BC Hydro
Power smart

Vegetation and Wildlife Mitigation and Monitoring Plan 2021 Annual Report

Site C Clean Energy Project

21 April 2022

Table of Contents

1.0 Introduction 5

2.0 Objective and Scope 5

3.0 Consultation 15

3.1 Canadian Wildlife Services 15

3.2 Consultation with the Province 15

4.0 Qualified professionals 16

5.0 Structure and Content 18

6.0 Implementation of Mitigation and Monitoring Measures – Federal Decision Statement Conditions 18

6.1 Federal Decision Statement Condition 9: Migratory Bird Mitigation and Monitoring 19

6.1.1 Condition 9.1 19

6.1.2 Condition 9.2 20

6.1.3 Condition 9.3 20

6.1.4 Condition 9.9.2 21

6.2 Federal Decision Statement Condition 10: Non-Wetland Migratory Bird Habitat Mitigation and Monitoring 22

6.2.1 Condition 10.3.1 23

6.2.2 Condition 10.3.2 23

6.2.3 Condition 10.3.3 23

6.2.4 Condition 10.3.4 25

6.2.5 Condition 10.3.5 25

6.2.6 Condition 10.3.6 25

6.3 Federal Decision Statement Condition 11: Wetland Mitigation and Monitoring 25

6.3.1 Condition 11.1 27

6.3.2 Condition 11.2 27

6.4 Federal Decision Statement Condition 16: Species at Risk Mitigation and Monitoring 30

6.4.1 Condition 16.3.3 31

6.4.2 Condition 16.3.4 33

6.4.3 Condition 16.3.6 33

6.4.4 Condition 16.3.7 35

7.0 Mitigation and Monitoring Measures-Environmental Assessment Certificate Conditions 37
7.1 EAC Condition 9 37
7.1.1 Invasive Plant Control 38
7.1.2 Inventory areas not already surveyed 38
7.1.3 Spatial database of known rare plant occurrences 39
7.1.4 Rare plant avoidance 39
7.1.5 Protect tufa seeps, wetlands and rare plants located adjacent to construction areas 40
7.1.6 Experimental Rare Plant Translocation Program 40
7.3 EAC Condition 11 40
7.3.1 Habitat Enhancement Projects in the RAA 41
7.3.2 Direct purchase of lands in the RAA to enhance or retain rare plant values 41
7.3.3 Engaging with FLNRORD, MOECCS and Indigenous Groups 41
7.4 EAC Condition 12 42
7.4.1 Wetland Mitigation and Compensation Plan 43
7.5 EAC Condition 14 44
7.5.1 Definition of the study design for the Experimental Rare Plant Translocation Program 45
7.5.2 Plan for monitoring translocations 47
7.5.3 Measurement criteria for effectiveness monitoring of habitat enhancement and compensation programs 47
7.6 EAC Condition 15 48
7.6.1 Measures to avoid, if feasible constructing in sensitive wildlife habitats 48
7.6.2 Setback buffers to avoid direct impacts to sensitive habitats 49
7.6.3 Mitigation of adverse effects to wildlife and wildlife habitat 49
7.6.4 Protocol to ensure that lighting is focused on work sites 50
7.6.5 Environmental training of workers 50
7.7 EAC Condition 16 50
7.7.1 Wetland compensation that includes fish-free areas 51
7.7.2 Mitigation for the loss of snake hibernacula 51
7.7.3 Nest boxes for cavity-nesting waterfowl 51
7.7.4 A design for bat roosting habitat in HWY 29 bridges 51
7.7.5 Creation of hibernating and roosting sites for bats 52
7.7.6 Resting sites for fisher 53
7.9 EAC Condition 21 54

7.9.1 Monitoring of Bald Eagle nesting populations..... 55
7.9.2 Monitoring waterfowl and shorebird populations..... 55
7.9.3 Monitor amphibian use of migration crossing structures installed along Project roads 55
7.9.4 Survey songbird and ground-nesting raptor populations during construction and operations..... 55
7.9.5 Annual reporting beginning 180 days following commencement of construction..... 56
7.10 Status of listed species..... 56
7.10.1 Rare Plants..... 56
7.10.2 Wildlife..... 56
7.11 Ungulate Winter Range..... 56

LIST OF TABLES

Table 1. Federal Decision Statement conditions and associated annual report sections..... 5
Table 2. Environmental Assessment Certificate conditions and associated annual report sections..... 8
Table 3. Status of Schedule A Program Area Plans as of 31 December 2021..... 15
Table 4. Qualified Professionals involved in development and implementation of programs in 2021..... 16
Table 5. Summary of programs not implemented in 2021..... 18

LIST OF APPENDICIES

Appendix 1. Site C Clean Energy Project Construction Schedule
Appendix 2. Breeding Bird Follow-up Monitoring - Songbirds 2021 Annual Report
Appendix 3. Waterbird Migration Follow-up Monitoring Program 2021 Annual Report
Appendix 4. Migratory Bird Nest Monitoring Program 2021 Annual Report
Appendix 5. Wetland Monitoring 2021 Field Summary Report
Appendix 6. 2021 Annual Report Pre-construction Rare Plant Surveys
Appendix 7. Portage Mountain Bat Studies: 2020 and 2021 Annual Report
Appendix 8. Experimental Rare Plant Translocation Program 2021 Annual Report
Appendix 9. Gartersnake Artificial Hibernacula Monitoring 2021
Appendix 10. Cavity Nesting Mitigation and Monitoring Program – 2021 Annual Report
Appendix 11. Bald Eagle Nest Surveys – Summary for 2021
Appendix 12. Ground Nesting Raptor Monitoring 2021 Annual Report

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 2021.

2.0 Objective and Scope

The objective of this VWMMP Annual Report (the Report) is to describe the mitigation and monitoring measures implemented in 2021 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 7.7.1)
	• 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 2021 is provided below.

3.1 Canadian Wildlife Services

In 2021 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 10 times from January through December 2021 to address the Program Areas laid out 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 2021.

Table 3. Status of Schedule A Program Area Plans as of 31 December 2021.

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
4. Bats	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
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
8.1. Breeding and Migratory Birds - Songbirds	In progress
8.2. Breeding and Migratory Birds – Waterbirds	In progress
8.4. Breeding and Migratory Birds – Woodpeckers	In progress
8.5. Breeding and Migratory Birds – Nest Monitoring	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 2021 are listed in Table 4.

Table 4. Qualified Professionals involved in development and implementation of programs in 2021

Qualified Professional	Area of Work
Brock Simons, M.Sc., R.P.Bio., BC Hydro	Vegetation and Wildlife
Natasha Bush, B.Sc. P.Ag., EcoLogic Consultants Ltd.	Experimental Rare Plant Translocation, Wetland Monitoring Program, Experimental Seeding and Planting Program for Butterfly Species at Risk.
Dan McAllister, M.Sc., P.Ag., EcoLogic	Experimental Rare Plant Translocation, Wetland Monitoring Program
Jamie Fenneman, Ph.D. R.P.Bio., EcoLogic	Experimental Rare Plant Translocation, Experimental Seeding and Planting Program for Butterfly Species at Risk.
Ryan Durand, M.Sc. R.P.Bio., EcoLogic	Experimental Rare Plant Translocation, Wetland Monitoring Program ~~and Hwy 29~~
Jason Jones, Ph.D. R. P. Bio., P. Biol., EcoLogic	Experimental Rare Plant Translocation, Wetland Monitoring, Downstream Vegetation Monitoring, Experimental Seeding and Planting Program for Butterfly Species at Risk.

Qualified Professional	Area of Work
Katherine Garrah, M.Sc. A.Ag. EcoLogic	Experimental Rare Plant Translocation, Experimental Seeding and Planting Program for Butterfly Species at Risk.
Holly Buehler, MSc. EcoLogic	Experimental Rare Plant Translocation
Alice Lee, MSc. EcoLogic	Pre-construction Rare Plant Surveys and 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	Experimental Rare Plant Translocation, Wetland Monitoring Program, Experimental Seeding and Planting Program for Butterfly Species at Risk.
Jeff Matheson M.Sc., R.P.Bio., P.Biol., Tetra Tech Canada Inc.	Breeding bird and raptor monitoring
Claudio Bianchini, R.P. Bio., Bianchini Biological Services	Breeding bird and raptor monitoring
Elyse Hofs, B.Sc., Dipl.T., Tetra Tech Canada Inc.	Breeding bird and raptor monitoring
Charlie Palmer, M.Sc., P.Biol., R.P.Bio, Hemmera Envirochem Inc.	Cavity nesting bird mitigation, waterbird monitoring, Portage Mountain bat monitoring, bald eagle monitoring, swallow and kingfisher, migratory bird nest monitoring
Jay Brogan M.Sc., R.P.Bio., Hemmera Envirochem Inc.	Cavity nesting bird mitigation, waterbird monitoring, Portage Mountain bat monitoring, bald eagle monitoring, swallow and kingfisher monitoring, migratory bird nest monitoring, beaver monitoring
Ryan Gill, R.P.Bio., Hemmera Envirochem Inc.	Cavity nesting bird mitigation, waterbird monitoring, Portage Mountain bat monitoring, bald eagle monitoring, swallow and kingfisher monitoring, migratory bird nest monitoring, beaver monitoring
Brian Paterson, B.Sc., R.P.Bio,	Bald eagle monitoring, fisher den box monitoring, Portage Mountain bat monitoring
Toby St. Clair, M.Sc., Hemmera Envirochem Inc.	Waterbird monitoring, swallow and kingfisher monitoring, migratory bird nest monitoring
Felix Martinez-Nunez, M.Sc., R.P.Bio, Hemmera Envirochem Inc.	Waterbird monitoring, Portage Mountain bat monitoring, cavity nesting bird monitoring
Catherine Craig, M.Sc., R.P.Bio., Hemmera Envirochem Inc.	Waterbird monitoring, swallow and kingfisher monitoring, migratory bird nest monitoring
Lorraine Andrusiak, M.Sc., R.P.Bio., Hemmera Envirochem Inc.	Swallow and kingfisher monitoring, bald eagle monitoring, Portage Mountain bat monitoring, cavity nesting bird monitoring, waterbird monitoring
Dan Webster, B.Sc., P.Ag., R.P.Bio., P.Biol., Eco-Web Ecological Consulting Ltd.	Portage Mountain bat monitoring, bald eagle monitoring, beaver monitoring
Chris Coxson, B.Sc., A.Ag Eco-Web Ecological Consulting Ltd.	Waterbird monitoring, Portage Mountain bat monitoring, cavity nesting bird monitoring, migratory bird nest monitoring
Burke Mckone, R.P.Bio, P.Biol.,	Portage Mountain bat monitoring

Qualified Professional	Area of Work
Eco-Web Ecological Consulting Ltd.	
Dan Daley, B.Sc., BIT Eco-Web Ecological Consulting Ltd.	Portage Mountain bat monitoring, cavity nesting bird monitoring
Iain Jones, M.Sc., Dipl. Tech., RPBio Golder Associates Ltd. Golder Senior Wildlife Biologist,	Wildlife mitigation structure monitoring program director, technical review and environmental compliance QEP
Tanya Seebacher, MSc, R.P.Bio Golder Associates Ltd.	Snake artificial den monitoring
Mike Sarell, R.P.Bio. Golder Associates Ltd.	Snake artificial den monitoring
Ilya Povalyaev, BSc, R.P.Bio. Golder Associates Ltd.	Bald eagle artificial nesting structure monitoring
Mitch Firman, B.Sc. Golder Associates Ltd.	Bat box and fisher den monitoring
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.

Several of the programs outlined in the Vegetation and Wildlife Mitigation Plan were not implemented in 2021. Table 5 below outlines which programs were not implemented, and when they will be implemented and reported on in annual reports.

Table 5. Summary of programs not implemented in 2021

Condition Number	Program to be Implemented	Planned Implementation Year	Planned Inclusion in Annual Report
FDS 10.3.3	Littoral zone enhancements	2022	2022
	Riparian plantings	TBD, after reservoir filling	TBD, 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 2021 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 2021, 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, last updated in February 2020, 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 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 2021 as part of the monitoring program. The Breeding Bird Follow-up Monitoring – Songbirds 2021 Annual Report can be found in Appendix 2.

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

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 2021 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 implemented in 2021 to monitor the potential disturbance to breeding migratory birds from fluctuating water levels caused by construction and operations activities. Eight weeks of nest searching and monitoring surveys were conducted from May 30 to July 21, 2021 and point count surveys were completed for nest monitoring plots between June 22 and June 26, 2021. The Migratory Bird Nest Monitoring Program 2021 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 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.

Construction of the transmission line is nearing completion. Once constructed the mitigations implemented will be documented in the appropriate VWMMP Annual Report.

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 2021 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 2021 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 2021 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.

Downstream of the dam, fish habitat offset works will be undertaken to:

- Increase the amount of available, permanently wetted habitat to:
  - Support primary and secondary production as food production for fish;
  - Provide rearing, feeding, overwintering, and potential spawning habitats for fish;
- Reduce fish stranding risk in the area; and
- Increase the complexity and variability of fish habitat to support a variety of life stage uses for local fish populations.

There are seven fish habitat offset projects:

- Reservoir Area Fish Habitat Offsets:
  - Site C Reservoir Shoreline Enhancement – Creation of littoral habitat at three locations in the reservoir.
  - Dam Site Material Relocation Site Enhancement - Spawning gravel and cobbles will be incorporated into the final capping of material relocation sites upstream of the dam that will be inundated by the reservoir to provide productive reservoir littoral fish habitat.
  - Peaceview Pit Fish Habitat Compensation – A borrow pit along Highway 29 that will be flooded when the reservoir is filled, creating littoral fish habitat.
  - Reservoir Shoreline Riparian Planting – A 15 m-wide riparian area will be planted along the reservoir shoreline adjacent to BC Hydro-owned farmland to provide riparian habitat and bank stabilization.
  - Hudson's Hope Shoreline Protection Enhancement - A 2.6 km shoreline protection berm that will incorporate fish habitat features.
- Downstream Fish Habitat Offsets
  - River Road Rock Spurs - The rock spurs will convert areas of deep, fast flowing water to calm water habitats.
  - Peace River Channel Contouring and Side Channel Enhancement – Involves excavation and contouring of instream gravel bars and the conversion of very shallow water to deeper water and deposition of excavated material at two sites between the dam and the confluence with the Pine River. The works will create shallow water that is consistently wetted throughout the year.

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].

[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 2021.

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 2021 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 2021 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.

BC Hydro is focussed on finding additional opportunities for wetland protection and enhancement, including on lands that allow use of resources for traditional purposes. Numerous potential candidate sites have been identified and evaluated with Ducks Unlimited Canada, although no new sites appropriate for wetland creation or enhancement have yet been confirmed.

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 2021 field program mostly focussed on wetlands last surveyed in 2019, while also including some wetlands last surveyed in 2016 and 2020. Wetland mapping was also refined for all wetlands surveyed. The wetland monitoring program annual report for 2021 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 2021 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 2021 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 2021 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 and Area E proposed aggregate extraction sites as well as the Area E proposed haul road (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 2021 rare plant data on 14 September, 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. 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, and that ongoing monitoring 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 2021 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 2021 pre-construction rare plant survey report, which includes methods and results from surveys conducted in 2015 through 2021, 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. In 2021, propagule collection continued, along with translocation implementation 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 2021. 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 2021 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 and federally listed as Special Concern on Schedule 1 of SARA.

6.4.3.3 Bat Mitigation Monitoring at Portage Mountain

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.

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

- 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. Bat species composition did not change between years. However, there appears to be a decrease in use of the monitored maternity roost, although data were insufficient for running a statistical test. Bat

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

activity showed a statistically significant negative relationship to blasting occurrence during the fall period. Bat activity during the hibernation period showed a statistically significant decline in 2018, 2019 and 2021 relative to 2017, despite no blasting occurring during the hibernation period, and limited quarry development occurring in 2018 other than late summer test blasts. Quarry activity may have affected swarming, which is the late summer / early fall activity peak associated with mating, because the behaviour could not be detected in in 2019 or 2020, although swarming was detected in 2021. Overall, bat activity was variable among years and causal factors are difficult to identify. 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 with consideration of all data collected in 2017 through 2021 is Appendix 7.

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 2021 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 during the river diversion period is planned to occur in 2022.

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 2021. The following documents were reviewed to identify changes to rankings of species documented in the LAA during baseline surveys[5]:

- 2021 BC Conservation Status Rank Review and Changes, vascular and non-Vascular Plants; and
- 2021 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, 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 2021 there were no 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 2021. No finalized recovery strategies for federally listed species likely to occur

[5] Government of British Columbia. 2021. 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: 31 January 2021.

within the Site C Project Area were released in 2021, although a proposed recovery strategy for bank swallow (*Riparia riparia*) was released in 2021.

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) reclassified short-eared owl as Threatened in 2021, and downgraded barn swallow and Canada warbler (*Cardellina canadensis*) to Special Concern.

In 2021, the BC Conservation Data Centre (CDC) listing did not change for any wildlife species with potential to occur in the Site C Project area.

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 2021 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 2021:

- 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 2021 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 2021 rare plant data on 14 September, when it was available to contractors for use in planning.

The 2021 rare plant data were submitted to the Program Botanist at the BC Conservation Data Center, MOECCS on 28 January 2021.

Voucher specimens were collected in 2021 and submitted to the UBC herbarium on 26 January 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 2021 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 is 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 will run off the North and South edges of the berm.

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. In 2021, propagule collection continued, along with translocation implementation and translocation monitoring. A technical memorandum summarizing the results of the 2021 field program is Appendix 8.

7.3 EAC Condition 11

This section of the annual report summarizes the programs implemented in 2019 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. BC Hydro hosted six environmental forums with Indigenous Groups remotely in 2021, covering 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 2019 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 was done in 2021 through the wetland monitoring program (Section 6.3.2).

7.5 EAC Condition 14

This section of the annual report summarizes the programs as implemented in 2021 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)[6]. 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 2021 is presented in Appendix 8.

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

[6] 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 2021).** 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)[7]. 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

[7] 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 in 2019, 2020 and 2021. 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 2021 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 2021 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

In 2019, Ducks Unlimited Canada conducted the physical works necessary at Golata Canyon Ranch to create approximately 50 ha of sedge wetland. That wetland is fed by non-fish bearing surface water, and the wetland is 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 in association with the Cache Creek Bridge, which is planned for construction in 2023. The 2021 annual report on monitoring of the installed gartersnake artificial hibernacula is Appendix 9.

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 2020, 266 nest boxes were installed on trees and structures on BC Hydro owned and managed lands, and on private lands where permission was granted. Twenty boxes have been installed near the lower reservoir, 77 near the eastern reservoir, 38 near the middle reservoir and 131 near the western reservoir. Nest boxes were strategically placed 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. In 2021, it was found that one box had been destroyed by a falling tree, 10 could not be found, and 14 boxes had been removed from areas where the clearing boundary had been updated and was overlapping the box locations. Boxes will be replaced when it is feasible to do so (i.e., when clearing and highway construction activities will not interfere). The Cavity Nesting Mitigation and Monitoring Program 2021 Annual Report is Appendix 10.

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"[8]. 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).

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);

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

- 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. 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 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.*

Twenty-five (25) coarse woody debris (CWD) piles for fisher have been created within the dam site area and 66 CWD piles were created along the transmission line. 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 has constructed and installed 88 fisher den boxes to help mitigate the loss of denning habitat due to reservoir clearing.

7.8 EAC Condition 19

This section of the annual report summarizes the programs implemented in 2021 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[9]).

7.9 EAC Condition 21

This section of the annual report summarizes the programs implemented in 2021 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 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.

[9] 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.

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 2021. A summary of the methods and results of bald eagle nest aerial monitoring in 2021 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 2021 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 from April 1 through September 30, following the requirements of the Site C Western Toad Management Procedure. That monitoring involved surveys for western toad activity that occur weekly during the caution period of April 1 to May 31 and August 16 to September 30, and daily surveys from June 1 to August 15. No western toad use of the crossing structure has yet been documented, but western toad activity in general has been low.

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 2021 Annual Report can be found in Appendix 2.

7.9.4.2 Ground-nesting raptors

Ground nesting raptor surveys in 2021 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 2021 to capture early, middle, and late stages of their breeding season. The ground-nesting raptor monitoring 2021 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 2021 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 2021 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.

Appendices

Appendix 1. Site C Clean Energy Project Construction Schedule

Site C Construction Schedule

February 2020
BCH20-176

Construction Activity	2015				2016				2017				2018				2019				2020				2021				2022				2023				2024				2025			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Dam Site Area	**2015**				**2016**				**2017**				**2018**				**2019**				**2020**				**2021**				**2022**				**2023**				**2024**				**2025**			
Clearing: dam site																																												
Access roads at the dam site																																												
Worker accommodation																																												
Peace River construction bridge																																												
Excavation and material relocation																																												
Cofferdams and diversion tunnels																																												
Earthfill dam																																												
Roller-compacted-concrete buttress																																												
Generating station and spillways																																												
Turbines and generators																																												
Substation																																												
Powerhouse transmission lines																																												
Viewpoint construction/landscaping																																												
Demobilization and site reclamation																																												
Roads and Highways*	**2015**				**2016**				**2017**				**2018**				**2019**				**2020**				**2021**				**2022**				**2023**				**2024**				**2025**			
Public road improvements																																												
240 Road																																												
269 Road																																												
271 Road																																												
Old Fort Road																																												
Highway 29 realignment																																												
Cache Creek West																																												
Cache Creek/Bear Flat																																												
Halfway River																																												
Dry Creek																																												
Farrell Creek																																												
Farrell Creek East																																												
Lynx Creek																																												
Peace River / Reservoir Area*	**2015**				**2016**				**2017**				**2018**				**2019**				**2020**				**2021**				**2022**				**2023**				**2024**				**2025**			
Clearing: Lower reservoir and Moberly Drainage																																												
Clearing: Eastern reservoir																																												
Clearing: Middle reservoir																																												
Clearing: Western reservoir																																												
River diversion																																												
Reservoir filling and operations																																												
Transmission Works*	**2015**				**2016**				**2017**				**2018**				**2019**				**2020**				**2021**				**2022**				**2023**				**2024**				**2025**			
Transmission line clearing																																												
Transmission line construction																																												
Extension of Peace Canyon switchyard																																												
Hudson's Hope Shoreline Protection	**2015**				**2016**				**2017**				**2018**				**2019**				**2020**				**2021**				**2022**				**2023**				**2024**				**2025**			
Hudson's Hope Berm/ DA Thomas Road upgrades																																												
Production & Transport of Materials	**2015**				**2016**				**2017**				**2018**				**2019**				**2020**				**2021**				**2022**				**2023**				**2024**				**2025**			
85th Avenue Industrial Lands																																												
Portage Mountain Quarry																																												
West Pine Quarry																																												
Wuthrich Quarry																																												

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 2020 Annual Report

Site C Clean Energy Project
Breeding Bird Follow-up Monitoring – Songbirds
2021 Annual Report

PRESENTED TO
BC Hydro and Power Authority

JANUARY 14, 2022
ISSUED FOR USE
FILE: 704-ENW.PENW03042-02.SONG
REVISION 1

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Tel 604.685.0275 Fax 604.684.6241

Site C Clean Energy Project Breeding Bird Follow-Up Monitoring - Songbirds 2021 Annual Report

FILE: 704-ENW.PENW03042-02.SONG
January 14, 2022

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

LIMITATIONS OF REPORT
This report and its contents are intended for the sole use of BC Hydro and Power Authority and their agents. Saulteau EBA Environmental Services Joint Venture does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than BC Hydro and Power Authority, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in Saulteau EBA Environmental Services Joint Venture's Services Agreement. Saulteau EBA Environmental Services Joint Venture's Limitations on Use of This Document are provided in Appendix D of this report.

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 2021. 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 2021 as part of the follow-up monitoring program. This report describes the methods used to conduct the 2021 surveys and a summary of the results.

Surveys were conducted June 3-24, 2021 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 92 bird species were detected, of which 76 were songbirds. Nine 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 8 (range 1 to 18).

Surveys conducted in 2021 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.

TABLE OF CONTENTS

EXECUTIVE SUMMARY ii

1.0 INTRODUCTION 1

2.0 METHODS 1
2.1 Survey Locations 1
2.2 Point Count Surveys 3

3.0 RESULTS AND DISCUSSION 5

4.0 REFERENCES 8

LIST OF TABLES

Table 1: Number of Songbird Point Count Stations and Surveys Conducted in 2021 by Bird Habitat Class. 5
Table 2: Songbird Species Observed during the 2021 Point Count Surveys. 6

LIST OF FIGURES

Figure 1. Overview of Songbird Point Count Locations 2
Figure 2. Songbird Point Count Locations 4

APPENDICES

Appendix A 2021 Point Count Stations
Appendix B Project Qualified Environmental Professionals
Appendix C Incidental Bird Observations
Appendix D Limitations on the Use of this Document

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 2021. 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 and 2021 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 2021 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).

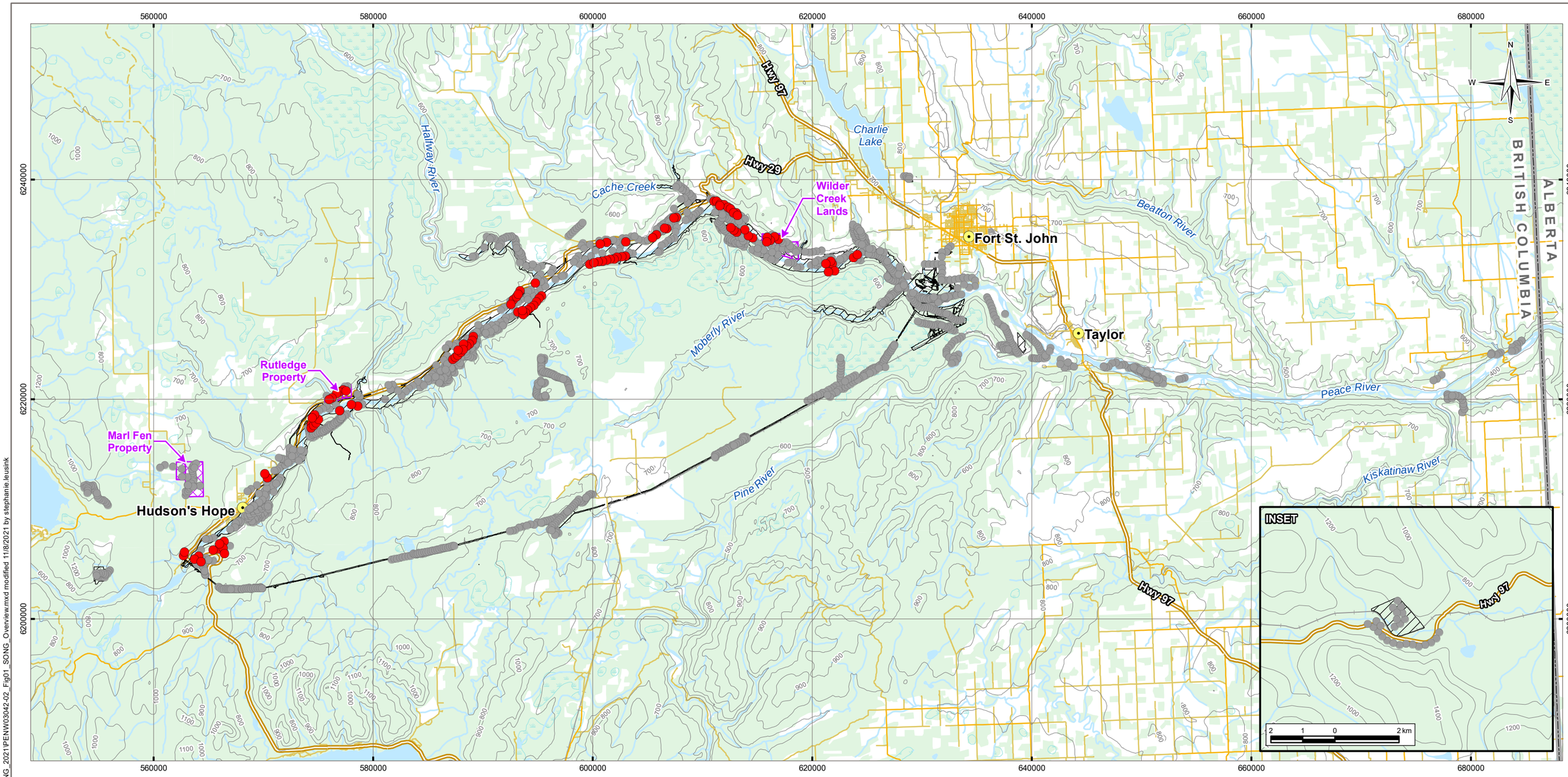
2.0 METHODS

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 2021 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.

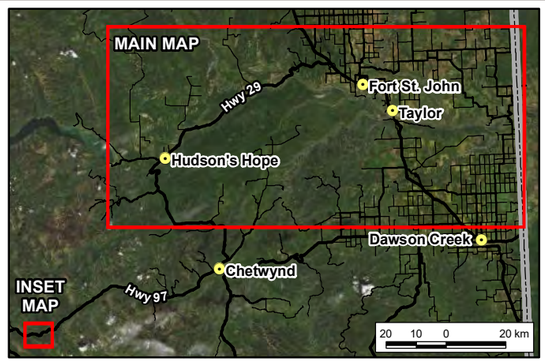


LEGEND

Songbird Survey Locations

Survey Year

- 2021
- 2006 to 2020
- 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 2021 ANNUAL REPORT

Songbird Survey Locations

PROJECTION UTM Zone 10		**DATUM** NAD83		**CLIENT** BC Hydro Power smart
Scale: 1:350,000 — 5 2.5 0 5 Kilometres				TETRA TECH
FILE NO. PENW03042-02_Fig01_SONG_Overview.mxd				
OFFICE TI-VANC	**DWN** SL	**CKD** YL	**APVD** EH	**REV** 0
DATE November 8, 2021	**PROJECT NO.** ENW.PENW03042-02			**Figure 1**

Q:\Vancouver\GIS\ENVIRONMENTAL\PENW\PENW03042-02\Maps\SONG_2021\PENW03042-02_Fig01_SONG_Overview.mxd modified 11/8/2021 by stephanie.leusink

Surveys conducted in 2021 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).

Eight of the 97 survey stations established in 2020 were not surveyed again in 2021 due to accessibility issues. Fourteen new survey stations were established in 2021 on cleared islands and at Watson Slough to provide a more accurate representation of the bird community in the Peace River Valley. In total, 103 stations were surveyed in 2021 (Figures 2a to 2d; Appendix A).

2.2 Point Count Surveys

Point counts were conducted on June 3-24, 2021 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.

608000 610000 612000 614000 616000 618000 620000 622000 624000 626000

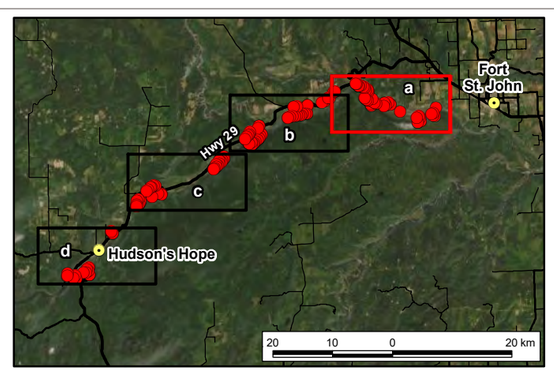
6238000 6236000 6234000 6232000 6230000

Cache Creek
Hwy 29 N
Wilder Creek
Peace River
Hilltop Dr
Alaska Hwy
244 Rd
242 Rd
Old Hope Rd
277 Rd
275 Rd
273 Rd
N
S
E
W

PC21-201
PC21-202
PC21-203
PC21-204
PC21-210
PC21-205
PC21-206
PC21-208
PC21-207
PC21-209
PC17-PR-38
PC17-PR-39
PC21-502
PC21-501
PC21-500
PC21-608
PC21-607
PC21-606
PC21-008
PC21-010
PC21-007
PC21-009
PC21-011
Wilder Creek Lands
PC21-602
PC21-601
PC21-604
PC21-605
PC21-603
PC21-004
PC21-005

LEGEND

- 2021 Songbird Survey Location
- Project Footprint
- Potential Mitigation Property
- Peace River Valley
- Highway
- Main Road
- Local Road
- Watercourse
- Waterbody



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

STATUS
ISSUED FOR USE

SITE C SONGBIRD 2021 ANNUAL REPORT

2021 Songbird Survey Locations

PROJECTION: UTM Zone 10	DATUM: NAD83			CLIENT: BC Hydro Power smart
Scale: 1:50,000 (1 0.5 0 1 Kilometres)				TETRA TECH
FILE NO.: PENW03042-02_Fig02_SONG_2021.mxd				
OFFICE: Tt-VANC	DWN: SL	CKD: YL	APVD: EH	REV: 0
DATE: November 8, 2021	PROJECT NO.: ENW.PENW03042-02			Figure 2a

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3.0 RESULTS AND DISCUSSION

Surveys were conducted in 15 bird habitat classes (Table 1). Each of the 103 point count stations were surveyed twice in June 2021 for a total of 206 surveys.

Table 1: Number of Songbird Point Count Stations and Surveys Conducted in 2021 by Bird Habitat Class

Bird Habitat Class	Stations	Surveys
Coniferous-shrub	4	8
Coniferous-young forest	8	16
Coniferous-mature forest	18	36
Deciduous-shrub	12	24
Deciduous-young forest	12	24
Deciduous-mature forest	13	26
Riparian-mixed shrub	8	16
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**	**206**

A total of 92 bird species were detected, of which 76 were songbirds (Table 2). Nine 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 8 (ranging from 1 to 18). Other bird species not classified as songbirds were recorded as incidental observations and are listed in Appendix C.

Surveys conducted in 2021 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 2021 Point Count Surveys

English Name	Scientific Name	BC List	COSEWIC	SARA Status	Survey Detections
Northern Flicker*	*Colaptes auratus*	Yellow	-	-	2
Downy Woodpecker*	*Dryobates pubescens*	Yellow	-	-	2
Hairy Woodpecker*	*Dryobates villosus*	Yellow	-	-	3
Pileated Woodpecker*	*Dryocopus pileatus*	Yellow	-	-	3
American Three-toed Woodpecker*	*Picoides dorsalis*	Yellow	-	-	6
Yellow-bellied Sapsucker*	*Sphyrapicus varius*	Yellow	-	-	17
Olive-sided Flycatcher	*Contopus cooperi*	Blue	Special Concern	Threatened	11
Western Wood-Pewee	*Contopus sordidulus*	Yellow	-	-	31
Alder Flycatcher	*Empidonax alnorum*	Yellow	-	-	42
Pacific-slope Flycatcher	*Empidonax difficilis*	Yellow	-	-	4
Hammond's Flycatcher	*Empidonax hammondii*	Yellow	-	-	2
Least Flycatcher	*Empidonax minimus*	Yellow	-	-	125
Eastern Kingbird	*Tyrannus tyrannus*	Yellow	-	-	4
Warbling Vireo	*Vireo gilvus*	Yellow	-	-	30
Red-eyed Vireo	*Vireo olivaceus*	Yellow	-	-	169
Philadelphia Vireo	*Vireo philadelphicus*	Yellow	-	-	1
Blue-headed Vireo	*Vireo solitarius*	Yellow	-	-	8
American Crow	*Corvus brachyrhynchos*	Yellow	-	-	24
Common Raven	*Corvus corax*	Yellow	-	-	27
Blue Jay	*Cyanocitta cristata*	Yellow	-	-	1
Canada Jay	*Perisoreus canadensis*	Yellow	-	-	11
Black-billed Magpie	*Pica hudsonia*	Yellow	-	-	15
Cedar Waxwing	*Bombycilla cedrorum*	Yellow	-	-	33
Black-capped Chickadee	*Poecile atricapillus*	Yellow	-	-	18
Cliff Swallow	*Petrochelidon pyrrhonota*	Yellow	-	-	3
Bank Swallow	*Riparia riparia*	Yellow	Threatened	Threatened	12
Tree Swallow	*Tachycineta bicolor*	Yellow	-	-	5
Violet-green Swallow	*Tachycineta thalassina*	Yellow	-	-	2
Ruby-crowned Kinglet	*Regulus calendula*	Yellow	-	-	4
Golden-crowned Kinglet	*Regulus satrapa*	Yellow	-	-	5
Marsh Wren	*Cistothorus palustris*	Yellow	-	-	3
Red-breasted Nuthatch	*Sitta canadensis*	Yellow	-	-	12
House Wren	*Troglodytes aedon*	Yellow	-	-	4
Brown Creeper	*Certhia americana*	Yellow	-	-	4

English Name	Scientific Name	BC List	COSEWIC	SARA Status	Survey Detections
Gray Catbird	*Dumetella carolinensis*	Yellow	-	-	8
Hermit Thrush	*Catharus guttatus*	Yellow	-	-	6
Swainson's Thrush	*Catharus ustulatus*	Yellow	-	-	126
American Robin	*Turdus migratorius*	Yellow	-	-	90
Purple Finch	*Haemorhous purpureus*	Yellow	-	-	2
Pine Siskin	*Spinus pinus*	Yellow	-	-	38
Canada Warbler	*Cardellina canadensis*	Blue	Special Concern	Threatened	20
Wilson's Warbler	*Cardellina pusilla*	Yellow	-	-	7
Mourning Warbler	*Geothlypis philadelphia*	Yellow	-	-	4
Common Yellowthroat	*Geothlypis trichas*	Yellow	-	-	43
Orange-crowned Warbler	*Leiothlypis celata*	Yellow	-	-	32
Tennessee Warbler	*Leiothlypis peregrina*	Yellow	-	-	14
Black-and-white Warbler	*Mniotilta varia*	Yellow	-	-	28
Connecticut Warbler	*Oporornis agilis*	Blue	-	-	1
Northern Waterthrush	*Parkesia noveboracensis*	Yellow	-	-	8
Ovenbird	*Seiurus aurocapilla*	Yellow	-	-	137
Bay-breasted Warbler	*Setophaga castanea*	Red	-	-	1
Yellow-rumped Warbler	*Setophaga coronata*	Yellow	-	-	73
Magnolia Warbler	*Setophaga magnolia*	Yellow	-	-	13
Black-throated Gray Warbler	*Setophaga nigrescens*	Yellow	-	-	2
Yellow Warbler	*Setophaga petechia*	Yellow	-	-	142
American Redstart	*Setophaga ruticilla*	Yellow	-	-	21
Blackpoll Warbler	*Setophaga striata*	Yellow	-	-	1
Cape May Warbler	*Setophaga tigrina*	Blue	-	-	1
Black-throated Green Warbler	*Setophaga virens*	Blue	-	-	12
Red-winged Blackbird	*Agelaius phoeniceus*	Yellow	-	-	87
Brewer's Blackbird	*Euphagus cyanocephalus*	Yellow	-	-	3
Baltimore Oriole	*Icterus galbula*	Blue	-	-	12
Brown-headed Cowbird	*Molothrus ater*	Yellow	-	-	15
Common Grackle	*Quiscalus quiscula*	Yellow	-	-	2
Dark-eyed Junco	*Junco hyemalis*	Yellow	-	-	49
Swamp Sparrow	*Melospiza georgiana*	Yellow	-	-	17
Lincoln's Sparrow	*Melospiza lincolnii*	Yellow	-	-	43
Song Sparrow	*Melospiza melodia*	Yellow	-	-	45

English Name	Scientific Name	BC List	COSEWIC	SARA Status	Survey Detections
Savannah Sparrow	*Passerculus sandwichensis*	Yellow	-	-	2
Fox Sparrow	*Passerella iliaca*	Yellow	-	-	2
Vesper Sparrow	*Pooecetes gramineus*	Yellow	-	-	13
Clay-colored Sparrow	*Spizella pallida*	Yellow	-	-	81
Chipping Sparrow	*Spizella passerina*	Yellow	-	-	22
White-throated Sparrow	*Zonotrichia albicollis*	Yellow	-	-	260
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Yellow	-	-	67
Western Tanager	*Piranga ludoviciana*	Yellow	-	-	62

* 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
2021 POINT COUNT STATIONS

Table A1: Songbird Point Count Stations Surveyed in 2021

Station	UTM Zone	UTM Easting	UTM Northing	Survey 1 Date	Survey 1 Time	Survey 2 Date	Survey 2 Time	Bird Habitat Class
PC21-601	10	623773	6232892	2021-06-03	06:12	2021-06-19	05:40	Riparian-mixed young forest
PC21-602	10	624125	6233158	2021-06-03	06:17	2021-06-19	05:46	Riparian-mixed shrub
PC21-603	10	621827	6232349	2021-06-03	04:50	2021-06-19	04:28	Riparian-mixed shrub
PC21-604	10	621685	6232571	2021-06-03	05:09	2021-06-19	05:50	Riparian-mixed shrub
PC21-605	10	621248	6232354	2021-06-03	05:32	2021-06-19	05:11	Riparian-mixed shrub
PC21-606	10	614571	6234696	2021-06-03	07:07	2021-06-19	06:28	Coniferous-shrub
PC21-607	10	614201	6234874	2021-06-03	07:27	2021-06-19	06:48	Riparian-mixed shrub
PC21-608	10	613880	6235428	2021-06-03	09:24	2021-06-19	08:48	Riparian-mixed shrub
PC21-500	10	613140	6235203	2021-06-03	08:14	2021-06-19	07:30	Deciduous-young forest
PC21-501	10	612849	6235419	2021-06-03	08:40	2021-06-19	08:02	Deciduous-mature forest
PC21-502	10	612581	6235611	2021-06-03	09:16	2021-06-19	08:32	Deciduous-mature forest
PC21-004	10	622034	6231701	2021-06-03	05:04	2021-06-19	04:40	Deciduous-mature forest
PC21-005	10	621480	6231575	2021-06-03	05:31	2021-06-19	05:08	Deciduous-young forest
PC21-007	10	616913	6234543	2021-06-03	08:08	2021-06-19	07:36	Dry slopes-grassland
PC21-008	10	616553	6234827	2021-06-03	07:44	2021-06-19	07:06	Dry slopes-shrubland
PC21-009	10	616192	6234479	2021-06-03	08:33	2021-06-19	07:59	Cultivated
PC21-010	10	615902	6234745	2021-06-03	07:12	2021-06-19	06:34	Dry slopes-shrubland
PC21-011	10	615862	6234301	2021-06-03	08:49	2021-06-19	08:15	Cultivated
PC21-019	10	603014	6234339	2021-06-08	04:21	2021-06-22	04:21	Dry slopes-grassland
PC21-021	10	601274	6234292	2021-06-08	04:48	2021-06-22	04:48	Deciduous-shrub
PC21-024	10	600679	6234123	2021-06-08	05:21	2021-06-22	05:18	Deciduous-shrub

Station	UTM Zone	UTM Easting	UTM Northing	Survey 1 Date	Survey 1 Time	Survey 2 Date	Survey 2 Time	Bird Habitat Class
PC21-027	10	605811	6234955	2021-06-06	09:50	2021-06-22	08:46	Fen/bog-shrub
PC21-032	10	594779	6230591	2021-06-08	05:50	2021-06-22	07:50	Coniferous-shrub
PC21-035	10	593385	6229860	2021-06-07	04:34	2021-06-22	05:49	Deciduous-shrub
PC21-038	10	592767	6229065	2021-06-07	05:25	2021-06-22	06:50	Dry slopes-shrubland
PC21-PR-38	10	607605	6236561	2021-06-08	07:23	2021-06-24	08:53	Wetland-graminoid
PC21-PR-39	10	607396	6236515	2021-06-07	05:46	2021-06-24	08:35	Wetland-shrub
PC21-039	10	592553	6228662	2021-06-08	07:45	2021-06-22	07:10	Cultivated
PC21-040	10	593058	6229341	2021-06-07	05:10	2021-06-22	06:28	Dry slopes-shrubland
PC21-PR-46	10	606770	6235559	2021-06-08	06:55	2021-06-22	09:04	Wetland-graminoid
PC21-050	10	593202	6229554	2021-06-07	04:52	2021-06-22	06:11	Dry slopes-shrubland
PC21-PR-56	10	605447	6234696	2021-06-06	09:28	2021-06-22	08:28	Coniferous-mature forest
PC21-069	10	577259	6220860	2021-06-06	08:31	2021-06-23	08:35	Dry slopes-shrubland
PC21-070	10	576921	6220683	2021-06-06	08:00	2021-06-23	07:59	Dry slopes-shrubland
PC21-071	10	576686	6220531	2021-06-06	07:37	2021-06-23	07:40	Deciduous-shrub
PC21-072	10	576256	6220108	2021-06-06	07:07	2021-06-23	07:06	Riparian-mixed young forest
PC21-073	10	576001	6219985	2021-06-06	06:45	2021-06-23	06:46	Cultivated
PC21-076	10	570355	6212864	2021-06-06	05:33	2021-06-23	05:36	Coniferous-young forest
PC21-077	10	570134	6213209	2021-06-06	05:54	2021-06-23	05:58	Coniferous-young forest
PC21-078	10	565870	6206360	2021-06-06	04:37	2021-06-23	04:38	Deciduous-mature forest
PC21-080	10	566416	6207084	2021-06-06	05:05	2021-06-23	05:11	Deciduous-shrub
PC21-081	10	566341	6206470	2021-06-06	05:48	2021-06-23	05:56	Wetland-shrub
PC21-082	10	564101	6205711	2021-06-06	07:02	2021-06-23	07:15	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
PC21-084	10	566021	6206826	2021-06-06	05:29	2021-06-23	05:37	Deciduous-shrub
PC21-085	10	563734	6205440	2021-06-06	07:39	2021-06-23	07:55	Fen/bog-shrub
PC21-086	10	564312	6205213	2021-06-06	08:13	2021-06-23	08:31	Deciduous-shrub
PC21-087	10	565416	6206263	2021-06-06	04:15	2021-06-23	04:16	Deciduous-shrub
PC21-088	10	562713	6205763	2021-06-06	04:20	2021-06-23	04:21	Deciduous-mature forest
PC21-089	10	562800	6206063	2021-06-06	04:50	2021-06-23	04:54	Deciduous-mature forest
PC21-101	10	566447	6205946	2021-06-06	06:15	2021-06-23	06:22	Coniferous-young forest
PC21-104	10	577541	6220783	2021-06-06	08:52	2021-06-23	08:58	Deciduous-young forest
PC21-144	10	606558	6235589	2021-06-08	08:19	2021-06-24	07:51	Wetland-graminoid
PC21-201	10	611065	6238042	2021-06-07	04:20	2021-06-22	04:19	Dry slopes-shrubland
PC21-202	10	611295	6238013	2021-06-07	04:43	2021-06-22	04:36	Deciduous-young forest
PC21-203	10	611606	6237736	2021-06-07	05:52	2021-06-22	05:22	Deciduous-mature forest
PC21-204	10	611968	6237681	2021-06-08	07:30	2021-06-22	05:55	Deciduous-young forest
PC21-205	10	612332	6237495	2021-06-08	07:00	2021-06-22	06:30	Deciduous-mature forest
PC21-206	10	612573	6237329	2021-06-08	06:21	2021-06-22	06:57	Wetland-shrub
PC21-207	10	613084	6236953	2021-06-08	05:42	2021-06-22	08:18	Wetland-shrub
PC21-208	10	612820	6236955	2021-06-08	04:54	2021-06-22	07:32	Deciduous-shrub
PC21-209	10	613174	6236752	2021-06-08	05:16	2021-06-22	07:55	Deciduous-young forest
PC21-210	10	611575	6237602	2021-06-07	05:22	2021-06-22	04:58	Wetland-shrub
PC21-A1	10	602990	6233046	2021-06-04	04:53	2021-06-20	04:40	Deciduous-mature forest
PC21-A10	10	599738	6232286	2021-06-04	08:56	2021-06-20	08:15	Coniferous-mature forest
PC21-A2	10	602661	6232990	2021-06-04	04:32	2021-06-20	04:16	Deciduous-shrub

Station	UTM Zone	UTM Easting	UTM Northing	Survey 1 Date	Survey 1 Time	Survey 2 Date	Survey 2 Time	Bird Habitat Class
PC21-A3	10	602233	6232962	2021-06-04	05:30	2021-06-20	05:10	Deciduous-shrub
PC21-A4	10	601952	6232770	2021-06-04	05:57	2021-06-20	05:35	Coniferous-mature forest
PC21-A5	10	601607	6232742	2021-06-04	06:25	2021-06-20	06:02	Coniferous-mature forest
PC21-A6	10	601260	6232688	2021-06-04	06:49	2021-06-20	06:25	Coniferous-mature forest
PC21-A7	10	600890	6232601	2021-06-04	07:29	2021-06-20	06:50	Coniferous-mature forest
PC21-A8	10	600496	6232512	2021-06-04	08:02	2021-06-20	07:17	Coniferous-mature forest
PC21-A9	10	600121	6232427	2021-06-04	08:30	2021-06-20	07:47	Coniferous-mature forest
PC21-B1	10	595349	6229423	2021-06-04	05:07	2021-06-20	04:48	Coniferous-young forest
PC21-B10	10	593197	6227928	2021-06-04	08:56	2021-06-20	08:20	Coniferous-shrub
PC21-B2	10	595098	6229182	2021-06-04	05:29	2021-06-20	05:09	Coniferous-mature forest
PC21-B3	10	594882	6228865	2021-06-04	05:58	2021-06-20	05:32	Coniferous-young forest
PC21-B4	10	594639	6228571	2021-06-04	06:33	2021-06-20	05:57	Coniferous-young forest
PC21-B5	10	594340	6228348	2021-06-04	06:56	2021-06-20	06:21	Deciduous-young forest
PC21-B6	10	594087	6228135	2021-06-04	07:21	2021-06-20	06:48	Deciduous-young forest
PC21-B7	10	593863	6227915	2021-06-04	07:43	2021-06-20	07:13	Deciduous-young forest
PC21-B8	10	593646	6227692	2021-06-04	08:10	2021-06-20	07:40	Coniferous-young forest
PC21-B9	10	593609	6228086	2021-06-04	08:37	2021-06-20	08:02	Coniferous-shrub
PC21-C1-1	10	589114	6225713	2021-06-05	07:52	2021-06-21	07:22	Deciduous-shrub
PC21-C1-2	10	589021	6225353	2021-06-05	08:23	2021-06-21	07:52	Coniferous-mature forest
PC21-C1-3	10	588775	6225032	2021-06-05	08:51	2021-06-21	08:22	Coniferous-mature forest
PC21-C1-4	10	588528	6224817	2021-06-05	09:15	2021-06-21	08:46	Coniferous-mature forest
PC21-C1-5	10	588244	6225026	2021-06-05	09:50	2021-06-21	09:18	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
PC21-C2-1	10	587264	6223631	2021-06-05	07:51	2021-06-21	07:12	Deciduous-young forest
PC21-C2-2	10	587483	6223815	2021-06-05	08:22	2021-06-21	07:42	Deciduous-young forest
PC21-C2-3	10	587687	6224007	2021-06-05	08:40	2021-06-21	08:00	Deciduous-young forest
PC21-C2-4	10	587990	6224257	2021-06-05	09:04	2021-06-21	08:26	Coniferous-young forest
PC21-C2-5	10	588205	6224535	2021-06-05	09:28	2021-06-21	09:00	Coniferous-mature forest
PC21-C2-6	10	587739	6224475	2021-06-05	09:58	2021-06-21	09:29	Riparian-mixed shrub
PC21-D1-1	10	574364	6217723	2021-06-05	04:30	2021-06-21	04:14	Riparian-mixed young forest
PC21-D1-2	10	574335	6217385	2021-06-05	04:58	2021-06-21	04:40	Coniferous-mature forest
PC21-D1-3	10	574574	6217605	2021-06-05	05:20	2021-06-21	05:03	Coniferous-mature forest
PC21-D1-4	10	574823	6217844	2021-06-05	05:48	2021-06-21	05:35	Deciduous-mature forest
PC21-D1-5	10	575018	6218149	2021-06-05	06:16	2021-06-21	05:58	Coniferous-mature forest
PC21-D2-1	10	578611	6219365	2021-06-05	05:43	2021-06-21	04:27	Coniferous-mature forest
PC21-D2-2	10	578018	6219525	2021-06-05	05:01	2021-06-21	05:00	Coniferous-mature forest
PC21-D2-3	10	576950	6218948	2021-06-05	04:32	2021-06-21	05:28	Riparian-mixed shrub
PC21-D2-4	10	574657	6218563	2021-06-05	06:29	2021-06-21	05:59	Deciduous-mature forest
PC21-D2-5	10	574463	6218308	2021-06-05	06:51	2021-06-21	06:18	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
Claudio Bianchini, R.P.Bio. Bianchini Biological Services	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
Green-winged Teal	*Anas crecca*	Yellow	-	-	1
Mallard	*Anas platyrhynchos*	Yellow	-	-	6
Canada Goose	*Branta canadensis*	Yellow	-	-	2
Bufflehead	*Bucephala albeola*	Yellow	-	-	1
Northern Shoveler	*Spatula clypeata*	Yellow	-	-	3
Blue-winged Teal	*Spatula discors*	Yellow	-	-	1
Ruffed Grouse	*Bonasa umbellus*	Yellow	-	-	2
Sora	*Porzana carolina*	Yellow	-	-	11
Spotted Sandpiper	*Actitis macularius*	Yellow	-	-	2
Wilson's Snipe	*Gallinago delicata*	Yellow	-	-	23
Solitary Sandpiper	*Tringa solitaria*	Yellow	-	-	4
Red-tailed Hawk	*Buteo jamaicensis*	Yellow	Not at Risk	-	2
Broad-winged Hawk	*Buteo platypterus*	Blue	-	-	1
Bald Eagle	*Haliaeetus leucocephalus*	Yellow	Not at Risk	-	1
Great Horned Owl	*Bubo virginianus*	Yellow	-	-	1
Merlin	*Falco columbarius*	Yellow	Not at Risk	-	2

APPENDIX D
LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

NATURAL SCIENCES

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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.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

SEES JV is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

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 – 2020

Site C Vegetation and Wildlife Waterbird Migration Follow-up Monitoring Program – 2021 Annual Report

Photo Credit: C.T.St.Clair

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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 and the Federal Decision Statement (FDS). In accordance with these requirements and conditions, 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 those 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 5 years, from 2017 through 2021, within study areas along 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 applied to determine waterbird abundance and diversity within the habitat types present and used by waterbirds, including baseline data on measures of abundance, density, species presence and habitat use (i.e., associations) for waterbirds, required by conditions of the FDS. The results collected to date are summarized as a whole and for the most recent monitoring year within this annual report. Monitoring data collected thus far will inform future annual efforts and, together with data collected under future project operations conditions, will be used to evaluate changes to baseline conditions in habitat, abundance and diversity of waterbirds, including species at risk, as per the objectives described above.

Results presented in this annual monitoring report describe the survey effort and the observed waterbird abundance and diversity within and between 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 2021 monitoring efforts and results from 2017 through 2021 are provided below for monitoring conducted along the Peace River between Hudson's Hope and the Alberta border, followed by results from wetlands surveys conducted on and adjacent to the transmission line ROW on the Moberly Plateau.

During the current year of reporting (2021) within the Peace River study area, a total of 2 surveys were conducted during waterbird migrations in spring (Apr 6 to Apr 13, 2021) and 3 surveys were conducted during waterbird migrations in fall (Aug 9 to Sept 28). Wetlands along and adjacent to the Project transmission line ROW were also surveyed during 2 and 3 survey rounds over the spring (May 3 to May 16, 2021) and fall migration periods (August 11 to October 6, 2021), respectively. ARU surveys in 2021 were conducted at a total of 7 locations on the Moberly Plateau during May, June, July and early August. Survey results specific to the current monitoring year are provided within the body of the report.

Surveys of the Peace River in 2017 through 2021 provide 5 years of data primarily reflecting baseline conditions. These data will be used together with data collected following Project construction to assess potential impacts of the Project on waterbirds within a before-after control-impact study design framework. A total of 76,197 waterbirds of 64 species were recorded during boat-based surveys conducted during the spring and fall of 2017 through 2021. From these results, summary statistics were calculated using pooled data from 45 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 confirm that areas of the Peace River downstream of the Pine River provide an appropriate control for assessing background variation for waterbirds, a key assumption of the before-after control-impact study framework within which Project-related changes to waterbirds in the Peace River will be assessed.

To describe variation in waterbird abundance across habitat types, sections of the river with similar habitat features (e.g., water flow volumes and depth, substrate type, and aquatic vegetation) were categorized into habitat types associated with flow rates and connectivity to the Peace River. The 3 habitat types assessed in this study are: Mainstem of the river (where water flow rates, depths and substrate size are greatest), Moderate Flow (consistently connected to the river and with moderate flows, generally no impediment to boat travel), and Limited Connectivity to the river (backchannels with limited connectivity to the river, typically only on the downstream end, and relatively low flow rate, access by boat is restricted in some areas, particularly when water levels are low). Abundance and diversity statistics are presented for each of these river habitat types, demonstrating that most birds (63%) were found in mainstem habitat (the largest habitat type by area), although higher densities were found in other habitat types. The greatest densities of waterbirds were observed in Limited Connectivity habitat, where they were more than 4-fold the densities observed in Moderate Flow habitat and more than 5-fold those in Mainstem habitat in both spring and fall.

Wetland surveys conducted from 2017 through 2021 (100-metre transects, and 20-minute stationary standwatch surveys) detected a total of 8,184 waterbirds of 46 species within 23 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 kilometres 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 method were applied and abundance and diversity statistics are presented for each. Standwatch surveys of open water habitat detected 7,837 individuals across 44 waterbird species in 2017 through 2021. Fewer individuals and species (347 individuals of 19 species) were observed within sedge and willow-sedge habitat with low water depth (i.e., less than 50 centimetres) surveyed by walking transects in 2018 through 2021. Transect surveys were conducted over the past 4 years, as compared to 5 years for standwatch and river surveys, and transect surveys provide data for habitat types with greater detection constraints (e.g., tall and thick vegetation) and for more cryptic species such as marsh birds.

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 2021 was conducted at a total of 18 locations during May, June, July, 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, and yellow rail (*Coturnicops noveboracensis*) was detected at approximately 40 percent of those locations. Virginia rail (*Rallus limicola*), a species only recently known to occur in the region and not reported from baseline studies, was detected at 3 of 13 locations where ARUs were deployed in 2020 and 2021. In contrast, American bittern (*Botaurus lentiginosus*) was not detected at any location in any year of monitoring. These surveys provide data on sora complimentary to those from transect surveys, demonstrating the species' ubiquity within vegetated wetlands. ARU survey results also confirm the rarity of American bittern in the region, the continued presence of yellow rail and the apparently emerging presence of Virginia rail within wetlands along and adjacent to the transmission line ROW, particularly within sedge-dominated habitat with low water levels.

TABLE OF CONTENTS

EXECUTIVE SUMMARY I

1.0 INTRODUCTION 1
1.1 Background 1
1.2 Monitoring Objectives 2
1.3 Study Area and Temporal Scope 3

2.0 MONITORING METHODS 5
2.1 Peace River Waterbird Surveys 5
2.1.1 Approach to Evaluating Change 5
2.1.2 Survey Methods 9
2.2 Transmission Line Wetland Surveys 10
2.2.1 Approach to Evaluating Change 10
2.2.2 Survey Methods 11
2.2.2.1 Transect and Standwatch Surveys 11
2.2.2.2 Bioacoustics Monitoring 13
2.3 Habitat Assessment 14
2.3.1 Peace River 14
2.3.2 Transmission Line Wetlands 16

3.0 DATA MANAGEMENT AND ANALYSIS 21
3.1 Data Management 21
3.2 Data Analysis 21
3.2.1 Peace River Waterbird Surveys 22
3.2.2 Transmission Line Wetland Surveys 23

4.0 RESULTS 24
4.1 Peace River Waterbird Surveys 24
4.1.1 Survey Effort and Timing 24
4.1.2 Habitat Assessment 25
4.1.3 Abundance and Density 28
4.1.4 Diversity 38
4.1.5 Waterbird Species at Risk 39
4.2 Transmission Line Wetland Surveys 40
4.2.1 Survey Effort and Timing 40
4.2.1.1 Transect and Standwatch Surveys 41
4.2.1.2 Bioacoustics Monitoring 42
4.2.2 Abundance and Density 46
4.2.2.1 Transect and Standwatch Surveys 46
4.2.2.2 Bioacoustics Monitoring 48

4.2.3 Diversity 51
4.2.4 Waterbird Species at Risk 54

5.0 DISCUSSION AND RECOMMENDATIONS 55
5.1 Habitat Assessment 55
5.2 Peace River Waterbird Surveys 55
5.3 Transmission Line Wetland Surveys 57

6.0 CLOSING 60

7.0 REFERENCES 61

LIST OF TABLES (WITHIN TEXT)

Table 1 Characteristics of River Habitat Types Used to Delineate Polygons along the Peace River 14
Table 2 Area of River Habitat Types, as Defined by Flow Volume and Connectivity, within the Peace River Study Area by Treatment Areas 16
Table 3 Wetland Habitat Types Adjacent to the Project Transmission Line ROW and Observed Presence 17
Table 4 Area of Wetland Habitat Types in the Peace River Valley and Moberly Plateau Study Area 17
Table 5 Peace River Survey Timing During 2017 Through 2021 Annual Waterbird Migration Monitoring 24
Table 6 Mean Hourly Water Flow Rates on the Peace River During Waterbird Surveys Across Years, Seasons, and Treatment Areas in 2017 Through 2021 26
Table 7 Mean Abundance Estimates (birds/survey round) of Waterbird Foraging Guilds within the Peace River During Spring and Fall of 2017 Through 2021 28
Table 8 Mean Abundance Estimates (birds/survey round) of Waterbird Foraging Guilds within the Peace River During Spring and Fall of 2021 29
Table 9 Mean 2017 Through 2021 Spring Densities (birds/km^2/survey round) and Estimated Abundances of Migrant Waterbirds by River Habitat Type and Treatment Area During 30
Table 10 Mean 2021 Spring Densities (birds/km^2/survey round) and Estimated Abundances of Migrant Waterbirds by River Habitat Type and Treatment Area 30
Table 11 Mean 2017 Through 2021 Fall Densities (birds/km^2/survey round) of Migrant Waterbirds by River Habitat Type and Treatment Area 31
Table 12 Mean 2021 Fall Densities (birds/km^2/survey round) of Migrant Waterbirds by River Habitat Type and Treatment Area 31
Table 13 Mean 2017 Through 2021 Diversity Metrics for Waterbird Foraging Guilds on the Peace River Across Seasons and Survey Periods 38
Table 14 Mean 2021 Diversity Metrics for Waterbird Foraging Guilds on the Peace River Across Seasons and Survey Periods 39

Table 15 Wetland Survey Timing During 2017 Through 2021 Annual Waterbird Migration Monitoring 40
Table 16 Survey Methods and Wetland Habitat Types Survey within Wetland Stations 41
Table 17 Number of Unique Wetland Surveys for Migrating Waterbirds Conducted by Standwatch and Transect Methods by Survey Period During 2017 Through 2021 42
Table 18 Mean 2017 Through 2021 Waterbird Densities (birds/km^2/survey) within Open Water Habitat Reported by Foraging Guild from Standwatch Surveys 46
Table 19 Mean 2021 Waterbird Densities (birds/km^2/survey) within Open Water Habitat Reported by Foraging Guild from Standwatch Surveys 47
Table 20 Mean 2018 through 2021 Waterbird Densities (birds/km/survey) within Vegetated Wetland (sedge, willow-sedge) Habitat Reported by Foraging Guild from Transect Surveys 48
Table 21 Mean 2021 Waterbird Densities (birds/km/survey) within Vegetated Wetland (sedge, willow-sedge) Habitat Reported by Foraging Guild from Transect Surveys 48
Table 22 Bioacoustics Monitoring Locations, Habitat Description, Survey Effort, and Confirmed Detections of Target Species 49
Table 23 Cumulative 2017 Through 2021 Species Richness of Waterbird Foraging Guilds Observed During Transect and Standwatch Surveys of Wetland Habitats 51
Table 24 Average 2017 Through 2021 Species Richness of Waterbird Foraging Guilds within Open Water Wetland Habitat By Survey Period Observed during Standwatch Surveys 52
Table 25 Species Richness in 2021 for Waterbird Foraging Guilds within Open Water Wetland Habitat By Survey Period Observed during Standwatch Surveys 52
Table 26 Average 2018 Through 2021 Species Richness of Waterbird Foraging Guilds within Sedge and Willows-sedge Wetland Habitat By Survey Period Observed during Transect Surveys 53
Table 27 Species Richness in 2021 for Waterbird Foraging Guilds within Sedge and Willows-sedge Wetland Habitat By Survey Period Observed during Transect Surveys 53

LIST OF FIGURES (WITHIN TEXT)

Figure 1 Study areas of the waterbird monitoring program on the Peace River (study area for boat-based surveys) and Moberly Plateau (study area along the transmission line right-of-way for vegetated transect and standwatch surveys). 4
Figure 2 Inundation Impact treatment area within the Peace River study area. 6
Figure 3 Flow Impact treatment area within the Peace River study area. 7
Figure 4 Control treatment area within the Peace River study area. 8
Figure 5 Wetland habitat types and historic yellow rail (*Coturnicops noveboracensis*) detections in and adjacent to the Peace River valley and transmission line ROW. 20

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 relative to across spring and fall migrations in 2017 through 2021. 27
Figure 7 Mean density (birds/km^2/survey round) of spring migrant waterbirds within Inundation Impact area habitat polygons from 2017 through 2021. 32
Figure 8 Mean density (birds/km^2/survey round) of spring migrant waterbirds within Flow Impact area habitat polygons from 2017 through 2021. 33
Figure 9 Mean density (birds/km^2/survey round) of spring migrant waterbirds within Control area habitat polygons from 2017 through 2021. 34
Figure 10 Mean density (birds/km^2/survey round) of fall migrant waterbirds within Inundation Impact area habitat polygons from 2017 through 2021. 35
Figure 11 Mean density (birds/km^2/survey round) of fall migrant waterbirds within Flow Impact area habitat polygons from 2017 through 2021. 36
Figure 12 Mean density (birds/km^2/survey round) of fall migrant waterbirds within Control area habitat polygons from 2017 through 2021. 37
Figure 13 Wetland survey stations and ARU monitoring locations on the transmission line ROW (east) assessed in 2021 monitoring report. 43
Figure 14 Wetland survey stations on the transmission line ROW (central) assessed in the 2021 annual monitoring report. 44
Figure 15 Wetland survey stations on the transmission line ROW (west) assessed in the 2021 annual monitoring report. 45

LIST OF PHOTOS (WITHIN TEXT)

Photo 1 Example of the Mainstem River Habitat Type. 15
Photo 2 Example of the Moderate Flow (center/right) and Limited Connectivity (left) River Habitat Types. 15
Photo 3 Example of a wetland standwatch survey of open water habitat within station OW-06. 18
Photo 4 Example of a transect survey of sedge-dominated wetland within station SE-04. 18
Photo 5 Example of a transect survey within a willow-sedge and scrub birch-dominated wetland within station WS-03. 19
Photo 6 Trumpeter swan (*Cygnus buccinator*) adults and juveniles using open water wetland habitat within station OW-06 19

LIST OF APPENDICES

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

Appendix B Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances from 2017 through 2021 (Table B-1 [2017, 2018, 2019, 2021] and B-2 [2021])

Appendix C Spatial Representation of Waterbird Observations within the Peace River Study Area in Spring and Fall 2021 (Figures C-1 to C-4)

Appendix D Wetland Survey Station Photos

Appendix E Mean and Standard Devation Statistics Tables for Relative Abundance and Diversity Results

Appendix F Flow Rates in 2021 during Surveys Relative to Flow Rates during All Spring and Fall Migration Periods

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
kHZ	kilohertz
km	kilometres
km^2	kilometres squared
km/h	klometres per hour
m	metre
QA	quality assurance
QC	quality control
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

Term	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 Project site.
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 species groups (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 **wetland study area**.
Treatment area	Geographical areas that are sub-areas of the **study area** in which either the impact or control condition is present and measured. There are two types of treatment areas within this BACI study: **control areas**, **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 Moberley Plateau within 3 kilometres of the Project transmission line.

1.0 INTRODUCTION

This report describes the combined annual results of the 2017 to 2021 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 artificial and created 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).

The Vegetation and Wildlife Technical Committee (VWTC) reviewed the summary of baseline studies for waterbirds and noted that no shorebirds were documented during helicopter and fixed-wing aircraft surveys between 2012 and 2014. The lack of shorebird observations during aerial surveys, as well as challenges in species identification from helicopters, prompted the VWTC to request that a follow-up monitoring program better suited to detecting and identifying a boader range of bird species be developed to provide a more complete assessment of waterbird use of the Peace River during spring and fall migration periods. The Waterbird Migration Follow-up Monitoring Program was designed in conjunction with the VWTC to meet this objective. This report presents Waterbird Migration Follow-up Monitoring Program data collected annually from 2017 through 2021 using methods designed to survey the full range of waterbird species present in the study area, including improved species identification of shorebirds and other small waterbirds.

Data from surveys before 2017 were not compared to or 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 data collected satisfy the waterbird monitoring requirements of the FDS and EAC by evaluating the effectiveness of mitigation and compensation measures for waterbirds and by verifying the accuracy of the predictions made in the EIS regarding waterbirds and their habitat. 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 conditions of the FDS.

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 foraging strategies: dabbling ducks (i.e., small waterfowl that feed primarily on aquatic vegetation), large dabblers (i.e., large waterfowl [e.g., geese and swans] that feed primarily on vegetation), piscivorous divers (i.e., diving birds that forage on fish), benthic feeding divers (i.e., small waterfowl and sea ducks that feed primarily on benthic invertebrates), gulls and surface-feeding terns (i.e., small to large size birds that forage on fish and insects near the water's surface, and occasionally garbage), hereafter referred to simply as 'gulls', shorebirds (i.e., plovers and sandpipers that feed primarily on or near the shoreline), and unidentified waterbirds. Foraging groups are used to categorize waterbird species because forage is expected to be an important driver of waterbird abundance during migration. The use of foraging groups also generally follows the waterbird species categorization approach used in the Environmental Impact Statement (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. Additional wetland habitat within the Moberly Plateau that was surveyed from fixed-wing aircraft during 2017 was not surveyed in subsequent years because species identification was seldom possible from the elevations required for safe flight, and access from the ground is limited. Sites with newly enhanced and created compensation wetlands with waterbird habitat will be included in the study as they are identified.

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 periods (Simpson and Andrusiak 2009; Hilton et al. 2013; eBird 2021).

To inform the timing and number of surveys conducted in 2020, 2021, and subsequent years, a power analysis was conducted using the Peace River waterbird survey data collected by boat in 2017, 2018, and 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. That is, they would allow for detection, with 80 percent (%) certainty, of a 50% change in abundance of each foraging guild in the Impact treatment area. Surveys in 2020 and 2021 were conducted in accordance with these 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.

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 which encompasses a defined period of spring or fall migration, including the peak migration of one or more species groups (i.e., foraging guilds).

Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

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

Legend

- Site C Local Assessment Area
- 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 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 2021 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 2018). Differences in site accessibility and detection constraints across habitat types and waterbird species required distinct survey methods for the Peace River study area and wetlands adjacent to the Project transmission line ROW. These methods are detailed 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 has been 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:

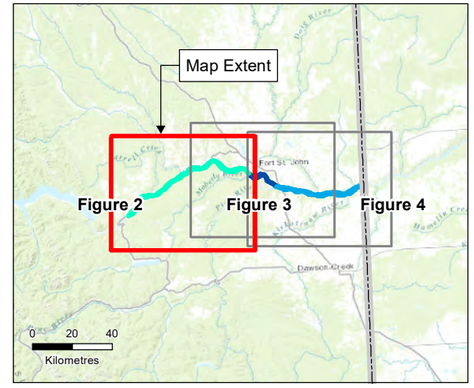
- Inundation Impact area - the Site C reservoir from Hudson's Hope to the Project site, to assess impact from inundation (**Figure 2**)
- Flow Impact area - the Peace River from the Site C dam to the Pine River confluence with the Peace River, to assess impact from change in flow regime (**Figure 3**)
- 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 will be moderated by inputs from the Pine River. Control and impact areas within the Peace River study area are, hereafter, collectively and individually referred to as *treatment areas*. The before period for the BACI design will be the time 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 immediately impacted by construction activity will ultimately be excluded from the before period dataset in future analyses of Project-related change.

Following collection and analysis of relative abundance data from both the before and after study periods, the BACI design will permit determination of Project-related impacts through assessing statistical significance of the interaction effect between treatment (i.e., control vs. impact) and survey period (before versus after [during Project operations]) factors.

Migratory Waterbird Follow-up Monitoring Program
2021 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

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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Page Size: 11" x 17"

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BC hydro

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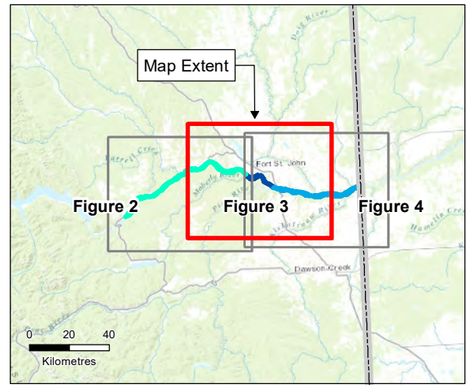
Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

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



Legend

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

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.

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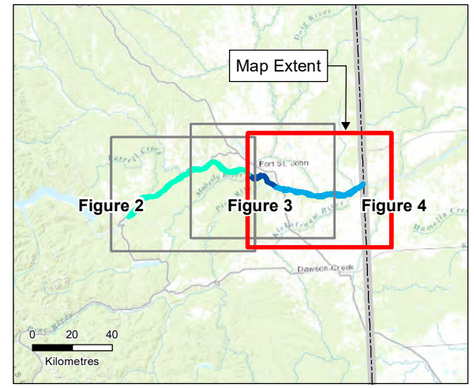
Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

Figure 4 - Control Area on the Peace River



Legend

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

Fort St. John
Old Fort
Taylor
Beatton River
Pine River
Peace River
Kiskatinaw River
BRITISH COLUMBIA
ALBERTA

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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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 (RIC 1998) and Inventory Methods for Waterfowl and Allied Species (RIC 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 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 prevent 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 spatial software. Only one surveyor entered data at any given time so at least one observer was available to search.

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). Weather was also deemed inclement when rain or fog resulted in poorvisibility within 1 km. Wave conditions reflecting a sea state greater than 3 on the Beaufort scale means frequent whitecaps, and waves higher than 1.5 m. Surveys were conducted up to wind speeds of 38 km/h (Beaufort 5) unless frequent whitecaps and wave heights reduced visibility at lower wind speeds.

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 “unidentified waterbird”. Two methods were employed to provide the data necessary to account for birds that were present during surveys but not detected by observers (i.e., incomplete detection). Distance sampling using line transect methods (Buckland et al. 2015) was applied starting in the fall of 2018 (and continuing throughout 2019, 2020, and 2021) 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 have 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 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 diversity in order to assess impacts to waterbirds associated with the Site C transmission line and reservoir inundation. 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 impacted habitat to estimate the abundance and species of birds (i.e., diversity) impacted by habitat changes within the transmission line footprint. Additionally, relative abundance and diversity metrics can be compared over time (e.g., before versus after reservoir inundation) to assess potential changes to wetland habitat use due to other impacts of the Project. Such impacts could include potential displacement of waterbirds from inundated river valley habitat into adjacent wetlands. The study provides data to compare abundances of waterbirds for habitat types surveyed before relative to after reservoir inundation (i.e., 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 before period prior to which a transmission line was in place (due to a pre-existing transmission line), and 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 2021 and prior years contained one or more focal habitat type. 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. Three unique survey methods were applied across wetland habitat types. The methods applied were selected to minimize detection constraints specific to each habitat type and maximize the amount of information obtained on waterbirds:

- 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 2021 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 detection through stationary survey methods. Also, 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 open water comprised an area of at least 0.25 hectares. Standwatch surveys are the most appropriate method for these habitats because visual 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 necessary, the 20-minute standwatch survey was divided into two 10-minute segments at 2 vantage points, while being 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. However, transect surveys were targeted for completion within 5 to 10 minutes, and the time taken was recorded 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 over a 2 to 3-day period (i.e., survey round). Two crews, 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 at least one, and a maximum of 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 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 (i.e., >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 (e.g., frequent whitecaps or large waves).

The following information was recorded at each wetland survey station:

- Wetland station ID
- Date and time
- Survey lead and field assistant names
- Weather data (temp, cloud cover, wind, precipitation) recorded within the hour
- Extent (percent) of each habitat type within the wetland or survey station (e.g., percent open water)
- 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).

The following information was recorded for each waterbird or flock observed 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, wetland 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. ARUs are designed to record acoustic data (e.g., calls and songs of birds) at specified time intervals over a period of days, weeks, or months. ARUs were programmed to record acoustic data between dusk and dawn during the peak vocalization period for rails and American bittern (i.e., from May through July [Conway 2011]).

In 2021, bioacoustics monitoring with ARUs was primarily focused on habitat types in which yellow rail had been recorded most consistently in prior years (sedge-dominated habitats) because this was the only species recorded with ARUs and not by other survey methods in the previous 4 years of monitoring. Consequently, bioacoustic monitoring in 2021 primarily targeted sedge-dominated habitats. ARUs were also deployed in sedge-dominated habitat adjacent to open water, as this habitat type was only surveyed via bioacoustics monitoring at two locations in prior years. As in previous years, ARUs were deployed at multiple locations and most were moved acrouss multiple locations over the course of the survey period (mid-May through mid-August) to increase the number of locations and habitat types surveyed. However, one ARU was left in the same location throughout the entire survey period to provide information regarding temporal variability of detections within locations. The location selected for assessment of temporal variability was one where yellow rail had been detected in previously.

All ARUs were fitted with omnidirectional SMM-A1 microphones recording at a sample rate of 16 kHz and gain of 0 dB. The microphones were installed approximately 2 m above ground and were set up to record acoustic data from 30 minutes before dusk to 30 minutes after dawn. 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 one week (i.e., 7 nights) at each site.

2.3 Habitat Assessment

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

2.3.1 Peace River

Within the Peace River, 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 notes regarding water depth 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 habitat selection and species composition, with dabbling ducks selecting habitat along a depth gradient relevant to their morphology, and piscivorous as well as benthic feeding divers typically preferring deeper water (Baschuk et al. 2012; Colwell and Taft 2000).

Portions of the river classified as Minimal Connectivity habitat were not accessible by boat and therefore were not surveyed in 2020 and 2021. 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**).

A photograph showing an example of the Mainstem river habitat type within the Peace River is presented in **Photo 1**, with a photograph of Moderate Flow and Limited Connectivity river habitat types in **Photo 2**.

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 inundatating most of the river bed. Aquatic vegetation is sparse.
Mainstem	Main channel of the river where water flow rates, depths, and substrate size (e.g., gravel, cobble) are greatest. Permananently inundated with aquatic vegetation sparse or absent.

Photo 1 Example of the Mainstem River Habitat Type.

Photo 2 Example of the Moderate Flow (center/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, 5.98 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. 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.

Table 2 Area of River Habitat Types, as Defined by Flow Volume and Connectivity, 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.

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. 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. 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.

2.3.2 Transmission Line Wetlands

The terrestrial ecosystem mapping (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 and Tamarack-sedge were discontinued as of 2019 due to a lack of observed use by waterbirds (**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	Consistent 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 tamarack-dominated overstorey	No
Sedge (SE)	Uniform sedge (*Carex* sp) flat low area with less than 10% willow – birch. Typically wetted and often with standing water.	Yes
Labrador tea-sedge (BT)	Labrador tea-dominated peat bogs, often with black spruce overstory	No
Willow-sedge (WS)	Sedge (*Carex* sp.) meadow with scattered (>10%) willows/scrub birch. Often bordering sedge habitat in slightly elevated and 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 2021. 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 was 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).

Photographs showing examples of standwatch and transect surveys and habitats surveyed by the respective methods are provided in **Photo 3**, **Photo 4** and **Photo 5**. An example of a waterbird observation within open water habitat is provided in **Photo 6**.

Photo 3 Example of a wetland standwatch survey of open water habitat within station OW-06.

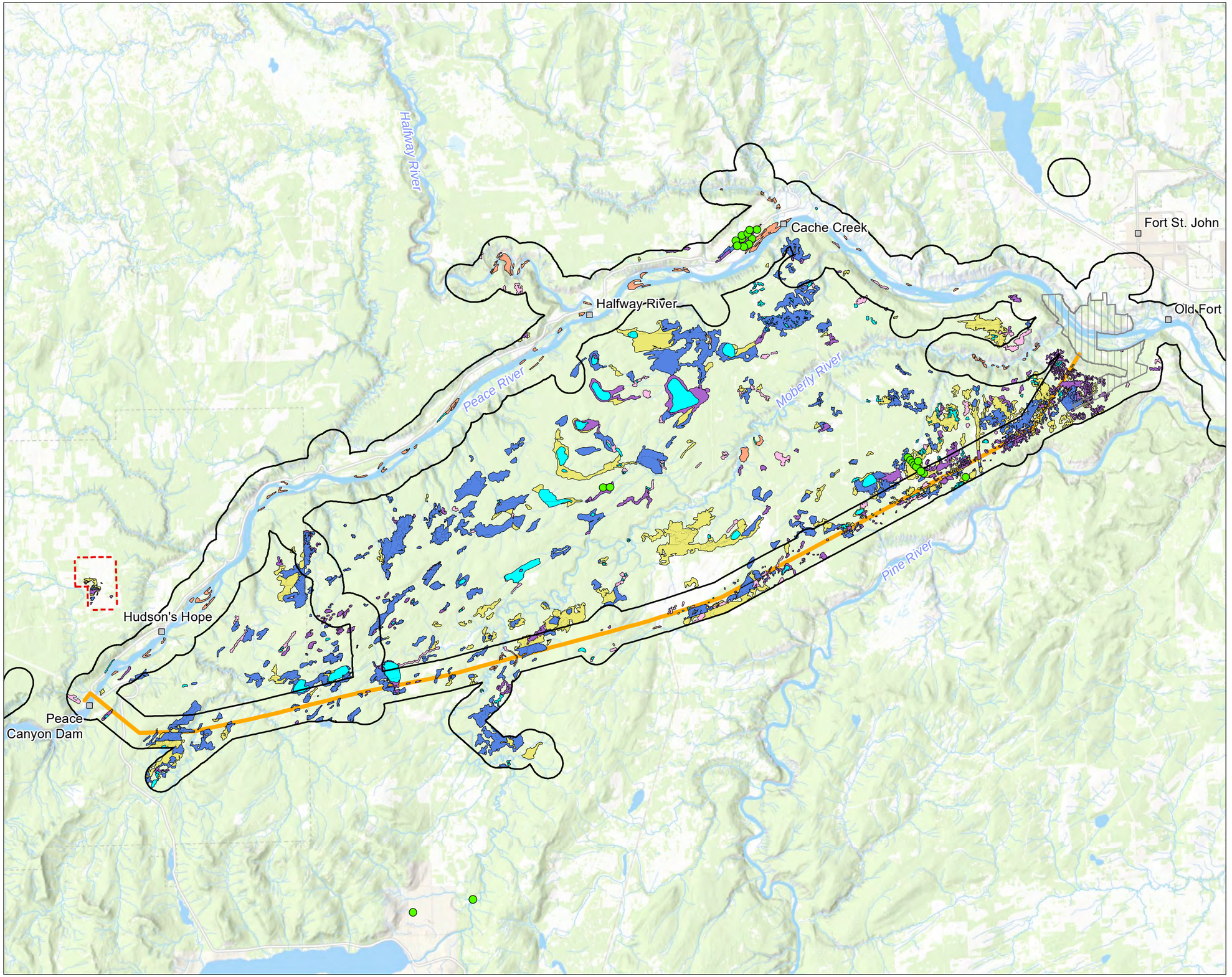
Photo 4 Example of a transect survey of sedge-dominated wetland within station SE-04.

Photo 5 Example of a transect survey within a 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 within station OW-06

Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

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



Legend

- Site C LAA
- 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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Kilometres

NAD 1983 UTM Zone 10N

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3.0 DATA MANAGEMENT AND ANALYSIS

This section details the methods applied for data management (e.g., QA/QC 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 2021 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 (QA) 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.

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. Measures of the proportion of birds not detected were obtained during surveys and are available to provide estimates of absolute abundance in future analyses of Project-related effects following data collection from the operations period. More specifically, 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 to assess the magnitude and significance of Project-related change. Throughout the remainder of this report, the terms abundance and density refer to relative abundance and relative density, as summary statistics are not corrected for detection rate via distance sampling or other means. Relative abundance refers to a measure, or 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 (RIC 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 known and 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. Additionally, a full list of the species observed was developed including the cumulative number of each species recorded across all study years and during 2021 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 (i.e., species richness), p_i is the proportion of all sampled 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 (e.g., 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 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 (e.g., some survey periods were not surveyed in all years), mean measures of density and abundance for each habitat types and treatment areas were calculated each survey period in each year, then averaged across years to provide average measures for each survey round across years, and averaged across survey rounds to provide average measures for each season.

To calculate measures of abundance and density, survey data were initially summarized in terms of the number of birds/ha within polygons of distinct habitat types in each study area. 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) and dividing cumulative counts from all combinations of habitat type and treatment area (**Table 1**) by the area of those factors that was surveyed during each survey round. Abundance data were summarized for each treatment area and habitat type by multiplying these 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. Additionally, 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 comparabale 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. These 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 limited 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. A complete list of the species and numbers of individual waterbirds observed is presented within **Appendix B** of the report.

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 were 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). Summarization of diversity statistics from wetland waterbird surveys was completed 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 standwarch 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 2021). 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.

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 at each monitoring station. 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 deemed necessary at a later date.

4.0 RESULTS

Results for the monitoring program from 2017 through 2021 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 this year's (i.e., 2021) 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 2020 and 2021 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 2021, boat-based surveys were conducted on the Peace River during spring (April 6 to April 13, 2021) and fall (August 11 to October 6, 2021) waterbird migrations. Over the course of these first 5 years of the monitoring program, 45 survey rounds were attempted and a total of 41 surveys of the full length of the Peace River study area were completed (**Table 5**). Details are provided below regarding issues preventing completion of the other 4 surveys and a required third day for completion of 2 survey rounds.

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
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
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
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
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
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
Late-Middle (Sep 15 to Oct 14)	Sep 21, 22 Sep 27, 28	Sep 20, 21 Oct 4, 05	Sep 16, 17 Sep 30, Oct 1	Sep 29, Sep 30	Sep 27, 28
Late (Oct 15 to Oct 30)	No surveys	Oct 15, 16	Oct 16, 17	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 (2) days were typically required to complete surveys; however, 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) occasionally required a third day for surveys. [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 2021 were completed successfully within two days each.

4.1.2 Habitat Assessment

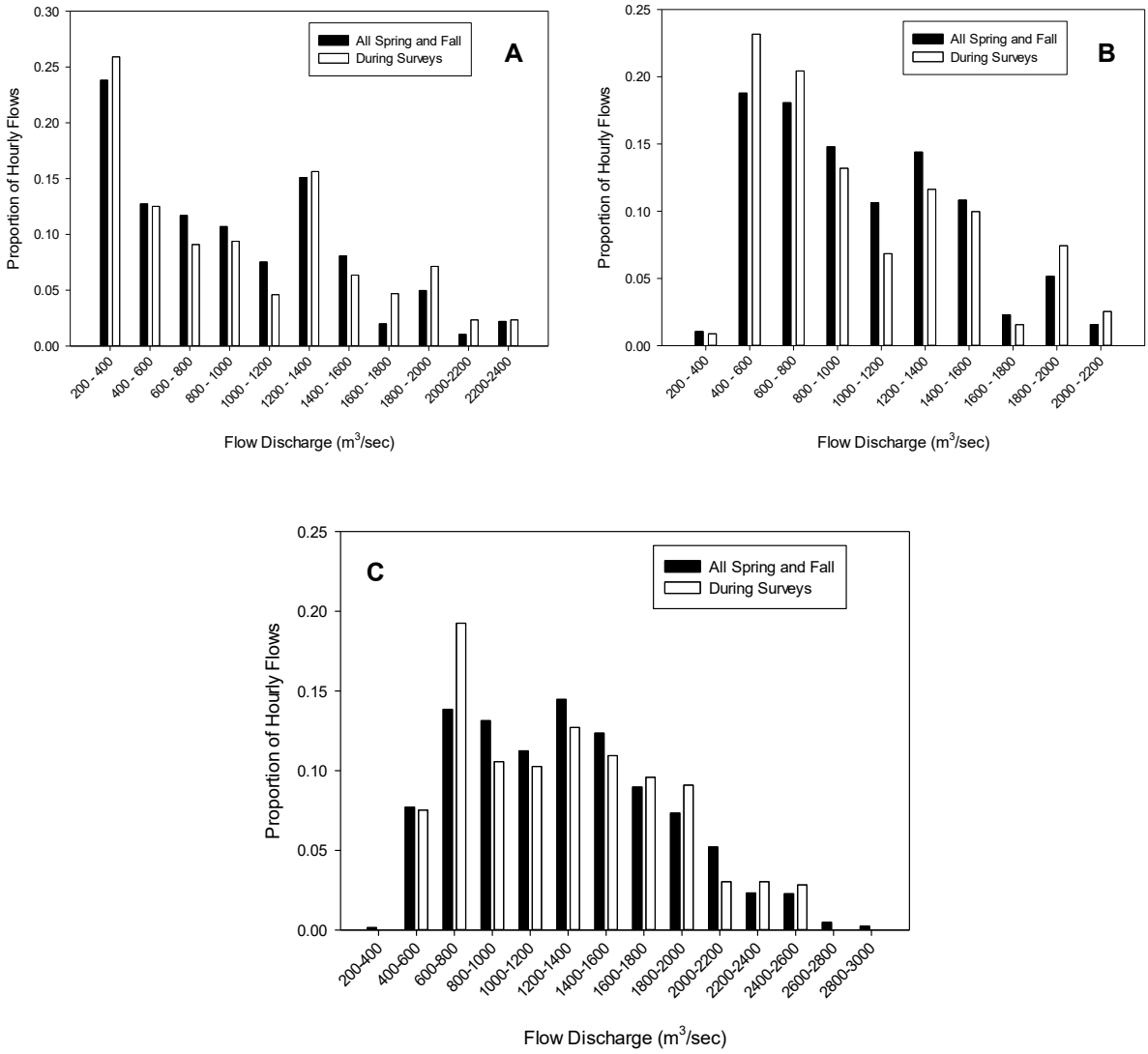
Locations with active hydrological monitoring gauges from which water flow data were obtained were as follows: Inundation Impact area - Hudson's Hope (2017, 2018)[1] and Peace Canyon Dam (2019, 2020, 2021); Flow Impact area - Old Fort (all years); Control area – Taylor (all years). The hydrological gauges 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 2021 are summarized across years, seasons, and treatment areas in **Table 6** and frequency distributions illustrating 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 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. Frequency distribution plots of flow rate data illustrated in **Figure 6** provide evidence that, across the 5 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 2021 flow rates during surveys relative to throughout spring and fall migration in **Appendix F**.

[1] The Hudsons' Hope gauge was discontinued in 2019 to facilitate the placement of rip-rap for Site C reservoir shoreline erosion protection. Thus, in 2019, 2020, and 2021, flow data for the Inundation Impact area was 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 2021

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**
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**

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 2019, 2020, and 2021. Data for the Flow Impact and Control area were collected from Old Fort and Taylor (downstream of the Pine River confluence), respectively. Data includes hourly flow rates during the day (0600 to 1800 hours) from the dates when Peace River waterbird surveys were conducted (**see Table 5**).



Note: Flow discharge data in the Inundation Area were collected from Hudson's Hope in 2017 and 2018 and from Peace Canyon Dam in 2019, 2020, and 2021, during April 1 to May 31 (spring migration) and August 1 to October 31 (fall migration). Data for the Flow Impact and Control area were collected from Old Fort and Taylor (downstream of the Pine River confluence), respectively, during the same dates.

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 relative to across spring and fall migrations in 2017 through 2021.

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 2021 (see waterbird location figures in **Appendix C: Figures C-1 to C-4**). There were a total of 76,197 individual waterbirds observed during Peace River boat surveys in 2017 through 2021 of which 93% were identified to species (**Appendix B-1**). In 2021, a total of 13,086 waterbirds were observed during Peace River boat surveys, of which 88% were identified to species (**Appendix B-2**).

Across all survey years, 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 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 adundant guilds (**Table 7**). Estimates of foraging guild abundances specific to survey periods in 2021 are presented in **Table 8**, and estimates of interannual variability are presented in **Appendix E** (**Table E-7**).

Table 7 Mean Abundance Estimates (birds/survey round) of Waterbird Foraging Guilds within the Peace River During Spring and Fall of 2017 Through 2021

Foraging Guild	Spring Survey Periods			Fall Survey Periods				Average of Survey Period Means
	Early	Middle	Late	Early	Early-Middle	Late-Middle	Late	
Benthic Feeding Divers	169	168	23	2	21	14	5	**57**
Dabbling Ducks	1,006	661	489	102	308	345	51	**423**
Gulls	2	69	32	776	697	314	102	**284**
Large Dabblers	2,280	502	538	233	455	738	623	**767**
Piscivorous Divers	311	95	51	44	33	21	12	**81**
Shorebirds	1	6	115	216	130	4	0	**67**
Unknown Waterbirds	92	128	59	18	7	20	13	**48**
Total (All Waterbirds)	**3,861**	**1,629**	**1,308**	**1,391**	**1,652**	**1,455**	**805**	

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.

Table 8 Mean Abundance Estimates (birds/survey round) of Waterbird Foraging Guilds within the Peace River During Spring and Fall of 2021

Foraging Guild	Spring Survey Periods			Fall Survey Periods				Average of Survey Period Means
	Early	Middle	Late	Early	Early-Middle	Late-Middle	Late	
Benthic Feeding Divers	152	-	-	2	1	6	-	**40**
Dabbling Ducks	2,422	-	-	64	689	31	-	**801**
Gulls	1	-	-	334	206	35	-	**144**
Large Dabblers	2,213	-	-	338	1,085	808	-	**1,111**
Piscivorous Divers	324	-	-	16	36	23	-	**100**
Shorebirds	0	-	-	224	206	3	-	**108**
Unknown Waterbirds	28	-	-	16	1	1	-	**11**
Total (All Waterbirds)	**5,139**	**-**	**-**	**993**	**2,224**	**907**	**-**	

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

Totals of mean densities of waterbird foraging guilds determined for 2017 through 2021 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 more than 10 times higher within Limited Connectivity habitat than in Mainstem habitat and approximately 4 times higher within Limited Connectivity habitat than in Moderate Flow habitat (**Table 9**, **Figure 7**, **Figure 8**, **Figure 9**). During fall, total waterbird densities across survey years were again greatest within Limited Connectivity habitat (**Table 11**). Mean densities 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 2021 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 2021 Spring Densities (birds/km^2/survey round) and Estimated Abundances of Migrant Waterbirds by River Habitat Type and Treatment Area During

Foraging Guild	Density by River Habitat Type			Density by Treatment Area		
	Limited Connectivity	Moderate Flow	Mainstem	Inundation Impact	Flow Impact	Control
Benthic Feeding Divers	17.6	3.0	1.5	2.7	6.2	1.7
Dabbling Ducks	108.6	29.6	8.8	9.1	36.2	23.0
Gulls	0.0	<0.1	0.5	0.3	1.7	0.1
Large Dabblers	210.9	47.6	17.5	32.1	19.9	38.3
Piscivorous Divers	17.9	7.3	2.8	7.0	2.5	1.5
Shorebirds	3.4	1.1	0.2	0.6	0.6	0.4
Unknown Waterbirds	6.1	2.1	1.0	1.8	1.0	1.1
Total (All Waterbirds)	**364.7**	**90.8**	**32.2**	**53.5**	**68.1**	**66.2**
Estimated Abundance	**1,187**	**679**	**1,400**	**1,417**	**407**	**1,441**

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/km^2/survey) within each habitat type across survey rounds first within periods 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. Total mean density is the sum of all foraging guild and unknown waterbird densities. Abundances calculated as density multiplied by area.

Table 10 Mean 2021 Spring Densities (birds/km^2/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	18.1	4.0	1.5	2.1	8.2	2.2
Dabbling Ducks	255.0	86.3	21.8	14.0	103.4	65.8
Gulls	0.0	0.0	<0.1	<0.1	0.0	0.0
Large Dabblers	245.6	71.2	20.3	47.7	24.2	36.9
Piscivorous Divers	20.7	12.9	3.7	9.9	1.3	2.5
Shorebirds	0.0	0.0	0.0	0.0	0.0	0.0
Unknown Waterbirds	0.0	0.5	0.6	0.8	0.0	0.3
Total (All Waterbirds)	**539.5**	**175.0**	**47.7**	**74.5**	**137.1**	**107.8**
Estimated Abundance	**1,756**	**1,307**	**2,077**	**1,972**	**820**	**2,347**

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/km^2/survey) within each habitat type across survey rounds first within periods 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. 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 2021 Fall Densities (birds/km^2/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	0.3	0.1
Dabbling Ducks	38.6	6.5	1.0	5.0	10.4	1.1
Gulls	2.3	0.9	11.8	8.3	50.9	0.2
Large Dabblers	51.9	9.4	5.4	7.6	12.1	9.1
Piscivorous Divers	3.1	0.8	0.3	0.7	0.3	0.4
Shorebirds	8.6	3.7	1.0	1.7	0.9	2.2
Unknown Waterbirds	3.0	0.2	0.1	0.3	0.7	<0.1
Total (All Waterbirds)	**107.9**	**21.5**	**19.8**	**23.9**	**75.5**	**13.1**
Estimated Abundance	**351**	**160**	**860**	**634**	**452**	**285**

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/km^2/survey) within each habitat type across survey rounds first within periods 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. Total mean density is the sum of all foraging guilds and unknown waterbird densities. Abundances calculated as density multiplied by area.

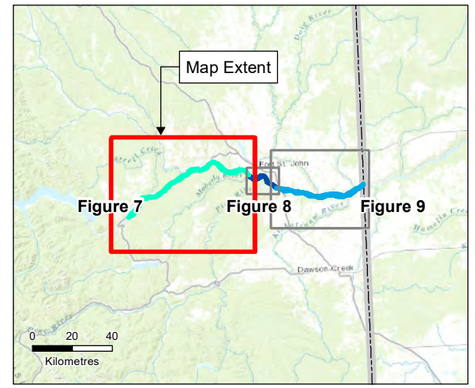
Table 12 Mean 2021 Fall Densities (birds/km^2/survey round) of Migrant Waterbirds by River Habitat Type and Treatment Area

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	0.1	0.1	0.0	0.0
Dabbling Ducks	5.6	30.6	0.3	9.4	1.3	0.2
Gulls	0.4	1.3	4.1	6.5	2.6	0.2
Large Dabblers	78.2	21.3	7.6	13.2	14.1	14.2
Piscivorous Divers	0.5	0.6	0.4	0.7	0.4	0.2
Shorebirds	12.2	6.2	1.3	3.3	1.0	2.3
Unknown Waterbirds	1.3	0.2	<0.1	0.2	0.2	<0.1
Total (All Waterbirds)	**98.3**	**60.2**	**13.9**	**33.4**	**19.6**	**17.1**
Estimated Abundance	**320**	**450**	**605**	**886**	**117**	**372**

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/km^2/survey) within each habitat type across survey rounds first within periods 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. 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
2021 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 2021



Legend

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

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

- 0.09 - 0.63
- 0.64 - 0.79
- 0.80 - 2.33
- 2.34 - 7.96

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

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989619-07	Production Date: Jan 14, 2022	Figure 7

Hemmera An Ausenco Company

BC hydro

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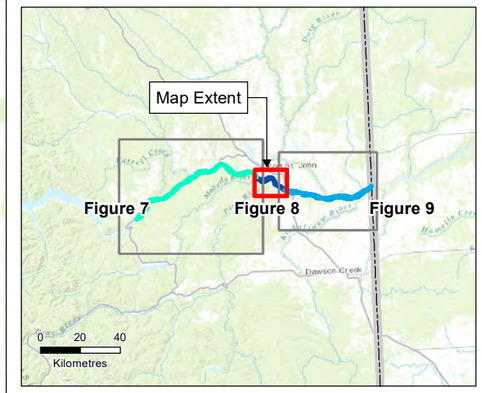
Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

Fig. 8 - Mean Density (birds/km^2/survey round) of Spring Migrant Waterbirds within Flow Regime Impact Area Habitat Polygons from 2017 through 2021



Old Fort

Peace River

Taylor

Pine River

Legend

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

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

- 0.09 - 0.63
- 0.64 - 0.79
- 0.80 - 2.33
- 2.34 - 7.96

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: Jan 14, 2022	Figure 8

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BC hydro

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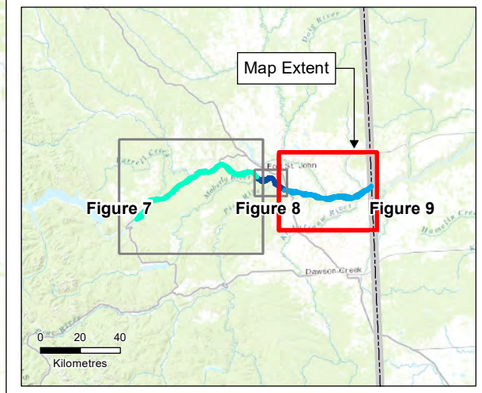
Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

Fig. 9 - Mean Density (birds/km^2/survey round) of Spring Migrant Waterbirds within Control Area Habitat Polygons from 2017 through 2021



Legend

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

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

- 0.09 - 0.63
- 0.64 - 0.79
- 0.80 - 2.33
- 2.34 - 7.96

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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Page Size: 11" x 17"

989619-07	Production Date: Jan 14, 2022	Figure 9

Hemmera An Ausenco Company

BC hydro

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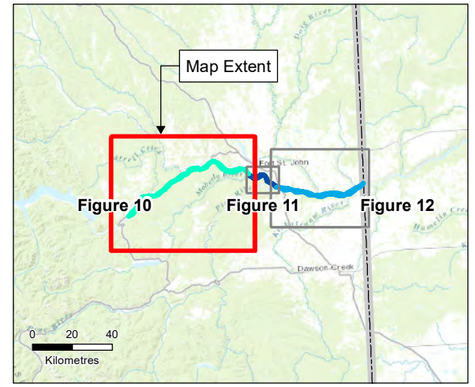
Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

Fig. 10 - Mean Density (birds/km^2/survey round) of Fall Migrant Waterbirds within Inundation Impact Area Habitat Polygons from 2017 through 2021



Halfway River
Charlie Lake
Cache Creek
Halfway River
Peace River
Moberly River
Pine River
Hudson's Hope
Peace Canyon Dam

Legend

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

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

- 0.08 - 0.14
- 0.15 - 0.23
- 0.24 - 1.10
- 1.11 - 3.13

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: Jan 14, 2022	Figure 10

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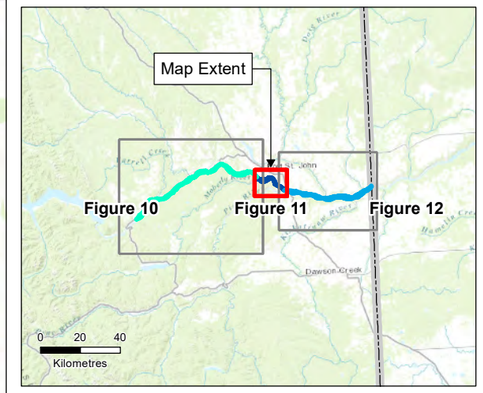
Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

Fig. 11 - Mean Density (birds/km^2/survey round) of Fall Migrant Waterbirds within Flow Regime Impact Area Habitat Polygons from 2017 through 2021



Old Fort

Peace River

Taylor

Pine River

Legend

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

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

- 0.08 - 0.14
- 0.15 - 0.23
- 0.24 - 1.10
- 1.11 - 3.13

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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Metres

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Page Size: 11" x 17"

989619-07	Production Date: Jan 14, 2022	Figure 11

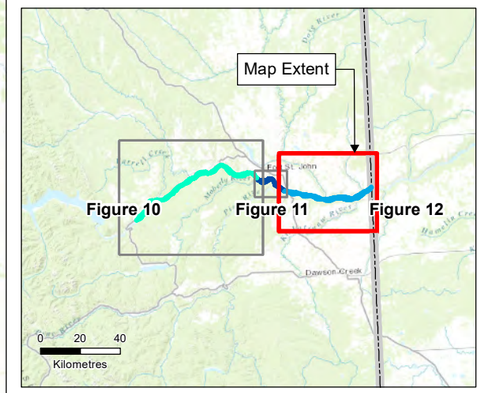
Hemmera An Ausenco Company

BC hydro

Path: S:\Geomatics\Projects\989619\07_waterfowl\mcd\MonitoringProgram\2021\Fig11_989619_07_WaterBirds_FallDensity_FlowRegimeChangeImpactArea_220114.mxd

Migratory Waterbird Follow-up Monitoring Program
2021 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 2021



Legend

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

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

- 0.08 - 0.14
- 0.15 - 0.23
- 0.24 - 1.10
- 1.11 - 3.13

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: Jan 14, 2022	Figure 12

Hemmera An Ausenco Company

BC hydro

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4.1.4 Diversity

A total of 64 waterbird species were detected across boat surveys of the Peace River conducted annually from 2017 through 2021 (**Appendix B-1**), including 36 species from 2021 surveys (**Appendix B-2**). Dabbling ducks (15 species) were the most species rich foraging guild observed, followed by piscivorous divers (14 species) and shorebirds (10 species) over the 5 years of monitoring that has been conducted (**Appendix B-1**). Mean annual species richness within Mainstem and Moderate Flow river habitats ranged from less than 1 to 7 species across foraging guilds and survey periods (**Table 13**). During spring, average species richness was generally higher for dabbling ducks than for other foraging guilds, particularly in the middle and late spring, and lowest for shorebirds (**Table 13**). During fall, the most species rich foraging guild was gulls, particularly in early fall, while species richness was lowest for benthic feeding divers. In 2017 through 2021, mean species evenness ranged from values of 0.4 to 0.6 across survey periods (**Table 13**). Survey results specific to 2021 are presented in **Table 14**. Variability in diversity metrics across years are presented in **Appendix E** (**Table E-13**).

Table 13 Mean 2017 Through 2021 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	Late		Early	Early-Middle	Late-Middle	Late	
Benthic Feeding Divers	2.3	2.8	3.7	**2.8**	0.6	0.5	1.0	0.0	**0.7**
Dabbling Ducks	4.8	6.3	7.0	**5.7**	2.3	3.3	2.4	1.5	**2.5**
Gulls	0.4	1.8	3.3	**1.4**	4.5	3.6	3.1	3.5	**3.7**
Large Dabblers	2.2	2.0	1.3	**1.9**	1.1	1.6	1.7	2.0	**1.5**
Piscivorous Divers	1.6	2.5	3.5	**2.3**	1.9	2.7	3.0	1.5	**2.4**
Shorebirds	0.6	0.5	1.2	**0.6**	2.6	1.2	1.0	0.0	**1.4**
Total Species Richness	**11.9**	**16.0**	**20.0**	**14.8**	**13.0**	**12.9**	**12.2**	**8.5**	**12.2**
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.

Table 14 Mean 2021 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	Late		Early	Early-Middle	Late-Middle	Late	
Benthic Feeding Divers	3.0	-	-	**3.0**	1.0	1.0	1.0	-	**1.0**
Dabbling Ducks	5.5	-	-	**5.5**	3.0	6.0	2.0	-	**3.7**
Gulls	0.5	-	-	**0.5**	6.0	5.0	3.0	-	**4.7**
Large Dabblers	2.0	-	-	**2.0**	1.0	1.0	1.0	-	**1.0**
Piscivorous Divers	2.0	-	-	**2.0**	2.0	4.0	5.0	-	**3.7**
Shorebirds	0.0	-	-	**0.0**	2.0	1.0	1.0	-	**1.3**
Total Species Richness	**13.0**	**-**	**-**	**13.0**	**15.0**	**18.0**	**13.0**	**-**	**15.3**
Species Evenness	**0.5**	**-**	**-**	**0.5**	**0.7**	**0.6**	**0.2**	**-**	**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. Dashes reflect no data collected during some survey periods as recommended by power analyses (**Appendix A**).

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 2021:

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

[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 less per species in total across years), with the exception of surf scoter (206 individuals), California gull (35 individuals), and red-necked phalarope (11) (**Appendix B-1**). Three at risk species were observed during 2021 surveys (**Appendix B-2**):

- Double-crested cormorant (not observed during previous study years)
- California gull
- Surf scoter.

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 this year's (i.e., 2021) surveys.

4.2.1 Survey Effort and Timing

In 2021, transect and standwatch surveys were conducted on the Moberly Plateau and adjacent to the Site C transmission line ROW during spring (May 3 to May 16, 2021) and fall (August 11 to October 6, 2021) waterbird migration periods (**Table 15**). Surveys in 2021 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 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 2021 was conducted from May 14 through August 19, 2021 (**Table 22**).

Table 15 Wetland 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
Spring					
Early (Apr 1 to Apr 14)	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
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
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
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
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
Late (Oct 15 to Oct 30)	No surveys	Oct 17, 18, 19	Oct 18, 19	No surveys	No surveys

4.2.1.1 Transect and Standwatch Surveys

In 2021, waterbird surveys were conducted within 22 wetland stations (**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 22 stations, 15 areas of open water habitat were surveyed by standwatch methods, 11 areas with willow-sedge habitat were surveyed by transect methods, and 12 areas with sedge habitat were also surveyed by transect methods. Standwatch surveys were conducted at 4 open water wetlands clear of vegetation (i.e., lakes), which provided unobstructed lines of sight, and 12 areas of open water interspersed with emergent or flooded vegetation. Photos of stations showing aerial views or representative habitat are provided in **Appendix D**.

Table 16 Survey Methods and Wetland Habitat Types Survey within Wetland Stations

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, 2021	2017, 2018, 2019, 2020, 2021
OW-02	-	-	2017, 2018, 2019, 2020, 2021
OW-04	-	-	2017, 2018, 2019, 2020, 2021
OW-06	2020	2020, 2021	2017, 2018, 2019, 2020, 2021
OW-07	-	-	2020, 2021
OW-09	-	-	2017, 2018, 2019, 2020, 2021
OW-10	-	-	2017, 2018, 2019, 2020, 2021
OW-11	-	-	2017, 2018, 2019, 2020, 2021
SE-01[3]	-	2018, 2019	-
SE-02	2021	2018, 2019, 2020, 2021	2020, 2021
SE-03	2021	2018, 2019, 2020, 2021	2020, 2021
SE-04	2018, 2019, 2020, 2021	2018, 2019, 2020, 2021	2020
SE-05	2017, 2019, 2020, 2021	2018, 2019, 2020, 2021	-
SE-06	2017, 2019, 2020	2018, 2019	2020, 2021
SE-07	-	2018, 2019, 2020, 2021	2020, 2021
SE-09	2020	2018, 2019, 2020, 2021	2020, 2021
SE-10	2017, 2019	2018, 2019, 2020, 2021	-
SE-11	2020, 2021	2018, 2019, 2020, 2021	-
SE-12	-	2018, 2019	2020, 2021
SE-14	-	2018, 2019, 2020, 2021	2020, 2021
WS-01	2019	2018, 2019, 2020, 2021	-
WS-02	-	2018, 2019, 2020, 2021	-
WS-03	2021	2018, 2019, 2020, 2021	-

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. Stations only surveyed in 2020 were surveyed using remotely piloted aircraft systems in 2018 and 2019
3. Discontinued after 2019. Replaced with more easily accessed habitat adjacent to OW-01

Within the wetland survey stations listed above, a total of 243 standwatch surveys of open water and 508 transect surveys of sedge and willow-sedge habitat were conducted under appropriate survey conditions during the spring and fall of 2017 through 2021 (**Table 17**). Of the total 751 surveys conducted across all years, 278 and 473 surveys were conducted during spring and fall, respectively, and 138 were conducted during 2021.

Table 17 Number of Unique Wetland Surveys for Migrating Waterbirds Conducted by Standwatch and Transect Methods by Survey Period During 2017 Through 2021

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	-	6	14	8	10	8	0	46
Total		**-**	**39**	**61**	**37**	**50**	**47**	**9**	**243**
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
Total		**-**	**76**	**102**	**83**	**108**	**112**	**27**	**508**
Grand Total		**-**	**115**	**163**	**120**	**158**	**159**	**36**	**751**

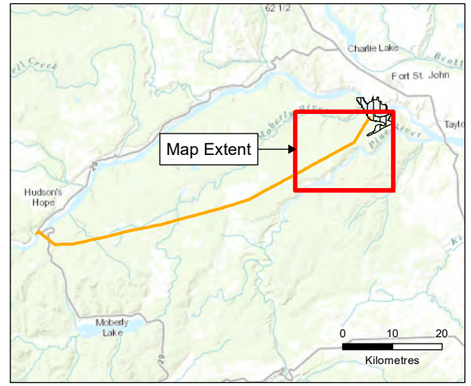
Note: Multiple transects conducted within the same habitat type counted as a single unique survey. Dashes indicate no surveys conducted during some years and survey periods. [1]No surveys were conducted during early spring and few surveys were conducted during late fall due to snow and ice cover of wetlands 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 2021 was conducted with ARU deployments at 12 wetland survey stations and 6 other locations (**Figure 13**) over a cumulative total of 547 nights including 257 nights from 7 locations in 2021 (**Table 22**). ARU surveys were conducted at 7 stations in 2021; at 3 stations where marsh bird surveys using ARUs were conducted in previous years and at 4 stations not surveyed previously.

Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

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



Legend

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

ARU Deployment Year

- 2017
- 2018
- 2019
- 2020
- 2021

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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Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-07	Production Date: Jan 14, 2022	Figure 13

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BC hydro

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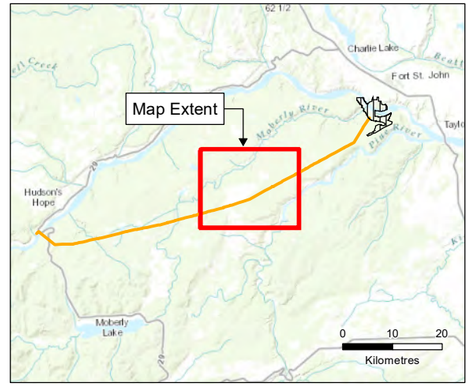
Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

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



Legend

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

ARU Deployment Year

- 2020
- 2021

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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Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-07	Production Date: Jan 14, 2022	Figure 14

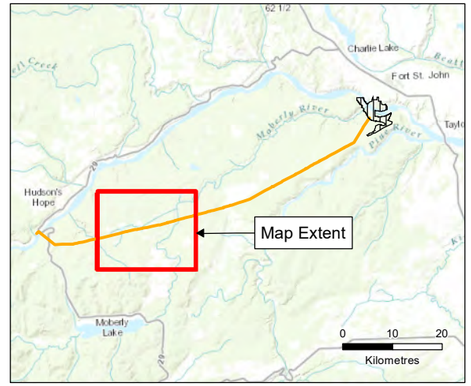
Hemmera An Ausenco Company

BC hydro

Path: S:\Generation\Projects\989619\07_waterfowl\mxd\MonitoringProgram\2021\Fig14_989619_07_WaterbirdLWetland_Survey_Stations_Central_220114.mxd

Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

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



Moberly River

SE01
OW01
ARU-23
SE02
ARU-26

Legend

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

ARU Deployment Year

- 2021

Positive Detections of Targeted Species

- SORA

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

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Page Size: 11" x 17"

989619-07	Production Date: Jan 14, 2022	Figure 15

Hemmera An Ausenco Company

BC hydro

Path: S:\Geomatics\Projects\989619\07_waterfowl\mxd\MonitoringProgram2021\Fig15_989619_07_WaterfowlMonitoringProgram_Wetland_Survey_Stations_West_220114.mxd

4.2.2 Abundance and Density

Summaries of waterbird obervations are presented below for habitat types surveyed by transect and standwatch methods. For the purposes of annual reporting, waterbird observation data are summarized primarily in terms of density by area of open water for standwatch surveys of open water habitat including permanent water features (e.g., lakes), as well as inundated sedge and willow-sedge habitats (**Table 18**, **Table 19**), and as mean density per 1 km 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

Standwatch surveys detected 8,184 waterbirds from 2017 through 2021 (**Appendix B-1**), including 1,821 individuals in 2021, of which 97% 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 2021 are presented in **Table 19**, and estimates of interannual variability are presented in **Appendix E** (**Table E-18**).

Table 18 Mean 2017 Through 2021 Waterbird Densities (birds/km^2/survey) within Open Water Habitat Reported by Foraging Guild from Standwatch Surveys

Foraging Guild	Spring		Fall			
	Middle	Late	Early	Early-Middle	Late-Middle	Late
Benthic Feeding Divers	143.0	131.3	227.6	181.0	151.8	41.2
Dabbling Ducks	530.5	596.5	694.8	631.6	489.0	96.2
Gulls	1.9	6.0	1.3	0.0	0.0	0.0
Large Dabblers	67.5	55.3	16.0	23.8	7.0	0.8
Marsh Birds	1.1	28.2	1.4	14.9	0.0	0.0
Piscivorous Divers	4.1	21.8	28.5	42.5	24.9	23.8
Shorebirds	19.5	91.1	107.4	12.4	0.0	0.0
Unknown Waterbirds	0.1	18.6	26.2	5.2	41.7	26.3
Total (All Waterbirds)	**767.7**	**949.1**	**1,103.1**	**911.3**	**714.4**	**188.4**

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.

Table 19 Mean 2021 Waterbird Densities (birds/km^2/survey) within Open Water Habitat Reported by Foraging Guild from Standwatch Surveys

Foraging Guild	Spring		Fall			
	Middle	Late	Early	Early-Middle	Late-Middle	Late
Benthic Feeding Divers	25.0	138.3	104.3	51.5	49.2	-
Dabbling Ducks	104.1	1,042.7	761.2	1,135.5	1,114.9	-
Gulls	0.0	6.2	4.4	0.0	0.0	-
Large Dabblers	0.0	79.2	55.5	35.5	68.4	-
Marsh Birds	0.0	7.0	4.9	0.0	1.4	-
Piscivorous Divers	0.0	33.5	23.5	52.5	123.0	-
Shorebirds	15.3	110.2	81.7	0.4	6.4	-
Unknown Waterbirds	0.0	0.0	0.0	15.4	0.0	-
Total (All Waterbirds)	**144.4**	**1,417.3**	**1,035.4**	**1,290.9**	**1,363.4**	**-**

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. Dashes indicate no surveys conducted during some survey periods.

Transect surveys of vegetated wetlands with low water levels detected 347 waterbirds within sedge and willow-sedge habitat across 2018 through 2021 (**Appendix B-1**)**,** including 44 individuals during surveys conducted in 2021 (**Appendix B-2**). Due to the close proximity of observations, 100% of waterbird individuals were identified to species in 2021. Mean densities observed within vegetated habitats were highest during late spring, with dabbling ducks the most densely occurring forgaging guild across seasons and survey periods (**Table 20**). 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 or 2021. 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 as foraging habitat. Estimates of foraging guild densities within open water habitats specific to survey periods in 2021 are presented in **Table 21**, and estimates of interannual variability are presented in **Appendix E** (**Table E-20**)**.**

Table 20 Mean 2018 through 2021 Waterbird Densities (birds/km/survey) 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
Benthic Feeding Divers	0.00	0.00	0.00	0.00	0.00	0.00
Dabbling Ducks	1.72	5.32	0.09	0.73	1.71	0.00
Gulls	0.00	0.00	0.00	0.00	0.00	0.00
Large Dabblers	0.33	0.10	0.00	0.00	0.00	0.00
Marsh Birds	0.74	3.09	1.32	1.49	0.26	0.00
Piscivorous Divers	0.00	0.11	0.00	0.00	0.00	0.00
Shorebirds	0.68	1.56	0.00	0.00	0.00	0.00
Unknown Waterbirds	0.00	0.00	0.00	0.00	0.00	0.00
Total (All Waterbirds)	**3.48**	**10.18**	**1.41**	**2.22**	**1.97**	**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.

Table 21 Mean 2021 Waterbird Densities (birds/km/survey) 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
Benthic Feeding Divers	0.00	0.00	0.00	0.00	0.00	-
Dabbling Ducks	0.23	0.50	0.00	0.09	0.68	-
Gulls	0.00	0.00	0.00	0.00	0.00	-
Large Dabblers	0.05	0.00	0.00	0.00	0.00	-
Marsh Birds	0.05	0.10	0.06	0.13	0.13	-
Piscivorous Divers	0.00	0.00	0.00	0.00	0.00	-
Shorebirds	0.05	0.00	0.00	0.00	0.00	-
Unknown Waterbirds	0.00	0.00	0.00	0.00	0.00	-
Total (All Waterbirds)	**0.36**	**0.60**	**0.13**	**0.22**	**0.74**	**-**

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. Dashes indicate no surveys conducted during some survey periods.

4.2.2.2 Bioacoustics Monitoring

Sora were detected at all locations monitored in 2017 through 2021 and no American bittern vocalizations were recorded at any location. Yellow rail was detected at 12 of 29 bioacoustics monitoring locations across years, and at 4 of 7 locations in 2021 (**Table 22**). Analysis of bioacoustics data for Virginia rail identified the species at 3 of 13 locations where ARUs were deployed across years (2020 and 2021) including at 1 of 7 locations in 2021 (**Table 22**). All species, when detected, were detected within the first 2 nights of ARU deployments and confirmed on subsequent nights.

Table 22 Bioacoustics Monitoring Locations, Habitat Description, Survey Effort, and Confirmed Detections of Target Species

ARU Survey ID	Latitude	Longitude	Habitat type	Wetland Survey Station	Dates of Acoustic Monitoring	Number of nights	SORA	YERA	AMBI	VIRA[3]
ARU-01	56.104658	-121.044231	Sedge and willow-sedge	SE-05[2]	May 16 to May 28, 2017	13	Yes	No	No	N/A
ARU-02	56.115311	-121.090337	Sedge and upland forested	N/A	May 16 to May 28, 2017	13	Yes	No	No	N/A
ARU-03	56.126825	-120.985543	Sedge and edge of open water	SE-10	May 28 to Jun 12, 2017	16	Yes	No	No	N/A
ARU-04	56.139182	-120.898154	Sedge and upland forested	SE-06	May 28 to Jun 12, 2017	16	Yes	No	No	N/A
ARU-05	56.134144	-120.941172	Sedge	N/A	Jun 12 to Jun 27, 2017	16	Yes	No	No	N/A
ARU-06	56.136775	-120.923437	Sedge	N/A	Jun 12 to Jun 24, 2017	13	Yes	No	No	N/A
ARU-07	56.113610	-121.094496	Sedge	SE-04	Jul 4 to Jul 23, 2018	20	Yes	Yes	No	N/A
ARU-08	56.126888	-120.986697	Sedge, willow-sedge, upland forested	SE-06	May 17 to May 24, 2019	8	Yes	Yes	No	N/A
ARU-09	56.139104	-120.897989	Open water, upland forested	SE-10	May 17 to May 24, 2019	8	Yes	No	No	N/A
ARU-10	56.114216	-121.08986	Open water, sedge, upland forested	SE-04[2]	May 17 to May 24, 2019	8	Yes	No	No	N/A
ARU-11	56.116424	-121.096006	Sedge, willow-sedge, upland forested	SE-04	May 24 to Jun 14, 2019	22	Yes	Yes	No	N/A
ARU-12	56.105986	-121.042059	Sedge, willow-sedge, upland forested	WS-01	May 24 to Jun 14, 2019	22	Yes	No	No	N/A
ARU-13	56.104382	-121.042940	Sedge, willow-sedge, upland forested	SE-05[2]	May 24 to Jun 14, 2019	22	Yes	Yes	No	N/A
ARU-14	56.154077	-120.866156	Sedge, willow-sedge, upland forested	N/A	Jul 22 to Aug 1, 2019	11	Yes	No	No	N/A
ARU-15	56.152748	-120.872644	Sedge	N/A	Jul 22 to Aug 1, 2019	11	Yes	No	No	N/A
ARU-16	56.148765	-120.880178	Sedge	N/A	Jul 22 to Aug 1, 2019	11	Yes	No	No	N/A
ARU-17	56.11519	-121.09466	Sedge, willow-sedge, upland forested	SE-04	May 6 to May 15, 2020	10	Yes	Yes	No	Yes

ARU Survey ID	Latitude	Longitude	Habitat type	Wetland Survey Station	Dates of Acoustic Monitoring	Number of nights	SORA	YERA	AMBI	VIRA[3]
ARU-18	56.10309	-121.04630	Sedge, upland forested, willow-sedge, open water	SE-05	May 6 to May 16, 2020	11	Yes	Yes	No	No
ARU-19	56.11307	-121.10017	Sedge and willow-sedge	SE-11	May 26 to June 5, 2020	10	Yes	Yes	No	No
ARU-20	56.14001	-120.89719	Sedge, upland forested, open water	SE-06	May 26 to June 4, 2020	9	Yes	No	No	No
ARU-21	56.01027	-121.42445	Sedge, upland forested, open water, willow-sedge	SE-09	June 16 to June 26, 2020	10	Yes	Yes	No	Yes
ARU-22	56.08691	-121.16201	Sedge, upland forested, willow-sedge, open water	OW-06	June 16 to June 26, 2020	10	Yes	No	No	No
ARU-23	55.99180	-121.66468	Open water, sedge, willow sedge	OW-01	May 16 to June 13, 2021	29	Yes	No	No	No
ARU-24	56.11592	-121.09529	Sedge, willow-sedge, upland forested	SE-04	May 14 to May 25, 2021	12	Yes	Yes	No	Yes
ARU-25a	56.10403	-121.04410	Sedge, upland forested, willow-sedge, open water	SE-05	May 14 to Jun 21, 2021	38	Yes	No	No	No
ARU-25b	56.10403	-121.04410	Sedge, upland forested, willow-sedge, open water	SE-05	Jun 24 to July 16 Aug 19, 2021	25	Yes	No	No	No
ARU-25c	56.10403	-121.04410	Sedge, upland forested, willow-sedge, open water	SE-05	July 16 to Aug 19, 2021	36	Yes	No	No	No
ARU-26	55.98771	-121.65892	Sedge, willow sedge, open water, upland forested	SE-02	Jun 21 to Jul 16, 2021	36	Yes	No	No	No
ARU-27	56.11402	-121.09871	Sedge, willow sedge	SE-11	Jun 21 to Jul 14, 2021	24	Yes	Yes	No	No
ARU-28	56.04991	-121.24299	Willow sedge, sedge, upland forested	WS-03	Jul 16 to Aug 13, 2021	29	Yes	Yes	No	No
ARU-29	56.05278	-121.24065	Open water, sedge, upland forested	SE-03	Jul 16 to Aug 13, 2021	29	Yes	Yes	No	No
					Totals	**547**	**29/29**	**12/29**	**0/29**	**3/13**

Notes:

1. Days ARU recorded acoustic data.
2. Adjacent to wetland station.
3. ARU data only reviewed for VIRA in 2020 and 2021 as the study area was considered outside of the species' range in prior years.

4.2.3 Diversity

Standwatch surveys detected 44 waterbird species during the spring and fall of 2017 through 2021 (**Table 23**), including 31 species in 2021 (**Appendix B-2**). Transect surveys detected 19 species during 2018, 2019, 2020, and 2021 (**Table 23**), 9 of which were observed in 2021 (**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 2021 (**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 2021		Standwatch Surveys 2017 to 2021	
	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	0.30
Gulls	0	0.00	4	0.09
Large Dabblers	2	0.11	2	0.05
Marsh Birds	3	0.16	2	0.05
Piscivorous Divers	1	0.05	10	0.23
Shorebirds	4	0.21	6	0.14
Total	**19**		**44**	

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 generally highest in the late spring (**Table 24**, **Table 26**). Species richness and evenness statistics are also provided for the current reporting year (**Table 25**, **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 Average 2017 Through 2021 Species Richness of Waterbird Foraging Guilds within Open Water Wetland Habitat By Survey Period Observed during Standwatch Surveys

Foraging Guild	Spring			Fall			
	Early	Middle	Late	Early	Early-Middle	Late-Middle	Late
Benthic Feeding Divers	-	2.6	3.1	1.8	1.9	2.2	2.0
Dabbling Ducks	-	5.6	7.2	5.3	6.3	4.6	4.0
Gulls	-	0.2	0.8	0.6	0.0	0.0	0.0
Large Dabblers	-	1.4	1.8	0.8	1.2	0.9	1.0
Marsh Birds	-	0.5	0.7	0.3	0.8	0.0	0.0
Piscivorous Divers	-	1.4	2.8	3.0	3.0	2.6	2.0
Shorebirds	-	0.8	2.2	1.4	0.4	0.0	0.0
Total Species Richness	**-**	**11.9**	**18.7**	**12.8**	**13.1**	**10.3**	**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. Dashes indicate no surveys conducted during some survey periods or insufficient data for summary statistic calculations.

Table 25 Species Richness in 2021 for Waterbird Foraging Guilds within Open Water Wetland Habitat By Survey Period Observed during Standwatch Surveys

Foraging Guild	Spring Survey Periods			Fall Survey Periods			
	Early	Middle	Late	Early	Early-Middle	Late-Middle	Late*
Benthic Feeding Divers	-	2.0	3.0	3.0	1.0	3.0	-
Dabbling Ducks	-	3.0	9.0	9.0	9.0	6.0	-
Gulls	-	0.0	2.0	0.0	0.0	0.0	-
Large Dabblers	-	0.0	2.0	1.0	1.0	1.0	-
Marsh Birds	-	0.0	1.0	0.0	1.0	0.0	-
Piscivorous Divers	-	0.0	3.0	5.0	4.0	7.0	-
Shorebirds	-	0.0	3.0	1.0	1.0	0.0	-
Total Species Richness	**-**	**5.0**	**23.0**	**19.0**	**17.0**	**17.0**	**-**
Species Evenness	**-**	**1.0**	**0.6**	**0.7**	**0.7**	**0.5**	**-**

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

Table 26 Average 2018 Through 2021 Species Richness of Waterbird Foraging Guilds within Sedge and Willows-sedge Wetland Habitat By Survey Period Observed during Transect Surveys

Foraging Guild	Spring			Fall			
	Early	Middle	Late	Early	Early-Middle	Late-Middle	Late
Benthic Feeding Divers	-	0.0	0.1	0.0	0.0	0.0	0.0
Dabbling Ducks	-	1.4	2.9	1.0	0.6	0.4	0.0
Gulls	-	0.0	0.0	0.0	0.0	0.0	0.0
Large Dabblers	-	0.6	0.1	0.0	0.0	0.0	0.0
Marsh Birds	-	1.3	1.9	1.5	1.4	0.5	0.0
Piscivorous Divers	-	0.0	0.3	0.0	0.0	0.0	0.0
Shorebirds	-	1.3	1.0	0.0	0.0	0.0	0.0
Total Species Richness	**-**	**4.4**	**6.3**	**2.8**	**1.5**	**0.9**	**0.0**
Species Evenness	**-**	**0.7**	**0.8**	**0.8**	**0.9**	**0.4**	**-**

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

Table 27 Species Richness in 2021 for Waterbird Foraging Guilds within Sedge and Willows-sedge Wetland Habitat By Survey Period Observed during Transect Surveys

Foraging Guild	Spring			Fall			
	Early	Middle	Late	Early	Early-Middle	Late-Middle	Late*
Benthic Feeding Divers	-	0.0	0.0	0.0	0.0	0.0	-
Dabbling Ducks	-	2.0	2.0	1.0	1.0	1.0	-
Gulls	-	0.0	0.0	0.0	0.0	0.0	-
Large Dabblers	-	1.0	0.0	0.0	0.0	0.0	-
Marsh Birds	-	2.0	1.0	2.0	2.0	1.0	-
Piscivorous Divers	-	0.0	0.0	0.0	0.0	0.0	-
Shorebirds	-	2.0	0.0	0.0	0.0	0.0	-
Total Species Richness	**-**	**7.0**	**3.0**	**3.0**	**3.0**	**2.0**	**-**
Species Evenness	**-**	**0.9**	**0.7**	**0.9**	**1.0**	**0.4**	**-**

Note: 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, *Species at Risk Act* (SARA), or Committee on the Status of Endangered Wildlife in Canada (COSEWIC) rankings, were observed during 2017 through 2021 transmission line wetland surveys:

- Eared grebe (*Podiceps nigricollis*), BC listing (Blue)
- Horned grebe (*Podiceps auratus*), COSEWIC (SC), SARA (SC)
- Long-tailed duck (*Clangula hyemalis*), BC listing (Blue)
- Red-necked phalarope (*Phalaropus lobatus*), BC listing (Blue)
- Surf scoter (*Melanitta perspicillata*), BC listing (Blue)
- Western grebe (*Aechmophorus occidentalis*), BC listing (Red), COSEWIC (SC), SARA (SC)
- Yellow rail (*Coturnicops noveboracensis*), BC listing (Red), COSEWIC (SC), SARA (SC).

Across years, the most commonly observed waterbird species at risk within wetlands was surf scoter (111 individuals). Horned grebes (83 individuals) and eared grebes (78 individuals) were also regularly recorded. Fewer than 30 individuals of other species at risk were recorded within wetalnds across the 5 survey years (**Appendix B-1**). Except for long-tailed duck, all of these species were observed during surveys of wetlands conducted in 2021 and red-necked phalarope was observed for the first time during transmission line wetland surveys in 2021 (**Appendix B-2**).

5.0 DISCUSSION AND RECOMMENDATIONS

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 species groups. 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 mapping and Peace River flow rates) collected during 2017 through 2021 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 improve on the data available prior to 2017, in which bird observations were recorded within 5 km segments without habitat characteristics. While TEM-based mapping 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. However, 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 (e.g., BACI models) to assess the influence of topographic features such as water depth on waterbirds. Similarly, river levels may influence waterbird abundances and / or diversity and can be considered in models assessing the magnitude and significance of Project-related changes to the abundance and diversity of waterbirds. 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), the Inundation Impact area will be buffered from the effects of river flow rates, at which point waterbird abundance and diversity metrics in that area will no longer be influenced by this factor. Reservoir levels can be recorded during this period and may also help to explain variations in the abundance and diversity of waterbirds, although fluctuations in reservoir water levels sufficient to affect waterbird distribution are expected to be rare.

5.2 Peace River Waterbird Surveys

Boat surveys of the Peace River in 2017 through 2021 have provided estimates of relative abundance and diversity throughout the spring and fall migrations to meet the waterbird monitoring program objectives (**Section 4.1**). All target taxa, including shorebirds, were observed during boat surveys. Results from Peace River observations in 2017 through 2021 identified 93% of birds at the species level and 97% 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 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 survey periods in relation to the allocation of effort prescribed by power analyses that informed the design of the study. The relative abundance of foraging guilds across habitat types is also discussed along with the distribution of waterbirds across treatment areas and implications for assessing Project-related change.

The most abundant foraging guilds observed in the 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 speices, which made up over 50% of the observed waterbirds (Robertson 1999; Robertson and Hawkes 2000; Hawkes et al. 2006).

Peace River waterbird surveys from the spring of 2017 through 2021 found the highest mean abundance and densities in early spring. Higher waterbird numbers in the early spring are likely driven by the lack of available wetland habitat on the plateau, which is typically frozen during this time, leaving few open water habitat alternatives other than the Peace River. Wetlands on the plateau typically thaw by late April, allowing waterbirds to disperse more broadly across open water habitat during the later spring survey periods. During the middle spring period, early and late migrant waterbirds use the river as a migratory stopover and for breeding. Consistent with results reported in previous years, 2021 analyses of diversity within Mainstem and Moderate Flow habitats found lower species diversity in the early spring (April 1 to April 14) relative to middle and late spring periods (April 15 through May 30). These results remain consistent with the findings of other researchers who found mid-May to be the peak of the spring migration (Siddle 2010).

Data collected in 2017 through 2021 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 vegatation. 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 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 because Mainstem habitat comprised the greatest area and proportion 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 used Moderate Flow habitat more than Mainstem, whereas that pattern was reversed in 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, which were primarily recorded in Mainstem habitat in both seasons.

Differences in detection rates across habitat types may contribute to higher apparent abundances 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 re-classifed 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 206 individuals observed across years, including 12 during monitoring in 2021. California gull and tundra swan are similar in appearance to other species, so their numbers may have been underestimated. Some California gull individuals may have been recorded as unknown gull species. Similarly, some tundra swan individuals 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 and within Confluence river reaches, particularly during fall, 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. 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 and post-construction 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 2021. Additionally, 5 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.

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*], and northern shoveler [*Spatula clypeata*]) and marsh birds (e.g., Wilson's snipe [*Gallinago delicata*], and sora [*Porzana carolina*]) were most abundant, with 171 and 117 records across years, respectively (**Appendix B-1**). Shorebirds (e.g., spotted sandpiper) were the next most abundant with 51 records. Results from 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 2018, 2019, 2020). Open water wetlands 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 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 (*Gallinago gallinago*), which seldom use flooded habitat and, consequently, are not seldom 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 in 2020 and 2021 and as planned in subsequent years.

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 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 be required to provide more accurate estimates of density.

Another challenge encountered during the 2021 monitoring program was changes to habitat within the wetland study area. During 2021, wetland survey stations SE-12 and OW-10 were drained of water, apparently due to the installation or modification of culverts 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 will be identified for surveys in subsequent years to replace these stations if they continue to be drained of water, as they would no longer represent suitable foraging habitat for waterbirds.

With regard to bioacoustics monitoring, ARU survey results are satisfying monitoring objectives to document trends in the presence of yellow rail, American bittern, and sora. In 2020 and 2021, ARUs were also used to document the presence of Virginia rail, which will continue through future monitoring. Observations of crepuscular marsh birds have been consistent across the wetlands during the 5 study

years, indicating that sora is common, yellow rail is uncommon but regularly occurs within relatively large areas of non-flooded sedge habitat, and American bittern is rare. Since no records of American bittern were confirmed during 5 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 have been detected consistently at every deployment conducted to date, including in all wetland and mixed habitat types surveyed and all portions of the bioacoustics monitoring period (**Table 22**). Furthermore, sora are often detected during wetland transect and standwatch surveys, providing robust data from multiple survey methods throughout the wetland study area. ARU bioacoustics monitoring confirms previous reports of yellow rail from call-playback and point-count surveys (Hilton et al. 2013) EIS, appendix R, part 4). Furthermore, ARU deployments in 2021 re-detected yellow rail at 3 sites (ARU deployments within sedge habitat at wetland stations SE-04, SE-05 and SE-11), indicating that the species occurs consistently across years within the study area in sedge-dominated wetlands. The detection of yellow rail at two new locations, within wetland stations WS-03 and SE-03, indicates that this species also inhabits mixed habitat or smaller areas of sedge habitat than reported up to this point. Additional monitoring will help to determine the frequency of yellow rail occurrence in mixed habitat where sedge habitat is present but not dominant. During bioacoustics monitoring in 2020 and 2021, Virginia rail was detected during May and June at locations surrounded by sedge, willow-sedge, and upland forested habitats (**Table 22**). Monitoring in 2022 will target similar locations and habitats during July and August to inform on whether Virginia rail is present and vocally active within the study area during the latter half of the monitoring period.

6.0 CLOSING

This Work was performed in accordance with Contract No. 95055-05 between Hemmera Envirochem Inc. (Hemmera), a wholly owned subsidiary of Ausenco Engineering Canada Inc. (Ausenco), and BC Hydro (Client), dated September 28, 2016 (Contract). This Report has been prepared by Hemmera, based on fieldwork conducted by Hemmera, for sole benefit and use by BC Hydro. In performing this Work, Hemmera 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.

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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7.0 REFERENCES

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APPENDIX A

Ducks Unlimited / Native Plant Solutions Technical Memo: 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

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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 Cumulative Abundances from 2017 through 2021 (Table B-1 [2017, 2018, 2019, 2021] and B-2 [2021])

Table B-1 Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances from 2017, 2018, 2019, 2020 and 2021

Foraging Guild	English Name	Scientific Name	River Boat Survey Abundance [a]	Wetland Standwatch Abundance [b]	Wetland Transect Abundance [c]
Benthic Feeding Divers			**2,504**	**1,290**	**1**
	American Dipper	*Cinclus mexicanus*	1	0	0
	Barrow's Goldeneye	*Bucephala islandica*	135	26	0
	Benthic Feeding Diver sp.	*n/a*	1	27	0
	Bufflehead	*Bucephala albeola*	205	821	1
	Common Goldeneye	*Bucephala clangula*	1,677	206	0
	Goldeneye sp.	*Bucephala sp.*	257	40	0
	Harlequin Duck	*Histrionicus histrionicus*	3	0	0
	Long-tailed Duck	*Clangula hyemalis*	1	22	0
	Ruddy Duck	*Oxyura jamaicensis*	5	28	0
	Scoter sp.	*Melanita sp.*	2	1	0
	Surf Scoter	*Melanitta perspicillata*	206	111	0
	White-winged Scoter	*Melanitta fusca*	11	8	0
Cranes and Herons			**56**	**0**	**0**
	Great Blue Heron	*Ardea herodias*	1	0	0
	Sandhill Crane	*Antigone canadensis*	55	0	0
Dabbling Ducks			**17,054**	**4,456**	**171**
	American Coot	*Fulica americana*	58	267	9
	American Wigeon	*Mareca americana*	1,517	307	7
	Blue-winged Teal	*Spatula discors*	443	310	15
	Canvasback	*Aythya valisineria*	19	106	0
	Cinnamon Teal	*Spatula cyanoptera*	2	0	2
	Dabbling Duck sp.	*n/a*	1,235	287	5
	Eurasian Wigeon	*Mareca penelope*	1	0	0
	Gadwall	*Mareca strepera*	30	12	0
	Greater Scaup	*Aythya marila*	28	43	0
	Green-winged Teal	*Anas crecca*	1,649	384	20
	Lesser Scaup	*Aythya affinis*	46	176	0
	Mallard	*Anas platyrhynchos*	9,849	1,082	47
	Northern Pintail	*Anas acuta*	1,617	78	4
	Northern Shoveler	*Spatula clypeata*	212	205	62
	Redhead	*Aythya americana*	7	5	0
	Ring-necked Duck	*Aythya collaris*	40	715	0
	Scaup sp.	*n/a*	144	460	0
	Teal sp.	*n/a*	157	19	0

Table B-1 Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances from 2017, 2018, 2019, 2020 and 2021

Foraging Guild	English Name	Scientific Name	River Boat Survey Abundance [a]	Wetland Standwatch Abundance [b]	Wetland Transect Abundance [c]
Gulls and Surface Feeding Terns			**14,214**	**195**	**0**
	Black Tern	*Chlidonias niger*	0	21	0
	Bonaparte's Gull	*Chroicocephalus philadelphia*	5,387	161	0
	California Gull	*Larus californicus*	35	0	0
	Franklin's Gull	*Leucophaeus pipixcan*	5,030	1	0
	Gull sp.	*n/a*	1,053	6	0
	Herring Gull	*Larus argentatus*	197	0	0
	Ring-billed Gull	*Larus delawarensis*	2,163	0	0
	Sabine's Gull	*Xema sabini*	1	0	0
	Short-billed Gull	*Larus brachyrhynchos*	342	6	0
	Iceland Gull	*Larus glaucoides*	6	0	0
Large Dabblers			**33,774**	**303**	**5**
	Cackling Goose	*Branta hutchinsii*	26	0	0
	Canada Goose[d]	*Branta canadensis*	33,078	93	3
	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*	434	210	2
	Tundra Swan	*Cygnus columbianus*	3	0	0
Marsh Birds			**0**	**53**	**117**
	Sora	*Porzana carolina*	0	43	53
	Wilson's Snipe	*Gallinago delicata*	0	10	61
	Yellow Rail	*Coturnicops noveboracensis*	0	0	3
Piscivorous Divers			**4,167**	**495**	**2**
	Arctic Tern	*Sterna paradisaea*	2	0	0
	Belted Kingfisher	*Megaceryle alcyon*	91	5	0
	Common Loon	*Gavia immer*	26	123	0
	Common Merganser	*Mergus merganser*	3,924	26	0
	Common Tern	*Sterna hirundo*	3	0	0
	Double-crested Cormorant	*Nannopterum auritum*	4	0	0
	Eared Grebe	*Podiceps nigricollis*	6	78	0
	Grebe sp.	*n/a*	2	7	0
	Hooded Merganser	*Lophodytes cucullatus*	27	32	0
	Horned Grebe	*Podiceps auritus*	2	83	0
	Loon sp.	*n/a*	5	0	0
	Merganser sp.	*n/a*	24	0	0
	Pacific Loon	*Gavia pacifica*	1	0	0
	Pied-billed Grebe	*Podilymbus podiceps*	0	43	2
	Piscivorous Diver sp.	*n/a*	3	0	0
	Red-breasted Merganser	*Mergus serrator*	11	6	0
	Red-necked Grebe	*Podiceps grisegena*	33	80	0
	Red-throated Loon	*Gavia stellata*	1	0	0
	Tern sp.	*n/a*	1	0	0
	Western Grebe	*Aechmophorus occidentalis*	1	12	0

Table B-1 Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances from 2017, 2018, 2019, 2020 and 2021

Foraging Guild	English Name	Scientific Name	River Boat Survey Abundance [a]	Wetland Standwatch Abundance [b]	Wetland Transect Abundance [c]
Shorebirds			**2,249**	**157**	**51**
	Greater Yellowlegs	*Tringa melanoleuca*	3	12	3
	Killdeer	*Charadrius vociferus*	28	1	0
	Least Sandpiper	*Calidris minutilla*	15	0	0
	Lesser Yellowlegs	*Tringa flavipes*	17	36	11
	Long-billed Dowitcher	*Limnodromus scolopaceus*	2	0	0
	Peep Sp.	*Calidris sp.*	37	0	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*	14	38	9
	Spotted Sandpiper	*Actitis macularius*	1,903	53	28
	Semipalmated Plover	*Charadrius semipalmatus*	11	0	0
	Semipalmated Sandpiper	*Calidris pusilla*	117	0	0
	Yellowlegs sp.	*Tringa sp.*	2	0	0
Unknown Waterbirds			**2,179**	**888**	**0**
	Diving Bird sp.	*n/a*	14	0	0
	Duck sp.	*n/a*	1,864	845	0
	Unknown sp.	*n/a*	301	43	0
Grand Total			**76,197**	**7,837**	**347**

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 2021

Foraging Guild	English Name	Scientific Name	River Boat Survey Abundance [a]	Wetland Standwatch Abundance [b]	Wetland Transect Abundance [c]
Benthic Feeding Divers			**241**	**261**	**0**
	Barrow's Goldeneye	*Bucephala islandica*	7	2	0
	Benthic Feeding Diver sp.	*n/a*	0	27	0
	Bufflehead	*Bucephala albeola*	23	158	0
	Common Goldeneye	*Bucephala clangula*	155	31	0
	Goldeneye sp.	*Bucephala sp.*	43	10	0
	Scoter sp.	*Mellanita sp.*	0	1	0
	Surf Scoter	*Melanitta perspicillata*	12	32	0
	White-winged Scoter	*Melanitta fusca*	1	0	0
Dabbling Ducks			**4,699**	**1,271**	**28**
	American Coot	*Fulica americana*	0	210	2
	American Wigeon	*Mareca americana*	250	23	0
	Blue-winged Teal	*Spatula discors*	4	73	0
	Canvasback	*Aythya valisineria*	4	0	0
	Dabbling Duck sp.	*n/a*	1,111	14	0
	Eurasian Wigeon	*Mareca penelope*	1	0	0
	Greater Scaup	*Aythya marila*	0	2	0
	Green-winged Teal	*Anas crecca*	137	37	1
	Lesser Scaup	*Aythya affinis*	4	6	0
	Mallard	*Anas platyrhynchos*	2,402	674	20
	Northern Pintail	*Anas acuta*	734	18	0
	Northern Shoveler	*Spatula clypeata*	41	14	5
	Redhead	*Aythya americana*	0	1	0
	Ring-necked Duck	*Aythya collaris*	3	194	0
	Scaup sp.	*Aythya sp.*	7	2	0
	Teal sp.	*n/a*	1	3	0
Gulls			**571**	**4**	**0**
	Black Tern	*Chlidonias niger*	0	1	0
	Bonaparte's Gull	*Chroicocephalus philadelphia*	226	3	0
	California Gull	*Larus californicus*	6	0	0
	Franklin's Gull	*Leucophaeus pipixcan*	139	0	0
	Gull sp.	*n/a*	106	0	0
	Herring Gull	*Larus argentatus*	10	0	0
	Ring-billed Gull	*Larus delawarensis*	66	0	0
	Short-billed Gull	*Larus brachyrhynchos*	18	0	0
Large Dabblers			**6,421**	**88**	**1**
	Cackling Goose	*Branta hutchinsii*	2	0	0
	Canada Goose [d]	*Branta canadensis*	6,227	19	1
	Trumpeter Swan [d]	*Cygnus buccinator*	26	69	0
	Large Dabbler sp.	*n/a*	164	0	0
	Snow Goose	*Anser caerulescens*	2	0	0

Table B-2 Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances in 2021

Foraging Guild	English Name	Scientific Name	River Boat Survey Abundance [a]	Wetland Standwatch Abundance [b]	Wetland Transect Abundance [c]
Marsh Birds			**0**	**4**	**13**
	Sora	*Porzana carolina*	0	4	6
	Wilson's Snipe	*Gallinago delicata*	0	0	7
Piscivorous Divers			**753**	**108**	**0**
	Belted Kingfisher	*Megaceryle alcyon*	3	0	0
	Common Loon	*Gavia immer*	2	18	0
	Common Merganser	*Mergus merganser*	729	0	0
	Double-crested Cormorant	*Nannopterum auritum*	4	0	0
	Eared Grebe	*Podiceps nigricollis*	0	1	0
	Grebe sp.	*n/a*	0	1	0
	Hooded Merganser	*Lophodytes cucullatus*	4	16	0
	Horned Grebe	*Podiceps auritus*	0	31	0
	Merganser sp.	*n/a*	6	0	0
	Pacific Loon	*Gavia pacifica*	1	0	0
	Pied-billed Grebe	*Podilymbus podiceps*	0	26	0
	Red-breasted Merganser	*Mergus serrator*	2	0	0
	Red-necked Grebe	*Podiceps grisegena*	1	9	0
	Red-throated Loon	*Gavia stellata*	1	0	0
	Western Grebe	*Aechmophorus occidentalis*	0	6	0
Shorebirds			**321**	**40**	**2**
	Killdeer	*Charadrius vociferus*	4	0	0
	Lesser Yellowlegs	*Tringa flavipes*	0	9	1
	Peep Sp.	*Calidris sp.*	3	0	0
	Red-necked Phalarope	*Phalaropus lobatus*	0	9	0
	Sandpiper sp.	*n/a*	9	1	0
	Shorebird sp.	*n/a*	1	0	0
	Solitary Sandpiper	*Tringa solitaria*	0	6	1
	Spotted Sandpiper	*Actitis macularius*	303	15	0
	Yellowlegs sp.	*Tringa sp.*	1	0	0
Unknown Waterbirds			**80**	**1**	**0**
	Duck sp.	n/a	63	1	0
	Unknown sp.	n/a	17	0	0
Grand Total			**13,086**	**1,777**	**44**

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.

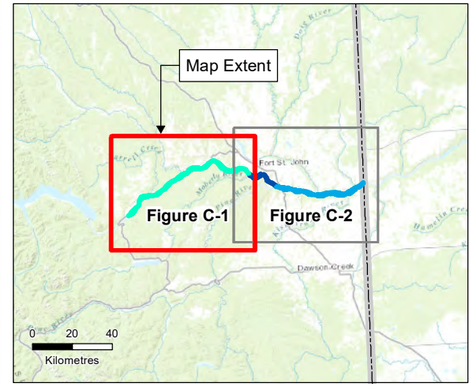
[d] - Trumpeter swans and Canada geese, include a small proportion (<5%) of tundra swans and cackling geese, respectively.

APPENDIX C

Spatial Representation of Waterbird Observations within the Peace River Study Area in Spring and Fall 2021 (Figures C-1 to C-4)

Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

Waterbirds Recorded within Inundation Impact Area Spring 2021



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: Jan 14, 2022	Figure C-1

Hemmera An Ausenco Company | BC hydro

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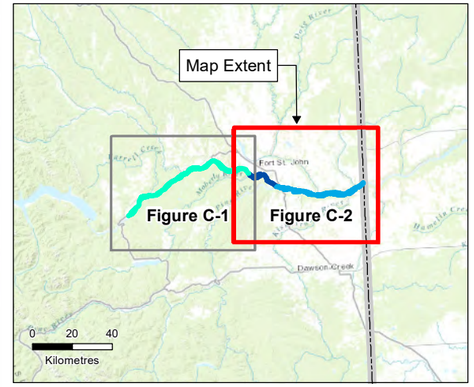
Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

Waterbirds Recorded within Flow Regime Impact Area and Control Area Spring 2021



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

Charlie Lake
Fort St. John
Old Fort
Taylor
Beatton River
Pine River
Peace River
Kiskatinaw River
BRITISH COLUMBIA
ALBERTA

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: Jan 14, 2022	Figure C-2

Hemmera An Ausenco Company

BC hydro

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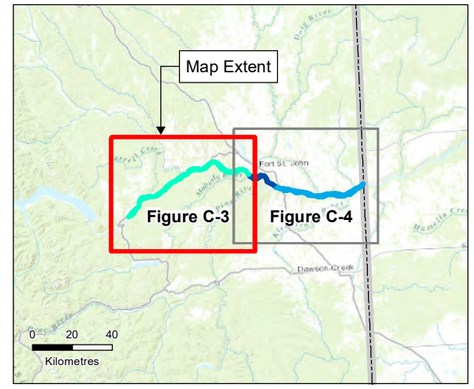
Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

Waterbirds Recorded within Inundation Impact Area Fall 2021



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: Jan 14, 2022	Figure C-3

Hemmera An Ausenco Company

BC hydro

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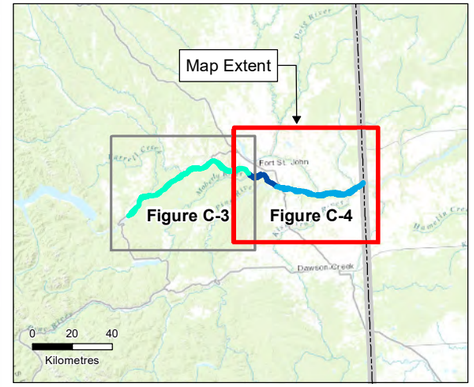
Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

Waterbirds Recorded within Flow Regime Impact Area and Control Area Fall 2021



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: Jan 14, 2022	Figure C-4

Hemmera An Ausenco Company

BC hydro

Path: S:\Geomatics\Projects\989619\07_waterfowl\mon\Monitoring\Program\2021\Fig\C-4_989619_07_Waterbirds_FallCount_FlowRegimeChangeImpactArea_Colormoke_220114.mxd

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)

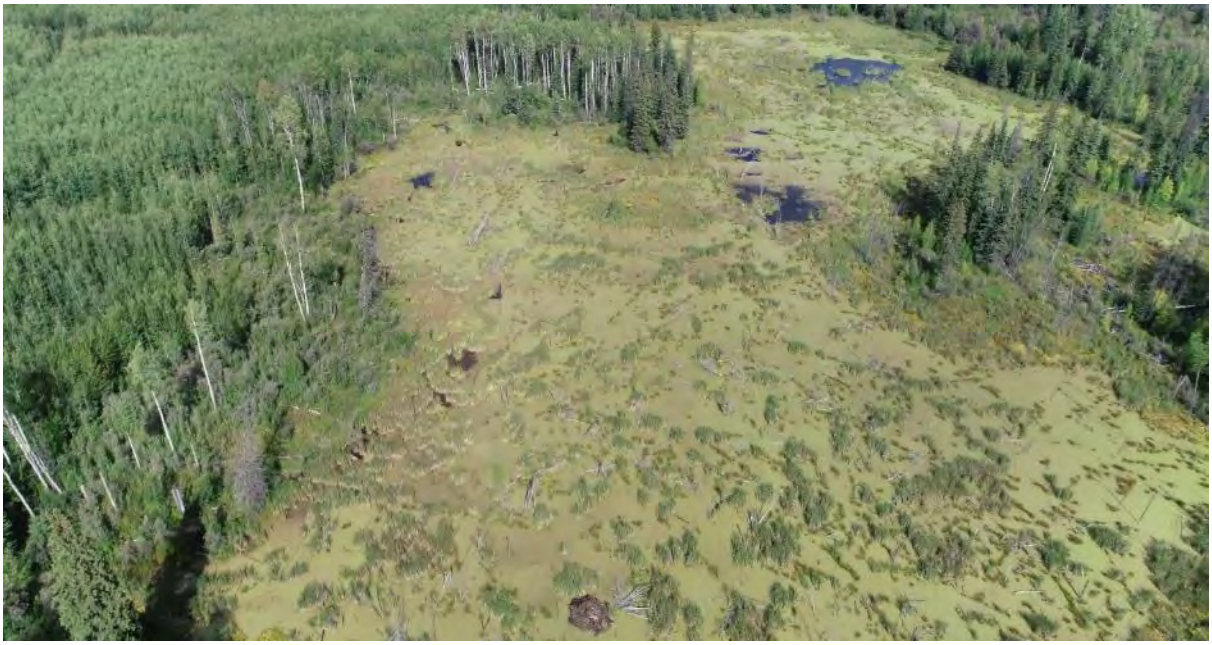


Photo 5 Aerial Photograph of Wetland Survey Station OW07 (August 22, 2019)

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)

APPENDIX E

Mean and Standard Devation 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 2021

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	169	76	168	196	23	14	2	3	21	44	14	19	5	-	**57**
Dabbling Ducks	1,006	870	661	346	489	115	102	51	308	229	345	470	51	-	**423**
Gulls	2	2	69	101	32	5	776	479	697	422	314	341	102	-	**284**
Large Dabblers	2,280	979	502	146	538	144	233	87	455	395	738	667	623	-	**767**
Piscivorous Divers	311	66	95	41	51	15	44	40	33	15	21	10	12	-	**81**
Shorebirds	1	1	6	6	115	33	216	151	130	96	4	3	0	-	**67**
Unknown Waterbirds	92	79	128	69	59	59	18	13	7	8	20	38	13	-	**48**
Total (All Waterbirds)	**3,861**	**-**	**1,629**	**-**	**1,308**	**-**	**1,391**	**-**	**1,652**	**-**	**1,455**	**-**	**805**	**-**	

Note: Sample size is 5 years except for late fall (2 years), 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 2021 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	17.6	11.6	3.0	2.1	1.5	0.8	2.7	1.8	6.2	3.7	1.7	1.7
Dabbling Ducks	108.6	84.5	29.6	32.1	8.8	7.7	9.1	3.9	36.2	40.9	23.0	24.6
Gulls	0.0	0.0	<0.1	0.1	0.5	0.7	0.3	0.4	1.7	2.7	0.1	0.1
Large Dabblers	210.9	178.3	47.6	27.1	17.5	12.6	32.1	17.6	19.9	3.7	38.3	41.5
Piscivorous Divers	17.9	5.5	7.3	4.5	2.8	1.8	7.0	3.8	2.5	1.9	1.5	1.0
Shorebirds	3.4	3.3	1.1	1.0	0.2	0.2	0.6	0.5	0.6	0.6	0.4	0.4
Unidentified Waterbirds	6.1	8.5	2.1	2.6	1.0	0.4	1.8	2.0	1.0	1.1	1.1	1.1
Total (All Waterbirds)	**364.7**	**-**	**90.8**	**-**	**32.2**	**-**	**53.5**	**-**	**68.1**	**-**	**66.2**	**-**
Total Estimated Abundance	**1,187**	**-**	**679**	**-**	**1,400**	**-**	**1,417**	**-**	**407**	**-**	**1,441**	**-**

Note: Sample size is 5 years. SD = standard deviation across years. Dashes indicate insufficient or inappropriate data for calculations.

Table E-11 Mean 2017 Through 2021 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	0.1	<0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.2	0.1	0.1
Dabbling Ducks	38.6	13.5	6.5	13.5	1.0	0.7	5.0	2.7	10.4	17.1	1.1	1.3
Gulls	2.3	0.8	0.9	0.8	11.8	4.7	8.3	4.9	50.9	30.1	0.2	0.2
Large Dabblers	51.9	7.0	9.4	7.0	5.4	3.2	7.6	5.5	12.1	10.9	9.1	5.0
Piscivorous Divers	3.1	0.5	0.8	0.5	0.3	0.1	0.7	0.5	0.3	0.2	0.4	0.4
Shorebirds	8.6	1.7	3.7	1.7	1.0	0.7	1.7	1.2	0.9	0.2	2.2	1.5
Unidentified Waterbirds	3.0	0.2	0.2	0.2	0.1	0.1	0.3	0.3	0.7	1.0	<0.1	0.05
Total (All Waterbirds)	**107.9**	**-**	**21.5**	**-**	**19.8**	**-**	**23.9**	**-**	**75.5**	**-**	**13.1**	**-**
Total Estimated Abundance	**351**	**-**	**160**	**-**	**860**	**-**	**634**	**-**	**452**	**-**	**285**	**-**

Note: Sample size is 5 years. SD = standard deviation across years. Dashes indicate insufficient or inappropriate data for calculations.

Table E-13 Mean 2017 Through 2021 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	2.3	0.8	2.8	0.8	3.7	1.0	**2.8**	**0.6**	0.6	0.5	0.5	0.5	1.0	1.2	0.0	-	**0.7**	**0.4**
Dabbling Ducks	4.8	0.8	6.3	1.2	7.0	1.0	**5.7**	**0.3**	2.3	0.8	3.3	1.6	2.4	0.7	1.5	-	**2.5**	**0.7**
Gulls	0.4	0.7	1.8	1.9	3.3	0.6	**1.4**	**0.8**	4.5	1.3	3.6	0.9	3.1	1.1	3.5	-	**3.7**	**0.8**
Large Dabblers	2.2	0.4	2.0	1.0	1.3	0.3	**1.9**	**0.3**	1.1	0.2	1.6	0.5	1.7	0.8	2.0	-	**1.5**	**0.3**
Piscivorous Divers	1.6	0.5	2.5	0.5	3.5	0.9	**2.3**	**0.4**	1.9	0.7	2.7	0.8	3.0	1.5	1.5	-	**2.4**	**0.8**
Shorebirds	0.6	0.4	0.5	0.5	1.2	0.3	**0.6**	**0.4**	2.6	2.5	1.2	0.4	1.0	0.4	0.0	-	**1.4**	**0.6**
Total Species Richness	**11.9**	**-**	**16.0**	**-**	**20.0**	**-**	**14.8**	**-**	**13.0**	**-**	**12.9**	**-**	**12.2**	**-**	**8.5**	**-**	**12.2**	**-**
Species Evenness	**0.5**	**-**	**0.6**	**-**	**0.6**	**-**	**0.5**	**-**	**0.6**	**-**	**0.5**	**-**	**0.5**	**-**	**0.4**	**-**	**0.5**	**-**

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-18 Mean 2017 Through 2021 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	143.0	1.2	131.3	1.1	227.6	0.8	181.0	1.9	151.8	2.3	41.2	-
Dabbling Ducks	530.5	4.3	596.5	3.7	694.8	3.3	631.6	4.1	489.0	4.7	96.2	-
Gulls and Surface-Feeding Terns	1.9	<0.1	6.0	0.1	1.3	0.0	0.0	<0.1	0.0	0.0	0.0	-
Large Dabblers	67.5	0.8	55.3	0.4	16.0	0.6	23.8	0.2	7.0	0.3	0.8	-
Marsh Birds	1.1	<0.1	28.2	0.4	1.4	0.2	14.9	<0.1	0.0	0.2	0.0	-
Piscivorous Divers	4.1	0.1	21.8	0.1	28.5	0.1	42.5	0.2	24.9	0.5	23.8	-
Shorebirds	19.5	0.3	91.1	1.0	107.4	0.5	12.4	1.6	0.0	0.2	0.0	-
Unknown Waterbirds	0.1	0.0	18.6	0.4	26.2	0.2	5.2	0.5	41.7	<0.1	26.3	-
Total (All Waterbirds)	**767.7**	**-**	**949.1**	**-**	**1,103.1**	**-**	**911.3**	**-**	**714.4**	**-**	**188.4**	**-**

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-20 Mean 2018 through 2021 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	1.72	2.21	5.32	3.45	0.09	0.18	0.73	0.64	1.71	3.42	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	0.33	0.23	0.10	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Marsh Birds	0.74	1.19	3.09	3.00	1.32	1.07	1.49	1.05	0.26	0.30	0.00	-
Piscivorous Divers	0.00	0.00	0.11	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Shorebirds	0.68	0.63	1.56	2.19	0.00	0.00	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)	**3.48**	**-**	**10.18**	**-**	**1.41**	**-**	**2.22**	**-**	**1.97**	**-**	**0.00**	**-**

Note: Sample size is 4 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 2021, 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	-	-	2.6	1.3	3.1	1.6	**2.9**	**1.3**	1.8	0.8	1.9	0.8	2.2	0.6	2.0	-	**2.0**	**0.5**
Dabbling Ducks	-	-	5.6	2.9	7.2	3.0	**6.4**	**2.6**	5.3	2.7	6.3	2.7	4.6	1.8	4.0	-	**5.3**	**1.9**
Gulls	-	-	0.2	0.4	0.8	0.8	**0.5**	**0.4**	0.6	0.9	0.0	0.0	0.0	0.0	0.0	-	**0.2**	**0.3**
Large Dabblers	-	-	1.4	0.9	1.8	0.6	**1.6**	**0.6**	0.8	0.4	1.2	0.3	0.9	0.2	1.0	-	**1.0**	**0.1**
Marsh Birds	-	-	0.5	0.5	0.7	0.4	**0.6**	**0.3**	0.3	0.4	0.8	0.6	0.0	0.0	0.0	-	**0.3**	**0.2**
Piscivorous Divers	-	-	1.4	1.8	2.8	1.3	**2.1**	**1.5**	3.0	1.6	3.0	1.5	2.6	2.6	2.0	-	**2.8**	**1.5**
Shorebirds	-	-	0.8	1.3	2.2	1.1	**1.5**	**1.0**	1.4	0.9	0.4	0.5	0.0	0.0	0.0	-	**0.5**	**0.2**
Total Species Richness	**-**	**-**	**11.9**	**8.4**	**18.7**	**7.5**	**15.3**	**7.2**	**12.8**	**4.6**	**13.1**	**4.4**	**10.3**	**4.2**	**9.0**	**-**	**12.1**	**3.8**
Species Evenness	**-**	**-**	**0.8**	**0.1**	**0.8**	**0.1**	**0.8**	**0.0**	**0.8**	**0.1**	**0.8**	**0.0**	**0.7**	**0.2**	**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 2021, with Variability (Standard Deviation)

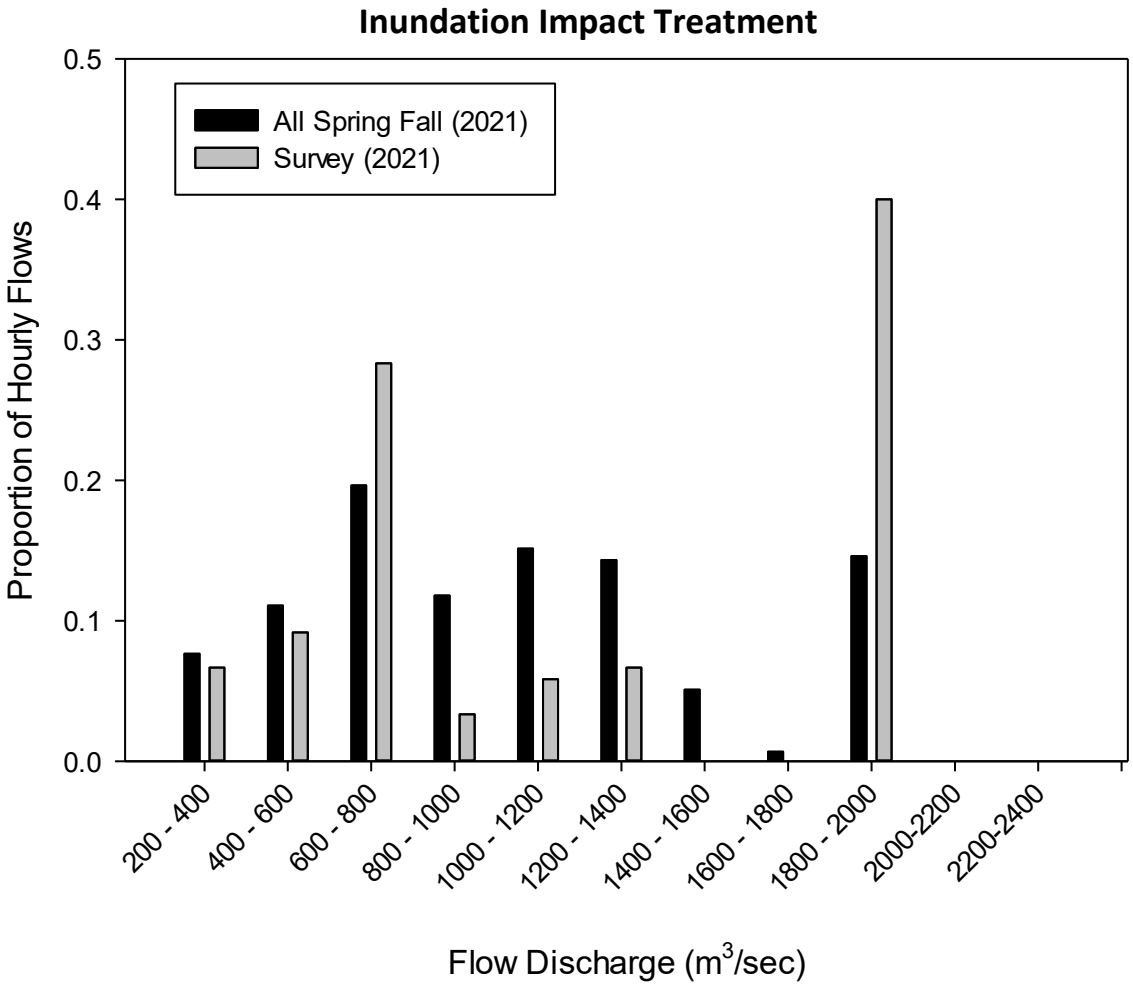
Foraging Guild	Spring species richness by survey period						Spring		Fall species richness by survey period								Fall	
	Early		Middle		Late				Early		Early-Middle		Late-Middle		Late			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Benthic Feeding Divers	-	-	0.0	0.0	0.1	0.3	**0.1**	**0.1**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	**0.0**	**0.0**
Dabbling Ducks	-	-	1.4	1.4	2.9	0.9	**2.1**	**0.6**	1.0	1.4	0.6	0.5	0.4	0.5	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	-	-	0.6	0.5	0.1	0.3	**0.4**	**0.1**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	**0.0**	**0.0**
Marsh Birds	-	-	1.3	1.5	1.9	0.9	**1.6**	**1.0**	1.5	1.0	1.4	0.5	0.5	0.6	0.0	-	**1.0**	**0.5**
Piscivorous Divers	-	-	0.0	0.0	0.3	0.5	**0.1**	**0.3**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	**0.0**	**0.0**
Shorebirds	-	-	1.3	1.0	1.0	1.1	**1.1**	**0.3**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	**0.0**	**0.0**
Total Species Richness	**-**	**-**	**4.4**	**4.3**	**6.3**	**3.0**	**5.3**	**2.3**	**2.8**	**1.7**	**1.5**	**1.3**	**0.9**	**0.9**	**0.0**	**-**	**1.5**	**1.0**
Species Evenness	**-**	**-**	**0.7**	**0.2**	**0.8**	**0.1**	**0.7**	**0.1**	**0.8**	**0.3**	**0.9**	**0.1**	**0.4**	**-**	**-**	**-**	**0.8**	**0.1**

Note: Sample size is 4 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.

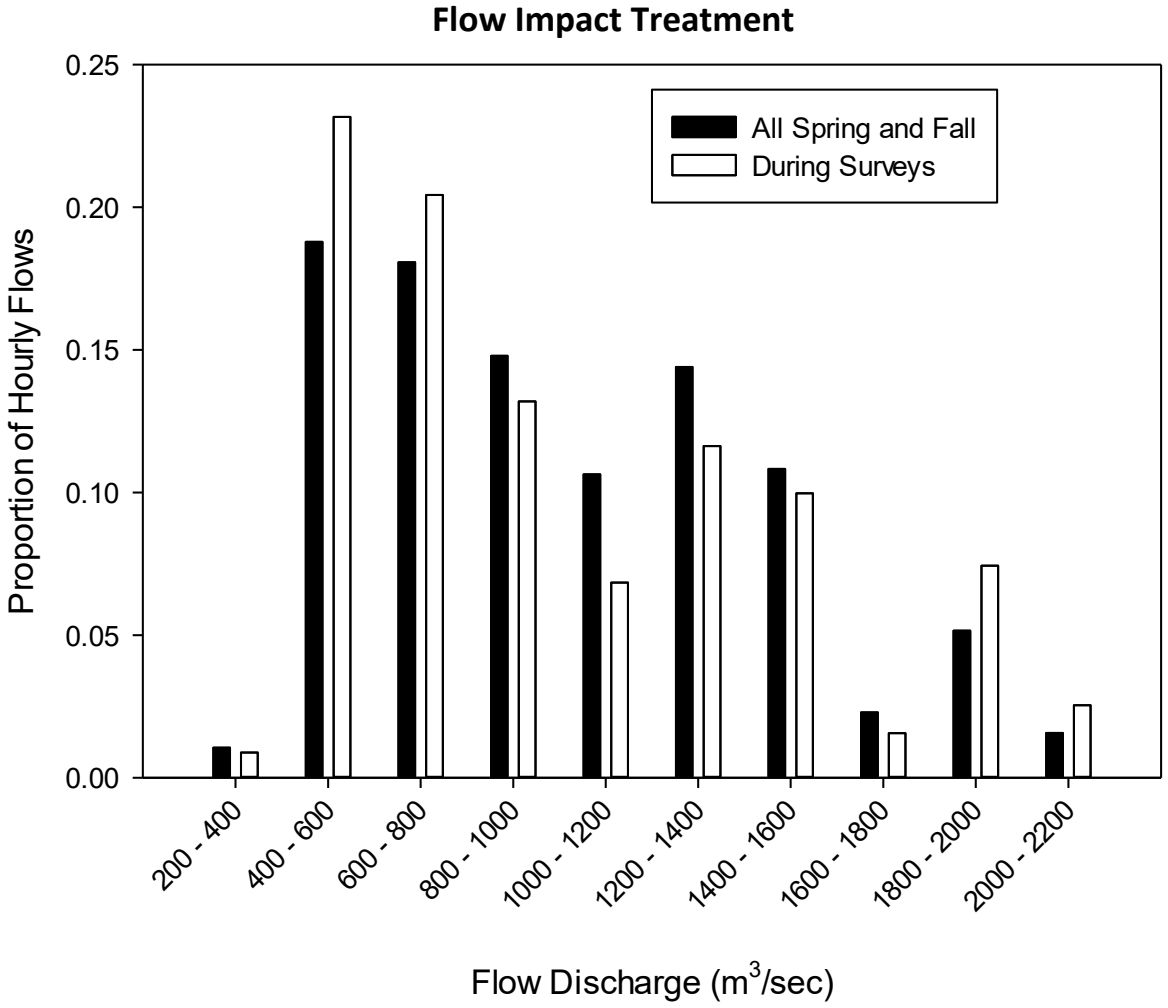
APPENDIX F

Flow Rates in 2021 during Surveys Relative to Flow Rates during All Spring and Fall Migration Periods

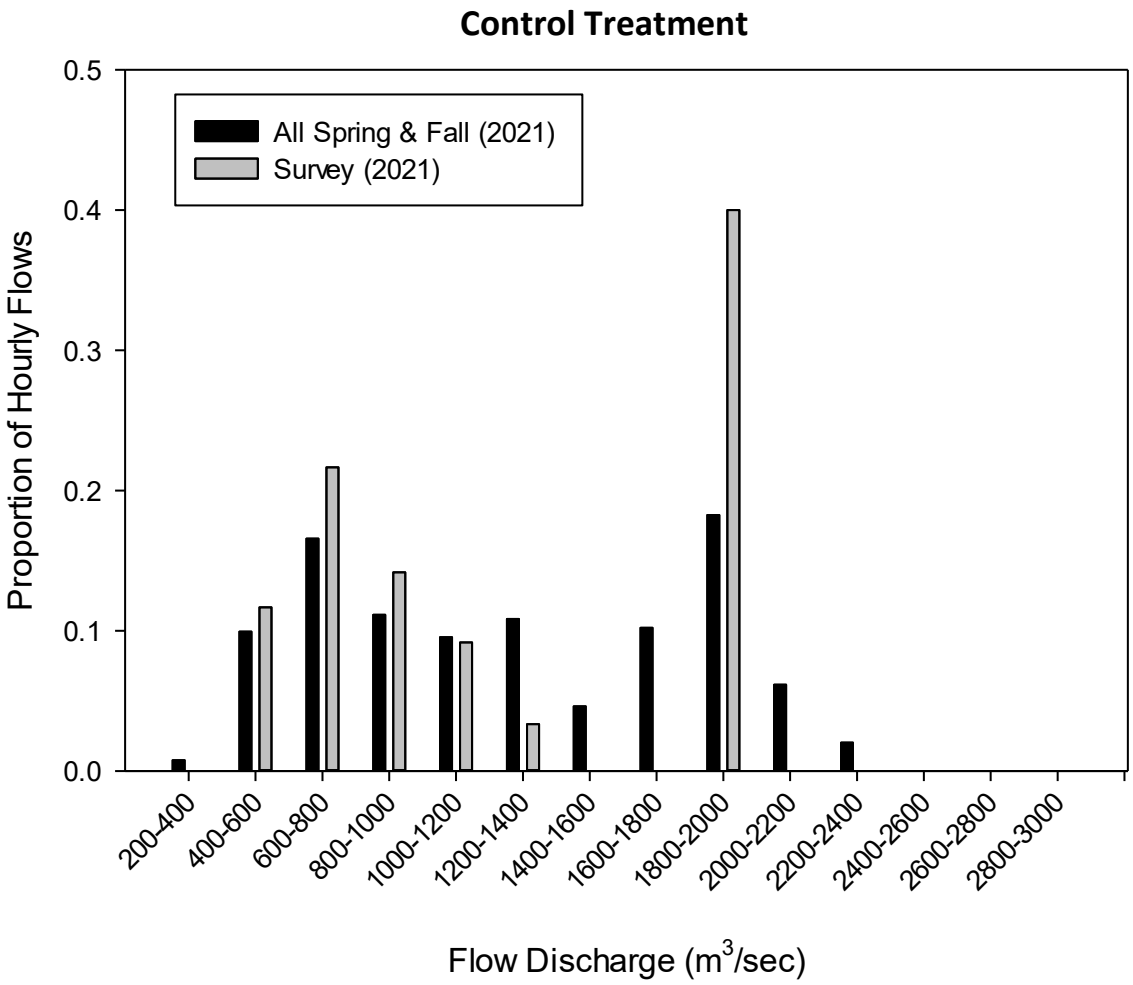
Appendix F-1 Distribution of 2021 hourly flow rates (shown as proportion of total) in the Inundation Impact treatment area during surveys relative to across spring and fall.



Appendix F-2 Distribution of 2021 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 2021 hourly flow rates (shown as proportion of total) in the Flow Control treatment area during surveys relative to across spring and fall.



Appendix 4. Site C Migratory Bird Nest Monitoring 2021 Annual Report

Site C Migratory Bird Nest Monitoring Program – 2021 Annual Report

Photo Credit: Shae Turner

Photo Credit: Chris Coxson

Prepared for:

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March 2, 2022

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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 and water level changes in the headpond (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 and these effects will be evaluated to determine the relative contribution of the Project to documented nest impacts.

The first year of nesting bird field surveys took place in 2021 and this annual report summarizes those survey results.

Two survey methods were used to assess the disturbance or mortality of nesting migratory birds in the study area:

1. Nest searching and monitoring – nesting attempts of migratory bird species were monitored on selected plots from the various habitat types within the study area.
2. Point count surveys – these surveys were used to describe the nesting migratory bird communities within the different habitat types within the study area.

Twenty-four plots covering an area of 33.1 ha were surveyed regularly during the 2021 breeding season. Eight weeks of nest searching and monitoring surveys were conducted from May 30 to July 21, 2021 and point count surveys were completed for 18 of the 24 nest monitoring plots between June 22 and June 26, 2021.

A total of 126 nests of 30 species were located, including 94 nests of 23 species that were on the intensively-surveyed nest monitoring plots. One federally listed species, Common nighthawk (*Chordeiles minor*), was detected nesting on a plot downstream of the dam site. Point counts detected 28 species on nest monitoring plots and 50 species overall.

Across the entire study area, 44% of nests detected were considered successful, 33% failed, and 23% had an unknown outcome. The most common cause of nest failure was predation, as is typical for breeding birds.

Flooding caused the failure of 6% of monitored nests and affected 7 nests in the headpond above the dam and 1 in the downstream river channel. There was an increase in water levels in late June and early July that overlapped with the peak in bird breeding activity, causing nest flooding to occur. Nest flooding affected 5 species and primarily impacted birds nesting on or low to the ground; however, it also affected cedar waxwing, which nested more than a metre (m) above the ground, but bred at a lower elevation. Notably, two nests were found on previously flooded plots after water levels dropped again in July, indicating that birds can be quick to begin using habitat again after flooding recedes.

One of the challenges in 2021 was inconsistencies in the previous habitat mapping, thus the accuracy of the habitat mapping will be improved prior to the 2022 field season. It is also suggested that point counts not be completed in 2022, and that the field surveys focus on documenting all breeding bird territories on nest monitoring plots to improve the accuracy of nest density estimates.

This work was performed in accordance with Contact No. 4500023118 between Hemmera Envirochem Inc. (Hemmera), a wholly owned subsidiary of Ausenco Engineering Canada Inc. (Ausenco), and BC Hydro (Client), dated December 22, 2021 (Contract). This report has been prepared by Hemmera, based on fieldwork conducted by Hemmera, for sole benefit and use by BC Hydro. In performing this work, Hemmera 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

EXECUTIVE SUMMARY I

LIST OF ACRONYMS AND ABBREVIATIONS VI

LIST OF SYMBOLS AND UNITS OF MEASURE VI

1.0 INTRODUCTION 1
1.1 Background 1
1.2 Study Area 1
1.3 Monitoring Objectives 3

2.0 METHODS 4
2.1 Habitat Classification and Plot Selection 4
2.2 Survey Timing 4
2.3 Field Surveys 4
2.3.1 Nest Monitoring 4
2.3.2 Point Counts 5
2.4 Data Management and Analysis 5
2.4.1 Water Levels 5
2.4.2 Nest Monitoring 5
2.4.3 Point Counts 7

3.0 RESULTS 8
3.1 Water Levels 8
3.2 Plot Selection and Habitat 9
3.3 Nest Monitoring 11
3.3.1 Survey Effort 11
3.3.2 Nest Records 11
3.3.3 Nest Elevation 14
3.3.4 Nest Habitat 14
3.3.5 Nest Phenology 15
3.3.6 Nest Outcomes 17
3.3.7 Nest Flooding 17
3.4 Point Counts 19
3.4.1 Survey Effort 19
3.4.2 Results Summary 19

4.0 DISCUSSION 21
4.1 Plot Selection and Habitat 21
4.2 Nest Monitoring 21
4.2.1 Nesting Species 21
4.2.2 Nest Densities and Habitat Sampling 22

4.2.3 Nest Phenology 22
4.2.4 Nest Outcomes and Flooding 23
4.3 Point Counts 23

5.0 RECOMMENDATIONS 24
5.1 Plot Selection and Habitat 24
5.2 Nest Surveys 24

6.0 CLOSURE 25

7.0 REFERENCES 26

LIST OF TABLES (WITHIN TEXT)

Table 3.1 Habitat Classifications, Area, and Elevations of Nest Monitoring Plots 10
Table 3.2 Habitat Sampling Summary 11
Table 3.3 Average Survey Effort on Nest Monitoring Plots by Habitat Type 11
Table 3.4 Nest Locations Summary 12
Table 3.5 Species Nesting in the Headpond (HPZ) and Downstream River Channel (DRC) 12
Table 3.6 Species Diversity and Nest Density Across Nest Plot Habitat Types 15
Table 3.7 Nest Outcomes – Percentage of Total Nests in Each Area 17
Table 3.8 Nest Outcomes – Percentage of Total Nests for Each Habitat Type 17
Table 3.9 Summary of Flooded Nests Observed within the Study Area 18
Table 3.10 Point Count Survey Results by Habitat Type 19
Table 3.11 Species Detected on Nest Monitoring Plots During Point Counts 19

LIST OF FIGURES (WITHIN TEXT)

Figure 1.1 Overview of Study Area and Nest Monitoring Plots 2
Figure 3.1 Water levels (m ASL) in the headpond (HPZ) and downstream river channel (DRC) during the 2021 bird breeding season. Data is from the Tea Creek 02 (HPZ) and Site C Construction Bridge Primary (DRC) monitoring stations. 8
Figure 3.2 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, 2021 14
Figure 3.3 Percent of monitored nests active on nest monitoring plots in the headpond (HPZ) and downstream river channel (DRC) throughout the field season. 15
Figure 3.4 Estimated first egg dates for species nesting in the headpond (HPZ, blue) and downstream river channel (DRC, red). 16

LIST OF PHOTOS (WITHIN TEXT)

Photo 1 Common nighthawk nest on plot 2 13
Photo 2 Flooded spotted sandpiper nest on plot 113 18

LIST OF APPENDICES

Appendix A Sample Point Count Data Sheet
Appendix B Nest Monitoring Plots

LIST OF ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Definition
DRC	Downstream river channel
Hemmera	Hemmera Envirochem Inc.
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

1.1 Background

BC Hydro used key species groups, including migratory birds, to assess the potential effects of the Site C Clean Energy Project (Project) on Wildlife Resources in the Site C Environmental Impact Statement. 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. The recommendations of the Joint Review Panel included that, should the Project proceed, 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 and, beginning in fall 2020, the river was diverted around the construction site, creating a headpond upstream of the site. During construction, water level changes in the headpond (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 pronounced changes to the water level have the potential to affect the productivity of nesting birds.

The Peace River water regime downstream of the Site C dam is expected to change very little during construction because the rate of water input from the Peace Canyon dam will be matched to outputs from the Site C dam (BC Hydro 2013).

The first year of field surveys took place in 2021 during the construction phase of the Project and this annual report summarizes those survey results. Additional background to the monitoring program is provided in the Site C Vegetation and Wildlife Migratory Bird Nest Monitoring Program (BC Hydro 2021).

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 British Columbia 1991).

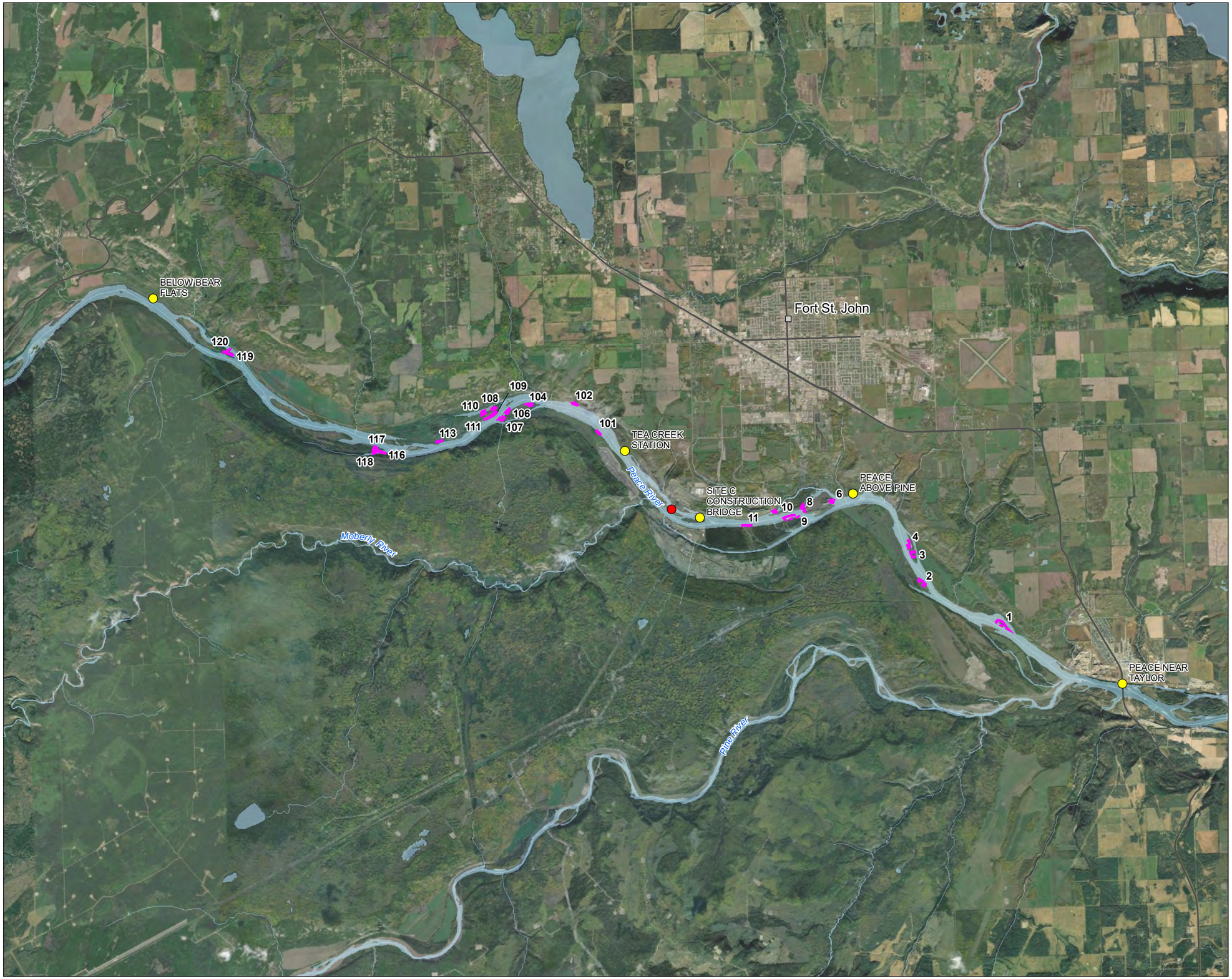
The study area for the nest monitoring program focuses on areas that may be affected by water level fluctuations and consists of 3 sub-areas:

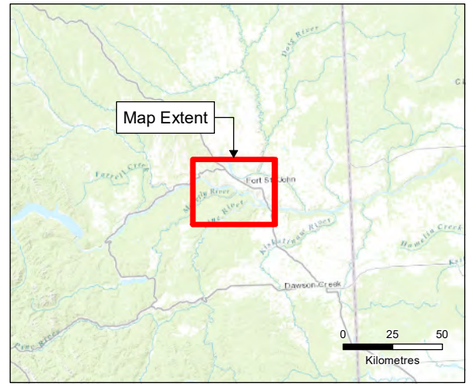
- Headpond Zone (HPZ): during construction, the temporary headpond upstream of the dam is expected to have pronounced fluctuations relative to normal river levels.
- Reservoir Drawdown Zone (RDZ): during operations, the water level of the reservoir impounded upstream of the dam will fluctuate. The zone 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.

Nest monitoring in 2021 took place within the HPZ and DRC. Once the dam is operating, upstream nest monitoring will shift from the HPZ to the RDZ.

2021 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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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 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

Previously completed habitat mapping had classified all habitat within the study area into 8 habitat categories: Aspen Shrubland, Forested Wetland, Grassland, Non Vegetated/Anthropogenic, Riparian Forest, Riparian Wetland, Upland Forest, and Water (BC Hydro 2013). The Nest Monitoring Plan (BC Hydro 2021) outlines methodology for sampling these habitats relative to their availability, and, prior to fieldwork, a tentative set of plots was selected. However, in many cases, the habitat observed in the field did not match the previously completed mapping. Much of the previously forested habitat had been logged and some areas that had been mapped as unvegetated at lower elevation were vegetated.

Thus, plots 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. These plots were classified into 7 general habitat types: riparian forest, upland forest, riparian shrub, upland shrub, wetland, open habitat (includes grassland), and unvegetated (includes sparsely vegetated habitat). These field-based habitat types were used when data were summarized by habitat.

2.2 Survey Timing

The avian 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 2021, field surveys were planned to cover an 8-week breeding season from late May though mid-July.

2.3 Field Surveys

Two survey methods were used to assess the disturbance or mortality of nesting migratory birds in the study area:

1. Nest searching and monitoring – nesting attempts of migratory bird species breeding in the sub-areas were monitored to provide a study of each of the habitats in the sub-areas during Site C construction and operations.
2. Point count surveys – these surveys were used to describe the nesting migratory bird community within the different habitat types encompassed by the study area. Point count surveys allowed for the detection of species with nests that may not have been encountered during nest searching.

2.3.1 Nest Monitoring

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 by accidentally flushing 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 detail in the Nest Monitoring Plan (BC Hydro 2021).

2.3.2 Point Counts

The methods for the collection of point count data were consistent with RIC methods (RIC 1999a), with the exception of using distance-to-detection intervals at 0-50 m, 51-100 m, and >100 m. A sample datasheet is provided in **Appendix A**. All surveys were completed in June within 4 hours of sunrise. Plots were not sampled if they were completely flooded because the intention of the surveys was to sample the species present in each habitat.

2.4 Data Management and Analysis

During the field season, the daily survey and plot visit data were tracked in spreadsheets and nest observation data were tracked on nest cards (see example in Nest Monitoring Plan (BC Hydro 2021)). This information was backed up daily to ensure no loss of information occurred.

After the field season, all data were entered into a custom database, which will provide consistent data management and organization throughout the nest monitoring program. For analysis, custom data queries were exported from the database and data analysis was completed using R (R Core Team 2021).

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.

To visualize overall water levels within the study sub-areas, we used the Tea Creek 02 station for the HPZ and the Site C Construction Bridge Primary station for the DRC (**Figure 1.1**). These stations are close to the nest monitoring plots and had few missing data.

When examining water level in relation to plot elevation, additional monitoring stations were included to reflect the water level at each plot more accurately. The additional stations were Below Bear Flats, which was closer to the most upstream HPZ plots, and Peace Above Pine and Peace Near Taylor, which were closer to the farthest downstream DRC 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 type.

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 type, 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 2021).

The numbers of nests detected within the HPZ and the DRC (both on and off plot), and within each habitat type, were calculated. For each habitat type, 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. 2020).

The ground elevation at the nest site and the nest height above ground were added together to determine the actual elevation in metres above sea level (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 were used when considering the potential for nests to interact with fluctuating water levels.

Nest phenology information was calculated for each nest, to allow for the estimation of the time periods during which nests are likely to be active for each species. The nest initiation date (the date when nest-building began) was either determined from recorded observations of nest-building activity in the field or estimated based on known nest construction timelines for that species if the clutch initiation date was known (or could be estimated). 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. 2020), and making the assumption that one 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 percentage of nests 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 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 type by dividing the sum of the numbers of nests found in each habitat type by the sum of the areas of the monitored plots for each habitat type. 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. Nest density calculations by habitat type are cumulative (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 type.

2.4.3 Point Counts

Data were summarized to provide information regarding the migratory bird species present within the study area. The numbers of individual birds detected within the HPZ and the DRC, and within each habitat type, were calculated. For each habitat type, 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 diversity metrics were calculated using the R package ‘vegan’ (Oksanen et al. 2020).

3.0 RESULTS

3.1 Water Levels

The water levels in the both the HPZ (Tea Creek Station) and DRC (Site C Construction Bridge Station) were decreasing during the early part of the breeding season and remained relatively low in early June before rising quickly toward the end of that month (**Figure 3.1**). Water levels peaked in early July and then decreased throughout the rest of the month. In the DRC, the fluctuation pattern was the same, but the relative change in elevation was smaller than in the HPZ (**Figure 3.1**).

The maximum water levels in the HPZ and DRC during the field season (May 28 through July 21) were 418.4 m ASL on July 5 and 411.3 m ASL on July 4, respectively. Nest monitoring plots were spread 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 the same pattern.

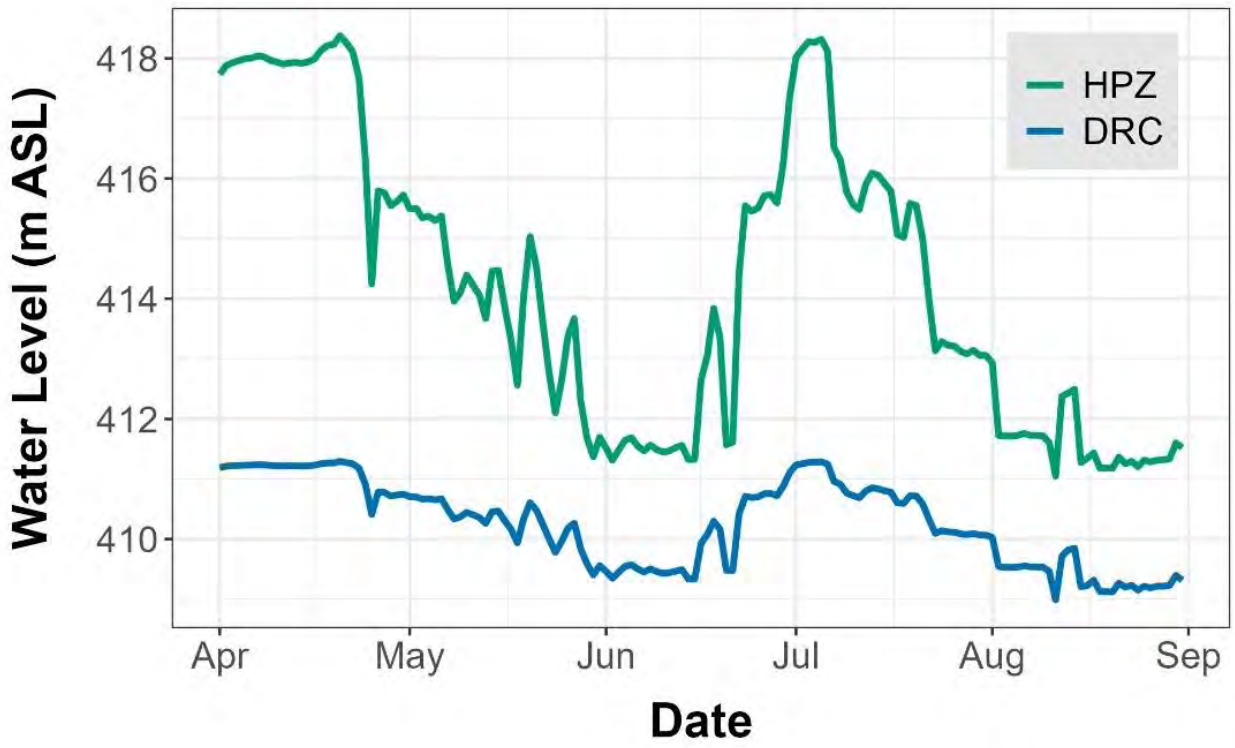

Figure 3.1 **Water levels (m ASL) in the headpond (HPZ) and downstream river channel (DRC) during the 2021 bird breeding season. Data is from the Tea Creek 02 (HPZ) and Site C Construction Bridge Primary (DRC) monitoring stations.**

3.2 Plot Selection and Habitat

Twenty-four plots covering an area of 33.1 ha were surveyed regularly during the 2021 breeding season, including 13.2 ha in the HPZ and 19.9 ha in the DRC. The elevations of plots surveyed in the HPZ and DRC ranged from 412 to 422 m and 405 to 412 m, respectively (**Table 3.1**).

Additional plots were surveyed during the early part of the season that were later dropped from regular surveying because there was not enough time to survey them thoroughly. The dropped plots represented additional areas of the same habitats represented in the final set of 24 plots.

Due to inaccuracies in existing habitat mapping, habitat plot selection was based on the habitat types observed in the field (see **Section 2.1**). The selected plots covered 5 of the 8 previously mapped habitat classes and were categorized into 7 field-based habitat types (**Table 3.1**). All 7 field-based habitat types were sampled in the HPZ; 3 of these habitat types were sampled in the DRC (**Table 3.2**).

Table 3.1 Habitat Classifications, Area, and Elevations of Nest Monitoring Plots

Plot ID	Mapped Habitat Type	Field Habitat Type	Area (ha)	Minimum Elevation (m ASL)	Average Elevation (m ASL)	Maximum Elevation (m ASL)
Headpond						
101	Upland Forest	Upland Shrub	0.42	413	418	419
102	Non Vegetated/Anthropogenic, Riparian Forest, Upland Forest, Water	Riparian Forest	0.40	412	416	422
104	Riparian Forest	Upland Shrub	0.90	416	418	419
106	Riparian Forest	Upland Forest	1.19	415	418	418
107	Riparian Forest	Riparian Forest	1.82	413	415	416
108	Non Vegetated/Anthropogenic	Open Habitat	0.82	414	415	415
109	Non Vegetated/Anthropogenic	Unvegetated	0.87	413	415	416
110	Non Vegetated/Anthropogenic	Riparian Shrub	1.58	414	415	416
111	Non Vegetated/Anthropogenic	Unvegetated	0.46	413	413	414
113	Non Vegetated/Anthropogenic	Riparian Shrub	0.38	415	416	416
116	Riparian Forest, Upland Forest, Water	Riparian Shrub	0.79	415	417	420
117	Upland Forest	Riparian Forest	1.20	416	418	421
118	Riparian Forest, Upland Forest	Wetland	1.02	416	416	418
119	Non Vegetated/Anthropogenic	Unvegetated	1.27	418	419	420
120	Riparian Wetland, Water	Unvegetated	0.13	418	419	419
Downstream River Channel						
1	Riparian Wetland, Water	Riparian Shrub	4.08	407	407	407
2	Non Vegetated/Anthropogenic	Riparian Shrub	2.76	405	407	408
3	Riparian Forest, Water	Riparian Forest	2.33	406	408	408
4	Non Vegetated/Anthropogenic, Water	Unvegetated	1.64	405	406	406
6	Non Vegetated/Anthropogenic, Riparian Forest, Water	Riparian Shrub	1.14	407	408	409
8	Non Vegetated/Anthropogenic, Water	Unvegetated	1.84	407	408	409
9	Non Vegetated/Anthropogenic, Water	Unvegetated	4.52	407	410	412
10	Non Vegetated/Anthropogenic, Upland Forest, Water	Riparian Shrub	0.83	409	411	412
11	Riparian Forest, Water	Riparian Shrub	0.76	409	410	411

Table 3.2 Habitat Sampling Summary

Habitat Type	Number of Plots Sampled (n)	Total Downstream (DRC) Area Sampled (ha)	Total Headpond (HPZ) Area Sampled (ha)	Total Area Sampled (ha)
Open Habitat	1	0	0.82	0.82
Riparian Forest	4	2.33	3.41	5.74
Riparian Shrub	8	9.57	2.75	12.32
Unvegetated	7	8.0	2.73	10.73
Upland Forest	1	0	1.19	1.19
Upland Shrub	2	0	1.32	1.32
Wetland	1	0	1.02	1.02
Total	**24**	**19.90**	**13.24**	**33.14**

3.3 Nest Monitoring

3.3.1 Survey Effort

Eight weeks of nest searching and monitoring surveys were conducted from May 30 to July 21, 2021. Total field effort totaled 524 person-hours, including 496 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 387 person-hours searching for nests, 81 checking nests, and 28 completing other field activities (e.g., point counts). On average, more effort was spent on plots with more complex vegetation structure (e.g., shrubs and forests) (**Table 3.3**).

Table 3.3 Average Survey Effort on Nest Monitoring Plots by Habitat Type

Habitat Type (Field Classified)	Number of Plots (n)	Average Nest Searching Effort (total person-hours)	Average Nest Checking Effort (total person-hours)	Average Other Activity Effort (total person-hours)	Average Total Effort (person-hours)
Open Habitat	1	1	0	0	2
Riparian Forest	4	27	6	2	35
Riparian Shrub	8	18	4	1	23
Unvegetated	7	2	1	1	3
Upland Forest	1	30	1	0	31
Upland Shrub	2	40	6	1	47
Wetland	1	16	7	2	25

3.3.2 Nest Records

A total of 126 nests were found in 2021, 60 in the HPZ and 66 in the DRC (**Table 3.4**). Ninety-four (75%) of the nests found were located on nest monitoring plots and 32 nests (25%) were found off-plot (**Table 3.4**).

Table 3.4 Nest Locations Summary

Nest Location	DRC	HPZ	Total
On-plot	51	43	**94**
Off-plot	15	17	**32**
Total	**66**	**60**	**126**

Thirty species were found nesting within the study area (**Table 3.5**). This included 23 species nesting on nest monitoring plots and 7 additional species detected nesting outside of nest monitoring plots. There were 22 species detected in the HPZ and 18 in the DRC.

The most nests were detected in the HPZ for song sparrow (*Melospiza melodia*, 8 nests), red-winged blackbird (*Agelaius phoeniceus*, 7 nests), and yellow warbler (*Setophaga petechia*, 6 nests) (**Table 3.5**). In the DRC, the most nests were detected for song sparrow (21 nests), spotted sandpiper (*Actitis macularius*, 17 nests), and American robin (*Turdus migratorius*, 8 nests) (**Table 3.5**).

Common nighthawk (*Chordeiles minor*), a species federally listed as threatened, was detected nesting on plot 2 in the DRC. It was first observed on the plot while surveying in early June, but, despite regular surveys, a nighthawk was not observed there again until the nest was found on July 21 (**Photo 1**).

Other notable observations included a trumpeter swan (*Cygnus buccinator*) nest in a wetland (off-plot) in the HPZ. This was the only location in the study area where wetland habitat was observed and a plot in this area was the only location where red-winged blackbirds were observed nesting.

Table 3.5 Species Nesting in the Headpond (HPZ) and Downstream River Channel (DRC)

Common Name	Scientific Name	DRC		HPZ		Total
		Off-plot	On-plot	Off-plot	On-plot	
Trumpeter swan	*Cygnus buccinator*	-	-	1	-	**1**
Canada goose	*Branta canadensis*	1	8	-	-	**9**
Mallard	*Anas platyrhynchos*	1	-	-	1	**2**
American coot	*Fulica americana*	-	-	-	1	**1**
Killdeer	*Charadrius vociferus*	-	2	-	-	**2**
Spotted sandpiper	*Actitis macularius*	3	10	1	3	**17**
Common nighthawk	*Chordeiles minor*	-	1	-	-	**1**
Alder flycatcher	*Empidonax alnorum*	1	1	-	4	**6**
Least flycatcher	*Empidonax minimus*	1	3	-	-	**4**
Eastern kingbird	*Tyrannus tyrannus*	1	-	-	-	**1**
Red-eyed vireo	*Vireo olivaceus*	-	-	-	1	**1**
American crow	*Corvus brachyrhynchos*	-	-	1	1	**2**
Black-capped chickadee	*Poecile atricapillus*	-	-	-	1	**1**
Swainson's thrush	*Catharus ustulatus*	-	-	1	-	**1**
American robin	*Turdus migratorius*	1	7	-	1	**9**

Common Name	Scientific Name	DRC		HPZ		Total
		Off-plot	On-plot	Off-plot	On-plot	
Gray catbird	*Dumetella carolinensis*	-	-	1	-	**1**
Cedar waxwing	*Bombycilla cedrorum*	1	3	2	2	**8**
Yellow warbler	*Setophaga petechia*	-	1	4	2	**7**
Yellow-rumped warbler	*Setophaga coronata*	-	1	-	-	**1**
Black-and-white warbler	*Mniotilta varia*	-	-	-	1	**1**
American redstart	*Setophaga ruticilla*	-	-	-	3	**3**
Common yellowthroat	*Geothlypis trichas*	1	-	-	-	**1**
Chipping sparrow	*Spizella passerina*	-	-	1	-	**1**
Clay-colored sparrow	*Spizella pallida*	-	2	2	1	**5**
Song sparrow	*Melospiza melodia*	1	12	3	5	**21**
Lincoln's sparrow	*Melospiza lincolnii*	1	-	-	3	**4**
White-throated sparrow	*Zonotrichia albicollis*	1	-	-	3	**4**
Dark-eyed junco	*Junco hyemalis*	-	-	-	3	**3**
Red-winged blackbird	*Agelaius phoeniceus*	-	-	-	7	**7**
Brewer's blackbird	*Euphagus cyanocephalus*	1	-	-	-	**1**
Total		**15**	**51**	**17**	**43**	**126**

Photo Credit: Chris Coxson

Photo 1 Common nighthawk nest on plot 2

3.3.3 Nest Elevation

Nests were located both at and above ground level on nest monitoring plots in both the DRC and 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 3.2**). This illustrates potential for nest flooding to occur if those nests are active at the time when the water level is at that elevation. Nest timing in relation to water levels is discussed below in **Section 4.2.4** Nest Outcomes and Flooding.

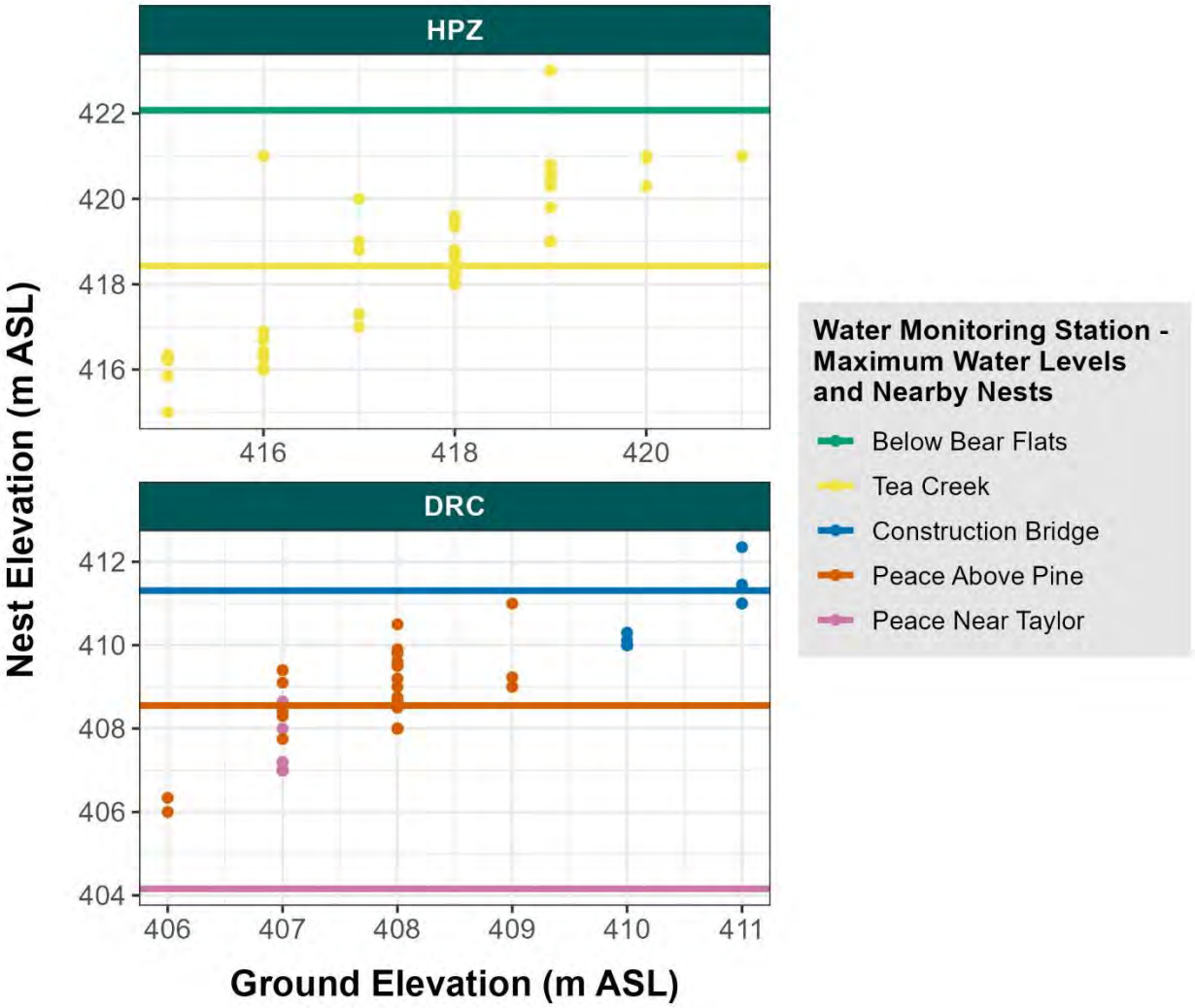

Figure 3.2 **Headpond (HPZ) and downstream river channel (DRC) nest elevations (points) and maximum water levels (horizontal lines) at nearby monitoring stations between April 1 and August 31, 2021.**

3.3.4 Nest Habitat

Species richness and diversity were highest in riparian forest, riparian shrub, and upland shrub (**Table 3.6**). Nest density was the highest in wetland, upland shrub, and riparian forest (**Table 3.6**). In the wetland habitat, nest density was higher, but diversity was low because most of the nests were red-winged blackbirds, which tend to nest in groups.

Only one nest (killdeer, *Charadrius vociferus*) was found in unvegetated habitat, and none were found in open habitat.

Table 3.6 Species Diversity and Nest Density Across Nest Plot Habitat Types

Habitat Type	Number of Nests (n)	Species Richness	Pielou Evenness	Nest Density (nests/ha)		
				DRC	HPZ	Overall
Open Habitat	0	-	-	-	-	-
Riparian Forest	32	13	0.92	6.01	5.27	5.57
Riparian Shrub	41	10	0.83	3.76	1.82	3.33
Unvegetated	1	1	-	0.13	-	0.09
Upland Forest	3	2	0.92	-	2.53	2.53
Upland Shrub	9	7	0.97	-	6.82	6.82
Wetland	8	2	0.54	-	7.85	7.85

3.3.5 Nest Phenology

Nest phenology curves show a similar trend in nest timing for the HPZ and DRC, with the peak in nesting activity in mid-June (**Figure 3.3**). The curve is cut off in late July because the field season ended on July 21.

There were differences in nest timing among some species (**Figure 3.4**). For example, song sparrow and American robin initiated nests throughout the season, whereas alder flycatcher (*Empidonax alnorum*) and cedar waxwing (*Bombycilla cedrorum*) did not begin nesting until later in June **(Figure 3.4**). For many species, the nest sample size after one year of data collection is relatively small.

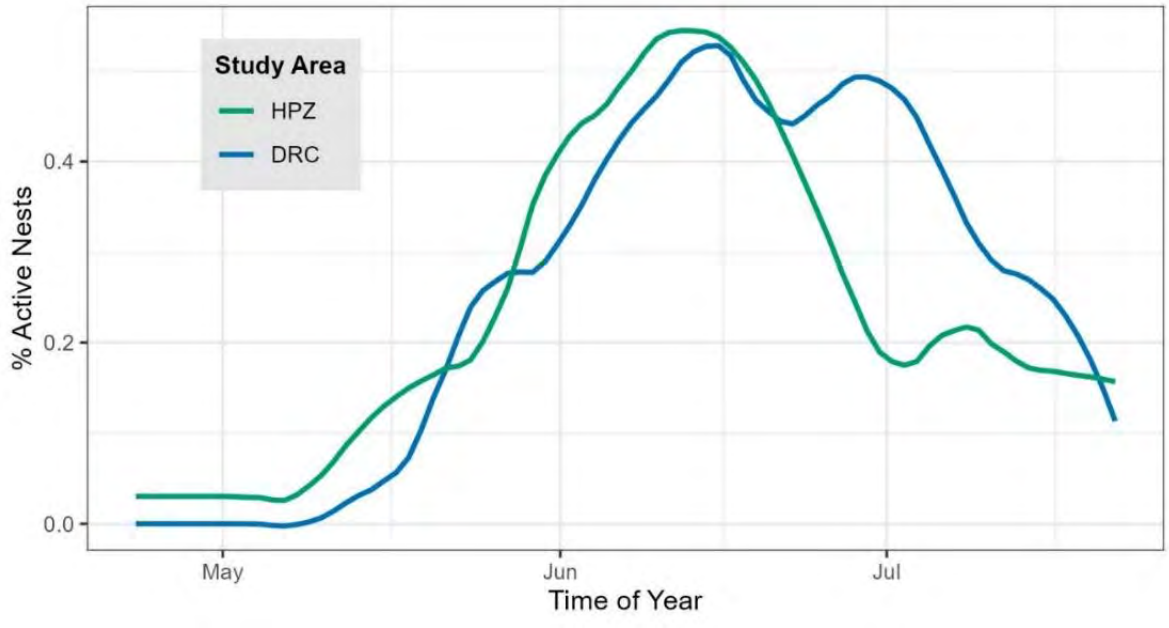

Figure 3.3 Percent of monitored nests active on nest monitoring plots in the headpond (HPZ) and downstream river channel (DRC) throughout the field season.

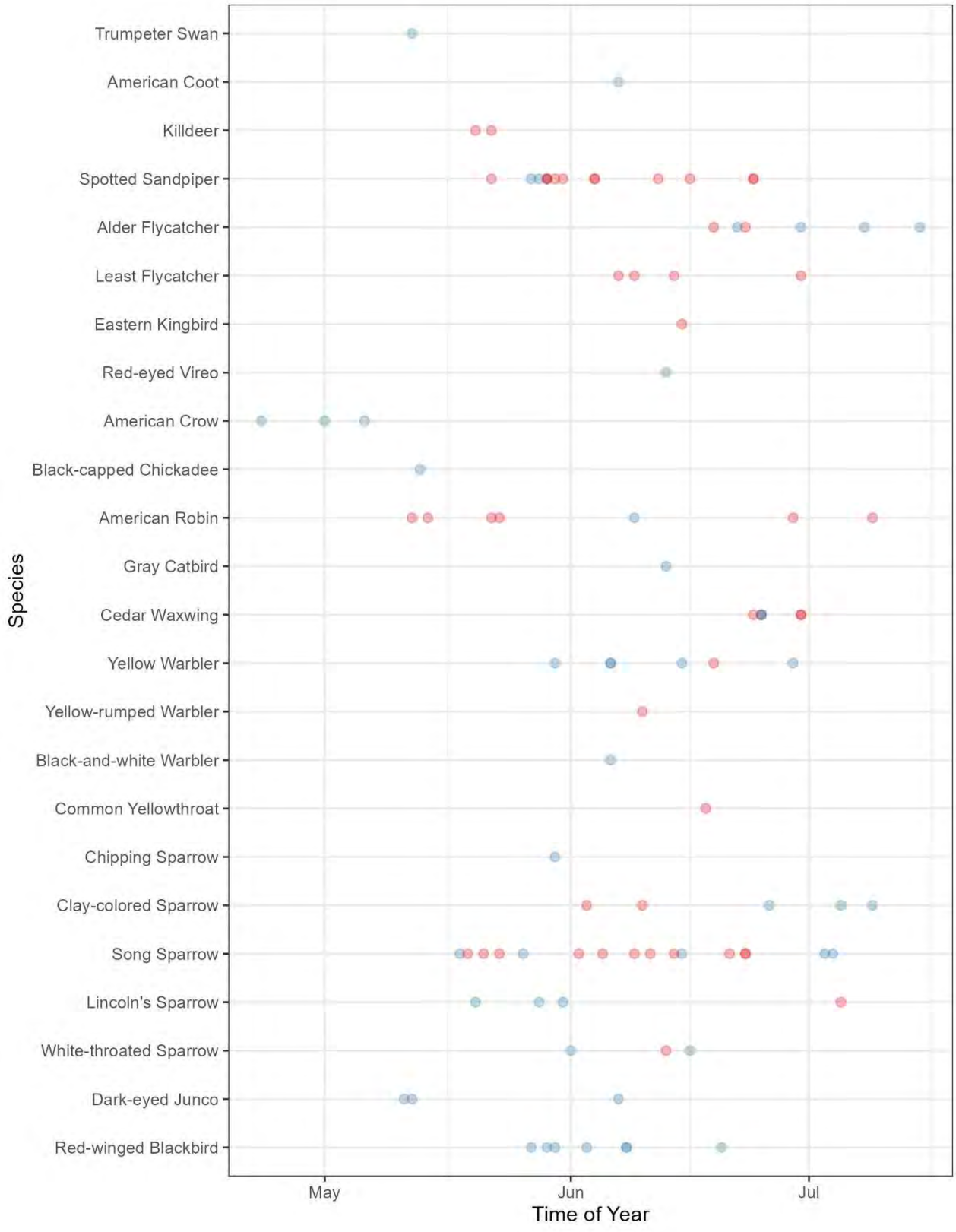

Figure 3.4 Estimated first egg dates for species nesting in the headpond (HPZ, blue) and downstream river channel (DRC, red).

3.3.6 Nest Outcomes

Across the entire study area, 44% of nests detected were considered successful, 33% failed, and 23% had an unknown outcome (**Table 3.7**). The most common cause of nest failure was predation. Flooding caused the failure of 6% of nests and affected 7 nests monitored in the HPZ and 1 in the DRC (**Table 3.7**).

Table 3.7 Nest Outcomes – Percentage of Total Nests in Each Area

Nest Outcome	HPZ (% of total nests)	DRC (% of total nests)	Overall (% of total nests)
Abandoned	3	0	2
Failed by unknown means	3	2	2
Flooded	12	2	6
Predation	25	21	23
Successful	35	52	44
Unknown	7	17	12
Unknown due to end of season	15	8	11

Nest outcomes were also examined by habitat, however some habitat types (e.g., unvegetated and upland forest) had very few nests (**Table 3.8**) so these percentages should be interpreted cautiously.

Table 3.8 Nest Outcomes – Percentage of Total Nests for Each Habitat Type

Habitat Type	Number of Nests (n)	Successful (%)	Failed – Flooding (%)	Failed – Predation (%)	Failed – Other (%)	Unknown (%)	Unknown (end of season) (%)
Open Habitat	0	-	-	-	-	-	-
Riparian Forest	32	40	3	25	6	-	25
Riparian Shrub	41	54	2	17	-	21	5
Unvegetated	1	100	-	-	-	-	-
Upland Forest	3	67	33	-	-	-	-
Upland Shrub	9	33	-	33	11	11	11
Wetland	8	50	25	25	-	-	-

3.3.7 Nest Flooding

Flooding affected 8 nests of 5 species (**Table 3.9**, **Photo 1**). Nest flooding occurred in late June and early July as the water level increased in both the HPZ and DRC (**Section 3.1** Water Levels).

Flooding primarily affected birds nesting on or low to the ground; however, it also affected cedar waxwing, which nested more than a metre above the ground, but bred on a lower elevation plot (**Table 3.9**).

Table 3.9 Summary of Flooded Nests Observed within the Study Area

Typical Nesting Location	Common Name	Plot Habitat Types	Number of Nests Flooded	Average Nest Height (m)	Average Nest Elevation (m ASL)	
					DRC	HPZ
Ground	Spotted sandpiper	Riparian forest, riparian shrub	2	0	407.0	416.0
	Dark-eyed junco	Upland forest	1	0	-	418.0
Low Shrub	Song sparrow	Upland shrub	1	0	-	417.0
	Red-winged blackbird	Wetland	2	0.51	-	416.5
Shrub	Cedar waxwing	Riparian shrub	2	1.26	-	416.3

Some nests were found on previously flooded plots after water levels dropped in July. On plot 110, a cedar waxwing was found on a nest in an area where 2 cedar waxwing nests had failed due to flooding. Additionally, a white-throated sparrow was found nesting on plot 107 soon after the water level dropped. This nest was elevated above the ground, which is less common for this typically ground-nesting sparrow. It is possible that the nest was initiated above water while the plot was still flooded, when nesting on the ground was not an option.

Photo Credit: Catherine Craig

Photo 2 Flooded spotted sandpiper nest on plot 113

3.4 Point Counts

3.4.1 Survey Effort

One point count survey was completed for 18 of the 24 nest monitoring plots between June 22 and June 26, 2021. The plots not surveyed were flooded by this date, meaning that the open habitat (grassland) plot and 5 unvegetated plots were not sampled (**Table 3.10**).

3.4.2 Results Summary

Fifty-seven species were detected during point count surveys, of which 28 were located on nest monitoring plots (**Table 3.11**). The greatest numbers of individual birds and bird species detected were in riparian forest, riparian shrub, and upland shrub habitat types (**Table 3.10**). Only one species, song sparrow, was detected on an unvegetated plot and it is unlikely that it was breeding there.

Table 3.10 Point Count Survey Results by Habitat Type

Habitat Type	Number of Plots	Number of Individuals	Species Richness	Pielou Evenness
Open Habitat	0	-	-	-
Riparian Forest	4	46	21	0.95
Riparian Shrub	8	45	14	0.85
Unvegetated	2	1	1	-
Upland Forest	1	11	8	0.97
Upland Shrub	2	23	10	0.96
Wetland	1	8	6	0.93
Total	**18**	**134**	**-**	-

Table 3.11 Species Detected on Nest Monitoring Plots During Point Counts

Common Name	Scientific Name	DRC	HPZ	Total
Alder flycatcher	*Empidonax alnorum*	1	9	10
American crow	*Corvus brachyrhynchos*	-	6	6
American redstart	*Setophaga ruticilla*	-	2	2
American robin	*Turdus migratorius*	7	4	11
Baltimore oriole	*Icterus galbula*	1	-	1
Black-and-white warbler	*Mniotilta varia*	-	1	1
Brewer's blackbird	*Euphagus cyanocephalus*	2	-	2
Brown-headed cowbird	*Molothrus ater*	1	2	3
Clay-colored sparrow	*Spizella pallida*	3	4	7
Common yellowthroat	*Geothlypis trichas*	-	9	9
Dark-eyed junco	*Junco hyemalis*	-	4	4
Downy woodpecker	*Dryobates pubescens*	1	-	1

Common Name	Scientific Name	DRC	HPZ	Total
Killdeer	*Charadrius vociferus*	1	-	1
Least flycatcher	*Empidonax minimus*	1	2	3
Lincoln's sparrow	*Melospiza lincolnii*	2	7	9
Northern waterthrush	*Parkesia noveboracensis*	-	2	2
Purple finch	*Haemorhous purpureus*	-	1	1
Red-eyed vireo	*Vireo olivaceus*	5	6	11
Red-winged blackbird	*Agelaius phoeniceus*	-	7	7
Rose-breasted grosbeak	*Pheucticus ludovicianus*	-	1	1
Song sparrow	*Melospiza melodia*	13	19	32
Spotted sandpiper	*Actitis macularius*	3	3	6
Swainson's thrush	*Catharus ustulatus*	-	1	1
Trumpeter swan	*Cygnus buccinator*	-	6	6
White-throated sparrow	*Zonotrichia albicollis*	-	5	5
Wilson's snipe	*Gallinago delicata*	-	1	1
Yellow-bellied sapsucker	*Sphyrapicus varius*	-	1	1
Yellow warbler	*Setophaga petechia*	5	6	11
	Total individuals detected	**46**	**109**	**155**

4.0 DISCUSSION

Results for the nest monitoring program from 2021 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 Plot Selection and Habitat

One of the challenges of the 2021 field season was that the previous habitat mapping did not accurately represent the distribution of habitat types observed in the field. This was partly due to logging for reservoir construction since the habitat mapping occurred, meaning that many previously forested areas had become early seral shrub habitat. However, there were inconsistencies with the other categories also, such that the previous mapping could not be used as a proxy for mapping new habitat types.

Due to these inconsistencies, time was spent at the beginning of the field season covering ground within the study area to determine how mapped habitat had changed, and what habitat types were present within the study area. Habitat selected for nest monitoring plots was classified into 7 habitat types, but these have not been mapped throughout the study area, so the total available area of each habitat type is unknown. This adjustment prevented us from meeting the habitat sampling goals outlined in the Nest Monitoring Plan (BC Hydro 2021) because meeting those sampling goals requires having knowledge of the total available area of each habitat type.

Based on field observations, the plots sampled are an approximate representation of available habitat, but this cannot be confirmed quantitatively. The sampling among habitats was more evenly distributed in the HPZ than in the DRC. There may also be additional habitat types available in the HPZ or DRC that were not observed and thus were not sampled this year.

4.2 Nest Monitoring

4.2.1 Nesting Species

Thirty species were found nesting during this first year of the study, and it is anticipated that additional nesting species will be detected in future years. During a similar project in southern BC, the cumulative species total increased quickly during the first few years of the study (Hemmera 2020).

The sub-areas had similar numbers of species detected nesting (22 in HPZ, 18 in DRC), but there were differences in the numbers of each species found in the sub-areas, and some species were only detected in one sub-area. For example, gray catbird (*Dumetalla carolinensis*) was only detected in the HPZ, and many more nests for spotted sandpiper were found in the DRC. Further sampling of habitats in each sub-area will provide additional insight into differences between the sub-areas.

The detection of common nighthawk nesting indicates the presence of breeding habitat for this at-risk species in the DRC. This species has high breeding site fidelity, suggesting that it may be present in this area in future years (Ng et al. 2018).

4.2.2 Nest Densities and Habitat Sampling

Species diversity was highest in more complex habitats because these provide a diversity of nest locations (i.e., ground, shrub, tree) suitable for a wider range of species. This finding matched the results of similar multi-species studies (Hemmera 2020). However, there were some species, such as killdeer, that were only found nesting in less complex habitats.

Due to the relatively small area of each habitat type surveyed so far and the lost survey effort on some plots due to flooding, the species-habitat associations and nest densities should be interpreted with caution, particularly for under-sampled habitats. For example, only 1 or 2 plots have been sampled so far for open habitat, upland forest, upland forest, and wetland, and an area of less than 2 ha was sampled for each habitat, compared to the 12 ha of riparian shrub that was sampled across 8 plots. Sampling was more evenly distributed in the HPZ than the DRC because not all habitat types were well-represented in the DRC.

Nest densities are likely slightly underestimated as there were known nesting pairs on plots that nests were not found for. This is particularly true for forested habitat types because nests situated higher up in trees are more difficult to detect.

Furthermore, unvegetated and open habitats were often at lower elevations, and some of these flooded early in the season. As they were then unavailable for monitoring, the nest densities calculated may be lower than they would have been if the habitats had remained available for nesting. Attempts will be made to locate some higher elevation plots of these habitats for monitoring in 2022.

4.2.3 Nest Phenology

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 May 28 and July 21, early- and late-nesting species are likely slightly under-represented so far in the study. 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.

There may also be a bias in the overall phenology estimate due to some habitats and related species being sampled more intensively. In the HPZ, habitats were sampled more evenly, but, in the DRC, most of the sampling occurred in only two habitat types (**Table 3.2**). This resulted in relatively larger numbers of spotted sandpiper, song sparrow, and American robin nests found in the DRC compared to other species, so the phenology of these species may be over-represented in **Figure 3.3**. Additional habitat types available within the DRC will be targeted for sampling in future years.

As noted above, some habitats were sampled less than others and lower elevation habitats were flooded, preventing the detection of later nesting species that might otherwise have used these habitats. This would be a larger factor in the HPZ where water level changes were more dramatic, and more plots were completely flooded. For example, the flooding of many plots in the HPZ occurred soon after cedar waxwing were first observed nest-building; therefore, it is possible we would have located additional nests of this late-nesting species if flooding had not occurred.

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). These adjustments will allow for early- and late-nesting species to be documented nesting in the study area.

4.2.4 Nest Outcomes and Flooding

The primary cause of nest failure was predation, which is typical for nest monitoring studies (Ricklefs 1969; Hemmera 2020; Thompson 2007). However, nest flooding caused the failure of 8 nests, including 7 in the HPZ where there was a larger increase in water level in comparison to the DRC. Nest flooding occurred because there were lower water levels throughout June while nests were being established, followed by a water level increase in late June and early July while those nests were still active (**Figure 3.1**). This water level change coincided with the peak of the bird breeding season (**Figure 3.3**), maximizing the potential for nest flooding impacts.

Nesting activity was documented after the water levels dropped on 2 plots that had flooded, indicating that previously flooded habitat can be quickly used by nesting birds if it becomes available again. The observation of the white-throated sparrow nesting above ground-level may also indicate a change in typical nest site choice in response to the flooding.

Once more data have been collected, it should be possible to examine factors affecting daily nest survival for more common species, such as spotted sandpiper and song sparrow, for comparison with similar studies (Hemmera 2020). With updated habitat maps it will be possible to estimate the total impact of nest flooding in the study area based on elevation and habitat availability.

One additional challenge with determining potential nest flooding impacts is that water level data do not have good connectivity with all plots because some plots are distant from a water monitoring station due to the size of the study area. This will simply add a bit of uncertainty to the estimates.

4.3 Point Counts

The sample size for most habitat types is not large (e.g., only a single plot for upland forest and wetland), so results should be interpreted cautiously. The lower sample size is partly due to some of the plots (6) being flooded prior to point count surveys taking place. Additionally, due to time spent early in the season determining which plots to sample in 2021, there was only time for one round of point counts to be completed in this initial year of the survey.

Fewer total species were detected on plots during point count sampling (28) compared to nest monitoring surveys (30), although an additional point count round would likely have increased the number of species detected using point counts. There were several species detected during point counts for which nests were not found, and which had also been observed incidentally while conducting nest monitoring surveys.

If off-plot detections are included, then point counts detected a much larger number of species (57), but some these detections cannot be related to habitat and may not be within an area likely to be affected by water fluctuations. Many of the nest monitoring plots had an irregular or linear shape to capture an area of habitat along the edge of the river.

The habitat types determined to have the greatest diversity from point count data were the same as the most diverse habitat types as determined by nest monitoring. Thus, the point counts did not add much additional information to what was already known from the time spent nest searching on plots.

5.0 RECOMMENDATIONS

5.1 Plot Selection and Habitat

As mentioned above, the habitat sampling plan outlined in the Nest Monitoring Plan (BC Hydro 2021) could not be followed due to inconsistences in the habitat mapping. Additional mapping of the habitat types within the DRC and HPZ will be completed prior to the 2022 field season using aerial imagery and elevation data collected by BC Hydro in 2021. This will allow for an estimate of the total available area for each habitat type so that habitat types are sufficiently sampled in each sub-area. Sufficient sampling of each habitat type for nesting birds will provide better estimates of the nest densities within each habitat type and sub-area, and of the potential impact of nest flooding.

For 2022, efforts will be made to locate and sample habitat types within the DRC that were not sampled in 2021 (i.e., upland forest, upland shrub, open habitat, and wetland), but that exist in the HPZ, as well as to increase the amount of open/grassland habitat sampled overall, if available and accessible. This will add confidence to our knowledge of which species nest in each habitat type within each sub-area.

Structurally complex habitat (e.g., forest) requires greater effort to survey than many other habitat types. Survey effort will be reallocated to reduce the area of complex habitat surveyed (in comparison to 2021) to ensure sufficient time to locate as many nests as possible in all habitat types.

5.2 Nest Surveys

For 2022, the planned 6 weeks of sampling will take place over the peak breeding period of June and early July. This will allow for the detection of as many nests and nesting species as possible in the HPZ during this last year of monitoring for the construction phase of the Project.

Point counts are planned to be discontinued in 2022 because these surveys provided little new information about the numbers of individuals and species present on nest monitoring plots. Due to the amount of time spent on plots nest searching using behavioural observations, the field crew was aware of the number of potential breeding pairs and species present on each plot prior to point counts occurring. For 2022, we plan to record data more formally on the number of territories suspected to be on a plot. Tracking territories provides a way to document these observations and this information can be used to improve estimates of nest density, particularly for habitats that are harder to search (e.g., forests and dense shrubs). For example, if a pair of birds is regularly present on a plot and observed exhibiting breeding behaviour, but a nest is not found, it can be assumed that there was a nesting attempt. In these cases, the total number of nests for the plot will include these suspected nests. Nest searching and monitoring will continue to provide information about nest placement and nest outcomes, including documenting flooding impacts.

6.0 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.

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APPENDIX A

Sample Point Count Data Sheet

Bird Point Count Data Form

Project: _____ Page ___ of ____

POINT: ____ TIME: _____ OBS: _____ DATE: _____
Month Day Year

Coordinates (UTM): _____ Zone: _____

Wind:
__ none
__ 1-5 kp/h (smoke drifts/leaves rustle)
__ 6-11 kp/h (wind felt on face)
__ 12-19 kp/h (flags extended/leaves move)
__ 20-28 kp/h (dust and small branches move)
__ >28 kp/h (branches of a moderate size move; small trees begin to sway)

Precipitation:
__ none
__ drizzling
__ raining

Temp: _____

% CC: _____

SPECIES	0-3 Minutes				3-5 Minutes				5-10 Minutes				NOTES
	< 50m	50-100	>100m	flyover	< 50m	50-100	>100m	flyover	< 50m	50-100	>100m	flyover	

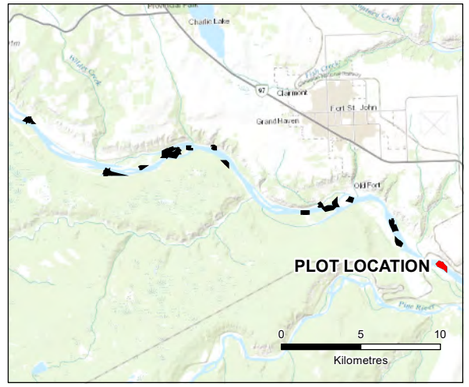
Comments: _____

Record each bird heard with a tick (I). Change (I) to a cross (+) if later determined to be male (e.g., singing). Enter "V" for visual sightings; if male enter a "+". Birds originally detected >50m should be re-recorded as <50m if they move into the area. + = male, I = female or undetermined sex, J = juvenile.

APPENDIX B
Nest Monitoring Plots

2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 1



Legend

- Nest Location
- Nest Monitoring Plot

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: © Google Earth, 2020. Date of Imagery: 06/25/2021
- 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"

103707-03	Production Date: Mar 1, 2022	Appendix B-1

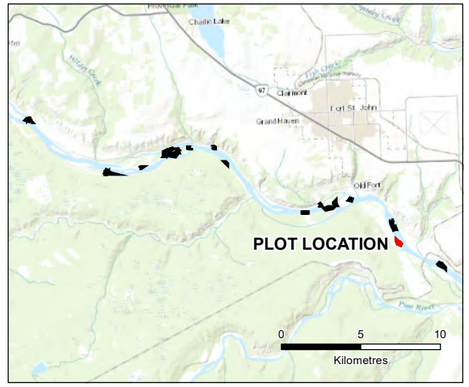
Hemmera An Ausenco Company

BC hydro

Path: S:\Geomatics\Projects\103707\03\mxd\Apx8 _ 103707_03_Plots_220301.mxd

2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 2



Legend

- Nest Location
- Nest Monitoring Plot

Notes

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Sources

- Aerial Image: © Google Earth, 2020. Date of Imagery: 06/25/2021
- 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"

103707-03	Production Date: Mar 1, 2022	Appendix B-2

Hemmera An Ausenco Company

BC hydro

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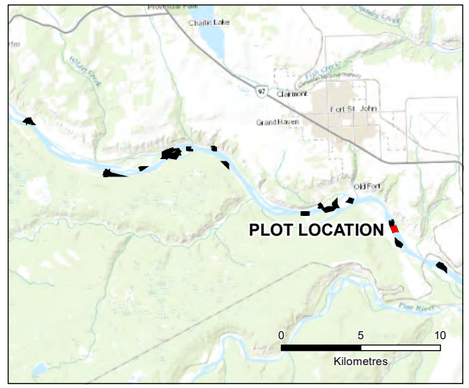
2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 3



Legend

- Nest Location
- Nest Monitoring Plot

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
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Sources

- Aerial Image: © Google Earth, 2020. Date of Imagery: 06/25/2021
- 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"

103707-03	Production Date: Mar 1, 2022	Appendix B-3

Hemmera An Ausenco Company

BC hydro

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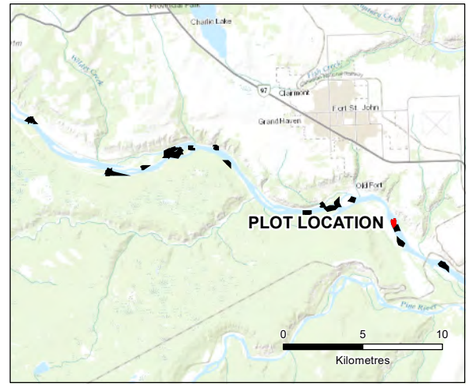
2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 4



Legend

- Nest Location
- Nest Monitoring Plot

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: © Google Earth, 2020. Date of Imagery: 06/25/2021
- 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"

103707-03	Production Date: Mar 1, 2022	Appendix B-4

Hemmera An Ausenco Company

BC hydro

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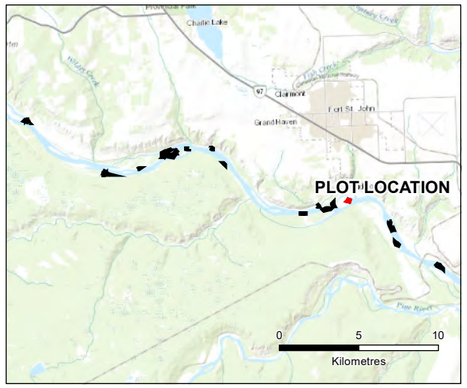
2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 6



Legend

- Nest Location
- Nest Monitoring Plot

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: © Google Earth, 2020. Date of Imagery: 04/24/2019
- Inset Basemap: ESRI World Topographic Map

N

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Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

103707-03	Production Date: Mar 1, 2022	Appendix B-5

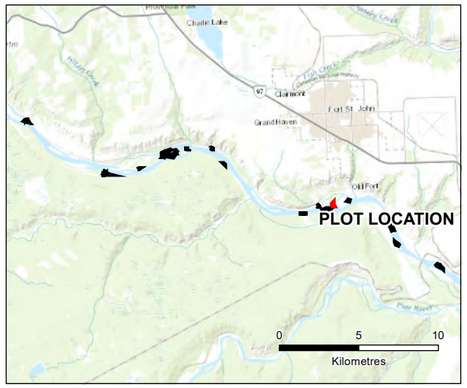
Hemmera An Ausenco Company

BC hydro

Path: S:\Geomatics\Projects\103707\03\mxd\Apx8_103707_03_Plot6_220301.mxd

2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 9



Legend

- Nest Location
- Nest Monitoring Plot

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: © Google Earth, 2020. Date of Imagery: 04/24/2019
- 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 1, 2022	Appendix B-6

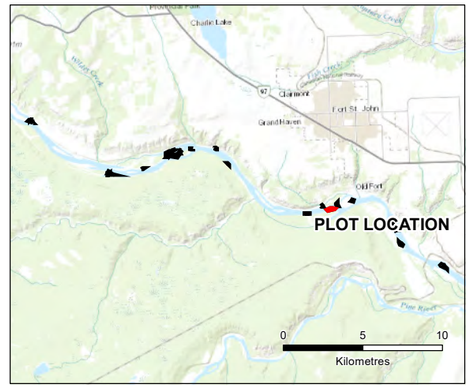
Hemmera An Ausenco Company

BC hydro

Path: S:\Geomatics\Projects\103707\03\mxd\Apx8_103707_03_Plots_220301.mxd

2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 8



Legend

- Nest Location
- Nest Monitoring Plot

Notes

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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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Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

103707-03	Production Date: Mar 1, 2022	Appendix B-7

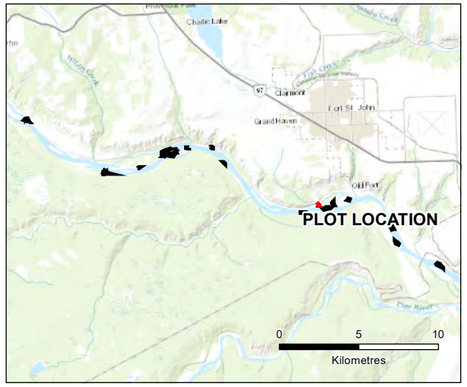
Hemmera An Ausenco Company

BC hydro

Path: S:\Geomatics\Projects\103707\03\mxd\AppB__103707_03_Plots_220301.mxd

2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 10



Legend

- Nest Location
- Nest Monitoring Plot

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
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Sources

- Aerial Image: © Google Earth, 2020. Date of Imagery: 04/24/2019
- 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 1, 2022	Appendix B-8

Hemmera An Ausenco Company

BC hydro

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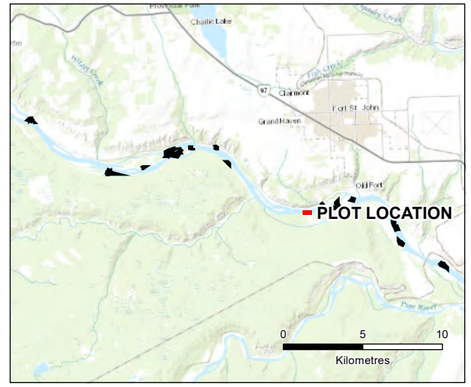
2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 11



Legend

- Nest Location
- Nest Monitoring Plot

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

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Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

103707-03	Production Date: Mar 1, 2022	Appendix B-9

Hemmera An Ausenco Company

BC hydro

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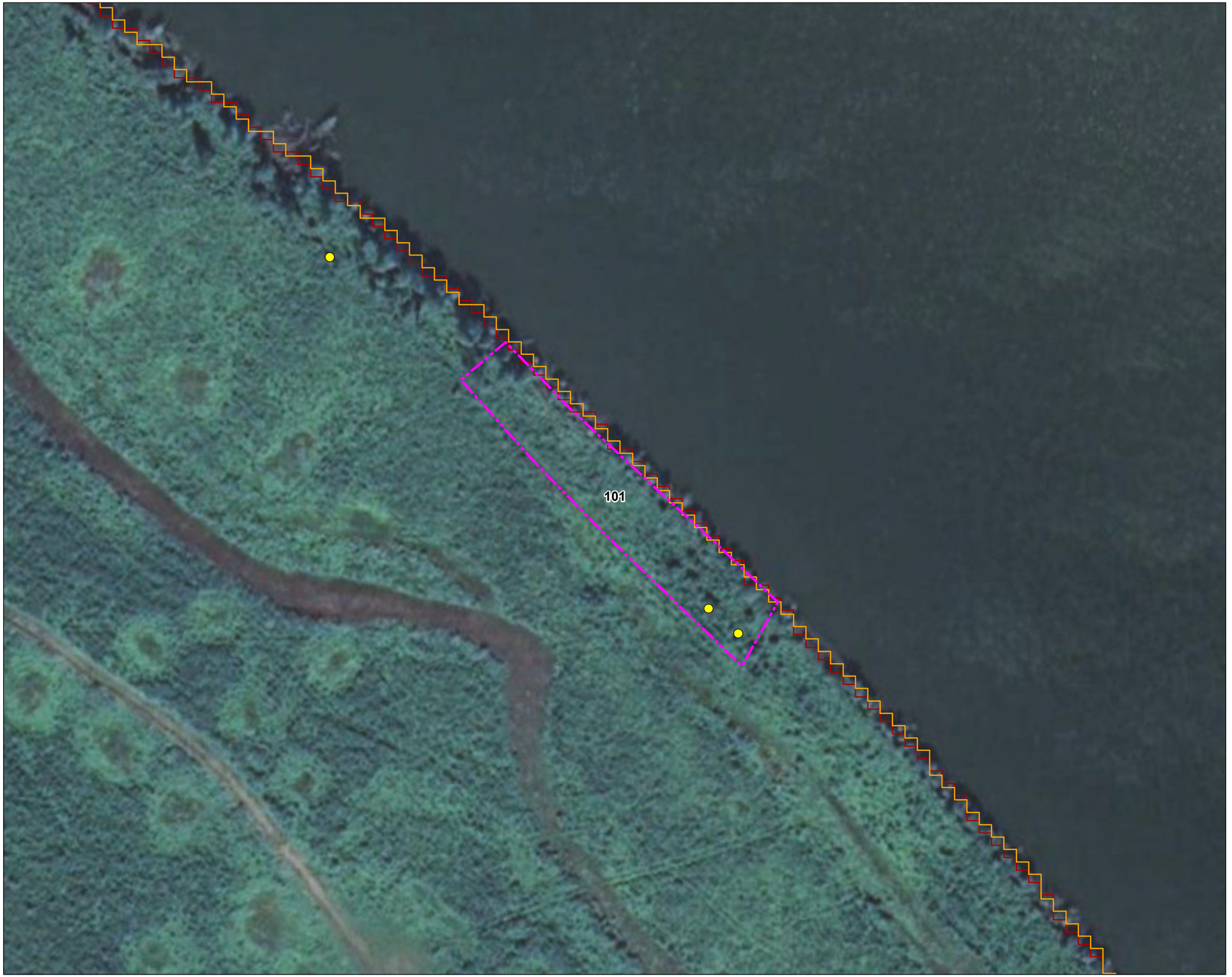
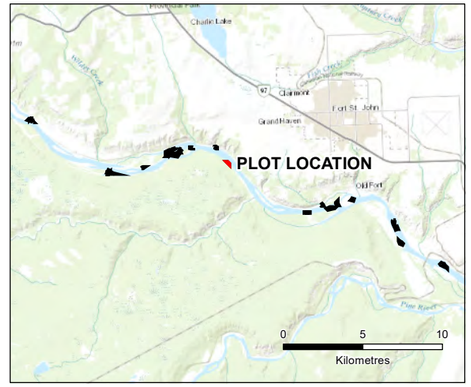


2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 101



Legend

- Nest Location
- Nest Monitoring Plot
- Headpond Zone Mininum Normal Reservoir Level
- Headpond Zone Maximum Normal Reservoir Level

Notes

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Sources

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Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

103707-03	Production Date: Mar 1, 2022	Appendix B-10

Hemmera An Ausenco Company

BC hydro

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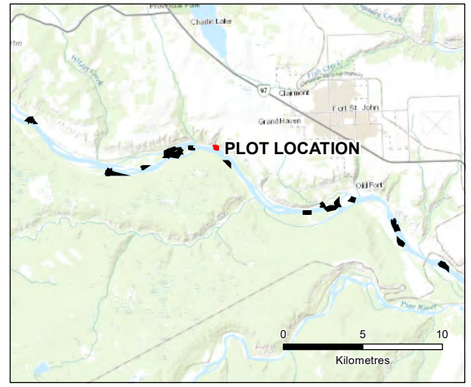
2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 102



Legend

- Nest Location
- Nest Monitoring Plot
- Headpond Zone Mininum Normal Reservoir Level
- Headpond Zone Maximum Normal Reservoir Level

102

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
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Sources

- Aerial Image: © Google Earth, 2020. Date of Imagery: 07/22/2021
- Inset Basemap: ESRI World Topographic Map

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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 1, 2022	Appendix B-11

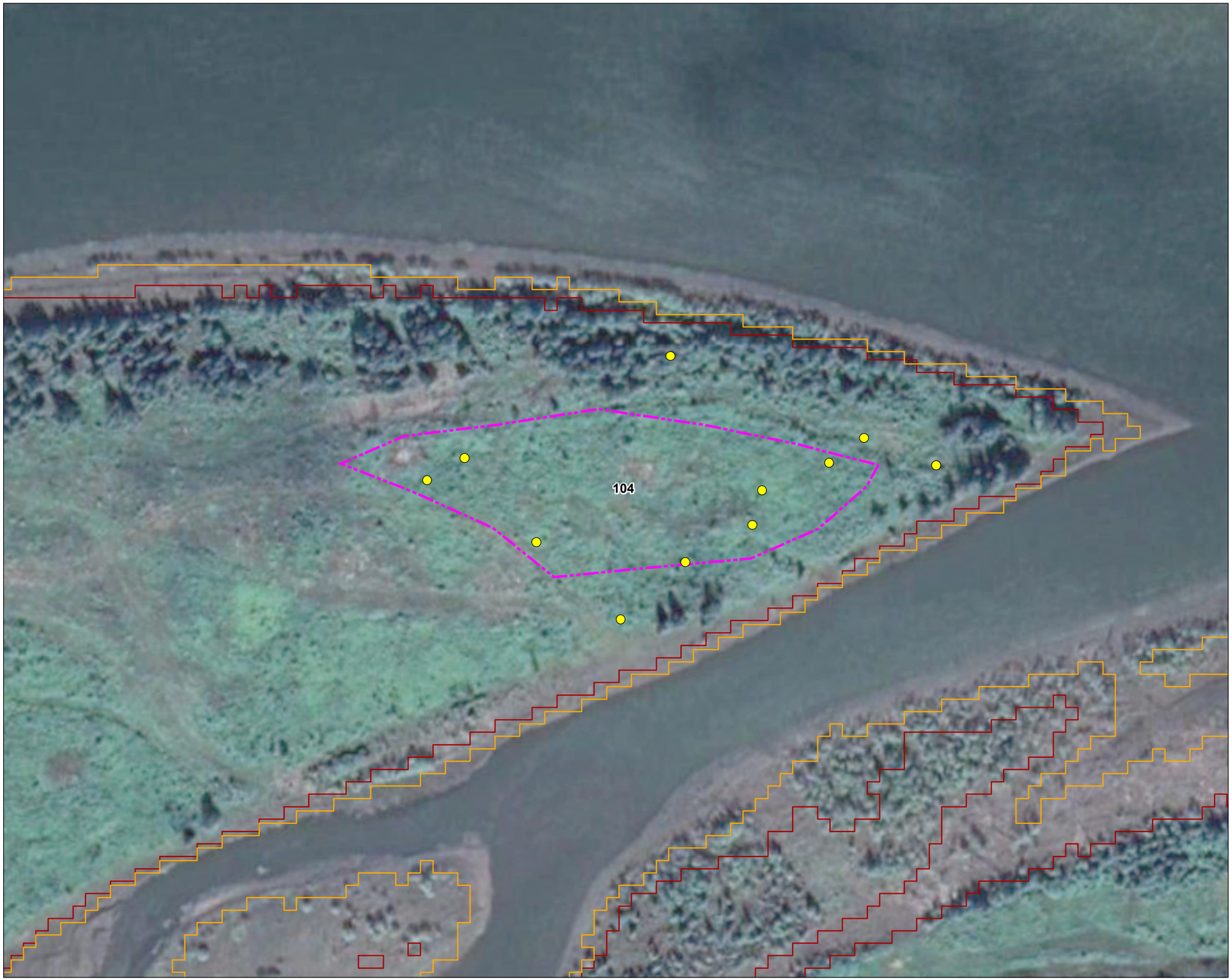
Hemmera An Ausenco Company

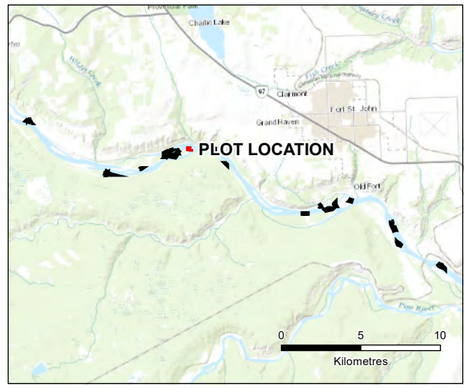
BC hydro

Path: S:\Geomatics\Projects\103707\03\mxd\AppB__103707_03_Plots_220301.mxd

2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 104





Legend

- Nest Location
- Nest Monitoring Plot
- Headpond Zone Mininum Normal Reservoir Level
- Headpond Zone Maximum Normal Reservoir Level

Notes

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Sources

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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 1, 2022	Appendix B-12

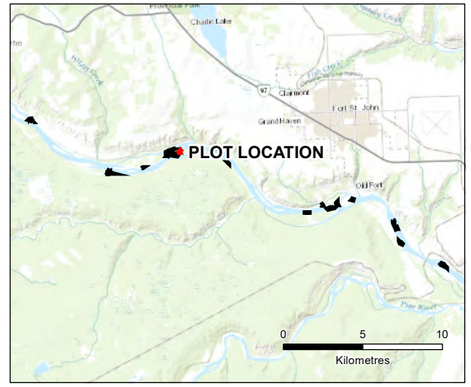
Hemmera An Ausenco Company

BC hydro

Path: S:\Geomatics\Projects\103707\03\mxd\AppB_103707_03_Plots_220301.mxd

2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 106



Legend

- Nest Location
- Nest Monitoring Plot
- Headpond Zone Mininum Normal Reservoir Level
- Headpond Zone Maximum Normal Reservoir Level

106

107

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
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Sources

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0 20 40 60 80 100

Metres

NAD 1983 UTM Zone 10N

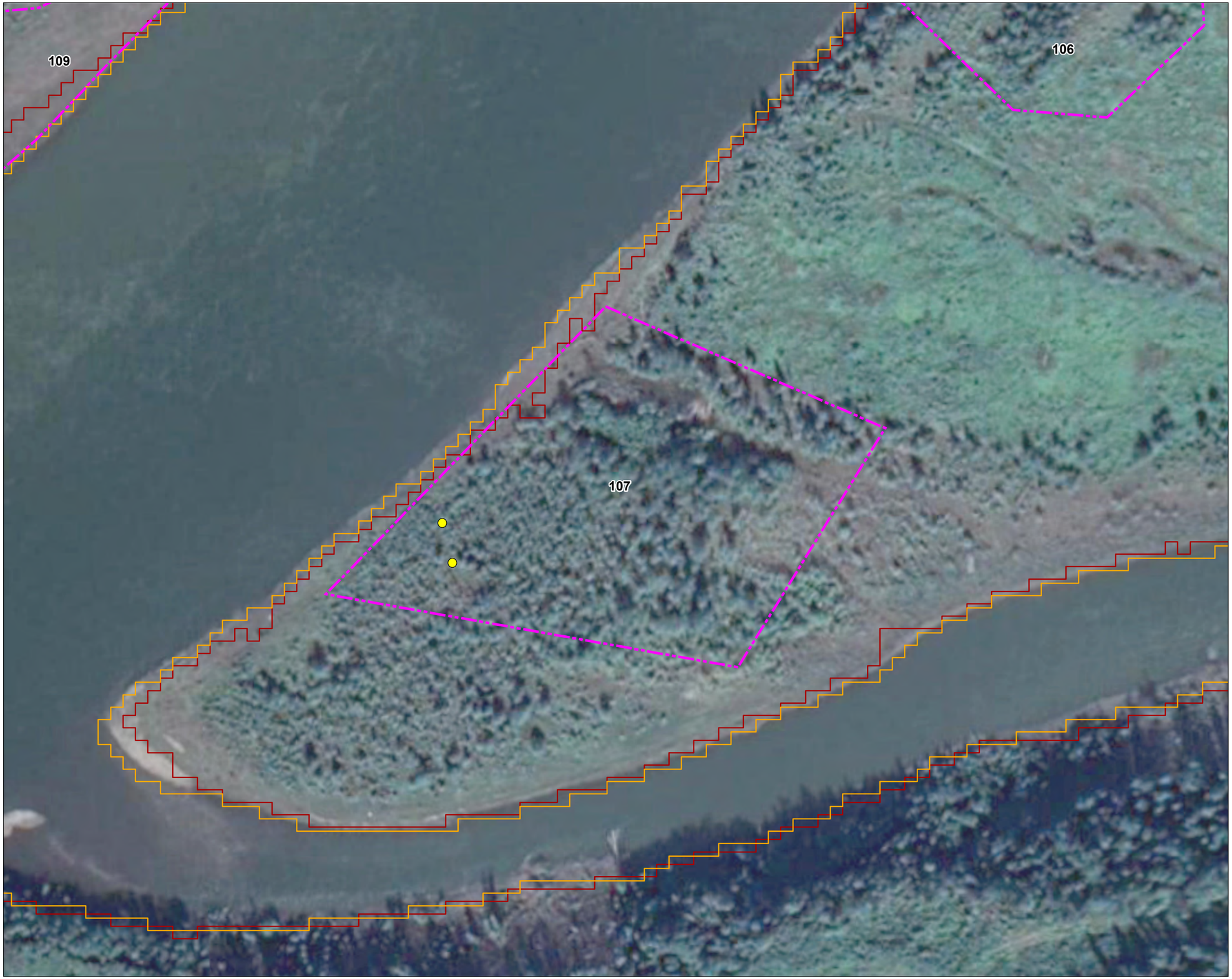
Page Size: 11" x 17"

103707-03	Production Date: Mar 1, 2022	Appendix B-13

Hemmera An Ausenco Company

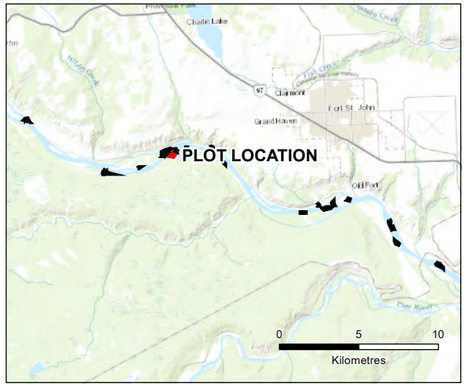
BC hydro

Path: S:\Geomatics\Projects\103707\03\mxd\AppB__103707_03_Plots_220301.mxd



2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 107



Legend

- Nest Location
- Nest Monitoring Plot
- Headpond Zone Mininum Normal Reservoir Level
- Headpond Zone Maximum Normal Reservoir Level

Notes

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Sources

- Aerial Image: © Google Earth, 2020. Date of Imagery: 07/22/2021
- Inset Basemap: ESRI World Topographic Map

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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 1, 2022	Appendix B-14

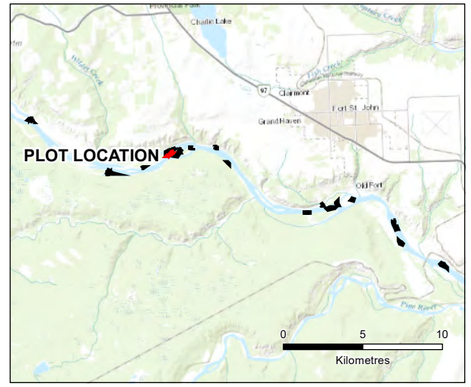
Hemmera An Ausenco Company

BC hydro

Path: S:\Geomatics\Projects\103707\03\mxd\Arp08_103707_03_Pole_220301.mxd

2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 109 and 111



Legend

- Nest Location
- Nest Monitoring Plot
- Headpond Zone Mininum Normal Reservoir Level
- Headpond Zone Maximum Normal Reservoir Level

Notes

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Sources

- Aerial Image: © Google Earth, 2020. Date of Imagery: 07/22/2021
- Inset Basemap: ESRI World Topographic Map

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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 1, 2022	Appendix B-15

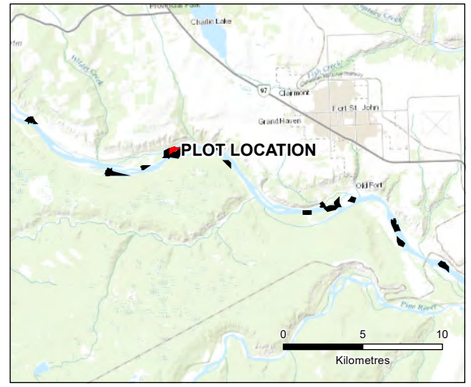
Hemmera An Ausenco Company

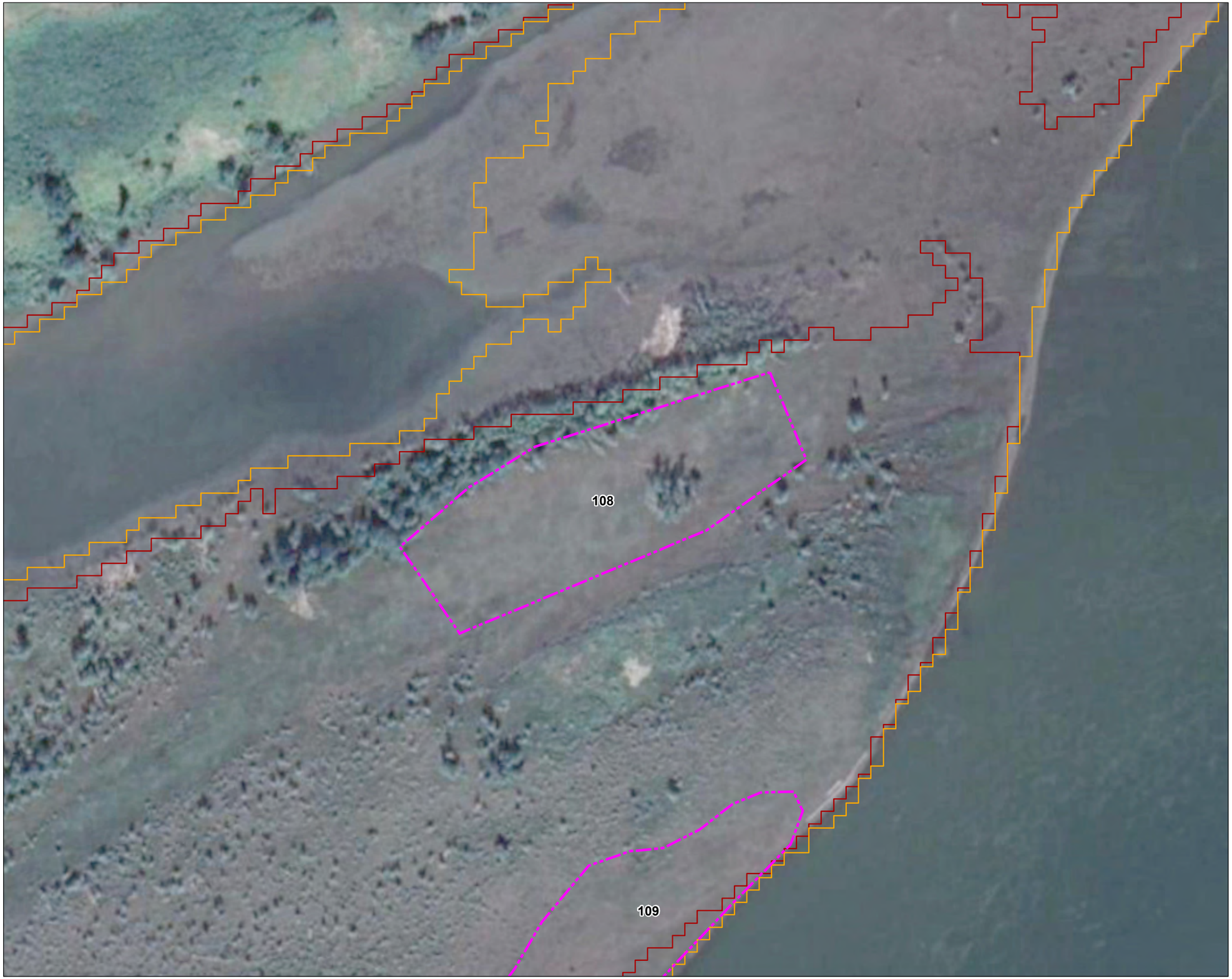
BC hydro

Path: S:\Geomatics\Projects\103707\03\mxd\Ap0B__103707_03_Plots_220301.mxd

2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 108





Legend

- Nest Monitoring Plot
- Headpond Zone Mininum Normal Reservoir Level
- Headpond Zone Maximum Normal Reservoir Level

Notes

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Sources

- Aerial Image: © Google Earth, 2020. Date of Imagery: 07/22/2021
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Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

103707-03	Production Date: Mar 1, 2022	Appendix B-16

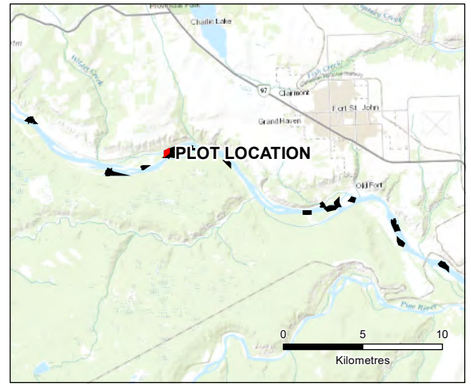
Hemmera An Ausenco Company

BC hydro

Path: S:\Geomatics\Projects\103707\03\mxd\AppB__103707_03_Pnts_220301.mxd

2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 110



Legend

- Nest Location
- Nest Monitoring Plot
- Headpond Zone Mininum Normal Reservoir Level
- Headpond Zone Maximum Normal Reservoir Level

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
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Sources

- Aerial Image: © Google Earth, 2020. Date of Imagery: 07/22/2021
- 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"

103707-03	Production Date: Mar 1, 2022	Appendix B-17

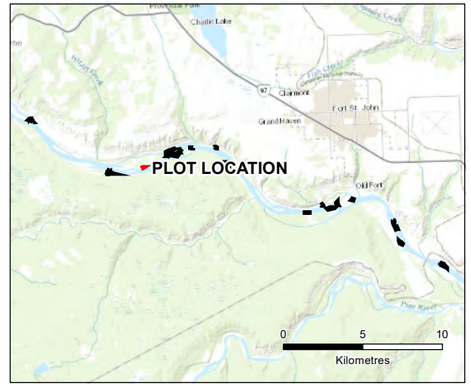
Hemmera An Ausenco Company

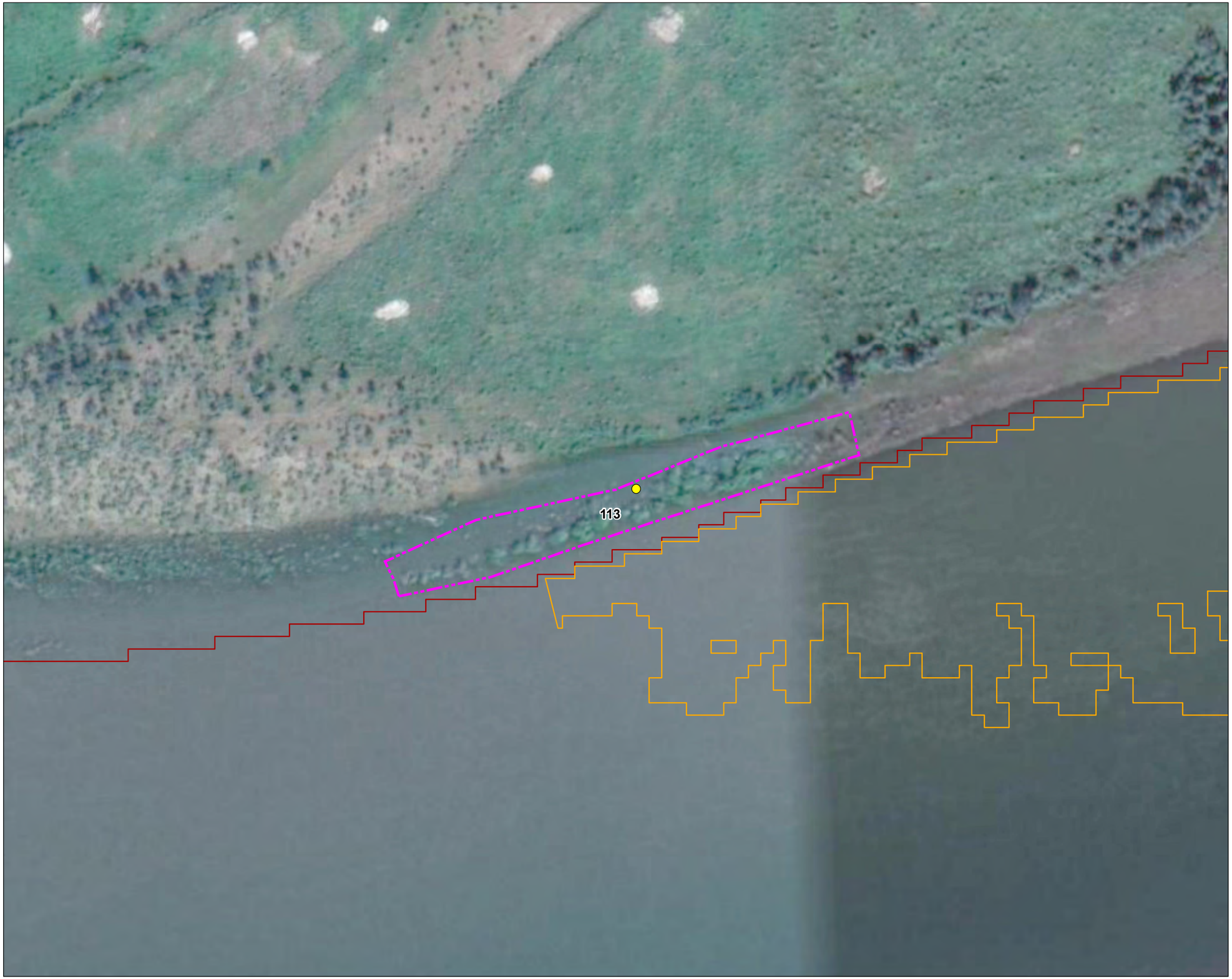
BC hydro

Path: S:\Geomatics\Projects\103707\03\mxd\AppB_103707_03_Plots_220301.mxd

2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 113





Legend

- Nest Location
- Nest Monitoring Plot
- Headpond Zone Mininum Normal Reservoir Level
- Headpond Zone Maximum Normal Reservoir Level

Notes

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Sources

- Aerial Image: © Google Earth, 2020. Date of Imagery: 07/22/2021
- Inset Basemap: ESRI World Topographic Map

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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 1, 2022	Appendix B-18

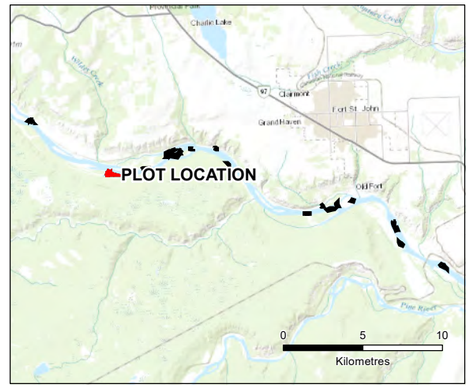
Hemmera An Ausenco Company

BC hydro

Path: S:\Geomatics\Projects\103707\03\mxd\App8_103707_03_Plots_220301.mxd

2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 116, 117, and 118



Legend

- Nest Location
- Nest Monitoring Plot

Notes

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Sources

- Aerial Image: © Google Earth, 2020. Date of Imagery: 06/28/2021
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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 1, 2022	Appendix B-19

Hemmera An Ausenco Company

BC hydro

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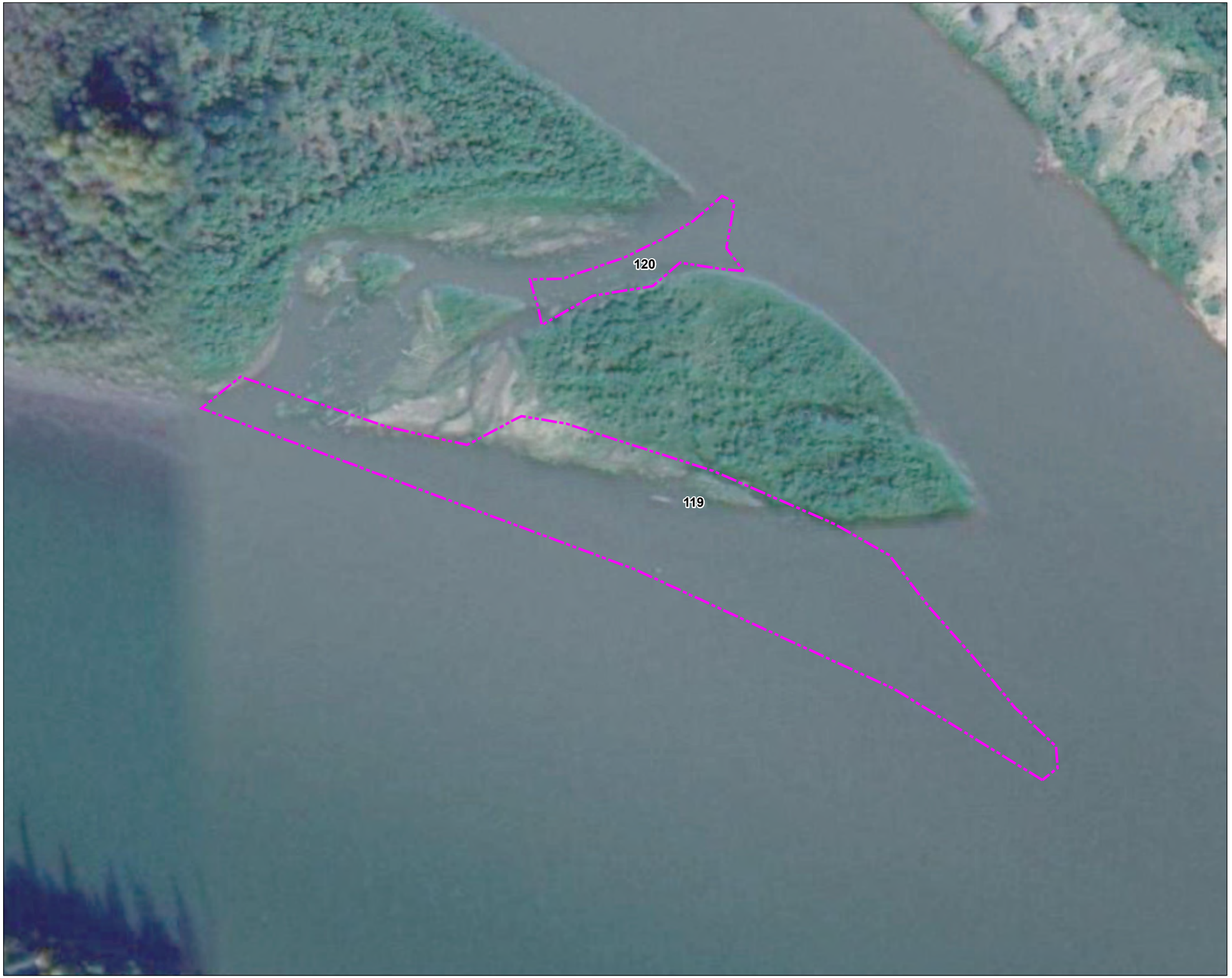
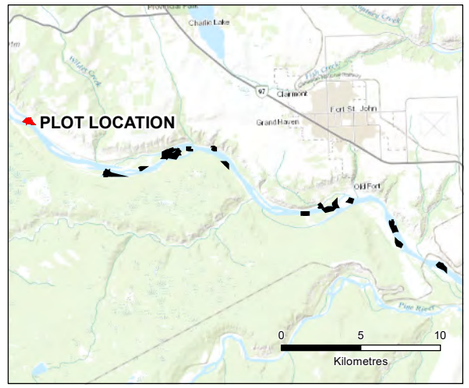


2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 119 and 120



Legend

Nest Monitoring Plot

Notes

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Sources

- Aerial Image: © Google Earth, 2020. Date of Imagery: 06/28/2021
- 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 1, 2022	Appendix B-20

Hemmera An Ausenco Company

BC hydro

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Appendix 5. Wetland Monitoring 2021 Field Summary Report

Site C Clean Energy Project
Wetland Monitoring Program
2021 Annual Report

DATE: MARCH 21, 2022

PRESENTED TO:

BC Hydro
1111 West Georgia Street, 9th floor
Vancouver, BC V6E 4G2

PRESENTED BY:

EcoLogic Consultants Ltd.
224 – 998 Harbourside Drive
North Vancouver, BC V7P 3T2
Phone: 604 803-7146

and

Tetra Tech Canada Incorporated
on behalf of Saulteau EBA Environmental Services Joint Venture (SEES JV)
885 Dunsmuir Street, Suite 1000
Vancouver, BC V6C 1N5
Phone: 604 685-0275

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 2021 field program was focused on construction phase monitoring of wetlands that were sampled in 2019, as well as full baseline assessment of the last two wetlands that were sampled in 2016 before the Project-specific monitoring methodologies were created. A total of 45 wetlands were sampled in 2021, with 40 sites along the transmission line and five sites in the downstream Project area along the Peace River. All targeted wetlands were sampled in 2021. From 2022 on, all field surveys will focus on construction phase monitoring, with 2022 resulting in the completion of the two-year sampling intervals. After 2022, wetlands will be re-assessed at five-year intervals. 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.

Data on the physical, ecological, biogeochemical, and hydrological conditions collected at each of the 2021 wetlands are presented in this report.

TABLE OF CONTENTS

Executive Summary i

Table of Contents ii

List of Figures iii

List of Tables iv

List of Plates v

List of Appendices vi

1. Introduction 1

1.1 Project Conditions 1

1.2 Project Overview 1

1.3 Study Area 2

2. Methods 3

2.1 Site Selection 3

2.2 Field Methodology 3

2.3 Ecosystem Classification and Mapping 4

2.4 Floristic Quality Index 6

2.4.1 Introduction 6

2.4.2 FQI Standards and Field Protocols 7

3. Results 10

3.1 Summary of 2021 Field Survey Effort 10

3.2 Ecosystem Classification and Mapping 17

3.3 Wetland Summaries 17

3.3.1 Bog Overview 17

3.3.2 Fen Overview 21

3.3.3 Marsh Overview 23

3.3.4 Shallow Open Water Overview 29

3.3.5 Swamp Overview 31

3.3.6 Floodplain Overview 33

3.4 Floristic Quality Index 36

3.4.1 Species Richness 36
3.4.2 Coefficient of Conservatism Values 37
3.4.3 Wetland Indicator Species 41
3.4.4 Non-Native Vegetation Species 43
3.4.5 FQI Score 44
3.4.6 FQI Discussion 45
4. Summary of Wetland Sampling: 2016−2021 47
5. Wetland Sampling Plan: 2022−2027 50
References 55

List of Figures

Figure 3.1-1. Location of 2021 Sample Sites 12
Figure 3.1-2. Location of 2021 Sample Sites – TL Phase B 13
Figure 3.1-3a. Location of 2021 Sample Sites – TL Phase A 14
Figure 3.1-3b. Location of 2021 Sample Sites – TL Phase A 15
Figure 3.1-4. Location of 2021 Sample Sites - Downstream 16
Figure 3.4-1. Individual Species Richness for Each Wetland Assessed in 2019 and 2021 36
Figure 3.4-2. Comparison of Species Richness by Wetland (2019 and 2021) 37
Figure 3.4-3. Coefficient of Conservatism Value Distribution for Fens Assessed in 2019 and 2021 38
Figure 3.4-4. Coefficient of Conservatism Value Distribution for Marshes Assessed in 2019 and 2021 38
Figure 3.4-5. Coefficient of Conservatism Value Distribution for Swamps Assessed in 2019 and 2021 39
Figure 3.4-6. Coefficient of Conservatism Value Distribution for Bogs Assessed in 2019 and 2021 39
Figure 3.4-7. Coefficient of Conservatism Value Distribution for Floodplains Assessed in 2019 and 2021 40
Figure 3.4-8. Coefficient of Conservatism Value Distribution for Open Water Wetlands Assessed in 2019 and 2021 40

Figure 3.4-9. Percentage of Wetland Indicator Species Identified for Each Wetland Assessed in 2019 and 2021 42

Figure 3.4-10. Comparison of Wetland Indicator Species by Wetland Type (2019 and 2021) 42

Figure 3.4-11. Comparison of Non-native Species by Wetland (2019 and 2021) 43

Figure 3.4-12. Percentage of Non-native Species Identified for Each Wetland Assessed in 2019 and 2021 44

Figure 3.4-13. Individual FQI Scores for Each Wetland Assessed in 2019 and 2021 44

Figure 3.4-14. Comparison of FQI Scores by Wetland Type (2019 and 2021) 45

List of Tables

Table 2.1-1. Target Number and Type of Construction Phase Wetlands for 2021 3

Table 2.2-1. Baseline and Construction Phase Wetland Monitoring Program: Data Categories and Parameters 4

Table 2.3-1. Crosswalk of Existing PAZ Ecosystem Classification and Current Provincial Ecosystem Mapping Codes 5

Table 2.3-2. Increments used for Recording Vegetation Cover for the Wetland FQI Quadrats as Adapted from the Ecological Land Survey Site Description Manual (ASRD 2003) 8

Table 2.3-3. Wetland Indicator Status Codes and Descriptions[1] 9

Table 3.1-1. Summary of Wetlands Sampled in 2021 10

Table 3.2-1. Summary of Ecosystem Classification and Mapping Changes 17

Table 3.3-1. Summary of Bogs Sampled in 2021 17

Table 3.3-2. Summary of Fens Sampled in 2021 21

Table 3.3-3. Summary of Marshes Sampled in 2021 23

Table 3.3-4. Summary of Shallow Open Water Sampled in 2021 29

Table 3.3-5. Summary of Swamps Sampled in 2021 31

Table 3.3-6. Summary of Floodplains Sampled in 2021 33

Table 3.4-1. Wetland indicator status codes and descriptions[1] 41

Table 4-1. Summary of Wetland Sampling; 2016-2021 47

Table 4-2. Baseline and Construction Monitoring Wetlands Sampled from 2018 to 2021 47

Table 5-1. Summary of Wetlands Sampled from 2016 to 2021 and Planned Construction Monitoring for 2021 to 2027 50

Table 5-2. Wetlands Sampled from 2016 to 2021 and Planned Construction Monitoring for 2021 to 2027 50

List of Plates

Plate 3.3-1. Wb03 Black spruce - Lingonberry - Peat-moss bog at wetland WL251 along the transmission line in 2019. 18

Plate 3.3-2. Wb03 Black spruce - Lingonberry - Peat-moss bog at wetland WL251 along the transmission line in 2021. 18

Plate 3.3-3. Wb06 Tamarack - Water sedge - Fen moss bog at WL228 along the transmission line in 2019. 19

Plate 3.3-4. Wb06 Tamarack - Water sedge - Fen moss bog at WL228 along the transmission line in 2021. 19

Plate 3.3-5. Wb08 Black spruce - Soft-leaved sedge - Peat-moss bog at WL221 along the transmission line in 2019. 20

Plate 3.3-6. Wb08 Black spruce - Soft-leaved sedge - Peat-moss bog at WL221 along the transmission line in 2021. 20

Plate 3.3-7. Wf01 Water sedge - Beaked sedge fen at PI4 along the transmission line in 2019. 21

Plate 3.3-8. Wf01 Water sedge - Beaked sedge fen at PI4 along the transmission line in 2021. 22

Plate 3.3-9. Wf02 Scrub birch - water sedge fen at MWL02 along the transmission line in 2019. 22

Plate 3.3-10. Wf02 Scrub birch - water sedge fen at MWL02 along the transmission line in 2021. 23

Plate 3.3-11. Wm00 Marsh (unclassified) at MWL19 along the transmission line in 2019. 24

Plate 3.3-12. Wm00 Marsh (unclassified) at MWL19 along the transmission line in 2021. 25

Plate 3.3-13. Wm01 Beaked sedge - Water sedge marsh at WL104 along the transmission line in 2018. 25

Plate 3.3-14. Wm01 Beaked sedge - Water sedge marsh at WL104 along the transmission line in 2021. 26

Plate 3.3-15. Wm02 Swamp horsetail - Beaked sedge marsh at MWL14 along the transmission line in 2019. 26

Plate 3.3-16. Wm02 Swamp horsetail - Beaked sedge marsh at WML14 along the transmission line in 2021. 27

Plate 3.3-17. Wm03 Awned sedge marsh at WML33 along the transmission line in 2019. 27

Plate 3.3-18. Wm03 Awned sedge marsh at WML33 along the transmission line in 2021. 28

Plate 3.3-19. Wm15 Bluejoint - Beaked sedge marsh at WML08 along the transmission line in 2019. 28

Plate 3.3-20. Wm15 Bluejoint - Beaked sedge marsh at MWL08 along the transmission line in 2021. 29

Plate 3.3-21. Shallow Open Water at MWL59 along the transmission line in 2019. 30

Plate 3.3-22. Shallow Open Water at MWL59 along the transmission line in 2021. 30

Plate 3.3-23. Ws02 Mountain alder – Pink spirea – Sitka sedge swamp at WL203 in the downstream portion of the Peace River in 2019. 31

Plate 3.3-24. Ws02 Mountain alder – Pink spirea – Sitka sedge swamp at WL203 in the downstream portion of the Peace River in 2021. 32

Plate 3.3-25. Ws03 Bebb's willow - Bluejoint swamp at MWL69 along the transmission line in 2019. 32

Plate 3.3-26. Ws03 Bebb's willow - Bluejoint swamp at MWL69 along the transmission line in 2021. 33

Plate 3.3-27. Fl00 Low bench floodplain (unclassified) at WL207 in the downstream portion of the Peace River in 2019. 34

Plate 3.3-28. Recently scoured Fl00 Low bench floodplain (unclassified) at WL207 in the downstream portion of the Peace River in 2021. 34

Plate 3.3-29. Fl06 Sandbar willow low bench floodplain community at WL204 in the downstream portion of the Peace River in 2019. 35

Plate 3.3-30. Fl06 Sandbar willow low bench floodplain community at WL204 in the downstream portion of the Peace River in 2021. 35

List of Appendices

Appendix A. Definition of Structural Stages and Successional Status

1. INTRODUCTION

1.1 PROJECT CONDITIONS

BC Hydro developed a Baseline and Construction Phase Wetland Monitoring Program (Native Plant Solutions (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 2021 annual report focuses on the continuation of the construction monitoring phase of the Project, with 43 of the 45 targeted wetlands previously sampled using the full BC Hydro Site C Vegetation and Wildlife Wetland Monitoring Program: Baseline and Construction Phase Wetland Monitoring (NPS 2020). The two wetlands that were previously sampled in 2016 were re-assessed during the 2021 field surveys using the full baseline methodology described by NPS (2020) applied to the existing data, instead of the construction phase monitoring methodology. Going forward, all future field surveys will be completed as per the construction phase monitoring methodology.

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 2021 field program included the first year of construction monitoring for wetlands that were initially sampled in 2019, as well as two wetlands that were sampled in 2016 that were not assessed in 2020 due to access constraints. A total of 45 construction phase wetlands were selected for 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 2021 consisted of six wetland types (Table 2.1-1), with 42 wetlands last surveyed in 2019, two in 2016, and one last surveyed in 2020. A total of 40 wetlands on the 2021 target list were located along the transmission line, primarily within the cleared corridor, and five were located downstream.

Table 2.1-1. Target Number and Type of Construction Phase Wetlands for 2021

Wetland Type	Code	2021 Target
Black spruce-Labrador tea-sphagnum	BT	13
Shallow open water	OW	1
Sedge wetland	SE	18
Tamarack sedge	TS	7
Willow sedge wetland	WS	2
Willow herb	WH	4

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 2021 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). The two wetlands that were previously sampled in 2016 were completed before the development of the full baseline monitoring program. Therefore, data were collected for these two wetlands as per the Baseline Monitoring Phase (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 (i.e., DeLong et al. 2011 and Mackenzie and Moran 2004) provincial classification. 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 – Peatmoss 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)

Wetland Class	Existing PAZ Ecosystem Units		Current Provincial Ecosystem Units	
	Wetland Type (Map Code)	Vegetation Community Description	Site Association	Vegetation Community Description
	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
	-	-	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, 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

[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).

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 2019 and 2021 wetland data were obtained from a list of CC values 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:

$$\mathbf{FQI = Mean\ CC_N\ /\ 10\ (\sqrt{N}\ /\ \sqrt{S})\ *\ 100}$$

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 monitoring wetland. Three pairs of quadrats (six quadrats in total) were deployed randomly throughout each wetland. A

power analysis conducted as part of the study by Wilson et al. (2013) showed that six quadrats was 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 meter 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 2.3-2 and from the comparison charts for estimation of foliage cover from the 2010 Field Manual for Describing Terrestrial Ecosystems (BC MOE and MOF 2010).
- 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 2.3-2. 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 (USDA 2020) Natural Resource Conservation Service (NRCS) Plants Database and is described below in Table 2.3-3. 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 2.3-3. Wetland Indicator Status Codes and Descriptions[1]

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

[1] Adapted from USDA Natural Resource Conservation Service Plants Database (USDA NRCS 2020).

3. RESULTS

3.1 SUMMARY OF 2021 FIELD SURVEY EFFORT

Field surveys were completed from July 27 to August 3, 2021, along the transmission line and within the downstream area. A total of 45 wetlands were sampled, including all of the targeted wetlands as per the sampling plan (Tables 3.1-1; Figure 3.1-1).

Table 3.1-1. Summary of Wetlands Sampled in 2021

Plot	Wetland Class	Site Association	Wetland Type	Previous Sample Date(s)	Sampled in 2021
BR2	Fen	Wf01	SE	2019	y
MWL02	Fen	Wf02	SE	2016, 2019	y
MWL08	Marsh	Wm15	SE	2016, 2019	y
MWL09	Marsh	Wm15	SE	2016, 2019	y
MWL10	Marsh	Wm03	SE	2016, 2019	y
MWL12	Marsh	Wm03	SE	2016, 2019	y
MWL13	Bog	Wb08	BT	2016, 2019	y
MWL14	Marsh	Wm02	SE	2016, 2019	y
MWL18	Bog	Wb06	TS	2016, 2019	y
MWL19	Marsh	Wm00	SE	2016, 2019	y
MWL33	Marsh	Wm03	SE	2016, 2019	y
MWL58	Marsh	Wm01	SE	2016, 2019	y
MWL59	Shallow Open Water	OW	OW	2016, 2019	y
MWL62	Marsh	Wm03	SE	2016, 2019	y
MWL69	Swamp	Ws03	WS	2016, 2019	y
MWL72	Bog	Wb03	BT	2016, 2019	y
OWL11	Marsh	Wm15	SE	2016	y
OWL61	Marsh	Wm03	SE	2016	y
PI1	Marsh	Wm01	SE	2019	y
PI2	Marsh	Wm01	SE	2019	y
PI4	Fen	Wf01	SE	2019	y
PR	Fen	Wf01	SE	2019	y
WL104	Marsh	Wm01	SE	2016, 2018, 2020	y
WL200	Bog	Wb08	BT	2019	y

Plot	Wetland Class	Site Association	Wetland Type	Previous Sample Date(s)	Sampled in 2021
WL201	Bog	Wb08	BT	2019	y
WL202	Bog	Wb03	BT	2016, 2019	y
WL203	Swamp	Ws02	WS	2019	y
WL204	Floodplain	Fl06	WH	2019	y
WL205	Floodplain	Fl00	WH	2019	y
WL206	Floodplain	Fl06	WH	2019	y
WL207	Floodplain	Fl00	WH	2019	y
WL215	Bog	Wb03	BT	2016, 2019	y
WL216	Bog	Wb06	TS	2019	y
WL217	Bog	Wb03	BT	2019	y
WL218	Bog	Wb03	BT	2016, 2019	y
WL219	Bog	Wb08	BT	2016, 2019	y
WL220	Bog	Wb06	TS	2016, 2019	y
WL221	Bog	Wb08	BT	2016, 2019	y
WL222	Bog	Wb08	BT	2019	y
WL223	Bog	Wb08	BT	2019	y
WL224	Bog	Wb03	BT	2016, 2019	y
WL225	Bog	Wb06	TS	2016, 2019	y
WL226	Bog	Wb06	TS	2019	y
WL228	Bog	Wb06	TS	2016, 2019	y
WL229	Bog	Wb06	TS	2019	y

Figure 3.1-5

Figure 3.1-4

Figure 3.1-3

Figure 3.1-2

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Site C Clean Energy Project

Location of 2021 Sample Sites

Figure 3.1-1

Date: 2022-01-14

Map Number: BCHWL-30

Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
Projection: Mercator Auxiliary Sphere
Datum: WGS 1984

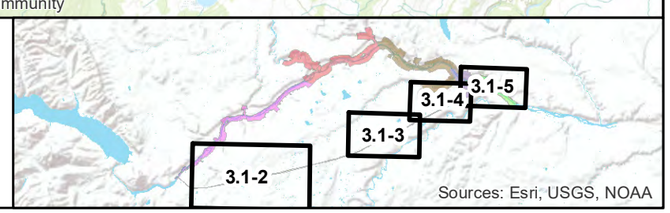
ECOLOGIC environmental consulting

Legend

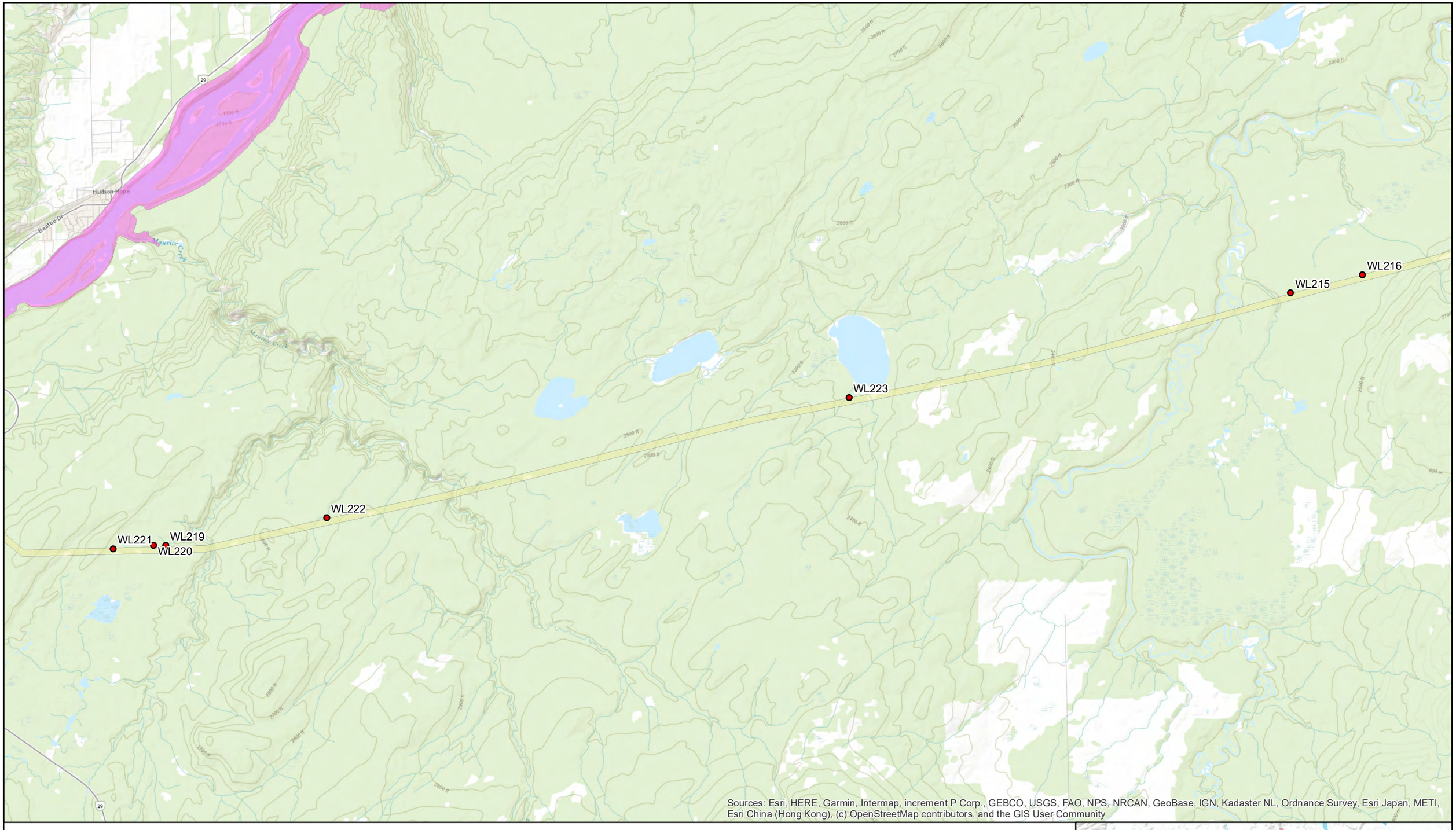
- 2021Wetland Sample Sites
- Dam Site Area
- Downstream
- Eastern Reservoir
- Existing Right-of-Way
- Middle Reservoir
- Project Access Road
- TL Phase A
- TL Phase B
- Western Reservoir

0 2 4 6 8 km

1:200,000



Sources: Esri, USGS, NOAA



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Site C Clean Energy Project

Location of 2021 Sample Sites - TL Phase B

Figure 3.1-2

Date: 2022-01-14

Map Number: BCHWL-30

Coordinate System: NAD 1983 UTM Zone 10N

Projection: Transverse Mercator

Datum: North American 1983

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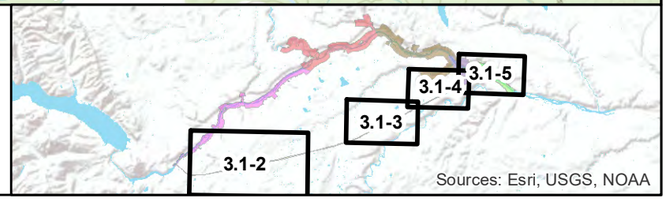
Legend

- 2021Wetland Sample Sites
- Dam Site Area
- Downstream
- Eastern Reservoir
- Existing Right-of-Way
- Middle Reservoir
- Project Access Road
- TL Phase A
- TL Phase B
- Western Reservoir

0 1 2 3 km

1:70,000



Sources: Esri, USGS, NOAA

PI2
WL202
MWL58
MWL72
MWL59
OWL61
MWL69
PI1
MWL08
MWL09
MWL10
WL104
MWL33
OWL11
MWL13
MWL12
WL218
WL217
MWL14
Jackfish Lake Rd
Monias
Pine River
Canadian National

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Site C Clean Energy Project

Location of 2021 Sample Sites - TL Phase A

Figure 3.1-3a

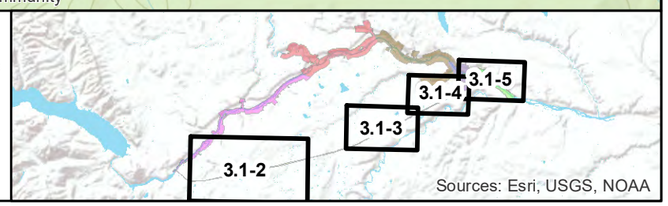
Date: 2022-01-14
Map Number: BCHWL-30
Coordinate System: NAD 1983 UTM Zone 10N
Projection: Transverse Mercator
Datum: North American 1983

ECOLOGIC environmental consulting

Legend

- 2021Wetland Sample Sites
- Dam Site Area
- Downstream
- Eastern Reservoir
- Existing Right-of-Way
- Middle Reservoir
- Project Access Road
- TL Phase A
- TL Phase B
- Western Reservoir

0 500 1,000 1,500
Meters
1:38,000



BR2
PI4
PR
WL224
WL225
WL226
WL201
WL200
WL229
WL228
MWL02
Canadian National

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Site C Clean Energy Project

Location of 2021 Sample Sites - TL Phase A

Figure 3.1-3b

Date: 2022-01-14

Map Number: BCHWL-30

Coordinate System: NAD 1983 UTM Zone 10N

Projection: Transverse Mercator

Datum: North American 1983

ECOLOGIC environmental consulting

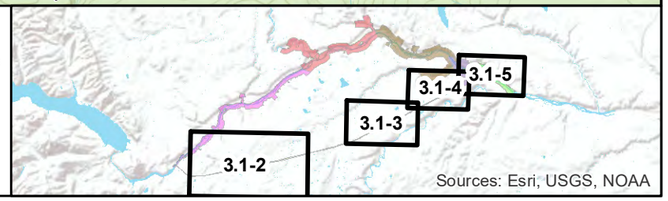
Legend

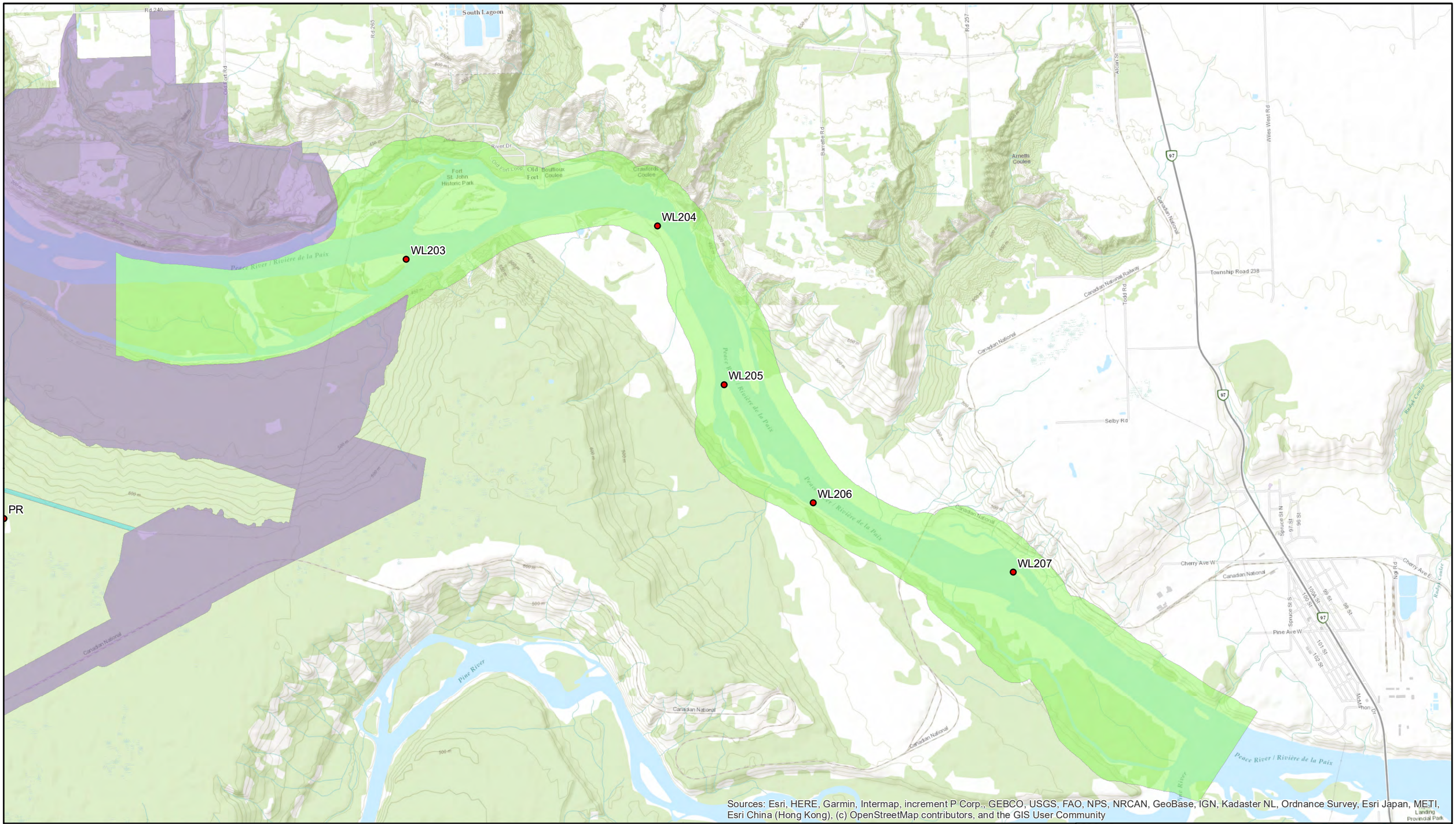
- 2021Wetland Sample Sites
- Dam Site Area
- Downstream
- Eastern Reservoir
- Existing Right-of-Way
- Middle Reservoir
- Project Access Road
- TL Phase A
- TL Phase B
- Western Reservoir

0 500 1,000 1,500

Meters

1:38,000





Site C Clean Energy Project

Location of 2021 Sample Sites - Downstream

Figure 3.1-4

Date: 2022-01-14

Map Number: BCHWL-30

Coordinate System: NAD 1983 UTM Zone 10N

Projection: Transverse Mercator

Datum: North American 1983

ECOLOGIC environmental consulting

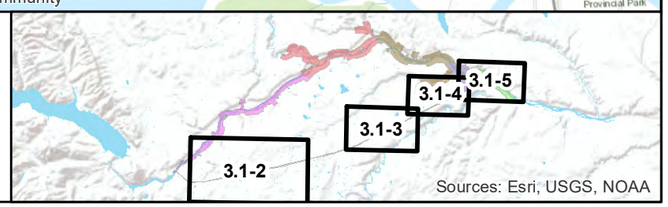
Legend

- 2021Wetland Sample Sites
- Dam Site Area
- Downstream
- Eastern Reservoir
- Existing Right-of-Way
- Middle Reservoir
- Project Access Road
- TL Phase A
- TL Phase B
- Western Reservoir

0 500 1,000 1,500

Meters

1:38,000



3.2 Ecosystem Classification and Mapping

Two wetlands were assessed in 2021 that were previously sampled in 2016. One of the wetlands, OWL61, was previously mapped as Field Truth Required (FTR) in the DWM indicating that the wetland classification was unknown. The other, OWL11, was mapped as SE. Both wetlands were updated as per the current provincial site associations (Table 3.2-1). These two wetlands were the last sites that required updating to the current ecosystem classification.

Table 3.2-1. Summary of Ecosystem Classification and Mapping Changes

Plot ID	DWM Wetland Type(s)	2021 Site Association	2021 Wetland Type	2021 Wetland Type Change
OWL11	SE	Wm15	SE	No
OWL61	FTR	Wm03	SE	Yes

3.3 Wetland Summaries

3.3.1 Bog Overview

Twenty bogs were sampled in 2021, comprising two wetland types (BT and TS) and three site associations (Table 3.3-1). All of the bogs were located in the transmission line right-of-way (ROW) and had been partially or entirely modified by clearing and/or grubbing from construction activities, and some had been modified by construction roads and tower pads. Initial regeneration was observed in most bogs with increased shrub and graminoid growth compared to the 2019 assessments, (Plates 3.3-1 to 3.3-6).

Table 3.3-1. Summary of Bogs Sampled in 2021

Wetland Class	Site Association	Wetland Type	Description	No. Sampled	Structural Stage(s)[(a)]	Successional Status(es)[(a)]	Hydrology
Bog	Wb03	BT	Black spruce - Lingonberry - Peat-moss	6	Low Shrub	Young Climax	Permanently to Semi-permanently Flooded
	Wb06	TS	Tamarack - Water sedge - Fen moss	7	Low Shrub, Tall Shrub	Young Seral	Permanently to Semi-permanently Flooded
	Wb08	BT	Black spruce - Soft-leaved sedge - Peat-moss	7	Graminoid, Low Shrub, Tall Shrub	Young Seral	Permanently to Semi-permanently Flooded
Total				**20**			

(a) See Appendix A for structural stage and successional status descriptions

Plate 3.3-1. Wb03 Black spruce - Lingonberry - Peat-moss bog at wetland WL251 along the transmission line in 2019.

Plate 3.3-2. Wb03 Black spruce - Lingonberry - Peat-moss bog at wetland WL251 along the transmission line in 2021.

Plate 3.3-3. Wb06 Tamarack - Water sedge - Fen moss bog at WL228 along the transmission line in 2019.

Plate 3.3-4. Wb06 Tamarack - Water sedge - Fen moss bog at WL228 along the transmission line in 2021.

Plate 3.3-5. Wb08 Black spruce - Soft-leaved sedge - Peat-moss bog at WL221 along the transmission line in 2019.

Plate 3.3-6. Wb08 Black spruce - Soft-leaved sedge - Peat-moss bog at WL221 along the transmission line in 2021.

3.3.2 Fen Overview

Two fens were sampled in 2021, comprising one wetland type (SE) and two site associations (Table 3.3-2). The fens ranged from largely undisturbed Wf01 pocket wetlands in the transmission line corridor and the groundwater well reference site (BR2) to highly disturbed (cleared and grubbed) and modified (hydrological alterations due to road construction) sites within the new transmission line corridor (Plates 3.3-7 to 3.3-10).

Table 3.3-2. Summary of Fens Sampled in 2021

Wetland Class	Site Association	Wetland Type	Description	No. Sampled	Structural Stage(s)[(a)]	Successional Status(es)[(a)]	Hydrology
Fen	Wf01	SE	Water sedge - Beaked sedge	3	Graminoid	Disclimax	Permanently to Semi-permanently Flooded
	Wf02	SE	Scrub birch-water sedge	1	Low Shrub	Young Seral	Permanently to Semi-permanently Flooded
Total				**4**			

(a) See Appendix A for structural stage and successional status descriptions

Plate 3.3-7. Wf01 Water sedge - Beaked sedge fen at PI4 along the transmission line in 2019.

Plate 3.3-8. Wf01 Water sedge - Beaked sedge fen at PI4 along the transmission line in 2021.

Plate 3.3-9. Wf02 Scrub birch - water sedge fen at MWL02 along the transmission line in 2019.

Plate 3.3-10. Wf02 Scrub birch - water sedge fen at MWL02 along the transmission line in 2021.

3.3.3 Marsh Overview

Fourteen marshes were sampled in 2021 (Table 3.3-3) along the transmission line, comprising one wetland type (SE) and five site associations (Plates 3.3-11 to 3.3-20). Due to the abnormally hot and dry summer, few of the marsh communities contained standing water in 2021. Most of the sampled marshes had minimal Project-related disturbances within the wetlands, but adjacent clearing, grubbing, construction roads, and tower sites were common.

Table 3.3-3. Summary of Marshes Sampled in 2021

Wetland Class	Site Association	Wetland Type	Description	No. Sampled	Structural Stage(s)[(a)]	Successional Status(es)[(a)]	Hydrology
Marsh	Wm00	SE	Marsh (unclassified)	1	Graminoid	Young Seral	Permanently to Semi-permanently Flooded
	Wm01	SE	Beaked sedge - Water sedge	4	Graminoid	Disclimax	Permanently to Semi-permanently Flooded
	Wm02	SE	Swamp horsetail - Beaked sedge	1	Graminoid	Disclimax	Permanently to Semi-permanently Flooded

Wetland Class	Site Association	Wetland Type	Description	No. Sampled	Structural Stage(s)[(a)]	Successional Status(es)[(a)]	Hydrology
	Wm03	SE	Awned sedge	5	Graminoid	Disclimax	Permanently to Semi-permanently Flooded
	Wm15	SE	Bluejoint - Beaked sedge	3	Graminoid	Disclimax	Permanently to Semi-permanently Flooded
Total				**14**			

(a) See Appendix A for structural stage and successional status descriptions

Plate 3.3-11. Wm00 Marsh (unclassified) at MWL19 along the transmission line in 2019.

Plate 3.3-12. Wm00 Marsh (unclassified) at MWL19 along the transmission line in 2021.

Plate 3.3-13. Wm01 Beaked sedge - Water sedge marsh at WL104 along the transmission line in 2018.

Plate 3.3-14. Wm01 Beaked sedge - Water sedge marsh at WL104 along the transmission line in 2021.

Plate 3.3-15. Wm02 Swamp horsetail - Beaked sedge marsh at MWL14 along the transmission line in 2019.

Plate 3.3-16. Wm02 Swamp horsetail - Beaked sedge marsh at WML14 along the transmission line in 2021.

Plate 3.3-17. Wm03 Awned sedge marsh at WML33 along the transmission line in 2019.

Plate 3.3-18. Wm03 Awned sedge marsh at WML33 along the transmission line in 2021.

Plate 3.3-19. Wm15 Bluejoint - Beaked sedge marsh at WML08 along the transmission line in 2019.

Plate 3.3-20. Wm15 Bluejoint - Beaked sedge marsh at MWL08 along the transmission line in 2021.

3.3.4 Shallow Open Water Overview

One shallow open water (OW wetland type) wetland was assessed in 2020 along the transmission line (Table 3.3-4). The shallow open water wetland had been modified due to Project construction activities (Plates 3.3-21 and 3.3-22).

Table 3.3-4. Summary of Shallow Open Water Sampled in 2021

Wetland Class	Site Association	Wetland Type	Description	No. Sampled	Structural Stage(s)[(a)]	Successional Status(es)[(a)]	Hydrology
Open Water	OW	OW	Shallow Open Water (unclassified)	1	Aquatic	NA	Permanently Flooded
Total				**1**			

(a) See Appendix A for structural stage and successional status descriptions

Plate 3.3-21. Shallow Open Water at MWL59 along the transmission line in 2019.

Plate 3.3-22. Shallow Open Water at MWL59 along the transmission line in 2021.

3.3.5 Swamp Overview

Two swamps (WS wetland type) were sampled in 2021, comprising two site associations (Table 3.3-5). The Ws02 association was located in the downstream portion of the Project area along the Peace River (Plates 3.3-24 and 3.3-25) and has not been directly affected by Project construction activities. The Ws03 association was located along the transmission line ROW and had minimal disturbance (some cutting and an adjacent temporary construction road) from construction activities (Plates 3.3-25 and 3.3-26).

Table 3.3-5. Summary of Swamps Sampled in 2021

Wetland Class	Site Association	Wetland Type	Description	No. Sampled	Structural Stage(s)[(a)]	Successional Status(es)[(a)]	Hydrology
Swamp	Ws02	WS	Mountain alder – Pink spirea – Sitka sedge	1	Tall Shrub	Young Seral	Seasonally to Intermittently Flooded
	Ws03	WS	Bebb's willow – Bluejoint	1	Tall Shrub	Young Seral	Seasonally to Intermittently Flooded
Total				**2**			

(a) See Appendix A for structural stage and successional status descriptions

Plate 3.3-23. Ws02 Mountain alder – Pink spirea – Sitka sedge swamp at WL203 in the downstream portion of the Peace River in 2019.

Plate 3.3-24. Ws02 Mountain alder – Pink spirea – Sitka sedge swamp at WL203 in the downstream portion of the Peace River in 2021.

Plate 3.3-25. Ws03 Bebb's willow - Bluejoint swamp at MWL69 along the transmission line in 2019.

Plate 3.3-26. Ws03 Bebb's willow - Bluejoint swamp at MWL69 along the transmission line in 2021.

3.3.6 Floodplain Overview

Four low bench floodplains were sampled in 2021 along the Peace River in the downstream Project area (Table 3.3-6), made up of two site associations that are both contained within the WH wetland type. All of the floodplain sites were outside of direct Project related construction activities but were subject to natural changes from scouring and deposition on a regular basis (Plate 3.3-27 to 3.3-30).

Table 3.3-6. Summary of Floodplains Sampled in 2021

Wetland Class	Site Association	Wetland Type	Description	No. Sampled	Structural Stage(s)[(a)]	Successional Status(es)[(a)]	Hydrology
Floodplain	Fl00	WH	Low bench floodplain (unclassified)	2	Low Shrub, Tall Shrub	Young Seral, Secondary Seral	Seasonally to Intermittently Flooded
	Fl06	WH	Sandbar willow	2	Tall Shrub	Young Seral	Seasonally to Intermittently Flooded
Total				**2**			

(a) See Appendix A for structural stage and successional status descriptions

Plate 3.3-27. Fl00 Low bench floodplain (unclassified) at WL207 in the downstream portion of the Peace River in 2019.

Plate 3.3-28. Recently scoured Fl00 Low bench floodplain (unclassified) at WL207 in the downstream portion of the Peace River in 2021.

Plate 3.3-29. Fl06 Sandbar willow low bench floodplain community at WL204 in the downstream portion of the Peace River in 2019.

Plate 3.3-30. Fl06 Sandbar willow low bench floodplain community at WL204 in the downstream portion of the Peace River in 2021.

3.4 FLORISTIC QUALITY INDEX

Each of the 2021 wetlands was assessed for species richness, distribution of CC values, percentage of wetland indicator species, percentage of non-native species, and FQI score. The data for 2019 is shown for reference.

3.4.1 Species Richness

Species richness was calculated for each wetland assessed in 2019 and 2021 individually (Figure 3.4-1) and then the data were combined, with average species richness calculated for each wetland type (Figure 3.4-2).

Species richness varied between individual wetlands and between monitoring years (Figure 3.4-1). In general, median species richness was found to be higher in bogs and floodplains than in fens, swamps, and marshes (Figure 3.4-2).

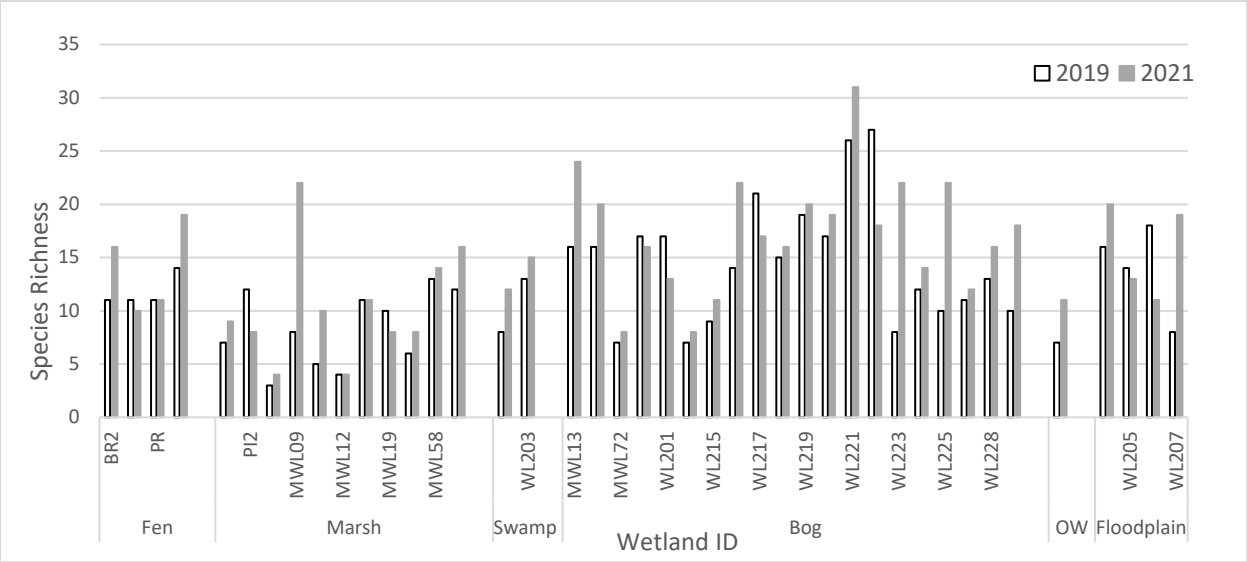


Figure 3.4-1. Individual Species Richness for Each Wetland Assessed in 2019 and 2021

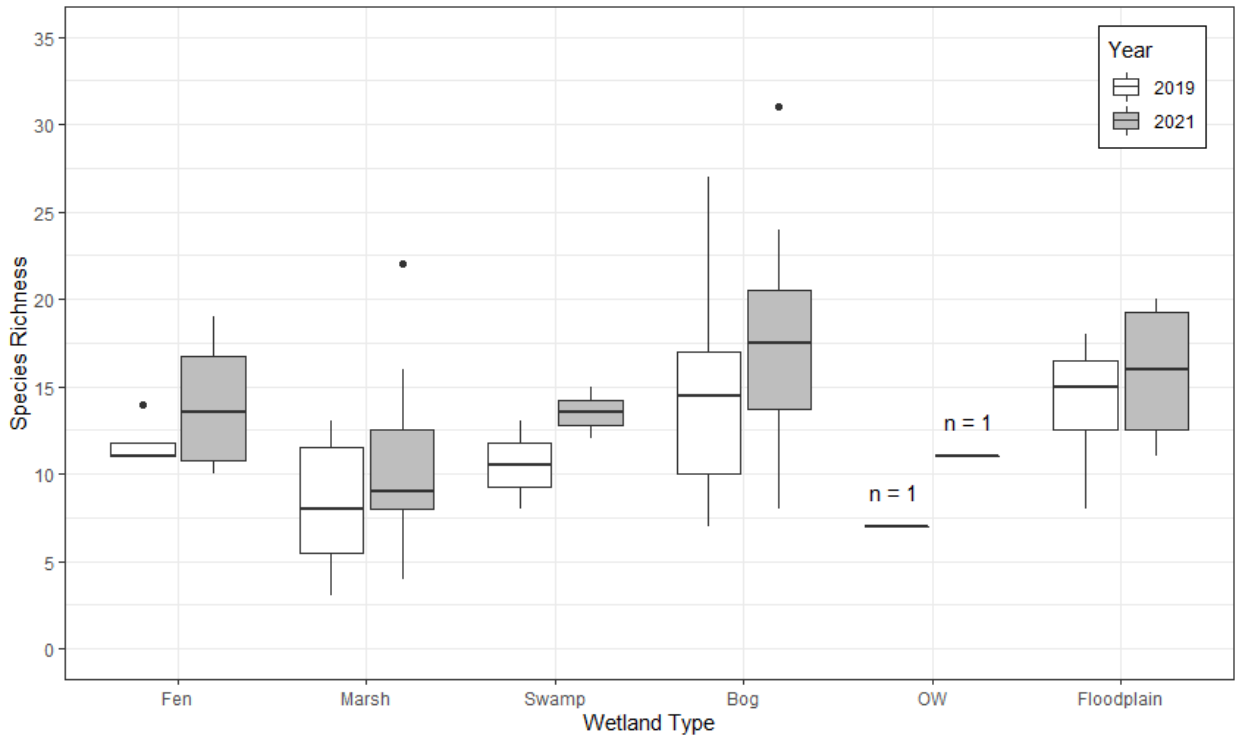


Figure 3.4-2. Comparison of Species Richness by Wetland (2019 and 2021)

3.4.2 Coefficient of Conservatism Values

The distribution of CC values assigned to the vegetation species found in each wetland type was plotted for 2019 and 2021 (Figures 3.4-3 to 3.4-8).

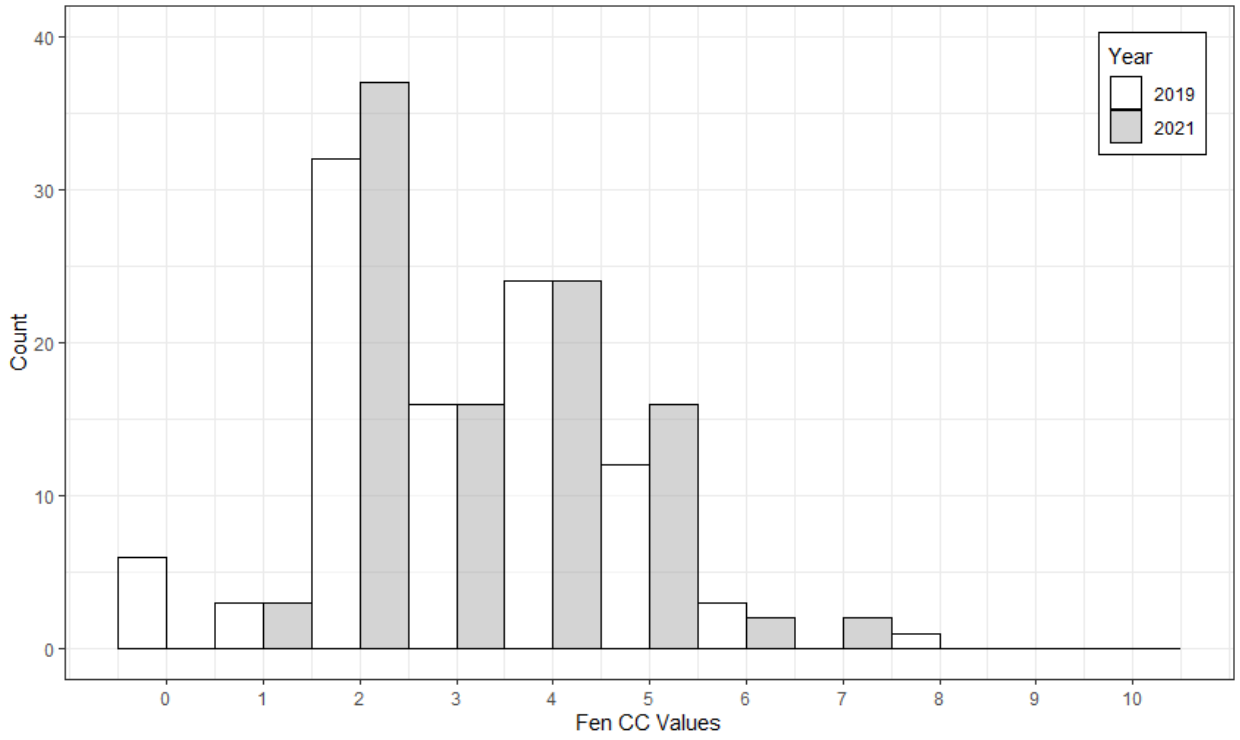


Figure 3.4-3. Coefficient of Conservatism Value Distribution for Fens Assessed in 2019 and 2021

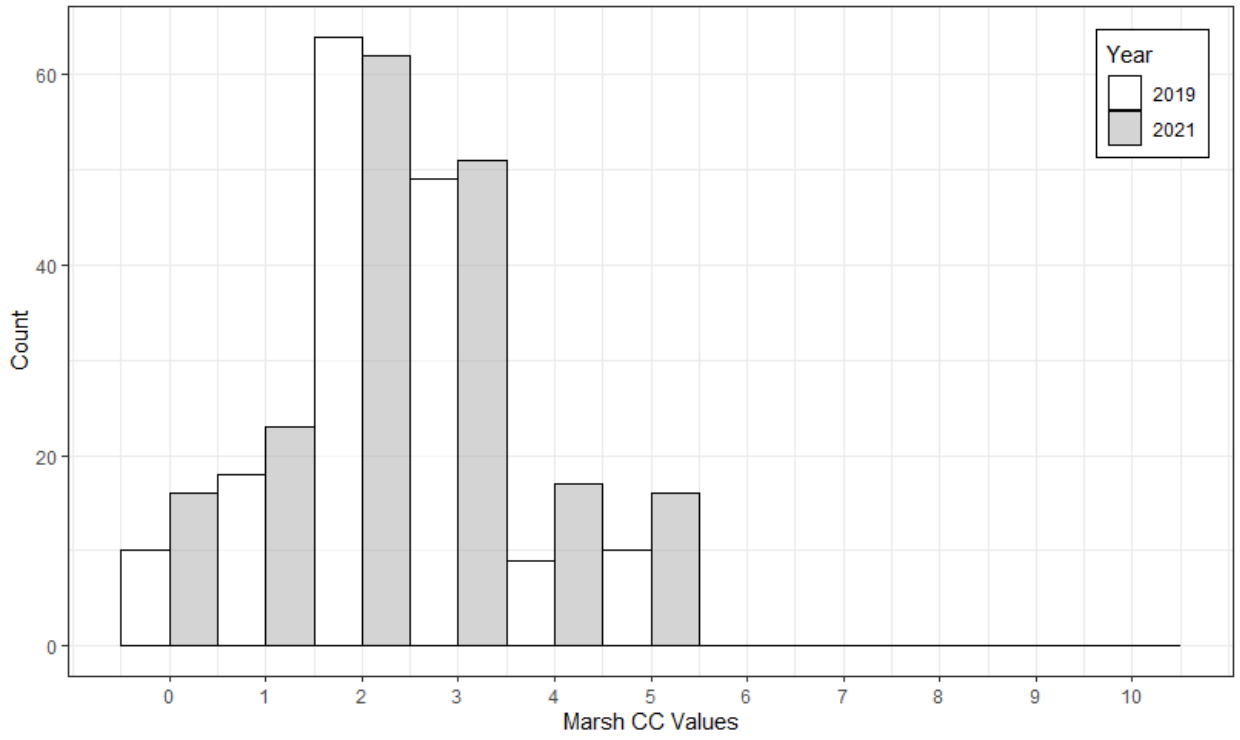


Figure 3.4-4. Coefficient of Conservatism Value Distribution for Marshes Assessed in 2019 and 2021

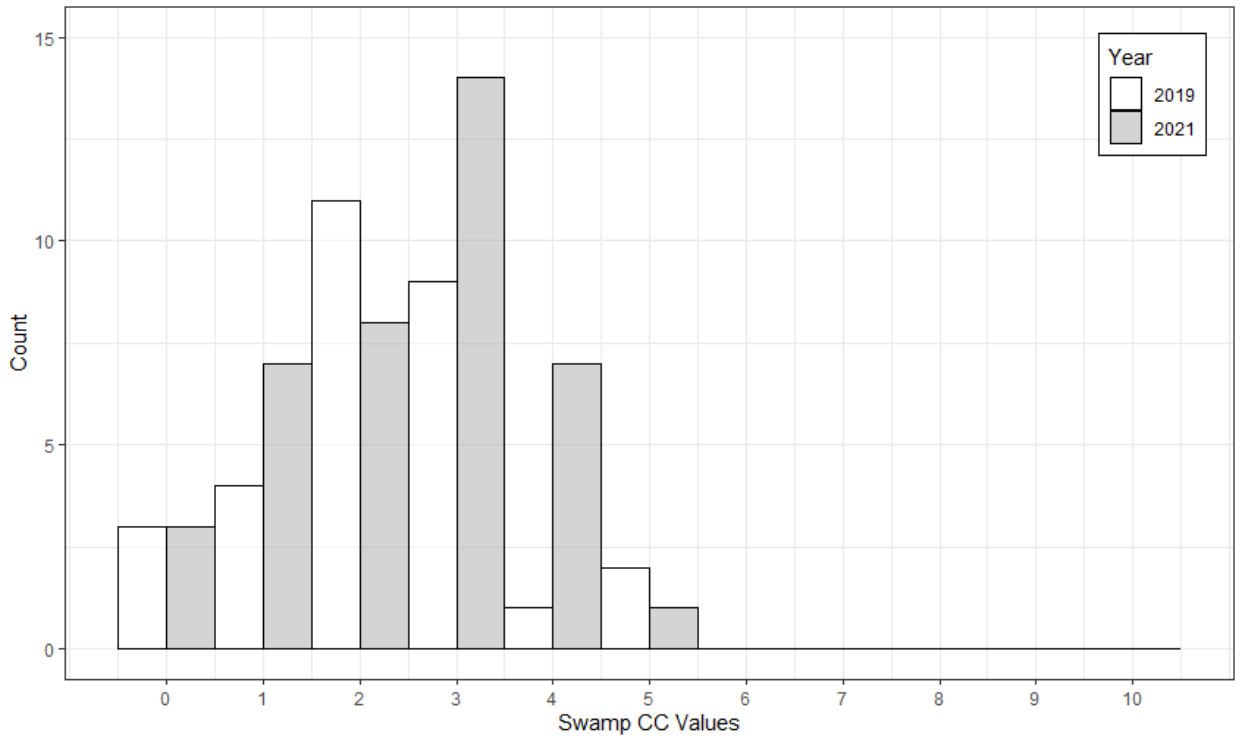


Figure 3.4-5. Coefficient of Conservatism Value Distribution for Swamps Assessed in 2019 and 2021

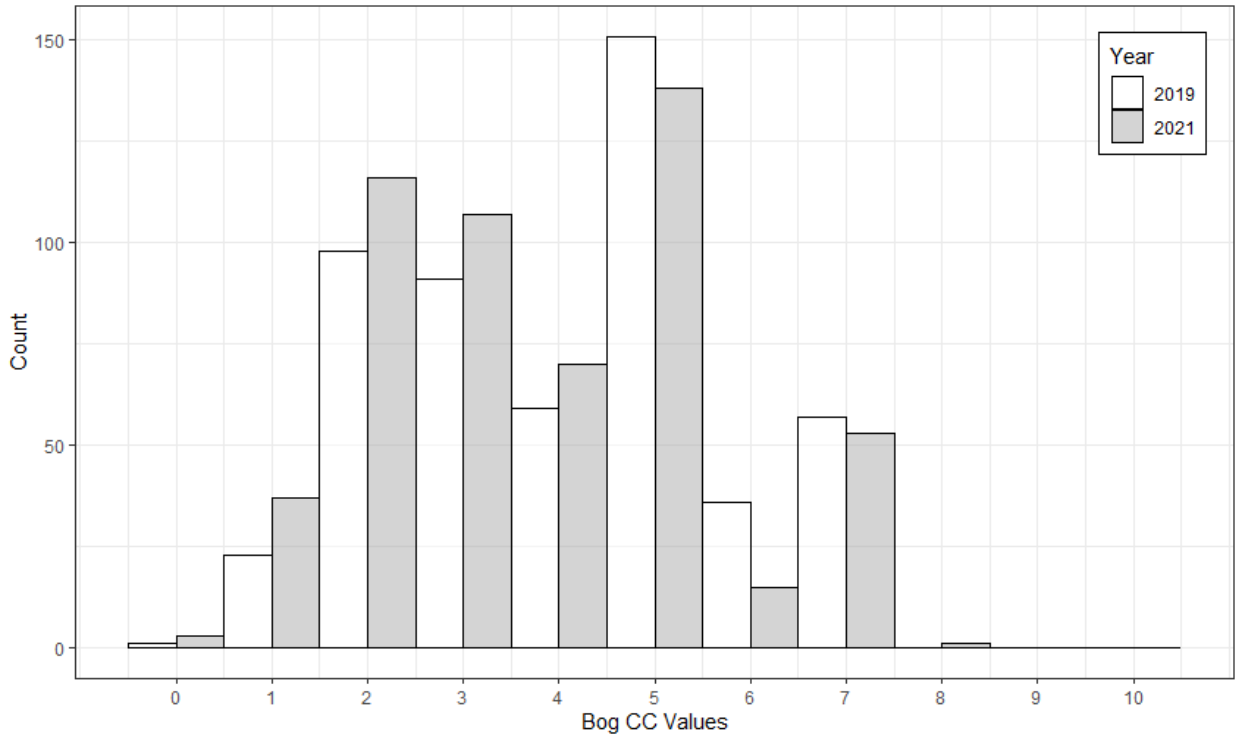


Figure 3.4-6. Coefficient of Conservatism Value Distribution for Bogs Assessed in 2019 and 2021

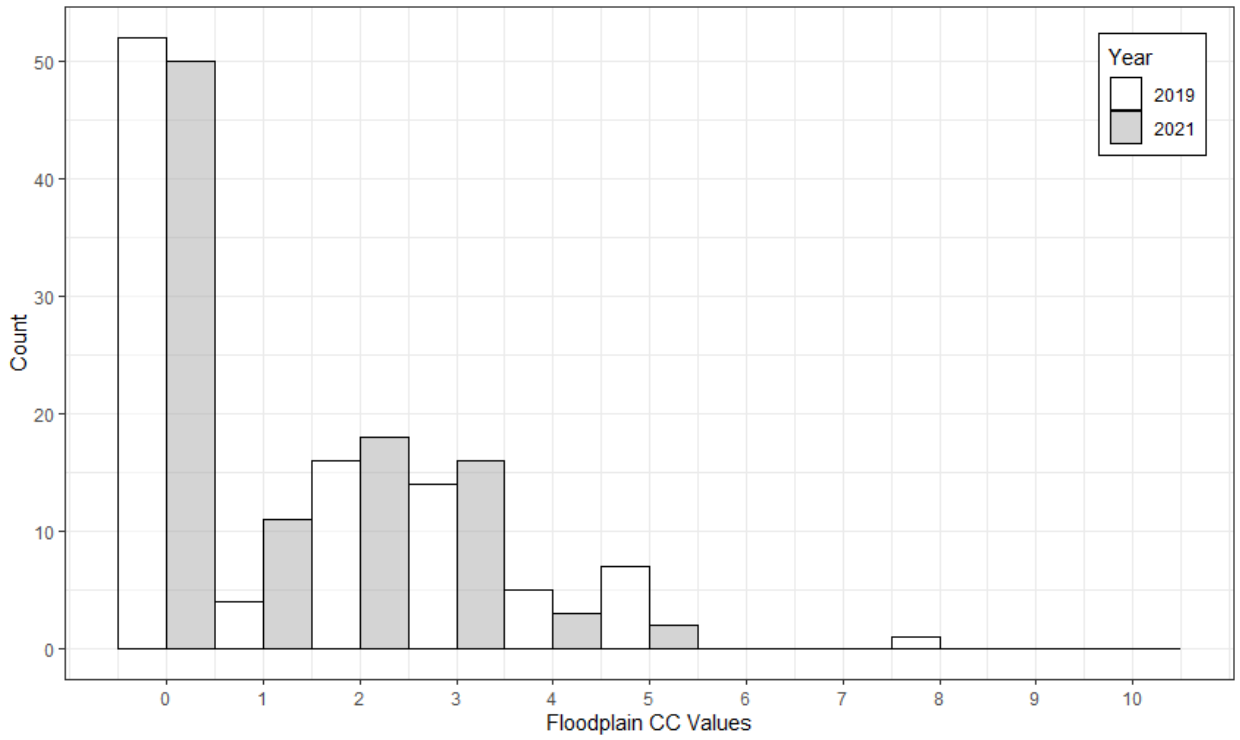


Figure 3.4-7. Coefficient of Conservatism Value Distribution for Floodplains Assessed in 2019 and 2021

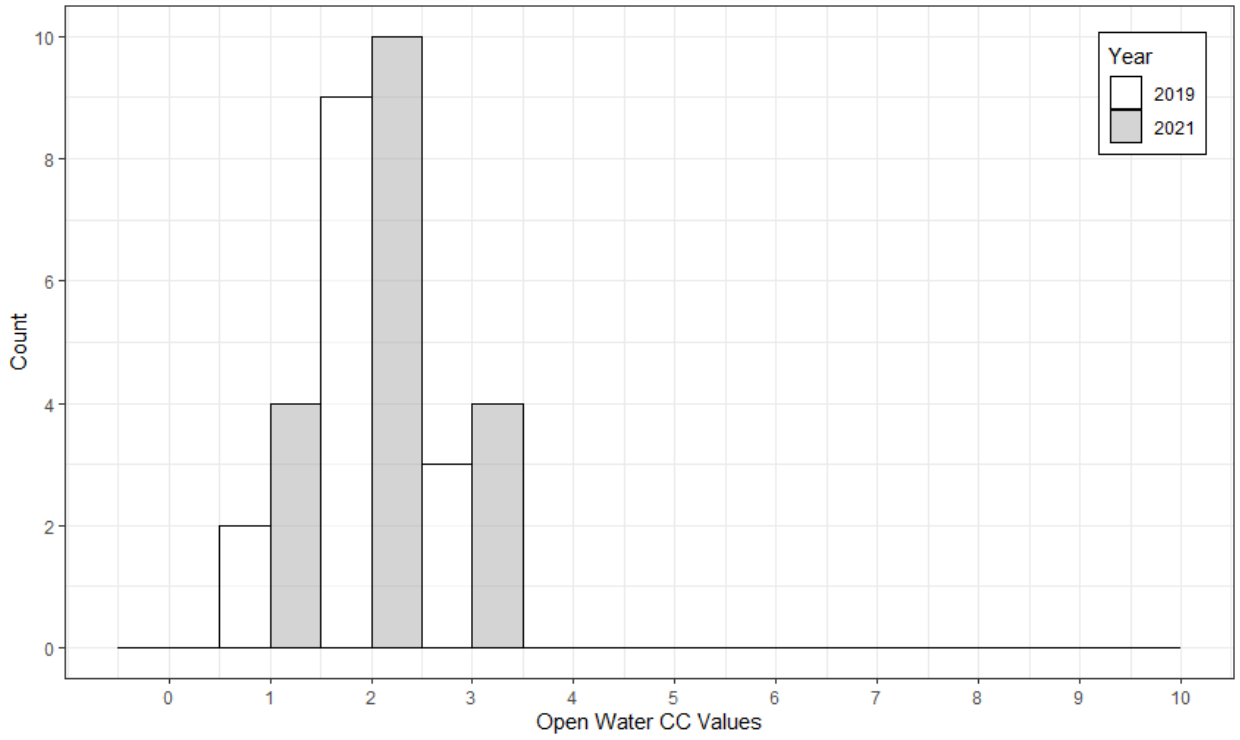


Figure 3.4-8. Coefficient of Conservatism Value Distribution for Open Water Wetlands Assessed in 2019 and 2021

The distribution of CC values within each wetland type was relatively similar between 2019 and 2021. Marsh, swamp, floodplain, and open water wetland types had a higher frequency of species with CC values between 0 and 3, and bog and fen wetlands had a higher frequency of species with CC values between 4 and 8. None of the wetlands contained species with CC values above 8. Out of all the wetland types, floodplains had the highest frequency of vegetation species with a CC value of 0.

3.4.3 Wetland Indicator Species

The wetland indicator status for each species was obtained from the United States Department of Agriculture (USDA) Natural Resource Conservation Service Plants Database (USDA NRCS 2020) and is described in Table 3.4-1. 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 3.4-1. Wetland indicator status codes and descriptions[1]

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

[1] Adapted from USDA Natural Resource Conservation Service Plants Database (USDA NRCS 2020).

The percentage of wetland indicator species identified during the 2019 and 2021 assessments was calculated for each wetland individually (Figure 3.4-9) and then the data were combined and plotted by wetland type (Figure 3.4-10).

The percentage of wetland indicator species varied between individual wetlands and between monitoring years (Figure 3.4-9). Floodplains had the lowest median percentage of wetland indicators when compared to the other wetland types, which all had relatively high median percentages of wetland indicators in both years (Figure 3.4-10).

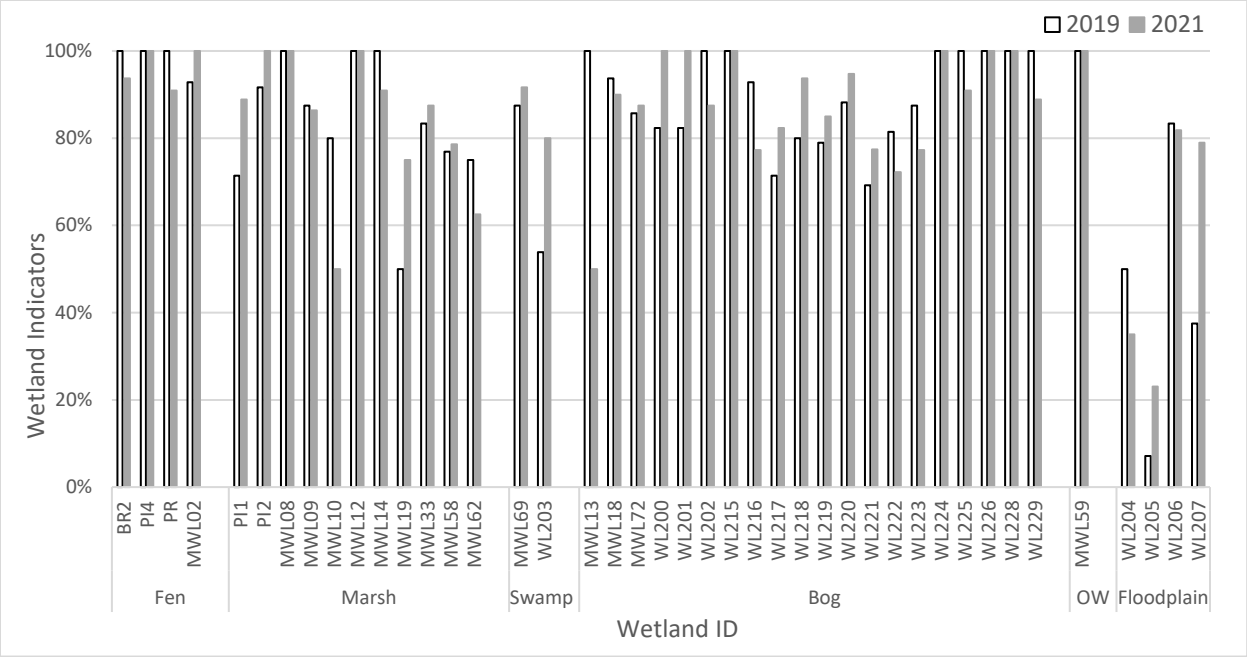


Figure 3.4-9. Percentage of Wetland Indicator Species Identified for Each Wetland Assessed in 2019 and 2021

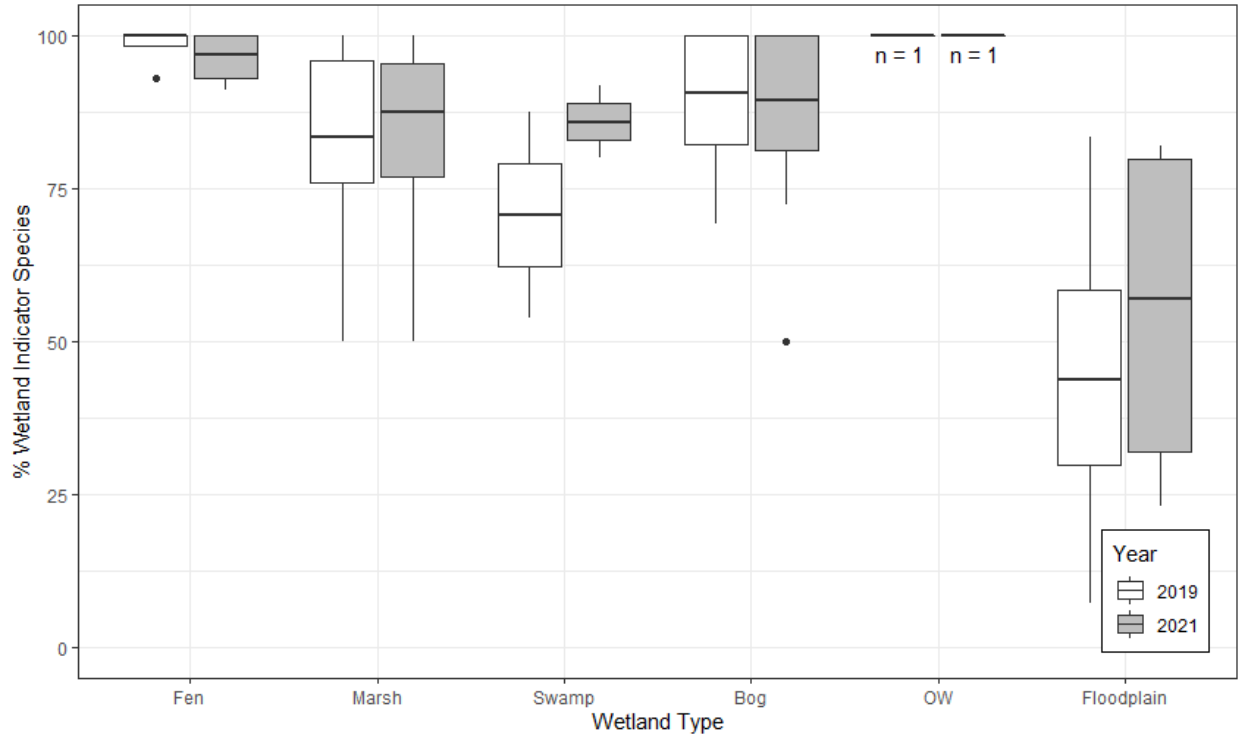


Figure 3.4-10. Comparison of Wetland Indicator Species by Wetland Type (2019 and 2021)

3.4.4 Non-Native Vegetation Species

The percentage of non-native vegetation species identified during the 2019 and 2021 assessments was calculated for each wetland individually (Figure 3.4-11) and then the data were combined and plotted by wetland type (Figure 3.4-12).

Non-native vegetation species were detected in 17 of the 42 wetlands, including at all four of the floodplains (Figure 3.4-11). Floodplains had the highest median percentage of non-native vegetation species. The median percentage of non-native vegetation species in fens, marshes, swamps, bogs and open water wetlands remained low (less than 15%) across both monitoring years (Figure 3.4-12).

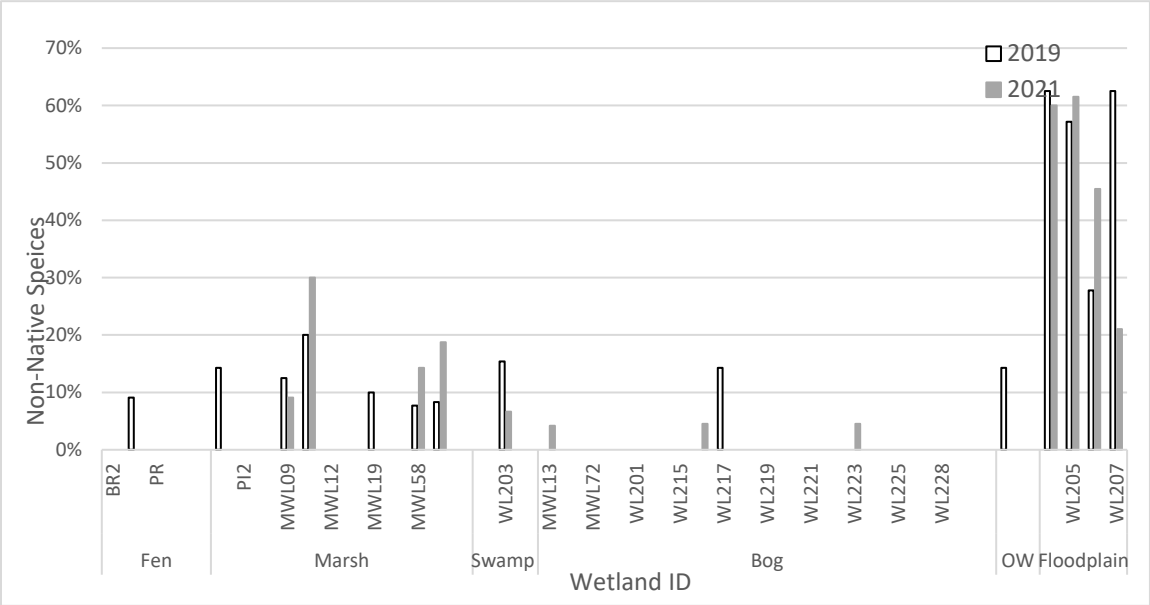


Figure 3.4-11. Comparison of Non-native Species by Wetland (2019 and 2021)

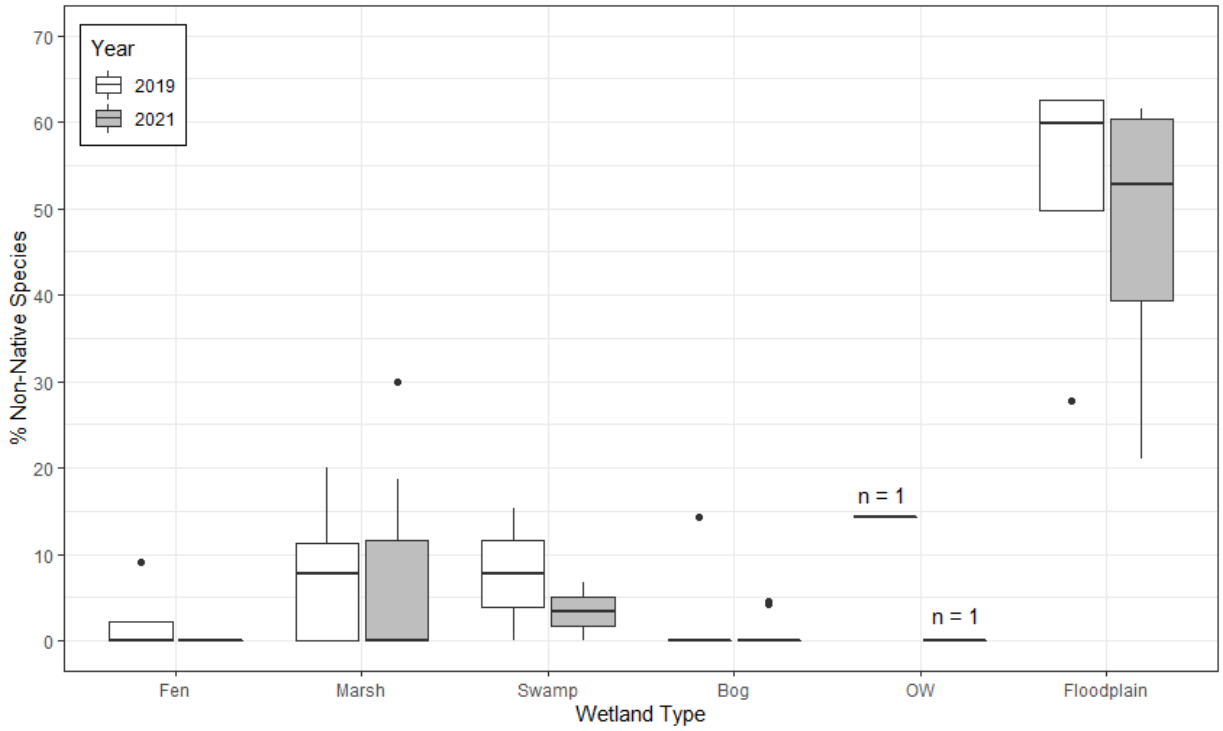


Figure 3.4-12. Percentage of Non-native Species Identified for Each Wetland Assessed in 2019 and 2021

3.4.5 FQI Score

FQI scores were calculated for each wetland assessed in 2019 and 2021 individually (Figure 3.4-13) and then the data were combined and plotted by wetland type (Figure 3.4-14).

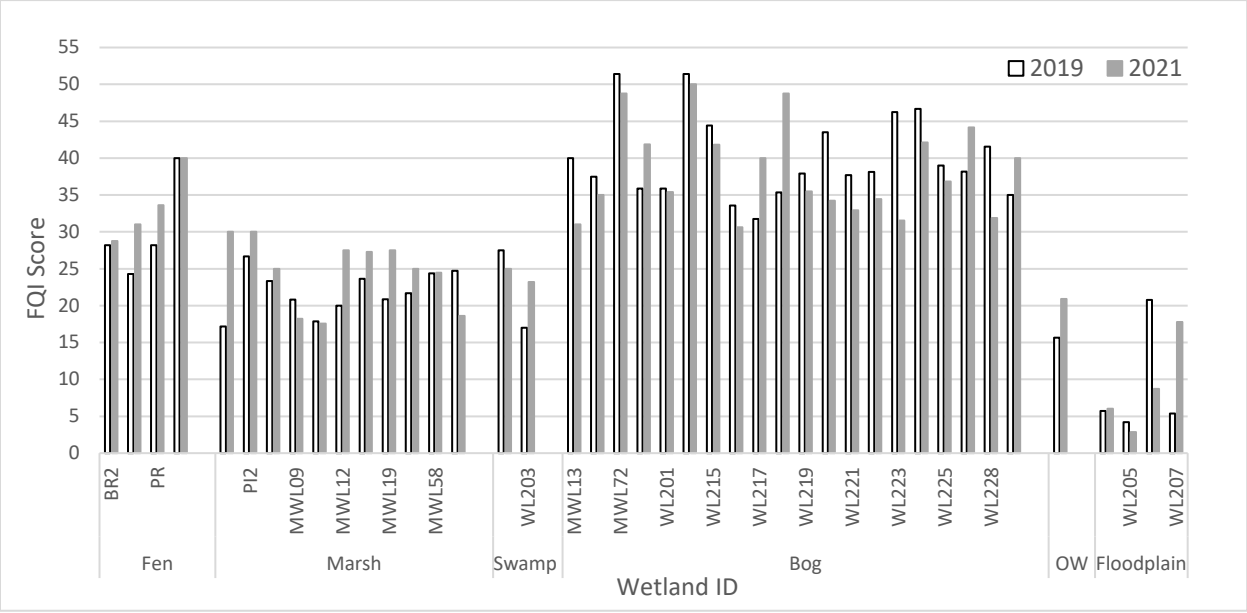


Figure 3.4-13. Individual FQI Scores for Each Wetland Assessed in 2019 and 2021

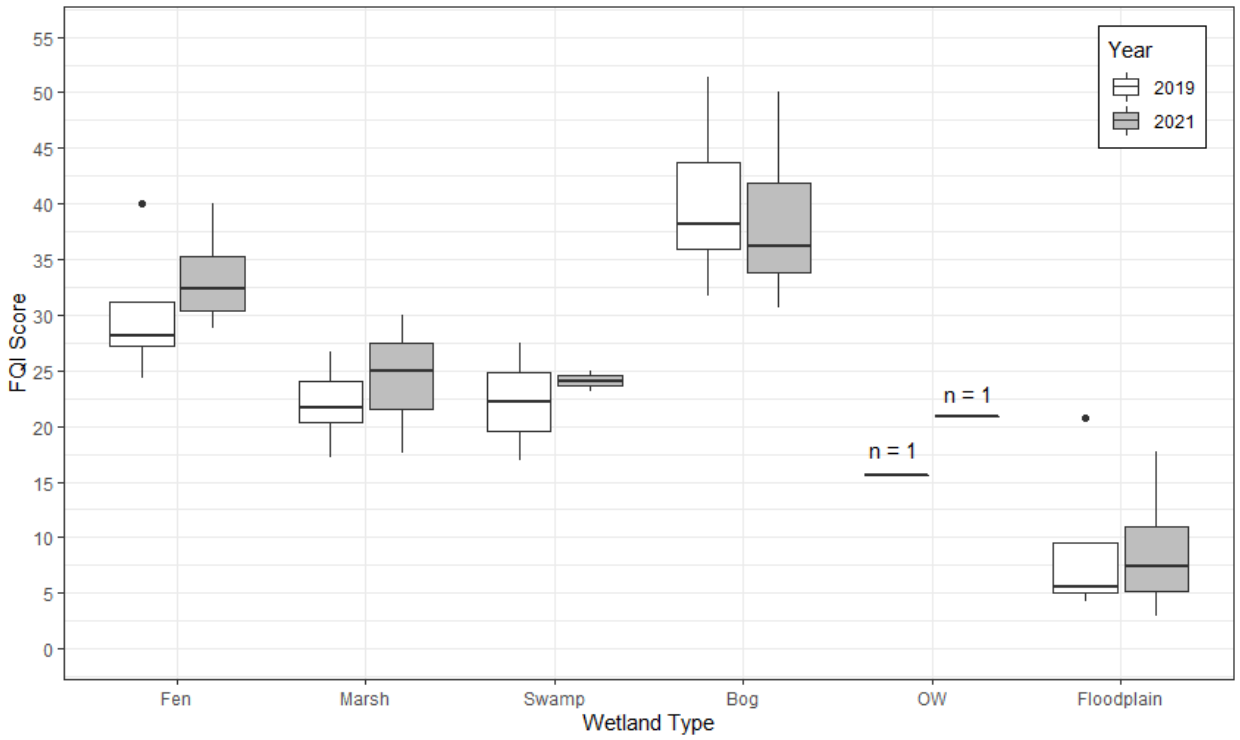


Figure 3.4-14. Comparison of FQI Scores by Wetland Type (2019 and 2021)

Individual FQI scores varied slightly between individual wetlands and between monitoring years (Figure 3.4-13). The median FQI scores are generally consistent between 2019 and 2021 for all of the wetland types. Overall, bogs had the highest median FQI score, and floodplains had the lowest median FQI score (Figure 3.4-14).

3.4.6 FQI Discussion

Overall, the results of the data analysis illustrated that the vegetation communities at the monitored wetlands were relatively consistent between 2019 and 2021. Slight variations between 2019 and 2021 are expected for species richness, distribution of CC values, percentage of wetland indicator species, and percentage of non-native vegetation species. Changes could be due to a number of factors, including differing weather patterns, wetland water levels, anthropogenic or project-related impacts, survey timing, and placement of quadrat locations. The 2021 data was collected during an abnormally dry and hot summer and therefore many of the wetlands surveyed were drier than had been observed in the past, including in 2019.

Non-native vegetation species were detected in 17 of the 42 wetlands. The median percentage of non-native vegetation species at floodplains was much higher (greater than 50%) than any other wetland type. The occurrence of non-native vegetation species in floodplain wetlands could be because this wetland type is located on a river system that can easily transport non-native plant fragments and seeds. Marshes are also more susceptible to establishment of non-native plants because marsh wetlands have more bare ground available for weed establishment as compared to open water wetlands, swamps, fens, and bogs.

In addition, marshes typically have less canopy cover, creating sunny conditions that are favorable for many weedy, non-native species, as compared to shady environments.

Species richness can easily be influenced by establishment of non-native or weedy vegetation species, and therefore is not always the best indicator of a healthy wetland. In addition, there are a number of naturally occurring wetland vegetation communities that have characteristically lower species richness but would still be considered healthy, intact, late succession wetland vegetation communities (e.g., poor fens). To adjust for the nuances that come with vegetation species richness in wetlands, we compared the distribution of CC values assigned to the vegetation species identified within the wetland types. Based on the two years of data available, bogs and fens appear to have more species that do not tolerate disturbance and are found in advanced stages of succession (higher CC values) compared to floodplains, marshes, and swamps.

FQI was found to be the highest in bogs and lowest in floodplains; these FQI scores are expected because bogs often contain a unique combination of plant species that are adapted to the acidic, nutrient-poor, stable water-level conditions typical of bogs (MacKenzie and Moran 2004) (e.g., a number of *Vaccinium* and *Drosera* species are often restricted to bogs). In addition, bog vegetation is often very slow growing, not tolerant of disturbances, and can be easily outcompeted if conditions, such as water level, change (MacKenzie and Moran 2004). Floodplains, on the other hand, have a higher potential for non-native species and often contain native species that are less specialized, more tolerant of disturbance and changing conditions, and that are often found in other environments.

4. SUMMARY OF WETLAND SAMPLING: 2016–2021

A total of 128 wetlands within the PAZ have been assessed since the beginning of the Program in 2016 (Table 4-1). Starting in 2018, with the development of a standard methodology (NPS 2020), wetlands surveyed in 2016 and 2017 were re-sampled so that all data were collected in a consistent manner.

Table 4-1. Summary of Wetland Sampling; 2016-2021

General Location	Pre-NPS Methodology		Baseline and/or Construction Monitoring			
	2016	2017	2018	2019	2020	2021
Downstream	-	-	-	5	-	5
Transmission Line	53	-	21	37	40	40
Reservoir	3	6	36	7	-	-
Total	**56**	**6**	**57**	**49**	**40**	**45**

Since 2018, all wetland sampling has been completed as per the *BC Hydro Site C Vegetation and Wildlife Wetland Monitoring Program: Baseline and Construction Phase Wetland Monitoring* (Appendix D of NPS 2020). The use of a current and standardized methodology allows for detailed classification of each wetland to the provincial Site Association level (Table 4-2). All wetlands assessed in 2022 and beyond will fall under the Construction Phase Monitoring portion of the project.

Table 4-2. Baseline and Construction Monitoring Wetlands Sampled from 2018 to 2021

Wetland Class	Site Association	Vegetation Community	No. Sampled			
			2018	2019	2020	2021
Reservoir Footprint						
Bog	Wb06	Tamarack – Water sedge – Fen moss	1			
Fen	Wf00	Fen (unclassified)	1			
Swamp	Ws00	Swamp (unclassified)	4			
	Ws02	Mountain alder – Pink spirea – Sitka sedge	1			
	Ws05	MacCalla's willow – Beaked sedge	1			
	Ws15	SwSb – Labrador tea – Glow moss	1			
Marsh	Wm00	Marsh (unclassified)	1			
	Wm02	Swamp horsetail – Beaked sedge	1			
	Wm03	Awned sedge	2			
	Wm04	Common spike-rush	1			
	Wm05	Cattail	1			

Wetland Class	Site Association	Vegetation Community	No. Sampled			
			2018	2019	2020	2021
	Wm06	Great bulrush	1			
Open Water	OW	Shallow Open Water (unclassified)	1			
Floodplain	Fl00	Low bench floodplain (unclassified)	8	1		
	Fl03	Pacific willow – Red-osier dogwood – Horsetail	1	1		
	Fl06	Sandbar willow	4	4		
	Fm00	Mid bench floodplain (unclassified)	2			
	Fm02	Cottonwood – Spruce – Red-osier dogwood	5			
		Reservoir Footprint Total	***36***	***7***	***0***	***0***
Downstream						
Swamp	Ws02	Mountain alder – Pink spirea – Sitka sedge		1		1
Floodplain	Fl00	Low bench floodplain (unclassified)		2		2
	Fl06	Sandbar willow		2		2
		Downstream Total		***5***		***5***
Transmission Line						
Bog	Wb03	Black spruce – Lingonberry – Peat-moss	1	6	1	6
	Wb05	Black spruce – Water sedge – Peat-moss	1		2	
	Wb06	Tamarack – Water sedge – Fen moss	3	7	4	7
	Wb08	Black spruce – Soft-leaved sedge – Peat-moss		7		7
	Wb09	Black spruce – Common horsetail – Peat-moss			1	
Fen	Wf01	Water sedge – Beaked sedge		3	1	3
	Wf02	Scrub birch – Water sedge	2	1	2	1
Swamp	Ws00	Swamp (unclassified)	1		2	
	Ws03	Bebb’s willow – Bluejoint		1	2	1
	Ws04	Drummond's willow – Beaked sedge	1			
	Ws05	MacCalla's willow – Beaked sedge			3	
	Ws06	Sitka willow – Sitka sedge	1			
	Ws07	Spruce – Common horsetail – Leafy moss	1		2	
	Ws14	Mountain Alder – Bebb’s Willow – Bluejoint	2		2	
Marsh	Wm00	Marsh (unclassified)		1	1	1
	Wm01	Beaked sedge – Water sedge	4	3	5	4
	Wm02	Swamp horsetail – Beaked sedge	1	1		1

Wetland Class	Site Association	Vegetation Community	No. Sampled			
			2018	2019	2020	2021
	Wm03	Awned sedge	1	4	8	5
	Wm05	Cattail	2		2	
	Wm15	Bluejoint – Beaked sedge		2		3
Open Water	OW	Shallow Open Water (unclassified)		1	2	1
		Transmission Line Total	***21***	***37***	***40***	***40***
		Grand Total	**57**	**49**	**40**	**45**

5. WETLAND SAMPLING PLAN: 2022–2027

As per *BC Hydro Site C Vegetation and Wildlife Wetland Monitoring Program: Baseline and Construction Phase Wetland Monitoring* (NPS 2020), wetlands are sampled two years after the initial baseline assessment, then every five years after that.

A summary of the total number of wetlands that have been sampled to date are presented in Table 5-1. This includes: 1) wetlands that have been re-assessed after the baseline visit; and 2) the expected number of wetlands to be sampled from 2022 to 2027. The first year that the two- and five-year construction monitoring assessments will be completed for all wetlands in the study will be 2027.

Table 5-1. Summary of Wetlands Sampled from 2016 to 2021 and Planned Construction Monitoring for 2021 to 2027

	Pre-NPS Methodology		Baseline and/or Construction Monitoring			Construction Monitoring						
General Location	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Downstream	-	-	-	5	-	5	-	-	-	-	5	-
Transmission Line	53	-	21	37	40	40	22	-	-	20	38	22
Reservoir	3	6	36	7	-	-	-	-	-	-	-	-
Total	**56**	**6**	**57**	**49**	**40**	**45**	**22**	**0**	**0**	**20**	**43**	**22**

The specific wetland sites that were sampled from 2016 to 2021, and those that will be sampled from 2022 to 2027, are presented in Table 5-2. Wetlands located within the reservoir area are not included in the construction monitoring, as they will be inundated as the reservoir is filled.

Table 5-2. Wetlands Sampled from 2016 to 2021 and Planned Construction Monitoring for 2021 to 2027

General Location	Site	Pre-NPS Methodology				Baseline and/or Construction Monitoring				Construction Monitoring			
		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Downstream	WL203				x		x					x	
	WL204				x		x					x	
	WL205				x		x					x	
	WL206				x		x					x	
	WL207				x		x					x	
Reservoir	WL001			x									
	WL002	x		x									
	WL003			x									
	WL004	x		x									

General Location	Site	Pre-NPS Methodology				Baseline and/or Construction Monitoring				Construction Monitoring			
		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Reservoir (cont'd)	WL005			x									
	WL006	x		x									
	WL007			x									
	WL008			x									
	WL009			x									
	WL010			x									
	WL011			x									
	WL012			x									
	WL013			x									
	WL014			x									
	WL015			x									
	WL016			x									
	WL017			x									
	WL018			x									
	WL019			x									
	WL022			x									
	WL023			x									
	WL024			x									
	WL025			x									
	WL026			x									
	WL027			x									
	WL028			x									
	WL029			x									
	WL030			x									
	WL031			x									
	WL032			x									
	WL033			x									
	WL034			x									
	WL035			x									
	WL036			x									
	WL037			x									
	WL038			x									
	WL208				x								

General Location	Site	Pre-NPS Methodology				Baseline and/or Construction Monitoring				Construction Monitoring			
		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Reservoir (cont'd)	WL209				x								
	WL210				x								
	WL211				x								
	WL212				x								
	WL213				x								
	WL214				x								
Transmission Line	BR2				x		x					x	
	MWL02	x			x		x					x	
	MWL08	x			x		x					x	
	MWL09	x			x		x					x	
	MWL10	x			x		x					x	
	MWL12	x			x		x					x	
	MWL13	x			x		x					x	
	MWL14	x			x		x					x	
	MWL18	x			x		x					x	
	MWL19	x			x		x					x	
	MWL33	x			x		x					x	
	MWL58	x			x		x					x	
	MWL59	x			x		x					x	
	MWL62	x			x		x					x	
	MWL69	x			x		x					x	
	MWL72	x			x		x					x	
	OWL001	x				x		x					x
	OWL011	x					x	x					x
	OWL021	x				x		x					x
	OWL026	x				x		x					x
	OWL027	x				x		x					x
	OWL030	x				x		x					x
	OWL032	x				x		x					x
	OWL034	x				x		x					x
	OWL035	x				x		x					x
	OWL053	x				x		x					x
	OWL060	x				x		x					x

General Location	Site	Pre-NPS Methodology				Baseline and/or Construction Monitoring				Construction Monitoring			
		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Transmission Line (cont'd)	OWL061	x					x	x					x
	OWL063	x				x		x					x
	OWL067	x				x		x					x
	OWL070	x				x		x					x
	OWL071	x				x		x					x
	OWL073	x				x		x					x
	OWL102		x			x		x					x
	OWL103		x			x		x					x
	OWL107		x			x		x					x
	OWL109		x			x		x					x
	OWL110		x			x		x					x
	PI1				x		x					x	
	PI2				x		x					x	
	PI4				x		x					x	
	PR				x		x					x	
	WL020	x		x		x					x		
	WL021	x		x		x					x		
	WL100			x		x					x		
	WL101	x		x		x					x		
	WL102	x		x		x					x		
	WL103	x		x		x					x		
	WL104	x		x		x	x					x	
	WL105	x		x		x					x		
	WL106	x		x		x					x		
	WL107			x		x					x		
	WL108	x		x		x					x		
	WL109			x		x					x		
	WL110			x		x					x		
	WL111			x		x					x		
	WL112			x		x					x		
	WL113			x		x					x		
	WL114			x		x					x		
	WL115	x		x		x					x		

General Location	Site	Pre-NPS Methodology				Baseline and/or Construction Monitoring				Construction Monitoring			
		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Transmission Line (cont'd)	WL116	x		x		x					x		
	WL117		x	x		x					x		
	WL118	x		x		x					x		
	WL200				x		x					x	
	WL201				x		x					x	
	WL202	x			x		x					x	
	WL215	x			x		x					x	
	WL216				x		x					x	
	WL217				x		x					x	
	WL218	x			x		x					x	
	WL219	x			x		x					x	
	WL220	x			x		x					x	
	WL221	x			x		x					x	
	WL222				x		x					x	
	WL223				x		x					x	
	WL224	x			x		x					x	
	WL225	x			x		x					x	
	WL226				x		x					x	
	WL228	x			x		x					x	
	WL229				x		x					x	

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APPENDIX A. DEFINITION OF STRUCTURAL STAGES AND SUCCESSIONAL STATUS CODES

Structural stage codes and structural stage modifiers are used to describe the vegetation structure and appearance in each ecosystem unit. Structural stage codes describe the relative age of a given ecosystem (i.e., shrub-dominated vs. old-growth forest) while the modifiers are used to provide additional descriptions of structural stages (BC MOE and MOF 2010). Note that while the successional status has been included in the summary tables for each wetland class, it has been loosely applied as the codes used to describe successional status in British Columbia were developed for forested communities and are not directly applicable to non-forested wetlands.

Structural Stage

Structural Stage	Description
Post-disturbance stages or environmentally induced structural development	
1 Sparse/bryoid	Initial stages of primary and secondary succession; bryophytes and lichens often dominant, can be up to 100%; time since disturbance less than 20 years for normal forest succession, may be prolonged (50–100+ years) where there is little or no soil development (bedrock, boulder fields); total shrub and herb cover less than 20%; total tree layer cover less than 10%.
1a Sparse	Less than 10% vegetation cover.
Stand initiation stages or environmentally induced structural development	
2 Herb	Early successional stage or herbaceous communities maintained by environmental conditions or disturbance (e.g., snow fields, avalanche tracks, wetlands, grasslands, flooding, intensive grazing, intense fire damage); dominated by herbs (forbs, graminoids, ferns); some invading or residual shrubs and trees may be present; tree layer cover less than 10%, shrub layer cover less than or equal to 20% or less than 1/3 of total cover, herb-layer cover greater than 20%, or greater than or equal to 1/3 of total cover; time since disturbance less than 20 years for normal forest succession; many herbaceous communities are perpetually maintained in this stage.
2a Forb-dominated	Herbaceous communities dominated (greater than 1/2 of the total herb cover) by non-graminoid herbs, including ferns.
2b Graminoid-dominated	Herbaceous communities dominated (greater than 1/2 of the total herb cover) by grasses, sedges, reeds, and rushes.
2c Aquatic	Herbaceous communities dominated (greater than 1/2 of the total herb cover) by floating or submerged aquatic plants; does not include sedges growing in marshes with standing water (which are classed as 2b).
3 Shrub/Herb	Early successional stage or shrub communities maintained by environmental conditions or disturbance (e.g., snow fields, avalanche tracks, wetlands, grasslands, flooding, intensive grazing, intense fire damage); dominated by shrubby vegetation; seedlings and advance regeneration may be abundant;

Structural Stage	Description
	tree layer cover less than 10%, shrub layer cover greater than 20% or greater than or equal to 1/3 of total cover.
3a Low shrub	Communities dominated by shrub layer vegetation less than 2 m tall; may be perpetuated indefinitely by environmental conditions or repeated disturbance; seedlings and advance regeneration may be abundant; time since disturbance less than 20 years for normal forest succession.
3b Tall shrub	Communities dominated by shrub layer vegetation that are 2–10 m tall; may be perpetuated indefinitely by environmental conditions or repeated disturbance; seedlings and advance regeneration may be abundant; time since disturbance less than 40 years for normal forest succession.
Stem exclusion stages	
4 Pole/Sapling	Trees greater than 10 m tall, typically densely stocked, have overtopped shrub and herb layers; younger stands are vigorous (usually greater than 10–15 years old); older stagnated stands (up to 100 years old) are also included; self-thinning and vertical structure not yet evident in the canopy - this often occurs by age 30 in vigorous broadleaf stands, which are generally younger than coniferous stands at the same structural stage; time since disturbance is usually less than 40 years for normal forest succession; up to 100+ years for dense (5,000–15,000+ stems per hectare), stagnant stands.
5 Young Forest	Self-thinning has become evident, and the forest canopy has begun differentiation into distinct layers (dominant, main canopy, and overtopped); vigorous growth and a more open stand than in the pole/sapling stage; time since disturbance is generally 40–80 years but may begin as early as age 30, depending on tree species and ecological conditions.
Understory re-initiation stage	
6 Mature Forest	Trees established after the last disturbance have matured; a second cycle of shade-tolerant trees may have become established; understories become well developed as the canopy opens up; time since disturbance is generally 80−250 years.
Old-growth stage	
7 Old Forest	Old, structurally complex stands composed mainly of shade-tolerant and regenerating tree species, although older seral and long-lived trees from a disturbance such as fire may still dominate the upper canopy; snags and coarse woody debris in all stages of decomposition typical, as are patchy understories; understories may include tree species uncommon in the canopy, due to inherent limitations of these species under the given conditions; time since disturbance generally greater than 250 years.

Structural Stage Modifiers are used to describe the overstorey structure of a forested stand, often related to disturbance history or edaphic conditions (BC MOE and MOF 2010).

Structural Stage Modifiers

Modifier	Description
s single storied	Closed forest stand dominated by the overstory crown class (dominant and co-dominant trees); intermediate and suppressed trees account for less than 20% of all crown classes combined, advance regeneration in the understory is generally sparse.
t two storied	Closed forest stand co-dominated by distinct overstory and intermediate crown classes; the suppressed crown class is lacking or accounts for less than 20% of all crown classes combined, advance regeneration is variable.
m multistoried	Closed forest stand with all crown classes well represented; each of the intermediate and suppressed classes account for greater than 20% of all crown classes combined, advance regeneration is variable.
o open	Forest stand with very open main and intermediate crown classes (totaling less than 25% cover); substantial understorey light levels commonly result in well-developed shrub and/or herb understorey.

Stand composition modifiers are used to provide additional descriptions of structural stages 3–7 and indicate the dominance of the stand by broadleaf, conifers, or a mixed forest (BC MOE and MOF 2010).

Stand Composition Modifiers

Modifier	Description
C - coniferous	Greater than 3/4 of total tree layer cover is coniferous.
B - broadleaf	Greater than 3/4 of total tree layer cover is broadleaf.
M - mixed	Neither coniferous nor broadleaf account for greater than 3/4 of total tree layer cover.

Successional status describes a temporal stage of a given ecosystem type in relation to its expected stable state for a given environment (BC MOE and MOF 2010). It is generally used to describe the development of a community after a large-scale disturbance (natural or human). The successional system was developed for forested ecosystems, but can be generally applied to other communities to describe the current status of the community relative to what is expected to occur on the site (BC MOE and MOF 2010).

Successional Status

Successional Status	Description
NV – Non-vegetated	Due to substrate or disturbance, vegetation cover is absent or less than five percent.
PS – Pioneer Seral	Initial stages of re-vegetation after disturbance.

Successional Status	Description
YS – Young Seral	Early successional community where competition has not created structural complexity. Often a mix of pioneer and early successional species. Forested stands are even-aged, and less than 60 years old.
MS – Maturing Seral	Early successional tree species that have gone through natural self-thinning. Overstorey and understory of trees present, with understory species including shade tolerant trees. Trees of mature age, generally 60–140 years old.
OS – Overmature Seral	Overstorey seral tree species are dying, usually older than 140 years.
YC – Young Climax	Young stand with trees species typical of climax expected for site. Composition and structure are underdeveloped.
MC – Maturing Climax	Mature (80–120 years old) stand of climax species that has undergone natural thinning, with few seral species remaining. Vertical structure is developed.
OC – Old Climax	Old (greater than 250 years) and composed of expected climax species. Vertical structure is well developed, including canopy gaps, and large woody debris is common on forest floor.
DC – Disclimax	Persistent community that does not reflect the expected species composition due to disturbance (historic or repeated). Used for species conditions where processes or events are holding natural succession from moving forward.

Appendix 6. 2021 Preconstruction Rare Plant Surveys

EAGLE CAP CONSULTING
environmental consulting services

2021 Annual Report
Pre-construction Rare Plant Surveys
Site C Clean Energy Project

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December 20, 2021

Contents

1. Introduction **3**

1.1. Background 3

1.2. Scope 4

1.3. Study Area 5

2. Methods **5**

2.1. Pre-field Review 5

2.2. Field Survey 7

2.3. Mitigation Planning and Implementation Assistance 11

2.4. Analysis 11

3. Results **12**

3.1. Pre-field Review 12

3.2. Field Survey 13

3.3. Mitigation Planning and Implementation 16

4. Discussion **19**

4.1. Coverage 19

4.2. Seasonal Timing 19

4.3. Remaining Areas to Survey 20

5. Closure **22**

6. References **23**

7. Appendices **27**

7.1. Appendix 1: Rare plant taxa with potential for occurrence in the Site C Project area 28

7.2. Appendix 2: Plant and lichen species recorded during the 2015–2021 surveys 32

7.3. Appendix 3: Species Accounts for Rare Plant Taxa Found During Preconstruction Surveys 41

7.3.1. Atriplex gardneri var. gardneri (Gardner's sagebrush) 42

7.3.2. Carex sprengelii (Sprengel's sedge) 43

7.3.3. Carex torreyi (Torrey's sedge) 45

7.3.4. Carex xerantica (dry-land sedge) 46

7.3.5. Lomatium foeniculaceum var. foeniculaceum (fennel-leaved desert-parsley) 47

7.3.6. Oxytropis campestris var. davisii (Davis' locoweed) 49

7.3.7. Penstemon gracilis (slender penstemon) 50

7.3.8. Piptatheropsis canadensis (Canada ricegrass) 52
7.3.9. Ranunculus rhomboideus (prairie buttercup) 53
7.3.10. Salix petiolaris (meadow willow) 55
7.3.11. Selaginella rupestris (rock selaginella) 56

1. INTRODUCTION

1.1. Background

The Environmental Assessment Certificate (EAC #E14-02) for the Site C Clean Energy Project (the Project) sets out the conditions that BC Hydro must comply with during construction and operation of the Project (BC Environmental Assessment Office 2014). Condition 9 states in part:

- *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 preconstruction 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.*

In addition, the Federal Decision Statement (FDS) issued under the Canadian Environmental Assessment Act sets out conditions relating to rare plants (Canadian Environmental Assessment Agency 2014). Condition 16 states in part:

- *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:*
    - *16.3.3. 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;*
    - *16.3.6. 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.*

To partially fulfill EAC condition 9 and FDS conditions 16.1, 16.2, 16.3.3, 16.3.4, 16.3.6 and 16.3.7, BC Hydro is conducting preconstruction rare plant surveys in previously unsurveyed areas of the proposed transmission line, access roads, and other construction corridors. By documenting additional occurrences of rare plants within the Project footprint, measures to mitigate effects to these occurrences—including seed recovery and translocation—can be identified.

Data collected during these pre-construction rare plant surveys are added to the Project's spatial environmental features database. These spatial data are used during detailed design and construction to identify opportunities for avoidance, areas where extra care is needed, and areas where losses will occur. The first season of pre-construction surveys was completed in the summer and fall of 2015, and the work has been proceeding every year since. This interim report documents the methods and results of the surveys completed from 2015 through the end of the 2021 field season.

1.2. Scope

The goals of the study are:

- to develop, maintain, and update a spatial database of rare plant occurrences in the vicinity of Project facilities;
- to determine the location of rare plant occurrences in previously unsurveyed areas that are proposed for ground or vegetation disturbance during construction and operation of the Project;
- to determine the location of rare plant occurrences within two mitigation parcels that will be used to compensate for project effects;
- to record detailed occurrence data in the master rare plant spatial database for all rare plant populations found, and submit these data to the B.C. Ministry of Environment and Climate Change Strategy (MOECCS) and—for taxa of federal concern—to Environment and Climate Change Canada (ECCC);
- to develop occurrence-specific mitigation measures to eliminate or reduce adverse effects to rare plant populations resulting from the Project; and
- to assist construction teams in implementing the ongoing rare plant mitigation measures.

1.3. Study Area

Pre-construction rare plant surveys are being conducted in:

- the Highway 29 realignment corridors;
- the proposed transmission line corridor;
- the proposed new or upgraded transmission line access road corridors;
- the proposed new or upgraded access road corridors into the reservoir clearing zone—excluding the reservoir footprint;
- the proposed aggregate extraction areas;
- the proposed haul road running along Ice Bridge and Septimus Roads from Area E to the Dam Site;
- the proposed Project Access Road corridor running from Jackfish Road to the Dam Site;
- the proposed access road extension at the Portage Mountain site;
- the 85th Avenue industrial site;
- the proposed conveyor corridor from the 85th Avenue industrial site to the dam site;
- the 204 hectare Rutledge mitigation parcel along Highway 29 at Dry Creek; and
- the 423 hectare Wilder Creek mitigation parcel located along the Peace River approximately six kilometres downstream from Bear Flat.

Pre-construction rare plant surveys were completed for some of these areas during the 2015 through 2020 field seasons. The 2021 work 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 and Area E proposed aggregate extraction sites as well as the Area E proposed haul road.

2. METHODS

2.1. Pre-field Review

Each year in the spring the investigation begins with a pre-field review designed to collect and analyze existing data. This information is used to create a field study plan and to identify data gaps in order to direct further research.

For the purpose of the investigation, “rare plants” are defined as the following vascular plants, mosses, and lichens:

- species listed on Schedule 1 of the Canadian Species at Risk Act (SARA) as amended (Government of Canada 2002);

- species assigned a status of Extinct, Extirpated, Endangered, Threatened, or Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2021); and
- species on the B.C. MOECCS' provincial Red or Blue lists (BCCDC 2021).

Since 2005, BC Hydro has been conducting rare plant surveys in the Project's Regional Assessment Area (RAA)—as defined in the Site C Environmental Impact Statement (Hilton et al. 2013). As such, much is known about the rare flora of the area, and the pre-field review is based heavily on rare plant occurrence data collected over the last 16 years. Currently, 26 different rare plant taxa are reported to occur in the Project area. Consequently, these 19 vascular plants, four lichens, and three mosses form the basis of the target species list for the work, comprising the rare species with the highest likelihood of occurrence.

Since 2011 all rare plant data for the Project are managed in a master rare plant spatial database. This database contains occurrence information for all known rare plant sites in the RAA, as well as rare plant survey tracks, field notes, species information, and other collected data relevant to the rare plant work. Periodically, the master rare plant spatial database is queried to update the Project's spatial environmental features database (separately maintained by BC Hydro). This environmental features database is made available to Project engineers for use in mitigation planning.

In order to identify additional rare plant species that could potentially occur in the Project area, each year the dataset of all B.C. vascular plants, mosses, and lichens is downloaded from the MOECCS' Species and Ecosystem Explorer (BCCDC 2021). Queries are run on the dataset to extract a list of the rare plant species that MOECCS associates with the Peace River Regional District and the Boreal Black and White Spruce Biogeoclimatic Zone. Each species on this list is further reviewed to determine its potential for occurrence within the areas targeted for survey.

In addition, the B.C. Conservation Data Centre's (BCCDC) occurrence dataset of all species and ecosystems at risk (MOECCS 2019) is downloaded from the B.C. Data Catalogue and added to the master rare plant spatial database. The dataset is queried to investigate historic and verified extant rare plant occurrences within the Project area.

All the above information is compiled to produce a list of target rare plant species potentially occurring within the Project area. This target list includes the 26 taxa currently reported to occur in the Project area, as well as numerous other possible Peace Region species uncovered during the pre-field review of data and literature. The target list is used as a working guideline and can never be an exhaustive list of all potential rare plants for a given area. For this reason, the botanists consider all described plant taxa while conducting surveys.

Aerial imagery, contour information, and project maps are reviewed to predict the habitat types present in the survey corridors. General plant communities are determined, and the locations of possible high-suitability rare plant habitat are noted.

To refine their search images for the target taxa, the surveyors study photographs, herbarium specimens, and species descriptions in various published references (Hitchcock et al. 1955; Flora of North America Editorial Committee 1993; Goward et al. 1994; McCune et al. 1995; Douglas et al. 1998; Goward 1999;

Brodo et al. 2001; Cronquist et al. 2013; Brodo 2016) and online databases (CNALH 2021; Klinkenberg 2021; NatureServe 2021). In addition, they review similar data for species that might be confused with the target taxa. Tables of summary identification characteristics are prepared for field use. The goals are to maximize detectability of the target species and to reduce surveyor bias during the field work.

The final field plan each year is designed to guide the methods, coverage, and timing of the rare plant surveys. Seasonal timing is based on the predicted phenologies of the target species.

2.2. Field Survey

The pre-construction surveys began in June of 2015 and have taken place every year since. Over the seven field seasons, 297 surveyor-days have been spent surveying a total transect distance of 1,753.9 kilometres (Table 1 and Figure 1).

Table 1: Rare Plant Survey Effort

Year	Start Date	End Date	Surveyor-Days	Total Survey Km
2015	June 30	September 7	42	209.8
2016	June 20	August 23	41	191.8
2017	June 23	August 12	12	51.7
2018	June 13	August 29	56	409.3
2019	May 31	August 15	46	250.7
2020	June 4	October 9	56	322.3
2021	June 8	September 4	44	318.3
Totals			**297**	**1,753.9**

Table notes:

- *Surveyor-Days = days spent surveying x number of botanists*
- *Total Survey Km = total survey transect distance*

For all seven years, the surveys were performed by two senior-level rare plant botanists, both of whom have been working with the rare flora of the Project area for the past 11 years. The surveyors primarily use a habitat-directed meander search protocol to cover the areas surveyed. This survey technique is based on floristic, intuitive-controlled meander search types outlined in various rare plant survey guidelines (Whiteaker et al. 1998; ANPC 2000; ANPC 2012; Penny & Klinkenberg 2012; MOECCS Ecosystems Branch 2018). The surveyors, working together or separately, walk the length of the linear corridors, zig-zagging back and forth from one edge of the proposed disturbance area to the other. For non-linear survey areas such as the Industrial 85th Avenue or Portage Mountain sites, the surveyors conduct meander transects to cover the entire area.

When using the habitat-directed meander search protocol:

- surveyors walk variable-width transects that are spaced relatively close together (typically so that the edge of the transect just surveyed is still visible to the surveyor or their partner—this distance varies based on the habitat surveyed and the detectability of the target species);
- surveyors attempt to locate all rare plant occurrences and high-suitability rare plant habitat within a defined unit in a systematic way (e.g., by walking in a zig-zag pattern along linear features, or in a contour pattern when surveying non-linear features); and
- surveyors attempt to traverse a representative cross-section of all low-suitability rare plant habitat within the unit.

The habitat-directed meander search preferentially covers high-suitability ecosystems over the more common low-suitability habitats (MacDougall & Loo 2002). The survey method is floristic in nature, meaning that all plant taxa encountered are recorded and identified to a level necessary to determine their rarity (ANPC 2012). Furthermore, the habitat-directed meander search pattern is of variable intensity, such that when a rare plant occurrence or high-suitability rare plant habitat is located, the surveyors increase the intensity of their survey by narrowing the spacing of the transect pattern they are walking. Depending on the kind of habitat being surveyed and the detectability of the target rare species, this can require very close, hands-and-knees survey work in some areas.

For certain linear corridors that traverse habitat with a low potential for rare plant occurrence, the botanists drive slowly along the corridor in a Utility Terrain Vehicle (UTV) or truck, scanning both sides for rare plants and pockets of high-suitability rare plant habitat. This procedure is only conducted in corridors where the majority of habitat is low-probability, and at a speed of approximately 5 kilometres per hour. If high-potential rare plant habitat is encountered—such as wetlands or rock outcrops—the surveyors exit the vehicle and survey the habitat on foot. In 2015, 5.1% of the total 209.8 kilometres traversed was surveyed from UTV and the rest was walked. In 2016 only 0.9% of the total 191.8 kilometres survey distance was covered by UTV. In 2017, none of the transects were surveyed by UTV. In 2018, 14.6% of the total 409.3 kilometres was covered by UTV or truck, and in 2019, 2.3% of the total 250.7 kilometres was covered by UTV. Likewise in 2020, 2.3% of the total 322.3 transect kilometres were surveyed in this way. No corridors were surveyed by UTV in 2021.

In 2016, surveys were conducted within the Rutledge and Wilder Creek mitigation parcels. These surveys were designed to provide a general overview of the rare plant populations present within the parcels, in order to inform mitigation planning. As such, these areas were surveyed at a lower intensity level, covering a smaller percentage of the suitable habitats than in the areas proposed for disturbance. Although the habitat-directed meander survey technique described above was used in the mitigation parcels, certain areas of suitable habitat were not covered.

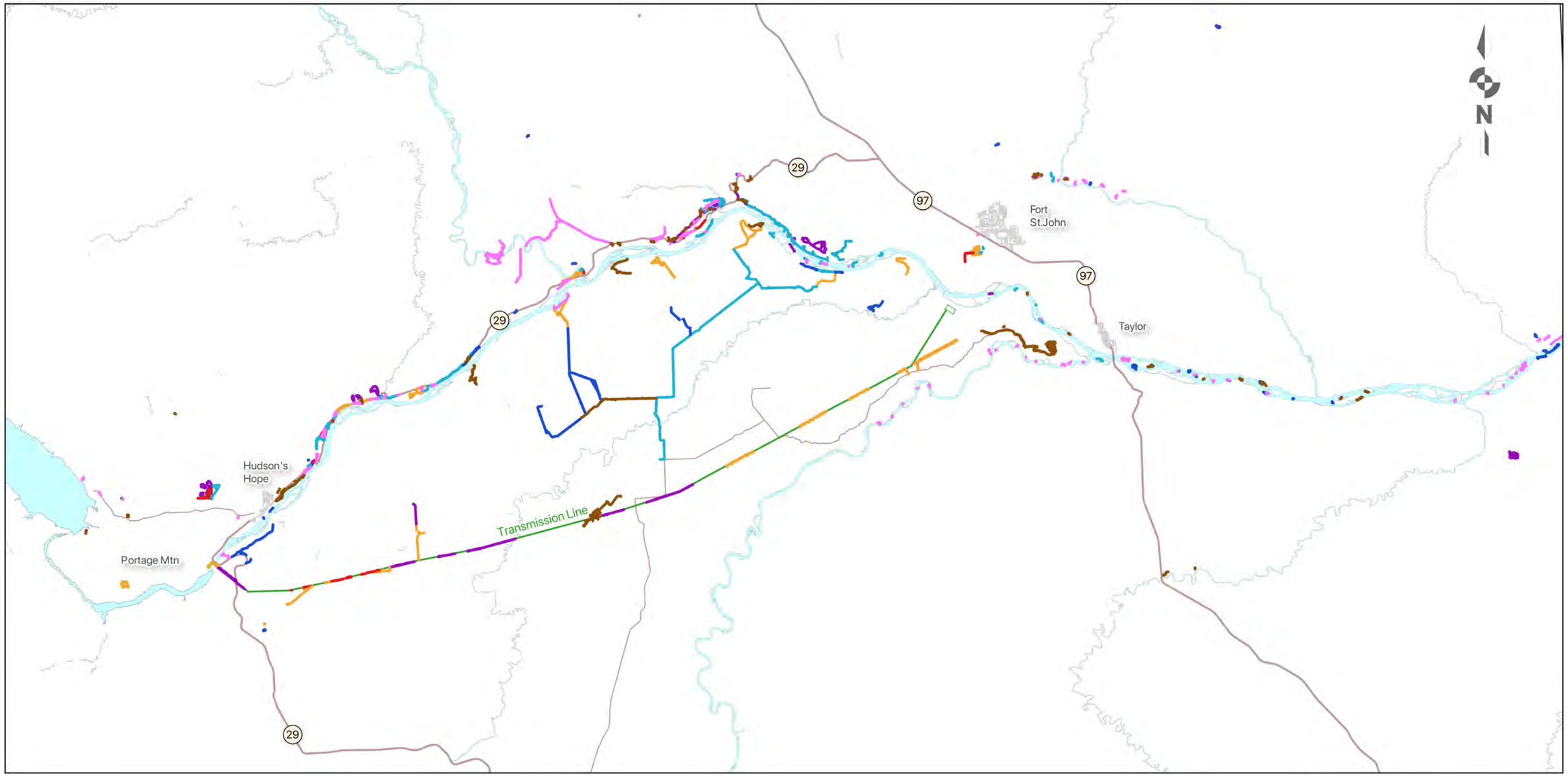
During the fieldwork, the surveyors constantly monitor all areas traversed for changes in habitat and plant association, as well as for previously unrecorded plant species (common and rare). Lists are kept of all plants and plant communities observed; unknown species are collected for later identification in the lab; Global Positioning System (GPS) units are used to mark location points as appropriate; and notes and

photographs are taken to record plants of interest, landforms and unique features, habitat quality and disturbance, and areas requiring further survey.

When target rare plants are found during the fieldwork, occurrence information is entered into custom-built digital forms or recorded on printed BCCDC rare plant survey forms (BCCDC 2012). Where paper forms are used, the information is later transcribed into digital format to facilitate analysis of the sites. Photographs are taken of both the individual plants and the surrounding habitat. Consistent with the B.C. Resource Information Standards Committee guidelines and the rare plant survey guidelines on the B.C. E-Flora website a voucher specimen is collected where permitted by the landowner, and when doing so would not compromise the viability of the population (RIC 1999; Penny & Klinkenberg 2012; MOECCS Ecosystems Branch 2018). At each vascular rare plant site, GPS units are used to record the boundary of the occurrence to facilitate mitigation planning.

Delimitation of occurrences is based on *A Habitat-Based Strategy for Delimiting Plant Element Occurrences* (NatureServe 2004). The Element Occurrence (EO) is a fundamental unit of information in the CDC system, and is defined as "an area of land and/or water in which a species or natural community is, or was present." (NatureServe 2002). Based on the NatureServe guidance, rare plants are typically grouped into a single occurrence when they are located closer than one kilometre from another individual of the same species. In some cases, occurrences are composed of two or more discrete patches—also referred to as "sites" in this report—spread out over a large area. These patches are mapped separately to facilitate mitigation planning, but are recorded as a single occurrence when the patches are closer than one kilometre to each other.

The botanists conducting the 2019, 2020, and 2021 preconstruction surveys were also working on the Site C Experimental Rare Plant Translocation program at the time, selecting and documenting potential recipient sites for translocation outplanting. When new rare plant sites were found during potential recipient site selection work, they were documented using the same methods as described above. All of the new rare plant sites found during the survey work for either program are reported here to provide a single document that contains all the new rare plant sites.



Map Notes:

1. Based on surveys completed through September 2021.
2. Map Datum: NAD83
3. Map Projection: UTM Zone 10 N
4. Water Features Base Data from BC FreshwaterAtlas.
5. Road Base Data from the BC Digital Roads Atlas project.
6. Project-specific spatial data supplied by BC Hydro.

Legend

Roads
- Highway
- Secondary Roads
- Urban

Survey Transects
- 2015
- 2016
- 2017
- 2018
- 2019
- 2020
- 2021

Map Scale 1:350000

0 10 20 30 km

SITE C CLEAN ENERGY PROJECT

BC hydro

EAGLE CAP CONSULTING environmental consulting services

Figure 1
Rare Plant Survey Routes 2015 to 2021

Date	December 10, 2021	DWG NO	2021-12-10-001	Revision 0

2.3. Mitigation Planning and Implementation Assistance

In certain priority cases, where rare plant occurrences are situated in or near Project construction zones, the botanists work with BC Hydro planning teams and contractors to develop mitigation measures designed to reduce or eliminate impacts to the occurrences. This takes place on an as-needed basis in situations where a species is particularly difficult to identify in the field, or the layout of the occurrence is complex and difficult to map on the ground. The mitigation measures developed are focussed on avoidance or impact reduction, and include flagging occurrences in the field, coordinating with on-site construction personnel, and assisting rare plant salvage operations.

In addition, for one Red-listed species confirmed for the project area in 2018—*Selaginella rupestris* (rock selaginella)—a set of mitigation options were developed for all known occurrences in the RAA.

2.4. Analysis

As field data are collected, they are imported into the master rare plant spatial database on a daily basis. This includes rare plant occurrence information, survey transect routes, and field notes. Collected data are encrypted and secured with multi-factor authentication protocols. The information and field photos are backed up nightly to secure off-site servers.

Following the field season, the collected rare plant information is compiled and analyzed in the Project rare plant Geographic Information System (GIS). Voucher specimens are examined and sent to outside experts when additional verification is required. New rare plant locations are compared with BCCDC data to determine if the newly discovered sites can be combined as extensions of previously recorded occurrences.

Every year, once the data have been compiled, verified, and cleaned, a submission package is prepared for the BCCDC. This dataset contains all the new rare plant occurrences found during the previous field season, as well as any updates and extensions to previously reported occurrences. The data are provided in a spatial format compatible with BCCDC submission requirements. Voucher specimens are prepared based on MOECCS guidelines (MOECCS 2018) and submitted to the appropriate herbarium (typically UBC).

The following quality assurance and quality control measures are applied to promote accurate data collection and analysis:

- The master rare plant spatial database, which contains all rare plant data for the project, is a custom-built spatial database (PostgreSQL 13.1 spatially enabled with PostGIS 3.1). The database server software is regularly updated to the latest stable versions and all security patches are applied soon after issue.
- The tables in the database have been normalized to reduce data redundancy and improve integrity.

- Primary key constraints are enforced for all relational tables to improve database integrity and allow complex queries to be run.
- Fields are constrained at the database level to ensure type-consistency. Electronic input forms also constrain entered data to provide front-end validation and user guidance.
- Regular updates are pulled from the MOECCS' Ecosystem Explorer and are added to the master database to ensure that analyses are performed using the latest BCCDC rare plant statuses and nomenclature.
- The data fields *UTM northing*, *UTM easting*, *lat_long,* and *occurrence area* are calculated programmatically from the rare plant polygons, for accuracy of the derived fields. Point data are also derived programmatically from the rare plant polygons for locational consistency between the spatial fields.
- Multipolygons—a GIS feature class that allows one or more closed plane figures to be recorded for each occurrence—are used as the basic spatial descriptor for the rare plant occurrences recorded after 2008. This allows for more precise avoidance mitigation than would be possible using single polygons or points.
- Custom-built electronic forms are used by the botanists to enter rare plant data in the field while at the occurrence. Paper versions of the forms are also used in cases where there are difficulties with the electronic entry devices. In these cases, the paper forms are transcribed onto the electronic forms as soon as possible to allow for data validation.
- Every record is reviewed for typographical and transcription errors at the end of the field season.
- Associated species lists are reviewed by a second botanist to ensure identification accuracy.
- Rare plant polygons are reviewed on aerial imagery and ecosystem layers in the GIS to check boundary accuracy by the botanist(s) who recorded the occurrence.
- Voucher specimens are collected where appropriate and verified in the lab and herbarium, or are sent to species experts for further verification when taxonomic questions still exist.

3. RESULTS

3.1. Pre-field Review

The 2021 pre-field review identified 102 rare plant taxa with potential for occurrence in the overall Project area (Appendix 1). The list comprises 38 vascular plant species, 47 bryophytes, and 17 lichens. As noted previously, this list was used for planning purposes and was not considered to be an exhaustive listing of all possible rare plant taxa in the project area. The surveyors considered all rare taxa during the surveys, whether they were on the target list or not.

It should also be noted that the BCCDC regularly reviews the statuses of the plant taxa in the province to determine if new information warrants a change in the rarity rankings. As the Site C rare plant work

proceeds, the numerous new occurrences that have been found during the surveys have allowed the BCCDC to reassess many of the plant taxa in the RAA. These reassessments are typically published by the BCCDC in May of the year, allowing Project botanists to incorporate the updates into the field plan for the upcoming season.

However, in 2019 the BCCDC status update was not published until July 5, after several weeks of field work had been completed. The update removed 10 RAA plant taxa from the Red or Blue lists, meaning that they no longer meet the definition of "rare plants" for the Project (see Section 2.1). This reduced the number of rare plant sites within the RAA by more than half, from 261 occurrences before the update, to 124 after the update.

In 2021, the BCCDC status updates were published in the first half of June, allowing time to incorporate the results into the 2021 field plan. However, the 2021 status changes were more limited than in 2019, resulting in only a few modifications to the target species list, and no changes to the statuses of species that have been observed during rare plant surveys for the Project.

3.2. Field Survey

The 2015 field surveys found 34 new sites of 14 different rare plant species—11 vascular plants and three lichens. Some of these new sites were within one kilometre of other occurrences of the same species found in previous years, and so were considered to be extensions of these previously reported occurrences. Of the 14 rare species, five were on the MOECCS's Red list, with the remaining nine being on the Blue list. None of the taxa were listed on Schedule 1 of the Species at Risk Act, or were considered to be Extinct, Extirpated, Endangered, Threatened, or Special Concern by COSEWIC (Government of Canada 2002; COSEWIC 2021). Some of the rare taxa found in 2015 have since had their statuses revised and are no longer Red- or Blue-listed by MOECCS.

In 2016, 88 new sites of 13 different rare plant species were found—10 vascular plants and three lichens. As in 2015, some of the new sites were considered to be extensions of occurrences found in previous years. Of the 13 rare species found in 2016, five were on the B.C. Red list, while the remaining eight were on the Blue list. None of the 2016 taxa were listed on Schedule 1 of the Species at Risk Act, or were considered to be Extinct, Extirpated, Endangered, Threatened, or Special Concern by COSEWIC (Government of Canada 2002; COSEWIC 2021). As with the 2015 rare plant taxa, some of the 13 rare plant species found in 2016 are no longer Red- or Blue-listed by the MOECCS.

In 2017, three new sites of two different lichen species were found. One of the sites was considered to be an extension of a previously reported occurrence, and two were new occurrences. Both taxa found in 2017 were on the B.C. Blue list, however they have both since been removed. Neither was listed on Schedule 1 of the Species at Risk Act, or was considered to be Extinct, Extirpated, Endangered, Threatened, or Special Concern by COSEWIC (Government of Canada 2002; COSEWIC 2021).

For the 2018 field season, 46 rare plant sites were found. Several of these were extensions of previously known occurrences. Fourteen different rare plant taxa were found: four B.C. Red list, and 10 Blue list. None of the 14 were listed on Schedule 1 of the Species at Risk Act, or were considered to be Extinct,

Extirpated, Endangered, Threatened, or Special Concern by COSEWIC (Government of Canada 2002; COSEWIC 2021). Several of the taxa documented in 2018 have since been removed from the B.C. Red/Blue lists.

In 2019, 21 occurrences of nine rare or formerly rare taxa were found or expanded. These 21 occurrences contained 47 separate patches. One of the taxa was on the B.C. Red list, six were on the Blue list, and two were on the Yellow list (*i.e.*, apparently secure) after being revised in July 2019 when the BCCDC status changes were published (BCCDC 2021). None of the nine taxa were listed on Schedule 1 of the Species at Risk Act, or was considered to be Extinct, Extirpated, Endangered, Threatened, or Special Concern by COSEWIC (Government of Canada 2002; COSEWIC 2021).

During the 2020 field season, 22 rare plant occurrences (comprising 47 separate patches) were discovered or expanded. Nine rare plant species were documented: three Red-listed taxa and six Blue-listed taxa. None of the nine species are listed on Schedule 1 of the Species at Risk Act or are considered to be Extinct, Extirpated, Endangered, Threatened, or Special Concern by COSEWIC (Government of Canada 2002; COSEWIC 2021).

The 2021 field surveys discovered or expanded 19 occurrences (comprising 43 separate patches) of eight different rare vascular plant taxa: two B.C. Red-listed taxa, and six B.C. Blue-listed taxa. None of the eight species are listed on Schedule 1 of the Species at Risk Act or are considered to be Extinct, Extirpated, Endangered, Threatened, or Special Concern by COSEWIC (Government of Canada 2002; COSEWIC 2021).

In total, 169 occurrences containing 360 patches of 29 currently or formerly listed rare plant taxa were discovered or expanded during the preconstruction surveys (Table 2 and Figure 2). Over the course of the seven survey years, the investigators recorded 697 vascular plant, bryophyte, and lichen taxa (Appendix 2).

Table 2: Rare plants found during the Site C Preconstruction surveys

Taxon	Common Name	Current BC List	Occurrences	Patches
Vascular Plants				
Artemisia herriotii	Herriot's sage	Yellow	7	24
Atriplex gardneri var. gardneri	Gardner's sagebrush	Red	2	3
Avenula hookeri	Spike-oat	Yellow	1	1
Calamagrostis montanensis	plains reedgrass	Yellow	5	14
Carex backii	Back's sedge	Yellow	4	11
Carex sprengelii	Sprengel's sedge	Blue	4	8
Carex torreyi	Torrey's sedge	Blue	6	11
Carex xerantica	dry-land sedge	Blue	13	25
Castilleja miniata var. fulva	tawny paintbrush	Yellow	1	1
Cirsium drummondii	Drummond's thistle	Yellow	4	13

Taxon	Common Name	Current BC List	Occurrences	Patches
Geum triflorum var. triflorum	old man's whiskers	Yellow	7	28
Juncus stygius var. americanus	bog rush	Yellow	1	1
Lomatium foeniculaceum var. foeniculaceum	fennel-leaved desert-parsley	Blue	1	1
Oxytropis campestris var. davisii	Davis' locoweed	Blue	20	33
Pedicularis parviflora	small-flowered lousewort	Yellow	1	2
Penstemon gracilis	slender penstemon	Blue	11	31
Piptatheropsis canadensis	Canada ricegrass	Red	5	17
Polypodium sibiricum	Siberian polypody	Yellow	1	12
Potentilla pulcherrima	pretty cinquefoil	Yellow	4	9
Ranunculus rhomboideus	prairie buttercup	Blue	7	11
Salix petiolaris	meadow willow	Blue	1	1
Selaginella rupestris	rock selaginella	Red	7	12
Silene drummondii var. drummondii	Drummond's campion	Yellow	3	3
Sphenopholis intermedia	slender wedgegrass	Yellow	7	13
Symphyotrichum puniceum var. puniceum	purple-stemmed aster	Yellow	7	7
Lichens				
Physcia biziana	frosted rosette	Yellow	16	28
Physcia stellaris	immaculate rosette	Yellow	8	11
Ramalina sinensis	threadbare ribbon	Yellow	14	25
Usnea cavernosa	pitted beard	Yellow	1	4

Table notes:

- *BC List (B.C. MOECCS): Red = Endangered, Threatened, or Extirpated; Blue = Special Concern; Yellow = Apparently Secure*
- *Occurrences: Includes newly discovered occurrences as well as occurrences expanded during the preconstruction surveys*

Many of the rare plant taxa found during the pre-construction surveys had been documented previously in other occurrences during the baseline surveys performed for the Project environmental impact assessment. Species descriptions for the eleven currently rare-listed taxa recorded during the 2015–2021 preconstruction surveys are presented in Appendix 3. Each section also contains an overview of the new sites documented in 2021, and to-date summary information on all reported occurrences for each of these taxa in the RAA.

In this report all of the rare plant taxa discussed in Appendix 3 are currently Red- or Blue-listed by the BCCDC. For clarity, rare species found in previous years that have subsequently been removed from the Red or Blue lists are not included. Although not currently of conservation concern, the occurrence data for these taxa have been retained in the master rare plant spatial database for future reference if needed.

Information on additional taxa and occurrences documented in the RAA prior to 2015 can be found in the following references:

- Site C Project Environmental Impact Statement, Volume 2, Appendix R, Part 1 (Hilton et al. 2013);
- Report: Site C Clean Energy Project: Pre-disturbance Rare Plant Assessment #1: Rolling Work Plan 10 (Eagle Cap Consulting Ltd 2014);
- Report: Site C Clean Energy Project: Wildlife, Vegetation and Mapping Inventory for the Marl Fen Property (Simpson et al. 2014); and
- B.C. Ecosystem Explorer website (BCCDC 2021).

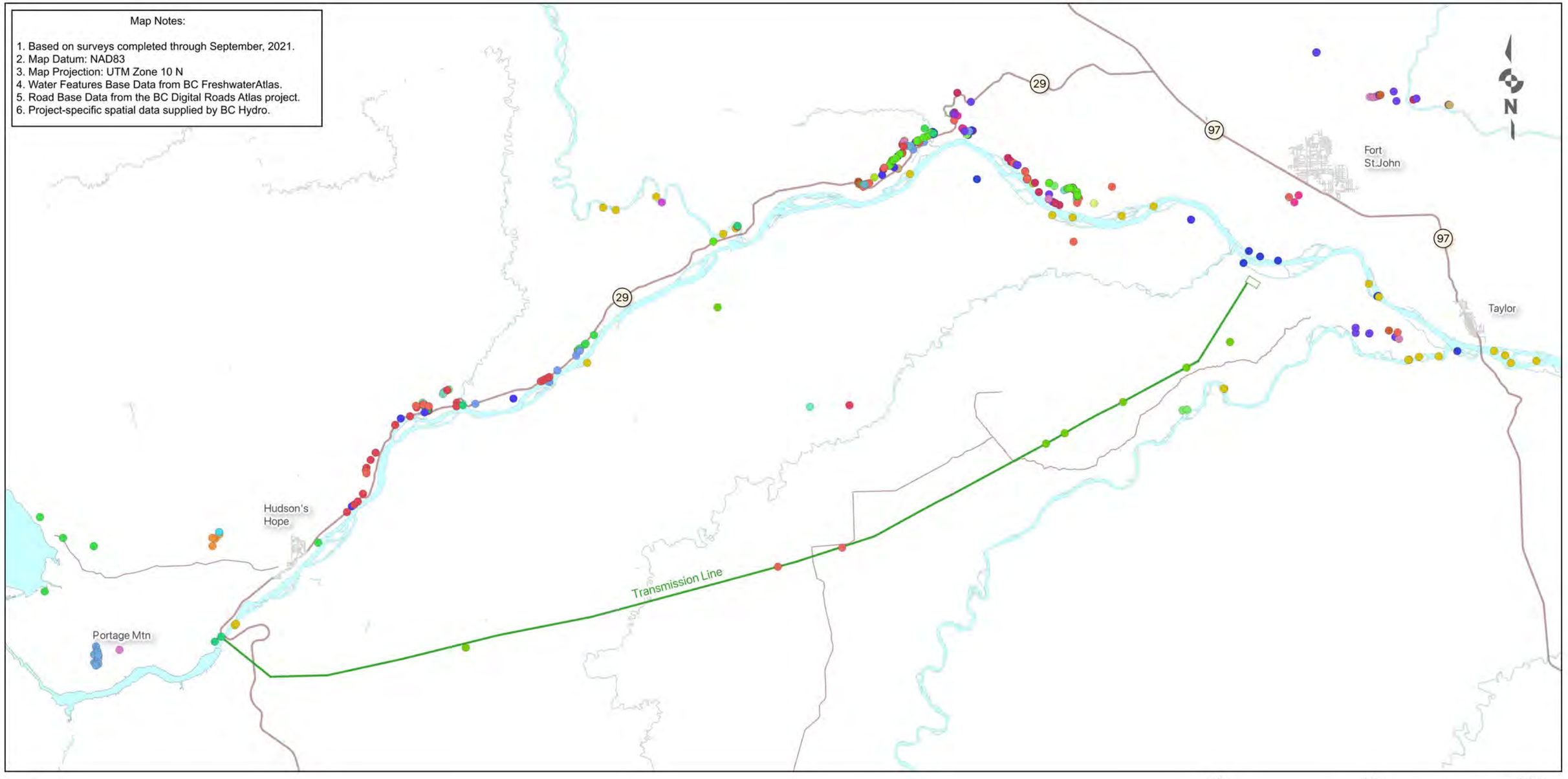
3.3. Mitigation Planning and Implementation

To-date, seven priority rare plant occurrences have required specific mitigation assistance from the pre-construction rare plant survey team. In 2018, two occurrences of Red-listed species—*Piptatheropsis canadensis* (Canada ricegrass) and *Atriplex gardneri* var. *gardneri* (Gardner's sagebrush)—adjacent to access roads in the Wilder Creek area were flagged, mapped, and photographed to assist the road crews in avoiding these occurrences. The forestry contractor responsible for the area was contacted so that crews understood how the sites were flagged and the importance of avoiding them in the field. Monitoring surveys conducted in 2019 found that both sites had been substantially avoided during the road work and the viability of the occurrences had not been threatened by the activity. The Canada ricegrass occurrence had been completely avoided, and the Gardner's sagebrush occurrence had only a few individuals impacted, leaving the majority untouched.

In 2019, a priority rare plant site in the Farrell Creek East Highway 29 realignment clearing zone was identified that required additional mitigation assistance. The site contained two priority rare plant occurrences—*Selaginella rupestris* (rock selaginella) and *Penstemon gracilis* (slender penstemon)—that could be reduced or extirpated by clearing activities. Due to access restrictions, propagule salvage operations could not occur at this site until BC Hydro acquired rights to the land. In cooperation with the BC Hydro off-dam environmental planning team, a mitigation plan was developed delaying clearing activities until 2021, allowing for propagule salvage after land acquisition. In 2021 the preconstruction botany team assisted the Experimental Rare Plant Translocation program team in salvaging some of the rock selaginella and slender penstemon individuals at this site, before the area was cleared for aggregate extraction.

Map Notes:

1. Based on surveys completed through September, 2021.
2. Map Datum: NAD83
3. Map Projection: UTM Zone 10 N
4. Water Features Base Data from BC FreshwaterAtlas.
5. Road Base Data from the BC Digital Roads Atlas project.
6. Project-specific spatial data supplied by BC Hydro.



- *Artemisia herriotii*
- *Atriplex gardneri var.gardneri*
- *Avenula hookeri*
- *Calamagrostis montanensis*
- *Carex backii*
- *Carex sprengelii*
- *Carex torreyi*
- *Carex xerantica*
- *Castilleja miniata var.fulva*
- *Cirsium drummondii*
- *Geum triflorum var.triflorum*
- *Juncus stygius var.americanus*
- *Lomatium foeniculaceum var.foeniculaceum*
- *Oxytropis campestris var.davisii*
- *Penstemon gracilis*
- *Physcia biziana*
- *Physcia stellaris*
- *Piptatheropsis canadensis*
- *Pohlia elongata*
- *Polypodium sibiricum*
- *Potentilla pulcherrima*
- *Ramalina sinensis*
- *Ranunculus rhomboideus*
- *Salix petiolaris*
- *Selaginella rupestris*
- *Silene drummondii var.drummondii*
- *Sphenopholis intermedia*
- *Symphyotrichum puniceum var.puniceum*
- *Usnea cavernosa*

Map Scale 1:250000

0 10 20 km

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Figure 2
Rare Plant Sites Found in Project Vicinity (2015-2021)

Date	December 10, 2021	DWG NO	2021-12-10-0002	Revision 0

In 2020, preconstruction rare plant surveys discovered an occurrence of *Carex sprengelii* (Sprengel's sedge) in an area at Dry Creek that had been recently cleared. The overstory trees and shrubs had been cut and removed, and some ground disturbance had taken place. In the opening, four Sprengel's sedge plants were found, all of which were in late fruit. The remaining undispersed Sprengel's sedge achenes were collected and sent to NATS Nursery in Langley, B.C. to be incorporated into the Project's Experimental Rare Plant Translocation program. The four plants were left in place and will be monitored in future years. In 2021 the site was revisited and it was found that all four of the original plants were persisting. In addition, a fifth individual plant was found near one of the others.

Also in 2020, late season field work within the Cache Creek Highway Realignment construction corridor discovered another new occurrence of Canada ricegrass. Nine separate patches were found in and adjacent to the Leave to Construct (LTC) corridor. Several detailed options were developed to mitigate impacts to the patches. Because clearing in this area was scheduled for the Fall of 2020, the rare plant botanists returned to the site in early October to implement and facilitate mitigation measures for the occurrence.

One of the nine patches was in an area that had been cleared. Twelve Canada ricegrass plants were still present along the edges of the former patch—some stems were broken but the remaining base and root portions of the plants were intact. Several of the stem heads contained undispersed fruit and 27 seeds were collected. After microscope examination, nine of the seeds were found to be apparently viable, and these were sent to NATS Nursery for storage and propagation as part of the Project's Experimental Rare Plant Translocation program. The 12 plants were salvaged and directly replanted at two suitable recipient sites outside of the LTC zone. The replanting work was fully documented and these two plantings will be monitored in future years.

The remaining eight patches had not been affected by project activities. Two of these patches are well away from the LTC zone and are not expected to be affected by the Project. The other six are in areas of the LTC zone where construction activities may be able to avoid disturbing the patches. These six were clearly flagged and staked in the field to facilitate avoidance. Personnel from the construction firms were contacted so that they were aware of the rare plant sites and understood how the patches are flagged in the field. In addition, the botanists met with a representative from the Site C off-dam environmental team and visited each of the flagged patches. This occurrence will be monitored in subsequent years to determine the success of these measures and implement additional mitigation (such as salvage) if needed.

In 2021, this Canada ricegrass occurrence at Cache Creek was again revisited to determine its status. As expected, the patch that had been cleared in 2020 was extirpated under the newly built highway. One other patch straddling the edge of the right-of-way (ROW) fence had been partially cleared by highway construction, although the portion outside of the ROW appeared to be unaffected. The remaining seven patches did not appear to have been directly impacted by highway construction.

Also in 2021, another Canada ricegrass occurrence near the proposed Area E aggregate extraction site was staked and flagged to facilitate contractor avoidance. This occurrence is located approximately 60 m outside of the extraction site boundary, and is not expected to be affected by construction activities. The

occurrence was flagged as a precautionary measure to reduce the chance that unintentional indirect impacts would occur within its boundaries.

4. Discussion

4.1. Coverage

Survey coverage of the areas proposed for construction disturbance—both the linear corridors and non-linear areas—was considered sufficient to locate the majority of identifiable target rare plant species. The field crew used a habitat-directed search protocol, employing a variable-intensity survey pattern that focussed time and effort on the habitats most likely to contain rare plant occurrences. Transects were spaced so that the majority of rare plant occurrences and high-suitability rare plant habitat would have been visible during the surveys. See Section 2.2 above for a complete description of the survey methods.

For the mitigation parcels—where the goal was to provide only a general overview of the rare plant populations present—the lower intensity meander surveys sampled most of the important habitats at both parcels. Although there are likely additional rare plant occurrences to be found at the mitigation parcels, the surveys provided a general picture of the rare plant resources present.

The logistics of performing rare plant surveys in the project area present certain challenges for coverage and timing. Several of the target rare plant species have extremely limited seasonal identification periods—some can only be optimally found during a four-week-long window that may change slightly from year to year depending on the weather. In addition, access is often unsafe or impossible during substantial periods of the growing season due to severe weather events, flooding, road wash-outs, and impassable wetland conditions. These physical access limitations are particularly constraining on the plateau south of the Peace River, but can also be challenging on the north side of the river. Furthermore, landowner restrictions prevent surveyors' access to certain areas until BC Hydro is able to acquire access rights to the specific survey parcels (and often the roads that lead up to them).

All these factors—target species identification periods, favourable weather and road conditions, legally granted access permission—must coincide for a successful survey visit. Often, repeated attempts are necessary. In a limited number of cases, it was not possible to access certain planned construction corridors at the appropriate time of year prior to clearing. Over the seven years of pre-construction surveys, an estimated 1,326 hectares of corridor have been surveyed (including the mitigation areas). Of that total, the surveyors found approximately 51.4 hectares (3.9% of the total) were cleared before they arrived. Nevertheless, these areas were surveyed using the standard methods described in Section 2.2 when rare plant habitat persisted following the clearing.

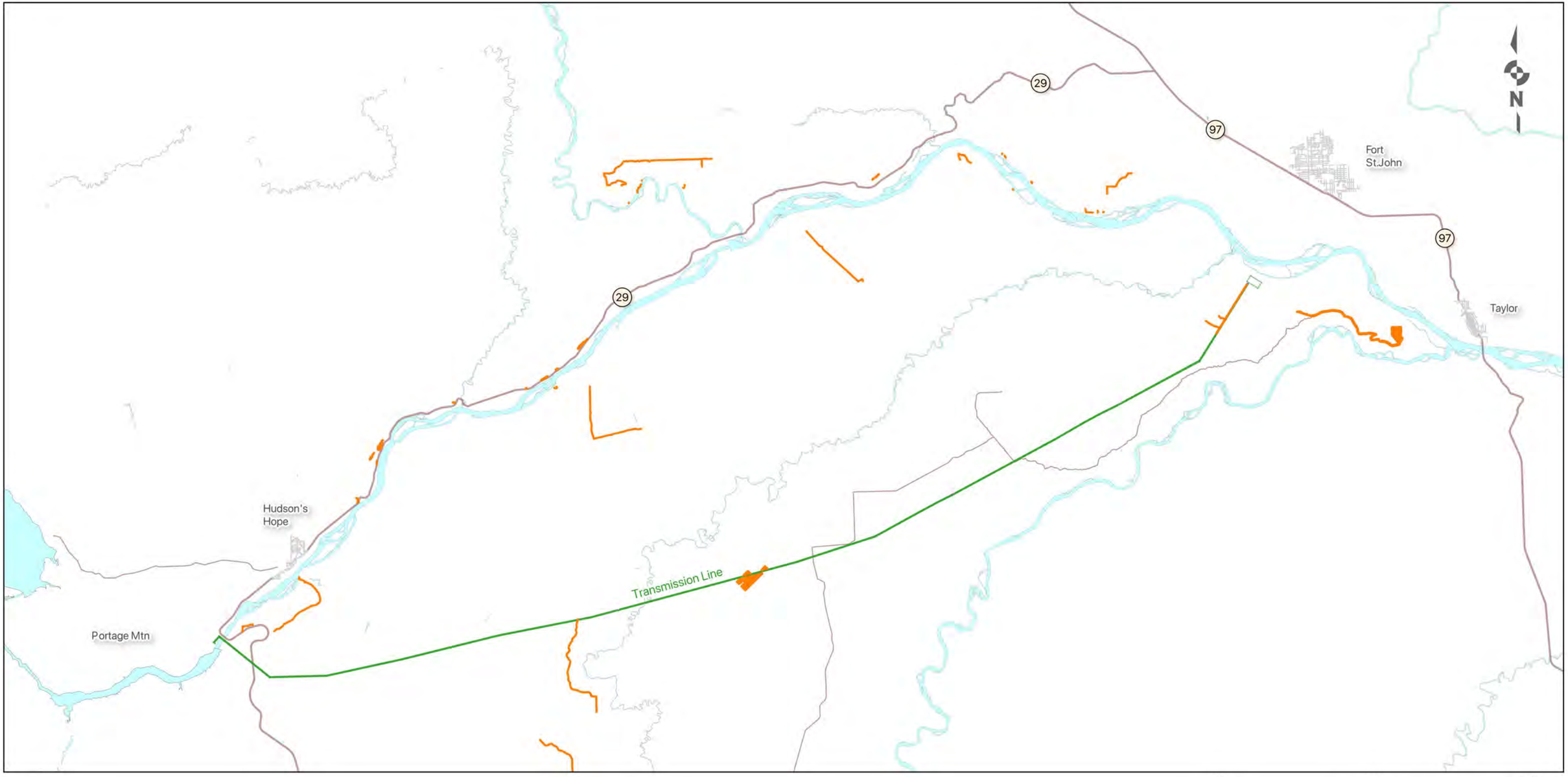
4.2. Seasonal Timing

Based on the observed phenology of the plants in the areas surveyed and data gathered during previous years' survey work, the seasonal timing of the surveys was sufficient to identify most of the target rare

plants. The June and early July work typically focussed on sites north of the Peace River, where floodplain and grassland habitats make up the majority of the high-potential rare plant habitats present. Target species in these habitats often bloom early in the season, and then wither by later in the summer (although some notable exceptions have been observed, such as Canada ricegrass, which is not clearly identifiable until later in the season). The late summer and early fall surveys mainly focussed on areas south of the Peace River, where wetlands are the primary high-potential rare plant habitats. Many of these wetland-associated target rare plants bloom later in the season, and persist longer into the fall than those found in the upland areas.

4.3. Remaining Areas to Survey

At the beginning of the 2021 field season, 365.1 hectares of preconstruction corridor remained to be surveyed. Field work began on those areas in early June and progressed well. Over the course of the summer, BC Hydro provided updates to the project facilities spatial layers, increasing the amount of required survey corridor. This increase was primarily a result of continuing refinements to the proposed access routes and additional layout changes to the Highway 29 realignment routes. In addition, in late summer, a proposal was made to use the Area E aggregate extraction site and associated haul road, increasing the required survey area further. By the end of the 2021 field season, 437.9 hectares of planned corridor and extraction areas remained to be surveyed (Figure 3). This includes corridors that need to be surveyed for the first time, as well as areas that need to be revisited to complete the coverage. Rare plant surveys of these areas are scheduled to take place during the 2022 field season.



Map Notes:

1. Based on surveys completed through September 2021.
2. Map Datum: NAD83
3. Map Projection: UTM Zone 10 N
4. Water Features Base Data from BC FreshwaterAtlas.
5. Road Base Data from the BC Digital Roads Atlas project.
6. Project-specific spatial data supplied by BC Hydro.

Legend

Roads
- *Highway*
- *Secondary A*
- *Urban*

Preconstruction Corridors
- *To Be Surveyed*

Map Scale 1:250000

0 10 20 km

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Figure 3
Remaining Preconstruction Survey Areas

Date	December 10, 2021	DWG NO	2021-12-10-0003	Revision 0

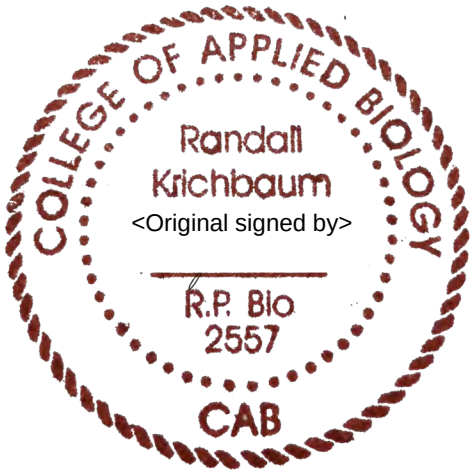
5. CLOSURE

Reviewed and approved:

<Original signed by>

Randy Krichbaum M.Sc., R.P. Bio., P. Biol.
Senior Ecologist
Eagle Cap Consulting Ltd.

<Original signed and sealed December 20, 2021 at Calgary, Alberta>



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7. APPENDICES

7.1. Appendix 1: Rare plant taxa with potential for occurrence in the Site C Project area

Scientific Name	Common Name	BC List	COSEWIC	SARA
VASCULAR PLANTS				
Acorus americanus	American sweet-flag	Blue		
Alopecurus magellanicus	alpine meadow-foxtail	Red		
Arctophila fulva	pendantgrass	Blue		
Artemisia alaskana	Alaskan sagebrush	Blue		
Atriplex gardneri var. gardneri	Gardner's sagebrush	Red		
Botrychium montanum	mountain moonwort	Blue		
Botrychium paradoxum	two-spiked moonwort	Blue		
Carex bicolor	two-coloured sedge	Blue		
Carex lapponica	Lapland sedge	Blue		
Carex sprengelii	Sprengel's sedge	Blue		
Carex torreyi	Torrey's sedge	Blue		
Carex xerantica	dry-land sedge	Blue		
Drosera linearis	slender-leaf sundew	Blue		
Epilobium saximontanum	Rocky Mountain willowherb	Blue		
Lomatium foeniculaceum var. foeniculaceum	fennel-leaved desert-parsley	Blue		
Oxytropis campestris var. davisii	Davis' locoweed	Blue		
Packera ogotorukensis	Ogotoruk Creek butterweed	Red		
Penstemon gormanii	Gorman's penstemon	Blue		
Penstemon gracilis	slender penstemon	Blue		
Piptatheropsis canadensis	Canada ricegrass	Red		
Polemonium boreale	northern Jacob's-ladder	Blue		
Polygala senega	Seneca-snakeroot	Red		
Polygonum ramosissimum ssp. prolificum	proliferous knotweed	Red		
Potentilla furcata	forked cinquefoil	Red		
Prenanthes racemosa	purple rattlesnake-root	Red		
Ranunculus cardiophyllus	heart-leaved buttercup	Red		
Ranunculus rhomboideus	prairie buttercup	Blue		
Rosa arkansana	Arkansas rose	Blue		
Salix petiolaris	meadow willow	Blue		
Salix raupii	Raup's willow	Red		

Scientific Name	Common Name	BC List	COSEWIC	SARA
Sarracenia purpurea ssp. purpurea	common pitcher-plant	Red		
Saussurea angustifolia var. angustifolia	northern sawwort	Red		
Selaginella rupestris	rock selaginella	Red		
Silene repens	pink campion	Blue		
Symphyotrichum falcatum var. commutatum	white prairie aster	Red		
Tephroseris palustris	marsh fleabane	Blue		
Thalictrum dasycarpum	purple meadowrue	Blue		
Utricularia ochroleuca	ochroleucous bladderwort	Blue		
LICHENS				
Anaptychia crinalis	electrified millepede	Red		
Anaptychia ulotrichoides	amputated millepede	Blue		
Cladonia parasitica	fence-rail pixie	Red		
Collema bachmanianum	Caesar's tarpaper	Blue		
Collema coniophilum	crumpled tarpaper	Red	T (2010)	1-T (2017)
Fulgensia desertorum	desert sulphur	Blue		
Fulgensia subbracteata	creeping sulphur	Blue		
Heterodermia speciosa	smiling centipede	Red		
Phaeophyscia adiastola	granulating shadow	Blue		
Phaeophyscia hispidula	whiskered shadow	Red		
Physcia dimidiata	exuberant rosette	Blue		
Physcia tribacia	beaded rosette	Red		
Physciella chloantha	downside shade	Blue		
Squamarina cartilaginea	pea-green dimple	Red		
Squamarina lentigera	snow-white dimple	Red		
Thyrea confusa	candied gummybear	Blue		
Xanthoparmelia camtschadalis	rockfrog	Red		
BRYOPHYTES				
Acaulon muticum var. rufescens	[no common name]	Red		
Amblyodon dealbatus	[no common name]	Blue		
Atrichum tenellum	[no common name]	Red		
Aulacomnium acuminatum	[no common name]	Blue		
Barbula convoluta var. gallinula	[no common name]	Red		
Bartramia halleriana	Haller's apple moss	Red	T (2011)	1-T (2003)
Bryobrittonia longipes	[no common name]	Blue		
Cynodontium glaucescens	[no common name]	Blue		

Scientific Name	Common Name	BC List	COSEWIC	SARA
Dicranum majus var. orthophyllum	[no common name]	Red		
Didymodon rigidulus var. icmadophilus	[no common name]	Blue		
Didymodon subandreaeoides	[no common name]	Red		
Encalypta brevicollis	[no common name]	Blue		
Encalypta intermedia	[no common name]	Blue		
Encalypta mutica	[no common name]	Blue		
Encalypta spathulata	[no common name]	Blue		
Grimmia teretinervis	[no common name]	Red		
Haplodontium macrocarpum	Porsild's bryum	Red	T (2017)	1-T (2011)
Hygrohypnum alpestre	[no common name]	Blue		
Hygrohypnum alpinum	[no common name]	Blue		
Lescuraea saxicola	[no common name]	Blue		
Meesia longiseta	[no common name]	Blue		
Myurella sibirica	[no common name]	Red		
Orthothecium strictum	[no common name]	Blue		
Philonotis yezoana	[no common name]	Blue		
Plagiobryum demissum	[no common name]	Red		
Pohlia bulbifera	[no common name]	Blue		
Pseudocalliergon turgescens	[no common name]	Blue		
Schistidium boreale	[no common name]	Blue		
Schistidium confertum	[no common name]	Red		
Schistidium pulchrum	[no common name]	Blue		
Schistidium robustum	[no common name]	Blue		
Schistidium trichodon	[no common name]	Blue		
Seligeria subimmersa	[no common name]	Red		
Seligeria tristichoides	[no common name]	Blue		
Sphagnum balticum	[no common name]	Blue		
Sphagnum contortum	[no common name]	Blue		
Sphagnum wulfianum	[no common name]	Blue		
Splachnum vasculosum	[no common name]	Blue		
Tayloria froelichiana	[no common name]	Blue		
Tayloria splachnoides	[no common name]	Red		
Tetraplodon urceolatus	[no common name]	Red		
Timmia norvegica	[no common name]	Blue		
Timmia sibirica	[no common name]	Red		
Tortella humilis	[no common name]	Red		

Scientific Name	Common Name	BC List	COSEWIC	SARA
Trichostomum crispulum	[no common name]	Blue		
Warnstorfia pseudostraminea	[no common name]	Blue		
Weissia brachycarpa	[no common name]	Blue		

Table notes:

- *B.C. List (B.C. Ministry of Environment): Red = Endangered, Threatened, or Extirpated; Blue = Special Concern*
- *COSEWIC (Committee on the Status of Endangered Wildlife in Canada): E = Endangered; T = Threatened; SC = Special Concern; DD = Data Deficient*
- *SARA (Species at Risk Act): 1-E = Schedule 1 Endangered; 1-T = Schedule 1 Threatened; 1-SC = Schedule 1 Special Concern*

7.2. Appendix 2: Plant and lichen species recorded during the 2015–2021 surveys

Vascular Plants

Acer glabrum var. douglasii
Acer negundo
Achillea alpina
Achillea borealis
Achillea millefolium var. lanulosa
Achnatherum nelsonii ssp. dorei
Achnatherum richardsonii
Aconitum delphiniifolium
Actaea rubra
Agropyron cristatum ssp. pectinatum
Agrostis capillaris
Agrostis exarata
Agrostis gigantea
Agrostis scabra
Alisma triviale
Allium cernuum
Allium cernuum var. cernuum
Allium schoenoprasum var. sibiricum
Alnus incana ssp. tenuifolia
Alnus viridis ssp. crispa
Alnus viridis ssp. sinuata
Alopecurus aequalis
Alopecurus pratensis
Amelanchier alnifolia
Amerorchis rotundifolia
Anaphalis margaritacea
Androsace septentrionalis
Anemone cylindrica
Anemone multifida var. multifida
Anemone patens ssp. multifida
Anemone virginiana var. cylindroidea
Angelica genuflexa
Antennaria howellii ssp. canadensis
Antennaria howellii ssp. petaloidea
Antennaria microphylla
Antennaria neglecta
Antennaria parvifolia
Antennaria pulcherrima ssp. pulcherrima
Antennaria racemosa
Antennaria rosea
Anthoxanthum hirtum
Apocynum androsaemifolium
Apocynum androsaemifolium var. androsaemifolium
Aquilegia brevistyla
Aralia nudicaulis
Arctium minus
Arctium sp.
Arctostaphylos uva-ursi
Arnica chamissonis
Arnica cordifolia
Artemisia biennis
Artemisia campestris ssp. pacifica
Artemisia dracunculus
Artemisia frigida
Artemisia herriotii
Askellia elegans
Asparagus officinalis
Astragalus agrestis
Astragalus alpinus var. alpinus
Astragalus americanus
Astragalus australis
Astragalus canadensis
Astragalus cicer
Astragalus eucosmus
Astragalus laxmannii var. robustior
Astragalus tenellus
Athyrium filix-femina ssp. cyclosorum
Atriplex gardneri var. gardneri
Avena sativa
Avenula hookeri
Axyris amaranthoides
Beckmannia syzigachne
Betula neoalaskana
Betula papyrifera
Betula pumila
Betula pumila var. glandulifera
Bidens cernua
Blitum capitatum
Boechera divaricarpa
Boechera grahamii
Boechera pendulocarpa
Boechera retrofracta
Boechera stricta
Botrypus virginianus
Brassica rapa var. rapa
Bromus ciliatus
Bromus inermis
Bromus pumpellianus ssp. pumpellianus
Calamagrostis canadensis
Calamagrostis canadensis var. langsdorfii
Calamagrostis montanensis
Calamagrostis purpurascens var. purpurascens

Calamagrostis stricta ssp. inexpansa
Calla palustris
Callitriche palustris
Caltha natans
Campanula rotundifolia
Canadanthus modestus
Capsella bursa-pastoris
Caragana arborescens
Cardamine oligosperma var. oligosperma
Carex aquatilis
Carex aquatilis var. aquatilis
Carex arcta
Carex atherodes
Carex atratiformis
Carex aurea
Carex backii
Carex bebbii
Carex brunnescens
Carex brunnescens ssp. brunnescens
Carex canescens ssp. canescens
Carex capillaris
Carex chordorrhiza
Carex concinna
Carex crawfordii
Carex cusickii
Carex deweyana var. deweyana
Carex diandra
Carex disperma
Carex duriuscula
Carex eburnea
Carex filifolia
Carex foenea
Carex gynocrates
Carex inops ssp. heliophila
Carex interior
Carex lasiocarpa
Carex limosa
Carex livida var. radicaulis
Carex magellanica ssp. irrigua
Carex microptera
Carex obtusata
Carex peckii
Carex pellita
Carex praticola
Carex retrorsa
Carex richardsonii
Carex rossii
Carex sartwellii
Carex siccata
Carex sprengelii
Carex tenera
Carex tenuiflora
Carex torreyi
Carex utriculata
Carex vaginata
Carex viridula ssp. viridula
Carex xerantica
Castilleja miniata
Castilleja miniata var. fulva
Centaurea stoebe ssp. micranthos
Cerastium arvense
Cerastium fontanum
Cerastium nutans
Chamerion angustifolium
Chenopodiastrum simplex
Chenopodium album
Chenopodium album ssp. album
Chenopodium album ssp. striatum
Chenopodium desiccatum
Chenopodium pratericola
Chrysosplenium tetrandrum
Cicuta bulbifera
Cicuta douglasii
Cicuta virosa
Cinna latifolia
Circaea alpina ssp. alpina
Cirsium arvense
Cirsium drummondii
Cirsium foliosum
Cirsium vulgare
Clematis occidentalis ssp. grosseserrata
Clematis tangutica var. tangutica
Coeloglossum viride var. virescens
Collomia linearis
Comandra umbellata
Comandra umbellata var. pallida
Comarum palustre
Conyza canadensis
Corallorhiza maculata
Corallorhiza striata var. striata
Corallorhiza trifida
Cornus canadensis
Cornus stolonifera
Corydalis aurea ssp. aurea

Corylus cornuta
Crepis tectorum
Cypripedium passerinum
Cystopteris fragilis
Dactylis glomerata
Dactylorhiza viridis
Danthonia intermedia ssp. intermedia
Danthonia spicata
Dasiphora fruticosa
Delphinium glaucum
Deschampsia cespitosa ssp. cespitosa
Descurainia sophia
Diphasiastrum complanatum
Dracocephalum parviflorum
Drosera linearis
Drosera rotundifolia
Drosera rotundifolia var. rotundifolia
Dryas drummondii
Drymocallis arguta
Dryopteris carthusiana
Dryopteris expansa
Elaeagnus commutata
Eleocharis mamillata ssp. mamillata
Eleocharis palustris
Elymus albicans
Elymus canadensis
Elymus glaucus
Elymus glaucus ssp. glaucus
Elymus lanceolatus ssp. lanceolatus
Elymus repens
Elymus trachycaulus
Elymus trachycaulus ssp. subsecundus
Elymus trachycaulus ssp. trachycaulus
Epilobium angustifolium
Epilobium ciliatum
Epilobium ciliatum ssp. ciliatum
Epilobium ciliatum ssp. glandulosum
Epilobium halleanum
Epilobium hornemannii ssp. hornemannii
Epilobium palustre
Equisetum arvense
Equisetum fluviatile
Equisetum hyemale
Equisetum hyemale ssp. affine
Equisetum laevigatum
Equisetum palustre
Equisetum pratense
Equisetum scirpoides
Equisetum sylvaticum
Equisetum variegatum ssp. variegatum
Erigeron caespitosus
Erigeron glabellus var. pubescens
Erigeron philadelphicus
Erigeron philadelphicus var. philadelphicus
Eriophorum angustifolium
Eriophorum chamissonis
Eriophorum gracile
Eriophorum sp.
Eriophorum viridicarinatum
Erysimum cheiranthoides
Euphrasia nemorosa
Eurybia conspicua
Eurybia sibirica
Fallopia convolvulus
Festuca rubra ssp. rubra
Festuca saximontana
Festuca trachyphylla
Fragaria vesca var. bracteata
Fragaria virginiana
Fragaria virginiana var. platypetala
Galearis rotundifolia
Galeopsis bifida
Galium boreale
Galium labradoricum
Galium trifidum
Galium trifidum ssp. trifidum
Galium triflorum
Gentianella amarella ssp. acuta
Geocaulon lividum
Geranium bicknellii
Geum aleppicum
Geum macrophyllum
Geum macrophyllum ssp. macrophyllum
Geum macrophyllum var. perincisum
Geum triflorum
Geum triflorum var. triflorum
Glyceria borealis
Glyceria grandis var. grandis
Glyceria striata
Gnaphalium uliginosum
Goodyera repens
Grindelia squarrosa var. quasiperennis
Gymnocarpium dryopteris
Halenia deflexa ssp. deflexa

Halerpestes cymbalaria
Hedysarum alpinum
Hedysarum boreale
Helictochloa hookeri
Heracleum maximum
Hesperostipa comata ssp. comata
Hesperostipa curtiseta
Heuchera richardsonii
Hieracium aurantiacum
Hieracium canadense
Hieracium umbellatum ssp. umbellatum
Hierochloë hirta ssp. arctica
Hippuris vulgaris
Hordeum jubatum ssp. jubatum
Hypopitys monotropa
Impatiens noli-tangere
Juncus alpinoarticulatus ssp. americanus
Juncus balticus ssp. ater
Juncus bufonius
Juncus dudleyi
Juncus nodosus
Juncus stygius ssp. americanus
Juncus vaseyi
Juniperus communis
Koeleria macrantha
Lactuca serriola
Lappula occidentalis var. occidentalis
Lappula squarrosa
Larix laricina
Lathyrus ochroleucus
Lemna minor
Lepidium densiflorum
Leucanthemum vulgare
Leymus innovatus ssp. innovatus
Limosella aquatica
Linaria genistifolia ssp. dalmatica
Linaria vulgaris
Linnaea borealis
Linum lewisii ssp. lewisii
Listera borealis
Listera cordata
Lithospermum incisum
Lomatium foeniculaceum var. foeniculaceum
Lonicera dioica var. glaucescens
Lonicera involucrata
Lotus corniculatus
Lycopodium dendroideum
Madia glomerata
Maianthemum canadense
Maianthemum racemosum ssp. amplexicaule
Maianthemum stellatum
Maianthemum trifolium
Matricaria discoidea
Medicago lupulina
Medicago sativa
Medicago sativa ssp. falcata
Melampyrum lineare var. lineare
Melica smithii
Melilotus albus
Melilotus officinalis
Mentha arvensis
Menyanthes trifoliata
Mertensia paniculata var. paniculata
Mitella nuda
Moehringia lateriflora
Monarda fistulosa var. menthaefolia
Moneses uniflora
Monotropa uniflora
Muhlenbergia glomerata
Mulgedium pulchellum
Myriophyllum sibiricum
Nassella viridula
Neslia paniculata
Nuphar sp.
Oplopanax horridus
Opuntia fragilis
Orobanche fasciculata
Orthilia secunda
Orthilia secunda var. secunda
Orthocarpus luteus
Oryzopsis asperifolia
Osmorhiza berteroi
Osmorhiza sp.
Oxybasis glauca
Oxytropis campestris var. davisii
Oxytropis deflexa
Oxytropis sericea var. speciosa
Oxytropis splendens
Packera paupercula
Packera plattensis
Packera streptanthifolia
Parnassia palustris
Pascopyrum smithii
Pedicularis groenlandica

Pedicularis labradorica
Pedicularis parviflora
Penstemon gracilis
Penstemon procerus var. procerus
Persicaria amphibia
Persicaria amphibia var. emersa
Persicaria amphibia var. stipulacea
Persicaria hydropiper
Persicaria lapathifolia
Persicaria sp.
Petasites frigidus var. palmatus
Petasites frigidus var. sagittatus
Phalaris arundinacea var. arundinacea
Phleum pratense ssp. pratense
Picea glauca
Picea mariana
Pinus contorta var. latifolia
Piptatheropsis canadensis
Piptatheropsis pungens
Piptatherum pungens
Plantago major
Platanthera aquilonis
Platanthera huronensis
Platanthera obtusata ssp. obtusata
Platanthera orbiculata
Platanthera sp.
Poa alpina ssp. alpina
Poa annua
Poa compressa
Poa glauca
Poa glauca ssp. glauca
Poa nemoralis ssp. interior
Poa palustris
Poa pratensis
Poa pratensis ssp. pratensis
Poa secunda
Polygonum achoreum
Polygonum aviculare
Polygonum douglasii
Polygonum fowleri
Polygonum ramosissimum
Polypodium sibiricum
Populus balsamifera
Populus tremuloides
Potamogeton alpinus
Potamogeton gramineus
Potamogeton pusillus ssp. tenuissimus
Potentilla anserina
Potentilla gracilis var. fastigiata
Potentilla hippiana
Potentilla norvegica
Potentilla pensylvanica
Potentilla pensylvanica var. pensylvanica
Potentilla pulcherrima
Prosartes trachycarpa
Prunus pensylvanica
Prunus virginiana ssp. melanocarpa
Prunus virginiana var. demissa
Pseudoroegneria spicata
Puccinellia distans
Puccinellia nuttalliana
Pulsatilla nuttalliana
Pyrola asarifolia
Pyrola chlorantha
Pyrola minor
Ranunculus acris
Ranunculus aquatilis var. aquatilis
Ranunculus aquatilis var. diffusus
Ranunculus cymbalaria
Ranunculus gmelinii
Ranunculus macounii
Ranunculus rhomboideus
Ranunculus sceleratus
Ranunculus sceleratus var. multifidus
Rhinanthus minor
Rhododendron groenlandicum
Ribes hudsonianum var. hudsonianum
Ribes lacustre
Ribes oxyacanthoides ssp. oxyacanthoides
Rorippa palustris
Rorippa palustris ssp. palustris
Rosa acicularis ssp. sayi
Rosa woodsii ssp. woodsii
Rubus arcticus ssp. acaulis
Rubus chamaemorus
Rubus idaeus ssp. strigosus
Rubus parviflorus var. parviflorus
Rubus pedatus
Rubus pubescens
Rumex britannica
Rumex crispus
Rumex fueginus
Rumex occidentalis
Rumex triangulivalvis

Salix arbusculoides
Salix bebbiana
Salix candida
Salix discolor
Salix drummondiana
Salix interior
Salix lasiandra var. lasiandra
Salix maccalliana
Salix myrtillifolia
Salix pedicellaris
Salix petiolaris
Salix planifolia
Salix prolixa
Salix pseudomonticola
Salix pseudomyrsinites
Salix pyrifolia
Salix scouleriana
Salix serissima
Salsola tragus
Sanicula marilandica
Saxifraga tricuspidata
Schedonorus arundinaceus
Schizachne purpurascens
Schoenoplectus tabernaemontani
Scirpus microcarpus
Scutellaria galericulata
Selaginella rupestris
Senecio eremophilus var. eremophilus
Senecio vulgaris
Shepherdia canadensis
Silene drummondii var. drummondii
Silene latifolia
Sisymbrium altissimum
Sisyrinchium montanum var. montanum
Sium suave
Solidago altissima ssp. gilvocanescens
Solidago bellidifolia
Solidago glutinosa
Solidago lepida var. lepida
Solidago lepida var. salebrosa
Solidago multiradiata
Solidago simplex var. simplex
Sonchus arvensis
Sonchus arvensis ssp. uliginosus
Sorbus scopulina var. scopulina
Sparganium emersum
Sparganium natans
Sparganium sp.
Sphenopholis intermedia
Spiraea betulifolia ssp. lucida
Spiraea lucida
Spiranthes romanzoffiana
Sporobolus cryptandrus
Stachys palustris ssp. pilosa
Stellaria borealis
Stellaria borealis ssp. borealis
Stellaria longifolia
Stellaria longipes var. longipes
Stellaria media
Stuckenia pectinata
Symphoricarpos albus
Symphoricarpos occidentalis
Symphyotrichum boreale
Symphyotrichum ciliolatum
Symphyotrichum ericoides var. pansum
Symphyotrichum laeve var. geyeri
Symphyotrichum lanceolatum var. hesperium
Symphyotrichum puniceum var. puniceum
Tanacetum vulgare
Taraxacum officinale
Thalictrum venulosum
Thinopyrum intermedium
Thlaspi arvense
Tofieldia pusilla
Tragopogon dubius
Triantha glutinosa
Trifolium hybridum
Trifolium pratense
Trifolium repens
Triglochin maritima
Triglochin palustris
Tripleurospermum inodorum
Triticum aestivum
Turritis glabra
Typha latifolia
Urtica dioica ssp. gracilis
Utricularia intermedia
Vaccinium caespitosum
Vaccinium membranaceum
Vaccinium myrtilloides
Vaccinium oxycoccos
Vaccinium vitis-idaea ssp. minus
Valeriana dioica ssp. sylvatica
Verbascum thapsus

Veronica americana
Veronica beccabunga ssp. americana
Veronica peregrina var. xalapensis
Veronica scutellata
Viburnum edule
Vicia americana
Viola adunca var. adunca
Viola canadensis var. rugulosa
Woodsia scopulina
Zizia aptera

Bryophytes

Abietinella abietina
Antitrichia curtipendula
Aulacomnium palustre
Barbula convoluta var. convoluta
Brachythecium salebrosum
Brachythecium sp.
Bryum argenteum
Ceratodon purpureus
Climacium dendroides
Dicranum polysetum
Dicranum undulatum
Didymodon fallax
Didymodon ferrugineus
Distichium capillaceum
Ditrichum flexicaule
Drepanocladus aduncus
Encalypta rhaptocarpa
Funaria hygrometrica
Hamatocaulis vernicosus
Hedwigia ciliata
Hylocomium splendens
Hymenostylium recurvirostre var. recurvirostre
Leptobryum pyriforme
Marchantia polymorpha
Marchantia quadrata
Mnium thomsonii
Orthotrichum anomalum
Orthotrichum obtusifolium
Orthotrichum speciosum
Philonotis fontana var. fontana
Plagiomnium cuspidatum
Plagiomnium ellipticum
Plagiomnium sp.
Pleurozium schreberi
Pohlia nutans
Polytrichum commune
Polytrichum juniperinum
Ptilium crista-castrensis
Pylaisiella polyantha
Sanionia uncinata
Sphagnum capillifolium
Sphagnum magellanicum
Sphagnum sp.
Syntrichia norvegica
Syntrichia ruralis
Tomentypnum nitens
Tortula mucronifolia

Lichens

Bryoria capillaris
Bryoria fuscescens
Bryoria lanestris
Bryoria sp.
Buellia elegans
Caloplaca cerina
Caloplaca holocarpa
Cetraria ericetorum
Cladina rangiferina
Cladina sp.
Cladonia carneola
Cladonia pocillum
Cladonia sp.
Collema furfuraceum
Diploschistes muscorum
Enchylium tenax
Endocarpon pusillum
Evernia mesomorpha
Flavocetraria cucullata
Hypogymnia occidentalis
Hypogymnia physodes
Icmadophila ericetorum
Lathagrium undulatum var. granulosum
Lecanora impudens
Leptogium saturninum
Leptogium teretiusculum
Lobaria pulmonaria
Melanelixia subaurifera
Melanohalea exasperatula
Melanohalea septentrionalis
Melanohalea subolivacea
Nephroma resupinatum
Parmelia fraudans
Parmelia sulcata
Parmeliopsis ambigua

Parmeliopsis hyperopta
Peltigera aphthosa
Peltigera britannica
Peltigera didactyla
Peltigera elisabethae
Peltigera extenuata
Peltigera lepidophora
Peltigera leucophlebia
Peltigera malacea
Peltigera neckeri
Peltigera sp.
Phaeophyscia orbicularis
Phaeophyscia sciastra
Phaeophyscia sp.
Physcia adscendens
Physcia aipolia
Physcia alnophila
Physcia biziana
Physcia caesia
Physcia phaea
Physcia stellaris
Physcia tenella
Physconia muscigena
Physconia perisidiosa
Platismatia glauca
Ramalina dilacerata
Ramalina obtusata
Ramalina sinensis
Rinodina sp.
Stereocaulon tomentosum
Tuckermannopsis americana
Tuckermannopsis sp.
Umbilicaria americana
Usnea cavernosa
Usnea filipendula
Usnea lapponica
Usnea scabrata
Usnea sp.
Usnea substerilis
Vulpicida pinastri
Xanthomendoza fallax
Xanthoparmelia wyomingica
Xanthoria candelaria

7.3. Appendix 3: Species Accounts for Rare Plant Taxa Found During Preconstruction Surveys

7.3.1. Atriplex gardneri var. gardneri (Gardner's sagebrush)

Gardner's sagebrush (Figure 4), a small perennial sub-shrub with a woody base, is a member of the Chenopodiaceae (goosefoot family). Variety *gardneri* is found on fine-textured saline soils and dry grassy slopes in the Great Plains and Intermountain regions of central North America (Douglas et al. 1998; Welsh 2003). In B.C., Gardner's sagebrush is known only from the Peace River region (BCCDC 2021). The taxon can be found as far east in Canada as southern Manitoba, and as far south as Utah and Colorado in the United States (Welsh 2003; NatureServe 2021).

Gardner's sagebrush has a rank of S2 (Imperilled) in B.C. and is on the province's Red list (BCCDC 2021). The taxon has a global classification of G5TNR (*Atriplex gardneri* as a species is ranked globally Secure, but variety *gardneri* has not been given a global rank). Several other sub-national jurisdictions provide a rank for Gardner's sagebrush: Saskatchewan and Montana S5 (Secure), Alberta S4 (Apparently Secure), and Utah and Nebraska S1 (Critically Imperilled) (NatureServe 2021).

Figure 4: *Atriplex gardneri* var. *gardneri* (Gardner's sagebrush)

No new occurrences of Gardner's sagebrush were reported in the Site C Regional Assessment Area (RAA) in 2021.

There are a total of four known occurrences (in five patches) of Gardner's sagebrush in the RAA. Three of these occurrences (four patches) are situated north of the Peace River near the Alberta border, and, excluding the patch located in 2020, are older records without information on the number of individuals or areal coverage. The patch found in 2020 contained an estimated 50 male and female plants over an

approximate area of 50 square metres. The fourth occurrence of Gardner's sagebrush, discovered in 2018 during Site C survey work, is some 60 kilometres to the west near Wilder Creek. Here, an estimated 150 male plants were found scattered over an area of 618 square metres; no female plants were observed at this site.

All four of the Gardner's sagebrush occurrences are situated on open, dry, south-facing grassland slopes. The dominant associated species include native grasses such as various wildryes (*Elymus* spp.), junegrass (*Koeleria macrantha*), and green needlegrass (*Nassella viridula*), and native forbs such as prairie sagewort (*Artemisia frigida*) and asters (*Symphyotrichum* spp.).

7.3.2. Carex sprengelii (Sprengel's sedge)

Sprengel's sedge (Figure 5) is a perennial herb belonging to the Cyperaceae (sedge family); plants have tall stems with fibrous bases and bear achenes in drooping heads. The species forms loose clumps in a variety of dry to wet habitats, including openings, slopes, and alluvial woodlands, often on calcareous substrates (Douglas et al. 1998; Ball & Reznicek 2002). Sprengel's sedge was only known from three locations in B.C. prior to the Site C rare plant survey work: two near Williams Lake, and one in the Peace River region (BCCDC 2021). The taxon ranges across North America as far east as New Brunswick, and as far south as Colorado, Missouri, and New Jersey. It is also reported from Alaska (Ball & Reznicek 2002; NatureServe 2021).

Figure 5: *Carex sprengelii* (Sprengel's sedge)

Sprengel's sedge has a rank of S3 (Vulnerable) in B.C., and is on the provincial Blue list (BCCDC 2021). Globally, the taxon is classed G5 (Secure). Across much of North America the taxon is classed as Secure (S5) or Apparently Secure (S4), but is considered rare on the western, southern, and eastern edges of its range: S3 (Vulnerable) in Québec, Pennsylvania, Illinois, Montana and Wyoming; S2 (Imperilled) in New Brunswick, Maine, Ohio, Missouri, and Colorado; S1 (Critically Imperilled) in Alaska, and SH (Possibly Extirpated) in Delaware (NatureServe 2021).

One new patch of Sprengel's sedge, consisting of one large plant in flower, was found in the study area in 2021, on the east edge of Dry Creek canyon north of Highway 29. The discovery extends a previously-known occurrence slightly, so that now five fruiting plants have been documented in four patches at this site, in an overall area of 95 square metres. The surveyors also noted that the southernmost plant at this occurrence had been partly covered by a pile of aspen logs, but was still in bloom. The habitat at this site consists of shrubby aspen woodland that has been recently cleared, and it is unknown whether further ground-disturbing work will eventually extirpate the occurrence; if the Sprengel's sedge plants are not disturbed further, they may survive if the surrounding vegetation is allowed to regrow.

In total, there are six known occurrences (in 11 patches) of Sprengel's sedge in the RAA. Four of these occurrences (eight patches)—found during survey work for the Site C project—are situated between Dry Creek and Wilder Creek, on flat to south-facing slopes north of the Peace River. An estimated 38 plants have been observed growing in a total approximate area of 17 square metres, in various shrub and woodland habitats. All of these sites are moist to mesic, and the Sprengel's sedge plants are generally found in relatively shaded microhabitats. Associated species are similar, including prairie saskatoon (*Amelanchier alnifolia*), prickly rose (*Rosa acicularis*), chokecherry (*Prunus virginiana*), aspen (*Populus tremuloides*), and native and weedy herbs such as smooth brome (*Bromus inermis*), northern bedstraw (*Galium boreale*), and American vetch (*Vicia americana*).

The remaining two sites of Sprengel's sedge in the RAA are derived from BCCDC records that lack certain population data. An occurrence of 20 plants in two patches was discovered between a hay field and a shrubby south-facing escarpment above the Pine River in 2016; areal extent, associated species, and other details of this occurrence were not documented. Additionally, a sixth occurrence of Sprengel's sedge, first observed in 2010, is reported from over 80 kilometres southwest, in moist balsam poplar (*Populus balsamifera*) woods north of the Moberly River. No clear information is available on the number of individuals or areal coverage (BCCDC 2021).

7.3.3. Carex torreyi (Torrey's sedge)

Torrey's sedge (Figure 6) is a soft-hairy perennial in the Cyperaceae (sedge family) found growing in montane meadows, shrublands, and moist woods (Douglas et al. 1998; Ball & Reznicek 2002). In B.C. the species is found only in the Peace River region (BCCDC 2021). Globally, Torrey's sedge is distributed east across Canada to Ontario, and south in the U.S. as far as Colorado and Wisconsin (NatureServe 2021).

Figure 6: *Carex torreyi* (Torrey's sedge)

Torrey's sedge is ranked S3? (Vulnerable?) in B.C. and is on the province's Blue list (BCCDC 2021). The species is ranked G4G5 (Apparently Secure or Secure) globally. Sub-national ranks vary—Torrey's sedge is classed as S4 (Apparently Secure) in Alberta and Saskatchewan, S3 (Vulnerable) in Manitoba and Montana, S2 (Imperilled) in Ontario and Wyoming, and S1 (Critically Imperilled) in Colorado and Wisconsin (NatureServe 2021).

No new sites of Torrey's sedge were documented in the study area in 2021.

There are a total of 11 occurrences (in 18 patches) of Torrey's sedge reported in the RAA. An estimated 550 plants have been observed growing in a total area of approximately 425 square metres. Ten of the occurrences are situated north of the Peace River; the 11th occurrence (not reconfirmed since the 1960 report) is located more than 45 kilometres south, near Dawson Creek, B.C. All of the occurrences were found on mesic to xeric south-facing slopes in open shrub grassland complexes. Associated species are similar at the sites and include native shrubs such as prickly rose, prairie saskatoon, and snowberry

(*Symphoricarpos* spp.); native and non-native graminoids such as smooth brome, bluegrasses (*Poa* spp.), and sedges (*Carex* spp.); and a diverse mix of native and weedy forbs.

7.3.4. Carex xerantica (dry-land sedge)

Dry-land sedge (Figure 7), a perennial herb with silvery-gold heads of the Cyperaceae (sedge family), is found in xeric steppe and montane habitats such as dry grasslands and hillsides, open forests, and rock outcrops (Douglas et al. 1998; Ball & Reznicek 2002). In B.C., dry-land sedge has been collected in the Peace River area as well as scattered locations in the central interior and central Rocky Mountains (BCCDC 2021; Klinkenberg 2021). There is some disagreement on the taxon's global range. Douglas et al. (1998) note that dry-land sedge extends east from B.C. to Manitoba, and south to Minnesota and Nebraska; Ball & Reznicek (2002) show the species occurring as far east as Ontario and also in Wyoming; and Natureserve (2021) reports the sedge from as far north as Yukon and Alaska, and as far south as Arizona and New Mexico.

Figure 7: *Carex xerantica* (dry-land sedge)

Dry-land sedge is classed as S3 (Vulnerable) in B.C., and is on the provincial Blue list (BCCDC 2021). Although globally the taxon is considered Secure (G5), most jurisdictions that provide a rank for the species indicate some degree of rarity: S1 (Critically Imperilled) in Alaska, Yukon and Wyoming; S2 (Imperilled) in Manitoba, Ontario, Nebraska, Colorado, and New Mexico; and S3 (Vulnerable) in Minnesota. Alberta and Saskatchewan rank the species S4 (Apparently Secure) (NatureServe 2021).

Eight new patches of dry-land sedge were recorded in the study area in 2021: four newly-found occurrences in 6 patches, and two occurrence extensions.

The first new occurrence (of two patches) was found on a gentle slope above Bentley Road, west of Cache Creek. A total of thirteen plants were observed over an area of two square metres in disturbed grassland and open woodland. A second new occurrence was discovered on a steep shrub-grassland slope above Highway 29 just east of Bear Flat: 21 plants were found growing in an approximate area of twelve square metres. The third new occurrence was documented 1.3 km to the northeast, on a gentle shrub-grassland hillside above Highway 29 at the Cache Hill truck pullout.

A fourth new occurrence of dry-land sedge was observed on south-facing shrubby grassland slopes along Ice Bridge Road, north of the Pine River. Here, eleven plants in two patches were found above the road, in an approximate total area of 6 square metres.

The remaining two new patches of dry-land sedge were determined to be extensions of previously-reported occurrences. The first of these was a patch of 2 plants found east of Bear Flat on a dry grassland hillside approximately 130 metres north northwest of an occurrence first documented in 2015.

The final new dry-land sedge patch consisted of the substantial expansion of a previously-known occurrence, on a grassland bench west of the confluence of the Peace and Pine Rivers (Area E). This site was first observed in 2012, when only a portion of the very large bench was surveyed; during the 2021 revisits, the estimated number of dry-land sedge plants was increased to 6,250 and the areal coverage was nearly doubled, to over 20 hectares (however, the full extent of the grassland bench remains unsurveyed). The diverse native plant community at this site is in very good condition and few non-native species were observed.

In total, there are 20 known occurrences of dry-land sedge (in 42 patches) in the RAA. An estimated 13,500 plants have been observed growing in an approximate total area of 29.8 hectares. Seventeen of the occurrences were found on south-facing slopes north of the Peace River from Bear Flat east to the Alberta border, and two occurrences were documented from a large bench and adjacent south-facing slopes on the south side of the Peace River at the Pine River. Dry-land sedge has also been collected on a slope above the Pouce Coupe River, over 25 kilometres to the south.

The dry-land sedge sites are invariably located in xeric grassland habitat, generally in the vicinity of low shrub thickets. The dominant associated species include native shrubs such as prairie saskatoon, prickly rose, and snowberry; native dryland sedges such as hay sedge (*Carex siccata*); and native grasses such as junegrass, short-awned porcupinegrass (*Hesperostipa curtiseta*), spike-oat (*Helictochloa hookeri*), wildryes, and needlegrasses (*Achnatherum* spp. and *Nassella viridula*). A diverse mix of native and non-native forbs are also present at dry-land sedge occurrences.

7.3.5. Lomatium foeniculaceum var. foeniculaceum (fennel-leaved desert-parsley)

Fennel-leaved desert-parsley (Figure 8), a low perennial herb with a long taproot, is a member of the Apiaceae (carrot family) (Douglas et al. 1998). The taxon is found on dry, open slopes across much of

central North America (Hitchcock et al. 1961; NatureServe 2021). Fennel-leaved desert parsley var. *foeniculaceum* is restricted to the Peace River region in British Columbia (BCCDC 2021), but its global range extends east as far as Manitoba and Missouri, and south into Texas (NatureServe 2021).

In B.C., fennel-leaved desert-parsley var. *foeniculaceum* carries a rank of S3 (Vulnerable) and is on the province's Blue list (BCCDC 2021). The taxon's global classification is G5T5 (Secure for both the species and the variety), however of the six other jurisdictions that provide a rank for this variety, four indicate some degree of rarity: S2 (Imperilled) in Colorado and Missouri, and S3 (Vulnerable) in Alberta and Manitoba. Wyoming and Saskatchewan class fennel-leaved desert-parsley var. *foeniculaceum* as S4 (Apparently Secure) and S5 (Secure), respectively (NatureServe 2021).

Figure 8: *Lomatium foeniculaceum var. foeniculaceum (fennel-leaved desert-parsley)*

One new occurrence of fennel-leaved desert-parsley was discovered in the study area in 2021. An estimated 50 to 250 individuals were found growing over an area of approximately 50 square metres on a steep, open-soiled grassland hillcrest above Highway 29 near Bear Flat. One plant was in fruit but the remainder either had not fruited or were past the fruiting stage. Associated species included low shrubs such as prairie saskatoon and prickly rose, and herbs such as thick-spike wildrye (*Elymus lanceolatus* ssp. *lanceolatus*), junegrass, and prairie sagewort.

A total of six occurrences of fennel-leaved desert-parsley are known from the RAA. In addition to the new occurrence described above, there are two dating from 1981, near the Peace River downstream of the Beatton River, and three from Site C survey work in 2017, of which two are above the Beatton River

and one is near Cache Creek. An estimated 950 plants have been documented in an approximate total area of 8,600 square metres. All fennel-leaved desert-parsley sites occur on steep, dry, south-facing grassland slopes in plant associations similar to the one described for the 2021 site.

7.3.6. Oxytropis campestris var. davisii (Davis' locoweed)

Davis' locoweed (Figure 9) is a small perennial in the Fabaceae (pea family) that grows on stream gravels and in mesic to dry meadows and forest openings in the montane zone (Elisens & Packer 1980; Welsh 1991; Douglas et al. 1998). Variety *davisii* is found in northeast B.C. where it can be locally abundant, and is also reported from Alberta (Welsh 2001; BCCDC 2021; NatureServe 2021). Davis' locoweed is classed S3? (Vulnerable?) by the BCCDC, and is on the provincial Blue list (BCCDC 2021). Globally, the variety is also ranked as Vulnerable (T3), due to its limited range. Alberta lists Davis' locoweed as S2? (Imperilled?) (NatureServe 2021).

Figure 9: *Oxytropis campestris* var. *davisii* (Davis' locoweed)

Two new sites of Davis' locoweed were documented in the study area in 2021; both were determined to be extensions of previously-reported occurrences. An estimated 100 plants were found over an area of 45 square metres in a cobble-soiled opening in mature forest on an island in the Peace River near Taylor, B.C. Associated species included white spruce (*Picea glauca*), balsam poplar, common juniper (*Juniperus communis*), kinnikinnick (*Arctostaphylos uva-ursi*), and weedy herbs such as smooth brome and

chick-pea milk-vetch (*Astragalus cicer*). The main patch of this occurrence was found in 2020 approximately 635 metres to the west in open areas of the same island.

A second new patch of an estimated 50 plants in bloom was found in an approximate area of 1,795 square metres on an island in the Peace River eight kilometres downstream from Taylor, B.C. The location of this new patch merged two previously-documented occurrences into one large occurrence of four separate patches. The Davis' locoweed plants were growing in a sparsely vegetated cobble-soiled opening in early seral balsam poplar.

There are a total of 27 occurrences of Davis' locoweed (in 40 patches) reported in the RAA. An estimated 70,000 plants have been recorded in an approximate total area of 13 hectares. Nineteen of the occurrences have been documented from along the Peace River, and many of these sites contain hundreds or thousands of individuals and cover relatively large areas of ground. Four occurrences have been observed along the Halfway River, and three on the Pine River near its confluence with the Peace River. There is also one historical record of Davis' locoweed on the Pine River at Highway 97, over 50 kilometres to the south (not reconfirmed since the 1954 report).

Except for the historical record on the Pine River, all Davis' locoweed occurrences in the RAA have been mapped within 400 metres of current river shorelines, on non-active cobble bars, floodplains or river benches. Habitat at the majority of sites is similar, consisting of open, often bare cobble-silt substrates and young to medium-aged balsam poplar. Other associated species include a relatively sparse cover of native and weedy herbs such as chick-pea milk-vetch, yellow mountain-avens (*Dryas drummondii*) and sweet-clover (*Melilotus* spp.) as well as quackgrass, slender wheatgrass, Canada wildrye (*Elymus* spp.) and other species of locoweeds. The notable exceptions to this early seral habitat are one occurrence of Davis' locoweed on a forested bedrock shoreline, and three patches in mature floodplain forest.

7.3.7. Penstemon gracilis (slender penstemon)

Slender penstemon (Figure 10) is a perennial herb of the Plantaginaceae (plantain family)—formerly of the Scrophulariaceae (figwort family)—that inhabits mesic to dry plains and grasslands (Hitchcock et al. 1959; Douglas et al. 1998; Freeman & Rabeler 2016). The species is commonly found throughout much of central North America, but in B.C. is restricted to the Peace River area (Hitchcock et al. 1959; BCCDC 2021; NatureServe 2021).

Figure 10: *Penstemon gracilis* (slender penstemon)

Slender penstemon is ranked S3 (Vulnerable) in B.C., and is on the province's Blue list (BCCDC 2021). The species' global status is G5 (Secure) (NatureServe 2021). Of the remaining 17 jurisdictions where it is known to occur, only four rank slender penstemon with any degree of rarity—Manitoba and Wyoming as S3 (Vulnerable), and Iowa and Michigan as S1 (Critically Imperilled) (NatureServe 2021).

Four new sites of slender penstemon were discovered in the study area in 2021. A small occurrence was recorded on a narrow southwest-facing ridge west of Cache Creek, in a grassland and woodland mosaic. Here, 10 slender penstemon plants in early flower were found growing in an area of 5.6 square metres. This occurrence is within the right-of-way of a newly-constructed segment of Highway 29 (not yet in use). A second small occurrence was documented on a steep, south-facing hillcrest above Highway 29 east of Bear Flat. Nine senescent slender penstemon plants were observed in an area of approximately 2 square metres.

The remaining two new sites of slender penstemon were determined to be extensions of previously-reported occurrences. A patch of 18 flowering and vegetative plants over approximately 29 square metres was located on a steep grassland opening west of Watson Slough; this site is in the right-of-way of a newly-constructed segment of Highway 29 (not yet in use). Finally, a patch of four flowering plants in two clusters was found on a steep shrub-grassland hillside east of Farrell Creek. This site is within the right-of-way of a proposed new segment of Highway 29.

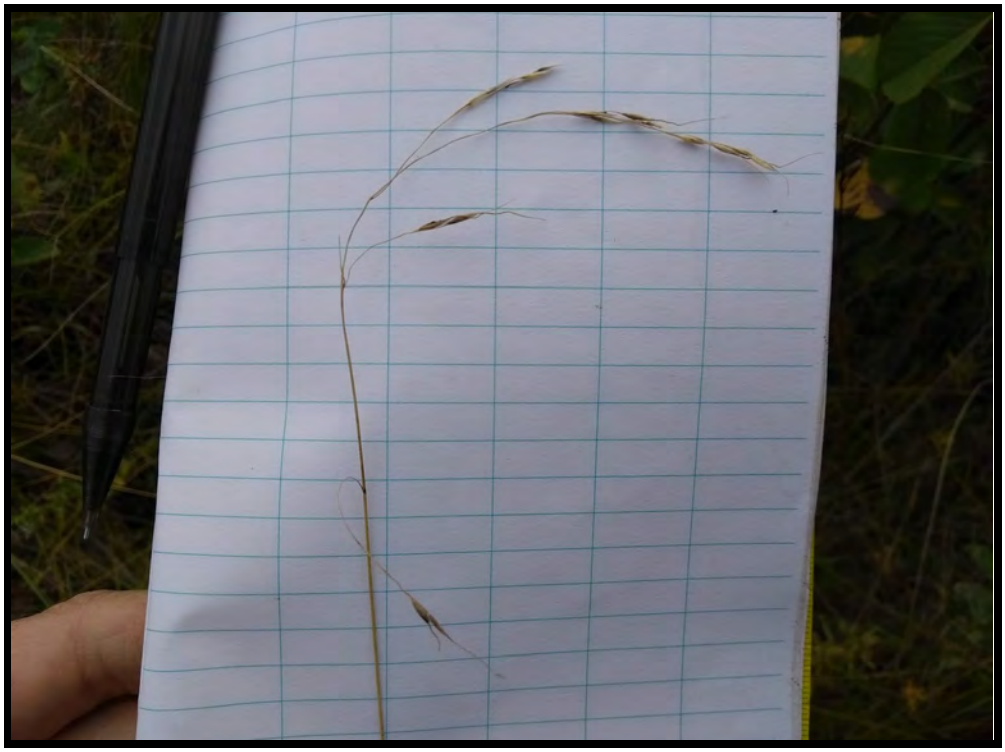
In total, there are 27 occurrences of slender penstemon (in 59 patches) reported in the RAA. All of the occurrences are situated north of the Peace River, from the Farrell Creek area east to the Alberta border.

An estimated 3,700 plants have been documented in an approximate total area of 4 hectares. All of the occurrences were found on south-facing slopes and invariably located in xeric grassland habitat, often in the vicinity of low shrub thickets. Dominant associated species include the native shrubs prairie saskatoon, kinnikinnick, and common snowberry (*Symphoricarpos albus*), native graminoids such as junegrass, wildryes, and dryland sedges, and a diverse mix of native and non-native forbs.

7.3.8. Piptatheropsis canadensis (Canada ricegrass)

Canada ricegrass (Figure 11) is a delicate perennial bunchgrass of the Poaceae (grass family). The species grows in grasslands and open woods and on hillsides and dry slopes; additionally, in eastern North American sites, the taxon is specifically reported from dry, sparsely-vegetated soils which are usually sandy or rocky, as well as moist peaty barrens. Canada ricegrass ranges from Alberta east across Canada to Newfoundland, and south into the U.S. Northeast and Great Lakes regions (Gray & Fernald 1950; Moss & Packer 1983; Lapin 2004; Barkworth 2007; BCCDC 2021). Prior to the 2018 Site C rare plant survey work, no verified extant occurrences of Canada ricegrass were known from B.C. (BCCDC 2021). Of note: the genus *Piptatheropsis* was only recently described (Romaschenko et al. 2011), therefore Canada ricegrass is still referred to by the name *Piptatherum canadense* in some important literature (Lapin 2004; Barkworth 2007; NatureServe 2021).

Figure 11: *Piptatheropsis canadensis* (Canada ricegrass)



Canada ricegrass is ranked S1 (Critically Imperilled) in B.C., and is on the province's Red list (BCCDC 2021). The taxon's global classification is G4G5 (Apparently Secure or Secure) (NatureServe 2021). However, although Canada ricegrass is widely distributed across North America, the species has few

reported occurrences and most of these are small (frequently less than 100 individuals at a site) (Lapin 2004). Accordingly, Canada ricegrass is generally classed as rare sub-nationally: SH (Possibly Extirpated) in Prince Edward Island; S1 (Critically Imperilled) in Manitoba, Wisconsin, West Virginia, and New Hampshire; S2 (Imperilled) in Alberta, New Brunswick, Nova Scotia, Newfoundland, Minnesota, Michigan, New York, and Maine; S3 (Vulnerable) in Saskatchewan; and S4 (Apparently Secure) in Ontario and Québec (NatureServe 2021).

Five new sites of Canada ricegrass were documented in the study area in 2021: one newly-found occurrence with four patches, and one occurrence extension. The new occurrence was discovered on a dry shrub-grassland hillcrest above a steep draw west of Watson Slough. Here, an estimated 45 fruiting plants were observed in four patches, with a total areal coverage of 21.8 square metres. It was noted that none of the plants appeared to have set any viable seed, perhaps as a result of an extreme heat event earlier in the growing season (Preprost 2021). The fifth new Canada ricegrass patch reported in 2021 consisted of an expansion to an occurrence first reported in 2020, on a native grassland bench near the confluence of the Peace and Pine Rivers. A few new plants were found and the total area of the occurrence was expanded by approximately 115 square metres. The fruiting panicles observed at this occurrence also did not appear to contain any viable seed.

There are a total of five known occurrences of Canada ricegrass (in 17 patches) in the RAA, all found during Site C survey work. The occurrences are located from the Cache Creek area east to the Pine and Beatton Rivers. An estimated total of 285 plants have been documented in an approximate total area of 745 square metres. All of the Canada ricegrass sites occur on level to gently sloped, open, good quality native shrub-grassland or remnants of such, usually in close proximity to aspen woodlands. Soils at the sites can be moist to dry. The Canada ricegrass plants grow scattered in dense vegetation consisting of a diverse assemblage of low shrubs and herbs. Dominant associated species are native plants and include the shrubs prairie saskatoon, prickly rose, and chokecherry; graminoids such as spreading needlegrass (*Achnatherum richardsonii*), slender wheatgrass (*Elymus trachycaulus* ssp. *subsecundus*), false melic (*Schizachne purpurascens*), and hay sedge, and forbs such as northern bedstraw and anemones (*Anemone* spp.). A few non-native species are also present at the sites, particularly Kentucky bluegrass (*Poa pratensis*).

7.3.9. Ranunculus rhomboideus (prairie buttercup)

Prairie buttercup (Figure 12) is a soft-hairy perennial of the Ranunculaceae (buttercup family). The species grows in grasslands, prairies, open woods and thickets across north-central North America (Whittemore & Parfitt 1997; Douglas et al. 1998). In B.C., prairie buttercup is only known from the Peace River region (BCCDC 2021). The taxon's range extends north to Northwest Territories and southeast through the Canadian prairie provinces and the northern U.S. Great Plains into Nebraska, Iowa, Illinois, Michigan, and southern Ontario (Whittemore & Parfitt 1997; NatureServe 2021).

Figure 12: Ranunculus rhomboideus (prairie buttercup)

Prairie buttercup has a ranking of S2S3 (Imperilled and Vulnerable) in B.C., and is on the province's Blue list (BCCDC 2021). Globally, the taxon is ranked G5 (Secure). Only sporadic sub-national ranks are provided for prairie buttercup: Alberta, Saskatchewan, Manitoba, and Ontario class the species as S4 (Apparently Secure); Iowa as S3 (Vulnerable); Illinois and Michigan as S2 (Imperilled); Nebraska as S1 (Critically Imperilled); and Québec as SX (Presumed Extirpated) (NatureServe 2021).

No new occurrences of prairie buttercup were documented in the study area in 2021.

In total, 11 occurrences of prairie buttercup (in sixteen patches) have been reported in the RAA. Eight of the occurrences (thirteen patches)—discovered during the Site C rare plant survey work—are situated north of the Peace River from the Cache Creek area east to the Pine River, and contain an estimated 220 plants in an approximate total area of 416 square metres. The remaining three occurrences are historical records not recently verified and with no information available on precise location, number of individuals or areal coverage. The habitat for prairie buttercup is somewhat variable: soils can range from moist to dry, shrub cover can be dense to sparse, and occurrence microsite can be flat to sloped. Dominant associated species include a wide variety of native forbs such as northern bedstraw and American vetch as well as weedy grasses such as smooth brome and Kentucky bluegrass. Native shrub species are also present, the most commonly reported being rose (*Rosa* spp.) and prairie saskatoon.

7.3.10. Salix petiolaris (meadow willow)

Meadow willow (Fig 13), a shrub or small tree of the Salicaceae (willow family), has long, slender leaves and is found in moist to wet habitats across north-central North America (Douglas et al. 1998; Argus 2010). In B.C., the species has only been collected in the northeast part of the province (BCCDC 2021; Klinkenberg 2021). Meadow willow extends north to Northwest Territories, east across Canada to Nova Scotia, and south in the United States as far as New Jersey, Missouri, and Colorado (NatureServe 2021).

Figure 13: *Salix petiolaris* (meadow willow)

Meadow willow is ranked S3 (Vulnerable) in B.C. and is on the Blue list for the province (BCCDC 2021); the species is classed as G5 (Secure) globally. Across much of North America the taxon is classed as Secure (S5) or Apparently Secure (S4), but is considered rare on the southern edge of its range: S1 (Critically Imperilled) in Prince Edward Island and Missouri; S2 (Imperilled) in Ohio and Colorado, and S3 (Vulnerable) in Nova Scotia and Illinois (NatureServe 2021).

One new occurrence of meadow willow was discovered in the study area in 2021: two female plants were found growing approximately 10 metres apart on the southern edge of a large wetland on the plateau between the Peace and Moberly Rivers. The plants were surrounded by deep standing water and were growing in partial shade in a thicket of diverse tree and shrub species along a weedy road edge. Associated species included *Salix discolor* (pussy willow), *Salix lasiandra* var. *lasiandra* (Pacific willow), *Salix bebbiana* (Bebb's willow), balsam poplar, western snowberry, and prickly rose.

Including the new site described above, there are a total of six reported occurrences of meadow willow in the RAA, five of which have not been recently field verified. Four records date from 1967 to 1976 and provide little or no information besides a collection point: two are from east of Fort St. John, B.C., and two are located to the south near Dawson Creek, B.C. The fifth occurrence was reported in 2008 from along a forest road south of Hudson's Hope, B.C., but subsequent attempts to relocate this site have not been successful and it is presumed that either the location data or the identification are incorrect. The record states that 250–1000 individuals were observed over an area of 1,500 square metres along the edge of a logging road in mixed upland forest.

7.3.11. Selaginella rupestris (rock selaginella)

Rock selaginella (Figure 14) is a small, mat-forming evergreen perennial in the Selaginellaceae (spike-moss family). The taxon is found in a variety of open, dry, rocky or gravelly habitats in eastern and central North America (Valdespino 1993; Douglas et al. 1998). In B.C., rock selaginella is known only from the Peace River region (BCCDC 2021; Klinkenberg 2021). The taxon ranges east across Canada to Nova Scotia and southeast in the U.S. to southern Georgia (Valdespino 1993; NatureServe 2021).

Figure 14: *Selaginella rupestris* (rock selaginella)

Rock selaginella is ranked S2 (Imperilled) in B.C., and is on the Red list for the province (BCCDC 2021). The taxon is classed as G5 (Secure) globally, but sub-national rankings vary. Of the jurisdictions providing a rank, rock selaginella is listed as S5 (Secure) in Ontario, Québec, Arkansas, Georgia, and Virginia; as S4 (Apparently Secure) in Saskatchewan, Manitoba, and New York; as S3 (Vulnerable) in Alberta, Illinois,

North Carolina, West Virginia, Vermont, and Massachusetts; as S2 (Imperilled) in Iowa, Alabama, and New Jersey; as S1 (Critically Imperilled) in New Brunswick, Nova Scotia, Ohio, Indiana, North Dakota, and Wyoming; and SX (Presumed Extirpated) in Delaware (NatureServe 2021).

One new patch of rock selaginella was documented in the study area in 2021; this was determined to be an extension of a previously-reported occurrence. An estimated 250–1,000 plants over an approximate area of 925 square metres were observed about 50 metres west of another large patch first discovered in 2018. The site is located on a steep shrub-grassland hillside above Highway 29 east of Farrell Creek.

In total, there are ten known occurrences of rock selaginella (in 15 patches) in the RAA. Nine of the occurrences—discovered or resurveyed as part of the Site C rare plant work—are located north of the Peace River, from Williston Reservoir east to the Alberta border, and contain an estimated 4,630 individuals in an approximate total area of 8,600 square metres.

The tenth occurrence of rock selaginella in the RAA, reported for 2020 but not part of the Site C work, consists of a collection from over 45 kilometres south of the Peace River. A few clumps were found on a dry grassland hillcrest north of Highway 97, sixteen kilometres southwest of Chetwynd, B.C.; areal extent, associated species, and other details were not documented.

The rock selaginella sites are dry and usually rocky; most of the occurrences are in open shrub-grassland habitat on south-facing hillsides or hillcrests, and slopes are often quite steep. Dominant associated species include the shrubs prairie saskatoon, kinnikinnick, and common juniper (*Juniperus communis*); graminoids such as junegrass, thickspike wildrye (*Elymus lanceolatus* ssp. *lanceolatus*), and various dryland sedge species; and forbs such as prairie sagewort, northern bedstraw, and woolly yarrow (*Achillea borealis*). The exceptions are two occurrences found in open forest near the east end of Williston Reservoir, where the rock selaginella was growing with mosses on rock in shaded, dry microsites.

Appendix 7. Portage Mountain Bat Studies: 2020 and 2021 Annual Report

Site C Wildlife Monitoring – Portage Mountain Bat Studies: 2020 and 2021 Annual Report

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April 14, 2022

EXECUTIVE SUMMARY

BC Hydro's quarry on Portage Mountain, which has been operating since 2019, supplies blast rock and fill materials for the Site C Clean Energy Project. The quarry is close to rock crevice habitat that is highly suitable for bats and is used by federally designated at-risk bat species. The Portage Mountain quarry operates under spatial and temporal constraints intended to minimize impacts on bats and bat habitat. Starting in 2016, BC Hydro undertook bat monitoring as part of its bat mitigation and monitoring plan, with the objective of collecting data to identify and characterize impacts to bats and bat habitat due to quarry construction and assess the effectiveness of mitigation. Mitigation included a 300-m spatial setback between all quarry activities and the approximate locations of crevices identified as potential hibernacula, and temporal constraints on blasting. Annual reports of monitoring results have been produced since 2016. This report contains the results of 2020-2021 monitoring, as well as statistical analyses of data collected since 2017 to assess temporal trends in bat activity and potential impacts of blasting on bat activity.

Bats have been monitored year-round between 2017 and 2021 (spring and fall monitoring occurred in 2016) using two types of data: emergence count data and data from acoustic detectors. Emergence counts were used to monitor two suspected maternity roosts. Detectors were used to provide continuous, long-term monitoring of bat activity at Portage Mountain. Noise and vibration produced by quarry activities (including blasting) were periodically monitored to assess compliance with thresholds recommended in *Best Management Practices (BMP) for Bats in British Columbia*.

The monitoring results indicate noise and vibration produced from the quarry appear to have remained below the provincial thresholds. 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, few baseline data were collected before quarry development and operation began. While some trends and correlations were identified in this report, conclusions based on those results are presented with caution due to the nature of the data and missing data due to equipment malfunctions.

The numbers of bats counted at roost sites over the years show that bats continue to use roost sites in the cliffs adjacent to the quarry based on annual surveys, and a maternity roost discovered during baseline surveys continues to provide functional habitat. An average of 40.5 bats had been counted exiting maternity roost 9247G during early-period roost surveys in 2018. Average emergence counts in subsequent years did not reach the peak observed in early 2018 and were variable, but appear to have generally declined, particularly in 2020 and 2021. There are insufficient data to assess the statistical significance of the differences and it is unknown whether the changes in numbers are due to effects from the quarry or represent natural variation in roost use.

Based on the results of acoustic analysis, bat species composition did not change between years. The relationship between bat acoustic activity data and temperature, precipitation, and year were modelled for different bat life stages to test for declines in bat activity related to quarry use, while controlling for weather conditions. The results indicate bat activity varied between years.

Summer activity showed a statistically significant decline in 2018 relative to 2017; however, changes in activity were not significantly different from 2017 in 2019 to 2021. Fall activity showed statistically significant declines in 2018 and 2019 relative to 2017, and a statistically significant increase in 2021 relative to 2017. Bat activity showed a statistically significant negative relationship to blasting occurrence during the fall period. Swarming, based on a peak of bat activity in late summer or early fall, could not be detected in 2019 or 2020 but was detected in 2021. Data were insufficient to determine a swarming period in 2017 or 2018. Bat activity during the hibernation period showed a statistically significant decline in 2018, 2019 and 2021 relative to 2017, despite no blasting occurring during the hibernation period. Bat activity in summer showed a statistically significant positive relationship with blasting occurrence, but that result is suspected to be due to an unmeasured confounding variable. There were too few data to test for potential impacts on acoustic bat activity during the emergence period. Bats selecting tree roosts within the 300-m spatial setback distance from the quarry may be subject to higher noise levels compared to bats using the rock crevice roosts outside that buffer.

Recommendations are provided to continue data collection to increase the quality and quantity of monitoring data to support additional analysis of quarry impacts. BC Hydro has no further plans for production blasting at Portage Mountain Quarry and plans to conduct additional monitoring. Considering the statistically significant negative relationship between bat activity and blasting occurrence in fall, it is recommended that to be precautionary, the no-blasting period for future mining and quarry projects in proximity to high-suitability bat hibernating habitat should be extended to include the swarming period (i.e., starting September 1).

This work was performed in accordance with 579005 between Hemmera Envirochem Inc. (Hemmera), a wholly owned subsidiary of Ausenco Engineering Canada Inc., and BC Hydro (Client), dated 21 June 2016 (Contract). This report has been prepared by Hemmera, based on fieldwork conducted by Hemmera, for sole benefit and use by BC Hydro. In performing this work, Hemmera has relied in good faith on information provided by others and assumes that information provided is complete and accurate. This work was performed to current industry standard practice for similar environmental work, within the relevant jurisdiction. The findings presented herein should be considered within the context of the scope of work and the findings 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. 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

EXECUTIVE SUMMARY I

LIST OF ACRONYMS AND ABBREVIATIONS VII

LIST OF SYMBOLS AND UNITS OF MEASURE VII

1.0 INTRODUCTION 1

2.0 STUDY AREA 2

3.0 BACKGROUND 4

3.1 Quarry Noise and Vibration Mitigation Thresholds 5

3.2 Known and Suspected Hibernacula and Maternity Roosts 7

3.3 Quarry Construction and Operation Activities and Bat Mitigation 7

4.0 METHODS 10

4.1 Weather and Sunset Data 10

4.2 Noise and Vibration Monitoring 10

4.3 Roost Emergence Counts, Roost Inspections, and Maternity Roost Monitoring 10

4.3.1 Roost Emergence Counts and Roost Inspections 11

4.3.2 Roost Monitoring 11

4.3.3 Data Analysis 12

4.3.4 Assumptions and Data Limitations 13

4.4 Long-term Passive Acoustic Monitoring 13

4.4.1 Detector Locations 14

4.4.2 Data Analysis 15

4.4.3 Assumptions and Data Limitations 19

5.0 RESULTS 21

5.1 Blasting, Noise and Vibration Monitoring 21

5.1.1 2020 21

5.1.2 2021 21

5.2 Maternity Roost Emergence Counts 22

5.2.1 2020 and 2021 Roost Emergence Counts and Roost Monitoring 22

5.2.2 Cumulative Roost Emergence and Roost Monitoring 23

5.3 Long-term Passive Acoustic Monitoring 24

5.3.1 Cumulative Survey Effort and Results 25

5.3.2 Bat Life Stages 29

5.3.3 Cumulative Trends in Bat Activity 35

6.0 DISCUSSION 44
6.1 Maternity Roost Monitoring 44
6.2 Bat Species Presence and Seasonal Bat Activity from Passive Acoustic Monitoring 45
6.2.1 Species Presence 45
6.2.2 Seasonal activity 47
6.3 Bat Response to Quarry Activity 48
7.0 CONCLUSIONS AND RECOMMENDATIONS 52
8.0 REFERENCES 54

LIST OF TABLES (WITHIN TEXT)

Table 3.1 Bat Species* Previously Recorded** at Portage Mountain 4
Table 3.2 Bat Monitoring Program Components Conducted at Portage Mountain 5
Table 3.3 Emergence Counts Previously Conducted at Portage Mountain 7
Table 3.4 Quarry Construction and Operation Activities 2017- 2021 8
Table 4.1 Long-term Passive Acoustic Monitoring Sites, 2017 to 2021 14
Table 5.1 Number of Blasts by Month at the Portage Mountain Quarry in 2020 21
Table 5.2 Number of Blasts by Month at the Portage Mountain Quarry in 2021 22
Table 5.3 Average Sound Levels (dBA) Recorded at the Portage Mountain Cliffs in May 2021 22
Table 5.4 Emergence Count Surveys Completed, and Average* Number of Bats by Survey Night, at Two Suspected Maternity Roost Sites on Portage Mountain, 2017-2021 23
Table 5.5 Emergence Counts Where 3-9 Bats Were Observed, 2018-2021 24
Table 5.6 Remote Detector Survey Effort (Nights When Detectors Were Operating), 2017-2021 25
Table 5.7 Timing of Data Gaps by Detector, 2017-2021 25
Table 5.8 Numbers of Bat Files by Detector (Excluding Social Calls), 2017-2021 28
Table 5.9 Files per Detector-Night by Identification Category (Excluding Social Calls), 2017-2021 28
Table 5.10 Yearly Bat Life Stages for *Myotis* sp. Bats at Portage Mountain 29
Table 5.11 Comparison of Bat Activity by Life Stage and Detector between Late Summer 2017 and Fall 2021 33
Table 5.12 Number of Files Recorded per Detector-night during December, January and February 2017 to 2021 34
Table 5.13 Model Selection Results for Emergence Bat Activity Models at Portage Mountain with Number of Parameters (K), Log-Likelihood (LL), and Akaike's Information Criterion (AIC) Score and Weight for each Model 35
Table 5.14 Model Selection Results for Summer Bat Activity Models at Portage Mountain with Number of Parameters (K), Log-Likelihood (LL), and Akaike Information Criterion (AIC) Score and Weight for each Model 35

Table 5.15 Model Selection Results for Fall Bat Activity Models at Portage Mountain with Number of Parameters (K), Log-Likelihood (LL), and Akaike Information Criterion (AIC) Score and Weight for each Model 36
Table 5.16 Model Selection Results for Hibernation Bat Activity Models at Portage Mountain with Number of Parameters (K), Log-Likelihood (LL), and Akaike Information Criterion (AIC) Score and Weight for each Model 36
Table 5.17 Model* of Yearly Bat Activity during the Summer Period at Portage Mountain 36
Table 5.18 Model* of Yearly Bat Activity during the Fall Period at Portage Mountain 36
Table 5.19 Model of Yearly Bat Activity during the Hibernation Period at Portage Mountain 37
Table 5.20 Model Selection Results for Summer Bat Activity Models at Portage Mountain with Number of Parameters (K), Log-Likelihood (LL), and Akaike Information Criterion (AIC) Score and Weight for each Model. 38
Table 5.21 Model Selection Results for Fall Bat Activity Models at Portage Mountain with Number of Parameters (K), Log-Likelihood (LL), and Akaike Information Criterion (AIC) Score and Weight for each Model. 38
Table 5.22 Model of Bat Activity in Response to Blasting During the Summer Period at Portage Mountain, Based on Data from 5 Detectors at 3 Areas 39
Table 5.23 Model of Bat Activity in Response to Blasting During the Fall Period at Portage Mountain, Based on Data from 5 Detectors at 3 Areas 39

LIST OF FIGURES (WITHIN TEXT)

Figure 2.1 Study Area and Bat Detector Locations for Portage Mountain Bat Monitoring 3
Figure 3.1 Cumulative Emergence Count Locations and Results, 2017-2021 6
Figure 4.1 Location of Detector TAL (arrow) at the Small Talus Field Downslope of the North Cliff 15
Figure 5.1 Graphical Representation of Detector Data Gaps 27
Figure 5.2 Myotis Calls from July 15 to September 30, 2019 with a Modified Gaussian 4-Parameter Bell Curve to Predict a Peak In Calls During the Swarming Period 30
Figure 5.3 Myotis Calls from July 15 to September 30, 2020 with a Modified Gaussian 5-Parameter Bell Curve to Predict a Peak in Calls During the Swarming Period 31
Figure 5.4 Myotis Calls from July 15 to September 30, 2021 with a Modified Gaussian 5-Parameter Bell Curve to Predict a Peak in Calls During the Swarming Period 32
Figure 5.5 Yearly Bat Activity by Bat Life Stage at Portage Mountain 37
Figure 5.6 Bat Calls Per Night During the Summer and Fall with Average Night Temperature and Days with Blasting (Red Lines) in 2018. 40
Figure 5.7 Bat Calls Per Night During the Summer and Fall with Average Night Temperature and Days with Blasting (Red Lines) in 2019 41
Figure 5.8 Bat Calls Per Night During the Summer and Fall with Average Night Temperature and Days with Blasting (Red Lines) in 2020 42
Figure 5.9 Bat Calls Per Night During the Summer and Fall with Average Night Temperature and Days with Blasting (Red Lines) in 2021. 43

LIST OF APPENDICES

Appendix A Acoustic Characteristics Used to Analyze Bat Species in the Study Area
Appendix B Portage Mountain Riprap Quarry – Blasting Vibration and Sound Levels Memo
Appendix C Site C Portage Mountain Quarry Hibernacula Noise and Vibration Study
Appendix D Results of 2020 and 2021 Emergence Counts, Roost Monitoring, and Long-term Acoustic Monitoring
Appendix E Weather Conditions During 2020 and 2021 Emergence Surveys
Appendix F Number of Nights Detectors were Active by Season
Appendix G Blast Model Results for Summers 2019 to 2021

LIST OF ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Definition
AIC	Akaike's Information Criterion
BC	British Columbia
BMP	Best Management Practice(s)
CI	Confidence interval
K	Number of parameters
LL	Log-likelihood
NA	Not applicable
quarry	Portage Mountain Quarry
Project	Site C Clean Energy Project
study area	Portage Mountain Quarry and adjacent cliffs
SARA	*Species at Risk Act*

LIST OF SYMBOLS AND UNITS OF MEASURE

Symbol / Unit of Measure	Definition
%	Per cent
dB	decibel
dBA	A-weighted decibels
in	inch
kHz	kilohertz
kPa	kilopascal
km	kilometre
m	metre
mm	millimetre
n	number

1.0 INTRODUCTION

Portage Mountain, approximately 15 kilometres (km) west of Hudson's Hope in northwestern BC (**Figure 1**), is the site of a quarry developed to supply the construction of the Site C Clean Energy Project in the Peace River valley. The Portage Mountain Quarry provides riprap material used for constructing the Highway 29 realignment and protecting the shoreline along the Peace River near Hudson's Hope during the eventual filling of the reservoir.

Baseline studies for the Site C Clean Energy Project (Andrusiak 2014; Simpson et al. 2013) as well as subsequent surveys (Sarell and Alcock 2017) identified cliff faces at Portage Mountain as hibernation and roosting habitat for bats, including two at-risk bat species: little brown myotis (*Myotis lucifugus*) and northern myotis (*Myotis septentrionalis*) are listed as endangered on Schedule 1 of the *Species at Risk Act* (SARA). Disturbance of bats during winter may cause them to arouse from hibernation and repeated arousals in response to disturbance are considered detrimental to their survival (Boyles 2017; Sheffield et al. 1992; Thomas 1995).

The potential effects of development and operation of the Portage Mountain Quarry (**Figure 2.1**) on nearby bats were assessed in the Site C Environmental Impact Statement (BC Hydro 2013) and monitoring and mitigation for bats is required by the provincial Environmental Assessment Certificate, the Federal Decision Statement, and Schedule A of the Project's conditional water licences. BC Hydro has implemented mitigation (BC Hydro 2020) to minimize the potential for impacts on bats, including the following:

- spatial setback of quarry activities from roost sites;
- temporal restrictions on high-intensity noise or vibration (i.e., blasting) from 15 September to 15 May to avoid disturbing bats during winter hibernation.

The objective of monitoring bat activity at Portage Mountain is to collect data to 'help identify and characterize any impacts to bats and bat habitat due to the construction and operation of Portage Mountain Quarry', as described in the *Bat Mitigation and Monitoring Plan* (BC Hydro 2020), which allows the efficacy of mitigation and previous predictions of impacts to be tested. Bat activity monitoring at Portage Mountain used the following general approaches:

- monitoring of noise and vibration from construction activities, including blasting, to assess whether the disturbance is within best management practices (BMP) guidelines (BC Ministry of Environment 2016c) and evaluate whether there are significant relationships with bat activity patterns (**Section 4.2**).
- emergence counts (**Section 4.3.1** and **Appendix D**) at identified maternity roosts (9427G and 6287F; **Figure 2.1**).
- additional emergence counts at roosts not yet determined to be occupied by maternity colonies (**Section 4.3.1** and **Appendix D**).
- roost monitoring using remote logger devices (**Section 4.3.2**) to sample activity, temperature, and humidity at the identified maternity roosts.
- long-term, year-round passive acoustic monitoring (**Section 4.4**) using remote bat detectors at the north and south cliffs and near the quarry. Data from acoustic monitoring provide ongoing documentation of bat species presence and activity to assess seasonal and year to year changes in bat activity and potential effects of quarry operation on bat activity and species presence.

This report summarizes the results of bat monitoring at Portage Mountain from late summer 2017 to fall 2021 undertaken to meet the objectives of the Bat Mitigation and Monitoring Plan (BC Hydro 2020).

2.0 STUDY AREA

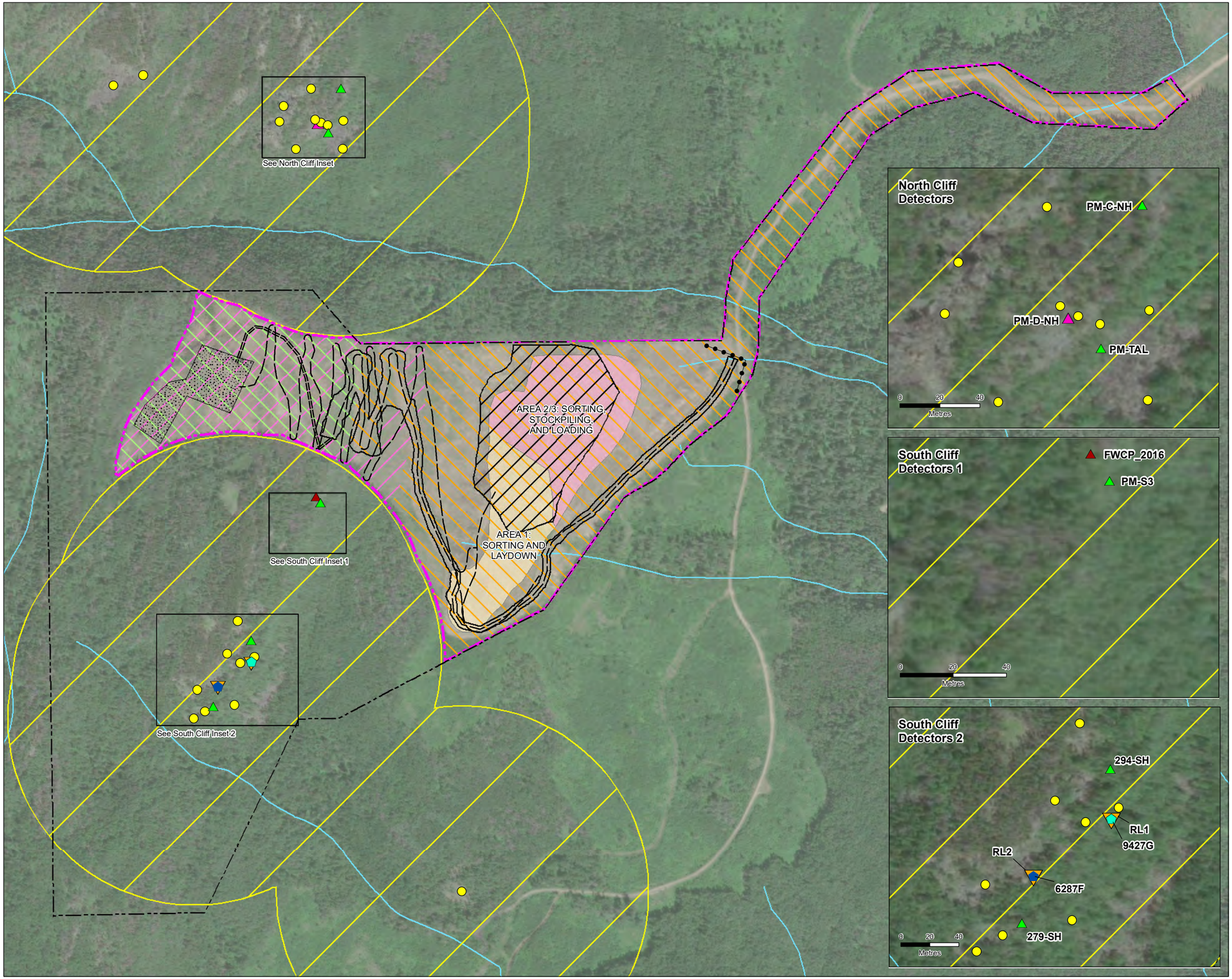
The study area has been described in Hemmera (2020) and is briefly summarized here. The bat monitoring study area (**Figure 2.1**) includes the quarry (BC Hydro 2020) and the adjacent cliffs to the north and south within approximately 750 metres (m) of the quarry. This study area has the following characteristics indicative of potential bat hibernacula (BC Ministry of Environment 2016a, 2016b; Nagorsen et al. 1993):

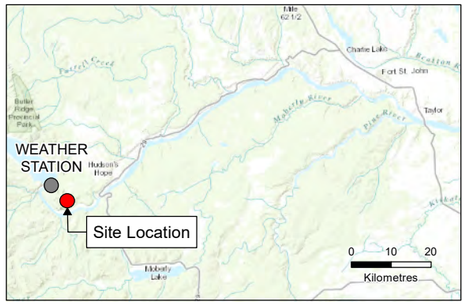
- large and exposed (i.e., sparsely vegetated) rock features that gain and maintain solar insolation and have numerous crevices; and
- deep crevices and caves (including mine adits) that provide cool and stable temperatures and high humidity for hibernating bats.

The Portage Mountain cliffs are located within boreal forest dominated by hybrid white spruce (*Picea engelmannii* x *glauca*) and trembling aspen (*Populus tremuloides*). The two main areas of cliff (north and south) are separated by an unnamed creek gully that drains into Dinosaur Reservoir. A stand of mature balsam poplar (*Populus balsamifera*) is present within the gully. Development of the Portage Mountain quarry, located on the south side of the creek gully, began in 2017 with clearing and access road construction. Production blasting and extraction of quarry rock began in the summer of 2019. Further details of quarry activities are provided in **Section 3.3**. The site is accessed by a forestry road (400 Road).

Site C Clean Energy Project
Wildlife Mitigation and Monitoring Services

Study Area and Bat Detector Locations for Portage Mountain Bat Monitoring





Legend

- Permanent Bat Detector
- Bat Detector (Historic)
- Short-Term Bat Detector
- Confirmed Maternity Roost
- Potential Hibernacula
- Potential Maternity Roost
- Roost Logger
- Weather Station
- Security Fencing
- In Quarry Access Road
- Quarry Haul Road
- Stockpile Road
- Site Boundary
- Potential Hibernacula - 300m Buffer
- Portage Mountain LOO
- Stripping/Overburden Stockpile Area
- Quarry Road
- Stockpile & Sort Area
- Quarry Development Area
- Grubbing Area by BC Hydro
- Clearing Area by BC Hydro
- Area 1: Sorting and Laydown
- Area 2/3: Sorting, Stockpiling, and Loading

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

- Base Data: BC Hydro, 2017
- Aerial Image: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

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BC hydro

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3.0 BACKGROUND

Bat studies were conducted from 2012 to 2014 at Portage Mountain to support the development of the Environmental Impact Statement for the Site C Clean Energy Project. Those studies determined that some rock features in the vicinity of the proposed quarry area were highly suitable for hibernating bats (Andrusiak 2014). Two at-risk bat species are known present at Portage Mountain and very likely hibernating based on the dates of detections: little brown myotis (*Myotis lucifugus*) and northern myotis (*Myotis septentrionalis*). Both species are listed as endangered on Schedule 1 of the *Species at Risk Act* (SARA) and both have been confirmed to use rock crevices for hibernation (COSEWIC 2013; White et al. 2020). The results of the previous surveys and the characteristics of the habitat led to the determination that rock crevices used by little brown myotis and northern myotis for hibernation at Portage Mountain meet the criteria for critical habitat under SARA (COSEWIC 2013). Six other bat species have been recorded at Portage Mountain, at least four of which are likely hibernating and all of which may be using maternity roosts (trees and rock crevices) in the vicinity (**Table 3.1**).

Table 3.1 Bat Species* Previously Recorded at Portage Mountain**

English Name	Scientific Name	BC Status	SARA Schedule 1 Status	Winter Behaviour
Long-eared myotis	*Myotis evotis*	Yellow	None	Hibernate
Little brown myotis	*Myotis lucifugus*	Yellow	Schedule 1 Endangered	Hibernate
Northern myotis	*Myotis septentrionalis*	Blue	Schedule 1 Endangered	Hibernate
Long-legged myotis	*Myotis volans*	Yellow	None	Hibernate
Silver-haired bat	*Lasionycteris noctivagans*	Yellow	None	Hibernate / Migrate
Eastern red bat	*Lasiurus borealis*	Unknown	None	Migrate
Hoary bat	*Lasiurus cinereus*	Yellow	None	Migrate
Big brown bat	*Eptesicus fuscus*	Yellow	None	Hibernate

*English and scientific names are those used by the BC Conservation Data Centre (2021)
**(Andrusiak 2014; Hemmera 2018, 2020; Sarell and Alcock 2017)

The bat studies conducted since 2014 (Andrusiak 2014; Hemmera 2018, 2020; Sarell and Alcock 2017) used a combination of passive acoustic surveys and emergence surveys to build an understanding of bat activity and habitat use, and provide evidence that bats are using Portage Mountain rock crevices for the following:

- hibernacula in the winter (typically both sexes, likely in small groups);
- maternity roosts in the summer where breeding females congregate to gestate, give birth, and raise young; and,
- day roosts in the spring, summer, and fall, used by single individuals or small groups of males or of non-reproductive females.

BC Hydro prepared a bat monitoring plan in 2017, which was updated in 2020 (BC Hydro 2020) with input from the Vegetation and Wildlife Technical Committee.

The ongoing bat monitoring program at Portage Mountain (**Table 3.2**) consists of:

- year-round acoustic monitoring;
- emergence counts at maternity roosts during the summer;
- monitoring of noise and vibration produced by quarry operation; and,
- monitoring of temperature and humidity at two roost locations (initiated in 2020).

Monitoring studies (Hemmera 2018, 2020) have been designed to determine the efficacy of mitigation implemented during construction and operation of the quarry to reduce the disturbance or displacement of bats that use rock crevices as maternity roosts and/or hibernacula (**Figure 2.1; Figure 3.1; Table 3.2**).

Table 3.2 Bat Monitoring Program Components Conducted at Portage Mountain

Monitoring Activity	2017	2018	2019	2020	2021
Passive acoustic bat activity	X	X	X	X	X
Maternity roost emergence counts / roost inspection	X	X	X	X	X
Temperature and humidity	–	–	–	X	X
Noise and vibration	–	X	X	X	X

Note: X = surveys were conducted, – = surveys were not conducted.

3.1 Quarry Noise and Vibration Mitigation Thresholds

There have been very few field tests of the actual impacts of blasting noise and vibration on hibernating bats (e.g., West Virginia Department of Environmental Protection, Office of Explosives and Blasting 2006). *Best Management Practices (BMP) for Bats in British Columbia* (BC Ministry of Environment 2016c) recommends that high-intensity activities, such as blasting or use of heavy machinery, not occur between October and April within 1 km of significant roosts, which includes occupied hibernacula. The provincial BMP also recommends that noise and vibration at significant occupied bat roosts as a result of blasting activities should remain below the following thresholds (BC Ministry of Environment 2016c):

- sound concussion less than 150 decibels (dB);
- shock wave less than 15 pounds per square inch (103.4 kPa); and,
- peak particle velocity less than 15 mm/second.

BC Hydro implemented a temporal restriction on all blasting activities between September 15 and May 15 to reduce the potential for disturbance to hibernating bats (BC Hydro 2020), as well as a 300-m setback between all quarry activities and the approximate locations of crevices identified as potential hibernacula. The 300-m setback area was used in the design of the quarry to avoid areas identified as supporting hibernating bats. The 300-m buffer used to design the quarry was based on identified potential hibernacula (Andrusiak 2014) rather than areas of suitable habitat. Modelling conducted by Horan and Frappell (2016) predicted that the noise and vibration of expected blasts at Portage Mountain would not exceed BC BMP thresholds at 150 m from the quarry development boundary, such that a 300-m buffer would be conservative.

The quarry is located approximately 350 m from the closest identified maternity roost (9427G) and approximately 130 m from the nearest rock feature (south cliff) that could provide roosting habitat. The quarry is therefore consistent with recommended BMP (BC Ministry of Environment 2016c) to avoid activities that modify habitat within 100 m of identified bat maternity and hibernation sites.

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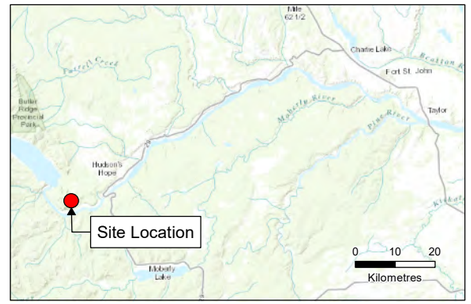
Wildlife Mitigation and Monitoring Services

Cumulative Emergence Count Locations and Results, 2017-2021



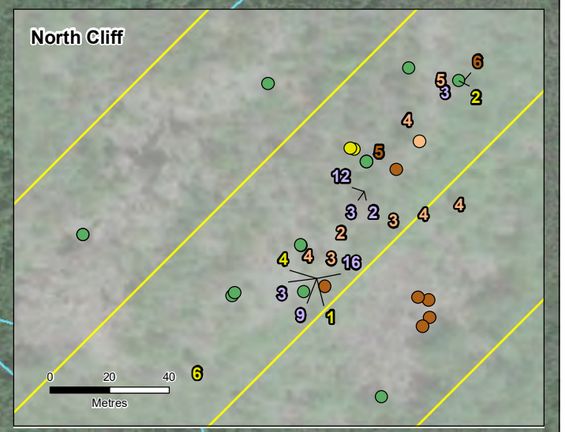
See North Cliff Inset

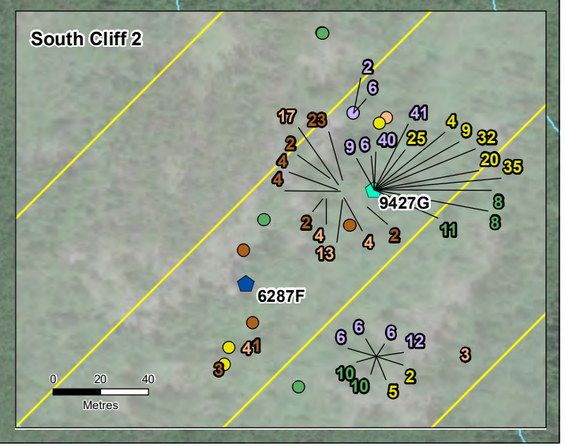
See South Cliff Inset 1

See South Cliff Inset 2

AREA 2/3: SORTING, STOCKPILING, AND LOADING

AREA 1: SORTING AND LAYDOWN





Legend

- 12 Bat Emergence Count
- No Bats Observed
- Confirmed Maternity Roost
- Potential Maternity Roost
- Security Fencing
- In Quarry Access Road
- Quarry Haul Road
- Stockpile Road
- Site Boundary
- Potential Hibernacula - 300m Buffer
- Portage Mountain LOO
- Stripping/Overburden Stockpile Area
- Quarry Road
- Stockpile & Sort Area
- Quarry Development Area
- Grubbing Area by BC Hydro
- Clearing Area by BC Hydro
- Area 1: Sorting and Laydown
- Area 2/3: Sorting, Stockpiling, and Loading

Year

- 2017
- 2018
- 2019
- 2020
- 2021

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The BMP thresholds do not include specifications for the frequency of blasting events or of the waveform frequencies produced by blasts, which are important considerations when assessing potential impacts of blasting noise and vibration (Orica Limited Group n.d.). “Significant” roosts have been defined in the provincial BMP (BC Ministry of Environment 2016c) based on characteristics that are difficult to apply directly at Portage Mountain because access and technical challenges prevent accurate determination of the species, sex and reproductive status of each individual exiting a cliff crevice. However, for practical purposes any roost identified as likely being a maternity roost and /or a hibernaculum is considered a significant roost at Portage Mountain.

3.2 Known and Suspected Hibernacula and Maternity Roosts

Early studies identified sections of the cliffs adjacent to the quarry and the adits of an abandoned mine (King Gething mine) as potential hibernacula (Andrusiak 2014; Sarell and Alcock 2017). Hemmera (2018a, 2018b, 2020) conducted passive acoustic monitoring over multiple years to identify peaks of bat activity during the mating period in the fall (swarming), some winter bat activity, and activity in the spring when bats start emerging from hibernation, supporting the conclusion that bats were hibernating at the cliff features at Portage Mountain.

Early studies also identified use of the cliffs as day roosts (Hemmera 2018, 2020). Emergence counts conducted in 2017, 2018, and 2019 (**Table 3.3**) identified potential maternity roosts (6287F, 9247G) in the cliffs south of the quarry (**Figure 3.1**) based on multiple individuals observed exiting the cliffs during emergence counts. Other counts identified areas of the cliff where smaller numbers of bats were observed emerging. However, finding specific roost crevices in the cliffs is difficult due to the presence of multiple crevices in close proximity, the height above ground of many crevices, and the steep and hazardous terrain that prevents surveyors from closely approaching crevices. Bats may also roost in the trees on Portage Mountain.

Table 3.3 Emergence Counts Previously Conducted at Portage Mountain

Year	Dates of Emergence Counts
2017	July 31 to August 10
2018	June 17 to June 20 June 30 to August 03
2019	June 09 to June 13 June 19 July 22 to July 25

3.3 Quarry Construction and Operation Activities and Bat Mitigation

Quarry construction and operation activities within the quarry boundaries (**Figure 2.1**) between 2019 and 2021 have included the following:

- developing and upgrading road access;
- clearing vegetation in the quarry area;
- blasting, excavating, and transporting material; and,
- rock sorting (in the lower area close to 400 Road).

Construction activities for road access, vegetation clearing, and the haul road began in 2016 and were completed in fall 2019 (**Table 3.4**). In 2020, riprap loading and sorting and tree clearing continued, and nighttime activities took place from July 1 to October 9. Production blasting occurred during 2020 and 2021.

Table 3.4 Quarry Construction and Operation Activities 2017- 2021

Dates	Location *	Activity
2016	Access road and quarry site	Clearing and access road construction
August 10 to August 14, 2018	Future quarry site	Test blasting
June 6 to September 15, 2019	Quarry and along 400 Road	Tree clearing
June 6 to August 20, 2019	Quarry	Blasting for haul road construction
August 21 to September 15, 2019	Pit	Production blasting
May 16 to September 14, 2020	Pit	Production blasting
May 16 to early November, 2020	Quarry, Stockpile and Sorting Area (Area 1) to Offsite Rip Rap Stockpile Area (Area 4)	Tree clearing
May 16 to early November 2020	Area 1 to Area 4	Riprap loading and sorting
July 1 to August 18, 2020	Area 1 to Area 4	Nighttime hauling
July 22 to August 18, 2020	Pit to Area 1	Nighttime hauling with vehicle lights only
July 22 to August 18, 2020	Pit	Nighttime excavation at the pit
August 9, 2020	Area 1	Installation of lights for safety at nighttime
August 28 to October 9, 2020	Area 1 to Area 4	Nighttime hauling
May 16 to August 17, 2021	Pit	Production blasting
March to April, 2021	Area 5	Clearing, grubbing, stripping and hauling
May to August 2021	Area 1 to Area 4	Nighttime hauling in areas 1 and 4
September to December, 2021	Area 1	Processing material

*See **Figure 2.1**.

Noise and vibration monitoring was conducted for representative test blasts at Portage Mountain Quarry in 2018 (Johnston et al. 2018), and for quarry construction and operation activity in 2019, 2020 and 2021 (Dailyde and Johnston 2020; Dailyde et al. 2022) to compare the noise and vibration produced at the quarry to the BMP thresholds (**Section 3.1**). The test blasting indicated that noise and vibration 300 m or more from blasts were below the thresholds described by the provincial BMPs (BC Ministry of Environment 2016c), with ground-borne vibrations below threshold by 141 and 228 m from the blast on the north and south cliffs, respectively, and air overpressure below threshold by 34 m from the blast (Johnston et al. 2018).

In 2020 artificial lights were used for safety at the Stockpile and Sorting Area (Area 1; **Figure 2.1; Table 1.3**). Artificial light at night has the potential to affect bat behavior (Rowse et al. 2016; Straka et al. 2019; Voigt et al. 2021). BC Hydro has minimized the use of artificial lights at the quarry to mitigate the potential adverse effects of light. Additional mitigation for the use of lights was as follows:

- lights had full directional capability with shrouding;
- lights were pointed down and away from the cliff faces; and,
- lights were turned off when not needed.

BC Hydro's mitigation plan for bats also includes potential creation of bat habitat during future reclamation of the quarry, if analyses of monitoring data determine that hibernating or roosting sites for bats were affected by quarry operations (BC Hydro 2020).

4.0 METHODS

Methods implemented at Portage Mountain from 2017 through 2021 were developed in consultation with the Vegetation and Wildlife Technical Committee and local biologists (Hemmera 2018). Methods are based on standard techniques used for bat studies (Bachen et al. 2020; BC Ministry of Environment 2016b) with minor variations to account for the specific habitats, terrain, and access challenges at the monitoring sites.

4.1 Weather and Sunset Data

Two temperature loggers were installed at the south cliff in 2020 (**Section 4.3.2**), but those units did not produce a complete data record due to rodent damage and premature battery failure. No provincial weather stations were located close enough to Portage Mountain for their data to be useful. BC Hydro provided hourly weather data from their weather station at the Portage Mountain quarry (**Figure 2.1**). Data included precipitation in millimetres (mm) and air temperature in degrees Celsius (°C), both reported hourly, but did not include barometric pressure. The time of sunset at Fort St. John on each day was obtained from National Research Council Canada (2021).

4.2 Noise and Vibration Monitoring

RWDI Consulting Engineers and Geoscientists (Dailyde et al. 2022) and TetraTech Canada (Nickoli et al. 2022) reported the results of noise and vibration (including blasting) monitoring and modelling at the north and south cliffs for 2020 and 2021. **Appendix A** and **Appendix B** include detailed descriptions of noise and vibration monitoring methods, which are briefly summarized here.

Baseline noise monitoring occurred in 2019 (Dailyde and Johnston 2020). Baseline measurements were completed at a representative location far enough away from the quarry that work there would not affect the noise levels measured. Quarry noise monitoring in 2020 and 2021 was carried out at both the north cliffs and the south cliffs.

No vibration monitoring occurred in 2020, as vibration data are more difficult to collect, and based on the expectation that blasts in 2020 would be similar to those in 2018 and 2019. Vibration monitoring occurred regularly at the south cliff and north cliff monitoring locations in 2021 (Dailyde et al. 2022). Blast monitoring was conducted from May through September in 2021.

Nickoli et al. (2022) used 2019 and 2021 blasting data provided by BC Hydro to develop site-specific best fit equations to calculate peak particle velocity and sound concussion for the north and south cliffs for the 2020 blasts that were not monitored. The resulting metrics for sound concussion (also known as the air overpressure or airborne vibration), shock wave, and peak particle velocity (also referred to as ground vibration) were compared against provincial BMP thresholds (**Section 3.1**) for noise and vibration due to blasting near bat habitat features (2016c). The results of the noise and vibration monitoring also provided additional environmental context to inform the analysis of bat activity over time (**Section 4.4.2.2**).

4.3 Roost Emergence Counts, Roost Inspections, and Maternity Roost Monitoring

Consistent daily emergence of bats from maternity roosts at dusk for feeding provides opportunities for roost identification and enumeration of bats via emergence counts. Roosts used by pregnant and nursing female bats have more regular patterns of emergence than roosts used by male or non-reproductive

individuals (Barclay 1989; BC Ministry of Environment 2016b). The objectives of the emergence surveys were to identify maternity roosts, to assess potential changes in use of the cliffs as maternity roosts, and to examine the relationship between any changes in maternity roost use and quarry operation.

Two methods were used to collect emergence data at identified and suspected maternity roosts and non-maternity roosts:

- emergence counts and roost inspections; and,
- continual roost monitoring with remote roost loggers placed near the roost entrances to record bat calls.

4.3.1 Roost Emergence Counts and Roost Inspections

Roost emergence counts were conducted in 2020 following methods described in Loeb et al. (2015) and Vonhof (2006). The methods have been previously described in Hemmera (2019). Information on site selection criteria was provided in the 2017 to 2019 bat monitoring report (Hemmera 2020). Physical inspections for roosting bats or bat sign such as guano were conducted where potential features could be safely accessed by surveyors.

Visual emergence counts were completed twice yearly during the maternity period: once ('early period') during pre-volancy (i.e., when pups are not able to fly) between June 1 and June 21, and once ('late period') during post-volancy (i.e., when pups can fly) from July to early August. Emergence counts were conducted from 30 minutes before dusk until approximately 1 hour after dusk, when visibility became a limiting factor, or until bats started to return to the roost. Each site on the north and south cliffs was surveyed on two consecutive nights both pre- and post-volancy (4 surveys total). Surveyors were equipped with handheld acoustic detectors (Echometer Touch) that recorded bat vocalizations in the vicinity of the surveys. Sites where no bats were observed were not resurveyed in subsequent years.

A single exploratory roost emergence count with multiple observers was conducted during the 2020 post-volancy period at the access road (400 Road) to investigate bat activity at the mouth of the gully located east of the quarry (**Figure 3.1**). This survey was focused on the mouth of a gully, upstream of which is a linear patch of mature balsam poplar with potential to provide tree roosting habitat for bats. The survey stations were located along 400 Road, where multiple observers visually scanned the edge of the forest. Surveyors used handheld bat detectors (Echometer Touch) to alert them to bats emerging from the stand and to record calls for later analysis.

4.3.2 Roost Monitoring

Two of the previously-identified maternity roosts at the south cliff (9427G and 6287F; **Figure 2.1**; Hemmera 2020) were monitored with Anabat roost loggers (Titley Scientific Inc.) from March 2, 2019 to through 2021. The roost loggers recorded acoustic data continuously for 24 hours, providing bat identification information, the daily timing of emergence from the roost, and quantification of movements in and out of the roost. The effective range of the loggers was 5 m. Files recorded within 90 minutes of sunset were considered to be recorded within roost emergence time.

In October 2020, roost logger RL1 was moved closer to roost 9427G with the aim of reducing the number of recordings from foraging bats and obtaining more recordings of bats emerging from and returning to the roost. Due to the lack of activity (no bats observed on emergence counts and low numbers of bat passes) at the 6287F roost, roost logger RL2 was relocated to roost 9427G with the intent of recording bats approaching that roost.

Temperature / humidity loggers (Onset HOBO model MX2302A) were installed in 2020 at the top of the south cliff and next to roost 9427G to assess relationships between bat activity and changes in the temperature and humidity. The loggers were attached to trees where they would remain in the shade to record ambient air temperature. The south cliff temperature logger was rendered non-functional by rodent damage in summer 2020 and was not replaced, leaving a single working unit at 9427G.

4.3.3 Data Analysis

Precipitation at the time of sunset was obtained from the BC Hydro weather station at the Portage Mountain quarry. Daily relative humidity data at sunset on each survey date were obtained from the temperature logger at 9427G and consisted of the value recorded closest to the sunset time on the date being assessed.

The numbers of bats observed exiting the cliff at each roost emergence count location on each date were totalled. Observations of bats foraging or flying by the observer were not included in the total unless the surveyor had observed the bats emerging from the cliff.

Acoustic data recorded by the Echometer Touch hand-held units during emergence counts were analysed using same process used for all of the other acoustic data analyses in this project (**Section 4.4**). Acoustic data were correlated with the visual observations made by the surveyors wherever possible, based on the location and time of the observations and of the recordings made by the hand-held units as well as the comments noted by the surveyors.

The bat mitigation and monitoring plan (BC Hydro 2020) and previous monitoring reports for Portage Mountain (Hemmera 2020) use a threshold of 10 bats emerging at a given site to define a ‘maternity roost’, although some of the provincial BMP definitions for a ‘significant’ roost (see **Section 3.1**) specify fewer individuals than the threshold of 10 bats used for this project. Hemmera is not aware of any literature that provides a minimum number of bats that constitute a maternity roost.

The following criteria were used to determine likely maternity roost occupancy:

- at least 10 bats emerging from a single feature during at least one emergence count during the maternity period (assumed to occur from mid-May to mid-August [Paterson, B., pers. comm., July 2019]);
- emergence timing at or near sunset (indicative of lactating females with dependent pups);
- observations of bats returning to the roost (i.e., to feed dependent pups) during the emergence survey; and,
- a marked increase in count numbers occurring at a single site over the pre-volant to volant period for young-of-year bats, in consideration of other influencing factors such as weather.

Daily emergence at or near sunset may indicate lactating female bats. Lactating bats leave their roosts at or near sunset because the energetic burdens of pregnancy and nursing require them to start foraging early to maximize foraging duration (Henry et al. 2002; Lemen et al. 2016). The daily emergence times of males and non-breeding females are more flexible because they have lower energy demands than lactating females and can use daily torpor to further decrease their metabolic requirements (Kurta et al. 1989; reviewed in Sedgeley 2001). Lactating females must also return to the roost during the night to nurse dependent pups.

The presence of juveniles also provides strong evidence of a maternity roost, at least up to the late summer period. The presence of juveniles in the roost can be inferred by a sudden increase in the number of bats counted during emergence counts late in the summer, when young-of-the-year can fly, compared to the number of bats counted during emergence surveys early in the summer.

4.3.4 Assumptions and Data Limitations

The assumptions in the emergence count data include:

- observers are able to accurately distinguish between a bat emerging from the cliff and a bat foraging along the cliff; and,
- vocalizations recorded on the observer's handheld detector at the time as a visual observation of an emerging bat are those of the bat observed.

The accuracy of emergence counts was limited by physical and weather conditions at the sites monitored. Surveyors had to choose vantage points that were safe for them to access, which often meant that they could not get the best view of emerging bats. Some bats emerged from crevices high on the cliffs and it was difficult for observers at the bottom of the cliffs to see them. Rain and fog impeded visibility on some counts as described in **Section 5.2**. The assumptions related to acoustic data recorded during emergence counts are similar to those described for long-term acoustic monitoring (**Section 4.4**).

4.4 Long-term Passive Acoustic Monitoring

Bioacoustic technology is an efficient, non-invasive tool for examining bat activity patterns and species diversity over long durations and provides a metric of bat activity based on the number of bat calls recorded within approximately 50 m of the detectors (Fraser et al. 2020; Lausen 2016). Year-round acoustic monitoring is used to assess ongoing bat activity and compare that activity between years and annual bat life stages. Acoustic data can confirm the presence of individual species and document any changes in bat species diversity between years. Acoustic data can also provide information to infer the use of hibernacula. Evidence of hibernation occurring in proximity to the detector includes:

- relatively high bat activity recorded during the fall mating and swarming periods;
- limited and localized winter activity; and,
- surges of activity during spring emergence.

4.4.1 Detector Locations

The rationale behind selection of locations for long-term bat detectors on the north and south cliffs (**Figure 2.1**) was described in Hemmera (2019). A single Songmeter detector was installed at each of 4 locations in November 2017 (**Figure 2.1**) and those locations have been monitored continuously to date, although some data gaps have occurred due to equipment issues. The SM2 detectors installed in 2017 at the beginning of the study period were replaced by new SM4BATZC units equipped with SMM-U1 or SMM-U2 microphones in summer 2019. One detector (PM-C-NH) was deployed at the north cliff, two (279-SH and 294-SH) on the south cliff, and one (PM-S3) between the south cliff and the quarry (**Table 4.1**). Those four locations have monitored year-round from 2017 through 2021. A fifth detector (PM-TAL) was installed on June 26, 2020, upslope from a talus field at the north cliff (**Figure 4.1**) and has been operating continuously since its installation.

Table 4.1 Long-term Passive Acoustic Monitoring Sites, 2017 to 2021

Name	General location	Distance (m) from closest quarry boundary	Comment
PM-D-NH	North cliff	320	
PM-C-NH	North cliff	402	
PM-TAL	North cliff talus	330	Installed 2020
279-SH	South cliff	401	Suspected maternity roost 6287F
294-SH	South cliff	334	Suspected maternity roost 9427G
PM-S3	Quarry	81	

Detector settings have been described in Hemmera (2019). Microphones were calibrated twice in summer 2020 (June 22 and July 15) and again in July 2021 to confirm sensitivity within the manufacturer's specified range and ensure consistency in data collection. The detectors were visited every other month to download data and verify detector operation.

The detectors were prepared for winter with protected microphones and cables, a water- and snow-resistant housing, and a combination battery/solar power supply. Each detector was outfitted with a 12-volt battery (7 amp-hours) powered by a Renogy 100-watt solar panel, and a Morningstar SS 20L-12V SunSaver 20-amp solar charge controller.

Equipment issues and cable damage by rodents has led to data loss. Additional gaps in recording have resulted from snowfall covering the solar panels.

Figure 4.1 Location of Detector TAL (arrow) at the Small Talus Field Downslope of the North Cliff

4.4.2 Data Analysis

Acoustic analysis methods used in 2020 and 2021 were identical to those of previous years although some classification categories were merged. The acoustic analysis followed a conservative approach as recommended for the analysis of acoustic data by Lausen (2016); only files with two or more echolocation pulses (Vonhof 2006) separated by at least one second (termed a bat 'pass', 'call' or 'file') were included in the analysis and were considered for classification to species level or species group. A series of bat passes could be made by the same bat flying multiple times in front of the microphone or by multiple individuals (Adams et al. 2015); therefore, the results provide a relative index of bat activity (files per detector-night) but do not represent an estimate of bat populations in the study area.

Bat files were classified based on acoustic parameters for the targeted bat species (summarized in **Appendix A**) using two automated species classifications: Kaleidoscope Pro (V3.1.6 Wildlife Acoustics Inc.) and species-specific filters developed for AnalookW V4.5 (Titley Electronics, Ballina, New South Wales, Australia). Noise files, such as ambient background sounds, were excluded from the dataset using a filter in AnalookW. The automated classification results were then manually verified based on professional judgement. Bat calls were either classified according to species or grouped into categories based on their acoustic parameters (**Appendix A**). Files with multiple species or individuals were assigned each of the relevant categories, i.e., were counted once for each species and individual. Social calls were identified through manual inspection.

The acoustic parameters used for the identification of each call were derived from accepted characteristics based on scientific studies and acoustic libraries (Lausen 2016). Updated provincial bat protocols for acoustic monitoring are not yet available; therefore, after consultation between Hemmera and a bat specialist with the BC Ministry of Forest, Lands, Natural Resource Operations and Rural Development (Hansen, I.J., pers. comm., September 2018), the methods used for 2017 to 2019 studies (Hemmera 2018, 2020) were repeated for the 2020 and 2021 analysis with minor improvements (summarized in **Appendix A**).

Bat echolocation calls, especially those from the *Myotis* genus, can be difficult to identify to species due to high variability within species (Obrist et al. 2004) and overlap in call characteristics among some species. Where Myotis calls could not be definitively identified to species, they were assigned to the Myotis category that includes little brown myotis, long-eared myotis, northern myotis, and long-legged myotis because of overlap in call characteristics (**Appendix A**). The Myotis category (**Appendix A**) was assumed to indicate the potential presence of the endangered little brown myotis or northern myotis. Similarly, silver-haired and big brown bat are often grouped together, as are eastern red bat and little brown myotis. Files known to be or potentially Myotis species (including all files identified as any of the Myotis species, the Myotis category, and the 35K eastern red bat/little brown myotis category) were merged into a broader Myotis group for analysis. The 'big brown bat' broad species group used for some summaries included files categorized as big brown bat and as big brown bat / silver-haired bat.

A night of monitoring by a single detector was termed a 'detector-night', assigned to the date on which the night began even though the file itself may have been recorded in the early morning of the next day. Each file was assigned to the detector-night on which it was recorded, and further assigned to an hour bin (0-23) that corresponded to the time at which the file was recorded. The numbers of bat passes recorded per detector-night were compared between detectors and over time to examine patterns in bat activity.

An R script was created to identify dates when no bat or noise files were recorded by each detector. Detector log files were not available for 2018 or 2019, so a subjective number of consecutive days without data was chosen to assess whether a detector was functioning correctly: if no bat calls or noise files were recorded for a period of 5 nights or more in summer or 20 or more nights in winter, fall, or spring, the detector was considered inactive. Each bat file was linked to the time of sunset on the night the file was recorded, and the quarry weather station temperature recorded closest to the file's time (**Section 4.1**).

4.4.2.1 Bat Life Stages

Bat annual life stages include hibernation, emergence, maternity (summer), and swarming. Bat activity levels vary considerably through the year, driven by seasonal weather patterns and life stages. The beginnings and ends of these stages are gradual rather than sharply defined by a single date (BC Ministry of Environment 2016b). However, to aid with the seasonal examination of bat data, dates corresponding to annual life stages were defined using yearly bat acoustic data. The species detected at Portage Mountain are a mixture of migratory and hibernating bats (**Table 3.1**), and the onset and duration of annual life stages will vary between species (Whitaker Jr and Rissler 1992; van Schaik et al. 2015) and by overwintering strategy. Ideally, life stage dates would have been defined for each species, but *Myotis* sp. made up the majority of bat calls in the Portage Mountain dataset, with too few calls of other acoustic classes to complete a quantitative analysis of life stages. Therefore, life stage dates were only based on data classified as being *Myotis* sp. files. For the bat life stage analysis, the Myotis group consisted of the following identification categories: all Myotis species, the red bat / little brown myotis groups (assumes there are few to no red bats in the group), and high-frequency bats. Data from all detectors on Portage Mountain were combined as it was assumed that any seasonal effects would apply to all detectors.

The method described by Meyer et al. (2016) was used to define the start and end of emergence and hibernation, which is based on the cumulative number of calls within defined periods. Hibernation start was defined as the date by which 95% of the cumulative sum of files had occurred between September 22 - November 15 and end was defined as the date by which 5% of the cumulative sum of files occurred between March 20 and June 1 (Meyer et al. 2016). Emergence start was defined as the date on which 5% of the cumulative sum of files occurred between March 20 and June 1 (i.e., hibernation end) and emergence end was the date on which 50% of the cumulative sum of files occurred between March 20 and June 1.

Bat activity increases just prior to hibernation at sites where they hibernate (Van Schaik et al. 2015). This increase in activity is termed 'swarming' and is believed to be associated with mating and the search for hibernacula (Parsons et al. 2003, Van Schaik et al. 2015). There is limited published work that uses a statistical approach to identify the swarming period with acoustic data. Part of the challenge in identifying a swarming period is the high variability in activity levels between nights due to factors such as temperature and precipitation (Parsons et al. 2003). However, by fitting a non-linear curve to the nightly count of bat files, it is possible to smooth out the nightly fluctuation and identify periods with a peak in activity that corresponds to swarming (Parsons et al. 2003). Another advantage of this method is that it provides an objective method to identify the swarming period as compared to visually looking for peaks in bat acoustic data.

Adopting the method of Parsons et al. (2003), non-linear equations were fitted for the total number of Myotis files per active detector-night between the period of July 15 and September 30 for the years that had sufficient data for this period: 2019, 2020, and 2021. This period was used to ensure that a peak was detected, despite July and early August being outside the typical swarming period (i.e., late August to late September). Following Parsons et al. (2003), SigmaPlot was used to fit non-linear curves to the data and the best-fitting curve was selected based on the R^2 value from the set of equations available in SigmaPlot. Equations tested were those available in the peak category: 3-parameter Gaussian, 4-parameter Gaussian, 4-parameter modified Gaussian, 5-parameter modified Gaussian, 3-parameter Lorentzian, 4-parameter Lorentzian, 4-parameter Pseudo-Voigt, 5-parameter Pseudo-Voigt, 3-parameter Log Normal, 4-parameter Log Normal, 4-Parameter Weibull, and 5-Parameter Weibull.

Once the best fitting curve was identified, the start and end dates of swarming were selected based on predicted values from the best-fitting equation. The date on which the increase in the slope of curve (i.e., predicted files) was ≥5 files from one night to the next and the decrease in file numbers was ≤5 files per night, respectively, were selected to identify the start and end dates of swarming. In other words, start of swarming was occurred when the slope of the curve of predicted bat activity started to increase and swarming ended when the slope the curve started to level out.

4.4.2.2 Trends in Bat Activity

There are two primary questions regarding the impacts of the Portage Mountain Quarry on bats:

1. Has seasonal bat activity decreased since 2017?
2. Does blasting associated with the quarry affect bat activity?

A null model, a base model and two *a-priori* models were used to examine effects of the quarry while accounting for the potentially confounding effect of weather conditions on seasonal bat activity:

1. Null model: Total bat calls per night ~ 1
2. Base model: Total bat calls per night ~ mean temperature + precipitation
3. Year model: Total bat calls per night ~ year + mean temperature + precipitation
4. Blast model: Total bat calls per night ~ blast + mean temperature + precipitation

As a response variable, calls from all acoustic groups were combined to provide the largest dataset possible. A null model was used to test the relative model fits of the Year and Blast models. Bat growing season activity and winter arousal is known to be correlated with weather, including temperature, barometric pressure, wind speed and precipitation (Ciechanowski et al. 2007; Erickson and West 2002; Gorman et al.

2021; Hayes 1997; Meyer et al. 2016; Paige 1995; Patriquin et al. 2016; Whitaker Jr et al. 1997; Wolbert et al. 2014; Voigt et al. 2011). Of these variables, nightly measurement of temperature and precipitation data were available (**Section 4.1**). As such, temperature and precipitation were included as base variables in the *a-priori* models and as a base model because these are known to have a large influence on bat activity, therefore interpreting the effects of year and blasting require holding weather effects constant. A base model was included for the same reasons as the null model, to test relative model fitness.

The Year model will test for a change in yearly bat activity. If there is a decrease in activity since 2017, the coefficient of years post 2017 will be negative and significantly different from zero. The Blast model will test for an effect of blasting (occurred/ did not occur) on bat activity during the night. If there is a negative relationship between blasting and bat activity, the blast coefficient will be negative and significantly different from zero.

To evaluate model fit, the Akaike's Information Criterion (AIC) scores of the Year and Blast models were compared to the null and base models. The model with the AIC weight closest to 1 was selected as the most parsimonious model that best explained the data from the set of models. We could not compare the Year and Blast models using AIC scores because they were generated using different datasets (i.e., year 2017 was dropped for the Blast model because no blasting occurred in that year). For model selection, we ran the null model and the base model on the same dataset as either the Year or Blast model.

Due to the influence of life stages on bat activity, each of the above models was evaluated during the following four bat life stages: emergence, summer (including maternity), swarming, and hibernation, which were calculated as described in **Section 4.4.2.1**. However, because we were only able to identify a swarming period in 2021 and there was no identifiable swarming period in 2019 and 2020 (**Section 5.3.2.2**), we defined a fall period instead of swarming. For the purposes of assessing bat activity, the fall period was defined as occurring from September 1 to the start of hibernation, the latter of which was defined on a yearly basis (**Table 5.10**).

We also considered investigating distance to quarry as predictor variable, to test if bat activity would be lower closer to the quarry. However, there was a natural effect of distance to quarry based on placement of the detectors, such that bats were most active at detectors furthest from the quarry before most construction activity at the quarry began (2017).

Decibel and peak particle velocity were also considered as model variables; however, these measurements were only available for 2021 and there were several gaps in the 2021 data. Therefore, to investigate the effects of the blasting we included blast by date only, as having occurred (yes, no) during the day as a model variable. There were two blast records that did not have a date (assumed to have occurred in 2019) and therefore were not included in the model. Blasting did not occur in 2017 and therefore this year was dropped from the Blast model. Because blasting only occurred during the summer and fall bat life stages, we only ran the Blast model during these periods. Dropping the year 2017 reduced the number of detectors used in the model to five detectors since PM-D-NH, which was located at the north cliff, only recorded in 2017.

A generalized linear mixed effects model with a negative binomial distribution was used for the above models. Due to the nature of bat acoustic data (e.g., spatial autocorrelation, temporal autocorrelation, and unequal sampling), generalized linear mixed effects models are regularly used to test bat acoustic data (Perks and Goodenough 2020; Jameson and Willis 2014; Muthersbaugh et al. 2019a). A negative binomial distribution was used because overdispersion was an issue when a Poisson distribution was used.

The variance of the data was much larger than the mean, further supporting the use of a negative binomial distribution. All models were tested for overdispersion using the ratio of the $\text{Pearson } x^2$ to the model degrees of freedom, and a threshold value of 5 was used (Payne et al. 2018).

The identity of the detector nested within the area was used as a random effect for each model. Using random effects accounts for the spatial and temporal autocorrelation (i.e. repeat sampling at one detector) of the study design and the difference in sampling effort between detectors (Gillies et al. 2006). Detectors were distributed across four main areas: south cliff, north cliff, quarry, and gully. Data from the acoustic detectors within an area are spatially autocorrelated due to the relatively small size of the area being studied. The detectors are all well within the foraging range of a single bat; 90 m separates the PMC-NH and TAL detectors and 120 m separates 279-SH and 294-SH. As such, individual bats recorded on one detector may also be recorded on other detectors depending on the bat's flight path. Data recorded by the detector at the gully were removed from the dataset because the detector was considered to have operated too infrequently, leaving six detectors in total (**Table 4.1**).

Year was included as a categorical variable with the lowest year (i.e., 2017) as the reference level to which the other years were compared. Mean temperature was the mean hourly temperature (˚C) between sunset and sunrise. Precipitation was the total precipitation (mm) between sunset and sunrise.

All continuous variables were standardized so that the mean was equal to zero and standard deviation was equal to one. Standardizing data improves model convergence, makes the standard deviation the unit of measurement, and therefore allows direct comparison of standardized model coefficients in terms of their influence on the response variable (Zuur et al. 2009). Variables were standardized using this formula:

$$\frac{x - mean(x)}{standard\ deviation(x)}$$

Due to the pseudo-replicated nature of acoustic data from detectors, the unit of sampling is not the number of nights the detector was active, but the number of detectors deployed. If the spatial autocorrelation is accounted for, the sample size is further reduced to 3 (i.e., north cliff, south cliff, and quarry). If the spatial autocorrelation is disregarded, the sample size is only 6 detectors (or 5 in the case of the Blast model). Data from five to six detectors at 3 areas is a relatively small sample size for the complexity of the models and this resulted in several challenges that required adjusting the model structure. For some seasonal models, the random effects structure of detectors nested in area was too complex for the data, resulting in a singular fit of the model. While the random effects structure was justified given the study design, there were likely too few data to support the more complex model. Singular fits can result in a lower power to detect significant trends (Matuschek et al. 2017). When models had a singular fit, area was removed as a random effect, the model AIC score was compared with the maximal model and the more parsimonious model was selected (Matuschek et al. 2017).

4.4.3 Assumptions and Data Limitations

Studies using bat activity as a metric have several assumptions (Gannon et al. 2003; Hayes 1997, 2000):

- recorded bat calls reflect the use of a site by bats.
- the probability of detecting an individual bat is the same for each detector and for each bat species.
- bats are randomly distributed in three-dimensional space.

The modelling approach described above includes several assumptions that should be noted:

- All bat species respond to yearly effects of the quarry and blasting effects in the same manner.
- Life stage dates based on Myotis activity are reflective of general activity patterns for other bat genera present at Portage Mountain.
- When models had to be simplified by removing area as a random effect, spatial autocorrelation was assumed to not affect model coefficients and their significance.
- Using date of blasting as a predictive model variable assumes that all blasts have an equal effect on bats and the blasts have an equal effect on bats at all areas.
- Any effect of year on bat activity is associated with quarry activity and is not related to natural causes.

There is a high level of natural variability in nightly bat activity, which can be influenced by insect phenology, time of day, and the gender and reproductive condition of individuals (Fischer et al. 2009; Gorman et al. 2021; Fraser et al. 2020; Hayes 1997; Sherwin et al. 2000; Talerico 2008), as well as weather and life stage as described earlier. This natural variability can make it challenging to detect trends due to change in the habitat (e.g., noise levels). Considering the amount of natural variability and the small sample size, models may be limited in power to detect trends.

5.0 RESULTS

5.1 Blasting, Noise and Vibration Monitoring

Blasting, noise and vibration monitoring began in 2019 and the results for 2019 are available in Hemmera (2020). Results of the blasting, noise, and vibration monitoring for 2020 and 2021 are briefly summarized below from Nickoli et al. (2022) and Dailyde et al. (2022), presented in **Appendices B** and **C**, respectively.

5.1.1 2020

One hundred one blasts took place at the Portage Mountain Quarry in 2020 between May 16 and September 14 (**Table 5.1**). Information on the daily timing of blasts was incomplete.

Table 5.1 Number of Blasts by Month at the Portage Mountain Quarry in 2020

Month	Number of Blasts
May	12
June	26
July	28
August	30
September	5
2020 Total	**101**

Vibration monitoring was not conducted in 2020. The best-fit equations calculated from the 2021 monitoring data were used with the 2020 blast data to estimate peak particle velocity for 2020. Based on this analysis, it was determined to be unlikely that any of the 2020 blasts exceeded the recommended thresholds (**Section 3.1**).

Monthly noise monitoring occurred during 2020 quarry operations between May and September at the north and south cliffs as well as the background location. Measured noise levels at the south cliff in 2020 ranged from 41-51 A-weighted decibels (dBA) during the day, and 32-43 dBA at night, levels at the north cliff ranged from 52-57 dBA during the day and 38-55 dBA at night, and background noise levels measured 5 km northeast from the quarry (daytime measurements only) ranged from 33-58 dBA (see Table 2 in **Appendix C**).

High-frequency noise (6,300 - 20,000 Hz) measured by a monitoring unit on the south cliff was examined to determine the differences in high-frequency noise levels during working hours between days when quarry construction was ongoing versus days without construction (Dailyde and Johnston 2020). Differences were very small (up to 0.07 dB), which the authors attributed to the speed at which high-frequency noise is attenuated. A similar analysis in 2021 (**Appendix C**) found slightly increased noise levels at the 6,300 Hz and 8,000 Hz frequency bands but lower noise levels in the higher-frequency bands.

5.1.2 2021

Sixty-one blasts took place at the quarry in 2021 between May 16 and August 17 (**Table 5.2**), almost all of which occurred between the hours of 1500 and 1800.

Table 5.2 Number of Blasts by Month at the Portage Mountain Quarry in 2021

Month	Number of Blasts
May	14
June	14
July	22
August	11
September	0
2021 Total	**61**

Noise monitoring was carried out at the south and north cliffs on May 31, 2021, for a duration of 64.7 hours at the south cliff and 85.5 hours at the north cliff (Dailyde et al. 2022). The results of the noise monitoring are presented in **Table 5.3**. Sound levels at the north cliffs were higher than those at the south, and levels of noise in general, and of high-frequency noise were similar to those measured in 2019. The levels of higher-frequency sound in the 6,300-8,000 Hz range were higher than pre-construction levels, but the levels of sound in the 10,000 to 20,000 Hz range were lower than pre-construction levels

Table 5.3 Average Sound Levels (dBA) Recorded at the Portage Mountain Cliffs in May 2021 (from Table 2 in Appendix C)

South Cliffs		North Cliffs	
Day	Night	Day	Night
45	40	53	42

Blast monitoring was conducted from May through September in 2021 (Dailyde et al. 2022). The maximum peak particle velocity recorded at either the south or north cliffs was 9 mm/second, the maximum sound concussion was 130 dB, and the maximum shock wave was 0.0095 psi – all measurements under the thresholds specified in BC Ministry of Environment (2016c). All of the blasts in 2021 were below (most of them well below) the threshold values for all three variables.

5.2 Maternity Roost Emergence Counts

5.2.1 2020 and 2021 Roost Emergence Counts and Roost Monitoring

The results of the 2020 and 2021 roost emergence counts and roost monitoring are detailed in **Appendix D** and only key results are summarized here. Thirty-nine emergence counts were conducted during June and July 2020 (**Figure 3.1**).

Most of the counts recorded one to four bats emerging, although 16 bats were counted exiting the gully during early period counts, and 17 bats were counted exiting the suspected maternity roost 9247G on the south cliff during the late period counts. The first bats that left 9247G during the two late period counts in 2020 exited the roost before sunset, and bats were observed returning to that roost during one of the late period counts. A maximum of four bats was observed during emergence counts at the other suspected maternity roost, 6287F, indicating that this site was less likely to be used as a maternity roost in 2020. One emergence count was conducted within the quarry on June 27 but no bats were observed exiting rock faces at that location.

Both roost loggers suffered from water damage in early 2020 and did not record data between May and late August. Although the loggers did not function as planned for much of the bat active period, activity at roost 9427G in 2020 was confirmed by the roost logger RL1. In total, 1,418 files were recorded in 2020, of which 1,390 were assigned to the Myotis category. Myotis activity was first recorded at 9247G in April and was increasing in early May when the loggers were compromised. Details are provided in **Appendix D**.

Thirty-two emergence counts were conducted during June and July 2021 (**Figure 3.1**). No bats were observed emerging on 13 of the counts. One to four bats were observed emerging on most of the remaining counts, although 23 bats were counted on June 19 at 9427G, the suspected maternity roost. The first bats were observed leaving 9247G 19 to 52 minutes after sunset during the early period and 33 to 35 minutes after sunset during the late period in 2021, and one bat was observed returning to the roost during one of the late surveys. A maximum of three bats was observed during emergence counts at the other suspected maternity roost, 6287F, indicating that this site was less likely to have been used as a maternity roost in 2021 according to the criteria in the bat mitigation and monitoring plan (BC Hydro 2020). One emergence count was carried out within the quarry on June 19 but no bats were observed.

RL1 recorded minimal activity at roost 9247G in 2021, and no activity after July. Only 45 files, almost entirely Myotis and 30K species groups, were recorded. The lack of data is likely due to a technical issue with the roost logger. The function of RL2 at roost 9247G was also compromised based on the lack of data recorded in July and August. RL2 began recording activity in April with a substantial increase in activity in May but stopped recording June 6. RL2 recorded eight files in August, and its last file on September 21. Details are provided in **Appendix D**.

5.2.2 Cumulative Roost Emergence and Roost Monitoring

Thirty-five maternity roost emergence counts have been conducted at the two suspected maternity roosts since 2017 (**Table 5.4**; **Figure 3.1**). No rain was recorded by the Portage weather station during the 2017 or 2018 emergence surveys. Rain occurred only on July 22 during the 2018 surveys, on June 24 and July 20 during the 2020 surveys, and on July 20 in 2021. The time that the first bat was detected was recorded irregularly during the 2017-2019 emergence counts.

Using the criterion of 10 bats and long-term activity to define a maternity roost, the 9247G site has continued to be used as a maternity roost from 2017 through 2021. The numbers of bats counted emerging from that roost have fluctuated both between years and between the early and late counts, with the highest number of emerging bats counted in 2018 early-period surveys (**Table 5.4**). Relatively few bats have been counted at 6827F since the peak number (10) was observed in 2017. No observations were recorded of bats returning to the 6827F roost.

Table 5.4 Emergence Count Surveys Completed, and Average* Number of Bats by Survey Night, at Two Suspected Maternity Roost Sites on Portage Mountain, 2017-2021

Maternity Roost ID	Session	Average bats counted (number of counts) 2017	Average bats counted (number of counts) 2018	Average bats counted (number of counts) 2019	Average bats counted (number of counts) 2020	Average bats counted (number of counts) 2021
9427G	Early	-	40.5 (2)	15 (3)	4 (2)	13.5 (2)
	Late	9 (3)	7.5 (2)	26.3 (3)	15 (2)	2.5 (4)
6287F	Early	-	6 (2)	4 (2)	3.5 (2)	0 (1)
	Late	10 (2)	9 (1)	0	-	2 (2)

*as sample sizes are small, no measure of variance has been calculated

In total, 152 emergence counts (including the maternity roost counts described above) have been completed between 2017 and 2021 (**Figure 3.1**). Two (NHEC2, NHEC3b) additional potential maternity sites were located in 2018 (**Table 5.5**), using the criterion of a minimum of 10 bats counted to define a maternity roost. Those sites had fewer than 10 bats counted in all subsequent years. There were multiple locations at which 3-9 bats were observed emerging between 2018 and 2021 (**Table 5.5**). Those locations are potentially maternity roosts used by fewer than 10 females.

Table 5.5 Emergence Counts Where 3-9 Bats Were Observed, 2018-2021

Location	Date of count	Survey period	Identifier	Lat	Long	Emerging bats counted
South	2018-06-17	Early	SHEC294	55.97412	-122.119	6
North	2018-06-19	Early	NHEC3b	55.98152	-122.117	3
North	2018-06-19	Early	NHEC1	55.98208	-122.116	3
North	2018-08-01	Late	NHEC3b	55.98152	-122.117	9
North	2018-08-02	Late	NHEC2	55.98178	-122.117	3
North	2019-06-09	Early	NHEC3b	55.98152	-122.117	4
North	2019-06-12	Early	north cliff	55.98124	-122.118	6
South	2020-06-22	Early	EC-DW1-062220	55.97324	-122.12	4
South	2020-06-22	Early	EC-JF1-062220	55.9746	-122.119	4
North	2020-06-24	Early	EC-JF3-062420	55.98199	-122.116	4
North	2020-06-24	Early	EC-FMN-200624	55.98169	-122.117	3
North	2020-06-25	Early	EC-DW4-062520	55.98174	-122.116	4
North	2020-06-25	Early	EC-JF4 062520	55.98171	-122.116	4
South	2020-06-27	Early	EC-DW6-062720	55.97321	-122.118	3
North	2020-07-17	Late	EC_JF04_071720_North Cliff	55.98211	-122.116	5
North	2020-07-17	Late	EC_FMN-NH	55.98158	-122.117	3
North	2020-07-18	Late	200728EC_FMN_NH	55.98159	-122.117	4
South	2021-06-18	Early	DW061821	55.97565	-122.117	3
South	2021-07-15	Late	DW071521	55.97316	-122.12	3
North	2021-07-18	Late	DW071821-NH	55.9819	-122.117	5
North	2021-07-18	Late	7/18/2021_BM_NH	55.98211	-122.116	6
South	2021-07-19	Late	7/19/2021_BM_sH	55.97577	-122.117	4

5.3 Long-term Passive Acoustic Monitoring

The results of the long-term passive acoustic monitoring for the years of 2020 and 2021 are presented in **Appendix D**. The cumulative results for 2017 to 2021 are provided below.

5.3.1 Cumulative Survey Effort and Results

The remote detectors on Portage Mountain have varied in number and dates of deployment. Equipment issues have also resulted in data gaps. A summary of cumulative survey effort (8 detectors) between 2017 and 2021 is presented in **Table 5.6**. The number of active detector nights per season and year is also available in **Appendix F**. The five permanent detectors recorded acoustic data on 5,447 detector-nights between August 21, 2017 and November 3, 2021 (**Table 5.6**).

Table 5.6 Remote Detector Survey Effort (Nights When Detectors Were Operating), 2017-2021

Detector	2017	2018	2019	2020	2021	Total Detector-nights
279-SH*	133	210	99	366	307	1,115
294-SH*	133	232	365	339	307	1,411
PM-C-NH*	85	223	249	342	307	1,264
PM-D-NH	126	-	-	-	-	126
PM-GULLY	-	-	-	11	-	11
PM-S3*	2	163	172	274	307	1,245
PM-TAL*	-	-	-	190	307	497
Total Detector-nights	**503**	**1,056**	**961**	**1,622**	**1,535**	**5,677**

*permanent detector

The timing of data gaps due to detector damage from rodents, power failures or other technical issues could affect the results of the analyses, especially if the gaps occurred during periods when high bat activity would have been expected. A summary of the data gaps by date is presented in **Table 5.7**, and a graphical representation of the gaps is presented in **Figure 5.1**.

Table 5.7 Timing of Data Gaps by Detector, 2017-2021

Detector	Data Gap	Gap Length (nights)
279-SH	Jul. 30, 2018 - Jul. 25, 2019	361
	Aug. 23, 2019 – Oct. 21, 2019	60
294-SH	Feb. 3, 2018 – Apr. 8, 2018	65
	Jul. 30, 2018 – Oct. 5, 2018	68
	Jun. 22, 2020 – Jul. 18, 2020	27
PMC-NH	Nov. 14, 2017 – Jan. 18, 2018	66
	Feb. 8, 2018 – Apr. 6, 2018	58
	Aug. 1, 2018 – Oct. 5, 2018	66
	Apr. 16, 2019 – Jun. 10, 2019	56
	Aug. 23, 2019 – Oct. 21, 2019	60
	Jun. 24, 2020 – Jul. 17, 2020	24
PM-GULLY	Jul. 1, 2020 – Jul. 8, 2020	8

Detector	Data Gap	Gap Length (nights)
PM-S3	Dec. 7, 2017 – Dec. 30, 2017	24
	Jan. 1, 2018 – Feb. 1, 2018	32
	Feb. 3, 2018 – Feb. 22, 2018	20
	Feb. 24, 2018 – Mar. 21, 2018	26
	Mar. 23, 2018 – Apr.13, 2018	22
	Apr. 15, 2018 – May 23, 2018	39
	Sep. 8, 2018 – Oct. 5, 2018	28
	Nov. 26, 2018 – Dec. 17, 2018	22
	Dec. 19, 2018 – Jan. 14, 2019	27
	Jan. 16, 2019 – Mar. 18, 2019	62
	Apr. 15, 2019 – Jun. 9, 2019	56
	Aug. 23, 2019 – Oct. 22, 2019	61
	Jan. 4, 2020 – Jan. 25, 2020	22
	Jan. 27, 2020 – Apr. 5, 2020	70

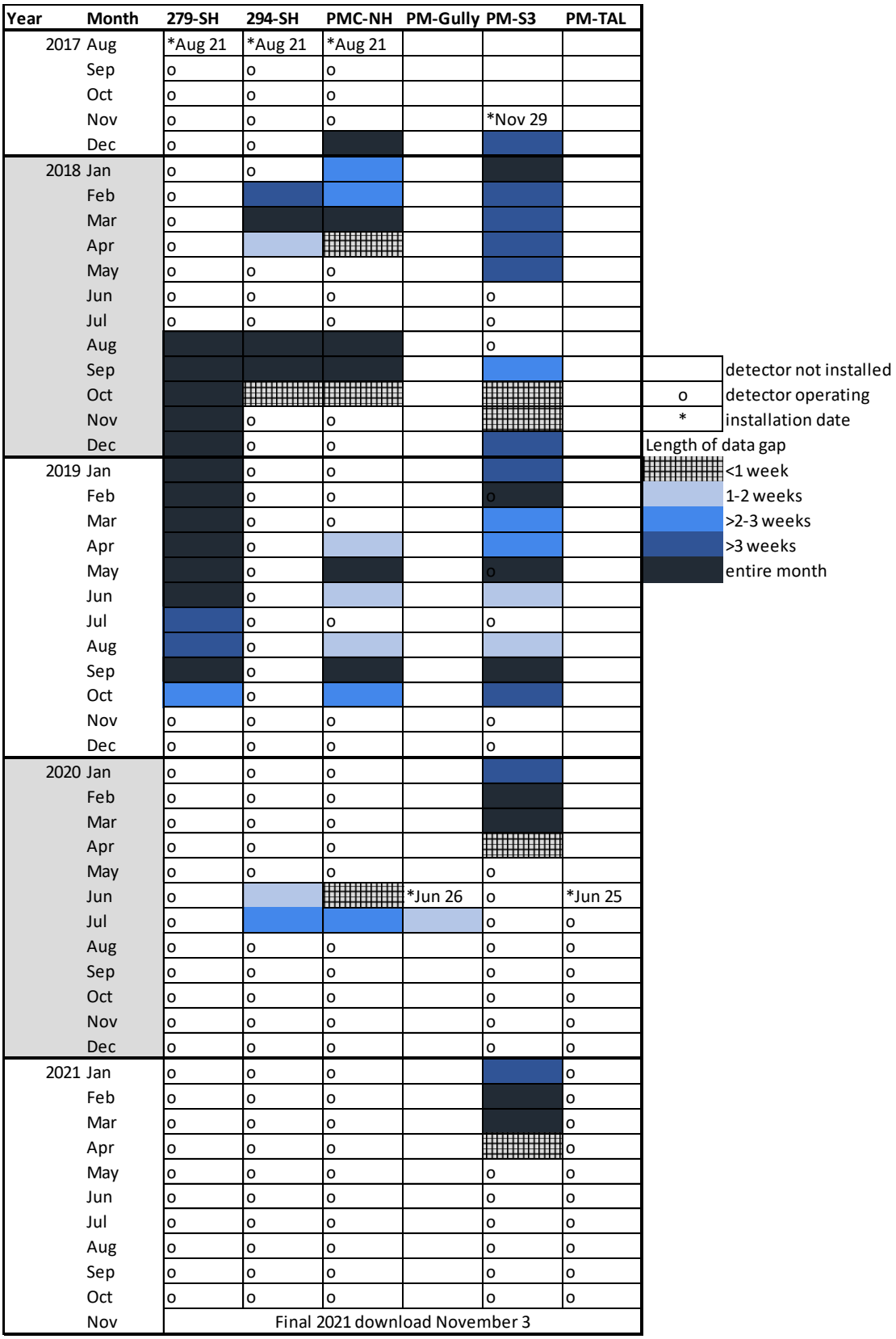


Figure 5.1 Graphical Representation of Detector Data Gaps

In total, over 300,000 bat calls were identified from the detector recordings between late summer 2017 and fall 2021 (**Table 5.8**). **Table 5.9** presents the number of files per detector-night for each identification category between 2017 and 2021. No measure of variation has been calculated because many of the categories overlap, depending on the quality of the file. All of the species expected, with the exception of long-legged myotis, have been detected every year.

Table 5.8 Numbers of Bat Files by Detector (Excluding Social Calls), 2017-2021

Year	279-SH	294-SH	PM-C-NH	PM-D-NH	PM-E-NH	PM-GULLY	PM-S3	PM-TAL	Grand Total
2017	17,464	4,786	-	2,631	13,276	-	3	-	38,160
2018	10,043	3,658	10,899	-	-	-	2,378	-	26,978
2019	11,557	6,232	12,945	-	-	-	2,118	-	32,852
2020	51,210	14,141	22,104	-	-	123	9,049	5,055	101,682
2021	48,765	26,294	31,927	-	-	-	21,295	10,901	139,182
Total	**139,039**	**55,111**	**77,875**	**2,631**	**13,276**	**123**	**34,843**	**15,956**	**338,854**

Table 5.9 Files per Detector-Night by Identification Category (Excluding Social Calls), 2017-2021

Identification category	2017	2018	2019	2020	2021
Low-frequency bat	2.392	2.250	2.020	0.700	6.466
High-frequency bat	0.000	0.003	0.185	0.000	0.001
Hoary bat	0.700	0.097	0.068	0.080	0.329
Big brown bat	2.903	2.005	1.165	2.184	2.318
Big brown bat / silver-haired bat	8.624	4.054	4.462	12.711	13.734
Silver-haired bat	0.398	0.009	0.360	0.224	0.550
Eastern red bat	0.034	0.035	0.106	0.066	0.128
Red bat / little brown myotis	0.014	0.020	0.776	0.361	0.262
Little brown myotis	0.177	0.292	0.764	0.699	0.460
Long-eared myotis	0.082	0.350	0.893	5.462	4.960
Long-legged myotis	0	0	0	0	0
Northern myotis	0.056	0.102	0.157	0.205	0.218
Myotis	60.487	16.332	23.228	40.938	62.870

5.3.2 Bat Life Stages

Based on the number of calls in spring and autumn, the date at which bat emergence started and ended varied from 2018 to 2021 but hibernation consistently started September 22 for most years, except in 2018 when it started two weeks later on October 6 (**Table 5.10**).

Table 5.10 Yearly Bat Life Stages for *Myotis* sp. Bats at Portage Mountain

Year	Emergence start*	Summer start*	Swarming start*	Swarming end*	Hibernation start
2017	NA	NA	NA	NA	22/09/2017
2018	16/04/2018	19/04/2018	NA	NA	06/10/2018
2019	11/04/2019	18/04/2019	None	None	22/09/2019
2020	11/04/2020	19/04/2020	None	None	22/09/2020
2021	09/04/2021	13/04/2021	02/09/2021	21/09/2021	22/09/2021

*NA indicates insufficient data to calculate a period. None indicates that there was no increase in activity to identify a swarming period.

Insufficient detector data were available in 2017 and 2018 during the months of August and September to estimate a swarming period for those years. Using data from July 15 - September 30 in 2019, 2020, 2021 we fit a non-linear curve to the number of Myotis calls per active detector-night to estimate swarming life stage in each year. In 2019, the best fit curve was a Weibull 5-parameter equation, however the model fit was moderate (R^2= 0.54, **Figure 5.2**). Using this equation, a peak in activity was estimated to have occurred in 2019 from July 20 to August 22, which likely coincides with the juvenile flight period and is too early to be considered a swarming period. There was no later peak in activity that occurred in 2019 and thus swarming was not detected in 2019. In 2020, there was no peak in activity to suggest that swarming occurred at either the south or north cliffs of the study area (**Figure 5.3**). A modified Gaussian 5 parameter equation was the best fit of the equations tested, but the fit (R^2=0.35) was poor. In 2021 a peak in activity occurred (**Figure 5.4**, **Table 5.10**), suggesting a swarming period may have occurred in the study area in that year. A modified Gaussian 5-parameter equation was the best fit (R^2=0.51) of the non-linear equations tested on the 2021 data, although the fit was only moderate. Based on predicted values from the best fit equation, the swarming period in 2021 is estimated to have started September 2 and ended September 21 (**Table 5.10)**.

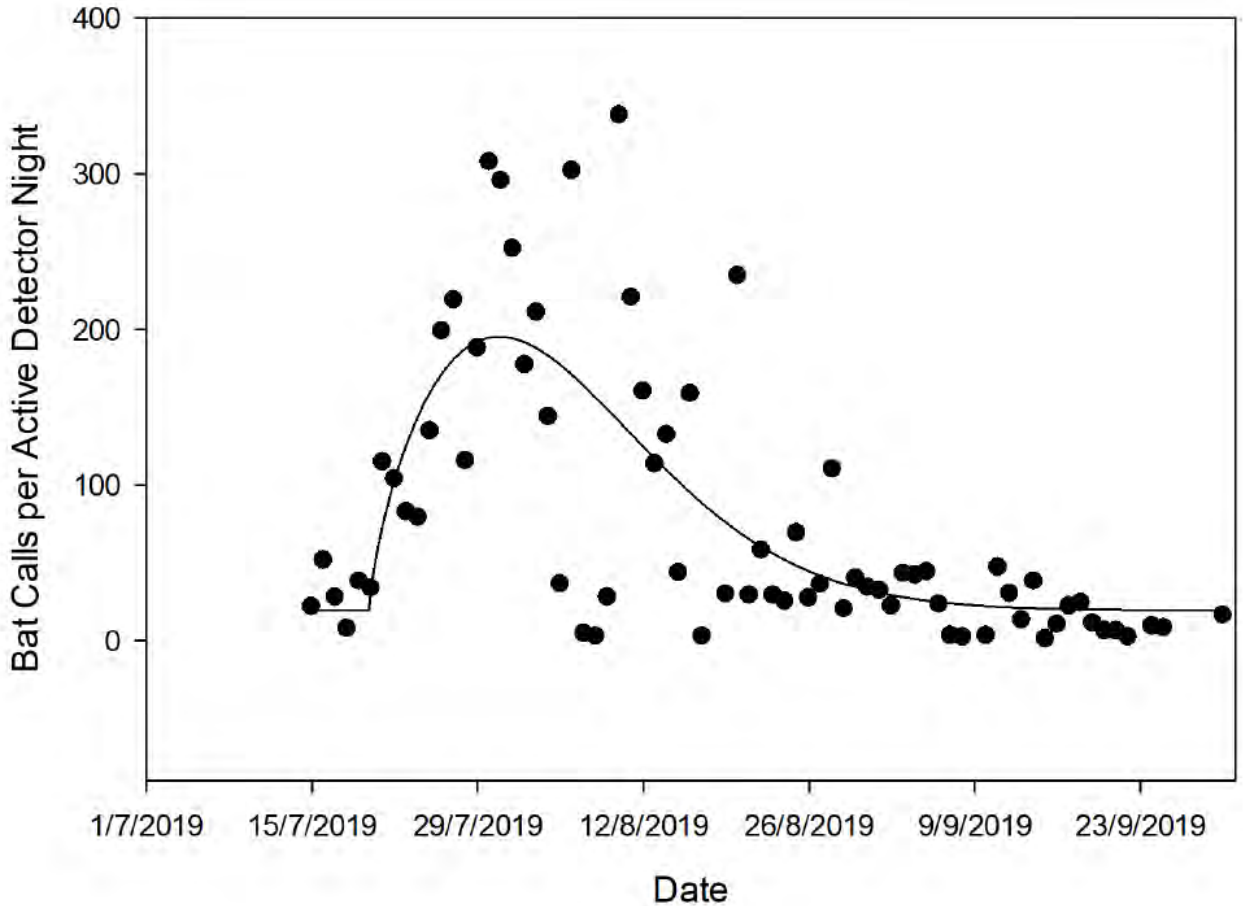


Figure 5.2 Myotis Calls from July 15 to September 30, 2019 with a Modified Gaussian 4-Parameter Bell Curve to Predict a Peak In Calls During the Swarming Period

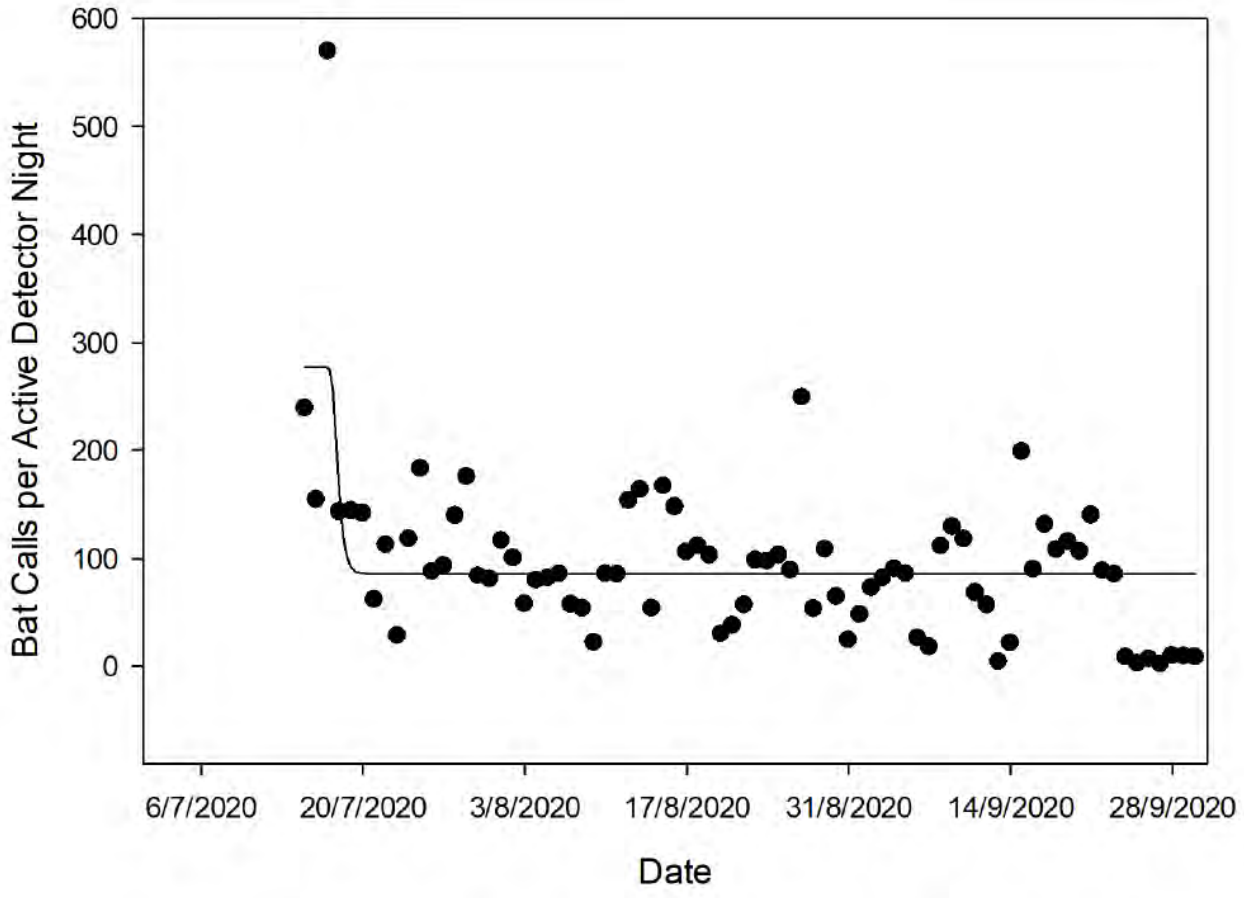


Figure 5.3 Myotis Calls from July 15 to September 30, 2020 with a Modified Gaussian 5-Parameter Bell Curve to Predict a Peak in Calls During the Swarming Period

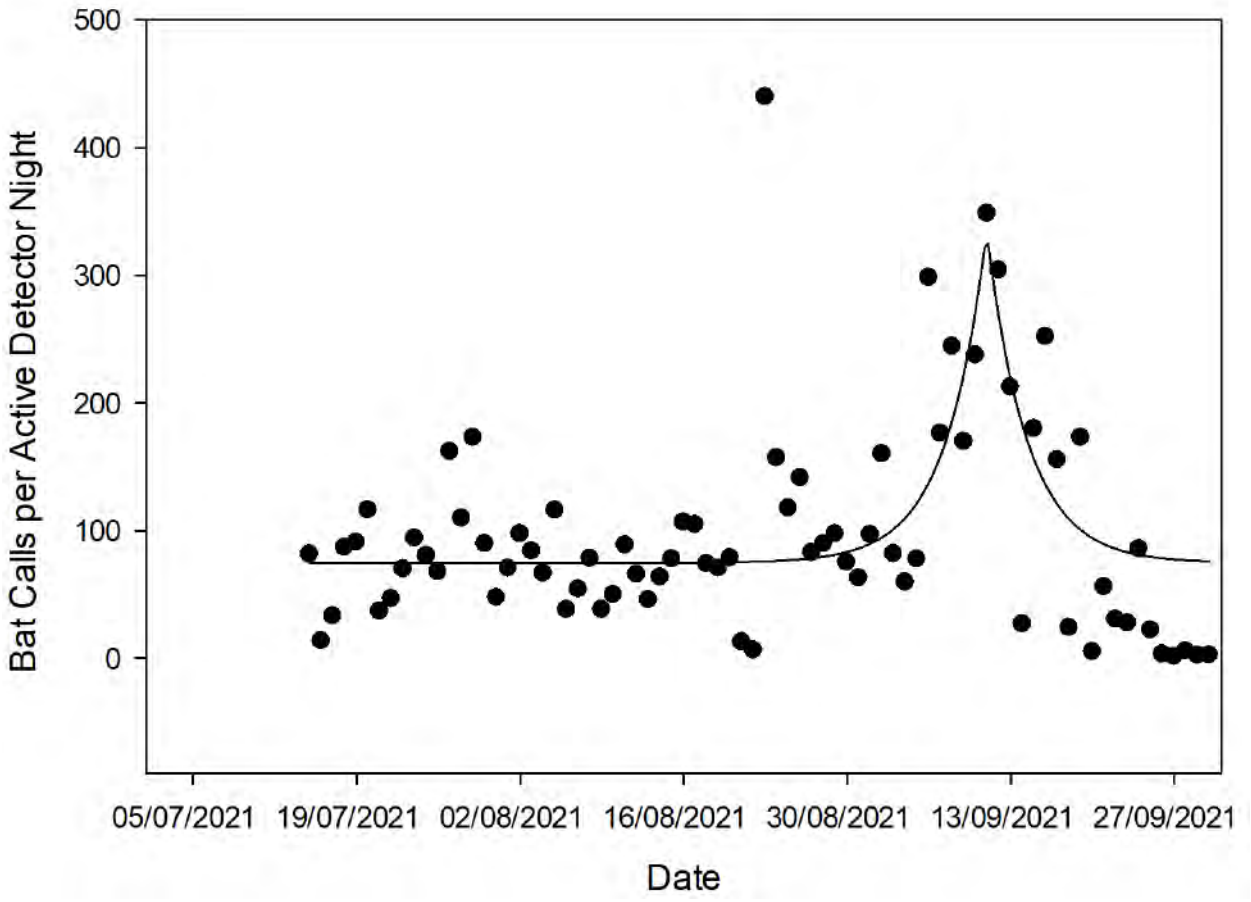


Figure 5.4 Myotis Calls from July 15 to September 30, 2021 with a Modified Gaussian 5-Parameter Bell Curve to Predict a Peak in Calls During the Swarming Period

A summary of bat activity by life stage and detector over all years is presented in **Table 5.11**. Standard deviations have not been provided as that measure of variation is based on the normal distribution and the data are not normally distributed.

The highest numbers of files recorded during all life stages were recorded at 279-SH, the detector located furthest from the quarry (**Figure 2.1**). Due to a lack of detectible swarming in 2019 and 2020 and insufficient data in 2017 and 2018, the fall period was defined as September 1 to the start of hibernation (**Table 5.10**) and this was applied to all years.

Table 5.11 Comparison of Bat Activity by Life Stage and Detector between Late Summer 2017 and Fall 2021

Detector	Bat life stage*	Total files	Active detector-nights	Files per detector-night
279-SH (south cliff)	emergence	628	15	41.87
	summer	102,008	417	244.62
	fall	32,933	84	392.06
	hibernation	3,698	599	6.17
294-SH (south cliff)	emergence	156	23	6.78
	summer	39,017	497	78.51
	fall	14,065	112	125.58
	hibernation	2,221	744	2.99
PM-C-NH (quarry)	emergence	58	20	2.90
	summer	58,487	440	132.93
	fall	30,242	84	360.02
	hibernation	2,429	662	3.67
PM-D-NH (north cliff)	summer	1,096	11	99.64
	fall	1,326	28	47.36
	hibernation	212	87	2.44
PM-GULLY	summer	123	11	11.18
PM-S3 (north cliff)	emergence	31	16	1.94
	summer	21,965	450	48.81
	fall	12,354	63	196.10
	hibernation	686	389	1.76
PM-TAL (north cliff)	emergence	4	4	1.00
	summer	13,065	209	62.51
	fall	2,317	56	41.38
	hibernation	706	228	3.10

*Bat life stage dates were based on Myotis activity but files are from all bat species detected.

5.3.2.1 Emergence from Hibernation

Emergence began consistently in the first or second week of April between 2018 and 2021 (**Table 5.10**), although data were limited by detector failures during April of 2018 and 2018 (**Figure 5.1**). The highest numbers of files per detector-night during the emergence period were recorded at the south cliff detectors 279-SH (**Table 5.11**) and 294-SH, with relatively little activity at the quarry detector (PM-C-NH) and north cliff detector (PM-S3 and PM-TAL).

The summer period also began consistently in mid-April (**Table 5.10**) within a few days of the start of emergence, indicating a swift increase in bat activity immediately after emergence. Summer activity was highest at 279-SH at the south cliff, followed by the quarry detector PM-C-NH and the other south cliff detector 294-SH.

5.3.2.2 Fall

Swarming was only detected in 2021 (**Table 5.10**). There was insufficient fall data in 2017 and 2018 due to detector failures (**Figure 5.1**) to assess for a peak in activity. In 2019 and 2020 no peak in activity was detected (**Figure 5.2 and Figure 5.3**). However, it's possible that detector failures (**Figure 5.1**) in 2019 contributed to a lack in our ability to detect swarming at Portage Mountain in that year as only one detector (294-SH) was active for the months of August and September and it's possible that bats did not swarm near this detector. Swarming in 2021 began September 2 and lasted just under two weeks. The highest cumulative levels of activity during fall were recorded at 279-SH on the south cliff and PMC-NH on the north cliff.

Social calls have been recorded by the Portage Mountain detectors as early as July, but most of the social calls recorded between 2017 and 2021 were from mid-August to late September, with the latest social call recorded in early October. Most of these social calls are probably emitted by big brown bat or silver-haired bat based on the call parameters (minimum frequency 23 to 27 kHz) and several characteristic search-phase big brown bat/ silver-haired bat calls recorded within seconds of when social calls were recorded. Social calls have been recorded every year between late summer 2017 and fall 2021.

5.3.2.3 Hibernation

September data were limited by detector failures in 2018 and 2019 (**Figure 5.1**). Hibernation began consistently on September 22 during 2017, 2019, 2020 and 2021, but in 2018 began two weeks later on October 6 (**Table 5.10**). Detector 279-SH recorded the highest cumulative activity during hibernation (6.17 files per detector-night (**Table 5.11**), nearly twice the number of files per detector-night recorded during hibernation than the detector with the next greatest number of files (PM-C-NH).

Some bat activity was recorded during the coldest months of the year (December, January, and February). Files identified as big brown bat or silver-haired bat were recorded during those months during all years but Myotis activity was not recorded during those periods (**Table 5.12**).

Table 5.12 Number of Files Recorded per Detector-night during December, January and February 2017 to 2021

Year	30K	Big brown bat	Big brown bat / silver-haired bat	Low-frequency bat	Myotis	Grand total
2017-2018	0	0.0571	0.3429	0.1143	0.000	0.5143
2018-2019	0	0.0000	0.5000	0.0000	0.0000	0.5000
2019-2020	0.0333	0.0167	0.3083	0.1667	0.0000	0.5250
2020-2021	0.0020	0.0143	0.3449	0.1388	0.0000	0.5000
Grand Total	**0.0073**	**0.0190**	**0.3397**	**0.1399**	**0.0000**	**0.5109**

5.3.3 Cumulative Trends in Bat Activity

5.3.3.1 Yearly Activity

There were only 78 active detector-nights in the emergence period between 2018 and 2021, which was insufficient to model yearly bat activity in the emergence period and as a result, the Year model failed to converge due to insufficient data (**Table 5.13**).

The Year model converged during the summer, fall, and hibernation periods (**Table 5.14,Table 5.15,Table 5.16**) and all models had sufficiently low overdispersion ratios to produce reliable results: the ratio of the $\text{Pearson } x^2$ to the model degrees of freedom was <3 (Payne et al. 2018) for all models. During summer, fall, and hibernation, the Year model was the top model based on AIC score and weight (**Table 5.14,Table 5.15,Table 5.16**). The Year model therefore explains more of the data than the base and null models.

Summer activity showed a statistically significant decline in 2018 relative to 2017, as well as an apparent decline in 2019 and 2020 and an increase in 2021 that were not statistically significant relative to 2017 (**Table 5.17, Figure 5.5**). Note that **Figure 5.5** does not account for differences in weather between years, but modelling results do. Fall activity showed statistically significant declines in 2018 and 2019 relative to 2017, and a statistically significant increase in 2021 relative to 2017 (**Table 5.18, Figure 5.5**). During hibernation, bat activity showed a statistically significant decline in 2018, 2019 and 2021 relative to 2017 and an apparent decline in 2020 that was not statistically significant (**Table 5.19, Figure 5.5**). Bat activity in all life stages increased with the average nightly temperature, and in summer and fall, bat activity decreased with the total amount of precipitation. During hibernation, bat activity increased with precipitation, but this is because the amount of precipitation does not include snow and therefore any rainfall would have been related to warmer temperatures (**Table 5.19**).

Table 5.13 Model Selection Results for Emergence Bat Activity Models at Portage Mountain with Number of Parameters (K), Log-Likelihood (LL), and Akaike's Information Criterion (AIC) Score and Weight for each Model

Emergence models	K	LL	AIC	AIC weight
Null: total bat calls per night ~ 1 + 1| Area/ Detector ID	4	-206.45	420.91	0.00
Base: total bat calls per night ~ mean temperature + precipitation + 1| Detector ID	5	-197.67	405.33	1.00
Year: total bat calls per night ~ year + mean temperature + precipitation + 1| Detector ID	8	-	-	-

Table 5.14 Model Selection Results for Summer Bat Activity Models at Portage Mountain with Number of Parameters (K), Log-Likelihood (LL), and Akaike Information Criterion (AIC) Score and Weight for each Model

Summer models	K	LL	AIC	AIC weight
Null: total bat calls per night ~ 1 + 1|Detector ID	3	-11,089.37	22,184.74	0.00
Base: total bat calls per night ~ mean temperature + precipitation + 1| Detector ID	5	-10,947.61	21,905.22	0.00
Year: total bat calls per night ~ year + mean temperature + precipitation + 1| Detector ID	9	-10,840.55	21,699.10	1.00

Table 5.15 Model Selection Results for Fall Bat Activity Models at Portage Mountain with Number of Parameters (K), Log-Likelihood (LL), and Akaike Information Criterion (AIC) Score and Weight for each Model

Fall models	K	LL	AIC	AIC weight
Null: total bat calls per night ~ 1 + 1|Detector ID	4	-2,623.36	5,254.73	0.00
Base: total bat calls per night ~ mean temperature + precipitation + 1| Detector ID	5	-2,595.79	5,201.58	0.00
Year: total bat calls per night ~ year + mean temperature + precipitation + 1| Detector ID	9	-2,560.93	5,139.87	1.00

Table 5.16 Model Selection Results for Hibernation Bat Activity Models at Portage Mountain with Number of Parameters (K), Log-Likelihood (LL), and Akaike Information Criterion (AIC) Score and Weight for each Model

Hibernation models	K	LL	AIC	AIC weight
Null: total bat calls per night ~ 1 + 1|Detector ID	3	-5216.80	10439.60	0.00
Base: total bat calls per night ~ mean temperature + precipitation + 1| Area/Detector ID	6	-4829.45	9670.90	0.00
Year: total bat calls per night ~ year + mean temperature + precipitation + 1| Detector ID	10	-4783.96	9587.91	1.00

Table 5.17 Model* of Yearly Bat Activity during the Summer Period at Portage Mountain

Variable	Coefficient estimate	Standard error	z value	Lower 95% C.I.	Upper 95% C.I.
Intercept	**3.66**	0.31	11.62	3.04	4.27
Year 2018	**-1.01**	0.21	-4.83	-1.42	-0.60
Year 2019	-0.39	0.21	-1.83	-0.80	0.03
Year 2020	-0.02	0.21	-0.10	-0.43	0.39
Year 2021	0.23	0.21	1.10	-0.18	0.63
Mean temperature	**1.01**	0.07	14.78	0.87	1.14
Total precipitation	**-0.42**	0.03	-15.67	-0.48	-0.37

* Model based on data from 6 detectors at 3 areas. The reference year was 2017. Coefficients in bold are statistically significant.

Table 5.18 Model* of Yearly Bat Activity during the Fall Period at Portage Mountain

Variable	Coefficient estimate	Standard error	z value	Lower 95% C.I.	Upper 95% C.I.
Intercept	**4.30**	0.39	11.08	3.54	5.06
Year 2018	**-1.09**	0.55	-1.99	-2.16	-0.01
Year 2019	**-1.88**	0.24	-7.69	-2.35	-1.40
Year 2020	-0.06	0.15	-0.43	-0.35	0.22
Year 2021	**0.37**	0.15	2.47	0.08	0.66
Mean temperature	**0.73**	0.17	4.21	0.39	1.07
Total precipitation	**-0.30**	0.05	-6.38	-0.39	-0.21

*Model based on data from 6 detectors at 3 areas. The reference year was 2017. Coefficients in bold are statistically significant.

Table 5.19 Model of Yearly Bat Activity during the Hibernation Period at Portage Mountain

Variable	Coefficient estimate	Standard error	z value	Lower 95% C.I.	Upper 95% C.I.
Intercept	**1.78**	0.21	8.58	1.37	2.18
Year 2018	**-0.58**	0.15	-3.86	-0.87	-0.29
Year 2019	**-1.10**	0.15	-7.47	-1.38	-0.81
Year 2020	-0.14	0.13	-1.07	-0.40	0.12
Year 2021	**-0.65**	0.14	-4.56	-0.93	-0.37
Mean temperature	**1.24**	0.05	27.49	1.15	1.33
Total precipitation	**0.18**	0.03	5.97	0.12	0.24

*Model based on data from 6 detectors at 3 areas. The reference year was 2017. Coefficients in bold are statistically significant.

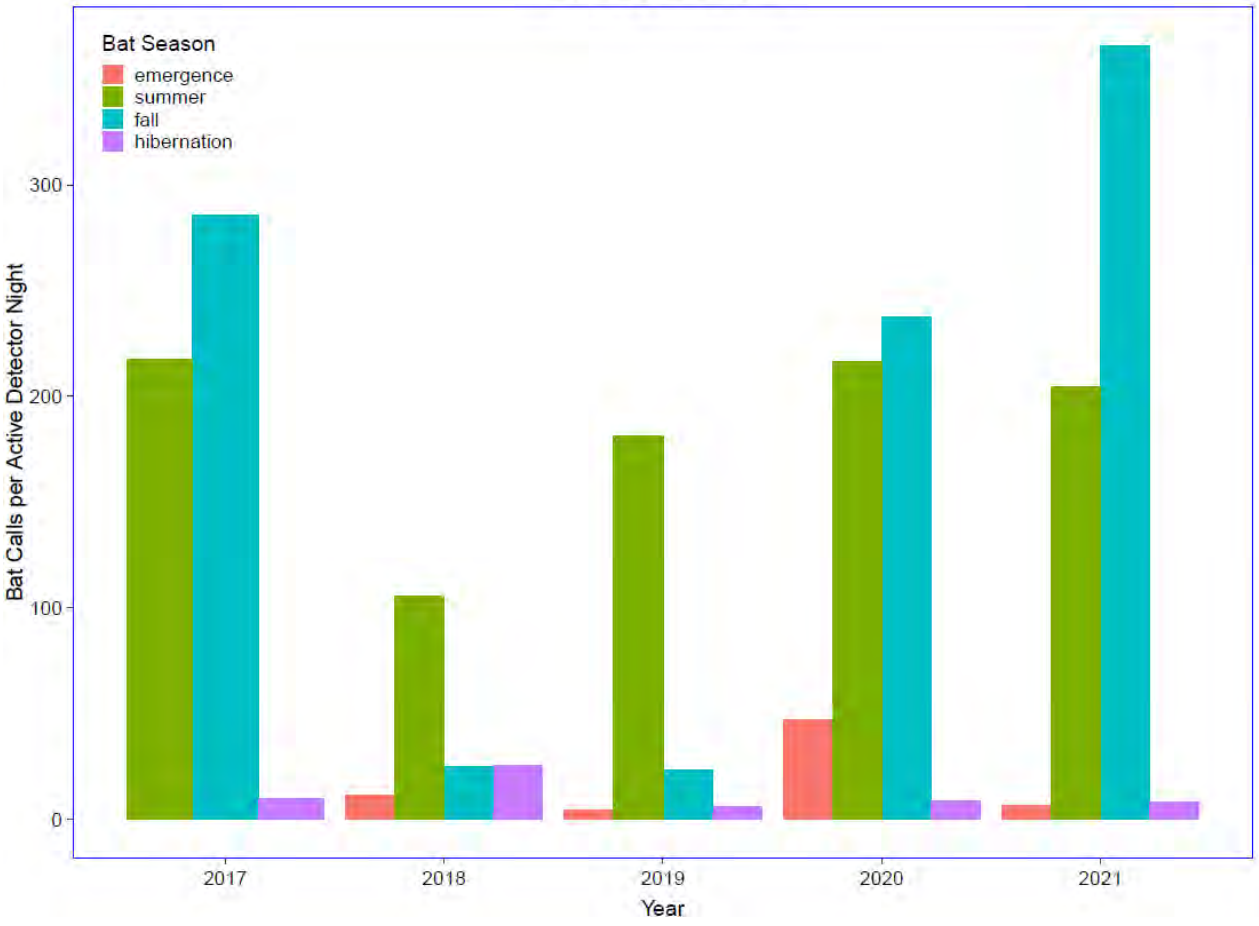


Figure 5.5 Yearly Bat Activity by Bat Life Stage at Portage Mountain

During summer and fall, the Blast model was the top AIC model as compared to the null and base models (**Table 5.20-Table 5.21**). In summer, bat acoustic activity showed a statistically significant positive relationship with blasting occurrence (**Table 5.22**). However, this effect disappears if the year 2018, which only included 5 blasts, is dropped from the data: blast becomes a non-significant model variable and the base model is the top AIC model (**Appendix G**). Bat activity showed a statistically significant negative relationship to blasting occurrence during the fall period (**Table 5.23**).

Graphs of bat calls per active detector-night plotted with blasting dates and temperature for years 2018-2021 are available in **Figure 5.6, Figure 5.7, Figure 5.8,** and **Figure 5.9**. Trends relative to blast dates are difficult to discern due to natural variability in the data but there does appear to be an associated decline in fall bat activity in 2019 and potentially in July of 2019 (**Figure 5.7**). In contrast, during summer and fall of 2020 blasting occurred on a near daily basis and a trend in bat activity is not easily observed (**Figure 5.8**). In 2021, the numbers of bat calls appear to be relatively low when blasting occurred compared to time intervals when there was no blasting (April to early May and mid-August to October) (**Figure 5.9**). Compared to 2019 and 2020, when blasting took place in early September, 2021 was the only year where blasting did not occur during the month of September and was also the only year in which a swarming period was identified.

Table 5.20 Model Selection Results for Summer Bat Activity Models at Portage Mountain with Number of Parameters (K), Log-Likelihood (LL), and Akaike Information Criterion (AIC) Score and Weight for each Model.

Summer models	K	LL	AIC	AIC weight
Null: total bat calls per night ~ 1 + 1|Detector ID	3	-10,805.56	21,617.11	0.00
Base: total bat calls per night ~ mean temperature + precipitation + 1| Detector ID	5	-10,666.08	21,342.15	0.00
Blast: total bat calls per night ~ blast + mean temperature + precipitation + 1| Detector ID	6	-10,654.42	21,320.85	1.00

Table 5.21 Model Selection Results for Fall Bat Activity Models at Portage Mountain with Number of Parameters (K), Log-Likelihood (LL), and Akaike Information Criterion (AIC) Score and Weight for each Model.

Fall Models	K	LL	AIC	AIC weight
Null: total bat calls per night ~ 1 + 1|Detector ID	4	-1921.68	3,851.35	0.00
Base: total bat calls per night ~ mean temperature + precipitation + 1| Detector ID	5	-1901.38	3,812.76	0.08
Blast: total bat calls per night ~ blast + mean temperature + precipitation + 1| Detector ID	6	-1897.88	3,807.75	0.92

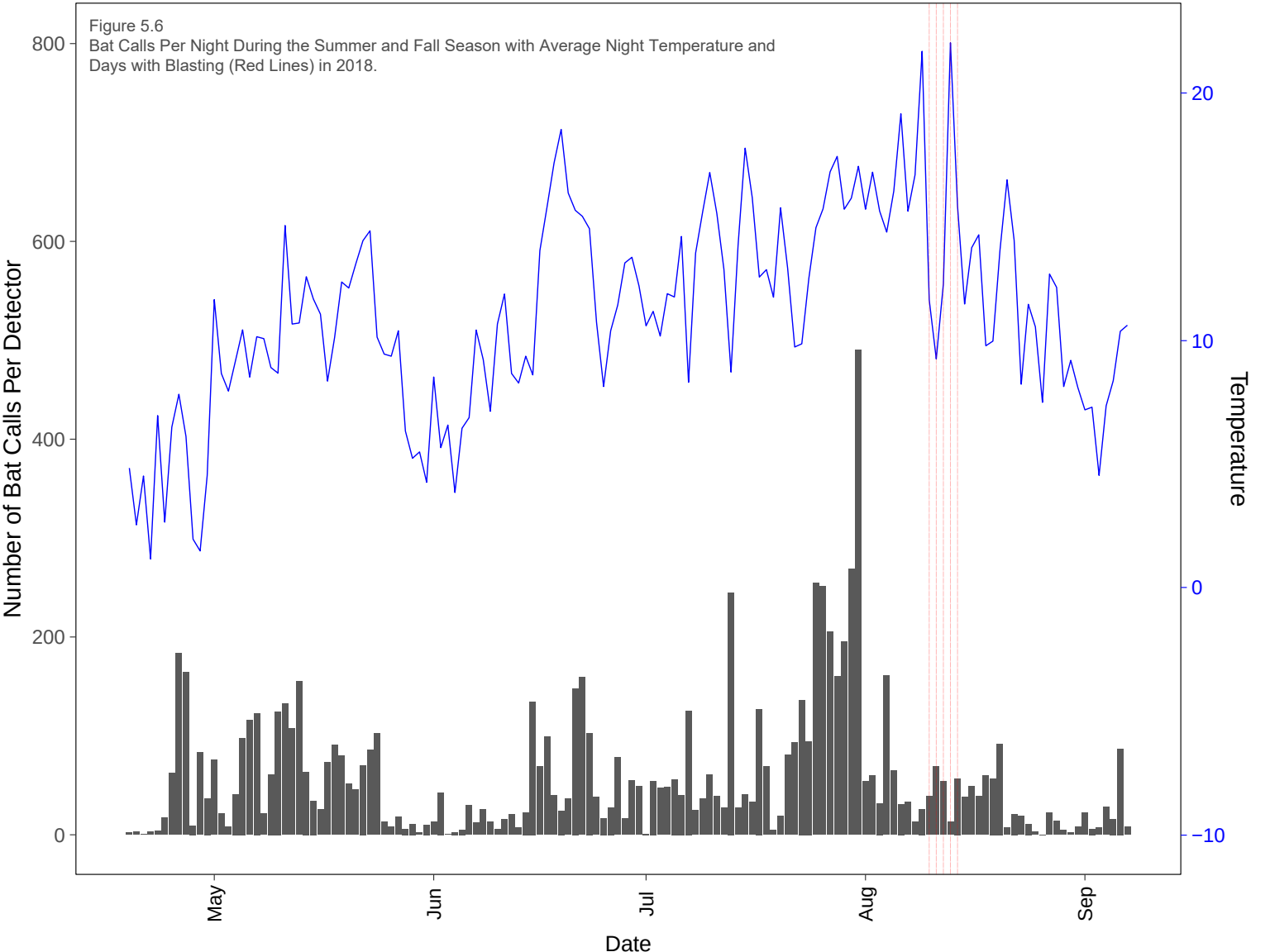
Table 5.22 Model of Bat Activity in Response to Blasting During the Summer Period at Portage Mountain, Based on Data from 5 Detectors at 3 Areas

Variable	Coefficient estimate	Standard error	z value	Lower 95% C.I.	Upper 95% C.I.
Intercept	**3.68**	0.27	13.80	3.16	4.21
Blast	**0.29**	0.06	4.80	0.17	0.40
Mean temperature	**0.75**	0.07	11.02	0.62	0.88
Total precipitation	**-0.43**	0.03	-16.13	-0.48	-0.37

Table 5.23 Model of Bat Activity in Response to Blasting During the Fall Period at Portage Mountain, Based on Data from 5 Detectors at 3 Areas

Variable	Coefficient estimate	Standard error	z value	Lower 95% C.I.	Upper 95% C.I.
Intercept	**4.49**	0.39	11.56	3.73	5.25
Blast	**-0.58**	0.21	-2.81	-0.98	-0.18
Mean temperature	**0.97**	0.26	3.74	0.46	1.48
Total precipitation	**-0.35**	0.04	-8.29	-0.44	-0.27

Figure 5.6
Bat Calls Per Night During the Summer and Fall Season with Average Night Temperature and Days with Blasting (Red Lines) in 2018.



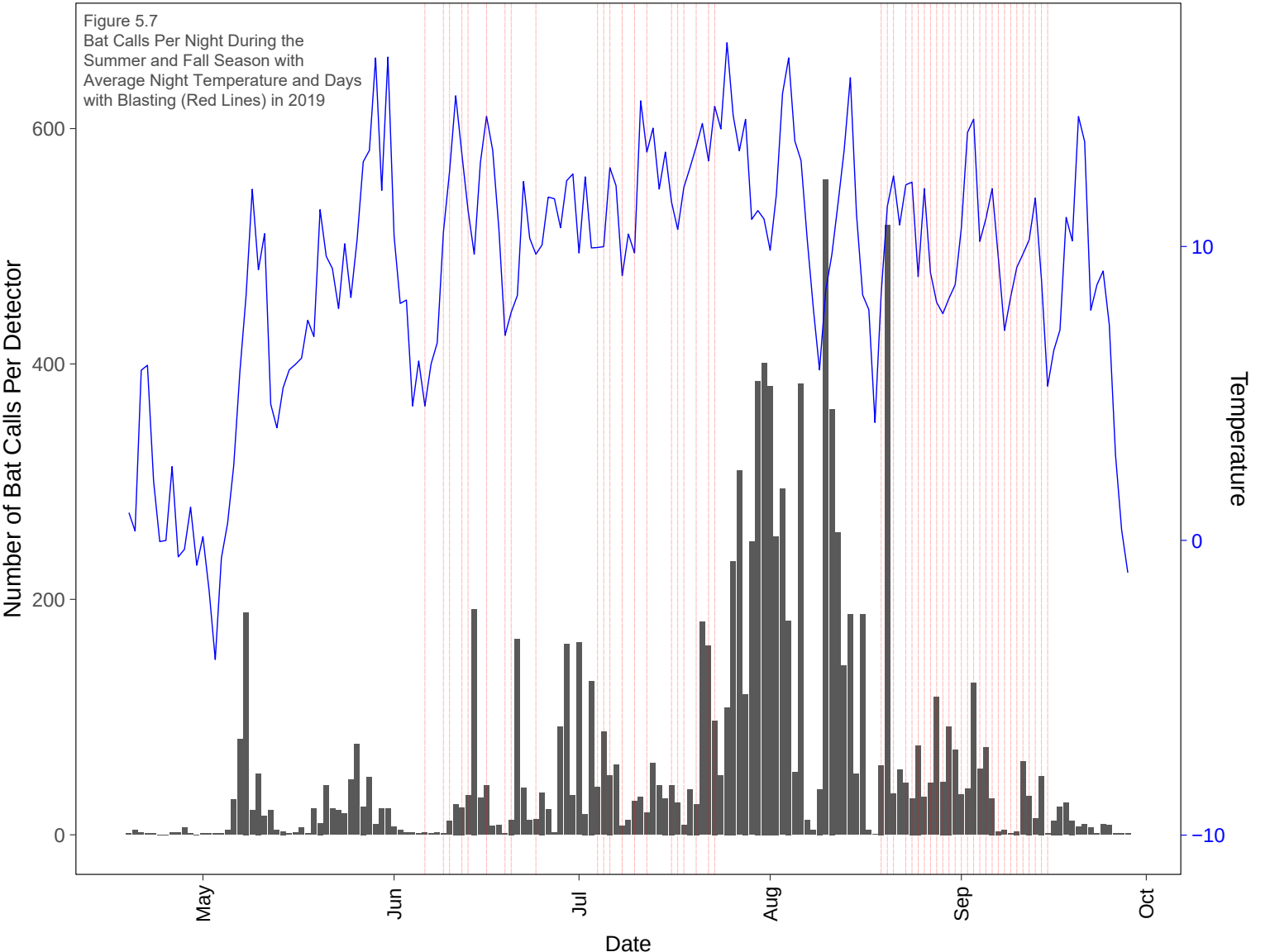


Figure 5.7
Bat Calls Per Night During the Summer and Fall Season with Average Night Temperature and Days with Blasting (Red Lines) in 2019
Number of Bat Calls Per Detector
0
200
400
600
Temperature
−10
0
10
May
Jun
Jul
Aug
Sep
Oct
Date

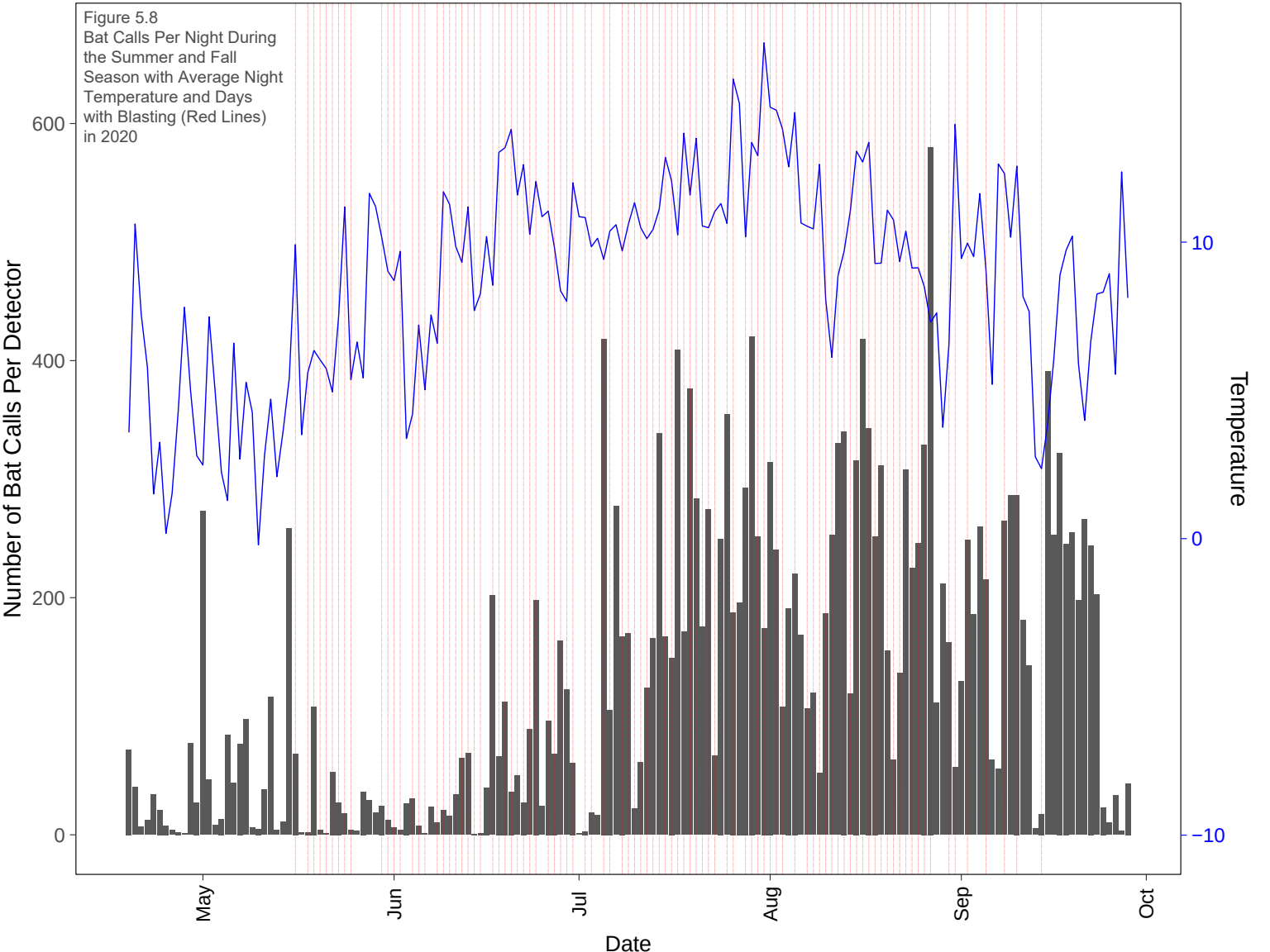
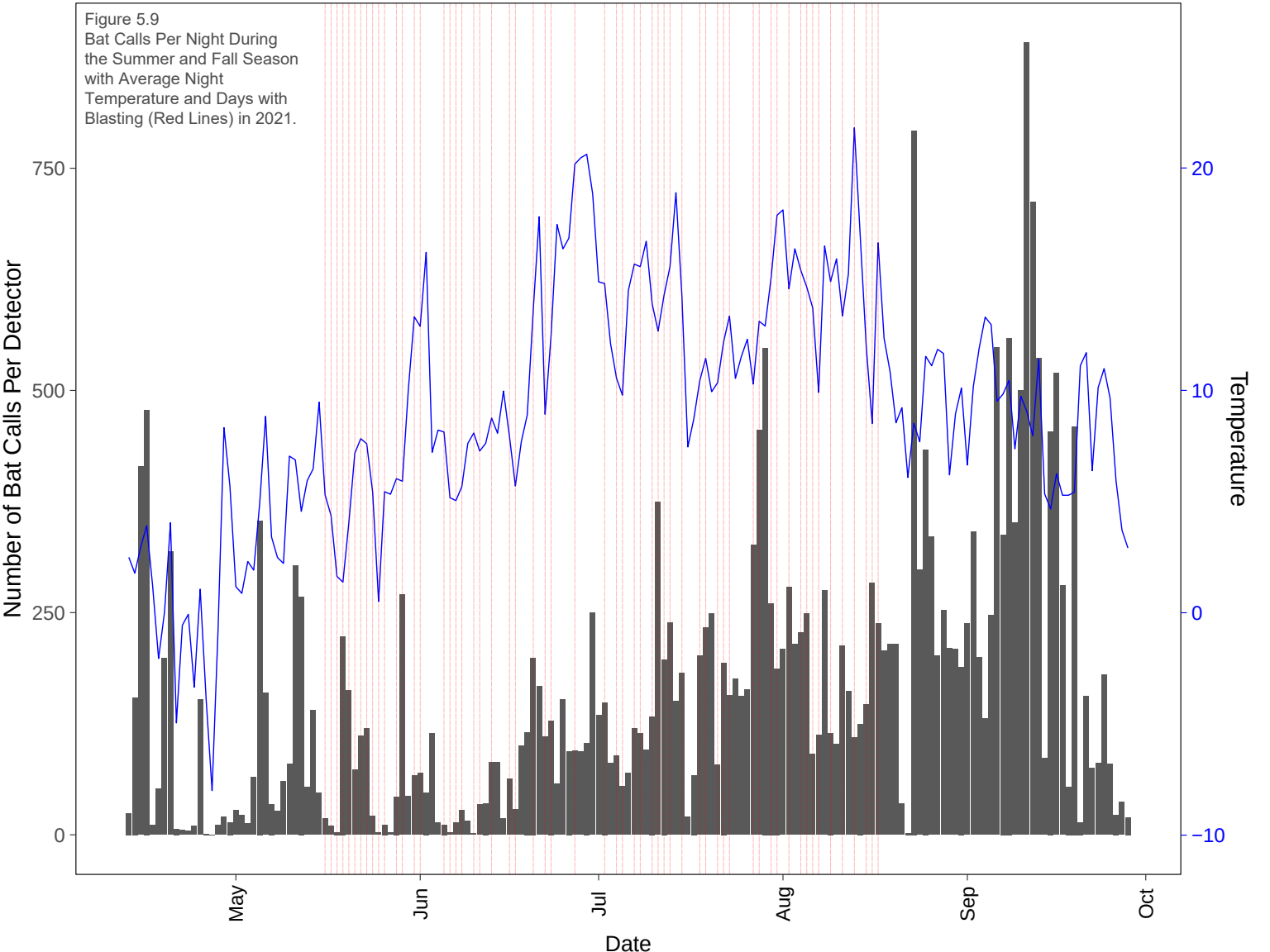


Figure 5.8
Bat Calls Per Night During the Summer and Fall Season with Average Night Temperature and Days with Blasting (Red Lines) in 2020
Number of Bat Calls Per Detector
600
400
200
0
Temperature
10
0
−10
May
Jun
Jul
Aug
Sep
Oct
Date

Figure 5.9
Bat Calls Per Night During the Summer and Fall Season with Average Night Temperature and Days with Blasting (Red Lines) in 2021.



6.0 DISCUSSION

6.1 Maternity Roost Monitoring

Maternity roost monitoring was conducted during the period when bats generally give birth; between June and July (BC Ministry of Environment 2016b). Bats were observed exiting the previously identified roost 9427G (Hemmera 2020) on the south cliff during emergence count surveys in 2020 and 2021 (**Section 5.2.1; Appendix D**). Early emergence from roosts is likely associated with nursing female bats needing to forage early in the night to meet the energy demands of nursing their pups (Barclay 1989; Kurta et al. 1989; Lee and McCracken 2001). Some bats at 9247G were observed leaving the roost before sunset during late period surveys in 2020 and returning to that roost during the late-season emergence counts in 2020 and 2021 (**Section 5.2.1**), behaviours consistent with females leaving early to forage and returning to nurse dependent pups. Female little brown myotis in Watson Lake, Yukon, emerged from their maternity roost significantly earlier relative to sunset during the lactation/volant young period than during the pregnancy period (Talerico 2008). Radio-tagged female little brown myotis in Quebec rarely returned to their maternity roost during the night during pregnancy but lactating females returned once or twice a night (Henry et al. 2002).

At site 9427G during the maternity roosting period, the consistent activity, the number of bats observed (e.g., 17 bats in July 2020 and 23 bats in June 2021) emerging, and observations of bats leaving the roost before sunset and returning to the roost during emergence surveys all provide evidence that this site was most likely still being used for maternity roosting in 2020 and 2021 (**Appendix D**).

The number of bats observed fluctuated between 2017 and 2021 at 9427G. An average of 40.5 bats had been counted exiting during early-period roost surveys in 2018 (**Table 5.4)**. Average emergence counts in subsequent years did not reach the peak observed in early 2018 and were variable, but appear to have generally declined, particularly in 2020 and 2021. The reason for the differences is unknown and there are insufficient data to assess the statistical significance of the differences in the context of natural variability. High variability between roost counts between years and seasons is not uncommon (Burles 2000; Kellner 2020). Schorr and Siemers (2021) captured adult female little brown myotis leaving a roost in Colorado each June over multiple years. Annual numbers of bats at that roost ranged from 30 to 162.

The variation in roost count numbers at Portage Mountain could be due to a number of factors, such as the following:

- roost switching by some individuals between years (**Section 5.2**), as roost-switching by female little brown myotis has been documented to occur frequently in the Yukon (Slough and Jung 2020) and in the lower mainland of BC (Rensel 2021);
- variation in weather during emergence counts resulting in some bats leaving the roost later;
- observer error in accurately counting distant, fast-moving bats in low-light conditions;
- quarry activity affecting the patterns of maternity roost use.

Previously suspected maternity roosts such as 6287F on the south cliff, and NHEC3b at the north cliff (Hemmera 2020), had low numbers of bats emerging during the 2017 to 2019 surveys compared with roost 9427G, and no bats were observed there in 2020 or 2021. As described above, roost-switching, observer error or quarry activity could be the cause of the observed cessation of use. Changes in the suitability of the roost itself (e.g., incursion of woodrats, parasite infestation, vegetation growth shading the roost) could also cause roost abandonment or roost-switching. The trees, cliffs and talus within the study area – and

in other forest stands and rock faces on Portage Mountain outside of the study area – offer multiple crevices that appear suitable for bat roosting and it is unlikely that bats at Portage Mountain are limited to specific features. There were multiple other sites in the north and south cliffs where bats were observed emerging (**Section 5.2**) that could also be maternity roosts, but were used by fewer bats than the threshold of 10 individuals used for determining likely maternity roosts (BC Hydro 2020).

No new roosts were identified during the 2020 and 2021 emergence counts, but continuous bat activity was observed visually and recorded on handheld detectors across the entire south and north cliffs at dusk during emergence counts. Continued observations of bats early in the evening at emergence time suggests that bats continue to use rock features in the cliffs as roosting sites despite quarrying activity. Bats may move between crevices at the north and south cliffs as well as between tree roosts, making the identification of specific roosts and ongoing monitoring of maternity colonies challenging. Ongoing technical issues have limited the utility of data from the roost loggers in assessing bat roosting activity. Although emergence counts of bats at sunset and inspection of rock features with roosting potential are the best and least invasive methods to monitor bat activity at specific rock roosting locations, these techniques are limited by the difficulties of safely accessing the rock faces and getting close enough to the features under study to conduct an accurate count.

Consistent with previous reports, there is still no evidence of roosting bat activity at the small rock outcrops at the top of the quarry and the small bluff previously surveyed by Hansen et al. (2016) where the detector PM-S3 is deployed. Those areas are close to quarry development and operation activities, including forest harvest and road-building beginning in 2016. Emergence counts conducted from 2017 to 2021 did not result in observations of bats emerging from those two locations. These results continue to suggest that the larger cliff bands (south and north cliffs) with their large, and more exposed complex roosting habitats provide more suitable habitat for bats than the rock outcrops at the top of the quarry and the small bluff next to the quarry.

There are other habitat types in the study area that are expected to be used by roosting bats, at least outside of the hibernation period. Individuals using tree roosts in the study area will also be recorded on the bat detectors and may switch between tree roosts and rock crevice roosts. All of the bat species present in northeastern BC may use trees as roosts (BC Ministry of Environment 2016b; Lausen et al. 2022b), of which there are many nearby. Bats have previously been observed moving back and forth between a mature stand of balsam poplars at the bottom of the gully between the north and south cliffs and larger forest polygons east of 400 Road (M. Sarell, pers. comm. 2018).

6.2 Bat Species Presence and Seasonal Bat Activity from Passive Acoustic Monitoring

6.2.1 Species Presence

Species diversity remains unchanged at Portage Mountain from 2017 through 2021. Seven of the eight bat species that have been identified from acoustic data previously in the study area between 2017 and 2019 continued to be detected in 2020 and 2021, including the at-risk little brown and northern myotis. Long-legged myotis was not detected during passive acoustic monitoring in 2020 and 2021. This species is difficult to distinguish acoustically from some other Myotis species (especially little brown myotis) so it may be present but not detected. Big brown bat and long-eared myotis were the most common bats in 2018 through 2021, while in 2017 more hoary bat, silver-haired bat and little brown myotis files were identified than long-eared myotis files. The 2017 monitoring did not begin until August 21, which may have resulted in relatively more migratory species being detected.

The bat species detected are discussed below, along with their presence through the seasons. Bat activity data confirm that the periods of hibernation and emergence for bats at Portage Mountain are within the no-blasting temporal exclusion period (September 15 – May 15), suggesting that the timing of this mitigation was appropriate to avoid impacts on those behaviours. Activity consistent with regular life stages of bats was recorded in 2021 after three years of quarry operation (i.e., emergence from hibernation, maternity roosting, swarming), and even detections during the coldest months of winter, which collectively is evidence that the habitat and conditions at Portage Mountain remain suitable for bats. The calls recorded during the winter and early spring suggest that bats are hibernating near the Portage Mountain detectors.

Hoary bat

Hoary bats were detected almost exclusively (96% of the files identified as hoary bat) in July through September from 2017 through 2021, suggesting that this species passes through the Portage Mountain area primarily while on fall migration and consistent with the results of other studies (Nagorsen et al. 2014). Spring migration may follow an alternate route. Migration routes of hoary bats are poorly known (Baerwald et al. 2014; Wieringa et al. 2021) and may exhibit a high degree of individual variation (Weller et al. 2016).

Eastern red bat

The eastern red bat is believed to be undergoing a range expansion in western Canada (Lausen et al. 2022a; Solick et al. 2020) and makes up just 0.1% of the calls recorded in 2020 and 2021. Eastern red bat was detected in all years, with the earliest detections recorded April 21 in 2020 and April 14 in 2021, and latest detections recorded on October 13 in 2018 and October 3 in 2020. This species was identified in June, July, and August in all years from 2018 through 2021 with peak numbers of detections in July and August.

Silver-haired/Big brown bat

Acoustic characteristics of silver-haired bat and big brown bat calls may overlap (Lausen et al. 2022a) and many files were assigned to the group that included both species (Appendix A). Files identified specifically as silver-haired bat first appeared in April. Only big brown bats were detected during winter studies along the Peace Reach of Williston Reservoir, and it has been hypothesized that silver-haired bats migrate to and from the Peace region seasonally (Paterson et al. 2017). Big brown bat files were recorded in all seasons and this species likely hibernates in the vicinity of Portage Mountain. The big brown bat is known to be particularly cold-tolerant (Baerwald 2017), and individuals hibernating in rock crevices in Alberta have been recorded arousing an average of 17 times per winter (Lausen et al. 2022a). Studies of hibernating big brown bats on the Canadian prairies revealed that winter flight was common, but individuals rarely switched hibernacula during mid-winter (Klüg-Baerwald et al. 2017).

Few bat calls were recorded at Portage Mountain during the coldest months (i.e., December, January, and February; **Table 5.12**). All were identified as big brown bat, big brown bat/silver-haired bat, or low-frequency bat. Of the 171 bat files recorded in January and February of 2021, 102 were recorded at detector 279-SH, the southernmost detector. All detectors except PM-S3 were functioning during those months (**Figure 5.1**). Bats active during these months may hibernate closer to detector 279-SH than to the other detectors, or the primary flight path of bats leaving and re-entering hibernacula during the winter is south over 279-SH, rather than north over the other detectors. The 279-SH detector is also one of the detectors furthest from quarry activity, although blasting and heavy construction have not occurred during the winter. The 279-SH detector also had a high average number of files recorded during the fall and during emergence (**Table 5.11**), further evidence that it is close to a hibernaculum.

Bats were recorded at Portage Mountain during temperatures as low as -7.4°C in April of 2021 (**Appendix D**). Bat activity during winter has been documented on many occasions in several bat species, including long-eared myotis and big brown bat at southern locations on the Canadian prairies (Lausen and Barclay 2006) and northern myotis and big brown bat in Nebraska (Lemen et al. 2016). However, few studies have focused on winter activity in northern climates (Reimer et al. 2014). Bat emergence during the hibernation period is still not well understood. Some studies and observations in the prairies have suggested that bats will arouse during winter to drink near or inside the hibernacula or move between winter roosts, and there have been records of mating activity (BC Ministry of Environment 2016b; Lausen and Barclay 2006; Lemen et al. 2016; Lowe 2012). Winter bat activity has been detected at -10.4°C in Alberta (Klüg-Baerwald et al. 2016).

Myotis

The Myotis species group includes the two species classified as endangered on Schedule 1 of SARA, little brown myotis and northern myotis. Hibernacula of these species have been identified as critical habitat features (Government of Canada 2018). Myotis species typically are inactive during the winter while in deep hibernation so late fall detections followed by early spring detections can be used to infer the nearby presence of hibernacula.

Paterson et al. (2017) reported no winter Myotis detections along the Peace Reach of Williston Reservoir (including 5 detectors within 15 km of the Portage Mountain Quarry) and noted that a general lack of winter Myotis activity seemed common to other studies within the Peace Region, even at locations where they were detected in late fall and early spring. Paterson et al. (2017) also reported Myotis emerging from hibernation in early to mid-April, consistent with the findings of this study. Lausen and Barclay (2006) reported Myotis detections on the Canadian prairies when temperatures at emergence were above -5.8°C.

Northern myotis had an 89% probability of detection during the winter in Nebraska at temperatures >5°C (Lemen et al. 2016). Northern myotis has been known to move between hibernacula during winter in southern regions (Whitaker Jr and Rissler 1992; Lemen et al. 2016), although no winter detections have been recorded in most of their range, including the Peace Region. This species tends to hibernate in smaller numbers and is not as active during the winter as other bats such as big brown bat and silver-haired bat (Caceres and Barclay 2000; Boyles et al. 2006), which could explain its absence from Portage Mountain winter records.

6.2.2 Seasonal activity

The bat activity patterns observed at Portage Mountain and the associated inferences drawn are consistent with those of other published studies (e.g., Barclay 1989; BC Ministry of Environment 2016b; Kurta et al. 1989). A summary of activity in each season is provided below.

Winter

Bats are not known to venture far from hibernacula during the low temperatures of winter due to the need for energy conservation (Holroyd et al. 2016), so it is likely that hibernation by big brown bats and Myotis species is occurring in or near Portage Mountain. The winter observations from acoustic monitoring suggest that hibernating big brown bats are occasionally active during the winter and are most likely using the rock crevices in the study area as hibernacula. It also suggests that Myotis species are virtually inactive during the winter, based on the lack of calls, but are very likely hibernating in the area based on calls recorded during late fall and very early in the spring.

The winter temporal restriction on blasting at the quarry between September 15 and May 15 eliminates disturbance from blasting during the hibernation period for Myotis (**Table 5.10**). Most non-migratory BC bat species form mating swarms in areas where they will hibernate during the winter, similar to other bat species in temperate areas (van Schaik et al. 2015).

Spring

Simpson et al. (2013) reported that Myotis activity was first detected in spring at potential hibernacula at the Alwin Holland cliffs on the Peace River on April 6 of 2011, five days after detector installation, and at Tea Creek on April 3, three days after detector installation, while the larger bat species were first recorded slightly earlier (the first or second day after detector installation). No detectors were deployed during the winter in that study. Bats in that study were first recorded at foraging sites (waterbodies) in mid to late April. Acoustic data indicate that Myotis bats begin emerging from hibernation on Portage Mountain in mid-April, and migratory bats start using the area at the end of April (**Appendix B; Table 5.10**). Big brown bats are active frequently through the winter so it is more difficult to define the date of the first spring activity The spring temporal restriction on blasting at the quarry to after May 15 eliminates disturbance from blasting during the emergence period and the beginning of the summer period for Myotis (**Table 5.10**).

Summer and fall

Summer bat activity recorded by the long-term detectors in 2020 and 2021 (**Appendix D**) showed increasing levels of activity in June and July, consistent with increased activity by reproducing females and the general pattern of bat activity increasing in response to warmer temperatures and greater availability of insects. Further increases in Myotis activity in mid-August into September are likely due to a combination of additional bats returning from their summer roosts, feeding activity as young of the year become volant, and fall swarming. Hibernating species begin fattening for winter by increasing their foraging activity, using torpor more frequently during the day and between foraging bouts, choosing cooler roosts to conserve energy and returning from their summer sites to the hibernating area in preparation for mating (MOE 2016a; Kerth et al. 2001; Lausen and Barclay 2003; Rintoul and Brigham 2014). Social calls are often an indication of mating behaviours (Pfalzer and Kusch 2003; van Schaik et al. 2015). The detection of social calls during the fall together with a peak of activity consistent with swarming in fall in 2021 (**Section 5.3.2.2**), provide additional evidence that bats are continuing to use the cliffs within the study area as hibernacula.

6.3 Bat Response to Quarry Activity

The noise and vibration from quarry activities appear to have remained below the thresholds specified in the bat mitigation and monitoring plan (BC Hydro 2020) despite the variation in year to year quarry activities (**Table 3.4**). Trend analysis of bat activity in response to quarry blasting has produced results (**Section 5.3.3**) that show variable interactions between bats and quarry activity. These results, which varied by year and by bat life stages, show that in some years and for some bats there are interactions that suggest a positive or negative trend as a result of quarry activity.

Emergence and Summer

The emergence period was too brief (3 to 8 days, depending on year) for there to be enough data to assess for temporal trends during the emergence period. The difference in bat activity during summer 2019 to 2021 compared to 2017 was not statistically significant, but this may be due to only 11 active detector-nights during which data were recorded in the 2017 summer period, (**Appendix F**), increasing the chance of a type II statistical error.

Blasting does not appear to have had a negative impact on bats during summer (**Table 5.22** and **Appendix G**).

Swarming

Pre-hibernation swarming activity in BC and in the Peace region typically occurs in fall. For example, high bat activity (up to 3,000 files - mostly Myotis - in a single night) recorded at the end of September 2011 at the Bear Flats cliffs on the Peace River was suggestive of swarming (Simpson et al. 2013). At Tea Creek, another suspected cliff hibernaculum on the Peace River, bat activity peaked between August 31 and September 10. Andrusiak (2014) conducted reconnaissance acoustic sampling at Portage Mountain in 2013 between August 29 and September 5, and the highest amount of activity was recorded September 2 to 3. At Portage Mountain in 2021 Myotis activity peaked somewhat later, in mid-September (**Appendix D**). This was the only year that a peak in bat activity at Portage Mountain could be detected within the usual fall swarming period (**Section 5.3.2.2**), however, detector failures during late August and September 2017 - 2019 (**Figure 5.1**) have limited the amount of data available for those months.

Blasting may have had an impact on swarming activity at Portage Mountain. Fall activity showed statistically significant declines in 2018 and 2019 relative to 2017, but a statistically significant increase in 2021 relative to 2017. Bat activity also showed a statistically significant negative relationship with blasting occurrence during the fall period (**Table 5.23**). Furthermore, in 2021 blasting ceased on August 17, which was earlier than other years and well before the 2021 swarming period (September 2 to September 21; **Table 5.2**) and 2021 was the only year during which a peak in bat activity at Portage Mountain was detected during the swarming period. Blasting in 2019 and 2020 continued until mid-September (**Table 3.4**), which overlaps with the typical swarming period in other parts of the Peace region. The earlier cessation of blasting in 2021 may have had less impact on swarming behaviours. Bats are very likely to have been using tree roosts as well as rock roosts during the swarming period, including tree roosts within the buffer zone and much closer to the quarry than the rock roosts that were monitored. An alternative explanation for the lack of detectible swarming is that the tree-roosting bats closer to the quarry may have been subject to higher levels of quarry noise and vibration disturbance from blasting, potentially altering swarming activity.

Swarming behaviour has been relatively little studied, and the purposes of swarming are still under investigation (Burns and Broders 2015; Neubaum and Siemers 2021). Most studies of swarming have been undertaken at large, point-location hibernacula such as caves or mines (Burns and Broders 2015; Lowe 2012; Muthersbaugh et al. 2019b; van Schaik et al. 2015), and the form of the behaviour at smaller, more dispersed rock crevice hibernacula, including its annual variability in space and time, is unclear. It is possible that swarming at Portage Mountain occurs during some years at other locations outside our study area, out of range of the detectors. Crevices potentially providing suitable hibernacula are broadly distributed across the north and south cliffs of the study area and beyond. The landscape at Bear Flats and Tea Creek on the Peace River where swarming was recorded in the fall (Simpson et al. 2013) differs from the study area in that these are prominent sites with extensive areas of concentrated vertical rock habitat and considerable clear airspace to facilitate recording bats.

Hibernation

During the hibernation period, bat activity showed a statistically significant decline in 2018, 2019 and 2021 relative to 2017 (**Table 5.19, Figure 5.5**). This suggests a potential influence from quarrying activity, although there was reduced quarry activity and no blasting during the hibernation period (**Section 3.1**).

There is minimal information in the literature regarding responses of hibernating bats to industrial activity. The arousal responses of four species of hibernating bats in an active mine to underground mining blasts in Wisconsin were studied by Summers (2017). Bat arousals increased significantly after underground blasts, although the study could not distinguish between multiple individuals arousing and multiple detections of the same individual (Summers 2017). Luo et al. (2014) studied the responses of torpid greater mouse-eared bats (*Myotis myotis*) to noise disturbance, finding that bats responded most strongly to colony (conspecific) and vegetation (wind in trees) noise while responses to anthropogenic (traffic) noise were relatively weak. There was evidence of rapid habituation to repeated and prolonged exposure to noise, with habituation to traffic noise being more pronounced than to bird, colony or vegetation noise (Luo et al. 2014).

Bat Responses to Noise

Bats' perception of noise is different from the way people perceive noise (Caltrans 2016, Page and Bernal 2020) and for this reason assessments of quarry effects should consider the sensitivity of bats to noise frequencies. There is little information available on the noise levels that result in disturbances to roosting bats, causing Caltrans (2016) to suggest as a conservative response to these unknowns that the minimum noise criterion for assessing potential adverse effects on bats is the distance at which project noise attenuates to background noise levels. Caltrans (2016) also noted that measured noise levels are likely overestimates of the actual noise that is within the spectral range of bat hearing. Background daytime noise levels measured near Portage Mountain in 2020 ranged from 33 dBA to 55 dBA and averaged 44.4 dBA (Dailyde and Johnston 2020; **Section 5.1** and **Appendix C**). Quarrying noise from all sources (i.e., blasting and other quarry operating activities) averaged within the range of background noise level but sometimes exceeded it: south cliff nighttime averaged 41 dBA (maximum 52.7 dBA) and during the day averaged 45-47 dBA (maximum 53.1 dBA), and at the north cliff averaged 48 dBA at nighttime (maximum 55 dBA) and 55 dBA (maximum 57 dBA) during the day. Again, bats roosting in trees within the Portage Mountain Quarry disturbance buffer may have been subject to increased noise disturbance compared to those roosting in the cliffs and trees outside the buffer.

Bats are rarely sensitive to noise frequencies below 12 kHz (Page and Bernal 2020) and as a result the sound spectra of construction and traffic noise 'do not appreciably overlap with most bat echolocation calls or their hearing of them' (Caltrans 2016). The audiometric range of the big brown bat spans 10 kHz to 100 kHz (Simmons et al. 2016) and its hearing is most sensitive at 20 kHz (Koay et al. 1997). The lower hearing limit of the little brown myotis has been reported as 10 kHz, with peaks in sensitivity at 20 and 60 kHz (Dalland 1965 as reproduced in Department of Psychology 2021). Blasts at Portage Mountain Quarry were typically in and around 15 Hz (Dailyde and Johnston 2020).

There was little difference in the amount of high-frequency (6,300-20,000 Hz) noise measured at the south cliff during days with construction versus days without construction (**Section 5.1**; Dailyde and Johnston 2020). The greatest difference was 0.07 dB, which the authors attributed to the speed at which high-frequency noise is attenuated. Ultrasound frequencies over 20 kHz may be more disturbing to bats than lower-frequency noises such as those from instruments like surveying equipment. However, ultrasound attenuates swiftly as it travels through air, meaning that an ultrasound source would need to be very close to a bat for the noise to be audible. Arnett (2013) noted that a 65 dB level of noise can only be achieved by ultrasound noise sources within 5-20 m, depending on the portion of the ultrasound spectrum. The rapid attenuation of ultrasound through air (Drew et al. 2016) combined with the additional shielding effects of the rock within which the bats are roosting, over 130 m away, make it very unlikely that bats in the identified rock roost locations at Portage Mountain would detect any ultrasound produced at the quarry. Bats were likely to have been roosting in trees within the 300-m spatial buffer, closer to the quarry, and may have been subject to high-frequency noise produced at the quarry.

Unmeasured Parameters

Some of the variation in interactions between bat and quarry activity across bat life stages may be due to uncontrollable variables. Bat activity is known to be influenced by wind speed but no local source of wind data was available so that variable could not be included in models. Bat responses to blasting disturbance could also be affected by the number of blasts per day, though it was rare that there was more than one blast in a day at Portage Mountain. In particular, the results of the Blast model during summer (**Table 5.22**) are likely due to confounding factors because a positive response of bat activity to blasting is unlikely.

The level of noise and how far noise travels is dependent on many variables, including distance to blast, vegetation, weather, and geography. For example, quarry noise levels at the north cliff are higher than at the south cliff because there is a clear line of sight from the quarry (Dailyde et al. 2020). Based on **Figure 5.7**, **Figure 5.8**, and **Figure 5.9,** bats do not appear to be responding to singular blast events, but during periods of concentrated blasting, activity might be depressed lower that what would be expected for the temperature and time of year. For example, in 2019, the highest concentration of blasting occurred in mid-August to mid-September when a peak in activity would have been expected due to swarming, but instead bat activity was relatively low. Bats may have a threshold response to disturbance (Bennett and Zurcher 2013), where no change is evident in bat activity until a particular level of disturbance is reached. That threshold may vary by species, life stage and sex, which could also affect the variation in the results of the trend analysis.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Acoustic monitoring conducted at the north and south cliffs confirm that the quarry blasting cessation period (September 15 to May 15) avoided the periods of hibernation and emergence but blasting did overlap the swarming period in early September. The data also confirm the maternity roost occupation period (June 1 to August 15). These results support the need for spatial (buffer zones) and temporal (no-blasting period) mitigation described in the *Bat Mitigation and Monitoring Program* (BC Hydro 2020).

Results of the monitoring data analysis suggest that quarry mitigation has been generally effective:

- Noise and vibration monitoring during 2018 through 2021 (Appendix C) confirmed that work activity within the quarry appears not to have exceeded the noise and vibration thresholds in the bat mitigation and monitoring plan (BC Hydro 2020).
- Nearly all bat species previously observed in the study area starting in 2013 continue to be present based on acoustic data, including little brown myotis and northern myotis. Long-legged myotis has not been confirmed in recent years but acoustic recordings of this common and widely-distributed species are extremely difficult to discern from those of other 40 kHz Myotis species (Lausen et al. 2022a).
- Data consistent with normal annual life stages of bats continue to be recorded in 2021 after three years of quarry operation, such as:
  - emergence from hibernation;
  - maternity roosting;
  - fall activity (swarming; albeit variable); and
  - production of social calls prior to winter hibernation.
- Ongoing detections of big brown bat during the coldest months of winter are consistent with continued hibernation by this species nearby.

While these results suggest that quarry mitigation has generally been effective, some results suggest potential adverse effects and / or improvements to mitigation that could increase effectiveness.

For example, the maternity roost 9427G continues to be used, although in general, fewer bats have been counted emerging there since the peak number observed in 2018. It is unclear if the change in numbers represents a real decline or natural variability in roost use (Kellner 2020; Schorr and Siemers 2021).

Additionally, the trend analysis of bat responses to quarry disturbance produced results that vary by year and by bat life stage. In general, there was a decline in bat activity in 2018 and 2019 relative to 2017 when the quarry started (**Table 5.17,Table 5.18,Table 5.19**), but in the 2021 fall period, bat activity increased, so the decline was not consistent. The decline was, however, fairly consistent during the hibernation period - bat activity at Portage Mountain decreased in all years relative to that recorded in 2017 although the decrease in 2020 was not statistically significant.

The modelling results indicate that bat activity declined in the fall period during blasting at the quarry (**Table 5.23**). Since bats tend to swarm where they hibernate (van Schaik et al. 2015) it's possible that quarry activities, such as blasting, are causing bats to swarm elsewhere and possibly hibernate elsewhere where overwintering conditions could be different and potentially less suitable.

Recommendations are described below. Implementation of these recommendations would increase the quantity of the monitoring data to support future analysis of the effects of the quarry. BC Hydro plans to continue monitoring bats at Portage Mountain. As rock extraction at the Portage Mountain Quarry by BC Hydro has now been completed, no recommendations have been developed for modification of the mitigation for Portage Mountain quarry operations specifically.

1. The 2020 bat mitigation plan specifies a threshold of 10 bats emerging to define a maternity roost (BC Hydro 2020). This threshold may be high as maternity roosts may have fewer than 10 bats (M. Sarell, pers. comm. 2019). Specifying a lower number of individuals to be used as the threshold in future roost monitoring would also be more consistent with the 'significant roost' definitions provided in the provincial BMP (BC Ministry of Environment 2016c), which include thresholds of 6 and 4 individuals for some species/sex criteria.
2. Monitoring of the maternity roost 9427G should be continued to confirm if the changing numbers of bats recorded emerging from this roost represent a persistent decline or a change that reverses due to a combination of natural variation and the decline in quarry activity.
3. Acoustic data collection should continue as reclamation activities begin at the quarry, with the objective of comparing 2022 data with previous years to assess whether bat activity levels increase once rock extraction at the quarry has been terminated.
4. Expanding the no-blasting period to include the swarming period, e.g., September 1 to May 15, should be considered for mitigation of future mining and quarrying operations in proximity to bat hibernacula, to avoid potential impacts of blasting during this period.

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APPENDIX A

Acoustic Characteristics Used to Analyze Bat Species in the Study Area

Text description of call characteristics of bat species in the study area, modified from Lausen, C. 2017. Bat data analysis cheatsheet. Unpubl.

Common name	Scientific name (species code)	Description*
Big brown bat / silver-haired bat	*Eptesicus fuscus / Lasionycteris noctivagans* (EPFU/LANO)	Calls are very similar. Diagnostic features include: LANO produces flat calls at 25 kHz, which EPFU does not; EPFU tends towards higher frequencies in clutter seen as an Fmax that can start above 60 kHz, whereas even with higher clutter calls (call duration < 6 ms), LANO tends towards Fmax values <50 kHz. The presence of second harmonic can aid in making differentiation because an Fmax <50 kHz can be attributed to species differences rather than distance of bat from microphone.
Eastern red bat	*Lasiurus borealis* (LABO)	Can have a low Sc <45 in open environments. Fmin ranges from 35 – 45 kHz and calls often have a characteristic "upturn" to the toe. MYLU in open environments can produce calls with very low Sc values also, so in an uncluttered situation, differentiating LABO and MYLU should be done using more than just call parameters. MYLU will generally have a more pronounced "elbow" or bend to its call (like a hockey stick shape) that you do not see in LABO (which instead is a smoothly curving call) Also, LABO, being a lasiurine, will tend to an undulating up/down call pattern
Hoary bat	*Lasiurus cinereus* (LACI)	Long passes containing numerous pulses will be needed to differentiate this species from other low-frequency bats unless the calls are obviously <20 kHz with long duration (>10 ms) and TBC* (>400 ms). When call Fmin is > 20 kHz, the duration and TBC is substantially less, but there will generally be an "up and down Fmin pattern" which characterizes this species
Long-eared myotis	*Myotis evotis* (MYEV)	Calls are generally steep (Sc>250+ but as low as 150 in some cases), with Fmin varying from 30 kHz up to 40. Can overlap with northern myotis at its highest Fmin (~39 - 42 kHz). At higher frequencies where MYEV and MYSE can overlap, these passes should be placed into a general “long-eared” category. EPFU/ LANO can produce calls around 25 kHz that are steep, so there is possibility of overlapping with this species group, however, their Sc^{+} values are usually <150, whereas long-eared calls are steeper than this
Northern myotis	*Myotis septentrionalis* (MYSE)	Calls are generally steep, but unlike some of the other long-eareds, their call body slopes are more often low (as low as 150 OPS). Individual calls are generally Fmin 38-48 kHz. Below 43 kHz, MYSE overlaps with MYEV and would thus be grouped within the “Long-eared” category.
Little brown myotis	*Myotis lucifugus* (MYLU)	Often included in a more general “Myotis” or “High-frequency” category as MYLU calls resemble those of other Myotis species. Generally, this species echolocates with Fmin 32-45 kHz with a highly variable slope (Sc can be as low as 20 OPS in extremely uncluttered situations, but higher than 400 OPS in a cluttered situation such as interacting with another bat or encountering vegetation). In low clutter, the low slope of MYLU generally allows it to be discerned from other myotis; a pronounced bend (elbow) in the pulse may be seen in low clutter, and this feature is typically not present in other 40 kHz myotis. This species is widespread across Canada and is versatile in its echolocation, such that variation is immense.
Long-legged myotis	*Myotis volans* (MYVO)	Similar call to MYLU. Include in a more general “Myotis” or “High-frequency” category.

* Fmin = minimum frequency, OPS = octaves per second, Sc = Slope of the call, TBC = Time between calls

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Acoustic Characteristics of Bat Species in the Study Area (modified from Lausen 2016 with input from Hansen, I-J (pers. comm. 2018)

Species Group*						Common Name	Acoustic Parameters									
Little Brown Myotis / Eastern Red Bat	Myotis Species	Big Brown / Silver-haired Bat	High-frequency Bat	Bats with Minimum Frequency 30 kHz	Low-frequency Bat	Species	Duration (milliseconds)		Maximum Frequency (kHz)		Minimum Frequency (kHz)		Characteristic Frequency (kHz)		Slope of Call Body (Octaves per second)	
							Avg**.	Range of Averages	Avg.	Range of Averages	Avg.	Range of Averages	Avg.	Range of Averages	Avg.	Range of Averages
						Hoary bat	9.5	7.2–3.5	34	24–42	21	18 - 23	22	20 - 24	29	13 - 57.5
						Silver-haired bat	7.3	4.9–12.1	37	28–49	25.5	23–27	27	25–28	36.5	11–73.5
						Big brown bat	7	3.3–13.3	41	26–62	25.5	21–31	27	21–32	48	12–135
						Long-eared myotis	4.1	1.4–2.4	64	49–88	34	29–41	42.8	34.5–66.6	343	158–855
						Long-legged myotis	3.2	1.7–6.3	68	56–85	41	36–45	47	39–63	202	64–503
						Eastern red bat	6.5	5–8	53	49–59	41	37–45	41	37–45	29	23–41
						Little brown myotis	3.5	1.6–6.7	76.5	49–91	42	32–47	48	38–57	175	63–464
						Northern myotis	1.9	1.0–2.7	71.5	51–81	42	38.5–44	51	45–57	354	211–484

*Grey cell = Bat categories are assigned to groups of bats based on the frequency (kHz) of their calls

**Avg. = average

APPENDIX B

Portage Mountain Riprap Quarry – Blasting Vibration and Sound Levels Memo

TETRA TECH

TECHNICAL MEMO

ISSUED FOR USE

To:	Brock Simons, MSc, RP Bio Terrestrial Biodiversity Specialist Site C Clean Energy Project	**Date:**	March 28, 2022
c:		**Memo No.:**	01
From:	Aaron Nickoli, P.Eng., Ben Howden, P.Eng.	**File:**	704-ENG.KGEO03574-01 Task 003
Subject:	Portage Mountain Riprap Quarry – Blasting Vibration and Sound Levels Memo		

1.0 INTRODUCTION

Tetra Tech Canada Inc. was retained by BC Hydro to complete an assessment of blast monitoring data from the riprap quarry at Portage Mountain, Hudson's Hope, BC. This report details the review of the available monitoring data from the 2019 and 2021 construction seasons and provides estimates for the sound concussion, shockwave and ground vibration produced from blasting at the Portage Mountain riprap quarry during the 2020 construction season. The estimated values were compared to the thresholds stated in the *Best Management Practices Guidelines for Bats in British Columbia, Chapter 2 (Holroyd and Craig, 2016).* These thresholds include the following with respect to blasting:

- Sound concussion of less than 150 decibels (dB);
- Shockwave of less than 15 p.s.i. (104 kPa); and
- Ground vibration of peak particle velocity (PPV) of less than 15 mm/s.

In 2019, the blasting at Portage Mountain Quarry (PMQ) was monitored to produce a baseline for the expected sound concussion, shockwave, and ground vibrations from blasting operations. The 2020 blasting program was planned to use similar blast layouts as in 2019 and therefore the blasts were not monitored. However, during the 2020 blasting program, the blast layouts changed without additional monitoring being undertaken. The purpose of this memo is to estimate the sound concussion, shockwave, and ground vibrations resulting from the 2020 blasts using the site-specific data collected from monitoring the 2019 and 2021 blasting programs.

Since the degree to which blasting sound and vibrations propagate is atmospheric and site dependent, site specific blasting parameters were developed based on the field reports supplied by BC Hydro. Tetra Tech's derivation of these site-specific parameters relied entirely on the field data available.

2.0 NOISE AND VIBRATION MONITORING DETAILS

Bat hibernacula are located to the north and south of the quarry. Monitoring locations were set up as part of the 2019 baseline data collection program near the hibernacula. These locations have been used for each subsequent annual blasting program. The coordinates for the monitoring locations are presented in Table 2.0-1 below.

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Table 2.0-1: Monitoring Location Coordinates

Monitoring Location	UTM (10U)
North Bluff	555132E, 6204447N
South Bluff	554963E, 6203616N

Baseline noise and blast vibration monitoring was conducted in 2019 by RWDI and the results provided in *Site C Portage Mountain Quarry Hibernacula Noise & Vibration Study 2019 Report*.

Spot noise monitoring was undertaken during the 2020 blasting season. No vibration monitoring was undertaken in 2020.

In 2021, noise and blast vibration monitoring was routinely undertaken at the north and south monitoring locations.

2.1 Blast Design Reports

The blast design reports and summary tables were provided for most blasts during the 2019, 2020, and 2021 blasting programs. When reviewing the blast design reports versus the summary blast information tables, some discrepancies and errors were found. Tetra Tech revised the summary blast information assuming the blast design and diagram information best represented the blasting undertaken.

3.0 BLAST VIBRATION ANALYSIS

3.1 Blast Vibration Data

The Instantel seismographs used to monitor blasting vibration measure the vibrations caused by the blast in three directions: longitudinal, transverse, and vertical. The peak particle velocity (PPV) for a blast is the highest of those three values recorded. The *Best Management Practices Guidelines for Bats in British Columbia* provide a ground vibration limit of less than 15 mm/s for the PPV.

The vibration monitoring data for the 2019 program was provided as peak vector sum (PVS) values. The PVS is the 3D sum of the three axes (3D Pythagoras). As a result, the PVS is always larger than the PPV and if used to develop a site-specific equation for a site, can result in a 10% to 25% over estimation of the PPV value. For this reason, the 2019 data was excluded from the data set used to develop a site-specific equation for the Portage Mountain Quarry site. However, even with the potential PVS overestimation of the PPV, all 2019 monitored blasts were under the 15 mm/s PPV limit.

The Instantel blast reports for both the north and south monitoring locations were provided for the 2021 blast monitoring, which gives the PPV for the longitudinal, transverse, and vertical directions. These data were used in the development of site-specific equations for PPV estimation.

3.2 Scaled Distance

Scaled Distance (SD) reduces two controllable blast variables, distance from the blast and, charge weight of explosives, to a single variable. In blasting, the charge weight of explosives is defined as the weight of explosive detonated within an 8-millisecond delay. This means that when using appropriate delays in a blast, a very large

blast acts as a series of smaller blasts. Therefore, increasing the number of holes in a blast does not necessarily correspond to an increase in peak vibrations, air overpressures, or noise expected with an increase in the total weight of explosive used.

The Scaled Distance is defined as:

$$SD = \left(\frac{D}{\sqrt{W}}\right)$$

Where: D = Distance from the blast, in metres
W = charge weight of explosives, in kg

To estimate the Peak Particle Velocity (PPV) the following equation is used:

$$PPV = k\left(\frac{D}{\sqrt{W}}\right)^{\beta}$$

Where k and β are site specific constants developed through a SD plot. These constants allow for the capture of site-specific conditions such as, but not limited to, explosive type, rock strength, rock mass conditions such as joints and faults and topography.

3.3 Scaled Distance Plots

A SD plot is a log-log scale plot of SD versus measured PPV. The trendline (best fit) of the plotted data provides the k and β in the equation of the trendline.

Typically for forecasting PPV for a blast, a 95% regression analysis is used. This equation can then be used to estimate the maximum charge weight per delay a blast could contain while providing a high degree of confidence that a blast designed using the 95% regression equation should not exceed site PPV limits. However, when back analyzing blasts to predict PPV, the charge weight per delay is a known parameter, and a 95% regression for back analysis would result in the same overestimation of PPV from a given blast. Therefore, when reviewing the 2020 blasts for compliance with the regulatory PPV limit, the best fit equation was used to produce more realistic or likely estimates of PPV generated from the blasts, with known charge weights per delay. An equation was also developed one standard deviation above the best fit line to increase confidence that PPV estimates would not have been exceeded.

The vibration monitoring data for each bluff was analyzed separately to account for variations in the rock mass between the two monitoring locations.

3.3.1 North Bluff Best Fit Analysis

Table 3.3.1-1 below, summarizes the available blast data at the North Bluff for the 2021 monitoring program. A few outlier blasts were removed from the data set with completion of the best fit analysis as they were skewing the resulting trendline plots outside of the expected range of values of k and β. The removed blasts either plotted much higher or much lower than would be expected given the SD for the blast. Review of the blast plans provided could not resolve the discrepancies and therefore the blasts were removed from the data set for purposes of developing the best fit equation.

Table 3.3.1-1: 2021 North Bluff Monitoring Data Summary

Data	Number
Total 2021 Blasts	60
Blasts Measured at North Bluff	42
Blasts with sufficient information for scaled distance calculation	39
Blasts used in best fit model	33
Average distance to blast	502 m

The resulting best fit equation for the North Bluff was estimated to be:

$$PPV = 831.26(SD)^{-1.622}$$

Table 3.3.1-2 presents a summary of the 2020 blasts monitored at the North Bluff.

Table 3.3.1-2: 2020 North Bluff PPV Estimate Summary

Data	Number
Total 2020 Blasts	100
Blasts with sufficient information for PPV estimation	97
Number of blasts with estimated PPV above limit using best fit equation	0
Number of blasts with estimated PPV above limit using one standard deviation equation	0

3.3.2 South Bluff Best Fit Analysis

Table 3.3.2-1 below, summarizes the available blast data at the South Bluff for the 2021 monitoring program. A few outlier blasts were removed from the data set when completing the best fit analysis as they were skewing the resulting trendline plots outside of the expected range of values of k and β. The removed blasts either plotted much higher or much lower than would be expected given the SD for the blast. Review of the blast plans provided could not resolve the discrepancies and therefore the blasts were removed from the data set for purposes of developing the best fit equation.

Table 3.3.2-1: 2021 South Bluff Monitoring Data Summary

Data	Number
Total 2021 Blasts	60
Blasts Measured at South Bluff	52
Blasts with sufficient information for scaled distance calculation	47
Blasts used in best fit model	41
Average distance to the blast	364 m

The resulting best fit equation for the South Bluff was found to be:

$$PPV = 789.83(SD)^{-1.602}$$

Table 3.3.2-2 presents a summary of the 2020 blasts monitored at the South Bluff.

Table 3.3.2-2: 2020 South Bluff PPV Estimate Summary

Data	Number
Total 2020 Blast	100
Blasts with sufficient information for PPV estimation	97
Number of blasts with estimated PPV above limit using best fit equation	0
Number of blasts with estimated PPV above limit using one standard deviation equation	0

Initial review of one blast on July 17, 2020 indicated a potential exceedance in PPV. However, upon more detailed analysis of its blast geometry, it was found that the blast was unlikely to have exceeded the 15 mm/sec limit. This is discussed further in Section 5.0 – Discussion of Results and Recommendations.

4.0 AIR OVERPRESSURE ANALYSIS

In the International Society of Explosive Engineers (ISEE) Blaster's Handbook it provides the following factors which influence air overpressures resulting from a blast:

- Charge weight
- Depth of burial
- Volume of displaced rock
- Delay time intervals
- Type of explosive
- Atmospheric conditions, including but not limited to temperature, wind, temperature inversions, weather condition
- Topography

This indicates that two identical blasts, initiated at two different times could have different air overpressure readings due to changes in atmospheric conditions, at the same location.

4.1 Noise and Air Overpressure Data

During the 2021 monitoring program, data were collected from both the north and south bluffs and provide a larger data set than previous years. As such, the 2021 data were used in the noise and air overpressure analysis.

4.2 Scaled Distance

Estimation of air overpressure also relies on scaled distance in the development of the equation. The scaled distance for air overpressure utilizes the same parameters as used in the PPV calculations, except the cube root of the charge weight is used instead of the square root.

The scaled distance is defined as:

$$SD = (D/(W^{\frac{1}{3}})$$

Where: D = Distance from the blast, in metres
W = charge weight of explosives, in kg

The best fit line to calculate the air overpressure from scaled distance is defined as:

$$P = A * (SD)^{-B}$$

Where: P = Air Overpressure (pascals)
SD = Air Overpressure scaled Distance (cube roots charge weight of explosives)
B = Slope of the line (slope is negative)

Sound pressure level (SPL) in decibels (dB) is then calculated using the equation below:

$$SPL = 20\log(P) + 154$$

4.3 Scaled Distance Plots

A scaled distance plot is a log-log scale plot of scaled distance versus measure peak air overpressure. The trendline of the plotted data provides the A and B in the equation of the trendline. The 2021 monitoring air overpressure data and trendlines were plotted separately for the North and South Bluffs. Efforts to reduce the randomness of the data by filtering by weather condition and further filtering by wind direction did not improve the fit of the trendline or the randomness of the data. This was likely due to the limited atmospheric data collected, such as wind speed and atmospheric pressure.

This resulted in it not being possible to create a site-specific Air Overpressure equation for the site.

4.4 Air Overpressure Prediction Equations

Tetra Tech compiled a list of air overpressure equations from a literature review. These equations are presented in Table 4.4-1 below. For each equation, the PMQ data were utilized to predict the air overpressures generated. A review of the actual measured air overpressure versus predicted values was completed.

Table 4.4-1: Air Overpressure Prediction Equations

Blasting	Equation	Units	Source
Quarry Face	$P = 1.32 * SD_3^{-0.97}$	psi	USBM RI 8485
Behind Free Face	$P = 0.056 * SD_3^{-0.515}$	psi	USBM RI 8485
Buried (total confinement)	$P = 0.061 * SD_3^{-0.96}$	psi	USBM RI 8485
Construction Blasting – Best Fit (mean)	$P = 0.14 * SD_3^{-0.89}$	psi	Konya (2021)
Construction Blasting (95% confidence)	$P = 0.95 * SD_3^{-0.89}$	psi	Konya (2021)
Surface Coal Mine	$P = 6.31 * e^{-b} * SD_3^{-1.16}$	kPa	Linehan and Wiss (1980)

The parameters for the equations in Table 4.4-1 are as follows:

P is peak overpressure measured in the units listed

SD_3 is the cube root scaled distance

e is the base natural logarithm (e = 2.7183) – used in the Surface Coal Mine equation

b is the scaled depth of burial ($C/W^{1/3}$), $m/kg^{1/3}$ – used in the Surface Coal Mine equation

C is the depth to center of gravity of charge in metres

W is charge weight per delay in kg

4.5 Air Overpressure Equation Analysis – 2021 Data

Utilizing the equations from Section 4.4, the air overpressures for the 2021 blasts were estimated. These estimations were then compared to the measured values obtained from the monitoring program.

Table 4.5-1: 2021 North Bluff – Estimated versus Measured Air Overpressures

Item Reviewed	Quarry Face	Behind Free Face	Buried (total confinement)	Construction Blasting – Best Fit (mean)	Construction Blasting (95% confidence)	Surface Coal Mine
Number of blasts with usable monitoring data	39	39	39	39	39	39
Number of estimates higher than measured	34	20	0	0	35	24
Percentage of estimates which overestimated the air overpressure value	87%	51%	0%	0%	90%	62%

The Quarry Face and the Construction Blasting (95% Confidence) equations provided the most conservative estimates for the air overpressure experienced at the North Bluff from blasting operations.

Table 4.5-2: 2021 South Bluff – Estimated versus Measured Air Overpressures

Item Reviewed	Quarry Face	Behind Free Face	Buried (total confinement)	Construction Blasting (mean)	Construction Blasting (95% confidence)	Surface Coal Mine
Number of blasts with usable monitoring data	47	47	47	47	47	47
Number of estimates higher than measured	47	44	0	15	47	47
Percentage of estimates which overestimated the air overpressure value	100%	94%	0%	32%	100%	100%

The Quarry Face, Construction Blasting (95% Confidence) and Surface Coal Mine equations all over-predicted the air overpressures at the South Bluff, with the Behind Free Face equation over-predicting the air overpressure 90% of the time.

The air overpressures indicated are all under the threshold limits for the 2020 data, even using the most conservative predictions.

5.0 DISCUSSION OF RESULTS AND RECOMMENDATIONS

The 2021 monitoring data and blast records provided the most complete set of records and were therefore used for development of site-specific equations for PPV estimation. The 2021 data were also used for the air overpressure analysis and review of published air overpressure estimation equations.

Engineering judgement was used when doing quality control and compilation of the blast data, particularly when blast records were incomplete or missing information. Blasts with incomplete or missing information were either excluded from the analysis or conservative assumptions were used to fill in minor gaps in the available information.

It should be noted that the distance from the monitoring location to the blast was calculated based off the coordinates provided on the blast plans. The methodology for determining the coordinate of the blast was not provided but was assumed to be the geometric center of the blast.

With regards to the estimated PPV of the 2020 blasting, the North Bluff, which is located further from the blasting, experienced lower estimated PPV values. None of the blasts were estimated by the best fit equation to be above the best practice 15 mm/s limit at the North Bluff.

The South Bluff is located closer to the location of the 2020 blasting, and as a result it was expected to have experienced higher PPV than would be recorded at the North Bluff for the same blast. None of the blasts were estimated by the best fit equation to be above the best practice 15 mm/s limit at the South Bluff.

The initial review of the 2020 blast data suggested the July 17, 2020 blast may have exceeded the *Best Management Practices Guidelines for Bats in British Columbia* for ground vibration which is 15 mm/s. This conclusion was reached based on the Scaled Distance calculation which looks at the distance from the blast and

the maximum weight of explosives per 8 millisecond delay (instantaneous charge). The blast records showed that the July 17, 2020 blast was not delayed and this was confirmed through email communication with the Blasting Contractor. Therefore, the total weight of explosives was applied as the maximum instantaneous charge of the blast. Using this full weight, the estimated PPV from the blast exceeded the 15 mm/s limit.

However, upon further analysis it was found that the July 17, 2020 blast was unique in that the blast pattern was a single row of 47 holes without a delay. From analysis of the blast geometry, spacing of the holes, length of the blast, and the velocity of detonation of the detonating cord, it was estimated that the entire blast would take 17 milliseconds to detonate. This equates to more than double the 8 millisecond delay time of the instantaneous charge criterion.

(2.5 m spacing x 47 holes = 115 m)/6,700 m/sec = 17.1 milliseconds

The maximum charge per 8 millisecond delay is 347.3 kg (23 holes) which would produce a resultant PPV of 9.2 mm/s.

Therefore, under more detailed scrutiny, we believe it is unlikely that the July 17, 2020 blast would have generated a PPV in exceedance of the 15 mm/s limit in the Best management Practices Guidelines.

For estimating the air overpressures resulting from the 2020 blasts, all 6 of the equations presented in Section 4.4 were applied to the 2020 blast data. For both the North and South Bluffs, all blasts were estimated to be under the *Best Management Practices Guidelines for Bats in British Columbia* threshold values of:

- Sound concussion of less than 150 decibels (dB)
- Shockwave of less than 15 p.s.i. (104 kPa)

Based on the percentage of 2021 blasts where the air overpressure was overestimated by the Quarry Face and Construction Blasting (95% Confidence) equations, it is unlikely that any of the 2020 blasts exceeded the sound concussion and shockwave thresholds.

With the difficulty in back analysis air overpressure values for blasts, it would be recommended that any future blasts be monitored to ensure compliance with the best practice guidelines.

6.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of BC Hydro and their agents. Tetra Tech Canada Inc. (Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than BC Hydro, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on the Use of this Document attached in the Appendix or Contractual Terms and Conditions executed by both parties.

7.0 CLOSURE

We trust this technical memo meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech Canada Inc.

<Original signed by>

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APPENDIX A

TETRA TECH'S LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

GEOTECHNICAL

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TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, TETRA TECH has not been retained to explore, address or consider and has not explored, addressed or considered any environmental or regulatory issues associated with development on the subject site.

1.8 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems, methods and standards employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. TETRA TECH does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

1.9 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

1.10 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historical environment. TETRA TECH does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional exploration and review may be necessary.

1.11 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

1.12 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

1.13 INFLUENCE OF CONSTRUCTION ACTIVITY

Construction activity can impact structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques, and construction sequence are known.

1.14 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, and the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

1.15 DRAINAGE SYSTEMS

Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function. Where temporary or permanent drainage systems are installed within or around a structure, these systems must protect the structure from loss of ground due to mechanisms such as internal erosion and must be designed so as to assure continued satisfactory performance of the drains. Specific design details regarding the geotechnical aspects of such systems (e.g. bedding material, surrounding soil, soil cover, geotextile type) should be reviewed by the geotechnical engineer to confirm the performance of the system is consistent with the conditions used in the geotechnical design.

1.16 DESIGN PARAMETERS

Bearing capacities for Limit States or Allowable Stress Design, strength/stiffness properties and similar geotechnical design parameters quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition used in this report. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions considered in this report in fact exist at the site.

1.17 SAMPLES

TETRA TECH will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

1.18 APPLICABLE CODES, STANDARDS, GUIDELINES & BEST PRACTICE

This document has been prepared based on the applicable codes, standards, guidelines or best practice as identified in the report. Some mandated codes, standards and guidelines (such as ASTM, AASHTO Bridge Design/Construction Codes, Canadian Highway Bridge Design Code, National/Provincial Building Codes) are routinely updated and corrections made. TETRA TECH cannot predict nor be held liable for any such future changes, amendments, errors or omissions in these documents that may have a bearing on the assessment, design or analyses included in this report.

APPENDIX C

Site C Portage Mountain Quarry Hibernacula Noise and Vibration Study

REPORT

SITE C PORTAGE MOUNTAIN QUARRY HIBERNACULA NOISE & VIBRATION STUDY

HUDSON'S HOPE, BC.

2020 – 2021 MEASUREMENT SUMMARY

RWDI # 2002354

January 14, 2022

SUBMITTED TO

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TABLE OF CONTENTS

1 INTRODUCTION 1

1.1 Site and Measurement Overview 1

1.2 Hibernacula Criteria 2

2 MEASUREMENT SUMMARY 3

2.1 Monthly Noise Monitoring: 2020 and 2021 3

2.2 Long-term Blast Monitoring 3

3 RESULTS 4

3.1 Monthly Noise Monitoring: 2020 and 2021 4

3.1.1 High Frequency Noise 5

3.2 Long-Term Blast Monitoring 6

3.2.1 Comparison on LZpeak and Overpressure / Sound Concussion (dBL) 8

4 CONCLUSIONS 8

5 REFERENCES 9

DRAFT

LIST OF TABLES

Table 1: Summary of the Monthly Noise Monitoring 3
Table 2: Monthly and Overall Average Sound Levels for North Bluff, South Bluff, and Background 4
Table 3: Maximum Measured Metrics Compared to Blasting Criteria 6
Table 4: Comparison of Measured Blast Levels using the MiniMate Overpressure Microphone and a Standard Microphone reporting LZ Peak 8

LIST OF FIGURES

Figure 1: Location of the noise and vibration monitoring locations, bat hibernacula, and Portage Mountain Quarry. 2
Figure 2: Average Overall Hourly LA_{EQ} for the South and North Bluffs (2020 and 2021 monitoring) 5
Figure 3: Comparison of High Frequency Sound Levels During Construction Activities to the 2019 Off Hours 6
Figure 4: Count of Blasts Binned by Recorded Sound Concussion (dBL) 7
Figure 5: Count of Blasts Binned by Recorded Peak Vector Sum (mm/s) 7

LIST OF APPENDICES

Appendix A: Monthly Monitoring Graphs
Appendix B: Summary of MiniMate Blasting Data

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VERSION HISTORY

Index	Date	Pages	Author
DRAFT	December 14, 2021	All	Matthew Johnston, P.Eng. Daniel Kremer, EIT, M.Sc.
DRAFT	January 14, 2022	All	Matthew Johnston, P.Eng. Daniel Kremer, EIT, M.Sc.

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1 INTRODUCTION

RWDI was retained by BC Hydro (BCH) to analyze noise and vibration data collected by BCH from the Portage Mountain Quarry (PMQ) operations over the years of 2020 and 2021. Monitoring was conducted at representative locations for nearby bat roosts (hibernacula). The monitoring programs were completed in the 2020 and 2021 summer months and covered the following:

1. Monthly noise measurements at the north bluff, south bluff, and background locations; and
2. Long-term sound concussion and vibration blast monitoring at the north bluff and south bluff.

We acknowledge this work is being conducted on the traditional territory of Treaty 8 First Nations of Dunne Zaa, Cree and Tse'khene cultural descent.

This report summarizes the findings from the monitoring. Where measurements captured blasting, the measured levels were compared to the specified criteria limits taken from the Best Management Practices (BMP) Guidelines for Bats in British Columbia (BC MOE 2016). The BMP suggests best practice limits for noise and vibration due to blasting with respect to levels experienced at hibernacula.

1.1 Site and Measurement Overview

The PMQ is located approximately 13 km southwest of the town of Hudson's Hope, BC. The quarry provides aggregate materials for the construction of the Site C hydroelectric dam. Bat hibernacula were identified on the north bluff and the south bluff overlooking the working area. Monitoring of noise and vibration was focused near the identified hibernacula. Background noise measurements were taken approximately 5 km northeast from the quarry.

Figure 1 shows the overview of the considered area highlighting the north and south bluff hibernacula areas, the PMQ footprint, and the locations of the monitoring. Both the monthly noise monitoring and the 2021 blast monitoring were conducted in the general areas marked for the north and south bluffs.

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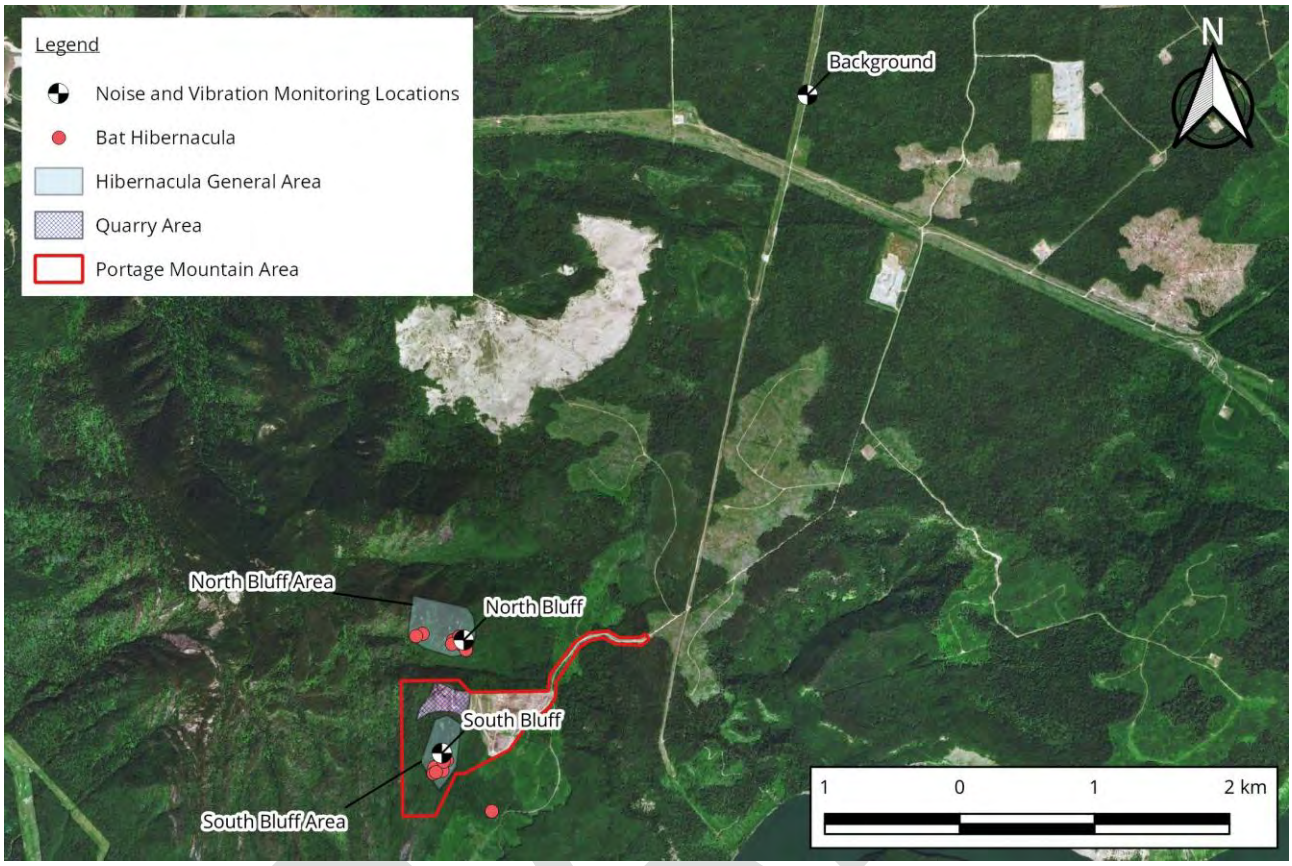

Figure 1: Location of the noise and vibration monitoring locations, bat hibernacula, and Portage Mountain Quarry.

1.2 Hibernacula Criteria

The guideline criteria specified in the Best Management Practices Guidelines for Bats in British Columbia (BC MOE 2016) for blasting states criteria of:

- sound concussion less than 150 dBL; and
- shockwave less than 15 psi (equivalent to 194 dB, using a reference pressure of 20 µPa)
- peak particle vibration level threshold of 15 mm/s.

Overall daytime and nighttime sound level limits do not have any specific criteria limits for the hibernacula. Overall levels are computed and presented for comparison to historic measured levels.

2 MEASUREMENT SUMMARY

2.1 Monthly Noise Monitoring: 2020 and 2021

Monthly noise monitoring was conducted by BCH staff during 2020 and 2021. In general, three measurements at different locations were taken during monthly monitoring. The first being at the south bluff, the second at the north bluff, and the third taken at a representative background noise location. The background noise measurements were taken at a distance such that the PMQ activities would not influence the sound levels.

Monitoring was conducted using a Bruel and Kjaer 2250 class 1 sound level meter. The sound level meter was deployed on a tripod approximately 1.5 m above the ground. The sound level meter was set to record continuous time weighted sound levels (Leq). The length of the measurement was at the discretion of BCH staff.

Table 1 lists the summary of the monthly monitoring data obtained from BCH. Figures of the measurement levels can be found in Appendix A.

Table 1: Summary of the Monthly Noise Monitoring

South Bluff		North Bluff		Background	
Deploy Date	Length of Measurement (Hours)	Deploy Date	Length of Measurement (Hours)	Deploy Date	Length of Measurement (Hours)
5/23/2020	23.7	5/24/2020	0.7	5/24/2020	0.9
6/26/2020	25.4	6/26/2020	0.8	6/25/2020	0.8
7/20/2020	23.7	7/21/2020	22.8	7/23/2020	0.5
8/15/2020	23.8	8/15/2020	8.2	8/17/2020	0.6
9/25/2020	23.8	9/27/2020	24.4	9/28/2020	1.0
5/31/2021	64.7	5/17/2021	85.5	-	-

Note: - indicates no measurement was conducted

2.2 Long-term Blast Monitoring

Long-term blast monitoring was conducted by BCH with support from Explotech and RWDI from May through September, 2021. The monitoring used the MiniMate Plus blast monitoring device, and measured overpressure and peak particle velocity (PPV). Both the north and south bluffs had one MiniMate monitor each. The system used a threshold trigger in both overpressure and PPV to log events, and was connected to a cellular modem for remote data collection.

In total, over 3,000 triggered events were recorded by the MiniMates at the two locations combined. RWDI received a log of the PMQ blasts for the 2021 year from BCH. The blast log was used to filter for blasting events recorded by the MiniMate by specifying exact times and dates.

3 RESULTS

3.1 Monthly Noise Monitoring: 2020 and 2021

The daytime and nighttime A-weighted average equivalent sound level (LA_{EQ}) per month has been calculated and are presented in Table 2. The average daytime and nighttime LA_{EQ} for the entire monitoring period of 47 dBA and 41 dBA respectively for the south bluff, and 55 dBA and 48 dBA respectively for the north bluff.

Table 2: Monthly and Overall Average Sound Levels for North Bluff, South Bluff, and Background

Month	Overall Sound Levels (dBA)					
	South Bluff		North Bluff		Background	
	Day[1]	Night[2]	Day[1]	Night[2]	Day[1]	Night[2]
May-20	41	32	55	-	55	-
Jun-20	48	43	57	-	49	-
Jul-20	51	41	52	38	33	-
Aug-20	49	43	52	43	38	-
Sep-20	47	42	55	55[3]	58	-
May-21	45	40	53	42	-	-
Overall	**47**	**41**	**55**	**48**	**-**	**-**
2019 Overall	45	41	ND			

Notes: [1] Daytime hours are from 07:00 to 22:00
[2] Nighttime hours are from 22:00 to 07:00
[3] Construction throughout the nighttime audible
- indicates no measurement conducted
ND indicates not determined in the 2020 report.

The table also compares the overall LA_{EQ} for the south bluff as measured during the 2019 south bluff monitoring program (RWDI, 2020), having average daytime and nighttime levels of 45 dBA and 41 dBA respectively. The overall sound levels demonstrate that levels have remained consistent for the three years during the monitoring months.

Of particular interest are the sound levels at the north bluff. The daytime levels may be explained by the vantage the north bluff has to the quarry: an almost unobstructed view, which would result in potential louder daytime levels.

The nighttime sound levels at the north bluff for September 2020 are equal to the daytime levels, and can be attributed to nighttime work. The audio for that period indicates that construction occurred continuously throughout the night.

The background measurements 5 km northeast from the quarry show how much the sound levels can change in a wooded environment. Daytime levels were measured as low as 33 dBA (similar to the nighttime levels on the south bluff), to as much as 58 dBA in the area.

For each hour of the day, an LA_{EQ} was computed for the entire monitoring period. Figure 2 shows the LA_{EQ} sound levels at the north and south bluffs, for each hour of the day. South bluff hourly data match the 2019 results with good agreement.

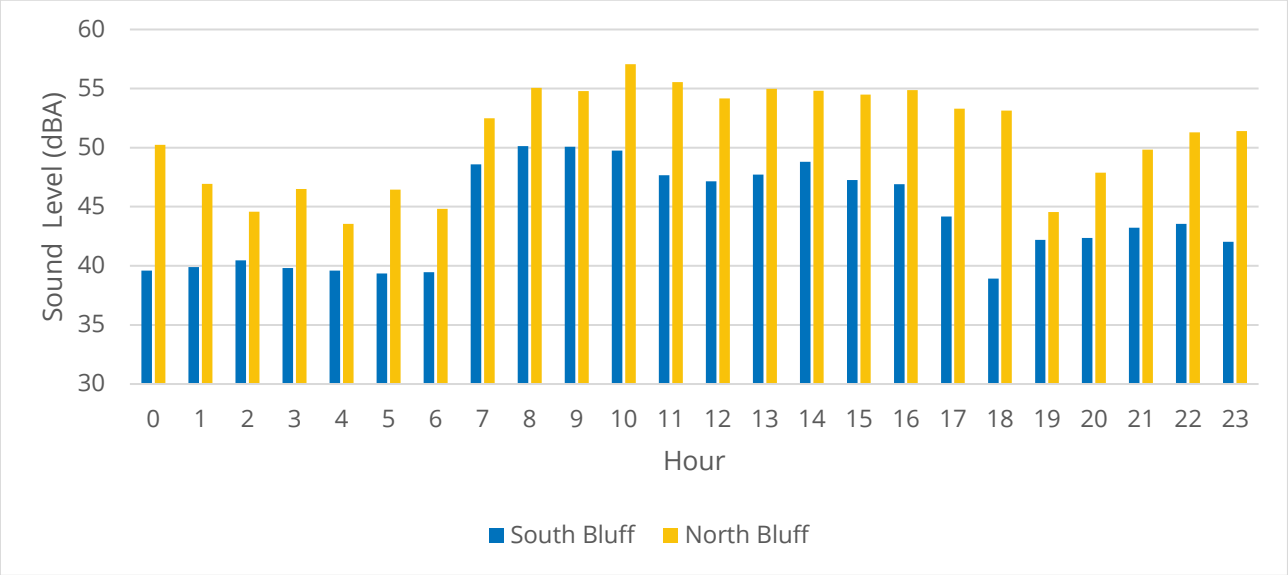

Figure 2: Average Overall Hourly LA_{EQ} for the South and North Bluffs (2020 and 2021 monitoring)

3.1.1 High Frequency Noise

As bats use high frequency acoustics for echolocation and communication, a review of the measured levels in the upper frequency ranges of the noise data unit was completed. There are no established criteria with which to compare high frequency noise, to determine if the levels are acceptable.

In the 2019 south bluff report, the high frequency noise components from 6300 Hz to 20000 Hz were reported using the 99th percentile values for daytime hours when construction was active and not active. The conclusion was that there was negligible difference between the construction and non-construction.

The same high frequency components were calculated for the south bluff using the same parameters for the daytime construction hours of 06:00 – 17:00 for the 2020/2021 program.

Figure 3 shows the computed the 99th percentile high frequency levels during construction (blue), and compares the data to the 2019 no construction levels (red). The figure shows that the levels are slightly different for the south bluff between the two monitoring programs (2019 and the 2020/2021 programs). The frequency bands of 6300 Hz and 8000 Hz show slightly increased levels at the south bluff, but that levels are lower in the higher frequency bands.

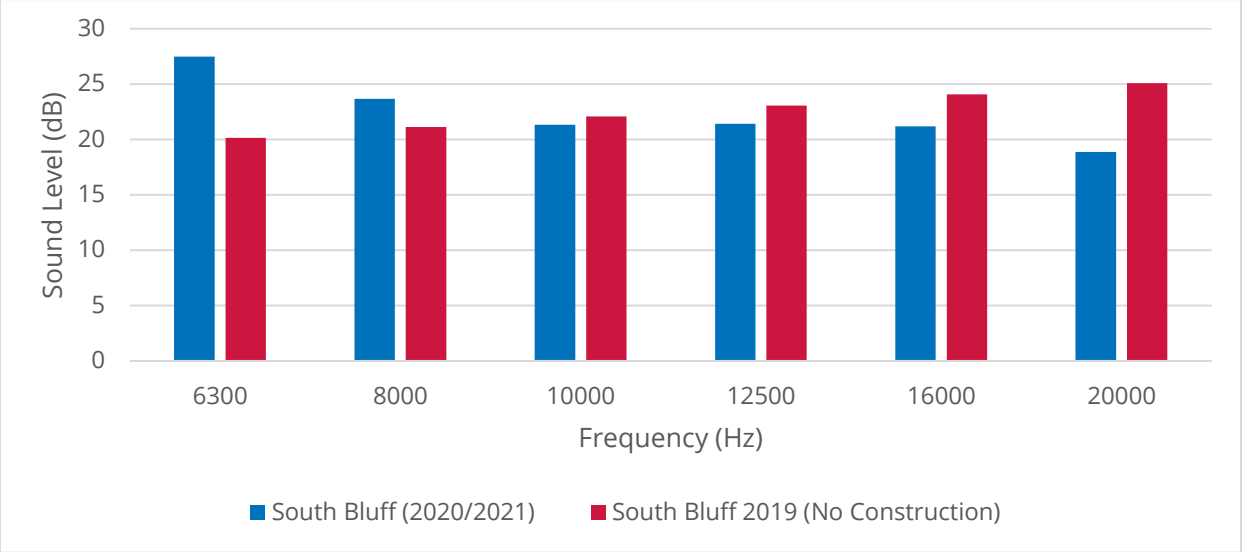

Figure 3: Comparison of High Frequency Sound Levels During 2020/2021 Construction to the 2019 Off Hours on the South Bluff

3.2 Long-Term Blast Monitoring

The MiniMate records sound concussion pressure in Pa, which has been converted to dBL using a reference pressure of 20 µPa. The MiniMate records ground-vibration as Peak Particle Velocity (PPV) in mm/s for the X, Y, and Z components of ground movement. The maximum PPV signal in the X, Y and Z components have been summed to provide the Peak Vector Sum (PVS) for comparison to criteria.

Table 3 shows the maximum recorded values at either south or north bluff, and their corresponding criteria limits.

Table 3: Maximum Measured Metrics Compared to Blasting Criteria

Metric	Measured	BC MOE 2016 Limit
Max PVS (mm/s)	9	15
Max Sound Concussion (dBL)	130	150
Max Shock Wave (psi)	0.0095	15

As shown in Table 3, the maximum measured metrics are all below the applicable criteria and therefore, all measured blasts are below the applicable criteria.

A full listing of the all the recorded blasts is provided in Appendix B. Figure 4 below shows the sound concussion for recorded blasts at the south and north bluffs in dBL. Figure 5 shows the PVS for recorded blasts at the south and north bluffs in mm/s.

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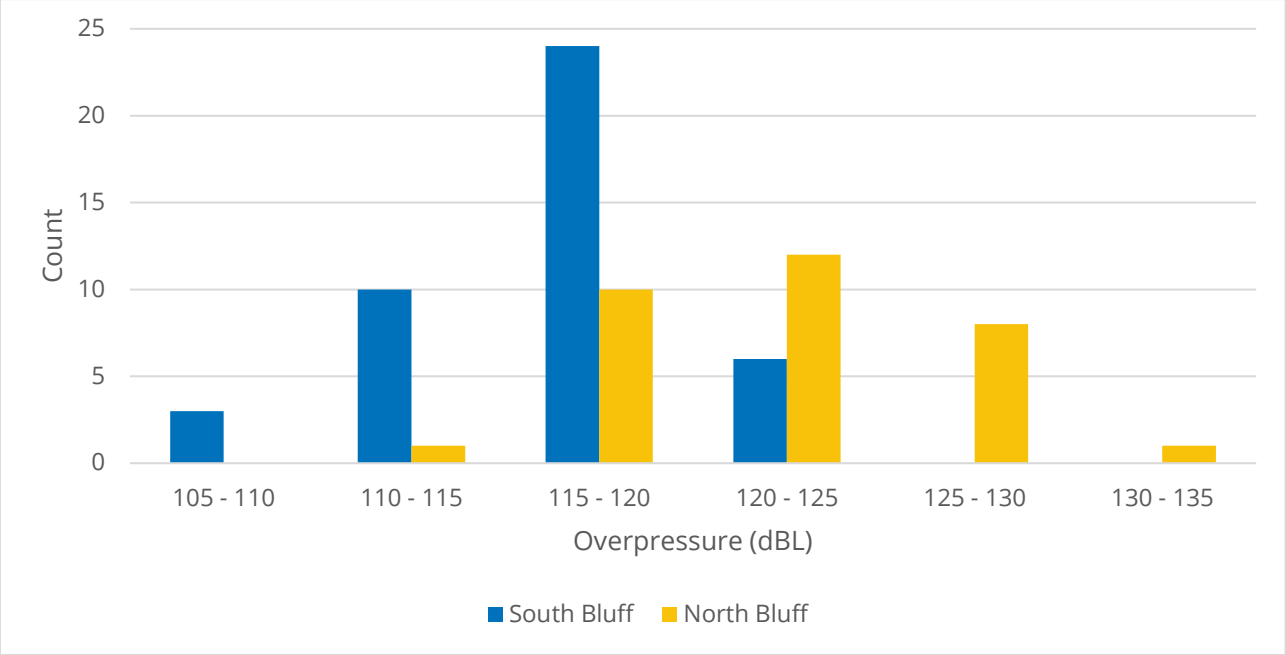

Figure 4: Count of Blasts Binned by Recorded Sound Concussion (dBL)

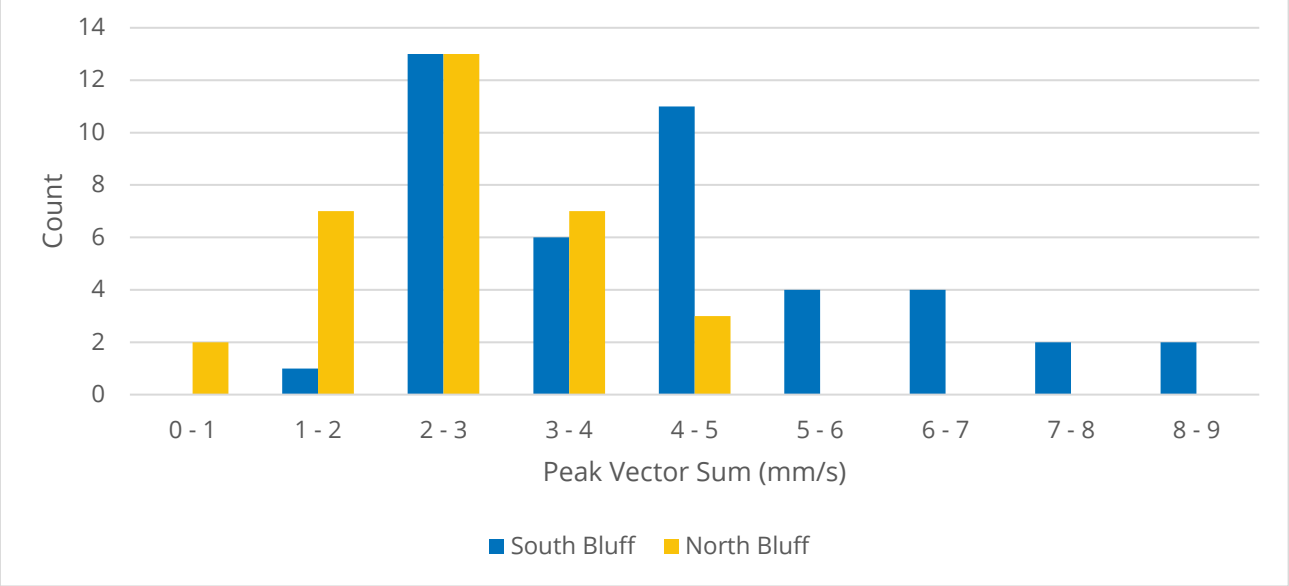

Figure 5: Count of Blasts Binned by Recorded Peak Vector Sum (mm/s)

3.2.1 Comparison on LZpeak and Overpressure / Sound Concussion (dBL)

In the 2019 PMQ measurements, a standard scientific IEPE microphone was used to obtain noise measurements. The LZpeak measurement level from this standard class 1 microphone was used to compare with BMP overpressure blast criteria.

The May 2021 noise measurements at the North Bluff captured LZpeak with the Bruel and Kjaer sound level meter, which uses a standard class 1 microphone. At the same time the MiniMate captured events using the overpressure microphone. Two blasts were captured on both devices at approximately the same distance from the blasts on the north face. These blasts are shown in Appendix A, Figure A17.

Table 1 shows the comparison of the two measurements from the two devices. The levels agree well with each other indicating that at these distances from a blast, a standard microphone reporting LZpeak is representative of overpressure.

Table 4: Comparison of Measured Blast Levels using the MiniMate Overpressure Microphone and a Standard Microphone reporting LZ Peak

Date	Time	MiniMate Overpressure (dBL)	Bruel and Kjaer LZ Peak (dB)
5/19/2021	6:02:50 PM	130	132
5/20/2021	5:59:31 PM	122	122

4 CONCLUSIONS

RWDI obtained and analyzed the blasting data for the two bluffs and compared the results to Best Management Practices (BMP) Guidelines for Bats in British Columbia (BC MOE 2016) criteria limits. The record showed that for the north and south bluffs all blasts were less than the specified criteria from the BMP.

Six months of monthly noise data were obtained for general construction noise at the two bluffs and key metrics were analyzed. Although there are no applicable noise limits for construction, the levels at the south bluff in 2020 and 2021 are similar (+2 dB for daytime hours) to previous measurements conducted in 2019. This indicates that sound levels from construction activities have remained relatively constant. High frequency noise has also remained objectively consistent, with octave bands in the 6300 Hz and 8000 Hz frequencies being greater and all remaining higher frequencies in 2020 and 2021 being less than previously measured in 2019.

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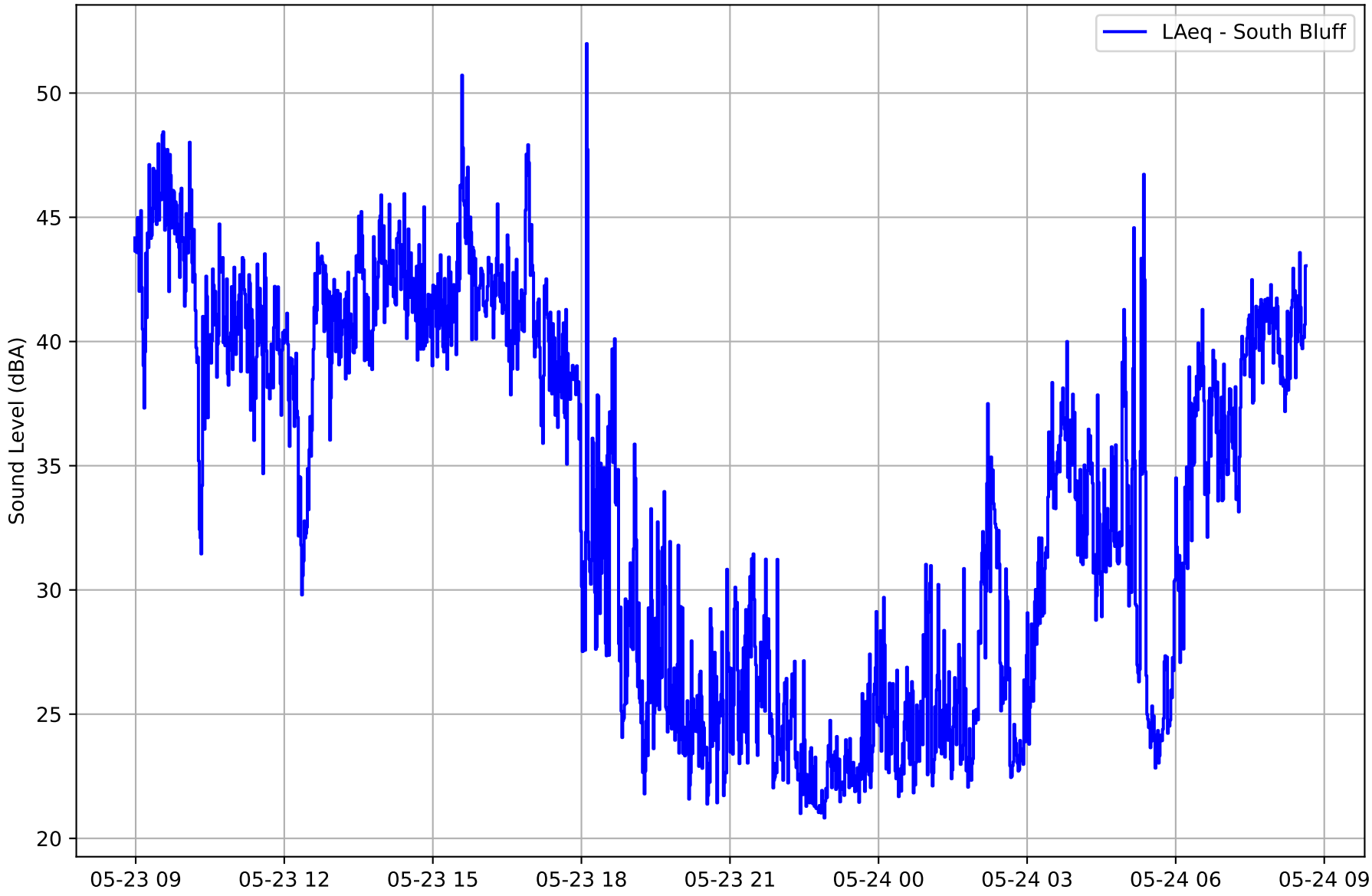


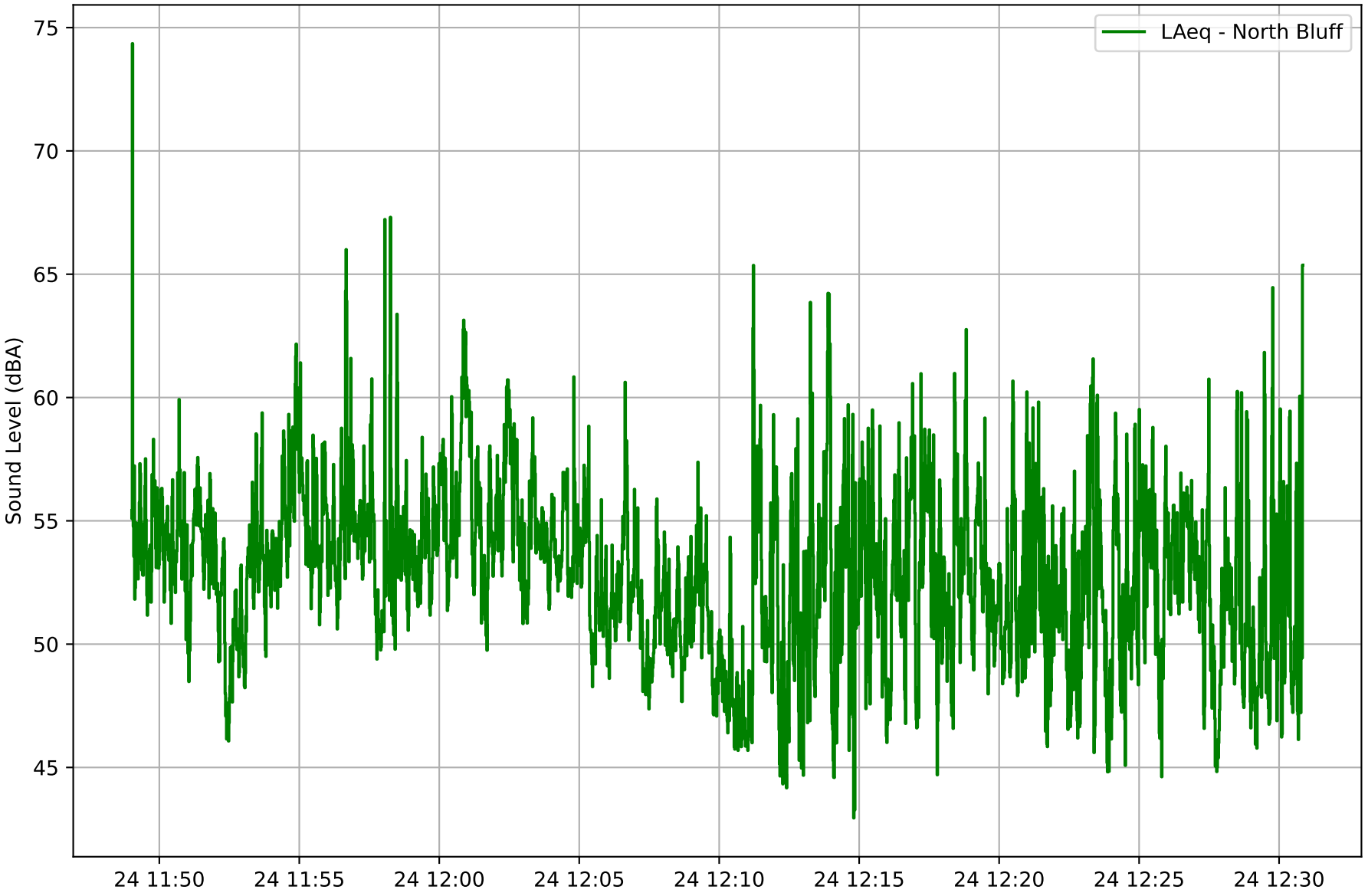
BC Hydro Site C
Monthly Noise Monitoring
May 2020 - South Bluff

Portage Quarry, British Colombia

Project #: 2002352

Figure No. A1

Date Revised: 2021-12-14



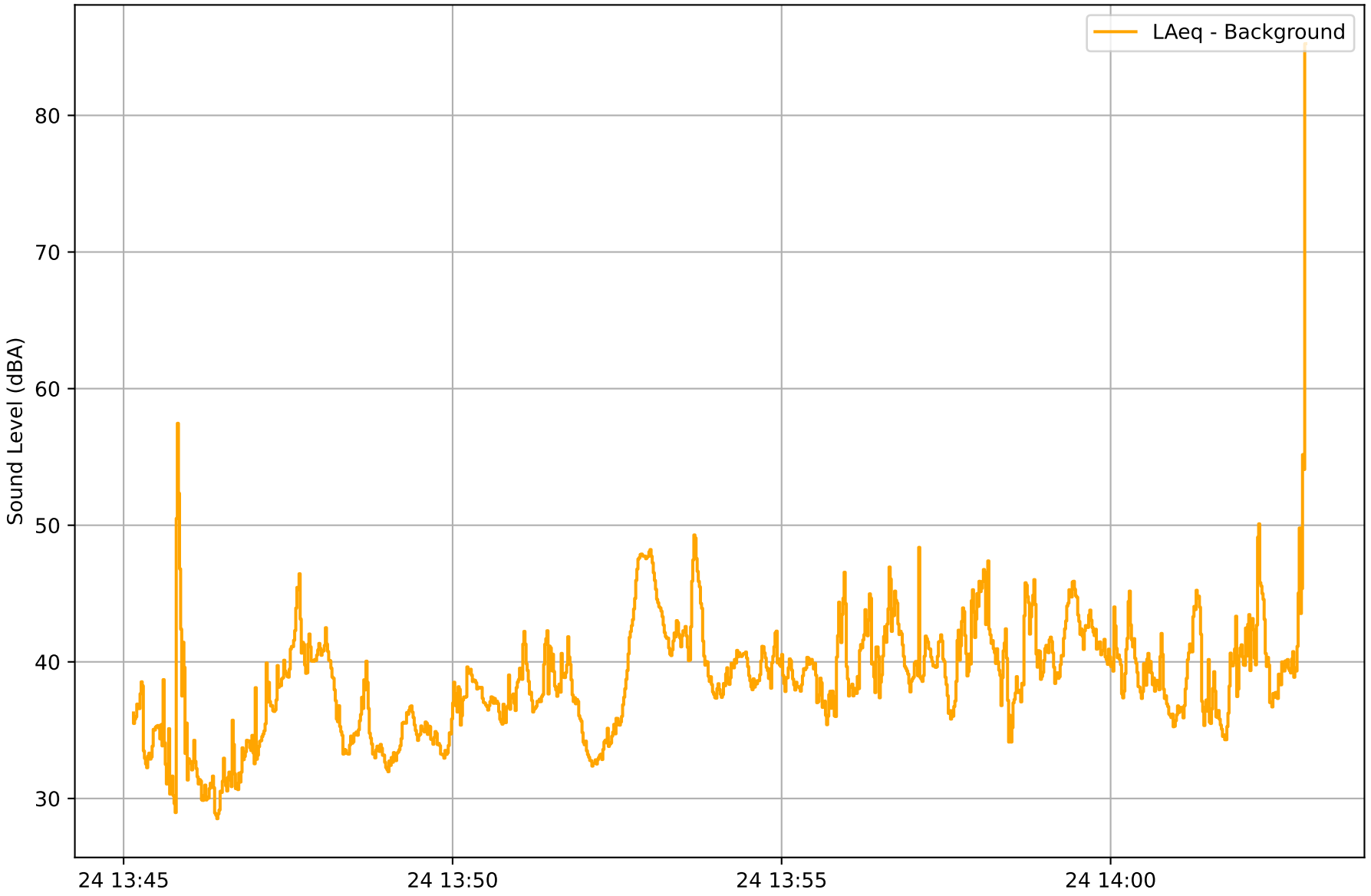
BC Hydro Site C
Monthly Noise Monitoring
May 2020 - North Bluff

Portage Quarry, British Colombia

Project #: 2002352

Figure No. A2

Date Revised: 2021-12-14



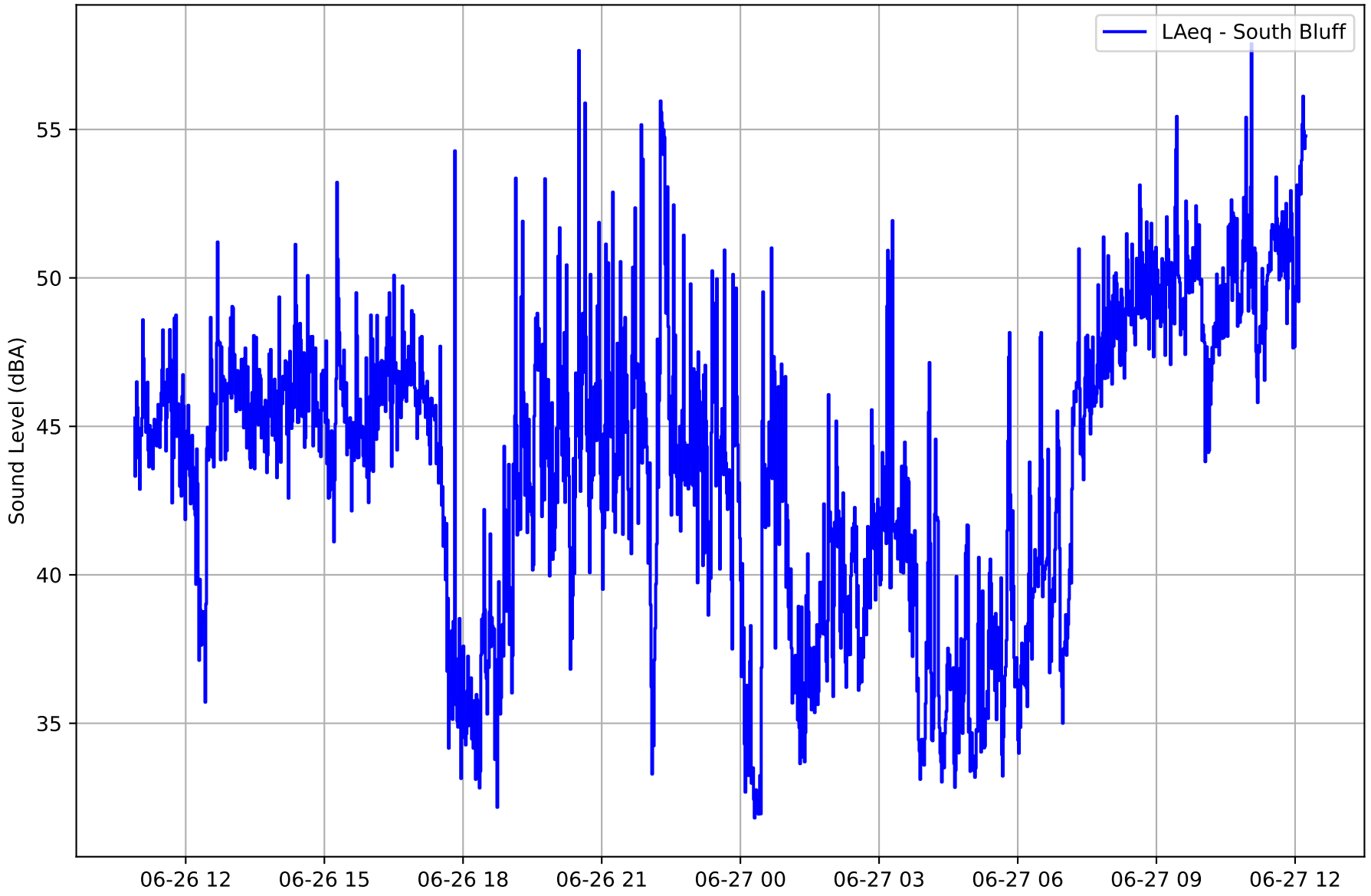
BC Hydro Site C
Monthly Noise Monitoring
May 2020 - Background

Portage Quarry, British Colombia

Project #: 2002352

Figure No. A3

Date Revised: 2021-12-14



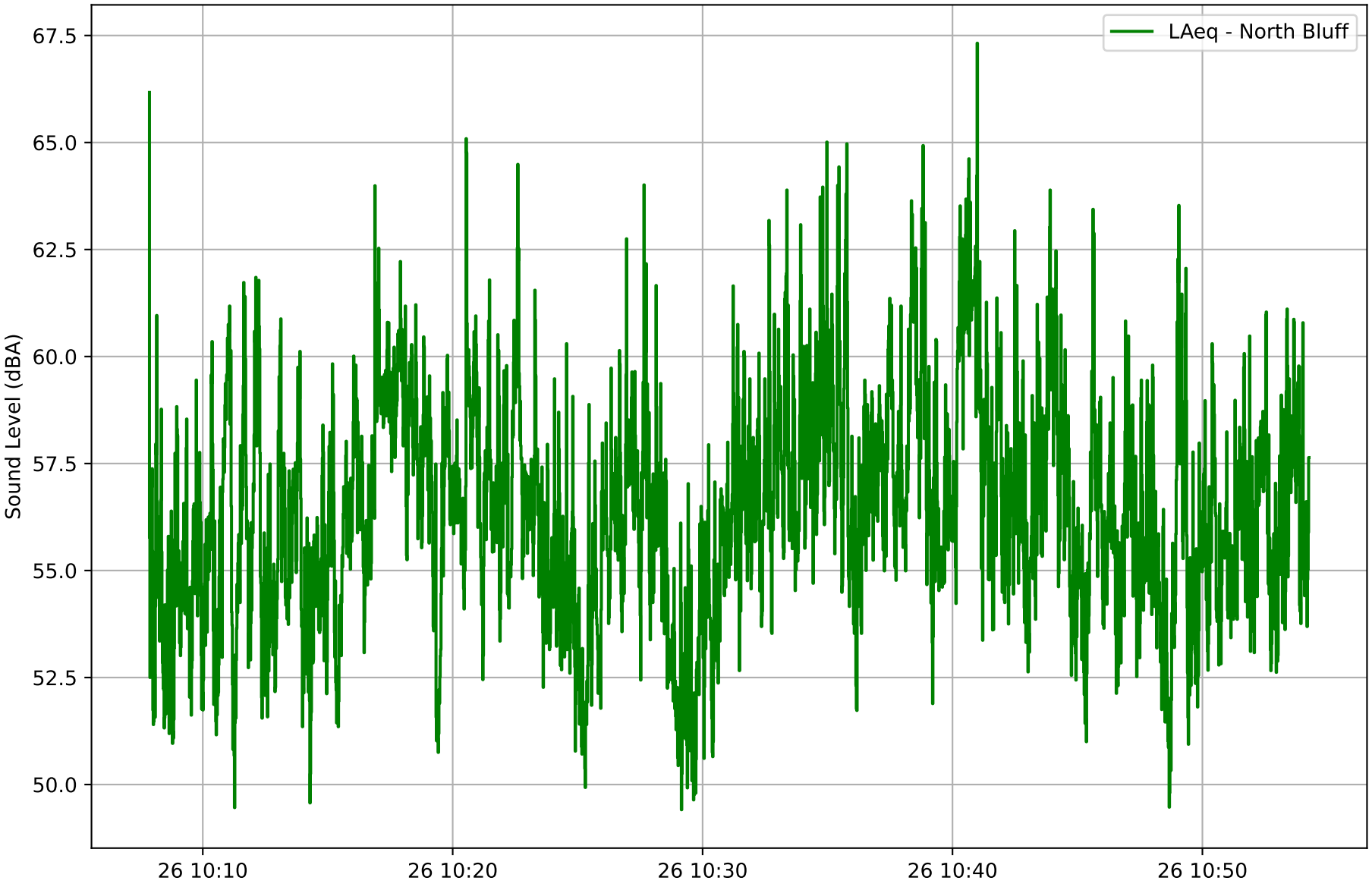
BC Hydro Site C
Monthly Noise Monitoring
June 2020 - South Bluff

Portage Quarry, British Colombia

Project #: 2002352

Figure No. A4

Date Revised: 2021-12-14



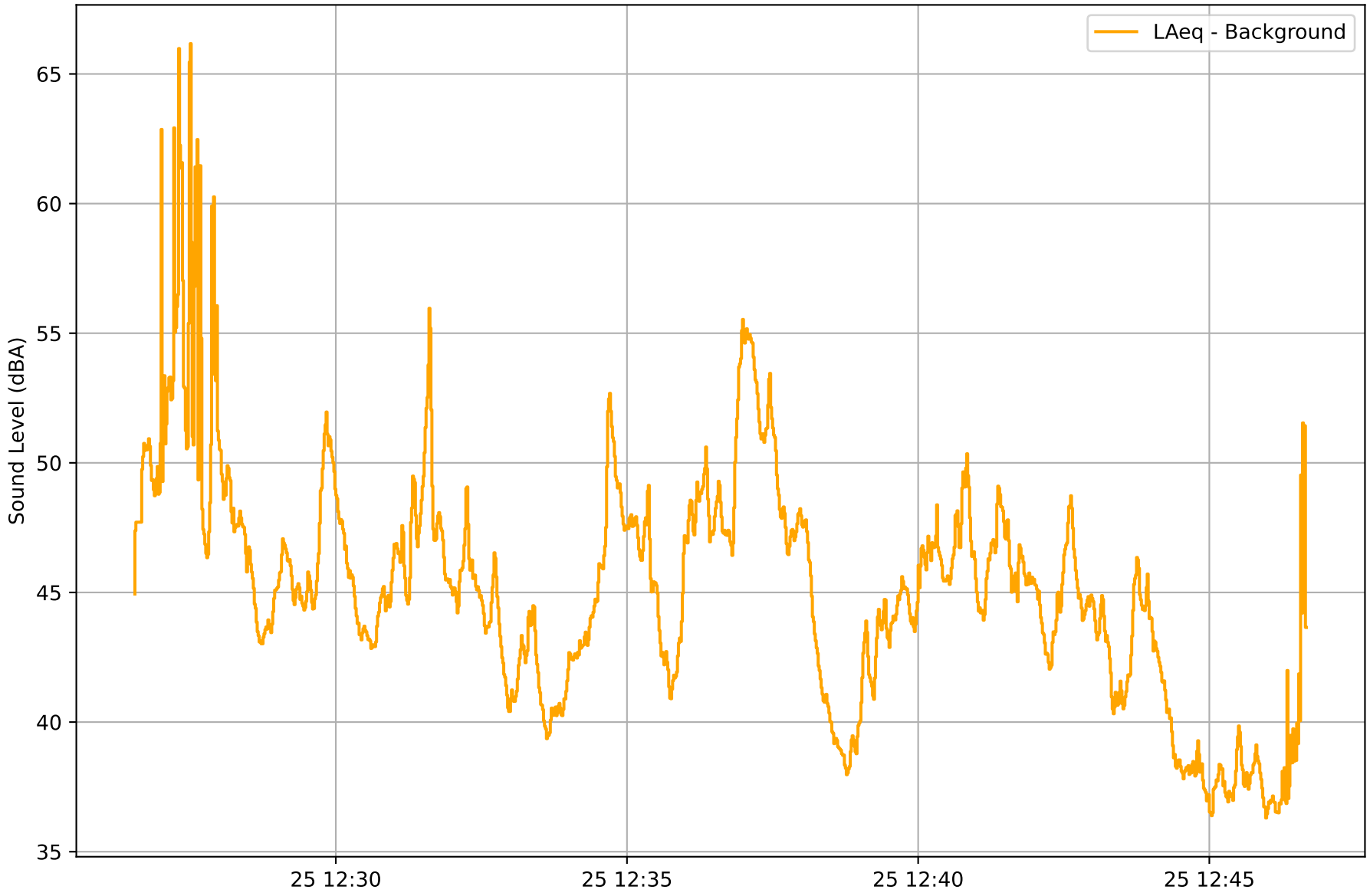
BC Hydro Site C
Monthly Noise Monitoring
June 2020 - North Bluff

Portage Quarry, British Colombia

Project #: 2002352

Figure No. A5

Date Revised: 2021-12-14



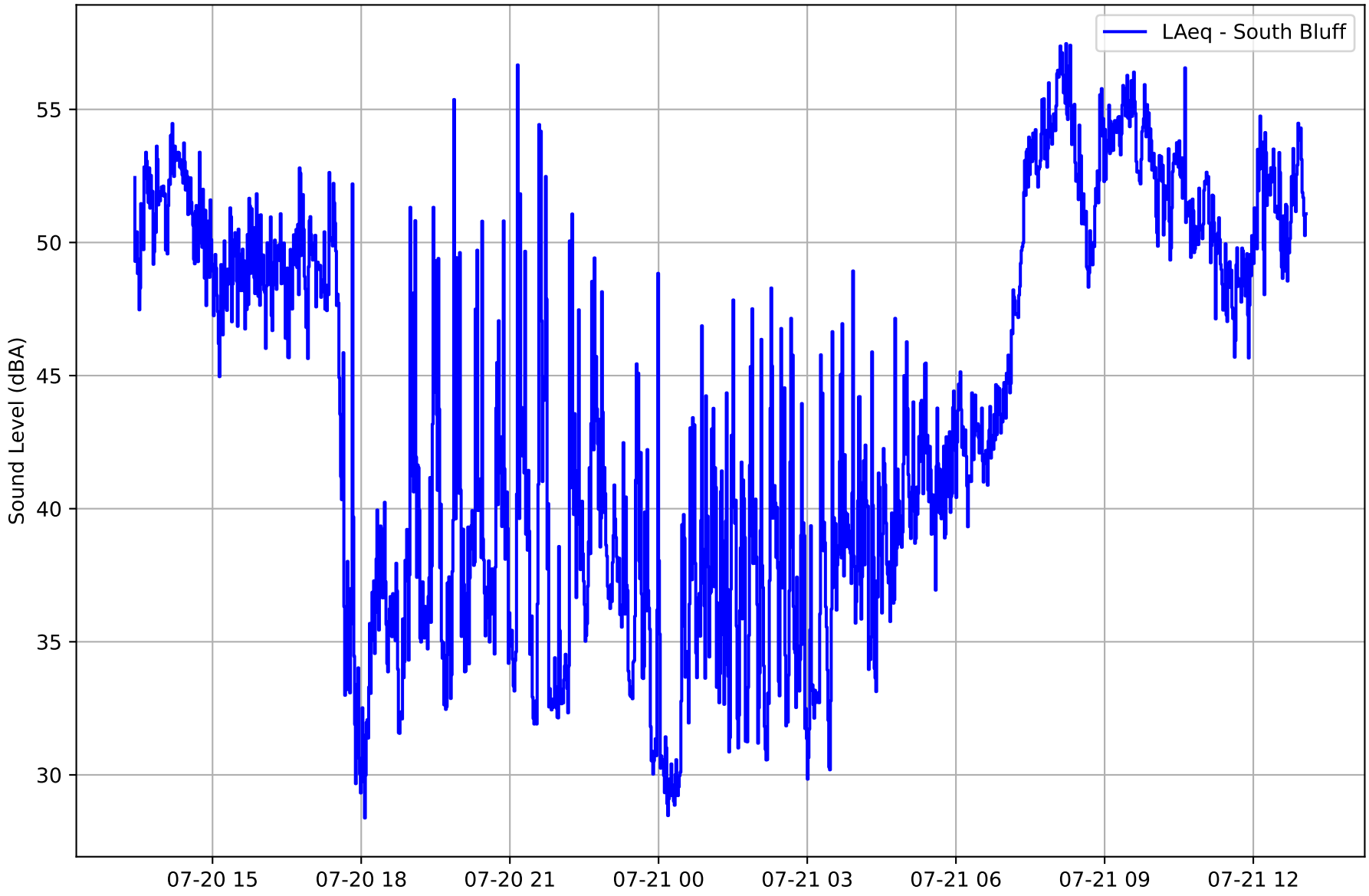
BC Hydro Site C
Monthly Noise Monitoring
June 2020 - Background

Portage Quarry, British Colombia

Project #: 2002352

Figure No. A6

Date Revised: 2021-12-14



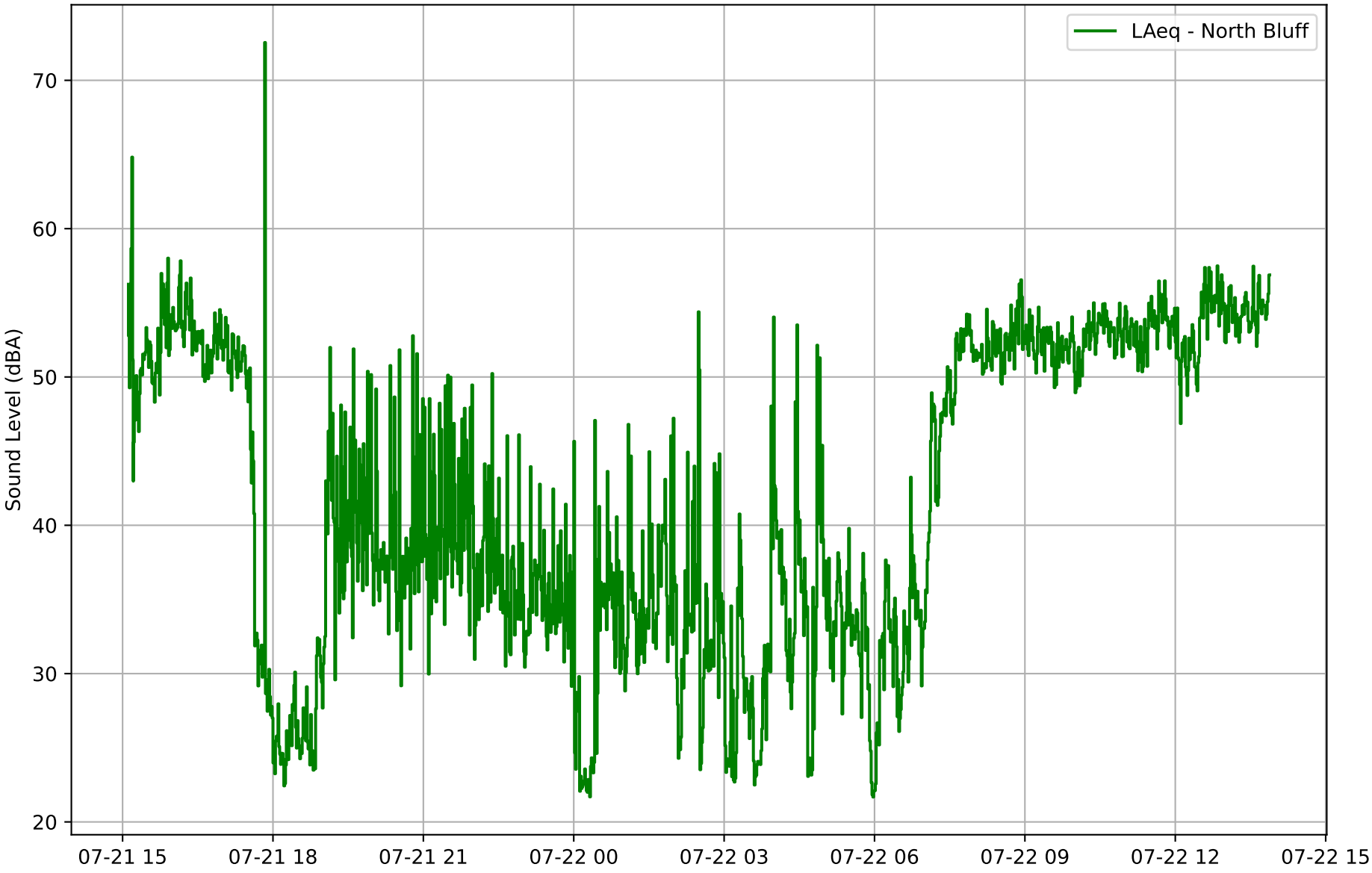
BC Hydro Site C
Monthly Noise Monitoring
July 2020 - South Bluff

Portage Quarry, British Colombia

Project #: 2002352

Figure No. A7

Date Revised: 2021-12-14



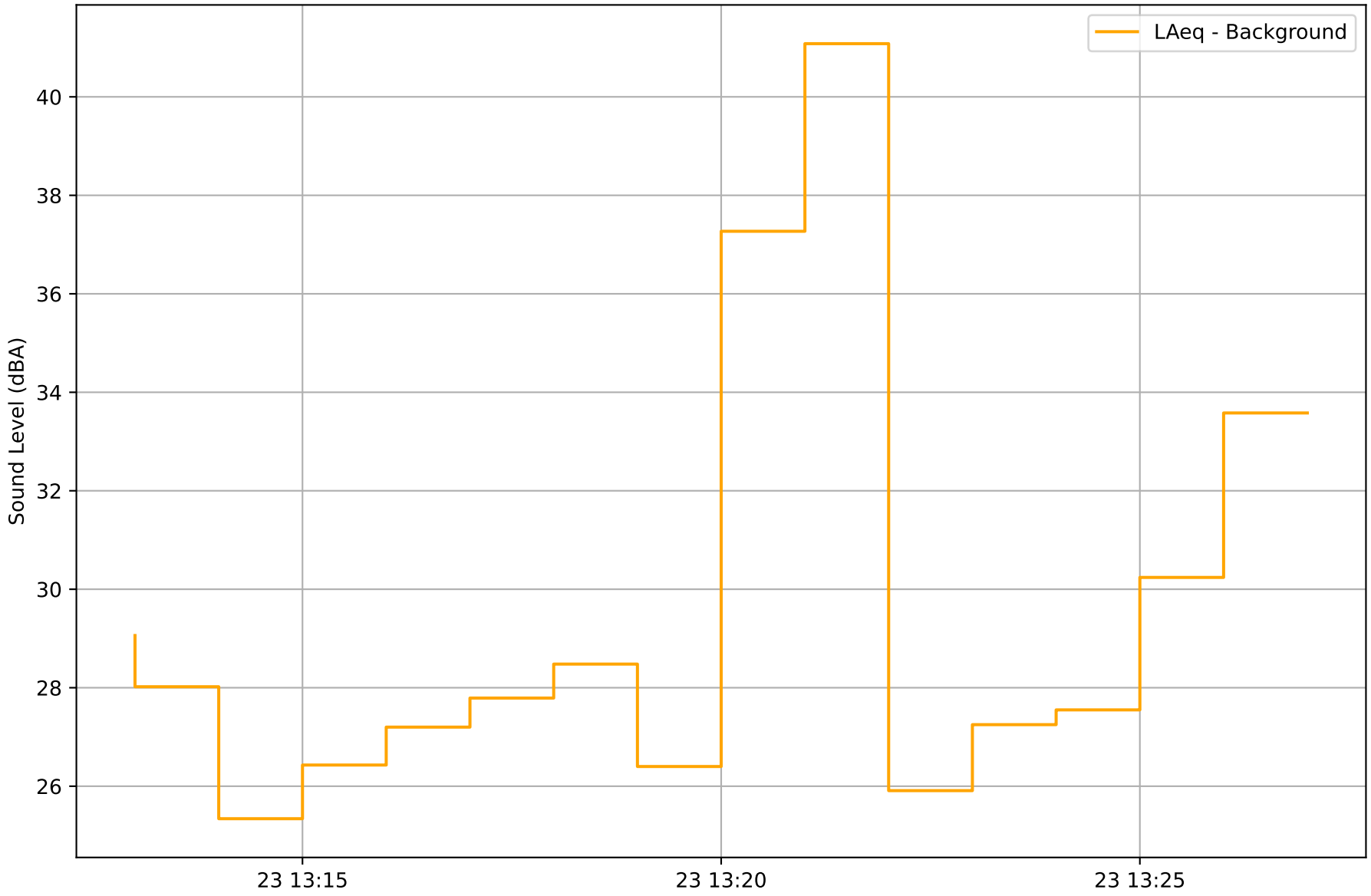
BC Hydro Site C
Monthly Noise Monitoring
July 2020 - North Bluff

Portage Quarry, British Colombia

Project #: 2002352

Figure No. A8

Date Revised: 2021-12-14



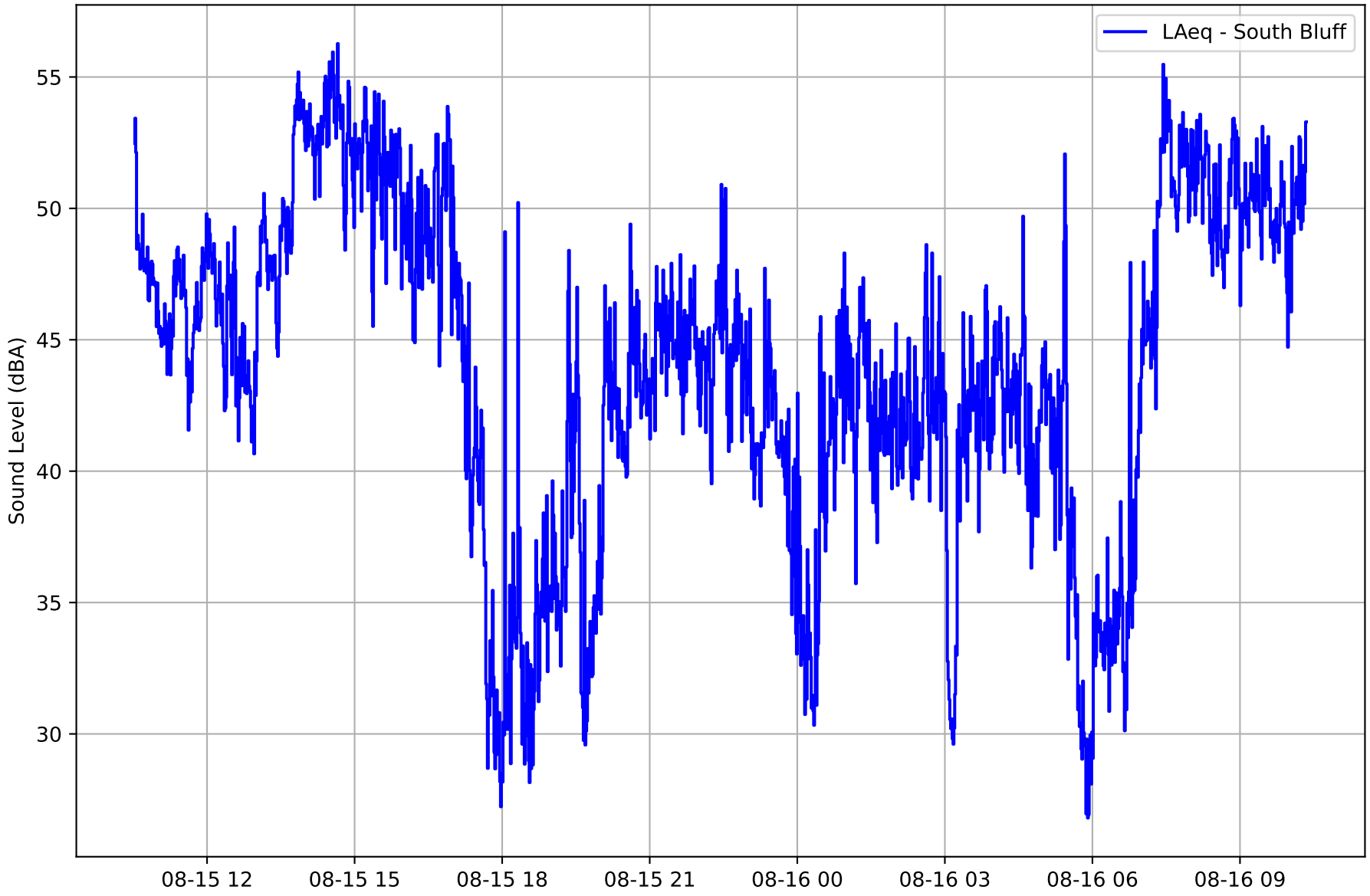
BC Hydro Site C
Monthly Noise Monitoring
July 2020 - Background

Portage Quarry, British Colombia

Project #: 2002352

Figure No. A9

Date Revised: 2021-12-14



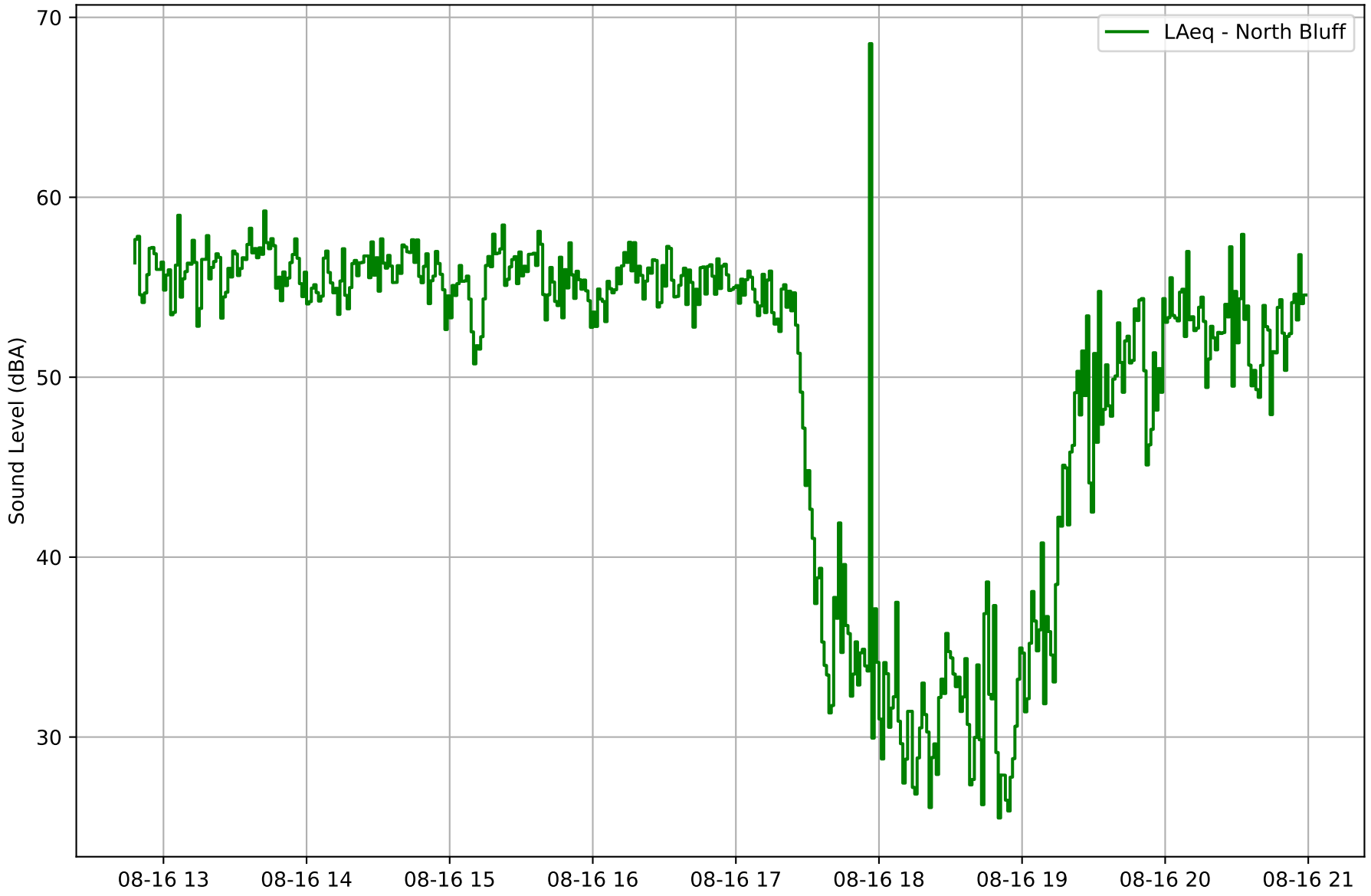
BC Hydro Site C
Monthly Noise Monitoring
August 2020 - South Bluff

Portage Quarry, British Colombia

Project #: 2002352

Figure No. A10

Date Revised: 2021-12-14



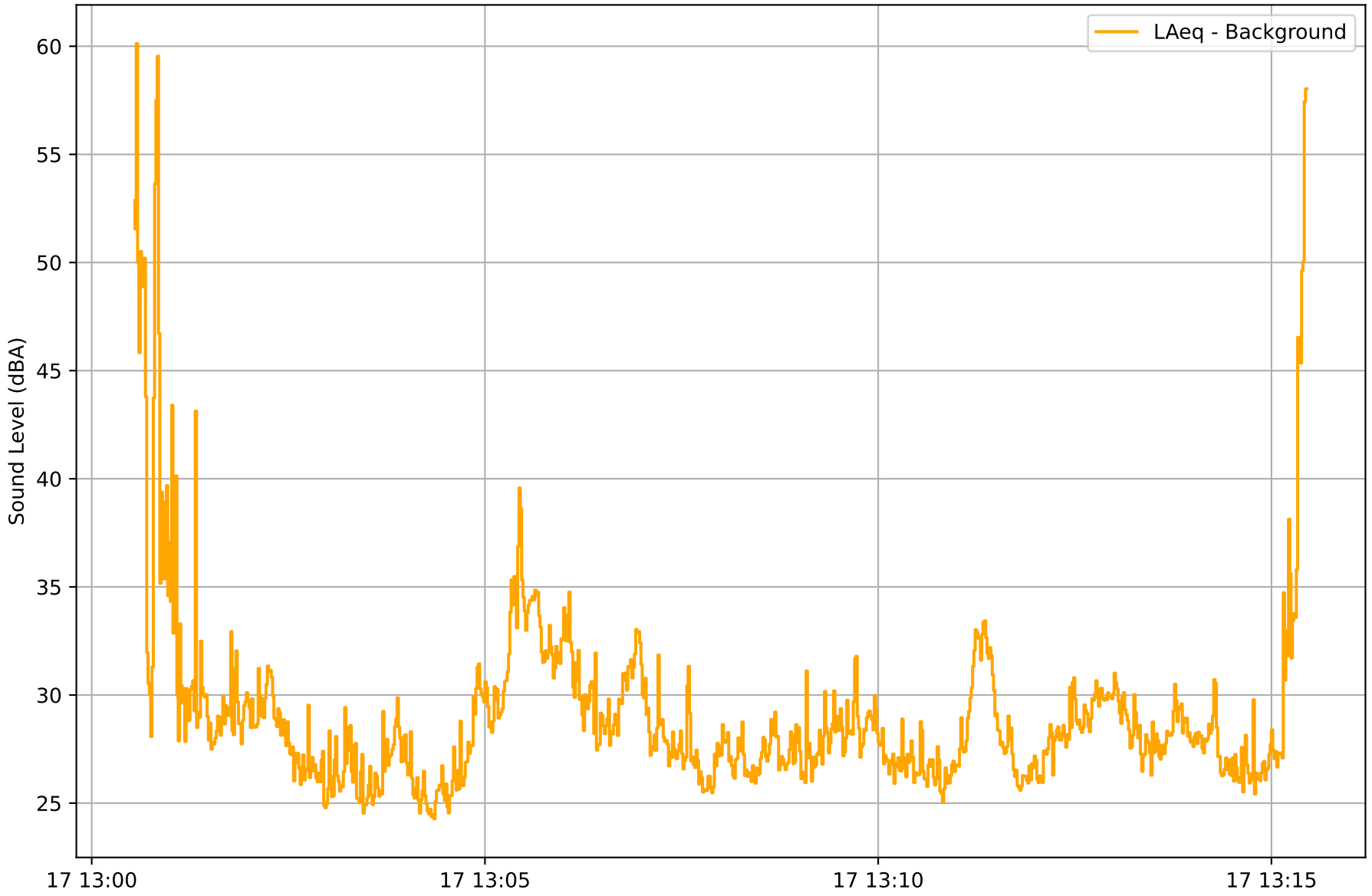
BC Hydro Site C
Monthly Noise Monitoring
August 2020 - North Bluff

Portage Quarry, British Colombia

Project #: 2002352

Figure No. A11

Date Revised: 2021-12-14



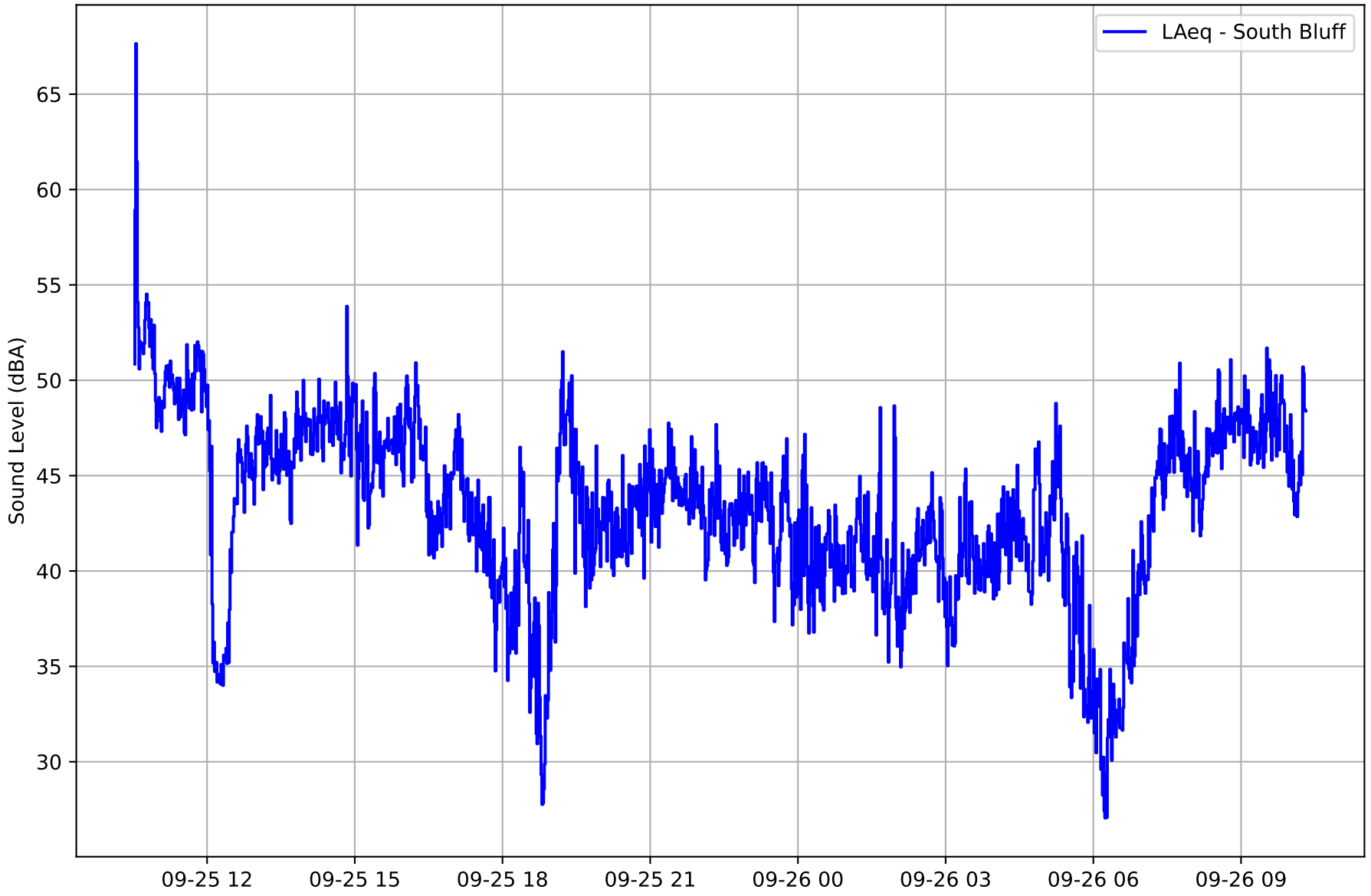
BC Hydro Site C
Monthly Noise Monitoring
August 2020 - Background

Portage Quarry, British Colombia

Project #: 2002352

Figure No. A12

Date Revised: 2021-12-14



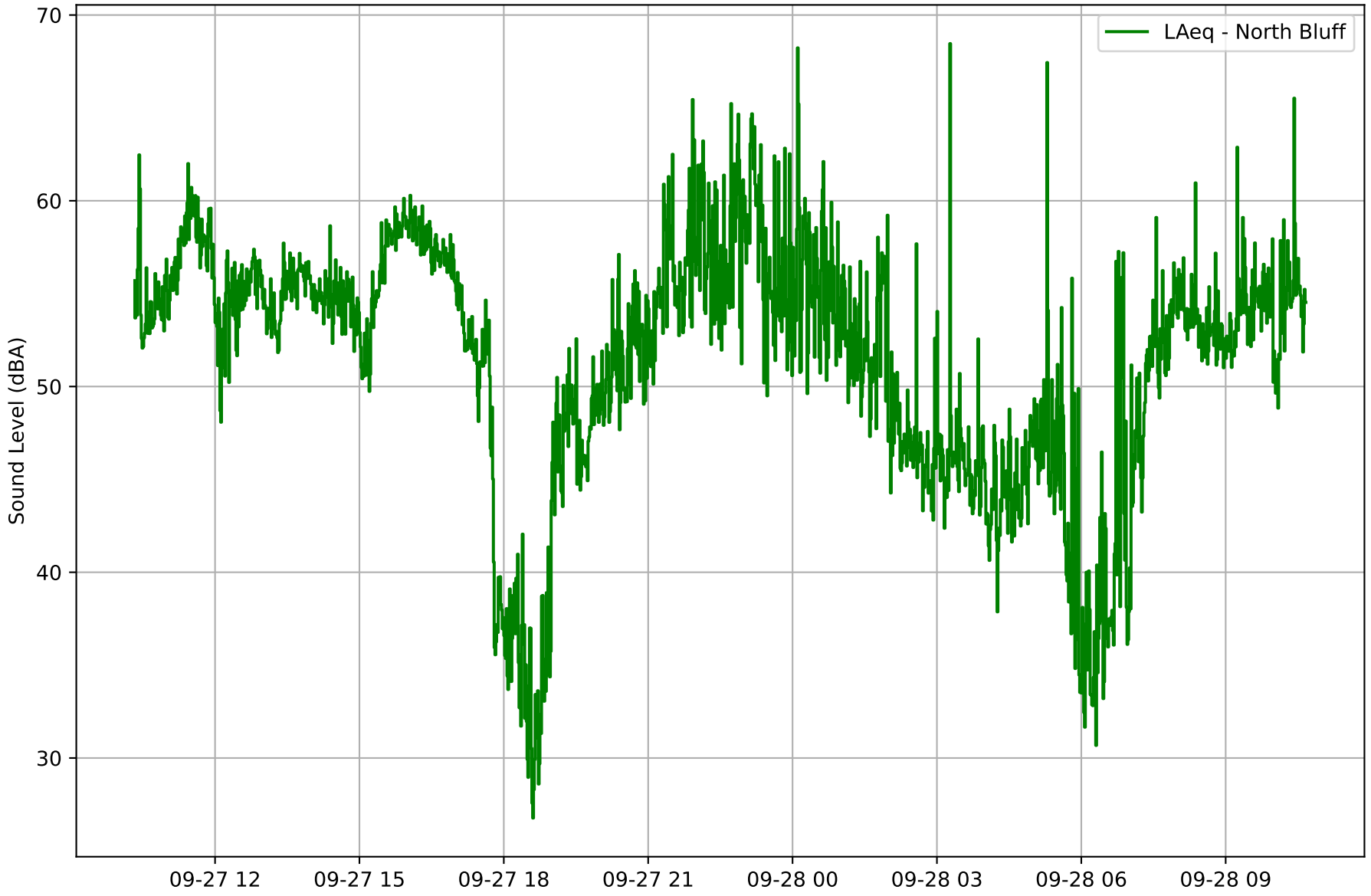
BC Hydro Site C
Monthly Noise Monitoring
September 2020 - South Bluff

Portage Quarry, British Colombia

Project #: 2002352

Figure No. A13

Date Revised: 2021-12-14



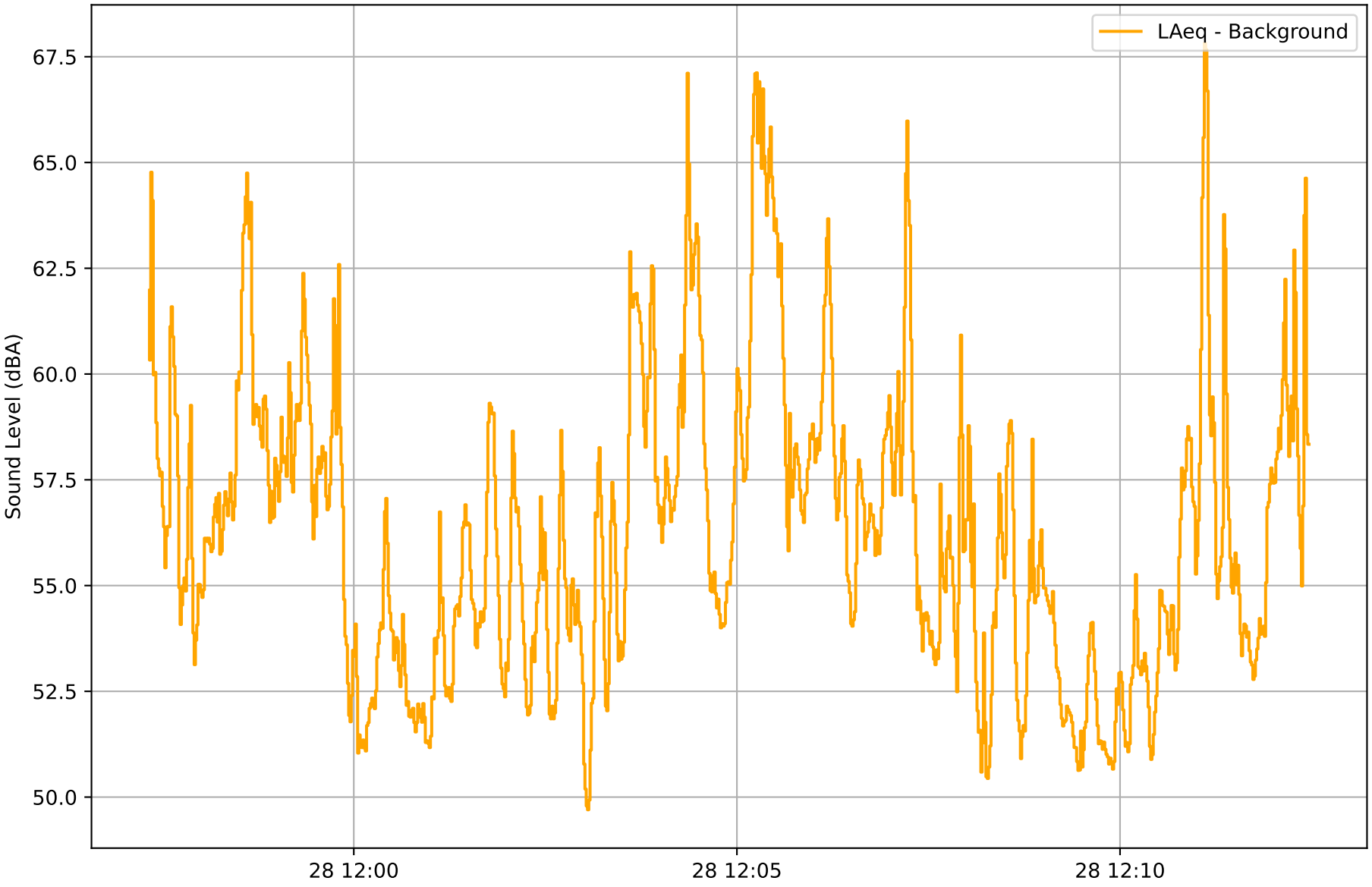
BC Hydro Site C
Monthly Noise Monitoring
September 2020 - North Bluff

Portage Quarry, British Colombia

Project #: 2002352

Figure No. A14

Date Revised: 2021-12-14



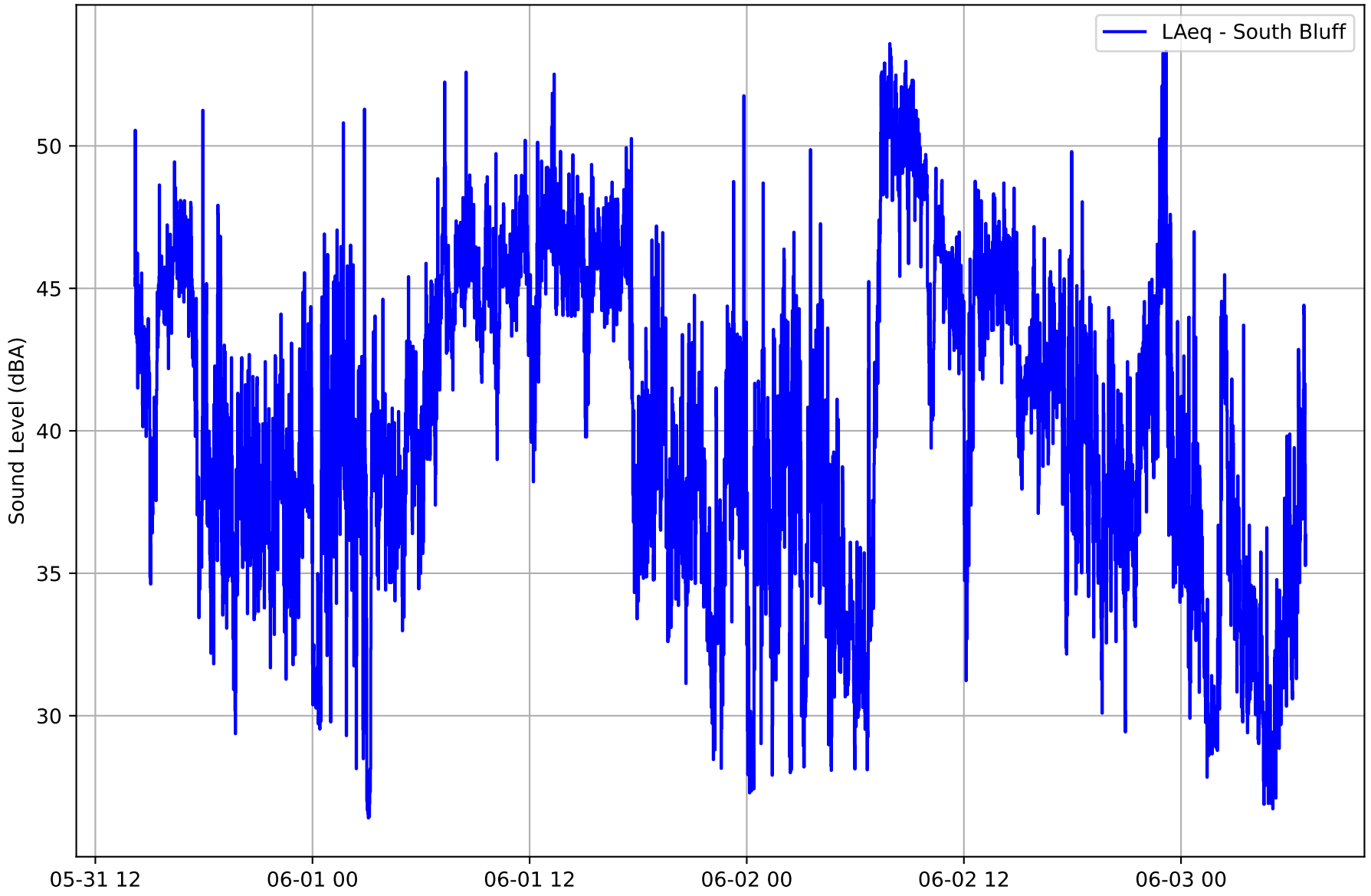
BC Hydro Site C
Monthly Noise Monitoring
September 2020 - Background

Portage Quarry, British Colombia

Project #: 2002352

Figure No. A15

Date Revised: 2021-12-14



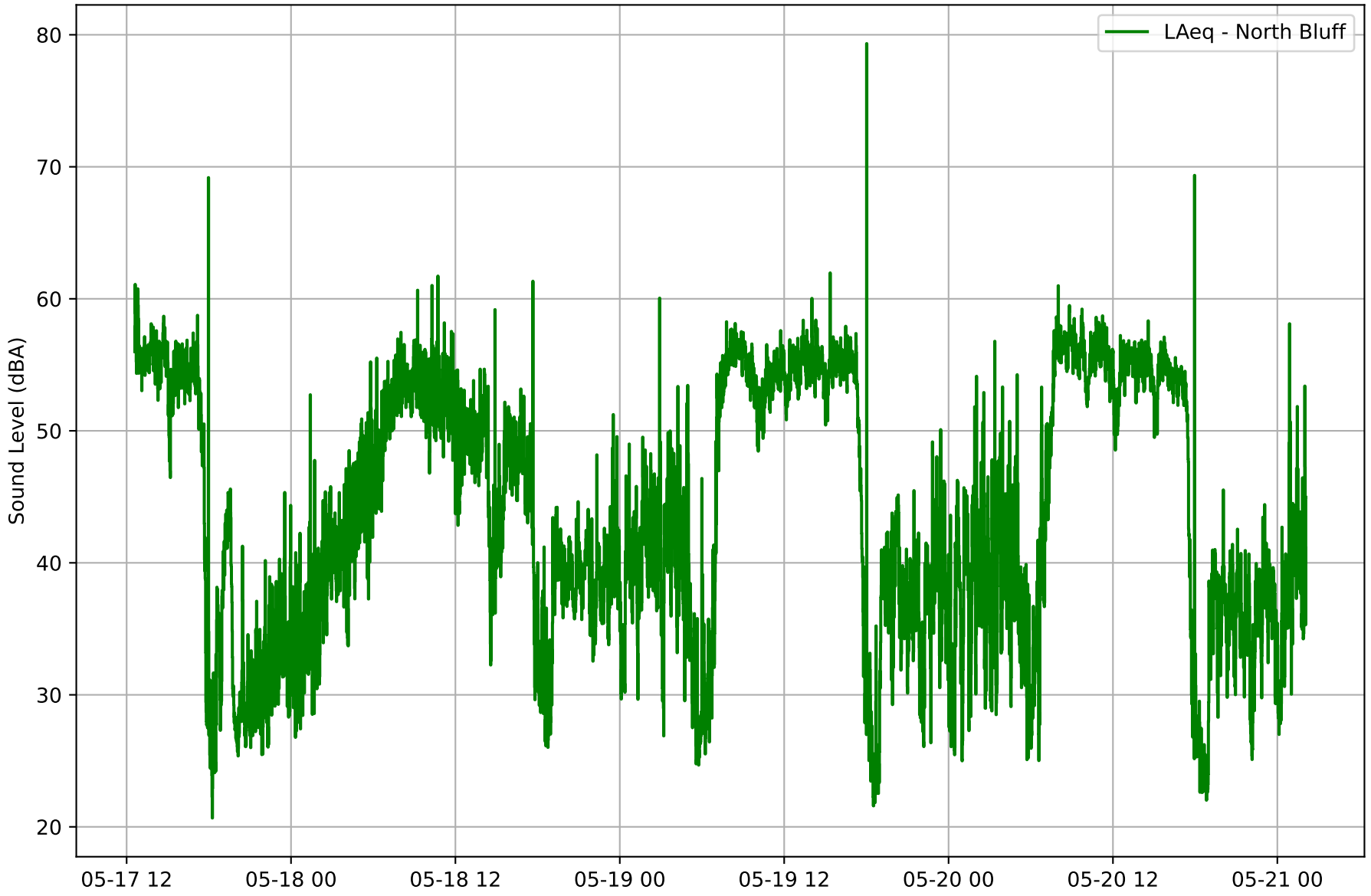
BC Hydro Site C
Monthly Noise Monitoring
May 2021 - South Bluff

Portage Quarry, British Colombia

Project #: 2002352

Figure No. A16

Date Revised: 2021-12-14



BC Hydro Site C
Monthly Noise Monitoring
May 2021 - North Bluff

Portage Quarry, British Colombia

Project #: 2002352

Figure No. A17

Date Revised: 2021-12-14

APPENDIX B

Appendix B – Blast Record

Date	BC Hydro Blast Record	Charge Weight (kg)	South Bluff MiniMate Unit BE11251				North Bluff MiniMate Unit BE20183			
			Time Recorded	PVS (mm/s)	Sound Concussion (dBL)	Shock Wave (psi)	Time Recorded	PVS (mm/s)	Sound Concussion (dBL)	Shock Wave (psi)
				Limits per Guidelines for Bats in British Columbia (BC MOE 2016)				Limits per Guidelines for Bats in British Columbia (BC MOE 2016)		
				15	150	15		15	150	15
5/19/2021	990-210519	1132	6:02:29 PM	8.72	122	0.0038	6:02:50 PM	1.3	130	0.0095
5/20/2021	990-R-210521	755	5:59:38 PM	4.59	119	0.0027	5:59:31 PM	0.5	122	0.0035
5/21/2021	980-P-210521	101	5:56:28 PM	2.06	110	0.0009	5:56:22 PM	3.2	118	0.0023
5/22/2021	1000-T-210522	298	5:56:02 PM	2.62	112	0.0012	-	-	-	-
5/23/2021	980-P-210523	1272	6:05:22 PM	2.51	118	0.0022	6:05:19 PM	2.9	120	0.0029
5/24/2021	1000-T-210524	359	6:07:24 PM	2.85	119	0.0026	-	-	-	-
5/25/2021	980-P-210525	1033	6:11:39 PM	2.17	122	0.0037	6:11:39 PM	2.4	124	0.0045
5/26/2021	1000-T-210527	1224	-	-	-	-	-	-	-	-
5/28/2021	980-P-210528	1181	5:55:42 PM	3.38	118	0.0024	5:55:48 PM	2.9	126	0.0055
5/29/2021	980-P-210529	1013	5:57:21 PM	3.4	119	0.0026	5:57:28 PM	1.9	129	0.0086
5/31/2021	980-P-2105231	2321	5:57:14 PM	4	118	0.0022	-	-	-	-

Date	BC Hydro Blast Record	Charge Weight (kg)	South Bluff MiniMate Unit BE11251				North Bluff MiniMate Unit BE20183			
			Time Recorded	PVS (mm/s)	Sound Concussion (dBL)	Shock Wave (psi)	Time Recorded	PVS (mm/s)	Sound Concussion (dBL)	Shock Wave (psi)
				Limits per Guidelines for Bats in British Columbia (BC MOE 2016)				Limits per Guidelines for Bats in British Columbia (BC MOE 2016)		
				15	150	15		15	150	15
6/1/2021	980-P-210602	2475	-	-	-	-	-	-	-	-
6/5/2021	980-P-210605	1582	5:56:45 PM	3.81	121	0.0033	5:57:04 PM	2.1	127	0.0066
6/6/2021	980-P-210606	1392	5:45:53 PM	4.09	125	0.0050	5:46:13 PM	2.5	124	0.0046
6/7/2021	980-P-210607	2215	5:57:26 PM	5.77	118	0.0023	5:57:49 PM	4.4	128	0.0074
6/8/2021	1000-T-210608	569	5:56:09 PM	4.15	117	0.0021	5:56:33 PM	2.9	127	0.0067
6/10/2021	980-P-210610	2395	-	-	-	-	5:44:19 PM	1.9	123	0.0043
6/11/2021	980-P-210611	592	-	-	-	-	5:57:49 PM	3.0	120	0.0029
6/13/2021	980-P-210613	1904	-	-	-	-	5:49:26 PM	3.1	121	0.0032
6/16/2021	980-P-210616	3483	6:02:45 PM	7.19	119	0.0025	6:02:46 PM	1.8	120	0.0029
6/17/2021	980-P-210617	1734	5:55:54 PM	5.17	119	0.0027	5:55:57 PM	3.0	125	0.0052
6/20/2021	980-P-210620	2143	5:55:15 PM	6.12	112	0.0012	5:55:22 PM	1.9	120	0.0029
6/22/2021	980-P-210622	1055	6:03:07 PM	6.39	122	0.0038	6:03:17 PM	2.4	119	0.0027
6/23/2021	980-P-210623	3270	5:57:48 PM	6.91	123	0.0041	5:58:00 PM	2.0	125	0.0054

Date	BC Hydro Blast Record	Charge Weight (kg)	South Bluff MiniMate Unit BE11251				North Bluff MiniMate Unit BE20183			
			Time Recorded	PVS (mm/s)	Sound Concussion (dBL)	Shock Wave (psi)	Time Recorded	PVS (mm/s)	Sound Concussion (dBL)	Shock Wave (psi)
				Limits per Guidelines for Bats in British Columbia (BC MOE 2016)				Limits per Guidelines for Bats in British Columbia (BC MOE 2016)		
				15	150	15		15	150	15
6/27/2021	980-P-210627	2250	-	-	-	-	-	-	-	-
7/2/2021	980-P-210702	1160	5:00:14 PM	8.38	118	0.0022	-	-	-	-
7/4/2021	980-P-210704	738	5:50:14 PM	2.65	117	0.0021	-	-	-	-
7/5/2021	980-P-210705	453	5:59:45 PM	2.44	119	0.0027	-	-	-	-
7/7/2021	980-P-210707	705	5:39:05 PM	1.72	111	0.0010	-	-	-	-
7/8/2021	980-P-210708	1255	5:56:08 PM	2.25	117	0.0021	-	-	-	-
7/10/2021	980-P-210710	1110	-	-	-	-	-	-	-	-
7/11/2021	980-P-210711	1775	5:36:57 PM	2.22	114	0.0015	5:37:36 PM	2.5	120	0.0030
7/12/2021	980-P-210712	1050	5:50:49 PM	3.8	119	0.0027	5:51:30 PM	3.2	114	0.0014
7/13/2021	980-P-210714	1600	-	-	-	-	-	-	-	-
7/15/2021	980-P-210715	4740	5:57:18 PM	5.76	116	0.0019	5:58:04 PM	3.9	120	0.0028
7/18/2021	980-P-210718	1050	-	-	-	-	5:33:22 PM	3.0	124	0.0049
7/19/2021	980-P-210719	1675	5:52:32 PM	2.26	119	0.0026	5:53:25 PM	2.8	118	0.0022

Date	BC Hydro Blast Record	Charge Weight (kg)	South Bluff MiniMate Unit BE11251				North Bluff MiniMate Unit BE20183			
			Time Recorded	PVS (mm/s)	Sound Concussion (dBL)	Shock Wave (psi)	Time Recorded	PVS (mm/s)	Sound Concussion (dBL)	Shock Wave (psi)
				Limits per Guidelines for Bats in British Columbia (BC MOE 2016)				Limits per Guidelines for Bats in British Columbia (BC MOE 2016)		
				15	150	15		15	150	15
7/21/2021	980-P-210721	1700	-	-	-	-	-	-	-	-
7/22/2021	980-P-210722	1475	6:01:10 PM	4.33	114	0.0014	6:02:09 PM	4.5	118	0.0024
7/23/2021	980-P-210723	84	5:34:04 PM	3.14	111	0.0010	-	-	-	-
7/27/2021	970-P-210727	3138	-	-	-	-	-	-	-	-
7/28/2021	970-P-210728	2929	5:53:42 PM	3.88	119	0.0025	5:53:49 PM	4.1	117	0.0020
7/30/2021	970-P-210730	1121	-	-	-	-	-	-	-	-
8/2/2021	970-P-210802	2230	-	-	-	-	-	-	-	-
8/4/2021	970-P-210804	1967	5:00:29 PM	6.99	118	0.0024	5:00:46 PM	3.2	118	0.0024
8/5/2021	970-P-210805	1039	5:14:23 PM	2.82	109	0.0008	5:14:42 PM	2.3	121	0.0033
8/6/2021	970-P-210806	958	5:39:03 PM	2.6	108	0.0007	5:39:23 PM	2.3	126	0.0058
8/7/2021	970-P-210807	1540	5:36:48 PM	5.88	119	0.0026	5:37:12 PM	0.5	121	0.0032
8/9/2021	970-P-210809	2289	-	-	-	-	-	-	-	-
8/11/2021	1002-P-210811	1440	5:56:01 PM	7.53	118	0.0024	-	-	-	-

Date	BC Hydro Blast Record	Charge Weight (kg)	South Bluff MiniMate Unit BE11251				North Bluff MiniMate Unit BE20183			
			Time Recorded	PVS (mm/s)	Sound Concussion (dBL)	Shock Wave (psi)	Time Recorded	PVS (mm/s)	Sound Concussion (dBL)	Shock Wave (psi)
				Limits per Guidelines for Bats in British Columbia (BC MOE 2016)				Limits per Guidelines for Bats in British Columbia (BC MOE 2016)		
				15	150	15		15	150	15
8/13/2021	1002-P-210813	930	5:52:42 PM	4.66	112	0.0012	-	-	-	-
8/15/2021	1002-P-210815	1300	-	-	-	-	-	-	-	-
8/16/2021	1002-P-210816	1414	5:52:59 PM	4.72	114	0.0015	-	-	-	-
8/17/2021	1002-P-210817	1230	5:53:29 PM	4.24	119	0.0027	-	-	-	-

Notes: - indicates that either the triggered thresholds of the device were not met and a event was not recorded, or the unit was without power.

APPENDIX D

Results of 2020 and 2021 Emergence Counts, Roost Monitoring, and Long-term Acoustic Monitoring

2020 and 2021 Emergence Counts

Results of the emergence counts conducted in 2020 and 2021 are described below.

2020 Emergence Counts

Thirty-nine emergence counts were conducted during June and July 2020 (**Table D.1; Figure 3.1**). Counts were completed within the general areas of:

- south cliff including the top of the quarry;
- north cliff;
- gully; and,
- the abandoned King Gething mine (outside the study area but briefly investigated to confirm lack of bat activity).

Emergence counts generally lasted about 1.5 hours, though surveyors ended counts early if there was moderate to heavy rain. Conditions were less than ideal for many emergence counts, with rain recorded on seven of the 12 nights surveyed, and 16 of the 39 emergence counts. Temperatures ranged from 10 °C to 16°C (**Appendix E**). Counts averaged 75 minutes in duration.

Table D.1 Survey Effort During the 2020 and 2021 Emergence Counts

Location	Session	Survey dates	Number of counts	Total of emerging bats counted	Average number of bats observed per count*
2020					
South cliff	Early	June 22, 23, 26, 27	10	23	2.3
	Late	July 14, 19, 20	8	32	4
North cliff	Early	June 24, 25	5	17	3.4
	Late	July 17, 18	4	12	3
Gully	Early	June 28	4	21	5.3
	Late	July 15, 16	4	9	2.3
King Gething mine	Early	Not surveyed	0	-	-
	Late	July 15, 16	4	1	.25
		Total	**39**	**36**	
2021					
South cliff including quarry	Early	June 14, 16, 18, 19	8	30	3.75
	Late	July 14, 15, 16, 19, 20	10	23	2.3
North cliff and talus	Early	June 15, 16, 17, 18	4	0	0
	Late	July 17, 18, 20	5	12	2.4
Gully	Early	June 14, 19, 20	3	18	9
	Late	July 13, 14	2	3	1.5
		Total	**32**	**86**	

*Averages provided as a rough index of use. As sample sizes are small, no variance has been calculated

At least one bat was seen emerging at 14 of 19 (74%) early counts and 10 of 20 (50%) late counts (**Table D.2**). One to four bats were observed emerging at most counts, although 16 bats (at the gully) and 17 bats (at the suspected maternity roost 9247G on the south cliff) were counted exiting during the early and late counts, respectively. Note that no particular roost tree was identified at the gully and bats counted there could potentially have exited from multiple roost trees farther west in the gully, so counts in this area represent an unknown number of roosts. Activity at the King Gething mine was minimal. One emergence count was conducted within the quarry on June 27, but no bats were observed exiting rock faces at that location. More bats were counted emerging from the south cliffs, although the numbers of non-zero counts were equivalent between the south and north cliffs.

Fourteen counts were done at 'new' sites, defined as sites more than 15 m away from locations of counts in previous years. One bat was observed emerging at each of two of those new sites. No new rock maternity roosts were detected based on the results from the early (June 22 to 28) and late (July 14 to 20) emergence counts in 2020 (i.e., no new sites where more than 10 bats were counted).

Table D.2 Results of the 2020 and 2021 Emergence Counts

Survey Period	Month-day	Location	Maternity Roost	Count ID	Number of Bats Observed
2020					
early	June 22	South	6287F	EC-DW1-062220	4
	June 22	South	-	EC-JF1-062220	4
	June 22	South	9427G	9427G	4
	June 23	South	-	EC-JF02-062320	0
	June 23	South	-	EC-DW2-062320	2
	June 23	South	-	EC_FM_200623	0
	June 24	North	-	EC-JF3-062420	4
	June 24	North	-	EC-FMN-200624	3
	June 24	South	-	EC- DW3-062420	2
	June 25	North	-	EC-JF4 062520	4
	June 25	Gully	-	EC-DW5-062620	0
	June 25	North	-	EC-DW4-062520	4
	June 25	North	-	EC_FMN_200625	2
	June 26	Gully	-	EC-FMN-200626	0
	June 27	South	9427G	9427G	4
	June 27	South	-	EC_FMN_200627	0
	June 27	South	6827F	EC-DW6-062720	3
	June 28	Gully	-	EC-FMN-200628	16
	June 28	Gully	-	EC-DW7-062820	5

Survey Period	Month-day	Location	Maternity Roost	Count ID	Number of Bats Observed
late	July 14	mine	-	EC-9415F	0
	July 14	South	-	EC_JF01_071420_South Cliff	0
	July 14	mine	-	EC-9415F	0
	July 15	Gully	-	EC_JB01_071520_ Gully	0
	July 15	Gully	-	EC_JF02_071520_Gully	3
	July 16	Gully	-	EC_FMN_Gully	6
	July 16	Gully	-	EC-gully	0
	July 16	mine	-	EC_JF03_071620_Old Mines	1
	July 16	mine	-	EC_JB02_071620_Old mine below gully	0
	July 17	North	-	EC_FMN-NH	3
	July 17	North	-	EC_JF04_071720_North Cliff	5
	July 17	North	-	EC_ST_NH	0
	July 18	South	-	EC_ST_NH	0
	July 18	North	-	200728EC_FMN_NH	4
	July 19	South	-	EC_JF06_South Cliff bear quarry	1
	July 19	South	-	EC_JB03_south cliff near quarry	0
	July 19	South	9427G	9427G	17
	July 20	South	9427G	9427G	13
	July 20	South	-	EC_JF07_South Cliff near quarry	0
	July 20	South	-	EC_JB03_south cliff near quarry	1
				Total	*115*

Survey Period	Month-day	Location	Maternity Roost	Count ID	Number of Bats Observed
2021					
early	June 14	South	9427G	9427G	4
	June 14	South	-	DW061421	0
	June 15	South	6827F	210615_EC_Bure	0
	June 15	South	-	210615_EC_FMN	0
	June 15	South	-	DW061521	0
	June 16	North	-	210616_FMN	0
	June 16	North	-	DW061621	0
	June 17	North	-	DW061721	0
	June 17	Talus	-	210617_Talus	0
	June 18	South	-	DW061821	3
	June 19	South	-	210619_EC_quarry_FMN	0
	June 19	South	9427G	9427G	23
	June 19	Gully	-	DW061921	0
	June 20	Gully	-	210620_EC_gully_FMN	9
	June 20	Gully	-	DW062021	9
late	July 13	Gully	-	210713_Gully_FMN	0
	July 13	Gully	-	DW071321	3
	July 14	South	9427G	210714_9427G_FMN	4
	July 14	South	6827F	DW071421	1
	July 15	South	9427G	210715_9427G_FMN	2
	July 15	South	6827F	DW071521	3
	July 16	Talus	-	210716_talus	0
	July 17	North	-	DW071721	1
	July 18	North	-	7/18/2021_BM_NH	6
	July 18	North	-	DW071821-NH	5
	July 18	Talus	-	210718_FMN_Talus	0
	July 19	South	9427G	210719_9427G_FMN	2
	July 19	South	-	7/19/2021_BM_sH	4
	July 19	South	-	DW071921-SH	2
	July 20	South	9427G	210720_9427G_FMN	2
	July 20	South	-	7/20/2021_BM_SH	1
	July 20	South	-	DW072021-SH	2
				Total	*86*

Emergence counts during 2020 confirmed the presence of bats at 9427G, a previously identified maternity roost (**Table D.2, Figure 3.1**). Four long-eared myotis (species identification from handheld detectors and manually verified) were observed exiting the roost at 9427G on both days of the early survey period, June 22 and 26. Seventeen bats (species undetermined) were observed exiting 9427G during the first count of the late survey period on July 19, and bats were observed to begin re-entering the roost at 2230 (64 minutes after sunset). Thirteen bats were seen exiting the roost on July 20, and three bats returned to the roost that night at 2146 (15 minutes after sunset). The first bats leaving the roost on the two late-period surveys exited before sunset. Bats leaving a roost early, foraging for a short time and then returning to the roost is behaviour consistent with females returning to nurse young pups. Observations of more than 10 bats are consistent with this location continuing to be used as a maternity roost.

On average, bats were observed emerging from the cliffs 33 minutes after sunset (range 8 minutes to 56 minutes). A maximum of 4 bats was observed emerging at 6287F, indicating that this site was less likely to be used as a maternity roost in 2020.

Calls from three Myotis species were recorded on handheld detectors during emergence counts in 2020 (**Table D.3**). Long-eared myotis, little brown myotis, northern myotis and unspecified Myotis were identified but it was often impossible to verify that the individuals exiting the roosts had produced the calls that were recorded. Precise emergence locations could not be determined for almost all sites, but a video recording was made of a bat emerging from behind a rock flake at 9427G (**Figure D.1).** Long-eared myotis, little brown myotis, and big brown bat were recorded on detectors as they were observed flying out from the gully next to the road but no specific roosting trees could be identified.

Table D.3 Bat species recorded on handheld detectors in 2020 at sites where emergence was observed

Date	Sample period	Location	Site	Emerging bats	Identification category
June 22	Early	South	9427G	4	Myotis
June 22	Early	South	EC-DW1-062220	4	Northern Myotis Myotis
June 23	Early	South	EC-DW2-062320	2	Long-eared Myotis Little Brown Myotis
June 24	Early	South	EC- DW3-062420	2	Myotis Northern Myotis
June 25	Early	North	EC-DW4-062520	4	Myotis Northern Myotis Little Brown Myotis
June 27	Early	South	EC-DW6-062720	3	Myotis Little Brown Myotis Long-eared Myotis
June 27	Early	South	9427G	4	Myotis Long-eared Myotis Little Brown Myotis
June 28	Early	Gully	EC-DW7-062820	5	Little Brown Myotis
June 28	Early	Gully	EC-FMN-200628	16	Little Brown Myotis Myotis
July 16	Late	Gully	EC_FMN_Gully	6	Long-eared Myotis Big Brown Bat
July 17	Late	North	EC_FMN-NH	3	Long--eared Myotis
July 18	Late	North	200728EC_FMN_NH	4	Long-eared Myotis Big Brown Bat

Calls of silver-haired bats and hoary bats were also recorded incidentally on acoustic detectors during early and late emergence surveys. Big brown bats and silver-haired bats were actively foraging (feeding buzzes and observations of foraging behaviour) at emergence time, together with long-eared myotis and little brown myotis.

Figure D.1 A Bat (White Circle) Emerges from Under a Slab of Rock (Arrow) at 9427G.

2020 Roost Monitoring

Both roost loggers suffered from water damage in early 2020 and did not record data between May and late August. The gap in bat activity and lower numbers of bat passes recorded in 2020 was caused by humidity and water entering both roost loggers early in the year. The roost loggers were operational, but the microphone sensors were compromised between April and August and required off-site repair. The roost loggers were dried and desiccant beads were added to absorb humidity during the July site visit. The roost loggers became operational just after August 30. Possibly residual humidity inside the loggers prevented them from operating normally until that date.

Although the loggers did not function as planned for much of the bat active period, activity at roost 9427G in 2020 was confirmed by the roost logger RL1. In total, 1,418 files were recorded in 2020, of which 1,390 were assigned to the Myotis category. Myotis bat activity was first recorded at 9247G in April and was increasing in early May when the logger was compromised. The last Myotis file was recorded on October 2 (**Table D.4**).

Roost logger RL2 deployed at potential maternity roost 6287F also recorded almost entirely Myotis files but only 104 files in total (**Table D.4**). RL2 was moved to 9247G in October (see 2021 results).

Table D.4 Bat Species Recorded by Roost Loggers in 2020

Identification category	Month							Grand total
	Apr	May	Jun	Jul	Aug	Sep	Oct	
RL1 total	**4**	**68**	**-**	**-**	**102**	**1,173**	**71**	**1,418**
30K	-	14	-	-	-	2	1	**17**
35K	-	8	-	-	-	-	-	**8**
Big brown bat / silver-haired bat	-	-	-	-	-	2	-	**2**
Long-eared myotis	-	-	-	-	-	1	-	**1**
Myotis	4	46	-	-	102	1,168	70	**1,390**
RL2 total	**-**	**-**	**-**	**-**	**1**	**72**	**31**	**104**
Myotis	-	-	-	-	1	72	31	**104**

2021 Emergence Counts

Thirty-two emergence counts were conducted during June and July 2021 (**Table D.1; Figure 3.1**). Counts were completed at:

- South cliffs, including the rock outcrop near the quarry; and,
- North cliff, including the talus slope below the cliff;
- Gully near 400 Rd (mature balsam poplar grove).

Rain was recorded on three nights during four of the 32 emergence counts. Temperatures at sunset during emergence counts as recorded by the Portage Mountain weather station ranged from 8 °C to 18 °C during the June counts and from 7°C to 21°C during the July counts (**Appendix E**). Counts averaged 83 minutes in duration.

No bats were observed emerging on 13 of the counts (**Table D.2**). One to four bats were observed emerging on most of the remaining counts, although 23 bats were counted on June 19 at 9427G, the suspected maternity roost. That observation confirms continued use of 9427 as a maternity roost based on the criterion of more than 10 bats emerging. A maximum of 3 bats was counted at 6827F, indicating that this site was unlikely to be used as a maternity roost in 2021.

Bats were observed emerging at 4 of the 15 early counts (27%) and 19 of 32 late counts (59%). The increase in numbers in the late counts was due to more bats observed emerging during counts at the south cliffs.

Five emergence counts in 2021 were located more than 15 m from counts conducted on previous years and are considered ‘new’ sites. One emergence count was carried out within the quarry on June 19 but no bats were observed. Unspecified Myotis, northern myotis and big brown bat were recorded on handheld detectors at sites where bats were observed emerging (**Table D.5**).

Table D.5 Bat species Recorded by Handheld Detectors in 2021 at Sites where Emergence was Observed

Date	Sample period	Location	Site	Emerging bats	Identification category
2021-06-18	early	South	DW061821	3	Big Brown Bat Myotis
2021-06-20	early	Gully	DW062021	9	Myotis Northern Myotis Little brown Myotis
2021-07-13	late	Gully	DW071321	3	Big brown Bat Northern Myotis
2021-07-14	late	South	DW071421	1	Myotis Big brown Bat
2021-07-15	late	South	DW071521	3	Myotis Big brown Bat
2021-07-17	late	North	DW071721	1	Myotis Big brown Bat
2021-07-18	late	North	DW071821-NH	5	Myotis
2021-07-19	late	South	DW071921-SH	2	Myotis Big Brown Bat
2021-07-20	late	South	DW072021-SH	2	Myotis

2021 Roost Monitoring

RL1 recorded minimal activity at roost 9247G in 2021, and no activity after July (**Table D.6**). Only 45 files, almost entirely Myotis and 30K species groups, were recorded. The lack of data is likely due to a technical issue with the roost logger.

The function of RL2 at roost 9247 G was also compromised based on the lack of data recorded in July and August (**Table D.6**). RL2 began recording activity in April with a substantial increase in activity in May but stopped recording June 6. RL2 recorded 8 files in August, and its last file on September 21.

Table D.6 Bat species Recorded by Roost Loggers in 2021

Identification category	Month								
	Jan	Mar	Apr	May	Jun	Jul	Aug	Sep	Grand Total
Roost logger 1 Total	**-**	**5**	**6**	**18**	**9**	**7**	**-**	**-**	**45**
30K	-	4	-	4	5	2	-	-	15
Big brown bat / silver-haired bat	-	1	-	-	-	-	-	-	1
Long-eared myotis	-	-	-	-	1	1	-	-	2
Myotis	-	-	6	13	3	4	-	-	26
Red bat / little brown myotis	-	-	-	1	-	-	-	-	1
Roost logger 2 Total	**1**	**-**	**200**	**1,892**	**153**	**-**	**8**	**176**	**2,430**
30K	-	-	30	14	2	-	-		46

Identification category	Month								
	Jan	Mar	Apr	May	Jun	Jul	Aug	Sep	Grand Total
Big brown bat / silver-haired bat	-	-	21	41	-	-	-	2	64
Eastern red bat	-	-	-	8	-	-	-		8
Long-eared myotis	-	-	1	1	2	-	-	5	9
Low frequency bat	-	-	2	6	-	-	-	7	15
Myotis	1	-	146	1,816	147	-	8	162	2,280
Red bat / little brown myotis	-	-	-	6	2	-	-	-	8

2020 and 2021 Long-term Acoustic Monitoring Results

Results of acoustic monitoring in 2020 and 2021 are described below.

2020 and 2021 Survey Effort

The 294-SH detector suffered damage from rodents chewing the cables with resulting loss of data for 27 days between June 22 and July 18 in 2020. The PM-C-NH detector also suffered rodent damage in 2020 and was not functional between June 24 and July 17. The new TAL detector recorded for 121 detector-nights from its installation on June 26, 2020 until December 31, 2020. Total survey effort in 2020 was 1,622 detector-nights over six detectors.

In 2021 5 detectors recorded from January 1, 2021, until the last download on November 3, 2021, totalling 307 nights for all five detectors, for a total survey effort of 1,535 detector-nights.

2020 and 2021 Activity

The first bat files recorded in January 2020 were categorized as big brown bat/silver-haired bat (23 files) and low-frequency bat (13 files), with the earliest file on the night of January 1 at detector PMC-NH.

The first Myotis group (all Myotis species, 35K and red bat/little brown myotis categories) file in 2020 was recorded the night of April 8, 2020 (at detector PMC-NH; **Table D.7**). The first file identified as little brown myotis in 2020 was recorded on May 15 (PMC-NH), and the first northern myotis file on April 4 (279-SH; **Table D.8**). Most (77%) of the Myotis group files recorded in April were recorded at 279-SH (**Table D.7**).

Table D.7 Numbers of Myotis Group Files Recorded n April and In Late Summer/Fall 2020

Detector	April	August	September	October	November	Total
279-SH	524	13,010	6,934	54	31	**20,553**
294-SH	40	4,438	1,965	16	23	**6,482**
PM-C-NH	104	4,235	6,545	36	77	**10,997**
PM-S3	9	3,583	1,646	66	9	**5,313**
PM-TAL	0	922	685	2	0	**1,609**
Total	**677**	**26,188**	**17,775**	**174**	**140**	**44,954**

Table D.8 Numbers of Bat Files in 2020 (Excluding Roost Logger Files and Social Calls) By Month

Identification Category	Month												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
30K	3	0	1	28	414	8	16	0	0	0	0	1	471
35K	0	0	0	64	739	1,493	1,696	6	3	0	0	0	4,001
Low-frequency bat	13	3	5	119	207	14	34	106	56	22	32	34	641
Hoary bat	0	0	0	0	0	0	57	57	14	1	0	0	129
Big brown bat	0	0	1	127	95	32	764	1,493	957	56	10	7	3,542
Big brown bat / silver-haired bat	23	6	25	1,049	726	149	3,193	6,880	6,332	1,719	424	96	20,643
Silver-haired bat	0	0	0	3	49	3	23	133	24	126	2	0	363
Eastern red bat	0	0	0	1	10	28	46	13	8	1	0	0	107
Red bat / little brown myotis	0	0	0	7	148	232	129	59	10	0	0	0	585
Myotis	0	0	0	215	1,800	3,255	16,499	23,225	15,647	158	121	0	60,930
Little brown myotis	0	0	0	0	10	133	683	168	124	1	16	0	1,135
Long-eared myotis	0	0	0	390	1,736	286	1,892	2,559	1,977	15	3	0	8,858
Northern myotis	0	0	0	1	25	46	75	171	14	0	0	0	332
Grand Total	**39**	**9**	**32**	**2,004**	**5,959**	**5,679**	**25,107**	**34,870**	**25,166**	**2,099**	**608**	**138**	**101,710**

Figure D.2 depicts the number of bat files per detector-night over time in 2020. The first substantial numbers of bat files in 2020 – mostly big brown bat - were recorded on serial week 16 in 2020, which corresponded to April 12-18. Myotis bat files began outnumbering big brown bat files two weeks later. Activity of both big brown bats and Myotis declined to a low on week 23 (May 31-June 6), presumably as emerging bats dispersed. Activity then showed a general increasing trend with file numbers peaking at week 34 (August 16-22) for big brown bats and week 35 (August 23-29) for Myotis. No fall peak consistent with swarming activity was apparent for either species group. Activity for both the big brown bat and Myotis group dropped off sharply in week 41 (October 4-10). Of the 43,963 Myotis files recorded in August through September in 2020, 19,944 (45%) were recorded at the 279-SH detector (**Table D.7**).

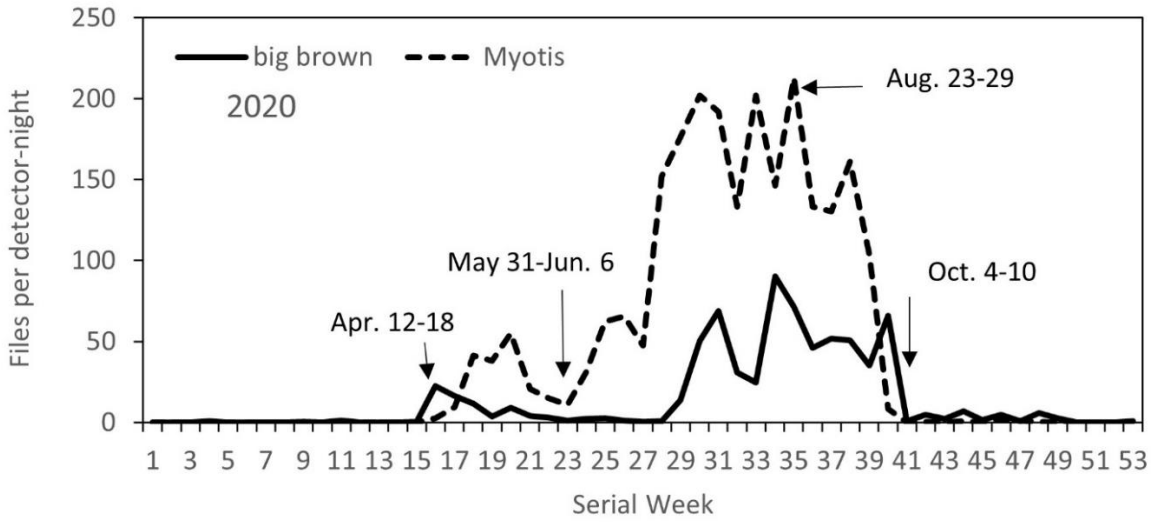


Figure D.2 Big Brown Bat and Myotis Activity Recorded Over Time During 2020, Excluding Roost Logger Data and Social Calls

The latest 2020 files (big brown bat/silver-haired bat) were recorded the night of December 30 at the PM-TAL detector. One hundred thirty-eight files were recorded during December and were assigned to the big brown bat (seven files), big brown bat/silver-haired bat (96 files), 30K bat (1 file) and low-frequency bat (34 files) species groups. The latest Myotis file was recorded November 26 (279-SH). Little brown myotis files were identified as late as November 15 (at PMC-NH), and the latest northern myotis files on the night of September 23 (at 279-SH).

Of the 140 Myotis group files recorded in November 2020, 77 were recorded at the PM-C-NH detector (**Table D.7**). There were no known detector issues during the months of August through December 2020 so all detectors had a similar number of operating nights. The detector with the greatest amount of activity between November 2020 through March 2021 for all species was 279-SH, the southernmost detector and the detector furthest from the quarry. Almost half (638) of the 1,318 files recorded during this period were recorded at that detector.

The earliest that bats were detected in 2021 was the night of January 7 when two calls identified as big brown bat/silver-haired bat were recorded at the PM-Talus detector. In total, 119 bat files were recorded in January 2021 (**Table D.9**) and were categorized as big brown bat/silver-haired bat, low-frequency bat, big brown bat, and 30K. Most (99) of the January files were recorded by the 279-SH detector on the south cliff, and 85 of those were recorded over a three-night interval on January 10, 11 and 12 during relatively mild temperatures of -1.3 to 3.6°C. Of the 136 bat files recorded in January and February of 2021, 100 were recorded at detector 279-SH, the southernmost detector.

The first Myotis group (all Myotis species, 35K and red bat/little brown myotis categories) file was recorded the night of April 6, 2021 (at detector 294-SH), the first file identified as little brown myotis on April 16 (279-SH), and the first northern myotis file on April 15 (279-SH). Of the 2,361 Myotis group files recorded in April, 1,259 (53%) were recorded at 279-SH (**Table D.10**), the same detector where the largest percentage of the April Myotis files were recorded in 2020. There were no known detector issues in 2021.

Table D.9 Locations and Numbers of Myotis Group Files Recorded in April, August, September and October

Detector	April	August	September	October	Total
279-SH	1,259	10,959	8,970	23	21,212
294-SH	191	4,372	6,401	16	10,980
PM-C-NH	439	5,273	11,974	111	17,797
PM-S3	62	4,069	10,017	28	14,176
PM-TAL	410	1,285	737	5	2,437
Total	2,361	25,958	38,099	183	66,602

The first peak of spring activity for Myotis species occurred during week 16 in 2021, which corresponds to April 11-17 (**Figure D.3**) and is consistent with 2020 (**Figure D.2**). There was a second peak around week 20 (also consistent with 2020), after which activity generally declined for both species groups to week 24, then increased again. The greatest peak of Myotis activity was recorded in weeks 37 and 38, which correspond to September 5-18, consistent with swarming. There was a dramatic drop-off in Myotis group passes after the end of week 39 on September 25, presumably indicating the onset of hibernation and consistent in timing with 2020 (**Figure D.2**). Of the 64,057 Myotis group files recorded in August and September of 2021 (**Table D.9**), 31% were recorded by the 279-SH detector. There was no peak of fall activity evident for big brown bats, only a gradual decline of activity (**Figure D.3**). The detectors were last downloaded on November 3, so the dates of the latest winter activity in 2021 are not yet known.

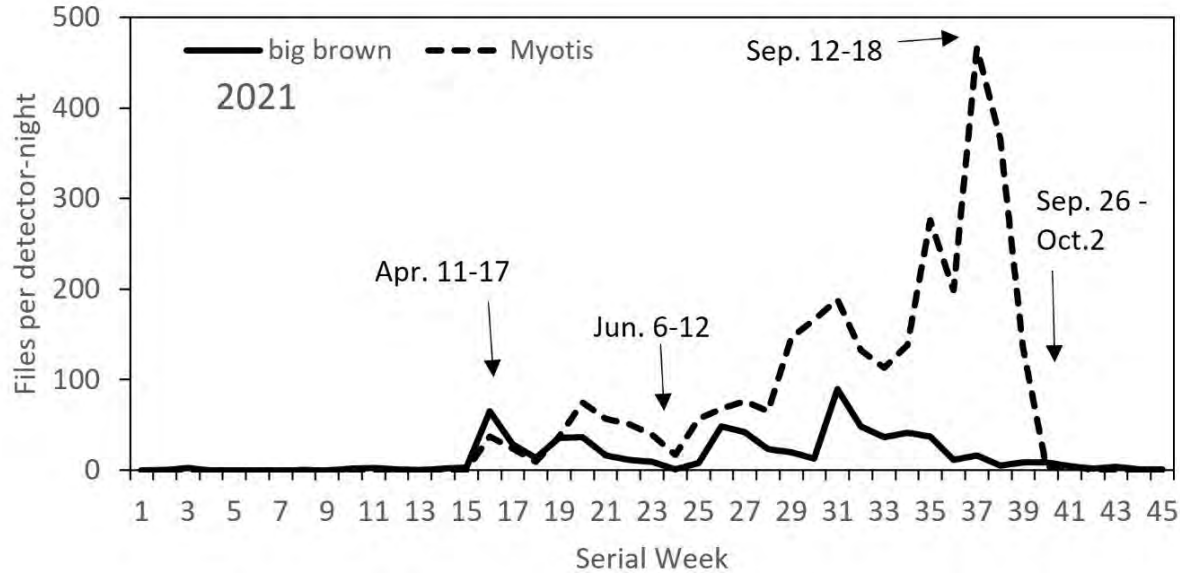


Figure D.3 Big Brown Bat and Myotis Activity Recorded During 2021, Excluding Roost Logger and Social Calls

Table D.10 Numbers of bat files identified in 2021 (excluding roost logger and social calls) by month

Identification category	Month											Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	
30K	1	0	6	387	403	99	156	69	32	1	0	**1,150**
Low-frequency bat	25	13	157	2,865	1,577	764	1,271	1,310	608	88	4	**8,682**
Hoary bat	0	0	0	1	2	2	159	239	101	1	0	**505**
Big brown bat	1	0	23	565	583	829	871	413	250	23	0	**3,558**
Big brown bat / silver-haired bat	91	0	211	3,322	3,096	2,264	4,786	5,410	1,431	380	26	**21,017**
Silver-haired bat	0	0	0	90	335	46	67	283	23	1	0	**845**
Eastern red bat	0	0	0	12	15	24	73	28	36	0	0	**188**
Red bat / little brown myotis	0	0	0	8	66	129	139	22	29	0	0	**393**
High- frequency bat	0	0	0	0	0	1	1	0	0	0	0	**2**
Myotis	0	4	7	1,248	5,999	6,849	18,819	23,696	37,406	169	1	**94,198**
Little brown myotis	0	0	0	2	11	82	383	135	93	0	0	**706**
Long-eared myotis	0	0	0	1,101	2,076	510	1,390	1,977	535	14	0	**7,603**
Northern myotis	0	0	0	2	2	19	147	128	36	0	0	**334**
Grand Total	**118**	**17**	**400**	**9,603**	**14,165**	**11,618**	**28,263**	**33,710**	**40,580**	**677**	**31**	**139,182**

Big brown bat, eastern red bat and silver-haired bat passes were well-distributed across the bat active period, although big brown bat activity began earlier and continued later in the year. Hoary bats were detected primarily in summer and fall (**Table D.10**). All of the Myotis species were first confirmed in April. Long-eared myotis had a bimodal activity pattern with peaks in April-May and in July-August. The highest numbers of northern and little brown myotis were recorded in July.

2020 and 2021 Species Presence

In total, 101,737 bat files (excluding roost logger files and social calls) were recorded in 2020, including 87,271 files assigned to species groups of two or more species and 14,466 files identified to a single species. The most commonly recorded bats were those from the *Myotis* group (almost 60% of calls) and the big brown bat / silver-haired bat group (20% of calls). Long-eared myotis and big brown bat were the species most often recorded of the files that could be identified to a single species (**Table D.11**). Seven of the eight bat species previously recorded within the study area (Keystone 2014; Hansen et al. 2016; Sarell and Alcock 2017) were identified in 2020, including the endangered little brown myotis and northern myotis. Long-legged myotis was not confirmed in 2020 although it was identified once in 2019 and twice in 2017.

Table D.11 Identification of Files Recorded In 2020 (Excluding Roost Logger and Social Calls)

Identification category	Per cent of total files recorded in 2020
30K	0.5
35K	3.9
Low-frequency bat	0.6
Hoary bat	0.1
Big brown bat	3.5
Big brown bat / silver-haired bat	20.3
Silver-haired bat	0.4
Eastern red bat	0.1
Red bat / little brown myotis	0.6
Myotis	59.9
Little brown myotis	1.1
Long-eared myotis	8.7
Northern myotis	0.3
Grand Total	**100.0**

In 2021, 139,255 bat files (excluding roost loggers and social calls) were recorded. The Myotis species group made up 68% of the total files recorded, and the big brown bat/silver-haired bat species group made up another 15% (**Table D.12**). Seven of the eight bat species previously recorded within the study area (Keystone 2014; Hansen et al. 2016; Sarell and Alcock 2017) were identified in 2021 (**Table D.12**). The endangered little brown myotis and northern myotis were both confirmed. As was the case for 2020, long-legged myotis was not identified in 2021 although it was recorded once in 2019 and twice in 2017. As in 2020, long-eared myotis and big brown bat were the species most commonly recorded. Note that comparison of **Table D.11** and **Table D.12** must consider the different survey effort (number of detector-nights) during the two years.

Table D.12 Identification of Files Recorded in 2021 (Excluding Roost Logger and Social Calls)

Identification category	Per cent of total files recorded in 2021
30K	0.8
35K	0.0
Low frequency bat	6.2
Hoary bat	0.4
Big brown bat	2.6
Big brown bat / silver-haired bat	15.1
Silver-haired bat	0.6
Eastern red bat	0.1
Red bat / little brown myotis	0.3
High frequency bat	0.0
Myotis	68.0
Little brown myotis	0.5
Long-eared myotis	5.5
Northern myotis	0.2
Grand Total	**100.0**

APPENDIX E

Weather Conditions During 2020 and 2021 Emergence Surveys

Survey Date	Sunset time	Sunset temperature[1] (°C)	Relative humidity[2] (%)	Wind speed[3] (km/hr)	Rain during survey period?[4]	Other comments
June 23, 2020	21:56	14.4	44.04	Not available	None	
June 24, 2020	21:56	13.3	37.05	Not available	None	
June 25, 2020	21:56	12.3	55.14	Not available	None	
June 26, 2020	21:56	12.1	43.28	Not available	None	
June 27, 2020	21:56	9.5	87.29	Not available	Yes	
June 28, 2020	21:55	10.4	71.88	Not available	Yes	
July 15, 2020	21:40	13.4	79.04	Not available	Yes	
July 17, 2020	21:37	11.7	72.77	Not available	Yes	
July 18, 2020	21:36	16.2	63.06	Not available	Yes	
July 19, 2020	21:34	14.5	48.49	Not available	None	
July 20, 2020	21:33	15.5	71.72	Not available	Yes	
July 21, 2020	21:31	13.5	75.87	Not available	Yes	
June 14, 2021	21:53	11.0		1	None	
June 15, 2021	21:54	12.1		1	None	
June 16, 2021	21:54	9.3		1	Yes	
June 17, 2021	21:55	7.8		1	None	
June 18, 2021	21:55	9.5		1	None	
June 19, 2021	21:55	10.1		1	None	
June 20, 2021	21:56	18.4		1	None	
July 13, 2021	21:43	18.5		1	None	
July 14, 2021	21:42	21.3		3	None	
July 15, 2021	21:41	18.6		9	None	
July 16, 2021	21:39	7.3		0	None	
July 17, 2021	21:38	9.0		4	Yes	Foggy
July 18, 2021	21:36	10.7		1	None	Foggy
July 19, 2021	21:35	12.4		1	None	
July 20, 2021	21:33	11.3		1	Yes	

1 From Portage Mountain quarry weather station
2 From 9147G data logger
3 From Hudson's Hope weather station; data not available before October 2020
4 From surveyor observations

APPENDIX F

Number of Nights Detectors were Active by Season

Table F.1 Number of Nights Detectors were Active and Number of Nights a Detectors was Inactive by Season and Year.

Year	Bat Life Stage	Number of Active Detector Nights	Number of Inactive Detector Nights
2017	fall	28	0
2017	hibernation	94	48
2017	summer	11	0
2018	emergence	3	3
2018	fall	7	35
2018	hibernation	192	190
2018	summer	135	68
2019	emergence	8	8
2019	fall	28	28
2019	hibernation	194	124
2019	summer	135	107
2020	emergence	8	0
2020	fall	28	0
2020	hibernation	195	92
2020	summer	135	27
2021	emergence	4	0
2021	fall	28	0
2021	hibernation	134	0
2021	summer	141	0

APPENDIX G

Blast Model Results for Summers 2019 to 2021

Below are the model selection results (**Table G.1**) and model coefficients (**Table G.2**) for the blast model using only data from 2019-2021, which excludes 2018 when only five blasts occurred. When the 2018 data is excluded the blast model is no longer the top AIC model and blast is not a significant model variable.

Table G.1 Models 1 and 3 of Summer Bat Activity at Portage Mountain Years 2019 - 2021, Number of Parameters (K) for the Generalized Linear Mixed Effects Models used to Predict the Number of Bat Calls Per Night, and the Model's Log-Likelihood (LL) and Akaike's Information Criterion (AIC) Score

Summer models	K	LL	AIC	AIC weight
Null: total bat calls per night ~ 1 + 1|Detector ID	3	-8,761.13	17,528.26	0.00
1: total bat calls per night ~ mean temperature + precipitation + 1| Detector ID	5	-8,634.51	17,279.01	0.69
3: total bat calls per night ~ blast + mean temperature + precipitation + 1| Detector ID	6	-8,634.33	17,280.65	0.31

Table G.2 Coefficient from Model of Bat Activity with Occurrence of Blasting During the Summer Period Years 2019 - 2021 at Portage Mountain, Based on Data from 5 Detectors at 3 Areas

Variable	Coefficient estimate	Standard error	z value	Lower 95% C.I.	Upper 95% C.I.
Intercept	**3.82**	0.28	13.77	3.27	4.36
Blast	0.04	0.07	0.60	-0.09	0.17
Mean temperature	**0.86**	0.08	11.29	0.71	1.01
Total precipitation	**-0.45**	0.03	-14.59	-0.51	-0.39

Appendix 8. Experimental Rare Plant Translocation Program 2021 Annual Report

Experimental Rare Plant Translocation Program
2021 Annual Report

Date: December 16, 2021

PRESENTED TO:

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PRESENTED BY:

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TABLE OF CONTENTS

Table of Contents i

Errata v

Acronyms & Abbreviations vi

1. Introduction 1
   1.1 Plant Species included in the Program and their Conservation Ranks 1

2. General Methods 3
   2.1 Phase 1. Propagule Collection 3
      2.1.1 *In-situ* Seed Collection 3
      2.1.2 *Ex-situ* Seed Collection 3
   2.2 Phase 2. *Ex-situ* Propagation 3
   2.3 Phase 3. Translocation 4
      2.3.1 Recipient Site Selection 4
      2.3.2 Transport and Plant Preparation 6
      2.3.3 Selection of Planting Locations within the Habitat Matrix 7
      2.3.4 Translocation at Recipient Sites 7
   2.4 Phase 4. Monitoring 8
   2.5 Quality Assurance and Control 9

3. Results 10
   3.1 Phase 1. Propagule Collection 10
   3.2 Phase 2. *Ex-situ* Propagation 12
   3.3 Phase 3. Translocation Implementation 15
      3.3.1 Sprengel's Sedge (*Carex sprengelii*) 20
      3.3.2 Torrey's sedge (*Carex torreyi*) 21
      3.3.3 Davis' locoweed *(Oxytropis campestris* var. *davisii)* 22
      3.3.4 Slender penstemon *(Penstemon gracilis)* 25
      3.3.5 Prairie buttercup *(Ranunculus rhomboideus)* 28
      3.3.6 Rock selaginella *(Selaginella rupestris)* 30
   3.4 Monitoring 32

3.4.1 Interim Monitoring 32
3.4.2 Year-end Monitoring 34
3.4.3 Canada mountain-ricegrass (*Piptatheropsis canadensis*) 35
3.4.4 Davis' locoweed (*Oxytropis campestris* var. *davisii*) 37
3.4.5 Dryland sedge (*Carex xerantica*) 38
3.4.6 Slender penstemon (*Penstemon gracilis*) 39
3.4.7 Sprengel's sedge (*Carex sprengelii*) 40
3.5 Plan Forward 41

References 42

List of Figures

Figure 3.1-1. Experimental Rare Plant Translocation Propagule Collection Locations 11

Figure 3.3-1. Experimental Rare Plant Translocation Western Recipient Site Locations 17

Figure 3.3-2. Experimental Rare Plant Translocation Central Recipient Site Locations 18

Figure 3.3-3. Experimental Rare Plant Translocation Eastern Recipient Site Locations 19

Figure 3.3-4. Planting Grid for Sprengel's Sedge at Site Id: CARESPR-2020-B 1A & 1B and CARESPR-2021-C 20

Figure 3.3-5. Planting Grid for Torrey's Sedge at Site Id: CARETOR-2021-A 22

Figure 3.3-6. Planting Grid for Davis' Locoweed at Site ID: OXYTCAM3-2020 24

Figure 3.3-7. Planting Grid for Slender Penstemon Mixed Planting with Rock Selaginella at Site ID: PENSGRA-2021-C 26

Figure 3.3-8. Planting Grid for Slender Penstemon at Site ID: PENSGRA-2020-B-50P 27

Figure 3.3-9. Planting Grid for Prairie Buttercup at Site Id: RANURHO-2021-A Cohort 1 28

Figure 3.3-10. Planting Grid for Prairie Buttercup at Site Id: RANURHO-2021-A Cohort 2 29

Figure 3.3-11. Planting Grid for Prairie Buttercup at Site Id: RANURHO-2021-B 29

Figure 3.3-12. Planting Grid for Slender Penstemon at Site ID: SELARUP-2021-B 31

List of Tables

Table 1.1-1. Species included in the Experimental Rare Plant Translocation Program 2

Table 3.1-1. Summary of 2020/ 2021 Propagule Collection Efforts 10

Table 3.2-1. Ex- situ Propagation Results from the 2021 Seed Collection Efforts 14

Table 3.3-1. Summary of Individuals Translocated by Species and Site ID in 2021. 15

Table 3.4-1. Summary of Recipient Sites and Current Status 33

Table 3.4-2. Summary of Year-end Monitoring Results for 2021 34

List of Plates

Plate 3.2-1. Canada mountain-ricegrass adult plants (1 Gallon) produced in 2021 13

Plate 3.2-2. Davis' locoweed seedlings (50P) grown in 2020 13

Plate 3.2-3. Prairie buttercup adults (1G) produced in 2020/2021. 13

Plate 3.2-4. Slender penstemon seedlings (50P) produced in 2020/2021. 13

Plate 3.2-5. Example of rock selaginella cuttings (Source: Eagle Cap Consulting). 15

Plate 3.2-6. Rock selaginella grown from cuttings in 2020/2021. 15

Plate 3.3-1. Planting site for Sprengel's sedge – CARESPR-2020-1A. 20

Plate 3.3-2 Planting site for Sprengel's sedge – CARESPR-2020-1B. 20

Plate 3.3-3. Installed Sprengel's sedge and identification tag 091– CARESPR-2020-1B. 21

Plate 3.3-4. Installed Sprengel's sedge and identification tag 086- CARESPR-2021-C. 21

Plate 3.3-5. Planting site for Torrey's sedge – CARETOR-2021-A. 21

Plate 3.3-6. Installed Torrey's sedge seedling (50P) and identification tag 092. 21

Plate 3.3-7. Example of seedling (50P) Davis' locoweed transplanted (Plot 22). 23

Plate 3.3-8. Example of transplanted clusters of Davis' locoweed adult plants (1G). 23

Plate 3.3-9. Pre-planting trench for Davis' locoweed seedlings. 23

Plate 3.3-10. Mesh fencing installed around plot 3 and a portion of plot 1B. 23

Plate 3.3-11. Salvaged slender penstemon that were transported to Site ID: PENSGRA-2021-C. 25

Plate 3.3-12. Shaded site at PENSGRA-2021-A where nursery-grown plants were transplanted on September 16, 2021. 25

Plate 3.3-13. Examples of translocated nursery-grown slender penstemon at PENSGRA-2021-C on September 16, 2021. 25

Plate 3.3-14. Example of translocated nursery-grown slender penstemon at PENSGRA-2020-B on June 09, 2021. 25

Plate 3.3-15. Example of caged prairie buttercup seedlings translocated on September 13, 2021 – RANURHO-2021-A (plot A). 30

Plate 3.3-16. Example of prairie buttercup seedling (75P) with identification tag 051 translocated on September 13, 2021 – RANURHO-2021-A. 30

Plate 3.3-17. Prairie buttercup translocation site– RANURHO-2021-B. 30

Plate 3.3-18. Example of prairie buttercup with identification tag translocated on June 8, 2021 – RANURHO-2021-B. 30

Plate 3.3-19. Example of salvaged rock selaginella translocated on June 13, 2021 – SELARUP-2021-A. 31

Plate 3.3-20. Example of nursery-grown rock selaginella translocated on September 16, 2021 – SELARUP-2021-A. 31

Plate 3.4-1. Canada mountain-ricegrass inflorescence during July 7, 2021 monitoring – PIPTCAN-2020-A. 36

Plate 3.4-2. Canada mountain-ricegrass (tag 084) during September 13, 2021, monitoring – PIPTCAN-2020-A. 36

Plate 3.4-3. Davis' locoweed adult plant flowering – OXTYCAM3-2020-C on June 12, 2021. 37

Plate 3.4-4. Davis' locoweed seedling plants flowering – OXTYCAM3-2020-B on June 12, 2021. 37

Plate 3.4-5. Showy locoweed adult plant flowering on June 12, 2021; this individual originated from seeds collected in 2017/2018 and represents accidental contamination during seed collection for Davis' locoweed – OXTYCAM3-2020-C. 38

Plate 3.4-6. Vigorous dry-land sedge transplant during August 2, 2021, monitoring – CAREXER-2020-D. 39

Plate 3.4-7. Dry-land sedge inflorescence during June 8, 2021, monitoring – CAREXER-2020-E. 39

Plate 3.4-8. Slender penstemon seed heads on July 7, 2021– PENSGRA-2020-A. 40

Plate 3.4-9. Slender penstemon seeds on July 7, 2021 – PENSGRA-2020-B. 40

Plate 3.4-10. *Carex sprengelii* seed development in July 7, 2021– CARESPR-2020-1B 2021. 40

Plate 3.4-11. *Carex sprengelii* seed development in September 10, 2021– CARESPR-2020-1A. 40

List of Appendices

Appendix A. Site C Experimental Translocation Project: Potential Recipient Site Selection Methods & Results Memo

Appendix B. Data Form – Translocation and Monitoring

ERRATA

In the Experimental Rare Plant Translocation Program's 2020 Annual Report, page 11, Section 3.2, Table 3.2-1: *Ex-Situ* Propagation Results from the 2019 Seed Collection Efforts, there was an error in the germination percentages reported for Davis' locoweed (*Oxytropis campestris* var. *davisii*); prairie buttercup (*Ranunculus rhomboideus*); and Sprengel's sedge (*Carex sprengelii*). The germination rates should have read, "19%; 2%; and 33%", respectively. The correct 2020 germination rates are provided in this document in Section 3.2, Phase 2 *Ex-Situ* Propagation.

ACRONYMS & ABBREVIATIONS

Term	Definition
B.C. CDC	B.C. Conservation Data Centre
EIL	Erosion Impact Line
ERPT	Experimental Rare Plant Translocation
ENSCONET	European Native Seed Conservation Network
PAZ	Potential Activity Zone
PRS	Potential Recipient Site
QA/QC	Quality Assurance and Quality Control
spp.	The abbreviation "spp." (plural) indicates "several species".
sp.	The abbreviation "sp." Refers to a single species.

1. INTRODUCTION

As part of the federal and provincial regulatory approvals of the Site C project, BC Hydro committed to the creation of an Experimental Rare Plant Translocation program (ERPT) to support the viability of target rare plant species affected by the project.

The ERPT program is designed to establish new populations of target rare plant species in areas that are secure, contain analogous habitat to the source populations, and are within the Peace Region. This program uses an experimental approach to identify critical factors affecting germination, establishment, growth, and survival of the target species, the results of which inform the scope of the design such that informed variations on salvage, propagation, and transplant methods can be employed. The ERPT program is updated on an ongoing basis to incorporate relevant information related to target rare plant species and translocation methods as it emerges.

The program is founded on positive working relationships with First Nation-owned, local businesses, and other consultants, and benefits from the shared knowledge and experience. The knowledge acquired and lessons learned can be employed to maximize the success of the program and can be shared among these partners to increase the overall understanding of these systems within the community of contributors.

This report summarizes the measures and activities undertaken in 2021. Included are a summary of the plant species of conservation concern included in the program and the general methods and activities completed for the four phases of the program: Phase 1 - propagule collection; Phase 2 - *ex-situ* propagation; Phase 3 - translocation implementation; and Phase 4 - post-translocation care, maintenance, and monitoring.

1.1 PLANT SPECIES INCLUDED IN THE PROGRAM AND THEIR CONSERVATION RANKS

The B.C. Conservation Data Centre (B.C. CDC) annually assesses the provincial conservation ranks of vascular plants and bryophytes in the province. This annual assessment incorporates new information about the abundance and distribution of the province's flora, as well as newly recognized threats (or lack thereof) to known populations. The ranking update published by the B.C. CDC in 2021 (B.C. CDC 2021) changed the conservation status rank of 37 species in the province relative to their status in 2020. No changes to the conservation status rank of species included in the ERPT program were made in 2021 (Table 1.1-1).

Table 1.1-1. Species included in the Experimental Rare Plant Translocation Program

Scientific Name	Common Name	B.C. CDC Provincial Rank	NatureServe Provincial Status	NatureServe Global Status
Canada mountain-ricegrass	*Piptatheropsis canadensis*	Red	S1 (2019)	G4G5 (2016)
Davis' locoweed	*Oxytropis campestris* var. *davisii*	Blue	S3? (2019)	G5T3 (2015)
Dryland sedge	*Carex xerantica*	Blue	S3 (2019)	G5 (2016)
Prairie buttercup	*Ranunculus rhomboideus*	Blue	S2S3 (2019)	G5 (2016)
Rocky Mountain willowherb	*Epilobium saximontanum*	Blue	S3 (2019)	G5 (1984)
Rock selaginella	*Selaginella rupestris*	Red	S2 (2019)	G5 (2016)
Slender penstemon	*Penstemon gracilis*	Blue	S3 (2019	G5 (2016)
Sprengel's sedge	*Carex sprengelii*	Blue	S3 (2019)	G5 (2016)
Torrey's sedge	*Carex torreyi*	Blue	S3? (2019)	G4G5 (2016)

2. GENERAL METHODS

2.1 PHASE 1. PROPAGULE COLLECTION

The standards for collecting and storing propagules for *ex-situ* conservation (e.g., timing, sampling, labelling, cleaning, processing, stratification, sowing, provenance) incorporate guidance outlined in Maslovat (2009) and by the European Native Seed Conservation Network (ENSCONET 2009).

The 2021 propagule collection phase included a combination of the following collection strategies:

- collection of seed from existing populations and sowing of seeds at a nursery, with the resulting seedlings targeted for out-planting at recipient sites;
- collection of mature plants, seedlings, and cuttings from existing populations, followed by *ex-situ* propagation at a nursery and eventual out-planting of propagated material at recipient sites; and
- collection of mature plants or seedlings from existing populations.

2.1.1 *In-situ* Seed Collection

The 2021 *in-situ* propagule collection efforts focused predominantly on augmenting existing seedbank resources for future propagation and for insurance against stochastic events (e.g., floods), human disturbance, and year-to-year climatic variability. Additional collection efforts focused on salvaging plants from within the project footprint and directly replanting them to areas outside of the footprint or sending them to the native plant nurseries for care and future propagation.

2.1.2 *Ex-situ* Seed Collection

Nursery staff collected seeds from the nursery stock derived from the 2017/2018 seed collection efforts. Nursery staff sorted the seeds to remove non-viable seeds (i.e., empty, or poorly developed), and the remaining seeds were cleaned and dried (where necessary) to maximize viability. Cleaning included the removal of waste material from around the seed capsule, and the use of sieves, hand separation, and air separation. Seeds were then placed in cold storage at the nursery to maintain seed quality and longevity. The provenance, seed collection procedures, and quantity collected were recorded.

2.2 PHASE 2. *EX-SITU* PROPAGATION

Ex-situ propagation involved stratification and propagation for each individual target species in a nursery environment. Curation protocols and recommendations (ENSCONET 2009) and professional horticultural experience were used to inform the methods for this aspect of the program.

Through the pre-treatment process, seeds were treated to simulate the natural conditions for breaking seed dormancy and initiating germination. Seeds were scarified and/or stratified as relevant. Scarification treatments included a short hot-water bath or sandpaper, while stratification included immersing the

seeds into cold temperatures with moisture to simulate natural germination conditions. Seeds that were not intended for planting in the subsequent year were not treated and are being stored as insurance for potential future use.

Propagation methods were developed based on the ecological conditions observed at the source populations, and included several measures and considerations (Vallee et al. 2004; Maslovat 2009) such as:

- examination of the ecological and, if available, translocation literature to determine experimental trials, including optimum founder size (i.e., number of individuals and composition of life stages), reproductive status relevant to propagation for each rare plant species, and out-planting requirements;
- review of common garden experiments as a potential source of horticultural information for a specific target species;
- exploration and implementation of a range of techniques (e.g., varying soil substrate) to determine the most effective propagation options for each target species;
- multiple germination trials to determine viability; and
- holding back source propagules in an *ex-situ* collection as material for future propagation.

All utilized *ex-situ* propagation methods have been documented, including the following:

- provenance (i.e., origin of material collected);
- type of material collected (e.g., seed, live plant);
- location and date of collection; and
- growing conditions such as potting media, temperature of propagation area, watering, and treatment of seeds.

2.3 PHASE 3. TRANSLOCATION

Translocation implementation included four components: (i) recipient site selection; (ii) transport and plant preparation; (iii) selection of planting locations with the habitat matrix; and (iv) translocation at recipient sites.

2.3.1 Recipient Site Selection

Selection of suitable recipient sites, based on the species-specific preferred habitat characteristics, was informed by the extensive existing information collected for Site C along with the expert knowledge of qualified botanists and ecologists who performed the field verification work (see Appendix A). Selected sites contained habitat analogous to that at the source populations and were situated in areas that are unlikely to be developed in the foreseeable future. All sites selected are located within the Peace Region.

The stated goal of recipient site selection in 2021 was to locate suitable recipient sites for four target rare plant species: Davis' locoweed, slender penstemon, Canada mountain-ricegrass, and rock selaginella. Before verifying and selecting recipient sites in the field, a desktop review was conducted to identify potential locations. The desktop review included literature reviews for each priority species to evaluate current and relevant species information such as habitat and translocation requirements, with a particular focus on reviewing new information that had been published since 2020. The updated B.C. CDC database was reviewed to ensure that all existing occurrences known were incorporated into the analysis, and queries were run on the project rare plant database to extract any habitat information that had been recorded during earlier years of the ERPT program.

The habitat requirements of the four target species were grouped into four main types that represent the ideal habitats for translocation, with the following characteristics:

1. river or large stream with level, open, non-active cobble bars; shading open to partial; sparsely vegetated; sandy, well-drained soil;
2. dry, steep, open, south-facing hillside; relatively sparse low shrubs; xeric grassland vegetation with tan-coloured appearance on aerial imagery;
3. mesic to dry, open, south-facing hillcrest or gentle slope; relatively dense low shrubs; grassland vegetation with a green appearance on aerial imagery; or
4. dry, steep, open, south-facing hillcrest/hillside; relatively sparse, low shrubs; xeric grassland vegetation with a tan-coloured appearance on aerial imagery.

Aerial imagery and GIS attributes were visually evaluated to identify locations with ideal ecological and logistical characteristics that would maximize opportunities for successful translocation. GIS layers that were assessed for this included: (i) aerial imagery of the Peace River region; (ii) property ownership (provided by BC Hydro); (iii) known element occurrences of the target species; (iv) potential recipient sites identified during earlier years of the project; (v) the Site C Project Activity Zone (PAZ); and (vi) the Site C preliminary Erosion Impact Line (EIL). This analysis resulted in the following criteria that were identified as indicative of suitable recipient sites:

1. accessible by road or boat during the entire growing season;
2. outside of the Site C PAZ;
3. not located below the reservoir preliminary Erosion Impact Line (i.e., a precautionary estimate of the amount of erosion that could occur over a 100-year period);
4. located on Crown land or BC Hydro land near the Peace River;
5. within range of cell service;
6. not requiring access through a locked gate or other landowner permission;
7. contains appropriate habitat for the priority species;
8. contains low density of non-native plants;

9. has low levels of anthropogenic disturbance;
10. greater than one kilometre from known sites of the same taxon;
11. not already occupied by other rare plant species; and
12. located close to a water source.

It is recognized that the list of desirable recipient site qualities describes a hypothetical ideal site. For example, field botanists attempted to avoid occupied sites when reviewing potential planting locations; however, this was only partially successful because suitable planting sites were often found to host target rare plant species. As a result, no site is likely to fulfill all the listed criteria, and trade-offs will always be necessary to ensure that the project can proceed.

Potential Recipient Sites (PRSs) were selected partially based on distance to other planting sites, with the aim of distributing them over a wide geographical extent. In some instances, a site was found to contain suitable habitat for several ERPT target species in close proximity, and so separate PRS plots were completed for each target species. While this does provide the option to plant multiple species at the same site, with the consequent increased risk of a single disturbance event impacting multiple species, the limited number of suitable sites available for some of the target species necessitated using one site for several species in some cases. In addition, several of the target species occur together in wild populations, and thus their co-occurrence is consistent with natural conditions.

Thirty-four PRSs were identified during this desktop exercise in 2021, of which 12 received field verification and were ranked for suitability using weighted desirable site characteristics. The 22 PRSs not field-verified were either too difficult to access, have been visited during earlier field surveys of PRSs, or are under consideration as future PRSs (see Appendix A). Of the sites that were checked, two PRSs were considered to be worth investigating further, and three PRS plots were completed between these two sites. At each PRS plot, vegetation composition and cover data were recorded for the overall site, as well as for three one-metre-square plots placed in representative locations. Despite challenges with avoiding sites in the vicinity of other rare plant populations and finding areas with water sources, the two best PRSs met the majority of the stated requirements. One of the PRS areas contains a variety of habitats and is suitable for multiple species translocation (see Appendix A); the remaining PRS was specifically selected for a single taxon (Davis' locoweed) due to its distinct habitat requirements. Supplemental planting areas (i.e., specific microsites) were marked within suitable habitat to provide increased planting options.

2.3.2 Transport and Plant Preparation

Nursery seedlings (i.e., small plants in 50P or 75P size plugs) and adult plants (i.e., medium to large plants in 1-gallon pots) were shipped from NATS nursery on May 31 and September 1, 2021. Plants arrived at Dunvegan Gardens (Dunvegan) in Fort St. John on June 2 and September 2, 2021, respectively. The plants were housed at the garden centre and moved to a private residence in Fort St. John until transplant at recipient sites in the following days. Plants were stored outside in June as temperatures were above freezing and in the Dunvegan greenhouses in September to be naturally hardened-off until planting was initiated on September 9, 2021.

2.3.3 Selection of Planting Locations within the Habitat Matrix

Planting locations within the larger habitat matrix at a recipient site were identified as those that were relatively easy to access, corresponded with known ecological conditions that support the species, supported plant diversity that is similar to the source populations, were on stable substrates that are not expected to undergo erosion or deposition, and were not accessible to cattle or used intensely by native herbivores. There was limited variability in the planting patterns within species, thereby minimizing constraints on comparability across sites within species. Within species, the planting plans sought to:

- establish plant groupings such that there were similar conditions in terms of microsite conditions (e.g., soils, slope, aspect);
- create plant groupings to encourage pollinator visitation; and
- space individuals to minimize potential trampling during planting and monitoring and to minimize interspecific competition for resources (e.g., minimize density-dependent effects on survival).

2.3.4 Translocation at Recipient Sites

The specific timing windows for planting were determined based on past years' experience regarding the average first and last frost-free days for Fort St. John, as well as plant phenology, the development stage of the propagated plants, the local weather, and soil moisture conditions. The timing for planting of two species also took into consideration the need to salvage plants prior to clearing activities occurring at one location.

The initial out-planting occurred from June 9 to 15, 2021, and a subsequent out-planting occurred from September 9 to 16, 2021. Some plant stock was withheld from planting as insurance against inclement conditions that could negatively affect the initial out-planting stock. Implementation of the translocation planting included the following:

- placement of plants into optimal microhabitats at the recipient sites, and in a spatial pattern suitable to the rare plant's biology as observed at the source populations or otherwise known;
- installation of durable, long-lasting tags to label individual plants and flagging tape to label plant groupings;
- code systems to differentiate various experimental trials as needed to retain as much information as possible on the pathway of a given plant (e.g., from seed collection to planting) to facilitate annual assessments of success;
- marked boundaries for plants, plant groupings, and translocation site boundaries using GPS points and imported into the project GIS system;
- care and maintenance at the time of planting, such as watering and creation of microhabitat as necessary;
- documentation of each translocation effort (including time spent on each phase), which included the methods used to prepare and transport the material from the nursery to the recipient site,

pre-translocation site preparation, environmental conditions, method of re-introduction, care and maintenance activities, planting density, and spatial pattern; and

- post-translocation follow-up to assess the health and status of a sample and to check for other possible problems, such as desiccation, pest insects, trampling, herbivory, or vandalism at a translocation site.

2.4 PHASE 4. MONITORING

Two levels of monitoring were conducted in 2021: interim monitoring and year-end monitoring. Interim monitoring efforts included general health assessments of the translocated plants as well as identification of threats and subsequent application of mitigation measures. Year-end monitoring included an assessment of: (i) **Survivorship** - to determine if individuals are surviving beyond the initial transplant year; (ii) **Maturity** - to determine if individuals are maturing to the flowering and fruiting stages; and (iii) **Reproduction** - to determine if individuals are successfully producing seeds. The following population traits were assessed during the monitoring program:

- plant presence (summarized as number of live/dead/absent individuals);
- vegetative growth (width or height) and/or health (qualitative assessment)[1];
- percent of individuals flowering/fruiting;
- seed production per individual; and
- spatial extent of the population.

Monitoring activities also re-evaluated sites for the one or more of the following to identify successes and failures to improve the survival of future plantings:

- invasive species presence, especially in close proximity to the translocated plants, and/or any species that may have inadvertently been introduced to the site during the translocation;
- herbivory or other possible problems (e.g., pest insects, trampling, ungulate grazing);
- human disturbance; and
- microsite habitat preferences.

Information gained from monitoring implementation of the various experimental translocation approaches used will help to identify which approaches are effective and to isolate inadequacies in specific methods, all within an adaptive management framework.

[1] This information was collected in 2021 but has yet to be analyzed.

2.5 QUALITY ASSURANCE AND CONTROL

Quality assurance and quality control (QA/QC) measures were used for capturing data within the field program so that methods were consistently replicated across all trials and years, and so that pertinent variables or any variations in methodology were recorded. The data form was designed to accommodate data capture at the transect, plot, or individual plant level across years (Appendix B). The data form included the following fields:

1. site details (i.e., Site ID, geographical location, slope, aspect, and elevation);
2. species information (i.e., species name, nursery of origin, seedlot, key metrics for survivorship, maturity, and reproduction);
3. potential threats (i.e., herbivory, drought, others); and
4. map outlining the relative location of each individual plant and plant grouping.

Photos were taken using the Solocator App (Civi Corp Pty Limited 2021), which were date- and time-stamped and included the UTM location of the site.

3. RESULTS

3.1 PHASE 1. PROPAGULE COLLECTION

The 2021 *in-situ* collection efforts focused on acquiring additional propagules for six species: Sprengel's sedge, Torrey's sedge, prairie buttercup, Canada mountain-ricegrass, slender penstemon, and rock selaginella (Table 3.1-1). No *in-situ* collections were made for Davis's locoweed and dry-land sedge as previous collection efforts have resulted in sufficient quantity for the translocation efforts. Additionally, no collections were made for Rocky Mountain willowherb; there have been a number of attempts in recent years to locate this species in and around the reported location, but no individuals or suitable habitat have been observed (Eagle Cap 2020). *Ex-situ* seed collections were made opportunistically for Davis' locoweed in August from NATS nursery stock, and the seeds were processed according to the methods outlined in Section 2.1.2.

Seeds were collected from existing *ex-situ* populations for two species: Sprengel's sedge and Torrey's sedge (from Dry Creek and Fish Creek, respectively, Figure 3.1-1; Eagle Cap 2021). These species were targeted for further collection to augment the existing seedbank housed at NATS nursery. The nursery will sow these seeds with the intent of generating future plant stock for transplant at recipient sites.

Mature plants (and/or seedlings) were collected from existing populations for two additional species: slender penstemon and rock selaginella. A substantial effort was invested in salvaging plants from Farrell Creek East in response to changes to the Hwy 29 realignment, which have resulted in the partial loss of this species occurrence. Penstemon plants along with rock selaginella sod blocks (approximately 30 cm x 25 cm) were salvaged in a manner that retained the top growth, roots, and potential seed bank intact.

Seed collections were also attempted for Canada mountain-ricegrass and prairie buttercup; however, no viable seeds were detected. Climatological conditions in 2021, particularly extreme heat during the early growing season (June), are likely the cause of poor detectability of Canada mountain-ricegrass.

Table 3.1-1. Summary of Successful 2020/ 2021 Propagule Collection Efforts

Common Name	Species Name	Propagule Amount and Type	Collection Timing	Collection Type	Collection Location
Davis' locoweed	*O. campestris* var. *davisii*	16,000 seeds*	August 17, 2021	*ex-situ*	NATS nursery
Rock selaginella	*S. rupestris*	~144 sod blocks	June 13, 2021	*in-situ*	Farrell Creek East
Slender penstemon	*P. gracilis*	~156 plants	June 13, 2021	*in-situ*	Farrell Creek East
Sprengel's sedge	*C. sprengelii*	25 seeds	August 5, 2021	*in-situ*	Dry Creek
Torrey's sedge	*C. torreyi*	100 seeds	August 03, 2021	*in-situ*	Fish Creek

* Quantity provided from the nursery is an estimate based on seed weight.

Site C Project

Experimental Rare Plant Translocation Propagule Collection Locations

Figure 3.1-1

Date: 12/8/2021

Map Number: BCH-052

Coordinate System: NAD 1983 UTM Zone 10N

Projection: Transverse Mercator

Datum: North American 1983

ECOLOGIC environmental consulting

2017-2020	2021	Target Species
●	■	Sprengel's sedge (*Carex sprengelli*)
●	■	Torrey's sedge (*Carex torreyi*)
●		Dryland sedge (*Carex xerantica*)
●		Davis' locoweed (*Oxytropis campestris var. davisii*)
●	■	Slender penstemon (*Penstemon gracilis*)
●		Canada mountain-ricegrass (*Piptatheropsis canadensis*)
●		Prairie buttercup (*Ranunculus rhomboideus*)
	■	Rock selaginella (*Selaginella rupestris*)

3.2 PHASE 2. *EX-SITU* PROPAGATION

Propagation efforts in 2021 focused on seven species: Canada mountain-ricegrass, Davis' locoweed, prairie buttercup, slender penstemon, Sprengel's sedge, Torrey's sedge, and rock selaginella (Table 3.2-1). Nursery staff primarily focused on trialing methods for the two species added to the program in 2020: Canada mountain-ricegrass and rock selaginella. These trials focused on determining stratification methods for Canada mountain-ricegrass and on determining suitable growing media for rock selaginella cuttings. Additional efforts were invested in refining the stratification methods for Davis' locoweed and Torrey's sedge, both of which had low germination rates in 2020. The stratification measures were not altered for the remaining species, which included prairie buttercup, slender penstemon, and Sprengel's sedge.

In total, 2,959 rare plants were propagated from seed along with two blocks (60 cm x 30 cm) of rock selaginella, which were grown from cuttings. The overwhelming majority of the plants propagated were Davis' locoweed (2,800 seedlings: Plate 3.2-1). Notably, the germination rate was increased to over 35% from 19% due to refinement of the stratification measures. The debut trial for Canada mountain-ricegrass resulted in a 47% germination rate yielding nine seedlings (Plate 3.2-2). Additionally, the germination rate for Torrey's sedge was increased to 19% from 2% and resulted in 50 seedlings. The germination results for Sprengel's sedge increased to 37% from 33% and resulted in 50 seedlings. The germination rate for prairie buttercup increased substantially from 2% in 2020 to 29% in 2021 (Plate 3.2-3), likely as a result of refined stratification methods for this species. Rock selaginella was grown from two clumps (10 x cm by 10 cm) submitted last year (Plate 3.2-4). This species was grown in various substrate types and resulted in two large trays, both measuring 30 cm by 60 cm (Plate 3.2-5). Sufficient stock for the 2021 translocation efforts was generated for all species.

Plate 3.2-1. Canada mountain-ricegrass adult plants (1 Gallon) produced in 2021.

Plate 3.2-2. Davis' locoweed seedlings (50P) grown in 2020.

Plate 3.2-3. Prairie buttercup adults (1G) produced in 2020/2021.

Table 3.2-1. Summary of *Ex- situ* Propagation Results from the Propagule Collection Efforts

Species Name	Nursery of Origin	Seedlot	Weight and No. of Seeds Stratified	Germination Percent		Quantity and Size Produced in 2020/2021
				2020	2021	
Canada mountain-ricegrass (*P. canadensis*)	NATS	EL-180-20 EL-109-20	< 0.1 g (19 seeds)	na	47	9 seedlings
Davis' locoweed (*O. campestris* var. *davisii*)	NATS	EL-127-19 EL-183-17 EL-128-19 EL-130-19 EL-115-17 EL-206-18 NN-33-20	8 g (~ 8,000 seeds)	~ 19	~ 35%	2,800 seedlings
Prairie buttercup (*R. rhomboideus*)	NATS	EL-173-19 EL-182-18	0.45 g (360 seeds)	~ 2	29	20 1 G and 30 seedlings
Sprengel's sedge (*C. sprengelii*)	NATS	EL-181-18 EL-176-19	< 0.5 g (135 seeds)	33	37	50 seedlings
Torrey's sedge (*C. torrey*i)	NATS	EL-87-20	0.3 g (258 seeds)	2	19	50 seedlings
Rock selaginella (*S. rupestris)*	NATS	P7525FS P50LR50	na	na	na	2 sod blocks (60 cm x 30 cm)
Total						**2,961**

Plate 3.2-4. Example of rock selaginella cuttings (Source: Eagle Cap Consulting Ltd.).

Plate 3.2-5. Rock selaginella grown from cuttings in 2020/2021.

3.3 PHASE 3. TRANSLOCATION IMPLEMENTATION

Translocation implementation focused on planting trials at recipient sites that have greater long-term security than the locations of the source material. The recipient sites are within the known distribution range for the target plant within the Peace Region and have similar habitat to the location of the source material.

Translocation trials were completed in June and September 2021 with more than 760 individuals planted at eight recipient sites (Figures 3.3-1 to 3.3-3; Table 3.3-1). Two priority species, rock selaginella and Torrey's sedge, were translocated for the first time in this program.

Table 3.3-1. Summary of Individuals Translocated by Species and Site ID in 2021

Species	Site ID	Translocation Date	No. of Seedlings*	No. of Adults **	Total
Davis' locoweed	OXYTCAM3-2020-C	11-Jun	298	47	345
		11-Sep	30	28	58
		16-Sep	7	41	48
Total			**335**	**116**	**451**
Prairie buttercup	RANURHO-2021-A	9-Jun	10	3	13
		13-Sep	15	2	17
	RANURHO-2021-B	8-Jun	10	4	14
Total			**35**	**9**	**44**
Slender penstemon	PENSGRA-2020-B	9-Jun	15	1	16
	PENSGRA-2021-C (salvage)	13-Jun	-	-	~104
	PENSGRA-2021-C	16-Sep	10	10	20
Total			**25**	**11**	**140**

Species	Site ID	Translocation Date	No. of Seedlings*	No. of Adults **	Total
Sprengel's sedge	CARESPR-2020-1A and 1B	15-Jun	6	2	8
	CARESPR-2021-C	15-Jun	0	1	1
Total			**6**	**3**	**9**
Torrey's sedge	CARETOR-2021-A	16-Sep	5	0	5
Total			**5**	**0**	**5**
Rock selaginella	SELARUP-2021-A (salvage)	13-Jun	-	~109	~109
	SELARUP-2021-A	16-Sep	-	2	2
Total					**111**
Grand Total					**760**

* Seedlings are provided in 50P plug size containers which are 5" deep by 2" wide.

**Adults are provided in 1-gallon pots; rock selaginella cuttings grown in trays were included in this category.

540000 550000 560000 570000 580000 590000 600000 610000

6230000 6220000 6210000 6200000

Williston Lake
Brenot Creek
Lynx Creek
Peace River
Pine River
Moberly River
Maurice Creek
Hudson's Hope
29

PENSGRA-2021-C
SELARUP-2021-A

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Site C Project

Experimental Rare Plant Translocation
Recipient Site Locations
Figure 3.3-1

Date: 12/8/2021
Map Number: BCH-057a
Coordinate System: NAD 1983 UTM Zone 10N
Projection: Transverse Mercator
Datum: North American 1983

ECOLOGIC environmental consulting

Legend

2021 Recipient Sites

- Slender penstemon (*Penstemon gracilis*)
- Rock selaginella (*Selaginella rupestris*)
- Highway

0 2 4 6 km
1:200,000

N

Sources: Esri, USGS, NOAA

570000 580000 590000 600000 610000 620000 630000 640000

6250000 6240000 6230000 6220000

Halfway River
Cache Creek
Farrell Creek
Charlie Lake
Moberly River
Peace River
Pine River
Fort St. John
29
97

CARETOR-2021-A
CAREXER-2019-C
SELARUP-2021-B

CARESPR-2020-1A & 1B
CARESPR-2021-B
CAREXER-2020-D
PENSGRA-2020-B
RANURHO-2021-A
RANURHO-2021-B

PENSGRA-2020-A
CAREXER-2020-E

CAREXER-2018-A
CAREXER-2018-B

N

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Site C Project

Experimental Rare Plant Translocation
Recipient Site Locations
Figure 3.3-2

Date: 12/8/2021
Map Number: BCH-057b
Coordinate System: NAD 1983 UTM Zone 10N
Projection: Transverse Mercator
Datum: North American 1983

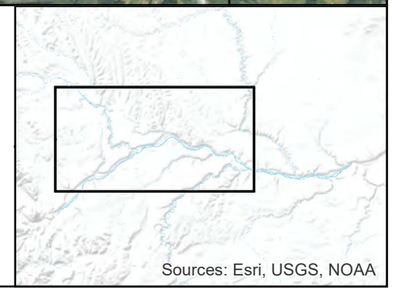
ECOLOGIC environmental consulting

Legend

- 2018-2021 Recipient Sites[1]
- Highway

0 2 4 6
1:200,000 km

[1]Site names correspond to the following species:
CAREXER - Dryland sedge (*Carex xerantica*)
CARETOR - Torrey's sedge (*Carex torreyi*)
PENSGRA - Slender penstemon (*Penstemon gracilis*)
RANURHO - Prairie buttercup (*Ranunculus rhomboideus*)
SELARUP - Rock selaginella (*Selaginella rupestris*)



Sources: Esri, USGS, NOAA

620000 625000 630000 635000 640000 645000 650000 655000 660000 665000 670000 675000 680000 685000 690000 695000

6240000 6235000 6230000 6225000 6220000 6215000 6210000 6205000 6200000

Taylor

OXYTCAM3-2018-A

OXYTCAM3-2020-B

OXYTCAM-2019-As
OXYTCAM3-2020-C

Beatton River

Peace River

Pine River

97

N

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Site C Project

Experimental Rare Plant Translocation
Recipient Site Locations
Figure 3.3-3

Date: 12/8/2021
Map Number: BCH-057c
Coordinate System: NAD 1983 UTM Zone 10N
Projection: Transverse Mercator
Datum: North American 1983

ECOLOGIC environmental consulting

Legend

2018-2021 Recipient Sites

Davis' locoweed (*Oxytropis campestris var. davisii*)

Highway

0 2 4 6
1:200,000 km

Sources: Esri, USGS, NOAA

3.3.1 Sprengel's Sedge (*Carex sprengelii*)

On June 15, 2021, existing populations of Sprengel's sedge (Site ID: CARESPR-2020-B-1A and 1B) were augmented with six seedlings at site CARESPR-2020-B-1A and two adult plants at site CARESPR-2020-B-1B (Figure 3.3-4; Plates 3.3-1 to 3.3-4). These sites were established on June 11, 2020, on the north side of Highway 29 above Bear Flat in a moist open willow thicket. One adult was also planted at site CARESPR-2021-C (Figure 3.3-4) in proximity to the trail towards site CAREXER-2020-D on June 15, 2021. The roots of each plant were gently loosened before placing each individual into excavated holes. Each hole was backfilled with the existing excavated soil and watered. Each plant was systematically tagged with a numbered yellow plastic tag fixed to the ground using 6-inch ground staples.

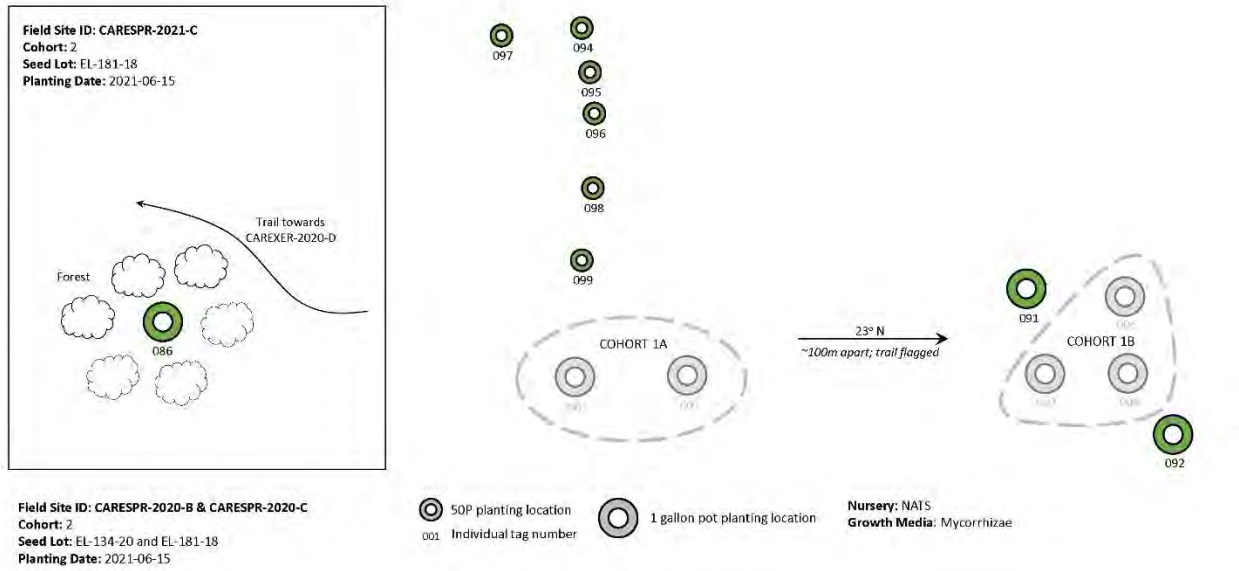


Figure 3.3-4. Planting Grid for Sprengel's Sedge at Site Id: CARESPR-2020-B 1A & 1B and CARESPR-2021-C

Plate 3.3-1. Planting site for Sprengel's sedge – CARESPR-2020-1A.

Plate 3.3-2 Planting site for Sprengel's sedge – CARESPR-2020-1B.

Plate 3.3-3. Installed Sprengel's sedge and identification tag 091– CARESPR-2020-1B.

Plate 3.3-4. Installed Sprengel's sedge and identification tag 086- CARESPR-2021-C.

3.3.2 Torrey's sedge (*Carex torreyi*)

On September 16, 2021, five seedlings were translocated in an open area with grasses and forbs adjacent to aspen forest (Site ID: CARETOR-2021-A). The planting site is close to a trail leading to site CAREXER-2019-C (Figure 3.3-5; Plates 3.3-5 and 3.3-6). The 2021 season represented the first attempt at out-planting Torrey's sedge.

Plate 3.3-5. Planting site for Torrey's sedge – CARETOR-2021-A.

Plate 3.3-6. Installed Torrey's sedge seedling (50P) and identification tag 092.

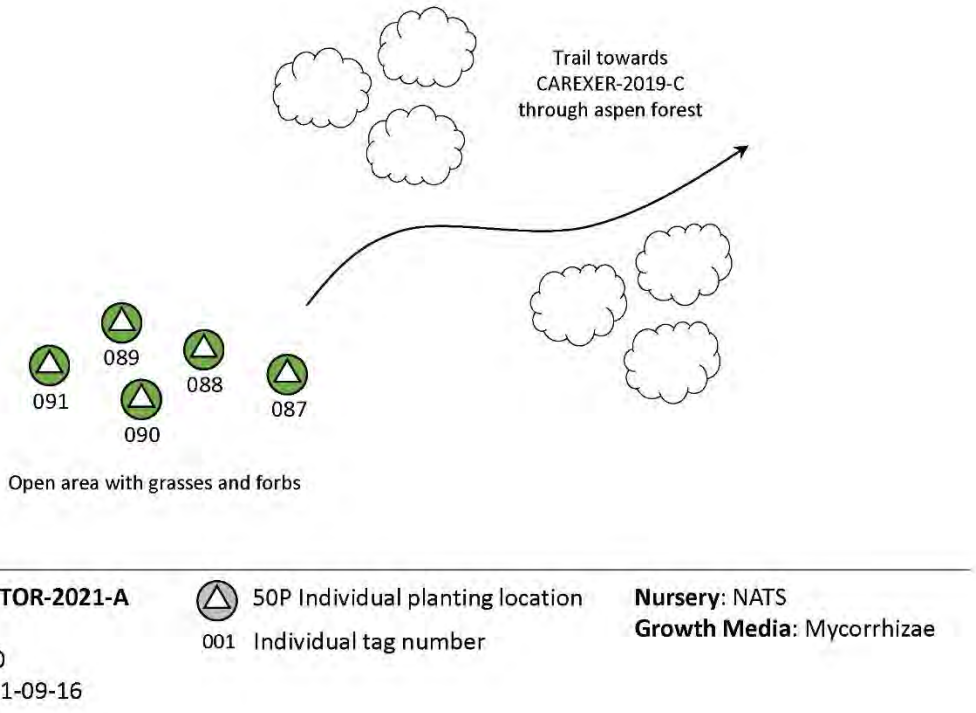


Figure 3.3-5. Planting Grid for Torrey's Sedge at Site Id: CARETOR-2021-A

3.3.3 Davis' locoweed *(Oxytropis campestris* var. *davisii)*

Existing populations of Davis' locoweed (Site ID: OXYTCAM3-2020-C) were augmented with a total of 451 individuals (116 adults and 335 seedlings; Figure 3.3-6, Plates 3.3-7 and 3.3-8). Forty-seven adults and 298 seedlings (Cohort 2) were planted on June 11, 2021; 28 adult and 30 seedlings (Cohort 3) were planted on September 11, 2021; and 41 adults and 7 seedlings (Cohort 3) were planted on September 14, 2021.

Davis' locoweed were planted in clusters and arranged in relatively close proximity to each other (see arrangement of individual plots in Figure 3.3-6). This planting arrangement was intended to encourage pollinator visitation, to minimize potential trampling during planting and monitoring, and to minimize inter-individual resources (i.e., minimize density-dependent effects on survival; Plate 3.3-8).

The planting method was similar to past years in the challenging cobbly substrate, where excavated sandy soil was separated from the cobble and mixed with wetted nursery soil to be used as back-fill (Plate 3.3-9). The cobble was then used to fill in gaps and was placed around each plant to be consistent with the existing grade. Any mosses that existed in the designated planting areas were carefully removed before excavation and replaced after planting. A water backpack was used to carry water from the river to provide additional moisture to recent plantings.

Mesh fencing was applied around plot 3 and a portion of plot 1B to deter herbivory by ungulates (Plate 3.3-10). Signs of elk were evident near the site and herbivory was observed on established transplants from the previous year.

Plate 3.3-7. Example of seedling (50P) Davis' locoweed transplanted (Plot 22).

Plate 3.3-8. Example of transplanted clusters of Davis' locoweed adult plants (1G).

Plate 3.3-9. Pre-planting trench for Davis' locoweed seedlings.

Plate 3.3-10. Mesh fencing installed around plot 3 and a portion of plot 1B.

Figure 3.3-6. Planting Grid for Davis' Locoweed at Site ID: OXYTCAM3-2020

3.3.4 Slender penstemon *(Penstemon gracilis)*

Slender penstemon at various life stages (i.e., young rosettes, flowering, seeding) were salvaged along with rock selaginella at the Farrell Creek East on June 13, 2021 (Plate 3.3-11), and transported to a new translocation site (PENSGRA-2021-C), a south-facing hill overlooking the Peace River (Figure 3.3-7; Plate 3.3-12). An additional 52 individuals were transported to NATS nursery as insurance against stochastic events.

Plate 3.3-11. Salvaged slender penstemon that were transported to Site ID: PENSGRA-2021-C.

Plate 3.3-12. Shaded site at PENSGRA-2021-A where nursery-grown plants were transplanted on September 16, 2021.

Plate 3.3-13. Examples of translocated nursery-grown slender penstemon at PENSGRA-2021-C on September 16, 2021.

Plate 3.3-14. Example of translocated nursery-grown slender penstemon at PENSGRA-2020-B on June 09, 2021.

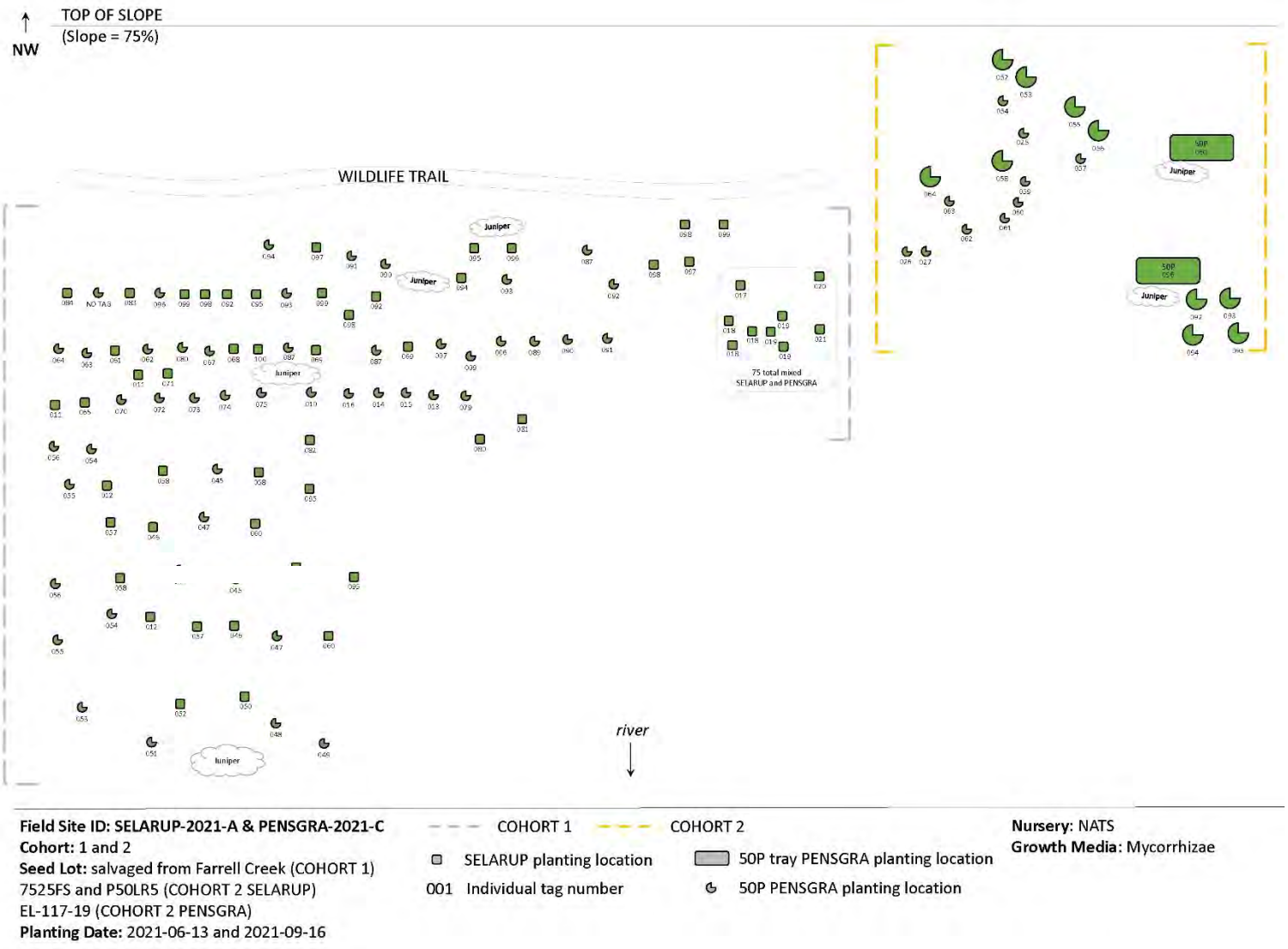


Figure 3.3-7. Planting Grid for Slender Penstemon Mixed Planting with Rock Selaginella at Site ID: PENSGRA-2021-C

At site PENSGRA-2021-C, slender penstemon were interplanted with rock selaginella (Figure 3.3-8). An estimated eight individuals were planted. Due to dry conditions, lack of a water source, and plant stress attributed to handling and transportation, many of the transplants in this initial cohort 1 were wilted at the time of planting despite having been stored in the shade. Follow-up watering was not completed as rainfall occurred directly after planting. At the same site but in a different location, 10 plugs (50P) and 10 1-gallon individuals (cohort 2) were planted to the east of the salvaged transplants on September 16, 2021 and labelled with orange tags (Figure 3.3-7; Plate 3.3-13). The second cohort was translocated to a shady upper portion of the slope which also contained stone-free soils of aeolian (wind-derived) origin. At site PENSGRA-2020-B-50P, 15 plugs (75P) were planted in a row above translocated individuals from the previous year (cohort 1); one additional adult was planted near cohort 1 as well (Figure 3.3-8; Plate 3.3-14).

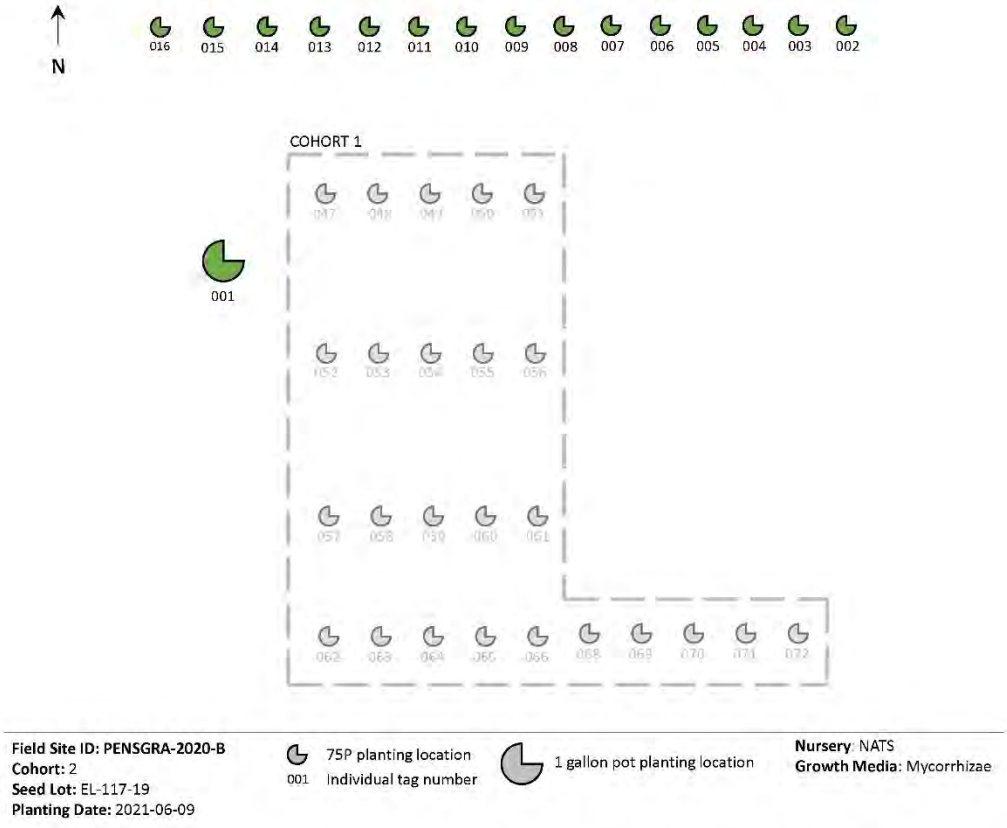


Figure 3.3-8. Planting Grid for Slender Penstemon at Site ID: PENSGRA-2020-B-50P

3.3.5 Prairie buttercup *(Ranunculus rhomboideus)*

Ten seedlings and three adult plants were planted at Site ID: RANURHO-2021-A on June 9, 2021 (cohort 1), within a saskatoon berry shrub and grass matrix (Figure 3.3-9). A second planting of 15 seedlings and 2 adult plants were also translocated at Site ID: RANURHO-2021-A on June 13, 2021 (cohort 2; Figure 3.3-10, Plates 3.3-15 and 3.3-16). The June 13 plantings were situated amongst rose, saskatoon berry, and snowberry shrubs, and wired cages and cones were established around these plantings to deter herbivory (Plate 3.3-15). On June 8, 2021, 10 seedlings (75P) and 4 (1G) adults were planted at site RANURHO-2021-B (Figure 3.3-11; Plates 3.3-17 and 3.3-18). The 2021 season represented the first attempts at out-planting this species for the ERPT program.

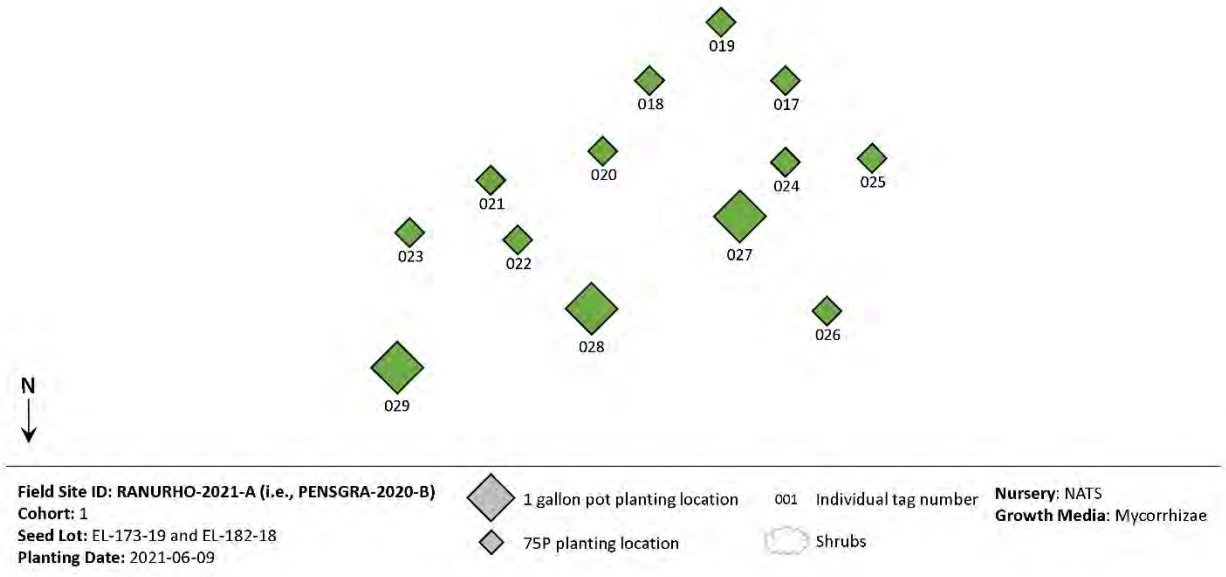


Figure 3.3-9. Planting Grid for Prairie Buttercup at Site Id: RANURHO-2021-A Cohort 1

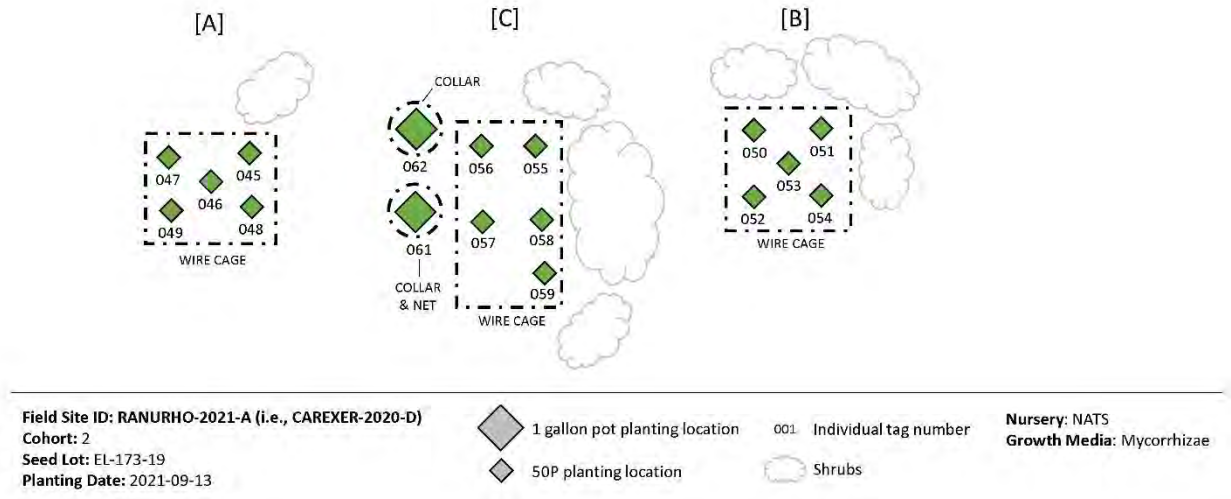


Figure 3.3-10. Planting Grid for Prairie Buttercup at Site Id: RANURHO-2021-A Cohort 2

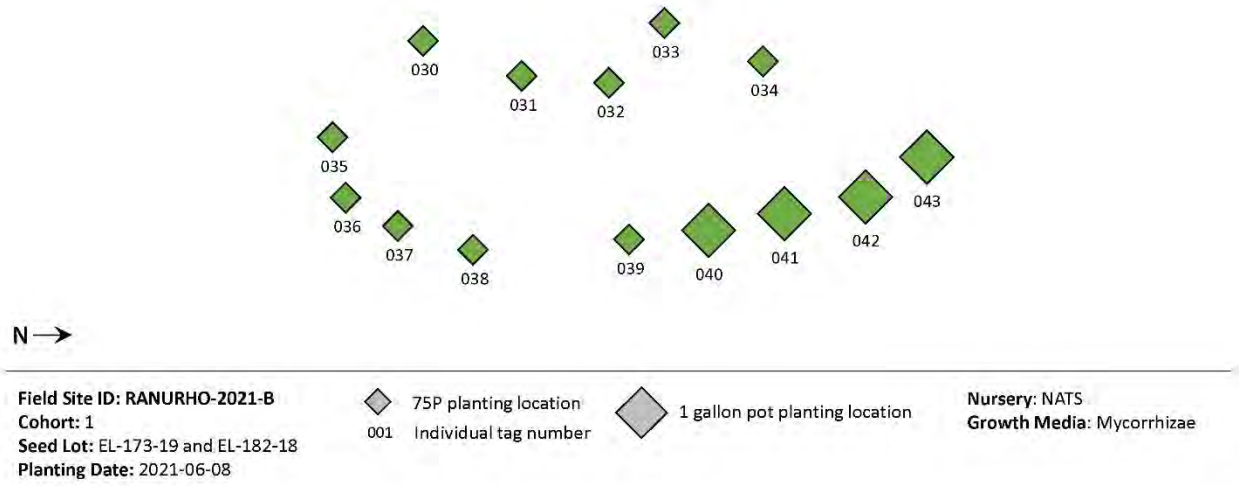


Figure 3.3-11. Planting Grid for Prairie Buttercup at Site Id: RANURHO-2021-B

Plate 3.3-15. Example of caged prairie buttercup seedlings translocated on September 13, 2021 – RANURHO-2021-A (plot A).

Plate 3.3-16. Example of prairie buttercup seedling (75P) with identification tag 051 translocated on September 13, 2021 – RANURHO-2021-A.

Plate 3.3-17. Prairie buttercup translocation site– RANURHO-2021-B.

Plate 3.3-18. Example of prairie buttercup with identification tag translocated on June 8, 2021 – RANURHO-2021-B.

3.3.6 Rock selaginella *(Selaginella rupestris)*

Approximately 136 rock selaginella blocks were salvaged along with slender penstemon at the Farrell Creek site on June 13, 2021. Individuals were mostly dormant at the time of salvage and were transported to a new translocation site (SELARUP-2021-A; Plate 3.3-19), a south-facing hill overlooking the Peace River, where they were interplanted with the slender penstemon (Figure 3.3-7). Thirty-five salvaged individuals were also transported to NATS nursery. At the same site but at a different location, two trays of nursery-grown rock selaginella were planted to the east of the salvaged transplants and watered (Figure 3.3-7; Plate 3.3-20). Eight clusters of salvaged rock selaginella were also planted at site SELARUP-2021-B adjacent to

site CAREXER-2019-C (Figure 3.3-12). An additional 35 blocks of selaginella were transported to NATS nursery as insurance against stochastic events. The 2021 season represented the first attempts at out-planting this species for the ERPT program.

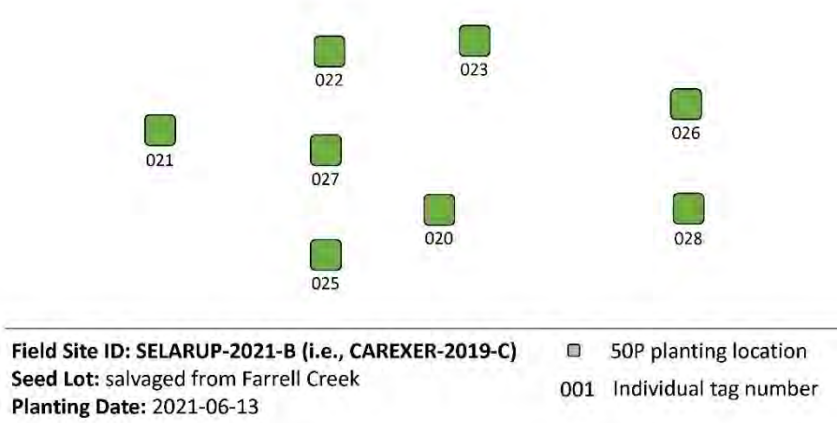


Figure 3.3-12. Planting Grid for Slender Penstemon at Site ID: SELARUP-2021-B

Plate 3.3-19. Example of salvaged rock selaginella translocated on June 13, 2021 – SELARUP-2021-A.

Plate 3.3-20. Example of nursery-grown rock selaginella translocated on September 16, 2021 – SELARUP-2021-A.

3.4 MONITORING

Translocated individuals were monitored two to three times in 2021 to correspond with seasonal changes in the phenology of each species. An early spring visit determined overwintering survival, a visit during the summer (targeted to correspond with the potential flowering period) assessed vigour and reproduction, and a visit during the fall assessed survival after transplant for those species planted in the preceding year. Monitoring frequency was increased following any interventions to address population or health declines.

3.4.1 Interim Monitoring

The translocated populations are being monitored at a frequency that permits the timely identification of threats such as vandalism, desiccation, or herbivory, and to allow for subsequent mitigation measures to address these issues. Issues identified during the interim monitoring along with follow-up measures identified in 2021 are summarized in Table 3.4-1.

Several sites were not monitored this year and are now considered inactive as they have low value for further translocation. For example, two dryland sedge sites (CAREXER-2018-A and CAREXER-2018-B) were designated as having low value for further translocation due to high herbivory and disturbance associated with cattle and deer at the site. In other instances, monitoring has been deferred to 2022 due to unforeseen logistical challenges in 2021. The remaining sites will remain active in 2022 and will be monitored. The monitoring dates as well as any follow-up actions are summarized by site in Table 3.4-1.

Table 3.4-1. Summary of Recipient Sites and Current Status

Species	Site Name	Status	Survey Date(s) 2021	Monitoring 2022	Follow-up Measures
Dryland Sedge (*C. xerantica*)	CAREXER-2018-A	Inactive	Not applicable	N	na
	CAREXER-2018-B	Inactive	Not applicable	N	na
	CAREXER-2019-C	Active	Not applicable	Y	Not determined
	CAREXER-2020-D	Active	June 8, August 2, September 13	Y	Initiate invasive plant removal and continue watering.
	CAREXER-2020-E	Active	July 9 and August 2	Y	Restrict site visits to 2 per year to minimize erosion of fine textured soils.
Canada mountain-ricegrass (*P. canadensis*)		Active	June 8, July 7, September 13	Y	None identified.
Davis' locoweed (*O. campestris* var. *davisii*)	OXYTCAM3-2018-A	Active	Not applicable	Y	Reassess site to determine if further monitoring of the plant trials is warranted. Site currently contains an existing occurrence of *O. campestris* and may serve as a future reference site.
	OXYTCAM3-2018-As	Active	Not applicable	Y	Monitor a selection of seed trials in 2022.
	OXYTCAM3-2020-B	Active	June 12	Y	Assess if fencing is required to address herbivory.
	OXYTCAM3-2020-C	Active	June 12 and September 12	Y	Evaluate the efficacy of trial fencing to address herbivory. Consider re-establishing phenocamera to track herbivory.
Prairie buttercup (*R. rhomboideus*)	RANURHO-2021-A	Active	June 8, July 7, September 10	Y	Bear encounter and signs of disturbance to plants in 2019.
	RANURHO-2021-B	Active	June 8, July 7, September 10	Y	Establish fencing to address herbivory.

Species	Site Name	Status	Survey Date(s) 2021	Monitoring 2022	Follow-up Measures
Rock selaginella (*Selaginella rupestris*)	SELARUP-2021-A	Active	July 7 and September 16	Y	None identified.
	SELARUP-2021-B	Active	July 7 and September 10	Y	None identified.
Slender penstemon *(P. gracilis*)	PENSGRA-2020-A	Active	June 08, August 25	Y	Continued watering.
	PENSGRA-2020-B	Active	June 08, August 25	Y	Continued watering.
	PENSGRA-2020-C	Active	July 7 and September 16	Y	Initiate watering in drought conditions, if needed.
Sprengel's sedge (*C. sprengelii*)	CARESPR-2020-1A	Active	June 15, July 7 and September 10	Y	Initiate watering in drought conditions, if needed.
	CARESPR-2020-1B	Active	June 15, July 7 and September 10	Y	Determine if fencing is needed to prevent animals from laying on the plants.
	CARESPR-2020-C	Active	September 10	Y	Initiate watering in drought conditions, if needed.

3.4.2 Year-end Monitoring

Year-end monitoring involved an evaluation of survivorship, maturity, and reproduction (Table 3.4-2). These metrics are being used to evaluate population viability at recipient sites and to track establishment of the translocated plants and resulting recruitment. The year-end monitoring is critical to ensure that issues with viability or establishment can be identified and addressed as they arise.

Table 3.4-2. Summary of Year-end Monitoring Results for 2021

		Survivorship		Maturity		Reproduction	
Species	Site Name	Survival in Relation to Total	Percent Flowering	Flowering in Relation to Total	Percent Flowering	Seed Production in Relation to Total	Percent Flowering
Canada mountain-ricegrass	PIPTCAN-2020-A	4/7	57%	2/7	29%	2/7	29%

		Survivorship		Maturity		Reproduction	
Species	Site Name	Survival in Relation to Total	Percent Flowering	Flowering in Relation to Total	Percent Flowering	Seed Production in Relation to Total	Percent Flowering
Davis' locoweed	OXTYCAM3-2020-B	78/89	88%	45	51%	_	_
	OXTYCAM3-2020-C	89/101	88%	51/101	50%	48/101	47%
Dryland sedge	CAREXER-2020-D	87/88	99%	_	_	62/88	70%
	CAREXER-2020-E	49/50	98%	_	_	49/50	98%
Slender penstemon	PENSGRA-2020-A	25/25	100%	25/25	100%	25/25	100%
	PENSGRA-2020-B	17/25	68%	16/25	64%	10/25	40%
Sprengel's sedge	CARESPR-2020-A	2/2	100%	1/2	50%	1/2	50%
	CARESPR-2020-B	3/3	100%	3/3	100%	3/3	100%

3.4.3 Canada mountain-ricegrass (*Piptatheropsis canadensis*)

Canada mountain-ricegrass at PIPTCAN-2020-A were monitored on June 8, July 7, and September 13, 2021 (Table 3.4-2). Of the 7 individuals planted in 2020, 2 individuals survived (29 %) and 0 individuals produced seeds (0 %; Plates 3.4-1 and 3.4-2). Lower-than-expected survivorship and reproduction in 2021 is possibly linked to the extreme climatic conditions (i.e., drought, 'heat dome') that occurred during the early growing season (June), which may have affected the establishment and growth of this species at the recipient sites. Reproduction and vigour at natural sites were found to have decreased substantially between 2020 and 2021 (see Appendix A), which supports the notion that this was the result of regional conditions rather than site-specific challenges.

Plate 3.4-1. Canada mountain-ricegrass inflorescence during July 7, 2021 monitoring – PIPTCAN-2020-A.

Plate 3.4-2. Canada mountain-ricegrass (tag 084) during September 13, 2021, monitoring – PIPTCAN-2020-A.

3.4.4 Davis' locoweed (*Oxytropis campestris* var. *davisii*)

Davis' locoweed at OXYTCAM3-2020-B and OXYTCAM3-2020-C were monitored on June 12. OXYTCAM3-2020-C was also monitored on September 12, 2021 (Table 3.4-2). Of the 101 individuals planted at OXTYCAM3-2020-B in 2020, 99 were assessed. Of these, 78 individuals survived (88%) and 45 individuals produced flowers (51%; Plate 3.4-3). During monitoring, all of the 101 individuals planted at OXTYCAM3-2020-C in 2020 were assessed. Of these, 89 individuals survived (88%), of which 48 produced seeds (47%; Plate 3.4-4). It was noted during monitoring that 10 of the translocated plants at OXYTCAM3-2020-B and 17 of the of the translocated plants at OXYTCAM3-2020-C are showy locoweed (*O. splendens*; Plate 3.4-5), which have not been included in the summary totals. These species are similar in appearance and commonly co-occur at the same sites. Thus, some showy locoweed seeds were accidentally mixed with the Davis' locoweed seeds collected in 2017 and/or 2018.

Plate 3.4-3. Davis' locoweed adult plant flowering – OXTYCAM3-2020-C on June 12, 2021.

Plate 3.4-4. Davis' locoweed seedling plants flowering – OXTYCAM3-2020-B on June 12, 2021.

Plate 3.4-5. Showy locoweed adult plant flowering on June 12, 2021; this individual originated from seeds collected in 2017/2018 and represents accidental contamination during seed collection for Davis' locoweed – OXTYCAM3-2020-C.

3.4.5 Dryland sedge (*Carex xerantica*)

Dryland sedge at CAREXER-2020-D and CAREXER-2020-E were monitored on August 2, 2021. Of the 99 individuals planted at CAREXER-2020-D in 2020, 88 were assessed. Of these, 87 individuals survived (98%) and 62 individuals produced seeds (70%; Plate 3.4-6). All of the 50 individuals planted at CAREXER-2020-E in 2020 were assessed; of these, 49 individuals survived (98%) and all 49 produced seeds (98%; Plate 3.4-7). Due to the timing of this assessment, inflorescences contained immature/sub-mature perigynia that had not yet reached the stage of dispersal; these were interpreted as being indicative of successful seed production during the 2021 year.

Plate 3.4-6. Vigorous dry-land sedge transplant during August 2, 2021, monitoring – CAREXER-2020-D.

Plate 3.4-7. Dry-land sedge inflorescence during June 8, 2021, monitoring – CAREXER-2020-E.

3.4.6 Slender penstemon (*Penstemon gracilis*)

Slender penstemon at PENSGRA-2020-A and PENSGRA-2020-B were monitored on August 25, 2021 (Table 3.4-2). All the 25 individuals planted at PENSGRA-2020-A in 2020 were assessed; of these, all 25 individuals survived (100%) and produced flower and seeds (100%; Plate 3.4-8). Of the 25 individuals planted at PENSGRA-2020-B, 17 survived (70%), 16 produced flowers, and 10 produced seeds (42%; Plate 3.4-9).

Plate 3.4-8. Slender penstemon seed heads on July 7, 2021– PENSGRA-2020-A.

Plate 3.4-9. Slender penstemon seeds on July 7, 2021 – PENSGRA-2020-B.

3.4.7 Sprengel's sedge (*Carex sprengelii*)

Sprengel's sedge at CARESPR-2020-A and CARESPR-2020-B were monitored on June 15, July 7, and September 10 (Table 3.4-2). Both individuals planted at CARESPR-2020-A survived (100%) and produced seeds (100%; Plate 3.4-10). All three of the individuals planted at CARESPR-2020-B also survived and produced seeds (100%; Plate 3.4-11).

Plate 3.4-10. *Carex sprengelii* seed development in July 7, 2021– CARESPR-2020-1B 2021.

Plate 3.4-11. *Carex sprengelii* seed development in September 10, 2021– CARESPR-2020-1A.

3.5 PLAN FORWARD

Information gained from the 2021 program will inform improvements to project methods and management in 2022. The propagation protocols continue to be developed for species that were new to the program in 2020 (i.e., Canada mountain-ricegrass, rock selaginella) and are being refined for species with lower germination rates (i.e., Davis' locoweed, Torrey's sedge). Additional propagule collection and/or recipient site selection for Canada mountain-ricegrass and rock selaginella will be a primary focus of the 2022 program, as will the augmentation of existing recipient sites for Davis' locoweed, Torrey's sedge, Sprengel's sedge, and prairie buttercup.

Future efforts will also focus on distributing sites as widely as possible to disperse the translocated plants across a larger number of recipient sites. This will build resilience into the program and help alleviate the impacts of stochastic events (e.g., floods, fires, landslides) on the overall program objectives. Although some sites will still receive multi-species plantings due to their accessibility, available planting area, available resources, and habitat conditions, additional single-species sites will be established where suitable habitats exist. New recipient sites will be evaluated with a stronger focus on the accessibility of resources, particularly water, as earlier translocation efforts have demonstrated that water availability can be a limiting factor at many sites.

In conjunction with enhancing existing populations, future efforts will be dedicated to understanding population dynamics of each species using ongoing monitoring data, including an assessment of recruitment (i.e., germination of the second and subsequent generations). However, at this early stage of program implementation, it is difficult to predict which analytical approaches will be appropriate to address questions related to population dynamics. For example, constraints imposed by small sample sizes or cohort sizes will limit analytical options for many target species. For species with larger potential sample sizes both within and across occupied sites (e.g., Davis' locoweed), standard vital rate regression-based analyses based on counts of individuals are planned for 2022. In addition, the program will evaluate whether analysis-based population-level data (e.g., percent cover), which are simpler to apply over broader spatial areas, may have value as a rapid assessment tool (e.g., Tredennick et al. 2017).

Future efforts will also focus on improving the detectability of species using alternate markings that are more visible throughout the entire growing season. Other mitigative measures, including protective fencing or cages to prevent damage from herbivory and the control of invasive plants, will be implemented in 2022. As all phases of the program work concurrently, opportunities for improvement will be identified within an adaptive management framework throughout the remaining lifespan of the program.

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APPENDIX A. SITE C EXPERIMENTAL TRANSLOCATION PROJECT: POTENTIAL RECIPIENT SITE SELECTION METHODS & RESULTS MEMO

Date: December 8, 2021

To: Natasha Bush (EcoLogic)

From: Randy Krichbaum (Eagle Cap), Margaret Krichbaum (Eagle Cap)

Subject: Site C Experimental Translocation Project: Potential Recipient Site Selection Methods & Results

Introduction

An important component of the Site C Experimental Rare Plant Translocation (ERPT) program is the selection of suitable recipient sites for planting of propagules collected from the project activity zone. Program planning in the spring of 2021 identified a need for five recipient sites to accommodate the propagules collected (or planned for collection). This memo outlines the methods and results of the recipient site selection work performed in 2021.

The goal of this work was to locate and document suitable recipient sites for planting of rare plant propagules (seeds, achenes, spores, and started plants). The sites needed to meet a number of criteria regarding habitat (both biotic and abiotic components), accessibility, and geographic location.

Methods

Prefield Review

A prefield review was conducted to identify and delineate possible recipient areas for later verification in the field. The review followed a structured workflow designed to locate the optimal planting locations based on the desired site characteristics.

A team of two qualified botanists completed the majority of the prefield and field portions of this work, in consultation with the ERPT project manager. The botanists have performed extensive rare plant work in the BC Peace River area, and as such are familiar with both the habitat requirements of rare species and the logistics of working in the Peace Region.

Four of the nine taxa currently in the ERPT program were selected by the program manager as 2021 target species in need of additional recipient sites for translocation:

- *Oxytropis campestris* var. *davisii* (Davis' locoweed)
- *Penstemon gracilis* (slender penstemon)
- *Piptatheropsis canadensis* (Canada mountain-ricegrass)
- *Selaginella rupestris* (rock selaginella)

The project botanical team met in May 2021 to review the target species list and define desired recipient site characteristics. Each desired site characteristic was also assigned a weighting to reflect its relative importance

to successful propagule establishment. This allowed for the potential recipient sites to be ranked for suitability following the field visits.

The prefield review identified thirteen desirable characteristics of the potential recipient sites. While no potential recipient site can meet all of the listed criteria, the intent of the work was to locate the best possible sites given the limitations present. An ideal site would have the following characteristics:

- contain suitable good-quality habitat for the specific rare plant taxon
- be located in the Peace River region of BC
- be located on land owned by BC Hydro or on Crown land
- not be located on lands requiring access through a locked gate or other owner permission
- not be located in the Site C Project Activity Zone (PAZ)
- not be located below the reservoir preliminary Erosion Impact Line (EIL - a precautionary estimate of the amount of erosion that could occur over a 100 year period)
- be accessible by road or boat during the entire growing season
- have a low likelihood of future disturbance
- have a low percentage of non-native plants
- have good cell service
- be more than one kilometre from known occurrences of the same taxon
- not contain known occurrences of other rare plant taxa
- be close to a source of water

A literature review was conducted for each of the nine species currently in the ERPT program to evaluate any new information relevant to the translocation work. This included checks of recent BC Conservation Data Centre (BCCDC) information to uncover any new element occurrences or changes to rare status, and a Google Scholar search for literature on the nine species published since 2020. The review supplemented literature searches conducted in previous years for the translocation project. Queries were also run on the project rare plant database to uncover apparent habitat associations for the four 2021 target species based on updated field data.

The habitat needs for the four target taxa were then reviewed and grouped into four types, in order to aid in the visual evaluation of aerial imagery:

1. river or large stream, with level, open, non-active cobble bar; shading open to partial; sparsely vegetated; sandy, well drained soil

2. dry, steep, open south-facing hillside; relatively sparse low shrub, xeric grassland vegetation with a tan-coloured appearance

3. mesic to dry, open, south-facing hillcrest or gentle slope; relatively dense low-shrub grassland vegetation with a green-coloured appearance

4. dry, steep, open south-facing hillcrest/hillside in close proximity to a gravel pit; relatively sparse low shrub, xeric grassland vegetation with a tan-coloured appearance

Using the list of desired site characteristics, the four habitat grouping types, and other collected information, Geographic Information System (GIS) layers were visually examined and potential recipient sites were selected. Primary GIS layers used for this phase of the prefield review were:

- aerial imagery of the BC Peace River region;
- property ownership provided by BC Hydro;
- known element occurrences of the priority taxa;
- potential recipient sites documented in previous years;
- the Site C Project Activity Zone; and
- the preliminary Erosion Impact Line.

Field Verification

Once recipient areas had been marked in the GIS, selected sites were inventoried in the field to determine suitability. Suitable Potential Recipient Sites (PRS) were evaluated and documented, with the data entered into a digital form for later analysis. Data elements collected included all those typically required by the BCCDC to document rare vascular plant element occurrences, as well as ratings for each of the thirteen desired site characteristics.

In addition to the vegetation composition and cover data recorded for the overall site, in certain cases three supplemental one-metre-square vegetation plots were placed in representative locations. Species codes, with their associated percent covers, were recorded on a paper form for later analysis.

Potential Recipient Sites were selected partially based on distance to other planting sites, with the aim of distributing them over a wide geographical extent. In some instances, a site was found to contain suitable habitat for several ERPT program species in close proximity, and so separate PRS plots were completed for each program species. While this does provide the option to plant multiple species at the same site, with the consequent increased risk of a single disturbance event impacting multiple species, the limited number of suitable sites available for some of the program species necessitated using one site for several species in some cases. In addition, several of the program species occur together in wild populations.

Results

Prefield Review

The literature search uncovered four recent references containing information potentially relevant to the translocation of the ERPT program species.

- *An Illustrated Key to the Onagraceae of Alberta* (Kershaw & Allen 2020)
- *Legumes of the great plains: an illustrated guide* (Stubbendieck et al. 2021)
- *Functional trait similarity predicts survival in rare plant reintroductions* (Ames et al. 2020)

- *Are large census-sized populations always the best sources for plant translocations?* (Van Rossum et al. 2021)

The queries run on the Site C rare plant database to identify habitat associations for the four 2021 target species returned three helpful correlations that may have not been otherwise noted. These refine the correlations uncovered during previous years' prefield reviews and are:

- For *Oxytropis campestris* var. *davisii*: 0-5° slope for all occurrences, except one, where slope was recorded (26 occurrences)
- For *Penstemon gracilis*: most occurrences (16 of 20) are on steeper slopes (15–30°) that are south facing (all aspects are S, SW, or SE where aspect is recorded)
- For *Selaginella rupestris*: all occurrences are on steep slopes (20–45°) where slope is recorded (6 of 10 occurrences); aspect is recorded as south facing and crown closure is listed as "open" or "partial" for all occurrences where those fields were recorded (8 of 10 occurrences)

A total of 34 planting areas that appeared to have a high likelihood of meeting the requirements for recipient sites were selected from the examination of the GIS layers (essentially these consisted of planting areas selected in the 2019 and 2020 prefield reviews that were still under consideration). The most weight was given to the *appropriate habitat types* and *ease of legal access* criteria. Some planting areas appeared to contain habitat specific to only one rare taxon, and other areas were thought to contain habitat for multiple rare taxa. Not all potential planting areas in the BC Peace Region were considered; rather the review focussed on areas that appeared to be easily accessible by road from Fort St. John, and on areas that were thought to be easily accessible by boat on the Peace River. Therefore, if additional potential recipient sites are required in the future, the as-yet unreviewed portions of the BC Peace region remain for consideration.

A unique PRS point was then generated for each planting area microsite thought to have suitable habitat for translocation of one of the four 2021 target species. These points were intended to speed the field verification work by directing the surveyors' effort on the ground towards microsites of the best quality habitat. There was no expectation that every PRS point would be field checked, and the exact location for each actual PRS plot was to be decided in the field after a cursory area survey.

The majority of the PRS points used for the 2021 recipient site evaluation work had been generated previously, in the prefield reviews completed in 2019 and 2020 for the project. Therefore few new PRS points were required for the four 2021 target taxa: 12 new points were generated for *Oxytropis campestris* var. *davisii* and one new point for *Penstemon gracilis.* No new PRS points were needed for *Piptatheropsis canadensis* or *Selaginella rupestris*.

Field Verification

The team of two botanists performed the field verification work between June 9 and 15, and on August 4 & 5, 2021. In preparation, the 34 selected planting areas were grouped according to the general access route to allow for efficient survey days. Of the 34 planting areas delineated, 12 received either complete or partial field checks (Table 1). Eleven areas were reached by road from Fort St. John, with the closest area located

approximately nine kilometres away, and the farthest area approximately 105 km from the town. The 12th area consisted of boat access sites along an approximately 35 km stretch of the Peace River below Fort St. John, BC.

The 22 planting areas not field checked in 2021 consist of 11 that are still considered to be of possible use if additional potential recipient sites are required in the future, and 11 that were field checked previously and have already had plots completed or have been set aside for future consideration.

Table 1: ERPT Potential Planting Areas Considered in 2021

Planting Area ID	Field Checked?	Field Check Date(s)	Details
4	yes	2020-06-07, 2021-06-13	Plots Completed in 2020
14	yes	2020-06-05	Set Aside for Future Consideration
15	yes	2019-06-02	Set Aside for Future Consideration
16	no		Possible for Future Evaluation
17	yes	2020-07-30	Set Aside for Future Consideration
22	yes	2020-06-12, 2021-06-15	Plots Completed in 2020 & 2021
23	yes	2020-08-06	Set Aside for Future Consideration
28	yes	2020-06-05, 2021-08-05	Plots Completed in 2020
29	yes	2021-06-10	Set Aside for Future Consideration
30	yes	2021-06-11	Set Aside for Future Consideration
31	yes	2019-06-07	Set Aside for Future Consideration
32	yes	2021-06-10, 11 & 2021-08-05	Set Aside for Future Consideration
34	yes	2020-06-09, 2021-06-11	Plots Completed in 2020 & 2021
35	no		Possible for Future Evaluation
36	no		Possible for Future Evaluation
37	no		Possible for Future Evaluation
38	no		Possible for Future Evaluation
39	yes	2020-06-07	Set Aside for Future Consideration
40	yes	2020-06-07, 2021-06-13	Plots Completed in 2020
41	no		Possible for Future Evaluation
42	no		Possible for Future Evaluation
43	yes	2020-08-03	Set Aside for Future Consideration
44	yes	2020-06-07	Plots Completed in 2020
45	yes	2020-06-08	Set Aside for Future Consideration
48	yes	2020-06-04	Set Aside for Future Consideration
49	yes	2020-06-09, 2021-06-13	Plots Completed in 2020
50	no		Possible for Future Evaluation

Planting Area ID	Field Checked?	Field Check Date(s)	Details
51	yes	2021-06-09	No Habitat for Target Species
52	yes	2020-08-02	Set Aside for Future Consideration
53	no		Possible for Future Evaluation
54	no		Possible for Future Evaluation
55	no		Possible for Future Evaluation
56	yes	2021-06-10	No Habitat for Target Species
57	yes	2020-10-08, 2021-08-03	Plots Completed in 2020

The 12 field checks produced the following results:

- two planting areas did not contain appropriate habitat for the target species;
- eight planting areas were set aside for future consideration; and
- two planting areas were considered to be worth investigating further.

A survey of each of the two "best choice" planting areas was performed, and a total of three PRS plots were completed (Table 2). Supplemental planting locations were also marked in suitable habitat near the PRS plots, where appropriate, to provide options for the planting crew.

It should be noted that during the course of the field verification surveys, eight new rare plant sites were discovered: five patches of *Carex xerantica*, and one patch each of *Lomatium foeniculaceum* var. *foeniculaceum* (fennel-leaved desert-parsley)*, Oxytropis campestris* var. *davisii,* and *Penstemon gracilis.*

The late-season *Piptatheropsis canadensis* PRS survey work was curtailed due to the greatly decreased detectability of the species in the 2021 growing season, possibly due to an extreme heat event in late June (Preprost 2021). One *Piptatheropsis canadensis* PRS point was field checked and set aside for future consideration, and two PRS points were marked for field evaluation in 2022.

Table 2: Potential Recipient Site Plots 2021

PRS Site ID	*Taxon*	Habitat	Survey Date	Area (sq m)
PRS-OXYTCAM3-019	*Oxytropis campestris var. davisii*	POPUBAL regrowth on cobble bar	2021-06-15	2,500
PRS-PENSGRA-019	*Penstemon gracilis*	Dry grassland shrub slope	2021-06-11	200
PRS-RANURHO-014	*Ranunculus rhomboideus*	Mesic shrubby meadow	2021-06-11	750

Discussion

The goal of the work was to locate one or two suitable recipient sites for the current year's target taxa based on the 13 criteria listed in the Methods section above. During the course of the field verification, it became clear that the first 10 criteria were relatively easy to meet (that is, accessible planting areas outside of the Site C PAZ and EIL, on Crown land near the Peace River, which contain appropriate rare plant habitat, low levels of both non-native plants and disturbance, and that have good cellular coverage).

However, the final three criteria proved much more challenging (i.e., planting areas greater than one kilometre from known sites of the same taxon, not already occupied by other rare plant species, and close to a source of water). While the prefield review specifically avoided known rare plant sites in choosing potential planting areas to evaluate, it was anticipated that new rare plant occurrences would be discovered since the goal was to target high-quality rare plant habitats. Thus, eight new rare plant sites were documented by the survey team during the field verification process. The surveyors attempted to avoid these new sites when placing PRS plots and marking supplemental planting locations, but this was not always successful: at both recommended planting sites, PRS plots had to be placed in the vicinity of other rare plant populations (natural or translocated). In addition, one of the new rare plant patches discovered in 2021 was located less than one kilometre from a 2019 recommended recipient site for the same species, consequently lowering the desirability of that particular site. However these compromises were accepted as reasonable considering that naturally-occurring multi-species rare plant sites are frequently found in the BC Peace region.

The final compromise for PRS plot placement, as anticipated, was that only the *Oxytropis campestris* var. *davisii* plots along the Peace River could be said to have a source of water. The remaining three priority taxa require mesic to xeric habitats generally found on dry slopes well above the river, and only rarely near year-round streams or springs.

Therefore, given the above caveats, the two planting areas where PRS plots were completed in 2021 do meet the majority of the requirements of an ideal recipient site. One of the planting areas contains a variety of habitats and is suitable for multiple species translocation. The remaining planting area was specifically selected for a single taxon.

The area chosen for multiple species translocation is a Crown parcel above Bear Flat on the north side of Highway 29. Two PRS plots were completed, for *Penstemon gracilis* and *Ranunculus rhomboideus.*

For *Oxytropis campestris* var. *davisii*, which requires a specific type of riparian habitat, one PRS plot was completed on an island in the Peace River, downstream of Taylor, BC, approximately 5 km above the confluence of the Beatton River.

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CLOSURE

Reviewed and approved:

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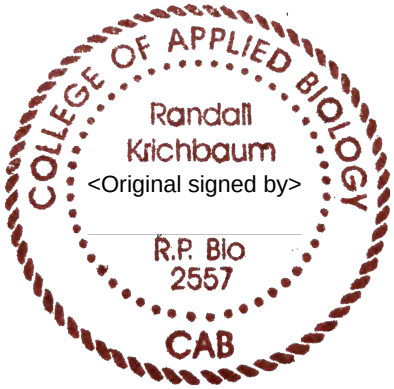

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APPENDIX B. DATA CAPTURE FORM – TRANSLOCATION

Experimental Rare Plant Translocation Program

ECOLOGIC	**TRANSECT / PLOT / INDIVIDUAL** **Data Capture Form**	SITE + T/P	[S-_____] +
		Data Sheet Tracking Number	

Data Recorder:		*Team:*	

TRANSECT / PLOT Level Information		**TRANSECT or PLOT**	*specify*	**ID:**	

Species Name	**Recipient Site Name**	**UTMZone**	**Easting**	**Northing**	**Elev. (m)**	**Plot Solocator Photos**
dd	dd					

Outplanting Conditions			**Nursery**	dd	
Date(yymmdd)	**Weather Cond**	**Ambient Temp (*C)**	**Date Removed**	**Plug Size (mm)**	**Growth Media**

TRANSECT or PLOT		**MAP**	Y/ N	**subPLOT Information**		
Dimensions (m x m)	**Shape & Orientation**	**Loc. of Map**		**subPlot ID**	**Dimensions (m x m)**	**subPL Photos**
		dd		dd		

General Comments	

PLANT OBVS	*Example*																									
TAG NUMBER	94																									
Plant Presence	psent																									
Plant Condition	dead																									
Inflorescences (#)	4																									
Seeds (#heads /pods)	1																									
Implem / Monitor	mon																									
Photos	meth																									
Height (cm)	3																									
Surf.Area cm2	200																									
%CV of Surf. Area	40																									
Soil Mositure	ories																									
Soil Temperature	deg C																									
Mulch Type	osses																									
Mulch Depth	2																									
MicroCatch Created	s / no																									
Damage1 Type	down																									
Damage1 Extent	down																									
Damage2 Type	down																									
Damage2 Extent	down																									
Damage3Type	down																									
Damage3 Extent	down																									
Planter (name)	Bush																									

Species	**Recip. Site**	**Nursery**	**Loc. of Map**	**subPlotID**	**Plant Presence**	**Plant Cond.**	**Inflorescences (#)**	**Seeds (#heads /pods)**
list	list	list	list	instructions	list	list	instructions	instructions

Experimental Rare Plant Translocation Program

Surf.Area cm2	%CV of Surf. Area	Mulch Type	Damage Type	Damage Extent
instructions	instructions	list	list	list

ECOLOGIC

MAP / SITE DIAGRAM

SITE + T/P [S-_____] +

Data Sheet Tracking Number

Map Recorder: | *Team:*

TRANSECT / PLOT Level Information

TRANSECT or PLOT | *specify T or P* | **ID:**

Species Name	Recipient Site Name	Slope (deg)	Aspect (T)	Draw Slope Direct.	North Arrow
dd	dd				

General Comments

Draw site diagram here. Clearly illustrate locations of specific tag numbers.

Appendix 9. Gartersnake Artificial Hibernacula Monitoring 2021

GOLDER
MEMBER OF WSP

REPORT

Site C Wildlife Mitigation Structures

Snake Hibernacula Monitoring 2021

Submitted to:

BC Hydro
111 West Georgia Street, 9th Floor
Vancouver, BC V6E 4G2
Attention: Brock Simons

Submitted by:

Golder Associates Ltd.
1935 Bollinger Road Nanaimo, British Columbia V9S 5W9 Canada

+1 250 754 5651

18113590-010-R-Rev2

19 January 2022

Distribution List

e-copy: BC Hydro

e-copy: Blueberry River Enterprises

e-copy: Golder Associates Ltd.

e-copy: Mike Sarell

Table of Contents

1.0 OVERVIEW 1

2.0 SNAKE HIBERNACULA DETAILS 1

3.0 2021 MONITORING SUMMARY 4

3.1 Occupancy Monitoring 4

3.1.1 Hudson's Hope Berm Construction Snake Salvage 6

3.2 Temperature Monitoring 7

4.0 FUTURE MONITORING AND RECOMMENDATIONS 9

5.0 LIMITATIONS 9

6.0 CLOSURE 10

7.0 REFERENCES 11

TABLES

Table 1: Snake Hibernacula Installation Details 3

Table 2: Results of the 2021 Snake Hibernacula Occupancy Monitoring Completed by Golder 4

Table 3: Ecofor Snake Salvage and Relocation to Installed Hibernacula 6

FIGURES

Figure 1: Installed snake hibernacula on the north side of the future Site C reservoir in 2020 2

Graph 1: Daily minimum temperatures within all hibernacula (coloured lines) and mean daily minimum ground surface temperature recorded across sites (black) during the monitoring period, July 2020 to May 2021. A reference line (dashed) has been drawn at 0°C. Inset shows daily minimum hibernacula temperatures from 1 February to 12-13 May 2021 8

APPENDICES

APPENDIX A
Mapbook

APPENDIX B
Photos

APPENDIX C
Field Data

1.0 OVERVIEW

The broad mitigation objectives of BC Hydro's snake hibernacula program are to mitigate short-term effects on snake denning habitat due to construction of the Site Clean Energy Project (The Project). Specifically, the aspects of the wildlife monitoring program conducted by Blueberry River Enterprises (BRE) consisted of the installation and monitoring of six snake hibernacula installed along the north side of the Peace River between Fort St. John and Hudson's Hope, BC (Figure 1, Appendix A: Figures 2-5).

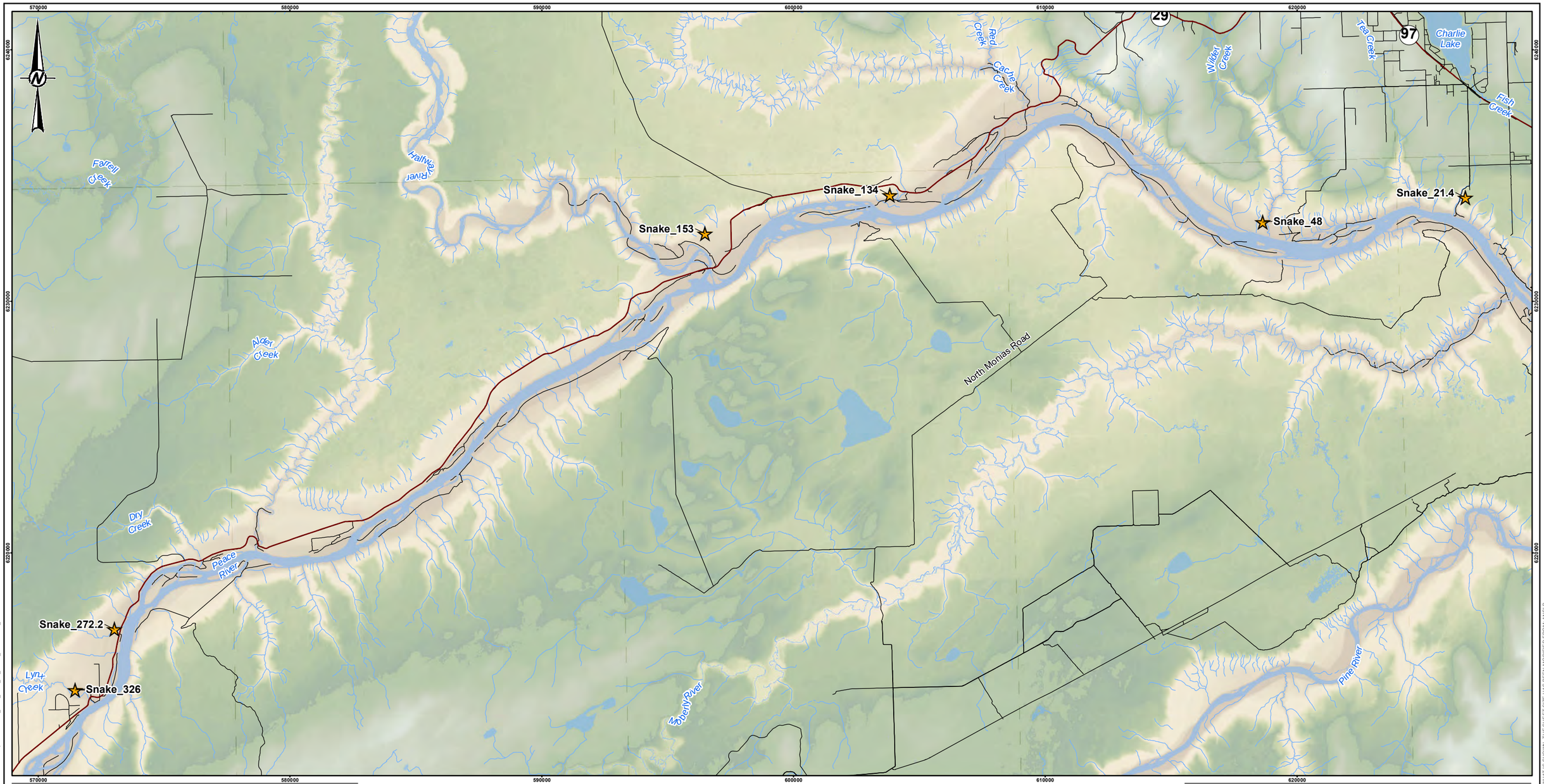
The requirements specific to snake hibernacula installation are detailed in the Construction Agreement between BC Hydro and Blueberry River Enterprises (BC Hydro Reference #686477). Golder Associates Ltd. (Golder) was contracted by BRE to provide technical expertise in support of the snake hibernacula monitoring program, and to lead field work in conjunction with BRE representatives. Mike Sarell, RPBio (Ophiuchus Consulting) was subcontracted by Golder as a Snake Technical Advisor to work on our team assisting with specific expertise relevant to the mitigation program. A total of six snake hibernacula were installed in the summer of 2020 as detailed in the Snake Hibernacula Installation Report (Golder 2020). The current report documents the results of snake hibernacula monitoring activities undertaken by BRE and Golder in 2021.

2.0 SNAKE HIBERNACULA DETAILS

The following details relating to installed snake hibernacula are summarized in Golder's 2020 installation report (Golder 2020) to provide background context and describe the configuration of the installed snake hibernacula.

Snake hibernacula were installed by Kalmar, BRE's construction contractor, with guidance from the original Gartersnake Mitigation and Monitoring Workplan (Hilton et al. 2013) with advice and proposed field-refinement by Mike Sarell. The Scope of Services from BC Hydro (2017) asked that three artificial bank-style hibernacula and three mound-style hibernacula be installed. Upon review of site conditions, and at the recommendation of Mike Sarell, all installed snake hibernacula were bank-style designs. The original intent of installing mound-style hibernacula was largely a consequence of anticipated difficulties finding sufficient sites to locate an adequate number of preferred bank-style hibernacula at sloped sites (Sarell, pers. comm. 2020). Mound-style hibernacula, sited on level ground, have been used in England with success (Cresswell et al. 2008) but have not been tested in BC (Sarell, pers. comm. 2020). For the six artificial hibernacula sites planned, the crew were able to find an adequate number of sloped sites for the preferred bank style hibernacula to be implemented. Known and suspected hibernacula in the Peace are typically situated on warm aspect slopes, and therefore this was determined to be a suitable model to follow for implementation of this Project (Sarell, pers. comm. 2020).

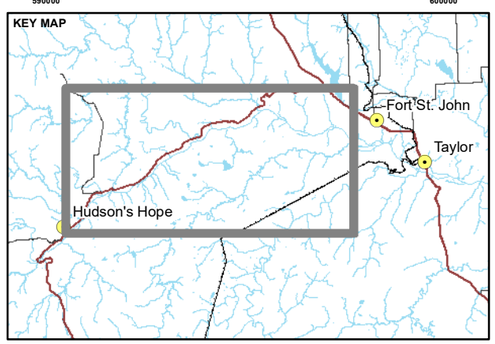
The locations of installed snake hibernacula are shown in Figure 1 and Appendix A (Figures 2-5) , with installation details summarized in Table 1.



LEGEND

- INSTALLED SNAKE HIBERNACULA LOCATION
- HIGHWAY
- ROAD
- WATERCOURSE
- WATERBODY

KEY MAP



0 3,000 6,000

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REFERENCE(S)

1. PRELIMINARY STABILITY IMPACT LINES AND GENERAL CLEARING AREAS OBTAINED FROM BC HYDRO.
2. TRANSPORTATION FEATURES OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
3. FISHER TYPE 1 DENNING STAND AND WATER BASE DATA OBTAINED FROM THE PROVINCE OF BRITISH COLUMBIA.

DATUM: NAD83 PROJECTION: UTM ZONE 10N

CLIENT
BC HYDRO

PROJECT
BRE WILDLIFE MITIGATION MONITORING PROGRAM

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-11-18
DESIGNED	JS
PREPARED	JP
REVIEWED	TS
APPROVED	IJ

TITLE
BRE SITE C MITIGATION SNAKE HIBERNACULA LOCATIONS

PROJECT NO.	CONTROL	REV.	FIGURE
18113590	1000	0	1

PATH: Y:\burnaby\CAD-GIS\Client\BC_Hydro\Site_C\99_PROJECTS\18113590\02_PRODUCTION\MXD\Report\18113590_1000_1004_01_Snake_Hibernacula_Installations.mxd PRINTED ON: 2021-11-18 AT: 9:16:37 AM
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25mm
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Table 1: Snake Hibernacula Installation Details

Hiberna-culum Name	Installation Date	Easting / Northing (NAD 83) UTM Zone 10V	Distance to 'General Clearing Area'	Distance from trail/road (m)	Distance to drainage feature (m)	Nearby Habitat Features and Distance (m)	Nearby Installed Cover Features
Snake 21.4	14 July 2020	626695, 6234126	65.0 m (River/Stream – Intermittent)	200.8 m (Road unclassified)	574.4 m (Eastern Reservoir Clearing)	■ Forested gully – 100 m west ■ Forested habitat – 30 m east	■ 2 patio stones – 2 m east and 2 m west of entrance
Snake 48	15 July 2020	618630, 6233149	159.0 m (Wilder Creek River/Stream – Definite)	149.6 m (Road unclassified)	91.4 m (Eastern Reservoir Clearing)	■ Wilder Creek valley – 150 m east ■ Forested habitat – 50 m south	■ 1 rock pile 3 m northeast of entrance ■ 2 patio stones – 2 m east and 2 m west of entrance
Snake 134	16 July 2020	603820, 6234237	52.9 m (River/Stream – Intermittent)	187.5 m (Trail)	85.0 m (Middle Reservoir Clearing)	■ Forested gully – 30 m southeast	■ 1 patio stone at entrance with small rock pile ■ 1 rock pile 3 m northeast of entrance
Snake 153	16 July 2020	596484, 6232690	58.7 m (Flow Connectors – Inferred)	222.8 m (Trail)	545.9 m (Middle Reservoir Clearing)	■ Silt bluffs – 700 m west ■ Forested habitat – 50 m north and west	■ 2 patio stones at entrance with small rock pile
Snake 272.2	17 July 2020	573017, 6216971	35.4 m (River/Stream – Definite)	105.9 m (Road unclassified)	54.7 m (Western Reservoir Clearing)	■ Beaver lodge and dugout pond - 15 m east ■ Forested habitat – 10 m north and south	■ 1 patio stone with three large rocks at entrance
Snake 326	18 July 2020	571450, 6214558	106.3m (Lynx Creek River/Stream – Definite)	44.2 (Road unclassified)	118.6m (Western Reservoir Clearing)	■ Buried vehicles - 30 m southeast	■ 2 patio stones 1 m east and 1 m west of the entrance and small rock pile

3.0 2021 MONITORING SUMMARY

Monitoring activities in 2021 consisted of two rounds of site visits to assess occupancy as well as internal and surface hourly temperature monitoring via temperature loggers at each hibernaculum (Site Photos; Appendix B). The following subsections provide summaries of these monitoring activities and related results.

3.1 Occupancy Monitoring

Two rounds of occupancy monitoring occurred in 2021, with round one occurring from 12-13 May and round two occurring from 10-11 June. Occupancy monitoring consisted of visual checks of the entrance and immediate area surrounding the hibernacula to look for individual snakes or snake sign (e.g., tracks, shed skins).Maintenance requirements for each hibernaculum were also assessed, with additional work consisting of gap filling and reinforcement of the hibernacula entrance completed during round two, where necessary.

Except for hibernaculum Snake 326 (Lynx Creek), snakes or snake sign were not observed during 2021 occupancy monitoring. On 13 May 2021, two male terrestrial gartersnakes (*Thamnophis elegans*) were observed at Snake 326 (Lynx Creek) under the left (western) cover tile (Appendix A, photo 7). On 11 June 2021, a total of four observations of at least two terrestrial gartersnakes were recorded, with one snake observed under the left (western) cover tile prior to flushing away from the hibernaculum. All other observations occurred in areas adjacent to the hibernaculum. Copies of field datasheets are found in Appendix C.

On 13 May 2021, Golder was notified by BC Hydro that a snake salvage was currently ongoing by Cantex and Ecofor Consulting Ltd. as part of construction of the Hudson's Hope Berm. BC Hydro indicated that salvaged snakes were being released at some of the installed hibernacula. Golder was provided data from this snake salvage for incorporation into this monitoring report (Cantex 2021). Snakes were salvaged from the Hudson's Hope Berm area between 30 April and 30 September 2021 (see Section 3.1.1).

Results of the occupancy monitoring are summarized in Table 2.

Table 2: Results of the 2021 Snake Hibernacula Occupancy Monitoring Completed by Golder

Hibernaculum Name	Date	Occupied	Snakes observed	Species	Comments
Snake 21.4 (Dam View)	12 May	No	No	-	Temperature logger data downloaded
	10 June	No	No	-	Gaps in hibernaculum entrance plugged using expanding insulating foam, rocks, and concrete/mortar/sand mixture (Appendix B, photos 9 and 10)
Snake 48 (Wilder Creek)	12 May	No	No	-	Temperature logger data downloaded
	11 June	No	No	-	Gaps in hibernaculum entrance plugged using expanding insulating foam, rocks, and concrete/mortar/sand mixture (Appendix B, photos 11 and 12)
Snake 134 (Watson Slough)	12 May	No	No	-	Temperature logger data downloaded
	10 June	No	No	-	Gaps in hibernaculum entrance plugged using expanding insulating foam, rocks, and concrete/mortar/sand mixture (Appendix B, photos 13-14)

Hibernaculum Name	Date	Occupied	Snakes observed	Species	Comments
Snake 153 (Halfway River)	13 May	No	No	-	Temperature logger data downloaded
	10 June	No	No	-	Additional soil placed on hibernaculum to attempt to improve insulation; gaps in hibernaculum entrance plugged using expanding insulating foam, rocks, and concrete/mortar/sand mixture (Appendix B, photos 15 and 16); adult western toad observed near hibernaculum entrance
Snake 272.2 (Peck's)	13 May	No	No	-	Temperature logger data downloaded; long-toed salamander observed near the entrance (Appendix B, photo 8)
	11 June	No	No	-	Additional soil placed on hibernaculum to attempt to improve its insulation (Appendix B, photos 19 and 20); gaps in hibernaculum entrance plugged using expanding insulating foam, rocks, and concrete/mortar/sand mixture (Appendix B, photos 17 and 18)
Snake 326 (Lynx Creek)	13 May	No	Yes	Terrestrial gartersnake	2 snakes observed near hibernaculum entrance; temperature logger data downloaded
	11 June	No	Yes	Terrestrial gartersnake	A minimum of 2 individual snakes observed 4 times; additional soil placed on hibernaculum to attempt to improve its insulation (Appendix B, photos 23 and 24); gaps in hibernaculum entrance plugged using expanding insulating foam, rocks, and concrete/mortar/sand mixture (Appendix B, photos 21 and 22); adult western toad emerged from hibernaculum entrance (Appendix B, photo 30)

The optimal hibernation temperature range for snakes is suspected to be between 4-7 °C in the Peace Region (Sarell, pers. comm. 2017), with unsuitable conditions occurring if temperatures within the hibernacula drop below 0 °C (Gregory 1971), although gartersnakes have been observed to survive at least 'short' periods of subzero conditions (100% survival after 48 hrs at -1°C: Costanzo et al. 1988; 50% survival after 10 hrs at -2.5°C: Churchill and Storey 1992). During the first monitoring visit, it was confirmed that temperatures in the hibernacula did fall below freezing over the winter of 2020 during an extreme cold weather period (see Section 3.2); therefore, modifications to the hibernacula were proposed during the second monitoring visit.

Modifications to hibernacula consisted of reducing the number of gaps at all hibernaculum entrances and further insulating select hibernacula to reduce internal heat loss. Expanding insulating foam and additional rocks were used to fill gaps, which were then reinforced with a concrete, sand, and mortar mix (Appendix B, photos 15-18, 21 and 22). A small PVC tube had been installed for a temperature probe to be placed at the bottom of each hibernaculum. It is possible that this tube served as an opening for the incursion of cold air. As such, a piece of solid foam approximately 30 cm in length was inserted into the tube, and a cap was sealed on top of the PVC pipe with silicone (Appendix B, photos 25-28). Finally, three hibernacula, Snake 326 (Lynx Creek), Snake 153 (Halfway River), and Snake 272.2 (Peck's), had additional soil added on top, which was then seeded, to create additional insulation (Appendix B, photos 19, 20, 23, 24).

Snake use of the hibernacula could not be confirmed in 2020.

3.1.1 Hudson's Hope Berm Construction Snake Salvage

Snake salvages were completed from 30 April to 30 September 2021 by Ecofor Consulting Ltd. (Ecofor) in support of BC Hydro's berm construction in the Hudson Hope area. Golder understands that berm construction work intersected a previously unknown snake hibernaculum. Enclosure fencing was installed, and traps were set to capture snakes to relocate out of the active work area (Cantex 2021). A total of 95 gartersnakes were captured and relocated, 81 of which were relocated to three of the six installed hibernacula. In addition, 13 gartersnakes had emerged in the middle of the active construction site and were moved upstream of the berm outside of active construction where abundant rocks and cracks were present in the bank for shelter. Ecofor relocated 3 terrestrial gartersnakes to Snake 153 (Halfway River), 10 terrestrial gartersnakes to Snake 272.2 (Peck's), and 67 terrestrial gartersnakes and 1 common gartersnake (*Thamnophis sirtalis*) to Snake 326 (Lynx Creek; Table 3). It is unknown if relocated snakes remained at the release locations or dispersed from the relocation areas.

Table 3: Ecofor Snake Salvage and Relocation to Installed Hibernacula

Date of Salvage	Number Relocated	Species	Release Location Hibernaculum Name
05-May-2021	3	Terrestrial Gartersnake	Snake 153 (Halfway River)
06-May-2021	6	Terrestrial Gartersnake	Snake 326 (Lynx Creek)
07-May-2021	1	Terrestrial Gartersnake	
08-May-2021	5	Terrestrial Gartersnake	
09-May-2021	5	Terrestrial Gartersnake	
10-May-2021	4	Terrestrial Gartersnake	
11-May-2021	2	Terrestrial Gartersnake	
12-May-2021	4	Terrestrial Gartersnake	
	1	Common Gartersnake	
13-May-2021	4	Terrestrial Gartersnake	
14-May-2021	7	Terrestrial Gartersnake	
17-May-2021	4	Terrestrial Gartersnake	
18-May-2021	1	Terrestrial Gartersnake	
19-May-2021	6	Terrestrial Gartersnake	
20-May-2021	4	Terrestrial Gartersnake	
21-May-2021	5	Terrestrial Gartersnake	
22-May-2021	4	Terrestrial Gartersnake	
23-May-2021	5	Terrestrial Gartersnake	
29-May-2021	1	Terrestrial Gartersnake	Snake 272.2 (Peck's)
31-May-2021	1	Terrestrial Gartersnake	
18-Jun-2021	1	Terrestrial Gartersnake	
21-Jun-2021	1	Terrestrial Gartersnake	
29-Aug-2021	1	Terrestrial Gartersnake	
30-Aug-2021	1	Terrestrial Gartersnake	
01-Sep-2021	1	Terrestrial Gartersnake	
29-Sep-2021	2	Terrestrial Gartersnake	
30-Sep-2021	1	Terrestrial Gartersnake	

3.2 Temperature Monitoring

Temperature monitoring was conducted at each hibernaculum to monitor the range of temperatures present, particularly if temperatures decreased below 0 °C where conditions may become unsuitable for hibernating snakes (Gregory 1971).

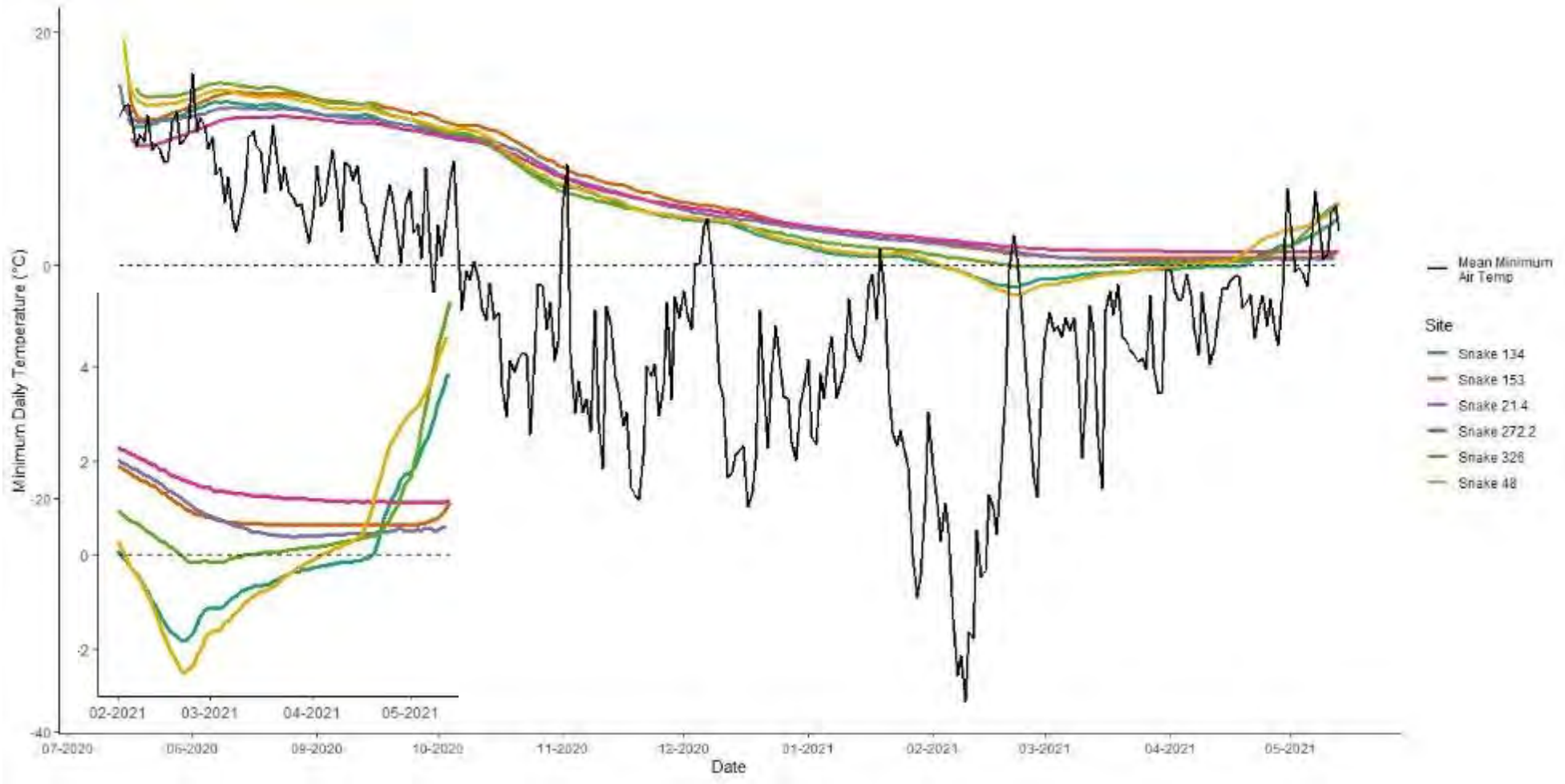
Temperature monitoring was conducted via two temperature loggers (HOBO USB Micro Station Logger with H21USB MicroStation Weatherproof datalogger [IP66]), which were deployed inside and outside of each of six hibernacula for a total of twelve temperature loggers to monitor both internal and surface temperatures. Monitoring commenced from 14-18 July 2020 and data were downloaded on 12-13 May 2021. Temperature loggers are still deployed and continue to monitor temperature. Hibernaculum Snake 48 was opportunistically visited on 14 October 2021 to verify that the logger remained in good working condition. No issues were noted at this location.

Minimum temperatures within the hibernacula decreased below 0 °C at three artificial hibernacula: Snake 48 (Wilder Creek), Snake 134 (Watson Slough), and Snake 326 (Lynx Creek). Temperatures fell below 0 °C at Snake 48 (Wilder Creek) and Snake 134 (Watson Slough) starting around early February 2021 and rose above 0 °C in early-April and mid-April 2021, respectively. At Snake 326 (Lynx Creek), temperatures fell below 0 °C in late-February 2021 and rose above 0 °C in mid-March 2021. The coldest surface temperatures at all six locations were experienced on 9 February 2021, with temperatures ranging from -35.4 °C to -39.8 °C, while coldest internal temperatures were experienced from February into May, depending on the location (Table 4; Graph 1). Notably, in April and May 2021, the same three hibernacula that had temperatures drop below freezing also had a rapid increase in hibernacula temperature, suggesting insufficient insulation at these locations.

While the internal temperature of only three hibernacula fell below 0 °C, loggers at all hibernacula recorded temperatures below 1.2 °C, below the 4-7 °C optimal hibernation temperature identified by Mike Sarell (pers. comm 2017). It is possible that snakes in the Peace Region are able to tolerate 'short' periods of subzero conditions (Costanzo et al. 1988, Churchill and Storey 1992). Regardless, efforts were made to further insulate hibernacula, including piling additional soil on and around three of the hibernacula (Snake 153, Snake 272.2 and Snake 326) and plugging gaps that could allow excess air circulation. There were constraints in the number of hibernacula able to be insulated with additional soil due to limitations of equipment and on-site soil availability. The success of these efforts will be revealed in the thermal data collected in the spring of 2022, which will help to inform further maintenance planning.

Table 4: Minimum Temperatures and Days below 0°C Recorded at each Hibernaculum

Hibernaculum Name	Minimum Internal Temperature (MIT)	Date of MIT	Minimum Surface Temperature Reading during MIT	Days below 0°C	Dates Range below 0°C
Snake 21.4 (Dam view)	0.38 °C	26-Mar-2021 / 27-Mar-2021	-11.94 °C / 0.38 °C	0	n/a
Snake 48 (Wilder Creek)	-2.51 °C	21-Feb-2021	4.19 °C	60	4-Feb-2021 to 4-Apr-2021
Snake 134 (Watson Slough)	-1.81°C	20-Feb-2021 / 21-Feb-2021 / 22-Feb-2021	-0.40 °C / -1.81 °C / 3.41 °C	77	2-Feb-2021 to 19-Apr-2021
Snake 153 (Halfway River)	0.63 °C	18-Mar to 3-May 2021	-11.36 °C to 8.82 °C	0	n/a
Snake 272.2 (Peck's)	1.13 °C	12-Apr-2021 to 11-May-2021 (intermittent)	-9.30 °C to 7.77 °C	0	n/a
Snake 326 (Lynx Creek)	-0.14 °C	23-Feb-2021 to 5-Mar 2021 (intermittent)	-17.60 °C to 0.14 °C	9	2-Feb-2021 to 15-Mar-2021



Graph 1: Daily minimum temperatures within all hibernacula (coloured lines) and mean daily minimum ground surface temperature recorded across sites (black) during the monitoring period, July 2020 to May 2021. A reference line (dashed) has been drawn at 0°C. Inset shows daily minimum hibernacula temperatures from 1 February to 12-13 May 2021.

4.0 FUTURE MONITORING AND RECOMMENDATIONS

The 2022 and 2023 monitoring schedule and requirements as established in the Monitoring Agreement (BC Hydro Reference #686477) require the following monitoring activities to be conducted at snake hibernacula:

- Two occupancy surveys at each hibernaculum per year during spring emergence (April – June) with timing to be determined by environmental conditions each year. Based on observations of spring emergence in 2021, it is anticipated that the first two weeks of May could be the most suitable timing for future monitoring visits.
- Assessment of the condition of each hibernaculum.
- Continued ongoing temperature monitoring via remote temperature loggers and data download during the spring emergence surveys. Internal hibernacula temperature data is recommended to be compared between 2021 and 2022 to monitor how internal hibernacula temperatures responded to measures to further insulate the entrances completed in the spring of 2021. The results of monitoring will help inform further maintenance planning.

5.0 LIMITATIONS

This report has been prepared by Golder Associates Ltd., on behalf of Blueberry River Enterprises, for BC Hydro solely for the use of Blueberry River Enterprises and BC Hydro, in partial fulfilment of the terms and conditions of the Monitoring Agreement #686477. This report is limited to the field data, collected under the supervision of Golder, to assess occupancy of the snake hibernacula installed in 2020.

The findings and conclusions documented in this report have been prepared for specific application to this Project and have been developed in a manner consistent with the level of care normally exercised by environmental professionals currently practicing under similar conditions in the jurisdiction. Golder makes no other warranty, expressed or implied.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Golder accepts no responsibility for damages, if any suffered, by any third party as a result of decisions made or actions based on this report.

6.0 CLOSURE

We trust that this report provides sufficient information for your needs. If you have any questions, please do not hesitate to contact the undersigned.

Golder Associates Ltd.

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Environmental Technician

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Josh Sutherby, MSc, BIT
Biologist

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Terrestrial Biologist

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Iain Jones, MSc, Dipl Tech, RPBio
Principal, Group Leader-Environmental Planning & Permitting

NM/JS/TMS/IJ/asd

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APPENDIX A

Mapbook

Wilder Creek

Fish Creek

Tea Creek

Peace River

Moberly River

N

Observed 2020 - subadult
6/23/2020/Sarell/R-THEL

Observed 2020 - subadult
6/23/2020/Sarell/R-THEL

Observed 2020 - adult
6/23/2020/Sarell/R-THEL

Snake48 - Installed 20200715

5/15/2011/Sarell / Andrusiak/R-THEL

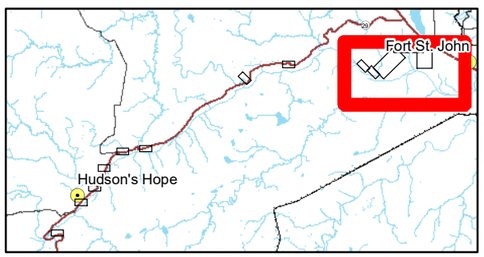
Snake21.4 - Installed 20200714

9/12/2011/Sarell / Andrusiak/R-THAM

9/12/2011/Sarell / Andrusiak/R-THAM

8/1/2016/Seebacher/R-THSI
8/8/2016/Seebacher/R-THSI
8/10/2016/Seebacher/R-THAM
8/11/2016/Seebacher/R-THAM
8/16/2016/Seebacher/R-THAM
8/22/2016/Seebacher/R-THAM

7/17/2016/Seebacher/R-THSI
7/19/2016/Seebacher/R-THSI
7/28/2016/Seebacher/R-THSI



1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Orthophotos: Bing
4. Property boundary locations are best available but should be considered approximate. Property information is a combination of surveyed data representing BC Hydro's current ownership records and ICIS data. Property data is current as of January 2, 2018.

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Legend

- Upper Limit of Proposed Reservoir (461.8 m)
- Preliminary Slope Stability Impact Line
- Installed Snake Hibernacula Locations 2020
- Snake Observation - 2020
- Historical BC Hydro Snake Observation
- Snake Observation

Species Code	Scientific Name	Common Name
R-THAM	*Thamnophis* sp.	Gartersnake sp.
R-THEL	*Thamnophis elegans*	Terrestrial Gartersnake
R-THIS	*Thamnophis sirtalis*	Common Gartersnake

Snake Hibernacula Monitoring Observations			
Round	Hibernacula	Species	Observed during Occupancy Monitoring
1	Snake 326	Terrestrial gartersnake	2
2	Snake 326	Terrestrial gartersnake	At least 2

1:50,000

0 2,400 Meters

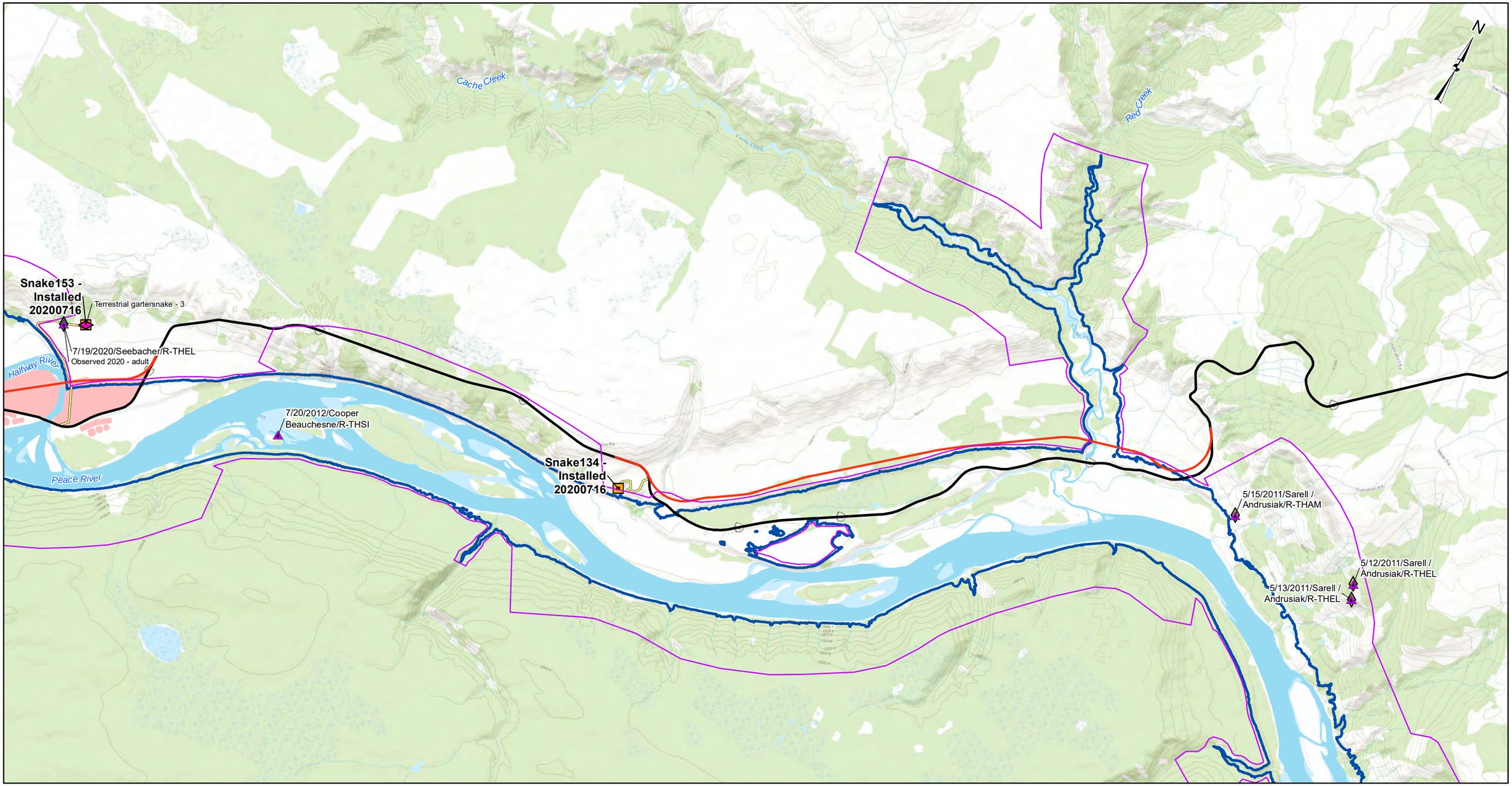
GOLDER

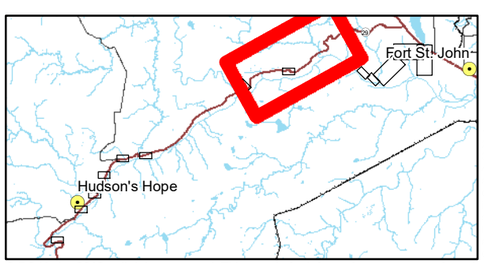
Figure 2
Snake Observations and Artificial Hibernacula (2020) (BRE Wildlife Mitigation Program)

Date	Dec. 13, 2021	DWG NO	1016-N11-00921-1	R a

Construction of the Site C Clean Energy Project is subject to required regulatory and permitting approvals.

Path: Y:\burnaby\CAD-GIS\Client\BC_Hydro\Site_C\99_PROJECTS\18113990\02_PRODUCTION\MXD\Report\1016_N11_00921_Site_C_Snake_den_installation_2021w.mxd





1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Orthophotos: Bing
4. Property boundary locations are best available but should be considered approximate. Property information is a combination of surveyed data representing BC Hydro's current ownership records and ICIS data. Property data is current as of January 2, 2018.

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Legend

- Upper Limit of Proposed Reservoir (461.8 m)
- Hwy 29 Re-Alignment Footprints
- Hwy 29 Re-Alignment Centerline
- Existing Hwy 29 Route
- Preliminary Slope Stability Impact Line
- Installed Snake Hibernacula Locations 2020
- Snake Observation - 2020
- Ecofor Salvage Release
- Historical BC Hydro Snake Observation
- Snake Observation

Species Code	Scientific Name	Common Name
R-THAM	*Thamnophis* sp.	Gartersnake sp.
R-THEL	*Thamnophis elegans*	Terrestrial Gartersnake
R-THIS	*Thamnophis sirtalis*	Common Gartersnake

Snake Hibernacula Monitoring Observations			
Round	Hibernacula	Species	Observed during Occupancy Monitoring
1	Snake 326	Terrestrial gartersnake	2
2	Snake 326	Terrestrial gartersnake	At least 2

1:50,000 0 2,400 Meters

GOLDER

Figure 3
Snake Observations and Artificial Hibernacula (2020) (BRE Wildlife Mitigation Program)

Date	Dec. 13, 2021	DWG NO	1016-N11-00921-2	R a

Construction of the Site C Clean Energy Project is subject to required regulatory and permitting approvals.

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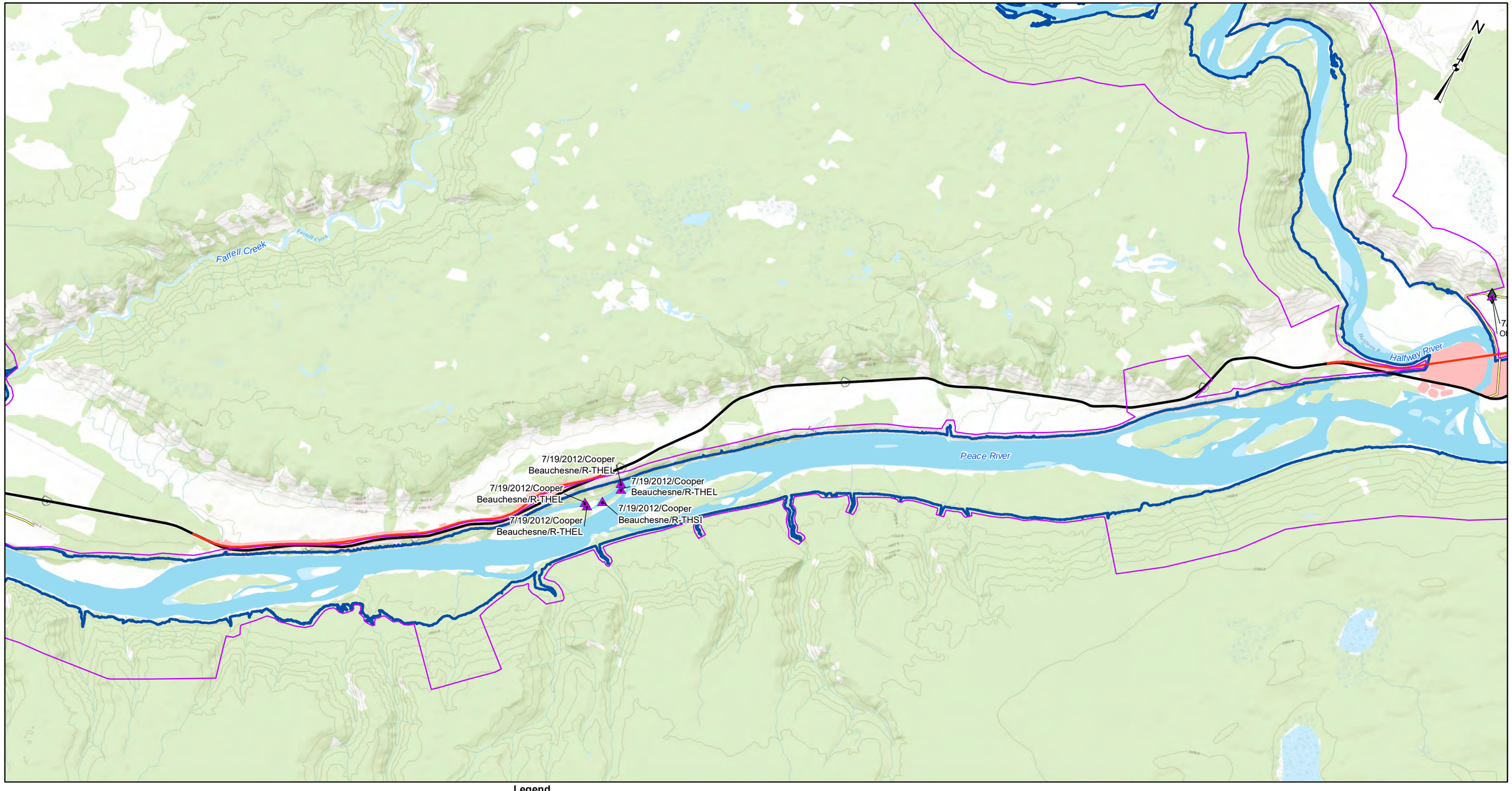

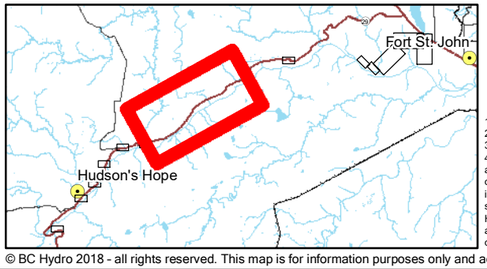

1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Orthophotos: Bing
4. Property boundary locations are best available but should be considered approximate. Property information is a combination of surveyed data representing BC Hydro's current ownership records and ICIS data. Property data is current as of January 2, 2018.

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Legend

- Upper Limit of Proposed Reservoir (461.8 m)
- Hwy 29 Re-Alignment Footprints
- Hwy 29 Re-Alignment Centerline
- Existing Hwy 29 Route
- Preliminary Slope Stability Impact Line
- Installed Snake Hibernacula Locations 2020
- Snake Observation - 2020
- Ecofor Salvage Release
- Snake Observation

Species Code	Scientific Name	Common Name
R-THAM	*Thamnophis* sp.	Gartersnake sp.
R-THEL	*Thamnophis elegans*	Terrestrial Gartersnake
R-THIS	*Thamnophis sirtalis*	Common Gartersnake

Snake Hibernacula Monitoring Observations			
Round	Hibernacula	Species	Observed during Occupancy Monitoring
1	Snake 326	Terrestrial gartersnake	2
2	Snake 326	Terrestrial gartersnake	At least 2

1:50,000 0 2,400 Meters

GOLDER

Figure 4
Snake Observations and Artificial Hibernacula (2020)
(BRE Wildlife Mitigation Program)

Date	Dec. 13, 2021	DWG NO	1016-N11-00921-3	R a

Construction of the Site C Clean Energy Project is subject to required regulatory and permitting approvals.

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Brenot Creek
Lynx Creek
Dry Creek
Farrell Creek
Peace River
Maurice Creek
Taylor Ave
Jamieson Ave
Alaska Rd
Cameron Rd
Lakeview Dr
Baker St
Thomas Rd
Lone Spruce Rd
Sylvan Rd
Davison Rd
100th St

5/28/2019/sunrise37 (iNaturalist)/R-THEL
Anecdotal Observvation - Patricia Cardinal
6/21/2020/Patricia Cardinal/R-THAM
Anecdotal Den - Ross Peck
/Ross Peck/R-THAM
7/14/2018/aerin_j (Inaturalist)/R-THEL
Terrestrial gartersnake - 10
Snake272.2 - Installed 20200717
Snake326 - Installed 20200718
Terrestrial gartersnake - 10
Common gartersnake - 1
/Hilton et al 2013/R-THAM
7/27/2013/Sarell / Andrusiak/R-THEL
8/24/2014/jb_from_bc (Inaturalist)/R-THEL

N

Fort St. John
Hudson's Hope

1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Orthophotos: Bing
4. Property boundary locations are best available but should be considered approximate. Property information is a combination of surveyed data representing BC Hydro's current ownership records and ICIS data. Property data is current as of January 2, 2018.

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Legend

- Upper Limit of Proposed Reservoir (461.8 m)
- Hwy 29 Re-Alignment Footprints
- Hwy 29 Re-Alignment Centerline
- Existing Hwy 29 Route
- Preliminary Slope Stability Impact Line
- Installed Snake Hibernacula Locations 2020
- Snake Observation - 2020
- Ecofor Salvage Release
- Historical BC Hydro Snake Observation
- Snake Observation

Species Code	Scientific Name	Common Name
R-THAM	*Thamnophis* sp.	Gartersnake sp.
R-THEL	*Thamnophis elegans*	Terrestrial Gartersnake
R-THIS	*Thamnophis sirtalis*	Common Gartersnake

Snake Hibernacula Monitoring Observations

Round	Hibernacula	Species	Observed during Occupancy Monitoring
1	Snake 326	Terrestrial gartersnake	2
2	Snake 326	Terrestrial gartersnake	At least 2

1:50,000

0 2,400 Meters

GOLDER

Figure 5
Snake Observations and Artificial Hibernacula (2020)
(BRE Wildlife Mitigation Program)

Date	Dec. 13, 2021	DWG NO	1016-N11-00921-4	R a

Construction of the Site C Clean Energy Project is subject to required regulatory and permitting approvals.

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APPENDIX B

Photos

Photo 1: Snake 21.4 (Dam View) entrance on 12 May 2021.

Photo 2: Snake 48 (Wilder Creek) entrance on 12 May 2021.

Photo 3: Snake 134 (Watson Slough) entrance on 12 May 2021.

Photo 4: Snake 153 (Halfway River) entrance on 13 May 2021.

Photo 5: Snake 326 (Lynx Creek) entrance on 13 May 2021.

Photo 6: Snake 272.2 (Peck's) entrance on 13 May 2021.

Photo 7: Two terrestrial gartersnakes found near the entrance to Snake 326 (Lynx Creek) on 13 May 2021.

Photo 8: A long-toed salamander found near the entrance to Snake 272.2 (Peck's) on 13 May 2021.

Photo 9: Snake 21.4 (Dam View) entrance on 10 June 2021 prior to filling excess gaps.

Photo 10: Snake 21.4 (Dam View) entrance on 10 June 2021 after filling excess gaps.

Photo 11: Snake 48 (Wilder Creek) entrance on 10 June 2021 prior to filling excess gaps.

Photo 12: Snake 48 (Wilder Creek) entrance on 10 June 2021 after filling excess gaps.

Photo 13: Snake 134 (Watson Slough) entrance on 10 June 2021 prior to filling excess gaps.

Photo 14: Snake 134 (Watson Slough) entrance on 10 June 2021 after filling excess gaps.

Photo 15: Snake 153 (Halfway River) entrance on 11 June 2021 prior to filling excess gaps.

Photo 16: Snake 153 (Halfway River) entrance on 11 June 2021 after filling excess gaps and adding additional soil.

Photo 17: Snake 272.2 (Peck's) entrance on 11 June 2021 prior to filling excess gaps.

Photo 18: Snake 272.02 (Peck's) entrance on 11 June 2021 after filling excess gaps.

Photo 19: Snake 272.2 (Peck's) prior to addition of extra soil.

Photo 20: Snake 272.2 (Peck's) after addition of extra soil.

Photo 21: Snake 326 (Lynx Creek) entrance on 11 June 2021 prior to filling excess gaps.

Photo 22: Snake 326 (Lynx Creek) entrance on 11 June 2021 after filling excess gaps.

Photo 23: Snake 326 (Lynx Creek) prior to addition of extra soil.

Photo 24: Snake 326 (Lynx Creek) after addition of extra soil.

Photo 25: Example of procedure to install extra insulation to the tube housing hibernaculum temperature logger. Tube cut close to ground level (11 June).

Photo 26: Example of procedure to install extra insulation to the tube housing hibernaculum temperature logger. Approximately 30 cm of foam added to top of tube (11 June).

Photo 27: Installation of extra insulation into the tube housing hibernaculum temperature logger. Insulating foam inserted into tube (11 June).

Photo 28: Installation of extra insulation to the tube housing hibernaculum temperature logger. Silicone sealant used to seal cap onto top of tube (11 June).

Photo 29: An adult western toad near the entrance of Snake 153 (Halfway River) on 10 June.

Photo 30: An adult western toad that emerged from Snake 326 (Lynx Creek) on 11 June.

APPENDIX C

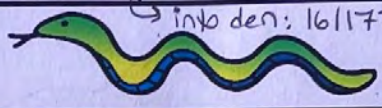
Field Data

Snake Hibernacula Monitoring - 2021

Sheet ____ of ____

Project Name	BRE Wildlife Mitigation
Project Number	18113590/4000/4003
Date (dd/mmm/yy)	12 May 2021
Observers	TMS, MS, PC.

Field QA/QC by	
Cloud Cover	0 1 2 3 4 5
Wind	0 1 2 3 4 5
Precip	—
Air Temp (°C)	14°C
Ground Temp (°C)	Bib: 26/32/31 Patio: 34/33
UTM	10 U 626695, 6234126



Hibernacula Name	Snake 21.4 (Dam View)
Hibernacula Occupied?	Yes (No) Unknown
Start Time (24h)	1000
End Time (24h)	

*** Reminder to rake sand at den entrance ✓

Site Notes	Stay to edge of field while driving in, do not drive into site if wet, call Jim Sodergren at home 250-785-6548 or on his cell 250-262-8350 before monitoring for gate access code

Cover Feature Type (e.g., rock pile, CWD)	Distance from Hibernacula (m)	Snake sign
1) Cover tile 1	2	—
2) Cover tile 2	2	—
3) Rocks at entrance	0.5	—
4) Sand at entrance (tracks)	0.1	—
4)		
5)		
6)		

General Wildlife Observations (Fill out detail on WSI form)

Waypoint #:

Black bear w 3 cubs. on far bank, 3 dens across valley
VGSW, HETH

Hibernacula condition (e.g., temperature logger, repairs required etc)

- some soil stuff ~0.5cm over lip onto bib.
- 2 ant colonies under patio stones (small / large)

Temp Logger - Data Download Notes

Battery - Good. - Downloaded data file, den did not get below zero.
- Push button start

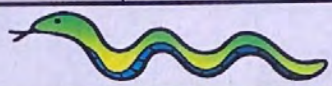
Snake Hibernacula Monitoring - 2021

Sheet ____ of ____

Project Name	BRE Wildlife Mitigation
Project Number	18113590/4000/4003
Date (dd/mmm/yy)	12 May 2021
Observers	TMS, MS, PC

Field QA/QC by	
Cloud Cover	0 1 2 (3) 4 5
Wind	0 1 2 (3) 4 5
Precip	light rain/sun.
Air Temp (°C)	16°C
Ground Temp (°C)	Sandpit: 22/22/21 Patio: 25/25 Den: 15
UTM	10U 618630, 6233149

Hibernacula Name	Snake 48 (Wilder Creek)		
Hibernacula Occupied?	Yes	(No)	Unknown
Start Time (24h)	13:00		
End Time (24h)	13:45		



Site Notes	48 hrs notice by telephone to: Owner at Ross and Deborah Peck 250.794.6269 and 250.261.0385, Mike Kroecher at 250.785.4956, Ray and Patty Hebert at 250.862.7657, Clay Peck 250-261-4815 and Katy Peck at 250.793.8222, and Blane Meek at 250-263-4174. Secondly Confirmation/Courtesy text Clay Peck – Cell 250-261-4815 to get gate code

Cover Feature Type (e.g., rock pile, CWD)	Distance from Hibernacula (m)	Notes
1) Cover tile 1	2	None
2) Cover tile 2	2	
3) Rock pile	3 to northeast	
4) Wilder Creek gully	150 m east	
5) Potential den past access gate	2 km by road	
6)		

General Wildlife Observations (Fill out detail on WSI form)

Waypoint #: RWBL, deer scat, bear scat, Mike found deer antler.

Hibernacula condition (e.g., temperature logger, repairs required etc)

Good condition, temp logger knocked off, put on with zap straps.

Temp Logger - Data Download Notes

GOOD Battery, -2°C at coldest ~~7 April~~ 4 Feb 2021 → 4 April 2021 below zero.

Cloud Cover Codes:	0 = clear/few clouds 1 = partly cloudy 2 = cloud/overcast 3 = fog 4 = drizzle 5 = showers
Wind Codes:	0 = vertical smoke (<1 kph); 1 = smoke drifts (1-5 kph); 2 = wind felt on face, leaves rustle (6-11 kph); 3 = leaves/twigs in constant motion (12-19 kph); 4 = raises dust, small branches sway (20-28 kph); 5 = trees sway (29-38 kph)
Precipitation Codes:	0 = none 1 = drizzle 2 = rain 3 = sleet 4 = fog 5 = snow

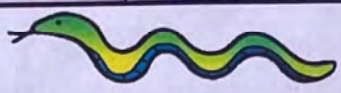
Snake Hibernacula Monitoring - 2021

Sheet _____ of _____

Project Name	BRE Wildlife Mitigation
Project Number	18113590/4000/4003
Date (dd/mmm/yy)	12 May 2021
Observers	TMS, MS, PC

Field QA/QC by	
Cloud Cover	0 1 (2) 3 4 5
Wind	0 1 2 (3) 4 5
Precip	—
Air Temp (°C)	21°C
Ground Temp (°C)	Sand: 38/34/25 Patio: 37 Den: 20°C
UTM	10U 603820, 6234237

Hibernacula Name	Snake 134 (Watson Slough)
Hibernacula Occupied?	Yes (No) Unknown
Start Time (24h)	15:45
End Time (24h)	16:30



Site Notes	Call XX before monitoring (None)

Cover Feature Type (e.g., rock pile, CWD)	Distance from Hibernacula (m)	Notes
1) Cover tile 1 2) Rocks at entrance	1 0.5	⊘
3) Rock pile	3 to northeast	
4)		
5)		
6)		

General Wildlife Observations (Fill out detail on WSI form)

Waypoint #: Bear across river observed, horses in lower field.

Hibernacula condition (e.g., temperature logger, repairs required etc)

Good condition, grass seed growing.

Temp Logger - Data Download Notes

Good condition, Battery: GOOD., temp below zero for ~2 months. (2 Feb 2021 → 19 April 2021.)

Cloud Cover Codes:	0 = clear/few clouds 1 = partly cloudy 2 = cloud/overcast 3 = fog 4 = drizzle 5 = showers
Wind Codes:	0 = vertical smoke (<1 kph); 1 = smoke drifts (1-5 kph); 2 = wind felt on face, leaves rustle (6-11 kph); 3 = leaves/twings in constant motion (12-19 kph); 4 = raises dust, small branches sway (20-28 kph); 5 = trees sway (29-38 kph)
Precipitation Codes:	0 = none 1 = drizzle 2 = rain 3 = sleet 4 = fog 5 = snow

Snake Hibernacula Monitoring - 2021

Sheet ____ of ____

Project Name	BRE Wildlife Mitigation
Project Number	18113590/4000/4003
Date (dd/mmm/yy)	13 May 2021
Observers	TMS, MS, PC

Field QA/QC by	
Cloud Cover	0 (1) 2 3 4 5
Wind	0 (1) 2 3 4 5
Precip	—
Air Temp (°C)	17°C
Ground Temp (°C)	Patio: 24/25 Sand: 31/33/35
UTM	10 U 596484, 6232690 Den: 16°C

Hibernacula Name	Snake 153 (Halfway River)		
Hibernacula Occupied?	Yes	(No)	Unknown
Start Time (24h)	1000		
End Time (24h)	1020		

Site Notes	No issues for access

Cover Feature Type (e.g., rock pile, CWD)	Distance from Hibernacula (m)	Notes
1) Cover tile 1	0.5	—
2) Cover tile 1	0.5	—
3) Rock pile at entrance	0.5	—
4) Silt bluffs	700 to west	
5)		
6)		

General Wildlife Observations (Fill out detail on WSI form)

Waypoint #: CA60, 2 kestrel, coyote scat at ~~top~~.

*Note, new access road and berm built into edge of agricultural field - berm piled to east.

Hibernacula condition (e.g., temperature logger, repairs required etc)

Good, could use more soil on top of entrance, washed away?

Temp Logger - Data Download Notes

Good battery life., coldest got to 0.6°C.

Cloud Cover Codes:	0 = clear/few clouds 1 = partly cloudy 2 = cloud/overcast 3 = fog 4 = drizzle 5 = showers
Wind Codes:	0 = vertical smoke (<1 kph); 1 = smoke drifts (1-5 kph); 2 = wind felt on face, leaves rustle (6-11 kph); 3 = leaves/twings in constant motion (12-19 kph); 4 = raises dust, small branches sway (20-28 kph); 5 = trees sway (29-38 kph)
Precipitation Codes:	0 = none 1 = drizzle 2 = rain 3 = sleet 4 = fog 5 = snow

May 6 → 4 snakes.
→ 2 snakes.

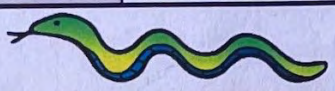
Snake Hibernacula Monitoring - 2021

Sheet ____ of ____

Project Name	BRE Wildlife Mitigation
Project Number	18113590/4000/4003
Date (dd/mmm/yy)	13 May 2021
Observers	TMS, MS, PC

Field QA/QC by	
Cloud Cover	0 1 2 (3) 4 5
Wind	0 1 (2) 3 4 5
Precip	—
Air Temp (°C)	19°C
Ground Temp (°C)	Patio: 44/45 °C Sand 51/47/46 Den: 22
UTM	10 U 571450, 6214558

Hibernacula Name	Snake 326 (Lynx Creek)
Hibernacula Occupied?	(Yes) No Unknown
Start Time (24h)	12:30
End Time (24h)	13:30



Site Notes	Please call Travis: 250-783-0529 or Steve: 250-783-0531 prior to access

Cover Feature Type (e.g., rock pile, CWD)	Distance from Hibernacula (m)	Notes
1) Cover tile 1	1	2 THEL ♂ → See over for more detail. *
2) Cover tile 2	1	— ants.
3) Rock pile	0.5	—
4) Buried vehicles	30 to southeast	—
5)		
6)		

General Wildlife Observations (Fill out detail on WSI form)

Waypoint #: RNSA tapping + calling.

Hibernacula condition (e.g., temperature logger, repairs required etc)

Good, some soil moved away from horses on NE side of den, would be good to add more! Grass not growing well in den area due to horses - re-seed??

Temp Logger - Data Download Notes

Good Battery Condition., coldest -0.1 °C between 20 Feb 2021 and 15 March 2021.

Cloud Cover Codes:	0 = clear/few clouds 1 = partly cloudy 2 = cloud/overcast 3 = fog 4 = drizzle 5 = showers
Wind Codes:	0 = vertical smoke (<1 kph); 1 = smoke drifts (1-5 kph); 2 = wind felt on face, leaves rustle (6-11 kph); 3 = leaves/twings in constant motion (12-19 kph); 4 = raises dust, small branches sway (20-28 kph); 5 = trees sway (29-38 kph)
Precipitation Codes:	0 = none 1 = drizzle 2 = rain 3 = sleet 4 = fog 5 = snow

Snake Hibernacula Monitoring - 2021

Sheet ____ of ____

Project Name	BRE Wildlife Mitigation
Project Number	18113590/4000/4003
Date (dd/mmm/yy)	13 May 2021
Observers	TMS, MS, PC

Field QA/QC by	
Cloud Cover	0 1 2 (3) 4 5
Wind	0 1 2 3 (4) 5
Precip	—
Air Temp (°C)	19°C
Ground Temp (°C)	~~19°C~~ Path D: 43°C
UTM	10 U 573017, 6216971 37/36/35 Sand Den: 15°C

Hibernacula Name	Snake 272.2 (Pecks)		
Hibernacula Occupied?	Yes	(No)	Unknown
Start Time (24h)	14:30		
End Time (24h)	15:10		

Site Notes	Please call both for Ross and Deborah prior to access: Ross: 250.261.0385 Deborah: 250.794.6269.

Cover Feature Type (e.g., rock pile, CWD)	Distance from Hibernacula (m)	Notes
1) Cover tile 1	1	Long toed salamander
2) Rocks at entrance	0.5	
3) Beaver lodge and dugout pond	15 m to east	Fresh beaver cutting.
4)		
5)		
6)		

General Wildlife Observations (Fill out detail on WSI form)

Waypoint #: GAGO x 30, PIWO.

Hibernacula condition (e.g., temperature logger, repairs required etc)

Good, grass growing well.

Temp Logger - Data Download Notes

Good Battery, All good., coldest temp 1.1°C; did not go below zero.

Cloud Cover Codes:	0 = clear/few clouds 1 = partly cloudy 2 = cloud/overcast 3 = fog 4 = drizzle 5 = showers
Wind Codes:	0 = vertical smoke (<1 kph); 1 = smoke drifts (1-5 kph); 2 = wind felt on face, leaves rustle (6-11 kph); 3 = leaves/twings in constant motion (12-19 kph); 4 = raises dust, small branches sway (20-28 kph); 5 = trees sway (29-38 kph)
Precipitation Codes:	0 = none 1 = drizzle 2 = rain 3 = sleet 4 = fog 5 = snow

Snake Hibernacula Monitoring - 2021

Sheet _____ of _____

Project Name	BRE Wildlife Mitigation
Project Number	18113590/4000/4003
Date (dd/mmm/yy)	10/Jun/21
Observers	JS/MS/PC

Field QA/QC by	
Cloud Cover	0 (1) 2 3 4 5
Wind	0 (1) 2 3 4 5
Precip	None.
Air Temp (°C)	13°C
Ground Temp (°C)	15.3°C
UTM	10 U 626695, 6234126

Hibernacula Name	Snake 21.4 (Dam View)		
Hibernacula Occupied?	Yes	No	Unknown
Start Time (24h)	9:30		
End Time (24h)			

*** Reminder to rake sand at den entrance

Site Notes	Stay to edge of field while driving in, do not drive into site if wet, call Jim Sodergren at home 250-785-6548 or on his cell 250-262-8350 before monitoring for gate access code

Cover Feature Type (e.g., rock pile, CWD)	Distance from Hibernacula (m)	Snake sign
1) Cover tile 1	2 17.5°C	
2) Cover tile 2	2 21.8°C	
3) Rocks at entrance	0.5 23.0°C	
4) Sand at entrance (tracks)	0.1 21.1°C	
4)		
5)		
6)		

General Wildlife Observations (Fill out detail on WSI form)

Waypoint #:

Hibernacula condition (e.g., temperature logger, repairs required etc)

① Shorten Temp Logger pipe + fill with 14" foam strip
② Spray expanding foam into upper chambers of den entrance (see photos)
③ Apply concrete + rock fill to all upper + side openings (see photos)

Temp Logger - Data Download Notes

deferred

Cloud Cover Codes:		0 = clear/few clouds 1 = partly cloudy 2 = cloud/overcast 3 = fog 4 = drizzle 5 = showers
Wind Codes:	2 - 3	0 = vertical smoke (<1 kph); 1 = smoke drifts (1-5 kph); 2 = wind felt on face, leaves rustle (6-11 kph); 3 = leaves/twings in constant motion (12-19 kph); 4 = raises dust, small branches sway (20-28 kph); 5 = trees sway (29-38 kph)
Precipitation Codes:	0	0 = none 1 = drizzle 2 = rain 3 = sleet 4 = fog 5 = snow

Snake Hibernacula Monitoring - 2021

Sheet _____ of _____

Project Name	BRE Wildlife Mitigation
Project Number	18113590/4000/4003
Date (dd/mmm/yy)	11 Jun '21
Observers	JS/MS/PC

Field QA/QC by	
Cloud Cover	(0) 1 2 3 4 5
Wind	0 1 2 3 (4) 5
Precip	none
Air Temp (°C)	
Ground Temp (°C)	22.3°C
UTM	10U 618630, 6233149

Hibernacula Name	Snake 48 (Wilder Creek)
Hibernacula Occupied?	Yes No (Unknown)
Start Time (24h)	9:46
End Time (24h)	

Site Notes	48 hrs notice by telephone to: Owner at Ross and Deborah Peck 250.794.6269 and 250.261.0385, Mike Kroecher at 250.785.4956, Ray and Patty Hebert at 250.862.7657, Clay Peck 250-261-4815 and Katy Peck at 250.793.8222, and Blane Meek at 250-263-4174. Secondly Confirmation/Courtesy text Clay Peck – Cell 250-261-4815 to get gate code

Cover Feature Type (e.g., rock pile, CWD)	Distance from Hibernacula (m)	Notes
1) Cover tile 1	2	30.7°C
2) Cover tile 2	2	27.1°C
3) Rock pile	3 to northeast	19.0°C
4) Wilder Creek gully	150 m east	
5) Potential den past access gate	2 km by road	
6)		

General Wildlife Observations (Fill out detail on WSI form)

Waypoint #:

Bald Eagle soaring directly above hibernacula.

Hibernacula condition (e.g., temperature logger, repairs required etc)

- filled gaps in entrance w/ foam
- reinforced gaps w/ concrete / mortar / sand mix.
- cut den temp logger ~5cm above ground, inserted foam, sealed w/ silicone.

Temp Logger - Data Download Notes

N/A

Cloud Cover Codes:	0 = clear/few clouds 1 = partly cloudy 2 = cloud/overcast 3 = fog 4 = drizzle 5 = showers
Wind Codes:	0 = vertical smoke (<1 kph); 1 = smoke drifts (1-5 kph); 2 = wind felt on face, leaves rustle (6-11 kph); 3 = leaves/twings in constant motion (12-19 kph); 4 = raises dust, small branches sway (20-28 kph); 5 = trees sway (29-38 kph)
Precipitation Codes:	0 = none 1 = drizzle 2 = rain 3 = sleet 4 = fog 5 = snow

SITE SKETCH

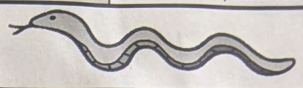
Snake Hibernacula Monitoring - 2021

Project Name	BRE Wildlife Mitigation
Project Number	18113590/4000/4003
Date (dd/mmm/yy)	10/Jun/21
Observers	FC/MS/PC

Sheet _____ of _____

Field QA/QC by	
Cloud Cover	0 1 2 3 (4) 5
Wind	0 1 (2) 3 4 5
Precip	light drizzle
Air Temp (°C)	
Ground Temp (°C)	16°C
UTM	10U 603820, 6234237

Hibernacula Name	Snake 134 (Watson Slough)
Hibernacula Occupied?	**Yes** **No** **(Unknown)**
Start Time (24h)	12:00
End Time (24h)	13:00



Site Notes

Call XX before monitoring

Cover Feature Type (e.g., rock pile, CWD)	Distance from Hibernacula (m)	Notes
1) Cover tile 1	1	25°C
2) Rocks at entrance	0.5	10.1°C
3) Rock pile	3 to northeast	15.3°C
4)		
5)		
6)		

General Wildlife Observations (Fill out detail on WSI form)

Waypoint #:

Hibernacula condition (e.g., temperature logger, repairs required etc)

- filled gaps in entrance w/ expanding foam
- reinforced cracks in entrance w/ concrete
- cut den temp probe ~5cm above ground level, filled w/ foam to insulate

Temp Logger - Data Download Notes

N/A.

Cloud Cover Codes:	0 = clear/few clouds 1 = partly cloudy 2 = cloud/overcast 3 = fog 4 = drizzle 5 = showers
Wind Codes:	0 = vertical smoke (<1 kph); 1 = smoke drifts (1-5 kph); 2 = wind felt on face, leaves rustle (6-11 kph); 3 = leaves/twings in constant motion (12-19 kph); 4 = raises dust, small branches sway (20-28 kph); 5 = trees sway (29-38 kph)
Precipitation Codes:	0 = none 1 = drizzle 2 = rain 3 = sleet 4 = fog 5 = snow

SITE SKETCH

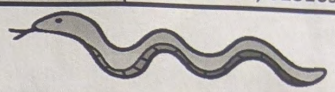
Snake Hibernacula Monitoring - 2021

Project Name	BRE Wildlife Mitigation
Project Number	18113590/4000/4003
Date (dd/mmm/yy)	10 Jun '21
Observers	JS/MS/PC

Sheet ____ of ____

Field QA/QC by	
Cloud Cover	0 1 2 3 (4) 5
Wind	0 (1) 2 3 4 5
Precip	light drizzle
Air Temp (°C)	
Ground Temp (°C)	21.0
UTM	10 U 596484, 6232690

Hibernacula Name	Snake 153 (Halfway River)		
Hibernacula Occupied?	**Yes**	**No**	**Unknown**
Start Time (24h)	14:00		
End Time (24h)	~~15:00~~ 15:40		



Site Notes

No issues for access

Cover Feature Type (e.g., rock pile, CWD)	Distance from Hibernacula (m)	Notes
1) Cover tile 1	0.5	32.6 °C
2) Cover tile 1	0.5	33.1 °C
3) Rock pile at entrance	0.5	27.1°C
4) Silt bluffs	700 to west	
5)		
6)		

General Wildlife Observations (Fill out detail on WSI form)

Waypoint #:

Adult WETO @ entrance to hibernacula on arrival

Bald Eagle soaring near parking spot in corner of field

Hibernacula condition (e.g., temperature logger, repairs required etc)

- Sealed ~~on~~ gaps in entrance w/ expanding insulating foam
- filled gaps w/ extra rocks
- placed concrete to cover gaps, seal rocks together
- cut pipe for dn temp logger, placed insulation + sealed w/ silicone.

Temp Logger - Data Download Notes

N/A

↳ added some additional soil ~~to~~ on top of dn entrance from slightly upslope.

Cloud Cover Codes:	0 = clear/few clouds 1 = partly cloudy 2 = cloud/overcast 3 = fog 4 = drizzle 5 = showers
Wind Codes:	0 = vertical smoke (<1 kph); 1 = smoke drifts (1-5 kph); 2 = wind felt on face, leaves rustle (6-11 kph); 3 = leaves/twings in constant motion (12-19 kph); 4 = raises dust, small branches sway (20-28 kph); 5 = trees sway (29-38 kph)
Precipitation Codes:	0 = none 1 = drizzle 2 = rain 3 = sleet 4 = fog 5 = snow

SITE SKETCH

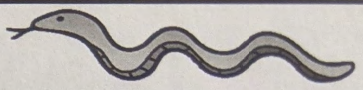
Snake Hibernacula Monitoring - 2021

Sheet ____ of ____

Project Name	BRE Wildlife Mitigation
Project Number	18113590/4000/4003
Date (dd/mmm/yy)	11 June '21
Observers	JS/MS/PC

Field QA/QC by	
Cloud Cover	(0) 1 2 3 4 5
Wind	0 (1) 2 3 4 5
Precip	None
Air Temp (°C)	
Ground Temp (°C)	23.4°C
UTM	10 U 573017, 6216971

Hibernacula Name	Snake 272.2 (Pecks)
Hibernacula Occupied?	Yes No (Unknown)
Start Time (24h)	15:15
End Time (24h)	17:00



Site Notes	Please call both for Ross and Deborah prior to access: Ross: 250.261.0385 Deborah: 250.794.6269.

Cover Feature Type (e.g., rock pile, CWD)	Distance from Hibernacula (m)	Notes
1) Cover tile 1	1	45.5°C
2) Rocks at entrance	0.5	36.1°C
3) Beaver lodge and dugout pond	15 m to east	
4)		
5)		
6)		

General Wildlife Observations (Fill out detail on WSI form)

Waypoint #:

- 2 little brown myotis in green house. (MS spp. ID)
- beaver near lodge in pond

Hibernacula condition (e.g., temperature logger, repairs required etc)

- filled gaps w/ expanding insulating foam.
- reinforced gaps w/ concrete/sand/mortar mix
- cut tube w/ den temp logger, inserted insulation, sealed w/ silicone.
- added additional soil, seeded

Temp Logger - Data Download Notes

N/A

Cloud Cover Codes:	0 = clear/few clouds 1 = partly cloudy 2 = cloud/overcast 3 = fog 4 = drizzle 5 = showers
Wind Codes:	0 = vertical smoke (<1 kph); 1 = smoke drifts (1-5 kph); 2 = wind felt on face, leaves rustle (6-11 kph); 3 = leaves/twings in constant motion (12-19 kph); 4 = raises dust, small branches sway (20-28 kph); 5 = trees sway (29-38 kph)
Precipitation Codes:	0 = none 1 = drizzle 2 = rain 3 = sleet 4 = fog 5 = snow

SITE SKETCH

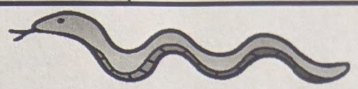
Snake Hibernacula Monitoring - 2021

Sheet _____ of _____

Project Name	BRE Wildlife Mitigation
Project Number	18113590/4000/4003
Date (dd/mmm/yy)	11 Jun '21
Observers	JS/MS/PC

Field QA/QC by	
Cloud Cover	(0) 1 2 3 4 5
Wind	0 1 (2) 3 4 5
Precip	None.
Air Temp (°C)	
Ground Temp (°C)	21.0°C
UTM	10 U 571450, 6214558

Hibernacula Name	Snake 326 (Lynx Creek)
Hibernacula Occupied?	(Yes) No Unknown
Start Time (24h)	13:15
End Time (24h)	15:00



Site Notes

Please call Travis: 250-783-0529 or Steve: 250-783-0531 prior to access

Cover Feature Type (e.g., rock pile, CWD)	Distance from Hibernacula (m)	Notes
1) Cover tile 1	1	38.7°C
2) Cover tile 2	1	33.6°C + 1 snake underneath.
3) Rock pile	0.5	28.3°C
4) Buried vehicles	30 to southeast	
5)		
6)		

General Wildlife Observations (Fill out detail on WSI form)

Waypoint #:

- Terrestrial garter beneath left cover tile. - flushed away from den
- WETO inside hibernacle entrance.
- Terrestrial observed on soil
- Terrestrial W of den
- Terrestrial on bare soil on den. - # of snakes unknown to probably 2.

Hibernacula condition (e.g., temperature logger, repairs required etc)

- Sealed gaps in entrance w/ insulating foam.
- reinforced gaps w/ concrete / mortar / sand mix
- cut pipe w/ den temp logger, filled w/ insulation, sealed w/ silicone.
- piled additional soil on top of den. + seeded.

Temp Logger - Data Download Notes

N/A

Cloud Cover Codes:	0 = clear/few clouds 1 = partly cloudy 2 = cloud/overcast 3 = fog 4 = drizzle 5 = showers
Wind Codes:	0 = vertical smoke (<1 kph); 1 = smoke drifts (1-5 kph); 2 = wind felt on face, leaves rustle (6-11 kph); 3 = leaves/twings in constant motion (12-19 kph); 4 = raises dust, small branches sway (20-28 kph); 5 = trees sway (29-38 kph)
Precipitation Codes:	0 = none 1 = drizzle 2 = rain 3 = sleet 4 = fog 5 = snow

SITE SKETCH

golder.com

Appendix 10. Cavity Nesting Mitigation and Monitoring Program – 2021 Annual Report

MEMORANDUM

Date:	January 26, 2022
To:	BC Hydro
From:	Hemmera Envirochem Inc.
File:	989619-08
Re:	Cavity Nesting Mitigation and Monitoring Program – 2021 Annual Report

1.0 INTRODUCTION

BC Hydro assessed the potential effects of the Site C Clean Energy Project on Wildlife Resources in the Site C Environmental Impact Statement (EIS) using key species groups (BC Hydro 2013). Cavity nesting bird species were assessed in the EIS as part of the migratory birds (passerines [songbirds], northern flicker, and waterfowl) and raptors (hawks and owls) groups (BC Hydro 2016). In 2017, a mitigation and monitoring plan for cavity nesting birds was developed with input from the Vegetation and Wildlife Technical Committee, which is comprised of representatives of the Canadian Wildlife Service, the BC Ministry of Environment and Climate Change Strategy and the BC Ministry of Forests, Lands, Natural Resources Operations and Rural Development.

The purpose of the Cavity Nesting Mitigation and Monitoring Program is to mitigate habitat loss for cavity nesting species associated with Site C reservoir vegetation clearing, and to monitor the effectiveness of that mitigation (BC Hydro 2018). Mitigating the impacts of habitat loss for cavity nesting birds is focused on areas that will be retained (i.e., not cleared and not flooded) and currently have a low density of suitable trees for cavity nesting species (i.e., structural stage 4 [pole-sapling] or 5 [young forest] habitats[1] that have few large-diameter live trees or snags). Mitigation of habitat loss will be achieved using different measures depending on the time period for the effects for which they are intended to mitigate (i.e., short-, medium-, or long-term). Nest box installation for cavity nesting species provides short-term mitigation, the results of which are the focus of this memo.

[1] Structural Stage 4 (pole-sapling forest): Trees >10 m tall, typically densely stocked, have overtopped shrub and herb layers; younger stands are vigorous (usually >10–15 years old); older stagnated stands (up to 100 years old) are also included; self-thinning and vertical structure not yet evident in the canopy – this often occurs by age 30 in vigorous broadleaf stands, which are generally younger than coniferous stands at the same structural stage; time since disturbance is usually <40 years for normal forest succession; up to 100+ years for dense (5000–15 000+ stems per hectare) stagnant stands.
Structural Stage 5 (young forest): Self-thinning has become evident and the forest canopy has begun differentiation into distinct layers (dominant, main canopy, and overtopped); vigorous growth and a more open stand than in the pole/sapling stage; time since disturbance is generally 40–80 years but may begin as early as age 30, depending on tree species and ecological conditions; from RIC (1998).

2.0 METHODS

2.1 Nest Box Construction

Cavity nesting birds differ in their habitat requirements and selection of cavities. Therefore, a variety of nest box designs were constructed to mitigate impacts on nesting habitat for cavity nesting birds due to activities associated with the Site C Clean Energy Project (**Figure 1**). Thirteen different nest box designs were constructed to accommodate 21 species of cavity nesting birds, with some box designs intended to support multiple species (BC Hydro 2018).

Figure 1 Nest Box Designs Built for the Cavity Nesting Mitigation and Monitoring Program.

2.2 Nest Box Installation

The selection of sites followed specifications described in the Cavity Nesting Species Mitigation and Monitoring Program (BC Hydro 2018). The selection of habitat and placement of nest boxes was guided based on information from James (1984) and Terrestrial Ecosystem Mapping data collected in 2016 along the anticipated reservoir. Boxes were placed on lands owned or leased by BC Hydro or on Crown land, in areas outside of planned clearing boundaries, above the high-water mark, and in areas of suitable but suboptimal habitat (i.e., areas of suitable age class but with a low number of cavity trees).

Box installation was specifically focussed on lower suitability habitat with a low proportion of potential cavity nesting trees (i.e., structural stages 4 to 5, but which have the greatest potential to develop into more suitable habitat over the short term (see **Figure 2** for an example of nest box installation). Additional information based on literature and expert knowledge were also considered for the installation of nest boxes:

- Proximity to a food source for all species (e.g., wetlands, water sources)
- Bird distribution and abundance information from Site C baseline studies in the area
- Known habitat associations
- Appropriate nest heights (**Table 1**)
- Density of nest boxes within an area (i.e., spacing between nest boxes) (**Table 1**).

Figure 2 Nest box design 'A,' intended for black-capped chickadee (*Poecile atricapillus*), boreal chickadee (*Poecile hudsonicus*), red-breasted nuthatch (*Sitta canadensis*), white-breasted nuthatch (*Sitta carolinensis*), house wren (*Troglodytes aedon*), and brown creeper (*Certhia americana*).

Table 1 Installation Guide Table Showing Minimum Distance Between Boxes and Height of Installation for the Different Types of Boxes Used in the Mitigation Plan

Species Group	Common Name	Scientific Name	Minimum Spacing Between Boxes (m)	Nest Box Height (m)
Passerines	black-capped chickadee	*Poecile atricapillus*	150-200	1.5 - 4.5
	boreal chickadee	*Poecile hudsonicus*	150-200	1.5 - 3
	brown creeper	*Certhia americana*	150	1.0 - 10
	red-breasted nuthatch	*Sitta canadensis*	50	1.5 - 4.5
	white-breasted nuthatch	*Sitta carolinensis*	300	1.5 - 6
	tree swallow	*Tachycineta bicolor*	10-30	1.5 - 1.8
	violet-green swallow	*Tachycineta thalassina*	10-30	2.75 - 4.5
	house wren	*Troglodytes aedon*	30	1.5 - 3
	mountain bluebird	*Sialia currucoides*	90	1.2 – 1.8
Waterfowl	Barrow's goldeneye	*Bucephala islandica*	150-200	1.8 - 6
	Bufflehead	*Bucephala albeola*	50-150	1.5 - 3
	common goldeneye	*Bucephala clangula*	1,000	1.8 - 9
	common merganser	*Mergus merganser*	100	2.4 - 5.2
	hooded merganser	*Lophodytes cucullatus*	30	1.8 - 7.6
Raptors and Owls	barred owl	*Strix varia*	1,000	4.5 - 9
	boreal owl	*Aegolius funereus*	150	≥3
	northern saw-whet owl	*Aegolius acadicus*	400-500	≥3
	northern pygmy-owl	*Glaucidium gnoma*	400-500	≥3
	northern hawk-owl	*Surnia ulula*	500-700	≥3
	American kestrel	*Falco sparverius*	500-800	3.5 – 6

2.3 Nest Box Monitoring and Maintenance

Nest boxes will continue to be monitored biennially through the Site C Clean Energy Project construction and the first ten years of operations (**Appendix A**). Boxes installed in 2017 were monitored in 2020 (Hemmera 2020) and will be monitored again in 2022 and every two years after that through the first 10 years of Project operations. Boxes installed in 2019 and 2020 were monitored in 2021 and will be monitored again in 2023.

Monitoring in 2021 was conducted by a qualified environmental professional in a manner that minimizes disturbance to active nests. Using the breeding period information provided in **Appendix B**, nest box visits were timed to coincide with nest stages in which the likelihood of detecting use is greatest (i.e., late incubation to early nestling stages).

Visits timed to coincide with nests at a stage with older nestlings are more likely to have their status determined, as parents are more likely to be feeding older nestlings more frequently. However, due to variation in brood timing within and among species, attempting to time surveys to coincide with the presence of older nestlings would increase the chance of arriving too late for direct observations of breeding activity for some nests. Therefore, a conservative estimate of the nesting window was applied to maximize the likelihood of observing active use and determining the species using each box.

During the monitoring work, surveyors approached the box discreetly, watching and listening for activity. When adults were attending a box, surveyors observed from a distance, recorded species, and attempted to determine stage (if nestlings were present, food delivery and fecal sac removal confirmed stage). If no use was evident from nest box observation, surveyors approached the nest box structure (tree or otherwise) and tapped lightly on it to elicit a response (Dudley and Saab 2003). If no bird appeared at the cavity entrance, a pole-mounted camera was used to examine the nest box contents. When nesting activity was documented but no adult birds were observed at the box, egg and nest characteristics (e.g., nesting material type, egg colour, shape, and size) were used to identify, where possible, the species or genus occupying the box. For species with similar eggs and nests, it is only possible to identify to genus (e.g., goldeneye species [*Bucephala* sp.]).

During each nest box visit surveyors recorded the following data electronically:

- Date and time
- Coordinates
- Surveyors
- Weather conditions
- Nest box ID
- Detection methods:
  - Adult behaviour
  - Audible nestlings
  - Food delivery
  - Pole camera examination
- Is box being used
- Species detected
- Notes informing environmental context, such as disturbance in the area.

Maintenance

Nest boxes have a 10 to 15-year lifespan with regular maintenance. Nest boxes in need of repair (e.g., broken or fallen boxes, loose lids or covers) were flagged during the monitoring season in 2020 and repaired during the monitoring period if feasible (e.g., not occupied, or salvageable). Maintenance and repair included replacing nesting material if necessary, and performing any replacement or repair of broken boxes.

3.0 RESULTS

3.1 Nest Box Installation

Between 2017 and 2020, 268 nest boxes were installed on trees and structures on BC Hydro-owned and managed lands, and on private lands where permission was granted (**Table 2**, **Figure 3**). Twenty-one (21) boxes have been installed near the lower reservoir, 78 near the eastern reservoir, 38 near the middle reservoir and 131 near the western reservoir.

In 2017, a total of 97 nest boxes were installed on the north side of the Peace River. In 2019, 83 additional nest boxes were installed on the south side of the Peace River, and the remaining 88 nest boxes were installed in spring 2020 on the north and south sides of the Peace River, for a total of 171 nest boxes installed from 2019 to 2020. The locations of the 2020 nest boxes were selected based on areas not covered in previous installations (2017 and 2019) and complementing habitat and species assemblage within the proposed reservoir following the same criteria for habitat selection (see **Section 2.2**). The installation of new nest boxes was completed in 2020. Reinstallation of five boxes that were damaged or removed was completed in 2021. **Table 2** describes the target species, habitat type and number of boxes of each design installed to date.

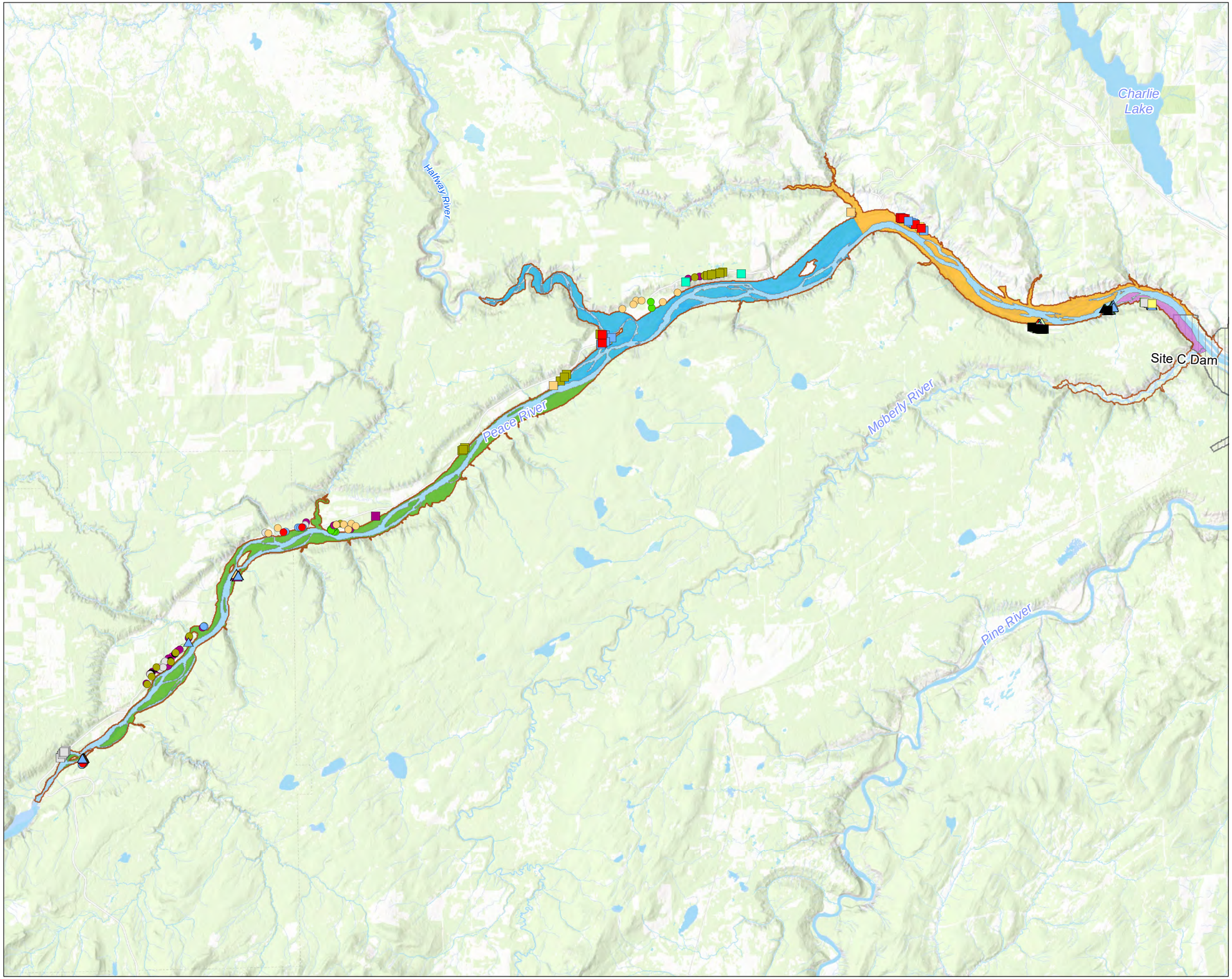
Table 2 Target Species, Habitat Preferences, and Total Number Nest Boxes Installed in 2017, 2019, and 2020

Species Group	Habitat Preference	Box Type	Species Supported	Number of Boxes Installed to Date
Passerine	Prefer a variety of habitat types, from dry to wet forests and in most structural stages Brown creeper and nuthatches prefer more mature forested habitats Swallows use wetland and cultivated field habitat Mountain bluebird require open field habitat	A / BC / B1	black-capped chickadee boreal chickadee red-breasted nuthatch white-breasted nuthatch house wren brown creeper	44
		A2 / B2	mountain bluebird tree swallow violet-green swallow	57
Waterfowl	Need an unobstructed flight path from suitable forage habitat to nesting features	E1	bufflehead	8
		F	Barrow's goldeneye common goldeneye hooded merganser	48
		D / G	common merganser	18
Raptors and Owls	Typically found in mesic to moist forests smaller species found in younger forests American kestrel requires open field habitat	E2	boreal owl northern saw-whet owl	27
		E3	American kestrel	17
		C	northern pygmy- owl	26
		B3	northern hawk-owl	20
		H	barred owl	3
			Total	**268**

Note: 264 boxes were proposed to be installed (BC Hydro 2018)

Site C Clean Energy Project
Peace River, BC

Nest Box Locations



Legend

- Proposed Dam Site
- 5 Year Beach Line
- Eastern Reservoir
- Lower Reservoir
- Middle Reservoir
- Western Reservoir

Nest Box Types

2017	2019	2020
○	△	A
●	▲	A2
○	△	B1
●	▲	B2
●	▲	B3
●	▲	BC
○	△	C
		D
○		E1
●	▲	E2
○	△	E3
●	▲	F
●	▲	G
	△	H

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

1:210,000

0 2 4 6 8 10
Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-08	Production Date: Dec 17, 2021	Figure 3

Hemmera An Ausenco Company

BC hydro

Path: S:\Geomatics\Projects\989619\08_cents_maintmnt\2021\Fig3_989619_08_CentsMaint_NestBoxLocation\2020_211217.mxd

3.2 Monitoring and Maintenance of Nest Boxes Installed in 2019 and 2020

Monitoring

From May 17 to 22, 2021 monitoring was conducted for 62 nest boxes installed in 2019 and 85 nest boxes installed in 2020, for a total of 147 boxes monitored. An additional 10 nest boxes scheduled for monitoring in 2021 could not be found, and were presumably lost during vegetation clearing after a change in clearing boundaries or during inclement weather. The status of each box at the time of monitoring can be found in **Appendix C**.

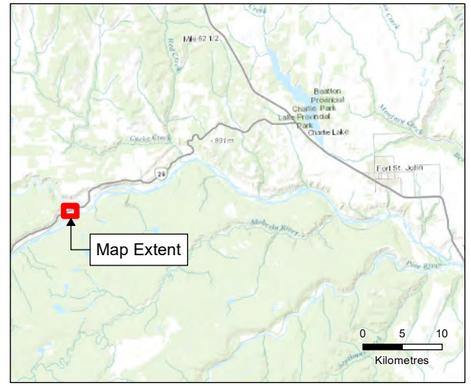
Forty (40) boxes showed signs of use such as nesting material, feathers, or eggs present. Eggs were present in 6 boxes, presumed to be in the incubation stage. The locations of the six boxes containing eggs are mapped in **Figure 4**, **Figure 5**, and **Figure 6**. American kestrel (*Falco sparverius*) eggs were documented in two nest boxes, one in box E1-09 installed on a trembling aspen (*Populus tremuloides*) in an immature aspen forest, and one in box D-03 installed on a trembling aspen in a mixed young forest. The kestrel nests contained two (at D-03) or three (at E1-09; **Figure 7**) eggs each. Three boxes installed on trembling aspens in aspen forest contained duck eggs. Of these, one was occupied by goldeneye (F-49), the other two (F-26 and G-04) by cavity nesting ducks known to have whitish-coloured eggs (i.e., bufflehead [*Bucephala albeola*], common merganser [*Mergus merganser*], or hooded merganser [*Lophodytes cucullatus*]). A mixed-clutch was documented in nest box G-04 (**Figure 8**), where three eggs were suspected to belong to common merganser, the fourth to a smaller species such as hooded merganser or bufflehead. Passerine eggs were documented in nest box OWL-3, installed on a trembling aspen on a steep slope above a gully. Species or genus could not be identified for these eggs, which had characteristics matching several species (e.g., red-breasted nuthatch [*Sitta canadensis*]). Broken eggs were documented in two additional nest boxes (F-41 and F-21), not shown on Figures 4-6. Nesting outcome (i.e., success or failure) could not be determined without additional information (e.g., species, clutch size); broken eggs may have been a result of hatching or predation.

House wren (*Troglodytes aedon*) nesting activity was high, with nests or nest building documented in 14 boxes, which is more than a quarter of the boxes with evidence of use in 2021. Eggs were not documented in house wren nests. Dead rodents or rodent remains were observed in two boxes with large enough openings for raptors (i.e., F-39, E2-14), suggesting use by raptors for feeding.

Signs of rodent use, such as droppings, teeth marks, potential den sites, or squirrel caches, were observed at 14 boxes during monitoring. Old wasp or hornet nests were documented and removed in two boxes.

Site C Clean Energy Project
Peace River, BC

Locations of Nest Boxes with Eggs #1



Legend

- 5 Year Beach Line
- Middle Reservoir
- Watercourse
- Waterbody

Nest Boxes with Eggs - Species

- American kestrel (*Falco sparverius*)

Other Nest Boxes - Year Installed

- 2020

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

- Aerial Image: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

N

1:5,000

0 50 100 150 200 250
Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-08	Production Date: Dec 17, 2021	Figure 4

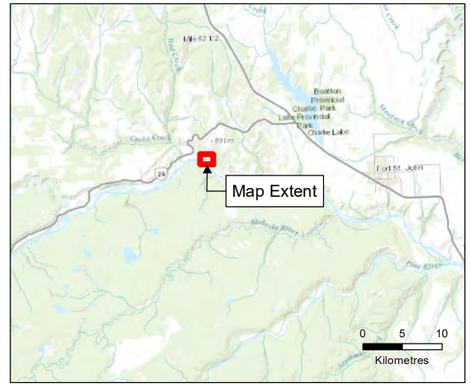
Hemmera An Ausenco Company

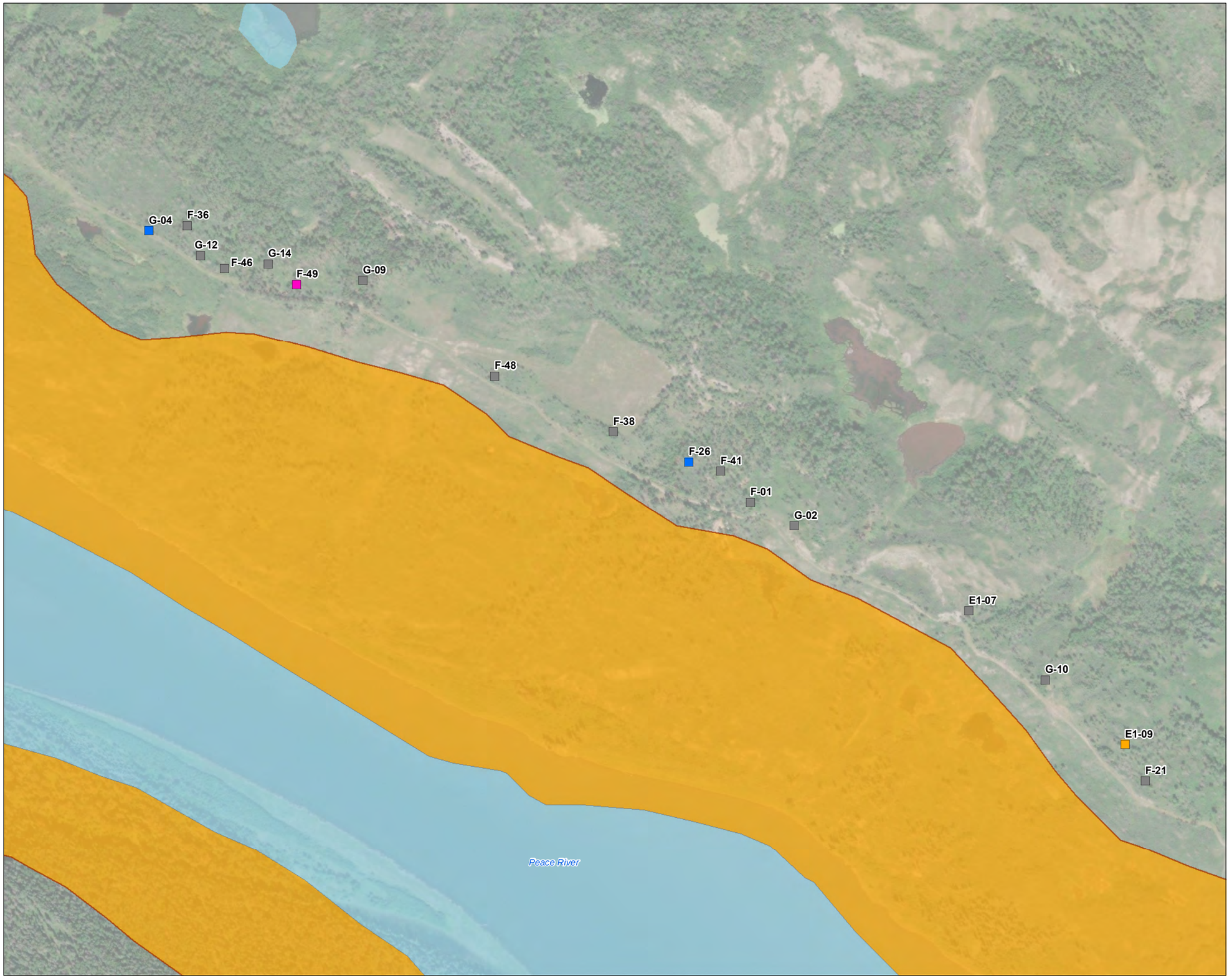
BC hydro

Path: S:\Geomatics\Projects\989619\08_vantly_ea\mxd\2021\Fig4_989619_08_CavityNest_Eggs.cor 1_211217.mxd

Site C Clean Energy Project
Peace River, BC

Locations of Nest Boxes with Eggs #2





Legend

- 5 Year Beach Line
- Eastern Reservoir
- Watercourse
- Waterbody

Nest Boxes with Eggs - Species

- American kestrel (*Falco sparverius*)
- Duck species
- Goldeneye (*Bucephala* sp.)

Other Nest Boxes - Year Installed

- 2020

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

- Aerial Image: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

N

1:5,000

0 50 100 150 200 250
Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-08	Production Date: Dec 17, 2021	Figure 5

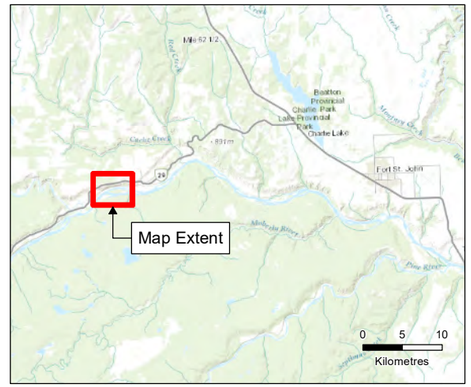
Hemmera An Ausenco Company

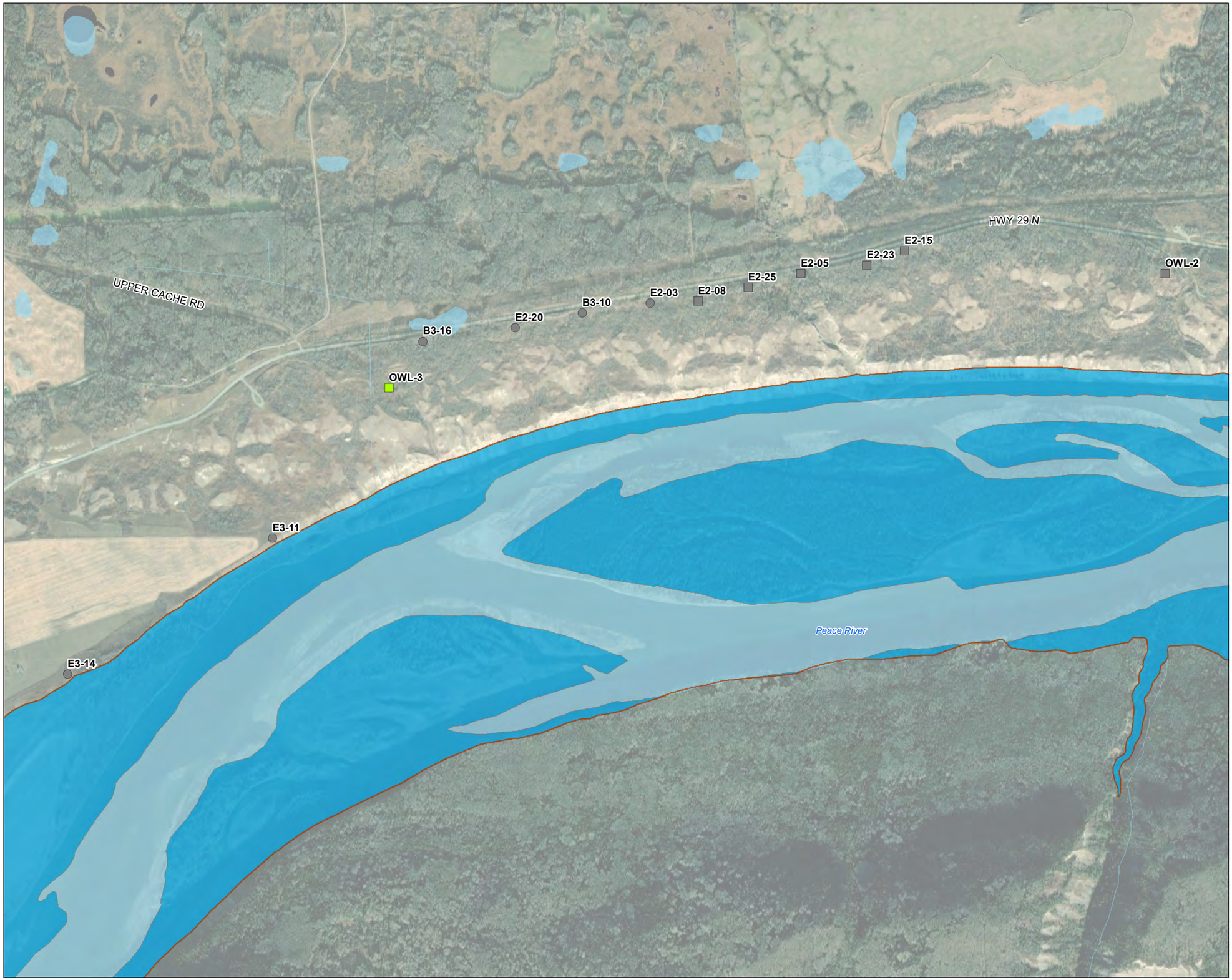
BC hydro

Path: S:\Geomatics\Projects\989619\08_cavity_nestmon\2021\Fig5_989619_08_CavityNest_Eggs2_211217.mxd

Site C Clean Energy Project
Peace River, BC

Locations of Nest Boxes with Eggs #3





Legend

- 5 Year Beach Line
- Middle Reservoir
- Watercourse
- Waterbody

Nest Boxes with Eggs - Species

- Passerine species

Other Nest Boxes - Year Installed

- 2017
- 2020

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

- Aerial Image: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

N

1:15,000

0 100 200 300 400 500
Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-08	Production Date: Dec 17, 2021	Figure 6

Hemmera An Ausenco Company

BC hydro

Path: S:\Geomatics\Projects\989619\08_canty_rev1\mxd\2021\Fig6_989619_08_CantyNest_EggLoc3_211217.mxd

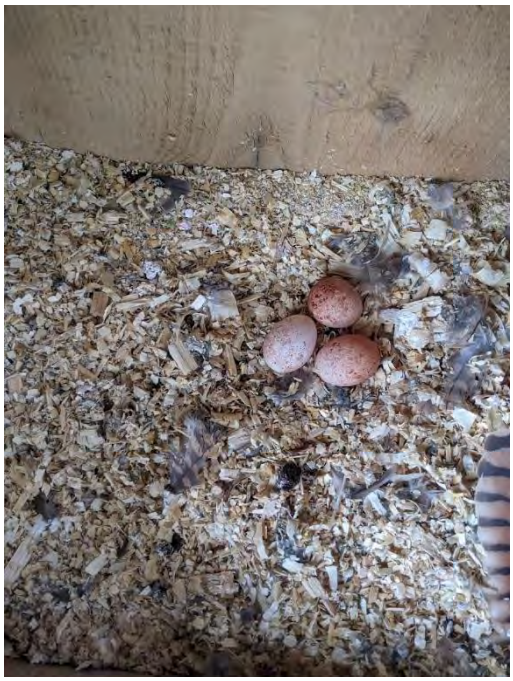


Figure 7 Example of American kestrel eggs documented in nest box E1-09.

Figure 8 Mixed-clutch duck nest found in box G-04.

Maintenance

Box maintenance in 2021 was completed simultaneously with monitoring from May 17 to 22 (**Appendix C**). Most maintenance completed comprised adding new wood shavings and minor repairs such as tightening screws and readjusting loose doors. Latching systems were installed at 122 nest boxes to secure the maintenance door from opening inadvertently or being accessed by predators. Detailed descriptions of maintenance completed can be found in **Appendix C**.

Two boxes sustained minor damage that did not affect their useability; these boxes were repaired. An additional two boxes appeared to have been struck by falling trees but were not damaged and left in place. A total of three boxes were unusable at the onset of monitoring. Of these, two that were impacted by falling trees were repaired and re-mounted, while the third was destroyed and could not be repaired.

Due to the updated linework for the Highway 29 realignment, two nest boxes (E3-08, scheduled for 2021 monitoring, and B3-13, scheduled for 2022 monitoring) were within 50 m of highway activities and were deactivated to prevent potential impact on nesting birds from work in the area. These boxes were assessed for occupancy, and when found to be unused, the entrances were blocked with a piece of wood to prevent birds from accessing the nest box. These boxes will be reactivated once BC Hydro confirms that Highway 29 road work in the area is complete. Another box (F-14) was relocated upslope due to its proximity to a boundary for logging activities.

4.0 DISCUSSION

Of the 171 boxes installed in 2019 and 2020, 144 were available for nesting at the onset of monitoring, 3 were unusable either due to damage from construction or falling trees, and 10 could not be found. The forestry team removed the remaining 14 boxes from areas where the clearing boundary was updated. Of the 144 available boxes, 51 were occupied or had evidence of use for nesting by birds in 2021 (i.e., nesting material, nests, or feathers), for an occupancy rate of 35%. This occupancy percentage is similar to other studies of artificial nests conducted on multiple species (Milligan and Dickinson 2016). When compared with data from 2020, 65 more nest boxes were available for use in 2021 and occupancy increased by 8% from 2020 to 2021. Rodent activity and wasp nests were observed in 10% of the available monitored nest boxes, likely precluding their use by target species. While one nest box installed in 2019 was deactivated during 2021 monitoring, it had been available at the onset of monitoring, thus it was considered available in the occupancy calculation.

Target species were documented with eggs in boxes intended for other species groups, a result commonly observed in studies of nest box use (e.g., Gauthier 1988; Bortolotti 1994). Both of the American kestrel clutches observed were laid in boxes intended for waterfowl (i.e., box types E1 and D in **Table 2**), while passerine eggs were laid in a box intended for owls. These observations indicate that boxes constructed for target species groups also provide opportunities to support species from other groups.

5.0 CLOSURE

This Work was performed in accordance with Contract No. 95055-08 between Hemmera Envirochem Inc. (Hemmera), a wholly owned subsidiary of Ausenco Engineering Canada Inc. (Ausenco), and BC Hydro, dated January 13, 2017 (Contract). This Report has been prepared by Hemmera, based on fieldwork conducted by Hemmera, for sole benefit and use by BC Hydro. In performing this Work, Hemmera 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.

If there are any questions, please do not hesitate to contact the undersigned.

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APPENDIX A
Monitoring and Maintenance Schedule

Table A Monitoring and Maintenance Schedule for Nest Boxes Installed in 2017, 2019, and 2020

Nest Box ID	Nest Box Type	Year Installed	Monitoring and Maintenance Schedule until 2027 (10 years after initial installation)						
			2021	2022	2023	2024	2025	2026	2027
A-002	A	2017		X		X		X	
A-010	A	2017		X		X		X	
A-011	A	2017		X		X		X	
A-014	A	2017		X		X		X	
A-017	A	2017		X		X		X	
A-020	A	2017		X		X		X	
A-021	A	2017		X		X		X	
A-025	A	2017		X		X		X	
A2-35	A2	2017		X		X		X	
A2-36	A2	2017		X		X		X	
A2-37	A2	2017		X		X		X	
A2-44	A2	2017		X		X		X	
A2-45	A2	2017		X		X		X	
A2-51	A2	2017		X		X		X	
A2-55	A2	2017		X		X		X	
A2-58	A2	2017		X		X		X	
A2-59	A2	2017		X		X		X	
A2-62	A2	2017		X		X		X	
A2-66	A2	2017		X		X		X	
A2-72	A2	2017		X		X		X	
A2-74	A2	2017		X		X		X	
A2-75	A2	2017		X		X		X	
A2-76	A2	2017		X		X		X	
A2-79	A2	2017		X		X		X	
B1-01	B1	2017		X		X		X	
B1-02	B1	2017		X		X		X	
B1-03	B1	2017		X		X		X	
B1-06	B1	2017		X		X		X	
B2-03	B2	2017		X		X		X	
B2-06	B2	2017		X		X		X	
B3-02	B3	2017		X		X		X	
B3-03	B3	2017		X		X		X	
B3-05	B3	2017		X		X		X	
B3-06	B3	2017		X		X		X	

Nest Box ID	Nest Box Type	Year Installed	Monitoring and Maintenance Schedule until 2027 (10 years after initial installation)						
			2021	2022	2023	2024	2025	2026	2027
B3-07	B3	2017		X		X		X	
B3-10	B3	2017		X		X		X	
B3-11	B3	2017		X		X		X	
B3-12	B3	2017		X		X		X	
B3-13	B3	2017		X		X		X	
B3-14	B3	2017		X		X		X	
B3-16	B3	2017		X		X		X	
B3-17	B3	2017		X		X		X	
B3-20	B3	2017		X		X		X	
BC-01	BC	2017		X		X		X	
BC-02	BC	2017		X		X		X	
BC-03	BC	2017		X		X		X	
BC-05	BC	2017		X		X		X	
C-01	C	2017		X		X		X	
C-02	C	2017		X		X		X	
C-03	C	2017		X		X		X	
C-08	C	2017		X		X		X	
C-12	C	2017		X		X		X	
C-13	C	2017		X		X		X	
C-15	C	2017		X		X		X	
C-18	C	2017		X		X		X	
C-22	C	2017		X		X		X	
E1-02	E1	2017		X		X		X	
E1-05	E1	2017		X		X		X	
E2-01	E2	2017		X		X		X	
E2-02	E2	2017		X		X		X	
E2-03	E2	2017		X		X		X	
E2-06	E2	2017		X		X		X	
E2-10	E2	2017		X		X		X	
E2-13	E2	2017		X		X		X	
E2-17	E2	2017		X		X		X	
E2-20	E2	2017		X		X		X	
E2-21	E2	2017		X		X		X	
E2-27	E2	2017		X		X		X	
E2-28	E2	2017		X		X		X	

Nest Box ID	Nest Box Type	Year Installed	Monitoring and Maintenance Schedule until 2027 (10 years after initial installation)						
			2021	2022	2023	2024	2025	2026	2027
E3-01	E3	2017		X		X		X	
E3-02	E3	2017		X		X		X	
E3-02	E3	2017		X		X		X	
E3-03	E3	2017		X		X		X	
E3-04	E3	2017		X		X		X	
E3-05	E3	2017		X		X		X	
E3-05	E3	2017		X		X		X	
E3-07	E3	2017		X		X		X	
E3-09	E3	2017		X		X		X	
E3-11	E3	2017		X		X		X	
E3-12	E3	2017		X		X		X	
E3-13	E3	2017		X		X		X	
E3-14	E3	2017		X		X		X	
E3-15	E3	2017		X		X		X	
E3-16	E3	2017		X		X		X	
F-03	F	2017		X		X		X	
F-07	F	2017		X		X		X	
F-08	F	2017		X		X		X	
F-11	F	2017		X		X		X	
F-17	F	2017		X		X		X	
F-18	F	2017		X		X		X	
F-29	F	2017		X		X		X	
F-31	F	2017		X		X		X	
F-32	F	2017		X		X		X	
F-42	F	2017		X		X		X	
G-07	G	2017		X		X		X	
G-08	G	2017		X		X		X	
G-13	G	2017		X		X		X	
G-15	G	2017		X		X		X	
A-004	A	2019	X		X		X		X
A-006	A	2019	X		X		X		X
A-007	A	2019	X		X		X		X
A-013	A	2019	X		X		X		X
A-015	A	2019	X		X		X		X
A-016	A	2019	X		X		X		X

Nest Box ID	Nest Box Type	Year Installed	Monitoring and Maintenance Schedule until 2027 (10 years after initial installation)						
			2021	2022	2023	2024	2025	2026	2027
A-022	A	2019	X		X		X		X
A-024	A	2019	X		X		X		X
A-026	A	2019	X		X		X		X
A2-27	A2	2019	X		X		X		X
A2-28	A2	2019	X		X		X		X
A2-29	A2	2019	X		X		X		X
A2-30	A2	2019	X		X		X		X
A2-32	A2	2019	X		X		X		X
A2-33	A2	2019	X		X		X		X
A2-34	A2	2019	X*		X		X		X
A2-38	A2	2019	X		X		X		X
A2-39	A2	2019	X		X		X		X
A2-42	A2	2019	X		X		X		X
A2-46	A2	2019	X		X		X		X
A2-47	A2	2019	X		X		X		X
A2-53	A2	2019	X*		X		X		X
A2-56	A2	2019	X		X		X		X
A2-57	A2	2019	X*		X		X		X
A2-63	A2	2019	X*		X		X		X
A2-64	A2	2019	X*		X		X		X
A2-67	A2	2019	X		X		X		X
A2-68	A2	2019	X		X		X		X
A2-69	A2	2019	X		X		X		X
A2-80	A2	2019	X		X		X		X
B1-04	B1	2019	X		X		X		X
B1-05	B1	2019	X		X		X		X
B1-06b	B1	2019	X		X		X		X
B2-01	B2	2019	X		X		X		X
B2-02	B2	2019	X		X		X		X
B2-04	B2	2019	X		X		X		X
B2-05	B2	2019	X		X		X		X
B3-01	B3	2019	X		X		X		X
B3-04	B3	2019	X		X		X		X
B3-08	B3	2019	X		X		X		X
B3-15	B3	2019	X		X		X		X

Nest Box ID	Nest Box Type	Year Installed	Monitoring and Maintenance Schedule until 2027 (10 years after initial installation)						
			2021	2022	2023	2024	2025	2026	2027
B3-18	B3	2019	X		X		X		X
BC-04	BC	2019	X		X		X		X
C-21	C	2019	X		X		X		X
E2-11	E2	2019	X		X		X		X
E2-18	E2	2019	X		X		X		X
E2-26	E2	2019	X		X		X		X
F-02	F	2019	X		X		X		X
F-04	F	2019	X		X		X		X
F-05	F	2019	X		X		X		X
F-06	F	2019	X		X		X		X
F-10	F	2019	X		X		X		X
F-14	F	2019	X		X		X		X
F-15	F	2019	X		X		X		X
F-16	F	2019	X		X		X		X
F-19	F	2019	X		X		X		X
F-22	F	2019	X		X		X		X
F-23	F	2019	X		X		X		X
F-24	F	2019	X		X		X		X
F-25	F	2019	X		X		X		X
F-28	F	2019	X		X		X		X
F-30	F	2019	X		X		X		X
F-37	F	2019	X		X		X		X
F-39	F	2019	X		X		X		X
F-40	F	2019	X		X		X		X
F-47	F	2019	X		X		X		X
G-05	G	2019	X		X		X		X
OWL-2	H	2020	X		X		X		X
OWL-3	H	2020	X		X		X		X
A-001	A	2020	X		X		X		X
A-003	A	2020	X		X		X		X
A-005	A	2020	X*		X		X		X
A-009	A	2020	X		X		X		X
A-012	A	2020	X		X		X		X
A-018	A	2020	X		X		X		X
A2-31	A2	2020	X		X		X		X

Nest Box ID	Nest Box Type	Year Installed	Monitoring and Maintenance Schedule until 2027 (10 years after initial installation)						
			2021	2022	2023	2024	2025	2026	2027
A2-41	A2	2020	X		X		X		X
A2-48	A2	2020	X		X		X		X
A2-49	A2	2020	X		X		X		X
A2-50	A2	2020	X		X		X		X
A2-52	A2	2020	X		X		X		X
A2-61	A2	2020	X		X		X		X
A2-70	A2	2020	X		X		X		X
A2-81	A2	2020	X		X		X		X
B1-00	B1	2020	X		X		X		X
B3-09	B3	2020	X		X		X		X
B3-19	B3	2020	X		X		X		X
BC-01S	BC	2020	X		X		X		X
BC-02b	BC	2020	X*		X		X		X
BC-03b	BC	2020	X		X		X		X
BC-04b	BC	2020	X		X		X		X
BC-NN	BC	2020	X		X		X		X
C-04	C	2020	X		X		X		X
C-05	C	2020	X		X		X		X
C-06	C	2020	X		X		X		X
C-09	C	2020	X		X		X		X
C-10	C	2020	X		X		X		X
C-11	C	2020	X		X		X		X
C-14	C	2020	X		X		X		X
C-16	C	2020	X		X		X		X
C-17	C	2020	X		X		X		X
C-19	C	2020	X		X		X		X
C-20	C	2020	X		X		X		X
C-23	C	2020	X		X		X		X
C-X1	C	2020	X		X		X		X
C-X2	C	2020	X		X		X		X
C-X3	C	2020	X		X		X		X
D-01	D	2020	X		X		X		X
D-02	D	2020	X		X		X		X
D-03	D	2020	X		X		X		X
E1-01	E1	2020	X		X		X		X

Nest Box ID	Nest Box Type	Year Installed	Monitoring and Maintenance Schedule until 2027 (10 years after initial installation)						
			2021	2022	2023	2024	2025	2026	2027
E1-03	E1	2020	X		X		X		X
E1-04	E1	2020	X		X		X		X
E1-07	E1	2020	X		X		X		X
E1-09	E1	2020	X		X		X		X
E2-04	E2	2020	X		X		X		X
E2-05	E2	2020	X		X		X		X
E2-07	E2	2020	X		X		X		X
E2-08	E2	2020	X		X		X		X
E2-12	E2	2020	X		X		X		X
E2-14	E2	2020	X		X		X		X
E2-15	E2	2020	X		X		X		X
E2-16	E2	2020	X		X		X		X
E2-19	E2	2020	X		X		X		X
E2-22	E2	2020	X		X		X		X
E2-23	E2	2020	X		X		X		X
E2-25	E2	2020	X		X		X		X
E2-27b	E2	2020	X		X		X		X
E3-01b	E3	2020	X		X		X		X
E3-08	E3	2020	X		X		X		X
F-01	F	2020	X		X		X		X
F-13	F	2020	X		X		X		X
F-21	F	2020	X		X		X		X
F-26	F	2020	X		X		X		X
F-27	F	2020	X		X		X		X
F-33	F	2020	X		X		X		X
F-34	F	2020	X*		X		X		X
F-35	F	2020	X		X		X		X
F-36	F	2020	X		X		X		X
F-38	F	2020	X		X		X		X
F-41	F	2020	X		X		X		X
F-43	F	2020	X		X		X		X
F-45	F	2020	X		X		X		X
F-46	F	2020	X		X		X		X
F-48	F	2020	X		X		X		X
F-49	F	2020	X		X		X		X

Nest Box ID	Nest Box Type	Year Installed	Monitoring and Maintenance Schedule until 2027 (10 years after initial installation)						
			2021	2022	2023	2024	2025	2026	2027
G-01	G	2020	X		X		X		X
G-02	G	2020	X		X		X		X
G-04	G	2020	X		X		X		X
G-06	G	2020	X		X		X		X
G-09	G	2020	X		X		X		X
G-10	G	2020	X		X		X		X
G-12	G	2020	X		X		X		X
G-14	G	2020	X		X		X		X

Notes:

X indicates the scheduled year for monitoring and maintenance; no boxes were installed in 2019.

* indicates boxes which could not be found in 2021, which were either missed during monitoring or destroyed during inclement weather. These boxes will be searched for again in 2023 to confirm their status.

APPENDIX B

Breeding Periods for Survey Timing

Table B Species Specific Breeding Periods

Species Group	Focal Species	Breeding Window Date Range[1, 2]	Late Incubation to Early Nestling Stages Date Range[2, 3]
Passerines	black-capped chickadee	Early March to early August	Mid-March to mid-July
	boreal chickadee	Mid-May to mid-July	Mid-May to mid-July
	brown creeper	Early April to late July	Early May to mid-June
	red-breasted nuthatch	Early April to late July	Mid-May to mid-June
	white-breasted nuthatch	Mid-April to early July	
	tree swallow	Mid-April to mid-September	Mid-May to mid-August
	violet-green swallow	Early April to late August	Early May to mid-July
	house wren	Mid-April to late August	Early May to mid-August
	mountain bluebird	Late March to early August	Mid-May to late July
Waterfowl	Barrow's goldeneye	Mid-March to late August	Early May to mid-July
	bufflehead	Mid-April to late August	Early June to mid-July
	common goldeneye	Early April to late August	Early May to mid-July
	common merganser	Early March to early September	Mid-April to late June
	hooded merganser	Late March to early October	Early May to early July
Raptors and Owls	barred owl	Mid-March to mid-August	Mid-April to late May
	boreal owl	Early April to mid-July	
	northern saw-whet owl	Early March to mid-August	Early April to mid-June
	northern pygmy owl	Mid-April to late August	Mid-May to mid-June
	northern hawk-owl	Mid-April to early August	
	American kestrel	Early April to late August	Early April to mid-July

Notes:

[1] the range of dates from egg-laying to fledging in BC for each focal species.

[2] information is based on Campbell et al. 1990a, 1990b, 1997.

[3] the range of dates when nests in BC are likely to be in the late incubation or early nestling stages.

APPENDIX C

2021 Monitoring and Maintenance Results

Table C-1 2021 Monitoring and Maintenance Results

Year Installed	Monitoring Date	Nest Box ID	Nest Box Type	Survey Method	Box in Use (Y/N)	Box Species	Box Status	Maintenance Completed	Comments
2019	2021-05-17	A-006	A	Pole camera examination	No	-	Operational	Visual examination, latch installed, good nesting material.	
2019	2021-05-17	A-013	A	Visual inspection	No	-	Operational	Nesting material added, latch installed.	
2019	2021-05-17	A-026	A	Visual inspection	No	-	Operational	Visual inspection, latch installed, nesting material added.	
2019	2021-05-17	A2-30	A	Visual inspection	No	-	Operational	Visual inspection, latch installed, nesting material added.	
2019	2021-05-17	A2-38	A	Visual inspection	No	-	Operational	Visual inspection, latch installed, nesting material added.	Rodent droppings.
2019	2021-05-17	A2-39	A	Visual inspection	No	-	Operational	Visual inspection, nesting material added, latch installed.	Signs of predation, rodent activity, potential rodent den.
2019	2021-05-17	A2-42	A	Visual inspection	No	-	Operational	Nesting material added, latch installed.	Old hornet nest in door, rodent droppings inside.
2019	2021-05-17	A2-56	A	Visual inspection	No	-	Operational	Visual inspection, latch installed, nesting material added.	
2019	2021-05-17	A2-67	A	Visual inspection	No	-	Operational	Visual inspection, latch installed, no nesting material needed.	Chewing marks from rodents at the entrance.
2019	2021-05-17	A2-68	A	Visual inspection	No	-	Operational	Visual inspection, nesting material added, latch installed.	Chewing marks at the entrance.
2019	2021-05-17	A2-69	A	Visual inspection	No	-	Operational	Visual inspection, latch installed, nesting material added.	
2020	2021-05-18	A-001	A	Visual inspection	No	-	Operational	Visual inspection, latch installed, nesting material added.	
2020	2021-05-18	A-003	A	Visual inspection	No	-	Operational	Visual inspection, nesting material added, box door is nailed.	
2019	2021-05-18	A-004	A	Visual inspection	No	-	Operational	Visual inspection, latch installed. Nearby tree impacted tree on which box installed but box not damaged.	
2019	2021-05-18	A-007	A	Visual inspection	No	-	Operational	Visual inspection, latch installed, nesting material added.	
2020	2021-05-18	A-009	A	Visual inspection	No	-	Operational	Visual inspection.	
2020	2021-05-18	A-012	A	Visual inspection	No	-	Operational	Visual inspection, latch installed, no nesting material needed.	
2019	2021-05-18	A-015	A	Visual inspection	No	-	Operational	Visual inspection, latch installed.	
2019	2021-05-18	A-016	A	Visual inspection	No	-	Operational	Visually inspected. Latch added.	
2020	2021-05-18	A-018	A	Visual inspection	No	-	Operational	Visual inspection, latch installed, nesting material added.	
2019	2021-05-18	A-022	A	Visual inspection	No	-	Operational	Visual inspection, nesting material added , latch installed.	
2019	2021-05-18	A-024	A	Visual inspection	No	-	Operational	Visual inspection, nesting material added, latch installed.	
2019	2021-05-18	A2-27	A	Visual inspection	Yes	House wren	Operational	Visual inspection, latch installed, no nesting material needed.	Old nest inside box, some chewing marks at the entrance
2019	2021-05-18	A2-28	A	Visual inspection	No	-	Operational	Visual inspection, latch installed, nesting material added.	Chewing marks at the entrance.
2019	2021-05-18	A2-29	A	Visual inspection	No	-	Operational	Visual inspection, nesting material added, no latch installed due to lost bits.	
2020	2021-05-18	A2-31	A	Visual inspection	No	-	Operational	Visual inspection, latch installed, nesting material added.	
2019	2021-05-18	A2-32	A	Visual inspection	Yes	House wren	Operational	Visual inspection, no nesting material needed, latch installed.	Old stick nest inside box with feathers. Probably used last year. A few chewing marks at the entrance.
2019	2021-05-18	A2-33	A	Visual inspection	No	-	Operational	Visual inspection, nesting material added, latch installed.	
2020	2021-05-18	A2-41	A	Visual inspection	Yes	House wren	Operational	Visually inspected, latch installed.	Stick nest.
2019	2021-05-18	A2-46	A	Visual inspection	Yes	House wren	Operational	Visual inspection, latch installed, no nesting material needed.	Chewing marks at the entrance, several birds in the area (robins, kinglets, warblers, sparrows, ...) but no activity around the box

Year Installed	Monitoring Date	Nest Box ID	Nest Box Type	Survey Method	Box in Use (Y/N)	Box Species	Box Status	Maintenance Completed	Comments
2019	2021-05-18	A2-47	A	Visual inspection	N/A	-	Operational	Box mounted, latch installed.	
2020	2021-05-18	A2-48	A	Visual inspection	Yes	House wren	Operational	Visual inspection, nesting material added, latch installed	Nesting material inside
2020	2021-05-18	A2-49	A	Visual inspection	Yes	House wren	Operational	Visually inspected, latch installed.	Feathers and twigs. Chew marks on entrance.
2020	2021-05-18	A2-50	A	Visual inspection	Yes	House wren	Operational	Visually inspected, latch installed.	Twigs
2020	2021-05-18	A2-52	A	Visual inspection	Yes	House wren	Operational	Visual inspection, latch installed.	Stick nest
2020	2021-05-18	A2-61	A	Visual inspection	Yes	House wren	Operational	Visually inspected, latch installed.	Sticknest.
2020	2021-05-18	A2-70	A	Visual inspection	No	-	Operational	Visual inspection,latch installed, nesting material added.	
2020	2021-05-18	A2-71	A	Visual inspection	Yes	-	Operational	Visual inspection,latch installed, nesting material added.	Old stick nest inside box,
2019	2021-05-18	A2-80	A	Visual inspection	N/A	-	Operational	Box found on the ground, probably hit by a tree, visual inspection, nesting material added, latch installed	
2020	2021-05-18	A2-81	A	Visual inspection	Yes	House wren	Operational	Visual inspection, latch installed.	Old nest inside box
2020	2021-05-18	B1-00	B	Visual inspection	No	-	Operational	Visual inspection, no nesting material needed. (creeper box without grooves (?)	
2019	2021-05-17	B1-04	B	Visual inspection	No	-	Operational	Visual inspection, latch installed, nesting material added.	
2019	2021-05-17	B1-05	B	Visual inspection	No	-	Operational	Visual inspection, nesting material added, latch installed.	
2019	2021-05-17	B2-01	B	Visual inspection	No	-	Operational	Nesting material added, latch installed.	
2019	2021-05-17	B2-02	B	Visual inspection	No	-	Operational	Visually inspected.	
2019	2021-05-17	B2-04	B	Visual inspection	No	-	Operational	Visual inspection, latch installed, nesting material added.	
2019	2021-05-17	B2-05	B	Visual inspection	No	-	Operational	Visual inspection, latch installed, nesting material added.	
2019	2021-05-17	B3-01	B	Visual inspection	Yes	-	Operational	Latch installed, visual inspection.	Potential old nesting material
2019	2021-05-18	B3-04	B	Visual inspection	No	-	Operational	Visual inspection, latch installed, nesting material added.	
2019	2021-05-19	B3-07	B	Pole camera examination	No	-	Operational	Visually inspected.	
2019	2021-05-17	B3-08	B	Visual inspection	No	-	Operational	Visual inspection, latch installed, nesting material added.	
2020	2021-05-18	B3-09	B	Visual inspection	Yes	-	Operational	Visual inspection, latch installed, nesting material added.	Sticks inside
2019	2021-05-17	B3-15	B	Visual inspection	No	-	Operational	Nesting material added, latch installed.	Bite marks around the box.
2019	2021-05-17	B3-18	B	Visual inspection	No	-	Operational	Visual inspection, nesting material added, latch installed.	
2020	2021-05-20	B3-19	B	Visual inspection	Yes	-	Operational	Visually inspected. Latch installed.	Grass, dry leaves and moss
2020	2021-05-18	BC-01s	BC	Visual inspection	No	-	Operational	Visual inspection, no nesting material needed.	
2020	2021-05-18	BC-03b	BC	Visual inspection	No	-	Operational	Visual inspection, nesting material added.	
2020	2021-05-18	BC-04b	BC	Visual inspection	No	-	Operational	Visual inspection, nesting material added, no latch needed.	
2020	2021-05-18	C-04	C	Visual inspection	No	-	Operational	Visual inspection, nesting material added, latch installed.	
2020	2021-05-19	C-05	C	Visual inspection	No	-	Operational	Visual inspection, nesting material added, latch installed.	
2020	2021-05-19	C-06	C	Visual inspection	No	-	Operational	Visual inspection, nesting material added, latch installed.	
2020	2021-05-19	C-09	C	Visual inspection	No	-	Operational	Visual inspection, nesting material added, latch installed.	
2020	2021-05-18	C-10	C	Visual inspection	Yes	House wren	Operational	Visually inspected, latch installed.	Sticknest.
2020	2021-05-19	C-11	C	Visual inspection	No	-	Operational	Visual inspection, nesting material added, latch installed.	
2020	2021-05-18	C-14	C	Visual inspection	Yes	-	Operational	Visually inspected, latch installed, nesting material added.	Twigs present.

Year Installed	Monitoring Date	Nest Box ID	Nest Box Type	Survey Method	Box in Use (Y/N)	Box Species	Box Status	Maintenance Completed	Comments
2020	2021-05-19	C-16	C	Visual inspection	No	-	Operational	Visually inspected, latch installed, nesting material added.	
2020	2021-05-18	C-19	C	Visual inspection	No	-	Operational	Visually inspected, latch installed.	
2020	2021-05-19	C-20	C	Visual inspection	No	-	Operational	Visually inspected, latch installed, nesting material added.	
2019	2021-05-18	C-21	C	Visual inspection	No	-	Operational	Visually inspected, latch installed, nesting material added.	
2020	2021-05-19	C-23	C	Visual inspection	No	-	Operational	Visually inspected, latch installed, nesting material added.	
2020	2021-05-19	C-X1	C	Visual inspection	No	-	Operational	Visually inspected, latch installed, nesting material added.	Box was painted black.
2020	2021-05-19	C-X2	C	Visual inspection	No	-	Operational	Visually inspected, latch installed, nesting material added.	Birds in the area: GCKI, BCCH, woodpeckers
2020	2021-05-19	C-X3	C	Visual inspection	N/A	-	Operational	Visually inspected, latch installed, nesting material added. Face panel reattached	
2020	2021-05-21	D-01	D	Visual inspection	Yes	-	Operational	Visually inspected, latch installed, nesting material added.	Twigs, rudimentary nest.
2020	2021-05-21	D-02	D	Visual inspection	Yes	-	Operational	Visually inspected, latch installed	Moss, grass.
2020	2021-05-21	D-03	D	Visual inspection	Yes	American kestrel	Operational	Visually inspected, latch installed.	2 eggs approx 4cm long
2020	2021-05-20	E1-01	E	Visual inspection	No	-	Operational	Visually inspected, latch installed, nesting material added.	
2020	2021-05-20	E1-03	E	Visual inspection	No	-	Operational	Visually inspected, latch installed.	
2020	2021-05-20	E1-04	E	Visual inspection	No	-	Operational	Visually inspected, latch installed, nesting material added.	
2020	2021-05-22	E1-07	E	Visual inspection	Yes	-	Operational	Visually inspected, latch installed, nesting material added.	Dried grass, rudimentary nest.
2020	2021-05-22	E1-09	E	Visual inspection	Yes	American kestrel	Operational	Visually inspected, latch installed.	3 speckled yellow eggs approx 4cm long
2020	2021-05-20	E2-04	E	Visual inspection	No	-	Operational	Visually inspected, latch installed, nesting material added.	
2020	2021-05-21	E2-05	E	Visual inspection	Yes	-	Operational	Visually inspected, latch installed, nesting material added.	Dried leaves
2020	2021-05-21	E2-07	E	Visual inspection	No	-	Operational	Visually inspected, latch installed, nesting material added. Fungus cached by squirrels was removed.	
2020	2021-05-21	E2-08	E	Visual inspection	Yes	-	Operational	Visually inspected, latch installed.	Dry grass and leaves.
2019	2021-05-18	E2-11	E	Visual inspection	No	-	Operational	Visual inspection, nesting material added, no latch installed.	
2020	2021-05-20	E2-12	E	Visual inspection	No	-	Operational	Visually inspected, latch installed.	Shows evidence of use by rodents.
2020	2021-05-21	E2-14	E	Visual inspection	No	-	Operational	Visually inspected, latch installed, nesting material added.	Remains of mouse found inside.
2020	2021-05-21	E2-15	E	Visual inspection	No	-	Operational	Visually inspected, latch installed, nesting material added.	
2020	2021-05-21	E2-16	E	Visual inspection	Yes	-	Operational	Visually inspected, latch installed.	Old nest, not actively being used.
2019	2021-05-17	E2-18	E	Visual inspection	No	-	Operational	Visually inspected, latch installed, nesting material added.	
2020	2021-05-20	E2-19	E	Visual inspection	No	-	Operational	Visually inspected, latch installed.	
2020	2021-05-20	E2-22	E	Visual inspection	Yes	-	Operational	Visually inspected, latch installed, nesting material added.	Center cleared of chips, evidence bird attempted to nest.
2020	2021-05-21	E2-23	E	Visual inspection	Yes	-	Operational	Visually inspected, latch installed.	Dried grass, leaves and twigs.
2020	2021-05-21	E2-25	E	Visual inspection	Yes	-	Operational	Visually inspected, latch installed.	Dry leaves, moss, owl feathers.
2019	2021-05-18	E2-26	E	Visual inspection	No	-	Operational	Visual inspection, no latch installed, nesting material added.	
2020	2021-05-21	E2-27b	E	Visual inspection	Yes	-	Operational	Visually inspected, latch installed.	Grass, dry leaves. Several cracked panels, may need replacement.
2020	2021-05-21	E3-01b	E	Visual inspection	No	-	Operational	Visually inspected, latch installed, nesting material added.	
2020	2021-05-22	E3-08	E	Visual inspection	No	-	Deactivated	Deactivated box, visual inspection, latch installed.	

Year Installed	Monitoring Date	Nest Box ID	Nest Box Type	Survey Method	Box in Use (Y/N)	Box Species	Box Status	Maintenance Completed	Comments
2020	2021-05-22	F-01	F	Visual inspection	Yes	-	Operational	Visually inspected, latch installed.	Feathers and bird scat
2019	2021-05-18	F-02	F	Visual inspection	Yes	-	Operational	Visual inspection, latch installed, no nesting material needed.	Moss sticks and branches inside (nesting signs)
2019	2021-05-17	F-04	F	Visual inspection	No	-	Operational	Visual inspection, latch installed, nesting material added.	One wasp, rodent droppings.
2019	2021-05-20	F-05	F	N/A	N/A	-	Not found	Destroyed by construction.	
2019	2021-05-18	F-06	F	Visual inspection	No	-	Operational	Visually inspected, latch installed, nesting material added.	
2019	2021-05-18	F-10	F	Visual inspection	Yes	-	Operational	Visual inspection, nesting material added, no latch installed.	Stick nest inside
2020	2021-05-20	F-13	E	Visual inspection	Yes	-	Operational	Visually inspected, latch installed.	Grass and feathers.
2019	2021-05-20	F-13	F	Visual inspection	Yes	-	Operational	Visually inspected, latch installed.	Feathers, grass, textiles.
2020	2021-05-17	F-14	F	Visual inspection	No	-	Operational	Visual inspection, latch installed, nesting material added, relocated upslope.	
2019	2021-05-18	F-15	F	Visual inspection	No	-	Operational	Visual inspection, latch installed, nesting material added.	
2019	2021-05-18	F-16	F	Visual inspection	No	-	Operational	Visual inspection, nesting material added, latch installed.	
2019	2021-05-18	F-19	F	Visual inspection	No	-	Operational	Visual inspection, latch installed, nesting material added.	
2020	2021-05-22	F-21	F	Visual inspection	Yes	-	Operational	Visual inspection, latch installed, nesting material added.	Feathers, cracked egg shell.
2019	2021-05-17	F-22	F	Visual inspection	No	-	Operational	Visual inspection, latch installed, no nesting material needed.	
2019	2021-05-18	F-23	F	Visual inspection	No	-	Operational	Visual inspection, latch installed, nesting material added. Box not recorded on original file.	
2019	2021-05-18	F-24	F	Visual inspection	Yes	-	Operational	Visually inspected. Latch installed.	Dry leaves and twigs.
2019	2021-05-18	F-25	F	Visual inspection	No	-	Operational	Visual inspection, nesting material added, no latch installed.	
2020	2021-05-22	F-26	F	Visual inspection	Yes	Duck species	Operational	Visually inspected, latch installed.	4 white eggs, approximately 5 cm in length
2020	2021-05-21	F-27	F	Visual inspection	No	-	Operational	Visually inspected, latch installed.	
2019	2021-05-17	F-28	F	Pole camera examination	No	-	Operational	Nesting material added, latch installed.	
2019	2021-05-17	F-30	F	Visual inspection	No	-	Operational	Nesting material replaced, latch installed, door was cracked and fixed with wire.	
2020	2021-05-20	F-33	F	Visual inspection	No	-	Operational	Visually inspected, latch installed, nesting material added.	
2020	2021-05-21	F-35	F	Visual inspection	No	-	Operational	Visually inspected, latch installed, nesting material added.	
2020	2021-05-22	F-36	F	Visual inspection	No	-	Operational	Visually inspected, latch installed, nesting material added.	
2019	2021-05-18	F-37	F	Visual inspection	No	-	Operational	Visually inspected, latch installed, nesting material added.	
2020	2021-05-22	F-38	F	Visual inspection	No	-	Operational	Visually inspected, latch installed.	
2019	2021-05-18	F-39	F	Visual inspection	Yes	-	Operational	Visual inspection, nesting material added, no latch.	Feathers and sticks inside. Dead rodent inside.
2019	2021-05-18	F-40	F	Visual inspection	Yes	-	Operational	Visual inspection, got hit by a tree but the box is still functional and attached to the tree. Latch installed. Nesting material added.	Old nesting material inside box
2020	2021-05-22	F-41	F	Visual inspection	Yes	-	Operational	Visually inspected, latch installed.	Old nest, evidence of successful hatch. Two different types of feathers present, yellow and black/brown. Five white eggs, approximately 5 cm long.
2020	2021-05-20	F-43	F	Visual inspection	Yes	-	Operational	Visually inspected, latch installed.	Moss, grass, leaves.
2020	2021-05-20	F-45	F	Visual inspection	No	-	Operational	Visually inspected, latch installed, nesting material added.	

Year Installed	Monitoring Date	Nest Box ID	Nest Box Type	Survey Method	Box in Use (Y/N)	Box Species	Box Status	Maintenance Completed	Comments
2020	2021-05-22	F-46	F	Visual inspection	Yes	-	Operational	Visually inspected, latch installed	Twigs, grass. Rudimentary nest.
2019	2021-05-18	F-47	F	Visual inspection	No	-	Operational	Visually inspected, latch installed, nesting material added.	No signs of use, chewing marks at the entrance and bottom.
2020	2021-05-22	F-48	F	Visual inspection	Yes	House wren	Operational	Visually inspected, latch installed.	Nesting material inside
2020	2021-05-22	F-49	F	Visual inspection	Yes	Goldeneye species	Operational	Visually inspected, latch installed.	3 eggs, greenish white 4-5 cm long.
2020	2021-05-20	G-01	G	Visual inspection	No	-	Operational	Visually inspected, latch installed, nesting material added.	
2020	2021-05-22	G-02	G	Visual inspection	No	-	Operational	Visually inspected, latch installed, nesting material added.	
2020	2021-05-22	G-04	G	Visual inspection	Yes	Duck species	Operational	Visually inspected, latch installed.	4 whitish eggs, approximately 4cm long.
2019	2021-05-18	G-05	G	Visual inspection	Yes	-	Operational	Visually inspected.	Dry leaves and twigs. Old nesting material inside.
2020	2021-05-21	G-06	G	Visual inspection	Yes	-	Operational	Visually inspected, latch installed.	Dry grass.
2020	2021-05-22	G-09	G	Visual inspection	Yes	-	Operational	Visually inspected, latch installed.	Dry grass, bark, moss. Old nest.
2020	2021-05-22	G-10	G	Visual inspection	Yes	-	Operational	Visually inspected, latch installed.	Feathers.
2020	2021-05-22	G-12	G	Visual inspection	Yes	-	Operational	Visually inspected, latch installed.	Old nest, moss, feathers and grass.
2020	2021-05-22	G-14	G	Visual inspection	Yes	-	Operational	Visually inspected, latch installed.	Feathers present
2020	2021-05-18	BC-NN	BC	Visual inspection	No	-	Operational	Visual inspection, no nesting material needed, no latch needed.	
2020	2021-05-21	OWL-2	H	Visual inspection	No	-	Operational	Visually inspected, nesting material added.	
2020	2021-05-21	OWL-3	H	Visual inspection	Yes	Passerine species	Operational	Visually inspected.	2 white eggs with brown speckles approx 3cm long
2020	2021-05-18	C-17	C	Visual inspection	No	-	Operational	Visually inspected, latch installed, nesting material added.	

Note: N/A - box was not available for monitoring because it was damaged by clearing, livestock, winds, and probably vandalism, or deactivated to prevent their use during construction activities; '-' – species was not present and could not be identified.

Table C-2 Nest Boxes Identified as Missing during 2021 Monitoring

Nest Box ID	Nest Box Type	Year Installed	Monitored in 2021	Comments
A-005	A	2020	N	Not found, potentially missed during site visit or destroyed during inclement weather
A2-34	A2	2019	N	Not found, potentially missed during site visit or destroyed during inclement weather
A2-57	A2	2019	N	Not found, potentially missed during site visit or destroyed during inclement weather
A2-63	A2	2019	N	Not found, potentially missed during site visit or destroyed during inclement weather
A2-71	A2	2019	N	Not found, potentially lost during vegetation clearing
BC-02b	BC	2020	N	Not found, potentially missed during site visit or destroyed during inclement weather
E1-06	E1	2020	N	Not found, potentially lost during vegetation clearing
F-09	F	2019	N	Not found, potentially lost during vegetation clearing
F-12	F	2019	N	Not found, potentially lost during vegetation clearing
G-03	G	2019	N	Not found, potentially lost during vegetation clearing

Appendix 11. Bald Eagle Nest Surveys – Summary for 2021

MEMORANDUM

Date:	December 21, 2021
To:	Brock Simons, Terrestrial Biodiversity Specialist, Site C Clean Energy Project
From:	Jason Brogan, M.Sc., R.P.Bio. Hemmera
File:	989619-05
Re:	Bald Eagle Nest Surveys – Summary 2021

1.0 INTRODUCTION

This memo summarizes the findings of the bald eagle (*Haliaeetus leucocephalus*) nest surveys on the Peace River conducted in May and June 2021. The purpose of the surveys was to document the status of known and newly constructed bald eagle nests along the Peace River, at wetlands near the Site C transmission line, and at artificial (mitigation) nesting structures. This is a continuation from the surveys that were completed in 2016 through 2020 (Hemmera 2016, 2018a, 2018b, 2019, 2021) and during baseline studies for the Site C Clean Energy Project (Keystone 2009).

Bald eagle nest surveys were conducted with two objectives:

1. Determine the status (active/not active) and productivity of known and newly constructed bald eagle nests in the study area (the Peace River between Hudson's Hope and the Alberta border, including areas encompassed by the Site C reservoir footprint); and
2. Provide the data to BC Hydro to inform Site C construction mitigation.

Data collected during this survey provide information on the spatial distribution, timing, and productivity of bald eagle nests in the study area.

2.0 METHODS

Surveys of bald eagle nests were conducted by helicopter on 12 and 28 May and 11 June 2021, with a two-person crew consisting of a crew lead and a technician, following methods outlined by the Resources Inventory Committee (RIC 2001). The study area is composed of the Peace River Valley from Hudson's Hope to the Alberta Border, as well as at natural wetlands adjacent to the Site C transmission line right-of-way.

Previously identified nest locations from past aerial surveys (Hemmera 2021) were visited. In addition to known nests, a search was conducted simultaneously for new nests, which were then added to the database with unique identification designations starting with both 10- and 11- for the 2021 surveys. Bald eagle nests reported by other crews working for BC Hydro were also visited. Nests that were known to be destroyed in 2019 (e.g., nest disintegrated, host tree failed naturally, or host tree was felled) were not visited in 2021, but searches were conducted in those areas for newly constructed nests.

The observations recorded at each known or new bald eagle nest (or stick nests constructed by other species) were the status of “active”, “inactive”, “not detected” or “tree gone”, or “unknown”, the associated species assigned to each nest, and the number of nestlings.

Status was determined by the presence of attending adults or evidence of nestlings. Productivity was estimated by counting the number of nestlings in each nest with the assumption that most nestlings reach fledging (Buehler 2021). Annual productivity was calculated as the sum of estimated productivity from active nests divided by the number of active nests. The following assumptions were used to determine nest status and productivity:

- Active nests included those with evidence of adults attending the nest during any one of the field surveys;
- The number of chicks in a nest at the last observation reflects the number fledged, except nests with three chicks which were only assumed to fledge two chicks; and
- No second clutches.

Nestlings grow quickly in the first days and weeks after hatching, resulting in large size differences between each sibling (Bortolotti 1986a). A third hatched chick is at a great disadvantage and will likely starve due to being out-competed by its larger siblings (Gerrard and Bortolotti 1988, as cited in Buehler 2021). In two-chick broods, both chicks generally survive (e.g., only two chicks from 37 two-chick broods in Saskatchewan died [(Bortolotti 1986b)]). Therefore, when calculating nest productivity, if two or three chicks were observed in a nest during the final survey round, it was assumed that two chicks survived and fledged.

Second clutches are not observed in natural bald eagle population of (Buehler 2021), likely due to the long duration of breeding, as speculated by Newton (2010). Exceptions are known when eggs or nestlings are artificially removed as part of captive breeding programs (Morrison and Walton 1980; Wood and Collopy 1993), or eggs are lost early in the season (Steenhof and Newton 2007). No second clutches have been observed in the study area to date.

Survey results were provided to BC Hydro in Excel (.csv) format, including applicable comments and coordinates for each nest.

Summary statistics were performed on the data. A Poisson regression was conducted on both total chicks, and active nests as a function of survey year to determine trends.

3.0 SURVEY RESULTS

A total of 55 potential bald eagle nests and 29 artificial nesting platforms were monitored in 2021 (**Appendix A**). None of the artificial nesting platforms were active. Of the 55 potential tree nests, 24 were active, 16 were inactive, one nest was not detected, and 14 of the host trees were gone (**Table 1**). The number of chicks observed at active nests ranged from one to three at the time of fledging, for a total of 37 assumed fledged chicks. The estimated bald eagle productivity for 2021 was 1.54 fledged chicks per active nest. One red tailed hawk (*Buteo jamaicensis*) was nesting in a previous bald eagle nest, Nest 608.

BC Hydro erected three artificial nesting structures in 2015 and an additional 26 structures in 2020. Of the 26 nesting structures erected in 2020, nest material was added by BC Hydro to seven and whole salvaged nests from nearby removed nest trees were placed in two of the nest structures. No evidence of bald eagle use of the artificial nesting structures was observed during the 2021 surveys. The artificial nesting structures are placed near the periphery of the future reservoir.

Bald eagle nesting activity data have been collected since 2016, with data sufficient for estimating nest productivity from 2017 onward. The average number of active nests was 28.2 ± 3.3 SD. The average percent occupied nests was 66.4 ± 8.4 standard deviation (SD) occupied nests. The average annual total chicks from 2017 to 2021 was 38.6 ± 5.1 SD. The average number of young fledged per active nest was 1.27 ± 0.11 SD.

Although the number of active nests appear to have declined over time, a Poisson regression demonstrated that the slope of that trend line is not statistically significant, with a coefficient of -0.075 ± 0.06 standard error (SE; p-value = 0.2). Poisson regression also did not show a statistically significant trend in the change in total chicks over time, with a coefficient of -0.005 ± 0.05 SE (p-value = 0.9) (**Figure 1**). A linear regression did not show a statistically significant change in the fledging success rate over time (i.e., young fledged per active nest; slope = 0.08 ± 0.08 SE, R^2 = 0.26, p-value = 0.38).

Table 1 Bald Eagle Nest Activity and Productivity on the Peace River (2016-2021)

Nest Status	2016	2017	2018	2019	2020*	2021
Tree Nests						
Active	NEI	34	28	29	25	25
Inactive	8	7	15	19	16	17
Percent Active	-	**83**	**65**	**60**	**61**	**60**
Not Detected/Tree Gone	-	18	4	6	11	15
Unknown	52	-	1	0	0	0
Total Nests Surveyed	**60**	**59**	**48**	**54**	**52**	**55**
Estimated productivity (total chicks)	**NEI**	**39**	**34**	**42**	**46**	**32**
Estimated young fledged per active nest (fledging success rate)	**NEI**	**1.15**	**1.21**	**1.45**	**1.84**	**1.28**
Artificial Nesting Structures						
Active	-	-	-	0	0	0
Inactive	-	-	-	3	3	29
Total Structures Surveyed	-	-	-	**3**	**3**	**29**
Estimated productivity (total chicks)	-	-	-	**0**	**0**	**0**
Estimated young fledged per active nest (fledging success rate)	-	-	-	**0**	**0**	**0**

Note: NEI = not enough information

"-" indicates no data

* Estimates of productivity (fledged per active nest) in 2020 were based on only two surveys rather than three and active nests may be an overestimate

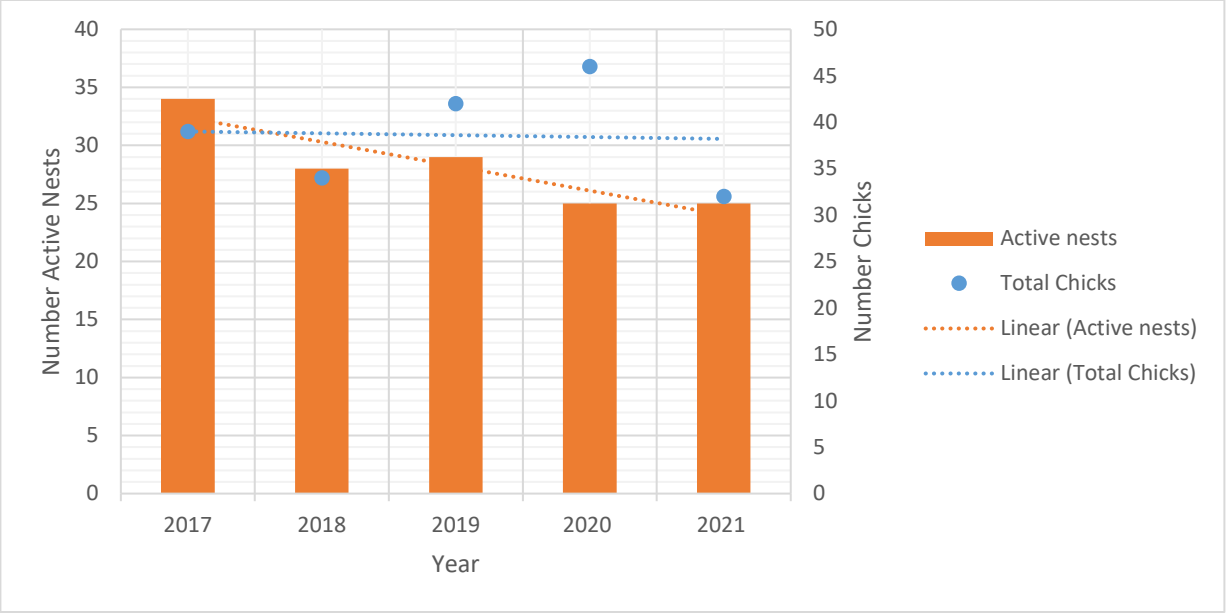

Figure 1 **Active nests (red bars) and total fledged chicks (blue dots) from 2017 to 2021, Peace River, BC. A linear trend line is displayed for active nests (red dashed line) and total fledged chicks (blue dash line).**

Figure 2 **Artificial nesting structure (Nest ID P32) for bald eagles and osprey, installed in 2015, as seen in 2021**

Figure 3 Artificial bald eagle nesting structure (Nest ID Eagle_326), installed in 2020, as seen in 2021

4.0 DISCUSSION

The 2021 surveys represent the fifth year of estimating the annual productivity of bald eagles in the study area (2017 through 2021). The total number of fledged chicks in 2020 (46 chicks) was the greatest number observed since the beginning of the monitoring program, while the number of fledged chicks observed in 2021 was 32, below the average estimated number of chicks produced per year across survey years (38.6 ± 5.1 SD chicks per year). The cause of the increased chick production in 2020 is unknown and may have resulted from good weather during the breeding period, and/or reduced competition from other nesting pairs from the reduced number of active nests.

Bald eagle reproduction and productivity rates are generally regulated by nest availability and prey quality and abundance (Newton 1998; Elliott and Norstrom 1998). Although the change in the number of active nests over time has not been statistically significant (coefficient = -0.075, p-value = 0.2) as nesting trees have been lost or been removed, the number has decreased from 34 active nest trees in 2017 to 25 active nest trees in 2021 as forested habitat is cleared. From 2017 through 2021, on average, 66% ± 8.4 SD of nests have been active in a given year. Thirty-four active bald eagle nests were reported along the Peace River between Hudson's Hope and the Alberta border in 2011, although productivity was not reported (Hilton et al. 2013). Occupancy was similar at Williston Reservoir, with 60% of eagles nests occupied in 1995 (Booth B., Merkens M. Wood M. D. 1999). Despite the apparent (albeit not statistically significant) decline in the number of active nests, the total number of chicks fledged has stayed relatively unchanged over time (coefficient = -0.005, p-value = 0.9) (**Figure 1**), such that the number of fledged young per active nest (i.e., nest productivity) has shown an apparent increase that was not statistically significant (slope = 0.08, R^2 = 0.26) from 1.15 chicks per active nest in 2017 to 1.24 in 2021.

The 29 artificial nesting structures erected in 2015 and 2020 have not been used by eagles to date. Three artificial nesting structures were placed around the planned reservoir footprint in 2015, which were designed to provide nesting substrates for both osprey (*Pandion haliaetus*) and bald eagle with an elevated platform (**Figure 2**). In late 2020, 26 additional nesting structures were erected, designed specifically for bald eagles with supports to hold a large cup nest (**Figure 3**). There has been no nesting activity observed at any of these structures yet. It's speculated that the structures are too far away from the current Peace River edge to be used by eagles while potential nest trees are still available closer to their foraging area. Both bald eagles and ospreys are known to use artificial nesting structures when natural nesting structures are limited (Bird et al. 1996; Hunter et al. 1997). It is anticipated that with the continued clearing of trees in the reservoir area, reducing the availability of natural nesting structures, intra-specific territoriality will increase, and the likelihood of artificial nesting structures being used will increase.

Surveys using the methods described here will continue in 2022 as per the commitments in the Site C Bald Eagle Mitigation and Monitoring Program (BC Hydro 2021).

5.0 CLOSURE

This Work was performed in accordance with BCO95055 between Hemmera Envirochem Inc. (Hemmera), a wholly owned subsidiary of Ausenco Engineering Canada Inc. (Ausenco), and BC Hydro (Client), dated 21 June 2016 (Contract). This Report has been prepared by Hemmera, based on fieldwork conducted by Hemmera, for sole benefit and use by BC Hydro. In performing this Work, Hemmera 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.

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APPENDIX A

Nest Survey Results for 2021

Nest Survey Results for 2021

Nest ID	Latitude	Longitude	Year First Detected*	Activity 2021	Nest Substrate
6	56.1378	-121.628	pre-2014	Active	Tree
8	56.18006	-121.526	pre-2014	tree gone	Tree
13	56.23497	-121.305	pre-2014	tree gone	Tree
22	56.13563	-120.641	pre-2014	Inactive	Tree
29	56.10791	-120.099	pre-2014	Active	Tree
38	56.10516	-120.442	pre-2014	Inactive	Tree
100	56.15796	-120.752	pre-2014	Active	Tree
101	56.15268	-120.742	pre-2014	tree gone	Tree
104	56.19497	-120.801	pre-2014	Inactive	Tree
127	56.23156	-121.337	pre-2014	Inactive	Tree
128	56.23103	-121.334	pre-2014	Active	Tree
132	56.16722	-121.572	pre-2014	tree gone	Tree
133	56.15651	-121.587	pre-2014	tree gone	Tree
138	56.09354	-121.812	pre-2014	Active	Tree
144	56.01341	-121.926	pre-2014	Inactive	Tree
146	56.0052	-121.96	pre-2014	Active	Tree
155	56.12454	-121.667	pre-2014	tree gone	Tree
203	55.99701	-121.721	pre-2014	Active	Tree
219	56.09443	-120.183	pre-2014	Active	Tree
222	56.0935	-120.35	pre-2014	Active	Tree
223	56.11221	-120.48	pre-2014	tree gone	Tree
224	56.11247	-120.482	pre-2014	Active	Tree
225	56.00347	-121.677	pre-2014	Inactive	Tree
600	56.03176	-121.893	2017	Inactive	Tree
601	56.09345	-121.812	2017	Inactive	Tree
602	56.11356	-121.77	2017	tree gone	Tree
607	56.1183	-120.545	2017	Active	Tree
608	56.14785	-120.709	2017	Inactive	Tree
610	56.05733	-121.116	2017	Active	Tree
611	56.00278	-121.68	2017	Inactive	Tree
701	56.05779	-121.112	2018	not detected	Tree
702	56.11453	-121.732	2018	Active	Tree
705	56.11264	-120.53	2018	tree gone	Tree
707	56.19025	-120.894	2018	tree gone	Tree
802	56.19521	-120.847	2019	Active	Tree
803	56.11214	-120.529	2019	Active	Tree

Nest ID	Latitude	Longitude	Year First Detected*	Activity 2021	Nest Substrate
804	56.13809	-120.02	2019	Active	Tree
805	56.06438	-121.095	2019	Inactive	Tree
806	56.13613	-120.643	2019	Active	Tree
901	56.22146	-121.07	2020	tree gone	Tree
902	56.22066	-121.06	2020	tree gone	Tree
903	56.04718	-121.863	2020	Inactive	Tree
904	56.20372	-121.472	2020	tree gone	Tree
1001	56.19021	-120.89	2021	Active	Tree
1100	55.99477	-121.657	2021	Inactive	Tree
1101	56.16626	-121.573	2021	Inactive	Tree
1102	56.10305	-120.255	2021	Active	Tree
1103	56.19153	-121.511	2021	Active	Tree
1105	56.24904	-121.146	2021	Active	Tree
1106	56.00555	-121.674	2021	Inactive	Tree
1107	56.155981	-121.589	2021	Active	Tree
1110	56.22109	-121.06	2021	Active	Tree
1108	56.20247	-121.473	2021	Active	Tree
1109	56.12386	-121.666	2021	Active	Tree
62c	56.19493	-120.849	pre-2014	tree gone	Tree
Eagle_134_West	56.24284	-121.326	2021	Inactive	Platform
Eagle_14.1	56.22483	-120.938	2021	Inactive	Platform
Eagle_142	56.24337	-121.394	2021	Inactive	Platform
Eagle_144	56.23522	-121.404	2021	Inactive	Platform
Eagle_147	56.23081	-121.414	2021	Inactive	Platform
Eagle_151	56.23171	-121.435	2021	Inactive	Platform
Eagle_153	56.22785	-121.451	2021	Inactive	Platform
Eagle_153_East	56.22949	-121.442	2021	Inactive	Platform
Eagle_167	56.25048	-121.506	2021	Inactive	Platform
Eagle_182C	56.18959	-121.516	2021	Inactive	Platform
Eagle_216B	56.1872	-121.525	2021	Inactive	Platform
Eagle_217	56.18436	-121.534	2021	Inactive	Platform
Eagle_246	56.1196	-121.701	2021	Inactive	Platform
Eagle_247 east	56.11782	-121.71	2021	Inactive	Platform
Eagle_249_East	56.11805	-121.721	2021	Inactive	Platform
Eagle_254_West	56.12484	-121.755	2021	Inactive	Platform
Eagle_257N	56.12191	-121.769	2021	Inactive	Platform
Eagle_258_East	56.12063	-121.777	2021	Inactive	Platform

Nest ID	Latitude	Longitude	Year First Detected*	Activity 2021	Nest Substrate
Eagle_326	56.07072	-121.854	2021	Inactive	Platform
Eagle_41.1A	56.21323	-121.064	2021	Inactive	Platform
Eagle_41.1B	56.21411	-121.076	2021	Inactive	Platform
Eagle_48	56.23015	-121.093	2021	Inactive	Platform
Eagle_49.1B	56.21772	-121.105	2021	Inactive	Platform
Eagle_49.2B	56.2156	-121.094	2021	Inactive	Platform
Eagle_75	56.25454	-121.185	2021	Inactive	Platform
Eagle_75.1	56.25009	-121.177	2021	Inactive	Platform
P32	56.24048	-121.13	2018	Inactive	Platform
P39	56.23498	-120.955	2018	Inactive	Platform
P47	56.23297	-121.1	2018	Inactive	Platform

Notes:

'*' - Year first observed for nests recorded before 2014 is not known as the Site C EIS does not provide this detail, but rather only that that BAEA nest surveys were conducted and the nests found in 2006, 2008, and 2011. Surveys were conducted in 2012, but no nests were detected.

Active – nest present and BAEA in area or using nest; Inactive – nest present but unused; Not Detected - nest not detected; Tree Gone - the nest tree is no longer standing

APPENDIX B

Active Bald Eagle Nests and Assumed Productivity 2021

Nest ID	Comments May 12	Comments May 28	Comments June 11	Estimated Productivity (if fledged)
6	Adult + 1 chick	Adult + 1 chick	Adult + 1 chick	1
29	Adult on nest	Adult + 1 chick	Adult + 1 chick	1
100	Adult + 2 chicks	1 chick	Adult + 1 chick	1
128	Adult + 2 chicks	Adult + 2 chicks	Adult + 2 chicks	2
138	Adult + 2 chicks	Adult + 2 chicks	2 chicks	2
146	Adult on nest	2 chicks	1 chick	1
203	Adult incubating	Adult + 2 chicks	Adult + 2 chicks	2
219	Adult on nest	Adult + 1 chick	Adult + 2 chicks	2
222	Adult + 2 chicks	Adult + 2 chicks	2 chicks	2
224	Adult + 1 chick	Adult + 1 chick	1 chick	1
607	Adult + 2 chicks	Adult + 1 chick	Adult + 1 chick	1
610	Adult incubating	Inactive	Inactive	0
702	2 chicks	Adult + 1 chick	2 chicks	2
802	Adult + 2 chicks	2 chicks	2 chicks	2
803	Adult + 1 chick	Adult + 2 chicks	Adult + 2 chicks	2
804	Adults+ 2 chicks	1 chick	Inactive	0
806	Adult + 1 chick	1 chick	Adult + 1 chick	1
1001	Adult + 2 chicks	Adult + 2 chicks	2 chicks	2
1002	Adult incubating	Inactive	Inactive	0
1003	Inactive	Adult + 1 chick	Inactive	0
1105	Adult nearby	Adult + 1 chick	1 chick	1
1107	Adult + 1 chick	Adult + 1 chick	2 adults + 1 chick	1
1108	Adult + 2 chicks	Adult + 2 chicks	Adult + 2 chicks	2
1109	Adult + 1 chick + 1 egg	Adult + 1 chick + 1 egg	Adult + 1 chick	1
1110	Adult + 2 chicks	2 chicks	2 chicks	2
Total Chicks				**32**

Note: Active – nest present and BAEA using nest; Inactive – nest present but unused

Appendix 12. Ground-Nesting Raptor Monitoring 2021 Annual Report

Site C Clean Energy Project
Ground-Nesting Raptor Monitoring
2021 Annual Report

PRESENTED TO

BC Hydro and Power Authority

NOVEMBER 4, 2021
ISSUED FOR USE
FILE: 704-ENW.PENW03042-02.GNRM

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Site C Clean Energy Project
Ground-Nesting Raptor Monitoring
2020 Annual Report

FILE: 704-ENW.PENW03042-02.GNRM
November 4, 2021

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LIMITATIONS OF REPORT

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EXECUTIVE SUMMARY

Saulteau EBA Environmental Services Joint Venture (SEES JV) completed surveys of ground-nesting raptors (i.e., Short-eared Owl [*Asio flammeus*] and Northern Harrier [*Circus hudsonius*]) in the area of BC Hydro and Power Authority's (BC Hydro) Site C Clean Energy Project ("Site C") in spring and summer 2021. The surveys were part of BC Hydro's Ground-Nesting Raptor Follow-up Monitoring Program. This report describes the methods used to conduct the surveys and provides a summary of the results.

The 2021 ground-nesting raptor surveys were conducted using two methods: (1) Field surveys were conducted along transects and at standwatch stations to detect Northern Harrier and Short-eared Owl, and (2) Autonomous Recording Units (ARUs) were established at select standwatch stations with the purpose of detecting Short-eared Owl through human-listening.

The ground-nesting raptor field surveys were completed within four cleared portions of the Site C construction headpond: Highway 29 near Watson Slough, Cache Creek, Bear Flats, and along the Peace River between the Halfway River and Moberly River. The surveys were conducted either through transects or through stationary standwatches. Ground-nesting raptor surveys were completed at each transect and standwatch station up to six times over May and June 2021 (three daytime visits and three evening surveys at select sites). The cleared portions near Bear Flats, Cache Creek, and Highway 29 were accessed on foot and the areas along the Peace River were accessed by boat.

ARUs were deployed at six stations throughout the survey area that were assessed as having the highest habitat potential for Short-eared Owl. These six stations were located along transects or at standwatch stations in the Bear Flats and Peace River survey areas in locations that had experienced between one to three growing seasons since clearing. The ARUs were retrieved after a month of recording and three audio recordings taken near sunset were randomly selected from separate nights at each station and analyzed and interpreted for Short-eared Owl through human listening.

No Short-eared Owls were detected during the field surveys or through human listening of the ARU recordings. Northern Harrier was observed twice within the Peace River area: once during the early June surveys (June 4 – June 8) and once during the late June surveys (June 18 – June 24). No behaviours suggestive of Northern Harrier nesting were observed. Surveys in 2022 will continue in all cleared areas within the construction headpond.

TABLE OF CONTENTS

EXECUTIVE SUMMARY I

1.0 INTRODUCTION 1

2.0 METHODS 1

2.1 Field Surveys 1

2.1.1 Transect Survey Protocol 3

2.1.2 Standwatch Survey Protocol Without Transects 3

2.2 Autonomous Recording Unit Surveys 4

3.0 RESULTS 5

3.1 Habitat at Survey Areas 5

3.2 Transect Results 7

3.3 Standwatch Results 7

3.4 Incidental Observations 7

3.5 ARU Survey Results 7

4.0 DISCUSSION 9

5.0 REFERENCES 9

LIST OF TABLES IN TEXT

Table 1: Species Covered in the Ground-Nesting Raptor Follow-up Monitoring Program 1
Table 2: 2021 Survey Areas with Dates and Times 2
Table 3. 2021 ARU Survey Station Locations 4
Table 4: Habitat at Peace River Standwatch Stations and Transects during the 2021 Surveys 5
Table 5: Northern Harrier Observations during the May/June 2021 Field Surveys. 8

APPENDIX SECTIONS

FIGURES

Figure 1 Project Overview
Figure 2 Bear Flats Transect Stations
Figure 3 Cache Creek, Highway 29 and Peace River Standwatch Stations
Figure 4 Peace River Standwatch Stations
Figure 5 Peace River Transect #1 and Transect #2 Standwatch Stations
Figure 6 Peace River Transect #3 Standwatch Stations
Figure 7 Peace River Transect #4 Standwatch Stations
Figure 8 Peace River Transect #5 Standwatch Stations

APPENDICES

Appendix A Incidental Wildlife Observations
Appendix B Survey Station HIstory 2016 - 2021
Appendix C Project Qualified Environmental Professionals
Appendix D Limitations on the Use of this Document

1.0 INTRODUCTION

Saulteau EBA Environmental Services Joint Venture (SEES JV) completed surveys of ground-nesting raptors in the area of BC Hydro and Power Authority's (BC Hydro) Site C Clean Energy Project ("Site C") in spring and summer 2021. The surveys were part of BC Hydro's Ground-Nesting Raptor Follow-up Monitoring Program (BC Hydro 2016). Ground-nesting raptor surveys have occurred annually since 2016. This report describes the methods used to conduct the surveys and provides a summary of the results from 2021.

The Ground-Nesting Raptor Follow-up Monitoring Program is specifically focused on two ground-nesting raptor species: Short-eared Owl (*Asio flammeus)* and Northern Harrier (*Circus hudsonius)* (Table 1).

Table 1: Species Covered in the Ground-Nesting Raptor Follow-up Monitoring Program

Common Name	Scientific Name	BC List	COSEWIC [1] Status	SARA [2] Status
Short-eared Owl	*Asio flammeus*	Blue	Special Concern	Schedule 1 – Special Concern
Northern Harrier	*Circus hudsonius*	Yellow	-	-

[1] COSEWIC – Committee on the Status of Endangered Wildlife in Canada.
[2] SARA – *Species at Risk Act*.

The objectives of the ground-nesting raptor monitoring program are to determine the following:

- The number of Northern Harrier and Short-eared Owl nesting in areas cleared within the construction headpond prior to reservoir filling;
- The effects of seasonal construction headpond flooding on Northern Harrier and Short-eared Owl nests; and
- The use of open fields within mitigation properties by Northern Harrier and Short-eared Owl as nesting habitat.

2.0 METHODS

The 2021 ground-nesting raptor surveys were conducted using two methods:

1. Field surveys were conducted along transects and at standwatch stations to detect Northern Harrier and Short-eared Owl; and
2. Autonomous Recording Units (ARUs) were deployed at select standwatch stations as a pilot study to determine if acoustic recordings could be used to detect Short-eared Owl in late-evening hours when sites cannot be surveyed by human observers.

Surveys were conducted in cleared portions of the construction headpond between the dam site and the Halfway River. Surveys of the mitigation properties were conducted in 2016 and 2017. Use of the mitigation properties in their current conditions (i.e., in the absence of any land-use changes or habitat modification) by ground-nesting raptors has been well documented and further surveys would likely not provide new information. Surveys of the mitigation properties were therefore not conducted in 2021. Surveys of these areas will be performed again when the reservoir has been inundated or when there are substantial land use changes or habitat modifications in the mitigation properties, whichever occur first.

2.1 Field Surveys

Surveys were conducted at 37 standwatch stations within the four areas outlined in Table 2 and on Figures 1 through 8 (see Appendix B for a full list of the standwatch stations surveyed in 2021 and the survey history of each station from 2016 – 2021):

- The Bear Flats area had a single transect with five standwatch stations located along its length (Figure 2).
- The Cache Creek area consisted of a single standwatch station (Figure 3). The Cache Creek transect could not be surveyed in 2021 due to active bridge construction that was underway. The construction prevented access to all five transect stations as well as to CCSW06. A single standwatch station, CCSW07, was newly established close to the abandoned station CCSW06 so that this area could continue to be surveyed.
- The Highway 29 area consisted of a single standwatch station, H29SW06 (Figure 3). H29SW01 was not surveyed this year, because this station had been established in an area that was outside of the ground-nesting raptor study area (i.e., outside of the headpond area).
- The Peace River area was the largest survey area, with five transects (for a total of 25 standwatch stations) between the Moberly River and Cache Creek and five standwatch stations located between Cache Creek and the Halfway River (Figures 3 to 8). No new survey stations were established within the Peace River area this year. The standwatch stations PRSW29, PRSW30, and PRSW36 were not surveyed this year because those stations had been established in areas outside of the ground-nesting raptor study area (i.e., outside of the headpond area).

Within these four areas, ground-nesting raptors were surveyed up to six times over May and June 2021 to capture earlier, middle, and later stages of their breeding season. The surveys were conducted using a combination of transects and stationary standwatches. The cleared Bear Flats, Cache Creek, Highway 29 areas were accessed by foot and the cleared Peace River areas were accessed by boat. Surveys were completed by two teams of two observers. Each team was composed of a biologist with raptor survey experience and an assistant (Appendix C).

Surveys were not conducted in the Moberly River area due to construction activity at the confluence with the Peace River and high water upstream making it inaccessible. The Lynx Creek survey area (LCSW01 and LCSW02) and Halfway River survey area (HRSW01) were not surveyed this year because those stations had been determined to be in areas outside of the ground-nesting raptor study area (i.e., outside of the construction headpond area).

Table 2: 2021 Survey Areas with Dates and Times

Survey Location	First Visit	Second Visit (Evening)	Third Visit	Fourth Visit (Evening)	Fifth Visit	Sixth Visit (Evening)
Bear Flats	May 6, 2021 09:00 – 11:29	May 6, 2021 20:39 – 21:30 (Only surveyed BFSW01 and BFSW02)	June 1, 2021 06:12 – 08:39	June 8, 2021 20:49 – 21:41 (Only surveyed BFSW01 and BFSW02)	June 24, 2021 06:45 – 09:28	June 24, 2021 20:54 – 21:50 (Only surveyed BFSW01)
Cache Creek	May 6, 2021 12:29 – 12:49	May 6, 2021 19:55 – 20:15	June 1, 2021 09:32 – 09:52	June 8, 2021 21:10– 21:30	June 24, 2021 07:02 – 07:22	June 24, 2021 22:02 – 22:22
Highway 29	May 6, 2021 12:55 – 13:15	May 6, 2021 19:30 – 19:50	June 1, 2021 09:36 – 09:56	June 8, 2021 20:40 – 21:00	June 24, 2021 06:34 – 06:54	June 24, 2021 22:03 – 22:23
Peace River	May 4, 2021 08:05 – 15:25 & May 5, 2021 07:29 – 15:38	No evening surveys conducted	June 2, 2021 06:54 – 15:07 & June 3, 2021 10:09 – 11:14	No evening surveys conducted	June 18, 2021 06:57 – 13:57 & June 19, 2021 09:17– 10:40	No evening surveys conducted

Northern Harrier are diurnal, and research suggests they are generally active between 05:30 and 21:30 (Smith et al. 2011). Short-eared Owl are a crepuscular species and optimal survey timing is in the evening just prior to civil twilight (Wiggins at al. 2006). While most surveys were conducted during daytime hours, three evening surveys were conducted at four select sites to enhance the possibility of detecting Short-eared Owl (the "evening" visit columns in Table 2). The evening surveys were limited to areas that could be safely accessed by truck due to the logistical and safety considerations that come with conducting surveys in cleared portions of the reservoir that require boat access. Evening surveys would require boating in very low light or dark conditions after surveys are complete, which would not be considered a safe work practice by BC Hydro.

2.1.1 Transect Survey Protocol

The transect surveys were conducted by walking at a speed of 0.5 – 2 km/hr, looking and listening for birds. Surveyors stopped whenever required to confirm identification and record data. The walking transects were located only in cleared portions of the reservoir. Surveyors selected walking paths to ensure visual coverage of the entire portion of suitable habitat in each area. During the transect, surveyors stopped at each established standwatch station to complete a standwatch survey. From each standwatch station the surveyors had a view from the previous standwatch station to the next station in the transect. Adding these standwatches into the transect surveys allowed surveyors to observe areas for longer periods to increase the potential to observe bird activity and to monitor potential nesting behaviour for the purpose of locating ground-nesting raptor nests. Standwatches were conducted by observing from a stationary position for approximately 20 minutes.

Surveys were not completed during periods of high wind (greater than Beaufort 3; 12 – 19 km/hr), rain or fog, when bird activity and detectability are likely to be low. The order that the stations were visited was different on each of the survey days so that time of day varied between visits.

For all raptor observations, species, sex, age, activity, distance and compass direction were recorded. Other species were recorded as incidental observations (Appendix A). For Northern Harrier or Short-eared Owl observations, if a pair was observed or there was evidence of nesting behaviour, a nest search was conducted to attempt to locate any nest that might be present in the area. Since ground-nesting raptor nests can easily be destroyed by human traffic, surveyors were instructed to observe for behaviour suggesting a nest was nearby (e.g., one or both of the pair returning to the same location with nesting materials or food, a pair of Northern Harriers exchanging prey or nesting materials through aerial passes, or a male Short-eared Owl defending a nest with distraction displays) rather than conduct intensive foot searches to locate a nest.

2.1.2 Standwatch Survey Protocol Without Transects

Standwatch surveys in the absence of associated transects were conducted in cleared portions of the reservoir that (1) could not be visited by foot due to impassible terrain and/or (2) could not be linked with other standwatch stations to form a transect. Standwatches were conducted by observing from a stationary position for approximately 20 minutes.

Surveys were not completed during periods of high wind (greater than Beaufort 3, 12 – 19 km/hr), rain or fog. The order that the stations were visited were different on each of the survey days.

Ground-nesting raptor observations were collected following the same protocol as described in Section 2.1.1 for transect surveys.

2.2 Autonomous Recording Unit Surveys

An ARU is a standalone audio recording device that can be deployed and left for a period of time to record vocalizations or other sounds. The audio recordings are analyzed and interpreted once the recording units have been retrieved. ARUs are a commonly used tool to survey birds (Shonfield and Bayne 2017). The benefit of using ARUs for bird surveys is that the units can be deployed during daylight hours in areas that cannot be easily or safely accessed in the evening/night (i.e. along the Peace River) when species such as Short-eared Owl are active, allowing for monitoring in areas that would otherwise be difficult to survey.

Short-eared Owl are not especially vocal (Wiggins et al. 2020) and surveys for this species are best conducted using visual ground surveys. However, ARUs could be a useful supplement to visual surveys if Short-eared Owl vocalizations can be reliably detected by a human listener in recordings. This would allow for listening of recordings at locations that could not otherwise be surveyed in evening hours.

To informally test the utility of ARUs for detecting Short-eared Owls and determine if ARUs could be a useful addition to supplement the ongoing visual ground surveys at Site C, an experimental trial was conducted in 2020 and 2021. ARUs were deployed at select standwatch stations with the intent that Short-eared Owl would be detected by visual survey and recordings could then be reviewed to identify Short-eared Owl vocalizations. Ideally, ARUs would be deployed at locations where Short-eared Owls are known to occur; however, previous surveys have not identified any Short-eared Owl in or adjacent to the reservoir area.

ARUs (Song Meter SM4 from Wildlife Acoustics Inc.) were deployed at six stations that were assessed as having the highest habitat potential for Short-eared Owl. These seven stations were located along transects or at standwatch stations in the Bear Flats and Peace River survey areas in locations that had experienced between one to three growing seasons since clearing (Table 3). These sites were abundant in low vegetation, grasses, shrubby regrowth, and had abundant coarse woody debris. A description of the habitat at each ARU survey station can be found in Section 3.1.

Table 3. 2021 ARU Survey Station Locations

ARU Survey Station	Location Reference	UTM Zone	UTM Easting	UTM Northing
PRSW03	Along Peace River Transect #1	10V	624355	6233276
PRSW07	Along Peace River Transect #2	10V	626626	6232622
PRSW12	Along Peace River Transect #3	10V	620711	6232634
PRSW23	Along Peace River Transect #4	10V	616002	6233032
PRSW26	Along Peace River Transect #5	10V	612217	6236472
BFSW03	Along the Bear Flats transect.	10V	612030	6237304

The ARUs were installed from May 4 to May 6, 2021 and were collected from June 18 to June 24, 2021. The ARUs were installed based on the deployment protocol of Lankau (2015). Each unit was mounted on a wooden stake or affixed to a tree approximately 1 m from the ground. The ARUs were set to record for 10 minutes every half hour each evening for the duration of deployment. The evening recordings were collected between 20:00 to 00:10 (i.e., midnight). The ARUs recorded 2-channel stereo, compressed W4V-8 files at 24 KHz.

To increase the probability of Short-eared Owl detection, recordings that could be selected for human listening were restricted to those taken as close to sunset (approximately 21:55 in June) as possible, when Short-eared Owls are likely to be most active. Three 10-minute recordings, taken at either 21:30 or 22:00, were randomly selected from each station for human listening, for a total of 18 recordings. The three recordings were selected from different

nights during the ARU deployment period. If a selected recording had persistent wind or rain, a new recording was randomly selected to avoid periods of low Short-eared Owl activity or decreased ability to detect sounds. The compressed W4V files were converted to uncompressed WAV files using the Kaleidoscope software (version 5.3.8) by Wildlife Acoustics. The uncompressed WAV files were then imported into Audacity (version 2.4.2) for human listening. The trained human listener played back each recording and was instructed to record Short-eared Owl calls, including barks, screams, bill snaps and male courtship hoots detected in 1-minute intervals; replay any section needed to accurately track and count Short-eared Owl detections; and estimate perceived distance to each individual (near, mid and far). Human listening was conducted by the same trained human listener for all recordings.

3.0 RESULTS

3.1 Habitat at Survey Areas

Habitat information for each survey station was noted during surveys to determine the quality of the cleared area as hunting and nesting habitat for ground-nesting raptors. Table 4, below, describes the habitat at each survey station. Photographs of the habitat at each station are presented on Figures 2-8.

Table 4: Habitat at Peace River Standwatch Stations and Transects during the 2021 Surveys

Transect or Survey Station	Cleared	Growing Seasons Since Clearing	Habitat
Bear Flats Survey Area – Transect Only			
Bear Flats Transect ▪ BFSW01 ▪ BFSW02 ▪ BFSW03 ▪ BFSW04 ▪ BFSW05	Winter 2018/2019	2	The cleared area was experiencing vegetation regrowth with high percent cover (80-90%) of grasses, forbs and shrubs. Shrubs were approximately 1 m high. The cleared area is bounded by the Peace River to the south and by aspen forests growing on dry south-facing slopes to the north.
Cache Creek Survey Area – Standwatch Only			
CCSW07	Partial clearing in Winter 2016/2017 Partial clearing in Winter 2018/2019	4 2	Reestablished vegetation is dominated by grasses and patches of low shrubs (1.0 m in height). The area is oriented south towards Cache Creek, bounded by Highway 29 to the north and surrounded by deciduous riparian forests.
Highway 29 Survey Area – Standwatch Only			
H29SW06	Winter 2016/2017	4	Vegetation regrowth consists of a dense cover of grasses, weeds, forbs, and shrubs approximately 1 m tall with trembling aspen saplings growing to up to 2 m tall on the western side. The Peace River and riparian balsam poplar forest lies to the south.
Peace River Survey Area – Transect and Standwatch			
Peace River Transect #1 ▪ PRSW02 ▪ PRSW03 ▪ PRSW04	Winter 2017/2018	3	A cleared and mulched bench in the river channel with thick herbaceous and shrubby regrowth (some greater than 1.0 m tall) covering 90% of the cleared area. It is bounded on the northern and southern sides by intact strips of open riparian forest between the cleared area and the Peace River.
Peace River Transect #2 ▪ PRSW05 ▪ PRSW06 ▪ PRSW07 ▪ PRSW08	Winter 2017/2018	3	A cleared stretch of coniferous forest on a north-facing slope with abundant grass, herb and shrub regrowth (some greater than 1 m tall) covering 90% of the area. It is bounded to the south by the Peace River, and to the north and west by coniferous forest.

Transect or Survey Station	Cleared	Growing Seasons Since Clearing	Habitat
Peace River Transect #3 ▪ PRSW11 ▪ PRSW12 ▪ PRSW13 ▪ PRSW14 ▪ PRSW15	Winter 2018/2019 (except PRSW15 which was cleared 2019 / 2020)	2 1	A large cleared and mulched area encompassing Tea Island. The eastern end of the transect has moderate vegetation regrowth of forbs, grasses and shrubs approximately 1 m covering about 75% of the ground. The western half of the transect has a higher percentage of vegetation cover (90%), and shrubs over 1 m in height are abundant. It is bounded by dry south-facing slopes to the north and an intact strip of riparian forest along the Peace River to the south.
Peace River Transect #4 ▪ PRSW16 ▪ PRSW17 ▪ PRSW18 ▪ PRSW19 ▪ PRSW20 ▪ PRSW21 ▪ PRSW22 ▪ PRSW23	Winter 2019/2020	1	The flat floodplain areas and the southern slopes were cleared and mulched. Some exposed soils, and abundant small and large woody debris still remain. Vegetation regrowth is moderate and consists of grasses, herbs and short shrubs (<1 m tall) covering approximately 75% of the area. It is bounded to the north by the Peace River, and to the south by coniferous forest. Riparian buffers were left around the perimeters of the clear-cut areas.
Peace River Transect #5 ▪ PRSW24 ▪ PRSW25 ▪ PRSW26 ▪ PRSW27 ▪ PRSW28	Winter 2019/2020	1	This area had been cleared and mulched. Some exposed soils, and abundant small and large woody debris still remain. Vegetation regrowth is moderate and consists of grasses, herbs and short shrubs (<1 m tall) covering approximately 60% of the area. It is bounded to the north by the Peace River, and to the south by coniferous forest. Riparian buffers were left around the perimeters of the clear-cut areas.
PRSW31	Winter 2019/2020	1	The area had been cleared and mulched. Vegetation regrowth is moderate (approx. 50%) and consists of grasses, herbs and low shrubs under 0.5 m in height. The station is located on a river island and a riparian buffer was left around the perimeter of the cleared island.
PRSW32	Winter 2019/2020	1	The area had been cleared and mulched. Vegetation regrowth is moderate (approx. 50%) and consists of grasses, herbs and low shrubs under 0.5 m in height. The station is located on a river island and a riparian buffer was left around the perimeter of the cleared island.
PRSW33	Winter 2019/2020	1	The area had been cleared and mulched. Vegetation regrowth is minimal (< 50%) and consists of grasses, herbs and low shrubs under 1.0 m in height. The station is located on a river island and a riparian buffer was left around the perimeter of the cleared island.
PRSW34	Winter 2019/2020	1	A small, cleared area surrounded by mainly deciduous trees. The cleared and grubbed area has moderate vegetation regrowth (approx. 60%) and consists mostly of grasses, herbs and low shrubs. It is bounded to the east and south by the Peace River and to the north by floodplains, and Highway 29.
PRSW35	Winter 2019/2020	1	A small, cleared area surrounded by mainly deciduous trees. The cleared and grubbed area has moderate vegetation regrowth (approx. 60%) and consists mostly of grasses, herbs and low shrubs. It is bounded to the east and south by the Peace River and to the north by floodplains, and Highway 29.

3.2 Transect Results

Two Northern Harriers were observed along transects within the Peace River survey area (Table 5). During the second visit in early June, one Northern Harrier was observed along the Peace River Transect #5 at PRSW24. During the third visit in late June, one Northern harrier was observed along the Peace River Transect #2 at PRSW06. No Northern Harrier were observed at any of the stations during the first visit in early May. No nests or potential nests were observed along any of the transects surveyed.

3.3 Standwatch Results

No Northern Harrier or Short-eared Owl were observed at any of the standwatch only stations.

3.4 Incidental Observations

There were no incidental Northern Harrier or Short-eared Owl observed during any of the three visits.

3.5 ARU Survey Results

Three 10-minute recordings from each of the six stations were analyzed through human listening, for a total of 18 recordings. No Short-eared Owls were detected through human listening.

Table 5: Northern Harrier Observations during the May/June 2021 Field Surveys.

Transect	Station	Date	Time	Count	Activity	Sex	Age Class	Observation Location			Comments[1]
								UTM Z	UTM E	UTM N	
Observations from Transects											
Peace River Transect #5	PRSW24	June 2, 2021	11:10	1	Flying	U	Adult	10V	613115	6235638	Observed NOHA[1] individual flying northwest approximately 500 m away at 140 degrees.
Peace River Transect #2	PRSW06	June 18, 2021	8:09	1	Flying	U	Adult	10V	626236	6232838	Observed NOHA flying approximately 500 m away at 200 degrees. Perched briefly in a few trees before flying east along treeline.

[1] NOHA = Northern Harrier

4.0 DISCUSSION

The 2021 ground-nesting raptor surveys detected Northern Harrier in and adjacent to the Project footprint. Northern Harriers were observed twice, once during the early June surveys, and once during the late June surveys. Both of these Northern Harrier observations occurred along the southern ridges and slopes of the Peace River, at the interface of cleared and forested areas. No behaviours suggestive of nesting were observed.

No Short-eared Owls were detected during the 2021 ground-nesting raptor surveys, which is consistent with the previous years' findings. No Short-eared Owls have been observed in or adjacent to the Project footprint since surveys began in 2016. The experimental use of ARUs to detect Short-eared Owl using audio recordings continues to be inconclusive since no Short-eared Owl were detected in 2020 or 2021. The ARU trial will be conducted again in 2022.

Areas surveyed within the headpond area in 2016 through 2021 will be surveyed again in 2022 in addition to any newly cleared areas within the headpond. Surveys in the headpond will continue until the reservoir has been filled. The first surveys in 2022 are expected to occur in the first week of May, consistent with previous years.

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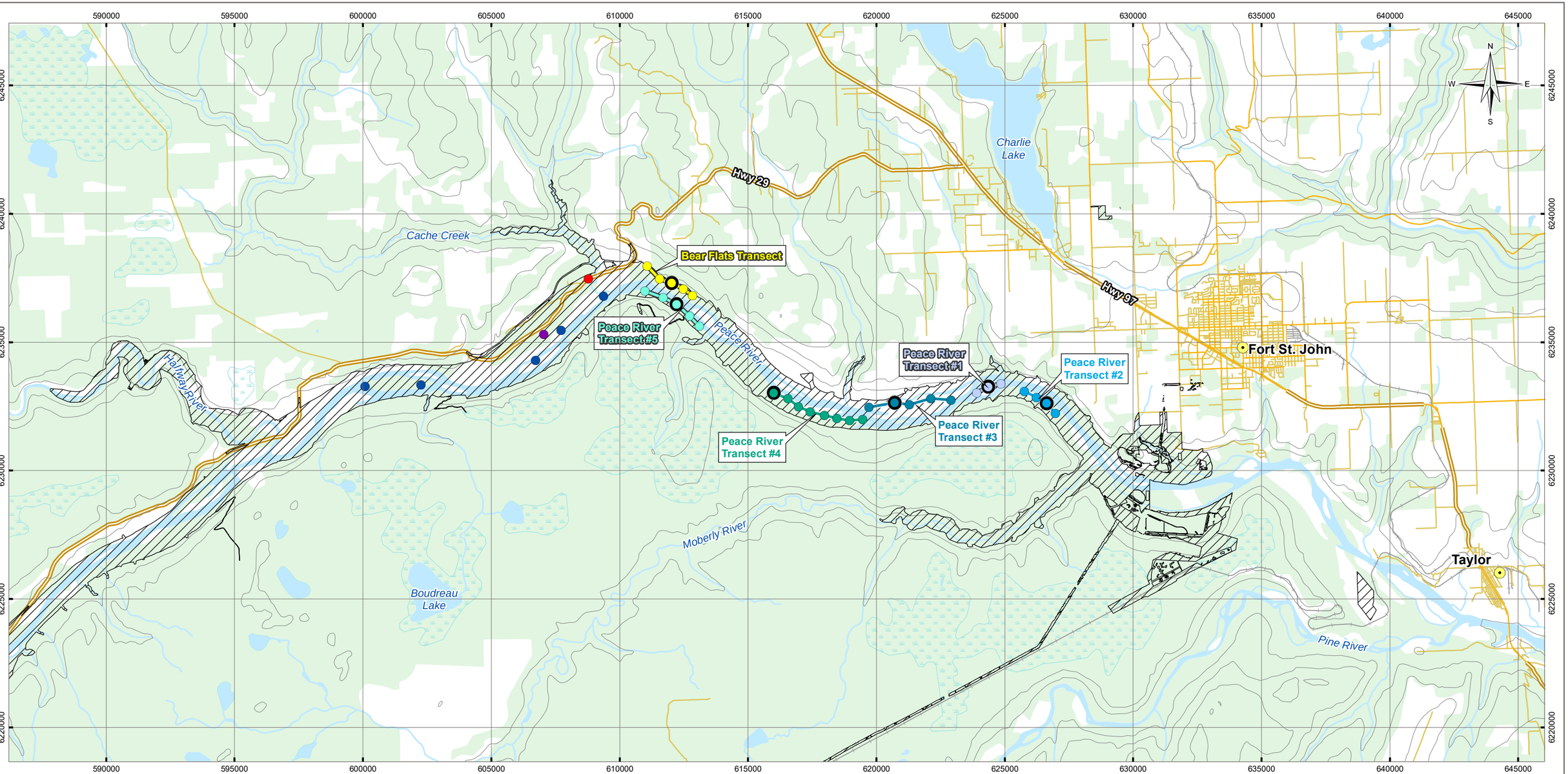
FIGURES

Figure 1 Project Overview
Figure 2 Bear Flats Transect Stations
Figure 3 Cache Creek, Highway 29 and Peace River Standwatch Stations
Figure 4 Peace River Standwatch Stations
Figure 5 Peace River Transect #1 and Transect #2 Standwatch Stations
Figure 6 Peace River Transect #3 Standwatch Stations
Figure 7 Peace River Transect #4 Standwatch Stations
Figure 8 Peace River Transect #5 Standwatch Stations



LEGEND

- Project Footprint
- ARU Station

Standwatch Station

- Cache Creek
- Highway 29
- Peace River

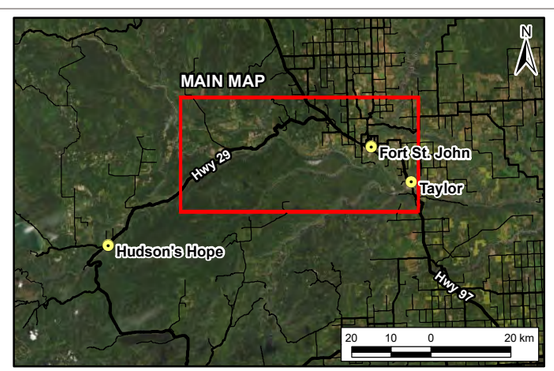
Transect Standwatch Station

- Bear Flats
- Peace River #1
- Peace River #2
- Peace River #3
- Peace River #4
- Peace River #5

Transect

- Bear Flats
- Peace River #1
- Peace River #2
- Peace River #3
- Peace River #4
- Peace River #5

- Populated Place
- Highway
- Main Road
- Local Road
- Resource/Recreational Road
- Railway
- Residential Area
- Contour (100 m)
- Watercourse
- Waterbody
- Wetland
- Wooded Area



NOTES
Base data source: CanVec 1:250,000 (2019).

STATUS
ISSUED FOR USE

SITE C GROUND-NESTING RAPTOR MONITORING 2021 ANNUAL REPORT

Project Overview

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DATE November 3, 2021	**PROJECT NO.** ENW.PENW03042-02				

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610500 611000 611500 612000 612500 613000 613500 614000

6238000 6237500 6237000 6236500

Hwy 29

BFSW01

Bear Flats Transect

BFSW02

BFSW03

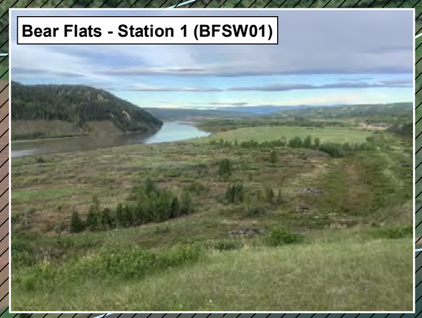
BFSW04

BFSW05

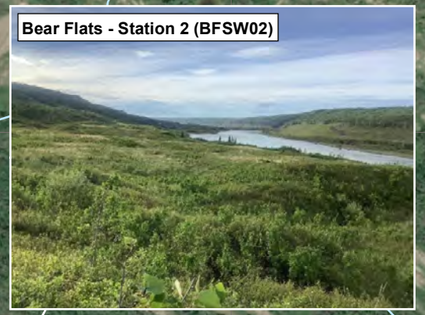
Peace River

N W E S

Bear Flats - Station 1 (BFSW01)

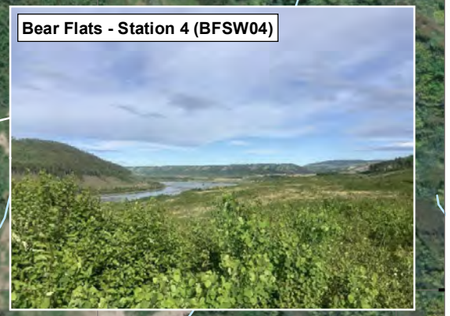


Bear Flats - Station 2 (BFSW02)

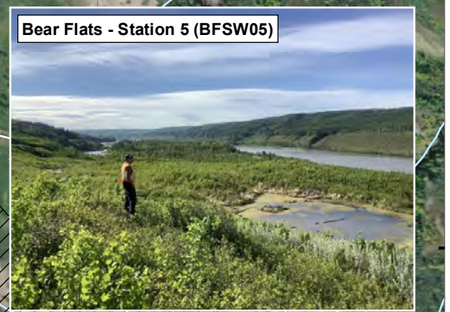


Bear Flats - Station 3 (BFSW03)

Bear Flats - Station 4 (BFSW04)



Bear Flats - Station 5 (BFSW05)

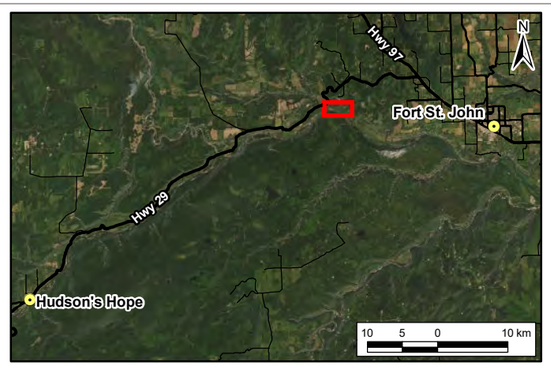


610500 611000 611500 612000 612500 613000 613500 614000

6238000 6237500 6237000 6236500

LEGEND

- ARU Station
- Bear Flats Transect Standwatch Station
- Bear Flats Transect
- Project Footprint
- Highway
- Watercourse
- Waterbody



NOTES
Base data source:
CanVec 1:50,000 (2019).
Imagery from ESRI; Maxar (2016).

STATUS
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Bear Flats Transect Stations

PROJECTION: UTM Zone 10			DATUM: NAD83		CLIENT: BC Hydro Power smart
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FILE NO.: PENW03042-02_Fig02_BearFlats.mxd					
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DATE: November 3, 2021	PROJECT NO.: ENW.PENW03042-02				

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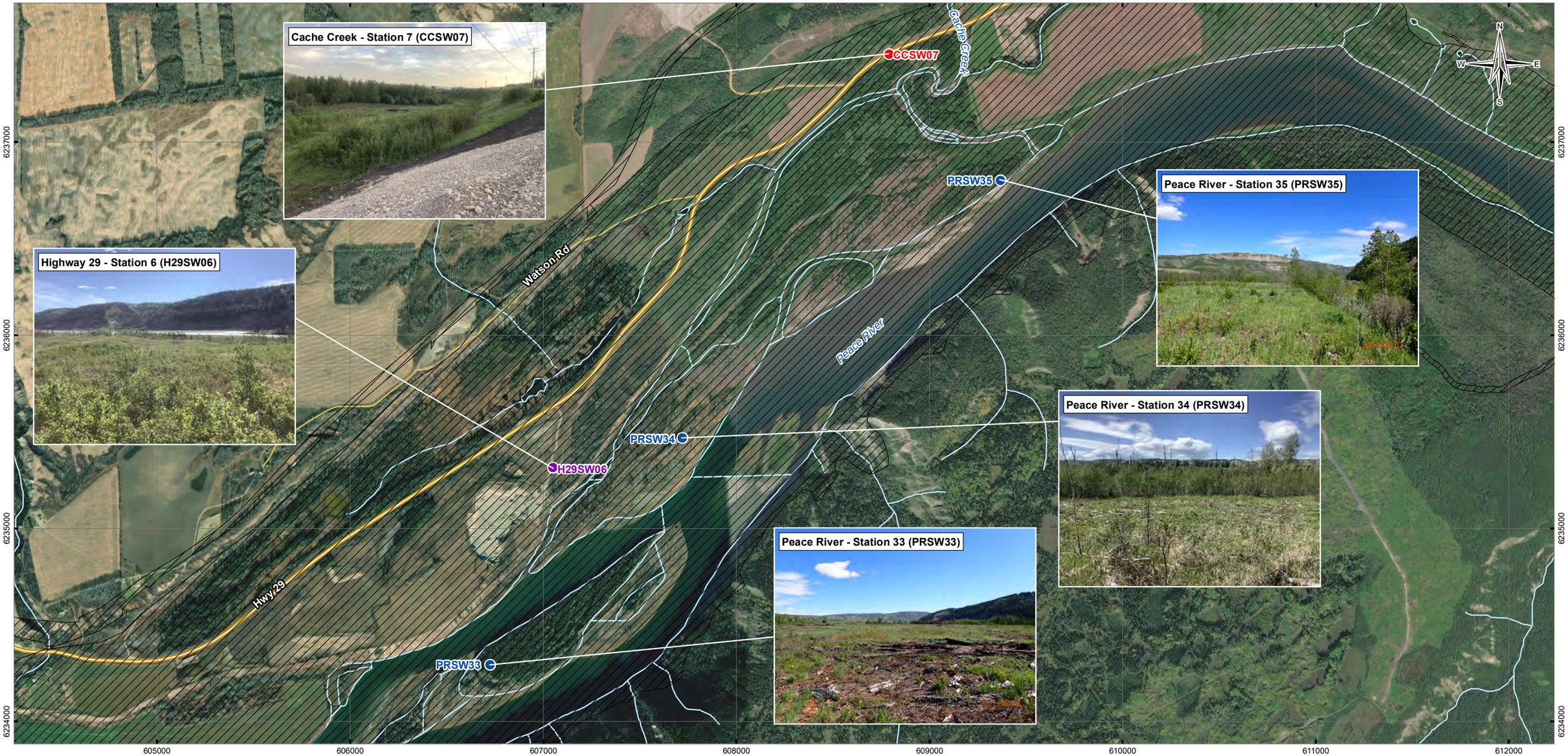
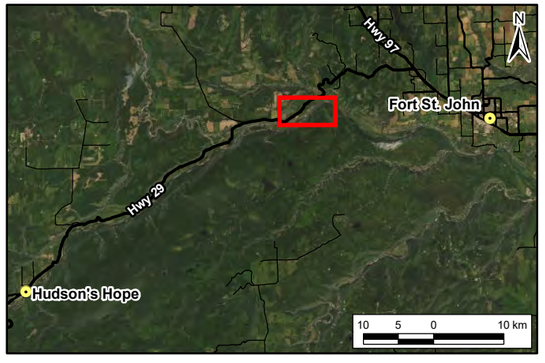


LEGEND

- Cache Creek Standwatch Station
- Highway 29 Standwatch Station
- Peace River Standwatch Station
- Project Footprint
- Highway
- Local Road
- Watercourse
- Waterbody



NOTES
Base data source:
CanVec 1:50,000 (2019).
Imagery from ESRI; Maxar (2016/2018).

STATUS
ISSUED FOR USE

SITE C GROUND-NESTING RAPTOR MONITORING 2021 ANNUAL REPORT

Cache Creek, Highway 29 and Peace River Standwatch Stations

PROJECTION UTM Zone 10			**DATUM** NAD83	**CLIENT** BC Hydro Power smart
Scale: 1:20,000 (400 200 0 400 Metres)				TETRA TECH
FILE NO. PENW03042-02_Fig03_CC_Hwy29_PR.mxd				
OFFICE TI-VANC	**DWN** SL	**CKD** BB	**APVD** EH	**REV** 0
DATE November 3, 2021	**PROJECT NO.** ENW.PENW03042-02			**Figure 3**

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598000 599000 600000 601000 602000 603000 604000 605000

6234000 6233000 6232000 6231000

Upper Cache Rd

Hwy 29

Szoo Rd

N W E S

PRSW31

PRSW32

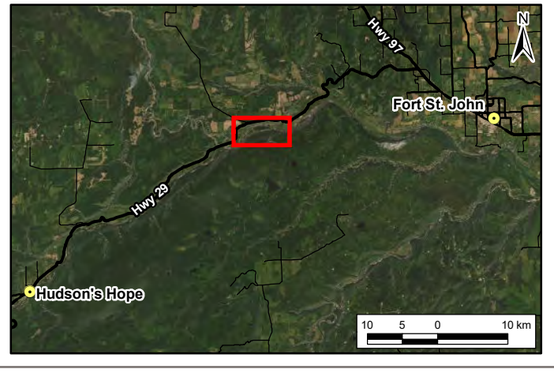
Peace River

Peace River - Station 31 (PRSW31)

Peace River - Station 32 (PRSW32)

LEGEND

- Peace River Standwatch Station
- Project Footprint
- Highway
- Local Road
- Watercourse
- Waterbody



NOTES
Base data source:
CanVec 1:50,000 (2019).
Imagery from ESRI; Maxar (2018).

STATUS
ISSUED FOR USE

SITE C GROUND-NESTING RAPTOR MONITORING 2021 ANNUAL REPORT

Peace River Standwatch Stations

PROJECTION: UTM Zone 10	DATUM: NAD83			CLIENT: BC Hydro Power smart
Scale: 1:20,000 (400 200 0 400 Metres)				TETRA TECH
FILE NO.: PENW03042-02_Fig04_PeaceR.mxd				
OFFICE: TI-VANC	DWN: SL	CKD: BB	APVD: EH	REV: 0
DATE: November 3, 2021	PROJECT NO.: ENW.PENW03042-02			Figure 4

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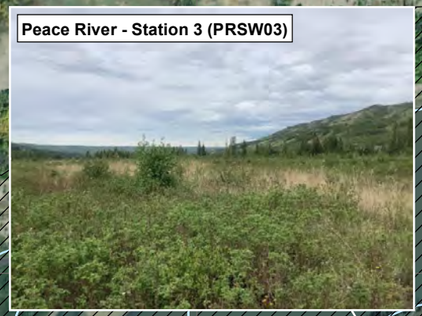
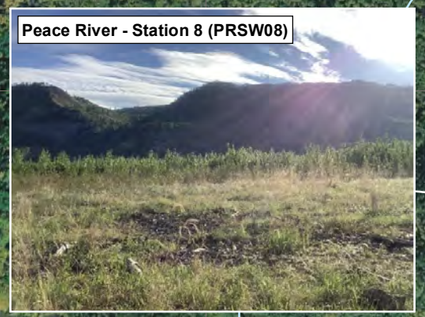
624000 624500 625000 625500 626000 626500 627000 627500

6233500

6233000

6232500





PRSW04

PRSW03

Peace River Transect #1

PRSW02

Peace River

PRSW05

Peace River Transect #2

PRSW06

PRSW07

PRSW08

N

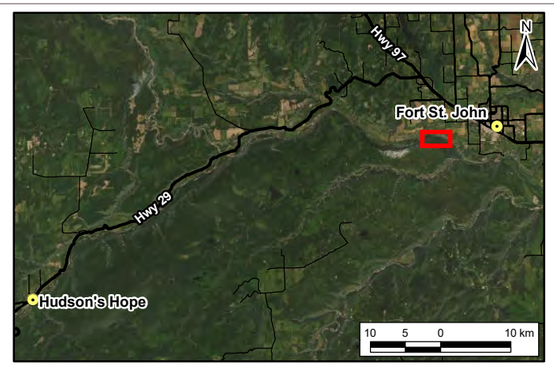
W E

S

624000 624500 625000 625500 626000 626500 627000 627500

LEGEND

- Northern Harrier Observation
- ARU Station
- Peace River Transect #1 Standwatch Station
- Peace River Transect #2 Standwatch Station
- Peace River Transect #1
- Peace River Transect #2
- Project Footprint
- Watercourse
- Waterbody



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

STATUS
ISSUED FOR USE

SITE C
GROUND-NESTING RAPTOR MONITORING 2021 ANNUAL REPORT

Peace River Transect #1 and Transect #2 Standwatch Stations

PROJECTION UTM Zone 10		**DATUM** NAD83			**CLIENT** BC Hydro Power smart
Scale: 1:10,000 — 200 100 0 200 Metres					TETRA TECH
FILE NO. PENW03042-02_Fig05_PeaceR_T1T2.mxd					
OFFICE Tt-VANC	**DWN** SL	**CKD** BB	**APVD** EH	**REV** 0	**Figure 5**
DATE November 3, 2021	**PROJECT NO.** ENW.PENW03042-02				

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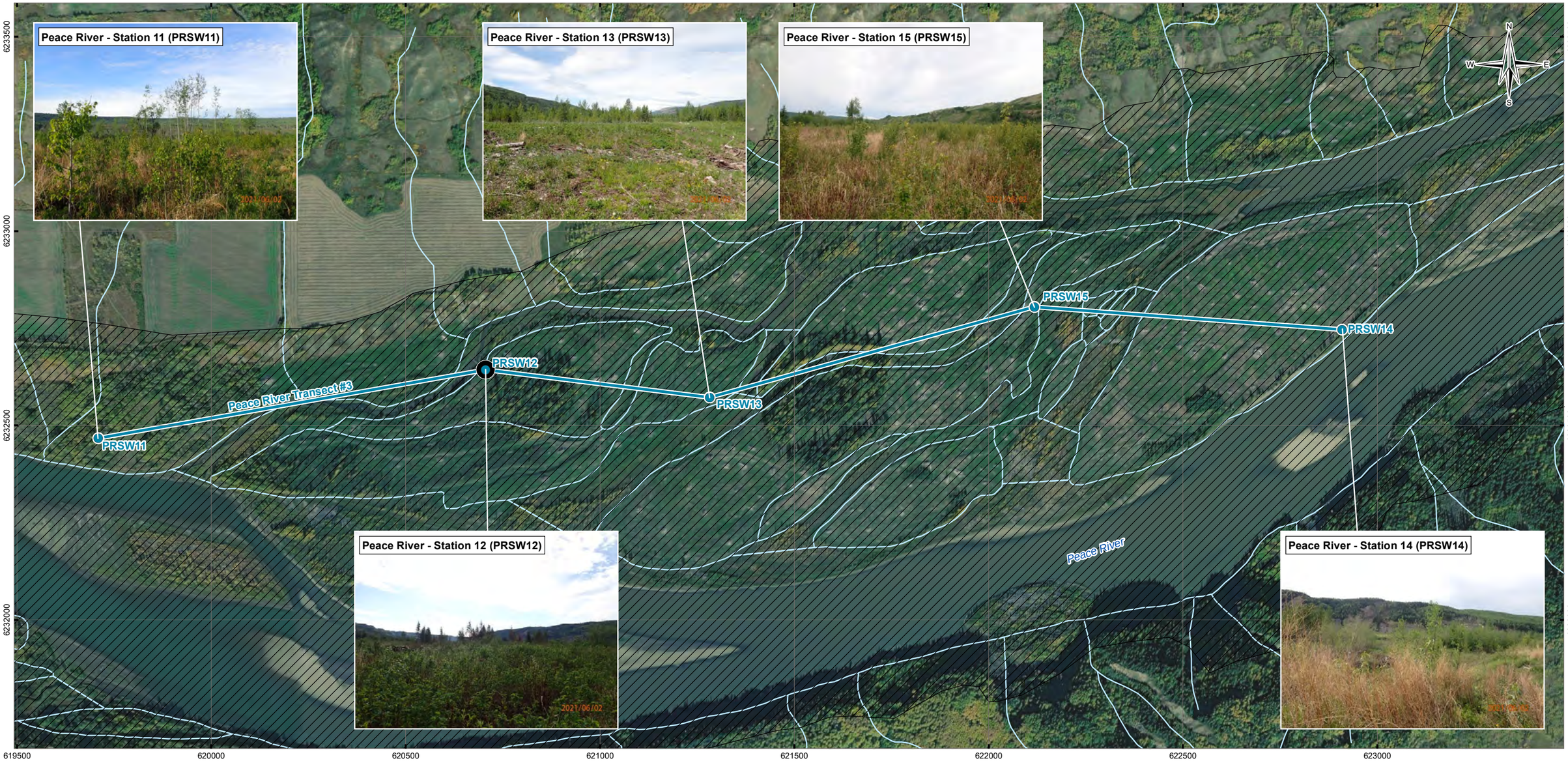
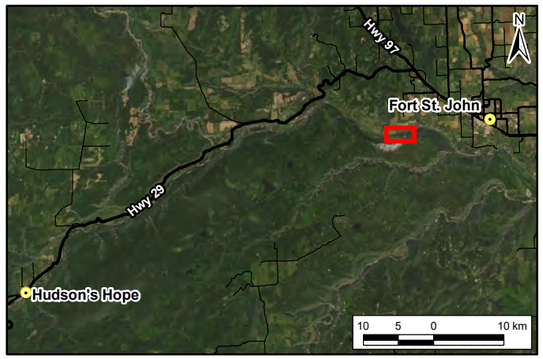


LEGEND

- ARU Station
- Peace River Transect #3 Standwatch Station
- Peace River Transect #3
- Project Footprint
- Watercourse
- Waterbody



NOTES
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CanVec 1:50,000 (2019).
Imagery from ESRI; Maxar (2017/2019).

STATUS
ISSUED FOR USE

SITE C GROUND-NESTING RAPTOR MONITORING 2021 ANNUAL REPORT

Peace River Transect #3 Standwatch Stations

PROJECTION UTM Zone 10		**DATUM** NAD83		**CLIENT** BC Hydro Power smart
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FILE NO. PENW03042-02_Fig06_PeaceR_T3.mxd				
OFFICE Tt-VANC	**DWN** SL	**CKD** BB	**APVD** EH	**REV** 0
DATE November 3, 2021	**PROJECT NO.** ENW.PENW03042-02			**Figure 6**

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615000 615500 616000 616500 617000 617500 618000 618500 619000 619500 620000 620500

6233500 6233000 6232500 6232000 6231500

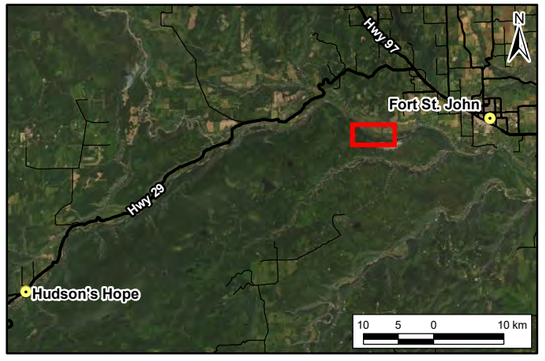
PRSW23 Peace River Transect #4 PRSW22 PRSW21 PRSW20 PRSW19 PRSW18 PRSW17 PRSW16

Peace River

N W E S

LEGEND

- ARU Station
- Peace River Transect #4 Standwatch Station
- Peace River Transect #4
- Project Footprint
- Watercourse
- Waterbody



NOTES
Base data source:
CanVec 1:50,000 (2019).
Imagery from ESRI; Maxar (2017/2018).

STATUS
ISSUED FOR USE

SITE C GROUND-NESTING RAPTOR MONITORING 2021 ANNUAL REPORT

Peace River Transect #4 Standwatch Stations

PROJECTION: UTM Zone 10	DATUM: NAD83			CLIENT: BC Hydro Power smart
Scale: 1:15,000 (200 100 0 200 Metres)				TETRA TECH
FILE NO.: PENW03042-02_Fig07_PeaceR_T4.mxd				
OFFICE: Tt-VANC	DWN: SL	CKD: BB	APVD: EH	REV: 0
DATE: November 3, 2021	PROJECT NO.: ENW.PENW03042-02			Figure 7

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610000 610500 611000 611500 612000 612500 613000 613500 614000 614500

6237000 6236500 6236000 6235500

PRSW28
Peace River Transect #5
PRSW27
PRSW26
PRSW25
PRSW24
Peace River

Peace River - Station 28 (PRSW28)

Peace River - Station 27 (PRSW27)

Peace River - Station 26 (PRSW26)

Peace River - Station 25 (PRSW25)

Peace River - Station 24 (PRSW24)

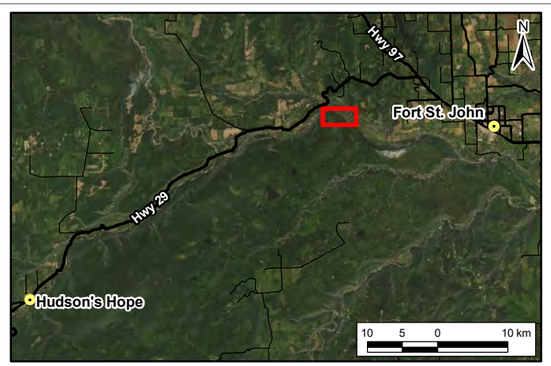
N W E S

610000 610500 611000 611500 612000 612500 613000 613500 614000 614500

6237000 6236500 6236000 6235500

LEGEND

- Northern Harrier Observation
- ARU Station
- Peace River Transect #5 Standwatch Station
- Peace River Transect #5
- Project Footprint
- Watercourse
- Waterbody



NOTES
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CanVec 1:50,000 (2019).
Imagery from ESRI; Maxar (2017/2019).

STATUS
ISSUED FOR USE

SITE C GROUND-NESTING RAPTOR MONITORING 2021 ANNUAL REPORT

Peace River Transect #5 Standwatch Stations

PROJECTION UTM Zone 10			**DATUM** NAD83		**CLIENT** BC Hydro Power smart
Scale: 1:12,000 — 200 100 0 200 Metres					TETRA TECH
FILE NO. PENW03042-02_Fig08_PeaceR_T5.mxd					
OFFICE Tt-VANC	**DWN** SL	**CKD** BB	**APVD** EH	**REV** 0	**Figure 8**
DATE November 3, 2021	**PROJECT NO.** ENW.PENW03042-02				

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APPENDIX A
INCIDENTAL WILDLIFE OBSERVATIONS

Table A.1: Incidental Observation of Other Raptors During Ground-Nesting Raptor Surveys

Common Name	Scientific Name	BC List	COSEWIC/SARA [1]	Number Observed			
				Bear Flats	Cache Creek	Hwy 29	Peace River
Great Horned Owl	*Bubo virginianus*	Yellow	-	-	-	-	1
Red-tailed Hawk	*Buteo jamaicensis*	Yellow	Not at Risk (May 1995)	-	-	-	1
Broad-winged Hawk	*Buteo platypterus*	Blue	-	-	-	-	1
Merlin	*Falco columbarius*	Yellow	Not at Risk (April 1985)	-	-	-	4
American Kestrel	*Falco sparverius*	Yellow	-	2	-	-	-
Bald Eagle	*Haliaeetus leucocephalus*	Yellow	Not at Risk (May 1984)	6	3	-	16
Unknown Raptor	-	-	-	-	-	-	2

APPENDIX B
SURVEY STATION HISTORY 2016 – 2021

Survey Area	Station	Accompanying Transect	UTM Coordinates			Survey Year					
			Zone	Easting	Northing	2016	2017	2018	2019	2020	2021
Compensation Sites	Wilder Creek Lands	No	-	-	-	Surveyed	Surveyed	Not surveyed *	Not surveyed *	Not surveyed *	Not surveyed *
	Ruttledge Property	No	-	-	-	Surveyed	Surveyed	Not surveyed *	Not surveyed *	Not surveyed *	Not surveyed *
	Marl Fen Property	No	-	-	-	Surveyed	Surveyed	Not surveyed *	Not surveyed *	Not surveyed *	Not surveyed *
Highway 29	H29SW01	No	10	604838	6234918		Surveyed	Surveyed	Surveyed	Active Haul Road	Active Haul Road
	H29SW02	No	10	607633	6236693		Surveyed	Surveyed	Surveyed	Surveyed	Not surveyed. Site not within Headpond Area.
	H29SW03	No	10	609150	6237937		Surveyed	Surveyed	Renamed CCSW05 and included in the CC Transect	Renamed CCSW05 and included in the CC Transect	Renamed CCSW05 and included in the CC Transect
	H29SW04	No	10	606078	6234708			Surveyed	Active Construction (Gravel Pit)	Active Construction (Gravel Pit)	Active Construction (Gravel Pit)
	H29SW05	No	10	606918	6235242			Surveyed	Surveyed	Disturbed by construction - soil piles, grading etc. Established H29SW06 nearby as replacement	Disturbed by construction - soil piles, grading etc. Established H29SW06 nearby as replacement
	H29SW06	No	10	607050	6235314					Established to replace H29SW05	Surveyed
Peace River	PRSW01	No	10	623128	6232853		Surveyed	Surveyed	Surveyed	Redundant	Redundant
	PRSW02	Peace River Transect 1	10	623914	6233025		Surveyed	Surveyed	Surveyed	Surveyed	Surveyed
	PRSW03		10	624359	6233273		Surveyed	Surveyed	Surveyed	Surveyed	Surveyed
	PRSW04		10	624854	6233389		Surveyed	Surveyed	Surveyed	Surveyed	Surveyed
	PRSW05	Peace River Transect 2	10	625768	6233094		Surveyed	Surveyed	Surveyed	Surveyed	Surveyed
	PRSW06		10	626233	6232844		Surveyed	Surveyed	Surveyed	Surveyed	Surveyed
	PRSW07		10	626635	6232616		Surveyed	Surveyed	Surveyed	Surveyed	Surveyed
	PRSW08		10	626969	6232228		Surveyed	Surveyed	Surveyed	Surveyed	Surveyed
	PRSW09		10	627381	6231920		Surveyed	Surveyed	Active Construction	Active Construction	Active Construction
	PRSW10	No	10	617729	6232813				Surveyed	Redundant	Redundant
	PRSW11	Peace River Transect 3	10	619709	6232467				Surveyed	Surveyed	Surveyed
	PRSW12		10	620706	6232643				Surveyed	Surveyed	Surveyed
	PRSW13		10	621282	6232572				Surveyed	Surveyed	Surveyed
	PRSW14		10	622910	6232747				Surveyed	Surveyed	Surveyed
	PRSW15		10	622118	6232805					Surveyed	Surveyed
	PRSW16	Peace River Transect 4	10	619462	6232003					Surveyed	Surveyed
	PRSW17		10	618963	6231942					Surveyed	Surveyed
	PRSW18		10	618468	6232038					Surveyed	Surveyed
	PRSW19		10	617978	623215					Surveyed	Surveyed
	PRSW20		10	617429	6232291					Surveyed	Surveyed
	PRSW21		10	616965	6232496					Surveyed	Surveyed
	PRSW22		10	616559	6232794					Surveyed	Surveyed
	PRSW23		10	616002	6233031					Surveyed	Surveyed
	PRSW24	Peace River Transect 5	10	613099	6235624					Surveyed	Surveyed
	PRSW25		10	612727	6236012					Surveyed	Surveyed
	PRSW26		10	612220	6236478					Surveyed	Surveyed
	PRSW27		10	611697	6236730					Surveyed	Surveyed
	PRSW28		10	610982	6236991					Surveyed	Surveyed

Survey Area	Station	Accompanying Transect	UTM Coordinates			Survey Year					
			Zone	Easting	Northing	2016	2017	2018	2019	2020	2021
	PRSW29	No	10	597439	6231064					Surveyed	Not surveyed. Site not within Headpond Area.
	PRSW30	No	10	598178	6232247					Surveyed	Not surveyed. Site not within Headpond Area.
	PRSW31	No	10	600081	6233281					Surveyed	Surveyed
	PRSW32	No	10	602255	6233351					Surveyed	Surveyed
	PRSW33	No	10	606725	6234293					Surveyed	Surveyed
	PRSW34	No	10	607721	6235469					Surveyed	Surveyed
	PRSW35	No	10	609368	6236803					Surveyed	Surveyed
	PRSW36	No	10	598278	6232689					Surveyed - Called HRSW04 in the field.	Not surveyed. Site not within Headpond Area.
Moberly River	MRSW01	No	10	628328	6230312				Surveyed	Active Construction	Active Construction
Bear Flats	BFSW01	Bear Flats Transect	10	611077	6237965				Surveyed	Surveyed	Surveyed
	BFSW02		10	611561	6237465				Surveyed	Surveyed	Surveyed
	BFSW03		10	612031	6237301				Surveyed	Surveyed	Surveyed
	BFSW04		10	612483	6237076				Surveyed	Surveyed	Surveyed
	BFSW05		10	612839	6236812				Surveyed	Surveyed	Surveyed
Cache Creek	CCSW01	Cache Creek Transect	10	607653	6239245				Surveyed	No Access due to high water levels	Active Construction
	CCSW02 / CCSW02B		10	608345	6239034				Surveyed	Surveyed	Active Construction
	CCSW03		10	608729	6238798				Surveyed	Surveyed	Active Construction
	CCSW04		10	609093	6238402				Surveyed	Surveyed	Active Construction
	CCSW05		10	609318	6237699				Surveyed	Surveyed	Active Construction
	CCSW06	No	10	609057	6237557					Surveyed	Active Construction
	CCSW07	No	10	608790	6237457						Established to replace CCSW06
Halfway River	HRSW01 / HRSW01-2	No	10	595783	6231568				Surveyed	Surveyed	Not surveyed. Site not within Headpond Area.
	HRSW02	No	10	596262	6231237				Surveyed	Active Construction	Active Construction
	HRSW03	No	10	595800	6231049				Surveyed	Active Construction	Active Construction
Lynx Creek	LCSW01	No	10	571702	6214556					Surveyed	Not surveyed. Site not within Headpond Area.
	LCSW02	No	10	572132	6214265					Surveyed	Not surveyed. Site not within Headpond Area.

Footnotes:

General - Green cell indicates the site was surveyed. Red cell indicates the site was not surveyed

* Surveys of the mitigiation areas will be performed again when the reservoir has been inundated or when there are substantial land use changes or habitat modifications.

APPENDIX C
PROJECT QUALIFIED ENVIRONMENTAL PROFESSIONALS

Name and Affiliation	Project Role
Jeff Matheson, M.Sc., R.P.Bio. Tetra Tech Canada Inc.	Project Manager, Report Reviewer
Elyse Hofs, B.Sc., Dipl.T., B.I.T. Tetra Tech Canada Inc.	Field Data Collection, Data Entry, Report Author
Claudio Bianchini, R.P.Bio. Bianchini Biological Services	Field Data Collection

APPENDIX D
LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

NATURAL SCIENCES

1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the "Professional Document").

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1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with SEES JV with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for SEES JV to properly provide the services contracted for in the Contract, SEES JV has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

1.5 INFORMATION PROVIDED TO SEES JV BY OTHERS

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.

1.6 GENERAL LIMITATIONS OF DOCUMENT

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.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

SEES JV is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

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.