Columbia River Project Water Use Plan

Arrow Reservoir Operations management Plan

Kinbasket and Arrow Lakes Reservoirs: Nest Mortality of Migratory Birds Due to Reservoir Operations

Implementation Year 6

Reference: CLBMON-36

Kinbasket and Arrow Lakes Reservoirs: Nest Mortality of Migratory Birds Due to Reservoir Operations

Study Period: 2013

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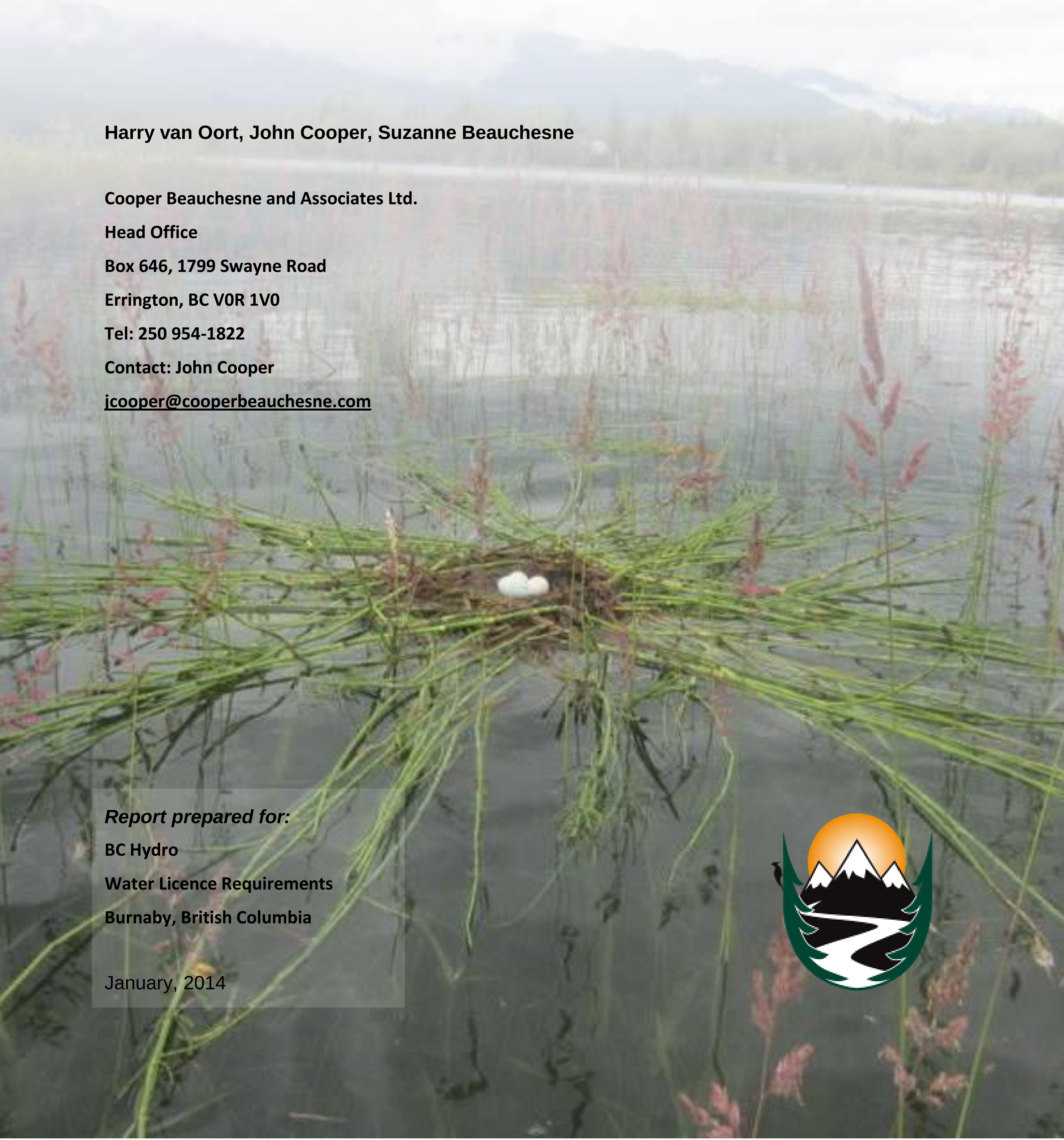
January 2014

CLBMON-36: Kinbasket and Arrow Lakes Reservoirs: Nest Mortality of Migratory Birds Due to Reservoir Operations

Year 6, 2013



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Cover photo: Two Pied-billed Grebe nests (fore-ground and mid-ground). These nests float, and become exposed as reservoir elevations force the nest up and out of their initial concealed locations as vegetation cover becomes inundated; predation of the nest typically follows (photo by Jason Fidorra)

EXCUTIVE SUMMARY

CLBMON-36 is a 10-year monitoring program designed to determine the effects of reservoir operations on the breeding success of birds nesting in the drawdown zone of Kinbasket and Arrow Lakes Reservoirs. The study has six objectives:

1) Determine the use of riparian habitats by breeding birds in the drawdown zone and identify important breeding habitats used by migratory birds in the drawdown zones in the Kinbasket Reservoir and Revelstoke Reach.

2) Determine the effects of reservoir operations on the nest mortality, nest and site productivity and juvenile survival of birds breeding in the drawdown zones of the Kinbasket Reservoir and Revelstoke Reach.

3) Determine the effects of reservoir operations on the quality and availability of nesting habitat at the nest and landscape levels in the drawdown zones of the Kinbasket Reservoir and Revelstoke Reach.

4) Inform and evaluate the effectiveness of physical works and revegetation efforts to enhance nesting success, nest and site productivity, or juvenile survival.

5) Assess the implementation of the soft constraints[1] and any incremental impacts resulting from the addition of unit 5 at Revelstoke Dam on nesting success, nest and site productivity, or juvenile survival.

6) Refine the habitat models developed previously for birds nesting in the drawdown zone of Revelstoke Reach (AXYS Environmental Consulting 2002).

Additionally, the results from this study can be used to assess the influence of dam expansion projects (two new turbines at Mica and one new turbine at Revelstoke Dam) on nest mortality.

Two approaches are currently being employed by CLBMON-36. "Nest mortality" monitoring involves finding nests of all birds nesting within 3 m of the ground in study site polygons, throughout the breeding season. This approach is used to document the communities of birds nesting in the drawdown zone, the nesting parameters for each species (especially where and when they nest), and the extent to which reservoir operations cause nest mortality. "Focal species" monitoring within and above the drawdown zone involves detailed study of four species: Traill's Flycatcher (*Empidonax traillii/E. alnorum*), Cedar Waxwing (*Bombycilla cedrorum*), Yellow Warbler (*Dendroica petechia*) and Savannah Sparrow (*Passerculus sandwichensis*). During this study, the nestlings of focal species were banded to track individuals and recruitment rates. Starting

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[1] The soft constraints defined for the Arrow Lakes Reservoir for wildlife are as follows:

- Ensure that inundation of nesting bird habitat by rising reservoir water levels in early summer is no worse than that which occurred on average over recent history (1984-1999). Match operating levels to inundation statistics for elevations 434 m (1424 ft) and above over the 1984-1999 period, which were used to produce the average historic performance measure score for spring/summer nesting short-eared owl habitat.
- Ensure that availability of migratory bird habitat in the fall is as good as or better than that which has been provided on average over recent history (1984-1999). Draft the reservoir quickly after full pool is reached, targeting a reservoir level of 438 m (1437 ft) or lower by 7 August.

in 2012, the nestlings of Yellow Warblers and Savannah Sparrows were tagged for radio telemetry to determine how reservoir operations affect juvenile survivorship within the study area. Focal species productivity was also monitored. This report summarizes the progress and results of Year 6 (2013) of the study. A multi-year analysis of Years 1-5 data was previously presented in a separate 5 Year Interim Report.

Two study areas were monitored in 2013: Canoe Reach in Kinbasket Reservoir, and Revelstoke Reach in Arrow Lakes Reservoir. In 2013, we increased allocation of effort towards the radio-telemetry study. Savannah Sparrows were studied in the Canoe Reach drawdown zone and Yellow Warblers were studied in the Revelstoke Reach drawdown zone. Initial comparisons suggest that juvenile survivorship may be higher in the Canoe Reach drawdown zone, compared with data gathered on this species above the drawdown zone in 2012. With Yellow Warblers, we observed greater survivorship in 2013 when nest habitat flooding was less severe.

In 2013, 2,286 person-hours of survey effort were spent conducting nest searches, monitoring nests and banding birds. Considerable variability in nest density and species diversity was observed among study areas and among habitat types within study areas. In total, 309 nests of 33 species were located and monitored until young fledged or the nests failed: 44 nests (14%) were found in Canoe Reach (6 species) and 266 nests (86%) were found in Revelstoke Reach (32 species).

The outcome of 272 nests was determined. Nesting success was greatest at Canoe Reach (81%), followed by Revelstoke Reach (32%). Predation was the most common cause of nest failure at all study areas. The cause of failure could not be assessed for all nests, but reservoir operations were known to destroy 28 nests in 2013 (17%): three from Canoe Reach and 25 in Revelstoke Reach.

To assess the productivity and survival of the four focal species, we determined the outcome of 151 nests:

- 33 Savannah Sparrow nests at Canoe Reach, and
- 21 “Traill's” (Willow or Alder) Flycatcher, 32 Cedar Waxwing, 62 Yellow Warbler and 3 Savannah Sparrow nests Revelstoke Reach:

Survival of juvenile Savannah Sparrow and Yellow Warbler was studied using radio telemetry. At Canoe Reach, 20 Savannah Sparrow young were tagged and 5 of 18 (27%) of the successfully fledged and monitored juveniles survived the monitoring period. Not counted in this estimate were two tagged young that died in the nest from reservoir flooding. In Revelstoke Reach, 12 Yellow Warbler young were tagged and 4 of 9 (44%) of the fledged and monitored juveniles survived the monitoring period. Potential evidence of young drowning (a submerged radio, possibly attached to a drowned young) was observed in one case. At both study areas, snakes were confirmed predators of tagged young. In Canoe Reach, falcons were suspected predators. Compared with data gathered in 2012, the 2013 data are consistent with the hypotheses that survivorship of Savannah Sparrows is relatively high in the Canoe Reach drawdown zone, and that increased habitat flooding may reduce juvenile survivorship for Yellow Warblers; however, considerably more data are needed to adequately test these theories.

The nesting models developed for the 5 Year Interim report were updated with Year 6 data, and applied to retrospectively predict the degree of nest flooding that may have occurred as a function of reservoir operations. We also compared these predictions with the observed proportion of flooded nests observed annually (n = 6 years). The latter correlations were strongly, positively and significantly correlated for both reservoirs ($r \geq 0.85$).

As shown in the 5 Year Interim report, nest mortality monitoring to date has been thorough with good coverage of all major drawdown zone habitats, with very few data gaps. In our discussion, we suggest which habitat types should be specifically selected for additional nest mortality monitoring in 2014. We also discuss progress with the radio-telemetry study on juvenile survivorship and the nesting models, the significance of fluctuating water levels at the Airport Marsh, and past and future events that impact this site.

KEYWORDS

reservoir operations, nest mortality, habitat distributions, habitat suitability, habitat selection, flooding, nest monitoring, nest survivorship, juvenile survivorship, Willow Flycatcher, *Empidonax traillii*, Cedar Waxwing, *Bombycilla cedrorum*, Yellow Warbler, *Dendroica petechia*, Savannah Sparrow, *Passerculus sandwichensis*, Arrow Lakes Reservoir, Kinbasket Reservoir, BC Hydro, British Columbia

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Many people contributed to field studies including: Devon Anderson, Corey Bird, Emily Braam, James Bradley, Russell Cannings, Stacey Carnochan, Dominic Cormier, Jason Fidorra, Ryan Gill, Jotvir Mann, Michal Pavlik, and Tim Sneider. Ryan Gill provided GIS mapping and analysis. Corey Bird and Harry van Oort planned the 2013 field study program. Suzanne Beauchesne provided overall supervision and monitoring of crews, and assisted with field studies in Arrow Lakes Reservoir. John Cooper acted as Project Manager.

CBA worked closely with Simon Fraser University throughout this study. Dr. David Green of Simon Fraser University coordinated some of the Yellow Warbler research in 2013, which was conducted by Matthew Hepp and Lena Ware. Dr. David Green provided scientific guidance to CBA.

Lesley-Anne Howes and Louise Laurin (Canadian Wildlife Service Bird Banding Office) processed bird banding and capture permits. All bird handling and telemetry protocols were approved by the Simon Fraser University Animal Care Committee, and under a Science Permit issued by Environment Canada (Permit no. BC-12-0010).

CBA would also like to thank the communities of Valemount and Revelstoke for providing safe and enjoyable home bases for field crews during the field season.

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1 INTRODUCTION

Riparian habitats are structurally complex with a diversity of vegetation species, and they support rich communities of breeding birds (Knopf and Samson 1994); but, these habitats are relatively rare landscape features (Skagen et al. 2005). In western North America, riparian habitats comprise less than 1% of terrestrial landscapes (Knopf et al. 1988). In British Columbia, about one-half of forest-dwelling terrestrial vertebrate species depend on riparian habitats for breeding and other life history requirements (Bunnell et al. 1999).

The Columbia River Basin is one of the most modified river systems in North America, and much of the natural riparian habitat has been removed or highly modified (Nilsson et al. 2005). Water storage reservoirs along the primary course of the Columbia River in British Columbia include the Kinbasket Reservoir, Lake Revelstoke and the Arrow Lakes Reservoir, which are positioned sequentially along the river's course. Natural riparian habitat has been retained in only a few intervening sections. The footprints of these reservoirs have removed most valley bottom habitat, and their substantial drawdown zones are typically comprised of steep, barren shorelines (Bonar 1979, 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).

Important breeding habitats for birds remain in Revelstoke Reach in Arrow Lakes Reservoir (Boulanger et al. 2002, Jarvis 2003, 2006, Boulanger 2005, Green and Quinlan 2007, CBA 2009, 2010, 2011, 2012, 2013), and in Canoe Reach and Bush Arm in Kinbasket Reservoir (CBA 2009, 2010, 2011, 2012, 2013). Because breeding habitats are located in reservoir drawdown zones, the operation of the reservoirs may have significant impacts on the productivity of resident bird populations that use these sites (Jarvis 2003, 2006, CBA 2009, 2010, 2011, 2012, 2013). It is possible that some nesting habitats within the reservoir act as ecological traps (Schlaepfer et al. 2002, Robertson and Hutto 2006, 2007, CBA 2013).

During the Columbia River Water Use Planning process (BC Hydro 2007), nest mortality caused by reservoir operations was identified as a critical issue. The primary concern was that the operations of Arrow Lakes and Kinbasket Reservoirs may reduce the productivity of breeding bird communities due to flooding of active nests, reducing habitat availability and reducing habitat quality. These concerns arose from earlier studies in Revelstoke Reach that documented a high diversity of birds using drawdown habitats during the breeding season (Boulanger et al. 2002, Boulanger 2005), and studies that documented nest mortality resulting from reservoir operations (Jarvis 2003, 2006). Furthermore, the discovery of a pair of Short-eared Owls (*Asio flammeus*) nesting within the drawdown zone in 2002 (Jarvis 2003) highlighted the potential for reservoir operations to have negative effects on breeding bird species that are protected under the federal *Species at Risk Act* (SARA). Under the direction of the Columbia River Water Use Plan, BC Hydro initiated CLBMON 36, a 10-year program designed to determine the effects of reservoir operations (water level management) on breeding success of birds nesting in the drawdown zone of Kinbasket and Arrow Lakes Reservoirs, and to provide feedback and guidance on the efficacy of methods used to enhance breeding habitats for birds in reservoir drawdown zones (revegetation and wildlife physical works).

1.1 Scope and Objectives

The general scope and objectives of CLBMON 36 were outlined by BC Hydro as follows[2]:

1) Determine the use of riparian habitats by breeding birds in the drawdown zone and identify important breeding habitats used by migratory birds in the drawdown zones in the Kinbasket Reservoir and Revelstoke Reach.

2) Determine the effects of reservoir operations on the nest mortality, nest and site productivity and juvenile survival on birds breeding in the drawdown zones of the Kinbasket Reservoir and Revelstoke Reach.

3) Determine the effects of reservoir operations on the quality and availability of nesting habitat at the nest and landscape levels in the drawdown zones of the Kinbasket Reservoir and Revelstoke Reach.

4) Inform and evaluate the effectiveness of physical works and revegetation efforts to enhance nesting success, nest and site productivity, or juvenile survival.

5) Assess the implementation of the soft constraints and any incremental impacts resulting from the addition of unit 5 at Revelstoke Dam on nesting success, nest and site productivity, or juvenile survival.

6) Refine the habitat models developed previously for birds nesting in the drawdown zone of Revelstoke Reach (AXYS 2002).

1.2 Management Questions

BC Hydro provided a series of management questions related to the objectives above. These management questions (or tasks, in some cases) are as follows[1]:

a) Which bird species breed in the drawdown zones of the Kinbasket and Arrow Lakes Reservoir and where do they occur?

b) What are the seasonal patterns of habitat use by birds nesting in the drawdown zone of the Kinbasket Reservoir and Revelstoke Reach?

c) Do reservoir operations directly affect nesting success (e.g. flooding of nests)?

d) What are the various factors (e.g. reservoir levels, predation, habit availability, etc) that influence nest mortality in the drawdown zone?

e) Do reservoir operations affect nesting success by altering nesting habitat quality (e.g. vegetation characteristics, habitat configuration) of nest sites[3] or the availability of nesting habitat at the landscape level?

f) If reservoir operations negatively affect the nesting success, what is the significance of these impacts on regional bird populations?[4]

g) Do reservoir operations affect juvenile survival and recruitment?

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[2] Wording and numbering are reproduced verbatim from BC Hydro RFP 771.

[3] The term 'site' is generally used to define independent locations where nest monitoring occurred in this study. Here the term refers to the habitat where nests are located.

[4] The term regional has not been defined.

h) Can the operations of the Kinbasket and Arrow Reservoirs be optimized to improve nesting success, nest productivity, site productivity, or juvenile survival?

i) Provide recommendations for physical works projects and revegetation efforts to increase nesting success, nest and site productivity and juvenile survival in the Kinbasket Reservoir and Revelstoke Reach.

j) Evaluate the effectiveness of revegetation efforts and physical works projects implemented during the course of this monitoring program for improving nesting success, nest and site productivity, or juvenile survival.

1.3 Management Hypotheses

To augment some of the management questions, BC Hydro provided a series of management hypotheses, which are listed below[5]:

H_1: The annual and seasonal variation of water levels in Revelstoke Reach and the Kinbasket Reservoir and the implementation of soft operational constraints and potential effects of unit 5 in Arrow Lakes Reservoir do not directly affect the nesting success of migratory breeding birds.

H_{1A}: Nest mortality is no greater in the drawdown zone than above the drawdown zone.

H_{1B}: Nest mortality in the drawdown zone is not caused directly by nest inundation.

H_2: The annual and seasonal variation of water levels in Revelstoke Reach and the Kinbasket Reservoir and the implementation of soft operational constraints and potential effects of unit 5 in Arrow Lakes Reservoir do not affect juvenile survival.

H_{2A}: Juvenile mortality is no greater in the drawdown zone than above the drawdown zone.

H_3: The annual and seasonal variation of water levels in Revelstoke Reach and the Kinbasket Reservoir and the implementation of soft operational constraints and potential effects of unit 5 in Arrow Lakes Reservoir do not affect nesting or recruitment habitat required by migratory breeding birds.

H_{3A}: Reservoir operations do not result in a reduction in the quality or availability of nesting or recruitment habitat at the site and landscape level.

H_{3B}: Nest mortality, site and nest productivity, and juvenile survival are not associated with changes in habitat conditions (e.g. structure, vegetation composition and extent of habitat) or reservoir operations in the drawdown zone.

H_4: Revegetation or physical works do not increase the utilization of habitats by nesting birds in the drawdown zone.

H_{4A}: Revegetation or physical works do not increase the species diversity or abundance of birds nesting in the drawdown.

H_{4B}: Revegetation or physical works are not effective at reducing nest mortality in the drawdown zone.

H_{4B}: Revegetation or physical works do not increase nest or site productivity in the drawdown zone.

[5] Wording and numbering are reproduced verbatim from BC Hydro, RFP 771.

H_{4C}: Revegetation or physical works do not increase the survival of juvenile birds in the drawdown zone.

H_{4E}: Revegetation or physical works do not increase the amount of bird habitat in the drawdown zone.

A table showing how the management objectives, questions and hypotheses are related is provided in Appendix 6-1.

1.4 Study Areas

Field studies in 2013 were conducted in two BC Hydro reservoirs located in southeastern British Columbia: Kinbasket Reservoir (Canoe Reach) and Arrow Lakes Reservoir (Revelstoke Reach; Figure 1-1). Details on the study areas are provided in the revised monitoring protocol report (CBA 2014), and are briefly described below.

1.4.1 Kinbasket Reservoir

Kinbasket Reservoir is the upper-most reservoir along the main branch of the Columbia River. Kinbasket Reservoir is a 216-km long hydroelectric reservoir operated by BC Hydro for power generation (1805 MW) and flood control. It extends from Donald, 39 km northwest of Golden, down the Columbia River and north up the Canoe River to 7 km south of Valemount. The reservoir is regulated by outflow from the Mica Dam (input is unregulated), and is licensed to operate between 707.41 m and 754.38 m for storage of up to 12 MAF (BC Hydro 2007). Additional storage may be attained (to an elevation of 754.68 m) with approval from the Comptroller of Water.

1.4.1.1 Canoe Reach Study Area

Canoe Reach is the northern arm of Kinbasket Reservoir, and is situated between the Monashee and Rocky Mountains (Figure 1-1). The study area is approximately 50 km long and extends from the northern end of the reservoir south as far as Hugh Allen Creek on the east shore and Windfall Creek on the west shore. The drawdown zone of this area is comprised largely of steep, unvegetated shorelines of sand, gravel and cobble, but includes vegetated habitats near seepage sites, which are characterized by grasses and sedges (Figure 1-2). Extensive remnant peat lands occur at the north end of Canoe Reach.

Canoe Reach occurs in the Interior Cedar–Hemlock moist mild (ICHmm) biogeoclimatic subzone (Meidinger and Pojar 1991), and receives moderate precipitation, primarily from Pacific frontal systems that shed snow during the winter. The reservoir is surrounded by steep slopes with managed coniferous forests.

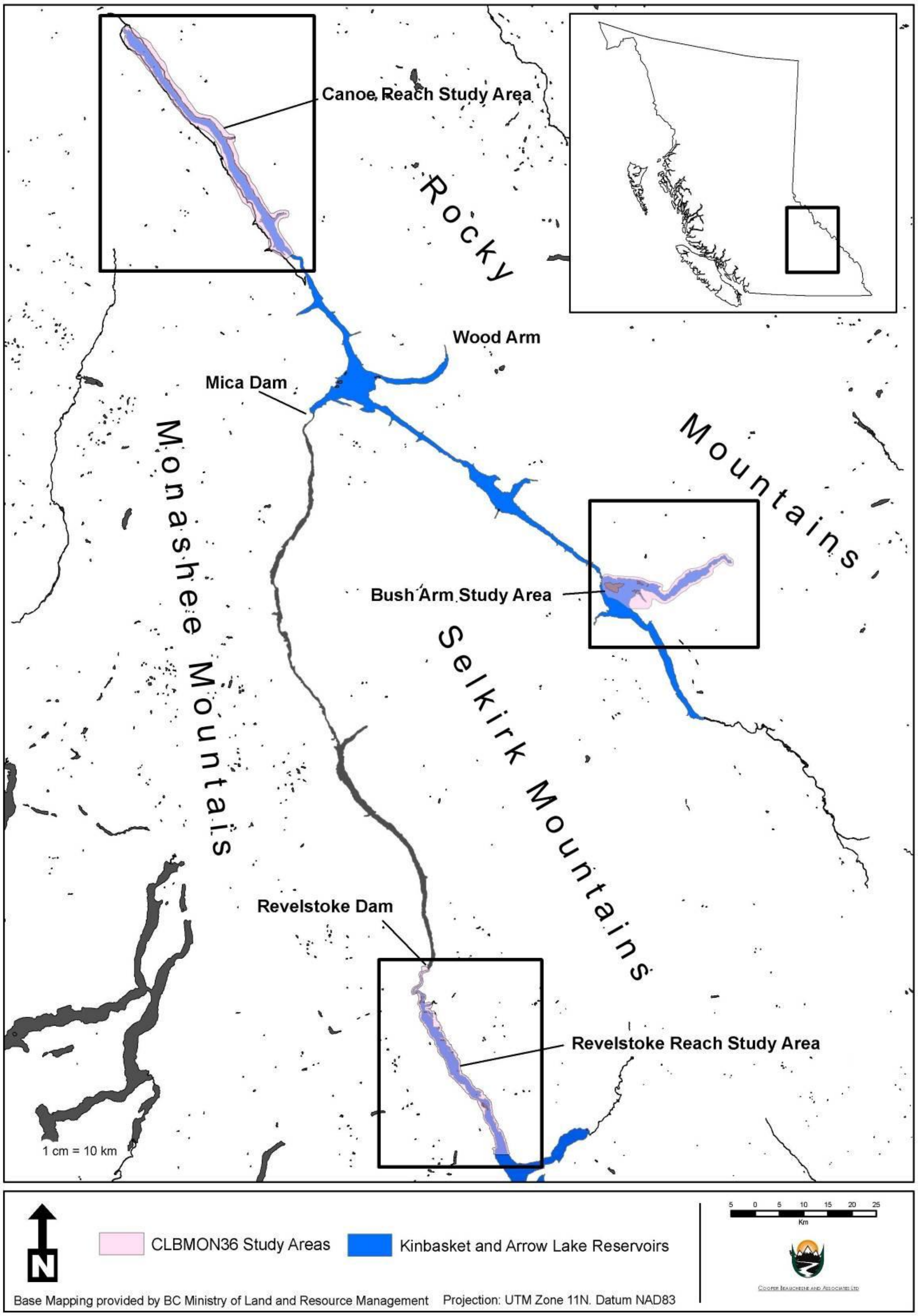

Figure 1-1: **Overview map of the three study areas (lakes are shown in black). Bush Arm was not monitored in 2013.**

Figure 1-2: Relatively well-vegetated drawdown habitat at Hugh Allen Bay, Canoe Reach

1.4.2 Arrow Lakes Reservoir

The Hugh Keenleyside Dam is located approximately 8 km north of Castlegar. The facility, completed in 1968, is capable of discharging 10,500 m^3/s (BC Hydro 2007), primarily through non-generating ports and spillways. Although the Hugh Keenleyside Dam was created primarily for flood control and water storage for downstream power generation in the U.S. (BC Hydro 2007), a 185-MW generating facility was added in 2002.

The completion of the Hugh Keenleyside Dam created the Arrow Lakes Reservoir, which extends approximately 240 km north to Revelstoke and has a licensed storage capacity of 7.1 MAF (BC Hydro 2007). The Arrow Lakes Reservoir is licensed to operate between 418.6 m and 440.1 m ASL. With approval from the Comptroller of Water Rights, the maximum allowable level is 440.75 m (BC Hydro 2007).

1.4.2.1 Revelstoke Reach Study Area

Revelstoke Reach forms the northernmost section of the Arrow Lakes Reservoir. From the Trans-Canada Highway, Revelstoke Reach extends south for about 42 km between the Monashee and Selkirk Mountain Ranges (Figure 1-1). The drawdown zone of the reservoir includes most of entire valley floor, and is largely comprised of grassy flats.

Habitats within the drawdown zone vary with topographic elevation. Grasses (e.g., *Phalaris arundinacea*), sedges (*Carex* spp.) and horsetails (*Equisetum* spp.) become well-established at 434 m; willow (*Salix* spp.) and cottonwood (*Poplar balsamifera*) become well-established at 438 m (Figure 1-3). Above 439 m, multi-storied mature cottonwood riparian forests have become established in some areas.

Revelstoke Reach occurs in the ICHmm (variants 2 and 3) biogeoclimatic subzone (Meidinger and Pojar 1991), and receives heavy precipitation, primarily from Pacific frontal systems that shed snow during the winter. The drawdown zone is surrounded by steep slopes with managed coniferous forests.

Figure 1-3: Shrubby habitat in the drawdown zone of Revelstoke Reach

1.5 Previous Work

A series of studies documented aspects of breeding birds in Arrow Lakes Reservoir (Revelstoke Reach) but not in Kinbasket Reservoir prior to the initiation of CLBMON-36 (Boulanger et al. 2002, Jarvis 2003, 2006, Boulanger 2005, Green and Quinlan 2007, 2008, Quinlan 2009). These studies played a role in the development of CLBMON-36. In particular, they demonstrated that a high diversity of birds occupy drawdown habitats during the breeding season (Boulanger et al. 2002, Boulanger 2005), and that there is potential[6] for nest flooding to occur (Jarvis 2003, 2006). Studies conducted by Simon Fraser University on Yellow Warbler productivity (Green and Quinlan 2007, 2008, Quinlan 2009, Rock 2011) have been integrated each year with work on CLBMON-36.

1.5.1 Year 1, 2008

CLBMON-36 was initiated in the spring of 2008 (Year 1), with nest monitoring studies being conducted at two study areas (Revelstoke Reach and Canoe Reach). The work included the study of three focal species: Willow Flycatcher (*Empidonax traillii*), Yellow Warbler (*Dendroica petechia*) and Savannah Sparrow (*Passerculus sandwichensis*) (CBA 2009).

In Year 1, the Arrow Lakes Reservoir filled rapidly, almost reached full pool (maximum water elevation reached was 439.96 m ASL), and remained relatively full into winter. All three focal species were observed at Revelstoke Reach, but Savannah Sparrows—which were chosen as a focal species because they are considered to be common in this area (Boulanger 2005)—were not observed to be nesting at the nest monitoring study sites surveyed in Year 1. Nest monitoring documented several cases of nest flooding among species that nest on the ground and in shrubs.

[6] The results were not necessarily representative of all operations. The nest mortality pilot studies were conducted in years when the operations resulted in relatively high water elevations early in the year (439 m by July 3 in 2003 and by June 26 in 2006)—conditions where nest sites are more likely to be flooded during the breeding season.

In Canoe Reach, the nesting community was less diverse than that documented in Revelstoke Reach. Savannah Sparrows were abundant, but no other focal species were present. Spotted Sandpiper (*Actitis macularius*) was one of the most abundant nesting species in this area. Nesting habitat was situated relatively high in the drawdown zone for all species observed, water levels did not reach those elevations until after the breeding season ended, and no nests were flooded. Nest predation rates were relatively low compared with those in Revelstoke Reach.

After Year 1, it was recommended that Cedar Waxwing (*Bombycilla cedrorum*), a shrub-nesting species, be added as a focal species because it was observed nesting in the Canoe Reach area, although only above the drawdown zone, and throughout shrub/tree habitats in Revelstoke Reach. It was postulated that this species may respond to revegetation efforts, which included attempts to increase the abundance of willow shrubs in the drawdown zone. For more information, refer to the Year 1 report (CBA 2009).

1.5.2 Year 2, 2009

In Year 2, Cedar Waxwing was included as a fourth focal species based on recommendations from Year 1.

In Canoe Reach, the same sites were monitored as in 2008, which produced similar results.

Operations in the Arrow Lakes Reservoir were moderate, with reservoir elevations never exceeding 437.6 m ASL; nest mortality due to reservoir operations were primarily observed among ground-nesting species, including a Red-listed species: American Avocet (*Recurvirostra americana*). Many new nest study sites were added to improve coverage of grassland habitats, but Savannah Sparrows were still found to be uncommon.

Savannah Sparrows colonized one Revelstoke Reach study site (9 Mile) unusually late in the season, which suggested that this species may seek replacement breeding territories after being displaced by the reservoir from their initial low elevation territories.

Reservoir operations impact breeding birds in two ways: by flooding nests/young, and by flooding habitats prior to nest initiation, thereby preventing nesting. A pilot analysis highlighted extreme variability in the potential for nesting and for nest flooding as a function of reservoir operations.

In Year 2, we indicated that monitoring juvenile survival is problematic using the approaches described for CLBMON 36 (mist netting); therefore, we recommended that radio-telemetry should be considered as an alternative. For more information, refer to the Year 2 report (CBA 2010).

1.5.3 Year 3, 2010

In Year 3, Bush Arm was introduced as a new study area in Kinbasket Reservoir, and a pilot study was conducted to locate and monitor nests. The data from 2010 suggested that drawdown habitats at Bush Arm supported a greater number of species than those at Canoe Reach.

In Year 3, we continued to monitor nest mortality and focal species productivity at the same Canoe Reach and Revelstoke Reach sites as in previous years (including some new sites at the latter area). We recorded the first documented case of reservoir flooding of nests at Kinbasket Reservoir. Nest mortalities due to reservoir operations were common at Revelstoke Reach, with both ground- and shrub-nesting species losing nests to flooding.

As in Year 2, Savannah Sparrows colonized the 9 Mile site relatively late in the season, after breeding territories had been established elsewhere in the study area, again suggesting that these birds might have been displaced from sites selected earlier in the season. Furthermore, we documented an increase in richness and abundance of nesting pairs of many species at the floating bog habitat in Montana Bay as reservoir elevations increased and other sites were flooded, which suggested that displacement also occurs among other bird species.

The previously identified need to use radio-telemetry for monitoring juvenile survival was corroborated in Year 3. That was the final year of the first contract for CLBMON 36. For more information, refer to the Year 3 report (CBA 2011).

1.5.4 New Terms of Reference and Goals for Years 4 and 5

Revised Terms of Reference were provided for a new contract to conduct CLBMON 36 in Years 4 and 5, and to complete the first multi-year (5-year) analysis of data. CBA's accepted proposal outlined an intention to use radio-telemetry to track juvenile songbirds.

1.5.5 Year 4, 2011

In Year 4, more effort was allocated in Bush Arm than in previous years, whereas monitoring efforts at Canoe Reach and Revelstoke Reach were slightly reduced. There was not enough time to organize a telemetry program in Year 4. A large focus of Year 4 monitoring was to ensure that nest mortality monitoring included a representative selection of habitat types. Habitat maps were available for Kinbasket Reservoir, but no appropriate habitat mapping was available for Revelstoke Reach. Site choice was based on professional judgement in Revelstoke Reach, and as a joint initiative between CLBMON 36 and CLBMON 40, we mapped drawdown habitats. This map was completed to a first draft stage in Year 4.

1.5.6 Year 5, 2012

2012 was an exceptionally wet year. The reservoirs had relatively extreme operations. Washouts caused us to terminate monitoring in Bush Arm prematurely. Telemetry studies began in Revelstoke Reach to study the effects of habitat flooding on juvenile survivorship. For this initial (pilot) year of telemetry work, we focussed on Yellow Warblers in the drawdown zone, and Savannah Sparrows above the drawdown zone. Unfortunately, the extreme water levels caused every Yellow Warbler study subject to fledge in flooded conditions. Site selection for nest mortality monitoring in Revelstoke Reach was done systematically using the new habitat map created in Year 4.

1.5.7 Year 5 Interim Report

Prior to Year 5, BCH requested that annual reports refrained from including analyses of more than one year of data. The first data detailed analysis for CLBMON-36 took place in 2012/2013 in preparation for the 5 year WLR Interim Meeting. In that report, some of the key results included were:

- nesting models that can be used to assess the impacts of reservoir operations at any elevation during the nesting season

- nest survivorship models which indicated that the Arrow Lakes Reservoir may be an ecological trap for Traill's Flycatchers and that flooded habitat improved nesting success for Yellow Warblers.

1.6 Scope of work in 2013

This report presents data collected in Year 6, 2013.

In Year 6 we decreased our nest mortality effort, and increased our focal species effort. Nest mortality monitoring did not take place in Bush Arm; effort was similar to previous years in Canoe Reach and Revelstoke Reach. Radio-telemetry work increased in effort, and we focussed on Yellow Warblers in Revelstoke Reach drawdown habitat, and on Savannah Sparrows in Canoe Reach drawdown habitat.

A concentrated effort was made on conducting productivity and telemetry monitoring of Savannah Sparrows in Canoe Reach, and Yellow Warblers in Revelstoke Reach (both within drawdown zone habitats). Additionally, some productivity monitoring occurred for Willow Flycatchers, Cedar Waxwings and Savannah Sparrows in Revelstoke Reach, but this generally occurred as part of the nest mortality work. Mist netting of focal species occurred in Revelstoke Reach only and focussed on Savannah Sparrows and Yellow Warblers. In general, population counts of Savannah Sparrows were not made in 2013, but available observations and data are reviewed in this report.

2 METHODS

The methods used in 2013 followed those used in previous years. A detailed description of methods is provided in the revised monitoring protocol report for CLBMON 36 (CBA 2014). A brief description of the data collection methods and relevant analytical methods is presented below to provide context for the reader.

2.1 Approaches and Site Selection

Two approaches were used to monitor bird populations: “nest mortality” monitoring and the “focal species” approach.

2.1.1 Nest Mortality Monitoring

Nest mortality monitoring was used to study productivity and diversity of nesting communities, and to associate those data with habitat type. Effort was focused on monitoring multiple sites in all available habitat types.

Within the study sites, we attempted to find all nests of all bird species. Nests located within 3 m of the ground were monitored. Nests were considered to be successful if at least one young fledged. Failed nests were assessed for causes of failure, whenever possible. Nest mortality monitoring data will be used to determine how nesting communities, their productivity and nest mortality rates vary with habitat type and reservoir operations.

Site selection for nest mortality monitoring followed a systematic sampling design. Annually, sites were systematically selected from each of the available habitat types (strata). Site accessibility and habitat patch size/configuration were considered during site selection, but we did not have, or use prior knowledge of the site’s suitability for nesting, when delineating the sites (CBA 2014). Sites were monitored for at least one breeding season. In Year 6, only sites within the drawdown zones were monitored. Some high elevation sites straddled the full pool elevation.

Habitat stratification could not be based on standard ecological classification systems (e.g., Meidinger and Pojar 1991) because drawdown zone habitats are not equivalent to natural ecosystems (Baxter 1977), and habitat mapping usually identifies only one habitat type for drawdown zone habitats (water). In Kinbasket Reservoir, we stratified the drawdown habitats by the vegetation communities identified by CLBMON 10 (Hawkes et al. 2010). In Revelstoke Reach, we stratified the drawdown zone by vegetation communities identified by a habitat map developed by CBA (CBA 2012). Habitat categories for both reservoirs are described in Appendix 6-2. All sites monitored in 2012 are described and mapped in Appendix 6-3, Appendix 6-4, and Appendix 6-5.

2.1.2 Focal Species Approach

Nest mortality monitoring was complemented with focal species monitoring in order to gain a more detailed understanding of the factors affecting populations. Previously, there were four focal species chosen for evaluating productivity, juvenile survivorship and recruitment: Savannah Sparrow, Cedar Waxwing, Yellow Warbler and Traill's Flycatcher. (For this study, we grouped Willow and Alder Flycatchers because the two species cannot always be separated in the field, have similar requirements, and because Willow Flycatchers are generally not found in Kinbasket Reservoir). Focal species work can include nest monitoring, banding nestlings and/or adults, and radio-telemetry tracking of juveniles. In 2013, we restricted our focal species work on radio-telemetry of Yellow Warblers and Savannah Sparrows (see Section 1.6 above).

2.1.3 Modified Monitoring Approaches for Special Cases

The nest mortality monitoring and focal species approaches have been modified for the following research initiatives:

2.1.3.1 Physical Works Projects

Monitoring has been conducted repeatedly at permanent sites where Wildlife Physical Works (WPW) or Revegetation Physical Works (RPW) projects are planned or have been implemented (Golder Associates 2009, Keefer and Moody 2010). Aside from using permanent plots monitored over many years, physical works were monitored the same as the nest mortality plots.

2.1.3.2 Airport Marsh

We have monitored a site in the Airport Marsh (Site ID = 30) annually because the marsh is an important wetland for breeding birds, and it exhibits considerable (unexplained) annual variability in water levels and bird populations.

2.1.3.3 Breeding Displacement

Evidence from Years 2–4 suggested that habitat selection in drawdown zones is dynamic due to breeding displacement caused by reservoir operations. To study this process, we adapted methods from both the focal species (mark-recapture of Savannah Sparrows) and nest mortality approaches by:

- identifying and monitoring early season nesting areas of Savannah Sparrows,
- attempting to capture and mark Savannah Sparrows at their early season nesting habitats to track their dispersal movements,

- monitoring the 9 Mile site where Savannah Sparrows are known to settle relatively late in the season, and
- continuing to monitor nesting at Montana Bay (Site ID = 39)—a floating bog that appears to be used by displaced birds.

Nest mortality monitoring at Montana Bay was used to track how the breeding community (density and diversity) changes within season and among years in order to determine if usage of this site is related to annual variations in reservoir operations.

2.2 Field Procedures

2.2.1 Nest Searching

Sites were surveyed by walking slowly and systematically while looking for nests or signs of nesting activity. Birds exhibiting nesting behaviour (e.g., giving warning calls; carrying nest material, fecal sacs or food) were watched for clues of nest locations (Martin and Geupel 1993). In grassland habitats, rope dragging was used to flush birds from nests (CBA 2014).

2.2.2 Nest Monitoring

Standard nest data were collected at all nests. Active nests were monitored every three or four days until young fledged or the nest failed. Evidence of nest outcome was documented for each nest. A nest was considered to be successful if it fledged one or more young. Nest failure was categorized as being caused by nest predators or reservoir operations, or as failed for unknown reasons. Nest outcomes were designated as “unknown” if it was unclear whether the nest had been successful or had failed. Nests that had well-developed young late in the nestling phase were deemed to be successful if the last observation of the active nest was after the minimum number of days recorded for fledging by that species. Information about fledging periods was obtained from *The Birds of North America* species accounts (Poole 2010).

2.2.3 Focal Species Capture

Targeted mist netting with call-playback was undertaken in areas with focal species. In 2013, efforts to capture adults focused on Savannah Sparrows and Yellow Warblers. Mist nets were set up near territorial males, and an audio recording of the species’ territorial song was played to lure the focal species into the nets. Once captured, all focal species were banded with a metal Canadian Wildlife Service (CWS) leg band inscribed with a unique number. Additionally, unique combinations of coloured plastic leg bands were applied to individuals of three of the focal species (Savannah Sparrow, Cedar Waxwing and Yellow Warbler) to allow field biologists to identify and track individual birds. Nestlings of these species were also colour banded. Only metal CWS number bands were placed on Traill's Flycatchers due to restrictions imposed by Environment Canada, which were based on concerns about leg injuries (Sedgwick and Klus 1997).

In 2013, we attempted to capture all territorial male Savannah Sparrows in the drawdown zone of Revelstoke Reach early in the breeding season in order to document habitat selection and dispersal within the drawdown zone later in the season.

2.2.4 Juvenile Survivorship and Recruitment

We recorded observations of previously colour-banded individuals to determine if any banded juveniles return to the study area.

To study juvenile survivorship, we used radio-telemetry. Lotek PicoPip Aeg 317 transmitters (0.45 g) telemetry transmitters were attached to one nestling per nest (Yellow Warbler or Savannah Sparrow). Tagged birds were monitored daily using a Communications Specialists R-1000 receiver equipped with a three element Yagi antenna until the bird died, or until the transmitter battery expired, or the bird could no longer be found (CBA 2014).

2.3 Data Summary and Analysis

Historic reservoir data reported included all data from Kinbasket Reservoir (July 1, 1976 to present) and all data from Arrow Lakes Reservoir following the completion of the Revelstoke Dam (January 1, 1984 to present).

Nest density was calculated for each nest monitoring plot by dividing the total number of nests found by the plot's area. Nesting success rate was calculated as the number of successful nests divided by the total number of nests with known outcomes. Predation rates were calculated as the number of confirmed predated nests divided by the number of nests with a known outcome. Productivity (average reproductive output) was estimated as the average number of nestlings fledged per nest, including both successful and unsuccessful nests. Site productivity was calculated as the nest success rate multiplied by nest density for each site.

We estimated clutch initiation dates (the date when the first egg was laid in a nest) by one of two methods:

Method 1 involved back-calculating dates from observations of nests during the laying or nestling stages. From laying observations, the date of the first egg was calculated by subtracting the number of days, equal to the number of eggs observed, and adding one day. For example, if two eggs were observed on June 2, the initiation date would be calculated as follows:

June 2 - (2 + 1) = June 1

From nestling observations, the date of the first egg was calculated by subtracting a time sum from the observation date. The time sum was calculated as the age of the nestlings + incubation period of the species + number of nestlings + unhatched eggs - 1. For example, if on June 30 we observed one egg and three 5-day old nestlings of a Song Sparrow (*Melospiza melodius*; incubation period = 13 days), the initiation date would be calculated as follows:

June 30 - (5 + 13 + 3 + 1 - 1) = June 9

Brown-headed Cowbird eggs and young were counted as host eggs/young in this calculation because cowbirds often eject host eggs when laying their own eggs.

Method 1 could not be applied to nests that were observed only during the incubation period. For such nests, we applied the less precise Method 2.

Method 2 involved calculating the span of days over which we monitored the nest while it was active, and subtracting this number from the species' incubation period to estimate the maximum possible amount of time left in the incubation period. We divided this number by two (rounding up if an odd number), added it to the monitoring period and the average species-specific clutch size, and subtracted 1. For example, if we observed a Song Sparrow nest to be active in the incubation stage from June 24 to June 30, the initiation date would be calculated as follows:

June 30–June 24 = 6 days monitored

13 - 6 = 7 days = maximum number of days of incubate unaccounted for

7 / 2 = 3.5; rounded up = 4

June 24 - (4 + 4 - 1) = June 17

While Method 2 is less precise, ~65 % of the values produced were within two days of the estimate provided by Method 1 for nests where this comparison could be made.

Nesting data from the Montana Bay floating bog habitat are omitted in some analyses in this report because nests may not be affected by reservoir operations like they are elsewhere in Revelstoke Reach.

Results are reported for all species from the pooled nest records.

To assess how complete our data sets were, we summed the areas mapped for each habitat/vegetation community type, the areas monitored in each type, and the number of nests found in each. For KIN, CLBMON-10 vegetation communities were summed from the 2010 shapefile and included all coverage. The Revelstoke Reach habitat map used for Revelstoke Reach was restricted to habitats below 441 m ASL; therefore, it included only habitats below the Maximum Historic Elevation (MHE). Using a spatial join, we assigned DEM values to all nests to determine if they were located within (≤ MHE) or above the drawdown zone (> MHE). The nest elevation was calculated by adding the nest DEM value to the nest height.

All nest data were used to determine species-specific nesting phenology for the species in nesting in the drawdown zones; species found nesting only above the drawdown zone were omitted. To estimate nest initiation dates, we used Method 1. To estimate the end of the nesting season, we used either the maximum nest termination date or the maximum estimated nest termination date for a successful nest, projected from the nest initiation dates. To obtain these results, we created a graph of these data points for each species.

To quantify nesting phenology in each reservoir, we developed a nesting phenology curve that showed the percentage of all nests that were active each day of the nesting season. To accomplish this we attempted to maximize the number of nests by including all nests for which we could estimate nest initiation using Method 1 and all other nests where nest initiation dates could be estimated using Method 2. The last observation at a nest was used to determine the end of the nesting period. A matrix containing 153 columns was built using a loop, with each column representing a day in the time span from April 1 to August 31. Each row in the matrix was a nest. The matrix was populated with values of 0 if the nest was not active (e.g., before/after the nesting period), or with values of 1 if the nest was active (during the nesting period). The percentage of nests that were active on each day was determined by summing the columns and dividing that value by the total number of nests. This was done separately for Kinbasket and Revelstoke Reach nest records. To model the nesting phenology curves for each reservoir, we used the `gam()` function from the gam package (Hastie 2012), fit using a loess smoother with a span = 0.1. This span provided the most satisfactory level of smoothing but predicted negative percentages at the start and end of the nesting season, when the number of active nests was calculated to be 0, so we manually changed the predicted values to 0 when this was the case.

To estimate nest densities, we summed the number of nests found in each habitat type (within nest mortality monitoring sites), and divided this number by the total area of each habitat type monitored (within nest mortality monitoring sites); polygons of habitat that were monitored for more than one year were treated as independent.

The nest mortality model developed in 2012 was updated with new data from 2013. This model considers how nesting is partitioned in time (seasonality) and space (habitat configuration and position in the drawdown zone). We used the nesting phenology curves to account for seasonality. The nest density estimates for drawdown zone habitats were used to project nest density throughout the mapped parts of the drawdown zone. GIS was then used to partition nest density into 0.5-m elevation bands in each reservoir, for all mapped areas above the lowest recorded nest elevation (nest density was estimated to be zero for all habitats positioned lower than the lowest recorded nest elevation in the drawdown zone). In Revelstoke Reach, we considered the floating BF habitat to be above the drawdown zone. The total area of each habitat in each elevation band was determined, and the nest density estimates were used to calculate the number of nests in each elevation band in each habitat type. We also determined the proportion of nests in each habitat type that were from ground-nesting species, species nesting low in shrubs, and species nesting in stumps, shrubs or trees (i.e., "shrub nests"). Low-nesting species had median nest heights that were less than 0.5 m; these were retained within the original elevation band. Shrub nests had a median nest height of 1.5 m, so we assigned the habitat-specific proportion of nests to the elevation band that was three bands (i.e., 50 cm) higher than the elevation band in which they were found. We assumed these proportions would be similar throughout the mapped habitat areas, and calculated how many of the total number of nests would be positioned in the ground, low shrub or shrub/tree nest locations. We then made a correction to the elevational distributions of nests. The total number of nests was summed for each 50-cm elevation band. Finally, to control for seasonality, we calculated the number of active nests on each day by multiplying the total number of nests by the nesting phenology curve estimates for each day of the breeding season. The end product was a matrix of values that estimated the number of active nests in each 0.5-m elevation band on each day of the year (hereafter referred to as the "nesting model"). We produced a nesting model for each reservoir.

All data manipulation, statistical computing and graphing was performed using R (R Development Core Team 2006). Graphs were produced using the ggplot2 package (Wickham 2009). Overplotting (where data overlap) in scatterplots was dealt with by setting the transparency of the points (the "alpha" setting). When "transparency = 1/2", two or more points overlapping are 100% opaque; when "transparency = 1/5", five or more points are required to make a point 100% opaque. We also occasionally used the "jitter" function to wiggle points slightly if they were overplotted (Wickham 2009).

3 RESULTS

3.1 Reservoir Operations

In the Kinbasket Reservoir, the water elevation was ~ 723 m ASL in early May, which was near the lower historic quartile, but filled over the course of the season to relatively high levels, and was near full pool elevation by late August (754.2 m ASL on August 31; Figure 3-1). The reservoir's maximum fill elevation in 2013 (a surcharge) occurred after the study period.

In the Arrow Lakes Reservoir, the water elevation was relatively high (~ 430 m ASL) in early May. Relatively high water elevations were maintained during the spring fill, particularly in late June (Figure 3-1). The reservoir peaked near full pool in early July (maximum elevation = 439.9 m ASL on July 4) and proceeded to draft relatively quickly over the remainder of the summer (Figure 3-1).

3.2 Other Annual Conditions in 2012

Relatively high rainfall was recorded at Revelstoke airport in June, 2013, and a very dry July was observed, compared to the previous years of monitoring (Figure 3-2). The Airport Marsh had shallow water in 2013, with the roots of emergent vegetation being poorly submerged; conversely, the Machete Ponds had relatively deep water during the 2013 field season.

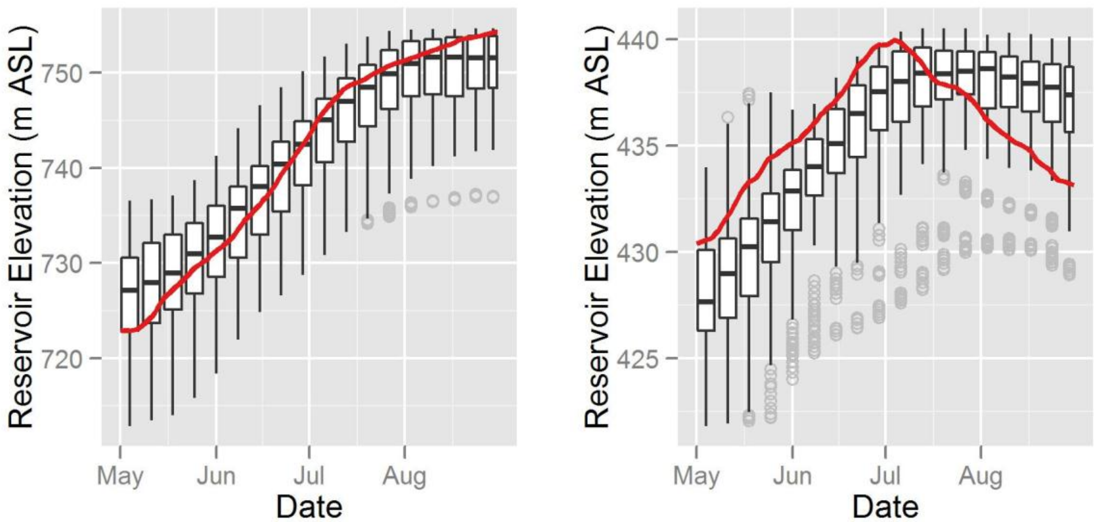

Figure 3-1: **Reservoir elevations at Kinbasket Reservoir (left) and Arrow Lakes Reservoir (right) plotted as weekly boxplots of historical data, with the 2013 elevations plotted in red**

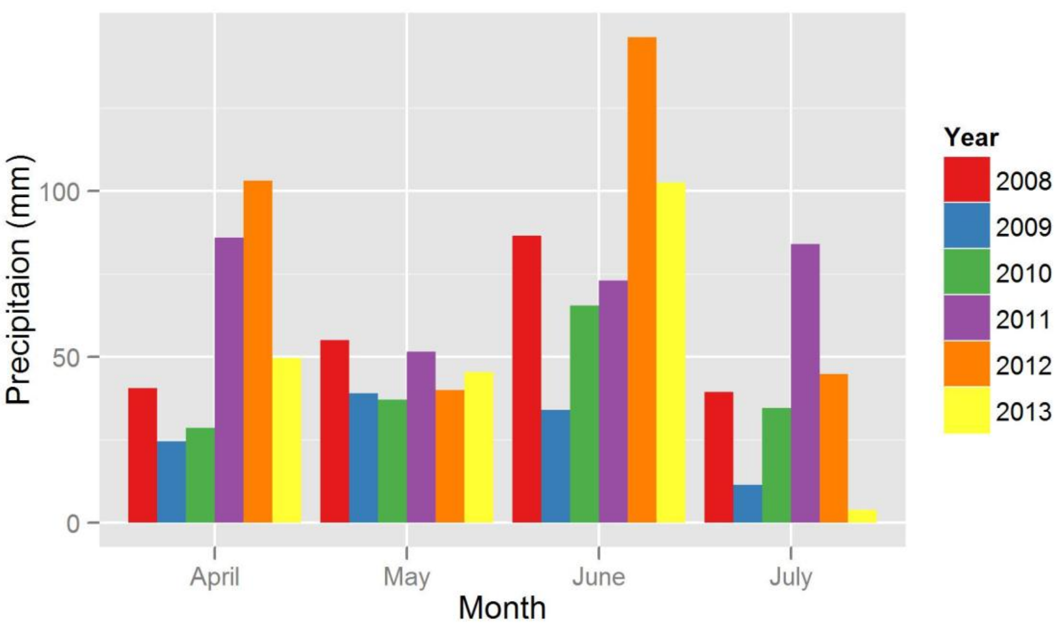

Figure 3-2: **Precipitation measured at the Revelstoke airport weather station over the course of five summers of CLBMON-36 monitoring**

3.3 Survey Effort

In both study areas, crew schedules were coordinated so that surveys were conducted almost daily.

In Canoe Reach, field sampling was conducted from June 4 to August 8, 2013. During this period, we monitored 25 nest mortality monitoring sites.

In Revelstoke Reach, field sampling was conducted from May 6 to August 13, 2013. During this period, 34 nest mortality study sites were monitored. Focal species were monitored at several additional areas outside these sites.

In 2013, we recorded 2,286 person-hours of field effort: 526 hours in Canoe Reach, the remainder (1760 hours) in Revelstoke Reach. The majority of the field effort (79%) was spent searching for nests.

3.4 Nest Mortality Monitoring

In 2013, 309 nests from 33 species were located and monitored until young fledged or the nest failed (Table 3-1). Nest locations are mapped in Appendix 6-4, and Appendix 6-5.

3.4.1 Kinbasket Reservoir Nest Records (Canoe Reach)

In Canoe Reach, 44 nests from six species were found, which accounted for 14% of the total nest records (Table 3-1); 43 of these nests (five species) were located in the drawdown zone; one nest was found above the drawdown zone (Greater Yellowlegs). The most abundant species found nesting in the drawdown zone was Savannah Sparrow (n = 33), followed by Killdeer (n = 5). All species recorded in the drawdown zone had been observed nesting in previous years.

Table 3-1: Bird species and number of nests found in Canoe Reach (Kinbasket Reservoir), and in Revelstoke Reach (Arrow Lakes Reservoir). Nests above the drawdown zone were found in sites that straddled the full pool elevation.

		Above Drawdown Zone		Within Drawdown Zone	
Common Name	Scientific Name	Canoe Reach	Revelstoke Reach	Canoe Reach	Revelstoke Reach
Common Loon	*Gavia immer*	0	0	0	2
Pied-billed Grebe	*Podilymbus podiceps*	0	0	0	4
Canada Goose	*Branta canadensis*	0	0	0	10
American Wigeon	*Anas americana*	0	0	0	5
Mallard	*Anas platyrhynchos*	0	0	0	10
Unidentified Teal	*Anas sp*	0	0	0	1
Green-winged Teal	*Anas crecca*	0	0	0	4
Unidentified Duck	*Anatinae (gen, sp)*	0	0	0	1
Virginia Rail	*Rallus limicola*	0	0	0	3
Sora	*Porzana carolina*	0	0	0	1
Killdeer	*Charadrius vociferus*	0	0	5	4
Spotted Sandpiper	*Actitis macularius*	0	0	2	0
Greater Yellowlegs	*Tringa melanoleuca*	1	0	0	0
Wilson's Snipe	*Gallinago delicata*	0	0	0	6
Willow Flycatcher	*Empidonax traillii*	0	0	0	26
Least Flycatcher	*Empidonax minimus*	0	0	0	2
Eastern Kingbird	*Tyrannus tyrannus*	0	0	0	1
Warbling Vireo	*Vireo gilvus*	0	0	0	1
Red-eyed Vireo	*Vireo olivaceus*	0	1	0	2
American Crow	*Corvus brachyrhynchos*	0	0	0	1
Veery	*Catharus fuscescens*	0	0	0	7
American Robin	*Turdus migratorius*	0	0	0	4
Gray Catbird	*Dumetella carolinensis*	0	0	0	9
Cedar Waxwing	*Bombycilla cedrorum*	0	0	0	34
Yellow Warbler	*Dendroica petechia*	0	0	0	66
American Redstart	*Setophaga ruticilla*	0	0	0	8
MacGillivray's Warbler	*Oporornis tolmiei*	0	0	0	2
Common Yellowthroat	*Geothlypis trichas*	0	0	0	7
Chipping Sparrow	*Spizella passerina*	0	0	0	6
Vesper Sparrow	*Pooecetes gramineus*	0	0	1	0

Continued		Above Drawdown Zone		Within Drawdown Zone	
Common Name	Scientific Name	Canoe Reach	Revelstoke Reach	Canoe Reach	Revelstoke Reach
Savannah Sparrow	*Passerculus sandwichensis*	0	0	33	3
Song Sparrow	*Melospiza melodia*	0	0	0	25
Lincoln's Sparrow	*Melospiza lincolnii*	0	0	2	0
Lazuli Bunting	*Passerina amoena*	0	0	0	1
Red-winged Blackbird	*Agelaius phoeniceus*	0	0	0	8

3.4.1.1 Distribution of Nests by Elevation and Site at Kinbasket Reservoir

In Canoe Reach, nests were located between 747.3 m and 754.8 m ASL (Figure 3-3).

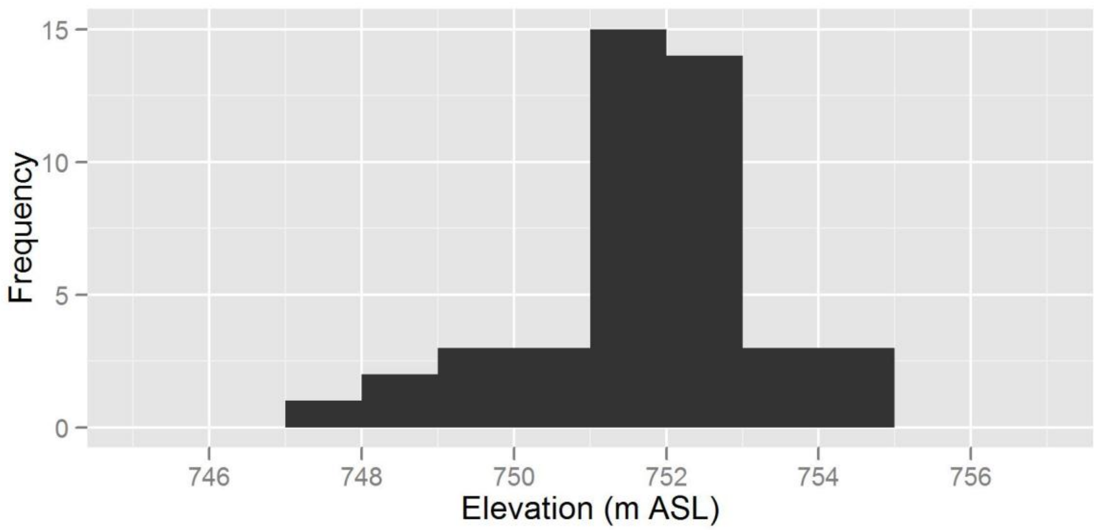

Figure 3-3: **Nest site elevations at Canoe Reach in Kinbasket Reservoir**

3.4.1.2 Distribution of Nests among Nest Mortality Study Sites in Kinbasket Reservoir

In Kinbasket Reservoir, nest density averaged 0.27 nests/ha and ranged up to 1.9 nests/ha (Figure 3-4). Maximum density was recorded at site 58832.

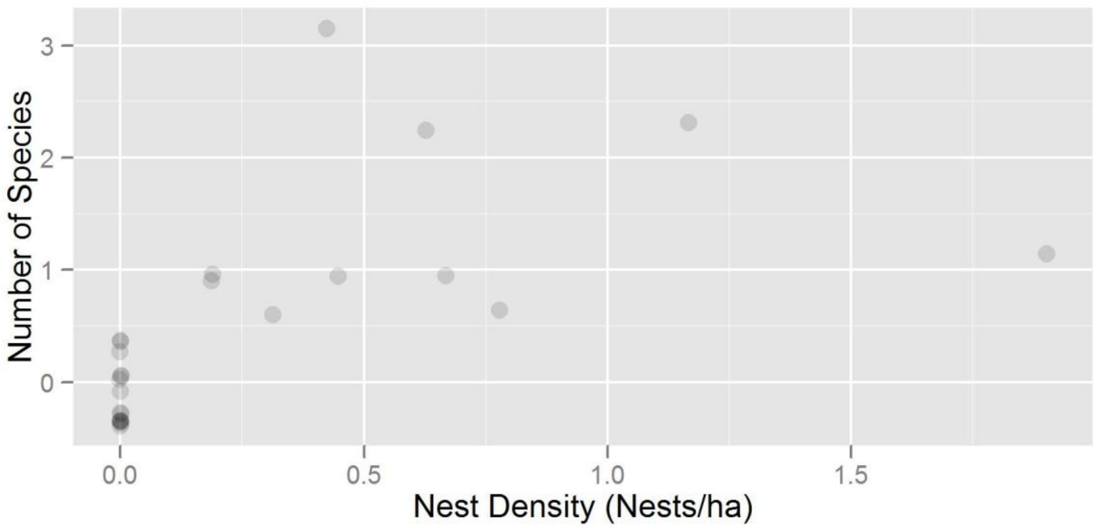

Figure 3-4: **Nest density and number of species recorded among nest mortality study sites in Kinbasket Reservoir (points are jittered in the Y axis; transparency = 1/8)**

3.4.1.3 Distribution of Nests among Habitat Types in Kinbasket Reservoir

Nine vegetation community types (Hawkes et al 2010) were mapped within the study sites monitored in Kinbasket Reservoir in 2013. Nest densities in different habitats ranged from 0.0 to 1.53 nests/ha. The greatest nest densities were found in the Willow Sedge (WS) vegetation community, followed by Wool-grass—Pennsylvania Buttercup (WB; Figure 3-5). The number of nesting species was greatest in Common Horsetail, Kellogg's Sedge, and Willow Sedge (CH, KS, WS; two species in each; Figure 3-5).

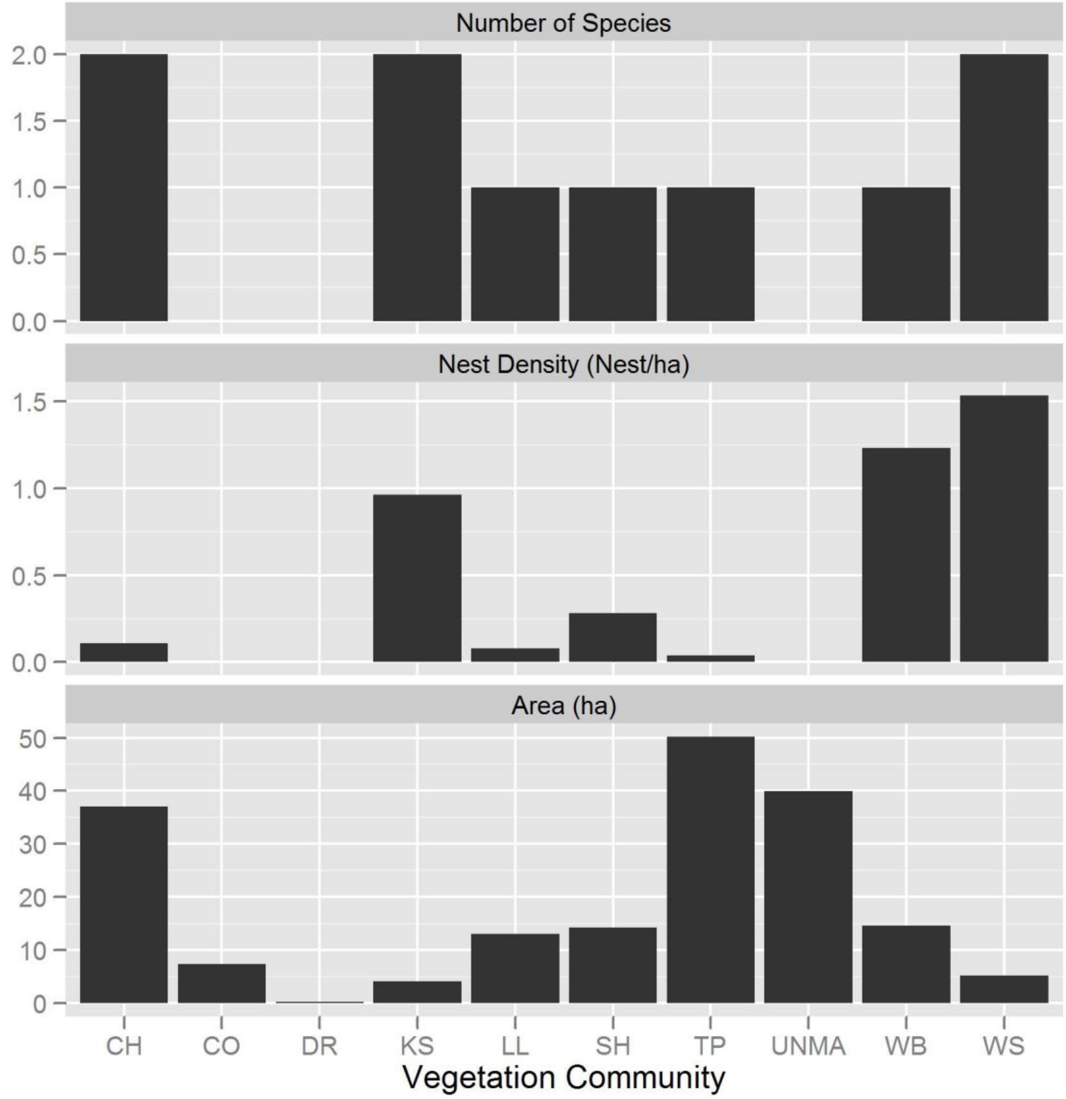

Figure 3-5: **Vegetation community types and total number of species found nesting (top), nest density (middle) and total area of habitat monitored (bottom) in Kinbasket Reservoir. Vegetation community codes are defined by Hawkes et al. 2010 except 'UNMA' which designates regions that were not mapped**

3.4.1.4 Species at Risk in Kinbasket Reservoir

No species at risk were found breeding in the Kinbasket Reservoir.

3.4.2 Revelstoke Reach Nest Records

3.4.2.1 Breeding Bird Community in Revelstoke Reach

With 266 nests from 32 species, the majority (86%) of nests were monitored at Revelstoke Reach. In the drawdown zone, 265 nests from 32 species were found; only one nest was monitored above the drawdown zone (Red-eyed Vireo). All species recorded nesting in the drawdown zone had been observed nesting there in previous years.

The most abundant nests in the nest mortality monitoring sites were those of Cedar Waxwing (n = 34), followed by Traill's Flycatcher (n = 26) and Song Sparrow (n = 25).

3.4.2.2 Distribution of Nests by Elevation and Site at Revelstoke Reach

Nest site elevations in the Revelstoke Reach drawdown zone ranged from 434.1 m to 440.7 m ASL (Figure 3-6). An unusually large number of nests were located at approximately 436 m, which was due almost entirely to nests found on the naturally floating bog habitat at Montana Bay (Figure 3-6). The number of species nesting in each monitoring site in Revelstoke Reach ranged from 0 to 15 and increased with nest density (Figure 3-7).

3.4.2.3 Distribution of Nests among Habitat Types in Revelstoke Reach

In Revelstoke Reach, 29 vegetation community types were mapped within the nest mortality study sites monitored. Nest densities in different habitats ranged from 0.0 to 15.9 nests/ha. The greatest nest density was found in Floating Bog (BF) habitat (15.9 nests/ha), followed by Pond habitat (PO; 11.0 nests/ha) and Shrub Wetland Complex (CW; 10.5 nests/ha) (Figure 3-8). The greatest number of species nested in the Floating Bog habitat (BF; 13 species), followed by the Riparian Forest and Shrub Savannah habitats (RF, SH; 11 species), and Shrub Wetland Complex (CW; 10 species) (Figure 3-8).

3.4.2.4 Species at Risk in Revelstoke Reach

No species at risk were observed nesting in the drawdown zone.

3.4.3 Nesting Phenology

The date when the first egg was laid was calculated for 161 nests monitored (Figure 3-9).

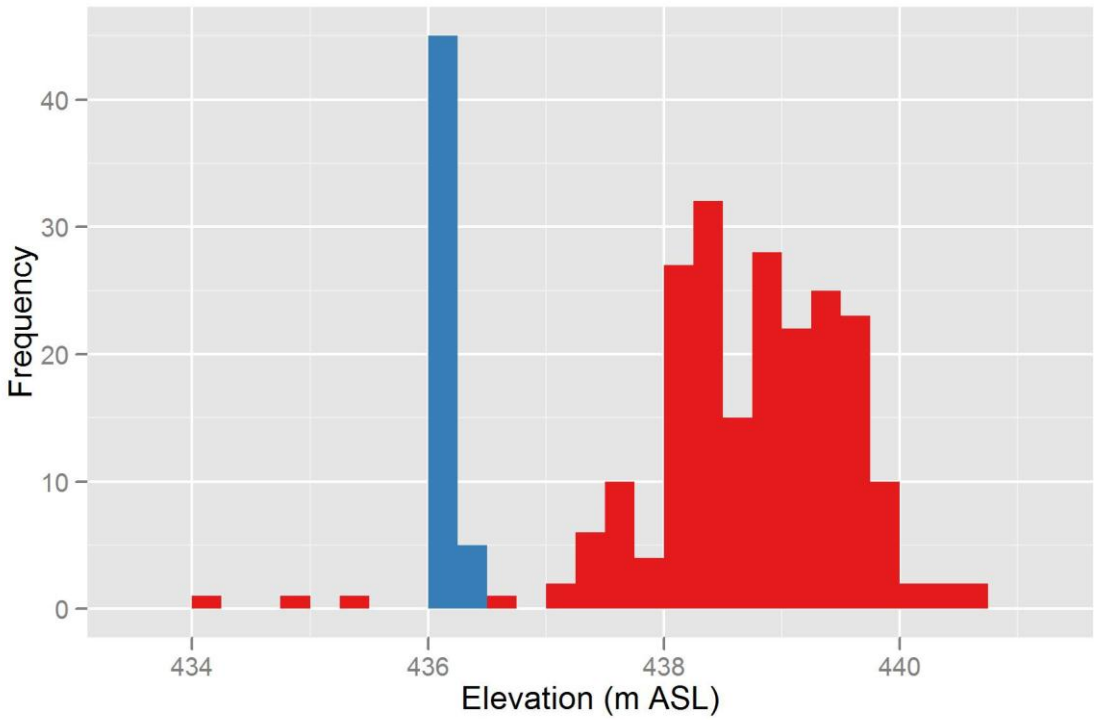

Figure 3-6: **Nest site elevations in or near the drawdown zone of Revelstoke Reach (blue = Montana Bay [Site ID = 39] nests; red = nests from all other sites)**

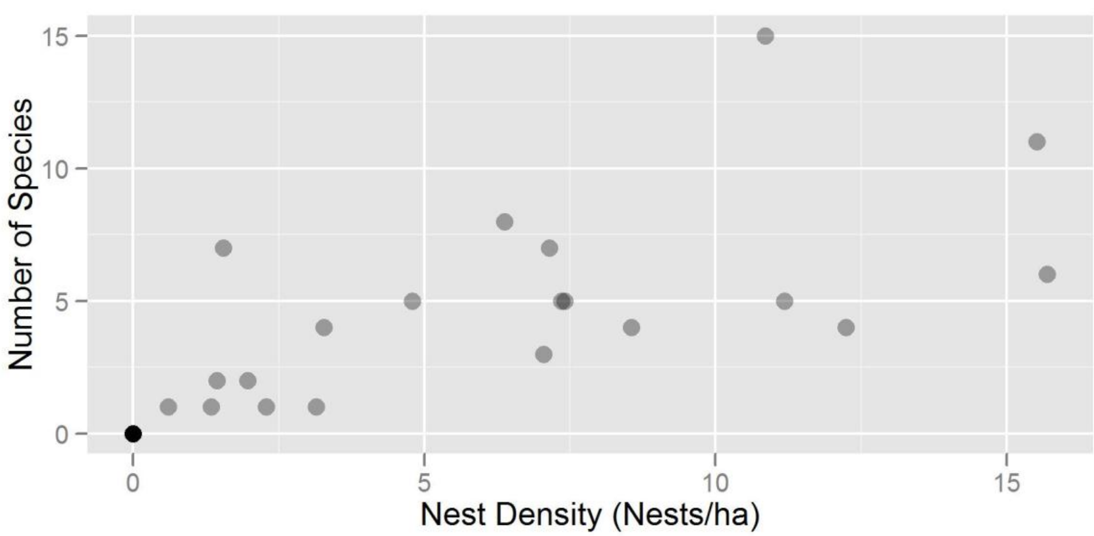

Figure 3-7: **Nest density and number of species among nest mortality study sites in Revelstoke Reach (transparency = 1/3)**

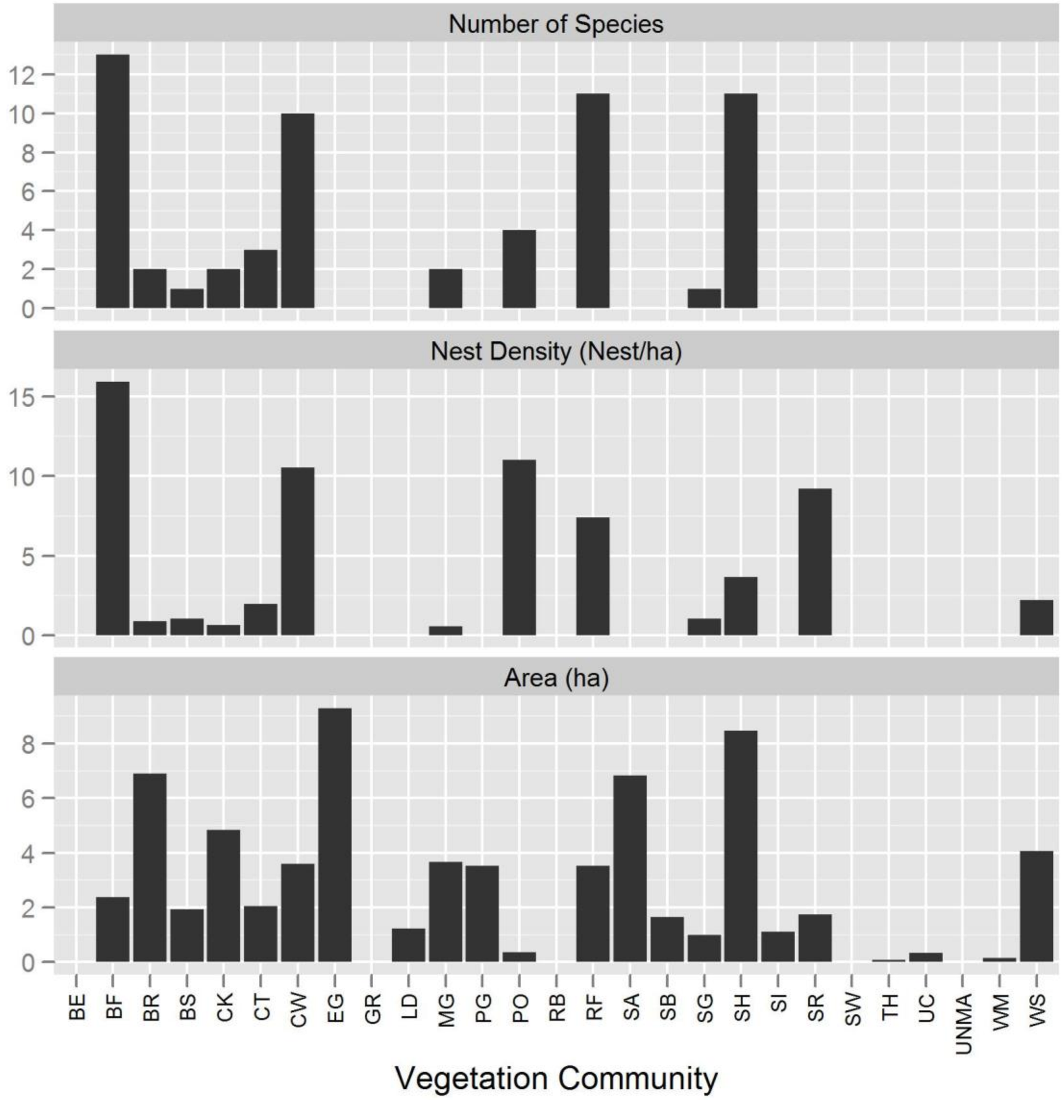

Figure 3-8: **Vegetation community types and total number of species found nesting (top), nest density (middle) and total area (ha) of habitat monitored (bottom) for all mapped parts of the nest mortality study sites monitored in Revelstoke Reach (UNMA = Unmapped habitat)**

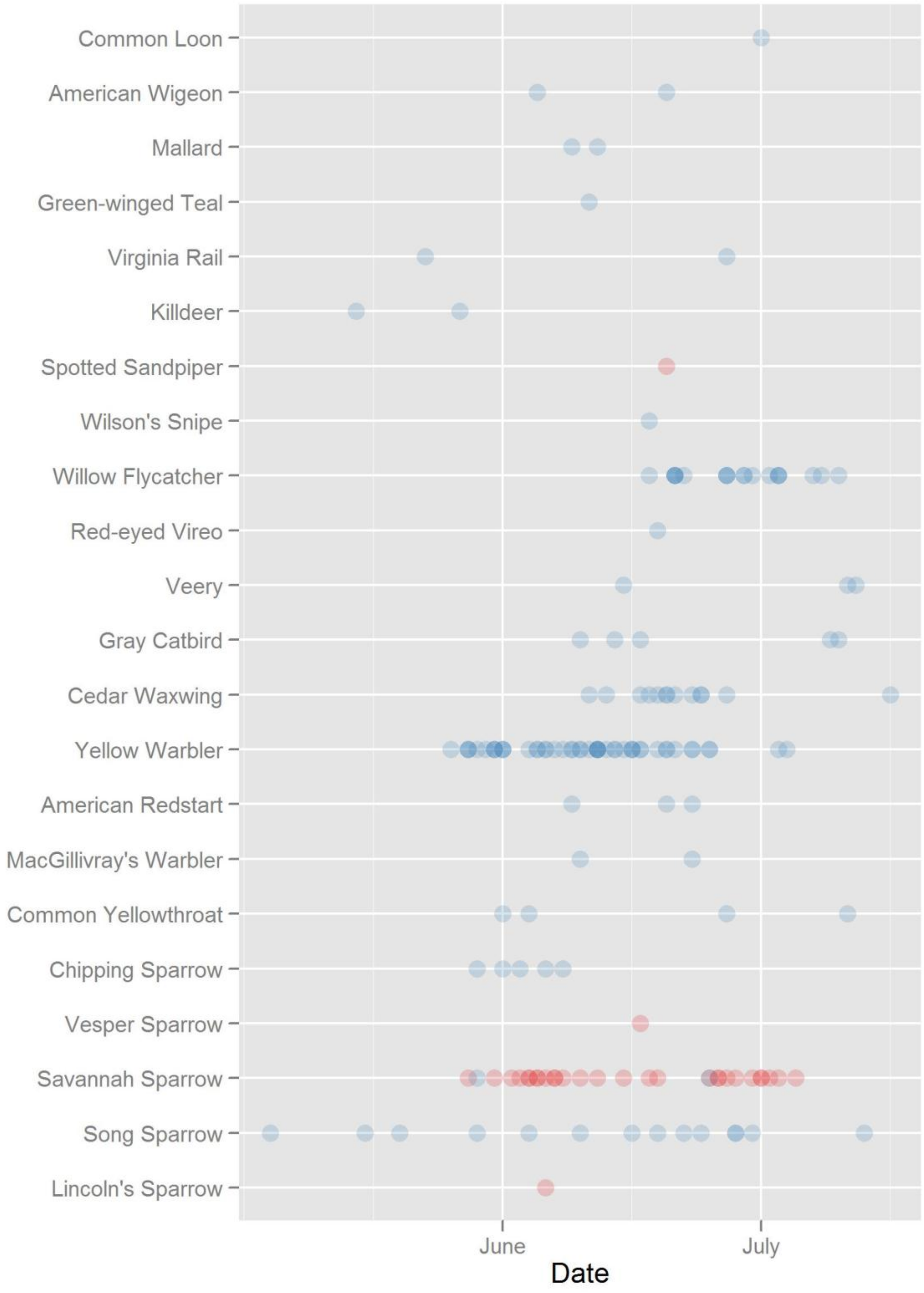

Figure 3-9: **Back-calculated dates for first egg laid for 161 nests in Canoe Reach (red), and Revelstoke Reach (blue; transparency = 1/5)**

3.4.4 Nest Monitoring Results

Of the nests for which outcomes were determined (*n* = 272, 88% of all nests), 109 (40%) were successful. Of the 163 documented nest failures (60% of nest outcomes), 103 (63%) failed due to predation, and 28 (17%) failed as a result of reservoir operations.

Within the drawdown zones, nest success rate was highest in Canoe Reach (81%); Revelstoke Reach had a considerably lower nest success rate (32%). Predation rates within the drawdown zones were 9.3% at Canoe Reach and 43% at Revelstoke Reach.

3.4.4.1 Mortality Due to Reservoir Operations

Reservoir operations directly flooded 28 monitored nests (Appendix 6-6). None of these were nests of species at risk.

Three nests were flooded by rising water in the Kinbasket Reservoir drawdown zone; these were ground nests (mean elevation = 751.5 m ASL).

Twenty-five active nests failed due to flooding in the Revelstoke Reach drawdown zone. Seven (28%) of these were ground nests, 11 were near the ground in the shrub/grass interface or were in emergent vegetation (44%), and 7 nests were located in shrubs (28%). The ground and near ground nests were positioned on average at 438.3 m ASL. The shrub nests that flooded were positioned at 437.4 m ASL on average.

3.5 Productivity, Juvenile Survival and Recruitment

3.5.1 Productivity of Focal Species

Productivity data from focal species nests with known nest outcomes are provided in Table 3-2.

Table 3-2: Productivity of focal species, and their nest locations in the drawdown zones of Arrow Lakes Reservoir (ALR) and Kinbasket Reservoir (KIN)

Reservoir	Common Name	Number of Nests	Nesting Success	Productivity	Standard Deviation
ALR	Cedar Waxwing	32	0.28	1.06	1.79
ALR	Savannah Sparrow	3	1.00	3.00	1.00
KIN	Savannah Sparrow	33	0.79	2.82	1.76
ALR	Willow Flycatcher	21	0.43	1.43	1.80
ALR	Yellow Warbler	62	0.35	1.10	1.63

3.5.2 Juvenile Survival

We tagged 12 Yellow Warbler and 20 Savannah Sparrow nestlings with radio transmitters; the former in Revelstoke Reach, and the latter in Canoe Reach. All of these individuals were from nests within the drawdown zone. For one Yellow Warbler, the transmitter failed. Two Savannah Sparrow young died after being tagged when their nests flooded, and three more were consumed by nest predators; two Yellow Warblers were killed by nest predators. Of the 15 Savannah Sparrows monitored after fledging, four (27%) survived the monitoring period. Causes of death included predation by snakes and, probably, falcons (American Kestrel and Merlin), but predators could not be determined in most cases. Of the nine monitored Yellow Warblers that fledged, four (44%) survived the monitoring period. One warbler was killed by a snake, but predation could otherwise not be determined. One transmitter was located submerged in water and could not be recovered.

3.5.3 Banding

In the Revelstoke Reach drawdown zone, we captured 11 Savannah Sparrows. One male was captured at Terminal Shrubs, one male at Cartier Bay, four in the 9 Mile South area (at least three other un-banded males were in the 9 Mile area), and five were captured in the 12 Mile area. Males observed at nests in the area were all observed to be un-banded. 31 adult Yellow Warblers were captured, and 44 nestlings were banded. In Canoe Reach, we banded 89 nestling Savannah Sparrows.

3.6 Multi-year results

3.6.1 Nest Phenology Curve

The nesting phenology curve showed a more pronounced peak in nesting activity in Kinbasket Reservoir, and a longer nesting season in the Arrow Lakes Reservoir (Figure 3-10).

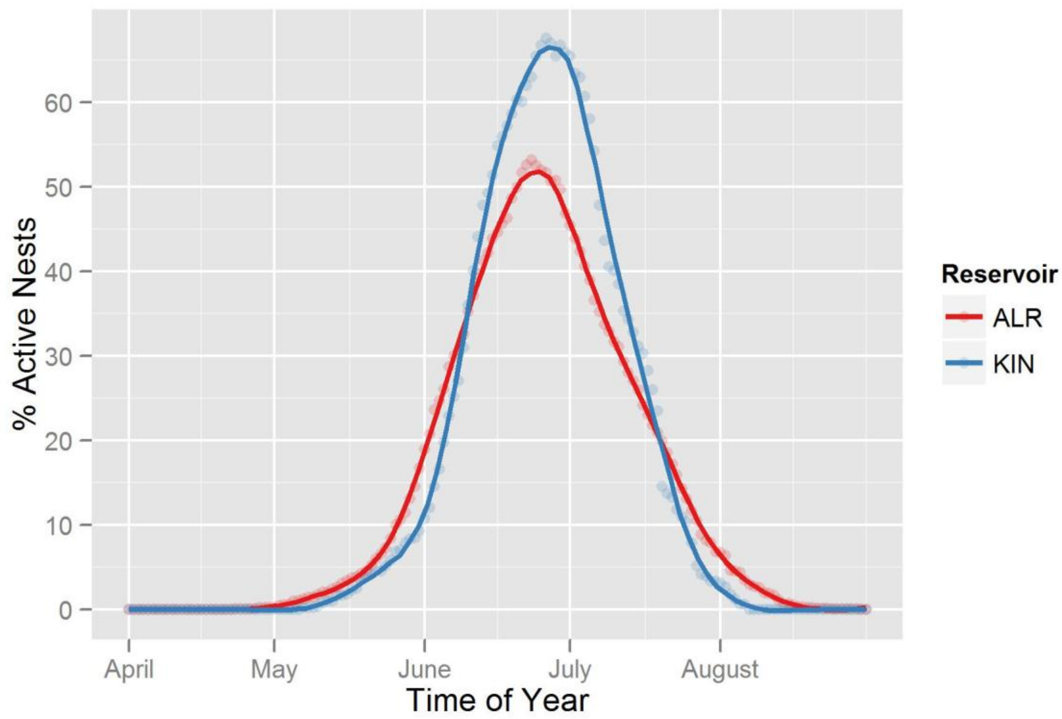

Figure 3-10: The nesting phenology curves predicted using nests monitored from 2008 through 2013

3.6.2 Nest Mortality Model

The nest flooding model was updated with the addition of new nest mortality monitoring results which we present as a heat map indicating the number of active nests as a function of time of year and elevation in the parts of the reservoir drawdown zones that have habitat mapping completed (Figure 3-11).

The operations of Kinbasket Reservoir had considerable potential to flood nests at lower elevations, but the filling rate diminished in early July, greatly reducing the nest flooding severity (Figure 3-11). When the nest flooding model was applied to the 2013 reservoir operation, it was ranked as 0.82 on a linear scale bounded by 0 (lowest impact operation ever observed) and 1 (the most severe nest flooding impact modelled for historic reservoir operations). In our empirical observations, we recorded three nest flooding events, which is relatively high, but particularly so, when compared with the relatively small number of monitored nests in 2013. During the six years of study, the modelled severity of reservoir operations experienced each year was positively strongly correlated (Pearson product moment correlation = 0.88) and significantly (P = 0.02, n = 6) correlated with the observed proportion of flooded nests observed (Figure 3-12).

The operations of Arrow Lakes Reservoir had a relatively severe potential to impact nesting in 2013 with an aggressive filling regime that put water levels at the highest levels observed in late June during the course of this study (Figure 3-11). While this early fill regime was high, the maximum elevation was not abnormally high. When the nest flooding model was applied to the 2013 reservoir operation, it was ranked as 0.88 on a linear scale bounded by 0 (lowest impact operation ever observed) and 1 (the most severe nest flooding impact modelled for historic reservoir operations). In our empirical observations, we recorded 25 nest flooding events, which is high compared with other years. During the six years of study, the modelled severity of reservoir operations experienced each year was positively, strongly (Pearson product moment correlation = 0.85), and significantly (P = 0.03, n = 6) correlated with the observed proportion of flooded nests observed (Figure 3-12).

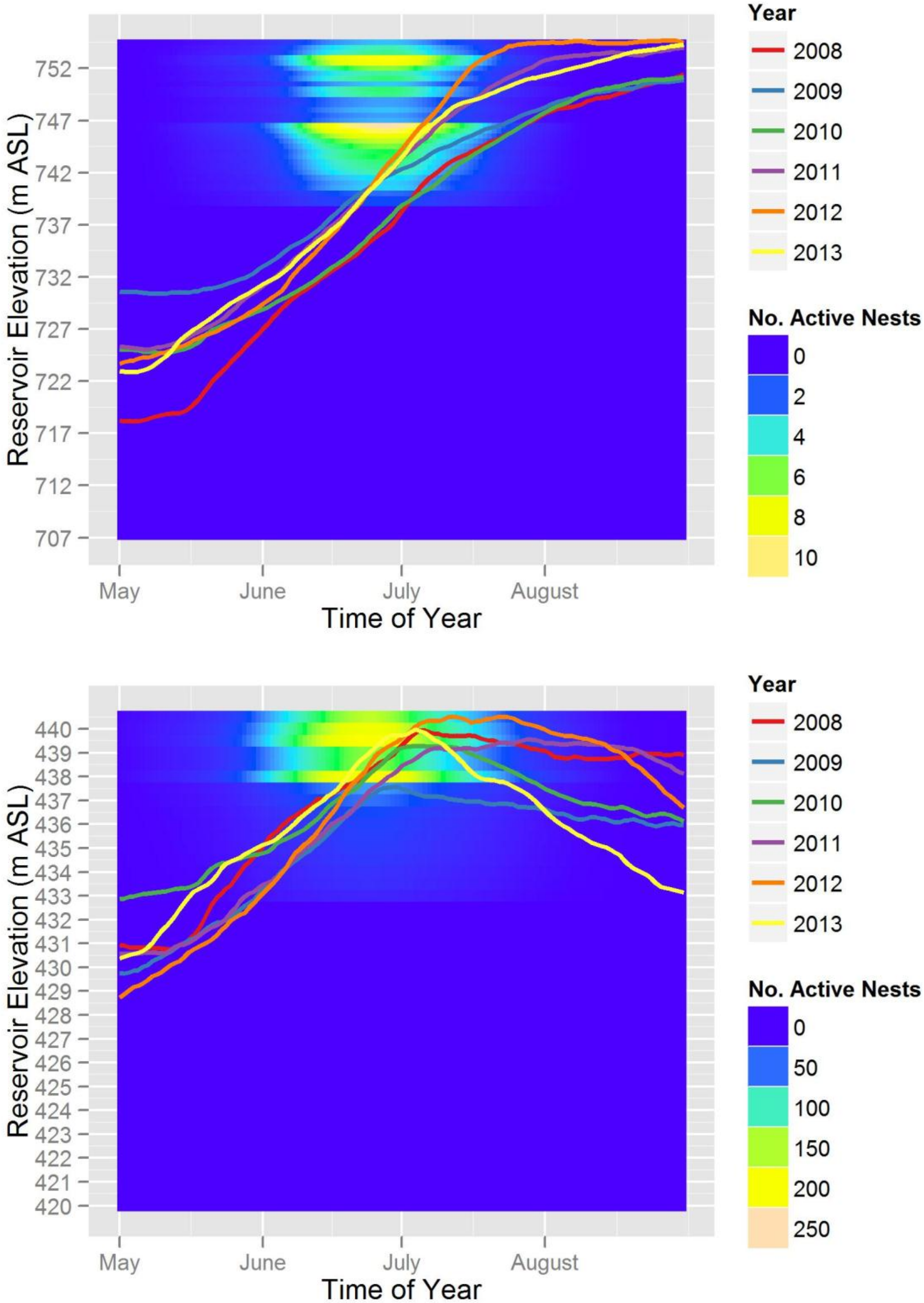

Figure 3-11: **Operations of Kinbasket Reservoir (top) and Arrow Lakes Reservoir (bottom) from 2008 through 2013 are plotted over a heatmap showing density of active nests modelled as a function of time and elevation in parts of the reservoirs where habitat mapping has occurred**

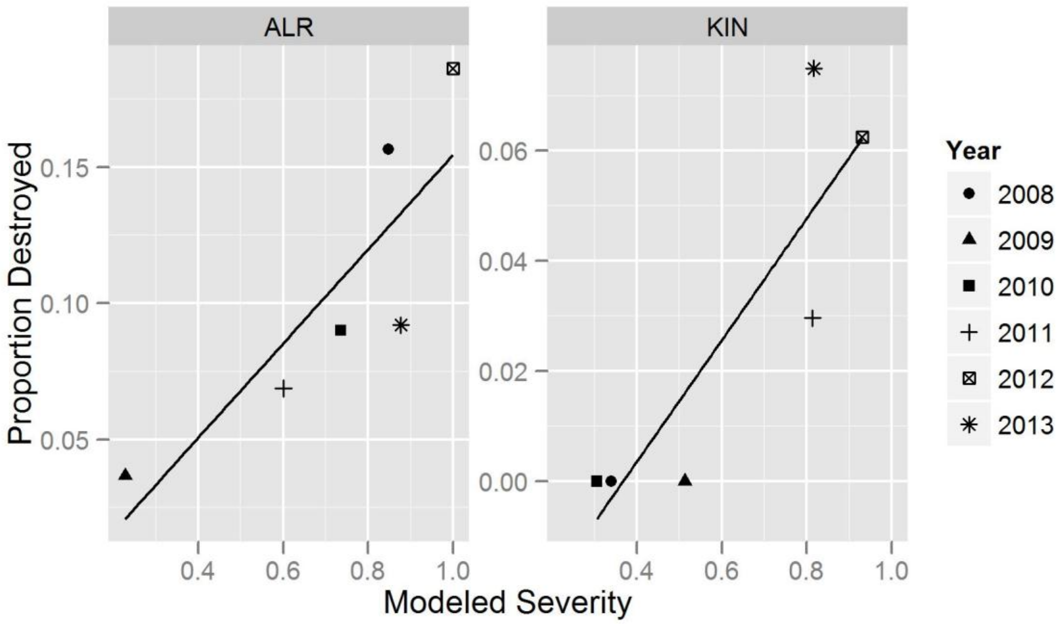

Figure 3-12: **The severity of nest flooding predicted from the nesting models (x) compared with the proportion of nests observed to have been flooded each year (y)**

4 DISCUSSION

CLBMON-36 is a 10-year project researching knowledge gaps related to the management of reservoirs (their habitat and operation) to enhance avian productivity and minimize the incidental take of nests caused by reservoir operations. This report summarizes progress made in the CLBMON-36 project in 2013. This was the 6^{th} year of research on this project, and the 2013 field studies commenced as the multi-year (5-year) analysis was completed (CBA 2013).

A strategic initial focus of study during the first five years was to establish a relatively complete and robust knowledge of which avian breeding communities exist in the drawdown zones of Kinbasket and Arrow Lakes Reservoirs, as this knowledge underpins all of the project's objectives (listed in Section 1.1). One of the major outcomes of the five year analysis was the production of a nest flooding model built using GIS maps of drawdown habitat communities, digital elevation models, and empirical knowledge of nesting phenology, and habitat-specific nesting patterns (nesting species, densities, and nest heights). While there is room to enhance the nesting model's complexity, it represents an enormous improvement over what was previously available (AXYS 2002, Korman 2008). Our nest flooding model can now predict how many nests and species are at risk of flooding on any date and reservoir level.

Following the five-year analysis, in Year 6 (2013), the field study program was similar to previous years, but there was a reduced allocation of effort towards biogeographic study (e.g., nest mortality monitoring), and greater emphasis placed on focal species work. Specifically, we expanded our field study of juvenile survival using radio telemetry.

In this report, we review salient aspects of data collection in 2013, following a similar format to previous annual reports. We also up-dated the nesting models using six years of data, and re-run comparisons made in the Interim report (CBA 2013) between modeled nest mortality and observed outcomes.

Below we (1) review progress and remaining data gaps in the biogeographical components of this study, (2) we provide a brief summary of the second year of radio-telemetry work, (3) we discuss the updated nest flooding model results, and (4) we discuss fluctuations in the Airport Marsh and implications of the wildlife physical works project recently completed (at Site 6A) under the CLBWORKS-30 program.

4.1 Habitat Monitoring for Nest Mortality Modeling

As noted in the 5 Year Interim report (CBA 2013), the knowledge gaps in biogeography are minor. To date, there are two habitats in Kinbasket Reservoir (MC and RD) that have not been monitored, but these are poorly represented in the mapped coverage, constituting less than 1 ha of habitat combined. MC (Mixed Conifer) habitat is located in a very remote part of Kinbasket on the northeast shore north of Sullivan Arm. Assuming that this habitat is flooded by reservoir operations very rarely, based on the habitat type (conifers do not tolerate flooding well), and given the extreme remote setting of this very small habitat patch, we have opted to not monitor this habitat type at this time. One 0.6 ha patch of RD (Common Reed) habitat has been mapped in Canoe Reach. This habitat patch should be a high priority monitoring site for 2014.

Until 2012, when the Kinbasket Reservoir elevation exceeded all historically observed elevations, we considered FO habitat to be above the full pool elevation and had excluded it from our monitoring program, and only a small effort has been made monitoring FO habitat to date. In 2013, we had intended to monitor additional FO habitat, but road washouts prevented access.

With one exception (FO), our monitoring effort in the 16 well-represented vegetation communities in Kinbasket is substantial, and at least one nest has been located in each habitat type. We suggest that the effort in monitoring representative habitats in KIN should continue so that there is an expanded level of site replication and monitoring in each habitat type over multiple years. Effort should be made to seek new monitoring sites, with additional effort directed towards habitats that have not yet been well monitored (e.g., FO, MC and RD). Additionally, unmapped regions should continue to be monitored. These habitats are typically barren and contain very low potential to attract nesting birds; nonetheless, it is necessary to demonstrate this with data.

At the Arrow Lakes Reservoir there has also been a strong effort monitoring most habitat types. To date 27 habitat types have been monitored (CBA 2013). Most of the 30 habitat types have been adequately monitored. Habitats not monitored (5 all together) include TH and GR which together form the Columbia River channel and the shoals and gravelly river bank habitat that floods naturally during spring freshet, and generally do not qualify as nesting habitat. We also omitted the uncommon UR habitat which is characterized as typically a paved road surface. While there is some potential that species such as Common Nighthawks and Killdeer nest on gravelly parts of UR habitat, these habitats are all located above the drawdown zone, and the most significant UR habitat patch is the Revelstoke Airstrip which is off limits to this study. For the present, we have also censored the BE (bedrock/bluffs) habitat as it is challenging to access and work on safely, and has very low potential for nesting. Finally, we have censored the CR (coarse rocks) habitat, which is very uncommon and also has very low potential for nesting. Outstanding are two habitats (SB and UC) that have had low monitoring effort, which we should specifically target in 2014.

An important data gap is the incomplete mapping coverage for Kinbasket Reservoir's drawdown zone. Our nest flooding models are highly sensitive to the area of mapped habitats, and there is considerably more habitat that has been mapped at low elevations, compared with high elevations, which is reflected in the distribution of nests predicted among elevations.

4.2 Telemetry

In 2013 we completed the second year of radio telemetry work in Revelstoke Reach and initiated the first year of telemetry study in Kinbasket Reservoir. These programs went well.

In Revelstoke Reach we succeeded in monitoring nine fledgling Yellow Warblers, and four of these (44%) survived through the monitoring period. By comparison, in 2012, the Yellow Warbler's post fledging habitat was inundated to a much greater degree, and two out of eight (25%) survived the monitoring period. It is too early to speculate if these differences are meaningful; an estimate of the degree to which reservoir inundation impacts juvenile survivorship requires several more years of continued research. The success of this research will be enhanced by variable reservoir conditions among years; years where habitat flooding is minimal will be particularly helpful.

In the Canoe Reach drawdown zone, we monitored 15 fledged Savannah Sparrow young using radio telemetry, and four of these (27%) survived the monitoring period. Among the young Savannah Sparrows that died in the nest were two that died due to nest flooding at an age when they could have fledged. These two latter cases will be important for estimating the age when juvenile Savannah Sparrows are able to escape reservoir flooding. This was the first year of radio telemetry study in Canoe Reach. In 2012, we monitored survival of seven fledged Savannah Sparrows above the drawdown zone, and one survived (14%). With the Savannah Sparrow work, we intend to conduct two types of analyses. First, we will attempt to monitor across juvenile survival within and above the drawdown zone of Kinbasket Reservoir. For this, it will be important to find as many different sites in both situations. Second, we will attempt to monitor survival of young exposed to reservoir flooding at different ages so that we can attempt to estimate the age when juveniles are able to deal well with this survival threat.

4.3 Nest Flooding Model

The nesting model was updated with current data. This entailed re-calculating nesting densities in each habitat type, and re-estimating the nesting phenology curves, using six years of data; these updates were then incorporated into the nesting model. Following, we applied the reservoir elevation data to estimate the severity of nest flooding each year, and scaled the data between 0 and 1 corresponding to the least and most severe operations estimated in the historical data. For Kinbasket Lake, all years were included in this last process; in Arrow Lakes Reservoir, we only considered years from 1984 through to present, corresponding to the completion of the Revelstoke Dam. From these results, it is clear that 2013 was the second most severe year for nest flooding in this study to date in both reservoirs, with Kinbasket scoring 0.82 and Arrow Lakes Reservoir scoring 0.88 in 2013.

As has been explained previously (CBA 2013), the nesting models are relatively simplistic. Nonetheless, these models are important landmarks because they are the first to use such a large database of local nesting data, and utilize a relatively fine scale of habitat mapping in Revelstoke Reach. There had been no nesting model produced for Kinbasket Reservoir previously. We also updated the validation performed in the Interim report (CBA 2013), adding one more year of data to the correlations. The addition of 2013 data did not change the conclusion made previously (CBA 2013); the strength and significance of correlation between observed nest flooding rates and predicted severity was held for both reservoirs. We suggest that the models are a valid tool for managing reservoir operations, even in their early stages of development, primarily because we are confident that the elevation and date limits of nesting are unlikely to change much with the addition of data or model refinement. Nonetheless, it is important that the models and validation are refined further; specifically, it is necessary to expand the mapping in Kinbasket, and to incorporate habitat specific phenology curves. The former will have a large consequence for determining the density of active nests in time and space. The latter will also allow spatiotemporal component to be greatly improved, but will also have significance for informing drawdown zone habitat management decisions.

4.4 WPW6A and Airport Marsh

The CLBMON-30 Wildlife Physical Works project at site 6A was completed in the fall of 2013 (Figure 4-1). This project attempts to control erosion that occurs in spring when the flooded marsh and meadows discharge water towards the Columbia River. The continued erosion, would undoubtedly have large negative impacts to the Airport Marsh. This project is an important step towards the conservation of what we believe is one of the most significant habitat areas in the entire impounded part of the Canadian part of the Columbia River. But besides erosion, there are other conservation issues that should be made known.

CBA has been monitoring the Airport Marsh since project inception. Entirely unrelated to the construction at the 6A site, we noticed in 2013 (Year 6) that the Airport Marsh water level was unusually low during the summer. A similar situation was observed in 2010 (Year 3), and at that time, we suggested that the low water levels impacted the productivity of the Airport Marsh. Specifically, with the emergent vegetation being positioned in dry situations, there was a dramatic reduction in the density of nesting Yellow-headed Blackbirds (CBA 2011). In 2013, we observed a similar effect: the marsh was unusually low, and we did not find a single Yellow-headed Blackbird nest - the entire colony was missing.

What causes the water levels of the Airport Marsh to fluctuate?

In 2010, we speculated that valley bottom snowpack may have played a role, or that perhaps flows of water through the airstrip may have increased (CBA 2011). In 2010, we also noted that the Machete Ponds dried out (CBA 2011). In 2013, the Machete Ponds did not dry out; in fact, these interconnected ponds, which are fed by water from the Airport Marsh, had an unusually high water level all year. So it is possible that the Airport Marsh was low, partially due to water loss into the Machete Ponds. This passage of water, incidentally, would serve to increase erosion at the WPW6A site. Snowpack in the winter of 2012-2013 was relatively normal, so the snowpack hypothesis does not appear to be a satisfactory explanation in 2013.

Figure 4-1: Early phase of construction at Wildlife Physical Works site 6A, fall, 2013. The goal of this CLBWORKS-30 project was to prevent an eroding channel from extending towards the Airport Marsh, via the Machete Ponds. The Machete Ponds are seen in the upper left corner

It is obvious that there is no clear explanation that can be identified as to why the Airport Marsh water level fluctuates as much as it does among years (prior to reservoir inundation). We believe that a physical works project that prevents water from pouring into the Machete Ponds would enhance the WPW6A project by diminishing flows towards the eroding channel and help maintain water levels in the marsh. But we suggest that study of hydrology of this marsh is warranted.

The Airport Marsh falls within the City of Revelstoke boundary, and is regarded as an ecologically important area. The wetland owes its great productivity to its incidental enhancement caused by the creation of the Revelstoke Airport and specifically through upgrades made to the airport after 1968 (Figure 4-2). Currently, plans are developing to expand the airstrip, which would undoubtedly reduce very important riparian habitat at Machete Island. Conversely, airport expansion projects could potentially enhance the wetland water stability. We encourage discussions to negotiate minimizing impacts to riparian habitats, and perhaps using the airport expansion to strategically improve water stability in the Airport Marsh.

Figure 4-2: Aerial photos of the Airport Marsh through time (1968 through 1996)

4.5 Recommendations and Key Summary Points

- Additional mapping of habitat in Kinbasket Lake Reservoir is desirable.
- Nest mortality monitoring should target FO, RD, and unmapped habitats in Kinbasket Reservoir.
- Nest mortality monitoring should target SB and UC habitat in Arrow Lakes Reservoir.
- Radio telemetry should continue and focus on Savannah Sparrows in Canoe Reach, and Yellow Warblers in Revelstoke Reach
- Savannah Sparrow telemetry work should target birds at many sites above the drawdown zones and at many sites within the Kinbasket drawdown zone.
- Savannah Sparrows that may be subjected to flooding should be monitored using telemetry whenever possible.
- A long-term goal should be to improve the nesting model.
- Staff gauges should be installed in the Airport Marsh and monitored.
- Additional work to determine why the Airport Marsh water levels fluctuate would be likely be necessary if enhancing productivity in the Marsh is of interest.

4.6 Conclusions

We have not made any research conclusions at this stage of CLBMON 36.

5 ADDITIONAL REPORTING REQUIREMENTS

5.1 Banded Birds

Birds were banded in accordance with national permit regulations. Only focal species were targeted, although incidental captures of a few non-focal species did occur, so these birds were also banded. All data were entered into Bandit 2.01 software and were submitted to the Bird Banding Office of the Canadian Wildlife Service. No mortalities or injuries occurred.

5.2 Provincially- and SARA-listed Species

No listed species nests were located.

5.3 Species with Provincial Jurisdiction

All nest records were reported to the Ministry of Environment following the Wildlife Species Inventory standards.

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Appendix 6-1: Status of management objectives, questions and hypotheses

STATUS OF OBJECTIVES, MANAGEMENT QUESTIONS AND HYPOTHESES

Objective 1*	Management Questions (MQ)	Management Hypotheses	Year 6 Status Summary Points
Determine the use of riparian habitats by breeding birds in the drawdown zone and identify important breeding habitats used by migratory birds in the drawdown zones in the Kinbasket Reservoir and Revelstoke Reach.	a) Which bird species breed in the drawdown zones of the Kinbasket and Arrow Lakes Reservoir and where do they occur?	N/A	• This MQ has been addressed adequately. Additional rare or uncommon species will undoubtedly be observed with additional work, but the we believe that the regularly nesting species are well documented • Additional monitoring will improve knowledge of (1) birds nesting in uncommon habitat types, and (2) uncommon birds within habitat types, in addition to improving precision of density estimates. • Densities do appear to vary among years, so there is a benefit to monitoring for an extended period of time • Additional work can be done to summarize the data in new ways (e.g., elevational profiles for each species)
	b) What are the seasonal patterns of habitat use by birds nesting in the drawdown zone of the Kinbasket Reservoir and Revelstoke Reach?	N/A	• This MQ has essentially been addressed, with a phenology curve fit separately for each reservoir • We suggest that while additional data will improve precision, there is sufficient data at this stage; however, additional numerical work should be done to improve the accuracy of the phenology models (for example by building separate phenology curves for each habitat type).

Objective 2	Management Questions	Management Hypotheses	Year 6 Status Summary Points
Determine the effects of reservoir operations on the nest mortality, nest and site productivity and juvenile survival on birds breeding in the drawdown zones of the Kinbasket Reservoir and Revelstoke Reach.	c) Do reservoir operations directly affect nesting success (e.g. flooding of nests)?	H_{1B}: Nest mortality in the drawdown zone is not caused directly by nest inundation.	• This MQ has been addressed. • This MQ can be addressed simply by documenting one or more flooded nests in each reservoir. • In this report we detail empirical and modelled results of nest flooding impacts. • There are many ways in which the models can be improved (e.g., in precision), however, our initial validation suggests that the existing models are accurate and capable of serving their purpose. • We believe that the largest improvements would be had by completing the mapping of habitats in the drawdown zones - specifically in KIN, where the nesting model is clearly influenced by the patchy and unevenly distributed mapping
	d) What are the various factors (e.g. reservoir levels, predation, habit availability, etc) that influence nest mortality in the drawdown zone?	N/A	• This MQ has been addressed at some level, but the MQ lacks clarity • We review the main factors as a discussion point speaking broadly about the nesting community • We also review nest survivorship analyses conducted for focal species
	f) If reservoir operations negatively affect the nesting success, what is the significance of these impacts on regional bird populations?	H_{1A}: Nest mortality is no greater in the drawdown zone than above the drawdown zone.	• This has not yet been addressed • A model is being worked on currently for Yellow Warblers. Most work on this topic will be done over years 6 though10. • In the 2013 Year 1-5 interim report, we presented data suggesting that the Savannah Sparrow population in ALR has declined, which, when compared with their poor nesting success due to reservoir operations, may be the result of reservoir operations. • The hypothesis has been tested for one species - Cedar Waxwing. Currently there is a low chance of testing this hypothesis for additional species without greatly increasing monitoring effort to habitats above the drawdown zones
	g) Do reservoir operations affect juvenile survival and recruitment?	H_{2A}: Juvenile mortality is no greater in the drawdown zone than above the drawdown zone.	• This MQ has not yet been addressed, but the research is progressing nicely. • Telemetry work began in Year 5 and has continued in Year 6. • To date the results have indicated a very large potential for juveniles to drown; 6 out of 8 juvenile Yellow Warblers may have drowned after fledging in Year 5 - in one case, this was confirmed. • The success of this study will mostly likely depend on whether reservoir operations are variable: 2012 and 2013 had relatively aggressive filling operations. Some 'dry' years would be beneficial. • There are two issues that should be explored here to address MQ-G: (1) survivorship of juveniles on the whole including direct and indirect effects of reservoir operations (e.g., to test H_{2A} which could show a positive effect of being raised in the KIN drawdown zone, and (2) survivorship of juveniles faced with habitat flooding (direct impacts only). • The former can be examined with Savannah Sparrows, the latter with Yellow Warblers and potentially Savannah Sparrows.
	h) Can the operations of the Kinbasket and Arrow Reservoirs be optimized to improve nesting success, nest productivity, site productivity, or juvenile survival?	N/A	• It would appear that this MQ can be answered in theory. Yes, of course the operations can be optimized to improve productivity, although the low impact options (e.g. minimize water fluctuations as an extreme example) might not be feasible given operational constraints, but we are not qualified to work with those parameters. • We suggest that the MQ can be improved

Objective 3	Management Questions	Management Hypotheses	Year 6 Status Summary Points
Determine the effects of reservoir operations on the quality and availability of nesting habitat at the nest and landscape levels in the drawdown zones of the Kinbasket Reservoir and Revelstoke Reach.	e) Do reservoir operations affect nesting success by altering nesting habitat quality (e.g. vegetation characteristics, habitat configuration) of nest sites or the availability of nesting habitat at the landscape level?	H_{3A}: Reservoir operations do not result in a reduction in the quality or availability of nesting or recruitment habitat at the site and landscape level. H_{3B}: Nest mortality, site and net productivity, and juvenile survival are not associated with changes in habitat conditions (e.g. structure, vegetation composition and extent of habitat) or reservoir operations in the drawdown zone.	• Currently, this MQ is not addressed. • Addressing this MQ and the hypotheses is generally beyond the capability of this project (note challenges presented to CLBMON10 and CLBMON33) • Note anecdotal observations presented in the Year 1-5 Interim report • We suggest this question is best addressed via discussion using professional judgement, knowledge of nesting requirements learned in CLMBON36, and the weight of evidence and results from CLBMON10 and 33.

Objective 4	Management Questions	Management Hypotheses	Year 6 Status Summary Points
Inform and evaluate the effectiveness of physical works and revegetation efforts to enhance nesting success, nest and site productivity, or juvenile survival.	i) Provide recommendations for physical works projects and revegetation efforts to increase nesting success, nest and site productivity and juvenile survival in the Kinbasket Reservoir and Revelstoke Reach.	N/A	• This MQ is addressed in the discussion of this report. • We suggest: (1) revegetation in KIN (2) physical works in KIN if necessary to support 1 above (3) nest boxes for Mountain Bluebirds in KIN (4) floating nesting islands in ALR • We suggest that additional recommendations should be made following additional focussed research and analysis. It would be highly beneficial to determine at what elevation shrub growth should be encouraged in the ALR, and where it should be discouraged. It is clear that shrubs in the drawdown zone encourage nesting, but there was also evidence that shrubs may constitute an ecological trap for one or more species.
	j) Evaluate the effectiveness of revegetation efforts and physical works projects implemented during the course of this monitoring program for improving	H_{4A}: Revegetation or physical works do not increase the species diversity or abundance of birds nesting in the drawdown. H_{4B}: Revegetation or physical works are not effective at reducing nest mortality in the drawdown zone.* H_{4B}: Revegetation or physical works do not increase nest or site productivity in the drawdown zone.* H_{4C}: Revegetation or physical works do not increase the survival of juvenile birds in the drawdown zone. H_{4E}: Revegetation or physical works do not increase the amount of bird habitat in the drawdown zone.	• This MQ has not yet been addressed. • It seems relatively safe to assume that the cottonwood stakes will have increasing value for nesting over time. Consequently, a formal survey of all staked habitat would be most effective after the plantations have matured. This MQ is therefore best dealt with in the final 5 years of the study. • To date only one nest has been located in cottonwood stake treatments, so we are unable to ascertain what nesting success is like in these altered habitats. • To address the hypothesis, we can say without statistics that the species that nested in the stakes (Chipping Sparrow) would not have nested at that site without the cottonwood stake. Fundamentally, we can argue that the staking did increase species diversity. With additional observations, we may want to perform formal tests to quantify this notion. • We see no impediment to this MQ being well-addressed over the remainder of the project period.

* the duplicate numbering system is consistent with the BC Hydro terms of reference.

Appendix 6-2: Habitat classes / vegetation communities used in Kinbasket Reservoir and Revelstoke Reach

Vegetation communities within the Kinbasket Reservoir drawdown zone mapped by CLBMON 10 (Hawkes et al. 2010)

Code	Vegetation Community	Description
BR	Bluejoint Reedgrass	Above CH, often above KS
BS	Buckbean–Slender Sedge	Very poorly drained, wetland association
CH	Common Horsetail	Well drained, above LL or lower elevation on sandy, well-drained soil
CO	Clover–Oxeye Daisy	Well drained, typical just below shrub line and above KS
CT	Cottonwood – Trifolium	Imperfectly to well drained, above CO, below MC and LH
DR	Driftwood	Long, linear bands of driftwood, very little vegetation
FO	Forest	Any forested community
KS	Kellogg's Sedge	Imperfectly to moderately well drained, above CH
LH	Lodgepole Pine–Annual Hawksbeard	Well drained, above CT along forest edge, very dry site
LL	Lady's Thumb–Lamb's Quarter	Imperfectly to moderately well drained; the lowest vegetated elevations
MA	Marsh Cudweed–Annual Hairgrass	Imperfectly to moderately well drained; common in the Bush Arm area
MC	Mixed Conifer	Well drained, above CT along forest edge
RC	Reed Canarygrass	Imperfectly to moderately well drained; similar elevation to CO community
RD	Common Reed	*Phragmites australis*
SH	Swamp Horsetail	Poorly drained, wetland association
TP	Toad Rush–Pond Water-starwort	Imperfectly drained, above LL, wet sites
WB	Wool-grass–Pennsylvania Buttercup	Poorly drained, wetland association
WD	Wood Debris	Thick layers of wood debris, no vegetation
WS	Willow–Sedge wetland	Very poorly drained, wetland association

Vegetation communities within the Revelstoke Reach drawdown zone

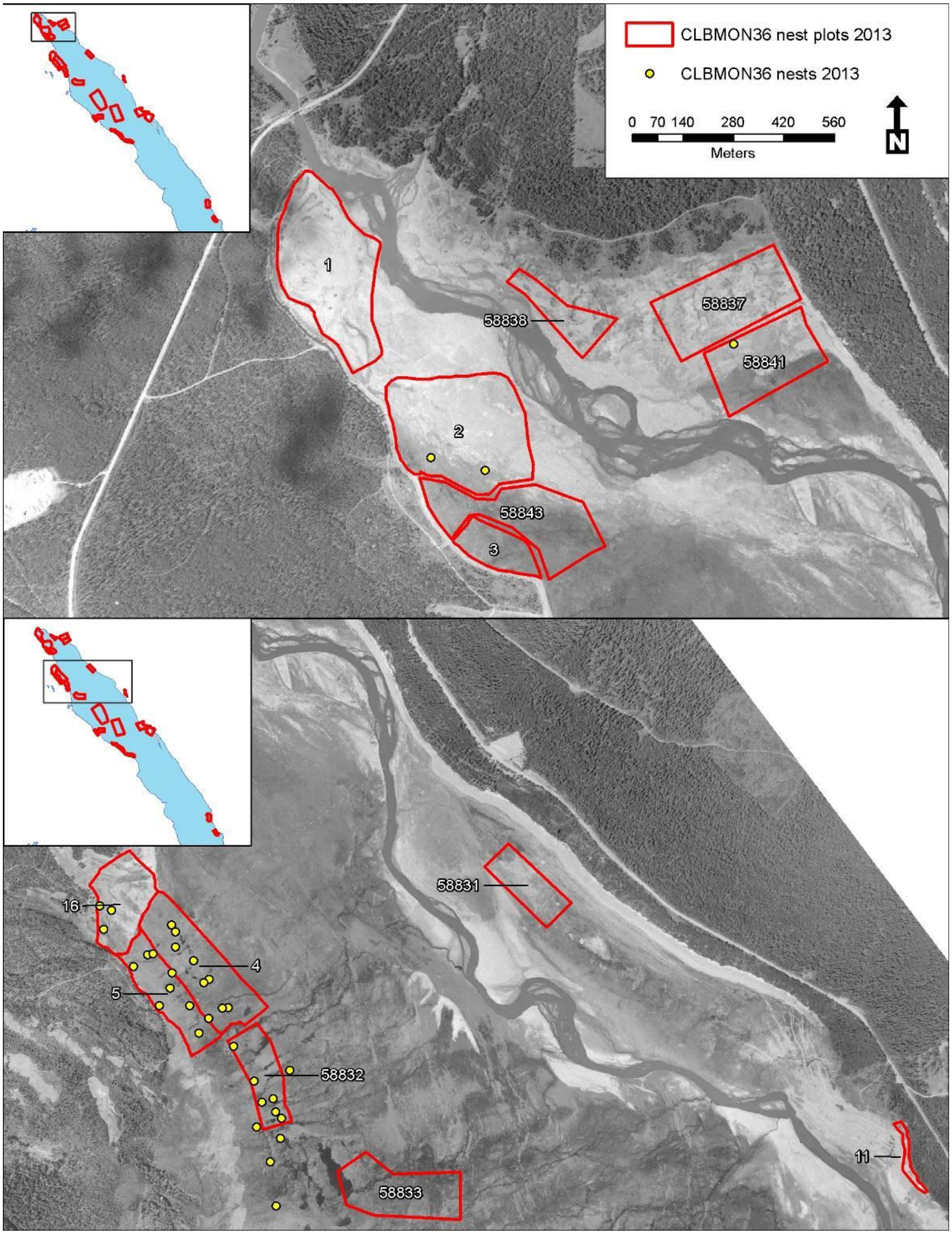
Code	Category	Description
RF	Riparian forest	Riparian forest with cottonwoods and shrubs, with variable conifer component
UC	Upland conifer	Conifer-dominated upland forest
UM	Upland mixed	Upland forests typically containing high amounts of birch and white pine
EG	Equisetum grassland	Horsetail-dominated grassland
MG	Mixed grassland	Grasslands with variable mixture of graminoids
PG	Sparse grassland	Grasslands with sparse/low graminoid cover
RC	Reed canarygrass	Grasslands dominated by well-developed reed canarygrass cover
SG	Sedge grassland	Sedge-dominated grassland
SH	Shrub savannah	Shrub-savannah
SR	Riparian shrub	Riparian shrub
BE	Steep bedrock	Bluffy steep banks comprised of bedrock slabs or cliffs. Variable vegetation and coarse woody debris
RB	Rocky bank	Steep banks comprised of boulders, talus, and loose rocks. Variable vegetation and coarse woody debris
SB	Sand bank	Sand banks - usually failing. Variable vegetation and coarse woody debris
TH	Thaliweg	Columbia River channel
CR	Coarse rocks	Coarse rocks, cobbles, boulders, etc.
GR	Gravel	Gravel, pebbles, etc.
SA	Sand	Sand
SI	Silt	Silt
UR	Urban	Residential, industrial, etc.
BF	Floating bog	Floating peat bog that provides island habitat
BR	Bulrush	Pond habitat with large stands or patches of bulrush
BS	Submerged buoyant bog	Peat bog that rises with water but becomes flooded
CK	Creek	Gravel/rocky creek channel or estuary
CT	Cattail	Cattail-dominated wetland
CW	Shrub wetland complex	Transitional, containing a mixture of wetland components, often with shrubs
LD	Low elevation draw	Muddy/clay depression or channel
PO	Pond	Open water pond habitat with variable amounts of submergent vegetation
SW	Swamp	High in the drawdown zone. Beaver ponds, skunk cabbage, alders, etc.
WM	Wet meadow	Sedge, grass, seasonally flooded area with depressions
WS	Water Sedge	Sedge-dominated marsh of fen

Appendix 6-3: Details of the CLBMON 36 nest mortality study sites

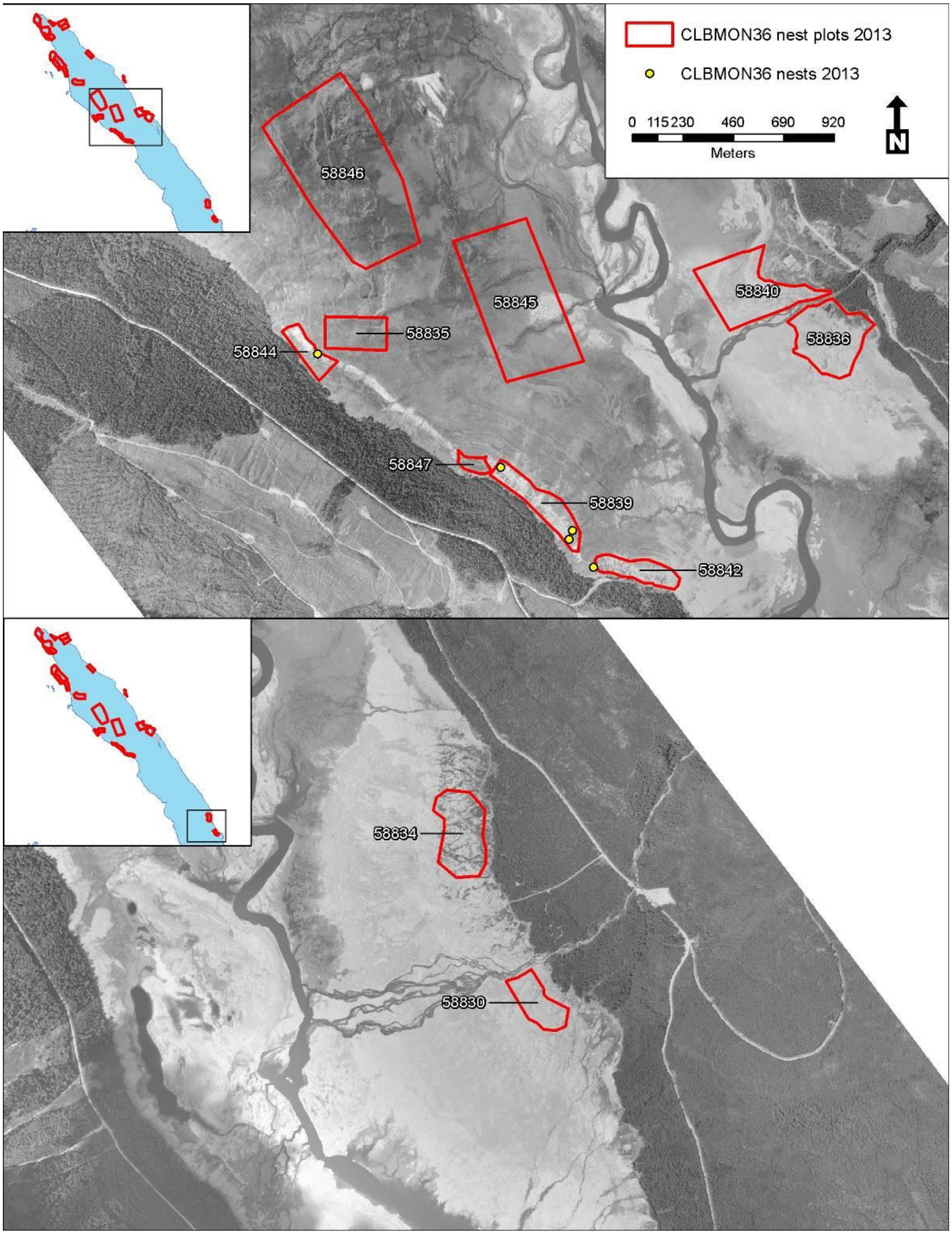
Site ID	Reservoir	Study Area	Area (ha)	No. of Nests	No. of Species	Nest Density
1	KIN	Canoe Reach	9.9	0	0	0
2	KIN	Canoe Reach	10.54	2	1	0.19
3	KIN	Canoe Reach	2.13	0	0	0
4	KIN	Canoe Reach	11.56	9	1	0.78
5	KIN	Canoe Reach	6.86	8	2	1.17
11	KIN	Canoe Reach	3.29	0	0	0
16	KIN	Canoe Reach	7.11	3	3	0.42
30	ALR	Revelstoke Reach	8.41	13	7	1.55
39	ALR	Revelstoke Reach	4.61	50	15	10.86
56371	ALR	Revelstoke Reach	1.36	10	5	7.35
56373	ALR	Revelstoke Reach	0.74	9	4	12.24
56374	ALR	Revelstoke Reach	0.75	1	1	1.34
56375	ALR	Revelstoke Reach	0.95	3	1	3.14
56376	ALR	Revelstoke Reach	1.02	2	2	1.96
56377	ALR	Revelstoke Reach	0.51	8	6	15.7
56378	ALR	Revelstoke Reach	0.99	7	3	7.05
56379	ALR	Revelstoke Reach	2.13	33	11	15.52
56380	ALR	Revelstoke Reach	0.44	1	1	2.29
56381	ALR	Revelstoke Reach	0.47	4	4	8.55
56382	ALR	Revelstoke Reach	1.04	5	5	4.79
56383	ALR	Revelstoke Reach	2.23	0	0	0
56386	ALR	Revelstoke Reach	4.97	0	0	0
56387	ALR	Revelstoke Reach	4.93	0	0	0
56389	ALR	Revelstoke Reach	0.94	0	0	0
56390	ALR	Revelstoke Reach	1.68	1	1	0.6
56392	ALR	Revelstoke Reach	1.33	0	0	0
56394	ALR	Revelstoke Reach	3.08	0	0	0
56395	ALR	Revelstoke Reach	2.24	16	7	7.15
56396	ALR	Revelstoke Reach	2.65	0	0	0
56397	ALR	Revelstoke Reach	3.4	0	0	0
56398	ALR	Revelstoke Reach	5.63	0	0	0
56399	ALR	Revelstoke Reach	0.88	0	0	0

56400	ALR	Revelstoke Reach	0.84	0	0	0
56401	ALR	Revelstoke Reach	1.39	2	2	1.44
56402	ALR	Revelstoke Reach	2.44	8	4	3.27
56403	ALR	Revelstoke Reach	1.22	9	5	7.41
56404	ALR	Revelstoke Reach	0.63	0	0	0
56405	ALR	Revelstoke Reach	0.46	0	0	0
56406	ALR	Revelstoke Reach	0.57	0	0	0
56407	ALR	Revelstoke Reach	1.34	15	5	11.18
56409	ALR	Revelstoke Reach	2.51	16	8	6.38
58830	KIN	Canoe Reach	3	0	0	0
58831	KIN	Canoe Reach	4.74	0	0	0
58832	KIN	Canoe Reach	5.26	10	1	1.9
58833	KIN	Canoe Reach	8.98	6	1	0.67
58834	KIN	Canoe Reach	5.71	0	0	0
58835	KIN	Canoe Reach	4.1	0	0	0
58836	KIN	Canoe Reach	8.62	0	0	0
58837	KIN	Canoe Reach	6.61	0	0	0
58838	KIN	Canoe Reach	2.29	0	0	0
58839	KIN	Canoe Reach	4.78	3	2	0.63
58840	KIN	Canoe Reach	10.24	0	0	0
58841	KIN	Canoe Reach	5.35	1	1	0.19
58842	KIN	Canoe Reach	3.2	1	1	0.31
58843	KIN	Canoe Reach	6.21	0	0	0
58844	KIN	Canoe Reach	2.24	1	1	0.45
58845	KIN	Canoe Reach	24.6	0	0	0
58846	KIN	Canoe Reach	33.51	0	0	0
58847	KIN	Canoe Reach	0.86	0	0	0

Appendix 6-4: Locations of study sites and the location of nests at Canoe Reach

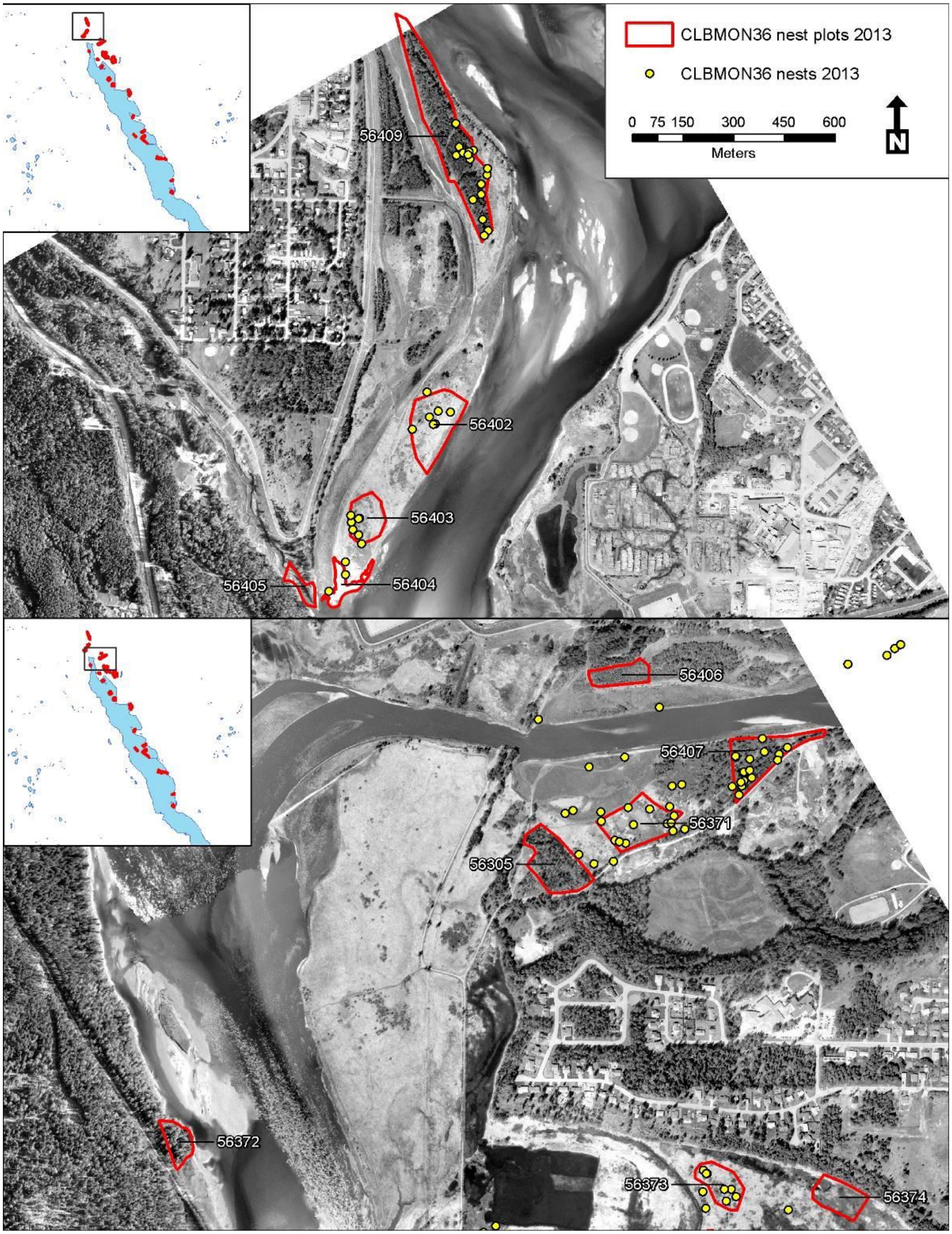


Northern Canoe Reach

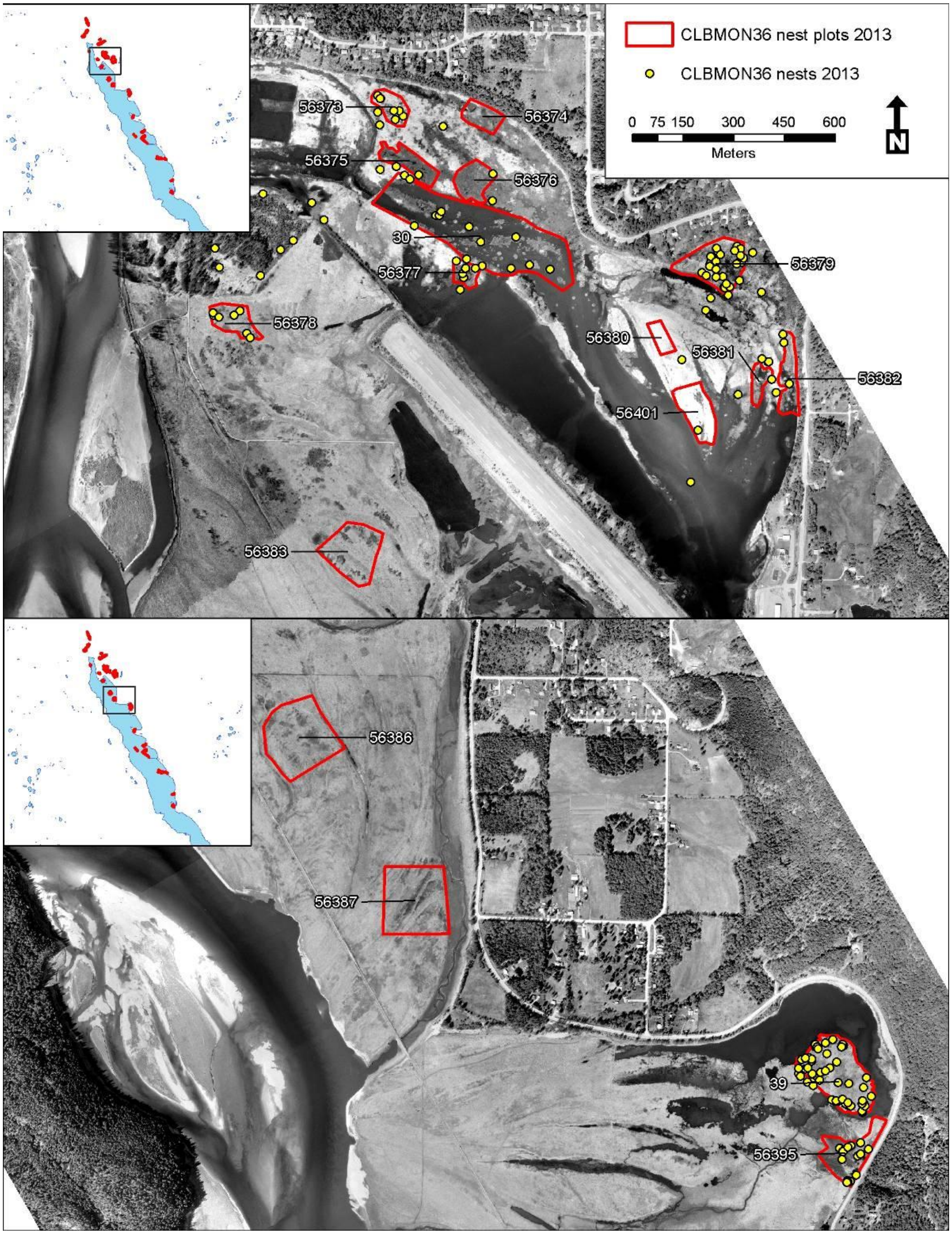


Southern Canoe Reach

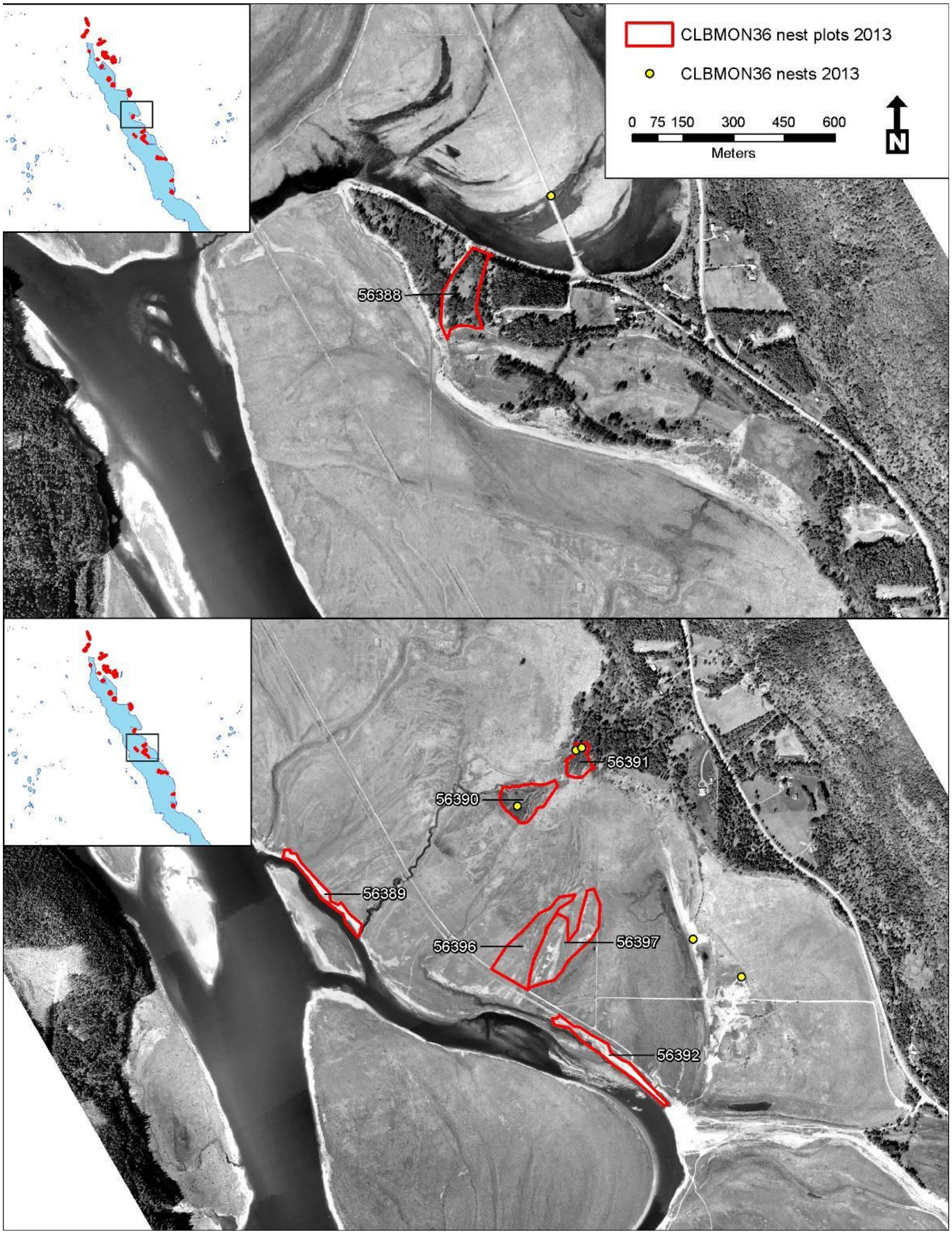
Appendix 6-5: Locations of study sites and nests at Revelstoke Reach



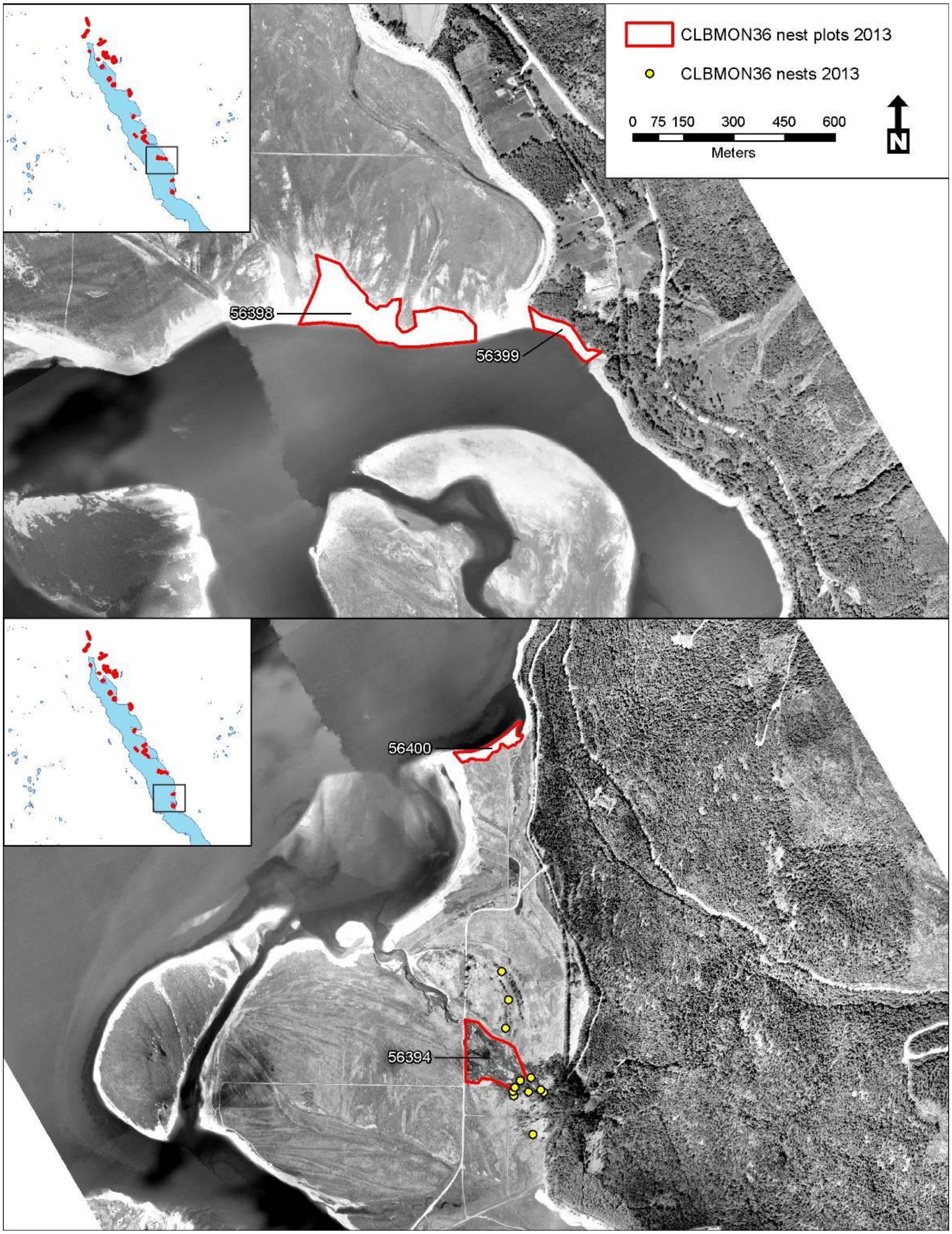
Northern Revelstoke Reach - West Side (top) and Illecillewaet/Airport Marsh (bottom)



Northern Revelstoke Reach. Airport Marsh (top). Montana Slough (bottom)



Revelstoke Reach - Cartier Bay (top), McKay Creek (bottom).



Revelstoke Reach. Greenslide (top); near 12 Mile (bottom).

Appendix 6-6: Nest mortalities due to reservoir operations (e.g., flooding) in 2013 in each study area (RR = Revelstoke Reach, CR = Canoe Reach)

Area	Nest ID	Nest Position	Species	Nest Elevation (m ASL)	Nest Height (m)
CR	62383	Ground	Savannah Sparrow	751.61	0.1
CR	62043	Ground	Savannah Sparrow	750.99	0
CR	61841	Ground	Savannah Sparrow	751.9	0
RR	60410	Ground	Common Loon*	436.12	0.2
RR	61579	Floating	Pied-billed Grebe*	438.86	0
RR	59195	Ground	American Wigeon	439.15	0
RR	59925	Ground	American Wigeon	439.22	0
RR	59044	Ground	American Wigeon	438.78	0
RR	59159	Ground	Mallard	438.23	0
RR	59938	Ground	Wilson's Snipe	438.33	0
RR	60077	Ground	Wilson's Snipe	438.26	0
RR	60135	Shrub	Willow Flycatcher	438.56	0.8
RR	60470	Shrub	Willow Flycatcher	438.27	1.5
RR	59387	Low in Shrub	Veery	438.82	0.2
RR	61981	Shrub	Gray Catbird	436.11	0.7
RR	59944	Shrub	Yellow Warbler	438.19	1.2
RR	59163	Shrub	Yellow Warbler	436.11	1.05
RR	65634	Shrub	Yellow Warbler	437.18	0.9
RR	65628	Shrub	Yellow Warbler	437.39	0.5
RR	59940	Low in Shrub	Common Yellowthroat	438.19	0
RR	59918	Low in Shrub	Common Yellowthroat	438.22	0.2
RR	59916	Low in Shrub	Common Yellowthroat	438.30	0.3
RR	58388	Low in Shrub	Chipping Sparrow	437.55	0.25
RR	59864	Low in Shrub	Song Sparrow	438.17	0.7
RR	59258	Low in Shrub	Red-winged Blackbird	438.33	0.4
RR	59052	Low in Shrub	Red-winged Blackbird	438.19	0.45
RR	62167	Low in Shrub	Red-winged Blackbird	438.19	0.45
RR	61287	Low in Shrub	Red-winged Blackbird	438.45	0.95

* these nests were not flooded, but were stranded away from the water's edge