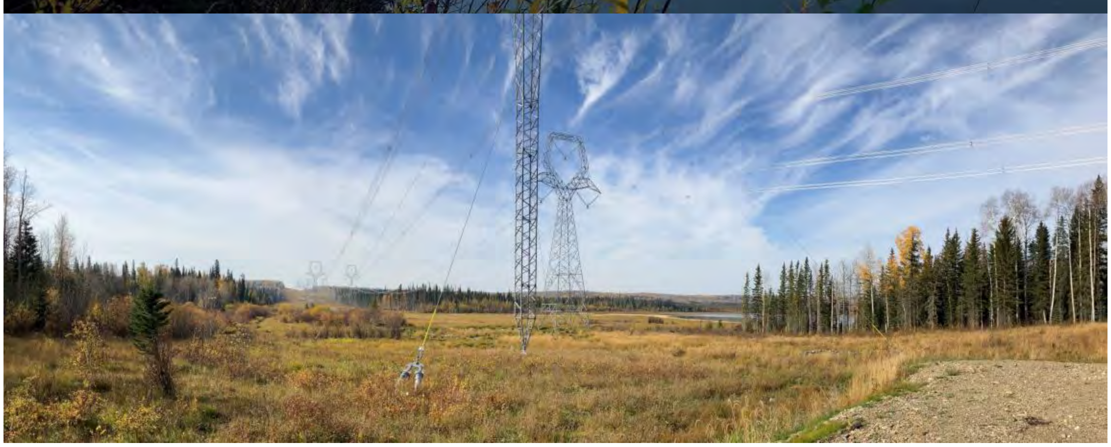

Photo Credit: C. Toby St. Clair

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Project No. 989619-07

March 10, 2023

Executive Summary

The Site C Waterbird Migration Follow-up Monitoring Program is being conducted to fulfill, in part, the requirements and conditions set forth in the Site C Clean Energy Project's (Project) Provincial Environmental Assessment Certificate (EAC) and the Federal Decision Statement (FDS). The objectives of the Site C waterbird monitoring program are as follows:

- Assess changes in waterbird wetland and non-wetland habitat on the Peace River and the transmission line right-of-way from Project construction through to the first 10 years of Project operations to assess Project-related impacts relative to the impacts predicted in the EIS.
- Document changes in waterbird abundance and diversity across habitats (Peace River and wetlands) during the first 10 years of Project operations relative to pre-reservoir and transmission line conditions to assess Project-related impacts relative to those predicted in the EIS.
- Monitor waterbird use of natural and created compensatory wetland features from Project construction through to the first 10 years of Project operations to evaluate the effectiveness of mitigation and compensation measures.

The monitoring program has been implemented annually for 6 years, from 2017 through 2022, within the Peace River and wetlands along the Project transmission line right-of-way (ROW) on the Moberly Plateau. Standwatch and transect surveys conducted on foot, river boat surveys, and bioacoustics monitoring surveys using autonomous recording units (ARUs) were carried out to determine waterbird abundance and diversity within the habitat types present and used by waterbirds. Baseline data required to be collected by FDS conditions included measures of abundance, density, species presence and habitat use (i.e., associations) for waterbirds. The results collected to date are summarized as a whole and for the most recent monitoring year within this annual report.

Results presented in this annual monitoring report describe the survey effort and the observed waterbird abundance and diversity within the spring migration (April 1 to May 30) and fall migration (August 1 to October 30), as well as variation in these parameters across habitat types and study areas. Results are summarized for cumulative counts of all waterbird species and for 7 foraging guilds comprised of species with similar morphology and foraging strategies: large dabblers, dabbling ducks, benthic-feeding divers, piscivorous divers, shorebirds, gulls and surface-feeding terns, and marsh birds. A summary of 2022 monitoring efforts and pooled results from 2017 through 2022 are provided below for monitoring conducted along the Peace River between Hudson's Hope and the Alberta border, followed by results from wetland surveys conducted on and adjacent to the transmission line ROW on the Moberly Plateau. Survey results specific to the current monitoring year are provided within the body of the report.

During northward waterbird migrations in spring 2022, 2 surveys were conducted along the Peace River (April 5 to April 12). During southward migrations in fall 2022, 3 surveys were conducted (August 8 to October 6). Wetlands along and adjacent to the Project transmission line ROW were also surveyed in 2022 during 2 and 3 survey rounds over the spring (May 5 to May 19) and fall migration periods (August 10 to October 7), respectively. ARU surveys in 2022 were conducted at 9 locations on the Moberly Plateau during May, June, July, and early August.

Surveys of the Peace River in 2017 through 2022 provide 6 years of data under primarily baseline conditions. These data will be used together with data collected during the Project operations phase to assess potential impacts of the Project on waterbirds within a before-after control-impact (BACI) study design framework. A total of 93,951 waterbirds of 65 species were recorded during boat-based surveys conducted during the spring and fall of 2017 through 2022. From these results, summary statistics were calculated using pooled data from 46 surveys of the Peace River across all seasons and years. As reported in previous years, all 7 foraging guilds occurring within areas of anticipated Project-related effects were also recorded in the Control portion of the study area. These results support the BACI study design assumption that areas of the Peace River downstream of the Pine River provide an appropriate control for assessing background variation for waterbirds, with which Project-related changes to waterbirds in the Peace River will be assessed.

To help describe variation in waterbird abundance and diversity along the Peace River, areas of the river with similar habitat features (e.g., water flow volumes, water depth, substrate type, connectivity to the mainstem of the river, aquatic vegetation) were categorized into 3 habitat types:

- Mainstem - areas of the river where water flow rates, depths and substrate size are greatest
- Moderate Flow - areas of the river consistently connected to the mainstem, with moderate flows, and generally no impediment to boat travel regardless of water levels
- Limited Connectivity - backchannels with limited connectivity to the river, typically only on the downstream end with relatively low flow rate, and for which access by boat is restricted in some areas, particularly when water levels are low.

Abundance, density, and diversity statistics are presented for each of these river habitat types. Across all survey years, more waterbirds (46% and 63% in spring and fall, respectively, across all survey years) were found in Mainstem river habitat, the largest habitat type by area, compared to Moderate Flow (21% and 12% in spring and fall, respectively, across years) and Limited Connectivity habitats (33% and 25% in spring and fall, respectively, across years). However, the greatest densities of waterbirds were observed in Limited Connectivity habitat. Waterbird densities within Limited Connectivity habitat were 3.7 and 4.8 times the densities observed in Moderate Flow habitat in spring and fall, respectively. Relative to Mainstem areas of the river, densities within Limited Connectivity habitat were 9.8 and 5.3 times greater in spring and fall, respectively.

Wetland surveys conducted from 2017 through 2022 (i.e., 100-metre transects and 20-minute stationary standwatch surveys) resulted in detections of a total of 9,783 waterbirds of 46 species within 25 areas containing wetland habitat used by waterbirds (i.e., wetland survey stations). These surveys provide season-specific estimates of abundance and diversity in habitats regularly used by waterbirds within 3 km of the transmission line ROW. Wetland survey stations contained varying combinations of open water, sedge, and willow-sedge habitat types. Survey methods appropriate for each habitat type were applied and abundance and diversity statistics are presented for each. Standwatch surveys of open water habitat detected 9,360 individuals of 44 waterbird species in 2017 through 2022. Relative to standwatch surveys of open water habitat, fewer individuals and species (423 individuals of 19 species) were observed within sedge and willow-sedge habitat surveyed by walking transects in 2018 through 2022. While fewer survey years and greater detection constraints in sedge and willow-sedge habitats contribute to the lower numbers and diversity reported from those habitats, open water habitats on the Moberly Plateau clearly support greater waterbird abundances and diversity.

Bioacoustics monitoring using ARUs provides additional data on marsh bird species, which can be detected more effectively using audio rather than visual survey methods. Bioacoustics monitoring in 2017 through 2022, including 40 ARU deployments, was conducted at 38 locations, primarily between the middle of May and early August, when marsh bird species' vocalizations are most frequent. ARUs were deployed to record bird vocalizations within sedge and willow-sedge habitat in addition to the edge of open water and upland forested areas.

Sora (*Porzana carolina*) was detected at all locations where ARUs were deployed with the exception of 2 late-season deployments in 2022. Yellow rail (*Coturnicops noveboracensis*) was detected at 13 (34%) of 38 locations. Virginia rail (*Rallus limicola*), a species only recently known to occur in the region and not reported from baseline studies, was detected at 6 (25%) of 24 locations where ARUs were deployed in 2020, 2021, and 2022. In contrast, American bittern (*Botaurus lentiginosus*) was not detected at any location in any year of monitoring. These surveys provide data on sora complementary to those from transect surveys, demonstrating the species' ubiquity within vegetated wetlands. ARU survey results also confirm the rarity of American bittern in the wetland study area (i.e., the Moberly Plateau), and the continued presence of yellow rail along and adjacent to the transmission line ROW, particularly within sedge-dominated habitat with low water levels and *Carex* sp. rather than *Typha* sp. (i.e., cattails). The continued presence of Virginia rail, a species not regularly documented in the region prior to 2019, was also documented in 2022 in areas within willow-sedge and *Carex*-dominated sedge wetlands.

This work was performed in accordance with Purchase Order 4130005793 under Master Service Agreement No. 579005 between Ausenco Sustainability Inc., a wholly owned subsidiary of Ausenco Engineering Canada Inc. (Ausenco), and BC Hydro (Client), dated June 21, 2016 (Contract). This report has been prepared by Ausenco, based on fieldwork conducted by Ausenco, for sole benefit and use by BC Hydro. In performing this work, Ausenco has relied in good faith on information provided by others, and has assumed that the information provided by those individuals is both complete and accurate. This work was performed to current industry standard practice for similar environmental work, within the relevant jurisdiction and same locale. The findings presented herein should be considered within the context of the scope of work and project terms of reference; further, the findings are time sensitive and are considered valid only at the time the report was produced. The conclusions and recommendations contained in this report are based upon the applicable guidelines, regulations, and legislation existing at the time the report was produced; any changes in the regulatory regime may alter the conclusions and/or recommendations.

This Executive Summary is not intended to be a stand-alone document, but a summary of findings as described in the following Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

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List of Acronyms and Abbreviations

Acronym / Abbreviation	Definition
ARU	Autonomous Recording Unit
BACI	before-after, control-impact
BC	British Columbia
cm	centimetre
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
dB	decibel
EAC	Environmental Assessment Certificate
EIS	Environmental Impact Statement
FDS	Federal Decision Statement
GPS	global positioning system
h	hour(s)
kHz	kilohertz
km	kilometres
km^2	square kilometres
km/h	kilometres per hour
m	metre
ROW	right-of-way
SC	special concern
SARA	*Species at Risk Act*
sec	second
TEM	terrestrial ecosystem mapping
UTM	Universal Transverse Mercator
VWTC	Vegetation and Wildlife Technical Committee
%	percent
<	lesser than
>	greater than

Glossary

Symbol / Unit of Measure	Definition
Absolute abundance	A measure of the true and exact number of individuals.
Control area	The Peace River from the Pine River confluence to the Alberta border.
Flow Impact area	The geographical area of the Peace River from the Site C dam to the Pine River confluence with the Peace River.
Foraging guild	Species groups comprised of waterbird species with similar morphology and foraging strategies.
Inundation Impact area	The geographical area of the Site C reservoir from Hudson's Hope to the Site C dam.
Relative abundance	A measure, or index, of abundance that can reveal changes over time (e.g., between baseline and Project operations conditions).
Peace River study area	The geographical area of the Peace River between Hudson's Hope and the Alberta border.
Species evenness	The degree of similarity in abundance of each species.
Species richness	The number of species.
Study area	The geographical area where all aspects of the study take place. The study area encompasses all sub-areas (e.g., **treatment areas**) including **control areas**, the **impact areas** and other defined areas as applicable.
Survey day	Survey effort in a given day, which covers only a portion of the transmission line right-of-way **wetlands** or **Peace River study areas**.
Survey period	A period of time which encompasses a defined period of spring or fall migration, including the peak migration of one or more **foraging guilds** (i.e., foraging guilds).
Survey round	A group of **survey days**, which together encompass the entire **Peace River study area** or all wetland survey stations within the **wetland study area**.
Treatment area	Geographical areas that are sub-areas of a **study area** in which either the impact or control condition is present and measured. There are 2 types of treatment areas within the Peace River study area: **control areas**, and **impact area**.
Waterbird	The collective name for shorebirds, marsh birds, waterfowl, and other birds associated with aquatic and wetland habitats.
Wetland study area	The geographical area of wetland habitat on the Moberly Plateau within 3 kilometres of the Project transmission line.

1.0 Introduction

This report describes the combined annual results of the 2017 to 2022 Waterbird Migration Follow-up Monitoring Program surveys for shorebirds, marsh birds, waterfowl, and other birds associated with aquatic and wetland habitats (collectively known as waterbirds). This program is being conducted to fulfill, in part, the requirements and conditions set forth in the Site C Clean Energy Project's Provincial Environmental Assessment Certificate (EAC) (Condition 21) and the Federal Decision Statement (FDS) (Conditions 10.2 10.3, 11.3 and 11.4) (BC Hydro 2013).

1.1 Background

In the Site C Environmental Impact Statement (EIS), BC Hydro assessed the potential effects of the Site C Clean Energy Project (Project) on Wildlife Resources using key species groups, including shorebirds, marsh birds, and waterfowl (BC Hydro 2013). Effects of the Project on these waterbirds were assessed in terms of habitat alteration and fragmentation, disturbance and displacement, and mortality (BC Hydro 2013).

The EIS assessed the residual effects of the Project on waterfowl and shorebirds as high magnitude because of the anticipated extent of river and back-channel habitat loss (i.e., habitat alteration and fragmentation). The duration and geographic extent of the effect is dependent on future waterbird use of the reservoir and wetlands created through habitat compensation. There was low confidence in the characterization of this expected use, because use will depend on the success of vegetation establishment along the boundaries of the reservoir, the extent of ice formation in the reservoir, the use of nest boxes, and the use of nesting habitat in constructed wetlands (BC Hydro 2013).

BC Hydro coordinated baseline studies of waterbirds in the Peace River and adjacent wetlands in 2006, 2008 and 2012 through 2014. Baseline surveys conducted for waterfowl between 2006 and 2014 were designed to assess species within the orders Anseriformes (i.e., ducks, geese, and swans), Procellariiformes (i.e., loons), and Podicipediformes (i.e., grebes). Surveys in 2015 and 2016 (Mushanski et al. 2015), using the same methods, expanded the focus to include Charadriiformes (e.g., snipe, sandpipers, phalaropes, plovers, gulls, terns, avocets), Gruiformes (e.g., rails), and Pelecaniformes (e.g., bitterns).

Baseline waterbird studies employed fixed-wing aircraft and twin-engine helicopter surveys and, to a lesser extent, ground and boat surveys (Simpson and Andrusiak 2009; BC Hydro 2013; Churchland et al. 2015). Waterbird surveys conducted using aerial approaches are limited in their accuracy, such that no shorebirds were documented during helicopter and fixed-wing aircraft surveys conducted between 2012 and 2014, and species identification from helicopters is challenging. Therefore, the waterbird follow-up monitoring program was modified through the VWTC to use exclusively boat and land-based approaches. This report presents Waterbird Migration Follow-up Monitoring Program data collected annually from 2017 through 2022 using methods designed to survey the full range of waterbird species present in the study area. Data from surveys before 2017 were not compared to nor compiled with those collected for this follow-up monitoring program due to inconsistencies in the timing of historical surveys and discrepancies between historic methods and those used in the updated survey protocols.

1.2 Monitoring Objectives

The overall objective of the Waterbird Migration Follow-up Monitoring Program is to address uncertainties regarding the effects of the Project (i.e., change from river valley to reservoir and changes in flow regime) on waterbirds that use habitat along and surrounding the Peace River (including wetland and non-wetland areas). The specific objectives of the monitoring program are as follows:

- Assess changes in waterbird wetland and non-wetland habitat on the Peace River and the transmission line right-of-way (ROW) from Project construction through to the first 10 years of Project operations to assess Project-related impacts relative to those predicted in the EIS (EIS Volume 2; Appendix R- Section 4.1) (BC Hydro 2013).
- Document changes in waterbird abundance and diversity across habitats (Peace River and wetlands) during the first 10 years of Project operations relative to pre-reservoir and transmission line conditions to assess Project-related impacts relative to those predicted in the EIS (EIS Volume 2; Appendix R- Section 4.1) (BC Hydro 2013).
- Monitor waterbird use of natural and created compensatory wetland features from Project construction through to the first 10 years of Project operations to evaluate the effectiveness of mitigation and compensation measures.

The survey methods applied in this monitoring program provide data on waterbird relative abundance and diversity within habitat types present and used by waterbirds in the study area. Distance and repeated survey data were collected (as described in **Section 2.1.2** and **2.2.2.1**) to provide measures of detectability and allow for estimates of absolute abundance in future analyses. Baseline measures of abundance, density, species presence, and habitat use (i.e., associations) for waterbirds are required by FDS conditions.

The study is designed to assess changes in abundance and diversity of waterbirds for each of 7 foraging guilds comprised of species with similar morphology and/or foraging strategies:

- Benthic-feeding divers: small waterfowl and sea ducks that feed primarily on benthic invertebrates
- Dabbling ducks: small waterfowl that feed primarily on aquatic vegetation
- Gulls and surface-feeding terns: small to large species that forage on fish and insects near the water's surface, and occasionally on garbage, hereafter referred to as 'gulls'
- Marsh birds: cryptic species that forage primarily under vegetated cover within wetlands
- Large dabblers: large waterfowl such as geese and swans that feed primarily on vegetation
- Piscivorous divers: diving birds that forage on fish at various depths within the water column
- Shorebirds: plovers and sandpipers that feed primarily on or near the shoreline.

Foraging guilds are used to categorize waterbird species because forage is expected to be an important driver of waterbird abundance during migration. The use of foraging guilds also generally follows the waterbird species categorization approach used in the EIS, which facilitates the comparison of measured to predicted effects of the Project.

1.3 Study Area and Temporal Scope

The overall study area for the Waterbird Migration Follow-up Monitoring Program comprises the Peace River between Hudson's Hope and the Alberta border, and wetland habitat on the Moberly Plateau within 3 kilometres (km) of the Project transmission line (**Figure 1**). Hereafter, these 2 areas are referred to separately as the Peace River study area and the wetlands study area. Areas of the Peace River within 2 km of the Site C dam site were not surveyed during the fall of 2021 or in either fall or spring of 2022, due to boat-related safety constraints and underwater hazards.

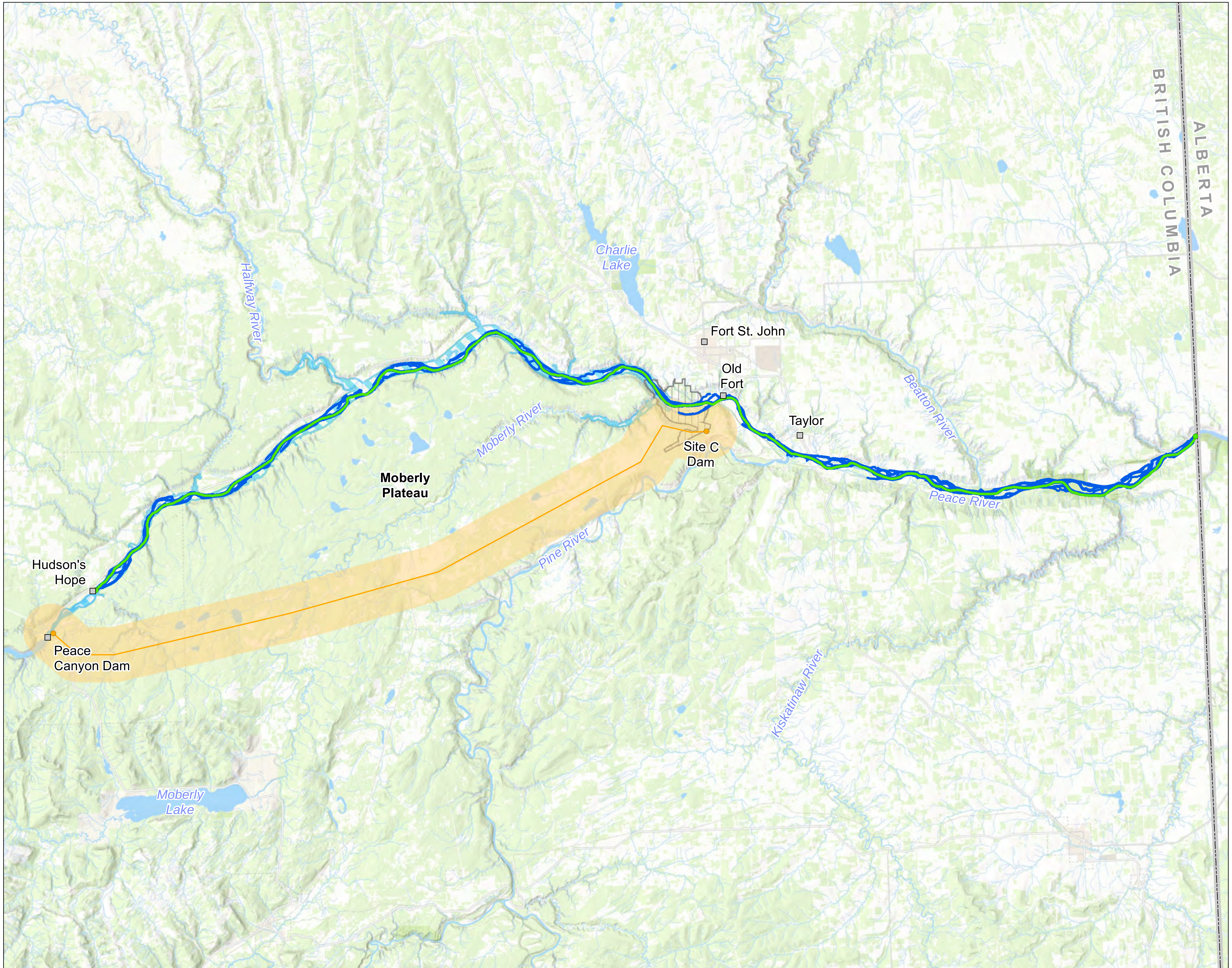
Waterbird survey data will be collected each year through Project construction and for the first 10 years of Project operations, as per EAC Condition 21. The monitoring program has been focused on spring migration (i.e., April and May) and fall migration (i.e., August, September, October) because the greatest numbers and diversity of waterbirds are present in the study area during those months (Simpson and Andrusiak 2009; Hilton et al. 2013; eBird 2022).

Within subsequent sections of this report, the following terminology is used to define the temporal scope of survey efforts:

- Survey day – Survey effort in a given day, which covers only a portion of the transmission line ROW wetlands or Peace River study areas
- Survey round – A group of survey days, which together encompass the entire Peace River study area or all wetland survey stations within the wetlands study area
- Survey period – A period of time (e.g., early spring, late fall) which encompasses a defined period of spring or fall migration, including the peak migration of one or more waterbird foraging guilds.

To inform the timing and number of surveys conducted in 2020 and subsequent years, a power analysis was conducted using the Peace River waterbird survey data collected by boat from 2017 through 2019 (**Appendix A**). The results of the analysis indicated that 2 surveys during the early spring migration (April 1 to 15) and one survey during each of the first 3 fall migration survey periods (encompassing August 1 to October 14) would be sufficient to meet the study objectives. Specifically, that survey timing and frequency was calculated to allocate effort to detect, with 80 percent (%) statistical power, a 50% change in abundance of each foraging guild in the Impact treatment area contrasted with no change in the control area over time. Surveys in 2020 through 2022 were conducted in accordance with those survey timing and frequency recommendations.

Surveys within the Peace River and wetlands study areas were conducted concurrently during the fall. However, during spring, Peace River surveys were started earlier than wetland surveys to document waterbirds using the river before upland wetlands thaw. Prior to thawing, wetlands along the transmission line ROW are unavailable for waterbird foraging use and waterbirds primarily use habitat along the Peace River.



Migratory Waterbird Follow-up Monitoring Program
2022 Report
Site C, Peace River, BC

Figure 1 - Study Areas of the Waterbird Monitoring Program on the Peace River and Moberly Plateau

Legend

- Proposed Dam Site
- Proposed Reservoir
- Peace River Study Area
- Wetlands Study Area
- Transmission Line
- Extent of Peace River Waterbird Surveys
- Provincial Border

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basemap: ESRI World Topographic Base

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2.0 Monitoring Methods

Survey methods developed to meet the monitoring program objectives were developed using guidance from provincial Resource Inventory Standards Committee protocols, with review from the VWTC and subsequent input from Environment and Climate Change Canada and Native Plant Solutions of Ducks Unlimited Canada. The survey methods employed during the 2022 field program and prior years are described in the following sections. Additional rationale for the methods is presented in the Site C Vegetation and Wildlife Waterbird Migration Follow-up Monitoring Program (BC Hydro 2022). Differences in site accessibility and waterbird detectability across habitat types and species required separate survey methods for the Peace River study area and for wetlands adjacent to the Project transmission line ROW. These methods are described in the following sections.

2.1 Peace River Waterbird Surveys

Surveys of the Peace River were conducted to assess the abundance and diversity of waterbirds using wetland and non-wetland habitats within the Peace River as per study objectives to document baseline conditions and to assess potential Project-related change. The approach by which Project-related change will be assessed, as per Condition 11.4.3 of the FDS, is presented in **Section 2.2.1**. The methods used to conduct surveys in the Peace River study area are described in **Section 2.1.2**.

2.1.1 Approach to Evaluating Change

A before-after, control-impact (BACI) study design is being applied to allow Project-related changes in waterbird abundance and diversity to be detected and distinguished from background (e.g., natural) variation within waterbird communities in the Peace River valley. Within the BACI study design framework, the areas surveyed to assess impacts are as follows:

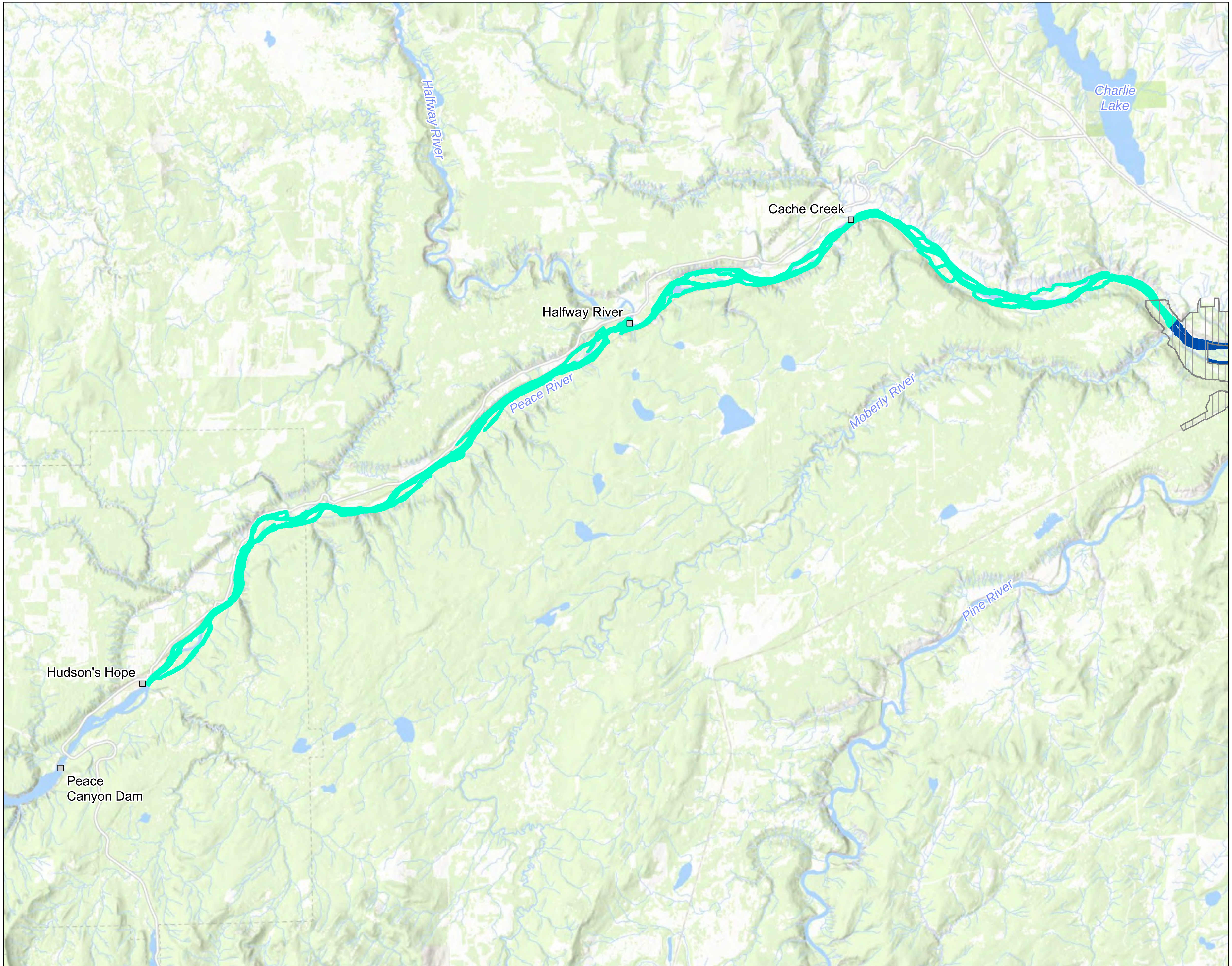
- Inundation Impact area – the Site C reservoir from Hudson's Hope to the Site C dam, to assess impact from inundation (**Figure 2**)
- Flow Impact area - the Peace River from the Site C dam to the Pine River confluence with the Peace River, to assess impact from change in flow regime (**Figure 3**)
- Control area - the Peace River from the Pine River confluence to the Alberta border, to assess background conditions (**Figure 4**).

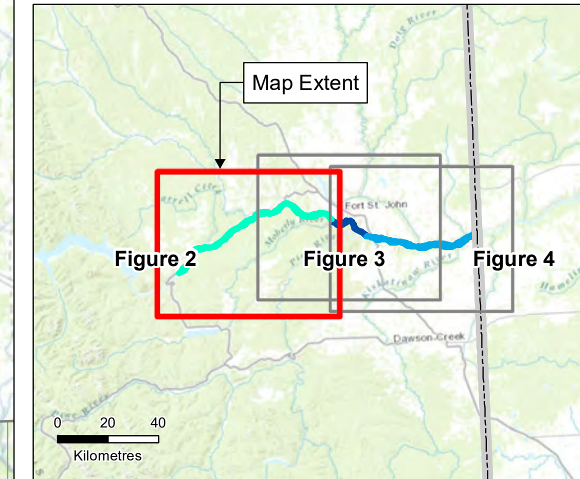
Below the confluence of the Peace and Pine rivers, Project-related changes in flow regime are expected to be moderated by inputs from the Pine River. Control and impact areas within the Peace River study area are, hereafter, referred to as *treatment areas*. The 'before' period for the BACI design will be prior to reservoir filling, which is planned to occur in fall 2023. Widespread impacts are expected once reservoir filling begins. The river diversion period (occurring from 2020 through reservoir filling) will be part of the 'before' period because water volumes and flow rates are expected to be mostly unchanged outside the immediate construction area and small headpond during this time. However, survey data from areas affected by construction activity prior to reservoir filling will ultimately be excluded from the 'before' period dataset in future analyses of Project-related change. The 'after' period will be during Project operations.

Following collection and analysis of relative abundance data from the 'before' and 'after' study periods, use of the BACI design will permit evaluation of Project-related impacts through tests of statistical significance of the interaction effect between treatment areas (control vs. impact) and study periods.

Migratory Waterbird Follow-up Monitoring Program
2022 Report
Site C, Peace River, BC

Figure 2 - Inundation Impact Area on the Peace River





Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Notes

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Sources

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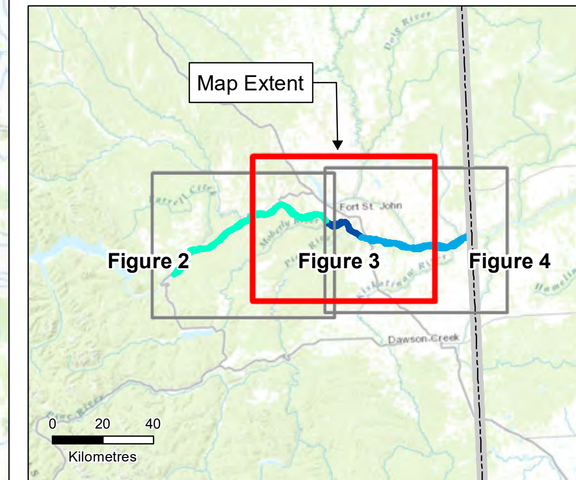
Migratory Waterbird Follow-up Monitoring Program
2022 Report
Site C, Peace River, BC

Figure 3 - Flow Regime Change Impact Area on the Peace River



Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

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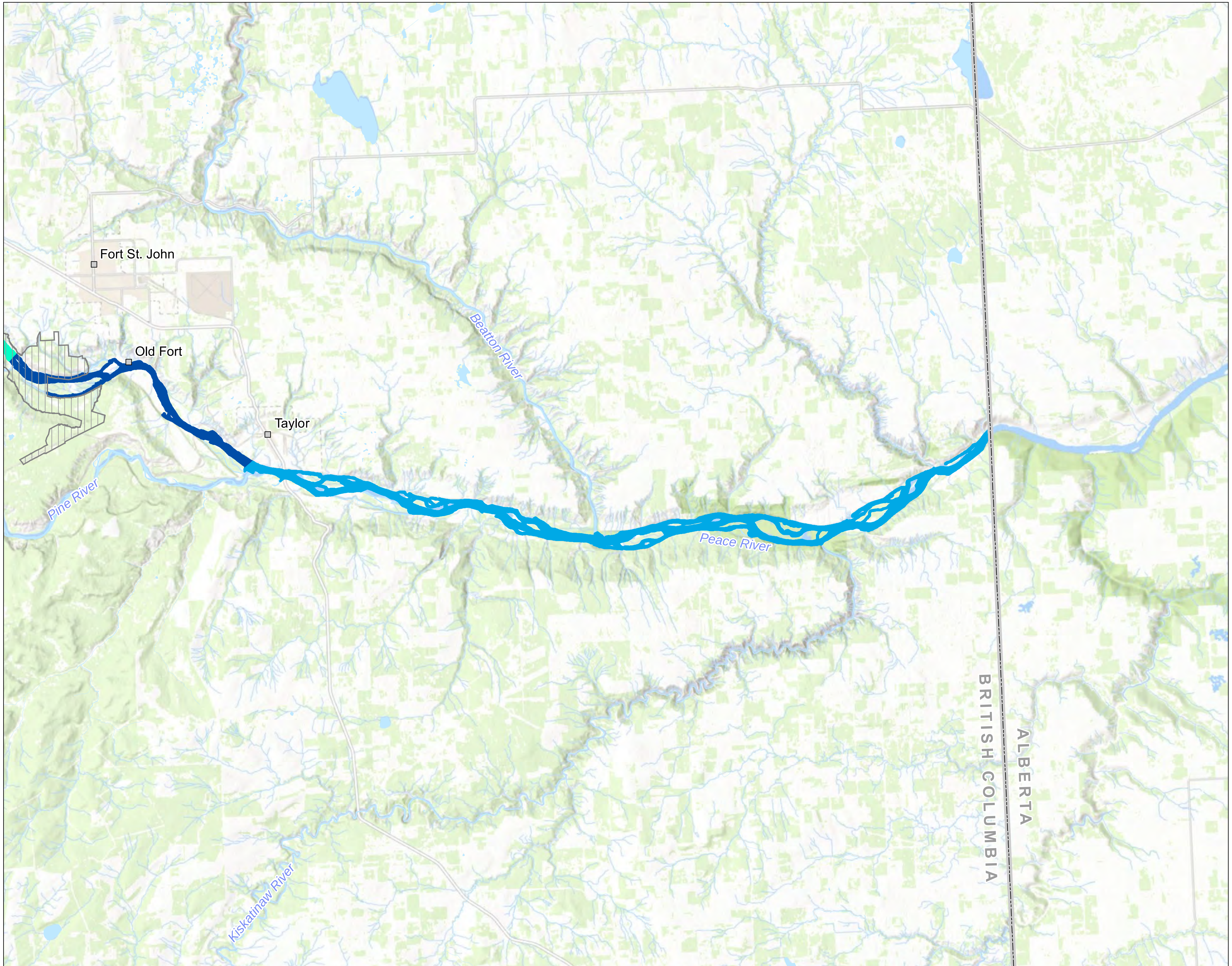
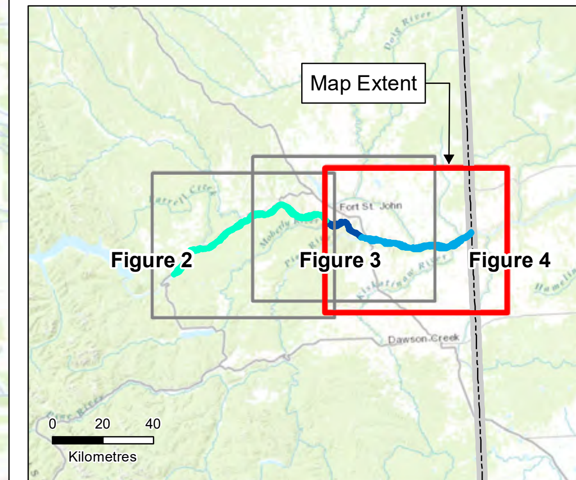
Migratory Waterbird Follow-up Monitoring Program
2022 Report
Site C, Peace River, BC

Figure 4 - Control Area on the Peace River





Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Notes

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Ausenco BC hydro

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2.1.2 Survey Methods

Boat surveys, following a modified version of the "Floating Rivers in Rafts or Kayaks" methods described in *Inventory Methods for Riverine Birds* (Resources Inventory Committee 1998) and *Inventory Methods for Waterfowl and Allied Species* (Resources Inventory Committee 1999), provided visual coverage throughout most of the Peace River study area from Hudson's Hope to the Alberta border (**Figure 1**). Boat surveys provided clear lines of sight of open water habitat as well as shoreline, nearshore areas, exposed sandbanks, gravel bars, and mudbanks/flats along the mainstem of the river, side channels, and many backchannels.

Survey routes circled around islands and side channels and extended up backchannels wherever water levels allowed. Areas where water levels were too low for boat access, or the entrance to backchannels or side channels was obstructed by debris, were not surveyed. Boat surveys were conducted at speeds of 30 to 40 km/h, except where shallow waters required faster speeds to prevent the boat from grounding on the riverbed. Also, speeds were slowed for 1 to 2 minutes to improve the accuracy of species identification and abundance estimates when large or multiple flocks of waterbirds were observed. Surveys usually required 2 days to provide coverage of the complete length of river from Hudson's Hope to the Alberta border (i.e., 2 days per survey round). Surveys took place in daylight hours (h) between 07:00 and 18:00. During a typical survey round, portions of the Peace River study area upstream of the Project dam site were surveyed during the first day and portions of the study area downstream of the dam site were surveyed during the second day. Surveys were conducted by biologists trained and experienced in waterbird identification and survey protocols. During boat surveys, 2 observers focused their respective survey efforts on opposite shores to the centre of the river and communicated bird movements to minimize the risk of double-counting birds. The observers scanned the river from the front of the boat using the naked eye to detect birds and used binoculars for species identification. Data were recorded using electronic data forms immediately following each observation using map-based software allowing for spatially explicit data entry including waterbird observation locations. Only one surveyor entered data at any given time so at least one observer was always available to survey for waterbirds.

Surveys were not conducted during sustained inclement weather conditions that would result in a reduced ability to detect waterbirds. Weather was judged inclement when wave conditions were associated with a sea state greater than 3 on the Beaufort scale as per provincial standards (RIC 1999). Wave conditions reflecting a sea state greater than 3 on the Beaufort scale mean frequent whitecaps and waves higher than 1m. Weather was also deemed inclement when rain or fog resulted in poor visibility within 1 km.

Field crews recorded the following information during each survey day:

- Survey date
- Start and end time
- Proportion of backchannels surveyed by boat and visible with binoculars if not surveyed by boat
- Global positioning system (GPS) track of the survey transect line
- Weather conditions at the start of surveys and any notable changes in weather
- Survey crew (including a third observer if present).

Field crews recorded the following information for each individual or flock of waterbirds observed:

- UTM coordinates
- Date and time (hour and minute)
- Species
- Number of individuals
- Habitat type (gravel bar, open river, riverbank, terrestrial)
- Distance to disturbance (Not disturbed, less than [<] 50 m, 50 m to <100 m, 100 m to <200 m, 200 m to 400 m, greater than [>] 400 m).

Waterbirds were identified to the most specific taxonomic classification possible. When species identification was not possible, birds were identified by genus or foraging guild. Only those birds that could not be identified at any of these levels were classified as "unknown duck" or "unidentified waterbird".

To provide the data necessary to account for birds that were present during surveys but not detected by observers (i.e., incomplete detection), 2 methods were applied. Distance sampling using line transect methods (Buckland et al. 2015) was applied starting in the fall of 2018 (and continuing throughout 2019, through 2022) by recording a track of each survey using a handheld GPS, from which distance can be calculated between the transect and each georeferenced waterbird record. Through data analysis, abundance and density estimates can be adjusted to account for birds not detected due to their distance from the survey transect based on the relationship between distance to birds from the path of the survey vessel (i.e., transect line) and the number of birds detected within various distance categories. Additionally, a subset of Peace River surveys has included a third observer to provide data that can be used to test assumptions of distance sampling (e.g., 100% detection along the transect line) and to specify the direction (i.e., positive versus negative) and magnitude of any resulting sampling biases.

2.2 Transmission Line Wetland Surveys

Surveys of wetlands were designed and conducted to assess the abundance and diversity of waterbirds using wetland habitats along the transmission line ROW (i.e., transmission line wetlands) as per study objectives to document baseline conditions and to assess potential Project-related change from those conditions. The approach by which Project-related change will be assessed, as per Condition 11.4.3 of the FDS, is presented in **Section 2.2.1**. The specific methods applied during transmission line wetland surveys are detailed in **Section 2.2.2**.

2.2.1 Approach to Evaluating Change

The survey methods applied to the study were selected to provide habitat-specific estimates of waterbird density and species composition to document changes in waterbird abundance and diversity associated with the Site C transmission line and reservoir inundation, as per study objectives (**Section 1.2**). Absolute density estimates, derived from relative abundance and detection rates or distance sampling data to account for incomplete detection, can be multiplied by the area of affected habitat to estimate the abundance of birds within each foraging guild affected by habitat changes within the transmission line footprint. Relative abundance and species richness can also be compared over time (e.g., before versus after reservoir inundation) within wetland stations surveyed consistently across years to assess potential changes to wetland habitat use. Changes have the potential to occur due to the displacement of waterbirds from inundated river valley habitat into adjacent wetlands. The study provides data to compare densities and abundances of waterbirds for habitat types surveyed before relative to after reservoir inundation, using a before-after analysis framework to assess change. A BACI study design framework will not be applied to assess change in the wetlands study area as there is no clear distinction between wetlands on the Moberly Plateau that would be affected by reservoir filling versus not, as required to define impact and control areas.

2.2.2 Survey Methods

Wetland survey stations assessed during surveys in 2022 and prior years contained one or more focal habitat types. Each wetland habitat type within a station was surveyed separately such that multiple surveys were often conducted at a single station in a single survey day or survey round. To minimize detection constraints specific to each habitat type and maximize the amount of information obtained on waterbirds, 3 unique survey methods were applied across wetland habitat types:

- Fixed-length transects of vegetated habitat with water depths less than 50 cm, traversed on foot
- Stationary standwatch surveys of open water and flooded wetland habitat
- Bioacoustics monitoring using autonomous recording units (ARUs) of vegetated wetlands as well as transition zones between vegetated wetlands other habitat types (e.g., open water, forests).

2.2.2.1 Transect and Standwatch Surveys

Wetland survey effort was standardized either by length (100-metre [m] transects) or time (20-minute standwatch surveys). Transect surveys were conducted in 2022 within sedge and willow-sedge habitats along the transmission line ROW. This method was considered appropriate given that vegetation obstructed lines of sight within these habitat types, thereby preventing bird detection through stationary survey methods. Vegetated habitat with water levels below 50 cm could be safely traversed on foot, which allowed close visual inspection of the surveyed area and increased detection by flushing birds hidden amongst vegetation. Stationary standwatch surveys were conducted in areas with open water habitat and flooded wetlands, including areas with open water interspersed with vegetation where visible open water comprised an area of at least 0.25 hectares. Standwatch surveys are the most appropriate method for these habitats because lines of sight from ground level, or from a slightly elevated perspective, provide efficient visual detection of waterbirds on the water’s surface across large areas.

Where areas of contiguous open water were obscured from a single vantage point, the 20-minute standwatch survey was divided into two 10-minute segments at 2 vantage points, while observers were cautious to avoid double-counting birds. The same vantage points were used to survey open water wetland stations during each survey round. Transects could not always be completed in a consistent time due to differences in conditions between stations and seasons such as variable terrain, vegetation, and water depth. Transect surveys were targeted for completion within 5 to 10 minutes, and the time taken was recorded to enable future analyses to account for differences in waterbird detections per transect due to differences in survey time and distance, if required. Wetland habitats at each station were surveyed once per survey round over a 2 to 3-day period.

Crews of 2 field staff, each consisting of a biologist and a field assistant, completed wetland surveys during daylight hours between 07:00 and 18:00. The biologists were experienced in visual and vocalization identification of wetland bird species and were trained in survey protocols as well as wetland habitat characterization (i.e., identification of habitat types). Sedge and willow-sedge wetlands with water levels less than 50 cm were surveyed with one to 3 transects at each wetland station. Where multiple wetland types were present within wetland stations, transects were conducted within distinct habitat types to provide data specific to each type. Transects were generally straight but followed meandering routes where necessary to stay within target habitat types or safe terrain. Transect surveys targeted vegetated wetlands with a minimum total width of 5 m of the target habitat type (e.g., sedge and/or willow-sedge habitat) and a minimum of 2 m of such habitat on either side of the transect line.

Surveys were not conducted during sustained inclement weather such as high winds (>5 on the Beaufort scale) or moderate to heavy precipitation that would impede visibility within 1 km. As stated above, to align with provincial survey standards, surveys were not conducted under conditions that would compromise detection of waterbirds.

The following information was recorded at each wetland survey station:

- Wetland station ID
- Date and time
- Survey lead and field assistant names
- Weather data (temperature, cloud cover, wind, precipitation) recorded within the hour
- Extent (percent) of each habitat type within the wetland or survey station
- Estimated average water depth within sedge and willow-sedge habitat types in survey area.

The following information was recorded for each survey:

- Start and end time of survey
- Start and end UTM coordinates
- Survey method (transect, standwatch) and ID (transect 1, transect 2)
- Area of habitat surveyed (area of open water, width of contiguous habitat along transect)
- Extent (percent) of each habitat type present within the surveyed area
- Estimated water depth for each habitat type within the area surveyed
- Estimate of average vegetation height (measure of detection constraint)
- Extent (percent) of vegetation present within open water areas (for standwatch surveys)
- Extent (percent) of Area Surveyed with visible open water (for standwatch surveys).

The following information was recorded for each waterbird or flock observed within habitats targeted during surveys:

- UTM coordinates
- Date and time (hour and minute)
- Species
- Number of individuals
- Habitat type in which the bird was observed
- Estimated water depth (dry, >0 cm to 10 cm, 10 cm to 50 cm, >50 cm) where flock was observed
- Primary behavior
- Detection type (e.g., detected while flushing, flying, not disturbed)
- Distance from the observer and transect (for transect surveys).

The methods of taxonomic classification and species identification applied for wetlands surveys were the same as described for surveys of the Peace River in **Section 2.1.2**. As detailed above, habitat data were collected at 3 scales (i.e., waterbird records, survey, station) for each bird or flock observed and at 2 scales for each survey (i.e., survey and station). This approach was taken to provide habitat association data for each waterbird record and to ensure that the size of wetland habitat patches and the habitat present within surrounding areas could be accounted for if either are found to be a factor affecting the abundance and/or diversity of waterbirds.

Wetland surveys were repeated within a subset of open water and flooded areas surveyed by standwatch methods to obtain a measure of the number of birds not detected during a typical survey (i.e., to inform detection rates). Transect surveys typically disturbed waterbirds, causing them to flush and leave the area, thereby altering abundances and leading to reduced numbers during repeated surveys. Consequently, repeated transect surveys were not informative of detection rates. Instead, distance to disturbance and from the transect was recorded during surveys of vegetated wetland habitat types to provide the data necessary to account for incomplete detection with distance sampling.

2.2.2.2 Bioacoustics Monitoring

Marsh bird species that can easily go undetected during standwatch and transect surveys (e.g., yellow rail [*Coturnicops noveboracensis*], American bittern [*Botaurus lentiginosus*]) were assessed with passive acoustic monitoring using ARUs (Song Meter 3 and Song Meter 4, Wildlife Acoustics Inc. Maynard, Massachusetts, USA). Passive acoustic monitoring using ARUs is particularly useful for detecting rail and bittern species as they have known call signatures but are rarely observed during time-constrained, daytime surveys due to scarcity on the landscape, cryptic appearance and behavior, and limited diurnal activity. Acoustic data from ARU deployments provide comparable and potentially greater detection rates for yellow rail as compared to call playback methods (Bayne et al. 2014) and reduce safety hazards associated with accessing and working in remote areas at night.

Bioacoustics monitoring for marsh birds in 2022 targeted mixed sedge, willow-sedge, and upland habitats in which yellow rail were detected in 2021, but where little effort had been invested in previous years relative to more open, and large sedge dominated areas. Wetland survey stations not surveyed in previous years were also assessed. Additionally, some stations where Virginia rail and yellow rail were detected in previous years during May and June were re-surveyed in 2022 during the latest survey round to inform the extent to which these species can be detected in late July and August.

ARUs are designed to record acoustic data (calls and songs of birds) at specified time intervals over a period of days, weeks, or months. ARUs were programmed to record acoustic data from 30 minutes before dusk to 30 minutes after dawn during May through July, when rails and American bittern vocalize most frequently (Conway 2011). The microphones were installed approximately 2 m above ground. Dusk and dawn recording times are recognized automatically by the internal GPS and clock of the ARU, which accurately detects the time zone where the ARU is recording. ARUs were deployed and recorded data for a minimum of 7 nights at each site. All ARUs were fitted with omnidirectional microphones (either built-in microphones on SM4 Wildlife Acoustics ARUs, or external SMM-A2 microphones on SM3 ARUs) recording at a sample rate of 16 kHz and gain of 0 decibels.

2.3 Habitat Assessment

Habitat types within the Peace River and wetland study areas were summarized in 2017 from existing Terrestrial Ecosystem Mapping (TEM) data using ArcGIS Desktop (v.10.5.1) software (Hemmera Envirochem Inc. 2018). The TEM data were complimented with satellite imagery and observations from the field to refine wetland and river habitat type classifications within study areas.

2.3.1 Peace River

Within the Peace River study area, waterbird habitat was classified into 4 types based on connectivity to the river and associated water flow rates and depths: Mainstem, Moderate Flow, Limited Connectivity, and Minimal Connectivity. Polygons of these habitat types were delineated across the study area using satellite imagery and water depth data collected during 2017 through 2021. Characteristics for each habitat type are detailed in **Table 1**. Habitat characteristics associated with flow rate and connectivity to the Peace River were considered relevant to waterbirds because they correspond with substrate type, the amount and type of aquatic vegetation available as a foraging resource for waterbirds (e.g., dabbling ducks, large dabblers), and the abundance and availability of other waterbird prey (e.g., fish and invertebrates). Additionally, water depth is known to influence waterbirds' habitat selection, with dabbling ducks selecting habitat along a depth gradient relevant to their morphology, and piscivorous and benthic-feeding divers typically preferring deeper water (Baschuk et al. 2012; Colwell and Taft 2000).

Table 1 Characteristics of River Habitat Types Used to Delineate Polygons along the Peace River

River Habitat Type	Characteristics
Minimal Connectivity	Minimal or no connectivity to the river (e.g., lentic water features) except during extreme high water or flooding events with minimal or no flow and silty or otherwise fine-grained substrates and mostly shallow, including ephemeral ponds. Both emergent and submergent aquatic vegetation proliferates in these habitats.
Limited Connectivity	Limited connectivity to the river (e.g., backchannels primarily connected to the river at the downstream end) with relatively low flow rate and volumes, fine substrates (e.g., silts and sands) and many shallow areas only inundated when river levels are high. Submergent aquatic vegetation occurs along the shoreline in these habitats.
Moderate Flow	Consistently connected to the river (e.g., side channels connected on up- and downstream ends) with relatively moderate flows, moderately sized substrates (e.g., sand, gravel) and shallow waters typically inundating most of the riverbed. Aquatic vegetation is sparse.
Mainstem	Main channel of the river where water flow rates, depths, and substrate size (e.g., gravel, cobble) are greatest. Permanently inundated with aquatic vegetation sparse or absent.

Portions of the river classified as Minimal Connectivity habitat were not accessible by boat and therefore were not surveyed in 2020 through 2022. Limited Connectivity habitat was also inaccessible by boat in a small proportion of areas (**Table 2**) and more broadly when river levels and associated flow rates were low. Despite these constraints on river boat survey methods, the power analysis conducted using data collected from 2017 through 2019 specified that surveys of areas accessible by boat would provide sufficient power to detect changes in waterbird abundance for all foraging guilds (**Appendix A**).

Table 2 Area of River Habitat Types Within the Peace River Study Area by Treatment Areas

Treatment Area	River Habitat Type Areas (km^2)				Total (km^2)	Boat Access (km^2)
	Minimal Connectivity (Boat Access)	Limited Connectivity (Boat Access)	Moderate Flow	Mainstem		
Control	0.93 (0.00)	1.14 (1.08)	4.23	16.47	**22.77**	**21.78**
Flow Impact	0.05 (0.00)	0.35 (0.35)	0.32	5.31	**6.03**	**5.98**
Inundation Impact	1.42 (0.00)	1.89 (1.83)	2.93	21.73	**27.98**	**26.48**
Total	**2.40 (0.00)**	**3.39 (3.25)**	**7.47**	**43.51**	**56.78**	**54.24**

Note: Minimal Connectivity habitat and some Limited Connectivity habitat were not accessible for boat surveys. The areas accessible by boat for these habitat types are provided in parentheses next to their total areas.

An example of the Mainstem river habitat type within the Peace River study area is presented in **Photo 1** and Moderate Flow and Limited Connectivity river habitat types in **Photo 2**.

Photo 1 Mainstem River Habitat Type

Photo 2 Moderate Flow (centre/right) and Limited Connectivity (left) River Habitat Types

The total length of river within the study area is 142.5 km; 78.1 km in the Inundation Impact area (**Figure 2**), 18.0 km in the Flow Impact area (**Figure 3**), and 46.5 km in the Control area (**Figure 4**). The total river area assessed in this study, including side channels and wetted backchannels, varies depending on water levels associated with discharge rates from the Peace Canyon dam and tributaries to the Peace River. The total mapped area of the Peace River as defined within TEM data is 56.78 square kilometres (km^2), with 27.98 km^2 in the Inundation Impact area, 6.03 km^2 in the Flow Impact area, and 22.77 km^2 in the Control area (**Table 2**). These statistics represent wetted areas under typical water levels and include a small proportion of areas not typically accessible by boat (**Table 2**). The actual wetted area in each treatment area varies from day to day and across survey rounds in association with precipitation rates, snow melt, and other factors.

All 4 river habitat types described in **Table 1** are present within the Inundation Impact and Control treatment areas (**Table 2**), and all habitat types but Minimal Connectivity are present and accessible by boat within the Flow Impact area. Mainstem habitat comprises the vast majority (77%) of the area of the Peace River, followed by Moderate Flow habitat (13%). Minimal and Limited Connectivity habitat comprise 4% and 6% of the total study area, respectively.

Water flow and depth are known to influence the abundance, distribution, and species composition of waterbirds within wetland systems (Colwell and Taft 2000; Baschuk et al. 2012). These factors are particularly important to consider on the Peace River given the pronounced fluctuations in flow associated with hydroelectric dams and the presence of the Peace Canyon dam immediately upstream of the study area. Hourly flow data were obtained from monitoring stations within each treatment area (Inundation Impact, Flow Impact, Control) since flows in each of these areas are uniquely influenced by inputs from tributaries along the course of the Peace River.

2.3.2 Transmission Line Wetlands

The TEM data developed for the Peace River Terrestrial Ecosystem Mapping Project (Keystone Wildlife Research Ltd. 2012) was also used to identify 6 habitat types with potential to be used by waterbirds across the wetlands study area (**Table 3**). Wetland surveys within Labrador-tea-sedge, tamarack-sedge and cultivated field ecosystem units were discontinued as of 2019 due to the limited number of waterbird detections (no more than one) in these habitats during 2017 and 2018 (**Table 3**). Consequently, wetland waterbird surveys in 2021 were focused on survey stations encompassing open water, sedge, and willow-sedge habitats.

Table 3 Wetland Habitat Types Adjacent to the Project Transmission Line ROW and Observed Presence

Wetland Habitat Type	Characteristics	Multiple Waterbird Observations in 2017 and 2018?
Open water (OW)	Open water with no (or limited) emergent vegetation, including shallow open water (less than 2 m depth), as well as ponds, and lakes transitioning or connected to wetlands	Yes
Tamarack-sedge (TS)	Fen with overstorey dominated by tamarack (*Larix laricina*)	No
Sedge (SE)	Uniform sedge (*Carex* sp.) flat low area with less than 10% willow – scrub birch (*Betula nana*). Typically wetted and often with standing water	Yes
Labrador-tea-sedge (BT)	Peat bogs dominated by Labrador-tea (*Rhododendron groenlandicum*), often with black spruce (*Picea mariana)* overstory	No
Willow-sedge (WS)	Sedge (*Carex* sp.) meadow with scattered (>10%) willows - scrub birch. Often bordering sedge habitat in slightly elevated areas with less standing water than sedge habitat	Yes
Cultivated field (CF)	Only considered if wetted and/or water source or wetland occurs within 100 m	No

Wetland habitat area has not changed appreciably since 2017, such that the proportional extent of habitat types is expected to have remained unchanged through 2022. According to the TEM data, the most widespread wetland habitat types in the study area are Labrador-tea-sedge and tamarack-sedge (**Table 4**, **Figure 5**). Sedge and open water are less widespread, and willow-sedge is the least common wetland habitat type. Habitat data were collected with waterbird observations as described above in **Sections 2.1** and **2.2** for each survey method.

Table 4 Area of Wetland Habitat Types in the Peace River Valley and Moberly Plateau Study Area

Wetland Habitat Type	Area (ha)
Labrador-tea-sedge	7,243
Tamarack-sedge	4,749
Cultivated field	3,845
Sedge	1,782
Open water	1,535
Willow-sedge	720
Non-forested floodplain wetlands	440

Note: Habitat areas presented here are derived from TEM data developed for the Peace River Terrestrial Ecosystem Mapping Project (Keystone Wildlife Research Ltd. 2012).

Photo 3, **Photo 4** and **Photo 5** show examples of standwatch and transect surveys and habitats surveyed by the respective methods. An example of a waterbird observation within open water habitat is provided in **Photo 6**. Examples of ARU deployments of bioacoustics monitoring of marsh birds are provided in **Photo 7** and **Photo 8**.

Photo 3 Wetland Standwatch Survey of Open Water Habitat Within Station OW-06

Photo 4 Transect Survey of Sedge-Dominated Wetland Within Station SE-04

Photo 5 Transect Survey of Willow-Sedge and Scrub Birch-Dominated Wetland Within Station WS-03.

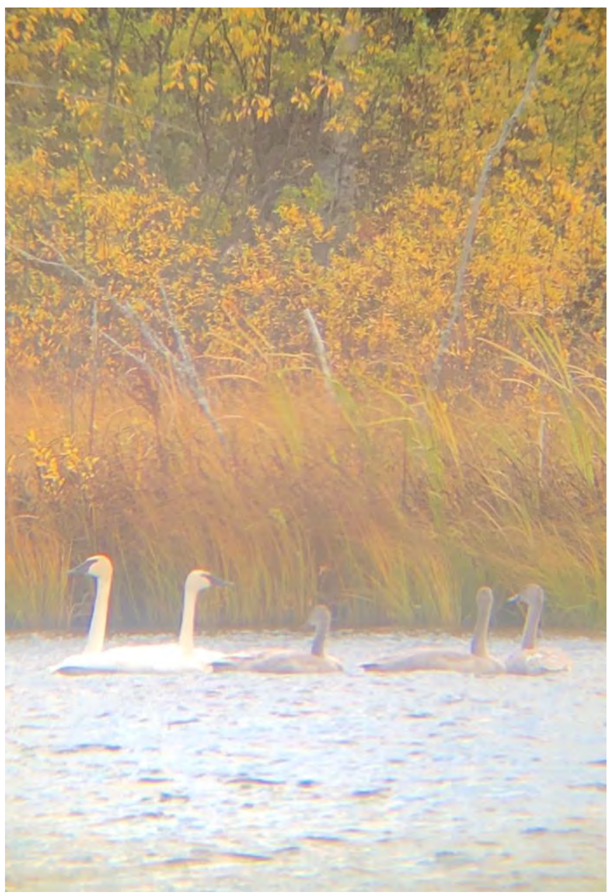

Photo 6 Trumpeter Swan (*Cygnus buccinator*) Adults and Juveniles Using Open Water Wetland Habitat at Station OW-06

Photo 7 Example Deployment of an SM3 Autonomous Recording Unit with External SMM-A2 Microphones for Bioacoustics Monitoring of Marsh Birds within Wetland Habitats

Photo 8 Example Deployment of an SM4 Autonomous Recording Unit with Internal Microphones for Bioacoustics Monitoring of Marsh Birds within Wetland Habitats

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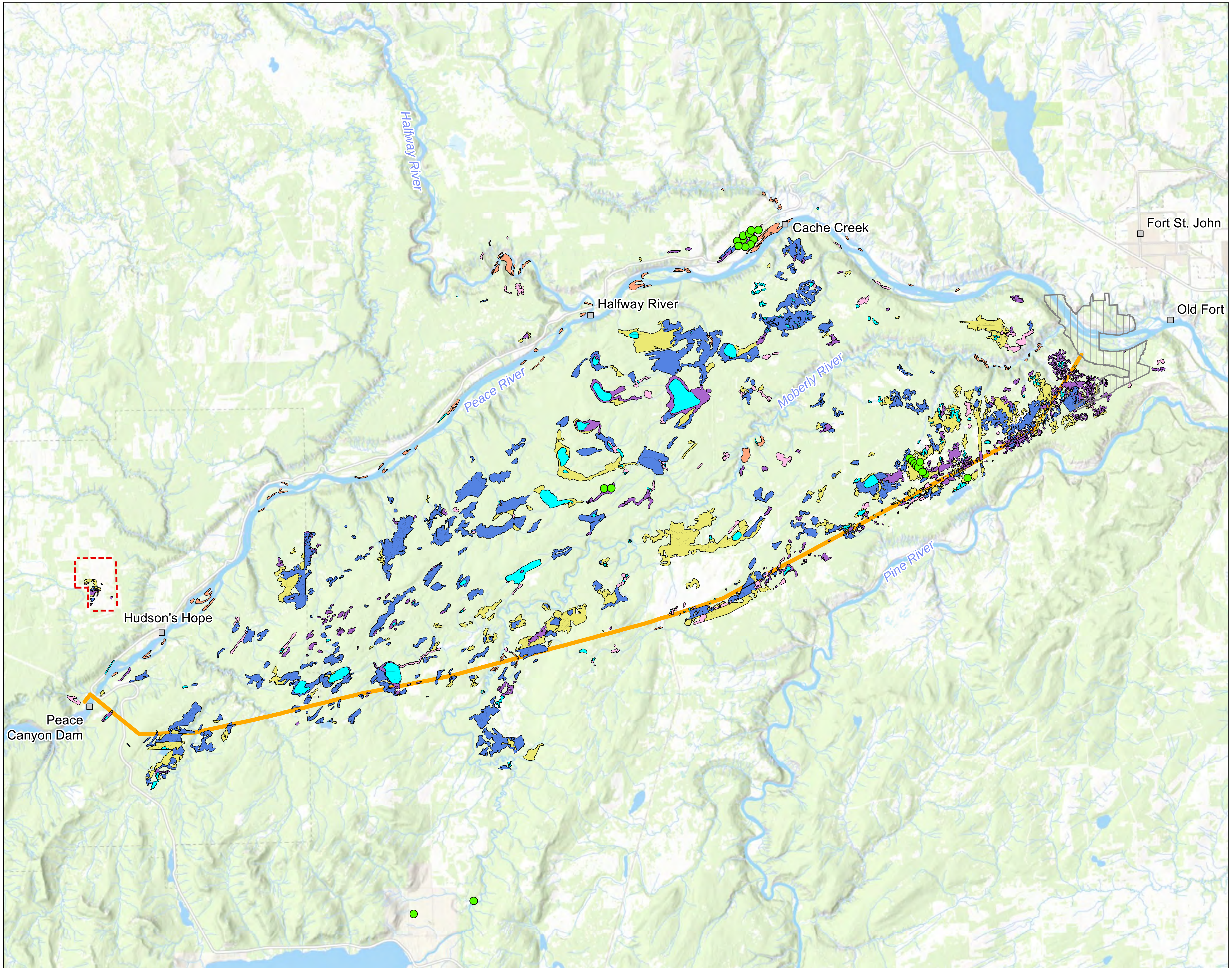
Figure 5 - Wetland Habitat Types and Historic Yellow Rail Detections in and Adjacent to the Peace River Valley and Transmission Line Route



Legend

- Proposed Dam Site
- Marl Fen Property - BC Hydro Wetland Compensation Site
- Transmission Line Right-of-Way
- Historic YERA records (prior to 2017) from eBird and Baseline Studies

Wetland Types

- Labrador-tea – sedge (BT)
- Non-forested floodplain wetland (WH)
- Sedge (SE)
- Open water (OW)
- Tamarack-sedge (TS)
- Willow sedge (WS)

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a “stand-alone” document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
3. OW has been used as the idientfier for Shallow Open Water wetland field locations; however, please note that the wetland classification also includes LA and PD habitat codes.

Sources

- Basemap: ESRI World Topographic Base

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1:250,000

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NAD 1983 UTM Zone 10N

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3.0 Data Management and Analysis

This section details the methods applied for data management (quality assurance, quality control and compilation) as well as calculation of summary statistics for waterbird abundance and diversity by season, survey period, and habitat type for Peace River and wetlands study areas as well as by treatment area for the Peace River study area.

3.1 Data Management

Waterbird records from 2022 surveys were screened and vetted for accuracy. Any outlying records (e.g., high counts, rare species) were verified by confirming with field staff and, where possible, by reviewing data sources such as hardcopy data forms, survey notes, and ARU recordings. Once these quality assurance measures were applied to identify anomalous species or counts, data from the current year were appended to a relational database management system (Microsoft Access) holding data from previous survey years.

Hourly flow data from 2022 obtained from gauges at monitoring stations within each treatment area (Inundation Impact, Flow Impact, Control) were compiled into a relational database (Microsoft Access) and appended to data from prior years. Hours for which data were not available were interpolated from surrounding hours or provided from secondary monitoring stations within the same treatment area, where observed flows were similar to the primary monitoring stations.

3.2 Data Analysis

As in previous years, the scope of this annual report is limited to descriptive statistics (e.g., ranges, means, and variability around means). These statistics are presented to demonstrate that survey methods are capturing the targeted foraging guilds across all study areas and treatment areas within relevant time periods and habitat types, as required to meet the study objectives. Metrics of waterbird diversity and relative abundance are reported for each foraging guild within study areas, treatment areas, seasons, survey periods, and habitat types. A full list of species observed and the guilds to which they are assigned is presented in **Appendix B-1**.

Measures of abundances in this report are presented in terms of relative abundance because they represent the number of waterbirds detected, rather than absolute abundances. Distance and repeated survey data were collected (as described in **Sections 2.1.2** and **2.2.2.1**) to provide measures of detectability and allow for estimates of absolute abundance in future analyses to assess Project-related change following data collection from the operations phase.

Throughout the remainder of this report, the terms abundance and density refer to relative abundance and relative density, as summary statistics are not yet corrected for detection rate via distance sampling or other means. Relative abundance is an index of abundance that can reveal changes over time (e.g., between baseline conditions and Project operations conditions). While relative abundance does not necessarily reflect the true and exact number of individuals, generally referred to as absolute abundance, it is a standard measure recognized as appropriate in British Columbia (BC) for monitoring studies assessing change (Resources Inventory Committee 1998). Measures of relative abundance are reported in terms of density per unit of survey area or transect length except in cases where abundances are reported for an entire study area (e.g., the Peace River study area), in which case the relevant area is specified within the results (see **Section 4.1.2**).

Waterbird diversity is presented for each survey period, with averages calculated as means across years, in terms of species richness (i.e., the number of species) and species evenness (i.e., the degree of similarity in abundance of each species) using Pielou's evenness index. A full list of the species observed was developed including the cumulative total of each species recorded across all study years and during 2022 monitoring. The equation for calculating Pielou's evenness index is reported by MacDonald et al. (2017):

$$Species\ evenness = \frac{(-\sum_{i=1}^{S}(p_i \times \ln p_i))}{(\ln S)}$$

Where *S* is the number of species detected (species richness), p_i is the proportion of all detected waterbirds represented by species *i,* and *ln* is the natural logarithm. MacDonald et al. (2017) generally recommend against using indices that combine measures of species richness and evenness (e.g., Shannon-Wiener index) for measuring changes in biodiversity because of the subjective nature of weighting diversity by evenness and outputs (indices) that are difficult to meaningfully interpret.

3.2.1 Peace River Waterbird Surveys

Waterbird data from Peace River surveys were summarized to provide mean measures of abundance and diversity across survey periods and seasons, and mean measures of density and abundance by habitat type and treatment area for each foraging guild. To calculate mean abundance and diversity measures for each survey period, density estimates were averaged first across survey rounds within survey periods of each year, then averaged across years. To compare the number of waterbirds observed across habitat types and treatment areas, density measures were calculated in addition to abundances to provide a measure that accounts for the variable size of habitat types and treatment areas. To account for variable survey timing across years (some survey periods were not surveyed in all years), mean measures of density and abundance for each habitat type and treatment area were calculated for each survey period in each year, then averaged across periods to provide mean statistics for each season in each year, then across years to, ultimately, provide average measures for each season.

Survey data were initially summarized in terms of the number of birds/ha within polygons of distinct habitat types in each study area to calculate habitat-specific measures of abundance and density. Each waterbird detection was assigned to the habitat polygon in which the bird was recorded in or closest to (i.e., birds within the polygon, on the shoreline, or within 100 m of the polygon). Cumulative counts from all combinations of habitat type and treatment area (**Table 1**) were divided by the area that was surveyed during each survey round. Abundance data were summarized for each treatment area and habitat type by multiplying density estimates (birds/km^2) by the total area within each treatment area and by the total area of each river habitat type within the study area as a whole for each survey round.

Determining densities based on assigning waterbird records to habitat polygons is a method that has been applied to other monitoring studies of wetland and riverine systems in British Columbia (Gill and Craig 2020). This method provides improved resolution for density determinations compared to estimates based on river length (e.g., birds/km), as it allows for separate estimates of density in unique habitats that occur within each of the treatment areas. The use of density by area estimates is aligned with the statistical power analyses that informed the level and timing of survey effort in 2020, in which measures of survey effort used to generate estimates of statistical power were adjusted based on the area covered during each round of surveys (**Appendix A**).

To provide comparable measures of diversity based on equivalent survey effort across surveys rounds, diversity statistics were derived from data collected in areas that were surveyed consistently in all completed survey rounds. Consequently, diversity estimates were derived from survey data collected from

Mainstem and Moderate Flow habitat types, as these areas were accessible by boat during both low and high river flow conditions. Those habitat types comprise the vast majority (approximately 90%) of the study area (**Table 2**). While some species that forage predominantly in shallow and low-flow habitats may be missed by these summaries of diversity, subsequent analyses of Project-related effects can apply more sophisticated analytical methods (e.g., species rarefaction / accumulation curves) to account for variable survey effort.

Data from surveys that did not cover the entire study area due to logistical constraints or inappropriate survey conditions were excluded from calculations of abundance and diversity. However, these data will be maintained within the monitoring program database and can be incorporated into more sophisticated analyses of Project-related effects in future years. Such analyses were considered beyond the scope of annual baseline monitoring reporting.

3.2.2 Transmission Line Wetland Surveys

Data from surveys conducted annually from 2017 through 2021 were summarized to provide estimates of average (mean) density and diversity for both standwatch and vegetated transect surveys. For transect surveys, the number of birds of each foraging guild observed in sedge and willow-sedge habitat was determined for each 100 m transect survey conducted. The mean number of birds observed per transect was calculated and extrapolated to an estimate of density per kilometre of transect by multiplying survey results by a factor of 10 (i.e., 10 x 100 m = 1 km). Data collected from standwatch surveys were used to provide estimates of density at stations with open water, and an average estimate of density was calculated across all these stations for each foraging guild based on the area of open water (i.e., total number of birds observed divided by total area surveyed). Diversity statistics from wetland waterbird surveys were summarized to provide estimates of mean diversity for each survey period, averaged across survey periods within years and then across years. Cumulative species richness for each foraging guild was also calculated for habitats surveyed by both standwatch and transect methods and the proportion of species within each foraging guild was determined.

Acoustic data were downloaded and analyzed using a cluster analysis method in Kaleidoscope Pro V.5.1.9 (Wildlife Acoustics, Inc.), followed by manual verification. Cluster analysis groups bird songs with similar parameters such as minimum and maximum frequency range of the song, duration of the song and inter-syllable gap. Reference songs of sora, yellow rail, and American bittern were obtained from the Cornell Laboratory of Ornithology (Macauley Library), and Xeno-canto (www.xeno-canto.org) and characteristics for several songs from each of these species were matched to the groups of songs from the cluster analysis. Recorded songs suspected to be of sora, yellow rail or American bittern were aurally verified and checked against the reference calls from the Macaulay Library. Although the Peace Region is outside of the recognized range of Virginia rail (*Rallus limicola*) (Conway 2021), an incidental observation of this species at Watson Slough in 2019 prompted a review of recent species records in the region, which revealed multiple records in 2019 and 2020 (eBird 2022). Consequently, bioacoustics data recorded from ARU deployments in 2020 and 2021 were also analyzed to identify vocalizations of Virginia rail, also using the methods described above.

Waterbirds recorded outside of target habitats (e.g., in open water during vegetated transect surveys, waterbirds flying over the transect or survey area) were recorded as incidental observations and are not included in summary statistics. Likewise, data obtained from repeat surveys has been recorded for assessment of detection rates to be used in future analyses but is not included in summary statistics of abundance or diversity in this report.

The number of nights that ARUs were deployed was recorded at each site and the results of acoustic data analyses were assessed as ‘present’ or ‘not detected’ for American bittern, sora, Virginia rail, and yellow rail for each deployment. Bioacoustics data cannot easily distinguish between individual birds to provide estimates of density at ARU monitoring sites. However, estimates of density for sora are provided from standwatch and transect surveys and all audio data has been archived for more detailed analyses if they are later deemed necessary.

3.2.3 Habitat Assessment

Data analysis for habitat assessment for annual reporting is limited to summarization of Peace River flow data. Hourly flow data were summarized using SigmaPlot (v.12.5) to illustrate the frequency of flow rates within each treatment area. To determine if surveys were conducted under representative flow conditions, frequency distributions of hourly river flow rates throughout the spring and fall of 2017 through 2021 were compared to frequency distributions from hours during which surveys were conducted in those years. Following subsequent years of data collection, flow rate data can also be used as a habitat variable in models describing waterbird distribution within the Inundation Impact area prior to inundation and within the Flow Impact and Control areas before and after inundation. After inundation, reservoir water level changes within the Inundation Impact area are expected to be minimal, with the exception of short-duration changes due to relatively rare, extreme events.

4.0 Results

Results for the monitoring program from 2017 through 2022 provide an overview of habitat data as well as estimates of waterbird relative abundance and diversity metrics within habitat types, seasons, and, where possible, survey periods. Results are summarized together for all years of monitoring and are also presented separately for 2022 surveys.

4.1 Peace River Waterbird Surveys

This section describes the results of the Peace River component of the monitoring program including the temporal and spatial scope of surveys attained relative to survey objectives (**Sections 4.1.1** and **4.1.2**).

4.1.1 Survey Effort and Timing

In 2017, 2018, and 2019 the Peace River study area was surveyed during 5 survey rounds in the spring and 6 survey rounds in the fall (**Table 5**). Survey effort and timing in subsequent years was adjusted in accordance with a power analysis of the first 3 years of data (**Appendix A**), resulting in 2 surveys in spring and 3 surveys in fall (**Table 5**). In 2022, boat-based surveys were conducted on the Peace River during spring (April 5 to April 12, 2022) and fall (August 8 to October 6, 2022) waterbird migrations. Over the course of these first 6 years of the monitoring program, 50 surveys of the full length of the Peace River study area were attempted and a total of 46 surveys were completed (**Table 5**).

Table 5 Peace River Survey Timing During 2017 Through 2021 Annual Waterbird Migration Monitoring

Survey Period	2017 Survey Dates	2018 Survey Dates	2019 Survey Dates	2020 Survey Dates	2021 Survey Dates	2022 Survey Dates
Spring						
Early (Apr 1 to Apr 14)	Apr 5, 6 Apr 12[2]	Apr 13, 14	Apr 3, 4, 8[1] Apr 11, 12	Apr 7, 8 Apr 13, 14	Apr 6, 7 Apr 12, 13	Apr 5, 6 Apr 11, 12
Middle (Apr 15 to May 6)	Apr 26, 27 May 3, 4	Apr 25, 26, May 1[1] May 5, 6	Apr 19, 24[2] May 1, 2	Apr 23, 24[2]	No surveys	No surveys
Late (May 7 to May 30)	May 10, 11 May 14, 15	May 10, 11 May 18, 19	May 9, 10	No surveys	No surveys	No surveys
Fall						
Early (Aug 1 to Aug 14)	Aug 8, 9 Aug 14, 15	Aug 4, 5	Aug 7, 9	Aug 5, 6	Aug 9, 10	Aug 8, 9
Early-Middle (Aug 15 to Sep 14)	Aug 22, 23 Aug 28, 29	Aug 20, 21 Sep 4, 5	Aug 19, 20 Sept 4, 5[2]	Aug 31, Sep 1	Aug 27, 28	Aug 29, 30

Survey Period	2017 Survey Dates	2018 Survey Dates	2019 Survey Dates	2020 Survey Dates	2021 Survey Dates	2022 Survey Dates
Late-Middle (Sep 15 to Oct 14)	Sep 21, 22 Sep 27, 28	Sep 20, 21 Oct 4, 5	Sep 16, 17 Sep 30, Oct 1	Sep 29, Sep 30	Sep 27, 28	Oct 5, 6
Late (Oct 15 to Oct 30)	No surveys	Oct 15, 16	Oct 16, 17	No surveys	No surveys	No surveys

Note: When multiple survey rounds were completed within a survey period, survey dates from each round are presented on separate lines. [1]Two days were typically required to complete surveys; however, due to inclement weather (e.g., heavy rain, snow, high winds), unsafe river conditions (e.g., release of ice-break up from tributaries into the Peace River), or logistical constraints (e.g., mechanical issues with boat) a third day for surveys was occasionally required. [2]In other cases, survey conditions and logistical constraints did not allow for complete coverage of the study area within a week and resulted in an incomplete survey.

Incomplete surveys and surveys requiring a third day were typically the result of poor survey conditions or mechanical issues with the boat. Due to rain and wind speeds that exceeded survey standards (**Section 2.1.2**), the Control area was not surveyed during the second survey round of the early spring period in 2017. The first survey of middle spring 2018 and early spring 2019 were not completed within the usual 2 days because ice from the Pine River entered the Peace River and a third survey day was required to complete these survey rounds. In 2019, the first round of middle spring surveys was not completed due to mechanical issues with the river boat and a lack of alternative options within the survey window (**Table 5**). Finally, a survey round in the middle period of spring 2020 (conducted prior to finalization of the power analysis) was cut short at the confluence with the Beatton River due to release of an ice break-up preventing access to areas of the Peace River downstream of that tributary. All survey rounds in 2022 were completed successfully within 2 days each.

4.1.2 Habitat Assessment

Locations with active hydrological monitoring gauges from which water flow data were obtained were as follows: Inundation Impact area - Hudson's Hope (2017, 2018)[1] and Peace Canyon Dam (2019 to 2022); Flow Impact area - Old Fort (all years); Control area – Taylor (all years). The hydrological gauges are located within or adjacent to the towns they are named after in **Figure 1**. Water flow data from these monitoring stations during the spring and fall migrations of 2017 through 2022 are summarized across years, seasons, and treatment areas in **Table 6**. Frequency distributions of the flow regime throughout the spring and fall migration within each treatment area relative to flows during surveys are presented in **Figure 6**.

Mean flow rates during waterbird surveys varied substantially across years and seasons, ranging from a low of 602 m^3/sec during the spring of 2019 to a high of 1,956 m^3/sec during spring 2021 (**Table 6**). Frequency distribution plots of flow rate data illustrated in **Figure 6** provide evidence that, across the 6 survey years, flow rates were similarly distributed and, thus, representative of flow rates throughout the spring and fall migration periods in all treatment areas. Similar figures are presented for 2022 flow rates during surveys relative to throughout spring and fall migration in **Appendix F**.

1 The Hudson's Hope gauge was discontinued in 2019 to facilitate the placement of rip-rap for Site C reservoir shoreline erosion protection. Thus, in 2019 and subsequent years, flow data for the Inundation Impact area were collected from a gauge immediately downstream of the Peace Canyon Dam.

Table 6 Mean Hourly Water Flow Rates on the Peace River During Waterbird Surveys Across Years, Seasons, and Treatment Areas in 2017 Through 2022

Season	Year	Water Flow (m^3/sec) within Treatment Areas			
		Inundation Impact	Flow Impact	Control	Mean
Spring	2017	650	909	1,412	991
	2018	594	862	1,626	1,027
	2019	520	559	725	602
	2020	1,383	1,364	1,492	1,413
	2021	1,943	1,953	1,972	1,956
	2022	1,375	1,418	1,452	1,415
Fall	2017	1,409	1,363	1,445	1,406
	2018	1,086	1,129	1,232	1,149
	2019	847	787	982	872
	2020	1,565	1,687	1,869	1,707
	2021	711	693	806	737
	2022	1,348	1,187	1,262	1,266

Note: Flow discharge rate data for the Inundation Area were collected from Hudson's Hope in 2017 and 2018 and from Peace Canyon Dam in subsequent years. Data for the Flow Impact and Control areas were collected from Old Fort and Taylor (downstream of the Pine River confluence), respectively (see **Figure 1**). Data include hourly flow rates during the day (0700 to 1800 hours) from the dates when Peace River waterbird surveys were conducted (**see Table 5**).

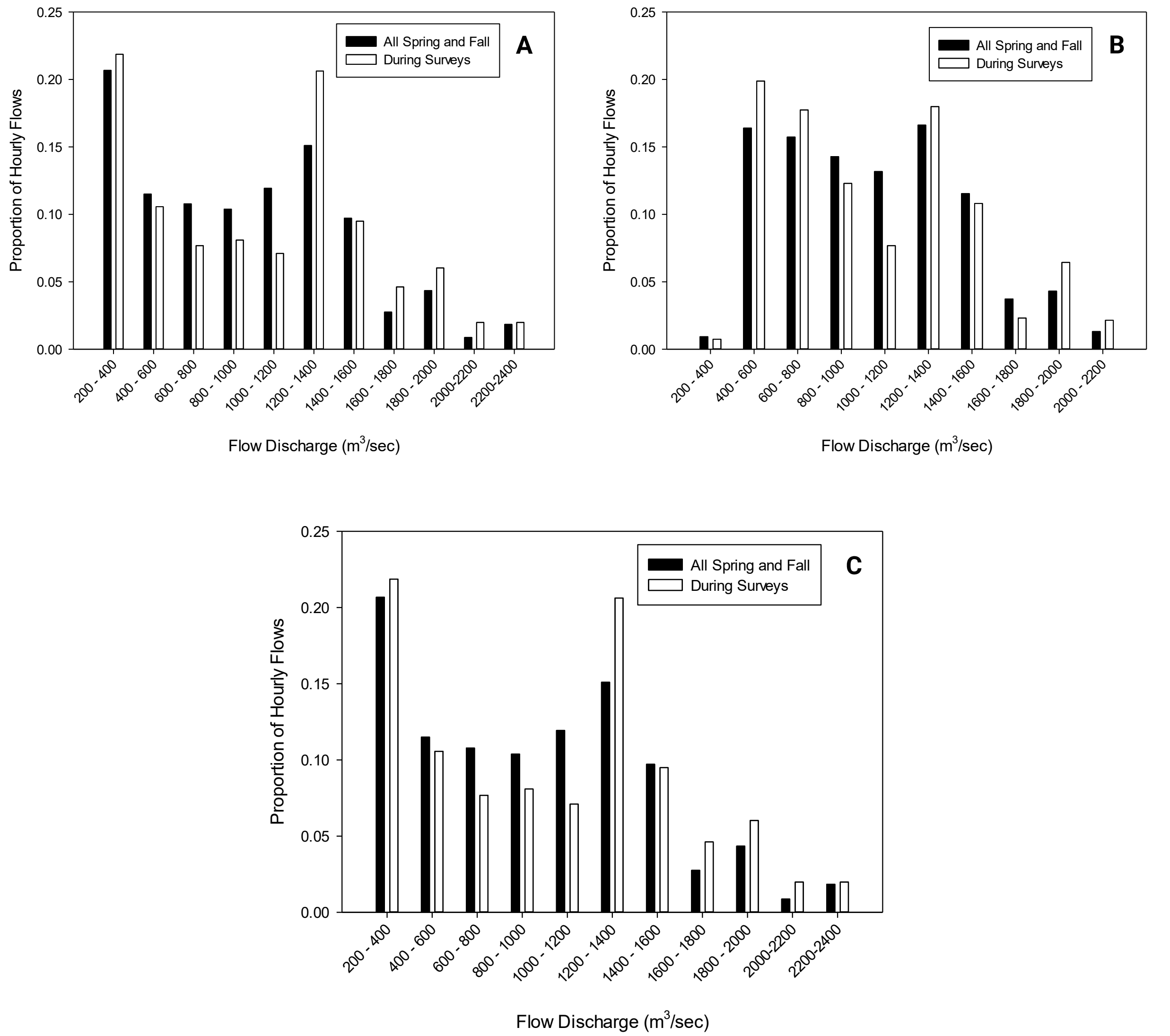


Figure 6 Distribution of Hourly Flow Rates (Shown as Proportion of Total) in the Inundation Impact (A), Flow Impact (B), and Control (C) Treatment Areas During Surveys (Hours 0700 through 1800 of Survey Days) Relative to During All Spring (April, May) and Fall (August, September, October) Migrations of 2017 through 2022.

4.1.3 Abundance and Density

As in previous years, waterbirds were observed along the entirety of the Peace River study area in spring and fall of 2022 (see waterbird location figures in **Appendix C: Figures C-1 to C-4**). A complete list of the species and numbers of waterbirds observed during Peace River surveys in 2022 and across all monitoring years is presented within **Appendix B**. In total, 91,729 waterbirds were observed and recorded during Peace River boat surveys in 2017 through 2022 of which 97% were identified to species (**Appendix B-1**). In 2022, a total of 17,067 waterbirds were observed during Peace River boat surveys, of which 96% were identified to species (**Appendix B-2**).

The highest mean waterbird abundances during spring were observed in the early survey period and during fall were found in the early-middle survey period (**Table 7**). Large dabblers, primarily Canada goose (*Branta canadensis*) (**Appendix B-1**), were the most abundant waterbirds observed overall, with the highest abundances observed during the early spring (more than 3-fold abundances observed during other survey periods). Dabbling ducks and gulls were the next most abundant guilds observed during surveys (**Table 7**). Estimates of foraging guild abundances specific to survey periods in 2022 are presented in **Table 8**, and estimates of interannual variability are presented in **Appendix E** (**Table E-7**). Note that means presented in **Table 7** from early spring and early through late-middle fall survey periods incorporate data collected across all survey years (2017-2022), while means from middle and late spring as well as late fall are calculated from data collected in 2017 through 2019.Surveys were not continued during the later survey periods of each season after 2019 as per guidance from Native Plant Solutions, informed by power analyses (**Appendix A**).

Table 7 Mean Abundance Estimates (Birds/Survey Round) of Waterbird Foraging Guilds within the Peace River, Spring and Fall of 2017 Through 2022

Foraging Guild	Spring Survey Periods			Fall Survey Periods				Average of Survey Period Means
	Early	Middle[1]	Late[1]	Early	Early-Middle	Late-Middle	Late[1]	
Benthic-feeding Divers	141	195	23	2	18	12	5	56
Dabbling Ducks	963	714	463	85	284	242	51	400
Gulls	2	69	32	659	588	262	102	245
Large Dabblers	2,417	750	560	215	441	685	623	813
Piscivorous Divers	271	105	43	31	30	16	12	73
Shorebirds	2	14	135	189	111	3	0	65
Unknown Waterbirds	75	128	61	15	6	21	13	46
Total (All Waterbirds)	**3,870**	**1,975**	**1,317**	**1,195**	**1,478**	**1,242**	**805**	**1,698**

Note: Mean abundances reflect relative rather than absolute abundances as they do not account for incomplete detection. Abundances within each survey round were calculated by extrapolating density estimates observed within each habitat across the entire study area to account for the areas not accessible by boat, which varied across survey rounds depending on water levels and boat access. Mean abundances were then calculated within each habitat type across survey rounds first within periods of each year, and then averaged across years.

[1]Means from middle and late spring as well as late fall are calculated from data collected prior to 2020. Surveys were not completed during these survey periods after 2019 as per Native Plant Solutions' guidance informed by power analyses.

Table 8 Mean Abundance Estimates (Birds/Survey Round) of Waterbird Foraging Guilds within the Peace River, Spring and Fall of 2022

Foraging Guild	Spring Survey Periods			Fall Survey Periods				Average of Survey Period Means
	Early	Middle[1]	Late[1]	Early	Early-Middle	Late-Middle	Late[1]	
Benthic-feeding Divers	20	-	-	0	1	0	-	5
Dabbling Ducks	817	-	-	2	180	100	-	275
Gulls	0	-	-	79	22	2	-	26
Large Dabblers	3,635	-	-	116	425	113	-	1,072
Piscivorous Divers	93	-	-	2	15	2	-	28
Shorebirds	2	-	-	68	14	0	-	21
Unknown Waterbirds	7	-	-	0	0	37	-	11
Total (All Waterbirds)	**4,574**	**-**	**-**	**266**	**658**	**254**	**-**	**1,438**

Note: Mean abundances reflect relative rather than absolute abundances as they do not account for incomplete detection. Abundances within each survey round were calculated by extrapolating density estimates observed within each habitat across the entire study area to account for the areas not accessible by boat, which varied across survey rounds depending on water levels and boat access. Mean abundances were then calculated within each habitat type across survey rounds first within periods of each year, and then averaged across years.

[1] Dashes reflect no data collected during some survey periods as per Native Plant Solutions' guidance informed by power analyses.

Totals of mean densities of waterbird foraging guilds determined for 2017 through 2022 varied across river habitat types, primarily reflecting the distribution of the most abundant guilds (i.e., large dabblers and dabbling ducks in spring [**Table 9**], gulls and large dabblers in fall [**Table 11**]). The highest mean densities of waterbirds observed across seasons and habitat types were in the spring within Limited Connectivity habitat. During spring, mean densities summed across foraging guilds were almost 10 times higher within Limited Connectivity habitat than in Mainstem habitat and almost 4 times higher within Limited Connectivity habitat than in Moderate Flow habitat (**Table 9**, **Figure 7**, **Figure 8**, **Figure 9**). Mean densities observed during spring were greater in the Flow Impact treatment area compared to other treatment areas (**Table 9**). During fall, total waterbird densities observed across survey years were again greatest within Limited Connectivity habitat (**Table 11**). Mean densities observed during fall were higher in the Flow Impact area compared to other treatment areas (**Table 11**, **Figure 10**, **Figure 11**, **Figure 12**). Survey results specific to 2022 are presented in **Table 10** for spring surveys and **Table 12** for fall surveys. Variability statistics across years are provided for spring and fall in **Appendix E** in **Table E-9** and **E-11**, respectively.

Table 9 Mean 2017 Through 2022 Spring Densities (Birds/km²/Survey Round) and Estimated Abundances of Migrant Waterbirds by River Habitat Type and Treatment Area

Foraging Guild	Density by River Habitat Type			Density by Treatment Area		
	Limited Connectivity	Moderate Flow	Mainstem	Inundation Impact	Flow Impact	Control
Benthic-feeding Divers	15.4	2.6	1.3	2.4	5.2	1.4
Dabbling Ducks	91.0	26.4	8.2	8.2	33.6	19.9
Gulls	0.0	<0.1	0.4	0.3	1.4	0.1
Large Dabblers	179.9	46.0	18.5	34.0	27.7	30.7
Piscivorous Divers	14.3	6.3	2.4	5.8	2.2	1.4
Shorebirds	4.6	0.7	0.1	0.4	0.5	0.5
Unknown Waterbirds	5.2	1.7	0.8	1.5	0.8	1.0
Total (All Waterbirds)	**310.4**	**83.7**	**31.8**	**52.6**	**71.5**	**55.0**
Estimated Abundance	**1,010**	**626**	**1,382**	**1,392**	**428**	**1,198**

Note: Mean densities reflect relative rather than absolute densities as they do not account for incomplete detection. Means were calculated by averaging density estimates (birds/km²/survey) within each habitat type across survey rounds first within periods of each year, then across periods for each season of each year, and then across years so that differences in sampling effort did not bias means towards results from years with more survey rounds or years with more survey periods. Total mean density is the sum of all foraging guild and unknown waterbird densities. Abundances calculated as density multiplied by area.

Table 10 Mean 2022 Spring Densities (Birds/km²/Survey Round) and Estimated Abundances of Migrant Waterbirds by River Habitat Type and Treatment Area

Foraging Guild	Density by River Habitat Type			Density by Treatment Area		
	Limited Connectivity	Moderate Flow	Mainstem	Inundation Impact	Flow Impact	Control
Benthic-feeding Divers	0.7	0.9	<0.1	0.1	0.4	0.3
Dabbling Ducks	22.9	12.7	5.5	7.7	20.9	3.6
Gulls	0.0	0.0	0.0	0.0	0.0	0.0
Large Dabblers	129.8	47.9	23.8	45.7	67.1	9.4
Piscivorous Divers	4.1	2.2	0.4	1.2	1.5	0.3
Shorebirds	0.3	0.0	0.0	0.0	0.0	0.0
Unknown Waterbirds	1.1	0.0	0.0	0.0	0.0	0.2
Total (All Waterbirds)	**158.9**	**63.6**	**29.7**	**54.7**	**89.9**	**13.7**
Estimated Abundance	**517**	**475**	**1,294**	**1,449**	**538**	**299**

Note: Mean densities reflect relative rather than absolute densities as they do not account for incomplete detection. Means were calculated by averaging density estimates (birds/km²/survey) within each habitat type across survey rounds first within periods of each year, then across periods for each season of each year, and then across years so that differences in sampling effort did not bias means towards results from years with more survey rounds or years with more survey periods. Total mean density is the sum of all foraging guild and unknown waterbird densities. Abundances calculated as density multiplied by area.

Table 11 Mean 2017 Through 2022 Fall Densities (birds/km²/survey round) of Migrant Waterbirds by River Habitat Type and Treatment Area

Foraging Guild	Density by River Habitat Type			Density by Treatment Area		
	Limited Connectivity	Moderate Flow	Mainstem	Inundation Impact	Flow Impact	Control
Benthic-feeding Divers	0.4	<0.1	0.2	0.3	0.2	0.1
Dabbling Ducks	28.6	5.9	0.9	4.5	7.4	0.7
Gulls	2.4	0.6	10.0	6.9	43.2	0.3
Large Dabblers	47.0	8.2	4.9	7.1	10.6	8.1
Piscivorous Divers	2.1	0.7	0.2	0.6	0.3	0.3
Shorebirds	7.6	3.1	0.9	1.5	0.7	1.9
Unknown Waterbirds	2.5	0.1	0.1	0.3	0.5	<0.1
Total (All Waterbirds)	**90.6**	**18.7**	**17.1**	**21.1**	**62.8**	**11.3**
Estimated Abundance	**295**	**140**	**745**	**559**	**376**	**245**

Note: Mean densities reflect relative rather than absolute densities as they do not account for incomplete detection. Means were calculated by averaging density estimates (birds/km²/survey) within each habitat type across survey rounds first within periods of each year, then across periods for each season of each year, and then across years so that differences in sampling effort did not bias means towards results from years with more survey rounds or years with more survey periods. Total mean density is the sum of all foraging guilds and unknown waterbird densities. Abundances calculated as density multiplied by area.

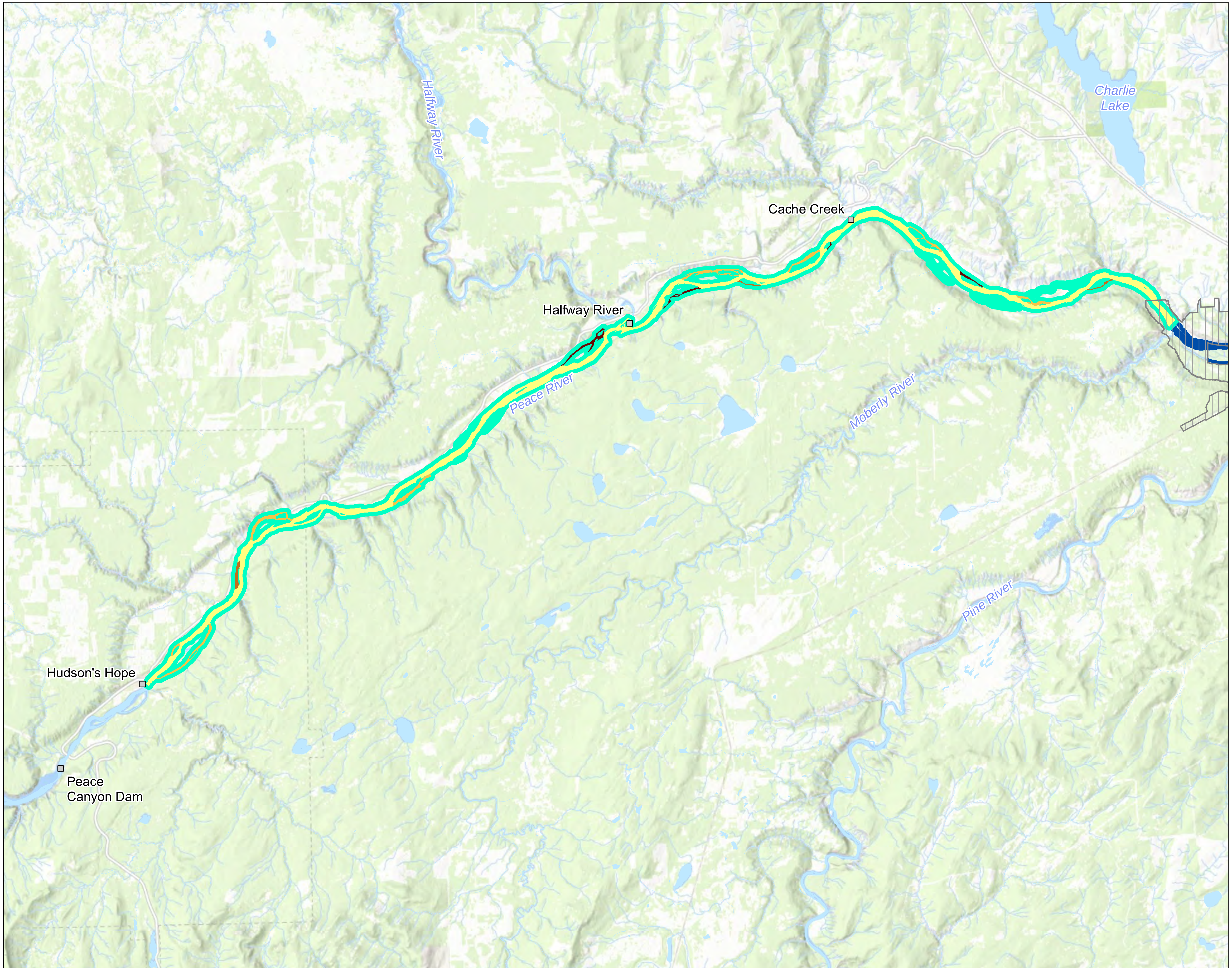
Table 12 Mean 2022 Fall Densities (birds/km²/survey round) of Migrant Waterbirds by River Habitat Type and Treatment Area

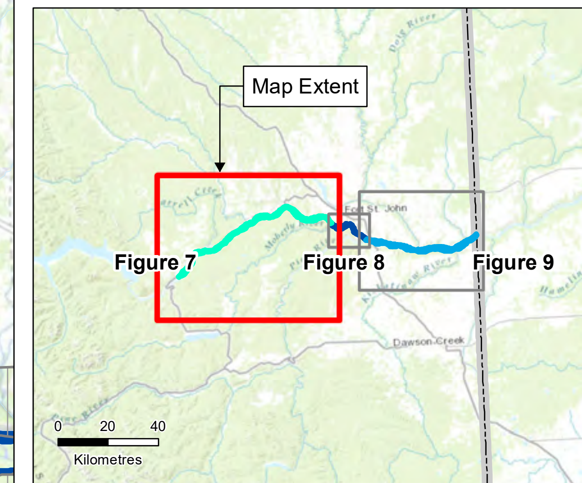
Foraging Guild	**Density by River Habitat Type**			**Density by Treatment Area**		
	Limited Connectivity	**Moderate Flow**	**Mainstem**	**Inundation Impact**	**Flow Impact**	**Control**
Benthic-feeding Divers	0.1	0.0	0.0	<0.1	0.0	0.0
Dabbling Ducks	13.4	1.1	0.4	2.2	1.6	<0.1
Gulls	0.1	0.0	0.7	0.1	4.5	<0.1
Large Dabblers	2.4	2.6	2.4	4.2	3.0	0.1
Piscivorous Divers	0.3	0.2	0.0	0.1	0.1	0.0
Shorebirds	1.9	0.9	0.3	0.6	0.2	0.5
Unknown Waterbirds	0.6	0.0	0.1	0.2	0.0	0.1
Total (All Waterbirds)	**18.8**	**4.8**	**3.9**	**7.4**	**9.3**	**0.7**
Estimated Abundance	**61**	**36**	**171**	**197**	**56**	**15**

Note: Mean densities reflect relative rather than absolute densities as they do not account for incomplete detection. Means were calculated by averaging density estimates (birds/km²/survey) within each habitat type across survey rounds first within periods of each year, then across periods for each season of each year, and then across years so that differences in sampling effort did not bias means towards results from years with more survey rounds or years with more survey periods. Total mean density is the sum of all foraging guilds and unknown waterbird densities. Abundances calculated as density multiplied by area.

Migratory Waterbird Follow-up Monitoring Program
2022 Report
Site C, Peace River, BC

Fig. 7 - Mean Density (birds/km^2/survey round) of Spring Migrant Waterbirds within Inundation Impact Area Habitat Polygons from 2017 through 2022





Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Waterbird densities (birds/km^2/survey round) by quartile [3]

- 7 - 53
- 54 - 99
- 100 - 244
- 245 - 1007

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
3. Waterbird density values were classified using approximate Quantile Breaks.

Sources

- Basemap: ESRI World Topographic Base

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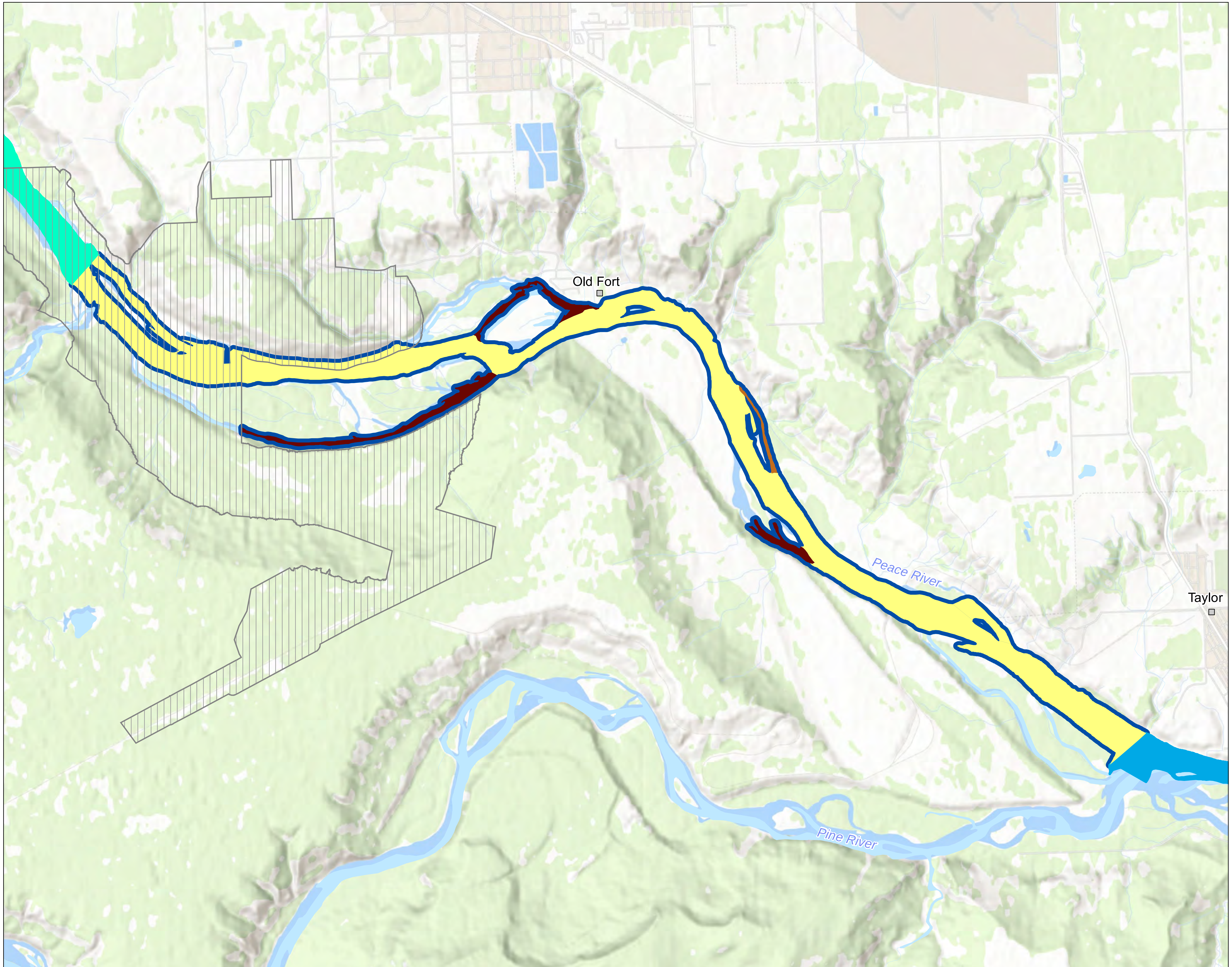
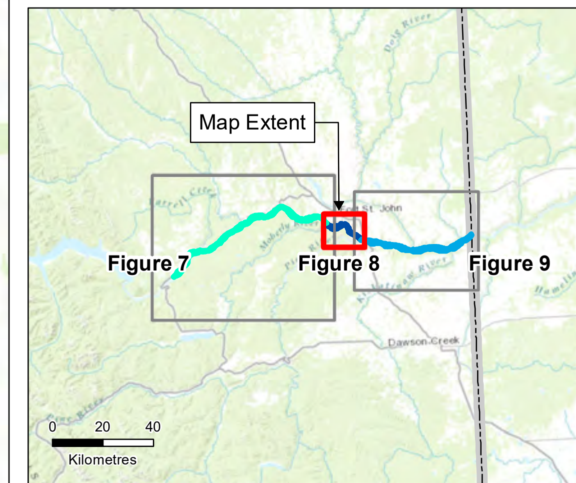
Ausenco BC hydro

Migratory Waterbird Follow-up Monitoring Program
2022 Report
Site C, Peace River, BC

Fig. 8 - Mean Density (birds/km^2/survey round) of Spring Migrant Waterbirds within Flow Regime Impact Area Habitat Polygons from 2017 through 2022





Legend

- Inundation Impact Area
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Waterbird densities (birds/km^2/survey round) by quartile [3]

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Sources

- Basemap: ESRI World Topographic Base

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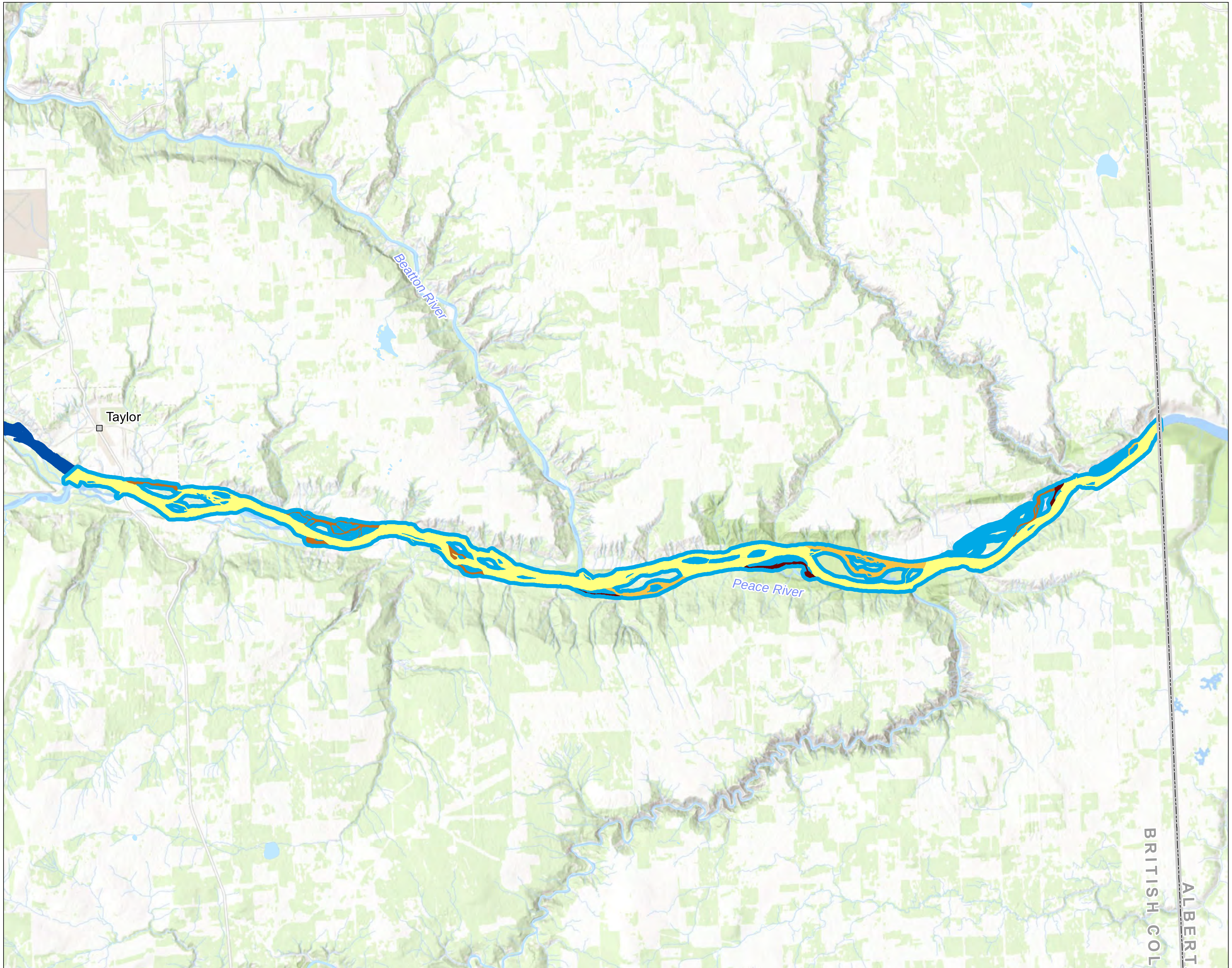
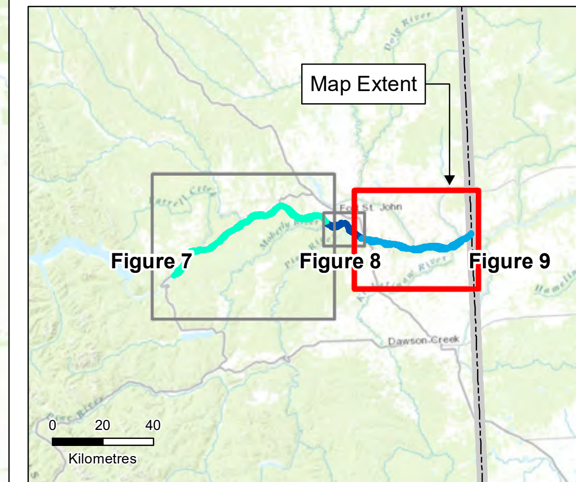
Migratory Waterbird Follow-up Monitoring Program
2022 Report
Site C, Peace River, BC

Fig. 9 - Mean Density (birds/km^2/survey round) of Spring Migrant Waterbirds within Control Area Habitat Polygons from 2017 through 2022





Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area

Waterbird densities (birds/km^2/survey round) by quartile [3]

- 7 - 53
- 54 - 99
- 100 - 244
- 245 - 1007

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3. Waterbird density values were classified using approximate Quantile Breaks.

Sources

- Basemap: ESRI World Topographic Base

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NAD 1983 UTM Zone 10N

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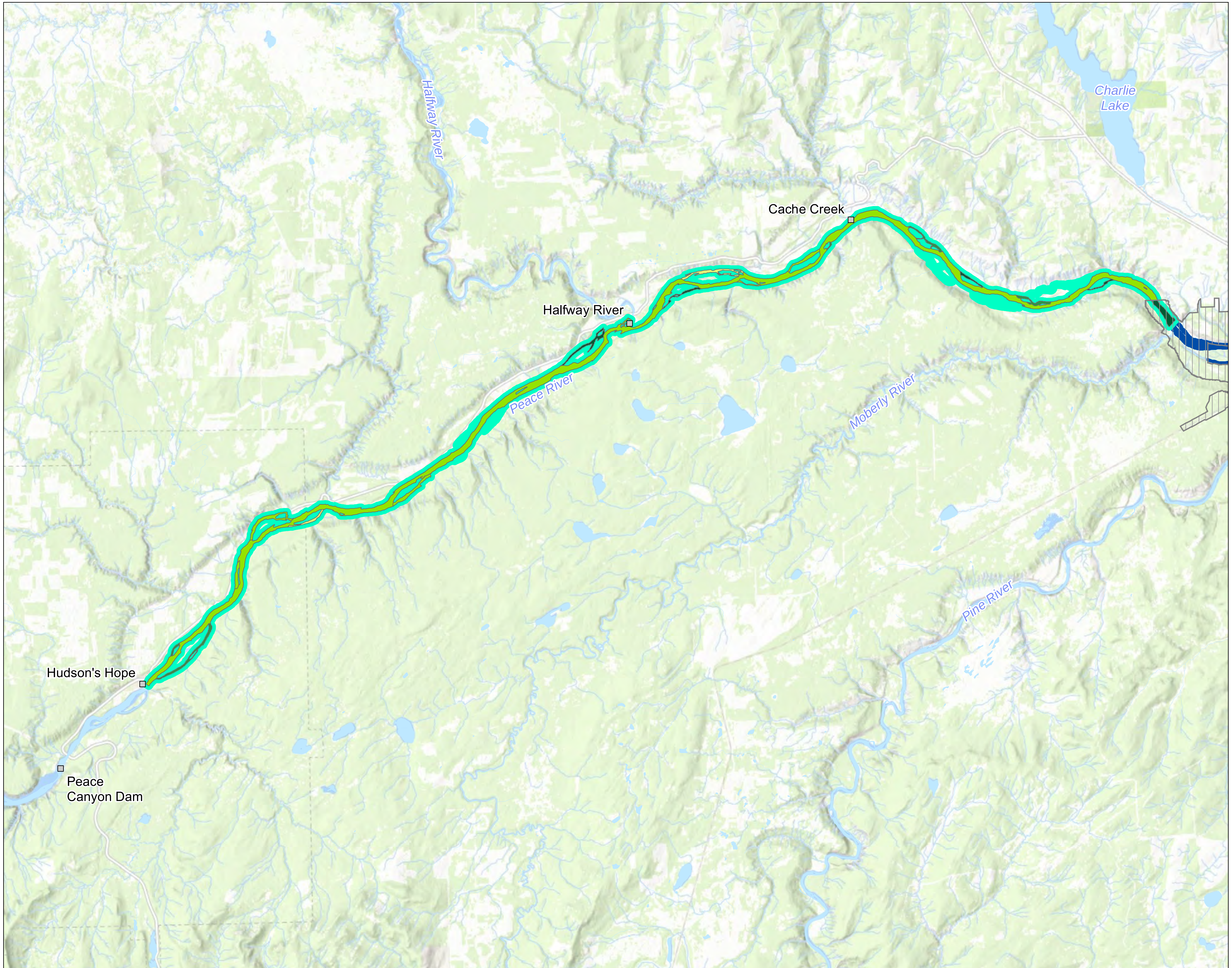
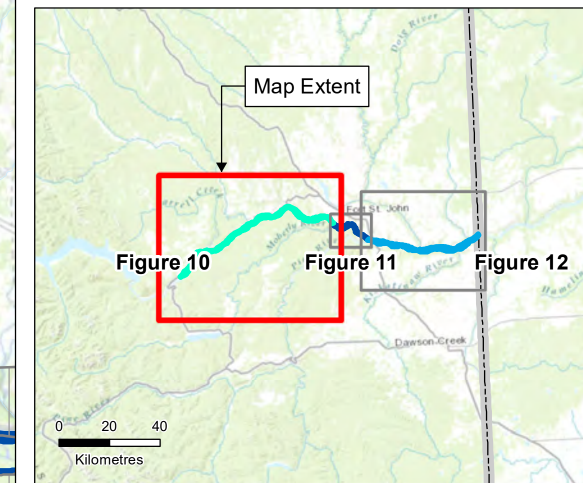
989619-07	Production Date: Mar 10, 2023	Figure 9

Ausenco BC hydro

Migratory Waterbird Follow-up Monitoring Program
2022 Report
Site C, Peace River, BC

Fig. 10 - Mean Density (birds/km²/survey round) of Fall Migrant Waterbirds within Inundation Impact Area Habitat Polygons from 2017 through 2022





Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Waterbird densities (birds/km²/survey round) by quartile [3]

- 2 - 10
- 11 - 22
- 23 - 65
- 66 - 519

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
3. Waterbird density values were classified using approximate Quantile Breaks.

Sources

- Basemap: ESRI World Topographic Base

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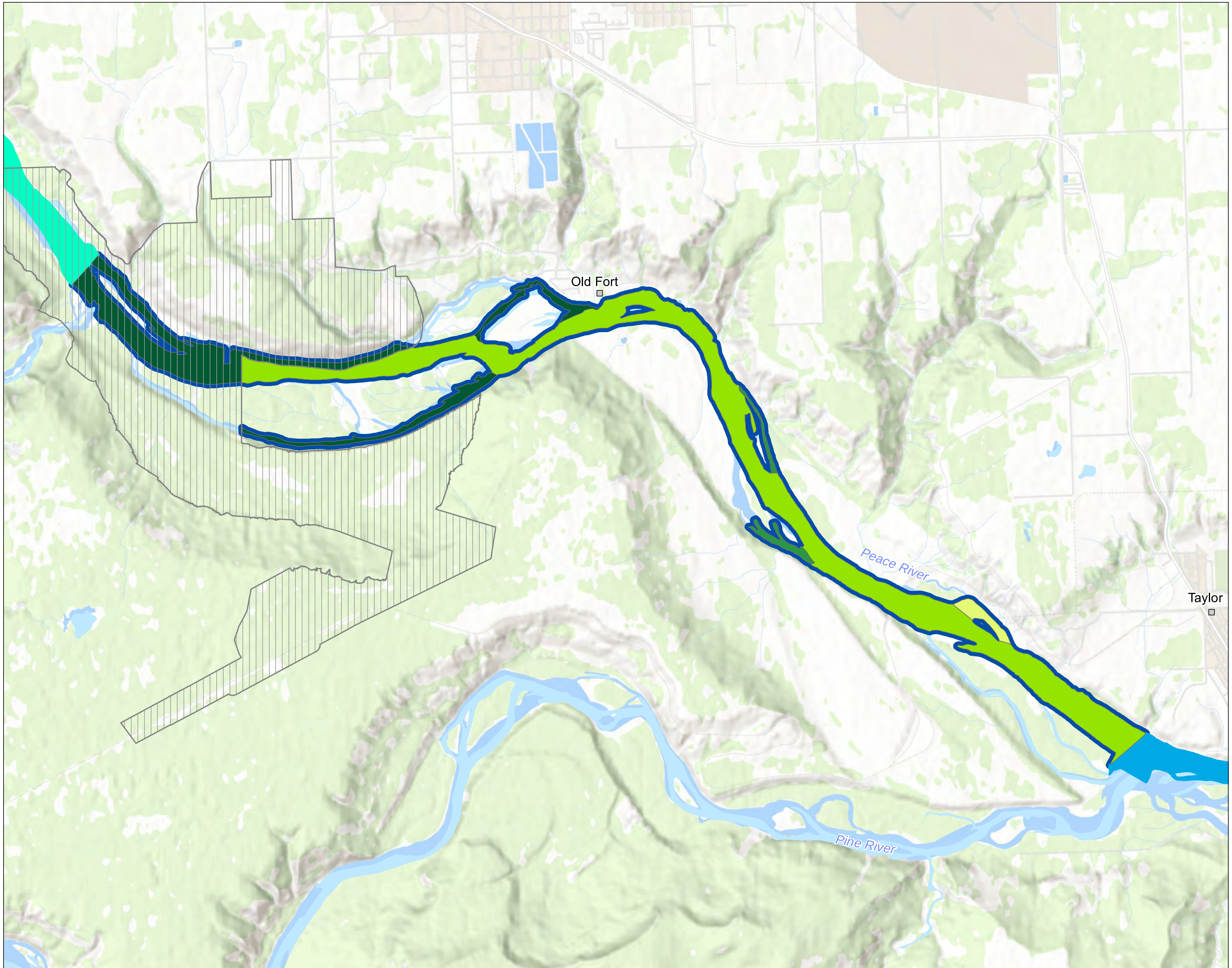
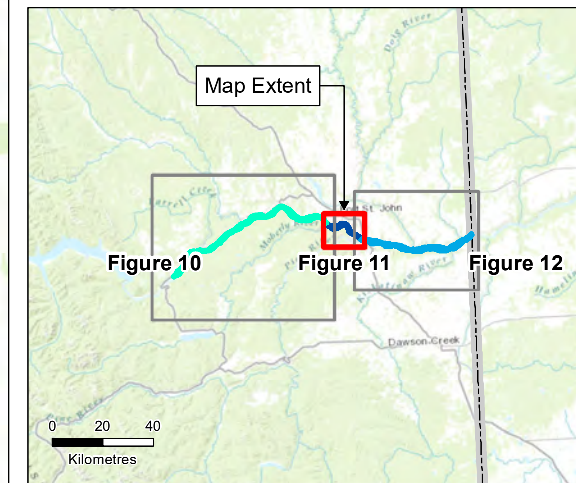
989619-07	Production Date: Mar 10, 2023	Figure 10

Ausenco BC hydro

Migratory Waterbird Follow-up Monitoring Program
2022 Report
Site C, Peace River, BC

Fig. 11 - Mean Density (birds/km^2/survey round) of Fall Migrant Waterbirds within Flow Regime Impact Area Habitat Polygons from 2017 through 2022





Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Waterbird densities (birds/km^2/survey round) by quartile [3]

- 2 - 10
- 11 - 22
- 23 - 65
- 66 - 519

Notes

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3. Waterbird density values were classified using approximate Quantile Breaks.

Sources

- Basemap: ESRI World Topographic Base

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989619-07	Production Date: Mar 10, 2023	Figure 11

Ausenco BChydro

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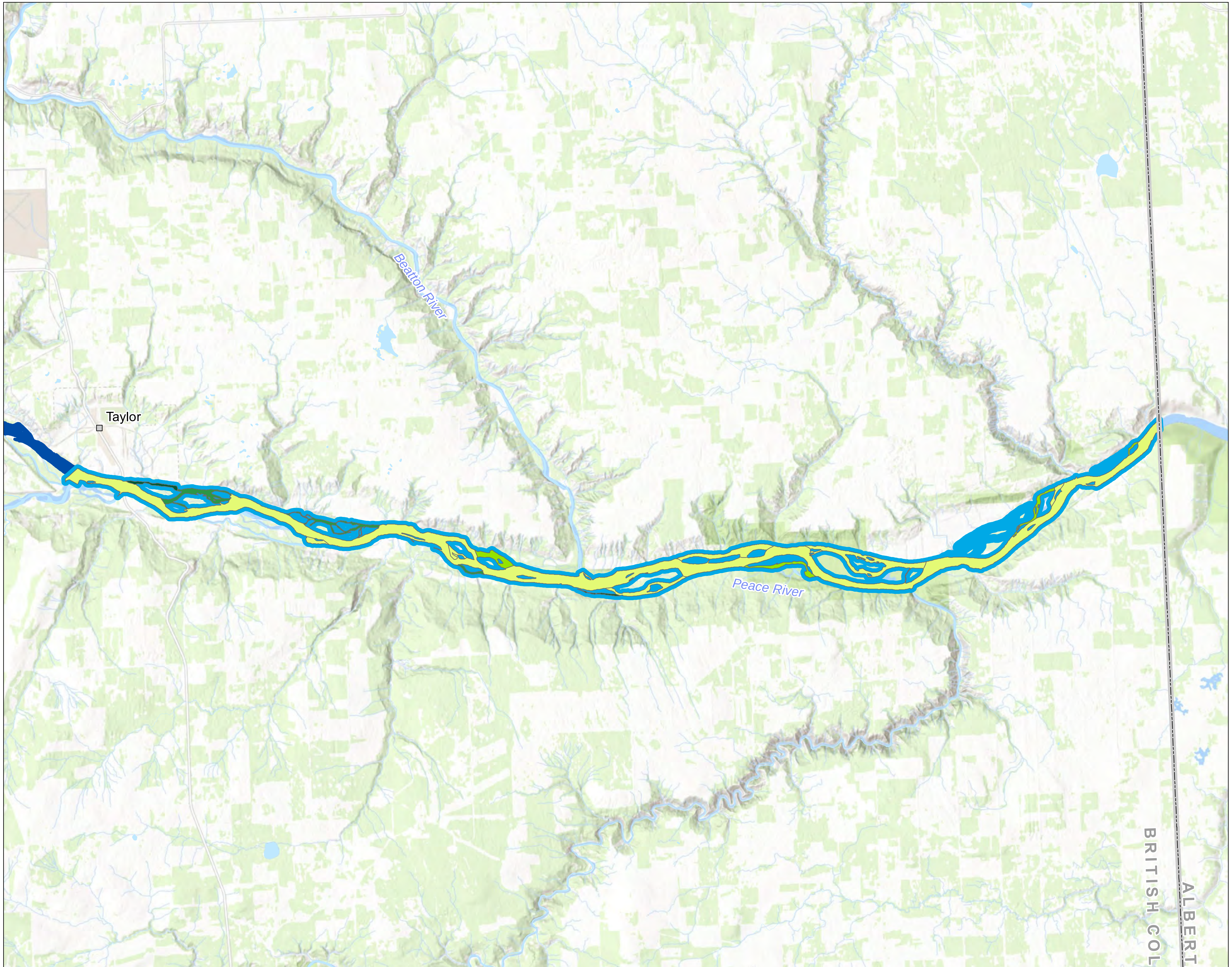
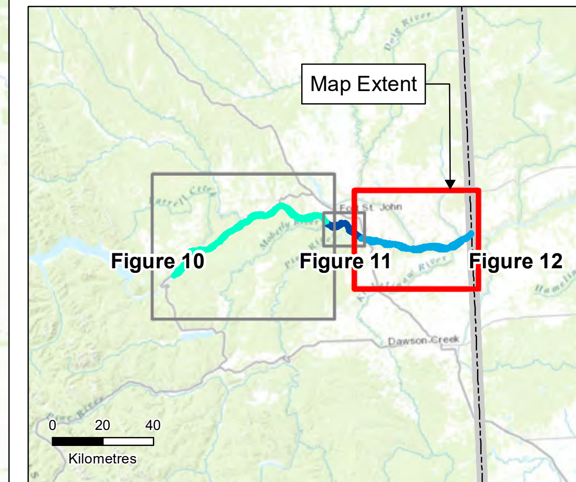
Migratory Waterbird Follow-up Monitoring Program
2022 Report
Site C, Peace River, BC

Fig. 12 - Mean Density (birds/km^2/survey round) of Fall Migrant Waterbirds within Control Area Habitat Polygons from 2017 through 2022





Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area

Waterbird densities (birds/km^2/survey round) by quartile [3]

- 2 - 10
- 11 - 22
- 23 - 65
- 66 - 519

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
3. Waterbird density values were classified using approximate Quantile Breaks.

Sources

- Basemap: ESRI World Topographic Base

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Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-07	Production Date: Mar 10, 2023	Figure 12

Ausenco BC hydro

Path: S:\Geomatics\Projects\989619\07_waterfowl\mxd\MonitoringProgram\2022\Fig12_989619_07_Waterbirds_FallDensity_ControlArea_230310.mxd

4.1.4 Diversity

A total of 65 waterbird species were detected across boat surveys of the Peace River conducted annually from 2017 through 2022 (**Appendix B-1**), including 29 species from 2022 surveys (**Appendix B-2**). Over the 6 years of monitoring conducted thus far, dabbling ducks (15 species) were the most species-rich foraging guild observed, followed by piscivorous divers (13 species) and shorebirds (10 species) (**Appendix B-1**). During spring, average species richness within Mainstem and Moderate Flow river habitats ranged from 11 to 20 across survey periods and was generally higher for dabbling ducks and lower for gulls than for other foraging guilds (**Table 13**). During fall, species richness within Mainstem and Moderate Flow river habitats ranged from 9 to 13 species across survey periods and the most species-rich foraging guild was gulls, while species richness was lowest for benthic-feeding divers. Survey results specific to 2022 are presented in **Table 14**. Variability in diversity metrics across years are presented in **Appendix E** (**Table E-13**).

Table 13 Mean 2017 Through 2022 Diversity Metrics for Waterbird Foraging Guilds on the Peace River Across Seasons and Survey Periods

Foraging Guild	Spring Species Richness			Spring Mean	Fall Species Richness				Fall Mean
	Early	Middle[1]	Late[1]		Early	Early-Middle	Late-Middle	Late[1]	
Benthic-feeding Divers	2.1	2.8	3.7	**2.5**	0.5	0.4	0.8	0.0	**0.5**
Dabbling Ducks	4.4	6.3	7.0	**5.2**	2.1	2.9	2.3	1.5	**2.3**
Gulls	0.3	1.8	3.5	**1.2**	4.3	3.3	2.6	3.5	**3.4**
Large Dabblers	2.1	2.0	1.3	**1.9**	1.1	1.5	1.6	2.0	**1.4**
Piscivorous Divers	1.5	2.5	3.3	**2.0**	1.6	2.4	2.8	1.5	**2.1**
Shorebirds	0.4	0.5	1.2	**0.4**	2.5	1.2	0.7	0.0	**1.3**
Total Species Richness	**10.8**	**16.0**	**20.0**	**13.2**	**13.2**	**12.9**	**12.1**	**8.5**	**11.1**
Species Evenness	**0.5**	**0.6**	**0.6**	**0.5**	**0.6**	**0.5**	**0.5**	**0.4**	**0.5**

Note: Mean species richness was calculated by averaging species richness across survey rounds first within periods each year, and then across years so that differences in sampling effort did not bias means towards diversity observed in years with more survey rounds. Data from Minimal and Limited Connectivity habitat are excluded due to inconsistent survey effort within these habitats due to variable access with fluctuations in water levels. Individual birds not identified to species are excluded from species richness totals and diversity calculations.

[1]Means from middle and late spring as well as late fall are calculated from data collected prior to 2020 because surveys were not completed during these survey periods after 2019 as per Native Plant Solutions' guidance informed by power analyses.

Table 14 Mean 2022 Diversity Metrics for Waterbird Foraging Guilds on the Peace River Across Seasons and Survey Periods

Foraging Guild	Spring Species Richness			Spring Mean	Fall Species Richness				Fall Mean
	Early	Middle[1]	Late[1]		Early	Early-Middle	Late-Middle	Late[1]	
Benthic-feeding Divers	1.0	-	-	**1.0**	0.0	0.0	0.0	-	**0.0**
Dabbling Ducks	3.0	-	-	**3.0**	1.0	1.0	2.0	-	**1.3**
Gulls	0.0	-	-	**0.0**	3.0	2.0	0.0	-	**1.7**
Large Dabblers	1.5	-	-	**1.5**	1.0	1.0	1.0	-	**1.0**
Piscivorous Divers	1.0	-	-	**1.0**	0.0	1.0	1.0	-	**0.7**
Shorebirds	0.0	-	-	**0.0**	1.0	1.0	0.0	-	**0.7**
Total Species Richness	**6.5**	**-**	**-**	**6.5**	**6.0**	**6.0**	**4.0**	**-**	**5.3**
Species Evenness	**0.3**	**-**	**-**	**0.3**	**0.7**	**0.3**	**0.7**	**-**	**0.6**

Note: Mean species richness was calculated by averaging species richness across survey rounds first within periods each year, and then across years so that differences in sampling effort did not bias means towards diversity observed in years with more survey rounds. Data from Minimal and Limited Connectivity habitat are excluded due to inconsistent survey effort within these habitats due to variable access with fluctuations in water levels. Individual birds not identified to species are excluded from species richness totals and diversity calculations.

[1] Dashes reflect no data collected during some survey periods as recommended by power analyses.

Due to unequal areas of the river habitat types and treatment areas (i.e., unequal survey effort and sample sizes; see **Table 2**), diversity statistics are not directly compared across habitat types or treatment areas.

4.1.5 Waterbird Species at Risk

The following species designated as at risk as per provincial, *Species at Risk Act* (SARA), or Committee on the Status of Endangered Wildlife in Canada (COSEWIC) rankings, were observed during Peace River surveys from 2017 through 2022:

- Double-crested cormorant (*Nannopterum auritum*), BC listing (Blue)
- California gull (*Larus californicus*), BC listing (Red)
- Eared grebe (*Podiceps nigricollis*), BC listing (Blue)
- Great blue heron (*Ardea herodias herodias*), BC listing (Blue)[2]
- Horned grebe (*Podiceps auratus*), COSEWIC and SARA (Special Concern)
- Long-tailed duck (*Clangula hyemalis*), BC listing (Blue)
- Red-necked phalarope (*Phalaropus lobatus*), BC listing (Blue), COSEWIC and SARA (Special Concern)
- Surf scoter (*Melanitta perspicillata*), BC listing (Blue)
- Tundra swan (*Cygnus columbianus*), BC listing (Blue)
- Western grebe (*Aechmophorus occidentalis*), BC listing (Red), COSEWIC and SARA (Special Concern).

[2] Great blue heron was not a target species and is not included in estimates of relative abundance or diversity due to its rarity in the region and unique foraging strategy compared to the species guilds assessed in this study.

Records of waterbird species at risk were generally few (i.e., 6 or fewer detections per species in total across years), with the exception of surf scoter (271 birds observed), California gull (35 birds observed), and red-necked phalarope (11 birds observed) (**Appendix B-1**). In 2022, the only at-risk waterbird observed during Peace River surveys was surf scoter (65 birds observed) (**Appendix B-2**).

4.2 Transmission Line Wetland Surveys

This section describes the results of the transmission line ROW wetland survey component of the monitoring program, including the temporal and spatial scope of surveys (**Sections 4.2.1** and **4.2.2**) relative to survey objectives. Estimates of mean abundance and diversity across years are summarized for each foraging guild by season, survey period, and habitat type. Diversity statistics are also summarized by foraging guild with means averaged across years provided for each survey period. Results are summarized together for all years of monitoring and are also presented independently for 2022 surveys.

4.2.1 Survey Effort and Timing

In 2022, transect and standwatch surveys were conducted on the Moberly Plateau adjacent to the Site C transmission line ROW during spring (May 2 through May 18) and fall (August 10 through October 7) waterbird migration periods (**Table 15**). Surveys in 2022 were conducted during 2 survey periods in spring and 3 survey periods in fall over a total of 18 days (7 days in spring and 11 days in fall). No transmission line wetland surveys were conducted in the early spring survey because wetlands were frozen and unavailable for waterbird foraging during that time (**Table 15**). Bioacoustics monitoring for marsh birds in 2022 was conducted from May 19 through August 31 (**Table 22**).

Table 15 Wetland Survey Timing During 2017 to 2022 Annual Waterbird Migration Monitoring

Survey Period	2017 Survey Dates	2018 Survey Dates	2019 Survey Dates	2020 Survey Dates	2021 Survey Dates	2022 Survey Dates
Spring						
Early (Apr 1 to Apr 14)	Wetlands Frozen	Wetlands Frozen	Wetlands Frozen	Wetlands Frozen	Wetlands Frozen	Wetlands Frozen
Middle (Apr 15 to May 6)	Apr 29, 30; May 1, 2	Apr 27, 28, 29 May 2, 3, 4	Apr 21, 22, 23 May 3, 4, 5	May 4, 5, 6	May 3, 4, 5, 6	May 2, 3, 4
Late (May 7 to May 30)	May 16, 17; May 18, 19, May 25, 26; May 27, 28	May 7, 8, 9 May 15, 16, 17	May 11, 12, 13 May 22, 23, 24	May 24, 25, 26, 27	May 14, 15, 16	May 16, 17, 18, 19
Fall						
Early (Aug 1 to Aug 14)	Aug 10, 11; 12, 13	Aug 6, 7, 8	Aug 10, 11, 12	Aug 7, 8, 9	Aug 11, 12, 13	Aug 10, 11, 12, 13
Early-Middle (Aug 15 to Sep 14)	Aug 24, 25; 26, 27	Aug 22, 23, 24, Sep 6, 7, 10	Aug 21, 22, 23 Sep 10, 11	Sep 2, 3, 4	Aug 26, 29, 30	Aug 31, Sep 1, 2,
Late-Middle (Sep 15 to Oct 14)	Sep 23, 24; 25, 26	Sep 17, 18, 19 Oct 1, 2, 3	Sep 18, 19, 20 Oct 2, 3	Sep 28, Oct 1, 2	Sep 29, 30, Oct 1, 2, 6	October 3, 4, 5, 7
Late (Oct 15 to Oct 30)	No surveys	Oct 17, 18, 19	Oct 18, 19	No surveys	No surveys	No surveys

4.2.1.1 Transect and Standwatch Surveys

In 2022, waterbird surveys were conducted within 23 of the 25 wetland stations surveyed since 2017 for which data are summarized in this report (**Figure 13**, **Figure 14**, **Figure 15**, **Table 16**). As described in **Section 2.2.2**, each wetland station included one or more habitat types in which waterbird surveys were conducted. Within the 23 stations surveyed in 2022, 15 areas of open water habitat were surveyed by standwatch methods, 11 areas with predominantly (60% or greater) willow-sedge habitat were surveyed by transect methods, and 14 areas with predominantly sedge habitat were also surveyed by transect methods. Photos of stations showing aerial views or representative habitat are provided in **Appendix D**.

Table 16 Survey Methods and Wetland Habitat Types Surveyed Within Wetland Stations by Year

Wetland Station ID	Bioacoustics (ARU) Surveys	Transect Surveys[1]	Standwatch Surveys[2]
	Sedge, Open Water, Willow-Sedge	Sedge, Willow-Sedge	Open Water
OW-01	2021	2020 - 2022	2017 - 2022
OW-02	-	-	2017 - 2022
OW-04	-	-	2017 - 2022
OW-06	2020	2020, 2021,2022	2017 - 2022
OW-07	2022	-	2020 - 2022
OW-09	-	-	2017 - 2022
OW-10	-	-	2017 - 2022
OW-11	-	-	2017 - 2022
OW-13	-	2022	2022
OW-14	-	-	2022
SE-01[3]	-	2018, 2019	-
SE-02	2021	2018 - 2022	2020 - 2022
SE-03	2021, 2022	2018 - 2022	2020 - 2022
SE-04	2018 - 2022	2018 - 2022	2020
SE-05	2017, 2019 - 2021	2018 - 2022	-
SE-06	2017, 2019, 2020	2018, 2019	2020 - 2022
SE-07	2022	2018 - 2022	2020, 2021
SE-09	2020, 2022	2018 - 2022	2020 - 2022
SE-10	2017, 2019	2018 - 2022	-
SE-11	2020 - 2022	2018 - 2022	-
SE-12	-	2018, 2019	2020, 2021
SE-14	2022	2018 - 2022	2020 - 2022
WS-01	2019	2018 - 2022	-
WS-02	2022	2018 - 2022	-
WS-03	2021	2018 - 2022	-

Notes: Dashes indicate no surveys conducted

[1] Surveys conducted with water depths of 0.5 m or less

[2] Surveys conducted in areas of 0.25 ha or more of open water

[3] Discontinued after 2019. Replaced with more easily accessed habitat adjacent to OW-01

Within the wetland survey stations listed above, 297 standwatch surveys of open water and 615 transect surveys of sedge and willow-sedge habitat were conducted under appropriate survey conditions during the spring and fall of 2017 through 2022 (**Table 17**). Of the total 859 surveys conducted across all years, 297 and 615 surveys were conducted during spring and fall, respectively, and 160 were conducted during 2022.

Table 17 Number of Unique Wetland Surveys for Migrating Waterbirds Conducted by Standwatch and Transect Methods by Survey Period, 2017 to 2022

Survey Method	Year	Spring			Fall				Total
		Early[1]	Middle	Late	Early	Middle-Early	Middle-Late	Late[1]	
Standwatch (OW)	2017	-	2	8	6	5	6	0	27
	2018	-	9	14	6	11	12	6	58
	2019	-	11	13	6	13	12	3	58
	2020	-	11	12	11	11	9	0	54
	2021	-	7	14	8	10	8	0	47
	2022		9	11	12	12	9	0	53
Total		**-**	**49**	**72**	**49**	**62**	**56**	**9**	**297**
Transect (WS, SE)	2017	-	-	-	-	-	-	-	-
	2018	-	11	32	20	27	37	21	148
	2019	-	26	36	20	37	37	6	162
	2020	-	20	22	21	23	20	0	106
	2021	-	19	12	22	21	18	0	92
	2022		18	25	21	20	23	0	107
Total		**-**	**94**	**127**	**104**	**128**	**135**	**27**	**615**
Grand Total		**-**	**134**	**188**	**141**	**178**	**182**	**36**	**859**

Note: Multiple transects conducted within the same habitat type counted as a single unique survey. [1]Dashes indicate no surveys conducted during some years and survey periods. No surveys were conducted during early spring and few surveys were conducted during late fall due to snow and ice cover of wetlands which restricted access and has also been found to be associated with limited use by waterbirds relative to warmer conditions.

4.2.1.2 Bioacoustics Monitoring

Bioacoustics monitoring during 2017 through 2022 was conducted with ARU deployments at 16 wetland survey stations (**Table 16)** and 6 other locations over a cumulative total of 788 nights including 240 nights from 8 locations in 2022 (**Table 22**). ARU surveys for marsh birds in 2022 were conducted at 4 stations where they were conducted in previous years and at 4 new stations (**Figure 13**). Species presence/not detected results from ARU deployments across all years are summarized in **Table 22** along with the coordinates, habitats surveyed, and results specific to each 2022 deployment. Deployment specific data from prior years are specified in the 2021 annual report (Hemmera Envirochem Inc. 2022).

The following wetland stations, habitat types, and time periods were selected for bioacoustics monitoring in 2022:

Mid-May to mid-June:

- **SE-14**: Mixed patches of sedge, open water and willow-sedge. Smaller areas of sedge relative to SE-11 and other stations where yellow rail have most often been detected. Similar habitat to SE-03 where yellow rail was recorded last year. This station had not previously been surveyed by ARU.
- **SE-07**: Mixed patches of sedge, open water and willow-sedge. Smaller areas of sedge relative to SE-11 and other stations where yellow rail have most often been detected, but similar to SE-03 where yellow rail was recorded last year. This station had not previously been surveyed by ARU.
- **SE-11**: Large patch of sedge where yellow rail is typically found, for comparison with SE-07 and SE-14 at the same time of year. Yellow rail was documented at this station in 2 prior years.

Mid-June to mid-July:

- **OW-07**: Mixed patches of sedge, open water and willow-sedge. Smaller areas of sedge relative to SE-11 and other stations where yellow rail are more traditionally documented, but similar to SE-03 where yellow rail was recorded last year. This station had not previously been surveyed by ARU.
- **WS-02**: Mixed patches of sedge, open water and willow-sedge. Smaller areas of sedge relative to SE-11 and other stations where yellow rail are more traditionally documented, but similar to SE-03 where yellow rail was recorded last year. This station had not previously been surveyed by ARU.
- **SE-03**: To determine whether this site consistently hosts yellow rail, or if last year was unique due to low water levels within the sedge habitat relative to other years.

Mid-July to mid-August:

- **SE-04, SE-09 and SE-11**: Virginia rail was detected at these stations in May/June during previous years. Detections in 2022 during mid-July to mid-August would indicate Virginia rail is also calling later in the season, supporting monitoring for this species at this time of year.

Migratory Waterbird Follow-up Monitoring Program
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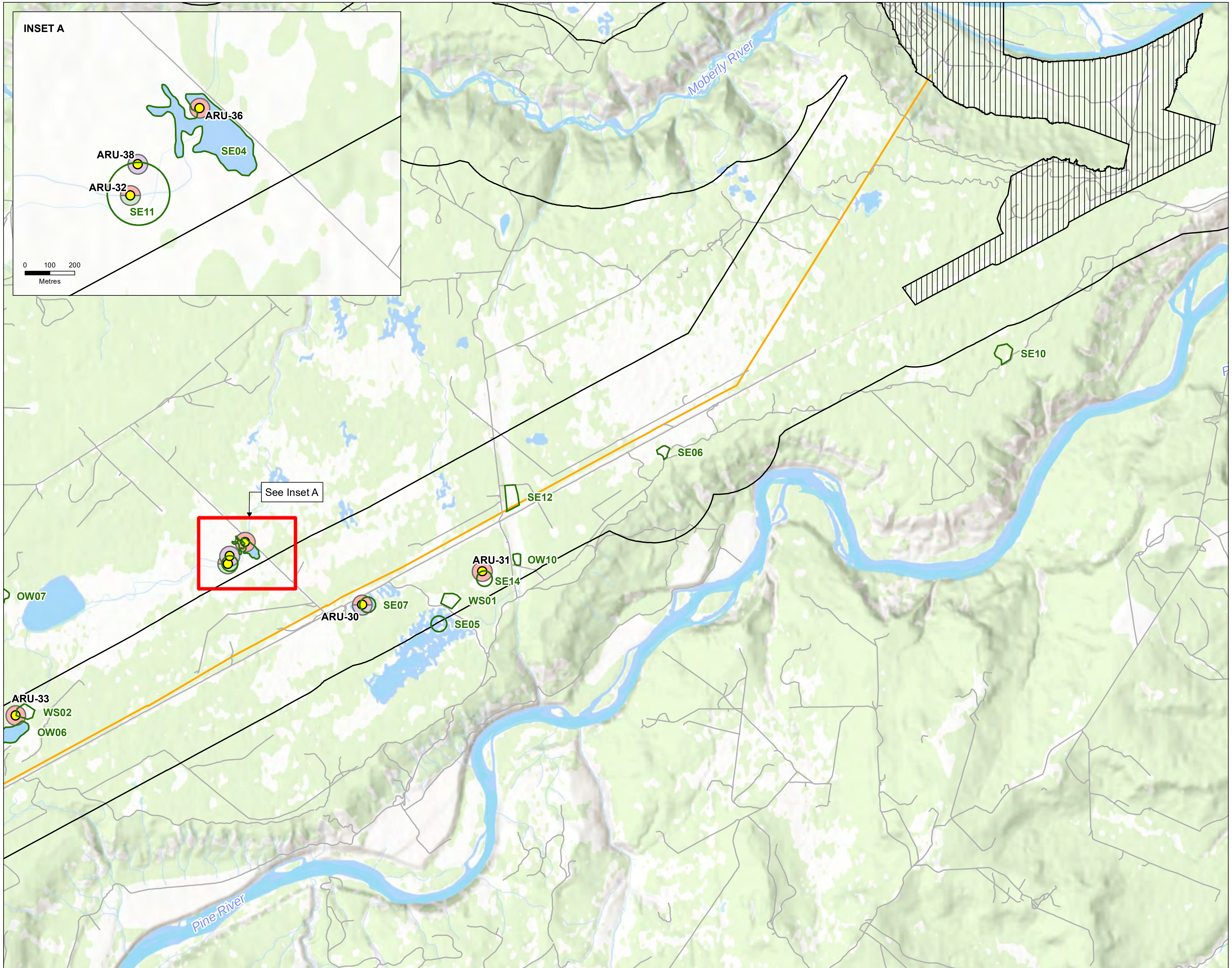
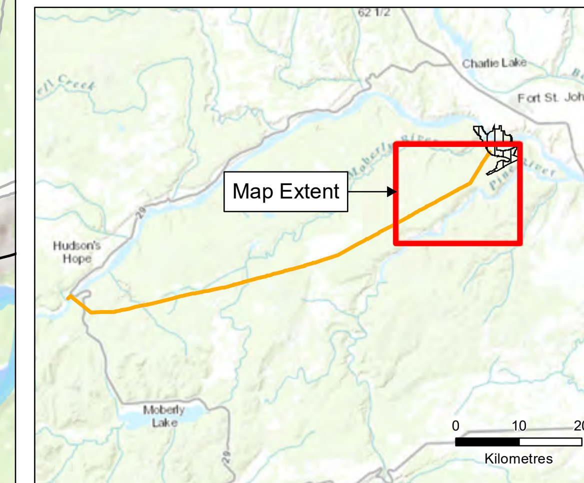
Site C, Peace River, BC

Figure 13 - Wetland Survey Stations and ARU Monitoring Locations on the Transmission Line Route (East)





Legend

- 2022 ARU Deployment
- Site C LAA
- Proposed Dam Site
- Wetland Survey Station
- Access / Service Road
- Transmission Line Right-of-Way

Positive Detections of Targeted Species

- SORA
- VIRA
- YERA

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
3. OW has been used as the idientfier for Shallow Open Water wetland field locations; however, please note that the wetland classification also includes LA and PD habitat codes.

Sources

- Basemap: ESRI World Topographic Base

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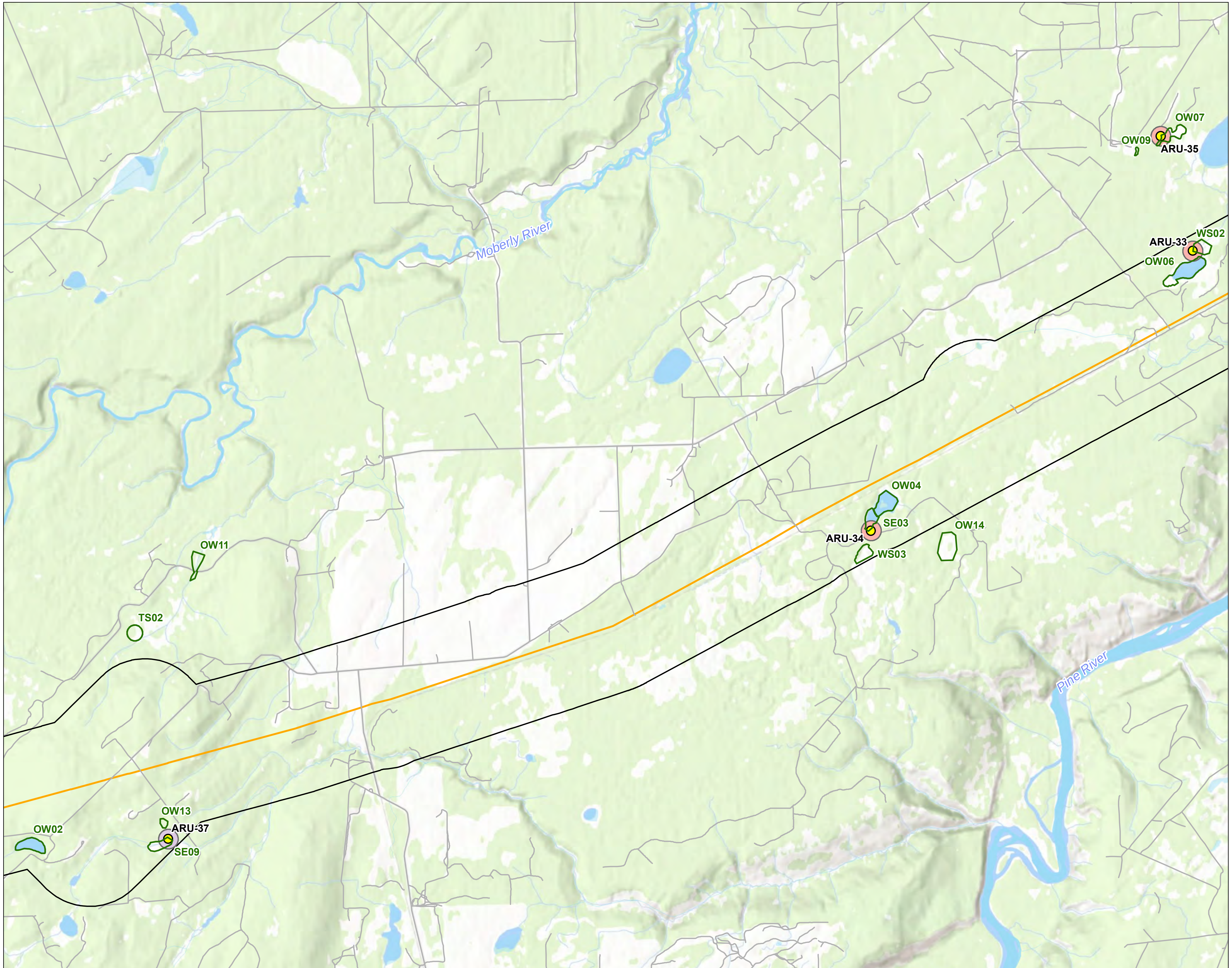
Page Size: 11" x 17"

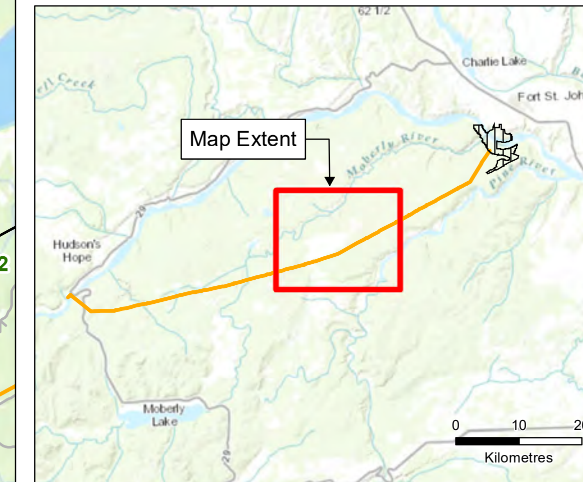
989619-07	Production Date: Mar 10, 2023	Figure 13

Ausenco BChydro

Migratory Waterbird Follow-up Monitoring Program
2022 Report
Site C, Peace River, BC

Figure 14 - Wetland Survey Stations Locations on the Transmission Line Route (Central)





Legend

- 2022 ARU Deployment
- Site C LAA
- Wetland Survey Station
- Access / Service Road
- Transmission Line Right-of-Way

Positive Detections of Targeted Species

- SORA
- VIRA

Notes

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3. OW has been used as the identfier for Shallow Open Water wetland field locations; however, please note that the wetland classification also includes LA and PD habitat codes.

Sources

- Basemap: ESRI World Topographic Base

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Kilometres

NAD 1983 UTM Zone 10N

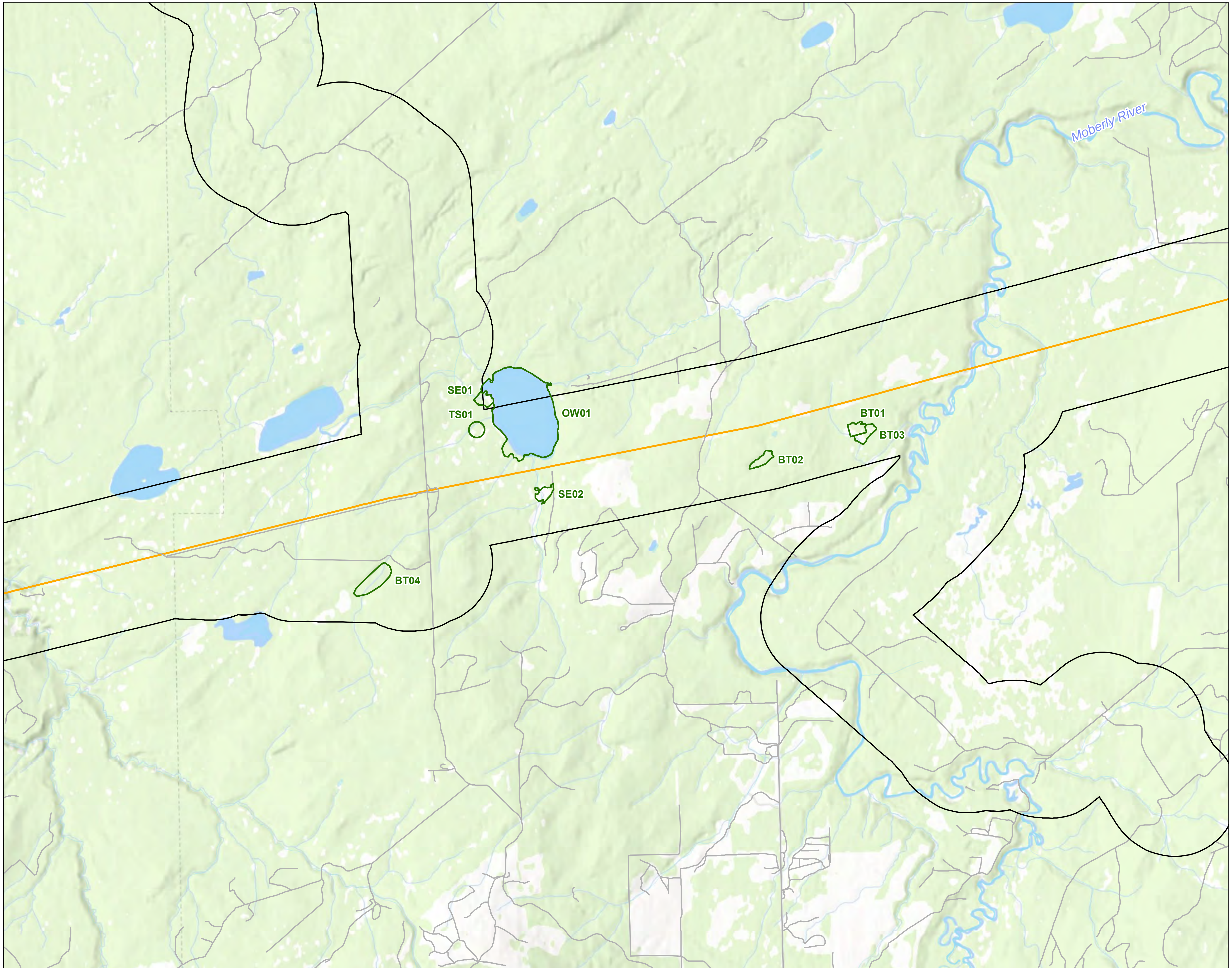
Page Size: 11" x 17"

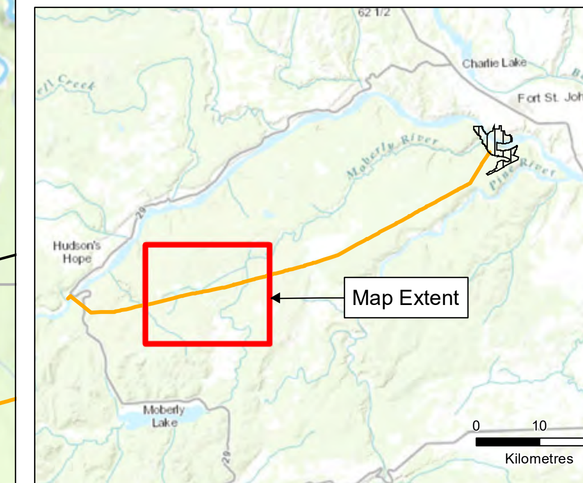
989619-07	Production Date: Mar 10, 2023	Figure 14

Ausenco BC hydro

Migratory Waterbird Follow-up Monitoring Program
2022 Report
Site C, Peace River, BC

Figure 15 - Wetland Survey Stations Locations on the Transmission Line Route (West)





Legend

- Site C LAA
- Wetland Survey Station
- Access / Service Road
- Transmission Line Right-of-Way

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
3. OW has been used as the idientfier for Shallow Open Water wetland field locations; however, please note that the wetland classification also includes LA and PD habitat codes.

Sources

- Basemap: ESRI World Topographic Base

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Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-07	Production Date: Mar 10, 2023	Figure 15

Ausenco BC hydro

4.2.2 Abundance and Density

Summaries of waterbird observations are presented below for habitat types surveyed by transect and standwatch methods. For the purposes of annual reporting, waterbird observation data are summarized in terms of density. For standwatch surveys of permanent water features (e.g., lakes) as well as inundated sedge and inundated willow-sedge habitats (**Table 18**, **Table 19**), density was calculated as the number of waterbirds per square kilometre of open water. For transect surveys, results are presented in terms of the density of waterbirds per kilometre of transect length within sedge and willow-sedge habitats with water levels less than 50 cm (**Table 20**, **Table 21**). The results of bioacoustics monitoring are described in terms of the proportion of monitoring locations where species were confirmed to be present, based on presence/not detected results for target species from each monitoring location (**Table 22**).

4.2.2.1 Transect and Standwatch Surveys

A list of the species and numbers of waterbirds observed during transect and standwatch surveys in 2022 and across all monitoring years is presented within **Appendix B**[3]. Standwatch surveys detected 9,360 waterbirds from 2017 through 2022 (**Appendix B-1**), including 1,523 waterbirds in 2022, of which 77% were identified to species (**Appendix B-2**). Across years, mean densities of waterbirds recorded during the late fall period were less than one third of any other period during spring or fall. Waterbirds observed during standwatch surveys were primarily comprised of dabbling ducks and benthic-feeding divers (**Table 18**). Estimates of foraging guild densities within open water habitats specific to survey periods in 2022 are presented in **Table 19**, and estimates of interannual variability are presented in **Appendix E** (**Table E-18**).

Table 18 Mean Waterbird Densities (Birds/km^2/Survey) within Open Water Habitat Reported by Foraging Guild from Standwatch Surveys, 2017 to 2022

Foraging Guild	Spring		Fall			
	Middle	Late	Early	Early-Middle	Late-Middle	Late[1]
Benthic-feeding Divers	162	125	196	166	143	41
Dabbling Ducks	696	576	752	690	517	96
Gulls	2	6	1	0	0	0
Large Dabblers	180	56	27	21	13	1
Marsh Birds	1	26	10	12	0	0
Piscivorous Divers	9	22	25	37	21	24
Shorebirds	53	102	96	10	0	0
Unknown Waterbirds	<1	18	22	5	35	26
Total (All Waterbirds)	**1,102**	**928**	**1,129**	**941**	**730**	**188**

Note: Mean densities reflect relative rather than absolute densities as they do not account for incomplete detection. Mean relative densities were calculated by averaging relative density across survey rounds first within each period per year, and then across years to avoid bias associated with uneven sampling effort in some periods and years. Results include survey data from permanent open water habitat, flooded vegetated wetlands, and open water areas with interspersed vegetation such as rushes and sedge.

[1]Means from late fall are calculated from data collected prior to 2020. Wetland surveys were not completed during late fall after 2019 as per Native Plant Solutions' guidance informed by power analyses.

[3] Total abundances of species presented in Appendix B and total species richness statistics in tables 23, 24, 25, and 26 exclude incidental records and results of repeated surveys conducted to estimate detection probability. For example, 3 Pacific loon (*Gavia pacifica*) were observed during a repeat survey at OW-01 during the fall of 2022, but species is not shown in summary statistics within Appendix B or in diversity statistics summarized in Section 4.2.3.

Table 19 Mean Waterbird Densities (Birds/km^2/Survey) within Open Water Habitat Reported by Foraging Guild from Standwatch Surveys, 2022

Foraging Guild	Spring		Fall			
	Middle	Late	Early	Early-Middle	Late-Middle	Late[1]
Benthic-feeding Divers	257	92	35	88	100	-
Dabbling Ducks	1,521	471	1,036	982	658	-
Gulls	1	4	2	0	0	-
Large Dabblers	740	57	83	7	45	-
Marsh Birds	0	12	54	0	0	-
Piscivorous Divers	34	22	9	8	4	-
Shorebirds	222	155	38	0	0	-
Unknown Waterbirds	0	13	1	3	0	-
Total (All Waterbirds)	**2,776**	**825**	**1,258**	**1,088**	**807**	**-**

Note: Mean densities reflect relative rather than absolute densities as they do not account for incomplete detection. Mean relative densities were calculated by averaging relative density across survey rounds first within each period per year, and then across years to avoid bias associated with uneven sampling effort in some periods and years. Results include survey data from permanent open water habitat, flooded vegetated wetlands, and open water areas with interspersed vegetation such as rushes and sedge.
[1] Dashes indicate no surveys conducted during the late fall survey period.

Transect surveys of vegetated wetlands with low water levels resulted in detections of 423 waterbirds within sedge and willow-sedge habitat across 2018 through 2022 (**Appendix B-1**)**,** including 76 waterbirds detected during surveys conducted in 2022 (**Appendix B-2**). Due to the proximity of observers, 99% of waterbird individuals were identified to species in 2022.

Mean densities observed within vegetated habitats were highest during late spring in all survey years (**Table 20**), as well as during 2022 (**Table 21**). In contrast, no waterbirds were detected during transect surveys on the Moberly Plateau and adjacent to the Site C transmission line ROW during surveys conducted in late fall during 2018 and 2019 (**Table 20**). Due to the lack of observations in these years, no transect surveys were conducted during late fall in 2020, 2021, or 2022. As mentioned previously, no surveys were conducted in the early spring because wetlands are largely covered in ice and snow during that time and are therefore unavailable to waterbirds. Estimates of foraging guild densities within open water habitats specific to survey periods in 2022 are presented in **Table 21**, and estimates of interannual variability are presented in **Appendix E** (**Table E-20**)**.**

Table 20 Mean Waterbird Densities (Birds/km/Survey) within Vegetated Wetland (Sedge, Willow-Sedge) Habitat Reported by Foraging Guild from Transect Surveys, 2018 through 2022

Foraging Guild	Spring		Fall			
	Middle	Late	Early	Early-Middle	Late-Middle	Late[1]
Benthic-feeding Divers	0.00	0.00	0.00	0.00	0.00	0.00
Dabbling Ducks	1.38	6.74	0.07	0.58	1.37	0.00
Gulls	0.00	0.00	0.00	0.00	0.00	0.00
Large Dabblers	0.27	0.24	0.00	0.00	0.00	0.00
Marsh Birds	0.79	3.43	1.34	1.39	0.30	0.00
Piscivorous Divers	0.00	0.09	0.00	0.00	0.00	0.00
Shorebirds	0.64	2.85	0.10	0.00	0.00	0.00
Unknown Waterbirds	0.00	0.00	0.00	0.00	0.00	0.00
Total (All Waterbirds)	**3.08**	**13.35**	**1.51**	**1.97**	**1.66**	**0.00**

Note: Mean densities reflect relative rather than absolute densities as they do not account for incomplete detection. Mean relative densities were calculated by averaging relative density across survey rounds first within each period per year, and then across years to avoid bias associated with variable survey effort across survey periods and years.

[1]Means from late fall are calculated from data collected prior to 2020. Wetland surveys were not completed during late fall after 2019 as per Native Plant Solutions' guidance informed by power analyses.

Table 21 Mean Waterbird Densities (Birds/km/Survey) within Vegetated Wetland (sedge, willow-sedge) Habitat Reported by Foraging Guild from Transect Surveys, 2022

Foraging Guild	Spring		Fall			
	Middle	Late	Early	Early-Middle	Late-Middle	Late[1]
Benthic-feeding Divers	0.00	0.00	0.00	0.00	0.00	-
Dabbling Ducks	0.00	1.16	0.00	0.00	0.00	-
Gulls	0.00	0.08	0.00	0.00	0.00	-
Large Dabblers	0.15	0.48	0.14	0.10	0.05	-
Marsh Birds	0.00	0.00	0.00	0.00	0.00	-
Piscivorous Divers	0.05	0.80	0.05	0.00	0.00	-
Shorebirds	0.20	2.52	0.19	0.10	0.05	-
Unknown Waterbirds	0.00	0.00	0.00	0.00	0.00	-
Total (All Waterbirds)	**0.40**	**5.04**	**0.38**	**0.20**	**0.09**	**-**

Note: Mean densities reflect relative rather than absolute densities as they do not account for incomplete detection. Mean relative densities were calculated by averaging relative density across survey rounds within each period.

[1] Dashes indicate no surveys conducted during the late fall survey period.

4.2.2.2 Bioacoustics Monitoring

Sora was detected at all locations monitored with bioacoustics methods in 2017 through 2021 and was detected from 7 of 9 ARU deployments in 2022 (**Table 22**). No American bittern vocalizations were recorded at any location in any year. Yellow rail was detected from 13 of 40 bioacoustics monitoring (i.e., ARU) deployments across years, and from one of 9 ARU deployments in 2022 (**Table 22**). Virginia rail was detected from 6 of 24 ARU deployments across years (2020, 2021, and 2022) including 3 of 9 deployments in 2022 (**Table 22**).

Table 22 Bioacoustics Monitoring Locations, Habitat Description, Timing, and Confirmed Detections of Target Species from 2022 and Summarized across all Years of Monitoring (2017 to 2022).

ARU Survey ID	Latitude	Longitude	Habitat type	Wetland Survey Station	Dates of Acoustic Monitoring	Number of Nights	Sora	Yellow Rail	American Bittern	Virginia Rail[1]
2022										
ARU-30	56.10633	-121.06543	Willow sedge, sedge, upland forested	SE-07	May 19 to Jun 8	20	Yes	No	No	Yes
ARU-31	56.11069	-121.03410	Willow sedge, sedge, upland forested	SE-14	May 19 to Jun 14	26	Yes	No	No	No
ARU-32	56.11282	-121.09993	Willow sedge, sedge, upland forested	SE-11	May 19 to Jun 15	27	Yes	Yes	No	No
ARU-33	56.09171	-121.15589	Upland forested, willow sedge, sedge	WS-02	Jun 15 to Jul 11	26	Yes	No	No	No
ARU-34	56.05245	-121.24100	Upland forested, open water, sedge	SE-03	Jun 15 to Jul 26	41	Yes	No	No	No
ARU-35	56.10845	-121.16341	Upland forested, open water, sedge	OW-07	Jun 15 to Jul 20	35	Yes	No	No	No
ARU-36	56.11591	-121.09529	Willow sedge, sedge	SE-04	Jul 26 to Aug 10	15	Yes	No	No	No
ARU-37	56.01027	-121.42457	Willow sedge, upland forested, sedge, open water	SE-09	Jul 27 to Aug 11	15	No	No	No	Yes
ARU-38	56.11394	-121.09940	Willow sedge, sedge, upland forested	SE-11	Jul 27 to Aug 31	35	No	No	No	Yes
2022 Totals						**240**	**7/9**	**1/9**	**0/9**	**3/9**
2017-2022 Totals						**788**	**38/40**	**13/40**	**0/40**	**6/24**

Notes: [1] ARU data only reviewed for Virginia rail in 2020 and subsequent years as the species was not assessed or documented within the study area during baseline studies and was considered outside of the species' range in 2019 and prior years.

4.2.3 Diversity

In total, but excluding repeated survey and incidental records, 45 waterbird species were detected from standwatch surveys conducted during the spring and fall of 2017 through 2022 (**Table 23**), including 37 species in 2022 (**Appendix B-2**). Transect surveys detected 19 species during 2018 to 2022 (**Table 23**), 12 of which were observed in 2022 (**Appendix B-2**).

The most diverse foraging guilds observed during standwatch surveys of open water and flooded wetlands were dabbling ducks followed by piscivorous divers with 13 and 10 species observed, respectively, from 2017 through 2022 (**Table 23**). During transect surveys of vegetated wetlands, dabbling ducks were the most species-rich guild observed, with 8 species. No more than 4 species of any other guild were observed during transect surveys and gulls were entirely absent from transect survey records.

Table 23 Cumulative 2017 Through 2021 Species Richness of Waterbird Foraging Guilds Observed During Transect and Standwatch Surveys of Wetland Habitats

Foraging Guild	Transect Surveys 2018 to 2022		Standwatch Surveys 2017 to 2022	
	Number of Species	Proportion of Species	Number of Species	Proportion of Species
Benthic-feeding Divers	1	0.05	7	0.16
Dabbling Ducks	8	0.42	13	0.29
Gulls	0	0.00	4	0.09
Large Dabblers	2	0.11	2	0.04
Marsh Birds	3	0.16	2	0.04
Piscivorous Divers	1	0.05	10	0.22
Shorebirds	4	0.21	7	0.16
Total	**19**		**45**	

Average species richness and evenness were calculated across years for each foraging guild in each survey period for standwatch surveys of open water habitat (**Table 24**) and transect surveys of vegetated habitat (**Table 26**). Diversity metrics within open water and vegetated habitats along the transmission line ROW were apparently highest in the late spring during 2022, and across all monitoring years (**Table 24**, **Table 25, Table 26, Table 27**). Species richness and evenness statistics are provided for the current reporting year in **Table 25** and **Table 27**, and statistics describing interannual variability are available in **Appendix E** for open water and vegetated wetland habitats within **Table E-24** and **Table E-26**, respectively.

Table 24 Mean 2017 Through 2022 Species Richness of Waterbird Foraging Guilds within Open Water Wetland Habitat by Survey Period Observed during Standwatch Surveys

Foraging Guild	Spring			Fall			
	Early[1]	Middle	Late	Early	Early-Middle	Late-Middle	Late[2]
Benthic-feeding Divers	-	2.5	3.6	2.0	1.9	2.3	2.0
Dabbling Ducks	-	6.0	7.5	5.6	6.4	5.5	4.0
Gulls	-	0.3	0.8	0.7	0.0	0.0	0.0
Large Dabblers	-	1.5	1.8	0.8	1.2	0.9	1.0
Marsh Birds	-	0.4	0.9	0.3	0.7	0.0	0.0
Piscivorous Divers	-	1.8	3.5	3.2	3.3	2.5	2.0
Shorebirds	-	1.0	2.5	1.5	0.3	0.0	0.0
Total Species Richness	**-**	**13.1**	**20.6**	**14.0**	**13.8**	**11.3**	**9.0**
Species Evenness	**-**	**0.8**	**0.8**	**0.8**	**0.8**	**0.7**	**0.7**

Note: Average diversity statistics were determined by calculating mean richness and evenness across survey rounds first within each period per year, and then across years to avoid bias associated with variable survey effort across survey periods and years.

[1] Dashes indicate no surveys conducted during some survey periods or insufficient data for summary statistic calculations.

[2]Means from late fall are calculated from data collected prior to 2020. Wetland surveys were not completed during late fall after 2019 as per Native Plant Solutions' guidance informed by power analyses.

Table 25 Species Richness in 2022 for Waterbird Foraging Guilds within Open Water Habitat by Survey Period Observed during Standwatch Surveys

Foraging Guild	Spring Survey Periods			Fall Survey Periods			
	Early[1]	Middle	Late	Early	Early-Middle	Late-Middle	Late[1]
Benthic-feeding Divers	-	2.0	6.0	3.0	2.0	3.0	-
Dabbling Ducks	-	8.0	9.0	8.0	7.0	10.0	-
Gulls	-	1.0	1.0	1.0	0.0	0.0	-
Large Dabblers	-	2.0	2.0	1.0	1.0	1.0	-
Marsh Birds	-	0.0	2.0	0.0	0.0	0.0	-
Piscivorous Divers	-	4.0	7.0	4.0	5.0	2.0	-
Shorebirds	-	2.0	4.0	2.0	0.0	0.0	-
Total Species Richness	**-**	**19.0**	**30.0**	**19.0**	**15.0**	**16.0**	**-**
Species Evenness	**-**	**0.8**	**0.8**	**0.8**	**0.7**	**0.8**	**-**

Note: [1] Dashes indicate no surveys conducted during some survey periods or insufficient data for summary statistic calculations.

Table 26 Mean 2018 Through 2022 Species Richness of Waterbird Foraging Guilds within Sedge and Willow-sedge Wetland Habitat by Survey Period Observed during Transect Surveys

Foraging Guild	Spring			Fall			
	Early[1]	Middle	Late	Early	Early-Middle	Late-Middle	Late[2]
Benthic-feeding Divers	-	0.0	0.1	0.0	0.0	0.0	0.0
Dabbling Ducks	-	1.1	3.5	0.8	0.5	0.3	0.0
Gulls	-	0.0	0.0	0.0	0.0	0.0	0.0
Large Dabblers	-	0.5	0.3	0.0	0.0	0.0	0.0
Marsh Birds	-	1.2	2.1	1.4	1.3	0.6	0.0
Piscivorous Divers	-	0.0	0.2	0.0	0.0	0.0	0.0
Shorebirds	-	1.2	1.2	0.2	0.0	0.0	0.0
Total Species Richness	**-**	**4.0**	**7.4**	**2.4**	**1.8**	**0.9**	**0.0**
Species Evenness	**-**	**0.7**	**0.8**	**0.8**	**0.7**	**0.2**	**-**

Note: Average diversity statistics were determined by calculating mean richness and evenness across survey rounds first within each period per year, and then across years to avoid bias associated with variable survey effort across survey periods and years.

[1]Dashes indicate no surveys conducted during some survey periods, or insufficient data for summary statistic calculations.

[2]Means from late fall are calculated from data collected prior to 2020. Wetland surveys were not completed during late fall after 2019 as per Native Plant Solutions' guidance informed by power analyses.

Table 27 Species Richness in 2022 for Waterbird Foraging Guilds within Sedge and Willow-sedge Wetland Habitat by Survey Period Observed during Transect Surveys

Foraging Guild	Spring			Fall			
	Early[1]	Middle	Late	Early	Early-Middle	Late-Middle	Late[1]
Benthic-feeding Divers	-	0.0	0.0	0.0	0.0	0.0	-
Dabbling Ducks	-	0.0	6.0	0.0	0.0	0.0	-
Gulls	-	0.0	0.0	0.0	0.0	0.0	-
Large Dabblers	-	0.0	1.0	0.0	0.0	0.0	-
Marsh Birds	-	1.0	3.0	1.0	1.0	1.0	-
Piscivorous Divers	-	0.0	0.0	0.0	0.0	0.0	-
Shorebirds	-	1.0	2.0	1.0	0.0	0.0	-
Total Species Richness	**-**	**2.0**	**12.0**	**2.0**	**1.0**	**1.0**	**-**
Species Evenness	**-**	**0.8**	**0.9**	**0.8**	**-**	**-**	**-**

Note: [1] Dashes indicate no surveys conducted during some survey periods or insufficient data for summary statistic calculations.

4.2.4 Waterbird Species at Risk

The following species designated as at risk, as per provincial, SARA, or COSEWIC rankings, were observed during 2017 through 2022 transmission line wetland surveys:

- Eared grebe, BC listing (Blue)
- Horned grebe, COSEWIC and SARA (Special Concern)
- Long-tailed duck, BC listing (Blue)
- Red-necked phalarope, BC listing (Blue). COSEWIC and SARA (Special Concern)
- Surf scoter, BC listing (Blue)
- Western grebe (*Aechmophorus occidentalis*), BC listing (Red), COSEWIC and SARA (Special Concern)
- Yellow rail (*Coturnicops noveboracensis*), BC listing (Red), COSEWIC and SARA (Special Concern).

Across years, the most commonly observed waterbird species at risk within wetlands was surf scoter (117 birds observed). Horned grebes (89 birds observed) and eared grebes (85 birds observed) were also regularly recorded. Fewer than 30 of other species at risk were counted within wetlands across the 5 survey years (**Appendix B-1**). Eared grebe (7 birds observed), horned grebe (6 birds observed), surf scoter (6 birds observed), and yellow rail (1 bird observed), were all recorded during wetland transect or standwatch surveys in 2022 (**Appendix B-2**).

5.0 Discussion

As per the objectives described in **Section 1.2**, the monitoring program has improved understanding of baseline conditions for waterbirds, including assessment of habitat and documentation of habitat-specific measures of relative abundance and diversity for waterbird foraging guilds. The results obtained are discussed below within the context of these monitoring objectives and prior understanding regarding baseline conditions for waterbirds and their habitat within the Peace River Valley and wetlands on the Moberly Plateau.

5.1 Habitat Assessment

Waterbird habitat associations (e.g., river and wetland habitat types) and habitat characteristic data (e.g., TEM and Peace River flow rates) collected during 2017 through 2022 improve understanding of baseline conditions and factors influencing the distribution and abundance of waterbirds. Waterbird location and habitat association data collected during this monitoring program provide increased resolution compared to the data available prior to 2017, in which bird observations were recorded within 5 km segments without habitat characteristics.

While TEM provides informative wetland habitat data, it does not include landform information pertinent to waterbird presence on the Peace River, where river dynamics can change habitat from year to year. Re-characterization of habitat types along the Peace River following Project commissioning will provide comparisons of habitat availability relative to Project-related changes to impact treatment areas. LiDAR data of the Peace River Valley may also be considered in future analyses to assess the influence of topographic characteristics such as water depth on waterbirds. Similarly, river levels may influence waterbird abundances or diversity and can be considered in models assessing the magnitude and significance of Project-related changes to those measures. Consideration of flow rate as a co-variate within future BACI models should account for the influence of river levels on waterbird abundance or density, including potential bias from surveys conducted under atypical conditions. For example, high river levels could result in a re-distribution of dabbling waterbirds from Mainstem and Moderate Flow habitats to more shallow areas such as Minimal and Limited Connectivity habitat types where suitable foraging depths persist. Inclusion of flow rate as a co-variate in analyses could account for such variation and increase power to detect change.

Once the Site C reservoir begins to fill (currently anticipated during fall 2023), waterbird abundance and diversity metrics in the Inundation Impact area will no longer be influenced by river flow rates. Reservoir levels can be recorded during this period, but fluctuations in reservoir water levels are unlikely to affect waterbird distribution.

5.2 Peace River Waterbird Surveys

Boat surveys of the Peace River in 2017 through 2022 have provided estimates of relative abundance and diversity throughout the spring and fall migrations to meet the waterbird monitoring program objectives (**Section 1.2**). All target taxa, including shorebirds, were observed during boat surveys. Results from Peace River observations in 2017 through 2022 identified 94% of birds to the species level and 98% of records to the foraging guild level at which Project-related effects are to be assessed (**Appendix B-1**). This represents a substantial improvement over survey methods applied prior to 2017, which were unable to detect shorebirds and had species identification rates under 80% (Hemmera Envirochem Inc. 2017). Results of

Peace River surveys are discussed below, first summarizing the relative abundance of foraging guilds and highlighting the most abundant species, then discussing patterns of abundance and diversity across habitat types along with the distribution of waterbirds across treatment areas and implications for assessing Project-related change.

Although analyzing trends and patterns of waterbird abundance and diversity across survey periods is not an objective of the study, it is nonetheless worth mentioning the data limitations that affect annual comparisons between survey periods within each season. A greater level of effort was applied during the first three years of monitoring (2017 through 2017) to inform an efficient allocation of survey effort and provide confidence in meeting the study objectives (see the power analysis described in Appendix A). Thus, data from these first three years of monitoring are the most suitable for evaluating temporal variation in abundance and diversity within seasons (i.e., among survey periods in spring and fall). Details and discussion of differences among survey periods assessed during the first 3 years of monitoring are provided in the 2019 annual report (Hemmera Envirochem Inc. 2020) and **Appendix A**. Subsequent surveys and assessments of project-related change will focus on the focal spring and fall survey periods assessed since 2020 and are not designed to assess or interpret variability among periods no longer surveyed.

The most abundant foraging guilds observed in the Peace River study area were large dabblers followed by dabbling ducks and gulls, while benthic-feeding divers, piscivorous divers, and shorebirds were the least-abundant waterbird guilds observed on the Peace River. At the species level, the most numerous waterbird observed on the Peace River across all years was Canada goose, followed by mallard, Bonaparte's gull (*Chroicocephalus philadelphia*), and Franklin's gull (*Leucophaeus pipixcan*) (**Appendix B-1**). Surveys in 1996 and 1999 resulted in similarly high abundances of Canada goose relative to other species, which made up over 50% of the observed waterbirds (Robertson 1999; Robertson and Hawkes 2000; Hawkes et al. 2006).

Data collected in 2017 through 2022 show that all habitats in the Peace River are used by waterbirds, with variations in timing, distribution and abundance for each foraging guild. The greatest densities of waterbirds were consistently observed within Limited Connectivity habitat, such as backchannels with little to no flow, silty sediments, and relatively abundant aquatic vegetation. Higher densities of dabbling ducks and large dabblers within more shallow habitats (e.g., Limited Connectivity and Moderate Flow habitats) align with findings from other studies assessing waterbirds associations with wetlands of various water depths (Colwell and Taft 2000; Baschuk et al. 2012). In contrast with findings from these prior studies, benthic-feeding and piscivorous divers were also observed in higher densities within shallow Limited Connectivity habitat as compared to deeper waters within Mainstem habitat of the Peace River. This result suggests that prey availability for diving birds is greater within shallow habitat but may also reflect higher use of these more sheltered habitats to reduce exposure to predators or to rest away from higher-energy flows within Mainstem habitat. Despite higher densities within Limited Connectivity habitat, more birds were observed within the Mainstem of the Peace River than in any other habitat type. This is not surprising given that Mainstem habitat comprised the greatest proportion (77%) of the study area.

While overall densities of waterbirds observed across Peace River habitat types were highest in Limited Connectivity habitat regardless of season, densities varied between Mainstem and Moderate Flow habitats between seasons. In spring, waterbirds were observed in higher densities within Moderate Flow compared to Mainstem habitat, whereas densities were relatively even during fall. This finding appears to be driven by relatively low densities of dabbling ducks and large dabblers (e.g., Canada goose) within Moderate Flow habitat in spring, and higher abundances of gulls in the fall in most years, which were primarily recorded in Mainstem habitat in both seasons. However, in 2022, densities of gulls within Mainstem habitat were far lower than in prior years. This result is likely due to the exclusion of areas immediately around the Site C dam, where large flocks of gulls (hundreds and occasionally over 1,000) had been recorded in prior years on gravel bars.

Differences in detection rates across habitat types may contribute to higher apparent densities of some species within Limited Connectivity and Moderate Flow relative to Mainstem habitats given that the distance to detection is typically smaller within shallower habitats and birds are more readily flushed and detected in these circumstances. Thus, it is likely that detection rates of small birds (e.g., benthic-feeding divers, shorebirds, dabbling ducks) was greater within Limited Connectivity and Moderate Flow as compared to Mainstem habitats. Such potential biases related to distance to detection can be accounted for in analyses of Project-related effects through the application of distance sampling (Buckland et al. 2015), for which distance to detection measures have been recorded during surveys. Waterbird records are not tied to the river habitat categories applied in the summary statistics of this report. Thus, habitat types and assignments can be refined or reclassified to account for other factors if they are found to explain variation in waterbird abundance better than the habitat types proposed here.

Surf scoter was the only species at risk regularly observed during Peace River surveys, with a total of 271 detected across years, including 65 during monitoring in 2022. California gull and tundra swan are similar in appearance to other species, so their numbers may have been underestimated. Some California gull detections may have been recorded as unknown gull species. Similarly, some tundra swan detections may have been recorded as unknown swan species or pooled with records of trumpeter swan (*Cygnus buccinator*).

The summary of data within treatment areas found that waterbird densities were similar within the Control and impact areas. All foraging guilds occurring within the impact areas were also found to be present within the Control area in both spring and fall, therefore meeting a standard assumption for BACI study design and data analysis. However, the numbers and densities of benthic-feeding divers and gulls observed within the control area are low relative to the impact areas. The high numbers of gulls in the Flow Impact area, particularly during fall in years prior to 2022, explain some of the divergence in gull densities across treatment areas. As described above, most gulls are concentrated around disturbed habitat at the Project construction site and close to the local landfill, but this area could not be surveyed by boat in 2022 due to the construction activities in the area. Exclusion of these areas will be accounted for in future analyses of project-related effects. While benthic-feeding divers are found in low densities within the Control relative to other treatment areas, they are present and will still provide some indication of background variations in density under baseline (i.e., ‘before’) and operations period (i.e., ‘after’) conditions.

5.3 Transmission Line Wetland Surveys

Wetland surveys along the transmission line successfully provided estimates of spring and fall relative abundance and diversity of waterbirds in suitable wetland habitat types. Survey results provide the data required to meet the study’s monitoring objectives (**Section 4.2**). A representative suite of sampling stations has been established, and consistent monitoring of these has been conducted in 2018 through 2022. Additionally, 6 consecutive years of monitoring have been conducted within open water wetland habitats surveyed by standwatch methods. Taken together, these methods provide density and relative abundance data for all wetland habitats where waterbirds have been found to regularly occur and are sufficient to characterize the relative abundance and diversity of waterbirds during spring and fall migration, which is briefly summarized below.

Due to a few records of large flocks of waterbirds observed at far distances (i.e., around 1 km) during standwatch surveys, relatively low species level identification (77% of waterbirds observed) was obtained during standwatch surveys conducted in 2022 compared to other recent years of monitoring (Hemmera Envirochem Inc. 2022). While species level identification was not possible for some of these flocks, observers were able to identify the foraging guild for 97% of the waterbirds observed. Thus, the lack of species level resolution from these records should not negatively impact the study's ability to detect changes in waterbird abundances at the foraging guild level, as per the study objective. However, in cases where 90% or more of observable birds cannot be identified to species, crews will approach the unidentifiable birds to obtain a positive identification. Nevertheless, the proportion of waterbird detections identified to the species level will be taken into consideration when assessing diversity across years and before versus after project operations.

The dabbling duck foraging guild, encompassing small species of duck that primarily forage on aquatic vegetation, were the most commonly recorded foraging guild in open water and flooded sedge and willow-sedge wetlands surveyed by standwatch. Ring-necked duck (*Aythya collaris*), American wigeon (*Mareca americana*), scaup species (*Aythya* spp.), green-winged teal (*Anas crecca*) and mallards were among the most numerous species observed. Vegetated wetland surveys conducted by walking transects found dabbling ducks (e.g., mallards, green- and blue-winged teal [*Spatula discors*], northern shoveler [*Spatula clypeata*]) and marsh birds (e.g., Wilson's snipe [*Gallinago delicata*], and sora) were most abundant, with 200 and 139 records across years, respectively (**Appendix B-1**). Shorebirds (e.g., spotted sandpiper [*Actitis macularius*]) were the next most abundant with 74 records.

The number of birds detected at the species level during wetland transect and standwatch surveys were similar to findings from 2006 and 2008, when mallards and American wigeons accounted for 69% of the observations in wetlands (EIS, Appendix R, part 4) and are aligned with prior reports from this monitoring program (Hemmera Envirochem Inc. 2018, 2019, 2020, 2021, 2022). Open water habitats such as lakes and ponds had the greatest number of waterbird observations and the highest diversity, mostly of dabbling ducks. Again, this is consistent with the 2006 through 2008 studies in the transmission line ROW area (EIS, appendix R, part 4) and 2017 (Hemmera Envirochem Inc. 2018). While fewer waterbirds were observed within sedge and willow-sedge habitats surveyed by transect methods, these surveys documented abundances of sora and Wilson's snipe, which seldom use flooded habitat and, consequently, are not observed during standwatch survey methods.

The timing of peak waterbird abundance and diversity is likely linked to spring thaw and the open water habitats on the Moberly Plateau becoming available. This coincides with reduced numbers of waterbirds on the Peace River, as waterbirds appear to relocate from river to upland wetlands in middle to late spring. Across survey periods, mean densities of waterbird foraging guilds were lowest in the late fall (i.e., after October 15). This likely reflects the increasingly cold conditions in mid-October and southward migration of some species. The absence of waterbirds observed from transect surveys of vegetated sedge and willow-sedge wetlands during the late fall survey periods suggests reduced vocalizations and/or presence of marsh birds and re-distribution of dabbling ducks into other habitat types during October. The lack of waterbird observations from transect surveys during late fall of 2017 through 2019 supports the discontinuation of transect surveys during this period from 2020 onwards.

Survey efforts within the wetland study area were not entirely consistent across years due to weather and access constraints. Measures of diversity will ultimately be refined by accounting for variation in survey effort in all survey years to provide cleaner comparisons, and including statistical significance tests, across years when assessing Project-related change to waterbird diversity. Similarly, while estimates of density per kilometre of transect are considered sufficient for the purposes of documenting annual data collection in this report and for documenting change over time, future analyses considering transect width and distance sampling will provide more accurate estimates of density.

Similar to the 2021 monitoring program, the 2022 study was challenged by changes to habitat within the wetland study area. During 2021 and 2022, wetland survey stations SE-12 and OW-10 were often drained of water, apparently due to the installation or modification of culverts unrelated to the project on the southern edge of these survey station polygons. Consequently, these areas were only surveyed on the rare occasions when water was present within them this year. Additional habitat was identified for surveys at stations OW-13 and OW-14 to replace these stations as stations SE-12 and OW-10 continued to be drained of water and no longer representative of suitable foraging habitat for waterbirds during surveys conducted in 2022.

The ARU survey results are satisfying monitoring objectives to document trends in the presence of yellow rail, American bittern, and sora. Beginning in 2020, ARUs have also successfully documented the presence of Virginia rail. In accordance with historical records of yellow rail illustrated in **Figure 5**, this study has regularly documented this species within relatively large areas of non-flooded sedge habitat (Hilton et al. 2013). Results from 2021 and 2022 suggest that yellow rail also occurs, albeit less-regularly, within mixed sedge and willow-sedge habitat adjacent to upland forested habitat. Results of bioacoustics monitoring also demonstrate that sora is common and American bittern is rare or absent in the wetland study area. Since no records of American bittern were confirmed during 6 years of monitoring or as part of any other Site C wildlife studies, it is unlikely that bioacoustics monitoring will yield meaningful estimates of density or distribution beyond what is already known; the species is rare and typically absent or undetected within suitable habitat in the region. In contrast, sora has been detected consistently at all but 2 deployments conducted to date, including in all wetland and mixed habitat types surveyed and all portions of the bioacoustics monitoring period (**Table 22**). Sora is often detected during wetland transect and standwatch surveys, providing robust data from multiple survey methods throughout the wetland study area.

Results of bioacoustics monitoring in 2022 and prior years provide some insight regarding potential variability in detection rates for different portions of the monitoring period applied thus far for marsh birds. Yellow rail does occur within wetlands through at least through late July, but considering that only 2 of 13 yellow rail detections were from this period, they may be less abundant or less vocally active at this time. Detections of Virginia rail in late July and August from 2 of 6 overall detections for this species are proportional to the level of effort applied to that season and do not suggest lower abundance or vocal activity at this time. The 2 ARU deployments from which sora was not detected in 2022, and the only deployments in which they were not detected across all years, were from the latest deployment period from late July and August. Sora was detected from all other later season deployments in 2022 and prior years, so the species is generally still abundant and vocal in late July and August. Virginia rail detections from 2022 indicate that presence may be consistent across years at some sites (e.g., SE-09), but not others (e.g., SE-04). Similar to sora and Virginia rail, as described above, yellow rail has been consistently recorded across years at some sites, but not others.

Continued bioacoustics monitoring with the same level of effort applied in 2022 are planned for 2023. Deployments of ARUs in 2023 are planned at stations with vegetated wetland habitat not surveyed in prior years (e.g., OW-04, OW-12, SE-12) to provide complete coverage of wetland stations before the operations period. ARUs are also planned at stations consistently monitored across years and where Virginia rail and yellow rail have both been detected previously (e.g., SE-04) to continue tracking inter-annual trends in these species' presence within the wetlands study area. Continued monitoring of open sedge and mixed willow-sedge/sedge/upland forest habitat is planned to obtain more data from habitat types with the most rail detections in prior years.

Monitoring conducted thus far has successfully collected data required to evaluate changes to baseline conditions in habitat, abundance, and diversity of waterbirds, including species at risk, as per the study objectives. Continued monitoring using methods described in this report, and applied in 2022, is planned to meet monitoring program requirements and for use in evaluations of project-related change to waterbird habitat and habitat use.

6.0 Closing

We sincerely appreciate the opportunity to have assisted BC Hydro with this project and if there are any questions, please do not hesitate to contact the undersigned by phone or email.

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Appendix A

Ducks Unlimited / Native Plant Solutions
Technical Memorandum - Waterbird Program Analysis: Statistical Analysis of Survey Effort and Timing, Combined 2017, 2018, and 2019 Peace River Waterbird Data

Ducks Unlimited Canada
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April 16, 2020

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ATTENTION: Brock Simons

RE: Waterbird Program Analysis:
Statistical Analysis of Survey Effort and Timing,
Combined 2017, 2018 and 2019 Peace River Waterbird Data

Overview

BC Hydro has requested Native Plant Solutions (NPS)/Ducks Unlimited Canada (DUC) to repeat statistical analyses performed in December 2019 on the Peace River Waterbird data, now with combined 2017, 2018 and 2019 data. The intent of this technical memo is to outline the results of the analysis, as part of preparation for the 2020 waterbird monitoring field season. Specifically, DUC reviewed survey effort and survey timing in 2017, 2018 and 2019, based on the data provided by Hemmera on November 19th, 2019 and December 18th, 2019. The review focused on the 2017-2019 River Transect Waterbird data, including statistical analyses of the difference in density observed during survey periods (Statistical Analysis #1) and the sampling effort required to detect change (Statistical Analysis #2). The analysis also determines what effect dropping the UAV portion of the survey program will have on the overall survey effort required.

Background to monitoring methodology

Statistical analysis was conducted on the combined 2017-2019 unmanned aerial vehicle (UAV) and river boat survey data. During each season of migration, the season was split into several periods (spring: early, mid, late; and fall: early, early-mid, late-mid and late). Survey effort in 2019 was kept the same as in 2018 with the goal of better capturing and defining optimal survey periods for each foraging group and determining if the late fall survey period added in 2018 improved detection of Benthic Divers. Table 1 lists the survey periods and dates for each field season.

Within most survey periods, two replicate surveys were conducted, with each survey taking two days to complete. There was an exception in 2018 where three days were required due to ice washing down the Peace River on April 26 in the middle of the survey. There was also an exception in 2019 where three days were required to complete the first survey of the season (April 3, 4, 8). Note that in spring 2017, one survey day was dropped from statistical analysis (April 12), due to poor weather and therefore low bird counts. Survey dates in 2017-2019 were as described in Table 1.

Table 1. Survey periods and dates in 2017, 2018 and 2019.

Period	2017 Dates	2018 Dates	2019 Dates
Spring_Early	Apr. 5, 6	Apr. 13, 14	Apr. 3, 4, 8; Apr. 11, 12
Spring_Mid	Apr. 26, 27; May 3, 4	Apr. 25, 26 & May 1; May 5, 6	Apr. 19, 24; May 1, 2
Spring_Late	May 10, 11; May 14, 15	May 10, 11; May 18, 19	May 9, 10
Fall_Early	Aug. 8, 9; Aug. 14, 15	Aug. 4, 5	Aug. 7, 9
Fall_Early-Mid	Aug. 22, 23; Aug. 28, 29	Aug. 20, 21; Sep. 4, 5	Aug. 19, 20; Sep. 4, 5
Fall_Late-Mid	Sep. 21, 22; Sep. 27, 28	Sep. 20, 21; Oct. 4, 5	Sep. 16, 17; Sep. 30, Oct. 1
Fall_Late	none	Oct. 15, 16	Oct. 16, 17

In this technical memo, the following terminology is used when referring to the waterbird monitoring program:

- **Survey period:** A survey period is the timing of when a survey happens within a season (i.e., spring or fall) to document migrants, including early, early-mid, mid, late-mid and late. The original study design of the Waterbird Migration Follow-up Monitoring Program (BC Hydro 2018) was structured to have two surveys within each period acting as replicates to provide measures of uncertainty around estimates of relative abundance and diversity. For example, late spring is a survey period, containing two surveys.
- **Survey:** A survey is the census of waterbirds over the length of the Peace River, from the Peace Canyon Dam (Hudson's Hope) to the Alberta border (BC Hydro 2018). A survey typically takes two survey days to complete. For example, April 5 and 6 in spring 2017 is an early survey. Survey effort is quantified as the total length (km) of the river impact and control areas surveyed over the course of a survey.
- **Survey day:** A survey takes two survey days (noting the above-mentioned exceptions) to complete, with half of the river study area being surveyed each day and, in most cases, the whole river being surveyed in consecutive days. Each day is referred to in this technical memo as a survey day. For example, 12 survey days were conducted in fall of 2017 (e.g., August 8, 9, 14, 15, 22, 23, 28 and 29, and September 21, 22, 27 and 28).
- **Survey Area:** A survey area is a portion of the river labelled as one of control, flow impact, and inundation impact. For the remainder of this technical memo, flow and inundation impacts will be treated together as the "impact" area.

Statistical Analysis #1 - Statistical analysis of differences in density observed during survey periods (i.e., early, mid and late) in spring and fall

Statistical Analysis #1 tests for differences among early, mid and late periods in both spring and fall survey periods. Based on the results of Statistical Analysis #1, the biological inference that can be made from this is to assess if the timing and number of survey periods in spring and fall of 2017, 2018 and 2019 were capturing peaks in abundance during migration and the specific survey timing recommended for capturing any peaks.

The spring and fall survey periods were analysed separately, fit with foraging group-specific negative binomial regression models, with total bird counts per complete river survey (normally completed over two consecutive days) as the response and survey period (Spring: early vs. mid vs. late; and Fall: early vs. early-mid vs. late-mid vs. late), study area (control vs flow and inundation impact) and year as predictors. The natural log of surveyed river length by study area (km) was used as an offset variable to scale total bird counts for differing effort across surveys. Survey period and study area were treated as additive predictors in the foraging group model since preliminary analyses suggested similar patterns in waterbird abundance peaks across the control and impact areas.

A complete list of species observed during spring and fall surveys in 2017, 2018 and 2019 is provided in Appendix A. Some species and foraging groups (e.g., bald eagles) were not included in the combined analysis due to the low densities observed. Differences in density among survey periods were also analyzed at a foraging group level. The allocation of species to each foraging group is also listed in Appendix A. Discussion of the 2017-2019 data is focused at the foraging group level because of the greater strength of inference analysis at the foraging group level allows (see NPS 2018 technical memo).

During spring migration surveys (Table 2), at a foraging group level, the early period yielded the highest counts for Large Dabblers and Piscivorous Divers and lowest counts for Surface Feeding Terns/Gulls. Late spring surveys yielded the highest counts for Shorebirds, Surface Feeding Terns/Gulls, with lowest counts for Benthic-Feeding Divers and Piscivorous Divers.

During fall migration surveys (Table 3), at a foraging group level, the early survey period yielded the highest counts for Shorebirds and lowest counts for Large Dabblers. Late-mid and late fall surveys yielded the highest counts for Large Dabblers.

Table 2. Spring survey periods results.

Forage Group	Differences in densities observed among Early, Mid, and Late Periods	Estimated number of birds seen per 100 km of river surveyed (standard error)[1]
Foraging Group Level[2]		
Benthic Feeding Divers	Early and Mid > Late	Control: E: 32.8 (12.1); M: 32.1 (12.2); L: 9.2 (3.2) Impact: E: 98.1 (36.8); M: 95.9 (29.5); L: 27.5 (10.1)
Dabbling Ducks	No	Control: 413.2 (49.2) Impact: 289.5 (33.3)
Surface Feeding Terns/Gulls	Mid and Late > Early	Control: E: 0.3 (0.3); M: 10.7 (5.4); L: 14.2 (7.5) Impact: E: 0.9 (0.6); M: 30.4 (14.8); L: 40.1 (21.2)
Large Dabblers (Geese and Swans)	Early > Mid and Late	Control: E: 1,154.0 (136.7); M: 444.3 (48.7); L: 365.8 (40.2) Impact: E: 1,151.3 (136.2); M: 443.3 (44.7); L: 365.0 (40.4)
Piscivorous Divers	Early > Mid > Late	Control: E: 79.6 (16.9); M: 33.5 (6.3); L: 19.2 (3.7) Impact: E: 183.7 (33.8); M: 77.4 (13.3); L: 44.2 (8.5)
Shorebirds	Late > Early and Mid	Control: E: 1.1 (0.6); M: 1.9 (0.9); L: 52.9 (15.7) Impact: E: 1.3 (0.6); M: 2.2 (0.8); L: 63.2 (22.6)

[1] – E: early; M: mid; L: late.

[2] – Highest survey counts for Foraging Groups are indicated in red.

Table 3. Fall survey periods results.

Species or Forage Group	Differences in densities observed among Early, Early-Mid, Late-Mid, and Late Periods	Estimated number of birds seen per 100 km of river surveyed (standard error)[1]
Foraging Group Level[2]		
Benthic-Feeding Divers	No	Control: 1.0 (0.6) Impact: 7.6 (2.9)
Dabbling Ducks	Early-Middle and Late-Middle > Late	Control: E: 16.2 (7.5); E-M: 30.2 (11.3); L-M: 35.9 (12.1); L: 4.4 (2.7) Impact: E: 185.0 (78.2); E-M: 344.2 (117.8); L-M: 409.9 (163.1); L: 50.2 (25.8)
Surface Feeding Terns/Gulls	Early, Early-Middle and Late-Middle > Late	Control: E: 12.3 (6.1); E-M: 24.8 (8.8); L-M: 9.5 (3.6); L: 1.7 (1.1) Impact: E: 591.3 (220.3); E-M: 1,190.9 (480.2); L-M: 458.1 (175.1); L: 82.5 (49.8)
Large Dabblers (Geese and Swans)	Late and Late-Middle > Early; Late-Middle > Early-Middle	Control: E: 255.0 (63.4); E-M: 469.9 (110.9); L-M: 939.5 (193.5); L: 780.6 (263.7) Impact: E: 145.1 (37.1); E-M: 267.3 (55.6); L-M: 534.5 (115.2); L: 444.1 (152.0)
Piscivorous Divers	No	Control: 16.6 (3.9) Impact: 20.7 (4.0)
Shorebirds	Early > Early-Mid > Late-Mid	Control: E: 228.5 (40.4); E-M: 96.7 (15.4); L-M: 3.5 (0.9); L: 0 (--) Impact: E: 112.2 (19.0); E-M: 47.5 (7.6); L-M: 1.7 (0.5); L: 0 (--)

[1] – E: early; E-M: early-mid; L-M: late-mid; L: late.

[2] – Highest survey counts for Foraging Groups are indicated in red.

Statistical Analysis #2 - Statistical power analysis to estimate sampling efforts required to detect change in impact area relative to control

The second objective of the statistical analysis was to conduct a power analysis, based on the available 2017, 2018 and 2019 survey data, to estimate the sampling effort required to detect change of a specific magnitude in the impact area relative to the control area. Based on the results of the statistical analysis, this provides guidance on determining the magnitude and possibilities for allocating effort to detect, with 80% statistical power, a 50% change in foraging group abundance in the impact area contrasted with no change in the control area over time.

For Statistical Analysis #2 a baseline average of relative abundances for the impact and control areas were calculated from the 2017, 2018 and 2019 survey data. Within the 2017-2019 survey data, some foraging groups exhibited differences in counts among survey periods in a season, whereas other foraging groups did not. For the foraging groups for which there were statistically detectable differences in counts across survey periods, relative abundance estimates from particular survey periods are informative baselines as identifiable 'optimal' survey periods, such that averaging across survey periods would conceal important within-season differences in relative abundances. Therefore, for foraging groups exhibiting statistically detectable differences in counts across survey periods, baseline bird densities were estimated using the survey periods that yielded the highest densities. For foraging groups without statistically detectable differences in counts across survey periods (i.e., either due to counts that did not vary much across survey periods over a season, or where counts varied greatly among surveys within a survey period), relative abundance estimates from particular survey periods are not informative baselines. Rather, pooled baseline estimates of abundance across a season are best and will mitigate the impacts of survey-specific variation. Therefore, for foraging groups where there were not statistically detectable differences in counts among survey periods, baseline bird densities were estimated using averages across all surveys.

Relative abundance is the average number of birds that were counted during a survey in a study area (control vs flow and inundation impact), per 100 km length of river surveyed. Given the best estimates of foraging group relative abundances (and their standard errors) from the 2017-2019 survey data, the statistical power analyses estimated the sampling efforts required to detect changes of a specified magnitude in the impact area as contrasted with no change in the control area. For the purposes of this analysis, a 50% change in relative abundance in the impact area was seen as a reasonable target (i.e., both statistical and biological; Hatch 2003). Tables 4 and 5 give the survey effort required to detect 50% change in relative abundance in the impact area versus no change in the control area given 2017-2019 spring (Table 4) and fall (Table 5) survey baselines. Note that survey effort is given in the number of surveys and the estimated number of years to detect change (i.e., should the current survey effort be maintained over time).

In spring (Table 4), the survey effort required to detect a 50% change in relative abundance (i.e., based on the 2017-2019 spring survey data) in the impact area versus no change in the control area was the least for Large Dabblers (Geese and Swans), with increasing survey effort to detect change in Piscivorous Divers, Dabbling Ducks, Benthic-Feeding Divers, and Surface Feeding Terns/Gulls. Note that early and mid surveys are not informative for estimating relative abundance of Shorebirds. In fall (Table 5), the survey effort required to detect a 50% change in relative abundance (i.e., based on the 2017-2019 fall survey data) in the impact area versus no change in the control area was the least for Shorebirds, with increasing survey effort to detect change in Large Dabblers, Dabbling Ducks, Piscivorous Divers, Surface Feeding Terns/Gulls, and Benthic-Feeding Divers.

Table 4. Survey effort required to detect a 50% change in relative abundance in the impact area contrasted with no change in the control area given a 2017-2019 Spring Survey baseline. [1]

Forage Group	Survey Periods Used for Estimating Baseline Abundance (number of complete river surveys in 2017-2019)	2017-2019 Baseline Average Relative Abundance per 100 km (Standard Error)	Estimated survey effort required beyond 2017-2020 baseline period
Benthic-Feeding Divers	Early & Mid (n = 10 surveys)	Control: 32.4 (9.7) Impact: 97.0 (24.8)	12 (3 years; assuming 2 early and 2 mid surveys each year)
Dabbling Ducks	Early, Mid, Late (n = 15 surveys)	Control: 413.2 (49.2) Impact: 289.5 (33.3)	9 (~3 years; assuming 4 complete river surveys per year)
Surface Feeding Terns/Gulls	Mid & Late (n = 11 surveys)	Control: 12.3 (4.9) Impact: 34.9 (13.5)	18 (~9 years; assuming 2 mid surveys per year)
Large Dabblers (Geese and Swans)	Early (n = 4 surveys)	Control: 1154.0 (136.7) Impact: 1151.3 (136.2)	1 (1 year; assuming 2 early surveys per year)
Piscivorous Divers	Early (n = 4 surveys)	Control: 79.6 (16.9) Impact: 183.7 (33.8)	3 (2 years; assuming 2 early surveys per year)
Shorebirds	Late (n = 5 surveys)	Control: 52.9 (15.7) Impact: 63.2 (22.6)	10 (n/a; no additional late surveys planned)

[1] – Red indicates foraging groups that should not be the focus of surveys within this season.

Table 5. Survey effort required to detect a 50% change in relative abundance in the impact area contrasted with no change in the control area given a 2017-2019 Fall Survey baseline. [1]

Forage Group	Survey Periods Used for Estimating Baseline Abundance (number of complete river surveys in 2017-2019)	2017-2019 Baseline Average Relative Abundance per 100 km (Standard Error)	Estimated survey effort required beyond 2017-2020 baseline period
Benthic-Feeding Divers	Early, Early-Mid, Late-Mid, Late (n = 18 surveys)	Control: 1.0 (0.6) Impact: 7.6 (2.9)	> 210 (> 70 years; assuming 3 complete river surveys per year)
Dabbling Ducks	Early, Early-Mid, Late-Mid, (n = 16 surveys)	Control: 26.0 (6.9) Impact: 296.7 (76.3)	9 (3 years; assuming 1 early, 1 early-mid and 1 late-mid survey per year)
Surface Feeding Terns/Gulls	Early, Early-Mid, Late-Mid (n = 16 surveys)	Control: 14.3 (4.2) Impact: 685.8 (173.2)	24 (~8 years; assuming 1 early, 1 early-mid and 1 late-mid survey per year)
Large Dabblers (Geese and Swans)	Early-Mid, Late-Mid, Late (n = 14 surveys)	Control: 701.1 (124.8) Impact: 398.8 (69.0)	2 (1 year; assuming 1 early-mid and 1 late-mid survey per year)
Piscivorous Divers	Early, Early-Mid, Late-Mid, Late (n = 18 surveys)	Control: 16.6 (3.9) Impact: 20.7 (4.0)	15 (5 years; assuming 1 early, 1 early-mid and 1 late-mid survey per year)
Shorebirds	Early (n = 4 surveys)	Control: 228.5 (40.4) Impact: 112.2 (19.0)	2 (2 years; assuming 1 early survey per year)

[1] – Red indicates foraging groups that should not be the focus of surveys within this season.

The sensitivity of these results to exclusion of the survey data collected on back channels via unmanned aerial vehicles (UAVs) was also examined. For each survey and survey area, the proportion of the area surveyed by UAV was excluded from the measure of survey effort (i.e., surveyed river length) and all birds observed during UAV surveys were excluded from total bird counts. A summary of the proportions of area surveyed by UAV and total birds counted by UAV is provided in Table 6. In the fall, UAV surveys accounted for a large proportion of the Large Dabblers counted overall and for Dabbling Ducks counted in the impact area.

Table 6. Average proportion of River Survey Area and Total Birds counted by UAV.

Study Area	River Area	Benthic-Feeding Divers	Dabbling Ducks	Surface-Feeding Terns/Gulls	Large Dabblers	Piscivorous Divers	Shorebirds
Spring Surveys							
Control	0.038	0.082	0.050	0.172	0.120	0.112	0.000
Impact	0.063	0.073	0.165	0.050	0.141	0.060	0.030
Fall Surveys							
Control	0.026	0.000	0.128	0.000	0.476	0.032	0.005
Impact	0.033	0.208	0.459	0.001	0.286	0.128	0.032

Adjusted baseline average relative abundances were calculated, omitting the UAV data, and power analyses re-run to estimate sampling effort required to detect, with 80% statistical power, 50% changes in relative abundance in the impact area versus no change in the control area given 2017-2019 spring (Table 7) and fall (Table 8) survey baselines.

Table 7. Survey effort required to detect a 50% change in relative abundance in the impact area contrasted with no change in the control area given a 2017-2019 Spring Survey baseline (UAV data omitted). [1]

Forage Group	Survey Periods Used for Estimating Baseline Abundance (number of complete river surveys in 2017-2019)	2017-2019 Baseline Average Relative Abundance per 100 km (Standard Error)	Estimated survey effort required beyond 2017-2020 baseline period
Benthic-Feeding Divers	Early & Mid (n = 10 surveys)	Control: 31.3 (9.6) Impact: 95.9 (24.7)	11 (~3 years; assuming 2 early and 2 mid surveys each year)
Dabbling Ducks	Early, Mid, Late (n = 15 surveys)	Control: 392.6 (44.8) Impact: 246.9 (27.3)	8 (2 years; assuming 4 complete river surveys per year)
Surface Feeding Terns/Gulls	Mid & Late (n = 11 surveys)	Control: 7.9 (3.3) Impact: 41.2 (16.9)	80 (40 years; assuming 2 mid surveys per year)
Large Dabblers (Geese and Swans)	Early (n = 4 surveys)	Control: 1121.6 (138.4) Impact: 1096.7 (134.5)	1 (~1 year; assuming 2 early surveys per year)
Piscivorous Divers	Early (n = 4 surveys)	Control: 79.0 (18.9) Impact: 197.3 (41.9)	2 (~2 years; assuming 2 early surveys per year)

Forage Group	Survey Periods Used for Estimating Baseline Abundance (number of complete river surveys in 2017-2019)	2017-2019 Baseline Average Relative Abundance per 100 km (Standard Error)	Estimated survey effort required beyond 2017-2020 baseline period
Shorebirds	Late (n = 5 surveys)	Control: 54.1 (13.1) Impact: 54.5 (15.2)	10 (n/a; no additional late surveys planned)

[1] – Red indicates foraging groups that should not be the focus of surveys within this season.

Table 8. Survey effort required to detect a 50% change in relative abundance in the impact area contrasted with no change in the control area given a 2017-2019 Fall Survey baseline (UAV data omitted). [1]

Forage Group	Survey Periods Used for Estimating Baseline Abundance (number of complete river surveys in 2017-2019)	2017-2019 Baseline Average Relative Abundance per 100 km (Standard Error)	Estimated survey effort required beyond 2017-2020 baseline period
Benthic-Feeding Divers	Early, Early-Mid, Late-Mid, Late (n = 18 surveys)	Control: 0.9 (0.6) Impact: 6.5 (3.2)	> 210 (> 70 years; assuming 3 complete river surveys per year)
Dabbling Ducks	Early, Early-Mid, Late-Mid, (n = 16 surveys)	Control: 24.8 (7.2) Impact: 198.9 (56.0)	12 (4 years; assuming 1 early, 1 early-mid and 1 late-mid survey per year)
Surface Feeding Terns/Gulls	Early, Early-Mid, Late-Mid (n = 16 surveys)	Control: 14.8 (4.4) Impact: 720.8 (184.5)	12 (4 years; assuming 1 early, 1 early-mid and 1 late-mid survey per year)
Large Dabblers (Geese and Swans)	Early-Mid, Late-Mid, Late (n = 14 surveys)	Control: 505.0 (89.2) Impact: 323.9 (57.6)	2 (1 year; assuming 1 early-mid and 1 late-mid survey per year)
Piscivorous Divers	Early, Early-Mid, Late-Mid, Late (n = 18 surveys)	Control: 15.6 (3.9) Impact: 17.8 (3.7)	13 (~4 years; assuming 1 early, 1 early-mid and 1 late-mid survey per year)
Shorebirds	Early (n = 4 surveys)	Control: 230.7 (40.4) Impact: 113.0 (19.0)	2 (2 years; assuming 1 early survey per year)

[1] – Red indicates foraging groups that should not be the focus of surveys within this season.

Given the estimates of survey effort required beyond 2019 and survey periods suited to characterizing relative abundance or use by each foraging group, we can consider different scenarios for survey plans in future years. Factors to consider for future efforts include the following:

- If a foraging group is observed in lower abundances or with greater variability across survey periods, the ability to detect a 50% change in relative abundance in the impact area contrasted with no change in the control area may not be achievable within a reasonable time period, which is defined as ≤ 10 years, or the post-construction monitoring period. The foraging groups shaded in grey tone in Tables 9 and 10 fall into this category. BC Hydro may want to consider tailoring their spring and fall survey plans to exclude certain foraging groups, for which detecting statistically significant differences over time is unlikely during the period of the waterbird monitoring program (e.g., Surface Feeding Terns/Gulls and shorebirds in spring; Benthic-Feeding Divers in fall).
- If peak abundances for a foraging group are observed uniquely in a survey period, the region should be surveyed during that time period. For example, the early survey period is important to characterize relative abundances of Large Dabblers and Piscivorous Divers in spring, compared to the early survey time for Shorebirds in fall.
- For species whose relative abundances or use are well captured during any survey within a survey period (e.g., Dabbling Ducks in spring and fall; Benthic-Feeding Divers and Piscivorous Divers in fall), the particular timing of surveys does not play much of a role. It is simply the overall survey effort that helps to moderate the variability observed across survey occasions.

Tables 9 and 10 consider the impacts of survey timing scenarios given that an early survey is necessary in the spring and late-mid or late surveys may be necessary in the fall. In general, a 50% change in relative abundance in the impact area contrasted with no change in the control area would be detected within 10 years for five of the foraging groups in spring. It will take 8 years of effort of 3 or more fall surveys/year to detect a 50% change in relative abundance in the impact area contrasted with no change in the control area for five of the foraging groups.

Table 9. Impacts of modified Spring Waterbird Survey plans beyond 2020. [1]

Foraging Group	Periods useful for Characterizing Foraging Group Use	Estimated survey effort (number of surveys) required beyond 2017-2020 baseline period	Number of years required if 1 Early Survey is conducted per year (*n= 2 survey days required/spring season)*	Number of years required if 2 Early Surveys is conducted per year *(n= 4 survey days required/spring season)*	Number of years required if 2 Early Surveys, 1 Mid Survey are conducted per year *(n= 6 survey days required/spring season)*	Number of years required if 2 Early Surveys, 2 Mid Surveys conducted are per year *(n= 8 survey days required/spring season)*
Dabbling Ducks	Any	9	9	5	3	3
Large Dabblers	Early	1	1	1	1	1
Piscivorous Divers	Early	3	3	2	2	2
Benthic Feeding Divers	Early, Mid	12	12	6	4	3
Surface Feeding Terns/Gulls	Mid, Late	18	-	-	18	9
Shorebirds	Late	10	-	-	-	-

[1] – Grey indicates foraging groups where 50% change cannot be detected within 10 years, with 80% statistical power, with the survey scenarios described.

Table 10. Impacts of modified Fall Waterbird Survey plans beyond 2020. [1]

Foraging Group	Periods useful for Characterizing Foraging Group Use	Estimated survey effort (number of surveys) required beyond 2017-2020 baseline period	Number of years required if 1 Early Survey, 1 Late-Mid Survey is conducted per year (*n= 4 survey days required/fall season)*	Number of years required if 1 Early Survey, 1 Late-Mid, 1 Late Survey are conducted per year (*n= 6 survey days required/fall season)*	Number of years required if 1 Early Survey, 1 Early-Mid, 1 Late-Mid Survey are conducted per year (*n= 6 survey days required/fall season)*	Number of years required if 1 Early Survey, 1 Early-Mid, 1 Late-Mid, 1 Late Survey are conducted per year (*n= 8 survey days required/fall season)*
Piscivorous Divers	Any	15	8	5	5	4
Large Dabblers	Early-Middle, Late-Middle, Late	2	2	1	1	1
Surface Feeding Terns/Gulls	Early, Early-Middle, Late-Middle	24	12	12	8	8
Dabbling Ducks	Early-Middle, Late-Middle, Late	9	9	5	5	3
Shorebirds	Early	2	2	2	2	2
Benthic-Feeding Divers	Any	> 210	> 105	> 70	> 70	> 53

[1] – Grey indicates foraging groups where 50% change cannot be detected within 10 years, with 80% statistical power, with the survey scenarios described.

Discussion

For the spring 2017-2019 survey data, optimal survey periods were identified for most foraging groups, except for Dabbling Ducks. The early and mid-surveys in spring yielded the highest counts for Benthic-Feeding Divers, Large Dabblers and Piscivorous Divers, while the late survey yielded the highest survey counts for Gulls/Surface Feeding Terns and Shorebirds. As presented in the statistical analyses of the 2017-2019 waterbird data, Dabbling Duck density was variable among surveys, but peak counts did not align with particular survey periods; it is overall survey effort rather than a particular allocation across survey periods that is useful for moderating the effects of survey-to-survey variability in Dabbling Duck counts.

For the fall 2017-2019 survey data, no optimal survey periods were clear for Piscivorous Divers or Benthic-Feeding Divers, due to high survey-to-survey variation in counts that did not align with particular survey periods. Low counts coupled with high variation, as seen with the Benthic-Feeding Divers, results in a high survey effort required to detect change in the fall (Table 5).

In order to efficiently detect, with 80% statistical power, 50% changes in relative abundance in the impact area versus no change in the control area, survey effort should be focused on the survey period(s) that best characterize the relative abundance of each foraging group. Tables 9 and 10 demonstrated various scenarios of survey effort and the subsequent number of years it will take to detect a 50% change in relative abundance in the impact area versus no change in the control for each foraging group.

Based on the results of the power analysis of survey effort scenarios in spring, conducting two early surveys per year will allow for the detection of 50% change in relative abundance in the impact area versus no change in the control within 1-6 years for Dabbling Ducks (n=18 field surveys days required), Large Dabblers (n=2 early field survey days required), Piscivorous Divers (n=6 early field survey days required) and Benthic-Feeding Divers (n=24 early or mid field survey days required) (Table 9). We recommend that Surface Feeding Terns/Gulls or Shorebirds not be the focus in spring surveys, because of the low likelihood of being able to detect statistically significant changes in these foraging groups within the waterbird monitoring program (i.e., during construction and the first 10 years of operations).

Based on the results of power analysis of survey effort scenarios in fall, conducting 1 early and 1 late-mid survey per year will allow for the detection of 50% change in relative abundance in the impact area versus no change in the control within 2-9 years for Piscivorous Divers (n=30 survey days), Large Dabblers (n=4 late-mid survey days), Dabbling Ducks (n=18 late-mid survey days) and Shorebird (n=4 early survey days). Changes in the impact areas (relative to no change in the control areas) for Surface Feeding Terns/Gulls can be detected within 12 years (n=48 survey days) with 1 early and 1 late-mid survey. Adding one more early, early-mid or late-mid survey per fall season does improve the power to detect changes in Surface Feeding Terns/Gulls in a shorter period (n=8 years; 48 survey days; Table 10).

For fall surveys we recommend that the focus is not on Benthic-feeding Divers because of the greater survey effort required to detect this foraging group within the fall season as compared to the spring season. Under the scenarios presented in Table 10 a 50% change in the impact area versus no change in the control for Benthic-Feeding Divers cannot be detected within 10 years.

Each foraging group varies from one another on life characteristics such as nesting and foraging behaviors, diet preferences and habitat preferences. Variation can also be seen within a foraging group as well. For example, Piscivorous Divers have similar food preferences, but vary in nesting behaviors. This makes it difficult to use one foraging group as an indicator for another. Statistically, Shorebirds and Surface Feeding Terns/Gulls have similar peaks in abundance, however they differ from all other foraging groups in this regard, which also makes the use of other foraging groups as an indicator difficult.

Overall, this suggests that to create more efficiency within the Waterbird survey program the early and mid surveys should be the focus during the spring survey period. Reduction in fall survey effort could include eliminating the early-mid and late-mid replicates, and the late period to detect of Surface Feeding Terns/Gulls within 8 years (n=48 survey days), with the caveat that focus of detecting Benthic Feeding Divers will be in the spring season.

The removal of the UAV data had little impact on the required survey effort (Tables 7 and 8) with exception to the Surface Feeding Terns/Gulls in the Spring survey period. Survey effort for this foraging group increased from 9 years to 40 years (given 2 mid surveys) with the exclusion of UAV data. If it is determined to be in the best interest of the survey program to eliminate the UAV portion of the waterbird surveys the detection of Surface Feeding Terns/Gulls should be focused on in the fall season.

References

BC Hydro. 2018. Site C Vegetation and Wildlife Waterbird Migration Follow-up Monitoring Program (v4 January 2018). 30 pp.

Hatch, S. A. 2003. Statistical power for detecting trends with applications to seabird monitoring. Biological Conservation 111:317-329.

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Appendix A – Complete list of species and foraging groups observed during 2017/2018/2019 surveys, along the Peace River.

Species Code	Common Name	Latin Name	Foraging Mode Species Group
CONI	Common Nighthawk	*Chordeiles minor*	Aerial Insectivores
AMDI	American Dipper	*Cinclus mexicanus*	Benthic-Feeding Divers
BAGO	Barrow's Goldeneye	*Bucephala islandica*	Benthic-Feeding Divers
BUFF	Bufflehead	*Bucephala albeola*	Benthic-Feeding Divers
COGO	Common Goldeneye	*Bucephala clangula*	Benthic-Feeding Divers
HADU	Harlequin Duck	*Histrionicus histrionicus*	Benthic-Feeding Divers
LTDU	Long-tailed Duck	*Clangula hyemalis*	Benthic-Feeding Divers
RUDU	Ruddy Duck	*Oxyura jamaicensis*	Benthic-Feeding Divers
SUSC	Surf Scoter	*Melanitta perspicillata*	Benthic-Feeding Divers
UNGO	Unknown Goldeneye	-	Benthic-Feeding Divers
UNKN SCOTER	Unknown Scoter	*Mellanita sp.*	Benthic-Feeding Divers
WWSC	White-winged Scoter	*Melanitta fusca*	Benthic-Feeding Divers
GBHE	Great blue heron	*Ardea herodias*	Cranes and Herons
SACR	Sandhill Crane	*Grus canadensis*	Cranes and Herons
AMCO	American Coot	*Fulica americana*	Dabbling Ducks
AMWI	American Wigeon	*Anas americana*	Dabbling Ducks
BWTE	Blue-winged Teal	*Anas discors*	Dabbling Ducks
CANV	Canvasback	*Aythya valisineria*	Dabbling Ducks
CITE	Cinnamon Teal	*Anas cyanoptera*	Dabbling Ducks
GADW	Gadwall	*Anas strepera*	Dabbling Ducks
GRSC	Greater Scaup	*Aythya marila*	Dabbling Ducks
GWTE	Green-winged Teal	*Anas crecca*	Dabbling Ducks
LESC	Lesser Scaup	*Aythya affinis*	Dabbling Ducks
MALL	Mallard	*Anas platyrhynchos*	Dabbling Ducks
NOPI	Northern Pintail	*Anas acuta*	Dabbling Ducks
NSHO	Northern Shoveler	*Anas clypeata*	Dabbling Ducks
REDH	Redhead	*Aythya americana*	Dabbling Ducks
RNDU	Ring-necked Duck	*Aythya collaris*	Dabbling Ducks
UNDA	Unknown Dabbling Duck	-	Dabbling Ducks
UNSC	Unknown Scaup	-	Dabbling Ducks
UNTE	Unknown Teal	-	Dabbling Ducks
BLTE	Black Tern	*Chlidonias niger*	Surface Feeding Terns/Gulls
BHGU	Black-headed Gull	*Chroicocephalus ridibundus*	Surface Feeding Terns/Gulls
BOGU	Bonaparte's Gull	*Chroicocephalus philadelphia*	Surface Feeding Terns/Gulls

Species Code	Common Name	Latin Name	Foraging Mode Species Group
CAGU	California Gull	*Larus californicus*	Surface Feeding Terns/Gulls
FRGU	Franklin's Gull	*Leucophaeus pipixcan*	Surface Feeding Terns/Gulls
HEGU	Herring Gull	*Larus argentatus*	Surface Feeding Terns/Gulls
MEGU	Mew Gull	*Larus canus*	Surface Feeding Terns/Gulls
RBGU	Ring-billed Gull	*Larus delawarensis*	Surface Feeding Terns/Gulls
SAGU	Sabine's Gull	*Xema sabini*	Surface Feeding Terns/Gulls
ICGU	Thayer's Gull	*Larus glaucoides*	Surface Feeding Terns/Gulls
UNGU	Unknown Gull	-	Surface Feeding Terns/Gulls
CACG	Cackling Goose	*Branta hutchinsii*	Large Dabblers
CAGO	Canada Goose	*Branta canadensis*	Large Dabblers
GWFG	Greater White-fronted Goose	*Anser albifrons*	Large Dabblers
SNGO	Snow Goose	*Chen caerulescens*	Large Dabblers
TRUS	Trumpeter Swan	*Cygnus buccinator*	Large Dabblers
TUSW	Tundra Swan	*Cygnus columbianus*	Large Dabblers
UNSW	Unknown Swan	-	Large Dabblers
SORA	Sora	*Porzana carolina*	Marsh Birds
WISN	Wilson's Snipe	*Gallinago delicata*	Marsh Birds
YERA	Yellow Rail	*Coturnicops noveboracensis*	Marsh Birds
ARTE	Arctic Tern	*Sterna paradisaea*	Piscivorous Divers
BEKI	Belted Kingfisher	*Megaceryle alcyon*	Piscivorous Divers
COLO	Common Loon	*Gavia immer*	Piscivorous Divers
COME	Common Merganser	*Mergus merganser*	Piscivorous Divers
COTE	Common Tern	*Sterna hirundo*	Piscivorous Divers
EAGR	Eared Grebe	*Podiceps nigricollis*	Piscivorous Divers
HOME	Hooded Merganser	*Lophodytes cucullatus*	Piscivorous Divers
HOGR	Horned Grebe	*Podiceps auritus*	Piscivorous Divers
PBGR	Pied-billed Grebe	*Podilymbus podiceps*	Piscivorous Divers
RBME	Red-breasted Merganser	*Mergus serrator*	Piscivorous Divers
RNGR	Red-necked Grebe	*Podiceps grisegena*	Piscivorous Divers
UNGR	Unknown Grebe	-	Piscivorous Divers
UNLO	Unknown Loon	-	Piscivorous Divers
UNME	Unknown Merganser	-	Piscivorous Divers

Species Code	Common Name	Latin Name	Foraging Mode Species Group
UNKN TERN	Unknown Tern	-	Piscivorous Divers
WEGR	Western Grebe	*Aechmophorus occidentalis*	Piscivorous Divers
AMKE	American Kestrel	*Falco sparverius*	Raptors
BAEA	Bald Eagle	*Haliaeetus leucocephalus*	Raptors
COHA	Cooper's Hawk	*Accipiter cooperii*	Raptors
GOEA	Golden Eagle	*Aquila chrysaetos*	Raptors
MERL	Merlin	*Falco columbarius*	Raptors
NOHA	Northern Harrier	*Circus cyaneus*	Raptors
OSPR	Osprey	*Pandion haliaetus*	Raptors
RTHA	Red-tailed Hawk	*Buteo jamaicensis*	Raptors
RLHA	Rough-legged Hawk	*Buteo lagopus*	Raptors
SSHA	Sharp-shinned Hawk	*Accipiter striatus*	Raptors
UNAC	Unknown Accipiter	-	Raptors
UNHA	Unknown Hawk	-	Raptors
UNRA	Unknown Raptor	-	Raptors
GRYE	Greater Yellowlegs	*Tringa melanoleuca*	Shorebirds
KILL	Killdeer	*Charadrius vociferus*	Shorebirds
LESA	Least Sandpiper	*Calidris minutilla*	Shorebirds
LEYE	Lesser Yellowlegs	*Tringa flavipes*	Shorebirds
LBDO	Long-billed Dowitcher	*Limnodromus scolopaceus*	Shorebirds
RNPH	Red-necked Phalarope	*Phalaropus lobatus*	Shorebirds
SEPL	Semi-palmated Plover	*Charadrius semipalmatus*	Shorebirds
SESA	Semi-palmated Sandpiper	*Calidris pusilla*	Shorebirds
SOSA	Solitary Sandpiper	*Tringa solitaria*	Shorebirds
SPSA	Spotted Sandpiper	*Actitis macularius*	Shorebirds
UNSA	Unknown Sandpiper	-	Shorebirds
UNSH	Unknown Shorebird	-	Shorebirds
PEEP	Unknown small calidrid	*Calidris sp.*	Shorebirds
UNYE	Unknown Yellowlegs	-	Shorebirds
UNDI	Unknown Diving Bird	-	Unknown Waterbirds
UNDU	Unknown Duck	-	Unknown Waterbirds
UNKN	Unkown spp	-	Unknown Waterbirds

Appendix B

Waterbird Species List, Foraging Guild Categories, and Abundances

Table B-1 Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances from 2017, 2018, 2019, 2020, 2021 and 2022

Foraging Guild	English Name	Scientific Name	River Boat Survey Abundance [a]	Wetland Standwatch Abundance [b]	Wetland Transect Abundance [c]
Benthic Feeding Divers			**2,809**	**1,623**	**1**
	American Dipper	*Cinclus mexicanus*	1	0	0
	Barrow's Goldeneye	*Bucephala islandica*	135	34	0
	Benthic Feeding Diver sp.	*n/a*	1	62	0
	Bufflehead	*Bucephala albeola*	216	1,011	1
	Common Goldeneye	*Bucephala clangula*	1,776	286	0
	Goldeneye sp.	*Bucephala sp.*	362	47	0
	Harlequin Duck	*Histrionicus histrionicus*	3	0	0
	Long-tailed Duck	*Clangula hyemalis*	1	22	0
	Ruddy Duck	*Oxyura jamaicensis*	5	30	0
	Scoter sp.	*Melanitta sp.*	19	1	0
	Surf Scoter	*Melanitta perspicillata*	271	117	0
	White-winged Scoter	*Melanitta fusca*	19	13	0
Cranes and Herons			**56**	**0**	**0**
	Great Blue Heron	*Ardea herodias*	1	0	0
	Sandhill Crane	*Antigone canadensis*	55	0	0
Dabbling Ducks			**20,892**	**5,365**	**200**
	American Coot	*Fulica americana*	58	291	9
	American Wigeon	*Mareca americana*	1,699	348	9
	Blue-winged Teal	*Spatula discors*	443	348	19
	Canvasback	*Aythya valisineria*	19	108	0
	Cinnamon Teal	*Spatula cyanoptera*	2	0	2
	Dabbling Duck sp.	*n/a*	1,719	404	5
	Eurasian Wigeon	*Mareca penelope*	1	0	0
	Gadwall	*Mareca strepera*	31	12	0
	Greater Scaup	*Aythya marila*	29	47	0
	Green-winged Teal	*Anas crecca*	1,732	466	30
	Lesser Scaup	*Aythya affinis*	46	235	0
	Mallard	*Anas platyrhynchos*	12,825	1,271	55
	Northern Pintail	*Anas acuta*	1,710	82	5
	Northern Shoveler	*Spatula clypeata*	227	218	66
	Redhead	*Aythya americana*	7	7	0
	Ring-necked Duck	*Aythya collaris*	40	921	0
	Scaup sp.	*n/a*	147	588	0
	Teal sp.	*n/a*	157	19	0
Gulls and Surface Feeding Terns			**15,033**	**221**	**0**
	Arctic Tern	*Sterna paradisaea*	3	0	0
	Black Tern	*Chlidonias niger*	0	24	0
	Bonaparte's Gull	*Chroicocephalus philadelphia*	5,608	184	0
	California Gull	*Larus californicus*	35	0	0
	Franklin's Gull	*Leucophaeus pipixcan*	5,260	1	0
	Gull sp.	*n/a*	1,073	6	0
	Herring Gull	*Larus argentatus*	202	0	0
	Ring-billed Gull	*Larus delawarensis*	2,489	0	0
	Sabine's Gull	*Xema sabini*	1	0	0
	Tern sp.	*n/a*	2	0	0
	Short-billed Gull	*Larus brachyrhynchos*	354	6	0
	Iceland Gull	*Larus glaucoides*	6	0	0
Large Dabblers			**45,814**	**373**	**7**
	Cackling Goose	*Branta hutchinsii*	26	0	0
	Canada Goose[d]	*Branta canadensis*	45,031	122	5
	Greater White-fronted Goose	*Anser albifrons*	11	0	0
	Large Dabbler sp.	*n/a*	219	0	0
	Snow Goose	*Anser caerulescens*	3	0	0
	Trumpeter Swan[d]	*Cygnus buccinator*	521	251	2
	Tundra Swan	*Cygnus columbianus*	3	0	0

Table B-1 Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances from 2017, 2018, 2019, 2020, 2021 and 2022

Foraging Guild	English Name	Scientific Name	River Boat Survey Abundance [a]	Wetland Standwatch Abundance [b]	Wetland Transect Abundance [c]
Marsh Birds			**3**	**56**	**139**
	Sora	*Porzana carolina*	0	44	59
	Wilson's Snipe	*Gallinago delicata*	3	11	76
	Yellow Rail	*Coturnicops noveboracensis*	0	0	4
	Rail sp.	*n/a*	0	1	0
Piscivorous Divers			**4,645**	**577**	**2**
	Belted Kingfisher	*Megaceryle alcyon*	94	6	0
	Common Loon	*Gavia immer*	31	138	0
	Common Merganser	*Mergus merganser*	4,361	27	0
	Common Tern	*Sterna hirundo*	3	0	0
	Double-crested Cormorant	*Nannopterum auritum*	4	0	0
	Eared Grebe	*Podiceps nigricollis*	6	85	0
	Grebe sp.	*n/a*	2	15	0
	Hooded Merganser	*Lophodytes cucullatus*	33	47	0
	Horned Grebe	*Podiceps auritus*	2	89	0
	Loon sp.	*n/a*	5	0	0
	Merganser sp.	*n/a*	38	0	0
	Pacific Loon	*Gavia pacifica*	1	0	0
	Pied-billed Grebe	*Podilymbus podiceps*	0	54	2
	Piscivorous Diver sp.	*n/a*	3	0	0
	Red-breasted Merganser	*Mergus serrator*	11	6	0
	Red-necked Grebe	*Podiceps grisegena*	48	98	0
	Red-throated Loon	*Gavia stellata*	2	0	0
	Western Grebe	*Aechmophorus occidentalis*	1	12	0
Shorebirds			**2,477**	**218**	**74**
	Greater Yellowlegs	*Tringa melanoleuca*	3	12	3
	Killdeer	*Charadrius vociferus*	31	1	0
	Least Sandpiper	*Calidris minutilla*	15	0	0
	Lesser Yellowlegs	*Tringa flavipes*	17	53	14
	Long-billed Dowitcher	*Limnodromus scolopaceus*	2	0	0
	Peep Sp.	*Calidris sp.*	37	2	0
	Red-necked Phalarope	*Phalaropus lobatus*	11	9	0
	Sandpiper sp.	*n/a*	29	7	0
	Shorebird sp.	*n/a*	60	1	0
	Solitary Sandpiper	*Tringa solitaria*	15	61	28
	Spotted Sandpiper	*Actitis macularius*	2,127	58	28
	Semipalmated Plover	*Charadrius semipalmatus*	11	0	0
	Semipalmated Sandpiper	*Calidris pusilla*	117	0	0
	Yellowlegs sp.	*Tringa sp.*	2	12	1
	Wilson's Phalarope	*Phalaropus tricolor*	0	2	0
Unknown Waterbirds			**2,222**	**927**	**0**
	Diving Bird sp.	*n/a*	16	0	0
	Duck sp.	*n/a*	1,904	884	0
	Unknown sp.	*n/a*	302	43	0
Grand Total			**93,951**	**9,360**	**423**

Notes:

[a] - Includes flying records as birds were often flushed to flight in front of boat. Includes all habitat types, all treatment areas, and data from incomplete surveys.

[b] - Excludes flying records. Includes records of birds observed in open water and sedge habitat.

[c] - Excludes flying records. Includes records of waterbirds observed in sedge, and willow sedge habitat.

[d] - Trumpeter swans and Canada geese, include a small proportion (<5%) of tundra swans and cackling geese, respectively.

Table B-2 Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances in 2022

Foraging Guild	English Name	Scientific Name	River Boat Survey Abundance [a]	Wetland Standwatch Abundance [b]	Wetland Transect Abundance [c]
Benthic Feeding Divers			**305**	**333**	**0**
	Barrow's Goldeneye	*Bucephala islandica*	0	8	0
	Benthic Feeding Diver sp.	*n/a*	0	35	0
	Bufflehead	*Bucephala albeola*	11	190	0
	Common Goldeneye	*Bucephala clangula*	99	80	0
	Goldeneye sp.	*Bucephala sp.*	105	7	0
	Ruddy Duck	*Oxyura jamaicensis*	0	2	0
	Scoter sp.	*Mellanita sp.*	17	0	0
	Surf Scoter	*Melanitta perspicillata*	65	6	0
	White-winged Scoter	*Melanitta fusca*	8	5	0
Dabbling Ducks			**3,838**	**909**	**29**
	American Coot	*Fulica americana*	0	24	0
	American Wigeon	*Mareca americana*	182	41	2
	Blue-winged Teal	*Spatula discors*	0	38	4
	Canvasback	*Aythya valisineria*	0	2	0
	Dabbling Duck sp.	*n/a*	484	117	0
	Gadwall	*Mareca strepera*	1	0	0
	Greater Scaup	*Aythya marila*	1	4	0
	Green-winged Teal	*Anas crecca*	83	82	10
	Lesser Scaup	*Aythya affinis*	0	59	0
	Mallard	*Anas platyrhynchos*	2,976	189	8
	Northern Pintail	*Anas acuta*	93	4	1
	Northern Shoveler	*Spatula clypeata*	15	13	4
	Redhead	*Aythya americana*	0	2	0
	Ring-necked Duck	*Aythya collaris*	0	206	0
	Scaup sp.	*Aythya sp.*	3	128	0
Gulls and Surface Feeding Terns			**803**	**26**	**0**
	Arctic Tern	*Sterna paradisaea*	1	0	0
	Black Tern	*Chlidonias niger*	0	3	0
	Bonaparte's Gull	*Chroicocephalus philadelphia*	221	23	0
	Franklin's Gull	*Leucophaeus pipixcan*	230	0	0
	Gull sp.	*n/a*	20	0	0
	Herring Gull	*Larus argentatus*	5	0	0
	Ring-billed Gull	*Larus delawarensis*	326	0	0
	Tern sp.	*n/a*	1	0	0
	Short-billed Gull	*Larus brachyrhynchos*	12	0	0
Large Dabblers			**12,040**	**70**	**2**
	Canada Goose	*Branta canadensis*	11,953	29	2
	Trumpeter Swan [d]	*Cygnus buccinator*	87	41	0
Marsh Birds			**3**	**3**	**22**
	Sora	*Porzana carolina*	0	1	6
	Wilson's Snipe	*Gallinago delicata*	3	1	15
	Yellow Rail	*Coturnicops noveboracensis*	0	0	1
	Rail sp.	*n/a*	0	1	0

Table B-2 Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances in 2022

Foraging Guild	English Name	Scientific Name	River Boat Survey Abundance [a]	Wetland Standwatch Abundance [b]	Wetland Transect Abundance [c]
Piscivorous Divers			**481**	**82**	**0**
	Belted Kingfisher	*Megaceryle alcyon*	3	1	0
	Common Loon	*Gavia immer*	5	15	0
	Common Merganser	*Mergus merganser*	437	1	0
	Eared Grebe	*Podiceps nigricollis*	0	7	0
	Grebe sp.	*n/a*	0	8	0
	Hooded Merganser	*Lophodytes cucullatus*	6	15	0
	Horned Grebe	*Podiceps auritus*	0	6	0
	Merganser sp.	*n/a*	14	0	0
	Pied-billed Grebe	*Podilymbus podiceps*	0	11	0
	Red-necked Grebe	*Podiceps grisegena*	15	18	0
	Red-throated Loon	*Gavia stellata*	1	0	0
Shorebirds			**228**	**61**	**23**
	Killdeer	*Charadrius vociferus*	3	0	0
	Lesser Yellowlegs	*Tringa flavipes*	0	17	3
	Peep Sp.	*Calidris sp.*	0	2	0
	Solitary Sandpiper	*Tringa solitaria*	1	23	19
	Spotted Sandpiper	*Actitis macularius*	224	5	0
	Yellowlegs sp.	*Tringa sp.*	0	12	1
	Wilson's Phalarope	*Phalaropus tricolor*	0	2	0
Unknown Waterbirds			**43**	**39**	**0**
	Diving Bird sp.	*n/a*	2	0	0
	Duck sp.	*n/a*	40	39	0
	Unknown sp.	*n/a*	1	0	0
Grand Total			**17,741**	**1,523**	**76**

Notes:

[a] - Includes flying records as birds were often flushed to flight in front of boat. Includes all habitat types, all treatment areas, and data from incomplete surveys.

[b] - Excludes flying records. Includes records of birds observed in open water and sedge habitat.

[c] - Excludes flying records. Includes records on waterbirds observed in sedge, and willow sedge habitat.

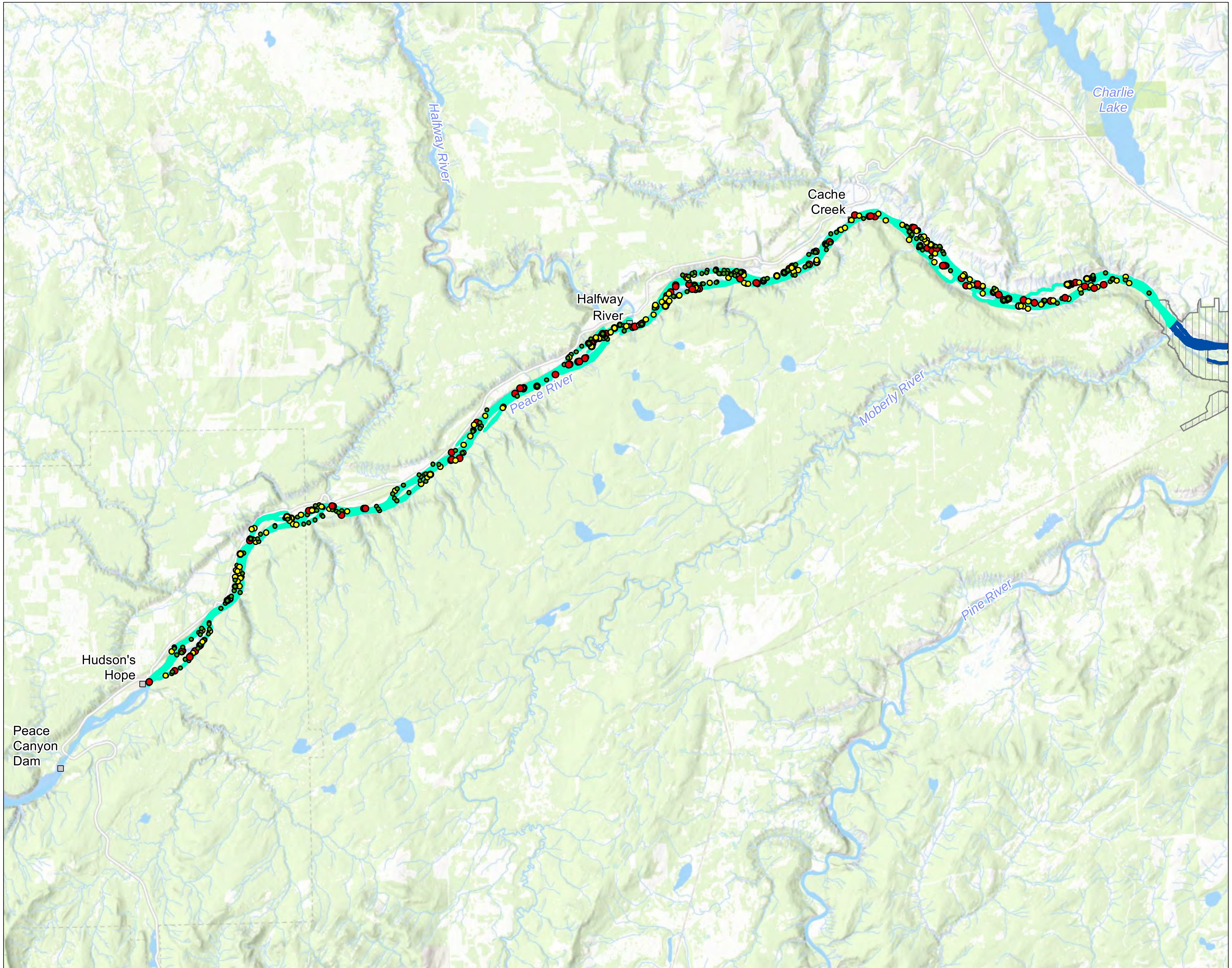
[d] - Trumpeter swans and Canada geese, include a small proportion (<5%) of tundra swans and cackling geese, respectively.

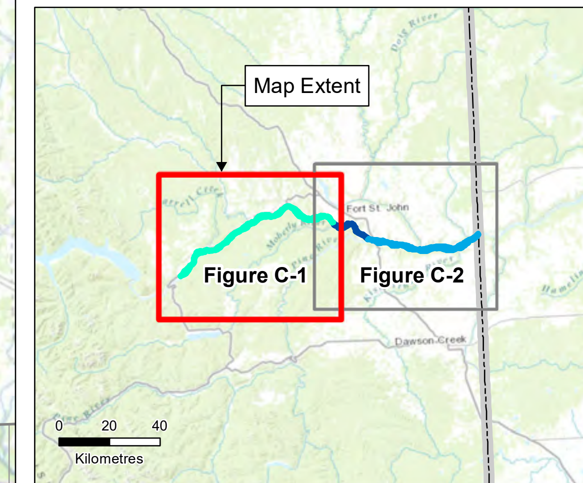
Appendix C

Spatial Representation of Waterbird Observations within the Peace River Study Area in Spring and Fall 2022 (Figures C-1 to C-4)

Migratory Waterbird Follow-up Monitoring Program
2022 Report
Site C, Peace River, BC

Waterbirds Recorded within Inundation Impact Area Spring 2022





Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Number of Bird Observations

- 1 - 2 birds
- 3 - 9 birds
- 10 or more birds

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a “stand-alone” document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basemap: ESRI World Topographic Base

N

1:220,000

0 2 4 6 8 10
Kilometres

NAD 1983 UTM Zone 10N

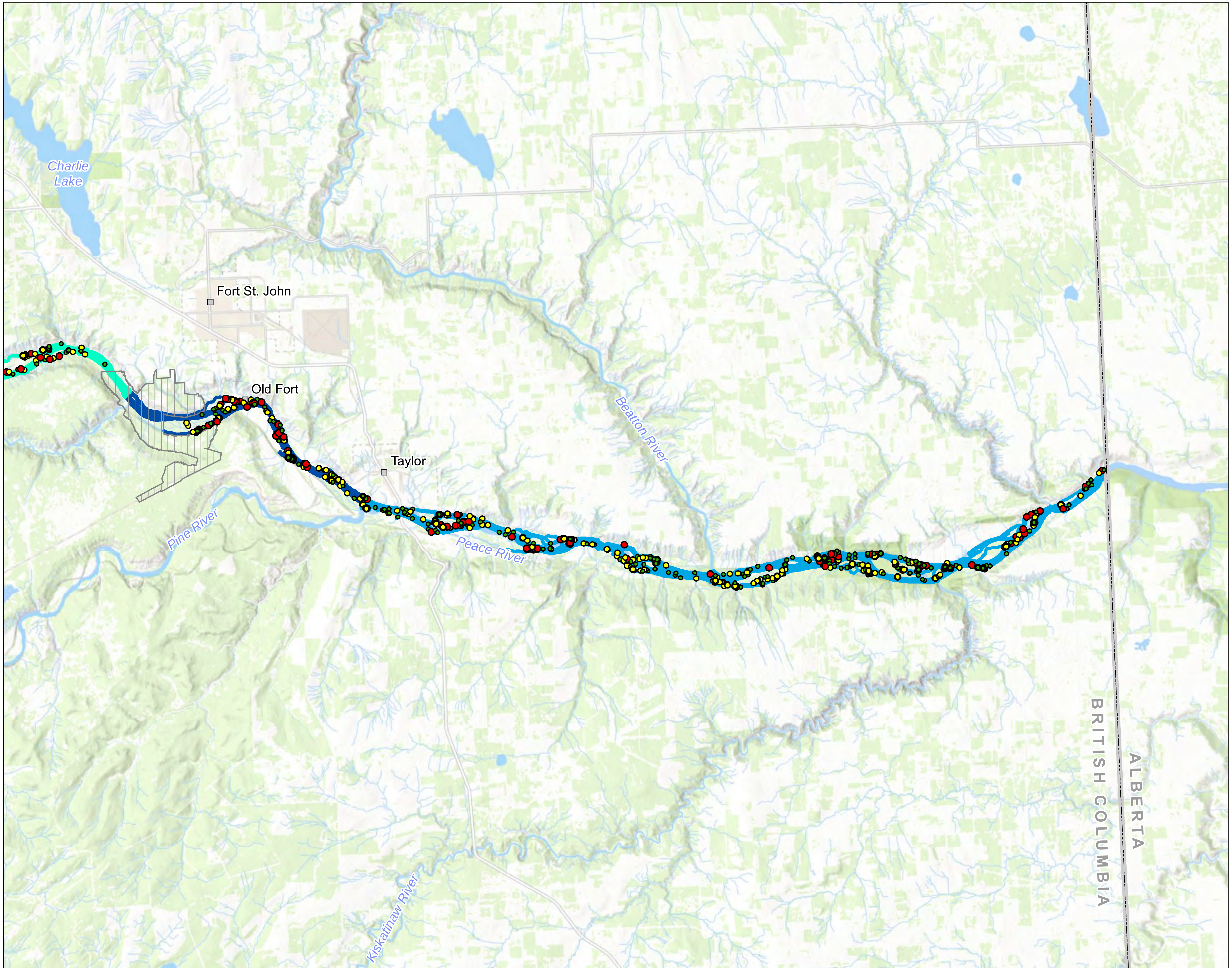
Page Size: 11" x 17"

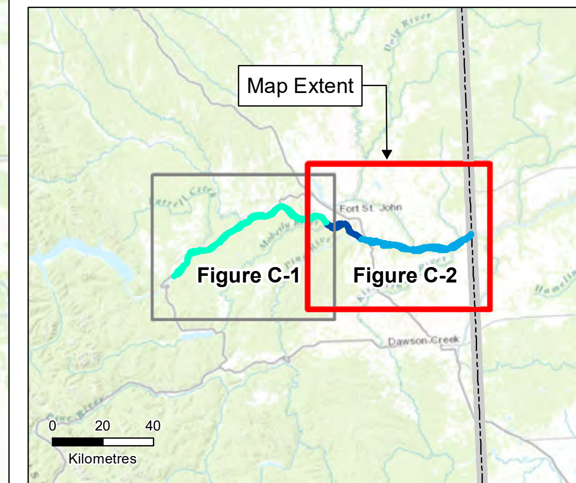
989619-07	Production Date: Mar 10, 2023	Figure C-1

Ausenco BC hydro

Migratory Waterbird Follow-up Monitoring Program
2022 Report
Site C, Peace River, BC

Waterbirds Recorded within Flow Regime Impact Area and Control Area Spring 2022





Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Number of Bird Observations

- 1 - 2 birds
- 3 - 9 birds
- 10 or more birds

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

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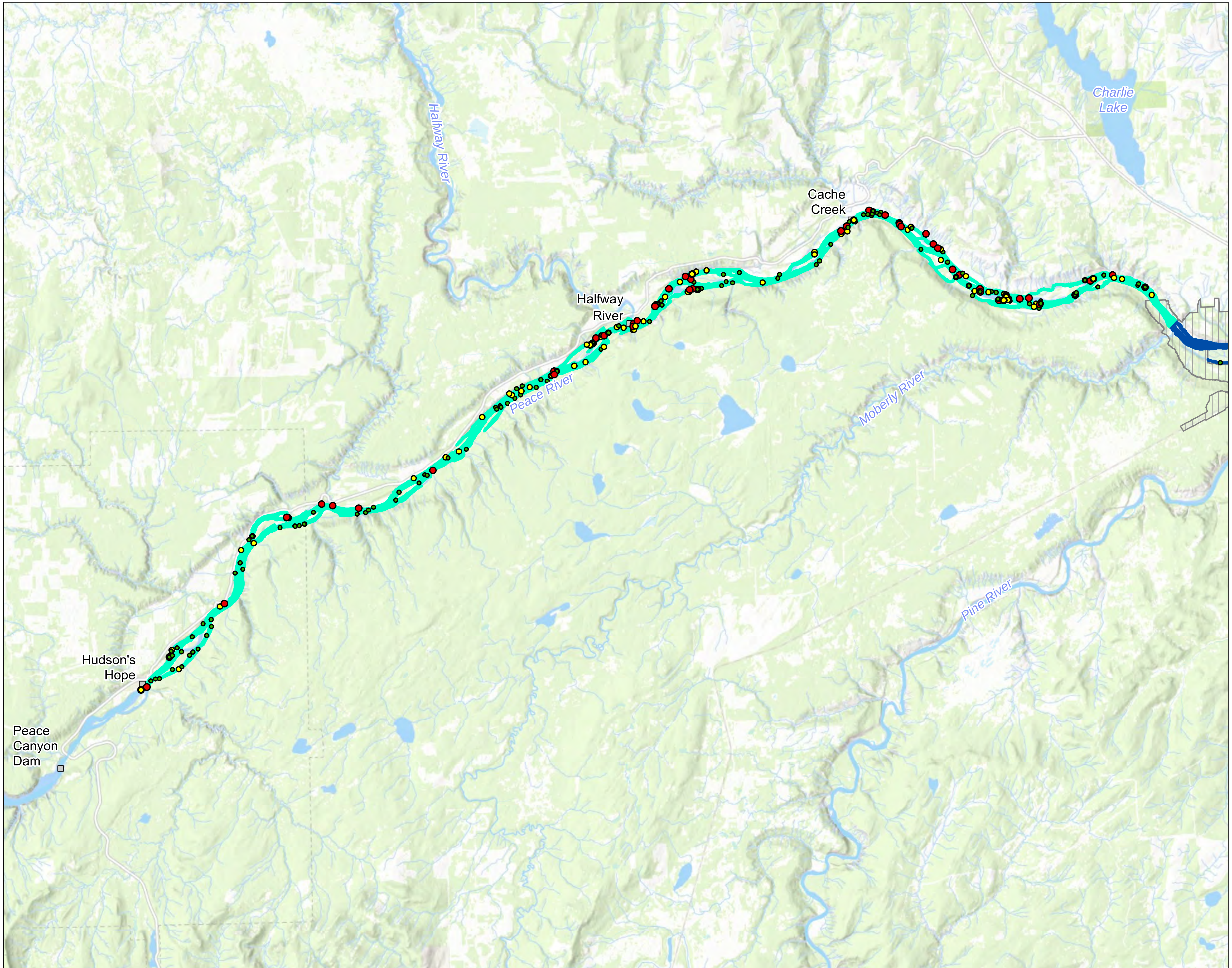
Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

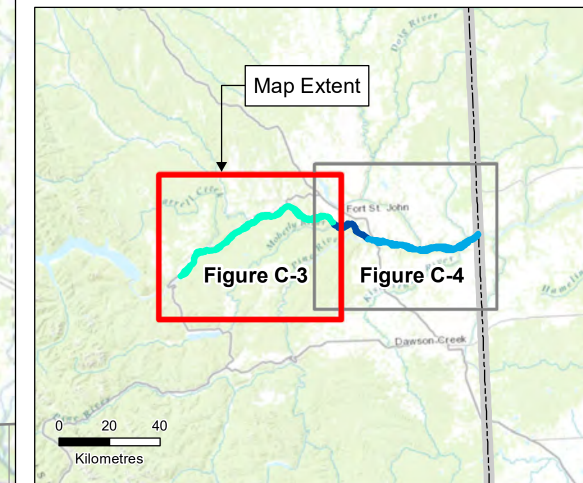
989619-07	Production Date: Mar 10, 2023	Figure C-2

Ausenco BC hydro



Migratory Waterbird Follow-up Monitoring Program
2022 Report
Site C, Peace River, BC

Waterbirds Recorded within Inundation Impact Area Fall 2022



Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Number of Bird Observations

- 1 - 2 birds
- 3 - 9 birds
- 10 or more birds

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basemap: ESRI World Topographic Base

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Kilometres

NAD 1983 UTM Zone 10N

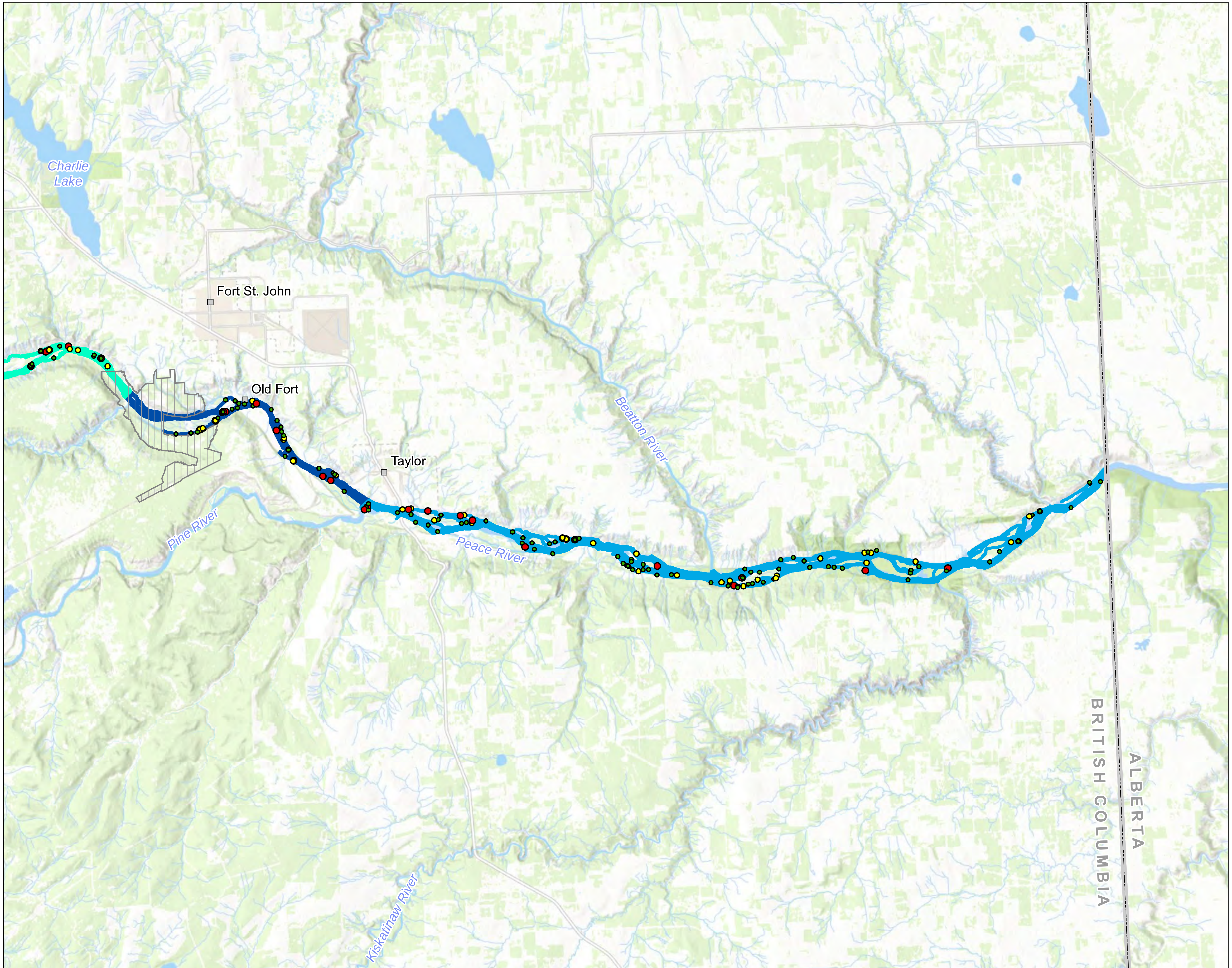
Page Size: 11" x 17"

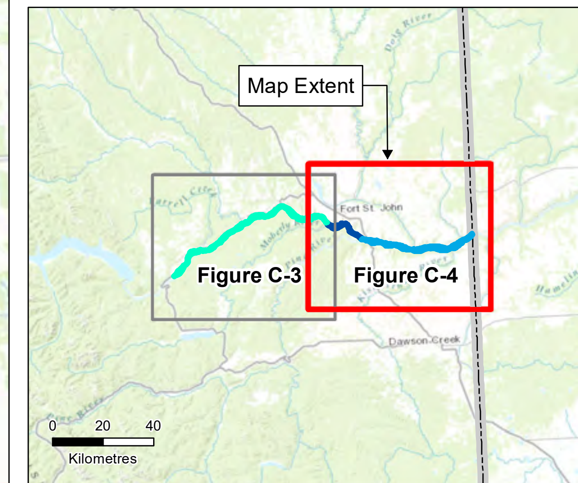
989619-07	Production Date: Mar 10, 2023	Figure C-3

Ausenco BC hydro

Migratory Waterbird Follow-up Monitoring Program
2022 Report
Site C, Peace River, BC

Waterbirds Recorded within Flow Regime Impact Area and Control Area Fall 2022





Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Number of Bird Observations

- 1 - 2 birds
- 3 - 9 birds
- 10 or more birds

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basemap: ESRI World Topographic Base

N

1:220,000

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Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-07	Production Date: Mar 10, 2023	Figure C-4

Ausenco BC hydro

Appendix D

Wetland Survey Station Photos

Photo 1 Aerial Photograph of Wetland Survey Station OW01 (September 9, 2018)

Photo 2 Aerial Photograph of Wetland Survey Station OW02 (September 18, 2018)

Photo 3 Aerial Photograph of Wetland Survey Station SE03 (lower left) and OW04 (upper right; August 22, 2019)

Photo 4 Aerial Photograph of Wetland Survey Station OW06 (October 17, 2018)

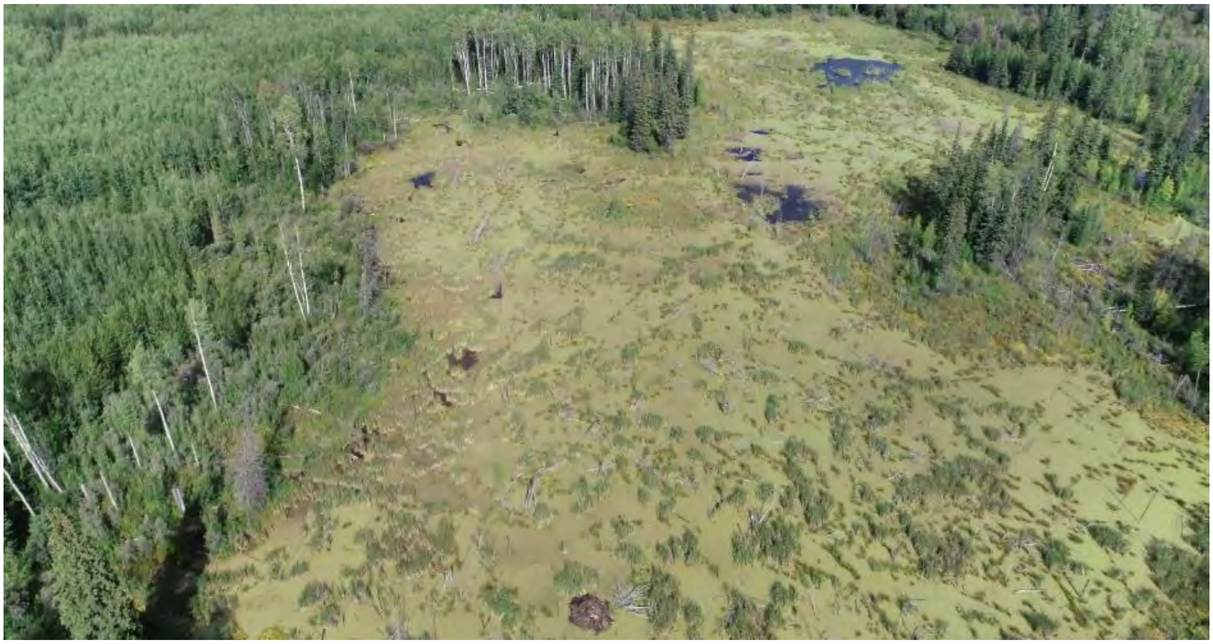


Photo 5 Aerial Photograph of Wetland Survey Station OW07 (August 22, 2019)

Photo 6 Photograph of Wetland Survey Station OW09 (October 17, 2018) Showing Habitat Representative of the Wetland Area Surveyed

Photo 7 Aerial Photograph of Wetland Survey Station OW10 (August 22, 2019)

Photo 8 Aerial Photograph of Wetland Survey Station OW11 (August 22, 2019)

Photo 9 Aerial Photograph of Wetland Survey Station SE02 (August 22, 2019)

Photo 10 Aerial Photograph of Wetland Survey Station SE04 (August 22, 2019)

Photo 11 Aerial Photograph of Wetland Survey Station SE05 (August 6, 2018)

Photo 12 Aerial Photograph of Wetland Survey Station SE06 (August 12, 2019)

Photo 13 Aerial Photograph of Wetland Survey Station SE07 (August 22, 2019)

Photo 14 Aerial Photograph of Wetland Survey Station SE08 (August 22, 2019)

Photo 15 Aerial Photograph of Wetland Survey Station SE09 (August 7, 2018)

Photo 16 Aerial Photograph of Wetland Survey Station SE10 (August 22, 2019)

Photo 17 Aerial Photograph of Wetland Survey Station SE11 (August 6, 2018)

Photo 18 Aerial Photograph of Wetland Survey Station SE12 (August 12, 2019)

Photo 19 Aerial Photograph of Wetland Survey Station SE14 (August 6, 2018)

Photo 20 Aerial Photograph of Wetland Survey Station WS01 (August 6, 2018)

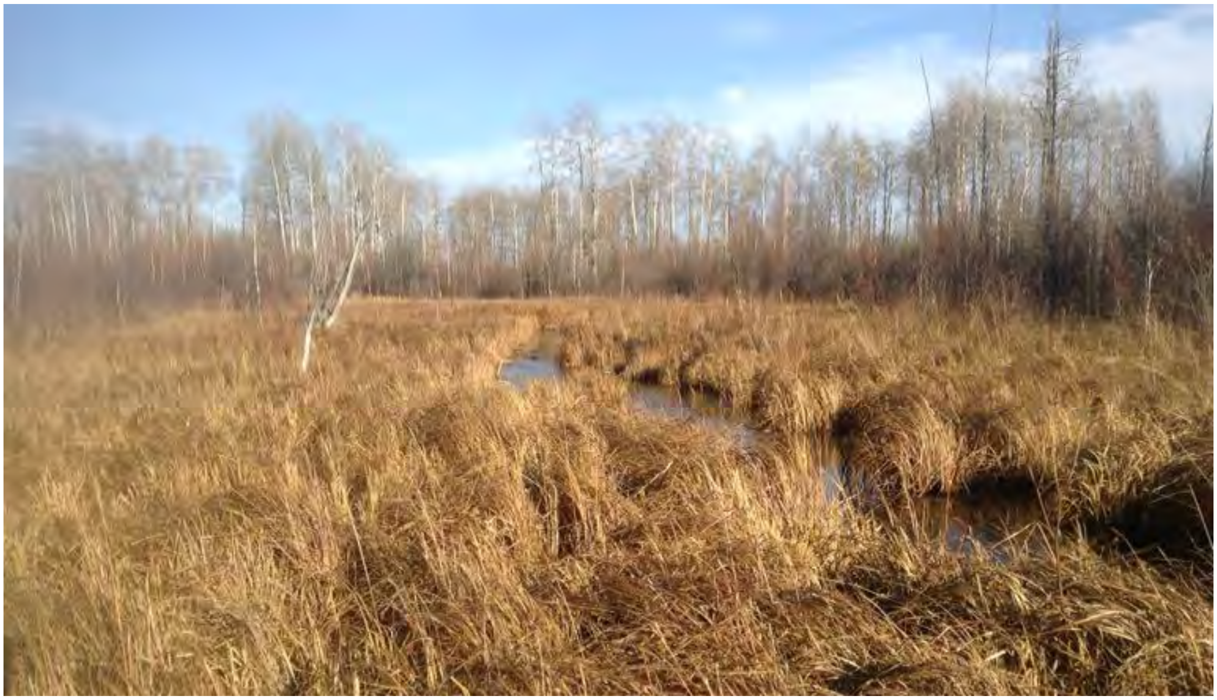


Photo 21 Photograph of Wetland Survey Station WS02 (October 17, 2018) Showing Habitat Representative of the Wetland Area Surveyed

Photo 22 Aerial Photograph of Wetland Survey Station WS03 (August 7, 2018)

Photo 23 Photograph of Wetland Survey Station OW13 (May 16, 2022) Showing Habitat Representative of the Wetland Area Surveyed

Photo 24 Aerial Photograph of Wetland Survey Station OW14 (May 5, 2022)

Appendix E

Mean and Standard Deviation Statistics Tables for Relative Abundance and Diversity Results

Note: To facilitate ease of referencing, tables in this appendix are numbered to correspond with tables in the report.

Table E-7 Mean Abundance Estimates (birds/survey round) and Variability (Standard Deviation) of Waterbird Foraging Guilds within the Peace River During Spring and Fall Survey Periods during 2017 Through 2022

Foraging Guild	Spring						Fall								Average of Means
	Early		Middle		Late		Early		Early-Middle		Late-Middle		Late		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Benthic Feeding Divers	141	88	195	170	23	14	2	3	18	40	12	18	5	-	**56**
Dabbling Ducks	963	791	714	342	463	106	85	61	284	211	242	353	51	-	**400**
Gulls	2	2	69	101	32	6	659	512	588	467	262	330	102	-	**245**
Large Dabblers	2,417	839	750	121	560	121	215	92	441	360	685	669	623	-	**813**
Piscivorous Divers	271	103	105	55	43	4	31	28	30	16	16	10	12	-	**73**
Shorebirds	2	1	14	20	135	20	189	144	111	91	3	3	0	-	**65**
Unknown Waterbirds	75	74	128	69	61	62	15	14	6	7	21	32	13	-	**46**
Total (All Waterbirds)	**3,870**	**-**	**1,975**	**-**	**1,317**	**-**	**1,195**	**-**	**1,478**	**-**	**1,242**	**-**	**805**	**-**	

Note: Sample size is 6 years except for late fall (2 years) and middle and late spring (3 years). SD = standard deviation across years. SD only presented when at least 3 years of data were available. Dashes indicate insufficient or inappropriate data for calculations.

Table E-9 Mean 2017 Through 2022 Spring Densities (birds/km^2/survey round), Estimated Abundances, and Variability (Standard Deviation) of Migrant Waterbirds by River Habitat Type and Treatment Area

Foraging Guild	Densities by River Habitat Type						Densities by Treatment Area					
	Limited Connectivity		Moderate Flow		Mainstem		Inundation Impact		Flow Impact		Control	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Benthic Feeding Divers	15.4	10.7	2.6	2.0	1.3	1.0	2.4	1.9	5.2	4.1	1.4	1.3
Dabbling Ducks	91.0	86.1	26.4	29.7	8.2	7.0	8.2	3.6	33.6	37.1	19.9	23.4
Gulls	0.0	0.0	<0.1	0.1	0.4	0.6	0.3	0.4	1.4	2.5	0.1	0.1
Large Dabblers	179.9	82.0	46.0	24.0	18.5	11.6	34.0	16.9	27.7	19.6	30.7	26.0
Piscivorous Divers	14.3	6.5	6.3	4.6	2.4	1.9	5.8	4.2	2.2	1.5	1.4	1.0
Shorebirds	4.6	5.0	0.7	0.9	0.1	0.2	0.4	0.5	0.5	0.6	0.5	0.6
Unidentified Waterbirds	5.2	7.6	1.7	2.4	0.8	0.6	1.5	1.8	0.8	1.1	1.0	1.1
Total (All Waterbirds)	**310.4**	**-**	**83.7**	**-**	**31.8**	**-**	**52.6**	**-**	**71.5**	**-**	**55.0**	**-**
Total Estimated Abundance	**1,010**	**-**	**626**	**-**	**1,382**	**-**	**1,392**	**-**	**428**	**-**	**1,198**	**-**

Note: Sample size is 6 years. SD = standard deviation across years. Dashes indicate insufficient or inappropriate data for calculations. Mean densities reflect relative rather than absolute densities as they do not account for incomplete detection. Means were calculated by averaging density estimates (birds/km^2/survey) within each habitat type across survey rounds first within periods of each year, then across periods for each season of each year, and then across years so that differences in sampling effort did not bias means towards results from years with more survey rounds or years with more survey periods. Total mean density is the sum of all foraging guild and unknown waterbird densities. Abundances calculated as density multiplied by area.

Table E-11 Mean 2017 Through 2022 Fall Densities (birds/km^2/survey round) and Variability (Standard Deviation) of Migrant Waterbirds by River Habitat Type and Treatment Area

Foraging Guild	Densities by River Habitat Type						Densities by Treatment Area					
	Limited Connectivity		Moderate Flow		Mainstem		Inundation Impact		Flow Impact		Control	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Benthic Feeding Divers	0.4	0.4	<0.1	0.1	0.2	0.2	0.3	0.3	0.2	0.2	0.1	0.1
Dabbling Ducks	28.6	28.9	5.9	12.1	0.9	0.7	4.5	2.7	7.4	11.9	0.6	0.8
Gulls	2.4	3.6	0.6	0.8	10.0	6.2	6.9	5.5	43.2	32.9	0.2	0.2
Large Dabblers	47.0	46.4	8.2	6.7	4.9	3.1	7.1	5.1	10.6	10.4	8.1	6.9
Piscivorous Divers	2.1	2.1	0.7	0.5	0.2	0.1	0.6	0.4	0.3	0.2	0.3	0.4
Shorebirds	7.6	5.0	3.1	1.9	0.9	0.7	1.5	1.1	0.7	0.3	1.9	1.5
Unidentified Waterbirds	2.5	3.4	0.1	0.2	0.1	0.1	0.3	0.3	0.5	0.8	<0.1	<0.1
Total (All Waterbirds)	**90.6**	-	**18.7**	-	**17.1**	-	**21.1**	-	**62.8**	-	**11.3**	-
Total Estimated Abundance	**295**	-	**140**	-	**745**	-	**559**	-	**376**	-	**245**	-

Note: Sample size is 6 years. SD = standard deviation across years. Dashes indicate insufficient or inappropriate data for calculations. Mean densities reflect relative rather than absolute densities as they do not account for incomplete detection. Means were calculated by averaging density estimates (birds/km^2/survey) within each habitat type across survey rounds first within periods of each year, then across periods for each season of each year, and then across years so that differences in sampling effort did not bias means towards results from years with more survey rounds or years with more survey periods. Total mean density is the sum of all foraging guild and unknown waterbird densities. Abundances calculated as density multiplied by area.

Table E-13 Mean 2017 Through 2022 Diversity Metrics for Waterbird Foraging Guilds on the Peace River Across Seasons and Survey Periods, with Variability (Standard Deviation)

Foraging Guild	Spring species richness by survey period						Spring		Fall species richness by survey period								Fall	
	Early		Middle		Late				Early		Early-Middle		Late-Middle		Late			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Benthic Feeding Divers	2.1	0.9	2.8	0.8	3.7	1.0	**2.5**	**0.9**	0.5	0.5	0.4	0.5	0.8	1.1	0.0	-	**0.5**	**0.4**
Dabbling Ducks	4.4	0.9	6.3	1.2	7.0	1.0	**5.2**	**1.1**	2.1	0.9	2.9	1.7	2.3	0.6	1.5	-	**2.3**	**0.8**
Gulls	0.3	0.6	1.8	1.9	3.5	0.5	**1.2**	**0.9**	4.3	1.3	3.3	1.0	2.6	1.6	3.5	-	**3.4**	**1.1**
Large Dabblers	2.1	0.5	2.0	1.0	1.3	0.3	**1.9**	**0.3**	1.1	0.2	1.5	0.5	1.6	0.8	2.0	-	**1.4**	**0.4**
Piscivorous Divers	1.5	0.5	2.5	0.5	3.3	0.8	**2.0**	**0.6**	1.6	1.0	2.4	1.0	2.8	1.6	1.5	-	**2.1**	**1.0**
Shorebirds	0.4	0.5	0.5	0.5	1.2	0.3	**0.4**	**0.5**	2.5	2.3	1.2	0.4	0.7	0.6	0.0	-	**1.3**	**0.6**
Total Species Richness	**10.8**	**-**	**16.0**	**-**	**20.0**	**-**	**13.2**	**-**	**12.0**	**-**	**11.8**	**-**	**10.8**	**-**	**8.5**	**-**	**11.1**	**-**
Species Evenness	**0.4**	**-**	**0.6**	**-**	**0.6**	**-**	**0.5**	**-**	**0.6**	**-**	**0.5**	**-**	**0.5**	**-**	**0.4**	**-**	**0.5**	**-**

Note: Sample size is 6 years except for late fall (2 years) and middle and late spring (3 years). SD = standard deviation across years. Dashes indicate insufficient or inappropriate data for calculations.

Table E-18 Mean 2017 Through 2022 Waterbird Densities (birds/ha/survey) and Variability (Standard Deviation) within Open Water Habitat Reported by Foraging Guild from Standwatch Surveys

Foraging Guild	Spring				Fall							
	Middle		Late		Early		Early-Middle		Late-Middle		Late	
	Mean Density	SD	Mean Density	SD	Mean Density	SD	Mean Density	SD	Mean Density	SD	Mean Density	SD
Benthic Feeding Divers	161.5	1.1	124.8	1.0	195.5	1.9	165.5	2.1	143.2	1.1	41.2	-
Dabbling Ducks	693.0	5.6	575.6	3.3	751.7	3.9	689.9	4.4	517.1	1.9	96.2	-
Gulls and Surface-Feeding Terns	1.8	<0.1	5.6	0.1	1.4	<0.1	0.0	0.0	0.0	0.0	0.0	-
Large Dabblers	177.5	2.8	55.6	0.4	27.1	0.3	21.0	0.2	13.3	0.2	0.8	-
Marsh Birds	0.9	<0.1	25.5	0.4	10.1	0.2	12.4	0.2	0.0	0.0	0.0	-
Piscivorous Divers	9.1	0.1	21.9	0.1	25.3	0.2	36.8	0.4	21.3	0.3	23.8	-
Shorebirds	53.0	0.9	101.7	0.9	95.9	1.5	10.3	0.2	0.0	0.0	0.0	-
Unknown Waterbirds	0.1	0.0	17.6	0.4	19.4	0.5	4.9	<0.1	34.8	0.6	26.3	-
Total (All Waterbirds)	**1,097**	**-**	**928**	**-**	**1,126**	**-**	**941**	**-**	**730**	**-**	**188**	**-**

Note: Sample size is 6 years except for late fall (2 years). SD = standard deviation across years. Dashes indicate insufficient or inappropriate data for calculations.

Table E-20 Mean 2018 through 2022 Waterbird Densities (birds/km/survey) and Variability (Standard Deviation) within Vegetated Wetland (sedge, willow-sedge) Habitat Reported by Foraging Guild from Transect Surveys

Foraging Guild	Spring				Fall							
	Middle		Late		Early		Early-Middle		Late-Middle		Late	
	Mean Density	SD	Mean Density	SD	Mean Density	SD	Mean Density	SD	Mean Density	SD	Mean Density	SD
Benthic Feeding Divers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Dabbling Ducks	1.38	2.06	6.74	3.98	0.07	0.16	0.58	0.64	1.37	3.06	0.00	-
Gulls	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Large Dabblers	0.27	0.25	0.24	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Marsh Birds	0.79	0.91	3.43	2.71	1.34	0.93	1.39	0.94	0.30	0.27	0.00	-
Piscivorous Divers	0.00	0.00	0.09	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Shorebirds	0.64	0.55	2.85	3.45	0.10	0.21	0.00	0.00	0.00	0.00	0.00	-
Unknown Waterbirds	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Total (All Waterbirds)	**3.08**	**-**	**13.35**	**-**	**1.51**	**-**	**1.97**	**-**	**1.66**	**-**	**0.00**	**-**

Note: Sample size is 5 years except for late fall (2 years). SD = standard deviation across years. Dashes indicate insufficient or inappropriate data for calculations.

Table E-24 Species Richness of Waterbird Foraging Guilds Observed During Standwatch Surveys of Wetland Habitats in 2017 through 2022, with Variability (Standard Deviation)

Foraging Guild	Spring species richness by survey period						Spring		Fall species richness by survey period								Fall	
	Early		Middle		Late				Early		Early-Middle		Late-Middle		Late			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Benthic Feeding Divers	-	-	2.5	1.2	3.6	1.8	**3.0**	**1.2**	2.0	0.9	1.9	0.7	2.3	0.6	2.0	-	**2.0**	**0.5**
Dabbling Ducks	-	-	6.0	2.8	7.5	2.8	**6.8**	**2.5**	5.6	2.6	6.4	2.4	5.5	2.7	4.0	-	**5.3**	**2.1**
Gulls	-	-	0.3	0.5	0.8	0.7	**0.6**	**0.4**	0.7	0.8	0.0	0.0	0.0	0.0	0.0	-	**0.2**	**0.3**
Large Dabblers	-	-	1.5	0.8	1.8	0.5	**1.6**	**0.6**	0.8	0.4	1.2	0.3	0.9	0.2	1.0	-	**1.0**	**0.1**
Marsh Birds	-	-	0.4	0.5	0.9	0.7	**0.7**	**0.3**	0.3	0.4	0.7	0.6	0.0	0.0	0.0	-	**0.3**	**0.2**
Piscivorous Divers	-	-	1.8	1.9	3.5	2.1	**2.7**	**1.9**	3.2	1.5	3.3	1.6	2.5	2.4	2.0	-	**2.8**	**1.4**
Shorebirds	-	-	1.0	1.2	2.5	1.3	**1.7**	**1.1**	1.5	0.8	0.3	0.5	0.0	0.0	0.0	-	**0.5**	**0.2**
Total Species Richness	**-**	**-**	**13.1**	**8.1**	**20.6**	**8.1**	**16.8**	**7.4**	**14.0**	**4.7**	**13.8**	**4.0**	**11.3**	**4.4**	**9.0**	**-**	**12.1**	**3.9**
Species Evenness	**-**	**-**	**0.8**	**0.1**	**0.8**	**0.1**	**0.8**	<0.1	**0.8**	**0.1**	**0.8**	<0.1	**0.7**	**0.1**	**0.7**	**-**	**0.8**	**0.1**

Note: Sample size is 5 years except for late fall (2 years). SD = standard deviation across years. Dashes indicate insufficient or inappropriate data for calculations.

Table E-26 Species Richness of Waterbird Foraging Guilds Observed During Transect Surveys of Wetland Habitats in 2018 through 2022, with Variability (Standard Deviation)

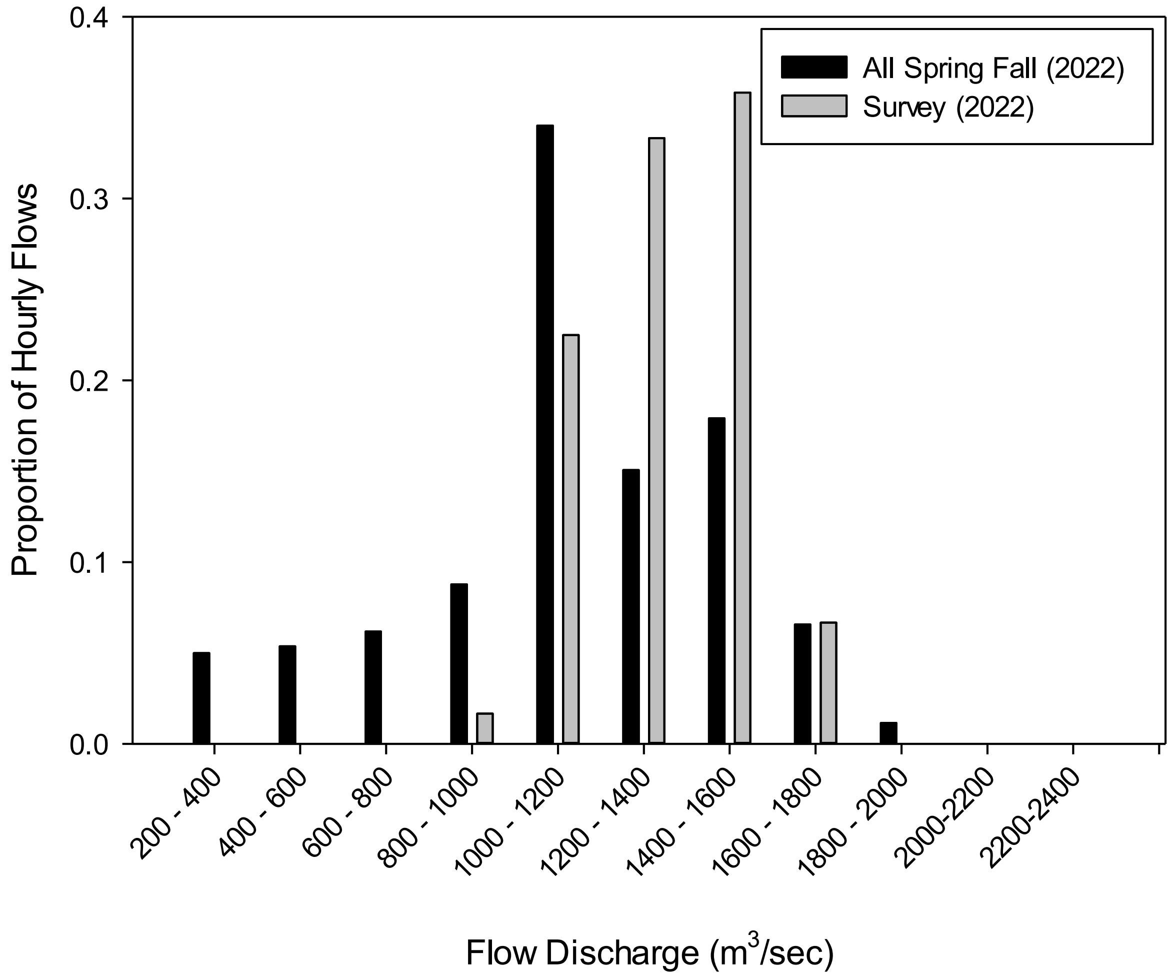
Foraging Guild	Spring species richness by survey period						Spring		Fall species richness by survey period								Fall	
	Early		Middle		Late				Early		Early-Middle		Late-Middle		Late			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Benthic Feeding Divers	-	-	0.0	0.0	0.1	0.2	**0.1**	**0.1**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	**0.0**	**0.0**
Dabbling Ducks	-	-	1.1	1.3	3.5	1.6	**2.3**	**0.7**	0.8	1.3	0.5	0.5	0.3	0.4	0.0	-	**0.6**	**0.6**
Gulls	-	-	0.0	0.0	0.0	0.0	**0.0**	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	**0.0**	**0.0**
Large Dabblers	-	-	0.5	0.5	0.3	0.4	**0.4**	**0.1**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	**0.0**	**0.0**
Marsh Birds	-	-	1.2	1.3	2.1	0.9	**1.7**	**0.9**	1.4	0.9	1.3	0.4	0.6	0.5	0.0	-	**1.0**	**0.4**
Piscivorous Divers	-	-	0.0	0.0	0.2	0.4	**0.1**	**0.2**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	**0.0**	**0.0**
Shorebirds	-	-	1.2	0.8	1.2	1.0	**1.2**	**0.3**	0.2	0.4	0.0	0.0	0.0	0.0	0.0	-	**0.0**	**0.1**
Total Species Richness	**-**	**-**	**4.0**	**3.8**	**7.4**	**3.7**	**5.7**	**2.1**	**2.4**	**1.8**	**1.8**	**0.9**	**0.9**	**0.7**	**0.0**	**-**	**1.6**	**0.8**
Species Evenness	**-**	**-**	**0.7**	**0.2**	**0.8**	**0.1**	**0.7**	**0.1**	**0.8**	**0.3**	**0.7**	**0.5**	**0.2**	**-**	**-**	**-**	**0.8**	**0.3**

Note: Sample size is 5 years except for early spring (no surveys) and late fall (2 years). SD = standard deviation across years. Dashes indicate insufficient or inappropriate data for calculations.

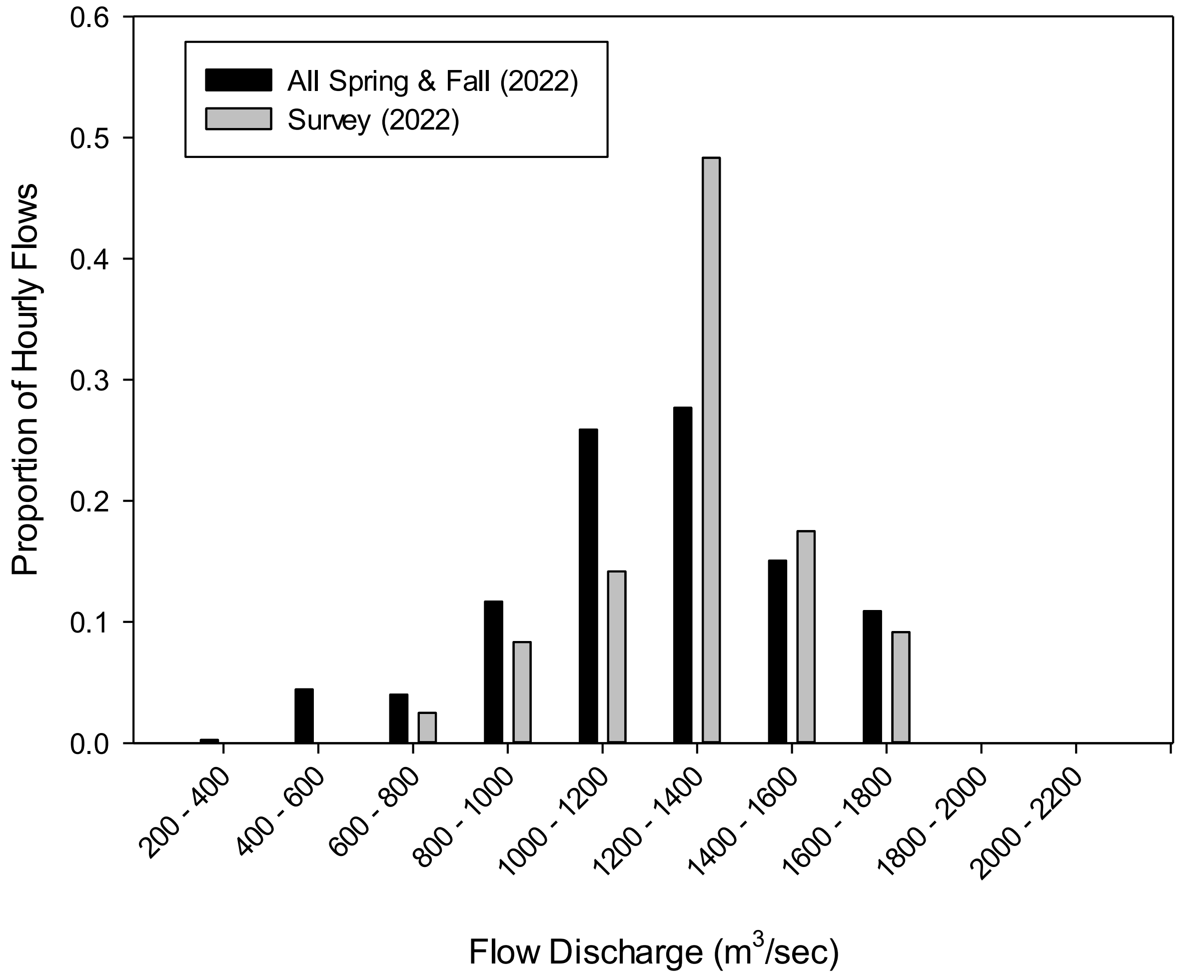
Appendix F

Peace River Flow Rates in 2022 during Surveys Relative to during the Entire Spring and Fall Migration Period

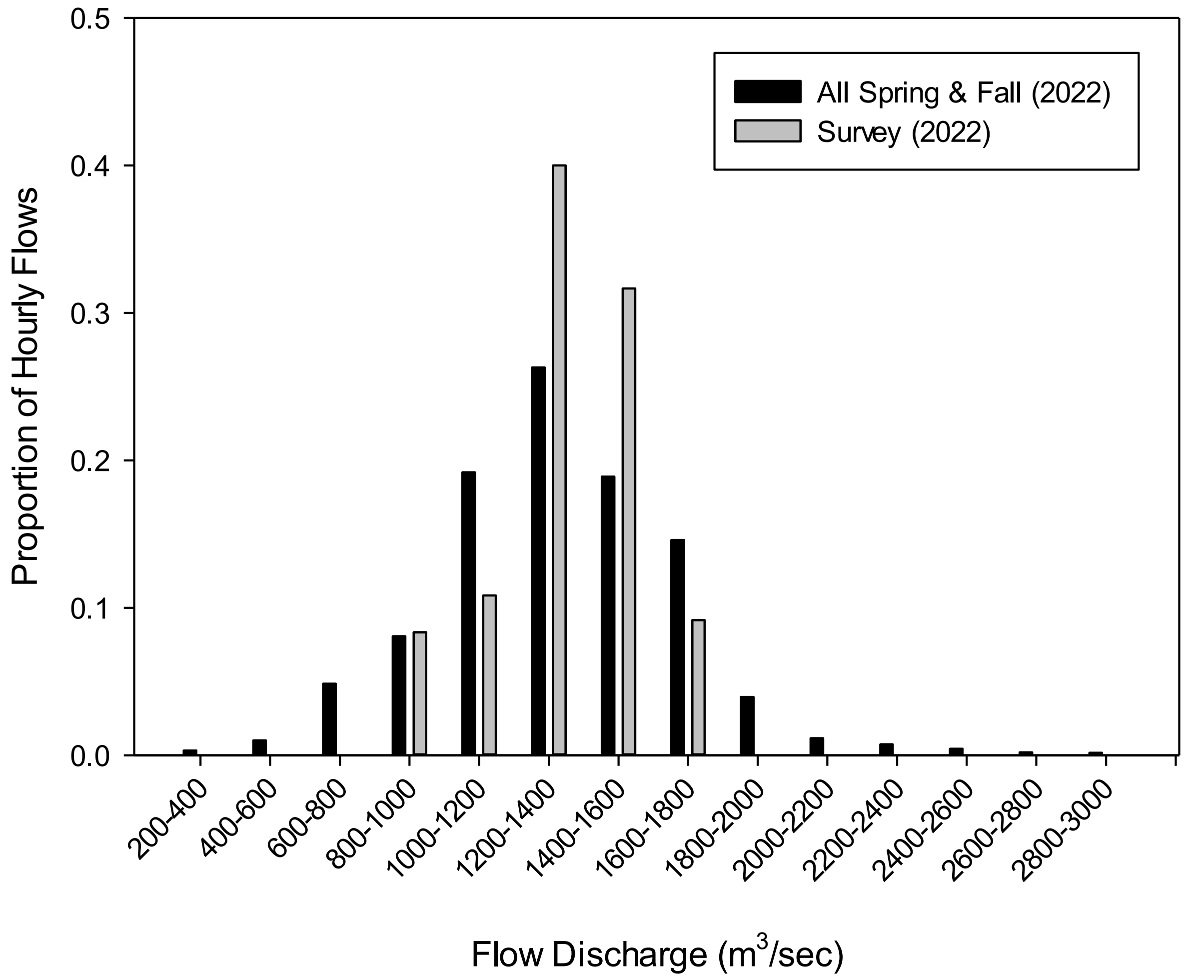
Appendix F-1 Distribution of 2022 hourly flow rates (shown as proportion of total) in the Inundation Impact treatment area during surveys relative to across spring and fall.



Appendix F-2 Distribution of 2022 hourly flow rates (shown as proportion of total) in the Flow Impact treatment area during surveys relative to across spring and fall.



Appendix F-3 Distribution of 2022 hourly flow rates (shown as proportion of total) in the Flow Control treatment area during surveys relative to across spring and fall.



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Appendix 4. Migratory Bird Nest Monitoring Program 2022 Annual Report

Site C Migratory Bird Nest Monitoring Program – 2022 Annual Report

Red-winged blackbird nest on plot 118. Photo Credit: Shae Turner

Morning in the headpond zone. Photo Credit: Chris Coxson

Cedar waxwing nest on plot 132. Photo Credit: Chris Coxson

Prepared for:

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Project No. 103707-03

March 23, 2023

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Executive Summary

BC Hydro has developed a program, in consultation with Environment Canada, to monitor and mitigate potential disturbance to breeding migratory birds during the Site C Clean Energy Project (the Project), where risks to migratory bird nests could occur during reservoir construction, filling, and operations.

The Project is currently in the construction phase. Since river diversion in fall 2020, water level changes in the headpond zone (upstream of the dam site) are expected to be pronounced relative to normal river level changes due to the flow restriction represented by the river diversion tunnels. These changes to the water level have the potential to affect the productivity of nesting birds. The migratory bird nest monitoring program gathers data to evaluate the relative contribution of the Project to documented nest impacts.

The first year of nesting bird field surveys took place in 2021. This report summarizes the second year of surveys in 2022.

The disturbance or mortality of nesting migratory birds in the study area was assessed using nest searching and monitoring. Nesting attempts of migratory bird species were monitored on selected plots in the various habitat types within both the headpond zone and river channel downstream of the dam site. Supplementary data were collected on the potential number of territories for each species observed on the monitoring plots.

Twenty-three plots totalling an area of 10 ha were surveyed regularly from June 2 to July 11, 2022. A total of 70 nests of 19 species were located, including 40 nests of 14 species within the intensively surveyed nest monitoring plots. A species federally listed as Threatened, common nighthawk (*Chordeiles minor*), was detected nesting on 2 plots within the headpond. Canada warbler (*Cardellina canadensis*), federally listed as Special Concern and provincially Blue-listed, was observed singing on a plot, but no nest was located.

Across the study area, 39% of nests detected were considered successful, 36% failed, and 25% had an unknown outcome. The most common cause of nest failure was predation, as is typical for breeding birds.

None of the monitored nests failed due to flooding in 2022. Overall, water levels were relatively low throughout the breeding season, reducing the area that was affected by water fluctuations.

No nest monitoring is planned for 2023, but monitoring will continue in 2024 within the reservoir drawdown zone and downstream river channel after the reservoir is filled.

This work was performed in accordance with Contact No. 4500023118 between Ausenco Sustainability Inc., a wholly owned subsidiary of Ausenco Engineering Canada Inc. (Ausenco), and BC Hydro, dated June 1, 2021 (Contract). This report has been prepared by Ausenco, based on fieldwork conducted by Ausenco, for sole benefit and use by BC Hydro. In performing this work, Ausenco has relied in good faith on information provided by others, and has assumed that the information provided by those individuals is both complete and accurate. This work was performed to current industry standard practice for similar environmental work, within the relevant jurisdiction and same locale.

The findings presented herein should be considered within the context of the scope of work and project terms of reference; further, the findings are time sensitive and are considered valid only at the time the report was produced. The conclusions and recommendations contained in this report are based upon the applicable guidelines, regulations, and legislation existing at the time the report was produced; any changes in the regulatory regime may alter the conclusions and/or recommendations.

This Executive Summary is not intended to be a stand-alone document, but a summary of findings as described in the following Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Table of Contents

List of Tables (Within text)

List of Figures (Within text)

Appendices

List of Acronyms and Abbreviations

Acronym / Abbreviation	Definition
Ausenco	Ausenco Sustainability Inc.
DRC	Downstream river channel
HPZ	Headpond zone
Project	Site C Clean Energy Project
RDZ	Reservoir drawdown zone

List of Symbols and Units of Measure

Symbol / Unit of Measure	Definition
ha	hectare
km	kilometre
m	metre
m ASL	metres above sea level

1.0 Introduction

The Site C Clean Energy Project (the Project) is currently under construction on the Peace River in northeastern British Columbia. BC Hydro has developed a program to monitor and mitigate potential disturbance to breeding migratory birds during the Project. The first year of nesting bird field surveys took place in 2021. This report summarizes the second year of surveys that took place in 2022.

1.1 Background

BC Hydro used key species groups, including migratory birds, to assess the potential effects of the Project on Wildlife Resources in the Site C Environmental Impact Statement (BC Hydro 2013). The report of the Joint Review Panel concluded that the Project would likely cause significant adverse effects to migratory birds relying on valley bottom habitat during their life cycle (Government of British Columbia and Government of Canada 2014). The Joint Review Panel recommended that BC Hydro develop a program in consultation with Environment Canada to monitor and mitigate potential disturbance to breeding migratory birds where risks to migratory bird nests could occur during reservoir construction, filling, and operations.

The Project is currently in the construction phase. Beginning in fall 2020, the Peace River was diverted, creating a headpond upstream of the dam site due to flow restrictions in the diversion tunnels. During construction, water level changes in the headpond are expected to be pronounced relative to normal river level changes (BC Hydro 2013). Downstream of the dam site, changes to the water levels during river diversion are expected to be smaller and smoother because the headpond will dampen flow rates (BC Hydro 2013). Thus, the more pronounced changes to water levels in the headpond will have the greater potential to affect the productivity of nesting birds.

Additional background on the bird nest monitoring program is provided in the Site C Vegetation and Wildlife Migratory Bird Nest Monitoring Program (BC Hydro 2021). The second year of field surveys took place in 2022 during the construction phase of the Project and this annual report summarizes those survey results.

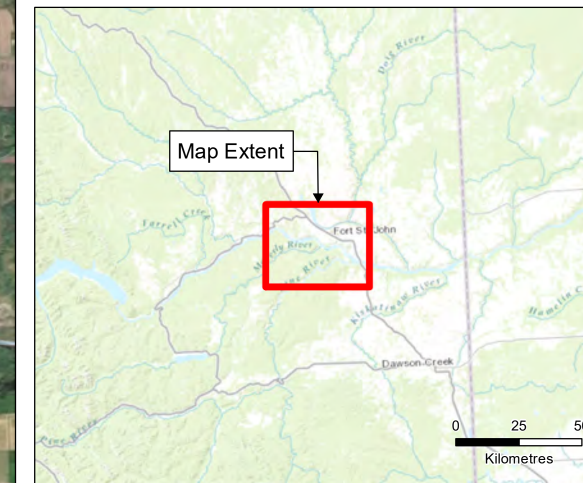
1.2 Study Area

The Peace River valley is in northeastern British Columbia and the Project site is along the river near Fort St. John (**Figure 1.1**). Above the dam site, the river flows east from the Williston and Dinosaur Reservoirs and, downstream of the dam, it continues through Alberta to Great Slave Lake.

The river valley is within the Moist Warm subzone of the Boreal White and Black Spruce biogeoclimatic zone. The zone receives little precipitation compared to other northern regions of the province and is dominated by upland forest and muskeg (Government of BC 1991).

2022 Nest Monitoring
Site C, Peace River, BC

Overview



Legend

- Site C Dam
- Water Level Monitoring Station
- Nest Monitoring Plot
- City
- Major Road
- Watercourse
- River / Waterbody

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Contains information licensed under the Open Government Licence - Province of British Columbia
- Aerial Image: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

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The study area for the nest monitoring program focuses on areas that may be affected by water level fluctuations and consists of 3 sub-areas:

- Headpond Zone (HPZ) - during construction, the temporary headpond upstream of the dam is expected to have pronounced water fluctuations relative to normal river levels. The area within the 90th percentile of headpond inundation will be monitored.
- Reservoir Drawdown Zone (RDZ) - during operations, the water level of the reservoir impounded upstream of the dam will fluctuate. The zone of fluctuation between the minimum normal (460 m) and maximum normal (461.8 m) reservoir water levels will be monitored.
- Downstream River Channel (DRC) - during construction and operations, the volume of water released from the Site C dam will dictate the river channel footprint between the Site C dam and the Pine River. The Pine River adds sufficient volume to make expected Site C fluctuations indistinguishable downstream of its confluence with the Peace River. The area of expected maximum and minimum flows will be monitored.

Nest monitoring in 2022 took place within the HPZ and DRC. Once the dam is operating, upstream nest monitoring will shift from the HPZ to the RDZ.

1.3 Monitoring Objectives

The objective of this program is to document the effects of fluctuating water levels due to the Site C Project on breeding migratory birds that use the habitat around the Site C reservoir and along the Peace River downstream of the dam. The disturbance to and mortality of breeding migratory birds (including eggs) caused by fluctuating water levels will be evaluated to determine the relative contribution of the Project to documented nest impacts.

Data gathered during the migratory bird nest monitoring program will address the following questions:

- During construction, 1) how many nesting migratory bird species and associated nests are present in the fluctuation zone of the construction headpond, and 2) how many of these nests experience disturbance or mortality due to fluctuating water levels?
- During operations, 1) how many nesting migratory bird species and associated nests are present in the Site C reservoir drawdown zone and in the Site C dam to Pine River zone of fluctuation, and 2) how many of these nests experience disturbance or mortality due to fluctuating water levels?

2.0 Methods

2.1 Habitat Classification and Plot Selection

In 2021, it was found that the habitat observed in the field did not closely match the previously completed mapping described in the 2021 Nest Monitoring Plan (BC Hydro 2021). For example, much of the area at lower elevations that had been mapped as unvegetated was found to be vegetated. Thus, plots in 2021 were re-selected to represent the range of habitat types that were observed in the field, to capture the diversity of habitats present in the study area.

Prior to the 2022 field season, updated aerial imagery and LiDAR data became available and this information was used to classify the terrestrial habitat within the HPZ and DRC into the following broad habitat strata: tree, shrub, herb, wetland, and unvegetated (**Table 2.1**). Some areas that were challenging to classify using the aerial imagery were examined in the field in 2022.

Plots were selected to represent each habitat stratum roughly in proportion to its availability within the study area and to include the variety of vegetation types observed within that stratum, where feasible. For example, shrub plots were selected to include a range of vegetation heights and species. The broad habitat strata were used for all summaries of nesting data by habitat provided in **Section 3.0** Results.

Table 2.1 Description of Habitat Strata Used for Habitat Classification in 2022

Habitat Stratum	Description	Total Area Available – Downstream River Channel (ha[1])	Total Area Available - Headpond (ha)	Total Area Available (ha)
Tree	Vegetation over 10 m tall. These locations were buffered by 1.5 m.	5.7	1.7	7.4
Shrub	Vegetation under 10 m tall and appearing to be shrubs (clumps of vegetation) on aerial imagery.	37.5	85.8	123.2
Herb	Vegetated areas that did not appear to be shrubs or trees (uniform and not clumped).	13.8	63.3	77.1
Wetland	One wetland is known within the study area. Other potential areas were examined in the field in 2022, but none were wetlands.	0.0	1.8	1.8
Unvegetated	Areas that did not appear to be vegetated on aerial imagery.	36.2	15.7	52.0
	Total	**93.2**	**168.3**	**261.5**

[1] ha = hectares

2.2 Survey Timing

The migratory bird breeding period in the study area is from late April to late August (the Project area falls within Zone B5 of the general nesting periods of migratory birds in Canada [Government of Canada 2018]), but late May through mid July is when most species likely to be found within the study area are expected to be actively breeding (Rousseu and Drolet 2015). In 2022, field surveys took place over 6 weeks from the end of May though early July.

Nest searching was conducted on each plot 1 to 2 times per week. More time was spent searching on plots with complex vegetation or known pairs for which nests had not yet been found. The days selected for searching typically coincided with the monitoring of active nests on the plot; these nest checks were completed every 3 to 4 days.

2.3 Field Surveys

Nest searching and monitoring field surveys were used to assess the disturbance or mortality of nesting migratory birds in the study area. The nesting attempts of migratory bird species breeding in the sub-areas were monitored in each of the habitats in the sub-areas during Site C dam construction in 2022.

Nest searching was primarily conducted by walking through plots and watching birds for behavioural cues indicating nesting. Occasionally, systematic searches were conducted in areas where nests were suspected. Nests were also found incidentally, such as when a surveyor accidentally flushed a bird from a nest while walking by. Nest searching was conducted in a manner that minimized disturbance to breeding birds and vegetation concealing the nest, while still maintaining search effectiveness. Nest searching and monitoring methods are described in more detail in the Nest Monitoring Plan (BC Hydro 2021).

In 2022, we also began recording the number of suspected territories for each species on each plot based on adults observed during nest surveys. The purpose of recording these territory mapping data was to provide some insight into the numbers of territories that may be present on a plot for which nests were never found.

2.4 Data Management and Analysis

In the field, data were recorded on field survey forms and nest cards printed on waterproof paper (see example in Nest Monitoring Plan [BC Hydro 2021]). All data, except for the territory mapping data, were entered daily into a custom nest monitoring database. Territory mapping data were entered into a shared spreadsheet. Custom data queries were then exported from the database and data analyses were completed using R (R Core Team 2022).

2.4.1 Water Levels

Water level data were available for multiple stations in the HPZ and DRC for every hour of each day. For plotting purposes, daily averages were calculated to minimize clutter on the figures. Water level / water elevation are presented throughout this report in metres above sea level (m ASL).To visualize overall water levels within the study sub-areas and for discussion of relative water level fluctuations, we used the Tea Creek 02 station for the HPZ and the Old Fort Primary station for the DRC (**Figure 1.1**). These stations are near the nest monitoring plots and had no missing data. When examining water level in relation to plot elevation (**Section 3.3.4** Nest Elevation), the Below Bear Flats station was also included because it was closer to the most upstream HPZ plots (**Figure 1.1**).

2.4.2 Nest Monitoring

A summary of nest monitoring survey effort was tabulated by calculating the number of person-hours spent conducting field activities on plots of each habitat stratum.

Nest records and monitoring data were summarized to provide information about migratory bird nesting activity within the study area. Only data from nest monitoring plots were included when summarizing results by habitat stratum, but all nest records were included for other types of summaries.

Taxonomic information was drawn from the most recent ABA Checklist, which follows changes made to the American Ornithological Society's North and Middle American Birds checklist (American Birding Association 2022).

The numbers of nests detected were calculated within the HPZ and the DRC (both on and off plot), and within each habitat stratum. For each habitat stratum, species richness (i.e., the number of species) and species evenness (i.e., the degree of similarity in abundance of each species) were calculated. Species evenness was calculated using Pielou's evenness:

$$Species\ evenness = \frac{(-\sum_{i=1}^{S}(p_i \times \ln p_i))}{(\ln S)}$$

where S is the number of species (i.e., species richness), p_i is the proportion of all sampled birds represented by species i, and ln is the natural logarithm (MacDonald et al. 2017). Species diversity metrics were calculated using the R package 'vegan' (Oksanen et al. 2022).

The ground elevation at the nest site and the nest height above ground were added together to determine the nest elevation in m ASL for each nest. Ground elevations for plots and nest locations were estimated from a digital elevation model (DEM) and compared to elevations recorded in the field with a handheld GPS. These nest elevations (in m ASL) were used when considering the potential for nests to interact with fluctuating water levels.

Nest phenology information was calculated for each nest to allow the estimation of the time periods during which nests are likely to be active for each species. Date of clutch initiation (date the first egg was laid) was estimated by combining recorded dates of egg laying (when eggs were counted) or nestling observations (when nestling age is estimated), with published knowledge of incubation periods (Billerman et al. 2022), and making the assumption that 1 egg was laid per day and that incubation began on the day when the final egg was laid.

The last observation at a nest was used to determine the end of the nesting period. Using the nest initiation dates and last observation dates, a data set was generated indicating the status of each nest (active/inactive, 1/0) on each day during the time span when known nests were active. The proportion of the total nests found that were active on each day was determined by summing the number of nests active on that day and dividing that value by the total number of nests in the 2022 data set. To visualize nest phenology, these values were then plotted using a loess smoother (span = 0.2) within the 'geom_smooth' function in the R package 'ggplot2' (Wickham 2016).

The number of nests per hectare (nest density) was calculated for each habitat stratum by dividing the sum of the numbers of nests found in each habitat stratum by the sum of the areas of the monitored plots for each habitat stratum. These estimates do not account for the detectability of individual species, thus should be considered minimums, although the repeated nest searching visits helps to decrease this uncertainty. In 2022, a second calculation of nest density was completed under the assumption that nests may have been present for pairs observed repeatedly on plots but for which nests were not found (i.e., pairs documented in territory mapping data). Nest density calculations by habitat strata are cumulative and include all nests from the entire monitoring period, thus do not represent the density of active nests on a plot at any one time.

Nest outcome percentages were calculated by dividing the total number of nests for each nest outcome by the total number of nests with known outcomes for the overall study area, each study sub-area, and each habitat stratum. Nests that may have been present based on territory mapping were not included in nest outcome calculations because nest presence and outcomes could not be determined.

3.0 Results

3.1 Water Levels

The water levels in the both the HPZ (Tea Creek 02 Station) and DRC (Old Fort Primary Station) were decreasing during the early part of the breeding season and remained relatively low throughout (**Figure 3.1**). Water levels were highest in early May and began to fluctuate to higher elevations again in late July and early August (**Figure 3.1**). Nest monitoring plots were distributed throughout the study area, and some were closer to other water monitoring stations, but for simplicity only 2 stations are shown in **Figure 3.1**. Water level fluctuations at all stations followed a similar pattern but the relative changes in elevation were smaller in the DRC than in the HPZ.

During the field season, the water level varied within a 4.0 m range (411.1 to 415.1 m ASL) in the HPZ and a 1.6 m range (406.2 to 407.8 m ASL) in the DRC. The maximum water levels during the field season occurred in both study areas on June 28. The water levels increased by 0.98 m in the HPZ and 0.39 m in the DRC between June 27 and 28, representing the largest increases in the daily average water levels during the field season.

The water level range over the entire bird breeding season (April 22 to August 24) was 6.0 m (410.9 to 416.9 m ASL) in the HPZ and 2.3 m (406.0 to 408.3 m ASL) in the DRC. The maximum water level in both study areas occurred on May 7. The largest increase in the daily average water level in the HPZ was 1.57 m on May 12. The largest increase in the daily average water level in DRC was 0.70 m on July 26.

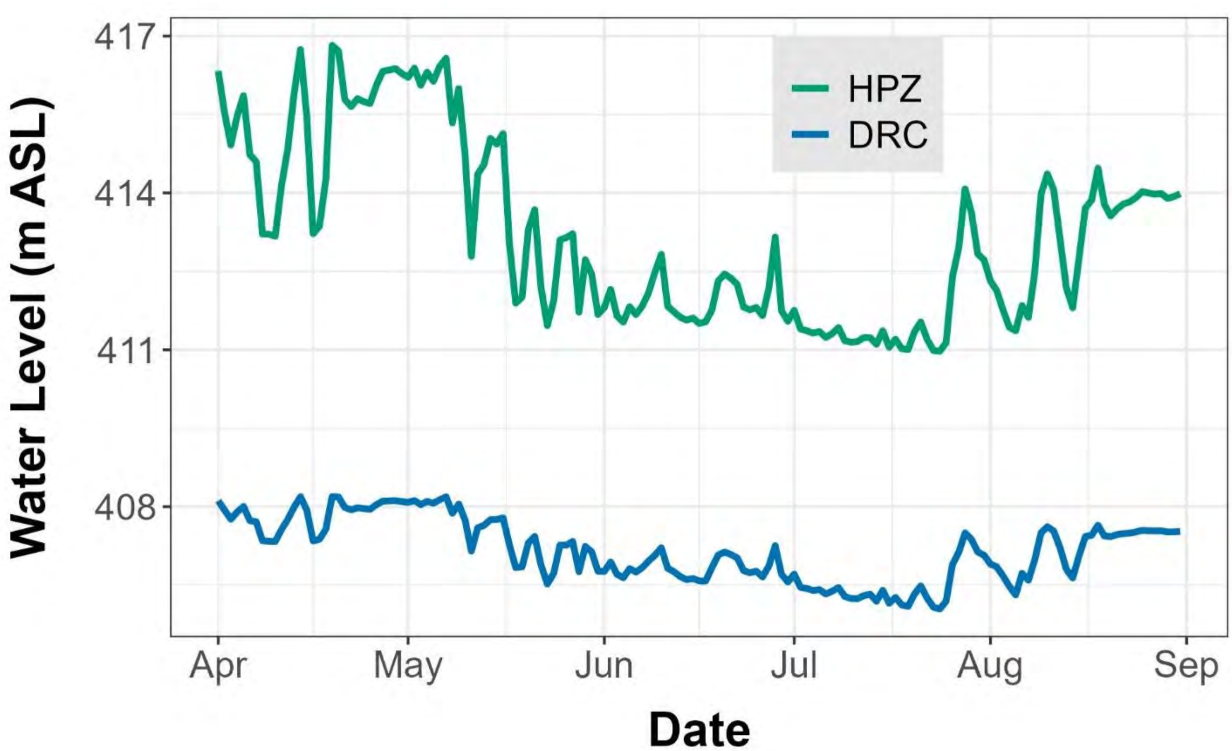

Figure 3.1 Water Levels (daily average m ASL) at Tea Creek 02 in the Headpond (HPZ) and Old Fort Primary in the Downstream River Channel (DRC) during the 2022 Migratory Bird Breeding Season.

3.2 Plot Selection and Habitat

Twenty-three plots totalling an area of 10 ha were surveyed regularly during the 2022 breeding season, including 5.7 ha in the HPZ and 4.3 ha in the DRC. The elevations of plots surveyed in the HPZ and DRC ranged from 413 to 419 m and 406 to 412 m, respectively (**Table 3.1**).

The selected plots included 5 habitat strata in the HPZ and 4 habitat strata in the DRC (**Table 3.2**). Wetland habitat is not present within the DRC.

Table 3.1 Habitat Stratum, Area, and Elevation of Nest Monitoring Plots

Plot ID	Habitat Stratum	Area (ha)	Minimum Elevation (m ASL)	Average Elevation (m ASL)	Maximum Elevation (m ASL)
Downstream River Channel					
12	Shrub	0.17	406	407	407
13	Tree	0.19	406	409	412
14	Herb	0.67	406	406	407
15	Herb	0.46	406	407	408
16	Herb	0.15	407	407	408
17	Shrub	0.29	407	408	408
18	Shrub	0.35	407	408	409
19	Shrub	0.42	407	408	410
20	Unvegetated	0.69	409	409	409
21	Herb	0.15	409	409	409
22	Unvegetated	0.72	409	410	410
24	Herb	0.08	407	408	408
Headpond					
118	Wetland	1.02	417	417	418
121	Herb	0.52	418	419	419
122	Shrub	0.34	417	418	418
125	Shrub	0.24	416	416	417
126	Herb	0.88	416	416	417
127	Unvegetated	0.72	415	416	416
128	Shrub	0.25	415	417	418
129	Tree	0.38	414	416	418
130	Shrub	0.23	416	417	418
131	Unvegetated	0.66	413	414	416
132	Shrub	0.42	414	416	417

Table 3.2 Habitat Sampling Summary

Habitat Stratum	Number of Plots Sampled	Total Downstream (DRC) Area Sampled (ha)	Total Headpond (HPZ) Area Sampled (ha)	Total Area Sampled (ha)
Tree	2	0.19	0.38	0.57
Shrub	9	1.23	1.48	2.72
Herb	7	1.51	1.40	2.92
Wetland	1	-	1.02	1.02
Unvegetated	4	1.41	1.38	2.78
Total	23	4.34	5.66	10.01

3.3 Nest Monitoring

3.3.1 Survey Effort

Prior to the initiation of field surveys, 2 days (1 day in each of the HPZ and DRC) were spent confirming habitat classification and plot selection for the 2022 field season. Nest monitoring field surveys were conducted over 39 days from June 2 to July 11, 2022. Total field survey effort totaled 343 person-hours, including 337 person-hours on nest monitoring plots (initial monitoring of plots that were later dropped from the survey set was considered off-plot monitoring). Survey effort on nest monitoring plots included 280 person-hours searching for nests, 52 checking nests, and 5 completing other field activities (e.g., confirming plot boundary was mapped correctly, confirming species identification at known nests). On average, more effort was spent on plots with more complex vegetation structure (e.g., shrubs and trees) (**Table 3.3**).

Table 3.3 Average Survey Effort on Nest Monitoring Plots by Habitat Stratum

Habitat Stratum	Number of Plots (n)	Average Nest Searching Effort (person-hours per plot)	Average Nest Checking Effort (person-hours per plot)	Average Other Activity Effort (person-hours per plot)	Average Total Effort (person-hours per plot)
Tree	2	22	2.2	0.3	24.5
Shrub	9	20	4.1	0.5	24.6
Herb	7	4.1	0.3	0	4.4
Wetland	1	19.1	8.9	0	28
Unvegetated	4	1.9	0.1	0.1	2.1

3.3.2 Nest Records

A total of 70 nests were found in 2022, 40 in the HPZ and 30 in the DRC (**Table 3.4**). Forty (57%) of the nests found were located on nest monitoring plots and 30 nests (43%) were found off-plot (**Table 3.4**).

Table 3.4 Nest Locations Summary

Nest Location	Downstream River Channel	Headpond	Total
On-plot	19	21	40
Off-plot	11	19	30
Total	30	40	70

Nineteen species were observed nesting within the study area in 2022 (**Table 3.5**). This included 14 species nesting on nest monitoring plots and 5 additional species detected nesting outside of nest monitoring plots. Sixteen species were detected in the HPZ and 11 in the DRC.

Most nests detected in the HPZ were those of red-winged blackbird (*Agelaius phoeniceus*, 9 nests), song sparrow (*Melospiza melodia*, 6 nests), and cedar waxwing (*Bombycilla cedrorum,* 5 nests) (**Table 3.5**). In the DRC, most nests detected were those of spotted sandpiper (*Actitus macularis*, 9 nests), common yellowthroat (*Geothlypis trichas*, 4 nests), and song sparrow (4 nests) (**Table 3.5**).

Common nighthawk (*Chordeiles minor*), a species federally listed as Threatened, was detected nesting in 2 off-plot locations within the HPZ (**Appendix A**). These nests were discovered at the incubation stage on July 7 and 8, 2022. Common nighthawk had not been observed during visits to these plots earlier the field season.

Canada warbler (*Cardellina canadensis*), federally listed as Special Concern and provincially Blue-listed, was observed regularly on 1 plot in the DRC. However, no nest was found for this singing male nor was a female observed.

Other notable observations during the field season included a trumpeter swan (*Cygnus buccinator*) family seen near the wetland plot (plot 118) in the HPZ. This was the only location in the study area where wetland habitat was observed, and trumpeter swans were also recorded nesting here in 2021. A Virginia rail (*Rallus limicola*) was also observed in the wetland, but no nest was found. As in 2021, this wetland was the only location where red-winged blackbirds were observed nesting.

Table 3.5 Species Nesting in the Downstream River Channel (DRC) and Headpond (HPZ)

Common Name	Scientific Name	DRC		HPZ		Total
		Off-plot	On-plot	Off-plot	On-plot	
Alder flycatcher	*Empidonax alnorum*	1	-	-	-	1
Black-and-white warbler	*Mniotilta varia*	1	1	-	1	3
Cedar waxwing	*Bombycilla cedrorum*	-	1	5	-	6
Chipping sparrow	*Spizella passerina*	-	-	2	1	3
Clay-colored sparrow	*Spizella pallida*	-	2	1	2	5
Common nighthawk	*Chordeiles minor*	-	-	2	-	2
Common yellowthroat	*Geothlypis trichas*	2	2	2	-	6
Dark-eyed junco	*Junco hyemalis*	-	-	-	1	1

Common Name	Scientific Name	DRC		HPZ		Total
		Off-plot	On-plot	Off-plot	On-plot	
European starling	*Sturnus vulgaris*	2	-	-	-	2
Lincoln's sparrow	*Melospiza lincolnii*	-	3	1	-	4
Red-eyed vireo	*Vireo olivaceus*	-	-	-	1	1
Red-winged blackbird	*Agelaius phoeniceus*	-	-	-	9	9
Song sparrow	*Melospiza melodia*	1	3	1	5	10
Sora	*Porzana carolina*	-	-	-	1	1
Spotted sandpiper	*Actitis macularius*	4	5	1	-	10
Swainson's thrush	*Catharus ustulatus*	-	-	1	-	1
Swamp sparrow	*Melospiza georgiana*	-	-	1	-	1
White-throated sparrow	*Zonotrichia albicollis*	-	1	2	-	3
Yellow-rumped warbler	*Setophaga coronata*	-	1	-	-	1
Total		**11**	**19**	**19**	**21**	**70**

3.3.3 Nest Habitat

In 2022, a minimum nest density for each habitat was calculated using only nests found and an adjusted nest density was calculated by incorporating territory mapping data (i.e., nests not found but may have been present for pairs observed repeatedly; **Table 3.6**). Nest density was highest on wetland and shrub plots and lowest on herb and unvegetated plots (**Table 3.6**). Species richness was highest on shrub plots and relatively low on plots of all other habitat strata (**Table 3.6**).

Table 3.6 Species Diversity and Nest Density Across Plot Habitat Strata

Habitat Stratum	Number of Nests (n)	Species Richness	Pielou Evenness	Nest Density (nests/ha)			
				DRC	HPZ	Overall	Overall + Territory Mapping
Tree	3	3	1.00	5.27	5.30	5.29	8.82
Shrub	25	10	0.87	12.90	6.08	9.18	11.80
Herb	1	1	-	0.66	-	0.34	0.34
Wetland	10	2	0.47	-	9.80	9.80	10.80
Unvegetated	1	1	-	0.71	-	0.36	0.36

Of the 3 species found on treed plots, 1 was a canopy nester (yellow-rumped warbler) and the other 2 nested on the forest floor (black-and-white-warbler [*Mniotilta varia*] and dark-eyed junco, [*Junco hyemalis*]) (**Table 3.7**).

On shrub plots, the most abundant nesting species was song sparrow, followed by spotted sandpiper, both which nested primarily on the ground (exclusively, in the case of the sandpiper) (**Table 3.7**).

In wetland habitat, nest density was high, but diversity was low because most of the nests were red-winged blackbirds, a species that typically nests colonially. The other species found nesting in the wetland was sora (*Porzana carolina*) (**Table 3.7**).

Only 1 nest was found on plots of the herb (Lincoln's sparrow [*Melospiza lincolnii*]) and unvegetated strata (spotted sandpiper). However, 1 of the common nighthawk nests was located just outside of the plot boundary of an unvegetated plot in similar habitat. The other common nighthawk nest was found in a sparsely vegetated cobbly area just outside the boundary of a tree plot.

Table 3.7 Number of Nests for Each Species Across Plot Habitat Strata

Species*	Tree	Shrub	Herb	Wetland	Unvegetated
Black-and-white warbler	1	1	-	-	-
Cedar waxwing	-	1	-	-	-
Chipping sparrow	-	1	-	-	-
Clay-colored sparrow	-	4	-	-	-
Common yellowthroat	-	2	-	-	-
Dark-eyed junco	1	-	-	-	-
Lincoln's sparrow	-	2	1	-	-
Red-eyed vireo	-	1	-	-	-
Red-winged blackbird	-	-	-	9	-
Song sparrow	-	8	-	-	-
Sora	-	-	-	1	-
Spotted sandpiper	-	4	-	-	1
White-throated sparrow	-	1	-	-	-

Notes: *Scientific names are provided above in **Table 3.5**.

3.3.4 Nest Elevation

Nests were located both at and above ground level on nest monitoring plots in both the DRC and HPZ (**Figure 3.2**). Overall nest heights above ground ranged from 0 to 10 m, and nearly half of nests were located on the ground (49%). Nest elevations above sea level ranged from 406.7 to 427.3 m in the DRC and 415.2 to 421.5 m in the HPZ (**Figure 3.2**).

Some nests were found at elevations below the maximum water level that was measured at the water monitoring station closest to the plot the nest was located on (indicated by the colours) (**Figure 3.3**). This illustrates the potential for nest flooding to occur if those nests are active at the time when the water level is at that elevation. However, some plots are relatively far (8+ km) from the nearest water monitoring station, so the relationship between the water elevation at the nearest monitoring station and water elevation at some nest sites is relatively weak. Nest timing in relation to water levels is discussed below in **Section 4.4** Nest Outcomes and Flooding.

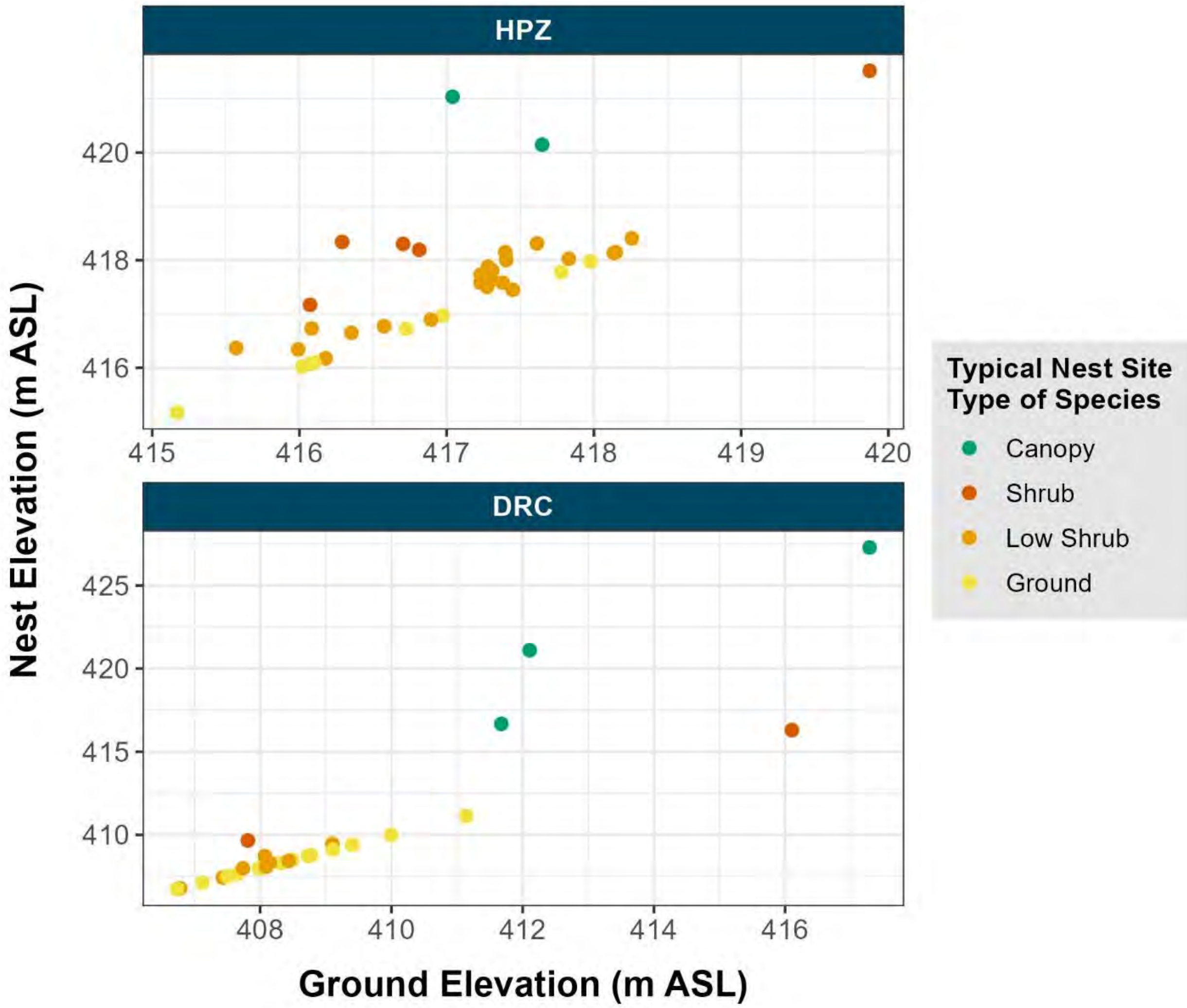

Figure 3.2 Ground Elevations and Nest Elevations for Nests (Grouped by Nest Site Type) Found within the Headpond (HPZ) and Downstream River Channel (DRC).

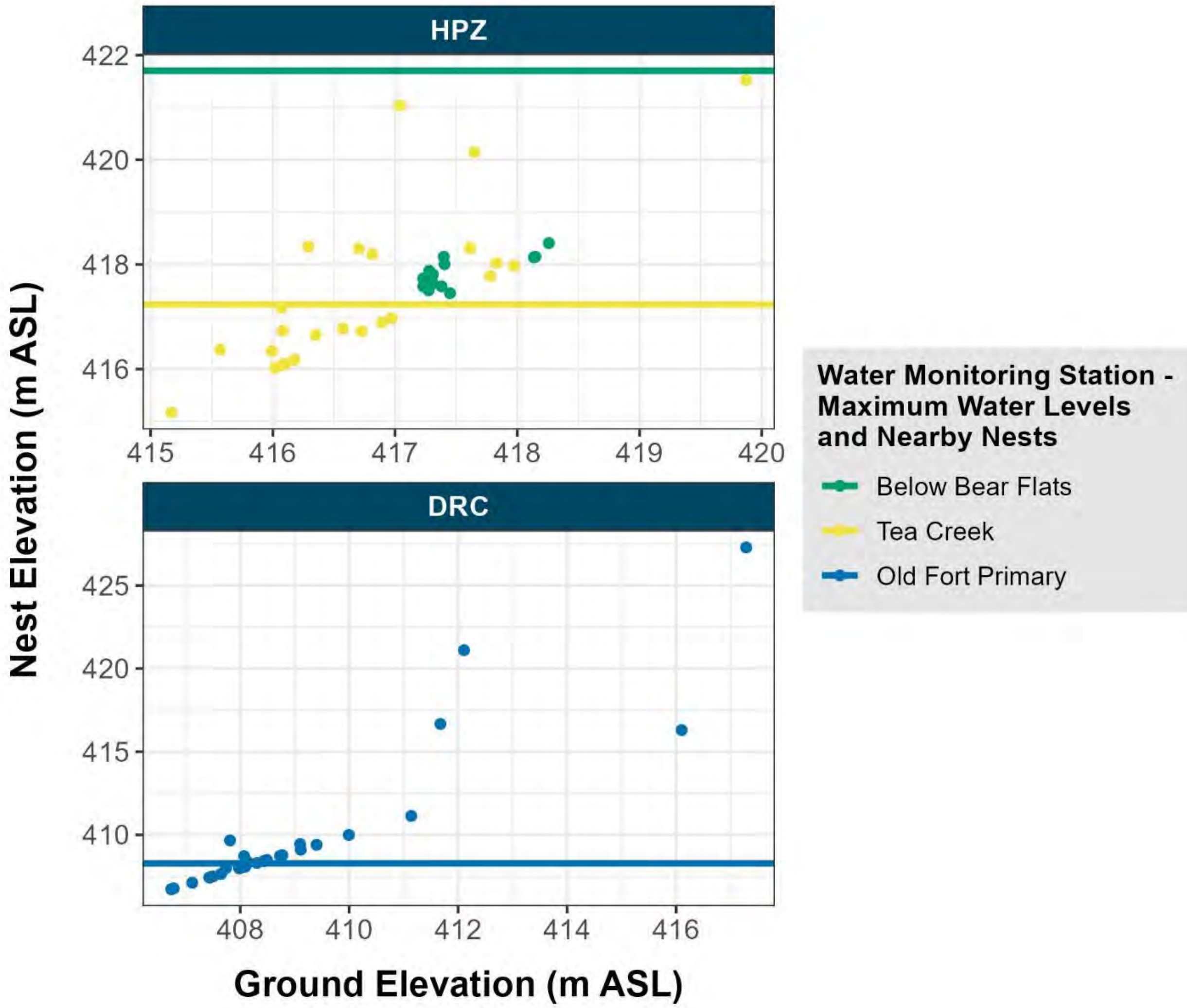

Figure 3.3 Headpond (HPZ) and Downstream River Channel (DRC) Nest Elevations (points) and Maximum Water Levels (horizontal lines) at Nearby Monitoring Stations between April 1 and August 31, 2022.

3.3.5 Nest Phenology

Nest phenology curves were plotted using the total estimated nesting period for each nest and they show a similar trend in nest timing for the HPZ and DRC, with the peak in nesting activity in mid-June (**Figure 3.4**). By early July, the number of monitored nests still active had decreased in both the HPZ and DRC; however, this decline began sooner in the DRC. The nest phenology curve is cut off in late July because the field season ended on July 11.

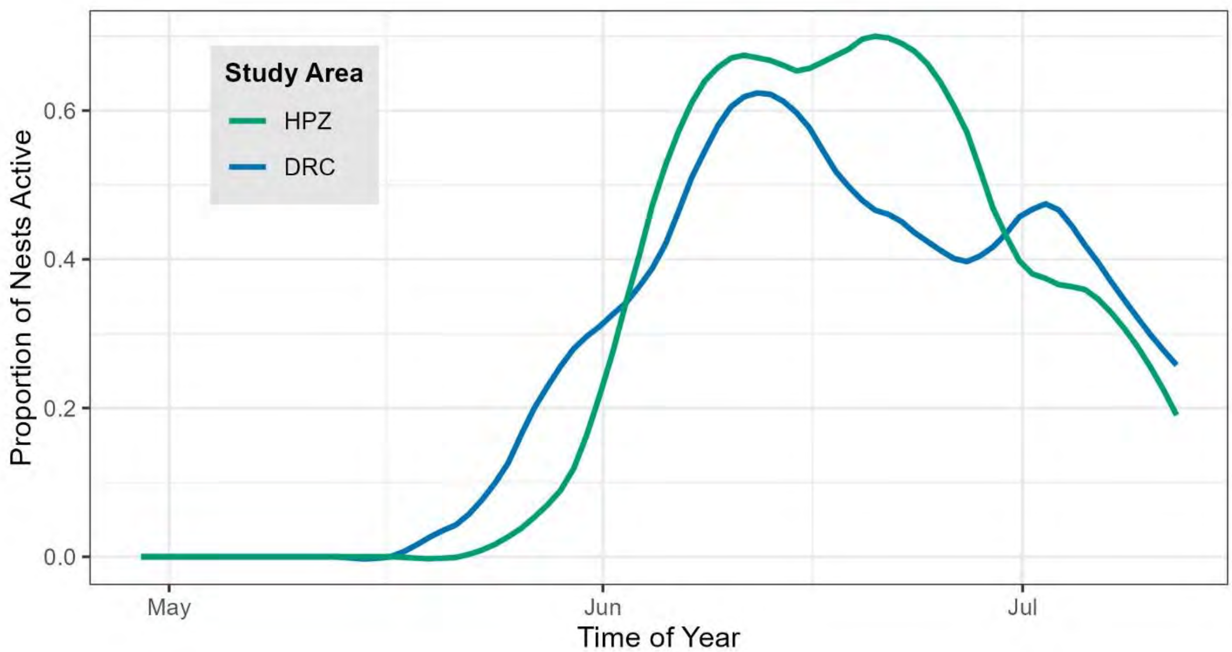

Figure 3.4 Proportion of Total Monitored Nests Active on Nest Monitoring Plots in the Headpond (HPZ) and Downstream River Channel (DRC) throughout the 2022 Field Season.

There were differences in nest timing among some species (**Figure 3.5**). For example, song sparrow and spotted sandpiper began nesting in May, whereas common nighthawk and cedar waxwing did not begin nesting until later in June (**Figure 3.5**). However, for many species, the nest sample size in 2022 was relatively small (**Table 3.5**).

Figure 3.5 Estimated First Egg Dates for Species Observed Nesting in the Headpond (HPZ, blue) and Downstream River Channel (DRC, red) in 2022.

3.3.6 Nest Outcomes

Across the entire study area, 39% of nests detected were considered successful, 36% failed, and 25% had an unknown outcome (**Table 3.8**). The most common cause of nest failure was predation; no nests failed due to flooding (**Table 3.8**). The number of nests with unknown outcomes due to the monitoring season ending was larger in 2022 (21%) than in 2021 (11%) because the field season ended earlier in the summer when more nests are still active. Nest outcomes do not include consideration of nests that may have been present based on territory mapping, because outcomes cannot be determined for nests that could not be found.

Table 3.8 Nest Outcomes – Percentage of Total Nests and in Each Area

Nest Outcome	HPZ (% of total nests)	DRC (% of total nests)	Overall (% of total nests)
Abandoned	2	0	1
Failed by unknown means	0	3	1
Flooded	0	0	0
Predation	38	27	33
Successful	38	40	39
Unknown	0	10	4
Unknown due to end of season	22	20	21

Nest outcomes for nests on monitoring plots were also examined by habitat. However, some habitat strata (e.g., tree, herb, and unvegetated) had very few nests so these percentages should be interpreted cautiously (**Table 3.9**).

Table 3.9 Nest Outcomes – Percentage of Total Nests for Each Habitat Stratum

Habitat Stratum	Number of Nests (n)	Successful (%)	Predation (%)	Unknown (%)	Unknown (end of season) (%)
Tree	3	100	-	-	-
Shrub	25	40	20	8	32
Herb	1	-	100	-	-
Wetland	10	50	50	-	-
Unvegetated	1	-	-	-	100

4.0 Discussion

Results for the nest monitoring program in 2022 provide information that will be useful for addressing the questions of how many migratory bird species and nests are present in the fluctuation zones of the HPZ and DRC, and how many nests are affected by fluctuating water levels. Further years of sampling will continue to enhance this knowledge and improve confidence in the results.

4.1 Nesting Species

Nineteen species were detected nesting within the study area in 2022, which is lower than the 30 detected in 2021 (Hemmera 2022). This difference is likely attributable to the shorter monitoring season used in 2022, as nest timing varies among species, and variation in the habitats found among the plots monitored in each year.

As in 2021, some species were only detected nesting in 1 sub-area. Most notable are the species that have only been detected at the 1 wetland plot in the HPZ: red-winged blackbird, sora, swamp sparrow, trumpeter swan, and Virginia rail. This habitat will be flooded when the reservoir is filled, and no similar habitat is known to be present elsewhere within the study area.

Four new species were detected nesting in 2022: European starling (*Sturnus vulgaris*), sora, swamp sparrow, and yellow-rumped warbler. The sora was within the 1 wetland plot in the HPZ and the swamp sparrow was adjacent to it. The European starling was observed nesting off-plot in the DRC and the yellow-rumped warbler was observed nesting on a tree plot in the DRC. This was the last season of nest monitoring within the HPZ, which will be flooded by reservoir inundation; however, it is likely additional species will continue to be observed nesting in the DRC when monitoring resumes in 2024.

The location of 2 common nighthawk nests within the HPZ indicates the presence of breeding habitat that will become unavailable once the reservoir has been filled. In 2021, common nighthawk was found nesting at 1 location in the DRC. This at-risk species has high breeding site fidelity, suggesting that it would likely nest in these areas in future years if the habitat remained available (Ng et al. 2018).

A second at-risk species, Canada warbler, was detected singing but no nest or pair was observed. The observation was on a plot in the DRC, thus the habitat will remain available and can be monitored for potential nesting activity again in the future.

4.2 Nest Densities and Habitat Sampling

As in 2021, species diversity in 2022 was highest in more complex habitats because these provide a diversity of nest locations suitable for a wider range of species. This result matches the findings of similar multi-species nesting studies (Hemmera 2020).

Nest densities were also higher in more complex habitats, as expected. In 2022, a minimum nest density for each habitat was calculated using only nests found and an adjusted nest density was calculated by incorporating territory mapping data (i.e., nests that may have been present based on repeatedly observed pairs but could not be found). We cannot be sure that the pairs observed on plots for which nests were never found did have nests, but it is reasonable to assume that at least some of them would have. The true nest density remains unknown, but including territory mapping information provides an upper estimate of potential nest density on each habitat stratum. Otherwise, nest densities are generally underestimates because there will always be nesting pairs on plots for which nests are not located. This is particularly true for forested habitat because nests situated high up in trees are more difficult to detect.

Compared to 2021, a larger proportion of nests located in 2022 were off-plot. This is likely due to the linear footprint of many 2022 plots, meaning that more nest-searching time is spent along a plot edge, thereby increasing the chances that nests detected would be outside the plot boundary.

4.3 Nest Phenology

As in 2021, nesting activity peaked in mid-June, indicating that this is the core of the breeding season, as was expected based on previous data (BC Hydro 2021). However, since sampling only occurred between June 2 and July 11, early- and late-nesting species could be under-represented in this year's data. Some early-nesting species whose nests were still active when sampling began may have been detected, but nests that were only active prior to the start of sampling would have been missed. Nest searching began only slightly earlier in 2021, but a greater proportion of nests detected that year were known to have been active in early and mid May. This could be related to the habitat sampled (and therefore the species present) in that year, but it does confirm that there are nests that could be missed by a later sampling start. Migratory songbird species determined to have started nesting in mid-May included American robin (*Turdus migratorius*), song sparrow, Lincoln's sparrow, dark-eyed junco, and black-capped chickadee (*Poecile atricapillus)*. Additionally, many spotted sandpiper nests and all killdeer nests were initiated prior to field surveys beginning in either year.

Similarly, the steep decline in nesting activity shown in July would likely be less dramatic had surveying continued because additional nests initiated in early July may have been located later in the month, during later stages of development (i.e., as nestlings rather than eggs). A larger number of nests were still active at the end of the season in 2022 compared to 2021. In both years, nests were found on the last day of field surveying, and it is likely that there were active nests on plots that were not found because the season ended. This means relatively fewer data may have been collected on later-nesting species such as common nighthawk, alder flycatcher (*Empidonax alnorum*), and cedar waxwing. There were also some species, such as song sparrow, that were observed nesting during the entire monitoring period, with later nests likely to be renests after failure or second clutches by successful pairs.

However, the nest monitoring program will sample these earlier and later segments of the breeding season in other years. As noted in the Nest Monitoring Plan, the monitoring schedule will be adjusted throughout the study to target the times and locations for which more sampling is needed to characterize the nesting activity within the study area (BC Hydro 2021). The 6-week sampling periods during the upcoming monitoring years will be staggered to cover a wider range of dates than have been sampled in the last 2 years. These adjustments will allow early- and late-nesting species to be documented nesting in the study area.

In 2022, the water levels fluctuated more and were at higher elevations during April and early May than they were during the rest of the breeding season. This may have decreased the number of nests initiated early in the season on the lower elevation plots; however, relatively few species begin nesting this early.

The reason for the earlier dip in nesting activity in late June within the DRC is unknown. No event, such as flooding, occurred that would have caused nests to fail or made plot habitat unavailable. It is possible that there was a lull in nest detection between first and second nests because locating a pair's second nest using adult behavioural cues can be challenging when fledglings from the first nest are still present within the territory. Additionally, the HPZ had more nests from the late-nesting species such as cedar waxwing and common nighthawk, which would have contributed to that sub-area having a larger proportion of its nests active later in the season.

4.4 Nest Outcomes and Flooding

The primary cause of documented nest failure was predation, which is typical for nest monitoring studies (Ricklefs 1969; Hemmera 2020; Thompson 2007). Nest failure due to flooding was not observed in 2022, though it could have occurred in areas that were not monitored. However, the relatively low water levels throughout the 2022 breeding season would have reduced the risk.

In 2022, water levels fluctuated more and were at higher elevations during April and early May than they were during the rest of the bird breeding season, meaning that maximum water levels in both study areas occurred when minimal migratory bird nesting activity would be expected. This contrasts with 2021, when water levels rose to back to April/May levels in late June and nests were flooded. During the 2022 field season, the greatest increase in daily average water level in the HPZ was ~0.98 m on June 28, whereas in 2021 there was a 2.8 m increase on June 22 and increases of >1 m on June 16, 23, and 30.

The larger number of unknown nest fates due to end of season (compared to 2021) is attributed to the slightly earlier field season end date. As noted above, the nest monitoring field season samples different dates each year to build up a complete picture of nesting throughout the breeding season and it is expected that nests will have unknown outcomes when monitoring ends earlier in the summer. These data still contribute valuable information about the species composition, nest density, nest phenology, daily survival rate, and the potential for nest flooding within the study area.

Future, multi-year analyses will examine factors affecting daily nest survival for more common species, such as spotted sandpiper and song sparrow, for comparison with similar studies (Hemmera 2020). Estimates will also be made of the total potential impact of nest flooding in the study area based on elevation and habitat availability. One challenge with determining potential nest flooding impacts is that water level data are not representative for all plots because some plots are distant (> 8 km) from a water monitoring station due to the size of the study area (as noted in **Section 3.3.4** Nest Elevation). This will increase the uncertainty around estimates of flooding impact.

5.0 Closure

We sincerely appreciate the opportunity to have assisted you with this project and if there are any questions, please do not hesitate to contact the undersigned by phone at 604.669.0424.

Report prepared by:
Ausenco Sustainability Inc.

ORIGINAL SIGNED

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Wildlife Biologist

Report reviewed by:
Ausenco Sustainability Inc.

ORIGINAL SIGNED

Lorraine Andrusiak, M.Sc., R.P.Bio.
Senior Terrestrial Biologist

6.0 References

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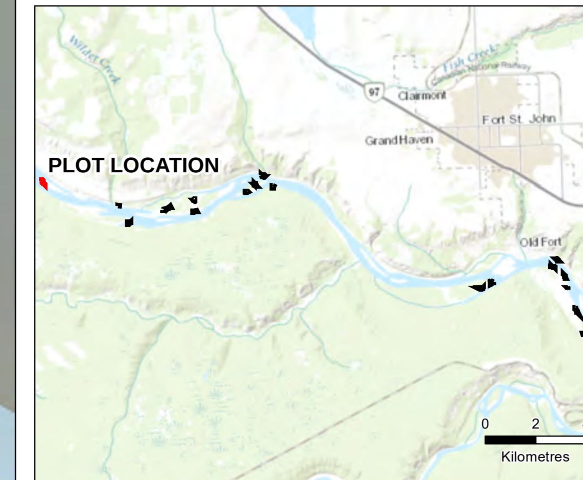
Appendix A

Nest Monitoring Plots

2022 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 121



Legend

Nest Monitoring Plot

Habitat Classification

- Herb
- Shrub
- Tree
- Unvegetated
- Water

Notes

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Sources

- Aerial Image: BC Hydro, 2021
- Inset Basemap: ESRI World Topographic Map

N

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0 20 40 60 80 100

Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

103707-03	Production Date: Mar 20, 2023	Appendix A-1

Ausenco BC hydro

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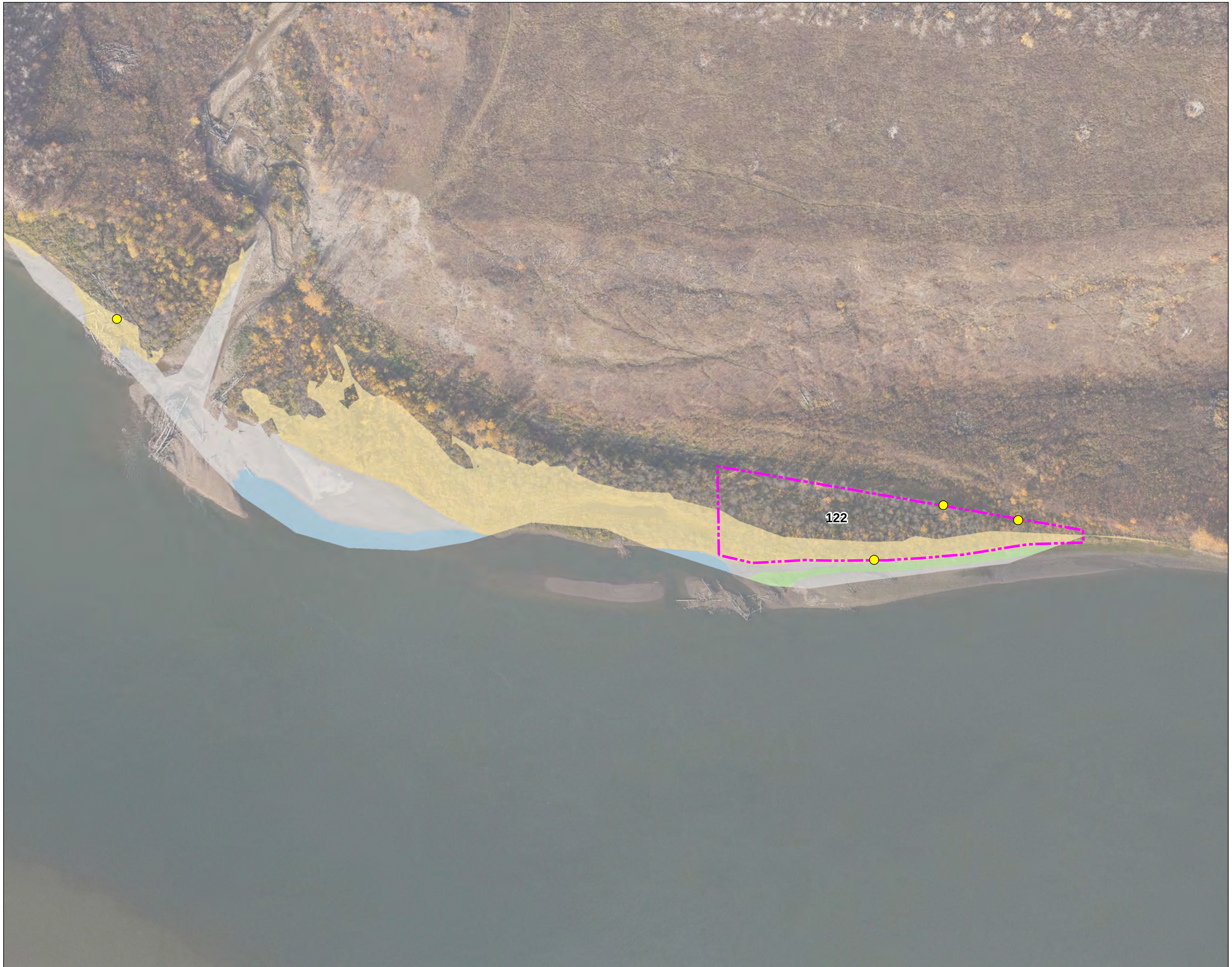
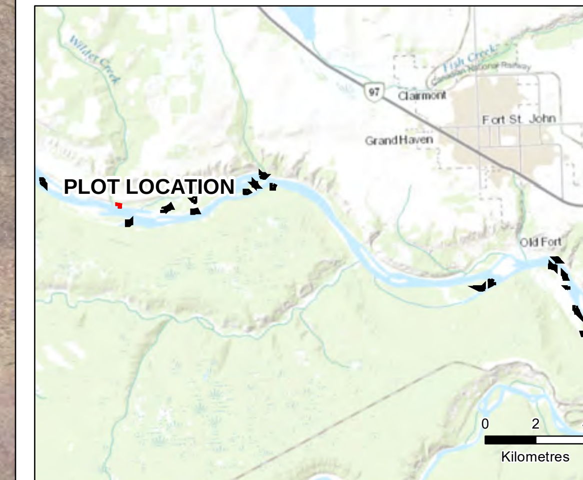


2022 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 122



Legend

- Nest Location
- Nest Monitoring Plot

Habitat Classification

- Herb
- Shrub
- Unvegetated
- Water

Notes

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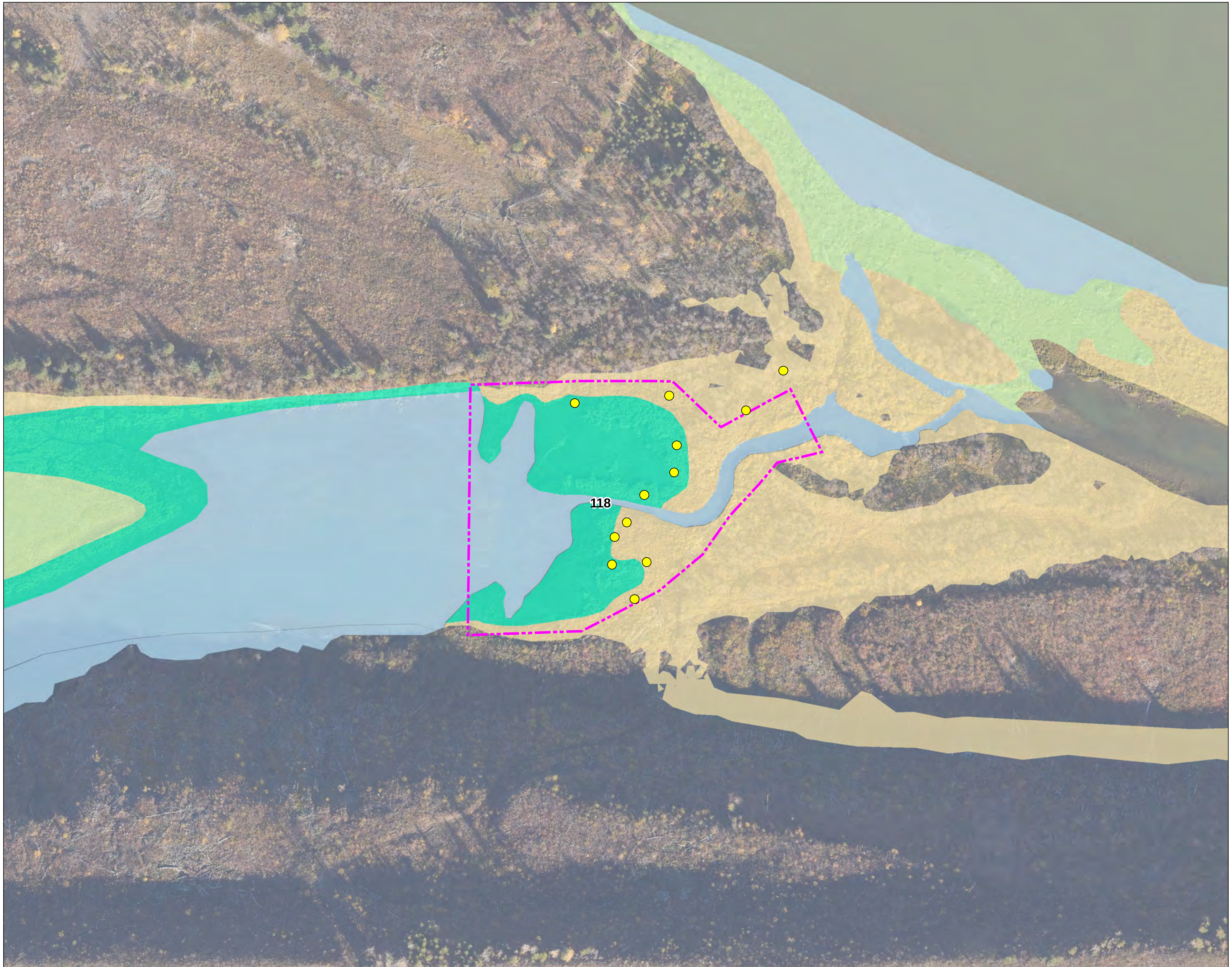
0 20 40 60 80 100
Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

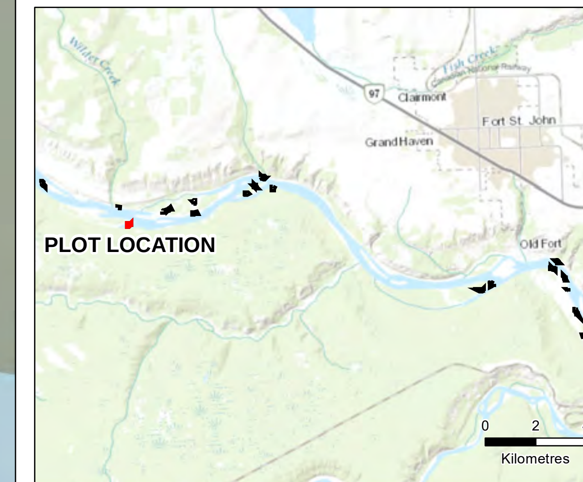
103707-03	Production Date: Mar 20, 2023	Appendix A-2

Ausenco BChydro



2022 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 118



Legend

- Nest Location
- Nest Monitoring Plot

Habitat Classification

- Herb
- Shrub
- Water
- Wetland

Notes

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Metres

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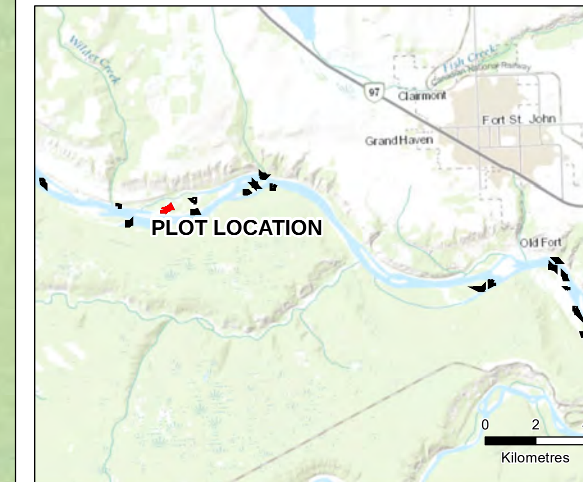
103707-03	Production Date: Mar 20, 2023	Appendix A-3

Ausenco BChydro

2022 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 125 and 126



Legend

- Nest Location
- Nest Monitoring Plot

Habitat Classification

- Herb
- Shrub
- Tree

Notes

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- Inset Basemap: ESRI World Topographic Map

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Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

103707-03	Production Date: Mar 20, 2023	Appendix A-4

Ausenco BChydro

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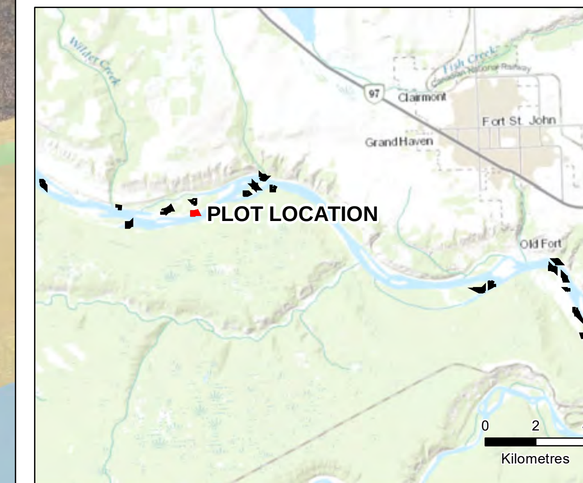
2022 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 127



Legend

- Common Nighthawk Nest Location
- Nest Monitoring Plot

Habitat Classification

- Herb
- Shrub
- Tree
- Unvegetated
- Water

Notes

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- Inset Basemap: ESRI World Topographic Map

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Metres

NAD 1983 UTM Zone 10N

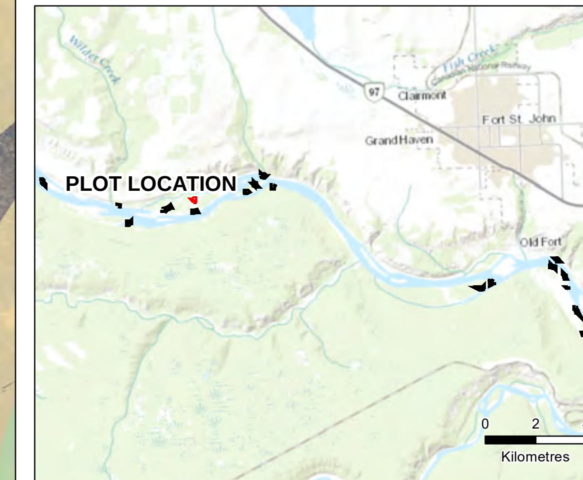
Page Size: 11" x 17"

103707-03	Production Date: Mar 20, 2023	Appendix A-5

Ausenco BC hydro

2022 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 128



Legend

- Nest Location
- Nest Monitoring Plot

Habitat Classification

- Herb
- Shrub
- Tree

Notes

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- Inset Basemap: ESRI World Topographic Map

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Metres

NAD 1983 UTM Zone 10N

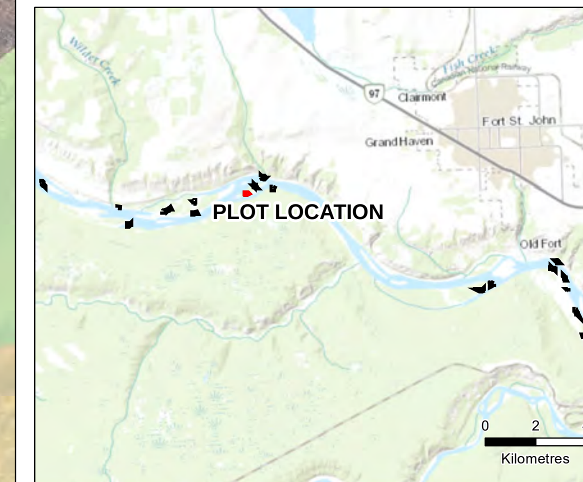
Page Size: 11" x 17"

103707-03	Production Date: Mar 20, 2023	Appendix A-6

Ausenco BC hydro

2022 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 129



Legend

- Common Nighthawk Nest Location
- Nest Location
- Nest Monitoring Plot

Habitat Classification

- Herb
- Shrub
- Tree
- Unvegetated
- Water

Notes

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- Inset Basemap: ESRI World Topographic Map

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Metres

NAD 1983 UTM Zone 10N

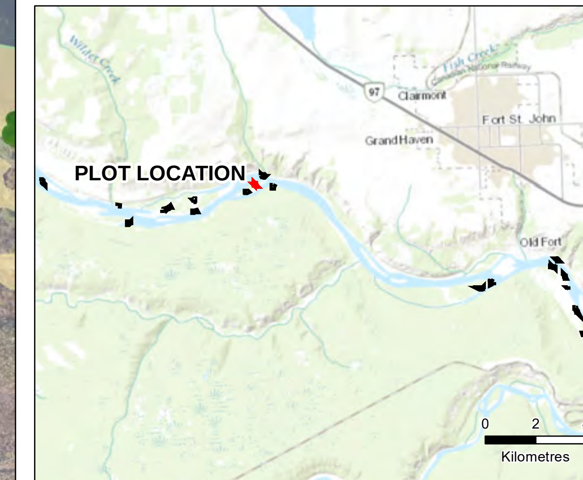
Page Size: 11" x 17"

103707-03	Production Date: Mar 20, 2023	Appendix A-7

Ausenco BC hydro

2022 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 130



Legend

- Nest Location
- Nest Monitoring Plot

Habitat Classification

- Herb
- Shrub
- Tree
- Unvegetated
- Water

Notes

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- Inset Basemap: ESRI World Topographic Map

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Metres

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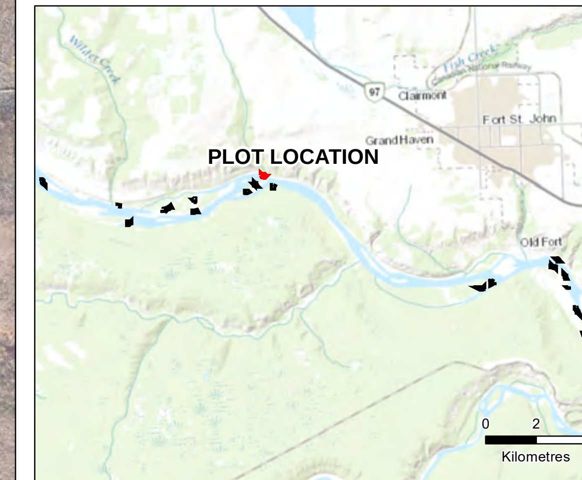
Page Size: 11" x 17"

103707-03	Production Date: Mar 20, 2023	Appendix A-8

Ausenco BChydro

2022 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 131



Legend

Nest Monitoring Plot

Habitat Classification

- Herb
- Shrub
- Tree
- Unvegetated
- Water

Notes

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- Inset Basemap: ESRI World Topographic Map

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Metres

NAD 1983 UTM Zone 10N

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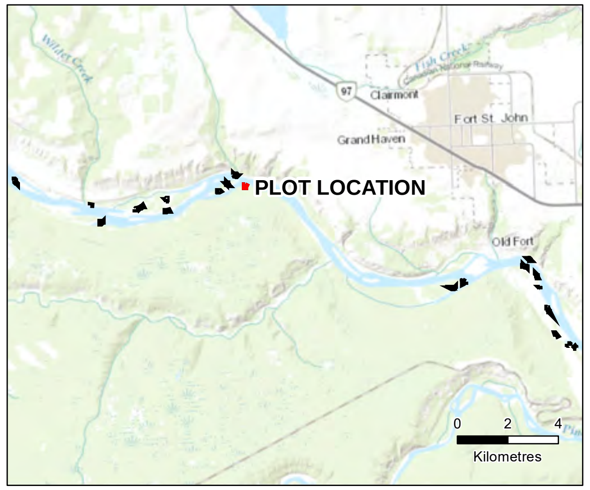
103707-03	Production Date: Mar 20, 2023	Appendix A-9

Ausenco BChydro

2022 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 132



Legend

- Nest Location
- Nest Monitoring Plot

Habitat Classification

- Shrub
- Tree
- Unvegetated

Notes

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Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

103707-03	Production Date: Mar 20, 2023	Appendix A-10

Ausenco BC hydro

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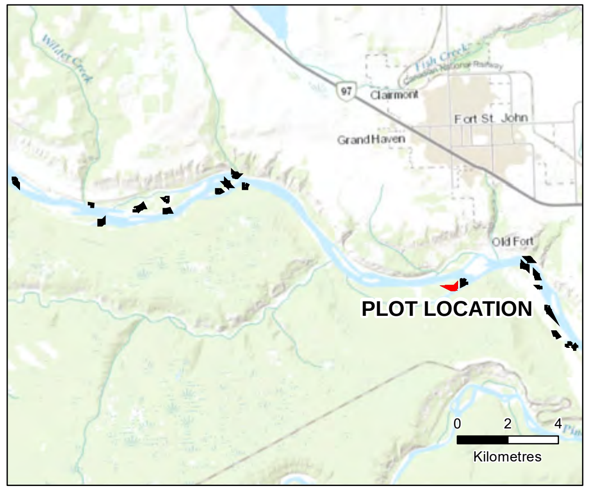
2022 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 22



Legend

- Nest Location
- Nest Monitoring Plot

Habitat Classification

- Herb
- Shrub
- Tree
- Unvegetated
- Water

Notes

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- Inset Basemap: ESRI World Topographic Map

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Metres

NAD 1983 UTM Zone 10N

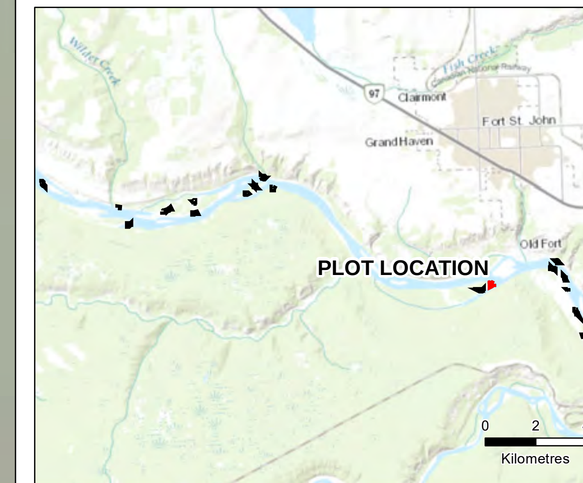
Page Size: 11" x 17"

103707-03	Production Date: Mar 20, 2023	Appendix A-11

Ausenco BC hydro

2022 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 20 and 21



Legend

Nest Monitoring Plot

Habitat Classification

- Herb
- Shrub
- Tree
- Unvegetated
- Water

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Metres

NAD 1983 UTM Zone 10N

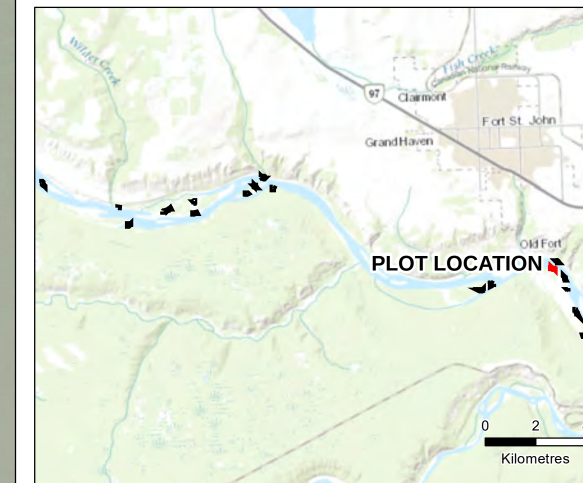
Page Size: 11" x 17"

103707-03	Production Date: Mar 20, 2023	Appendix A-12

Ausenco BChydro

2022 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 18



Legend

- Nest Location
- Nest Monitoring Plot

Habitat Classification

- Herb
- Shrub
- Tree
- Unvegetated
- Water

Notes

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Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

103707-03	Production Date: Mar 20, 2023	Appendix A-13

Ausenco BC hydro

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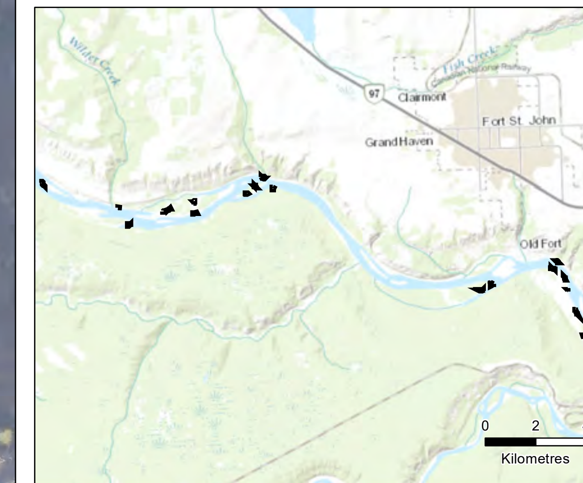
2022 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 19 and 24



Legend

- Nest Location
- Nest Monitoring Plot

Habitat Classification

- Herb
- Shrub
- Tree
- Unvegetated
- Water

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N

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Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

103707-03	Production Date: Mar 20, 2023	Appendix A-14

Ausenco BChydro

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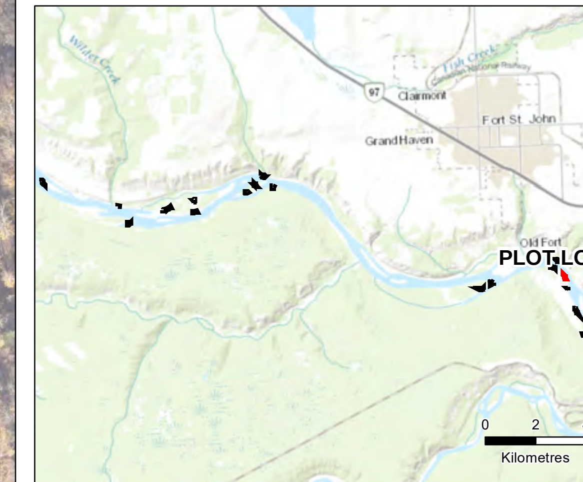
2022 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 17



Legend

- Nest Location
- Nest Monitoring Plot

Habitat Classification

- Herb
- Shrub
- Tree
- Unvegetated
- Water

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N

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Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

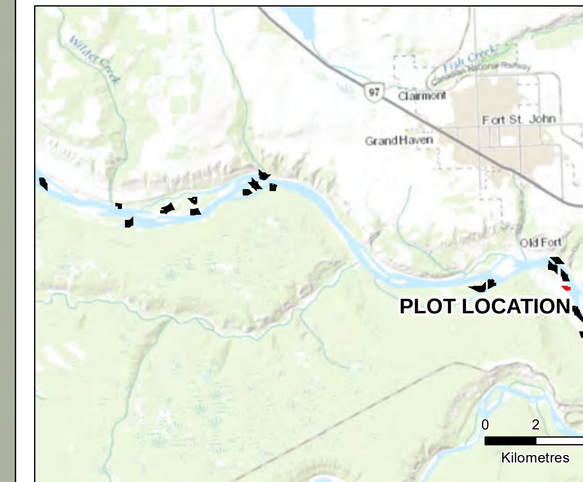
103707-03	Production Date: Mar 20, 2023	Appendix A-15

Ausenco BChydro

Path: S:\Geomatics\Projects\103707\03\mxd\2022 Report\AppA_103707_03_Plots_230320.mxd

2022 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 16



Legend

Nest Monitoring Plot

Habitat Classification

Herb

Shrub

Tree

Unvegetated

Water

Notes

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N

1:1,500

0 20 40 60 80 100

Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

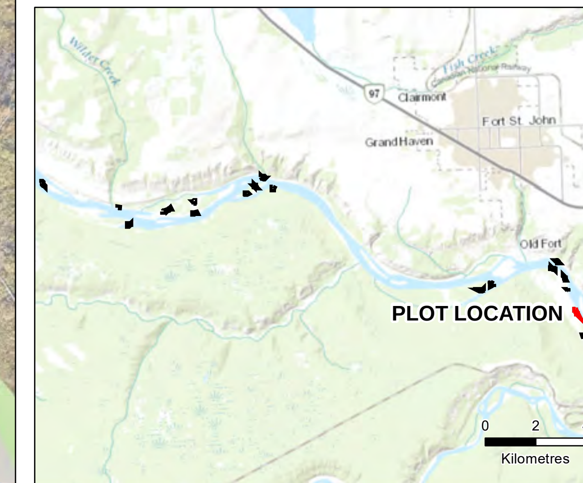
103707-03	Production Date: Mar 20, 2023	Appendix A-16

Ausenco BChydro

Path: S:\Geomatics\Projects\103707\03\mxd\2022 Report\AppA_103707_03_Plots_230320.mxd

2022 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 15



Legend

- Nest Location
- Nest Monitoring Plot

Habitat Classification

- Herb
- Shrub
- Tree
- Unvegetated
- Water

Notes

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N

1:1,500

0 20 40 60 80 100

Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

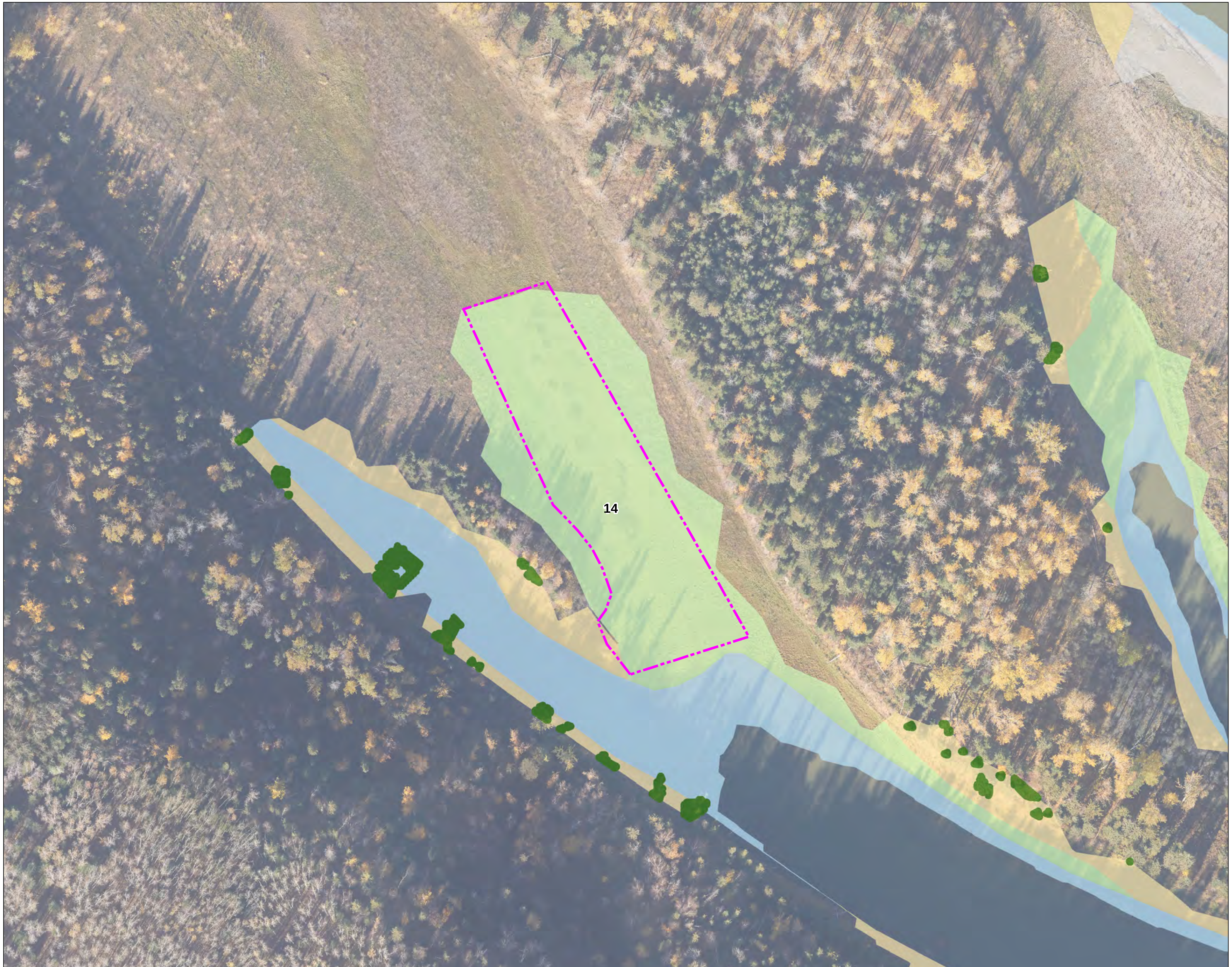
103707-03	Production Date: Mar 20, 2023	Appendix A-17

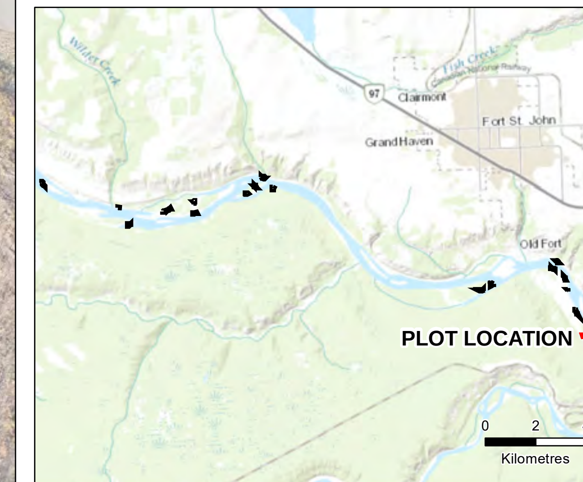
Ausenco BC hydro

Path: S:\Geomatics\Projects\103707\03\mxd\2022 Report\AppA_103707_03_Plots_230320.mxd

2022 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 14





Legend

Nest Monitoring Plot

Habitat Classification

- Herb
- Shrub
- Tree
- Unvegetated
- Water

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Metres

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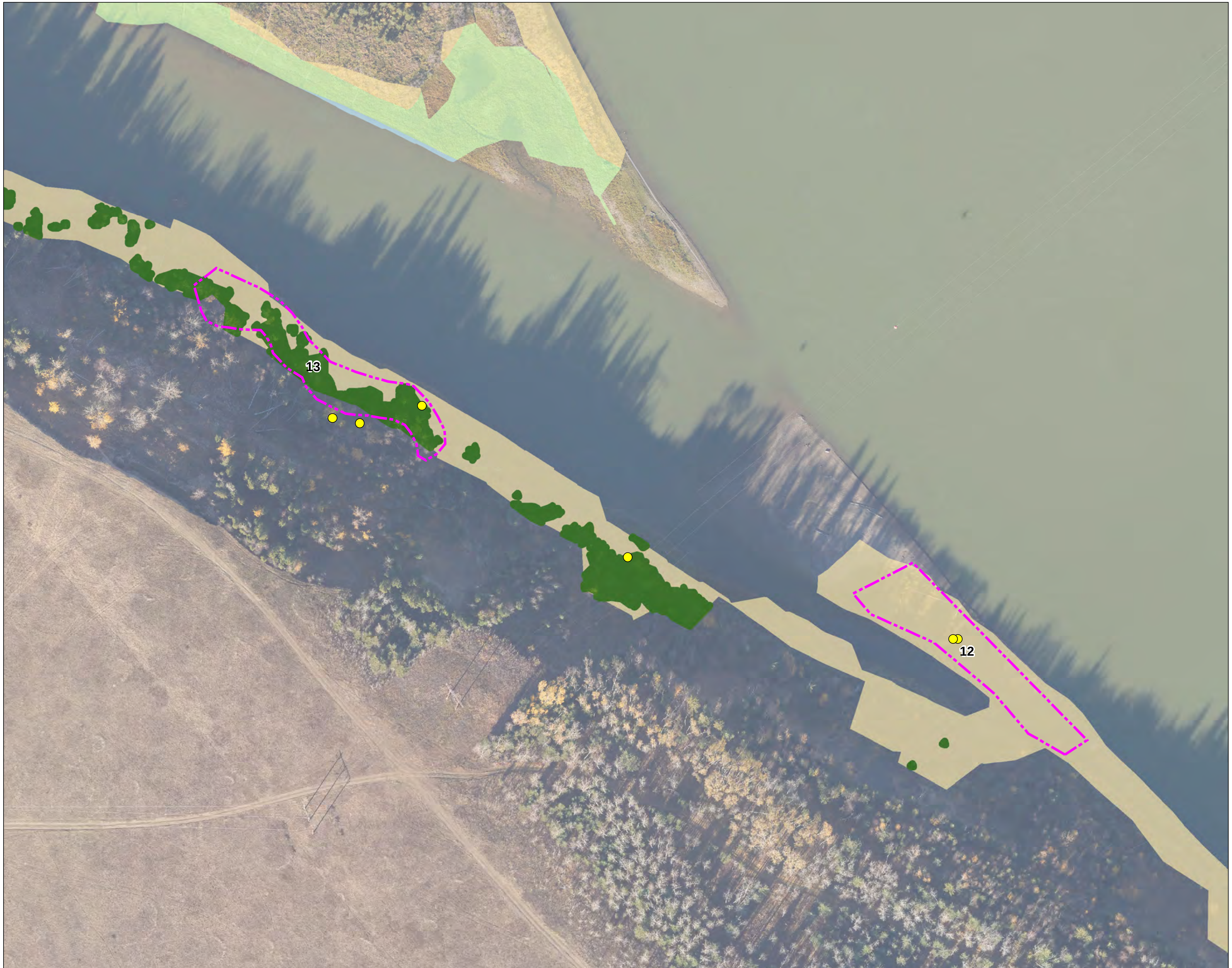
Page Size: 11" x 17"

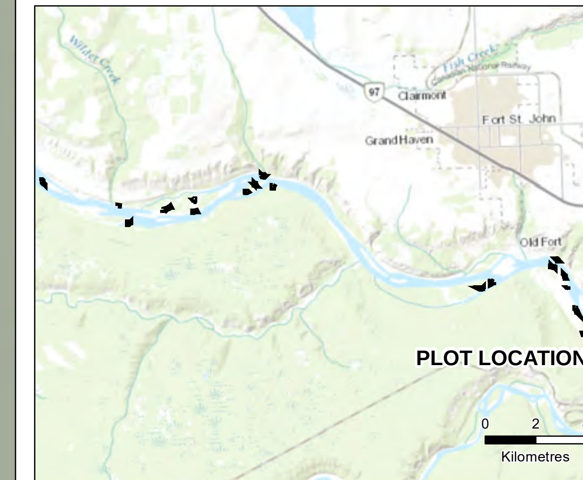
103707-03	Production Date: Mar 20, 2023	Appendix A-18

Ausenco BC hydro



2022 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 12 and 13



Legend

- Nest Location
- Nest Monitoring Plot

Habitat Classification

- Herb
- Shrub
- Tree
- Unvegetated
- Water

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Aerial Image: BC Hydro, 2021
- Inset Basemap: ESRI World Topographic Map

N

1:1,500

0 20 40 60 80 100

Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

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Appendix 5. Wetland Monitoring 2022 Field Summary Report

Site C Clean Energy Project
Wetland Monitoring Program
2022 Annual Report

DATE: FEBRUARY 22, 2023

PRESENTED TO:

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PRESENTED BY:

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EXECUTIVE SUMMARY

BC Hydro developed a Wetland Monitoring Program (the Program) for the Site C Clean Energy Project to address, in part, requirements outlined in the Federal Decision Statement (FDS) condition 11 and Environmental Assessment Certificate (EAC) condition 12:

- ***FDS condition 11.4.1****. Baseline data on the biogeochemical, hydrological and ecological functioning of the wetlands and associated riparian habitat in the area affected by the Designated Project, including: ground and surface water quality and quantity; vegetation cover; biotic structure and diversity; migratory bird abundance, density, diversity and use; species at risk abundance, density, diversity and use; and current use of the wetlands for traditional purposes by Aboriginal people, including the plant and wildlife species that support that use.*

- ***FDS condition 11.4.3****. An approach to monitor and evaluate any changes to baseline conditions, as defined in condition 11.4.1 and identify improvements based on monitoring data.*

- ***EAC condition 12****. The EAC Holder must monitor construction and operation activities that could cause changes in wetland functions.*

The Program consists of two components: baseline wetland monitoring, which is focused on gathering information on the physical, ecological, biogeochemical, and hydrological conditions of wetlands prior to construction activities; and wetland monitoring during construction and operations, which is focused on gathering information to evaluate changes from baseline conditions due to Site C Project activities.

The 2022 field program focused on the construction phase monitoring of wetlands that were sampled in 2020 and 2021. A total of 21 wetlands were sampled in 2022, with all sites located along the transmission line. The 2022 wetland program marks the end of construction monitoring, with all wetlands now sampled. Monitoring will occur again in 2025, and by 2027 all wetlands in the monitoring program will have a two and five-year monitoring assessment completed, which should allow for an analysis of change in wetland parameters and an assessment of the need to continue monitoring each wetland (i.e., if change is not present and/or not ongoing, then further monitoring is not likely to result in useful additional data).

Data on the physical, ecological, biogeochemical, and hydrological conditions collected at each of the 2022 wetlands are presented in this report.

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1. INTRODUCTION

1.1 PROJECT CONDITIONS

BC Hydro developed a Baseline and Construction Phase Wetland Monitoring Program (NPS 2020) for the Site C Clean Energy Project (the Project) to address, in part, requirements outlined in the Federal Decision Statement (FDS) condition 11 and Environmental Assessment Certificate (EAC) condition 12.

> ***FDS condition 11.4.1****. Baseline data on the biogeochemical, hydrological and ecological functioning of the wetlands and associated riparian habitat in the area affected by the Designated Project, including: ground and surface water quality and quantity; vegetation cover; biotic structure and diversity; migratory bird abundance, density, diversity and use; species at risk abundance, density, diversity and use; and current use of the wetlands for traditional purposes by Aboriginal people, including the plant and wildlife species that support that use.*
>
> ***FDS condition 11.4.3****. An approach to monitor and evaluate any changes to baseline conditions, as defined in condition 11.4.1 and identify improvements based on monitoring data.*
>
> ***EAC condition 12****. The EAC Holder must monitor construction and operation activities that could cause changes in wetland functions.*

1.2 PROJECT OVERVIEW

The Wetland Monitoring Program (the Program; NPS 2018) consists of two components:

1. Baseline wetland monitoring – gathers information (i.e., biogeochemical, hydrological, and ecological) on wetlands prior to construction activities, including verification of ecosystem mapping and wetland condition.
2. Construction and operations wetland monitoring – gathers information at two and five-year intervals after initiation of construction to evaluate changes from baseline conditions due to Project activities.

The Program is designed to allow for the following:

- collection of baseline data on the biogeochemical, hydrological, and ecological functioning of the wetlands and associated riparian habitat in the area affected by the Project;
- an evaluation of the change to baseline wetland conditions due to the Project;
- selection of mitigation measures for loss of wetland areas and functions, including reclamation, improvement, creation, and protection (BC Hydro 2015); and

- flexibility in the monitoring program to allow for further refinement in the characterization of baseline and affected wetlands, as data become available.

This 2022 annual report focuses on the completion of the construction monitoring phase of the Project, with all of the 21 wetlands targeted for assessment in 2022 previously sampled using the full BC Hydro Site C Vegetation and Wildlife Wetland Monitoring Program: Baseline and Construction Phase Wetland Monitoring (NPS 2020).

1.3 STUDY AREA

The study area includes three distinct areas within the project activity zone (PAZ) and the downstream area of the dam site:

1. the reservoir footprint (the future inundation zone), which is composed of the Western Reservoir, Middle Reservoir, Eastern Reservoir, Lower Reservoir, and the Dam Site Area;
2. the transmission line, separated into Phase A and Phase B; and
3. the downstream area.

2. METHODS

2.1 SITE SELECTION

The 2022 field program involved monitoring 19 wetlands that were sampled in 2020, as well as two wetlands that were sampled in 2021.

Sites were selected based on the program sampling design of re-assessing (construction phase wetland monitoring) wetlands two years after the baseline data collection, and then every five years after that (NPS 2020). The wetlands selected for 2022 consisted of four wetland types (Table 2.1-1). All of the targeted 2022 wetlands were located along the transmission line, primarily within the cleared corridor.

Table 2.1-1. Target Number and Type of Construction Phase Wetlands for 2022

Wetland Type	Code	2022 Target
Black spruce-Labrador tea-sphagnum	BT	2
Shallow open water	OW	2
Sedge wetland	SE	12
Willow sedge wetland	WS	5

2.2 FIELD METHODOLOGY

Field surveys were conducted to collect site-level information for site-level data categories (Table 2.2-1). The surveys used standardized methodologies to collect a wide range of physical and ecological characteristics of each wetland. Any observed changes or disturbances such as vegetation removal, soil disturbance, dust deposition, and alterations to hydrology were also described for each wetland using the condition assessment forms created by NPS (2020).

The following field data were collected through the 2022 field program:

- field plot data;
- spatial data of plot locations and wetland delineation;
- plot photographs;
- vegetation floristic quality index data;
- analytical data (laboratory analysis of water quality); and
- wetland condition assessments.

Comprehensive and detailed methods are provided in the BC Hydro Site C Wetland Monitoring Program Field Manual; Baseline and Construction Phase (Appendix D of NPS 2020).

Table 2.2-1. Baseline and Construction Phase Wetland Monitoring Program: Data Categories and Parameters

Category	Parameter	Monitoring Phase [a]	Federal Condition 11.4.1
Site Information	Photo stations	B/C	–
	Site diagram	B/C	–
	Wetland ecosystem classification	B/C	–
Physical Parameters	Wetland delineation	B/C *	–
	Adjacent ecosystems	B/C *	–
	Slope position	B	–
Ecological Parameters	Cover type and percent open water	B/C	Biotic structure, biotic diversity
	Vegetation cover and communities present	B/C	Vegetation cover, biotic structure, biotic diversity
	Successional stage and structural stage	B/C	Biotic structure, biotic diversity
	Incidental wildlife observations	B/C	Biotic structure, biotic diversity
Biogeochemical Parameters	Water quality sampling	B/C *	Groundwater quality, surface water quality
	Soil profiles	B	–
Hydrological Parameters	*Hydrology*	B/C	–
	Water depth	B/C	Surface water quantity
	Inlets/outlets	B/C	–

[a] B = baseline field monitoring; C = construction phase monitoring;
* - reduced construction phase monitoring.
Italicized parameters indicate key parameters that will be used to define wetland types.
Source: NPS 2020.

2.3 ECOSYSTEM CLASSIFICATION AND MAPPING

The existing Site C ecosystem mapping for the PAZ includes three distinct but related products: Terrestrial Ecosystem Mapping (TEM); broad habitat mapping; and Detailed Wetland Mapping (DWM). The existing ecosystem classification and mapping is based on *A Field Guide for Identification and Interpretation of Ecosystems of the Northeast Portion of the Prince George Forest Region* (DeLong et al. 1990), *Wetlands of British Columbia* (MacKenzie and Moran 2004), and units created for the Project (2006 to 2012) by regional forest ecologists (Andrusiak and Simpson 2012).

In order to achieve the stated goals of the monitoring program and to satisfy the federal and provincial approval conditions for the Project, it is important that the wetland classification used is structured to accommodate the current provincial classification (i.e., DeLong et al. 2011 and Mackenzie and Moran

2004). Therefore, Table 2.3-1 presents a crosswalk table that uses a "best fit" process to correlate existing PAZ ecosystem classification and current provincial classification system units. The crosswalk table was created by Tetra Tech and refined by EcoLogic for the wetland field program (NPS 2018). All wetlands were classified using the current Site Association descriptions to ensure a consistent mapping product.

Table 2.3-1. Crosswalk of Existing PAZ Ecosystem Classification and Current Provincial Ecosystem Mapping Codes

	Existing PAZ Ecosystem Units		Current Provincial Ecosystem Units	
Wetland Class	Wetland Type (Map Code)	Vegetation Community Description	Site Association	Vegetation Community Description
Bog	BT	Sb – Labrador tea – Sphagnum	Wb03	Black spruce – Lingonberry – Peat-moss
	BT	Assumed Wb05 included in BT	Wb05	Black spruce – Water sedge – Peat-moss
	TS	Tamarack - Sedge	Wb06	Tamarack – Water sedge – Fen moss
	BT	-	Wb08	Black spruce – Soft-leaved sedge – Peat-moss bog
	BT	-	Wb09	Black spruce – Common horsetail – Peat-moss
Fen	SE	Sedge Wetland	Wf00	Fen (unclassified)
	SE	Sedge Wetland	Wf01	Water sedge – Beaked sedge
	-	-	Wf02	Scrub birch – water sedge
Marsh	SE	Sedge Wetland	Wm00	Marsh (unclassified)
	SE	Sedge Wetland	Wm01	Beaked sedge – Water sedge
	SE	Sedge Wetland	Wm02	Swamp horsetail – Beaked Sedge
	SE	Sedge Wetland	Wm03	Awned sedge
	SE	Sedge Wetland	Wm04	Common spike-rush
	SE	Sedge Wetland	Wm05	Cattail
	SE	Sedge Wetland	Wm06	Great bulrush
	SE	Sedge Wetland	Wm15	Bluejoint – Beaked sedge
Swamp	-	-	Ws00	Swamp (unclassified)
	WS	Willow Sedge Wetland	Ws02	Mountain alder – Pink spirea – Sitka sedge
	WS	Willow Sedge Wetland	Ws03 (Ws14)	Bebb's willow – Bluejoint
	WS	Willow Sedge Wetland	Ws04	Drummond's willow – Beaked sedge
	WS	Willow Sedge Wetland	Ws05	MacCalla's willow – Beaker sedge
	WS	Willow Sedge Wetland	Ws06	Sitka willow – Sitka sedge
	-	-	Ws07	Spruce – Common horsetail – Leafy moss

Wetland Class	Existing PAZ Ecosystem Units		Current Provincial Ecosystem Units	
	Wetland Type (Map Code)	Vegetation Community Description	Site Association	Vegetation Community Description
	-	-	Ws15	SwSb – Labrador tea – Glow moss
Open Water	OW	Shallow open water	OW	Shallow Open Water (unclassified)
Floodplain	WH	Willow – Horsetail – Sedge – Riparian Wetland	Fl00	Low bench floodplain (unclassified)
	WH	Willow – Horsetail – Sedge – Riparian Wetland	Fl03	Pacific willow – Red-osier dogwood – Horsetail
	WH	Willow – Horsetail – Sedge – Riparian Wetland	Fl06	Sandbar willow
	-	-	Fm00	Mid bench floodplain (unclassified)
	Fm02 (09)[1]	ActSw - Red-osier dogwood	Fm02 (112)	Cottonwood – Spruce – Red-osier dogwood

2.4 Floristic Quality Index

2.4.1 Introduction

To supplement the vegetation sampling methods outlined in Section 4.0 of the BC Hydro Site C Wetland Monitoring Program Field Manual (NPS 2020), a vegetation monitoring technique was implemented that uses random sample plots to facilitate the calculation of the Floristic Quality Index (FQI) of wetlands. The FQI is a measurement of the quality of wetland vegetation communities and has been found to be a good indicator of plant conditions, habitat quality, and wetland health. The FQI was developed from a 2013 University of Alberta study titled the “Floristic Quality Assessment for Marshes in Alberta’s Northern Prairie and Boreal Regions” (Wilson et al. 2013). Iterations of the FQI have been used as part of wetland monitoring protocols across Canada and the United States. FQI has been intensively researched and is now being used as an indicator across North America because it can be adapted to a region’s unique vegetation assemblages (Washington 1984, Rooney and Rogers 2002, Bourdaghs et al. 2006).

Each wetland vegetation species identified within a wetland is assigned a coefficient of conservatism (CC) value; the CC value for each species is based on an average value between 0-10 that is assigned by a group of expert botanists. The CC value is an indicator of a species’ tolerance to disturbance and specificity to a particular habitat type (e.g., species adapted to disturbed areas have a low CC value, whereas species with specific habitat requirements and are not tolerant of disturbance have higher CC values) (Cretini and Steyer 2011). The CC values used to analyze the 2022 wetland data were obtained from a list of CC values

[1] Map codes do not exist for the floodplain site associations. The site series associated with the Fm02 changed from 09 to 112 in the updated field guide (DeLong et al. 2011).

compiled by the BC Wildlife Federation (2018). The CC values used are wetland specific and based on the plant communities found in British Columbia, east of the Cascade Mountains.

In general, the following categories and definitions were used for the CC values:

- **0** – non-native species and ruderal species growing on waste ground;
- **1–3** – species commonly found in a wide variety of conditions with a high tolerance to disturbance;
- **4–6** – species usually found within a specific plant community, but tolerant of moderate disturbance;
- **7–8** – species found in advanced stages of succession that tolerate minor disturbance; and
- **9–10** – species with very low tolerance to disturbance.

The FQI equation shown below was used to calculate FQI scores. The equation is unbiased by species richness and provides a measurement of wetland health:

$$\mathbf{FQI = Mean\ CC_N / 10\ (\surd N / \surd S) * 100}$$

Where:
CC_N = Coefficient of Conservatism for all species
N = Number of native species
S = Total number of species

The FQI results for each wetland are compared across monitoring years to highlight consistencies and/or differences in the datasets, and ultimately to identify trends in wetland health over time.

2.4.2 FQI Standards and Field Protocols

The following standards and field protocols were used for vegetation FQI sampling:

- The standard seven-letter code naming system established for British Columbia (BC MOE and MOF 2010) was used for recording observed species. Naming conventions used for vegetation species were from the British Columbia Species and Ecosystem Explorer (BC CDC 2020);
- Floristic Quality Index plots were established and surveyed within each wetland being monitored. Three pairs of quadrats (six quadrats in total) were deployed randomly throughout each wetland. A power analysis conducted by Wilson et al. (2013) showed that six quadrats were sufficient to detect differences in species richness between monitored wetlands within the same type or class;
- Each wetland is broadly divided into thirds and one pair of quadrats is established within each of the three sampling areas. The quadrats are tossed in a randomly selected cardinal direction to add randomness to the location;
- Quadrat pairs were positioned directly beside each other;
- Each quadrat measures one square metre. Quadrats were measured in the field with a square PVC tube quadrat measuring 1 m in length and width;

- Quadrat data were recorded on standard FQI field sheets using the standard naming convention established for the Wetland Monitoring Program;
- Within each of the quadrats, all herbaceous, shrub, and tree species and their percent cover were recorded. Percent cover estimations included overlapping vegetation and therefore the total percent cover could be greater than 100%. For example, if an overhead shrub species covered 100% of the quadrat, the percent cover of herbaceous species present in the understory were still recorded;
- Percent cover of live vegetation was estimated for each species present using the recording increment vegetation cover method shown in Table 2.4-1 and from the comparison charts for estimation of foliage cover from the 2010 Field Manual for Describing Terrestrial Ecosystems (BC MOE and MOF 2010); and
- Photos of each quadrat were taken to further document the wetland vegetation community being monitored. Photos were taken using the Solocator Application (Civi Corp Pty Limited 2021) for iPhones, which records the cardinal direction the photo was taken in and the UTM location of the photo.

Table 2.4-1. Increments used for Recording Vegetation Cover for the Wetland FQI Quadrats as Adapted from the Ecological Land Survey Site Description Manual (ASRD 2003)

Cover Range	Recording Increment (%)	Examples (%)
A single plant	Exactly 0.1	0.1
Several plants	Exactly 0.5	0.5
1-10%	To the nearest 1	1, 2, 3, 5, 8
10-30%	To the nearest 5	10, 15, 25
30-100%	To the nearest 10	30, 40, 50, 60, 70, 80, 90

The wetland indicator status for each species was obtained from the United States Department of Agriculture's (USDA 2020) Natural Resource Conservation Service (NRCS) Plants Database and is described below in Table 2.4-2. When available, the Alaska wetland region was used. In the event that the Alaska status was not provided, the wetland status for the Great Plains region was used as a substitute.

Table 2.4-2. Wetland Indicator Status Codes and Descriptions (Adapted from USDA 2020)

Indicator Code	Indicator Status	Description
OBL	Obligate Wetland	Almost always occur in wetlands
FACW	Facultative Wetland	Usually occur in wetlands, but may occur in non-wetlands
FAC	Facultative	Occur in wetlands and non-wetlands
FACU	Facultative Upland	Usually occur in non-wetlands, but may occur in wetlands
UPL	Obligate Upland	Almost never occur in wetlands

3. RESULTS

3.1 SUMMARY OF 2022 FIELD SURVEY EFFORT

Field surveys were completed from August 16-19, 2022, along the transmission line. A total of 21 wetlands were sampled, including all of the targeted wetlands as per the sampling plan (Table 3.1-1; Figure 3.1-1).

Table 3.1-1. Summary of Wetlands Sampled in 2022

Plot	Wetland Class	Site Association	Wetland Type	Last Sample Date
OWL001	Open Water	OW	OW	2020
OWL011	Marsh	Wm15	SE	2021
OWL021	Marsh	Wm03	SE	2020
OWL026	Marsh	Wm03	SE	2020
OWL027	Marsh	Wm01	SE	2020
OWL030	Swamp	Ws00	WS	2020
OWL032	Swamp	Ws05	WS	2020
OWL034	Fen	Wf01	SE	2020
OWL035	Bog	Wb09	BT	2020
OWL053	Swamp	Ws00	WS	2020
OWL060	Marsh	Wm03	SE	2020
OWL061	Marsh	Wm03	SE	2021
OWL063	Marsh	Wm03	SE	2020
OWL067	Marsh	Wm03	SE	2020
OWL070	Marsh	Wm03	SE	2020
OWL071	Marsh	Wm03	SE	2020
OWL073	Marsh	Wm01	SE	2020
OWL102	Swamp	Ws05	WS	2020
OWL103	Open Water	OW	OW	2020
OWL107	Swamp	Ws07	WS	2020
OWL109	Bog	Wb05	BT	2020