Peace Project Water Use Plan

WILLISTON RESERVOIR WETLAND HABITAT MONITORING

Implementation Year 9

Reference: GMSMON-15

Study Period: April 2019 to November 2019

LGL Limited environmental research associates
9768 Second Street
Sidney, BC V8L 3Y8

January 23, 2020

EA3901

PEACE PROJECT WATER USE PLAN

Program No. GMSMON-15

Williston Reservoir Wetland Habitat Monitoring




Final Report Year 9 (2019)

Prepared for

BC Hydro

BC Hydro Generation
Peace River Water Use Plan
6911 Southpoint Drive
Burnaby, BC

BC Hydro Reference # EC13-490459

Prepared by:

Marc V. d'Entremont, PhD, R.P. Bio., Nathan Hentze, M.Sc., Krysia Tuttle, M.Sc., R.P. Bio, Shane Johnson, B.Sc. and Lucia Ferreria, B.Sc.

LGL Limited environmental research associates

Technical Contact: Marc V. d'Entremont, PhD, R.P. Bio.
mdentremont@lgl.com; 1.250.656.0127

January 23, 2020

LGL LIMITED environmental research associates

Suggested Citation:

d'Entremont, M.V., N. Hentze, K. Tuttle, S. Johnson, and L. Ferreria. 2020. GMSMON-15: Williston Reservoir Wetland Habitat Monitoring. Year 9 Annual Report – 2019. LGL Report EA3901. Unpublished report by LGL Limited environmental research associates, Sidney, B.C for BC Hydro Generations, Water License Requirements, Burnaby, B.C. 59 pp + Appendices.

Cover photos:

From left to right: Airport Lagoon, Western Toad (*Anaxyrus boreas)* tadpoles in Beaver Pond, Habitat diversity, Common Loons (*Gavia immer*). All photos © Guy Monty, LGL Limited.

EXECUTIVE SUMMARY

Under project GMSWORK-17 (Williston Reservoir Trial Wetlands), BC Hydro selected two Wetland Demonstrations Sites (WDS) for detailed design and construction in the Parsnip Arm of the Williston Reservoir to improve foreshore habitat for fisheries, wildlife, and riparian areas. The two sites are identified as Airport Lagoon and Beaver Pond. At Airport Lagoon, two 1200 mm diameter culverts with an invert elevation of approximately 664.5 masl, along a causeway at the southern end of the lagoon, were replaced with new 1200 m diameter culverts with staggered invert elevations, starting at 666.99 to 667.05 masl. The objective of this treatment was to create 27 to 34 ha of permanently wetted habitat upstream of the causeway. At Beaver Pond, a water control structure was constructed, approximately 3 m in height with an invert elevation of 667.25 masl, at the inlet to the pond. This created a 0.3 ha inundated area when reservoir levels are below 667.25 masl. Monitoring the effectiveness of these wetland demonstration projects in improving fish and wildlife habitat on the reservoir is being completed under GMSMON-15 Williston Reservoir Wetland Habitat Monitoring. GMSMON-15 is a 10-year monitoring program designed to determine the response of selected indicator groups (i.e., waterfowl, songbirds, amphibians, and vegetation) to the wetland enhancements. Fish populations were also identified for monitoring as fish were observed at both of the selected demonstration sites.

Four management questions and associated hypotheses were developed at the commencement of GMSMON-15 to direct the study design and monitoring program. This report presents the results of the ninth year of the program. The ability to observe possible effects of wetland enhancement depends upon the availability of robust occurrence data (i.e., multiple confirmations of species identifications over multiple years). In 2019, species from all indicator groups were observed.

Vegetation: Terrestrial habitat classifications at Airport Lagoon, generated in 2016 have remained relatively stable over time, with little change in species composition of each community (i.e., the same dominant species can be used to define each community). However, the area and coverage of these communities has changed in the past two years. The biggest changes were a decrease in the area coverage for Basin Moss and Basin Smartweed and an increase in the coverage of Shoreline Driftwood (i.e., coarse woody debris). The predominant changes in habitat structure between 2016 and 2018 at Beaver Pond included small increases in the area of Basin Crypantha and the coverage of water surface (i.e., streams and ponds). This resulted in small decreases in other habitat classes, but most notable was the 1.7% reduction in the area of shoreline clay.

At Airport Lagoon, 59 herb species were recorded across 12 survey transects. The most common species detected were *Persicaria amphibia* (water smartweed), *Potentilla norvegica* (Norweigan cinquefoil) and *Calamagrostis canadensis* (bluejoint). Three species of moss were recorded on nine of the transects with the highest coverage being present on transect AL-4 where *Drepanocladus aduncus* (common hook moss) was present. Shrubs species were predominantly willow (*Salix* sp.) and their coverage along the transects was relatively low. Trace amounts of sapling regeneration for *Pinus contorta* (lodgepole pine) and *Populus tremuloides* (trembling aspen) was present on two transects. At Beaver Pond, 45 herb species were recorded across the five transects. The most common species detected were *Potentilla norvegica* (Norweigan cinquefoil), *Equisetum arvense* (common horsetail), and *Carex lenticularis* (lakeshore sedge). Four species of moss were recorded on the transects with the highest coverage being present on transect BP-1. Three shrub species were recorded, which

were predominantly willow species. One *Pinus contorta* (lodgepole pine) seedling was recorded. Vegetation species identified in the terrestrial components of the wetlands can be classified as both terrestrial plant species and aquatic plant species, which provides evidence of annual and/or frequent flooding. This flooding likely influences the density, diversity and spatial extent of vegetation at the enhancement sites.

At Airport Lagoon the aquatic macrophyte community is relatively well developed in the shallower portions of the wetland; however, this community type remains poorly developed at Beaver Pond. Eleven species of aquatic plants were recorded at Airport Lagoon. The frequency ranged from 1.7% for *Hippuris vulgaris* (mare's tail) to a high of 80.0% for *Myriophyllum sibiricum* (Siberian water-milfoil). Sampling depths were between 20 cm and 240 cm. Four aquatic plant species were recorded at Beaver Pond in 2019: *Potamogeton foliosus* and *Ranunculus aquatilis* has the highest frequencies. The majority of the aquatic vegetation samples were collected at depths between 50 cm and 100 cm.

Waterfowl and Shorebirds: Three replicates of waterfowl and shorebird surveys were completed at Airport Lagoon and only two replicates were completed at Beaver Pond. At Airport Lagoon, 27 individuals from five species of shorebirds and 13 waterfowl species, totaling 690 individuals, were recorded. At Beaver Pond, 14 individuals from four species of shorebirds and only two waterfowl species were recorded. Species diversity for shorebirds was highest in June, whereas it was highest for waterfowl in April. Likewise, for the number of individuals observed; more waterfowl were using the Airport Lagoon in April and numbers declined in May and June. Conversely, shorebird numbers were highest in June compared to the previous months. It is expected that waterfowl would use Airport Lagoon as stopover habitat in subsequent years.

Songbirds: At Airport Lagoon, 42 songbird species (365 detections of 473 individuals) were recorded. The ten most frequently detected species accounted for 57.8% of all detections and comprised representatives from five bird families: sparrows (4 species), swallows (1 species), warblers (2 species), thrushes (2 species) and vireos (1 species). Savannah Sparrow (*Passerculus sandwichensis*) was the most frequently detected songbird (40 detections). Forest habitat types had higher species richness and diversity than the drawdown zone or shrub habitats. At Beaver Pond, 23 species (84 detections of 86 individuals) were recorded. Eight bird families were represented by observations at Beaver Pond including warblers (7 species), sparrows (5 species), flycatchers (4 species), thrushes (3 species), vireos, kinglets, swallows, and chickadees (each with 1 species). Drawdown zone habitat types had lower species richness and diversity than forest or shrub habitats, neither of which significantly differed from each other.

Amphibians: In 2019, three species of amphibian were recorded: Western Toad (*Anaxyrus boreas*), Columbia Spotted Frog (*Rana luteiventris*) and Wood Frog (*Lithobates sylvatica*). Only one species (Western Toad) was recorded at both Airport Lagoon and Beaver Pond. At Airport Lagoon, amphibians were detected at the northern most section of the wetland where water is shallower and aquatic macrophyte species are more prevalent. At Beaver Pond, amphibians were detected in both upper and lower wetlands (above and below beaver dam). Qualitatively, it appears that the productivity of Western Toads is consistent between years, as egg masses and juveniles/adults have been repeatedly detected at the same locations each year.

Fish: Minnow traps and nets were deployed at Airport Lagoon in May and July, 2019, and the reach at Airport Lagoon was electrofished each month. At Beaver Pond, minnow traps and a fyke net were deployed in May and July 2019. Water levels were too shallow to electrofish. Eleven fish species from five families were captured in Airport Lagoon in 2019. In total, 7,348 fish, predominantly adults, were captured, with most (77%; 5,682) sampled in May. Minnows (*Cyprinidae*) dominated catches, followed by suckers (*Catostomidae*), Prickly sculpin (*Cottus asper*) and Rainbow trout (*Oncorhynchus mykiss*). At Beaver Pond, two minnow species (Northern Pikeminnow and Lake Chub) were captured with minnow traps.

Data collected in 2019 for the GMSMON-15 project showed that species from all indicator groups continue to be present at both wetland demonstration projects. The methods implemented to date will enable the collection of an adequate amount of data that can be used to address each management question and associated hypothesis.

Management Question (MQ)	Management Hypothesis	Year 9 (2019) Status
MQ1: Are the enhanced (or newly created) wetlands used by fish?	H_{01}: Fish species composition and density in wetland changes following enhancement.	Fish species were present in both wetlands in 2019. Species composition appears to be relatively consistent across monitoring years but will be fully assessed at the conclusion of Year 10 of the monitoring program.
MQ2: Are the enhanced (or newly created) wetlands used by waterfowl and other wildlife?	H_{03}: The species composition and density of waterfowl and songbirds changes following enhancement.	Both wetlands continue to show use by waterfowl and shorebird species, as do the upland habitats in terms of songbird use. Annual variation is evident, so a full assessment of this hypothesis will be prepared at the conclusion of Year 10 of the monitoring program.
	H_{04}: Amphibian abundance and diversity in the wetland changes following wetland enhancement.	Annual differences in amphibian species composition have been observed to date. Species composition appears to change throughout the monitoring program. A full assessment of this hypothesis will be prepared at the conclusion of Year 10 of the monitoring program.
MQ3: Is there a change in the abundance, diversity, and extent of vegetation in the enhancement area?	H_{02}: The density, diversity and spatial extent of riparian and aquatic vegetation changes following enhancement.	Changes in habitat classification and spatial extent have been observed to date. There have also been changes in species composition and abundance of both terrestrial and aquatic vegetation. The significance of these changes will be assessed at the conclusion of Year 10 of the monitoring program.
MQ4: Is the area and quality of fish and wildlife habitat created by the wetland enhancement maintained over time?		The area of wetland habitat at Airport Lagoon and Beaver Pond appears to be remaining stable. A full assessment of this management question will be prepared at the conclusion of Year 10 of the monitoring program.

ACKNOWLEDGEMENTS

The authors express their appreciation to the following individuals for their assistance in coordinating and conducting this study: Teri Neighbour (BC Hydro) and Kate Froats (BC Hydro). Benita Kaytor, Jeff Strohm, Dillon Hamelin, Caroline Walter, Kristin Marini and Marty Izony from Chu Cho Environmental participated in the data collection in the field. Chu Cho Environmental participation was overseen and coordinated by Mike Tilson and Sean Rapai, who also provided logistical support. Julia Burger and Ryan Batten provided technical support in the field. Lucia Ferreira of LGL Limited assisted with GIS analysis.

List of contributors – LGL Limited environmental research associates

Marc d'Entremont, PhD, R.P.Bio.
Douglas Adama, B.Sc., R.P.Bio.
Naira Johnson, M.Sc., R.P.Bio.
Nathan Hentze, M.Sc.
Krysia Tuttle, M.Sc., R.P.Bio.
Jason Smith, M.Sc., R.P.Bio.
Ian Beveridge, M.Sc., R.P.Bio.
Shane Johnson, B.Sc.
Steven Roias, B.Sc.
Lucia Ferreira, B.Sc.
Mike Miller, PhD
Julio Novoa, M.Sc.

TABLE OF CONTENTS

LIST OF TABLES

LIMITED
environmental research associates

LIST OF FIGURES

LGL LIMITED
environmental research associates

1.0 INTRODUCTION

The annual reservoir cycling in Williston Reservoir created a drawdown zone of approximately 450 km^2 that was unproductive in both the inundated state as aquatic habitat and the drawdown state as terrestrial habitat (BC Hydro 2003). The Peace Water Use Plan Committee (hereafter known as the Committee) recognized that the largely unproductive drawdown zone on Williston Reservoir contributed to low fishery productivity, a lack of riparian and wildlife habitat, and potentially increased predation risk for wildlife. To address this issue, the Committee recommended the Riparian and Wetland Habitat management plan to improve foreshore habitat for fisheries, wildlife, and riparian areas. The components of the plan were an inventory of sites that were potentially suitable for enhancement, selection of sites for implementation of demonstration wetland enhancement projects, and a monitoring program to test their effectiveness in improving riparian and foreshore habitat for wetland species over the life of the project.

Under GMSWORKS-16 Williston Reservoir Wetlands Inventory, a total of 42 candidate sites in the Parsnip Arm of the Williston Reservoir were surveyed as potential wetland enhancement sites by Golder Associates Ltd. (2010). Candidate sites were assessed based on biological, geotechnical and archaeological considerations as well as factors including cost, feasibility and potential benefits to wildlife. Through this work, the list of candidate sites was narrowed to five Wetland Demonstration Sites (Golder Associates Ltd. 2010). BC Hydro selected two Wetland Demonstrations Sites (WDS) for detailed design and construction: WDS 6-2 (Airport Lagoon) and WDS 34 (Beaver Pond). This phase was completed under GMSWORKS-17 Williston Reservoir Trial Wetland. At Airport Lagoon, two 1200 mm diameter culverts with an invert elevation of approximately 664.5 masl, along a causeway at the southern end of the lagoon, where replaced with new 1200 mm diameter culverts with staggered invert elevations, starting at 666.99 to 667.05 masl. The objective of this treatment was to create 27 to 34 ha of permanently wetted habitat upstream of the causeway. At Beaver Pond, a water control structure was constructed, approximately 3 m in height with an invert elevation of 667.25 masl, at the inlet to the pond. This created a 0.3 ha inundated area when reservoir levels are below 667.25 masl. Monitoring of the effectiveness of the wetland demonstration projects in improving wildlife habitat on the reservoir will be completed under GMSMON-15 Williston Reservoir Wetland Habitat Monitoring.

1.1 Study Species

This effectiveness monitoring program is designed to determine the response of selected indicator groups to the wetland enhancements and to increase knowledge of wildlife use of the drawdown zone for the selected groups, particularly birds and amphibians. To provide some indication of wildlife response to the wetland enhancement BC Hydro (2008) identified waterfowl, songbirds, amphibians, and vegetation as the wildlife indicator groups to be used for monitoring in GMSMON-15. Fish populations were also identified for monitoring as fish were observed at both of the selected demonstration sites (Golder Associates Ltd. 2010, 2011). While improving fish habitat is not one of the goals of the wetland enhancement projects, little is known about the fish species composition and distribution at the selected locations (BC Hydro 2008).

2.0 STUDY OBJECTIVES

In 2011, BC Hydro initiated a long-term monitoring program (GMSMON-15) to assess the effectiveness of wetland enhancement in meeting the objectives of the Riparian and Wetland Habitat management plan (BC Hydro 2007). If wetland enhancement is deemed successful by this monitoring program, additional sites may be enhanced in the future.

2.1 Study Design

The general study design is to collect annual data on each of the indicator groups at locations within the core area of the enhancement treatments and in peripheral riparian areas. The multi-year time-series dataset, which includes data on the indicators groups both before and after the enhancements were in place, will be analyzed to assess the programs' management questions and hypotheses.

2.2 Management Questions and Hypotheses

BC Hydro developed four management questions (MQs) to address the effectiveness of wetland enhancement to improve fish and wildlife habitat:

MQ1: Are the enhanced (or newly created) wetlands used by fish?

MQ2: Are the enhanced (or newly created) wetlands used by waterfowl and other wildlife?

MQ3: Is there a change in the abundance, diversity, and extent of vegetation in the enhancement area?

MQ4: Is the area and quality of fish and wildlife habitat created by the wetland enhancement maintained over time?

Based on the management questions, the study was designed to test the following alternate hypotheses stated in the Terms of Reference (BC Hydro 2008):

H_{01} Fish species composition and density in wetland changes following enhancement.

H_{02} The density, diversity and spatial extent of riparian and aquatic vegetation changes following enhancement.

H_{03} The species composition and density of waterfowl and songbirds changes following enhancement.

H_{04} Amphibian abundance and diversity in the wetland changes following wetland enhancement.

These questions and hypotheses are tested directly by this monitoring program to test the effectiveness of wetland enhancement to improve fish and wildlife habitat as well as maintain this habitat over the life of the project.

3.0 STUDY AREA

3.1 Williston Reservoir

Williston Reservoir is located in northeastern British Columbia and was created by construction of the W.A.C. Bennett Dam at the head of the Peace River Canyon, about 20 km west of Hudson's Hope, B.C (BC Hydro 2015). The reservoir extends for about 260 km along the Rocky Mountain Trench from the Finlay River in the north to the Parsnip River in the south (Figure 1). The reservoir is generally divided into three geographic regions (from north to south): Finlay Reach, Peace Reach and Parsnip Reach (BC Hydro 2015).

Since 1971, reservoir elevations have ranged between 654 m and 672 m, with reservoir elevations fluctuating from year to year, driven by inflow and system generation needs. Inflows to the reservoir are primarily driven by snowmelt in the Peace River watershed and are much higher in summer than in winter. The reservoir is typically ice covered between the end of January and the beginning of May and generally reaches an annual minimum elevation in April or May, followed by reservoir refilling in the spring freshet. The reservoir generally reaches the maximum elevation in July or August and is then drafted through the winter as generation is increased to meet peak winter energy demands. The Normal Maximum Reservoir Level (NMRL) is 672 m and BC Hydro normally maintains a minimum elevation of approximately 655 m (BC Hydro 2015).

3.2 Physiography

The Williston Reservoir is nestled between the Hart Range of the Northern Rocky Mountains on its east and the Omineca Mountains on its west, which lie in a north-northwest to south-southeast orientation. The Finlay and Parsnip Reaches lie within the wide, flat-bottomed Rocky Mountain Trench and the former stream channels are deeply incised. Glacial till is the most abundant surficial deposit in the region.

The reservoir is located within the Sub-Boreal Spruce and Boreal White and Black Spruce biogeoclimatic zones (Meidinger and Pojar 1991). The Sub-Boreal Spruce zone is the dominant zone and occurs as two subzones and variants at lower elevations along most of the reservoir (Meidinger and Pojar 1991). The Boreal White and Black Spruce zone occurs only at the northern end of the reservoir in the Finlay Arm (Meidinger and Pojar 1991). The drawdown zone consists of large areas of mud, sand, and gravel flats with stranded large woody debris. Limited amounts of vegetation occur even following extended periods of drawdown.

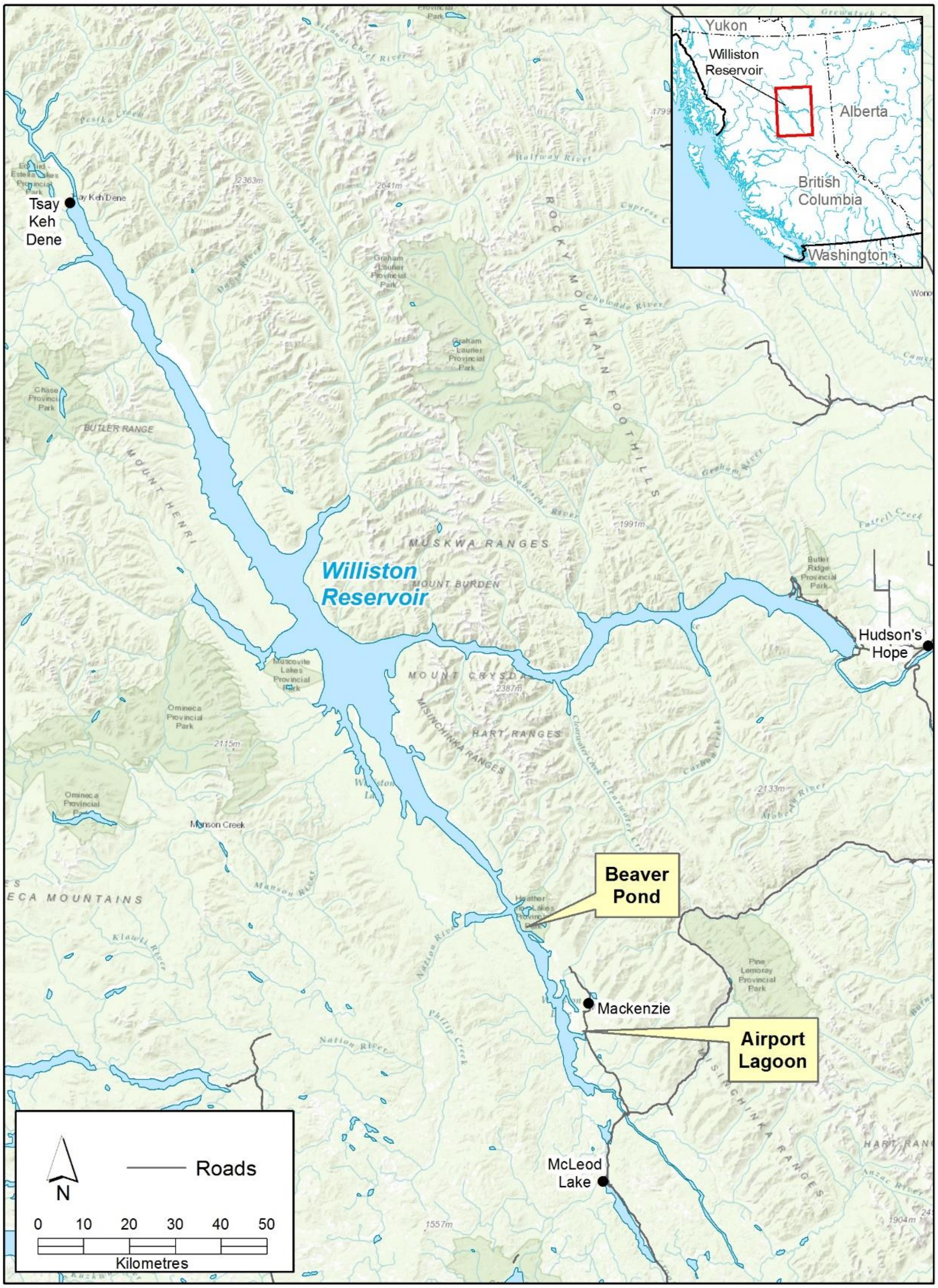


Figure 1. Location of the Williston Reservoir in northern British Columbia and locations of enhanced wetlands (Airport Lagoon and Beaver Pond) sampled for GMSMON-15 in 2019.

LGL LIMITED
environmental research associates

3.3 Climatology

Daily weather in the region is influenced by middle-latitude cyclones, which typically move from southwest to northeast British Columbia that respond to large scale features of the Rocky Mountains (Whiteman 2000, Klock and Mullock 2001). These lows tend to move over mountains and produce a widespread area of precipitation as well as unstable air where bands of clouds and showers develop. The middle-latitude cyclones dominate the weather during the fall through spring, while convection dominates during the summer months. The lows can become very slow moving and result in large amounts of precipitation in one place (Klock and Mullock 2001); combined with moist air that originates over the Pacific Ocean, which makes its way eastward through the narrow and deep valleys that occur through the Rocky Mountains (Vickers et al. 2001). The region experiences long, cold winters and ice formation on the reservoir begins as early as November and can extend into the beginning of May. Annual precipitation ranges between 40 cm to 50 cm with snowfall accounting for 35-45% of the annual precipitation. The Williston Reservoir receives and stores most of its hydrologic input from snowmelt. The large spring runoff typically begins in mid-May and peaks in June (Stockner et al. 2005).

3.3.1 Study Locations

The two locations identified for the wetland demonstration projects are both located on the east side of the Parsnip Reach (Figure 2). The uniqueness of both sites, along with the completed enhancements, means there are no associated control or reference sites for this program. As such, pre-construction baseline data will be used to assess the post-construction changes associated with each enhancement.

<u>Airport Lagoon</u>

The Airport Lagoon site (WDS 6-2) is located approximately six kilometres south of Mackenzie and is an approximately 75 ha site on the upstream side of a forest service road causeway. Except for two culverts at the base of the causeway, the area is isolated from the main reservoir. Water supply to the lagoon is primarily from two unnamed streams located at the north end of the lagoon. Prior to the enhancements, water levels in the lagoon corresponded to the reservoir level when water levels were >664.5 m. To create a larger area of permanently flooded habitat and reduce water level changes, the existing culverts were removed in May of 2013 and two new culverts were installed at an elevation of 666.99 m for the west culvert and 667.05 m for the east culvert, raising the pond elevation by ~2.5 m (Golder Associates Ltd. 2013).

<u>Beaver Pond</u>

The Beaver Pond site (WDS 34) is located approximately 22 km northwest of Mackenzie at the end of a narrow inlet on Heather Point. At this site there were two beaver ponds located at the head of the inlet with a small stream draining the ponds. In 2014, a berm was constructed part way up the inlet at an elevation of 667.25 m, which created a wetland of approximately 0.3 ha (Golder Associates Ltd. 2015). When reservoir levels are above this measure, the wetland is directly connected to the reservoir; however, more stable water levels remain in the enhanced area as the reservoir levels recede (Golder Associates Ltd. 2015).

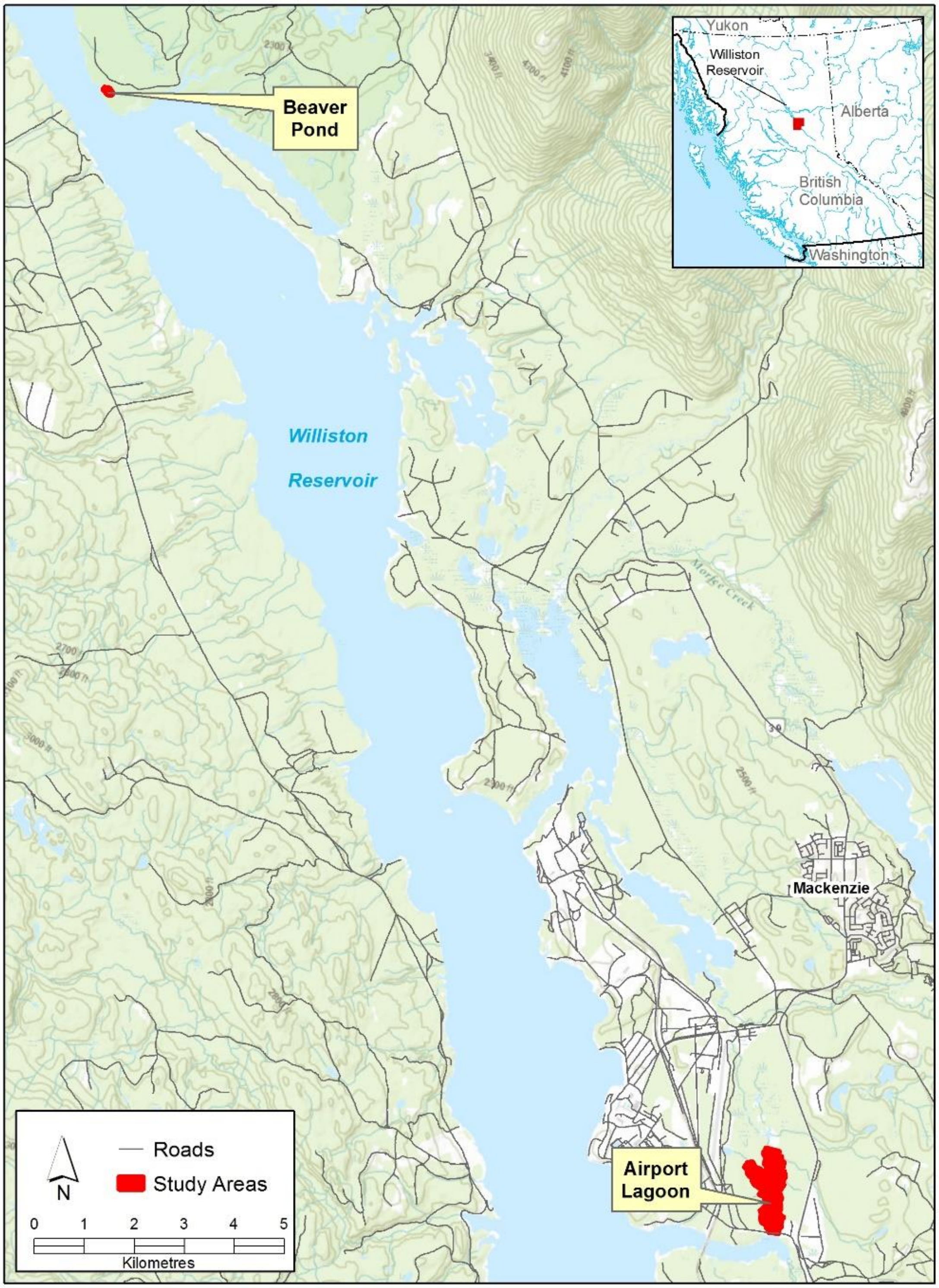


Figure 2. Location of the two wetland demonstration sites on the Parsnip Reach of Williston Reservoir.

4.0 METHODS

The field sampling methods employed in Year 9 of the GMSMON-15 were consistent with those used in the previous years of the monitoring program. The sampling methods for each of the indicator groups are described below, along with any adjustments that were required due to reservoir elevation or weather conditions at the time of sampling.

4.1 Environmental Conditions

Daily reservoir elevations were provided by BC Hydro (BC Hydro Commercial Resource Optimization (CRO) database) and daily mean air temperature and precipitation data prior to and during the survey period were downloaded from the Environment and Climate Change Canada's historical climate data web portal (Environment and Climate Change Canada 2019). Accumulated degree days were also calculated using a base temperature of 5°C as an additional method to compare environmental conditions between years. Accumulated degree days are used to measure the passage of time and temperature simultaneously, which can be used as an indicator of developmental activities. The base temperature of 5°C was selected as an indicator of activity for breeding amphibians; the minimum night-time temperature of 5°C was used as an indicator for the timing of early season call surveys (Weir and Mossman 2005, Bird Studies Canada 2018).

Specific data was compiled from the Mackenzie Airport weather station (Station name: Mackenzie Airport Auto). Daily environmental parameters, specific to each survey type, were recorded at the start of each survey and periodically during the surveys. These parameters included temperature, precipitation, cloud cover, relative humidity, wind speed and direction (Appendix 9-1).

4.2 Vegetation Surveys

A combination of ground sampling of terrestrial vegetation and sampling for aquatic vegetation was used in 2019 to address the following management question and associated alternative hypothesis:

- **MQ3**: Is there a change in the abundance, diversity and extent of vegetation in the enhancement area?
- **H_{02}**: The density, diversity and spatial extent of riparian and aquatic vegetation changes following enhancement.

4.2.1 Habitat Classification

Habitat class descriptions and their spatial distribution were reviewed in Year 6 (2016) of the monitoring program. Twelve habitat classes were identified at Airport Lagoon and six habitat classes were identified at Beaver Pond based on aerial imagery taken in 2014 (MacInnis et al. 2017). Each habitat class was based on the common plant species assemblages and elevation within the drawdown zone.

High resolution orthomosaic imagery of Airport Lagoon and Beaver Pond were obtained in May 2018 (Teri Neighbour, pers. comm.). The habitat class polygons delineated in 2016 were updated using a heads up (i.e., on screen) approach where each polygon was assessed relative to the 2018 imagery. Based on the visual comparison of 2016 to 2018, polygons delineated in 2016 were either left unchanged, modified to fit the extent of vegetation cover on the 2018 images, or deleted. Imagery interpretation was completed in QGIS (Version 3.4.1).

4.2.2 Ground Sampling of Terrestrial Vegetation

Ground sampling of terrestrial (i.e., riparian) vegetation was conducted between June 25-29, 2019 along 17 belt-transects at the study sites (i.e., 12 transects at Airport Lagoon and five transects at Beaver Pond). Belt-transects were 20 m in length and consisted of ten 2 m by 0.5 m quadrats to allow for sub-sampling and to increase the accuracy of vegetation cover estimates (Figure 3). Each transect was laid out using a 30 m measuring tape and a 2 m measuring rod. Transect start and end coordinates were recorded and photographs were taken at both the start and end points. Within each quadrat, vegetation was identified to species and the percent cover of each species was recorded.

All vegetation within or overhanging each quadrat was identified to species, or in some cases to genus. Per cent cover (vertical crown projection) of each taxon was visually estimated and rounded as follows: <1% - traces; 1-10% - rounded to nearest 1%; 11-30% - rounded to nearest 5%; 31-100% - rounded to nearest 10%.

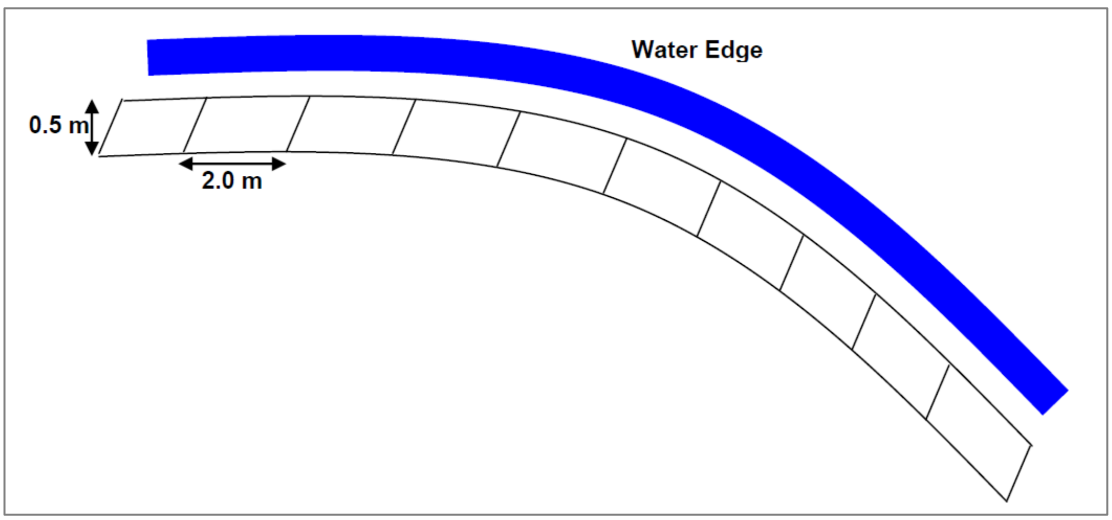


Figure 3. Schematic of belt transect survey design for the ground sampling of terrestrial vegetation at Airport Lagoon and Beaver Pond.

In 2019, four of the previously established transects (two at Airport Lagoon and two at Beaver Pond) were flooded during the time of the survey so transects at the water's edge were established (Figure 4).

Site and soil characteristics for each transect were recorded on provincial ecosystem field forms (Province of British Columbia 2010). The ground cover (per cent area) of each quadrat was apportioned among substrate classes as follows: organic matter, coarse woody debris, rock, mineral soil, and water (standing and flowing). Additional field observations on vegetation composition and structure made during ground inspections of the study sites assisted with ground-truthing the polygon mapping and with updating habitat class abundance and distribution.

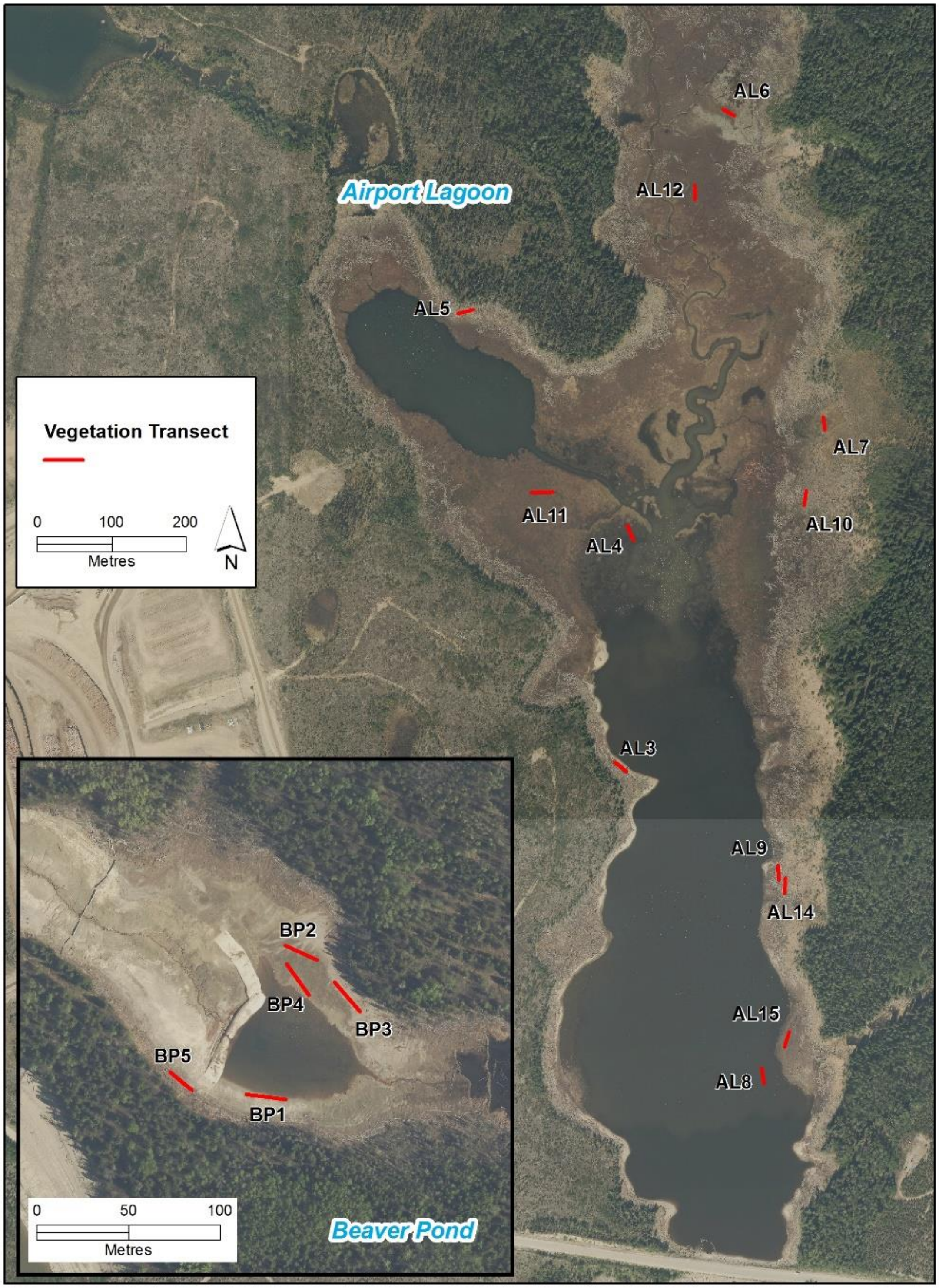


Figure 4. Location of belt transects surveyed for the ground sampling of terrestrial vegetation at Airport Lagoon and Beaver Pond in 2019.

4.2.3 Sampling of aquatic vegetation

Sampling of aquatic vegetation occurred at the end of June 2019 and was based on a systematic design (Hawkes et al. 2011, Miller and Hawkes 2013) using transects spaced at 100 m to 400 m intervals with sampling points located every 25 m to 50 m along each transect (Figure 5). Transect length and spacing varied depending on the width of the wetland and environmental conditions at the time of the survey. Geographical coordinates corresponding to the sample points were loaded into a hand-held GPS unit to facilitate navigation from point to point in the field.

Aquatic macrophyte species composition and relative abundance was recorded at each sample point using a benthic rake drags (i.e., using a double-headed rake attached to a rope). At each location the rake was dropped to the bottom and dragged for a distance of 1-3 m. A cluster sampling approach was used in which two samples were taken at each location. The volume of each sample was estimated based on a categorical scale from 1 to 3 (Table 1). Also, each macrophyte species in the sample was assigned a relative cover class (Table 2). Water depths were measured by dropping a weighted tape measure to the bottom at each surface sample point.

Table 1. Volume classes for vegetation samples collected during the sampling of aquatic vegetation in 2019.

Volume Class	Sample Volume	Definition
1	Trace	Sample is restricted to one or very few strands of vegetation
2	Small	Sample fills less than half of the tines of the sampling rake
3	Large	Sample fills half or more of the tines of the sampling rake

Table 2. Cover class for vegetation samples collected during the sampling of aquatic vegetation in 2019.

Cover Class	Definition
T	Species is present but contributes negligibly (< 1 per cent) to the sample volume
1	Species contributes less than 10 per cent of the sample volume
2	Species contributes 11–20 per cent of the sample volume
3	Species contributes 21–50 per cent of the sample volume
4	Species contributes 51–75 per cent of the sample volume
5	Species contributes 76–100 per cent of the sample volume

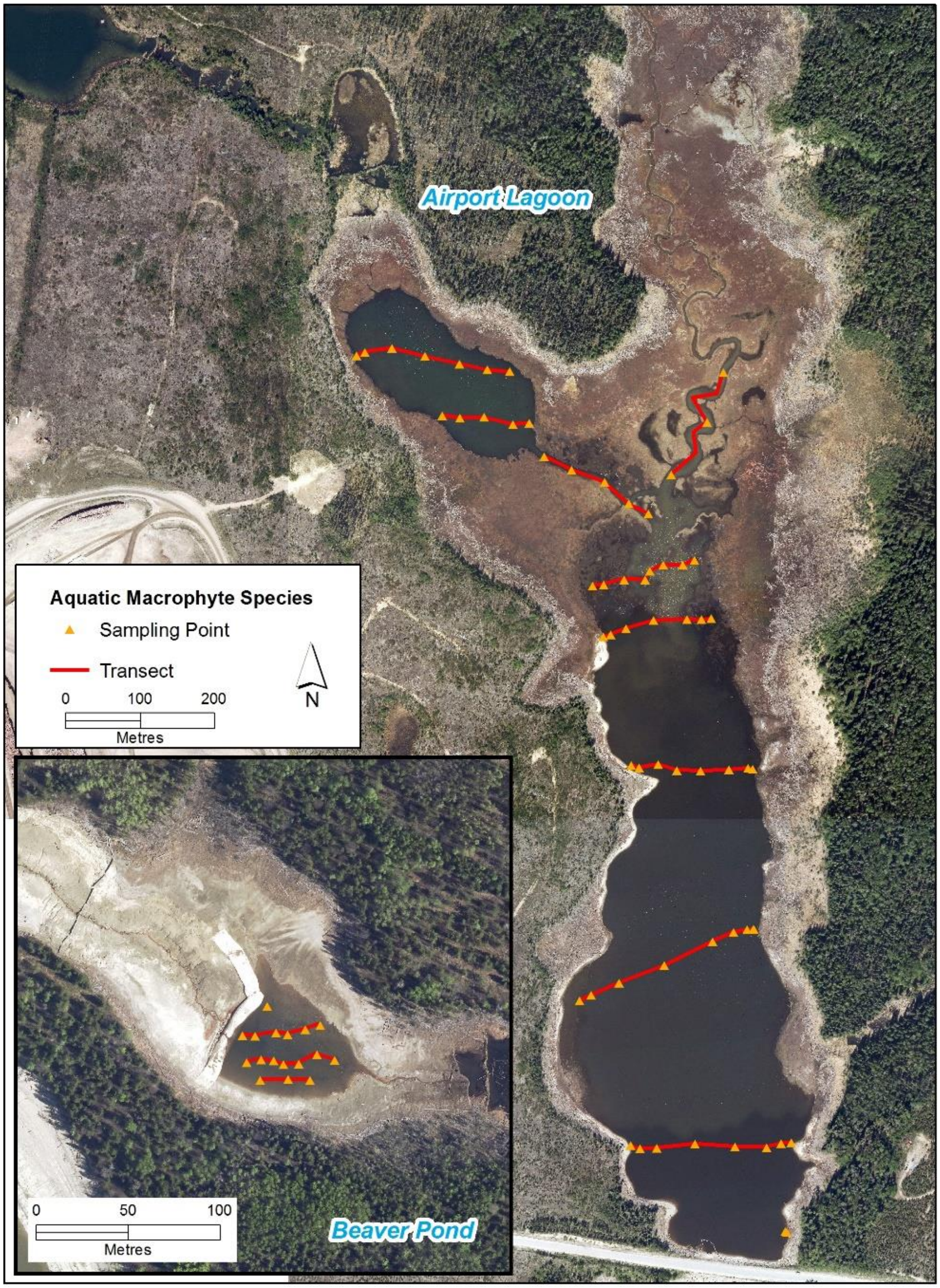


Figure 5. Locations of transects and sampling points used in 2019 in the sampling of aquatic macrophyte species at Airport Lagoon and Beaver Pond.

4.3 Waterfowl and Shorebird Surveys

Data on waterfowl and shorebirds was collected to address the following management questions and hypothesis:

- **MQ2:** Are the enhanced (or newly created) wetlands used by waterfowl and other wildlife?
- **MQ4:** Is the area and quality of fish and wildlife habitat created by the wetland enhancement maintained over time?
- **H_{03}:** The species composition and density of waterfowl[1] changes following enhancement.

Three replicates of waterfowl and shorebirds surveys were conducted between April and June 2019. Survey methods were consistent with all previous years of the project (McInnis et al. 2017, d'Entremont et al. 2019) and followed provincial standards for relative abundance inventories (RIC 1999a). Surveys were conducted at five observation stations at Airport Lagoon and one observation station at Beaver Pond (Figure 6). Data on flock or individual number, species, sex, behaviour, and general habitat (e.g., mid pond, in water near pond edge, standing on shore in water, on shore) were recorded on a modified Resource Inventory Committee data form (RIC 1999a) and their corresponding location was recorded on a map with an orthophoto background of each site. Weather conditions were recorded at the beginning and end of each survey, and any unusual conditions or circumstances that potentially affected waterfowl and shorebird presence in the wetland areas were noted.

4.4 Songbird Surveys

Data on songbirds was collected to address the following management questions and hypothesis:

- **MQ2:** Are the enhanced (or newly created) wetlands used by waterfowl and other wildlife?
- **MQ4:** Is the area and quality of fish and wildlife habitat created by the wetland enhancement maintained over time?
- **H_{03}:** The species composition and density of waterfowl *and songbirds* changes following wetland enhancement[2].

Songbird surveys were conducted in late May/early June 2019 and were consistent with previous years of the project (MacInnis et al. 2017, d'Entremont et al. 2019), while following provincial standards and established protocols (Ralph et al. 1995, RIC 1999b, Bird Studies Canada 2009). Point count surveys were conducted at 17 stations at Airport Lagoon and three stations at Beaver Pond (Figure 7) during acceptable weather conditions according to modified standards (RIC 1999b; Hentze and Cooper 2006). Surveys commenced at dawn and ended within four hours to capture the most stable song period

[1] Shorebirds have been included in the surveys since Year 2 (2012) of the monitoring program to provide additional detail on bird use of the enhancement areas.

[2] Hypothesis H_{03} originally did not include reference to songbirds (BC Hydro 2008); however, the annual report from Year 1 includes songbirds in the hypothesis (MacInnis et al. 2012).

Figure 6. Waterfowl and shorebird survey stations at Airport Lagoon and Beaver Pond sampled in 2019.

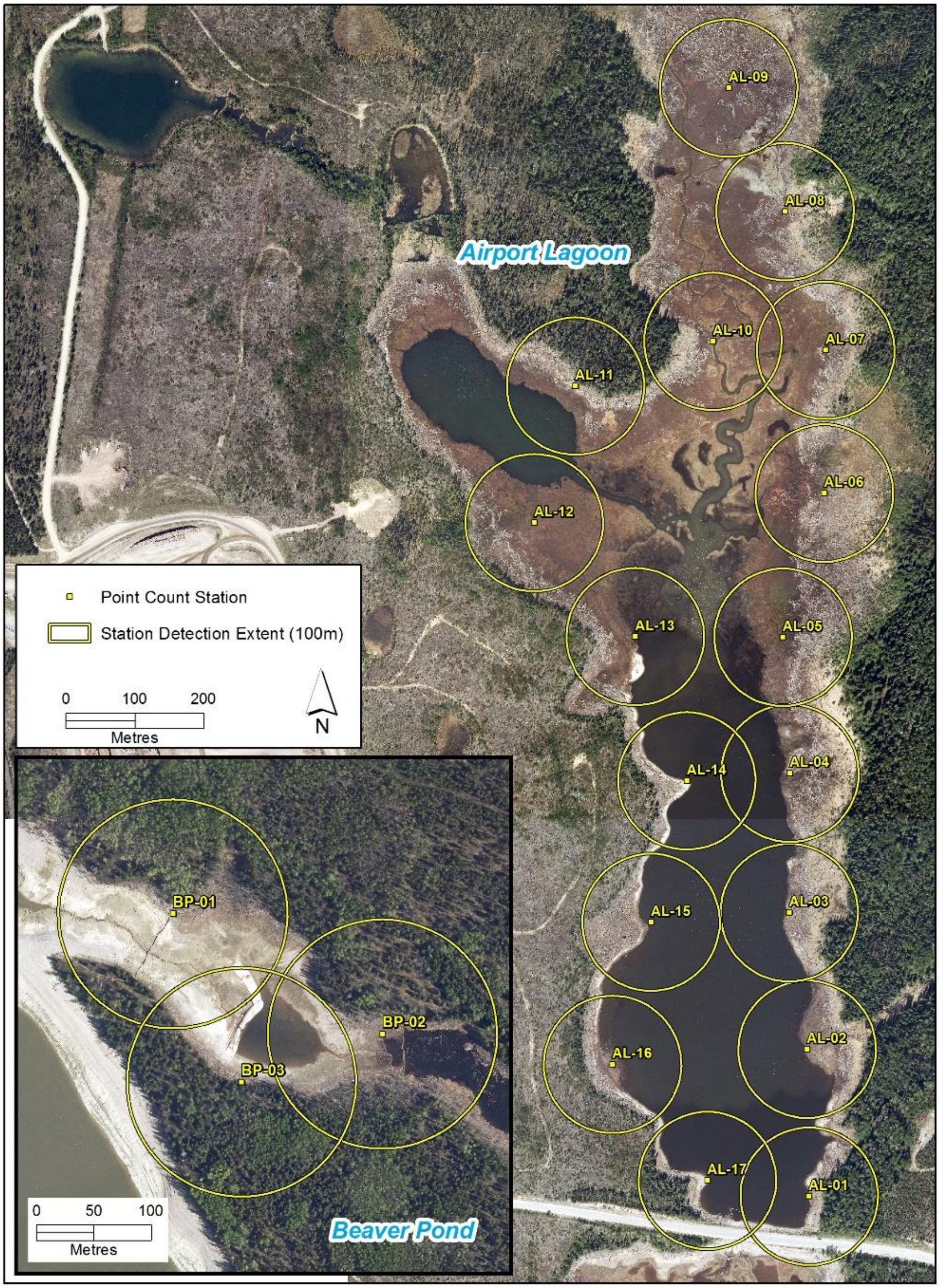


Figure 7. Point count station locations at Airport Lagoon and Beaver Pond sampled in 2019. The yellow circles represent the 100 m detection radius.

(Ralph et al. 1995). At each station, counts were conducted for a duration of 5 minutes, during which all birds detected were recorded. Each detection was assigned to a temporal category based on the time of detection (0-3 and 3-5 minutes), and the species, sex, age, detection distance from the point count centre, direction to the bird, detection type, and habitat was recorded. Additional comments, such as breeding evidence, were also noted. Each point count station at Airport Lagoon and Beaver Pond was surveyed on three separate visits (i.e., replicates).

4.5 Amphibian Surveys

Amphibian surveys were conducted to address the following management questions and hypothesis:

- **MQ2:** Are the enhanced (or newly created) wetlands used by waterfowl and other wildlife?
- **MQ4:** Is the area and quality of fish and wildlife habitat created by the wetland enhancement maintained over time?
- **H_{04}:** Amphibian abundance and diversity in the wetland changes following wetland enhancement.

Amphibian surveys occurred over three sampling intervals (i.e., replicates) between April and June 2019. Two main methods were employed: visual encounter surveys and nocturnal surveys (Airport Lagoon only). In 2019, three replicates of amphibian surveys were completed at Airport Lagoon and two replicates were completed at Beaver Pond (Table 3). Access to Beaver Pond at the end of April 2019 was not possible due to the ice conditions on Williston Reservoir at the time of the survey.

Table 3. Dates for the amphibian surveys at Airport Lagoon and Beaver Pond in 2019.

Site	Survey Dates		
Airport Lagoon	April 24, 2019	May 24, 25, 2019	May 31, June 4, 5, 2019
Beaver Pond		May 26, 2019	June 2, 2019

Visual Encounter Surveys (VES) followed the inventory methods for pond-breeding amphibians (MELP 1998) and the study design of MacInnis et al. (2017). At Airport Lagoon 11 transects distributed along the periphery of the inundated areas were sampled; whereas, at Beaver Pond the entire site was considered a single transect (Figure 8). The search area included shallow water (< 1 m deep), the shorelines, and areas within 3 m of the shoreline. A zig-zag search pattern was applied to areas above the waterline.

A Nocturnal Call/Road Survey was conducted on May 24, 2019 along Airport Lagoon Road to detect species of amphibian moving in/out of the enhancement area along the main access road. The night survey was completed between 21:00 and 24:00, when air temperature was above 5°C and wind not exceeding 15 km/hr.

Observational data was recorded on animal observation forms modified from MELP (1998). Environmental conditions were recorded at the start and end of each transect. Species, developmental stage, behavior and habitat variables were recorded for each

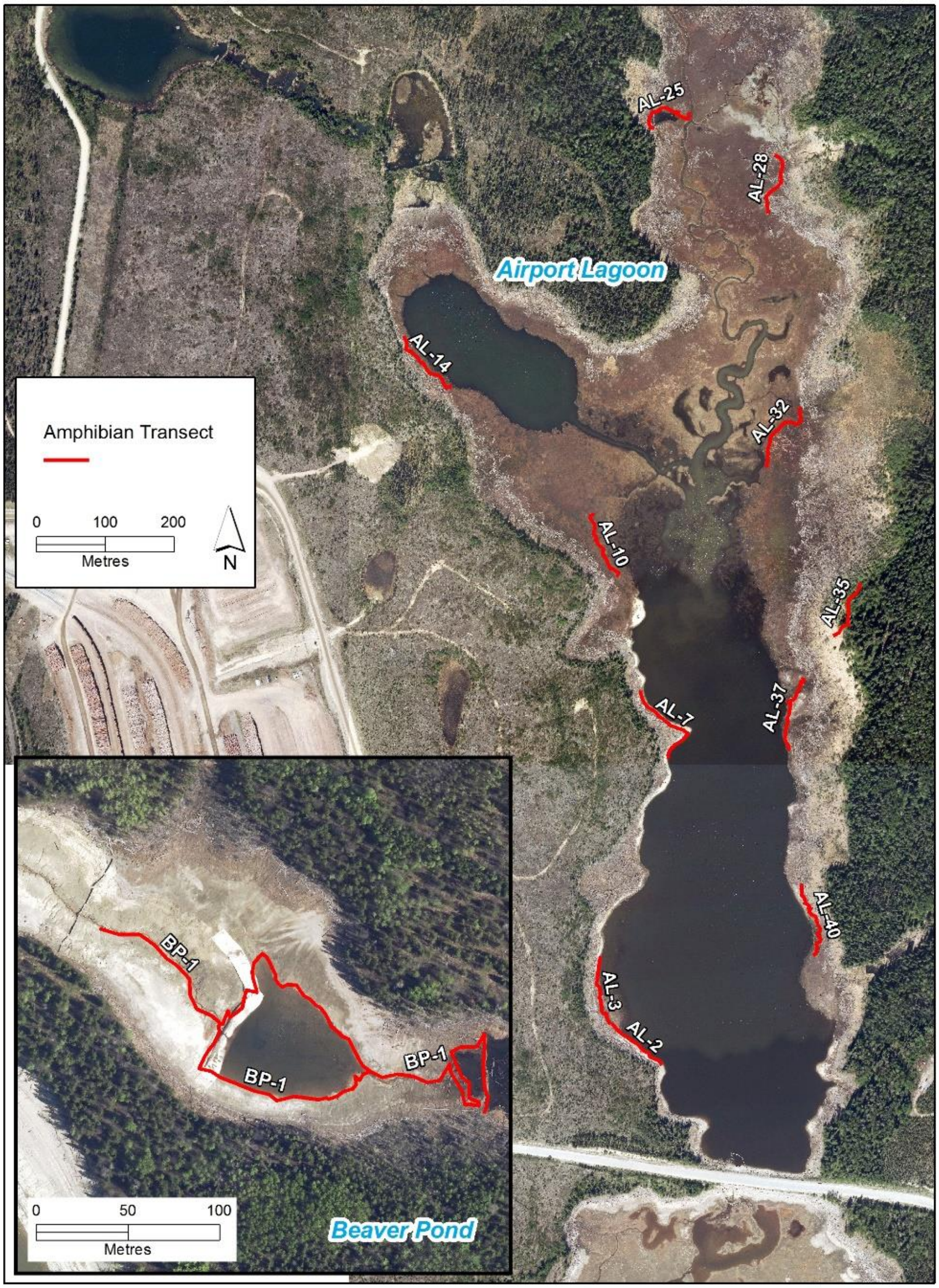


Figure 8. Amphibian survey transect locations at Airport Lagoon and Beaver Pond sampled in 2019.

adult, larvae and egg mass observed. Aggregations of tadpoles and metamorph amphibians were treated as a single detection and the total number of individuals was estimated.

Amphibian survey work was conducted under Wildlife Act Permit PG19-469635, which was valid from April 25, 2019 to July 31, 2019.

4.6 Fish Surveys

Fish surveys were conducted to address the following management questions and hypothesis:

- **MQ1:** Are the enhanced (or newly created) wetlands used by fish?
- **MQ4:** Is the area and quality of fish and wildlife habitat created by the wetland enhancement maintained over time?
- **H_{01}:** Fish species composition and density of waterfowl changes following enhancement.

Fish survey methods and effort were consistent with the Terms of Reference (BC Hydro 2008), previous years of the project (McInnis et al. 2017, d'Entremont et al. 2019), and provincial standards (RIC 2001; Figure 9). Two sampling sessions were completed, one in May 2019 and the second in July 2019. A combination of methods were used to capture and sample both large and small fish.

At Airport Lagoon, 12 minnow traps were deployed, one reach was electrofished, and two fyke nets were deployed – in May and in July 2019 (Figure 10 and 11). At the Beaver Pond site, sampling also occurred in May and July 2019, when six minnow traps were deployed. Given the size of the Beaver Pond, only one fyke net was deployed. Insufficient water levels prevented effective electrofishing (Figure 12 and 13).

When catches were high for a species and method, the first 50 fish were measured for length (mm) and the remainder were enumerated without measurement. All salmonids, cyprinids, and suckers were measured for fork length and total length was recorded for sculpins.

Fish sampling was conducted under Scientific Fish Collection Permit # PG19-464955 issued by the Ministry of Forest, Lands and Natural Resource Operations.

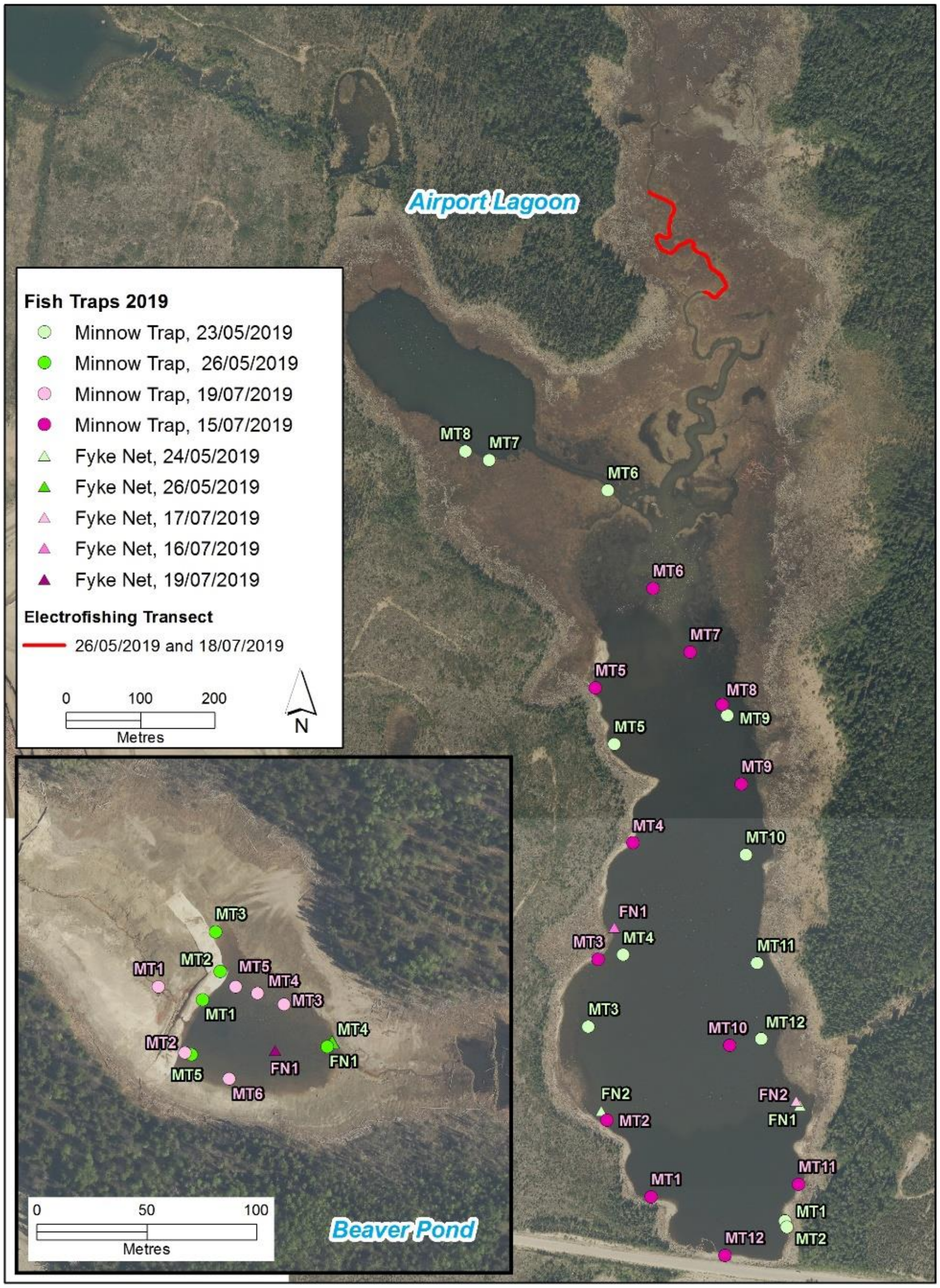


Figure 9. Fish sampling locations by data and method at the Airport Lagoon and Beaver Pond sites.

Image 1: Airport Lagoon conditions (July 16, 2019).

Image 2: Airport Lagoon minnow trap installatio (May 23, 2019).

Image 3: Looking upstream at Electrofishing reach (Part 1; May 26, 2019).

Image 4: Looking upstream at Electrofishing reach (Part 2; May 26, 2019).

Image 5: Fyke net set-up (Part 1; May 24, 2019).

Image 6: Fyke net set-up (Part 2; May 24, 2019)

Figure 10. Conditions at Airport Lagoon for sampling fish in May 2019.

Image 7: Airport Lagoon conditions (July 16, 2019).

Image 8: Airport Lagoon minnow trap (July 15, 2019).

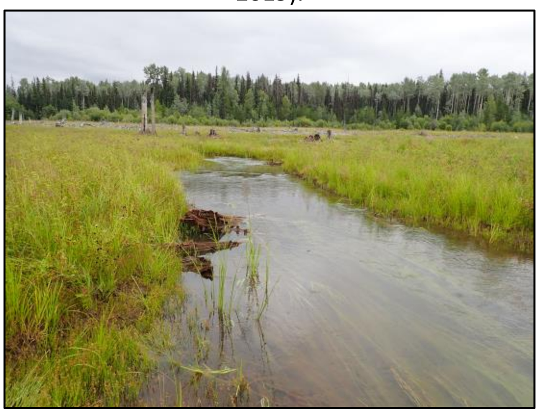


Image 9: Looking downstream at Electrofishing reach (July 18, 2019).

Image 10: Looking downstream at Electrofishing crew (July 18, 2019).

Image 11: Fyke net set-up (Part 1; July 16, 2019).

Image 12: Fyke net set-up (Part 2; July 16, 2019)

Figure 11. Conditions at Airport Lagoon for sampling fish in July 2019.

Image 13: Looking downstream from the Beaver Pond impoundment (May 26, 2019).

Image 14: Looking upstream from the Beaver Pond impoundment (May 26, 2019).

Image 15: Looking east at the Beaver Pond impoundment with fyke net (May 26, 2019).

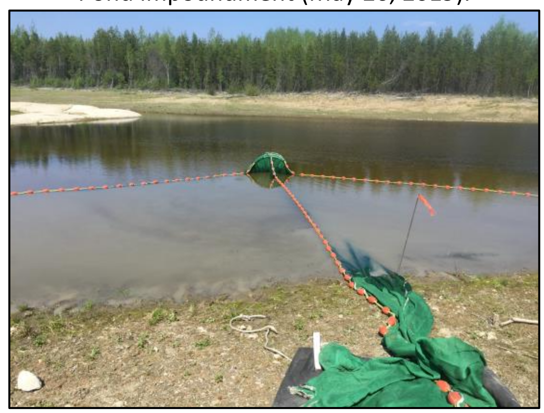


Image 16: Looking east at the Beaver Pond impoundment with fyke net (May 26, 2019).

Image 17: Looking upstream from the upstream portion of the Beaver Pond impoundment (May 26, 2019).

Image 18: Looking downstream from the upstream portion of the Beaver Pond impoundment (May 26, 2019).

Figure 12. Conditions at Beaver Pond in May 2019.

Image 19: Looking north at the Beaver Pond impoundment (July 19, 2019).

Image 20: Looking upstream from the downstream portion of the Beaver Pond impoundment (July 19, 2019).

Image 21: Looking north at the Beaver Pond impoundment with fyke net (July 19, 2019).

Image 22: Looking west at the Beaver Pond impoundment with fyke net (July 19, 2019).

Image 23: Looking upstream from the upstream portion of the Beaver Pond impoundment (July 19, 2019).

Image 24: Looking downstream from the upstream portion of the Beaver Pond impoundment (July 19, 2019).

Figure 13. Conditions at Beaver Pond in July 2019.

4.7 Data Entry and Analysis

Data was collected on printed data forms in the field and transcribed into Microsoft Excel. GPS waypoint and photographs were downloaded and labelled accordingly.

Other than the results of the habitat classification, data analysis presented in this report is for data that was collected in Year 9 only. The comprehensive report, prepared at the conclusion of Year 10 of the monitoring program, will test the null hypotheses of no effect or difference.

4.7.1 Vegetation

Presence/not detected data was used to assess the species diversity and abundance of terrestrial and aquatic plant species. The average percent cover of terrestrial species across the 10 quadrats in each transect was calculated. These averages were used to calculate an average per cent cover by vegetation layer (e.g., moss, herb, shrub, tree) for each transect. Species richness (i.e., the number of species by vegetation layer) across each transect was calculated.

Aquatic macrophyte frequency (defined as the proportion of sample plots in which a species or group of species was detected) was compared across each site. Macrophyte frequency (a proxy for overall cover) was calculated as the number of sample points in which a species was detected divided by the total number of sample points. For analysis, macrophyte abundance was estimated for each species and sample point as volume multiplied by relative cover (Miller and Hawkes 2013).

Volume classes ranged from 1 through 3, and relative abundance classes ranged from 0.1 (for trace) to 1 through 5 (Table 1, Table 2). For each sample point, the values were averaged across two rake grabs. Thus, the minimum possible volume value was 0.5 and the minimum possible relative cover value was 0.05. The minimum possible (non-zero) value for the volume x cover metric was then 0.5 x 0.05 = 0.025, and the maximum possible value for the volume x cover metric was 3 x 5 = 15.

4.7.2 Waterfowl and Shorebirds

The total count of each species at a survey site, during each survey, was used as the basic statistical unit. These data were used to infer relative abundance and species composition on a seasonal basis. Seasonal periods included early spring (i.e., April), late-spring (i.e., May) and early summer (i.e., June). Field maps of waterbird observations were imported into GIS and specific locations and the relative abundance of each species was used to document the distribution of waterfowl and shorebird species in each study site.

4.7.3 Songbirds

Songbird data were summarized for 2019 as a component of the alternate hypothesis to test if the composition and density (abundance) of songbirds changes following enhancement. Songbird data summaries were based on the point count station as the basic sampling unit. Point count data were constrained to passerine (i.e., “songbirds”) and hummingbird detections within 75 m of the point count centre. Birds detected as fly-overs were excluded, as these individuals may not utilize the treatment area containing the point count; excepting swallows, which were included as they are aerial foragers and are almost exclusively detected in flight, and hummingbirds. At each point count station, the total number of individuals was determined by taking the sum of counts for a species over all visits during the field season. Individuals in this sense refers to the number of birds detected over all visits and does not imply population size as the same individual birds may be recorded over multiple visits.

Habitat was defined based on the micro-habitat that an individual bird was utilizing at the time of observation. Habitats classified as "Coniferous", "Deciduous", "Mature Mixedwood", or second-growth (coniferous, deciduous or mixed) were labelled as "Forest"; habitats classified as "drawdown zone", "reservoir", or "sedge" were labelled as "DDZ", and habitats classified as "shrub" were labelled as "Shrub". Any observations with unknown habitat classifications were excluded from summaries involving habitat (i.e., boxplots and Venn diagrams).

At each point count station, songbird richness was defined as the number of species present, meeting the above detection criteria, and calculated using the 'specnumber' function in the vegan package (Oksanen et al. 2017) in R statistical programming language (R Development Core Team 2014). Songbird diversity (Shannon's diversity index [H]) was determined using the 'diversity' function in the vegan package, and calculated as follows:

$$H = -\sum_{i=1}^{q} p_i \log p_i$$

where q is species richness and p_i is the relative frequency or proportion (on a 0 to 1 scale) of observations of species i. H is maximum when the observations are equally distributed among the q species, H is lower when one or a few species exhibit stronger dominance, and H=0 when there is only one species detected. H increases with the number of species and thus, has no predefined maximum. That is, diversity is related to richness but accounts for species abundance. Using both richness and diversity indices together provides insight into the composition of the communities. Both songbird richness and diversity were examined through boxplots.

Richness and diversity based on each point count station (with visits to a point count station summed) were summarized using box plots, since these display the differences between groups of data without making any assumptions about their underlying statistical distributions and show their dispersion and skewness (Sokal and Rohlf 1995; Massart et al. 2005; Krzywinski and Altman 2014). Boxes represent between 25 percent and 75 percent of the ranked data. The horizontal line inside the box is the median. Whiskers are drawn from the top of the box to the largest observation within 1.5 interquartile range of the top, and from the bottom of the box to the smallest observation within 1.5 interquartile range of the bottom of the box. Outliers beyond the whiskers are plotted as hollow dots. "Notched" boxplots were used on the Airport Lagoon data allowing for direct comparisons of group differences with visual examination; where notches do not overlap between groups there is strong evidence that their medians significantly differ (Chambers et al. 1983). Notched boxplots were not used for Beaver Pond sites due to graphical anomalies resulting from a small sample size, and instead the distribution of data was explored using regular boxplots. Box plots are recommended for a sample size of at least five, which makes them useful for sampling designs with low replication (Krzywinski and Altman 2014).

The similarity of songbird communities was assessed using Venn diagrams, with the eulerr package in R.

4.7.4 Amphibians

Total survey time per person was recorded to calculate detection rates (a proxy for catch per unit effort time or CPUE) for each survey site, field session and species. Detection rates were calculated for each site by dividing the total number of observations by the time spent searching the site. Comparisons of species richness (i.e., the number of species per study site) were made by standardizing capture data, which was corrected for total time surveyed per area (e.g., number of observations per hour). Finally, site occupancy was assessed by the presence of any life stage of a species at a site.

4.7.5 Fish

To assess fish composition and density, fish abundance data was standardized to the number of individuals per trap hour (Catch Per Unit of Effort [CPUE]), which accounted for the differences in trap effort between the May and July replicates.

5.0 RESULTS

Our ability to observe possible effects of wetland enhancement depends upon the availability of robust occurrence data (i.e., multiple confirmations of species identifications over multiple years), which for this monitoring program relates to vegetation, waterfowl and shorebirds, passerines, amphibians and fish. In 2019, species from all groups were observed, the results of which are presented below.

5.1 Reservoir Conditions

During the 2019 field season, the elevation of Williston Reservoir ranged from a daily average low of 656.28 m ASL in late April to a daily average high of 668.83 m ASL in the middle of July (Table 4). Reservoir elevations reached the height of the enhancement structures on August 22, 2019 at Airport Lagoon and on August 25, 2019 at Beaver Pond.

Table 4. Dates and reservoir elevations of each 2019 field session.

	2019		Reservoir Elevation (m ASL)*		
Field Session	Start Date	End Date	Min	Max	Mean
Waterfowl / Amphibian	Apr 24	Apr 25	656.28	656.32	656.30
Waterfowl / Amphibian	May 25	May 26	659.76	660.01	659.88
Fish	May 24	May 27	659.51	660.27	659.89
Songbirds	May 31	Jun 6	661.35	662.47	661.98
Waterfowl / Amphibian	Jun 2	Jun 5	661.84	662.35	662.11
Vegetation	Jun 25	Jun 29	664.32	664.59	664.46
Fish	Jul 16	Jul 20	665.48	665.69	665.58

*elevations where the wetland features begin to get inundated: Airport Lagoon=666.99 masl; Beaver Pond = 667.25 masl.

Reservoir elevations in 2019 were lowest in April, hitting the lowest daily average (656.48 m ASL) on April 6, 2019 (Figure 14). Water levels increased after that, peaking on October 7, 2019 (668.58 m ASL). In 2019, during the survey periods the reservoir levels were approximately 2 m lower than the previous year. Over the monitoring period for GMSMON-15, the reservoir elevation in 2019 was one of the lowest overall (Figure 14).

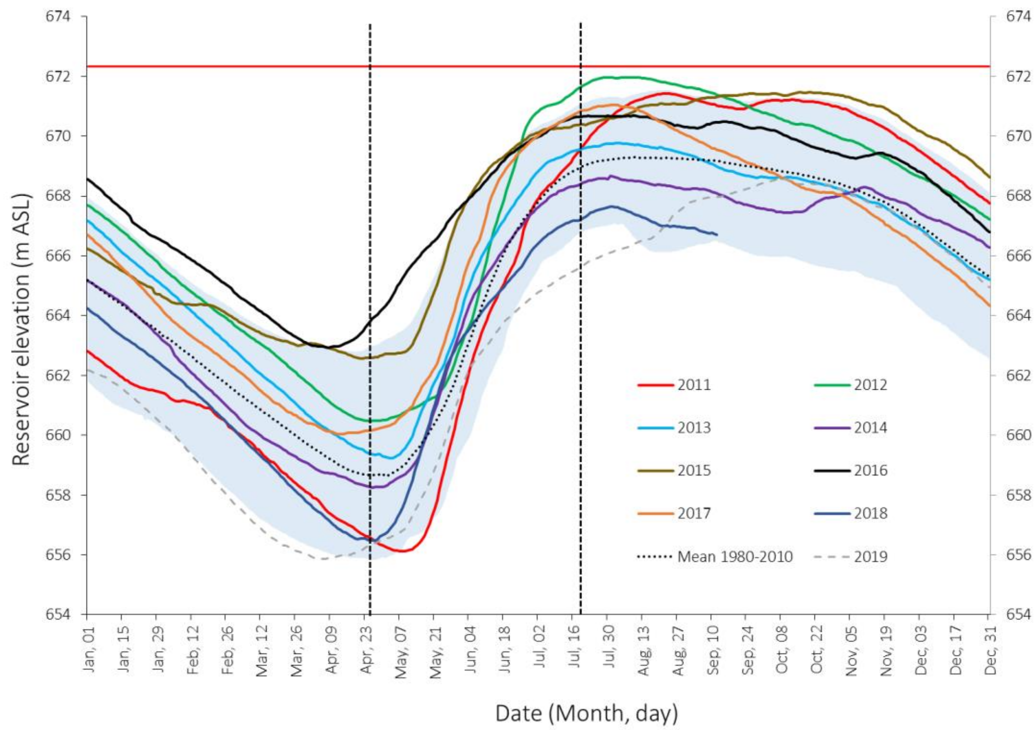


Figure 14. Williston Reservoir elevations for 2011 to 2019. The shaded area represents the 10th and 90th percentile for the period 2011 to 2018; the horizontal red line is the normal operating maximum. Vertical dashed lines indicated start and end dates of sampling in 2019.

5.2 Environmental Conditions

The average daily temperatures in 2019 were within the range of variability of the daily mean temperatures during the previous years of monitoring (Figure 15). Daily mean temperatures were warmer during the surveys in May, rapidly increased in early June, but remained cooler in July.

Cumulative precipitation during the survey period in 2019 was more extreme compared to the range of variability measured during the previous years of monitoring (Figure 16). Conditions in April 2019 appeared to be wetter than normal, whereas conditions in May and June of 2019 appeared to be drier. Likewise, conditions in July 2019 appeared to be much wetter than the other months.

In regard to accumulated degree days, Year 9 of the monitoring program was the third warmest during the survey period. While warmer than the long-term average, the accumulated degree days in 2019 were cooler than what was experienced in 2015 and 2016, but were similar to 2017 and 2018 (Figure 17).

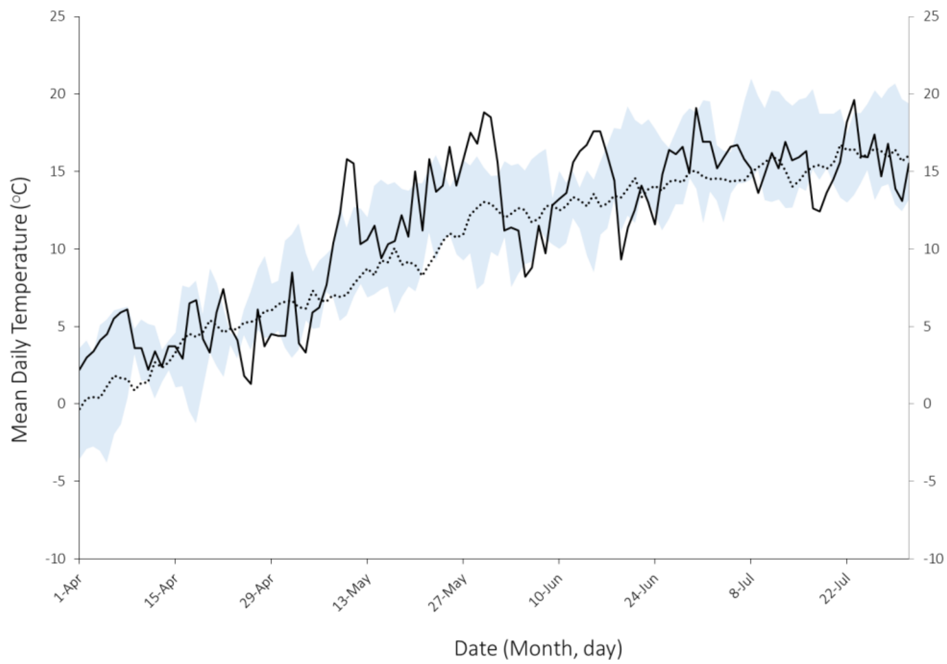


Figure 15. Daily mean air temperature for 2019 (black line) in the study region for the monthly periods when field surveys occurred. The shaded area represents the standard deviation (+/-) of the daily mean air temperatures for Years 1-8 (2011-2018) of the monitoring program. The dotted line represents the average mean temperature from 1980-2010.

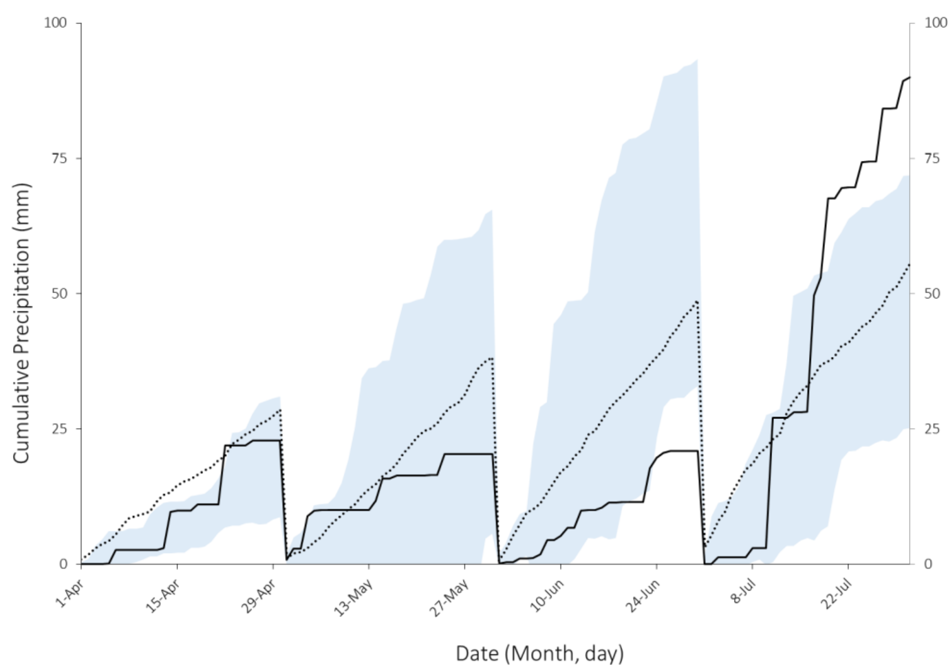


Figure 16. Cumulative monthly total precipitation for 2019 (black line) in the study region for the monthly periods when field surveys occurred. The shaded area represents the standard deviation (+/-) of the cumulative monthly total precipitation for Years 1-8 (2011-2018) of the monitoring program. The dotted line represents the average cumulative precipitation from 1980-2010.

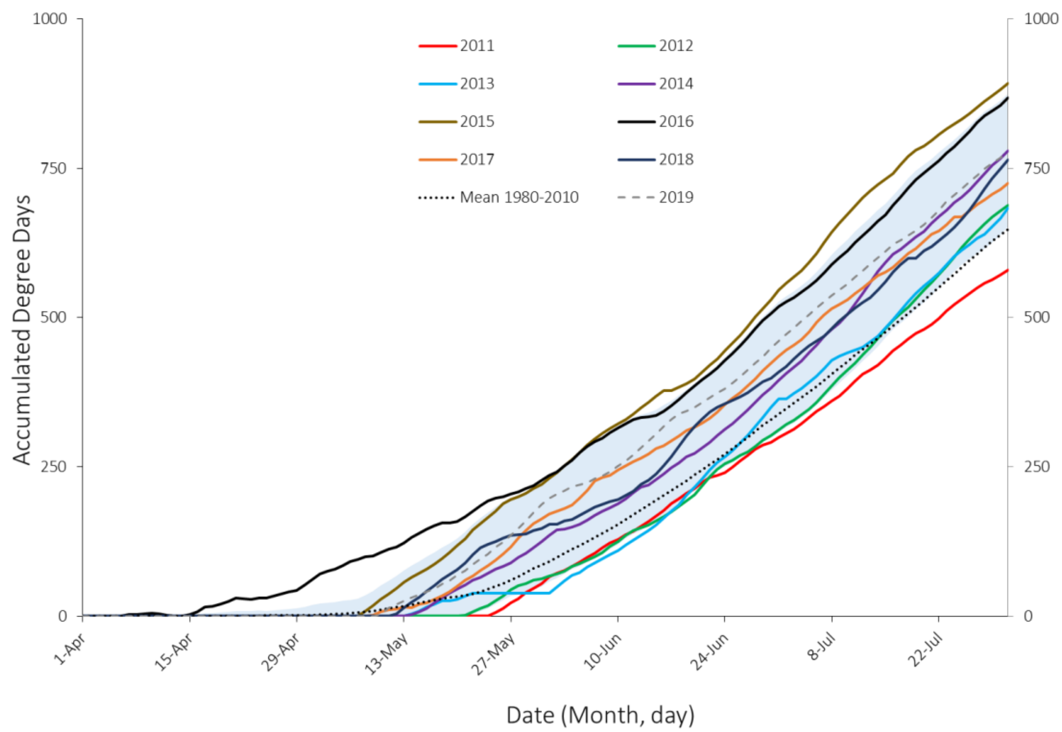


Figure 17. Accumulated degree days (5°C base temperature) and the long-term average (1980-2010) in the region. The shaded area represents the 10th and 90th percentile for the period 2011 to 2018. Calculated from Environment and Climate Change Canada daily maximum and minimum temperatures observed at the Mackenzie Airport (Station names: Mackenzie A and Mackenzie Airport Auto).

5.3 Vegetation

Plant species identified in Year 9 of the monitoring program are presented here. These results are used to characterize the vegetation coverage in the riparian area and characterize the dominant species in the aquatic macrophyte communities. Habitat classification for Beaver Pond was not presented in the Year 8 report since the spatial data for the previous years was not provided to LGL Limited until after the submission of the Year 8 final report. Habitat classification for Year 8 at Beaver Pond is presented below, plus the habitat classification for Airport Lagoon that was completed in 2018 is repeated here for reference.

5.3.1 Habitat Classification

The vegetation data collected at each site was used to determine whether the species composition of those communities changed over time.

<u>Airport Lagoon</u>

The classifications generated in 2016 at Airport Lagoon have remained relatively stable over time, with little change in species composition of each community (i.e., the same dominant species can be used to define each community); however, the area and coverage of these communities has changed between 2016 and 2018 (Table 5).

Table 5. Habitat classification summary, area for habitat classes identified during photo interpretation for the Airport Lagoon site in Year 8 compared to the previous results from Year 6. Refer to Appendix 9-2 for detailed descriptions of the habitat classes.

Habitat Class	Habitat Class Description	Year 8 Area (ha)	Year 8 Per cent of total area	Year 6 Area (ha)	Year 6 Per cent of total area	Difference between Year 8 and Year 6 (total area)	Difference between Year 8 and Year 6 (%)
BM	Basin Moss	14.6	22.3%	18.0	27.6%	-3.4	-5.3%
BS	Basin Smartweed	3.1	4.7%	4.8	7.4%	-1.8	-2.7%
FI	Floating Island	0.0	0.0%	0.1	0.1%	-0.1	-0.1%
SD	Shoreline Driftwood	11.0	16.8%	8.1	12.4%	2.9	4.4%
SG	Shoreline Grassland	2.2	3.3%	0.4	0.7%	1.8	2.7%
SP	Streams and Ponds	27.0	41.3%	26.1	40.0%	0.9	1.3%
SS	Shoreline Sand	0.7	1.1%	1.2	1.8%	-0.5	0.7%
SW	Shoreline Willow	3.9	6.0%	3.6	5.6%	0.3	0.4%
WD	Wetland Dead Trees	0.2	0.3%	0.2	0.3%	0.0	0.0%
WH	Wetland Horsetail	0.7	1.1%	0.8	1.2%	0.0	0.0%
WS	Wetland Sedge	1.1	1.6%	1.1	1.6%	0.0	0.0%
WW	Wetland Willow	0.9	1.4%	0.9	1.4%	0.0	0.0%

The biggest changes were a decreased in the area coverage for Basin Moss (BM) and Basin Smartweed (BS) and an increase in the coverage of Shoreline Driftwood (i.e., coarse woody debris; Figure 18).

<u>Beaver Pond</u>

The predominant changes in habitat structure between 2016 and 2018 at Beaver Pond included small increases in the area of Basin Crypantha and the coverage of water surface (i.e., streams and ponds; Table 6). This resulted in small decreases in other habitat classes, but most notable was the 1.7% reduction in the area of shoreline clay (Figure 19).

Table 6. Habitat classification summary, area for habitat classes identified during photo interpretation for the Beaver Pond site in Year 8 compared to the previous results from Year 6. Refer to Appendix 9-2 for detailed descriptions of the habitat classes.

Habitat Class	Habitat Class Description	Year 8 Area (ha)	Year 8 Per cent of total area	Year 6 Area (ha)	Year 6 Per cent of total area	Difference between Year 8 and Year 6 (total area)	Difference between Year 8 and Year 6 (%)
BC	Basin Crypantha	1.2	25.5%	0.9	21.6%	0.2	3.9%
SC	Shoreline Clay	1.6	35.1%	1.6	36.8%	> 0.1	-1.7%
SE	Stream Sedge	0.0	0.2%	0.0	0.7%	> -0.1	-0.4%
SP	Streams and Ponds	0.4	8.3%	0.3	7.8%	> 0.1	0.4%
SR	Shoreline Gravel	0.2	3.3%	0.2	3.6%	> -0.1	-0.2%
SW	Shoreline Driftwood	0.9	20.5%	0.9	22.0%	> -0.1	-1.4%

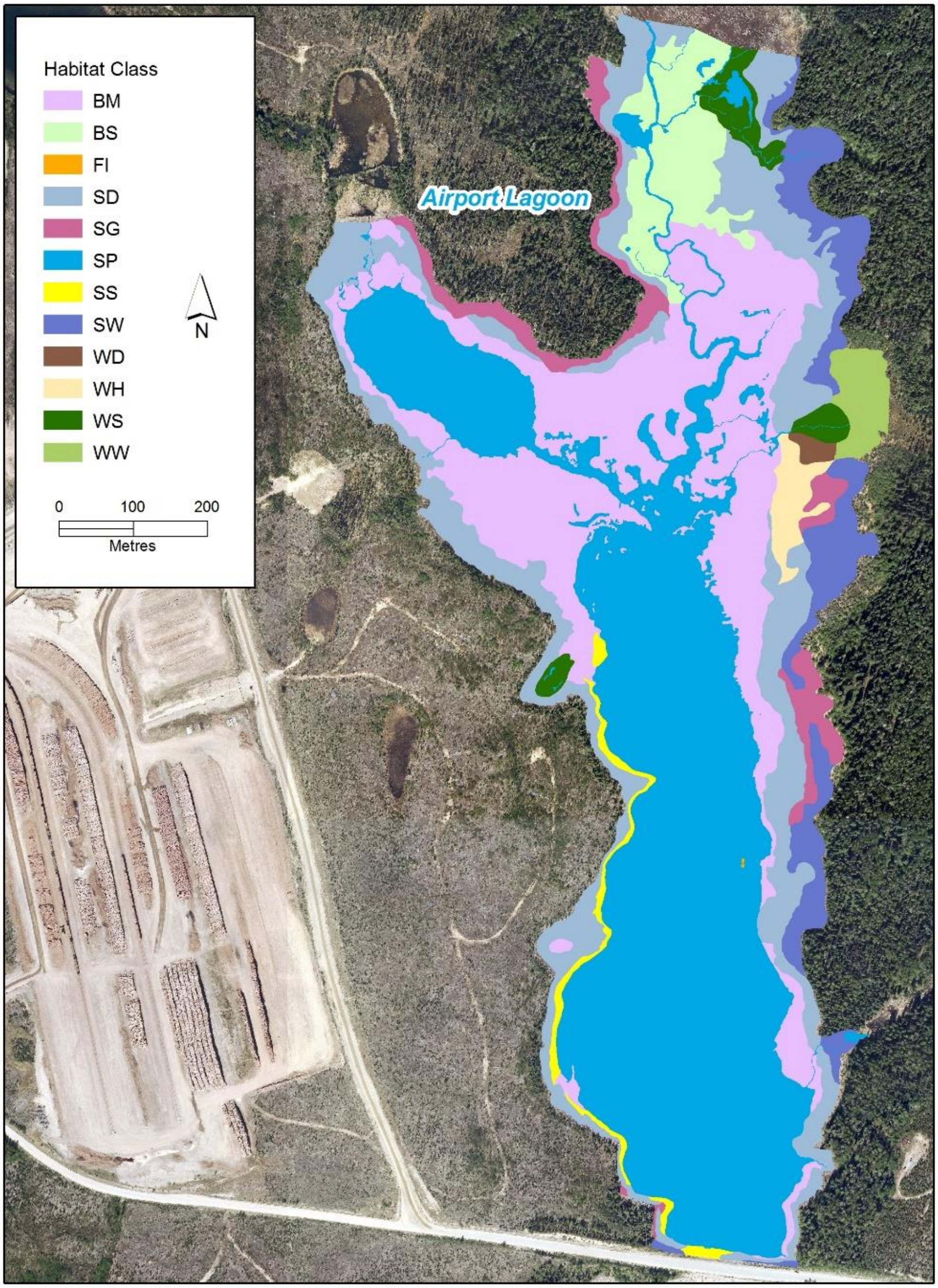


Figure 18. Spatial extent of habitat classes delineated at Airport Lagoon based on updated orthophoto imagery acquired in May 2018.

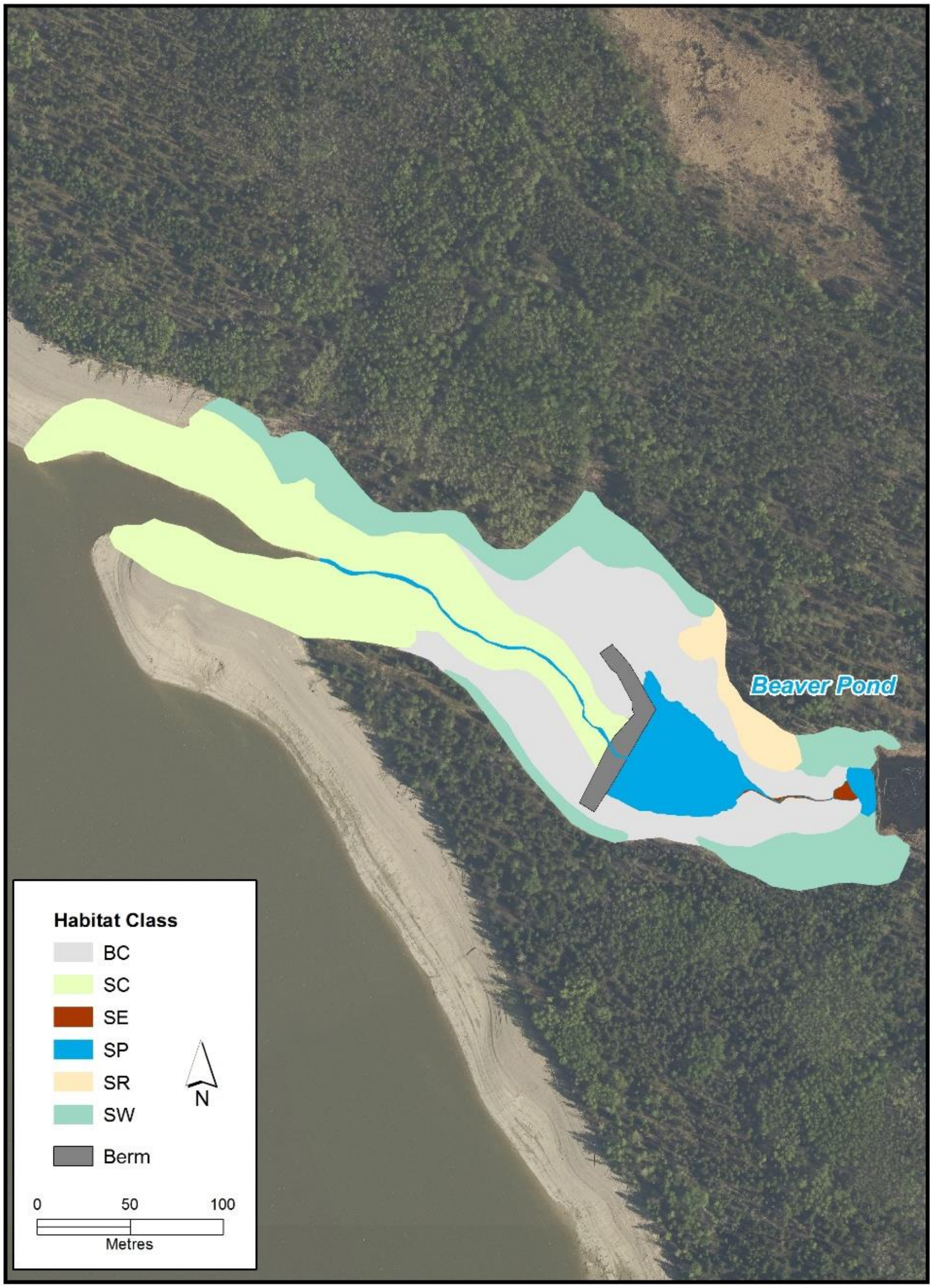


Figure 19. Spatial extent of habitat classes delineated at Beaver Pond based on updated orthophoto imagery acquired in May 2018.

5.3.2 Drawdown Zone Vegetation

At Airport Lagoon, terrestrial vegetation surveys were completed on June 25, 27, 28 and 29, 2019. Twelve belt transects that were surveyed in 2018 were also surveyed in 2019. As in previous years, transects AL-1 and AL-2 were not surveyed due to the water levels at Airport Lagoon.

Five belt transects were surveyed on June 26, 2019 at Beaver Pond. All five transects were also surveyed in 2018.

<u>Airport Lagoon</u>

Vegetation transects at the Airport Lagoon were generally located on moist, organic rich soils, with slight to gentle slopes that are subject to annual flooding and are therefore dominated by graminoid species. Overall the surface substrate was dominated by organic matter; a subset of the transects were covered with a large proportion of mineral soil (sand) and coarse woody debris (driftwood). The amount of surface water on most transects was relatively low at the time of the survey. Only transect AL-4 had any substantial amount of water present (Table 7).

Substantial tree cover was absent on all transects; however, trace amounts of sapling regeneration for *Pinus contorta* (lodgepole pine) and *Populus tremuloides* (trembling aspen) was present on transects AL-11 and AL-15. Average per cent cover of herb species ranged from a low of 3.43% (AL-4) to a high of 94.10% (AL-6). A total of 59 herb species were recorded across the 12 transects. The most common species detected were *Persicaria amphibia* (water smartweed), *Potentilla norvegica* (Norweigan cinquefoil) and *Calamagrostis canadensis* (bluejoint). Three species of moss were recorded on nine of the transects with the highest coverage being present on transect AL-4 where *Drepanocladus aduncus* (common hook moss) was present. Shrubs species were predominantly willow (*Salix* sp.) and their coverage along the transects was relatively low (Table 8).

A summary of the terrestrial plant species and percent cover for each transect will be prepared for the final report.

Table 7. Site characteristics for vegetation transects sampled in Year 9 at the Airport Lagoon.

Transect	Water Source[1]	Soil Moisture Regime[2]	Soil Nutrient Regime[3]	Successional Status[4]	Structural Stage[5]	Elevation (m)[6]	Slope (%)	Aspect (°)	% Organic Matter	% Rocks	% Mineral Soil	% Course Woody Debris	% Surface Water[7]	Drainage[8]	Flood Regime[9]
AL-3	P	2	A	DC	2b	677	15	30	53.9	0.0	41.1	11.7	0.0	r	A
AL-4	F	7	-	-	-	-	-	-	79.9	0.0	0.0	6.0	28.6	v	A
AL-5	P	3	B	DC	2b	679	15	169	46.2	0.0	16.1	36.6	0.0	r	A-F
AL-6	F	7	E	DC	2b	673	1	-	99.8	0.0	0.0	2.0	0.0	p	F
AL-7	F	7	E	DC	2b	676	3	260	100.0	0.0	0.0	0.0	0.0	v	F
AL-8	F	7	C	DC	2a	674	3	260	99.1	0.0	0.0	1.5	0.0	i	A
AL-9	P	6	E	DC	2b	675	6	272	60.7	0.0	2.3	39.5	0.0	i	A
AL-10	F	7	E	DC	2b	675	2	284	73.0	0.0	0.0	27.2	1.0	v	A-F
AL-11	G	6	E	DC	2a	676	0	-	99.0	0.0	0.0	0.0	0.0	v	A
AL-12	G	6	E	DC	2a	666	0	-	98.8	0.0	0.0	6.0	0.0	-	-
AL-14	P	6	E	DC	2b	676	5	272	84.4	0.0	0.0	19.8	0.0	i	A
AL-15	P	6	-	-	-	-	-	-	100.0	0.0	0.0	1.0	0.0	-	-

[1] P=Precipitation, G=Groundwater, S=Snowmelt, F=Stream sub-irrigation and flooding, M=Mineral spring, T=Tidal, freshwater, E=Tidal, saltwater, Z=Permafrost

[2] 0=Very Xeric, 1 = Xeric, 2 = Subxeric, 3= Submesic, 4= Mesic, 5= Subhygric, 6=Hygric, 7=Subhydric, 8=Hydric

[3] A=Very poor, B=Poor, C=Medium, D=Rich E=Very rich, F=Saline

[4] DC = Disclimax

[5] 2a= Forb dominated – includes non-graminoid herbs and ferns; 2b= Graminoid dominated – includes grasses, sedges, reeds, and rushes

[6] Values represent observations in 2016.

[7] Area of transect covered by surface water.

[8] v=very poorly drained, p=poorly drained, i=imperfectly drained, m=moderately well drained, w=well drained, r=rapidly drained, x = very rapidly drained

[9] A=annual flood, O=occasional flooding, F=frequent flooding

Table 8. Vegetation cover summary for transects sampled in Year 8 at the Airport Lagoon.

Transect	No. herb species	Average % herb cover	No. moss species	Average % moss cover	No. shrub species	Average % shrub cover
AL-3	12	3.51	0	0.00	0	0.00
AL-4	7	3.43	1	76.20	1	0.11
AL-5	16	21.12	0	0.10	0	0.00
AL-6	24	94.10	1	26.80	1	0.01
AL-7	17	55.10	1	95.10	3	8.83
AL-8	23	27.67	0	0.00	1	0.53
AL-9	15	20.50	2	1.46	0	0.00
AL-10	13	18.40	2	27.10	2	0.50
AL-11	15	12.90	2	47.00	3	3.80
AL-12	12	72.56	1	3.81	0	0.00
AL-14	10	42.70	1	0.47	0	0.00
AL-15	14	23.00	1	49.01	3	1.01
Average		***32.92***		***30.50***		***1.23***

Beaver Pond

The five vegetation transects at the Beaver Pond were located on clay rich soils with gentle to moderate slopes and were frequent to annual flooding (Table 9). Overall the surface substrate was dominated by mineral soil, except for transects BP-4 and BP-5, which were dominated by organic matter. None of the transects had any surface water at the time of the survey in 2019.

One *Pinus contorta* (lodgepole pine) seedling was present on transect BP-2. Tree cover was absent on all other transects. Average per cent cover of herb species on all transects was higher than what was recorded in 2018 but remained considerably less than Airport Lagoon. A total of 45 herb species were recorded across the five transects. The most common species detected were *Potentilla norvegica* (Norweigan cinquefoil), *Equisetum arvense* (common horsetail), and *Carex lenticularis* (lakeshore sedge). Four species of moss were recorded on the transects with the highest coverage being present on transect BP-1. Three shrub species were recorded, which were predominantly willow species (Table 10).

LGL LIMITED environmental research associates

Table 9. Site characteristics for vegetation transects sampled in Year 9 at the Beaver Pond.

Transect	Water Source[1]	Soil Moisture Regime[2]	Soil Nutrient Regime[3]	Successional Status[4]	Structural Stage[5]	Elevation (m)[6]	Slope (%)	Aspect (°)	% Organic Matter	% Rocks	% Mineral Soil	% Course Woody Debris	% Surface Water[7]	Drainage[8]	Flood Regime[9]
BP-1	P	4	D	DC	2b	673	-	-	31.9	2.8	74.3	0.6	0.0	m	A-F
BP-2	P	3	B	DC	2b	675	-	-	3.5	4.7	95.6	0.3	0.0	r	A-F
BP-3	P	3	B	DC	2b	675	25	230	1.0	29.1	70.1	0.6	0.0	r	A-F
BP-4	G	7	D	DC	2a	673	5	227	87.9	1.4	12.1	4.4	0.0	m	A
BP-5	P	4	D	DC	2a	685	20	44	54.6	0.0	5.1	39.5	0.0	m	A-F

[1] P=Precipitation, G=Groundwater, S=Snowmelt, F=Stream sub-irrigation and flooding, M=Mineral spring, T=Tidal, freshwater, E=Tidal, saltwater, Z=Permafrost

[2] 0=Very Xeric, 1 = Xeric, 2 = Subxeric, 3= Submesic, 4= Mesic, 5= Subhygric, 6=Hygric, 7=Subhydric, 8=Hydric

[3] A=Very poor, B=Poor, C=Medium, D=Rich E=Very rich, F=Saline

[4] DC = Disclimax

[5] 2a= Forb dominated – includes non-graminoid herbs and ferns; 2b= Graminoid dominated – includes grasses, sedges, reeds, and rushes

[6] Values represent observations in 2016.

[7] Area of transect covered by surface water.

[8] v=very poorly drained, p=poorly drained, i=imperfectly drained, m=moderately well drained, w=well drained, r=rapidly drained, x = very rapidly drained

[9] A=annual flood, O=occasional flooding, F=frequent flooding

Table 10. Vegetation cover summary for transects sampled in Year 8 at the Beaver Pond.

Transect	No. herb species	Average % herb cover	No. moss species	Average % moss cover	No. shrub species	Average % shrub cover
BP-1	28	7.21	1	21.60	2	0.81
BP-2	21	8.78	2	0.53	3	0.06
BP-3	14	3.94	0	0.00	1	0.01
BP-4	22	6.50	0	0.00	1	0.49
BP-5	20	11.67	3	7.80	0	0.00
Average		***7.62***		***12.09***		***0.27***

5.3.3 Aquatic Vegetation

Data on aquatic plants was collected at Airport Lagoon between June 26-28, 2019. Beaver Pond was sampled on June 28, 2019.

Airport Lagoon

Eleven species of aquatic plants were recorded at Airport Lagoon in 2019 (Table 11). The frequency ranged from 1.7% for *Hippuris vulgaris* (mare's tail) to a high of 80.0% for *Myriophyllum sibiricum* (Siberian water-milfoil). The other most commonly encountered species were *Drepanocladus aduncus* (common hook moss) and *Stuckenia pectinata* (fennel pondweed). Sampling depths were between 20 cm and 240 cm.

Table 11. Per cent frequency and average volume:abundance metric of aquatic macrophyte species detected in random samples (rake grabs) at Airport Lagoon in 2019.

Scientific Name	Common Name	Frequency (%)	Average volume x Abundance
Ceratophyllum demersum	common hornwort	28.3	2.01
Chara sp.	stonewort	13.3	0.46
Drepanocladus aduncus	common hook moss	36.7	2.37
Hippuris vulgaris	mare's tail	1.7	0.08
Myriophyllum sibiricum	Siberian water-milfoil	80.0	6.58
Potamogeton foliosus	closed-leaved pondweed	25.0	1.54
Potamogeton praelongus	long-stalked potamogeton	11.7	1.16
Ranunculus aquatilis	whitewater buttercup	10.0	0.21
Stuckenia pectinata	fennel pondweed	36.7	0.86

Beaver Pond

Four aquatic plant species were recorded at Beaver Pond in 2019. *P. foliosus* and *R. aquatilis* had the highest frequencies. *P. praelongus* was also fairly common at the site (Table 12). The majority of the aquatic vegetation samples were collected between 50 cm and 100 cm in depth.

Table 12. Per cent frequency and average volume:abundance metric of aquatic macrophyte species detected in random samples (rake grabs) at Beaver Pond in 2019.

Scientific Name	Common Name	Frequency (%)	Average volume x Abundance
Potamogeton foliosus	closed-leaved pondweed	50.0	2.37
Potamogeton natans	broad-leaved pondweed	6.3	0.23
Potamogeton praelongus	long-stalked potamogeton	43.8	1.56
Ranunculus aquatilis	whitewater buttercup	50.0	1.38

5.4 Waterfowl and Shorebirds

In 2019, three replicates of waterfowl and shorebird surveys were completed at Airport Lagoon and only two replicates were completed at Beaver Pond (Table 13). Access to Beaver Pond at the end of April 2019 was not possible due to the ice conditions on Williston Reservoir at the time of the survey. Data was collected on multiple days at Beaver Pond during the June 2019 visit, so the maximum count of species recorded on these days was used in the analysis.

Table 13. Dates for the waterfowl and shorebird surveys at Airport Lagoon and Beaver Pond in 2019.

Site		Survey Dates	
Airport Lagoon	April 24, 2019	May 25, 2019	June 5, 2019
Beaver Pond		May 26, 2018	June 2, 3, 4, 2018

5.4.1 Airport Lagoon

At Airport Lagoon, all five of the survey stations were visited during each of the replicates. Survey effort (i.e., observation time) ranged from 10 minutes to 33 minutes at each observation station. A total of 27 individuals from the shorebird group were recorded for five species: Greater Yellowlegs (GRYE, *Tringa melanoleuca*; n=9), Spotted Sandpiper (SPSA, *Actitis macularius*; n = 9), Killdeer (KILL, *Charadrius vociferous*; n=5), Lesser Yellowlegs (LEYE, *Tringa flavipes*; n= 2), and Solitary Sandpiper (SOSA, *Tringa solitaria*; n=2) (Figure 20).

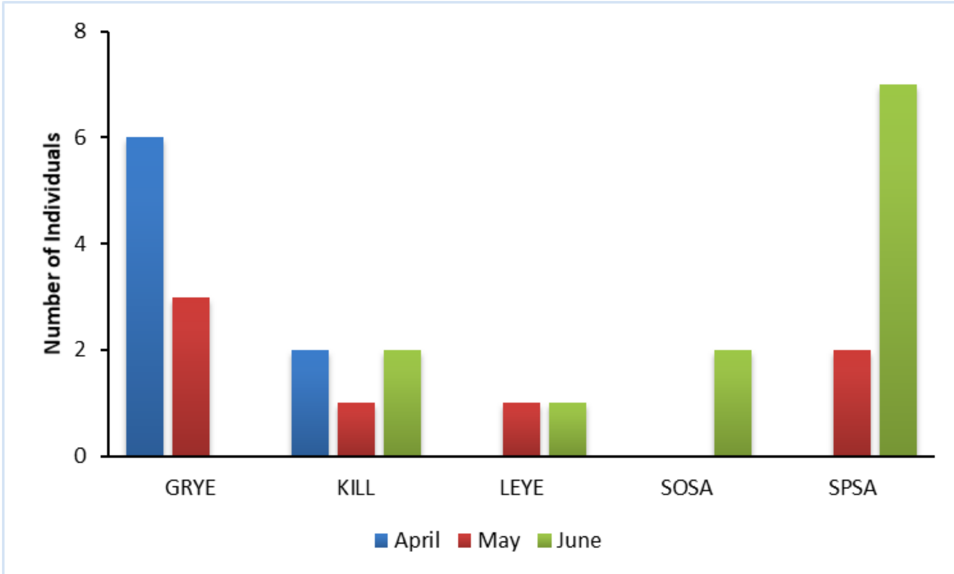


Figure 20. Species composition of shorebirds observed at Airport Lagoon during the surveys in April, May and June 2019.

Thirteen waterfowl species and a total of 690 individuals were recorded at Airport Lagoon. Waterfowl species observed at Airport Lagoon (Figure 21) included American Wigeon (AMWI, *Mareca americana*; n=303), Mallard (MALL, *Anas platyrhynchos*; n=137), Green-winged Teal (GWTA, *Anas crecca*; n=131), Canada Goose (CAGO, *Branta canadensis*; n=49), Northern Pintail (NOPI, *Anas acuta*; n=42), Gadwall (GADW, *Mareca Strepera*, n=6), Common Merganser (COME, *Mergus merganser*; n=5), Blue-winged Teal (BWTE, *Spatula discors*; n=4), Lesser Scaup (LESC, *Aythya affinis*; n=4), Bufflehead (BUFF, *Bucephala albeola*; n=3), Trumpeter Swan (TRUS, *Cygnus buccinator*; n=3), Ring-necked Duck (RNDU, *Aythya affinis*; n=2), and Eurasian Wigeon (EUWI, *Mareca penelope*; n=1).

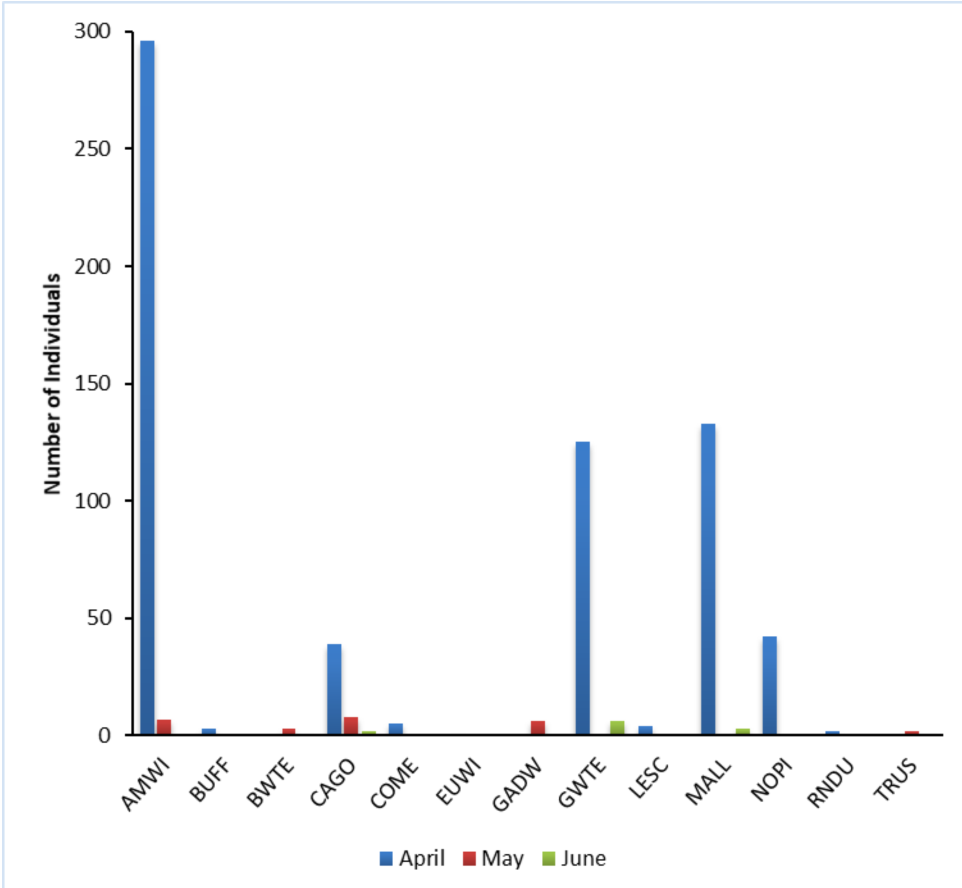


Figure 21. Species composition of waterfowl observed at Airport Lagoon during the surveys in April, May and June 2019.

Species richness for shorebirds was highest in June, whereas it was highest for waterfowl in April. Likewise, for the number of individuals observed; more waterfowl were using the Airport Lagoon in April and numbers declined in May and June. Conversely, the number of shorebird species was highest in June compared to the previous months (Figure 22).

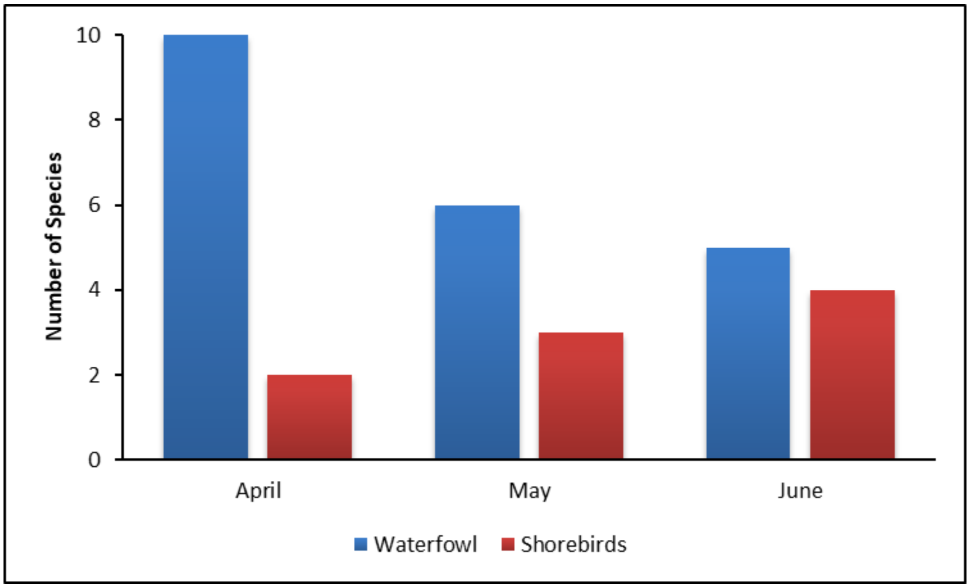


Figure 22. Species richness for shorebirds and waterfowl at Airport Lagoon in 2019.

The majority of shorebird and waterfowl observations were recorded in the northern half of the Airport Lagoon. Other water-associated birds recorded at Airport Lagoon during the replicate surveys were Belted Kingfisher (*Megaceryle alcyon*; n=1), Common Loon (*Gavia immer*; n=2), Bonaparte's Gull (*Chroicocephalus philadelphia*; n=2), California Gull (*Larus californicus*; n=15), Herring Gull (*Larus argentatus*; n=2) and Ring-billed Gull (*Larus delawarensis*; n=7). Three additional waterfowl species and two shorebird species were recorded at Airport Lagoon during the Songbird Survey in June 2019. These included Northern Shoveler (*Spatula clypeata*, n=10), Common Goldeneye (*Bucephala clangula*, n=1), Red-breasted (*Mergus serrator*, n=1), Wilson's Snipe (*Gallinago delicata*, n=2) and Wilson's Phalarope (*Phalaropus tricolor*, n=1).

Nesting activity was recorded for two waterbird species (Common Loon and Trumpeter Swan) during the June survey.

5.4.2 Beaver Pond

Survey effort at Beaver Pond was 70 minutes in May and between 20 and 33 minutes in June. A total of 14 individuals from the shorebird group were recorded for three species: Spotted Sandpiper (n = 6), Killdeer (n=5), and Greater Yellowlegs (n=3). Two waterfowl species were recorded in May: Canada Goose (n=8) and Bufflehead (n=2). Only one waterfowl species was recorded in June: Blue-winged Teal (n=1). One Solitary Sandpiper was recorded at Beaver Pond during the Songbird Survey. No new waterfowl species were documented at this time.

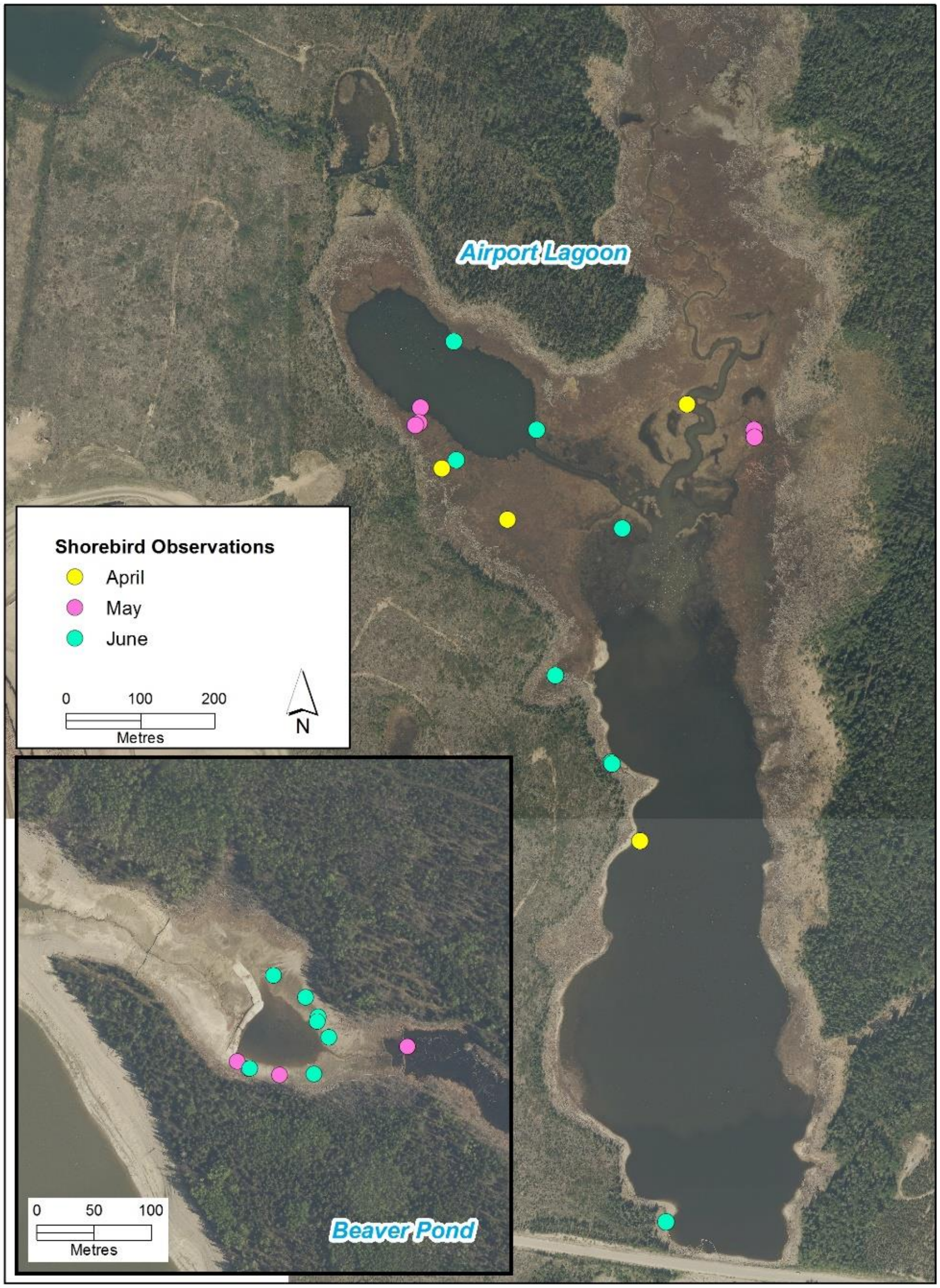


Figure 23. Distribution of shorebird detections by survey date at Airport Lagoon and Beaver Pond in 2019.

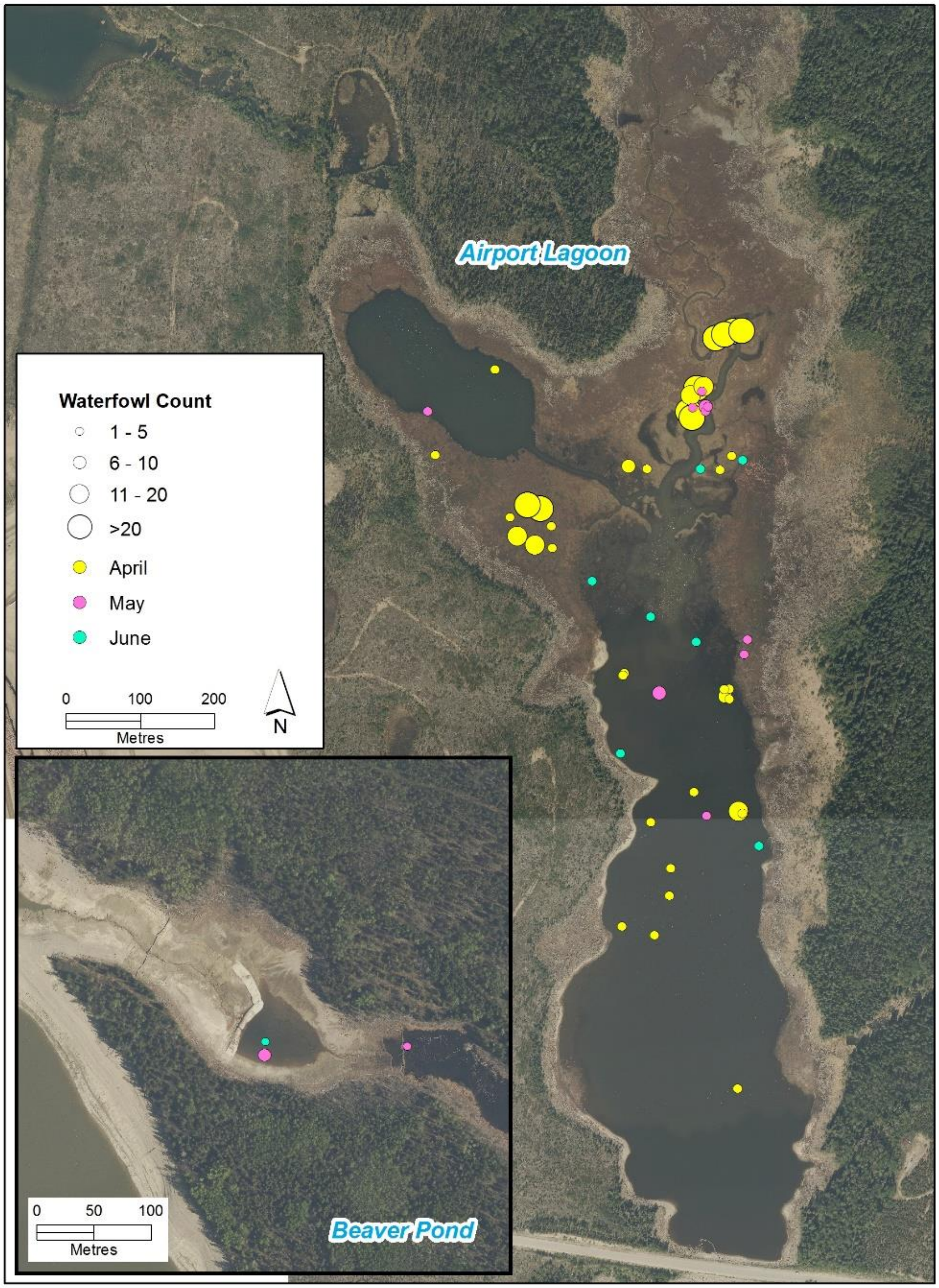


Figure 24. Distribution of waterfowl detections by survey date at Airport Lagoon and Beaver Pond in 2019. The different size circles represent the relative abundances observed during the surveys.

5.5 Songbirds

Point count surveys were completed at Airport Lagoon on May 30, 31 and June 1, 2019, and at Beaver Pond on June 2, 3, and 4, 2019.

5.5.1 Airport Lagoon

At Airport Lagoon, a total of 73 species were documented in 2019 from all species groups during songbird point count surveys. These included two species listed as "Threatened" on Schedule 1 of the *Species at Risk Act* (*SARA*): Bank Swallow (*Riparia riparia*), and Barn Swallow (*Hirundo rustica*). Additionally, the Olive-sided Flycatcher (*Contopus cooperi*) is listed as "Special Concern" under *SARA*.

For songbird and hummingbird species only, a total of 42 species were recorded in 2019. These comprised 365 observations of 473 individuals, excluding fly-overs and observations >75 m from the point count centre. Savannah Sparrow (*Passerculus sandwichensis*) was the most frequently detected songbird (n=40), followed by Lincoln's Sparrow (*Melospiza lincolnii*; n=33), Swainson's Thrush (*Catharus ustulatus*; n=22) and Tree Swallow (*Tachycineta bicolor*; n=22). The ten most frequently detected species accounted for 57.8% of all detections and comprised representatives from five bird families: sparrows (4 species), swallows (1 species), warblers (2 species), thrushes (2 species) and vireos (1 species). In total 15 songbird/hummingbird families were represented.

Forest habitat types had higher richness and diversity than DDZ or Shrub habitats (Figure 25). Shrub habitat had the lowest richness and diversity (Figure 25).

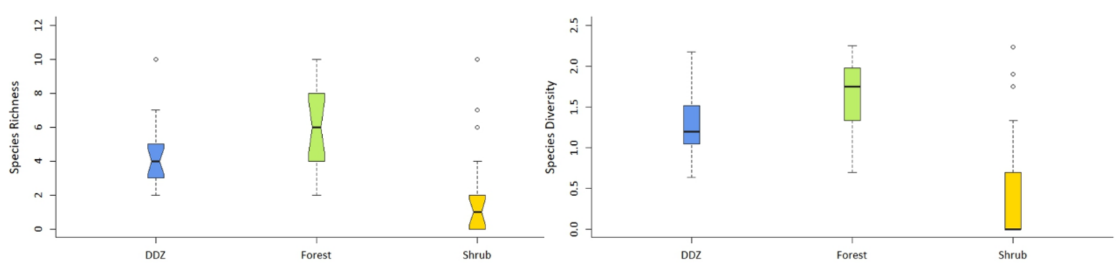


Figure 25. Boxplots showing species richness (left panel) and diversity (right panel) at three habitat types (drawdown zone (DDZ), forest, and shrub) at Airport Lagoon. Both richness and diversity were highest in forest habitats, while significantly lower in shrub habitat. Boxplots were generated based on the richness and diversity values as calculated for each point count station (observations at a point count station were summed across all visits; n=17 for each habitat type).

Only two bird species were detected in all three habitat types. Twenty-six species were only found in one habitat type (Figure 26). The two species unique to Shrub habitats were the Black-capped Chickadee (*Poecile atricapillus*) and Yellow Warbler (*Setophaga petechia*). Those unique to DDZ habitats were predominantly aerial insectivores (i.e., swallows) and open-country passerines such as American Pipit (*Anthus rubescens*) and Savannah Sparrow. Species unique to forest habitat types included several flycatchers (e.g., Olive-sided Flycatcher, Hammond's Flycatcher [*Empidonax hammondii*], Pacific-slope Flycatcher [*Empidonax difficilis*]), kinglets, thrushes (e.g., Varied Thrush [*Ixoreus naevius*], Hermit Thrush [*Catharus guttatus*]) and other woodland species.

Figure 26. Venn diagram showing the number of species unique to each habitat type at Airport Lagoon, and the shared number of species between each pair-wise comparison of habitats as well as all habitats together.

In some cases, unique species within a habitat are in-part due to few detections, and likely do not have an actual affinity to that habitat specifically (e.g., Black-capped Chickadee in Shrub habitats). It is also informative to look at the dispersion of observations by habitat type within those species with a higher number of detections to visualize habitat preferences. For example, Lincoln's Sparrow was documented from all habitat types, though the majority were in DDZ, while Northern Waterthrush (*Parkesia noveboracensis*) were more evenly detected in Forest and Shrub habitat around the Airport Lagoon (Figure 27).

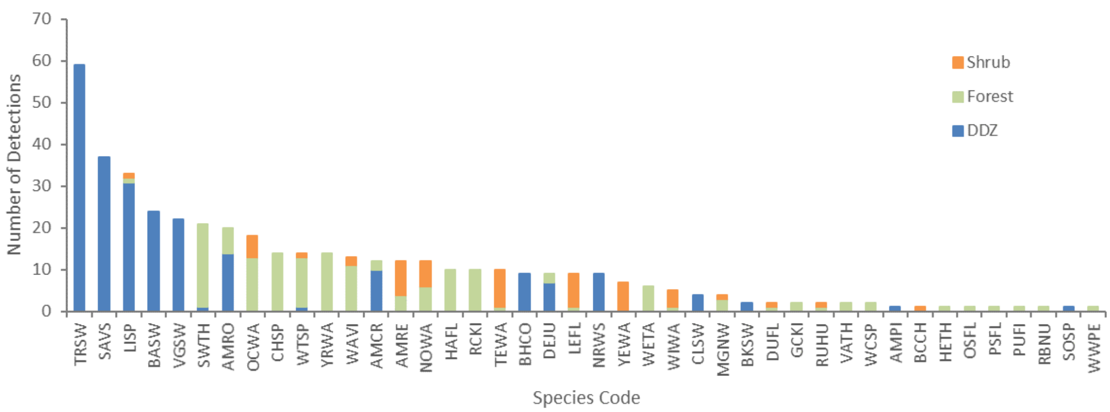


Figure 27. Total number of songbird individuals of each species per habitat type at Airport Lagoon. Species associated with their respective codes are presented in Appendix 9-3.

5.5.2 Beaver Pond

At Beaver Pond, a total of 34 species were documented in 2019 from all species groups during songbird point count surveys. No species of provincial or federal conservation concern were detected.

For songbird species only, a total of 23 species were recorded comprising 84 detections of 86 individuals in 2019. The five most frequently detected species (all with >5 individuals) accounted for 47.6% of all detections, while the ten species with 1 or 2 detections accounted for 15.5% of all detections. Eight bird families were represented by observations at Beaver Pond including warblers (7 species), sparrows (5 species), flycatchers (4 species), thrushes (3 species), and vireos, kinglets, swallows, and chickadees (each with 1 species).

Drawdown zone habitat types had lower richness and diversity than Forest or Shrub habitats (Figure 28). Forest had significantly higher richness and diversity than either shrub or DDZ habitats.

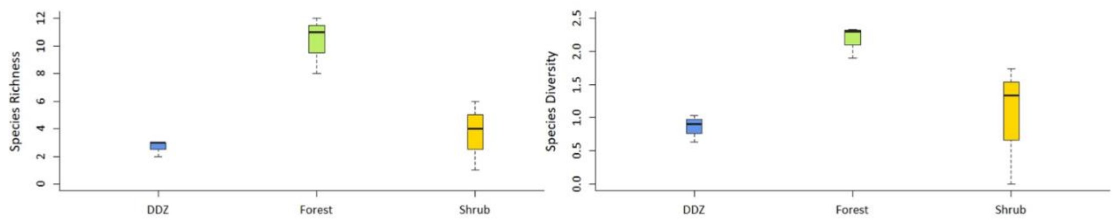


Figure 28. Boxplots showing species richness (left panel) and diversity (right panel) at three habitat types (drawdown zone (DDZ), forest, and shrub) at Beaver Pond. Both richness and diversity were significantly lower in DDZ habitats, while no difference exists between forest and shrub habitats. Boxplots were generated based on the richness and diversity values as calculated for each point count station (observations at a point count station were summed across all visits; n=3 for each habitat type).

Only one species, Lincoln's Sparrow, was detected in all three habitat types. The greatest amount of habitat overlap among songbirds occurred between the Forest and Shrub habitats (4 shared species). There were only two shared species between DDZ and Shrub and DDZ and Forest habitats (Figure 29). Consistent with Airport Lagoon, the species unique to DDZ included an aerial insectivore (Northern Rough-winged Swallow [*Stelgidopteryx serripennis*]) and Savannah Sparrow. Shrub habitats alone hosted Least Flycatcher (*Empidonax minimus*), and Song Sparrow (*Melospiza melodia*), while unique species in Forested habitats included warblers (Magnolia [*Setophaga magnolia*], Orange-crowned [*Leiothlypis celata*], Yellow-rumped [*Setophaga coronate*], and Ovenbird [*Seiurus aurocapilla*]), thrushes (Swainson's Thrush and Hermit Thrush), and other woodland species (e.g., kinglets, vireos and chickadees).

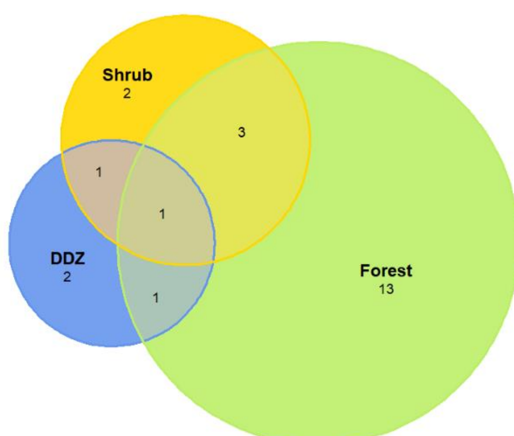


Figure 29. Venn diagram showing the number of species unique to each habitat type at Beaver Pond, and the shared number of species between each pair-wise comparison of habitats as well as all habitats together.

Within the Beaver Pond area, most birds were observed in forest habitat, though this varied by species. For example, the Lincoln's Sparrow was detected in all three habitat types, but with a greater number of observations in shrub habitat. Northern Waterthrush were detected equally in DDZ and shrub habitats, while the most frequently detected species, American Redstart (*Setophaga ruticilla*), was mostly recorded in forest habitat despite also occurring in shrubs (Figure 30).

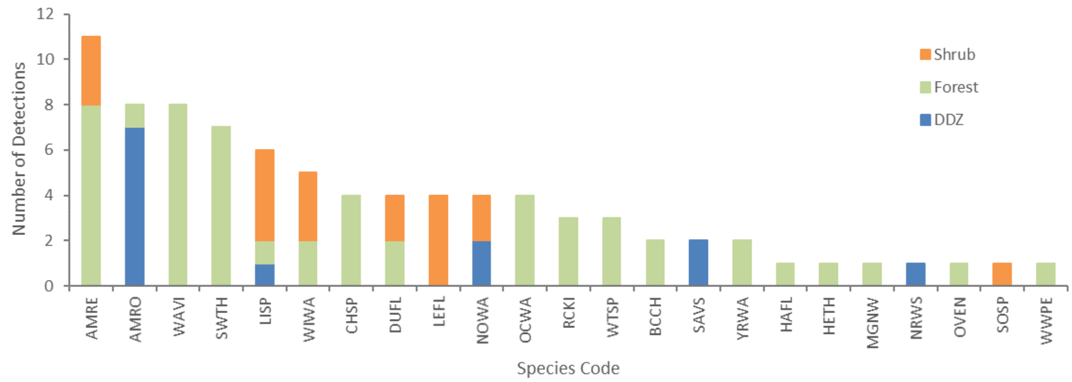


Figure 30. Total number of songbird individuals of each species per habitat type at Beaver Pond. Species associated with their respective codes are presented in Appendix 9.3.

5.6 Amphibians

In 2019, three species of amphibian were detected across the two study sites; only Western Toad (*Anaxyrus boreas*) was detected at both sites (Table 14).

Table 14. Species of amphibian detected at Airport Lagoon and Beaver Pond in 2019.

Species	Survey Location	
	Airport Lagoon	Beaver Pond
Western Toad	✓	✓
Columbia Spotted Frog	✓	
Wood Frog		✓

5.6.1 Airport Lagoon

Across the three replicate surveys 9.26 person-hours were spent surveying for amphibians on the 11 transects. On average 16.8 minutes were spent on each transect by two observers. No amphibians were detected during the April or May surveys. However, one adult, female Western Toad was incidentally recorded in a small wetland west of Airport Lagoon on May 24, 2019. In June 2019, one juvenile Western Toad was detected on transect 25 and tadpole and adult Columbia Spotted Frogs (*Rana luteiventris*) were observed along transects 25 and 32 (Table 15).

Table 15. **Amphibians detected and catch per unit effort at both enhancement sites on the Williston Reservoir during the surveys in 2019.**

Site	Survey Date	# detections	Survey effort (min)	Catch per unit effort (CPUE)
Airport Lagoon	April 24, 2019	0	140	0
	May 24, 2019	1	60	0.017
	May 25, 2019	0	160	0
	June 4, 2019	3	115	0.026
	June 5, 2019	1	81	0.012
Beaver Pond	May 26, 2019	2	58	0.034
	June 2, 2019	17	86	0.198

5.6.2 Beaver Pond

A total of 2.5 person-hours was spent surveying at Beaver Pond over the two visits (i.e., 45 minutes per visit). Observations of Western Toad tadpoles and metamorphs (small toad, or toadlet, that has recently developed from a tadpole) were recorded during the site visit on May 26, 2019. During the second replicate on June 2, 2019, multiple observations of Western Toad tadpoles, juvenile and adults were recorded, as well as five subadult/adult Wood Frogs (*Lithobates sylvaticus*) (Table 15).

5.7 Fish

Minnow traps were deployed at Airport Lagoon on May 23, 2019 and retrieved on May 24, 2019. The two fyke nets were deployed at the Airport Lagoon on May 24, 2019. The reach at Airport Lagoon was electrofished on May 26, 2019. During the second sampling session, minnow traps were deployed on July 15, 2019 and retrieved on July 16, 2019. One fyke net was deployed on July 16, 2019 and retrieved on July 17, 2019. The second fyke net was deployed on July 17, 2019 and retrieved on July 18, 2019. The reach was electrofished on July 18, 2019. Captures from the fyke nets were processed on July 17 and 18, 2019.

At the Beaver Pond, minnow traps and the fyke net were deployed on May 26, 2019 and retrieved on May 27, 2019. During the second sampling session, minnow traps and the fyke net were deployed on July 19, 2019 and retrieved on July 20, 2019. During both sampling sessions, water levels were too shallow to electrofish. There was also a high abundance of tadpoles and some frogs in sampling area.

5.7.1 Airport Lagoon

Eleven fish species from four families were captured in Airport Lagoon in 2019 (Figure 31; Table 16). In total, 7,461 fish were captured, with most (77%; 5,783) sampled in May. Minnows (Cyprinidae) dominated catches, followed by suckers (Catostomidae), Prickly sculpin (*Cottus asper*), Salmonids (Rainbow trout [*Oncorhynchus mykiss*], and Bull trout [*Salvelinus confluentus*]). The CPUE was highest in May for both fyke nets, the minnow traps, and electrofishing.

Brassy minnow (*Hybognathus hankinsoni*) were the most common species captured for each method in each month. Redside shiner (*Richardsonius balteatus*) and Lake chub (*Couesius plumbeus*) were also captured in high numbers. Largescale suckers (*Catostomus macrocheilus*), Northern pikeminnow (*Ptychocheilus oregonensis*) and Bull trout were only captured in May.

Length measurements were collected from each of the 11 species sampled. Results for the two sampling periods were pooled and are presented in Table 17. Length histograms were produced for the three most abundant species: Brassy minnow, Lake chub, and Redside shiner (Figure 32).

LGL LIMITED environmental research associates

Image 25: Bull Trout (*Salvelinus confluentus*) caught on May 25, 2019.

Image 26: Rainbow trout (*Oncorhynchus mykiss*) caught on May 25, 2019.

Image 27: Redside shiner (*Richardsonius balteatus*) caught on May 25, 2019.

Image 28: Brassy minnow (*Hybognathus hankinsoni*) caught on May 24, 2019.

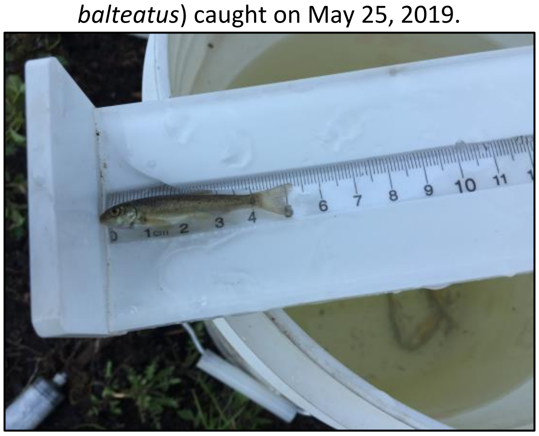


Image 29: Lake chub (*Couesius plumbeus*) caught on May 24, 2019.

Image 30: Largescale sucker (*Catostomus macrocheilus)* caught on May 24, 2019.

Figure 31. Sample images of some of the fish species caught in the Airport Lagoon in 2019.

Table 16. Summary of fish species captured, by method and sampling period, at Airport Lagoon, 2019.

Species			Method[a] and Sampling Period[b]								Grand
			EF		MT		FN[c]		Totals		
Family	Scientific name	Common name	May	July	May	July	May	July	May	July	Total
Catostomidae	*Catostomus catostomus*	Longnose sucker	0	0	0	0	52	3	52	3	55
	C. commersoni	White sucker	0	0	0	0	1	72	1	72	73
	C. macrocheilus	Largescale sucker	0	0	0	0	7	0	7	0	7
		Unidentified sucker	0	0	0	1	0	1	0	2	2
		Subtotal	*0*	*0*	*0*	*1*	*60*	*76*	*60*	*77*	*137*
Cottidae	*Cottus asper*	Prickly sculpin	4	1	0	0	23	6	27	7	34
		Unidentified sculpin	0	0	0	1	0	0	0	1	1
		Subtotal	*4*	*1*	*0*	*1*	*23*	*6*	*27*	*8*	*35*
Cyprinidae	*Couesius plumbeus*	Lake chub	31	18	45	34	905	41	981	93	1,074
	Hybognathus hankinsoni	Brassy minnow	1	0	5	0	2,477	931	2,483	931	3,414
	Mylocheilus caurinus	Peamouth chub	0	0	0	0	2	0	2	0	2
	Ptychocheilus oregonensis	Northern pikeminnow	0	0	0	0	8	0	8	0	8
	Richardsonius balteatus	Redside shiner	173	4	88	351	1,951	209	2,212	564	2,776
		Unidentified minnow	0	0	0	0	0	3	0	3	3
		Subtotal	*205*	*22*	*138*	*385*	*5,343*	*1,184*	*5,686*	*1,591*	*7,277*
Salmonidae	*Oncorhynchus mykiss*	Rainbow trout	0	0	0	0	4	7	4	7	11
	Salvelinus confluentus	Bull trout	0	0	0	0	1	0	1	0	1
		Subtotal	*0*	*0*	*0*	*0*	*5*	*7*	*5*	*7*	*12*
		Airport Lagoon Totals	209	23	138	387	5,436	1,280	5,783	1,690	7,461
		Effort[d]	800	914	229.6	204.9	47.4	38.7			
		CPUE[e]	15.7	1.5	0.6	1.9	114.6	33.1			

[a] EF = backpack electrofisher; MT = minnow trap; FN = fyke net

[b] 23-26 May 2019; 15-18 July 2019

[c] Two fyke nets set were set in May and July.

[d] Electrofishing effort = seconds; minnow trap and fyke net effort = combined hours for all traps or nets fished during a sampling period.

[e] Catch per unit effort (CPUE): electrofishing CPUE = fish/minute; minnow trap and fyke net CPUE = fish/hour.

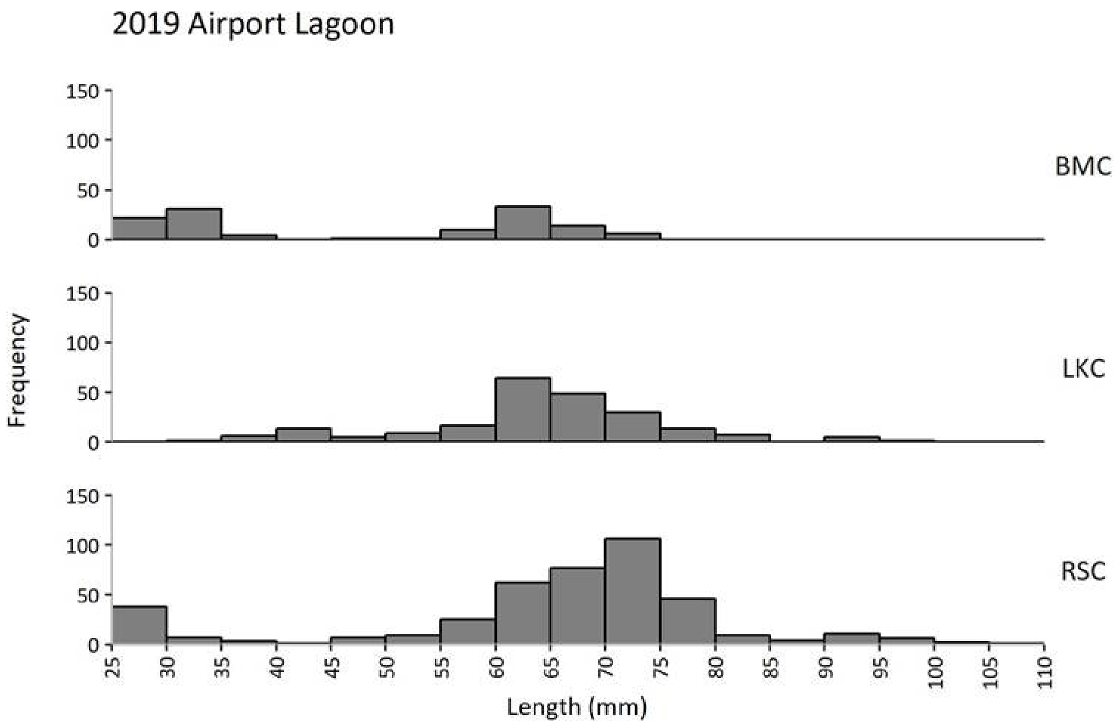


Figure 32. Length-frequency histograms for the three most abundant species captured at Airport Lagoon in 2019: Brassy minnow (BMC), Lake chub (LKC), and Redside shiner (RSC).

Table 17. Length summary of fish species sampled at the Airport lagoon site, 2019.

	Species		Length (mm)[a]			
Family	**Scientific name**	**Common name**	**n**	**Average**	**Min**	**Max**
Catostomidae	*Catostomus catostomus*	Longnose sucker	55	210	112	345
	C. commersoni	White sucker	73	152	36	274
	C. macrocheilus	Largescale sucker	7	168	48	241
		Unidentified sucker	2	45	43	46
Cottidae	*Cottus asper*	Prickly sculpin	34	67	41	135
Cyprinidae	*Couesius plumbeus*	Lake chub	224	65	31	99
	Hybognathus hankinsoni	Brassy minnow	127	49	26	75
	Mylocheilus caurinus	Peamouth chub	2	223	175	270
	Ptychocheilus oregonensis	Northern pikeminnow	8	122	68	262
	Richardsonius balteatus	Redside shiner	450	64	15	111
Salmonidae	*Oncorhynchus mykiss*	Rainbow trout	11	226	168	268
	Salvelinus confluentus	Bull trout	1	228	228	228

[a] Total length for prickly sculpin and fork length for all other species.

5.7.2 Beaver Pond

Four fish species from three families were captured in the Beaver Pond in 2019. In total, 184 fish were captured, with most (60%; 111) sampled in July. Suckers (Catostomidae) dominated catches, followed by minnows (Cyprinidae). White sucker (*Catostomus commersonii*) and Redside shiner were the most common species captured in the fyke net in each month (Table 18).

Length measurements were collected from each of the five species sampled. Results for the two sampling periods were pooled and are presented in Table 19. The white suckers had a variety of size classes ranging from 28 mm to 241 mm. The Redside shiners also had a variety of size classes ranging from 25 mm to 65 mm.

Table 18. Summary of fish species captured, by method and sampling period, at the Beaver Pond site, 2019.

			Method[a] and Sampling Period[b]								
	Species		EF[c]		MT		FN		Totals		Grand
Family	Scientific name	Common name	May	July	May	July	May	July	May	July	Total
Catostomidae	*C. commersoni*	White sucker	-	-	3	0	61	33	64	33	97
Cottidae	*Cottus asper*	Prickly sculpin	-	-	0	0	0	1	0	1	1
		Unidentified sculpin	-	-	0	0	0	32	0	32	32
Cyprinidae	*Richardsonius balteatus*	Redside shiner	-	-	0	0	9	44	9	44	53
	P. oregonensis	Northern pikeminnow	-	-	0	1	0	0	0	1	1
		Beaver Pond Totals	-	-	3	1	70	110	73	111	184
		Effort	-	-	100.7	124.6	19.3	19.6			
		CPUE	-	-	0.0	0.0	3.6	5.6			

[a] EF = backpack electrofisher; MT = minnow trap; FN = fyke net

[b] 26-27 May 2019; 19-20 July 2019.

[c] Effective electrofishing could not be conducted due to insufficient water levels above and below the Beaver Pond berm.

Table 19. Length summary of fish species sampled at the Beaver Pond site, 2019.

	Species		Length (mm)[a]			
Family	Scientific name	Common name	n	Average	Min	Max
Catostomidae	*C. commersoni*	White sucker	97	92	28	241
Cottidae	*Cottus asper*	Prickly sculpin	1	135	135	135
		Unidentified sculpin	32	34	30	36
Cyprinidae	*Ptychocheilus oregonensis*	Northern pikeminnow	1	110	110	110
	Richardsonius balteatus	Redside shiner	53	49	25	65

[a] Total length for prickly and unidentified sculpins and fork length for all other species.

6.0 DISCUSSION

GMSMON-15, initiated in 2011, is a long-term monitoring program that aims to understand the effectiveness of the wetland demonstration projects in improving fish and wildlife habitat on the Williston Reservoir. Data collected in 2019 represented Year 9 of the 10-year monitoring. The Airport Lagoon enhancements were completed in May 2013, so data collected in Year 9 represented the sixth full year of post-construction monitoring. The Beaver Pond enhancements were completed in June 2014, so the data collected in Year 9 represented the fifth full year of post-construction monitoring for that site.

For the most part, the methods employed in previous years of the monitoring program were used in Year 9. Previous annual reports (e.g., Year 2 to Year 6) have provided qualitative assessments of changes observed in earlier years of the monitoring program. We have not taken that approach here and discuss the results of Year 9 only.

6.1 Environmental Conditions

Reservoir operations and annual environmental conditions can affect the availability and suitability of habitats in the drawdown zone; which can result in annual variability in the data collected for the target species. Fish and wildlife response variables (e.g., presence/not detected, relative abundance, species richness and diversity, presence and relative abundance of native versus non-native species), patterns of habitat use, and habitat suitability are expected to vary across the sampling years. Therefore, factors such as reservoir elevations and environmental conditions will be considered as covariates in the comprehensive analyses, conducted after data collection in Year 10, to account for possible confounding effects of these variables on response variables.

6.2 Vegetation

Vegetation species identified during the belt transect sampling can be classified as both terrestrial plant species and aquatic plant species, which provides evidence of annual and/or frequent flooding. This flooding likely influences the density, diversity and spatial extent of vegetation at the enhancement sites.

The habitat classes at both sites have responded to the wetland enhancements and the annual flooding. The amount of surface water (e.g., pond) has appeared to have increased at both sites leaving a varied shoreline/riparian area. At Airport Lagoon, the general pattern of riparian habitat from the water's edge starts with either mineral soil (sand) or mosses and perennials that transitions into a band of coarse woody debris (driftwood) followed by graminoid-dominated areas and then shrub habitats. Tree seedlings were documented in Year 9, but it may be too early to determine if these trees can become established. At Beaver Pond, mud and clay remains present at the water's edge, but perennial species are becoming established. The partitioning of communities observed along these gradients suggests that succession to stable wetland/riparian communities will require additional time, but that this successional trajectory is occurring.

Aquatic plant sampling was initiated in 2014 (Year 4) to monitor the development of aquatic plant communities at Airport Lagoon and Beaver Pond following completion of the wetland enhancement projects. The overall macrophyte community at Beaver Pond remains poorly developed. The same is not true at Airport Lagoon where macrophytes are relatively well developed in the shallower sections of the lagoon, including areas that are directly influenced by the enhancements.

6.3 Waterfowl and Shorebirds

Analysis of migratory waterfowl and shorebirds can be complicated by the highly variable nature of avian species. In 2019, most species of waterfowl appeared to be using the Airport Lagoon during their northward migration. The highest numbers of waterfowl were observed at the end of April, despite sections of the wetland being covered with ice. In 2019, the majority of waterfowl individuals were recorded at the northern end of Airport Lagoon where shallow water occurs and a higher prevalence of aquatic macrophyte species is present, compared to other areas of the wetland. The environmental conditions at the end of April may have influenced the higher prevalence of dabbling species. However, it is expected that waterfowl would use these areas as stopover habitat in subsequent years regardless of the climatic conditions. The reduction of waterfowl sightings in May and June was expected, given the onset of the breeding period during this time.

6.4 Songbirds

Songbird surveys in 2019 provided an indication of the species assemblage utilizing the study areas and a comparison of how birds were using different habitat types within the enhancement areas. A wide variety of species were documented during songbird surveys reflecting the variety of micro-habitats at both Airport Lagoon and Beaver Pond. These data show that songbirds, and other birds, are using enhanced wetlands and adjacent habitat.

The pattern of use was not exactly the same at both study sites. At both Airport Lagoon and Beaver Pond the forest habitat type had the greatest mean number of species, but at Beaver Pond this trend was more pronounced. Shrub habitat appeared to be utilized less around Airport Lagoon than Beaver Pond. Forests had the most unique species in both study areas, and also significantly higher richness and diversity, though this was expected given the greater structural heterogeneity and prevalence of migratory, forest-dwelling songbirds. At both Airport Lagoon and Beaver Pond forest and shrub habitats had the greatest amount of species overlap. Despite this, the drawdown zone was utilized by a number of species (especially at Airport Lagoon where 10 species were unique to DDZ habitat) including representation from a number of aerial insectivores (i.e., swallows) and other open-country passerines (e.g., Savannah Sparrow). Based on 2019 songbird data it appears that birds utilize the drawdown zone around the Beaver Pond, but to a limited extent.

6.5 Amphibians

Since the inception of GMSMON-15, the four species of amphibians that were expected to occur at the study sites have been detected; all four at Airport Lagoon and only three species at Beaver Pond. However, since amphibian abundances (detection rates) vary from year to year, more detections of individual species, which currently have few detections, are required to confirm occupancy.

At Airport Lagoon, the most productive area for amphibians appears to be transects 25 and 28 in the northeastern section of the wetland. Western Toad and Columbia Spotted Frog were the two amphibian species observed at Airport Lagoon in 2019, which is consistent with previous years of data collection for Western Toad, but Columbia Spotted Frogs were new for this transect. Breeding was not confirmed for Airport Lagoon for any amphibian species in 2019 as no observations of mating, eggs, tadpoles, or metamorphs were made.

At Beaver Pond, Western Toad was recorded in its tadpole form. Tadpoles were first observed here in late May and early June. The timing of metamorphosis for this population is currently unknown for this site, as previous year's metamorphs were detected in 2019 around the edges of the pond. Subadult/adult Wood Frogs were detected in 2019 at Beaver Pond, although the detected species diversity was lower in 2019 compared to previous years.

Amphibian populations naturally exhibit large degrees of variation with the number detected dependent upon current environmental conditions, overwinter survival, and predation pressure (Hansen et al. 2012). Some species (e.g., Long-toed Salamander [*Ambystoma macrodactylum*]) are often difficult to locate because they have an early breeding period and are inconspicuous during the remainder of the year (Wilkinson and Hanus 2002), which likely contributes to the lack of Long-toed Salamander observations in 2019.

Amphibian productivity has not been explicitly studied in Williston Reservoir. Qualitatively, it appears that the productivity of Western Toads is consistent between years, as egg masses and adults have been repeatedly detected at the same locations. However, in the absence of data from a suitable control site, we cannot know for certain how productivity is affected by the enhancements.

6.6 Fish

In Year 9 of the monitoring program, electrofishing, minnow traps, and fyke nets proved effective at capturing eleven species of fish with different life histories and habitat preferences (e.g. pelagic vs. benthic), including species with relatively very low abundance (e.g. Bull trout), at Airport Lagoon. Past fish surveys here (e.g. MacInnis et al. 2017) found that the lagoon supported resident cyprinid, sculpin, and sucker populations. Our 2019 results add further support to this conclusion. Brassy minnow and Redside shiners were captured in very high (relative to other species) numbers and several were observed with spawning colours during May. Lake chub and White suckers were also caught in relatively high numbers, which indicated that the increased available habitat is being utilized by these species.

The Rainbow trout and Bull trout captured are likely resident in the Williston Reservoir and are taking advantage of the abundant prey available in the lagoon. These fish are likely accessing the lagoon through the upgraded culverts at the south end when the reservoir elevation exceeds 667 m, which was reached during the July sampling (Figure 14). The increase in the Rainbow trout catch during July supports this conclusion. Further, no salmonid spawning habitat was observed and no juvenile fish (<20 cm) were captured. The four Rainbow trout captured in during May sampling are expected to have overwintered in the lagoon.

Both minnow traps and a fyke were set at the Beaver Pond site in May and July. Due to insufficient water levels electrofishing could not be conducted. The inlet and outlet streams from the impounded pond were nearly dry and could not be sampled. In 2019, most of the fish captured were primarily captured in the fyke net at the Beaver Pond (Table 16). From 2011 to 2016, five species (Peamouth chub [*Mylocheilus caurinus*], Northern pikeminnow, Redside shiner, Longnose sucker [*Catostomus catostomus*], and Prickly sculpin) have been sampled with minnow traps at the Beaver Pond site. In 2019, four species were sampled (White sucker, Redside shiner, Prickly sculpin and Northern pikeminnow). No Peamouth chubs or Longnose suckers, were captured or observed.

Recent post-construction sampling found that fish were using the outlet stream downstream of the berm. The lack of streamflow during our May and July sampling suggests that water levels at this site have changed from previous years. Sampling in 2020 will help determine if our 2019 observations were atypical or if a longer-term change is occurring at the Beaver Pond site.

7.0 CONCLUSIONS

Data collected in 2019 for the GMSMON-15 project show that species from all indicator groups continue to be present at both wetland enhancement projects. The methods implemented to date will enable the collection of an adequate amount of data that can be used to address each management question and associated hypothesis. In particular, the time-series data can be linked to broader management questions and will be tested statistically.

Vegetation development and establishment can be a relatively slow ecological process, so the longer time series (i.e., 10 years) is necessary and the conditions under which the vegetation communities persist will become evident with the proceeding results. Likewise, the full understanding of how bird, amphibian and fish species composition and abundance has changed over time following wetland enhancement and will be addressed in the comprehensive report at the conclusion of the 10-year monitoring program in 2020.

8.0 REFERENCES

BC Hydro. 2003. Consultative committee report: Peace River water use plan. Prepared by the Peace River Water Use Plan Committee.

BC Hydro. 2007. Peace Project Water Use Plan – Revised for Acceptance by the Comptroller of Water Rights. British Columbia Hydro and Power Authority, Burnaby, BC. 17 pp + appendices.

BC Hydro. 2008. Peace Project Water Use Plan Monitoring Program Terms of Reference – GMSMON-15 Reservoir Wetland Habitat. British Columbia Hydro and Power Authority, Burnaby, BC. 11 pp.

BC Hydro. 2015. W.A.C. Bennett Riprap Upgrade Project. Exhibit B-1 submitted to the British Columbia Utilities Commission, November 13, 2015. British Columbia Hydro and Power Authority, Burnaby, BC. 705 pp.

Bird Studies Canada. 2009. British Columbia breeding bird atlas. Guide for atlassers. British Columbia Breeding Bird Atlas, Delta.

Bird Studies Canada. 2018. Amphibian Surveys Overview – Marsh Monitoring Program. URL: https://www.birdscanada.org/volunteer/glmmp/index.jsp?targetpg=glmmpfrog. Accessed November 15, 2018.

Chambers, J. M., W.S. Cleveland, B. Kleiner and P.A. Tukey. 1983. Graphical Methods for Data Analysis. Wadsworth & Brooks/Cole.

d'Entremont, M.V., N. Hentze, I. Beveridge and L. Ferreria. 2019. GMSMON-15: Williston Reservoir Wetland Habitat Monitoring. Year 8 Annual Report – 2018. LGL Report EA3901. Unpublished report by LGL Limited environmental research associates, Sidney, B.C for BC Hydro Generations, Water License Requirements, Burnaby, B.C. 55 pp + Appendices.

Environment and Climate Change Canada. 2019. Historical data – climate. Available at URL: http://climate.weather.gc.ca/historical_data/search_historic_data_e.html. Accessed October 1, 2019.

Golder Associates Ltd. 2010. GMSWORKS 16. Williston Reservoir wetlands inventory. BC Hydro, Burnaby, BC. 81 pp + appendices.

Golder Associates Ltd. 2011. GMSWORKS 17. Williston Reservoir wetlands demonstration sites. BC Hydro, Burnaby, BC.

Golder Associates Ltd. 2013. GMSWORKS 17. BC Hydro - Williston Reservoir wetlands demonstration site 6-2 Airport Lagoon Completion Report. BC Hydro Report #N3589. Golder Associates Ltd., Burnaby, BC. 7 pp + appendices.

Golder Associates Ltd. 2015. GMSWORKS 17. BC Hydro - Williston Reservoir wetlands demonstration site 34 Beaver Pond Completion Report. BC Hydro Report #N3699. Golder Associates Ltd., Burnaby, BC. 23 pp + appendices.

Hansen, C.P., R.B., Renken, and J.J. Millspaugh. 2012. Amphibian Occupancy in Flood-Created and Existing Wetlands of the Lower Missouri River Alluvial Valley. River Research and Applications, 28: 1488–1500.

Hawkes, V.C., M. Miller, J.D. Fenneman, and N. Winchester. 2011. CLBMON-11B4 monitoring wetland and riparian habitat in Revelstoke Reach in response to wildlife physical works. Annual Report – 2010. LGL Report EA3232. Unpublished report by LGL Limited environmental research associates, Sidney, B.C., for BC Hydro Generations, Water Licence Requirements, Burnaby, B.C.

Hentze, N. T., and J. M. Cooper. 2006. Donna Creek Forestry/Biodiversity project (Phase III): Breeding-bird and cavity-nest monitoring 2006. Manning, Cooper and Associates Ltd., Prince George, BC.

Klock, R. and J. Mullock. 2001. The Weather of British Columbia: Graphic Area Forecast 31. Nav Canada, Ottawa.

Krzywinski, M. and N. Altman. 2014. Visualizing samples with box plots. Nature Methods 11: 119-120.

MacInnis, A.J., K. Bachmann and A. Carson. 2012. GMSMON-15: Reservoir Wetland Habitat Monitoring, Year 1 – Final Report. Unpublished report by Cooper Beauchesne and Associates Ltd., Errington, BC, for BC Hydro Generation, Water Licence Requirements, Burnaby, BC. 39pp. + Appendices.

MacInnis, A.J., V. Prigmore, and A. Carson. 2017. GMSMON-15: Reservoir Wetland Habitat Monitoring, Year 6 – Final Report. Unpublished report by Cooper Beauchesne and Associates Ltd., Prince George, BC, for BC Hydro Generation, Water Licence Requirements, Burnaby, BC. x + 81pp. + Appendices.

Massart, D.L., J. Smeyers-Verbeke, X. Capron, and K. Schlesrer. 2005. Visual presentation of data by means of box-plots. Lc-Gc Europe 18:215–218.

Meidinger, D., and J. Pojar. 1991. Ecosystems of British Columbia. BC Ministry of Forests, Victoria, B.C

MELP (Ministry of Environment, Lands and Parks). 1998. Inventory methods for pond-breeding amphibians and painted turtle. Ministry of Environment, Lands and Parks Resource Inventory Branch for the Terrestrial Ecosystem Task Force Resource Inventory Committee. The Province of British Columbia, Victoria, BC. 101 pp.

Miller, M.T. and V.C. Hawkes. 2013. CLBMON-11B4 Monitoring Wetland and Riparian Habitat in Revelstoke Reach in Response to Wildlife Physical Works. Annual Report – 2012. LGL Report EA3413. Unpublished report by Okanagan Nation Alliance and LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generation, Water Licence Requirements, Burnaby, BC. 52 pp.

Miller, M.T. and V.C. Hawkes. 2013. CLBMON-11B4 Monitoring Wetland and Riparian Habitat in Revelstoke Reach in Response to Wildlife Physical Works. Annual Report – 2012. LGL Report EA3413. Unpublished report by Okanagan Nation Alliance and LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generation, Water Licence Requirements, Burnaby, BC.

Oksanen, J., F.G. Blanchet, M. Friendly, R. Kindt, P. Legendre, D. McGlinn, P. R. Minchin, R.B. O'Hara, G.L. Simpson, P. Solymos, M.H.H. Stevens, E. Szoecs and H. Wagner. 2017. vegan: Community Ecology Package. R package version 2.4-2. https://CRAN.R-project.org/package=vegan

Province of British Columbia. 2010. Field manual for describing terrestrial ecosystems – 2nd edition. Ministry of Forests and Range and Ministry of Environment, Forest Science Program, Victoria, BC.

R Development Core Team. 2014. R A language and environment for statistical computing. Vienna: R Foundation for Statistical Computing. http:// www.R-project.org.

Ralph, C.J., J.R. Sauer, and S. Droege (eds.). 1995. Monitoring bird populations by point counts. Gen Tech. Rep. PSW-GTR-149. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S Department of Agriculture. 187 pp.

Resources Inventory Committee (RIC). 1999a. Inventory methods for waterfowl and allied species: loons, grebes, swans, geese, ducks, American Coot, and Sandhill Crane. Ministry of Environment, Lands and Parks, Victoria, B.C. 90 pp.

Resources Inventory Committee (RIC). 1999b. Inventory Methods for Forest and Grassland Songbirds. Standards for Components of British Columbia's Biodiversity No. 15. Ministry of Environment, Lands and Parks, Victoria, BC. 37 pp.

Resources Inventory Committee (RIC). 2001. Reconnaissance (1:20 000) fish and fish habitat inventory: standards and procedures. BC Fisheries Information Services Branch, Victoria, BC. 170 pp.

Sokal, R.R., and F.J. Rohlf. 1995. Biometry. Third edition. W.H. Freeman and Company, New York.

Stockner, J., A. Langston, D. Sebastian and G. Wilson. 2005. The limnology of Williston Reservoir: British Columbia's largest lacustrine ecosystem. Water Quality Research Journal of Canada 40:28-50.

Vickers, G., S. Buzza, D. Schmidt, and J. Mullock. 2001. The Weather of the Canadian Prairies: Graphic Area Forecast 32 Prairie Region. Nav Canada, Ottawa, ON.

Weir, L. A., and M. J. Mossman. 2005. North American Amphibian Monitoring Program (NAAMP). Pages 307–313 in Michael Lannoo, editor. Amphibian declines: the conservation status of United States species. University of California Press, Berkeley.

Whiteman, C. D. 2000. Mountain Meteorology: Fundamentals and Applications. Oxford University Press, New York.

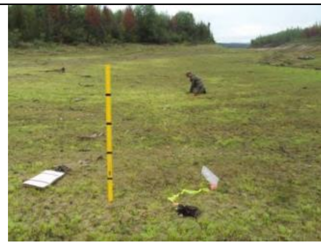
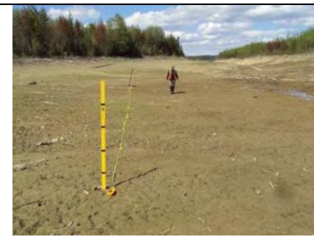
Wilkinson, L., and S. Hanus. 2002. Long-toed salamander (*Ambystoma macrodactylum*) conservation in the Alberta foothills: 2002 field summary report. Alberta Sustainable Resource Development, Fish and Wildlife Division, Edmonton, AB.

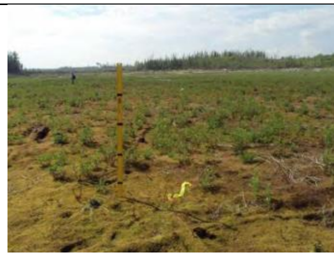
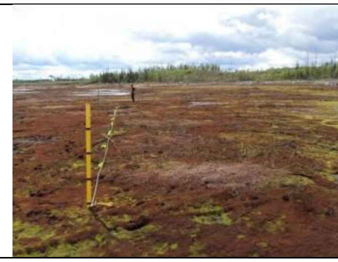
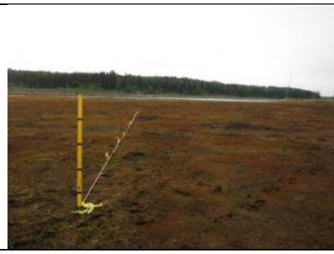
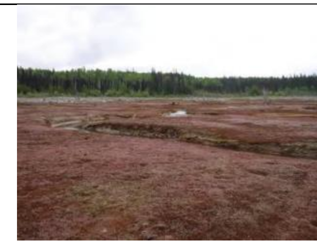
9.0 APPENDICES

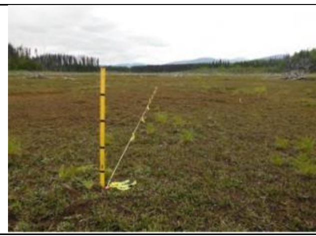
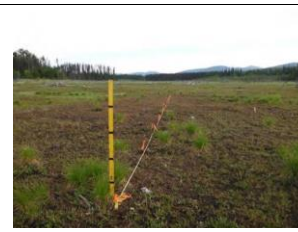
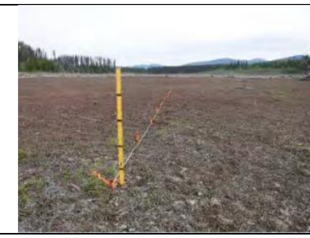
Appendix 9-1: Water quality data collected during fish sampling at Airport Lagoon and Beaver Pond in 2019.

Location	Date	Time	Waypoint	Zone	Easting	Northing	Depth (m)	Temp (°C)	DO (mg/L)	Conductivity (uS)	pH	Rel. Turbidity	Secchi Depth1 (cm)	Secchi Depth2 (cm)	Comment
Airport Lagoon	5/24/2019	10:45	294	10	492451	6125816	1	17.2	8.01	173	7.75	clear	na	na	Partly cloudy
Airport Lagoon	5/24/2019	10:45	294	10	492451	6125816	0.5	17.9	8.12	170	7.7	clear	na	na	Partly cloudy
Airport Lagoon	5/25/2019	13:15	302	10	492637	6125703	1	17.5	8.05	177	7.4	clear	na	na	Mostly sunny
Airport Lagoon	5/25/2019	13:15	302	10	492637	6125703	0.5	18.2	8.1	171	7.6	clear	na	na	Partly cloudy
Airport Lagoon	5/26/2019	11:24	305	10	492568	6126704	0.3	15.5	8.07	na	7.8	clear	na	na	At start of electrofishing transect
Beaver Pond	5/26/2019	14:16	312	10	479272	6148263	1.2	19.5	7.5	na	7.2	clear	na	na	
Beaver Pond	5/26/2019	15:10	312	10	479272	6148263	1.2	20	7.6	na	7.4	clear	na	na	
Beaver Pond	5/27/2019	11:00	312	10	479272	6148263	1.2	19	7.9	na	7.8	clear	na	na	
Airport Lagoon	7/15/2019	17:57	014	10	492580	6125414	1	20.3	8.55	na	8.7	clear	na	na	Overcast, a few showers, and some distant thunder.
Airport Lagoon	7/16/2019	9:36	004	10	492464	6125967	0.57	19.4	8.04	na	na	clear	na	na	Using YSI (Comparing YSI temp to alcohol thermometer temp.)
Airport Lagoon	7/16/2019	9:36	004	10	492464	6125967	0.7	18.5	na	na	na	na	na	na	Alcohol thermometer
Airport Lagoon	7/17/2019	12:48	015	10	492701	6125595	1	19.6	7.31	na	7.55	clear to moderate	na	na	Dark, cloudy day, not condusive for Sechi measurements
Airport Lagoon	7/18/2019	9:21	FYKE2	10	4292439	6125853	0.7	16.3	8.69	na	na	na	na	na	
Airport Lagoon	7/18/2019	13:20	016	10	492560	6126714	0.41	14.8	10.39	6	7.83	na	na	na	At start of electrofishing transect
Airport Lagoon	7/18/2019	15:14	018	10	492496	6126211	1.5	14.7	11.31	na	na	clear to moderate	1.5	1.5	Measured temp and DO at bottom
Airport Lagoon	7/18/2019	15:15	018	10	492496	6126211	0.5	15.6	10.88	3	7.98	clear to moderate	na	na	Measured temp and DO at surface
Airport Lagoon	7/18/2019	15:25	019	10	492553	6125627	1.5	18.5	10.01	na	na	clear to moderate	1.5	1.5	Measured temp and DO at bottom
Airport Lagoon	7/18/2019	15:26	019	10	492553	6125627	0.5	18.8	8.97	2	8.01	clear to moderate	na	na	Measured temp and DO at surface
Airport Lagoon	7/18/2019	15:33	020	10	492590	6125458	1.5	18.4	9.39	na	na	clear to moderate	1.75	1.75	Measured temp and DO at bottom
Airport Lagoon	7/18/2019	15:34	020	10	492590	6125458	0.5	18.8	8.87	2	7.94	clear to moderate	na	1.75	Measured temp and DO at surface
Readings in RED were done with the cap on the meter. Not reliable.															
Airport Lagoon	7/20/2019	12:31	073	10	492582	6125414	surface	18.4	na	196	8.43	clear to moderate	na	na	
Airport Lagoon	7/20/2019	12:39	074	10	492698	6125588	surface	18.8	na	186	8.72	clear to moderate	na	na	
Beaver Pond	7/19/2019	14:14	072	10	479270	6148251	1	17.5	7.3	na	na	clear to moderate	na	na	Measured at 1.0 m depth. Impounded area, measured at berm. Upstream of berm.
Beaver Pond	7/19/2019	14:19	072	10	479270	6148251	surface	18	6.3	78	8.1	clear to moderate	na	na	Measured at surface. Impounded area, measured at berm. Upstream of berm.
Beaver Pond	7/19/2019	14:20	063	10	479252	6148269	surface	17.1	9.2	113	8	clear to moderate	na	na	Measured at surface, downstream of the berm, at MT 1.
Beaver Pond	7/19/2019	14:20	063	10	479252	6148269	0.5	16.9	8.2	na	na	clear to moderate	na	na	Measured at 0.5 depth (bottom) downstream of the berm, at MT 1.

Appendix 9-2: Habitat class descriptions at the Airport Lagoon and Beaver Pond sites.

Habitat Class	Representative Photographs (Beaver Pond)		
BC	**2011**	**2012**	**2013**
			
	2014	**2015**	**2016**
			
	2017	**2018**	**2019**
	Picture Not Available		
	Description		
	Basin Cryptantha (BC): Moderate herbaceous perennial cover with negligent coarse woody debris and low coarse rock cover (5%) on a plain to gentle sloping surface expression. Common species includes Torrey's cryptantha (*Cryptantha torreyana*), purslane speedwell (*Veronica peregrina* var. *xalapensis*), red sand-spurry (*Spergularia rubra*) and Arctic pearlwort (*Sagina saginoides*). Soils are composed of a deep clay mineral layer; organic layer is absent. Groundwater is the main water source, soils are very poorly drained and reservoir flooding is expected to occur annually.		

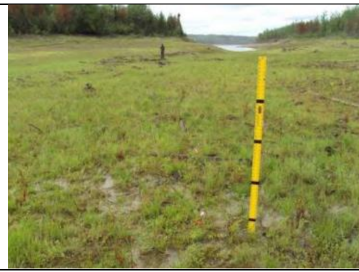
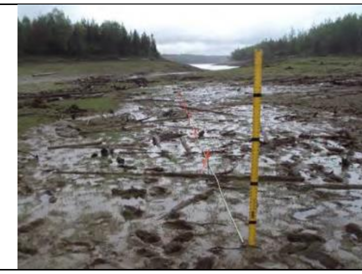
Habitat Class	Representative Photographs (Airport Lagoon)		
BM	**2011**	**2012**	**2013**
			
	2014	**2015**	**2016**
		Picture Not Available	
	2017	**2018**	**2019**
	Picture Not Available		
	Description		
	Basin Moss (BM): Moderate to high bryophyte and low to moderate herbaceous perennial cover; low coarse woody debris cover on a plain to hummock surface depression. Dominating species include common hook-moss, lady's thumb (*Persicaria maculosa*), water smartweed (*Persicaria amphibia*), common mare's-tail (*Hippularis vulgaris*) and Norwegian cinquefoil (*Potentilla norvegica*). Soils are composed of a shallow to moderate organic layer (at least 30 cm) overlying a clay mineral layer. Groundwater is the main water source, soils are very poorly drained. Reservoir flooding is expected to occur annually.		

Habitat Class	Representative Photographs (Airport Lagoon)		
	2011	**2012**	**2013**
		Picture Not Available	
	2014	**2015**	**2016**
			
BS	**2017**	**2018**	**2019**
	Picture Not Available	Picture Not Available	
	Description		
	Basin Smartweed (BS): High cover of water smartweed and sedge (*Carex* spp.), with low to high coarse wood debris cover (0-50%) on a plain to hummock surface expression. Other species present may include lady's thumb and common hook-moss. Soils are composed of shallow to moderate organic layer (approx. 25 cm depth) overlying a clay mineral layer. Groundwater is the main water source; soils are imperfectly drained and reservoir flooding is expected to occur annually.		

Habitat Class	**Representative Photographs (Airport Lagoon)**		
FI			
			
	Description		
	Floating Island (FI): Large, persistent, floating masses of organic matter, coarse woody debris and mineral soil. High bryophyte cover and low to moderate perennial herb cover. Common species include common hook-moss, lady's thumb, water smartweed and spring water-starwort (*Callitriche palustris*), purple-leaved willowherb (*Epilobium ciliatum* ssp. *ciliatum*) and a variety of sedges. The elevation of these islands is expected to rise and fall with water levels. Over time, shrubs, such as willow (*Salix* spp.), have become well established on the islands.		

Habitat Class	Representative Photographs (Beaver Pond)		
SC			
	2014	**2015**	**2016**
	Picture Not Available	Picture Not Available	Picture Not Available
	2017	**2018**	**2019**
	Picture Not Available		
	Description		
	Shoreline Clay (SC): Sparse herbaceous vegetation cover with low coarse woody debris and coarse rock cover on gentle to moderate sloping surface expression. The most common species present are lady's thumb, lamb's quarters (*Chenopodium album* ssp. *striatum*) common horsetail (*Equisetum arvense*) and Norwegian cinquefoil. Water source is precipitation and flooding is expected to be annual to frequent (every 2 to 5 years).		

Habitat Class	Representative Photographs (Airport Lagoon)		
SD	**2011**	**2012**	**2013**
			
	2014	**2015**	**2016**
			
	2017	**2018**	**2019**
	Picture Not Available		
	Description		
	Shoreline Driftwood (SD): Low to Moderate, grass dominated vegetation cover with high coarse woody debris cover (ranging from 20-50%) on a gently sloping (3 to 15°) surface expression. Common species include bluejoint (*Calamagrostis canadensis*), common horsetail, water smartweed (*Persicaria amphibia*), uplifting suncress (*Boechera divaricarpa*) and reed canarygrass (*Phalaris arundinacea*). A diversity of bryophytes such as marsh thread moss (*Bryum pseudotriquetum*), tree moss (*Climancium dendroides*) and purple horn-toothed moss (*Ceratodon purpureus*) may be present. Soils consist of a shallow (1-10 cm depth) organic layer overlying a moderate (11-30 cm) sandy mineral layer. Precipitation is the main water source, soils are rapidly drained and reservoir flooding expected to be annual to frequent.		

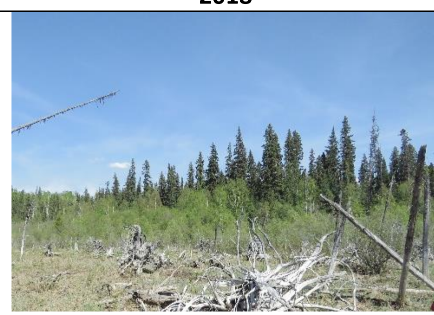
Habitat Class	Representative Photographs (Beaver Pond)		
SE	**2011**	**2012**	**2013**
			
	2014	**2015**	**2016**
	Picture Not Available	Picture Not Available	Picture Not Available
	2017	**2018**	**2019**
	Picture Not Available		
	Description		
	Stream Sedge (SE): Moderate to high sedge and bryophyte cover with negligible coarse woody and low water cover on a plain to gently sloping surface expression. Common species include sedges sp., bluejoint, lady's thumb, Torrey's cryptantha and spring water-starwort. Soil are composed of a minor organic layer (10 cm depth) overlying a clay and sand mineral layer. Surface and groundwater are the main water sources, soils are very poorly drained and annual flooding is expected to occur.		

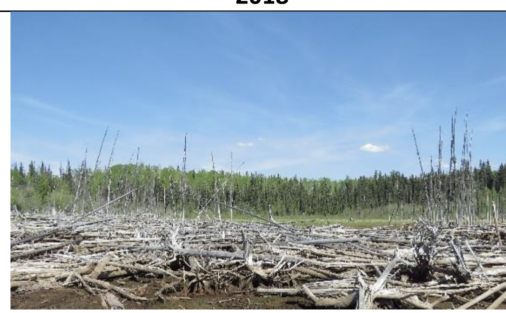
Habitat Class	Representative Photographs (Airport Lagoon)		
			2013
			Picture Not Available
	2014	**2015**	**2016**
	Picture Not Available	Picture Not Available	Picture Not Available
	2017	**2018**	**2019**
SG	Picture Not Available		
	Description		
	Shoreline Grassland (SG): Very high grass dominated vegetation cover with low coarse woody debris cover on a gently sloping surface expression. Common species may include bluejoint, common horsetail, reed canarygrass, large-leaved avens (*Geum macrophyllum* ssp. *perincisum*) and a few unidentified grasses.		

Habitat Class	Representative Photographs (Airport Lagoon & Beaver Pond)		
	2011	2012	2013
			
	2014	2015	2016
SP			
	2017	2018	2019
	Picture Not Available		
	Description		
	Streams and Ponds (SP): Areas of open water and perennial water flow. Emergent or submergent vegetation identified include lady's thumb, white water-buttercup (*Ranunculus aquatilis*), spring water-starwort, common mare's-tail, water smartweed, fennel-leaved pondweed (*Stuckenia pectinata*), variegated yellow pond-lily (*Nuphar variegata*), common hornwort (*Ceratophyllum demersum*), verticillate water-milfoil (*Myriophyllum verticillatum*), wavy water nymph (*Najas flexilis*) and closed-leaved potamogeton (*Potamogeton foliosus*).		

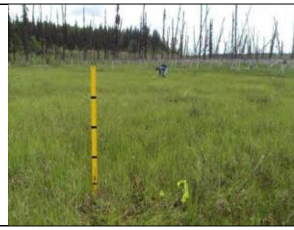
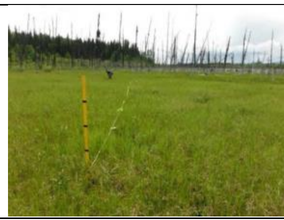
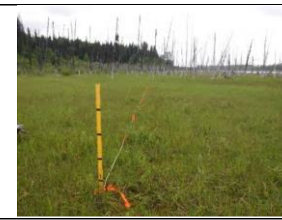
Habitat Class	Representative Photographs (Beaver Pond)		
	2011	**2012**	**2013**
			
	2014	**2015**	**2016**
			
SR	**2017**	**2018**	**2019**
	Picture Not Available		
	Description		
	Shoreline Gravel (SR): Low to moderate grass dominated vegetation cover with negligent coarse woody debris and moderate coarse rock cover on a gently to moderate sloping surface expression. Dominant species include bluejoint, bronze sedge (*Carex aenea*), purslane speedwell, red sand-spurry and Norwegian cinquefoil. Soils are composed of a deep sand and gravel mineral layer; organic layer is absent. Precipitation is the main water source, soils are rapidly drained and reservoir flooding is expected to be rare (only during extreme events).		

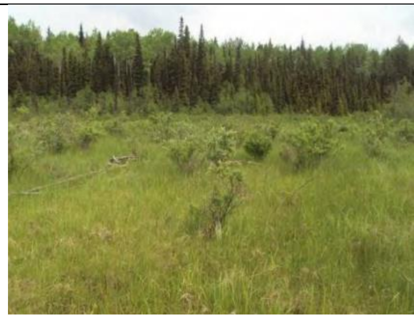
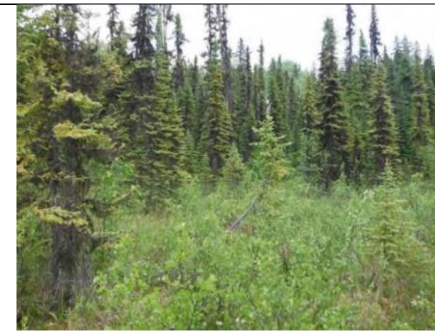
<table>
<tr><th>Habitat Class</th><th colspan="3">Representative Photographs (Airport Lagoon)</th></tr>
<tr><td rowspan="7">SS</td><td>2011</td><td>2012</td><td>2013</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>2014</td><td>2015</td><td>2016</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>2017</td><td>2018</td><td>2019</td></tr>
<tr><td>Picture Not Available</td><td></td><td></td></tr>
<tr><td colspan="3">Description
Shoreline Sand (SS): Sparse herbaceous vegetation cover with low (5 to 15%) coarse woody debris cover on a gentle to moderate (15 to 26°) sloping surface expression. Common species include bluejoint, lady’s thumb, Norwegian cinquefoil, bronze sedge (Carex aenea), marsh yellow cress (Rorippa palustris) and pink corydalis (Corydalis sempervirens). Soils are composed of a deep (30-50 cm) sandy mineral layer; organic layer is absent. Precipitation is the main water source, soils are rapidly drained and reservoir flooding is expected to be annual to frequent.</td></tr>
</table>

Habitat Class	Representative Photographs (Airport Lagoon & Beaver Pond)		
SW	2011	2012	2013
			
	2014	2015	2016
			
	2017	2018	2019
	Picture Not Available		
	Description		
	Shoreline Willow (SW): High grass and shrub dominated vegetation cover with high coarse woody debris cover on a gently to moderate sloping surface expression. Common species include common horsetail, fireweed, bluejoint, Norwegian cinquefoil, and small bedstraw (Galium trifidum) with patches of live and dead willow (e.g., Alaska willow [Salix alaxensis], Barclay’s willow [Salix barclayi]. Soils are composed of a shallow organic layer overlying a clay mineral layer. Precipitation is the main water source, soils are moderately well drained and flooding is expected to be frequent to rare.		

Habitat Class	Representative Photographs (Airport Lagoon)		
			
		2015	2016
		Picture Not Available	Picture Not Available
WD	2017	2018	2019
	Picture Not Available		
	Description		
	Wetland Dead Trees (WD): High herbaceous perennial and low dead standing tree (snag) cover with low to moderate coarse woody debris cover on a gently sloping surface expression. Common species include swamp horsetail, water smartweed, buckbean, sedges and slender cottongrass (*Eriophorum gracile*). A low cover (approximately 15%) of standing dead black spruce (*Picea mariana*) trees is present as well as a variety of bryophytes. Groundwater is the main water source (surface and subsurface seepage), soils are very poorly drained and flooding is expected to be annual to frequent.		

<table>
<tr><th>Habitat Class</th><th colspan="3">Representative Photographs (Airport Lagoon)</th></tr>
<tr><td rowspan="8">WH</td><td>2011</td><td>2012</td><td>2013</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>2014</td><td>2015</td><td>2016</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>2017</td><td>2018</td><td>2019</td></tr>
<tr><td>Picture Not Available</td><td>Picture Not Available</td><td></td></tr>
<tr><td colspan="3">Description</td></tr>
<tr><td colspan="3">Wetland Horsetail (WH): High horsetail and bryophyte dominated vegetation cover with low to moderate coarse woody debris cover on a plain to gently sloping surface expression. Common species include swamp horsetail, Norwegian cinquefoil, buckbean, small bedstraw, willows, and a diversity of bryophytes (marsh thread moss, giant calliergon moss, glow moss, and purple horn-toothed moss). Soils are composed of a moderate organic layer; mineral layer is absent. Groundwater is the main water source surface and subsurface seepage), soils are very poorly drained, and flooding is expected to be annual to frequent</td></tr>
</table>

Habitat Class	Representative Photographs (Airport Lagoon)		
	2011	**2012**	**2013**
			
	2014	**2015**	**2016**
			
	2017	**2018**	**2019**
WS	Picture Not Available	Picture Not Available	
	Description		
	Wetland Sedge (WS): High sedge and bryophyte dominated vegetation cover with negligible coarse woody debris cover on a plain to depressed surface expression. Common species include hook moss, marsh thread moss, giant calliergon moss, common cattail, bronze sedge (along with 2 to 3 other species of sedges [*Carex* spp.]), swamp horsetail (Equisetum fluviatile), small bedstraw (*Galium trifidum*), water smartweed (*Persicaria amphibia*), common mare's-tail (*Hippuris vulgaris*) and buckbean (*Menyanthes trifoliata*). Soils are composed of a deep organic layer either overlying a clay mineral layer or mineral layer absent. Groundwater is the main water source (surface and subsurface seepage), soils are very poorly drained and reservoir flooding is expected to be annual to frequent.		

<table>
<tr><th>Habitat Class</th><th colspan="3">Representative Photographs (Airport Lagoon)</th></tr>
<tr><td rowspan="5">WW</td><td></td><td></td><td></td></tr>
<tr><td>2017</td><td>2018</td><td>2019</td></tr>
<tr><td>Picture Not Available</td><td></td><td></td></tr>
<tr><td colspan="3">Description</td></tr>
<tr><td colspan="3">Wetland Willow (WW): Moderate shrub and high grass/sedge dominated vegetation cover with negligible coarse woody debris cover and a gentle sloping surface expression. Species present consist of a variety of willows, sedges, grasses and bryophytes. Flooding is expected to be frequent to rare.</td></tr>
</table>

Appendix 9-3: All bird species detected during songbird point counts at Airport Lagoon and Beaver Pond in 2019. Species are listed alphabetically.

Species Code	Common Name	Scientific Name	Species Group	Conservation Status		Study Area	
				COSEWIC	BC List	Airport Lagoon	Beaver Pond
AMCR	American Crow	*Corvus brachyrhynchos*	Songbirds	v	Yellow	✓	
AMPI	American Pipit	*Anthus rubescens*	Songbirds	.	Yellow	✓	
AMRE	American Redstart	*Setophaga ruticilla*	Songbirds	.	Yellow	✓	✓
AMRO	American Robin	*Turdus migratorius*	Songbirds	.	Yellow	✓	✓
ATTW	American Three-toed Woodpecker	*Picoides dorsalis*	Woodpeckers and Allies	.	Yellow	✓	
BAEA	Bald Eagle	*Haliaeetus leucocephalus*	Hawks, Eagles, and Allies	Not at Risk	Yellow	✓	
BASW	Barn Swallow	*Hirundo rustica*	Songbirds	Threatened	Blue	✓	
BCCH	Black-capped Chickadee	*Poecile atricapillus*	Songbirds	.	Yellow	✓	✓
BEKI	Belted Kingfisher	*Megaceryle alcyon*	Kingfishers and Allies	.	Yellow	✓	
BHCO	Brown-headed Cowbird	*Molothrus ater*	Songbirds	.	Yellow	✓	
BKSW	Bank Swallow	*Riparia riparia*	Songbirds	.	Yellow	✓	
BOGU	Bonaparte's Gull	*Chroicocephalus philadelphia*	Shorebirds, Gulls, Auks, and Allies	Threatened	Yellow	✓	
BWTE	Blue-winged Teal	*Spatula discors*	Waterfowl	.	Yellow	✓	
CAGO	Canada Goose	*Branta canadensis*	Waterfowl	.	Yellow	✓	✓
CEWA	Cedar Waxwing	*Bombycilla cedrorum*	Songbirds	.	Yellow		✓
CHSP	Chipping Sparrow	*Spizella passerina*	Songbirds	.	Yellow	✓	✓
CLSW	Cliff Swallow	*Petrochelidon pyrrhonota*	Songbirds	.	Yellow	✓	
COGO	Common Goldeneye	*Bucephala clangula*	Waterfowl	.	Yellow	✓	
COLO	Common Loon	*Gavia immer*	Loons	.	Yellow	✓	
CORA	Common Raven	*Corvus corax*	Songbirds	.	Yellow	✓	
COYE	Common Yellowthroat	*Geothlypis trichas*	Songbirds	.	Yellow	✓	
DEJU	Dark-eyed Junco	*Junco hyemalis*	Songbirds	Not at Risk	Yellow	✓	
DUFL	Dusky Flycatcher	*Empidonax oberholseri*	Songbirds	.	Yellow	✓	✓
GCKI	Golden-crowned Kinglet	*Regulus satrapa*	Songbirds	.	Yellow	✓	
GRYE	Greater Yellowlegs	*Tringa melanoleuca*	Shorebirds, Gulls, Auks, and Allies	.	Yellow	✓	✓
GWTE	Green-winged Teal	*Anas crecca*	Waterfowl	.	Yellow	✓	
HAFL	Hammond's Flycatcher	*Empidonax hammondii*	Songbirds	.	Yellow	✓	✓

Species Code	Common Name	Scientific Name	Species Group	Conservation Status		Study Area	
				COSEWIC	BC List	Airport Lagoon	Beaver Pond
HAWO	Hairy Woodpecker	*Dryobates villosus*	Woodpeckers and Allies	Special Concern	Yellow		✓
HETH	Hermit Thrush	*Catharus guttatus*	Songbirds	.	Yellow	✓	✓
KILL	Killdeer	*Charadrius vociferus*	Shorebirds, Gulls, Auks, and Allies	.	Yellow	✓	✓
LEFL	Least Flycatcher	*Empidonax minimus*	Songbirds	.	Yellow	✓	✓
LEYE	Lesser Yellowlegs	*Tringa flavipes*	Shorebirds, Gulls, Auks, and Allies	.	Yellow	✓	
LISP	Lincoln's Sparrow	*Melospiza lincolnii*	Songbirds	.	Yellow	✓	✓
MALL	Mallard	*Anas platyrhynchos*	Waterfowl	.	Yellow	✓	
MGNW	Magnolia Warbler	*Setophaga magnolia*	Songbirds	.	Yellow	✓	✓
MODO	Mourning Dove	*Zenaida macroura*	Pigeons and Doves	.	Yellow		✓
NOSL	Northern Shoveler	*Spatula clypeata*	Waterfowl	.	Yellow	✓	
NOWA	Northern Waterthrush	*Parkesia noveboracensis*	Songbirds	Special Concern	Yellow	✓	✓
NRWS	Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	Songbirds	.	Yellow	✓	✓
OCWA	Orange-crowned Warbler	*Leiothlypis celata*	Songbirds	.	Yellow	✓	✓
OSFL	Olive-sided Flycatcher	*Contopus cooperi*	Songbirds	.	Blue	✓	
OSPR	Osprey	*Pandion haliaetus*	Hawks, Eagles, and Allies	.	Yellow	✓	
OVEN	Ovenbird	*Seiurus aurocapilla*	Songbirds	.	Yellow		✓
PAWR	Pacific Wren	*Troglodytes pacificus*	Songbirds	.	Yellow	✓	
PIWO	Pileated Woodpecker	*Dryocopus pileatus*	Woodpeckers and Allies	.	Yellow	✓	
PSFL	Pacific-slope Flycatcher	*Empidonax difficilis*	Songbirds	.	Yellow	✓	
PUFI	Purple Finch	*Haemorhous purpureus*	Songbirds	.	Yellow	✓	
RBGR	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Songbirds	.	Yellow	✓	✓
RBGU	Ring-billed Gull	*Larus delawarensis*	Shorebirds, Gulls, Auks, and Allies	.	Yellow	✓	
RBME	Red-breasted Merganser	*Mergus serrator*	Waterfowl	Special Concern	Yellow	✓	
RBNU	Red-breasted Nuthatch	*Sitta canadensis*	Songbirds	.	Yellow	✓	
RCKI	Ruby-crowned Kinglet	*Regulus calendula*	Songbirds	.	Yellow	✓	✓
RNDU	Ring-necked Duck	*Aythya collaris*	Waterfowl	.	Yellow	✓	
RUGR	Ruffed Grouse	*Bonasa umbellus*	Upland Game Birds	.	Yellow	✓	✓
RUHU	Rufous Hummingbird	*Selasphorus rufus*	Swifts and Hummingbirds	.	Yellow	✓	

Species Code	Common Name	Scientific Name	Species Group	Conservation Status		Study Area	
				COSEWIC	BC List	Airport Lagoon	Beaver Pond
SACR	Sandhill Crane	*Antigone canadensis*	Rails, Cranes, and Allies	.	Yellow	✓	
SAVS	Savannah Sparrow	*Passerculus sandwichensis*	Songbirds	.	Yellow	✓	✓
SOSA	Solitary Sandpiper	*Tringa solitaria*	Shorebirds, Gulls, Auks, and Allies	.	Yellow	✓	✓
SOSP	Song Sparrow	*Melospiza melodia*	Songbirds	.	Yellow	✓	✓
SPSA	Spotted Sandpiper	*Actitis macularius*	Shorebirds, Gulls, Auks, and Allies	.	Yellow	✓	✓
SWTH	Swainson's Thrush	*Catharus ustulatus*	Songbirds	Not at Risk	Yellow	✓	✓
TEWA	Tennessee Warbler	*Leiothlypis peregrina*	Songbirds	.	Yellow	✓	
TRSW	Tree Swallow	*Tachycineta bicolor*	Songbirds	.	Yellow	✓	
TRUS	Trumpeter Swan	*Cygnus buccinator*	Waterfowl	.	Yellow	✓	
UNSA	Unidentified Sapsucker	*Sphyrapicus (sp)*	Woodpeckers and Allies	.	.	✓	✓
VATH	Varied Thrush	*Ixoreus naevius*	Songbirds	.	Yellow	✓	
VGSW	Violet-green Swallow	*Tachycineta thalassina*	Songbirds	.	Yellow	✓	
WAVI	Warbling Vireo	*Vireo gilvus*	Songbirds	.	Yellow	✓	✓
WCSP	White-crowned Sparrow	*Zonotrichia leucophrys*	Songbirds	.	Yellow	✓	
WETA	Western Tanager	*Piranga ludoviciana*	Songbirds	.	Yellow	✓	
WIPH	Wilson's Phalarope	*Phalaropus tricolor*	Shorebirds, Gulls, Auks, and Allies	Not at Risk	Yellow	✓	
WISN	Wilson's Snipe	*Gallinago delicata*	Shorebirds, Gulls, Auks, and Allies	.	Yellow	✓	
WIWA	Wilson's Warbler	*Cardellina pusilla*	Songbirds	.	Yellow	✓	✓
WTSP	White-throated Sparrow	*Zonotrichia albicollis*	Songbirds	.	Yellow	✓	✓
WWPE	Western Wood-Pewee	*Contopus sordidulus*	Songbirds	.	Yellow	✓	✓
YEWA	Yellow Warbler	*Setophaga petechia*	Songbirds	.	Yellow	✓	
YRWA	Yellow-rumped Warbler	*Setophaga coronata*	Songbirds	.	Yellow	✓	✓
					Total	73	34

Appendix 9-4: Number of detections and individuals of all songbird and hummingbird species located within 75 m during point count surveys at Airport Lagoon and Beaver Pond sites in 2019. Species are listed in taxonomic order.

Code	Common Name	Airport Lagoon		Beaver Pond	
		Observations	Individuals	Observations	Individuals
RUHU	Rufous Hummingbird	2	2		
OSFL	Olive-sided Flycatcher	1	1		
WWPE	Western Wood-Pewee	1	1	1	1
LEFL	Least Flycatcher	10	10	4	4
HAFL	Hammond's Flycatcher	12	12	1	1
DUFL	Dusky Flycatcher	2	2	4	4
PSFL	Pacific-slope Flycatcher	1	1		
WAVI	Warbling Vireo	14	14	8	8
AMCR	American Crow	8	13		
BKSW	Bank Swallow	2	5		
TRSW	Tree Swallow	22	67		
VGSW	Violet-green Swallow	5	22		
NRWS	Northern Rough-winged Swallow	4	9	1	1
BASW	Barn Swallow	6	24		
CLSW	Cliff Swallow	1	4		
BCCH	Black-capped Chickadee	1	1	2	2
RBNU	Red-breasted Nuthatch	1	1		
GCKI	Golden-crowned Kinglet	2	2		
RCKI	Ruby-crowned Kinglet	11	11	3	3
SWTH	Swainson's Thrush	22	22	7	7
HETH	Hermit Thrush	1	1	1	1
AMRO	American Robin	17	20	8	10
VATH	Varied Thrush	2	2		
AMPI	American Pipit	1	1		
PUFI	Purple Finch	1	1		
CHSP	Chipping Sparrow	14	14	4	4
DEJU	Dark-eyed Junco	7	9		
WCSP	White-crowned Sparrow	2	2		
WTSP	White-throated Sparrow	14	14	3	3
SAVS	Savannah Sparrow	40	40	2	2
SOSP	Song Sparrow	2	2	1	1
LISP	Lincoln's Sparrow	33	37	6	6
BHCO	Brown-headed Cowbird	8	11		
OVEN	Ovenbird			1	1
NOWA	Northern Waterthrush	12	12	4	4
TEWA	Tennessee Warbler	12	12		
OCWA	Orange-crowned Warbler	20	20	4	4
AMRE	American Redstart	12	12	11	11
MGNW	Magnolia Warbler	5	5	1	1
YEWA	Yellow Warbler	8	8		
YRWA	Yellow-rumped Warbler	15	15	2	2
WIWA	Wilson's Warbler	5	5	5	5
WETA	Western Tanager	6	6		
	Total	*365*	*473*	*84*	*86*