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 13

Reference: CLBMON-11B1

Final Annual Report

Study Period: 2022

Okanagan Nation Alliance, Westbank, BC

and

LGL Limited environmental research associates
Sidney, BC

January 26, 2024

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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 2022

Prepared for

BC Hydro Generation

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 exclusively monitoring past revegetation efforts to focusing on the physical works constructed at Burton Creek. Effectiveness monitoring of the physical works at Burton Creek continued in 2022, which is the subject of this report.

Sampling to establish a baseline dataset for birds and arthropods occurred in 2018 and 2019. Additional baseline monitoring included bat acoustic monitoring from 2017 to 2019, wildlife camera trapping in 2019, and odonate (i.e., dragonflies) surveys conducted in 2019. The first phase of the physical works was constructed at Burton Creek in September 2019. The second phase of the physical works was completed in March and April 2021, and revegetation occurred 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 the final revegetation planting in the fall. In 2022, as in previous years, we surveyed birds, bats, amphibians, and other wildlife to document their usage of constructed ponds and mounds. Aquatic macroinvertebrates were monitored for the first time in 2021, with repeat sampling in 2022 at the wetland features. There were no terrestrial arthropod surveys in 2021 or 2022; this group is scheduled to be surveyed again in 2023.

We surveyed songbird activity using acoustic autonomous recording units (ARUs) and variable-radius point count surveys. Waterfowl and other water and shoreline-associated bird species were also surveyed from April to October. Ultrasonic ARUs were deployed to document bats from late spring through summer. We recorded wildlife activity using remote cameras and incidental wildlife observations. We conducted a visual encounter survey (VES) for amphibians and scanned acoustic ARU with a Western Toad (*Anaxyrus boreas*) classifier to detect calls of this species. Using kick and sweep nets, we sampled all available ponds (when not inundated by the reservoir) for aquatic macroinvertebrates. We installed data loggers to continuously record dissolved oxygen (mg/L), conductivity (µS/cm), and water temperature (°C) in ponds A1-A6, B1, and D2 in May through November to characterize seasonal shifts in and the impact of reservoir inundation on these quality parameters, as these can impact the use of the ponds by specific taxa.

We found aquatic macroinvertebrates in every pond that was surveyed. Ponds A1 and A2 were associated with the greatest number and diversity of aquatic invertebrates, including those at multiple life stages (e.g., juveniles and adults). Given that the ponds have replaced terrestrial habitat, this could be considered a net gain in aquatic macroinvertebrate species compared with pre-WPW conditions. Other factors that may influence the 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 33 species of birds on acoustic ARUs, 27 of which were songbirds. This included species such as the American Robin (*Turdus migratorius*), Chipping

Sparrow (*Spizella passerina*), and Willow Flycatcher (*Empidonax traillii*). Some of the species detected, such as Common Yellowthroat (*Geothlypis trichas*) and Western Meadowlark (*Sturnella neglecta*), are associated with wets or open/grassy habitats, making them likelier to use the WPW habitat. Variable-radius point count surveys documented 11 species.

Waterbird surveys recorded 39 species of waterfowl, loons, grebes, and shorebirds, as well as 56 species of landbirds. 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. Several waterfowl species were recorded in the constructed ponds in 2022, including Mallards (*Anas platyrhynchos*), Canada Geese (*Branta canadensis*) and Common Mergansers (*Mergus merganser*). 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 fall migration, the additional presence of juvenile birds, and Kokanee (*Oncorhynchus nerka*) spawning up Burton Creek.

For other wildlife, we recorded ten species of bat in the Burton WPW area, predominantly Myotis species. We recorded three species of amphibians in the WPW area, including the Pacific Chorus Frog (*Pseudacris regillla*), the Columbia Spotted Frog (Rana luteiventris), and the Western Toad. Western Toad eggs and tadpoles were observed in the burrow pits below the WPW, and Pacific Chorus Frog egg masses were observed in ponds A1, A2, and A5. Although no Columbia Spotted Frog egg masses were observed, a Columbia Spotted Frog tadpole was observed in pond A2. The most common mammal species recorded by wildlife cameras was the 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.

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 (WUP) 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 WUP Consultative Committee supported the following projects to enhance wildlife habitat in Arrow Lakes Reservoir, in lieu of maintaining lower reservoir levels:

1) A program to increase vegetation growth in the drawdown zone (CLBWORKS-2);
2) Scoping studies to evaluate the feasibility of physical works projects for protecting, enhancing, or creating wildlife habitat in the drawdown zone in Revelstoke Reach (CLBWORKS-29A) and the Upper and Lower Arrow Lakes Reservoir (CLBWORKS-29B); and
3) Informed by projects in 2 (above), Wildlife Physical Works (WPW) projects were implemented by separate programs in Revelstoke Reach (CLBWORKS-30A) and the Upper and Lower Arrow Lakes Reservoir (CLBWORKS-30B).

In association with the above CLBWORKS projects, the Consultative Committee recommended effectiveness monitoring to evaluate whether the revegetation treatments and WPW projects provide the intended environmental benefits in the Arrow Lakes Reservoir. Effectiveness monitoring is being conducted under:

1) Arrow Lakes Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis (CLBMON-12), initiated in 2009 and concluded in 2019; and
2) Arrow Lakes Reservoirs Effectiveness Monitoring of Revegetation and WPW (CLBMON-11B), initiated in 2009.

Between 2019 and 2021, a wetland enhancement project near Burton was implemented under CLBWORKS-30B (Miller and Hawkes 2020; Miller and Hawkes 2021). The project modified an existing shallow wetland/wet meadow habitat in the southeast section of the drawdown zone. Most of the habitat modified was relatively homogenous and dominated by undesirable species such as Reed Canarygrass (*Phalaris arundinacea*). The wetland construction at Burton Flats was anticipated to benefit a diversity of wetland wildlife including birds (songbirds, waterfowl, and shorebirds), amphibians, reptiles, mammals (e.g., bats), and insects (dragonflies), among others (BC Hydro 2017; Hawkes and Tuttle 2016). Species with provincial or federal conservation designations 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*).

CLBMON-11B1 assesses the effectiveness of the physical works program at Burton to improve the suitability of wildlife habitats. Dedicated baseline monitoring at this site was initiated in 2017. Post-construction effectiveness monitoring began in 2020 (Waytes et al.

2021). The 2021 field season was the first year of effectiveness monitoring following Phase 2 at the Burton Creek WPW. This report summarizes wildlife effectiveness monitoring and results from 2022.

The indicator taxa selected for monitoring at the Burton Creek WPW site include birds (songbirds and waterbirds), amphibians, bats, invertebrates, and wildlife usage patterns. Terrestrial arthropods were monitored post-construction in 2019 and will be surveyed again in 2023. Aquatic invertebrates were surveyed for the first time in 2021, after the completion of Phase 1 and 2 construction activities. The rationale for including each of these groups was provided in Waytes et al. (2021 and 2022).

2.0 OBJECTIVES

The aim of this project component of CLBMON-11B1 (post-2019) is to assess the effectiveness of the Burton Creek WPW project at improving wildlife habitat in the drawdown zone of Arrow Lakes Reservoir.

The objectives of CLBMON-11B are to:

1. Assess the effectiveness of the revegetation program (CLBWORKS-2) with respect to wildlife use of the drawdown zone of the Arrow Lakes Reservoir.
2. Assess the effectiveness of the wildlife physical works projects (CLBWORKS-30A, CLBWORKS-30B) at improving and/or sustaining conditions for nesting and migratory birds and wildlife in the drawdown zone of Arrow Lakes Reservoir.
3. Provide recommendations on revegetation or wildlife physical works methods or techniques most likely to be effective at enhancing or protecting the productivity of wildlife habitat.
4. Monitor specific areas that provide high-value wildlife habitat to determine opportunities for protection and enhancement within the Arrow Lakes Reservoir.

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 dependent on wetland and riparian habitats with other values such as recreational opportunities, flood control and power generation.

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

3.0 STUDY AREA

3.1 Burton Creek Wildlife Physical Works 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. (Figure 3-1; Carr et al. 1993, Jackson et al. 1995). 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.

The Burton Creek WPW is located south of Nakusp, on the east side of the Arrow Lakes Reservoir (Figure 3-1). It is adjacent to Highway 6, and accessible via Robazzo Road.

The site is highly visible from Highway 6 and is well-used by the public for recreation (e.g., picnics, camping, off-road vehicle use, dog walking, etc.). Before 2019, the site had low vegetation species diversity, dominated by non-native Reed Canarygrass (Hawkes and Tuttle 2016).

Prior to 2019, 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 indicates 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).

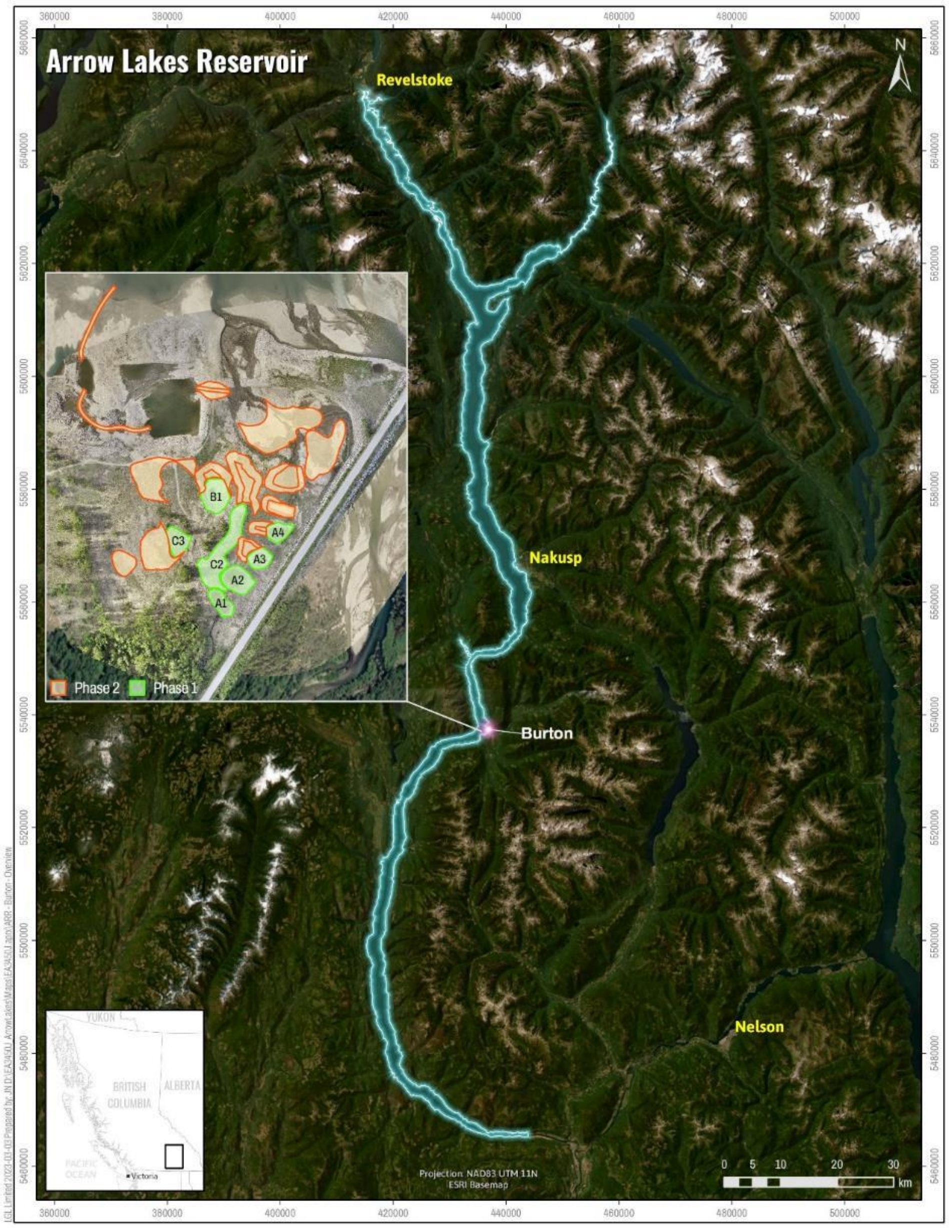

Figure 3-1. The location of constructed wetlands at Burton Creek (inset) in the drawdown zone of Arrow Lakes Reservoir, British Columbia.

3.2 Wildlife Physical Works Habitat Construction

As stated by Kerr Wood Leidel (2018), the purpose of this wildlife physical works project was to create shallow wetland habitat for Western Toad (assessed as a species of Special Concern by the Committee on the Status of Endangered Species in Canada; COSEWIC 2012), nesting and migratory birds, and other wildlife by excavation of pools and construction of water retention berms or similar to meet the terms of the Columbia Order. The goal was to retain site drainage and groundwater to promote stability of the wetland habitat. The objectives were to:

- Increase the spatial and temporal availability of shallow wetland habitat for wildlife in the drawdown zone of Arrow Lakes Reservoir within the habitat window of interest of April 1 to October 31.
- Improve habitat complexity in the drawdown zone of Arrow Lakes Reservoir.
- Improve wildlife habitat suitability by creating habitat that will benefit several groups of wildlife including migratory birds, nesting birds, pond-breeding amphibians, reptiles, bats, insects, and mammals.
- Reduce the cover of Reed Canary Grass (RCG) in the drawdown zone to promote the growth of native plants through terrestrial revegetation program that will follow the completion of the physical works.
- Revegetate the new wetland habitat with native aquatic macrophytes and riparian vegetation.

Wildlife Physical Works at Burton Creek was implemented in two phases. The first phase was initiated in 2019 with the construction of five ponds (A1-A4 and B1) and two mounds (C2 and C3) in September and October of 2019 (Figure 3-2). The constructed terrain was revegetated with a combination of native sedges, shrubs, and trees using locally salvaged material and nursery stock (Miller and Hawkes 2020).

Phase 2 took place in 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 (KWL 2021; Figure 3-2 and Figure 3-3). Additionally, revegetation prescriptions were applied concurrently with construction activities in April, September, and October of 2021 (Miller and Hawkes 2022). Artificial snags were installed on the constructed mounds in 2019, and bat boxes were installed in 2021 (Gidora et al. 2022). For comparison, before and after images of the wetland and mound features are provided in Figures 3-4 and 3-5**.** he general characteristics of the constructed features at Burton are summarized in Table 3-1.

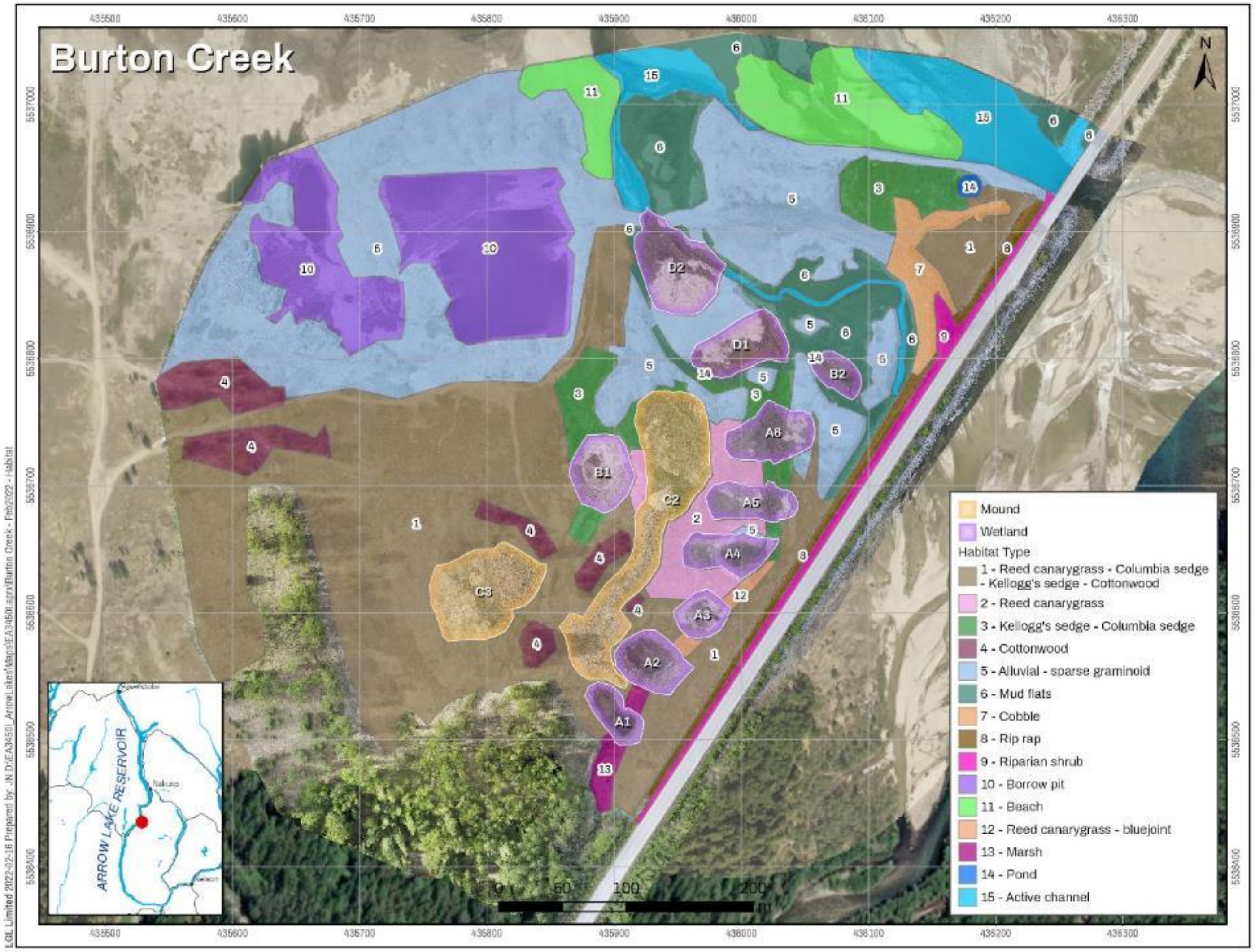

Figure 3-2. **Phase 1 and 2 constructed features and surrounding habitat at the Burton Creek Wildlife Physical Works project in Arrow Lakes Reservoir, Burton, BC. Background image date in 2020.**

Figure 3-3. Photos of constructed ponds A1-A6, D1, and D2 taken at Burton Creek. Credit: G. Davidson.

Figure 3-4. Pre-treatment (left; spring 2019) and post-treatment (right; pond A2 in spring 2021) photos of the Burton Creek Wildlife Physical Works location.


Figure 3-5. 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.

Table 3-1. Characteristics of shallow ponds, deep ponds, and mounds constructed at Burton as part 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					

4.0 RESERVOIR LEVELS AND POND INUNDATION

4.1 Arrow Lakes Reservoir Hydrograph

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). The range of operations (10th and 90th percentiles for 1969-2022) and levels from 2007 to 2022 are shown in Figure 4-1.

In the spring of 2022, reservoir elevations were lowest on March 13th (426.43 m ASL; Figure 4-1). Reservoir levels peaked on July 9th and 10th (438.67 m ASL). From the summertime peak, water levels dropped through the fall and into winter. The lowest level in 2023 occurred on December 31st (424.55 m ASL); however, levels dropped further in 2023.

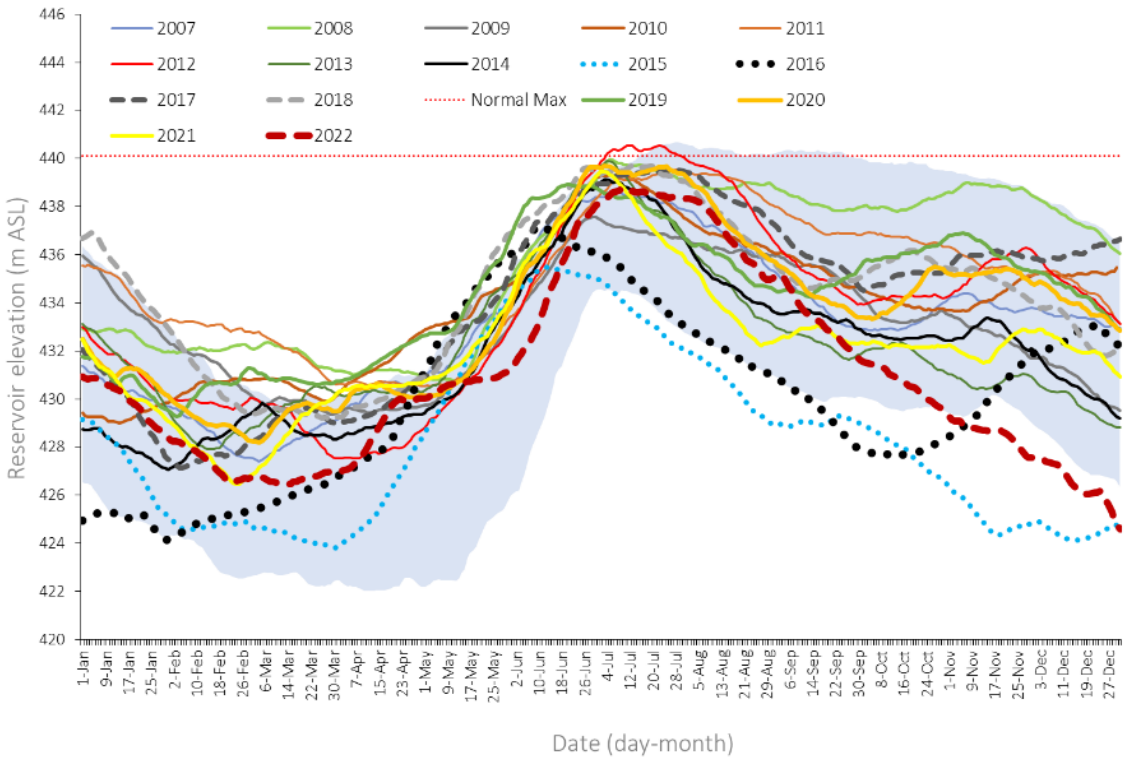

Figure 4-1. Arrow Lakes Reservoir elevations for 2007 through 2022. The 10th and 90th percentiles are shown for 1969-2022 (shaded area); m ASL= metres above sea level. Data source: Water Survey of Canada Station 08NE102[1].

[1] https://wateroffice.ec.gc.ca/report/real_time_e.html?stn=08NE102

4.2 Pond Inundation

Pond availability and pond depth are dependent on reservoir levels. At low reservoir levels, the wetland ponds are available as habitat for wildlife; however, as the reservoir fills the ponds flood and when over topped by rising reservoir levels, the ponds are no longer available as habitat. When reservoir levels drop below the elevation of the pond outlet, the ponds become exposed and are again available as pond habitat.

In 2022, the number of days the reservoir overtopped the ponds ranged from between 0 and 106 days and ponds were overtopped by the reservoir by up to 619 cm (Table 4-1). The lowest pond (D2) was overtopped on June 7, 2022, and the last pond to be flooded was A2 on July 2, 2022. Pond A1 was not flooded in 2022; however, the water levels came to within 4 cm of the surveyed pond outlet and likely affected water levels within the pond through infiltration and back flooding from the small watercourse that originates from a culvert under Highway 6 and is fed by shallow subsurface flow from Burton Creek.

Pond flooding in 2020, 2021, and 2022, assessed as the proportion of each month each pond was inundated by the reservoir, was based on the elevation of pond outlets derived from the 2019 Digital Elevation Model (DEM) (Table 4-2). Across all elevations, 2020 had a higher proportion of flooding, while 2021 had the lowest proportion of flooding. In 2022, the proportion of flooding was slightly higher than in 2021. Nevertheless, the tiered design of the physical works provides some pond habitat for most of the year.

Table 4-1. Flooding and exposure dates, maximum flooding depth, and the total days the reservoir overtopped the ponds. Flooding and exposure dates were estimated from the surveyed pond elevations and from the hydrometric data of Arrow Lakes Reservoir at Nakusp, B.C. the excavated ponds at Burton in 2022.

Pond	Elevation	Date Flooded	Week # Flooded	Date Exposed	Week # Exposed	Total Days Overtopped	Flooding Depth (cm)
A1	438.75	-	-	-	-	0	- 4
A2	438.24	2022-07-02	27	2022-08-03	32	32	47
A3	437.25	2022-06-23	26	2022-08-10	33	48	146
B1	436.31	2022-06-20	26	2022-08-16	34	57	240
A4	435.86	2022-06-19	26	2022-08-19	34	61	285
A5	435.39	2022-06-17	25	2022-08-24	35	68	332
A6	434.85	2022-06-15	25	2022-09-03	36	80	386
B2	434.33	2022-06-13	25	2022-09-05	37	84	438
D1	433.54	2022-06-11	24	2022-09-10	37	91	517
D2	432.52	2022-06-07	24	2022-09-21	39	106	619

Table 4-2. The proportion of each month (2020, 2021, and 2022) that each constructed pond at Burton was inundated. 0.00 indicates not inundated. Shading indicates partial (>0 but < 1) or complete (1.00) inundation for a given month. Proportions were summed across rows and columns.

		Month (2020)												
Pond	**Elevation**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
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	1.39
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	1.58
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	1.93
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	2.32
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	2.62
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	3.16
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	4.42
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	5.04
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	6.32
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	7.10
	Total	0.00	0.00	0.00	0.00	0.25	6.82	10	7.58	2.71	2.64	3.91	1.97	**35.88**

		Month (2021)												
Pond	**Elevation**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
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	0.39
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	0.65
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	1.00
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	1.45
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	1.77
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	2.00
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	2.13
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	2.26
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	2.62
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	4.29
	Total 37.12	0.00	0.00	0.00	0.00	0.45	6.81	8.13	1.94	0.68	0.00	0.26	0.29	**18.56**

		Month (2022)												
Pond	**Elevation**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
A1	438.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	438.75
A2	438.24	0.00	0.00	0.00	0.00	0.00	0.00	0.97	0.10	0.00	0.00	0.00	0.00	439.31
A3	437.25	0.00	0.00	0.00	0.00	0.00	0.26	1.00	0.32	0.00	0.00	0.00	0.00	438.83
B1	436.31	0.00	0.00	0.00	0.00	0.00	0.35	1.00	0.52	0.00	0.00	0.00	0.00	438.18
A4	435.86	0.00	0.00	0.00	0.00	0.00	0.39	1.00	0.61	0.00	0.00	0.00	0.00	437.86
A5	435.39	0.00	0.00	0.00	0.00	0.00	0.45	1.00	0.77	0.00	0.00	0.00	0.00	437.61
A6	434.85	0.00	0.00	0.00	0.00	0.00	0.52	1.00	1.00	0.10	0.00	0.00	0.00	437.47
B2	434.33	0.00	0.00	0.00	0.00	0.00	0.58	1.00	1.00	0.16	0.00	0.00	0.00	437.07
D1	433.54	0.00	0.00	0.00	0.00	0.00	0.65	1.00	1.00	0.32	0.00	0.00	0.00	436.51
D2	432.52	0.00	0.00	0.00	0.00	0.00	0.77	1.00	1.00	0.68	0.00	0.00	0.00	435.97
	Total	0.00	0.00	0.00	0.00	0.00	3.97	8.97	6.32	1.26	0.00	0.00	0.00	**20.52**

5.0 WATER QUALITY DATA

Dissolved oxygen, conductivity, and water temperature were monitored continuously to assess the water physicochemistry of aquatic (pond) habitats. PME (Precision Measurement Engineering) miniDOT dissolved oxygen (DO) loggers and HOBO Fresh Water Conductivity Loggers (Onset; U24-001) were installed in ponds A1-A6, B2, and D1 (Precision Measurement Engineering; Appendix A). The miniDOT DO loggers were installed on May 25, 2022. For consistency, the DO loggers were installed at similar depths ranging from 40 cm to 47 cm (mean = 42.7 cm, std deviation = 2.2 cm). The conductivity loggers were installed at similar depths on June 7, 2022 (mean = 43.2 cm, std deviation = 2.9 cm). As in 2021, data loggers were not installed in pond B1 as it had too little water to sample (Figure 5-1). Data loggers were retrieved on November 8th, 2022. Dissolved oxygen (DO; mg/L), temperature (°C), and conductivity (µS/cm) were recorded every ten minutes.

Figure 5-1. Images showing the lack of water in pond B1 on May 13th, 2021 (left) and on May 26th, 2022 (right).

Water temperatures in the ponds ranged from 4.3 ºC to 24.8 ºC (Table 5-1). Pond A1 was cooler than all other ponds, while pond A3 was the warmest, followed by A2 and ponds B2 and D1. As expected, pond temperatures were generally warmest in August, followed by July and September and cooler in June and October.

Following inundation from the reservoir, the water temperature in the ponds declined by an average of 2.3 ºC (Figure 5-2). Pond D2 exhibited the largest decline in water temperature of 6.2 ºC (from 13.5 ºC to 7.3 ºC) following inundation, while pond A3 declined the least (0.3 ºC). Water temperature in ponds A2, A3, A4, and A5 recovered (i.e., reached or exceeded their pre-inundation temperature) within 1 to 3 days, while the water temperature in ponds A1, A6, and B2 recovered between 10 and 12 days. Water temperature in pond D1 did not recover until 31 days after inundation.

It is important to note that while the timing of temperature fluctuations appears to be influenced by changes in reservoir levels (i.e., flooding and receding), changes in water temperature were likely influenced by daily weather events and seasonal climate patterns, confounding the interpretation of these data. For example, during the second week of June, when several ponds became inundated (pond D1, B2 and A6), heavy rainfall accompanied by cooler air temperatures likely contributed to cooler pond temperatures.

Table 5-1. Monthly mean water temperatures (℃) recorded from June 1 to Oct 31, 2022, in the constructed ponds at Burton. Monthly mean temperatures were shaded in 2 ℃ bins from 8 to 18 ℃: white is 8 to 10 ℃, blue is 10 to 12 ℃, yellow is 12 to 14 ℃, orange is 14 to 16 ℃, and red is 16 to 18 ℃. Overall mean, minimum, and maximum water temperatures for the ponds and months are in italics.

	Month							
Pond	**June**	**July**	**August**	**Sept**	**Oct**	***Mean***	***Min***	***Max***
A1	11.1	11.1	13.8	12	8.3	*11.3*	*4.3*	*20.4*
A2	13.1	13.4	14.9	15.2	9.9	*13.3*	*5.3*	*24.8*
A3	12.5	16.5	16.7	13.8	10.0	*13.8*	*6.4*	*21.7*
A4	8.8	12.7	14.7	14.8	10.3	*12.2*	*6.6*	*19.9*
A5	9.7	13.5	14.8	12.4	10.1	*12*	*6.7*	*18.5*
A6	10.4	13.8	16.1	11.5	9.6	*12.2*	*7.1*	*18.1*
B2	10.4	14.3	16.4	13.6	10.6	*13*	*7.5*	*18.6*
D1	10.9	13.5	16.4	13.8	10.2	*13*	*6.5*	*18.1*
Mean	*10.9*	*13.6*	*15.5*	*13.4*	*9.9*			
Min	*6.5*	*8.1*	*9.4*	*6.9*	*4.3*			
Max	*18.4*	*20.0*	*23.9*	*24.8*	*18.6*			

Between June 1st to Oct 31st, 2023, dissolved oxygen concentrations (DO) in the ponds varied from 0.01 mg/L to 18.55 mg/L (Table 5-2, Figure 5-2). Ponds B2 and D1 had the highest mean DO (> 9.0 mg/l), while pond 3 had the lowest at 4.50 mg/l. Pond DO was generally higher in the deeper ponds; however, the relationship between pond elevation and average DO was not linear as the two uppermost ponds (ponds A1 and A2) diverged from this pattern and had higher DO than pond A (Table 5-2).

Table 5-2. Monthly mean dissolved oxygen concentrations (mg/l) recorded from June 1 to Oct 31, 2022, in the constructed ponds at Burton. Monthly mean dissolved oxygen concentrations are shaded in 3 mg/l bins from 0 mg/l to 12 mg/l: white is 0 to 3 mg/l, yellow is 3 to 6 mg/l, orange is 6 to 9 mg/l, and blue is 9 to 12 mg/l. Overall mean, minimum, and maximum DO concentrations for the ponds and months are in italics.

	Month							
Pond	**June**	**July**	**August**	**Sept**	**Oct**	***Mean***	***Min***	***Max***
A1	7.85	4.55	6.70	9.30	9.91	*7.64*	*0.70*	*11.16*
A2	6.22	5.11	3.64	7.49	6.80	*5.84*	*0.13*	*18.45*
A3	3.72	6.35	2.05	4.98	5.42	*4.50*	*0.03*	*13.42*
A4	4.91	9.65	3.86	6.71	7.86	*6.59*	*0.05*	*11.89*
A5	7.04	8.87	5.45	4.99	6.06	*6.49*	*0.01*	*11.64*
A6	8.27	9.68	7.86	5.19	6.57	*7.54*	*0.03*	*14.77*
B2	9.23	10.49	9.12	7.23	9.00	*9.03*	*0.02*	*18.55*
D1	9.65	10.78	10.40	8.49	9.56	*9.79*	*2.15*	*14.73*
Mean	*7.11*	*8.18*	*6.14*	*6.80*	*7.65*			
Min	*0.55*	*0.10*	*0.01*	*0.01*	*0.15*			
Max	*13.14*	*13.24*	*14.43*	*18.45*	*18.55*			

In general, DO concentrations increased in June, remained moderate to high (above 6 mg/l but reaching above 10 mg/l) through July or early August, declined in mid to late August or early September, and then increased again in late September and October

(Figure 5-2). This pattern was observed in all ponds except pond A1, where DO decrease from June to early August, then increased to October. It is likely that reservoir levels the reservoir influenced DO in the ponds; however, discerning reservoir effect(s) is likely confounded by seasonal climate patterns and weather events.

Among the eight ponds, conductivity values ranged from 25.8 µS/cm to 141 µS/cm over the study period (Table 5-3), and three patterns were observed in these data. First, ponds at higher elevations had higher conductivity values than ponds lower in the reservoir. Second, conductivity values increased through the summer, peaked in August or early September, and then declined in the fall (Figure 5-3). Third, in most ponds, a decline in conductivity occurred in June when the reservoir levels overtopped the ponds (Figure 5-3). However, as mentioned, seasonal climate and weather events confound these data. For example, the drop in conductivity in pond 1 that occurred during the second week of June likely corresponded to the heavy rainfall event mentioned previously, while the smaller drop in conductivity in early July likely corresponded to flooding from the reservoir. Thus, any inferences regarding the impact of reservoir levels must be interpreted cautiously.

Table 5-3. Monthly mean conductivity values recorded from June 1 to Oct 31, 2022, in the constructed ponds at Burton. Monthly mean conductivity values are shaded in 50 µS/cm mg/l bins from 0 to 150 µS/cm mg/l: white is 0 to 50 µS/cm, yellow is 50 to 100 µS/cm, and orange is 100 to 150 µS/cm. Overall mean, minimum, and maximum conductivity values for the ponds and months are in italics.

	Month							
Pond	**June**	**July**	**August**	**Sept**	**Oct**	***Mean***	***Min***	***Max***
A1	105.0	119.1	129.8	126.8	112.1	*117.1*	*70.3*	*141.0*
A2	117.7	121.8	123.6	113.7	102.7	*114.4*	*83.2*	*136.7*
A3	101.9	95.5	119.7	94.8	82.7	*97.3*	*64.5*	*132.3*
A4	65.2	45.3	101.2	112.1	96.4	*84.5*	*25.8*	*121.2*
A5	53.8	58.4	87.5	95.8	91.8	*78.6*	*34.2*	*104.7*
A6	59.2	70.1	94.2	93.3	93.2	*83.1*	*42.4*	*103.0*
B2	46.6	77.9	91.1	78.9	78.5	*75.7*	*28.8*	*100.0*
D1	51.3	68.7	87.0	94.9	88.3	*79.0*	*31.8*	*100.5*
Mean	*75.1*	*82.1*	*104.3*	*101.3*	*93.2*			
Min	*27.2*	*25.8*	*74.0*	*71.4*	*72.7*			
Max	*128.3*	*132.0*	*141.0*	*140.0*	*96.4*			

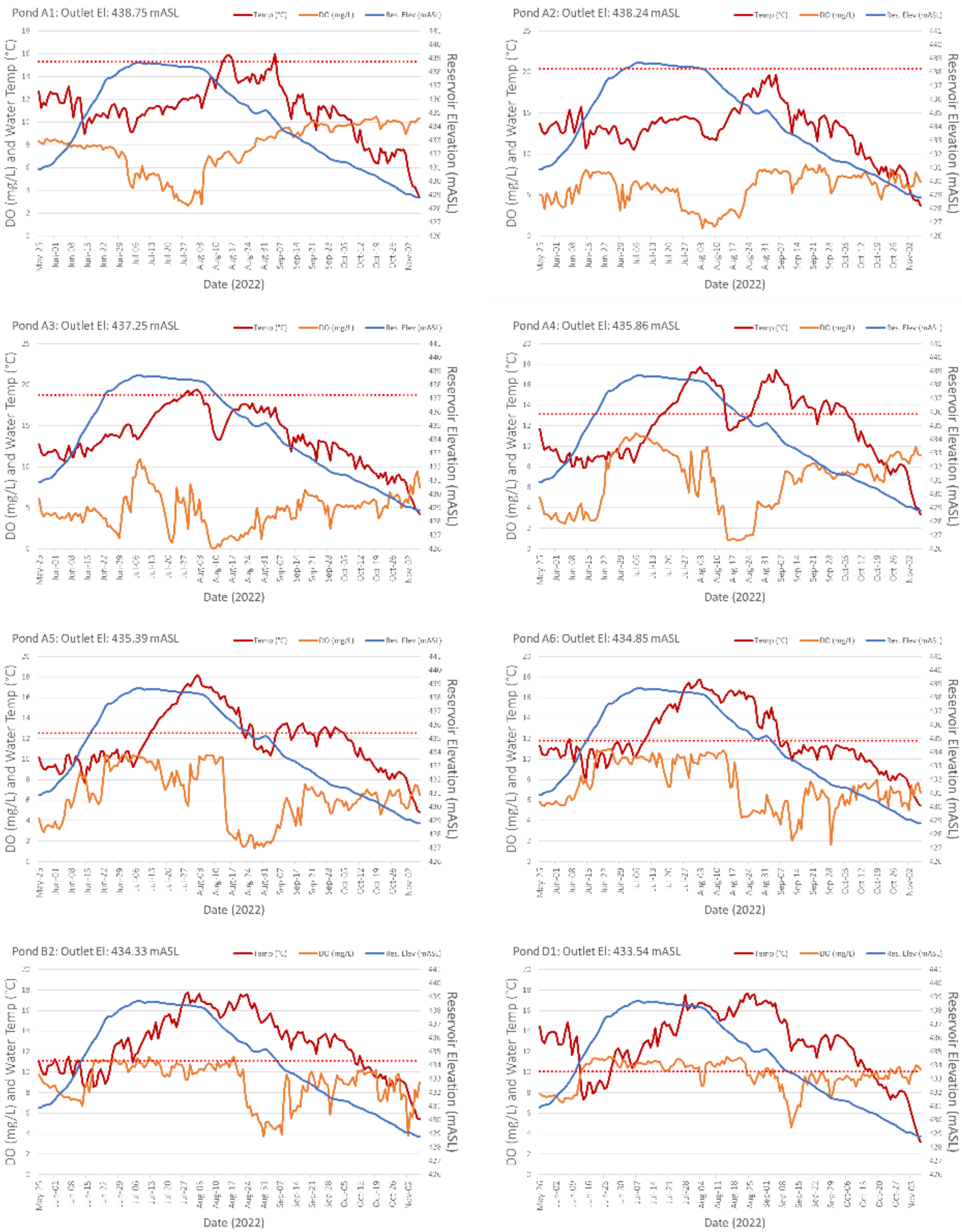

Figure 5-2. Water temperature (°C) and dissolved oxygen (DO, mg/L) for ponds A1-A6, B2, and D1 from May 25 to November 7, 2022. Reservoir elevations are plotted (blue line) for reference; mASL= metres above sea level. The red line represents temperature, and the orange line represents dissolved oxygen.

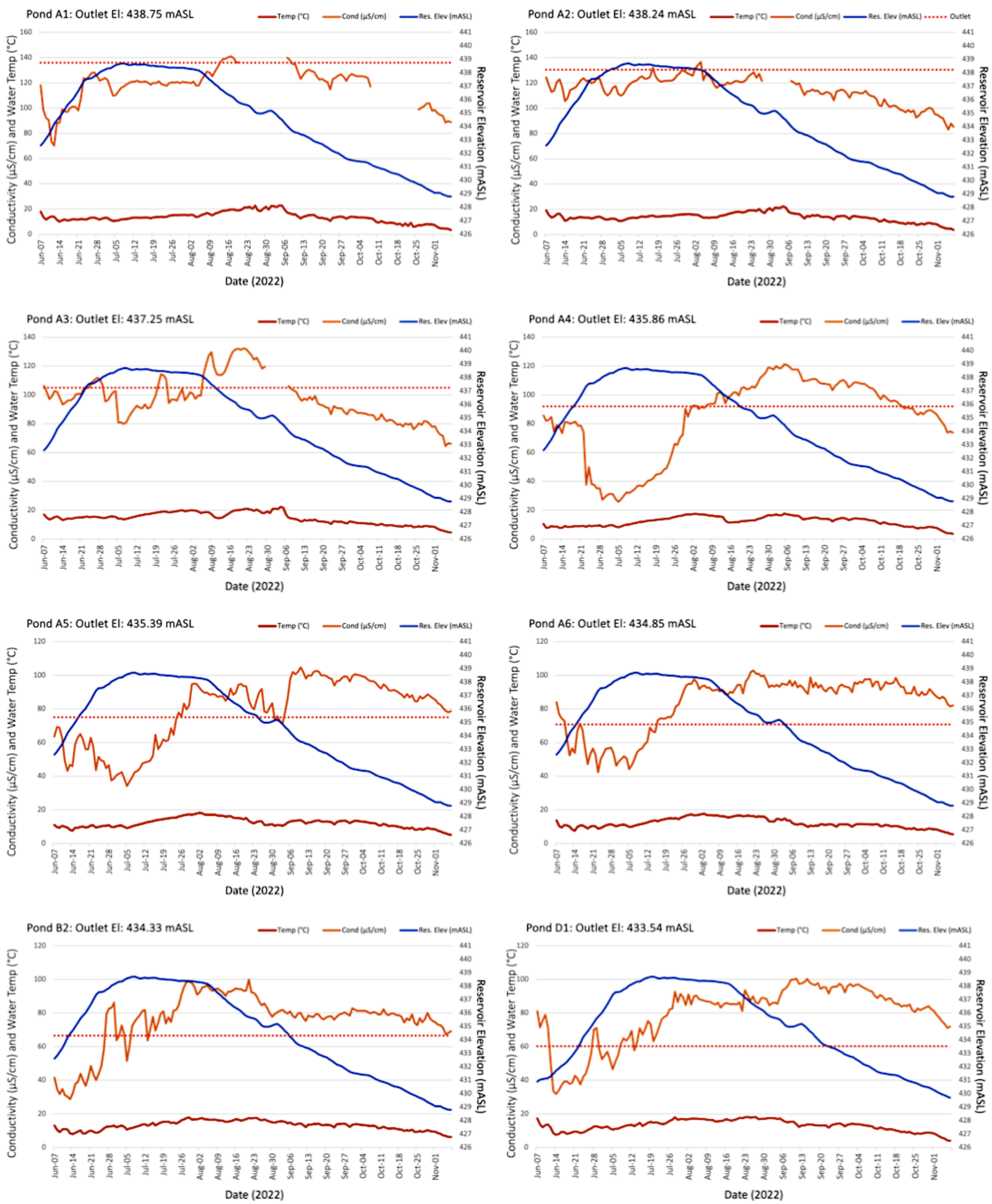

Figure 5-3. Water temperature (°C) and conductivity (µS/cm) for ponds A1-A6, B2, and D1 from May 25 to November 7, 2022. Reservoir elevations are plotted (blue line) for reference; mASL= metres above sea level. The red line represents temperature, and the orange line represents conductivity. Gaps in the data occurred when ponds depths drop below the conductivity sensor (e.g., ponds A1, A2, and A3).

6.0 AQUATIC MACROINVERTEBRATES

6.1 Aquatic Macroinvertebrate Sampling

Aquatic macroinvertebrates were collected for the first time at the Burton Creek WPW in 2021 and subsequent sampling was conducted in 2022. Collection protocols followed those recommended by the Canadian Aquatic Biomonitoring Network (CABIN) for sampling in wetland habitats (Armellin et al. 2019). The sampling focused on ponds established during Phase 1, including ponds A1-A6. Pond B1 was excluded from macroinvertebrate surveys in both years due to a lack of water at the time of the surveys, though pond B2 was sampled in 2022. Ponds D1 and D2 were surveyed opportunistically. Macroinvertebrate surveys occurred on May 5th and 6th, 2021, and June 8th, 2022.

A surveyor used a sweep net with 400-μm mesh and a 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 two minutes. 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). The maximum water depth in the ponds at the time of the surveys was also measured.

6.2 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.

6.3 Aquatic Macroinvertebrate Results

Aquatic macroinvertebrates were present in every pond surveyed. The type and number of invertebrates varied as some ponds hosted a limited number of individuals, while others had comparatively greater diversity and abundance (Table 6-1). Pond A1, for example, had a notable diversity of individuals, including amphipods, snails, and insects. In addition, pond D1 sported a high abundance of Corixidae and Chironomidae relative to the other ponds. Parasitic leeches were also found in two of the ponds and one member of the family Glossiphonidae was found carrying 29 young in pond B2 (Figure 6-1) Pupa of Non-biting Midges (Chironomidae) were present in all ponds except for D2 and were the most abundant organism sampled in ponds A3, A5 and D1, respectively. Predaceous diving beetle adults (Dytiscidae) were collected in four of the nine ponds and Mayfly's (Ephemeroptera) were found in two ponds. Freshwater amphipods (Hyallelidae) were abundant and found in every pond except for pond A6. In ponds A1 and A2, amphipods outnumbered any other organism by a ratio > 3:1.

Table 6-1. Aquatic macroinvertebrates collected from ponds A1-A6, B2, D1 and D2 in May of 2021 and June of 2022 at Burton Creek Flats. Invertebrate findings are presented in alphabetical order based on the highest taxonomic classification. Specimens unidentifiable to Order were not included in the table. A small number of degraded specimens were able to be identified to the level of Order but not Family. 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	A5	A6	B2	D1	D2
Clitellata	Gnathobdellidae	Hirudinidae	Adult	-	-	-	-	-	-	-	1	-
Clitellata	Rhynchobdellida	Glossiphonidae	Adult	-	-	-	-	-	-	1	-	-
Clitellata	Rhynchobdellida	Glossiphonidae	Juvenile	-	-	-	-	-	-	29	-	-
Gastropoda	Basommatophora	Lymnaeidae	Adult	20	1	-	-	-	-	-	-	-
Gastropoda	Basommatophora	Physidae	Adult	2	-	1	-	-	-	-	1	-
Gastropoda	Hygrophila	Planorbidae	Adult	2	-	-	-	-	-	-	-	-
Insecta	Coleoptera	Dyticidae	Adult	4	2	-	-	2	-	-	1	-
Insecta	Coleoptera	Dyticidae	Larva	-	3	-	-	-	-	-	4	-
Insecta	Coleoptera	Haliplidae	Adult	-	1	-	-	-	-	-	-	-
Insecta	Coleoptera	Noteridae	Adult	1	5	1	4	-	-	-	-	-
Insecta	Diptera	Ceratopogonidae	Pupa	11	-	-	-	-	-	-	-	1
Insecta	Diptera	Ceratopogonidae	Larva	3	-	-	-	-	-	-	-	-
Insecta	Diptera	Chironomidae	Larva	3	2	4	12	6	2	4	48	-
Insecta	Diptera	Chironomidae	Pupa	3	-	-	14	-	-	-	-	-
Insecta	Diptera	Empididae	Adult	1	-	-	-	-	-	-	-	-
Insecta	Diptera	Ephydridae	Larva	-	-	-	-	-	-	-	1	-
Insecta	Diptera	Tipulidae	Larva	-	-	-	-	-	3	-	-	-
Insecta	Ephemeroptera	Siphlonaridae	Larva	1	-	-	2	-	-	-	-	-
Insecta	Ephemeroptera	Unknown	Exuviae	3	-	-	-	-	-	-	-	-
Insecta	Ephemeroptera	Unknown	Larva	2	-	-	-	-	-	-	-	-
Insecta	Hemiptera	Corixidae	Adult	-	-	1	3	5	1	18	27	3
Insecta	Hemiptera	Corixidae	Juvenile	-	3	1	-	-	-	-	5	2
Insecta	Hemiptera	Gerridae	Adult	-	-	-	-	1	-	-	-	-
Insecta	Odonata	Coenagrionidae	Larva	-	1	-	-	-	-	-	-	-
Insecta	Odonata	Petaluridae	Larva	-	2	-	-	-	-	-	-	-
Insecta	Trochoptera	Hydroptilidae	Larva	-	-	-	-	-	-	1	-	-
Malacostraca	Amphipoda	Hyallelidae	Adult	74	99	3	25	4	-	14	30	3
			Number of Families Collected	10	9	5	5	5	3	5	8	3

Figure 6-1. Aquatic macroinvertebrates collected from the constructed ponds in the Burton Creek WPW. Clockwise from top left, invertebrates are Amphipods, an adult Leech (Family: Glossiphonidae) carrying its young, Biting Midge pupae (Family: Ceratopogonidae), and an immature Mayfly (Order: Ephemeroptera).

6.4 Aquatic Macroinvertebrate Discussion

Results from the aquatic macroinvertebrate surveys indicate that invertebrates are using the ponds and are present at multiple life stages (e.g., juveniles and adults). This is a positive indication that invertebrates may be establishing in the ponds. Aquatic macroinvertebrate surveys were not conducted in the low elevation borrow pits before pond construction, 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 stands that the productivity of macroinvertebrates will increase in the area relative to pre-physical works conditions.

Ponds A1, A2, and D1 were associated with the greatest number and diversity of aquatic macroinvertebrates (130 individuals representing 10 families, 119 individuals representing 9 families, and 118 individuals representing 8 families, respectively). Ponds A1 and A2 had comparatively higher vegetation diversity than other ponds (Miller and Hawkes 2022), including more emergent vegetation. Pond 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. Despite pond D1 being a lower elevation pond with less emergent vegetation, in the summer of 2022, this pond had warmer water temperatures compared to the other ponds (Table 6-1) and had the highest mean dissolved oxygen content of any pond throughout June, July, and August (Table 6-2). These factors could contribute to the comparatively higher number of resident aquatic invertebrates.

Aquatic invertebrate surveys conducted in 2021 and 2022 were completed prior to the inundation of any of the ponds by the reservoir. It is unclear how changes in water quality throughout the summer and changes in water depth in the ponds affected invertebrate presence in the ponds. The low oxygen conditions in early July of 2021 could have impacted pond residents. This may partially explain why more diversity and abundance in aquatic macroinvertebrates was observed in 2022. Aquatic invertebrates can differ in their responses to oxygen concentration, with some species having a higher sensitivity than others (Davis 1975). Although 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). 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, availability throughout the season, and water physicochemistry.

7.0 BIRDS

7.1 Songbird Surveys

7.1.1 Autonomous Recording Units (ARUs)

Following a modified approach to songbird surveys first used in 2020 (Waytes et al. 2021), we utilized Wildlife Acoustics Song Meter ARUs (SM4 Wildlife Acoustics, Inc., Maynard, Massachusetts, USA) to passively record bird vocalizations during the breeding season in the spring and summer of 2022. Five units were deployed in late May to monitor bird songs in the WPW area (Appendix E), and they were collected in early November. Acoustic ARU recordings offer valuable information on bird species presence and can detect birds to a level comparable to humans (Castro et al. 2019). While we cannot assess species abundance or habitat use from recordings, they were used to indicate species presence and provide continuity with 2020 and 2021 ARU data.

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 sampling periods for each acoustic ARU (Table 7-1); the sampling 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 windows are also consistent with survey dates in previous years. For all ARUs, the survey hour relative to sunrise was also randomized for each visit. Possible time intervals were: (1) within one hour of sunrise; (2) one to two hours after sunrise; and (3) two to three hours after sunrise. If sub-optimal weather conditions (e.g., rain, strong winds) occurred on the first chosen date, an adjacent date within the sampling period was selected. On selected dates and times for each ARU, an ornithologist analysed six-minute recording intervals to simulate a point count survey, and all bird detection were transcribed. For recordings containing multiple individuals of the same species, the spacing and amplitude of vocalizations were used to differentiate individuals. Each distinguishable bird was considered a count.

Table 7-1. Acoustic ARU stations (see Appendix E) and associated dates and time intervals of songbird surveys from 2022 monitoring.

ARU Name	Visit 1	Interval	Visit 2	Interval
ARU01	07-Jun-22	1	22-Jun-22	1
ARU02	10-Jun-22	3	25-Jun-22	2
ARU03	08-Jun-22	3	22-Jun-22	1
ARU04	05-Jun-22	1	21-Jun-22	1
ARU05	10-Jun-22	3	21-Jun-22	3

We presented the bird species detected and associated counts for each species from the acoustic ARU recordings. 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 for all ARUs in the WPW due to their proximity to each other (<250 m). Species counts were first summarized for each ARU and the maximum count of each species was determined for each visit.

Figure 7-1. An acoustic (left) and ultrasonic (right) ARU attached to a snag above a wildlife camera in the WPW area in 2021. Arrows indicate location of ARUs.

7.1.2 Point Count Surveys

Time-constrained, variable-radius[2] point count surveys were used to assess the diversity and relative abundance of songbirds (Ralph et al. 1995). A total of 12 point count stations were distributed in and adjacent to the WPW area (Appendix E). We attempted to survey each point count twice through the survey period; however, due to higher reservoir water levels, some stations were either not accessible or sampled at the nearest point above the water line.

The timing of point count surveys (June 13 and 27) coincides with the height of the breeding season at which time locally breeding passerines are on territory and are highly vocal, enabling surveyors to document the number and diversity of breeding birds. Surveys commenced at sunrise and ended within ~4 hours of sunrise (Ralph et al. 1995). Songbird surveys were done during favourable weather conditions only (i.e., no heavy wind or precipitation) to standardize surveys and minimize variable detections associated with sub-optimal environmental conditions. All songbird surveys conformed to the provincial standard (RIC 1999).

The point count survey method involved standing at a fixed point and documenting all birds seen and/or heard during a six-minute count period. The species of bird, as well as the distance (from the observer), were recorded. Additional data recorded included the sex and age class of the bird (when known) and the type of detection (call, song, or visual), and notes were made to differentiate fly-over birds from the rest of the detections. Furthermore, because the detectability of different bird species varies depending on the amount of time devoted to each survey (Bibby et al., 2000), the portion of the six-minute count period in which each individual is detected was recorded (0-3 minutes, 3-5 minutes, 5-6 minutes).

At each point count station, the following data were collected:

1. **Physical information:** site number, point count number, GPS coordinates, weather (wind speed, temperature, relative humidity [measured with a Kestrel® 4000 Pocket Weather Meter], current survey conditions), date, time of day, visit number;
2. **Bird observations (sight or sound) in point count plots:** species, approximate age (adult/juvenile), location of each bird heard or seen within point count plot, location mapped on point count form, estimate of the horizontal distance between each detected bird and the observer, detection type (sight or sound);
3. **Bird observations outside point count plots:** incidental observations of birds located outside the point count area at each site.

Results from point count surveys were constrained to observations within 30 m from the observer (point count centre) to minimize duplicating records of the same individuals in the study area.

7.1.3 Waterbird Surveys

Waterbird surveys were completed on 18 dates from April 9th through October 31st, 2022. These surveys monitored 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 categories, “waterbirds” and “landbirds,”

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[2] Variable in the sense that observations are categorized by distance from the point count centre.

for mapping purposes. The area surveyed included the WPW area plus adjacent locations to ensure that bird usage of the WPW location was put into the context of the surrounding area.

7.2 Bird Results

7.2.1 Autonomous Recording Units

In total, 33 bird species (27 of which were songbirds) were detected from analysed ARU recordings over the two simulated visits (

Table 7-2). This includes 23 species during early June (Visit 1) and 25 species in late June (Visit 2). Common Yellowthroat had the highest maximum count in each visit. The only species of conservation concern recorded was Killdeer (*Charadrius vociferus*), which is provincially blue-listed.

Table 7-2. Detected bird species and associated maximum counts from Burton Creek WPW acoustic ARU recordings by visit in June 2022.

Common Name	Scientific Name	Species Count	
		Visit 1	Visit 2
American Crow	*Corvus brachyrhynchos*	1	1
American Redstart	*Setophaga ruticilla*	2	1
American Robin	*Turdus migratorius*	3	1
Bald Eagle *	*Haliaeetus leucocephalus*	0	1
Black-capped Chickadee	*Poecile atricapillus*	0	1
Brown-headed Cowbird	*Molothrus ater*	1	0
Canada Goose *	*Branta canadensis*	0	1
Cassin's Vireo	*Vireo cassinii*	0	1
Cedar Waxwing	*Bombycilla cedrorum*	1	1
Chipping Sparrow	*Spizella passerina*	1	0
Common Raven	*Corvus corax*	0	1
Common Yellowthroat	*Geothlypis trichas*	3	3
Downy Woodpecker	*Dryobates pubescens*	1	0
Golden-crowned Kinglet	*Regulus satrapa*	1	0
Hammond's Flycatcher	*Empidonax hammondii*	1	1
Killdeer * ‡	*Charadrius vociferus*	1	0
MacGillivray's Warbler	*Geothlypis tolmiei*	0	1
Mallard*	*Anas platyrhynchos*	2	1
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	1	0
Pine Siskin	*Spinus pinus*	1	0
Red-eyed Vireo	*Vireo olivaceus*	1	2
Red-winged Blackbird	*Agelaius phoeniceus*	0	1
Savannah Sparrow	*Passerculus sandwichensis*	0	1
Song Sparrow	*Melospiza melodia*	0	1
Spotted Sandpiper *	*Actitis macularius*	2	2
Swainson's Thrush	*Catharus ustulatus*	1	1
Tree Swallow	*Tachycineta bicolor*	0	1
Varied Thrush	*Ixoreus naevius*	1	1
Warbling Vireo	*Vireo gilvus*	2	1
Western Meadowlark	*Sturnella neglecta*	1	2
Willow Flycatcher	*Empidonax traillii*	1	1
Yellow Warbler	*Setophaga petechia*	1	1
Yellow-rumped Warbler	*Setophaga coronata*	1	0

* Indicates non-songbirds (e.g., waterfowl, raptors, shorebirds, woodpeckers), which were not a focal group of the surveys but are included here as incidental observations.
‡ Indicates blue-listed status in BC

7.2.2 Point Count Surveys

A total of 11 songbird species comprised of 49 individuals were recorded within 30 metres of point count centres during two survey sessions around the Burton WPW area in June 2022 (Table 7-3).

Table 7-3. Detected songbird species and combined counts from point count surveys in and adjacent to the Burton Creek WPW by visit in June 2022. Species count pertains to individuals recorded within 30 m of point count centres.

		Species Count	
Common Name	**Scientific Name**	Visit 1 (n=12)	Visit 2 (n=11)
American Robin	*Turdus migratorius*	1	1
Brown-headed Cowbird	*Molothrus ater*	3	0
Cassin's Vireo	*Vireo cassinii*	1	0
Cedar Waxwing	*Bombycilla cedrorum*	1	0
Chipping Sparrow	*Spizella passerina*	1	0
Common Raven	*Corvus corax*	1	0
Common Yellowthroat	*Geothlypis trichas*	7	9
Red-winged Blackbird	*Agelaius phoeniceus*	1	0
Western Meadowlark	*Sturnella neglecta*	1	9
Willow Flycatcher	*Empidonax traillii*	7	4
Yellow Warbler	*Setophaga petechia*	2	0

Common Yellowthroat was the most common species recorded during point counts, followed by Willow Flycatcher and Western Meadowlark. Most species recorded are associated with or commonly utilize wetland and riparian habitats, including those created through physical works.

An additional 24 species (including non-passerines) comprised of 148 individuals were recorded in open, grassy, and shrubby habitats (i.e., upper elevations of the drawdown zone) beyond 30 m from the point count surveyor, including the WPW area (Table 7-4). The only species of conservation concern recorded was the provincially blue-listed Killdeer.

Table 7-4. Combined counts of additional birds recorded during point count surveys in and adjacent to the Burton Creek WPW by visit in June 2022. Species count pertains to individuals recorded greater than 30 m from point count centres.

Common Name	Scientific Name	Species Count Visit 1 (n=12)	Visit 2 (n=11)
American Redstart	*Setophaga ruticilla*	1	1
Belted Kingfisher	*Megaceryle alcyon*	0	1
Black-capped Chickadee	*Poecile atricapillus*	0	1
Brown-headed Cowbird	*Molothrus ater*	0	1
Cedar Waxwing	*Bombycilla cedrorum*	25	1
Chipping Sparrow	*Spizella passerina*	1	3
Common Loon	*Gavia immer*	1	0
Common Yellowthroat	*Geothlypis trichas*	5	9
Greater Yellowlegs	*Tringa melanoleuca*	0	1
Hammond's Flycatcher	*Empidonax hammondii*	0	3
Hermit Thrush	*Catharus guttatus*	0	1
Killdeer‡	*Charadrius vociferus*	2	0
Lazuli Bunting	*Passerina amoena*	0	4
Mallard	*Anas platyrhynchos*	3	3
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	1	0
Red-eyed Vireo	*Vireo olivaceus*	0	2
Savannah Sparrow	*Passerculus sandwichensis*	1	0
Spotted Sandpiper	*Actitis macularius*	5	10
Tennessee Warbler	*Leiothlypis peregrina*	0	1
Tree Swallow	*Tachycineta bicolor*	1	1
Turkey Vulture	*Cathartes aura*	2	0
Vaux's Swift	*Chaetura vauxi*	1	0
Violet-green Swallow	*Tachycineta thalassina*	1	2
Warbling Vireo	*Vireo gilvus*	1	2
Western Kingbird	*Tyrannus verticalis*	0	1
Western Meadowlark	*Sturnella neglecta*	7	6
Western Wood-Pewee	*Contopus sordidulus*	0	2
White-throated Sparrow	*Zonotrichia albicollis*	0	1
Willow Flycatcher	*Empidonax traillii*	11	11
Wilson's Warbler	*Cardellina pusilla*	2	0
Yellow Warbler	*Setophaga petechia*	7	1
Yellow-rumped Warbler	*Setophaga coronata*	0	1

‡ Indicates blue-listed status in BC

7.2.3 Waterbirds and Landbirds

In total, 39 species of waterfowl, loons, grebes, shorebirds, and herons (hereafter collectively referred to as "waterbirds") were recorded during spring through autumn waterbird surveys in 2022 at Burton Creek (Appendix B). In addition to waterbirds, 56 species of landbirds, including but not limited to songbirds, raptors, pigeons, and swifts, were observed at Burton Creek (Appendix C). A total of 3,568 individuals were recorded during 2022 surveys, some of which were likely repeat individuals between months (Appendix D). Of these, 2,639 sightings were of waterbirds.

The months with the greatest waterbird sightings were August, September, and October (in that order). These three months also had the highest waterbird abundance during 2021 surveys. June and July had the lowest number of sightings, which was inconsistent with 2021 results, where May had the fewest. June only had one survey, and July had two, compared to the other months, which had three. However, as seen in Figure 7-2, when monthly counts were normalized by the number of surveys in each month, June and July still had the fewest sightings.

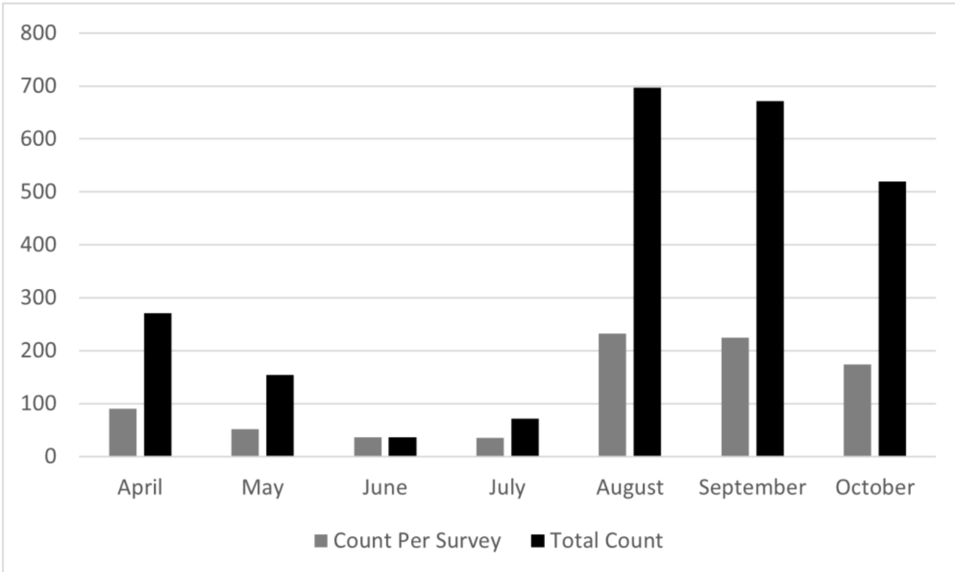

Figure 7-2. Burton Creek monthly waterbird survey total counts and average count per survey.

The months with the most landbird sightings were September, October, and May (in that order). June had the fewest sightings. When normalized by the number of surveys per month, these rankings stayed the same, as seen in Figure 7-3.

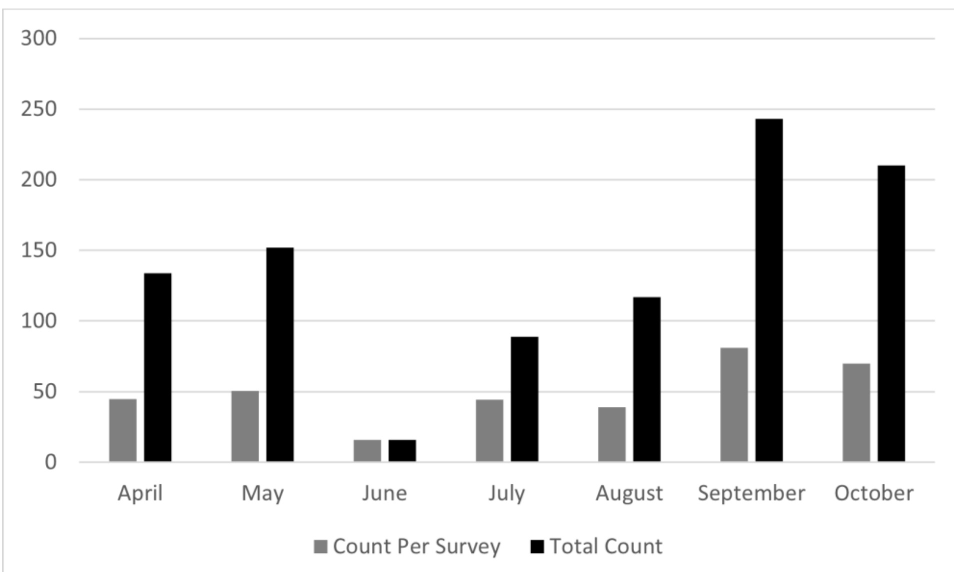

Figure 7-3. Burton Creek monthly landbird total counts and average count per survey.

Canada Goose, Mallard, Common Merganser, Common Loon (*Gavia immer*), Green-winged Teal (*Anas crecca*), American Wigeon (*Mareca americana*), and California Gull (*Larus californicus*) were the most recorded species (in that order) from the waterbird surveys. Over a third of all sightings were Canada Geese, which were most seen from August through October. Mallards were present consistently throughout the year but had the most records in October and August.

Bald Eagle and American Crow were the most common species recorded during landbird species surveys. Both were recorded primarily in September and October, with over 90% of all Bald Eagle observations and 95% of all American Crow observations occurring in this period. Other common landbird species spotted during surveys included Cliff Swallow (*Petrochelidon pyrrhonota*), Tree Swallow (*Tachycineta bicolor*), and Barn Swallow (*Hirundo rustica*), American Pipit (*Anthus rubescens*), and Brewer's Blackbird (*Euphagus cyanocephalus*)

As in previous years, many waterbird sightings followed the reservoir edge, but various bird species were also recorded interacting with WPW features (Table 7-5). Mallards, Ring-necked Ducks (*Aythya collaris*), Green-winged Teal, and Canada Geese were among the most common species recorded in or near the features. Land-associated birds such as the Common Raven, Bald Eagle, American Kestrel (*Falco sparverius*), and Turkey Vulture were recorded on snags in the WPW area by the field observer and documented on remote cameras (Figure 7-4).

Similar to previous years, several species of special concern were recorded in proximity to the Burton Creek WPW area during 2022 water and land bird surveys. Bank and Barn Swallows were recorded from late spring through summer and listed federally as endangered on Schedule 1 of the SARA. Evening Grosbeak, Horned and Western Grebes, and Red-necked Phalarope are listed as species of special concern on Schedule 1 of the SARA. Provincially, Red-necked Phalarope is blue-listed, and Western Grebe is red-listed.

Table 7-5. Waterbirds and landbirds recorded using WPW features (ponds A1-A6, D1-D2, and B1-B2 or mound C2) or close to them (e.g., pond shoreline) during waterbird surveys in 2022. Species counts are presented by date recorded.

Date	Species Code	Common Name	Pond/Mound Abundance						
			A1	A2	A5	A6	C2	D1	D2
09-Apr	MALL	Mallard				4			
	RNDU	Ring-necked Duck	1						
20-Apr	PBGR	Pied-billed Grebe						1	
	RNDU	Ring-necked Duck						2	
	WISN	Wilson's Snipe		1					
29-Apr	BAEA	Bald Eagle					1		
	CAGO	Canada Goose							2
	GWTE	Green-winged Teal				1			
	RNDU	Ring-necked Duck				2			
	WISN	Wilson's Snipe	3	1	1				
05-May	AMKE	American Kestrel					1		
	BUFF	Bufflehead							1
	GRSC	Greater Scaup							1
	MALL	Mallard						1	
21-May	AMWI	American Wigeon							1
	BUFF	Bufflehead							2

Date	Species Code	Common Name	Pond/Mound Abundance						
			A1	A2	A5	A6	C2	D1	D2
	CANG	Canada Goose							2
	GADW	Gadwall							1
	MALL	Mallard							7
	RNDU	Ring-necked Duck							4
	SPSA	Spotted Sandpiper						1	
31-May	MALL	Mallard						3	
	TUVU	Turkey Vulture					7		
17-Jun	CITE	Cinnamon Teal				1			
07-Jul	COLO	Common Loon				2			
	LESC	Lesser Scaup					1		
08-Aug	MALL	Mallard		7					
30-Aug	AMKE	American Kestrel					1		
	GWTE	Green-winged Teal				1		10	
	MALL	Mallard				3			
	NOSL	Northern Shoveler						1	
10-Sep	AMWI	American Wigeon						12	
18-Sep	CAGO	Canada Goose						6	
	CORA	Common Raven						4	
25-Sep	CAGO	Canada Goose						1	
	HOME	Hooded Merganser							2
04-Oct	MALL	Mallard		1					
21-Oct	RNDU	Ring-necked Duck							1
31-Oct	RNDU	Ring-necked Duck							2
Grand Total			**4**	**10**	**1**	**14**	**11**	**42**	**26**

Figure 7-4. A wildlife camera photograph taken in the WPW area on July 6, 2021 shows a Canada Goose browsing on vegetation in the foreground. A Bald Eagle perches on an artificial snag and a Tree Swallow landing on a planted stake in the background

7.3 Bird Discussion

We recorded 27 species of songbirds on acoustic ARUs in the WPW area or adjacent to it, and 33 bird species in total when including non-passerine groups. Many of the species detected were recorded during previous surveys (Waytes et al. 2021; Waytes et al. 2022). Common Yellowthroat was again the most frequently 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, Canada Geese, and Mallards could likewise be breeding in the area. Other species such as the Chipping Sparrow, American Robin, and Willow Flycatcher may be using features in the WPW area to perch but were likely not breeding in the immediate WPW area. As shrubs and stakes planted in the WPW mature, they will provide cover for tree or shrub-nesting birds. Likewise, birds such as the Tree and Northern Rough-winged Swallows were likely foraging or perching but not nesting in the WPW area. Features such as snags, which in the future, may 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 and Red-eyed Vireo, were likely not present in the WPW area but rather in adjacent mature deciduous and mixedwood forest habitat.

Songbird point counts provided additional information about songbirds near the Burton WPW area, including open, grassy areas that are also subject to inundation. Constraining the results to birds within 30 m of the point count centres minimizes double-counting individuals but also ensures observations are tied to areas relevant to WPW monitoring. The results from point counts matched the ARU results, with Common Yellowthroat as the most recorded species. The other 10 species recorded within 30 m were also detected in ARU recordings.

The waterbirds detected in 2022 followed similar distribution patterns to those observed over the previous three years of surveys, as they were found to largely follow the rising shoreline due to reservoir inundation. An increase in bird photographs on remote cameras in the WPW area in June and July was likely due to the higher reservoir levels (see Section 10.3). Nonetheless, as in the 2020 surveys, several species (such as Canada Geese) were recorded using the constructed ponds. High waterbird abundances in August, September, and October can be attributed to fall migration, the presence of juvenile birds, and the concentration of food resources resulting from Kokanee (*Oncorhynchus nerka*) spawning in Burton Creek.

Twenty species of land and water birds were documented using the ponds and mounds and perching on the 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 continue to grow, they will provide increased nesting opportunities for a variety of bird species.

8.0 BATS

8.1 Bat Sampling

There are 11 bat species potentially occurring in the Burton Creek area (Table 8-1), most confirmed by live capture studies in the region. Of these species, Townsend's Big-eared Bat (*Corynorhinus townsendii*), Northern Myotis (*Myotis septentrionalis*), and Fringed Myotis (*M. thysanodes*) are blue-listed by the BC 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 2023). Federally, Northern Myotis and Little Brown Myotis (*M. lucifugus*) were emergency listed under the *SARA* 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 2013). Fringed Myotis is considered Data Deficient by COSEWIC, meaning there is not enough scientific information available to support status designation.

Table 8-1. Provincial and national status of bat species potentially occurring in the Mid-Arrow Lakes area. 1-E = Endangered on Schedule 1 of the *SARA*.

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

To study bat presence in the Burton Creek WPW area, three Wildlife Acoustics Song Meter ultra-high frequency autonomous recording units (uARU, model SM4BAT Wildlife Acoustics, Inc., Maynard, Massachusetts, USA) were deployed from June to mid-September in 2022 (Appendix F). 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 it will sample from almost all directions projecting 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). Unfortunately, one of the uARUs was tampered with and the data could not be recovered.

8.2 Data Analyses

Bat presence and activity in 2022 were assessed by analyzing recordings from Wildlife Acoustics Song Meter units using their automatic classification software (Kaleidoscope Pro v. 5.4.8). 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 confirmed in the West Kootenays were selected for use in the analysis of 2022 WPW 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, the distance of bats from the ARU, 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 differentiate some species confidently (Table 8-2; also, Szewczak et al. 2011a,b). Thus, species assignment is based partly on the 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 each area.

Table 8-2. 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 cumulative detection rate (i.e., number of identified files per detector-hour) for each species and functioning ARU. The cumulative detection rate for each species was compared between years, with baseline data sets from 2017 (n=3 ARUs), 2018 (n=3), and 2019 (n=2), to post-WPW construction from 2020 (n=5), 2021 (n=4), and 2022 (n=2). The number of ARUs listed reflects the number of working units; non-functioning units over the course of the study have been excluded from analyses. In 2022, one ARU (BUWPW5) had no bat detections, likely due to microphone malfunction.

8.3 Bat Results

A total of 10 species of bat were classified from autonomous recording units from the WPW area using Kaleidoscope bat auto-ID software. These were predominantly *Myotis* species, with Little Brown Myotis having the most detections overall (Table 8-3).

Table 8-3. Recordings per detector-hour for bat detectors deployed in the Burton Creek WPW area in 2022. 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 **8-1**.

Species	UARU01	UARU02
CORTOW	0.0028	0.0114
EPTFUS	0.0934	0.0457
LASCIN	0.3055	0.1714
LASNOC	0.5941	1.92
MYOCAL	0.4696	0.3257
MYOEVO	0.0283	0.0057
MYOLUC	5.0028	0.7086
MYOSEP	0.0071	0.0057
MYOTHY	-	-
MYOVOL	0.2687	0.0114
MYOYUM	0.3013	0.0971
Richness	**10**	**10**

Of the two functioning bat detectors, UARU01 recorded the most calls (7.07 per detector-hour) and UARU02 recorded the least (3.30 calls per detector-hour) (Figure 8-1). Despite the proximity of the two units, there was a large amount of within-site (between-detector) variation. Little Brown Myotis was the most detected species at UARU01, while Silver-haired Bat was classified more than any other species at UARU02.

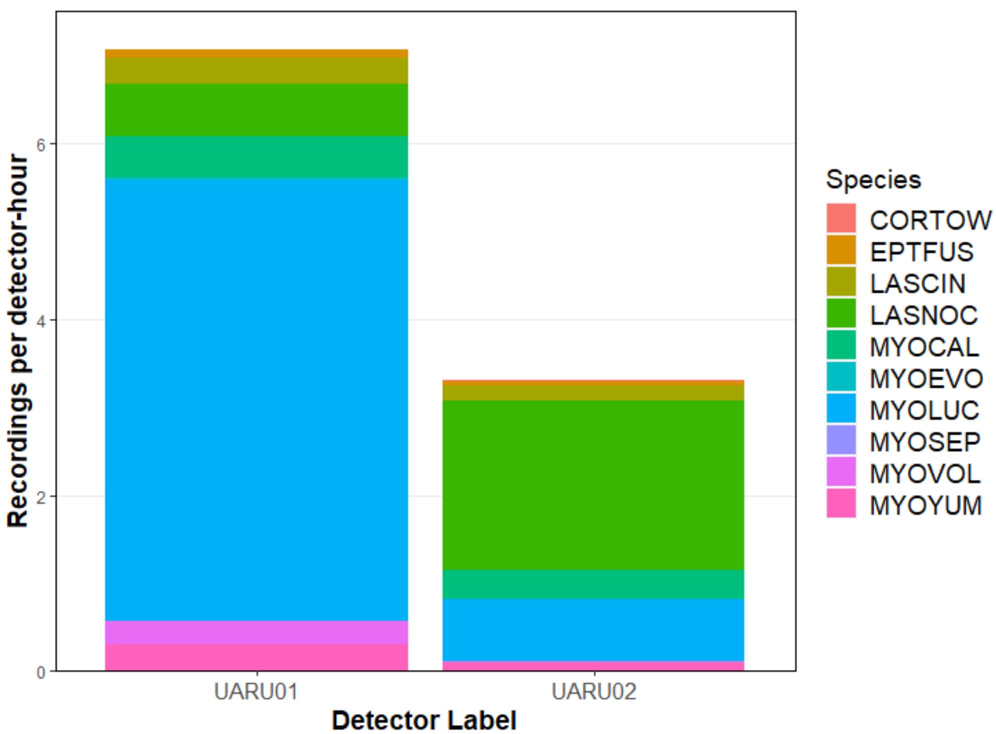

Figure 8-1. Relative abundance (recordings per detector-hour) of bat species by detector around the Burton WPW area, 2022.

Most species had higher detection rates at UARU01 in 2022, with Silver-haired and Townsend's Big-eared bats being the exceptions. Species detection rates from 2022 were comparable to previous years but were often at the lower end (Figure 8-2). Northern Myotis had a higher-than-average year in 2022, while California, Fringed, Little Brown, and Yuma Myotises had their lowest year to date.

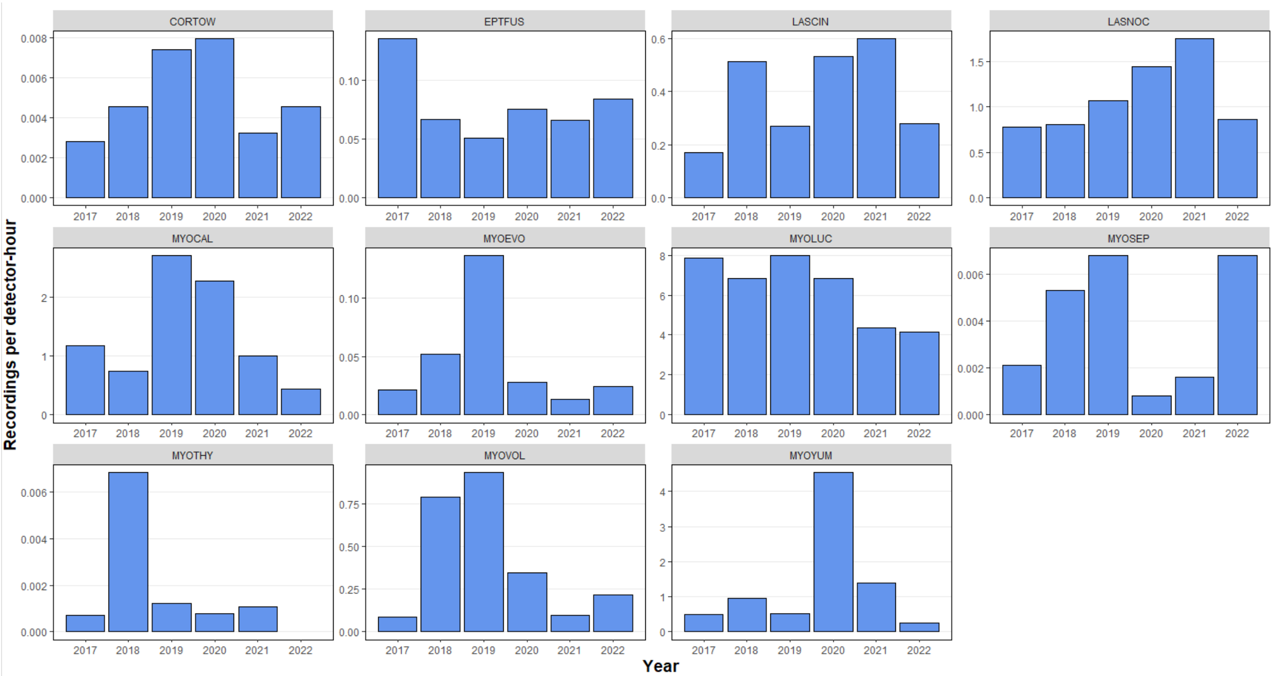

Figure 8-2. Comparison of annual detection rates (recordings per detector-hour) for each bat species documented by ARUs deployed in the Burton Creek WPW area. Bat species were monitored in 2017 (n=3 ARUs), 2018 (n=3), 2019 (n=2), 2020 (n=5), 2021 (n=4), and 2022 (n=2). Species codes are provided in Table 8-1.

8.4 Bat Discussion

The ten bat species detected at Burton Creek in 2022 was less than in previous years (Hentze et al. 2019; Waytes et al. 2020; Waytes et al. 2021; Waytes et al. 2022) due to the lack of Fringed Myotis detections; however, this species is usually recorded in low numbers and may be the result of misclassifications by Kaleidoscope. Once again, the federally endangered Little Brown Myotis was documented and was the most frequently recorded bat species around the Burton WPW. Little Brown Myotis 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 2013). The Northern Myotis, another federally endangered bat primarily due to White-nose Syndrome, was detected at Burton Creek, and the blue-listed Townsend's Big-eared Bat was also recorded.

In previous years (especially in 2020), one location had high levels of Yuma Myotis activity, which could indicate the presence of a nearby natural roost (e.g., large cottonwood snag). This location was not sampled in 2022, as the survey effort was refined to specifically document bat use of the Burton WPW. Detections of Yuma Myotis in 2022 was lower than in all previous years of monitoring.

9.0 AMPHIBIANS

9.1 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 providing information on species presence, richness, and habitat use. These surveys include searching for adults, larvae, and egg masses.

Two observers conducted a VES in the Burton Creek WPW area on May 26, 2022. The survey was conducted during late morning and early afternoon and followed a similar approach to previous years (2020 and 2021). The surveyors searched the perimeter and shallow areas of the ponds (<100 cm in depth) and as well as the connecting water courses between the ponds. The survey extended from pond A1 down to the large burrow pit in the drawdown zone of the reservoir. Surveyors spent approximately 2.15 hrs each for a total survey effort of 4.3 hours. Incidental observations of amphibians (and reptiles) were also recorded during other project activities (e.g., deploying data loggers) and surveys.

Acoustic ARUs allow passive documentation of the occurrence of amphibians at the WPW, including when researchers are not present at the site. The Wildlife Acoustics Song Meter autonomous recording units (SM4) deployed for songbird sampling were also used to monitor amphibian calls, primarily Western Toad. See Section 7.1 for more details on ARU deployment and Appendix E for a map of sampled locations.

9.2 Data Analyses

We scanned the acoustic ARU recordings using a Western Toad recognizer with Song Scope™ software to detect vocalizations. The survey period was restricted to the peak of the amphibian breeding season (Hawkes et al. 2020), which included the period of ARU deployment (25 May 2022) 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/). 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. We used the suggested Quality (30) and Score (50) threshold settings for the analyses. The outputs of the recognizer scans were then reviewed by human listening and/or spectrogram visualization to determine whether they correctly captured the target species calls (i.e., Western Toad) or were falsely classified.

9.3 Amphibian Results

The results of the VES conducted on May 26, 2022, included observations of Pacific Chorus Frog, Columbia Spotted Frogs, and Western Toads adults and egg masses and/or tadpoles. Adult Pacific Chorus Frogs and Columbia Spotted Frogs were also encountered incidentally while installing data loggers, ARUs, and wildlife cameras or conducting other surveys (Figure 9-1). Two species of reptiles were also observed incidentally. Common Garter Snakes were observed three times on the constructed mounds and ponds. In addition, a Western Terrestrial Garter Snake was observed sunny on a large piece of woody debris west of the constructed mounds and ponds (Figure 9-1). Appendix H provides a map that shows the distribution of amphibians and reptiles observed incidentally and during the VES. Table 15-1 and Table 15-2 in Appendix I provide the observation date and time, the number of animals observed, and their age class. Table 15-1 summarizes the results of the amphibian survey, and Table 15-2 summarizes the incidental observations.

Adult Western Toads were observed breeding in the burrow pit during the VES in May. Multiple egg strings were observed; however, it was difficult to obtain an accurate count as they were often overlapping. Nevertheless, at least one egg mass had begun to hatch out, and free-swimming tadpoles were observed. No Western Toad adults, tadpoles, or egg masses were observed in the constructed ponds.

Pacific Chorus Frog egg masses were observed in ponds A1 (n=1), A2 (n=1), and A5 (n=3). Adult Pacific Chorus Frogs were observed in or along the shoreline of ponds A2 and A3. Adult Columbia Spotted Frogs were observed in ponds A1 (n =1), A2 (n=4), and A5 (n=1). A single Columbia Spotted Frog tadpole (Gosner stage 25/26; Gosner 1960) was observed in pond A2. No Columbia Spotted Frog egg masses were observed.

Western Toad vocalizations were not detected on five acoustic ARUs deployed around the WPW area. Pacific Chorus Frog calls were incidentally detected in ARU recordings over the duration of the May 25 to July 1, 2022, sampling period. The Western Toad recognizer picked up Pacific Chorus Frog calls as false positives, and each unit had at least one occurrence.

9.4 Amphibian Discussion

All three species observed in 2022 were also observed or recorded in 2021 and 2020 (Waytes et al. 2022; Waytes et al. 2021). In addition, these species were previously documented in the Burton Creek area during CLBMON-37 surveys from 2008 to 2016 (Hawkes et al. 2020). Two amphibian species (the Pacific Chorus Frog and the Columbia Spotted Frog) were documented using the constructed ponds. In contrast, and as observed in previous years, Western Toads were only observed in the adjacent burrow pits.

Despite the successful breeding of three amphibian species in the constructed ponds and adjacent borrow pits, the survival of the eggs and tadpoles is uncertain due to inundation from the reservoir. For amphibians breeding in lower ponds, there would likely be insufficient time for the tadpoles to reach metamorphosis. For example, Hawkes et al. (2011) reported that between 2008 and 2010, Western Toad tadpoles completed metamorphosis in the Burton area from the first week of July to early August. The borrow pit where Western Toad egg strings and recently hatched tadpoles were observed is at an elevation of 432.9 m ASL and is below and outside the WPW treatment area. On June 9, 2022, 14 days later, the reservoir inundated the pond, likely resulting in the loss of this cohort as they would lack the swimming ability at an early developmental stage (i.e., likely less than Gosner stage 30) to migrate to protected waters.

The WPW ponds containing Pacific Chorus Frog and Columbia Spotted Frog eggs and tadpoles are located at higher elevations and were subsequently inundated later in June through to early July; pond A5 was inundated on June 15th, and pond A1 was inundated on July 1st. The likelihood of amphibian larvae surviving likely increases with elevation as the larvae in these ponds would have more time to develop and would be more capable of migrating to warmer protected waters. However, inundation from the reservoir may create additional factors and stressors for early larval stages, reducing larval survival. For example, cooler water from reservoirs reduces tadpole growth and delays metamorphosis (Wheeler et al. 2015), increases predation vulnerability (Catenazzi and Kupferberg 2018) and can alter periphyton communities toward taxa inedible by tadpoles (Furey et al. 2014).

Collectively, these factors and stressors may result in high levels of larvae mortality in years when reservoir levels come up quickly and remain high over the summer months.

Figure 9-1. Amphibians and reptiles observed at Burton in 2022. Upper row: adult Pacific Chorus Frog and (right) a Columbia Spotted Frog. Second row: (left) Pacific Chorus Frog egg mass and (right) Western Toads in amplexus. Third Row: Western Toad Egg Strings (left) and tadpoles (right); Forth Row: (left) Common Garter Snake; (right) Western Terrestrial Garter Snake.Photo Credits: D. Adama (images in the upper 3 rows), Mike Miller (*T. sirtalis*), and Naira Johnston (*T. elegans*).

Without confirming the survival of later-stage tadpoles or the presence of metamorphs on site, the effectiveness of the WPW at benefiting amphibian populations is uncertain. As stated in WPW Performance Measures 2b (Section 12.0) “egg development should be tracked to determine if eggs metamorphose into froglets or toadlets.” Tracking amphibian egg and larval development through to metamorphosis would provide a better assessment of the effectiveness of the WPW at benefiting amphibian populations than merely documenting the presence of eggs and tadpoles.

10.0 GENERAL WILDLIFE

Remote wildlife cameras are a cost-effective, non-invasive tool for assessing and monitoring many terrestrial species. They are particularly effective for monitoring medium and large-sized animals and inconspicuous (e.g., nocturnal) species (Kucera and Barrett 2011). With sufficient maintenance, wildlife cameras can provide long-term monitoring of an area. Remote cameras have the potential to provide complete information about the suite of species using an area since they record 24 hours a day. In addition, 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 return/response of wildlife to restoration efforts on anthropogenically altered habitats.

Wildlife camera photos taken in 2022 can be compared to those taken pre-WPW construction. It is anticipated that the restoration project has increased habitat complexity and improved habitat suitability for a variety of wildlife. Thus, we expect the data will show an increase in species richness and frequency of use over time.

10.1 General Wildlife Sampling

RECONYX® HyperFire 2™ cameras were set up in the Burton Creek WPW area to monitor wildlife use of the WPW in the spring and fall of 2022 (Appendix G). Seven cameras were deployed in the spring on 26 May 2022 and removed on June 22, 2022, to prevent flooding from the reservoir. Four cameras were redeployed on Sept 6th, 2022, and removed on Nov 8, 2022. The cameras were programmed to take ten photos with each trigger using the ‘RapidFire’ setting, which takes up to five frames per second. After the last photo, each camera was programmed for a quiet period of one minute. Trigger sensitivity was set to medium-high.

Unlike previous years, most of the wildlife cameras were positioned directly over the ponds to capture use by aquatic species of birds and mammals. The cameras were mounted to t-bar fencing or large wood debris at the edge of each pond (Figure 10-1). Consequently, the data may not be directly comparable to previous years where the cameras were located at upland positions. Further, water levels and camera malfunctions did not allow for constant monitoring of each site. From June 8 to June 22, 2022, two wildlife cameras were temporarily positioned upland on the mounds.

Figure 10-1 Wildlife camera positioned at the edge of a constructed wetland.

10.2 Data Analyses

Wildlife camera images were processed using TimeLapse software (Greenberg 2019). Each image was visually assessed for wildlife, and the species and the number of individuals were recorded. The image capture data has been summarized by the species, site, and the number of images captured for each camera. It should be noted that wildlife capture images are not directly related to animal abundance, as one animal can trigger multiple photographs, and multiple cameras may record the same animal.

10.3 Wildlife Results and Discussion

7,359 images were captured at the Burton Creek WPW, including 4,218 in the spring and 3,141 in the fall. Table 10-1 shows the number of images captured by habitat feature in the WPW area excluding misfires caused by wind, sun, and other causes. In total, 1,273 images of wildlife were captured, with 940 and 333 captured during the spring and fall sampling session, respectively. Waterfowl were the most photographed taxa of birds, comprising 96% of all birds captured by the wildlife cameras.

Table 10-1. The number of images taken from wildlife cameras by habitat feature in the Burton WPW area in 2022. Capture nights are the number of nights the cameras were operated.

Habitat Feature	Spring		Fall	
	Capture Night	Wildlife Images	Capture Nights	Wildlife Images
Pond A1	26	47	-	-
Pond A2	12	25	62	141
Pond A3	12	488	62	70
Pond A4	26	15	62	122
Pond A5	12	70	-	-
Pond A6	12	224	-	-
Pond B2	12	21	-	-
Mound C2 NE	12	50	-	-
Mound C2 SE	12	0	-	-
Total		940		333

Table 10-2. The number of images captured by species from wildlife cameras in the Burton WPW area in 2022.

Taxa/Species	Fall	Spring	Total
Avian	**174**	**882**	**1056**
Bald Eagle		30	30
Blue Winged Teal		54	54
Canada Goose	94	3	97
Canada Goose, Mallard		21	21
Gadwall		36	36
Great Blue Heron	4		4
Mallard	56	273	329
Northern Pintail	10		10
Unknown Bird	3		3
Unknown Duck		465	465
Unknown Raptor	7		7
Mammal	**159**	**280**	**439**
American black bear	10		10
Human		222	222
White-tailed deer	149	58	207
Grand Total	**333**	**1162**	**1495**

10.4 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. The high use of the ponds by waterfowl is remarkable as suggests the ponds are of value this group of wildlife.

11.0 CONCLUSIONS

Initiated in 2009, CLBMON-11B1 is a long-term wildlife monitoring project that, at first, focused on assessing the efficacy of revegetation prescriptions (2009 – 2019). During that time, baseline data were collected at the Burton site as part of the revegetation monitoring, and additinally, in anticipation of a Burton WPW project. Until the Burton WPW project became defined, early baseline data collection was limited in scope, and efficiencies were found by recognizing the existence of suitable data collected under separate related monitoring studies (CLBMON-37 and CLBMON-33). Beginning in 2017, the Burton WPW project was selected for implementation, and project definition began. In 2018, sampling of baseline conditions for effectiveness monitoring of the Burton WPW project was initiated (this project). 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 low for most species (Hawkes and Tuttle 2016; 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 federal species of Special Concern, Western Toad; the provincially blue-listed Townsend's Big-eared Bat and Fringed Myotis; and the federally endangered Little Brown Myotis.

Results of the 2022 monitoring indicated that wildlife are using constructed habitat features, including species with provincial or federal designation. This included waterbird and amphibian use of the constructed 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 ponds A1, A2, and D1 hosted a greater family richness and a greater total number of individuals observed compared to the other respective ponds.

Amphibian use of the constructed ponds and burrow pits was considerable in 2022. Breeding evidence (i.e., pairs in amplexus or egg masses) of Western Toad was observed in the burrow ponds and egg masses of Pacific Chorus Frogs, and Columbia Spotted Frog, was observed in the constructed WPW ponds. However, the success of these breeding events was not monitored over the course of the spring and summer and cannot be confirmed. Reservoir levels were likely detrimental to amphibian eggs and larvae at lower elevations (i.e., burrow pits) but amphibian eggs and larvae may have survived in the upper WPW ponds (e.g., pond A1 and A2) as they were not flooded for extended periods (pond A1 was not flooded at all).

12.0 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 adapted from 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 0) and expansion of wetland habitats in the vicinity of ponds A1 and A2.
    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 pond depth required to support amphibian breeding and larval development (Section 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 aquatic 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.
    c. Evidence of breeding by amphibians. 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.

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, and generally only when inundated by Arrow Lakes Reservoir.

e. Evidence of use of the constructed wetland by bats (as determine by autonomous recording units. The use of enhancements such as bat boxes, snags, or other enhancements) is currently being assessed under CLBMON-11B5 (Nupqu 2022).

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 in 2022 confirmed the continued use of 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.

13.0 RECOMMENDATIONS

In 2017, the Terms of Reference for CLBMON-11B1 were revised (Revision 1, June 29, 2017, BC Hydro 2017). The work completed in 2022 represents the fifth year of implementation under these revised Terms of Reference. The surveys in 2022 represent the third year of the WPW monitoring after its establishment, and the second 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. **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. (Performance Measures 2b).

2. **Monitor the water depths in the ponds.**

   Water levels in the ponds should be monitored from early spring to last fall to track pond depths, confirm the timing, duration, and magnitude of inundation, and determine water level when the ponds are not inundated. These data will aid in assessing the effectiveness of the ponds in meeting the requirements of amphibians and help inform aspects of macrophyte and macroinvertebrate establishment (Performance Measures 1b, 2a, and 2b).

3. **Monitor the Burton WPW to determine if amphibians develop to metamorphosis.** Amphibian surveys should focus on tracking amphibian larvae through the spring and summer to determine if amphibian larvae in the constructed ponds complete metamorphosis (Performance Measures 2c).

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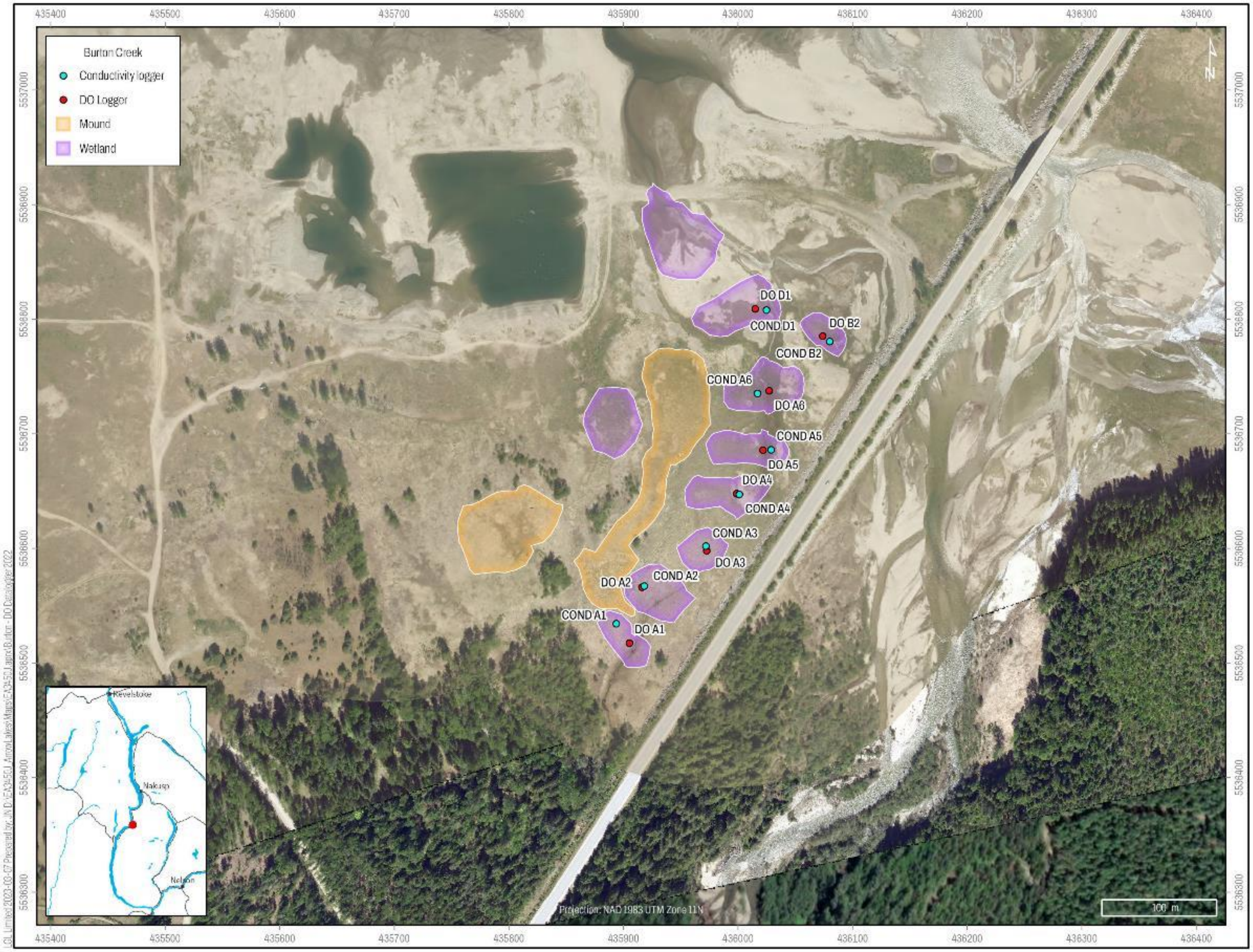
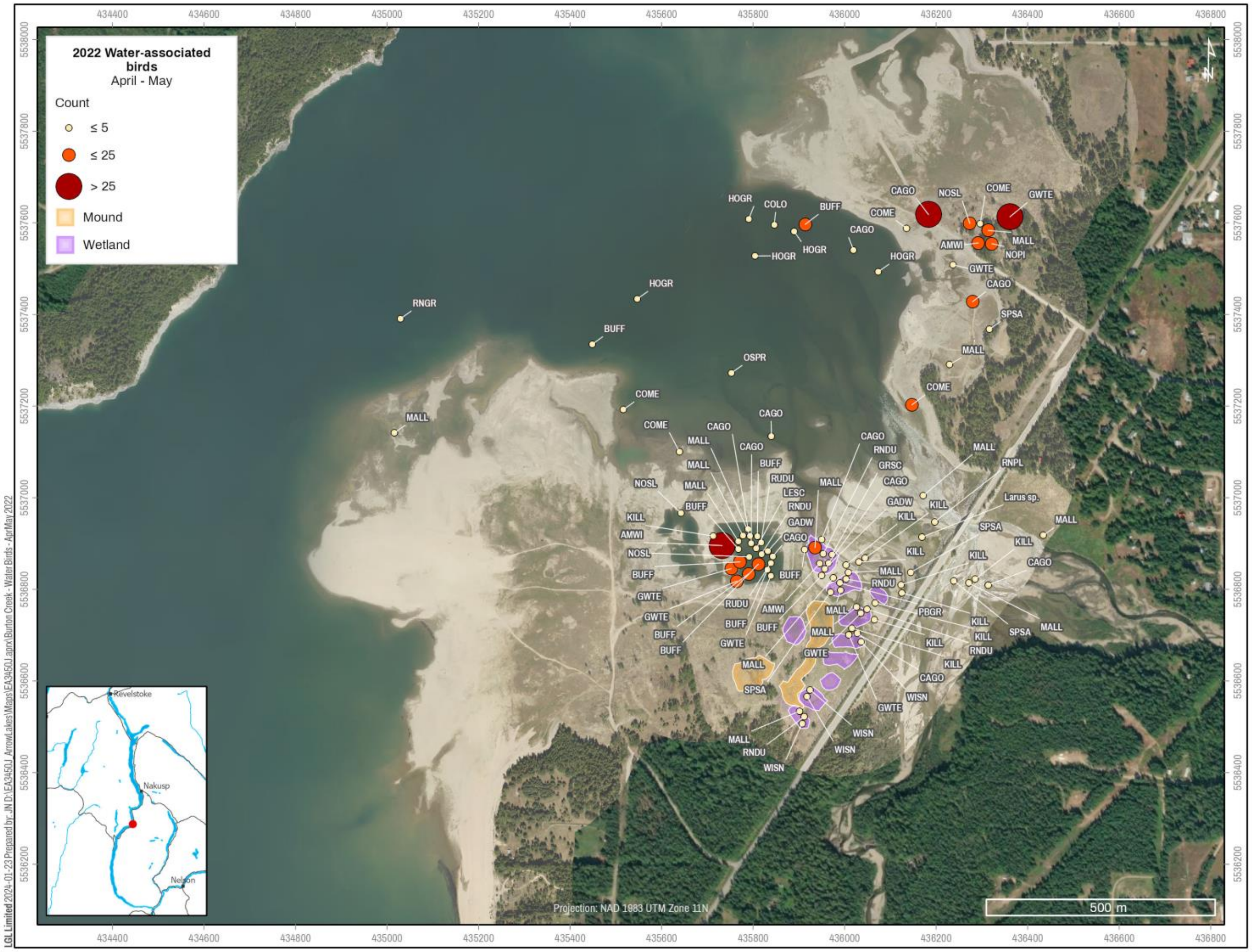
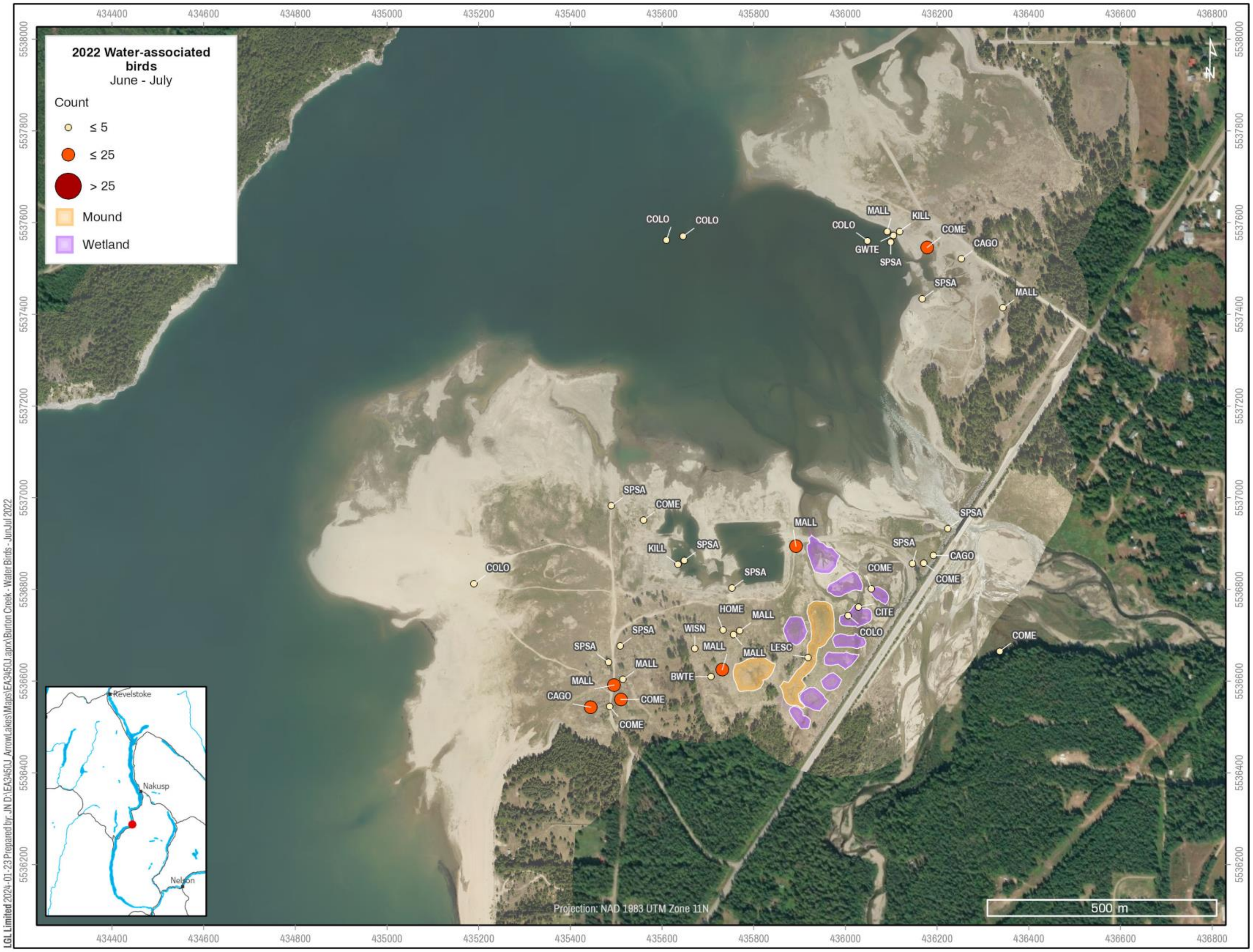
15.0 APPENDICES

Appendix A: Map showing the location of the dissolved oxygen and conductivity data loggers deployed in 2022.



Appendix B: Distribution of waterbird species using the constructed Burton Creek wildlife physical works features (mound and wetland polygons) and surrounding areas in April/May 2022 (first figure), June/July 2022 (second figure), August/September 2022 (third figure), and October/November 2022 (fourth figure).




2022 Water-associated birds
June - July
Count
≤ 5
≤ 25
> 25
Mound
Wetland
Revelstoke
Nakusp
Nelson
Projection: NAD 1983 UTM Zone 11N
500 m
LGL Limited 2024-01-23 Prepared by: JN D:\EA3450J_ArrowLakes\Maps\EA3450J_ArrowLakes\EA3450J.aprx\Burton Creek - Water Birds - JunJul 2022
COLO
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HOME
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BWTE
LESC
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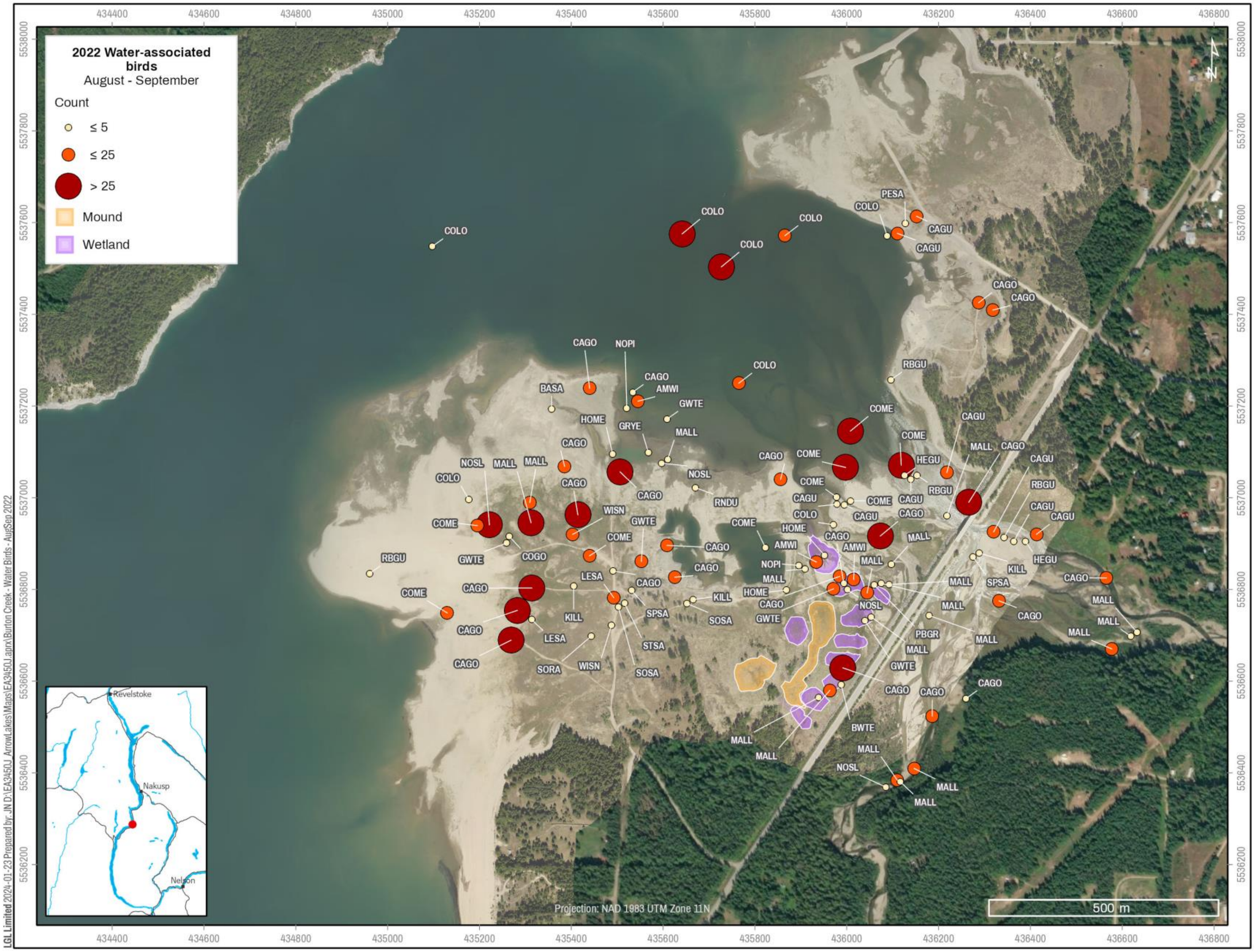
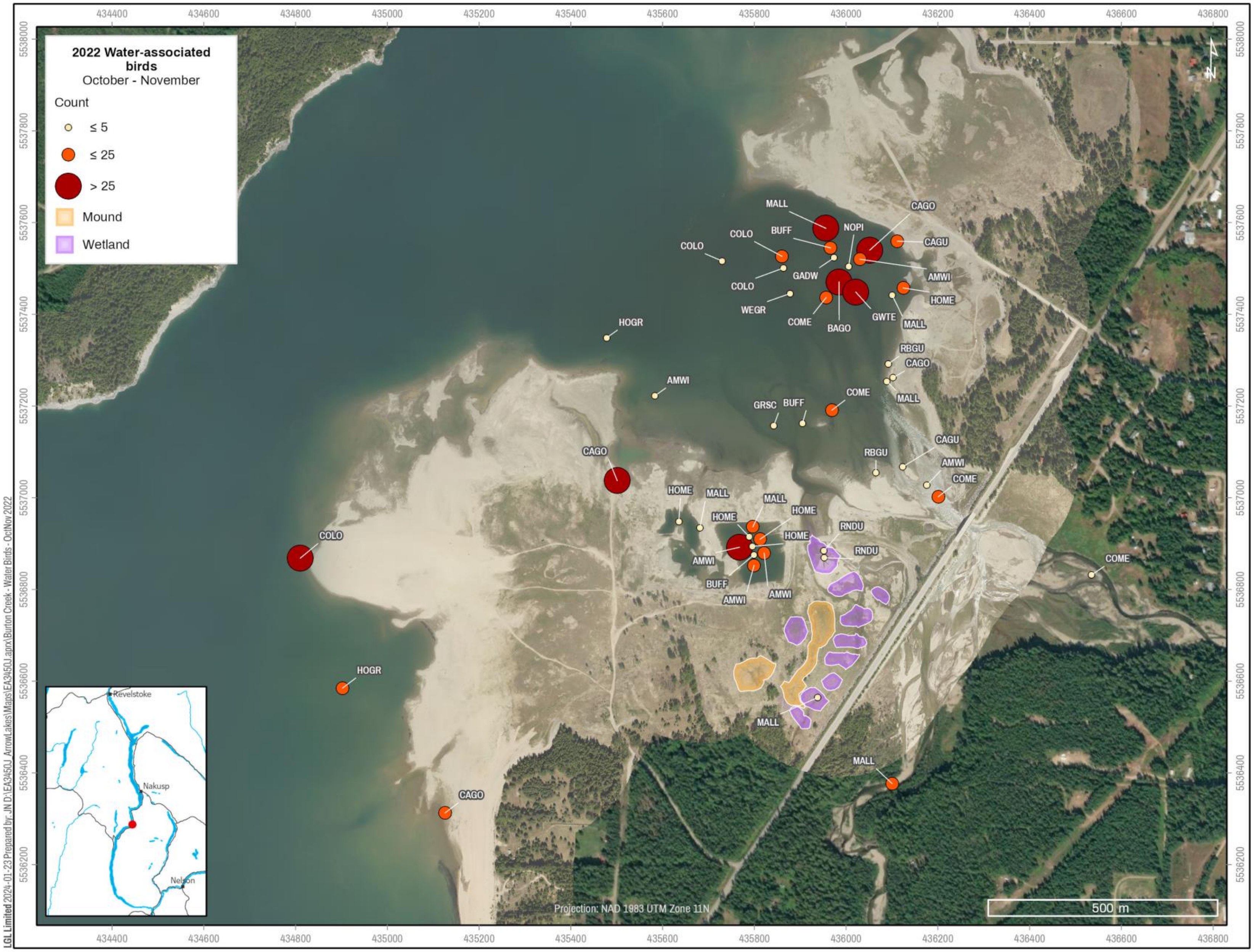
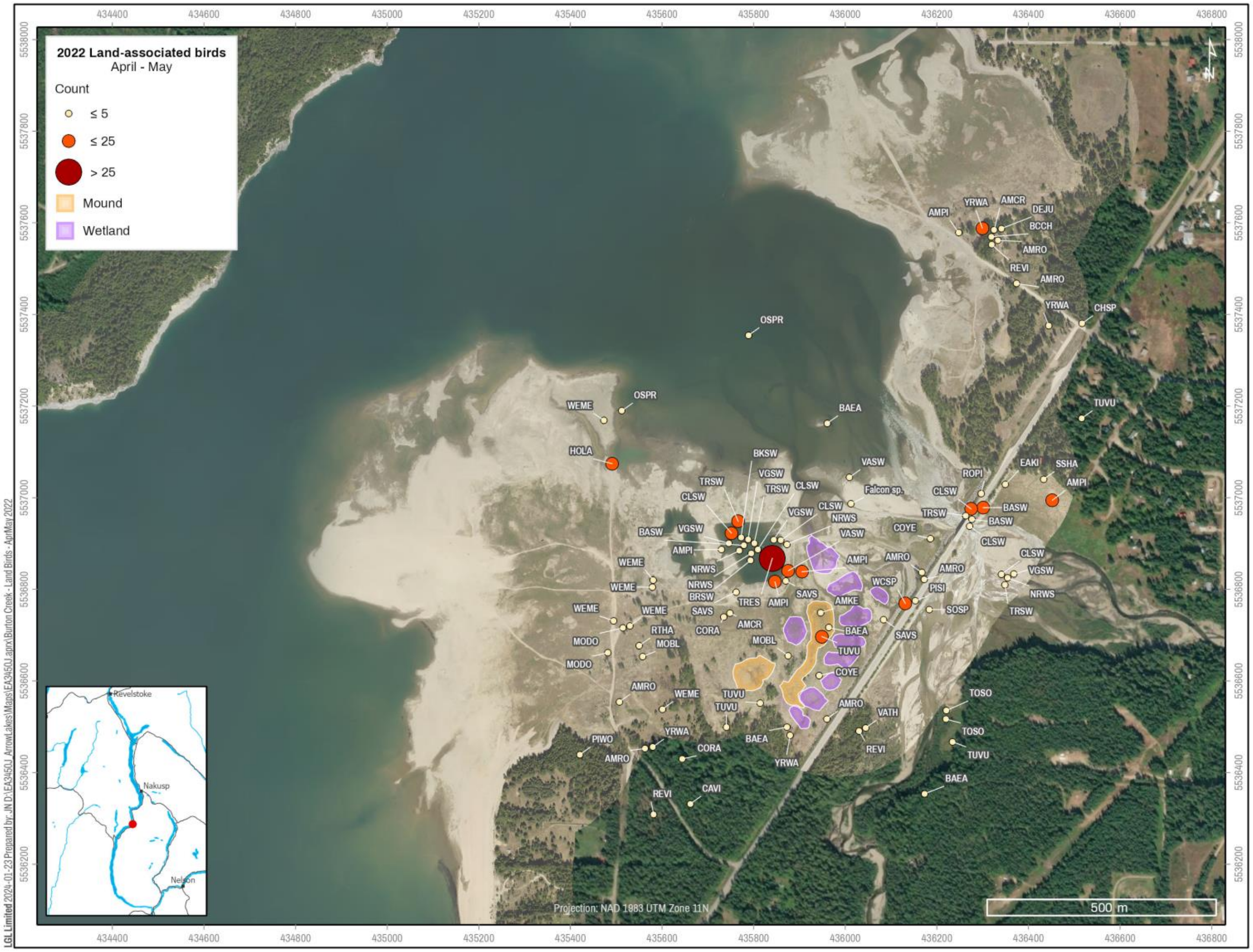
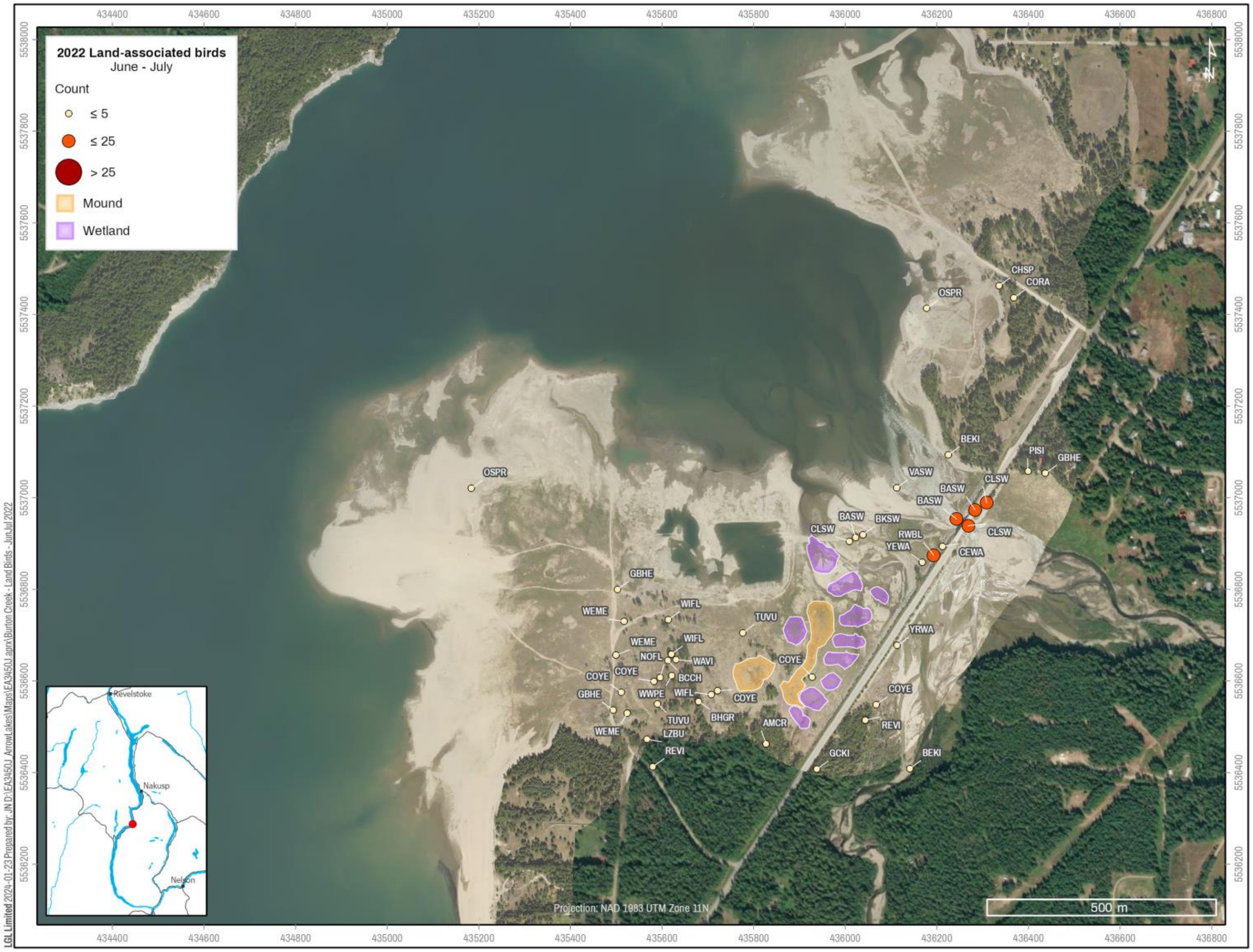
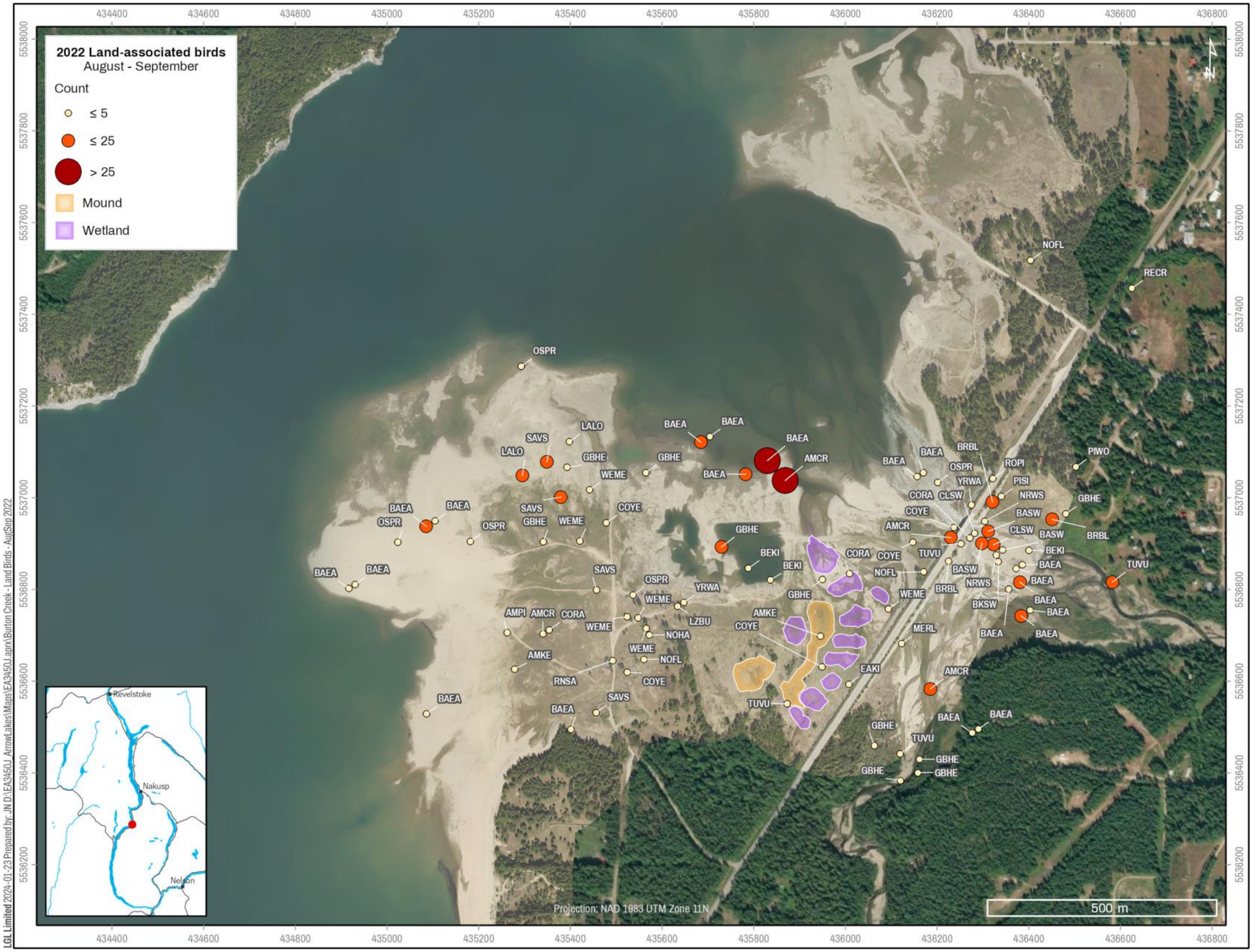

2022 Water-associated birds
August - September
Count
≤ 5
≤ 25
> 25
Mound
Wetland
Revelstoke
Nakusp
Nelson
Projection: NAD 1983 UTM Zone 11N
500 m
LGL Limited 2024-01-23 Prepared by: JN D:\EA3450J_ArrowLakes\Maps\EA3450J.aprx\Burton Creek - Water Birds - AugSep 2022

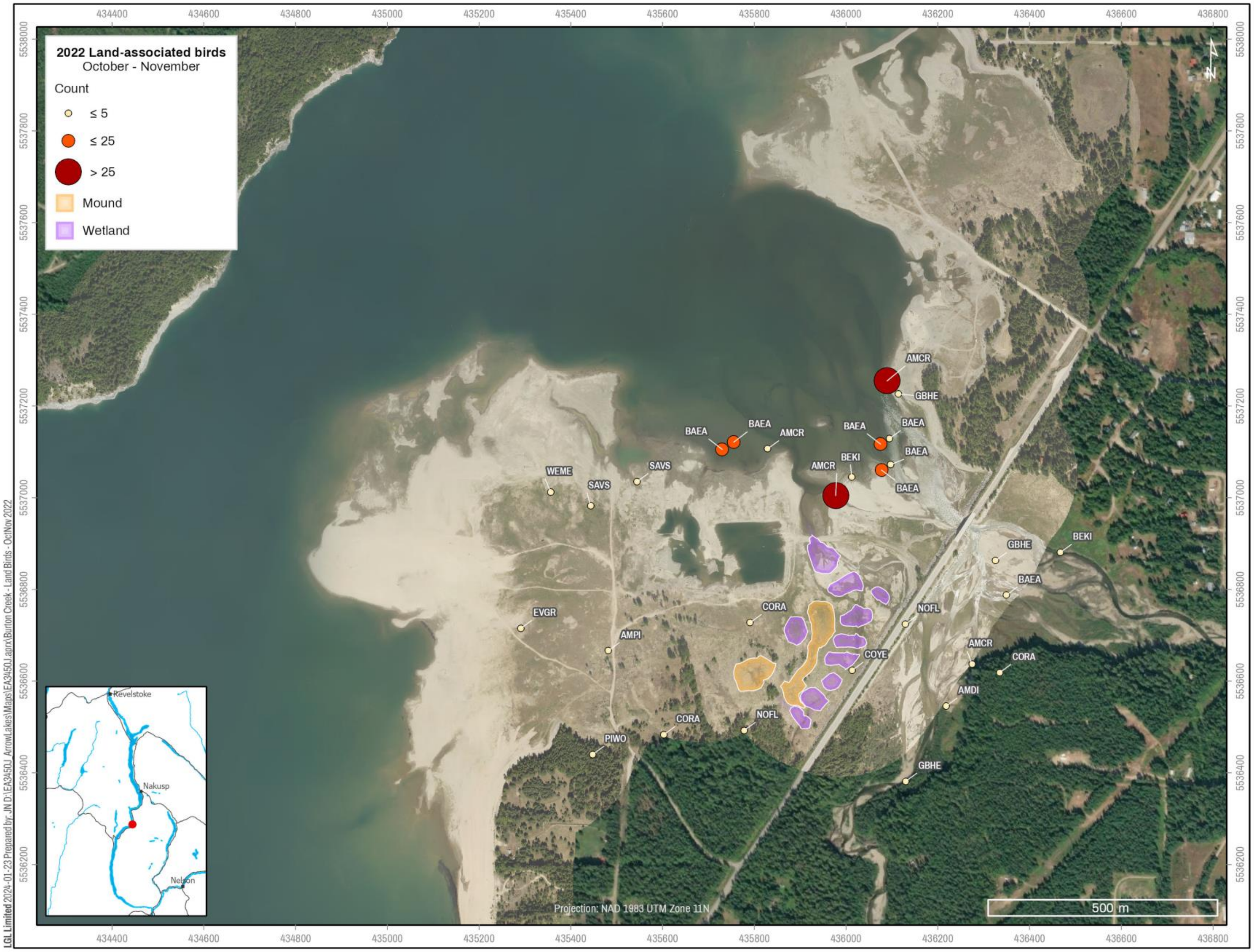

2022 Water-associated birds
October - November
Count
≤ 5
≤ 25
> 25
Mound
Wetland
Revelstoke
Nakusp
Nelson
Projection: NAD 1983 UTM Zone 11N
500 m
LGL Limited 2024-01-23 Prepared by: JN D:\EA3450J_ArrowLakes\Maps\EA3450J.aprx\Burton Creek - Water Birds - OctNov 2022

Appendix C: Distribution of land bird species recorded during waterbird surveys using the constructed Burton Creek wildlife physical works features (mound and wetland polygons) and surrounding areas in April/May 2022 (first figure), June/July 2022 (second figure), August/September 2022 (third figure), and October/November 2022 (fourth figure).




2022 Land-associated birds
June - July
Count
≤ 5
≤ 25
> 25
Mound
Wetland
Revelstoke
Nakusp
Nelson
Projection: NAD 1983 UTM Zone 11N
500 m
OSPR
CHSP
CORA
BEKI
PISI
GBHE
VASW
BASW
CLSW
BKSW
RWBL
YEWA
CEWA
WIFL
TUVU
WEME
NOFL
WAVI
COYE
BCCH
WWPE
BHGR
AMCR
LZBU
REVI
YRWA
GCKI
LGL Limited 2024-01-23 Prepared by: JN D:\EA3450U_ArrowLakes\Maps\EA3450U.aprx\Burton Creek - Land Birds - Jun-Jul 2022


2022 Land-associated birds
August - September
Count
≤ 5
≤ 25
> 25
Mound
Wetland
Revelstoke
Nakusp
Nelson
Projection: NAD 1983 UTM Zone 11N
500 m


2022 Land-associated birds
October - November
Count
≤ 5
≤ 25
> 25
Mound
Wetland
AMCR
GBHE
BAEA
BEKI
SAVS
WEME
EVGR
AMPI
CORA
NOFL
COYE
PIWO
AMDI
Revelstoke
Nakusp
Nelson
Projection: NAD 1983 UTM Zone 11N
500 m
LGL Limited 2024-01-23 Prepared by: JN D:\EA3450_ArrowLakes\Maps\EA3450J.aprx\Burton Creek - Land Birds - OctNov 2022

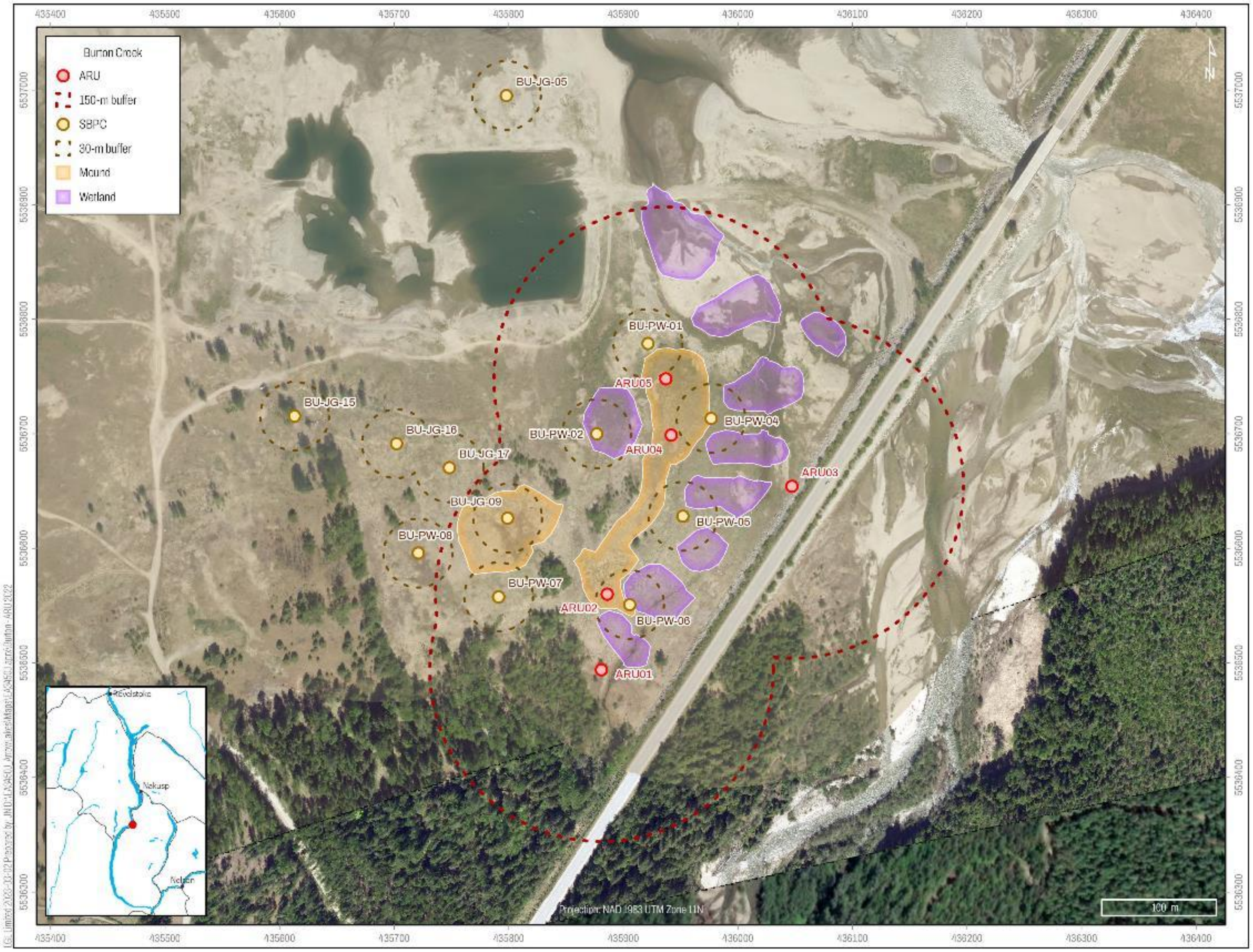
Appendix D: Number of observations of all waterbird and land bird species detected during waterbird surveys by month in 2022. Tables sorted alphabetically by species.

	Month							
Waterbird Species	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
American Wigeon	53	1	0	0	10	20	75	159
Baird's Sandpiper	0	0	0	0	0	5	0	5
Barrow's Goldeneye	0	0	0	0	0	0	56	56
Blue-winged Teal	0	0	0	1	2	0	0	3
Bufflehead	34	10	0	0	0	0	9	53
California Gull	0	0	0	0	14	83	15	112
Canada Goose	8	63	0	27	383	260	178	919
Cinnamon Teal	0	0	1	0	0	0	0	1
Common Goldeneye	0	0	0	0	5	0	0	5
Common Loon	0	1	2	4	16	97	54	174
Common Merganser	4	26	9	11	38	157	48	293
Gadwall	0	2	0	0	0	0	4	6
Great Blue Heron	0	0	0	3	9	16	4	32
Greater Scaup	0	1	0	0	0	0	3	4
Greater Yellowlegs	0	0	0	0	0	1	0	1
Green-winged Teal	86	2	2	0	12	9	53	164
Gull sp.	0	1	0	0	0	0	0	1
Herring Gull	0	0	0	0	1	1	0	2
Hooded Merganser	0	0	0	1	2	3	21	27
Horned Grebe	7	2	0	0	0	0	8	17
Killdeer	9	10	3	0	4	0	0	26
Least Sandpiper	0	0	0	0	9	0	0	9
Lesser Scaup	1	0	0	1	0	0	0	2
Mallard	30	19	12	22	118	20	171	392
Northern Pintail	6	0	0	0	1	1	3	11
Northern Shoveler	15	0	0	0	61	4	0	80
Osprey	1	0	0	0	0	0	0	1
Pectoral Sandpiper	0	0	0	0	0	3	0	3
Pied-billed Grebe	1	0	0	0	2	0	0	3
Red-necked Grebe	2	0	0	0	0	0	0	2
Red-necked Phalarope	0	4	0	0	0	0	0	4
Ring-billed Gull	0	0	0	0	0	5	4	9
Ring-necked Duck	7	4	0	0	0	3	3	17
Ruddy Duck	1	4	0	0	0	0	0	5
Solitary Sandpiper	0	0	0	0	4	0	0	4
Sora	0	0	0	0	1	0	0	1
Spotted Sandpiper	0	4	7	3	4	0	0	18
Stilt Sandpiper	0	0	0	0	1	0	0	1
Western Grebe	0	0	0	0	0	0	1	1
Wilson's Snipe	6	0	0	1	9	0	0	16

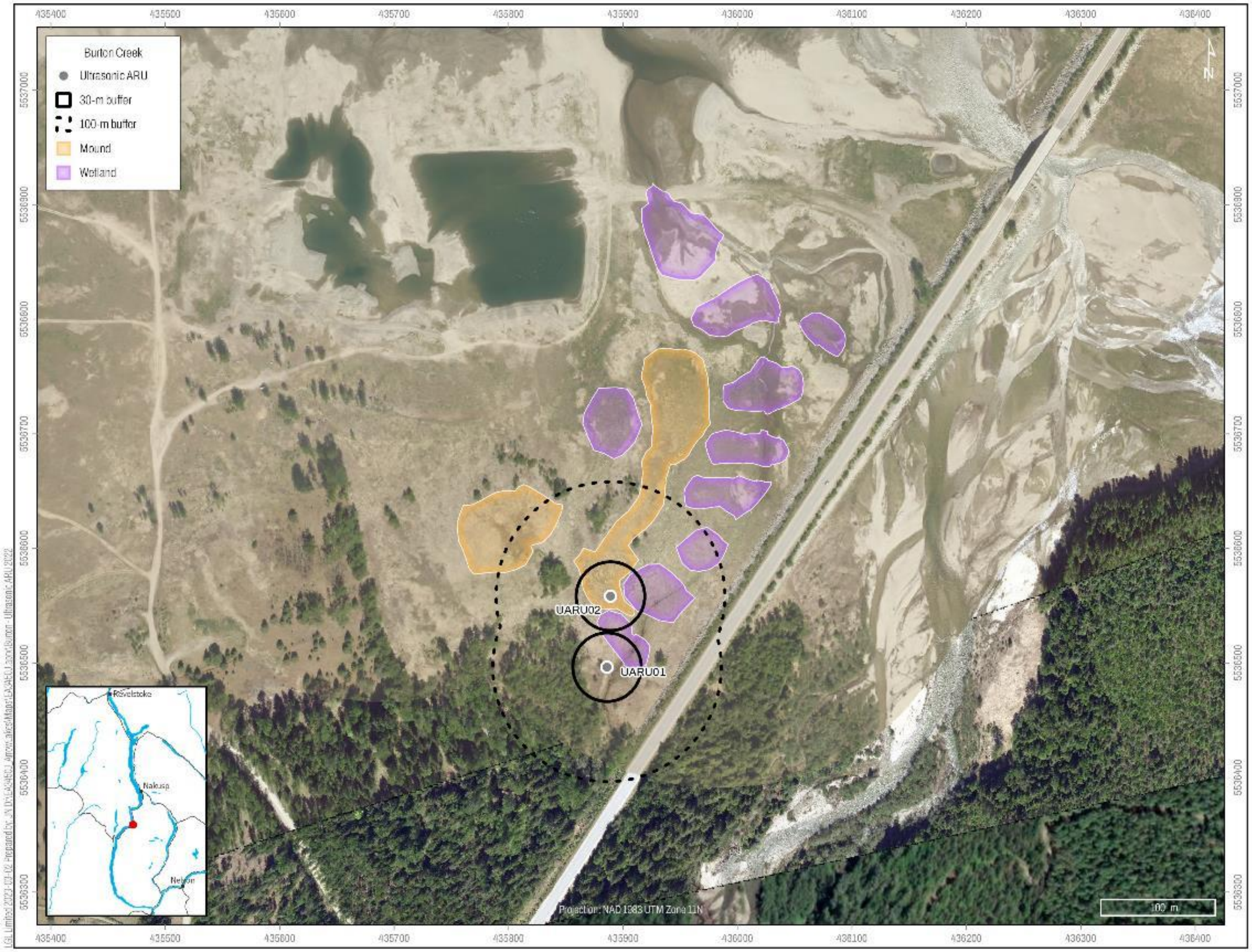
Landbird Species	Month Apr	May	Jun	Jul	Aug	Sep	Oct	Total
American Crow	2	2	0	1	3	60	105	173
American Dipper	0	0	0	0	0	0	2	2
American Kestrel	0	1	0	0	1	2	0	4
American Pipit	21	15	0	0	0	2	2	40
American Robin	5	6	0	0	0	0	0	11
Bald Eagle	5	0	0	0	12	93	76	186
Bank Swallow	0	1	0	1	5	0	0	7
Barn Swallow	0	18	4	13	21	0	0	56
Belted Kingfisher	0	0	0	2	3	1	2	8
Black-capped Chickadee	3	0	0	1	0	0	0	4
Black-headed Grosbeak	0	0	0	1	0	0	0	1
Brewer's Blackbird	0	0	0	0	17	13	0	30
Cassin's Vireo	0	1	0	0	0	0	0	1
Cedar Waxwing	0	0	0	1	0	0	0	1
Chipping Sparrow	0	2	0	1	0	0	0	3
Cliff Swallow	2	20	4	28	12	0	0	66
Common Raven	2	1	0	1	1	6	8	19
Common Yellowthroat	0	2	0	5	0	7	1	15
Dark-eyed Junco	5	0	0	0	0	0	0	5
Eastern Kingbird	0	1	0	0	1	0	0	2
Evening Grosbeak	0	0	0	0	0	0	1	1
Falcon sp.	1	0	0	0	0	0	0	1
Golden-crowned Kinglet	0	0	1	0	0	0	0	1
Horned Lark	0	13	0	0	0	0	0	13
Lapland Longspur	0	0	0	0	0	11	0	11
Lazuli Bunting	0	0	0	1	1	0	0	2
Merlin	0	0	0	0	0	1	0	1
Mountain Bluebird	2	0	0	0	0	0	0	2
Mourning Dove	0	7	0	0	0	0	0	7
Northern Flicker	0	0	0	1	3	1	2	7
Northern Harrier	0	0	0	0	0	1	0	1
Northern Rough-winged Swallow	5	4	0	0	4	0	0	13
Osprey	1	1	1	1	7	3	0	14
Pileated Woodpecker	1	0	0	0	0	1	1	3
Pine Siskin	0	1	0	1	0	1	0	3
Red Crossbill	0	0	0	0	0	1	0	1
Red-eyed Vireo	0	3	2	0	0	0	0	5
Red-naped Sapsucker	0	0	0	0	0	1	0	1
Red-tailed Hawk	0	1	0	0	0	0	0	1
Red-winged Blackbird	0	0	0	15	0	0	0	15
Rock Pigeon	0	1	0	0	0	1	0	2
Savannah Sparrow	1	4	0	0	3	13	3	24
Sharp-shinned Hawk	0	1	0	0	0	0	0	1

	Month							
Landbird Species cont.	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
Song Sparrow	1	0	0	0	0	0	0	1
Townsend's Solitaire	3	0	0	0	0	0	0	3
Tree Swallow	38	21	0	0	0	0	0	59
Turkey Vulture	4	8	1	1	7	4	0	25
Varied Thrush	1	0	0	0	0	0	0	1
Vaux's Swift	0	7	0	1	0	0	0	8
Violet-green Swallow	11	4	0	0	0	0	0	15
Warbling Vireo	0	0	0	1	0	0	0	1
Western Meadowlark	5	4	1	4	5	4	3	26
Western Wood-Pewee	0	0	1	0	0	0	0	1
White-crowned Sparrow	6	0	0	0	0	0	0	6
Willow Flycatcher	0	0	1	2	0	0	0	3
Yellow Warbler	0	0	0	1	0	0	0	1
Yellow-rumped Warbler	9	2	0	2	2	0	0	15
Total (all birds)	**405**	**306**	**52**	**160**	**814**	**915**	**916**	**3568**

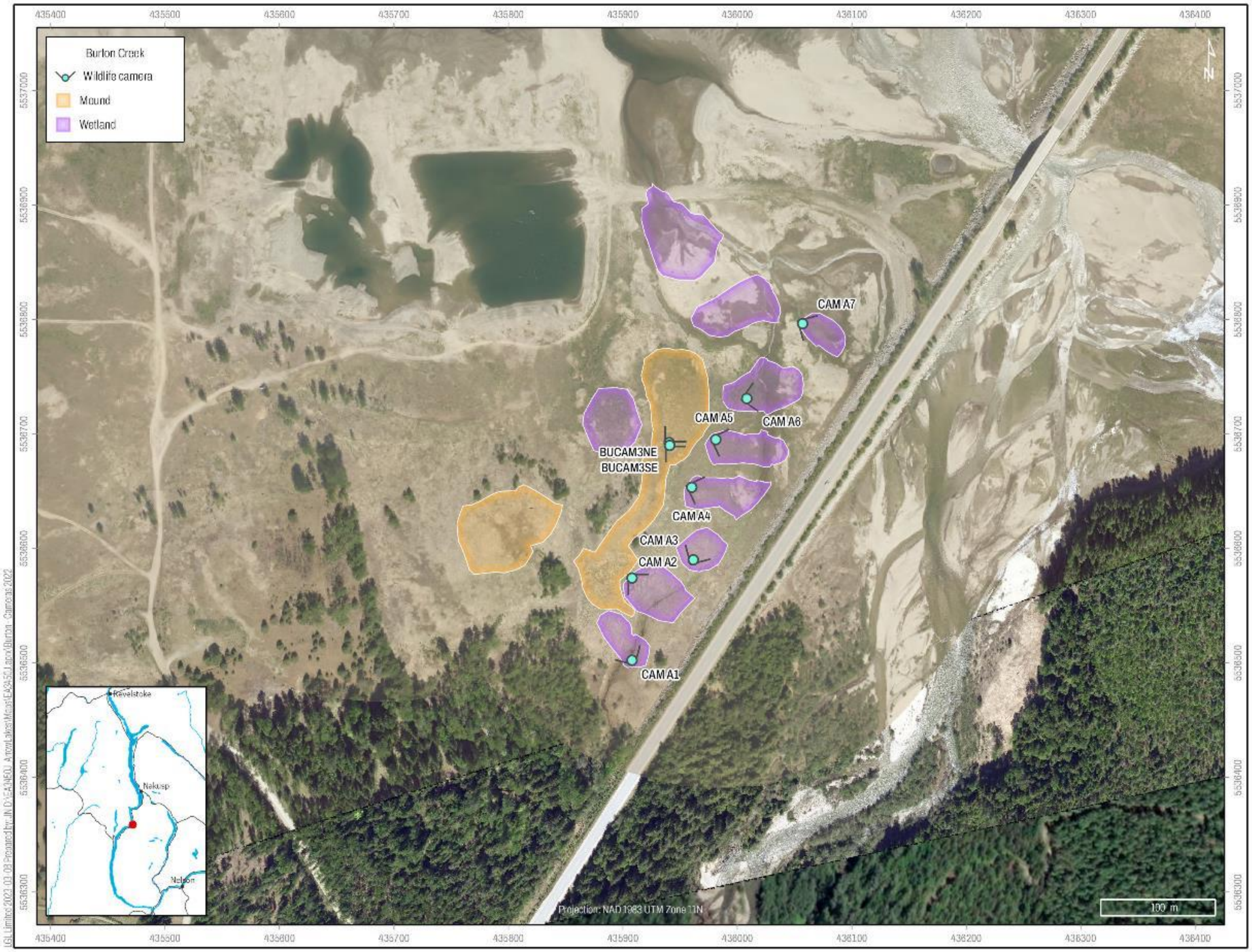
Appendix E: Map of acoustic ARU sampling locations and point count locations for 2022. The 150 m indicate the approximate bird detection range of ARUs. Buffers around the point counts show the local area sampled.



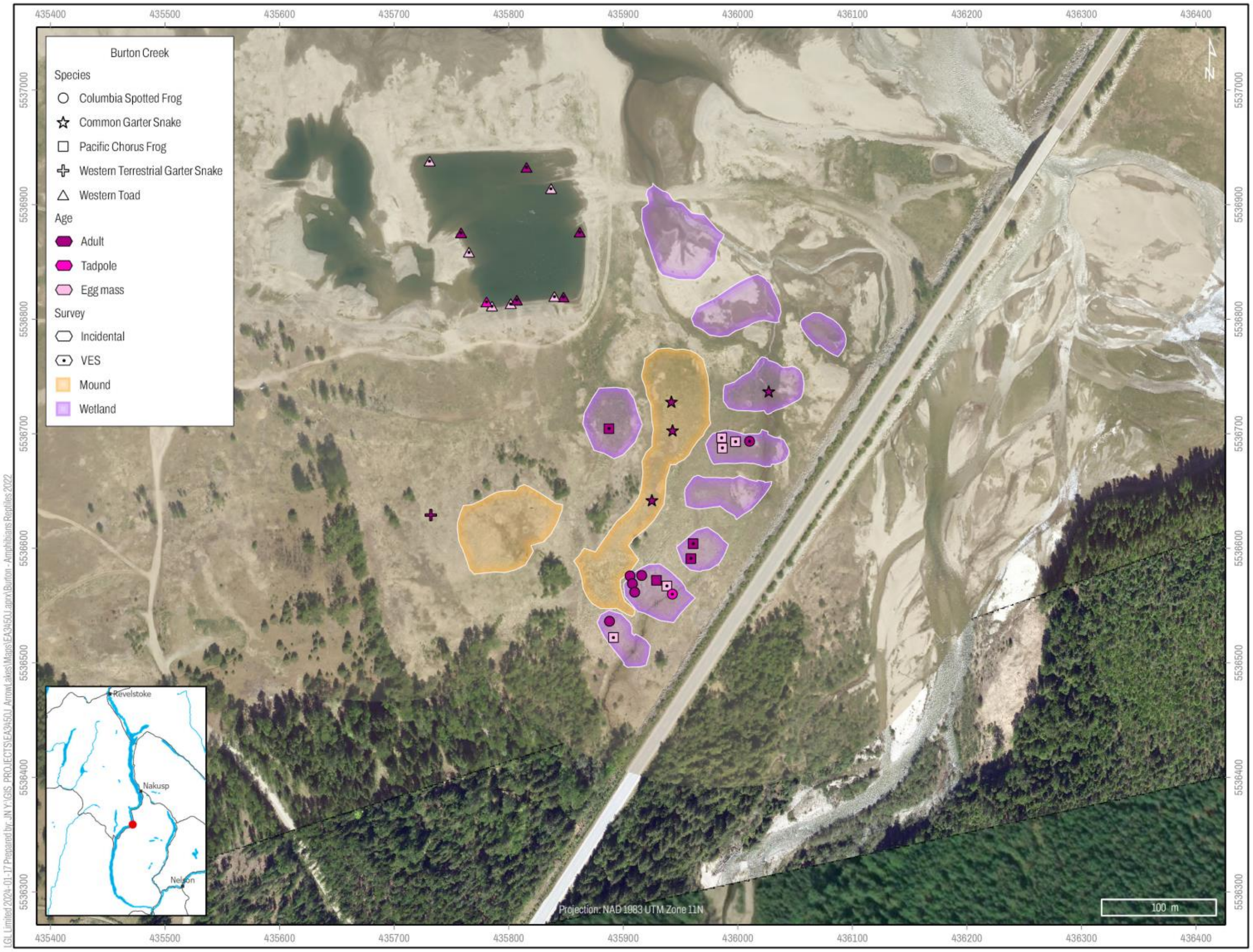
Appendix F: Map of ultrasonic ARU sampling locations for 2022. Buffers indicate the range at which bat species can be detected by ultrasonic ARUs (30 m for small species, 100 m for large species).



Appendix G: Map of remote wildlife camera sampling locations for 2022, with camera view direction indicated by lines.



Appendix H: Distribution of amphibian and reptile species observed using the constructed Burton Creek wildlife physical works features (blue polygon) and surrounding areas. Includes species observed during a Visual Encounter Survey on May 26, 2022, and incidental observations made during equipment deployment and retrieval and vegetation and bird surveys.



Appendix I: Amphibian and Reptile Observations in 2022.

Table 15-1. Amphibians observed during VES on May 26, 2022

Date	Time	Taxa	Code	Count	Age	Associated Habitat Feature	UTM E	UTM N
26-May-22	11:11 AM	Amphibian	PSRE	1	Adult	Pond B1	435888	5536704
26-May-22	11:16 AM	Amphibian	ANBO	2	Egg mass	Burrow Pit	435840	5536820
26-May-22	11:19 AM	Amphibian	ANBO	2	Adult - Amplexus	Burrow Pit	435848	5536819
26-May-22	11:23 AM	Amphibian	ANBO	1	Adult	Burrow Pit	435862	5536876
26-May-22	11:24 AM	Amphibian	ANBO	1	Egg mass	Burrow Pit	435837	5536914
26-May-22	11:25 AM	Amphibian	ANBO	1	Adult	Burrow Pit	435816	5536933
26-May-22	11:29 AM	Amphibian	ANBO	1	Egg mass	Burrow Pit	435731	5536938
26-May-22	11:30 AM	Amphibian	ANBO	2	Adult - Amplexus	Burrow Pit	435758	5536875
26-May-22	11:31 AM	Amphibian	ANBO	1	Egg mass	Burrow Pit	435765	5536858
26-May-22	11:32 AM	Amphibian	ANBO	1	Egg mass	Burrow Pit	435785	5536811
26-May-22	11:35 AM	Amphibian	ANBO	1000s	Tadpole	Burrow Pit	435781	5536815
26-May-22	11:36 AM	Amphibian	ANBO	1	Egg mass	Burrow Pit	435802	5536813
26-May-22	11:37 AM	Amphibian	ANBO	2	Adult	Burrow Pit	435807	5536817
26-May-22	12:09 PM	Amphibian	RALU	1	Adult	Pond A5	436010	5536693
26-May-22	12:11 PM	Amphibian	PSRE	1	Egg mass	Pond A5	435998	5536693
26-May-22	12:16 PM	Amphibian	PSRE	2	Egg mass	Pond A5	435986	5536697
26-May-22	12:18 PM	Amphibian	PSRE	1	Egg mass	Pond A5	435986	5536688
26-May-22	12:36 PM	Amphibian	PSRE	1	Adult	Pond A3	435959	5536591
26-May-22	12:42 PM	Amphibian	PSRE	1	Adult	Pond A3	435961	5536604
26-May-22	12:46 PM	Amphibian	PSRE	1	Egg mass	Pond A2	435938	5536567
26-May-22	12:49 PM	Amphibian	RALU	1	Tadpole	Pond A2	435943	5536560

Species codes: ANBO = Western Toad; PSRE = Pacific Chorus Frog; Columbia; RALU = Spotted Frog

Table 15-2. Incidental amphibian and reptile observations from 2022.

Date	Time	Taxa	Code	Count	Age	Associated Habitat Feature	UTM E	UTM N
20-May-22	12:32 PM	Amphibian	RALU	1	Adult	Pond A2	435906	5536576
20-May-22	12:50 PM	Amphibian	RALU	1	Adult	Pond A1	435888	5536536
20-May-22	1:34 PM	Reptile	THSI	1	Adult	Mound C2	435943	5536703
25-May-22	10:51 AM	Amphibian	PSRE	1	Adult	Pond A2	435929	5536572
25-May-22	12:09 PM	Reptile	THSI	1	Adult	Mound C2	435942	5536728
25-May-22	2:29 PM	Reptile	THSI	1	Adult	Pond A6	436027	5536737
26-May-22	3:11 PM	Amphibian	RALU	1	Adult	Pond A2	435908	5536569
8-Jun-22	9:50 AM	Amphibian	RALU	1	Adult	Pond A2	435916	5536576
27-Jun-22	8:00 AM	Reptile	THEL	1	Adult	Meadow	435732	5536629
6-Sep-22	5:11 PM	Amphibian	RALU	1	Adult	Pond A2	435910	5536562
28-Sep-22	1:47 PM	Reptile	THSI	1	Adult	Mound C2	435925	5536642

Species codes: ANBO = Western Toad; PSRE = Pacific Chorus Frog; Columbia; RALU = Spotted Frog