BC Hydro
Power smart

Vegetation and Wildlife Mitigation and Monitoring Plan 2019 Annual Report

Site C Clean Energy Project

March 31, 2020

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1.0 Introduction

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

The purpose of this annual report is to describe the mitigation and monitoring measures that are described in the VWMMP and were implemented in 2019.

2.0 Objective and Scope

The objective of the VWMMP Annual Report (the Report) is to describe the mitigation and monitoring measures implemented in 2019 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
10.3	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 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.	Section 6.3.2

FDS Condition	Condition	Report Section
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
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	2015 Annual Report (Section

FDS Condition	Condition	Report Section
	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	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:	
	Invasive Species	
	• Surveys of existing invasive species populations	2015 Annual Report (Section

EAC Condition	Condition	Report Section
	prior to construction.	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 implement an experimental rare plant translocation program in consultation with MOE using the BC MOE's Guidelines for Translocation of Plant	Section 7.1.6

EAC Condition	Condition	Report Section
	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 include at least the following:	

EAC Condition	Condition	Report Section
	• 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 enhancement and possible compensation programs.	7.5.3

EAC Condition	Condition	Report Section
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 the following measures, which must be described in the Vegetation and Wildlife Mitigation and Monitoring Plan.	Section 7.7

EAC Condition	Condition	Report Section
	The Vegetation and Wildlife Mitigation and Monitoring Plan must include the following compensation measures:	
	• 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 7.7.1
	• 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 7.7.2
	• Following rock extraction at Portage Mountain, creation of hibernating and roosting sites for bats.	Section 7.7.3 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 7.7.4
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 Plan must be developed by a QEP.	Section 4.0
	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

EAC Condition	Condition	Report Section
	• 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 2019 is provided below.

3.1 Canadian Wildlife Services

In 2019 BC Hydro continued to consult with the Canadian Wildlife Service (CWS) during plan development and implementation. Consultation with CWS in 2019 continued primarily regarding the Bat Mitigation and Monitoring Plan and various migratory bird mitigation and monitoring plans. 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 (MOE) 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 ten (10) times between January and December 2019 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 2019.

Table 3. Status of Schedule A Program Areas as of 31 December 2019.

Program Area	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	Status
10. Cavity Nesting Species	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
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
11.1. Rare Plants - Translocation	In progress

4.0 Qualified professionals

The Qualified Professionals involved in the development and implementation of vegetation and wildlife mitigation and monitoring programs in 2019 are listed in Table 4.

Table 4. Qualified Professionals involved in development and implementation of programs in 2019

Qualified Professional	Area of Work
Brock Simons, M.Sc., R.P.Bio. BC Hydro	Vegetation and Wildlife
Lisette Ross, M.Sc., P.Biol., Native Plant Solutions	Wetland Function Assessment, Wetland Monitoring Program
Lynn Dupuis, M.Sc.,P.Biol., Native Plant Solutions	Wetland Function Assessment, Wetland Monitoring Program
Llwellyn Armstrong, M.Sc., Ducks Unlimited Canada	Statistician - Wetland Function Assessment, Wetland Monitoring Program
Melissa Mushanski, M.Sc., Native Plant Solutions	Wetland Monitoring Program
Justin Vitt, Native Plant Solutions	GIS – Wetland mapping, Wetland Monitoring Program
Natasha Bush, B.Sc. P.Ag., EcoLogic Consultants Ltd.	Experimental Rare Plant Translocation, Wetland Monitoring Program
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 and Wetland Monitoring Program
Ryan Durand, M.Sc. R.P.Bio., EcoLogic	Experimental Rare Plant Translocation, Wetland

Qualified Professional	Area of Work
	Monitoring Program and Hwy 29
Jason Jones, Ph.D. R. P. Bio., P. Biol., EcoLogic	Experimental Rare Plant Translocation, migratory bird monitoring, Wetland Monitoring, Downstream Vegetation Monitoring
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	Pre-construction Rare Plant Surveys and Experimental Rare Plant Translocation
Jeff Matheson M.Sc., R.P.Bio., P.Biol., Tetra Tech Canada Inc.	Breeding bird and raptor monitoring
Claudio Bianchini, R.P. Bio., Bianchini Biological Services	Breeding bird and raptor monitoring
Camille Roberge, B.Sc., E.Pt., Tetra Tech Canada Inc.	Breeding bird and raptor monitoring
Elyse Hofs, B.Sc., Dipl.T., Tetra Tech Canada Inc.	Breeding bird and raptor monitoring
Damian Power, R.P.Bio., Wolfhound Wildlife Services	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
Beth Boyce, M.Sc., EPt., Hemmera	Cavity nesting bird mitigation, waterbird monitoring, Portage Mountain bat monitoring, bald eagle monitoring
Ryan Gill, R.P.Bio., Hemmera	Swallow and kingfisher monitoring, cavity nesting bird monitoring
Brian Paterson, B.Sc., R.P.Bio, Hemmera	Bald eagle monitoring
Kyle Routledge, B.Sc., R.P.Bio, Hemmera	Waterbird monitoring
Toby St. Clair, M.Sc., Hemmera	Waterbird monitoring, western toad and gartersnake monitoring, swallow and kingfisher monitoring
Felix Martinez-Nunez, M.Sc., R.P.Bio, Hemmera	Waterbird monitoring, Portage Mountain bat monitoring, gartersnake monitoring, cavity nesting bird monitoring
Jay Brogan M.Sc., R.P.Bio., Hemmera	Waterbird monitoring, western toad and gartersnake monitoring, bald eagle monitoring, cavity nesting bird monitoring
Dan Webster, B.Sc., P.Ag., R.P.Bio., P.Biol., Eco-Web Ecological Consulting Ltd.	Portage Mountain bat monitoring, bald eagle monitoring
Jodi Fleming, B.Sc., P.Ag., R.P.Bio, P.Biol Eco-Web Ecological Consulting Ltd.	Waterbird monitoring, Portage Mountain bat monitoring, western toad monitoring, gartersnake monitoring
Chris Coxson, B.Sc., A.Ag Eco-Web Ecological Consulting Ltd.	Waterbird monitoring, Portage Mountain bat monitoring, western toad and gartersnake monitoring
Valerie Schmidt, B.Sc., BIT	Waterbird monitoring, Portage Mountain bat

Qualified Professional	Area of Work
Eco-Web Ecological Consulting Ltd.	monitoring, western toad and gartersnake monitoring
Dan Daley, B.Sc., BIT Eco-Web Ecological Consulting Ltd.	Waterbird monitoring, Portage Mountain bat monitoring, and cavity nesting bird 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 2019. 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 2019

Condition Number	Program to be Implemented	Planned Implementation Year	Planned Inclusion in Annual Report
FDS 9.3	Nest Monitoring	2021	2021
FDS 10.3.3	Littoral zone enhancements	2021	2021
	Riparian plantings	TBD	TBD
EAC 16	Construction of artificial snake hibernacula	2020	2020

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 2019 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 within are present in areas scheduled to be cleared. The protocol also describes the approach for

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

determining appropriate situation and species-specific disturbance setback buffers to be applied around locations where nests are likely to be present.

In 2019, pre-clearing nesting activity surveys were completed between April and August along the planned Highway 29 realignment, as well as and various other locations where small-scale clearing was required. If active or suspected nest areas were identified, protective buffers were established around the nest area, as determined by a Qualified Environmental Professional (QEP).

After each area was surveyed, a free-to-work survey report was produced. The report maps the area surveyed and indicates which areas were free-to-work, any conditions placed on work activities, location of buffered nests and the expiry date of the free-to-work period.

6.1.2 Condition 9.2

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

An initial construction schedule was submitted to CEAA on 17 October 2014. The most recently revised construction schedule, updated in 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 in 2016, 2017, 2018 and 2019 as part of the monitoring program. The Breeding Bird Follow-up Monitoring – Songbirds 2019 Annual Report can be found in Appendix 2.

6.1.3.2 Common nighthawk surveys

Common Nighthawk is designated as Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), Threatened under Schedule 1 of the Species at Risk Act (SARA), and listed as Yellow (secure) in British Columbia. Common nighthawk surveys were conducted in 2010 and 2012 in support of the EIS. Surveys are again occurring 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 2019 Annual Report can be found in Appendix 3.

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 can be found in Appendix 4.

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'). Waterbirds 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 in 2018 or 2019. The Waterbirds Follow-up Monitoring 2019 Annual Report can be found in Appendix 5.

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 bottom of the guy wires are marked with bright yellow plastic guards, which will increase their visibility, and further reduce risk to birds.

The transmission line has not yet been constructed, but 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 2019 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 2019 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 2019 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 five 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.

  - o Peaceview Pit Fish Habitat Compensation – A borrow pit along Highway 29 that will be flooded when the reservoir is filled, creating littoral fish habitat.
  - o 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.
  - o Hudson's Hope Shoreline Protection Enhancement - A 2.6 km shoreline protection berm that will incorporate fish habitat features.
- Downstream Fish Habitat Offsets
  - o River Road Rock Spurs - The rock spurs will convert areas of deep, fast flowing water to calm water habitats.
  - o 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 seven 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].

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. No new properties were added to the program in 2019.

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.*

BC Hydro has not been made aware of any current use of its fee simple lands for traditional purposes by Indigenous peoples. The purchase and retention, by BC Hydro, of fee simple lands is 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.

[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

6.2.6 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 2019 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 2019 in accordance with the requirements of FDS condition 11.9. For context, the complete requirements of FDS condition 11 are shown 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 2017, BC Hydro and Ducks Unlimited Canada identified a candidate wetland for restoration on private land at Golata Canyon Ranch. In 2019, a conservation covenant was approved by the Agricultural Land Commission (ALC) and secured to the land title. Also 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.

At the suggestion of Indigenous Groups, BC Hydro continues to focus efforts on finding opportunities for wetland protection and enhancement on BC Crown lands, so that benefits can be realized for use of those lands and resources for traditional purposes. Although numerous potential candidate sites have been evaluated with Ducks Unlimited Canada, no appropriate site for wetland creation or enhancement has yet been identified.

A wetland monitoring program has been developed through consultation with and review by MoE, 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 spring and fall waterfowl and shorebird surveys conducted in 2019). 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.

As in 2018, the priority for the wetland monitoring program in 2019 was to sample wetland habitats for which baseline data may be insufficient, and which are likely to soon be impacted by clearing or construction activities. Wetland mapping was refined for all wetlands surveyed. The wetland monitoring program annual report for 2019 is Appendix 6.

6.3.3 Condition 11.4.3

This section summarizes actions taken in accordance with the following requirement of Condition 11.2: *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 as a result 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 likely to be impacted by the transmission line RoW. See Section 6.3.2 and Appendix 6 for a description of the wetland monitoring program that was implemented in 2019.

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*.

Wetland function will be maintained for wetlands that will not be permanently lost through timing of works (e.g. winter to minimize ground disturbance), maintenance of hydrology through the installation of culverts during road construction (see Section 7.5.1.2), and approaches to minimize impacts to wetlands through careful construction practices (see Section 6.3.1). The Wetland Function Assessment tool and 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 the plan for monitoring and evaluating changes to baseline 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 the 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 MOE.

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 2019 in accordance with the requirements of FDS condition 16.6.

For context, the complete requirements of FDS condition 16 are shown 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 2019 the following measures were implemented to mitigate effects on species at risk and at-risk and sensitive ecological communities and rare plants:

- Completion of pre-construction rare plant surveys focussed access roads on the south side of the Peace River, and on segments of the Highway 29 realignment corridor on the north side of the River (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 2019 rare plant data on 22 July 2019 and 14 February 2020, and posted for contractors to access for planning purposes;
- Further development and implementation of the Experimental Rare Plant Translocation program in consultation with MOE, 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 2019 in areas of the planned Project footprint not previously surveyed. The resultant data served as inputs to the final design of access roads, helped inform mitigation to avoid or minimize impacts to rare plant occurrences near construction sites, and identified 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 2019 pre-construction rare plant survey report, which includes methods and results from surveys conducted in 2015-2019, is Appendix 7.

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

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, MOE and CWS through the VWTC, and can be found in Appendix 6 of the 2017 Annual Report. 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 MOE, FLNRORD and CWS through the VWTC (see Section 7.5.1 and 7.5.2). Collection of seeds began in 2017. In 2019, propagule collection continued, along with translocation implementation (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 2019. 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 2019 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 the hibernacula at Portage Mountain that may be used by little brown myotis and northern myotis, BC Hydro redesigned the 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 2019, which included blasting for haul road construction and aggregate production. That monitoring 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).

In addition, BC Hydro is conducting year-round monitoring of bat use 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;

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

- 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.

No apparent effects of quarry activity on bats has yet been detected by the monitoring program.

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 and 2019. Western toad is federally listed as Special Concern under COSEWIC, SARA Schedule 1 – Special Concern, but is considered not at risk in BC. The 2019 annual report of this program is in Appendix 8.

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 2019 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. A technical memorandum summarizing program activities in 2019 is Appendix X.

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 2019. The following documents were reviewed to identify changes to rankings of species documented in the LAA during baseline surveys[5]:

- 2019 BC Conservation Status Rank Review and Changes, for vascular and non-

[5] Ministry of Environmental Protection and Sustainability. 2018. 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: 14 March 2019.

Vascular Plants; and

- 2019 BC Conservation Status Rank Review and Changes, invertebrate and vertebrate animals.

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 are 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 2019 the conservation status of nine species with potential to occur in the Site C Project area changed (Table 6). All changes for previously listed species represented reductions in conservation status, largely due to the results of regional rare plant surveys (see Section 7.2.1 and Appendix 9 of the 2017 Annual Report) showing that rare plants identified during Site C baseline surveys are not as rare as previously believed. In 2019, the conservation status of one species changes from Red to Blue, and the status of seven species changed from Blue to Yellow. The formerly identified species *Erigeron pacalis* (Peace Daisy) has now been deleted from the B.C. Conservation Data Centre’s list because the original occurrence is believed to have been misidentified, and no other occurrences have been documented despite the considerable search effort expended (see Appendix 9 of the 2017 Annual Report).

Table 6. BC conservation status rank for plant species at risk occurring in and around the Site C Project Area

Scientific Name	Common Name	2017 Status	2018 Status	2019 Status
Antennaria neglecta	field pussytoes	Blue	Yellow	Yellow
Avenula hookeri	spike-oat	Blue	Yellow	Yellow
Botrychium crenulatum	dainty moonwort	Blue	Yellow	Yellow
Calamagrostis montanensis	plains reedgrass	Blue	Yellow	Yellow
Carex backii	Back's sedge	Blue	Blue	Yellow
Carex heleonastes	Hudson Bay sedge	Blue	Yellow	Yellow
Cirsium drummondii	Drummond's thistle	Blue	Blue	Yellow
Epilobium halleanum	Hall's willowherb	Blue	Yellow	Yellow
Glyceria pulchella	slender mannagrass	Blue	Yellow	Yellow
Lempholemma polyanthes	mourning phlegm	Blue	Yellow	Yellow
Leptogium intermedium	fourty-five vinyl	Blue	Yellow	Yellow
Malaxis brachypoda	white adder's-mouth orchid	Blue	Yellow	Yellow
Phaeophyscia kairamoi	five o'clock shadow	Blue	Yellow	Yellow
Physcia biziana	frosted rosette lichen	Blue	Blue	Yellow
Physcia stellaris	immaculate rosette lichen	Blue	Blue	Yellow
Ramalina sinensis	threadbare ribbon lichen	Blue	Blue	Yellow
Schizachyrium scoparium var. scoparium	little bluestem	Blue	Blue	Yellow
Silene drummondii var. drummondii	Drummond's campion	Blue	Yellow	Yellow
Sphenopholis intermedia	slender wedgegrass	Blue	Yellow	Yellow
Stuckenia vaginata	sheathing pondweed	Blue	Yellow	Yellow
Usnea cavernosa	pitted beard	Blue	Yellow	Yellow
Artemisia herriotii	Herriot's sage	Red	Blue	Blue
Carex sprengelii	Sprengel's sedge	Red	Blue	Blue
Carex torreyi	Torrey's sedge	Red	Red	Blue
Chrysosplenium iowense	Iowa golden-saxifrage	Red	Blue	Blue
Drosera linearis	slender-leaf sundew	Red	Blue	Blue
Erigeron pacalis	Peace Daisy	Red	Red	[deleted]

Scientific Name	Common Name	2017 Status	2018 Status	2019 Status
Geum triflorum var. triflorum	old man's whiskers	Red	Yellow	Yellow
Leptogium tenuissimum	birdnest vinyl	Red	Yellow	Yellow
Pedicularis parviflora	small-flowered lousewort	Red	Blue	Blue
Penstemon gracilis	slender penstemon	Red	Blue	Blue
Polypodium sibiricum	Siberian polypody	Red	Blue	Yellow
Potentilla pulcherrima	pretty cinquefoil	Red	Yellow	Yellow
Ranunculus rhomboideus	prairie buttercup	Red	Blue	Blue
Rorippa calycina	persistent-sepal yellowcress	Red	[not tracked]	[not tracked]
Fulgensia subbracteata	creeping sulphur	[not tracked]	Red	Red

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 2019. In addition, no recovery strategies for federally listed species likely to occur within the Site C Project Area were released in 2019.

In 2019, the BC Conservation Data Centre (CDC) listing did not change for any wildlife species that occur in the LAA.

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 2019 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 2019:

- 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;

- In 2018, BC Hydro utilized the Main Civil Works contractor's onsite wash station to keep vehicles free of dirt and invasive plants. Use of that wash station will continue until a permanent wash station is constructed. Construction and commissioning of the permanent wash station was completed in October of 2019 and it will be operational for 2020.
- 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 2019 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 2019 rare plant data on 22 July 2019 and 14 February 2020 and posted in the data room for contractors to access in their planning.

The 2019 rare plant data was submitted to Jennifer Penny, Program Botanist at the BC Conservation Data Center, MOE, on 29 January 2020.

Voucher specimens were submitted to the Herbarium at the University of British Columbia in the fall of 2019 and winter of 2019/2020.

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 2019 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 in which 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, through 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 where feasible.

A Tufa Seep will be partially impacted due to the construction of the Hudson's Hope shoreline protection berm, which is planned to occur 2020-2022. Impacts will be reduced through design, and fencing is planned to protect areas of the tufa seep that can be avoided.

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 MOE, FLNRORD and CWS through the VWTC, and is described in detail in Section 7.5.1. Collection of seeds began in 2017. In 2019, propagule collection continued, along with translocation implementation. A technical memorandum summarizing the results and recommendations arising from the 2019 field program is in Appendix 10.

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, MOE 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 MOE 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 forums. BC Hydro hosted an environmental forum with Indigenous Groups in Fort St. John on 13 November 2018, which was focussed on mitigation and compensation for wetlands and rare plants.

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 6.3.2 for a summary of wetland mitigation plan development.

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), including 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; however, because up to three wetland types (and potentially more than three wetlands) can be found within a TEM polygon, the TEM habitat mapping's usefulness for characterizing wetlands that may be affected is limited.

Detailed wetland mapping was created by BC Hydro to be a finer scale wetland mapping inventory 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 2019 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 2019 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 out-planting; and
- the field of plant translocation based on the findings from the seeding, propagation, out-planting, management, and monitoring measures.

The primary objective of the ERPT is to establish new 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 the creation of the reservoir).
2. Document the survival of the translocated rare plants through population monitoring at re-location sites.
3. Manage translocated populations for seven years after translocation to maximize plant survival and fitness.
4. Improve the theory and practice of rare plant translocation, and increase knowledge of the biology and ecology of targeted rare plant species.

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

The results of the study will be made publically 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 2019 is presented in Appendix 10.

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

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 2020).** 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 2021).** 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 includes 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. Through the pre-treatment and stratification process, seeds are being treated to simulate the relevant natural conditions for breaking seed dormancy and initiating germination. Seeds that do not require stratification are being 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.

[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.

4. **Translocation implementation (2018 to 2021).** The detailed methods for translocation implementation are being refined based on data collected during field activities. Translocation implementation includes preparation at pre-translocation sites 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 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 out-planting occurred in September 2018. Additional planting was completed in the spring of 2019 and planting is also scheduled for the spring and/or fall of 2020. 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 2022).** Post-translocation care, maintenance, and monitoring commence immediately after each translocation event is completed. Post-translocation plant care and site management assess the survival of translocated populations and address factors affecting the survival or health of the translocated plants. Monitoring the success or failure of the methods will assist in identifying opportunities for improvement within an adaptive management framework. The first four 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 thus require more active management. Monitoring the success or failure of the methods will assist in identifying opportunities for improvement within an adaptive management framework. Importantly, 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 2019 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 7.5.1, 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. Revision 5 of the CEMP (Section 4.17) specifies 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 conducted, 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 2019 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 Nest boxes for cavity-nesting waterfowl

In 2017, 269 nest boxes were constructed for cavity nesting bird species. Of these, 76 nest boxes were constructed for waterfowl; 9 for bufflehead, 49 for Barrow’s goldeneye, common goldeneye or hooded merganser; and 18 for common merganser. Also in 2017, 96 nest boxes were installed on the north side of the Peace River on trees and structures on BC Hydro owned and managed lands, and private lands where permission was granted. Of those, 16 nest boxes were designed to be suitable for waterfowl; two for bufflehead, 10 for Barrow’s goldeneye, common goldeneye or hooded merganser; and four for common merganser. No nest boxes were installed in 2018. In 2019, an additional 84 nest boxes were installed on the south side of the Peace River. 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. The remaining 89 nest boxes are planned to be installed in spring 2020.

Monitoring of nest boxes installed in 2017 is now planned to begin in the breeding season of 2020 (May to July). Since the nest boxes were installed in different years, monitoring of nest boxes will be staggered. Boxes installed in 2019 are planned to be monitored in 2021, and boxes installed in 2020 are planned to be monitored in 2022 (as well as nest boxes from 2017).

7.7.2 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.

7.7.3 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 hibernacula entrances 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 2019, which included blasting for haul road construction and aggregate production. The monitoring 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). 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 is constructing and installing 120 roost boxes and one large bat house in suitable habitat near the future reservoir and dam site. In 2018, 60 bat roost boxes were installed. In 2019, 54 bat boxes were installed.

7.7.4 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 were created within the dam site area in 2016. An additional 31 CWD piles were created for fisher along the transmission line in 2018, and 33 in 2019. Signs were also installed at existing CWD piles indicating that they were designated fisher habitat to prevent their inadvertent disturbance by construction activities.

In addition to CWD piles, BC Hydro is also constructing and installing 88 fisher den boxes to help mitigate the loss of denning habitat due to reservoir clearing. In 2018, BC Hydro installed 10 den boxes on the south side of the Peace River near the Moberly River. In 2019, BC Hydro installed an additional 39 fisher den boxes on the south side of the Peace River.

7.8 EAC Condition 19

This section of the annual report summarizes the programs implemented in 2019 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 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[9]).

7.9 EAC Condition 21

This section of the annual report summarizes the programs implemented in 2019 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 2019. A summary of the methods and results of bald eagle nest monitoring in 2019 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 2019 Annual Report can be found in Appendix 5.

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 2019 Annual Report can be found in Appendix 2.

7.9.4.2 Ground nesting raptors

Ground nesting raptor surveys in 2019 were conducted at six cleared portions of the Site C reservoir along the Peace River and Highway 29 (Bear Flats area). Ground nesting raptor surveys were completed up to four times per site over May and June 2019 to capture early, middle, and late stages of their breeding season. The ground nesting raptor monitoring 2019 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 2019 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 2019 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 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.

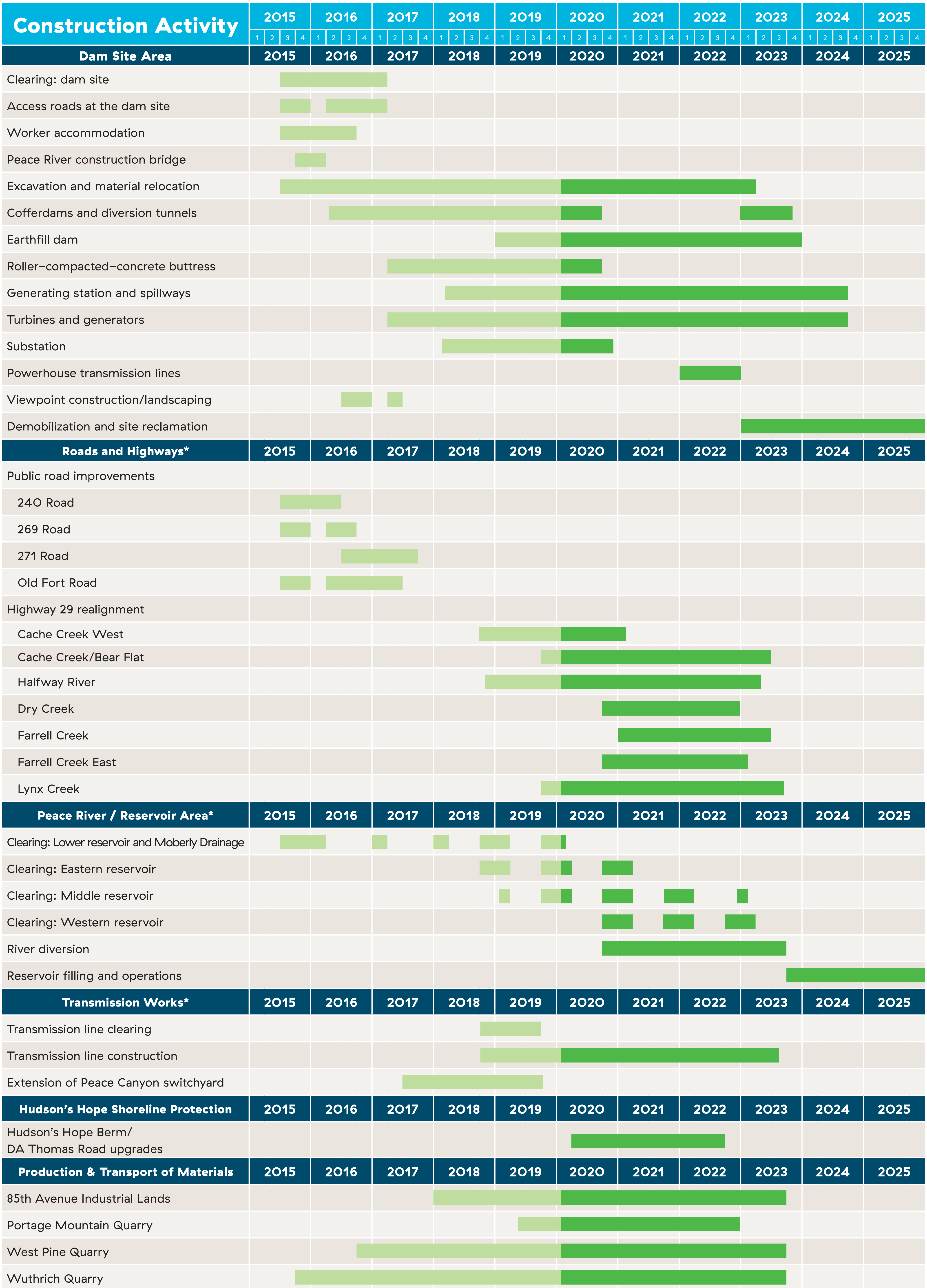
FLNRORD is in the process of identifying appropriate lands for moose winter range as mitigation for that expected to be impacted by the Project. BC Hydro has provided $10,000 to FLNRORD to support the Indigenous consultation necessary to identify and protect appropriate moose winter range.

Appendices

Appendix 1. Site C Clean Energy Project Construction Schedule

Site C Construction Schedule

February 2020
BCH20-176



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 2019 Annual Report

Site C Clean Energy Project
Breeding Bird Follow-up Monitoring - Songbirds
2019 Annual Report

PRESENTED TO

BC Hydro and Power Authority

MARCH 30, 2020
ISSUED FOR USE
FILE: 704-ENV.VENV03095-01.SONG-2019

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

Site C Clean Energy Project Breeding Bird Follow-Up Monitoring – Songbirds
2019 Annual Report

FILE: 704-ENV.VENV03095-01.Song-2019
DECEMBER 20 2019

PRESENTED TO

Site C Clean Energy Project
BC Hydro and Power Authority
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FILE: 704-ENV.VENV03095-01.SONG-2019

Karla Langlois, B.Sc., P.Biol. **2020-03-20**
Senior Biologist

EXECUTIVE SUMMARY

Saulteau EBA Environmental Services Joint Venture completed breeding bird point count surveys in the area of BC Hydro and Power Authority's Site C Clean Energy Project in spring and summer 2019. The surveys were part of BC Hydro's Breeding Bird Follow-up Monitoring Program. The breeding birds 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. Surveys were again conducted in 2016, 2017, 2018 and 2019 as part of the follow-up monitoring program. The purpose of this report is as follows:

- Describe the songbird surveys conducted in 2019 (survey information from previous years has already been reported in other annual reports); and
- Analyze the data collected since 2006 to provide a measure of abundance, occupancy or incidence (depending on the characteristics of the data) for each species and by habitat.

In 2019, songbird surveys were conducted primarily in the western portion of the reservoir footprint, from the Halfway River west to Hudson's Hope, at 72 locations. Each station was surveyed twice except for two stations that could not be accessed a second time due to access restrictions. Songbird surveys have been conducted at 2,267 plot locations (4,081 surveys) since 2006. Surveys in all years utilized standardized point counts.

Density and occupancy models were used to describe distribution and abundance of songbirds by habitat in the Peace River valley upstream of the Pine River. If a density model could not be fit for an individual species due to insufficient observations per habitat type, then an occupancy model was used. If an occupancy model could not be fit, then the counts across all surveys for each species were summed and presented by habitat.

There have been 104 songbird species detected during point counts since 2006, including 11 species listed provincially or federally as at-risk. Density models could be fit for 36 of the 104 songbird species. Occupancy models could be fit for 39 species. A habitat model could not be fit for the remaining 20 songbird species detected during songbird surveys due to insufficient observations per habitat type.

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APPENDICES

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 2019. The surveys were part of BC Hydro's Breeding Bird Follow-up Monitoring Program (Volume 2, Section 14 in BC Hydro 2013).

The breeding birds 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 [1]. Songbird baseline surveys were conducted in 2006, 2008, 2011 and 2012. Surveys were again conducted in 2016, 2017, 2018 and 2019 as part of the follow-up monitoring program. The purpose of the surveys is as follows:

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.

With the completion of surveys in 2019, the reservoir footprint has been intensively surveyed since 2006 and there are few remaining areas that have not been surveyed. Portions of the reservoir have already been cleared and clearing will continue for the next 2-3 years. Given these factors, the monitoring program is at an appropriate point to complete a comprehensive analysis of all breeding bird data collected since 2006.

The purpose of this report is to do the following:

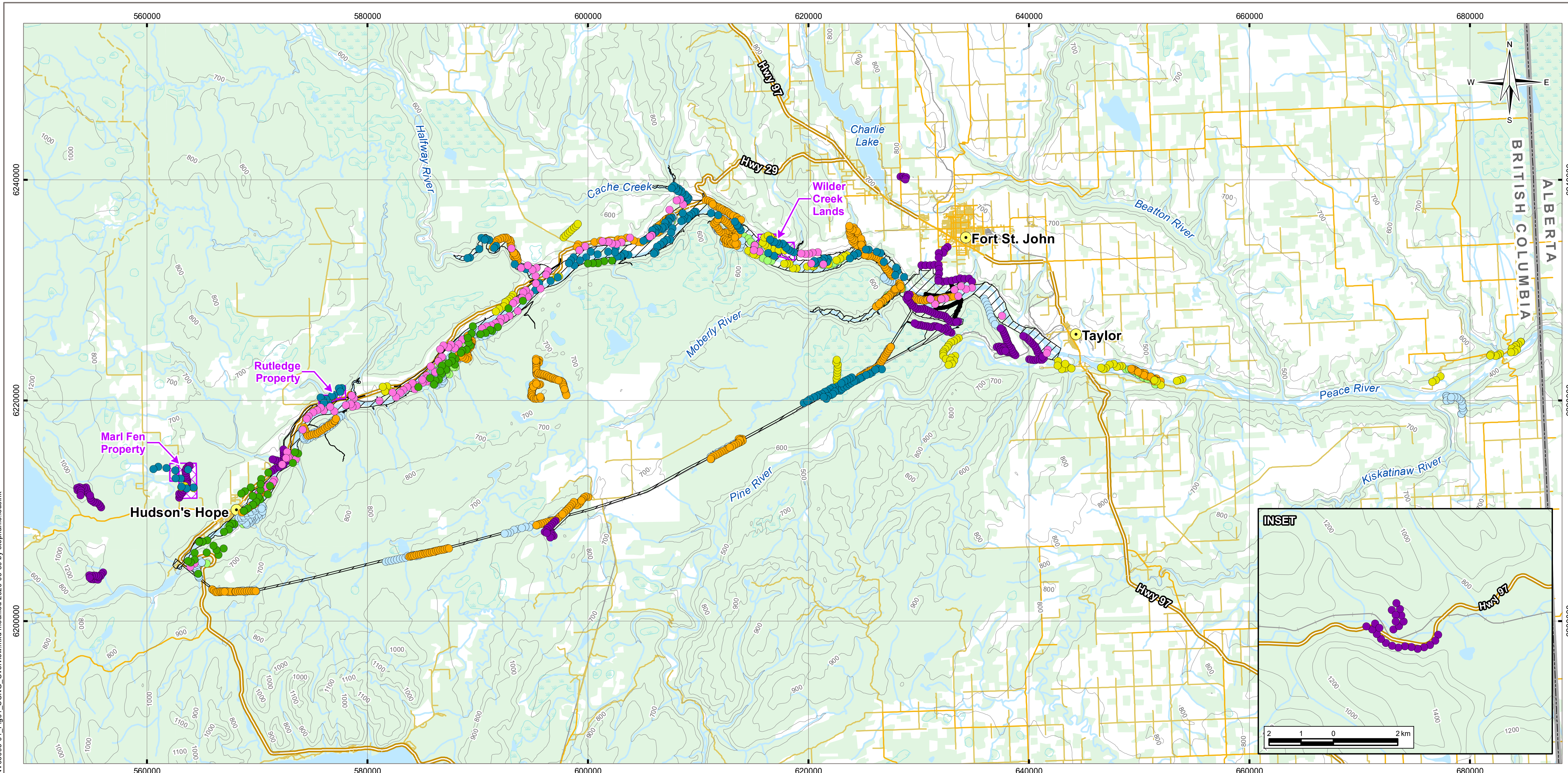
- Describe the songbird surveys conducted in 2019 (survey information from previous years has already been reported in other annual reports); and
- Analyze the data collected since 2006 to provide a measure of abundance, occupancy or incidence (depending on the characteristics of the data) for each species and by habitat.

2.0 METHODS

2.1 Survey Station Locations

In 2019, songbird point count surveys were primarily conducted in the western portion of the reservoir footprint, from the Halfway River west to Hudson's Hope, though some surveys were completed in other areas in habitats that had not been well surveyed in the past (Figure 1). Songbird surveys were conducted at 72 locations in 2019 (Table 1, Figure 1 and Appendix A). Stations were surveyed twice in 2019 except for two stations that could only be surveyed once due to access restrictions.

[1] Woodpeckers and Common Nighthawk are also included under BC Hydro's Breeding Bird Follow-up Monitoring Program, though separate surveys were conducted for each and results of those surveys are reported elsewhere.



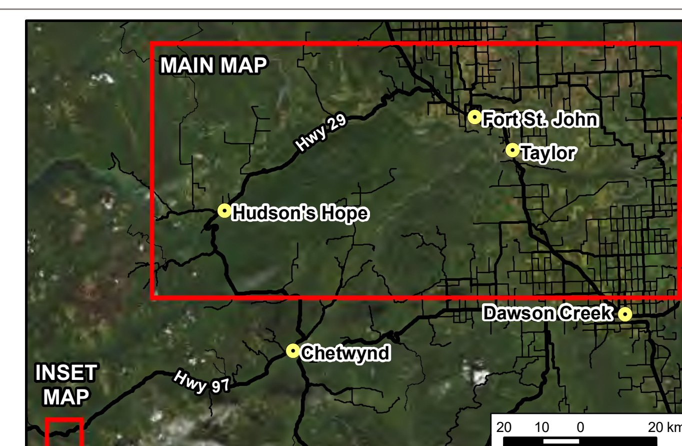
LEGEND

Songbird Survey Locations

Survey Year

- 2006
- 2008
- 2011
- 2012
- 2016
- 2017
- 2018
- 2019

- 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 2019 ANNUAL REPORT

Songbird Survey Locations

PROJECTION	DATUM
UTM Zone 10	NAD83

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

CLIENT

TETRA TECH

FILE NO.
VENV03095-01_Fig01_SONG_Overview.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	YL	JM	0

DATE	PROJECT NO.
March 30, 2020	ENV.VENV03095-01

Figure 1

Surveys in previous years were located throughout the reservoir footprint, in the dam site area, the Peace River valley outside the footprint, the transmission line area south of the Peace River valley and in other parts of the region (Figure 1, Table 2). Stations in 2016, 2017 and 2018 were generally surveyed twice; several stations in each year could not be surveyed a second time due to access restrictions. Point count stations surveyed between 2006 and 2011 were surveyed one to four times in each of those years.

Table 1. Number of songbird point count stations and surveys conducted from 2006 to 2019.

Survey Year	Stations	Surveys
2006	307	478
2008	393	785
2011	716	1,077
2012	243	740
2016	143	275
2017	179	358
2018	115	226
2019	72	142
Total	**2,168**	**4,081**

Table 2. Number of songbird point count stations and surveys conducted from 2006 to 2019 relative to the project footprint and the Peace River valley.

Location	Stations	Samples
Peace River valley, in footprint	724	1,325
Peace River valley, outside footprint	782	1,490
Footprint outside of valley	257	431
Other areas	405	836
Total	**2,168**	**4,081**

Songbird survey station locations were stratified by habitat. The specific approach to habitat stratification in 2019 was the same as the approach used in 2017 and 2018. Terrestrial Ecosystem Mapping (TEM) developed for the EIS (Hilton et al., 2013) was used as the primary habitat base. Forty-one ecosystem types (site series/map codes) and seven structural stages were mapped in the project footprint. Site series/map codes and structural stages were mapped together to form ecosystem units; 95 ecosystem units were mapped in the footprint and 151were mapped in the region. The TEM units provide habitat mapping that is too fine-scale to effectively stratify sampling because there are too many different ecosystem units to achieve an adequate number of samples in each for analysis. To address this, an intermediate-scale habitat classification was developed by combining similar ecosystem units based on dominant vegetation and stand age to form 20 habitat classes (listed in Section 2.3). The fine-scale TEM ecosystem units are nested within the intermediate-scale habitat classes to form a hierarchical classification system. Both levels were used to stratify and track sampling. The habitat classes were used to stratify and establish sampling targets. Within each habitat class, the goal was to sample the range of ecosystem units found in each class. Some survey stations were placed outside the project footprint but still within the Peace River valley to allow for surveys within specific habitat types known or expected to occur in the footprint but could not be surveyed due to inaccessibility, uncertain mapped location or small mapped area. Habitat stratification prior to 2017 was done using a broad-scale habitat classification system.

2.2 Point Count Surveys

Songbirds were surveyed in all years using point counts consistent with standards recommended by the Resources Information Standards Committee (RISC 1999). Surveys conducted prior to 2017 utilized a 5-minute point period and a fixed survey radius of 100 m. Beginning in 2017, the survey protocol was modified to include unlimited radius point counts conducted for 10 minutes each. Point counts in 2017, 2018 and 2019 were conducted as unlimited radius point counts with distance-to-detection intervals set at 0-50 m, 51-100 m and >100 m. The unlimited radius distance allows for greater potential for species detection during surveys. The detection distance intervals allow for distance-based estimates of absolute abundance, if that analytical approach is utilized in future analyses. Each point-count survey was conducted over ten minutes (instead of the 5-minute survey period conducted previously) and bird detections were recorded in three intervals: 0-3 minutes, 3-5 minutes and 5-10 minutes. The longer survey period allows for more numerous bird detections. The three time intervals allow for time-of-detection estimates of absolute abundance if that analytical approach is utilized in the future.

Point counts in 2019 were conducted May 31 to June 26. Point counts took place from sunrise to approximately four hours after sunrise. At each station, the surveyor waited one minute upon arriving, 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 bird species 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 of a rare species, date, time, GPS location, gender, behavior and habitat was recorded.

2.3 Habitat Classification and Site-Level Habitat Data Collection

The 151 unique ecosystems units (combination of site series and structural stage) mapped in the region were collapsed in to 20 broader units referred to as bird habitat classes based on dominant vegetation and stand age (Table 3). The dominant bird habitat class mapped using TEM within 100 m of the survey station centre was assigned to each station. The assigned bird habitat class was cross-checked with site-level data to ensure accurate assignment. For some of the analyses, the bird habitat classes were combined and referred to as broad bird habitat classes (Table 3).

Site-level habitat attributes were recorded for each station surveyed in 2019. These data were recorded on a Site Visit form (SIVI; British Columbia Ministry of Forests and Range and British Columbia Ministry of Environment 2010) and included all site and vegetation fields with the exception of soil characteristics. The site-level habitat data can be used at a later date to further describe and define attributes associated with songbird observations, if useful.

Table 3. Bird habitat classes.

Code	Bird Habitat Class	Broad Bird Habitat Class
CSH	Coniferous-shrub	Coniferous
CYF	Coniferous-young forest	Coniferous
CMF	Coniferous-mature forest	Coniferous
DSH	Deciduous-shrub	Deciduous
DYF	Deciduous-young forest	Deciduous
DMF	Deciduous-mature forest	Deciduous
RSH	Riparian-mixed shrub	Riparian forest
RYF	Riparian-mixed young forest	Riparian forest
RMF	Riparian-mixed mature forest	Riparian forest
FBS	Fen/bog-shrub	Wetland
FBT	Fen/bog-treed	Coniferous
WGR	Wetland-graminoid	Wetland
WSH	Wetland-shrub	Wetland
WRI	Wetland-riparian	Wetland
DSG	Grassland-dry slopes	Dry slopes
DSS	Shrubland-dry slopes	Dry slopes
CUL	Cultivated	Cultivated
NVE	Non-vegetated	Non-vegetated
ANT	Anthropogenic	Not used

2.4 Analyses

Use of a statistical model to estimate absolute density (i.e., the number of individuals per hectare) produces the most informative measure of bird abundance but requires sufficient detections for statistical confidence. In cases where a density model cannot be fit to survey data, an occupancy model, based on detection-non-detection of a species over multiple visits to a site, can be used to estimate probability of occurrence in place of density. To obtain the best possible estimate of abundance or occupancy for each detected songbird species, the following hierarchy of options was used when analyzing the data:

1. Density estimate using all bird habitat classes;
2. Density estimate using the broad classification of the bird habitat classes; and
3. Occupancy estimate using the broad classification of the bird habitat classes.

Initial trials showed that option 1 with all bird habitat classes could only be used for the most abundant species, and the broader classification had to be used for all remaining species, regardless of the estimating model used (density or occupancy).

If neither a density or occupancy model can be fit, then the remaining option is to summarize total counts by bird habitat class. This provides an indication of where species detections have been made but there is no accounting for sampling biases since a statistical model could not be used.

Point count stations were typically placed at least 100 m from a habitat edge. Only birds detected within 100 m of the survey station centre were included in the habitat analysis to minimize the inclusion of birds present in adjacent habitats.

For the density and occupancy estimation, only stations located within the Peace River valley and upstream of the confluence of the Pine River with the Peace River were included in the analyses. This was done because songbird data from outside of the Peace River valley or further downstream may not be representative of the songbird community in and around the project footprint and could bias interpretations of habitat associations within the footprint.

2.4.1 Density Estimation

Bird survey counts are an incomplete measure of bird abundance as they do not account for the probability of detecting a species. Measures of absolute bird abundance or density (number per unit area) are preferable to raw count data because they allow for comparisons among species and to other datasets, and better support monitoring and conservation objectives. To estimate absolute bird density from the point count data, the QPAD approach was used (Solymos et al. 2013). The QPAD approach uses statistical offsets to correct for methodology and detectability differences across species and survey times and locations. The offsets can then be used in statistical models to estimate absolute density from the original raw counts. The parameter estimates used to calculate offsets were developed from the Boreal Avian Modelling (BAM) project database that includes over 230,000 survey events (for QPAD version 3) across the Boreal region of North America (Solymos 2016). One of the benefits of using the QPAD approach is it provides a methodology to correct for imperfect detection and estimate absolute density that otherwise would be very complex or impossible, especially in smaller datasets or with species with lower detections.

QPAD provides estimates for two components of detectability: availability for detection (p; based on singing rate) and detectability (q; based on perceptibility as a function of distance). The QPAD model parameter estimates for p and q can be retrieved from the QPAD database according to predictor variables (Table 4). The specific combination of best predictor variables depends on the species. The QPAD approach was developed for boreal birds considered to be singing species that can mostly be detected by auditory cues. QPAD version 3 has parameter estimates for 141 species.

QPAD calculates an offset for each observation given the availability and detectability parameters retrieved from the QPAD database. The offsets together with raw count data can then be used in a model to estimate bird density by bird habitat class. The QPAD estimates are provided as a package in R (R Core Group 2019). The methods used to retrieve the estimates for the Site C songbird data followed those specified in Solymos (2016).

Generalized Linear Mixed Models (GLMMs) were used to estimate absolute density. Bird habitat class and year (to control for differences among survey years) were considered fixed effects and survey station was included as a random effect to account for the repeated measures at each station. Three candidate models were evaluated:

m0: Intercept only (null model);

m1: Bird habitat class; and

m2: Bird habitat class + year.

Table 4. Predictor variables in QPAD used to estimate offsets

Parameter	Predictor Variable [1]	Description and Source Data
Availability (*p*)	Julian Day	The number of days between the date of survey and the start of the year.
	Time Since Local Sunrise	The time of survey since local sunrise, in hours. Source: National Research Council Sunrise/Sunset Calculator.
	Days Since Local Spring	Survey date minus date of average last spring frost. Source: Climate Atlas of Canada (Prairie Climate Centre 2019).
Detectability (*q*)	Tree Cover	Proportion tree cover at survey station. MODIS vegetation cover (Townshend et al. 2019).
	Land Cover (4-class and 2-class)	The Land Cover of Canada classes as two separate variables: a 4-class variable (DecidMixed, Conif, Open, and Wet) and a 2-class variable (Forest, and OpenWet).

[1] The QPAD model also uses quadratic terms (x^2) of the first three variables.

The candidate models were compared using Akaike's Information Criterion corrected for small samples (AIC_c). The bird density model (i.e., model 2 or 3 listed above) with the lowest AIC_c was selected as best. If a density model could not be fit using bird habitat class, then the modelling processes was repeated using the broad bird habitat classes. If a model could not be fit using the broad bird habitat classes, then an occupancy model was used (Section 2.4.2).

All analyses were conducted using the R package glmmTMB (Brooks et al. 2017) in R (R Core Group 2019). Means and confidence intervals were calculated using the R package 'emmeans' (Lenth 2019). When the best model included year, the effect of year was held constant to provide mean density by habitat over all years (the conditional mean).

2.4.2 Occupancy Analysis

Presence-absence data from repeated visits to a site can be analyzed using an occupancy model. An occupancy model simultaneously accounts for both imperfect detection of a species and the probability of occupancy. Occupancy was estimated using the approach of Mackenzie et al. (2002 and 2018) using the 'occu' function in the R package 'unmarked' (Fiske and Chandler 2011). Model variables used for occupancy analysis were broad bird habitat class and three survey-level variables to account for differences in survey timing: year, ordinal day (day of the year) and time since sunrise. Nine candidate models were evaluated:

m0: Intercept only (null model).

m1: Bird habitat class.

m2: Bird habitat class + year.

m3: Bird habitat class + day.

m4: Bird habitat class + time since sunrise.

m5: Bird habitat class + year + day.

m6: Bird habitat class + year + time since sunrise.

m7: Bird habitat class + day + time since sunrise.

m8: Bird habitat class + year + day + times since sunrise.

The candidate models were compared using AIC_c. The occupancy model with the lowest AIC_c was selected as best.

3.0 RESULTS AND DISCUSSION

3.1 Surveyed Habitats

Songbird surveys were conducted in all bird habitat classes, with the largest number of surveys in the most common bird habitat classes deciduous-young, coniferous-mature forest and coniferous-young forest (Table 5).

Table 5. Number of songbird point count stations and surveys by bird habitat class.

Code	Bird Habitat Class	Stations	Surveys
CSH	Coniferous-shrub	23	49
CYF	Coniferous-young forest	278	518
CMF	Coniferous-mature forest	290	547
DSH	Deciduous-shrub	114	231
DYF	Deciduous-young forest	726	1,385
DMF	Deciduous-mature forest	192	312
RSH	Riparian-mixed shrub	62	113
RYF	Riparian-mixed young forest	44	78
RMF	Riparian-mixed mature forest	61	115
FBS	Fen/bog-shrub	55	84
FBT	Fen/bog-treed	35	62
WGR	Wetland-graminoid	45	79
WSH	Wetland-shrub	15	28
WRI	Wetland-riparian	43	75
DSG	Grassland-dry slopes	35	63
DSS	Shrubland-dry slopes	34	72
CUL	Cultivated	79	188
NVE	Non-vegetated	19	32
ANT	Anthropogenic	7	21
Unknown	Unknown	10	30
	Total	**2,167**	**4,081**

3.2 Songbird Detections

There have been 104 songbird species detected during point counts since 2006 (Table 6), though only 95 were detected in the Peace River valley upstream of the Pine River. The most frequently detected species are White-throated Sparrow, Yellow Warbler and Least Flycatcher. Eight species were only detected once in the eight years of survey: Black Swift, Ruby-throated Hummingbird, Calliope Hummingbird, Rufous Hummingbird, Cliff Swallow, Gray-crowned Rosy Finch, Nashville Warbler and Golden-crowned Sparrow. Thirteen provincially or federally listed species have been detected:

- Black Swift
- Ruby-throated Hummingbird
- Olive-sided Flycatcher
- Bank Swallow
- Barn Swallow
- Winter Wren
- Evening Grosbeak
- Canada Warbler
- Connecticut Warbler
- Bay-breasted Warbler
- Cape May Warbler
- Rusty Blackbird
- Baltimore Oriole

Table 6: Songbirds observed during surveys from 2006 to 2019.

Common Name	Code	BC List	COSEWIC/ SARA [a]	Total Detections Over All Surveys									Model Type [b]
				2006	2008	2011	2012	2016	2017	2018	2019	Total Count	
			Number of surveys	***478***	***785***	***1,077***	***740***	***275***	***358***	***226***	***142***	***4,081***	
Mourning Dove	MODO	Yellow	-	-	1	1	-	1	-	-	-	3	Incidence
Black Swift	BLSW	Blue	E / 1-E	-	-	1	-	-	-	-	-	1	Incidence
Ruby-throated Hummingbird	RTHU	Blue	-	-	-	1	-	-	-	-	-	1	Incidence
Calliope Hummingbird	CAHU	Yellow	-	1	-	-	-	-	-	-	-	1	NA
Rufous Hummingbird	RUHU	Yellow	-	-	-	-	-	-	-	1	-	1	Incidence
Belted Kingfisher	BEKI	Yellow	-	8	6	10	4	-	4	1	1	34	Occupancy
Olive-sided Flycatcher	OSFL	Blue	SC / 1-T	13	11	22	1	13	13	2	5	80	Occupancy
Western Wood-Pewee	WWPE	Yellow	-	70	71	65	32	16	33	26	9	322	Density
Alder Flycatcher	ALFL	Yellow	-	25	110	161	89	52	32	44	8	521	Density
Pacific-slope Flycatcher	PSFL	Yellow	-	16	19	27	1	-	3	7	8	81	Occupancy
Yellow-bellied Flycatcher	YBFL	Yellow	-	2	17	3	19	-	-	-	-	41	Occupancy
Hammond's Flycatcher	HAFL	Yellow	-	7	2	1	51	4	-	-	-	65	Incidence
Least Flycatcher	LEFL	Yellow	-	336	662	784	467	92	120	106	33	2,600	Density
Dusky Flycatcher	DUFL	Yellow	-	-	-	1	9	-	-	5	-	15	Occupancy
Eastern Phoebe	EAPH	Yellow	-	10	7	6	13	1	-	1	-	38	Occupancy
Say's Phoebe	SAPH	Yellow	-	-	1	3	-	-	-	-	-	4	Incidence
Eastern Kingbird	EAKI	Yellow	-	6	6	10	-	4	3	-	-	29	Occupancy
Northern Shrike	NOSH	Yellow	-	2	-	-	-	-	-	-	-	2	Incidence
Cassin's Vireo	CAVI	Yellow	-	-	-	-	5	-	-	-	-	5	NA
Warbling Vireo	WAVI	Yellow	-	179	290	318	330	39	44	20	31	1,251	Density
Red-eyed Vireo	REVI	Yellow	-	353	462	482	226	128	298	268	70	2,287	Density
Philadelphia Vireo	PHVI	Yellow	-	3	3	1	1	-	4	-	1	13	Occupancy
Blue-headed Vireo	BHVI	Yellow	-	37	39	47	43	14	9	11	3	203	Density

Common Name	Code	BC List	COSEWIC/ SARA [a]	Total Detections Over All Surveys									Model Type [b]
				2006	2008	2011	2012	2016	2017	2018	2019	Total Count	
			Number of surveys	***478***	***785***	***1,077***	***740***	***275***	***358***	***226***	***142***	***4,081***	
American Crow	AMCR	Yellow	-	71	82	108	57	7	24	31	16	396	Density
Common Raven	CORA	Yellow	-	47	74	91	376	160	140	104	33	1,025	Density
Blue Jay	BLJA	Yellow	-	16	5	22	4	8	19	6	3	83	Occupancy
Canada Jay	GRJA	Yellow	-	55	59	78	37	12	19	7	11	278	Density
Black-billed Magpie	BBMA	Yellow	-	14	3	18	36	19	37	28	4	159	Occupancy
Cedar Waxwing	CEWA	Yellow	-	32	33	102	45	87	36	36	26	397	Density
Bohemian Waxwing	BOWA	Yellow	-	-	-	2	-	-	-	-	-	2	NA
Black-capped Chickadee	BCCH	Yellow	-	127	147	80	116	24	12	7	2	515	Density
Boreal Chickadee	BOCH	Yellow	-	23	16	35	8	4	3	4	3	96	Occupancy
Barn Swallow	BASW	Blue	T / 1-T	-	-	-	12	3	-	-	-	15	NA
Cliff Swallow	CLSW	Yellow	-	-	-	-	1	-	-	-	-	1	NA
Bank Swallow	BKSW	Yellow	T / 1-T	74	11	142	18	-	26	0	13	284	Occupancy
Northern Rough-winged Swallow	NRWS	Yellow	-	-	2	-	-	-	2	-	-	4	Incidence
Tree Swallow	TRSW	Yellow	-	14	22	71	27	49	7	-	-	190	Occupancy
Violet-green Swallow	VGSW	Yellow	-	6	3	25	4	2	-	-	-	40	Occupancy
Ruby-crowned Kinglet	RCKI	Yellow	-	21	89	119	55	11	20	20	23	358	Density
Golden-crowned Kinglet	GCKI	Yellow	-	78	26	62	65	-	-	11	12	254	Occupancy
Marsh Wren	MAWR	Yellow	-	5	8	3	-	1	7	-	-	24	Occupancy
Red-breasted Nuthatch	RBNU	Yellow	-	39	121	296	55	8	24	23	15	581	Occupancy
White-breasted Nuthatch	WBNU	Yellow	-	-	3	4	7	-	-	-	-	14	Occupancy
House Wren	HOWR	Yellow	-	15	53	43	72	9	15	22	2	231	Density
Winter Wren	WIWR	Blue	-	14	8	1	7	3	-	-	2	35	Occupancy
Pacific Wren	PAWR	Yellow	-	-	-	-	15	-	-	-	1	16	Incidence
Brown Creeper	BRCR	Yellow	-	3	1	2	-	-	-	2	-	8	Incidence

Common Name	Code	BC List	COSEWIC/ SARA [a]	Total Detections Over All Surveys									Model Type [b]
				2006	2008	2011	2012	2016	2017	2018	2019	Total Count	
			Number of surveys	***478***	***785***	***1,077***	***740***	***275***	***358***	***226***	***142***	***4,081***	
Gray Catbird	GRCA	Yellow	-	1	1	-	4	6	16	8	-	36	Occupancy
Hermit Thrush	HETH	Yellow	-	123	157	305	273	69	143	67	28	1,165	Density
Swainson's Thrush	SWTH	Yellow	-	366	474	559	290	89	245	138	127	2,288	Density
Varied Thrush	VATH	Yellow	-	-	1	21	56	-	-	1	-	79	NA
Townsend's Solitaire	TOSO	Yellow	-	1	-	5	6	-	2	-	-	14	Incidence
American Robin	AMRO	Yellow	-	166	242	479	403	173	181	89	77	1,810	Density
LeConte's Sparrow	LCSP	Yellow	-	-	3	5	1	-	-	-	-	9	Incidence
American Pipit	AMPI	Yellow	-	-	-	-	33	-	-	-	-	33	Incidence
Evening Grosbeak	EVGR	Yellow	SC / 1-T	25	19	11	10	1	-	3	-	69	Occupancy
Purple Finch	PUFI	Yellow	-	18	17	71	55	3	10	6	1	181	Occupancy
Gray-crowned Rosy Finch	GCRF	Yellow	-	-	-	1	-	-	-	-	-	1	NA
Red Crossbill	RECR	Yellow	-	7	-	9	9	3	-	-	-	28	Occupancy
White-winged Crossbill	WWCR	Yellow	-	4	28	92	10	-	0	40	3	177	Occupancy
Pine Siskin	PISI	Yellow	-	4	27	145	499	27	8	6	1	717	Density
Canada Warbler	CAWA	Blue	T / 1-T	106	75	40	30	-	2	5	6	264	Density
Wilson's Warbler	WIWA	Yellow	-	3	10	5	64	9	22	11	14	138	Occupancy
Mourning Warbler	MOWA	Yellow	-	30	59	64	36	-	-	6	-	195	Occupancy
MacGillivray's Warbler	MACW	Yellow	-	-	-	10	16	1	6	1	-	34	Occupancy
Common Yellowthroat	COYE	Yellow	-	66	113	149	22	42	100	18	2	512	Occupancy
Orange-crowned Warbler	OCWA	Yellow	-	102	133	213	139	19	29	21	14	670	Density
Tennessee Warbler	TEWA	Yellow	-	139	130	533	185	1	36	4	18	1,046	Occupancy
Nashville Warbler	NAWA	Yellow	-	-	-	-	-	-	1	-	-	1	NA
Black-and-white Warbler	BAWW	Yellow	-	75	81	107	52	24	34	11	12	396	Density
Connecticut Warbler	COWA	Blue	-	8	20	25	13	10	1	-	-	77	Occupancy

Common Name	Code	BC List	COSEWIC/ SARA [a]	Total Detections Over All Surveys									Model Type [b]
				2006	2008	2011	2012	2016	2017	2018	2019	Total Count	
			Number of surveys	***478***	***785***	***1,077***	***740***	***275***	***358***	***226***	***142***	***4,081***	
Northern Waterthrush	NOWA	Yellow	-	29	47	85	81	24	65	5	-	336	Occupancy
Ovenbird	OVEN	Yellow	-	309	489	512	218	43	126	131	107	1,935	Density
Bay-breasted Warbler	BAYW	Red	-	-	3	1	-	1	2	3	-	10	Incidence
Yellow-rumped Warbler	YRWA	Yellow	-	293	435	731	549	27	89	96	82	2,302	Density
Magnolia Warbler	MGNW	Yellow	-	90	69	29	21	14	18	29	10	280	Occupancy
Black-throated Gray Warbler	BTGW	Yellow	-	-	-	-	-	-	1	-	3	4	Incidence
Yellow Warbler	YEWA	Yellow	-	344	622	864	550	181	181	136	53	2,931	Density
American Redstart	AMRE	Yellow	-	184	235	249	140	67	108	117	18	1,118	Density
Blackpoll Warbler	BKPW	Yellow	-	4	5	17	12	-	-	-	-	38	Occupancy
Cape May Warbler	CMWA	Blue	-	-	-	5	1	3	7	-	2	18	Occupancy
Townsend's Warbler	TOWA	Yellow	-	1	-	-	58	-	3	-	2	64	Incidence
Black-throated Green Warbler	BTNW	Blue	-	159	144	122	60	3	8	14	4	514	Occupancy
Red-winged Blackbird	RWBL	Yellow	-	45	178	98	113	306	115	16	7	878	Density
Rusty Blackbird	RUBL	Blue	SC / 1-SC	2	8	10	-	-	-	-	-	20	Incidence
Brewer's Blackbird	BRBL	Yellow	-	6	40	29	10	11	17	1	-	114	Occupancy
Baltimore Oriole	BAOR	Blue	-	38	39	39	14	4	6	1	-	141	Occupancy
Brown-headed Cowbird	BHCO	Yellow	-	59	157	239	244	12	27	9	3	750	Density
Common Grackle	COGR	Yellow	-	2	1	6	-	-	-	-	-	9	Incidence
Western Meadowlark	WEME	Yellow	-	-	-	-	-	1	2	-	-	3	Incidence
Dark-eyed Junco	DEJU	Yellow	-	137	158	196	127	29	47	36	23	753	Density
Swamp Sparrow	SWSP	Yellow	-	1	17	8	8	44	46	7	3	134	Density
Lincoln's Sparrow	LISP	Yellow	-	60	242	437	266	73	113	25	15	1,231	Density
Song Sparrow	SOSP	Yellow	-	31	49	125	33	42	97	45	18	440	Density
Savannah Sparrow	SAVS	Yellow	-	2	9	32	104	49	6	2	2	206	Density

Common Name	Code	BC List	COSEWIC/ SARA [a]	Total Detections Over All Surveys									Model Type [b]
				2006	2008	2011	2012	2016	2017	2018	2019	Total Count	
			Number of surveys	***478***	***785***	***1,077***	***740***	***275***	***358***	***226***	***142***	***4,081***	
Fox Sparrow	FOSP	Yellow	-	35	5	44	23	3	-	4	1	115	Occupancy
Vesper Sparrow	VESP	Yellow	-	4	6	12	66	80	21	12	-	201	Occupancy
Clay-colored Sparrow	CCSP	Yellow	-	47	97	187	264	119	56	50	2	822	Density
Chipping Sparrow	CHSP	Yellow	-	107	212	414	154	14	19	64	36	1,020	Density
White-throated Sparrow	WTSP	Yellow	-	396	741	942	725	253	347	244	163	3,811	Density
Golden-crowned Sparrow	GCSP	Yellow	-	-	-	-	1	-	-	-	-	1	NA
White-crowned Sparrow	WCSP	Yellow	-	-	1	19	24	-	2	-	1	47	Incidence
Rose-breasted Grosbeak	RBGR	Yellow	-	171	183	327	108	34	44	35	20	922	Density
Western Tanager	WETA	Yellow	-	196	245	296	105	32	92	83	71	1,120	Density

[a] COSEWIC = Committee on the Status of Endangered Wildlife in Canada, SARA = Species at Risk Act, SC = Special Concern, T = Threatened, E = Endangered, 1 = SARA Schedule 1

[b] Species indicated as NA (not applicable) were not found in the Peace River valley upstream of the Pine River during point count surveys.

3.3 Density and Occupancy Estimates

The density and occupancy analysis was conducted using survey data only from areas in the Peace River valley and upstream of the Pine River (Table 7). The fen/bog classes (FBS and FBT) were combined into one class as these habitats tend to occur in a matrix. The dry slope classes (DSG and DSS) were also combined for the same reason. Surveys in anthropogenic areas were not included in the analysis because of their small sample size.

Table 7: Point count surveys in the Peace River valley and upstream of the Pine River used for density and occupancy estimates.

Code	Bird Habitat Classes	Surveys (sample size)	Label for Analysis	Broad Bird Habitat Class
CSH	Coniferous-shrub	12	CSH	Coniferous
CYF	Coniferous-young forest	353	CYF	Coniferous
CMF	Coniferous-mature forest	410	CMF	Coniferous
DSH	Deciduous-shrub	49	DSH	Deciduous
DYF	Deciduous-young forest	937	DYF	Deciduous
DMF	Deciduous-mature forest	186	DMF	Deciduous
RSH	Riparian-mixed shrub	104	RSH	Riparian forest
RYF	Riparian-mixed young forest	76	RYF	Riparian forest
RMF	Riparian-mixed mature forest	97	RMF	Riparian forest
FBS	Fen/bog-shrub	11	FBS/FBT	Wetland
FBT	Fen/bog-treed	15	FBS/FBT	Coniferous
WGR	Wetland-graminoid	22	WGR	Wetland
WSH	Wetland-shrub	26	WSH	Wetland
WRI	Wetland-riparian	63	WRI	Wetland
DSG	Grassland-dry slopes	51	DSG/DSS	Dry slopes
DSS	Shrubland-dry slopes	59	DSG/DSS	Dry slopes
CUL	Cultivated	74	CUL	Cultivated
NVE	Non-vegetated	32	NVE	Non-vegetated
ANT	Anthropogenic	12	Not used	Not used
	Total	**2,589**	**-**	**-**

Density models could be fit for 36 of the 95 songbirds found within the Peace River valley. Occupancy models could be fit for 39 species. A model could not be fit for the remaining 20 (Table 6). Density and occupancy estimates are presented in Tables 8, 9 and 10, and incidence in Table 11. Graphical presentations of the density and occupancy estimates are provided in Appendix B.

Results of the model selection and the parameter estimates for the best model for each species are in Appendices C and D. For nearly all species, density and occupancy were found to be better predicted by bird habitat class than not. For all 36 species where density could be estimated, one or both habitat models (m1: bird habitat class or m2: bird habitat class + year) were an improvement (better relative fit) over the null model with no covariates (m0) based on differences in AIC_c. For Gray Jay and Swamp Sparrow, the difference between the habitat model with the lowest AIC_c score and the null model was less than two[1] , indicating that the habitat model with the lowest score did not offer better explanatory strength than the null model.

For 37 of the 39 species where occupancy modelling was used, nearly all eight habitat models tested (m1 to m8) were an improvement over the null model with no covariates (m0) for each species. For Red Crossbill however, the difference in AIC_c between the habitat model with the lowest AIC_c score and the null model was less than two, again indicating that the habitat model with the lowest score did not offer better explanatory strength than the null model. For the remaining 2 of 39 species (Philadelphia Vireo and White-breasted Nuthatch), the null model with no covariates had the lowest AIC_c, though in both cases model with the next lowest AIC_c score differed in score by less than two.

[1] A general rule of thumb is that a model with a ΔAIC less than 2 compared to the model with the lowest AIC is about as good as the model with the lowest AIC (Burnham and Anderson 2002).

Table 8. Estimated density of songbirds by bird habitat class.

English Name	Code	Estimated Density (males/ha)[a]															
		CSH	CYF	CMF	DSH	DYF	DMF	RSH	RYF	RMF	FBS/FBT	WGR	WSH	WRI	DSG/DSS	CUL	NVE
American Redstart	AMRE	0.212	0.037	0.178	0.110	0.089	0.169	0.099	0.217	0.325	0.109	0.028	0.077	0.038	0.047	0.061	0.029
American Robin	AMRO	0.823	0.299	0.307	0.646	0.313	0.321	0.432	0.472	0.426	0.245	0.211	0.393	0.465	0.303	0.439	0.374
Brown-headed Cowbird	BHCO	0.054	0.053	0.039	0.127	0.068	0.083	0.040	0.084	0.045	0.155	0.085	0.158	0.058	0.031	0.027	0.044
Cedar Waxwing	CEWA	0.156	0.050	0.021	0.127	0.051	0.019	0.039	0.039	0.011	0.196	0.090	0.078	0.036	0.052	0.033	0.035
Chipping Sparrow	CHSP	0.285	0.183	0.109	0.068	0.083	0.121	0.153	0.123	0.105	0.395	0.138	0.070	0.318	0.038	0.088	0.171
Hermit Thrush	HETH	0.071	0.147	0.069	0.291	0.192	0.097	0.199	0.268	0.080	0.185	0.066	0.104	0.163	0.097	0.179	0.186
Least Flycatcher	LEFL	0.245	0.185	0.199	0.305	0.514	0.596	0.256	0.384	0.397	0.025	0.118	0.326	0.154	0.201	0.195	0.381
Lincoln's Sparrow	LISP	0.327	0.054	0.040	0.227	0.074	0.059	0.315	0.099	0.050	0.274	0.274	0.155	0.411	0.041	0.128	0.178
Ovenbird	OVEN	0.315	0.362	0.312	0.236	0.502	0.604	0.109	0.176	0.269	0.029	0.048	0.000	0.067	0.088	0.156	0.074
Ruby-crowned Kinglet	RCKI	0.058	0.018	0.017	0.006	0.003	0.008	0.005	0.004	0.003	0.078	0.015	0.058	0.006	0.000	0.003	0.000
Red-eyed Vireo	REVI	0.579	0.389	0.616	0.472	0.594	0.602	0.596	0.514	0.731	0.186	0.000	0.318	0.427	0.581	0.588	0.466
Swainson's Thrush	SWTH	0.170	0.484	0.552	0.194	0.316	0.552	0.262	0.330	0.464	0.236	0.150	0.461	0.163	0.098	0.135	0.263
Warbling Vireo	WAVI	0.190	0.199	0.110	0.120	0.163	0.169	0.066	0.125	0.127	0.200	0.021	0.181	0.057	0.052	0.081	0.071
Western Tanager	WETA	0.057	0.446	0.517	0.112	0.220	0.293	0.102	0.167	0.293	0.292	0.105	0.149	0.077	0.036	0.108	0.113
White-throated Sparrow	WTSP	1.494	0.697	0.695	1.336	1.015	0.833	0.542	0.678	0.969	0.461	0.548	0.476	0.420	0.899	0.594	0.644
Western Wood-Pewee	WWPE	0.026	0.051	0.031	0.013	0.066	0.038	0.012	0.005	0.004	0.029	0.068	0.256	0.021	0.016	0.013	0.022
Yellow Warbler	YEWA	0.372	0.337	0.517	0.834	0.643	0.723	0.469	0.601	0.591	0.327	0.310	0.595	0.504	0.611	0.396	0.464
Yellow-rumped Warbler	YRWA	0.240	0.776	0.589	0.135	0.284	0.489	0.158	0.189	0.456	0.258	0.176	0.312	0.300	0.040	0.149	0.355

[a] 95% confidence intervals are not included here but are shown on bar graphs in Appendix B.

Table 9. Estimated density of songbirds by broad bird habitat class.

English Name	Code	Estimated Density (males/ha) [a]						
		Coniferous	Deciduous	Dry slopes	Riparian Forest	Wetland	Cultivated	Non-vegetated
Alder Flycatcher	ALFL	0.004	0.012	0.063	0.016	0.040	0.020	0.025
American Crow	AMCR	0.004	0.003	0.009	0.006	0.015	0.001	0.014
Black-and-white Warbler	BAWW	0.035	0.041	0.003	0.064	0.034	0.005	0.024
Black-capped Chickadee	BCCH	0.051	0.040	0.025	0.055	0.059	0.020	0.025
Blue-headed Vireo	BHVI	0.029	0.011	0.016	0.005	0.003	0.013	0.011
Canada Warbler	CAWA	0.004	0.002	0.000	0.000	0.000	0.000	0.001
Clay-colored Sparrow	CCSP	0.018	0.091	0.459	0.080	0.069	0.236	0.263
Common Raven	CORA	0.025	0.028	0.083	0.052	0.011	0.034	0.024
Dark-eyed Junco	DEJU	0.144	0.064	0.058	0.071	0.117	0.083	0.023
Gray Jay	GRAJ	0.002	0.000	0.000	0.000	0.000	0.000	0.000
Canada Jay	GRJA	0.002	0.000	0.000	0.000	0.000	0.000	0.000
House Wren	HOWR	0.003	0.011	0.017	0.001	0.002	0.002	0.000
Orange-crowned Warbler	OCWA	0.041	0.099	0.091	0.035	0.017	0.049	0.039
Pine Siskin	PISI	0.012	0.006	0.002	0.006	0.019	0.003	0.012
Rose-breasted Grosbeak	RBGR	0.109	0.141	0.088	0.144	0.089	0.036	0.160
Red-winged Blackbird	RWBL	0.000	0.001	0.000	0.000	0.017	0.000	0.000
Savannah Sparrow	SAVS	0.000	0.000	0.001	0.002	0.002	0.110	0.002
Song Sparrow	SOSP	0.023	0.024	0.019	0.099	0.188	0.017	0.241
Swamp Sparrow	SWSP	0.000	0.000	0.000	0.000	0.003	0.000	0.000

[a] 95% confidence intervals are not included here but are shown on figures in Appendix B.

Table 10. Occupancy of songbirds by broad bird habitat class.

English Name	Code	Estimated Occupancy[a]						
		Coniferous	Deciduous	Riparian Forest	Wetland	Dry slopes	Cultivated	Non-vegetated
Baltimore Oriole	BAOR	0.022	0.274	0.133	0.066	0.000	0.094	0.000
Black-billed Magpie	BBMA	0.060	0.060	0.298	0.280	0.230	0.208	0.107
Belted Kingfisher	BEKI	0.027	0.003	0.137	0.039	0.000	0.000	0.000
Blackpoll Warbler	BKPW	0.002	0.001	0.007	0.000	0.000	0.000	0.000
Bank Swallow	BKSW	0.011	0.014	0.007	0.081	0.150	0.000	0.242
Blue Jay	BLJA	0.031	0.009	0.033	0.067	0.000	0.000	0.000
Boreal Chickadee	BOCH	0.053	0.007	0.008	0.022	0.000	0.000	0.000
Brewer's Blackbird	BRBL	0.000	0.326	0.201	0.000	0.122	0.825	0.000
Black-throated Green Warbler	BTNW	0.492	0.158	0.162	0.000	0.000	0.048	0.000
Cape May Warbler	CMWA	0.003	0.001	0.006	0.000	0.003	0.000	0.000
Connecticut Warbler	COWA	0.006	0.011	0.000	0.042	0.000	0.000	0.000
Common Yellowthroat	COYE	0.055	0.116	0.209	0.641	0.060	0.071	0.217
Dusky Flycatcher	DUFL	0.000	0.002	0.007	0.009	0.019	0.000	0.000
Eastern Kingbird	EAKI	0.012	0.117	0.784	0.042	0.000	0.000	0.000
Eastern Phoebe	EAPH	0.040	0.075	0.056	0.086	0.145	0.090	0.000
Evening Grosbeak	EVGR	0.091	0.063	0.127	0.000	0.000	0.000	0.163
Fox Sparrow	FOSP	0.114	0.075	0.472	0.223	0.389	0.170	0.986
Golden-crowned Kinglet	GCKI	0.538	0.064	0.094	0.000	0.000	0.000	0.177
Gray Catbird	GRCA	0.000	0.006	0.000	0.000	0.316	0.022	0.000
MacGillivray's Warbler	MACW	0.622	0.000	0.000	0.000	0.007	0.000	0.000
Marsh Wren	MAWR	0.005	0.033	0.000	0.926	0.000	0.000	0.000
Magnolia Warbler	MGNW	0.335	0.102	0.219	0.209	0.000	0.000	0.082
Mourning Warbler	MOWA	0.204	0.191	0.135	0.070	0.258	0.089	0.211
Northern Flicker	NOFL	0.090	0.148	0.141	0.167	0.119	0.091	0.000
Northern Waterthrush	NOWA	0.215	0.212	0.396	0.504	0.281	0.000	1.000

English Name	Code	Estimated Occupancy[a]						
		Coniferous	Deciduous	Riparian Forest	Wetland	Dry slopes	Cultivated	Non-vegetated
Olive-sided Flycatcher	OSFL	0.163	0.023	0.100	0.199	0.110	0.236	0.000
Philadelphia Vireo	PHVI	0.003	0.004	0.007	0.009	0.000	0.000	0.000
Pacific-slope Flycatcher	PSFL	0.092	0.140	0.042	0.000	0.016	0.000	0.000
Purple Finch	PUFI	0.030	0.038	0.017	0.020	0.021	0.047	0.000
Red-breasted Nuthatch	RBNU	0.394	0.137	0.156	0.110	0.016	0.000	0.058
Red Crossbill	RECR	0.007	0.005	0.004	0.000	0.000	0.000	0.000
Tennessee Warbler	TEWA	0.308	0.192	0.261	0.196	0.020	0.016	0.079
Tree Swallow	TRSW	0.018	0.060	0.018	0.655	0.280	0.065	0.305
Vesper Sparrow	VESP	0.007	0.025	0.000	0.008	0.517	0.417	0.061
Violet-green Swallow	VGSW	0.026	0.057	0.000	0.000	0.213	0.000	0.222
White-breasted Nuthatch	WBNU	0.002	0.004	0.007	0.000	0.000	0.000	0.000
Wilson's Warbler	WIWA	0.010	0.006	0.004	0.003	0.005	0.010	0.000
Winter Wren	WIWR	0.425	0.058	0.000	0.000	0.000	0.000	0.000
White-winged Crossbill	WWCR	0.033	0.007	0.003	0.005	0.000	0.000	0.000
Yellow-bellied Flycatcher	YBFL	0.045	0.215	0.000	0.000	0.000	0.000	0.000

[a] 95% confidence intervals are not included here but are shown on figures in Appendix B.

Table 11. Incidence for songbirds that a density or occupancy model could not be fit.

Code	English Name	Total Count of Detections Over All Surveys																
		CSH	CYF	CMF	DSH	DYF	DMF	RSH	RYF	RMF	FBS/FBT	WGR	WSH	WRI	DSG/DSS	CUL	NVE	Total
	Number of surveys	*12*	*353*	*410*	*49*	*937*	*186*	*104*	*76*	*97*	*26*	*22*	*26*	*63*	*110*	*74*	*32*	***2,577***
AMPI	American Pipit	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	**2**
BAYW	Bay-breasted Warbler	-	1	4	1	1	1	-	-	2	-	-	-	-	-	-	-	**10**
BLSW	Black Swift	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	**1**
BRCR	Brown Creeper	-	3	2	-	1	-	-	-	1	-	-	-	-	-	-	-	**7**
BTGW	Black-throated Gray Warbler	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**3**
COGR	Common Grackle	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	**3**
HAFL	Hammond's Flycatcher	-	1	4	-	4	-	-	-	-	-	-	-	-	4	-	-	**13**
LCSP	LeConte's Sparrow	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	**2**
MODO	Mourning Dove	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	**1**
NOSH	Northern Shrike	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	**2**
NRWS	Northern Rough-winged Swallow	-	-	-	-	2	-	-	-	-	-	2	-	-	-	-	-	**4**
PAWR	Pacific Wren	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	**1**
RTHU	Ruby-throated Hummingbird	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	**1**
RUBL	Rusty Blackbird	-	-	-	1	2	-	-	-	-	1	-	-	-	-	-	-	**4**
RUHU	Rufous Hummingbird	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	**1**
SAPH	Say's Phoebe	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	**1**
TOSO	Townsend's Solitaire	-	1	1	1	2	-	-	-	-	-	-	-	-	2	-	-	**7**
TOWA	Townsend's Warbler	-	1	1	-	1	-	-	-	-	-	-	-	-	-	1	-	**4**
WCSP	White-crowned Sparrow	-	1	-	-	15	2	-	-	-	-	-	-	2	2	5	-	**27**
WEME	Western Meadowlark	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	**1**

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APPENDIX A
SONGBIRD SURVEYS IN 2019

Table A.1: Songbird surveys in 2019.

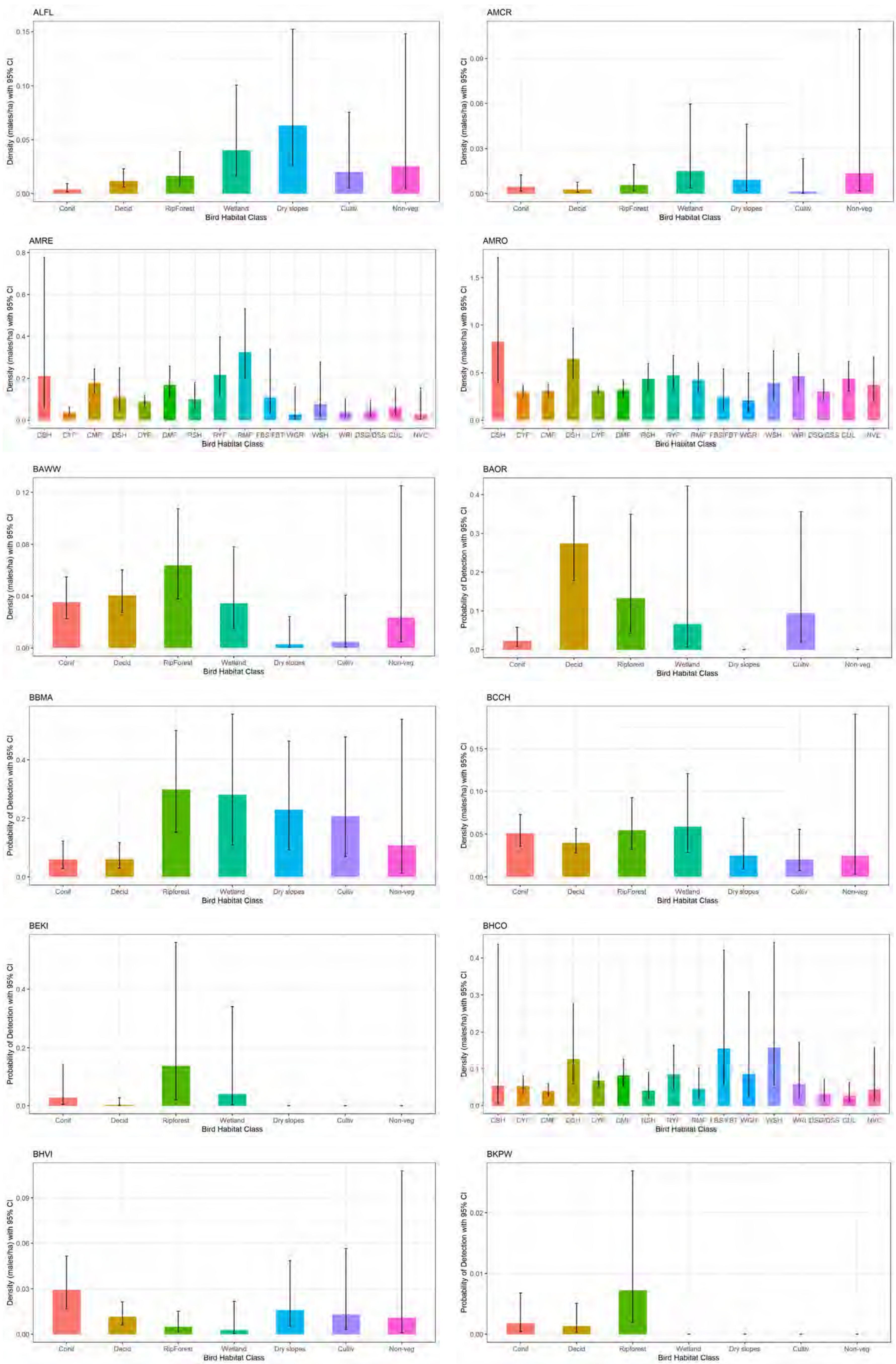
Station	UTM Zone	UTM Easting	UTM Northing	Bird Habitat Class	Survey 1 Date	Survey 1 Time	Survey 2 Date	Survey 2 Time
PC19-027	10	602179	6232686	Coniferous-young forest	2019-06-07	7:39:00 AM	2019-06-26	6:20:00 AM
PC19-028	10	601480	6232611	Coniferous-mature forest	2019-06-07	8:12:00 AM	2019-06-26	6:51:00 AM
PC19-029	10	600929	6232434	Deciduous-young forest	2019-06-07	8:38:00 AM	2019-06-26	7:15:00 AM
PC19-030	10	600443	6232459	Deciduous-young forest	2019-06-07	8:21:00 AM	2019-06-26	6:42:00 AM
PC19-032	10	599985	6232402	Deciduous-mature forest	2019-06-07	7:47:00 AM	2019-06-26	6:11:00 AM
PC19-049	10	594092	6229025	Wetland-riparian	2019-06-07	6:43:00 AM	2019-06-21	8:27:00 AM
PC19-054	10	592802	6228349	Non-vegetated	2019-06-07	6:09:00 AM	2019-06-21	8:20:00 AM
PC19-057	10	591820	6226652	Coniferous-young forest	2019-06-07	5:32:00 AM	2019-06-19	5:49:00 AM
PC19-058	10	591309	6226307	Coniferous-mature forest	2019-06-07	4:48:00 AM	2019-06-19	5:06:00 AM
PC19-060	10	591126	6226413	Deciduous-young forest	2019-06-06	7:18:00 AM	2019-06-19	4:43:00 AM
PC19-062	10	590717	6226119	Deciduous-young forest	2019-06-06	7:44:00 AM	2019-06-19	6:24:00 AM
PC19-063	10	590240	6226001	Deciduous-young forest	2019-06-06	8:20:00 AM	2019-06-19	5:48:00 AM
PC19-065	10	589579	6226720	Non-vegetated	2019-06-07	5:44:00 AM	2019-06-19	7:30:00 AM
PC19-067	10	589449	6226073	Coniferous-mature forest	2019-06-06	7:06:00 AM	-	-
PC19-068	10	589344	6224986	Coniferous-young forest	2019-06-04	5:43:00 AM	2019-06-19	7:56:00 AM
PC19-069	10	589198	6225288	Coniferous-young forest	2019-06-04	5:08:00 AM	2019-06-19	7:32:00 AM
PC19-070	10	589104	6225693	Deciduous-young forest	2019-06-04	4:21:00 AM	2019-06-19	6:50:00 AM
PC19-071	10	588983	6224587	Coniferous-mature forest	2019-06-04	6:20:00 AM	2019-06-20	6:17:00 AM
PC19-073	10	588600	6224515	Coniferous-young forest	2019-06-04	6:53:00 AM	2019-06-20	5:39:00 AM
PC19-074	10	588471	6224318	Coniferous-mature forest	2019-06-04	7:21:00 AM	2019-06-20	5:10:00 AM
PC19-077	10	588003	6223748	Deciduous-young forest	2019-06-04	7:59:00 AM	2019-06-20	5:20:00 AM
PC19-078	10	587942	6223259	Coniferous-young forest	2019-06-06	5:16:00 AM	2019-06-20	7:34:00 AM
PC19-081	10	587692	6223996	Deciduous-young forest	2019-06-04	8:22:00 AM	2019-06-20	4:50:00 AM
PC19-082	10	587643	6223585	Deciduous-young forest	2019-06-06	4:49:00 AM	2019-06-20	8:07:00 AM
PC19-084	10	587359	6223376	Deciduous-young forest	2019-06-06	5:00:00 AM	2019-06-20	6:53:00 AM
PC19-086	10	587141	6222785	Deciduous-young forest	2019-06-06	5:50:00 AM	2019-06-21	5:10:00 AM

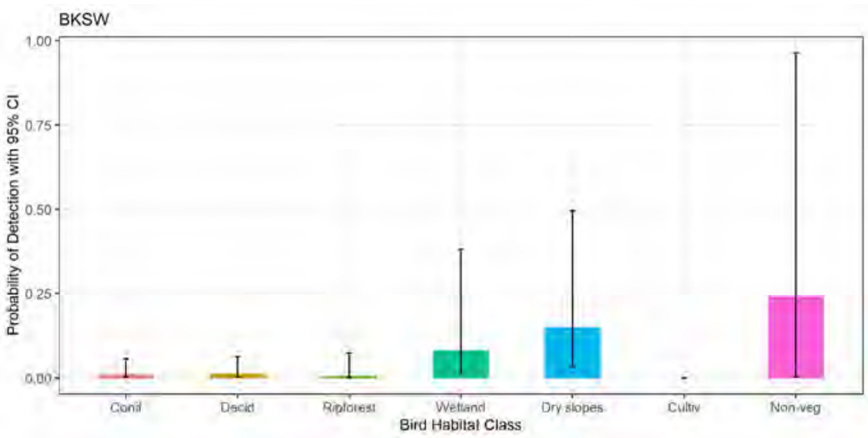
Station	UTM Zone	UTM Easting	UTM Northing	Bird Habitat Class	Survey 1 Date	Survey 1 Time	Survey 2 Date	Survey 2 Time
PC19-088	10	586739	6223156	Deciduous-young forest	2019-06-03	8:46:00 AM	2019-06-20	7:25:00 AM
PC19-089	10	586733	6222394	Coniferous-young forest	2019-06-03	7:58:00 AM	2019-06-21	5:54:00 AM
PC19-090	10	586620	6222673	Deciduous-young forest	2019-06-03	8:19:00 AM	2019-06-20	8:05:00 AM
PC19-092	10	586476	6221895	Deciduous-young forest	2019-06-03	7:23:00 AM	2019-06-21	6:20:00 AM
PC19-093	10	586169	6221795	Deciduous-young forest	2019-06-03	6:59:00 AM	2019-06-21	5:54:00 AM
PC19-094	10	586049	6221463	Deciduous-young forest	2019-06-03	6:25:00 AM	2019-06-21	5:24:00 AM
PC19-096	10	585701	6222001	Coniferous-young forest	2019-06-03	5:43:00 AM	2019-06-21	4:44:00 AM
PC19-100	10	584627	6221222	Deciduous-mature forest	2019-06-03	4:45:00 AM	2019-06-21	7:18:00 AM
PC19-139	10	573717	6215187	Coniferous-young forest	2019-06-02	4:55:00 AM	2019-06-18	5:51:00 AM
PC19-141	10	573422	6215324	Non-vegetated	2019-06-02	5:35:00 AM	2019-06-18	6:46:00 AM
PC19-143	10	573249	6214336	Coniferous-young forest	2019-06-02	5:54:00 AM	2019-06-18	6:00:00 AM
PC19-152	10	571162	6212279	Wetland-riparian	2019-06-02	5:00:00 AM	2019-06-18	5:06:00 AM
PC19-153	10	571024	6213438	Deciduous-young forest	2019-06-08	4:14:00 AM	2019-06-23	4:16:00 AM
PC19-157	10	570966	6211489	Riparian-mixed shrub	2019-06-01	7:20:00 AM	2019-06-18	4:39:00 AM
PC19-158	10	570363	6212873	Coniferous-young forest	2019-06-08	4:12:00 AM	2019-06-23	4:54:00 AM
PC19-160	10	570318	6211873	Coniferous-young forest	2019-06-01	8:07:00 AM	2019-06-18	4:25:00 AM
PC19-161	10	570313	6212401	Coniferous-mature forest	2019-06-08	4:56:00 AM	2019-06-23	5:03:00 AM
PC19-162	10	570291	6211007	Coniferous-young forest	2019-06-01	6:22:00 AM	2019-06-17	8:21:00 AM
PC19-163	10	570135	6211256	Coniferous-young forest	2019-05-31	9:10:00 AM	2019-06-17	7:47:00 AM
PC19-164	10	569929	6210809	Deciduous-young forest	2019-06-01	5:46:00 AM	2019-06-17	8:46:00 AM
PC19-165	10	569623	6210549	Coniferous-young forest	-	-	2019-06-17	8:08:00 AM
PC19-166	10	569599	6211353	Riparian-mixed shrub	2019-06-01	4:34:00 AM	2019-06-17	7:06:00 AM
PC19-167	10	569426	6212121	Coniferous-young forest	2019-06-08	4:55:00 AM	2019-06-23	4:23:00 AM
PC19-168	10	569156	6210234	Coniferous-young forest	2019-05-31	9:18:00 AM	2019-06-17	7:12:00 AM
PC19-172	10	568881	6211771	Coniferous-young forest	2019-06-08	5:42:00 AM	2019-06-23	5:46:00 AM
PC19-173	10	568793	6209983	Riparian-mixed shrub	2019-05-31	8:30:00 AM	2019-06-17	6:30:00 AM
PC19-176	10	568563	6211544	Coniferous-young forest	2019-06-08	5:40:00 AM	2019-06-23	5:47:00 AM

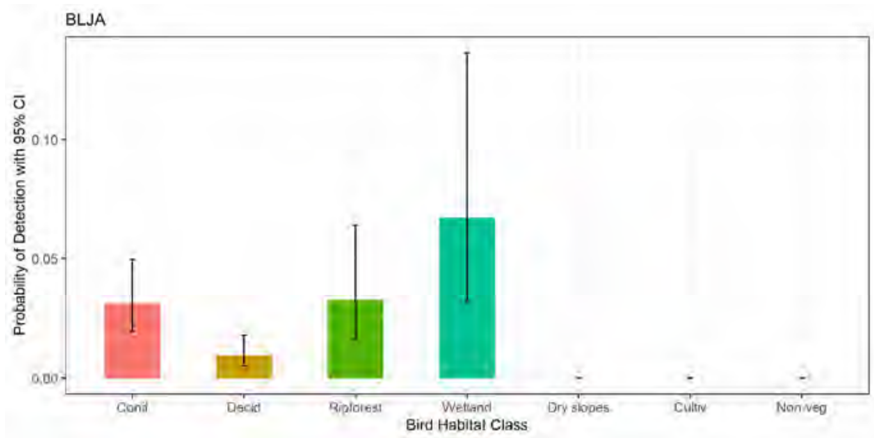
Station	UTM Zone	UTM Easting	UTM Northing	Bird Habitat Class	Survey 1 Date	Survey 1 Time	Survey 2 Date	Survey 2 Time
PC19-181	10	567939	6208797	Non-vegetated	2019-05-31	6:35:00 AM	2019-06-17	4:25:00 AM
PC19-182	10	567731	6208829	Riparian-mixed young forest	2019-05-31	6:39:00 AM	2019-06-17	4:43:00 AM
PC19-183	10	567500	6208643	Coniferous-young forest	2019-05-31	7:14:00 AM	2019-06-17	5:17:00 AM
PC19-184	10	567446	6208292	Coniferous-mature forest	2019-05-31	7:22:00 AM	2019-06-17	5:48:00 AM
PC19-188	10	566988	6208096	Coniferous-mature forest	2019-05-31	8:00:00 AM	2019-06-17	6:25:00 AM
PC19-189	10	566965	6206582	Coniferous-young forest	2019-06-09	7:22:00 AM	2019-06-24	5:56:00 AM
PC19-190	10	566488	6206022	Deciduous-young forest	2019-06-09	7:02:00 AM	2019-06-24	5:41:00 AM
PC19-191	10	566303	6206471	Coniferous-young forest	2019-06-09	6:06:00 AM	2019-06-23	8:05:00 AM
PC19-192	10	566035	6206832	Deciduous-shrub	2019-06-09	6:08:00 AM	2019-06-23	8:08:00 AM
PC19-193	10	565483	6207315	Coniferous-young forest	2019-05-31	4:51:00 AM	2019-06-17	4:34:00 AM
PC19-194	10	565420	6206229	Deciduous-shrub	2019-06-09	5:02:00 AM	2019-06-23	7:17:00 AM
PC19-195	10	565043	6207186	Coniferous-young forest	2019-05-31	5:32:00 AM	2019-06-17	5:10:00 AM
PC19-197	10	564737	6207201	Riparian-mixed shrub	2019-05-31	5:03:00 AM	2019-06-17	5:41:00 AM
PC19-198	10	564643	6204285	Deciduous-young forest	2019-06-09	8:55:00 AM	2019-06-25	6:43:00 AM
PC19-199	10	564335	6206190	Coniferous-young forest	2019-06-09	9:00:00 AM	2019-06-25	7:43:00 AM
PC19-200	10	564335	6205582	Deciduous-young forest	2019-06-09	4:30:00 AM	2019-06-23	6:44:00 AM
PC19-204	10	563959	6205286	Deciduous-young forest	2019-06-09	4:24:00 AM	2019-06-23	6:37:00 AM
PC19-206	10	563742	6205455	Fen/bog-shrub	2019-06-09	5:07:00 AM	2019-06-23	7:14:00 AM

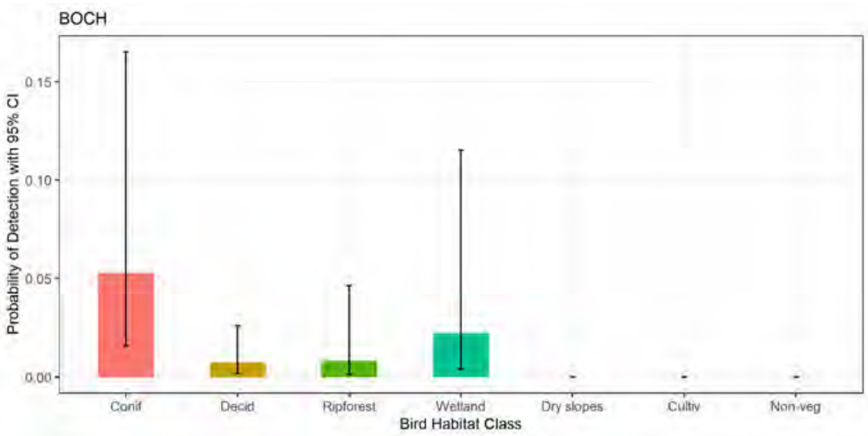
APPENDIX B
DENSITY AND OCCUPANCY ESTIMATE PLOTS

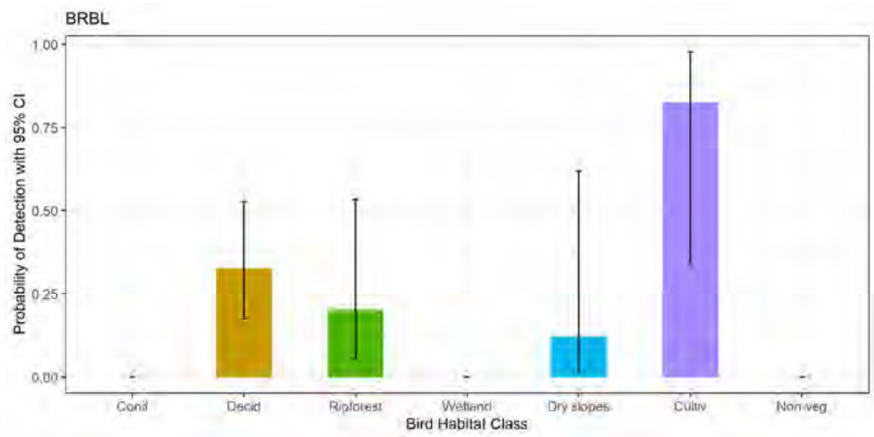
Figure B.1 Plots of density or occupancy for each songbird species that a statistical model could be fit.

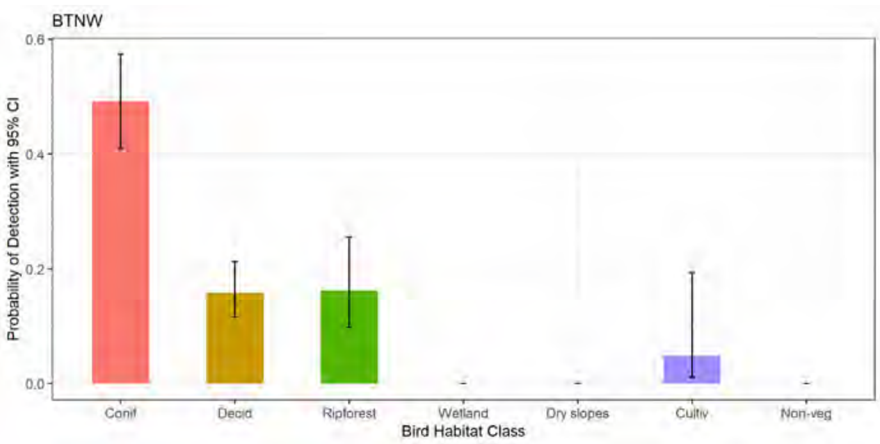


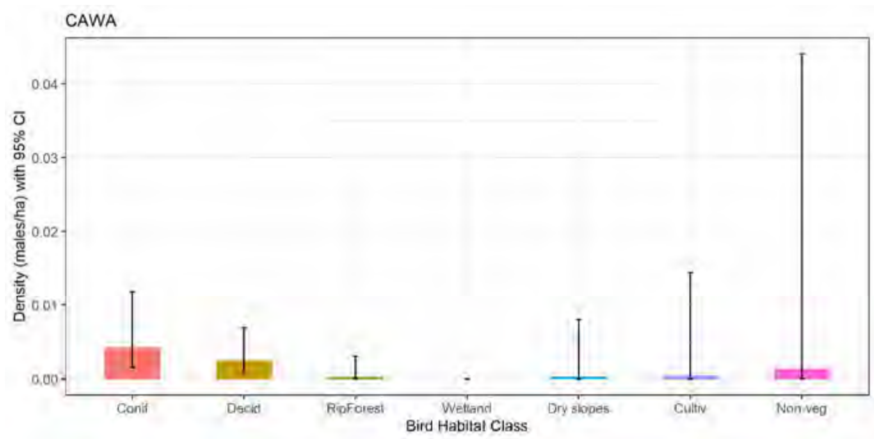

BKSW
Probability of Detection with 95% CI
Conif Decid Ripforest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

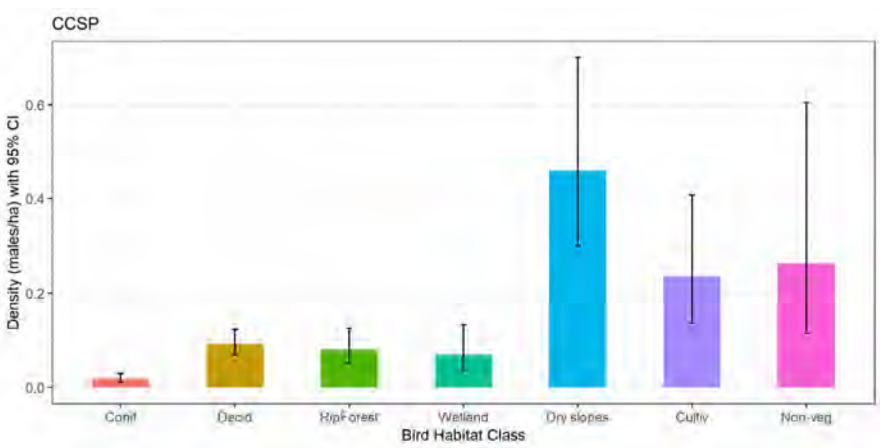

BLJA
Probability of Detection with 95% CI
Conif Decid Ripforest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

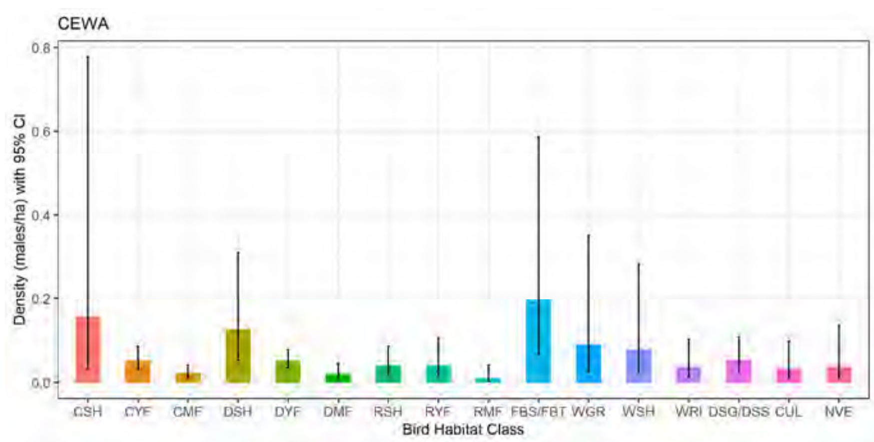

BOCH
Probability of Detection with 95% CI
Conif Decid Ripforest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

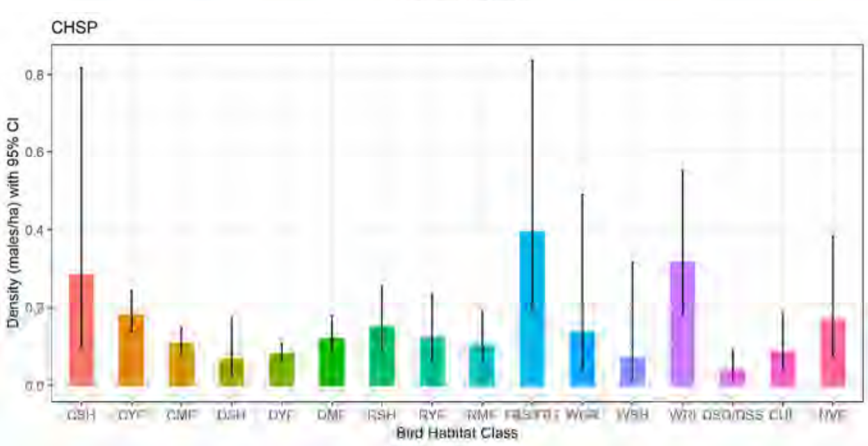

BRBL
Probability of Detection with 95% CI
Conif Decid Ripforest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

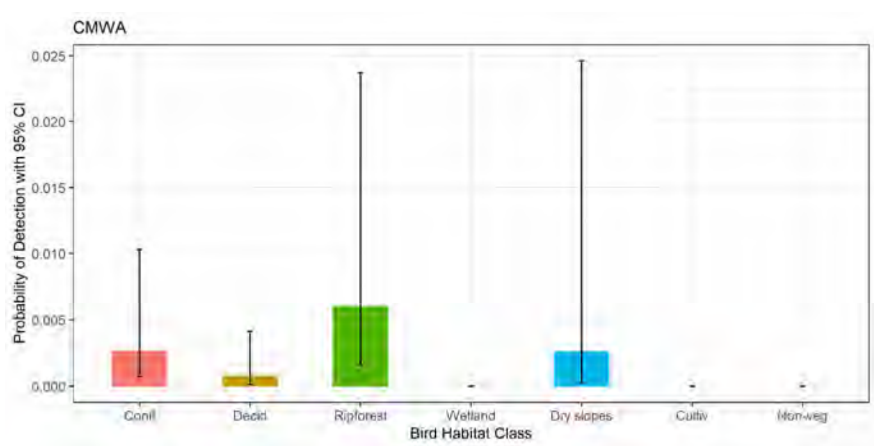

BTNW
Probability of Detection with 95% CI
Conif Decid Ripforest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

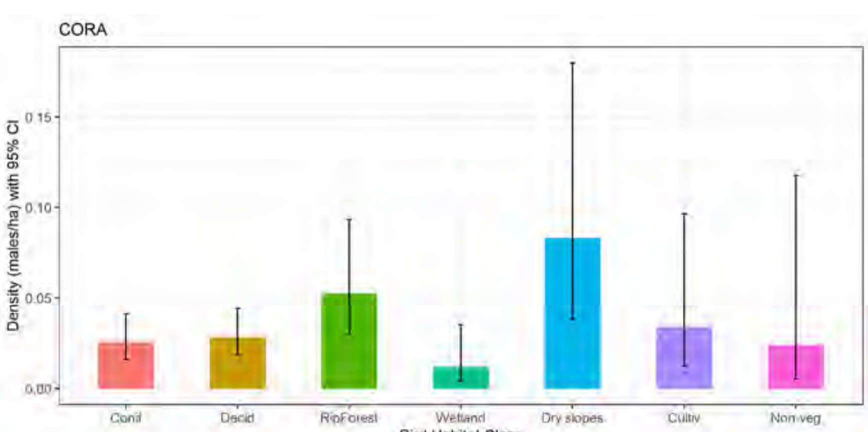

CAWA
Density (males/ha) with 95% CI
Conif Decid RipForest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

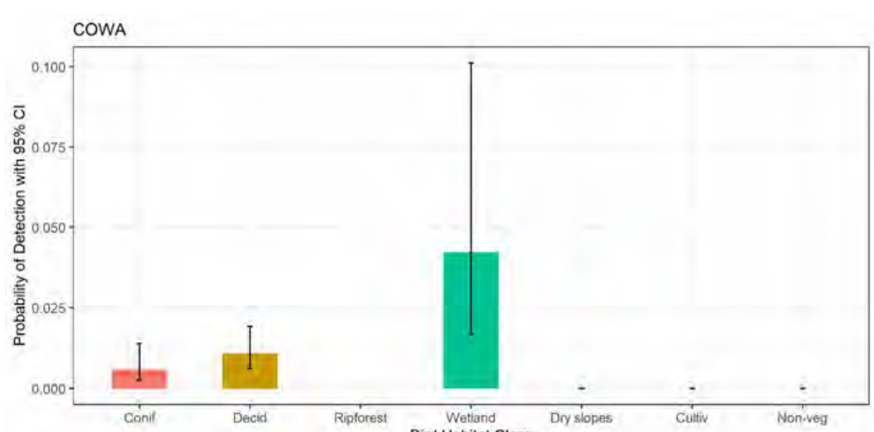

CCSP
Density (males/ha) with 95% CI
Conif Decid RipForest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

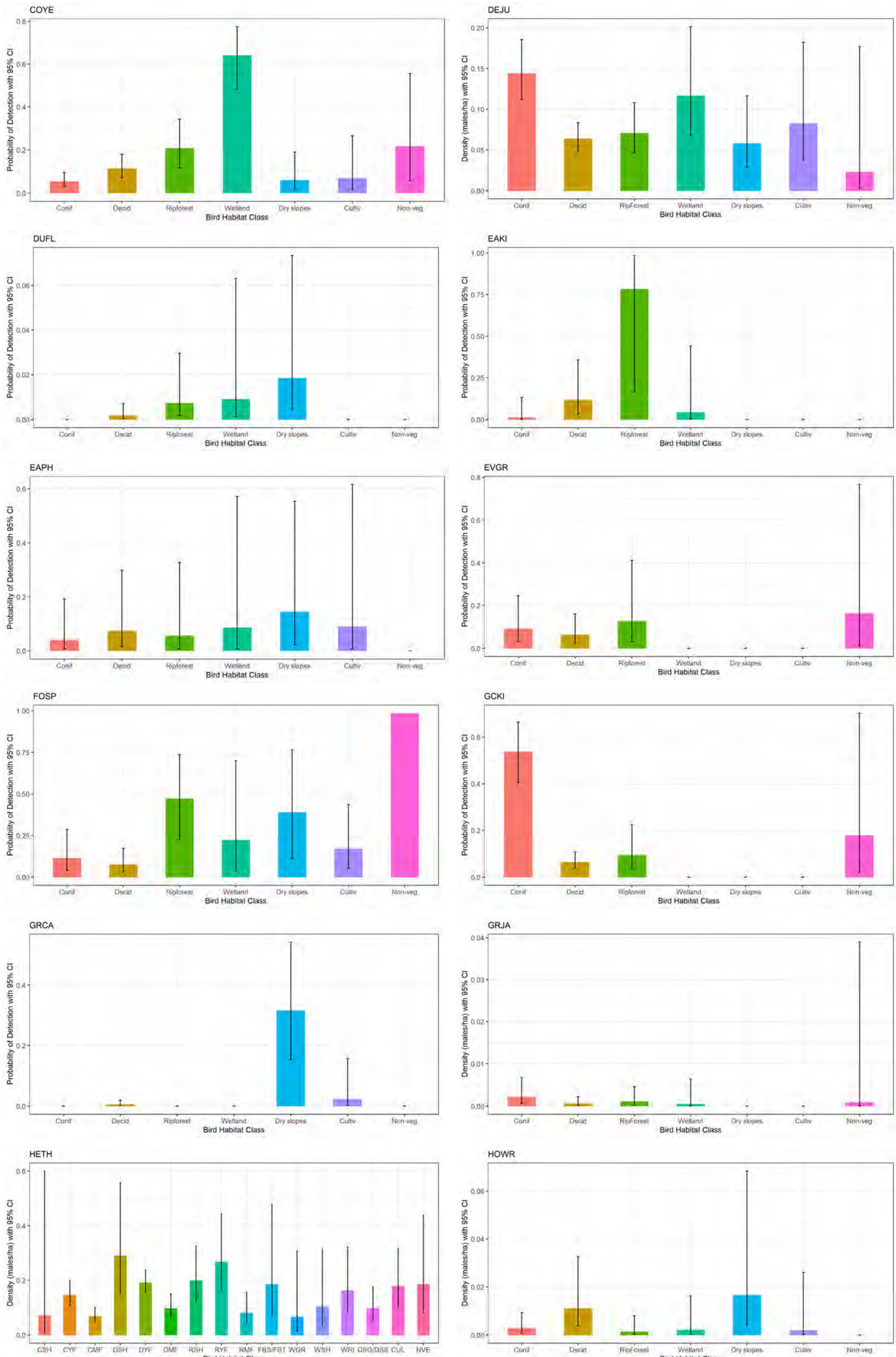

CEWA
Density (males/ha) with 95% CI
CSH CYF CMF DSH DYF DMF RSH RYF RMF FBS/FBT WGR WSH WRI DSG/DSS CUL NVE
Bird Habitat Class

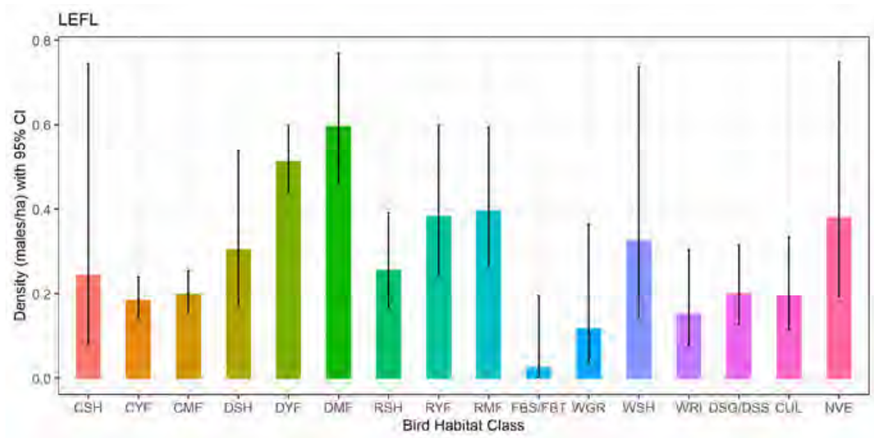

CHSP
Density (males/ha) with 95% CI
CSH CYF CMF DSH DYF DMF RSH RYF RMF FBS/FBT WGR WSH WRI DSG/DSS CUL NVE
Bird Habitat Class

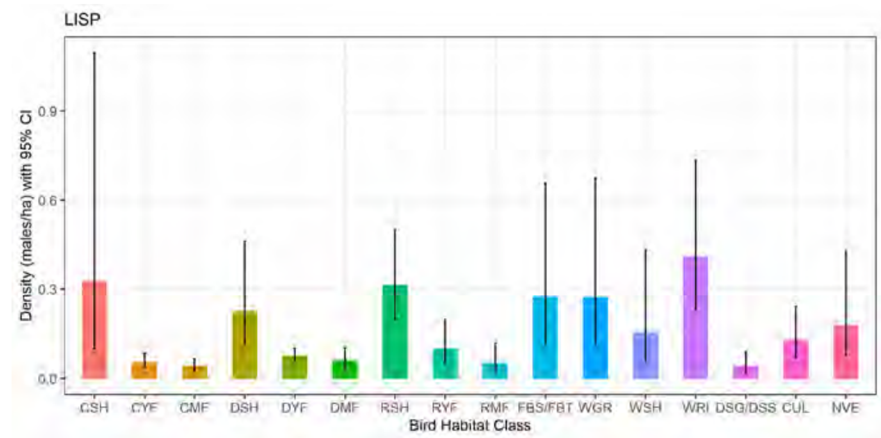

CMWA
Probability of Detection with 95% CI
Conif Decid Ripforest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

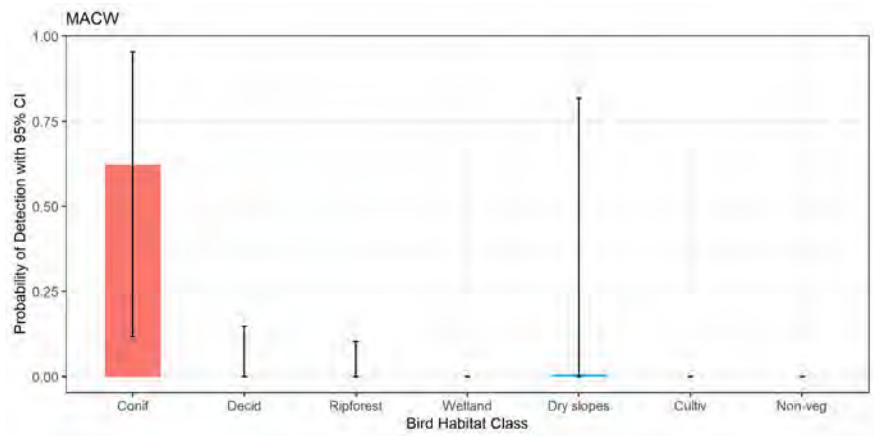

CORA
Density (males/ha) with 95% CI
Conif Decid RipForest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

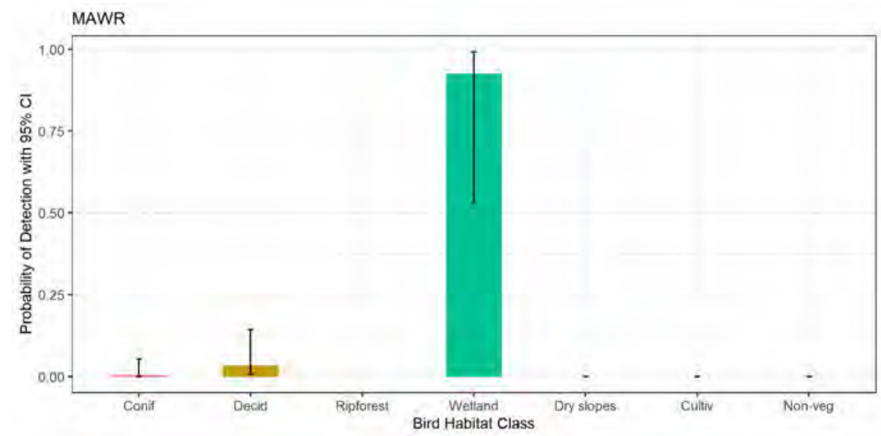

COWA
Probability of Detection with 95% CI
Conif Decid Ripforest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

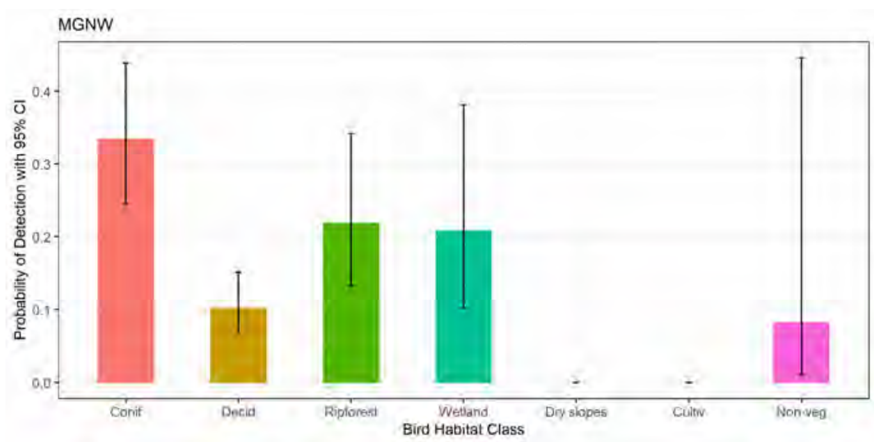

COYE
Probability of Detection with 95% CI
Conif Decid Ripforest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class
DEJU
Density (males/ha) with 95% CI
Conif Decid RipForest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class
DUFL
Probability of Detection with 95% CI
Bird Habitat Class
EAKI
Probability of Detection with 95% CI
Bird Habitat Class
EAPH
Probability of Detection with 95% CI
Bird Habitat Class
EVGR
Probability of Detection with 95% CI
Bird Habitat Class
FOSP
Probability of Detection with 95% CI
Bird Habitat Class
GCKI
Probability of Detection with 95% CI
Bird Habitat Class
GRCA
Probability of Detection with 95% CI
Bird Habitat Class
GRJA
Density (males/ha) with 95% CI
Bird Habitat Class
HETH
Density (males/ha) with 95% CI
CSH CYF CMF DSH DYF DMF RSH RYF RMF FBS/FBT WGR WSH WRI DSG/DSS CUL NVE
Bird Habitat Class
HOWR
Density (males/ha) with 95% CI
Bird Habitat Class

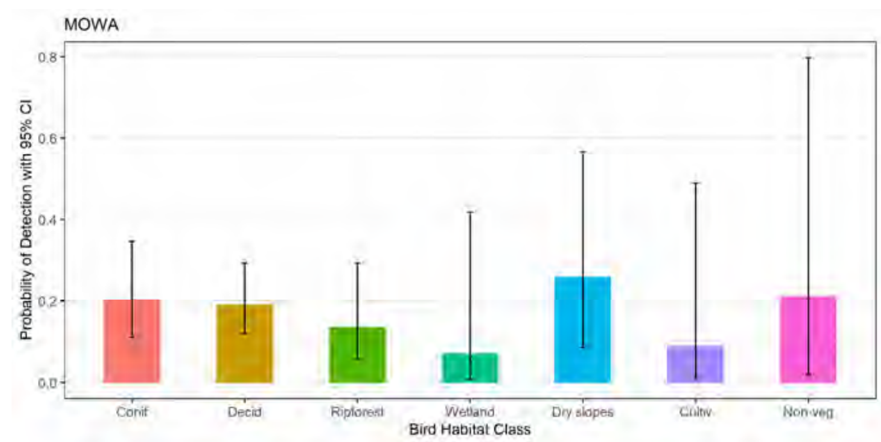

LEFL
Density (males/ha) with 95% CI
CSH CYF CMF DSH DYF DMF RSH RYF RMF FBS/FBT WGR WSH WRI DSG/DSS CUL NVE
Bird Habitat Class

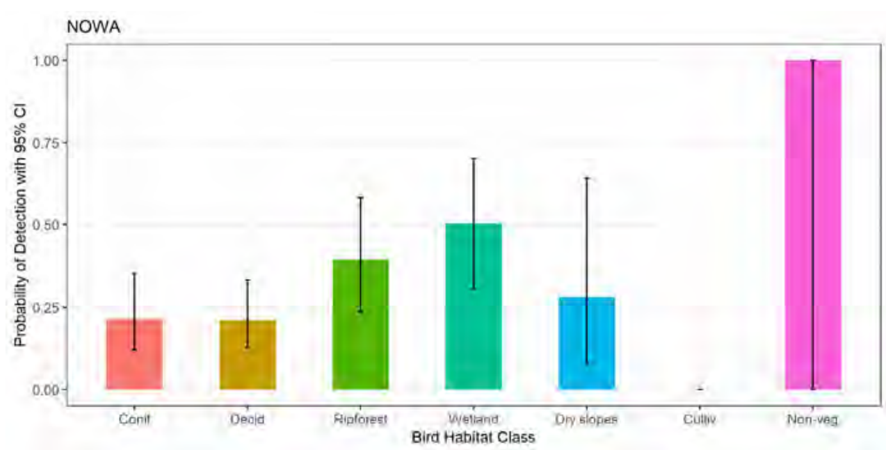

LISP
Density (males/ha) with 95% CI
CSH CYF CMF DSH DYF DMF RSH RYF RMF FBS/FBT WGR WSH WRI DSG/DSS CUL NVE
Bird Habitat Class

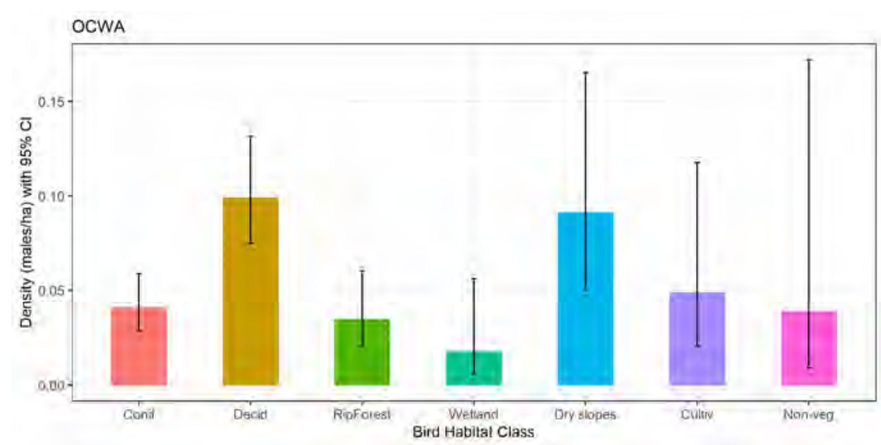

MACW
Probability of Detection with 95% CI
Conif Decid Ripforest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

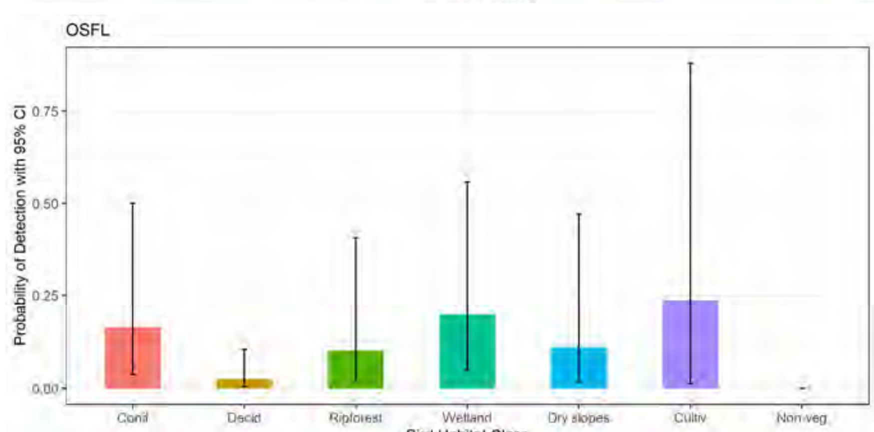

MAWR
Probability of Detection with 95% CI
Conif Decid Ripforest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

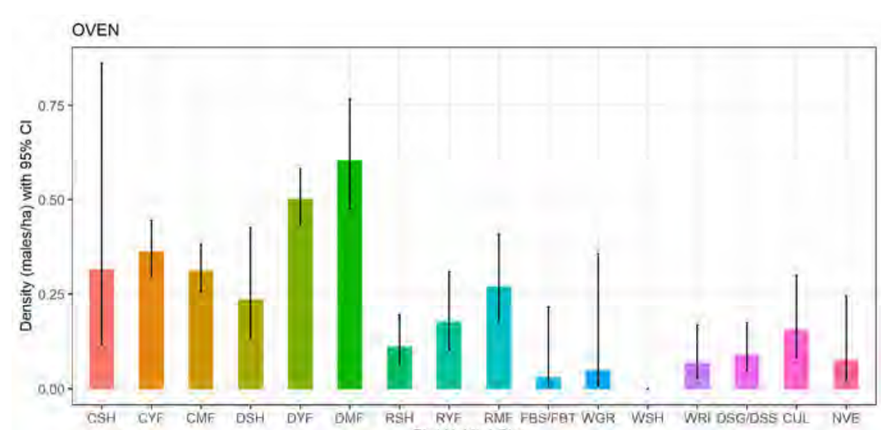

MGNW
Probability of Detection with 95% CI
Conif Decid Ripforest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

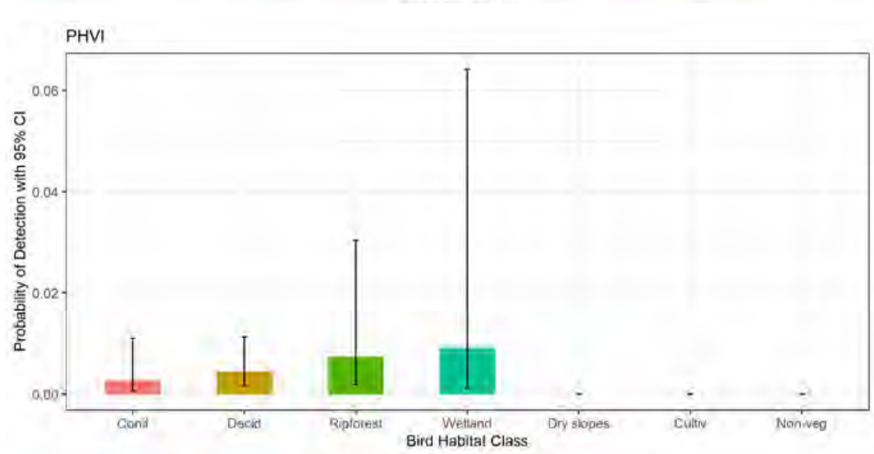

MOWA
Probability of Detection with 95% CI
Conif Decid Ripforest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

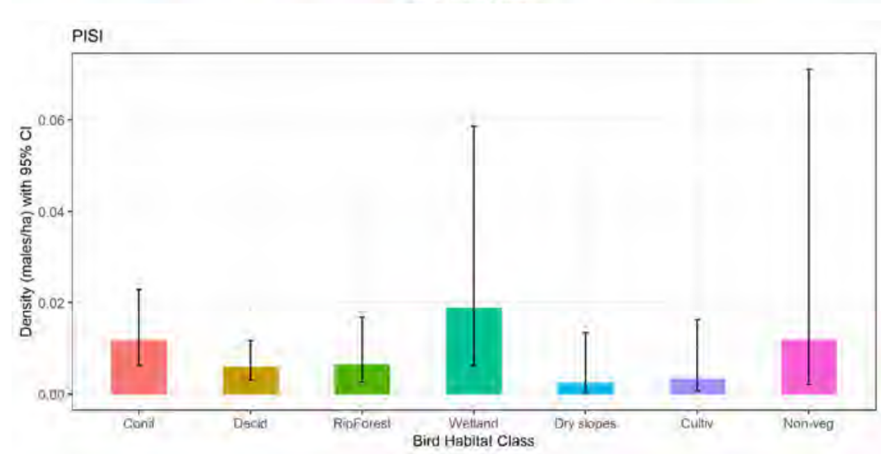

NOWA
Probability of Detection with 95% CI
Conif Decid Ripforest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

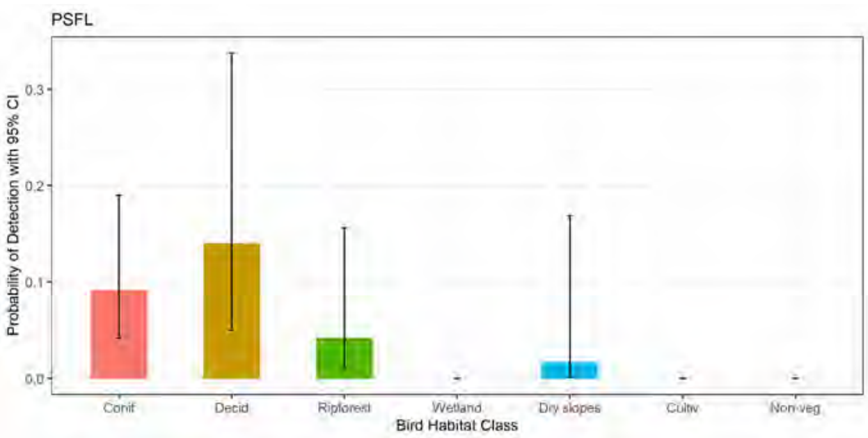

OCWA
Density (males/ha) with 95% CI
Conif Decid RipForest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

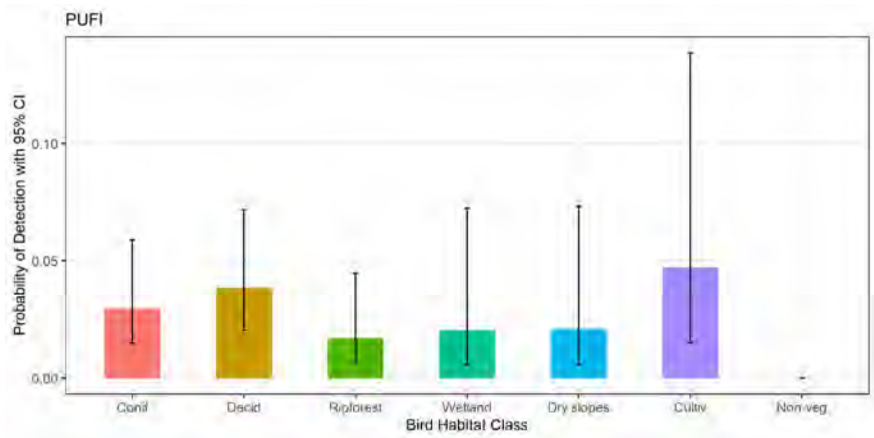

OSFL
Probability of Detection with 95% CI
Conif Decid Ripforest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

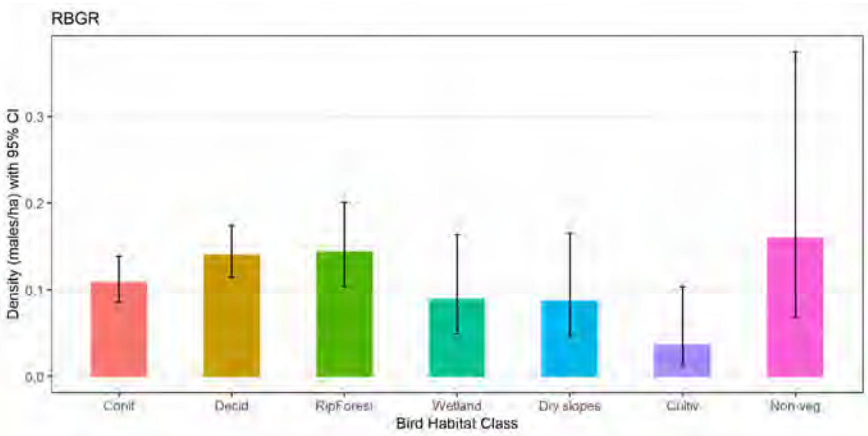

OVEN
Density (males/ha) with 95% CI
CSH CYF CMF DSH DYF DMF RSH RYF RMF FBS/FBT WGR WSH WRI DSG/DSS CUL NVE
Bird Habitat Class

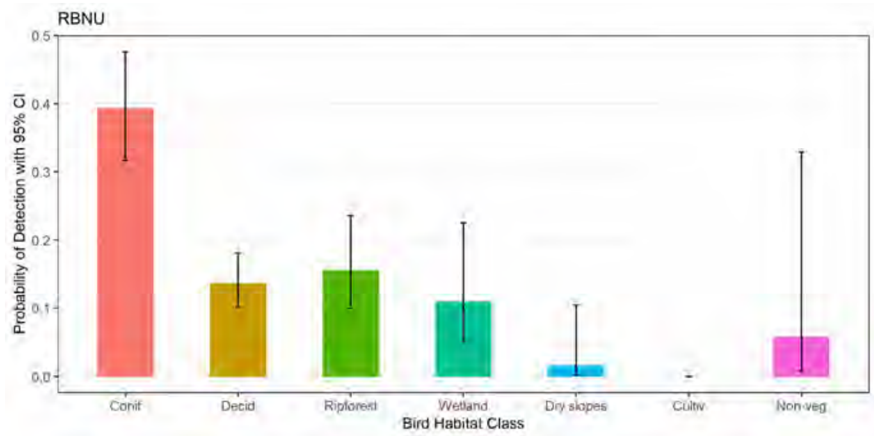

PHVI
Probability of Detection with 95% CI
Conif Decid Ripforest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

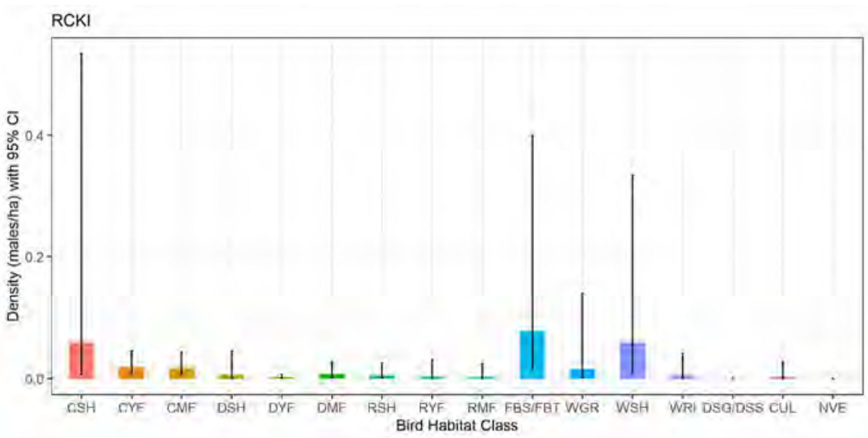

PISI
Density (males/ha) with 95% CI
Conif Decid RipForest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

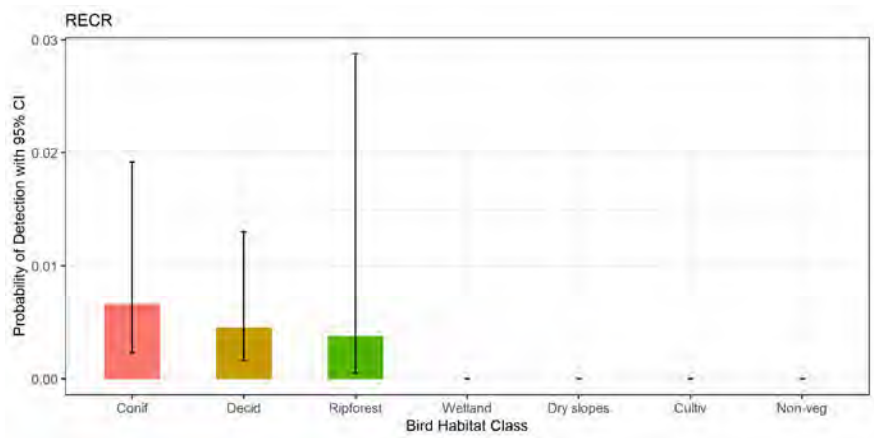

PSFL
Probability of Detection with 95% CI
Conif Decid Ripforest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

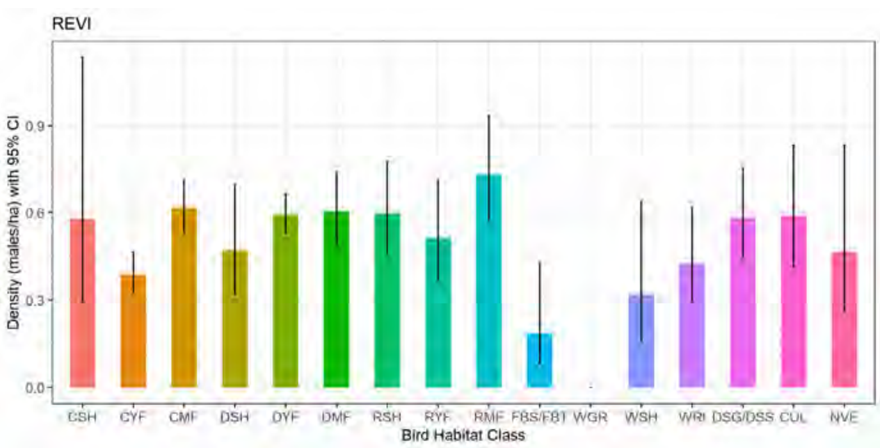

PUFI
Probability of Detection with 95% CI
Conif Decid Ripforest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

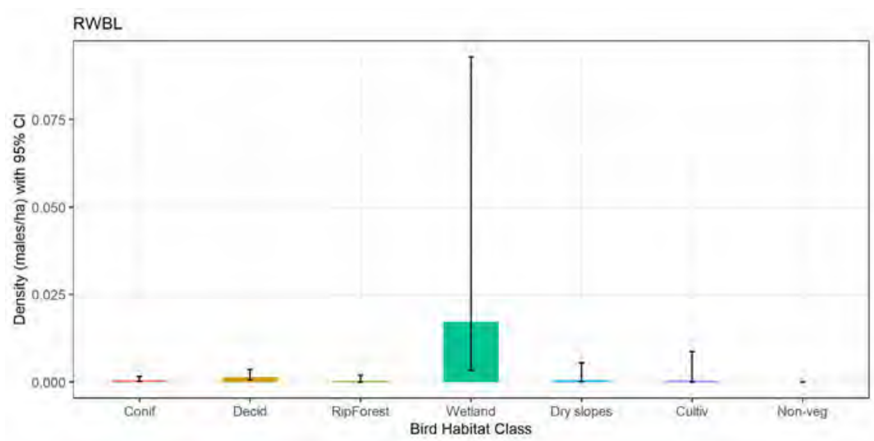

RBGR
Density (males/ha) with 95% CI
Conif Decid RipForest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

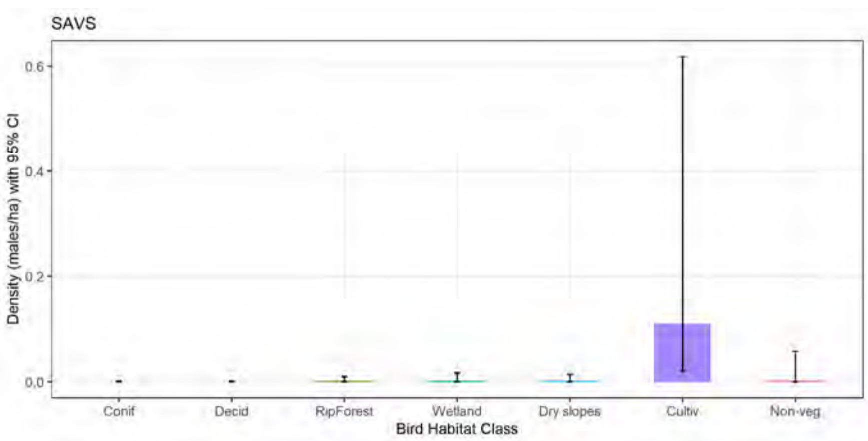

RBNU
Probability of Detection with 95% CI
Conif Decid Ripforest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

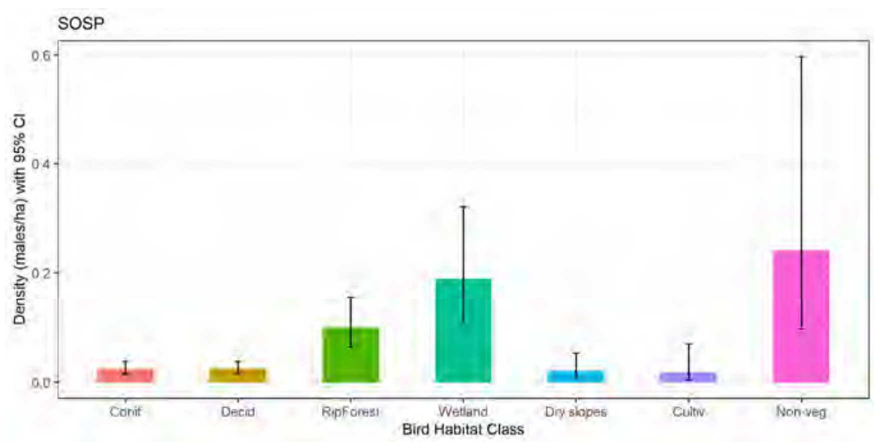

RCKI
Density (males/ha) with 95% CI
CSH CYF CMF DSH DYF DMF RSH RYF RMF FBS/FBT WGR WSH WRI DSG/DSS CUL NVE
Bird Habitat Class

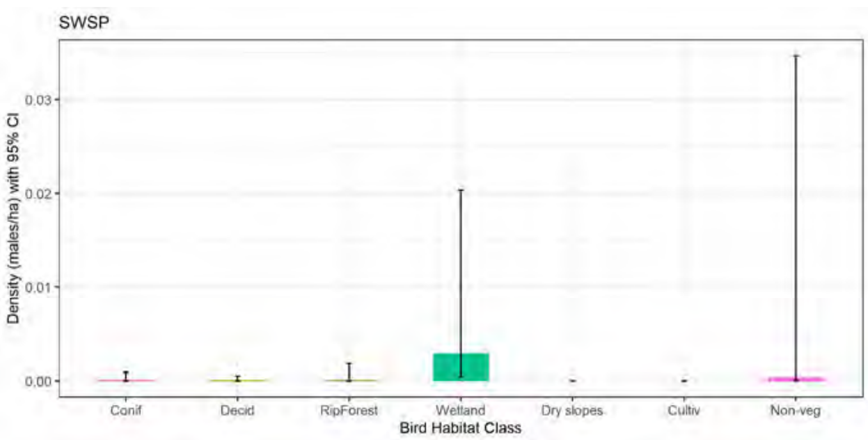

RECR
Probability of Detection with 95% CI
Conif Decid Ripforest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

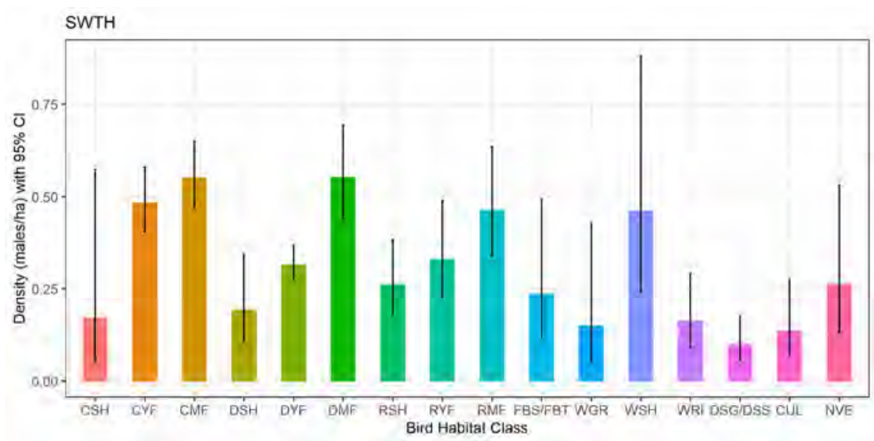

REVI
Density (males/ha) with 95% CI
CSH CYF CMF DSH DYF DMF RSH RYF RMF FBS/FBT WGR WSH WRI DSG/DSS CUL NVE
Bird Habitat Class

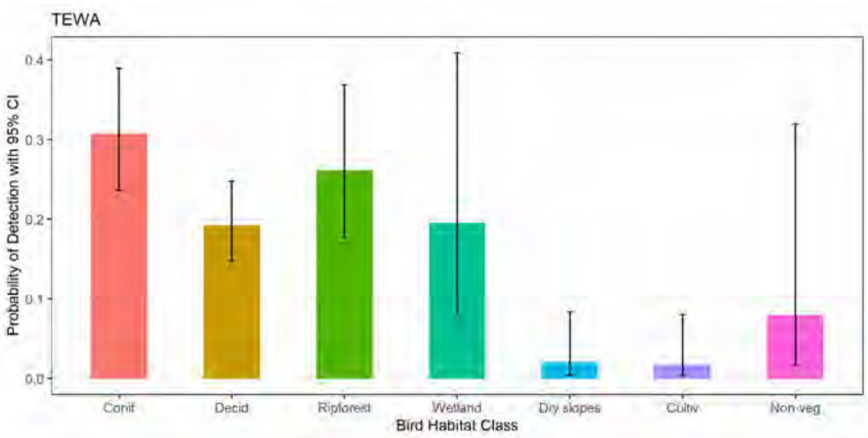

RWBL
Density (males/ha) with 95% CI
Conif Decid RipForest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

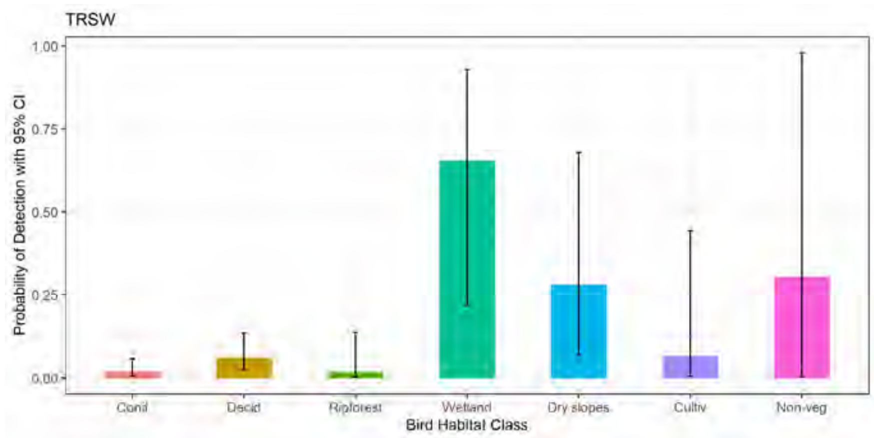

SAVS
Density (males/ha) with 95% CI
Conif Decid RipForest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

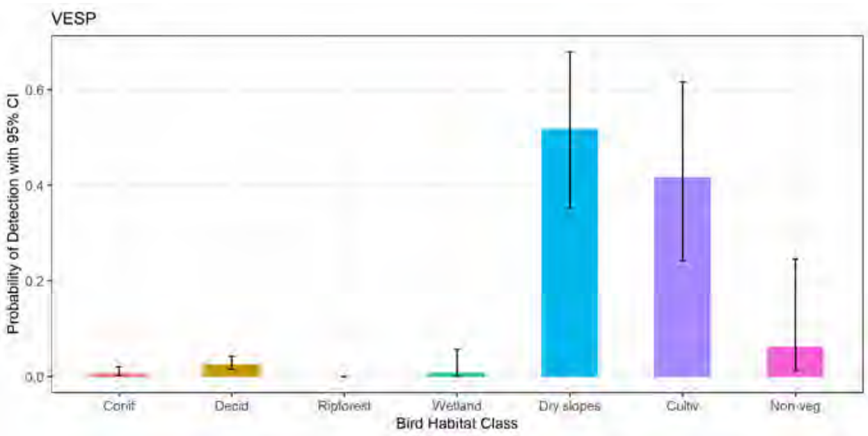

SOSP
Density (males/ha) with 95% CI
Conif Decid RipForest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

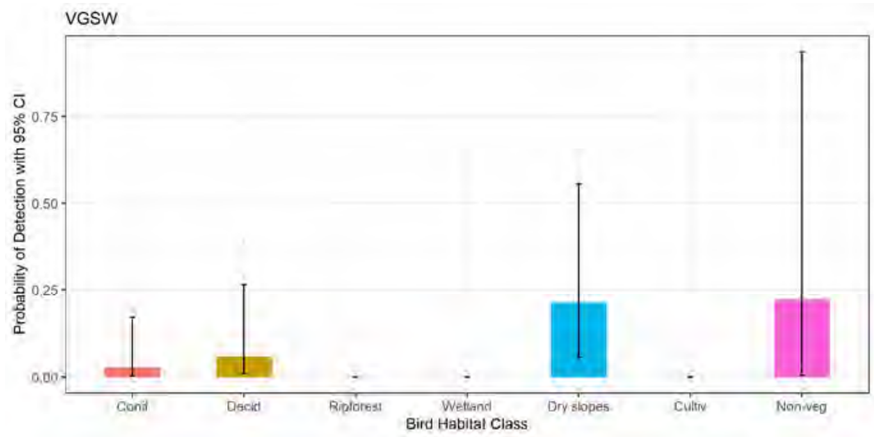

SWSP
Density (males/ha) with 95% CI
Conif Decid RipForest Wetland Dry slopes Cultiv Non-veg
Bird Habitat Class

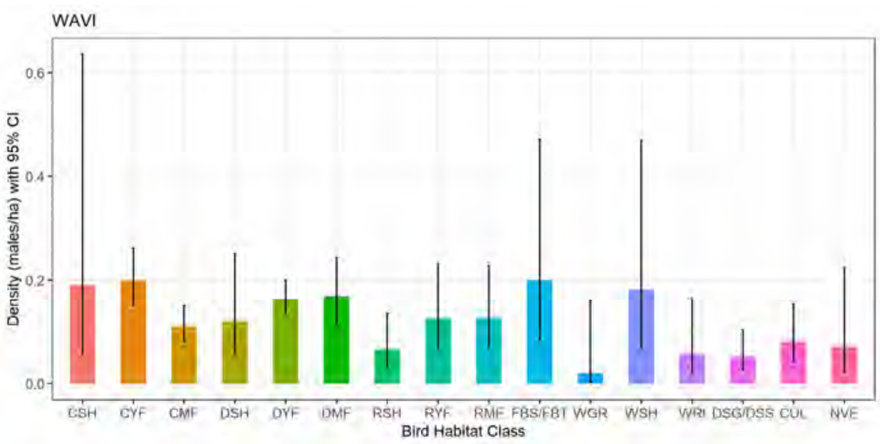

SWTH
Density (males/ha) with 95% CI
CSH CYF CMF DSH DYF DMF RSH RYF RMF FBS/FBT WGR WSH WRI DSG/DSS CUL NVE
Bird Habitat Class

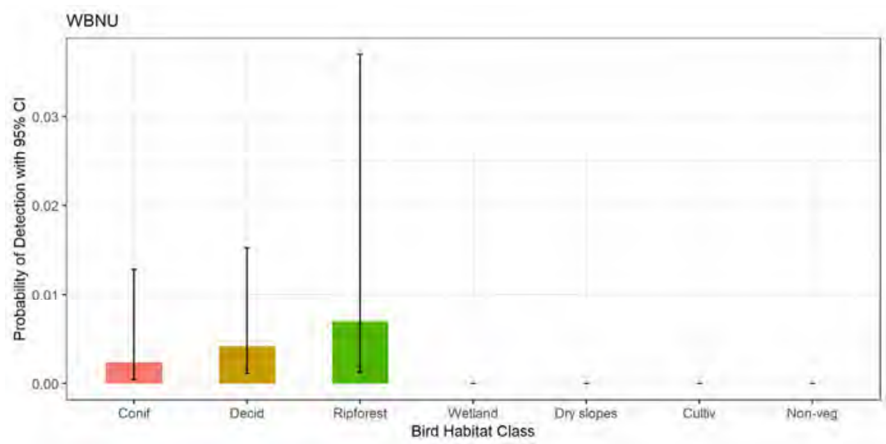

TEWA
Probability of Detection with 95% CI
Conif
Decid
Ripforest
Wetland
Dry slopes
Cultiv
Non-veg
Bird Habitat Class

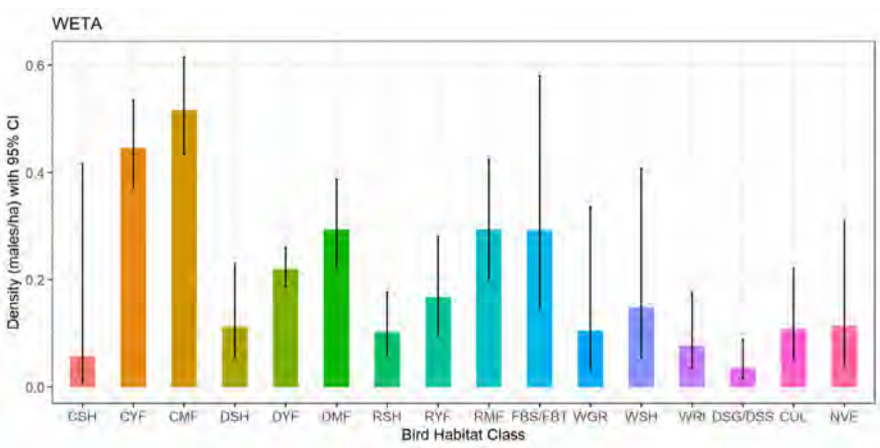

TRSW
Probability of Detection with 95% CI
Conif
Decid
Ripforest
Wetland
Dry slopes
Cultiv
Non-veg
Bird Habitat Class

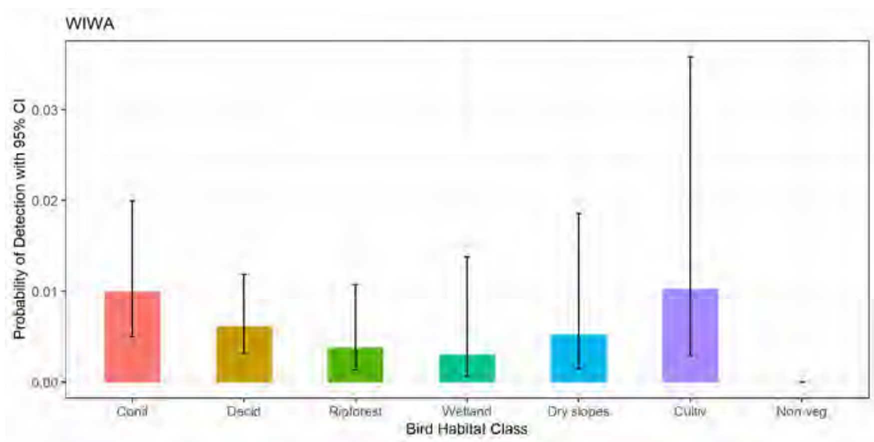

VESP
Probability of Detection with 95% CI
Conif
Decid
Ripforest
Wetland
Dry slopes
Cultiv
Non-veg
Bird Habitat Class

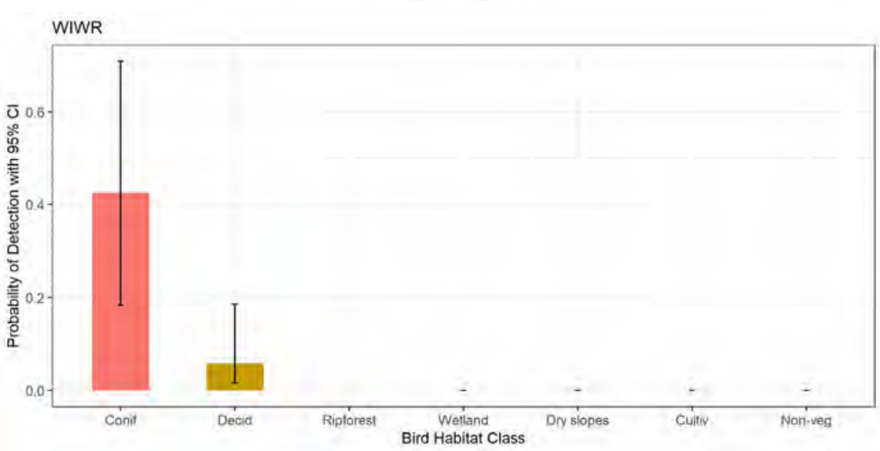

VGSW
Probability of Detection with 95% CI
Conif
Decid
Ripforest
Wetland
Dry slopes
Cultiv
Non-veg
Bird Habitat Class

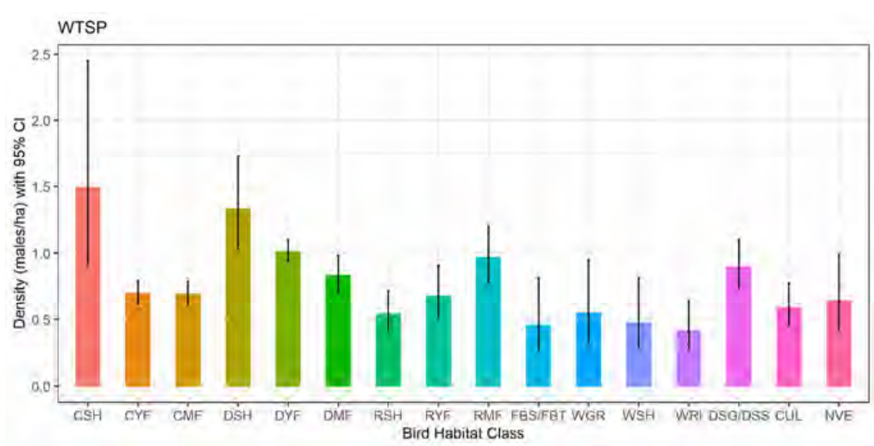

WAVI
Density (males/ha) with 95% CI
CSH
CYF
CMF
DSH
DYF
DMF
RSH
RYF
RMF
FBS/FBT
WGR
WSH
WRI
DSG/DSS
CUL
NVE
Bird Habitat Class

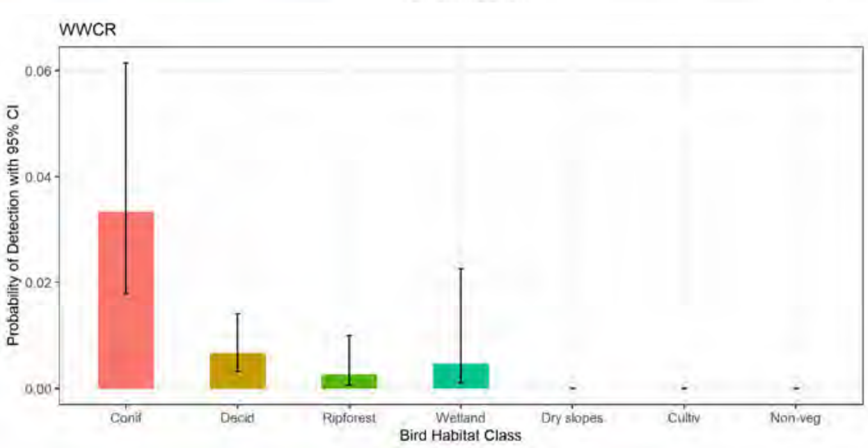

WBNU
Probability of Detection with 95% CI
Conif
Decid
Ripforest
Wetland
Dry slopes
Cultiv
Non-veg
Bird Habitat Class

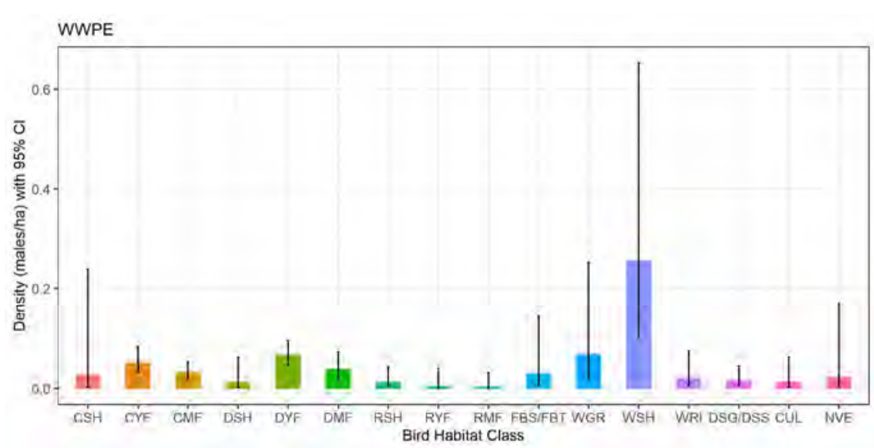

WETA
Density (males/ha) with 95% CI
CSH
CYF
CMF
DSH
DYF
DMF
RSH
RYF
RMF
FBS/FBT
WGR
WSH
WRI
DSG/DSS
CUL
NVE
Bird Habitat Class

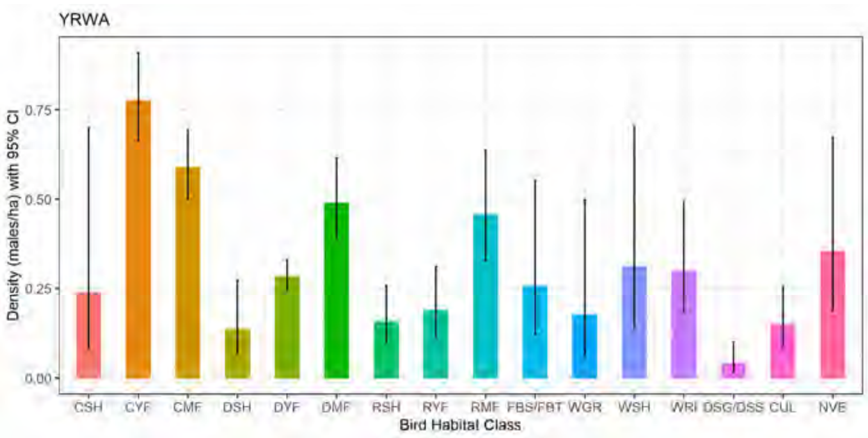

WIWA
Probability of Detection with 95% CI
Conif
Decid
Ripforest
Wetland
Dry slopes
Cultiv
Non-veg
Bird Habitat Class

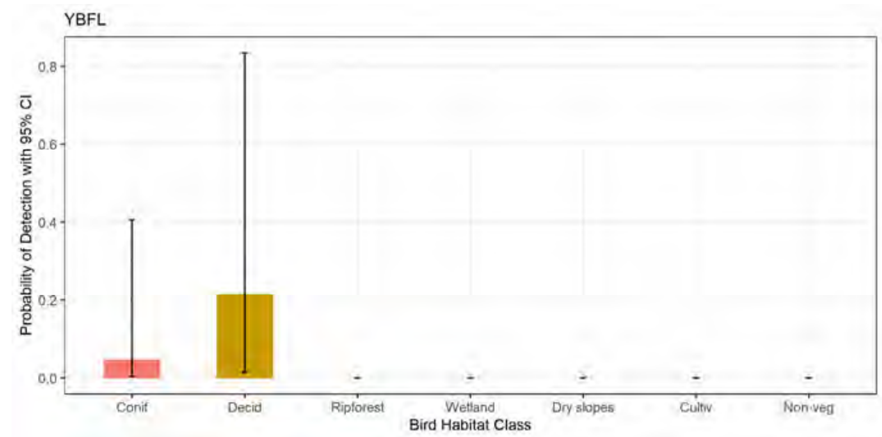

WIWR
Probability of Detection with 95% CI
Conif
Decid
Ripforest
Wetland
Dry slopes
Cultiv
Non-veg
Bird Habitat Class

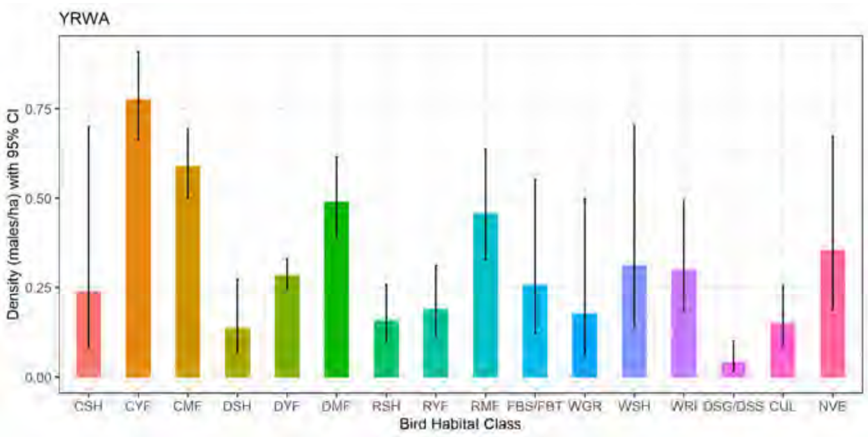

WTSP
Density (males/ha) with 95% CI
CSH
CYF
CMF
DSH
DYF
DMF
RSH
RYF
RMF
FBS/FBT
WGR
WSH
WRI
DSG/DSS
CUL
NVE
Bird Habitat Class


WWCR
Probability of Detection with 95% CI
Conif
Decid
Ripforest
Wetland
Dry slopes
Cultiv
Non-veg
Bird Habitat Class


WWPE
Density (males/ha) with 95% CI
CSH
CYF
CMF
DSH
DYF
DMF
RSH
RYF
RMF
FBS/FBT
WGR
WSH
WRI
DSG/DSS
CUL
NVE
Bird Habitat Class


YRWA
Density (males/ha) with 95% CI
0.00
0.25
0.50
0.75
CSH
CYF
CMF
DSH
DYF
DMF
RSH
RYF
RMF
FBS/FBT
WGR
WSH
WRI
DSG/DSS
CUL
NVE
Bird Habitat Class


YBFL
Probability of Detection with 95% CI
0.0
0.2
0.4
0.6
0.8
Conif
Decid
Ripforest
Wetland
Dry slopes
Cultiv
Non-veg
Bird Habitat Class


YRWA
Density (males/ha) with 95% CI
0.00
0.25
0.50
0.75
CSH
CYF
CMF
DSH
DYF
DMF
RSH
RYF
RMF
FBS/FBT
WGR
WSH
WRI
DSG/DSS
CUL
NVE
Bird Habitat Class

APPENDIX C
DENSITY MODEL RESULTS

Table C.1. Summary of density model selection using Akaike's Information Criterion for small samples (AIC_c).

Species	AIC_c		
	m0	m1	m2
ALFL	1140.219	1101.884	1098.27
AMCR	1424.478	1432.174	1420.099
AMRE	3052.295	2978.093	2965.251
AMRO	4092.336	4098.638	4062.818
BAWW	1512.056	1504.168	1495.724
BCCH	2115.666	2101.88	1962.164
BHCO	2571.177	2541.781	2409.163
BHVI	993.5604	978.1244	980.502
CAWA	1247.002	1240.676	1208.636
CCSP	2543.167	2363.017	2312.521
CEWA	1644.787	1636.122	1615.678
CHSP	2880.702	2849.095	2786.104
CORA	1915.695	1895.511	1847.819
DEJU	2665.662	2627.761	2617.197
GRAJ	876.9984	876.78	880.6805
HAWO	1053.585	1043.985	1021.009
HETH	3291.476	3250.401	3177.308
HOWR	1083.208	1072.408	1072.913
LEFL	5776.999	5582.159	5484.134

Species	AIC_c		
	m0	m1	m2
LISP	2369.992	2314.1	2287.104
OCWA	2019.549	1964.901	1939.879
OVEN	4857.174	4650.564	4635.676
PISI	1339.88	1349.255	1260.473
RBGR	2912.091	2886.317	2822.626
RCKI	895.0196	887.2108	890.2897
REVI	5374.233	5321.568	5281.09
RWBL	1625.402	1614.274	1612.992
SAVS	443.3047	424.2247	429.4057
SOSP	1776.897	1684.925	1673.888
SWSP	400.38	399.4957	401.3568
SWTH	4920.462	4777.581	4723.611
WAVI	3440.152	3353.691	3279.026
WETA	3875.053	3661.507	3629.664
WTSP	6194.441	6085.357	5997.642
WWPE	1724.565	1690.945	1671.738
YBSA	3738.005	3681.961	3584.452
YEWA	6015.246	5952.597	5874.159
YRWA	5224.659	4931.323	4865.644

Habitat model with lowest AIC_c used to estimate density.

Models:

m0: Intercept only (null model)
m1: Bird Habitat Class
m2: Bird Habitat Class + Year

Each model included station as a random effect to account for the repeated measures at each station.

Table C.2. Density model parameters for the best model for each songbird species.

Species	Effect	Group	Term	Estimate	Std.error	Statistic	p.value
ALFL	fixed	NA	(Intercept)	-6.4743	0.47838	-13.5338	9.88E-42
ALFL	fixed	NA	Decid	0.948655	0.404443	2.34558	0.018997
ALFL	fixed	NA	RipForest	1.456788	0.48333	3.014065	0.002578
ALFL	fixed	NA	Wetland	2.627223	0.535441	4.906656	9.26E-07
ALFL	fixed	NA	Dry slopes	3.331174	0.543895	6.124667	9.09E-10
ALFL	fixed	NA	Cultiv	2.109774	0.700211	3.013056	0.002586
ALFL	fixed	NA	Non-veg	2.295174	0.881005	2.605176	0.009183
ALFL	ran_pars	Station	sd__(Intercept)	2.217464	NA	NA	NA
AMCR	fixed	NA	(Intercept)	-7.84909	0.500646	-15.6779	2.14E-55
AMCR	fixed	NA	Decid	-0.51862	0.353126	-1.46864	0.14193
AMCR	fixed	NA	RipForest	-0.50665	0.546806	-0.92656	0.354155
AMCR	fixed	NA	Wetland	0.146221	0.671178	0.217858	0.82754
AMCR	fixed	NA	Dry slopes	-0.52705	0.844724	-0.62393	0.532672
AMCR	fixed	NA	Cultiv	-1.70414	1.630527	-1.04515	0.295955
AMCR	fixed	NA	Non-veg	0.535751	1.145366	0.467755	0.63996
AMCR	ran_pars	Station	sd__(Intercept)	4.141927	NA	NA	NA
AMRE	fixed	NA	(Intercept)	-1.33356	0.671184	-1.98687	0.046937
AMRE	fixed	NA	CYF	-2.12456	0.709772	-2.99329	0.00276
AMRE	fixed	NA	CMF	-0.37917	0.682621	-0.55546	0.578581
AMRE	fixed	NA	DSH	-0.82739	0.7892	-1.04839	0.294458
AMRE	fixed	NA	DYF	-1.24924	0.678606	-1.84089	0.065638
AMRE	fixed	NA	DMF	-0.53587	0.698472	-0.7672	0.442963
AMRE	fixed	NA	RSH	-0.98462	0.730809	-1.3473	0.177885
AMRE	fixed	NA	RYF	-0.32559	0.733471	-0.4439	0.657116
AMRE	fixed	NA	RMF	0.341692	0.712256	0.479732	0.631418
AMRE	fixed	NA	FBS/FBT	-0.90667	0.887858	-1.02119	0.307165
AMRE	fixed	NA	WGR	-2.22337	1.105749	-2.01073	0.044354
AMRE	fixed	NA	WSH	-1.20353	0.929918	-1.29423	0.195586
AMRE	fixed	NA	WRI	-1.83666	0.832001	-2.20752	0.027278
AMRE	fixed	NA	DSG/DSS	-1.67527	0.75085	-2.23116	0.02567
AMRE	fixed	NA	CUL	-1.78409	0.809483	-2.20398	0.027525
AMRE	fixed	NA	NVE	-2.38134	1.097718	-2.16936	0.030056
AMRE	ran_pars	Station	sd__(Intercept)	1.359358	NA	NA	NA
AMRO	fixed	NA	(Intercept)	-1.25561	0.387846	-3.23738	0.001206
AMRO	fixed	NA	CYF	-0.67462	0.400184	-1.68576	0.091841
AMRO	fixed	NA	CMF	-0.75032	0.399394	-1.87865	0.060293
AMRO	fixed	NA	DSH	-0.19249	0.44122	-0.43627	0.662641

Species	Effect	Group	Term	Estimate	Std.error	Statistic	p.value
AMRO	fixed	NA	DYF	-0.63283	0.392187	-1.6136	0.106615
AMRO	fixed	NA	DMF	-0.73522	0.411104	-1.7884	0.073711
AMRO	fixed	NA	RSH	-0.53927	0.421384	-1.27977	0.200626
AMRO	fixed	NA	RYF	-0.4236	0.429738	-0.98573	0.324268
AMRO	fixed	NA	RMF	-0.55339	0.425643	-1.30013	0.193555
AMRO	fixed	NA	FBS/FBT	-1.01907	0.562948	-1.81024	0.070259
AMRO	fixed	NA	WGR	-1.02879	0.587339	-1.75162	0.079839
AMRO	fixed	NA	WSH	-0.31886	0.501835	-0.63539	0.525173
AMRO	fixed	NA	WRI	-0.55437	0.44219	-1.25368	0.209958
AMRO	fixed	NA	DSG/DSS	-0.63171	0.422606	-1.4948	0.134968
AMRO	fixed	NA	CUL	-0.03074	0.424835	-0.07235	0.94232
AMRO	fixed	NA	NVE	-0.39751	0.488189	-0.81426	0.415496
AMRO	ran_pars	Station	sd__(Intercept)	0.515324	NA	NA	NA
BAWW	fixed	NA	(Intercept)	-3.35676	0.222564	-15.0822	2.12E-51
BAWW	fixed	NA	Decid	0.053968	0.20081	0.268752	0.78812
BAWW	fixed	NA	RipForest	0.493485	0.269163	1.833406	0.066742
BAWW	fixed	NA	Wetland	0.033614	0.409268	0.082133	0.934541
BAWW	fixed	NA	Dry slopes	-2.27623	1.042788	-2.18283	0.029049
BAWW	fixed	NA	Cultiv	-1.88802	1.07568	-1.75519	0.079226
BAWW	fixed	NA	Non-veg	-0.25432	0.85366	-0.29791	0.76577
BAWW	ran_pars	Station	sd__(Intercept)	1.471541	NA	NA	NA
BCCH	fixed	NA	(Intercept)	-2.40616	0.162008	-14.8521	6.74E-50
BCCH	fixed	NA	Decid	-0.24886	0.163419	-1.52285	0.127796
BCCH	fixed	NA	RipForest	-0.90376	0.281383	-3.21186	0.001319
BCCH	fixed	NA	Wetland	-0.77637	0.38628	-2.00987	0.044445
BCCH	fixed	NA	Dry slopes	-1.60646	0.524984	-3.06003	0.002213
BCCH	fixed	NA	Cultiv	-0.94025	0.547457	-1.71748	0.085891
BCCH	fixed	NA	Non-veg	-1.65307	1.086327	-1.52171	0.128082
BCCH	ran_pars	Station	sd__(Intercept)	1.381433	NA	NA	NA
BHCO	fixed	NA	(Intercept)	-3.4372	1.125112	-3.05498	0.002251
BHCO	fixed	NA	CYF	0.963823	1.136459	0.848093	0.396386
BHCO	fixed	NA	CMF	0.57586	1.138262	0.505911	0.612919
BHCO	fixed	NA	DSH	1.020565	1.195366	0.853768	0.393234
BHCO	fixed	NA	DYF	1.352671	1.126127	1.201171	0.229685
BHCO	fixed	NA	DMF	1.390034	1.138804	1.220608	0.222234
BHCO	fixed	NA	RSH	0.006477	1.19044	0.005441	0.995659
BHCO	fixed	NA	RYF	1.001359	1.170781	0.855291	0.39239
BHCO	fixed	NA	RMF	0.145987	1.194672	0.122198	0.902742

Species	Effect	Group	Term	Estimate	Std.error	Statistic	p.value
BHCO	fixed	NA	FBS/FBT	1.333541	1.244251	1.071762	0.283827
BHCO	fixed	NA	WGR	0.542902	1.317418	0.412095	0.68027
BHCO	fixed	NA	WSH	1.306589	1.253097	1.042687	0.297093
BHCO	fixed	NA	WRI	-0.21633	1.251684	-0.17283	0.862782
BHCO	fixed	NA	DSG/DSS	-0.30655	1.196928	-0.25611	0.797864
BHCO	fixed	NA	CUL	0.397148	1.19655	0.331911	0.739957
BHCO	fixed	NA	NVE	0.449252	1.299527	0.345704	0.729565
BHCO	ran_pars	Station	sd__(Intercept)	1.11583	NA	NA	NA
BHVI	fixed	NA	(Intercept)	-3.62189	0.28853	-12.5529	3.83E-36
BHVI	fixed	NA	Decid	-0.94819	0.248434	-3.81668	1.35E-04
BHVI	fixed	NA	RipForest	-1.83504	0.561342	-3.26901	0.001079
BHVI	fixed	NA	Wetland	-2.42367	1.064143	-2.27758	0.022752
BHVI	fixed	NA	Dry slopes	-0.61215	0.542342	-1.12871	0.259021
BHVI	fixed	NA	Cultiv	-0.81721	0.730285	-1.11903	0.263126
BHVI	fixed	NA	Non-veg	-1.00224	1.159814	-0.86414	0.387512
BHVI	ran_pars	Station	sd__(Intercept)	1.724353	NA	NA	NA
CAWA	fixed	NA	(Intercept)	-5.62996	0.528655	-10.6496	1.75E-26
CAWA	fixed	NA	Decid	-0.52828	0.334922	-1.57733	0.114721
CAWA	fixed	NA	RipForest	-2.62951	1.111648	-2.36542	0.01801
CAWA	fixed	NA	Wetland	-18.5415	4705.23	-0.00394	0.996856
CAWA	fixed	NA	Dry slopes	-2.45571	1.538358	-1.59632	0.110418
CAWA	fixed	NA	Cultiv	-2.15444	1.688689	-1.2758	0.202025
CAWA	fixed	NA	Non-veg	-1.14734	1.74709	-0.65671	0.511365
CAWA	ran_pars	Station	sd__(Intercept)	4.038662	NA	NA	NA
CCSP	fixed	NA	(Intercept)	-4.16748	0.230681	-18.066	5.91E-73
CCSP	fixed	NA	Decid	1.666783	0.219153	7.605568	2.84E-14
CCSP	fixed	NA	RipForest	1.314676	0.278999	4.712111	2.45E-06
CCSP	fixed	NA	Wetland	1.116599	0.372166	3.000268	0.002697
CCSP	fixed	NA	Dry slopes	3.31443	0.292625	11.32655	9.70E-30
CCSP	fixed	NA	Cultiv	3.046455	0.34436	8.846712	9.01E-19
CCSP	fixed	NA	Non-veg	2.501191	0.470302	5.318262	1.05E-07
CCSP	ran_pars	Station	sd__(Intercept)	1.153267	NA	NA	NA
CEWA	fixed	NA	(Intercept)	-2.77353	0.850209	-3.26217	0.001106
CEWA	fixed	NA	CYF	-1.14804	0.86944	-1.32044	0.186689
CEWA	fixed	NA	CMF	-1.92071	0.884028	-2.17268	0.029804
CEWA	fixed	NA	DSH	-0.13192	0.956721	-0.13789	0.890325
CEWA	fixed	NA	DYF	-1.25258	0.852103	-1.46999	0.141566
CEWA	fixed	NA	DMF	-1.89483	0.927848	-2.04218	0.041134

Species	Effect	Group	Term	Estimate	Std.error	Statistic	p.value
CEWA	fixed	NA	RSH	-0.99504	0.920305	-1.08121	0.279605
CEWA	fixed	NA	RYF	-1.27057	0.970233	-1.30955	0.190347
CEWA	fixed	NA	RMF	-2.42725	1.075857	-2.25611	0.024064
CEWA	fixed	NA	FBS/FBT	0.370898	1.017383	0.364561	0.715439
CEWA	fixed	NA	WGR	-0.12541	1.079108	-0.11622	0.907478
CEWA	fixed	NA	WSH	-0.06004	1.056791	-0.05681	0.954697
CEWA	fixed	NA	WRI	-1.21725	0.987031	-1.23324	0.217485
CEWA	fixed	NA	DSG/DSS	-0.46757	0.90532	-0.51647	0.605526
CEWA	fixed	NA	CUL	-1.32058	0.999418	-1.32135	0.186385
CEWA	fixed	NA	NVE	-0.85808	1.075015	-0.7982	0.424755
CEWA	ran_pars	Station	sd__(Intercept)	1.535059	NA	NA	NA
CHSP	fixed	NA	(Intercept)	-1.50661	0.556637	-2.70663	0.006797
CHSP	fixed	NA	CYF	-0.27582	0.568771	-0.48494	0.627716
CHSP	fixed	NA	CMF	-0.68604	0.570346	-1.20285	0.229033
CHSP	fixed	NA	DSH	-1.5821	0.731669	-2.16232	0.030594
CHSP	fixed	NA	DYF	-1.01031	0.563299	-1.79355	0.072884
CHSP	fixed	NA	DMF	-0.69791	0.585187	-1.19263	0.233015
CHSP	fixed	NA	RSH	-0.82546	0.609248	-1.35489	0.175453
CHSP	fixed	NA	RYF	-1.01893	0.638954	-1.59468	0.110784
CHSP	fixed	NA	RMF	-1.10272	0.628771	-1.75377	0.07947
CHSP	fixed	NA	FBS/FBT	0.093719	0.680113	0.137799	0.890399
CHSP	fixed	NA	WGR	-1.43695	0.863035	-1.66499	0.095914
CHSP	fixed	NA	WSH	-1.83181	0.951654	-1.92487	0.054246
CHSP	fixed	NA	WRI	-0.22876	0.620034	-0.36894	0.712169
CHSP	fixed	NA	DSG/DSS	-2.36195	0.705314	-3.34879	8.12E-04
CHSP	fixed	NA	CUL	-1.33967	0.665962	-2.01163	0.044259
CHSP	fixed	NA	NVE	-0.36767	0.69328	-0.53034	0.595877
CHSP	ran_pars	Station	sd__(Intercept)	0.941308	NA	NA	NA
CORA	fixed	NA	(Intercept)	-5.55547	0.262106	-21.1955	1.05E-99
CORA	fixed	NA	Decid	0.041289	0.237586	0.173786	0.862034
CORA	fixed	NA	RipForest	0.680051	0.314607	2.161592	0.03065
CORA	fixed	NA	Wetland	-0.32265	0.545358	-0.59162	0.554103
CORA	fixed	NA	Dry slopes	2.009713	0.412401	4.873202	1.10E-06
CORA	fixed	NA	Cultiv	1.441899	0.549717	2.622983	0.008716
CORA	fixed	NA	Non-veg	0.743911	0.766257	0.970837	0.331629
CORA	ran_pars	Station	sd__(Intercept)	1.992552	NA	NA	NA
DEJU	fixed	NA	(Intercept)	-1.99001	0.11572	-17.1967	2.81E-66
DEJU	fixed	NA	Decid	-0.81201	0.137659	-5.89872	3.66E-09

Species	Effect	Group	Term	Estimate	Std.error	Statistic	p.value
DEJU	fixed	NA	RipForest	-0.91594	0.218024	-4.20109	2.66E-05
DEJU	fixed	NA	Wetland	-0.51055	0.283023	-1.80392	0.071244
DEJU	fixed	NA	Dry slopes	-1.31349	0.356686	-3.68249	2.31E-04
DEJU	fixed	NA	Cultiv	-0.77884	0.400596	-1.9442	0.051871
DEJU	fixed	NA	Non-veg	-2.09054	1.047944	-1.99489	0.046055
DEJU	ran_pars	Station	sd__(Intercept)	1.161607	NA	NA	NA
GRAJ	fixed	NA	(Intercept)	-6.36038	0.557265	-11.4136	3.58E-30
GRAJ	fixed	NA	Decid	-1.26556	0.46491	-2.72216	0.006486
GRAJ	fixed	NA	RipForest	-0.94479	0.68299	-1.38331	0.166569
GRAJ	fixed	NA	Wetland	-1.64105	1.290014	-1.27212	0.20333
GRAJ	fixed	NA	Dry slopes	-19.3784	8623.958	-0.00225	0.998207
GRAJ	fixed	NA	Cultiv	-17.5386	4434.192	-0.00396	0.996844
GRAJ	fixed	NA	Non-veg	-0.84554	1.955963	-0.43229	0.665531
GRAJ	ran_pars	Station	sd__(Intercept)	4.88517	NA	NA	NA
GRJA	fixed	NA	(Intercept)	-6.7526	0.57515	-11.7406	7.89E-32
GRJA	fixed	NA	Decid	-1.17355	0.444355	-2.64102	0.008266
GRJA	fixed	NA	RipForest	-0.76499	0.651967	-1.17335	0.240654
GRJA	fixed	NA	Wetland	-1.48837	1.242338	-1.19804	0.230902
GRJA	fixed	NA	Dry slopes	-21.146	23823.78	-8.88E-04	0.999292
GRJA	fixed	NA	Cultiv	-17.2943	4270.592	-0.00405	0.996769
GRJA	fixed	NA	Non-veg	-0.88976	1.888678	-0.4711	0.637568
GRJA	ran_pars	Station	sd__(Intercept)	4.533856	NA	NA	NA
HAWO	fixed	NA	(Intercept)	-3.64806	0.294518	-12.3865	3.09E-35
HAWO	fixed	NA	Decid	-0.63316	0.250372	-2.52886	0.011443
HAWO	fixed	NA	RipForest	-0.02394	0.331537	-0.0722	0.942445
HAWO	fixed	NA	Wetland	-1.23238	0.68112	-1.80935	0.070397
HAWO	fixed	NA	Dry slopes	-20.7324	11918.34	-0.00174	0.998612
HAWO	fixed	NA	Cultiv	-1.61288	1.120415	-1.43954	0.149999
HAWO	fixed	NA	Non-veg	-18.2273	6495.858	-0.00281	0.997761
HAWO	ran_pars	Station	sd__(Intercept)	1.809484	NA	NA	NA
HETH	fixed	NA	(Intercept)	-4.09721	1.101688	-3.71903	2.00E-04
HETH	fixed	NA	CYF	1.180868	1.108726	1.065068	0.286845
HETH	fixed	NA	CMF	0.284138	1.113505	0.255175	0.798588
HETH	fixed	NA	DSH	1.472575	1.151909	1.278377	0.201116
HETH	fixed	NA	DYF	1.486221	1.102906	1.34755	0.177803
HETH	fixed	NA	DMF	0.710258	1.120634	0.6338	0.526212
HETH	fixed	NA	RSH	1.241632	1.127264	1.101457	0.270698
HETH	fixed	NA	RYF	1.652188	1.129203	1.463146	0.143428

Species	Effect	Group	Term	Estimate	Std.error	Statistic	p.value
HETH	fixed	NA	RMF	0.389142	1.15026	0.338308	0.735131
HETH	fixed	NA	FBS/FBT	1.219089	1.205604	1.011185	0.311928
HETH	fixed	NA	WGR	0.326406	1.351776	0.241464	0.809195
HETH	fixed	NA	WSH	0.961415	1.23532	0.778272	0.436409
HETH	fixed	NA	WRI	0.937906	1.153746	0.812923	0.416262
HETH	fixed	NA	DSG/DSS	0.862569	1.137443	0.75834	0.448247
HETH	fixed	NA	CUL	1.884684	1.135411	1.659913	0.096932
HETH	fixed	NA	NVE	1.328806	1.183132	1.123126	0.261384
HETH	ran_pars	Station	sd__(Intercept)	1.013925	NA	NA	NA
HOWR	fixed	NA	(Intercept)	-6.79476	0.618814	-10.9803	4.75E-28
HOWR	fixed	NA	Decid	1.395108	0.377135	3.699229	2.16E-04
HOWR	fixed	NA	RipForest	-0.67099	0.804266	-0.83429	0.404116
HOWR	fixed	NA	Wetland	-0.26603	0.975943	-0.27259	0.785168
HOWR	fixed	NA	Dry slopes	1.795459	0.612052	2.933507	0.003352
HOWR	fixed	NA	Cultiv	-0.41763	1.309183	-0.319	0.749728
HOWR	fixed	NA	Non-veg	-15.1896	3249.879	-0.00467	0.996271
HOWR	ran_pars	Station	sd__(Intercept)	2.636843	NA	NA	NA
LEFL	fixed	NA	(Intercept)	-1.43256	0.592721	-2.41693	0.015652
LEFL	fixed	NA	CYF	-0.08343	0.605231	-0.13785	0.89036
LEFL	fixed	NA	CMF	0.057662	0.602766	0.095662	0.923789
LEFL	fixed	NA	DSH	0.164509	0.662488	0.24832	0.803887
LEFL	fixed	NA	DYF	1.083775	0.595107	1.821143	0.068585
LEFL	fixed	NA	DMF	1.112999	0.60542	1.838392	0.066005
LEFL	fixed	NA	RSH	-0.10589	0.630248	-0.16801	0.866574
LEFL	fixed	NA	RYF	0.404141	0.634229	0.637216	0.523984
LEFL	fixed	NA	RMF	0.379921	0.627577	0.605378	0.544928
LEFL	fixed	NA	FBS/FBT	-2.34272	1.199593	-1.95293	0.050828
LEFL	fixed	NA	WGR	-1.0561	0.840789	-1.25609	0.209084
LEFL	fixed	NA	WSH	0.115095	0.729821	0.157703	0.874691
LEFL	fixed	NA	WRI	-0.79799	0.689101	-1.15802	0.246858
LEFL	fixed	NA	DSG/DSS	-0.47385	0.634849	-0.74639	0.45543
LEFL	fixed	NA	CUL	-0.18637	0.653429	-0.28522	0.775475
LEFL	fixed	NA	NVE	0.306504	0.694463	0.441354	0.658957
LEFL	ran_pars	Station	sd__(Intercept)	0.980019	NA	NA	NA
LISP	fixed	NA	(Intercept)	-1.9997	0.649206	-3.08022	0.002068
LISP	fixed	NA	CYF	-1.24806	0.675609	-1.84731	0.064702
LISP	fixed	NA	CMF	-1.66374	0.681022	-2.443	0.014566
LISP	fixed	NA	DSH	-0.2633	0.741689	-0.355	0.72259

Species	Effect	Group	Term	Estimate	Std.error	Statistic	p.value
LISP	fixed	NA	DYF	-0.84671	0.654186	-1.29429	0.195564
LISP	fixed	NA	DMF	-1.21466	0.693606	-1.75122	0.079907
LISP	fixed	NA	RSH	0.228372	0.68236	0.33468	0.737867
LISP	fixed	NA	RYF	-0.86537	0.731183	-1.18352	0.236602
LISP	fixed	NA	RMF	-1.72188	0.775721	-2.21972	0.026438
LISP	fixed	NA	FBS/FBT	0.082019	0.791928	0.103569	0.917512
LISP	fixed	NA	WGR	0.224314	0.800063	0.28037	0.779193
LISP	fixed	NA	WSH	-0.30255	0.832821	-0.36328	0.716396
LISP	fixed	NA	WRI	0.207486	0.709604	0.292397	0.769983
LISP	fixed	NA	DSG/DSS	-1.70878	0.744962	-2.29378	0.021803
LISP	fixed	NA	CUL	-0.13363	0.714457	-0.18704	0.851629
LISP	fixed	NA	NVE	-0.13335	0.78854	-0.1691	0.865715
LISP	ran_pars	Station	sd__(Intercept)	1.107844	NA	NA	NA
OCWA	fixed	NA	(Intercept)	-2.88845	0.174541	-16.5488	1.63E-61
OCWA	fixed	NA	Decid	0.884315	0.167865	5.268005	1.38E-07
OCWA	fixed	NA	RipForest	-0.47214	0.300839	-1.56941	0.116553
OCWA	fixed	NA	Wetland	-1.3652	0.613815	-2.22413	0.02614
OCWA	fixed	NA	Dry slopes	0.250869	0.328546	0.763573	0.445122
OCWA	fixed	NA	Cultiv	-0.08439	0.461263	-0.18295	0.85484
OCWA	fixed	NA	Non-veg	-0.20276	0.771809	-0.26271	0.792777
OCWA	ran_pars	Station	sd__(Intercept)	1.011186	NA	NA	NA
OVEN	fixed	NA	(Intercept)	-1.89907	0.520011	-3.65198	2.60E-04
OVEN	fixed	NA	CYF	0.204395	0.526704	0.388064	0.697969
OVEN	fixed	NA	CMF	0.083694	0.5262	0.159053	0.873627
OVEN	fixed	NA	DSH	-0.29843	0.597931	-0.4991	0.61771
OVEN	fixed	NA	DYF	0.519446	0.521521	0.996021	0.31924
OVEN	fixed	NA	DMF	0.611264	0.531237	1.150644	0.249879
OVEN	fixed	NA	RSH	-1.24659	0.594918	-2.09539	0.036136
OVEN	fixed	NA	RYF	-0.75784	0.590257	-1.28392	0.199169
OVEN	fixed	NA	RMF	-0.26419	0.559065	-0.47255	0.636535
OVEN	fixed	NA	FBS/FBT	-2.51043	1.148411	-2.186	0.028816
OVEN	fixed	NA	WGR	-2.21601	1.152405	-1.92294	0.054487
OVEN	fixed	NA	WSH	-17.9302	2273.144	-0.00789	0.993706
OVEN	fixed	NA	WRI	-1.72632	0.700429	-2.46466	0.013714
OVEN	fixed	NA	DSG/DSS	-1.57792	0.62009	-2.54466	0.010939
OVEN	fixed	NA	CUL	-0.95844	0.614564	-1.55954	0.118868
OVEN	fixed	NA	NVE	-1.49017	0.799273	-1.86441	0.062264
OVEN	ran_pars	Station	sd__(Intercept)	0.745465	NA	NA	NA

Species	Effect	Group	Term	Estimate	Std.error	Statistic	p.value
PISI	fixed	NA	(Intercept)	-5.68764	0.509257	-11.1685	5.81E-29
PISI	fixed	NA	Decid	-0.19262	0.400402	-0.48107	0.630466
PISI	fixed	NA	RipForest	-0.7674	0.681753	-1.12563	0.260321
PISI	fixed	NA	Wetland	-0.37759	0.87582	-0.43113	0.666377
PISI	fixed	NA	Dry slopes	-1.38142	1.291703	-1.06946	0.284863
PISI	fixed	NA	Cultiv	-0.14969	1.188974	-0.1259	0.899811
PISI	fixed	NA	Non-veg	0.249808	1.426976	0.175061	0.861031
PISI	ran_pars	Station	sd__(Intercept)	4.795526	NA	NA	NA
RBGR	fixed	NA	(Intercept)	-2.7542	0.107669	-25.5802	2.54E-144
RBGR	fixed	NA	Decid	0.245216	0.115288	2.126977	0.033422
RBGR	fixed	NA	RipForest	-0.06624	0.179991	-0.36805	0.712839
RBGR	fixed	NA	Wetland	-0.75843	0.318239	-2.3832	0.017163
RBGR	fixed	NA	Dry slopes	-0.81323	0.331503	-2.45316	0.014161
RBGR	fixed	NA	Cultiv	-1.47843	0.539238	-2.74171	0.006112
RBGR	fixed	NA	Non-veg	0.092318	0.451283	0.204568	0.83791
RBGR	ran_pars	Station	sd__(Intercept)	0.82256	NA	NA	NA
RCKI	fixed	NA	(Intercept)	-3.37458	1.129682	-2.98719	0.002816
RCKI	fixed	NA	CYF	-1.19441	1.130798	-1.05626	0.290851
RCKI	fixed	NA	CMF	-1.24003	1.126917	-1.10038	0.271168
RCKI	fixed	NA	DSH	-2.31093	1.462159	-1.58049	0.113994
RCKI	fixed	NA	DYF	-3.09986	1.144187	-2.70923	0.006744
RCKI	fixed	NA	DMF	-1.98827	1.18511	-1.67771	0.093403
RCKI	fixed	NA	RSH	-2.50759	1.321364	-1.89772	0.057732
RCKI	fixed	NA	RYF	-2.7324	1.449037	-1.88566	0.05934
RCKI	fixed	NA	RMF	-3.02495	1.469133	-2.059	0.039494
RCKI	fixed	NA	FBS/FBT	0.287712	1.344746	0.213953	0.830584
RCKI	fixed	NA	WGR	-1.37828	1.543414	-0.89301	0.371852
RCKI	fixed	NA	WSH	-0.009	1.381171	-0.00652	0.994801
RCKI	fixed	NA	WRI	-2.31188	1.429285	-1.61751	0.105768
RCKI	fixed	NA	DSG/DSS	-20.4565	4792.82	-0.00427	0.996595
RCKI	fixed	NA	CUL	-3.01988	1.52005	-1.9867	0.046956
RCKI	fixed	NA	NVE	-22.9203	39221.84	-5.84E-04	0.999534
RCKI	ran_pars	Station	sd__(Intercept)	2.269871	NA	NA	NA
REVI	fixed	NA	(Intercept)	-1.05941	0.347858	-3.04551	0.002323
REVI	fixed	NA	CYF	-0.67017	0.358174	-1.87108	0.061334
REVI	fixed	NA	CMF	-0.09745	0.353326	-0.2758	0.782702
REVI	fixed	NA	DSH	-0.30556	0.400388	-0.76316	0.445367
REVI	fixed	NA	DYF	-0.21055	0.350255	-0.60114	0.547748

Species	Effect	Group	Term	Estimate	Std.error	Statistic	p.value
REVI	fixed	NA	DMF	-0.1784	0.361579	-0.49339	0.621736
REVI	fixed	NA	RSH	-0.17454	0.370554	-0.47103	0.637617
REVI	fixed	NA	RYF	-0.32055	0.383523	-0.83581	0.403263
REVI	fixed	NA	RMF	0.138426	0.368372	0.375779	0.707081
REVI	fixed	NA	FBS/FBT	-1.3167	0.550369	-2.39239	0.016739
REVI	fixed	NA	WGR	-18.0891	1871.398	-0.00967	0.992288
REVI	fixed	NA	WSH	-0.86668	0.498484	-1.73862	0.082101
REVI	fixed	NA	WRI	-0.40932	0.393666	-1.03977	0.298445
REVI	fixed	NA	DSG/DSS	-0.22397	0.370674	-0.60422	0.545697
REVI	fixed	NA	CUL	-0.39585	0.389167	-1.01718	0.309068
REVI	fixed	NA	NVE	-0.63968	0.457335	-1.39871	0.161901
REVI	ran_pars	Station	sd__(Intercept)	0.435682	NA	NA	NA
RWBL	fixed	NA	(Intercept)	-8.54977	0.580111	-14.7382	3.67E-49
RWBL	fixed	NA	Decid	1.021196	0.505138	2.02162	0.043216
RWBL	fixed	NA	RipForest	-0.69348	1.040554	-0.66645	0.505122
RWBL	fixed	NA	Wetland	3.502114	0.822163	4.259633	2.05E-05
RWBL	fixed	NA	Dry slopes	0.10462	1.160615	0.090142	0.928174
RWBL	fixed	NA	Cultiv	-0.09244	1.502326	-0.06153	0.950937
RWBL	fixed	NA	Non-veg	-14.8897	3514.898	-0.00424	0.99662
RWBL	ran_pars	Station	sd__(Intercept)	5.251611	NA	NA	NA
SAVS	fixed	NA	(Intercept)	-10.2477	1.487607	-6.88868	5.63E-12
SAVS	fixed	NA	Decid	1.06539	1.492935	0.713621	0.475461
SAVS	fixed	NA	RipForest	3.076677	1.442443	2.132963	0.032928
SAVS	fixed	NA	Wetland	3.181026	1.554619	2.046178	0.040739
SAVS	fixed	NA	Dry slopes	2.560676	1.719556	1.489149	0.136448
SAVS	fixed	NA	Cultiv	7.172569	1.558445	4.602388	4.18E-06
SAVS	fixed	NA	Non-veg	3.244865	2.019984	1.606381	0.10819
SAVS	ran_pars	Station	sd__(Intercept)	3.642096	NA	NA	NA
SOSP	fixed	NA	(Intercept)	-4.31587	0.228233	-18.91	9.44E-80
SOSP	fixed	NA	Decid	0.0434	0.222231	0.195291	0.845165
SOSP	fixed	NA	RipForest	1.59292	0.254528	6.258318	3.89E-10
SOSP	fixed	NA	Wetland	2.12861	0.314035	6.778268	1.22E-11
SOSP	fixed	NA	Dry slopes	-0.17534	0.509765	-0.34396	0.730876
SOSP	fixed	NA	Cultiv	-0.55468	0.721783	-0.76849	0.442198
SOSP	fixed	NA	Non-veg	2.324397	0.501566	4.634281	3.58E-06
SOSP	ran_pars	Station	sd__(Intercept)	1.488776	NA	NA	NA
SWSP	fixed	NA	(Intercept)	-9.55924	0.972478	-9.82978	8.38E-23
SWSP	fixed	NA	Decid	-0.67227	1.071948	-0.62715	0.530561

Species	Effect	Group	Term	Estimate	Std.error	Statistic	p.value
SWSP	fixed	NA	RipForest	-0.45379	1.608654	-0.28209	0.777873
SWSP	fixed	NA	Wetland	3.108193	0.976198	3.183978	0.001453
SWSP	fixed	NA	Dry slopes	-17.3062	11034.06	-0.00157	0.998749
SWSP	fixed	NA	Cultiv	-16.1477	7603.364	-0.00212	0.998305
SWSP	fixed	NA	Non-veg	1.025404	2.343262	0.437597	0.661679
SWSP	ran_pars	Station	sd__(Intercept)	5.951736	NA	NA	NA
SWTH	fixed	NA	(Intercept)	-2.40356	0.633576	-3.79365	1.48E-04
SWTH	fixed	NA	CYF	1.097245	0.639078	1.716918	0.085994
SWTH	fixed	NA	CMF	1.303792	0.637559	2.044976	0.040857
SWTH	fixed	NA	DSH	0.183136	0.698664	0.262123	0.793226
SWTH	fixed	NA	DYF	0.64607	0.636284	1.015379	0.309925
SWTH	fixed	NA	DMF	1.139716	0.643213	1.771909	0.07641
SWTH	fixed	NA	RSH	0.339098	0.66173	0.512442	0.608342
SWTH	fixed	NA	RYF	0.668498	0.663885	1.006949	0.313959
SWTH	fixed	NA	RMF	0.971077	0.653533	1.485889	0.137308
SWTH	fixed	NA	FBS/FBT	0.317696	0.741784	0.428286	0.668443
SWTH	fixed	NA	WGR	-0.37031	0.835814	-0.44306	0.657726
SWTH	fixed	NA	WSH	0.816833	0.719216	1.135726	0.256071
SWTH	fixed	NA	WRI	-0.11698	0.69978	-0.16716	0.867243
SWTH	fixed	NA	DSG/DSS	-0.87585	0.699507	-1.25209	0.210536
SWTH	fixed	NA	CUL	-0.75906	0.731744	-1.03733	0.299584
SWTH	fixed	NA	NVE	0.369134	0.730843	0.50508	0.613503
SWTH	ran_pars	Station	sd__(Intercept)	0.654923	NA	NA	NA
WAVI	fixed	NA	(Intercept)	-2.13789	0.627901	-3.40482	6.62E-04
WAVI	fixed	NA	CYF	0.411166	0.639762	0.642686	0.520428
WAVI	fixed	NA	CMF	-0.14509	0.642518	-0.22582	0.82134
WAVI	fixed	NA	DSH	-0.5308	0.73184	-0.72529	0.468274
WAVI	fixed	NA	DYF	0.241406	0.631288	0.382403	0.702163
WAVI	fixed	NA	DMF	-0.0749	0.651862	-0.1149	0.908524
WAVI	fixed	NA	RSH	-1.42542	0.725504	-1.96473	0.049446
WAVI	fixed	NA	RYF	-0.56909	0.700907	-0.81193	0.41683
WAVI	fixed	NA	RMF	-0.60957	0.693612	-0.87883	0.379494
WAVI	fixed	NA	FBS/FBT	0.19335	0.76783	0.251813	0.801185
WAVI	fixed	NA	WGR	-2.37622	1.220698	-1.9466	0.051582
WAVI	fixed	NA	WSH	-0.13961	0.798248	-0.1749	0.86116
WAVI	fixed	NA	WRI	-1.69576	0.826453	-2.05186	0.040184
WAVI	fixed	NA	DSG/DSS	-1.72206	0.715347	-2.4073	0.016071
WAVI	fixed	NA	CUL	-0.79284	0.705427	-1.12391	0.26105

Species	Effect	Group	Term	Estimate	Std.error	Statistic	p.value
WAVI	fixed	NA	NVE	-0.95219	0.867263	-1.09793	0.272236
WAVI	ran_pars	Station	sd__(Intercept)	0.953063	NA	NA	NA
WETA	fixed	NA	(Intercept)	-3.19818	1.018939	-3.13873	0.001697
WETA	fixed	NA	CYF	2.050605	1.021965	2.006531	0.0448
WETA	fixed	NA	CMF	2.332071	1.02093	2.284262	0.022356
WETA	fixed	NA	DSH	0.68818	1.082917	0.635487	0.525111
WETA	fixed	NA	DYF	1.379615	1.020632	1.351726	0.176463
WETA	fixed	NA	DMF	1.623752	1.027474	1.580334	0.11403
WETA	fixed	NA	RSH	0.545993	1.055071	0.517494	0.604811
WETA	fixed	NA	RYF	1.04662	1.051767	0.995106	0.319685
WETA	fixed	NA	RMF	1.611996	1.035643	1.556517	0.119585
WETA	fixed	NA	FBS/FBT	1.599578	1.080223	1.480785	0.138664
WETA	fixed	NA	WGR	0.372031	1.180889	0.315043	0.752729
WETA	fixed	NA	WSH	0.747809	1.144066	0.653642	0.513343
WETA	fixed	NA	WRI	0.227417	1.100918	0.20657	0.836346
WETA	fixed	NA	DSG/DSS	-0.70563	1.114592	-0.63308	0.52668
WETA	fixed	NA	CUL	0.214791	1.082395	0.198441	0.8427
WETA	fixed	NA	NVE	0.66353	1.141453	0.581303	0.561037
WETA	ran_pars	Station	sd__(Intercept)	0.47642	NA	NA	NA
WTSP	fixed	NA	(Intercept)	-0.68502	0.266378	-2.5716	0.010123
WTSP	fixed	NA	CYF	-0.53172	0.273374	-1.94503	0.051771
WTSP	fixed	NA	CMF	-0.58025	0.272914	-2.12612	0.033493
WTSP	fixed	NA	DSH	-0.10949	0.300658	-0.36416	0.715735
WTSP	fixed	NA	DYF	-0.11804	0.268409	-0.43977	0.660104
WTSP	fixed	NA	DMF	-0.40378	0.279032	-1.44707	0.147877
WTSP	fixed	NA	RSH	-0.98421	0.302072	-3.2582	0.001121
WTSP	fixed	NA	RYF	-0.7386	0.305423	-2.41828	0.015594
WTSP	fixed	NA	RMF	-0.3985	0.289921	-1.37452	0.169279
WTSP	fixed	NA	FBS/FBT	-1.10181	0.398782	-2.76294	0.005728
WTSP	fixed	NA	WGR	-0.81298	0.391985	-2.074	0.038079
WTSP	fixed	NA	WSH	-0.90666	0.384337	-2.35901	0.018324
WTSP	fixed	NA	WRI	-1.326	0.343971	-3.85496	1.16E-04
WTSP	fixed	NA	DSG/DSS	-0.31256	0.285705	-1.09401	0.27395
WTSP	fixed	NA	CUL	-0.48776	0.300757	-1.62176	0.104854
WTSP	fixed	NA	NVE	-0.62575	0.349354	-1.79116	0.073267
WTSP	ran_pars	Station	sd__(Intercept)	0.242522	NA	NA	NA
WWPE	fixed	NA	(Intercept)	-3.96755	1.148483	-3.4546	5.51E-04
WWPE	fixed	NA	CYF	0.366125	1.161937	0.315099	0.752686

Species	Effect	Group	Term	Estimate	Std.error	Statistic	p.value
WWPE	fixed	NA	CMF	0.186561	1.161574	0.160611	0.8724
WWPE	fixed	NA	DSH	-0.79764	1.395748	-0.57148	0.567673
WWPE	fixed	NA	DYF	0.757157	1.147258	0.659971	0.509272
WWPE	fixed	NA	DMF	0.185115	1.177992	0.157144	0.875131
WWPE	fixed	NA	RSH	-0.93646	1.296872	-0.72209	0.470239
WWPE	fixed	NA	RYF	-1.72704	1.535861	-1.12447	0.260812
WWPE	fixed	NA	RMF	-1.89149	1.533298	-1.23361	0.217349
WWPE	fixed	NA	FBS/FBT	0.013157	1.411224	0.009323	0.992561
WWPE	fixed	NA	WGR	0.816876	1.329865	0.614255	0.539047
WWPE	fixed	NA	WSH	2.248785	1.244208	1.807403	0.070699
WWPE	fixed	NA	WRI	-0.32721	1.308434	-0.25007	0.80253
WWPE	fixed	NA	DSG/DSS	-0.72532	1.24695	-0.58168	0.560785
WWPE	fixed	NA	CUL	-1.15933	1.376843	-0.84202	0.399776
WWPE	fixed	NA	NVE	-0.48646	1.554002	-0.31303	0.754254
WWPE	ran_pars	Station	sd__(Intercept)	1.309404	NA	NA	NA
YBSA	fixed	NA	(Intercept)	-2.67046	0.778702	-3.42938	6.05E-04
YBSA	fixed	NA	CYF	0.906167	0.786144	1.152673	0.249044
YBSA	fixed	NA	CMF	0.901429	0.785148	1.1481	0.250927
YBSA	fixed	NA	DSH	0.485442	0.84528	0.574298	0.565766
YBSA	fixed	NA	DYF	0.999514	0.780923	1.279913	0.200576
YBSA	fixed	NA	DMF	0.961371	0.791774	1.214198	0.224672
YBSA	fixed	NA	RSH	-0.16422	0.828786	-0.19814	0.842936
YBSA	fixed	NA	RYF	0.249904	0.829855	0.301142	0.763306
YBSA	fixed	NA	RMF	0.761642	0.808199	0.942394	0.345991
YBSA	fixed	NA	FBS/FBT	-0.02076	0.956109	-0.02171	0.982678
YBSA	fixed	NA	WGR	-0.28815	1.007418	-0.28603	0.774855
YBSA	fixed	NA	WSH	0.406532	0.916518	0.443561	0.65736
YBSA	fixed	NA	WRI	-1.2561	0.981373	-1.27995	0.200564
YBSA	fixed	NA	DSG/DSS	-0.38261	0.836799	-0.45723	0.647507
YBSA	fixed	NA	CUL	0.001416	0.847974	0.001669	0.998668
YBSA	fixed	NA	NVE	-0.07846	0.948245	-0.08275	0.934053
YBSA	ran_pars	Station	sd__(Intercept)	0.79463	NA	NA	NA
YEWA	fixed	NA	(Intercept)	-1.36852	0.469992	-2.9118	0.003594
YEWA	fixed	NA	CYF	0.015981	0.480517	0.033257	0.973469
YEWA	fixed	NA	CMF	0.540204	0.476507	1.133675	0.256931
YEWA	fixed	NA	DSH	0.761466	0.50639	1.503713	0.132655
YEWA	fixed	NA	DYF	0.761298	0.472177	1.612312	0.106894
YEWA	fixed	NA	DMF	0.82668	0.480013	1.722204	0.085033

Species	Effect	Group	Term	Estimate	Std.error	Statistic	p.value
YEWA	fixed	NA	RSH	0.170481	0.494358	0.344852	0.730205
YEWA	fixed	NA	RYF	0.462002	0.498464	0.926851	0.354004
YEWA	fixed	NA	RMF	0.411437	0.495573	0.830225	0.406411
YEWA	fixed	NA	FBS/FBT	-0.18399	0.595218	-0.30912	0.757229
YEWA	fixed	NA	WGR	-0.2853	0.592033	-0.48191	0.629872
YEWA	fixed	NA	WSH	0.438539	0.557722	0.786303	0.43169
YEWA	fixed	NA	WRI	0.074831	0.514734	0.145377	0.884413
YEWA	fixed	NA	DSG/DSS	0.3683	0.488382	0.754123	0.450775
YEWA	fixed	NA	CUL	0.062908	0.50594	0.124338	0.901048
YEWA	fixed	NA	NVE	0.293531	0.549397	0.534278	0.59315
YEWA	ran_pars	Station	sd__(Intercept)	0.616685	NA	NA	NA
YRWA	fixed	NA	(Intercept)	-1.56098	0.563754	-2.7689	0.005625
YRWA	fixed	NA	CYF	1.515197	0.567455	2.670164	0.007581
YRWA	fixed	NA	CMF	1.198604	0.56747	2.112188	0.03467
YRWA	fixed	NA	DSH	-0.48883	0.667401	-0.73244	0.463898
YRWA	fixed	NA	DYF	0.555433	0.565862	0.98157	0.326312
YRWA	fixed	NA	DMF	0.952399	0.573277	1.661324	0.096648
YRWA	fixed	NA	RSH	-0.47848	0.614404	-0.77877	0.436117
YRWA	fixed	NA	RYF	-0.15196	0.616758	-0.24638	0.805389
YRWA	fixed	NA	RMF	0.656483	0.58776	1.116925	0.264026
YRWA	fixed	NA	FBS/FBT	0.084996	0.688158	0.123513	0.901701
YRWA	fixed	NA	WGR	-0.60338	0.778841	-0.77471	0.43851
YRWA	fixed	NA	WSH	3.20E-04	0.703305	4.55E-04	0.999637
YRWA	fixed	NA	WRI	0.131506	0.616626	0.213268	0.831118
YRWA	fixed	NA	DSG/DSS	-2.01176	0.72505	-2.77464	0.005526
YRWA	fixed	NA	CUL	-0.2597	0.621801	-0.41766	0.676196
YRWA	fixed	NA	NVE	0.4585	0.652983	0.702162	0.482578
YRWA	ran_pars	Station	sd__(Intercept)	0.607955	NA	NA	NA

APPENDIX D
OCCUPANCY MODEL RESULTS

Table D.1. Summary of occupancy model selection using Akaike's Information Criterion for small samples (AIC_c).

Species	m0	m1	m2	m3	m4	m5	m6	m7	m8
ATTW	499.70	486.61	501.38	477.31	487.59	478.84	502.80	492.00	480.77
BAOR	761.00	700.12	751.93	699.30	693.20	692.61	728.42	727.92	675.75
BBMA	716.93	687.07	714.88	688.86	687.78	689.61	706.71	708.64	690.00
BEKI	254.01	241.24	-	238.62	238.91	236.45	250.69	250.35	231.20
BKPW	266.59	259.20	-	222.34	261.19	224.33	264.39	228.71	220.23
BKSW	309.67	304.00	304.97	304.85	299.70	301.12	293.89	295.68	284.04
BLJA	519.69	497.75	517.95	498.51	496.65	497.31	519.84	521.50	499.31
BOCH	592.87	529.79	593.90	523.23	531.79	525.03	584.70	572.08	519.04
BRBL	367.22	343.55	364.54	344.78	345.03	346.01	365.35	366.60	347.22
BTNW	1805.91	1672.04	1773.39	1646.60	1644.34	1623.08	-	-	-
CMWA	156.67	157.00	155.16	153.28	156.61	152.86	151.85	147.36	149.26
COWA	303.55	296.03	296.22	296.89	289.01	289.87	297.57	298.46	291.06
COYE	1126.40	1029.80	1128.07	1020.29	1022.42	1012.54	-	-	-
DOWO	595.28	587.70	597.26	582.25	589.61	-	594.69	586.93	584.01
DUFL	100.62	100.56	100.54	102.50	101.36	103.28	96.66	98.67	104.72
EAKI	197.18	199.61	195.13	201.59	194.47	196.48	197.01	198.97	197.73
EAPH	314.87	323.69	316.77	322.42	325.60	324.32	311.58	310.43	319.04
EVGR	433.41	433.87	434.12	426.79	434.68	427.45	414.34	408.64	412.86
FOSP	488.72	478.66	490.60	469.51	480.51	471.20	487.07	479.27	468.03
GCKI	916.73	820.77	914.89	820.22	817.53	817.73	901.42	902.35	812.76
MACW	198.33	202.97	186.58	199.85	189.97	186.98	188.49	186.91	175.24
MAWR	207.36	182.24	208.85	183.96	174.89	176.87	209.77	212.78	175.28
MGNW	1345.92	1279.95	1337.22	1280.10	1272.37	1272.36	-	-	-
MOWA	866.46	861.74	863.14	862.66	860.16	860.97	841.27	841.12	839.03
NOFL	970.27	965.05	965.72	967.07	961.22	963.23	967.41	969.30	965.02
NOWA	1020.95	933.18	1021.71	926.96	934.46	928.40	-	-	-
OSFL	368.46	350.27	369.79	352.28	350.66	352.69	371.32	373.24	353.41
PHVI	134.88	143.49	136.83	144.57	145.39	146.48	138.78	140.01	148.37
PIWO	527.44	530.12	525.87	531.90	529.26	531.07	518.35	520.29	526.39
PSFL	574.80	573.82	573.92	497.46	573.97	496.01	575.50	502.53	-
PUFI	984.87	945.06	982.76	841.76	943.31	840.39	971.79	859.75	840.74
RBNU	1867.00	1751.39	1868.42	1742.76	1753.39	1744.78	-	-	-
RECR	167.31	174.79	166.32	175.44	174.46	175.04	168.23	168.71	177.04
TEWA	2053.63	1999.42	2054.51	1754.37	2000.84	1756.32			
TRSW	465.46	434.02	467.45	431.09	436.04	433.10	467.43	465.69	423.97
VESP	716.39	529.30	709.81	530.76	527.55	529.11	670.93	672.81	525.74

Species	m0	m1	m2	m3	m4	m5	m6	m7	m8
VGSW	227.44	228.27	223.78	230.11	225.84	227.52	217.26	218.98	220.35
WBNU	134.89	142.80	136.61	142.11	144.52	143.79	138.00	137.30	145.46
WIWA	512.23	510.11	494.31	501.21	493.66	483.85	460.06	440.84	435.51
WIWR	275.95	-	244.44	237.07	233.22	235.20	241.81	243.37	233.55
WWCR	648.88	598.97	641.37	470.85	585.20	462.01	643.38	516.61	462.14

Habitat model with lowest AIC_c used to estimate occupancy.

Models:

m0. Intercept only (null model).
m1. Bird habitat class.
m2. Bird habitat class + year.
m3. Bird habitat class + day.
m4. Bird habitat class + time since sunrise.
m5. Bird habitat class + year + day.
m6. Bird habitat class + year + time since sunrise.
m7. Bird habitat class + day + time since sunrise.
m8. Bird habitat class + year + day + times since sunrise.

Table D.2. Occupancy model parameters for best model for each songbird species.

Species	psi(Int)	p(Int)	p(Decid)	p(Ripforest)	p(Wetland)	p(Dry slopes)	p(Cultiv)	p(Non-veg)	p(day)	p(tssr)	p(Year)
ATTW	-0.356	-7.727	-1.325	-0.905	-1.622	-10.059	-0.185	-21.021	12.010	-	-
BAOR	-1.392	-1.125	2.828	1.925	1.160	-7.993	1.536	-7.065	-5.686	-2.569	-1.069
BBMA	-0.841	-2.752	0.008	1.898	1.810	1.544	1.413	0.631	-	-	-
BEKI	-0.862	1.902	-2.088	1.744	0.364	-8.223	-7.464	-6.553	-12.109	-1.821	-0.859
BKPW	5.709	14.765	-0.292	1.437	-10.432	-8.783	-7.915	-6.338	-48.413	5.820	-0.996
BKSW	-0.413	-4.358	0.218	-0.485	2.058	2.759	-8.865	3.352	-3.279	21.651	-1.455
BLJA	5.920	-3.702	-1.227	0.047	0.804	-11.185	-8.643	-7.031	-	4.353	-
BOCH	3.704	-6.942	-2.078	-1.949	-0.909	-9.427	-8.793	-7.973	8.439	5.165	-0.567
BRBL	-2.477	-10.199	9.474	8.819	-0.072	8.222	11.748	-0.728	-	-	-
BTNW	-0.026	4.766	-1.638	-1.613	-9.534	-10.040	-2.945	-11.080	-9.607	-8.810	-
CMWA	6.473	4.779	-1.231	0.829	-14.547	-0.019	-9.318	-8.728	-24.465	2.343	0.933
COWA	9.337	-4.242	0.618	-22.421	2.019	-10.179	-8.174	-6.919	-	-14.718	-
COYE	-0.265	-6.109	0.815	1.516	3.429	0.102	0.272	1.568	8.232	-6.415	-
DOWO	10.272	-0.288	0.760	-0.034	-11.177	0.177	1.129	-6.271	-8.770	-	-
DUFL	7.277	-16.233	9.868	11.317	11.542	12.264	-3.451	-2.496	-	-	-
EAKI	-3.149	-2.309	2.394	5.701	1.286	-7.725	-7.416	-6.679	-	-34.509	-
EAPH	-1.755	0.441	0.661	0.346	0.815	1.402	0.859	-8.508	-8.962	5.874	-0.870
EVGR	-1.654	3.174	-0.408	0.373	-10.766	-10.270	-10.325	0.665	-13.209	6.354	-1.193
FOSP	-1.987	4.660	-0.469	1.935	0.797	1.595	0.458	6.290	-15.545	3.111	-0.681
GCKI	-1.093	2.218	-2.838	-2.424	-12.814	-12.372	-11.662	-1.689	-4.571	-0.628	-0.460
GRCA	0.361	-23.419	11.269	-5.667	-2.614	15.545	12.534	-2.184	16.014	-	-
MACW	-2.996	16.125	-9.681	-10.255	-34.370	-5.501	-26.786	-18.024	-37.916	19.521	5.773
MAWR	-2.127	-3.318	1.947	-20.922	7.856	-7.080	-5.398	-4.452	-	-32.991	-
MGNW	-0.348	-1.759	-1.484	-0.584	-0.645	-14.109	-11.350	-1.722	3.231	-5.918	-
MOWA	-1.360	-3.443	-0.081	-0.494	-1.221	0.307	-0.965	0.043	4.250	3.226	-0.960
NOFL	-0.545	-2.598	0.555	0.498	0.701	0.311	0.009	-9.319	-	4.733	-
NOWA	-1.428	2.212	-0.019	0.870	1.307	0.353	-9.482	10.905	-7.900	-	-
OSFL	-1.733	-1.633	-2.129	-0.559	0.239	-0.457	0.461	-11.809	-	-	-
PHVI	7.104	-5.954	0.508	1.038	1.263	-8.337	-9.965	-9.060	-	-	-
PIWO	1.636	-3.100	-0.217	0.180	-0.606	-8.547	-0.387	-5.717	-1.114	0.422	-0.520
PSFL	-1.817	-20.679	0.482	-0.837	-19.502	-1.817	-12.476	-20.173	42.502	-7.681	-
PUFI	1.518	9.070	0.268	-0.580	-0.395	-0.371	0.482	-9.319	-28.810	3.591	-
RBNU	0.396	1.942	-1.408	-1.257	-1.659	-3.715	-12.525	-2.349	-5.353	-	-

Species	psi(Int)	p(Int)	p(Decid)	p(Ripforest)	p(Wetland)	p(Dry slopes)	p(Cultiv)	p(Non-veg)	p(day)	p(tssr)	p(Year)
RECR	5.557	-4.393	-0.383	-0.573	-9.036	-8.236	-7.242	-6.321	-	-10.166	-
TEWA	0.055	14.554	-0.625	-0.228	-0.603	-3.107	-3.286	-1.646	-34.635	-	-
TRSW	-1.251	-0.694	1.232	-0.028	4.624	3.041	1.316	3.160	-8.687	9.227	-1.179
VESP	0.816	-5.583	1.306	-12.304	0.100	5.050	4.647	2.253	1.082	1.980	0.482
VGSW	-2.030	-6.834	0.815	-21.756	-8.323	2.310	-8.972	2.361	3.772	25.336	-1.483
WBNU	4.990	-0.045	0.563	1.082	-8.724	-7.780	-7.439	-5.959	-13.513	-	-
WIWA	9.884	3.809	-0.491	-0.984	-1.220	-0.654	0.029	-8.192	-19.233	1.957	1.401
WIWR	-2.831	0.734	-2.489	-21.663	-9.520	-10.111	-10.945	-9.975	-	-16.998	-
WWCR	0.797	-21.068	-1.649	-2.610	-2.004	-9.483	-11.018	-24.711	38.724	8.608	-
YBFL	-3.140	-1.834	1.750	-21.846	-8.502	-8.071	-13.586	-12.804	-	-19.839	-

APPENDIX E
PROJECT QUALIFIED ENVIRONMENTAL PROFESSIONALS

Name and Affiliation	Project Role
Jeff Matheson, M.Sc., R.P.Bio. Tetra Tech Canada Inc.	Project manager, report author
Claudio Bianchini, R.P.Bio. Bianchini Biological Services	Field data collection
Camille Roberge, B.Sc., E.Pt. Tetra Tech Canada Inc.	Field data collection, data entry
Elyse Hofs, B.Sc., Dipl.T. Tetra Tech Canada Inc.	Field data collection, data entry
Damian Power Wolfhound Wildlife Services	Field data collection
Karla Langlois, B.Sc., P.Biol. Tetra Tech Canada Inc.	Reviewer

APPENDIX F
LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

NATURAL SCIENCES

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

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Appendix 3. Common Nighthawk Follow-up Monitoring 2019 Annual Report

Site C Clean Energy Project
Common Nighthawk Follow-up Monitoring: 2018-2019 Summary Report

PRESENTED TO

BC Hydro and Power Authority

MARCH 30, 2020
ISSUED FOR USE
FILE: 704-ENV.VENV03095-01.NIGHTHAWK

Saulteau EBA Environmental Services Joint Venture.
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Site C Clean Energy Project Common Nighthawk Follow-Up Monitoring – 2018-2019 Summary Report

FILE: 704-ENV.VENV03095-01.Nighthawk
March 30, 2020

PRESENTED TO

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FILE: 704-ENV THAWK

Elyse Hofs, B.Sc., Dipl.T **2020-03-30**
Environmental Scientist

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EXECUTIVE SUMMARY

Surveys of Common Nighthawk (*Cordeiles minor*) were completed in the area of BC Hydro and Power Authority's Site C Clean Energy Project in the spring and summer of 2018 and 2019. A report was completed after the 2018 surveys to provide interim results of the surveys completed in that year. This report includes the results from both 2018 and 2019.

Autonomous Recording Units (ARUs) were used as the primary method to survey Common Nighthawk. ARUs were deployed in the reservoir footprint, the BC Hydro proposed mitigation properties and immediately downstream of the dam in areas that may be affected by fluctuating water levels. The audio recordings were analyzed in two ways: human listening and automated recognition. Point counts combined with ARU recordings were also completed at select locations to allow for comparison of ARU human listening data to point counts at the same time and same place.

Common Nighthawk were found widely along the Peace River, occurring in more than three-quarters of stations surveyed in 2018 and 2019. Of the stations where Common Nighthawk were detected, 82% had territorial males, suggesting that most areas with Common Nighthawk have suitable breeding habitat or it is present nearby.

Automated detection identified 10 survey stations with Common Nighthawk that human listening had failed to detect. In the reverse, automated recognition failed to detect Common Nighthawk at seven sites where they were known to occur based on human listening. Each station that automated recognition predicted as having Common Nighthawk was validated by a human listener to confirm that Common Nighthawk were truly present. Many of the stations lacking Common Nighthawk (18) had false positive predictions, indicating the importance of validation. The purpose of the automated recognition was to determine if there is Common Nighthawk presence at sites where human listening initially failed to detect it. Automated detection proved to be a beneficial complement to human listening.

Common Nighthawk relative abundance counts and occupancy were greatest in riparian-mixed shrub. The lowest relative abundance counts and occupancy were documented in wetland-graminoid habitats.

Surveys at the Wilder Creek mitigation property found Common Nighthawk at two of the four survey stations; both stations were located in areas classified as cultivated. Common Nighthawk were reported at one of four survey stations at Marl Fen. There were only two calls identified in the eight recordings analyzed, and previous surveys at Marl Fen had not reported Common Nighthawk. No Common Nighthawk were detected at the Rutledge Property.

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1.0 INTRODUCTION

Common Nighthawk (*Cordeiles minor*) surveys were conducted in the area of BC Hydro and Power Authority's (BC Hydro) Site C Clean Energy Project ("Site C") in the spring and summer of 2018 and 2019. The surveys were part of BC Hydro's Breeding Bird Follow-up Monitoring Program (Volume 2, Section 14 in BC Hydro 2013). 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. The monitoring program for Common Nighthawk is described in the Common Nighthawk program plan (BC Hydro 2017).

The Common Nighthawk monitoring program has three objectives:

1. Determine the distribution and relative abundance of Common Nighthawk within habitat lost or fragmented by the Project.

2. Identify attributes of habitat used by Common Nighthawk, to help identify habitats for offsetting impacts.

3. Determine whether the mitigation properties offset habitat impacts to Common Nighthawk.

A report was completed after the 2018 Common Nighthawk surveys to provide interim results of the surveys completed in that year. This report includes the results from both 2018 and 2019. Some of the analyses also include data collected during baseline studies in 2010 and 2012 (documented in BC Hydro 2013).

2.0 METHODS

2.1 Approach

An Autonomous Recording Units (ARU) is a standalone audio recording unit installed and left for a period of time to record bird vocalizations or other sounds. The audio recordings are analyzed and interpreted at a later date once the recording units have been retrieved. ARUs are becoming a common approach for surveys of birds (review by Shonfield and Bayne 2017) and have been used to survey for Common Nighthawk (e.g., Knight and Bayne 2017 and Knight et. al 2019). The benefit of using ARUs for Common Nighthawk 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 Common Nighthawk are active, allowing for monitoring in areas that would otherwise be more difficult to survey. ARUs also allow for longer periods of data collection, increasing the potential for detection of species of interest.

Bird survey counts (from either ARUs or human-conducted point counts) are an incomplete measure of bird abundance because they do not account for the probability of not detecting birds that are present. Measures of absolute abundance or density (number per unit area) are preferable to count data because they facilitate unbiased comparisons between species and habitat types, and therefore better support monitoring objectives. Detection coefficients can be estimated from point count data through distance sampling and time-removal models, if certain assumptions are maintained (Matsuoka et al. 2017). This can work for point counts where distance to each detection can be estimated by human observers, but not for ARUs where distance to detection cannot be estimated using typical single-unit deployments. However, detection coefficients developed from point counts can be applied to counts from ARUs if it is assumed that detectability is the same between point counts and ARU human listening, or if a correction factor can be estimated and applied to account for differences, as demonstrated by Van Wilgenberg et al (2017) using paired sampling.

The design of the Site C Common Nighthawk sampling and analyses was based on the following:

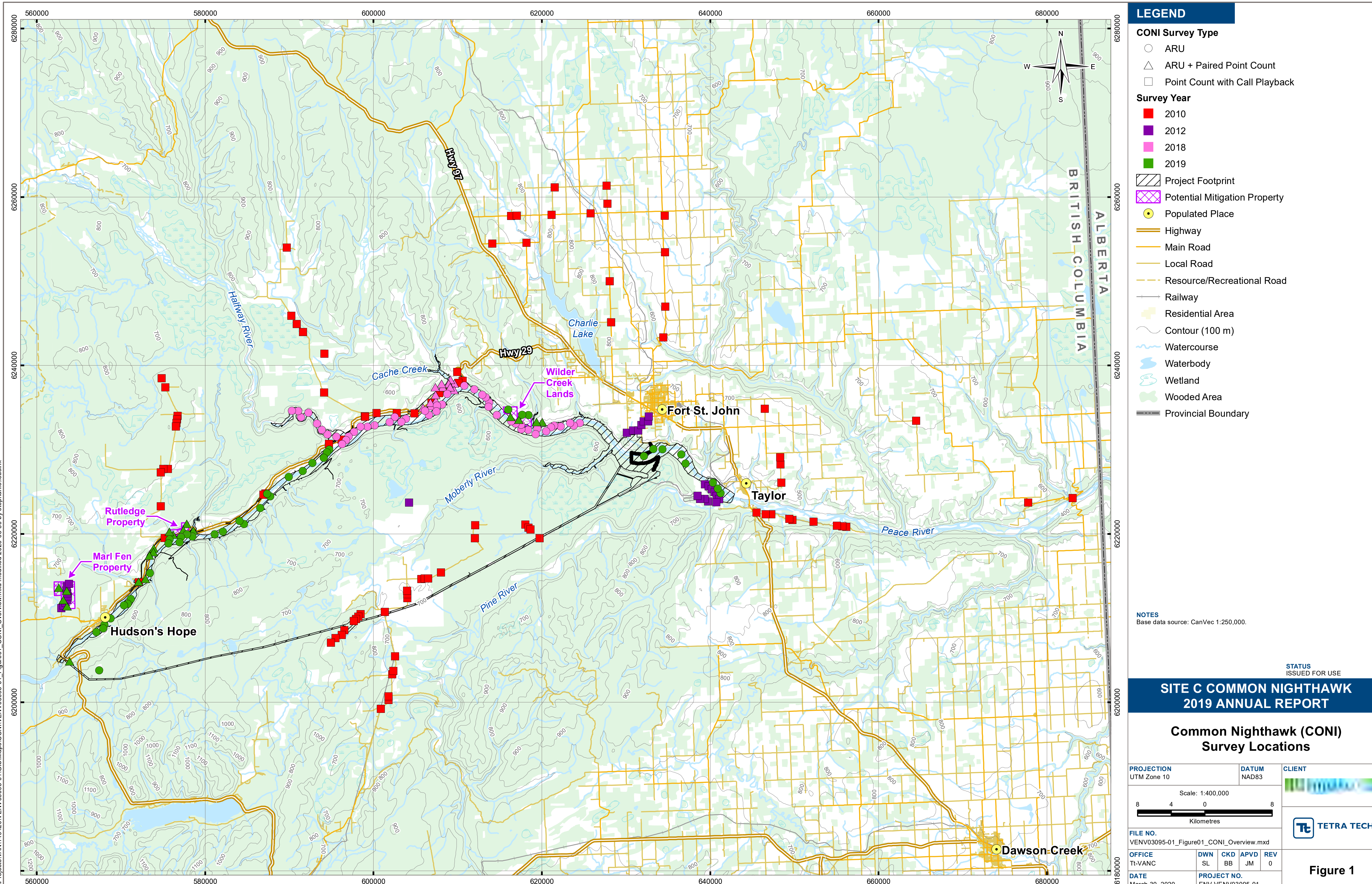
- The majority of the Site C footprint is only accessible by boat, and ARUs provide a method of conducting surveys that otherwise could not be done at night using point counts. Human listening of a subset of recordings provides an estimated count of individual Common Nighthawk at each site.
- Point counts conducted by human observers completed in portions of the footprint that can be accessed at night (i.e., by road) can provide data for estimating coefficients of detection. Those coefficients can then be used for estimating Common Nighthawk absolute abundance from counts, provided there are enough detections to allow for statistical estimation. Common Nighthawk point count data collected in previous years (2010 and 2012) could also be used to supplement this analysis.
- Point counts conducted by human observers paired with simultaneous ARU recordings (with subsequent human listening) allow for analysis to determine if there are differences in mean counts and to determine a correction factor between the two survey methods, provided there are enough detections to allow for statistical estimation.
- Human listening of ARU recordings allows for analysis of only a sample of recordings made at a site because of the time required to listen to recordings in real time. Automated detection (use of computer software trained to recognize vocalizations in a recording) of Common Nighthawk allows for a scan of all recordings made at a site to determine if there are additional detections of Common Nighthawk presence at sites where ARU human listening found none.

2.2 Survey Area and Station Locations

Common Nighthawk surveys in 2018 and 2019 were completed in the reservoir footprint, BC Hydro mitigation properties, and between the dam and the confluence of the Peace River and Pine River, where habitat may be affected by fluctuating water levels (Figure 1). Surveys were completed at 59 locations in 2018 and 60 locations in 2019 for a total of 119 stations. The number of survey stations was based on the availability of suitable open habitat (non-forested habitat), and nearly all undisturbed suitable areas within the reservoir footprint surveyed over the two years. Where feasible, survey stations were placed in the centre of a homogenous habitat type. However, that was not always feasible because of the heterogeneity and complexity of the Peace River valley and the detection radius of the ARUs (at least 200 m or much more in open habitats).

2.3 ARU Data Collection

Fifteen ARUs (Song Meter SM4 from Wildlife Acoustics Inc.) were used for audio recording. The ARUs were initially deployed at 15 stations for seven days and then rotated to 15 new stations three additional times to survey 60 stations in each year. ARUs were left to record for at least seven days per station between June 1 and July 4, 2018 and May 31 to July 3, 2019. Recordings collected beyond the first seven days at a station were not used in analyses. 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 hour on the hour for each day of deployment. Recordings from times when Common Nighthawk are typically less active were not analyzed but kept for potential use in other monitoring programs. The ARUs recorded 2-channel stereo, uncompressed WAV files at 24 KHz. Of the 119 ARU survey stations, two had malfunctioning ARUs and no audio recordings were made, leaving 117 for analyses.


LEGEND
CONI Survey Type
ARU
ARU + Paired Point Count
Point Count with Call Playback
Survey Year
2010
2012
2018
2019
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 COMMON NIGHTHAWK
2019 ANNUAL REPORT
Common Nighthawk (CONI)
Survey Locations
PROJECTION
UTM Zone 10
DATUM
NAD83
CLIENT
Scale: 1:400,000
8 4 0 8
Kilometres
TETRA TECH
FILE NO.
VENV03095-01_Figure01_CONI_Overview.mxd
OFFICE
Tt-VANC
DWN
SL
CKD
BB
APVD
JM
REV
0
DATE
March 30, 2020
PROJECT NO.
ENV.VENV03095-01
Fort St. John
Taylor
Hudson's Hope
Dawson Creek
Charlie Lake
Hwy 97
Hwy 29
Cache Creek
Halfway River
Moberly River
Pine River
Peace River
Wilder Creek Lands
Rutledge Property
Marl Fen Property
BRITISH COLUMBIA
ALBERTA
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560000
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Figure 1

2.4 Processing of ARU Recordings

ARU recordings were analyzed in two ways: human listening and automated detection. Human listening allows for detection of both the Common Nighthawk foraging call ("peent") and the low frequency, non-vocal display sound (wing booms). Automated detection has the benefit of analyzing many recordings without human intervention, though is limited to the Common Nighthawk foraging call because low-frequency sounds (like the Common Nighthawk wing boom) are more difficult for automated recognition software to identify.

2.4.1 Human Listening

Two 10-minute recordings were randomly selected from each station for human listening. Only recordings made within two hours of sunset were considered for analysis (22:00 and 23:00)[1]. The two recordings for human listening were selected from different nights. If a selected recording had persistent wind or rain, a new recording was selected to avoid periods of low Common Nighthawk activity or decreased ability to detect sounds.

The process for human listening was based on the protocols in Lankau et. al (2015) and Wild Research (2015). Recordings were played back using Audacity® (Audacity Team, 2018). The trained human listener played back each recording and noted all Common Nighthawk calls and wing booms in 1-minute intervals. The listener replayed any section needed to accurately track and count Common Nighthawk detections. The number of individual Common Nighthawk were estimated based on overlapping calls or calls so close together that it was apparent that more than one individual was present. This approach is conservative, and the number of Common Nighthawk detected at a station may be an underestimate. An estimate of perceived distance to each individual was also recorded (near, mid and far). Human listening was conducted by the same trained human listener for all recordings for both years.

2.4.2 Automated Detection

Processing

Automated detection of Common Nighthawk calls was completed using Kaleidoscope Pro (Version 5; Wildlife Acoustics Inc.), a software application used to visualize, isolate, sort and identify vocalizations in sound recordings. Kaleidoscope uses signal detection and cluster analysis to group similar vocalizations based on their spectral characteristics. A species-specific recognizer (referred to as a classifier in Kaleidoscope; however, the term recognizer will be used in this document) is developed using training data manually selected by a human listener. This recognizer is then applied to new audio recordings to isolate vocalizations similar to those identified in the training data. A Common Nighthawk recognizer was developed using 97 manually identified Common Nighthawk calls sourced from 30 10-minute audio recordings (the training data). For the recognizer to differentiate Common Nighthawk vocalizations from other detected sounds, 361 non-Common Nighthawk vocalizations were also identified. The training data excluded those recordings used for human listening so that the performance of the recognizer could be evaluated against data not used to develop the recognizer.

The recognizer was first applied to a benchmark dataset to evaluate its performance (described further below) and then to all 2018 and 2019 station recordings made at 22:00 and 23:00. The audio recordings were processed using the parameter settings listed in Table 1.

[1] During the survey period, sunset ranged from 21:39 to 21:55.

Table 1. Parameter settings used to process recordings and develop a recognizer in Kaleidoscope Pro.

Parameter	Setting
Signal parameters	
Frequency range	1000 – 10000 Hz.
Minimum and maximum length of detection	0.1 – 0.7 seconds.
Maximum inter-syllable gap	0.05 sec [a]
Cluster analysis (when developing recognizer)	
Maximum distance from cluster center to include outputs in cluster	1.0
FFT Window	5.33 ms
Max states	12
Maximum distance from cluster center for building clusters	0.5
Cluster analysis (when recognizer was applied to new recordings)	
Maximum distance from cluster center to include outputs in cluster	2.0
FFT Window	5.33 ms
Max states	12
Maximum distance from cluster center for building clusters	0.5

[a] Since the Common Nighthawk call is only one syllable, an inter-syllable gap of 0 seconds was initially used but was found to produce very few Common Nighthawk hits.

The ARUs have two microphones corresponding to left and right channel. Both channels were included in the automated detection to maximize the potential for Common Nighthawk detection.

Evaluation of Recognizer Performance on Benchmark Data

To evaluate the performance of the recognizer, a benchmark dataset of 50 recordings (500 minutes) was selected from the pool of recordings used for the human listening analysis. The benchmark dataset was selected from the recordings used in the human listening so that recognizer detections could be compared to the human listening results.

Knight et al. (2017) conducted a comparison of various acoustic recognizers and recommended several metrics to evaluate their performance:

Precision - The proportion of recognizer hits that are true detections of Common Nighthawk, calculated as

$$Precision = \frac{True\ Positive}{True\ Positive + False\ Positive}$$

Recall – The proportion of Common Nighthawk vocalizations classified as hits, calculated as

$$Recall = \frac{True\ Positive}{True\ Positive + False\ Negative},$$

F-score – The combination of precision and recall in to a single score (harmonic mean), calculated as

$$F - score = \frac{2 * Precision * Recall}{Precision + Recall}.$$

False negative for *recall* was calculated as the total number of Common Nighthawk detections from human listening minus the number of recognizer *True Positive* detections.

Precision, recall and *F-score* should be reported for varying levels of recognizer score (Knight et al. 2017). Score refers to a measure of confidence that a target vocalization match has been found. A high score (closer to 1 on a scale of 0-1) would indicate higher confidence of a match. Kaleidoscope Pro uses cluster analysis to group similar recordings and each detected vocalization is assigned a distance from the centre of the cluster that it has been assigned to. A low distance (closer to 0) would indicate a higher confidence of a match, and therefore a higher score. To allow comparison with other studies, distance was converted to score by dividing the distance of individual Common Nighthawk hits ($Distance_i$) by the maximum distance of all Common Nighthawk hits ($Distance_{max}$) and subtracting from 1.

$$Score = 1 - \frac{Distance_i}{Distance_{max}}$$

Calculations of p*recision*, *recall* and *F-score* at varying distance thresholds were done by repeatedly selecting a subset of the validated recognizer results in distance increments of 0.01. This produced 100 distance thresholds where each metric was calculated using the detections with distances less than the specified threshold increment.

Knight et al. (2017) also recommended a fourth metric: area under the curve (AUC), where *precision* is plotted against *recall*. This was problematic to calculate because of the cluster analysis approach used by Kaleidoscope Pro. The *precision-recall* AUC plot requires that the number of true positives, false positives and false negatives that are used for the calculation of *precision* and *recall* be calculated at varying distance thresholds. In Kaleidoscope Pro's cluster analysis, false negatives from the non-Common Nighthawk detections are on a different distance scale than the Common Nighthawk detections used in the true positive and false positive calculations. The result is an AUC plot that is difficult to interpret and would not be comparable to *precision-recall* plots from other studies. As an alternative to *precision-recall* AUC, a plot of the rate of true positives against the rate of false positives, referred to as Receiver Operating Characteristics (ROC) curve, was used. ROC does not incorporate non-Common Nighthawk detections, and therefore avoids the problem encountered with the *precision-recall* curve. All analyses were completed using R (R Core Team 2019).

Performance of the Recognizer to Predict Presence-Absence in Benchmark Data

The Common Nighthawk recognizer was also evaluated in terms of its ability to predict Common Nighthawk presence in a recording relative to human listening. *Precision* and *recall* were calculated in the following way:

$$Presence - Absence\ Precision = \frac{True\ Presence\ Samples}{True\ Presence\ Samples + False\ Presence\ Samples}, and$$

$$Presence - Absence\ Recall = \frac{True\ Presence\ Samples}{True\ Presence\ from\ Human\ Listening}.$$

Validation of Common Nighthawk Presence in all Recordings

The results of the automated detection when the recognizer was applied to all 2018 and 2019 recordings made at 22:00 and 23:00 were validated by reviewing Common Nighthawk hits by ear and visual inspection of the spectrogram until the first true-positive detection was encountered.

2.5 Point Count Surveys

Point counts were conducted at 13 locations in 2018 and 19 locations in 2019 within the reservoir footprint that could be accessed by vehicle and foot. The point count surveys in 2018 began at around sunset, as indicated for Common Nighthawk in the BC RISC Standards (RIC 1998). In 2019, the first evening surveys began a little earlier, up to a half-hour before sunset, as recommended by Wild Research (2015). Sunset ranged from 21:39 to 21:55. Surveys continued for approximately two hours after commencement of the first survey of the evening. The 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 10 minutes and the first detection of an individual Common Nighthawk was recorded in one of three intervals: 0-3 minutes, 3-5 minutes and 5-10 minutes. An audio recording was collected using the station ARU and corresponded to the exact time period the point count was conducted.

Surveys were not conducted in inclement weather conditions (i.e., wind speed > Beaufort 3, steady rain, temperature < 7 ^{o}C). UTM coordinates (NAD 83), survey start and end time, and weather conditions (i.e., wind, cloud cover, precipitation, and temperature) were recorded for each station. When Common Nighthawk were detected, surveyors recorded the detection type (i.e. visual, foraging call or wing boom) and time, the activity, the number heard/seen, and the estimated distance and direction to the initial detection location. All field data were recorded on standard point count survey forms. Incidental observations of other wildlife were recorded during surveys and while in the field.

2.6 Common Nighthawk Surveys in 2010 and 2012

Common Nighthawk surveys were completed in 2010 and 2012 as part of baseline studies. The survey techniques utilized point counts accompanied by pre-recorded call playback and surveys were conducted according to the standards outlined in Inventory Methods for Nighthawk and Poorwill (RIC 1998). Surveys were conducted from sunset to dark, during the breeding period. Stations were placed along existing roads and were visited at least three times. Interstation distance was at least 400 metres in 2010 and 500 metres in 2012. At each station, observers played a commercially-obtained recording of a male Common Nighthawk over a speaker (FoxPro FX-3) to elicit a response from territorial males in the area. Playbacks consisted of five to six calls broadcast in series, followed by at least 30 seconds of silence where surveyors listened for a response. This sequence was repeated for five minutes, followed by two minutes of silent listening, for a total station time of seven minutes. Calls were not played if Common Nighthawk were spontaneously calling when the survey commenced. Surveys were not completed in inclement weather conditions—wind greater than 20 kilometres per hour, steady rain, and temperature less than 7 °C. If a nighthawk was detected, surveyors recorded the detection type and time, the sex and age class if possible, the activity, the number of individuals heard/seen, and the estimated distance and direction to the initial detection location. Surveys were completed at 91 unique locations at least 3 times, for a total of 345 surveys (Figure 1).

The 2010 and 2012 Common Nighthawk survey data were used in two ways:

- To show the incidence (presence-not detected) of Common Nighthawk across all areas surveyed, in conjunction with the 2018-2019 data; and,
- To attempt to calculate coefficients of detection and density from point counts.

The 2010 and 2012 survey data were not used for estimates of relative abundance for two reasons:

- Common Nighthawk surveys in those years used pre-recorded call-playback, which would potentially bias estimates of relative abundance; and,
- The majority of survey stations in 2010 and 2012 were from outside the Peace River valley, which may not be representative of the density of Common Nighthawk in and around the project footprint and could bias interpretations of habitat loss within the footprint.

2.7 Coefficients of Detection and Density from Point Counts

Time-removal models and distance sampling analysis can be used to account for the probability of a bird singing given that it was present at the time of a survey (time-removal model), and the probability that the bird is detected (distance sampling). The product of these two analyses is a detection coefficient that can be used to generate estimates of absolute abundance from count data. The analytical methods planned to be used were those advocated by Matsuoka et. al (2014), and as applied by Solymos et al. (2013).

Distance sampling analyses assume that the probability of detecting an individual decreases with distance from an observer, according to a decay curve. During initial data review, Common Nighthawk detections from point counts conducted in 2010, 2012, 2018 and 2019 were tallied by distance class. The number of Common Nighthawk detected increases with distance from observer (Figure 2), the opposite of what might be expected and typically used in distance sampling (Buckland et al, 1993). This pattern is most likely related to the difficulty in estimating distance during Common Nighthawk points due to the following:

- Low or no light at the time of survey that diminishes or eliminates visual distance references, making distance estimation challenging;
- Nearly all Common Nighthawk detections are when individuals are flying, and their constant and unpredictable movements make distance estimation challenging; and,
- Common Nighthawk calls can be heard at great distance since surveys are done in open habitats and often when there are few other sounds that might mask their calls.

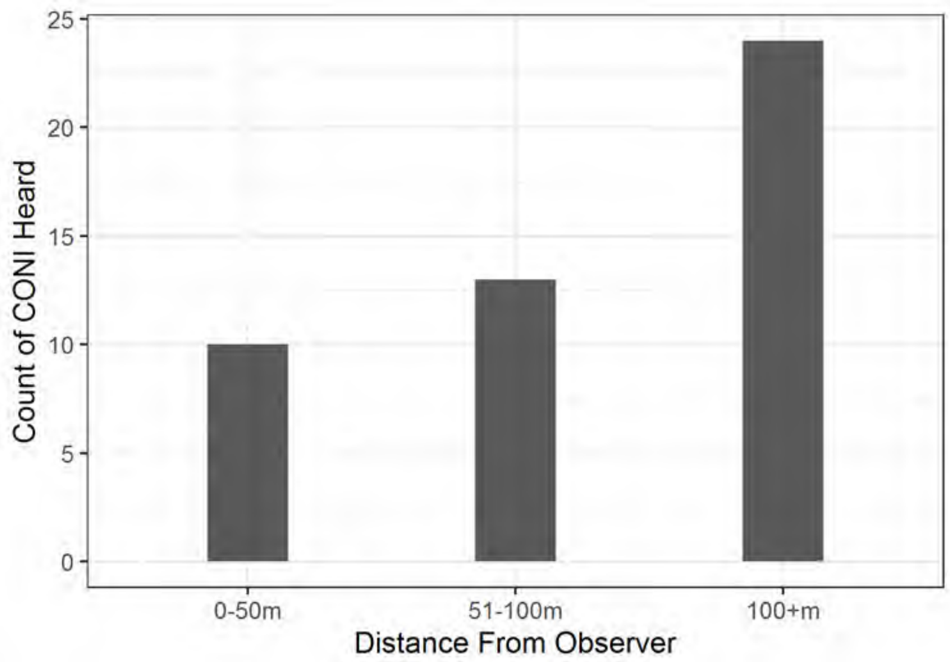


Figure 2. Number of Common Nighthawk detections by distance from observer for point counts conducted in 2010, 2012, 2018 and 2019.

Development of coefficients of detection from the point count data was not completed because the most basic assumption for distance sampling could not be satisfied (i.e., that the probability of detecting an individual decreases with distance from an observer, which it does not for Common Nighthawk). Use of a time-removal model was not pursued because an overall detection coefficient cannot be estimated without the distance-sampling component. All estimates of Common Nighthawk abundance that are described below are therefore relative abundance (i.e., number of Common Nighthawk per station).

2.8 Comparison of Point Counts and ARU Counts

Point counts conducted by human observers paired with simultaneous ARU recordings (with subsequent human listening) allow for a direct comparison to determine differences in counts between the two survey methods. If differences are present, a correction factor could be estimated for use on ARU data. However, as described in Section 2.7, a detectability coefficient cannot be estimated from the point count data, and therefore absolute abundance cannot be estimated using Common Nighthawk count data. However, the analysis does provide an interesting comparison of the two survey methods and could provide an indication of whether ARU counts provide comparable abundance estimates to point counts.

Common Nighthawk relative abundance was estimated for the paired point count-ARU data by fitting a Generalized Linear Mixed Models (GLMM) with a Poisson distribution. Survey type (point count or ARU) was included as a fixed effect. Survey station was included as a random effect to account for differences among stations. Mean relative abundance with 95% confidence interval (CI) was estimated for each survey type. The correction factor was calculated as mean relative abundance for point counts divided by mean relative abundance for ARU data. All analyses were conducted using R (R Core Group 2019). Means and confidence intervals were calculated using the R package ‘emmeans’ (Brooks et al. 2017).

2.9 Habitat Classification and Site-Level Habitat Data Collection

Ecosystem mapping was previously completed for the area around the Site C Project: Terrestrial Ecosystem Mapping (TEM; using air photo interpretation) for the Site C Local Assessment Area (the Peace River and area around the transmission line) and Predictive Ecosystem Mapping (PEM; digital model using forest cover and other land cover data) for a larger area outside the Local Assessment Area (LAA). There are 147 unique ecosystems units (combination of site series and structural stage) mapped in the region and these were collapsed in to 20 broader units referred to as bird habitat classes based on dominant vegetation and stand age:

- Coniferous-shrub
- Coniferous-young forest
- Coniferous-mature forest
- Deciduous-shrub
- Deciduous-young forest
- Deciduous-mature forest
- Riparian-mixed shrub
- Riparian-mixed young forest
- Riparian-mixed mature forest
- Fen/bog-shrub
- Fen/bog-treed
- Wetland-graminoid
- Wetland-shrub
- Wetland-riparian
- Dry slopes- grassland
- Dry slopes- shrubland
- Cultivated
- Non-vegetated
- Anthropogenic
- Water

The dominant bird habitat class mapped within 100 m of the survey station centre was assigned to each station. The assigned bird habitat class was cross-checked with habitat data collected at each site to ensure accurate assignment.

Site-level habitat data was recorded on a Site Visit form (SIVI; British Columbia Ministry of Forests and Range and British Columbia Ministry of Environment 2010) and included all site and vegetation fields with the exception of soil characteristics.

2.10 Abundance

Common Nighthawk relative abundance was estimated for each Bird Habitat Class using the ARU human listening count data. Relative abundance was estimated by fitting a Generalized Linear Mixed Models (GLMM) with a poisson distribution. Variables included to account for survey-level variability (temporal factors) were:

- Year, to account for differences between years;
- Ordinal day (the number of days between the date of survey and the start of the year, standardized as day/365); and
- Time of day (hour, standardized as hour/24).

The counts of individuals from each 10-minute recording were treated as a separate sample. Survey station was included as a random effect in the model to account for the repeated measures (two) at each station. Candidate model equations with all possible combinations of the four fixed effect variables plus survey station as a random effect (12 models; see Appendix E for model equations) were evaluated and compared using Akaike's Information Criterion for small samples sizes (AIC_c). The model with the lowest AIC_c was selected as the model with the best fit.

Mean relative abundance (Common Nighthawk per station) with 95% confidence interval (CI) was estimated for each habitat. All analyses were conducted using R (R Core Group 2019). Means and confidence intervals were calculated using the R package 'emmeans' (Brooks et al. 2017).

2.11 Occupancy of Territorial Males

The ARU human listening count data is a measure of the relative abundance of Common Nighthawk detected through the feeding calls ('peent'; both males and females) and the territorial wing boom (males only). Areas used for feeding do not necessarily represent areas suitable for nesting. The presence of wing booms in a sample indicates a territorial male and suitable breeding habitat may be nearby. The wing booms are easily identified by a human listener, though it was difficult to estimate the number of individuals issuing wing booms. The wing boom data are therefore best analyzed as presence-absence (or detected-not detected).

Presence-absence data from repeated visits to a site can be analyzed using an occupancy model. An occupancy model simultaneously accounts for both imperfect detection of a species and the probability of occupancy. Occupancy of territorial males was estimated using the approach of Mackenzie et Al. (2002 and 2018) using the 'occu' function in the R package 'unmarked' (Fiske and Chandler 2011). The same model variables used for the abundance estimates (i.e., bird habitat class, year, ordinal day and time of day) were used in the occupancy models to estimate occupancy by bird habitat class and account for survey-level variability. Candidate models with all possible combinations of the variables, but without interaction terms (12 models; see Appendix F for model equations), were evaluated and compared using Akaike's Information Criterion for small sample sizes (AIC_c). The model with the lowest AIC_c was selected as the model with the best fit.

3.0 RESULTS

3.1 Common Nighthawk Incidence and Distribution

Common Nighthawk surveys were conducted in 10 bird habitat classes (Table 2).

Table 2. Number of Common Nighthawk survey stations in each bird habitat class

Bird Habitat Class	Code	Number of Stations
Deciduous-shrub (includes recently cleared areas)	DSH	13
Riparian-mixed shrub	RSH	28
Wetland-graminoid	WGR	3
Wetland-shrub (combined with Wetland-graminoid for habitat analyses)	WSH	1
Wetland-riparian	WRI	15
Dry slopes- grassland [a]	DSG	4
Dry slopes- shrubland	DSS	2
Cultivated (includes pasture)	CUL	24
Non-vegetated (gravel bars, some with sparse shrub)	NVE	23
Anthropogenic (gravel pit, campground)	ANT	3
	Total	**117**

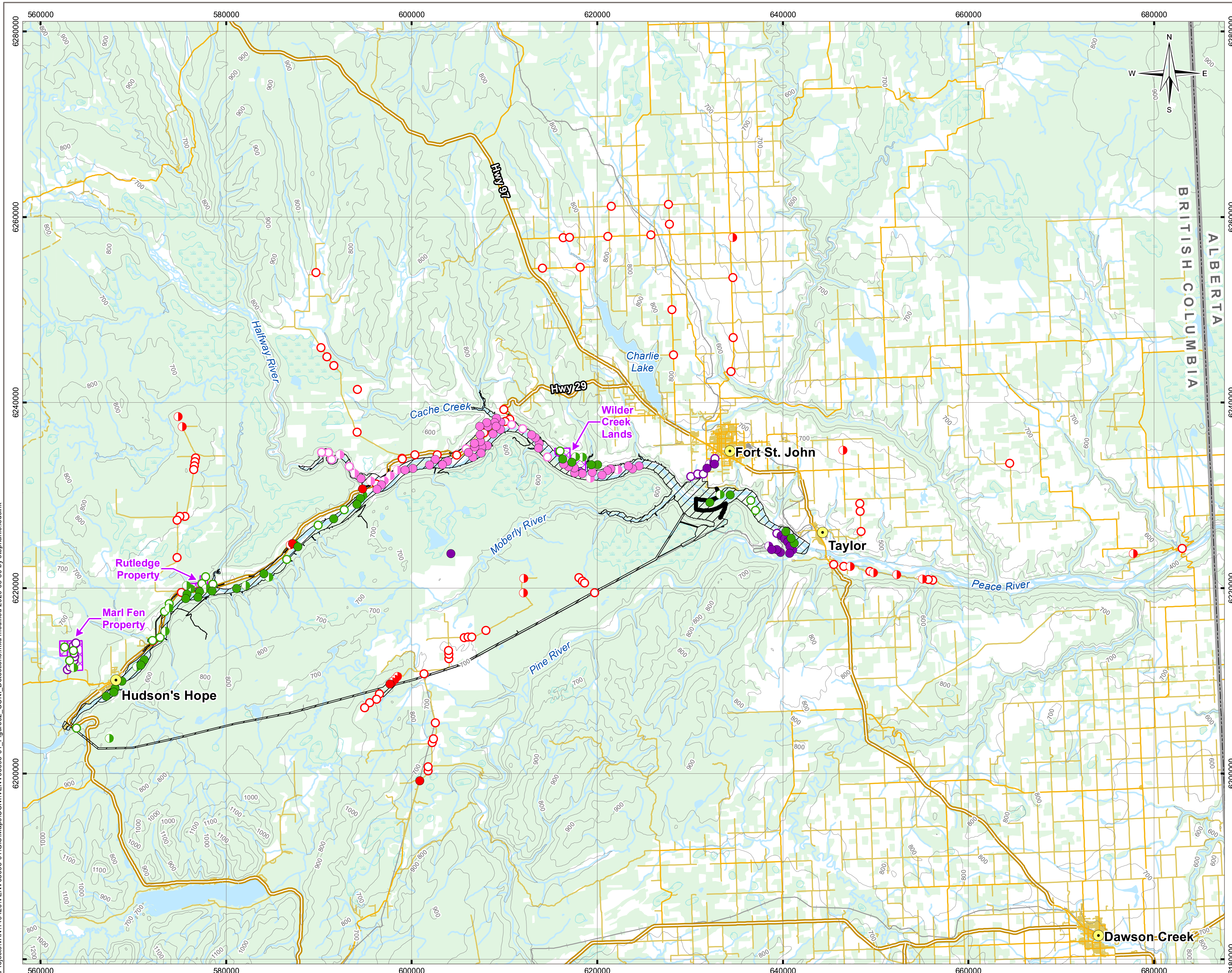
[a] For the habitat analyses, Dry slopes-grassland were grouped with Dry slopes-shrubland because they occur in a natural complex, and the majority of Dry slopes-grassland sites have at least some shrub cover.

Common Nighthawk were detected at 92 of the 117 survey stations (Figure 3 and Table 3). Human listening and automated detection had similar rates of presence-absence detection, though there were differences in the stations at which Common Nighthawk were detected; there were 10 stations where Common Nighthawk were found by automated detection and not by human listening and the reverse was true at seven stations. For the human listening data, most but not all of the stations that had Common Nighthawk had Common Nighthawk that were booming (80%).

For the paired sampling (i.e., point counts conducted by human observers paired with simultaneous ARU recordings), each survey method identified Common Nighthawk at the same number of stations, though each detected Common Nighthawk at one station when the other method did not.

Table 3. Summary of the results of the Common Nighthawk surveys using human listening, automated detection and point counts.

Survey Approach	Proportion of Stations with Common Nighthawk Detections	Proportion of Stations with Common Nighthawk Booming
Human Listening of ARU Recordings (n=117)	70.1%	57.2%
Automated Detection of ARU Recordings (n=117)	72.6%	Not available
Point Counts (n=32)	31.3%	18.8%
Human Listening of ARU Recordings Paired with Point Count (n=32)	31.3%	21.9%
Any Survey Approach (n=117)	78.6%	Not applicable since not all survey methods can detect booms



LEGEND

CONI Detection Type
- Not Detected
- Calls Only
- Wing Booms

Survey Year
- 2010
- 2012
- 2018
- 2019
- 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 COMMON NIGHTHAWK 2019 ANNUAL REPORT

Common Nighthawk (CONI) Detections

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	

Scale: 1:400,000
8 4 0 8
Kilometres

TETRA TECH

FILE NO.
VENV03095-01_Figure02_CONI_Detections.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	BB	JM	0

DATE
March 30, 2020

PROJECT NO.
ENV.VENV03095-01

Figure 2

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3.2 Automated Detection

3.2.1 Recognizer Performance on Benchmark Data

Kaleidoscope Pro's signal detection algorithm identified 19,450 vocalizations in the 500 minutes of benchmark recordings selected from the pool of recordings used for the human listening analysis (Section 2.4.2). The Common Nighthawk recognizer predicted 3,543 of those vocalizations as Common Nighthawk (18%). Recognizer results from analysis of the 500 minutes of benchmark recordings (both Common Nighthawk and non-Common Nighthawk) were validated and assigned true positive, false positive, false negative or true negative. Most automated detections are at cluster distances around 1.0 (Figure 4), which would be equivalent to low recognizer score values.

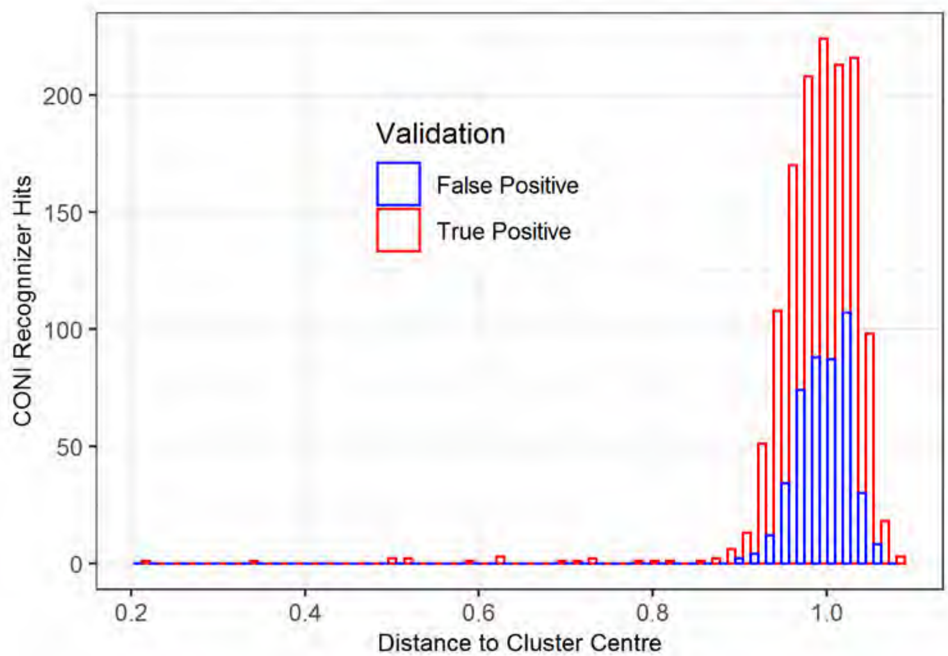

Figure 4. Distribution of true positive and false positive Common Nighthawk hits by distance to cluster centre.

Precision (proportion of recognizer hits that are true detections of Common Nighthawk), *recall* (proportion of Common Nighthawk vocalizations classified as hits) and *F-score* (combination of *precision* and *recall*) varied with recognizer distance (Figure 5). *Precision* is perfect (i.e., equals 1.0) at most distances when the recognizer is detecting very few hits. At distances around 1.0, *precision* declines to about 0.75. *Recall* shows the opposite pattern; recall is low when there are very few hits and tops out at 0.58 when hits at all distances (scores) have been tallied.

The ROC curve and associated calculation of AUC (0.65) (Figure 6) indicates that the ability of the recognizer to differentiate Common Nighthawk from non-Common Nighthawk is low (Strainer and Cairney, 2007). The ROC curve is most useful when comparing results to other recognizers and is provided here as reference for other studies.

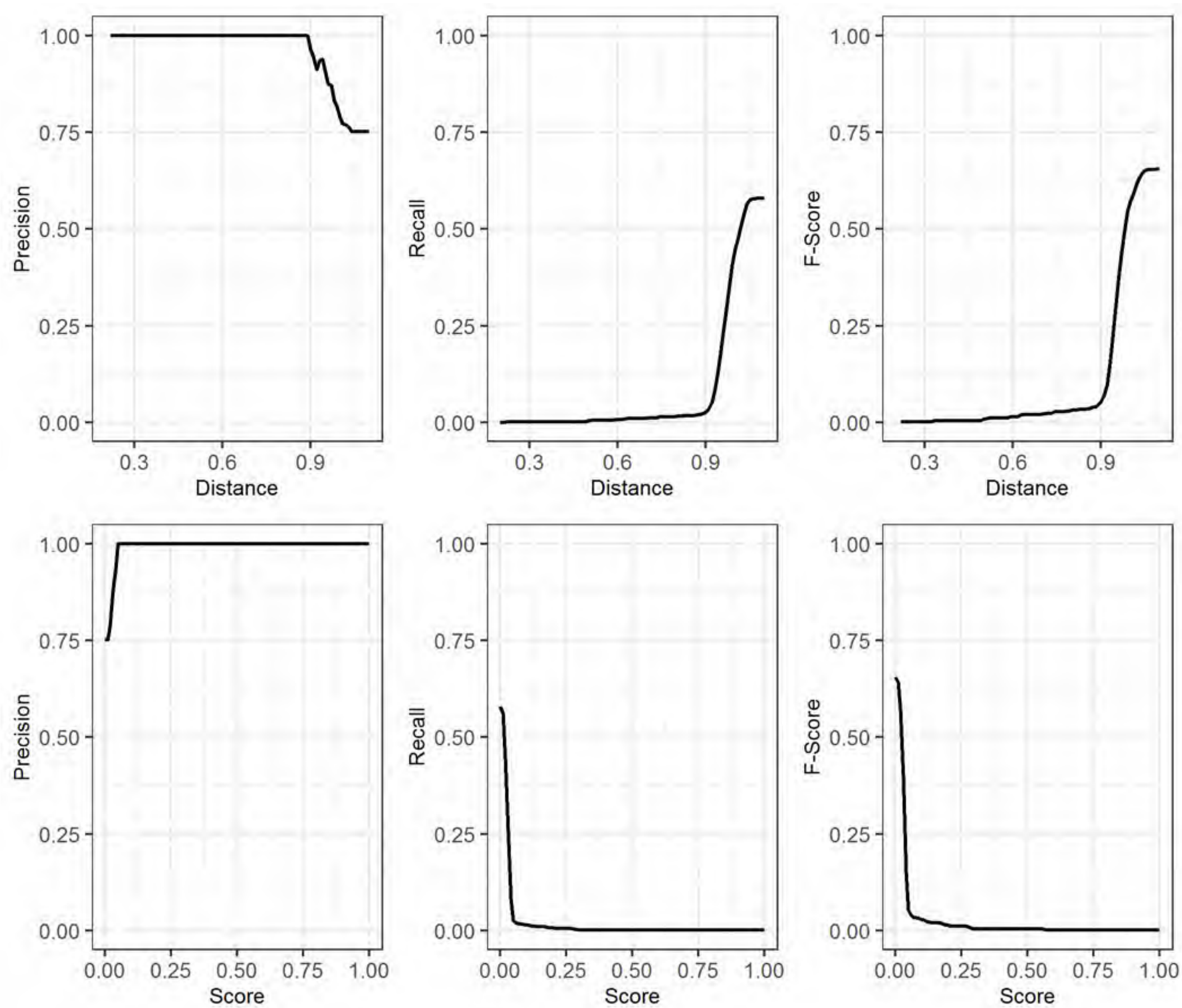

Figure 5. *Precision*, *recall* and *F-score* of Common Nighthawk detections at varying thresholds.

The top row presents the three metrics by distance to cluster centre (the value produced by Kaleidoscope for each hit produced by the recognizer). The second row presents the three metrics as a standardized score (inverse of rescaled distance) to allow comparison with other automated detection recognizers.

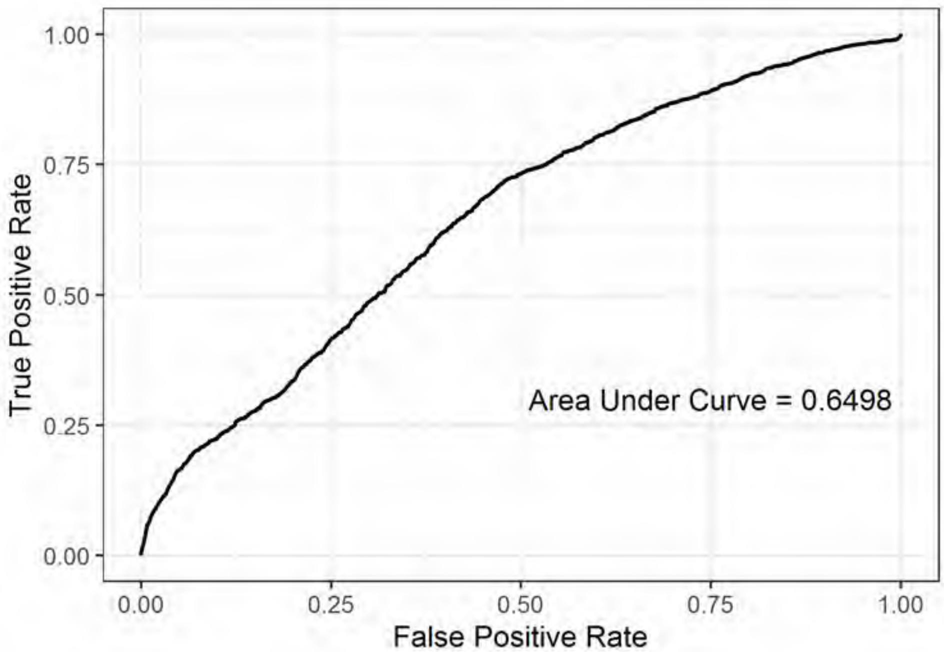

Figure 6. Receiver Operating Characteristic (ROC) curve of Common Nighthawk detections using automated detection.

3.2.2 Presence-Absence Precision and Recall Relative to Human Listening

Presence-absence precision and *recall* were calculated by comparing the benchmark automated detection to the Human Listening results for each of the 50 recordings (Table 4). Automated detection correctly predicted presence of Common Nighthawk (relative to Human Listening) in 58% (18/31) of the recordings. Automated detection found Common Nighthawk in 60% (18/30) of the recordings where Human Listening found Common Nighthawk.

Table 4. Comparison of automated detection predictions with human listening by individual recording.

		Human Listening	
		Present (n=30)	**Not detected (n=20)**
Automated Detection	**Present (n=31)**	18	13
	Not detected (n=19)	12	7

Presence-Absence Precision for individual recordings = 0.58
Presence-Absence Recall for individual recordings = 0.60

3.2.3 Automated Detection on all Recordings

The results when the recognizer was applied to all recordings (2 per night x 7 days x 117 stations = 1,638 recordings) were validated by a human listener by reviewing Common Nighthawk hits until the first true positive hit was encountered. If no true positive hits were encountered, then the station was marked as 'not detected'. Automated detection and Human Listening were in agreement (as either Common Nighthawk present or not detected) at 100 of the 117 stations (85%) (Table 5). When compared to Common Nighthawk presence determined by either method, automated detection outperformed human listening (*presence-absence recall* = 0.92) by a small amount. When detection methods were used together, Common Nighthawk were detected at more stations than either method determined alone.

Table 5. Comparison of automated detection predictions with human listening for all Common Nighthawk survey stations.

		Human Listening (2 recordings per station)		
		Present	**Not detected**	**Total**
Automated Detection with Validation (14 recordings per station)	**Present**	75	10	**85**
	Not detected	7	25	**32**
	Total	**82**	**35**	**117**

Number of survey stations with Common Nighthawk detected by either method = 92

	Presence-Absence Recall
Automated Detection	**85/92 = 0.92**
Human Listening	**82/92 = 0.90**

3.3 Comparison of Point Counts to ARU Human Listening

Of the 32 stations with paired sampling, 21 stations had no Common Nighthawk present (i.e., no Common Nighthawk found by either survey method) leaving only 9 stations with Common Nighthawk available for detection. Mean relative abundance was slightly higher for point counts (0.18 versus 0.17 Common Nighthawk per station for ARU human listening; Figure 7). Confidence intervals are large, and any differences are not statistically meaningful (see Appendix B for model results).

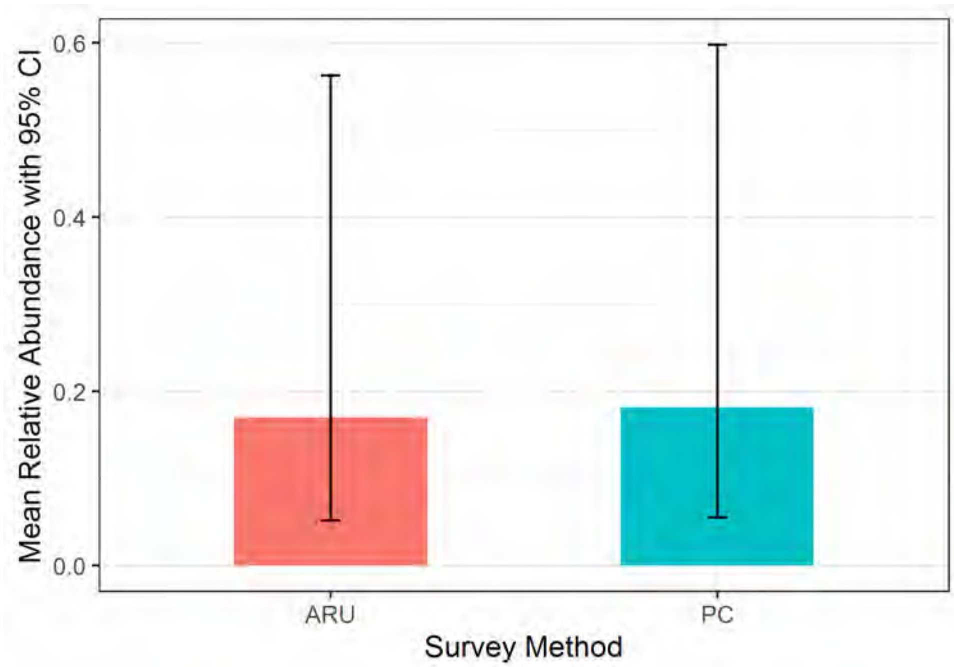

Figure 7. Comparison of mean relative abundance (counts) for paired ARU and point count (PC) data collected at the same time and same place.

3.4 Relative Abundance from ARU Human Listening

Common Nighthawk relative abundance was best explained by bird habitat class, year and hour (see Appendix E for model results). Common Nighthawk relative abundance counts were highest in riparian-mixed shrub (Figure 8). These areas predominantly occur along shorelines and on islands of the Peace River and often have exposed gravel intermixed or present nearby[2]. The next highest relative abundance counts were in anthropogenic and wetland-riparian[3] habitats. Three anthropogenic sites were surveyed (6 samples): one gravel pit and two campgrounds. Wetland-riparian occurred along shorelines and islands of the Peace River.

[2] The Riparian mixed shrub Bird Habitat Class is composed of the Trembling Aspen/Spruce - Red-osier dogwood ecosystem unit.
[3] This is the Willow – Horsetail – Sedge – Riparian Wetland ecosystem unit.

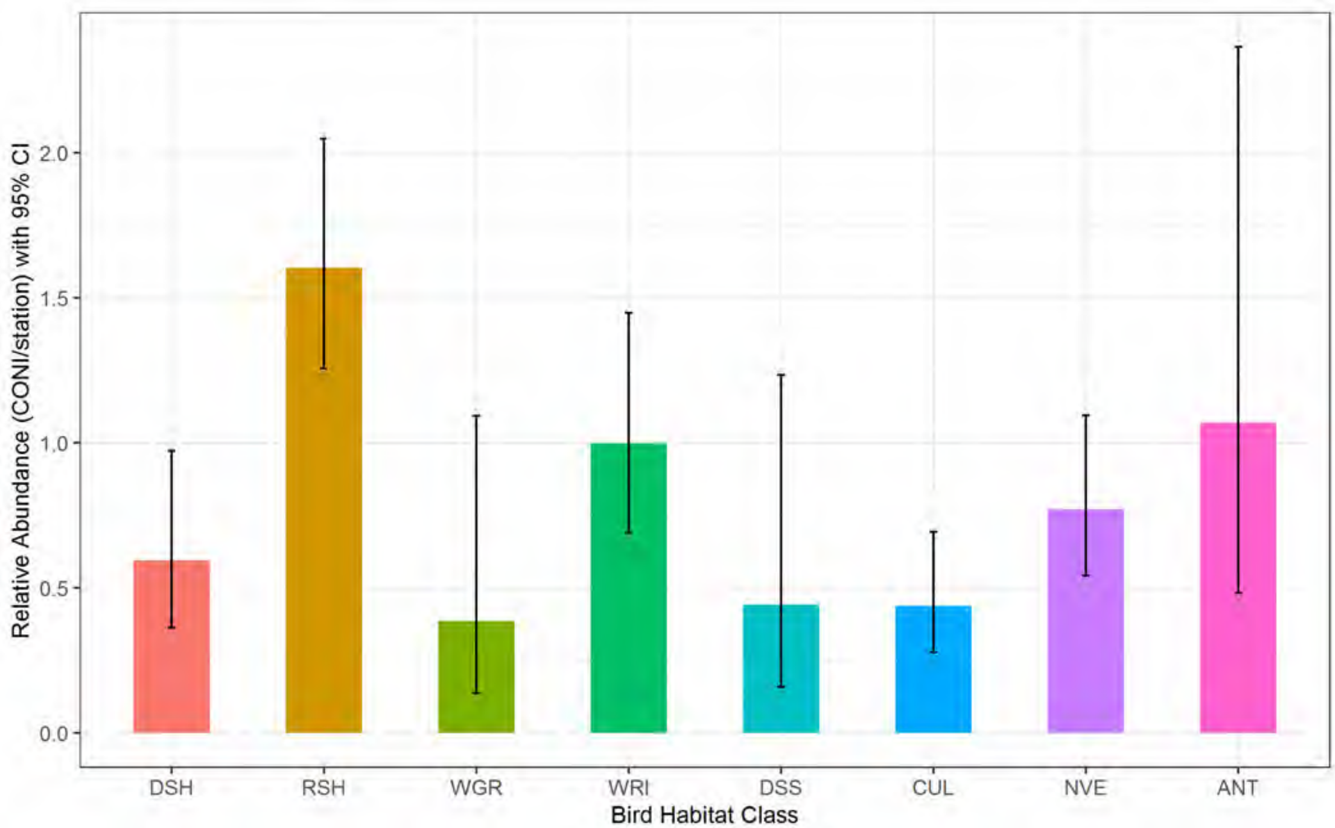

Figure 8. Estimates of Common Nighthawk relative abundance by bird habitat class

(DSH, deciduous-shrub; RSH, riparian-mixed shrub; WGR, wetland-graminoid (include wetland-shrub); WRI, wetland-riparian; DSS, dry slopes- shrubland (includes dry slope-grassland); CUL, cultivated; NVE, non-vegetated; and ANT, anthropogenic).

3.5 Occupancy of Territorial Males

The probability of a territorial male Common Nighthawk was best explained by bird habitat class, year and hour (see Appendix F for model results), the same as found for the analysis of Common Nighthawk relative abundance. Occupancy differs between 2018 and 2019, though the pattern among Bird Habitat Classes is similar between years (Figure 9). Occupancy is highest in riparian-mixed shrub. Similar to the results for relative abundance, wetland-graminoid has the lowest probability of detecting territorial male Common Nighthawk.

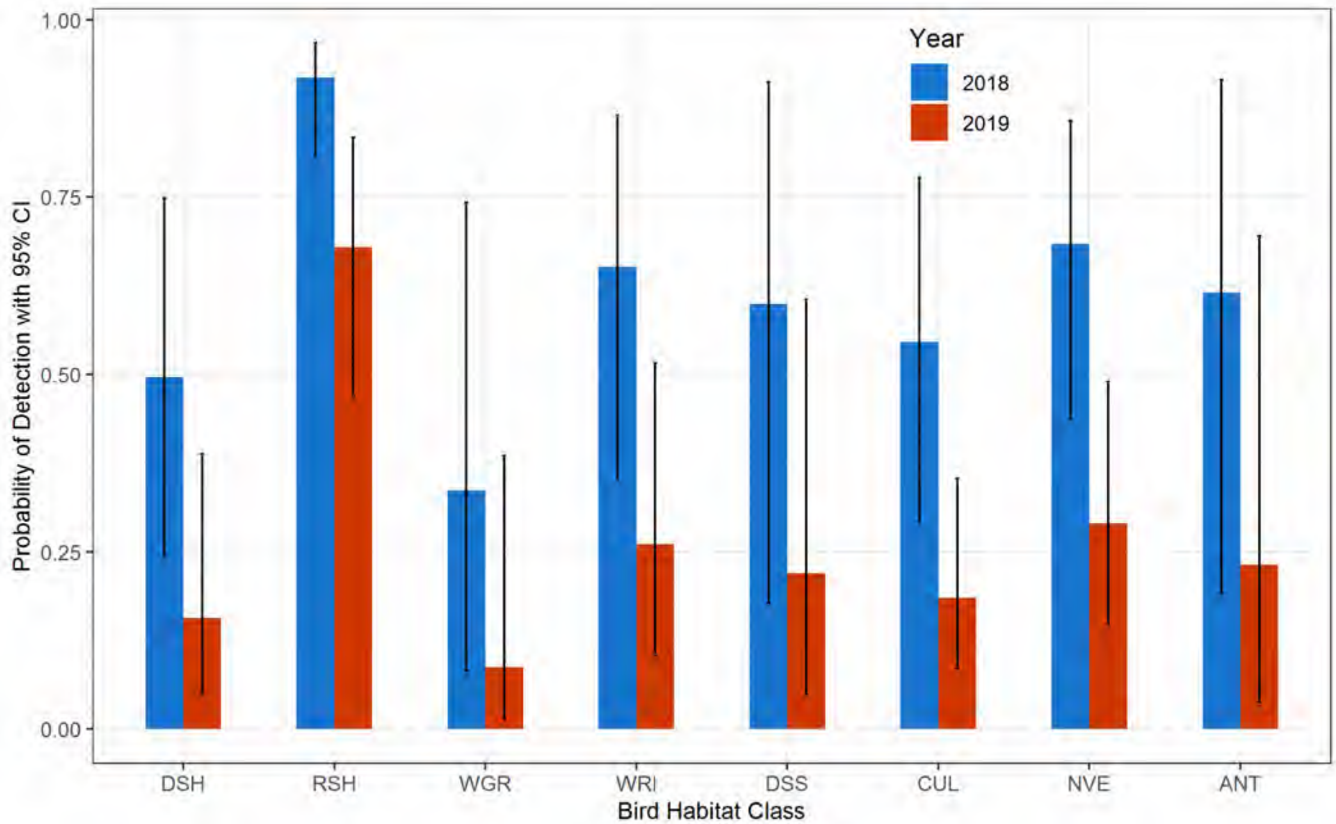

Figure 9. Estimates of occupancy (probability of detection) of booming male Common Nighthawk by year surveyed and bird babitat class

(DSH, deciduous-shrub; RSH, riparian-mixed shrub; WGR, wetland-graminoid (include wetland-shrub); WRI, wetland-riparian; DSS, dry slopes- shrubland (includes dry slope-grassland); CUL, cultivated; NVE, non-vegetated; and ANT, anthropogenic).

3.6 Common Nighthawk in Mitigation Properties

Common Nighthawk were detected at two of the three mitigation properties: Wilder Creek and Marl Fen (Table 6 and Appendix Table A.1). There was one individual Common Nighthawk detected at Marl Fen (two calls). Previous surveys at Marl Fen in 2010 and 2012 did not detect Common Nighthawk. The detection in 2019 may have been a flyover, and presence of Common Nighthawk at Marl Fen appears unlikely based on data collected to date, though suitable habitat appears to be present. Common Nighthawk relative abundance at the mitigation properties was estimated separately by fitting a GLMM in the same way as for the analysis of all sites, except with only Mitigation Property as a covariate due to the small sample size.

Table 6. Common Nighthawk detections at survey stations located within the mitigation properties.

Mitigation Property	Detections	Relative Abundance (Common Nighthawk per Station)
Marl Fen	Detected at 1 of 4 stations (1 of 8 samples)	<0.0001 (95% CI: N/A)
Rutledge	Not detected	0
Wilder Creek	Detected at 2 of 4 stations (4 of 8 samples)	0.50 (95% CI: 0.070-3.55)

4.0 DISCUSSION

Common Nighthawk Distribution

Common Nighthawk were found to be widely distributed along the Peace River, occurring in more than three-quarters of stations surveyed in 2018 and 2019. Of the stations where Common Nighthawk were detected, 82% had territorial males, suggesting that most areas with Common Nighthawk have suitable breeding habitat or it is present nearby. Surveys outside the Peace River valley conducted in 2010 and 2012 found fewer locations with Common Nighthawk, though comparisons are difficult due to differences in survey methodologies (i.e., former use of call playback and many surveys were along roads), and the types of habitat surveyed, which appears to have included many forested sites.

Automated Detection

Automated detection using the Common Nighthawk recognizer found 10 survey stations with Common Nighthawk where human listening had found none. Common Nighthawk were clearly not present or available for detection on every night or every evening hour. This underscores the benefit of more samples or longer survey periods that can typically only be provided using automated detection.

In the reverse, the Common Nighthawk recognizer failed to detect Common Nighthawk at the seven sites where they were known to occur from human listening. The comparison of the Common Nighthawk recognizer results to individual benchmark recordings found that only 60% of recordings with Common Nighthawk were correctly identified as having Common Nighthawk.

For the larger dataset of recordings at all stations, each station that the recognizer predicted as having Common Nighthawk was validated by a human listener to confirm that Common Nighthawk were truly present. Many of the stations (18) had false positive predictions, indicating the critical importance of validation, at least for the recognizer developed here. The validation takes time (about 3-4 hours in this case) but is only a fraction of the time that would be needed to listen to all recordings.

Development of the recognizer, validation of benchmark Common Nighthawk and non-Common Nighthawk hits and calculation of the benchmark evaluation metrics were time-consuming. Future use of the recognizer developed here will benefit from not having to redo these tasks, leading to better overall efficiency.

The purpose of the automated detection was to determine if there is Common Nighthawk presence at sites where human listening found none. The recognizer did achieve this and proved to be a beneficial complement to human listening, even though the benchmark metrics indicate only low to moderate recognizer performance. Even if the recognizer had achieved higher levels of performance, the recognizer still could not have provided the estimates of relative abundance that human listening can.

Common Nighthawk Relative Abundance and Occupancy of Territorial Males

Common Nighthawk relative abundance and probability of occupancy appeared to be highest in riparian-mixed shrub. Wetland-graminoid showed the lowest relative abundance and occupancy of territorial males of all eight surveyed Bird Habitat Classes.

Mitigation Properties

Surveys at the Wilder Creek mitigation property found Common Nighthawk at two of the four survey stations, and both stations were in areas classified as Cultivated. Common Nighthawk were reported at one of four survey stations at Marl Fen. There were only two calls in the eight recordings and previous surveys at Marl Fen had not reported Common Nighthawk. No Common Nighthawk were detected at the Rutledge Property.

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APPENDIX A
POINT COUNT LOCATIONS, DATES, TIMES AND SURVEYORS

Table A.1 List of point count locations, dates, times and surveyors.

Station	UTM Zone	UTM Easting	UTM Northing	Visit Date	Start Time	End Time	Surveyors (Observer, Assistant)
CONI18-033	10	609589	6237884	2018-06-01	21:45	21:55	Jeff Matheson, Wes Anderson
CONI18-036	10	608934	6237847	2018-06-01	22:00	22:10	Camille Roberge, Elyse Hofs
CONI18-047	10	607335	6237423	2018-06-01	22:18	22:28	Jeff Matheson, Wes Anderson
CONI18-040	10	608083	6237844	2018-06-01	23:11	23:21	Jeff Matheson, Wes Anderson
CONI18-043	10	607400	6235619	2018-06-01	22:48	22:58	Jeff Matheson, Wes Anderson
CONI18-038	10	608220	6237434	2018-06-01	23:29	23:39	Jeff Matheson, Wes Anderson
CONI18-035	10	609118	6238297	2018-06-01	22:28	22:38	Camille Roberge, Elyse Hofs
CONI18-041	10	609097	6237429	2018-06-01	00:26	00:36	Jeff Matheson, Wes Anderson
CONI18-034	10	609568	6237086	2018-06-01	22:50	23:00	Camille Roberge, Elyse Hofs
CONI18-051	10	606765	6235591	2018-06-01	23:46	23:56	Jeff Matheson, Wes Anderson
CONI18-046	10	607362	6236506	2018-06-01	00:13	00:23	Camille Roberge, Elyse Hofs
CONI18-049	10	606800	6235200	2018-06-01	23:12	23:22	Camille Roberge, Elyse Hofs
CONI18-052	10	605871	6234986	2018-06-01	23:37	23:47	Camille Roberge, Elyse Hofs
CONI19-012	10	622251	6232757	2019-06-18	22:17	22:27	Camille Roberge, Ashley Watson
CONI19-013	10	621469	6232854	2019-06-18	20:42	20:52	Camille Roberge, Ashley Watson
CONI19-016	10	619464	6232492	2019-06-18	21:46	21:56	Camille Roberge, Ashley Watson
CONI19-017	10	619270	6231848	2019-06-18	21:26	21:36	Camille Roberge, Ashley Watson
CONI19-113	10	578568	6220384	2019-06-08	22:23	22:33	Camille Roberge
CONI19-118	10	577804	6221194	2019-06-09	22:32	22:42	Camille Roberge, Ashley Watson
CONI19-119	10	577396	6220467	2019-06-09	22:30	22:40	Damian Power, Reece Cameron
CONI19-126	10	576163	6219912	2019-06-09	23:00	23:10	Damian Power, Reece Cameron
CONI19-128	10	575727	6220249	2019-06-09	23:15	23:25	Camille Roberge, Ashley Watson
CONI19-136	10	573890	6218301	2019-06-08	22:00	22:10	Camille Roberge
CONI19-138	10	573855	6217847	2019-06-09	21:55	22:05	Camille Roberge, Ashley Watson
CONI19-142	10	573353	6217458	2019-06-09	22:00	22:10	Damian Power, Reece Cameron
CONI19-145	10	572879	6214668	2019-06-09	21:20	21:30	Damian Power, Reece Cameron
CONI19-148	10	572071	6214334	2019-06-09	21:21	21:31	Camille Roberge, Ashley Watson

Station	UTM Zone	UTM Easting	UTM Northing	Visit Date	Start Time	End Time	Surveyors (Observer, Assistant)
CONI19-205	10	563873	6204870	2019-06-08	21:22	21:32	Camille Roberge
CONI19-208	10	563578	6211435	2019-06-09	21:45	21:55	Claudio Bianchini, Reign Walker
CONI19-209	10	563550	6213236	2019-06-09	22:14	22:24	Claudio Bianchini, Reign Walker
CONI19-211	10	563127	6212151	2019-06-09	21:22	21:32	Claudio Bianchini, Reign Walker

APPENDIX B

SUMMARY OF CONI SURVEYS CONDUCTED IN 2018 AND 2019

Table B.1 Summary of surveys and comparison of Common Nighthawk detections from surveys conducted in 2018 and 2019.

Survey Station	Mitigation Property	UTM Zone	UTM Easting	UTM Northing	Bird Habitat Class	ARU Human Listening							ARU Automated Detection [a]	Paired Sampling							Detection Summary
							Sample 1			Sample 2					Point Count			ARU Human Listening			
						ARU Deploy Date	Individual Count	Call Count	Boom Count	Individual Count	Call Count	Boom Count		Survey Date	Individual Call Only	Individual Boom	Individual Count	Individual Count	Call Count	Boom Count	
CONI18-009	-	10	624506	6233168	Riparian-mixed shrub	2018-06-09	2	216	16	4	503	31	P	-	-	-	-	-	-	-	Wing Booms
CONI18-010	-	10	623804	6232853	Riparian-mixed shrub	2018-06-09	2	255	22	3	110	24	P	-	-	-	-	-	-	-	Wing Booms
CONI18-011	-	**10**	623359	6233148	Non-vegetated	2018-06-09	2	209	18	2	49	2	P	-	-	-	-	-	-	-	Wing Booms
CONI18-012	-	10	622251	6232757	Non-vegetated	2018-06-09	0	0	0	1	50	0	P	-	-	-	-	-	-	-	Calls Only
CONI18-013	-	10	621469	6232854	Wetland-riparian	2018-06-09	1	5	4	1	4	7	P	-	-	-	-	-	-	-	Wing Booms
CONI18-014	-	10	621091	6232656	Riparian-mixed shrub	2018-06-09	1	46	2	2	112	9	P	-	-	-	-	-	-	-	Wing Booms
CONI18-015	-	10	620505	6232169	Non-vegetated	2018-06-09	0	0	0	3	307	27	P	-	-	-	-	-	-	-	Wing Booms
CONI18-016	-	10	619464	6232492	Deciduous-shrub	2018-06-09	1	49	12	1	12	0	P	-	-	-	-	-	-	-	Wing Booms
CONI18-017	-	10	619270	6231848	Wetland-riparian	2018-06-09	0	0	0	1	67	0	P	-	-	-	-	-	-	-	Calls Only
CONI18-018	-	10	618386	6232336	Riparian-mixed shrub	2018-06-09	3	399	26	2	177	12	P	-	-	-	-	-	-	-	Wing Booms
CONI18-019	-	10	617578	6232428	Riparian-mixed shrub	2018-06-09	3	270	10	2	71	0	P	-	-	-	-	-	-	-	Wing Booms
CONI18-020	-	10	617528	6232949	Deciduous-shrub	2018-06-09	1	61	0	1	59	14	P	-	-	-	-	-	-	-	Wing Booms
CONI18-021	-	10	616882	6233111	Riparian-mixed shrub	2018-06-09	2	72	17	2	319	23	P	-	-	-	-	-	-	-	Wing Booms
CONI18-022	-	10	616365	6233365	Riparian-mixed shrub	2018-06-09	2	118	9	3	323	39	P	-	-	-	-	-	-	-	Wing Booms
CONI18-023	-	10	614657	6234104	Non-vegetated	2018-06-27	0	0	0	0	0	0	ND	-	-	-	-	-	-	-	Not Detected
CONI18-025	-	10	613730	6235615	Riparian-mixed shrub	2018-06-27	3	223	14	3	331	49	P	-	-	-	-	-	-	-	Wing Booms
CONI18-026	-	10	613671	6235098	Riparian-mixed shrub	2018-06-27	2	53	1	1	89	2	P	-	-	-	-	-	-	-	Wing Booms
CONI18-027	-	10	613322	6236196	Riparian-mixed shrub	2018-06-09	4	591	37	4	730	68	P	-	-	-	-	-	-	-	Wing Booms
CONI18-028	-	10	612916	6236518	Deciduous-shrub	2018-06-27	2	187	23	3	324	16	P	-	-	-	-	-	-	-	Wing Booms
CONI18-030	-	10	611970	6237162	Deciduous-shrub	2018-06-27	0	0	0	0	0	0	ND	-	-	-	-	-	-	-	Not Detected
CONI18-032	-	10	610775	6237610	Cultivated	2018-06-27	0	0	0	0	0	0	ND	-	-	-	-	-	-	-	Not Detected
CONI18-033	-	10	609589	6237884	Cultivated	2018-06-01	1	22	4	0	0	0	P	2018-06-01	1	0	1	2	105	0	Wing Booms
CONI18-034	-	10	609569	6237086	Wetland-riparian	2018-06-01	1	5	0	0	0	0	P	2018-06-01	0	0	0	1	0	2	Wing Booms
CONI18-035	-	10	609118	6238297	Riparian-mixed shrub	2018-06-01	2	132	6	1	1	0	P	2018-06-01	0	1	1	2	209	4	Wing Booms
CONI18-036	-	10	608934	6237846	Deciduous-shrub	2018-06-01	1	31	0	2	282	15	P	2018-06-01	0	1	1	1	273	12	Wing Booms
CONI18-037	-	10	608756	6236632	Wetland-riparian	2018-06-27	1	9	0	2	116	6	P	-	-	-	-	-	-	-	Wing Booms
CONI18-038	-	10	608220	6237434	Anthropogenic	2018-06-01	3	20	20	2	237	17	P	2018-06-01	0	1	1	2	123	5	Wing Booms
CONI18-039	-	10	608157	6235358	Non-vegetated	2018-06-27	1	31	1	3	193	2	P	-	-	-	-	-	-	-	Wing Booms
CONI18-040	-	10	608083	6237844	Deciduous-shrub	2018-06-01	3	6	20	1	83	6	P	2018-06-01	0	1	1	1	187	7	Wing Booms
CONI18-041	-	10	609097	6237429	Riparian-mixed shrub	2018-06-01	0	0	0	2	144	5	P	2018-06-01	3	0	3	2	323	1	Wing Booms
CONI18-043	-	10	607400	6235815	Deciduous-shrub	2018-06-01	2	10	1	2	167	4	P	2018-06-01	0	0	0	0	0	0	Wing Booms
CONI18-044	-	10	607552	6235214	Wetland-riparian	2018-06-27	1	1	0	3	250	13	P	-	-	-	-	-	-	-	Wing Booms
CONI18-045	-	10	607485	6234555	Riparian-mixed shrub	2018-06-27	2	89	13	3	231	23	P	-	-	-	-	-	-	-	Wing Booms

Survey Station	Mitigation Property	UTM Zone	UTM Easting	UTM Northing	Bird Habitat Class	ARU Human Listening							ARU Automated Detection [a]	Paired Sampling							Detection Summary
							Sample 1			Sample 2					Point Count			ARU Human Listening			
						ARU Deploy Date	Individual Count	Call Count	Boom Count	Individual Count	Call Count	Boom Count		Survey Date	Individual Call Only	Individual Boom	Individual Count	Individual Count	Call Count	Boom Count	
CONI18-046	-	10	607362	6236506	Wetland-shrub	2018-06-01	0	0	0	1	150	5	P	2018-06-01	0	0	0	0	0	0	Wing Booms
CONI18-047	-	10	607335	6237423	Cultivated	2018-06-01	1	9	0	1	21	6	P	2018-06-01	1	0	1	1	153	0	Wing Booms
CONI18-049	-	10	606800	6235200	Anthropogenic	2018-06-01	1	1	0	2	90	2	P	2018-06-01	0	0	0	0	0	0	Wing Booms
CONI18-050	-	10	606573	6234119	Riparian-mixed shrub	2018-06-27	4	529	24	4	323	9	P	-	-	-	-	-	-	-	Wing Booms
CONI18-051	-	10	606765	6235591	Wetland-graminoid	2018-06-01	2	240	0	1	36	10	P	2018-06-01	2	0	2	1	138	0	Wing Booms
CONI18-052	-	10	605871	6234986	Wetland-graminoid	2018-06-01	0	0	0	0	0	0	ND	2018-06-01	0	0	0	0	0	0	Not Detected
CONI18-053	-	10	606120	6234613	Cultivated	2018-06-01	1	0	1	1	61	7	P	-	-	-	-	-	-	-	Wing Booms
CONI18-056	-	10	603851	6233681	Cultivated	2018-06-27	2	225	11	2	114	3	P	-	-	-	-	-	-	-	Wing Booms
CONI18-057	-	10	603287	6233305	Riparian-mixed shrub	2018-06-27	2	312	14	3	324	23	P	-	-	-	-	-	-	-	Wing Booms
CONI18-058	-	10	602521	6233858	Wetland-riparian	2018-06-27	2	73	5	2	122	2	P	-	-	-	-	-	-	-	Wing Booms
CONI18-059	-	10	601912	6233276	Riparian-mixed shrub	2018-06-19	3	511	36	4	521	23	P	-	-	-	-	-	-	-	Wing Booms
CONI18-060	-	10	600111	6232908	Non-vegetated	2018-06-19	2	249	4	2	204	10	P	-	-	-	-	-	-	-	Wing Booms
CONI18-061	-	10	599260	6232722	Wetland-riparian	2018-06-19	3	333	17	4	370	24	P	-	-	-	-	-	-	-	Wing Booms
CONI18-063	-	10	598463	6232735	Riparian-mixed shrub	2018-06-27	1	16	0	1	19	0	ND	-	-	-	-	-	-	-	Calls Only
CONI18-064	-	10	597683	6232112	Cultivated	2018-06-19	0	0	0	0	0	0	P	-	-	-	-	-	-	-	Calls Only
CONI18-065	-	10	597047	6231579	Cultivated	2018-06-19	0	0	0	0	0	0	P	-	-	-	-	-	-	-	Calls Only
CONI18-066	-	10	596738	6231137	Non-vegetated	2018-06-19	2	48	7	1	48	0	P	-	-	-	-	-	-	-	Wing Booms
CONI18-067	-	10	596265	6230672	Non-vegetated	2018-06-19	1	6	1	1	110	9	P	-	-	-	-	-	-	-	Wing Booms
CONI18-069	-	10	595587	6231547	Deciduous-shrub	2018-06-19	1	41	0	0	0	0	P	-	-	-	-	-	-	-	Calls Only
CONI18-071	-	10	594541	6231795	Non-vegetated	2018-06-19	0	0	0	1	30	1	P	-	-	-	-	-	-	-	Wing Booms
CONI18-074	-	10	593865	6232367	Non-vegetated	2018-06-19	1	2	0	0	0	0	ND	-	-	-	-	-	-	-	Calls Only
CONI18-076	-	10	593270	6233080	Riparian-mixed shrub	2018-06-19	0	0	0	0	0	0	ND	-	-	-	-	-	-	-	Not Detected
CONI18-077	-	10	592275	6234376	Wetland-riparian	2018-06-19	0	0	0	1	2	0	ND	-	-	-	-	-	-	-	Calls Only
CONI18-078	-	10	591375	6233825	Deciduous-shrub	2018-06-19	0	0	0	0	0	0	ND	-	-	-	-	-	-	-	Not Detected
CONI18-079	-	10	591052	6234588	Wetland-riparian	2018-06-19	0	0	0	0	0	0	ND	-	-	-	-	-	-	-	Not Detected
CONI18-080	-	10	590310	6234618	Deciduous-shrub	2018-06-19	0	0	0	0	0	0	ND	-	-	-	-	-	-	-	Not Detected
CONI19-001	-	10	641223	6224832	Cultivated	2019-05-31	1	54	1	0	0	0	P	-	-	-	-	-	-	-	Wing Booms
CONI19-002	-	10	640904	6225366	Cultivated	2019-05-31	1	21	0	1	21	5	P	-	-	-	-	-	-	-	Wing Booms
CONI19-003	-	10	640308	6226087	Wetland-riparian	2019-05-31	0	0	0	1	0	1	P	-	-	-	-	-	-	-	Wing Booms
CONI19-004	-	10	637063	6228349	Cultivated	2019-05-31	0	0	0	0	0	0	ND	-	-	-	-	-	-	-	Not Detected
CONI19-005	-	10	636570	6229433	Cultivated	2019-05-31	0	0	0	0	0	0	ND	-	-	-	-	-	-	-	Not Detected
CONI19-006	-	10	634317	6230055	Riparian-mixed shrub	2019-05-31	3	656	46	3	680	56	P	-	-	-	-	-	-	-	Wing Booms
CONI19-009	-	10	633233	6230076	Non-vegetated	2019-05-31	1	4	0	1	7	0	P	-	-	-	-	-	-	-	Calls Only
CONI19-010	-	10	632118	6229235	Riparian-mixed shrub	2019-05-31	2	249	19	1	57	3	P	-	-	-	-	-	-	-	Wing Booms
CONI19-012	-	10	620031	6233296	Shrubland-dry slopes	2019-06-18	0	0	0	1	8	0	ND	2019-06-18	0	1	1	0	0	0	Wing Booms

Survey Station	Mitigation Property	UTM Zone	UTM Easting	UTM Northing	Bird Habitat Class	ARU Human Listening							ARU Automated Detection [a]	Paired Sampling							Detection Summary
							Sample 1			Sample 2					Point Count			ARU Human Listening			
						ARU Deploy Date	Individual Count	Call Count	Boom Count	Individual Count	Call Count	Boom Count		Survey Date	Individual Call Only	Individual Boom	Individual Count	Individual Count	Call Count	Boom Count	
CONI19-013	-	10	619348	6233314	Grassland-dry slopes	2019-06-18	1	17	5	1	2	1	P	2019-06-18	0	0	0	0	0	0	Wing Booms
CONI19-014	Wilder	10	618391	6234108	Cultivated	2019-06-18	0	0	0	0	0	0	P	-	-	-	-	-	-	-	Calls Only
CONI19-015	Wilder	10	617649	6234154	Shrubland-dry slopes	2019-06-18	0	0	0	0	0	0	P	-	-	-	-	-	-	-	Calls Only
CONI19-016	Wilder	10	617248	6233564	Cultivated	2019-06-18	1	149	10	1	68	0	P	2019-06-18	0	0	0	0	0	0	Wing Booms
CONI19-017	Wilder	10	616276	6233920	Cultivated	2019-06-18	2	47	3	2	185	19	P	2019-06-18	1	2	3	1	0	68	Wing Booms
CONI19-018	-	10	615999	6234770	Grassland-dry slopes	2019-06-18	0	0	0	0	0	0	ND	-	-	-	-	-	-	-	Not Detected
CONI19-044	-	10	594729	6230030	Non-vegetated	2019-05-31	0	0	0	0	0	0	P	-	-	-	-	-	-	-	Calls Only
CONI19-047	-	10	594481	6229663	Wetland-riparian	2019-06-27	2	194	0	2	176	2	P	-	-	-	-	-	-	-	Wing Booms
CONI19-049	-	10	594093	6229026	Non-vegetated	2019-05-31	1	37	3	0	0	0	P	-	-	-	-	-	-	-	Wing Booms
CONI19-054	-	10	592726	6228411	Non-vegetated	2019-05-31	0	0	0	0	0	0	ND	-	-	-	-	-	-	-	Not Detected
CONI19-059	-	10	591585	6227458	Non-vegetated	2019-06-27	0	0	0	2	170	8	P	-	-	-	-	-	-	-	Wing Booms
CONI19-065	-	10	589926	6226752	Non-vegetated	2019-05-31	0	0	0	0	0	0	ND	-	-	-	-	-	-	-	Not Detected
CONI19-080	-	10	587708	6224476	Riparian-mixed shrub	2019-05-31	0	0	0	1	0	1	ND	-	-	-	-	-	-	-	Wing Booms
CONI19-085	-	10	587354	6224767	Wetland-riparian	2019-05-31	0	0	0	1	41	0	P	-	-	-	-	-	-	-	Calls Only
CONI19-091	-	10	586547	6223069	Non-vegetated	2019-05-31	0	0	0	0	0	0	ND	-	-	-	-	-	-	-	Not Detected
CONI19-101	-	10	584598	6221577	Wetland-riparian	2019-06-27	1	57	0	1	90	0	P	-	-	-	-	-	-	-	Calls Only
CONI19-102	-	10	584058	6221549	Wetland-riparian	2019-06-27	1	78	2	0	0	0	P	-	-	-	-	-	-	-	Wing Booms
CONI19-107	-	10	582107	6220265	Cultivated	2019-06-27	0	0	0	0	0	0	P	-	-	-	-	-	-	-	Calls Only
CONI19-108	-	10	581110	6219940	Riparian-mixed shrub	2019-06-27	1	0	2	0	0	0	P	-	-	-	-	-	-	-	Wing Booms
CONI19-113	-	10	578568	6220384	Deciduous-shrub	2019-06-08	0	0	0	0	0	0	ND	2019-06-08	0	0	0	0	0	0	Not Detected
CONI19-114	-	10	578489	6219686	Riparian-mixed shrub	2019-06-27	1	0	3	0	0	0	ND	-	-	-	-	-	-	-	Wing Booms
CONI19-116	-	10	577849	6219954	Riparian-mixed shrub	2019-06-27	1	2	0	0	0	0	P	-	-	-	-	-	-	-	Calls Only
CONI19-118	Rutledge	10	577804	6221194	Grassland-dry slopes	2019-06-08	0	0	0	0	0	0	ND	2019-06-09	0	0	0	0	0	0	Not Detected
CONI19-119	Rutledge	10	577396	6220467	Cultivated	2019-06-08	0	0	0	0	0	0	ND	2019-06-09	0	0	0	0	0	0	Not Detected
CONI19-120	-	10	577133	6219627	Cultivated	2019-06-27	2	41	2	1	6	0	P	-	-	-	-	-	-	-	Wing Booms
CONI19-121	-	10	576971	6219017	Riparian-mixed shrub	2019-06-27	1	11	2	1	69	9	P	-	-	-	-	-	-	-	Wing Booms
CONI19-126	Rutledge	10	576163	6219912	Cultivated	2019-06-08	0	0	0	0	0	0	P	2019-06-09	0	0	0	0	0	0	Calls Only
CONI19-128	Rutledge	10	575727	6220249	Grassland-dry slopes	2019-06-08	0	0	0	1	2	0	ND	2019-06-09	0	0	0	0	0	0	Calls Only
CONI19-129	-	10	575764	6219354	Riparian-mixed shrub	2019-06-27	1	87	4	2	256	11	P	-	-	-	-	-	-	-	Wing Booms
CONI19-130	-	10	575626	6218873	Wetland-riparian	2019-06-27	2	111	1	0	0	0	P	-	-	-	-	-	-	-	Wing Booms
CONI19-136	-	10	573890	6218301	Cultivated	2019-06-08	0	0	0	0	0	0	ND	2019-06-08	0	0	0	0	0	0	Not Detected
CONI19-138	-	10	573855	6217847	Cultivated	2019-06-08	0	0	0	0	0	0	P	2019-06-09	0	0	0	0	0	0	Calls Only
CONI19-141	-	10	573423	6215348	Non-vegetated	2019-06-27	0	0	0	0	0	0	P	-	-	-	-	-	-	-	Calls Only
CONI19-142	-	10	573353	6217458	Deciduous-shrub	2019-06-08	0	0	0	0	0	0	ND	2019-06-09	0	0	0	0	0	0	Not Detected
CONI19-145	-	10	572879	6214668	Anthropogenic	2019-06-08	0	0	0	0	0	0	ND	2019-06-09	0	0	0	0	0	0	Not Detected

Survey Station	Mitigation Property	UTM Zone	UTM Easting	UTM Northing	Bird Habitat Class	ARU Human Listening							ARU Automated Detection [a]	Paired Sampling							Detection Summary
							Sample 1			Sample 2					Point Count			ARU Human Listening			
						ARU Deploy Date	Individual Count	Call Count	Boom Count	Individual Count	Call Count	Boom Count		Survey Date	Individual Call Only	Individual Boom	Individual Count	Individual Count	Call Count	Boom Count	
CONI19-148	-	10	572071	6214334	Cultivated	2019-06-08	0	0	0	0	0	0	ND	2019-06-09	0	0	0	0	0	0	Not Detected
CONI19-152	-	10	571163	6212274	Non-vegetated	2019-06-27	1	18	0	2	136	5	P	-	-	-	-	-	-	-	Wing Booms
CONI19-157	-	10	570792	6211684	Non-vegetated	2019-06-18	1	21	0	2	240	12	P	-	-	-	-	-	-	-	Wing Booms
CONI19-159	-	10	570342	6211508	Wetland-riparian	2019-06-18	2	62	0	0	0	0	P	-	-	-	-	-	-	-	Calls Only
CONI19-173	-	10	568761	6209981	Riparian-mixed shrub	2019-06-18	2	235	4	3	417	0	P	-	-	-	-	-	-	-	Wing Booms
CONI19-180	-	10	568017	6209196	Non-vegetated	2019-06-18	1	54	1	0	0	0	P	-	-	-	-	-	-	-	Wing Booms
CONI19-181	-	10	567888	6208777	Non-vegetated	2019-06-18	2	81	9	1	21	2	P	-	-	-	-	-	-	-	Wing Booms
CONI19-185	-	10	567378	6208774	Non-vegetated	2019-06-18	1	34	0	0	0	0	P	-	-	-	-	-	-	-	Calls Only
CONI19-187	-	10	567056	6208349	Riparian-mixed shrub	2019-06-18	1	45	2	1	13	0	P	-	-	-	-	-	-	-	Wing Booms
CONI19-205	-	10	563873	6204870	Deciduous-shrub	2019-06-08	0	0	0	0	0	0	ND	2019-06-08	0	0	0	0	0	0	Not Detected
CONI19-208	Marl Fen	10	563578	6211435	Cultivated	2019-06-08	0	0	0	0	0	0	P	2019-06-09	0	0	0	0	0	0	Calls Only
CONI19-209	Marl Fen	10	563549	6213236	Cultivated	2019-06-08	0	0	0	0	0	0	ND	2019-06-09	0	0	0	0	0	0	Not Detected
CONI19-211	Marl Fen	10	563127	6212151	Wetland-graminoid	2019-06-08	0	0	0	0	0	0	ND	2019-06-09	0	0	0	0	0	0	Not Detected
CONI19-214	Marl Fen	10	562602	6213628	Cultivated	2019-06-08	0	0	0	0	0	0	ND	2019-06-09	0	0	0	0	0	0	Not Detected

[a] P = Present, ND = Not Detected

APPENDIX C
SUMMARY OF CONI SURVEYS CONDUCTED IN 2010 AND 2012

Table C.1 Summary of Common Nighthawk surveys conducted in 2010 and 2012.

Station ID	UTM Zone	UTM Easting	UTM Northing	Bird Habitat Class	Number of Surveys	Maximum Count Calling	Maximum Count Booming	Maximum Count	Detection Summary
85-C-01	10	630097	6232000	Non-vegetated	3	0	0	0	Not Detected
85-C-02	10	630830	6232274	Anthropogenic	3	0	0	0	Not Detected
85-C-03	10	631435	6232292	Cultivated	3	0	0	0	Not Detected
85-C-04	10	631834	6232933	Cultivated	3	0	1	1	Wing Booms
85-C-05	10	632106	6233377	Anthropogenic	3	1	0	1	Calls Only
85-C-06	10	632645	6233380	Cultivated	3	3	1	4	Wing Booms
85-C-07	10	632706	6233947	Anthropogenic	3	0	0	0	Not Detected
AE-C-01	10	639366	6225879	Deciduous-young forest	3	0	0	0	Not Detected
AE-C-02	10	639818	6225659	Cultivated	3	0	1	1	Wing Booms
AE-C-03	10	640179	6225301	Coniferous-young forest	3	1	1	2	Wing Booms
AE-C-04	10	640530	6224952	Coniferous-young forest	3	0	1	1	Wing Booms
AE-C-05	10	640758	6224510	Coniferous-young forest	3	0	1	1	Wing Booms
AE-C-06	10	641053	6224110	Coniferous-young forest	3	1	0	1	Calls Only
AE-C-07	10	640713	6223739	Deciduous-young forest	3	1	1	2	Wing Booms
AE-C-08	10	604211	6223718	Coniferous-mature forest	3	1	2	3	Wing Booms
AE-C-09	10	639728	6223845	Deciduous-young forest	3	1	3	4	Wing Booms
AE-C-10	10	639323	6224141	Cultivated	3	4	2	4	Wing Booms
AE-C-11	10	638800	6224143	Deciduous-mature forest	3	1	1	1	Wing Booms
AE-C-12	10	638498	6224537	Deciduous-mature forest	3	1	0	1	Calls Only
CH01-1	10	683053	6224258	Deciduous-young forest	2	0	0	0	Not Detected
CH01-2	10	664468	6233442	Deciduous-young forest	3	0	0	0	Not Detected
CH01-3	10	677784	6223702	Cultivated	1	1	0	1	Calls Only
CL04-1	10	614120	6254465	Deciduous-young forest	3	0	0	0	Not Detected
CL04-2	10	618177	6254580	Cultivated	3	0	0	0	Not Detected
CL04-3	10	621160	6257900	Cultivated	3	0	0	0	Not Detected
CL04-4	10	621540	6261145	Cultivated	2	0	0	0	Not Detected

Station ID	UTM Zone	UTM Easting	UTM Northing	Bird Habitat Class	Number of Surveys	Maximum Count Calling	Maximum Count Booming	Maximum Count	Detection Summary
CL04-5	10	627688	6261332	Cultivated	3	0	0	0	Not Detected
CL04-6	10	627778	6259206	Cultivated	3	0	0	0	Not Detected
CL04-7	10	628058	6250001	Cultivated	3	0	0	0	Not Detected
CL04-8	10	628223	6245128	Cultivated	2	0	0	0	Not Detected
CL05-1	10	616328	6257760	Cultivated	3	0	0	0	Not Detected
CL05-2	10	617008	6257788	Cultivated	3	0	0	0	Not Detected
CL05-3	10	625794	6258039	Cultivated	3	0	0	0	Not Detected
CL05-4	10	634603	6257772	Cultivated	3	1	0	1	Calls Only
CL05-5	10	634631	6253441	Cultivated	3	0	0	0	Not Detected
CL05-6	10	634654	6246977	Cultivated	2	0	0	0	Not Detected
CL05-7	10	634432	6243324	Cultivated	2	0	0	0	Not Detected
CR-E-01	10	562915	6211199	Cultivated	1	0	0	0	Not Detected
CR-E-02	10	563186	6211497	Cultivated	1	0	0	0	Not Detected
CR-E-03	10	563401	6211834	Cultivated	1	0	0	0	Not Detected
CR-E-04	10	563605	6212177	Cultivated	1	0	0	0	Not Detected
CR-E-05	10	563696	6212567	Cultivated	1	0	0	0	Not Detected
CR-E-06	10	563595	6212955	Cultivated	1	0	0	0	Not Detected
CR-E-07	10	563524	6213351	Cultivated	1	0	0	0	Not Detected
CR-E-08	10	563541	6213751	Cultivated	1	0	0	0	Not Detected
CR-E-09	10	563803	6214060	Cultivated	1	0	0	0	Not Detected
DR01-1	10	604022	6212356	Cultivated	3	0	0	0	Not Detected
DR01-10	10	618032	6221097	Fen/bog-shrub	3	0	0	0	Not Detected
DR01-11	10	618417	6220742	Fen/bog-shrub	3	0	0	0	Not Detected
DR01-12	10	618653	6220533	Fen/bog-shrub	3	0	0	0	Not Detected
DR01-13	10	619716	6219470	Deciduous-shrub	3	0	0	0	Not Detected
DR01-14	10	600850	6199237	Coniferous-shrub	3	0	1	1	Wing Booms
DR01-15	10	601795	6200295	Cultivated	3	0	0	0	Not Detected

Station ID	UTM Zone	UTM Easting	UTM Northing	Bird Habitat Class	Number of Surveys	Maximum Count Calling	Maximum Count Booming	Maximum Count	Detection Summary
DR01-16	10	601779	6200727	Cultivated	3	0	0	0	Not Detected
DR01-17	10	602207	6203334	Cultivated	3	0	0	0	Not Detected
DR01-18	10	602371	6203735	Cultivated	3	0	0	0	Not Detected
DR01-19	10	602561	6205476	Deciduous-mature forest	3	0	0	0	Not Detected
DR01-2	10	604007	6212832	Cultivated	3	0	0	0	Not Detected
DR01-20	10	601334	6210728	Cultivated	3	0	0	0	Not Detected
DR01-3	10	603996	6213233	Cultivated	3	0	0	0	Not Detected
DR01-4	10	605681	6214649	Cultivated	3	0	0	0	Not Detected
DR01-5	10	606067	6214695	Cultivated	3	0	0	0	Not Detected
DR01-6	10	606494	6214701	Cultivated	3	0	0	0	Not Detected
DR01-7	10	608008	6215402	Deciduous-shrub	3	0	0	0	Not Detected
DR01-8	10	612056	6219496	Deciduous-mature forest	3	1	0	1	Calls Only
DR01-9	10	612067	6221046	Anthropogenic	3	1	0	1	Calls Only
DR03-1	10	598472	6210477	Coniferous-mature forest	3	2	0	2	Calls Only
DR03-2	10	598174	6210182	Coniferous-mature forest	3	2	0	2	Calls Only
DR03-3	10	597902	6209907	Coniferous-mature forest	3	1	0	1	Calls Only
DR03-4	10	597631	6209644	Coniferous-mature forest	2	1	1	2	Wing Booms
DR03-5	10	596517	6208575	Coniferous-mature forest	2	0	0	0	Not Detected
DR03-6	10	596220	6208006	Coniferous-mature forest	2	0	0	0	Not Detected
DR03-7	10	595488	6207636	Coniferous-mature forest	2	0	0	0	Not Detected
DR03-8	10	594947	6207073	Deciduous-young forest	2	0	0	0	Not Detected
HH01-1	10	596201	6231192	Riparian-mixed shrub	3	0	0	0	Not Detected
HH01-2	10	594689	6230689	Anthropogenic	3	1	1	1	Wing Booms
HH01-4	10	587142	6224787	Deciduous-young forest	2	1	1	2	Wing Booms
HH01-5	10	586913	6224667	Anthropogenic	1	1	0	1	Calls Only
HH01-6	10	575193	6219528	Grassland-dry slopes	3	0	0	0	Not Detected
HH01-7	10	572112	6214274	Deciduous-young forest	2	0	0	0	Not Detected

Station ID	UTM Zone	UTM Easting	UTM Northing	Bird Habitat Class	Number of Surveys	Maximum Count Calling	Maximum Count Booming	Maximum Count	Detection Summary
HH02-1	10	574810	6238472	Cultivated	3	1	0	1	Calls Only
HH02-10	10	574713	6223271	Cultivated	3	0	0	0	Not Detected
HH02-2	10	575269	6237383	Anthropogenic	3	2	0	2	Calls Only
HH02-3	10	576718	6234002	Deciduous-mature forest	3	0	0	0	Not Detected
HH02-4	10	576642	6233599	Coniferous-shrub	3	0	0	0	Not Detected
HH02-5	10	576569	6233174	Cultivated	3	0	0	0	Not Detected
HH02-6	10	576511	6232769	Cultivated	3	0	0	0	Not Detected
HH02-7	10	575560	6227721	Cultivated	3	0	0	0	Not Detected
HH02-8	10	575030	6227704	Cultivated	3	0	0	0	Not Detected
HH02-9	10	574726	6227308	Cultivated	2	0	0	0	Not Detected
HW01-1	10	609936	6239222	Grassland-dry slopes	3	0	0	0	Not Detected
HW01-10	10	610568	6238171	Cultivated	2	0	0	0	Not Detected
HW01-2	10	610083	6237922	Cultivated	2	0	0	0	Not Detected
HW01-3	10	607800	6236723	Cultivated	3	0	0	0	Not Detected
HW01-4	10	606890	6235555	Deciduous-young forest	4	0	1	1	Wing Booms
HW01-5	10	604876	6234328	Cultivated	3	0	0	0	Not Detected
HW01-6	10	600341	6234345	Deciduous-young forest	3	0	0	0	Not Detected
HW01-7	10	598956	6233982	Deciduous-young forest	3	0	0	0	Not Detected
HW01-8	10	598987	6233907	Grassland-dry slopes	3	0	0	0	Not Detected
HW01-9	10	602773	6234339	Grassland-dry slopes	3	0	0	0	Not Detected
HW02-1	10	589694	6254000	Cultivated	3	0	0	0	Not Detected
HW02-2	10	590245	6245899	Cultivated	3	0	0	0	Not Detected
HW02-3	10	590887	6244921	Deciduous-shrub	3	0	0	0	Not Detected
HW02-4	10	591624	6243974	Deciduous-shrub	3	0	0	0	Not Detected
HW02-5	10	594166	6241402	Cultivated	3	0	0	0	Not Detected
HW02-6	10	594124	6236779	Cultivated	1	0	0	0	Not Detected
TR01n-1	10	648435	6226094	Cultivated	5	0	0	0	Not Detected

Station ID	UTM Zone	UTM Easting	UTM Northing	Bird Habitat Class	Number of Surveys	Maximum Count Calling	Maximum Count Booming	Maximum Count	Detection Summary
TR01n-2	10	648341	6228252	Cultivated	5	0	0	0	Not Detected
TR01n-3	10	648313	6229085	Cultivated	4	0	0	0	Not Detected
TR01n-4	10	646484	6234857	Cultivated	4	1	0	1	Calls Only
TR01s-1	10	656185	6220830	Deciduous-shrub	5	0	0	0	Not Detected
TR01s-2	10	655705	6220893	Deciduous-shrub	5	0	0	0	Not Detected
TR01s-3	10	655064	6220979	Cultivated	5	1	0	1	Calls Only
TR01s-4	10	652272	6221459	Deciduous-mature forest	5	1	0	1	Calls Only
TR01s-5	10	649767	6221632	Cultivated	5	1	0	1	Calls Only
TR01s-6	10	649384	6221794	Cultivated	5	0	0	0	Not Detected
TR01s-7	10	647266	6222341	Deciduous-young forest	5	1	0	1	Calls Only
TR01s-8	10	646589	6222325	Deciduous-shrub	5	0	0	0	Not Detected
TR01s-9	10	645517	6222524	Deciduous-young forest	5	0	0	0	Not Detected

APPENDIX D
PAIRED SAMPLING MODEL RESULTS

Model Summary

```
Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) ['
glmerMod']
 Family: poisson  ( log )
Formula: Count ~ Method + (1 | StationID)
   Data: paired

     AIC      BIC   logLik deviance df.resid
   109.7    116.2    -51.9    103.7       61

Scaled residuals:
    Min      1Q  Median      3Q     Max
-0.5998 -0.3346 -0.3232 -0.1050  1.1465

Random effects:
 Groups    Name        Variance Std.Dev.
 StationID (Intercept) 2.24     1.497
Number of obs: 64, groups:  StationID, 32

Fixed effects:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -1.77389    0.61150  -2.901  0.00372 **
MethodPC     0.06899    0.37150   0.186  0.85267
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Correlation of Fixed Effects:
         (Intr)
MethodPC -0.314
```

Marginal Means

Method	Log Scale					Response Scale		
	mean	SE	df	asymp.LCL	asymp.UCL	mean	LCL	UCL
ARU	-1.7738	0.611497	Inf	-2.9724	-0.57538	0.169672	0.051179	0.562505
PC	-1.7049	0.607593	Inf	-2.89576	-0.51404	0.181791	0.055256	0.598088

APPENDIX E
ABUNDANCE MODEL RESULTS

The best model was selected using Akaike's Information Criteria (AIC). The model with the lowest AIC_c (in bold) was selected as the best model. All models had Station as a random effect to account for multiple samples at a station.

ID	Fixed Effect Model Terms	AIC_c
0	Intercept only	611.49
1	Bird Habitat Class	585.258
2	Year	590.4699
3	Day	610.3642
4	Hour	609.2399
5	Bird Habitat Class + Year	570.5853
6	Bird Habitat Class + Day	586.1357
7	Bird Habitat Class + Hour	580.4066
8	Bird Habitat Class + Year + Day	571.7244
9	Bird Habitat Class + Day + Hour	581.7325
10	**Bird Habitat Class + Year + Hour**	**564.9878**
11	Bird Habitat Class + Year + Day + Hour	566.6224
12	Year + Day	589.2226
13	Year + Hour	587.2782
14	Year + Day + Hour	586.5053

Best Model Summary

```
Formula:          Count ~ BHC + year + hour + (1 | Station)
Data: arudat
      AIC       BIC    logLik  df.resid
 563.7986  601.8071 -270.8993       223
Random-effects (co)variances:

Conditional model:
 Groups  Name        Std.Dev.
 Station (Intercept) 0.2919

Number of obs: 234 / Conditional model: Station, 117

Fixed Effects:

Conditional model:
(Intercept)       BHCRSH       BHCWGR       BHCWRI       BHCDSS       BHCCUL       BHCNVE
BHCANT
     8.5582       0.9929      -0.4272       0.5195      -0.2937      -0.3031       0.2611
0.5882
   year2019         hour
    -0.6971      -9.3421
> summary(m10)
 Family: poisson  ( log )
Formula:          Count ~ BHC + year + hour + (1 | Station)
Data: arudat

     AIC      BIC   logLik deviance df.resid
   563.8    601.8   -270.9    541.8      223

Random effects:

Conditional model:
 Groups  Name        Variance Std.Dev.
 Station (Intercept) 0.08519  0.2919
Number of obs: 234, groups:  Station, 117

Conditional model:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)   8.5582     3.1670   2.702 0.006887 **
BHCRSH        0.9929     0.2634   3.770 0.000163 ***
BHCWGR       -0.4272     0.5736  -0.745 0.456452
BHCWRI        0.5195     0.3016   1.722 0.084993 .
BHCDSS       -0.2937     0.5848  -0.502 0.615440
BHCCUL       -0.3031     0.3361  -0.902 0.367107
BHCNVE        0.2611     0.2969   0.879 0.379190
BHCANT        0.5882     0.4622   1.273 0.203183
year2019     -0.6971     0.1645  -4.239 2.25e-05 ***
hour         -9.3421     3.4007  -2.747 0.006012 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Marginal Means Calculated From Best Model

Bird Habitat Class	Log Scale					Response Scale		
	mean	SE	Df	lower.CL	upper.CL	mean	LCL	UCL
DSH	-0.52035	0.251341	223	-1.01566	-0.02505	0.59431	0.363134	0.972656
RSH	0.472593	0.124565	223	0.22711	0.718069	1.604148	1.256644	2.047749
WGR	-0.94755	0.528959	223	-1.98995	0.094846	0.387689	0.137475	1.093308
WRI	-8.71E-04	0.189594	223	-0.3745	0.372753	0.999129	0.689027	1.448795
DSS	-0.8141	0.52233	223	-1.84343	0.215238	0.44304	0.159157	1.233272
CUL	-0.82344	0.232784	223	-1.28218	-0.3647	0.438919	0.278121	0.692682
NVE	-0.25927	0.178576	223	-0.61118	0.092641	0.771614	0.543743	1.094982
ANT	0.067819	0.404675	223	-0.72966	0.865295	1.070171	0.484158	2.365482

APPENDIX F
OCCUPANCY MODEL RESULTS

The best occupancy model was selected using Akaike's Information Criteria for small sample sizes (AIC_c). The model with the lowest AIC_c (in bold) was selected as the best model.

ID	Fixed Effect Model Terms	AIC_c
0	Intercept only	303.8237
1	Bird Habitat Class	297.8096
2	Year	289.4264
3	Day	295.7988
4	Hour	302.676
5	Bird Habitat Class + Year	282.9019
6	Bird Habitat Class + Day	287.8074
7	Bird Habitat Class + Hour	297.5775
8	Bird Habitat Class + Year + Day	285.3385
9	Bird Habitat Class + Day + Hour	286.8309
10	**Bird Habitat Class + Year + Hour**	**281.4367**
11	Bird Habitat Class + Year + Day + Hour	283.9202
12	Year + Day	291.1918
13	Year + Hour	289.0189
14	Year + Day + Hour	290.6955

Best Model Summary

```
Call:
occu(formula = ~BHC + Year + hour ~ 1, data = unmarkeddat)

Occupancy:
 Estimate    SE    z P(>|z|)
      1.8 0.599 3.01 0.00261

Detection:
            Estimate    SE      z  P(>|z|)
(Intercept)   16.057 8.313  1.932 5.34e-02
BHCRSH         2.436 0.693  3.515 4.40e-04
BHCWGR        -0.661 1.036 -0.639 5.23e-01
BHCWRI         0.644 0.748  0.861 3.89e-01
BHCDSS         0.420 1.055  0.398 6.90e-01
BHCCUL         0.201 0.694  0.290 7.72e-01
BHCNVE         0.790 0.678  1.166 2.43e-01
BHCANT         0.487 1.113  0.438 6.62e-01
Year2019      -1.669 0.428 -3.899 9.65e-05
hour         -17.211 8.829 -1.949 5.13e-02

AIC: 278.9224
```

Occupancy predictions by bird habitat class and year. The effect of hour was held constant at the average value (0.9375). The effect of year could not be averaged as it is a categorical variable.

BHC	Year	Predicted	SE	Lower CI	Upper CI
DSH	2018	0.496	0.141	0.245	0.748
RSH	2018	0.918	0.038	0.808	0.968
WGR	2018	0.337	0.198	0.082	0.742
WRI	2018	0.652	0.143	0.353	0.865
DSS	2018	0.599	0.237	0.178	0.912
CUL	2018	0.546	0.135	0.292	0.778
NVE	2018	0.684	0.113	0.438	0.857
ANT	2018	0.615	0.230	0.192	0.915
DSH	2019	0.156	0.083	0.051	0.388
RSH	2019	0.679	0.096	0.471	0.834
WGR	2019	0.087	0.077	0.014	0.386
WRI	2019	0.261	0.109	0.105	0.516
DSS	2019	0.220	0.148	0.049	0.606
CUL	2019	0.185	0.068	0.086	0.353
NVE	2019	0.290	0.090	0.148	0.490
ANT	2019	0.232	0.184	0.038	0.695

APPENDIX G
PROJECT QUALIFIED ENVIRONMENTAL PROFESSIONALS

Name and Affiliation	Project Role
Jeff Matheson, M.Sc., R.P.Bio. Tetra Tech Canada Inc.	Project manager, report author
Camille Roberge, B.Sc., E.Pt. Tetra Tech Canada Inc.	Field data collection, data entry
Elyse Hofs, B.Sc., Dipl.T. Tetra Tech Canada Inc.	Field data collection, data entry, analysis, report co-author
Todd Heakes Tetra Tech Canada Inc.	Field data collection
Claudio Bianchini, R.P.Bio. Bianchini Biological Services	Field data collection
Kerrith McKay, M.Sc. McKay Environmental Consulting Ltd.	Field data collection

APPENDIX H
LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

NATURAL SCIENCES

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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.

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

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

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

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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 4. Breeding Bird Follow-up Monitoring – Woodpeckers 2019 Annual Report

Site C Clean Energy Project
Breeding Bird Follow-up Monitoring - Woodpeckers
2019 Annual Report

PRESENTED TO

BC Hydro and Power Authority

MARCH 30, 2020
ISSUED FOR USE
FILE: 704-ENV.VENV03095-01.WOODPECKERS

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

Site C Clean Energy Project Breeding Bird Follow-Up Monitoring - Woodpeckers
2019 Annual Report

FILE: 704-ENV.VENV03095-01.Woodpeckers
March 30, 2020

PRESENTED TO

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BC Hydro and Power Authority
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Jeff Matheson, M.Sc., R.P.Bio. **2020-03-30**
Senior Biologist

Reviewed by: <Original signed by>

FILE: 704-EN PECKERS
FILE: 704-EN PECKERS

Karla Langlois, B.Sc., P.Biol. **2020-03-30**
Senior Biologist

EXECUTIVE SUMMARY

Woodpecker point count surveys with call-playback were conducted in the area of BC Hydro and Power Authority's Site C Clean Energy Project in spring and summer 2018 and 2019. Surveys were conducted twice during the breeding season at 101 locations in 2018 and 118 locations in 2019.

Yellow-bellied Sapsucker was the most-frequently detected species with more than twice the number of detections of Hairy Woodpecker, the next most-frequently detected species. Black-backed Woodpecker was detected at only two locations over the two years of surveys.

American Three-toed Woodpecker were detected in all habitat classes, with relative abundance appearing to be highest in fen/bog and the coniferous forest types. Of the two detections of Black-backed Woodpecker, one each were found in coniferous-mature forest and deciduous-mature forest. Downy Woodpeckers were recorded at very low densities in six of the 10 bird habitat classes. Hairy woodpeckers were the second-most abundant woodpecker and were found in all bird habitat classes except for the fen/bog classes. Northern Flickers were found in all bird habitat classes, with highest relative abundances observed in shrubby habitats. Pileated Woodpecker were recorded at very low relative abundances in all habitat classes. Yellow-bellied Sapsuckers were also detected in all habitat classes, with the highest relative abundances recorded in fen/bog,

Woodpecker surveys were completed at two of the three mitigation properties. Surveys were not completed at the Wilder Creek property as it is predominantly non-forested. One Hairy Woodpecker was observed at the Marl Fen property during the 12 surveys conducted there. No woodpeckers were detected at the Rutledge property.

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1.0 INTRODUCTION

Woodpecker surveys were conducted 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 2018 and 2019. The surveys were part of BC Hydro's Breeding Bird Follow-up Monitoring Program (Volume 2, Section 14 in BC Hydro 2013). The monitoring program for woodpeckers is described in the woodpecker program plan (BC Hydro 2018a).

Seven woodpecker species are known to occur in the Peace River Valley (Table 1). None of the woodpecker species are considered species at risk (i.e., not listed as Red or Blue in BC, nor listed under the Committee on the Status of Endangered Wildlife in Canada [COSEWIC] or the Species at Risk Act [SARA]).

Table 1: Woodpecker species known to occur in the Peace River Valley.

Common Name	Scientific Name	Species Code	BC List	COSEWIC	SARA
American Three-toed Woodpecker	*Picoides dorsalis*	ATTW	Yellow	-	-
Black-backed Woodpecker	*Picoides arcticus*	BBWO	Yellow	-	-
Downy Woodpecker	*Dryobates pubescens*	DOWO	Yellow	-	-
Hairy Woodpecker	*Dryubates villosus*	HAWO	Yellow	-	-
Northern Flicker	*Colaptes auratus*	NOFL	Yellow	-	-
Pileated Woodpecker	*Dryocopus pileatus*	PIWO	Yellow	-	-
Yellow-bellied Sapsucker	*Sphyrapicus varius*	YBSA	Yellow	-	-

Woodpecker surveys are conducted to satisfy three objectives (BC Hydro 2018a):

1. Determine the distribution and relative abundance of woodpeckers within habitat expected to be lost or otherwise affected by the project to verify the predictions made in the Environmental Impact Statement (EIS). This information, together with the existing baseline woodpecker data, will be used to more precisely identify and quantify the species that are currently present within the project footprint and whose habitat will be lost or affected as a result of the project.

2. Identify habitat associations and habitat attributes used by woodpeckers to help identify areas for offsetting impacts. Species-habitat relationships will be used to help determine appropriate compensation for non-wetland migratory bird habitat.

3. Conduct effectiveness monitoring to determine the degree to which mitigation areas offset impacts to woodpeckers and their habitat and determine further woodpecker mitigation requirements.

This report summarizes the results of woodpecker surveys completed in 2018 and 2019. A report was completed after the 2018 woodpecker surveys to provide interim results of the surveys completed in that year. Some of the data collected during pre-approval baseline studies in 2010 (documented in BC Hydro 2013) is also summarized here.

2.0 METHODS

2.1 Survey Area

Woodpecker surveys in 2018 and 2019 were completed in and around the Project footprint in the Peace River valley and in the BC Hydro proposed mitigation properties (Figure 1). The footprint is primarily composed of the dam, generating station and spillways, reservoir, transmission line and construction access roads, as well as the areas along the Peace River between the dam and the confluence with the Pine River that could be affected by fluctuating water levels.

2.2 Survey Station Locations

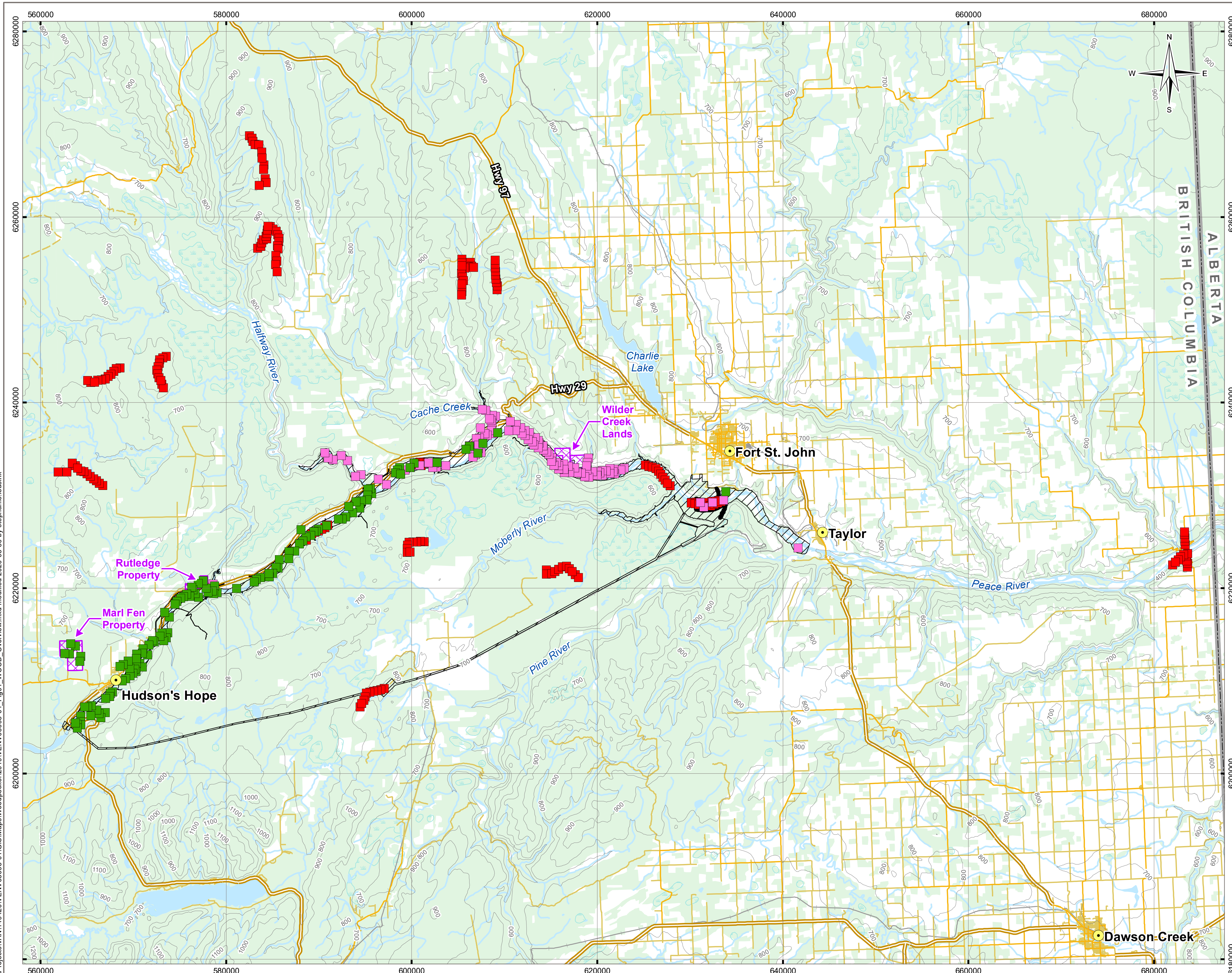
Survey station locations were stratified by habitat type. Terrestrial Ecosystem Mapping (TEM) developed for the EIS (Hilton et al., 2013) was used as the primary habitat base. Forty-one ecosystem types (site series/map codes) and seven structural stages were mapped in the project area. Site series/map codes and structural stages were mapped together to form ecosystem units; 95 ecosystem units were mapped in the footprint (151 in the region), 73 of which could support woodpeckers (i.e. have trees or shrubs).

The TEM units provide fine-scale habitat mapping; however, there are too many to effectively stratify sampling and it was not feasible to achieve an adequate number of samples in each of the 73 units for analysis. To address this, an intermediate-scale habitat classification was developed by combining similar ecosystem units based on dominant vegetation and stand age to form 20 habitat classes (listed in Section 2.4). The fine-scale TEM ecosystem units are nested within the intermediate-scale habitat classes to form a hierarchical classification system. Both levels were used to stratify and track sampling. The habitat classes were used to stratify and establish sampling targets. Within each habitat class, the goal was to sample the range of ecosystem units found in each class. Some survey stations were placed outside the Project footprint, but still within the Peace River valley, to allow for surveys within specific habitat types known or expected to occur in the footprint but that could not be surveyed due to inaccessibility, uncertain location or small mapped area.

Woodpecker surveys were conducted at 101 locations in 2018 and 118 locations in 2019 (Table 2, Figure 1 and Appendix A). Each station was generally surveyed twice during the breeding season, though four stations were surveyed three times in 2018 and three stations in 2019 could only be surveyed once due to access restrictions. No survey stations were in the dam site area, the lower Moberly River, and the Peace River valley from the dam site west to Tea Creek and Tea Island because these areas were predominantly cleared in 2016/2017. Attempts were made to access the portion of the Moberly River that has not yet been cleared (i.e., the upper portion of the Moberly River valley within the footprint), however, high-water levels and fast water flows prevented safe boat access.

Table 2. Number of woodpecker stations and surveys conducted in 2018 and 2019.

Year	Stations	Surveys
2018	101	206
2019	118	233



LEGEND

Woodpecker Survey Locations

Survey Year

- 2010 (Baseline)
- 2018
- 2019
- 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 WOODPECKER 2019 ANNUAL REPORT

Woodpecker Survey Locations

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	

Scale: 1:400,000

8 4 0 8
Kilometres

TETRA TECH

FILE NO.
VENV03095-01_Fig01_WOOD_Overview.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	YL	JM	0

DATE
March 30, 2020

PROJECT NO.
ENV.VENV03095-01

Figure 1

2.3 Woodpecker Surveys

Call-playback surveys were used to survey woodpeckers. Surveys were completed in June, between sunrise and approximately 10 AM on each survey day. Call playback stations were placed no closer than 400 metres (m) apart. At each station, observers played commercially obtained woodpecker recordings over a speaker (FoxPro NX4 game caller) to elicit a response from any individuals in the area. After a one-minute initial listening period, calls for all seven woodpecker species were played at each station. Calls and territorial drums for each selected species were played consecutively, starting with the smallest woodpecker and ending with the largest. Playbacks for each individual species consisted of up to 20 seconds of calls followed by 30 seconds of silence, during which observers looked and listened for a response. That sequence was repeated twice for each species. The same sequence of woodpecker calls was played during each survey at each station even when spontaneous calls were heard.

Many of the woodpecker call-playback surveys were conducted at the same location as songbird point counts for logistical efficiency. For those surveys, the woodpecker survey was conducted immediately after the songbird point count so that woodpecker call playback could not affect the songbird survey results.

Surveys were not done in inclement weather conditions (i.e., wind speed > Beaufort 3, steady rain, temperature <7 ^{o}C). Universal Transverse Mercator (UTM) coordinates (NAD 83), station start and end time, and weather conditions (i.e., wind, cloud cover, precipitation, and temperature) were recorded for each call station. When a woodpecker was detected, surveyors recorded the species, sex and age class (if possible), the activity, the number heard/seen, and the estimated distance (0-50 m, 50-100 m or >100 m) and direction to the initial detection location. Woodpecker detections were recorded as either spontaneously calling or as a call-playback response:

- Spontaneously calling - a woodpecker calling, drumming or observed during the initial 1-min listening period or at other times during the survey except during or after its own call or drum being played; or
- Call playback response – a woodpecker calling, drumming or observed when its own call or drum was being played or in the listening interval after.

All field data were recorded on standard forms for call-playback surveys. Incidental observations of other wildlife were recorded during surveys and while in the field.

Any woodpecker nests observed while completing call-playback and songbird surveys were recorded. Data on tree height, tree species, diameter at breast height and decay class were recorded along with woodpecker species, nest height and cavity size. Nest searches were not performed.

2.4 Habitat Classification and Site-Level Habitat Data Collection

The 151 unique ecosystems units (combination of site series and structural stage) mapped in the region were collapsed into 20 broader units, referred to as bird habitat classes, based on dominant vegetation and stand age:

- Coniferous-shrub
- Coniferous-young forest
- Coniferous-mature forest
- Deciduous-shrub
- Deciduous-young forest
- Deciduous-mature forest
- Riparian-mixed shrub
- Riparian-mixed young forest
- Riparian-mixed mature forest
- Fen/bog-shrub
- Fen/bog-treed
- Wetland-graminoid
- Wetland-shrub
- Wetland-riparian
- Grassland-dry slopes
- Shrubland-dry slopes
- Cultivated
- Non-vegetated
- Anthropogenic
- Water

For the estimation of relative abundance, the dominant bird habitat class mapped within 100 m of the survey station centre was assigned to each station. The assigned bird habitat class was cross-checked with site-level data to ensure accurate assignment.

Site-level habitat attributes were recorded for each station. These data were recorded on a Site Visit form (SIVI; British Columbia Ministry of Forests and Range and British Columbia Ministry of Environment 2010) and included all site and vegetation fields with the exception of soil characteristics. In addition to the SIVI form attributes, data on dead standing trees were recorded. The number of dead standing trees >15 centimetre (cm) diameter at breast height were recorded within a 11.3 m radius of the plot centre according to decay class. In addition, the number of dead standing trees >15 cm diameter at breast height within 50 m of plot centre of any decay class were estimated.

The site-level habitat data can be used at a later date to further describe and define attributes associated with woodpecker observations, if useful.

2.5 Relative Abundance

Woodpecker relative abundance was estimated for each bird habitat class. Stations were placed so that at least 100 m radius from the station centre was in a uniform bird habitat class. Only woodpecker counts within 100 m of the survey station centre should therefore be included. but judging the exact distance to a woodpecker detection is difficult, and woodpeckers further than 100 m may be recorded accidentally. Since the area surveyed is fixed at 100 m radius, the area surveyed at each station is 3.14 hectares (ha). Although the area at each station is known, as it is not known if all woodpeckers were detected within 100 m, the estimates of abundance are relative.

Mean relative abundance was estimated by fitting a Generalized Linear Mixed Model (GLMM) with a Poisson distribution. Variables included to account for survey-level variability (temporal factors) were as follows:

- Year, to account for differences between years;
- Ordinal day (the number of days between the date of survey and the start of the year, standardized as day/365); and,
- Time of day (hour, standardized as hour/24).

The counts from each 10-minute survey were treated as an independent sample. Survey station was included as a random effect in the model to account for the two repeated measures at each station. Candidate model equations with bird habitat class with all possible combinations of the three temporal variables, but without considering interaction terms, plus survey station as a random effect, were evaluated and compared using Akaike's Information Criterion for small samples (AIC_c) (model equations are listed in Appendix B). The bird habitat class model with the lowest AIC_c was selected as the model with the best fit.

Mean relative abundance with a 95% confidence interval (CI) was estimated for each bird habitat class for each woodpecker species. All analyses were conducted using the R package glmmTMB (Brooks et al. 2017) in R (R Core Group 2019). Means and confidence intervals were calculated using the R package 'emmeans' (Lenth 2019).

2.6 Baseline Woodpecker Surveys 2010

Baseline woodpecker call-playback surveys in 2010 were conducted at 187 stations with each station surveyed either two or three times for a total of 478 surveys. Survey stations were established along transects in a range of habitats. Surveys were completed in the breeding season, between 30 minutes after sunrise and noon. Stations were placed at 400 metre intervals, where observers played commercially obtained woodpecker recordings over a speaker (FoxPro FX-3) to elicit a response from any individuals in the area. Calls for two to four of the seven woodpecker species were played at each station, with a different species composition used at each station. Calls and/or territorial drums for each selected species were played consecutively, starting with the smallest woodpecker and ending with the largest. Playbacks for each individual species consisted of 20 seconds of calls followed by 30 seconds of silence, during which observers looked and listened for a response. That sequence was repeated three times for each species (2.5 minutes per species per station); with a two-minute pause between each species. Surveys were not done in inclement weather conditions (wind speed > Beaufort 3, steady rain, temperature < 7°C).

Location coordinates, station start and end time, and weather conditions (wind, cloud cover, precipitation, and temperature) were recorded for each survey, as well as the woodpecker species played at each station. If a woodpecker was detected, surveyors recorded the detection type and time, the species, sex and age class (if possible), the activity, the number heard/seen, and the estimated distance and direction to the initial detection location.

The 2010 woodpecker data were used to show the incidence (presence-not detected) of woodpeckers across areas surveyed, in conjunction with the 2018-2019 data. The 2010 data could not be combined with the 2018-2019 data for estimates of relative abundance because of differences in survey methodology (different and variable survey duration lengths and differing number of calls played during each survey) that could not be adequately accounted for in a statistical model.

3.0 RESULTS AND DISCUSSION

3.1 Incidence and Distribution

The number of stations surveyed in 2018 and 2019 in each Bird Habitat Class is provided in Table 3. Habitats not surveyed were dry slopes-shrubland, dry slopes-grassland, non-vegetated and water.

There were 418 woodpecker detections over both surveys at all stations (Table 4). All seven species of woodpecker known to occur in the Peace River area were detected. The 418 detections represent a conservative estimate of 307 individual woodpeckers detected when considering the maximum count from repeated surveys at a station, added over all stations (Table 4). Of the 307 individuals counted, 20 could not be identified to the species level (4.7%). Yellow-bellied Sapsucker was the most frequently observed (n=156), while only two Black-backed Woodpeckers were recorded. All species except Pileated Woodpecker were found to respond to their species' call-playback more often than spontaneously calling. The geographic distribution for each woodpecker species detections are shown in Figures 2-8. No woodpecker nests were recorded during the 2018-2019 surveys, although focussed nest searches were not performed.

Table 3. Number of stations and surveys in each bird habitat class in 2018 and 2019.

Bird Habitat Category (BHC)	BHC Code	2018		2019	
		Stations	Surveys [a]	Stations	Surveys [b]
Coniferous-young forest	CYF	2	4	31	61
Coniferous-mature forest	CMF	13	28	14	27
Deciduous-shrub	DSH	7	14	8	16
Deciduous-young forest	DYF	15	30	22	44
Deciduous-mature forest	DMF	23	48	10	20
Riparian-mixed shrub	RSH	11	22	8	14
Riparian-mixed young forest	RYF	10	20	4	8
Riparian-mixed mature forest	RMF	15	30	10	19
Fen/bog-shrub	FBS	0	0	2	4
Fen/bog-treed	FBT	1	2	1	2
Wetland-shrub	WSH	1	2	0	0
Wetland-riparian	WRI	3	6	6	13
Cultivated	CUL	0	0	1	2
Anthropogenic	ANT	0	0	1	2
Total		**101**	**206**	**118**	**232**

[a] Four stations were surveyed three times.

[b] Four stations were surveyed only once.

Table 4: Woodpeckers observed during surveys in 2018 and 2019.

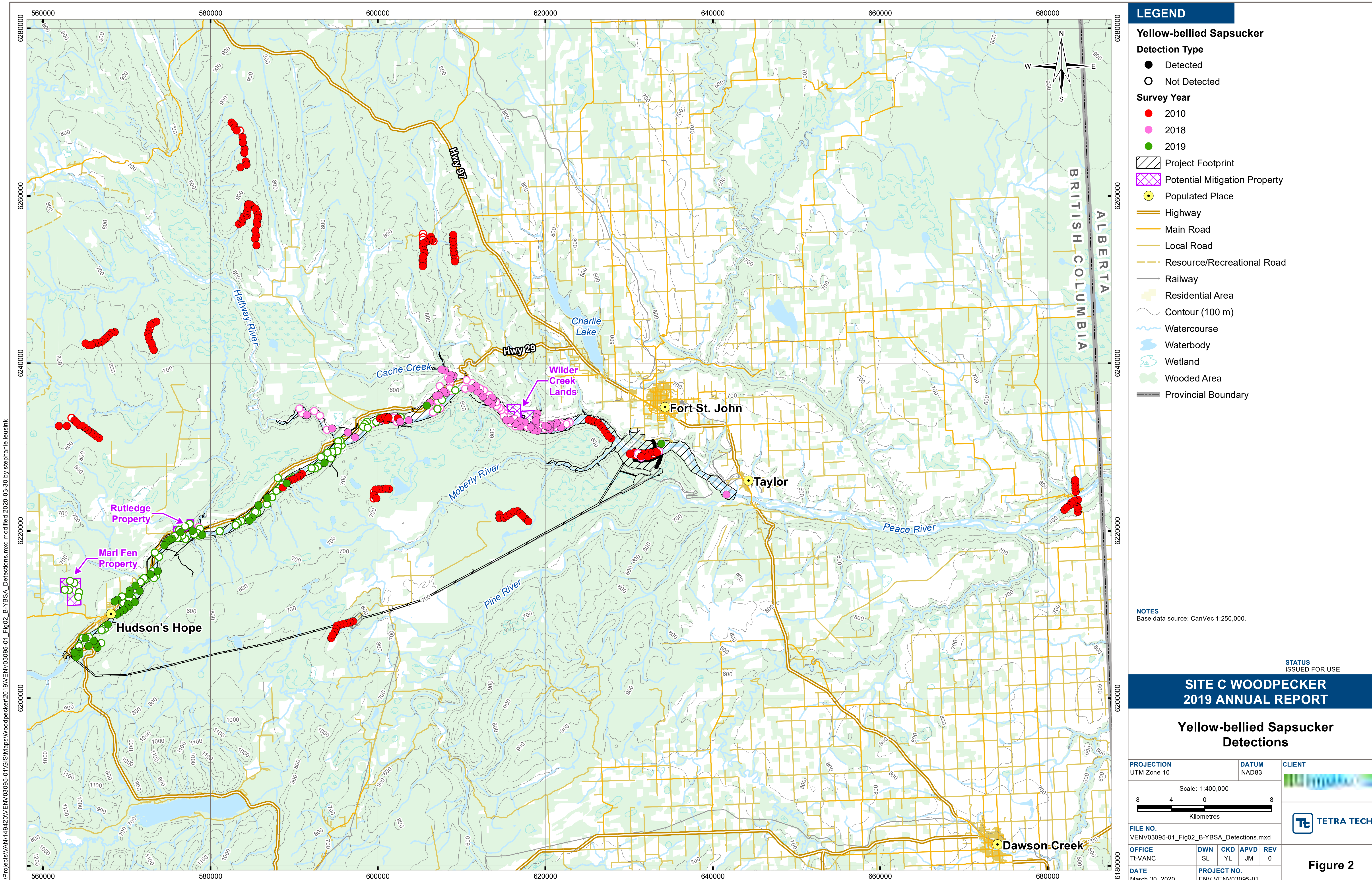
Common Name	Woodpecker Detections[1]			Total Detections[3]	Total Maximum Count[4]
	Spontaneously Calling	Call Playback Response	NA[2]		
American Three-toed Woodpecker	14	35	1	50	39
Black-backed Woodpecker	0	2	0	2	2
Downy Woodpecker	9	17	1	27	24
Hairy Woodpecker	30	41	1	72	62
Northern Flicker	23	30	3	56	46
Pileated Woodpecker	21	14	0	35	31
Yellow-bellied Sapsucker	68	88	0	156	103
Unknown woodpecker species	-	-	20	20	-
Total	165	227	26	418	307

[1] The total number of detections over both surveys at all stations.

[2] Call type was written as NA (not available) when call type (i.e. spontaneously or call playback response) was uncertain.

[3] The total number of detections over both surveys at all stations.

[4] The greater number of each species found over both surveys at a station, totaled over all stations.



LEGEND
Yellow-bellied Sapsucker
Detection Type
Detected
Not Detected
Survey Year
2010
2018
2019
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 WOODPECKER
2019 ANNUAL REPORT
Yellow-bellied Sapsucker
Detections
PROJECTION
UTM Zone 10
DATUM
NAD83
CLIENT
Scale: 1:400,000
8 4 0 8
Kilometres
FILE NO.
VENV03095-01_Fig02_B-YBSA_Detections.mxd
TETRA TECH
OFFICE
Tt-VANC
DWN
SL
CKD
YL
APVD
JM
REV
0
DATE
March 30, 2020
PROJECT NO.
ENV.VENV03095-01
Figure 2
BRITISH COLUMBIA
ALBERTA
Fort St. John
Taylor
Hudson's Hope
Dawson Creek
Charlie Lake
Cache Creek
Halfway River
Moberly River
Pine River
Peace River
Hwy 97
Hwy 29
Wilder Creek Lands
Rutledge Property
Marl Fen Property
560000
580000
600000
620000
640000
660000
680000
6280000
6260000
6240000
6220000
6200000
6180000
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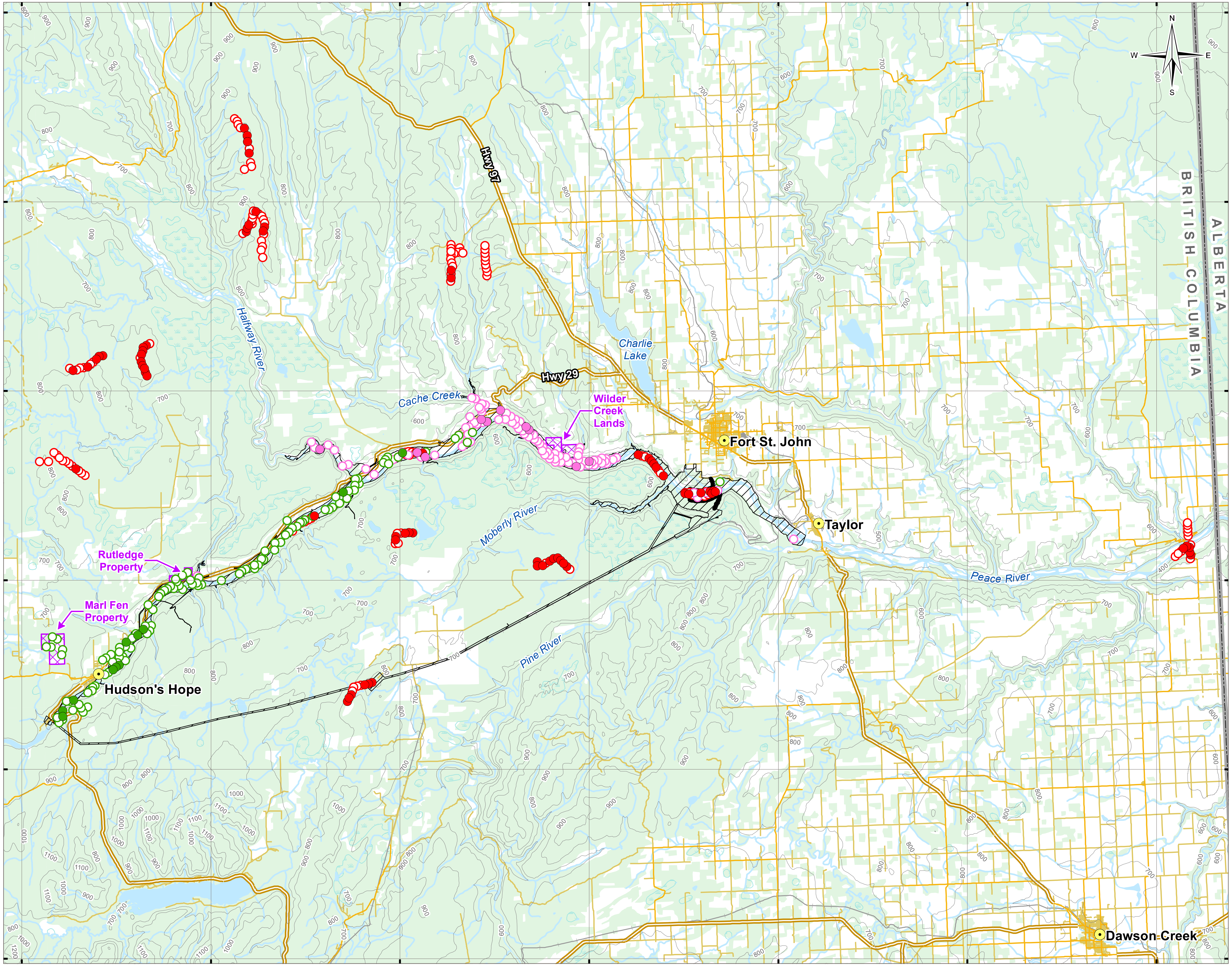

LEGEND

Downy Woodpecker

Detection Type

- Detected
- Not Detected

Survey Year

- 2010
- 2018
- 2019

- 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 WOODPECKER
2019 ANNUAL REPORT

Downy Woodpecker Detections

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	

Scale: 1:400,000

8 4 0 8
Kilometres

TETRA TECH

FILE NO.				
VENV03095-01_Fig03_B-DOWO_Detections.mxd				
OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	YL	JM	0
DATE	PROJECT NO.			
March 30, 2020	ENV.VENV03095-01			

Figure 3

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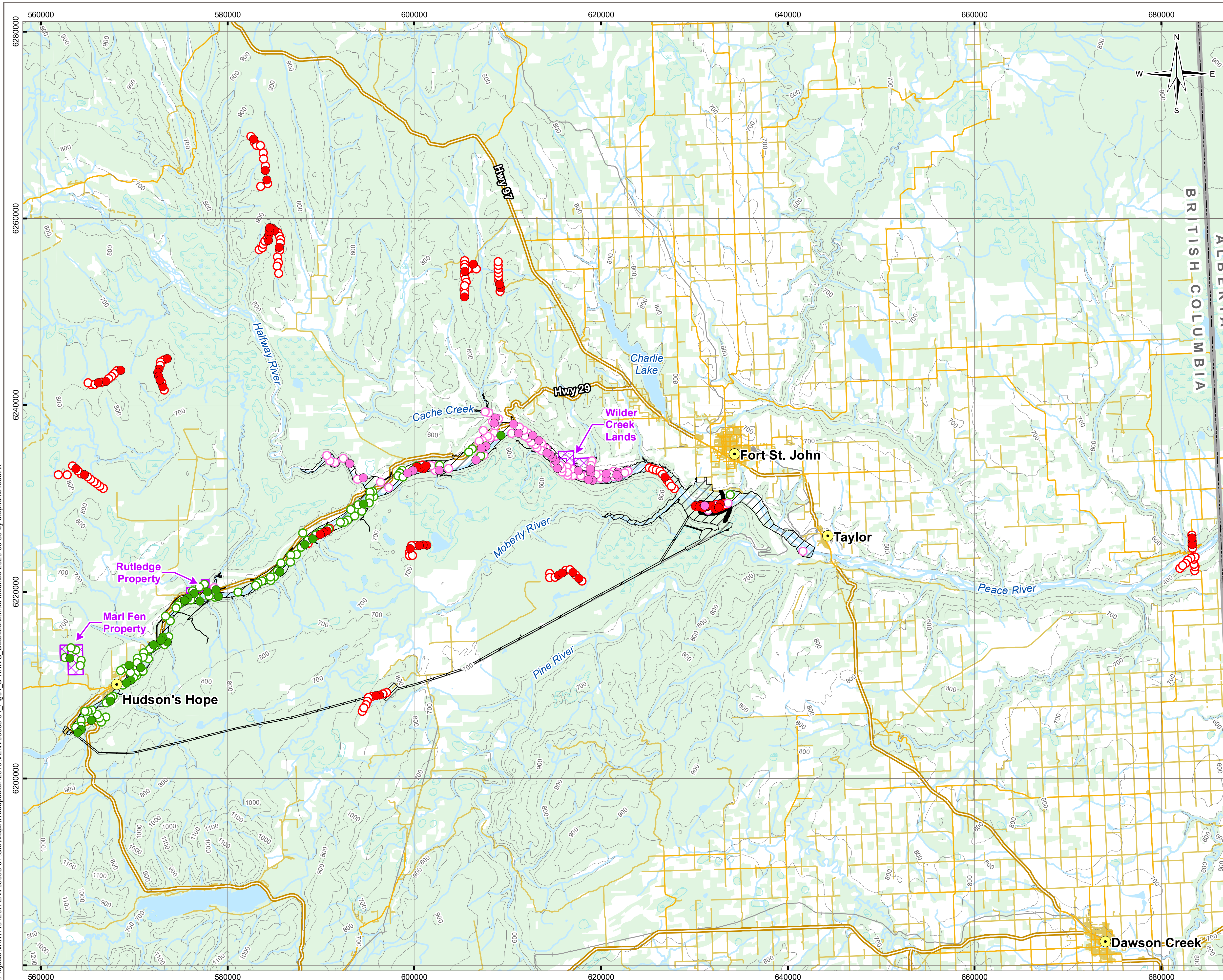

LEGEND

Hairy Woodpecker

Detection Type

- Detected
- Not Detected

Survey Year

- 2010
- 2018
- 2019

- 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 WOODPECKER 2019 ANNUAL REPORT

Hairy Woodpecker Detections

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	

Scale: 1:400,000
Kilometres

TETRA TECH

FILE NO.
VENV03095-01_Fig04_B-HAWO_Detections.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	YL	JM	0

DATE
March 30, 2020

PROJECT NO.
ENV.VENV03095-01

Figure 4

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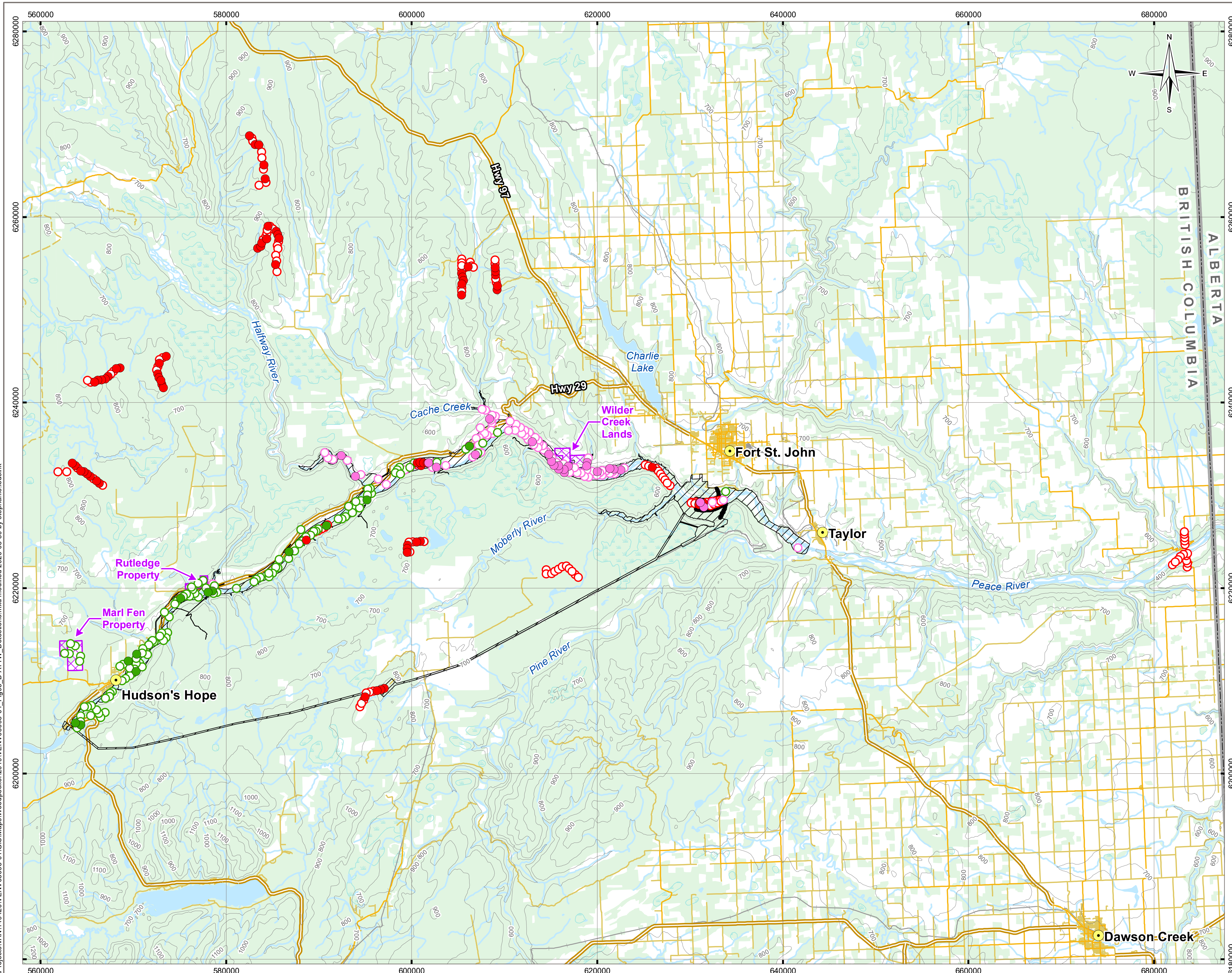


LEGEND

American Three-toed Woodpecker

Detection Type

- Detected
- Not Detected

Survey Year

- 2010
- 2018
- 2019

- 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 WOODPECKER 2019 ANNUAL REPORT

American Three-toed Woodpecker Detections

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	

Scale: 1:400,000

8 4 0 8

Kilometres

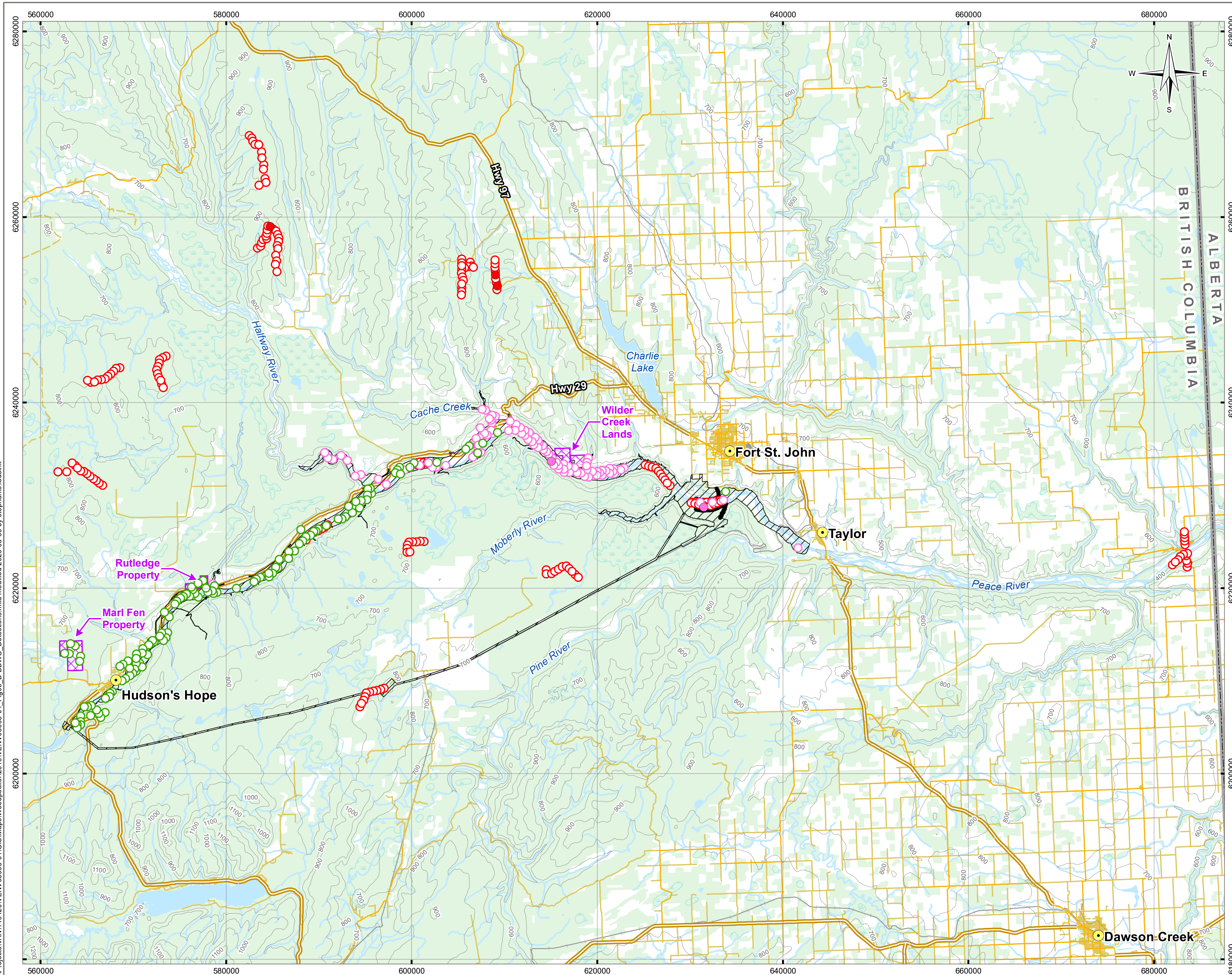
TETRA TECH

FILE NO.
VENV03095-01_Fig05_B-ATTW_Detections.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	YL	JM	0

DATE	PROJECT NO.
March 30, 2020	ENV.VENV03095-01

Figure 5



LEGEND

Black-backed Woodpecker

Detection Type

- Detected
- Not Detected

Survey Year

- 2010
- 2018
- 2019

- 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 WOODPECKER 2019 ANNUAL REPORT

Black-backed Woodpecker Detections

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	

Scale: 1:400,000

8 4 0 8

Kilometres

FILE NO.
VENV03095-01_Fig06_B-BBWO_Detections.mxd

TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	YL	JM	0

DATE
March 30, 2020

PROJECT NO.
ENV.VENV03095-01

Figure 6

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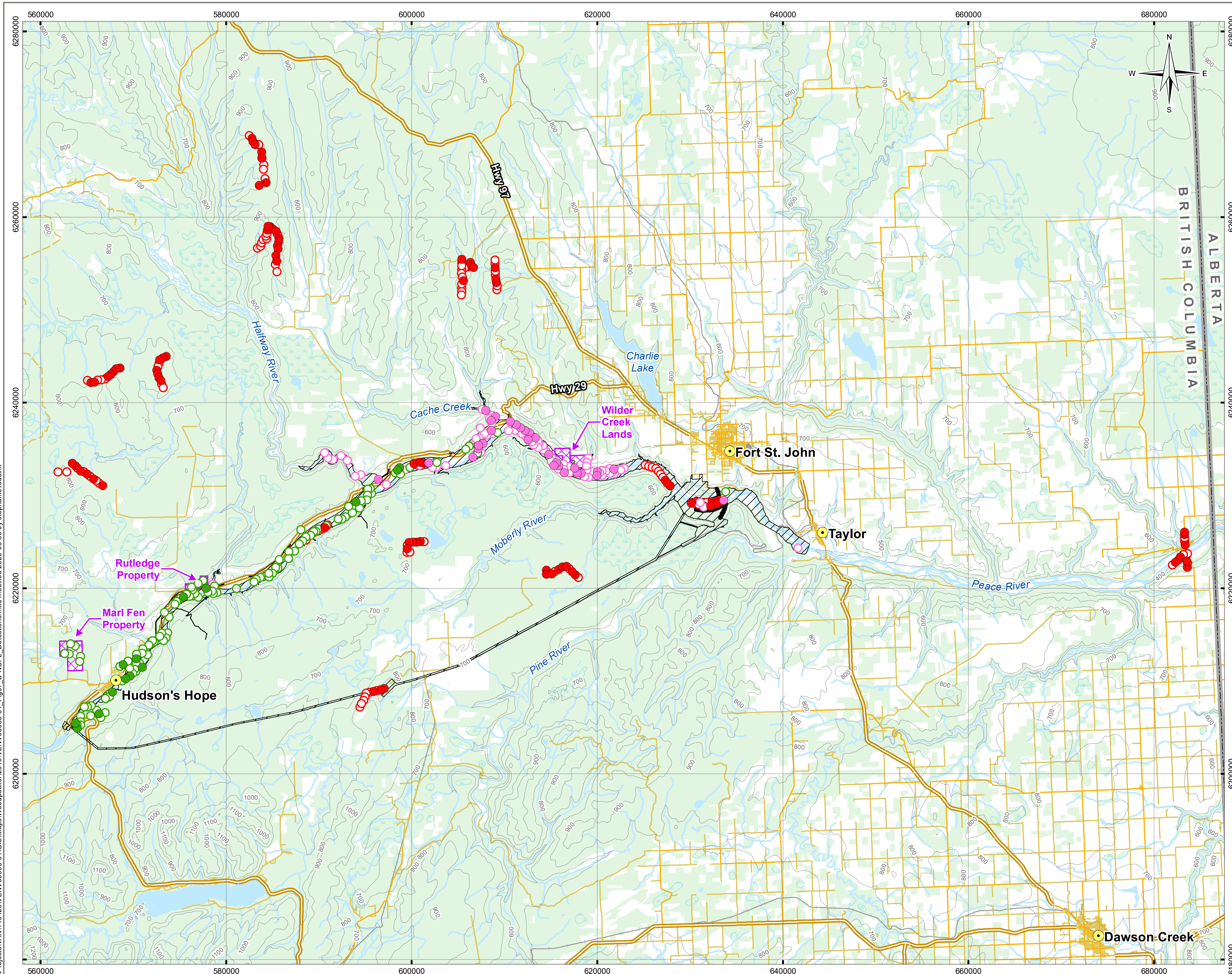

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LEGEND

Northern Flicker

Detection Type

- Detected
- Not Detected

Survey Year

- 2010
- 2018
- 2019

- 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 WOODPECKER 2019 ANNUAL REPORT

Northern Flicker Detections

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	

Scale: 1:400,000
8 4 0 8
Kilometres

TETRA TECH

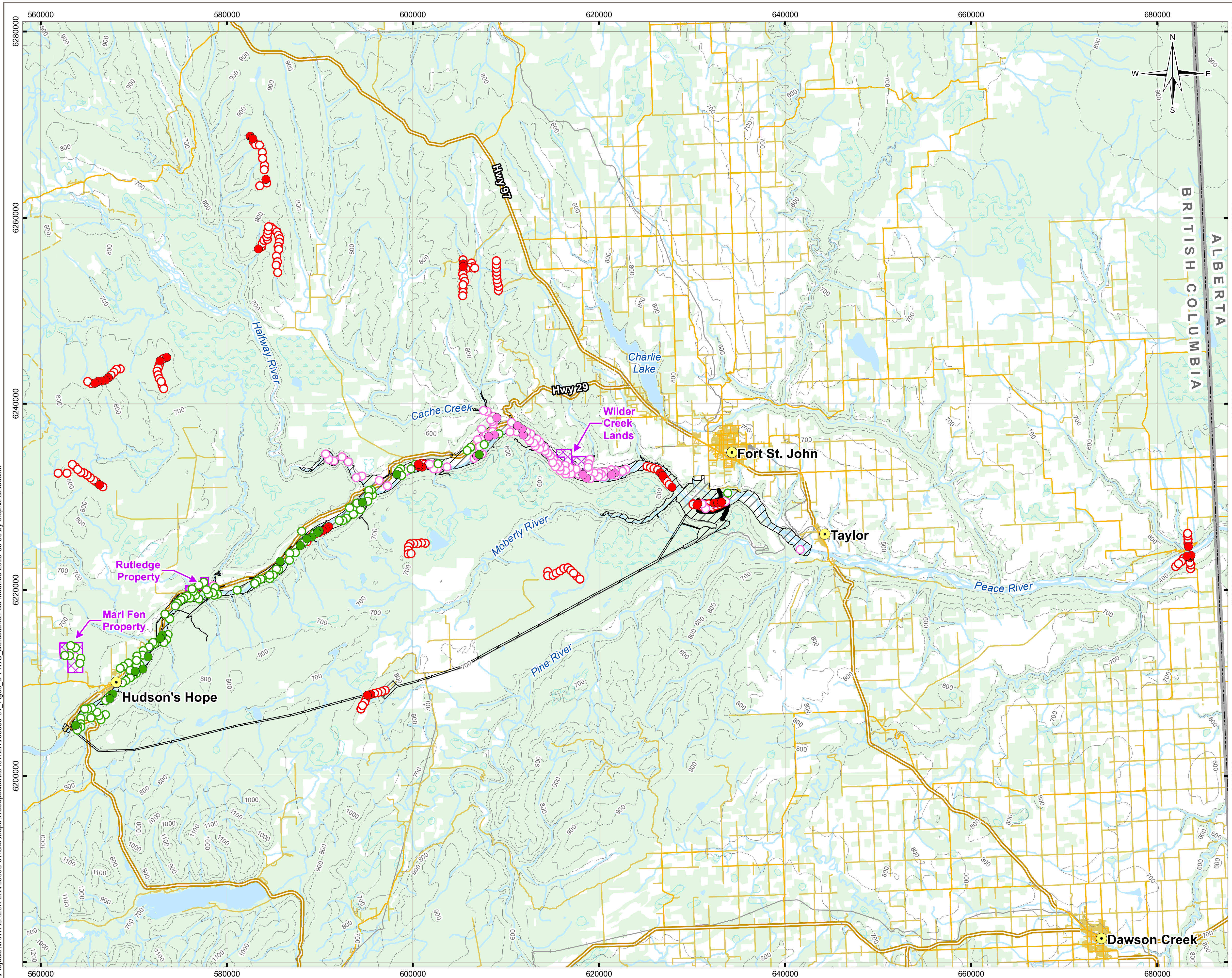
FILE NO.
VENV03095-01_Fig07_B-NOFL_Detections.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	YL	JM	0

DATE
March 30, 2020

PROJECT NO.
ENV.VENV03095-01

Figure 7



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LEGEND

Pileated Woodpecker

Detection Type

- Detected
- Not Detected

Survey Year

- 2010
- 2018
- 2019

- 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 WOODPECKER 2019 ANNUAL REPORT

Pileated Woodpecker Detections

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	

Scale: 1:400,000

8 4 0 8

Kilometres

FILE NO.
VENV03095-01_Fig08_B-PIWO_Detections.mxd

TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	YL	JM	0

DATE	PROJECT NO.
March 30, 2020	ENV.VENV03095-01

Figure 8

3.2 Relative Abundance

For the analysis of relative abundance, three of the bird habitat classes were combined due to the small number of samples in each class: the fen/bog classes were combined with coniferous-young forest (CYF) and wetland-shrub was combined with wetland-riparian (WSH/WRI) (Table 5). The surveys in cultivated and anthropogenic habitats were not included in the analysis.

Table 5. Sample size by bird habitat class for the analysis of relative abundance.

Bird Habitat Category	BHC Code	Number of Surveys	Samples for Analysis (n)
Coniferous-young forest	CYF	65	73
Coniferous-mature forest	CMF	55	55
Deciduous-shrub	DSH	30	30
Deciduous-young forest	DYF	74	74
Deciduous-mature forest	DMF	68	68
Riparian-mixed shrub	RSH	36	36
Riparian-mixed young forest	RYF	28	28
Riparian-mixed mature forest	RMF	49	49
Fen/bog-shrub	FBS	4	Combined with CYF
Fen/bog-treed	FBT	4	
Wetland-shrub	WSH	2	21
Wetland-riparian	WRI	19	
Cultivated	CUL	2	Not included
Anthropogenic	ANT	2	Not included
Total		**438**	**434**

Estimates of relative abundance by bird habitat class for each woodpecker species is listed in Table 6 and shown in Figures 9-15. Results of the model selection and the parameter estimates for the best model for each species are in Appendix B. The inclusion of year, day and hour in the best model varied among species and there was no consistency.

Table 6. Estimated woodpecker relative abundance by bird habitat class.

Bird Habitat Class	Mean Relative Abundance (Woodpeckers/Station) (95% CI)						
	ATTW	BBWO	DOWO	HAWO	NOFL	PIWO	YBSA
Coniferous-young forest	0.14 (0.05-0.37)	0.00 (0.00-0.00)	0.03 (0.01-0.12)	0.05 (0.02-0.14)	0.13 (0.05-0.30)	0.01 (0.00-0.05)	0.23 (0.13-0.41)
Coniferous-mature forest	0.13 (0.06-0.32)	0.01 (0.00-0.15)	0.00 (0.00-0.00)	0.19 (0.10-0.38)	0.08 (0.03-0.20)	0.01 (0.00-0.05)	0.16 (0.08-0.33)
Deciduous-shrub	0.02 (0.00-0.15)	0.00 (0.00-0.00)	0.00 (0.00-0.00)	0.22 (0.09-0.52)	0.22 (0.09-0.52)	0.02 (0.00-0.14)	0.34 (0.16-0.72)
Deciduous-young forest	0.01 (0.00-0.07)	0.00 (0.00-0.00)	0.03 (0.01-0.14)	0.10 (0.05-0.21)	0.03 (0.01-0.11)	0.02 (0.01-0.08)	0.32 (0.20-0.52)
Deciduous-mature forest	0.05 (0.02-0.16)	0.01 (0.00-0.11)	0.01 (0.00-0.08)	0.16 (0.08-0.32)	0.08 (0.03-0.18)	0.04 (0.01-0.14)	0.27 (0.16-0.46)
Riparian-mixed shrub	0.01 (0.00-0.10)	0.00 (0.00-0.00)	0.03 (0.00-0.17)	0.08 (0.03-0.25)	0.27 (0.13-0.56)	0.01 (0.00-0.10)	0.18 (0.08-0.40)
Riparian-mixed young forest	0.01 (0.00-0.12)	0.00 (0.00-0.00)	0.05 (0.01-0.31)	0.03 (0.00-0.21)	0.09 (0.03-0.26)	0.01 (0.00-0.12)	0.18 (0.08-0.44)
Riparian-mixed mature forest	0.04 (0.01-0.14)	0.00 (0.00-0.00)	0.01 (0.00-0.10)	0.14 (0.06-0.31)	0.01 (0.00-0.10)	0.05 (0.01-0.19)	0.20 (0.10-0.39)
Wetland-riparian/Wetland-shrub	0.07 (0.01-0.37)	0.00 (0.00-0.00)	0.00 (0.00-0.00)	0.18 (0.06-0.53)	0.08 (0.02-0.35)	0.01 (0.00-0.17)	0.32 (0.13-0.81)

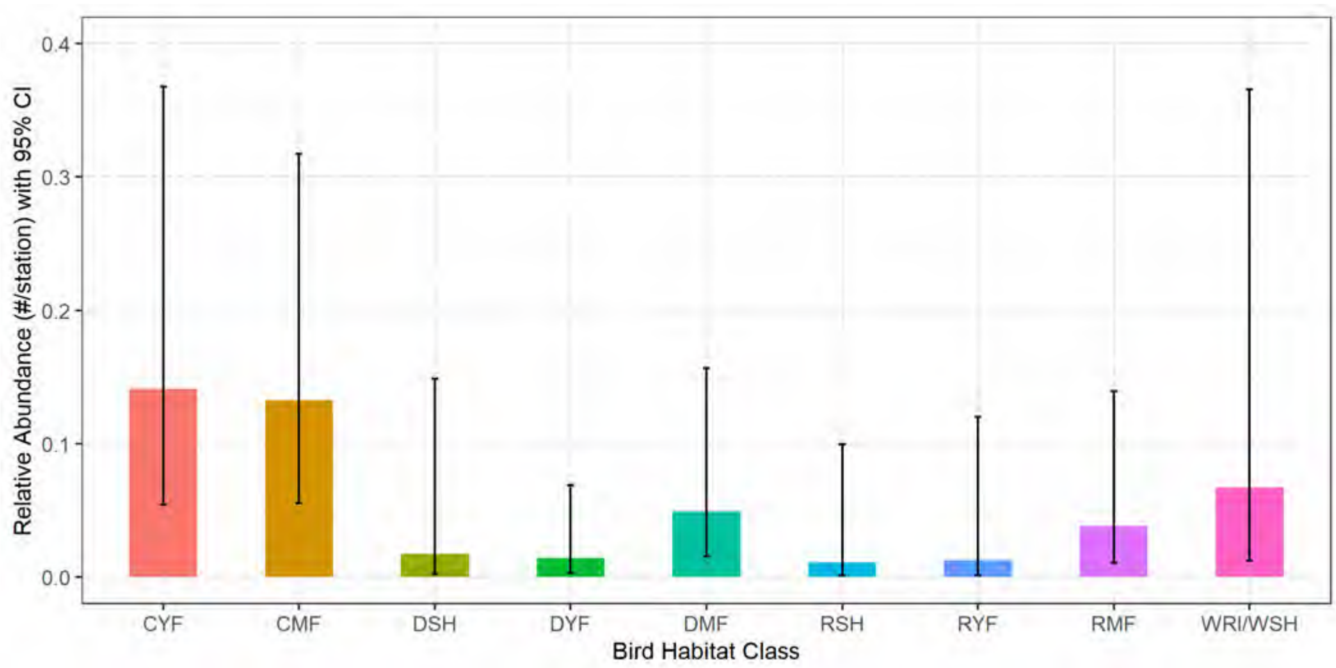

Figure 9. American Three-toed Woodpecker Relative abundance

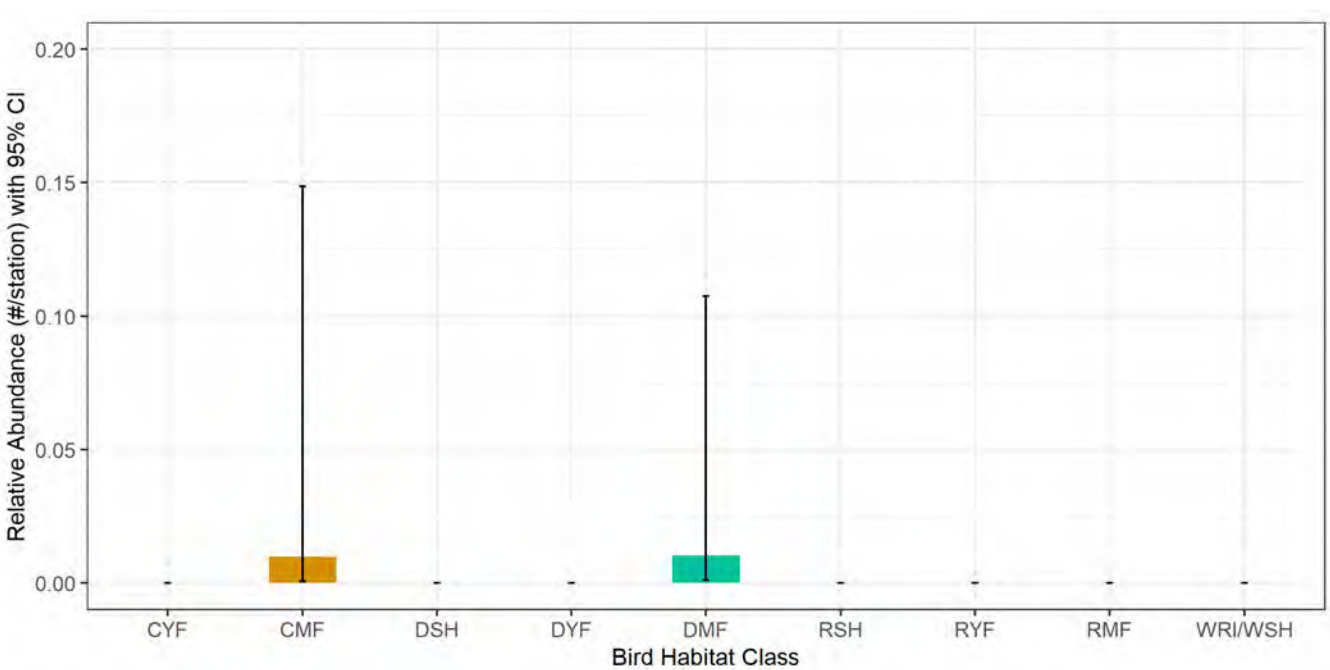

Figure 10. Black-backed Woodpecker relative abundance by bird habitat class.

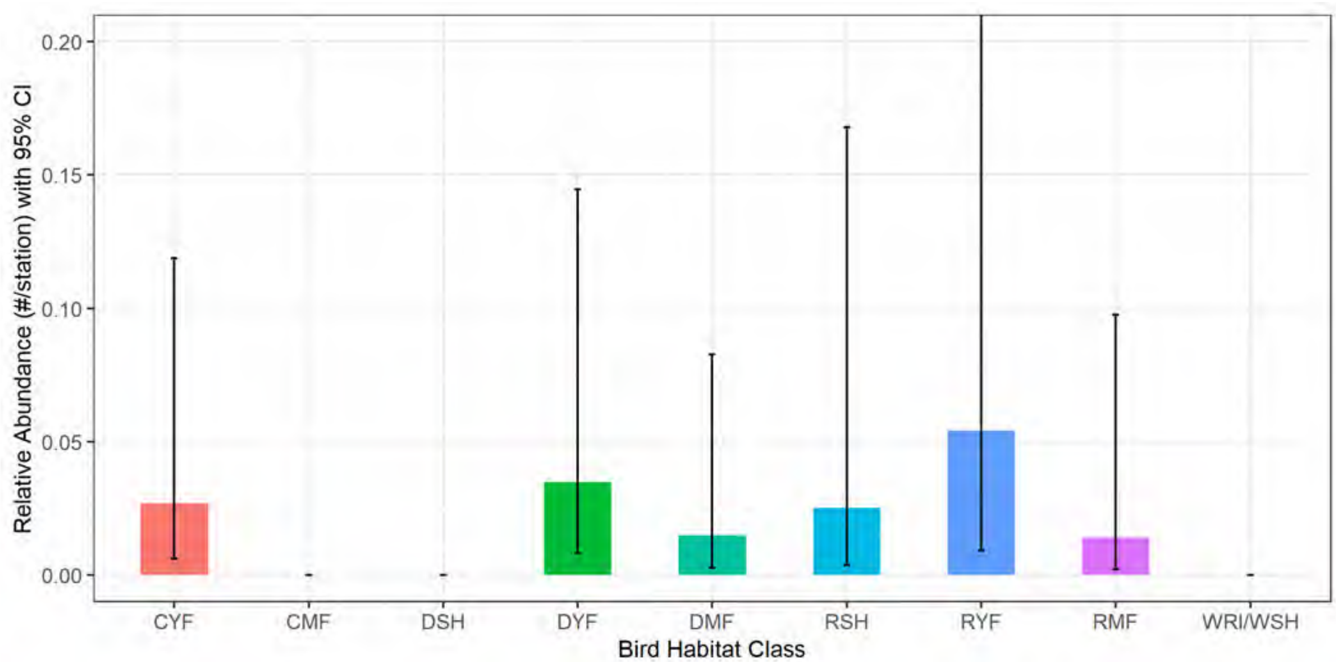

Figure 11. Downy Woodpecker relative abundance by bird habitat class.

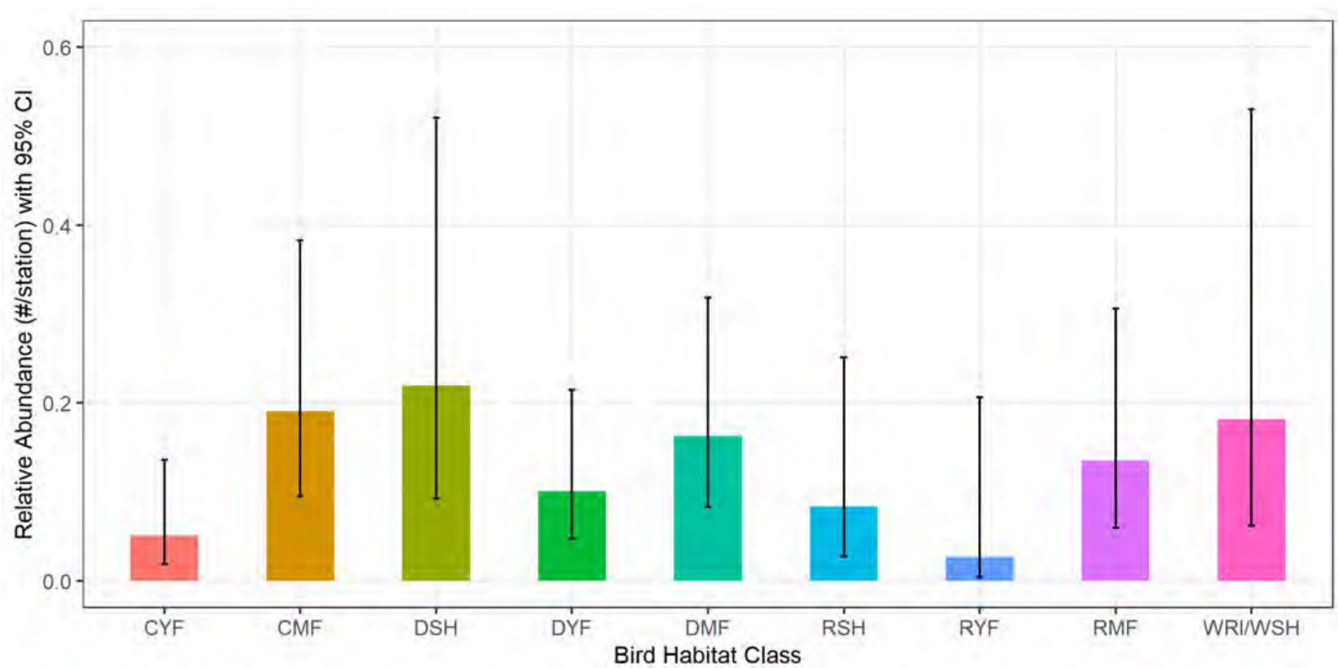

Figure 12. Hairy Woodpecker relative abundance by bird habitat class.

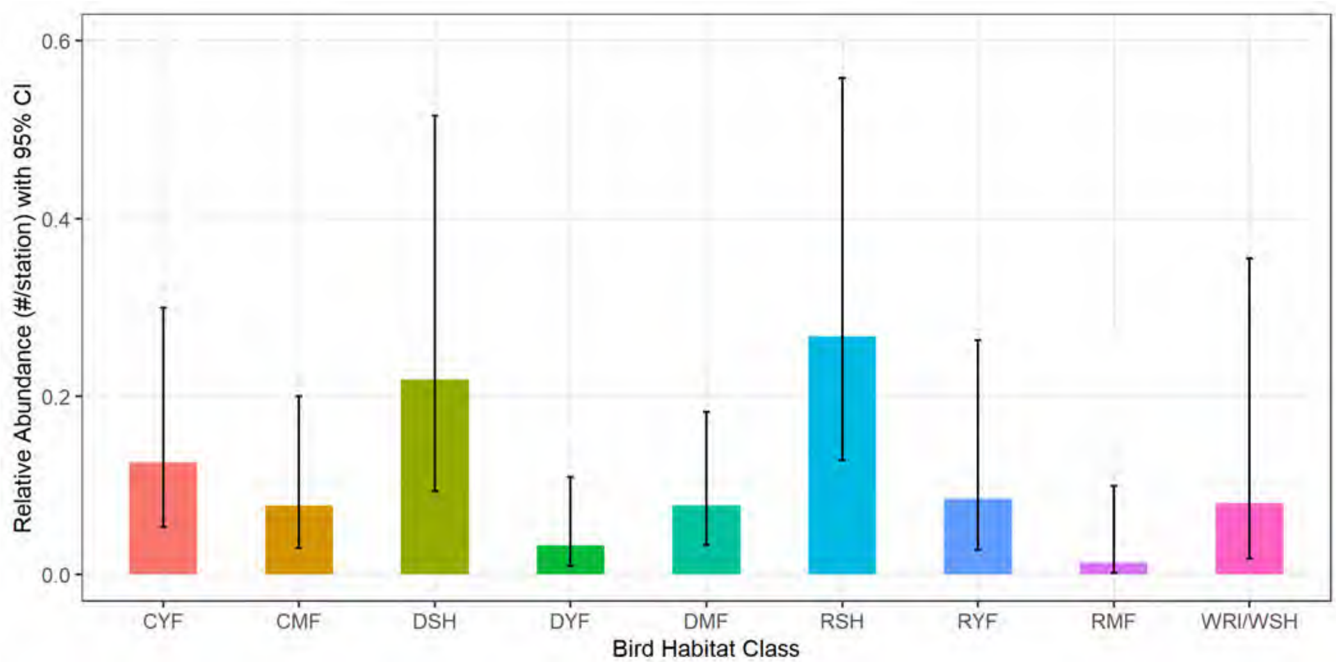

Figure 13. Northern Flicker relative abundance by bird habitat class.

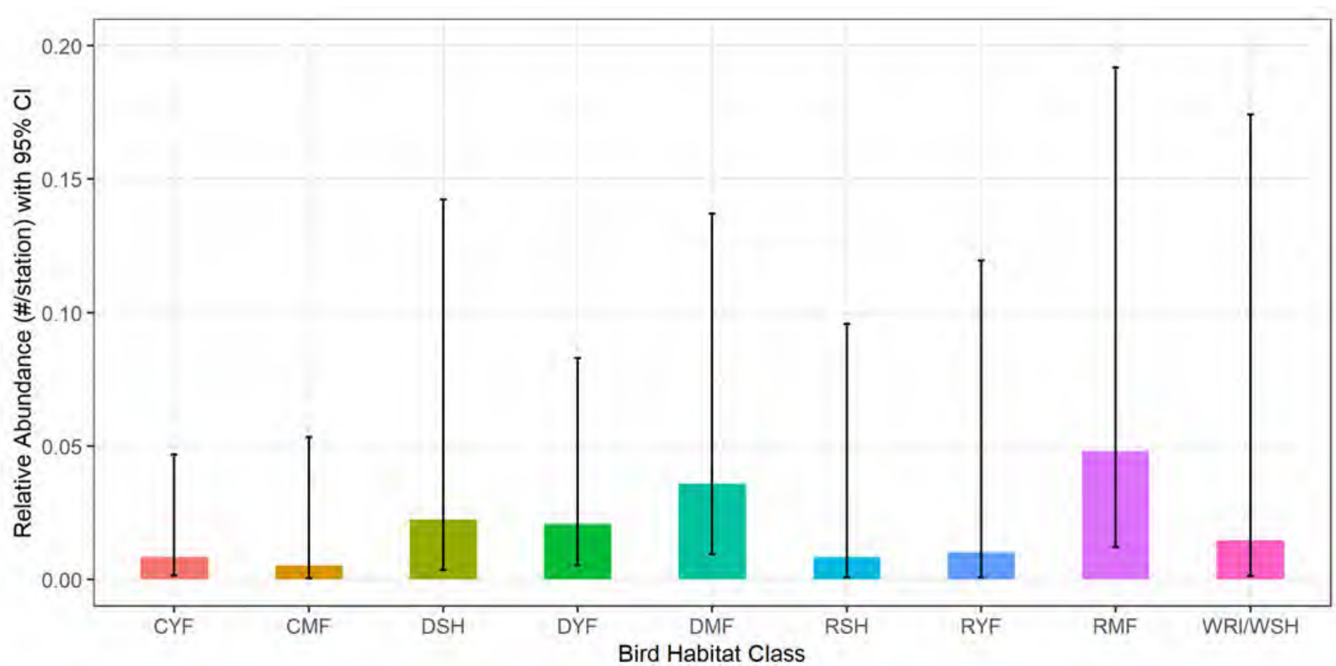

Figure 14. Pileated Woodpecker relative abundance by bird habitat class.

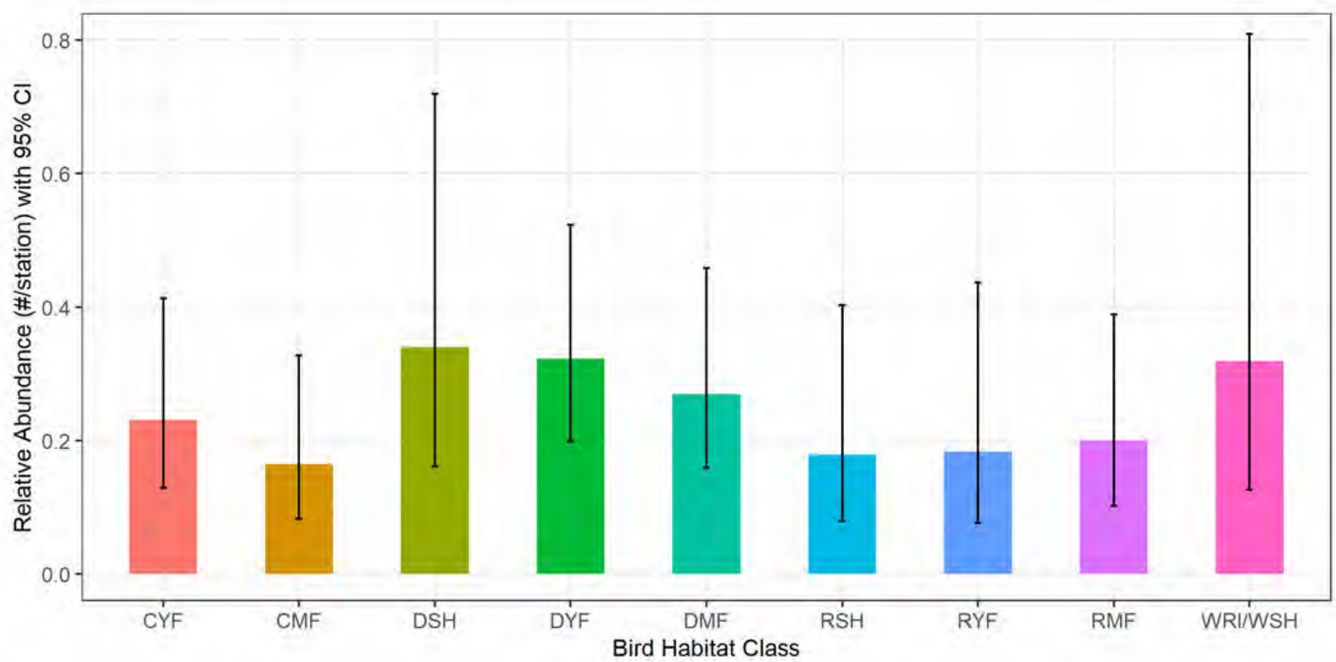

Figure 15. Yellow-bellied Sapsucker relative abundance by bird habitat class.

American Three-toed Woodpecker were detected in all habitat classes, with relative abundance appearing to be highest in fen/bog and the coniferous forest types. Of the two detections of Black-backed Woodpecker, one each were found in coniferous-mature forest and deciduous-mature forest. Downy Woodpeckers were recorded at very low densities in six of the 10 bird habitat classes. Hairy woodpeckers were the second-most abundant woodpecker and were found in all bird habitat classes except for the fen/bog classes. Northern Flickers were found in all bird habitat classes, with highest relative abundances observed in shrubby habitats. Pileated Woodpecker were recorded at very low relative abundances in all habitat classes. Yellow-bellied Sapsuckers were also detected in all habitat classes, with the highest relative abundances recorded in fen/bog,

The estimates of relative abundance for most bird habitat classes have large confidence intervals and differences in relative abundance among classes may not be statistically meaningful. There may be other site-level habitat variables that better explain a species' relative abundance; these site-level relationships can be further investigated on a species-by-species basis, after more data are collected, and where that information is relevant.

3.3 Mitigation Properties

Woodpecker surveys were completed at two of the three existing mitigation properties (Table 7). Surveys were not completed at the Wilder Creek property as it is predominantly non-forested. One Hairy Woodpecker was observed at the Marl Fen property during the 12 surveys conducted there. No woodpeckers were observed at the Rutledge property.

Table 7. Woodpecker surveys in the mitigation properties.

Mitigation Property	Number of Survey Stations	Woodpecker Observations
Marl Fen	6	Hairy Woodpecker (1 observation)
Rutledge	3	None
Wilder Creek	Not surveyed (non-treed)	Not applicable

4.0 REFERENCES

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APPENDIX A
WOODPECKER SURVEY STATIONS IN 2018-2019

Table A.1: Woodpecker call playback survey locations in 2018 and 2019.

Station	Mitigation Property	UTM Zone	UTM Easting	UTM Northing	Bird Habitat Class	Survey Dates
WP18-001	No	10	641639	6224309	Riparian-mixed mature forest	2018-06-08, 2018-06-21
WP18-002	No	10	633602	6229458	Riparian-mixed shrub	2018-06-08, 2018-06-21
WP18-003	No	10	632417	6229230	Riparian-mixed mature forest	2018-06-08, 2018-06-21
WP18-004	No	10	631488	6228735	Coniferous-mature forest	2018-06-08, 2018-06-21
WP18-005	No	10	631099	6229226	Coniferous-mature forest	2018-06-08, 2018-06-21
WP18-006	No	10	622925	6232926	Riparian-mixed mature forest	2018-06-05, 2018-06-28
WP18-007	No	10	622555	6232738	Coniferous-mature forest	2018-06-05, 2018-06-28
WP18-008	No	10	621857	6232323	Riparian-mixed mature forest	2018-06-05, 2018-06-22
WP18-009	No	10	621810	6232833	Deciduous-mature forest	2018-06-05, 2018-06-28
WP18-010	No	10	621689	6232556	Riparian-mixed mature forest	2018-06-05, 2018-06-28
WP18-011	No	10	621362	6232894	Riparian-mixed mature forest	2018-06-05, 2018-06-28
WP18-012	No	10	621366	6232348	Riparian-mixed mature forest	2018-06-09, 2018-06-28
WP18-013	No	10	620935	6232637	Riparian-mixed mature forest	2018-06-09, 2018-06-28
WP18-014	No	10	620529	6232153	Wetland-riparian	2018-06-10, 2018-06-22
WP18-015	No	10	620530	6232670	Deciduous-young forest	2018-06-09, 2018-06-28
WP18-016	No	10	620271	6232422	Riparian-mixed shrub	2018-06-10, 2018-06-28
WP18-017	No	10	620013	6232570	Deciduous-young forest	2018-06-10, 2018-06-28
WP18-018	No	10	619957	6232152	Riparian-mixed shrub	2018-06-05, 2018-06-22
WP18-019	No	10	619501	6232556	Deciduous-young forest	2018-06-05, 2018-06-28
WP18-020	No	10	619089	6231954	Deciduous-mature forest	2018-06-05, 2018-06-23, 2018-06-28
WP18-021	No	10	619041	6234009	Deciduous-young forest	2018-06-09, 2018-06-22
WP18-022	No	10	618930	6233543	Riparian-mixed young forest	2018-06-09, 2018-06-22
WP18-023	No	10	618874	6232727	Riparian-mixed shrub	2018-06-09, 2018-06-22
WP18-024	No	10	618864	6233150	Riparian-mixed mature forest	2018-06-09, 2018-06-22
WP18-025	No	10	618646	6232004	Deciduous-mature forest	2018-06-05, 2018-06-23, 2018-06-28
WP18-026	No	10	618268	6232370	Wetland-riparian	2018-06-05, 2018-06-22

Station	Mitigation Property	UTM Zone	UTM Easting	UTM Northing	Bird Habitat Class	Survey Dates
WP18-027	No	10	617820	6232407	Riparian-mixed shrub	2018-06-05, 2018-06-22
WP18-028	No	10	617576	6232945	Deciduous-mature forest	2018-06-05, 2018-06-18
WP18-029	No	10	617020	6232467	Riparian-mixed mature forest	2018-06-05, 2018-06-22
WP18-030	No	10	616897	6233118	Riparian-mixed shrub	2018-06-05, 2018-06-18
WP18-031	No	10	616446	6232443	Coniferous-mature forest	2018-06-05, 2018-06-23, 2018-06-28
WP18-032	No	10	616369	6233374	Riparian-mixed shrub	2018-06-05, 2018-06-18
WP18-033	No	10	616393	6232805	Coniferous-mature forest	2018-06-05, 2018-06-23, 2018-06-28
WP18-034	No	10	615844	6232810	Coniferous-mature forest	2018-06-07, 2018-06-28
WP18-035	No	10	615847	6233185	Coniferous-mature forest	2018-06-07, 2018-06-28
WP18-036	No	10	615585	6233526	Deciduous-mature forest	2018-06-10, 2018-06-29
WP18-037	No	10	615317	6233228	Coniferous-mature forest	2018-06-07, 2018-06-29
WP18-038	No	10	615117	6234060	Deciduous-mature forest	2018-06-10, 2018-06-29
WP18-039	No	10	615062	6233655	Deciduous-mature forest	2018-06-10, 2018-06-29
WP18-040	No	10	614793	6234423	Coniferous-mature forest	2018-06-07, 2018-06-29
WP18-041	No	10	614549	6234686	Coniferous-mature forest	2018-06-07, 2018-06-07
WP18-042	No	10	614210	6234883	Riparian-mixed mature forest	2018-06-07, 2018-06-29
WP18-043	No	10	614139	6235318	Riparian-mixed young forest	2018-06-06, 2018-06-20
WP18-044	No	10	613742	6235636	Riparian-mixed young forest	2018-06-06, 2018-06-20
WP18-045	No	10	613635	6235919	Riparian-mixed young forest	2018-06-06, 2018-06-20
WP18-046	No	10	613635	6235134	Wetland-riparian	2018-06-06, 2018-06-20
WP18-047	No	10	613328	6236197	Riparian-mixed shrub	2018-06-06, 2018-06-18
WP18-048	No	10	613161	6235423	Deciduous-mature forest	2018-06-06, 2018-06-29
WP18-049	No	10	613003	6235785	Coniferous-mature forest	2018-06-06, 2018-06-20
WP18-050	No	10	612686	6236761	Deciduous-mature forest	2018-06-10, 2018-06-20
WP18-051	No	10	612552	6235999	Deciduous-mature forest	2018-06-06, 2018-06-29
WP18-052	No	10	612218	6236450	Deciduous-mature forest	2018-06-06, 2018-06-20
WP18-053	No	10	612211	6236997	Deciduous-shrub	2018-06-10, 2018-06-20

Station	Mitigation Property	UTM Zone	UTM Easting	UTM Northing	Bird Habitat Class	Survey Dates
WP18-054	No	10	611867	6236644	Deciduous-young forest	2018-06-10, 2018-06-29
WP18-055	No	10	611744	6237305	Deciduous-shrub	2018-06-10, 2018-06-20
WP18-056	No	10	611259	6237635	Deciduous-shrub	2018-06-10, 2018-06-20
WP18-057	No	10	611156	6236994	Coniferous-mature forest	2018-06-10, 2018-06-29
WP18-058	No	10	610608	6237961	Deciduous-young forest	2018-06-03, 2018-06-24
WP18-059	No	10	610461	6236966	Deciduous-mature forest	2018-06-10, 2018-06-29
WP18-060	No	10	609194	6236762	Riparian-mixed shrub	2018-06-03, 2018-06-21
WP18-061	No	10	609036	6238518	Deciduous-mature forest	2018-06-03, 2018-06-21
WP18-062	No	10	608770	6236650	Deciduous-young forest	2018-06-03, 2018-06-21
WP18-063	No	10	608698	6238604	Riparian-mixed mature forest	2018-06-03, 2018-06-21
WP18-064	No	10	608639	6237777	Coniferous-young forest	2018-06-06, 2018-06-18
WP18-065	No	10	608567	6238059	Deciduous-mature forest	2018-06-02, 2018-06-18
WP18-066	No	10	608571	6237001	Riparian-mixed young forest	2018-06-03, 2018-06-21
WP18-067	No	10	608388	6238236	Coniferous-young forest	2018-06-06, 2018-06-18
WP18-068	No	10	608162	6236483	Deciduous-young forest	2018-06-03, 2018-06-29
WP18-069	No	10	607989	6239142	Riparian-mixed young forest	2018-06-03, 2018-06-21
WP18-070	No	10	607888	6236654	Deciduous-young forest	2018-06-03, 2018-06-24
WP18-071	No	10	607685	6235599	Deciduous-shrub	2018-06-12, 2018-06-29
WP18-072	No	10	607597	6239258	Riparian-mixed mature forest	2018-06-21, 2018-06-29
WP18-073	No	10	607477	6234613	Deciduous-mature forest	2018-06-12, 2018-06-29
WP18-074	No	10	607416	6237266	Deciduous-young forest	2018-06-06, 2018-06-18
WP18-075	No	10	607302	6236178	Deciduous-mature forest	2018-06-03, 2018-06-24
WP18-076	No	10	607154	6235037	Riparian-mixed shrub	2018-06-03, 2018-06-24
WP18-077	No	10	606970	6236096	Wetland-shrub	2018-06-03, 2018-06-24
WP18-078	No	10	606856	6234373	Riparian-mixed mature forest	2018-06-12, 2018-06-29
WP18-079	No	10	606572	6234119	Riparian-mixed shrub	2018-06-12, 2018-06-29
WP18-080	No	10	606212	6235316	Fen/bog-treed	2018-06-03, 2018-06-24

Station	Mitigation Property	UTM Zone	UTM Easting	UTM Northing	Bird Habitat Class	Survey Dates
WP18-081	No	10	607214	6235407	Deciduous-shrub	2018-06-03, 2018-06-24
WP18-082	No	10	603660	6233206	Deciduous-mature forest	2018-06-11, 2018-06-29
WP18-084	No	10	602661	6233041	Deciduous-mature forest	2018-06-12, 2018-06-29
WP18-085	No	10	602464	6233469	Riparian-mixed young forest	2018-06-11, 2018-06-28
WP18-086	No	10	602239	6232979	Deciduous-young forest	2018-06-12, 2018-06-29
WP18-087	No	10	601823	6233491	Riparian-mixed mature forest	2018-06-11, 2018-06-28
WP18-088	No	10	600857	6233244	Deciduous-mature forest	2018-06-11, 2018-06-28
WP18-089	No	10	600271	6233456	Riparian-mixed young forest	2018-06-11, 2018-06-28
WP18-090	No	10	599832	6232981	Riparian-mixed young forest	2018-06-11, 2018-06-28
WP18-091	No	10	599287	6232721	Deciduous-young forest	2018-06-11, 2018-06-28
WP18-092	No	10	598260	6232430	Deciduous-shrub	2018-06-11, 2018-06-28
WP18-093	No	10	597266	6231178	Deciduous-mature forest	2018-06-11, 2018-06-28
WP18-094	No	10	596396	6231752	Riparian-mixed young forest	2018-06-07, 2018-06-30
WP18-095	No	10	594547	6232230	Coniferous-mature forest	2018-06-07, 2018-06-20
WP18-096	No	10	593936	6232047	Deciduous-mature forest	2018-06-07, 2018-06-20
WP18-097	No	10	593059	6233754	Deciduous-mature forest	2018-06-07, 2018-06-20
WP18-098	No	10	592405	6234286	Deciduous-mature forest	2018-06-07, 2018-06-20
WP18-099	No	10	591515	6233829	Deciduous-young forest	2018-06-07, 2018-06-20
WP18-100	No	10	590979	6234003	Deciduous-young forest	2018-06-07, 2018-06-20
WP18-101	No	10	590642	6234575	Deciduous-young forest	2018-06-07, 2018-06-20
WP18-102	No	10	578574	6220431	Deciduous-shrub	2018-06-11, 2018-06-27
WP19-035	No	10	598702	6232989	Riparian-mixed shrub	2019-06-05, 2019-06-23
WP19-036	No	10	598463	6232720	Riparian-mixed shrub	2019-06-05, 2019-06-26
WP19-037	No	10	598260	6232426	Deciduous-shrub	2019-06-05, 2019-06-23
WP19-038	No	10	595680	6230173	Deciduous-shrub	2019-06-05, 2019-06-26
WP19-039	No	10	595549	6230738	Riparian-mixed mature forest	2019-06-05, 2019-06-26
WP19-040	No	10	595279	6230665	Deciduous-young forest	2019-06-05, 2019-06-26

Station	Mitigation Property	UTM Zone	UTM Easting	UTM Northing	Bird Habitat Class	Survey Dates
WP19-041	No	10	595241	6230009	Coniferous-young forest	2019-06-05, 2019-06-21
WP19-042	No	10	595175	6229496	Coniferous-young forest	2019-06-05, 2019-06-21
WP19-045	No	10	594553	6229411	Coniferous-young forest	2019-06-04, 2019-06-21
WP19-046	No	10	594403	6228631	Coniferous-young forest	2019-06-05, 2019-06-26
WP19-050	No	10	594006	6229313	Coniferous-young forest	2019-06-04, 2019-06-21
WP19-051	No	10	593621	6228112	Coniferous-mature forest	2019-06-05, 2019-06-26
WP19-052	No	10	593219	6228796	Coniferous-mature forest	2019-06-05, 2019-06-21
WP19-053	No	10	592876	6227671	Coniferous-young forest	2019-06-03, 2019-06-26
WP19-055	No	10	592514	6227437	Coniferous-young forest	2019-06-03, 2019-06-26
WP19-056	No	10	592096	6227429	Coniferous-young forest	2019-06-03, 2019-06-26
WP19-061	No	10	590804	6226725	Coniferous-mature forest	2019-06-03, 2019-06-19
WP19-064	No	10	589919	6226362	Deciduous-mature forest	2019-06-03, 2019-06-20
WP19-066	No	10	589686	6226108	Deciduous-young forest	2019-06-03, 2019-06-19
WP19-067	No	10	589449	6226073	Coniferous-mature forest	2019-06-06
WP19-070	No	10	589104	6225693	Deciduous-young forest	2019-06-04, 2019-06-19
WP19-072	No	10	588610	6225496	Riparian-mixed mature forest	2019-06-03, 2019-06-19
WP19-007	No	10	633855	6230392	Riparian-mixed mature forest	2019-05-31
WP19-019	No	10	609266	6236758	Riparian-mixed shrub	2019-06-06, 2019-06-26
WP19-022	No	10	607681	6235607	Deciduous-shrub	2019-06-06, 2019-06-26
WP19-023	No	10	607140	6234555	Riparian-mixed mature forest	2019-06-06, 2019-06-26
WP19-024	No	10	606210	6235312	Fen/bog-treed	2019-06-06, 2019-06-23
WP19-025	No	10	605831	6234974	Fen/bog-shrub	2019-06-06, 2019-06-23
WP19-026	No	10	602727	6233532	Riparian-mixed young forest	2019-06-06, 2019-06-26
WP19-031	No	10	600260	6233470	Riparian-mixed young forest	2019-06-06, 2019-06-26
WP19-033	No	10	599823	6232983	Riparian-mixed young forest	2019-06-06, 2019-06-26
WP19-034	No	10	598786	6232278	Riparian-mixed mature forest	2019-06-05, 2019-06-26
WP19-075	No	10	588264	6225075	Riparian-mixed mature forest	2019-06-03, 2019-06-19

Station	Mitigation Property	UTM Zone	UTM Easting	UTM Northing	Bird Habitat Class	Survey Dates
WP19-076	No	10	588063	6226297	Deciduous-mature forest	2019-06-06, 2019-06-25
WP19-079	No	10	587895	6224757	Riparian-mixed mature forest	2019-06-03, 2019-06-19
WP19-083	No	10	587381	6223986	Deciduous-young forest	2019-06-03, 2019-06-19
WP19-087	No	10	586768	6223923	Coniferous-young forest	2019-06-02, 2019-06-19
WP19-088	No	10	586739	6223156	Deciduous-young forest	2019-06-03, 2019-06-20
WP19-095	No	10	585734	6223064	Deciduous-young forest	2019-06-02, 2019-06-20
WP19-097	No	10	585604	6222173	Deciduous-young forest	2019-06-02, 2019-06-20
WP19-098	No	10	585340	6222233	Deciduous-mature forest	2019-06-02, 2019-06-20
WP19-099	No	10	585013	6221585	Deciduous-mature forest	2019-06-02, 2019-06-20
WP19-100	No	10	584627	6221222	Deciduous-young forest	2019-06-03, 2019-06-21
WP19-101	No	10	584600	6221574	Wetland-riparian	2019-06-02, 2019-06-20
WP19-103	No	10	583685	6221145	Riparian-mixed mature forest	2019-06-02, 2019-06-20
WP19-104	No	10	583246	6220940	Coniferous-young forest	2019-06-02, 2019-06-20
WP19-105	No	10	583016	6220669	Coniferous-young forest	2019-06-02, 2019-06-20
WP19-109	No	10	581104	6219943	Wetland-riparian	2019-06-02, 2019-06-21
WP19-110	No	10	579025	6219519	Coniferous-mature forest	2019-06-02, 2019-06-20
WP19-111	No	10	578765	6220213	Riparian-mixed mature forest	2019-06-05, 2019-06-22
WP19-112	No	10	578637	6219418	Coniferous-mature forest	2019-06-02, 2019-06-20
WP19-114	No	10	578499	6219683	Wetland-riparian	2019-06-02, 2019-06-20
WP19-115	No	10	578052	6219564	Coniferous-mature forest	2019-06-02, 2019-06-20
WP19-116	No	10	577840	6219979	Wetland-riparian	2019-06-02, 2019-06-20
WP19-117	Rutledge	10	577543	6220797	Deciduous-young forest	2019-06-05, 2019-06-22
WP19-121	No	10	577013	6219012	Wetland-riparian	2019-06-01, 2019-06-18
WP19-122	Rutledge	10	576991	6220497	Deciduous-young forest	2019-06-05, 2019-06-22
WP19-123	No	10	576640	6219409	Riparian-mixed shrub	2019-06-01, 2019-06-18
WP19-124	No	10	576402	6219832	Deciduous-young forest	2019-06-04, 2019-06-22
WP19-125	Rutledge	10	576271	6220094	Deciduous-young forest	2019-06-04, 2019-06-22

Station	Mitigation Property	UTM Zone	UTM Easting	UTM Northing	Bird Habitat Class	Survey Dates
WP19-127	No	10	576064	6219094	Coniferous-mature forest	2019-06-01, 2019-06-18
WP19-129	No	10	575748	6219361	Wetland-riparian	2019-06-01, 2019-06-18
WP19-131	No	10	575392	6219075	Deciduous-young forest	2019-06-02, 2019-06-18
WP19-132	No	10	575085	6218920	Deciduous-young forest	2019-06-02, 2019-06-18
WP19-133	No	10	574673	6218557	Deciduous-mature forest	2019-06-02, 2019-06-18
WP19-134	No	10	574479	6218278	Deciduous-mature forest	2019-06-02, 2019-06-18
WP19-137	No	10	573882	6216875	Coniferous-young forest	2019-06-01, 2019-06-18
WP19-139	No	10	573717	6215187	Coniferous-young forest	2019-06-02, 2019-06-18
WP19-140	No	10	573551	6214653	Deciduous-mature forest	2019-06-01, 2019-06-18
WP19-142	No	10	573351	6217369	Cultivated	2019-06-04, 2019-06-22
WP19-143	No	10	573249	6214336	Coniferous-young forest	2019-06-02, 2019-06-18
WP19-144	No	10	573048	6215145	Deciduous-mature forest	2019-06-04, 2019-06-22
WP19-146	No	10	572855	6214792	Deciduous-mature forest	2019-06-04, 2019-06-22
WP19-147	No	10	572252	6214182	Riparian-mixed mature forest	2019-06-04, 2019-06-22
WP19-148	No	10	572080	6214322	Deciduous-young forest	2019-06-04, 2019-06-23
WP19-150	No	10	571682	6213868	Coniferous-young forest	2019-06-04, 2019-06-22
WP19-151	No	10	571546	6212804	Deciduous-mature forest	2019-06-01, 2019-06-17
WP19-153	No	10	571024	6213438	Deciduous-young forest	2019-06-08, 2019-06-23
WP19-154	No	10	570973	6212968	Anthropogenic	2019-06-04, 2019-06-22
WP19-156	No	10	570705	6211881	Coniferous-mature forest	2019-06-01, 2019-06-17
WP19-157	No	10	570966	6211489	Riparian-mixed shrub	2019-06-01, 2019-06-18
WP19-158	No	10	570363	6212873	Coniferous-young forest	2019-06-08, 2019-06-23
WP19-160	No	10	570318	6211873	Coniferous-young forest	2019-06-01, 2019-06-18
WP19-161	No	10	570313	6212401	Coniferous-mature forest	2019-06-08, 2019-06-23
WP19-162	No	10	570291	6211007	Coniferous-young forest	2019-06-01, 2019-06-17
WP19-163	No	10	570135	6211256	Coniferous-young forest	2019-05-31, 2019-06-17
WP19-164	No	10	569929	6210809	Deciduous-young forest	2019-06-01, 2019-06-17

Station	Mitigation Property	UTM Zone	UTM Easting	UTM Northing	Bird Habitat Class	Survey Dates
WP19-165	No	10	569623	6210549	Coniferous-young forest	2019-06-01, 2019-06-17
WP19-166	No	10	569599	6211353	Riparian-mixed shrub	1900-01-00, 2019-06-17
WP19-167	No	10	569426	6212121	Coniferous-young forest	2019-06-08, 2019-06-23
WP19-168	No	10	569156	6210234	Coniferous-young forest	2019-05-31, 2019-06-17
WP19-172	No	10	568881	6211771	Coniferous-young forest	2019-06-08, 2019-06-23
WP19-173	No	10	568793	6209983	Riparian-mixed shrub	2019-05-31, 2019-06-17
WP19-176	No	10	568563	6211544	Coniferous-young forest	2019-06-08, 2019-06-23
WP19-182	No	10	567731	6208829	Riparian-mixed young forest	2019-05-31, 2019-06-17
WP19-183	No	10	567500	6208643	Coniferous-young forest	2019-05-31, 2019-06-17
WP19-184	No	10	567446	6208292	Coniferous-mature forest	2019-05-31, 2019-06-17
WP19-188	No	10	566988	6208096	Coniferous-mature forest	2019-05-31, 2019-06-17
WP19-189	No	10	566965	6206582	Coniferous-young forest	1900-01-00, 2019-06-24
WP19-190	No	10	566488	6206022	Deciduous-young forest	2019-06-08, 2019-06-24
WP19-191	No	10	566303	6206471	Coniferous-young forest	2019-06-09, 2019-06-23
WP19-192	No	10	566035	6206832	Deciduous-shrub	2019-06-08, 2019-06-23
WP19-193	No	10	565488	6207324	Coniferous-young forest	2019-05-31, 2019-06-17
WP19-194	No	10	565420	6206229	Deciduous-shrub	2019-06-08, 2019-06-23
WP19-195	No	10	565057	6207179	Coniferous-young forest	2019-05-31, 2019-06-17
WP19-197	No	10	564737	6207201	Riparian-mixed shrub	2019-05-31
WP19-199	No	10	564335	6206190	Coniferous-young forest	2019-06-09, 2019-06-25
WP19-200	No	10	564335	6205582	Deciduous-young forest	2019-06-08, 2019-06-23
WP19-201	No	10	564334	6205243	Deciduous-shrub	2019-06-04, 2019-06-21
WP19-202	Marl Fen	10	564336	6212646	Deciduous-young forest	2019-06-05, 2019-06-21
WP19-203	Marl Fen	10	564223	6212082	Coniferous-mature forest	2019-06-05, 2019-06-21
WP19-204	No	10	563959	6205286	Deciduous-young forest	2019-06-09, 2019-06-23
WP19-205	No	10	563939	6204917	Deciduous-shrub	2019-06-04, 2019-06-21
WP19-206	No	10	563742	6205455	Fen/bog-shrub	2019-06-09, 2019-06-23

Station	Mitigation Property	UTM Zone	UTM Easting	UTM Northing	Bird Habitat Class	Survey Dates
WP19-207	Marl Fen	10	563738	6213747	Deciduous-young forest	2019-06-05, 2019-06-21
WP19-210	Marl Fen	10	563251	6213987	Deciduous-shrub	2019-06-05, 2019-06-21
WP19-212	Marl Fen	10	563101	6212914	Coniferous-mature forest	2019-06-05, 2019-06-21
WP19-213	Marl Fen	10	562595	6212938	Coniferous-young forest	2019-06-05, 2019-06-21

APPENDIX B
RELATIVE ABUNDANCE MODEL RESULTS

Table B.1. Summary of model selection using Akaike's Information Criterium for small samples (AIC_c).

Model	AIC_c						
	ATTW	**BBWO**	**DOWO**	**HAWO**	**NOFL**	**PIWO**	**YBSA**
m0	312.33	29.55	192.41	415.21	337.58	240.69	658.49
m1	313.05	Could not fit	199.12	418.39	331.66	249.11	669.85
m2	306.94	Could not fit	200.84	420.28	323.01	249.48	670.12
m3	312.87	Could not fit	201.22	420.26	333.61	235.72	671.96
m4	315.16	41.73	200.10	419.59	333.31	251.21	662.85
m5	307.67	Could not fit	202.96	422.22	324.41	233.89	672.19
m6	314.98	Could not fit	202.16	421.47	335.26	237.83	664.94
m7	309.04	Could not fit	201.82	421.52	324.26	251.59	662.80
m8	309.77	42.49	203.91	423.47	325.66	236.00	664.92

Best model (lowest AIC_c) used to estimate relative abundance by bird habitat class shown in bold.

Models:

m0: count ~ (1|Station) (null model for reference only)

m1: count ~ BHC + (1|Station)

m2: count ~ BHC + Year + (1|Station)

m3: count ~ BHC + day + (1|Station)

m4: count ~ BHC + hour + (1|Station)

m5: count ~ BHC + Year + day + (1|Station)

m6: count ~ BHC + day + hour + (1|Station)

m7: count ~ BHC + Year + hour + (1|Station)

m8: count ~ BHC + hour + day + Year + (1|Station)

Table B.2. Parameters for best model for each woodpecker species.

Species	Effect	Group	Term	Estimate	SD	Statistic	p-value
ATTW	fixed	NA	(Intercept)	-2.60538	0.509	-5.119	0.000
	fixed	NA	CMF	0.648577	0.571	1.135	0.256
	fixed	NA	DSH	-1.53465	1.157	-1.326	0.185
	fixed	NA	DYF	-1.73716	0.855	-2.031	0.042
	fixed	NA	DMF	-0.16065	0.595	-0.270	0.787
	fixed	NA	RSH	-1.7131	1.142	-1.500	0.134
	fixed	NA	RYF	-1.46776	1.163	-1.262	0.207
	fixed	NA	RMF	-0.47364	0.690	-0.686	0.493
	fixed	NA	WRI/WSH	-0.43384	0.947	-0.458	0.647
	ran_pars	Station	sd__(Intercept)	1.347906	NA	NA	NA
BBWO	fixed	NA	(Intercept)	-25.5067	40520.594	-0.001	0.999
	fixed	NA	CMF	21.49935	40520.594	0.001	1.000
	fixed	NA	DSH	-1.70441	153453.673	0.000	1.000
	fixed	NA	DYF	-4.34897	355866.333	0.000	1.000
	fixed	NA	DMF	21.28717	40520.594	0.001	1.000
	fixed	NA	RSH	-2.37182	192904.738	0.000	1.000
	fixed	NA	RYF	-1.63078	153189.585	0.000	1.000
	fixed	NA	RMF	-3.16142	243150.901	0.000	1.000
	fixed	NA	WRI/WSH	-1.6366	175712.684	0.000	1.000
	ran_pars	Station	sd__(Intercept)	5.01E-11	NA	NA	NA
DOWO	fixed	NA	(Intercept)	-3.61961	0.759	-4.766	0.000
	fixed	NA	CMF	-28.3228	753730.385	0.000	1.000
	fixed	NA	DSH	-20.3585	19028.762	-0.001	0.999
	fixed	NA	DYF	0.263972	0.740	0.357	0.721
	fixed	NA	DMF	-0.58643	0.884	-0.664	0.507
	fixed	NA	RSH	-0.06178	0.957	-0.065	0.949
	fixed	NA	RYF	0.703891	0.911	0.773	0.440
	fixed	NA	RMF	-0.65007	0.997	-0.652	0.514
	fixed	NA	WRI/WSH	-19.0706	11944.879	-0.002	0.999
	ran_pars	Station	sd__(Intercept)	1.664831	NA	NA	NA
HAWO	fixed	NA	(Intercept)	-2.97527	0.500	-5.946	0.000
	fixed	NA	CMF	1.31849	0.567	2.325	0.020
	fixed	NA	DSH	1.4587	0.621	2.350	0.019
	fixed	NA	DYF	0.678896	0.585	1.161	0.246
	fixed	NA	DMF	1.160516	0.559	2.078	0.038
	fixed	NA	RSH	0.494419	0.715	0.691	0.489
	fixed	NA	RYF	-0.63633	1.128	-0.564	0.573

Species	Effect	Group	Term	Estimate	SD	Statistic	p-value
	fixed	NA	RMF	0.974349	0.604	1.614	0.106
	fixed	NA	WRI/WSH	1.272036	0.705	1.804	0.071
	ran_pars	Station	sd__(Intercept)	0.789942	NA	NA	NA
NOFL	fixed	NA	(Intercept)	-2.68426	0.463	-5.800	0.000
	fixed	NA	CMF	0.124141	0.608	0.204	0.838
	fixed	NA	DSH	1.152227	0.584	1.974	0.048
	fixed	NA	DYF	-0.8449	0.725	-1.166	0.244
	fixed	NA	DMF	0.309409	0.556	0.557	0.578
	fixed	NA	RSH	1.450296	0.534	2.714	0.007
	fixed	NA	RYF	0.419152	0.694	0.604	0.546
	fixed	NA	RMF	-1.52711	1.097	-1.392	0.164
	fixed	NA	WRI/WSH	0.015675	0.870	0.018	0.986
	ran_pars	Station	sd__(Intercept)	0.854363	NA	NA	NA
PIWO	fixed	NA	(Intercept)	-4.09695	0.786	-5.212	0.000
	fixed	NA	CMF	-0.77803	1.253	-0.621	0.535
	fixed	NA	DSH	0.789273	1.016	0.777	0.437
	fixed	NA	DYF	0.687669	0.833	0.825	0.409
	fixed	NA	DMF	1.089905	0.812	1.343	0.179
	fixed	NA	RSH	-0.3801	1.279	-0.297	0.766
	fixed	NA	RYF	-0.13565	1.303	-0.104	0.917
	fixed	NA	RMF	1.478826	0.828	1.787	0.074
	fixed	NA	WRI/WSH	0.155142	1.339	0.116	0.908
	ran_pars	Station	sd__(Intercept)	1.505991	NA	NA	NA
YBSA	fixed	NA	(Intercept)	-1.59038	0.293	-5.437	0.000
	fixed	NA	CMF	-0.24299	0.439	-0.554	0.580
	fixed	NA	DSH	0.479552	0.463	1.036	0.300
	fixed	NA	DYF	0.456523	0.363	1.256	0.209
	fixed	NA	DMF	0.326378	0.378	0.863	0.388
	fixed	NA	RSH	-0.12839	0.487	-0.264	0.792
	fixed	NA	RYF	0.082336	0.511	0.161	0.872
	fixed	NA	RMF	0.048978	0.428	0.114	0.909
	fixed	NA	WRI/WSH	0.317396	0.546	0.582	0.561
	ran_pars	Station	sd__(Intercept)	0.904004	NA	NA	NA

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 author
Claudio Bianchini, R.P.Bio. Bianchini Biological Services	Field data collection
Camille Roberge, B.Sc., E.Pt. Tetra Tech Canada Inc.	Field data collection, data entry
Elyse Hofs, B.Sc., Dipl.T. Tetra Tech Canada Inc.	Field data collection, data entry
Damian Power Wolfhound Wildlife Services	Field data collection
Karla Langlois, B.Sc., P.Biol. Tetra Tech Canada Inc.	Reviewer

APPENDIX D
LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

NATURAL SCIENCES

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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.

Appendix 5. Waterbird Migration Follow-up Monitoring Program – 2019

Site C Vegetation and Wildlife Waterbird Migration Follow-up Monitoring Program – 2019 Annual Report

Prepared for:

BC Hydro
Site C Clean Energy Project
1055 Dunsmuir Street
PO Box 49260, BC V7X 1V5

Project No. 989619-07

Prepared by:

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February 28, 2020

EXECUTIVE SUMMARY

Waterbird surveys were conducted on the Peace River and transmission line portions of the Site C Clean Energy Project study area in 2017, 2018, and 2019. Ground (i.e., on-foot), river boat, remotely piloted aircraft systems (RPAS [i.e., drones]), and autonomous recording unit (ARU) survey methods were used to obtain records of waterbird abundance, distribution, and habitat associations. Survey results will be used to assess Project-related changes in waterbird abundance, density, and diversity, as per the objectives of the Waterbird Migration Follow-up Monitoring Program.

This report details the results of surveys conducted in 2017, 2018, and 2019. Descriptive statistics present the results relative to monitoring objectives. Results presented herein describe survey effort, variation in waterbird abundance, density, and diversity within and between seasons (during three survey periods within spring migration [April 1 to May 30] and four survey periods within fall migration [August 1 to October 30]) as well as across habitat types and study areas. Results are summarized for cumulative counts of all waterbird species and for seven 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.

Surveys of the Peace River in 2017, 2018, and 2019 provide three years of baseline data to assess potential impacts of the Project on waterbirds within a before-after control-impact (BACI) study design framework. Surveys in 2019 were conducted between Hudson's Hope and the Alberta Border, with a total of five and six survey rounds during waterbird migrations in spring and fall, respectively. Results were compiled using pooled data from counts of 63,673 waterbirds of 59 species from surveys following consistent survey methods and protocols in 2017, 2018, and 2019. During both spring and fall, overall waterbird densities (i.e., across foraging guilds) were generally similar in areas with anticipated impacts from reservoir inundation (Inundation Impact area), changes in flow regime (Flow Impact area), and areas downstream of the Pine River where changes to the Peace River will be moderated by natural flows (Control area). These results indicate that the area downstream of the Pine River provides a representative control site for the study.

The highest abundances of waterbirds in spring were recorded during the early survey period (April 1 to 14), with 2,802 birds observed across the Peace River study area on average (i.e., mean abundance across years). Mean waterbird abundances recorded in early spring were higher than any other period. During fall, the highest waterbird abundances were recorded within the late-middle survey period (September 15 to October 14; 2,214 birds). The most abundant species guild was large dabblers (26,617 individuals across years), followed by dabbling ducks (14,576 individuals) and gulls (11,445 individuals). To describe variation in waterbird abundance across habitat types, all sections of the river with the same contiguous habitat features were categorized into one of four reach types: a single large channel (Mainstem), multiple large channels surrounding river islands (Island), a mix of large channels and smaller backchannels (Off-channel), and river confluences with a major tributary (Confluence). Across reach types, the greatest mean densities of waterbirds (birds/kilometer[km]/survey) during spring were recorded in Island (16.5 birds/km) and Off-channel (16.0 birds/km) reaches, and in Confluence (49.5 birds/km) reaches during fall. The relatively high waterbird densities observed within Confluence reaches during fall were primarilly driven by large flocks of gulls adjacent to the Project site.

Regarding diversity, 15 to 17 species were typically observed across the Peace River study area during surveys, with the exception of lower species richness in the early spring and late fall (October 15 to October 30) when 11 to 13 species were observed on average, and the late spring (May 7 to May 30) when 22 species were observed on average. Diversity estimates measured with the Shannon-Wiener Index (SWI), ranged from inter-annual means of 1.6 to 1.8 during the middle and late spring (April 15 through May) as well as early and early-middle fall (August 1 to September 14), and were lower (mean SWI of 0.8-1.2) earlier in the spring and later in the fall.

Wetlands along the Project transmission line right-of-way (ROW) on the Moberly Plateau were surveyed during four and six survey rounds over the course of spring (April 20 to May 13, 2019) and fall (August 10 to October 19, 2019), respectively. A total of 25 wetland stations were surveyed in 2019 within areas of open water, sedge, and willow-sedge habitat types where waterbirds were regularly observed during surveys conducted in 2017 and 2018. Wetland surveys in 2017, 2018, and 2019 (100 m transects, stationary standwatch, and aerial RPAS surveys) detected a total of 5,485 waterbirds of 44 species, providing season-specific estimates of density and diversity within habitats with demonstrated use by waterbirds. Standwatch surveys of wetlands that were at least 75% open water habitat detected 4,378 individuals across 43 waterbird species in 2017 through 2019. Fewer individuals and species were observed within wetlands with a mix of open water (>10% to <75%) and vegetated habitat surveyed by RPAS (876 individuals of 18 species) and within sedge and willow-sedge habitat with low water depth (<50 cm) surveyed by walking transects (231 individuals of 18 species). However, these surveys were conducted over fewer years (2018 and 2019), and provide data for habitat types with more challenging detection constraints (e.g., tall and thick vegetation) and for some cryptic species (e.g., marsh birds).

The greatest densities of waterbirds within open water, flooded sedge, and flooded willow-sedge habitat were observed during early fall (August 1 to August 14). In contrast, the highest densities of waterbirds observed during transect surveys within vegetated habitat were documented during the late spring. Dabbling ducks were the most abundant waterbirds across all wetland types and survey methods, with the exception of transect surveys where marsh birds were detected in higher densities on average than any other foraging guild during the fall. Lower waterbird densities and diversity within weltands during the early spring (April) and late fall (October) were influenced by freezing conditions associated with relatively limited use of wetlands by waterbirds.

Bioacoustic monitoring using ARUs provides additional data on marsh species, which are more easily detected using audio rather than visual survey methods. ARU surveys in 2017, 2018, and 2019 were conducted at a total of 16 sites from May through July, when the target species' vocalizations are most frequent. Sora (*Porzana carolina*) was detected at all sites, and yellow rail (*Coturnicops noveboracensis*) was detected at four sites. 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 continued presence of yellow rail within wetlands along the transmission line, particularly within sedge-dominated habitat with low water levels.

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1.0 INTRODUCTION

This report describes the combined results of the 2017, 2018, and 2019 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 (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 (the 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 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 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 a helicopter, prompted the VWTC to request that a follow-up monitoring program better suited to detecting and identifying a wide 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. Such a program was developed in conjunction with the VWTC, and this report provides a summary of results from 2017, 2018, and 2019.

1.2 Monitoring Objectives

The objective of the 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). Data collected helps to satisfy the monitoring requirements of the Federal Decision Statement 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 specific objectives are to:

1. 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);

2. Document changes in waterbird relative abundance and diversity across habitats (Peace River and wetlands) during the first 10 years of Project operations relative to pre-reservoir and transmission line (2017-2019) conditions to assess Project-related impacts relative to those predicted in the EIS (EIS Volume 2; Appendix R- Section 4.1); and
3. 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 will improve understanding of baseline conditions for waterbirds, and allow a robust assessment of Project-related changes in habitat and habitat use by waterbirds. This report contains data from 2017, 2018, and 2019 using methods designed to provide improved species identification of shorebirds and other small waterbirds. As such, more recent data cannot be readily pooled with, or results compared to data collected in prior years using aerial survey methods. Comparisons to data from boat surveys conducted in 2006 and 2008 were not conducted due to inconsistencies in the timing of historical surveys and discrepancies between historic methods and those used in the updated survey protocols.

1.3 Study Area and Temporal Scope

The 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 2 kilometres (km) of the Project transmission line local assessment area (**Figure 1**). Additional wetland habitat within the Moberly Plateau that was surveyed from fixed-wing aircraft during 2017 was not surveyed in 2018 or 2019 because species identification was seldom possible from the elevations required for flight safety, 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 ten years of Project operations, as per EAC Condition 21. The monitoring program was focused on spring and fall migration periods 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). In 2017, surveys of the Peace River, and wetland habitats adjacent to the Project transmission line were conducted during three survey periods within each of the spring (April/May) and fall (August/September) migrations to document early, middle, and late migrants in each season. In 2018 and 2019, fall surveys of the Peace River were extended into October with a fourth survey period included to obtain additional data on late migrating waterbird species (e.g., merganser [*Mergus*] and goldeneye [*Bucephala*] species). During the spring, Peace River surveys have been initiated earlier than wetland surveys along the transmission line to document waterbirds using the river before upland wetlands thawed. Prior to thawing, wetlands along the transmission line are unavailable for waterbird foraging use and waterbirds primarily use habitat along the Peace River. During the fall, river and transmission line surveys are conducted concurrently.

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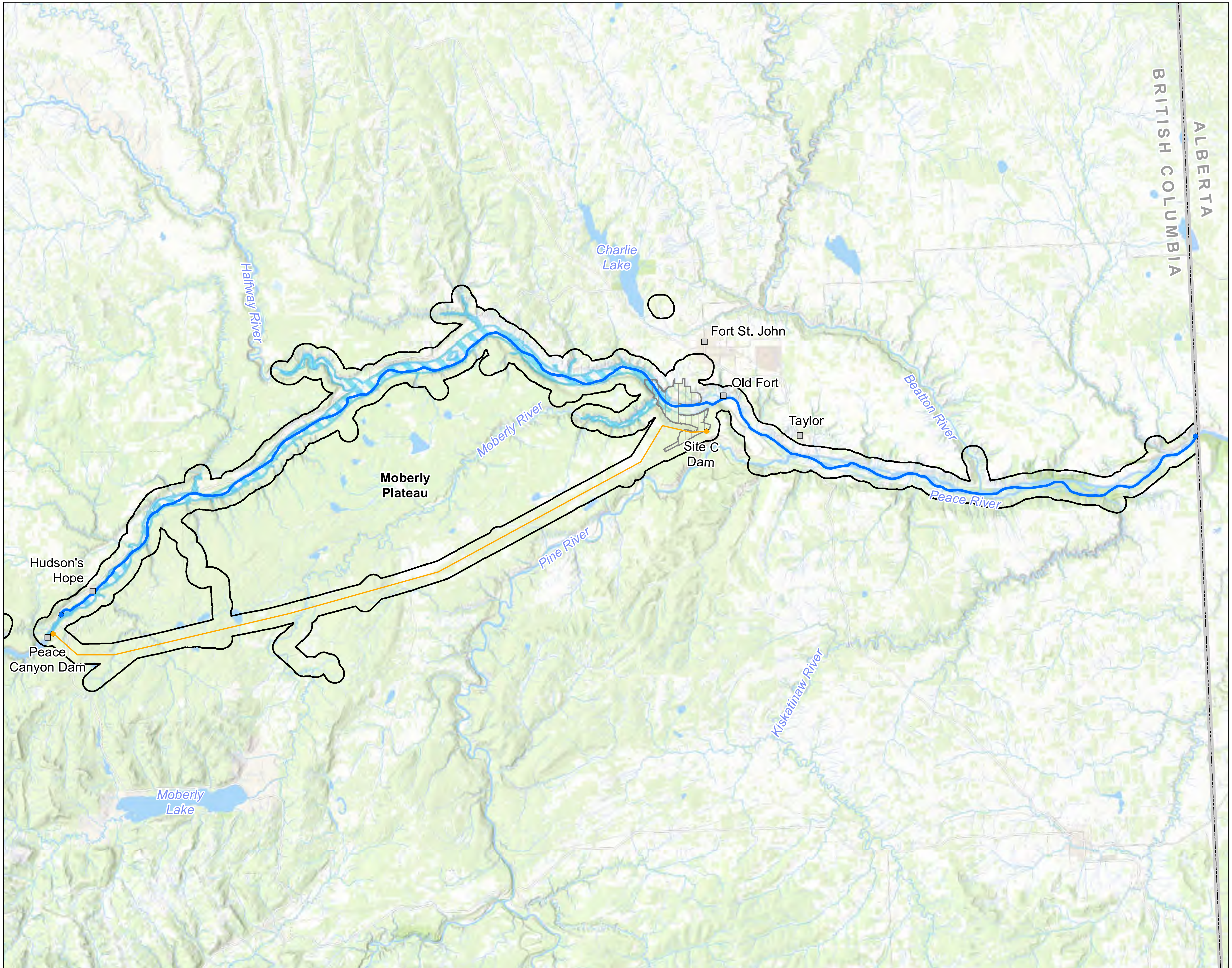
Study Areas of the Waterbird Monitoring Program on the Peace River and Moberly Plateau



Legend

- Site C LAA
- Proposed Dam Site
- Proposed Reservoir
- Wetlands Survey Adjacent to Transmission Line Right of Way
- Peace River Boat Survey Transect
- 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 to meet the objectives of the waterbird monitoring program were developed using guidance from Resource Inventory Standards Committee (RISC) 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 2019 field program are described in the following sections. Additional rationale for the methods is presented in the workplan (BC Hydro 2018).

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). The Waterbird Migration Follow-up Monitoring Program is designed to survey the full range of waterbirds present in the study area.

Differences in site accessibility and detection constraints across habitat types and study species required multiple survey methods for the Peace River and wetlands adjacent to the Project transmission line. The Peace River was surveyed by boat along the mainstem of the river and within any channels accessible by boat. Remotely piloted aircraft systems (RPAS) were used to survey areas of the river that were either too shallow or otherwise obstructed from boat access. Wetlands along the Project transmission line were surveyed using fixed-length transects in all vegetated habitat, standwatch stationary surveys in open water habitat with unobstructed lines of sight, and RPAS surveys in wetlands with areas of open water where lines of sight from the ground were obstructed by vegetation. Finally, autonomous recording units (ARUs) were used within wetland habitats along the Project transmission line to monitor vocalizations of marshbird species more readily detected using audio as compared to visual survey methods.

All waterbirds and provincially or federally-listed species observed were recorded during waterbird surveys. The time and precise (Universal Transverse Mercator [UTM]) location of waterbird observations using time-referenced waypoints were recorded, along with species, number of individuals, habitat characteristics, and distance measures from observation locations. The distribution of habitat types across the study area was derived from available terrestrial ecosystem mapping (TEM) data and satellite imagery to categorise wetland and river reach types. Data will be analyzed for potential changes to waterbird relative abundance and diversity across habitat types (BC Hydro 2018).

Within the subsequent sections, 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 or all wetlands within transmission line ROW study area
- **Survey Period** – A period of time which encompasses a defined period of spring or fall migration, typically encompassing the peak migration of one or more species groups (i.e., foraging guilds).

2.1 Habitat Assessment

Prior to field surveys in 2017, the area of wetland habitat types within the Peace River Valley and Moberly Plateau study areas were summarized from existing TEM data using ArcGIS Desktop (v.10.5.1) software (Hemmera 2018). The most widespread wetland habitat types in the study area are Labrador tea-sedge and tamarack-sedge (**Table 1**, **Figure 5**). Sedge and open water were less widespread, and willow-sedge was the least common wetland habitat type. Habitat parameters for which data were collected with waterbird observations are described for each survey method in **Sections 2.2** and **2.3**. Wetland habitat area has not changed appreciably since 2017 such that the proportional extent of habitat types also remains unchanged.

Table 1 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

Water discharge data can help to explain variation in water flow and depth within the Peace River, which may influence waterbird abundance and distribution. Hourly waterflow data were obtained from BC Hydro and summarized using SigmaPlot (v.12.5) to illustrate the frequency of flow rates at representative sites within study areas along the Peace River. These data were also used to verify that waterbirds were observed at flow rates representative of the study area during migration. The frequency distribution of hourly river flows (i.e., discharge rates) during the spring and fall of 2017, 2018, and 2019 were compared to flows during waterbird surveys to determine if surveys were conducted under representative conditions. 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.

2.2 Peace River Waterbird Surveys – Boat and RPAS

2.2.1 Study Design

The Peace River surveys assess the relative abundance and diversity of waterbirds using riverine and backchannel habitat in the Peace River valley. Five surveys were conducted for the spring and six surveys were conducted in the fall, with shorter time between spring surveys compared to fall surveys to account for higher variance during that season and its shorter and more condensed migration period.

To assess the relative abundance and diversity of waterbirds along the Peace River, a before-after, control-impact (BACI) design is being used to distinguish between background and Project-related changes in waterbird relative abundance and diversity. Areas surveyed to assess impacts are: (i) the Site C reservoir from the Hudson's Hope to the Project site (impact from inundation; **Figure 2**), (ii) the Peace River from the Site C dam to the Pine River confluence with the Peace River (impact from change in flow regime; **Figure 3**), and (iii) the Peace River from the Pine River confluence to the Alberta border (control; **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, referred to as 'treatment areas'.

The before condition for the BACI design will be that which exists prior to reservoir filling, which is planned to occur in fall 2023. Impacts are expected once reservoir filling begins. The river diversion period (planned to occur fall 2020 to fall 2023) will be part of the before condition because water volumes and flow rates are expected to be mostly un-changed outside of the immediate construction area and small headpond during this period.

The total length of river within the study area is 146.5 km; 82.1 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**). Four reach types were delineated across the Peace River study area using recent aerial photographs and satellite imagery to characterize areas dominated by similar habitat as one of the following: Off-channel, Mainstem, Island and Confluence habitats (**Table 2**).

Table 2 Reach types and definitions used to classify Peace River habitat

Reach Type	Definition
Mainstem	Reaches where the river consists of one large channel
Island	Reaches where the river is split relatively evenly around islands
Off-channel	Reaches where a small portion of the river runs around islands, or where there are backchannels and/or bodies of water that are only connected to the river during high flows
Confluence	Reaches where major tributaries such as the Pine, Beatton, Halfway and Moberly rivers join the Peace River

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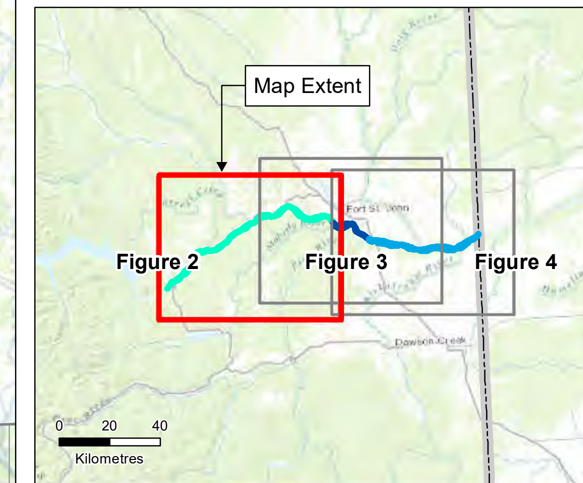
Inundation Impact Area on the Peace River



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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Migratory Waterbird Follow-up Monitoring Program
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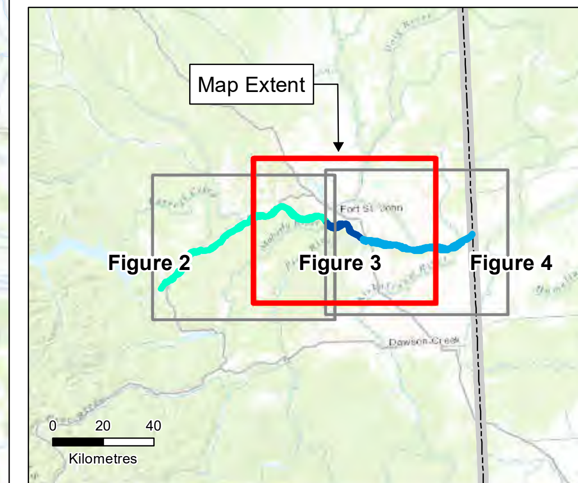
Flow Regime Change Impact Area on the Peace River



Legend

- Inundation Impact Area
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- Control Area
- Proposed Dam Site

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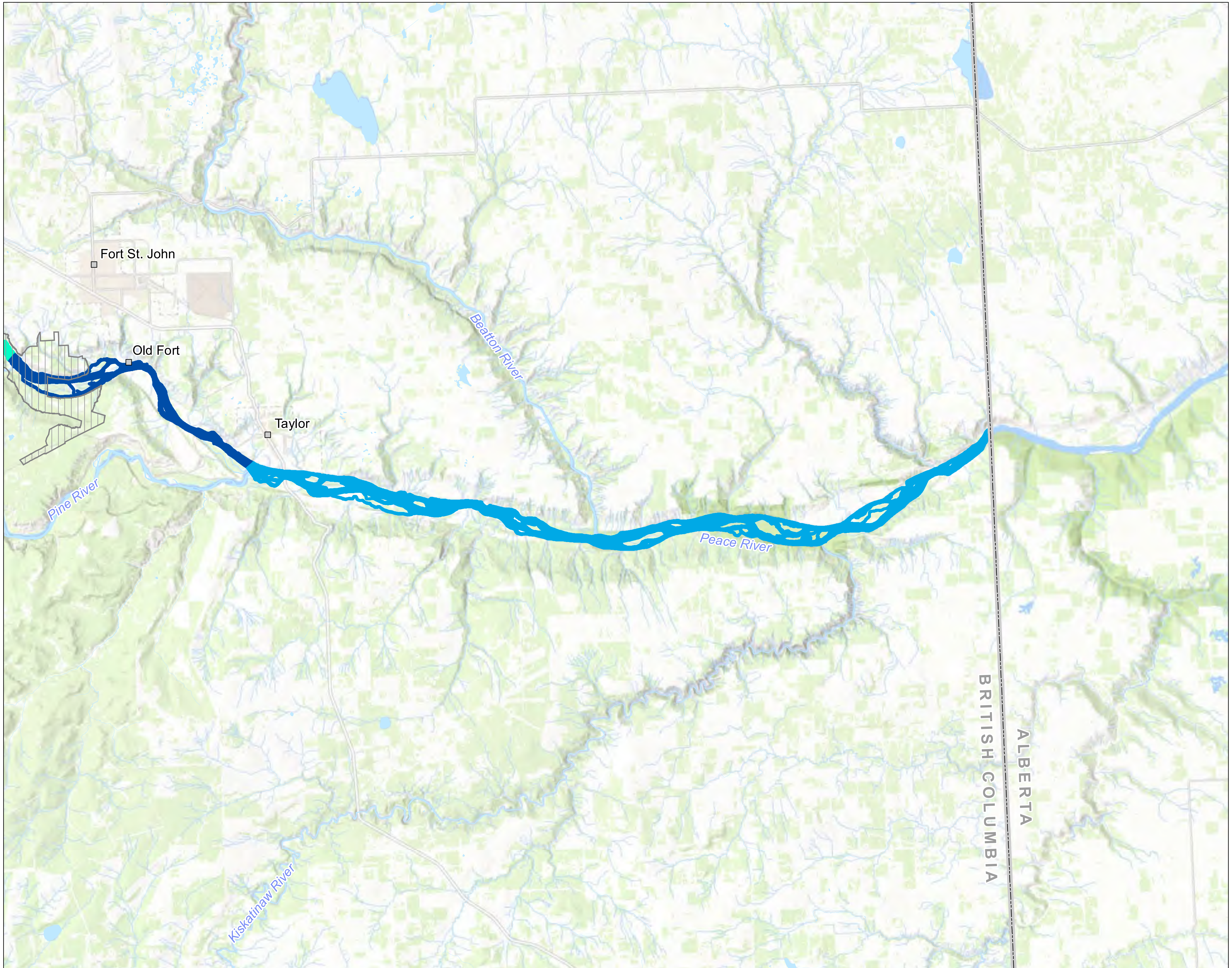
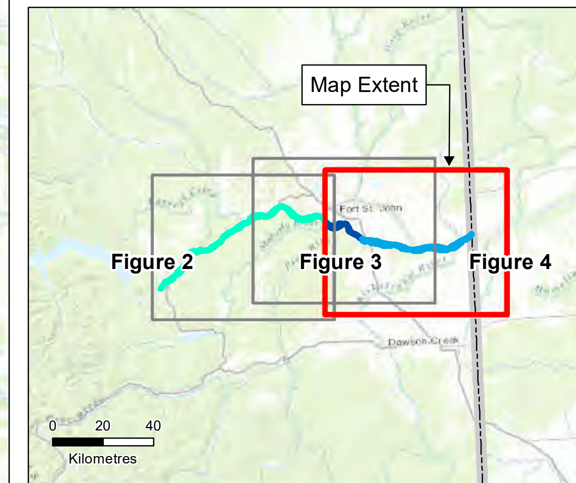
Migratory Waterbird Follow-up Monitoring Program
2019 Report
Site C, Peace River, BC

Control Area on the Peace River





Legend

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

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2.2.2 Survey Methods

Boat surveys followed 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). Surveys took place in daylight hours between 07:00 and 18:00 over the length of the Peace River, from Hudson’s Hope to the Alberta border using a jet boat (Peace River Boat Survey Transect; **Figure 1**). Surveys required two days to cover this 146.5 km section of river. For each survey, the upstream portion of the river was surveyed on the first day and the downstream portion of the river was surveyed the second day. Boat surveys allowed visual coverage of the river, shoreline, nearshore areas, exposed sandbanks, gravel bars, and mudbanks/flats. Surveyors circled around islands and observed up backchannels wherever water levels were high enough for boat access. The boat survey was conducted at a speed of 30 to 40 km/hour, except when low water levels required faster speeds to prevent the boat from grounding on the riverbed. Also, speeds were slowed to improve the accuracy of species identification and abundance estimates when multiple flocks of waterbirds were observed. Surveys were conducted by biologists trained in waterbird identification. Two observers focused their respective survey efforts on opposite shores to the center 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 (i.e., wind speeds greater than three on the Beaufort scale [>10 km/h], any rain or fog that resulted in poor visibility [<1 km], <1.5 metre (m) waves [no whitecaps]); as per RISC standards (RIC 1999).

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, <50 m, 50-<100 m, 100-<200 m, 200-400 m, >400 m).

RPAS surveys recorded birds in areas that could not be accessed by boat due to shallow water or other obstructions. RPAS surveys recorded video footage of such areas with a camera displaying a live video to surveyors on the ground. To minimize any disturbance to waterfowl, the RPAS was deployed at least 100 m from any observed birds, sudden movements were avoided, and any observations requiring close investigation involved approaching individuals at angles not steeper than 20° (Vas et al. 2015). RPAS surveys were standardized by flying at a consistent height, speed and camera angle, whenever possible. The location of RPAS observations was determined by recording a survey site ID at the beginning of each video and cross-checking satellite imagery with landscape features (e.g., islands and channels) within the site. Species were identified from raw video footage, or with still frames and video at two times magnification when necessary. All species found on the RPAS video footage were recorded, with the information bulleted above collected, in addition to the height of the RPAS at the time of observation.

During river surveys in 2018 and 2019, surveyors recorded GIS tracks of the boat survey route as part of broader efforts to assess waterbird detectability across the monitoring program. Tracks were used in conjunction with the coordinates of waterbirds, recorded on iPads in the field, to determine the approximate perpendicular distance from the boat survey route to each record. These data can be used to assess and account for the extent to which the likelihood of detectiing a bird decreases with distance from observers (i.e., distance sampling). Additionally, a third observer recorded species during one spring and two fall surveys in 2019 to provide data allowing for assessment of the proportion of birds missed during typical surveys (i.e., to account for incomplete detection).

2.3 Transmission Line Wetland Surveys ‐ Transect, Standwatch, RPAS, and ARU

2.3.1 Study Design

The transmission line wetland surveys are designed to assess impacts associated with the Site C transmission line. To assess impacts of the transmission line (e.g., expanding the area of cleared vegetation along the transmission line ROW), the study provides estimates of waterbird densities and diversity within impacted habitat types used by waterbirds. Habitat-specific densities of waterbirds provided by the study can be compared to the area of impacted habitat to estimate the number and species of birds impacted by the transmission line. To assess potential changes to wetland habitat use due to other impacts of the project (e.g., potential displacement of waterbirds from inundated river valley habitat into adjacent wetlands), the study provides data to compare abundances within habitat types before relative to after Project operations.

To assess the relative abundance and diversity of waterbirds using wetland habitats on the Moberly Plateau and adjacent to the Project transmission line ROW, surveys were conducted using the following methods:

- walking fixed-length transects (100 m) of vegetated habitat
- stationary standwatch surveys of open water habitat with clear lines of sight
- recording aerial video of open water habitat with surrounding vegetation using RPAS
- recording acoustic data using ARUs for specific cryptic and nocturnally/crepuscularly active species.

Unique survey methods were applied as necessary to account for distinct access and detection constraints across habitats and focal species. Habitat types with lower detection rates can negatively bias estimates of abundance and density relative to other habitats. However, the methods applied to wetlands surveys are designed to minimize detection constraints and include measures of detection rate that can be used to account for habitat-specific differences in waterbird detectability.

Accessible wetlands where suitable waterbird habitat was observed in 2017 were also surveyed in 2018 and 2019. In 2018, additional wetlands further west along the transmission line ROW were included to broaden the spatial scope of the study and encompass a larger proportion of areas with potential to be impacted by the Project. In 2019, survey efforts included the same broadened spatial scope, but focused on wetland habitat types where waterbirds were observed during 2017 and 2018 within 25 survey stations. Furthermore, some survey stations where sedge transects were conducted in 2018 were dropped or replaced with sedge transects at other stations due to site access constraints and safety hazards. On survey days when wetland habitat was fully or partially frozen, surveys of open water habitat were conducted where accessible, but vegetated transect surveys were not done due to the risk of surveyors falling through partially frozen wetlands where water depth could not be safely assessed.

Wetland habitats at each station were surveyed once over a two to three-day period (i.e., survey round). Surveys at each station were conducted over four rounds following thaw in the spring, and six rounds in the fall. Wetland survey effort was standardized either by length (100 m transects), time (20-minute standwatch surveys), or area (RPAS survey polygons).

For species of marsh birds not easily detected using diurnal standwatch, transect, or RPAS survey methods (e.g., yellow rail [*Coturnicops noveboracensis*]), field studies employed acoustic monitoring using ARUs (Song Meter 3 and Song Meter 4, Wildlife Acoustics Inc. Maynard, Massachusetts, USA). ARUs are designed to record acoustic data for long periods of time. These data were filtered for target species with known call signatures and are therefore well suited for detecting rare species (e.g., American bittern [*Botaurus lentiginosus*]) and species that are less active during daylight hours when other survey methods were employed. ARUs were programmed to record audio data during time periods when the target species are most active (dusk and dawn in the case of yellow rail and American bittern), for a minimum of three nights during the peak vocalization period (i.e., from May to July [Conway 2011]). Sora (*Porzana carolina*) was detected regularly and at many stations during wetland surveys in 2017 and 2018. American bittern was not detected during 2017 or 2018 monitoring and has only been recorded within the Peace Region on a few occasions. Yellow rail was not detected in 2017, but was detected at one wetland site in 2018 and there are several recent records of the species within the Project study area (Hilton et al. 2013). Bioacoustic monitoring in 2019 targeted the area of the Moberly Plateau where yellow rail was observed in 2018 and previously (**Figure 5**).

2.3.2 Survey Methods

Waterbird surveys of wetlands during the 2017 and 2018 monitoring program confirmed waterbirds' use of sedge, open water, and willow-sedge wetlands, but found little evidence of use of cultivated fields, or Labrador tea-sedge, and tamarack-sedge wetlands (**Table 3**). Survey effort along wetlands adjacent to the transmission line ROW in 2019 was therefore focused on sedge, open water, and willow-sedge habitat.

2.3.2.1 Transect, Standwatch, and RPAS

Two crews, each consisting of a biologist and a field technician, completed the surveys during daylight hours between 07:00 and 18:00. Biologists were experienced in visual and vocalization identification of wetland bird species and were trained in vegetation species identification for wetland habitat characterization. Surveys were not conducted during sustained inclement weather such as high winds (i.e., >3 on the Beaufort scale) or moderate to heavy precipitation.

Fixed length transect surveys of 100 m were conducted in 2019 in two of the three wetland habitats surveyed for waterbirds along the transmission line: sedge and willow-sedge. This method is considered appropriate given the lack of visibility from the ground or air within these wetland types. Wetlands with at least twenty percent coverage of such vegetated wetland types, and with water levels less than 50 cm, were surveyed with at least one transect. Where multiple wetland types were present within wetland stations, transects were conducted within distinct habitat types to provide data specific to each wetland type. Transects were generally straight but followed slightly meandering routes where necessary to stay within habitat types or as needed for safe movement. Areas where water levels within sedge or willow-sedge habitat were greater than 50 cm were generally surveyed by RPAS.

Stationary standwatch surveys of 20-minute duration were conducted in 2017, 2018, and 2019 at wetlands with open water habitat and small lakes with clear lines of sight. This method is considered most appropriate for these habitats given that visual lines of sight from ground-level provide efficient visual detection of waterbirds on the water's surface across large areas. Wetlands in which open-water was the dominant habitat type were surveyed by this method with a single 20-minute survey. Where necessary, the 20-minute survey was divided into two 10-minute segments at two 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.

RPAS surveys encompassing a maximum area of five hectares (ha) were conducted in 2018 and 2019 at wetlands with open water habitat where vegetation obscured lines of sight from the ground level, but not from an aerial perspective. No other survey method was able to effectively assess waterbird abundances in such habitat, where open water areas were surrounded by sedges and cattails. RPAS surveys of such wetlands focused effort on areas of open water and where vegetation was flooded within wetland station polygons. Efforts were made to provide still video footage at a low angle for all waterbirds observed to allow for species identification upon review of the footage. RPAS surveys were of variable duration given the variety in the area of open water and flooded wetland habitat across stations and survey dates. The average area of flooded habitat within each season was determined based on aerial imagery to provide estimates of density (e.g., waterbirds/ha of flooded habitat).

Many of the wetland stations surveyed were comprised of a mosaic of wetland types and varied seasonally in the depth and extent of open water. The survey methods described above were applied to habitat whenever it was present within a wetland station. Consequently, multiple survey methods were often used at a wetland station in a single day (e.g., RPAS and transect surveys at a wetland dominated by sedge habitat, but also containing extensive open water habitat). Station conditions (e.g., percent open water habitat) and the survey methods employed were recorded during each survey. Survey results were compiled across habitats surveyed with the same methods.

Wetland surveys were repeated within a subset of open water and flooded areas surveyed by RPAS and standwatch methods to provide estimates of detection rate (i.e., to obtain a measure of the number of birds not observed during a typical survey). Transect surveys typically disturbed waterbirds causing them to flush and leave the area, thereby altering abundances and leading to reduced numbers during the second survey. Consequently, repeated transect surveys were not informative of detection rates and distance to disturbance and from the transect were recorded instead.

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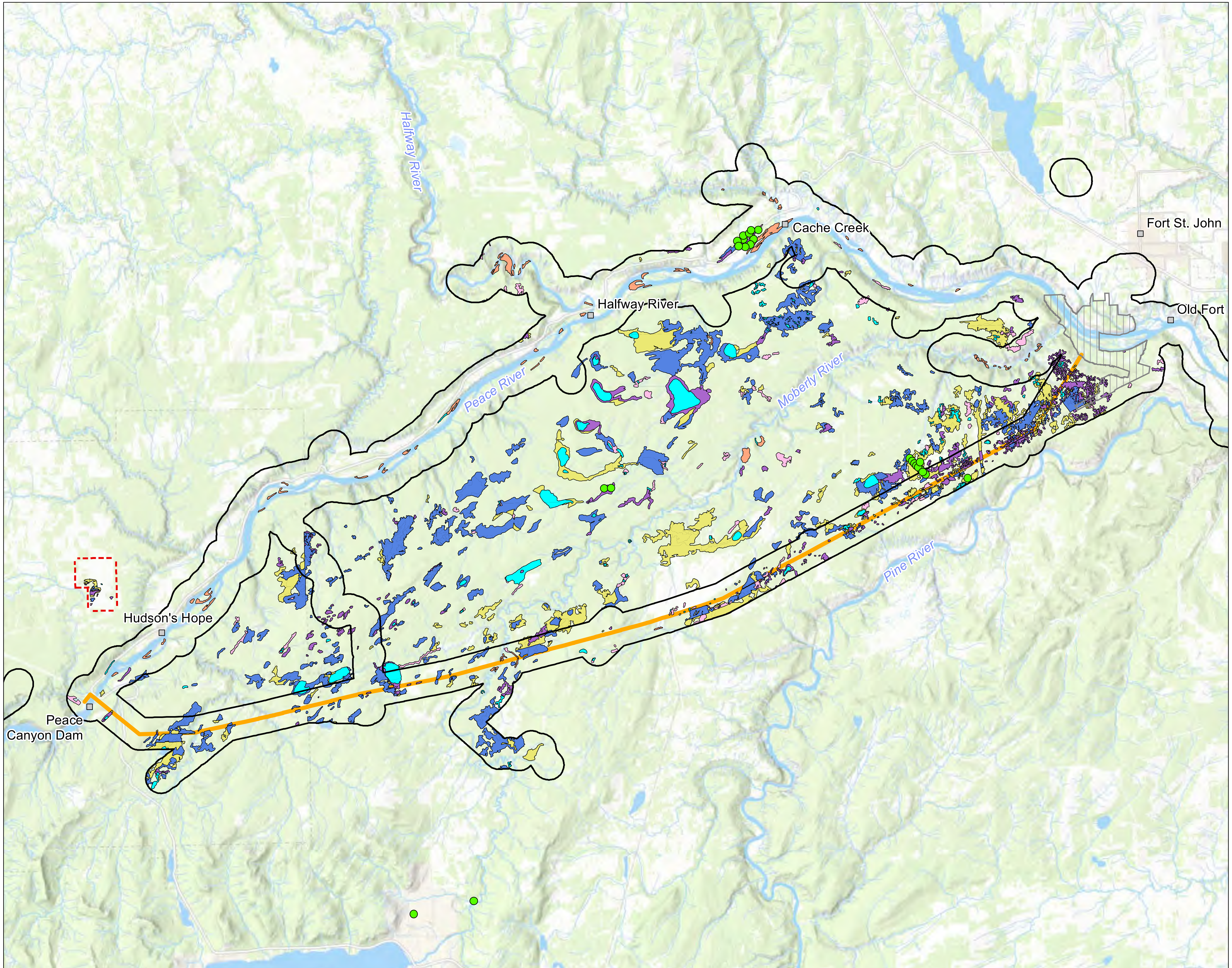
Wetland Habitat Types and Historic Yellow Rail Detections in and Adjacent to the Peace River Valley and Transmission Line Route



Legend

- Site C LAA
- Proposed Dam Site
- Marl Fen Property - BC Hydro Wetland Compensation Site
- Transmission Line Right-of-Way
- Historic YERA Observations from eBird and Baseline Studies

Wetland Types

- Labrador-tea – sedge (BT)
- Non-forested floodplain wetland (WH)
- Sedge (SE)
- Shallow 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

N

1:250,000

0 2 4 6 8 10

Kilometres

NAD 1983 UTM Zone 10N

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Table 3 Wetland habitat types suitable for waterbirds adjacent to the Project transmission line ROW

Wetland Habitat Type	Characteristics	Waterbirds Expected?
Open water (OW)	Open water with no (or limited) emergent vegetation including shallow open water (<2 m depth), as well as ponds, and lakes transitioning or connected to wetlands.	Yes, waterbirds are abundant in open water habitat.
Tamarack-sedge (TS)	Fen with tamarack dominated overstorey	While Twedt et al. (1998) suggest potential for use, few waterbirds were observed in 2017 and 2018. Waterbirds are no longer considered likely to be observed in this habitat.
Sedge (SE)	Uniform sedge (*Carex* sp) flat low area, typically wetted and often with standing water. Often surrounding or bordering open water habitats.	Yes, provided there is low density overstory vegetation.
Labrador tea-sedge (BT)	Labrador tea-dominated peat bogs	No, waterbirds are not anticipated to occur in peat bogs (Eifrig 1911), and few waterbirds were observed in 2017 and 2018. Waterbirds are no longer considered likely to be observed in this habitat.
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, waterbirds are present when willows are in low densities
Cultivated field (CF)	Only considered if wetted and/or water source or wetland occurs within 100 m	Only when flooded. Few waterbirds were noted in 2017 and 2018. Waterbirds are no longer considered likely to be observed in this habitat.

The following information was recorded at each wetland survey station:

- UTM coordinates
- Date
- Start and end time of survey
- Proportion of each habitat type within the wetland or survey station
- Approximate water depth within each habitat type.

The following information was recorded for each survey 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

- Water depth where the bird was observed
- Behavior
- Distance from the observer and transect

The area of habitat types within each surveyed wetland, as a percentage of the total area, were recorded based on visual estimation from the ground and aerial imagery when available from RPAS surveys. These data were used to determine the dominant and sub-dominant habitat within each wetland station. For the purposes of this study, dominant was considered the most common habitat type, and sub-dominant was the next most widespread wetland type at the station, assuming at least 20% coverage of the wetland station on average. In cases where no other wetland type comprised at least 20% of the station, the dominant wetland type was also considered as the sub-dominant type.

2.3.2.2 Autonomous Recording Units

The presence of marsh birds was monitored with Song Meters (SM3 and SM4) ARUs (Wildlife Acoustics, Inc., Maynard, Massachusetts, USA). ARUs 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 were deployed during the breeding period in suitable nesting habitat for yellow rail and American bittern (i.e., open marsh or pond edges with emergent vegetation, tall grasses, rushes and bulrushes [Goldade et al. 2002, Bayne et al. 2014]). 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. Data for the number of nights that ARUs were deployed was recorded, and results were assessed as present or not detected at each monitoring station.

3.0 DATA MANAGEMENT AND ANALYSIS

Waterbird records from 2019 surveys were compiled into the existing database from 2017 and 2018 using Microsoft Access software for data management. Once data were compiled, quality assurance measures were applied to identify anomalous species or count data. Any outlying records (e.g., high counts, rare species) were verified by confirming with field staff and, where possible, by reviewing data sources (e.g. RPAS footage, ARU files).

The scope of this annual report is limited to descriptive statistics (primarily ranges and means) to demonstrate that survey methods are capturing the targeted species guilds across all study areas within relevant time periods and habitat types, and to highlight broad patterns in abundance and distribution. Metrics of waterbird diversity and abundance are reported for each study area, season and survey periods within seasons, as well as across habitat types. Abundance and diversity data are also summarised by species guilds defined by method of foraging: 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. Birds that were not identified to species were recorded to the most specific taxonomic level possible. A full list of species observed and the guilds to which they are assigned is presented in **Appendix A**.

Abundances are described in terms of relative abundance and relative density because they represent the number of waterbirds detected, rather than true (i.e., absolute) abundance, which requires estimates of the proportion of birds not detected. Distance and repeated survey data were collected (as described in **Section 2.2.2** and **2.3.2**) 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.

Waterbird diversity is presented as species richness (i.e., number of species), species diversity using the Shannon-Wiener Index (SWI), and species evenness.

The SWI is a measure of diversity that considers both species richness and evenness, calculated as (MacDonald et al. 2017):

$$SWI = -\sum_{i=1}^{s}(p_i \times \ln p_i)$$

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. Species diversity, as measured by the SWI, increases with the number of species, and with the evenness of the distribution of number of individuals per species.Species evenness is the degree of similarity in abundance of each species using Pielou's evenness index, calculated as (MacDonald et al. 2017):

$$Species\ evenness = \frac{SWI}{\ln S}$$

Where SWI is the Shannon-Wiener Index and *S* is species richness. Species evenness is presented with values ranging from zero to one, where values tending towards one represent more even proportions of species and values tending towards zero represent communities dominated by fewer species.

3.1 Peace River Waterbird Surveys – Boat and RPAS

Waterbird data were summarized to provide mean relative abundance and diversity across sections of the Peace River that will be differentially affected by the Project (i.e., treatment areas), seasons, and survey periods. Relative abundance data were also summarized by river reach categories by calculating summary statistics for all sections of the river with the same contiguous habitat features (**Table 2**). To control for variation in relative abundance due to the size of a reach or study area rather than habitat type or a treatment effect, data are summarized in terms of number of individuals observed per km of river (i.e., relative density by river length), as per RISC standards (RIC 1999).

3.2 Transmission Line Wetland Surveys – Transect, Standwatch, RPAS and ARU

Data from 2017, 2018, and 2019 surveys were summarized to provide estimates of relative abundance and diversity for each survey. These estimates were compared across survey periods, seasons, and years. The number of birds observed within each habitat type was presented per unit of survey effort. For transect surveys, the number of birds observed within sedge and willow-sedge during each survey were determined per 100 m transect conducted in each habitat type. The mean number of birds within each foraging guild observed per transect was calculated for each wetland type and multiplied by 10 to provide an estimate of the number of birds per km of transect. Data collected from standwatch surveys were used to provide estimates of density at stations with permanent 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. Seasonally flooded areas and sub-dominant open water areas were surveyed by RPAS. To avoid biased estimates of density in such areas surveyed by RPAS, waterbird observations within flooded or open water habitat were summarized as a density by dividing the number of birds observed by the average area of flooded habitat within the season (e.g., spring or fall) they were observed.

Acoustic data were downloaded and analyzed using a cluster analysis method in Kaleidoscope Pro (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 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.

4.0 RESULTS

Results for the monitoring program from 2017, 2018, and 2019 provide an overview of habitat data as well as waterbird abundance and diversity indices within habitat types, seasons, and, where possible, survey period. Statistical comparisons and modeling planned for subsequent years of data collection are discussed in **Section 5.0**.

4.1 Peace River Waterbird Surveys – Boat and RPAS

4.1.1 Timing

The Peace River study area was surveyed each year during five survey rounds in the spring and six survey rounds in the fall (**Table 4**). Due to rain and wind speeds that exceeded survey standards (**Section 2.2.2**), 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 two 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, two surveys were incomplete: the first round of middle spring surveys, due to mechanical issues with the river boat and a lack of alternative options within the survey window, and the early-middle fall survey due to poor weather (**Table 4**).

Table 4 Peace River survey timing during the 2017, 2018, and 2019 migratory waterbird monitoring program

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

Note: When multiple survey rounds were completed within a survey period, survey dates from each round are presented on separate lines. *Second day of survey round not completed due to inclement weather; **Third day required to complete survey round due to interruption from ice flow out of the Pine River; ***Survey of Impact areas only due to mechanical issues; ****Survey of Inundation Impact area only due to weather conditions in violation of survey standards.

4.1.2 River Reaches and Study Areas

All four reach types are present in the Inundation Impact and Control areas, while Island reaches are absent from the Flow Impact area (**Table 5**). Off-channel, Island, and Mainstem reaches make up 37%, 28% and 29% of the study area, respectively, while Confluence reaches make up 6%. The length of Off-channel reaches is greater than other reaches in the Flow Impact and Inundation Impact treatment areas, making up 47% and 42% of the areas, respectively. Island reaches comprise most (54%) of the Control treatment area. Three river reaches upstream of Hudson's Hope surveyed in 2017 and 2018 were beyond the scope of monitoring requirements and were not included in 2019 surveys.

Table 5 Types, numbers, and length of river reaches within Peace River treatment areas

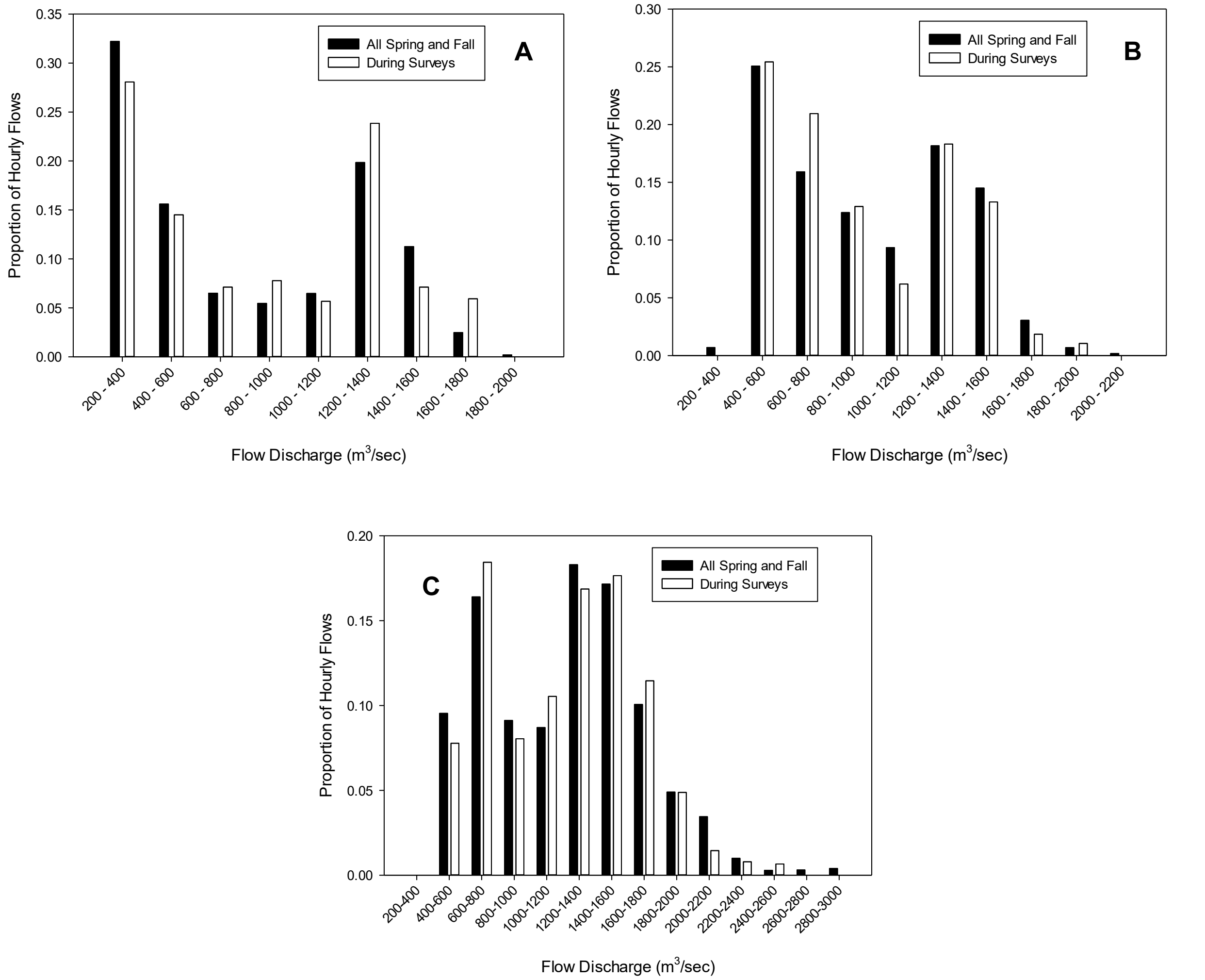
Treatment Area	Off-channel		Island		Mainstem		Confluence	
	Reaches (no.)	Length (km)	Reaches (no.)	Length (km)	Reaches (no.)	Length (km)	Reaches (no.)	Length (km)
Control	5	11.4	8	25.0	5	7.9	2	2.1
Flow Impact	4	8.5	0	0.0	4	6.1	2	3.4
Inundation Impact	13	34.6	5	15.9	16	28.7	2	2.9
Total	22	54.5	13	40.9	25	42.7	6	8.4

Note: Surveys in 2019 excluded one off-channel reach (2.5 km), island reach (1.8 km), and mainstem reach (3.1 km), as they were upstream of Hudson's Hope and, thus, beyond the scope of monitoring requirements

4.1.3 Peace River Water Flow Regime

Peace River water flow (i.e., discharge) data from Hudson's Hope, Peace Canyon Dam[1], Old Fort, and Taylor (**Figure 1**) were plotted to illustrate the flow regime throughout the spring and fall migration within each treatment area relative to the flow conditions during surveys (**Figure 6**). Surveys were conducted over the span of approximately 250 hours, representing ~7% of the spring and fall migration period over the three survey years (3,675 total hours; April 1 to May 31 [spring migration] and August 1 to October 31 [fall migration]). Flow data show that the proportion of hourly flow records within flow rate categories during surveys were similar to the proportion of hourly flow records within flow rate categories for the spring and fall migration periods overall (**Figure 6**).

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, flow data for the Inundation Impact area was collected from a gauge at Peace Canyon Dam.



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, 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, 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) areas during surveys relative to across spring and fall migrations in 2017, 2018, and 2019

4.1.4 Relative Abundance and Density

As in previous years, waterbirds were observed along the entirety of the Peace River study area in spring and fall of 2019 (see location figures in **Appendix B – Figures B-1 to B-4**). There were a total of 63,673 individual waterbirds observed during Peace River surveys in 2017 through 2019 (**Appendix A-1**), of which 89% were identified to species (**Table 9**). In 2019, a total of 25,164 waterbirds were observed, of which 87% were identified to species (**Appendix A-2**).

Mean relative abundances were highest during the early survey period in spring and the late-middle survey period in the fall (**Table 6**). Large dabblers, primarily Canada goose (*Branta canadensis*), were the most abundant waterbirds overall with the highest relative abundances observed during the early spring, and in fall during late-middle and late survey periods. Dabbling ducks and gulls were the next most adundant guilds (**Table 6**).

Table 6 Mean relative abundance of waterbird foraging guilds (birds/survey round) along the Peace River during spring and fall of 2017, 2018, and 2019

Foraging Guild	Spring Survey Periods			Fall Survey Periods				Total
	Early	Middle	Late	Early	Early-Middle	Late-Middle	Late	
Benthic Feeding Divers	114	188	31	4	34	10	7	387
Dabbling Ducks	534	705	400	175	278	433	151	2,676
Gulls	2	78	33	942	688	396	102	2,240
Large Dabblers	1,720	633	532	297	358	1,162	1,262	5,964
Piscivorous Divers	250	91	48	39	33	23	26	510
Shorebirds	2	5	74	259	106	4	0	450
Unknown Waterbirds	180	244	155	67	78	186	49	958
Total	2,802	1,942	1,273	1,783	1,576	2,214	1,597	

Note: Mean relative abundances were calculated by averaging relative abundance counts across survey rounds first within periods each year, and then across years so that differences in sampling effort did not bias means towards abundances observed in years with more survey rounds.

Totals of mean relative densities of waterbird foraging guilds varied across reach types, primarily reflecting the distribution of the most abundant guilds (i.e., large dabblers and dabbling ducks in spring, gulls and large dabblers in fall; **Table 7, Table 8**). During spring, mean relative densities (calculated as the mean of annual means for each survey period) within Island and Off-channel reaches were about twice those found in Mainstem and Confluence reaches (**Table 7, Figure 7, Figure 8, Figure 9**). The highest mean relative densities observed across seasons and reach types was in the fall at Confluence reaches, primarily due to large flocks of gulls roosting near the Site C Dam site at the confluence of the Moberly River (**Table 8, Figure 10, Figure 11, Figure 12**).

Mean relative densities for overall waterbirds were similar (range of 12.4 to 13.7 birds per km) across treatment areas in the spring (**Table 7, Figure 7, Figure 8, Figure 9**). In contrast, mean densities during fall were higher in the Flow Impact area compared to other treatment areas, primarilly due to high numbers of gulls in the Confluence reach adjacent to the Project site, as described above (**Table 8, Figure 10, Figure 11, Figure 12**).

Table 7 Mean relative density (birds/km/survey) of spring migrant waterbirds by river reach category and treatment area during 2017, 2018, and 2019

Foraging Guild	River Reach Category				Treatment Area		
	Off-channel	Island	Mainstem	Confluence	Inundation Impact	Flow Impact	Control
Benthic Feeding Divers	1.0	0.9	0.5	0.3	1.1	0.7	0.3
Dabbling Ducks	4.3	4.8	1.8	1.2	2.9	4.1	4.6
Gulls	0.2	0.1	0.1	1.7	0.2	0.8	0.1
Large Dabblers	7.4	8.0	3.1	3.6	6.5	5.1	6.2
Piscivorous Divers	1.1	0.9	0.7	0.5	1.2	0.5	0.4
Shorebirds	0.2	0.4	0.1	0.1	0.2	0.2	0.3
Unidentified Waterbirds	1.9	1.4	0.4	0.1	1.6	1.0	0.9
Total	**16.0**	**16.5**	**6.8**	**7.5**	**13.7**	**12.4**	**12.6**

Note: Mean relative densities were calculated by averaging relative density across survey rounds first within periods each year, and then across years so that differences in sampling effort did not bias means towards densities observed in years with more survey rounds. Data from incomplete survey rounds are excluded.

Table 8 Mean relative density (birds/km/survey) of fall migrant waterbirds by river reach category and treatment area during 2017, 2018, and 2019

Foraging Guild	River Reach Category				Treatment Area		
	Off-channel	Island	Mainstem	Confluence	Inundation Impact	Flow Impact	Control
Benthic Feeding Divers	0.1	0.0	0.1	0.0	0.1	0.1	0.0
Dabbling Ducks	4.7	0.8	0.1	0.5	2.6	4.4	0.4
Gulls	2.0	0.2	2.4	41.8	1.8	23.1	0.2
Large Dabblers	8.7	3.2	2.2	6.9	3.5	4.9	8.7
Piscivorous Divers	0.2	0.3	0.1	0.0	0.2	0.1	0.2
Shorebirds	0.5	1.1	0.3	0.1	0.5	0.3	0.9
Unidentified Waterbirds	1.6	0.3	0.1	0.0	0.7	1.3	0.7
Total	**17.9**	**5.8**	**5.4**	**49.5**	**9.4**	**34.2**	**11.0**

Note: Mean relative densities were calculated by averaging relative density across survey rounds first within periods each year, and then across years so that differences in sampling effort did not bias means towards densities observed in years with more survey rounds. Data from incomplete survey rounds are excluded.

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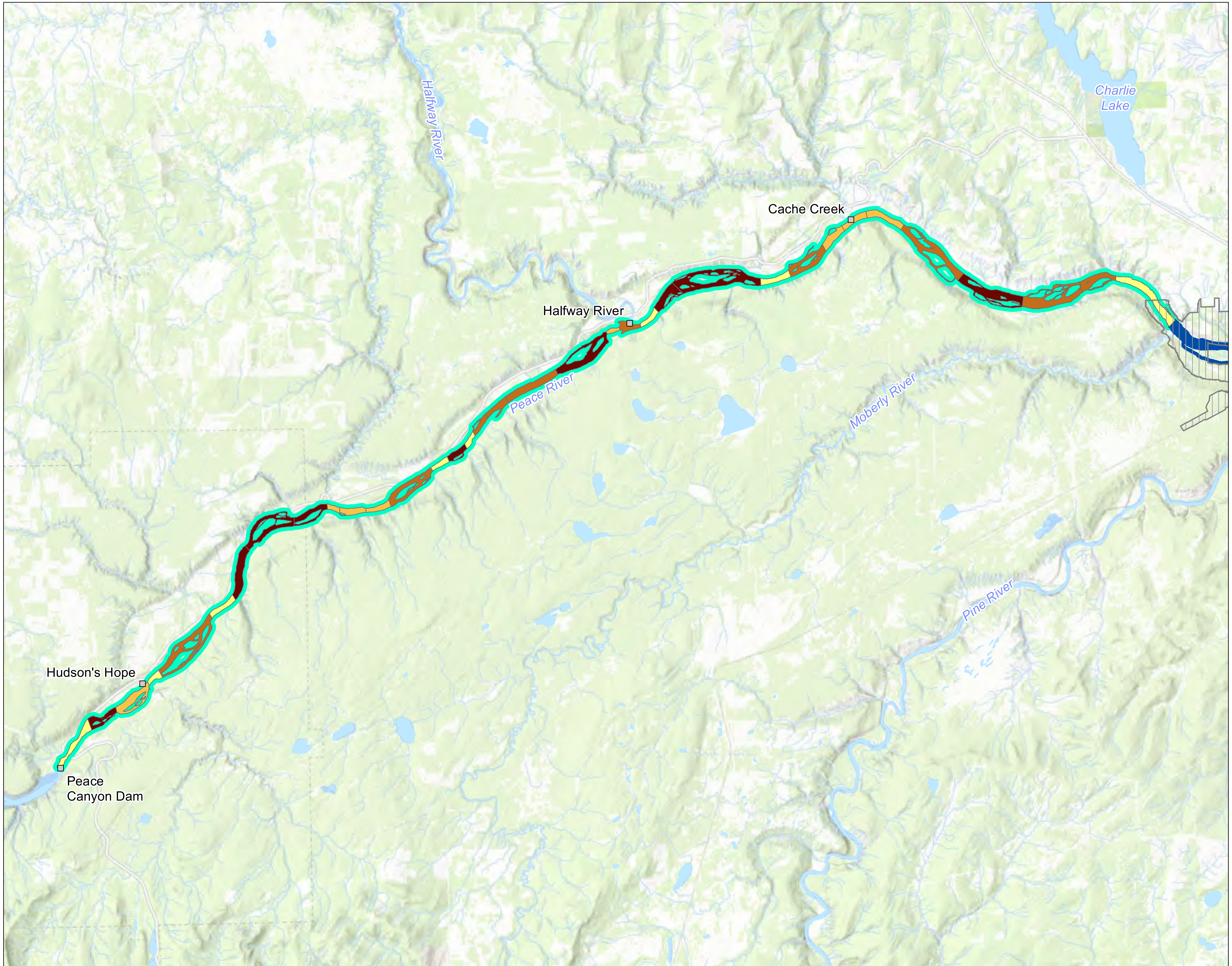
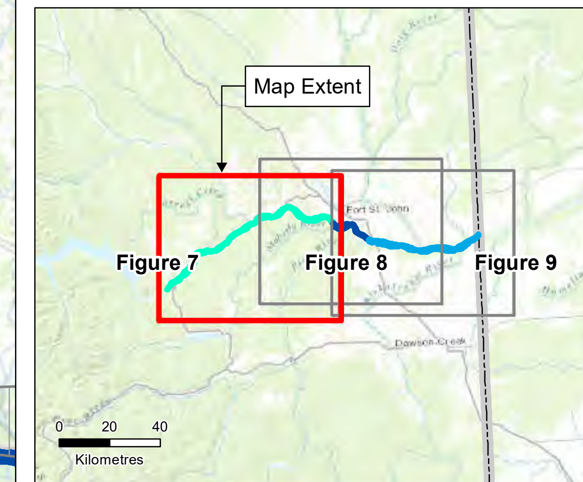
Mean Relative Density (birds/km/survey) of Spring Migrant Waterbirds in Reaches of the Inundation Impact Treatment Area based on Annual Means from 2017, 2018, and 2019





Legend

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

Waterbird Count per Kilometer per Survey

- 6 - 16
- 17 - 31
- 32 - 51
- 52 - 112

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 count values were classified using approximate Quantile Breaks.

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"

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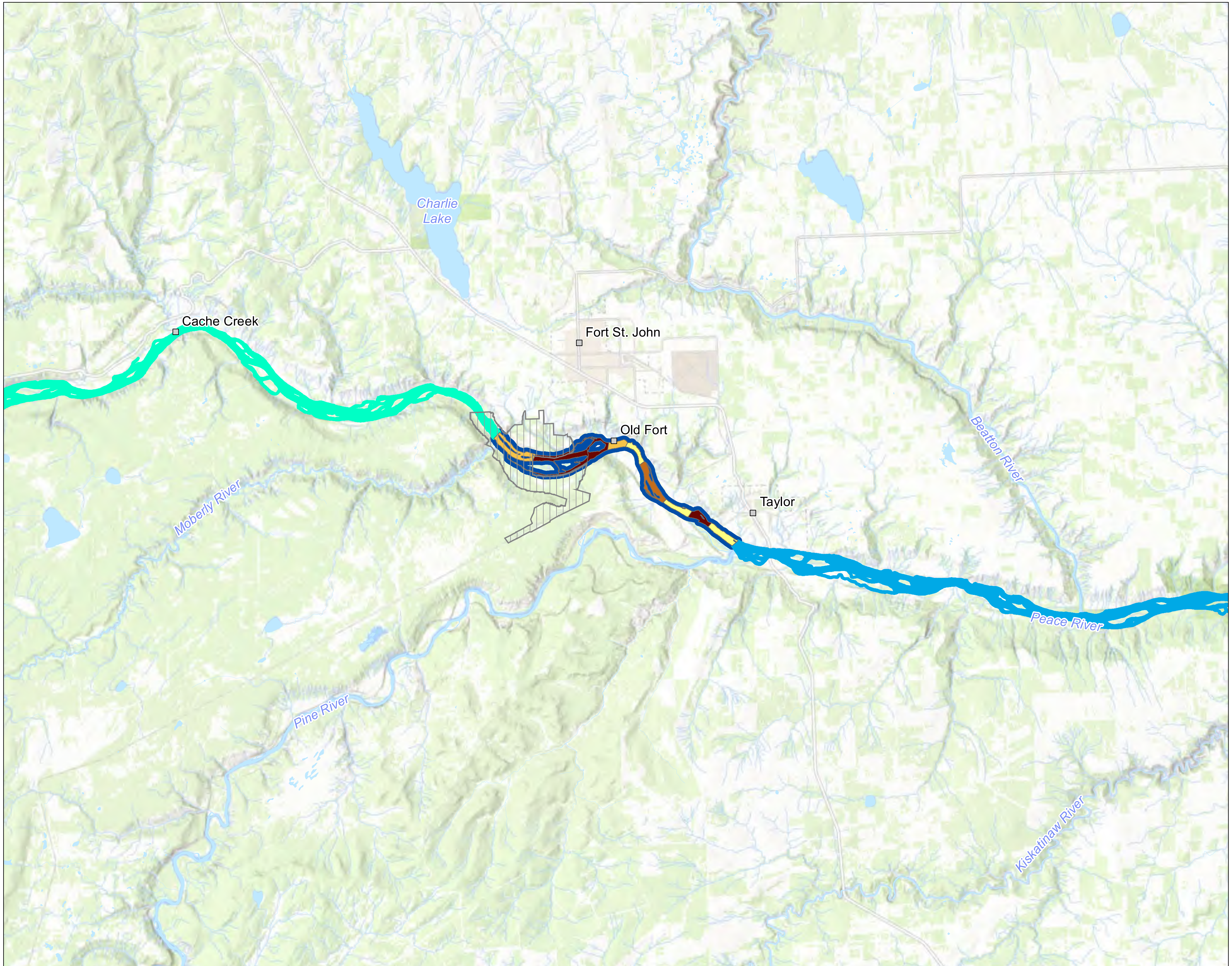
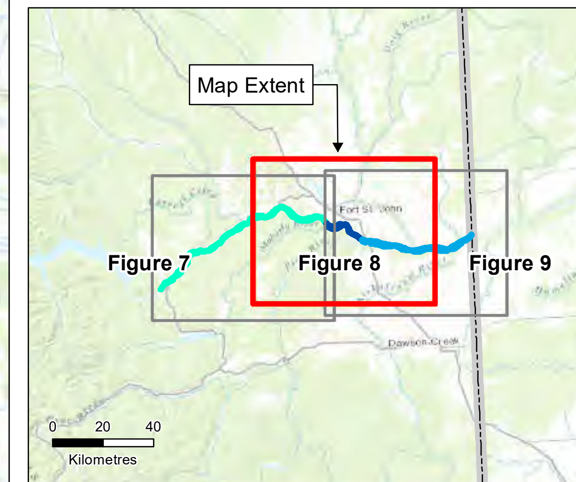
Migratory Waterbird Follow-up Monitoring Program
2019 Report
Site C, Peace River, BC

Mean Relative Density (birds/km/survey) of Spring Migrant Waterbirds in Reaches of the Flow Regime Impact Treatment Area based on Annual Means from 2017, 2018, and 2019





Legend

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

Waterbird Count per Kilometer per Survey

- 6 - 16
- 17 - 31
- 32 - 51
- 52 - 112

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 count values were classified using approximate Quantile Breaks.

Sources

- Basemap: ESRI World Topographic Base

N

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0 2 4 6 8 10
Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

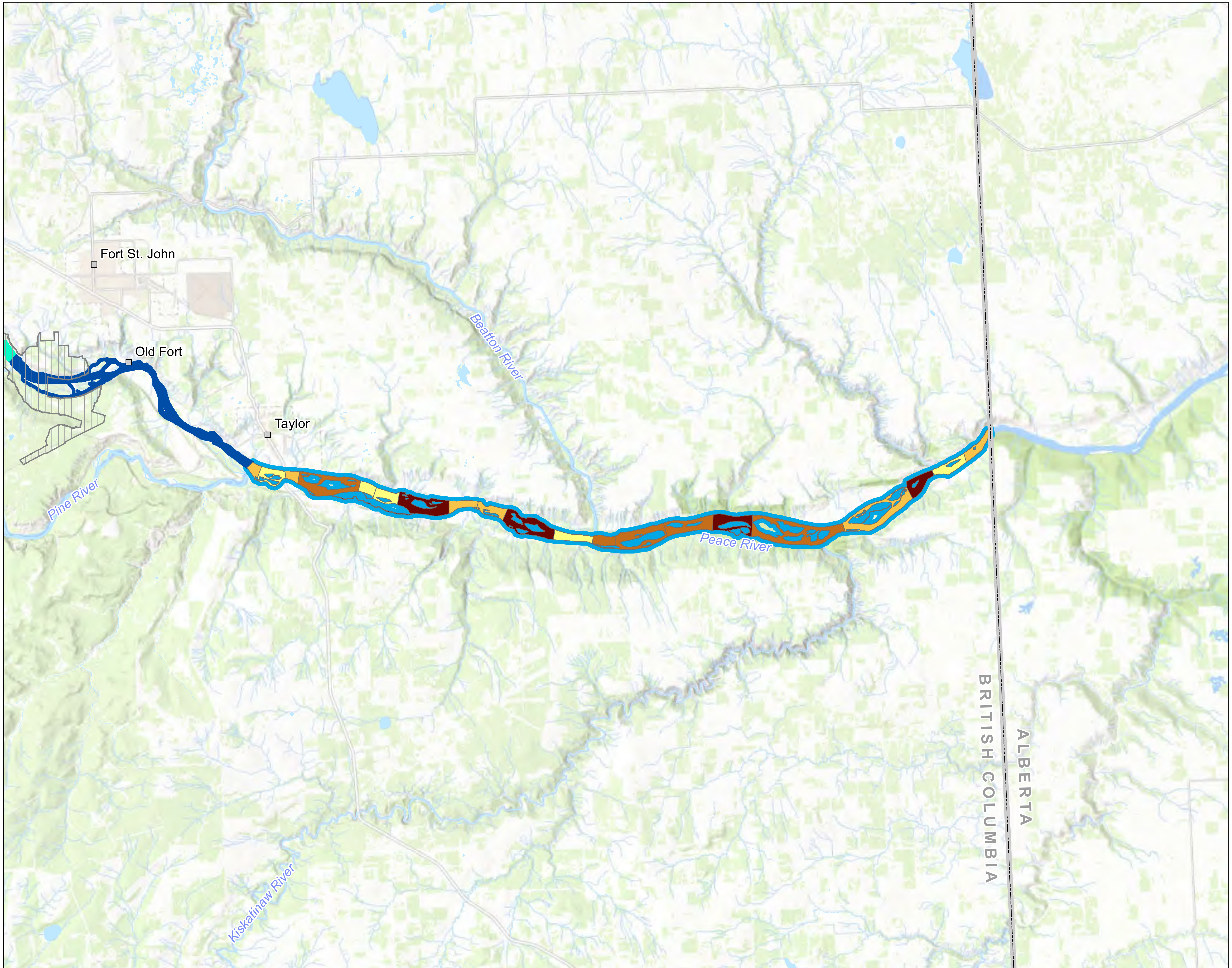
989619-07	Production Date: Feb 27, 2020	Figure 8

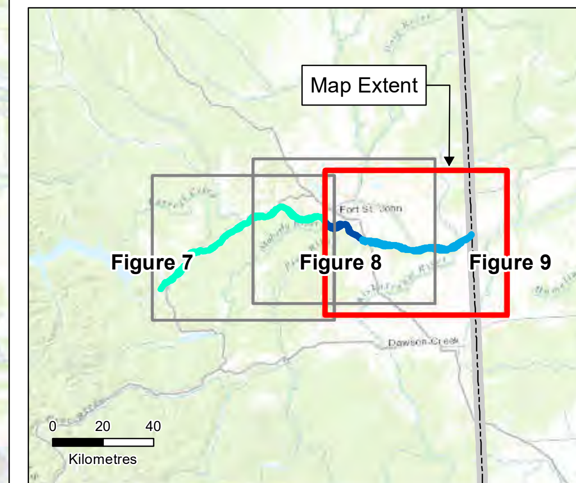
Hemmera An Ausenco Company

BC hydro

Migratory Waterbird Follow-up Monitoring Program
2019 Report
Site C, Peace River, BC

Mean Relative Density (birds/km/survey) of Spring Migrant Waterbirds in Reaches of the Control Treatment Area based on Annual Means from 2017, 2018, and 2019





Legend

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

Waterbird Count per Kilometer per Survey

- 6 - 16
- 17 - 31
- 32 - 51
- 52 - 112

Notes

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

Sources

- Basemap: ESRI World Topographic Base

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0 2 4 6 8 10
Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

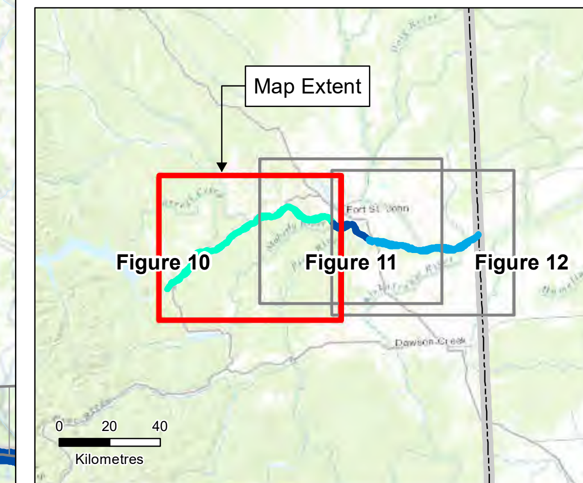
989619-07	Production Date: Feb 27, 2020	Figure 9

Hemmera An Ausenco Company | BC hydro

Path: S:\Geomatics\Projects\989619\07_waterfowl\mxd\MonitoringProgram2019\Fig9_989619_07_Waterbirds_SpringDensity_ControlArea_200227.mxd

Migratory Waterbird Follow-up Monitoring Program
2019 Report
Site C, Peace River, BC

Mean Relative Density (birds/km/survey) of Fall Migrant Waterbirds in Reaches of the Inundation Impact Treatment Area based on Annual Means from 2017, 2018, and 2019



Legend

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

Waterbird Count per Kilometer per Survey

- 0 - 8
- 9 - 15
- 16 - 50
- 51 - 502

Notes

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

Sources

- Basemap: ESRI World Topographic Base

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0 2 4 6 8 10
Kilometres

NAD 1983 UTM Zone 10N

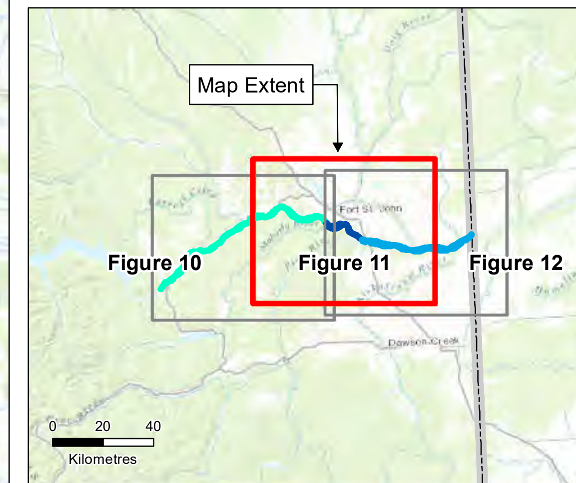
Page Size: 11" x 17"

989619-07	Production Date: Feb 27, 2020	Figure 10

Hemmera An Ausenco Company   BC hydro

Migratory Waterbird Follow-up Monitoring Program
2019 Report
Site C, Peace River, BC

Mean Relative Density (birds/km/survey) of Fall Migrant Waterbirds in Reaches of the Flow Regime Impact Treatment Area based on Annual Means from 2017, 2018, and 2019



Legend

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

Waterbird Count per Kilometer per Survey

- 0 - 8
- 9 - 15
- 16 - 50
- 51 - 502

Notes

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

Sources

- Basemap: ESRI World Topographic Base

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1:220,000

0 2 4 6 8 10

Kilometres

NAD 1983 UTM Zone 10N

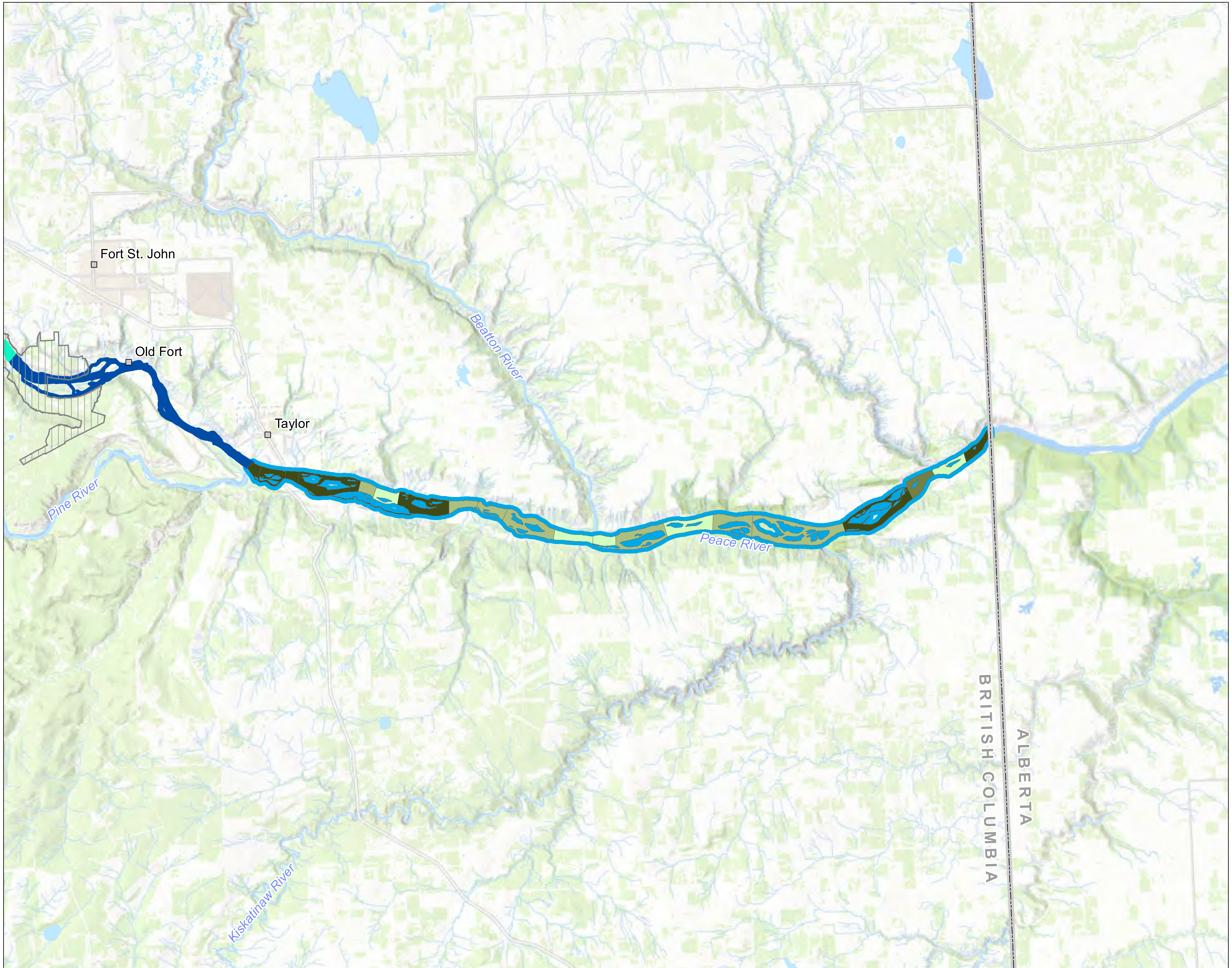
Page Size: 11" x 17"

989619-07	Production Date: Feb 27, 2020	Figure 11

Hemmera An Ausenco Company

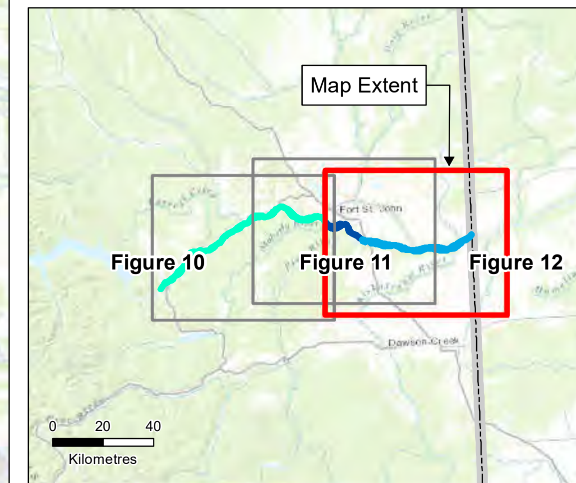
BC hydro

Path: S:\Geomatics\Projects\989619\07_waterfowl\mxd\MonitoringProgram2019\Fig11_989619_07_Waterbirds_FallDensity_FlowRegimeChangeImpactArea_200227.mxd



Migratory Waterbird Follow-up Monitoring Program
2019 Report
Site C, Peace River, BC

Mean Relative Density (birds/km/survey) of Fall Migrant Waterbirds in Reaches of the Control Treatment Area based on Annual Means from 2017, 2018, and 2019



Legend

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

Waterbird Count per Kilometer per Survey

- 0 - 8
- 9 - 15
- 16 - 50
- 51 - 502

Notes

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

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1:220,000

0 2 4 6 8 10
Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-07	Production Date: Feb 27, 2020	Figure 12

Hemmera
An Ausenco Company

BC hydro

4.1.5 Diversity

A total of 59 waterbird species were detected across the 2017, 2018, and 2019 waterbird surveys of the Peace River (**Table 9; Appendix A-1**). Dabbling ducks and piscivorous divers were the most species rich foraging guilds observed, followed by shorebirds (**Table 9**).

Table 9 Mean diversity metrics for waterbird foraging guilds on the Peace River across seasons and survey periods during, 2017, 2018, and 2019.

Foraging Guild	Spring species richness			Spring Mean	Fall species richness				Fall Mean
	Early	Middle	Late		Early	Early-Middle	Late-Middle	Late	
Benthic Feeding Divers	2.2	3.2	4.3	3.2	1.3	1.0	1.0	1.5	1.2
Dabbling Ducks	4.7	6.5	7.3	6.2	2.7	4.0	4.5	3.5	3.7
Gulls	0.0	1.7	3.3	1.7	3.8	3.5	3.5	3.5	3.6
Large Dabblers	2.5	1.8	2.2	2.2	1.5	2.3	2.5	2.0	2.1
Piscivorous Divers	1.5	3.0	3.5	2.7	2.2	2.8	3.3	2.0	2.6
Shorebirds	0.7	1.0	1.5	1.1	4.2	1.8	1.7	0.0	1.9
Total Species Richness	**11.5**	**17.2**	**22.2**	**16.9**	**15.7**	**15.5**	**16.5**	**12.5**	**15.0**
Species Evenness	**0.5**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.4**	**0.3**	**0.5**
Shannon-Wiener Index	**1.2**	**1.7**	**1.8**	**1.5**	**1.7**	**1.6**	**1.2**	**0.8**	**1.3**

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 incomplete survey rounds are excluded. Individual birds not identified to species are excluded from species richness totals and diversity calculations.

Due to unequal river reach lengths (i.e., unequal survey effort and sample sizes) across river reach habitat categories and treatment areas in the Peace River study area (**Table 5**), diversity indices cannot be compared directly across reach types or areas.

4.1.6 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 the 2017, 2018, and 2019 Peace River surveys:

- 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)

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

- 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).

Records of waterbird species at risk across years were generally few (i.e., 11 or fewer individuals), with the exception of surf scoter (157 individuals) and California gull (28 individuals) (**Appendix A-1**).

4.2 Transmission Line Wetland Surveys

4.2.1 Timing

In 2019, transect, standwatch and RPAS surveys were conducted on the Moberly Plateau and adjacent to the Site C transmission line ROW during spring (April 21 to May 24, 2019) and fall (August 10 to October 19, 2019) waterbird migrations (**Table 10**). Surveys were conducted during two survey periods in spring and four survey periods in fall over a total of 27 days (12 days in spring and 15 days in fall). Survey effort was evenly spaced over time within both spring and fall to sample waterbirds throughout their northward and southward migrations. No wetland surveys were conducted in the early spring survey period in 2017, 2018, or 2019 because wetlands were frozen and unavailable for waterbird foraging during that period (**Table 10**). Bioacoustic monitoring for marsh birds was conducted from May 19 through June 27 of 2017, from July 4 through July 23 of 2018, and from May 17 through August 1 of 2019 (**Table 13**).

Table 10 Wetland survey dates and periods during the 2017 through 2019 migratory waterbird follow-up monitoring program

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

4.2.2 Habitats

In 2019, 25 wetland stations were surveyed (**Figure 13**, **Figure 14**, **Figure 15**) encompassing a total of 19 open water areas surveyed by standwatch (6 stations) and RPAS (13 stations), 12 areas of sedge habitat and 12 areas of willow-sedge habitat (**Appendix C**). Stations from which standwatch data were compiled and summarized contained at least 75% open water habitat and were often surrounded by sedge habitat. Stations from which RPAS data were compiled contained more than 10% but less than 75% open water habitat along with variably flooded areas of sedge and willow-sedge habitat. Vegetated transects contained a minimum of 5 m width of sedge or willow-sedge habitat and surveys in these habitats did not consider birds observed within open water areas near the transects. Photos of each station showing aerial views or representative habitat are provided in **Appendix D**.

All survey stations were surveyed within each survey period with the exception of the early spring, when wetlands were still frozen, and late fall, when snow on the final survey day did not provide comparable conditions to other surveys (**Table 11**). A total of 326 surveys of open water, sedge, and willow-sedge habitat were conducted under appropriate survey conditions during 214 visits to wetland survey stations in 2019 (**Table 12, Appendix C**).

Table 11 Number of wetland stations surveyed by current methods adjacent the transmission line ROW by survey period and dominant habitat type during 2017, 2018, and 2019

Dominant Habitat Type	Year	Spring			Fall				Total
		Early	Middle	Late	Early	Middle-Early	Middle-Late	Late*	
Open water	*2017*	*Frozen*	2	2	4	4	4	0	16
	2018	*Frozen*	6	8	7	8	8	8	45
	2019	*Frozen*	8	8	8	8	8	4	44
Sedge	*2017*	*Frozen*	0	0	0	0	0	0	0
	2018	*Frozen*	10	14	13	14	14	14	79
	2019	*Frozen*	14	14	14	14	14	4	74
Willow-sedge	*2017*	*Frozen*	0	0	0	0	0	0	0
	2018	*Frozen*	3	3	3	3	3	3	18
	2019	*Frozen*	3	3	3	3	3	0	15
Total	**2017**	**0**	**2**	**2**	**4**	**4**	**4**	**0**	**16**
	2018	**0**	**19**	**25**	**23**	**25**	**25**	**25**	**142**
	2019	**0**	**25**	**25**	**25**	**25**	**25**	**8**	**133**

*10 cm of snow fell during the second day of the late fall survey period (October 19, 2019) covered all wetlands, and prevented completion of surveys under appropriate survey conditions

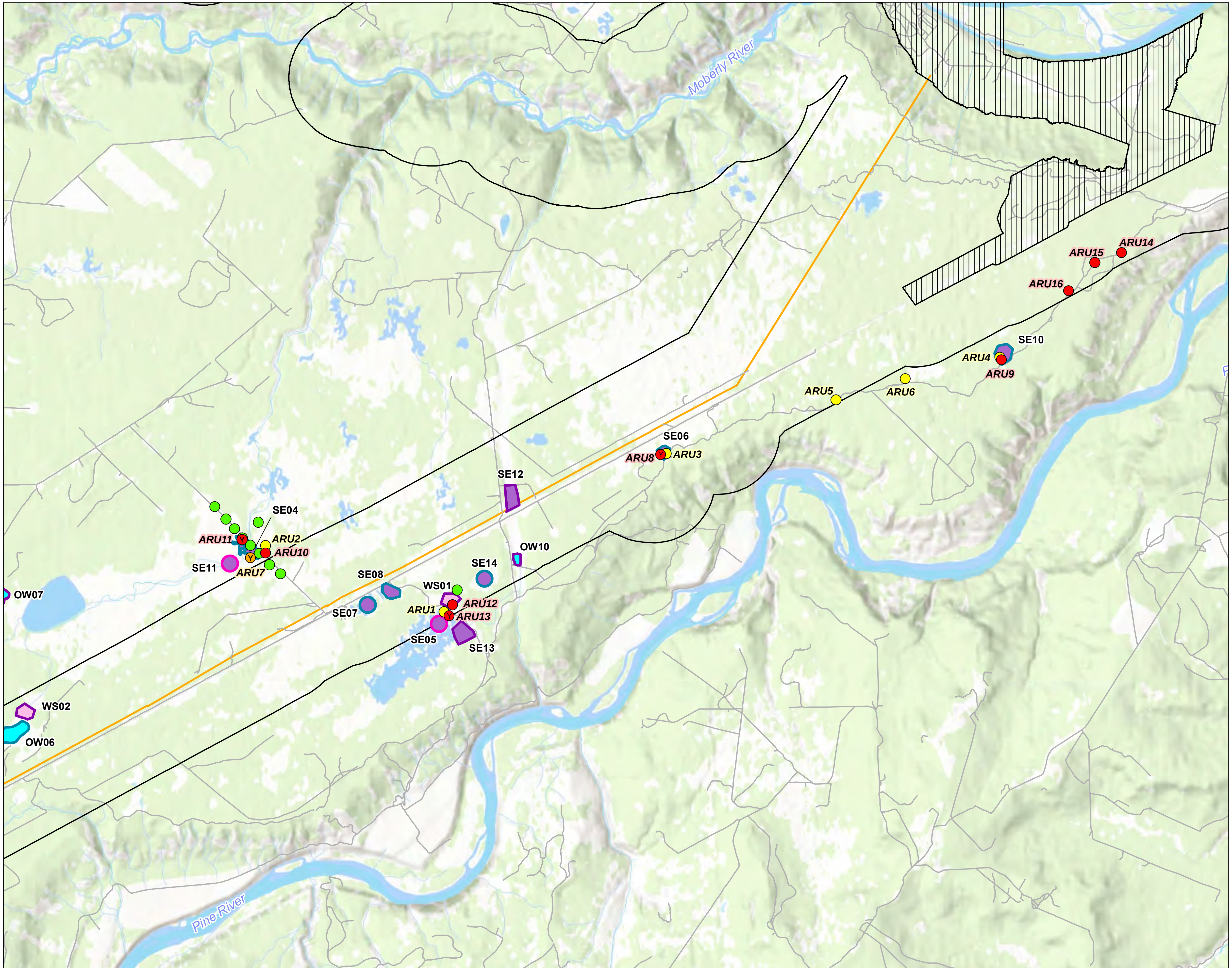
Table 12 Number of wetland surveys conducted using current methods adjacent the transmission line ROW by survey period and survey type during 2017, 2018, and 2019

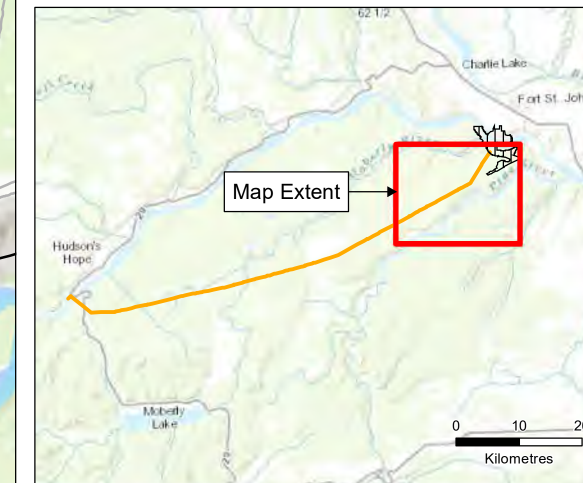
Survey Method	Year	Spring			Fall				Total
		Early	Middle	Late	Early	Middle-Early	Middle-Late	Late	
Standwatch (OW)	2017	*Frozen*	2	4	6	4	4	4	24
	2018	*Frozen*	8	12	6	11	12	6	55
	2019	*Frozen*	9	11	5	12	12	3	52
RPAS (OW,WS,SE)	2017	*Frozen*	0	0	0	0	0	0	0
	2018	*Frozen*	5*	6	10	16	13	10	60
	2019	*Frozen*	22	19	9	22	23	4	99
Transect (WS,SE)	2017	*Frozen*	0	0	0	0	0	0	0
	2018	*Frozen*	7*	44	32	38	44	35	200
	2019	*Frozen*	28	39	25	36	41	6	175
Total	**2017**	**0**	**2**	**4**	**6**	**4**	**4**	**4**	**24**
	2018	**0**	**20**	**62**	**48**	**65**	**69**	**51**	**315**
	2019	**0**	**71**	**119**	**81**	**124**	**133**	**58**	**326**

Note: *Few samples due to late thaw and associated snow and ice cover in vegetated wetlands.

Migratory Waterbird Follow-up Monitoring Program
2019 Report
Site C, Peace River, BC

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





Legend

- Site C LAA
- Proposed Dam Site
- Access / Service Road
- Transmission Line Right-of-Way
- 2019 Bioacoustic Monitoring Station
- 2018 Bioacoustic Monitoring Station
- 2017 Bioacoustic Monitoring Station
- Bioacoustic Monitoring Station with YERA Detected
- Historic YERA observations from eBird and Baseline Studies

Survey Station - Dominant Wetland Types

- Sedge (SE)
- Shallow open water (OW)
- Willow sedge (WS)

Survey Station - Sub-dominant Wetland Types

- Sedge (SE)
- Shallow open water (OW)
- Willow sedge (WS)

Notes

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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

N

1:60,000

0 0.5 1 1.5 2 2.5
Kilometres

NAD 1983 UTM Zone 10N

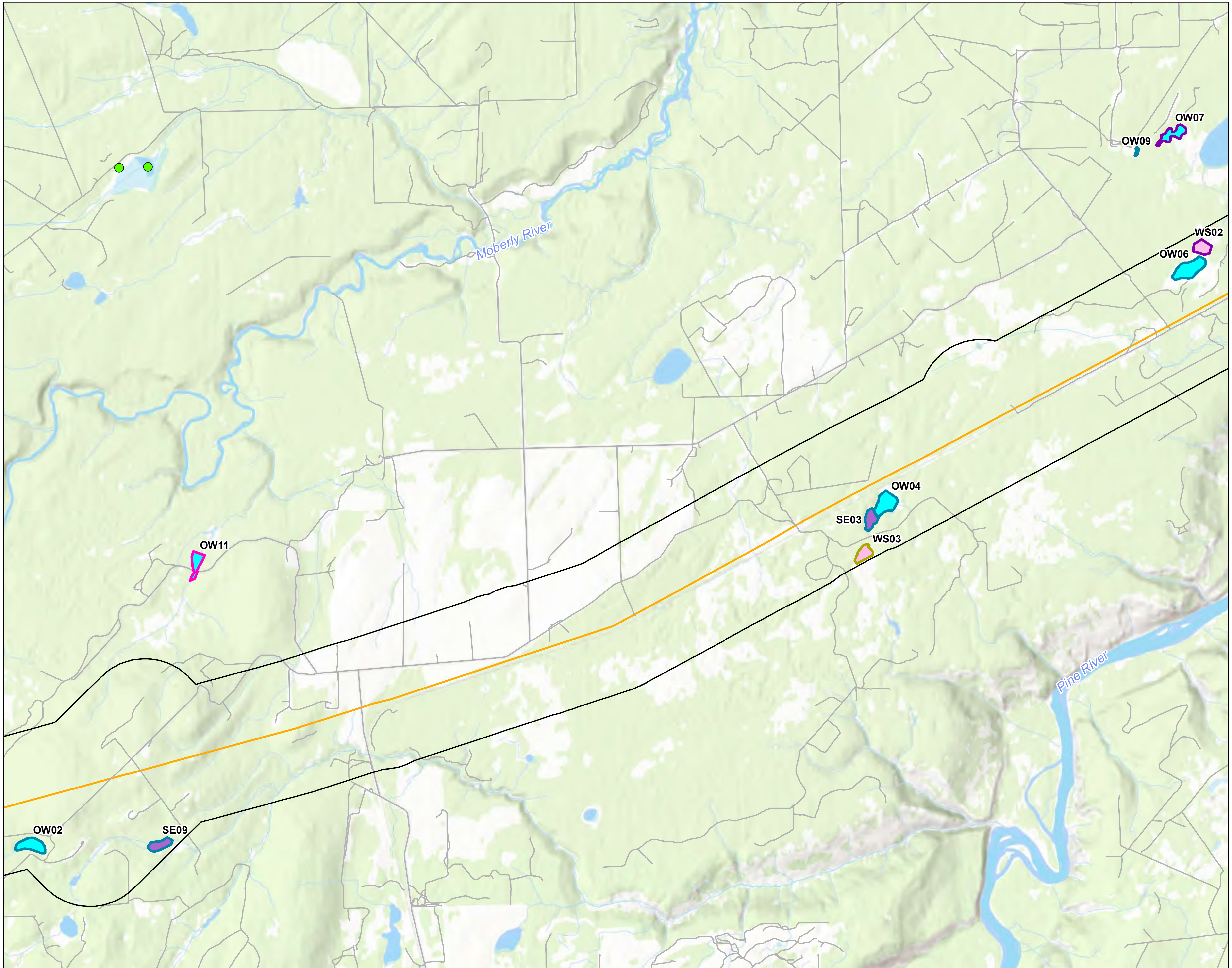
Page Size: 11" x 17"

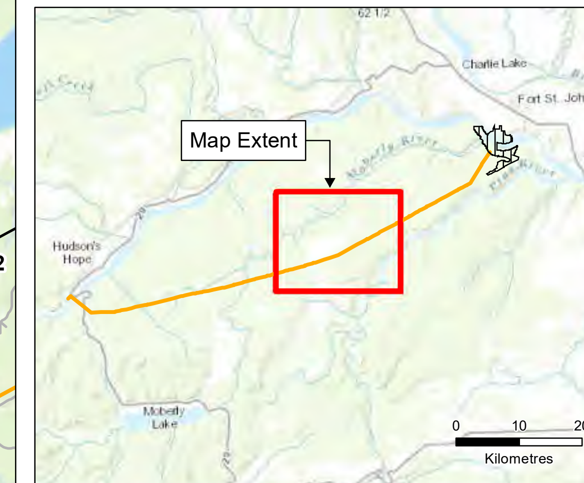
989619-07	Production Date: Feb 27, 2020	Figure 13

Hemmera
An Ausenco Company
BC hydro

Migratory Waterbird Follow-up Monitoring Program
2019 Report
Site C, Peace River, BC

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





Legend

- Site C LAA
- Access / Service Road
- Transmission Line Right-of-Way
- Historic YERA observations from eBird and Baseline Studies

Survey Station - Dominate Wetland Types

- Sedge (SE)
- Shallow open water (OW)
- Willow sedge (WS)

Survey Station - Sub-dominant Wetland Types

- Sedge (SE)
- Shallow open water (OW)
- Tamarack-sedge (TS)
- Willow sedge (WS)

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N

1:60,000

0 0.5 1 1.5 2 2.5
Kilometres

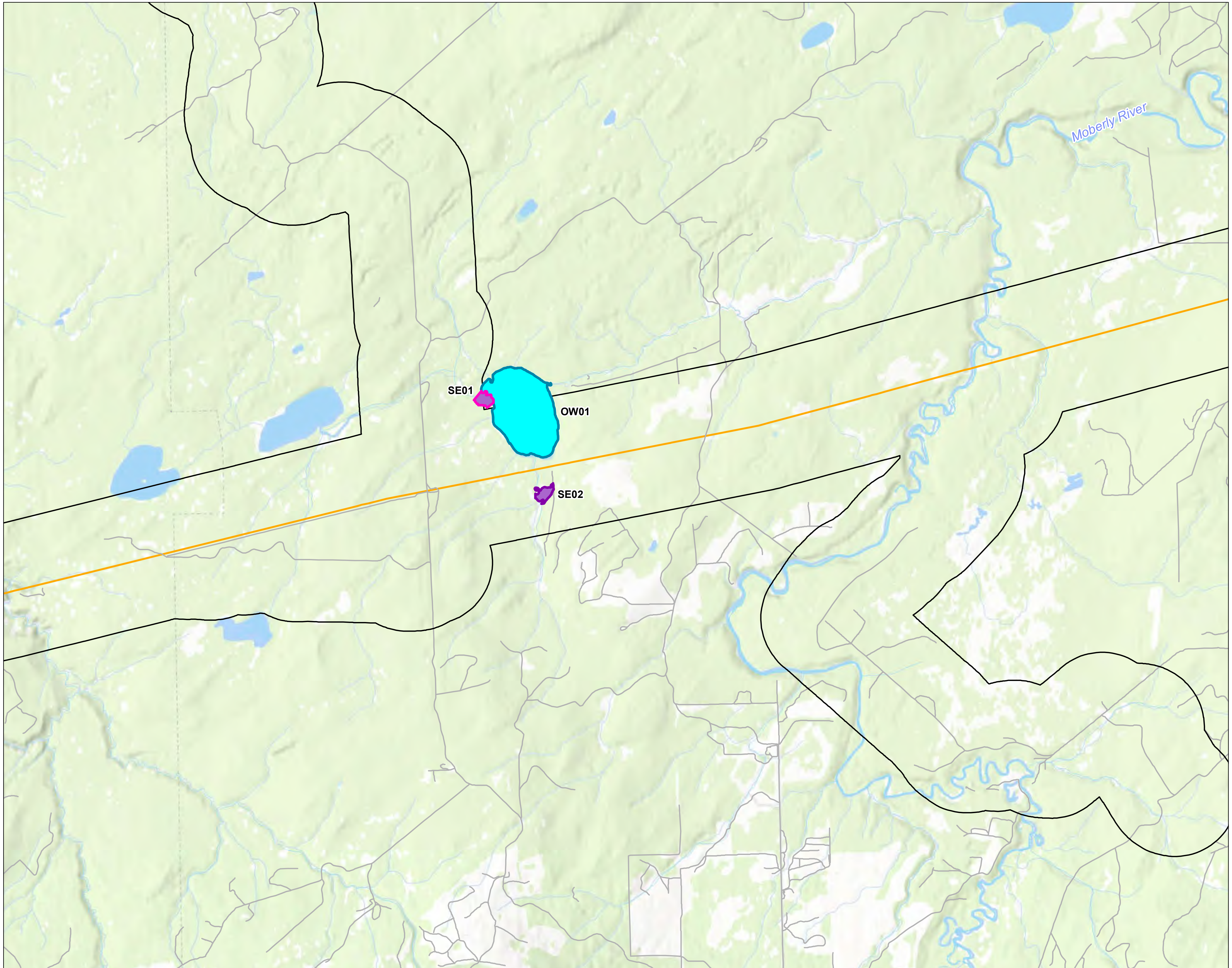
NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-07	Production Date: Feb 27, 2020	Figure 14

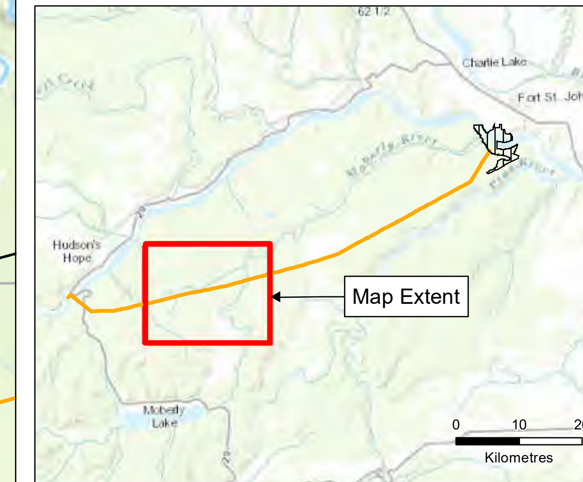
Hemmera An Ausenco Company

BC hydro



Migratory Waterbird Follow-up Monitoring Program
2019 Report
Site C, Peace River, BC

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



Legend

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

Survey Station - Dominate Wetland Types

- Sedge (SE)
- Shallow open water (OW)

Survey Station - Sub-dominant Wetland Types

- Sedge (SE)
- Shallow open water (OW)
- Willow sedge (WS)

Notes

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Sources

- Basemap: ESRI World Topographic Base

N

1:60,000

0 0.5 1 1.5 2 2.5
Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-07	Production Date: Feb 27, 2020	Figure 15

Hemmera An Ausenco Company · BC hydro

4.2.3 Autonomous Recording Units (ARU)

Bioacoustic monitoring with ARU devices was conducted at 16 sites and recorded acoustic data over a total of 221 survey nights during the 2017, 2018, and 2019 monitoring program (**Figure 13**). These included a total of 79 nights from six locations in 2017, 19 nights from one location in 2018, and 123 nights from nine locations in 2019 (**Table 13**). Sora were ubiquitous, having been detected at all sites in all years. No American bittern were observed in 2017, 2018, or 2019. Yellow rail was not detected in 2017, but was detected at the one site surveyed in 2018, and at three sites in 2019 (**Table 13**). Both yellow rail and sora were only detected at sites where sedge-dominated habitat was present.

Table 13 ARU location, habitat description, survey effort, and detections of target species during 2017, 2018, and 2019

ARU Survey ID	Latitude	Longitude	Habitat type	Wetland Survey Station	Deployment start and end date	Number of days[1]	SORA	YERA	AMBI
ARU-01	56.104658	-121.044231	Sedge and willow-sedge	SE-05 [2]	May 16 to May 28, 2017	12	Yes	No	No
ARU-02	56.115311	-121.090337	Sedge and upland forested	None	May 16 to May 28, 2017	12	Yes	No	No
ARU-03	56.126825	-120.985543	Sedge and edge of open water	SE-10	May 28 to Jun 12, 2017	14	Yes	No	No
ARU-04	56.139182	-120.898154	Sedge and upland forested	SE-06	May 28 to Jun 12, 2017	14	Yes	No	No
ARU-05	56.134144	-120.941172	Sedge	None	Jun 12 to Jun 27, 2017	15	Yes	No	No
ARU-06	56.136775	-120.923437	Sedge	None	Jun 12 to Jun 24, 2017	12	Yes	No	No
ARU-07	56.113610	-121.094496	Sedge	SE-04	Jul 4 to Jul 23, 2018	19	Yes	Yes	No
ARU-08	56.126888	-120.986697	Sedge, willow-sedge, upland forested	SE-06	May 17 to May 24, 2019	8	Yes	Yes	No
ARU-09	56.139104	-120.897989	Open water, upland forested	SE-10	May 17 to May 24, 2019	8	Yes	No	No
ARU-10	56.114216	-121.08986	Open water, sedge, upland forested	SE-04 [2]	May 17 to May 24, 2019	8	Yes	No	No
ARU-11	56.116424	-121.096006	Sedge, willow-sedge, upland forested	SE-04	May 24 to Jun 14, 2019	22	Yes	Yes	No
ARU-12	56.105986	-121.042059	Sedge, willow-sedge, upland forested	WS-01	May 24 to Jun 14, 2019	22	Yes	No	No
ARU-13	56.104382	-121.042940	Sedge, willow-sedge, upland forested	SE-05 [2]	May 24 to Jun 14, 2019	22	Yes	Yes	No
ARU-14	56.154077	-120.866156	Sedge, willow-sedge, upland forested	None	Jul 22 to Aug 1, 2019	11	Yes	No	No
ARU-15	56.152748	-120.872644	Sedge	None	Jul 22 to Aug 1, 2019	11	Yes	No	No
ARU-16	56.148765	-120.880178	Sedge	None	Jul 22 to Aug 1, 2019	11	Yes	No	No
					Totals	**221**	**16/16**	**4/16**	**0/16**

[1] Days ARU recorded acoustic data.
[2] Adjacent to wetland station.

4.2.4 Relative Abundance and Density

Summaries of relative abundance are provided below by survey method and the habitat types assessed by each method (**Table 14**, **Table 15**, **Table 16**). Waterbird abundances are summarized as mean densities for standwatch and RPAS surveys of open water, inundated sedge and willow-sedge habitats (i.e., mean across years of the number of individuals per area of inundated habitat in each survey period; **Table 14**, **Table 16**), and as mean relative abundance for transect surveys of sedge and willow-sedge habitats (**Table 15**).

Standwatch surveys detected 4,378 waterbirds across 2017, 2018, and 2019 (**Appendix A-1**), including 1,930 individuals in 2019, of which 89% were identified to species (**Appendix A-2**). Across 2017, 2018, and 2019 standwatch surveys, mean relative densities of waterbirds recorded during the late fall period were less than half of any other period during spring or fall. Waterbirds observed during standwatch surveys were primarily comprised of dabbling ducks and benthic feeding divers (**Table 14**).

Transect surveys of vegetated wetlands with low water levels detected 231 waterbirds within sedge and willow-sedge habitat during 2018 and 2019 (**Appendix A-1**), including 66 individuals during 2019 (**Appendix A-2**). Due to the close proximity of observations, 100% were identified to species in 2019. Mean relative abundances observed within vegetated habitats were higher during the late spring compared to other survey periods due to high numbers of dabbling ducks and shorebirds observed during that time. No waterbirds were detected during transect surveys on the Moberly Plateau and adjacent to the Site C transmission line during the late-middle or late fall **(Table 15**). Dabbling ducks were the most abundant foraging guild within vegetated wetlands during spring. Little else apart from dabbling ducks were detected during the middle spring survey period, but marsh birds and shorebirds were also observed in late spring. In fall, marsh birds and dabbling ducks were the only foraging guilds observed on transect surveys (**Table 15**).

In 2018 and 2019, RPAS surveys of open water habitat surrounded or interspersed with sedge, cattail, and willow-sedge habitat detected 883 waterbirds (**Appendix A-1**), including 685 individuals during 2019 surveys of which 62% were identified to species and 71% were identified to foraging guild (**Appendix A-2**). Mean relative densities of waterbirds were higher in early fall and lower in late fall compared to other survey periods (**Table 16**). Across foraging guilds, dabbling ducks were observed in the greatest densities and were observed during all survey periods. Large dabblers and benthic feeding divers were observed in all survey periods except late fall, when only dabbling ducks were found. Other foraging guilds were only observed in late spring (all foraging guilds) or early fall (piscivorous divers) (**Table 16**).

As mentioned previously, no surveys were conducted in the early spring because waterbirds are assumed to be absent due to wetlands being frozen and therefore unavailable as foraging habitat during that time.

Table 14 Mean relative density (waterbirds/ha/survey) of waterbird foraging guilds during 2017, 2018, and 2019 standwatch surveys at open water wetland stations with surrounding sedge habitat

Foraging Guild	Spring		Fall			
	Middle	Late	Early	Early-Middle	Late-Middle	Late
Benthic Feeding Divers	0.84	0.82	2.07	2.24	1.33	0.28
Dabbling Ducks	2.90	1.99	3.08	2.31	3.58	0.64
Gulls	0.04	0.00	0.01	0.00	0.00	0.00
Large Dabblers	0.36	0.19	0.04	0.08	0.07	0.01
Marsh Birds	0.02	0.01	0.02	0.13	0.00	0.00
Piscivorous Divers	0.02	0.11	0.21	0.19	0.18	0.11
Shorebirds	0.00	0.44	0.77	0.14	0.00	0.00
Unknown Waterbirds	0.00	0.01	0.29	0.06	0.56	0.18
Total	**4.18**	**3.56**	**6.49**	**5.16**	**5.72**	**1.21**

Note: 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.

Table 15 Mean relative abundance (waterbirds/km/survey) of foraging guilds during 2018 and 2019 transect surveys within vegetated wetland (sedge, willow-sedge) habitat

Foraging Guild	Spring		Fall			
	Middle	Late	Early	Early-Middle	Late-Middle	Late
Benthic Feeding Divers	0.0	0.0	0.0	0.0	0.0	0.0
Dabbling Ducks	2.1	7.5	0.2	1.1	0.0	0.0
Gulls	0.0	0.0	0.0	0.0	0.0	0.0
Large Dabblers	0.2	0.2	0.0	0.0	0.0	0.0
Marsh Birds	0.0	2.1	1.8	1.7	0.0	0.0
Piscivorous Divers	0.0	0.0	0.0	0.0	0.0	0.0
Shorebirds	0.2	4.1	0.0	0.0	0.0	0.0
Unknown Waterbirds	0.0	0.0	0.0	0.0	0.0	0.0
Total	**2.5**	**14.0**	**2.0**	**2.8**	**0.0**	**0.0**

Note: 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.

Table 16 Mean relative density (waterbirds/ha/survey) of foraging guilds during 2018 and 2019 RPAS surveys of open water, flooded sedge, and flooded willow-sedge habitat

Foraging Guild	Spring		Fall			
	Middle	Late	Early	Early-Middle	Late-Middle	Late
Benthic Feeding Divers	0.11	0.07	0.23	0.03	0.01	0.00
Dabbling Ducks	1.49	0.83	5.80	1.73	1.20	0.34
Gulls	0.00	0.02	0.00	0.00	0.00	0.00
Large Dabblers	0.26	0.09	0.33	0.22	0.12	0.00
Marsh Birds	0.00	0.02	0.00	0.00	0.00	0.00
Piscivorous Divers	0.00	0.05	0.10	0.00	0.00	0.00
Shorebirds	0.00	0.05	0.00	0.00	0.00	0.00
Unknown Waterbirds	1.28	1.49	3.03	0.92	1.08	0.06
Total	**3.14**	**2.62**	**9.49**	**2.91**	**2.41**	**0.40**

Note: 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.

4.2.5 Diversity

Standwatch surveys detected 43 waterbird species across 2017, 2018, and 2019 (**Appendix A-1**), including 36 species in 2019 (**Appendix A-2**). Transect surveys detected 16 species during 2018 and 2019, eight of which were observed in 2019. During the same years, RPAS surveys detected 18 species of waterbirds, all of which were observed in 2019 (**Appendix A**).

Weather related changes to access constraints resulted in variable survey effort across years and survey periods (**Table 12**). Comparisons of diversity across survey periods and years, and determination of inter-annual means as presented elsewhere in this report, would require further analyses (e.g., species rarefaction/ accumulation curves) to account for variation in survey effort. However, survey effort was applied evenly to all foraging guilds as all guilds were targeted during each survey. Thus, wetland survey data pooled across years provide comparable measures of species richness for foraging guilds as observed by each survey method (**Table 17**).

The most diverse foraging guilds observed by each survey method were dabbling ducks followed by piscivorous divers (**Table 17**). During transect surveys of vegetated wetlands, dabbling ducks and shorebirds were the most species rich guilds observed, with six and five species, respectively. No more than two species of any other guild were observed during transect surveys, with gulls and piscivorous divers entirely absent from survey records. During RPAS surveys, the dabbling duck foraging guild was the most diverse, with more than twice the number of species observed compared to other guilds (**Table 17**).

Table 17 Species richness of waterbird foraging guilds observed during transect, RPAS, and standwatch surveys of wetland habitats

Foraging Guild	Transect Surveys (2018-2019)		RPAS Surveys (2018-2019)		Standwatch Surveys 2017-2019	
	Number of Species	Proportion of Species	Number of Species	Proportion of Species	Number of Species	Proportion of Species
Benthic Feeding Divers	1	0.06	2	0.11	7	0.16
Dabbling Ducks	6	0.38	8	0.44	13	0.30
Gulls	0	0.00	1	0.06	3	0.07
Large Dabblers	2	0.13	2	0.11	2	0.05
Marsh Birds	2	0.13	1	0.06	2	0.05
Piscivorous Divers	0	0.00	3	0.17	10	0.23
Shorebirds	5	0.31	1	0.06	6	0.14

4.2.6 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 the 2017, 2018, and 2019 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)
- 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).

The most commonly observed species at risk within wetlands was surf scoter (65 individuals). Horned and eared grebe individuals and pairs were also regularly recorded (28 individuals of both species). Long-tailed duck was only observed in 2019 (23 individuals), primarily from a single flock of 17 males within open water habitat (**Appendix A-1**). Fewer than ten individuals of other species at risk were recorded within wetalnds across the three survey years.

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 abundance, density, 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 Assessments

Waterbird habitat associations (e.g., river reach and wetland types) and habitat characteristic data (e.g., TEM mapping and Peace River flow rates) collected during 2017, 2018, and 2019 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 five 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 reach 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 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 relative 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. The Inundation Impact area will be buffered from the effects of water discharge rates once the reservoir begins to fill, at which point waterbird abundance and diversity metrics in that area will no longer be influenced by this factor. However, reservoir levels can be recorded during this period and may also help to explain variations in the abundance and diversity of waterbirds.

5.2 Peace River Waterbird Surveys

Boat and RPAS surveys of the Peace River in 2017 through 2019 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 and RPAS surveys. Adapted RPAS survey techniques have helped to improve species identification with video of waterbirds recorded at lower heights, lower camera angles, standardized flight speed, and with longer periods of stable imagery. Evidence for these improvements in RPAS survey method is apparent in continuing declines in the proportion of unidentifiable birds observed by RPAS across years, with 30% unknown birds observed in 2019, compared to 41% and 33% in 2017 and 2018, respectively. Taken together with survey results from the riverboat, 89% of Peace River observations in 2017 through 2019 were identified to species (**Appendix A-1**). This represents a substantial improvement over survey methods applied prior to 2017 that were unable to detect shorebirds and had species identification rates under 80% (Hemmera 2017).

In 2019 Peace River surveys, 9,225 waterbirds were observed with RPAS as compared to 3,538 waterbirds observed by this method in 2018. The increase in RPAS records in 2019 is likely due to lower flow levels on the Peace River during 2019 which necessitated that backchannels typically surveyed by boat were more often surveyed by RPAS (i.e., greater RPAS survey effort in 2019).

The most common waterbird species 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 A-1**). The two most abundant species in 2019, Canada goose and mallard, were also the most abundant in 2018 and 2017 (**Appendix A-1; Appendix A-2;** Hemmera 2018, 2019). Surveys in 1996 and 1999 resulted in similarly high proportions of Canada geese, which made up over 50% of the observed waterbirds (Robertson 1999, Robertson and Hawkes 2000 and Hawkes et al. 2006).

Regarding foraging guilds, large dabblers were observed in the greatest abundances overall, while benthic feeding divers and shorebirds were the least-observed waterbird guilds on the Peace River. Timing of peak abundance for each waterbird foraging guild was variable. In spring, with the exception of shorebirds, most guilds arrived in the early to middle survey periods (i.e., during April) and were less numerous during the late survey period in May. In fall, variability in peak abundances across guilds was greater with shorebird and gull abundances peaking in the earlier half of the season (i.e., August through mid-September), large dabbler abundance peaking in the latter half (i.e., later September through October), dabbling ducks and benthic feeding diver abundance peaking in the middle, and piscivorous divers maintaing fairly consistent abundances throughout. Patterns of abundance for each foraging guild are described in detail below.

Large dabbling ducks, made up primarily of Canada geese (95% of 2019 records for this guild), were observed in abundances more than twice those of any other guild across survey periods (**Table 6**). The Peace River is functioning as a stopover site during spring and fall migration and as a breeding site for Canada geese. Large dabblers were found in the greatest abundances in the early spring (i.e., early April) and the latter survey periods in fall (i.e., late September and October). Their migration timing highlights the importance of the Peace River for the most numerous waterbird guild during survey periods closest to winter, including times when alternative habitats (e.g., wetlands) are less available due to freeze-thaw conditions. Their greatest abundances were found within Island and Off-channel reaches (**Table 7**). Off-channel and Island reaches have more low-lying vegetated habitats with shallower water compared to other reach types that offer forage for this herbivorous waterbird, as well as nesting habitat (Mowbray et al. 2002).

Dabbling ducks, primarily mallards (58% of records), were the second most abundant guild over 2017, 2018, and 2019 (**Table 6**, **Appendix A-1**). Mallards are known to be one of the first waterbirds to arrive during spring migration, usually just as ice on the Peace River thaws (Drilling et al. 2018). Survey results reported here indicate that mallards comprise large numbers on the Peace River in the early spring period (**Table 6**), though the highest numbers of dabbling ducks observed in the study area during spring were in the middle survey period, and during the middle-late period of the fall. Similar to large dabblers, dabbling ducks were observed in the highest densities within Off-channel and Island reach types where forage is available for primarily herbivorous species.

Gulls were the third most abundant waterbird guild overall, and the most abundant waterbird guild observed during fall of 2017, 2018, and 2019 (**Table 6**), indicating that they were primarily using the survey area as a fall migration stopover site. Gulls were most dense in Confluence reaches where they were approximately six times more abundant than any other guild (**Table 8**), specifically at the confluence of the Moberly River adjacent to the Site C dam construction zone. The most abundant gulls were the Franklin's, Bonaparte's and ring-billed gulls in 2019. Increases in the abundance of Franklin's gull in 2018 and 2019 may be due to the agitation of the river, upwelling invertebrates that Franklin's primarily feed on (Burger and Gochfeld 2009).

Piscivorous divers, primarily common merganser (*Mergus merganser*) (91% of individuals: **Appendix A-1**), were most abundant in the early spring (i.e., early April), with declining abundances through the later spring survey periods, and stable abundances through all fall survey periods. These results indicate the piscivorous divers primarily use the Peace River as a migratory stopover during the northward migration. The density of piscivorous divers was observed to be similar across reach types, indicating that features used to classify reach types (e.g., water depth, and flow rate) do not influence the distribution of these birds, and their prey (primarily fish) may be more evenly distributed across reach types as compared to other foraging guilds.

Benthic feeding divers, primarily goldeneye (*Bucephala sp.*) (80% of individuals: **Appendix A-1**), were observed in the highest abundances during early and middle spring survey periods (i.e., April through early May). Similar to piscivorous divers, abundances of benthic feeding divers declined later in the spring and remained low throughout the fall indicating their primary use of the Peace River occurs during northward migration. Higher mean densities of this foraging group were observed within Off-channel and Island reaches compared to Mainstem and Confluence reaches during spring, but little variation in densities was apparent across reach types during fall.

Shorebirds arrive in late spring (i.e., May) as they migrate through the region, and their peak abundances occur in the early fall (i.e., the first half of August). This timing for peak abundance, and the relatively low diversity, was consistent with survey results from previous years (Hemmera 2018, 2019). Mean shorebird densities within Island reaches were at least double those observed in other reach types in both spring and fall. The vast majority (80%) of shorebirds observed across survey years were spotted sandpiper (*Actitis macularia*), followed by semipalmated sandpiper (*Calidris pusilla*) for which a single flock of 115 individuals in 2019 accounts for all but two individuals and 6% of all shorebird records (**Appendix A-1**). In 2019, there were ten shorebird species observed, whereas in 2017 and 2018 there were six species recorded. Although greater species richness was observed in 2019, shorebird abundance in 2019 (699 individuals) was similar to that observed 2018 (627 individuals). These totals indicate that, with the exception of spotted sandpiper, the Peace River is not heavily used by migratory shorebirds, and do not support hypotheses of more substantial use (e.g., Blood 1979).

Peace River waterbird surveys from the spring of 2017 through 2019 found the highest mean relative abundance and densities in the 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 survey periods. During the middle spring period, early and late migrant waterbirds use the river for mate selection, as a migratory stopover, and for breeding. We 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), consistent with the findings of other researchers who found mid-May to be the peak of the spring migration (Siddle 2010).

Peace River surveys in the fall found that diversity, as measured by SWI, declined in the late-middle and late survey periods (i.e., after September 15) as compared to earlier survey periods. By late fall, the diversity of waterbirds is the lowest observed in any survey period. At this time in the year, waterbirds have mostly migrated through the region, and only late migrants and year-round resident species are present (Siddle 2010). Despite the relatively low abundances of other species guilds, large dabblers (primarily Canada goose) are found in some of their highest numbers during late fall and late-middle fall (i.e., after September 15). The only other survey period in which Canada goose was observed in similarly high abundances was early spring (i.e., early April).

The spatial distribution of waterbirds varied between seasons. In spring, waterbirds used Off-channel and Island reaches more than they did the Mainstem and Confluence reaches. In the fall, Island and Mainstem reaches were used less than Off-channel and Confluence reaches; this finding was driven by the high abundance of large dabblers (e.g., Canada goose) in Off-channel wetlands and diverse gull species using the open Confluence reach habitats.

Surf scoter was the only species at risk regularly observed during Peace River surveys, with 21 separate observations compared to six or fewer for all other species at risk. 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, and trumpeter swan may have been recorded as unknown swan species or pooled with records of trumpeter swan (*Cygnus buccinator*).

Peace River Summary

Data collected in 2017, 2018, and 2019 show that all habitats in the Peace River are used by waterbirds, with variations in timing, distribution and abundance for each of the guilds. Large dabbling ducks (Canada goose), gulls and dabbling ducks are the most commonly seen waterbirds, and shorebirds are only present in low numbers with most during the late spring and early fall. Off-channel, Island and Confluence habitats are used the most by waterbirds, with seasonal variation in the timing of peak presence in each type. A more-diverse suite of shorebirds was observed in 2019, potentially reflecting increased use of the Peace River valley across shorebird species in this year compared to 2017 and 2018; however overall numbers were similar to those observed in the previous two years.

The summary of data within treatment areas found that waterbird densities within the Control and Inundation Impact areas were generally representative of each other, therefore meeting a standard assumption for BACI study design and data analysis. The only exceptions to this were benthic feeding divers in the spring and gulls in the fall, when densities of these foraging guilds are low within the Control relative to Impact areas. The high numbers of gulls in the Flow Impact area and within Confluence river reaches, particularly during fall, explains some of the divergence in gull densities across treatment areas. This appears to be an artefact of construction activities, as most gulls are concentrated around disturbed habitat at the Project construction site. 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 and 2019. Additionally, three consecutive years of monitoring have been conducted at stations surveyed by standwatch methods since 2017. Taken together, these methods provide density and relative abundance data within all wetland habitats where waterbirds have been found to regularly occur.

Standardized survey area and distance for each of the methods has allowed for improved density metrics to be obtained, particularly for RPAS surveys. RPAS surveys in 2019 also used aerial imagery obtained from RPAS footage to provide season-specific estimates of the area of open water and flooded habitat, thereby improving estimates of density relative to previous estimates (reported in 2017 and 2018), based on the area of the survey station polygon. Results presented in this report also expand data summarization to include waterbirds' use of flooded sedge and willow-sedge habitat. Data summarization in 2017 and 2018 reported waterbirds observed within open water habitat during standwatch and RPAS surveys. Inclusion of RPAS and standwatch records of waterbirds within flooded sedge and flooded willow-sedge habitat in this report provides additional density and distribution data for waterbirds using wetland habitat along and adjacent to the transmission line ROW. Geographic representativeness was maintained in 2019 by the continued inclusion of surveys in the western portion of the study area (**Figure 17**), while focusing effort on habitat types with confirmed waterbird presence in 2017 and 2018.

A total of 44 species were detected during wetland surveys across habitat types in 2017 through 2019, including the 24 species that were detected during transmission line surveys in 2008, prior to the initiation of the current follow-up monitoring program (EIS, appendix R, part 4). The increased diversity recorded under the current monitoring efforts likely reflects increased survey effort relative to 2008 surveys as well as the more focused effort applied in 2019 to wetland habitats with regular waterbird occurrence.

Dabbling ducks were the most commonly recorded foraging guild in open water and flooded sedge and willow-sedge wetlands on the transmission line. Ring-necked duck (*Aythya collaris*), American wigeon (*Anas americana*), scaup species (*Aythya* spp.), green-winged teal (*Anas crecca*) and mallards were among the most-numerous species observed. In vegetated wetlands, dabbling ducks and large dabblers (e.g., mallards, green- and blue-winged teal [*Anas discors*], and northern shoveler [*Anas clypeata*]) were most abundant, followed by marsh birds (e.g., Wilson's snipe [*Gallinago delicata*] and sora [*Porzana carolina*]) and shorebirds (e.g., spotted sandpiper) (**Appendix A**). These observations 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 from 2017 and 2018 surveys (Hemmera 2018; 2019). 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 captured through RPAS or 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. Mean densities of waterbird foraging guilds were lowest in the late fall (i.e., after October 15) in 2019, as in 2017 and 2018. This likely reflects the increasingly cold conditions in mid-October, such as the snowfall (~10 cm) observed on October 19, 2019 and earlier southward migration of some species. During October surveys, some wetlands were observed to be frozen and hence unavailable to waterfowl, and snowfall in late October was accumulating[3]. The absence of waterbirds observed from transect surveys of vegetated sedge and willow-sedge wetlands during the late-middle and late survey periods indicates reduced vocalizations and/or presence of marsh birds and re-distribution of dabbling ducks into other habitat types during late September and October. The lack of waterbird observations from transect surveys during late fall brings into question the value of conducting such surveuys during the later fall survey periods. A third year of transect surveys in 2020 should provide more conclusive evidence on the value of continuing surveys during this time.

Observations of crepuscular marsh birds have been consistent across the wetlands during the three study years, indicating that sora are common, yellow rail are uncommon but regularly occur within relatively large areas of non-flooded sedge habitat, and American bittern are rare. These surveys satisfy monitoring objectives to document trends in the presence of yellow rail, American bittern, and sora. ARU bioacoustics monitoring confirms previous reports of yellow rail from call-playback and point-count surveys (Hilton et al. 2013). EIS studies also identified yellow rail in the Del Rio area (EIS, appendix R, part 4). American bittern was not detected during 2017, 2018, or 2019 waterbird surveys or as part of any other Site C wildlife studies. In addition to sora detections during wetland transect surveys, sora was consistently detected during ARU surveys in 2017, 2018 and 2019, corroborating previous detections from formal point count and waterfowl surveys conducted for the EIS in 2006 through 2011 (EIS, appendix R, part 4).

[3] Due to safety concerns, vegetated wetlands were not surveyed by transect in 2019 under freeze-thaw conditions (spring and fall), and any data collected during snowfall, rain, high winds was excluded from the survey results as per the surveying standards (**Section 2.3.2**).

6.0 CLOSING

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

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

Appendix A-1: Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances from 2017, 2018, and 2019

Foraging Guild	English Name	Scientific Name	River Survey Abundance [a]	Wetland Standwatch Abundance [b]	Wetland RPAS Abundance [c]	Wetland Transect Abundance [d]
Benthic Feeding Divers			**1952**	**782**	**21**	**1**
	Common Goldeneye	*Bucephala clangula*	1182	127	0	0
	Unknown Goldeneye	*Bucephala sp.*	240	21	0	0
	Bufflehead	*Bucephala albeola*	217	528	20	1
	Surf Scoter	*Melanitta perspicillata*	157	65	0	0
	Barrow's Goldeneye	*Bucephala islandica*	130	10	1	0
	White-winged Scoter	*Melanitta fusca*	12	1	0	0
	Ruddy Duck	*Oxyura jamaicensis*	7	8	0	0
	Harlequin Duck	*Histrionicus histrionicus*	3	0	0	0
	Unknown Scoter	*Mellanita sp.*	2	0	0	0
	Long-tailed Duck	*Clangula hyemalis*	1	22	0	0
	American Dipper	*Cinclus mexicanus*	1	0	0	0
Cranes and Herons			**56**	**0**	**0**	**0**
	Sandhill Crane	*Grus canadensis*	1	0	0	0
	Great blue heron	*Ardea herodias*	55	0	0	0
Dabbling Ducks			**14576**	**2034**	**490**	**125**
	Mallard	*Anas platyrhynchos*	8395	284	182	24
	Green-winged Teal	*Anas crecca*	1913	265	61	19
	American Wigeon	*Anas americana*	1284	220	34	0
	Northern Pintail	*Anas acuta*	776	39	0	4
	Unknown Dabbling Duck	*n/a*	711	0	20	0
	Blue-winged Teal	*Anas discors*	466	160	23	17
	Unknown Scaup	*n/a*	313	308	1	0
	Unknown Teal	*n/a*	214	16	43	1
	Northern Shoveler	*Anas clypeata*	184	63	33	55
	Ring-necked Duck	*Aythya collaris*	103	404	85	0
	American Coot	*Fulica americana*	87	25	7	5
	Lesser Scaup	*Aythya affinis*	40	89	0	0
	Gadwall	*Anas strepera*	32	10	1	0
	Greater Scaup	*Aythya marila*	28	41	0	0
	Canvasback	*Aythya valisineria*	15	106	0	0
	Redhead	*Aythya americana*	13	4	0	0
	Cinammon teal	*Anas cyanoptera*	2	0	0	0

Appendix A-1: Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances from 2017, 2018, and 2019

Foraging Guild	English Name	Scientific Name	River Survey Abundance [a]	Wetland Standwatch Abundance [b]	Wetland RPAS Abundance [c]	Wetland Transect Abundance [d]
Gulls and Surface Feeding Terns			**11445**	**147**	**1**	**0**
	Bonaparte's Gull	*Chroicocephalus philadelphia*	5115	140	0	0
	Franklin's Gull	*Leucophaeus pipixcan*	3192	1	0	0
	Ring-billed Gull	*Larus delawarensis*	1823	0	0	0
	Unknown Gull	*n/a*	789	0	0	0
	Mew Gull	*Larus canus*	324	6	0	0
	Herring Gull	*Larus argentatus*	167	0	0	0
	California Gull	*Larus californicus*	28	0	0	0
	Thayer's Gull	*Larus glaucoides*	6	0	0	0
	Sabine's Gull	*Xema sabini*	1	0	0	0
	Black Tern	*Chlidonias niger*	0	0	1	0
Large Dabblers			**26617**	**164**	**52**	**3**
	Canada Goose [e]	*Branta canadensis*	25668	47	23	1
	Trumpeter Swan [e]	*Cygnus buccinator*	908	117	29	2
	Cackling Goose	*Branta hutchinsii*	24	0	0	0
	Greater White-fronted Goose	*Anser albifrons*	13	0	0	0
	Tundra Swan	*Cygnus columbianus*	3	0	0	0
	Snow Goose	*Chen caerulescens*	1	0	0	0
Marsh Birds			**0**	**14**	**1**	**56**
	Wilson's Snipe	*Gallinago delicata*	0	8	0	34
	Sora	*Porzana carolina*	0	6	1	22
Piscivorous Divers			**2407**	**270**	**6**	**0**
	Common Merganser	*Mergus merganser*	2190	26	3	0
	Belted Kingfisher	*Megaceryle alcyon*	85	8	0	0
	Red-necked Grebe	*Podiceps grisegena*	32	58	0	0
	Unknown Merganser	*n/a*	29	0	0	0
	Common Loon	*Gavia immer*	21	78	0	0
	Hooded Merganser	*Lophodytes cucullatus*	20	16	0	0
	Red-breasted Merganser	*Mergus serrator*	8	6	0	0
	Eared Grebe	*Podiceps nigricollis*	6	28	0	0
	Unknown Loon	*n/a*	4	0	0	0
	Common Tern	*Sterna hirundo*	3	0	0	0
	Horned Grebe	*Podiceps auritus*	2	28	1	0
	Unknown Grebe	*n/a*	2	6	0	0
	Arctic Tern	*Sterna paradisaea*	2	0	0	0
	Pied-billed Grebe	*Podilymbus podiceps*	1	10	2	0
	Western Grebe	*Aechmophorus occidentalis*	1	6	0	0
	Unknown Tern	*n/a*	1	0	0	0

Appendix A-1: Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances from 2017, 2018, and 2019

Foraging Guild	English Name	Scientific Name	River Survey Abundance [a]	Wetland Standwatch Abundance [b]	Wetland RPAS Abundance [c]	Wetland Transect Abundance [d]
Shorebirds			**1846**	**132**	**3**	**46**
	Spotted Sandpiper	*Actitis macularius*	1486	11	0	35
	Semi-palmated Sandpiper	*Calidris pusilla*	117	0	0	0
	Unknown Shorebird	*n/a*	64	0	0	0
	Unknown Peep Sandpiper	*Calidris sp.*	34	0	0	0
	Killdeer	*Charadrius vociferus*	23	1	0	1
	Greater Yellowlegs	*Tringa melanoleuca*	21	10	2	2
	Unknown Sandpiper	*n/a*	21	5	1	0
	Lesser Yellowlegs	*Tringa flavipes*	17	21	0	4
	Least Sandpiper	*Calidris minutilla*	15	0	0	0
	Solitary Sandpiper	*Tringa solitaria*	13	19	0	4
	Unknown Yellowlegs	*Tringa sp.*	11	0	0	0
	Semi-palmated Plover	*Charadrius semipalmatus*	11	0	0	0
	Red-necked Phalarope	*Phalaropus lobatus*	11	0	0	0
	Long-billed Dowitcher	*Limnodromus scolopaceus*	2	0	0	0
	Pectoral Sandpiper	*Calidris melanotos*	0	65	0	0
Unknown Waterbirds			**4774**	**835**	**302**	**0**
	Unknown Duck	*n/a*	2621	812	83	0
	Unknown spp	*n/a*	2113	23	102	0
	Unknown Diving Bird	*n/a*	40	0	6	0
Grand Total			**63673**	**4378**	**876**	**231**

Notes:

[a] - Includes flying records as birds were often flushed to flight in front of boat. Includes all habitat types from the entire Peace River study area including all treatment areas.

[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 open water, and flooded sedge, and willow sedge habitat.

[d] - Excludes flying records. Includes records on waterbirds observed in sedge, and willow sedge habitat.

[e] - Trumpeter swans and Canada geese, include a small proportion of tundra swans and cackling geese, respectively.

Appendix A-2: Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances in 2019

Foraging Guild	English Name	Scientific Name	River Survey Abundance [a]	Wetland Standwatch Abundance [b]	Wetland RPAS Abundance [c]	Wetland Transect Abundance [d]
Benthic Feeding Divers			**351**	**428**	**21**	**0**
	Common Goldeneye	*Bucephala clangula*	135	98	0	0
	Surf Scoter	*Melanitta perspicillata*	101	39	0	0
	Unknown Goldeneye	*Bucephala sp.*	55	6	0	0
	Bufflehead	*Bucephala albeola*	43	248	20	0
	Barrow's Goldeneye	*Bucephala islandica*	9	7	1	0
	White-winged Scoter	*Melanitta fusca*	4	0	0	0
	Ruddy Duck	*Oxyura jamaicensis*	3	8	0	0
	Long-tailed Duck	*Clangula hyemalis*	1	22	0	0
Cranes and Herons			**56**	**0**	**0**	**0**
	Sandhill Crane	*Grus canadensis*	55	0	0	0
	Great blue heron	*Ardea herodias*	1	0	0	0
Dabbling Ducks			**5552**	**992**	**408**	**30**
	Mallard	*Anas platyrhynchos*	3116	67	136	15
	Green-winged Teal	*Anas crecca*	898	106	42	5
	Unknown Dabbling Duck	*n/a*	711	0	20	0
	American Wigeon	*Anas americana*	411	58	31	0
	Unknown Scaup	*n/a*	134	141	1	0
	Ring-necked Duck	*Aythya collaris*	91	343	85	0
	Northern Shoveler	*Anas clypeata*	64	35	23	1
	Northern Pintail	*Anas acuta*	51	39	0	0
	Unknown Teal	*n/a*	45	0	43	0
	Blue-winged Teal	*Anas discors*	24	15	19	9
	Lesser Scaup	*Aythya affinis*	5	46	0	0
	Gadwall	*Anas strepera*	2	0	1	0
	Canvasback	*Aythya valisineria*	0	96	0	0
	Greater Scaup	*Aythya marila*	0	33	0	0
	American Coot	*Fulica americana*	0	13	7	0
Gulls			**4014**	**134**	**1**	**0**
	Franklin's Gull	*Leucophaeus pipixcan*	2648	0	0	0
	Ring-billed Gull	*Larus delawarensis*	430	0	0	0
	Bonaparte's Gull	*Chroicocephalus philadelphia*	323	128	0	0
	Unknown Gull	*n/a*	256	0	0	0
	Mew Gull	*Larus canus*	204	6	0	0
	Herring Gull	*Larus argentatus*	145	0	0	0
	Thayer's Gull	*Larus glaucoides*	6	0	0	0
	California Gull	*Larus californicus*	1	0	0	0
	Sabine's Gull	*Xema sabini*	1	0	0	0
	Black Tern	*Chlidonias niger*	0	0	1	0
Large Dabblers			**11806**	**54**	**46**	**1**
	Canada Goose [e]	*Branta canadensis*	11240	20	23	1
	Trumpeter Swan [e]	*Cygnus buccinator*	527	34	23	0
	Cackling Goose	*Branta hutchinsii*	24	0	0	0
	Greater White-fronted G	*Anser albifrons*	13	0	0	0
	Tundra Swan	*Cygnus columbianus*	2	0	0	0

Appendix A-2: Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances in 2019

Foraging Guild	English Name	Scientific Name	River Survey Abundance [a]	Wetland Standwatch Abundance [b]	Wetland RPAS Abundance [c]	Wetland Transect Abundance [d]
Marsh Birds			**0**	**2**	**1**	**32**
	Wilson's Snipe	*Gallinago delicata*	0	2	0	26
	Sora	*Porzana carolina*	0	0	1	6
Piscivorous Divers			**808**	**159**	**6**	**0**
	Common Merganser	*Mergus merganser*	742	3	3	0
	Belted Kingfisher	*Megaceryle alcyon*	33	4	0	0
	Unknown Merganser	*n/a*	17	0	0	0
	Red-necked Grebe	*Podiceps grisegena*	6	44	0	0
	Common Loon	*Gavia immer*	4	40	0	0
	Common Tern	*Sterna hirundo*	3	0	0	0
	Red-breasted Merganse	*Mergus serrator*	2	6	0	0
	Pied-billed Grebe	*Podilymbus podiceps*	1	8	2	0
	Horned Grebe	*Podiceps auritus*	0	28	1	0
	Hooded Merganser	*Lophodytes cucullatus*	0	14	0	0
	Western Grebe	*Aechmophorus occidentalis*	0	6	0	0
	Unknown Grebe	*n/a*	0	4	0	0
	Eared Grebe	*Podiceps nigricollis*	0	2	0	0
Shorebirds			**699**	**105**	**3**	**3**
	Spotted Sandpiper	*Actitis macularius*	457	9	0	0
	Semi-palmated Sandpip	*Calidris pusilla*	117	0	0	0
	Unknown Peep Sandpip	*Calidris sp.*	31	0	0	0
	Greater Yellowlegs	*Tringa melanoleuca*	18	0	2	0
	Lesser Yellowlegs	*Tringa flavipes*	17	20	0	3
	Least Sandpiper	*Calidris minutilla*	15	0	0	0
	Semi-palmated Plover	*Charadrius semipalmatus*	11	0	0	0
	Unknown Yellowlegs	*Tringa sp.*	11	0	0	0
	Killdeer	*Charadrius vociferus*	7	0	0	0
	Unknown Sandpiper	*n/a*	6	5	1	0
	Unknown Shorebird	*n/a*	6	0	0	0
	Long-billed Dowitcher	*Limnodromus scolopaceus*	2	0	0	0
	Solitary Sandpiper	*Tringa solitaria*	1	6	0	0
	Pectoral Sandpiper	*Calidris melanotos*	0	65	0	0
Unknown Waterbirds			**1878**	**56**	**198**	**0**
	Unknown Duck	*n/a*	1020	49	82	0
	Unknown spp	*n/a*	826	7	111	0
	Unknown Diving Bird	*n/a*	32	0	5	0
Grand Total			**25164**	**1930**	**684**	**66**

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 open water, and flooded sedge, and willow sedge habitat.

[d] - Excludes flying records. Includes records on waterbirds observed in sedge, and willow sedge habitat.

[e] - Trumpeter swans and Canada geese, include a small proportion of tundra swans and cackling geese, respectively.