Columbia River Project Water Use Plan

KINBASKET AND ARROW LAKES RESERVOIRS

Reference: CLBMON 40

Arrow Lakes Reservoir Shorebird and Waterbird Monitoring Program: Year 5

Study Period: 2012

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CLBMON 40: Arrow Lakes Reservoir Shorebird and Waterbird Monitoring Program

Year 5, 2012

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Cover photo: Mallards in flooded grasslands, near Machete Island, Revelstoke Reach, spring 2012. Photo: Harry van Oort, 2012.

EXCUTIVE SUMMARY

Waterbirds include all wetland bird families including: waterfowl (divers, grebes, cormorants, swans, geese, ducks, coots and rails); gulls, terns and herons; and water-dependent birds of prey[1]. Impoundments along the Columbia River have greatly reduced wetland availability for waterbirds, and shorebirds. Several remnant wetlands remain in Revelstoke Reach, Arrow Lakes Reservoir, but these are periodically flooded by the reservoir's operations. The CLBMON 40 waterbird and shorebird monitoring program aims to document how reservoir operations affect waterbirds and shorebirds in Revelstoke Reach wetlands. This report summarizes data recorded in 2012 (Year 5 of this 10-year study). Quantitative analyses of the data will be performed on the 5 year data set and reported in a separate report.

Waterfowl

During **spring migration**, 5,221 waterfowl (25 species) were counted during eight land-based surveys: Canada Goose (*Branta canadensis*), American Wigeon (*Anas americana*) and Mallard (*Anas platyrhynchos*) were the most common species. Most waterfowl were observed at Cartier Bay (46%), followed by Airport Marsh (25%) and Downie Marsh (9%). Aerial surveys showed similar results, and, being complete census counts, provided estimates of how many waterfowl could be using the study area during the migrations. Mallard was the leading species recorded during spring aerial surveys (≤ 503), followed by Canada Goose (≤ 212) and American Wigeon (≤ 152). The spring migration peaked near mid-April (1,322 waterfowl observed via aerial survey).

During **fall migration** , 5,025 waterfowl (21 species) were counted during eight land-based surveys: Canada Goose, American Wigeon and Mallard were the most common species. Most waterfowl were observed at Cartier Bay (32%), followed by Airport Marsh (28%) and Locks Creek Outflow (17%). Canada Goose was also the leading species recorded during fall aerial surveys (≤ 1,462), followed by Mallard (≤ 303) and American Coot (*Fulica americana;* ≤ 110). The fall migration peaked in the third week of October (2,903 waterfowl observed via aerial survey).

Across the study area, we observed different distributions of waterfowl in spring versus fall (four and three aerial surveys, respectively). Grassland habitats, and sites at higher geographic elevations within the drawdown zone were selected to a much greater degree in fall, compared with spring. Wetlands were used to a greater degree in spring. Within wetland sites (monitored by the land-based surveys), mapped waterfowl locations also showed large spatio-temporal variability in habitat use. In contrast with 2011, there was very little spatial variation at Locks Creek Outflow in 2012 when compared between spring and fall. Both scales of spatio-temporal variability, and differences among years were likely driven by differences in the reservoir elevations of spring and fall, but this cannot be confirmed until a multi-year data set is analyzed.

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[1] According to the terms of reference for this project, 'waterbirds' is defined to also include 'shorebirds', but we removed shorebirds for the functional definition in this report, in order to be consistent with title of this project and elsewhere in the terms of reference. Many results refer to 'waterfowl', the subset of waterbirds that are dominant in the project area.

Shorebirds

During most of the **fall migration**, reservoir elevations were relatively high, inundating many of the sites normally used by shorebirds, but shorebirds were still detected (244 from 14 species). Spotted Sandpiper (*Actitis macularius*) was the most abundant species (55%), followed by Solitary Sandpiper (*Tringa solitaria*; 11%). The migration peaked from late July through early August. Shorelines became more sandy or muddy as reservoir elevations decreased during the end of the survey period. From a subset of comparable data, the greatest diversity and count of shorebirds was recorded at the Airport West Pond (8 species, 39 individuals) and at Wigwam Flats (6 species, 40 individuals) near the Akolkolex River.

Productivity

During six weeks of bi-weekly brood surveys, 34 waterfowl broods were observed (315 young). Most broods were detected in Montana Bay (56%), Airport Marsh (18%) and Cartier Bay (12%). Canada Goose was the most common brood-bearing species (79%), followed by Mallard (15%), Pied-billed Grebe (*Podilymbus podiceps*; 3%) and Common Merganser (*Mergus merganser;* 3%). No American Wigeon broods were observed. Two of seven monitored Osprey (*Pandion haliaetus*) pairs had successful nests (2 young fledged in total). Three nesting Bald Eagle (*Haliaeetus leucocephalus*) pairs were monitored in 2012, and all were successful (3 young fledged in total). No Short-eared Owl (*Asio flammeus*) or Northern Harrier (*Circus cyaneus*) nests were detected, and these species were not commonly seen after the late spring migration period.

Data from Year 5 differ from those of previous years in many regards. Multi-year analyses will demonstrate the degree to which reservoir operations account for the variability in habitat distribution and productivity over time. We discuss progress made in building the data sets necessary for answering the management questions, and suggest that most management questions will be addressed adequately using current methods.

Status of Objectives, Management Questions and Hypotheses. PM = Productivity Monitoring (Brood Surveys, and monitoring of Bald Eagles, Ospreys, Short-eared Owls and Northern Harriers); Aerial = Aerial Surveys; LBWB = Land-based Waterbird Surveys; Shorebird = Shorebird Surveys (Land- and Boat-based). Progress made in addressing each management question is outlined. No questions have yet been addressed with formal analysis. This will be performed for the Year 1–5 analysis report (in preparation).

Objectives M	**anagement Questions**	Answered?	**Management Hypotheses**	**Approaches**	**Year 5 (2012) Status**
Determine the abundance, distribution, and habitat use of waterbirds and migratory shorebirds and the productivity of waterbirds in Revelstoke Reach	1) What are the: I. seasonal and annual variations the abundance and spatial distribution of waterbirds in Revelstoke Reach; and II. variations in the abundance and spatial distribution of shorebirds during fall migration in Revelstoke Reach?	No	N/A	Aerial LBWB Shorebird	Annual data production is satisfactory. Additional years with a wide range of reservoir levels are still required.
	3) Which habitats within the drawdown zone in Revelstoke Reach are utilized by shorebirds and waterbirds and what are their characteristics (e.g. foraging substrate, vegetation, elevation, and distance to the waters edge)?	No	N/A	Aerial LBWB Shorebird	Annual data production is on target to address questions in Years 5 and 10.
	4) What is the annual variation in the productivity of waterbirds in Revelstoke Reach and does productivity vary spatially (e.g. are there areas of higher waterbird productivity or brood counts)?	No	N/A	PM	Annual data production is satisfactory. Additional years with a good range of reservoir levels are still required. Some recommendations for improving the quality of the science used and the ability to locate nests are provided.
Examine how variation in flow and reservoir water elevations influence seasonal and yearly abundance, distribution, and habitat use of waterbirds and migratory shorebirds and the	2) What impacts do year-to-year and within-year reservoir operations have on resident and migratory waterbirds and migratory shorebird populations?	No	N/A	PM, LBWB Shorebird	Annual data production is satisfactory. Additional years with a good range of reservoir levels are still required.
	5) Which species of shorebirds and waterbirds are most likely to be affected by reservoir operations?	No	H1A Reservoir operations do not result in decreased species diversity in waterbirds or migratory shorebirds in Revelstoke Reach.	PM, LBWB Shorebird	Annual data production is satisfactory. Additional years with a good range of reservoir levels are still required.

productivity of waterbirds in Revelstoke Reach	6) Do reservoir operations (e.g. daily and maximum monthly water levels) influence the distribution and abundance of waterbirds and shorebirds in Revelstoke Reach?	No	H1: The annual and seasonal variation in water levels resulting from reservoir operations, the implementation of soft constraints, and the potential impact from Rev 5, ("reservoir operations"), do not result in a reduction of waterbird or shorebird use in Revelstoke Reach. H1B Reservoir operations do not result in a decrease in the abundance of waterbirds or migratory shorebirds in Revelstoke Reach. H1C Reservoir operations do not result in changes in waterbird or shorebird distribution in Revelstoke Reach.	Aerial LBWB Shorebird	Improvements in mapping proved beneficial in Year 3. Annual data production is satisfactory. Additional years with a good range of reservoir levels are still required. It is recommended that complete aerial surveys be conducted throughout both the spring and fall migrations.
	7) To what extent do water levels in Arrow Lakes Reservoir influence the productivity of waterbirds in Revelstoke Reach between years?	No	H1D Reservoir operations do not result in a decrease in the productivity of waterbirds in Revelstoke Reach.	PM	Annual data production is satisfactory. Additional years with a good range of reservoir levels are still required. Some recommendations for improving the quality of the science used and the ability to locate nests are provided.
Examine how variation in flow and reservoir water elevations influence seasonal and yearly abundance, distribution, and habitat use of waterbirds and migratory shorebirds and the productivity of waterbirds in Revelstoke Reach	8) Can minor adjustments be made to reservoir operations to minimize the impact on migrating waterbirds and shorebirds or on waterbird productivity?	No	H1E Reservoir operations do not result in a decrease in shorebird foraging habitat in the drawdown zone. H2: Annual variation in reservoir water levels, reservoir operations, the implementation of soft constraints, and the potential impact from Rev 5, do not result in a reduction or degradation of waterbird or shorebird habitats.	LBWB Shorebird	Annual data production is satisfactory. Additional years with a good range of reservoir levels are still required.
Inform how physical works and revegetation can be designed to mitigate adverse impacts to waterbirds and shorebirds resulting from reservoir operations	9) Can physical works be designed to mitigate any adverse impacts on migrating waterbirds and shorebirds or on waterbird productivity resulting from reservoir operations?	No	H3A: Revegetation and wildlife physical works do not increase the species diversity or abundance of shorebird or waterbirds in Revelstoke Reach.	LBWB Shorebird	Annual data production is satisfactory. Additional years with a good range of reservoir levels are recommended before physical works plans can be fully justified.
Assess the effectiveness of physical works and revegetation at enhancing habitat for waterbirds and shorebirds	10) Does revegetating the drawdown zone affect the availability and use of habitat and it's use by shorebirds or waterbirds in Revelstoke Reach?	No	H3: Revegetation and wildlife physical works do not increase the utilization of habitats by birds in Revelstoke Reach. H3B: Revegetation and wildlife physical works do not increase the productivity of waterbirds in Revelstoke Reach. H3D: Revegetation and wildlife physical works do not increase the amount of shorebird or waterbird habitat in Revelstoke Reach.	Aerial LBWB Shorebird PM	This question is challenging to address for these study species and by using CLBMON 40 methods. Nesting data from CLBMON 36 can be used to address this question for CLBMON 40.
	11) Do wildlife physical works projects implemented during the course of this monitoring program affect waterbird and shorebird abundance, and/or diversity, or waterbird productivity?	No			Annual data production is satisfactory. Additional years with a good range of reservoir levels are still required.

KEYWORDS

BC Hydro, Water Licence Requirements, Arrow Lakes Reservoir, Revelstoke Reach, reservoir operations, waterbirds, waterfowl, shorebirds, Short-eared Owl, Northern Harrier, Osprey, Bald Eagle, wetlands, productivity, migration, water management.

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CBA staff Corey Bird, Ryan Gill, Michal Pavlik, Harry van Oort, Devon Anderson and Raven Douglas conducted field studies on waterbirds, shorebirds and raptors. Ryan Gill and Harry van Oort conducted aerial waterfowl surveys. Ryan Gill provided GIS mapping and analysis. Suzanne Beauchesne provided overall supervision and monitoring of crews. John Cooper acted as Project Manager.

We would like to thank Rod Watt at Canadian Helicopters for providing exceptionally safe and consistent piloting of his aircraft, and personnel at BC Hydro Aircraft Operations for helping to assure that our flying was performed in safe flying conditions.

The report was written by Harry van Oort, Corey Bird and John Cooper. Tracey Hooper provided a technical edit of the draft report. We would also like to thank Jason Watson for his review and comments.

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1 INTRODUCTION

The Columbia River is one of the most modified rivers systems in North America (Nilsson et al. 2005), and its flow is controlled by many hydroelectric dams and water storage reservoirs. A relatively large proportion of the water in the Columbia River basin originates from winter snowpack in south-eastern British Columbia and is discharged into the river during the spring freshet. The flow of water out of British Columbia is controlled by dams, with water stored for controlled release throughout the year (BC Hydro 2007). Decisions to store or release water are made in accordance with international agreements between Canada and the United States under the Columbia River Treaty and through Non-treaty Storage Agreements, but they can be modified to a degree via Water Use Planning (BC Hydro 2007).

Water storage reservoirs along the primary course of the Columbia River in British Columbia include the Kinbasket Reservoir (Mica Dam, 1973), Lake Revelstoke (Revelstoke Dam, 1984) and Arrow Lakes Reservoir (Hugh Keenleyside Dam, 1968). These three reservoirs are positioned serially along the river, and there are few intervening sections where natural riparian habitats and wetlands remain.[2] The footprint areas of these reservoirs have removed much of the valley-bottom habitat, and their drawdown zones are typically comprised of steep shorelines (Enns et al. 2007, Utzig and Schmidt 2011). In the upper elevations of the drawdown zones, the growth of riparian and wetland vegetation is possible, but such habitats are uncommon (Enns et al. 2007, Hawkes et al. 2007).

The northern reach of the Arrow Lakes Reservoir, known as Revelstoke Reach (Figure 1-1; Figure 1-2), provides a relatively high concentration of productive wetland habitat. Within the upper portion of Revelstoke Reach, there is a variety of wetlands, including a reservoir-altered bog, an extensive and diverse cattail/bulrush marsh, and several ponds. The rarity of such habitats in the landscape makes Revelstoke Reach an area of great regional importance for wetland wildlife throughout the year (Tremblay 1993, Jarvis and Woods 2001, CBA 2012a, 2012b).

The operation of Arrow Lakes Reservoir is thought to affect the availability and quality of habitat in Revelstoke Reach for waterbirds and shorebirds. The vegetation communities in the drawdown zone are governed by water storage regimes because plant species differ in their tolerance to periods of inundation (Korman 2002). Habitat quality for waterbirds and shorebirds varies greatly as a direct function of the reservoir’s water elevations because vegetation cover and foraging substrates may be exposed or submerged, and the modulation of water column depth affects foraging opportunities (Rundle and Fredrickson 1981, Parsons 2002). How reservoir operations affect waterbird use of the drawdown zone has not been studied in detail, and the relationship between reservoir operations and habitat quality is poorly understood.

[2] Between Castlegar and Valemount, an approximate linear distance of 400 km of valley bottom was impounded, and natural habitats (including riparian and wetland) were converted to a reservoir. Additionally, between Mica and Donald along Columbia Reach of Kinbasket Reservoir, an approximate linear distance of 100 km of valley-bottom habitat was converted.

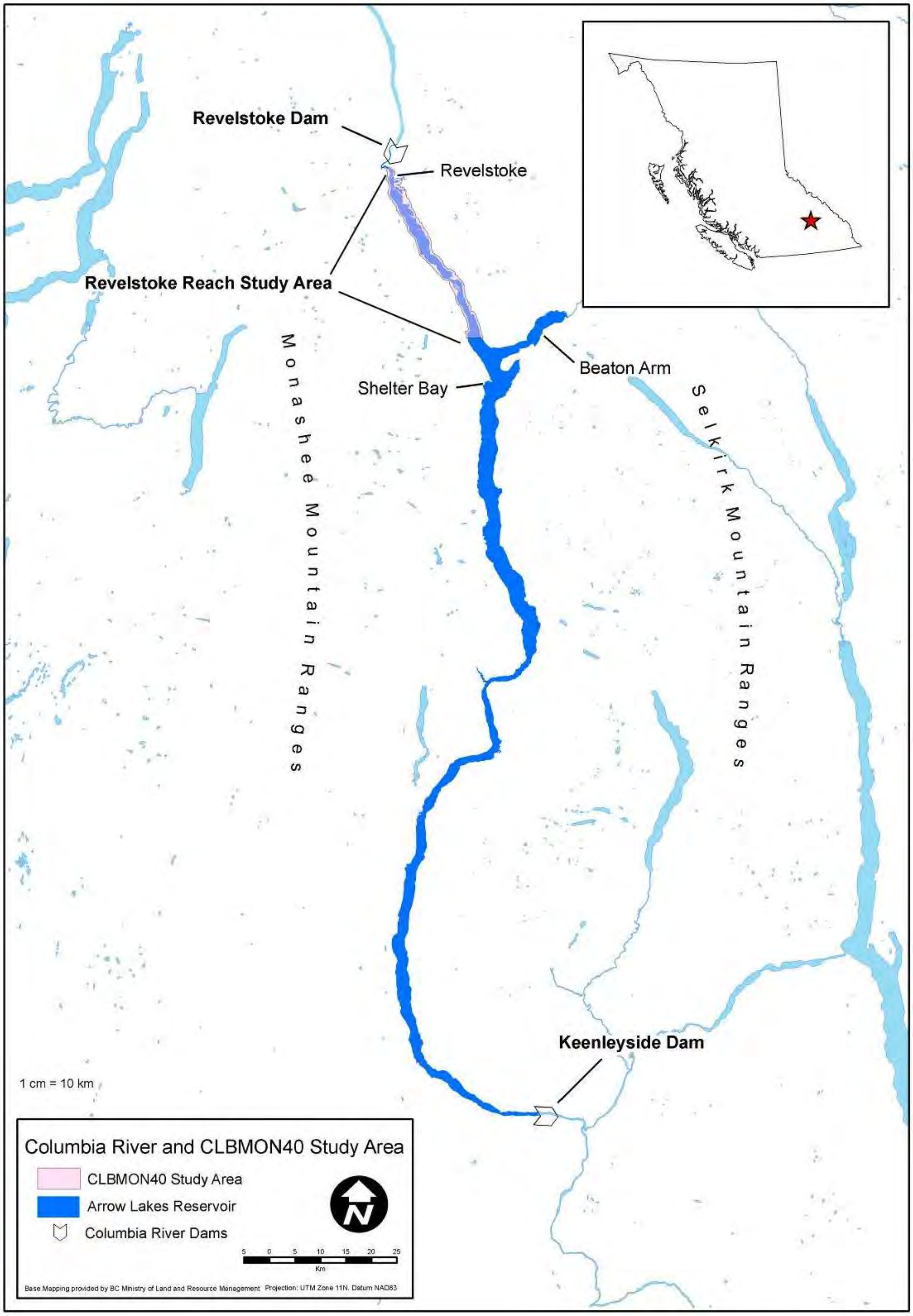

Figure 1-1: The study area was confined to Revelstoke Reach, which is the northernmost arm of the Arrow Lakes Reservoir

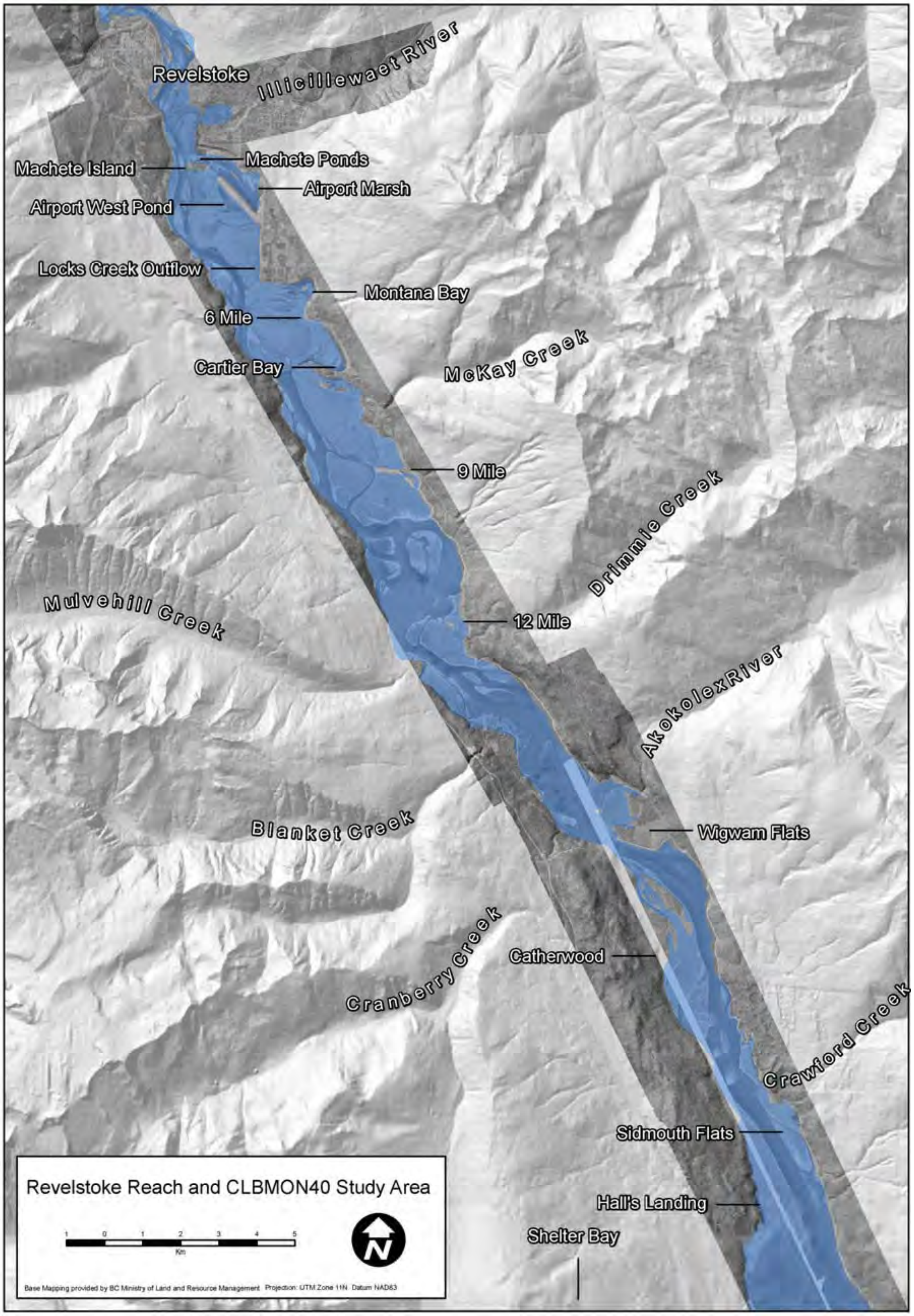

Figure 1-2: Overview map of Revelstoke Reach, with geographic features labelled

During the Columbia River Water Use Planning process, a number of potential impacts from reservoir operations on shorebirds and waterbirds in Revelstoke Reach were identified as key wildlife management concerns by the Consultative Committee (BC Hydro 2005). As a result, a Water Licence Requirements study (CLBMON 40) was developed to improve understanding of how reservoir operations affect waterbirds and shorebirds in Revelstoke Reach.

For the CLBMON 40 monitoring program, the following groups of birds are defined:

- “Waterbird” is a species from any of the following families: Gaviiformes (loons), Podicipediformes (grebes), Phalacrocoracidae (cormorants), Anseriformes (swans, geese, ducks), Rallidae (rails and coots) and Laridae (gulls and terns). In addition, four species of raptors that depend on aquatic, marshy or grassland habitats of the drawdown zone were defined as waterbirds for the purpose of this study: Bald Eagle (*Haliaeetus leucocephalus*), Osprey (*Pandion haliaetus*), Northern Harrier (*Circus cyaneus*) and Short-eared Owl (*Asio flammeus*). Herons were not included as waterbirds because they were to be monitored under a separate Water Licence Requirements study.
- “Waterfowl” is used to identify the subset of waterbirds that forage by swimming in the water (loons, grebes, cormorants, swans, ducks, geese and coots).
- “Shorebirds” are members of the families Charadriidae (plovers), Scolopacidae (sandpipers) and Recurvirostridae (stilts and avocets).

1.1 Scope and Objectives

CLBMON 40 will determine if and how reservoir operations affect waterbird populations, and if the effects are negative, how to mitigate those effects. The specific objectives of the 10-year project are to:

1) determine the abundance, distribution, and habitat use of waterbirds and migratory shorebirds and the productivity of waterbirds in Revelstoke Reach;

2) examine how variation in flow and reservoir water elevations influence seasonal and yearly abundance, distribution, and habitat use of waterbirds and migratory shorebirds and the productivity of waterbirds in Revelstoke Reach;

3) inform how physical works and revegetation can be designed to mitigate adverse impacts to waterbirds and shorebirds resulting from reservoir operations, and

4) assess the effectiveness of physical works and revegetation at enhancing habitat for waterbirds and shorebirds.

For the purposes of this study, we defined the term “productivity” as (an index of) the average reproductive output (the number of offspring produced) of a population.

1.2 Manageme nt Questions

To meet the above objectives, 11 management questions (research questions) were composed:

1. What are the:

I. seasonal and annual variations the abundance and spatial distribution of waterbirds in Revelstoke Reach; and

II. variations in the abundance and spatial distribution of shorebirds during fall migration in Revelstoke Reach?

2. What impacts do year-to-year and within-year reservoir operations have on resident and migratory waterbirds and migratory shorebird populations?

3. Which habitats within the drawdown zone in Revelstoke Reach are utilized by shorebirds and waterbirds and what are their characteristics (e.g. foraging substrate, vegetation, elevation, and distance to the waters edge)?

4. What is the annual variation in the productivity of waterbirds in Revelstoke Reach and does productivity vary spatially (e.g. are there areas of higher waterbird productivity or brood counts)?

5. Which species of shorebirds and waterbirds are most likely to be affected by reservoir operations?

6. Do reservoir operations (e.g. daily and maximum monthly water levels) influence the distribution and abundance of waterbirds and shorebirds in Revelstoke Reach?

7. To what extent do water levels in Arrow Lakes Reservoir influence the productivity of waterbirds in Revelstoke Reach between years?

8. Can minor adjustments be made to reservoir operations to minimize the impact on migrating waterbirds and shorebirds or on waterbird productivity?

9. Can physical works be designed to mitigate any adverse impacts on migrating waterbirds and shorebirds or on waterbird productivity resulting from reservoir operations?

10. Does revegetating the drawdown zone affect the availability and use of habitat and it's use by shorebirds or waterbirds in Revelstoke Reach?

11. Do wildlife physical works projects implemented during the course of this monitoring program affect waterbird and shorebird abundance, and/or diversity, or waterbird productivity?

As part of BC Hydro's Water Licence Requirements, BC Hydro is required to adequately address these 11 questions over a 10-year study period.

1.3 Manageme nt Hypotheses

From these management questions, several management hypotheses were outlined by BC Hydro for testing by the CLBMON 40 research[3]:

H_1: The annual and seasonal variation in water levels resulting from reservoir operations, the implementation of soft constraints, and the potential impact from Rev 5, ("reservoir operations"), do not result in a reduction of waterbird or shorebird use in Revelstoke Reach.

H_{1A} Reservoir operations do not result in decreased species diversity in waterbirds or migratory shorebirds in Revelstoke Reach.

H_{1B} Reservoir operations do not result in a decrease in the abundance of waterbirds or migratory shorebirds in Revelstoke Reach.

[3] The wording of the management objectives, questions and hypotheses stated in the BC Hydro terms of reference for CLBMON 40 are presented verbatim.

H_{1C} Reservoir operations do not result in changes in waterbird or shorebird distribution in Revelstoke Reach.

H_{1D} Reservoir operations do not result in a decrease in the productivity of waterbirds in Revelstoke Reach.

H_{1E} Reservoir operations do not result in a decrease in shorebird foraging habitat in the drawdown zone.

If changes in species diversity, abundance, distribution or productivity are detected over time, the following hypotheses will be tested to determine whether these changes can be attributed to changes in habitat quality or availability as a result of reservoir operations, or to revegetation efforts or physical works projects implemented during the course of this monitoring program.

H_2: Annual variation in reservoir water levels, reservoir operations, the implementation of soft constraints, and the potential impact from Rev 5, do not result in a reduction or degradation of waterbird or shorebird habitats.

H_3: Revegetation and wildlife physical works do not increase the utilization of habitats by birds in Revelstoke Reach.

H_{3A}: Revegetation and wildlife physical works do not increase the species diversity or abundance of shorebird or waterbirds in Revelstoke Reach.

H_{3B}: Revegetation and wildlife physical works do not increase the productivity of waterbirds in Revelstoke Reach.

H_{3D}: Revegetation and wildlife physical works do not increase the amount of shorebird or waterbird habitat in Revelstoke Reach.

The monitoring program designed to address these questions/hypotheses—CLBMON 40—was initiated in 2008. Several approaches are being used to answer these management objectives, questions and hypotheses (see Executive Summary). The research program will span 10 years in order to determine the effect of reservoir operations (water level management) on the abundance, distribution and productivity of waterbirds and shorebirds and to assess and inform physical works.

This report includes results from the spring, summer and fall of Year 5 (2012). Winter data for Year 5 are not included here but will be reviewed and analyzed in the 5-year analysis report that is currently in preparation.

1.4 Study Area

Revelstoke Reach is the northernmost arm of the Arrow Lakes Reservoir, which extends north of Shelter Bay and Beaton Arm to the Revelstoke town site between the Monashee and Selkirk Mountains (Figure 1-1, Figure 1-3). This area lies within the “interior wet belt” of British Columbia (ICHmw2 and ICHmw3) and receives most of its precipitation in the form of snowfall delivered by Pacific frontal systems during winter (Meidinger and Pojar 1991).

Revelstoke Reach contains the Columbia River as it flows south from the Revelstoke Dam towards the Arrow Lakes Reservoir, and is flooded annually by the reservoir (Figure 1-2, Figure 1-3). When water levels are sufficiently low, Revelstoke Reach consists largely of a floodplain (flats) that is vegetated primarily by reed canarygrass (*Phalaris arundinacea*) and sedges (*Carex* spp.). The subtle topography of the flats was shaped by the erosion and deposition of material from the Columbia River, and contains oxbow lakes, old back channels and sand bars. Historically, this area was naturally forested by western redcedar (*Thuja plicata*), Engelmann spruce (*Picea engelmannii*) and black cottonwood (*Populus balsamifera*). Prior to the completion of the Hugh Keenleyside Dam near Castlegar, Revelstoke Reach was used as farmland, and it contained the Arrowhead branch of the Canadian Pacific Railway. The old roads and rail grades influence the hydrology of the study area in some locations.

Most of the permanent wetlands in Revelstoke Reach are located in its northern portion. They include several natural and human-made ponds, a large cattail marsh near the Revelstoke Airport (Figure 1-4) and a bog wetland in Montana Bay. Cartier Bay contains an oxbow lake. There are also many seasonally flooded depressions scattered throughout the study area. The Revelstoke Reach floodplain gradually decreases in elevation towards the southern end of the reach (Korman 2002); therefore, the south end is flooded for longer periods and is more sparsely vegetated than is the northern end. Extensive tracts of non-vegetated habitat (sand or silt) are present at low water levels (Korman 2002).

Three of the wetlands (Near Pond, Square Pond and Far Pond) are collectively known as the Machete Ponds, and are connected to the Airport Marsh and the Airport West pond to form one large wetland complex surrounding the Revelstoke Airport runway.

Figure 1-3: Revelstoke Reach in spring. Dra wdown wetland habitat is v isible near th e Revelstoke Airport (left). With the e xception of the airs trip, the dra wdown zone is well defined in this photo as the habitat between the coniferous forests on either side of the valley

Figure 1-4: The Airport Marsh is comprised of extensive tracts of cattail and sedge and many bulrush "islands". It is flooded by about 90 cm of reservoir water in this photo

1.5 Arrow Lakes Reservoir Operations

The Arrow Lakes Generating Station adjacent to the Hugh Keenleyside Dam is a relatively small component of the generation system, and the Arrow Lakes Reservoir is operated primarily by BC Hydro for downstream flood control and power generation in the U.S.. Reservoir levels are maintained through precipitation (snow and rain), discharge from the Mica and Revelstoke Dams, and outflow from Hugh Keenleyside Dam and the Arrow Lakes Generating Station. The reservoir is licensed to operate between elevations of 420 m and 440.1 m. With approval from the Comptroller of Water Rights, the maximum allowable level is 440.75 m. Since 1968, the typical operation of Arrow Lakes Reservoir has involved storing water during the spring freshet and drafting the reservoir in fall and winter; thus, the reservoir elevation cycles annually, with high water levels in summer and low water levels in late winter/early spring (Figure 1-5).

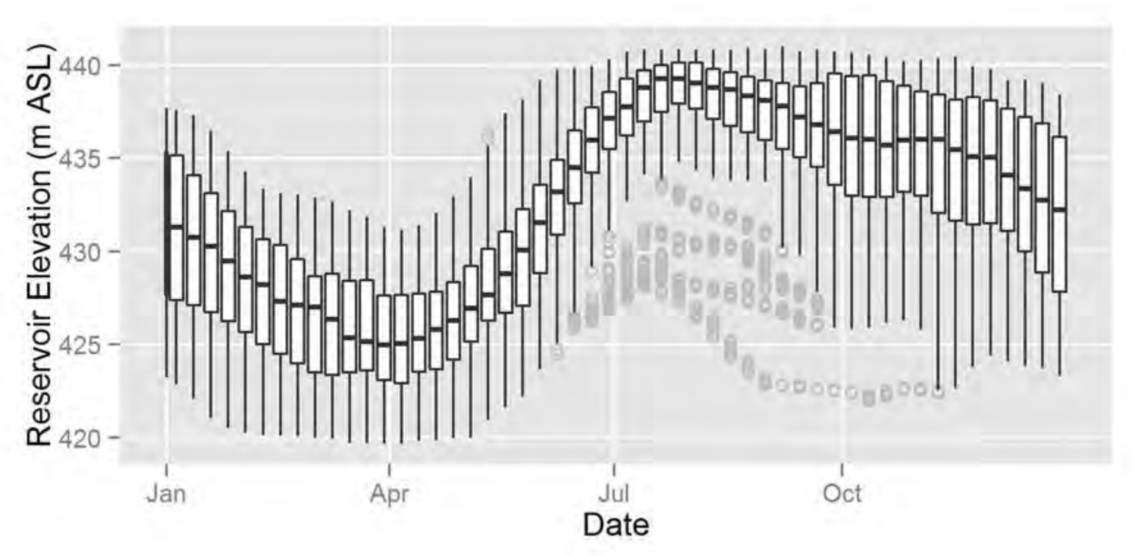

Figure 1-5: **Boxplot graph of historical weekly water elevations for Arrow Lakes Reservoir (1968 through October 2012)**

2 METHODS

The methods used for the various surveys and analyses are described briefly below. For more detailed information, refer to the monitoring protocol report (CBA 2013).

In 2012, CLBMON 40 included six types of surveys:

1. land-based waterbird surveys in spring, fall and winter
2. aerial waterfowl surveys in spring and fall
3. shorebird surveys during the fall migration
4. productivity monitoring of waterfowl
5. productivity monitoring of Bald Eagles and Ospreys
6. productivity monitoring of Short-eared Owls and Northern Harriers

Shorebird habitat monitoring could not be conducted in 2012 because water levels covered all the sampling sites.

2.1 Land-based Waterbird Surveys

Land-based surveys were used to monitor seasonal and spatial patterns of usage by waterbirds within the most important wetlands.[4] Weekly land-based waterbird surveys

[4] "Important wetlands" are those used by a large number of waterbirds on a regular basis, and those that will be modified by physical works. Aerial surveys (see below) were used to provide unbiased habitat selection data across the entire study area.

were conducted for eight weeks in the spring (April and May) and eight weeks in the fall (September and October). Observations were made from fixed observation stations (CBA 2013) and were used to quantify waterbird usage of nine wetlands (Figure 2-1).

During these surveys, we recorded all waterbirds at all accessible wetlands that are particularly suitable for waterfowl. We report raw numbers of all waterbirds recorded annually, but in some cases, we focus on waterfowl in order to remove variation caused by species that are less dependent on these wetlands (e.g., raptors and gulls).

Monitoring has been conducted at seven of the monitored sites since 2008: Downie Marsh, Airport Marsh, Cartier Bay, Locks Creek Outflow, Montana Bay, 9 Mile and 12 Mile (Figure 2-1). We have also monitored several supplementary observation stations, which have been added to the program since 2008. Station 12 at Square Pond was included in 2009 in order to monitor one of the Machete Ponds, which are associated with Wildlife Physical Works 6A (WPW6A). This station can be monitored only when water levels are low. In the spring of 2012 the Machete Ponds were not monitored because the access road was closed. Station 29, which allowed for improved monitoring of WPW14 and 15A, was added in 2009. In 2010 we added Station 30A to monitor an isolated pond near 6 Mile (Pond G) which was regularly used by waterfowl.

During each survey, the group size, species and location of all waterbirds visible from each station were recorded. The locations of groups of birds were mapped on field maps as points or polygons. The activity of the waterbirds (e.g., foraging, resting, preening) and the type of habitat they were using was also noted (CBA 2013). A minimum of 5 minutes was used to scan for waterfowl, but the amount of time spent at a station varied considerably due to the high variability in the time required to identify and count waterbirds and map their locations (CBA 2013). Shortly after each survey, the maps were digitized and the data were entered into the database.

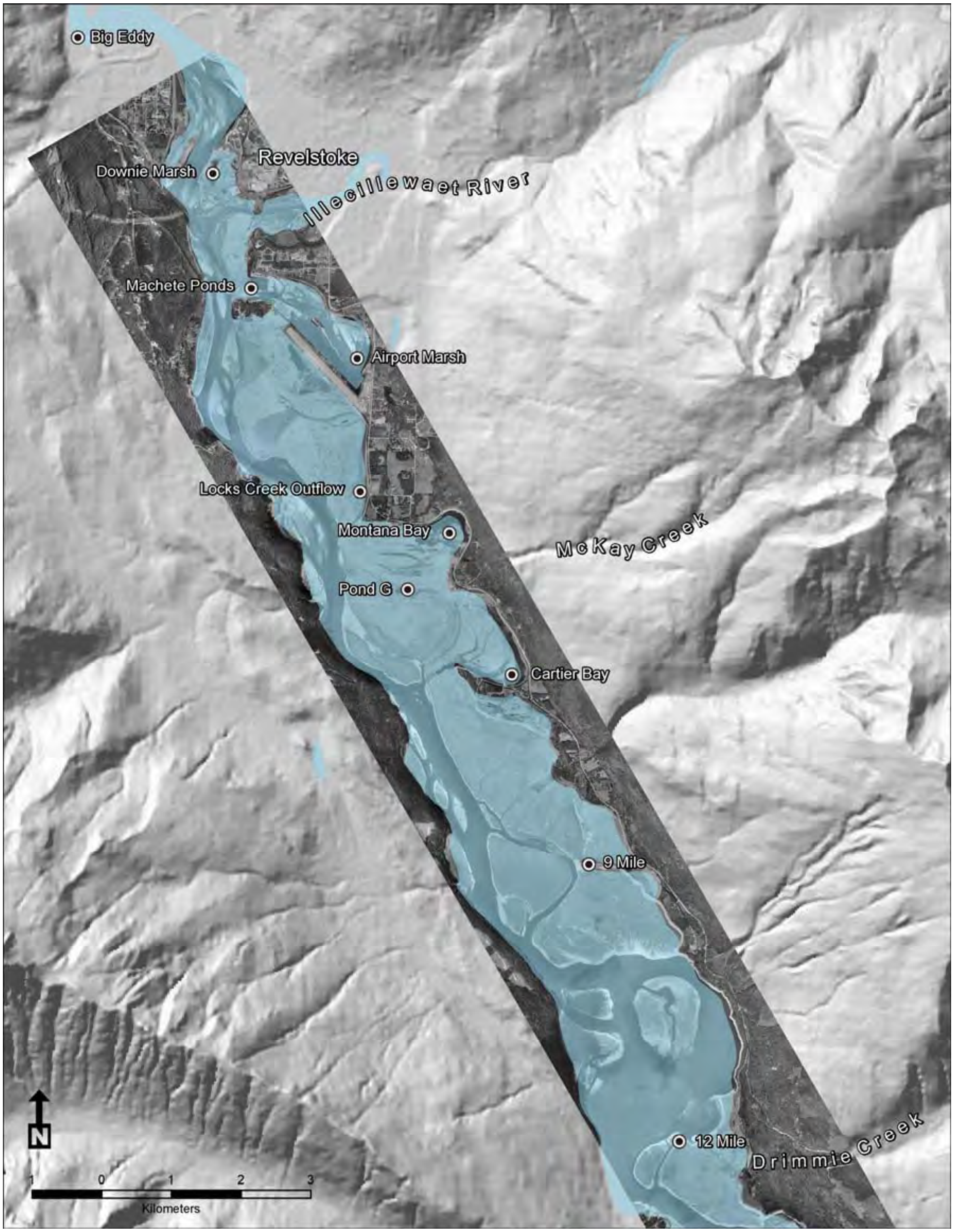

Figure 2-1: Locations of wetlands in Revelstoke Reach where land-based waterbird surveys and brood surveys were conducted

2.2 Aerial Waterfowl Surveys

Helicopter-based aerial waterfowl surveys began in 2009. During the 2012 season, we surveyed on four occasions in the spring (April through to the middle of May) and on three occasions in the fall (September and October). All aerial surveys covered the entire study area. All observations of waterfowl were assigned to one of 129 habitat polygons (Table 2-1), which are mapped in the CLBMON 40 protocol report (CBA 2013).

Aerial waterfowl surveys followed the methods outlined by the Resource Inventory Standards Committee (Resource Inventory Committee 1999). Two personnel were required for these surveys: one observer and one recorder. A Bell 206B helicopter was used for all aerial waterfowl surveys in 2012. The observer was seated next to the pilot, and used a global positioning system (GPS) and laptop computer for real-time tracking and navigation using DNR-Garmin software. The observer made a complete count of waterfowl within the polygons. Waterfowl were identified to species when possible but were not sexed.

Table 2-1: Number of Revelstoke Reach aerial survey polygons in each habitat category

Elevation (m ASL)	Grass	Dense Shrub/Forest	Unvegetated	River Channel	Wetland	Total
431	3		6	31		40
432	3		6	5		14
433	5	2	4	1	1	13
434	11		1	2		14
435	8		1	1	3	13
436	8	2	1	1	1	13
437	7	1				8
438	3				4	7
439	1	4				5
441	1					1
443	1					1
Total	51	9	19	41	9	129

2.3 Shorebird Surveys

Shorebird surveys were conducted during the fall migration period (July 15 to October 5). In 2012 we monitored 37 sites for shorebird activity (Figure 2-2); 13 sites were accessed either by land or kayak depending on reservoir elevations, and other sites were always accessed by boat. Four of the land-accessed sites were control sites located above the drawdown zone; the remaining sites were located within the reservoir drawdown zone. Boat-based observations were made on a bi-weekly schedule, and land-based surveys were conducted on a weekly schedule.

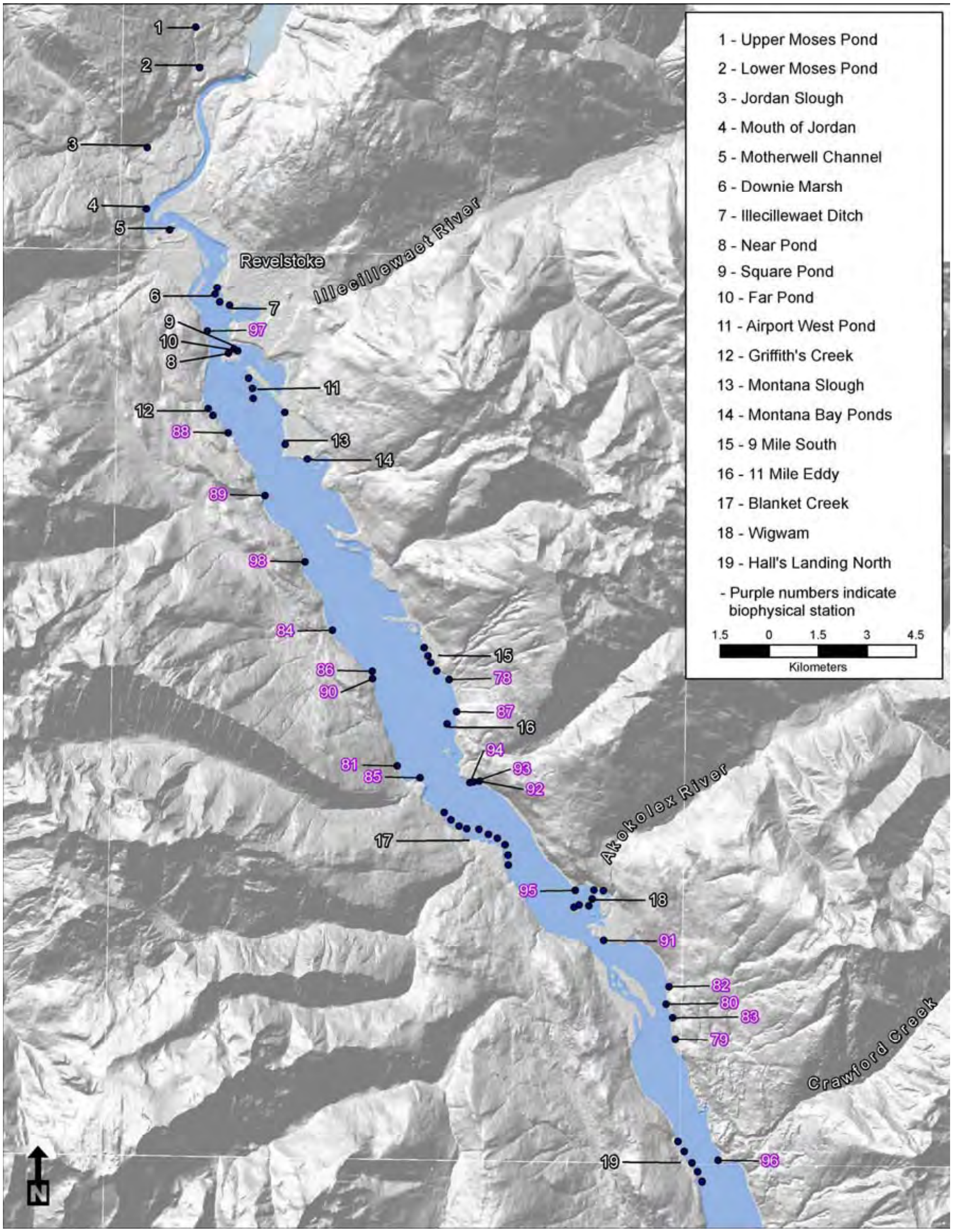

Figure 2-2: **Locations of shorebird surveys in Revelstoke Reach. Black points show approximate locations of observation stations. Purple indicates survey stations added in 2011 to increase the diversity of habitat types sampled**

Two land-accessed sites within the reservoir were influenced more by river flow and discharge from Revelstoke Dam than by reservoir elevations—these were positioned north of the Trans-Canada Highway along the edge of the Columbia River. Originally 19 sites were chosen for their potential to be used by shorebirds (black labels in Figure 2-2). The remaining 18 sites (21 stations) were added in 2011 to sample a larger range of habitats during our boat-based surveys. These sites were chosen to systematically sample from the habitat types available, as mapped by the CLBMON 11B-1 biophysical mapping (Hawkes et al. 2011, CBA 2013).

All surveys involved two biologists. Boat-based surveys also included a boat operator. Observations were made from semi-fixed survey stations. The larger wetlands required multiple observation stations. Locations of survey stations were not entirely fixed: they changed somewhat in relation to the shoreline, which moved according to reservoir levels. Our goal was to make a complete census of the numbers of shorebirds present in the surveyed habitats on each survey occasion. This can be challenging in a reservoir system where habitats and shorelines keep moving or disappearing altogether. When boats or kayaks were used, a spotting scope was not effective, so we included a slow transect between survey stations to ensure we were not missing shorebirds.

At each station, two surveyors scanned all appropriate habitats in order to make a complete count of shorebirds. The species, number of birds, behaviour and habitat being used were recorded for each group of shorebirds detected. Locations were recorded on field maps and were digitized during data entry. All shorebirds observed were identified to species, whenever possible; however, some closely related species could not always be reliably separated in the field. These included the following:

- Both Long-billed and Short-billed Dowitchers occur in the study area. In non-breeding plumage they cannot be reliably identified to species in the field; therefore, dowitchers were often recorded as “dowitcher sp.”.
- Both Greater and Lesser Yellowlegs occur in the study area, but they could not always be reliably separated; therefore, they were sometimes identified as “yellowlegs sp.”.
- Distinguishing Western, Least and Semipalmated Sandpipers can be challenging; therefore, these species were sometimes classified to genus (*Calidris* sp.). See the protocol report for more detail on the methods used (CBA 2013).

Habitat conditions were qualitatively described at each site on every survey occasion by estimating the percentage of the site’s shorelines comprised of each habitat category (e.g., sand, vegetation, mud, cobbles) as seen from the observation stations (CBA 2013).

2.4 Productivity Monitoring of Waterfowl

Waterfowl brood surveys were conducted during a six-week period from June 15 to July 30. Surveys were conducted twice per week for a total of 13 surveys. The methods and locations used for the waterfowl brood surveys were identical to those for the land-based waterbird surveys (Section 2.1), but the size, age and number of broods was also recorded (Gollop and Marshall 1954). Waterfowl that were a similar size as their parents were classified as juveniles; we did not included juveniles in counts of broods of Canada Geese, which become challenging to separate from adults. Broods of Canada Goose were often grouped together, which made individual broods impossible to count; therefore, the total number of young and attending adults were counted. The number of broods was estimated based on these counts (e.g., 18 young attended by 6 adults = 3 broods).

2.5 Productivity Monitoring of Bald Eagles and Ospreys

Monitoring the productivity of Bald Eagles and Ospreys involved locating their nests, and monitoring the nests to determine nesting activity and the outcome of each nesting attempt (nest success and the number of young fledged).

Many Osprey and Bald Eagle nests along Revelstoke Reach were first identified and mapped in earlier years (2008 until the present year), but searches for new nests were conducted annually. Both Ospreys and eagles re-use old nests in consecutive years, but they may also alternate between nests from year to year. One aerial survey was conducted on June 28, 2012 using a Bell 206B helicopter, and involved checks of previously located nests and approximately 1.5 hours of nest searching.

Prior to surveying, the coordinates of known nest sites were compiled and uploaded into a hand-held GPS (model Garmin Map76CSx). Two observers, positioned on either side of the helicopter, conducted the surveys. The survey area included the shoreline and slopes above the entire Revelstoke Reach study area (Figure 1-1). Previously known nests were checked, and searches for new nest sites were conducted using a meandering transect over appropriate habitats situated immediately above the reservoir. When new nests were located, the coordinates and other details were recorded on a nest observation form. Nest monitoring was conducted throughout the breeding season until active nests were terminated (failed or fledged). Where possible, nests were observed from land; others were monitored while conducting boat-based shorebird surveys.

On all nest monitoring occasions, observers recorded the location of the adults, as well as the species, nesting behaviour (i.e., incubating or brooding), and number of eggs, nestlings and fledglings. One or more of these data were used to determine if the nest was active. Additionally, any breeding behaviour of adult birds attending the nest was recorded. All observations were recorded on a standardized nest observation form (CBA 2013).

2.6 Productivity Monitoring of Short-eared Owls and Northern Harriers

Short-eared Owls and Northern Harriers occasionally nest in the drawdown zone of Revelstoke Reach (Jarvis 2003, CBA 2011). We attempted to monitor productivity of these species when one or more pairs were nesting; however, we altered our survey methodology for the 2012 season so that we could increase our effort in tracking potentially nesting birds and minimizing time spent in areas not being used by these species. Over the past four years we have noted that these species select habitats just south of Machete Island, and are rarely seen in the more southern part of the study area. Nonetheless, we surveyed the entire study area (all grasslands north of Drimmie Creek) using five monitoring stations, and surveyed each at least two times during the monitoring season to ensure that these species were not established in non-typical sites (Figure 2-3). Each observation location (i.e., Machete Island, Gawiuk Peninsula, Cartier Bay, 9-Mile and 12-Mile) provided an extensive view of most of the suitable habitat within Revelstoke Reach. Within each of these areas, we spent a minimum of 30 minutes scanning for Short-eared Owls and Northern Harriers on each survey occasion.

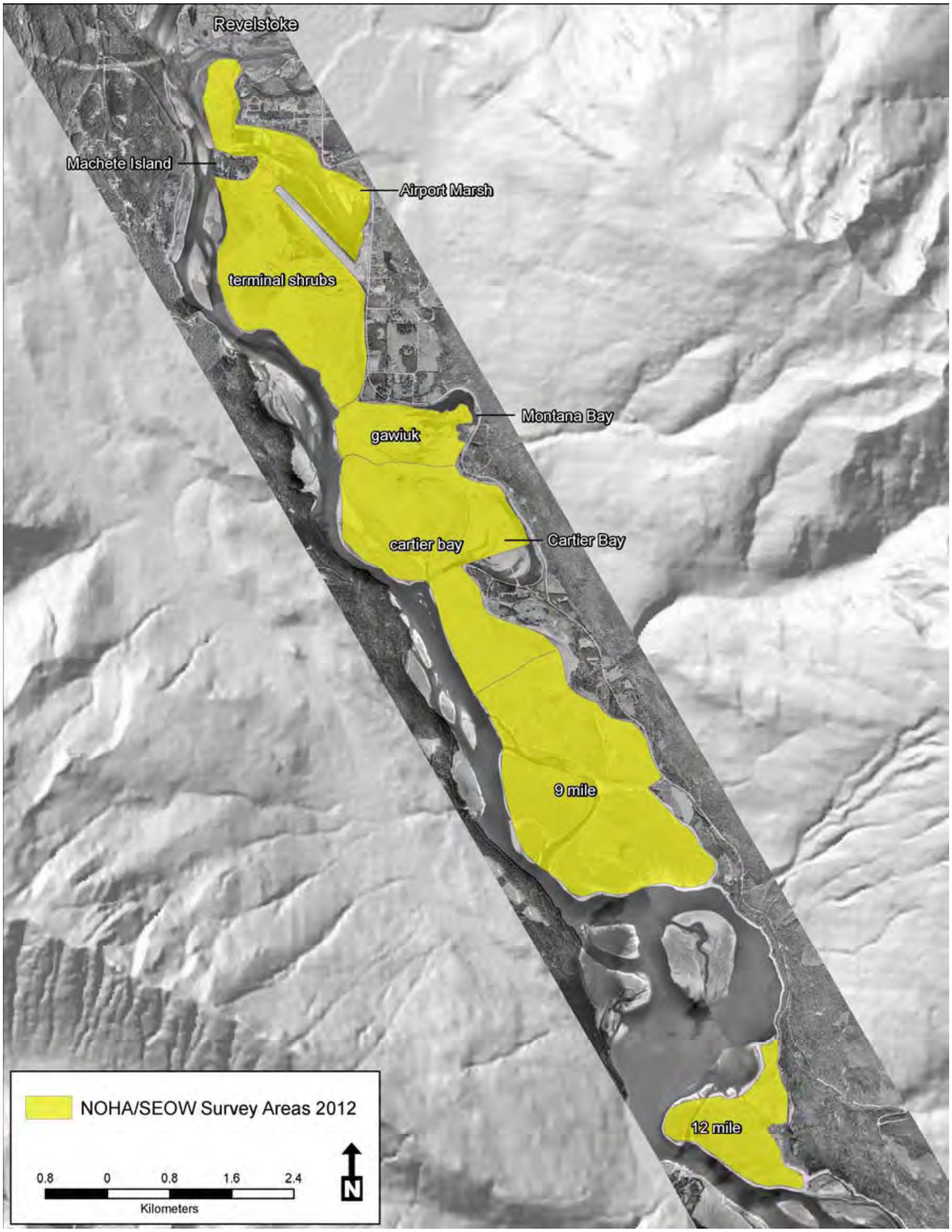

Figure 2-3: Five areas monitored for Short-eared Owls and Northern Harriers. Non-nesting activity has been observed in all of these areas, but all known nesting and most activity occurred in the Terminal Shrubs area

In areas where owls or harriers were observed, we continued monitoring for a minimum of one hour for signs of nesting activity, and made additional area visits to assess breeding activity. Additional monitoring effort was concentrated in the area south of Machete Island where Short-eared Owls and Northern Harriers have been repeatedly observed each year and are known to nest. In this area, we spent a minimum of one hour at sunrise and/or at sunset (twice per week) monitoring for owl and harrier nesting activity.

Both species nest on the ground (Macwhirter and Bildstein 1996, Wiggins et al. 2006), and locating nests of either species is challenging. If nesting of either of these species was suspected, nest searches were initiated and the survey effort was confined to a relatively small geographic area by employing a systematic grid search. If located, nest monitoring was conducted on a weekly schedule, taking care to minimize disturbance to these birds.

These surveys were preformed by two observers for one day per week from mid-April until the end of May.

2.7 Monitoring Wildlife Physical Works and Revegetation

As part of the sample site selection, we included sites where Wildlife Physical Works (WPW) have been proposed. In 2012, we monitored three proposed WPW projects. Effectiveness monitoring of WPW6A (Golder Associates 2009a, 2009b) focused entirely on the habitat being protected by WPW6A (Machete Ponds and Airport Marsh), not on the actual work site. We monitored this WPW project by aerial and land-based waterbird surveys, brood surveys and shorebird surveys.

WPW14 and 15A (Golder Associates 2009a, 2009b) are related projects planned at Cartier Bay. For these projects, we used the same sampling approach as those for WPW6A, except that no shorebird surveys were conducted because the site is typically flooded by the reservoir during the survey period, which leaves very little habitat.

Several Revegetation Physical Works (RPW) treatments were completed within the study area during fall 2009 and spring 2010 and 2011. These terrestrial treatments have very little relevance to waterbirds, with the exception of their nesting habitat. Nest searching plots within treated areas were monitored by CLBMON 36 and will provide data on the effectiveness of RPW treatments for waterbirds. These sites were also monitored during the aerial surveys.

2.8 Anal ytical Methods

This report provides a summary of progress made in field data collection in 2012. Quantitative analyses will be performed after five years of data collection.

In this report, data are summarized in tables generated using standard data manipulation functions in R (R Development Core Team 2006), including functions from the reshape package (Wickham 2007). Aerial survey results were summarized by calculating the average number of waterfowl within habitat polygons.

Cumulative waterfowl habitat use within wetlands was mapped using Arcview 10. Waterfowl observations mapped as polygons were converted to point locations by randomly generating points within the polygons. The number of points generated was equivalent to the group size mapped by the polygon.

Statistical computing was performed using R software (R Development Core Team 2006). All graphing was done using the ggplot2 package for R (Wickham 2009). Boxplots were used to display historical daily reservoir elevations within one week bins. Over-plotting (where data points overlap) was dealt with primarily by plotting the data as transparent points (i.e., by altering the “alpha level”). A transparency level of 1/4 indicates that a minimum of four points over-plotted is required to make the point appear 100% opaque. We indicate the transparency levels in the figure captions. If transparency was insufficient to deal with extreme over-plotting, we used the "geom_jitter" function (Wickham 2009), where the exact coordinates of data points on the graph are randomly moved slightly in both axes; the default jitter-settings were used in this report.

Average reproductive success for Bald Eagles and Ospreys was calculated as the total number of young produced, divided by the total number of nesting attempts.

3 RESULT S

3.1 Water Levels in Arrow Lakes Reservoir

Reservoir water levels in April and May were initially quite high relative to historical operations and increased thorough June and July, peaking close to record elevations at 440.52 m on July 22 (Figure 3-1). Reservoir water elevations stayed near the peak elevation for approximately five weeks and then dropped rapidly through mid-August and September. Water levels during the latter part of the summer and early fall were low compared with historical operations. The reservoir water elevation changed very little during October.

3.2 Other Annual Conditions

Following a typical winter with a persistent valley-bottom snowpack, the 2012 spring field season began with wet and cool conditions. This pattern of cool weather with frequent precipitation and lower than average temperatures continued through spring and early summer. April and June were both unusually wet, at least compared with the previous four years (CBA 2012c); flooding was common throughout the province, and large volumes of water were discharged out the spillway of the Revelstoke Dam upstream of the study area. In August, this weather pattern changed, and the remainder of the summer and early fall was relatively dry with warm, sunny weather and little precipitation. Water levels were relatively high in Airport Marsh and Machete Ponds throughout most of the 2012 study period.

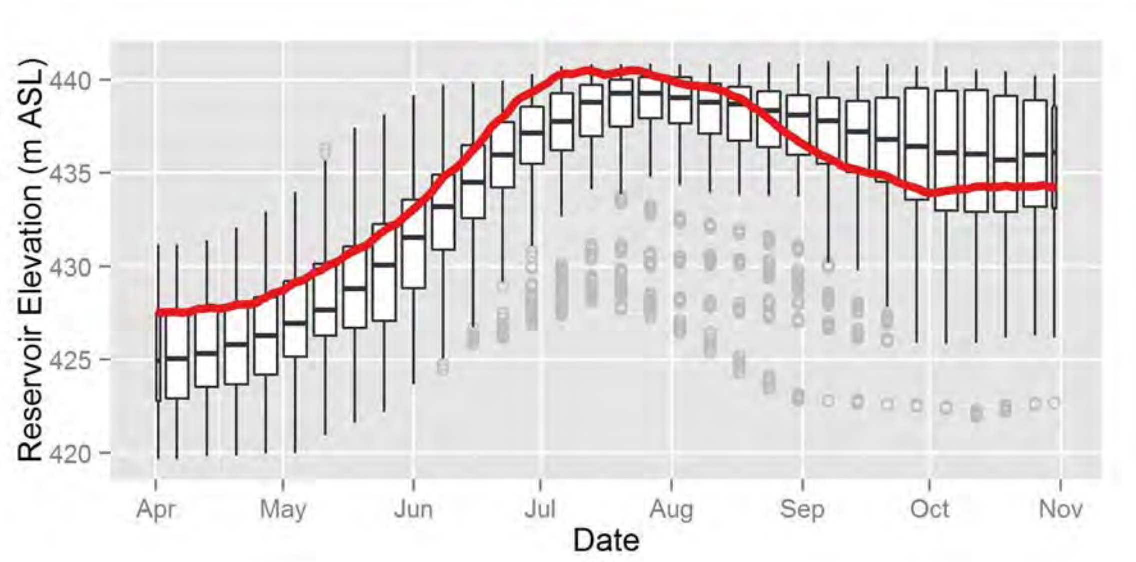

Figure 3-1: **Elevation of the Arrow Lakes Reservoir from April 1 to October 31, 2012 is plotted in red; the historical range of values is plotted in weekly intervals as boxplots**

3.3 Land-based Waterbird Surveys

During the spring and fall land-based waterbird surveys, 11,015 waterfowl from 27 species were observed (Figure 3-2; Appendix 6-1). Canada Goose (*Branta canadensis*) was the most abundant species, followed by American Wigeon (*Anus americana*), Mallard (*Anus platyrhynchos*) and American Coot (*Fulicia american*; Figure 3-2).

3.3.1 Spring Migration

During the spring land-based waterbird surveys, 5,221 waterbirds (25 species) were counted (Appendix 6-1), including 1,385 Canada Geese (27%), 1,275 American Wigeon (24%), 736 Mallards (14%), 287 Ring-necked Ducks (*Aythya collaris*; 6%) and 257 American Coots (5%). The spring migration peaked in the second week of April, following ice breakup at the end of March (Figure 3-3).

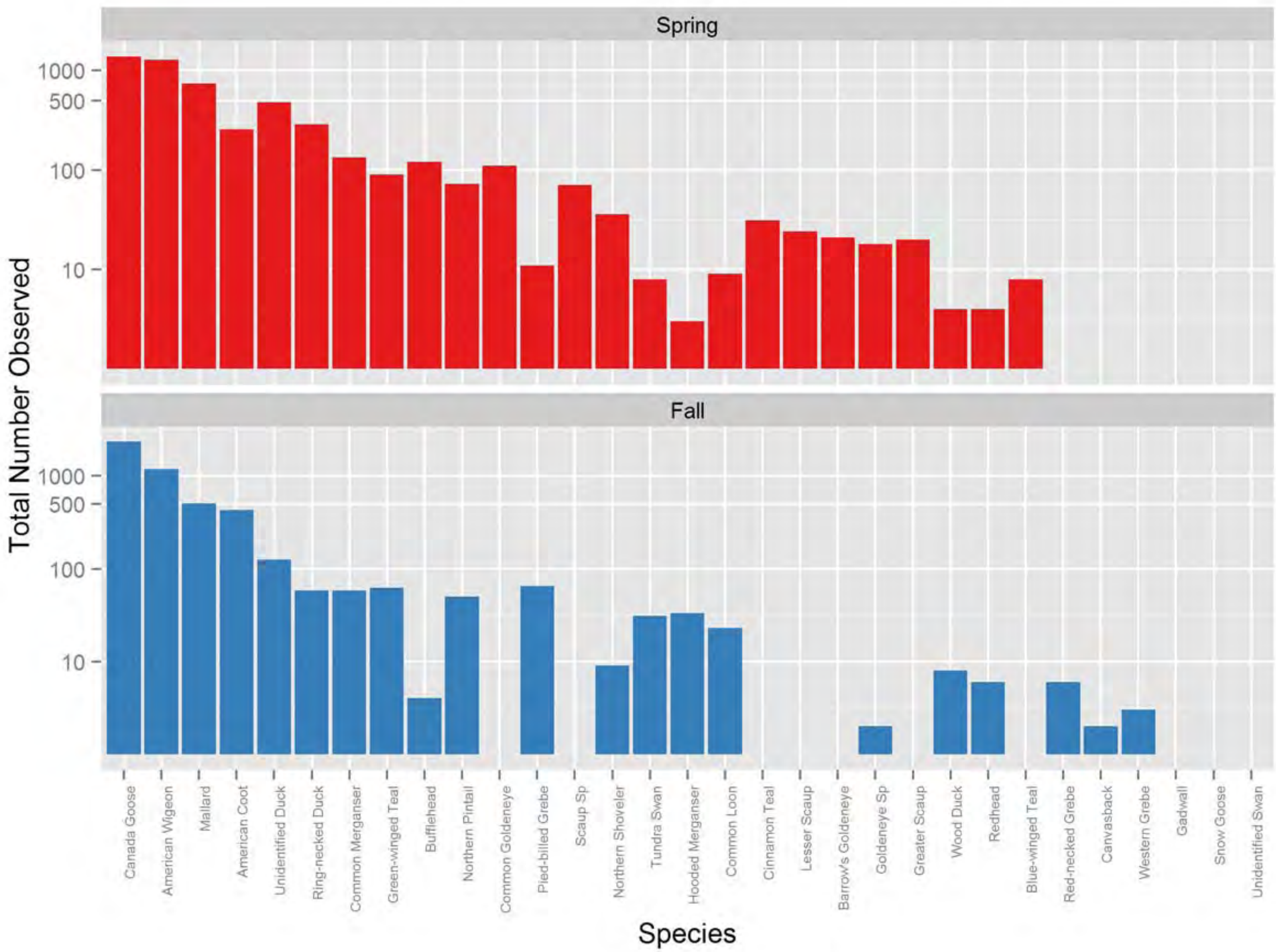

Figure 3-2: **Total number of detections of waterfowl species in 2012 (y-axis has a logarithmic scale). If only one individual of a species was detected, it is listed but not plotted (due to scaling in the y-axis)**

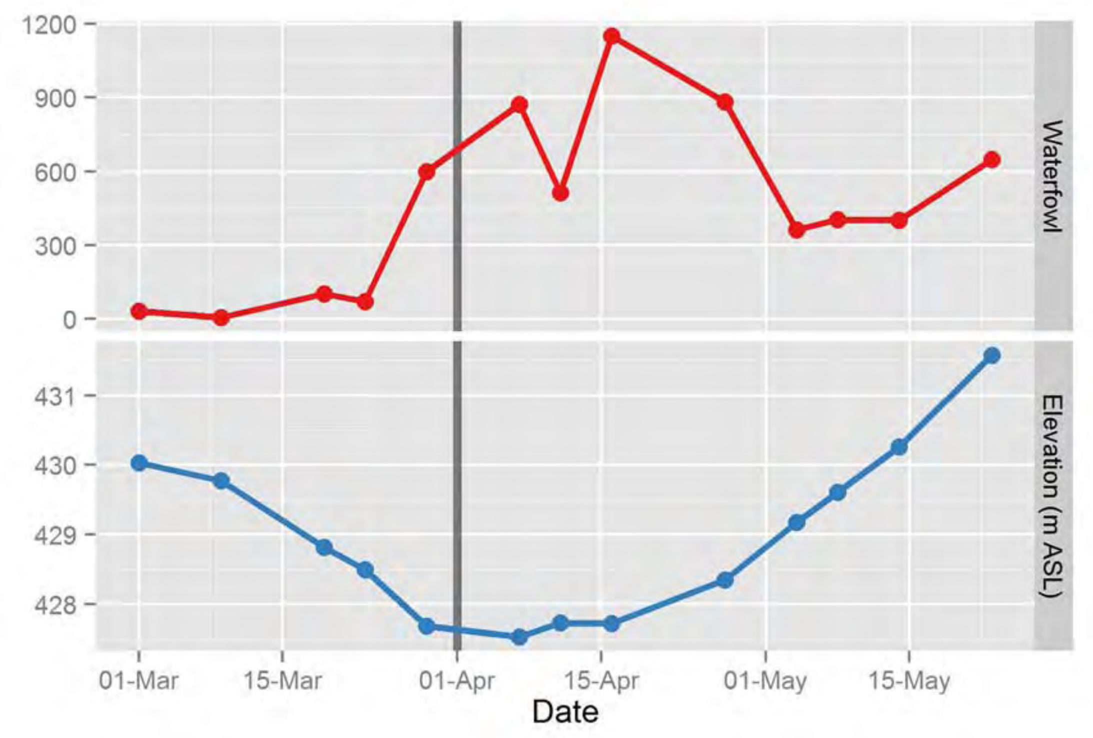

Figure 3-3: **Land-based waterbird survey results for 2012. The total number of waterfowl is plotted for each observation occasion, starting in late winter and extending through the spring observation period. The elevation of the Arrow Lakes Reservoir is plotted for reference. The vertical line marks the beginning of the spring sampling period**

Observations of waterfowl were not evenly distributed among wetlands (Table 3-1). During spring migration, most waterfowl were recorded at Cartier Bay (46%), followed by Airport Marsh (25%), and Downie Marsh (9%). Among the stations with limited access across the year, we observed 376 waterfowl at station 12, and 328 waterfowl at station 29.

Table 3-1: **Total number of waterfowl recorded at the wetlands from stations with year-round access in 2012**

Wetland Area	Fall	Spring
11 Mile Eddy	41	21
9 Mile	342	69
Airport Marsh	1321	1120
Big Eddy	28	12
Cartier Bay	1463	2076
Downie Marsh	236	402
Locks Creek Outflow	981	288
Montana Bay	472	203
Pond G	100	319
Total	4984	4510

3.3.2 Fall Migration

During the fall land-based waterbird surveys, 5,025 waterbirds (21 species) were counted (Appendix 6-1), including 2,352 Canada Geese (47%), 1,186 American Wigeon (24%), 510 Mallards (10%), and 430 American Coots (9%). The peak migration was recorded via the land-based survey during the third week of October (Figure 3-4).

During fall migration, most waterfowl were recorded at Cartier Bay (32%), followed by Airport Marsh (28%) and Locks Creek Outflow (17%; Table 3-1). At the stations with limited access across the year, 219 waterfowl were recorded at observation station 12 (Machete Ponds), 632 waterfowl were recorded at station 29, and 7 waterfowl were recorded at station 11a.

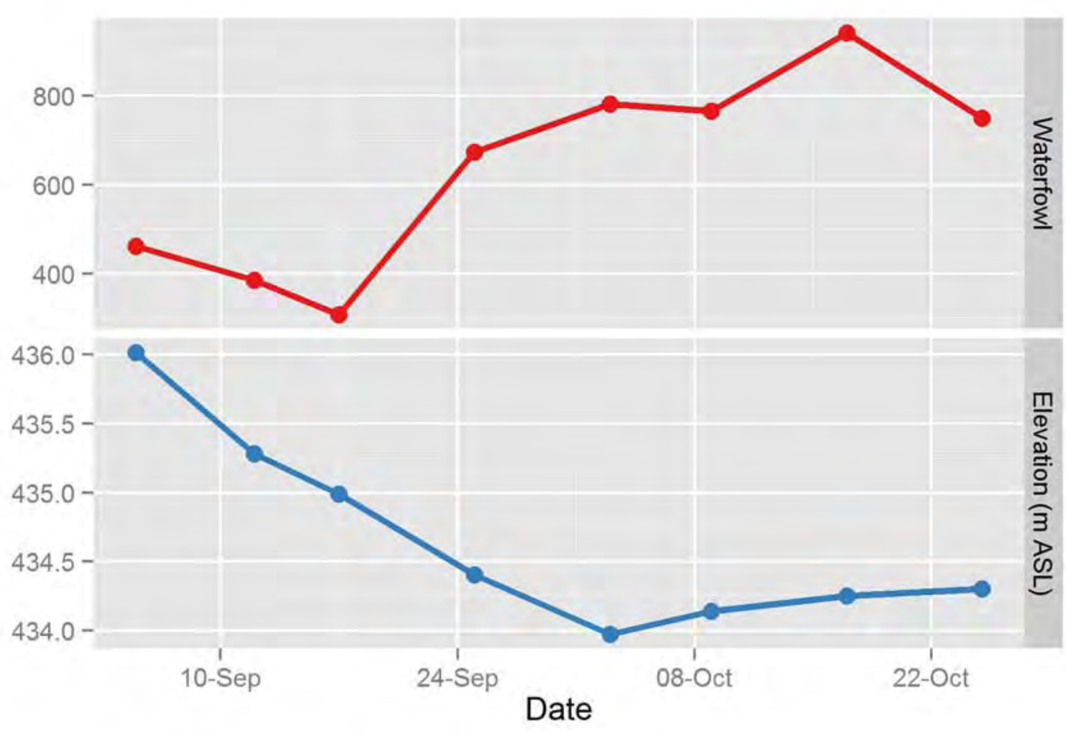

Figure 3-4: Total numb er of waterfowl ob served in fall from eight l and-based survey occasions. The elevation of the Arrow Lakes Reservoir is plotted for reference

3.3.3 Waterfowl Distribution within Wetlands

There was relatively low variability in the distribution of waterfowl at Locks Creek Outflow between spring and fall (Figure 3-5). In other areas, waterfowl distribution was considerably variable within the wetlands and over time (Appendix 6-3).

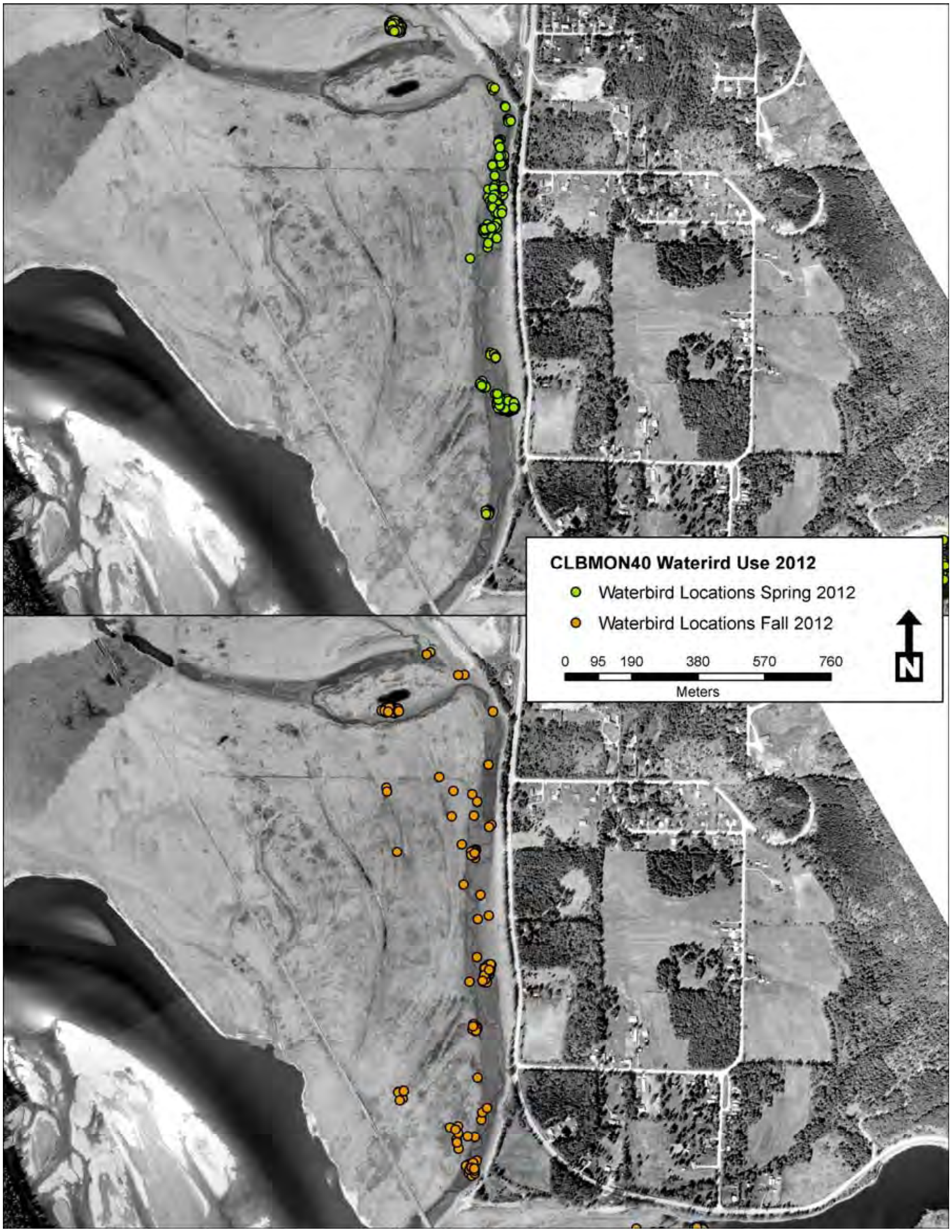

Figure 3-5: Locations of waterfowl at Locks Creek Outflow in 2012

3.4 Aerial Waterfowl Surveys

3.4.1 Spring Migration

Four aerial waterfowl surveys were conducted in the spring. The total number of waterfowl recorded during the spring aerial waterfowl surveys peaked between the first half of April (Figure 3-6). A total of 4,088 waterfowl were counted during these surveys, and 13 species were identified (Appendix 6-2). Mallard was the most numerous species (21.6% of all detections, ≤ 503 per survey), followed by Canada Goose (20.2%, ≤ 212), American Wigeon (11.6%, ≤ 152) and American Coot (6.6%, ≤ 150; Appendix 6-2).

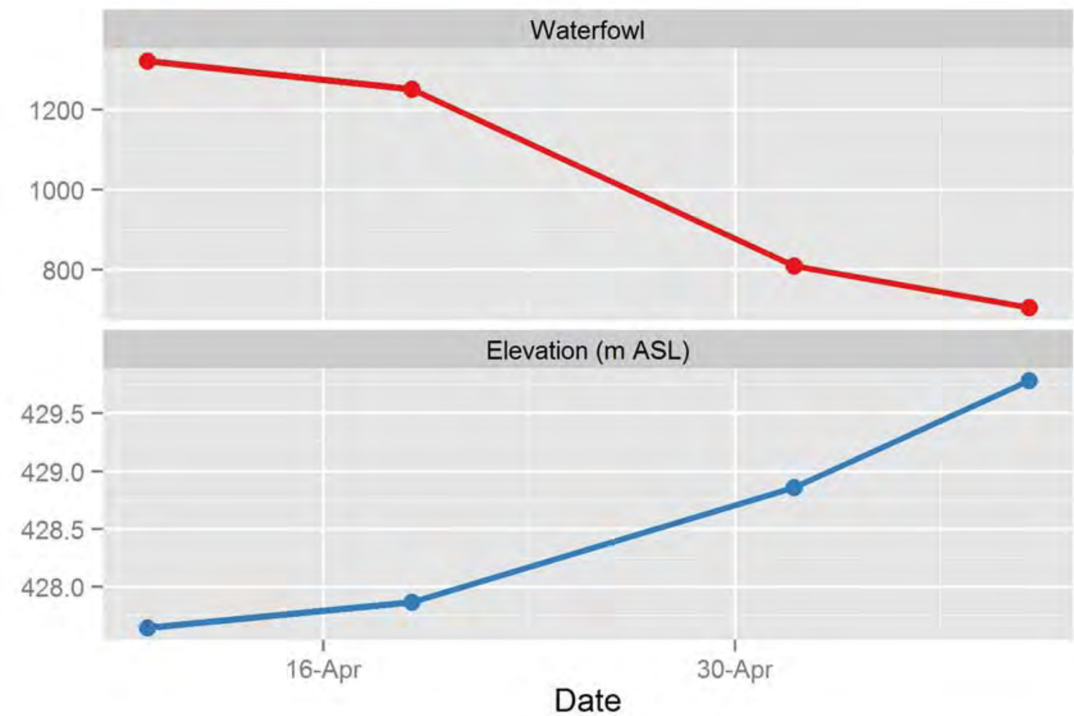

Figure 3-6: Total number of waterfowl recorded during the spring aerial waterfowl surveys. Reservoir elevations are plotted for reference

3.4.2 Fall Migration

Three aerial waterfowl surveys were conducted in the fall, and in agreement with the land-based results (Figure 3-4), the data suggest that the migration intensified later in the fall migration monitoring period (Figure 3-7). A total of 5,203 waterfowl were counted during these surveys, and 11 species were identified (Appendix 6-2). Canada Goose was the most common species recorded (52.9% of all detections, ≤ 1,462 per survey), followed by Mallard (31.7%, ≤ 303), American Coot (2.1%, ≤ 45) and American Wigeon (1.8%, ≤ 93; Appendix 6-2). A large proportion of waterfowl (31.7%) could not be identified to species from the air.

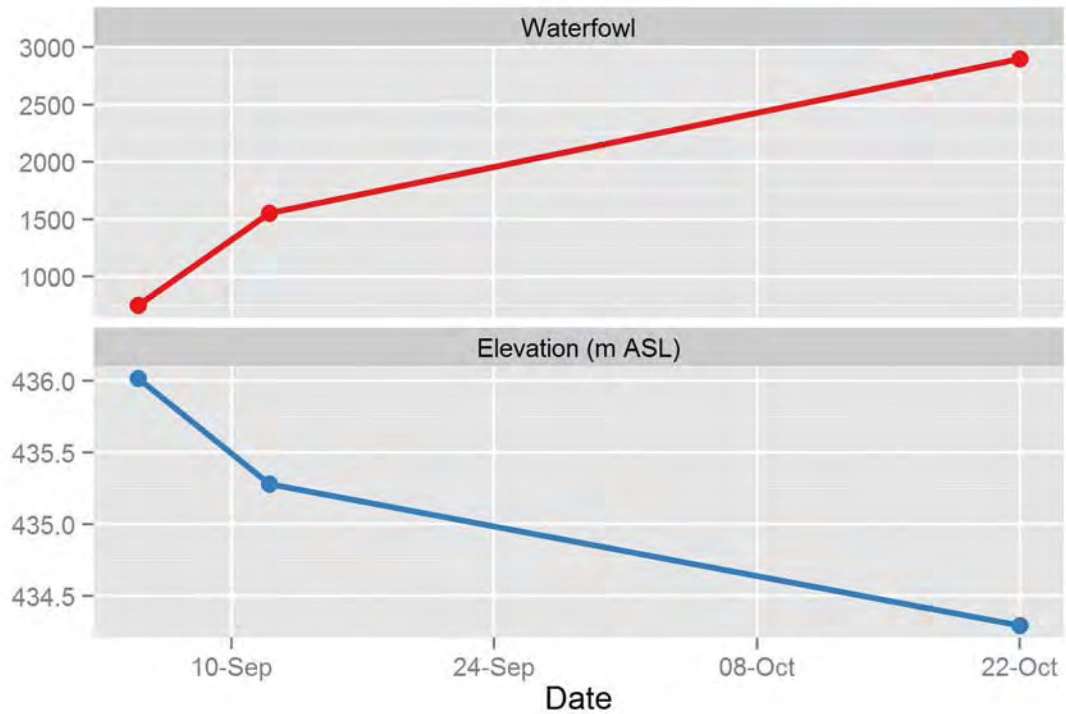

Figure 3-7: Total number of waterfowl recorded during the fall aerial waterfowl surveys. Reservoir elevations are plotted for reference

3.4.3 Waterfowl Distribution during Aerial Surveys

Densities of waterfowl varied considerably among habitat polygons (Figure 3-8, Figure 3-9). In the fall, most waterfowl were observed in grassland polygons; wetland polygons were well used in both seasons (Figure 3-10). A graph of waterfowl habitat use in relation to drawdown zone elevations indicated that birds generally selected high elevation habitats, but use varied considerably between the spring and fall aerial surveys: selected habitats in fall were at higher elevations than those selected in spring (Figure 3-11). Waterfowl also used grassland habitats more frequently but wetlands less frequently as reservoir elevations increased (Figure 3-12).

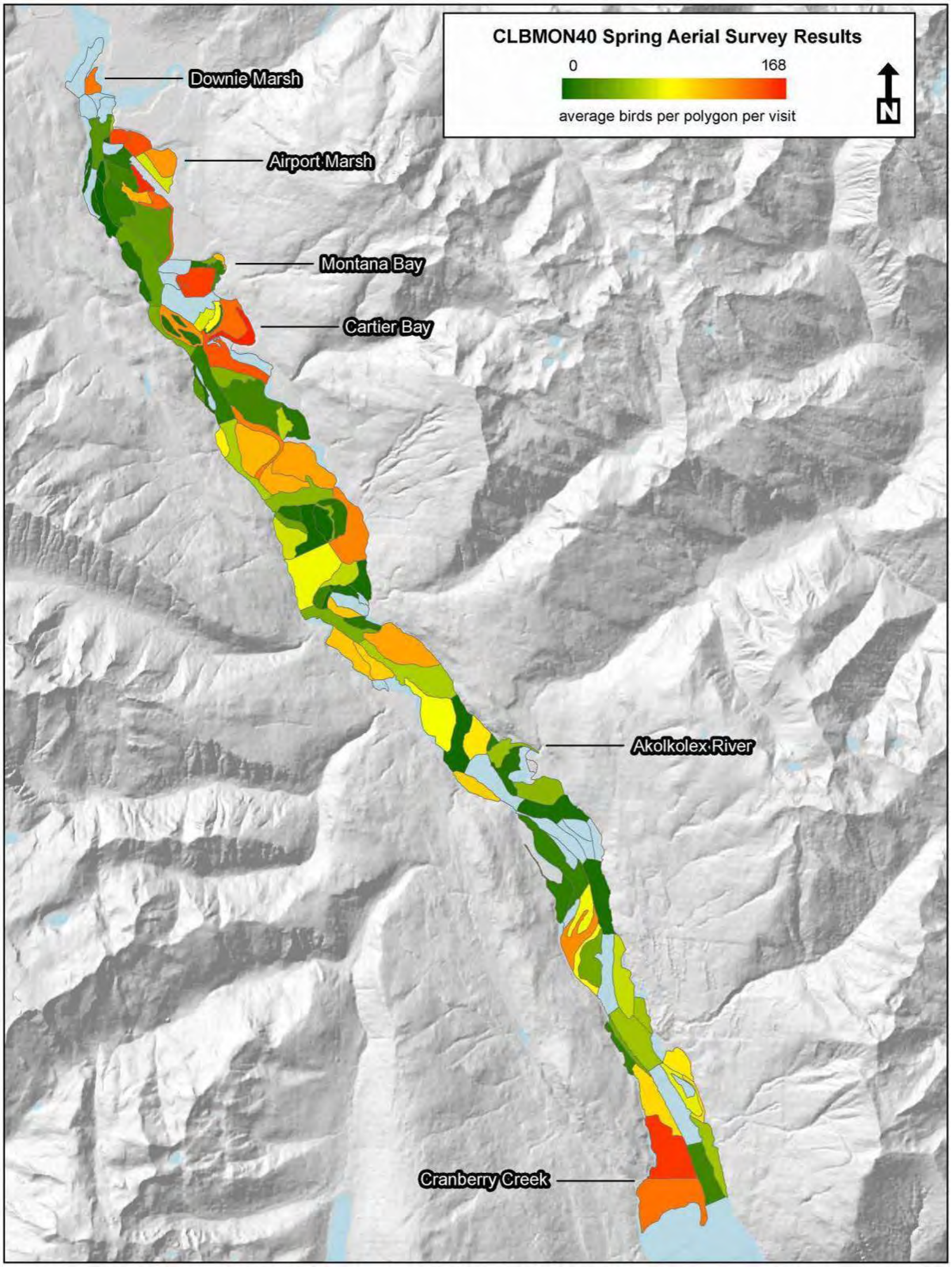

Figure 3-8: **Average nu mber of waterfowl o bserved in habitat poly gons during th e spring aerial surveys. Polygons with no detections are transparent**

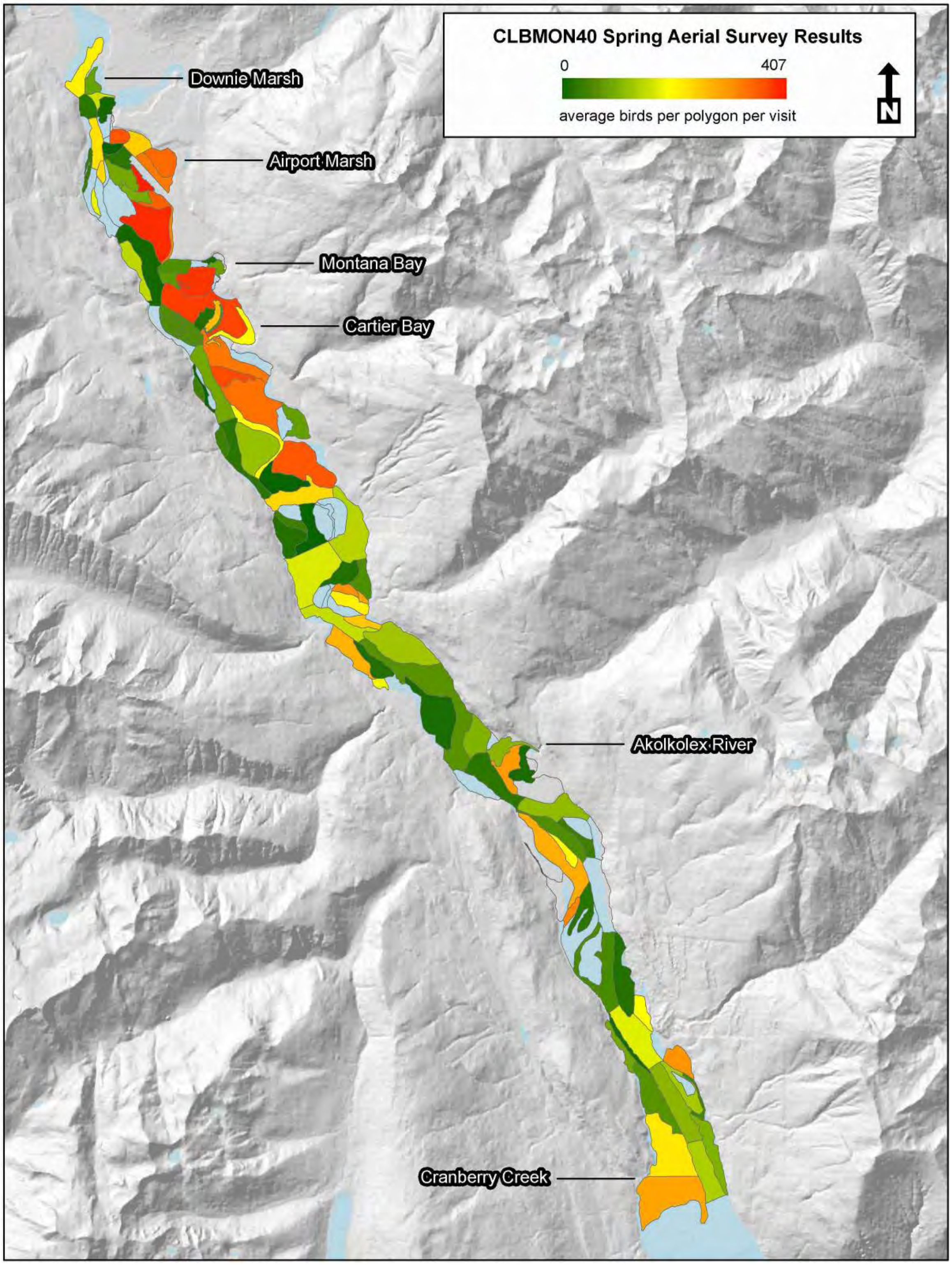

Figure 3-9: **Average number of waterfowl observed in habitat polygons during the fall aerial surveys. Polygons with no detections are transparent**

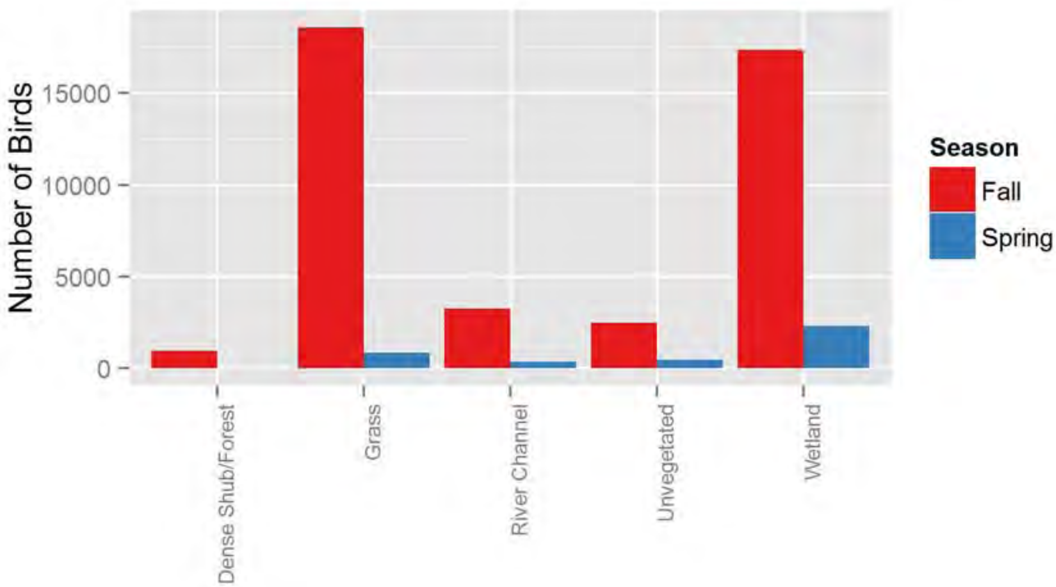

Figure 3-10: **Total numb er of waterfowl d etections during s pring and fall aerial su rveys plotted against habitat strata**

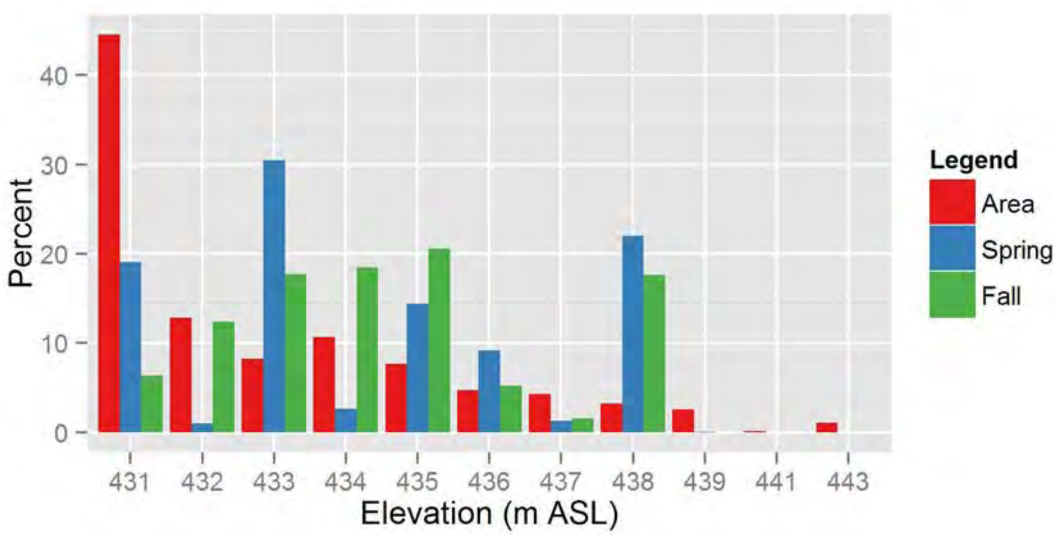

Figure 3-11: **The perc entage of waterfowl d etections during spring and fall sur veys, by 1-m elevational band, plotted against percentage of total area**

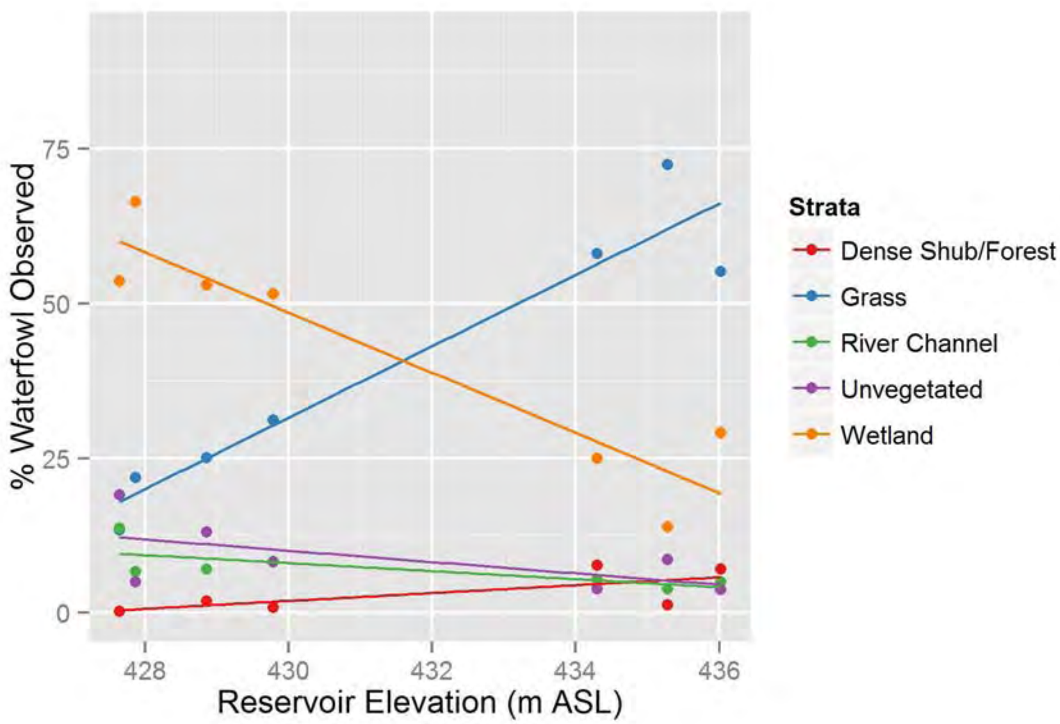

Figure 3-12: **Percentage of waterfowl counted in each habitat stratum during spring and fall aerial surveys plotted as a function of reservoir elevation. Linear functions are provided for visual aid, and are not representative of validated analysis**

3.5 Shorebird Surveys

During shorebird surveys in 2012, 244 individuals and 13 species were observed (Table 3-2, Appendix 6-4). Spotted Sandpiper (*Actitis macularius*) was the most abundant species (55%), followed by Solitary Sandpiper (*Tringa solitaria*; 11%). Most shorebird species were recorded prior to September (Appendix 6-4, Figure 3-13). More shorebird species (species richness = 13) were recorded during the land-based shorebird surveys than during the boat-based surveys (species richness = 8; Appendix 6-4), but the number of shorebirds observed during the two types of surveys did not differ greatly (Figure 3-13).

Shorebirds were observed in a wide variety of shoreline habitat types, but most species appeared to avoid cobble or bedrock habitats (Table 3-3). Spotted Sandpipers, Red-necked Phalaropes (*Phalropus lobatus*), dowitchers (*Limnodromus* spp.) and Killdeer (*Charadrius vociferus*) were commonly observed using unvegetated substrates, whereas Wilson's Snipes (*Gallinago delicata*), Semipalmated Plovers (*Charadrius semipalmatus*), Semipalmated Sandpipers (*Calidris pusilla*) Western Sandpipers (*Calidris mauri*) and Pectoral Sandpipers (*Calidris melanotos*) were commonly observed in vegetated substrates. During the shorebird monitoring period, the reservoir elevation decreased, which corresponded to changes in the habitats along the shoreline that became exposed by receding water levels (Figure 3-14). More sand and mud-like habitats were available as reservoir elevations decreased (Figure 3-14).

Table 3-2: Shorebird species detected during land- and boat-based surveys in 2012

Common Name	Scientific Name	Total Number of Detections
Semipalmated Plover	*Charadrius semipalmatus*	1
Killdeer	*Charadrius vociferus*	9
Spotted Sandpiper	*Actitis macularius*	134
Solitary Sandpiper	*Tringa solitaria*	27
Greater Yellowlegs	*Tringa melanoleuca*	10
Lesser Yellowlegs	*Tringa flavipes*	7
Semipalmated Sandpiper	*Calidris pusilla*	1
Western Sandpiper	*Calidris mauri*	3
Least Sandpiper	*Calidris minutilla*	5
Pectoral Sandpiper	*Calidris melanotos*	11
Dowitcher sp.	*Limnodromus* sp.	23
Unidentified Shorebird		2
Wilson's Snipe	*Gallinago delicata*	9
Red-necked Phalarope	*Phalaropus lobatus*	2
Total		**244**

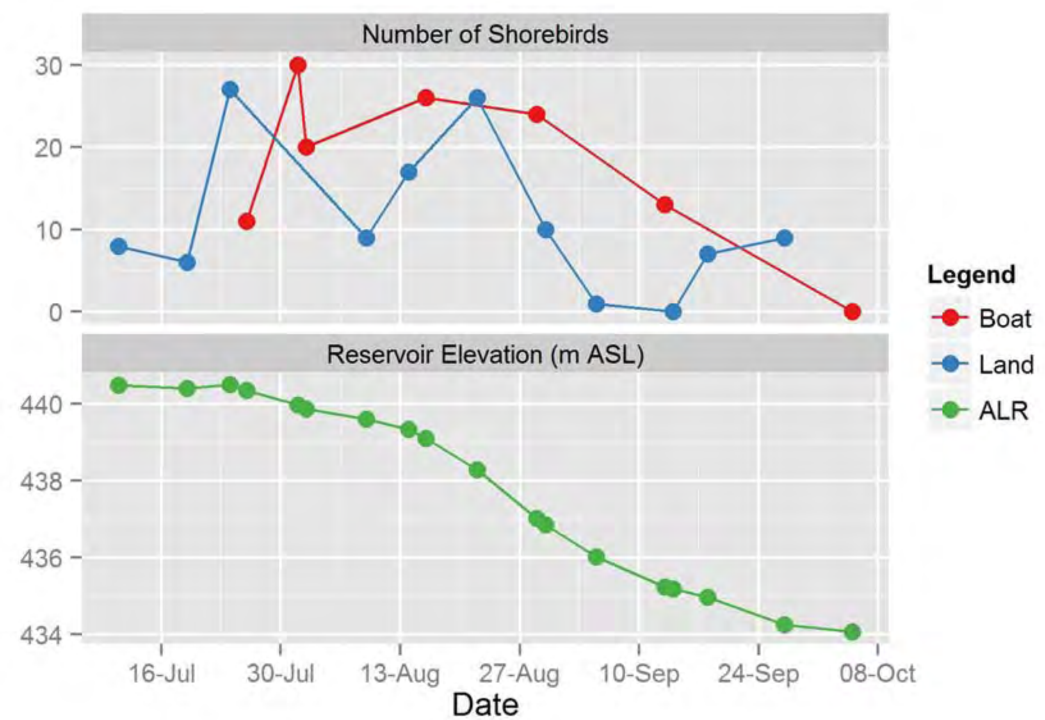

Figure 3-13: Numbers of shorebirds detected during boat-based shorebird surveys and land-based shor ebird surv eys in 2012. Res ervoir elev ations (ALR) are plotted for reference

Table 3-3: Percentage of shorebird species detections in each habitat category. Each bird observation could be assigned to more than one category

Common Name	Mud	Sand	Gravel	Cobble	Bedrock	Grass	Flooded_Veg
Semipalmated Plover	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Killdeer	22.2	0.0	22.2	0.0	0.0	0.0	22.2
Spotted Sandpiper	9.0	17.2	14.2	9.0	4.5	3.7	3.0
Solitary Sandpiper	40.7	7.4	11.1	0.0	0.0	11.1	3.7
Greater Yellowlegs	30.0	0.0	20.0	0.0	0.0	10.0	20.0
Lesser Yellowlegs	14.3	0.0	14.3	0.0	0.0	0.0	0.0
Semipalmated Sandpiper	100.0	0.0	0.0	0.0	0.0	100.0	0.0
Western Sandpiper	0.0	0.0	0.0	0.0	0.0	33.3	0.0
Least Sandpiper	0.0	0.0	20.0	0.0	0.0	20.0	0.0
Pectoral Sandpiper	18.2	0.0	0.0	0.0	0.0	45.5	9.1
Dowitcher sp.	17.4	0.0	8.7	0.0	0.0	0.0	0.0
Wilson's Snipe	33.3	0.0	0.0	0.0	0.0	55.6	22.2
Red-necked Phalarope	100.0	0.0	0.0	0.0	0.0	0.0	0.0

3.5.1 Site Usage

Shorebird abundance varied among sites (Appendix 6-5). In 2012, most shorebird detections were recorded at land-based site SB11 (Airport West Pond), where 75 individuals were observed. At the boat-accessed site SB18 (Wigwam Flats), 40 individuals were detected; three other sites had between 14 and 20 detections. These numbers are not directly comparable, however, due to differences in survey effort in land- and boat-based sampling. Adjusting for effort by considering only data collected in weeks when both surveys were conducted showed that SB11 and SB18 were used to a similar degree (SB11 accounted for 39 detections).

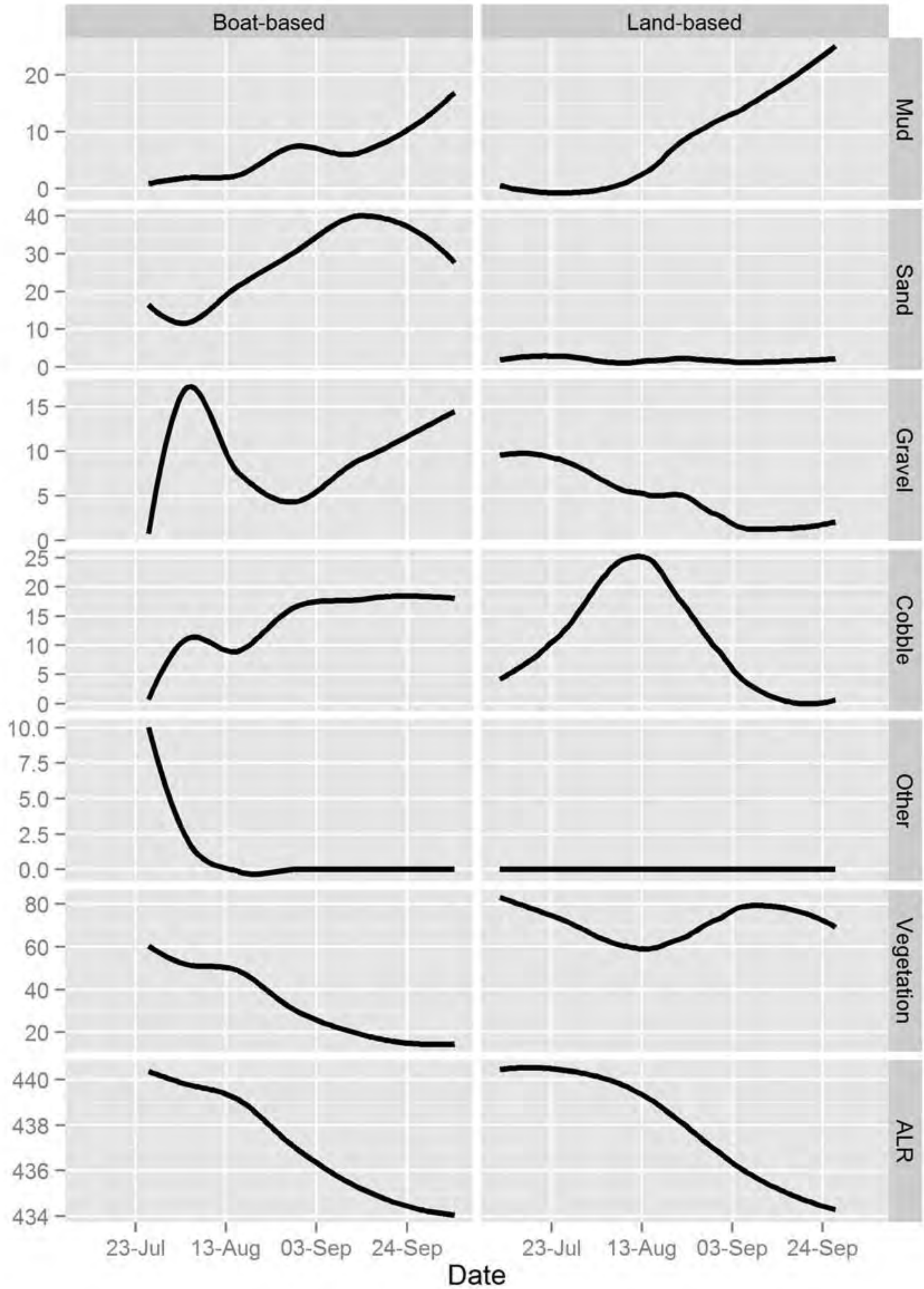

Figure 3-14: **Changes in shoreline habitat qualitatively observed from boat-based and land-based survey stations during the shorebird surveys in 2012. The reservoir elevation (ALR) is provided (m ASL); all other y-axis values are measured as percent of shoreline**

3.6 Waterfow l Productivity Monitoring

Reservoir elevations increased during the brood survey period (Figure 3-15). During brood surveys, fewer than 100 adult waterfowl were observed after late June, and the number of adults and young remained low throughout the brood monitoring season (Figure 3-15). A total of 34 broods (315 young) was detected (Table 3-4). Canada Goose was the most commonly detected species with broods (79% of all broods), followed by Mallard (15%), Pied-billed Grebe (*Podilymbus podiceps*; 3%) and Common Merganser (*Mergus merganser*; 3%; Table 3-4). The age class data showed that observed young were older as the season progressed (Table 3-5).

Most of the 34 broods detected were found in Montana Bay (*n* = 19, 56%), Airport Marsh (*n* = 6, 18%) and Cartier Bay (*n* = 4, 12%). Another three broods (9%) were detected at Downie Marsh, and one brood (3%) was detected at each of Locks Creek Outflow and Big Eddy. Excluding the Canada Goose broods, 7 broods were detected (Table 3-4); three of these broods were detected at Downie Marsh (9%). Single non-goose broods were detected at Airport Marsh, Big Eddy, Cartier Bay and Locks Creek Outflow (3% each).

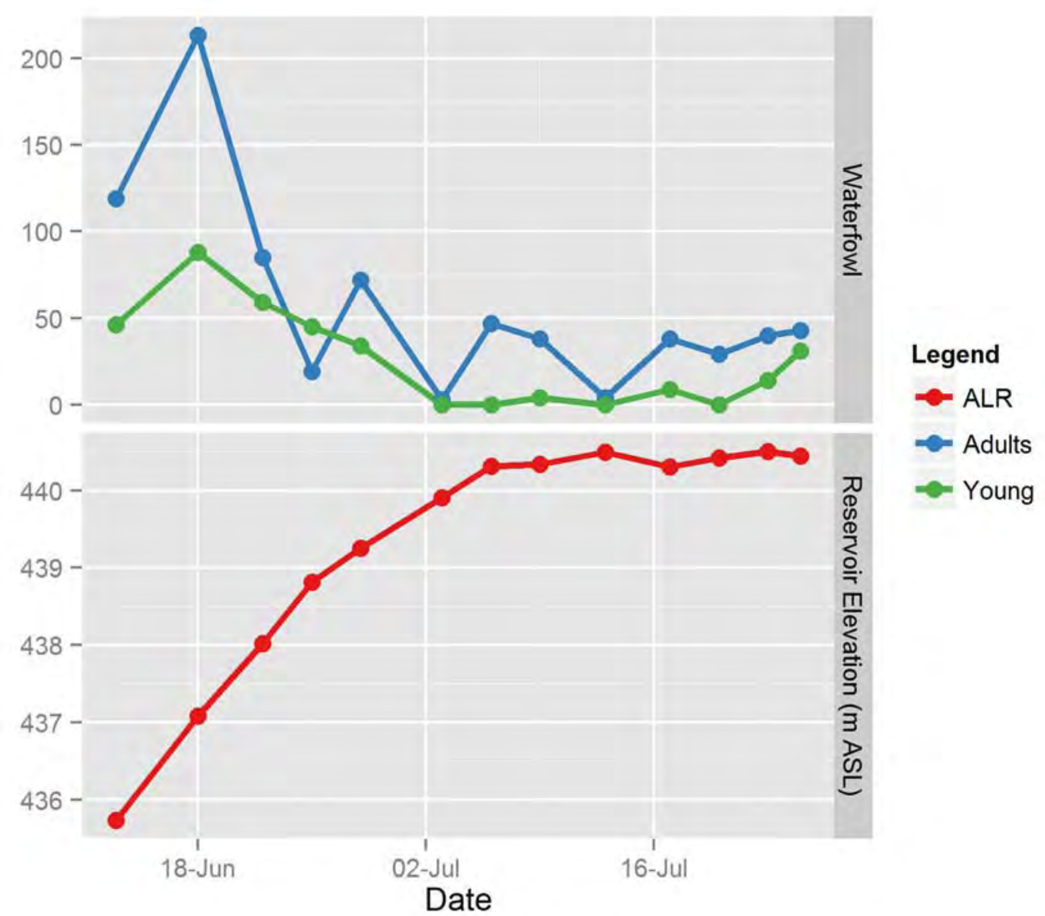

Figure 3-15: **Number o f waterfowl adults and y oung obs erved during surv eys in 2012. Reservoir elevation (ALR) is plotted for reference**

Table 3-4: Number of waterfowl broods, young and adults recorded during brood surveys in Revelstoke Reach in 2012

Common Name	Scientific Name	No. Adult	No. Young	No. Broods
Common Loon	*Gavia immer*	30	0	0
Pied-billed Grebe	*Podilymbus podiceps*	17	5	1
Canada Goose	*Branta canadensis*	216	280	27
Gadwall	*Anas strepera*	1	0	0
American Wigeon	*Anas americana*	91	0	0
Mallard	*Anas platyrhynchos*	196	29	5
Cinnamon Teal	*Anas cyanoptera*	12	0	0
Northern Pintail	*Anas acuta*	1	0	0
Green-winged Teal	*Anas crecca*	5	0	0
Lesser Scaup	*Aythya affinis*	1	0	0
Scaup sp.	*Aythya* sp.	1	0	0
Bufflehead	*Bucephala albeola*	2	0	0
Goldeneye sp.	*Bucephala* sp.	2	0	0
Common Merganser	*Mergus merganser*	30	1	1
American Coot	*Fulica americana*	29	0	0
Total		634	315	34

Table 3-5: Number of waterfowl broods observed each week during surveys in 2012, categorized by age class

Age	13/06/2012	18/06/2012	22/06/2012	25/06/2012	28/06/2012	03/07/2012	06/07/2012	09/07/2012	13/07/2012	17/07/2012	20/07/2012	23/07/2012	25/07/2012	31/08/2012	Total
1b	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
1c	6	5	5	0	0	0	0	0	0	0	0	0	0	0	16
2a	3	1	2	2	0	0	0	0	0	0	0	0	0	0	8
2c	0	0	0	0	4	0	0	0	0	1	0	1	1	0	7

3.7 Bald Eagle and Osprey Productivity Monitoring

We located one new Osprey nest in 2012, and there were three known nest structures destroyed prior to the 2012 surveys. In 2012, we checked 23 nest sites (Figure 3-16). Among these, there were seven confirmed nesting attempts made by Ospreys (Table 3-6). Two of these nests were successful, with an average of 0.29 fledglings per nest. There were three nesting attempts made by Bald Eagles. All three were successful, with one fledgling produced per nest.

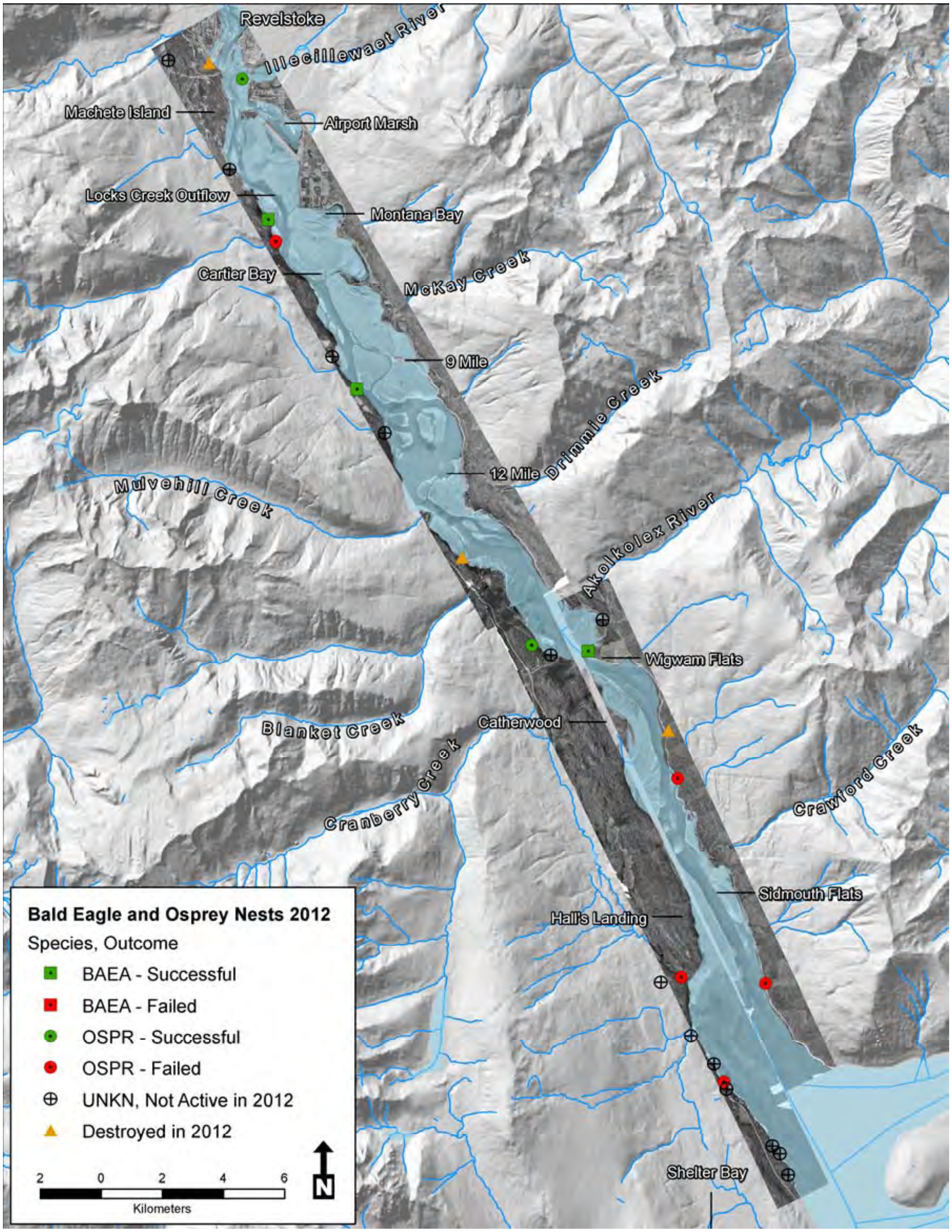

Figure 3-16: **Locations of Bald Eagle (BAEA) and Osprey (OSPR) nests in Revelstoke Reach in 2012. Newly built nests and nests destroyed since the previous year are noted**

Table 3-6: Productivity results from Bald Eagle and Osprey nest monitoring in 2012

Common Name	Scientific Name	Outcome	Number of Nests	Number of Young Fledged
Bald Eagle	*Haliaeetus leucocephalus*	Successful	3	3
Osprey	*Pandion haliaetus*	Failed	5	0
		Successful	2	2
		Unknown	1	0
Unknown	Unknown	Not currently active	12	0
Total			**23**	**5**

3.8 Short-eared Owl and Northern Harrier Productivity Monitoring

No Short-eared Owl nests were located in 2012. Short-eared Owls were observed twice in mid-April south of Machete Island (Table 3-7). However, there were no observations after April 18 (prior to the reservoir flooding their habitat), thus suggesting that no nesting attempts were made during 2012.

No Northern Harrier nests were located in 2012. Harriers were observed primarily in late April and early May (Table 3-7), but there was no indication of pairs attempting to nest.

Table 3-7: Number of Short-eare d O wl and No rthern Harrier de tections rec orded during surveys conducted in 2012

Date Northern	Harrier	Short-eared Owl
2012-04-17	0	3
2012-04-18	0	3
2012-04-23	0	0
2012-04-25	1	0
2012-05-02	5	0
2012-05-08	0	0
2012-05-09	3	0
2012-05-14	0	0
2012-05-15	0	0
2012-05-22	1	0
2012-05-23	0	0

4 DISCUSSION

CLBMON 40 is a 10-year monitoring program designed to assess the impacts of the operations of Arrow Lakes Reservoir on waterbirds and shorebirds that use Revelstoke Reach Reservoir. This study monitors distributions of waterbirds and shorebirds to determine habitat use, monitors productivity of waterbirds, and will provide guidelines for habitat management and water use planning. This report marks the completion of Year 5 of CLBMON 40 data collection. A comprehensive report will follow, which will include a detailed analysis of data from 2008 to 2012 that will address the 11 management questions (MQ) related to these themes. The following discussion highlights several noteworthy occurrences in 2012, and briefly reviews how the field study approaches will allow the management questions to be addressed. Cross-year comparisons will be made in the more detailed multi-year analysis report.

Considerable differences in the results have occurred among the five years of the study, but there have also been some strong similarities. Cartier Bay was once again the most important wetland area during the spring migration. There were concentrations of waterfowl at Cartier Bay and Airport Marsh in the fall of 2012. As in previous years, usage of grasslands was greater in the fall when the grasslands were flooded, which suggests that reservoir operations have an impact on habitat quality for waterfowl.

During the 2012 shorebird monitoring season, reservoir elevations were considerably higher than in previous years. However, shorebirds were relatively more common in 2012 than in 2011 (although still less common than in 2009 and 2010), and we recorded the greatest diversity of shorebirds to date. Further, we recorded the greatest abundance of Spotted Sandpipers to date, with 134 birds observed (compared with 68, 81 and 67 in 2011, 2010 and 2009, respectively). In 2012, Spotted Sandpipers accounted for 55% of all shorebirds observed, and 37% were birds observed during boat-based surveys. Site SB11 (Airport West Pond) and site SB18 (Wigwam Flats near the Akolkolex River) provided most of the shorebird sightings. These sites are noteworthy because even at high water they some suitable habitat for a diversity of shorebirds. In particular, the steep gravel banks along the Revelstoke Airport runway at site SB11 are selected by a diversity of shorebirds at high water. Further, both SB11 and SB18 collect a considerable amount of detritus (i.e., logs and floating vegetation that washes up at high water), which may have contributed to the selection of these sites by migrating shorebirds.

In 2012, fewer Bald Eagles attempted to nest than in 2009, 2010 and 2011. Ospreys made the same number of nesting attempts in 2012 as in 2011 but fewer attempts than in 2010 and 2009. Both Bald Eagles and Ospreys produced the least number of young of all years to date (3 Bald Eagle and 2 Osprey). It is unclear what causes annual changes in the population size and productivity of these species in our study area. It is possible that the rainy spring weather contributed to a low productivity in 2012. No Northern Harriers or Short-eared Owls were observed nesting in 2012.

Waterfowl productivity was low in 2012. This is consistent with the hypothesis that ground-nesting duck productivity is limited by reservoir operations due to nest failure and reduced availability of nesting habitat. This year, water levels were relatively high at the beginning of the monitoring season. They then rose quickly, peaked at near record levels, and remained high for an extended period. Examination of the age class of waterfowl young over the monitoring season suggested that only an early single cohort of young was produced, and that there were very few successful late nests (e.g., re-nesting).

The results are discussed in greater detail below with respect to their relevance to the management questions for CLBMON 40.

4.1 Distribution and Abundance of Waterbirds and Shorebirds

MQ-1 asks: What are the seasonal and annual variations in the abundance and spatial distribution of waterbirds in Revelstoke Reach, and what are the variations in the abundance and spatial distribution of shorebirds during fall migration in Revelstoke Reach?[5] This MQ should be addressed in conjunction with MQ-6 because the effects of reservoir operations will need to be controlled to address this question. This question can be addressed both among and within sites. Results of land-based, boat-based and aerial surveys will contribute to addressing this question.

The aerial survey method provides snapshots of the distribution of waterfowl within Revelstoke Reach on each survey occasion, and is therefore the best method for determining spatial distribution of waterfowl within the study area. To date, the data consistently demonstrate the existence of hotspots where waterfowl tend to congregate, although the relative rankings of these sites vary considerably over time. Cartier Bay has been consistently selected by large numbers of waterfowl, especially in spring. Airport Marsh, Locks Creek Outflow, Montana Bay and the Airport West Pond are also important sites for waterfowl. Aerial surveys also show that waterfowl are repeatedly observed in some more remote areas, such as Hall's Landing. Over time, we will have conducted many aerial sampling occasions (potentially 16 per year), and the data gathered will provide an accurate depiction of waterfowl distribution within Revelstoke Reach.

Aerial survey methods can also provide accurate data for determining seasonal variation in waterbird abundance because a complete population census is conducted over the entire study area on each occasion. This means that this method has a much greater potential to determine how waterfowl shift habitats as a function of reservoir elevations, compared with land-based methods. However, this method is expensive and limited by weather conditions; therefore, it can be used on only a limited number of occasions. Land-based survey methods provide an alternative option for tracking abundance over time. A complete sampling program can be achieved with these methods because minimal costs and logistics are required. Land-based survey data co-vary with aerial survey data, and therefore provide an index of relative abundance. Regressions can be used to validate this assumption. Land-based surveys have repeatedly shown clear evidence of temporal variation in spring and fall migrations, and we expect that the development of predictive non-linear functions of temporal abundance will be made possible by CLBMON 40 monitoring. Land-based waterbird surveys also provide precise spatial data on the distributions of waterbirds at the site scale, and therefore provide another (more detailed) method of addressing MQ-1.

Shorebird surveys have produced variable results among years, but there have also been some commonalities. Small *Calidris* sandpipers (e.g., "peeps") and yellowlegs have been relatively early migrants, while dowitchers have been late migrants. A small subset of monitored sites, such as the Airport West Pond and Wigwam Flats, appear to be selected by a relatively large number and diversity of migrant shorebirds. Spotted Sandpipers, however, have repeatedly been distributed over a more widespread area compared with other migrant shorebirds. This species has been commonly observed throughout the southern sites that were accessed by boat.

The predictable set of sites where shorebirds are most likely to be found in abundance and the predictable timing of their migrations suggest that MQ-1 will be adequately addressed by our methods.

[5] Wording has been modified to fit the sentence. See Appendix 6-1 for the official wording used by BC Hydro.

4.2 Impacts of Reservoir Operations on Waterfowl and Shorebirds

We expect that reservoir operations will affect the distribution of waterfowl and shorebirds because they are known to favour particular water column depths (Rundle and Fredrickson 1981, Colwell and Taft 2000, Parsons 2002, Paracuellos and Tellaria 2004). MQ-6 asks "Do reservoir operations (e.g., daily and maximum monthly water levels) influence the distribution and abundance of waterbirds and shorebirds in Revelstoke Reach?"

Over time, we have observed large seasonal variation in the distribution and abundance of waterfowl and shorebirds during the migrations, and large seasonal variation in the elevation of the reservoir. However, the effects of reservoir operations will be masked by seasonal effects on bird abundance: the effect of reservoir operations is collinear with the effect of season. Including many years of data will control for non-linear patterns of bird abundance. Nonetheless, the data show striking differences among years, both in the numbers of birds and the locations where they are found. Based on the data collected to date, it appears that reservoir operations do have a large impact on the distributions of these birds, but this will be explored quantitatively in the multi-year analysis.

Addressing MQ-6 will likely demonstrate a rationale for considering the needs of waterfowl and shorebirds when planning water use in the reservoir system. Water use planning attempts to provide guidelines for reservoir operations that balance the requirements of power generation, flood control, recreation, fish and wildlife management, and many other factors. Addressing MQ-5 and MQ-2 will provide further guidance to water use planners. MQ-5 asks "Which species of shorebirds and waterbirds are most likely to be affected by reservoir operations?" MQ-2 asks "What impacts do year-to-year and within-year reservoir operations have on resident and migratory waterbirds and migratory shorebird populations?"

MQ-5 can be addressed directly by developing separate models of abundance for common species or groups of waterfowl (e.g., Canada Geese, grebes, dabbling ducks diving ducks) as a function of reservoir operations (after controlling for seasonal effects), and comparing the size of effects fit by these models. This analytical approach considers impacts on waterbirds during migration.

During the breeding season, reservoir operations may reduce productivity of Short-eared Owls, Northern Harriers and ground-nesting ducks due to nest flooding. Species that nest later in the season and lower in the drawdown zone (e.g., American Wigeon) will be more vulnerable to nest flooding than those that nest earlier in the season or higher in the drawdown zone (e.g., Canada Goose). The impacts associated with nest flooding will be addressed using data from both CLBMON 36 and CLBMON 40. In the multi-year analyses, we will determine if certain species show strong correlations between productivity and the number of broods observed each year.

MQ-2 is more challenging to answer directly with data, and will likely be addressed by considering results generated from several of the other MQs. We can summarize how reservoir operations appear to affect resident waterbird populations by using the productivity monitoring data. For migrants, the consequences of the impacts are less clear. The availability of a suitable stop-over site may vary among years, but we will not be able to say what the consequences are for migrant populations by using quantitative evidence because we do not catch or track migrant waterbirds or shorebirds and do not study them outside of our study area.

Given that the Arrow Lakes Reservoir is operated under constraints imposed by the Columbia River Treaty, the potential for adjusting reservoir operations for effective management of waterbird and shorebird habitat is constrained; realistically, only minor adjustments to operations can be considered. MQ-8 asks “Can minor adjustments be made to reservoir operations to minimize the impact on migrating waterbirds and shorebirds or on waterbird productivity?” This question is particularly important because minor changes in reservoir elevations can result in large changes in habitat availability and suitability.

As water levels decline, the drawdown habitats provide different suites of shoreline habitats. Some habitat characteristics, such as the amount of grass and sedge, peak at mid-elevations in the drawdown zone. Hence, it is likely that the suitability of shorelines for shorebirds is modulated by reservoir operations. Multi-year monitoring data will be used to determine which elevations are associated with increased usage at each site, and this can be linked to the selection of certain types of shoreline substrates.

In the multi-year analyses, we will model how reservoir operations are associated with wetland usage by waterfowl and shorebirds. These models will identify optimal and suboptimal reservoir elevations for each wetland site. Because each wetland is situated at a different elevation, there may be a range of optimal reservoir elevations. It is possible that there will be water elevations where no wetlands are in optimal condition, and the results will be used to provide recommendations on adjusting reservoir operations to manage water levels for waterfowl and shorebirds.

Data from CLBMON 36, the CLBMON 40 brood surveys, and Northern Harrier/Short-eared Owl surveys will be used to model how waterbird nest mortality can be managed.

4.3 Productivity

Two management questions are related to the productivity of waterbirds. MQ-4 asks “What is the annual variation in the productivity of waterbirds in Revelstoke Reach and does productivity vary spatially (e.g. are there areas of higher waterbird productivity or brood counts)?” This question is addressed by brood surveys and raptor nest monitoring, and does not require complex analyses.

To date, we have observed great annual variability in brood numbers, with the greatest productivity occurring in 2009 (CBA 2010a), a year in which nest mortality rates caused by reservoir operations were relatively low (CBA 2010b). In 2011, we observed very few broods, fewer than in 2010 and approximately half of those observed in 2009. Productivity dropped even lower in 2012. For example, Mallard productivity measures were approximately half of those recorded in 2011. Hence, waterfowl productivity can vary considerably among years.

There has also been considerable patchiness in the distribution of broods. Our data on brood distributions will highlight important brood-rearing habitats. Annually, we have detected most broods at Cartier Bay, Montana Bay and Airport Marsh. CLBMON 36 will show where waterfowl establish nests, and may be able to provide maps of waterfowl nesting density.

We have also observed annual variation in the number of Bald Eagles and Ospreys attempting to nest and in the number of young produced. In 2008, nest were located and monitored during boat-based shorebird surveys. Helicopters have been used for nest searches and some monitoring since 2009, which has allowed us to conduct more thorough censuses. Since that time, the number of Ospreys nesting has varied from 7 to 12 pairs. Osprey nesting success rate has varied from 50% to 80%; in 2012 it was only 29%, possibly due to high levels of precipitation during the 2012 breeding season. The number of Bald Eagle pairs nesting each year has varied from 3 to 7, and their nesting success has varied from 66% to 100%.

Bald Eagle and Osprey nests have been patchily distributed: certain parts of the study area have had high densities of nests, while other areas have had very low densities. Variation in forest characteristics (e.g., stand age) could account for this patchiness, but it could also be partly explained by the availability of foraging habitat in the reservoir. It may be possible to test the association between nest density and forest age using forest cover maps.

The second management question related to waterbird productivity, MQ-7, asks “To what extent do water levels in Arrow Lakes Reservoir influence the productivity of waterbirds in Revelstoke Reach between years?

Our brood survey data suggest that waterfowl productivity is linked to annual differences in reservoir operations, but this needs to be quantified by careful analysis, and alternative interpretations need to be considered. An advantage of the brood survey method is that broods are easily observed and counted, whereas the nests of many waterfowl are challenging to find. As such, brood surveys, especially when conducted annually, are advantageous for estimating waterbird productivity in the Revelstoke Reach wetlands. One shortcoming of brood survey data from the reservoir system is that there may be a detection bias due to shifting brood-rearing habitats associated with changing reservoir elevations. During periods of high water, when wetland habitats are flooded, brood rearing may move away from traditional wetland sites (where we are monitoring) and into flooded terrestrial habitats, such as the willow-shrub habitats that surround many of the wetlands. Therefore, care needs to be taken when drawing conclusions about sources of variation in brood numbers among years.

How waterfowl productivity is correlated with reservoir operations should be examined separately for groups of species to account for the diversity of nesting habitats used and variation in timing of nesting among species. Linkages between reservoir operations and number of broods can be made by comparing results across years. For example, the Mallard, which is a relatively early nesting species but is vulnerable to flooding, may be able to reproduce before the reservoir floods in years of late filling. High reservoir elevations early in the year (early filling) and high maximum water elevations will likely limit Mallard nesting success. An examination of brood age variability among years may also reveal which factors influence brood numbers annually. Specifically, successful re-nesting following flooding will cause average brood ages to be younger later in the season.

For the formal analyses, we plan to augment the brood survey results by including CLBMON 36 nest monitoring data. Analyses comparing nest mortality rates, brood survey results and reservoir operations can be used to support the use of brood survey methodology and validate interpretations; nest monitoring results can also provide better data on nesting habitats.

We suspect that the biological effect of reservoir operations on nesting success or productivity of Bald Eagles and Ospreys is limited given that their nests are not vulnerable to flooding. With the small number of nests monitored annually, it will likely be challenging to detect relationships between reservoir operations and productivity based on 10 years of monitoring. Monitoring prey delivery rates to nestlings would be a much more powerful method of determining how reservoir operations limit these species (CBA 2011).

Monitoring productivity of Short-eared Owls and Northern Harriers is more challenging than that of Bald Eagles and Ospreys because owl and harrier numbers are very low, and their nests are very difficult to find. CLBMON 40 documented Short-eared Owls nesting in the study area in only one year: 2010. This species is known to nest in only one part of the study area, which in some years is vulnerable to flooding prior to young fledging.

4.4 Habitat Use and Enhancement

Documenting habitat use by waterbirds and shorebirds is required to address MQ-3: "Which habitats within the drawdown zone in Revelstoke Reach are utilized by shorebirds and waterbirds and what are their characteristics (e.g. foraging substrate, vegetation, elevation, and distance to the waters edge)?"

We intend to study habitat selection at three scales: across the entire study area (aerial waterfowl surveys), across sites (shorebird surveys), and within sites (land-based waterbird surveys).

4.4.1 Habitat Selection across Revelstoke Reach

We can address MQ-3 at the landscape scale by using the aerial survey data. Spring aerial surveys have consistently shown that Cartier Bay and a few other wetland polygons at the north end of the study area are heavily used by waterfowl. Habitat usage is clearly weighted towards habitats at mid to high elevations. In the fall, Cartier Bay is not used by many waterfowl. We expect that formal analyses will show that reservoir operations account for these seasonal differences because reservoir elevations are typically higher in the fall (Figure 1-5).

As in previous years, the proportion of waterfowl found in each habitat stratum varied with reservoir elevation. When reservoir elevations were relatively high, the proportion of waterfowl detected in grassland polygons increased, while the proportion detected in wetland polygons decreased. This relationship appeared to be almost linear in 2011 and in 2012. However, this is likely a function of the range of reservoir elevations over which we have made observations. If observations were made at higher elevations, we would possibly see a decrease in usage of grassland polygons. We therefore expect that the relationship is not linear, and that grassland usage would decrease if reservoir elevations were even higher than when we sampled in 2011/12 (e.g., > 439 m ASL). Regardless, this observation shows that the definition of habitat should consider water depth as a variable when waterfowl habitat selection is being assessed (Rundle and Fredrickson 1981, Colwell and Taft 2000, Parsons 2002, Paracuellos and Tellaria 2004). Therefore, reservoir operations should be included in habitat selection analyses.

CBA developed a GIS shapefile layer to map terrestrial habitat types in Revelstoke Reach. This data layer could be used to add detail to this large scale habitat analysis, which would allow us to test if there is selection for certain vegetation communities within strata.

4.4.2 Habitat Selection among Sites

The use of aerial surveys for shorebird monitoring is not possible because the birds are difficult to detect from the air. It is more appropriate to study shorebird habitat selection by comparing usage among representative sites that have been monitored (e.g., Paracuellos and Tellaria 2004). This approach is suitable for our study because we are monitoring many sites.

In this report we used qualitative descriptions of shoreline habitats observed during surveys to describe how shoreline habitats vary with reservoir elevation. There was considerable variation in the amount of sand, cobble, gravel and vegetation in shoreline habitats as reservoir elevations changed. Many of results had similarities to those observed in 2011 (CBA 2012d).

Although we have not yet run multivariate analyses of habitat selection among sites, our shorebird data show strong indications of selectivity for two sites. Repeatedly, we have found that the Airport West Pond and the Wigwam Flats areas are selected by migrating shorebirds.

4.4.3 Habitat Selection within Wetlands

Since 2010, we have been using digitized polygons to map the exact locations of waterfowl observations. These data can be compiled to generate raster “heatmaps” of regions within wetlands that are used most frequently. These maps show considerable variability in waterfowl usage of regions within the wetlands that are being monitored. This can likely be explained, to some degree, by differences in habitats within these wetlands.

CBA previously conducted some habitat measurements within the wetlands being monitored by land-based waterbird surveys (CBA 2011), but this component of CLBMON 40 became redundant and was terminated when BC Hydro commissioned a separate study (CLBMON 11B-4) to measure and monitor wetland habitats within Airport Marsh, Montana Bay and Cartier Bay. LGL Ltd. began pilot studies of these habitats in 2010 (Hawkes et al. 2011). Habitat sampling conducted under the CLBMON 11B-4 program measures habitat variables at fixed sampling locations. The bathymetry of the wetlands will be mapped, and spatio-temporal variation in the communities of aquatic macrophytes, aquatic macro-invertebrates and abiotic factors will be monitored. Collaboration between the CLBMON 11B-4 and CLBMON 40 projects will allow analyses of habitat selection within wetlands to be performed. Results from these analyses will be useful for identifying goals for habitat enhancements.

4.4.4 Habitat Enhancements

The goal of water use planning is to manage the impacts of reservoir operations. However, the scope for adjusting water use planning is limited by treaty requirements and other water use planning objectives. When the impacts cannot be managed through water use planning, they can potentially be mitigated by revegetation or wildlife physical works. This is the topic of MQ-9: “Can physical works be designed to mitigate any adverse impacts on migrating waterbirds and shorebirds or on waterbird productivity resulting from reservoir operations?” CLBMON 40 can help answer this question by providing suggestions for habitat enhancement. The availability of funding and engineering required for physical works is not addressed in this monitoring program.

Results from CLBMON 40 have previously suggested that the development of a regulated wetland at or just above full pool would be beneficial given that there are few available habitats for shorebirds when reservoir elevations are near full pool. We do not advocate embarking on such a project until the relationship between shorebird habitat distribution and reservoir operations is adequately understood. In 2012, we detected more shorebirds than expected during very high water conditions, lending less support for this idea.

Completed and planned habitat enhancements (RPW and WPW projects) are currently being monitored by CLBMON 40. MQ-10 asks “Does revegetating the drawdown zone affect the availability and use of habitat and it’s use by shorebirds or waterbirds in Revelstoke Reach?” Similarly, MQ-11 asks “Do wildlife physical works projects implemented during the course of this monitoring program affect waterbird and shorebird abundance, and/or diversity, or waterbird productivity?” Monitoring how habitat enhancements are used by the study species is conducted under many of the CLBMON 40 monitoring programs.

Waterfowl numbers and productivity have been monitored in Cartier Bay for four years. The planned WPW14/15A projects will modify this wetland, and may be implemented in the near future. The desired effect is to elevate the minimum water levels of Cartier Bay by about 1 m to increase the area of permanent shallow water habitat for ducks, but some deeper pools will also be created (Golder Associates 2009a, 2009b). This is generally expected to be beneficial for many waterbird species (Colwell and Taft 2000). These projects may also reduce impacts of reservoir operations on waterfowl by decreasing the time over which the wetland is flooded. Having four or more years of monitoring prior to project implementation at this site and at other control sites will provide an opportunity to compare habitat selection by using a modified before-after, control-impact analysis (Stewart-Oaten and Murdoch 1986).

MQ-10 is a challenging question for CLBMON 40 to answer because revegetation procedures do not modify aquatic habitats, which are the focus of the CLBMON 40 monitoring program. Revegetation could possibly affect waterfowl by modifying nesting habitat, which is monitored adequately by CLBMON 36. We intend to use data from that program to address this question.

Monitoring usage of revegetation sites when they are flooded has some potential for addressing MQ-10, but this approach is limited because many planted habitats are not flooded during the monitoring periods, and when flooded, they are challenging to access and monitor with the land-based monitoring procedure. The aerial methods monitor treated sites, but we doubt that there will be sufficient resolution to detect differences in habitat use at such a fine scale using aerial surveys.

4.5 Recommendations

We recommend that changes to CLBMON 40, which have been implemented, should be permanently adopted. These include extending the brood survey season to the end of July, and extending the land-based waterbird monitoring throughout the winter.

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6 APPENDICES

Appendix 6-1: Total n umbers o f waterbirds ob served during land-b ased waterbird surveys during the spring, summer (brood counts) and fall monitoring periods

Spring migration

Common Name	Scientific Name	Total
Common Loon	*Gavia immer*	9
Pied-billed Grebe	*Podilymbus podiceps*	11
Tundra Swan	*Cygnus columbianus*	8
Unidentified Swan	*Cygnus* sp.	1
Snow Goose	*Chen caerulescens*	1
Canada Goose	*Branta canadensis*	1,385
Wood Duck	*Aix sponsa*	4
Gadwall	*Anas strepera*	1
American Wigeon	*Anas americana*	1,275
Mallard	*Anas platyrhynchos*	736
Blue-winged Teal	*Anas discors*	8
Cinnamon Teal	*Anas cyanoptera*	31
Northern Shoveler	*Anas clypeata*	36
Northern Pintail	*Anas acuta*	72
Green-winged Teal	*Anas crecca*	90
Canvasback	*Aythya valisineria*	1
Redhead	*Aythya americana*	4
Ring-necked Duck	*Aythya collaris*	287
Greater Scaup	*Aythya marila*	20
Lesser Scaup	*Aythya affinis*	24
Scaup sp.	*Aythya* sp.	71
Bufflehead	*Bucephala albeola*	121
Common Goldeneye	*Bucephala clangula*	110
Barrow's Goldeneye	*Bucephala islandica*	21
Goldeneye sp.	*Bucephala* sp.	18
Hooded Merganser	*Lophodytes cucullatus*	3
Common Merganser	*Mergus merganser*	134
Unidentified Duck	*Anatinae*	482
American Coot	*Fulica americana*	257
Total		5,221

Brood surveys (adults only)

Common Name	Scientific Name	Total
Common Loon	*Gavia immer*	39
Pied-billed Grebe	*Podilymbus podiceps*	42
Canada Goose	*Branta canadensis*	614
Wood Duck	*Aix sponsa*	5
Gadwall	*Anas strepera*	1
American Wigeon	*Anas americana*	115
Mallard	*Anas platyrhynchos*	287
Cinnamon Teal	*Anas cyanoptera*	12
Northern Shoveler	*Anas clypeata*	2
Northern Pintail	*Anas acuta*	5
Green-winged Teal	*Anas crecca*	15
Lesser Scaup	*Aythya affinis*	1
Scaup sp.	*Aythya* sp.	3
Bufflehead	*Bucephala albeola*	2
Goldeneye sp.	*Bucephala* sp.	2
Common Merganser	*Mergus merganser*	40
Unidentified Duck	*Anatinae*	277
American Coot	*Fulica americana*	40
Total		1,502

Fall migration

Common Name	Scientific Name	Total
Common Loon	*Gavia immer*	31
Pied-billed Grebe	*Podilymbus podiceps*	92
Red-necked Grebe	*Podiceps grisegena*	6
Western Grebe	*Aechmophorus occidentalis*	3
Tundra Swan	*Cygnus columbianus*	31
Canada Goose	*Branta canadensis*	2675
Wood Duck	*Aix sponsa*	13
American Wigeon	*Anas americana*	1210
Mallard	*Anas platyrhynchos*	602
Blue-winged Teal	*Anas discors*	1
Northern Shoveler	*Anas clypeata*	11
Northern Pintail	*Anas acuta*	52
Green-winged Teal	*Anas crecca*	72
Canvasback	*Aythya valisineria*	2
Redhead	*Aythya americana*	6
Ring-necked Duck	*Aythya collaris*	58
Scaup Sp	*Aythya sp.*	2
Bufflehead	*Bucephala albeola*	4
Common Goldeneye	*Bucephala clangula*	1
Goldeneye Sp	*Bucephala* sp.	2
Hooded Merganser	*Lophodytes cucullatus*	33
Common Merganser	*Mergus merganser*	68
Unidentified Duck	*Anatinae*	378
American Coot	*Fulica americana*	441
Total		5794

Appendix 6-2: Total numbers of waterbirds observed during aerial waterfowl surveys during the spring and fall monitoring periods

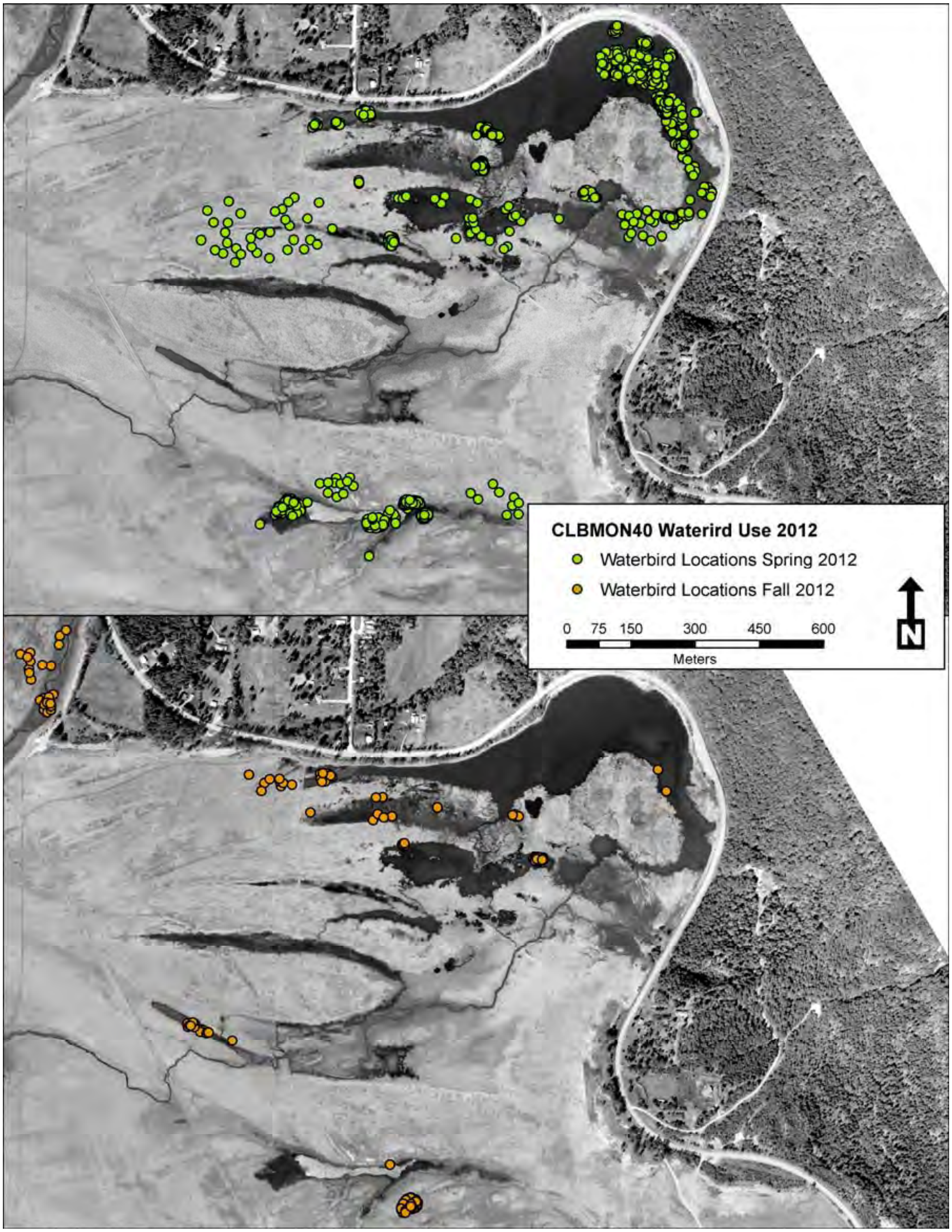
Spring migration

Common Name	Scientific Name	2012-04-10	2012-04-19	2012-05-02	2012-05-10
Red-necked Grebe	*Podiceps grisegena*	0	0	10	0
Unidentified Grebe	*Podiceps* sp.	0	0	3	0
Unidentified Swan	*Cygnus* sp.	6	1	0	0
Canada Goose	*Branta canadensis*	198	210	206	212
American Wigeon	*Anas americana*	93	90	152	139
Mallard	*Anas platyrhynchos*	503	157	110	115
Cinnamon Teal	*Anas cyanoptera*	0	2	1	0
Unidentified Teal	*Anas* sp.	0	0	2	0
Northern Shoveler	*Anas clypeata*	0	0	2	24
Northern Pintail	*Anas acuta*	35	0	0	0
Green-winged Teal	*Anas crecca*	68	80	33	0
Ring-necked Duck	*Aythya collaris*	13	122	20	0
Scaup sp.	*Aythya* sp.	0	25	5	20
White-winged Scoter	*Melanitta fusca*	0	0	9	0
Bufflehead	*Bucephala albeola*	25	24	93	33
Goldeneye sp	*Bucephala* sp.	0	7	0	0
Common Merganser	*Mergus merganser*	81	17	10	9
Unidentified Duck	*Anatinae*	280	367	153	53
American Coot	*Fulica americana*	20	150	0	100
Total		**1,322**	**1,252**	**809**	**705**

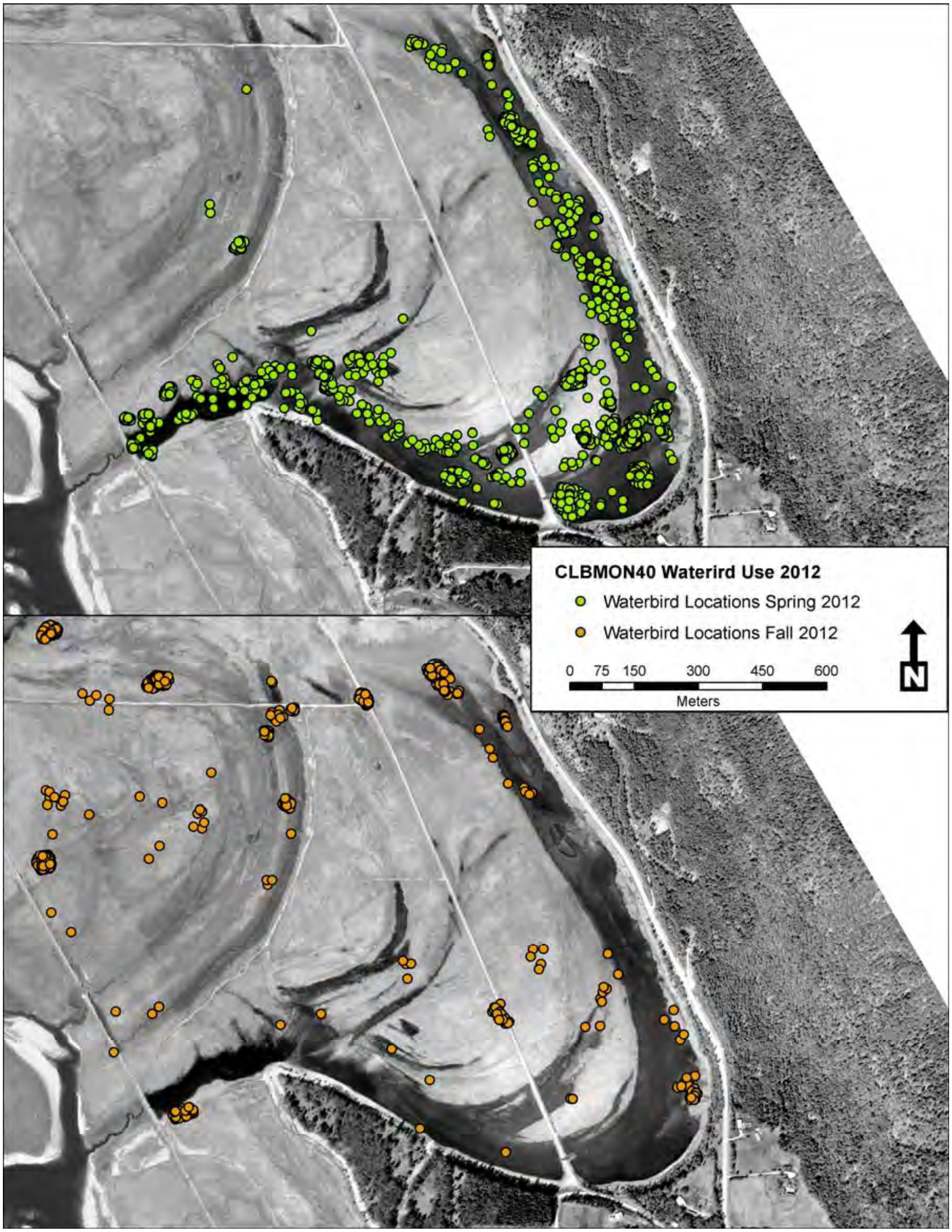
Fall migration

Common Name	Scientific Name	2012-09-05	2012-09-12	2012-10-22
Common Loon	*Gavia immer*	11	5	2
Horned Grebe	*Podiceps auritus*	0	6	0
Western Grebe	*Aechmophorus occidentalis*	0	0	4
Unidentified Grebe		8	3	2
Unidentified Swan	*Cygnus* sp.	0	0	26
Canada Goose	*Branta canadensis*	348	944	1,462
American Wigeon	*Anas americana*	0	0	93
Mallard	*Anas platyrhynchos*	24	91	303
Unidentified Teal	*Anas* sp.	4	0	19
Ring-necked Duck	*Aythya collaris*	0	0	20
Bufflehead	*Bucephala albeola*	0	0	36
Hooded Merganser	*Lophodytes cucullatus*	0	0	9
Common Merganser	*Mergus merganser*	7	0	19
Unidentified Duck	*Anatinae*	305	479	863
American Coot	*Fulica americana*	40	25	45
Total		747	1,553	2,903

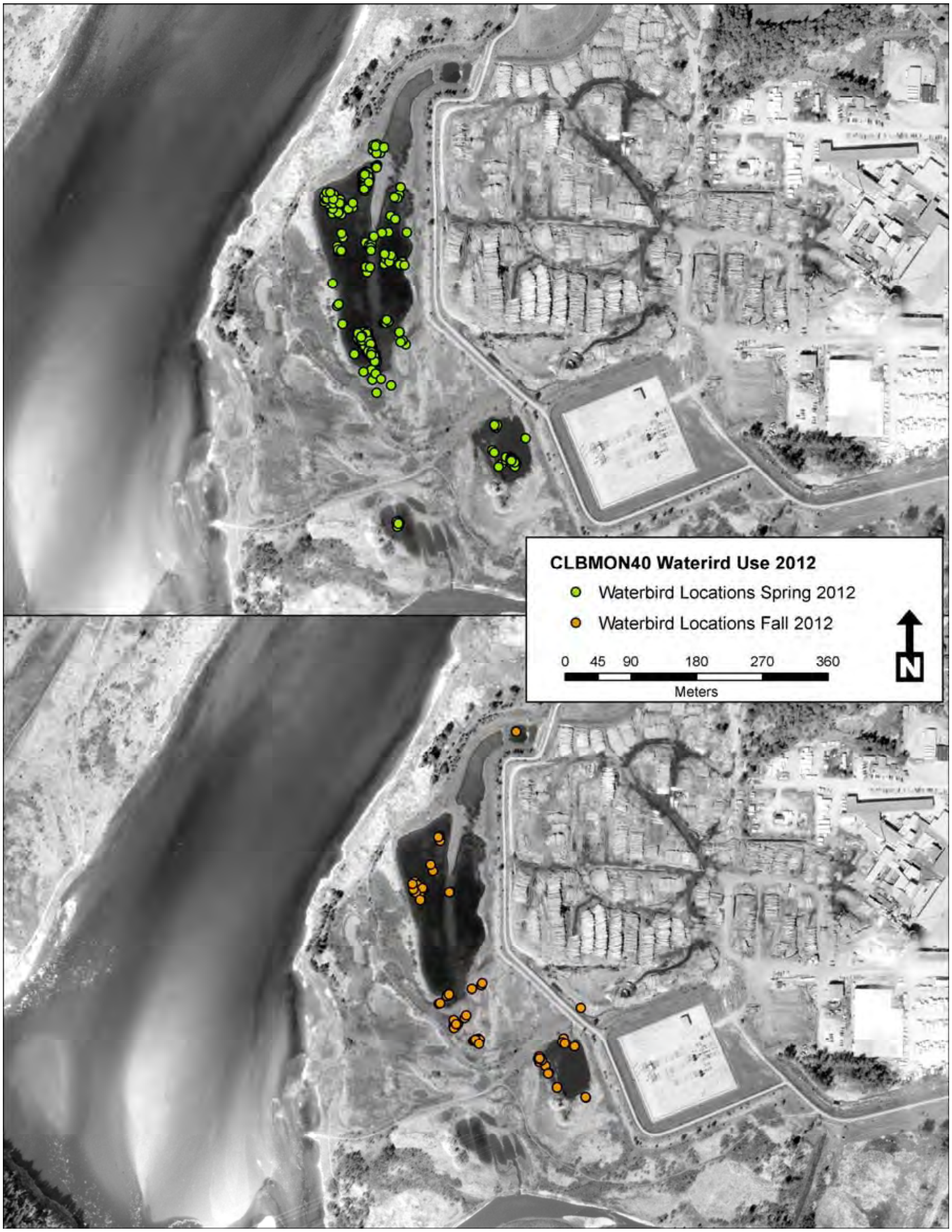
Appendix 6-3: Locations of waterbirds observed at select wetlands during spring and fall


CLBMON40 Waterird Use 2012
Waterbird Locations Spring 2012
Waterbird Locations Fall 2012
0 75 150 300 450 600
Meters
N

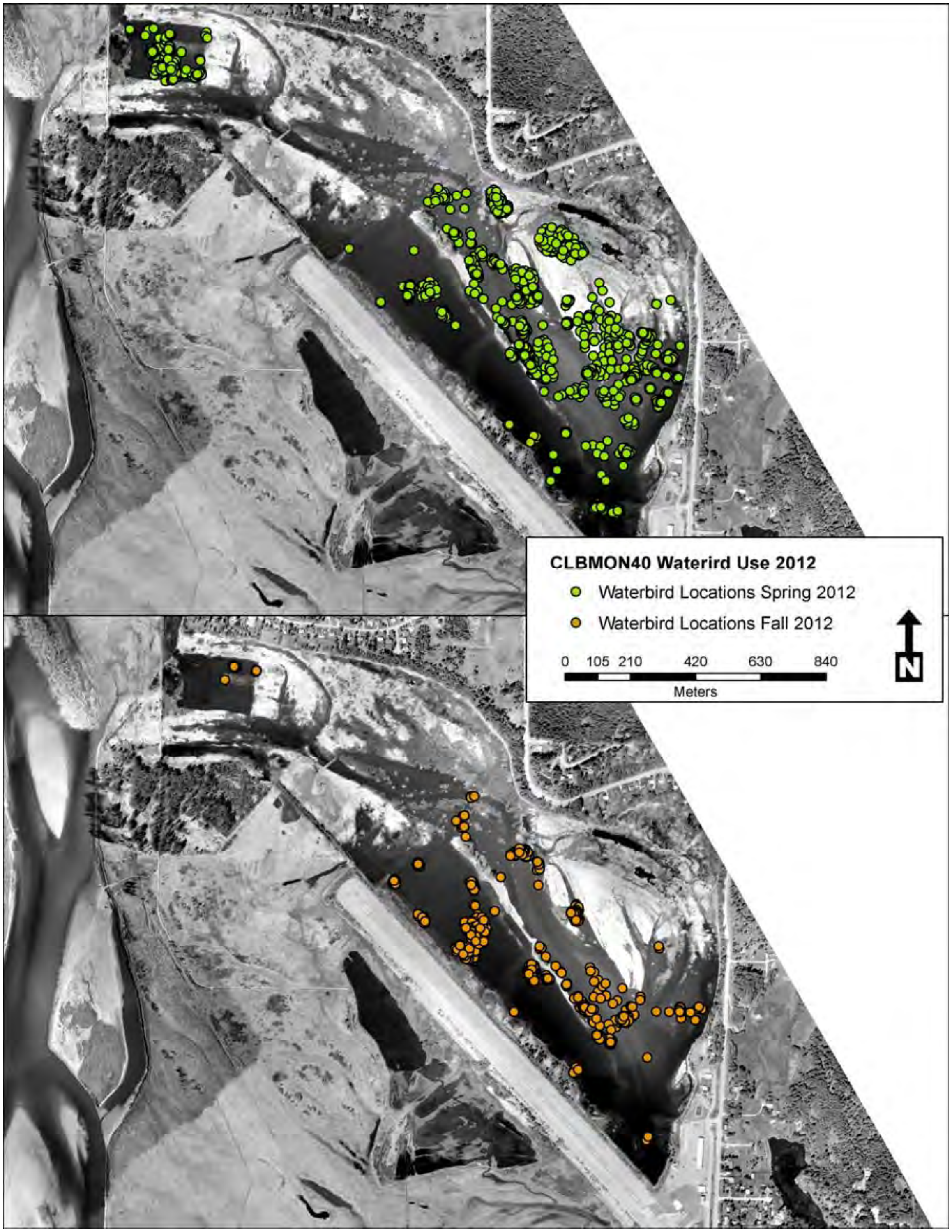
Montana Bay


CLBMON40 Waterird Use 2012
Waterbird Locations Spring 2012
Waterbird Locations Fall 2012
0 75 150 300 450 600
Meters
N

Cartier Bay



Downie Marsh



Airport Marsh

Appendix 6-4: Total numbers of shorebirds recorded during the fall migration in Revelstoke Reach, from mid-July until the end of September

Common Name	Scientific Name	Survey Type	11/07/2012	19/07/2012	24/07/2012	26/07/2012	01/08/2012	02/08/2012	09/08/2012	14/08/2012	16/08/2012	22/08/2012	29/08/2012	30/08/2012	05/09/2012	13/09/2012	14/09/2012	18/09/2012	27/09/2012	05/10/2012
Semipalmated Plover	*Charadrius semipalmatus*	Land-based										1								
Killdeer	*Charadrius vociferus*								1	2		4								
Spotted Sandpiper	*Actitis macularius*		8	3	6				7	9		8		2						
Solitary Sandpiper	*Tringa solitaria*			3	13				1											
Greater Yellowlegs	*Tringa melanoleuca*											2								
Lesser Yellowlegs	*Tringa flavipes*				5					1		1								
Western Sandpiper	*Calidris mauri*											3								
Least Sandpiper	*Calidris minutilla*									5										
Pectoral Sandpiper	*Calidris melanotos*											1						2		
Unidentified Calidris sandpiper	*Calidris* sp.														1					
Short-billed Dowitcher	*Limnodromus griseus*				1															
Unidentified Dowitcher	*Limnodromus* sp.													7						
Long-billed Dowitcher	*Limnodromus scolopaceus*																	4	9	
Unidentified Shorebird																		1		
Wilson's Snipe	*Gallinago delicata*											6		1						
Red-necked Phalarope	*Phalaropus lobatus*				2															
Killdeer	*Charadrius vociferus*	Boat-based						2												
Spotted Sandpiper	*Actitis macularius*					11	24	8			11		24			13				
Solitary Sandpiper	*Tringa solitaria*						2	4			4									
Greater Yellowlegs	*Tringa melanoleuca*						4	4												
Semipalmated Sandpiper	*Calidris pusilla*										1									
Pectoral Sandpiper	*Calidris melanotos*										8									
Long-billed Dowitcher	*Limnodromus scolopaceus*							2												
Wilson's Snipe	*Gallinago delicata*										2									
Total			8	6	27	11	30	20	9	17	26	26	24	10	1	13	0	7	9	0

Appendix 6-5: Variability in the number and diversity of shorebirds recorded at each shorebird site during weeks when boat-based sampling was conducted

In Drawdown Zone?	Type of Survey	Site	Total Number Detected	No. Species	No. of Observation Stations
No	Land-based (every 2 week subset)	SB01	12	3	1
		SB02	7	1	1
		SB03	5	2	1
Yes	Land-based (every 2 week subset)	SB04	1	1	1
		SB05	0	0	1
		SB06	5	2	3
		SB07	2	1	1
		SB08	0	0	1
		SB09	0	0	1
		SB10	0	0	1
		SB11	39	8	3
		SB13	3	1	2
		SB14	0	0	1
Yes	Boat-based (all data)	SB12	8	1	2
		SB15	20	1	3
		SB16	0	0	1
		SB17	6	1	10
		SB18	40	6	6
		SB19	6	2	5
		SB20	1	1	1
		SB21	0	0	1
		SB22	0	0	1
		SB23	1	1	1
		SB24	0	0	1
		SB25	1	1	1
		SB26	0	0	1
		SB27	0	0	1
		SB28	0	0	1
		SB29	7	1	1
		SB30	4	1	1
		SB31	0	0	1
		SB32	1	1	1
		SB33	0	0	1
		SB34	1	1	1
		SB35	0	0	1
		SB36	5	1	3
		SB37	3	1	2