Columbia Wetlands Marsh Bird Monitoring Project (CWMBMP)
Final Report

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Executive Summary

The Columbia Wetlands are the largest contiguous wetlands in North America, making them an important refuge for species which rely on wetlands for important stages of their life history. Marsh birds are dependent on wetland habitats with reports increasingly indicating that many marsh bird populations are in decline. Many marsh bird species are inconspicuous and challenging to detect, resulting in significant gaps in our understanding of their population status and how best to support them.

The Columbia Wetlands Marsh Bird Monitoring Project (CWMBMP) was a multi-year study designed to estimate marsh bird populations, assess the distribution of target species, and identify significant breeding areas or habitat types within the Columbia Wetlands. A standardized call-broadcast protocol was used to conduct point count surveys at stations throughout the Columbia Wetlands. These stations were surveyed multiple times during the breeding season and most stations were visited annually across the course of the study. Call-broadcast recordings were focused on five focal species of secretive marsh birds: American bittern (*Botaurus lentiginosus*), Virginia rail (*Rallus limicola*), sora (*Porzana carolina*), pied-billed grebe (*Podilymbus podiceps*), and American coot (*Fulica americana*). Visual and aural observations of all bird species present during a 15-minute survey were recorded. Additional habitat surveys, focusing on major habitat types and the vegetation community, were conducted annually at each survey station.

All five focal and most primary species were present in the Columbia Wetlands over the course of this study, including nine species considered to be at-risk either provincially and/or federally. Of these, four of the focal species and five primary species were observed with enough frequency to estimate their abundance within the Columbia Wetlands. The abundance estimates for pied-billed grebe in particular are significant in that they will be used to nominate the Columbia Wetlands as an 'Important Bird and Biodiversity Area'. CWMBMP results supported the existing literature proposing that a 'hemi-marsh' state (a well-interspersed 50:50 ratio of emergent vegetation and open water) is important habitat condition for many marsh bird species. Based on point count surveys, key areas with particularly abundant species richness and/or hosting at-risk species were identified, including Reflection Lake, Radium Mill Pond, and the wetlands surrounding Brisco. The data collected in this study is unique as it relates to elusive species identification and will continue to be influential in design of future projects in the Columbia Wetlands, including management recommendations, restoration projects, and outreach programming.

The CWMBMP has fostered relationships and developed partnerships with local organizations, community members, land-owners, and First Nations throughout this project. Volunteer opportunities have encouraged the interested public to increase their knowledge of wetland ecology and gain better understanding marsh bird conservation. These partnerships have to date created opportunities to further conservation efforts within the Columbia Wetlands, including the installation of breeding boxes, the Reflection Lake Restoration Project, and the involvement of private land-owners expressing interest in habitat improvements and restoration efforts private properties within the Columbia Wetlands.

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1.0 Introduction

1.1 Background

Most marsh bird species are difficult to detect due to their cryptic coloration and secretive behaviours. Since they are seldom seen, little is known about their population status. Information on status and population trends of marsh birds in the western mountain's region was identified as a gap in the final report of the Avian Monitoring Review (Avian Monitoring Review Steering Committee, 2012). From what is known, most marsh bird species populations are thought to be in decline. A recent report estimates that 2.9 billion birds of various species have disappeared in Canada and the United States since 1970 – a population decrease of 29 per cent (Rosenberg et al., 2019). In British Columbia, wetlands comprise about 5.28 million hectares (Government of BC, 2012), suggesting that this province is a significant site in reference to the important populations of these secretive marsh birds and their utilization of these unique habitats. There has been to date, however, minimal existent data to document this premise.

The Columbia Wetlands Marsh Bird Monitoring Project (CWMBMP) comprises a four-year project (2016-2019) collecting annual baseline data on marsh birds in the Columbia Wetlands during the breeding season. In collaboration with the Population Assessment Unit of the Canadian Wildlife Service (CWS), Goldeneye Ecological Services (GES) (a private company owned and operated by the principal author) initiated a pilot project in 2016. This pilot was called the CWMBMP and the chief goal was to address information deficiencies by conducting repeated surveys to collect inventory data on marsh bird species. Thirty-one survey stations were established in 2016 and in 2017 the project expanded to include 58 monitoring stations; 22 accessed by kayak. In 2018, one more survey route was added, and marsh bird data was collected at 65 survey stations for a total 191 marsh bird surveys in that year. Habitat surveys were conducted at all stations annually throughout all years. Starting in 2017, volunteer opportunities to participate with the principal author were introduced in marsh bird surveys to support community involvement – thereby increasing the spectrum of local teaching opportunities. In 2018, GES added a conservation component (landowner outreach) to the CWMBMP in the North Columbia sub-region, which is partially outlined in the CIJV Implementation Plan (Harrison et al., 2010).

As the availability of wetland habitat fluctuates yearly with weather conditions, marsh bird occupancy changes from year to year and accordingly, collection of data is necessarily required over multiple years to accommodate for differences in wetland availability. The final data acquisition took place in 2019 completing the four-year study with provision of a robust four-year baseline dataset.

1.2 Project objectives in 2019

It is critical to determine if the Columbia Wetlands provides ample habitat for marsh birds, ensuring that informed recommendations can be made to protect important bird habitat.

Goldeneye Ecological Services and other agencies/organizations face a knowledge deficit when determining where priority bird habitat areas are situated; including how to maintain, conserve or enhance them, without first gathering an initial baseline database. The 2019 project objectives were to: a) continue with the final year of baseline data acquisition at 65 survey stations; b) use resulting data to determine population estimates for the CWMBMP focal and primary birds; c) engage the public living in the North Columbia sub-region (a priority region for the FWCP) in bird conservation and volunteer opportunities; and d) provide recommendations to protect habitat for breeding marsh birds. Focal birds for this project were the American bittern (*Botaurus lentiginosus*), Virginia rail (*Rallus limicola*), sora (*Porzana carolina*), pied-billed grebe (*Podilymbus podiceps*), and American coot (*Fulica americana*).

1.3 Goals and objectives with project linkages to FWCP action plans

The CWMBMP matches the Fish and Wildlife Compensation Programs (FWCP's) three objectives including: 1) working to maintain and improve the integrity and productivity of marsh bird habitat, 2) improving opportunities for sustainable use, and 3) building on relationships with stakeholders (e.g. Regional Districts, Rod and Gun Clubs) and aboriginal communities (Ktunaxa, Akisqnuk Band; Metis Nation Columbia River). The CWMBMP additionally aligns with two FWCP Columbia Region priorities: 1) a project that involves implementation of riparian and wetland restoration and conservation activities, and 2) delivery of project objectives within the North Columbia District. The CWMBMP also provides important data which operates in concert with two FWCP action plans: the Riparian and Wetlands Action Plan (research and information acquisition, habitat-based actions, monitoring and evaluation) and the Species of Interest Action Plan (research and information acquisition).

It is expected that this completed four-year dataset will serve as a reference condition for birds in wetland and riparian areas in the Columbia Valley FWCP Focal Area — a Priority 1 Action in the Riparian and Wetlands Action Plan (Table 1, Action 5). For instance, by replicating the marsh bird survey protocol in future years and assessing changes in the baseline dataset; this will facilitate examination of how climate change (or other environmental impacts) is affecting the Columbia Wetlands environmental health. This project to date has collected significant data and has extrapolated statistically accurate population estimates — monitoring four-year trends of 46 FWCP Inventory Species and 6 FWCP Focal Species in wetland and riparian areas of the Columbia Wetlands. Data resulting from this project will assist in shaping and directing future conservation initiatives in the Columbia Wetlands ensuring that limited conservation dollars can be used most effectively.

2.0 Study Area

The Columbia Wetlands (51.593984; -116.282094) are located at the headwaters of the Columbia River, in the valley bottom within the Rocky Mountain Trench, situated between the Rocky Mountains and the Purcell Mountains in southeastern British Columbia. This area of study comprises a mosaic of wetlands and vegetation; marshes with associated emergent vegetation mixed with shallow water wetlands, river channels, deciduous shrubs, deciduous levees (alluvial banks) of the main river stem and its channels, and mixed forest types. This study area extends for 180 kilometers, from Canal Flats to Donald located near the southern end of the Kinkasket Reservoir, and covers more than 26,000 hectares (Pedology Consultants, Quadra Economic Consultants Ltd, Robinson Consulting & Associates Ltd., and Glen Smith Wildlife Resource Consultant Ltd., 1983). The CWMBMP survey stations are identified in Figure 1.

Several communities are located adjacent to the Columbia Mountains, including Canal Flats, Fairmont, Invermere, Radium, Brisco, Nicholson, and Golden. Approximately half of the Columbia Wetlands are found within the Regional District of East Kootenay (RDEK) Area's F and G, with the remaining half in the Columbia Shuswap Regional District (CSRD) Area A's jurisdiction. Approximately 60.1% of the Columbia Wetlands complex has been designated as the Columbia Wetlands Wildlife Management Area (WMA), managed by the British Columbia (BC) provincial government; the Ministry of Forest, Lands and Natural Resource Operations and Rural Development (MFLNRORD).

Additional private land parcels (5.6%) are conservation properties owned by The Nature Conservancy of Canada or The Nature Trust (TNT). These include four TNT properties managed by the Federal Government (Canadian Wildlife Service) as the Columbia National Wildlife Area. The study area additionally encompasses a significant amount of private land (at least 21.2%) including First Nation Reserve Lands (BC Hydro, 2014), with much of the private land located within the Agricultural Land Reserve. The study area includes one Class A Provincial Park in the Columbia Wetlands (Burges James Gadsden Provincial Park), locally known as Moberly Marsh. In 2005, the Columbia Wetlands were recognized as a RAMSAR site under the Ramsar Treaty; and as such is recognized as a wetland with international significance.

In July 2007, Environment Canada released a report entitled, "*The Conservation Rationale for Regulating the Use of Navigable Waters in British Columbia's Columbia Wetlands*." This document provided a strong rationale for developing boating regulations to protect the ecological values and wildlife within this internationally recognized wetland complex. After a series of public negotiations, federal regulations with two provisions with respect to the Columbia Wetlands came into effect on June 28, 2008, applying to the area from Fairmont Hot Springs in the south to Donald Station in the north, but not to Columbia Lake or Lake Windermere which are popular recreational destinations. The provisions were enacted by Transport Canada Marine Safety and Security and are described as follows in the Regulations Amending the Vessel Operation Restricting Regulations:

1. A prohibition on the operation of power-driven vessels and vessels driven by electrical propulsion in the wetlands of the Columbia River.
2. A prohibition on towing persons on water skis, surfboards, or other similar equipment in the main channel of the Columbia River, at any time.
An exception has been made for trappers holding a provincial licence who require access to the wetlands year-round and to the main channel during the seasonal closure. These persons operate small boats with small motors and their industry association is intensively aware of wildlife issues in the area. An exception has also been made for persons engaged in subsistence hunting and trapping (Department of Transport, 2009).

In 2016, the final provision of the three-part Transport Canada boating regulations came into effect. This regulation prohibits vessel operation on the main channel of the Columbia River, and its tributaries within the floodplain, to a motor with an engine power of 15 kilowatts or less (Department of Transport, 2016). The use of land-based motorized recreational vehicles is also prohibited in the Columbia Wetlands restricting travel in the wetlands to exclude any conveyance that has ten horsepower or more (Phase II Ventures, 2019).

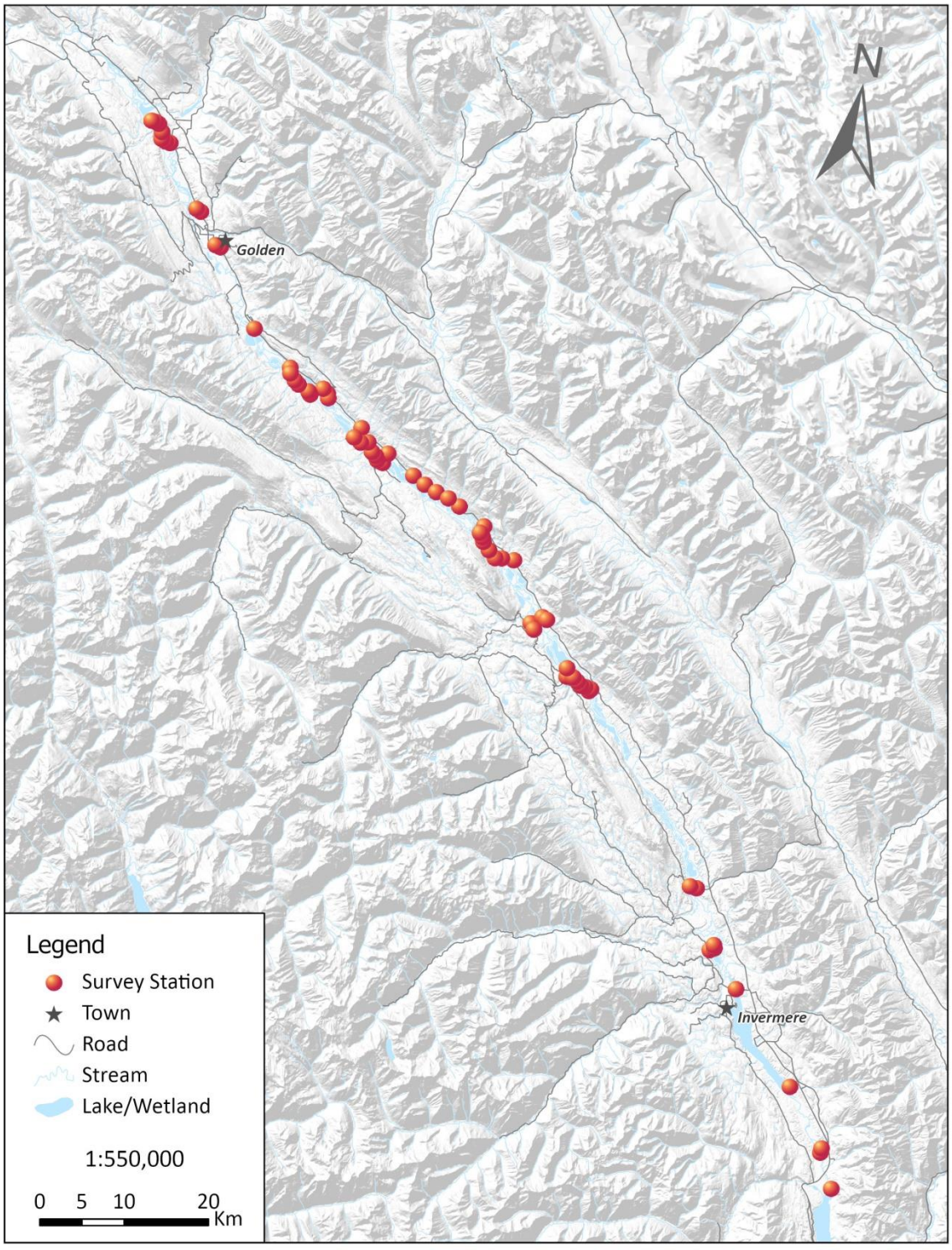

Figure 1. Map of the study area in the Columbia Wetlands, depicting the 65 survey stations in 2019.

3.0 Methods

3.1 Point Counts

The study identified and employed 65 survey stations located in the Columbia Wetlands to conduct marsh bird surveys using broadcast survey equipment to elicit detectable visual or audible responses in marsh bird species. Most of the survey stations and survey routes were established during previous years of survey effort (2016-2017), with addition of seven new stations in 2019 located in the Burges James Gadsden Provincial Park. The stations in the provincial park were created to collect baseline data on marsh birds predating any restoration activities that are anticipated to take place in the next few years (a proposed BC Parks led initiative). Additionally, five survey stations were removed in 2019; these were located at higher elevation lakes and used during 2016-2018 study years (Darvill & Westphal, 2019). Stations were selected at a variety of locations within the Columbia Wetlands designed to represent the diversity of habitat types identified in the wetlands landscape. Survey routes were determined in previous years and planned used Google Earth Pro (Version 7.3.0.3832). To avoid double counting of birds, survey stations along a route were located at least 500 meters apart.

To conduct marsh bird surveys, the study used the standardized protocol as described in the Prairie and Parkland Marsh Monitoring Program Manual developed by Bird Studies Canada (BSC) (2010). Each survey was conducted in the morning by one primary observer per station, often accompanied by a volunteer. The surveys began no earlier than 30 minutes before sunrise and ended no later than 10:00 am on each survey date (BSC, 2010). Each station was visited three times during the 2019 breeding season (May 14-June 30th) with one exception (Beaver Lk 2 was visited two times), for a total of 193 marsh bird surveys. Surveys were conducted only when weather conditions were favorable, e.g. no precipitation, minimal wind, good visibility. If weather conditions were unfavourable, or turned unfavorable partway through a survey route, the remaining surveys were postponed and conducted on an alternate day. Appendix 1 lists the GPS coordinates for each survey station, as well as the survey dates from each station.

To improve upon visual observation as a sole identification technique, it has previously been documented that elusive marsh bird species are more effectively detected using equipment to broadcast bird calls (Conway, 2011). Gibbs and Melvin (1993) found detection of sora improved by nearly 600% when using broadcast calls rather than passive listening alone. The study employed a combination of both call-broadcast and passive listening to detect marsh birds, to enhance marsh bird detection probability (Conway & Nadeau, 2010).

In this study protocol, a primary observer stood at a central location and used a 5-minute silent/listening period, followed by a 5-minute period during which calls of selected focal species [sora, Virginia rail, American bittern, American coot, pied-billed grebe] were played using broadcast equipment (FoxPro Firestorm). This was followed by another 5-minute silent/listening period. During the 15-minute survey, observations (visual and/or aural) of all bird species detected within

a 100-meter radius were recorded. Observed birds were recorded under one of four categories: focal species, primary species, secondary species, and additional species (Darvill & Westphal, 2019) (Appendix 1).

Focal species were monitored minute-by-minute during the 5-minute listening period; whereas all additional bird species present were recorded, but not followed minute-by-minute. Observations of birds beyond the 100-meter radius were identified and recorded in the study as occurring outside of the focal area. If a secondary species was identified beyond 100 meters, it was indicated as present at the station, but the number of individuals was not recorded. For all 'additional species' observed during surveys, presence was indicated (both male and females), but those individuals were not counted, — the exception being red-winged blackbird (*Agelaius phoeniceus*) and yellow-headed blackbird (*Xanthocephalus xanthocephalus*). For both red-winged and yellow-headed blackbirds, only males were recorded since these species are polygamous and there are often too many females to track with accuracy (BSC, 2010).

3.2 Habitat monitoring

The habitat monitoring protocol utilized was recommended and provided by Environment and Climate Change Canada's Canadian Wildlife Service (NAMBMP, 2009). To minimize disturbance to breeding marsh birds ensuring that marsh bird data would not be compromised, habitat monitoring was conducted at each survey station only after the final of three point counts concluded. Due to unforeseen circumstances, the only station that did not undergo habitat monitoring in 2019 was Parson–Beaver Lk 3.

Using the previously described habitat monitoring protocol, we recorded the percent of major wetlands habitats within 100 meters of the focal point. Major wetland habitats studied included herbaceous emergent vegetation cover; large patches of open water/floating plants, exposed mud/sand/rock, trees, and shrubs. If floating plants were present, the percent of open water covered by floating plants was estimated and floating plant species were identified. Of the total percent of emergent vegetation cover, the percent of each dominant species contribution was estimated; however, only species contributing 10% or more of the total emergent vegetation cover were considered dominant. All CWMBMP data was entered into an excel database required under contract by the Canadian Wildlife Service; and additionally, transcribed into the Species Inventory (SPI) provincial central repository, available online.

3.3 Volunteer recruitment, outreach and nest boxes

In the recruitment of volunteers, an advertisement was placed in the Wings Over the Rockies Festival Guide (Appendix 2). The principal author used social media and partnering stakeholders (e.g. Columbia Wetlands Stewardship Partners) to spread messaging regarding volunteer opportunities to assist a biologist in the field during marsh bird surveys. Community engagement (presentations), volunteer opportunities, and landowner outreach mainly took place within the

FWCP priority North Columbia sub-region (i.e., Golden and surrounding area), expanding educational engagement opportunities with interest groups in that priority region. Nest boxes designed for cavity nesting waterfowl were built by students from Golden Senior Secondary students and provided to GES by the Golden Rod and Gun Club. Goldeneye Ecological Services purchased cedar posts and attached the nest boxes to these posts; metal flashing was cut to size and attached to the post in a cylindrical shape to act as a predator guard. The offering and distribution of installed nest boxes was made to several landowners in the North Columbia and Upper Columbia Valley via emails and word of mouth.

3.4 Forming abundance estimates using 2016-2019 CWMBMP data

To estimate species abundance there are two main requirements: knowledge of 1) the area being estimated, and 2) the density of the population of interest. Pedology Consultants et al. (1983) published detailed habitat assessments of the Columbia Wetlands which allowed the authors to address the first requirement. Pedology Consultants et al. (1983) concluded that approximately 9,220 hectares of marsh habitat, flooded periodically or year-round, was present in the Columbia Wetlands at the time of publication. To our knowledge, these are the most up-to-date habitat assessments available with this level of detail.

Given the amount of time that has elapsed since the publication of these habitat assessments, there have been changes in wetland area within sections of the Columbia Wetlands (see Carli & Bayley, 2015). While acknowledging the chance of error using these dated habitat assessments (as it relates to the undocumented progressive changes in marsh habitat with time or differences due to the expected annual changes to marsh area within the Columbia Wetlands), we believe that any changes to marsh area that have occurred are likely to be minimal and inconsequential for our estimates when considered over the scale of the Columbia Wetlands.

The second objective of this current study was to address the requirement of estimating population density. When a species is detected during a survey, two conditions have been met: 1) the species was present, and 2) the species was detected. Not detecting a species can indicate one of two scenarios: 1) the species was not present, frequently termed a “true zero”, or 2) the species was present during the survey but was simply not detected, a “false zero”. The secretive nature of the target species makes them inherently difficult to accurately detect. An important consideration in this study relates to the increased risk of accumulating “false zeros” and underestimating species density. To address this risk factor, the call-back methods used significantly increase the accuracy of surveys (Gibbs & Melvin, 1993; Conway & Nadeau, 2010; Conway, 2011).

Distance sampling methods can account for remaining imperfect observation error (i.e., the accumulation of “false zeroes”) when producing estimates. Distance sampling methodology requires an observer to estimate the distance between themselves and the species of interest during a survey. Models can be produced relating this distance to the probability of detecting the species with refinements incorporating additional variables (habitat characteristics) enhancing this

observation probability and thereby assisting in estimation of the true species density at each survey station.

It is important to note that not all observations of focal and primary species were included in calculating species density and abundance. To maintain consistent survey effort across all visits, only observations which occurred within the 15-minute survey window were included in estimating abundance. In a few rare instances, observations were not included because the distance between the observer and the bird was not recorded during the survey. These observations are, however, included in the total observations in each season.

Additional data collected at two small sub-groups of survey stations were as well not included as we concluded that the data would not contribute meaningfully to our analyses. The first group included five higher elevation lake stations located between 939 and 1,295 meters. These stations represent elevations reasonably different from survey stations within the Columbia Wetlands. The second group included seven stations within the Burges James Gadsden Provincial Park which were only surveyed in 2019. This provincial park has been heavily influenced by anthropogenic factors (i.e., diking, agricultural infilling, etc.). Given the extensive impacts to this area, we concluded that these stations would not be representative of the Columbia Wetlands and did not include them in estimating abundance.

Abundance estimates of focal and primary species were calculated using 2016-2019 CWMBMP data and the Distance Windows package, version 7.3 (Thomas et al., 2010). Data for each species were tabulated in Excel spreadsheets containing station names, survey effort, year, date of each survey, observations, and habitat variables. These spreadsheets were converted to tab-delimited text files and loaded into Distance for analysis. As recorded during surveys, observations were defined as binned distances in three categories: 0-50 meters, 50-100 meters, and 100-300 meters. Buckland et al., (2001) provide detailed background for Distance sampling theory and modelling methodology. Following their recommended approach, we first selected a key function followed by a series expansion (Buckland et al., 2001). In most cases, models using the key function "Half-normal" outperformed those using "Hazard-rate" or "Uniform". "Half-normal" models performed best with the "cosine" series expansion. For species which had fewer than 30 observations per season, models using the "Uniform" function tended to perform best. In instances where 10 or fewer individuals were detected in a season, models tended to fail or produce unreliable estimates which are not included in this report. Habitat variables were incorporated as co-variates to explore more complex models and increase the accuracy of our estimates. Once a full set of models were run, maximum likelihood methods using the Akaike Information Criterion (AIC and AICc, which is the AIC corrected for small sample sizes) were used to assess model fit (Buckland et al., 2001). AIC and AICc assess how much information is gained or lost by a model and estimates the quality of each model relative to others in the set. Abundance is essentially calculated by multiplying species density by area. The final models provide a means of estimating density by relating the probability of detecting a bird at monitored survey stations to the distance from the observer and taking into consideration the influence of habitat/temporal variables (e.g. % open water, % emergent vegetation) at each station. This density can then be extrapolated over the entire available marsh

habitat within the Columbia Wetlands to estimate the abundance of marsh bird species present. To produce the final abundance estimates, model-averaged estimates were calculated using the Akaike weight of each model. The Akaike weight provides the relative likelihood of a given model in a set of models being correct and can be used to produce a weighted average for each parameter.

A range of habitat and temporal variables were collected to better examine habitat selection by breeding marsh bird species. Based on local expertise and a literature review, a set of habitat and temporal variables were selected to be incorporated into the Distance models. These variables were used to see if they improved model quality and the accuracy of abundance estimates. Seasonal timing, including species arrival at its breeding area, is frequently considered in the literature but its importance and effects vary between species (Harms & Dinmore, 2014; Tozer, Drake, & Falconer, 2016). The probability of observation may be higher earlier in the season for some species, such as sora, versus later in the season for others, such as Virginia rail (Tozer et al., 2016). We used both fine- and coarse-scale measurements to explore the potential relationship between seasonal timing and abundance. We used "day since 1 May" (e.g. a survey on 10 May would be day 10) as a fine-scale measure allowing us to consider day-by-day differences of when observations take place. At a coarser-scale, "visit" (i.e., visit 1, 2, or 3) considers the breeding season divided into three, broad time windows, which may be more appropriate for species less sensitive to seasonal timing.

Woody vegetation (i.e., trees and shrubs) can be negatively correlated with the presence and/or abundance of some marsh bird species (Bolenbaugh, Krementz, & Lehnen, 2011; Nielson, 2016). This negative relationship may be due to an increased risk of predators being present (Naugle, Higgins & Nusser, 1999; Darrah & Krementz, 2010) or perhaps reflect reduced nesting and/or foraging areas with increased woody vegetation growth. Marsh bird presence is often correlated with emergent vegetation cover (Bolenbaugh et al., 2011; Fairbairn & Dinsmore, 2001; Lor & Malecki, 2006; Baschuk, Koper, Wrubleski, & Goldsborough, 2012), which frequently provides nesting material, protective cover, and/or food sources. Two variables were considered separately for emergent vegetation: 1) total percent cover of emergent vegetation and 2) percent cover of "tall vegetation", i.e., cattails (*Typha* spp.) and rushes (*Juncus/Scirpus* spp.) specifically. Cattail and rush stems tend to persist overwinter and are commonly used nesting materials for marsh birds (Lor & Malecki, 2006). Open water is also an important variable to consider, especially for American coot and pied-billed grebe as both species build floating nests (Gorenzel, Ryder, & Braun, 1982; Forbes, Barkhouse, & Smith, 1989) and feed at least in part by diving for submerged food. Elevation of the survey station was also considered. Survey stations ranged in elevation from 781-815 meters. A correlation matrix between all pairs of habitat variables was created to ensure highly correlated (r >0.7) variables were not considered within the same model. Variables which were "nested" within one another or closely related measures, such as "tall vegetation" within "emergent vegetation", were not considered within the same model.

4.0 Results and Outcomes

4.1 Distribution of focal and primary marsh bird species in the Columbia Wetlands

All five focal species were detected in each study year (Figure 2). Across study years, sora was the most frequently detected focal species and American bittern was the least frequently detected. When compared to the data collected in 2017 and 2018, the sora detections in 2019 increased, pied-billed grebe numbers decreased, American bittern and Virginia rail stayed relatively stable, and the number of American coot detected also increased (Figure 2). Each year, the most frequently detected primary species was red-winged blackbird. Most primary birds were detected across all study years, apart from Brewer's blackbird (*Euphagus cyanocephalus*) which was detected in 2016 only; eared grebe (*Podiceps nigricollis*) detected in all years other than 2017; and horned grebe (*Podiceps auritus*) detected only during 2019. The rusty blackbird (*Euphagus carolinus*) was the only primary species not detected during any study year, even though this species has been known to occupy the Columbia Wetlands. The rusty blackbird is an at-risk species. It is a blue-listed species provincially and is listed as a Species of Special Concern under the Species at Risk Act; it has been subject to a population crash of up to 85% since the mid-1960's (Nature Canada, n.d.).

Of all bird species encountered during surveys, yellow warbler (*Setophaga petechia*) was detected at the highest number of survey stations (61 of 65 survey stations) in 2019 (Table 1). Whereas song sparrow (*Melospiza melodia*) was detected at the highest number of survey stations (58 of 65 stations surveyed) in 2018 (Darvill & Westphal, 2019); yet song sparrow was not one of the top 10 species detected in 2019. The species detected at the second highest number of survey stations in 2019 were Canada goose (*Branta canadensis*) and red-winged blackbird, both detected at 59 of 65 stations respectively (Table 1). The red-winged blackbird and Canada goose are not focal, primary, or secondary species of the project, but they are 'additional species'. Nine bird species considered to be at-risk (through provincial and/or federal listings) were detected in 2019 and are listed in Table 2.

In 2019, the survey stations with the highest species richness were: Fairmont 2, Warner's Slough, Radium Mill Pond 1, and Harrogate-Castledale 1 (Table 3). Also, there were five survey stations (i.e., Spilli 1km S, Beaver Lk 2, Parson xing East, Reflection Lake, Reflection Lake 2) where four of the five focal marsh bird species were detected during at least one of the three site visits (Table 3). At each of those five stations, there were also three to four primary birds detected; these stations had varying degrees of bird species richness (21 to 32 bird species). These five sites had habitat attributes with varying percentages of emergent herbaceous vegetation (30%-85%) and open water patches (10%-60%). All of these five stations had some percentage of cattail in the total amount of emergent herbaceous vegetation present, from 30% to 85%.

Habitat surveys determined that 18 of 65 survey stations had no cattail present; but other species of emergent herbaceous vegetation were present (complete habitat assessments are found in Appendix 3). At these 18 stations, there were none or one focal bird species detected within the focal area (100 m). However, there were higher indices of species richness detected at some of the

stations presenting no emergent cattail (e.g. 41 bird species at Fairmont 2; 37 bird species at Harrogate-Castledale 3) when compared to sites that had cattail present along focal and higher numbers of primary marsh birds (e.g. 21 bird species at Reflection Lake; 22 bird species at Parson xing East). Species richness at these stations was mainly due to passerines such as flycatcher spp., vireo spp., swallow spp., warbler spp., and sparrow spp.

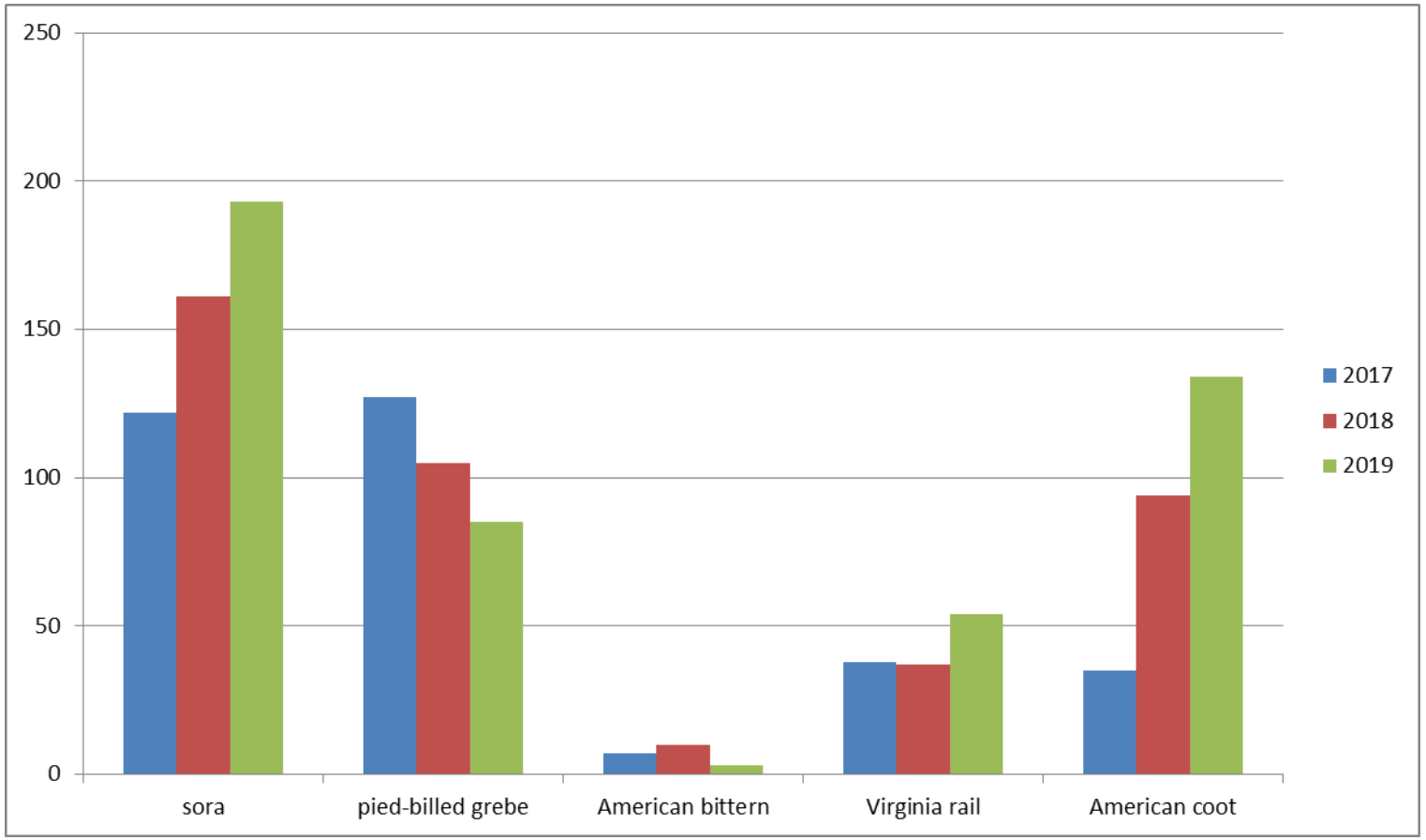

Figure 2. A comparison showing the number of times that focal marsh bird species were observed during repeated marsh bird surveys in 2017, 2018, and 2019. Note: there was 174 point counts conducted at 61 survey stations in 2017, whereas 191 point counts were conducted at 65 survey stations in 2018; and 193 point counts at 65 survey stations in 2019. The pilot year of 2016 is not included for comparison due to lower survey effort.

Table 1. Listing of the top 10 bird species that were observed at the highest number of survey stations.

Species common name	No. of stations species was detected (out of possible 65)
yellow warbler	61
Canada goose	59
red-winged blackbird	59
willow flycatcher	57
tree swallow	56
mallard	53
common yellowthroat	52
brown-headed cowbird	51
American crow	48

Table 2. At-risk bird species observed during the 2019 CWMBMP, including the number of survey stations where each species was observed.

At-risk species detected	No. of stations detected (out of possible 65)
great blue heron	22
barn swallow	11
bank swallow	5
black swift	3
American bittern	2
horned grebe	1
eared grebe	1
double-crested cormorant	1
Lewis's woodpecker	1

Table 3. Survey stations indicating important habitat attributes and distribution of focal and primary birds across stations.

	Station Name	% large patches of open water	% emergent vegetation cover	% of cattail in total emergent vegetation	Focal Species Detected					Primary Species Detected	# of bird species detected
					American Bittern	American coot	pied-billed grebe	sora	Virginia rail		
1	Spilli xing west	20	75	95					X	RWBL, WISN	31
2	Spilli xing east	35	40	45				X		MAWR, RWBL	30
3	Stewart's Slough	30	60	60		X		X	X	MAWR, RWBL , WISN	28
4	Warner's Slough	30	60	5				X[1]		RWBL[1], WISN[1], YHBL	**40***
5	Brisco xing 2	20	30	0				X[1]		RWBL[1], WISN[1], YHBL[1]	31
6	Brisco xing	40	45	40	X		X	X		MAWR, RWBL, WISN, YHBL[1]	26
7**	Spilli 1km S	60	30	100		X	X	X	X	MAWR, RWBL[1], YHBL[1]	31
8	Beaver Lk 1	25	65	60		X	X	X		MAWR, RWBL, WISN, YHBL	29
9**	Beaver Lk 2	35	45	40		X	X	X	X	MAWR, RWBL, WISN, YHBL[1]	30
10	Parson xing West	15	55	15			X[1]	X		MAWR, RWBL[1], WISN, YHBL[1]	33
11**	Parson xing East	10	85	60		X	X	X	X	MAWR, RWBL, YHBL	22
12	Imler Rd	25	30	20			X	X		MAWR[1], RWBL, WISN	36
13	McMurdo South	5	60	45				X		MAWR, RWBL, WISN, YHBL[1]	32
14	Birchlands	5	80	15				X	X	MAWR, RWBL[1], WISN, YHBL[1]	33
15	9 Mile Slough	10	90	60				X	X	MAWR, RWBL, WISN[1], YHBL	29
16**	Reflection Lake	20	70	90		X	X	X	X	EAGR[1], MAWR, RWBL, YHBL	21
17**	Reflection Lake 2	40	40	80		X	X	X	X	EAGR, MAWR, RWBL, YHBL[1]	32
18	Edelweiss 1	13	70	50			X[1]	X		MAWR, RWBL, WISN[1], YHBL	27
19	Edelweiss 2	0	60	50		X		X		MAWR, RWBL, YHBL	24
20	Davidson	20	60	35			X	X	X	MAWR, RWBL, WISN[1], YHBL	23
21	Beards Creek Rd N	80	20	95		X	X	X[1]		MAWR, RNGR, RWBL, YHBL[1]	22
22	Castledale North	60	35	10		X	X	X[1]		RWBL, YHBL	20
23	Beards Creek Rd S	75	15	90			X	X[1]	X	MAWR, RWBL, YHBL, WISN[1]	25
24	Castledale Rest Area	90	5	90		X	X[1]			RNGR, RWBL, YHBL, WISN	26
25	McKeeman's	80	10	0		X	X[1]			MAWR, RWBL, YHBL	33
26	Salsbury Rd N	10	80	20		X[1]	X	X	X	MAWR, RWBL, YHBL, WISN[1]	28
27	Old Barns Slough	0	80	25		X	X[1]		X[1]	MAWR[1], RNGR[1], RWBL, YHBL[1]	35
28	Radium Mill Pond 1	80	15	90		X[1]	X	X	X[1]	MAWR, RNGR[1], RWBL, YHBL[1]	**39***
29	Radium Mill Pond 2	30	45	85			X[1]	X		HOGR[1], MAWR, RWBL, YHBL, WISN[1]	36
30	Wilmer 1	25	70	20		X[1]	X	X		RNGR, RWBL, YHBL	19
31	Wilmer 2	80	10	0				X[1]		MAWR[1], RNGR[1], RWBL[1], YHBL[1], WISN[1]	**37***
32	Wilmer 3	5	75	80			X[1]	X[1]		MAWR, RWBL, WISN	31
33	Brisco-Spilli 1	20	65	70				X[1]	X	MAWR, RWBL[1]	33
34	Brisco-Spilli 2	30	50	20		X[1]		X		MAWR, RWBL[1], WISN[1]	32
35	Brisco-Spilli 3	45	35	10	X[1]			X[1]		MAWR[1], RWBL[1], WISN[1]	35
36	Brisco-Spilli 4	20	60	10				X[1]		RWBL[1], WISN[1]	30
37	Brisco-Spilli 5	55	30	0						WISN[1]	26
38	Harrogate-Castledale 1	50	35	35			X[1]			MAWR[1], RWBL[1]	**39***
39	Harrogate-Castledale 2	50	30	0			X[1]			WISN[1]	28
40	Harrogate-Castledale 3	0	65	0				X		MAWR, RWBL[1], WISN[1]	**37***
41	Harrogate-Castledale 4	60	30	0				X[1]		RWBL[1]	28
42	Harrogate-Castledale 5	50	40	0				X[1]		RWBL[1], WISN[1]	27
43	Harrogate-Castledale 6	55	20	0						RWBL[1], YHBL[1]	31
44	Parson - Beaver Lk 1	55	35	0			X[1]	X	X[1]	RWBL[1], WISN[1], YHBL[1]	36
45	Parson - Beaver Lk 2	25	70	25			X[1]	X	X	MAWR, RWBL[1], WISN	**38***
46	Parson - Beaver Lk 3	n/a	n/a	n/a						MAWR[1], RWBL[1], WISN	21
47	Parson - Beaver Lk 4	55	25	0			X			MAWR, RWBL[1], YHBL[1], WISN	33
48	Parson - Beaver Lk 5	20	45	0				X		MAWR, RWBL, WISN	35
49	North Parson 2	75	10	0						RWBL, WISN	33
50	North Parson 3	30	35	50				X		MAWR, RWBL, WISN	33
51	North Parson 4	65	25	10						WISN	36
52	North Parson 5	45	35	10				X		RWBL[1], WISN	35
53	North Parson 7	35	45	40				X	X	MAWR, RWBL, YHBL, WISN[1]	**38***
54	Athalmer	0	98	65				X	X	MAWR[1], RWBL, WISN[1]	26
55	SE Lake Windemere	80	15	95			X[1]			MAWR[1], RNGR, RWBL, YHBL[1]	32
56	Fairmont	15	75	0				X[1]		RWBL[1], WISN[1]	35
57	Fairmont 2	30	40	0				X		RWBL, WISN[1]	**41***
58	Columbia Lk N	5	85	95						RWBL, WISN	22
59	Moberly Marsh 1	0	80	20						MAWR[1]	24
60	Moberly Marsh 2	5	55	35						MAWR[1], RWBL[1]	28
61	Moberly Marsh 3	0	85	0							29
62	Moberly Marsh 4	5	80	0						RWBL[1]	32
63	Moberly Marsh 5	25	55	60			X[1]	X	X	MAWR, RWBL, YHBL[1], WISN	36
64	Moberly Marsh 6	30	60	90			X[1]			RWBL, YHBL[1], WISN	**37***
65	Moberly Marsh 7	35	20	0						WISN	32

Note: [1] indicates the bird was detected outside focal area (>100m). Also, * indicates the surveys stations with highest bird species richness in 2019. ** indicates the survey stations that detected four focal species. EAGR= eared grebe, MAWR= marsh wren, HOGR= horned grebe, RNGR=red-necked grebe, RWBL=red-winged blackbird, YHBL=yellow-headed blackbird, WISN= Wilson's snipe.

4.2 Abundance estimates from 2016-2019 data

As stated previously, certain conditions need to be met for observations to be included in estimating species abundance. To standardize survey effort, observations which occurred immediately before or after the 15-minute survey window were not included in estimating abundance. These observations are included in the total observations for focal birds from 2017-2019, as described above (Figure 2). Abundance estimates were formed as a weighted average across models, however, the "top" selected model (i.e., the model with the lowest AIC value) may provide insight into which factors influence species presence/abundance. In one fifth of the cases, species abundance was best modelled using a key function and expansion without incorporating seasonal timing or habitat variables. This tended to be the case where fewer (<50) individuals were observed. In approximately two thirds of the top models, seasonal timing was not selected. In the remaining third, "day since 1 May" and "visit" were equally selected for. Marsh wren (*Cistothorus palustris*) and American coot were the only species where models consistently incorporated seasonal timing in some form. Of the top models incorporating habitat variables, "woody vegetation" was the most frequently selected, followed by "water" and "tall vegetation".

The abundance estimates here are the number of individuals within the Columbia Wetlands, based on the assumption of there being 9,220 hectares of marsh habitat available (Pedology Consultants et al., 1983). Of the focal species, sora was the most frequently observed and produced the highest abundance estimates with relatively low uncertainty, as demonstrated by the coefficient of variation (Table 4). In 2016, there were estimations of 4,253 sora (95% CI = 3,163-5,719) in the Columbia Wetlands. 2017 estimations of sora was recorded at 1,118 (95% CI = 784-1,594), 2,043 individuals (95% CI = 1,544-2,702) in 2018, and 3,234 individuals (95% CI = 2,621-3,991) in 2019 (Table 4 and 5). Despite an initial decrease in 2017, sora numbers tended to increase over the course of the study. In comparison, Virginia rail increased in numbers over the course of the study. Estimations recorded 414 (95% CI = 150-1,143) Virginia rail present in 2016; 961 (95% CI = 519-1,781) in 2017, 1,315 (95% CI = 750-2,307) in 2018, and 2,116 (95% CI = 1,409-3,179) in 2019. Pied-billed grebe abundance estimates in the Columbia Wetlands had relatively low uncertainty and consistent numbers across study years. In 2016 estimations were 1,187 (95% CI = 838-1,682) pied-billed grebe in the area, 792 (95% CI = 577-1,086) in 2017, 1,006 (95% CI = 689-1,468) in 2018, and 887 (95% CI = 633-1,243) in 2019. American coot had the highest abundance estimates during 2016 with 3,019 individuals (95% CI = 1,340-6,800); 533 (95% CI = 167-1701) in 2017, 2,430 (95% CI = 1,128-5,238) in 2018, and 718 (95% CI = 507-1,019) in 2019. Model-averaged abundance estimates of American coot had higher uncertainty in all study years except 2019, possibly due to their tendency to be observed either in groups or not at all.

American bittern was the only focal species with ten or fewer detections in each study year, which were considered quite low overall (Table 4). Abundance estimates for American bittern will not be reported on due to the low number of observations likely to generate inflated or unreliable estimates. American bittern tended to be observed at the five same stations within the same general area around Brisco from year to year. Four of these stations are protected as either a

Wildlife Management Area or National Wildlife Area, leaving one site (Brisco xing) unprotected and on private land.

Across study years both Brewer's blackbird and eared grebe had fewer than ten observations in a single season (Table 6). As such their abundance was as well not estimated due to the low number of observations. Among the primary species, red-winged blackbird and marsh wren were the most frequently observed. They also produced the highest abundance estimates of the primary species with relatively low uncertainty, likely due to a high number of observations (Table 6). Estimation of marsh wren abundance was 2,589 (95% CI = 1,768-3,791) individuals in 2016, 3,987 (95% CI = 2,898-5,487) in 2017, 3,304 in 2018 (95% CI = 2,324-4,697), and 4,330 in 2019 (95% CI = 3,507-5,345). For red-winged blackbirds, estimation of abundance was 3,416 individuals in 2016 (95% CI = 2,548-4,580), 3,111 in 2017 (95% CI = 2,467-3,923), 3,033 in 2018 (95% CI = 2,384-3,778), and 3,155 in 2019 (95% CI = 2,743-3,629).

Table 4. Model-averaged abundance estimates and summary table for focal marsh bird species. Abundance estimates are for the entirety of the Columbia Wetlands, based on the assumption of 9,220 hectares of available marsh habitat.

Species	Year	Number observed	Survey effort	Avg per visit	Abundance estimate	CV (%)	95% CI	
Sora	2016	151	88	1.72	4253	15	3163	5719
	2017	122	159	0.77	1118	18	784	1594
	2018	161	177	0.91	2043	14	1544	2702
	2019	193	172	1.12	3234	11	2621	3991
Virginia rail	2016	11	88	0.13	414	49	160	1076
	2017	38	159	0.24	961	32	519	1781
	2018	37	177	0.21	1315	29	750	2307
	2019	54	172	0.31	2116	20	1409	3179
Pied-billed grebe	2016	108	88	1.23	1187	18	838	1682
	2017	127	159	0.80	792	16	577	1086
	2018	105	177	0.59	1006	19	689	1468
	2019	85	172	0.49	887	17	633	1243
American coot	2016	109	88	1.24	3019	42	1340	6800
	2017	35	159	0.22	533	63	167	1701
	2018	94	177	0.53	2430	40	1128	5238
	2019	134	172	0.78	718	18	507	1019
American bittern	2016	1	88	0.01	N/A	N/A	N/A	N/A
	2017	7	159	0.04	N/A	N/A	N/A	N/A
	2018	10	177	0.06	N/A	N/A	N/A	N/A
	2019	3	172	0.02	N/A	N/A	N/A	N/A

Note: The 95% Confidence Interval (CI) is the plausible range for the population parameters given the collected data. CV (%) denotes the Coefficient of Variation, which is the relative standard deviation and is given as a percentage. The number of individuals observed may differ from summaries provided in Figure 2 as only observations within the 15-minute survey window were used to estimate abundance.

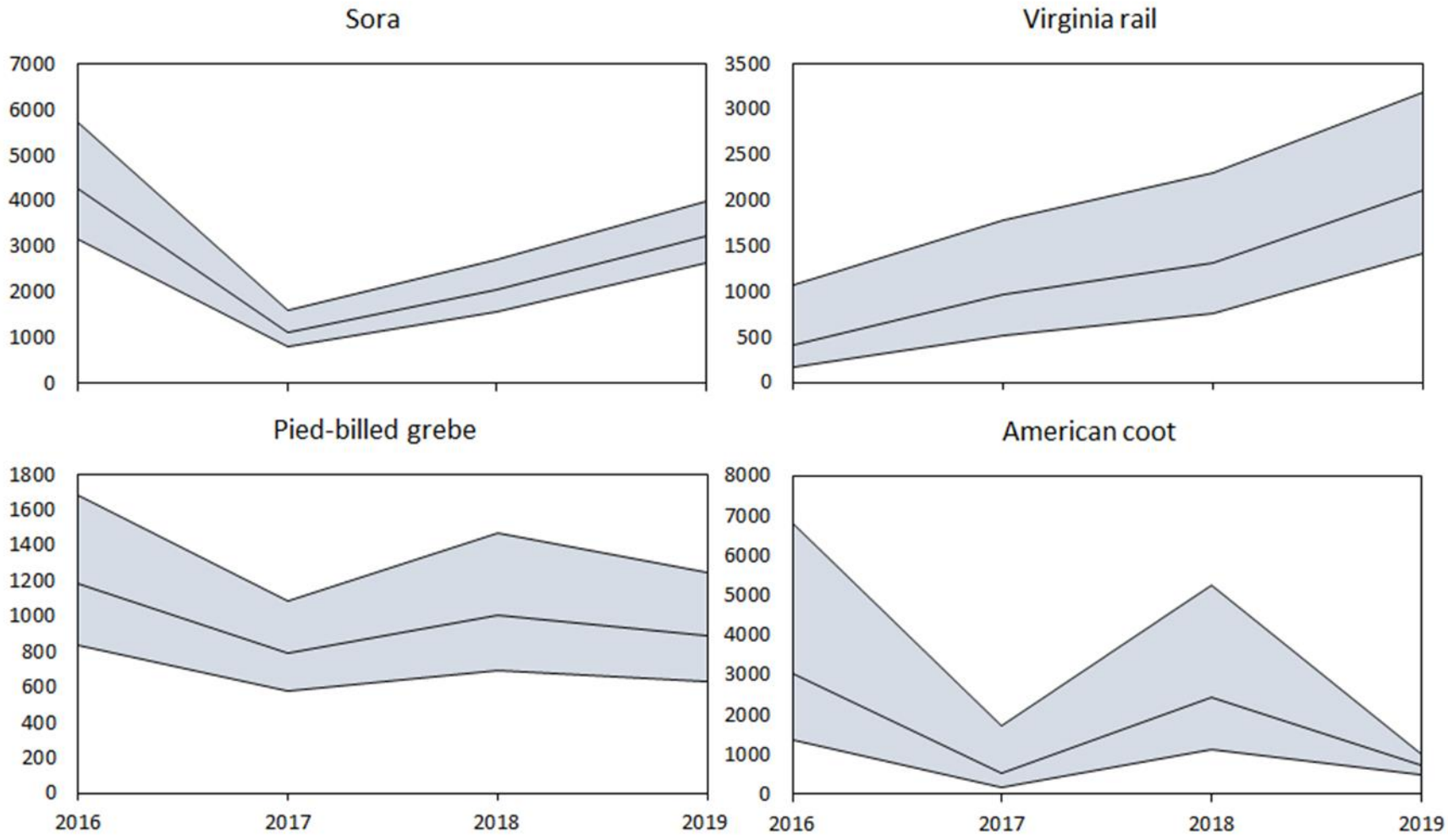

Figure 3. Visual representation of Table 4, centre lines are abundance estimates with surrounding shaded area indicating the 95% confidence interval.

Table 5. Model-averaged abundance estimates and summary table for primary marsh bird species. Abundance estimates are for the entirety of the Columbia Wetlands, based on the assumption of 9,220 hectares of available marsh habitat.

Species	Year	Number observed	Survey effort	Avg per visit	Abundance estimate	CV (%)	95% CI	
Brewer's Blackbird	2016	9	88	0.10	N/A	N/A	N/A	N/A
	2017	0	159	N/A	N/A	N/A	N/A	N/A
	2018	0	177	N/A	N/A	N/A	N/A	N/A
	2019	0	172	N/A	N/A	N/A	N/A	N/A
Eared Grebe	2016	6	88	0.07	N/A	N/A	N/A	N/A
	2017	0	159	N/A	N/A	N/A	N/A	N/A
	2018	6	177	0.03	N/A	N/A	N/A	N/A
	2019	4	172	0.03	N/A	N/A	N/A	N/A
Marsh Wren	2016	130	88	1.48	2589	19	1768	3791
	2017	211	159	1.33	3987	16	2898	5487
	2018	175	177	0.99	3304	18	2324	4697
	2019	193	172	1.12	4330	11	3507	5345
Red-necked Grebe	2016	12	88	0.14	221	53	73	665
	2017	11	159	0.07	23	30	12	43
	2018	24	177	0.14	44	20	29	67
	2019	39	172	0.23	155	25	94	258
Red-winged Blackbird	2016	180	88	2.05	3416	15	2548	4580
	2017	306	159	1.92	3111	12	2467	3923
	2018	339	177	1.92	3033	11	2384	3778
	2019	382	172	2.22	3155	7	2743	3629
Wilsons Snipe	2016	28	88	0.32	104	19	71	152
	2017	25	159	0.16	51	20	34	77
	2018	62	177	0.35	483	23	306	763
	2019	77	172	0.45	430	16	314	589
Yellow-headed Blackbird	2016	54	88	0.61	880	36	436	1776
	2017	58	159	0.36	235	29	134	414
	2018	96	177	0.54	496	27	292	846
	2019	112	172	0.65	773	17	551	1083

Note: The 95% Confidence Interval (CI) is the plausible range for the population parameters given the collected data. CV (%) denotes the Coefficient of Variation, which is the relative standard deviation and is given as a percentage. The number of individuals observed may differ from summaries provided in Figure 2 as only observations within the 15-minute survey window were used to estimate abundance.

4.3 Outreach and stakeholder engagement in 2019

During 2019, ten volunteers assisted the principal author with conducting marsh bird surveys in the field, using kayaks to access the stations. Additionally, the principal author visited with five different land owners in the Columbia Valley and installed nest boxes (for cavity nesting waterfowl) on their private land located adjacent to or within the Columbia Wetlands (Figure 4). During visits, aspects around the importance of conserving marsh bird habitat were discussed. The principal author also delivered presentations and provided findings on the CWMBMP to the following groups:

- Columbia Wetlands Stewardship Partners (in Brisco),
- Columbia Mountains Institute Researchers Forum (in Golden),
- BC Field Ornithologists Annual General Meeting (in Golden),
- FWCP Columbia Region Board and Technical Review Committee members (in Brisco),
- a presentation delivered at the Public Library in the community of Golden.

The CWMBMP has continued to develop a growing partnership with Canadian Wildlife Service (CWS). In addition to its financial contributions to the study, this agency assisted the project with the provision of services of a Master's (candidate) student; instrumental in analyzing the dataset and compilation of population estimates for focal marsh birds. GES throughout the process of the study continued in its ongoing dialogue and collaboration with groups that have working experience with landowner outreach in the region, (Kootenay Conservation Program (KCP), Farmland Advantage). The CWMBMP was included in KCP's Private Landowner Toolkit; listed both online and in brochure format.

Figure 4. Nesting box with predator guard in place; erected on private land for cavity nesting waterfowl.

5.0 Discussion

5.1 Distribution of marsh birds and important habitat types

As in previous years of CWMBMP survey data results, marsh birds were not distributed equally across survey stations in 2019 (Darvill & Westphal, 2019). Certain species of emergent vegetation [i.e., cattail (*Typha latifolia*), bulrush (*Scirpus* spp.), horsetail (*Equisitum* spp.) and sedge (*Carex* spp.)] were strongly associated with the presence of focal marsh bird species, as well as with some primary marsh bird species, during CWMBMP surveys. An environmental evaluation conducted between Canal Flats and Edgewater in 1978 stated that "[e]mergent species are probably the most 'important' vegetation to wildlife populations," in the Columbia Wetlands, specifically Carex, Scirpus, Equisetum, and Salix (Entech Environmental Consultants Ltd, 1978).

Our work supports this finding, but results indicate that cattail (*Typha* spp.) should also be included as a species of emergent herbaceous vegetation important to breeding birds. Emergent vegetation in the Columbia Wetlands has been previous described as being dominant in three floodplain marsh types:

> *1. Levee Marshes – These have no defined channel connection with the river. They are recharged by the river overflowing its banks and/or by runoff from flooding tributaries and/or from snowmelt on adjacent uplands (e.g. Wilmer).*
>
> *2. Restricted Inlet/Outlet Marshes – These marshes have developed in response to natural or man-made river restrictions. The largest in the study area occur near Dutch and Toby creeks' alluvial fans.*
>
> *3. Unrestricted Inlet/Outlet Marshes – These marshes feature water levels which fluctuate directly with river levels; e.g. Mud Lake, Rushmere; they are directly connected to the mainstem.* (Entech Environmental Consultants Ltd, 1978).

A 50:50 ratio of interspersed emergent vegetation mixed with open water patches has been termed the "hemi-marsh" condition. This type of wetland has been used globally for the management of wetlands for waterfowl and other birds (Smith, Haukos, & Prather, 2004). A greater abundant species richness and usually higher numbers of waterfowl density in hemi-marsh wetlands are generally identified in these areas, an observation attributed to more plentiful food, as well as the visual isolation that is provided between breeding pairs (Smith, Haukos, & Prather, 2004). The CWMBMP results also support that the hemi-marsh condition is important for breeding marsh birds. CWMBMP survey stations exhibiting a fairly equally distribution of emergent herbaceous vegetation mixed with patches of open water tended to have more focal species, primary species and overall species richness when compared to other stations; whereas survey stations that had little-to-no open water, and/or a small amount of emergent vegetation tended to have less focal and primary species detected within the focal area.

CWMBMP observations additionally indicate that the wetland site association known as 'WM05 Cattail' [described by McKenzie and Moran (2004)] is strongly associated with the presence of breeding marsh birds in the Columbia Wetlands. At survey stations where cattail was present, steadfast populations of focal marsh bird counts were always dependably present. The 'Wm06 Great Bulrush' site association is also important as breeding sites for marsh birds, especially for the at-risk American bittern. Hay (2006) reported that American bittern typically use tall emergent vegetation and CWMBMP data support this observation.

Bolenbaugh, Krementz, & Lehnen (2011) state that "[l]and managers interested in marsh bird management or conservation may want to consider focusing efforts on landscapes with high amounts of emergent herbaceous vegetation and low amounts of woody wetland, and managing for high amounts of water-vegetation interspersion within the wetland." Woody vegetation may act as perch site or corridor for predators, increasing nest predation; it may also decrease the amount of emergent herbaceous vegetation necessary for breeding marsh birds (Naugle et al., 1999; DeLuca,

Studds, Rockwood & Marra 2004). While emergent vegetation is considered the most important habitat feature to maintain in the Columbia Wetlands to ensure persistence of breeding habitat for focal marsh birds of the CWMBMP, additional habitat types within the wetlands are as well important to maintain for the diversity of other bird species breeding in the wetlands. Red-necked grebe were observed to be associated with shallow open water wetlands where floating aquatic plants were in high abundance. Aquatic plants such as bulrush (*Scirpus* spp.), cattail (*Typha* spp.), sedge (*Carex* spp.), willow (*Salix* spp.), pond lily (*Nuphar* spp.) and horsetail (*Equisetum* spp.) are used as materials by red-necked grebes for building floating nests, and for coverage and anchorage (Stout & Nuechterlein, 1999). The most common floating plant species observed in Columbia Wetlands habitat used by breeding red-necked grebes were Rocky Mountain pond-lily (*Nuphar polysepala engelm*).

Passerine species detected with a high frequency during marsh bird surveys (e.g. willow flycatcher and yellow warbler), were observed to be strongly associated with the levee shrubs (e.g. *Salix* spp.). The Columbia Wetlands Waterbird Survey additionally identified large patches of shallow water in the Columbia Wetlands complex as being the most important habitats to maintain migratory waterfowl for resting and feeding areas during bird migration (Darvill, 2020). Management for multiple bird species is challenging, given that different species have distinct habitat requirements and distinct response patterns to varying habitat types (Bolenbaugh et al., 2011). Therefore, maintaining a heterogeneous habitat to maintain habitat for a variety of species in the Columbia Wetlands is of paramount importance.

5.2 Focal and primary bird abundance in the Columbia Wetlands

While marsh bird populations around the world are facing significant population declines, the Columbia Wetlands continues to provide refuge for multiple breeding marsh birds with its ample, and relatively ecologically intact, breeding habitat. Apart from a few species, our data identifies all focal and primary birds as present in the Columbia Wetlands with varying levels of abundance. An unanticipated result of this study was the identification of a relatively high abundance of both sora and pied-billed grebes breeding in the wetlands. The resultant abundance estimates for pied-billed grebe will be used to nominate the Columbia Wetlands into the 'Important Bird and Biodiversity Area' (IBA) program. The IBA initiative works to identify, monitor and protect the world's most important bird habitats. To achieve IBA status for an area, certain thresholds or criteria must be met; one of which is:

> *"[t]he site is known or thought to hold, on a regular basis, 1% of more of the Neartic (North American) bird population during breeding, wintering, foraging, roosting, rafting, or migration (Moore & Courturier, 2011).*

One percent of the regional population of pied-billed grebes is approximately 1,000 - 1,200 birds; If the higher end of the plausible range for the pied-billed grebe population parameters is considered

(Table 4), CWMBMP abundance estimates achieve the IBA threshold for pied-billed grebe in all study years.

5.3 Ecological threats to the Columbia Wetlands

Whereas the Columbia Wetlands has been the recipient of initial protection strategies as described, the International Union for the Conservation of Nature (IUCN) Protected Areas Categories states that a Wildlife Management Area designation (i.e. VI: Managed Resource Protected Area) (which is the designation over the majority of the CWMBMP study area) remains the lowest form of protection for a conservation area (IUCN, 2017). The added restriction of motorized boating in the wetlands, although recognized as an important addition to the safeguards of this ecosystem, continues to be challenging to enforce due to limited available resources to ensure compliance.

During the 2017 Columbia Valley Conservation Action Planning Forum, several ecological threats were identified as impacting the Columbia Wetlands including: direct loss or modification, transportation and utilities, invasive species, recreational pressures, climate change impacts and cumulative effects (Mahr, 2017). There continues to be no Official Community Plan, Riparian Area Regulations, nor any zoning or bylaws in place for CSRD Area A. It is promising however that the Steamboat-Jubilee Mountain Official Community Plan (OCP) in the Regional District of East Kootenay is being updated in 2020 to include both Environmentally Sensitive Areas (ESAs) and Development Permit Areas (DPAs). The OCP updates are using bird species at risk data accumulated through the CWMBMP to inform ESAs and DPAs. Also, development is regulated on private land parcels located within the Agricultural Land Reserve.

Increasing levels of recreational use taking place in the Columbia Wetlands are as well likely problematic for sensitive bird species. Several studies (e.g. Liddle & Scorgie, 1980; Korschgen, George & Green, 1985; Hockin et al., 1992; Korschgen & Dahlgren, 1992; York, 1994) have reported a wide range of potentially detrimental behavioural patterns for waterbirds in response to recreationists including:

- multiple flushing and extended flight times resulting in increased energy expenditure by birds and reduction of energy intake activities including lost foraging opportunities and fewer resting periods
- increased incidences of nest abandonment and egg loss
- discouragement of breeding by late-nesting pairs as spring and summer recreational traffic increases
- disruption of pair bonding and parent-offspring bonds
- reduced use of feeding, resting and breeding sites

Repetitive disturbances eventually cause ducks and other nesting species to nest elsewhere or not at all (Korschgen & Dahlgren, 1992). In order to address these potential threats, interested

stakeholder groups must work together and agree as to the best strategy to tackle them. Dependent on the specific identified threat, various forms of management strategies will likely be required; including, but not necessarily limited to, the recommendations listed in the conclusion of this paper.

5.4 Outreach leading to recommendations for habitat-based action

Through participation in this science project, involved individuals gained insight into biological systems, learned how to identify species, expanded personal horizons in terms of environmental awareness and stewardship; and dependant upon particular circumstances, participation may even influence individual career paths (Cartwright, Cvetkovic, Graham, Tozer, & Chow-Fraser, 2013). The outreach focus of this project involved educating rural landowners as to the importance of their land in terms of its habitat value to birds, with discussions relating to potential enhancement or restoration projects. There are four landowners living in the North Columbia with properties encompassing or contiguous to the wetland that have expressed interest in habitat restoration or enhancement activities relating to their private properties. Given that approximately 21% of the Columbia Wetlands is privately owned (BC Hydro, 2014), activities on private lands may have a significant ecological impact on its inherent value to existing wildlife.

One agricultural landowner and cattle rancher has expressed a willingness to have riparian planting occur along a marsh where vegetation had previously been cleared for cattle. A second landowner has expressed an interest in removing toxic creosote-soaked railway ties from their property; previously constructed in the wetlands and serving as a bridge across the water. Two additional landowners have, upon reflection and on their own initiative, come forward requesting that specific wetland areas on their land be restored as best as possible to their natural state in order to create improved habitat condition for birds. While there are inherent challenges implementing these projects on privately owned land with the available limited financial resource and time sensitive constraints, these projects should be pursued as resources allow.

During the 2018 and 2019 CWMBMP, Canfor Forest Products was approached as part of the landowner outreach component. Canfor had previously constructed an old wood mill site in the Parson area, historically situated upon a filled-in portion of the Columbia Wetlands. In 2018, Canfor agreed to have GES work on development of a plan to restore this site to its former wetland condition. To determine costs associated with removing the wood waste from this mill site, (a critical initial phase required to help restore the site), a quote was sought out and provided by a heavy-machine contractor. The cost to remove and dispose of wood waste was prohibitive (approximately $500,000 for 1 hectare). The Columbia Shuswap Regional District was subsequently approached to determine if they could utilize the wood waste as coverage of landfill waste to help reduce wildlife attractants, but the offer was declined. To date, an alternative solution for the wood waste disposal phase of this project has yet to be determined. Further funding and allotted time will be required to advance these potential habitat-based action projects, including consultation with wetland restoration specialists to restore these habitat areas.

5.5 Additional uses of CWMBMP data

Information arising from the 2016-2019 CWMBMP has been provided to, and has assisted, various agencies and in their deliberations and understanding of the needs of the wetlands, including:

- BC provincial government (MFLNRORD), where CWMBMP data (on birds and habitat utilization) was used during revisions currently being made to the Columbia Wetlands Wildlife Management Area Management Plan.

- Columbia Wetlands Stewardship Partners (CWSP) with information relating to habitat types important for breeding marsh birds, including provision of CWMBMP information at a time when CWSP were developing the Columbia Wetlands Conservation Action Framework 2020-2025 (Mahr, 2019); with specific interest directed to identification of, and locations for, bird species at risk.

- CWMBMP species at risk occurrences was provided to a contractor in the process of updating the Regional District of East Kootenay's Steamboat-Jubilee Mountain Official Community Plan (OCP); information is currently being used to help identify Environmentally Sensitive Areas and Development Permit Areas in the OCP.

- Provision of species at risk information from the CWMBMP to assist in development of a new four-year initiative in the Columbia Valley [Kootenay Connect (Proctor & Mahr, 2019)] defining several conservation action items within the Kootenay region. In this instance, CWMBMP data is being used to help identify the location of biodiversity hotspots and riparian wildlife corridors in the Columbia Wetlands.

- Details on specific private land parcels within the Columbia Wetlands that have been identified as important bird habitat, have been provided to land trust organizations for potential land acquisition for conservation purposes.

One marsh bird survey station located outside of the CWWMA (Reflection Lake, an area well-used by public and tourists as a bird-watching destination), is experiencing a noticeable increase in the amount of emergent cattail. This increase in cattail growth can be due to disruptions in hydrology, nutrient enrichment or wildfire suppression; all of which favor cattail growth (Apfelbaum, 1985). Through 2017-2018 marsh bird surveys, CWMBMP determined that Reflection Lake provides breeding marsh bird habitat for at least 26 marsh bird species, including the blue-listed eared grebe. Wetlands containing monocultures of cattail are not heavily used by waterbirds; cattail monocultures threaten marsh bird habitat, as well as general natural plant diversity and habitat heterogeneity (Apfelbaum, 1985). This is particularly evident at the Reflection Lake study site.

As mentioned previously, it is well documented that maximum waterbird use is found in wetlands with well-interspersed 50:50 vegetative cover/open water (termed the hemi-marsh condition) (Weller & Spatcher, 1965; Kaminski & Prince, 1981; Murkin, Kaminski, & Titman, 1982). As a result of the 2018 CWMBMP observations, GES forwarded a separate funding application to the FWCP to implement an on-the-ground habitat-based action project in 2019, involving experimental cattail manipulations on Reflection Lake in efforts to explore methods of reducing the existing cattail structure, thereby increasing breeding bird habitat. The Reflection Lake Restoration Project (which has been funded and is now underway) has provided hands-on opportunities to 16 students at the College of the Rockies and has included involvement with the Akisqnuk First Nations whom have utilized the cattail harvest for traditional cultural purposes, e.g. basket/mat weaving.

A further development followed a recommendation from the 2018 CWMBMP Final Report outlining that: "updated habitat mapping information for the Columbia Wetlands is recommended, so that further priority habitat areas for marsh bird species can be identified, e.g. identify all the areas of the Columbia Wetlands with cattail marsh" (Darvill & Westphal, 2019). Subsequent to that recommendation, the Columbia Wetlands Stewardship Partners have now acquired the necessary funding and are currently undertaking a large-scale habit mapping project utilizing orthophography and Lidar imagery to map the Columbia Wetlands. Once completed, this habitat mapping will additionally assist in the identification of specific emergent plant species locations, and thus detection of the best breeding habitat types used by marsh birds in the Columbia Wetlands.

6.0 Recommendations

The CWMBMP data has appreciably contributed to the advancement of scientific understanding of marsh bird species populations in the Columbia Wetlands. Interpretation and conclusions from the collected data suggest that the following recommendations if implemented, will provide measurable enhancement of habitat level protection for marsh birds.

- Repetition of this study following the same protocols over 3-5 year increments to determine status of population changes using marsh birds as an indicator species measuring impact of environmental factors including climate change.

- Upon completion of habitat mapping for the Columbia Wetlands (anticipated for March 2020), employing the use of updated mapping to identify areas of emergent herbaceous vegetation, including the three floodplain marshes previously described: levee marshes, restricted inlet/outlet marshes, unrestricted inlet/outlet marshes, and areas with cattail.

- Conservation of areas with abundant growth of emergent herbaceous vegetation, especially in areas where there are reduced amounts of woody vegetation, and equal amounts of water interspersed amongst emergent vegetation.

- While emergent herbaceous vegetation is crucial for breeding marsh birds, maintaining a heterogeneous habitat remains the most beneficial approach with consideration of the multiple habitat requirements to address the needs of the approximately 260 bird species that utilize the Columbia Wetlands.

- Increasing levels of non-motorized use by recreationists likely will be cumulatively problematic for sensitive waterbird species with abandonment of high-quality habitat areas and adoption of lower quality habitat when disturbed. Accordingly, it is recommended that with respect to the emergent vegetation, efforts should be undertaken to create and publicly promote buffer distances secluding this breeding habitat — particularly adhered to during the peak breeding periods (mid-May until mid-July) with best efforts to limit all traffic including non-motorized recreationists during this critical season.

- Widespread public education regarding the impacts associated with human use in wetlands with high bird habitat suitability is encouraged.

- Radium Mill Pond (identified as one of the survey stations with the highest species count) is connected to the flow regime of the Columbia River through a system of culverts that were placed below Horsethief Creek Road, a road that bisects the Columbia Wetlands (Entech Environmental Consultants, 1978). Dense stands of cattail appear to be aggressively growing at the west end of Radium Mill Pond obstructing flow of water, suggesting that the culvert system is obstructed. It is recommended that these culverts be examined for their

current effectiveness and subsequent action be taken to repair or unplug the flowage system if they are no longer functioning adequately.

- All American bittern observations during 2016-2019 were situated in the Brisco area. Only one specific survey station is not currently designated as a conservation area (e.g. WMA, NWA). This specific site should be further examined with specific attention to potential chemical leaching from a nearby commercial plant. This private land parcel should also be acquired through private land purchase for conservation purposes.

- Expansion of the Columbia Wetlands Wildlife Management Area boundaries to include Reflection Lake.

- Continued explorative dialogue and consideration of potential projects with private landowners (comprising at least 21.2% of existent wetland area) relating to habitat-based actions, including restoration of wetlands on private lands where warranted.

- Install additional nesting boxes on lands where habitat is limited, according to Best Practices for installation [e.g. pole/post mount (not tree), predator guard in place] (Bailey & Bonter, 2017; Ducks Unlimited Canada, n.d.).

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The cover photo of this report features a pied-billed grebe and was taken by Rachel Darvill at the Radium Mill Pond.

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9.0 Appendices

Appendix 1. Bird species observed during 2019 and their relevant listings.

Species (Common Name)	Scientific Name	MBMP Focal/Primary/Secondary	FWCP Focal (Y/N)	FWCP Priority (Y/N)	CIJV Priority (Y/N)	Federal listing	Provincial listing	BC List
Sora	Porzana carolina	Focal		Y			S5	Yellow
Virginia Rail	Rallus limicola	Focal		Y	Y		S4S5	Yellow
American Bittern	Botaurus lentiginosus	Focal	Y		Y		S3B, SNRN	Blue
American Coot	Fulica americana	Focal		Y		Not at Risk	S4S5B	Yellow
Pied-billed Grebe	Podilymbus podiceps	Focal		Y			S4S5	Yellow
Red-necked Grebe	Podiceps grisegena	Primary		Y		Not at Risk	S5?B	Yellow
Horned Grebe	Podiceps auritus	Primary		Y	Y	Special Concern	S4B, SNRN	Yellow
Eared Grebe	Podiceps nigricollis	Primary		Y			S3B, SNRN	Blue
Wilson's Snipe	Gallinago delicata	Primary		Y			S5B	Yellow
Marsh Wren	Cistothorus palustris	Primary					S5	Yellow
Red-winged Blackbird	Agelaius phoeniceus	Primary					S5B, S5N	Yellow
Yellow-headed Blackbird	Xanthocephalus xanthocephalus	Primary		Y			S4B	Yellow
Canada Goose	Branta canadensis	Secondary					S5	Yellow
Wood Duck	Aix sponsa	Secondary		Y			S4B, S4N	Yellow
Mallard	Anas platyrhynchos	Secondary			Y		S5B, S5N	Yellow
Green-winged Teal	Anas carolinensis	Secondary			Y		S5B, S5N	Yellow
American Wigeon	Mareca americana	Secondary			Y		S5B, S5N	Yellow
Northern Shoveler	Anas clypeata	Secondary					S5B, S5N	Yellow
Blue-winged Teal	Anas discors	Secondary		Y			S4S5B	Yellow
Cinnamon Teal	Anas cyanoptera	Secondary		Y	Y		S4B	Yellow
Redhead	Aythya americana	Secondary		Y	Y		S4B, S5N	Yellow
Ring-necked Duck	Aythya collaris	Secondary		Y	Y		S5B, S5N	Yellow
Lesser Scaup	Aythya affinis	Secondary		Y			S5B, S5N	Yellow
Common Goldeneye	Bucephala clangula	Secondary		Y			S5	Yellow
Bufflehead	Bucephala albeola	Secondary		Y	Y		S5B, SNRN	Yellow
Common Merganser	Mergus merganser	Secondary		Y			S5	Yellow
Hooded Merganser	Lophodytes cucullatus	Secondary		Y	Y		S5	Yellow
Ruddy Duck	Oxyura jamaicensis	Secondary			Y		S5	Yellow
Common Loon	Gavia immer	Secondary	Y		Y	Not at Risk	S5	Yellow
Double-crested Cormorant	Phalacrocorax auritus	Secondary			Y	Not at Risk	S3S4B	Blue
Great Blue Heron	Ardea herodias	Secondary	Y		Y	Special Concern	S3	Blue
Osprey	Pandion haliaetus	Secondary	Y				S5B	Yellow
Northern Harrier	Circus cyaneus	Secondary		Y	Y	Not at Risk	S4B	Yellow
Bald Eagle	Haliaeetus leucocephalus	Secondary		Y		Not at Risk	S5B, S5N	Yellow
Sandhill Crane	Grus canadensis	Secondary				Not at Risk	S4B	Yellow
Killdeer	Charadrius vociferus	Secondary		Y			S4S5B	Yellow
Spotted Sandpiper	Actitis macularius	Secondary					S5B	Yellow
Vaux's Swift	Chaetura vauxi	Secondary	Y				S5B	Yellow
Belted Kingfisher	Megaceryle alcyon	Secondary		Y			S4S5	Yellow
Willow Flycatcher	Empidonax traillii	Secondary		Y			S5B	Yellow
Tree Swallow	Tachycineta bicolor	Secondary		Y			S4S5B	Yellow
Violet-green Swallow	Tachycineta thalassina	Secondary		Y			S4S5B	Yellow
Bank Swallow	Riparia riparia	Secondary				Threatened	S4B	Yellow
Northern Rough-winged Swallow	Stelgidopteryx serripennis	Secondary		Y			S4S5B	Yellow
Cliff Swallow	Petrochelidon pyrrhonota	Secondary		Y			S4S5B	Yellow
Barn Swallow	Hirundo rustica	Secondary		Y		Threatened	S3S4B	Blue
Yellow Warbler	Setophaga petechia	Secondary	Y				S5B	Yellow
MacGillivray's Warbler	Geothlypis tolmiei	Secondary					S5B	Yellow
Wilson's Warbler	Cardellina pusilla	Secondary					S5B	Yellow

Species (Common Name)	Scientific Name	MBMP Focal/Primary/Secondary	FWCP Focal (Y/N)	FWCP Priority (Y/N)	CIJV Priority (Y/N)	Federal listing	Provincial listing	BC List
Northern Waterthrush	Parkesia noveboracensis	Secondary		Y			S5B	Yellow
Common Yellowthroat	Geothlypis trichas	Secondary		Y			S5B	Yellow
Bullock's Oriole	Icterus bullockii	Secondary					S5B	Yellow
Alder Flycatcher	Empidonax alnorum						S5B	Yellow
American Crow	Corvus brachyrhynchos						S5	Yellow
American Kestrel	Falco sparverius						S4S5B	Yellow
American Redstart	Setophaga ruticilla			Y			S5B	Yellow
American Robin	Turdus migratorius						S5	Yellow
Black Swift	Cypseloides niger			Y		Endangered	S2S3B	Blue
Black-billed Magpie	Pica hudsonia						S5	Yellow
Black-capped Chickadee	Poecile atricapillus			Y			S5	Yellow
Black-headed Grosbeak	Pheucticus melanocephalus			Y			S5B	Yellow
Brewer's Blackbird	Euphagus cyanocephalus						S5	Yellow
Brown-headed Cowbird	Molothrus ater						S5	Yellow
Cassin's Vireo	Vireo cassinii						S5B	Yellow
Cedar Waxwing	Bombycilla cedrorum						S5	Yellow
Chipping Sparrow	Spizella passerina						S5B	Yellow
Clay-colored Sparrow	Spizella pallida						S5B	Yellow
Common Raven	Corvus corax						S5	Yellow
Dark-eyed Junco	Junco hyemalis						S5	Yellow
Downy Woodpecker	Picoides pubescens			Y			S5	Yellow
Dusky Flycatcher	Empidonax oberholseri						S5B	Yellow
Eastern Kingbird	Tyrannus tyrannus			Y			S5B	Yellow
Eurasian Collared Dove	Streptopelia decaocto							Exotic
European Starling	Sturnus vulgaris							Exotic
Gray Catbird	Dumetella carolinensis			Y			S5B	Yellow
Great Horned Owl	Bubo virginianus						S5	Yellow
Hairy Woodpecker	Dryobates villosus						S5	Yellow
Hammond's Flycatcher	Empidonax hammondii			Y			S5B	Yellow
Lazuli Bunting	Passerina amoena						S5B	Yellow
Least Flycatcher	Empidonax minimus						S5B	Yellow
Lewis's Woodpecker	Melanerpes lewis					Threatened	S2S3B	Blue
Lincoln's Sparrow	Melospiza lincolnii						S5B, SNRN	Yellow
Magnolia Warbler	Setophaga magnolia						S5B	Yellow
Mourning Dove	Zenaida macroura						S4?B	Yellow
Northern Flicker	Colaptes auratus						S5	Yellow
Orange-crowned Warbler	Vermivora celata						S5B	Yellow
Pileated Woodpecker	Dryocopus pileatus			Y			S5	Yellow
Pine Siskin	Spinus pinus						S5B	Yellow
Red Crossbill	Loxia curvirostra						S5	Yellow
Red-breasted Nuthatch	Sitta canadensis						S5	Yellow
Red-eyed Vireo	Vireo olivaceus			Y			S5B	Yellow
Red-naped Sapsucker	Sphyrapicus nuchalis			Y			S5B	Yellow
Red-tailed Hawk	Buteo jamaicensis						S5	Yellow
Rock Pigeon	Columba livia							Exotic
Ruby-crowned Kinglet	Regulus calendula						S5	Yellow
Ruffed Grouse	Bonasa umbellus			Y			S5	Yellow
Rufous Hummingbird	Selasphorus rufus			Y			S4S5B	Yellow
Savannah Sparrow	Passerculus sandwichensis						S5B	Yellow
Song Sparrow	Melospiza melodia						S5	Yellow
Swainson's Thrush	Catharus ustulatus						S5B	Yellow

Species (Common Name)	Scientific Name	MBMP Focal/Primary/Secondary	FWCP Focal (Y/N)	FWCP Priority (Y/N)	CIJV Priority (Y/N)	Federal listing	Provincial listing	BC List
Townsend's Warbler	Setophaga townsendi						S5B	Yellow
Trumpeter Swan	Cygnus buccinator				Y	Not at Risk	S4B,S5N	Yellow
Turkey Vulture	Cathartes aura						S4	Yellow
Varied Thrush	Ixoreus naevius						S5	Yellow
Veery	Catharus fuscescens			Y			S5B	Yellow
Vesper Sparrow	Pooecetes gramineus						S5B	Yellow
Warbling Vireo	Vireo gilvus						S5B	Yellow
Western Meadowlark	Sturnella neglecta						S4B,SNRN	Yellow
Western Tanager	Piranga ludoviciana						S5B	Yellow
Western Wood-Pewee	Contopus sordidulus			Y			S5B	Yellow
White-crowned Sparrow	Zonotrichia leucophrys						S5	Yellow
White-throated Sparrow	Zonotrichia albicollis						S5	Yellow
White-winged Crossbill	Loxia leucoptera						S5	Yellow
Yellow-rumped Warbler	Setophaga coronata						S5B	Yellow

Appendix 2. Survey station locations and site visit dates.

	Station Name	lat	long	elev	1st Visit	2nd Visit	3rd Visit
1	Spilli xing west	50.89764	116.38917	796	May 22	Jun 14	Jun 26
2	Spilli xing east	50.90453	116.36983	794	May 22	Jun 14	Jun 26
3	Stewart's Slough	50.89091	116.38342	797	May 22	Jun 14	Jun 26
4	Warner's Slough	50.84223	116.32513	794	May 22	Jun 14	Jun 26
5	Brisco xing 2	50.82823	116.28915	794	May 22	Jun 14	Jun 26
6	Brisco xing	50.82977	116.28352	796	May 22	Jun 14	Jun 26
7	Spilli 1km S	50.90178	116.36221	792	May 22	Jun 14	Jun 26
8	Beaver Lk 1	51.13290	116.74829	788	May 22	Jun 08	Jun 29
9	Beaver Lk 2	51.12802	116.74682	791	n/a	Jun 13	Jun 25
10	Parson xing West	51.06161	116.64994	791	May 20	Jun 12	Jun 25
11	Parson xing East	51.07185	116.64146	788	May 20	Jun 12	Jun 25
12	Imler Rd	51.09775	116.68826	793	May 20	Jun 12	Jun 25
13	McMurdo South	51.13787	116.75592	786	May 20	Jun 10	Jun 25
14	Birchlands	51.15865	116.81362	785	May 29	Jun 12	Jun 25
15	9 Mile Slough	51.19847	116.87725	788	May 20	Jun 10	Jun 25
16	Reflection Lake	51.28328	116.94142	784	May 20	Jun 10	Jun 29
17	Reflection Lake 2	51.28545	116.94985	784	May 20	Jun 10	Jun 29
18	Edelweiss 1	51.32010	116.97759	784	May 20	Jun 10	Jun 25
19	Edelweiss 2	51.32313	116.98531	786	May 20	Jun 10	Jun 25
20	Val Davidson	51.06456	116.65958	788	May 21	Jun 10	Jun 24
21	Beards Creek Rd N	51.04951	116.59720	801	May 21	Jun 10	Jun 24
22	Castledale North	51.04049	116.57732	793	May 21	Jun 10	Jun 24
23	Beards Creek Rd S	51.03299	116.55724	792	May 21	Jun 10	Jun 24
24	Castledale Rest Area	51.02691	116.53631	798	May 21	Jun 10	Jun 24
25	McKeeman's	51.01866	116.51701	791	May 21	Jun 10	Jun 24
26	Salsbury Rd N	50.99863	116.47415	794	May 21	Jun 10	Jun 24
27	Old Barns Slough	50.96389	116.42146	806	May 21	Jun 10	Jun 24
28	Radium Mill Pond 1	50.62204	116.09402	801	May 14	Jun 01	Jun 23
29	Radium Mill Pond 2	50.62389	116.10498	797	May 14	Jun 01	Jun 23
30	Wilmer 1	50.55660	116.06824	800	May 14	Jun 01	Jun 23
31	Wilmer 2	50.55863	116.06068	811	May 14	Jun 01	Jun 23
32	Wilmer 3	50.56212	116.06171	814	May 14	Jun 01	Jun 23
33	Brisco-Spilli 1	50.83211	116.29366	791	May 19	May 31	Jun 17
34	Brisco-Spilli 2	50.83319	116.30087	793	May 19	May 31	Jun 17
35	Brisco-Spilli 3	50.83746	116.30698	794	May 19	May 31	Jun 17
36	Brisco-Spilli 4	50.84179	116.31397	794	May 19	May 31	Jun 17
37	Brisco-Spilli 5	50.85126	116.32491	793	May 19	May 31	Jun 17
38	Harrogate-Castledale 1	50.96533	116.44205	786	May 28	Jun 15	Jun 30
39	Harrogate-Castledale 2	50.96503	116.45348	794	May 28	Jun 15	Jun 30
40	Harrogate-Castledale 3	50.97353	116.46438	791	May 28	Jun 15	Jun 30

	Station Name	lat	long	elev	1st Visit	2nd Visit	3rd Visit
41	Harrogate-Castledale 4	50.98212	116.47411	792	May 28	Jun 15	Jun 30
42	Harrogate-Castledale 5	50.98709	116.47594	792	May 28	Jun 15	Jun 30
43	Harrogate-Castledale 6	50.99172	116.48063	791	May 28	Jun 15	Jun 30
44	Parson - Beaver Lk 1	51.06898	116.66265	789	May 20	Jun 09	Jun 24
45	Parson - Beaver Lk 2	51.07295	116.66894	787	May 20	Jun 09	Jun 24
46	Parson - Beaver Lk 3	51.08289	116.67593	789	May 20	Jun 09	n/a
47	Parson - Beaver Lk 4	51.08228	116.68871	790	May 20	Jun 09	Jun 24
48	Parson - Beaver Lk 5	51.08756	116.70011	785	May 20	Jun 09	Jun 24
49	North Parson 2	51.13098	116.77771	790	May 22	Jun 13	Jun 25
50	North Parson 3	51.13446	116.78103	786	May 22	Jun 13	Jun 25
51	North Parson 4	51.14123	116.79841	788	May 22	Jun 13	Jun 25
52	North Parson 5	51.14575	116.80497	795	May 22	Jun 13	Jun 25
53	North Parson 7	51.15272	116.81291	790	May 22	Jun 13	Jun 25
54	Athalmer	50.51605	116.02212	800	May 23	Jun 12	Jun 28
55	SE Lake Windemere	50.41394	115.92677	802	May 23	Jun 12	Jun 28
56	Fairmont	50.34489	115.87254	806	May 23	Jun 12	Jun 28
57	Fairmont 2	50.34953	115.8708	802	May 23	Jun 12	Jun 28
58	Columbia Lk N	50.30677	115.85259	815	May 23	Jun 12	Jun 28
59	Moberly Marsh 1	51.39154	117.03539	777	May 17	May 30	Jun 21
60	Moberly Marsh 2	51.39314	117.04337	788	May 17	May 30	Jun 21
61	Moberly Marsh 3	51.39566	117.05027	779	May 17	May 30	Jun 21
62	Moberly Marsh 4	51.40292	117.05022	786	May 17	May 30	Jun 21
63	Moberly Marsh 5	51.41143	117.05626	778	May 17	May 30	Jun 21
64	Moberly Marsh 6	51.41351	117.06187	778	May 17	May 30	Jun 21
65	Moberly Marsh 7	51.41449	117.06874	778	May 17	May 30	Jun 21

Appendix 3. Advertisement to recruit volunteers.

Appendix 4. Habitat survey information collected at each survey station in 2019.

	Station Name	Survey Date	% herb	% water	% mud	% trees	% shrubs	% Lemna	% Nuphar	% Potamogeton	% Nyphaea	% Cattail	% Reeds	% Grass/Sedge	% Rushe	% Equisetum
1	Spilli xing west	Jun 26	75	20			5	50				95				
2	Spilli xing east	Jun 26	40	35	5		20		70	5		45	20	30		
3	Stewart's Slough	Jun 26	60	30		5	5					60				30
4	Warner's Slough	Jun 26	60	30			10					5	15	65		
5	Brisco xing 2	Jun 26	30	20		20	30						20	80		
6	Brisco xing	Jun 26	45	40	10		5					40			60	
7	Spilli 1km S	Jun 26	30	60			10		95			100				
8	Beaver Lk 1	Jun 29	65	25		5	5					60			40	
9	Beaver Lk 2	Jun 25	45	35		5	15		3			40				55
10	Parson xing West	Jun 25	55	15	5	5	20					15	25	50		
11	Parson xing East	Jun 25	85	10								60			25	
12	Imler Rd	Jun 25	30	25	5	5	35					20		60		
13	McMurdo South	Jun 25	60	5		5	30					45		25		
14	Birchlands	Jun 25	80	5			15					15		85		
15	9 Mile Slough	Jun 25	90	10					5	20		60			30	
16	Reflection Lake	Jun 29	70	20			10				2	90				
17	Reflection Lake 2	Jun 29	40	40		5	15					80		10		
18	Edelweiss 1	Jun 25	70	13		2	15			30		50			30	10
19	Edelweiss 2	Jun 25	60		15	15	10					50			30	10
20	Val Davidson	Jun 24	60	20		15	5			5		35		25	40	
21	Beards Creek Rd N	Jun 24	20	80					75			95				
22	Castledale North	Jun 24	35	60			5		90			10			80	
23	Beards Creek Rd S	Jun 24	15	75		5	5		65			90				
24	Castledale Rest Area	Jun 24	5	90					85			90				
25	McKeeman's	Jun 24	10	80		5	5		5					2	95	
26	Salsbury Rd N	Jun 24	80	10		5	5					20			80	
27	Old Barns Slough	Jun 24	80				20					25		40		10
28	Radium Mill Pond 1	Jun 23	15	80			5					90		10		
30	Wilmer 1	Jun 23	70	25			5					20			80	

	Station Name	Survey Date	% herb	% water	% mud	% trees	% shrubs	% Lemna	% Nuphar	% Potamogeton	% Nyphaea	% Cattail	% Reeds	% Grass/Sedge	% Rushe	% Equisetum
31	Wilmer 2	Jun 23	10	80		10			15	2				70		
32	Wilmer 3	Jun 23	75	5			20					80				20
33	Brisco-Spilli 1	Jun 17	65	20			15					70		30		
34	Brisco-Spilli 2	Jun 17	50	30								20		70		10
35	Brisco-Spilli 3	Jun 17	35	45			10					10			80	10
36	Brisco-Spilli 4	Jun 17	60	20			20					10		10		78
37	Brisco-Spilli 5	Jun 17	30	55			15		40					55		35
38	Harrogate-Castledale 1	Jun 30	35	50		5	15		90			35		40		25
39	Harrogate-Castledale 2	Jun 30	30	50		10	10							80		20
40	Harrogate-Castledale 3	Jun 30	65		5		30							100		
41	Harrogate-Castledale 4	Jun 30	30	60		5	5							100		
42	Harrogate-Castledale 5	Jun 30	40	50			20							70		30
43	Harrogate-Castledale 6	Jun 30	20	55		10	15							100		
44	Parson - Beaver Lk 1	Jun 24	35	55			20							20		60
45	Parson - Beaver Lk 2	Jun 24	70	25								25		20	45	
46	Parson - Beaver Lk 3	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47	Parson - Beaver Lk 4	Jun 24	25	55			20							45	45	10
48	Parson - Beaver Lk 5	Jun 24	45	20											55	40
49	North Parson 2	Jun 25	10	75			15							10	85	
50	North Parson 3	Jun 25	35	30			35					50		25		20
51	North Parson 4	Jun 25	25	65			10					10		45		35
52	North Parson 5	Jun 25	35	45		5	15					10		30		50
53	North Parson 7	Jun 25	45	35			20					40		60		
54	Athalmer	Jun 28	98				2					65		30		
55	SE Lake Windemere	Jun 28	15	80			5		8			95		5		
56	Fairmont	Jun 28	75	15			10							85		
57	Fairmont 2	Jun 28	40	30		5	25							35	45	
58	Columbia Lk N	Jun 28	85	5								95				
59	Moberly Marsh 1	Jun 21	80				20					20		65	15	
60	Moberly Marsh 2	Jun 21	55	5		20	20					35		50	15	
61	Moberly Marsh 3	Jun 21	85			5	10								90	
62	Moberly Marsh 4	Jun 21	80	5			15							80		15
63	Moberly Marsh 5	Jun 21	55	25			20					60		30	10	
64	Moberly Marsh 6	Jun 21	60	30			10					90				
65	Moberly Marsh 7	Jun 21	20	35		5	40							80	10	