Columbia River Project Water Use Plan

Kinbasket and Arrow Lakes Reservoir

Arrow Lakes Reservoir: Wildlife Effectiveness Monitoring and Enhancement Area Identification for Lower and Mid-Arrow Lakes Reservoir

Wildlife Physical Works Baseline Data Collection: Burton Creek Flats

Implementation Year 12

Reference: CLBMON-11B1

Study Period: 2021

Okanagan Nation Alliance, Westbank, BC

and

LGL Limited environmental research associates
Sidney, BC

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KINBASKET AND ARROW LAKES RESERVOIRS

Monitoring Program No. CLBMON-11B1

Wildlife Effectiveness Monitoring and Enhancement Area Identification for Lower and Mid-Arrow Lakes Reservoir




Wildlife Physical Works Baseline Data Collection: Burton Creek Flats
Final Report 2021

Prepared for

BC Hydro

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Water Licence Requirements
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From left to right: Pond B1 during construction, Hudsonian Godwit (*Limosa haemastica*), Western Toad (*Anaxyrus boreas*), and Pond A2 following construction. Photos credits: Mike Miller, Gary Davidson, Doug Adama, Gary Davidson.

EXECUTIVE SUMMARY

CLBMON-11B1, initiated in 2009, is a long-term wildlife monitoring project to assess the efficacy of revegetation and Wildlife Physical Works (WPW) projects (CLBWORKS-2 and CLBWORKS-30) at enhancing the suitability of habitats in the drawdown zone of Arrow Lakes Reservoir for wildlife. Wildlife effectiveness monitoring of revegetation occurred from 2009 until 2019. In 2020 effectiveness monitoring shifted from revegetation to focus entirely on the physical works construction at Burton Creek. Effectiveness monitoring of the physical works at Burton Creek continued in 2021.

Baseline bird and arthropod sampling at the Burton Creek project occurred in 2018 and 2019. Additional baseline monitoring included bat acoustic monitoring (2017-2019), wildlife camera trapping (2019), and odonate (i.e., dragonflies) surveys (2019). The first phase of the physical works was constructed at Burton Creek in September 2019. In 2021 the second phase of the physical works was constructed in March and April and revegetation occurred at the site in the spring and fall of that year.

The 2021 sampling year was the first sampling period influenced by Phase 2 construction, although it occurred before additional revegetation was planted in the fall. The continuation of the COVID-19 pandemic restricted some in-person surveys, but most of the proposed surveys were completed.

As in previous years, we surveyed birds, bats, and wildlife to document their usage of constructed ponds and mounds. Aquatic macroinvertebrates were monitored for the first time in the wetland features. There were no terrestrial arthropod surveys in 2021; this group is scheduled to be surveyed again in 2023 to allow time for the establishment of revegetation.

We surveyed songbird activity with the use of acoustic autonomous recording units (ARUs) and bat activity with the use of ultrasonic ARUs. Additionally, waterfowl and other water and shoreline-associated bird species were surveyed in-person from April to October. We recorded wildlife activity with the use of remote cameras and incidental wildlife observations. We conducted in-person visual encounter surveys (VES) for amphibians and scanned acoustic ARU recordings with a Western Toad (*Anaxyrus boreas*) classifier to detect calls of this species. We sampled all available ponds (when not inundated by the reservoir) for aquatic macroinvertebrates with the use of a sweep net. We installed data loggers in ponds A1-A4 in May through November to characterize seasonal shifts in and the impact of reservoir inundation on certain water quality parameters (dissolved oxygen, temperature, and conductivity), as these can impact use of the ponds by certain taxa.

We found aquatic macroinvertebrates in every pond that was surveyed. Pond A1 was associated with the greatest number and diversity of aquatic invertebrates, including at multiple life stages (e.g., juveniles and adults). Given that the ponds replaced largely terrestrial habitat, this could be considered a net gain in aquatic macroinvertebrate species compared with pre-WPW conditions. Different factors that could be influencing colonization of the ponds by invertebrates include proximity to natural sources, water quality, plant diversity, and pond elevation (as it relates to reservoir inundation).

We recorded 24 species of birds on acoustic ARUs, 20 of which were songbirds. This included species such as the Chipping Sparrow (*Spizella passerina*), Gray Catbird (*Dumetella carolinensis*), and the federally listed Bank Swallow (*Riparia riparia*). Some of the species detected, such as Common Yellowthroat (*Geothlypis trichas*), are associated with wetland or open/grassy habitat, making them likelier to be using the WPW habitat. Field surveys could confirm where and how bird species are using the WPW area (as opposed to adjacent habitat).

Waterbird surveys recorded 47 species of waterfowl, loons, grebes, and shorebirds, as well as 52 species of terrestrial birds. As in previous years, waterbirds were often detected along the reservoir shoreline, and thus moved up or down from the upland areas depending on reservoir elevation. Canada Geese (*Branta canadensis*) and Common Mergansers (*Mergus merganser*) were recorded in the constructed ponds. Terrestrial birds such as Bald Eagles (*Haliaeetus leucocephalus*), American Kestrels (*Falco sparverius*), and Turkey Vultures (*Cathartes aura*) were recorded using snags in the WPW area. The months with the highest waterbird abundances were August, September, and October, which can be attributed to the fall migration and the added numbers due to the presence of juveniles.

For other wildlife, we recorded 11 species of bat in the Burton WPW area, which were predominantly species of *Myotis*. We recorded three species of amphibians in the WPW area, including Pacific Treefrog (*Pseudacris regillla*), Columbia Spotted Frog (*Rana luteiventris*), and Western Toad. Columbia Spotted Frog and Pacific Treefrog egg masses were found in pond A1. The most common mammal species recorded by wildlife cameras was White-tailed Deer (*Odocoileus virginanus*), and the most common animal recorded was the Canada Goose.

Key Words: Arrow Lakes Reservoir, physical works, songbirds, aquatic invertebrates, bats, amphibians, wildlife, effectiveness monitoring, drawdown zone, Burton Creek, hydro

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ACRONYMS AND DEFINITIONS

To ensure that readers of this report interpret the terminology used throughout, the following definitions are provided.

Aquatic macroinvertebrate: Animal lacking a backbone that can be seen without the aid of a microscope and has an aquatic or semi-aquatic life history (i.e., can be found in water at some point during its development).

Drawdown Zone: a general term referring to the area ≤ 440.1 m ASL in a study site which is influenced by reservoir inundation. The drawdown zone encompasses the Wildlife Physical Works (WPW) location.

Wildlife Physical Works (WPW): The first stage of the Burton Creek WPW project was implemented in the fall of 2019 and the second stage of construction occurred in the spring of 2021. Additional revegetation was planted in the spring and fall of 2021. The physical works at Burton Creek includes a series of tiered wetlands, soil mounds to increase topographic heterogeneity, and a diverse community of planted vegetation.

COVID-19

The COVID-19 pandemic, which had a major impact on CLBMON-11B1 monitoring activities in 2020, continued to affect certain monitoring activities into 2021. Travel restrictions and other precautionary measures imposed to control the virus outbreak impacted the ability of personnel to conduct certain surveys, such as in-person songbird counts and odonate surveys.

1.0 INTRODUCTION

The Columbia River Water Use Plan was developed as a result of a multi-stakeholder consultative process to determine how to best operate BC Hydro's Mica, Revelstoke, and Keenleyside facilities to balance environmental values, recreation, power generation, culture/heritage, navigation, and flood control. The goal of the Water Use Plan is to accommodate these values through operational means (i.e., patterns of water storage and release) and non-operational physical works in lieu of changing reservoir operations to address specific interests.

During the Water Use Planning process, the Consultative Committee supported the following projects to enhance wildlife habitat in the Arrow Lakes Reservoir, in lieu of maintaining lower reservoir levels:

1) A revegetation program to increase vegetation growth in the drawdown zone (CLBWORKS-2).
2) A study to evaluate the feasibility of enhancing or creating wildlife habitat in the drawdown zone in Revelstoke Reach (CLBWORKS-29A).
3) A study to identify high-value wildlife habitat sites for enhancement or protection in the Mid and Lower Arrow Lakes Reservoir (CLBWORKS-29B).
4) The implementation of wildlife physical works identified in CLBWORKS-29A and CLBWORKS 29B (CLBWORKS-30A and CLBWORKS-30B).

Revegetation was implemented in the drawdown zone of Arrow Lakes Reservoir under CLBWORKS-2 between 2008 to 2011. Revegetation effectiveness as a wildlife habitat enhancement strategy was assessed from 2009 to 2019 under CLBMON-11B1. South of Revelstoke Reach, options for wildlife enhancement strategies were developed under CLBWORKS-29B (Hawkes and Howard 2012; Hawkes and Tuttle 2016). The first phase of the Wildlife Physical Works was implemented under CLBWORKS-30B in the fall of 2019 (Miller and Hawkes 2020) and the second phase was implemented in the spring and fall of 2021 (Miller and Hawkes 2021, draft). In 2020 the focus of CLBMON-11B1 effectiveness monitoring shifted to the post-construction Wildlife Physical Works area at Burton Creek (Waytes et al. 2021), which continued in 2021. The physical works project modified an existing shallow wetland/wet meadow in the southeast section of the drawdown zone; however, the majority of the habitat affected was relatively homogenous and dominated by undesirable species such as reed canarygrass (*Phalaris arundinacea*). This study is intended to assess the effectives of the physical works program at Burton to improve wildlife habitat suitability.

The 2021 field season was the first year of effectiveness monitoring of Phase 2 post-construction Burton Creek Wildlife Physical Works (WPW). Previous effectiveness monitoring in 2020 was focused on Phase 1 construction (Waytes et al. 2021). Prior to the construction of the WPW, there were two years of baseline surveys in the area (Hentze et al. 2019; Waytes et al. 2020).

The wetland construction at Burton Flats is anticipated to benefit wetland wildlife including birds (songbirds, waterfowl, and shorebirds), amphibians, reptiles, mammals (bats), and insects (dragonflies), among others (Hawkes and Tuttle 2016). Species with provincial or federal conservation designation that may benefit from this project include the *Species at Risk Act* (*SARA*)-listed Western Toad

(*Anaxyrus boreas*; Special Concern) and Little Brown Myotis (*Myotis lucifugus*; Endangered), and the provincially blue-listed Townsend's Big-eared Bat (*Corynorhinus townsendii*) and Fringed Myotis (*Myotis thysanodes*).

2.0 OBJECTIVES

The objective of this project component of CLBMON-11B (post-2019) is to assess the effectiveness of the Burton Creek WPW project at improving conditions for nesting and migratory birds and wildlife in the drawdown zone of Arrow Lakes Reservoir. Baseline studies in the WPW area were initiated in 2017 and project construction began in 2019, with Phase 2 construction in 2021. Effectiveness monitoring began in 2020 and continued in 2021.

Key Water Use Decisions Affected

The Terms of Reference for CLBMON-11B1 indicate that the results of this study will aid in more informed decision-making with respect to the need to balance the requirements of wildlife that are dependent on wetland and riparian habitats with other values such as recreational opportunities, flood control and power generation.

The key water use planning decisions affected by the results of this monitoring program are whether revegetation and wildlife physical works are effective in enhancing wildlife habitat. Results from this study will also assist in refining the approaches and methods for enhancing wildlife habitat through adaptive management.

3.0 STUDY AREA

The Hugh Keenleyside Dam, completed in 1968, impounded two naturally occurring lakes to form the Arrow Lakes Reservoir, an approximately 230-km long section of the Columbia River drainage between Revelstoke and Castlegar, B.C. (Map 1; Carr et al. 1993, Jackson et al. 1995). Two biogeoclimatic zones occur within the study area: Interior Cedar Hemlock (ICH) and Interior Douglas-fir (IDF). The reservoir has a north-south orientation and is set in the valley between the Monashee Mountains in the west and Selkirk Mountains in the east. Arrow Lakes Reservoir has a licensed storage volume of 7.1 million-acre feet (BC Hydro 2007). The normal operating range of the reservoir is between 418.64 m and 440.1 m above sea level (m ASL).

3.1 Burton Creek Existing Habitat

The Burton Creek WPW area was considered relative to existing vegetation at the site (Figure 3-1). A habitat map was created relative to conditions observed in the 2019 aerial photos obtained for Arrow Lakes Reservoir. The habitat mapping was done at a slightly larger scale than the previous habitat mapping (i.e., CLBMON-33) but Table 3-1 provides a description of each habitat type in Figure 3-1, with the corresponding vegetation community type analogues from CLBMON-33. The habitat map includes an overlay of the Phase 1 and 2 ponds and mounds (features A1 through A6, B1 and B2, C2 and C3, and D1 and D2). These features were constructed in habitats dominated by native and non-native grasses and sedges (Reed canarygrass–Columbia sedge–Kellogg's sedge–Cottonwood, Reed canarygrass–bluejoint, Reed canarygrass, Kellogg's sedge–Columbia sedge), Marsh, and to a lesser extent alluvial–sparse graminoid dominated areas. Changes in habitat type can be assessed over time relative to the revegetation prescriptions applied for Phases 1 and 2.

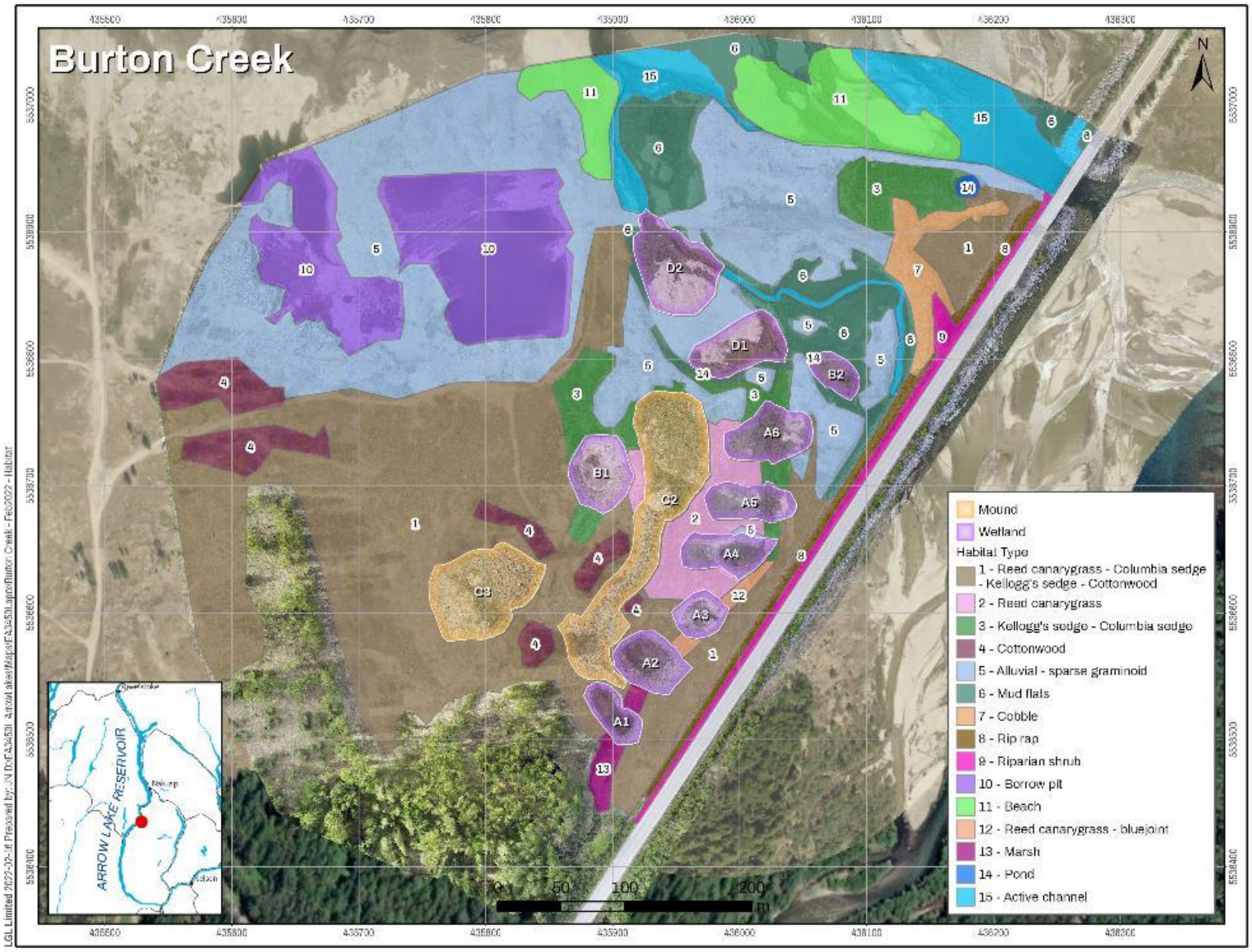


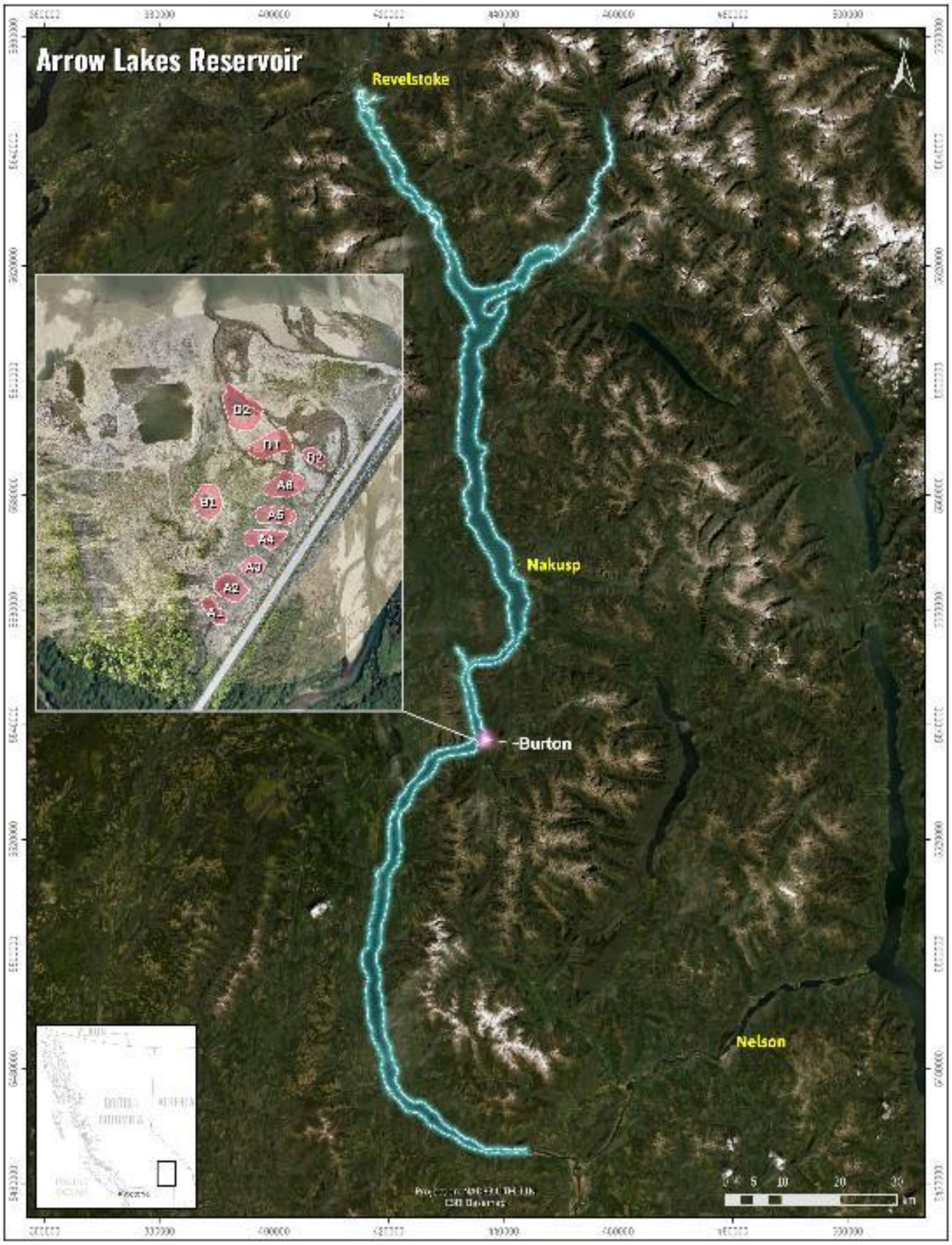
Figure 3-1. Pre-existing (2019) habitats mapped at the Burton Creek wildlife physical works location with Phase 1 and 2 constructed features overlaid, Arrow Lakes Reservoir, Burton, BC.

Table 3-1. Pre-existing (2019) habitat type name, description, and relationship to existing vegetation community type (VCT) mapped for CLBMON-33.

Code	Name	Description	VCT analogue
1	Reed canarygrass–Columbia sedge–Kellogg's sedge–Cottonwood	Association of non-native grasses (primarily reed canarygrass), native sedges (primarily Columbia sedge), and sporadic shrubs (mainly cottonwood); occurring at higher elevations on flat to convex topography, typically on well drained, coarse (gravely) substrates.	PA, BG, PC
2	Reed canarygrass	Dense reed canarygrass stands supporting minimal cover of other species; at mid elevations on flat to concave topography, typically on mesic, loamy substrates.	PC
3	Kellogg's sedge–Columbia sedge	Dense to moderately dense stands of Kellogg's and Columbia sedge, sometimes with a lesser component of reed canarygrass; occurring on some depressional terrain and along small water courses, on sandy to loamy substrates.	PC, RR, BG
4	Cottonwood	Small mature or semi-mature cottonwood stands occurring at high elevations and generally associated with (1).	CR, PA
5	Alluvial–sparse graminoid	Sparse ruderal cover of reed canary grass, Kellogg's sedge, horsetail, and annual forbs; occurring at mid to lower elevations on coarse gravel and gravelly sand (alluvial substrates).	PC, BG, BE
6	Mud flats	Low elevation, wet, generally unvegetated depressional flats and shallow basins adjacent to active channels.	BE, PE
7	Cobble	Cobble deposits, typically unvegetated.	BB
8	Rip rap	Rip rap used to reinforce highway bank; unvegetated	BB, IN
9	Riparian shrub	Shrub strip on steep slope of highway embankment (willows, red-osier dogwood, alder, cottonwood).	n/a
10	Borrow pit	Low elevation, remnant constructed borrow pits; ponded for a significant portion of the growing season; may support submergent macrophytes. Banks support ruderal annuals including the rare (S3/S4) moss grass.	n/a
11	Beach	Sparsely to unvegetated sandy beach.	BE, BG
12	Reed canarygrass–bluejoint	Transitional wetland graminoid association supported by subterranean creek flow; drier and less diverse than wetland immediately upstream (13).	RR
13	Marsh	Graminoid marsh fed by watercourse entering the drawdown zone from an upstream highway culvert; rich substrate supporting a dense cover of marsh plants including beaked sedge, bluejoint, small-flowered bulrush, marsh cinquefoil, and water smartweed.	RR
14	Pond	Low elevation, naturally formed shallow ponds adjacent to Burton Creek.	PO
15	Active channel	Active channels associated with Burton Creek; unvegetated.	n/a

3.2 Burton Creek Wildlife Physical Works

The Burton Creek WPW is located south of Nakusp, on the east side of the Arrow Lakes Reservoir. It is adjacent to Highway 6 from which it is highly visible, and accessible via Robazzo Road. The site is well-used by the public for recreation (e.g., picnics, camping, off-road vehicle use, dog walking, etc.). Prior to construction activities in 2019, this site was a depression with low vegetation species diversity, including non-native reed canarygrass (Figure 3-2; Figure 3-3). Most of the site was deemed unsuitable for aquatic invertebrates and aquatic macrophytes. While some wildlife use (e.g., songbirds and amphibians) had been documented from this area (Hawkes and Tuttle 2016), an influx of waterbirds and other species during periods of inundation indicate that the area is underutilized by wildlife when reservoir elevations are lower, including during key periods for migration or nesting for animals (Waytes et al. 2020).



Map 1. **Location of 2021 Wildlife Physical Works at Burton Creek (inset) within the drawdown zone of Arrow Lakes Reservoir, British Columbia.**

Figure 3-2. Pre-treatment (left; spring 2019) and post-treatment (right; pond A2 in spring 2021) photos of the Burton Creek Wildlife Physical Works location. Credit: R. Waytes (left) and D. Adama (right).

Figure 3-3. Photos of the pre-treatment (top; spring 2019) and Phase 2 post-treatment (bottom; pond A5 in spring 2021) Burton Creek Wildlife Physical Works location. Credit: R. Waytes (top) and D. Adama (bottom).

The first phase of the physical works project was initiated at Burton Creek in September 2019. Five ponds (A1-A4 and B1) and two mounds (C2 and C3) were constructed at Burton Creek in September and October of 2019 (Miller and Hawkes 2020). The constructed terrain was subsequently revegetated with a combination of native plants (sedges, shrubs, and trees) using locally salvaged material as well as nursery stock.

Phase 2 construction took place in March and April of 2021. Ponds A2 and A3 were deepened, pond A4 was finished, the area of mounds C2 and C3 were increased, and ponds A5, A6, B2, D1, and D2 were constructed for Phase 2 of the WPW (KWL 2021; Figure 3-4). Additionally, revegetation prescriptions were applied in April (concurrently with construction activities) and in September and October of 2021 (Miller and Hawkes 2021, draft). Artificial snags were incorporated on constructed mounds in 2019 as additional wildlife habitat, and in 2021 bat boxes were installed on the constructed mounds to further enhance the area for wildlife. The environmental objectives for the physical works are found in Kerr Wood Leidel

(2018). Pre-construction wildlife habitat suitability was considered to be low and is expected to increase substantially with the implementation of the physical works (Hawkes and Tuttle 2016). Various characteristics of the constructed features at Burton are provided in Table 3-2.

Table 3-2. Characteristics of shallow ponds, deep ponds, and mounds constructed at Burton as past of the physical works project. Water_Up refers to upper elevation of water in pond; Water_Low, the lower elevation.

		Elevation (mASL)				Area (m^2)		
Label	Feature	Outlet/Min	Max	Water_Up	Water_Low	Phase 1	Phase 2	Wetted
A1	Shallow Pond	438.75	--	438.40	438.10	1298	1298	800
A2	Shallow Pond	438.24	--	437.40	437.10	2072	2072	790
A3	Shallow Pond	437.25	--	436.35	436.05	1175	1175	372
A4	Shallow Pond	435.86	--	435.50	435.10	1140	1886	670
A5	Shallow Pond	435.39	--	435.10	434.80	--	1700	720
A6	Shallow Pond	434.85	--	434.40	434.10	--	2173	870
B1	Shallow Pond	436.31	--	435.00	434.70	2348	2348	694
B2	Shallow Pond	434.33	--	434.25	433.95	--	812	608
D1	Deep pond	433.54	--	433.40	433.10	--	2504	2024
D2	Deep pond	432.52	--	432.35	432.05	--	3616	2360
C3	Mound	438.89	439.61					
C2	Mound	435.82	440.2					

Sampling in 2021 focused on those ponds completed during Phase 1 (i.e., A1, A2, AQ3, and A4). Features constructed during Phase 2 were not assessed as the prescriptions (i.e., planting) were not completed until October 2021. All features (Phase 1and Phase 2) will be sampled in subsequent years of CLBMON-11B1 (i.e., 2022 and 2023).

Figure 3-4. Photos of constructed ponds A1-A6, D1, and D2 taken at Burton Creek in 2021. Credit: G. Davidson. See Appendix A for a photographic time series (August to November 2021) of the constructed ponds A1-A4.

Pond availability, assessed as the proportion of each month each pond was not inundated, based on the elevation of the outlet derived from the 2019 Digital Elevation Model (DEM) was calculated for all ponds in 2020 and 2021 (Table 3-3). As expected, pond availability was correlated with elevation: the lower the elevation of the outlet, the fewer days the pond was available (i.e., not inundated by the reservoir). Availability differed between years with lower elevation ponds more available in 2021 than 2020 (e.g., ponds A6 through D2). In general, lower elevation ponds (D1 and D2) were inundated starting in April with inundation persisting through December. Upper elevation ponds (e.g., A1, 2 and 3) were inducted July through august in 2020 and June and July in 2021. Overall, the tiered design of the physical works provides some pond habitat for most of the year.

Table 3-3. Proportion of each month (2020 and 2021) that each pond constructed at Burton was inundated. 0.00 indicates not inundated. Shading indicates partial (>0 but < 1) or complete (1.00) inundation for a given month.

		Month (2020)											
Pond	Elevation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A1	438.75	0.00	0.00	0.00	0.00	0.00	0.23	1.00	0.16	0.00	0.00	0.00	0.00
A2	438.24	0.00	0.00	0.00	0.00	0.00	0.29	1.00	0.29	0.00	0.00	0.00	0.00
A3	437.25	0.00	0.00	0.00	0.00	0.00	0.48	1.00	0.45	0.00	0.00	0.00	0.00
B1	436.31	0.00	0.00	0.00	0.00	0.00	0.58	1.00	0.74	0.00	0.00	0.00	0.00
A4	435.86	0.00	0.00	0.00	0.00	0.00	0.68	1.00	0.94	0.00	0.00	0.00	0.00
A5	435.39	0.00	0.00	0.00	0.00	0.00	0.81	1.00	1.00	0.13	0.16	0.06	0.00
A6	434.85	0.00	0.00	0.00	0.00	0.00	0.87	1.00	1.00	0.29	0.29	0.94	0.03
B2	434.33	0.00	0.00	0.00	0.00	0.00	0.94	1.00	1.00	0.42	0.42	0.97	0.29
D1	433.54	0.00	0.00	0.00	0.00	0.06	0.97	1.00	1.00	0.90	0.77	0.97	0.65
D2	432.52	0.00	0.00	0.00	0.00	0.19	0.97	1.00	1.00	0.97	1.00	0.97	1.00

		Month (2021)											
Pond	Elevation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A1	438.75	0.00	0.00	0.00	0.00	0.00	0.10	0.29	0.00	0.00	0.00	0.00	0.00
A2	438.24	0.00	0.00	0.00	0.00	0.00	0.23	0.42	0.00	0.00	0.00	0.00	0.00
A3	437.25	0.00	0.00	0.00	0.00	0.00	0.42	0.58	0.00	0.00	0.00	0.00	0.00
B1	436.31	0.00	0.00	0.00	0.00	0.00	0.61	0.84	0.00	0.00	0.00	0.00	0.00
A4	435.86	0.00	0.00	0.00	0.00	0.00	0.77	1.00	0.00	0.00	0.00	0.00	0.00
A5	435.39	0.00	0.00	0.00	0.00	0.00	0.87	1.00	0.13	0.00	0.00	0.00	0.00
A6	434.85	0.00	0.00	0.00	0.00	0.00	0.90	1.00	0.23	0.00	0.00	0.00	0.00
B2	434.33	0.00	0.00	0.00	0.00	0.00	0.97	1.00	0.29	0.00	0.00	0.00	0.00
D1	433.54	0.00	0.00	0.00	0.00	0.13	0.97	1.00	0.52	0.00	0.00	0.00	0.00
D2	432.52	0.00	0.00	0.00	0.00	0.32	0.97	1.00	0.77	0.68	0.00	0.26	0.29

3.3 Arrow Lakes Hydrograph

Reservoir elevations in 2021 were lowest in February, hitting the lowest yearly point at the end of February (February 23-25; 426.48 m ASL; Figure 3-5). Water levels increased after that, peaking on July 2 (439.47 m ASL). From a summertime peak, water levels dropped, plateauing from the end of August through November. Following that, reservoir levels continued to drop and are expected to lower until the annual minima.

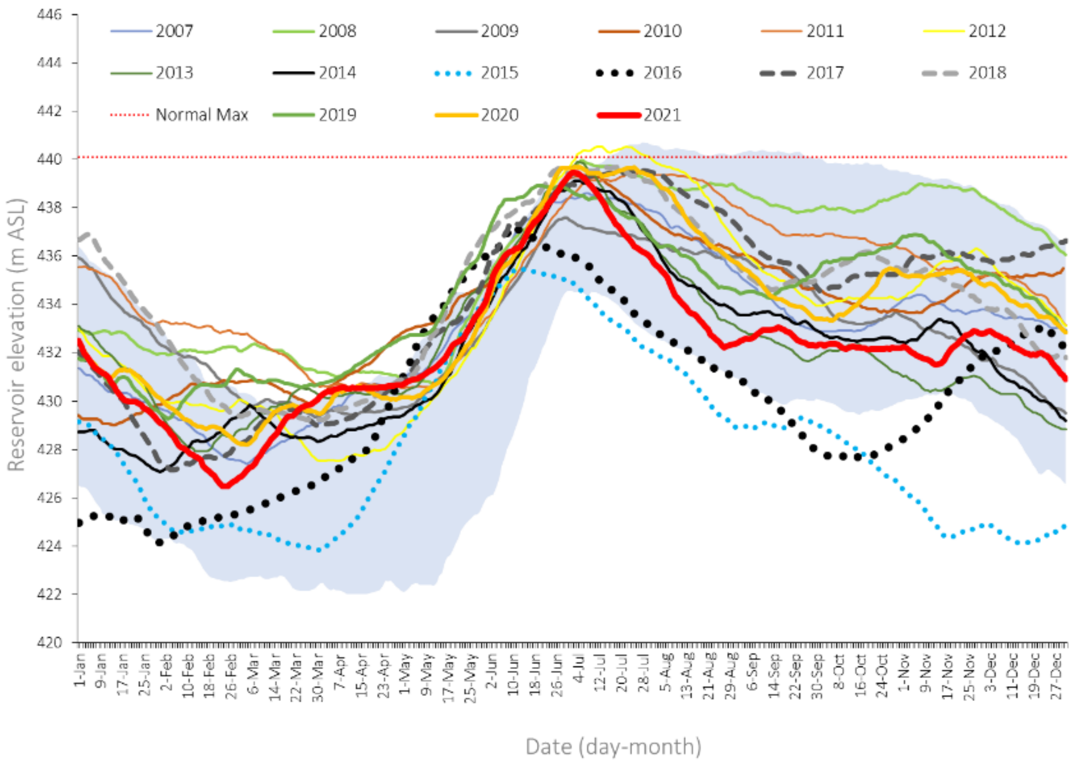


Figure 3-5. Arrow Lakes Reservoir elevations for 2007 to 31 December 2021. The 10th and 90th percentiles are shown for 1969-2021 (shaded area); m ASL= metres above sea level.

3.4 Water Quality Data

We measured water quality parameters to contextualize wildlife interactions with constructed wetlands. Water quality data were recorded in ponds A1-A4 with the use of miniDOT data loggers (Precision Measurement Engineering) and HOBO Fresh Water Conductivity Loggers (Onset; U24-001) from May 5 and 6 to November 5, 2021. The data recorded included dissolved oxygen (DO; mg/L), temperature (°C), and conductivity (µS/cm). We considered these parameters in the context of seasonal variation and reservoir inundation for each of the ponds measured. The timing of the reservoir inundation overlapped with an extreme temperature event (heat dome) in BC that occurred between June 25 and July 1, which could have affected the various physical water data parameters in the ponds. Due to the overlapping timing of reservoir inundation and the heat dome, it is difficult to parse out the individual effects of each.

Most of the ponds, except for pond A1, showed a spike in dissolved oxygen as they were inundated by the reservoir, followed by a drop as it receded (Figure 3-6). Pond A1 had less overall variation in DO levels compared to the other ponds but did show a decline in DO as it was overtopped by the reservoir. Dissolved oxygen in all ponds reached hypoxic levels (<2 mg/L) in early July, conditions which were sustained for longer in ponds A2 and A4.

Ponds A2 and A4 were associated with spikes in temperature around the end of June and early July, followed by a rapid decline. Temperature eventually peaked again in August for these ponds, followed by a gradual decline into the fall. Temperature increases for ponds A1 and A3 were less extreme, possibly due to the timing of the reservoir inundation. Pond A3 was at peak temperatures in August, with a gradual decline thereafter. The inundation by the reservoir may have counterbalanced rising water temperatures in late June/early July.

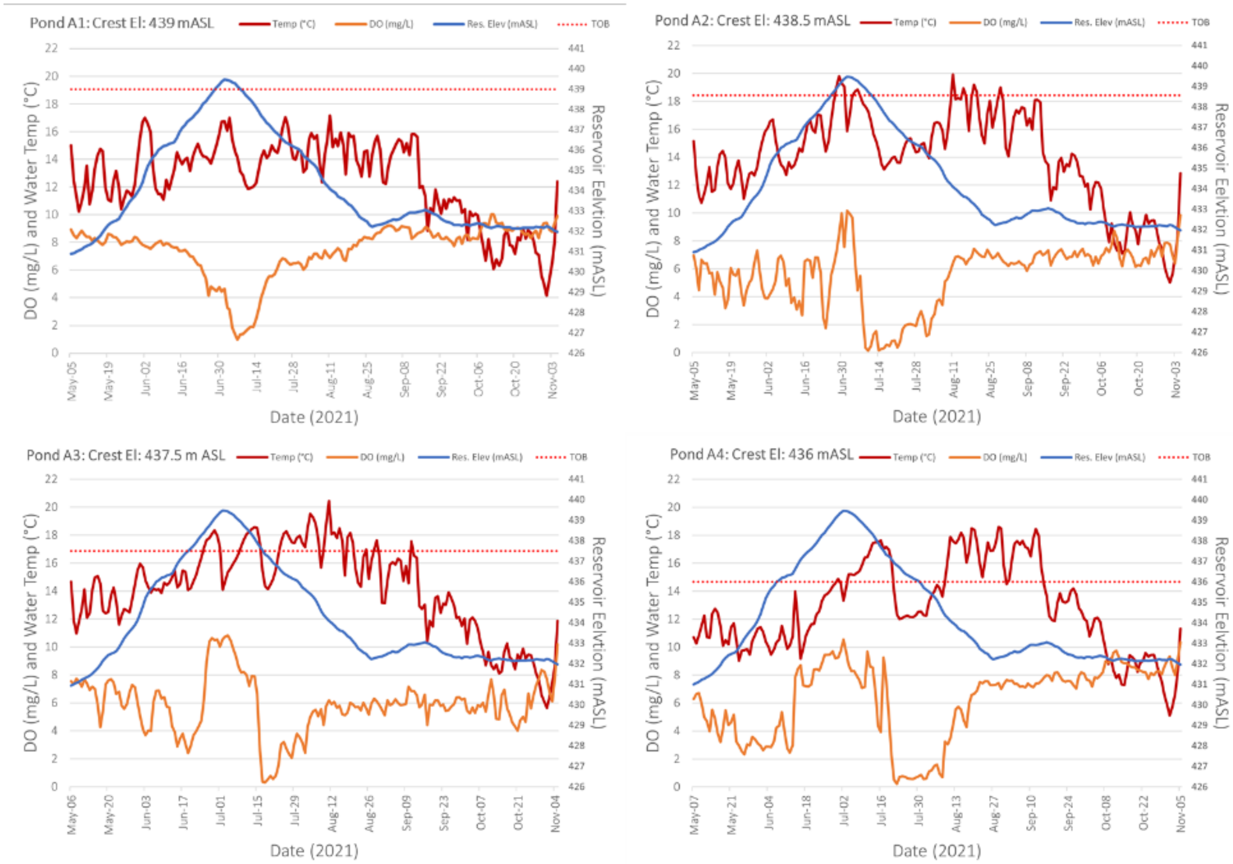


Figure 3-6. Water temperature (°C) and dissolved oxygen (DO, mg/L) for ponds A1-A4 from May 5-6 to November 7, 2021. Reservoir elevation is plotted as a reference against pond TOB; mASL= metres above sea level.

Figure 3-7. Water temperature (°C) and conductivity (µS/cm) for ponds A1-A4 from May 5-6 to November 7, 2021. Reservoir elevation is plotted as a reference against pond TOB; mASL= metres above sea level.

Conductivity was relatively consistent for most of the ponds until August and September, where there was a rapid decline, followed by sudden increase (Figure 3-7). Pond A1 had a second decline in October before it returned to levels similar to those before the decline. The exception to the August decline in conductivity was for pond A4, whose major decline seemed to correspond to being overtopped by the reservoir.

Inundation by the reservoir did affect the physical characteristics of the ponds, but other factors (including temperature and variation in water depth) may have also played a role. Increases in temperature can affect the solubility of oxygen in water, as well as the biogeochemical processes that regulate nutrients in wetlands (Kadlec and Reddy 2001). It is possible that increased temperatures in late June and early July, possibly driven by the heat dome, affected water quality characteristics. However, to some extent fluctuations in conductivity and dissolved oxygen may have been normal seasonal variation. Water quality characteristics can vary over time in ephemeral aquatic habitats (Boeckman and Bidwell 2007).

Low oxygen conditions may affect organisms using the pond, depending on their life stage and degree of mobility. Sedentary taxa such as benthic invertebrates and aquatic vegetation would likely be the most impacted by sudden shifts in water quality. Desiccation is another important consideration for wetland ponds, depending on how low water levels get. Given this, it is important to have a clear understanding of the seasonal shifts in water quality and availability. Future monitoring of water quality is advised to understand whether the patterns seen in 2021 are typical for the Burton Creek wetland ponds.

4.0 INDICATOR TAXA

An effectiveness monitoring program should be designed to determine how well management activities, decisions, or practices meet the stated objectives of the program (Marcot 1998; Noon 2003). Key to designing an effectiveness monitoring program is the selection of sensitive and readily measurable response variables that are appropriate to the objectives of the management action (Machmer and Steeger 2002); however, the selection of indicators (e.g., focal species) can be challenging (Andersen 1999).

The selection of indicator taxa should be guided by their sensitivity to the management practice, the ease of collecting data, and the usefulness of the information to address the management activity (Chase and Guepel 2005). Potential indicators may include habitat attributes, keystone species, species at risk, species that are sensitive to specific habitat requirements, or species that can be readily monitored (Feinsinger 2001; Chase and Guepel 2005). The selection of indicators should also be appropriate to the spatial scale of the applied management activity and must take into consideration factors that are external to the monitoring program, such as inter- and intra-specific competition, predation, climatic change, disease, time of year, and in the case of CLBMON-11B1, normal reservoir operations.

The efficacy of the physical works constructed at Burton Creek was assessed using a Before-After assessment. Baseline data collection from 2017-2019 that occurred in the physical works area prior to its construction encompassed terrestrial arthropods, birds (songbirds and waterfowl), bats, and amphibians and reptiles (obtained from CLBMON-37). Large mammal use (e.g., ungulates) of the physical works location was based on opportunistic observations of wildlife and associated signs, as well as the use of remotely triggered wildlife cameras in 2019. Starting in 2020, data reflects post-construction conditions of the physical works.

The indicator taxa selected for monitoring at the Burton Creek WPW site include birds (songbirds and waterbirds), bats, invertebrates, and wildlife usage patterns. Terrestrial arthropods were monitored post-construction in 2019 and will be surveyed again in 2023, once revegetation has had time to establish. Aquatic invertebrates were surveyed for the first time in 2021, after the completion of Phase 1 and 2 construction activities. The rationale for the inclusion of each of these groups is provided below.

5.0 AQUATIC MACROINVERTEBRATES

Aquatic macroinvertebrates are a useful monitoring tool for wetland environments (Adamus et al. 2001). They are indicators of water quality and the health of aquatic habitats (Gaufin 1973; Wallace et al. 1996; Ofenböck et al. 2004) and can indicate the effects of human activities on the environment (Fore et al. 1996). They are diverse, relatively abundant, and are easy to sample given their more sedentary nature. They can serve as important food resources to wildlife, including focal groups such as amphibians, bats, and insectivorous birds.

5.1 Aquatic Macroinvertebrate Sampling

Aquatic macroinvertebrates were collected for the first time at the Burton Creek WPW in 2021. Collection protocols followed those recommended by the Canadian Aquatic Biomonitoring Network (CABIN) for sampling in wetland habitats (Armellin et al. 2019). The sampling focus was on ponds established during Phase 1, which included ponds A1-A4. The pond B1 was excluded from macroinvertebrate surveys due to a lack of water at the time of the surveys. Pond D1 was surveyed opportunistically. Macroinvertebrate surveys took place on May 5 and 6 of 2021.

A surveyor used a sweep net with 400-µm mesh and detachable sample cup to collect invertebrates in the ponds. The sweep net was submerged and moved in a zig-zag pattern around each pond for a two-minute duration. All areas of the pond were incorporated into the survey, including the edges and middle, as well as any vegetation. After the two-minute period, the contents of the net were placed in a sample jar with a 10% Buffered Formalin solution and later transferred into 95% ethanol.

Water quality measurements were taken at each pond at the time of macroinvertebrate sampling. These included air and water temperature, specific conductance (µS/cm), and dissolved oxygen (DO mg/L and % DO). The maximum depth of the water in the ponds at the time of the surveys was also measured.

5.2 Sample Processing and Identification

Aquatic macroinvertebrates were identified to the most specific taxonomic level possible, which in most cases was to family. In certain cases, damaged or degraded specimens or specimens present only as pupae were noted but could not be identified to a lower taxonomic level. Exuviae were identified to the extent possible. Terrestrial bycatch (e.g., adult non-aquatic insects) were noted but excluded from the results, as they were not the focus of these surveys.

5.3 Aquatic Macroinvertebrate Results

Aquatic macroinvertebrates were present in every pond surveyed. The type and number of invertebrates varied, with most ponds having a limited number of individuals (Table 5-1). An exception to this was pond A1, which had a notable diversity of individuals including amphipods, snails, and insects. Pupal exuviae of Non-biting Midges (Chironomidae) were present in pond A4, as well as several adults of that family which may have been recently emerged. Predaceous Diving Beetle adults (Dytiscidae) were collected in three of the five ponds.

Table 5-1. Aquatic macroinvertebrates collected from ponds A1-A4 and D1 in May of 2021 at Burton Creek Flats. Insects are indicated by growth form. Specimens unidentifiable to Order were not included in the table. While exuviae are included on the table, it is important to note that they represent a sign of invertebrate presence rather than an actual invertebrate.

				Counts				
Class	Order	Family	Growth form	A1	A2	A3	A4	D1
Malacostraca	Amphipoda	Hyallelidae		9	.	.	.	.
Gastropoda	Basommatophora	Lymnaeidae		1	.	.	.	.
		Physidae		2	.	.	.	.
Insecta	Coleoptera	Dytiscidae	Adult	7	1	.	.	1
	Diptera	Ceratopogonidae	Larva	3	.	.	.	.
			Pupa	10	.	.	.	.
		Chironomidae	Exuvia*	.	.	.	14	.
	Ephemeroptera		Immature	2	.	.	.	.
			Exuvia*	3	.	.	.	.
	Hemiptera	Corixidae	Adult	.	.	1	.	.

Figure 5-1. Aquatic macroinvertebrates collected from the constructed ponds in the Burton Creek WPW. Clockwise from top left, invertebrates are amphipods, an adult Predaceous Diving Beetle (Family: Dytiscidae), Biting Midge pupae (Family: Ceratopogonidae), and an immature Mayfly (Order: Ephemeroptera). Photo credit: R. Waytes.

5.4 Aquatic Macroinvertebrate Discussion

Results from the aquatic macroinvertebrate surveys indicate that invertebrates are using the ponds, and that they are present at multiple life stages (e.g., juveniles and adults). This was especially true for pond A1. This is a positive indication that invertebrates may be establishing in the ponds. There were no aquatic macroinvertebrate surveys in the existing wetlands in the WPW area prior to the construction of the ponds, so we cannot compare the results of these surveys with baseline data. Given that the WPW construction increased the aquatic portions of the WPW habitat through the expansion of the existing wetland habitat and replacement of some of the terrestrial habitat, it is anticipated that the productivity of macroinvertebrates will increase in the area.

Pond A1 was associated with the greatest number and diversity of aquatic invertebrates. This pond, along with pond A2, had a comparatively higher vegetation diversity than other ponds (Miller and Hawkes 2021, draft), including more emergent vegetation. A1 is the highest elevation pond and is directly downstream from a natural wetland that could serve as a source of invertebrates. It was also one of the only ponds in 2021 that did not undergo construction activity. These factors could contribute to the comparatively higher number of resident aquatic invertebrates.

Aquatic invertebrate surveys were conducted in May, prior to the inundation of any of the ponds by the reservoir and the heat dome event that began in late June. It is unclear how changes in water quality throughout the summer, as well as changes in water depth in the ponds, affected invertebrate presence in the ponds. The low oxygen conditions in early July (see Section 3.4) could have impacted residents of the pond. Aquatic invertebrates can differ in their responses to oxygen concentration, with some species having a higher sensitivity than others (Davis 1975). While low oxygen conditions will affect invertebrate reproduction and growth, some invertebrates may be able to tolerate temporary stressful conditions (Galic et al. 2019). Extended low oxygen conditions would select for species with a high tolerance to oxygen deprivation. Desiccation may also play an important role in shaping the macroinvertebrate taxa present in the ponds, depending on the permanency of the ponds throughout the season (Gleason and Rooney 2018).

One of the performance measures suggested for assessing the success of wetland productivity was the successful establishment of native macroinvertebrates within five years of the construction of the ponds (Hawkes and Tuttle 2016). This is the first indication that aquatic macroinvertebrates are establishing in the ponds. While it is still too early to define their presence as successful, it is a promising sign. The continued establishment of vegetation at the edges of the ponds and submersed vegetation within the ponds, which offer habitat and resources to aquatic invertebrates, may promote further aquatic invertebrate activity. Other factors that may influence aquatic invertebrate establishment in the ponds are water depth and availability throughout the season, as well as water quality characteristics.

6.0 BIRDS

Monitoring the response of birds to management strategies has proven a pragmatic approach on several levels. For example, songbird monitoring can (1) measure the effectiveness of restoration and enhancement; (2) provide the necessary feedback for adaptive management; (3) guide restoration design by providing information on the health and habitat associations of the local bird populations; (4) be cost effective; and (5) provide education and outreach opportunities (Burnett et al. 2005). Because birds occupy an extremely diverse range of niches within an ecosystem and a relatively high position in the food chain, they are ideal indicators of environmental conditions (DeSante and Geupel 1987; Temple and Wiens 1989; Rich 2002). Along with the relative ease of study and the cost effectiveness of a songbird monitoring program, songbird monitoring provides researchers with feedback from a whole community of organisms, not just a single species. Thus, songbirds are model organisms for measuring the efficacy of restoration or enhancement projects. However, study designs need to account for the spatial characteristics of bird responses to restoration or enhancement projects, and they may not always be suitable for assessing fine-scale changes within broader landscape contexts.

The construction the Burton Creek WPW is expected to increase the availability of wetlands to waterfowl and other water-associated birds (e.g., herons and shorebirds). In addition to songbird monitoring, documenting the activities of waterbirds in the area can indicate how they interact with WPW features.

6.1 Songbird Surveys

A modified approach to songbird surveys was used in 2021, following methodology used in 2020 (Waytes et al. 2021). This approach utilized Wildlife Acoustics Song Meter autonomous recording units (ARUs; SM4 Wildlife Acoustics, Inc., Maynard, Massachusetts, USA) to record bird songs in the place of more traditional in-person songbird point count surveys. Six units were deployed in spring (4 and 5 May 2021) to monitor bird songs in the WPW area (Appendix E). They were collected on November 4, 2021. Due to limited field presence because of travel restrictions, nest searches were not conducted in 2021. Acoustic ARU recordings offer valuable information on bird species presence and can detect birds to a level similar to humans (Castro et al. 2019). While we cannot assess species abundance or habitat use from the recordings, they were used to indicate species presence

We used the acoustic ARU recordings to generate data on bird species in the area. The protocols used for selecting the seasonal window, time of day, and appropriate weather for the surveys adhered to provincial standards for breeding bird surveys (RIC 1999). Two dates were randomly chosen within constrained time periods (within three hours of sunrise) for each acoustic ARU (Table 6-1); the time periods were 5-10 June for Visit 1 and 20-25 June for Visit 2. These dates coincide with the height of the songbird breeding season when locally breeding passerines are on territory and highly vocal. These times are also consistent with survey dates in previous years. If sub-optimal weather conditions (e.g., rain, strong winds) occurred on the first chosen date a second date was selected . Consistent with previously collected songbird data, an ornithologist analyzed six-minute intervals of recordings from each ARU on the chosen dates, and recorded all bird species detected. Two ARUs (at ARU03 and 04) did not have usable recordings, so they were removed from analysis.

Table 6-1. Acoustic ARU stations (see Appendix E) and associated dates of recording review.

ARU Name	Visit 1	Visit 2
ARU01	05-Jun-21	22-Jun-21
ARU02	07-Jun-21	22-Jun-21
ARU05	06-Jun-21	24-Jun-21
ARU06	10-Jun-21	25-Jun-21

We presented the bird species detected and associated counts for each species from the acoustic ARU recordings. We separated species and counts by ARU group, which were determined by the relative proximity of acoustic ARUs to each other. The purpose of the acoustic ARUs was to monitor the WPW area, and as such their placement was focused on coverage of the WPW and not necessarily ensuring spatial independence of recording units. Acoustic ARUs have radii of around 150 m, although the loudness and frequency range of various species' vocalizations will also affect the detection range. Because of this, species detections by many of the ARUs cannot be considered fully independent due to the possibility of detection by multiple ARUs. In reporting species counts, we pooled the data of three of the ARUs in the WPW (ARU01, ARU02, and ARU05; "ARU Group 1") due to their close proximity to each other (<250 m); the recording output of ARU06 was presented separately from these units ("ARU Group 2"). Species counts were first summarized for each ARU and the max count of each species was taken between both visitations to control for temporal pseudoreplication. The max count of each species was then calculated for ARU Groups 1 and 2.

Figure 6-1. An acoustic (left) and ultrasonic (right) ARU attached to a snag above a wildlife camera in the WPW area in 2021. Credit: D. Adama.

6.2 Waterbird and Land Bird Surveys

Surveys focused on waterbirds were completed on 20 dates from 4 April through 27 October 2021. These surveys were conducted to monitor waterbird use in the WPW constructed ponds and nearby area. During each survey period a map showing the survey area and approximated reservoir elevation for the survey date was provided, and the number and species of birds were recorded onto the map. Birds were split into two different categories, "waterbirds" and "land birds," for mapping purposes. The area surveyed included the WPW area plus additional and adjacent locations to ensure that bird usage of the WPW location was put into context of the surrounding area.

6.3 Bird Results

6.3.1 Autonomous Recording Units

In total, 24 bird species (20 of which were songbirds) were detected from analysed ARU recordings over the two simulated visits (Table 6-2). This includes sixteen species during early June (Visit 1) and twenty species in late June (Visit 2). One threatened species, the Bank Swallow (*Riparia riparia*), was recorded by ARU02 (COSEWIC 2013a).

Table 6-2. Bird species detected at the Burton Creek WPW from acoustic ARU recordings in June of 2021 and associated counts. Species counts are presented by ARU Groups 1 (ARU01, ARU02, and ARU05) and 2 (ARU06).

Common Name	Scientific Name	Species Count ARU Group 1	Species Count ARU Group 2
American Crow	*Corvus brachyrhynchos*	1	1
American Redstart	*Setophaga ruticilla*	2	0
American Robin	*Turdus migratorius*	2	2
Bank Swallow**	*Riparia riparia*	1	0
Black-capped Chickadee	*Poecile atricapillus*	0	1
Canada Goose*	*Branta canadensis*	1	1
Cassin's Vireo	*Vireo cassinii*	1	0
Cedar Waxwing	*Bombycilla cedrorum*	1	1
Chipping Sparrow	*Spizella passerina*	0	1
Common Yellowthroat	*Geothlypis trichas*	3	2
Gray Catbird	*Dumetella carolinensis*	1	0
Killdeer*	*Charadrius vociferus*	1	0
Lazuli Bunting	*Passerina amoena*	1	2
Mallard*	*Anas platyrhynchos*	2	2
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	1	0
Red-eyed Vireo	*Vireo olivaceus*	2	1
Spotted Sandpiper*	*Actitis macularius*	2	1
Swainson's Thrush	*Catharus ustulatus*	1	0
Western Meadowlark	*Sturnella neglecta*	2	2
Western Tanager	*Piranga ludoviciana*	1	0
Western Wood-Pewee	*Contopus sordidulus*	1	0
Willow Flycatcher	*Empidonax traillii*	1	1
Yellow Warbler	*Setophaga petechia*	1	0
Yellow-rumped Warbler	*Setophaga coronata*	1	0

*Indicates non-songbirds (i.e., shorebirds and waterfowl), which were not a focal group of the surveys but are included here as incidental observations.
**Indicates a listed species of songbird.

6.3.2 Waterbirds and Land Birds

In total, 47 species of waterfowl, loons, grebes, shorebirds, and herons (hereafter collectively referred to as "waterbirds") were recorded during spring through autumn waterbird surveys in 2021 at Burton Creek (Appendix B). In addition to waterbirds, 52 species of terrestrial birds, including but not limited to songbirds, raptors, pigeons, and swifts, were recorded at Burton Creek during in-person surveys (Appendix C). A total of 4,088 birds identified over the course of the summer, some of which were likely repeat individuals between months (Appendix D). Of these, 3,124 sightings were of waterbirds.

The months with the greatest waterbird abundances were September, October, and August (in that order). May had the lowest number of sightings, which was consistent with 2020 results. California Gulls (*Larus californicus*) were the most recorded bird species in the area, although their records were concentrated to August through October. Canada Geese (*Branta canadensis*) had the second highest number of records in the area and were present more consistently throughout the year. Other frequently recorded waterbird species included

Mallards (*Anas platyrhynchos*), Common Mergansers (*Mergus merganser*), and Common Loons (*Gavia immer)*.

As in previous years, many waterbird sightings followed the reservoir edge, but a variety of bird species were also recorded interacting with WPW features (Table 6-3). Canada Geese, Common Mergansers, Mallards, and Spotted Sandpipers were recorded in or near the constructed ponds. Terrestrial birds such as Bald Eagles (*Haliaeetus leucocephalus*), American Kestrels (*Falco sparverius*), and Turkey Vultures (*Cathartes aura)* were recorded on snags in the WPW area by an in-person observer, as well as documented to some extent on remote cameras (Figure 6-2).

Table 6-3. Waterbirds and land birds recorded using WPW features (ponds A1-A6, D1-D2, and B1-B2 or mounds C2-C3) or in close proximity to them (e.g., on shore of pond) during waterbird surveys in 2021. Species are presented by date recorded and abundance. See Appendix B and C for mapped distribution of species.

Date	Species Code	Common Name	Abundance	Pond	Mound
07-Apr-21	CAGO	Canada Goose	2	A2	
27-Apr-21	COME	Common Merganser	1	A5	
27-Apr-21	YRWA	Yellow-rumped Warbler	1	A1	
18-May-21	AMKE	American Kestrel	2		C2
18-May-21	CAGO	Canada Goose	2	D2	
29-May-21	BWTE	Blue-winged Teal	3	D1	
29-May-21	SPSA	Spotted Sandpiper	2	A2	
29-May-21	WEME	Western Meadowlark	1		C2
15-Jun-21	CAGO	Canada Goose	6	A6	
15-Jun-21	MALL	Mallard	10	D1	
29-Jun-21	SPSA	Spotted Sandpiper	1		C3
07-Jul-21	BAEA	Bald Eagle	1		C3
07-Jul-21	WEME	Western Meadowlark	1		C3
07-Jul-21	MALL	Mallard	1	A2	
07-Jul-21	CAGO	Canada Goose	18		C2
21-Jul-21	TUVU	Turkey Vulture	10		C2
21-Jul-21	AMRO	American Robin	1		C2
21-Jul-21	CAGO	Canada Goose	50	A4/A5	
21-Jul-21	SPSA	Spotted Sandpiper	3	A5/A6	
07-Aug-21	MALL	Mallard	1	D1	
07-Aug-21	MALL	Mallard	8	B2	
17-Aug-21	MALL	Mallard	1	A5	
17-Aug-21	SPSA	Spotted Sandpiper	1	A5	
17-Aug-21	TUVU	Turkey Vulture	8		C2
10-Sep-21	HOME	Hooded Merganser	1	A4	
30-Sep-21	CAGO	Canada Goose	9	A6	
30-Sep-21	CAGO	Canada Goose	7	B2/D1	
12-Oct-21	CAGO	Canada Goose	3	B1	
12-Oct-21	RNDU	Ring-necked Duck	4		C3
12-Oct-21	BAGO	Barrow's Goldeneye	1		C3
12-Oct-21	HOME	Hooded Merganser	2		C3
12-Oct-21	CAGO	Canada Goose	35		C2
19-Oct-21	BAGO	Barrow's Goldeneye	2	B1	
19-Oct-21	LESC	Lesser Scaup	1	B1	

A number of listed waterbird species were recorded in proximity to the Burton Creek WPW area. Federally listed species include the threatened Lesser Yellowlegs (*Tringa flavipes*; COSEWIC 2020) and Hudsonian Godwit (*Limosa haemastica*; COSEWIC 2019; Figure 6-3), as well as Horned Grebes (*Podiceps auritus*) and Western Grebes (*Aechmophorus occidentalis*), which are both species of special concern (COSEWIC 2009; COSEWIC 2014). In addition to listed waterbirds, both Bank Swallows (threatened) and Barn Swallows (*Hirundo rustica*; species of special concern; COSEWIC 2021) were recorded in the area. Provincially listed species included the American Bittern (*Botaurus lentiginosus*; Blue-listed; Figure 6-3) and the Great Blue Heron (*Ardea herodias*), which was likely ssp. *herodias* due to the geographic location (Blue-listed).

Figure 6-2. A wildlife camera photograph taken on July 6, 2021 in the WPW area shows a Canada Goose browsing on vegetation in the foreground, while in the background a Bald Eagle perches on an artificial snag and a Tree Swallow lands on a planted stake.

Figure 6-3. Waterbirds photographed in the Burton Creek area in 2021. From top left clockwise, a Hudsonian Godwit, a Parasitic Jaeger, and an American Bittern. Credit: G. Davidson.

6.4 Bird Discussion

We recorded 20 species of songbirds on acoustic ARUs in the WPW area or adjacent to it, and 24 bird species in total when including waterfowl and shorebirds. Many of the species detected were previously detected during 2020 surveys (Waytes et al. 2021). Common Yellowthroat (*Geothlypis trichas*) was the most commonly detected songbird species; its association with wetland habitats means that it has a high potential to breed in the area. Non-songbird species that were detected during the ARU surveys such as Spotted Sandpipers (*Actitis macularius*) and Mallards (*Anas platyrhynchos*) could likewise be breeding in the area. Other species such as the Chipping Sparrow (*Spizella passerine)*, the American Robin (*Turdus migratorius*), and Gray Catbird (*Dumetella carolinensis)* may be using features in the WPW area to perch but were likely not breeding in the immediate WPW area. Currently the shrubs and stakes planted in the WPW are still too young to provide enough cover for tree- or shrub-nesting birds. Likewise, birds like the Tree Swallow (which was not recorded during the acoustic surveys but was recorded during in-person waterfowl surveys and on wildlife cameras) were likely foraging or perching but not nesting in the WPW area. Features such as snags, which in the future could provide cavities for cavity-nesting birds like Tree Swallows, are still too new to provide sufficient nesting space. Some forest-associated species detected such as the American Redstart (*Setophaga ruticilla)* were likely not recorded in the WPW area but the nearby woodland.

The waterbirds detected in 2021 followed similar distribution patterns to those observed in 2019 and 2020 surveys, as they were found to largely follow the rising shoreline due to reservoir inundation. An increase in bird photographs in June and July on remote cameras in the WPW area was likely due to the higher reservoir levels (see Section 9.3). Nonetheless, as in the 2020 surveys, there were several species (such as Canada Geese) recorded as using WPW constructed ponds. High waterbird abundances in August, September, and October can be attributed to fall migration, as well as added numbers due to the presence of juvenile birds. This is the second year after WPW construction that Horned Grebes, a listed species, were detected in the Burton Creek area.

Various terrestrial and water birds were documented using the ponds and perching on artificial snags and planted stakes. These interactions with WPW features are a positive indication of their usefulness to wildlife species in the area. As the planted live stakes and shrubs in the WPW area become established and continue to grow, they will provide increased nesting opportunities for certain species.

7.0 BATS

There are 11 bat species potentially occurring in the Burton Creek area (Table 7-1), most confirmed by live capture studies. Of these species, Townsend's Big-eared Bat (*Corynorhinus townsendii*), Western Small-footed Myotis, Northern Myotis (*M. septentrionalis*), and Fringed Myotis (*M. thysanodes*) are blue-listed by the Conservation Data Centre (CDC), which is a status assigned to species that are particularly sensitive to impacts from human activities or natural events (BC CDC 2019). Federally, Northern Myotis and Little Brown Myotis (*M. lucifugus*) were emergency listed under the *Species at Risk Act* as Endangered (17 December 2014) due to the potential threat of White Nose Syndrome, a fungus caused by *Pseudogymnoascus destructans* that has been spreading westward since it was first documented in North America (COSEWIC 2013b). Fringed Myotis is considered Data Deficient by COSEWIC, meaning there is not enough scientific information available to support status designation.

Monitoring of bat species in the WPW area has occurred since 2017. Bat monitoring in the WPW area is important for the documentation of species at risk utilizing the area. Bat monitoring after WPW construction can also be used to compare against baseline pre-construction data.

Table 7-1. Provincial and national status of bat species potentially occurring in the Mid-Arrow Lakes area. 1-E = Schedule 1 of the *Species at Risk Act*; Endangered Status.

Common Name	Scientific Name	Code	Present	CDC Status	COSEWIC Status	SARA
Townsend's Big-eared Bat	*Corynorhinus townsendii*	COTO	Yes	Blue		
Big Brown Bat	*Eptesicus fuscus*	EPFU	Yes	Yellow		
Hoary Bat	*Lasiurus cinereus*	LACI	Yes	Yellow		
Silver-haired Bat	*Lasionycteris noctivagans*	LANO	Yes	Yellow		
California Myotis	*Myotis californicus*	MYCA	Yes	Yellow		
Long-eared Myotis	*Myotis evotis*	MYEV	Yes	Yellow		
Little Brown Myotis	*Myotis lucifugus*	MYLU	Yes	Yellow	Endangered	1-E (2014)
Northern Myotis	*Myotis septentrionalis*	MYSE	Yes	Blue	Endangered	1-E (2014)
Fringed Myotis	*Myotis thysanodes*	MYTH	Yes	Blue	Data Deficient	3 (2005)
Long-legged Myotis	*Myotis Volans*	MYVO	Yes	Yellow		
Yuma Myotis	*Myotis yumanensis*	MYYU	Yes	Yellow		

7.1 Bat Sampling

To study bat presence in the Burton Creek WPW area, six Wildlife Acoustics Song Meter autonomous recording units (SM4BAT Wildlife Acoustics, Inc., Maynard, Massachusetts, USA) were deployed from May to mid-July in 2021 (Appendix E). Each unit was programmed with a schedule to record bat calls during two periods: i) half an hour before sunset for 5.5 hours, and ii) an hour before sunrise for 1.5 hours, for a total of 7 hours per 24-hour period.

Under ideal conditions, Wildlife Acoustics Song Meter detectors will sample bats in an airspace of 30 to 100m from the microphone, with bats emitting higher frequencies (e.g., *Myotis septentrionalis*) detected more often in the 30 m zone and bats emitting lower frequencies (e.g., *Lasionycteris noctivagans* and *Lasiurus cinereus*) detected up to ~100m from the microphone. The microphone paired with a Song Meter unit is omnidirectional, meaning that it will sample from almost all directions projecting out from the microphone. The microphones were set approximately 2m above ground or higher, attached to either extendable aluminum poles or tree branches, and the pitch of the microphone was set at approximately 90° (horizontal).

7.2 Data Analyses

Bat presence and activity in 2021 was assessed by analyzing recordings from Wildlife Acoustics Song Meter units using their automatic classification software (Kaleidoscope Pro v. 5.4.6). Kaleidoscope utilizes classifiers developed from libraries of species-verified recordings to generate complex algorithms used in the automated identification process. Species classifiers can be selected to match the expected bat fauna in an area. The classifiers for 11 species that have been confirmed in the West Kootenays were selected for use in analysis of 2021 Wildlife Physical Works data. Auto ID analysis is intended for use on recordings of single bats in a low clutter environment, but some environmental (e.g., rain, wind, surface echoes, temperature changes, etc.) and biological (e.g., number of bats present, distance of bats, etc.) factors cannot be controlled and thus recording quality may vary. In addition, the acoustic signatures of many bat species overlap in their frequency ranges, making it difficult to confidently differentiate some species (Table 7-2; also, Szewczak et al. 2011a,b). Thus, the assignment of species is based in part on a probability that the species is present, and we treat our classifications as indicative rather than definitive. Data collected by autonomous recording devices do not provide an indication of the number of individual bats present in a given area.

Table 7-2. Typical frequencies (kHz) of calls from bat species expected to occur in habitats associated with the drawdown zone of the Lower and Mid-Arrow Lakes Reservoir.

Species	Frequency (kHz) Characteristic (f_c)	Highest Apparent (Hi f)	Lowest Apparent (Lo f)
Corynorhinus townsendii	21 - 26	40 - 45	19 - 23
Eptesicus fuscus	27 - 30	50 - 63	26 - 29
Lasiurus cinereus	18 - 22	21 - 31	18 - 22
Lasionycteris noctivagans	26 - 27	33 - 50	24 - 27
Myotis californicus	47 - 51	89 - 111	43 - 47
Myotis evotis	33 - 36	64 - 93	26 - 31
Myotis lucifugus	39 - 42	63 - 86	36 - 40
Myotis septentrionalis	40 - 47	95 - 114	32 - 42
Myotis thysanodes	23 - 26	57 - 88	17 - 22
Myotis volans	39 - 44	78 - 101	34 - 40
Myotis yumanensis	47 - 52	77 - 103	44 - 47

We calculated bat species richness for the WPW area and the number of recordings per detector-hour for each species and ARU. The number of recordings per detector-hour for each species was compared between years, with baseline data sets from 2017 (n=3 ARUs), 2018 (n=3), and 2019 (n=2) and ARU data from the first year of post-WPW construction in 2020 (n=5). Two ARUs from 2021 (ARU03 and 07), which recorded no bat calls over the duration of their deployment, were removed from analysis as this was likely due to a loss of function.

7.3 Bat Results

All 11 species of bat were detected by autonomous recording units from the wildlife physical works area. These were predominantly species of *Myotis*, with Little Brown Myotis having the most calls at each detector (Table 7-3). Of the four bat detectors, ARU06 recorded the most calls (13.96 per detector-hour) and ARU01 recorded the least (6.57 calls per detector-hour) (Figure 7-1). There was a large amount of within-site (between-detector) visitation. General patterns of recordings per detector-hour were fairly consistent between years, although calls per detector-hour declined for several species in 2021 compared to earlier years, including Little Brown Myotis and California Myotis (*Myotis californicus*) (Figure 7-2). For the second year in a row, ARU06 had a noticeably higher detection rate of Yuma Myotis (*Myotis yumanensis*) than other ARUs, although it was not as high as in 2020.

Table 7-3. Recordings per detector-hour for bat detectors deployed in the Burton Creek WPW area in 2021. Richness refers to the total number of species detected by the ARU. The most detected species at each detector is highlighted in light green. Species codes are provided in Table 7-1.

Species	ARUBUWPW1	ARUBUWPW2	ARUBUWPW5	ARUBUWPW6
CORTOW	0.002	0.007	0.002	0.002
EPTFUS	0.055	0.077	0.101	0.030
LASCIN	0.709	0.761	0.720	0.220
LASNOC	1.549	2.335	2.498	0.635
MYOCAL	0.478	0.496	0.447	2.545
MYOEVO	0.017	0.016	0.010	0.011
MYOLUC	3.393	3.597	4.609	5.733
MYOSEP	0.002	-	-	0.004
MYOTHY	-	-	-	0.004
MYOVOL	0.030	0.119	0.144	0.101
MYOYUM	0.332	0.309	0.263	4.672
Richness	10	9	9	11

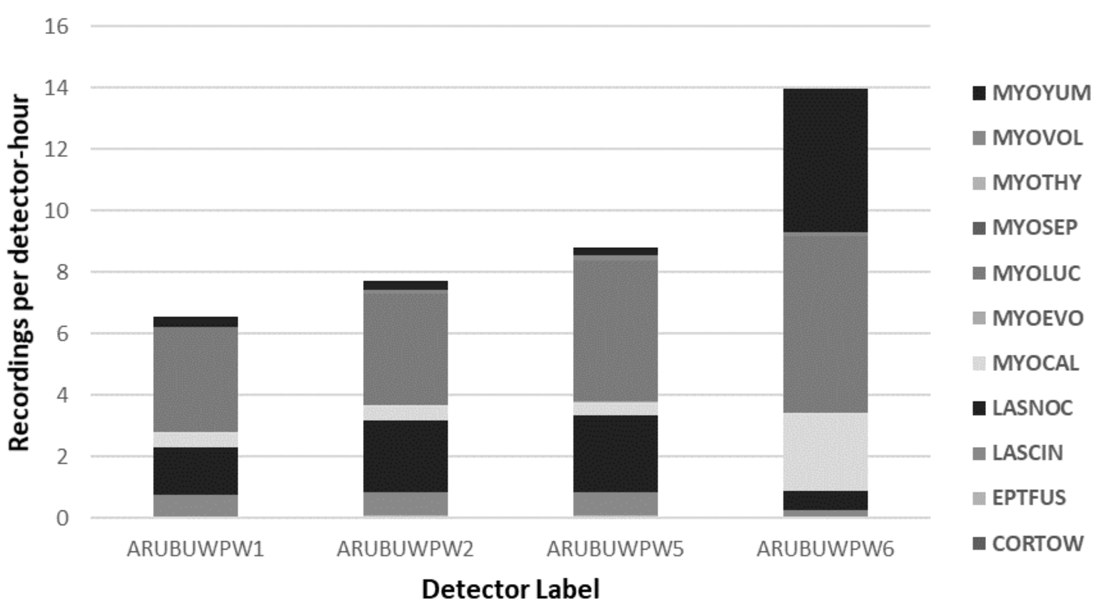


Figure 7-1. Relative abundance (recordings per detector-hour) of bat species by detector and site within Arrow Lake Reservoir, 2021.

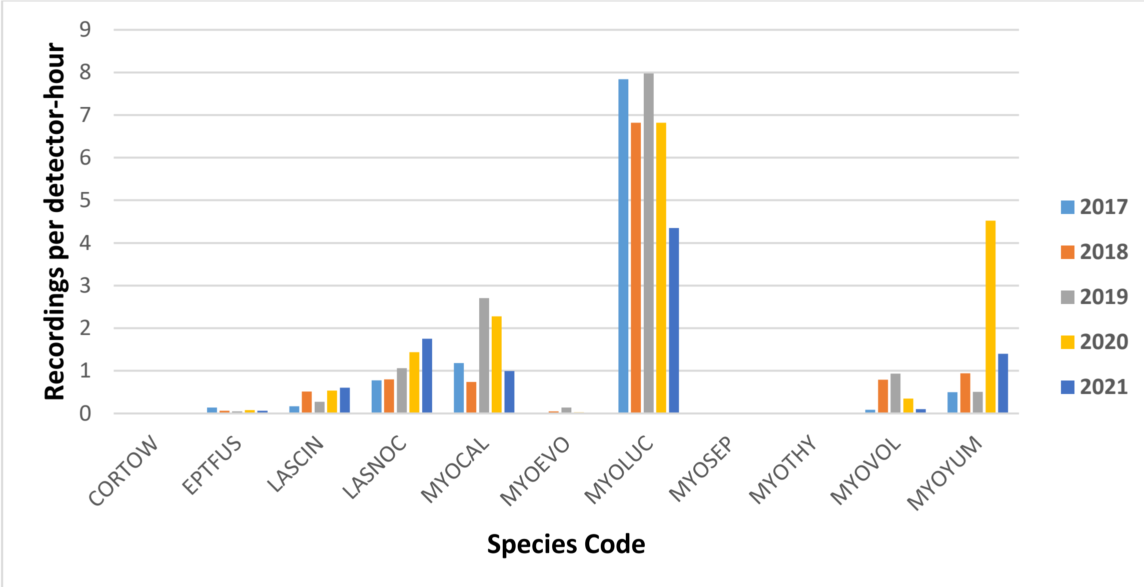


Figure 7-2. Proportion of recordings per detector-hour for all bat species documented by autonomous recording units deployed in the Burton Creek Wildlife Physical Works area. Bat species were monitored in 2017 (n=3 ARUs), 2018 (n=3), 2019 (n=2), 2020 (n=5), and 2021 (n=4). Species codes are provided in Table 7-1.

7.4 Bat Discussion

The 11 species of bat detected at Burton Creek in 2021 were consistent with those detected in previous years (Hentze et al. 2019; Waytes et al. 2020; Waytes et al. 2021). This includes the federally endangered Little Brown Myotis, which was one of the most frequently recorded bats at the site. This species is designated as secure (yellow) in British Columbia but has experienced severe declines in other parts of its range due in part to the impact of the White-nose Syndrome (COSEWIC 2013b). Another federally designated bat, Northern Myotis, was detected at Burton Creek in low numbers, as well as the blue listed Townsend's Big-eared Bat and Fringed Myotis. Yuma Myotis had a higher number of detections in both 2020 and 2021 at the same location (ARU06), which could indicate the presence of a roost in the nearby area. An in-person survey while bats are active in the summer months could confirm whether this was the case.

8.0 AMPHIBIANS

Amphibians interact with both the terrestrial and aquatic components of an environment, and as such can be valuable indicators of changes to the ecosystem. Most amphibians breed in water (Duellman and Trueb 1986), making water availability essential for reproduction. Water quality and variability can affect amphibian development (Schmuck et al. 1994), and fluctuations in abiotic variables in the local environment (such as in ephemeral aquatic habitats) can influence the developmental rate of juveniles (Gerlanc and Kaufman 2005).

Amphibians are expected to benefit from the addition of the constructed ponds in the WPW area, especially during the breeding season (May-August). Amphibian species found previously in the area include the Western Toad (*Anaxyrus boreas*), a species of special concern (COSEWIC 2012), Columbia Spotted Frog (*Rana luteiventris*), and Pacific TreeFrog (*Pseudacris regilla*) (Hawkes et al. 2020). Given that amphibians were identified as one of the groups of wildlife that would benefit from the construction of wetlands at Burton Creek it is important to understand how amphibians in the area interact with the WPW features.

8.1 Amphibian Sampling

Visual Encounter Surveys (VES) and acoustic ARUs were used to detect amphibians in the Burton Creek WPW area. VES are a commonly used technique for detecting conspicuous species and provide information on species presence, richness, and habitat use. These surveys incorporated searches for both adults as well as egg masses.

Two observers conducted VES in the Burton Creek WPW area in May 2021 to document signs of amphibians. Surveys were conducted during the late morning and early afternoon of May 4 and May 6 of 2021. Surveyors spent approximately 1.2 hrs each on May 4 and 0.75 hours each on May 6 for VES, for a total survey effort of 4.75 hours over the two survey days. The surveys on May 4 focused on walking the perimeter of the constructed ponds, the nearby reservoir edge, and searching the adjacent drawdown zone, while on May 6 the surveys were restricted to the perimeter of constructed ponds. In addition to targeted VES in May, incidental observations of amphibians were recorded opportunistically throughout the season.

Acoustic ARUs allow passive documentation of the occurrence of amphibians at the WPW, including when researchers are not present at the site. The focus of acoustic ARU recordings was on breeding adults, primarily Western Toad. The Wildlife Acoustics Song Meter autonomous recording units (SM4) deployed for songbird sampling were used to monitor for the calls of amphibians, including Western Toads. See Section 6.1 for more details on ARU deployment and Appendix E for a map of sampled locations.

8.2 Data Analyses

We scanned the acoustic ARU recordings using a Western Toad recognizer to detect vocalizations with Song Scope™ software. The survey period was restricted to the peak of the amphibian breeding season (Hawkes et al. 2020), which included the period of ARU deployment (4 or 5 May 2021) to July 1. The Western Toad recognizer was developed by the Bioacoustic Unit, a group within the Alberta Biodiversity Monitoring Unit (http://bioacoustic.abmi.ca/). We used the suggested Quality (30) and Score (50) threshold settings. This recognizer is species-specific and can detect the primary mating vocalizations of male Western Toads, allowing large amounts of data to be efficiently processed. The outputs of the recognizer scans were then reviewed by human listening and/or spectrogram visualization to determine whether they correctly captured target calls (i.e., Western Toad) or were false hits.

8.3 Amphibian Results

The May VES results included observations of Pacific Treefrog in constructed ponds A1 and A2. This included a live Pacific Treefrog adult in pond A2, a dead adult in pond A1, and eight egg masses in pond A1. Additional incidental amphibian encounters in 2021 included a Columbia Spotted Frog egg mass in pond A1 on April 8, a Columbia Spotted Frog in a constructed pond on May 22 (Figure 8-1), and a Columbia Spotted Frog in pond A1 on October 4.

Western Toad vocalizations were detected on an acoustic ARU (ARU06) on June 25 and 28 (Figure 8-2). Additionally, incidental Pacific Treefrog calls were recorded almost daily from May 5 to July 1 on ARUs, and their calls were picked up at least once on each of the four units (although they were predominantly recorded on ARU01).

Figure 8-1. From left to right, a Pacific Treefrog, a Columbia Spotted Frog, and a Columbia Spotted Frog egg mass photographed in the WPW area. Photo Credits: D. Adama (left) and M. Miller (middle and right).

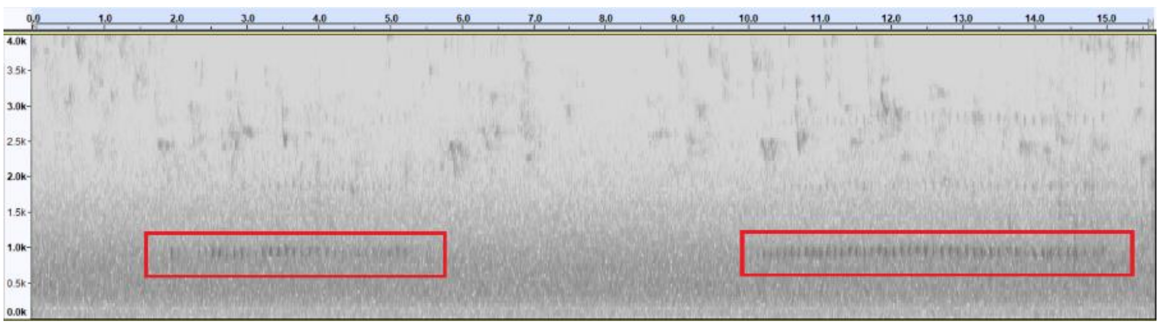


Figure 8-2. A spectrogram of a Western Toad call from June 25, 2022. Vocalization is highlighted in red.

8.4 Amphibian Discussion

Three amphibian species were documented using the constructed ponds and vocalizing in the WPW area. These species were also recorded in the area in 2020 (Waytes et al. 2021) and were previously documented in the Burton Creek area during work associated with CLBMON-37 (Hawkes et al. 2020). The Western Toad is currently listed as Special Concern by COSEWIC (2012) and was listed under Schedule 1 of the *SARA* in 2005. The management objective outlined by Environment and Climate Change Canada (2016) is "to maintain stable or increasing populations distributed throughout the species' present range in Canada". The construction of wetland/pond habitat at the Burton Creek location should provide suitable breeding habitat for Western Toad thereby contributing to the maintenance of Western Toad populations at this location. The use of the area by Long-toed Salamander (*Ambystoma macrodactylum*) is expected but surveys during late April (and at night) would determine whether the species is in the area and using the WPW ponds at Burton Creek.

The presence of both adults and egg masses in the constructed ponds is a positive indication that the WPW features are providing habitat to local amphibian species. Amphibian activity largely occurred in the ponds A1 and A2. These ponds had the greatest diversity of planted vegetation (Miller and Hawkes 2021, draft), and the higher abundance of aquatic invertebrates in pond A1 (see Section 5.0) could serve as a food source for amphibians. Pond A1 was also the only pond not affected by construction activity in 2021, and spring construction could have affected amphibian use of the other ponds that year.

The low oxygen conditions of the ponds in July could be of some concern for amphibian development. Low oxygen concentrations can adversely affect amphibian development; sustained hypoxic conditions may result in higher mortality (Sparling 2009). The degree that this would affect amphibians depends on the timing of breeding (as oxygen levels were higher in spring) and whether low DO was associated with egg deposition or free-swimming life forms (tadpoles, juveniles, and adults). It is also unclear whether these conditions are typical or were influenced by unusually high ambient temperatures in late June and early July during the heat dome.

9.0 GENERAL WILDLIFE

Remote wildlife cameras are a cost effective, non-invasive tool for assessing and monitoring many terrestrial wildlife species, especially large- and medium-sized animals, as well as more inconspicuous species. With sufficient maintenance, wildlife cameras can provide long-term monitoring of an area. When deployed appropriately they can be used to study the use and distribution of wildlife species across areas and habitats (Burton et al. 2015). As such, wildlife cameras provide a tool for continuously monitoring the returnresponse of wildlife to restoration efforts on anthropogenically altered habitats.

9.1 Wildlife Sampling

Wildlife use of the WPW area was recorded with wildlife camera photos as well as incidental observations. Incidental wildlife observations were recorded opportunistically during other site surveys. Six RECONYX® HyperFire 2™ cameras were set up in the Burton Creek WPW area to monitor wildlife use of the WPW and surrounding areas (Appendix F; Appendix G). Cameras were deployed on 4-5 May 2021 and removed on November 11, 2021. The data from two cameras, BUCAM1 and BUCAM4, were only recorded through the end of June as the quantity of photographs taken exceeded the camera storage at that time. Cameras were programmed to take ten photos with each trigger using the 'RapidFire' setting, which takes about two frames per second. After the last photo, each camera was programmed with a quiet period of one minute. Trigger sensitivity was set to medium-high. Remote cameras have the potential to provide more complete information about the suite of species using an area since they record 24 hours a day. Wildlife camera photos taken in 2021 can be compared to those taken pre-WPW construction. It is expected that the wetland project will increase habitat suitability for a variety of wildlife, thus, we expect an increase in species richness using this site.

9.2 Data Analyses

Wildlife photographs were processed using Reconyx MapView Professional™. Each photograph was visually assessed for wildlife. If wildlife were present, they were sorted by species and number of individuals. We presented wildlife photographs by species and the associated number of photographs. It should be noted that wildlife photographs are not directly related to animal abundance, as one animal can trigger multiple photographs and multiple cameras may record the same animal. These data should be used only as a general reference for which species of wildlife are found in the area.

9.3 Wildlife Results

There were 4,948 photographs of wildlife taken at the Burton Creek WPW from May to November 2021, excluding photographs triggered by humans, dogs, and vegetation. The most common species photographed were Canada Goose, followed by White-tailed Deer (*Odocoileus virginianus*) and Bald Eagle (Table 9-1; Figure 9-1 and Figure 9-2). Canada Goose were associated with the largest range of individuals captured by wildlife cameras, with groups of 1 to 30 individuals photographed. The highest number of photographs of waterbirds was in June and July, which corresponded with increased reservoir levels and the inundation of the WPW area (Figure 9-3). Other species of note captured by wildlife cameras included a Coyote (*Canis latrans*), an Elk (*Cervus canadensis*), a Tree Swallow (*Tachycineta bicolor*), and a Barn Swallow (*Hirundo rustica*).

Table 9-1. Wildlife species photographed by remote cameras in the Burton WPW area in 2021. The number of recordings refers to the total number of wildlife camera photographs taken of a particular species, while the range of individuals refers to the minimum and maximum (in parentheses) number of individuals appearing in each photograph.

Species	Number of recordings	Range of individuals
Bald Eagle	528	1(1)
Barn Swallow	4	1(1)
Canada Goose	2435	1(30)
Common Merganser	19	1(2)
Common Raven	200	1(2)
Coyote	56	1(1)
Elk	9	1(1)
Mallard	341	1(9)
Tree Swallow	30	1(1)
White-tailed Deer	1318	1(4)

Figure 9-1. Photographs of waterbirds taken by remote cameras in the Burton Creek WPW area in 2021. From left to right, species are a Mallard, a Common Merganser, and Canada Geese.

Figure 9-2. Photographs of wildlife taken by remote cameras in the Burton Creek WPW area in 2021. From left to right, species are a White-tailed Deer, a Coyote, and a Bald Eagle.

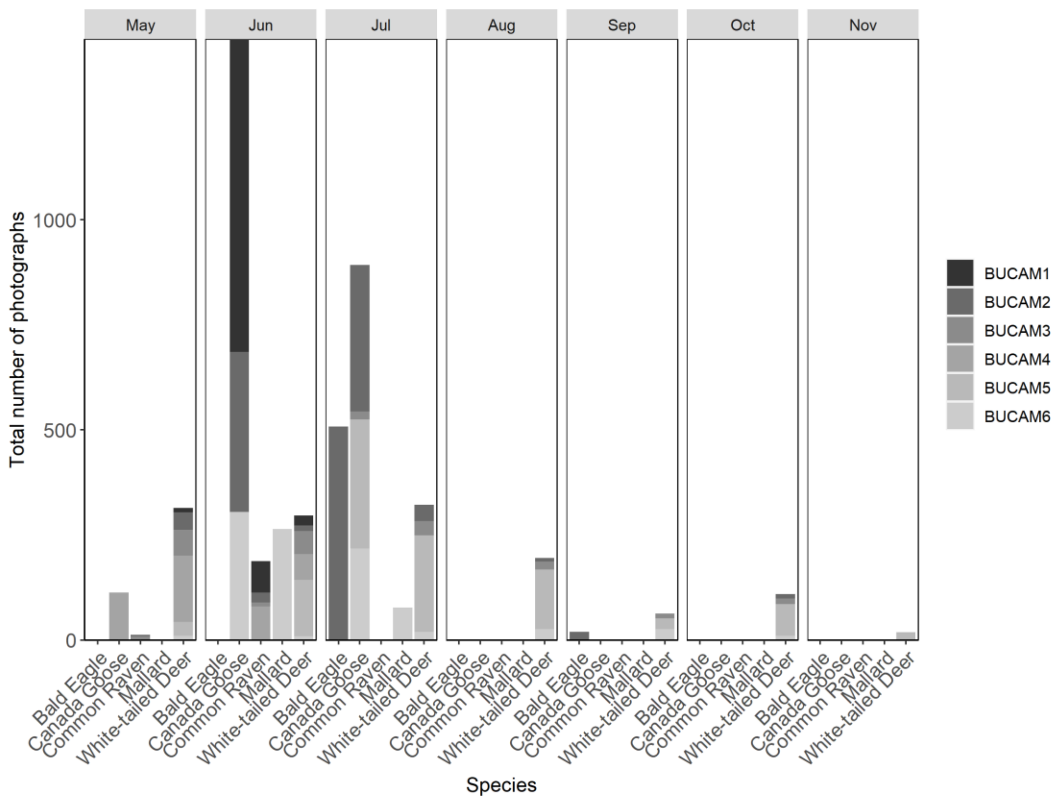


Figure 9-3. The number of wildlife camera photos taken per month by species and wildlife camera at the Burton Creek WPW area in 2021. Only those species with over 100 photographs taken over the course of the summer were included. The data from cameras BUCAM1 and BUCAM4 are restricted to May through June.

Incidental observations of wildlife in the area included a sighting of a Common Garter Snake (*Thamnophis sirtalis*) in May and two River Otters (*Lontra canadensis*) in October. In March and April of 2021, pollinators such as hoverflies (Syrphidae) were observed visiting planted willow stakes for pollen. The call of an American Pika (*Ochotona princeps*) was picked up by ARU02 on May 5.

9.4 Wildlife Discussion

The remote cameras provided evidence of continued wildlife use of the Burton Creek WPW area and documented wildlife interactions with WPW features, such as the use of snags and planted stakes by birds. White-tailed Deer were the most photographed mammal in the area and their presence was relatively consistent throughout the season. Photographs of Coyotes and Elk are evidence that other species use the area as well, although less frequently. The acoustic recoding of an American Pika on May 5 was particularly interesting, as this animal is not known to frequent the area. This species was not specifically targeted for monitoring with acoustic ARUs, so it is not known to what extent it was in the area other than the date the call was picked up. The riprap along the highway bordering the WPW area may provide possible habitat for this species. Bird activity in the WPW area that was documented on wildlife cameras, including Bald Eagle use of artificial snags, is discussed in greater detail in Section 6.4.

10.0 CONCLUSIONS

CLBMON-11B1, initiated in 2009, is a long-term wildlife monitoring project that first aimed to assess the efficacy of revegetation prescriptions (2009 – 2019) and then to assess the efficacy of wildlife physical works for enhancing the suitability of habitats in the drawdown zone for wildlife (starting in 2019). Wildlife physical works surveys focused on songbirds, bats, amphibians, aquatic invertebrates, and general wildlife. Prior to WPW construction, the suitability of the habitat in the area was considered to be low for most species (Hawkes and Tuttle 2016). This is consistent with the results of baseline studies in 2018 and 2019 (Hentze et al. 2019; Waytes et al. 2020).

The WPW construction at Burton Creek is anticipated to improve habitat suitability for wildlife including birds, amphibians, reptiles (Burton Creek currently has high suitability for snakes, which is not expected to change), mammals (bats), and insects (dragonflies), among others. Species with provincial or federal conservation designation that will benefit from this project include the provincially blue-listed and COSEWIC species of Special Concern, Western Toad; the provincially blue-listed Townsend's Big-eared Bat and Fringed Myotis; and the COSEWIC endangered Little Brown Myotis.

Results of the 2021 monitoring indicated that wildlife were using the area, including species with provincial or federal designation. This included waterbird and amphibian use of the WPW ponds, as well as terrestrial bird use of the artificial snags and planted stakes. Aquatic macroinvertebrate surveys confirmed the presence of invertebrates in all the ponds surveyed, although the most notable presence was in pond A1. Amphibian presence was also greatest at pond A1 and included signs of breeding amphibians (egg masses). Pond A1 was the only wetland feature that did not experience construction work in 2021, which could explain a greater amphibian and aquatic invertebrate presence in that year. Pond A1 had a greater plant diversity than some of the other ponds, is the highest elevation pond, and is directly downstream from a natural wetland, which could also impact its use by organisms. Continued monitoring will indicate the degree to which construction activities versus other factors affect use of the ponds by wildlife.

11.0 WILDLIFE PHYSICAL WORKS PERFORMANCE MEASURES

The final phase of construction for the Burton Creek WPW was completed in 2021. With the completion of the design work, the performance measures suggested by Hawkes and Tuttle (2016) can be reviewed and revised as needed. The objectives and performance measures as outlined by Hawkes and Tuttle (2016) are:

1. Creation of new wetland habitat in an area dominated by grasses (i.e., no current wetland habitat – see Section 3.0) and expansion of wetland habitats in the vicinity of ponds A1 and A2 (Map 1).
    a. Temporal availability of wetland overlaps with the migratory bird (particularly wetland-associated species) and amphibian breeding seasons (May-August). The permanence of the wetland should be assessed (i.e., is the wetland available each year and for how long?)
    b. Minimum depth of pond required to support amphibian breeding and larval development (Section 3.0).
2. Wetland productivity.
    a. Successful establishment of native macrophytes (planted or natural) into newly created wetlands within five years. "Successful establishment" is defined here as continuous species presence for at least two years. Currently there are no macrophytes at the site proposed for physical works.
    b. Successful natural establishment of native macroinvertebrates (e.g., odonates, cladocerans, gastropods) into newly created wetlands within 5 years. "Successful establishment" is defined here as continuous species presence for at least two years. The current biomass of macroinvertebrates at this site is nil.
    c. Evidence of breeding by amphibians (specifically Western Toad). The number of egg strings or masses should be counted on an annual basis following the implementation of the physical works. Egg development should be tracked to determine if eggs metamorphose into froglets or toadlets. Western Toads currently breed in the ponds situated at elevations <434 m ALS, but do not breed at the site proposed for physical works.
    d. Evidence of use of the wetland by waterfowl and shorebirds. Waterfowl have been observed using the area proposed for physical works, but only in small numbers, especially when inundated by Arrow Lakes Reservoir.
    e. Evidence of use of habitat enhancements (e.g., nest boxes, floating islands) by target waterfowl species (which will need to be determined) following completion of construction.
    f. Evidence of use of the constructed wetland by bats (as determine by autonomous recording units and use of enhancements such as bat boxes, snags, or other enhancements).

Monitoring in 2021 provided the first insights into WPW performance measures following the completion of the WPW construction in the spring of 2021. Continued monitoring will confirm the successful establishment of organisms such as aquatic macroinvertebrates in constructed ponds, as well as indicate shifts in wildlife use of WPW features as revegetation continues to establish in the area. Each of the WPW performance measures will be assessed following completion of the post-construction monitoring in 2023.

12.0 RECOMMENDATIONS

In 2017, the Terms of Reference for CLBMON-11B1 were revised (Revision 1, June 29, 2017, BC Hydro 2017). The work completed in 2021 represents the fourth year of implementation under these revised Terms of Reference. The surveys in 2021 represent the second year of the WPW monitoring after its establishment, and the first year after the completion of both Phase 1 and Phase 2 construction. The recommendations provided below are intended to assess the suitability of the Wildlife Physical Works at Burton Creek as construction continues.

1. **Summarize post-construction activities in and around the ponds and their affect on wildlife.** Maintenance activities of WPW features (such as Reed Canarygrass cutting) may affect wildlife interactions with the site.
2. **Conduct targeted surveys for odonates in the Burton Creek Wildlife Physical Works site.** CLBWORKS-29B specifically mentions odonates as taxa predicted to benefit from the creation of the wetland habitat at this site (Hawkes and Tuttle 2016). Baseline data on odonates that was gathered before the implementation of the WPW (Hentze et al. 2019; Waytes et al. 2020) will serve as a comparison to future odonate surveys.
3. **Incorporate water quality monitoring upstream of the drawdown zone and monitor changes in water depths throughout the season.** Monitoring upstream of the WPW wetland can provide a reference for water quality outside of the influence of reservoir activity. Understanding how the water depth of the ponds changes throughout the season can help inform fluctuations in physical water quality measurements, as well as give an idea of water availability throughout the season. This would require the installation of level loggers in all or a selection of the constructed ponds.
4. **Incorporate surveys for Long-toed Salamander (*Ambystoma macrodactylum*) into amphibian sampling.** This species is expected to be present in the area, but surveys during late April (and at night) would confirm this.

13.0 REFERENCES

Adamus, P., T.J. Danielson, and A. Gonyaw. 2001. Indicators for monitoring biological integrity of inland, freshwater wetlands: A survey of North American technical literature (1990-2000). United States Environmental Protection Agency, Washington, D.C. EPA843-R-01.

Armellin, A., D. Baird, C. Curry, N. Glozier, A. Martens, and E. McIvor. 2019. CABIN wetland macroinvertebrate protocol. Environment and Climate Change Canada, Gatineau, Q.C. 50 pp + Appendices.

Andersen, A.N. 1999. My bioindicator or yours? Making the selection. Journal of Insect Conservation 3:61-64.

B.C. Conservation Data Centre. 2019. BC Species and Ecosystems Explorer. B.C. Ministry of Environment, Victoria B.C. Available: http://a100.gov.bc.ca/pub/eswp/

BC Hydro. 2007. Columbia River project water use plan. BC Hydro Generation, Burnaby B.C.

BC Hydro. 2017. Columbia River Project Water Use Plan, Monitoring Terms of Reference: CLBMON 11B wildlife effectiveness monitoring of revegetation in Arrow Lakes Reservoir. BC Hydro, Burnaby, B.C. Revision 1, June 29, 2017.

Boeckman, C.J. and J.R. Bidwell. 2007. Spatial and seasonal variability in the water quality characteristics of an ephemeral wetland. Proceedings of the Oklahoma Academy of Science 87: 45-54.

Burnett, R.D., T. Gardali, and G.R. Geupel. 2005. Using songbird monitoring to guide and evaluate riparian restoration in salmonid-focused stream rehabilitation projects. In: Ralph, C.J. and T.D. Rich. Bird Conservation Implementation and Integration in the Americas: Proceedings of the Third International Partners in Flight Conference. 2002 March 20-24. Asilomar, CA: US Department of Agriculture, Forest Service, Pacific Southwest Research Station 191: 533–536.

Burton, A.C., E. Neilson, D. Moreira, A. Ladle, R. Steenweg, J.T. Fisher, E. Bayne, and S. Boutin. 2015. Wildlife camera trapping: a review and recommendations for linking surveys to ecological processes. Journal of Applied Ecology 52: 675-685.

Carr, W.W., A.E. Brotherston, and A.I. Moody. 1993. BC Hydro Upper Arrow dust control program, revegetation and special studies: program summary and recommendations 1990–1993.

Castro, I., A. De Rosa, N. Priyadarshani, L. Bradbury, and S. Marsland. 2019. Experimental test of birdcall detection by autonomous recorder units and by human observers using broadcast. Ecology and evolution 9(5): 2376–2397.

Chase, M.K. and G.R. Guepel. 2005. The use of avian focal species for conservation planning in California. USDA Forest Service General Technical Report PSW-GTR-191. 2005:130–142.

COSEWIC. 2009. COSEWIC assessment and status report on the Horned Grebe *Podiceps auritus*, Western population and Magdalen Islands population, in

Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 42 pp.

COSEWIC. 2012. COSEWIC assessment and status report on the Western Toad *Anaxyrus boreas* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xiv + 71 pp.

COSEWIC. 2013a. COSEWIC assessment and status report on the Bank Swallow *Riparia riparia* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. ix + 48 pp.

COSEWIC. 2013b. COSEWIC assessment and status report on the Little Brown Myotis *lucifugus*, Northern Myotis *septentrionalis* and Tri-colored Bat *Perimyotis subflavus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xxiv + 93 pp.

COSEWIC. 2014. COSEWIC assessment and status report on the Western Grebe *Aechmophorus occidentalis* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 55 pp.

COSEWIC. 2019. COSEWIC assessment and status report on the Hudsonian Godwit *Limosa haemastica* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 50 pp.

COSEWIC. 2020. COSEWIC assessment and status report on the Lesser Yellowlegs *Tringa flavipes* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 64 pp.

COSEWIC. 2021. COSEWIC assessment and status report on the Barn Swallow *Hirundo rustica* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xii + 60 pp.

Davis, J.C. 1975. Minimal dissolved oxygen requirements of aquatic life with emphasis on Canadian species: a review. Journal of the Fisheries Research Board of Canada 32(12): 1975.

DeSante, D.F. and G.R. Geupel. 1987. Landbird productivity in central coastal California: the relationship to annual rainfall, and a reproductive failure in 1986. Condor: 636–653.

Duellman, W.E. and L. Trueb. 1986. Biology of Amphibians. Johns Hopkins University Press, Baltimore, MD, USA.

Environment and Climate Change Canada. 2016. Management Plan for the Western Toad (*Anaxyrus boreas*) in Canada [Proposed]. *Species at Risk Act* Management Plan Series. Environment and Climate Change Canada, Ottawa. iv + 38 pp.

Feinsinger, P. 2001. Designing field studies for biodiversity conservation. Island Press, Washington, D.C.

Fore, L.S., J.R. Karr and R.W. Wisseman. 1996. Assessing invertebrate response to human activities: evaluating alternative approaches. The North American Benthological Society, 15(2):212-231.

Galic, N., T. Hawkins, and V.E. Forbes. 2019. Adverse impacts of hypoxia on aquatic invertebrates: A meta-analysis. Science of the Total Environment 652: 736-743.

Gaufin, A.R. 1973. Use of aquatic invertebrates in the assessment of water quality. Biological Methods for the Assessment of Water Quality, American Society for Testing and Materials, pp. 96-116.

Gerlanc, N.M. and G.A. Kaufman. 2005. Habitat of origin and changes in water chemistry influence development of Western Chorus Frogs. Journal of Herpetology 39(2): 254-265.

Gleason, J.E. and R.C. Rooney. 2018. Pond permanence is a key determinant of aquatic macroinvertebrate community structure in wetlands. Freshwater Biology 63: 264-277.

Hawkes, V.C. and J. Howard. 2012. CLBMON-11B1. Kinbasket and Arrow Lakes Reservoirs: wildlife effectiveness monitoring and enhancement area identification for lower and mid-Arrow Lakes Reservoir. wildlife enhancement prescriptions. LGL Report EA3274. Unpublished report by LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generations, Water Licence Requirements, Burnaby, B.C.

Hawkes, V.C. and K. Tuttle. 2016. CLBMON-29B. Arrow Feasibility Study of High Value Habitat for Wildlife Physical Works. 2016 Update. LGL Report EA3714. Unpublished report by LGL Limited environmental research associates, Sidney, B.C., for B.C. Hydro Generation, Water Licence Requirements, Burnaby, BC. 86 pp. + Appendices.

Hawkes, V.C., K.N. Tuttle, J.M. McAllister, and K.J. Meyers. 2020. CLBMON-37. Kinbasket and Arrow Lakes Reservoir: Amphibian and Reptile Life History and Habitat Use Assessment. Final Report 2008–2018. LGL Report EA3533F. Unpublished report by Okanagan Nation Alliance, Westbank, B.C., and LGL Limited environmental research associates, Sidney, B.C., for BC Hydro Generation, Water Licence Requirements, Burnaby, B.C. 95 pp. + Appendices.

Hentze, N.T., R. Waytes, C.M. Wood, V.C. Hawkes, and J. Gatten. 2019. CLBMON-11B1. Kinbasket and Arrow Lakes Reservoirs: Wildlife Effectiveness Monitoring and Enhancement Area Identification for Lower and Mid-Arrow Lakes Reservoir. Annual Report – 2018. LGL Report EA3450. Unpublished report by Okanagan Nation Alliance, Westbank, B.C. and LGL Limited environmental research associates, Sidney, B.C., for BC Hydro Generation, Water Licence Requirements, Burnaby, BC. 69 pp. + Appendices.

Jackson, J.L., K. Hennebury, and D. Baker. 1995. The Technical and Research Committee on Reclamation. Proceedings of the 19th Annual British Columbia Mine Reclamation Symposium in Dawson Creek, B.C. pp 75–87.

Kadlec, R.H. and K.R. Reddy. 2001. Temperature effects in treatment wetlands. Water Environment Research 73(5): 543-557.

Kerr Wood Leidel. 2018. Detailed design report: wildlife enhancement program at Burton Flats. Draft Report July 2018. KWL Project No. 0478.203. 156 pp.

Kerr Wood Leidal. 2021. Wildlife Enhancement Program at Burton Flats: Phase 2 Construction Completion. Draft Report. (KWL Project No.0478.203-300). 19 pp + appendices.

Machmer, M., and C. Steeger. 2002. Effectiveness monitoring guidelines for ecosystem restoration. B.C. Ministry of Environment, Victoria, B.C.

Marcot, B.G. 1998. Selecting appropriate statistical procedures and asking the right questions: a synthesis. *In* Statistical methods for adaptive management. Edited by V. Sit and B. Taylor. B.C. Ministry of Forests, Research Branch, Victoria, B.C.

Miller, M.T. and V.C. Hawkes. 2020. CLBWORKS-30B Arrow Lakes Reservoir Wildlife Enhancement Program. Burton Flats Planting Project (Phase 1). Final Report – 2019. LGL Report EA3957. Unpublished report by LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generatio Water Licence Requirements, Burnaby, BC. 38 pp.

Miller, M.T. and V.C. Hawkes. 2021. CLBWORKS-30B Arrow Lakes Reservoir Wildlife Enhancement Program. Burton Flats Planting Project (Phase 2). Draft Report – 2021. LGL Report EA4177. Unpublished report by LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generation Water Licence Requirements, Burnaby, BC. 29 pp.

Noon, B. R. 2003. Conceptual issues in monitoring ecological resources. *In:* Monitoring Ecosystems: Interdisciplinary Approaches for Evaluating Ecoregional Initiatives *Edited by* D. E. Busch, and J. C. Trexler. Island Press, Washington.

Ofenböck, T., O. Moog, J. Gerritsen, and M. Barbour. 2004. A stressor specific multimetric approach for monitoring running waters in Austria using benthic macro-invertebrates. Hydrobiologia 516: 251-268.

Resources Inventory Committee. 1999. Inventory methods for forest and grassland of songbirds: No. 15. Standardized Inventory Methodologies for Components of British Columbia's Biodiversity. Ministry of Environment, Lands and Parks, Government of British Columbia, Victoria, British Columbia.

Rich, T.D. 2002. Using breeding land birds in the assessment of western riparian systems. Wildlife Society Bulletin: 1128–1139.

Schmuck, R., W. Geise, and K.E. Linsenmair. 1994. Life cycle strategies and physiological adjustments of Reedfrog Tadpoles (Amphibia, Anura, Hyperoliidae) in relation to environmental conditions. Copeia 4: 996-1007.

Sparling, D.W. 2009. Water-quality criteria for amphibians. From: Amphibian Ecology and Conservation: A Handbook of Techniques. C.K. Dodd [Ed.] Oxford University Press, New York, U.S.A.

Szewczak, J.M., Corcoran, A.J., Kennedy, J.K., Ormsbee, P.C. & Weller, T.E. 2011a. Echolocation Call Characteristics of Western US Bats. Humboldt State University Bat Lab, Arcata, California. http://www.sonobat.com/download/WesternUS_Acoustic_Table_Mar2011.pdf

Szewczak, J.M., Corcoran, A.J., Kennedy, J.K., Ormsbee, P.C. & Weller, T.E. 2011b. Echolocation Call Characteristics of Eastern US Bats. Humboldt State University Bat Lab, Arcata, California. http://www.sonobat.com/download/EasternUS_Acoustic_Table_Mar2011.pdf

Temple, S.A. and J.A. Wiens. 1989. Bird populations and environmental changes: Can birds be bio-indicators? American Birds 43(2): 260–270.

Wallace, J.B., J.W. Grubaugh, and M.R. Whiles. 1996. Biotic indices and stream ecosystem processes: results from an experimental study. Ecological Applications 6(1): 140-151.

Waytes, R., N.T. Hentze, C.M. Wood, V.C. Hawkes, and J. Gatten. 2020. CLBMON-11B1. Kinbasket and Arrow Lakes Reservoirs: Wildlife Effectiveness Monitoring and Enhancement Area Identification for Lower afnd Mid-Arrow Lakes Reservoir. Annual Report – 2019. LGL Report EA3450. Unpublished report by Okanagan Nation Alliance, Westbank, B.C. and LGL Limited environmental research associates, Sidney, B.C., for BC Hydro Generation, Water Licence Requirements, Burnaby, BC. 80 pp. + Appendices.

Waytes, R., V.C. Hawkes, N.T. Hentze, J. Gatten, and M.T. Miller. 2021. CLBMON-11B1. Kinbasket and Arrow Lakes Reservoirs: Wildlife Effectiveness Monitoring and Enhancement Area Identification for Lower and Mid-Arrow Lakes Reservoir. Wildlife Physical Works Baseline Data Collection: Burton Creek Flats. LGL Report EA3450. Unpublished report by Okanagan Nation Alliance, Westbank, B.C. and LGL Limited environmental research associates, Sidney, B.C., for BC Hydro Generation, Water Licence Requirements, Burnaby, BC. 43 pp. + Appendices.

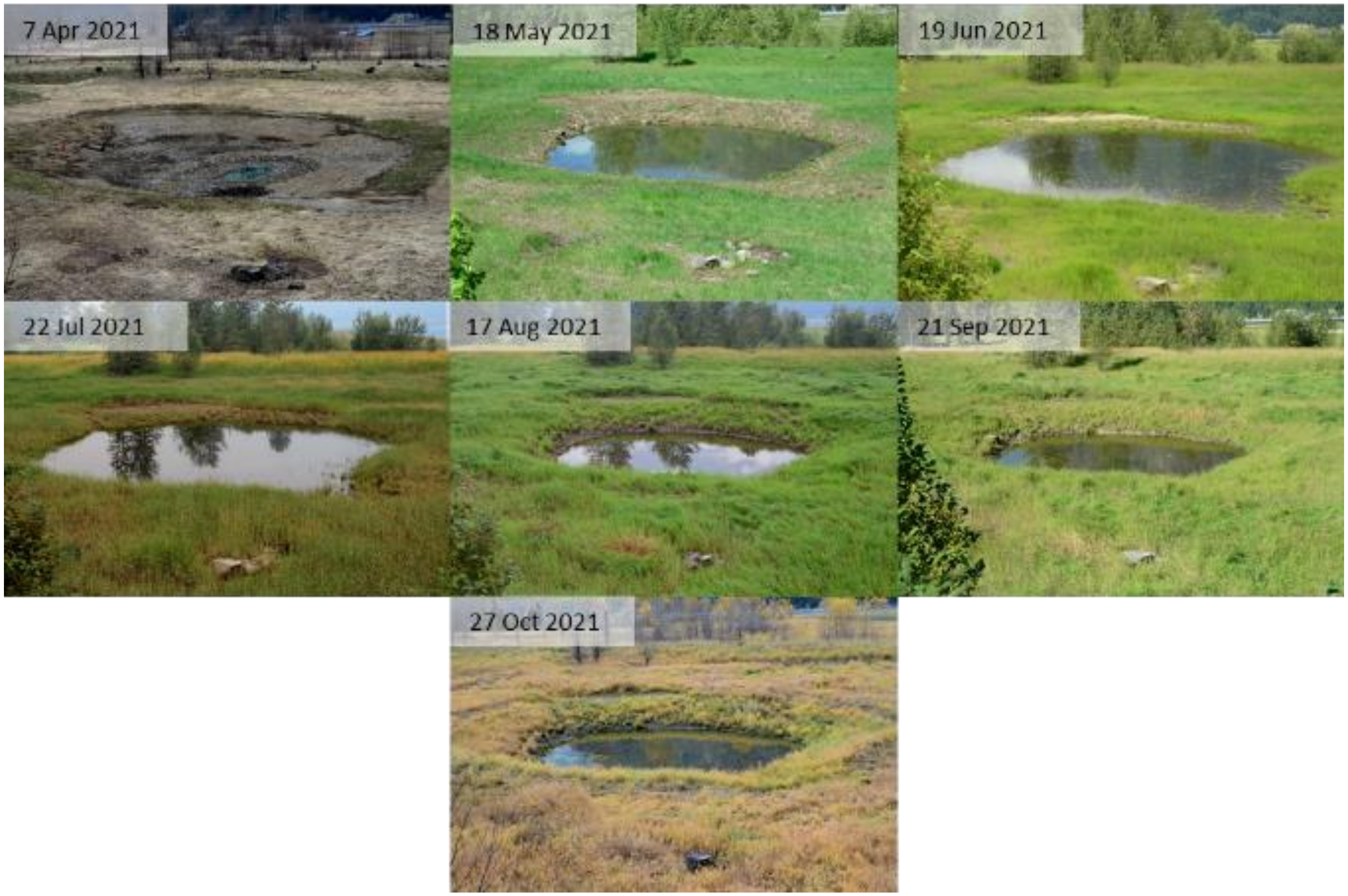
14.0 APPENDICES

Appendix A: Photographic time series for constructed physical works ponds A1-A4. Photos taken at Burton Creek from 7 April to 27 October 2021. Photo credit: G. Davidson.

CLBWORKS-30B
Pond A1

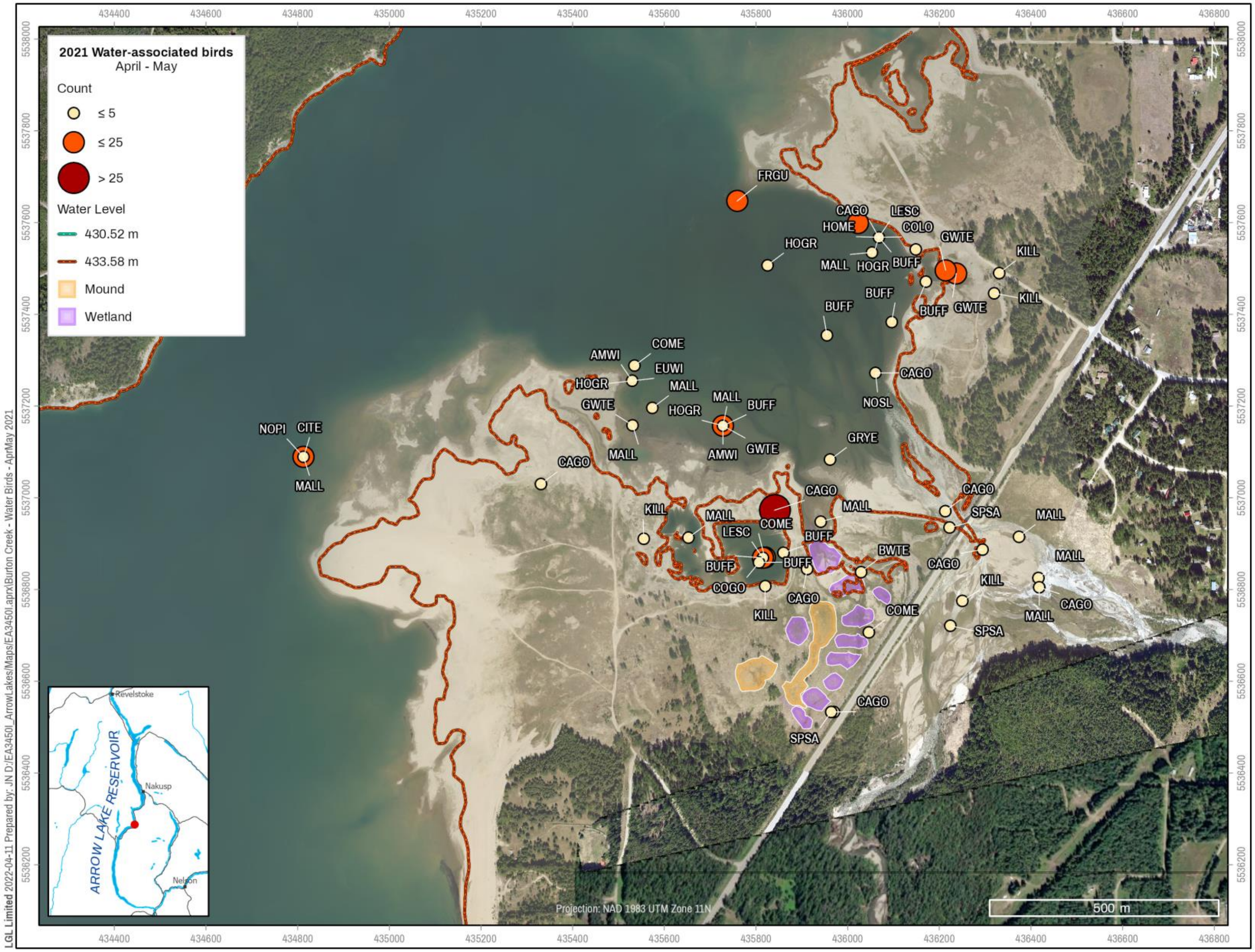
CLBWORKS-30B
Pond A2

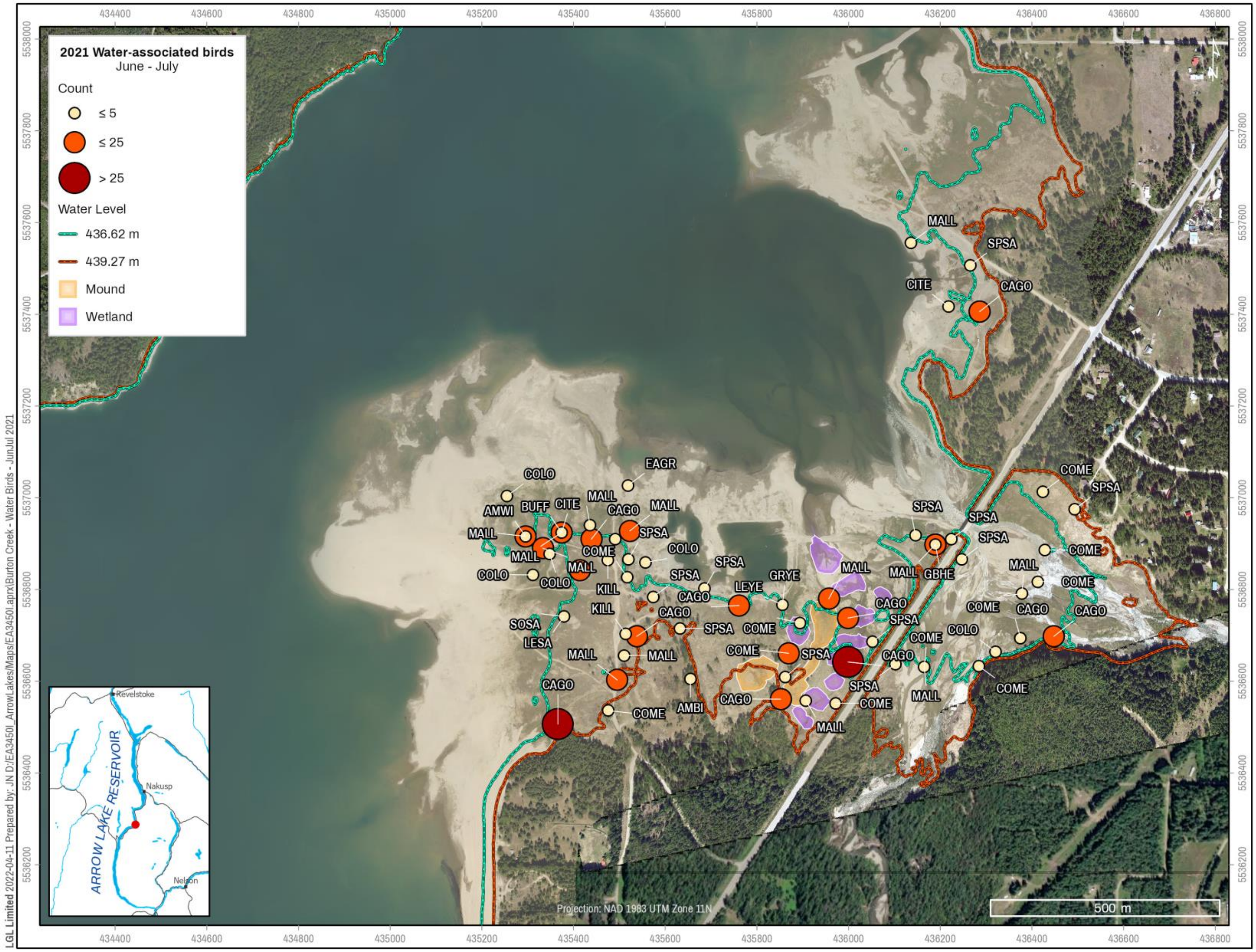
CLBWORKS-30B
Pond A3

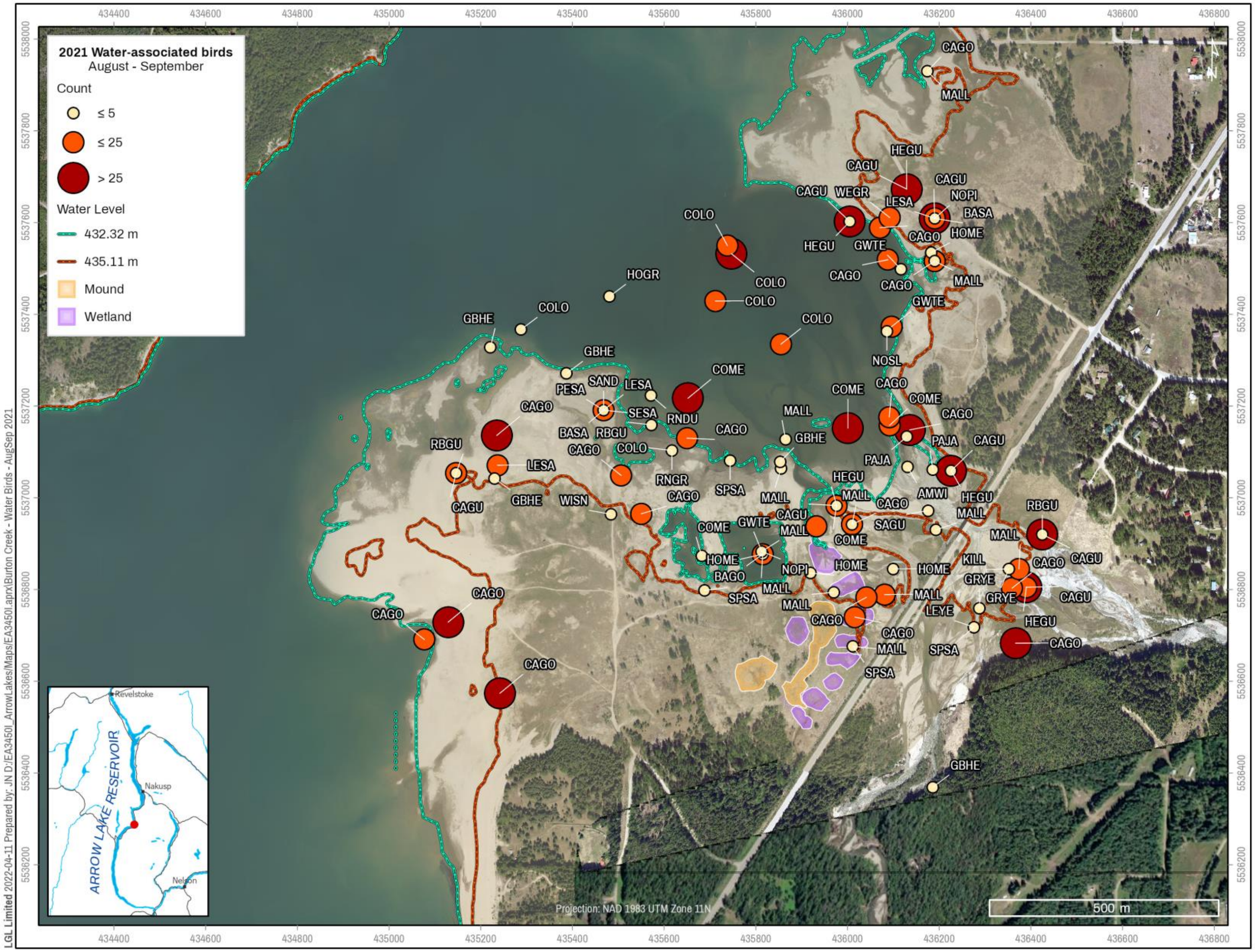


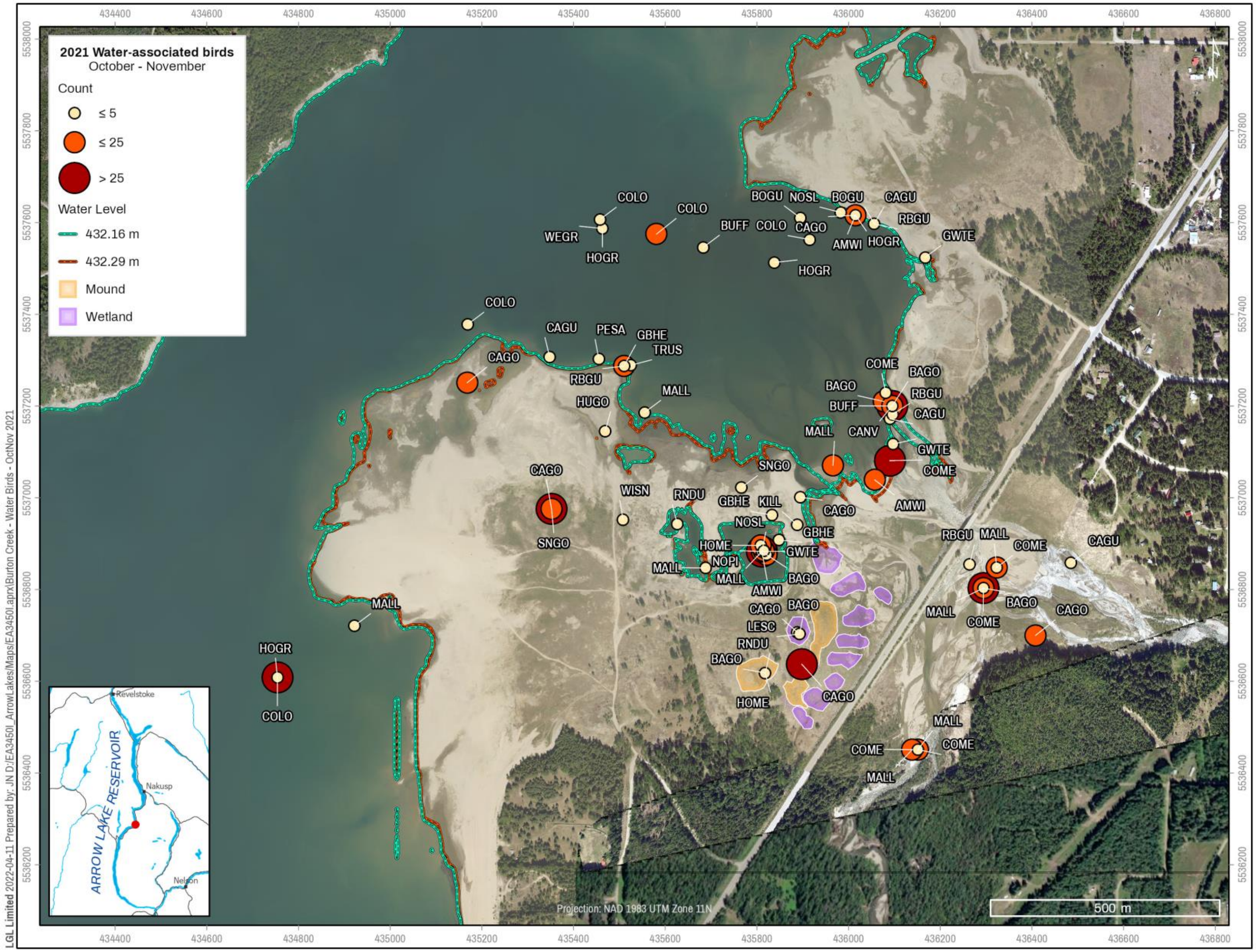
CLBWORKS-30B
Pond A4

Appendix B: Distribution of waterbird species using the constructed Burton Creek wildlife physical works features (blue polygon) and surrounding areas in April/May 2021 (first figure), June/July 2021 (second figure), August/September 2021 (third figure), and October/November 2021 (fourth figure).


2021 Water-associated birds
April - May
Count
≤ 5
≤ 25
> 25
Water Level
430.52 m
433.58 m
Mound
Wetland
Revelstoke
ARROW LAKE RESERVOIR
Nakusp
Nelson
Projection: NAD 1983 UTM Zone 11N
500 m
LGL Limited 2022-04-11 Prepared by: JN D:\EA3450_ArrowLakes\Maps\EA3450I.aprx\Burton Creek - Water Birds - AprMay 2021
FRGU
CAGO
HOME
LESC
COLO
GWTE
HOGR
MALL
BUFF
KILL
COME
AMWI
EUWI
NOSL
GRYE
NOPI
CITE
CAGO
SPSA
BWTE
COGO
CAGO


2021 Water-associated birds
June - July
Count
≤ 5
≤ 25
> 25
Water Level
436.62 m
439.27 m
Mound
Wetland
Revelstoke
Nakusp
Nelson
ARROW LAKE RESERVOIR
Projection: NAD 1983 UTM Zone 11N
500 m
LGL Limited 2022-04-11 Prepared by: JN D:\EA3450I_ArrowLakes\Maps\EA3450I.aprx\Burton Creek - Water Birds - JunJul 2021

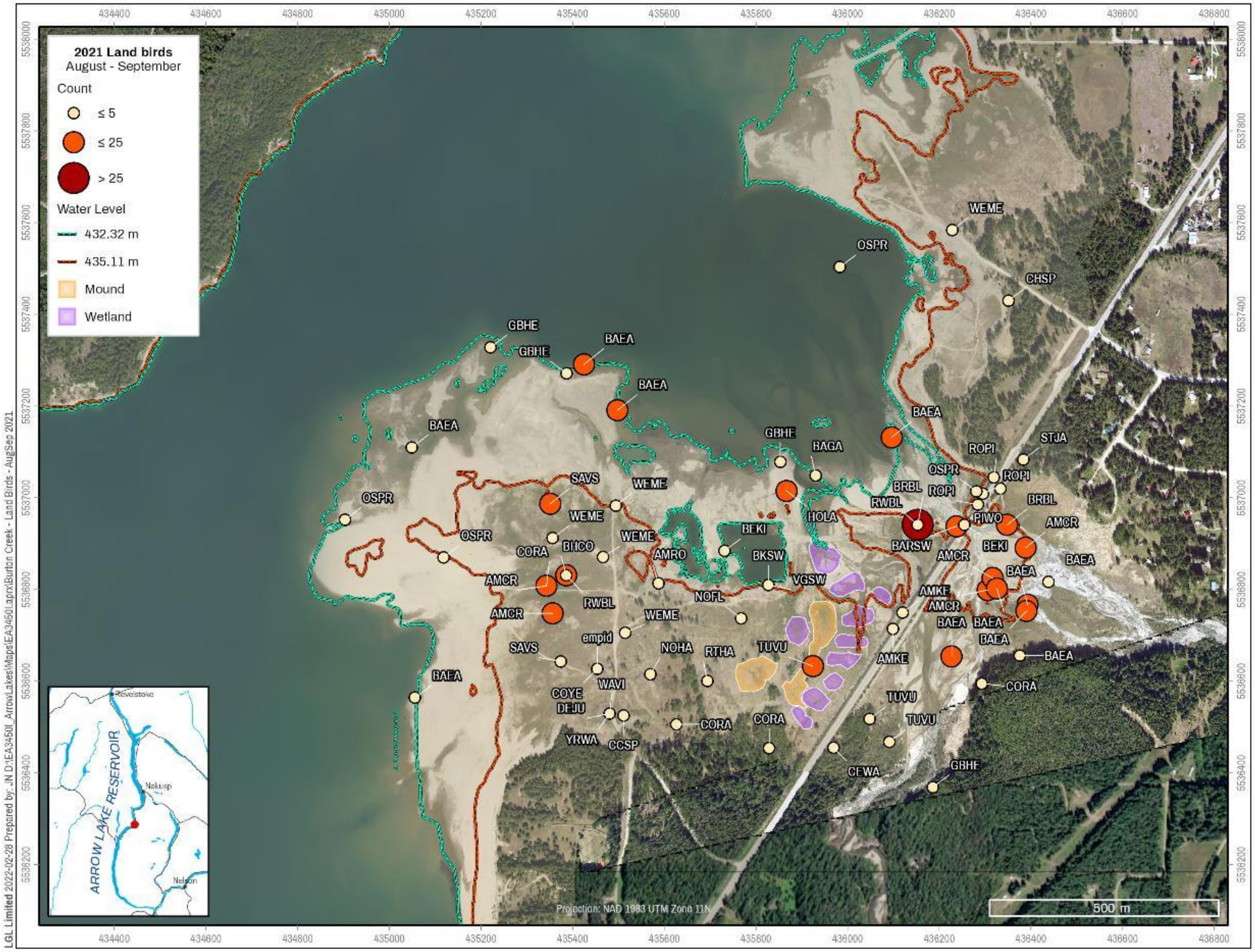

2021 Water-associated birds
August - September
Count
≤ 5
≤ 25
> 25
Water Level
432.32 m
435.11 m
Mound
Wetland
Revelstoke
Nakusp
Nelson
ARROW LAKE RESERVOIR
Projection: NAD 1983 UTM Zone 11N
500 m
LGL Limited 2022-04-11 Prepared by: JN D:\EA3450I_ArrowLakes\Maps\EA3450I.aprx\Burton Creek - Water Birds - AugSep 2021

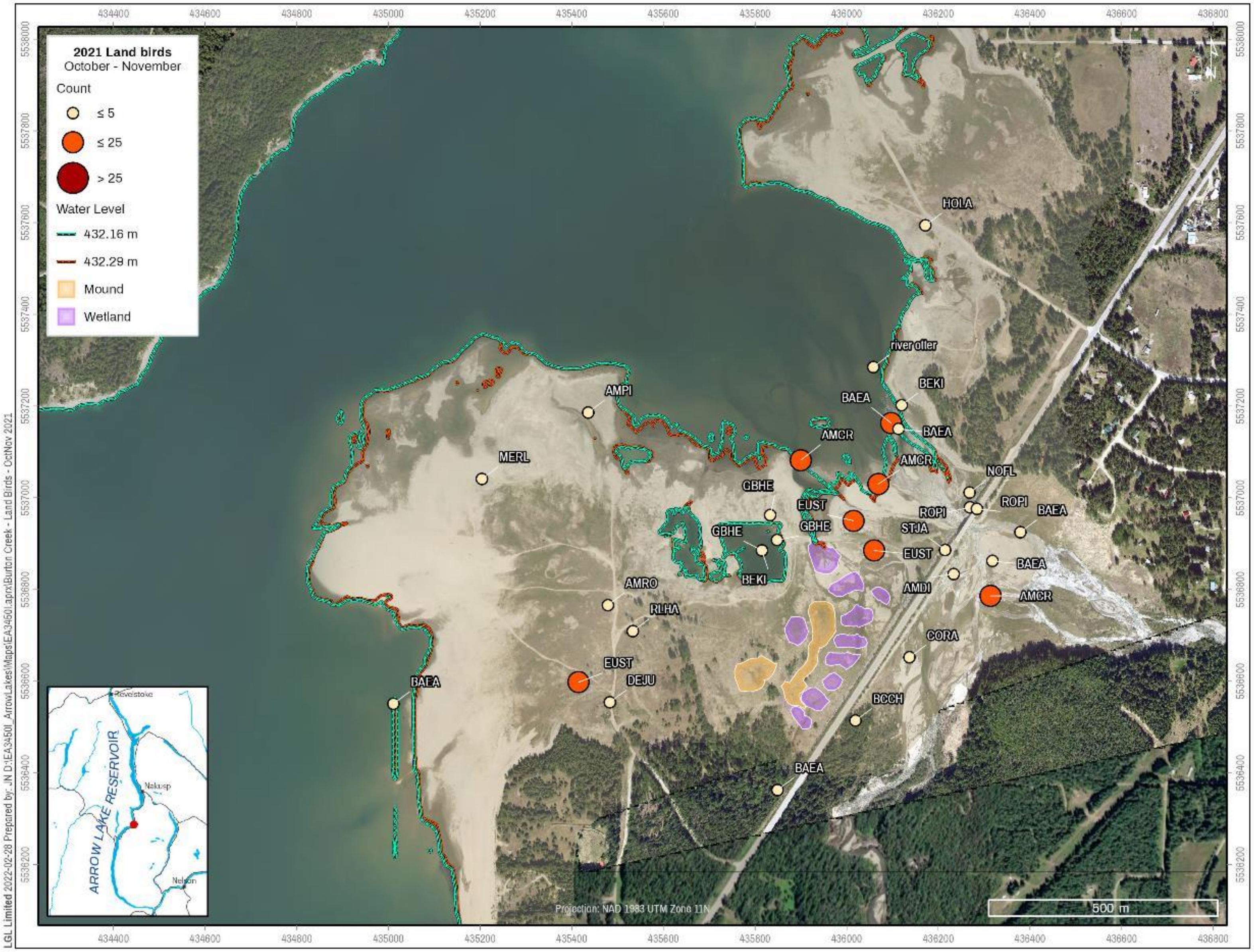

2021 Water-associated birds
October - November
Count
≤ 5
≤ 25
> 25
Water Level
432.16 m
432.29 m
Mound
Wetland
Revelstoke
Nakusp
Nelson
ARROW LAKE RESERVOIR
Projection: NAD 1983 UTM Zone 11N
500 m
LGL Limited 2022-04-11 Prepared by: JN D:/EA3450I_ArrowLakes/Maps/EA3450I.aprx\Burton Creek - Water Birds - OctNov 2021

Appendix C: Distribution of land bird species recorded during waterbird surveys using the constructed Burton Creek wildlife physical works features (blue polygon) and surrounding areas in April/May 2021 (first figure), June/July 2021 (second figure), August/September 2021 (third figure), and October/November 2021 (fourth figure).


2021 Land birds
April - May
Count
≤ 5
≤ 25
> 25
Water Level
430.52 m
433.58 m
Mound
Wetland
ARROW LAKE RESERVOIR
Revelstoke
Nakusp
Nelson
Projection: NAD 1983 UTM Zone 11N
500 m
MOBL
WEMF
YRWA
CBCH
WAVI
RBNU
CHSP
AMCR
WEME
TUVU
BARSW
BAEA
CLSW
BAKSW
BHCO
AMPI
VGSW
TREESW
NRWS
AMRO
ECDO
AMDI
TRSW
AMKE
MODO
NOFL
VASW
COYE
RCKI
YEWA
LGL Limited 2022-02-28 Prepared by: JN


2021 Land birds
June - July
Count
≤ 5
≤ 25
> 25
Water Level
436.62 m
439.27 m
Mound
Wetland
Projection: NAD 1983 UTM Zone 11N
500 m
ARROW LAKE RESERVOIR
Revelstoke
Nakusp
Nelson
LGL Limited 2022-02-28 Prepared by: JN D:\EA3450I_ArrowLakes\Maps\EA3450I.aprx\Burton Creek - Land Birds - JunJul 2021


2021 Land birds
August - September
Count
≤ 5
≤ 25
> 25
Water Level
432.32 m
435.11 m
Mound
Wetland
Projection: NAD 1983 UTM Zone 11N
500 m
ARROW LAKE RESERVOIR
Revelstoke
Nakusp
Nelson
LGL Limited 2022-02-28 Prepared by: JN D:\EA3450I_ArrowLakes\Maps\EA3450I.aprx\Burton Creek - Land Birds - AugSep 2021


2021 Land birds
October - November
Count
≤ 5
≤ 25
> 25
Water Level
432.16 m
432.29 m
Mound
Wetland
HOLA
river otter
BEKI
BAEA
AMCR
AMPI
MERL
NOFL
GBHE
EUST
ROPI
STJA
AMDI
AMRO
RTHA
CORA
DEJU
BCCH
Revelstoke
Nakusp
Nelson
ARROW LAKE RESERVOIR
Projection: NAD 1983 UTM Zone 11N
500 m
LGL Limited 2022-02-28 Prepared by: JN D:\EA3450I_ArrowLakes\Maps\EA3450I.aprx\Burton Creek - Land Birds - OctNov 2021

Appendix D: Number of observations of all waterbird and land bird species detected during waterbird surveys by month in 2021. Tables sorted alphabetically by species.

	Month							
Waterbird Species	Apr	May	Jun	Jul	Aug	Sep	Oct	**Total**
American Bittern				1				**1**
American Wigeon	9		1			11	73	**94**
Baird's Sandpiper					15			**15**
Barrow's Goldeneye					1		121	**122**
Blue-winged Teal		3						**3**
Bonaparte's Gull							5	**5**
Bufflehead	33	11	1				58	**103**
California Gull					122	730	11	**863**
Canada Goose	15	39	30	167	311	50	135	**747**
Canvasback							2	**2**
Cinnamon Teal	2		3					**5**
Common Goldeneye		1						**1**
Common Loon	1		4	7	18	39	77	**146**
Common Merganser	2	20	16	14	28	96	86	**262**
Eared Grebe			2					**2**
Eurasian Wigeon	1							**1**
Franklin's Gull		14						**14**
Gadwall							3	**3**
Great Blue Heron				8	2	5	23	**38**
Greater Scaup							1	**1**
Greater Yellowlegs	1			2	2			**5**
Green-winged Teal	36		1			12	13	**62**
Herring Gull					3	50		**53**
Hooded Merganser	2				6	2	22	**32**
Horned Grebe	9					1	8	**18**
Hudsonian Godwit							1	**1**
Killdeer	6	3	3		1		1	**14**
Least Sandpiper				1	16			**17**
Lesser Scaup	2						2	**4**
Lesser Yellowlegs				1	5			**6**
Mallard	17	10	79	17	40	4	183	**350**
Northern Pintail	7				3	1	5	**16**
Northern Shoveler	5					1	5	**11**
Parasitic Jaeger						2		**2**
Pectoral Sandpiper					1		2	**3**
Red-necked Grebe					1			**1**
Ring-billed Gull					3	2	4	**9**
Ring-necked Duck						3	25	**28**

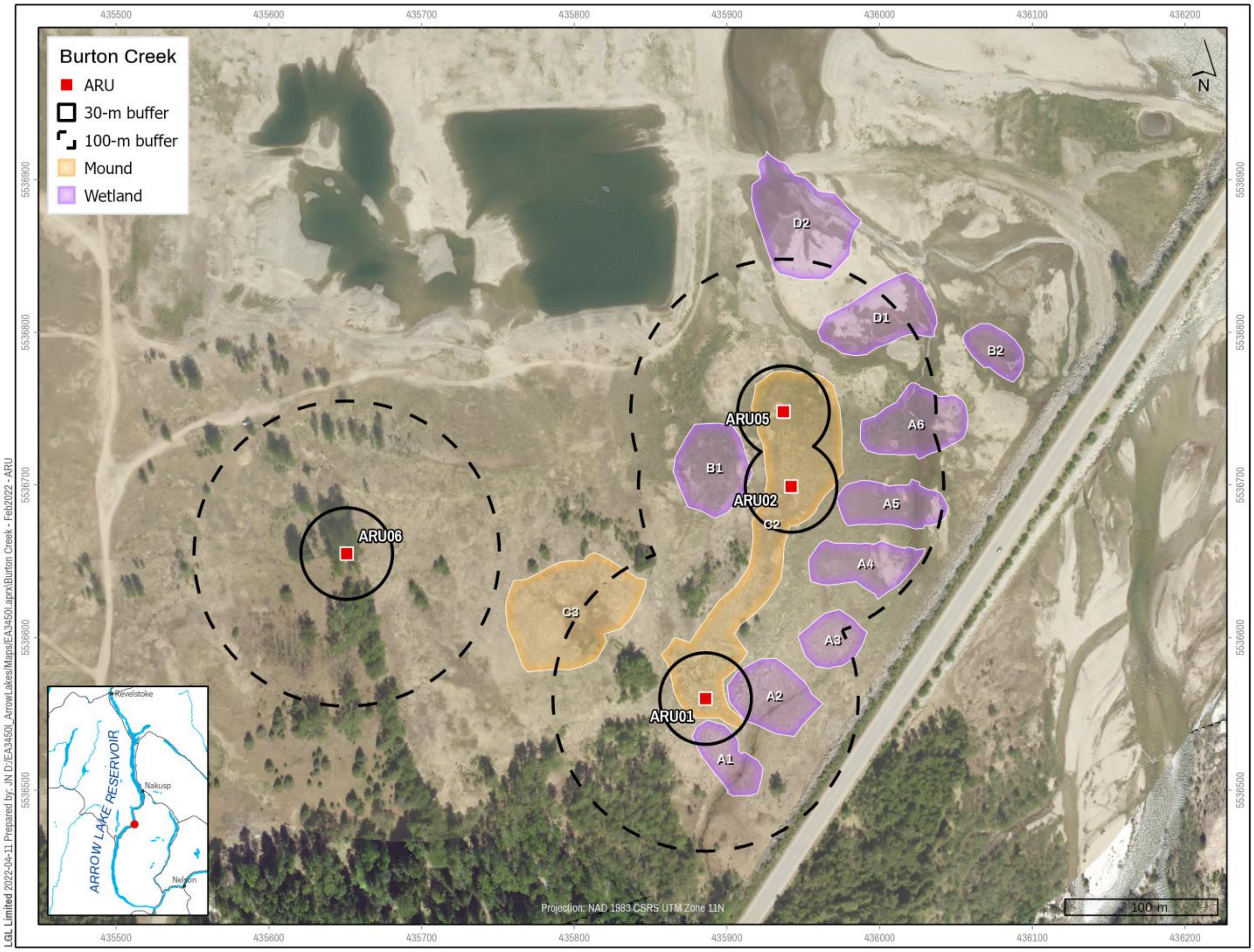
Sabine's Gull						1		**1**

	Month							
Waterbird Species (*continued*)	Apr	May	Jun	Jul	Aug	Sep	Oct	**Total**
Sanderling					1			**1**
Semipalmated Sandpiper					1			**1**
Snow Goose							10	**10**
Solitary Sandpiper				1				**1**
Spotted Sandpiper		4	8	9	5			**26**
Trumpeter Swan							6	**6**
Western Grebe						12	2	**14**
Wilson's Snipe				1	2		1	**4**
Total	**148**	**105**	**148**	**229**	**587**	**1022**	**885**	**3124**

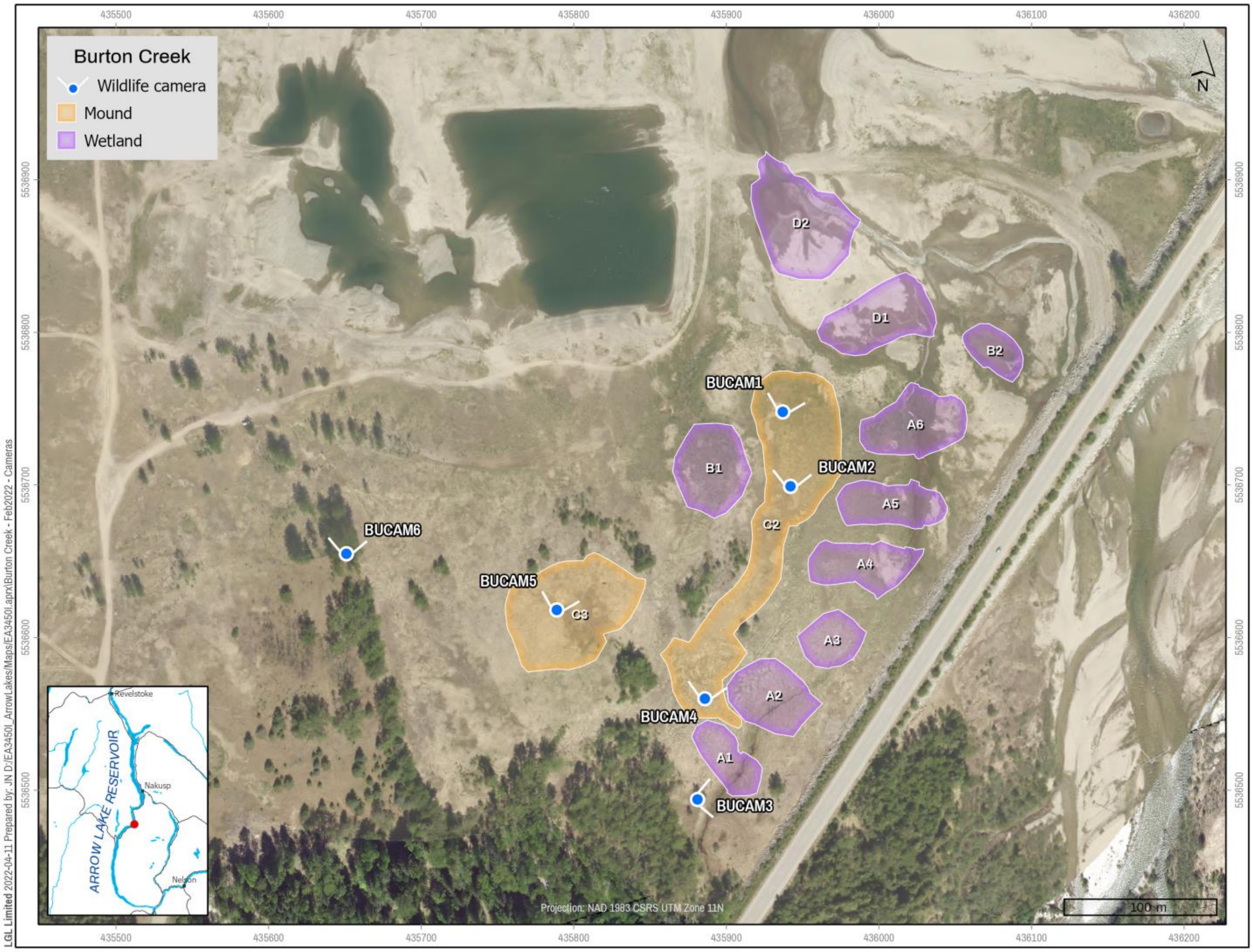
	Month							
Land Bird Species	April	May	June	July	August	September	October	**Total**
American Crow	9	4			22	42	37	**114**
American Dipper	1						1	**2**
American Kestrel	1	2				3		**6**
American Pipit	10						2	**12**
American Robin	8	1	2	3		1	1	**16**
Bald Eagle		3	1	2	18	91	24	**139**
Bank Swallow		1			1			**2**
Barn Swallow		2	25	12	12			**51**
Belted Kingfisher			1		1	1	2	**5**
Black-capped Chickadee							1	**1**
Brewer's Blackbird					57			**57**
Brown-headed Cowbird		1			1			**2**
Cedar Waxwing				9	1			**10**
Chestnut-backed Chickadee		1						**1**
Chipping Sparrow		1	1		3			**5**
Clay-colored Sparrow						1		**1**
Cliff Swallow		6	25	12	6			**49**
Common Raven			1	4	12	6	1	**24**
Common Yellowthroat		2	1	2		1		**6**
Dark-eyed Junco						1	3	**4**
Eurasian Collared-Dove		1						**1**
European Starling							56	**56**
Gray Catbird				1				**1**
Horned Lark						7	2	**9**
Lazuli Bunting			1	1				**2**
Merlin							1	**1**
Mountain Bluebird	6	3						**9**
Mourning Dove		1						**1**
Northern Flicker	1			2		2	1	**6**
Northern Harrier					1			**1**

Land Bird Species (*continued*)	Month April	May	June	July	August	September	October	**Total**
Northern Rough-winged Swallow	2			12				**14**
Osprey			1		1	3		**5**
Pileated Woodpecker						1		**1**
Red-breasted Nuthatch	1							**1**
Red-eyed Vireo				2				**2**
Red-tailed Hawk						2		**2**
Red-winged Blackbird					10			**10**
Rock Pigeon				1	1	2	2	**6**
Rough-legged Hawk							1	**1**
Ruby-crowned Kinglet	1							**1**
Savannah Sparrow					20	10		**30**
Steller's Jay						2	1	**3**
Swainson's Thrush			1					**1**
Tree Swallow	5			12				**17**
Turkey Vulture	4	1		10	9	3		**27**
Vaux's Swift		2						**2**
Violet-green Swallow	12	1			202			**215**
Warbling Vireo		1				1		**2**
Western Meadowlark	2	6	2	3	4	4		**21**
Willow Flycatcher			1					**1**
Yellow Warbler		1	1	1				**3**
Yellow-rumped Warbler	3	1				1		**5**
Total	**66**	**42**	**64**	**89**	**382**	**185**	**136**	**964**

Appendix E: Map of ultrasonic and acoustic ARU sampling locations for 2021. Buffers indicate the range at which bat species can be detected by ultrasonic ARUs (30 m for small species, 100 m for large species).



Appendix F: Map of remote wildlife camera sampling locations for 2021, with camera view direction indicated by lines.



Appendix G: Sample photos from each wildlife camera deployed in the Burton Creek WPW area in 2021.