Peace Project Water Use Plan

Reservoir Wetland Habitat Monitoring

Implementation Year 6

Reference: GMSMON-15

Study Period: April 2016 to February 2017

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GMSMON-15: Reservoir Wetland Habitat Monitoring
Year 6 – REVISED Report (v2)

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Cover photo: Woody debris and floating island habitat detached from original location, Airport Lagoon site, Williston Reservoir. Photo © A. MacInnis, Cooper Beauchesne and Associates Ltd.

EXECUTIVE SUMMARY

Reservoir operations have created large unproductive areas within the drawdown zone of Williston Reservoir. This has reduced the area's capacity to support fish and wildlife and potentially increased the risk of predation for terrestrial wildlife using the drawdown zone. To address these impacts, the Riparian and Wetland Habitat Management Plan was developed under the Peace Water Use Plan to investigate the creation or enhancement of perched wetland areas to increase riparian and wetland habitat. An inventory of potential enhancement trial sites was completed under GMSWORKS-16 *Williston Reservoir Wetlands Inventory* and detailed designs for two locations were completed under GMSWORKS-17 *Williston Reservoir Trial Wetlands*. The Airport Lagoon trial site was constructed in late May 2013 and the Beaver Pond trial site was constructed in May 2014.

The GMSMON-15 project is a 10-year program to monitor the effectiveness of the two demonstration wetland enhancement projects at improving wildlife habitat and maintaining the habitat over the life of the projects. Due to uncertainty in the final design of the projects it was not possible to make specific predictions about the responses of individual taxa or functional groups. The two projects were expected to provide benefits to wildlife and vegetation through an increase in shallow water habitat and a higher, more stable water level. Waterfowl, songbirds, amphibians, and vegetation were identified as the indicator groups for determining the effectiveness of the wetland projects. Fish populations are also being monitored, although improving fish habitat is not one of the goals of the wetland projects. This report presents the results from the sixth year of monitoring under GMSMON-15. The results provide the third full year of post-construction data for the Airport Lagoon project and the second full year of post-construction data results from the Beaver Pond project.

Terrestrial and Aquatic Vegetation: The additional data collected in Year 6 provided information on the vegetation types that remain following the completion of the wetland enhancement projects. The observed variation in terrestrial vegetation at both sites appears to be primarily associated with the peak reservoir elevation in the preceding year. Coarse Woody Debris (CWD) is abundant at upper elevations at the **Airport Lagoon** site and appears to be an important limiting factor in vegetation establishment due to scouring and shading. At the **Airport Lagoon**, the completion of the enhancement projects is allowing for the development and expansion of aquatic vegetation that was previously limited in extent. Aquatic vegetation is currently non-existent at the **Beaver Pond** site and its development may be limited by reservoir conditions.

Waterfowl and Shorebirds: A total of 315 individuals representing 26 species were recorded during the 2016 surveys. The majority of observations occurred during the first two surveys of the season. At the **Airport Lagoon** site, American Wigeon was the most abundant species, followed by Northern Shoveler and Long-billed Dowitcher. American Golden-Plover was the only new species recorded. Waterfowl abundance appears to have increased during the later surveys and shorebird abundance and species richness has increased following construction of the wetland enhancement. Waterfowl use at the site has shifted to the newly created shallow water habitats and away from locations that shifted from shallow to deep water habitat. At the **Beaver Pond** site, there were few waterfowl or shorebird detections. Canada Goose was the most abundant species, with Mallard and Spotted Sandpiper being the only other species represented. The small size of this wetland is expected to limit the number of waterfowl and shorebirds observed at this site.

Songbirds: At the **Airport Lagoon** site, a total of 398 individuals representing 58 species were recorded. The number of detections at Airport Lagoon was consistent with all previous study years but species richness at this site was at its highest since the inception of the monitoring program. The number of songbird detections in the drawdown zone during post-construction surveys has been consistently higher than pre-construction levels. At the **Beaver Pond** site, a total of 36 individuals representing 17 species were recorded. Survey replicates at Beaver Pond were reduced to two rather than the usual three due to inclement weather so number of detections and species richness were lower than in previous years. The number of detections recorded in the drawdown zone at Beaver Pond in 2016 was the highest recorded since the location data was added in 2012. This reflects double the percentage of detections in the drawdown zone recorded in the previous year and appears to be an increasing trend following construction of the wetland.

Amphibians: Western Toad was the most frequently detected species at both sites. At the **Airport Lagoon**, low numbers of amphibians were recorded in 2016 with Western Toad as the only species detected. All of the detections were recorded on the same transect during the first two surveys of the year. There is no clear pattern in amphibian abundance following construction of the wetland enhancement. At the **Beaver Pond** site, Western Toad, Wood Frog, and Long-toed Salamander were recorded. At least one amphibian species was detected during each of the surveys at this site in 2016. The numbers of Western Toad and Long-toed Salamander recorded have been higher during post-construction surveys compared to the pre-construction period.

Fish: At the **Airport Lagoon**, the number and relative abundance of fish collected was lower than recorded in 2014 and 2015, particularly for captures by fyke net. The lower numbers were in part associated with the locations of the nets and high reservoir levels in July 2016. Abundances of the three most common fish species (Redside Shiner, Lake Chub, and Brassy Minnow) have increased in the post-construction period likely due to the increase in habitat area. Less abundant species such as Longnose Sucker and Prickly Sculpin also appear to be increasing but additional sampling will be required to detect a response in these species. At the **Beaver Pond** site, consistent with previous years, low numbers of fish were captured. Fish were captured in the impoundment prior to inundation. These fish would have entered the impoundment when it was inundated during previous summers.

The data collected to date in the GMSMON-15 project appear to support the preliminary predictions that the wetland demonstration projects would result in benefits to waterfowl and wildlife. Both projects are considered to have not yet reached a post-construction equilibrium but are expected to be at or approaching a post-construction equilibrium by the end of the monitoring program. The three years of post-construction data collected from the Airport Lagoon identified changes in all indicator groups that are likely associated with the new water level and associated habitat. The Beaver Pond project was completed in spring 2014 and the first two years post-construction data identified changes in some of the indicator groups. Although completed at a lower elevation than designed, it is expected that the project will improve wildlife habitat and increase wildlife use of this areas. Additional years of monitoring will be required to confirm what changes in the indicator groups are associated with the enhancement projects and those that are due to natural variability and reservoir levels.

MANAGEMENT SUMMARY: STATUS OF GMSMON-15 MANAGEMENT QUESTIONS AND HYPOTHESES – YEAR 6

Management Question	Management Hypothesis (Null)	Year 6 (2016) Status
Is there a change in the abundance, diversity and extent of vegetation in the enhancement area?	H_{01}: The density, diversity and spatial extent of riparian and aquatic vegetation does not change following enhancement.	No changes in riparian vegetation have been detected at the **Airport Lagoon** site. The third year of post-construction monitoring shows a continued increase in the extent of aquatic vegetation associated with the new water level. No changes in riparian or aquatic vegetation were detected in two years of post-construction monitoring at the **Beaver Pond** site.
Are the enhanced (or newly created) wetlands used by waterfowl and other wildlife?		The three years of post-construction data from the **Airport Lagoon** project shows continued use by waterfowl and other wildlife. The two years of post-construction data from the **Beaver Pond** project is consistent with the baseline data with limited use by waterfowl and other wildlife.
	H_{02}: The species composition and density of waterfowl and songbirds does not change following enhancement.	The three years of post-construction data from the **Airport Lagoon** show a shift in waterfowl activity to the shallow water habitat created and an increase songbird species composition and density. The two years of post-construction data from the **Beaver Pond** project is consistent with the baseline data. Additional monitoring will be required for testing of this hypothesis.
	H_{03}: Amphibian abundance and diversity in the wetland does not change following wetland enhancement.	The three years of post-construction data from the **Airport Lagoon** showed variable amphibian abundance with increases in the first two years post-construction and low numbers in the third year post-construction. The two years of post-construction data from the **Beaver Pond** site showed increases in amphibian abundance. Additional monitoring will be required for testing of this hypothesis.
Is the area and quality of wildlife habitat created by the wetland enhancement maintained over time?		With three years of post-construction data from the **Airport Lagoon** site and two years of post-construction data from the **Beaver Pond** project it is not possible to comment on the long term persistence and quality of habitat. The area of wetland habitat at both sites has remained stable to date.

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Field work was completed by CBA staff Andrew MacInnis, Allan Carson, Vicki Prigmore, Karl Bachmann, and Emily Braam. Andrew MacInnis (CBA Senior Fisheries Biologist) was Project Manager with assistance from John Cooper the Project Advisor.

The report was written by Andrew MacInnis, Vicki Prigmore, and Allan Carson. Ryan Gill conducted the GIS analyses and prepared maps for the report. John Cooper provided a review of the draft report.

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1 INTRODUCTION

1.1 Background

During consultations under the Peace Water Use Plan (WUP), the Consultative Committee recognized that reservoir operations created large unproductive areas within the drawdown zone of Williston Reservoir (Anon. 2003). The resulting limited aquatic and riparian habitats were hypothesized to have two primary impacts: they limit the area's capacity to support fish and wildlife and they potentially increase the risk of predation for terrestrial wildlife utilizing the drawdown zone. The large area (~450 km^2) of the drawdown zone between the low and high water levels provides little wildlife habitat when exposed during low water levels and little habitat for fish when inundated (Anon. 2003). The fluctuating water levels were also identified as affecting riparian productivity around the reservoir.

It was noted that when water levels recede during drawdown, pools and isolated backwater areas formed in some locations around the reservoir. The contribution of these pools and backwaters to wildlife and fish productivity is variable, depending on the location. The Riparian and Wetland Habitat Management Plan was developed within the WUP to investigate the possibility of creating or enhancing additional perched wetland areas to increase riparian and wetland habitat (Anon. 2003). 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.

The inventory of potential enhancement sites was completed under GMSWORKS-16 *Williston Reservoir Wetlands Inventory*. A total of 42 sites in the Parsnip Arm were reviewed as potential wetland enhancement sites by Golder (2010). Of the 42 sites reviewed, five candidate sites were identified for demonstration projects on the basis of a combination of factors including (but not limited to) cost, feasibility, and potential benefit to wildlife (Golder 2010). The second phase was completed under GMSWORKS-17 *Williston Reservoir Trial Wetland*. Two of the five candidate sites were selected as demonstration sites and detailed designs developed (Golder 2011). Monitoring of the effectiveness of the wetland demonstration projects in improving wildlife habitat on the reservoir will be completed under GMSMON-15 *Reservoir Wetland Habitat*.

1.2 Monitoring Plan Overview

The GMSMON-15 project is a 10-year monitoring program to assess the effectiveness of the demonstration wetland enhancement projects at improving wildlife habitat and maintaining the habitat over the life of the two projects (BC Hydro 2010). 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. Monitoring the responses of all species is not feasible; therefore, BC Hydro (2010) 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 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 2010).

This report presents the results from the sixth year of the GMSMON-15 monitoring program and includes the third year of post-construction data from the Airport Lagoon site and the second year of post-construction data from the Beaver Pond site.

2 MANAGEMENT QUESTIONS AND HYPOTHESES

The monitoring objectives and hypotheses for GMSMON-15 were stated in the Terms of Reference for the project (BC Hydro 2010). These are restated below along with a brief summary of how the testing of each hypothesis is approached in the study design.

Three key management questions regarding the effectiveness of the wetland enhancements were identified for the Reservoir Wetland Habitat monitoring program:

1. Are the enhanced (or newly created) wetlands used by waterfowl and other wildlife?
2. Is there a change in the abundance, diversity and extent of vegetation in the enhancement area?
3. Is the area and quality of wildlife habitat created by the wetland enhancement maintained over time?

Based on these management questions, the study was designed to test the following hypotheses stated in the Terms of Reference:

H_{01}: The density, diversity and spatial extent of riparian and aquatic vegetation does not change following enhancement;
H_{02}: The species composition and density of waterfowl and songbirds does not change following enhancement;
H_{03}: Amphibian abundance and diversity in the wetland does not change following wetland enhancement.

The monitoring program collects annual data on riparian and aquatic vegetation density, diversity, and spatial extent; waterfowl and songbird abundance and diversity; and amphibian abundance and diversity. The project tasks also include annual monitoring of fish diversity and abundance at the trial sites. There are no specific management questions or hypotheses for fish to be tested as the focus of the projects is on enhancing wildlife habitat rather than fish habitat.

The general approach is to sample each of the indicator groups at locations within the core area of the enhancement treatments and in peripheral riparian areas at both sites. Riparian vegetation is monitored using annual quadrat sampling and aerial photo analysis. Songbirds are surveyed using breeding bird point counts and nest searches. Waterfowl and shorebirds are surveyed by land-based observations. Amphibians are inventoried using systematic surveys to determine relative abundance. Fish population are sampled with minnow traps, fyke nets, and by electrofishing.

3 STUDY AREA

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 2007). 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. The reservoir is generally divided into three geographic regions (from north to south): Finlay Reach, Peace Reach and Parsnip Reach (BC Hydro 2007).

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. The water level varies annually with reservoir filling and drafting.

The two locations identified for the wetland demonstration projects are both located on the east side of the Parsnip Reach of the reservoir (Figure 1). 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 was isolated from the main reservoir. Water supply to the lagoon is primarily from two unnamed streams located at the north end of the lagoon. At reservoir elevations >664.5 m, the reservoir was connected to the lagoon and water levels in the lagoon correspond to reservoir levels. The goal of the project was to create a larger area of permanently flooded habitat and reduce water level changes that would allow for colonization by submergent and emergent vegetation as well as enhance the riparian zone to benefit waterfowl, wading birds and amphibians (Golder 2011). In May 2013, the existing culverts were removed and two new culverts were installed at an elevation of two new culverts at an elevation of 666.99 m for the west culvert and 667.05 m for the east culvert (Golder 2013).

Water levels observed in the lagoon in spring 2016 were at the design levels as a result of inundation by the reservoir in 2014 and natural inflows to the site. The new permanent water level in the lagoon is shown in Figure 2 along with the pre-construction water level. The post-construction water level in the Airport Lagoon was mapped using aerial imagery acquired by UAV on June 21, 2014 when the reservoir level was 666.6 m and below the new culvert outlet elevation of 666.8 m. As in 2014 and 2015, some variation in the lagoon water level was observed in spring 2016 as a result of changes in flow from upland areas. An estimated 0.2-0.3 m drop in water level was observed at the Airport Lagoon following the spring freshet in this low elevation watershed.

The Beaver Pond site (WDS 34) is located approximately 22 km northwest of Mackenzie at the end of a narrow inlet on Heather Point. There are two beaver ponds located at the head of the inlet with a small stream draining the ponds. The stream also appeared to be partially supplied by an area of ground water seepage. The trial approach for this site was the installation of a berm to create a wetland of approximately 0.9 ha in area (Golder 2011). The proposed elevation for the berm was 669 m resulting in the wetland being directly connected to the reservoir during periods when it exceeds this elevation. Prior to construction, this area was dry (with the exception of the stream and an adjacent area of groundwater seepage) when water levels are below 666 m. The creation of an area with stable water levels is designed to allow for colonization by submergent and emergent vegetation, and enhance the riparian zone to benefit wading birds and amphibians (Golder 2011).

Construction of the Beaver Pond project was completed on May 24 – June 10, 2014. The berm was constructed in the planned location but did not reach the design elevation of 668.2 m due to challenges encountered during installation. The final elevation of the spillway was 667.25 m, reducing the area of the constructed wetland to approximately 0.3 ha. The new permanent water level in the lagoon is shown in Figure 3 along with the pre-construction water level. The extent of flooding is approximate and is based on the proposed berm, the as-built elevation, and observed post-construction water levels in the wetland. Elevation contours were generated from a digital elevation model (DEM) provided by BC Hydro. The shapefile of the proposed berm was provided by Golder Associates Ltd. (Golder 2011).

The uniqueness of both sites, along with the specific physical works proposed for each, means there are no associated control or reference sites in this project. Pre-construction baseline data from both sites will used to assess the post-construction changes associated with each project.

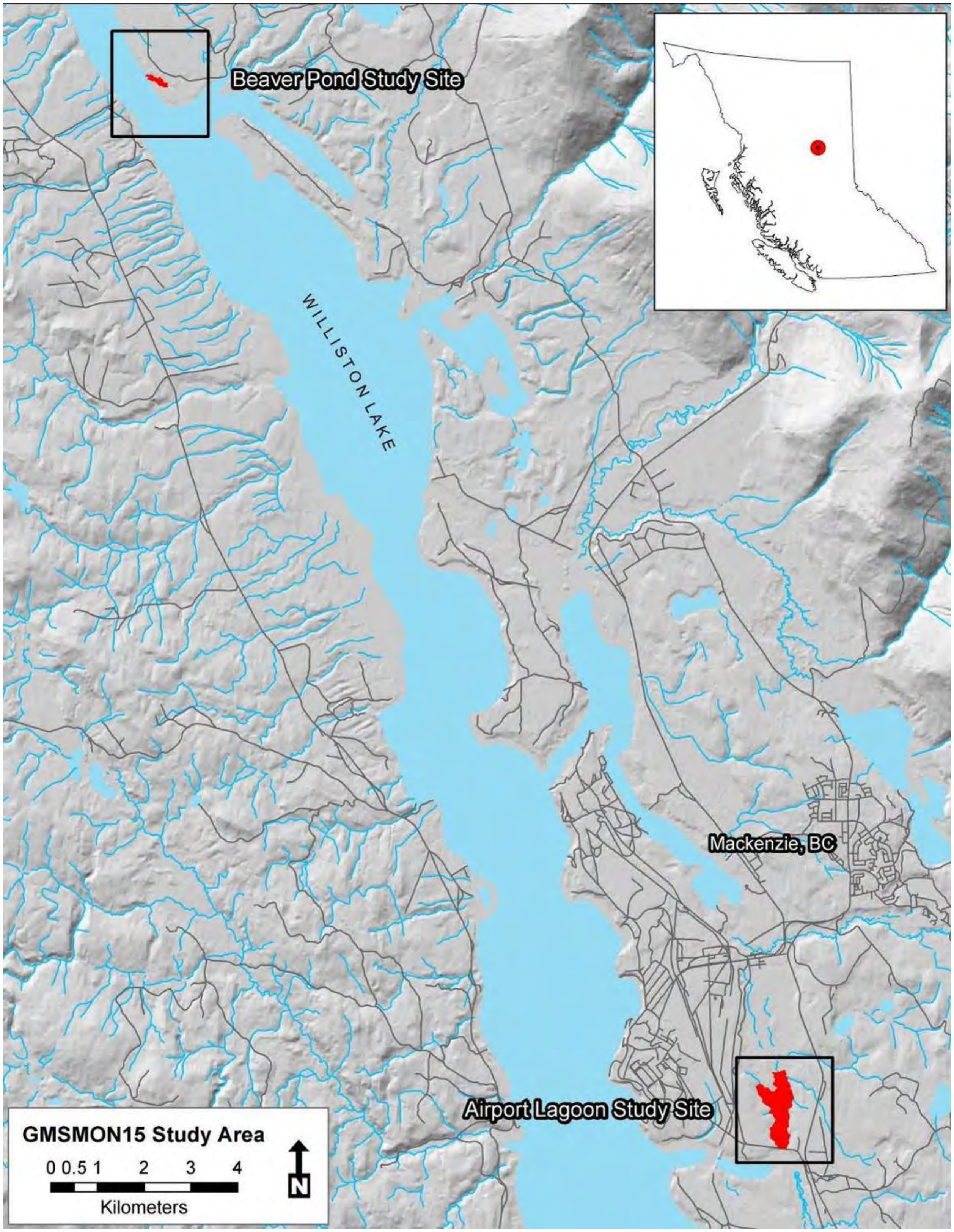

Figure 1. **Location of the two wetland demonstration sites on the Parsnip Reach of Williston Reservoir.**

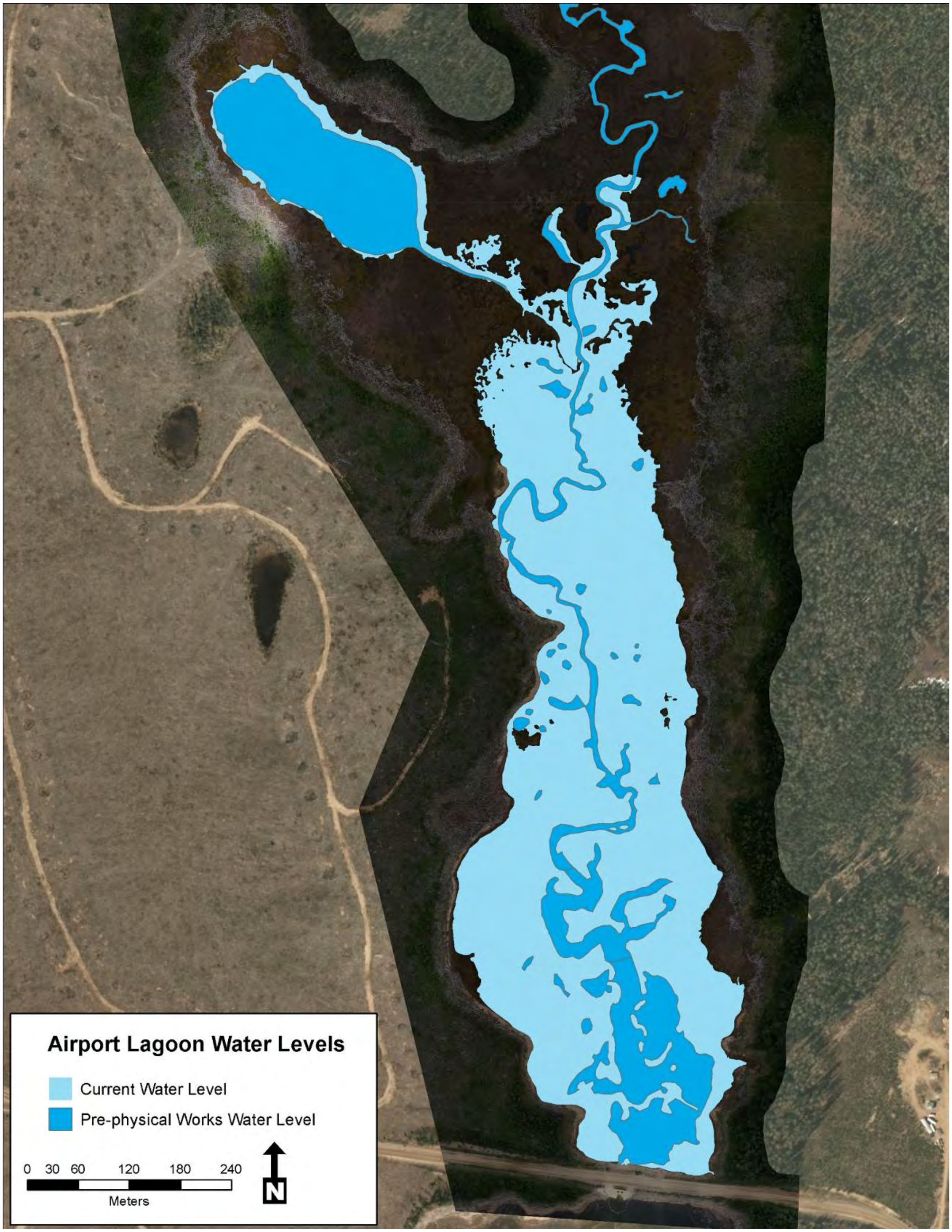

Figure 2. The pre- and post-enhancement permanent water levels at the Airport Lagoon.

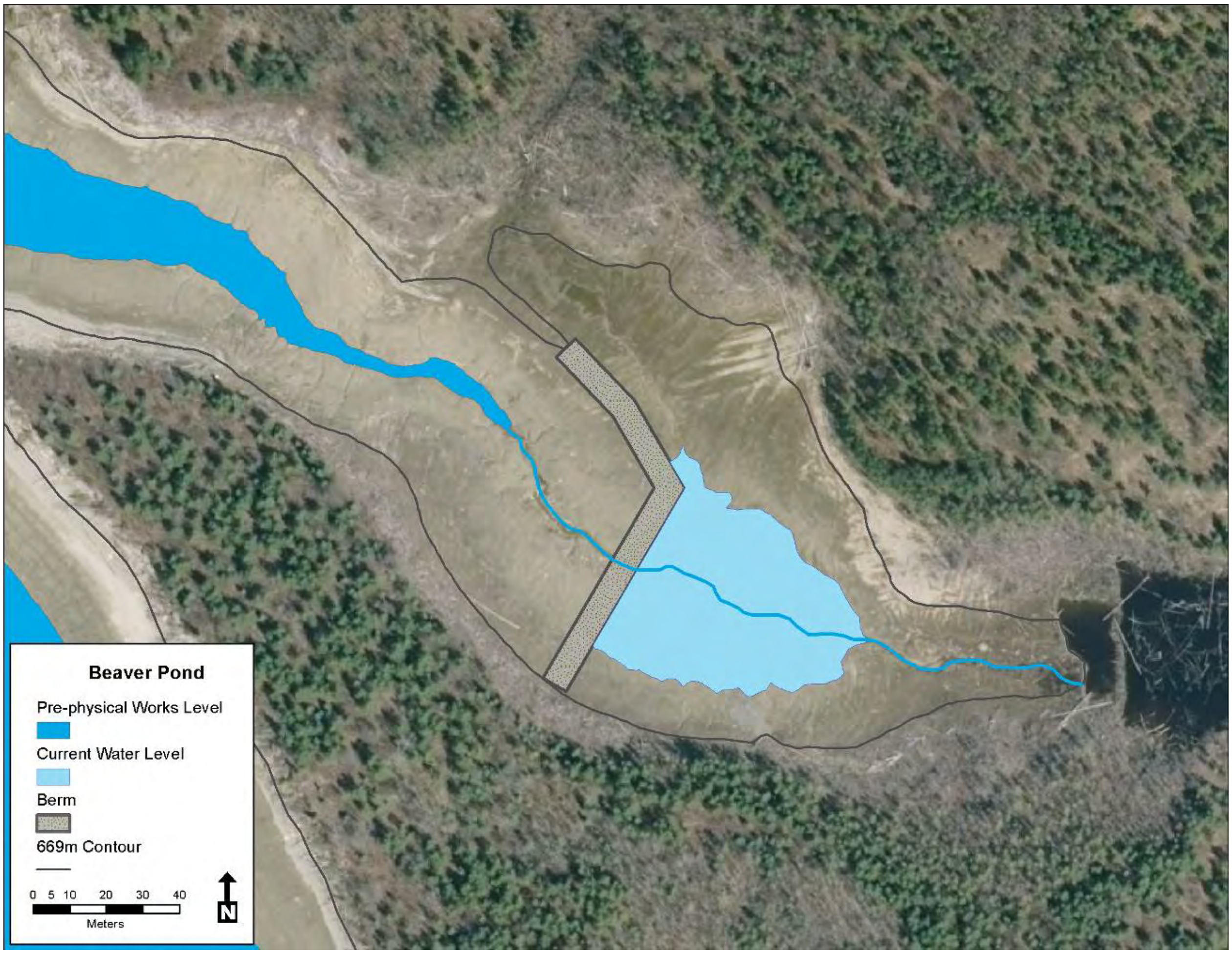

Figure 3. The pre- and post-enhancement permanent water levels at the Beaver Pond.

4 METHODS

The sampling methods used in Year 6 were consistent with those used in the previous years of the monitoring program. As in previous years, minor adjustments in the sampling program were required in Year 6 to account for changes in reservoir elevation and weather conditions. 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

Environmental conditions specific to each survey type were recorded at the start of each survey and periodically during the surveys. Daily reservoir elevations were provided by BC Hydro (BC Hydro Commercial Resource Optimization (CRO) database). Daily mean air temperature and precipitation data prior to and during the survey period were obtained from Environment Canada and observed at the Mackenzie Airport weather station (Station name: Mackenzie Airport Auto).

Accumulated degree days were also calculated using a base temperature of 5°C as an additional method to compare environmental conditions between years. The base temperature of 5°C was selected as an indicator of activity for breeding amphibians. A minimum night-time temperature of 5°C is used as an indicator for the timing of early season call surveys (e.g., USGS North American Amphibian Monitoring Program (Weir and Mossman 2005), Bird Studies Canada Marsh Monitoring Program (n.d.)).

4.2 Vegetation Surveys

A combination of air photo interpretation, ground sampling of terrestrial vegetation, and surface sampling for aquatic plants was used to describe terrestrial and aquatic vegetation communities at the project sites (Parsons 2001, Province of British Columbia 2010, RISC 2010). The terrestrial ecosystem mapping (TEM) standards (Province of British Columbia 2010) were used to complete ground sampling of terrestrial vegetation as the plant species assemblages and soil profiles identified within the project sites were not consistent with the wetland classes described by Mackenzie and Moran (2004). Mackenzie and Moran (2004) describe naturally recurring wetlands within British Columbia that are relatively stable in terms of their hydrologic cycle and plant species composition and have established over long periods of time. Due to variability of flood events in the drawdown zone from reservoir operations, the plant species assemblages identified in this project are in constant transition to a stable state. Aquatic plant sampling was initiated in 2014 (Year 4) and was used to monitor the development of aquatic plant communities at Airport Lagoon and Beaver Pond following completion of the wetland enhancement projects. Protocols for surface inventories described by the Washington State Department of Ecology (Parsons 2001) were followed for the aquatic plant sampling effort.

All photo interpretation was completed in 2-D softcopy using ArcGIS (version 9.3, ESRI 2008). Digital ortho-rectified 1:5000 air photos (2011) of both sites provided by BC Hydro and a high resolution orthomosaic (5cm pixel resolution, 2014) of the Airport Lagoon provided by JR Canadian Mapping were used as the background layer for delineating polygons. As the high resolution orthomosaic was obtained one year post-construction, it will provide a baseline for monitoring the progression of vegetation changes. Field notes on vegetation composition and structure from informal inspections of the study sites prior to the air photo interpretation also assisted with establishing and updating habitat classes.

A habitat classification scheme based on RISC (RISC 2010) was developed to capture all the habitat classes in the study area visible at the resolution available. Habitat classes were first determined from an overview of the study area to identify the larger vegetation features. As the study area was viewed at finer scales during photo interpretation more vegetation features were identified. As new vegetation features were encountered, additional habitat classes were created to accommodate them. Each habitat class was identified based on a common plant species assemblage and elevation within the drawdown zone. The spatial arrangement of habitat classes often followed a similar pattern. For example, at the Airport Lagoon, a band of coarse woody debris and grass/shrub cover parallel to the edge of the reservoir at full pool usually transitioned downslope into a band of sparsely vegetated sand followed by an area of sparsely vegetated mud adjacent to the water's edge.

The high resolution orthomosaic obtained for the Airport Lagoon in Year 4 allowed for the development of a coarse woody debris (CWD) density classification scheme. The objective for the classification scheme was to act as an additional aid for describing habitat, as well as for providing a benchmark for monitoring changes in distribution of CWD. The CWD density classes for the Airport Lagoon site were established by identifying and delineating areas of homogenous CWD cover. Areas representing a specific density class were delineated separately from the other classes, beginning with the highest density class and ending with the lowest. Once the delineation of polygons for a specific class was complete, all polygons for the class were reviewed to ensure that CWD densities were similar and representative.

The spatial extent of aquatic plant communities across the Airport Lagoon site was identified and delineated through the interpretation of the high-resolution air photos collected in Year 4 (2014), the air photos collected in 2011 (Year 1), and information collected during the surface sampling for aquatic plants. Aquatic plant communities at the site were first defined based on a dominant plant species for each community. The spatial extent of each community was then estimated using known occurrences of the dominant species, relative water depth and the distribution of permanent water cover (i.e., ponds and perennial streams) prior to construction of the wetland enhancement.

Due to the relatively small area of both of the study sites, a map scale of 1:1000 was used as the initial resolution for polygon typing. Where required, a larger scale was used to differentiate similar or small area polygons. Overall, the scale varied roughly between 1:2000 and 1:200 throughout the interpretation process depending on the size of the habitat polygon.

Ground sampling of terrestrial vegetation was conducted to support the interpretation of habitat classes and provide a description (e.g., species composition) of plant communities at the sites. Ground sampling was completed along established vegetation transects each year at both sites in early to mid-June. The timing of ground sampling was selected to aid in the identification of plant species by attempting to observe species as close to the date of flowering as possible (as inflorescence is often required to identify a species), but prior to the sites being flooded by rising reservoir levels.

In Year 6 (2016), ground sampling was completed at ten of the previously established vegetation transects (seven transects at Airport Lagoon and three transects at Beaver Pond). Wetland enhancements completed in Year 3 at Airport Lagoon and at Beaver Pond in Year 4 resulted in the permanent flooding of six of the existing vegetation transects (four transects at Airport Lagoon and two transects at Beaver Pond). Thus, ground sampling was completed at transects located above the new water level. Prior to the sampling effort, the list of species detected at the two study sites, along with the list of red and blue-listed plant species from the Conservation Data Centre (CDC, May 2016) was updated and reviewed.

Ground sampling was completed on May 31 – June 2, 2016. Due to an above average reservoir elevation for this time of year, some areas above the new permanent water level at the Airport Lagoon were already flooded. As a result, one additional transect at Airport Lagoon was flooded and not sampled.

As the habitats being surveyed were often linear in shape, a transect-based method for vegetation sampling was selected over a grid-based method (using design components from LGL (2007) and US EPA (2002a)). A 20 m long belt-line quadrat transect consisting of ten 2 m × 0.5 m rectangles was laid out (Figure 5) using a 30 m tape and 2 m measuring rod. UTM coordinates were recorded for the transect start and endpoints, and a spray-painted piece of re-bar was driven in the ground at both points. Photographs looking along each transect were taken at both the start and end points of each transect.

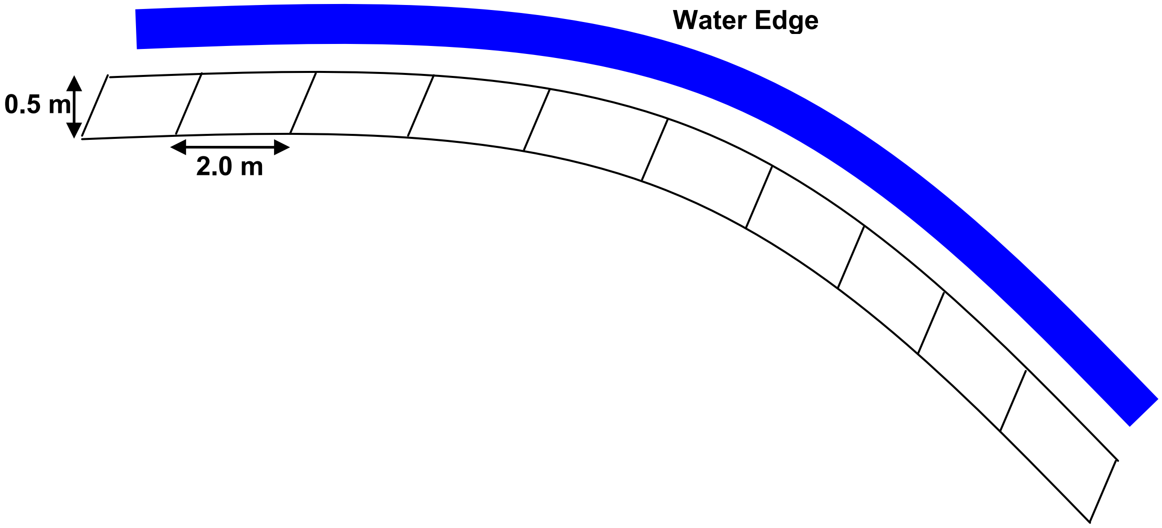

Figure 4. **Belt-line quadrat transect for a sample site laid out adjacent to the riparian area.**

Site and soil characteristics for the entire transect were recorded on provincial ecosystem field forms (Province of British Columbia 2010), including seral and structural stage characteristics (Appendix 2). Site characteristics representative of the whole site were recorded and a representative location was chosen for the soil pit. Within each quadrat, vegetation was identified to species and the percent cover of each species recorded. The terrestrial ecosystem keys (Province of British Columbia 2010) were used to describe soil characteristics and plant species were identified using MacKinnon et al. (1999). Where identification of species was not possible or uncertain, samples were taken and identified in the botany laboratory of the University of Northern British Columbia (UNBC) using the Illustrated Flora of British Columbia (Douglas et al. 1998) and Flora of the Pacific Northwest (Hitchcock and Cronquist 1973). Where species identification was still problematic or where correct identification was particularly important (i.e., a potential red-listed species), a plant taxonomy expert from UNBC was asked to confirm the initial result. Plants listed as rare or endangered at the provincial or federal level were recorded on a Rare Plant Observation Form and submitted to the BC Conservation Data Centre.

Beginning in Year 4, surface sampling for aquatic plants (Parsons 2001) was initiated at the Airport Lagoon site to monitor the development of aquatic plant communities associated with the new, stable water level. Prior to installation of the new culverts, aquatic vegetation was limited due to the annual drawdown of the site. The objective of the sampling was to identify the spatial extent and species composition of aquatic plant communities at the sites. This will allow for monitoring of changes in the abundance and distribution of aquatic vegetation over time now that the wetland enhancement has been completed. Surface sampling was completed in late-July. This timing was selected to aid in the identification of aquatic plant species by attempting to sample the sites during a period when a majority of aquatic plant species were expected to be flowering.

In Year 6, surface sampling for aquatic plants was completed at the Airport Lagoon site on July 13 and 14, 2016. The Beaver Pond site was sampled on July 15, 2016. Surface sampling included visual observations of aquatic plant cover along the shoreline and shallow water areas (water depth <2 m) as well as dredge sampling at various locations away from the shoreline where water depth limited visual observations of aquatic plant cover (>2 m depth). Dredge sampling was also completed on the vegetation transects that were flooded as a result of the wetland enhancement to monitor the post-construction changes in species composition.

Dredge sampling for aquatic plants used a rake sampler constructed of two back to back garden rakes attached to a rope to collect plant samples from the bottom of the flooded area. At each location selected for dredging, the rake was dropped to the bottom and dragged for a distance of approximately 1 to 3 m to collect samples. This was repeated a total of three times at each dredge location to obtain information on species composition and relative abundance. The monitoring of the development of aquatic vegetation will assist in monitoring changes in aquatic habitat from the increase in the permanently flooded area.

Where the identification of aquatic plant species was not possible or uncertain, samples were taken and identified in the botany laboratory at UNBC using the Illustrated Flora of British Columbia (Douglas et al. 2001a, 2001b) and Flora of the Pacific Northwest (Hitchcock and Cronquist 1973). Where species identification was still problematic or where correct identification was particularly important (i.e., a potential red-listed species), samples were sent to a taxonomic expert at the Royal BC Museum.

4.3 Waterfowl and Shorebird Surveys

Land-based surveys, following the protocols for absolute abundance inventories of waterfowl species (RIC 1999a), were used to record waterfowl and shorebird occurrence at the study sites. The survey methods were the same as those used in the previous years of the monitoring program. Shorebirds have been included in the surveys since 2012 to provide additional detail on bird use of the sites. Surveys began in early spring to capture migrating waterfowl and continued through to late spring. Waterfowl surveys were completed on April 29, and May 10, 21, and 31 at the Airport Lagoon site and on April 28, May 17, and June 1 and 5 at the Beaver Pond site. Surveys are planned to account for the fact that typically the timing of surveys at Beaver Pond is limited by access issues (ice on Williston Reservoir and/or unfavourable weather conditions). Unseasonably warm spring temperatures facilitated early ice-off on Williston Reservoir so the Beaver Pond site was accessible for the early spring survey effort. Surveys at both sites were completed at the previously established stations at each site (Figures 6 and 7). Coordinates for the survey stations are provided in Appendix 3.

A combination of a modified RIC data form (1999a) and a map with an orthophoto background of each site was used to record waterfowl observations (Appendix 4). Survey conditions (temperature, wind direction, wind speed, precipitation, cloud cover, and ceiling height) were noted at the beginning and end of each survey, and unusual circumstances (if any) in the wetland area that may have affected survey results. Upon arrival at a station, the observer scanned the area with binoculars to obtain an overview of birds present and also note any bird or group of birds that may have taken flight upon arrival. Any birds that took flight on arrival at the station were recorded on the data form. Observers ensured that groups of birds were not double counted if they could be seen from more than one observation station. To avoid double counting birds, observers noted a suitable landmark to set the limit of the observations taken from that station. The location of such a boundary changed from survey to survey depending on water levels and the distribution of groups of waterfowl.

From a survey station, the respective survey area was slowly and systematically scanned at low magnification with binoculars. A spotting scope was used to identify birds or groups of birds that could not be identified with binoculars due to small size or distance from the observer. Observers drew a polygon with a unique ID number for every group of birds on field data maps created for this purpose (Appendix 4). Care was taken to draw the polygon as accurately as possible by matching up landmarks with their corresponding location on the orthophoto background. On the observation form, a new data line was recorded for all groups that could be defined by species and number of individuals, with associated information such as number of broods present, sex, behaviour, and habitat descriptors within each polygon. Species codes followed RIC (2008).

Figure 5. Waterfowl survey station location at the Beaver Pond site.

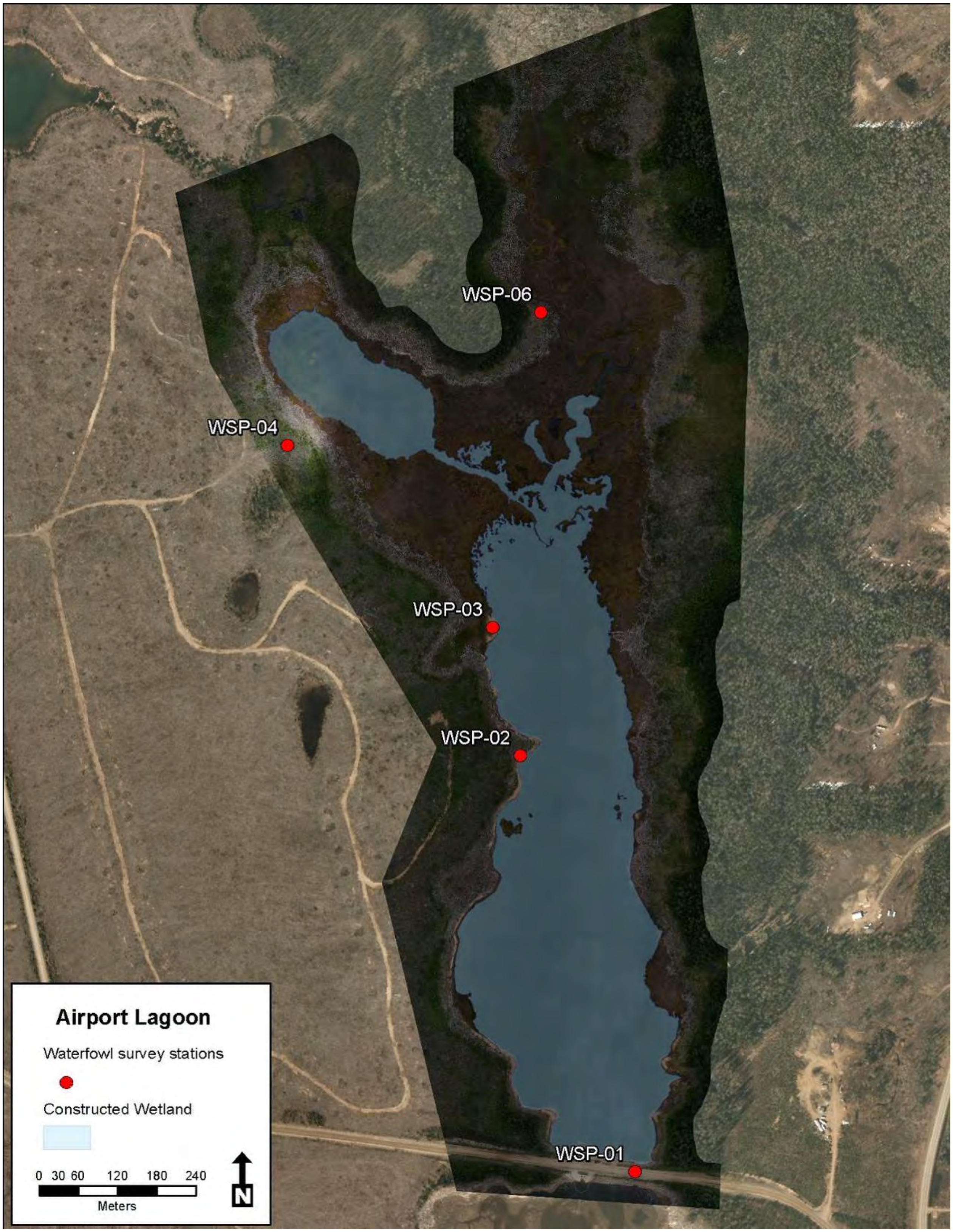

Figure 6. **Waterfowl survey station locations at the Airport Lagoon site.**

4.4 Songbird Surveys

The point count survey methodology was consistent with all previous years of the project. Variable radius point counts and nest searches consistent with Bird Studies Canada and RIC methods (RIC 1999b, Bird Studies Canada 2009) were used to record breeding bird occurrences at the study sites. Point count surveys were conducted from June 1-6, 2016. During this period three replicates were completed at the Airport Lagoon site (June 3, 4, and 6) and two replicates were completed at Beaver Pond (June 1 and 5). Inclement weather on June 2 precluded point count surveys. All surveys were completed during the breeding season (May 28 - July 10) and within four hours of sunrise (Bird Studies Canada 2009). Based on previous experience conducting point count surveys in the cool, wet northern BC spring (Hentz and Cooper 2006, CBA 2008), surveys were conducted according to 'modified' RISC standards for environmental conditions (RIC 1999). These standards are as follows: wind speed ≤ Beaufort 3 (gentle breeze, leaves and twigs constantly move), precipitation = 'very' light rain, temperature > 3˚C. Species codes followed RIC (2008).

Previous studies also suggested that peak breeding season for songbirds in the area occurs in mid-June (Hentz and Cooper 2006, CBA 2008). Survey dates fell within this window and were consistent with the timing of pre-enhancement monitoring efforts. Three replicates were completed at each site to give a 'snapshot' of the breeding bird community (RIC 1999b).

Consistent with survey effort in previous years, point counts were completed at the three established survey stations at the Beaver Pond site (Figure 8) and the 17 established survey stations at Airport Lagoon (Figure 9). Coordinates for the point count stations are provided in Appendix 5. Point count stations were distributed throughout the study sites to ensure maximum coverage. The centres of adjacent point count stations were located a minimum of 200 m apart to prevent overlap of the 100 m radius survey areas.

Survey stations were approached quietly to minimize disturbance. Upon arrival, observers waited silently at the point count station for one minute to allow any effects of disturbance on resident birds to dissipate before commencing the survey. Point counts were conducted for five minutes.

The data form (Appendix 6) was oriented to the north for each survey, and environmental variables (ceiling, cloud cover, wind, precipitation) (Appendix 7) and time of day were noted. All birds seen or heard during the survey were recorded. Each detection (a detection can include more than one individual; e.g. a flock of 12 Pine Siskin could account for a single detection) within 100 m of the centre of the point count station was spatially mapped on a data sheet with concentric radii of 25, 50, 75 and 100 m (Appendix 6). Birds beyond 100 m were noted on the data sheets but not spatially located, as distance estimation at greater distances is problematic (Alldredge et al. 2007).

Detections were assigned to one of two time intervals (0-3 and 3-5 minutes) based on the time that they were initially noted. They were categorised as in the drawdown zone; in the shrub fringe at the upper edge of the drawdown zone; in forested habitat bordering the shrub fringe; as 'flying-over' and not associated with any vegetation type; or unknown.

Opportunistic nest searches were conducted daily, following the completion of point count surveys. Searches were focused on areas where breeding behaviour (e.g., carrying food or nest-building material) had been observed within the drawdown zone and adjacent areas (within 50 m of the drawdown zone). Data including UTM coordinates, type of nest, species using it, height above ground and coarse resolution of vegetation composition in the surrounding area were recorded for each nest.

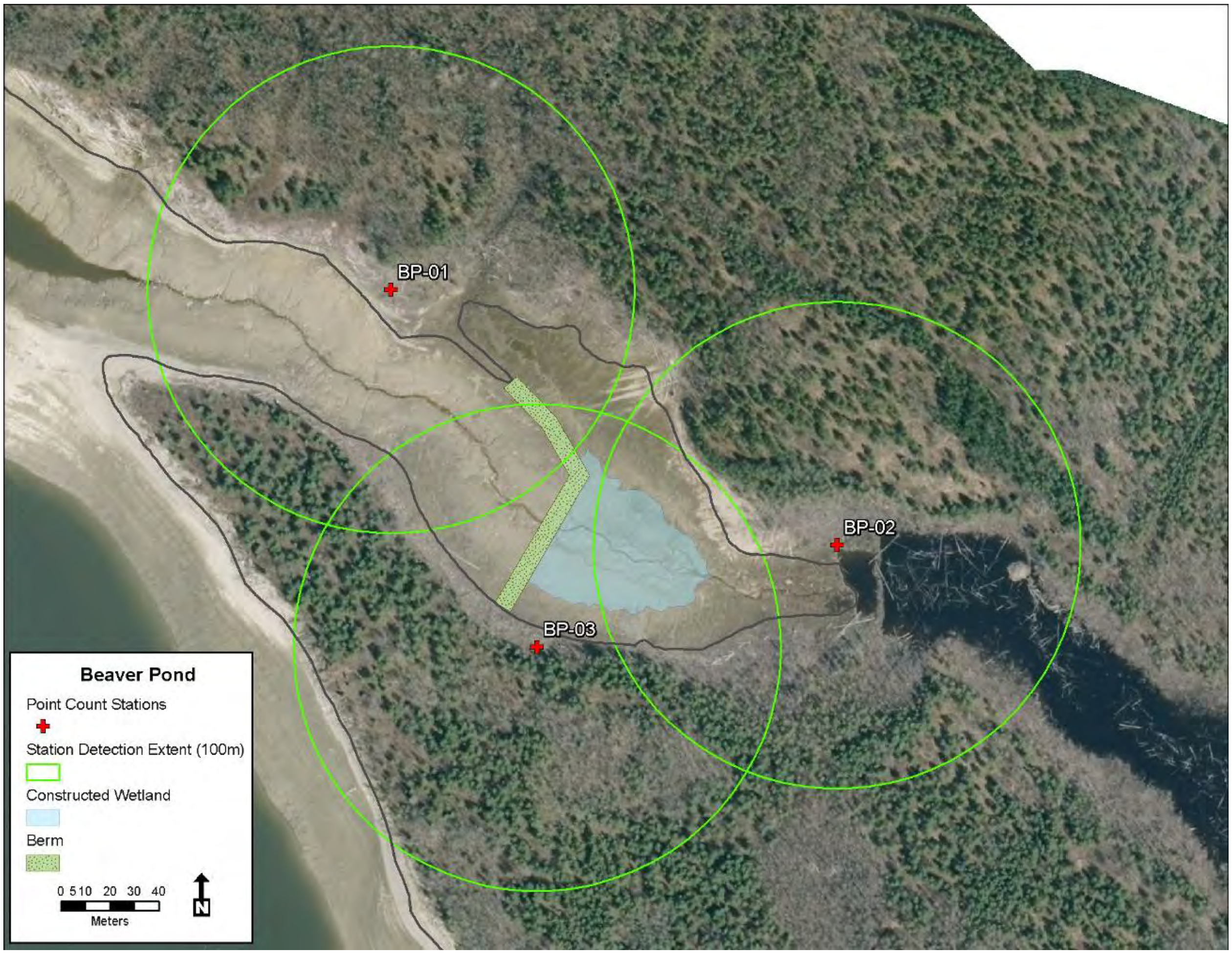

Figure 7. Point count station locations at the Beaver Pond site.

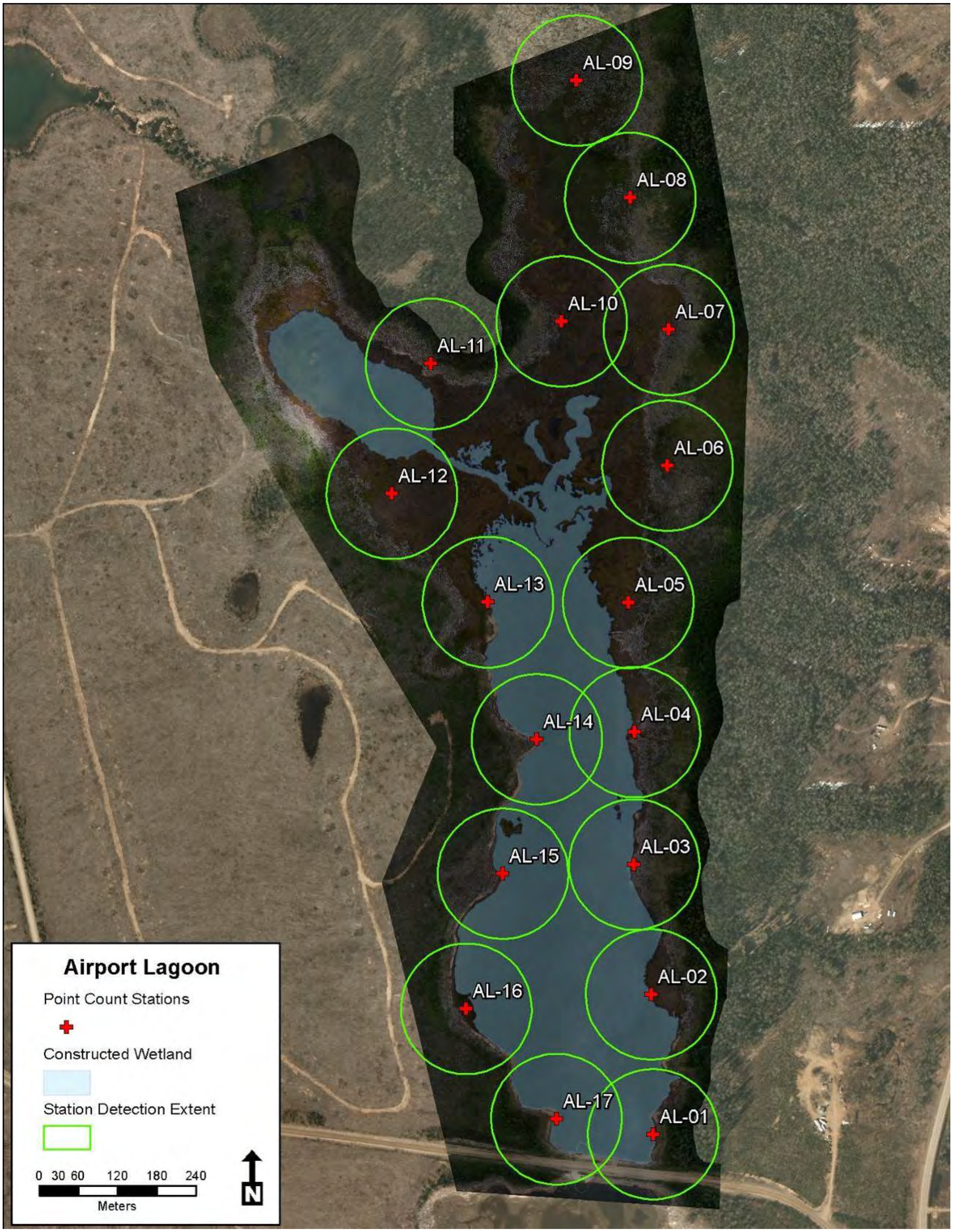

Figure 8. **Point count station locations at the Airport Lagoon site.**

4.5 Amphibian Surveys

Systematic surveys consistent with inventory methods for pond-breeding amphibians were used to determine the diversity and relative abundance of amphibian species at Airport Lagoon and Beaver Pond (RIC 1998). Due to a lack of obvious strata, both sites were treated as a single stratum (RIC 1998). Survey efforts included 4 replicates of 11 randomly distributed transects along the peripheries of the inundated area of Airport Lagoon and 3 replicates at Beaver Pond, where the entire site was considered as a single transect. The 2016 survey dates for both sites are included in Table 1.

Table 1. 2016 amphibian survey dates by site.

Site	Survey 1	Survey 2	Survey 3	Survey 4
Airport Lagoon	April 29	May 10	May 21	May 31
Beaver Pond	April 28	May 17	June 1	June 5

Completion of the projects at both sites resulted in increased water levels that required the adjustment of eight of the original transects at Airport Lagoon and modifications to the Beaver Pond transect. The potential for modification of some transects after project construction was anticipated during development of the monitoring program. Changes to the transects at the Airport Lagoon and Beaver Pond sites are illustrated in Figures 10 and 11, respectively.

Prior to field surveys, a list of amphibian species likely to be encountered at each site was compiled based on the findings of Hengeveld (2000) along with the results from the first four years of this project (CBA 2012, 2013, 2014, 2015, 2016). A photograph was taken from the start point of each transect, oriented towards the end point. To allow for replication and calculation of detections per unit area, a hand-held GPS unit was used to record the start and end points along with the survey tracks for all transects.

The search area included shallow water (<1 m deep), the shorelines and areas within 3 m of the shoreline of the reservoir, ponds, streams, and riparian areas. A zig-zag search pattern applied above the waterline along with a linear search of shorelines ensured complete coverage of the area. On the shore, observers checked for the presence of amphibians underneath pieces of woody debris and other potential cover objects before returning all materials to their original position. Individuals were only captured on rare occasions when identification was not possible during the initial sighting and all amphibians were released immediately upon identification. Matsuda et al. (2006) and an unpublished tadpole key from the Ministry of Environment in Fort St John were used to confirm species identification. Species codes followed RIC (2008).

Data was recorded on RISC animal observation forms for amphibians (Appendix 8). Survey conditions including precipitation, ambient temperature, wind speed, cloud cover, ceiling height, water temperature and condition (if applicable) were noted at the beginning and end of each transect. Species, developmental stage, behaviour, and habitat variables were recorded for each adult, larvae, and egg mass observed. Where it was not possible to exactly count large numbers of tadpoles (>100), they were simply recorded as 'tadpoles'.

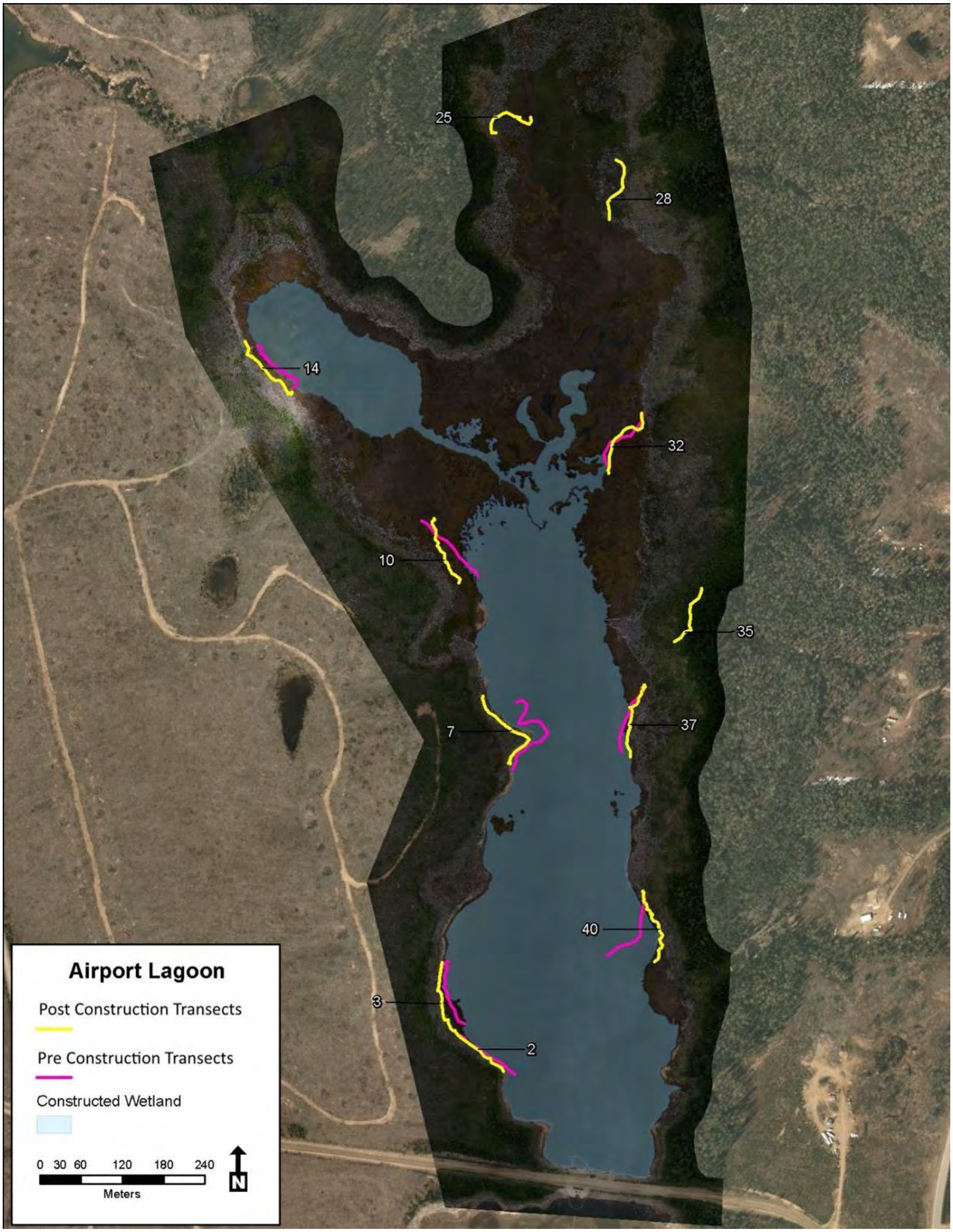

Figure 9. Amphibian survey transect locations at the Airport Lagoon site.

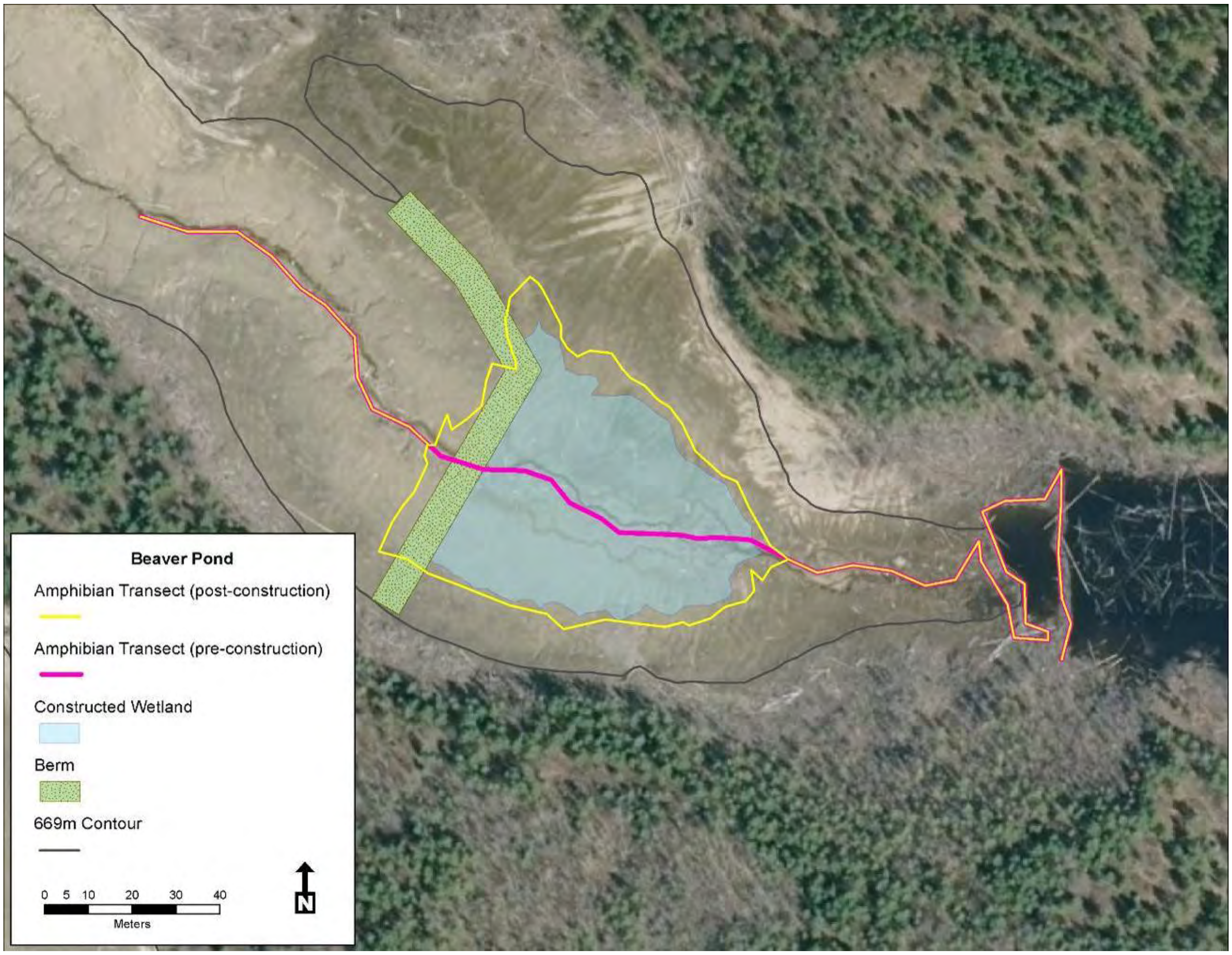

Figure 10. **Amphibian survey tracks locations at the Beaver Pond site.**

4.6 Fish Surveys

Fish populations were sampled at both sites using a combination of methods following RIC (2001) guidelines. Fish sampling was conducted under Scientific Fish Collection Permit PG16-230258 issued by the Ministry of Forests, Lands and Natural Resource Operations. A combination of methods was used to ensure sampling of both large and small fish at each site and the different habitats available at low and high reservoir levels. In Year 6, fish sampling at the Beaver Pond and Airport Lagoon sites was completed using minnow traps, backpack electrofishing, and fyke nets.

Fish sampling was completed at the Airport Lagoon site on May 18-20 and July 13-14, 2016 and at the Beaver Pond site on May 17-18 and July 15-16, 2016. The sampling locations are shown in Figures 12 and 13 for the Airport Lagoon and Beaver Pond sites, respectively. The methods used on each date are summarized in Table 2. As the upper pond in the northwest arm of the lagoon is not accessible by boat at early season water levels, fish sampling was completed with minnow traps at this location. The May fish sampling at the Beaver Pond site was completed prior to this area being inundated.

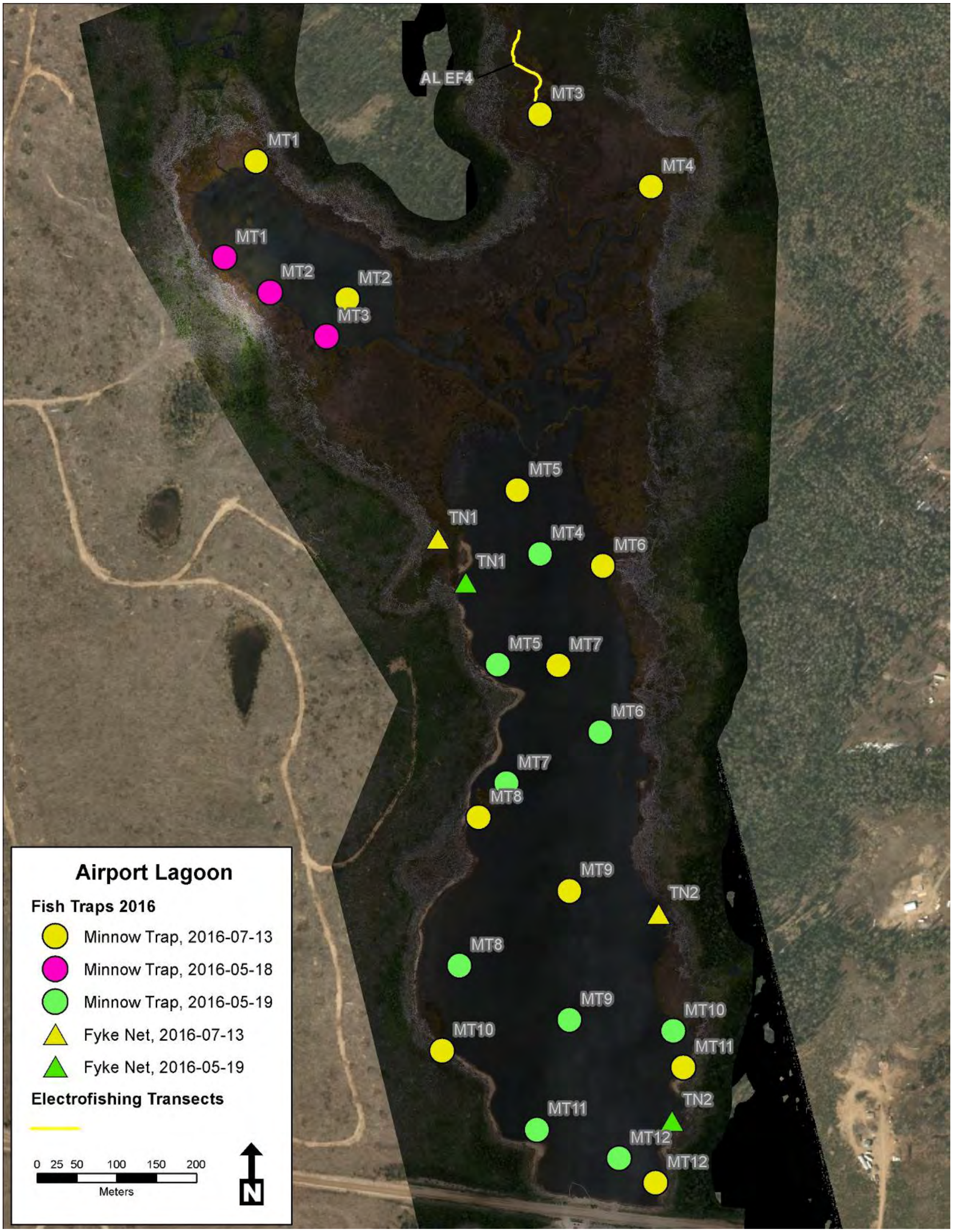

Figure 11. **Fish sampling locations by date and method at the Airport Lagoon site.**

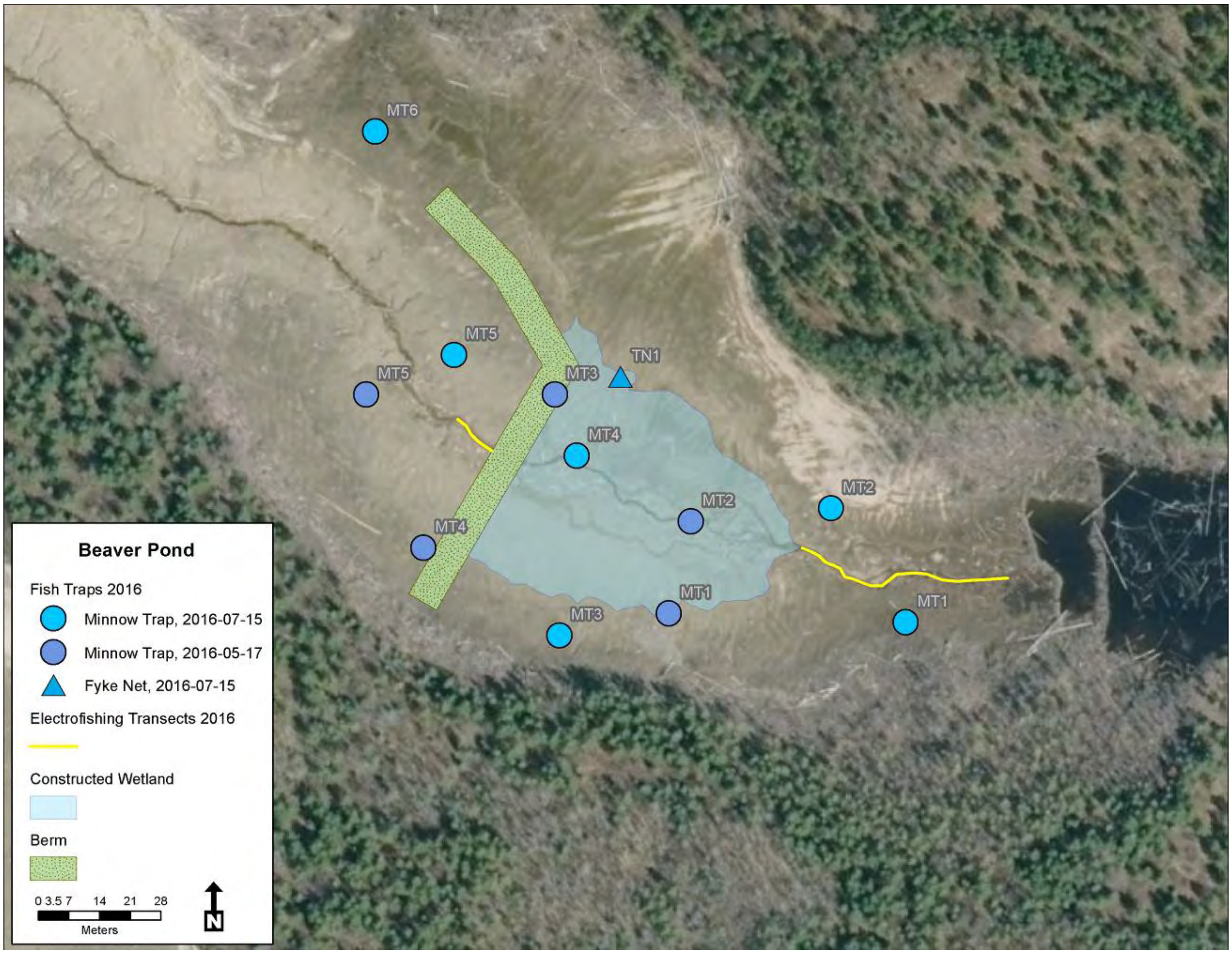

Figure 12. Fish sampling locations by date and method at the Beaver Pond site.

Table 2. Fish sampling methods in 2016 at the Airport Lagoon and Beaver Pond sites.

Site	Date	Method	Number of Samples
Airport Lagoon	May 18	Electrofishing	1 reach
	May 19-20	Minnow trap Fyke net	12 traps 2 nets
	July 13-14	Minnow trap Fyke net	12 traps 2 nets
Beaver Pond	May 17-18	Electrofishing Minnow trap	2 reaches 5 traps
	July 15-16	Minnow trap Fyke net	6 traps 1 net

In 2016, two minnow trap sampling sessions were completed at both the Airport Lagoon and Beaver Pond sites. At both sites, the first sampling session was completed prior to inundation and the second session was completed after inundation. This is the first year after construction of the wetland that minnow trapping was completed at the Beaver Pond site prior to inundation. Minnow traps were baited with cat food and set for a minimum of 12 hours at random locations at each site.

Twelve minnow traps were used for each sampling session at the Airport Lagoon. During the first sampling session, three minnow traps set in random locations around the pond in the northwest arm of the lagoon and the other nine minnow traps were set at random locations in the new pond created by the higher elevation culverts. During the second session (after inundation) the 12 minnow traps were deployed at random locations throughout the lagoon. At the Beaver Pond site, five minnow traps were used during the first sampling with four set at random locations around the impoundment and one below the berm. Six minnow traps were used during the second sampling session and were deployed at random locations within the inlet.

Backpack electrofishing (Smith-Root LR-20B) was used to sample the stream habitat that is present at both sites prior to inundation by the reservoir. A single reach was sampled at the Airport Lagoon site (Figure 12). This is the only one of the four previously sampled stream reaches at this site not affected by the new water level. Electrofishing at the Beaver Pond site occurred in the portions of the two stream reaches sampled in previous years that were not flooded by the new wetland (Figure 13).

Fyke net construction was based on the design in Bonar et al. (2000). Two nets were used at the Airport Lagoon during the May and July sampling. A single fyke net was used at the Beaver Pond site during the July sampling. Fyke nets were randomly deployed at each site with the lead anchored to the shore and the net set perpendicular to the shoreline. All sets were overnight for a minimum of 12 hours. While fyke nets were randomly deployed, an alternate site often needed to be selected in the field to ensure an effective net set. The fyke nets are 1 m deep and setting them with the cod end in water deeper than 1.5 m reduces the effectiveness by providing more opportunity for fish to avoid the cod end of the net. At high reservoir elevations, potential setting locations are further reduced by steep slopes requiring the fyke nets to be set in water deeper than the net.

All collected fishes were held in live wells after capture and processed as soon as the electrofishing pass, or net/trap haul was complete. Captured fishes were anaesthetized using $CO_{2.}$ to ease handling and reduce the potential for handling injury. Captured fishes were identified to species, enumerated, and the fork length (total length for Burbot and sculpins) recorded to the nearest millimetre. All anaesthetized fishes were allowed to fully recover prior to release.

Due to high catch rates at the Airport Lagoon, subsampling was employed for the most abundant species to minimize holding and processing time. Subsampling was limited to fishes less than 100 mm fork length (FL) and to the most common species. For all electrofishing, minnow trap, and fyke net catches, a sample of approximately 50 individuals of the most common species (e.g., Lake Chub, Brassy Minnow, Redside Shiner, and juvenile suckers) were measured and the remaining fishes of the subsampled species were only counted. Separate subsamples were obtained for each gear type (minnow trap and fyke net) due to differences in selectivity between the methods (CBA 2014).

Environmental data were also collected during field visits to record the sampling conditions during each site visit. Additional data included water temperature, water depth, water clarity (relative turbidity or Secchi depth), pH, dissolved oxygen (DO), and conductivity. Water temperature, pH, DO, and conductivity were recorded at the surface using a calibrated YSI Pro Plus multi-parameter meter (YSI Inc., Ohio). Relative turbidity was recorded for each electrofishing reach according to RIC (2001) standards. Secchi depth (20 cm diameter disk) was used as a measure of turbidity for the inundated areas. The fish data collected were standardized to catch-per-unit-effort (CPUE) for each gear type (electrofishing = fish/minute, minnow traps and fyke nets = fish/hour) to allow for interannual comparison of fish diversity and relative abundance to identify changes related to the wetland treatments.

4.7 Data Entry and Analysis

Immediately after a field survey was completed, data sheets were scanned into pdf documents and stored in a redundant file storage system. Similarly, photographs taken during field surveys were labelled and filed by survey type. All data were entered into a customized database designed to minimize data entry errors by restricting the permissible range of values for a field or by using selections from drop-down lists.

Data were exported from the database to MS Excel to provide data summaries for each component of the monitoring project. Data from each vegetation transect were summarized to provide an overview of the vegetation community at each site. The vegetation percent cover data from each of the ten quadrats in a belt-transect were pooled to provide an average percent cover for each species. Waterfowl and amphibian survey results were summarized by survey date and site. As the intent of the breeding bird survey was to provide a snapshot of the breeding bird community at a site, data from all three replicates were pooled to provide summaries on species richness and relative abundance.

The collection of baseline data for the two sites is now complete with the construction of the Airport Lagoon project in May 2013 and the Beaver Pond project in 2014. Year 6 was the third full year of post-construction data from the Airport Lagoon and the second full year of post-construction data from the Beaver Pond site. Initial comparisons of the post-construction results to the baseline are provided for both sites. More detailed analyses are planned once additional years of post-construction data are collected.

5 RESULTS

5.1 Environmental Conditions

The annual change in water level for Year 6 (2016) and the previous five years of this study (Year 1: 2011, Year 2: 2012, Year 3: 2013, Year 4: 2014, and Year 5: 2015) are shown in Figure 13 along with the mean reservoir level.

In 2016, the reservoir reached its lowest level of 662.9 m on April 7. This is earlier and higher than in the previous years of the monitoring program (8 May 2011, 25 April 2012, 3 May 2013, 26 April 2014, and 21 April 2016). As in 2015, the minimum elevation was more than 4 m above the average for this date and almost 2 m higher than on the same date in 2012 (the year with the next highest minimum elevation in the study period). Water levels in 2016 increased relatively slowly compared to previous years but they were well above reservoir elevations in previous years of the study until late June. The reservoir reached a maximum of 670.7 m on July 21 which is above average but below the full pool elevation of 672.08 m. The timing and duration of the peak elevation in 2016 was similar to average conditions and previous years of the project (Figure 1). Reservoir levels in all six years of the project were higher than in 2010 when the reservoir elevation only reached a maximum of 665.54 m on November 8, 2010 (BC Hydro CRO database).

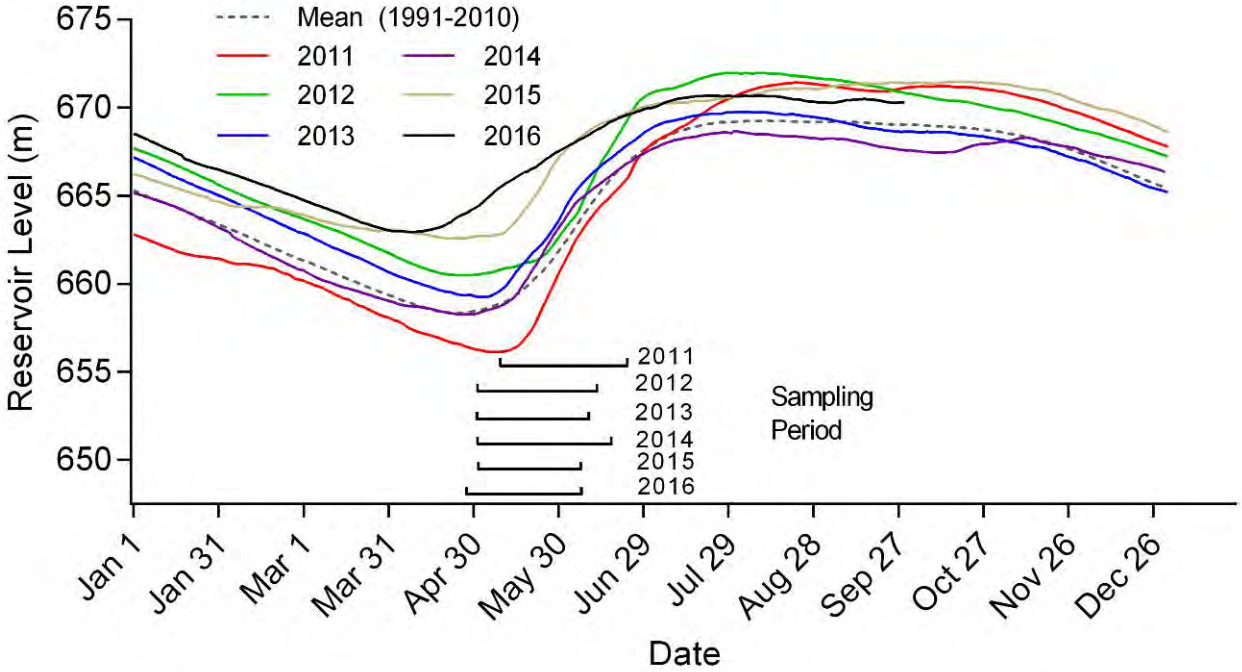

Figure 13. Annual Williston Reservoir elevations for 2011 to 2016 (BC Hydro CRO database).

In Year 6 (2016), temperatures throughout April were generally well above average (Figure 14). This trend continued into early May and coincided with the start of the 2016 surveys. Temperatures throughout the rest of the sampling period were generally closer to average with fluctuation above and below the long term mean (Figure 14). Cumulative precipitation in Year 6 was average for April, below average in May, and average for the first half of June (Figure 15). Cumulative precipitation was above average for the second half of June as a result of a single rainfall event on June 15. Precipitation in Year 6 was generally consistent with the previous years of the sampling program. Conditions appeared to be drier than normal at the start of sampling in 2016 and this was assumed to be due to the warm temperatures in April. This was also the first year that the Beaver Pond site was accessible at the beginning of the sampling program. In previous years, the site was inaccessible at the beginning of May due to a combination of ice on the reservoir and roads still blocked by snow.

Based on accumulated degree days, Year 6 was consistently warmer than all previous years with degree days accumulating earlier than in the previous five years (Figure 16). The warmer temperatures in spring 2016 suggested that vegetation growth and animal activity (e.g., amphibian breeding may have occurred earlier than in previous years. Degree day accumulation remained higher than all previous years until late May when it was only exceeded by Year 5 (2015). While temperatures in April were generally well above average, they were not consistently above 5°C until April 27 which is similar to most previous years of the project (Year 1: May 3, Year 2: April 25, Year 3: April 23, Year 4: April 25, and Year 5: May 6).

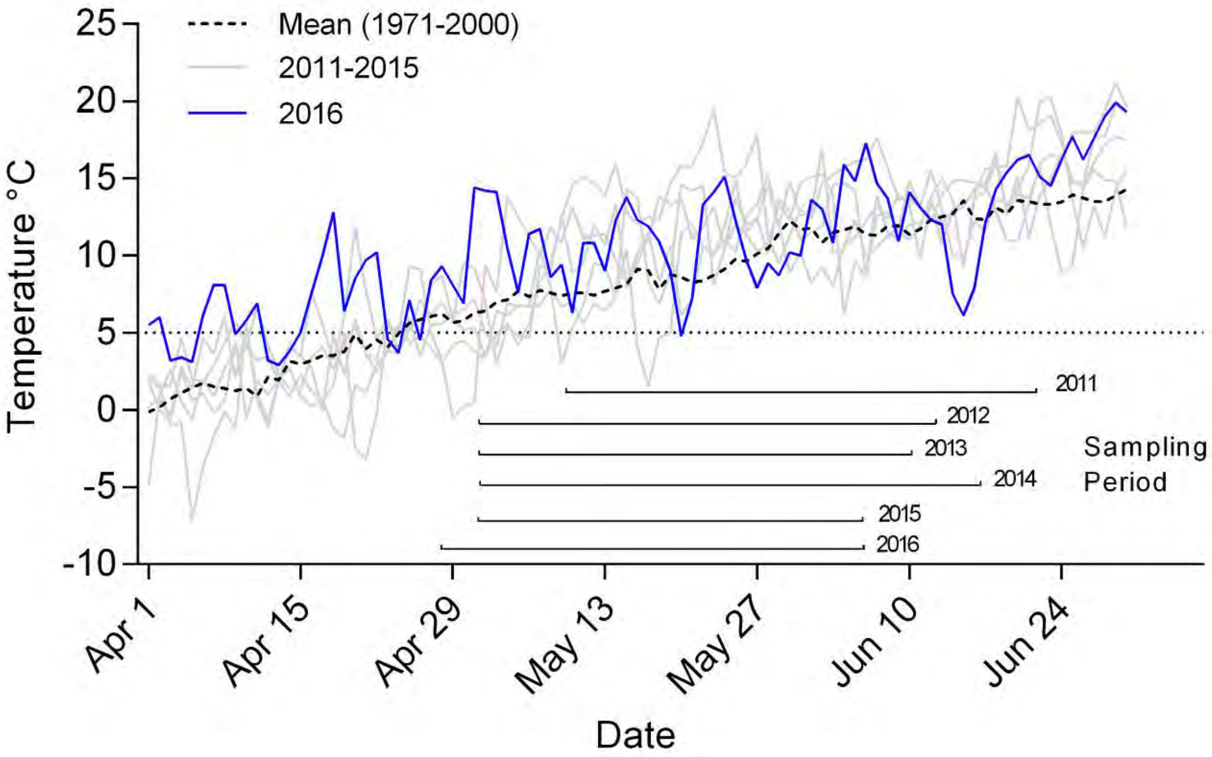

Figure 14. **Daily mean air temperature and the long term mean (1971-2000) in the study region. Data from Environment Canada and observed at the Mackenzie Airport weather station (Station names: Mackenzie A and Mackenzie Airport Auto).**

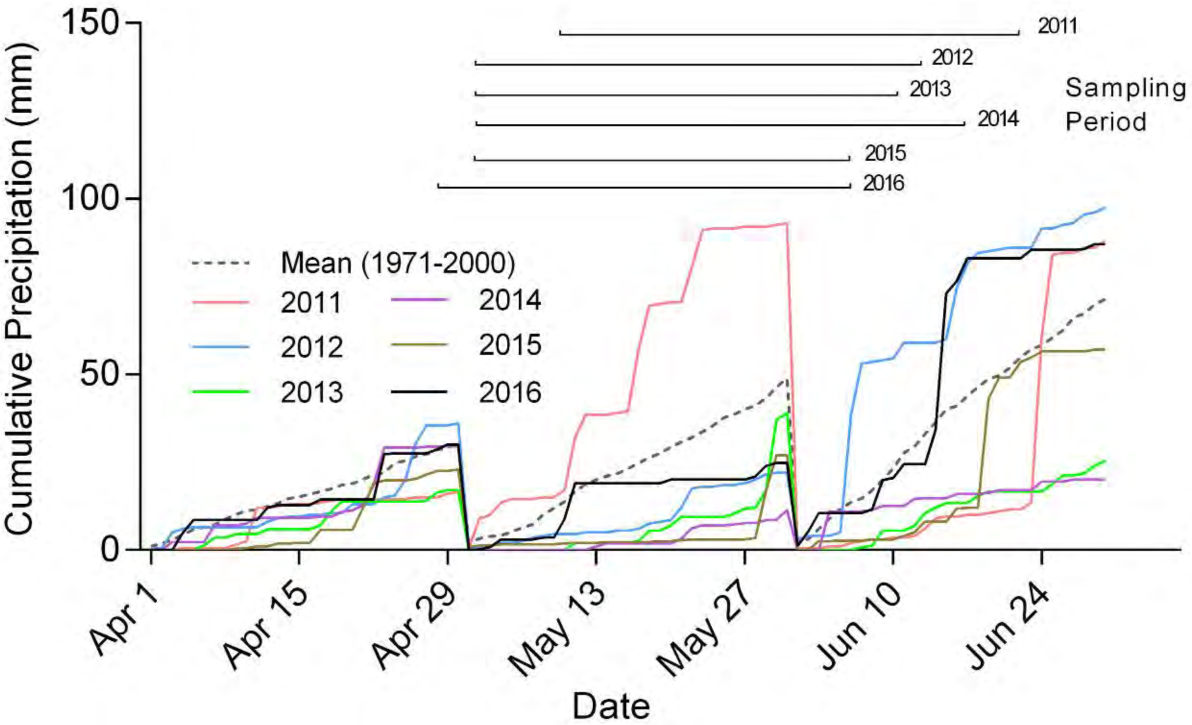

Figure 15. **Cumulative monthly total precipitation and the long term (1971-2000) means in the study region. Data from Environment Canada and observed at the Mackenzie Airport weather station (Station names: Mackenzie A and Mackenzie Airport Auto).**

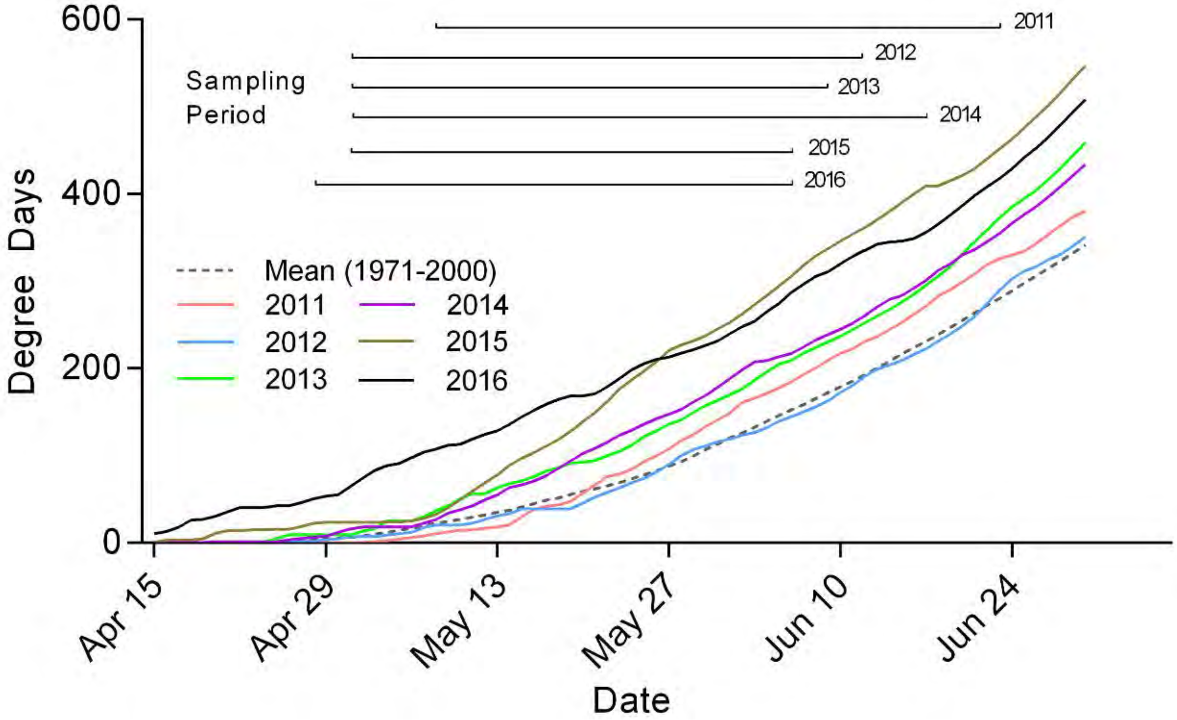

Figure 16. **Accumulated degree days (5°C base temperature) and the long term mean (1971-2000) in the study region. Calculated from Environment Canada daily maximum and minimum temperatures observed at the Mackenzie Airport weather station (Station names: Mackenzie A and Mackenzie Airport Auto).**

5.2 Vegetation Surveys

5.2.1 Drawdown Zone Vegetation

Airport Lagoon

A total of 13 habitat classes describing vegetation communities at the Airport Lagoon site were identified and mapped in Year 1 of the study (CBA 2012). The plant species assemblages identified within habitat classes consisted mostly of herbaceous perennials (grasses and herbs) and bryophytes with minimal woody shrubs and no live tree cover (with the exception of occasional paper birch [*Betula papyrifera*] and trembling aspen [*Populus tremuloides*] seedlings). A few classes had a high percentage of coarse woody debris (≥50%) from driftwood accumulation. The habitat classifications and their spatial distribution were reassessed in Years 2, 3, and 4 and the classifications and mapping refined as additional information was collected. As result, the original 13 classes were reduced to 12 in Year 4 (CBA 2015). Some of the habitat class names were also revised to more accurately reflect the observed vegetation cover and location.

In Year 6, the habitat class descriptions and their spatial distribution were again reviewed. No substantial changes in the distribution and abundance of habitat classes were observed, resulting in the total number of classes remaining at 12. With the exception of the Floating Island (FI) habitat class, the distribution and abundance of habitat classes has remained unchanged following the initial changes after construction. Minor changes in the location and number of floating islands were observed at the Airport Lagoon. During the July aquatic plant surveys in both Year 5 and 6, it appeared that some of the smaller floating islands had drifted to new locations and it is possible that a few new small islands had formed. However, delineating the exact number and location of these smaller islands was not possible as high resolution aerial photos of the site were not collected in either year. A summary of the habitat classification schemes for Year 6 is provided in Table 3 and detailed descriptions of each class are provided in Appendix 9.

In Year 6, a total of 12 habitat classes were identified at the Airport Lagoon site (Table 3 and Figure 17). Habitat classes were defined by a total of 121 polygons, covering a total area of 65.21 ha (Table 3). The number of polygons for each habitat class ranged from one (classes SG, WD, WH and WW) to 49 (class SP; Table 3). The percentage of total area covered by habitat classes ranged from 0.13% (class FI) to 40.03% (class SP).

The most abundant habitat classes at the Airport Lagoon by number of polygons were SP (49 polygons), and BM (33 polygons). All other classes had eight or fewer polygons. By area, habitat classes SP and BM accounted for the largest area, covering 67.60% of the total area at the Airport Lagoon site. The next largest habitat class by area was class SD, accounting for 12.39% of the total area at this site. All other classes at this site had a cover of <8% (Table 3).

Vegetation transects at the Airport Lagoon site were generally located on moist, organic rich soils, with slight to gentle slopes and frequent to annual flooding (Table 4). All transects were in a graminoid-dominated structural stage (with the exception of habitat class SW). No mature tree cover was observed on any of the survey transects (dead standing trees were present within habitat class WD). The surface substrate at the site was dominated by organic matter or decayed wood, with a subset having a large percentage of exposed mineral soil (Table 4).

During Year 6 ground sampling for terrestrial vegetation, a total of 35 herb species were recorded across seven transects. Average percent herb cover by transect ranged from 5.7% to

47.9% (Table 5). Six species of moss were recorded during ground sampling on four of the ten transects. On transects where moss species did occur, the percent cover ranged from 7.4% to 94.4% (Table 5). One shrub species (willow) occurred on two of the ten transects, and only in the C layer (0-15cm height). On transects where willow did occur, the percent cover ranged from 1.5% to 2.6% (Table 5). A summary of the terrestrial plant species and percent cover for each transect is provided in Appendix 10.

A majority of the terrestrial plant species were observed at Airport Lagoon during Year 6 ground sampling were common to habitat classes located in the upper elevations of the drawdown zone as the lowest elevations are now permanently flooded at the Airport Lagoon site. Most of the species observed during the Year 6 ground sampling were also observed during previous years of the study.

Examples of the most common of these species (observed on 3 or more survey transects) include bluejoint (*Calamagrostis canadensis*), common horsetail (*Equisetum arvense)*, lady's thumb (*Persicaria maculosa*), water smartweed (*Persicaria amphibia*), sedges (*Carex* spp.), common mare's-tail (*Hippuris vulgaris*) and common hook-moss (*Drepanocladus aduncus*). The common species are all assumed to be tolerant to some degree of flooding. In an experiment testing the tolerance of a few species of herbaceous perennials to a variety of flooding regimes, bluejoint was identified as a species with a relatively high tolerance to flooding (Kercher and Zedler 2004). Other species identified as having a high tolerance were sedges, reed canarygrass (*Phalaris arundinacea*), and common cattail (Kercher and Zedler 2004). These species were also observed at the Airport Lagoon site.

Table 3. Habitat classification summary, number of polygons and area for habitat classes identified during photo interpretation for the Airport Lagoon site in Year 6. Refer to Appendix 9 for detailed descriptions of the habitat classes.

Habitat Class	Habitat Class Description	Number of Polygons	Mean Polygon Area (ha)	Total Area (ha)	Percent of Total Area
BM	Basin Moss	33	0.54	17.98	27.57
BS	Basin Smartweed	5	0.96	4.82	7.40
FI	Floating Island	7	0.01	0.08	0.13
SD	Shoreline Driftwood	8	1.01	8.08	12.39
SG	Shoreline Grassland	1	0.43	0.43	0.65
SP	Streams and Ponds	49	0.53	26.10	40.03
SS	Shoreline Sand	3	0.39	1.18	1.82
SW	Shoreline Willow	5	0.73	3.63	5.56
WD	Wetland Dead Trees	1	0.17	0.17	0.26
WH	Wetland Horsetail	1	0.75	0.75	1.15
WS	Wetland Sedge	7	0.15	1.06	1.63
WW	Wetland Willow	1	0.92	0.92	1.41
Totals		**121**		**65.21**	**100**

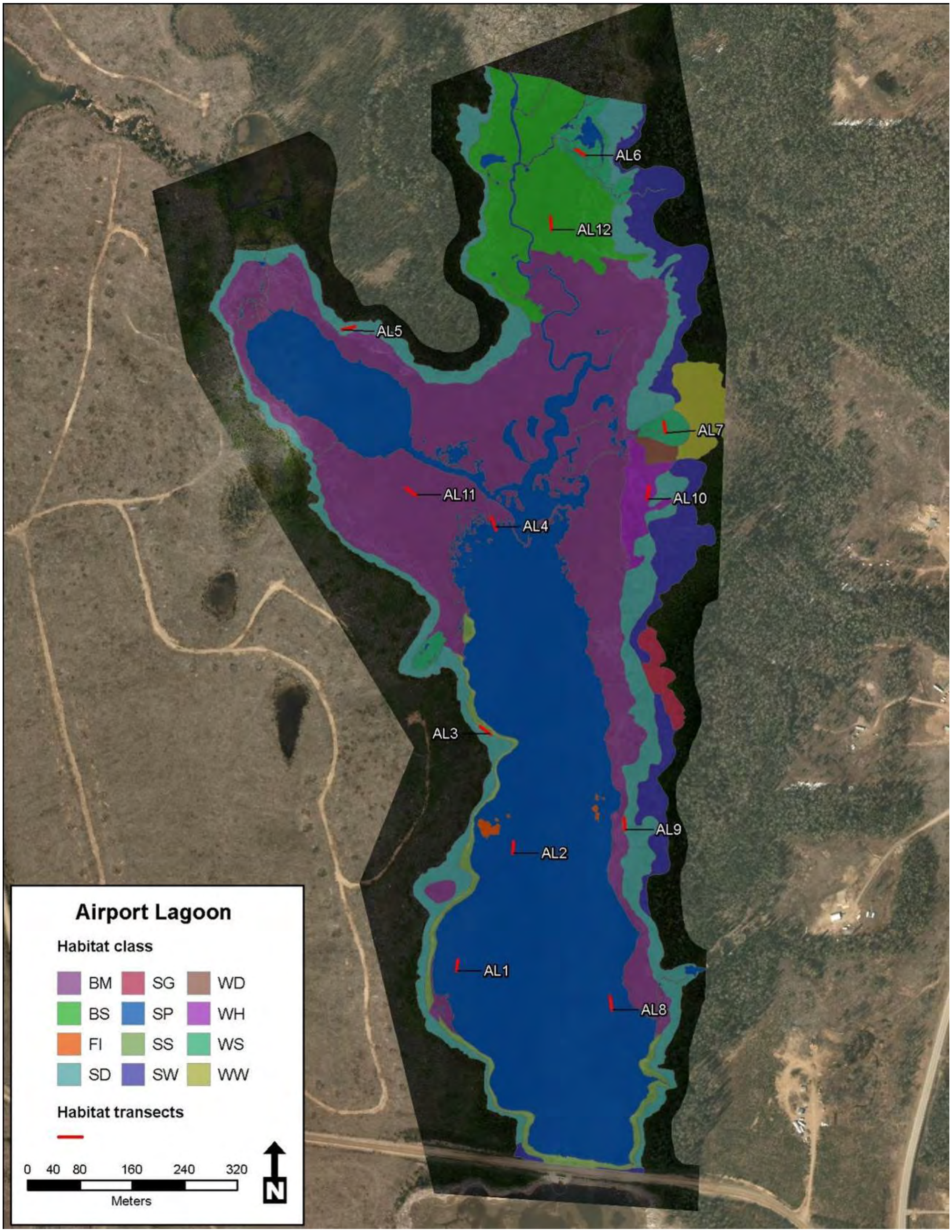

Figure 17. **Post-construction habitat classes and transect locations in the Airport Lagoon site.**

Table 4. **Site characteristics for vegetation transects sampled in Year 6 at the Airport Lagoon site.**

Transect	Water Source[1]	Soil Moisture Regime[2]	Soil Nutrient Regime[3]	Successional Status[4]	Structural Stage[5]	Elevation (m)	Slope (%)	Aspect (°)	% Organic Matter[6]	% Rocks[6]	% Decayed Wood[6]	% Mineral Soil[6]	% Bedrock[6]	% Surface Water[6,7]	Drainage[8]	Flood Regime[9]
AL1*	n/a													100	n/a	
AL2*	n/a													100	n/a	
AL3	P	2	A	DC	2b	677	15	30	50	0	5	45	0	0	r	A
AL4*	n/a														n/a	
AL5	P	3	B	DC	2b	679	15	169	51	0	44	5	0	0	r	A-F
AL6	F	7	E	DC	2b	673	1	999	95	0	5	0	0	0	p	F
AL7	F	7	E	DC	2b	676	3	260	97	0	3	0	0	0	v	F
AL8*	n/a													100	n/a	
AL9	P	6	E	DC	2b	675	6	272	58	0	38	4	0	0	i	A
AL10	F	7	E	DC	2b	675	2	284	64	0	35	0	0	1	v	A-F
AL 11	G	6	E	DC	2a	676	0	999	0	0	0	0	0	100	v	A
AL 12	G	6	E	DC	2a	666	0	999	100	0	0	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=Subhygric, 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

* Transects that have been permanently flooded as a result of the wetland enhancement completed at Airport Lagoon in Year 3 (2013).

Table 5. Vegetation cover summary for transects sampled in Year 6 at the Airport Lagoon site.

Transect	No. herb species	Average % Herb cover	No. moss/ lichen species	Average % Moss/Lichen Cover	No. shrub species	Average % shrub cover
AL3	10	7.8	0	0.0	0	0.0
AL5	11	12.0	0	0.0	0	0.0
AL6	8	47.9	1	7.4	0	0.0
AL7	7	30.5	2	94.4	1	2.6
AL9	8	5.7	3	2.1	0	0.0
AL10	12	28.5	4	30.4	1	1.5
AL12	4	28.0	0	0.0	0	0.0
		22.9		**19.2**		**0.6**

Values represent the number of species and the average % cover based on plot surveys completed in 2016.

Beaver Pond

A total of eight habitat classes describing vegetation communities at the Beaver Pond sites were identified and mapped in Year 1 of the study (CBA 2012). The plant species assemblages identified within habitat classes consisted mostly of herbaceous perennials (grasses and herbs) with mostly absent shrub cover (with the exception of the habitat class located at the edge of the forest cover) and no tree cover. One class had a high percentage of coarse woody debris (27%; Table 7) from driftwood accumulation. The habitat classifications and their spatial distribution were reassessed in Years 2, 3, and 4 and the classifications and mapping refined as additional information was collected. As result, the original eight classes were reduced to six in Year 4 (CBA 2015). Some habitat class names were also revised to more accurately reflect the observed vegetation cover and location.

Habitat class descriptions and their spatial distribution were again reviewed in Year 5 and 6. No substantial changes in the distribution and abundance of habitat classes were observed, resulting in the total number of classes remaining at six. The distribution and abundance of habitat classes has remained unchanged following the initial changes after construction. A summary of the habitat classification schemes for Year 6 at the Beaver Pond site is provided in Table 6 and detailed descriptions of each class are provided in Appendix 9.

In Year 6, a total of six habitat classes were identified at the Beaver Pond site (Table 6 and Figure 18). Habitat classes were defined by a total of 19 polygons, covering a total area of 4.13 ha (Table 6). The number of polygons for each habitat class ranged from one (class SR) to 6 (class SE; Table 6). The percentage of total area covered by habitat classes ranged from 0.92% (class FI) to 38.79% (class SP).

The most abundant habitat class by number of polygons was SE (6 polygons). However, by area, habitat class SE accounted for only 0.92% of the total area of the site. The largest habitat classes were SC, BC and SW, which accounted for 38.79%, 31.86% and 22.98%.of the total area respectively. The remaining three habitat classes each represented less than 4% of the total area (Table 6).

Vegetation transects at the Beaver Pond site were located on clay rich soils with gentle to moderate slopes and frequent to annual flooding (Table 7). All transects were in a graminoid-dominated structural stage (with the exception of habitat class SW). No mature tree cover was observed on any of the survey transects. The surface substrate at the site was dominated by exposed mineral soil with minimal woody debris and little to no organic matter (Table 7).

During Year 6 ground sampling for terrestrial vegetation, a total of 23 herb species were recorded across three transects. Average percent herb cover by transect ranged from 5.5% to 9.3% (Table 9). No species of moss or shrub were observed on any of the transects. A summary of the terrestrial plant species and percent cover for each transect is provided in Appendix 10.

Most of the species observed during the Year 6 ground sampling were also observed during previous years of the study. Examples of the most common of these species (observed on 2 or more survey transects) include common horsetail, lady's thumb, Torrey's cryptantha (*Cryptantha torreyana*), sedges (*Carex* spp.) and red sand-spurry (*Spergularia rubra*). The common species are all assumed to be tolerant to some degree of flooding.

Table 6. Habitat classification summary, number of polygons and area for habitat classes identified during photo interpretation for the Beaver Pond site in Year 6. Refer to Appendix 9 for detailed descriptions of the habitat classes.

Habitat Class	Habitat Class Description	Number of Polygons	Mean Polygon Area (ha)	Total Area (ha)	Percent of Total Area
BC	Basin Cryptantha	2	0.66	1.32	31.86
SC	Shoreline Clay	4	0.40	1.60	38.79
SE	Stream Sedge	6	0.01	0.04	0.92
SP	Shoreline Gravel	2	0.03	0.07	1.60
SR	Streams and Ponds	1	0.15	0.15	3.74
SW	Shoreline Driftwood	4	0.24	0.95	22.98
Totals		**19**		**4.13**	**100**

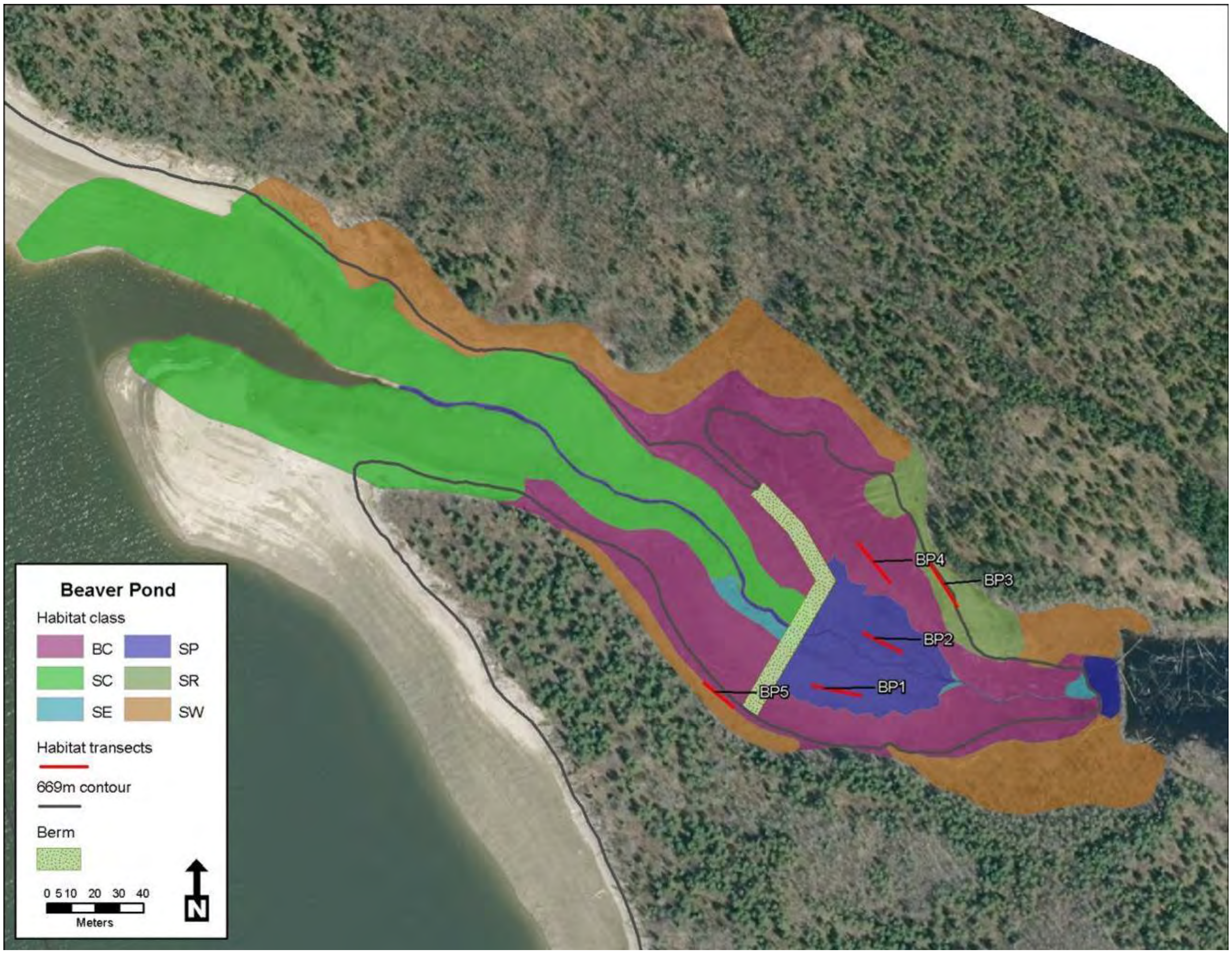

Figure 18. **Post-construction habitat classes and transect locations in the Beaver Pond site.**

Table 7. **Site characteristics for vegetation transects sampled in Year 6 at the Beaver Pond site.**

Transect	Water Source[1]	Soil Moisture Regime[2]	Soil Nutrient Regime[3]	Successional Status[4]	Structural Stage[5]	Elevation (m)	Slope (%)	Aspect (°)	% Organic Matter[6]	% Rocks[6]	% Decayed Wood[6]	% Mineral Soil[6]	% Bedrock[6]	% Water[6, 7]	Drainage[8]	Flood Regime[9]
BP1*	n/a													100	n/a	
BP2*	n/a													100	n/a	
BP3	P	3	B	DC	2b	675	25	230	0	25	1	74	0	0	r	A-F
BP4	G	7	D	DC	2a	673	5	227	0	0	0	100	0	0	m	A
BP5	P	4	D	DC	2b	685	20	44	20	0	27	53	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=Subhygric, 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

* Transects that have been permanently flooded as a result of the wetland enhancement completed at Airport Lagoon in Year 3 (2013).

Table 8. **Vegetation cover summary for transects sampled in Year 6 at the Beaver Pond site.**

Transect	No. herb species	Average % Herb cover	No. moss/ lichen species	Average % Moss/Lichen Cover	No. shrub species	Average % shrub cover
BP3	11	8.5	0	0.0	0	0.0
BP4	10	9.3	0	0.0	0	0.0
BP5	10	5.5	0	0.0	0	0.0
		7.8		**0.0**		**0.0**

Values represent the number of species and the average % cover based on plot surveys completed in 2016.

5.2.2 Coarse Woody Debris (CWD)

Mapping of CWD in Year 4 identified a total of four CWD density classes based on percent cover of CWD at the Airport Lagoon (Table 9). The density classes include minimal (0-5%), low (6-10%), moderate (11-30%) and high (31-50%). The number of polygons for each density class ranged from five (minimal) to 35 (moderate). The percentage of total area covered by the density classes ranged from 15.87% (high CWD) to 66.44% (minimal CWD).

The low, moderate and high density classes were located along the perimeter of the site in the upper portion of the drawdown zone, with the exception of some moderate density class areas identified above the upper drawdown on the east side of the site (Figure 19). The minimal density class occurred within remaining lower portion of the drawdown zone.

Table 9. **Density, number of polygons, and areas of CWD identified through photo interpretation for the Airport Lagoon in Year 4.**

Site	CWD Density	Number of Polygons	Area (ha)				Percent of Total Area
			Minimum	Maximum	Mean	Total	
Airport Lagoon	Minimal	5	0.02	41.20	8.66	43.32	66.44
	Low	25	0.01	0.84	0.12	4.40	6.75
	Moderate	35	0.01	2.22	0.20	7.13	10.94
	High	23	<0.01	2.76	0.45	10.35	15.87
	Totals	**88**				**65.21**	**100**

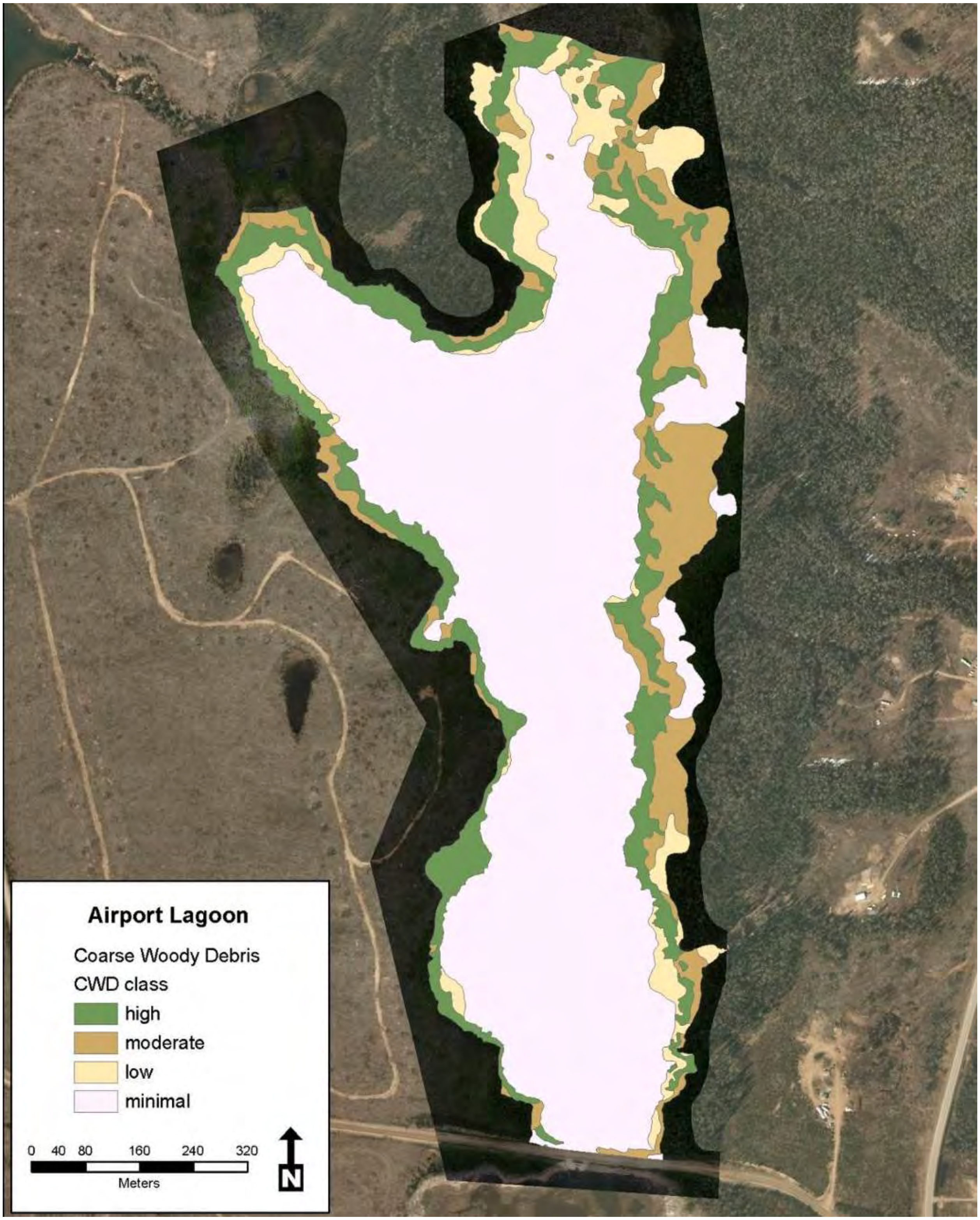

Figure 19. CWD density classes at the Airport Lagoon site in Year 4.

5.2.3 Aquatic Vegetation

Airport Lagoon

In Year 6, a re-assessment of the aquatic plant communities at the Airport Lagoon site was completed. As a result of the re-assessment, two aquatic plant communities were merged, reducing the total number of classes from five to four. In addition, the name of a single plant community was revised. Changes to Year 5 aquatic plant communities were based on information collected during of Year 6 surface sampling and include:

- Merging of Closed-leaved Pondweed and Fennel-leaved Pondweed plant communities. Based on field observations and confirmation of species identification completed in Year 5 and 6 (taxonomic expert at the Royal BC Museum), it was determined that fennel-leaved pondweed was misidentified in Year 4. The correct species identification was closed-leaved pondweed. As a result, the two plant communities have been merged.

- Lady's Thumb plant community name has been revised to Lady's Thumb/Water Smartweed plant community. The two semi-aquatic plant species are most commonly found in shallow waters (1-2m) at Airport Lagoon. However, water smartweed can tolerate deeper water than Lady's thumb. In Year 4, reservoir levels were much lower during the growing season in comparison to Year 5 and 6, resulting in large areas of very shallow water (<1m). Under these conditions, lady's thumb dominated the shoreline. In Year 5 and 6, lady's thumb could not tolerate the deeper water conditions along the shoreline and so water smartweed was the dominant species.

The four aquatic plant communities were identified and mapped along the water surface and shoreline at the Airport Lagoon are summarized in Table 10 and Figure 20. The plant communities were identified by the dominant species for the community and include Closed-leaved Pondweed, Common Hornwort, Water Smartweed/Lady's Thumb, and Water Smartweed. A fifth non-aquatic plant community was also identified (Non-aquatic); no extensive cover of aquatic plant species was observed within this community.

Aquatic plant communities were distributed throughout the inundated portion of the site (Figure 20). The most common and widely distributed community was the Closed-leaved Pondweed community, which was observed in the central area of the site at water depths of 1-3 m. The Common Hornwort plant community occurred in deeper water (>2 m depth) on the west side of the site. The Smartweed/Lady's Thumb community occurred within shallow water (<1 m depth) and along the shoreline of the lagoon. The Water Smartweed community occurred in the area at the north end of the lagoon. Areas that were mapped as a Non-aquatic plant community were located in areas of the site that lacked permanent water cover prior to the construction of the wetland enhancement in Year 3.

The number of polygons for each aquatic plant community ranged from one (Closed-leaved Pondweed, Fennel-leaved Pondweed, Water Smartweed, and Common Hornwort) to three (Water Smartweed/Lady's Thumb; Table 10). The percentage of total area covered by the aquatic plant communities ranged from 3.35% (Water Smartweed) to 43.63% (Close-leaved Pondweed); the second largest portion of the water surface and shoreline at Airport Lagoon was determined to be a non-aquatic plant community (Non-aquatic; 27.02%; Table 10).

During Year 6 surface sampling for aquatic plants, a total of 11 aquatic plant species were identified at Airport Lagoon (Table 11). Species observed included long-stalked pondweed (*Potamogeton praelongus*), closed-leaved pondweed (*Potamogeton foliosus*), verticillate watermilfoil (*Myriophyllum verticillatum*), spring water-starwort (*Callitriche palustris*), common mare's-tail (*Hippuris vulgaris*), common bladderwort (*Utricularia macrorhiza*), common hornwort (*Ceratophyllum demersum*), stonewort (*Chara spp.*), water smartweed (*Persicaria amphibia*), lady's thumb (*Persicaria maculosa*) and variegated yellow pond-lily (*Nuphar variegata*). Closed-leaved pondweed and spring water-starwort was commonly observed in the central area of the lagoon at water depths of 1-2m. Common hornwort, verticillate watermilfoil and long-stalked pondweed was observed in deeper water (>2 m depth) in the northwest arm of the lagoon. Large mats of decayed verticillate watermilfoil along the shoreline and a dense cover of common hornwort reaching the water surface was observed in the area. Water smartweed and lady's thumb was observed along the shorelines (1-2 m depth) at the north end of Airport Lagoon; water smartweed provided substantial vegetation cover throughout the northeast arm. All other species were uncommonly observed across the site. A summary of the aquatic plant species detected at each of the sampled dredge points is provided in Appendix 11.

Table 10. Number of polygons and areas of aquatic plant community polygons identified during photo interpretation for the Airport Lagoon in Year 6.

Aquatic Plant Community	Number of Polygons	Area (ha)				Percent of Total Area
		Minimum	Maximum	Mean	Total	
Closed-leaved Pondweed	1	12.24	12.24	12.24	12.24	43.63
Common Hornwort	1	2.86	2.86	2.86	2.86	10.20
Water Smartweed/Lady's Thumb	3	0.06	4.31	1.48	4.43	15.81
Water Smartweed	1	0.94	0.94	0.94	0.94	3.35
Non-aquatic	10	<0.01	5.18	0.76	7.58	27.02
Totals	**16**				**28.05**	**100**

Table 11. Aquatic plant species identified during surface sampling in Year 6 at the Airport Lagoon study site.

Common Name	Latin Name
long-stalked pondweed	*Potamogeton praelongus*
closed-leaved pondweed	*Potamogeton foliosus*
verticillate water-milfoil	*Myriophyllum verticillatum*
spring water-starwort	*Callitriche palustris*
common mare's-tail	*Hippuris vulgaris*
common bladderwort	*Utricularia macrorhiza*
common hornwort	*Ceratophyllum demersum*
stonewort	*Chara* spp.
water smartweed	*Persicaria amphibia*
lady's thumb	*Persicaria maculosa*
variegated yellow pond-lily	*Nuphar variegata*

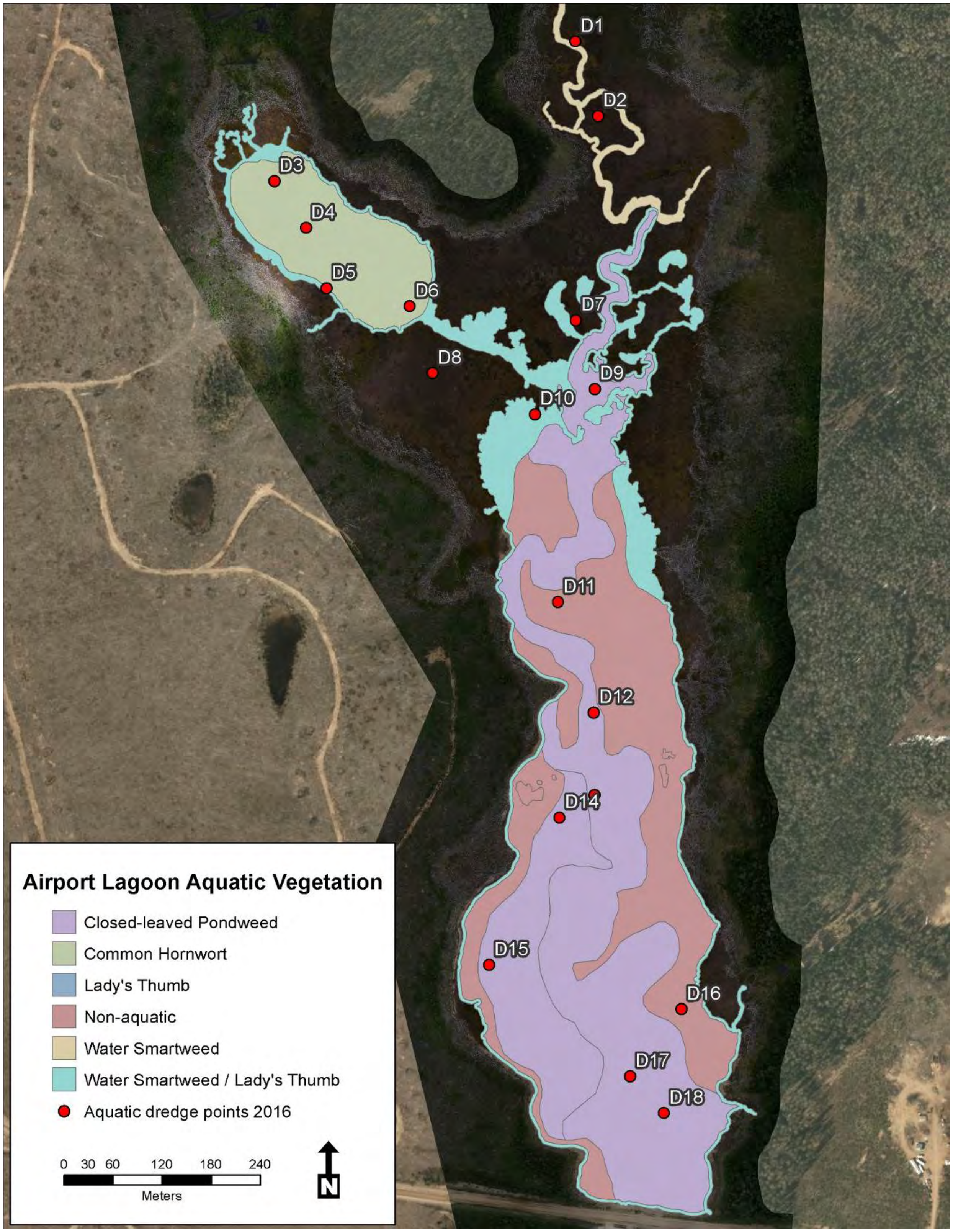

Figure 20. **Post-construction aquatic vegetation distribution at the Airport Lagoon site in Year 6.**

Beaver Pond

Surface sampling for aquatic plants was completed at the Beaver Pond Site during the July fish sampling. The sampling revealed no cover of aquatic plants within the project area.

5.3 Waterfowl and Shorebird Surveys

During the 2016 surveys at the Airport Lagoon site, a total of 303 individuals representing 25 waterfowl and shorebird species were detected (Table 12). This includes the lowest number of annual waterfowl detections (199 individuals) since the inception of this project (Table 12). Shorebird numbers were higher this year than they have been since the last full year of pre-construction data, collected in 2012 (Table 12). Waterfowl species richness (15 species) was the same as last year, while shorebird species richness (10 species) has increased gradually over the years and was the highest observed to date (Table 12). A summary of all waterfowl and shorebird observations by species and survey date for 2011-2016 is included in Appendix 12.

Table 12. Summary of waterfowl and shorebird observations in 2011, 2012, 2013, 2014, 2015 and 2016 at the Airport Lagoon site, Williston Reservoir, BC. Other includes water-dependent species (Gulls. Osprey, Kingfisher).

		2011	2012	2013	2014	2015	2016
No. of Individuals	Waterfowl	225	296	387	320	277	199
	Shorebirds	*	125	30	68	62	104
	Other	*	0	2	20	20	6
	Total	225	421	419	408	359	309
No. of Species	Waterfowl	25	16	12	18	15	15
	Shorebirds	*	7	6	8	8	10
	Other	*	0	2	4	3	1
	Total	25	23	20	30	26	26

* – Shorebirds were not a component of the 2011 surveys

During the 2016 surveys, the highest number of waterfowl and shorebird detections (140) was recorded during the second survey of the year on May 10. Common waterfowl species included Canada Goose, American Wigeon, Mallard, and Northern Shoveler. No new waterfowl species were recorded. For shorebirds, Long-billed Dowitcher were recorded in higher numbers than any other shorebird species at the Airport Lagoon site, though they were only recorded during two of the four surveys. Other common shorebird species included Least Sandpiper, Killdeer, and Lesser Yellowlegs. The majority of waterfowl and shorebirds observed during the surveys are migrants.

When pre- and post-construction surveys were plotted by survey date, the highest recorded waterfowl and shorebird abundance (number of individuals) was during the early season prior to construction of the wetland enhancement (Figure 21). Waterfowl and shorebird abundance also appeared to decline rapidly from the early to later surveys prior to construction of the wetland enhancements (Figure 21). In the post-construction period, the observed waterfowl and shorebird abundance during the early surveys has been lower than the pre-construction period (Figure 21). However, waterfowl and shorebird abundance does not appear to decline as rapidly from the early to late surveys in the post-construction period. Waterfowl and shorebird abundance also appears to have increased in the later surveys compared to the pre-construction values (Figure 21).

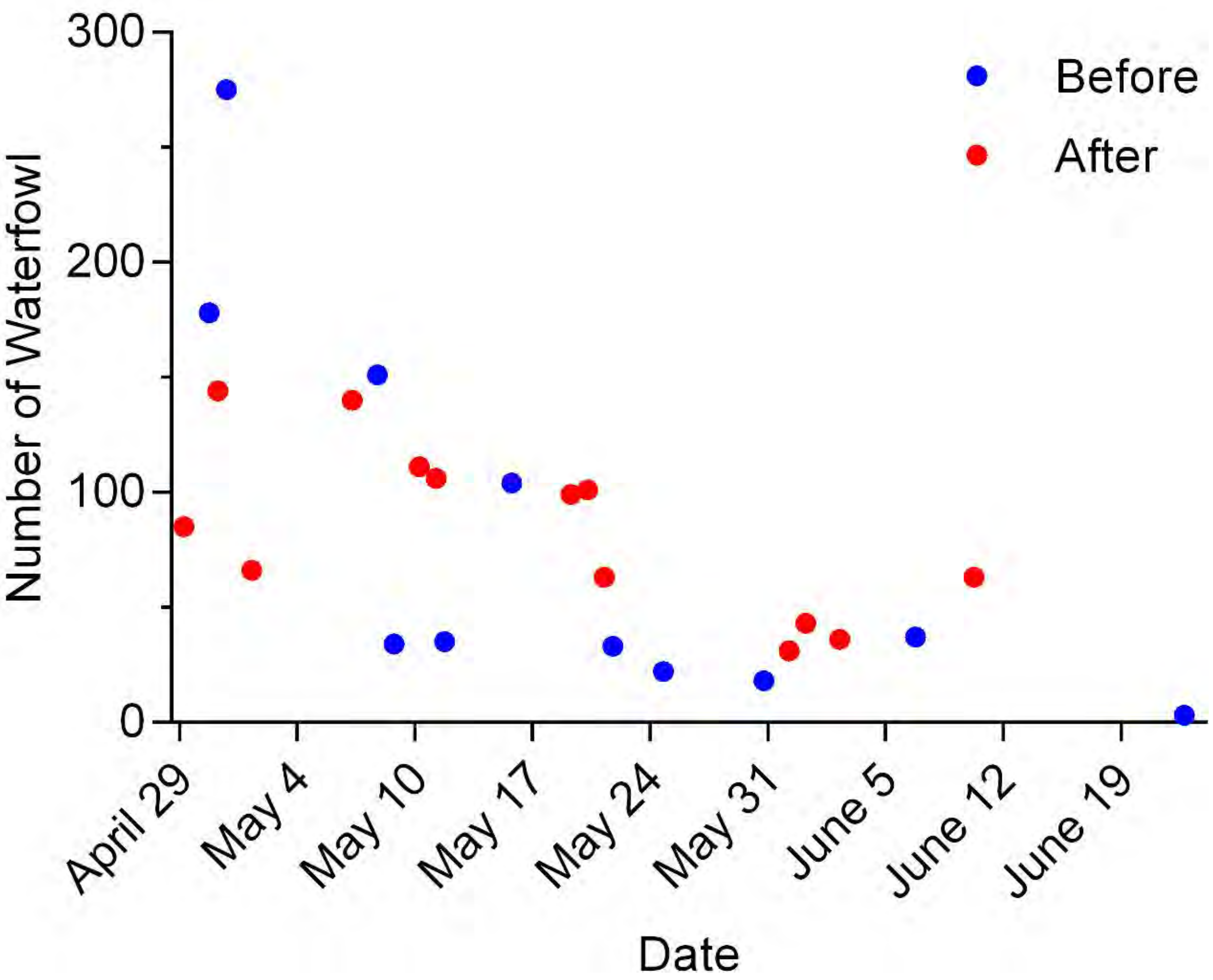

Figure 21. **Seasonal abundance of waterfowl and shorebirds at the Airport Lagoon site before and after completion of the wetland enhancement project.**

When plotted by survey station, Year 6 data was consistent with the previous two years of post-construction surveys. Comparisons between the pre- and post-construction surveys show decreased waterfowl and shorebird abundance at WSP-01 and WSP-02, particularly during the early surveys (Figure 22). Large increases in waterfowl abundance were observed at WSP-03 throughout the season following the completion of the physical works. At WSP-04, post-construction waterfowl abundance was lower than pre-construction levels during the early season surveys but they are consistent or slightly higher post-construction in surveys completed after the first week of May each year (Figure 22).

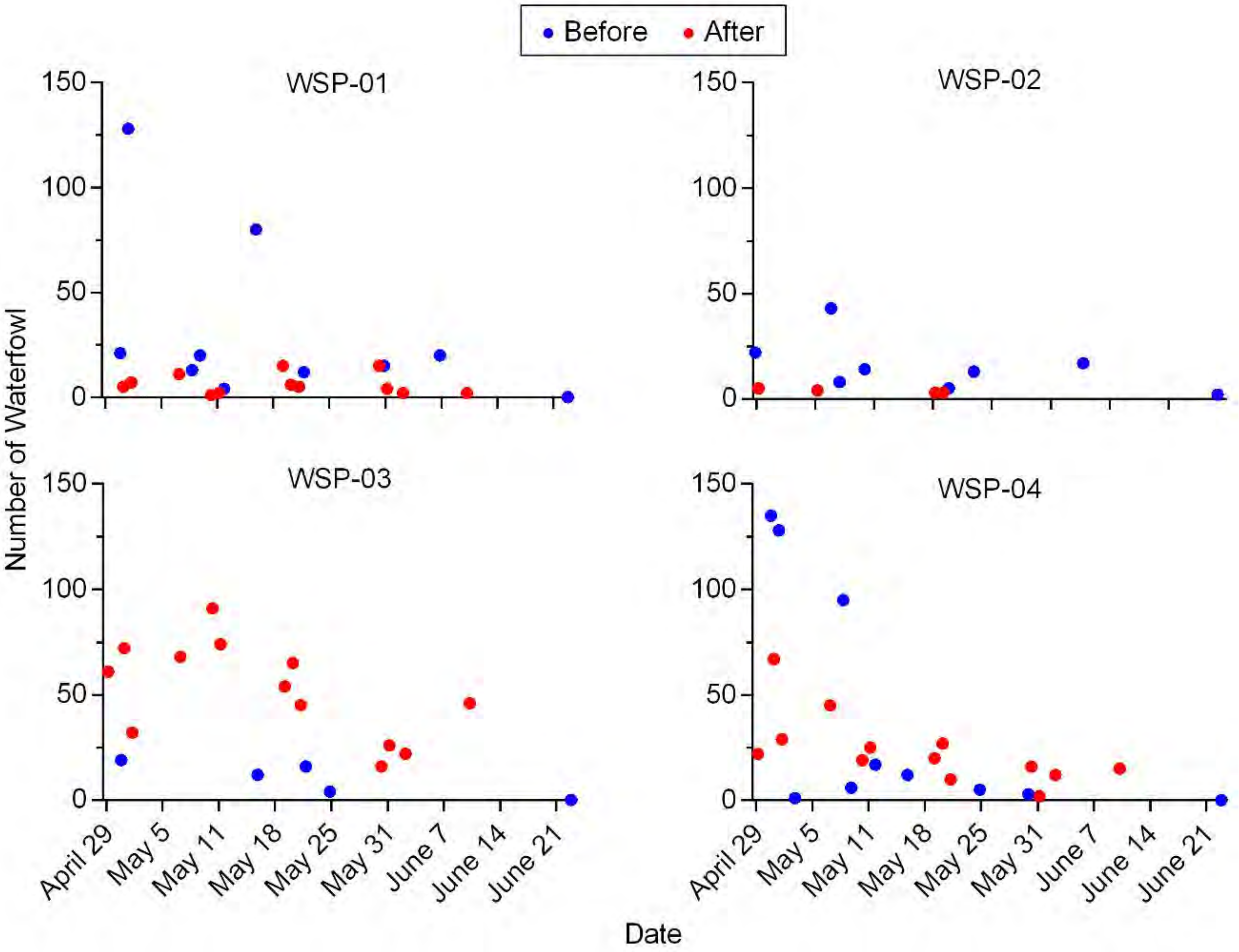

Figure 22. Seasonal abundance of waterfowl and shorebirds by survey station at the Airport Lagoon site before and after completion of the wetland enhancement project.

Consistent with the waterfowl and shorebird abundance by station, the locations of waterfowl detections were primarily located in the north end of the Airport Lagoon site during the 2016 surveys (Figure 23). There were few detection in the southern portion of the site and those primarily occurred during later surveys (Figure 23). This is consistent with the general pattern of waterfowl and shorebird detection locations observed post-construction (Figure 24). Prior to the construction of the new culverts at the Airport Lagoon site, waterfowl detections were distributed throughout the site and generally associated with shallow water habitat (Figure 24). During post-construction surveys, there appears to have been a shift in use patterns towards the north end of the site to a large area of shallow water habitat created by construction of the project. The decline in activity in the southern end of the lagoon following construction is likely associated with the change from shallow to deep water habitat (Figure 24).

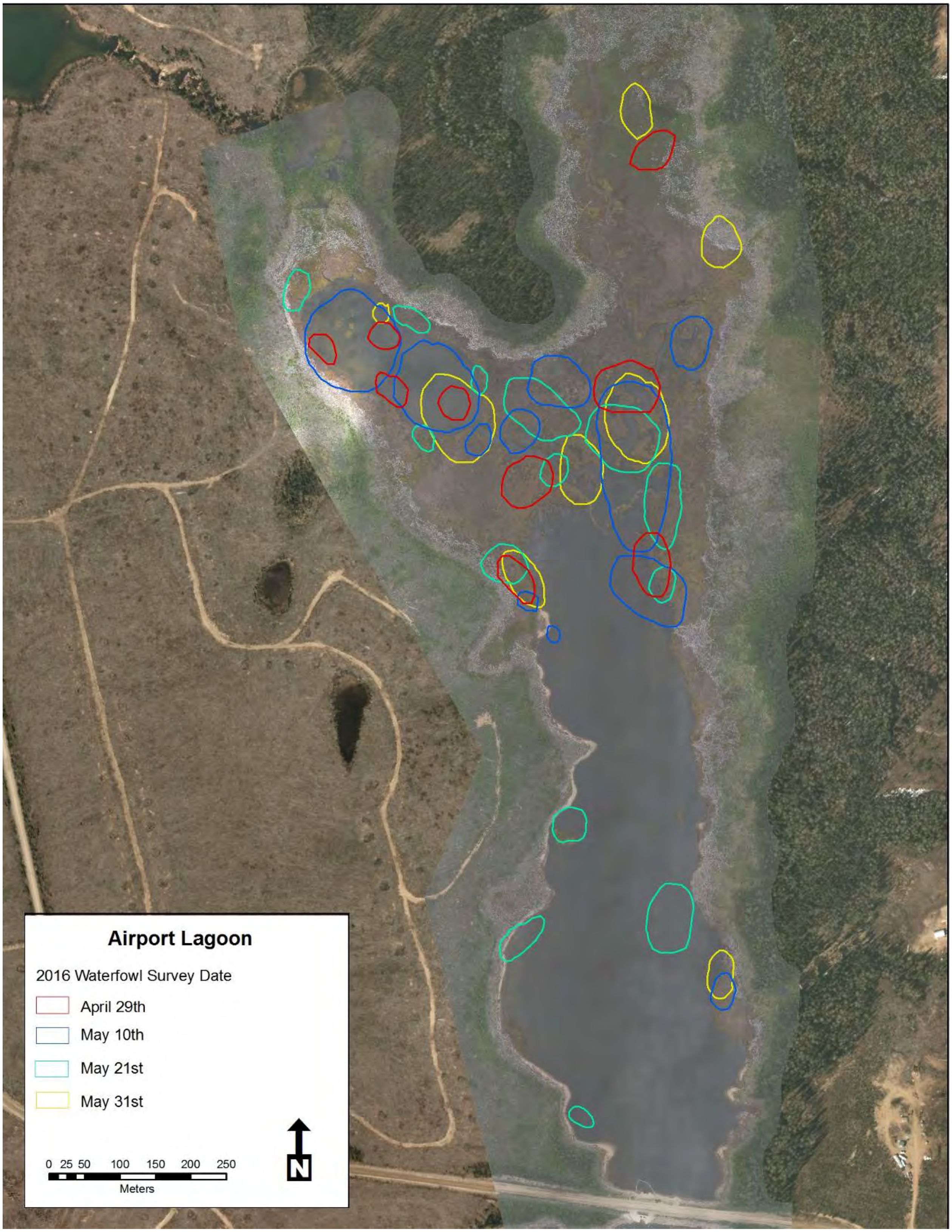

Figure 23. **Distribution of waterfowl detections by survey date at the Airport Lagoon site during 2016 surveys.**

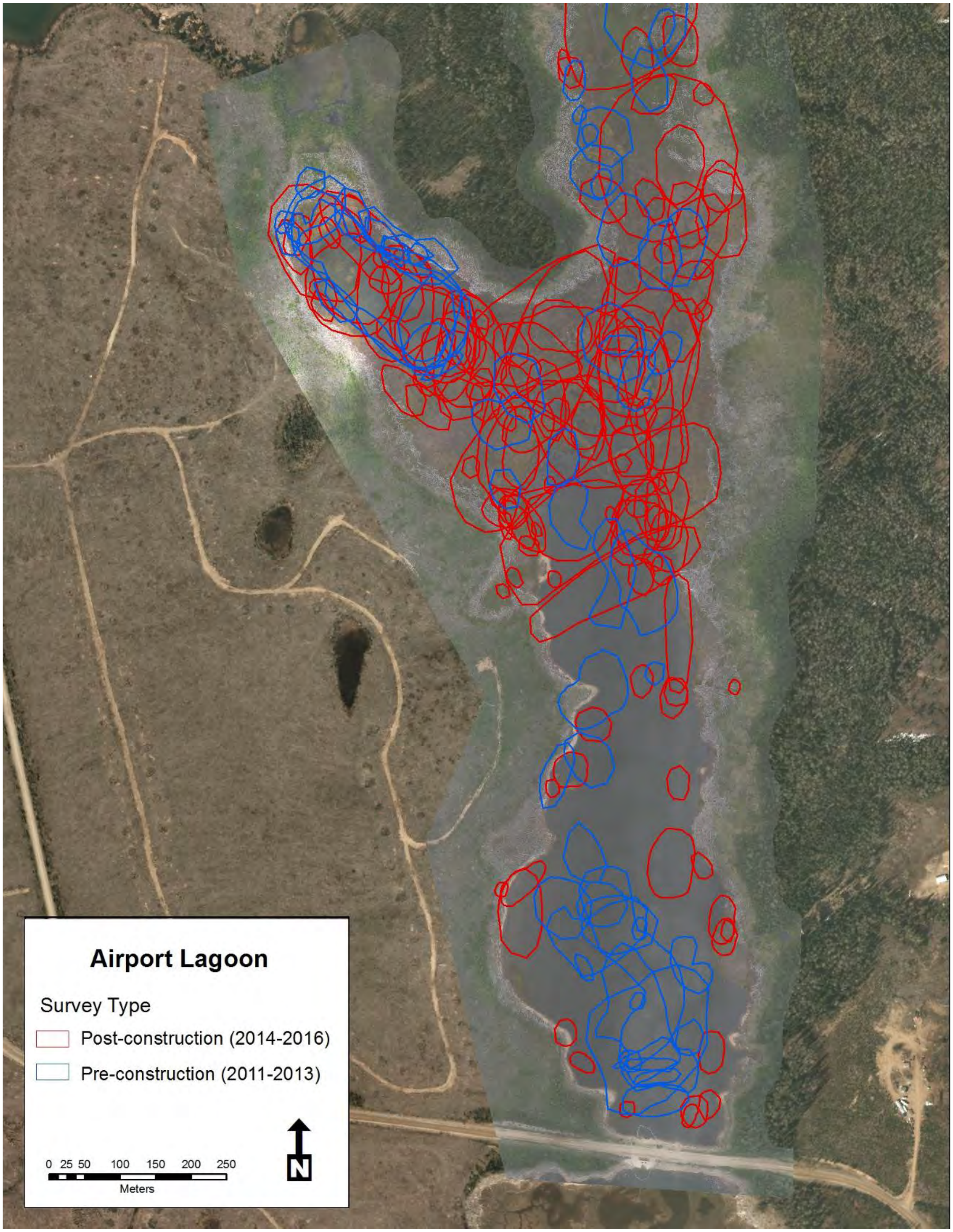

Figure 24. Distribution of waterfowl detections before and after construction of the habitat enhancements at the Airport Lagoon site.

Beaver Pond

Consistent with previous surveys at the Beaver Pond site, waterfowl and shorebird abundance and species richness were very low. No detections were recorded for three years between 2012 and 2014. The total of 5 individuals representing 2 species of waterfowl was slightly higher than the abundance (4) and species richness (1) observed in 2015 (Table 15). With the exception of a single Mallard observed during the June 5, 2016 survey, species composition for waterfowl (Canada Goose) and shorebirds (Spotted Sandpiper) has remained constant throughout the post-construction phase of the project. Fewer Spotted Sandpiper were observed in 2016 than the previous year (Table 15).

Table 13. Summary of waterfowl and shorebird observations in 2011, 2012, 2013, 2014, 2015 and 2016 at the Airport Lagoon site, Williston Reservoir, BC. Other includes water-dependent species (Gull species. Osprey, Belted Kingfisher).

		2011	2012	2013	2014	2015	2016
No. of Individuals	Waterfowl	6	0	0	0	4	5
	Shorebirds	*	2	0	0	6	1
	Total	6	2	0	0	10	6
No. of Species	Waterfowl	2	0	0	0	1	2
	Shorebirds	*	2	0	0	1	1
	Total	2	2	0	0	2	3

* – Shorebirds were not a component of the 2011 surveys

5.4 Songbird Surveys

Airport Lagoon

The 359 detections recorded in 2016 represented 398 individuals from 58 species. These results are slightly higher than the previous year and generally consistent with all other survey years. Species richness (58) in Year 6 was the highest recorded since this project was initiated and average number of species per station (15.4) was very close to the record high observed in 2014. (Table 16). A summary of species detected by station during Year 6 surveys is included in Appendix 12.

Table 14. Summary of the number of species detected and mean species per station for songbird point count surveys over six years at the 17 stations at the Airport Lagoon site.

	Year					
	2011	2012	2013	2014	2015	2016
Number of Detections	416	367	320	415	356	359
Number of Species	57	56	56	54	49	58
Species per Station	13.8	14.5	12.1	15.5	13.4	15.4

Detection location has been included in the data collected since the 2012 surveys. Prior to and during the construction year for the project, the majority of detections occurred in the shrubby areas at the edge of the drawdown zone and the forested areas above the drawdown zone (Figure 25). Following construction of the project in spring 2013, there was an increase in the number of detections recorded in the drawdown zone (Figure 25). Drawdown zone detections have remained elevated in the post-construction phase compared to the pre-construction period. The number of detections in the shrubs appears to have been gradually increasing in the post-construction period while detections from the forest above the drawdown zone have declined to the location with the lowest number of detections in 2016.

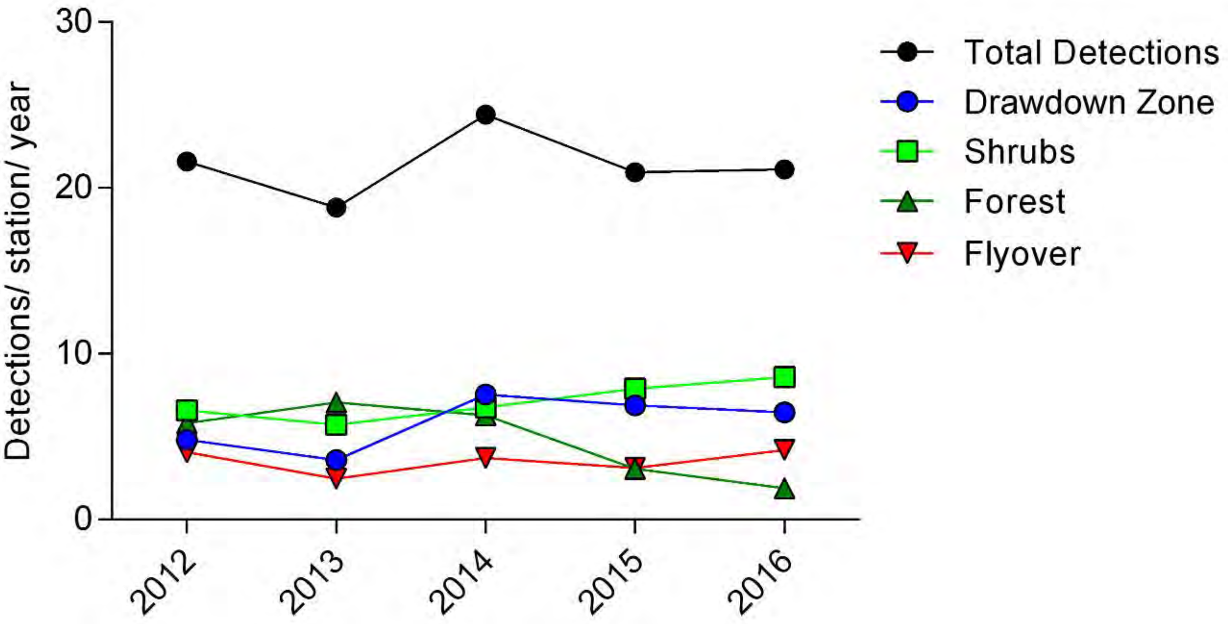

Figure 25. Summary of detection locations for songbird point count surveys in 2012, 2013, 2014, 2015, and 2016 at the Airport Lagoon site. Survey results are standardized as the mean detections per station per year. Detection location was not recorded in 2011.

The number of songbird detections and the species richness recorded in the drawdown zone has been consistently higher during the post-construction surveys (after 2013) when compared to the pre-construction data (Figure 26). While there appears to be a gradual decline in both the number of detections and the number of individuals since the first year of post-construction surveys in 2014, both continue to be elevated above values recorded in the pre-construction period (Figure 26). A similar pattern is observed when only water-dependent species (waterfowl, shorebirds, and gulls) are considered (Figure 26). The number of species recorded in the drawdown zone has also increased following construction of the project.

European Starling, Downy Woodpecker, Rusty Blackbird and Townsend's Warbler were recorded for the first time at Airport Lagoon during the 2016 point count surveys. A total of 44.8% (n=58) of species detected during the Year 6 surveys have been observed during every year of the project to date. Greater Yellowlegs, Common Yellowthroat and Song Sparrow were not detected in 2016 but had been observed in every other year at this site. When only species detected within the drawdown zone are considered, 41.9% (n=31) have been observed every year since the start of the project while nine species that had been observed every year prior to this season were not detected during the 2016 point count surveys.

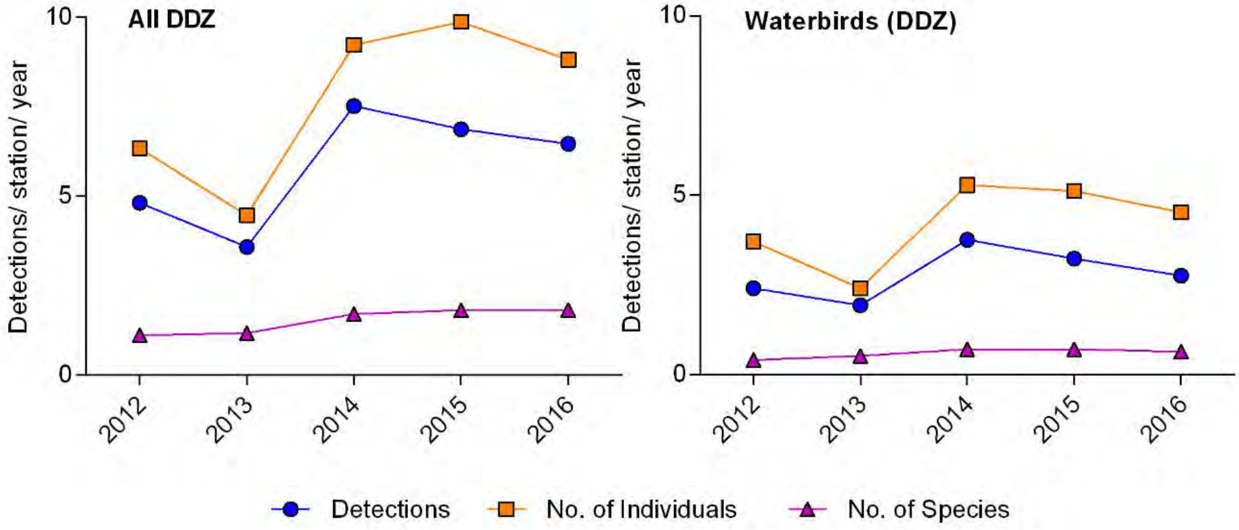

Figure 26. **Summary of drawdown zone detections for both all detections (All DDZ) and waterbirds only (Waterbirds (DDZ)) during point count surveys in 2012, 2013, 2014, 2015, and 2016 at the Airport Lagoon site. Survey results are standardized as the mean per station per year. Detection location was not recorded in 2011.**

Beaver Pond:

Due to inclement weather, only two out of the planned three point count surveys were completed at the Beaver Pond site in 2016. A total of 36 individuals representing 17 species were documented during the two completed surveys. When the average of detections recorded in any two surveys during previous years were taken, the number of detections in 2016 was consistent with surveys completed during the construction and post-construction efforts. During the baseline surveys there was an increasing trend in the number of detections and species richness at the Beaver Pond site. There was a sharp decline in 2014 that was attributed to disturbance due to construction of the berm during the survey period. Post-construction surveys have recorded a slight but continued decline in detections, although species richness in 2015 returned to baseline levels. As expected due to the lower number of surveys, species richness (17) for Year 6 at this site is lower than all other years (Table 19). A summary of species detected by station during Year 6 surveys is included in Appendix 12.

Table 15. **Summary of the number of species detected and mean species per station for songbird point count surveys over six years at the three stations at the Beaver Pond site.**

	Year					
	2011	2012	2013	2014	2015	2016
Number of Detections	63	73	81	56	50	36*
Average detections from 2 surveys	47	49	61	38	38	36
Number of Species	21	24	23	19	22	17
Species per Station	11.3	12	14.7	11.7	11.3	9

* - Only 2 point count surveys were completed in 2016

Detection location has been included in the data collected since the 2012 surveys. The highest percentage of detections has been recorded in the forest just above the drawdown zone every year (Figure 27). The Year 6 results continue this trend although the number of detections continues to decline from the pre-construction period (Figure 27). Despite the continued decline in the total number of detections at this site, there is an increasing number of detections from the drawdown zone in the post-construction period with this location having the second highest number of detections in 2016 (Figure 27). No birds were detected in the shrubs at the forest edge during the 2016 surveys.

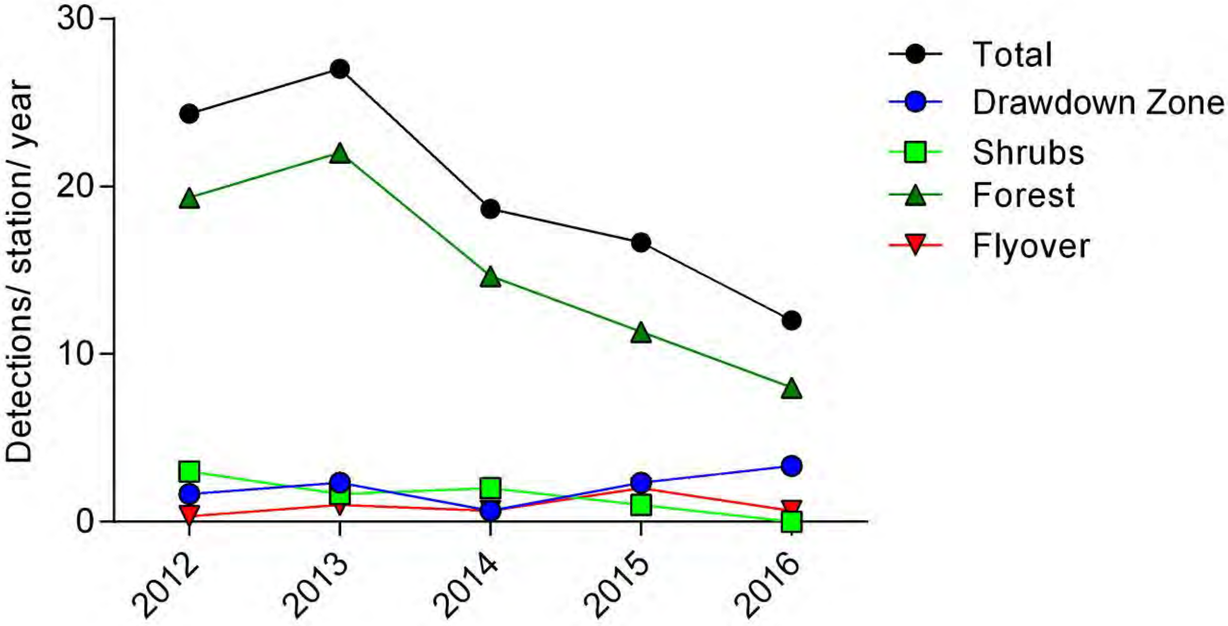

Figure 27. **Summary of detection locations for songbird point count surveys in 2012, 2013, 2014, 2015, and 2016 at the Beaver Pond site. Survey results are standardized as the mean detections per station per year. Detection location was not recorded in 2011.**

Belted Kingfisher and Song Sparrow were identified for the first time during point counts at Beaver Pond in 2016. No species has been detected in all of the survey years, though American Robin and Chipping Sparrow have been recorded during five out of six survey years. Dark-eyed Junco have been recorded every year since construction of the berm and Northern Waterthrush was present up until 2014 but have not been detected during the post-construction surveys to date.

5.5 Amphibian Surveys

Airport Lagoon

The lowest number of amphibians to date at the Airport Lagoon site was recorded during the Year 6 surveys with only four Western Toad observed (Table 21).The only species detected was Western Toad although frog egg masses were observed on Transect 25 during the April 29 survey. The four Western Toads observed this year equals the previous low recorded in 2012. All four individuals were located along Transect 25 and recorded during the first two surveys of the year (75% detected during survey 1 and 24% during survey 2). Transect 25 has been the most productive for western toad detections every year to date (Appendix 13). No detections were recorded at this site during the last two surveys of the season.

When detections are standardized to CPUE (detections/hour), Year 6 (2016) is also the lowest of the six years of the monitoring program (Figure 25). A large spike in Western Toad CPUE occurred in the year (2014) following construction of the project (Figure 25). Western Toad also appeared to remain elevated in 2015, two years post-construction (Figure 25). This was then followed by the lowest CPUE for any amphibian detections during the six years of the project (Figure 25).

Table 16. **Adult and juvenile amphibian detections survey date in 2016 at the Airport Lagoon site.**

Species	April 29	May 10	May 21	May 31	Total
Western Toad	3	1	-	-	4
Columbia Spotted Frog	-	-	-	-	-
Wood Frog	-	-	-	-	-
Long-toed Salamander	-	-	-	-	-
Total	3	1	-	-	4

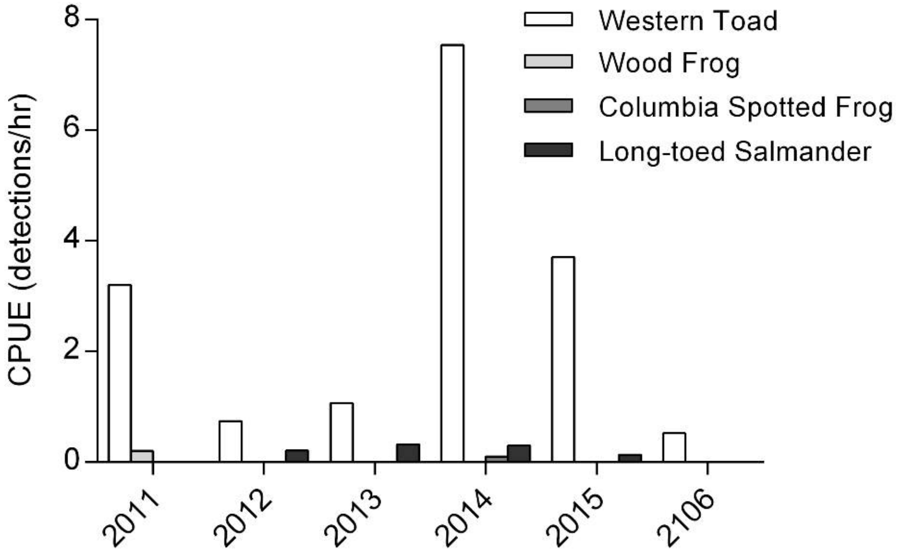

Figure 28. **Total CPUE of adult and juvenile amphibians by year and species at the Airport Lagoon site. The Airport Lagoon project was constructed in late spring 2013.**

Beaver Pond

During the Year 6 surveys at the Beaver Pond site, three species of amphibians were detected (Table 22). Long-toed Salamanders (5.5% of total detections) were only observed during the first survey of the year and were the only species detected during the first survey. The most productive survey was conducted on May 17 and accounted for almost half (47.3%) of the total detections. Western Toad were observed during the last three surveys and accounted for 90.9% of total detections at this site. One Wood Frog was recorded during both the May 17 and June 5 surveys (Table 22). Consistent with previous years (with the exception of Year 1) Western Toad were the most abundant species (90.9% of total detections in 2016) and Wood Frog was the least prevalent species (3.6% of total detections in 2016) recorded at Beaver Pond (Appendix 13).

Similar to what was observed at the Airport Lagoon site following construction, a spike in Western Toad CPUE was observed in the year immediately following construction (2015, Figure 26). This trend continued two years post-construction as well with elevated Western Toad CPUE in 2016. The CPUE for the other two amphibian species detected at this site, Wood Frog and Long-toed Salamander, also appeared to be slightly elevated in the post-construction period (Figure 25).

Table 17. Adult and juvenile amphibian detections survey date in 2016 at the Beaver Pond site.

Species	April 28	May 17	June 1	June 5	Total
Western Toad		25	4	21	50
Wood Frog		1		1	2
Long-toed Salamander	3				3
Total	3	26	4	22	55

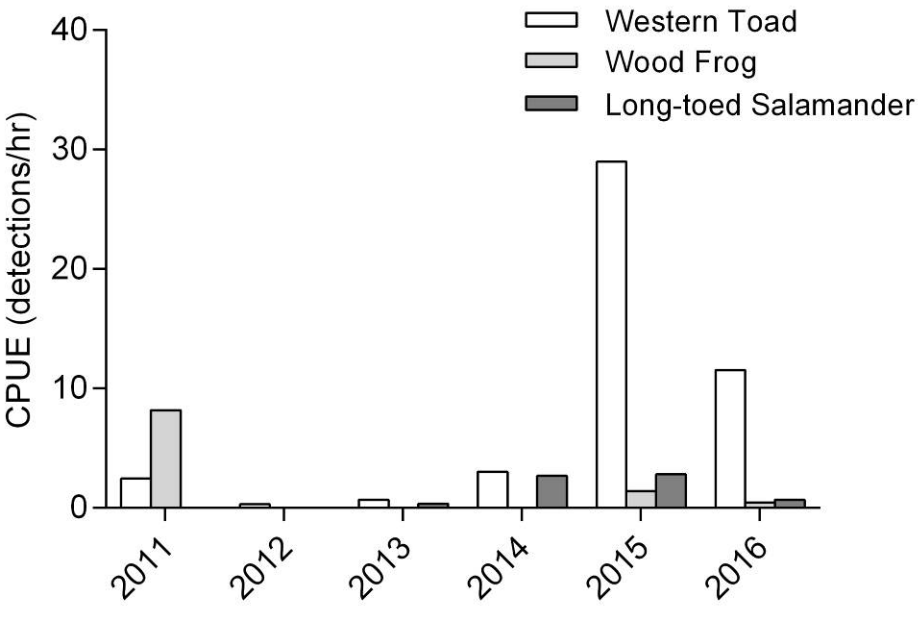

Figure 29. Total CPUE of adult and juvenile amphibians by year and species at the Beaver Pond site. The Beaver Pond project was constructed in late spring 2014.

5.6 Fish Surveys

Airport Lagoon

A total of 1,819 fishes representing 11 species were collected at the Airport Lagoon site over the duration of the sampling program in Year 6 (Table 24). The majority of fish were collected by minnow trap (1,129), followed by fyke net (389), and electrofishing (302) (Table 24). The majority of fish were captured during the May sampling session (1,519) with fewer captures during the July sampling session (295). This was true even when the fish captured by electrofishing were excluded. Electrofishing was completed on the single transect at the Airport Lagoon that was not flooded following project construction. The overall numbers of fish captured were lower than in the previous two years of the project.

Brassy Minnow (*Hybognathus hankinsoni*) and Lake Chub (*Couesius plumbeus*) were the most abundant species captured by electrofishing. Redside Shiner (*Richardsonius balteatus*) and Lake Chub were the most abundant species captured in both the fyke nets and minnow traps. Burbot (*Lota lota*) and juvenile suckers (*Catostomus* sp.) were only collected by electrofishing while Northern Pikeminnow (*Ptychocheilus oregonensis*) and White Suckers (*C. commersonii*) were only collected in the minnow traps and fyke nets. Peamouth (*Mylocheilus caurinus*) and Rainbow Trout (*Oncorhynchus mykiss*) were only collected by fyke net.

Table 18. Summary of fish species captured by method in 2016 at the Airport Lagoon site.

Species	Method and Sampling period					Totals
	Electrofish	Minnow Trap		Fyke Net		
	May	May	July	May	July	
Lake Chub	97	151	17	7	1	269
Brassy Minnow	146	34		2		182
Peamouth				1		1
Northern Pikeminnow		1		27	5	33
Redside Shiner	26	628	239	238	11	1093
Longnose Sucker	3	35	1	13		52
White Sucker		6		43	7	56
Largescale Sucker	1	8	2	26	3	40
Sucker sp.	2					2
Rainbow Trout				3	2	5
Burbot	8					8
Prickly Sculpin	18		7			25
Totals	302	863	266	360	29	1819
Effort[1]	2629	223.58	175.53	40.7	36.57	
CPUE[2]	6.892	3.86	1.51	8.845	0.793	

[1] – Electrofishing effort in seconds (active sampling), minnow traps and fyke nets in hours (passive sampling)

[2] – Electrofishing CPUE = fish/minute; minnow trap and fyke net CPUE = fish/hour

The total number of fish captured at the Airport Lagoon in Year 6 was generally lower than in previous years (Figure 25). The only exception to this was electrofishing with a higher CPUE than recorded in the previous five years of the program (Figure 25). The increase in CPUE was primarily a result of a large increase in the Brassy Minnow catch and a smaller increase in Lake Chub catch (refer to Appendix 14 for CPUE results for each species by method and year). The increase in CPUE occurred despite a notable decrease in the catch of Redside Shiner. For other species captured by electrofishing there were smaller changes in relative abundance although both Burbot and Prickly Sculpin (*Cottus asper*) did show increases.

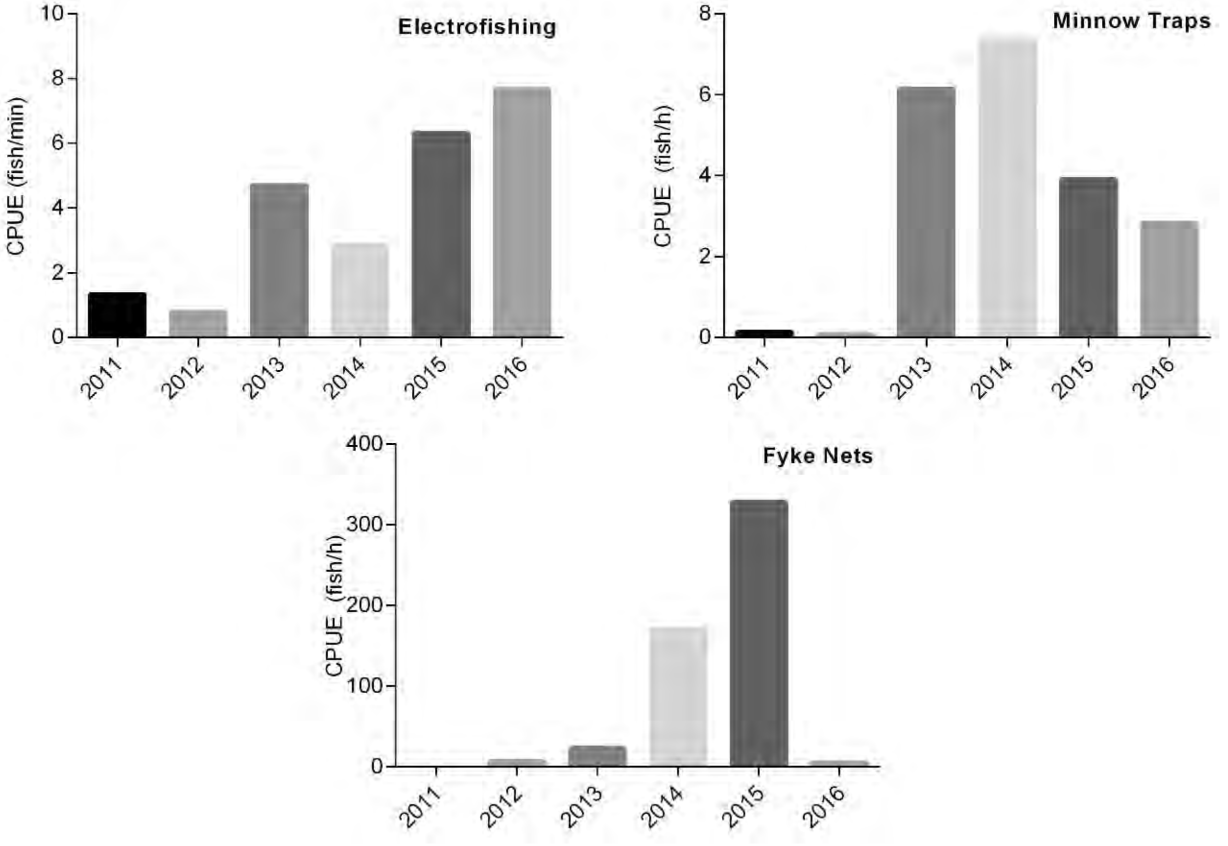

Figure 30. Annual total CPUE for each of the three sampling methods used at the Airport Lagoon site. Construction of the project was completed in spring 2013.

The overall CPUE for both the minnow traps and fyke nest was lower in Year 6 compared to previous years, particularly for the fyke net catches (Figure 25). The minnow trap CPUE by species were also lower for most species in Year 6 than in previous years but the proportional abundances in the catches remained similar (Appendix 14). The most notable changes in CPUE was a decline for Lake Chub and an increase for Redside Shiner compared to previous years. Redside Shiner was the most abundant species in both the May and July minnow trap catches.

The fyke net catches followed the general pattern observed in previous years with the highest catches during the May sampling and lower catches during the July sampling (Table 24). However, the extremely high catch rates observed in both Year 4 (2014) and Year 5 (2015) did not occur in Year 6 (Figure 25). In Year 6, catch rates were lower for almost all species compared to previous years, particularly for Lake Chub, Brassy Minnow, and Redside Shiner, the most abundant species (Appendix 14). Redside Shiner was the most abundant species in

Year 6 in both the May and July and increased in abundance relative to Lake Chub and Brassy Minnow in the fyke net catches.

Although the CPUE at the Airport Lagoon site was generally lower in Year 6 compared to previous years (with the exception of electrofishing) the species composition and relative abundance for all species was similar to previous years. Lake Chub, Brassy Minnow, and Redside Shiner continued to be the most common species regardless of capture method. These three species along with juvenile suckers (<70 mm FL) increased in abundance after construction of the project and have remained at higher abundance than in the preconstruction period (Figure 26). There was little change in the abundance of other species between the pre- and post- construction periods (Figure 26). However, there do appear to be some increases in abundance (CPUE) for the three sucker species, Rainbow Trout, and Prickly Sculpin after construction of the project.

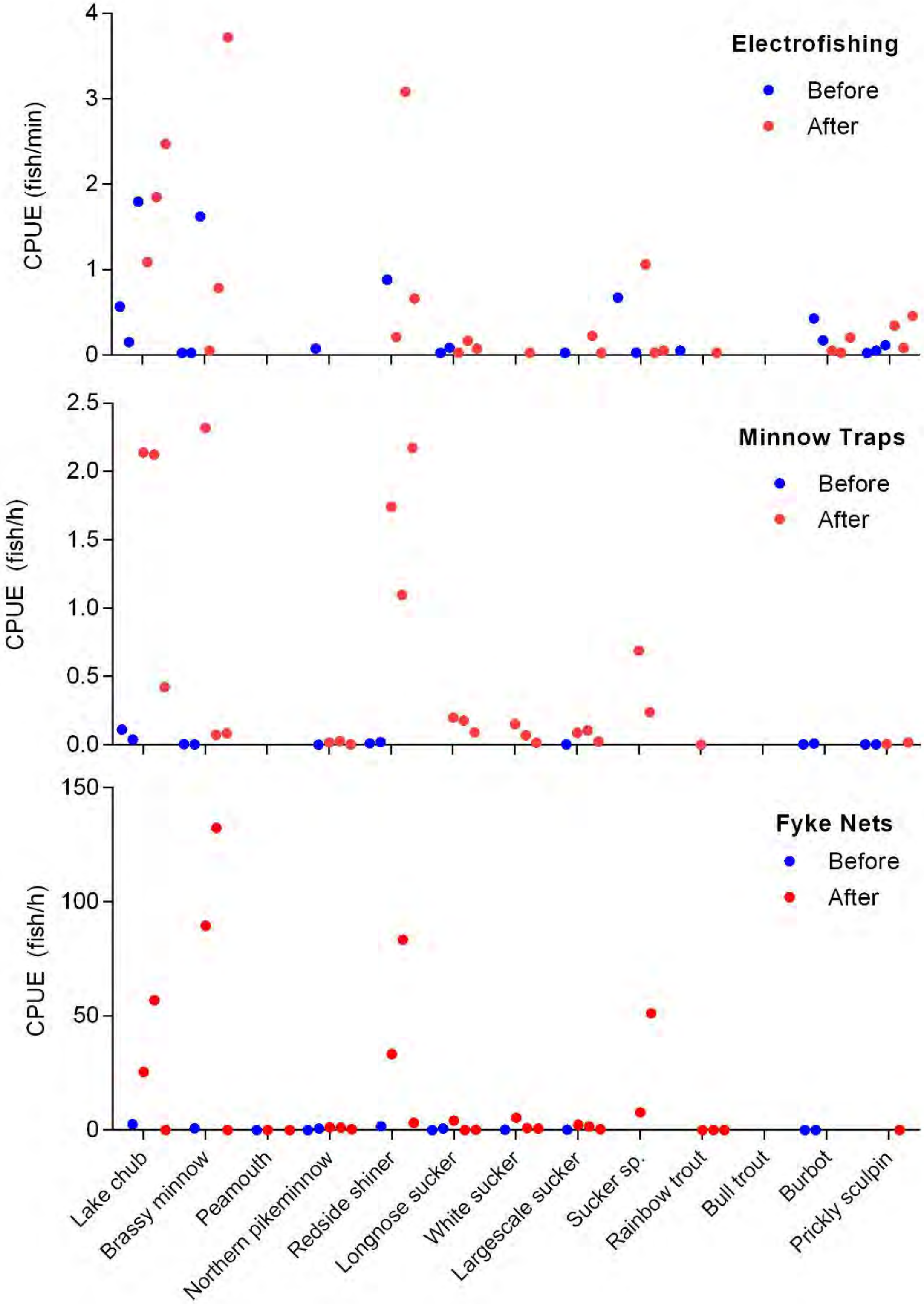

Figure 31. Changes in CPUE by sampling method and species before and after construction of the Airport Lagoon project in 2013. Note the different scale and units for CPUE (y-axis) for each method.

Beaver Pond

Consistent with sampling results from previous years, few fish were captured during sampling at the Beaver Pond site. A total of 48 fish representing six species were collected over the duration of the sampling program in Year 6 (Table 25). The most fish were collected by electrofishing (26 fish), followed by fyke net (13 fish), and minnow trap (9 fish) (Table 25). More than half of fish were captured during the May sampling session (33 fish) with fewer captures during the July sampling session (15 fish). Most fish were captured by electrofishing on the downstream side of the berm. The May 2016 minnow trapping is the first fish sampling completed in the new impoundment when the reservoir elevation is below the elevation of the berm.

The Year 6 electrofishing at the Beaver Pond was completed at a much higher reservoir elevation (>6 m above average) compared to previous spring sampling at this site. As a result, the electrofishing transect downstream of the berm was limited to immediately below the rip rap at the base of the berm and some of the rip rap. As in previous years, a large school of small fish was present at the stream outlet and the fish captured were part of this school. A single Prickly Sculpin was captured in the upstream transect at the point where the stream enters the new impoundment.

The total CPUE for all sampling methods was within the range of values for previous sampling at this site (Figure 27). The total CPUE at this site has been variable over the duration of the monitoring program and there were no apparent changes associated with construction of the project in 2014 (Figure 27). There was also no apparent changes observed when the pre- and post-construction values were plotted for individual species and sampling methods (Figure 28). The results from electrofishing and minnow trapping suggest there may be an increase in Prickly Sculpin and Redside Shiner. However, due to the variability in catches at this site and the low numbers of fish collected, additional data will be required to confirm if these changes are associated with the project.

Table 19. Summary of fish species captured by method in 2016 at the Beaver Pond site.

Species	Method and Sampling period					Totals
	Electrofish	Minnow Trap		Fyke Net		
	May	May	July	May	July	
Lake Chub						
Peamouth					2	2
Northern Pikeminnow					10	10
Redside Shiner			1			1
Longnose Sucker	2	1				3
Largescale Sucker	3					3
Sucker sp.	14					14
Burbot					1	1
Prickly Sculpin	7	6	1			14
Totals	26	7	2		13	48
Effort[1]	456	108.55	133.58		22.83	
CPUE[2]	3.421	0.064	0.015		0.569	

[1] – Electrofishing effort in seconds (active sampling), minnow traps and fyke nets in hours (passive sampling)

[2] – Electrofishing CPUE = fish/minute; minnow trap and fyke net CPUE = fish/hour

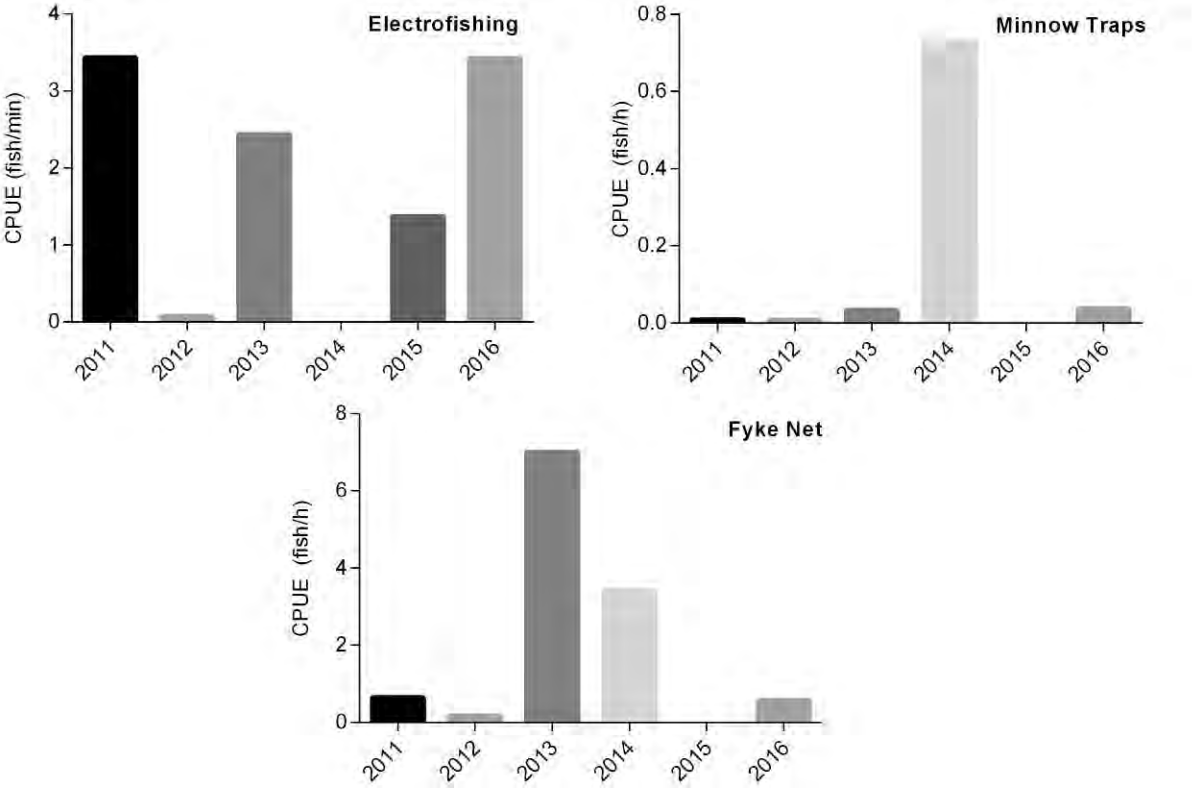

Figure 32. Annual total CPUE for each of the three sampling methods used at the Beaver Pond site. Construction of the project was completed in spring 2014.

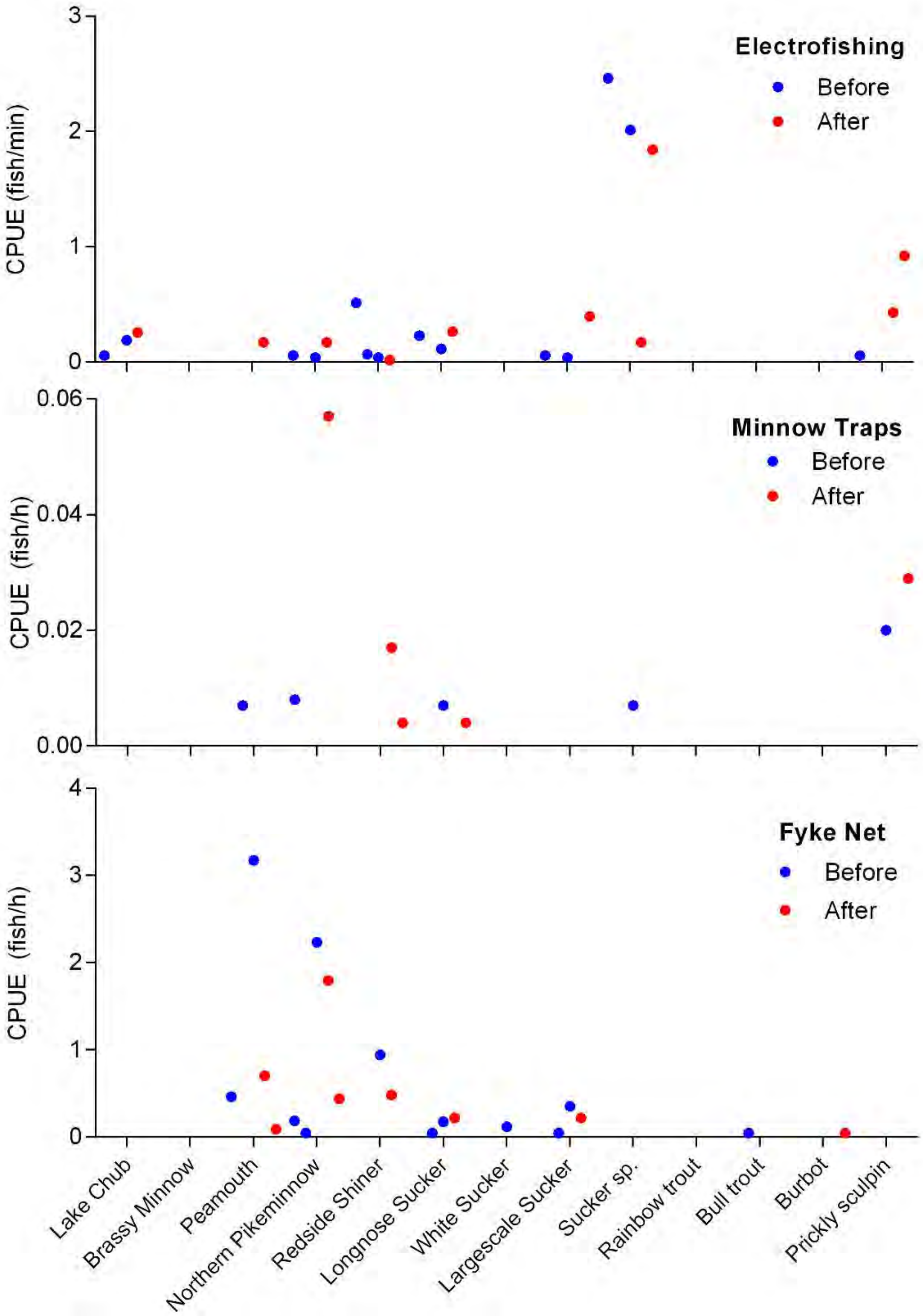

Figure 33. **Changes in CPUE by sampling method and species before and after construction of the Beaver Pond project in 2014. No sampling by minnow trap or fyke net was completed at the site in 2015. Note the different scale and units for CPUE (y-axis) for each method.**

6 DISCUSSION

The data collected in 2016 is for Year 6 of a ten year monitoring program to determine the effectiveness of two trial wetland projects at enhancing wildlife habitat on the foreshore of Williston Reservoir. The results from Year 6 provide additional information on the wildlife habitats and indicator groups at the project sites and initial information on the effectiveness of the projects. The Airport Lagoon project was completed in late May 2013, so the data collected from this site in Year 6 is the third full year of post-construction monitoring. The Beaver Pond project was completed in early June 2014, so the data collected from this site is the second full year of post-construction observations. A summary of the progress towards addressing the management questions and hypotheses is provided in Table 28.

6.1 Environmental Conditions

As noted in previous years (CBA 2012, 2013, 2014, 2015, 2016), environmental conditions including temperature, precipitation, and reservoir elevations are considered to be an important component of variation in the survey results for all indicator groups. In Year 6, temperatures were above average prior to the sampling period and generally average throughout the sampling program. The warmer temperatures prior to the sampling period were also confirmed by degree day calculations (5°C base temperature) with more degree days accumulated on any given date in Year 6 up to May 26 than in any of the previous five years. The warmer temperatures prior to the sampling period would be expected to result in an earlier start to amphibian activity than in previous years and may influence the timing for migratory waterfowl. The warmer temperatures prior to the sampling period may have also resulted in earlier snowmelt and ice-off and contributed to an earlier start for amphibian activity. Earlier ice-off would also contribute to more open water being available for migratory waterfowl resulting in lower numbers observed, particularly during the earliest surveys.

The general conditions observed at both sites in Year 6 were more similar to Years 2 and 3 than Years 4 and 5. There was less vegetation cover present in Years 2, 3, and 6 compared to Years 4 and 5 (refer to Appendix 9 for examples of the differences in vegetation between years). The differences in vegetation cover are considered to be primarily a result of the peak reservoir elevation in the year preceding the surveys (i.e., the peak elevation in 2015 affected the results of the 2016 vegetation surveys). Lower peak reservoir elevations increase the area of drawdown zone habitat that can be colonized by plants. When surveys occur the following spring, the vegetation is then in its second growing season. The Year 4 and 5 surveys both occurred following a year of near average peak reservoir elevations (2-3 m lower than 2011 and 2012) The Years 2, 3, and 6 surveys occurred following years where the reservoir either was close to (2011 and 2015) or at (2012) full pool and both sites were inundated for an extended period during the growing season. The Year 4 and 5 surveys occurred following years of close to average reservoir levels (2-3 m lower than in 2011 and 2012).

Table 20. **The status of the GMSMON-15 management questions and hypotheses following completion of Year 6 of the monitoring program.**

Management Question	Management Hypothesis (Null)	Year 6 (2016) Status
Is there a change in the abundance, diversity and extent of vegetation in the enhancement area?	H_{01}: The density, diversity and spatial extent of riparian and aquatic vegetation does not change following enhancement.	No changes in riparian vegetation have been detected at the **Airport Lagoon** site. The third year of post-construction monitoring shows a continued increase in the extent of aquatic vegetation associated with the new water level. No changes in riparian or aquatic vegetation were detected in two years of post-construction monitoring at the **Beaver Pond** site.
Are the enhanced (or newly created) wetlands used by waterfowl and other wildlife?		The three years of post-construction data from the **Airport Lagoon** project shows continued use by waterfowl and other wildlife. The two years of post-construction data from the **Beaver Pond** project is consistent with the baseline data with limited use by waterfowl and other wildlife.
	H_{02}: The species composition and density of waterfowl and songbirds does not change following enhancement.	The three years of post-construction data from the **Airport Lagoon** show a shift in waterfowl activity to the shallow water habitat created and an increase songbird species composition and density. The two years of post-construction data from the **Beaver Pond** project is consistent with the baseline data. Additional monitoring will be required for testing of this hypothesis.
	H_{03}: Amphibian abundance and diversity in the wetland does not change following wetland enhancement.	The three years of post-construction data from the **Airport Lagoon** showed variable amphibian abundance with increases in the first two years post-construction and low numbers in the third year post-construction. The two years of post-construction data from the **Beaver Pond** site showed increases in amphibian abundance. Additional monitoring will be required for testing of this hypothesis.
Is the area and quality of wildlife habitat created by the wetland enhancement maintained over time?		With three years of post-construction data from the **Airport Lagoon** site and two years of post-construction data from the **Beaver Pond** project it is not possible to comment on the long term persistence and quality of habitat. The area of wetland habitat at both sites has remained stable to date.

6.2 Vegetation

The habitat classes observed at both sites have developed in response to the annual flooding regime from normal reservoir operations. The general pattern of habitats was a band of coarse woody debris and shrub/grass cover parallel to the edge of the reservoir at full pool transitioning into a band of sparsely vegetated sand or clay to an area of sparsely vegetated mud adjacent to the water's edge. As the timing of reservoir filling and the maximum elevation reached varies from year to year, the species present in each of the habitat classes is expected to be variable, particularly in higher elevation habitat classes that may not be flooded every year. In 2010 the reservoir elevation did not exceed 665 m during the growing season resulting in most of the mapped area at both sites not being flooded. This allowed for colonization by species that are less tolerant of inundation.

The higher elevation of the new culverts at the Airport Lagoon reduces the influence of reservoir on the lagoon water level to only when the reservoir elevation exceeds 667 m. In years with low reservoir elevations (<667 m), lagoon water levels will be unaffected as they are maintained by existing, upstream inflows. Similarly, the impoundment created at the Beaver Pond site will only be influenced by the reservoir elevations >667.5 m. At lower reservoir elevations, the impoundment water level will be maintained by upstream inflows and a ground water seep. Reservoir levels in subsequent years of the project were much higher with water levels near or at full pool in Years 1 (2011), 2 (2012), and 5 (2015) and near average water levels in Years 3 (2013) and 4 (2014). The maximum water levels reached were 671.4 m in late August 2011, 672 m at the end of July 2012, 669.8 m in early August 2013, 668.7 m at the end of July 2014 and 671.5 m in late October 2015. As a result, all transects and the majority of mapped habitat classes at both sites were inundated in 2011, 2012, and 2015 while the higher elevation transects were either not flooded or only partially flooded in 2013 and 2014.

Terrestrial plant species identified at the study sites during Year 1 ground surveys that were not detected (either absent or only dead remains were observed) during the Year 2-6 ground surveys are likely to be intolerant to flooding events. Based on their life history, some of the species identified are adapted to dry to mesic soils (e.g., fireweed, red raspberry, and trembling aspen) and therefore, their intolerance of flooding is expected. However, a few species identified are adapted to moist to wet soils and yet were still found to be intolerant to flooding (e.g., dead remains of Norwegian cinquefoil and common cattail were apparent across the Airport Lagoon site). Their intolerance may partly be related to the timing (early to middle of the growing season) of flooding but may also a result of the depth (can be >4 m) and duration of flooding (the remainder of the growing season).

All terrestrial species identified during Year 6 ground sampling are likely to be tolerant to flooding events and regular inundation by the reservoir. A majority of these species are adapted to wet soils that are often saturated for a portion of or the entire growing season (e.g., lady's thumb, common horsetail, water smartweed, and common hook-moss). Many of these species have also been observed as regularly occurring within the drawdown zone of other reservoirs located in B.C (e.g., bluejoint, reed canarygrass, common and swamp horsetail, and water sedge at Arrow Lakes and Kinbasket Lake).

Airport Lagoon

The post-construction terrestrial vegetation mapping and ground-truthing identified 11 vegetated habitat classes and one non-vegetated (open water) habitat class at Airport Lagoon. No significant changes in the abundance, diversity and extent of vegetation was observed in Year 6 in comparison to Year 5.

The number and locations of the floating islands at Airport Lagoon in Year 6 appeared to differ in comparison to the previous year. These islands are likely to degrade overtime as a result of physical disturbances from the rise and fall of reservoir levels and so reductions in the size, number, and location of the islands is expected.

The distribution of Coarse Woody Debris (CWD) at Airport Lagoon site in Year 4 was reflective of elevation within the drawdown zone with the highest densities of CWD occurring at the upper limits of the drawdown zone and decreasing densities with decreasing elevation. The one exception to this are areas at elevations above the high density CWD class on the east side of Airport Lagoon where the CWD density is moderate. Qualitative observations during the Year 6 field surveys indicated that there had been substantial movement and redistribution of CWD in some areas. The distribution and movement of CWD also appears to play a role in the establishment of vegetation communities in the drawdown zone.

The distribution of aquatic plant communities (as defined by a dominant species) observed at the Airport Lagoon site in Year 6 was similar to the previous year. In terms of water depth, aquatic plant communities dominated by emergent species (e.g., water smartweed, lady's thumb) occurred along the shoreline and shallow waters in comparison to communities dominated by submergent aquatic species (e.g., common hornwort and closed-leaved pondweed) that occurred within deeper water at the site. Overall, aquatic plant communities were primarily located in areas of the site where permanent water cover (either stream or pond) existed prior to the construction of the wetland enhancement. In areas where a permanent water body did not exist prior to enhancement, the occurrence of aquatic plants was sparse but appears to be increasing over time.

In Year 6, aquatic plants where observed in areas where no aquatic plants were observed in Year 4. These observations suggest that the distribution of aquatic plants within Airport Lagoon may be expanding into areas previously uninhabited by these species as a result of permanent flooding from the wetland enhancement.

Most of the aquatic plant species identified at Airport Lagoon during Year 6 were present in Year 4. Although no sampling of aquatic plants was conducted during Years 1-3, it is assumed that most species were also present in the areas of permanent open water that existed prior to construction. All species identified are expected to continue to be present at the site in future years. Within the areas where aquatic species were observed, species distribution was primarily based on life history (i.e., emergent versus submergent). Most submergent species (e.g., common hornwort) were only observed within areas where a permanent water body existed prior to wetland enhancement as they are intolerant to exposure to the air. In contrast, most emergent species (e.g., water smartweed) are found in shallow waters and along the shoreline and have a higher tolerance to changes in water level. Reservoir elevation may influence the annual distribution of submergent aquatic vegetation within the wetland enhancement. In years with high reservoir elevations, light penetration will be reduced due to water depth and may limit the extent of aquatic vegetation at the site. Continued monitoring in July will assist in confirming the role of reservoir elevation in the variation and distribution of aquatic vegetation at this site

As with terrestrial plant species, the abundance and distribution of some aquatic plant species observed at Airport Lagoon is likely to vary from year to year as a result of the timing of reservoir filling and the maximum elevation reached. For example, during aquatic plant surveys in Year 4, lady's thumb was commonly distributed throughout the lagoon and provided substantial vegetation cover in shallow water along the shorelines. In contrast, lady's thumb was mostly absent from Airport Lagoon in Years 5 and 6. The opposite occurred with water smartweed as it provided considerably higher plant cover in the northeast arm of the lagoon in Year 5 compared to Year 4. Reservoir levels at Airport Lagoon in Years 5 and 6 were higher than in Year 4, which suggests that water smartweed may be able to tolerate deeper water in comparison to lady's thumb. This pattern is expected to continue in future years with water smartweed more common in years with high reservoir elevations and lady's thumb more common in years with a lower reservoir elevations.

Beaver Pond

The post-construction terrestrial vegetation mapping and ground-truthing identified 5 vegetated habitat classes and one non-vegetated (open water) habitat class at Beaver Pond. No significant changes in the abundance, diversity, and extent of vegetation were observed in Year 6 in comparison to Year 5. The as-built elevation (667.5 m) of this project was considerably lower than the original design (669 m). Therefore most of the drawdown zone adjacent to the new pond is still inundated by the reservoir in most years. As a result, no significant changes in the mapped vegetation classes are anticipated at this site.

In Year 6, no aquatic plant species were observed occurring within the new permanent flooded area that has developed as a result of the enhancement works. As aquatic plant species were not present in this specific area of the site prior to the enhancement, it is expected that colonization from natural dispersal of seed, if it occurs, will be slow. Colonization by aquatic plants is further limited by the depth of annual inundation by the reservoir and the high turbidity of the reservoir.

6.3 Waterfowl and Shorebirds

Waterfowl were identified as one of the two target groups for monitoring the effectiveness of the wetland enhancements for wildlife (BC Hydro 2010). It was expected that by stabilizing the water level at the site habitat conditions for migrating waterfowl would be improved while maintaining habitat availability for shorebirds (Golder 2011).

Airport Lagoon

Waterfowl abundance at the Airport Lagoon site in Year 6 was the lowest recorded since the start of the project. This includes the 2011 results when only three rather than four surveys were conducted. The total number of waterfowl species detected at Airport Lagoon has declined every year since 2013. Waterfowl species richness in Year 6 (15) remained the same as in 2015.

Variability in environmental conditions, timing, and route of migration from year to year are likely contributors to the differences in species composition detected during the annual surveys. In an attempt to ensure as much continuity in the characterization of habitat use as is possible, survey dates in 2016 were once again consistent with those conducted in previous years. Unseasonably warm temperatures and dry spring conditions in both 2015 and 2016 may have impacted the timing of migration sufficiently to have produced these results. There was also likely more habitat available for migrating waterfowl due to more open water from the mild temperatures in April.

The decline in waterfowl numbers at survey stations WSP-01 and WSP-02, particularly during the first two surveys of the season (Figure 22), is considered to be a result of the increase in water depth and loss of shallow water habitat at these locations as a result of the wetland enhancement. Conversely, the increase in waterfowl abundance observed at survey station WSP-03 is a result the increased water level from wetland enhancement creating a new large area of shallow water habitat that was previously exposed drawdown zone habitat. Prior to construction, there was also a large area of shallow water habitat present at WSP-04. Construction of the wetland has increased the water depth at this site but there has been little change in waterfowl observations. The post-construction trend at WSP-04 has been for decreased waterfowl abundance early in the season but with increased abundance during later surveys. The post-construction changes in waterfowl distribution are considered to be a result of the increased water level and associated habitat changes. This pattern is expected to continue for the duration of the monitoring program.

The observed post-construction shift in waterfowl distribution away from the south end of the Airport Lagoon site is considered to be a result of the increased water level and associated habitat changes. This is likely due to the fact that the pond at the northwest corner is a permanent fixture with shallow water and emergent vegetation which provides good feeding habitat for many waterfowl species. The move away from the causeway area is likely due to the increase in water depth, reducing the availability vegetation and associated food sources for dabbling ducks. The availability of deeper water habitat has also potentially increased the abundance and size of fish that are able to survive in the Airport Lagoon. This in turn will potentially provide good feeding habitat for diving ducks and fishing birds (Osprey, Bald Eagle, Belted Kingfisher) and is predicted to result in increased use by some of these species. The extent of the increase for these species is expected to be variable and may be limited by territory size (e.g., an Osprey already nest annually at this site).

During post-construction surveys at Airport Lagoon, detections of Common Loon, which require larger bodies of water (Evers et al. 2010), have been slightly higher than they were during baseline surveys. Other species including American Wigeon, Northern Shoveler, Blue-winged Teal, and Gadwall that prefer shallow water with emergent or submerged vegetation have been also been recorded in higher numbers or at later dates during the post-construction surveys (Dubowy 1996, Leschack et al. 1997, Rohwer et al. 2002, Mini et al. 2014). This may be an early indication that the elevated water levels and more stable hydro-period is influencing habitat use by some species at the site. Differences in environmental conditions, timing, and migration route from year to year are likely contributors to the variability in waterfowl and shorebird species composition detected during the surveys.

No active waterfowl nests have been detected to date at the Airport Lagoon site. However, incidental observations of old nests, egg shells, adults sitting on old Osprey nests, and pairs with broods confirms that Canada Goose nest within or close to the drawdown zone at the Airport Lagoon site. Other waterbird species that have been confirmed to nest at this site have included Spotted Sandpiper, Killdeer, and Bonaparte’s Gull. Greater and Lesser Yellowlegs are also suspected of nesting adjacent to the site. However, despite the confirmed nesting by these species, high quality nesting habitat for most waterfowl species is limited at this site. The limited number of nests detected suggests that most waterfowl and shorebird use of the site is by migrants with some use for foraging by birds nesting locally (but not at the Airport Lagoon) and a small resident population.

Shorebirds were first recorded during the Year 2 (2012) surveys and they have been included annually since then. The 104 individuals representing 10 species observed during the 2016 surveys are the highest recorded post-construction shorebird abundance and species richness. The lowest shorebird species richness and abundance was in 2013 when the surveys coincided with construction of the wetland enhancement. Due to the lower number of shorebirds compared to waterfowl, this component of the surveys appears to have more variability. The variability is the result of the occasional presence of a large flock of migratory shorebirds during the surveys (e.g., Long-billed Dowitcher, Appendix 12). When these outliers are removed, there appears to be a slight increase in the post-construction shorebird abundance in Year 6. If this pattern continues in future years, it would suggest that the wetland enhancement has positively impacted shorebird abundance and species richness at the Airport Lagoon site.

The largest of the floating islands identified during previous post-construction years were not floating or had broken down at the time of the 2016 surveys. Incidental observations of Killdeer and Spotted Sandpipers were previously recorded on the smaller floating islands but no nesting or breeding behaviour was observed this year. Since nesting Killdeer pairs used the larger islands last year, it seems likely that the size of islands is a factor when shorebirds select these islands for nesting. Other changes to the vegetation cover resulting from the wetland enhancements are expected to take several years. The reduced fluctuations in water level resulting from the extended hydro-period should encourage the development of emergent and aquatic vegetation and well-vegetated grass and shrublands. Increased vegetation cover would increase availability and improve the quality of nesting habitat for most waterfowl species. However, the development of vegetation cover at elevations above the wetland enhancement are still primarily influenced by the annual peak reservoir elevation.

Beaver Pond

The 2016 effort represents the second year of post-construction waterfowl and shorebird surveys at the Beaver Pond site. Consistent with previous years, there were few waterfowl and shorebirds detected. Waterfowl species composition has remained the same between baseline and post-construction surveys with Canada Goose and Mallard being the only species represented. Semipalmated Sandpiper and Killdeer were the only shorebird species detected in the baseline surveys and Spotted Sandpiper is the only species recorded since then.

The addition of the berm has provided a larger permanent water body, potentially enhancing habitat for feeding and other water based activities. Incidental observations in Years 5 and 6 have included a number of shorebirds (Greater Yellowlegs, Spotted Sandpiper, and Killdeer) feeding on large numbers of Western Toad tadpoles in shallow water along the peripheries of the new pond. Other incidental observations include a pair of Spotted Sandpiper exhibiting nesting behaviours within proximity to the drawdown zone. However, no shorebird nests were located at this site during the 2016 season.

The small size of the Beaver Pond site along with the low elevation of the pond in the drawdown zone means that inundation by the reservoir will be a major limiting factor in the development of any additional vegetation at this site. Small changes in waterfowl and shorebird use such as those already observed for shorebirds are expected to be the extent of changes in the use of this site for this indicator group.

6.4 Songbirds

Songbirds were not the primary target of the wetland enhancement projects but were identified as a group that could potentially benefit and were included as an indicator group in the project terms of reference (BC Hydro 2010). Benefits to this indicator group could potentially arise through improved foraging or breeding habitat.

Airport Lagoon

In 2016, species richness (58) reached and exceeded baseline levels for the first time at the Airport Lagoon site and was the highest recorded to date. The average number of species per station (15.4, n=17) was only slightly lower than the peak number (15.5, n=17) recorded in Year 4. The number of detections per station was consistent with previous years. There is difference of less than 100 detections between the highest (416) recorded in 2011 and the lowest (320) recorded in 2013. The construction and installation of the culverts was still ongoing during the 2013 point count surveys, so the low number of detections can be attributed in part to the higher than normal level of disturbance. Other than the drop in detections due to construction disturbance in 2013, most of the interannual differences in detections is assumed to be due to natural variability.

The percentage of detections recorded in the drawdown zone (30.6%, n=359) in Year 6 was slightly lower than the other post-construction surveys but species richness (31) remained the same as the record high observed in 2015. Post-construction detections in the drawdown zone continue to be higher than the pre-construction results. This suggests that the distribution of songbirds at the Airport Lagoon site maybe changing with a larger percentage using the drawdown zone following completion of the wetland enhancement.

When only water-dependent genera (shorebirds, waterfowl, and gulls) are considered, there appears to be a slight downward trend in the number of detections and number of individuals observed during post-enhancement surveys. These numbers remain higher than the results from the pre-construction phase of the monitoring project. Waterbird species richness was slightly lower than the previous two years but remains higher than the pre-construction levels.

During the 2016 surveys, European Starlings were detected and confirmed to be nesting at the Airport Lagoon site for the first time in this project. Cavity nests for Tree Swallows and Northern Flicker were also identified in snags along the waters' edge. No songbird nests were located on the ground in the drawdown zone during the Year 6 nest searching efforts. The only active ground nest located within the drawdown zone was a Spotted Sandpiper located amongst the coarse woody debris near the top of the drawdown zone.

Inherent variability in nest searching success along with the small size of the study area relative to the nesting territories of some species means that even small changes in nesting patterns by some species will influence the number of nests located from year to year. Once again few nests were located during the Year 6 effort, but nesting and feeding behaviours and other indications of species nesting at the site were observed. For the second successive year a Canada Goose was observed occupying an old Osprey nest; egg shell fragments and old nests for this species were located during the search effort. The nest occupied by the Osprey pair was still active at the time of the final surveys of the season so was likely successful this year. Canada Goose, Killdeer, and Spotted Sandpiper with broods were included amongst incidental observations.

Savannah Sparrows nest almost exclusively on the ground and require sufficient dead and green grasses, sedges and other herbaceous cover. There was a noticeable decline in the number of Savannah Sparrows (2) detected in 2016, following two years of record detections at Airport Lagoon. A similar crash in Savannah Sparrow numbers was observed in 2013 following two years of above average reservoir elevations. Vegetation cover was considerably reduced and did not immediately recover to pre-2012 levels (CBA 2013). Reservoir elevations have been above average in 2015 and 2016. Savannah Sparrows may prove to be a good indicator species to determine how quickly vegetation cover recovers to usable nesting habitat levels.

Beaver Pond

Inclement weather reduced the number of point count replicates at the Beaver Pond site from three to two during the Year 6 survey effort. The number of detections (36), species richness (17) and average number of species per station (9) were all noticeably lower than all other years where three replicates were completed. In order to meaningfully contrast the 2016 data with results from previous years the average number of detections from two surveys in each year were calculated and used for comparison. The number of detections in 2016 was consistent with the numbers recorded during the preceding two years of post-construction data but continued a downward trend from a peak in 2013. Higher numbers of detections and species richness were recorded in the pre-construction surveys when compared to the post-enhancement results.

Consistent with every other year at Beaver Pond, a majority of the detections were located in the forested area above the drawdown zone (Figure 27). Despite the declining trend in songbird detections at this site since the peak in 2103, the number of detections in the drawdown zone has continued to increase. More detections were recorded in the drawdown zone in year 6 than in any previous year of the project. Drawdown zone use by songbirds has been consistently higher during the post-construction surveys than baseline levels. Similar patterns have been observed at the Airport Lagoon site and this may be an early indication that the enhancements are having a positive impact on songbird habitat use within the drawdown zone.

No nests were located during the 2016 search effort at Beaver Pond. However, a pair of Spotted Sandpipers were observed demonstrating nesting and feeding behaviours at the edge of the drawdown zone.

6.5 Amphibians

Together with waterfowl, amphibians were identified as one of the two target groups for monitoring the effectiveness of the wetland enhancements for wildlife (BC Hydro 2010). It was expected that by stabilizing the water level at a higher elevation, additional wetland habitat would be available for breeding amphibians (Golder 2011).

Airport Lagoon

As expected based on the results from the previous five years of this study along with other inventory work in the Williston watershed (Hengeveld 2000), Western Toad were once again the most frequently detected species. For the first time since the inception of this project, Western Toad was the only species detected at the Airport Lagoon site. The four individuals observed along transect 25 during the first two surveys of the season is the lowest abundance and species richness recorded to date. However, with the exception of 2016 data, Western Toad numbers have been higher in the post-construction surveys when compared to baseline data.

The timing of first survey of the season is designed to account for early season breeding amphibians, particularly Wood Frog and Long-toed Salamander. It is completed as early in the season as conditions will allow and ideally before ice and snow cover recedes (Matsuda et al. 2006). For the second consecutive year, unseasonably warm and dry spring conditions meant that the study sites were both ice and snow free well before the first surveys were initiated. The early onset of spring is likely a major factor in the lack of amphibian detections particularly Wood Frog and Long-toed Salamander, because the timing of the breeding season likely preceded the first surveys of 2016. Western Toads hibernate for three to six months and become active and congregate to breed shortly after ice breakup (Slough and Mennell 2006) or when daily minimum and maximum temperatures exceed 0 C and 10 C respectively (Gyug 2000). These conditions were met as early as April 6 and 7 in 2016, 10 days earlier than the first day that met these conditions in 2015.

The detection of 20 separate frog egg masses in the permanent pond at transect 25 confirms that breeding had occurred at this location prior to the April 29 survey. Despite the lack of adult and juvenile amphibian detections at the Airport Lagoon sited during the Year 6 surveys, there is evidence to support the fact that both Western Toad and Wood Frog continue to use the area for breeding. Large aggregations of Western Toad tadpoles were observed in the water at transect 25 during the May 21 and 31 surveys. A smaller number of Wood Frog tadpoles were also present during the May 21 effort.

Activity levels in ectothermic amphibians are limited by environmental conditions. They are most active and therefore easier to detect during warm weather, shortly after rainfall events (RIC 1998). While amphibian surveys are conducted under the best conditions possible, it is not always possible to conduct the surveys under ideal conditions. Weather conditions prior to and on the day of the survey are likely to be an important contributor to the observed variation in survey results. Baseline survey results were consistent with these assertions with the highest number of detections recorded in Year 1 (higher than average temperatures and above average precipitation). Conversely the lowest number of detections was recorded in Year 2 (cooler with below average precipitation). In Year 6, the days leading up to all four surveys in Airport Lagoon were warm, a small amount of rain just before the April 28 and May 10 surveys may account for the detection of small numbers of Western Toad. No precipitation was recorded for over a week leading up to the May 21 survey and for several days prior to the May 31 effort. The dry conditions at the time of the last two surveys of the year were considered less favourable for amphibian activity and likely explains the lack of detections later in the season.

Consistent with the data for the previous five years, transect 25 was the most productive for western toad detections. This is likely influenced by the availability of high quality amphibian habitat including a permanent pond with emergent vegetation surrounded by a diverse range of vegetated and bare ground with an abundance of coarse woody debris.

A considerable degree of year to year variability in amphibian populations is expected (RIC 1998, US EPA 2002). Variation in the adult amphibian population is often due to juvenile recruitment, predominantly larval survival. Increasing the permanent water level at the Airport Lagoon has altered habitats creating new shallow water habitat and inundating breeding habitat that existed previously. These changes could have both positive and negative effects on amphibian populations. Post-construction results have shown increases in fish populations at the Airport Lagoon site (CBA 2015, 2016) and the increase in predators may have a negative impact upon tadpole survival rates. Shorebird use of the site also appears to have increased and this may be another source of predation.

The anticipated positive impacts on amphibian populations from the more stable hydroperiod and reduced fluctuations in water levels afforded by the habitat enhancement efforts are expected to take several years to be realized. Vegetation cover and the quality of amphibian habitat in the drawdown zone were reduced by high water levels between the 2011 and 2012 surveys at Airport Lagoon. Vegetation has not recovered to pre-2013 levels (CBA 2013, 2014, 2015). Reservoir water levels from early September 2015 through mid-June 2016 were at the highest elevations observed since the start of this project. This means that certain areas of the drawdown zone were inundated for a longer period of time than in other years. This may well set succession back once again and increase the time it will take for vegetation to progress to a point where connectivity between breeding and seasonal terrestrial habitats is sufficient to affect population abundance and habitat use.

Beaver Pond

This was the second year of post-construction surveys at the Beaver Pond site. Consistent with Year 5 results, three amphibian species (Western Toad, Long-toed Salamander and Wood Frog) were detected. Columbia Spotted Frogs have not been detected at the Beaver Point since this project was initiated in 2011, though they are known to breed within the Williston watershed

(Hengeveld 2000). Although the abundance of each species was generally lower than in 2015, the numbers were higher than those recorded during the pre-construction surveys.

In 2016, the first survey of the season for Beaver Pond was conducted on April 28, approximately two weeks earlier than in previous years. Three Long-toed Salamanders were the only amphibians detected during this survey. Western Toads were observed during the remaining three surveys and they accounted for the majority of amphibian detections at this site. The breeding seasons for Wood Frog and Long-toed Salamander are short and occur earlier than this site becomes accessible so the surveys are unlikely to coincide with peak breeding and migration events for these species (Matsuda et al. 2006). The early breeding season would account for the low number of detections for these species and the absence of Long-toed Salamanders in the later surveys. The detection of ten Long-toed Salamander egg masses during the first survey of the year confirms that breeding occurred prior to April 28 this year.

Environmental conditions and survey timing may have also contributed to some of the results for Western Toad. Observations of a high number of Western Toads on June 5, 2015 (Year 5) may have coincided with environmental conditions that resulted in a peak movement period for toads (CBA 2016). A similar pattern was observed in 2016 with an increase in the number of toads between the June 1 and June 5 surveys (Table 22). A small rain event and increasing temperatures between these two dates may have contributed to the higher number of detections on June 5.

Large aggregations of Western Toad tadpoles in the new impoundment were recorded during the two post-construction survey years. In 2016, Western Toad tadpoles were observed in high concentrations during both the June 1 and 5 surveys. Incidental observations in the field suggest that some of these tadpoles may originate from the beaver ponds immediately upstream as tadpoles have been observed getting washed over the beaver dam and flushed downstream. Prior to construction of the wetland enhancements, tadpoles would be flushed into the reservoir. It is assumed that some of the tadpoles hatch from eggs deposited in the new impoundment as Western Toads in amplexus have been observed although no egg strings have been encountered during the surveys.

While Western Toad tadpoles are generally avoided by fish, there is no vegetation or other cover in the shallows of the newly created pond so they are vulnerable to other predators. Incidental observations included Spotted Sandpipers feeding on these tadpoles for extended periods and returning frequently, so mortality due to predation may be high. Variation in the adult amphibian population is often due to juvenile recruitment, predominantly larval survival. The lower than designed elevation of the wetland increases the influence of the reservoir on the wetland and may impact tadpole survival to metamorphosis in some years depending on the timing of inundation. Early inundation by the colder reservoir water could slow tadpole development or reduce tadpole survival to metamorphosis.

Habitat quality is also likely to be a limiting factor in this project showing positive benefits for amphibians. The impoundment is surrounded by large areas of bare ground with little coarse woody debris or vegetation. No vegetation recruitment around the pond is expected as the elevation of the berm is lower than designed so the fluctuations in water levels and influence of the reservoir will continue to be larger than originally intended. High quality amphibian habitat requires protection from desiccation and predation, vegetation and coarse woody debris, rocks, etc. (Davis 2000, Bartelt et al. 2004). High quality amphibian habitat requires protection from desiccation and predation, vegetation and coarse woody debris, rocks, etc. (Davis 2000, Bartelt et al. 2004). This would be difficult to replicate and maintain at the Beaver Pond site due to the continued influence of the reservoir. Increasing the attractiveness of the impoundment to amphibians would not be a recommended approach due to the low elevation of the pond and the potential for negative impacts on amphibians through reduced recruitment.

6.6 Fish

The improvement of fish habitat was not one of the goals of the wetland enhancement projects (BC Hydro 2010). However, monitoring of fish populations was included in the monitoring program as little is known about the fish species composition and distribution at the two sites selected for the trial wetland enhancements(BC Hydro 2010). Fish were observed at both of the selected demonstration sites during the initial review of potential wetland enhancement sites (Golder 2010, 2011).

Fish sampling in 2016 by electrofishing, minnow trapping, and fyke nets continued to be effective sampling methods for monitoring fish populations at both wetland enhancement sites. The three methods of sampling resulted in the collection of 11 of 22 species known to occur in the reservoir in 2016. All species collected in 2016 were observed in previous years. Between the two sites a total of 13 fish species have been observed over the first six years of the project.

Airport Lagoon

Based on the high catches in 2014 and 2015, the catch rates observed during the July 2016 minnow trap and fyke net sampling at the Airport Lagoon were lower than expected. The lower than expected catch is considered to be a result of the high reservoir elevation at the time of sampling. The reservoir elevation at the time of sampling in 2016 was higher than during any of the previous July fish sampling at the Airport Lagoon. The high reservoir elevation increased the habitat are available to the lagoon fish population so that trap and net encounter rates would be considerably lower compared to spring sampling at low water. The reservoir elevation was also high enough to refloat stranded debris around the lagoon. This limited the locations where the fyke nets could be set to deeper locations and reducing the catch efficiency and CPUE.

While the results for 2016 showed some declines and increased variability, fish abundance continued to be higher than in the pre-construction period confirming that the increase in permanent (year-round) habitat area has allowed the resident fish population to increase. The area of permanent fish habitat has increased from 7.28 ha to 26.10 ha following construction of the wetland enhancement. The installation of the new culverts may have also improved fish passage in an out of the lagoon when the reservoir elevation is at the culvert elevation or higher (≥667 m). The observed differences in abundance also suggest that peak reservoir elevation may be one of the factors influencing the variability of the resident fish population.

The fish sampling results for 2016 from the Airport Lagoon provide additional support to the conclusion (CBA 2014, 2015, 2016) that this site has a resident fish population of cyprinids, suckers, and sculpins. The most abundant species continued to be Lake Chub, Brassy Minnow, and Redside Shiner with varying abundance depending on the sampling gear and period. These three species have also shown the largest post-construction increases in CPUE (Figure 31). These species also have relatively short time to maturity (<3 years) compared to the three sucker species (>3 years) (McPhail 2007). The short time to maturity combined with their abundance means that population changes associated with increase in habitat area would be observed in these species first. If the project has a positive effect on species with a longer time to maturity such as the sucker species, this should be apparent in future monitoring years. Results to date suggest that the project has increased recruitment of suckers with post-construction increases in juvenile suckers (<70 mm FL) (Figure 31). Effects of the wetland enhancement on less common species such as Prickly Sculpin should also become apparent in future monitoring years as the population increases.

Beaver Pond

Based on the description of the Beaver Pond site (Golder 2010, 2011) and the limited habitat, it was originally expected that few fish would be encountered at this location. However, early season fish captures have been variable over the first six years of the monitoring project. High numbers of fish were captured by electrofishing in 2011 and 2013 (pre-construction) and suggested that the small stream and inlet may have provided rearing habitat for juvenile fish (CBA 2012, 2014). The continued capture of fish in the downstream portion of the stream and observation of schools of juvenile fish at the stream outlet following suggests that there has been little change in use of this site by fish following construction.

Minnow trap and fyke net sampling was completed again at the Beaver Pond site in Year 6 with minnow trapping occurring on two different occasions (May and July). The relative abundance of fish at this site continues to be relatively low and variable between years. Over the first four years of the project, the relative abundance of fish, based on captures by minnow trap and fyke net, at the Beaver Pond site appeared to be increasing but this trend did not continue to Year 6. The low numbers of fish captured by all methods make it difficult to identify and changes in abundance for individual species to date. However, there appear to be increases in both Redside Shiner and Prickly Sculpin in the post-construction period based on the results from electrofishing and minnow trapping (Figure 33).

Increases in fish abundance would be expected following construction of the impoundment as it approximately 0.4 ha of permanent (year-round) habitat at the site. However, construction of the wetland has changed the amount and type of habitat available to juvenile fish at low reservoir elevations from a small, shallow stream to a combination of the stream and the impoundment. At reservoir elevations that inundate the site, conditions are unchanged although there may be some localized changes in water quality as a result of the berm. For example, water quality monitoring data (Appendix 14) collected in July 2016 showed that some stratification is occurring on the inside of the berm. Additional years of monitoring will provide more information on variation in fish abundance at this site and factors that may influence the variability.

7 CONCLUSIONS

The information collected to date in the GMSMON-15 project has shown changes appears to support the preliminary impact and benefit predictions identified for both wetland enhancements (Golder 2011). Changes in the abundance of waterfowl, shorebirds, songbirds, amphibians, and fishes have been observed at both the Airport Lagoon and Beaver Pond sites that show increased use of the sites by these indicator groups following construction. Additional years of post-construction monitoring data will be required to confirm if the increases are sustained and a result of the enhancement project, particularly for species with longer generation times. Both projects are considered to have not yet reached a post-construction equilibrium based on the observed variability. It is expected that the indicator groups will be at or approaching a post-construction equilibrium by the end of this monitoring program. As observed in the baseline data, there is expected to be continued variability in the data due to natural variation and annual differences in reservoir and environmental conditions. Additional details are provided below for the progress of each wetland enhancement in relation to the project management questions. The existing monitoring protocols are expected to answer the management questions and hypotheses and allow for evaluation of the trial wetlands.

Airport Lagoon

The three years of post-construction observations at the Airport Lagoon in Years 4, 5, and 6 provide some evidence that the project is achieving the desired results and that the survey methods will detect changes associated with the enhancement projects. General increases in relative abundance were observed for waterfowl, shorebirds, songbirds, amphibians, and fishes. Additional years of post-construction monitoring data will be required to confirm if the increases are sustained and a result of the enhancement project. As observed in the baseline data, there is expected to be continued variability in the data due to natural variation and annual differences in reservoir and environmental conditions.

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

The enhanced wetland at the Airport Lagoon site is being used by waterfowl and other wildlife including amphibians, songbirds, and fish. Differences in annual waterfowl and shorebird abundance and species richness during the pre-construction surveys were attributed to natural variability. This is also likely to be a factor in the results from post-construction surveys. Mild temperatures and low precipitation during the last two springs may explain the decline in waterfowl detections at the Airport Lagoon site since 2014. The subsequent early ice-off on the main reservoir in 2015 and 2016 would have opened up habitat not usually available during the first surveys of the year and contributed to the low numbers of waterfowl detected relative to previous years. Observations fewer waterfowl while travelling to the site in spring 2016 compared to previous years also provide some qualitative support to this explanation.

The increase in water depth at the Airport Lagoon from the wetland enhancement was expected to change patterns of habitat use by waterfowl due to changes in the location and amount of shallow water habitat. The early post-construction survey results support this prediction. In both the pre- and post-construction surveys higher numbers of waterfowl and shorebirds were recorded at survey stations with great amounts of shallow water habitat. With the increase in water level following installation of the new culverts, detection rates have declined at survey stations that had shallow water habitat prior to the enhancement works but now have deeper water and little or no shallow water habitat. Additionally, there has been a large increase in detections from stations where shallow water habitat was created by the enhancement project but was primarily unvegetated drawdown habitat prior to construction. This suggests that the wetland enhancement project has increased the availability of shallow water with emergent and submergent vegetation attracts higher numbers of waterfowl. This trend has been most noticeable during the first two surveys of the year when higher numbers of migratory waterfowl and shorebirds are present.

Shorebird abundance and species richness increased in 2016 and were at the highest level since 2012. The record low numbers of waterfowl recorded in Year 6 along with the apparent downward trend in abundance since 2014 may be due to natural variability and differences in migration timing between years. Further analysis will be required once additional post-construction data is collected. However, the new wetland is being used by waterfowl and shorebirds and the initial results indicate that there may be increased abundance and diversity of waterfowl and shorebirds following completion of the enhancement project.

The differences in songbird abundance at the Airport Lagoon site during the pre-construction phase of the project were attributed to natural fluctuations in songbird populations and habitat use. As anticipated, the early post-construction survey results showed similar variability, though detections and species richness are higher than baseline levels. One of the potential benefits of predicted from the stabilized higher water level from the project was the development of wetland and riparian habitat for songbirds at the upper elevations of the drawdown zones. However, peak reservoir elevations have exceeded average values (1991-2010) every year of the study to date with the exception of 2014. This may slow the rate of establishment for some vegetation species and rate of succession for some vegetation communities. Therefore this will increase the timeframe for any positive impacts to songbird populations to be realized to beyond the time frame of this study.

Even under ideal conditions, the changes to vegetation from the enhancement project that were predicted to benefit songbird habitat may not be measureable within the scope of this monitoring program. Songbird habitat along the margins of the drawdown zone is still influenced primarily by the annual peak reservoir elevation with more and higher quality habitat available following years with lower peak elevations. Any changes in the results of the point count surveys due to the wetland enhancement project are more likely to be observed in water-dependent species (shorebirds, waterfowl, and gulls) than in more terrestrial songbirds.

The slight downward trend in detections of water-dependent species detected in Year 5 continued in 2016. However, post-construction numbers of detections and species richness of water-dependent species during the songbird point counts at the Airport Lagoon site remain higher than baseline levels. Due to the timing of the songbird point counts, it is likely that most water dependent species identified are either resident in the lagoon and adjacent areas or are resident in the local area.

Prior to the enhancement works, the percentage of detections recorded in the forest and shrubs were consistently higher than drawdown zone detections. There was little variation in the number of detections recorded in the drawdown zone and shrubs during the pre-construction surveys, allowing for the detection of even small changes in habitat use patterns. These habitats were expected to be the most affected or potentially affected by the enhancement efforts. During the first post-construction survey in 2014 the highest percentage of detections was recorded in the drawdown zone. For the last two years of post-enhancement surveys the percentage of detections in the drawdown zone has remained above 30%, while there appears to have been a slight shift in detections from the forest to the shrubs at the upper elevations of the drawdown zone. These results are potentially early indications suggesting that the enhancements are having some positive impacts at this site.

Stabilization of the water regime was predicted to allow for development of wetland and riparian vegetation at both sites and therefore increase habitat availability for both waterfowl and songbirds. The natural process of re-vegetation is likely to take several years and is limited by inundation by the reservoir which can increase the water level in the lagoon by up to 5 m above the elevation of the wetland enhancement.

A total of three amphibian species were detected at the Airport Lagoon site prior to the completion of the habitat enhancements. A fourth species (Columbia Spotted Frog) was detected during the first post-construction season in 2014, but has not been observed in subsequent surveys. Wood Frog has not been detected at this site during the amphibian surveys since the first year of the project (a single Wood Frog was observed incidentally in 2015). An increase in mean abundance of as few as four to five individuals during the post-construction surveys should be detectable due to the low mean abundance of amphibians detected during the baseline surveys provided variance remains similar in the post-construction monitoring phase. Early post-enhancement surveys show higher variability in abundance and may impact these calculations. If the habitat enhancements are effective in increasing populations, larger increases will be observed.

The low detections of amphibians, particularly Western Toad, during the 2016 surveys is inconsistent with the high numbers recorded during the first two seasons of post-construction amphibian surveys. It is too early to determine if the differences are due to environmental conditions and the timing of breeding events relative to survey dates or if they can be attributed to the habitat enhancements and higher than average water levels over the last two years. Further monitoring will be required to determine if the 2016 data should be treated as an outlier or if it indicates the beginning of a sharp decline in post-construction amphibian populations at this site.

At the Airport Lagoon, the numbers of fish captured were lower than in 2014 and 2015, particularly for the May fyke net sampling. While the catches of the three most common species (Lake Chub, Brassy Minnow, and Redside Shiner) varied depending on the gear type, the results do provide additional confirmation that the project has resulted in increased abundance of these three species. If the project has provided increased habitat for less common species with longer generation times (>3 years) this should be evident in the next few years of the project. The completion of the project has increased the amount of habitat for fish due to reduced seasonal fluctuations in water level and the associated large reductions in habitat. However, populations of these species began increasing prior to construction of the wetland enhancement. The pre-construction increases were considered to be associated with higher reservoir levels in 2011 and 2012 compared to 2010 that increased the amount of habitat available (CBA 2014). For other species (e.g., suckers, and Northern Pikeminnow), the high reservoir levels may have limited the potential for young-of-the-year fish to move into the lagoon (CBA 2014).

For other species captured at the Airport Lagoon, there continued to be little interannual variability in the relative abundance (CPUE) collected by all methods. As there was little variability in most species, it was expected that the existing sampling methods would detect small increases in relative abundance for most species (CBA 2015). The sampling results also suggest that the Redside Shiner population is continuing to increase and is becoming proportionally more abundant than either Lake Chub or Brassy Minnow. Continued population monitoring will be required to detect changes in the populations of less common species and to determine the extent of variation in abundance for the common species. The low catches in July 2015 and 2016 appear to be associated with the high reservoir elevation and not a change in the Airport Lagoon fish population.

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

For terrestrial and aquatic vegetation, the additional data collected in Year 6 provided a better characterization of the vegetation types that remain following the completion of the wetland enhancement projects. Some of the vegetation habitat classes identified during the pre-construction surveys were flooded as a result of the wetland enhancement and were changed to aquatic habitat types.

For terrestrial and riparian vegetation, the increased water level at the Airport Lagoon reduces the influence of reservoir conditions but do not entirely eliminate them. Vegetation communities above the wetland enhancement design elevations continue to be primarily influenced by annual reservoir elevations. Changes in vegetation communities as a result of the wetland enhancements are most likely to be observed in areas that are permanently flooded (change from drawdown zone to aquatic habitat) and in areas adjacent to the new wetlands as a result of the increased and stabilized water levels.

The completion of this project has allowed the development of aquatic vegetation that was previously limited in extent. In Year 4, aquatic plant sampling at the Airport Lagoon site identified areas within the created wetland where aquatic plant species were sparse to absent. Observations from Years 5 and 6 suggest that some of these areas are now beginning to be colonized by aquatic plants and it is expected that further colonization is likely to occur over time through natural dispersal of seed from areas within the permanent water body where aquatic plants are well established.

3. Is the area and quality of wildlife habitat created by the wetland enhancement maintained over time?

The completion of three years of post-construction monitoring data for this project is considered insufficient to comment on the long term persistence and quality of habitat created at the Airport Lagoon site. Post-construction changes in terrestrial and aquatic vegetation are on ongoing. The area of the wetland habitat created has remained stable to date and there are no indications of any processes that would affect the long term stability of the habitat. Annual inundation by the reservoir elevation will continue to be an important factor affecting annual variability in habitat quality at the site.

Beaver Pond

Early season access limitations to the Beaver Pond site continue to limit the available data at that site. The smaller than planned size and lower elevation of the wetland at the Beaver Pond site will reduce the magnitude of any changes that occur at this site. The smaller size reduces the amount of habitat potentially available and the lower elevation increases the influence of the reservoir on the site. The increased influence of the reservoir is expected to limit the potential for changes in riparian and aquatic vegetation. However, as the baseline use of the site by the indicator groups is low it is expected that even small changes will be detectable.

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

Despite the small size and low elevation of the wetland created at the Beaver Pond site, it is being used by waterfowl, shorebirds, amphibians, and fish. The small size of the project along with the lower than planned elevation are likely to limit the use of the site by waterfowl and other wildlife. The low elevation and small size is also a challenge for natural vegetation recruitment that makes significant changes in waterfowl and shore birds use unlikely at this site. Since the baseline data showed little to no use by waterfowl and shorebirds prior to the enhancement project, the detection of small changes in use will be possible.

The highest proportion of songbird detections at the Beaver Pond site have consistently been recorded in the forest just above the drawdown zone. Despite a reduced survey effort in Year 6, the number of drawdown zone detections appear to be increasing and were higher than the pre-construction results. The increase in drawdown zone detections was in contrast to a declining trend from the forest and shrub habitat. While it is still too early to draw any significant inferences, the apparent increasing trend in drawdown detections suggests that construction of the wetland has increased bird use of the drawdown zone. With only two years of post-construction data from this site, additional monitoring to determine if the changes are in response to the habitat enhancements rather than natural variability.

A total of three amphibian species have been detected at the Beaver Pond site during pre- and post-construction surveys. Columbia Spotted Frog is the only species that has not been detected at this site during the monitoring program. Similarly to the Airport Lagoon data, an increase in mean abundance of between four and five individuals should be detectable, but larger increases would be expected if the habitat enhancements were effective in increasing amphibian populations. The creation of a permanent pond behind the berm at Beaver Pond has resulted in a large increase in available breeding and rearing habitat. Although detections were lower than the Year 5 results, post-construction amphibian abundance continues to be higher than the baseline levels, particularly for western toad. Longer term monitoring beyond the scope of this project to evaluate the survival rate of these cohorts would be required in order to determine if the new pond acts as a population sink.

The completed Beaver Pond project has reduced the amount of stream habitat available prior to inundation by the reservoir but this is expected to have minimal effects on fish use of this area. Numerous small fish were captured at the stream mouth during construction (DWB 2014), a school of small fish was observed at the base of the berm during vegetation sampling in June 2014 (post-construction), and fish were captured downstream of the berm in 2015 and 2016. The potential for fish to become trapped in the wetland during years when reservoir levels exceed the height of the proposed berm was confirmed in 2015 with incidental observations of fish jumping in the new wetland and in 2016 with the completion of minnow trapping prior to inundation. The reservoir elevation was higher than the new wetland in both 2014 and 2015. The presence of fish jumping in 2015 and minnow trap captures in May 2016 indicates that the new wetland does offer suitable conditions for fish to overwinter. Early season fish sampling in the stream and the wetland will continue at this site to determine the extent of fish use of the constructed wetland.

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

For terrestrial and aquatic vegetation, the additional data collected in Year 6 provided a better characterization of the vegetation types that remain following the completion of the wetland enhancement project at the Beaver Pond site. Some of the vegetation habitat classes identified during the pre-construction surveys were flooded as a result of the wetland enhancement and were changed to aquatic habitat types. The completion of this project may for allow the development of aquatic vegetation that is currently non-existent.

For terrestrial and riparian vegetation, the wetland constructed at the Beaver Pond site has reduced the influence of reservoir conditions by creating a new area of permanently flooded habitat. However, vegetation communities above the wetland enhancement design elevations are expected to be primarily influenced by annual reservoir elevations. Changes in terrestrial and riparian vegetation communities as a result of the wetland enhancement are not expected.

Unlike the Airport Lagoon site, there was no existing aquatic vegetation at the Beaver Pond site to colonize the new wetland. The only potential source to colonize the new wetland would be the two beaver ponds located immediately upstream. However, little submergent vegetation has been observed in either of the two beaver ponds. The influence of the reservoir will also limit the establishment of submergent aquatic vegetation due to reduced light penetration once the site is inundated by the relatively turbid water in the reservoir.

Stabilization of the water regime was predicted to allow for development of wetland and riparian vegetation at the Beaver Pond site and therefore increase habitat availability for wildlife. If it occurs, the natural process of re-vegetation is likely to take several years and be limited by the large areas of bare ground immediately surrounding the new impoundment. The lower than designed elevation of the berm will also mean a greater influence of the reservoir on the site than was originally anticipated. Any longer term changes resulting from the enhancement may be small in magnitude and difficult to separate from reservoir influenced changes.

3. Is the area and quality of wildlife habitat created by the wetland enhancement maintained over time?

The completion of only two years of post-construction monitoring data for this project is considered insufficient to comment on the long term persistence and quality of habitat created at the Beaver Pond site. Post-construction changes at the site are ongoing. The smaller than planned size and the lower than planned elevation of the impoundment at the Beaver Pond site is a limiting factor in the quality of the wildlife habitat created. The area of the wetland habitat created has remained stable following construction and would be expected to remain for the life of the geosynthetic bags used to create the impoundment.

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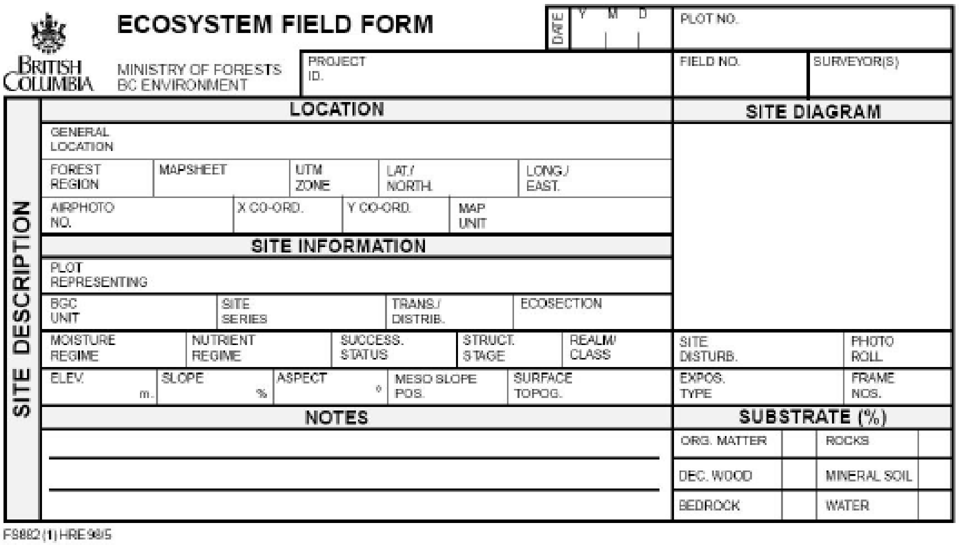
Appendix 1. Locations of vegetation belt-transects.

Site	Transect[1]	UTM Zone	Easting	Northing
Airport Lagoon	AL1-1	10U	492406	6125720
	AL1-2	10U	492404	6125703
	AL2-1	10U	492491	6125900
	AL2-2	10U	492490	6125882
	AL3-1	10U	492440	6126076
	AL3-2	10U	492456	6126064
	AL4-1	10U	492457	6126395
	AL4-2	10U	492465	6126375
	AL5-1	10U	492229	6126681
	AL5-2	10U	492249	6126686
	AL6-1	10U	492586	6126956
	AL6-2	10U	492601	6126947
	AL7-1	10U	492721	6126541
	AL7-2	10U	492723	6126524
	AL8-1	10U	492641	6125643
	AL8-2	10U	492638	6125664
	AL9-1	10U	492660	6125937
	AL9-2	10U	492661	6125918
	AL10-1	10U	492695	6126423
	AL10-2	10U	492698	6126442
	AL11-1	10U	492327	6126440
	AL11-2	10U	479231	6126428
	AL12-1	10U	492548	6126834
	AL12-2	10U	492548	6126853
Beaver Pond	BP1-1	10U	479296	6148230
	BP1-2	10U	479276	6148234
	BP2-1	10U	479313	6148248
	BP2-2	10U	479297	6148256
	BP3-1	10U	479335	6148268
	BP3-2	10U	479321	6148284
	BP4-1	10U	479307	6148277
	BP4-2	10U	479295	6148294
	BP5-1	10U	479243	6148225
	BP5-2	10U	479231	6148235

[1] -The '1' suffix denotes the beginning of a transect and the '2' suffix the end

.

Appendix 2. Ecosystem field forms used for ground sampling of vegetation polygons.



ECOSYSTEM FIELD FORM

DATE Y M D

PLOT NO.

BRITISH COLUMBIA
MINISTRY OF FORESTS
BC ENVIRONMENT

PROJECT ID.

FIELD NO.

SURVEYOR(S)

SITE DESCRIPTION

LOCATION

GENERAL LOCATION				
FOREST REGION	MAPSHEET	UTM ZONE	LAT./ NORTH.	LONG./ EAST.
AIRPHOTO NO.	X CO-ORD.	Y CO-ORD.	MAP UNIT	

SITE INFORMATION

PLOT REPRESENTING				
BGC UNIT	SITE SERIES	TRANS./ DISTRIB.	ECOSECTION	
MOISTURE REGIME	NUTRIENT REGIME	SUCCESS. STATUS	STRUCT. STAGE	REALM/ CLASS
ELEV. m.	SLOPE %	ASPECT °	MESO SLOPE POS.	SURFACE TOPOG.

NOTES

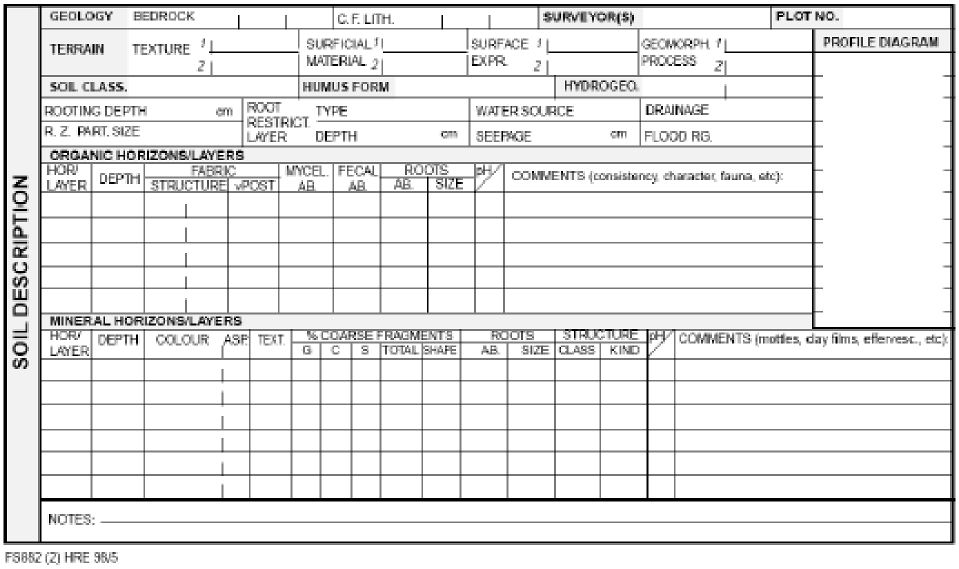
SITE DIAGRAM

SITE DISTURB.	PHOTO ROLL
EXPOS. TYPE	FRAME NOS.

SUBSTRATE (%)

ORG. MATTER		ROCKS	
DEC. WOOD		MINERAL SOIL	
BEDROCK		WATER	

FS882 (1) HRE 98/5



SOIL DESCRIPTION

GEOLOGY BEDROCK | C.F. LITH. | **SURVEYOR(S)** | **PLOT NO.**

TERRAIN TEXTURE 1 2 | SURFICIAL MATERIAL 1 2 | SURFACE EXPR. 1 2 | GEOMORPH. PROCESS 1 2

PROFILE DIAGRAM

SOIL CLASS. | **HUMUS FORM** | HYDROGEO.

ROOTING DEPTH cm	ROOT RESTRICT. LAYER	TYPE	WATER SOURCE	DRAINAGE
R. Z. PART. SIZE		DEPTH cm	SEEPAGE cm	FLOOD RG.

ORGANIC HORIZONS/LAYERS

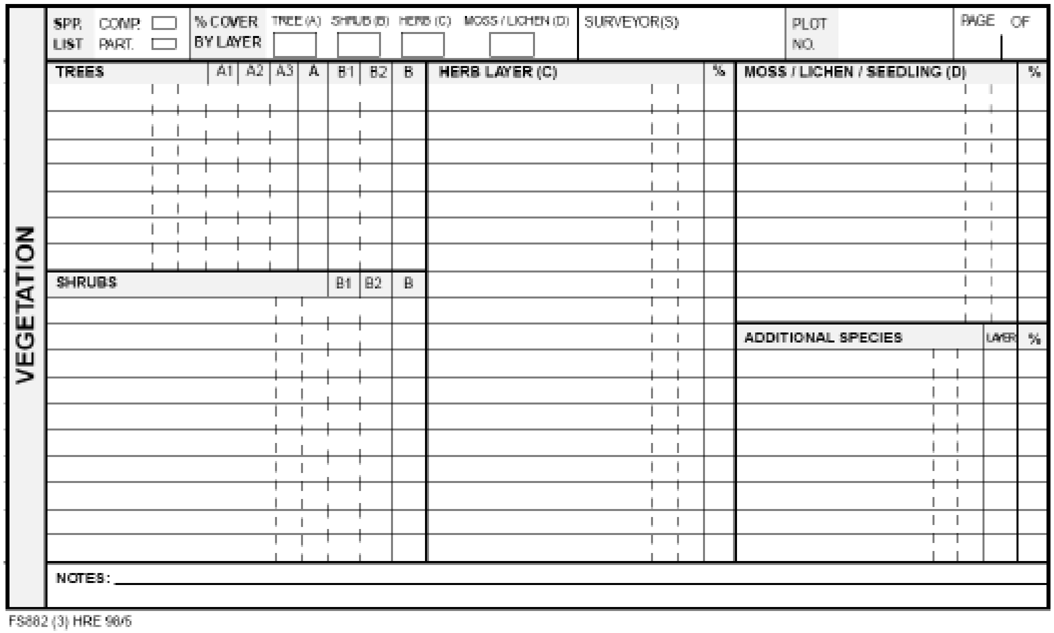
HOR/ LAYER	DEPTH	FABRIC		MYCEL. AB.	FECAL AB.	ROOTS		pH	COMMENTS (consistency, character, fauna, etc):
		STRUCTURE	vPOST			AB.	SIZE		

MINERAL HORIZONS/LAYERS

HOR/ LAYER	DEPTH	COLOUR	ASP.	TEXT.	% COARSE FRAGMENTS					ROOTS		STRUCTURE		pH	COMMENTS (mottles, clay films, effervesc., etc):
					G	C	S	TOTAL	SHAPE	AB.	SIZE	CLASS	KIND		

NOTES:

FS882 (2) HRE 98/5



VEGETATION

SPP. LIST COMP. ☐ PART. ☐

% COVER BY LAYER TREE (A) ☐ SHRUB (B) ☐ HERB (C) ☐ MOSS / LICHEN (D) ☐

SURVEYOR(S)

PLOT NO.

PAGE OF

TREES	A1	A2	A3	A	B1	B2	B

SHRUBS	B1	B2	B

HERB LAYER (C)	%

MOSS / LICHEN / SEEDLING (D)	%

ADDITIONAL SPECIES	LAYER	%

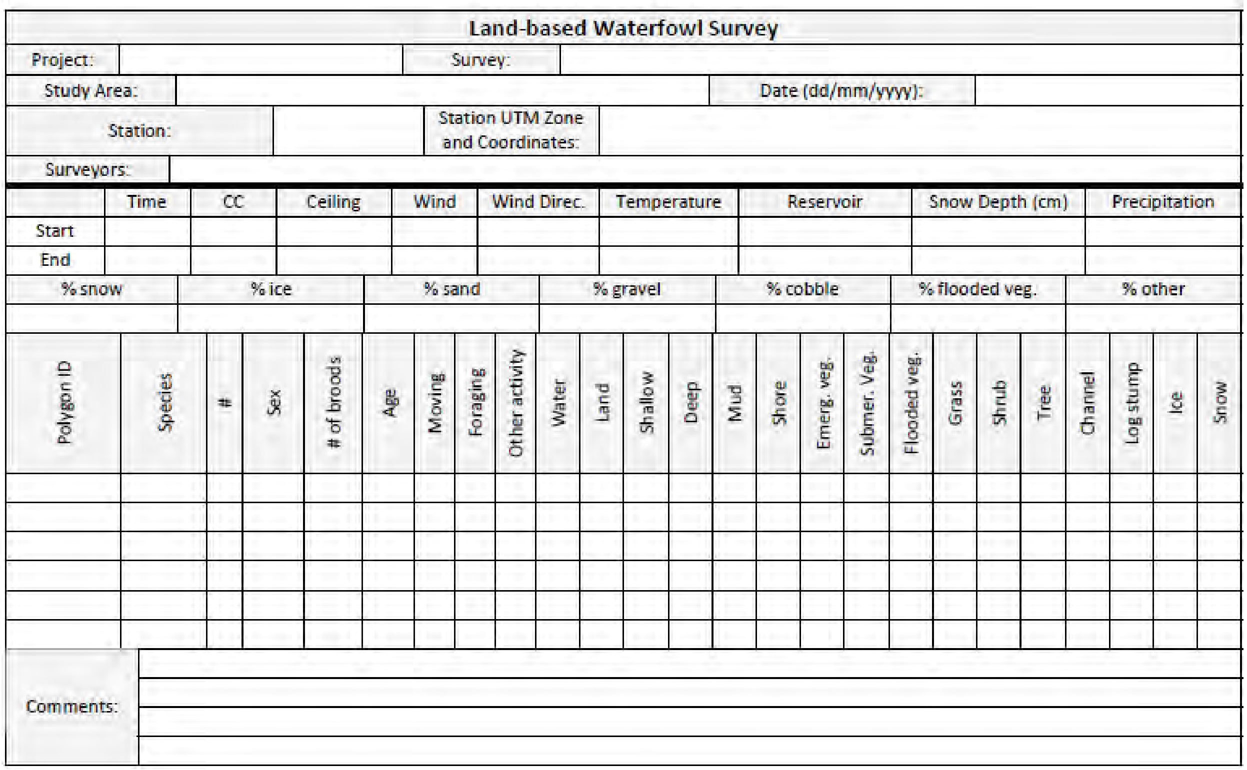
NOTES:

FS882 (3) HRE 98/5

Appendix 3. Waterfowl survey station UTM coordinates on Williston Reservoir, BC.

Site	Station	UTM Zone	Easting	Northing
Airport Lagoon	WSP-01	10U	492643	6125394
	WSP-02	10U	492468	6126031
	WSP-04	10U	492112	6126506
	WSP-03	10U	492426	6126227
	WSP-06	10U	492500	6126710
Beaver Pond	WSP-05	10U	479160	6148304

Appendix 4. Field form and site maps for waterfowl surveys.



Land-based Waterfowl Survey

Project:		Survey:	
Study Area:		Date (dd/mm/yyyy):	
Station:		Station UTM Zone and Coordinates:	
Surveyors:			

	Time	CC	Ceiling	Wind	Wind Direc.	Temperature	Reservoir	Snow Depth (cm)	Precipitation
Start									
End									

% snow	% ice	% sand	% gravel	% cobble	% flooded veg.	% other

Polygon ID	Species	#	Sex	# of broods	Age	Moving	Foraging	Other activity	Water	Land	Shallow	Deep	Mud	Shore	Emerg. veg.	Submer. Veg.	Flooded veg.	Grass	Shrub	Tree	Channel	Log stump	Ice	Snow

Comments:

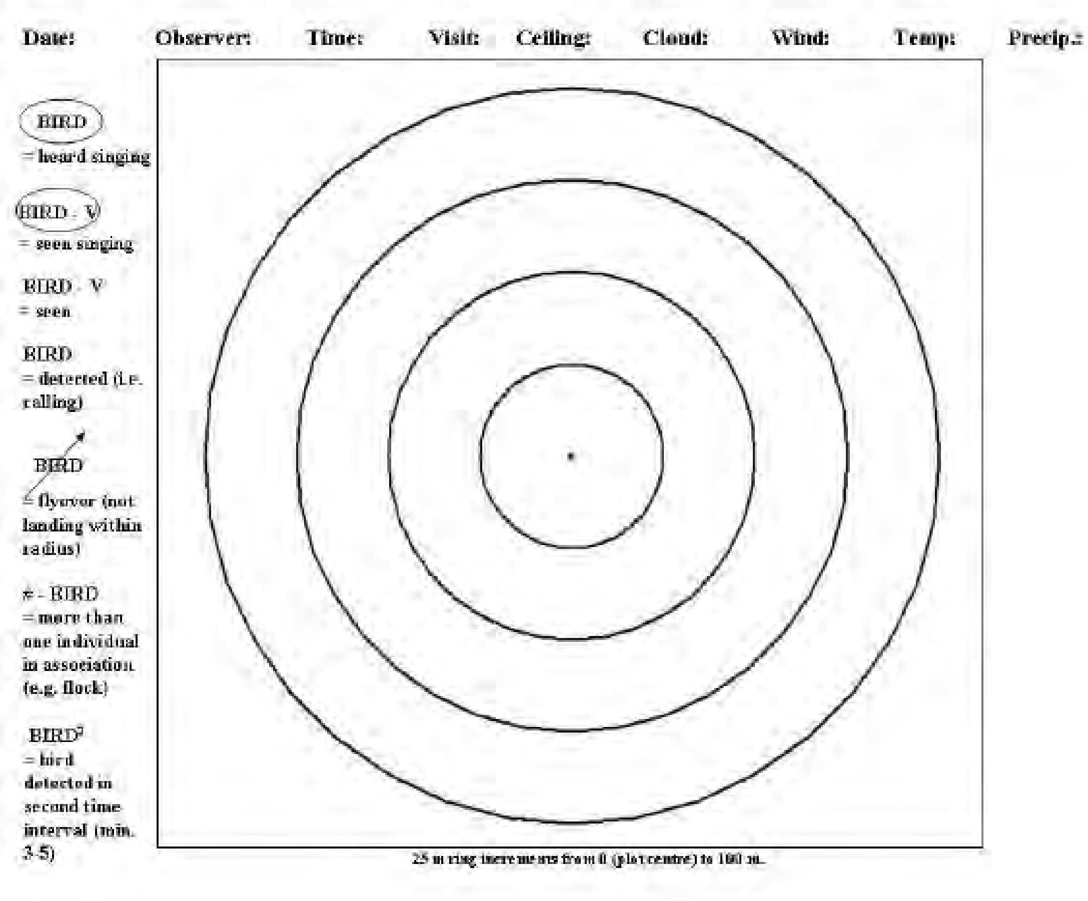

0 0.125 0.25 Kilometers


Beaver Pond
0 0.05 0.1 Kilometers
N

Appendix 5. UTM coordinates of point count stations at the Airport Lagoon and Beaver Pond sites on Williston Reservoir, BC.

Site	Point Count Station	UTM Zone	Easting	Northing
Airport Lagoon	AL-01	10U	492671	6125451
	AL-02	10U	492668	6125665
	AL-03	10U	492642	6125864
	AL-04	10U	492643	6126067
	AL-05	10U	492633	6126265
	AL-06	10U	492693	6126475
	AL-07	10U	492695	6126683
	AL-08	10U	492636	6126885
	AL-09	10U	492554	6127065
	AL-10	10U	492531	6126696
	AL-11	10U	492331	6126631
	AL-12	10U	492271	6126432
	AL-13	10U	492418	6126266
	AL-14	10U	492493	6126056
	AL-15	10U	492441	6125850
	AL-16	10U	492385	6125643
	AL-17	10U	492523	6125474
Beaver Pond	BP-01	10U	479204	6148354
	BP-02	10U	479387	6148249
	BP-03	10U	479264	6148207

Appendix 6. Field form for breeding bird surveys.



Date: **Observer:** **Time:** **Visit:** **Ceiling:** **Cloud:** **Wind:** **Temp:** **Precip.:**

BIRD = heard singing

BIRD - V = seen singing

BIRD - V = seen

BIRD = detected (i.e. calling)

BIRD = flyover (not landing within radius)

- BIRD = more than one individual in association (e.g. flock)

BIRD² = bird detected in second time interval (min. 3-5)

25 m ring increments from 0 (plot centre) to 100 m.

Appendix 7. Environmental variable codes and definitions for breeding bird surveys.

Ceiling:
The height of cloud cover. Record the average height of clouds during the survey.

ATT = Above Tree-tops
BTT = Below Tree-tops
AR = Above Ridge
BR = Below Ridge
H = High
VH = Very High

Cloud Cover (CC):
The extent of cloud cover during the survey period.

1 = clear, 0% cloud cover
2 = scattered clouds, <50% cloud cover
3 = scattered clouds, >50% cloud cover
4 = unbroken clouds, 100% cloud cover

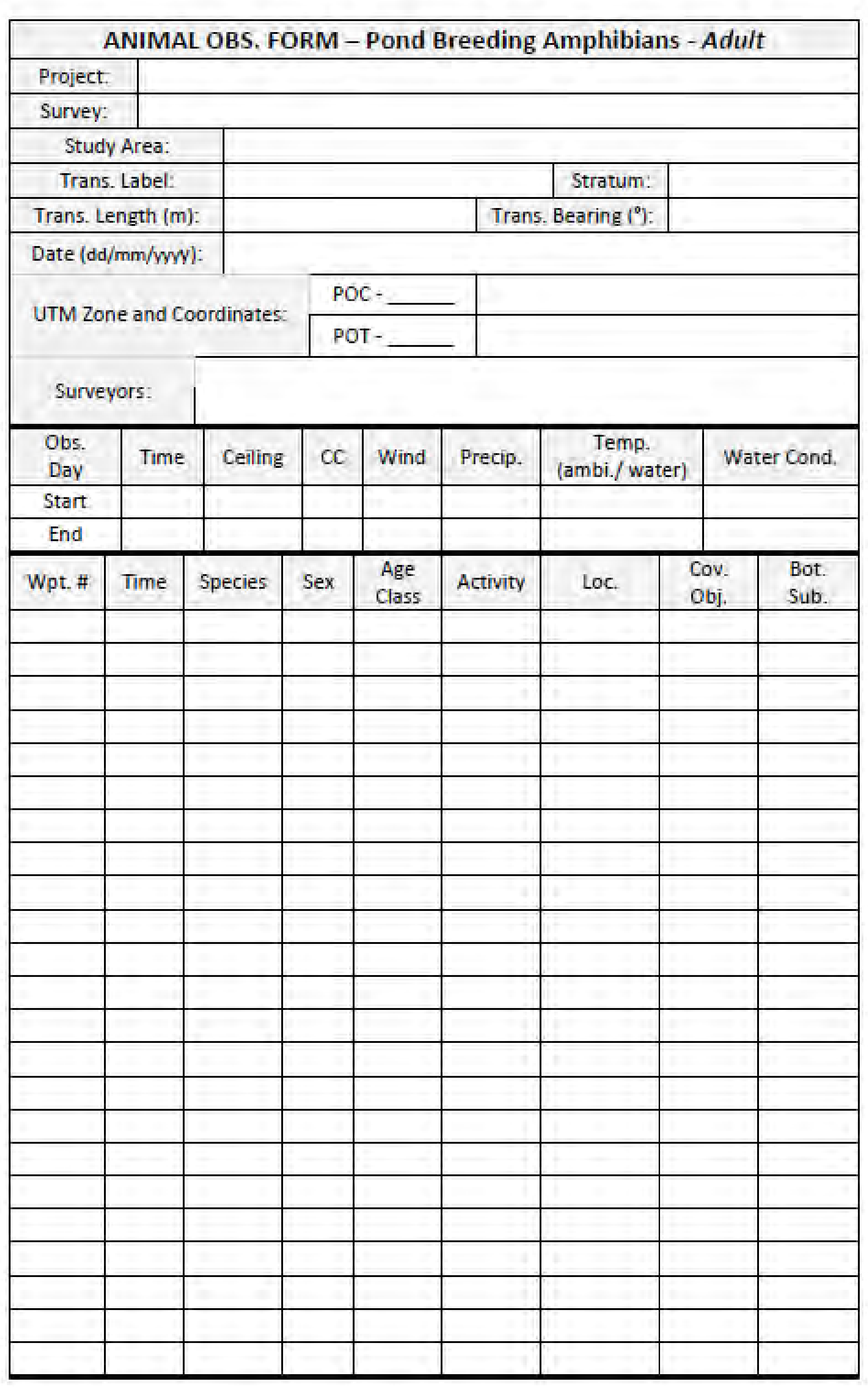
Wind:
The strength of the dominant wind over the survey period using the Beaufort Scale. If wind strength split evenly between 1 or more classes, choose that which best characterized the conditions and detectability of birds. Acceptable conditions are Winds 0-3. >3 is considered unacceptable for conducting point counts.

0 = calm (<2 km/h)
1 = light air (2-5 km/h)
2 = light breeze, leaves rustle (6-12 km/h)
3 = gentle breeze, leaves and twigs constantly move (13-19 km/h)
4 = moderate breeze, small branches move, dust rises (20-29 km/h)
5 = fresh breeze, small trees sway (30-39 km/h)
6 = strong breeze, large branches moving, wind whistling (40-49 km/h)
7 = moderate gale+, whole trees in motion (≥50 km/h)

Precipitation:
The type of precipitation (if any) during the survey period. Acceptable conditions are no rain through very light drizzle.

N = None
F = Fog
M = Misty Drizzle
D = Drizzle
LR = Light Rain
HR = Hard Rain
LS = Light Snow/Flurries
HS = Heavy Snow

Appendix 8. Field form for systematic amphibian surveys.



ANIMAL OBS. FORM – Pond Breeding Amphibians - *Adult*

Project:

Survey:

Study Area:

Trans. Label: Stratum:

Trans. Length (m): Trans. Bearing (°):

Date (dd/mm/yyyy):

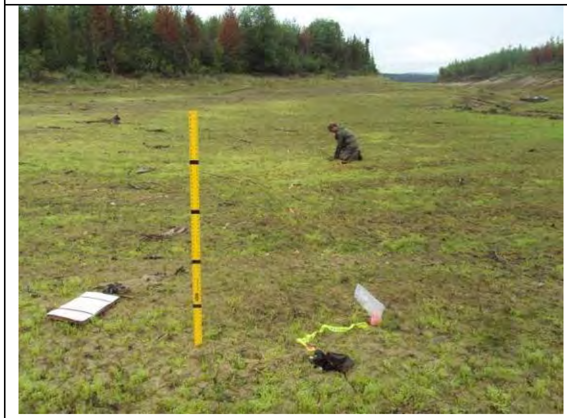
UTM Zone and Coordinates: POC - ______ POT - ______

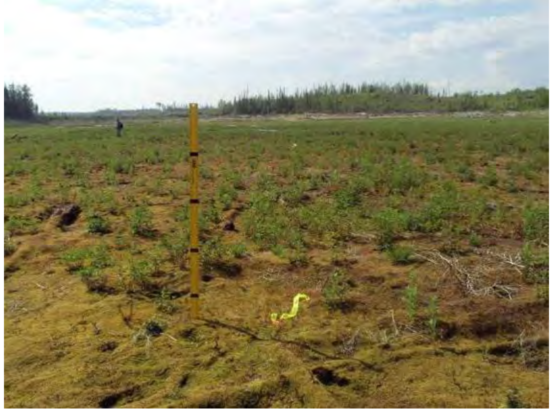
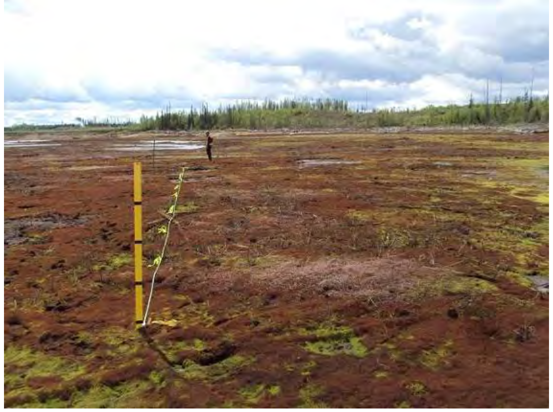
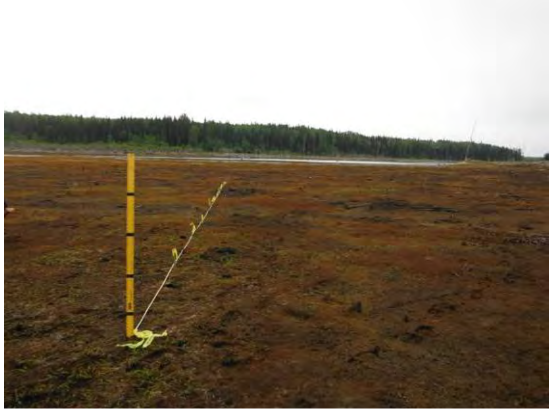
Surveyors:

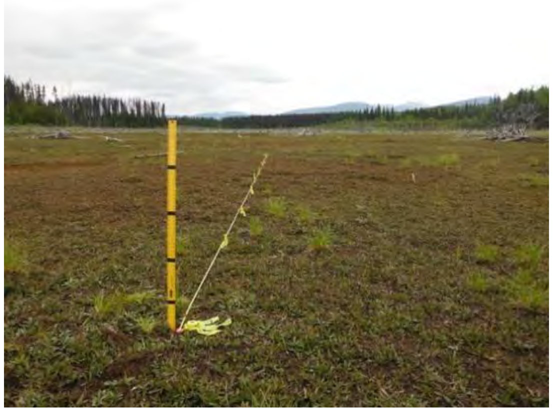
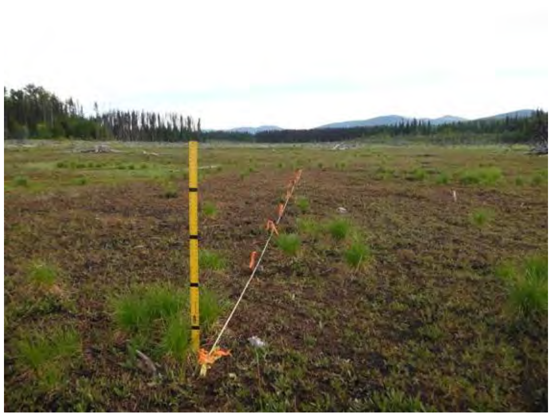
Obs. Day	Time	Ceiling	CC	Wind	Precip.	Temp. (ambi./ water)	Water Cond.
Start							
End							

Wpt. #	Time	Species	Sex	Age Class	Activity	Loc.	Cov. Obj.	Bot. Sub.

Appendix 9. Habitat class descriptions in the draw-down zone at the Airport Lagoon and Beaver Pond sites.

<table>
<tr><th>Habitat Class</th><th colspan="3">Representative Photographs</th></tr>
<tr><td rowspan="6">BC</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 colspan="3">Description</td></tr>
<tr><td colspan="3">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 (<i>Cryptantha torreyana</i>), purslane speedwell (<i>Veronica peregrina</i> var. <i>xalapensis</i>), red sand-spurry (<i>Spergularia rubra</i>) and Arctic pearlwort (<i>Sagina saginoides</i>). 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.</td></tr>
</table>

<table>
<tr><th>Habitat Class</th><th colspan="3">Representative Photographs</th></tr>
<tr><td rowspan="5">BM</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>Picture Not Available</td><td></td></tr>
<tr><td colspan="3">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 (<i>Persicaria maculosa</i>), water smartweed (<i>Persicaria amphibia</i>), common mare’s-tail (<i>Hippularis vulgaris</i>) and Norwegian cinquefoil (<i>Potentilla norvegica</i>). 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.</td></tr>
</table>

<table>
<tr><th>Habitat Class</th><th colspan="3">Representative Photographs</th></tr>
<tr><td rowspan="6">BS</td><td>2011</td><td>2012</td><td>2013</td></tr>
<tr><td></td><td>Picture Not Available</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 colspan="3">Description</td></tr>
<tr><td colspan="3">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.</td></tr>
</table>

<table>
<tr><th>Habitat Class</th><th colspan="3">Representative Photographs</th></tr>
<tr><td rowspan="3">FI</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="3">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 (<i>Callitriche palustris</i>), purple-leaved willowherb (<i>Epilobium ciliatum ssp. ciliatum</i>) 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 (<i>Salix</i> spp.), have become well established on the islands.</td></tr>
</table>

Habitat Class	**Representative Photographs**		
SC			
	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		
SD	2011	2012	2013
			
	2014	2015	2016
			
	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.		

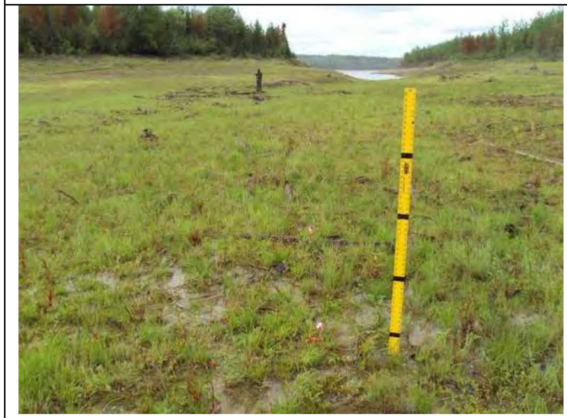
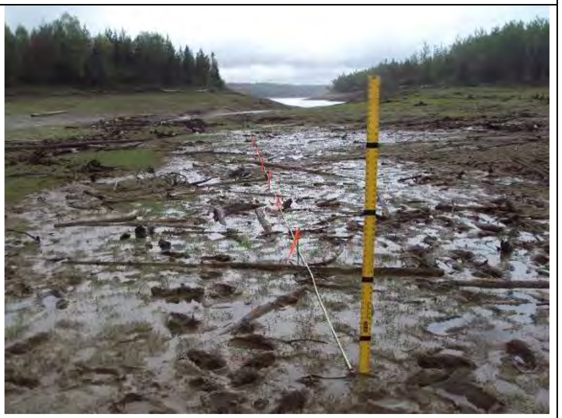
<table>
<tr><th>Habitat Class</th><th colspan="3">Representative Photographs</th></tr>
<tr><td rowspan="4">SG</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="3">Description</td></tr>
<tr><td colspan="3">Shoreline Grassland (SG): Very high grass dominated vegetation 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 (<i>Geum macrophyllum</i> ssp. <i>perincisum</i>) and a few unidentified grasses.</td></tr>
</table>

<table>
<tr><th>Habitat Class</th><th colspan="3">Representative Photographs</th></tr>
<tr><td rowspan="6">SR</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 colspan="3">Description</td></tr>
<tr><td colspan="3">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 (<i>Carex aenea</i>), 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).</td></tr>
</table>

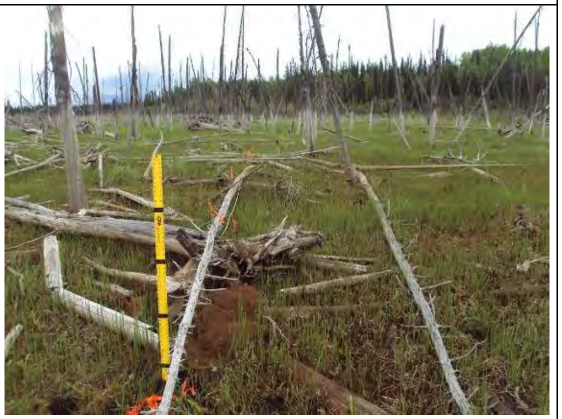
Habitat Class	Representative Photographs		
SS	**2011**	**2012**	**2013**
			
	2014	**2015**	**2016**
			
	Description		
	Shoreline Sand (SS): Sparse herbaceous vegetation cover with low (5 to 15%) coarse woody debris cover on a gentle to moderate (15 to 26°) sloping surface expression. Common species 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.		

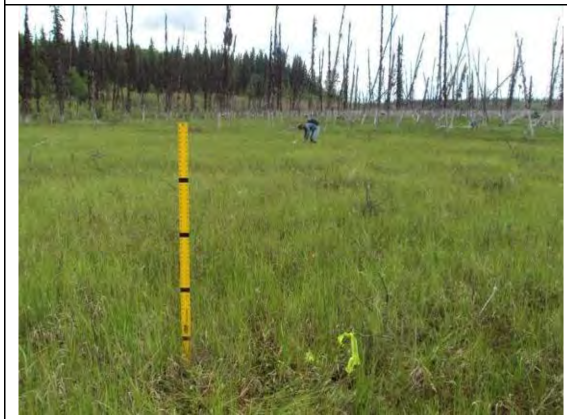
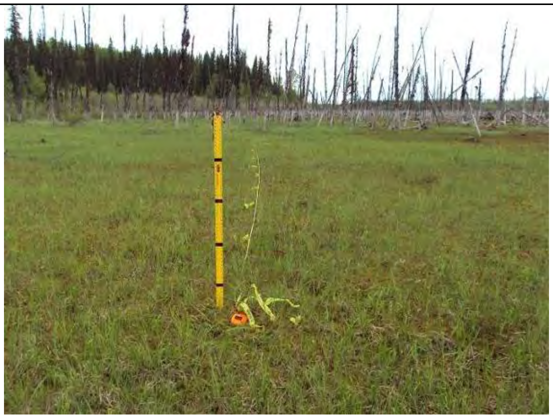
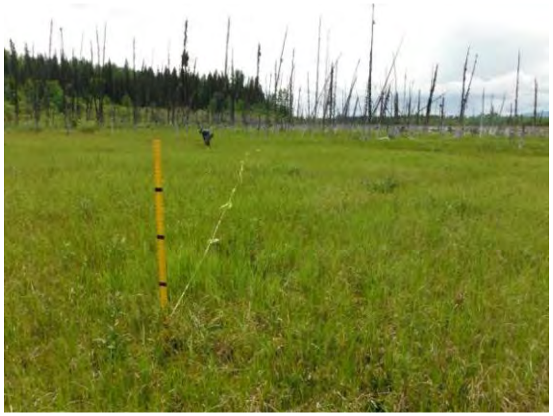
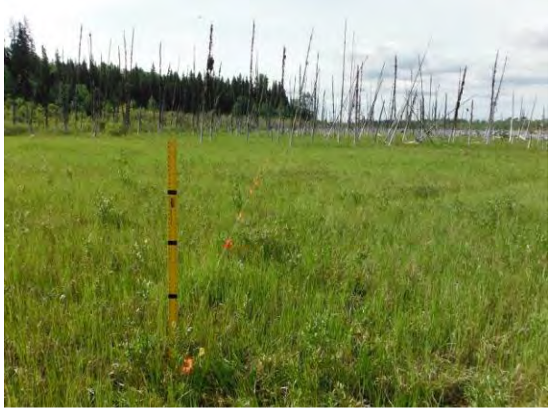
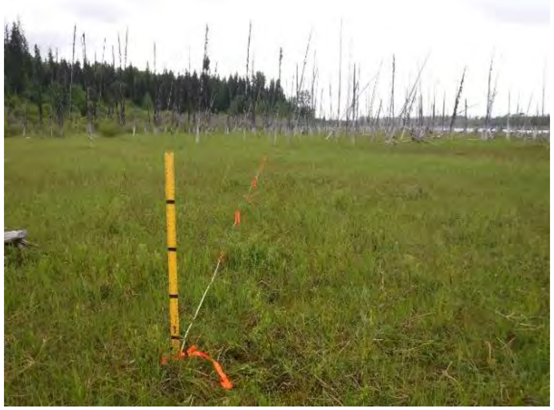
Habitat Class	**Representative Photographs**		
SW	**2011**	**2012**	**2013**
			
	2014	**2015**	**2016**
			
	Description		
	Shoreline Willow (SW): High grass and shrub dominated vegetation cover with high coarse woody debris cover on a gently to moderate sloping surface expression. Common species include 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		
SP			
			
	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		
SE	**2011**	**2012**	**2013**
			
	2014	**2015**	**2016**
	Picture Not Available	Picture Not Available	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
WD	   
	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</th></tr>
<tr><td rowspan="6">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 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>

<table>
<tr><th>Habitat Class</th><th colspan="3">Representative Photographs</th></tr>
<tr><td rowspan="6">WS</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 colspan="3">Description</td></tr>
<tr><td colspan="3">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 [<i>Carex</i> spp.]), swamp horsetail (<i>Equisetum fluviatile</i>), small bedstraw (<i>Galium trifidum</i>), water smartweed (<i>Persicaria amphibia</i>), common mare's-tail (<i>Hippuris vulgaris</i>) and buckbean (<i>Menyanthes trifoliata</i>). 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.</td></tr>
</table>

Habitat Class	Representative Photographs		
WW			
	Description		
	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.		

Appendix 10. Summary of percent cover by plant species averaged across 10 quadrats in a 20 m belt-transect for vegetation transects sampled in Year 6 at Airport Lagoon and Beaver Pond study sites.

Group	Species	Transect										Total
		AL3	AL5	AL6	AL7	AL9	AL10	AL12	BP3	BP4	BP5	
Herbs/Forbs/ Graminoids	bluejoint	0	4.3	0	0	0	0.8	0	0	0	0	**5.1**
	spring water-starwort	0.1	0	0	0	0	0	0	0	3.1	0	**3.2**
	sedge	0	0	0.6	5.5	0.1	0.1	0.3	3.2	0	0.3	**10**
	lamb's-quarters	0	0	0	0	0	0	0	0.2	0	0	**0.2**
	Torreys cryptantha	0	0	0	0	0	0	0	0.5	0	1.2	**1.6**
	common spike-rush	0	0	0.1	0.6	0	0	0	0	0	0	**0.7**
	common horsetail	0	1.1	0	0	0.8	0	0	0.9	0	2.5	**5.3**
	swamp horsetail	0	0	19.3	0.5	0	10.6	0	0	0	0	**30.4**
	small bedstraw	0	0	9	0	0.1	4.5	0.1	0	0	0.1	**13.7**
	grass family	0	0.3	1.7	7	2.6	8.9	0	0	0	0.4	**20.9**
	common mare's-tail	0	0	0.1	0	0	0	0	0	0	0	**0.1**
	pineapple weed	0.1	0	0	0	0	0	0	0	0.1	0	**0.2**
	buckbean	0	0	0	6.2	0	0	0	0	0	0	**6.2**
	water smartweed	0.1	2.6	13.4	3.6	1.8	2.1	27.3	0	0	0.1	**50.9**
	lady's thumb	6.7	0	0	0	0.1	0.1	0	0.2	0.1	0	**7.1**
	bluegrass	0.1	0	0	0	0	0	0	0	2.2	0	**2.2**
	marsh cinquefoil	0	0	0	7.1	0	0.7	0	0	0	0	**7.8**
	little yellowrattle	0	0	0	0	0	0	0	0	0	0.1	**0.1**
	marsh yellow cress	0.4	0.1	0	0	0	0.5	0	0	0	0	**1**
	arctic pearlwort	0	0	0	0	0	0	0	0.1	3.2	0.1	**3.4**
	red sand-spurry	0	0	0	0	0	0	0	2.5	0	0	**2.5**
	UNKN20	0.1	1.1	0	0	0	0	0	0	0	0	**1.2**
	UNKN21	0.1	1	0	0	0	0	0	0.5	0	0	**1.5**
	UNKN26	0	0	3.8	0	0	0	0	0	0	0	**3.8**
	UNKN32	0	0	0	0	0	0	0	0.1	0	0	**0.1**
	UNKN37	0	0	0	0	0	0.1	0	0	0	0	**0.1**
	UNKN40	0.1	0	0	0	0	0	0	0.3	0.1	0	**0.5**
	UNKN41	0	0.4	0	0	0.1	0	0	0	0.1	0.1	**0.6**
	UNKN42	0	0	0	0	0	0	0	0	0.2	0	**0.2**
	UNKN46	0	0	0	0	0	0	0	0.1	0	0	**0.1**
	UNKN49	0.1	0	0	0	0	0	0	0	0	0	**0.1**
	UNKN50	0	0	0	0	0	0	0	0	0.1	0	**0.1**
	UNKN73	0	1	0	0	0	0	0	0	0	0	**1**
	UNKN137	0	0.2	0	0	0	0	0	0	0	0	**0.2**

Group	**Species**	**Transect**										**Total**
		AL3	**AL5**	**AL6**	**AL7**	**AL9**	**AL10**	**AL12**	**BP3**	**BP4**	**BP5**	
	UNKN138	0	0.1	0	0	0	0.2	0.4	0	0	0	**0.7**
	UNKN140	0	0	0	0	0	0.1	0	0	0	0.6	**0.7**
	UNKN142	0	0	0	0	0	0	0	0	0.1	0	**0.1**
	UNKN144	0	0	0	0	0.1	0	0	0	0	0	**0.1**
	Herb/Forb/Graminoid Total	**7.8**	**12**	**47.9**	**30.5**	**5.7**	**28.5**	**28**	**8.5**	**9.3**	**5.5**	
Moss	marsh thread moss	0	0	0	0	0.3	5.8	0	0	0	0	**6.1**
	giant calliergon moss	0	0	0	88.7	0	0	0	0	0	0	**88.7**
	tree moss	0	0	0	0	0	0.2	0	0	0	0	**0.2**
	common hook-moss	0	0	7.4	5.7	1.7	0.5	0	0	0	0	**15.3**
	fertile feathermoss	0	0	0	0	0	23.9	0	0	0	0	**23.9**
	UNKN34	0	0	0	0	0.1	0	0	0	0	0	**0.1**
	Moss Total	**0**	**0**	**7.4**	**94.4**	**2.1**	**30.4**	**0**	**0**	**0**	**0**	
Shrubs	willow	0	0	0	2.6	0	1.5	0	0	0	0	**4.1**
	Shrub Total	**0**	**0**	**0**	**2.6**	**0**	**1.5**	**0**	**0**	**0**	**0**	

Values represent the number of species and the average % cover for each vegetation transect based on plot surveys completed in 2016.

Appendix 11. Summary of the presence/not-detected of aquatic plant species at dredge points sampled in Year 6 at Airport Lagoon.

Species	Dredge Point[1]																	
	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17	D18
common hook-moss	-	-	-	-	-	-	-	P	P	P	P	P	-	P	P	P	-	-
long-stalked pondweed	-	-	-	-	-	P	P	-	-	-	-	-	-	-	-	-	-	-
closed-leaved pondweed	-	-	P	-	P	P	-	-	P	P	P	P	P	P	P		-	-
verticillate water-milfoil	-	-	P	-	P	P	-	-	-		P		-	-	-	-	-	-
spring water-starwort	P	P	-	-	-	-	P	-	-	-	-	-	-	-	-	-	-	-
common mare's-tail	P		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
common bladderwort	-	P	-	-	-	-	-	-	P	-	-	-	-	-	-	-	-	-
common hornwort	-	-	P	P	P		-	-	P	-	-	-	P	-	-	-	-	P
stonewort	-	-	P		P	P	-	-	P	-	-	-	-	-	-	-	-	-

[1] For each dredge location (D), species were either present (P) or not-detected (-).

Appendix 12. Summary of waterfowl and shorebird observations in 2011, 2012, 2014, 2015, and 2016 at the Airport Lagoon site, Williston Reservoir, BC. Shorebirds were not a component of the 2011 surveys.

Waterfowl

	2011				2012					2013					2014					2015					2016				
	May 9	**May 22**	**June 7**	**Total**	**May 1**	**May 9**	**May 16**	**May 31**	**Total**	**May 1**	**May 12**	**May 25**	**June 10**	**Total**	**May 1**	**May 11**	**May 2**	**June 2**	**Total**	**May 1**	**May 7**	**May 19**	**May 31**	**Total**	**April 29**	**May 10**	**May 21**	**May 31**	**Total**
Greater White-fronted Goose	1			1																									
Canada Goose	35	8	27	70	19	5	7	18	49	12	2	10	10	34	6	4	2	7	19	12	8	19	11	50	6	2	4	14	26
American Widgeon	37			37	34		4		38	44			2	46	26	6	14	1	47	22	39	4		65	28	8	8	8	52
Mallard	6	4	4	14	9		3		12	49	3	7	30	89	16	42	25	14	97	6	8	11		25	2	4	2	3	11
Blue-winged Teal		3		3				1	1		14	2	3	19		1	7	3	11		3	2		15		3	5		8
Cinnamon Teal		1		1							1			1															
Northern Shoveler	4	2	3	9	12		4		16	3	1	2	2	8	8	6	3		17	1		8	1	10	8	4	11	8	31
Northern Pintail			1	1	9	6			15	5		2	5	12	18	9	3	2	32	4	12	2	8	26	4	4	4		12
Green-winged Teal	4	2		6	18	5	4		27	85	2		5	92	24	3	1		28	8	25	1		34	12	4	4		20
Canvasback						2			2								1		1						4	1			5
Ring-necked Duck	35	4	2	41	49				49	33				33	10	6	15	4	35	2	15	1		28		8			8
Lesser Scaup	15	3		18	6				6						9				9		2	2		4					
Greater Scaup																	1		1						1				1
Bufflehead	5	4		9	7				7	22	1			23	5	2	1		8		3	1		4	2	6			8
Barrow's Goldeneye	4			4	1				1	17				17	6				6										
Common Goldeneye																3			3										
Hooded Merganser					2				2								1		1			1		1					
Common Merganser					10				10	13				13						4	2			6	2				2
Red-breasted Merganser																		1	1										
Common Loon						1	1		2							1		2	3	1		1	1	3			2	2	4
Gadwall																					2	2		4			6	3	9
Redhead																						2		2					
Red-necked Grebe	5	2		7	1				1																				
Trumpeter Swan															1				1								2		2
Totals	**151**	**33**	**37**	**221**	**177**	**19**	**23**	**19**	**238**	**283**	**24**	**23**	**57**	**387**	**129**	**83**	**74**	**34**	**320**	**60**	**119**	**57**	**21**	**277**	**69**	**44**	**48**	**38**	**199**

Shorebirds

	2012					2013					2014					2015					2016				
	May 1	**May 9**	**May 16**	**May 31**	**Total**	**May 1**	**May 12**	**May 25**	**June 1**	**Total**	**May 1**	**May 11**	**May 20**	**June 2**	**Total**	**May 1**	**May 7**	**May 19**	**May 31**	**Total**	**April 29**	**May 10**	**May 21**	**May 31**	**Total**
Semipalmated Plover		4	3		7		1			1					0			1		1			2		2
Killdeer		4	1	2	7	3	1	1	3	8	2	4	7	3	16	2	5	2	1	10	2	10	8	2	22
Spotted Sandpiper			3	1	4		1	1	3	5	1		4		5		1	2	4	7			3		3
Greater Yellowlegs			6	4	12	3				3	5		5		10	6	9	8	5	28		2			2
Lesser Yellowlegs	7		13		20		5	3		8	5	8	8		21	1	2	4		7	5	7	7		19
Semipalmated Sandpiper		6	1		7		5			5			3		3					0	1				1
Pectoral Sandpiper													3		3					0		1	1		2
Long-billed Dowitcher			68		68							5	3		8		4			4		30		1	31
Wilson's Phalarope													2		2			3		3					
Least Sandpiper																		2		2		16			16
American Golden Plover																						1			1
Totals	**7**	**14**	**95**	**7**	**125**	**6**	**13**	**5**	**6**	**30**	**13**	**17**	**35**	**3**	**68**	**9**	**21**	**22**	**10**	**62**	**8**	**67**	**21**	**3**	**99**

* – Shorebirds were not a component of the 2011 surveys.

Appendix 13. **Summary of bird detections by point count station in 2016 across three replicates at the Airport Lagoon site and two replicates at the Beaver Pond site, Williston Reservoir, BC.**

Airport Lagoon

Species	Point Count Station																	Species Totals
	AL-01	AL-02	AL-03	AL-04	AL-05	AL-06	AL-07	AL-08	AL-09	AL-10	AL-11	AL-12	AL-13	AL-14	AL-15	AL-16	AL-17	
Canada Goose		4		4		8	4		2	3			2			5	2	34
Trumpeter Swan					1													1
Mallard				1										1				2
Blue-winged Teal												2	2					4
Green-winged Teal													2					2
Northern Shoveler		2											3					5
American Wigeon						6												6
Common Loon					1										2			3
Osprey		1	3	1	2		1	2	1		1	1		1	2	1		17
Bald Eagle										2			1					3
Red-tailed Hawk								1										1
Killdeer									1	1	3	3	3					11
Lesser Yellowlegs							5			5		5	1					16
Spotted Sandpiper		4		1	1		1		1		1		1		1	1		12
Wilson's Snipe								1	1		1							3
Ring-billed Gull		1			4			5					3					13
Belted Kingfisher		1				1							1				1	4
Downy Woodpecker	1																2	3

Species	Point Count Station																	Species Totals
	AL-01	AL-02	AL-03	AL-04	AL-05	AL-06	AL-07	AL-08	AL-09	AL-10	AL-11	AL-12	AL-13	AL-14	AL-15	AL-16	AL-17	
Red-breasted Sapsucker			1															1
Northern Flicker	2	1											2			1	1	7
Alder Flycatcher						1	1								1			3
Least Flycatcher					1	1												2
Olive-sided Flycatcher												1						1
Dusky Flycatcher													1	1	3	2	1	8
Western Wood-Pewee							1											1
Warbling Vireo					1	2		2		1		1	2	2			1	12
American Crow							7					1	10					18
Common Raven		2	2	1	1	1					5	2		1	1			16
Tree Swallow					10	7		1		4			8	2				32
Northern Rough-winged Swallow														2				2
Barn Swallow	2				1										2			5
Violet Green Swallow		3					3			6		2		1	3			18
Black-capped Chickadee				1											1			2
Red-breasted Nuthatch	1																	1
Ruby-crowned Kinglet	3			1							1							5
Swainson's Thrush	1						1				1	1	1			1	2	8
Hermit Thrush														1				1
American Robin	4	1				2	2	4	2	2	4	1	2	2	1	2	1	30
Mountain Bluebird							1									1		2
Tennessee Warbler		1	1	4	3	2	3	1	2		1	1						19
Orange-crowned Warbler	1		3		1		1			2	1	2		2			1	14

Species	**Point Count Station**																	**Species Totals**
	AL-01	**AL-02**	**AL-03**	**AL-04**	**AL-05**	**AL-06**	**AL-07**	**AL-08**	**AL-09**	**AL-10**	**AL-11**	**AL-12**	**AL-13**	**AL-14**	**AL-15**	**AL-16**	**AL-17**	
Yellow Warbler					1			1	1		1	1						5
Magnolia Warbler	1		1															2
Yellow-rumped Warbler		1		1	1	1		2			2	1		1			1	11
Townsend's Warbler						1												1
American Redstart	4	1		2	1			3				1					1	13
Northern Waterthrush	2	2				1	1	1	1			2		1		1	2	14
Wilson's Warbler	1				1													2
Chipping Sparrow		2			1	1	2	1				1		1	2			11
Savannah Sparrow									1	1								2
White-crowned Sparrow															2			2
Lincoln's Sparrow				1	2	1	1	1	3	1		1		1			1	13
White-throated Sparrow	2	1	1	1				1			1		1			1	1	10
Dark-eyed Junco	1		1	3	2	1		1	1	1	3	1		1	2		1	19
Western Tanager	1				1		1	1							1			5
Brown-headed Cowbird									1								1	2
Rusty Blackbird							1											1
European Starling		1																1
Station Totals	27	29	13	22	37	37	37	29	18	29	26	31	46	21	24	16	20	462

Beaver Pond

Species	**Point Count Station**			**Species Totals**
	BP-01	**BP-02**	**BP-03**	
Ruffed Grouse	1		1	2
Killdeer	1	1		2
Belted Kingfisher		1		1
Dusky Flycatcher	1			1
Warbling Vireo			1	1
Tree Swallow			2	2
American Robin	1	1	1	3
Swainson's Thrush			1	1
Tennessee Warbler	2	1	1	4
Orange-crowned Warbler		2		2
Yellow-rumped Warbler	1	1	1	3
American Redstart	2		2	4
Chipping Sparrow			2	2
Song Sparrow		1		1
Lincoln's Sparrow		1	2	3
White-throated Sparrow			2	2
Dark-eyed Junco		2		2
Station Totals	9	11	16	36

Appendix 14. Summary of adult and juvenile amphibian detections with survey effort 2011 - 2016 at the Airport Lagoon and Beaver Pond sites.

Airport Lagoon

Transect	Species																								Survey Effort (h:mm)					
	Western Toad						Wood Frog						Columbia Spotted Frog						Long-toed Salamander											
	2011	2012	2013	2014	2015	2106	2011	2012	2013	2014	2015	1016	2011	2012	2013	2014	2015	2016	2011	2012	2013	2014	2015	2016	2011	2012	2013	2014	2015	2016
2[a]																									0:17	0:55	0:31	0:35	0:35	0:27
3[a]	1																								0:21	0:33	0:58	0:32	0:30	0:28
7[a]		1					1														1				0:29	0:56	0:33	0:44	0:18	0:38
10[a]	2		3																						0:22	0:55	1:19	0:33	0:34	0:31
14[a]	2																								0:27	1:04	0:50	0:55	0:23	0:46
25	7	4	6	72	23	4										1				2		1			0:51	1:33	1:31	2:08	1:14	1:16
28																									0:29	0:43	1:02	0:51	0:42	0:40
32[a]	1	1	1	2																			1		0:24	0:52	0:40	1:09	0:44	0:38
35		1																							0:29	0:43	0:42	0:39	0:27	0:38
37[a]	3				3																1				0:22	0:27	0:42	0:48	0:50	0:37
40[a]					1																1	2			0:29	0:46	0:31	0:55	1:09	0:38
	16	7	10	74	27	4	1									1				2	3	3	1		5:00	9:27	9:19	9:49	7:26	7:37

[a] - Transect adjusted in 2014 to accommodate post-construction water levels.

Beaver Pond

Species	2011	2012	2013	2014	2015	2016
Western Toad	3	1	2	9	82	50
Wood Frog	10				4	2
Long-toed Salamander			1	8	8	3
Total	13	1	3	17	94	55
Survey Effort	1:13	3:02	2:59	2:59	2:50	4:20

Appendix 15. UTM coordinates of amphibian detections in 2016 at the Airport Lagoon and Beaver Pond sites on Williston Reservoir, BC.

Airport Lagoon

Date	Transect	Time	Easting	Northing	Species	Number	Age Class	Comment
29/04/2016	25	11:15	492466	6126941	Western toad	3	Adults	In water
29/04/2016	25	12:15	492466	6126941	Frog sp.	20	Egg masses	Wood frog and/or Columbia spotted frog
10/05/2016	25	12:18	492468	6126949	Western toad	1	Juvenile	Under log
21/05/2016	25	11:30	492468	6126947	Western toad	5000+	Tadpoles	In pond
21/05/2016	25	11:30	492468	6126947	Wood frog	500+	Tadpoles	In pond
31/05/2016	25	10:05	492469	6126947	Western toad	5000+	Tadpoles	In pond

Beaver Pond

Date	Time	Easting	Northing	Species	Number	Age Class	Comment
28/04/2016	16:30	479396	6148252	Long-toed Salamander	2	Adult	Under log
28/04/2016	16:35	479401	6148220	Long-toed Salamander	1	Adult	Under log
28/04/2016	16:20	479387	6148247	Long-toed Salamander	5	Egg Masses	Pond
28/04/2016	16:25	479385	6148250	Long-toed Salamander	3	Egg Masses	Pond
28/04/2016	16:32	479410	6148237	Long-toed Salamander	1	Egg Masses	Pond
28/04/2016	16:33	479394	6148228	Long-toed Salamander	1	Egg Masses	Pond
17/05/2016	10:34	479228	6148322	Western Toad	1	Juvenile	Under log
17/05/2016	10:43	479272	6148279	Western Toad	1	Juvenile	Under berm
17/05/2016	11:14	479380	6148226	Western Toad	3	Juvenile	Under log
17/05/2016	11:12	479377	6148226	Western Toad	1	Juvenile	Shore
17/05/2016	11:17	479362	6148228	Western Toad	1	Juvenile	Under log
17/05/2016	11:18	479360	6148230	Western Toad	1	Juvenile	Under log
17/05/2016	11:19	479357	6148229	Western Toad	1	Juvenile	Under log
17/05/2016	11:28	479331	6148216	Western Toad	1	Juvenile	Under log
17/05/2016	11:29	479329	6148215	Western Toad	1	Juvenile	Under log
17/05/2016	11:34	479304	6148217	Western Toad	1	Juvenile	Under log
17/05/2016	11:38	479272	6148218	Wood Frog	1	Juvenile	Under log
17/05/2016	11:41	479259	6148230	Western Toad	2	Juvenile	Under berm
17/05/2016	11:42	479258	6148230	Western Toad	1	Juvenile	Under berm
17/05/2016	11:43	479255	6148228	Western Toad	3	Juvenile	Under berm

Date	Time	Easting	Northing	Species	Number	Age Class	Comment
17/05/2016	11:44	479255	6148226	Western Toad	2	Juvenile	Under berm
17/05/2016	11:45	479245	6148235	Western Toad	4	Juvenile	Under berm
17/05/2016	11:46	479250	6148237	Western Toad	1	Juvenile	Under berm
01/06/2016	9:25	492468	6126947	Western Toad	50	Tadpoles	Pond
01/06/2016	9:27	479395	6148246	Western Toad	5000+	Tadpoles	Pond
01/06/2016	9:33	479345	6148232	Western Toad	1000	Tadpoles	Pond
01/06/2016	9:38	479281	6148298	Western Toad	500	Tadpoles	Pond
01/06/2016	9:40	479259	6148312	Western Toad	1	Juvenile	Under berm
01/06/2016	9:41	479256	6148308	Western Toad	2	Juvenile	Under berm
01/06/2016	9:48	479196	6148344	Western Toad	1	Adult	Under berm
05/06/2106	8:31	479228	6148254	Western Toad	1	Juvenile	Under log
05/06/2106	8:35	479249	6148235	Western Toad	2	Juvenile	Under berm
05/06/2106	8:36	479247	6148233	Western Toad	1	Juvenile	Under log
05/06/2106	8:37	479254	6148230	Western Toad	2	Juvenile	Under berm
05/06/2106	8:39	479256	6148231	Western Toad	1	Juvenile	Under berm
05/06/2106	8:44	479316	6148217	Western Toad	1	Juvenile	Under log
05/06/2106	8:46	479326	6148212	Western Toad	1	Juvenile	Under log
05/06/2106	8:50	479352	6148223	Western Toad	1	Adult	Under log
05/06/2106	8:50	479352	6148223	Western Toad	1	Juvenile	Under log
05/06/2106	8:51	479357	6148227	Western Toad	1	Juvenile	Under log
05/06/2106	9:01	479407	6148240	Western Toad	10	Tadpoles	Shore
05/06/2106	9:06	479387	6148244	Western Toad	5000+	Tadpoles	Shore
05/06/2106	9:10	479380	6148237	Wood Frog	1	Juvenile	Shore
05/06/2106	9:15	479365	6148232	Western Toad	1	Adult	Under log
05/06/2106	9:24	479266	6148307	Western Toad	1	Adult	Under berm
05/06/2106	9:36	479267	6148306	Western Toad	1	Adult	Under berm
05/06/2106	9:27	479257	6148311	Western Toad	2	Juvenile	Under berm
05/06/2106	9:28	479253	6148311	Western Toad	2	Juvenile	Under berm
05/06/2106	9:28	479254	6148308	Western Toad	2	Juvenile	Under berm

Appendix 16. Fish CPUE[1] by method and species at the Airport Lagoon and Beaver Pond sites for 2011 – 2016 (Years 1-6).

Airport Lagoon

Method	Year	Species														
		Lake Chub	Brassy Minnow	Peamouth	Northern Pikeminnow	Redside Shiner	Longnose Sucker	White Sucker	Largescale Sucker	Sucker sp.	Rainbow trout	Bull trout	Burbot	Prickly sculpin	Slimy sculpin	Total
Electrofish	2011	0.567	0.026							0.670	0.052			0.026		1.340
	2012	0.151	0.025		0.075		0.025		0.025				0.427	0.050		0.780
	2013	1.794	1.623			0.883	0.085			0.028			0.171	0.114		4.699
	2014	1.087	0.053			0.212	0.027			1.061			0.053	0.345		2.837
	2015	1.848	0.784			3.081	0.168	0.028	0.224	0.028	0.028		0.028	0.084		6.303
	2016	2.47	3.718			0.662	0.076		0.025	0.051			0.204	0.458		7.666
Minnow Trap	2011	0.111	0.005			0.011							0.003	0.003	0.003	0.134
	2012	0.039	0.004		0.002	0.019			0.004				0.009	0.004		0.080
	2013	1.357	4.674		0.017	0.033	0.037		0.012	0.012						6.143
	2014	2.138	2.320		0.017	1.742	0.198	0.150	0.089	0.689	0.002			0.005		7.351
	2015	2.124	0.074		0.029	1.097	0.177	0.069	0.105	0.239						3.913
	2016	0.421	0.085		0.003	2.172	0.090	0.015	0.025					0.018		2.829
Fyke Net	2011				0.050		0.025						0.025			0.101
	2012	2.538	0.810	0.015	0.657	1.727	0.734	0.214	0.138				0.107			6.925
	2013	8.796	6.990		0.722	6.301	0.164		0.066							23.039
	2014	25.478	89.545	0.063	1.132	33.291	4.165	5.495	2.365	7.801	0.025					169.351
	2015	56.985	132.457		1.104	83.445	0.087	0.929	1.597	51.191	0.087			0.073		327.955
	2016	0.104	0.026	0.013	0.414	3.222	0.168	0.647	0.375		0.065					5.034

[1] – Electrofishing CPUE = fish/minute; minnow trap and fyke net CPUE = fish/hour

Beaver Pond

Method	Year	Species														
		Lake Chub	Brassy Minnow	Peamouth	Northern Pikeminnow	Redside Shiner	Longnose Sucker	White Sucker	Largescale Sucker	Sucker sp.	Rainbow trout	Bull trout	Burbot	Prickly sculpin	Slimy sculpin	Total
Electrofish	2011	0.057			0.057	0.515	0.229		0.057	2.462				0.057		3.435
	2012					0.067										0.067
	2013	0.190			0.038	0.038	0.114		0.038	2.013						2.430
	2014															
	2015	0.2568		0.1712	0.171	0.171				0.171				0.428		1.369
	2016						0.263		0.395	1.842				0.921		3.421
Minnow Trap	2011				0.008											0.008
	2012			0.007												0.007
	2013						0.007			0.007				0.020		0.033
	2014				0.057	0.017										0.073
	2015															-
	2016					0.004	0.004							0.029		0.037
Fyke Net	2011			0.460	0.184											0.644
	2012				0.044		0.044		0.044			0.044				0.176
	2013			3.176	2.235	0.941	0.176	0.118	0.353							7
	2014			0.701	1.796	0.482	0.219		0.219							3.417
	2015															
	2016			0.088	0.438								0.044			0.569

Appendix 17. Water quality data collected during fish sampling at the Airport Lagoon and Beaver Pond sites in 2016.

Site	Date	Location	Temperature (°C)	Conductivity (µS/cm)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)
Airport Lagoon	May 18	stream (EF4)	14.7	194.3	7.51	-[1]	n/a
	May 19	surface (log boom)	14.5	161.2	6.83	7.91	0.75
		mid-water (2 m, log boom)	14.4	161.3	7.18	6.91	
	July 13	surface (upper pond)	19.9	147.3	7.9	7.75	3.18
		bottom (upper pond)	16.1	-[2]	7.47	-[2]	
		surface (log boom)	19.9	132.1	8.02	7.95	3.63
		bottom (7 m, log boom)[3]	16.6	137.5	7.29	1.09	
Beaver Pond	July 15	surface (inside berm)	17.0	111.6	7.66	8.89	-
		bottom (4 m, inside berm)	14.3	115.9	7.54	6.08	
		surface (log boom)	16.5	111.1	7.84	9.13	1.96
		bottom (8 m, log boom)	16.2	112.4	7.83	9.04	

[1] - DO sensor out of calibration, [2] - reading not possible due to dense macrophytes, [3] - thermocline at 5.5 m