**Environment and Climate Change Canada**

**Canada Nature Fund: Community-Nominated Priority Places for Species at Risk**

# Kootenay Connect: 6CW Columbia Wetlands:

## Hydrology and Beavers: Columbia Wetlands Floodplain Hydrology and the Role of Beaver Dams

**March 31, 2025. Final Report: Year 6**


**Columbia Wetlands Stewardship Partners**

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# 1. Executive Summary

In 2024, CWSP continued to study the hydrology and ecology of the Columbia River floodplain wetlands. We monitored water levels and water quality in 37 wetlands and conducted migratory bird surveys in 20 wetlands. This is the fifth year we have monitored water levels, and the fourth year we have surveyed migratory birds, allowing us to draw conclusions from multiple years of data. We have also continued to apply for permits to be able to build Beaver Dam Analogues to restore deeper water levels to certain wetlands and increase habitat diversity.

In previous years, CWSP has used water level to determine hydrological differences between wetlands and group wetlands according to their connectivity to the Columbia River into three groups: Most, Partially, and Least Connected. We then used levee gap and beaver dam measurements to see the impacts of these features on wetland groups. These three groups differ hydrologically, with Most Connected wetlands responding rapidly to the Columbia River flood pulse, and then retaining little water over the winter due to the presence of large levee gaps. Partially and Least Connected wetlands retain more water over the winter and have either levee gaps which are dammed by beaver dams or no levee gaps at all. Thus, these wetland types still having standing water in the spring

2024 was a low water year, with the flood pulse being small, resulting in mean maximum depths of only 2m as opposed to mean maximum depths of 2.5m in the high water years of 2020, 2021, and 2022. 2023 was also a low water year, with a mean maximum depth of 2.25m, suggesting that successive low water years result in increased impacts in the wetlands. The Least Connected wetlands were the least affected by this low flood pulse, retaining mean water depths of 1.5m in the spring and fall, while both Most Connected wetlands retained a mean of less than 0.5m of water in the spring and fall.

We have recorded 164 waterbird species in and around our study wetlands either during dedicated waterbird counts or incidentally while working in the wetlands between 2021 and 2024. 14 of these are Species at Risk (SAR). The use of wetlands by these species varies widely, from ducks using open water to rest and feed, swallows and other insect eating birds catching food over the wetlands, small passerines such as warblers nesting in wetland vegetation, and shorebirds using exposed mud and short vegetation around the edges of wetlands to feed.

During our dedicated spring and fall waterbird counts, we recorded 80 species of birds, of which four are SAR, and 29,658 individual birds. In comparing spring and fall counts, we find that in spring more species are recorded (44 species observed in spring compared to 39 in fall), with twelve species only being observed in spring and six only observed in fall. We have also observed that in spring, while number of individual birds does not differ significantly between wetlands groups, number of species does differ significantly, while in the fall, neither number of individuals nor number of species differs significantly between wetland groups. This supports our hypothesis that Partially and Least Connected wetlands are particularly important for providing suitable habitat for waterbirds in spring, as this is when the wetlands are at their driest, prior to the flood pulse.

In 2023, we identified three sites suitable for potential restoration using Beaver Dam Analogues to repair old blown-out beaver dams. We have been applying for permits to do so since December 2023.

# 2. Introduction

## 2.1 The Columbia Wetlands

The Columbia Wetlands, stretching from Columbia Lake in the south to just north of Golden in the north, are floodplain wetlands along the only undammed portion of the Columbia River, and are one of the longest contiguous wetlands in North America (Zimmerman, 2004). The elevation gradient of the Columbia River between Columbia Lake and Golden is very low, at about 19 cm/km, meaning that the river meanders substantially through the valley bottom, with multiple side channels and many wetlands created by erosion and deposition across the floodplain (Environmental Stewardship Division Kootenay Region, 2004) (Figure 1).

Figure 1: Aerial photo of a section of the Columbia Wetlands just upstream of Spillimacheen in May 2022.

As floodplain wetlands in an undammed system, they are maintained by the natural flood pulse of water flowing over the natural river levees and advancing and retreating across the valley, a process that has major effects on all aspects of the wetlands (MacDonald Hydrology Consultants Ltd., 2021; Makaske *et al.,* 2009). The flood pulse – the overbank flow of water across the landscape during a high water period (Junk *et al.*, 1989) – is an essential driver that determines floodplain connectivity and transport of both organic and inorganic material, from organisms to sediment, but other sources of water such as local rainfall or rising groundwater also contribute to the hydrological and ecological dynamics of floodplain wetlands (Amoros and Bornette, 2002; Junk *et al.,* 1989; Tockner *et al.*, 2000). Like all floodplain wetlands, the Columbia Wetlands are a complex system, with many processes operating at different temporal and spatial scales. While many rivers and floodplains systems around the world have been heavily modified by humans, floodplain hydrological and ecological dynamics are complex in both degraded and more natural temperate and tropical systems (Amoros and Bornette, 2002).

The Columbia Wetlands show anastomosing morphology, with multiple interconnected channels enclosing flood basins, and with stable channels and frequent crevassing of the natural levees to form gaps (Makaske *et al.,* 2009). The wetland system is approximately 180 km long and over 26,000 ha in area (Environment and Climate Change Canada, 2018), and provides important wildlife habitat and ecosystem services such as groundwater recharge, water for agriculture and residential use, flooding mitigation, and recreational use. The wetlands are important culturally to both First Nations and settlers in the Columbia Valley and are located on the traditional territories of the Ktunaxa Nation, Secwepemc First Nation, Shuswap First Nations Band, and Metis Nation Columbia River.

Among the many ecosystem services they provide, the Columbia Wetlands are habitat for a tremendous diversity of organisms. A 2004 survey found 4 species of fungi, 268 species of plants, 34 species of invertebrates, 2 species of amphibians, 1 species of reptile, 112 species of birds, and 17 species of mammals within the Columbia National Wildlife Area, which at 1,001 ha comprises 3.9% of the entire Columbia Wetlands complex (Environment and Climate Change Canada, 2018). The Columbia Wetlands provide habitat for many wetland-dependent mammals such as North American river otter (*Lontra canadensis*, American beaver (*Castor canadensis*), and muskrat (*Ondatra zibethicus),* as well as important habitat for species that use wetlands for at least part of the year such as elk (*Cervus canadensis*) and American black bear (*Ursus americanus*), and provide corridors to traverse the valley for upland animals such as grizzly bear (*Ursus arctos*).

The Columbia Wetlands are a particularly vital habitat for migrating birds (Figure 2). They comprise an important part of the Pacific Flyway; one of North America's four major migratory routes (Environment and Climate Change Canada, 2018). They provide a stopover site for migratory birds, including provincially listed species such as tundra swan (*Cygnus columbianus*) which is on the BC Blue List 'of special concern' with a Provincial Conservation Status of S3N (special concern, non-breeding population). The Columbia Wetlands Waterbird Survey, which covered approximately 39% of the total Columbia Wetlands area, found that in 2019, across three dates, 41,095 birds of 90 different species were present in the wetlands, and across the five years of the survey 163 bird species were documented, with a maximum single day count of 20,822 individuals on 15th October 2016 (Darvill, 2020).

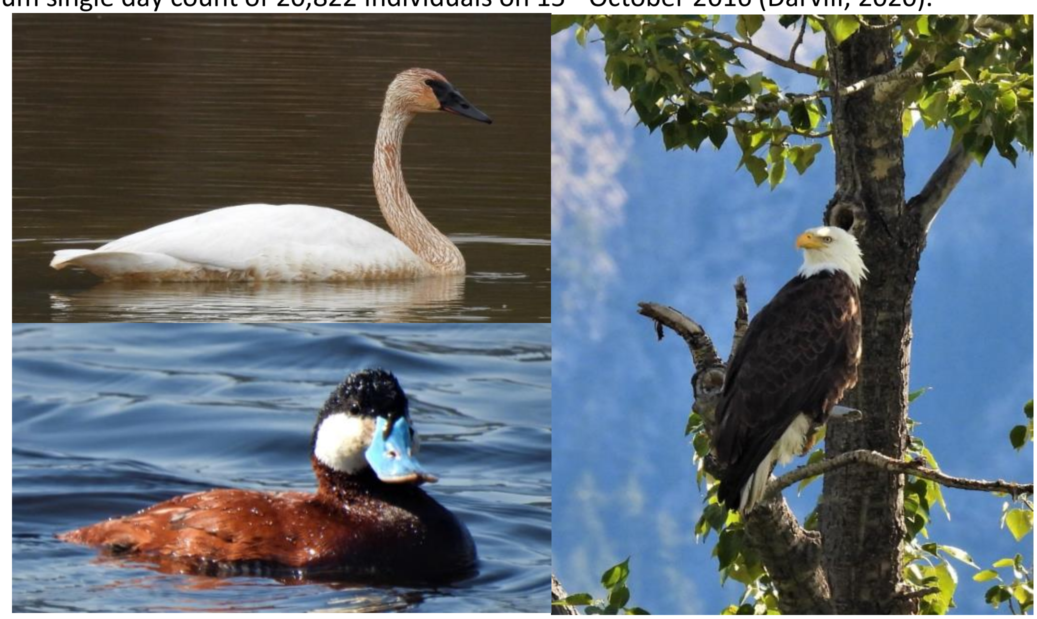

Figure 2: Three bird species found in the Columbia Wetlands. Top left: Trumpeter Swan, Bottom left: Ruddy duck, Right: Bald Eagle.

This importance is recognized provincially, federally, and globally: the Columbia Wetlands have been designated a RAMSAR site since 2004, qualifying under all eight RAMSAR criteria (Zimmerman, 2004). They are being proposed as an Important Bird Area (Darvill, 2020) and are protected variously as the Columbia Wetlands Wildlife Management Area under the British Columbia (BC) Wildlife Management Act, the Columbia National Wildlife Area under the Canada Wildlife Act, and as Nature Trust of Canada and Nature Conservancy of Canada properties.

## 2.2 Climate Change and the Columbia Wetlands

The Columbia Wetlands face many threats, despite these protections and recognitions, and we do not have a good understanding of how these threats will affect wildlife and ecosystem services, particularly in combination. Although the Columbia Wetlands remain undammed, there is nonetheless rapid residential, agricultural, and recreational growth in the Columbia Valley (Environment and Climate Change Canada, 2018) which threatens the wetlands – and the organisms living within them – from disturbances due to boat or ATV users, to water being removed from the wetlands for agricultural irrigation or residential use. While these wetlands are critical habitat for birds and other organisms, we do not have a good understanding of how these varied threats will affects wildlife.

One of the main threats facing the Columbia Wetlands, and the subject of recent research (e.g., Hopkinson *et al.,* 2020; Utzig, 2021), is climate change. The Columbia Wetlands are particularly sensitive to climate change for several reasons. It has been suggested that mountainous regions are more sensitive to climate change because they are experiencing faster temperature increases and changes to precipitation than the global land average. While results globally are inconclusive (Rangwala and Miller, 2013), in western North America glaciers are shrinking due to increasing temperatures, with some having retreated up to 2 km since 1900; corresponding decreases in streamflow have been recorded, including in the Canadian Rocky Mountains (Moore *et al.,* 2009). Across the Rocky Mountains, particularly in the Northern Rockies and Upper Columbia River, the observed late 20$^{th}$ century snowpack declines resulting from springtime warming are almost unprecedented in magnitude, with corresponding impacts on streamflow and water supply (Pederson *et al.,* 2011).

Annual temperatures in the Columbia Wetlands have already increased by 1˚C and further increases of 2 ˚C to 4 ˚C are projected. Changes to precipitation amounts, timing, and form are also predicted by models, with less snow and more rain falling in the valley (Utzig, 2021). As the Columbia Wetlands are dependent on the natural flood pulse, which is primarily driven by snowmelt and rainfall depending on season (Makaske *et al.,* 2009), the decreasing snowpack of the Canadian Rockies and changes in precipitation are a direct and urgent threat to the hydrology of the Columbia River and its floodplain wetlands. There is less water in the Columbia Wetlands today than historically (Hopkinson *et al.*, 2020), and projections indicate that there will be increasingly less water in the future (Utzig, 2021).

## 2.3 Beavers and the Columbia Wetlands

Beavers may provide some natural mitigation of the effects of climate change on the Columbia Wetlands by increasing wetland resilience and complexity, and specifically by increasing open water area (Hood and Bayley, 2008). Beavers have profound effects on wetlands and are often termed ecosystem engineers for the extensive changes they provoke, providing both direct ecosystem services and economic benefits to people (Thompson *et al.*, 2021). They shape the wetland systems that they occur in by changing the hydrology and associated processes such as sediment transport and increasing habitat complexity and biodiversity across all taxonomic groups, from invertebrates to mammals (Larsen *et al.*, 2021; Nummi and Holopainen, 2020).

Due to the large impacts that beavers have they have been widely studied in both Europe and in North America (while North American beaver (*Castor canadensi*s) and European beaver (*Castor castor*) are different species, as ecosystem engineers they function very similarly), in both river and floodplain contexts (Larsen *et al.*, 2021). However, most of the research undertaken on beavers has not been in a floodplain system the size of the Columbia Wetlands, where the river is large and undammed and the floodplain is up to 2 km across. Beavers in the Columbia Wetlands are not damming the Columbia River itself, they are damming small side channels and wetlands within the floodplain, and the impacts of this type of dam-building activity are very different from the impacts of dam-building activity in incised streams or even in river floodplains of around 500 m in width.

Crucially, while in an incised stream system water flow is unidirectional, only flowing over the beaver dams one way, in a floodplain system the water flows over beaver dams in both directions. In the spring, as the flood pulse rises, water flows over the beaver dams from the Columbia River into the wetlands; once the flood pulse has receded, the water flows out of the wetlands (either over, through, or under the dams, if they are present) into the Columbia River (Figure 3).

Figure 3: Beaver dam found within the Columbia Wetlands. The Columbia River is behind the photographer.

Many of the individual wetlands within the Columbia Wetlands complex have one or more gaps in the natural levees that enclose them, that allow for greater connectivity to the Columbia River, as water is able to flow through these gaps before the river floods enough to overtop the levees. The Columbia River only floods high enough to overtop the levees in approximately 65% of years (Rodrigues *et al.*, 2024), that these levee gaps are the only way that water is able to enter the wetlands in years when the river does not flood over the natural levees.

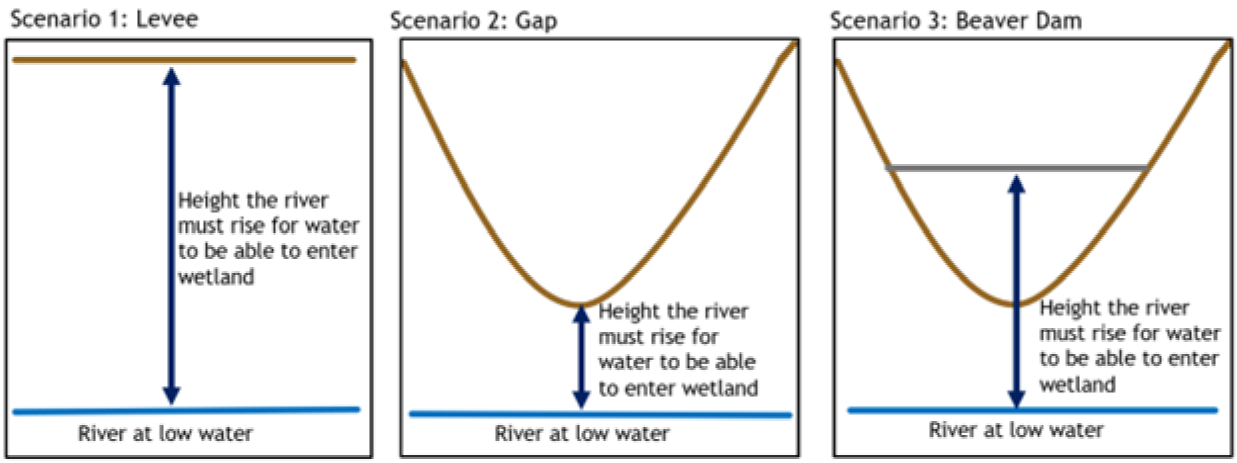


Figure 4: Schematic of the role of levee gaps and beaver dams in influencing the flood pulse entering wetlands.

In Scenario 1 in Figure 4, the natural levee surrounding a wetland, built by the gradual deposition of sediment over many years, is unbroken, without any gaps in it. Thus, the river must rise more than 2.5 metres from its pre-flood pulse depth so it can overtop the levee and enter the wetland. However, while it is harder for water to enter the wetland, it is also harder for water to leave the wetland, and so these wetlands will hold more water as the flood pulse recedes. In scenario 2, the natural levees have a gap in them, and so the water has to rise much less and will be able to easily flow into and out of this wetland. In scenario 3, beavers have built a dam across the gap in the levee and so have created an intermediate scenario, with water not having to rise as high to enter the wetland, but also being retained within the wetland by the beaver dam as the flood pulse recedes.

## 2.4 Beaver dam analogues (BDAs)

Beaver dam analogues are human-built structures that mimic or reinforce natural beaver dams. They try to replicate the features of natural beaver dams, and so are semi-porous, temporary features, built with natural local materials including sediment, wooden posts, and branches. They are constructed either in a location where there used to be a beaver dam (these are the locations CWSP is targeting in our work) or locations where it would be plausible that a beaver would build a dam. They aim to mimic the effects of natural beaver dams as well, by retaining water within a system, slowing down its progress across the landscape, and thus hopefully resulting in positive impacts to habitat complexity, biodiversity, and the other myriad impacts of beaver dams discussed above.

While there is extensive research on the impacts of beaver dams on wetlands (see above), there is far less research available on the impacts of Beaver Dam Analogues (BDAs), particularly on longer term impacts on biodiversity. As a small-scale, low-tech way to restore streams and wetlands they are currently very popular as a restoration technique; however, we are not certain if they will mimic natural beaver dams (Lautz *et al.*, 2019). Munir and Westbrook (2021) found that in small mountains streams they did mimic the impacts of natural beaver dams in raising the water table and retaining water on the landscape, but Wolf and Hammill (2023) found that BDAs did not support the same diversity of amphibians as natural beaver dams, perhaps because the natural dams were far older than the BDAs and biodiversity does not respond instantly. Thus, monitoring wetlands before and after the installation of BDAs is clearly essential to study their short- and long-term effects.

We hope that BDAs will, much like natural beaver dams, increase the amount of water retained in wetlands, particularly over the winter, so that open water habitat is available for migratory waterbirds when they migrate through the Columbia Valley before the Columbia River flood pulse begins. In order to determine whether BDAs are a feasible and effective way to increase wetland water retention and thus make different habitats available, we are trialing BDA installation in wetlands within the Columbia Wetlands complex (Figure 5).

Figure 5: Beaver dam analogue built by CWSP in Site 38 in fall 2021. Photograph from early May 2023.

# 3. Findings and Analyses

We have been studying 37 individual wetlands within the Columbia Wetlands complex between Invermere and Parson since 2020 (Figure 6; Appendix 1). Each year we collect a variety of data from these wetlands using both fieldwork and remote sensing methods. We use water level loggers to collect water level data between May and October and measure water quality several times during that same period and have collected sediment samples from all the wetlands. We have surveyed levee gaps and beaver dams across all the wetlands. In 16 of the wetlands, we have conducted more intense monitoring, including migratory waterbird surveys in spring and fall 2021, 2022, 2023, and 2024, and submerged aquatic vegetation (SAV) surveys in August 2021 and 2023. A more detailed description of our fieldwork methods and a full list of site coordinates can be found in Appendix 1 and 2.

Collecting data over multiple years allows us to build a better understanding of this complex system, as it means we can compare between years with different conditions, look at the differences in wetlands pre- and post- restoration, and perhaps even begin to predict and document the impacts of climate change.

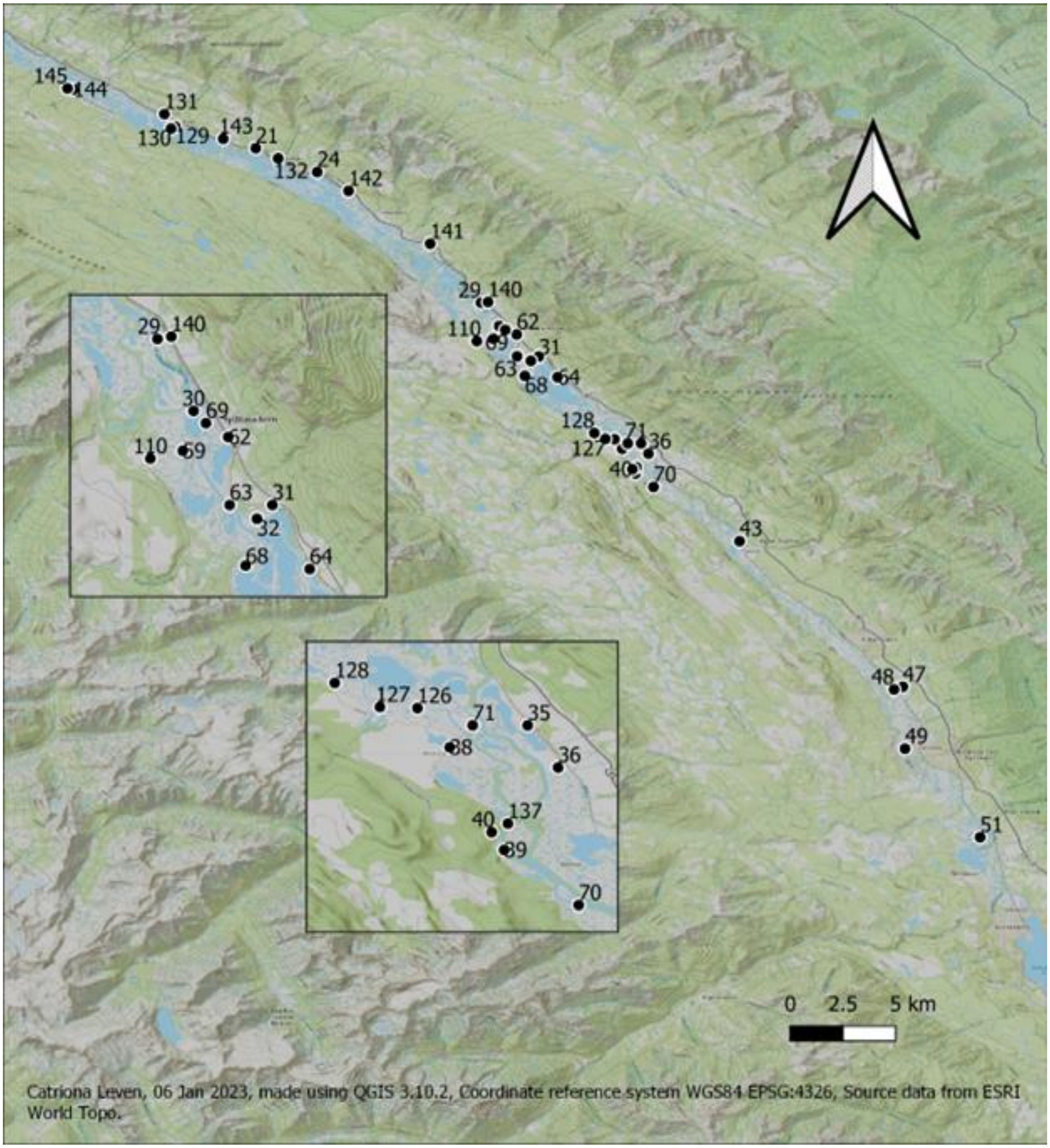


Figure 6: Map of study sites in the Columbia Wetlands.

## 3.1 Hydrologic classification of the Columbia Wetlands

In 2024 we continued to monitor water levels in 37 wetlands and the Columbia River (Fig 6). As per our 2023 report (cite), we have classified our study wetlands into groups defined by their connectivity to the Columbia River: 1) Most Connected, 2) Partially Connected, and 3) Least Connected. By understanding differences in hydrology between wetlands, we can better understand the functioning of the Columbia Wetlands as a whole and the various driving factors of the wetland complex. We can also look at the ecological differences resulting from the different wetland hydrology, such as the different habitats provided for bird species.

The different wetland groups can be recognised on the landscape, with Most Connected wetlands tending to have shallow water in the spring and fall, while Least and Partially Connected wetlands retain deeper water all year round (Figure 7). The different vegetation found in the different wetlands can also be seen, with Least Connected wetlands having more Cattails growing in them, while Most Connected wetlands have more Sedges and Horsetail species in them. Here beaver dams retain water in the Least Connected wetland (indicated in the photograph).

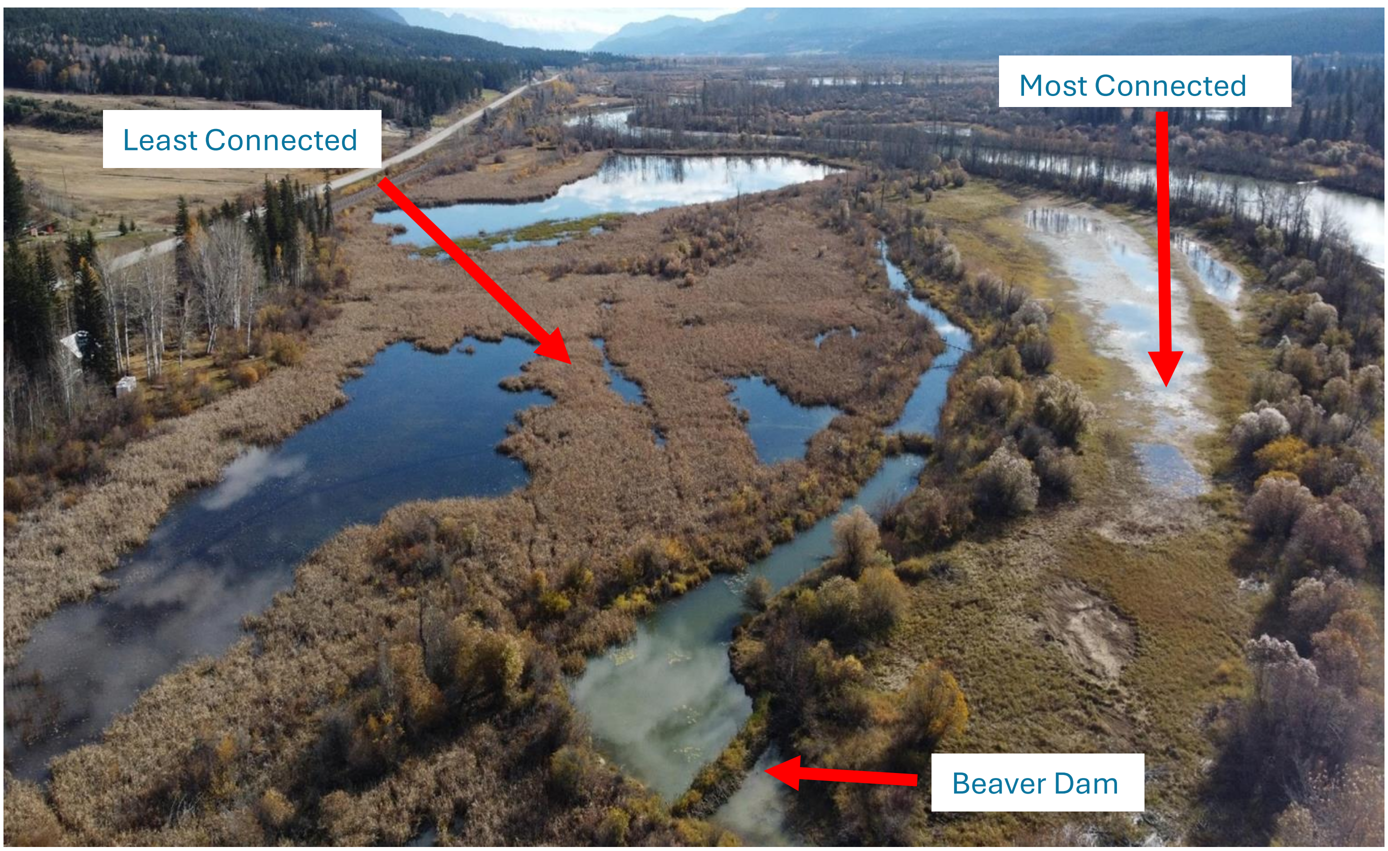


Figure 7: Aerial photograph of two wetlands within the Columbia Wetlands complex (Site 140 on the left, and Site 29 on the right), with wetland connectivity group indicated: Site 140 is a Least Connected Wetland and Site 29 is a Most Connected Wetland. October 2024.

Beaver dams and levee gaps play an important role in creating these different wetland groups, with levee gaps being associated with Most Connected wetlands while beaver dams and levees without gaps are associated with Partially and Least Connected wetlands (Figure 8). The Partially Connected group is the most variable in terms of gap and beaver dam status and is also the most variable hydrologically. Beaver dams play a major role in the variability and impact on wetland hydrology.

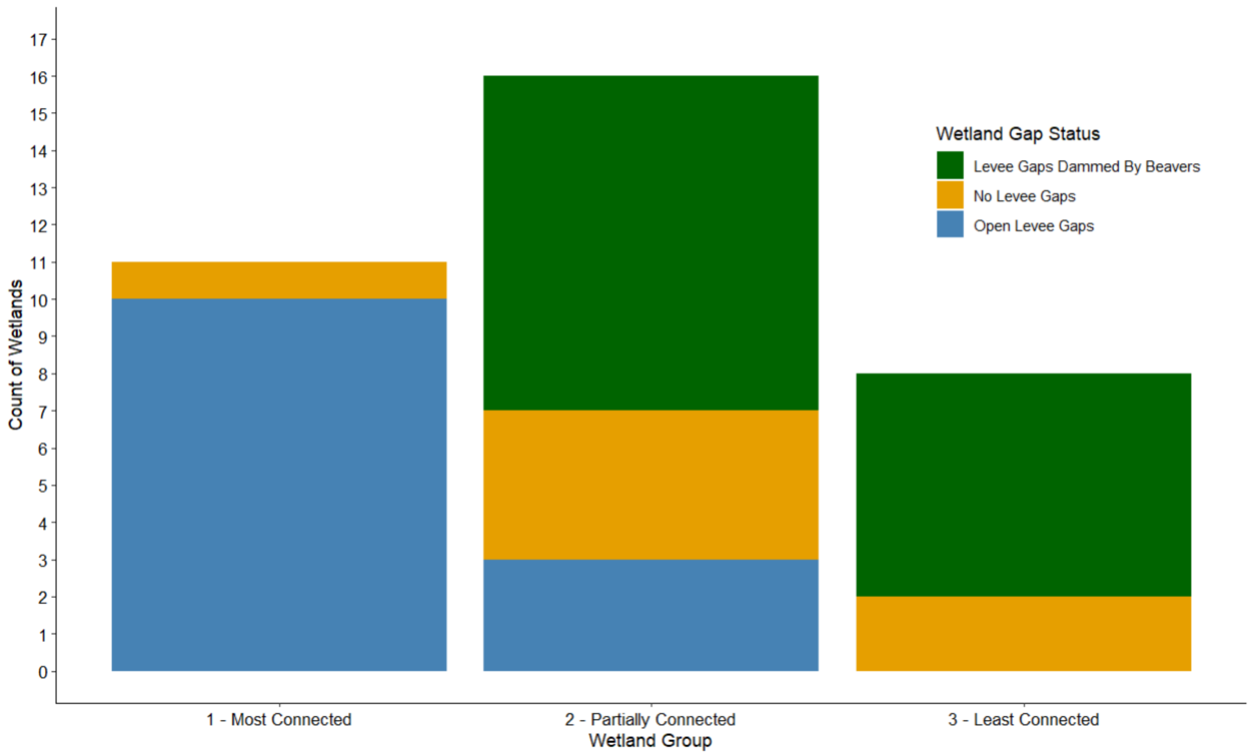


Figure 8: Number of wetlands with open levee gaps (blue), no levee gaps (yellow), or levee gaps dammed by beavers (green) in each of the three wetland groups.

We have continued this work by comparing water depths across the five years of our study (2020 – 2024). 2020, 2021, and 2022 were all high-water years, while 2023 and 2024 were low water years, which can clearly be seen both in the overall response of all the wetlands in each year and within each wetland group (Figure 9). In 2020, 2021, and 2022, the mean highest depth of wetlands was more than 2.5m, while in 2023 it was approximately 2.25m and in 2024 approximately 2m, indicating the reduced flood pulse in these low water years. We can also see that in 2024 the Most and Partially Connected wetland groups both started and ended lower than in 2023, indicating that successive dry years have a larger impact than separated dry years, with the impacts being magnified in each successive year. The Least Connected groups show the least response to these low water years, as might be expected, with baseline water depths in these wetlands remaining at 1.5m however large the flood pulse is. This indicates that the river is having a smaller impact on these wetlands, perhaps due to them having other sources of water such as groundwater springs or creeks.

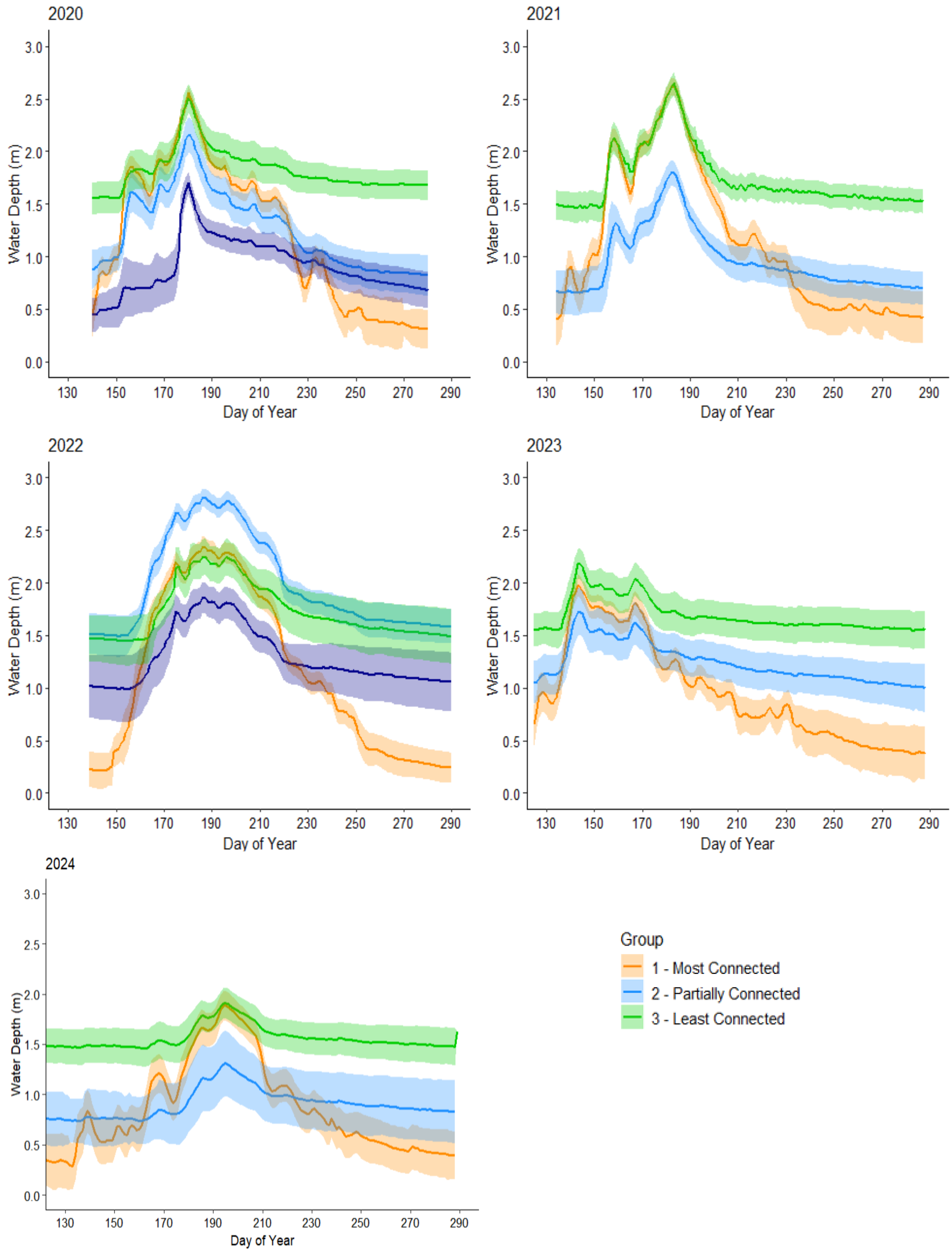


Figure 9: Mean water depth in all wetland groups across all five studied years. Shaded areas represent standard error for each wetland group.

This work also shows the benefits of longer-term research projects. The amount of variability shown in the five years we have water depth data for the Columbia Wetlands demonstrates that studying only one, or even three, of these years would not have provided an adequate picture of how the system is functioning because the Columbia River and associated wetlands are so variable. Only by collecting multiple years of data can we begin to understand how these systems are functioning, and how these systems are changing and may continue to change over time, particularly in the face of climate change. By being able to compare both high and low water years we can make better predictions about changes in response to climate change.

## 3.3 Ecological differences between wetland groups

We are also studying the ecological differences between wetland groups. We want to understand how these groups differ in terms of water quality, plants, and birds in order to better understand the rich diversity of the Columbia Wetlands complex. We also want to better understand how to protect and conserve this diversity, and understanding how different wetland groups contributes to that will allow us to make better informed conservation decisions.

### 3.3.1 Water quality

We measured different aspects of water quality throughout the year (Appendix 9). We found the most useful measures to be specific conductance and turbidity. Specific conductance is conductivity standardised to temperature and is a measure of the capability of the water to pass an electric charge, which is a result of the ionic concentration of the water. Conductivity is an indication of water source, with water of a higher conductivity tending to be groundwater, as the passage through the earth increases the ions present in the water, while water of a lower conductivity tends to be river water which has less ions in it. Turbidity is a measure of the cloudiness of the water and indicates the amount of particles present in the water. The Columbia River is most turbid during high flow, as this is when it is carrying the most sediment.

These two variables vary through the year and by individual wetland, with some wetlands always having unusually high or low measurements. Site 35, for example, always has very high conductivity (over 1000 uS/cm), due to receiving a lot of water from high conductivity springs. High conductivity generally indicates more groundwater input, while the Columbia River has relatively low conductivity (Figure 10; red squares indicate River measurements). There is great variation between other groups.

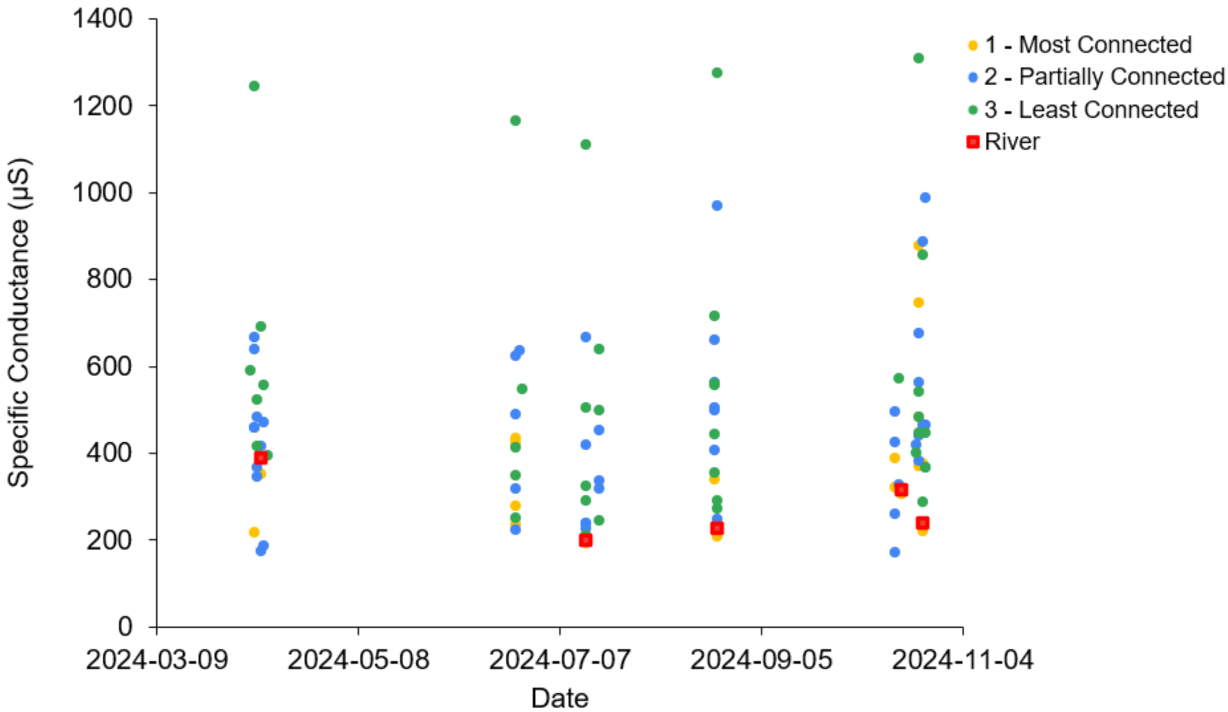


Figure 10: Specific conductance measured in floodplain wetlands in 2024. There are less Most Connected wetland measurements as these wetlands often do not contain enough water in which to measure conductivity in May and October.

Turbidity is also an indicator of river connectivity, as when the Columbia River is in flood its turbidity is very high. However, high turbidity can also be seen in less connected wetlands with large amounts of organic matter present in the water. As can be seen on Figure 11A, the Columbia River is in fact so turbid that it makes the other values hard to compare, so for Figure 11B, the three outlying measurements have been removed. Due to the very low flood pulse in 2024, the turbidity in all wetlands did not show an increase associated with the flood pulse, and river turbidity remained relatively low until August, whereas in high water years river turbidity increases in June (Figure 11).

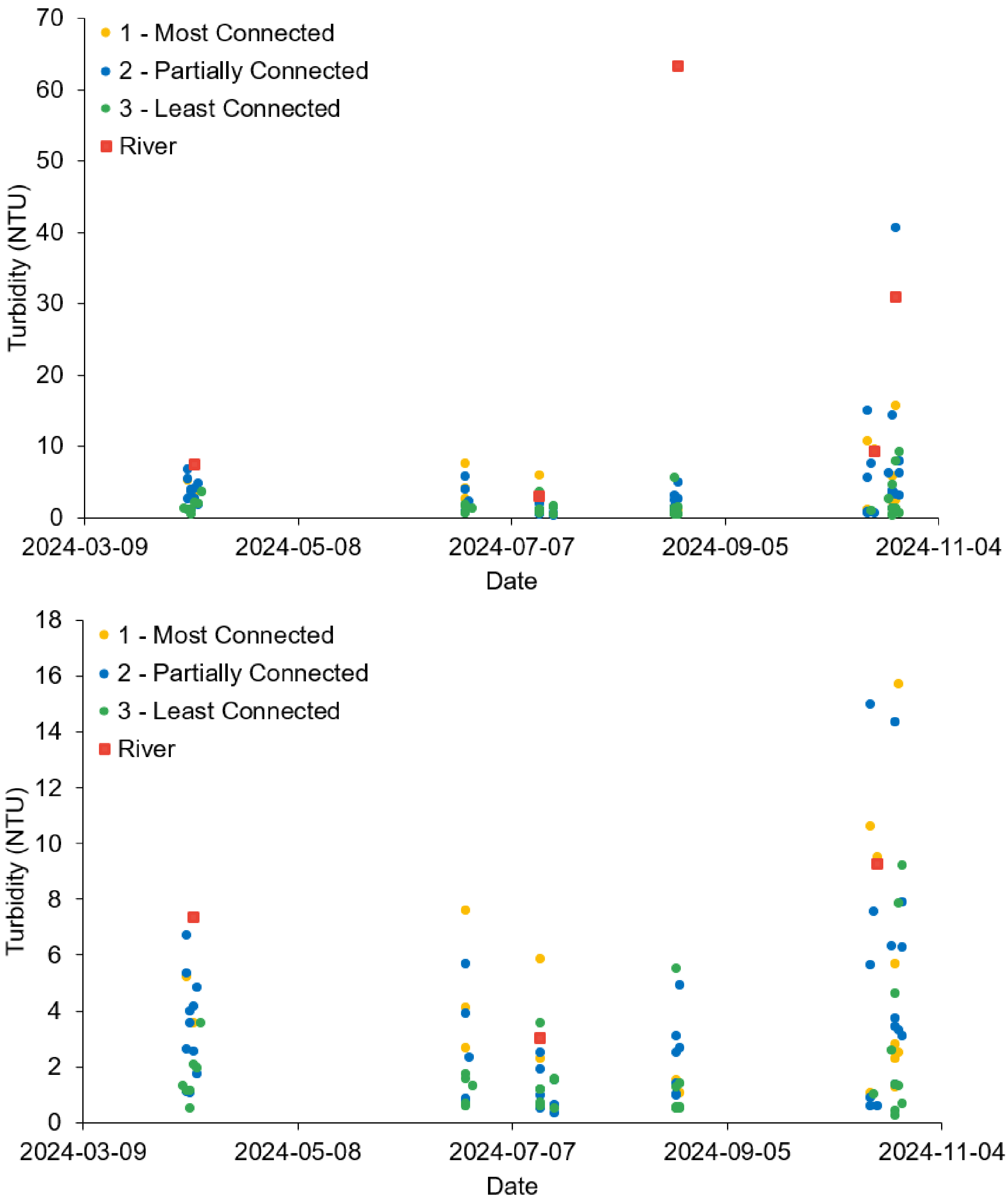


Figure 11: A) All turbidity measurements from wetlands and the Columbia River in 2024. B) Turbidity measurements with the three very high outliers removed, so as to make the other data points easier to compare.

### 3.3.3 Birds

#### General Bird Observations

We have recorded 164 species in and around our study wetlands either during dedicated waterbird counts or incidentally while working in the wetlands (full list of species in Appendix 3) between 2021 and 2024. 14 of these are Species at Risk (Appendix 5). The use of wetlands by these species varies widely, from ducks using open water to rest and feed, swallows and other insect eating birds catching food over the wetlands, small passerines such as warblers nesting in wetland vegetation, and shorebirds using exposed mud and short vegetation around the edges of wetlands to feed.

#### Spring and Fall Migratory Waterbird Counts

During spring and fall migratory waterbird counts at 20 sites (full methods in Appendix 2), we have recorded 80 species of birds, of which four are SAR (full list of observations in Appendix 4), and 29,658 individual birds. Of these, Mallard was the most commonly observed species, with 4277 individuals being observed across the four years of counts. 14 species have been observed only once, including American Bittern, a Blue-listed species in BC.

Our target species for these counts are waterbirds and raptors, as spring and fall is when these birds are migrating through the Columbia Wetlands, and we are interested in seeing how these species are using the wetlands. We also use a count strategy most appropriate for large birds like these, observing the wetlands from a distance, so as to not scare away any of the birds present.

Across the four years of counts, we have observed 50 species of waterbirds and raptors, with 24,624 individual birds counted. Of these, seven species have been observed only once. These include American Bittern, as mentioned above, and also Golden Eagle, Snow Goose, Solitary Sandpiper, Wilson's Snipe, Canvasback, Eurasian Wigeon, and California Gull.

In our 2023 report, we compared spring waterfall counts in 2022 and 2023. We are particularly interested in wetland use by waterbirds during spring migration, as this is when water levels are at their lowest. Most waterbirds migrate through the Columbia Valley in April, which is prior to the Columbia River flood pulse, and so the water present in the wetlands at this time is a combination of water retained from the previous year, local snow and ice melt, and groundwater input. Water retained from the previous year is partly due to the presence of beaver dams, as wetlands with beaver dams or with unbroken levees retain water over the winter (as discussed above).

However, migratory waterbirds also pass through the Columbia wetlands in fall, when water levels are dropping, and the impact of beaver dams and levee gaps is still very important. We believe that the role of beaver dams is particularly important in low water years, such as 2023 and 2024, as the water input to all wetlands from the flood pulse is smaller (as discussed above). Thus, this year we have focused on looking at both spring and fall migratory waterbird counts, to gain a better understanding of how migratory waterbirds are using these wetlands.

In general, slightly more birds are observed in fall (a total of 9959 individual birds counted in spring, and 10,665 counted in fall), while more species are observed in spring (a total of 44 species counted in spring, and 39 in the fall). These differences are more obvious within a year, with the more species consistently being observed in spring counts rather than fall counts (Figure 12). 37 species total were observed in both spring 2023, and 36 species total in spring 2024, while only 31 and 29 species total were observed in 2023, and 2024, respectively. Given the great differences in wetlands, the average values are not significantly different.

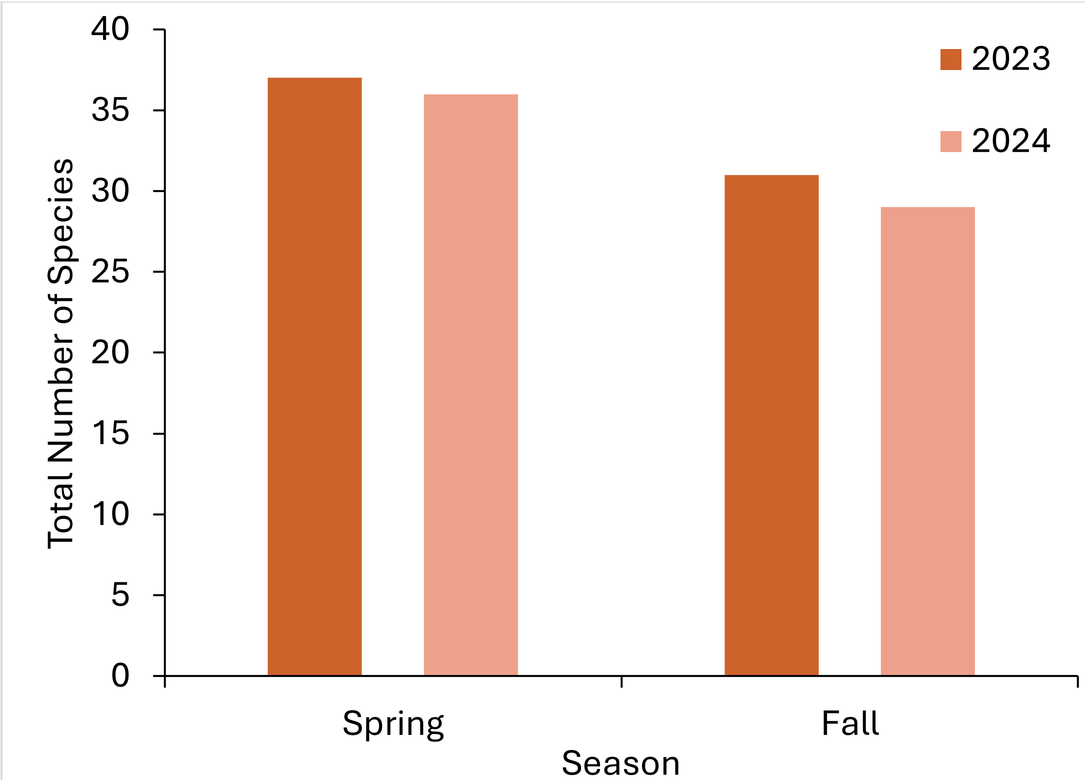

Figure 12: Total number of bird species observed in wetlands in spring and fall 2023 and 2024.

Twelve species have only been observed in spring, while six species have only been observed in fall (Table 1). This is likely due to differences in breeding and migration patterns. Several of the species observed only in spring are birds that breed in the Columbia Wetlands, such as American Bittern, Osprey, Sora, and Virginia Rail. Thus, by the end of April they are arriving, ready to begin the breeding season, while by October they have long finished breeding and have migrated away from the Columbia Valley. The fact that more species have only been observed in spring aligns with the total number of species observed in spring being higher.

Table 1: List of species observed only in spring or only in fall across four years of bird counts.

| **Spring Only** | **Fall Only** |
|---|---|
| American Bittern | California Gull |
| Cackling Goose | Gadwall |
| Canvasback | Long-billed Dowitcher |
| Eurasian Wigeon | Lesser Yellowlegs |
| Golden Eagle | Western Grebe |
| Osprey | Wilson's Snipe |
| Sandhill Crane | |
| Snow Goose | |
| Sora | |
| Solitary Sandpiper | |
| Tundra Swan | |
| Virginia Rail | |

The distribution of species that have been observed both in fall and spring also differs between the two seasons (Table 2). For example, we have recorded 750 American Coots in spring, but only 23 American Coots in fall. This indicates that species have different patterns in their spring and fall migration and are using the wetlands differently. Many species of bird have been documented having different migration routes in spring and fall, and fall migration also generally takes place over a longer time period. Some species such as Canada Goose remain in northern areas until there is no longer any open water, and so in their case the lower fall counts may be because many birds that breed further north have not yet started their southward migration yet.

Table 2: Combined counts (i.e. across all four years of bird surveys) of the top ten most common spring migratory waterbird species, showing difference between spring and fall counts.

| Species | Combined Spring Count | Combined Fall Count |
|---|---|---|
| Mallard | 1830 | 2447 |
| American Wigeon | 1277 | 2284 |
| Canada Goose | 1132 | 578 |
| Northern Pintail | 1002 | 503 |
| Ring-necked Duck | 930 | 681 |
| American Coot | 750 | 23 |
| Green-winged Teal | 742 | 882 |
| Common Goldeneye | 604 | 62 |
| Bufflehead | 485 | 82 |
| Hooded Merganser | 276 | 164 |

Waterbird migration is difficult to study, as there are many species involved and many factors affecting migration, resulting in large variation between different years and locations. Often long-term datasets are required to assess changes (e.g. a 60 year dataset used by Cox *et al.*, 2023 to investigate differences in fall migration of Mallard, Northern Pintail, and Blue-winged Teal). Thus, drawing conclusions about overall trends from our relatively limited dataset is difficult.

As well as overall numbers and species of birds, we are particularly interested in how birds are using the different wetland groups. As we discussed in 2023, there are clear differences in number of species and the identity of those species using the different wetland groups. However, our fall data is quite different. All wetland groups are clearly important to waterbirds in the fall, with an average of between 50 and 170 birds observed per hectare (Figure 13). The average number of individual birds does not differ significantly between the groups. The average number of birds is very similar between different years in both the Most and Least Connected wetlands. The Partially Connected wetlands show the biggest variation in number of birds, likely because they are the most varied wetland group.

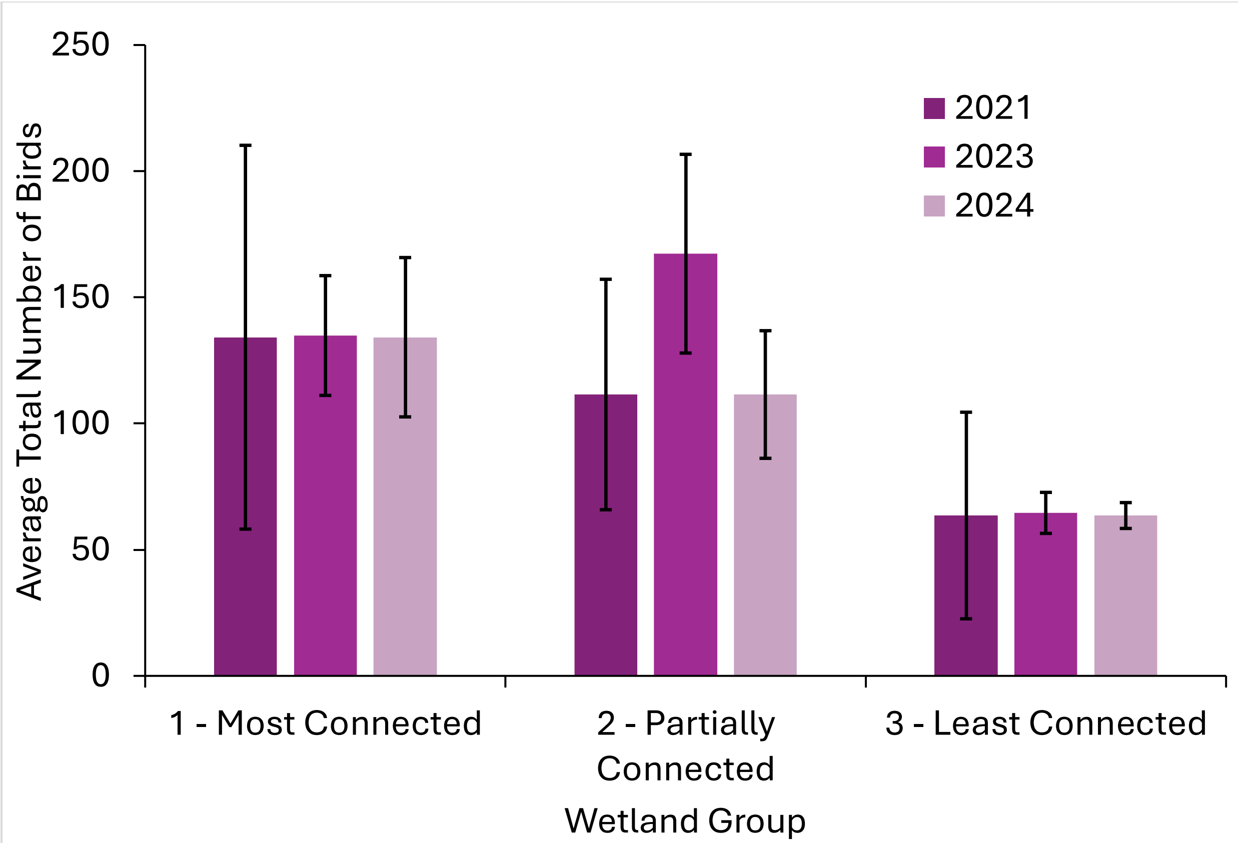

Figure 13: Average total number of birds per hectare in each wetland group across the three years of fall bird surveys. Error bars are standard error.

The total number of individual birds is only part of the picture, and so we have also looked at number of species found in each wetland group. There are no significant differences between wetland groups over the three years for which we have fall data, and average number of species between both years and groups is fairly consistent, indicating that birds are not selecting one wetland type over another (Figure 14).

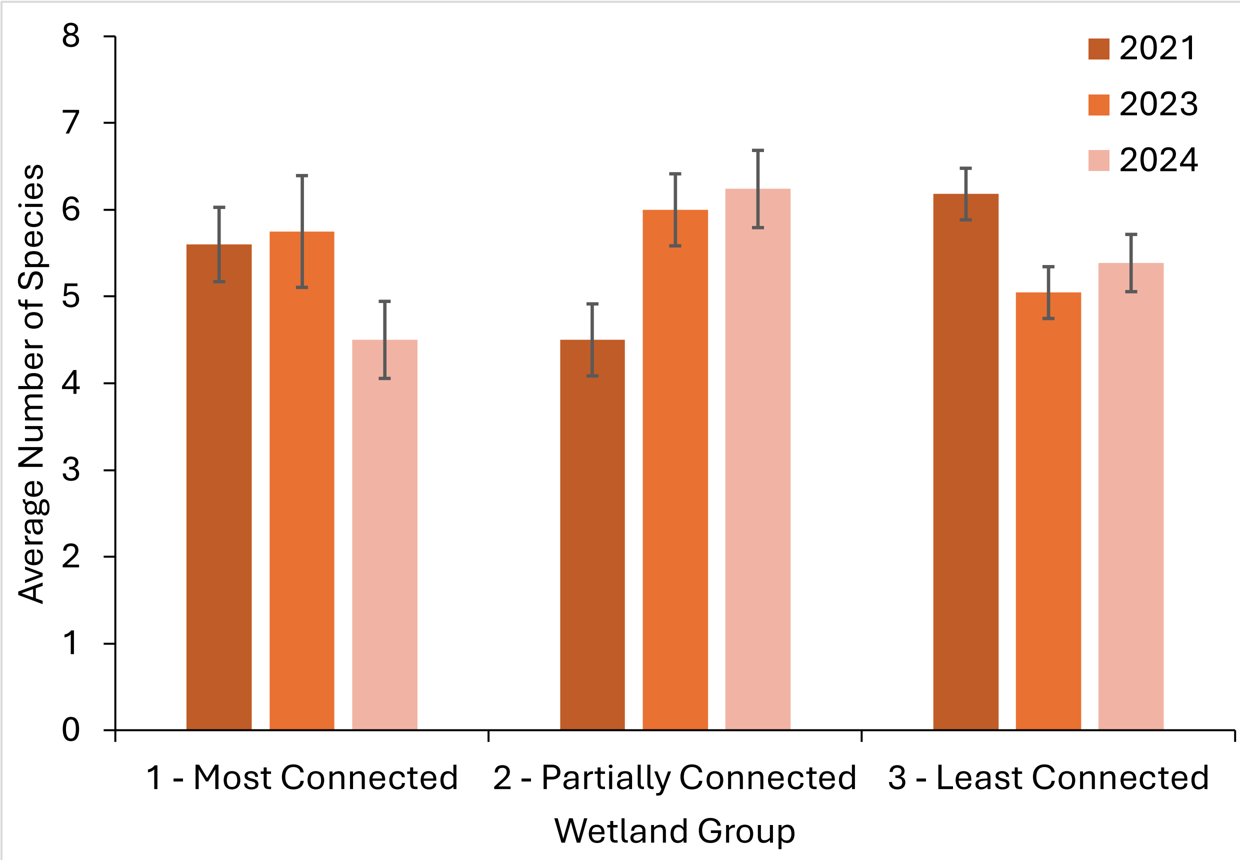


Figure 14: Mean number of bird species counted in fall across 2021, 2023, and 2024, by wetland group. Error bars are standard error.

The differences between spring and fall both in number of individuals and number of species are apparent. The variation between number of individuals on each wetland is greater in spring than in fall (Figure 15A; variation denoted by the error bars). For the Least Connected group, there are significantly more individual birds on this wetland type in spring than in fall. There is also more variation in number of species on each wetland in the spring than the fall, and the average number of species is larger in the spring (Figure 15B). In the spring, there are significant differences in number of species on the different wetland groups, while in the fall there are not. Further, in the fall, the average number of species is remarkably consistent both between and within groups, while in the spring there is great variation both between and within wetland groups.

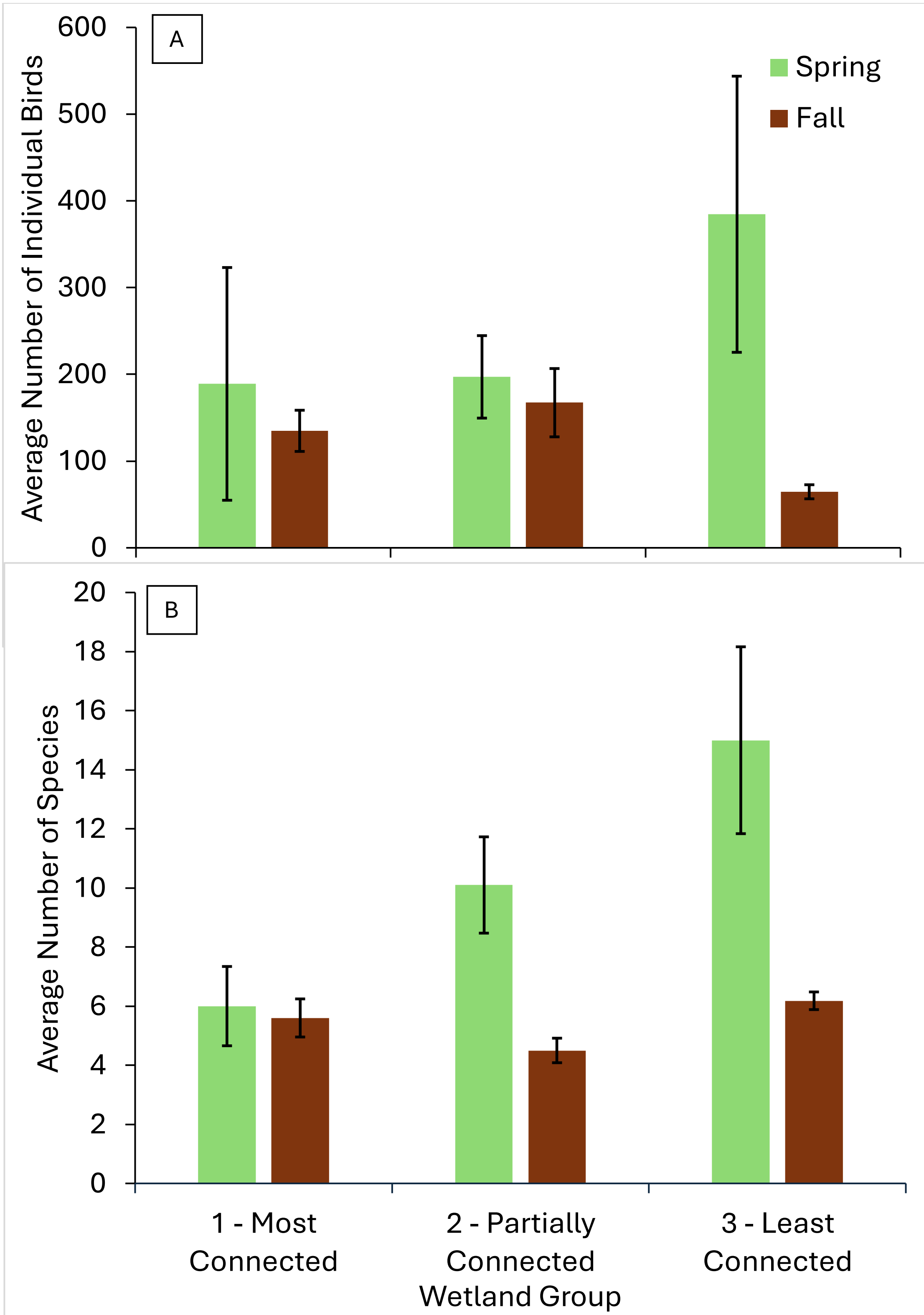


Figure 15: Comparison of 2023 spring and fall counts of A) mean total number of birds and B) mean total number of species across the three wetland groups. Error bars are standard error.

This does support our hypothesis that the differences between wetland groups are indeed more important in the spring than the fall, due to the overall low water levels in the spring. In the fall, water levels are higher across the wetlands, and particularly in the Most Connected wetlands, which depending on the year may still be receiving water from the river. In the spring, however, many wetlands in the Most Connected group are at their driest, because they have received no river input since the preceding year. Therefore, the water retained in the Partially and Least Connected wetlands by the natural levees and beaver dams is essential to providing habitat for these migratory waterbirds in the spring.

## 3.4 Restoration using beaver dam analogues: Permit Issues

There are clear ecological differences between the different wetland groups, and for the Columbia Wetlands to be an intact and diverse ecosystem, all these different wetland groups must be present. Most Connected wetlands comprise a greater area of the Columbia Wetlands and are the wetland group that will dominate without the actions of beaver or conservation actions by people. As the Partially and Least Connected wetlands are particularly important for waterbirds during spring migration, where due to their higher water levels, they provide habitat for a greater variety of species than the Most Connected wetlands, maintaining Partially and Least Connected wetlands is essential. They also provide habitat for plant species such as *Nymphaea tetragona*, which require year-round immersion in water and will not tolerate the high scour or potential for drying out found in Most Connected wetlands.

One way to do that is by building Beaver Dam Analogues. With these, we can retain water in wetlands, thus providing this less common habitat type, and increasing diversity across the wetland complex. We have identified three sites for building Beaver Dam Analogues, and we spent 2024 applying for permits.

Permit applications for BDA projects in the Columbia Wetlands are significantly more difficult than on the western upland bench. Due to the larger amount of water that can be stored in these sites (more than 10,000 m3), water licenses are required, and these projects would trigger dam safety regulations. Despite multiple meetings with the province, we have yet to obtain the appropriate permits for these structures. Conversations about larger BDA projects are ongoing, and we are working with the Nature Trust of BC, ECCC, and the Shuswap Band to try and obtain water licenses to complete these works. Unfortunately, due to perceived risk and liability, these conversations are slow moving and require additional information to be prepared. We have recently been told that Shuswap Band will not be recognized as a government entity that can hold a water license on provincial crown land – meaning that for any proposed projects on crown land in the valley bottom, CWSP will need to apply for crown land tenure. We have not decided if this route is worthwhile yet.

Despite these difficulties, CWSP continues to try and implement BDA structures in the valley bottom wetlands of the Columbia Valley. We opted to apply for post-only structures to install in the spring of 2025 to encourage beavers to build a dam in our identified locations or could act as our base for a future BDA construction (once a water license has been obtained). The permit application preparation required the 3-page portal submission and environmental management plan (approximately 50-page document). There are also additional information requests from the province that needed to be addressed, and permission from the railway must be obtained before we are allowed to construct projects on the Eastern edge of the valley. Unfortunately, two of these applications have been rejected as the province will only approve BDA projects under a water license on private land. CWSP may still be able to pursue post only structures at one of these application sites under a Section 11, but an additional 50-page document (Beaver Dam Management Plan) will need to be prepared for this site. A DFO Request for

Review was also submitted for these sites but based on the rejection of the applications they are no longer in progress. We are now working with The Nature Trust of Canada for two sites ( #71 & #24) and will investigation other options for Site 145. When we actually get the permits, we will be storing 65, 250 m3 at Site 24 and 23, 560 m3 at Site 145. We will actually not be increasing the storage at Site 71 because the beaver have naturally raised the water levels to the maximum possible height but we wanted to put in posts to prevent the Columbia River from eroding the beaver dams. We are continuing to try to get the permits since the value of a BDA is significant for waterbirds and mitigation of climate change impacts in Columbia Wetlands.

# 4. Communications

As well as conducting research and restoring wetlands, we also endeavour to communicate with both the general public and with other conservation and research organisations in various ways. We have given several presentations to different groups of people (Table 3).

Table 3: List of presentations given by CWSP personnel between April 2024 and March 2025.

| Date | Presenter(s) | Occasion | Presentation Title |
|---|---|---|---|
| May 2024 | Suzanne Bayley, Catriona Leven | Wings Over The Rockies Festival | Birding walk and talk at Radium Mill Pond |
| June 2024 | Suzanne Bayley | CWSP AGM | Overview of CWSP project activities and funders |
| June 2024 | Catriona Leven | CWSP AGM | The role of beavers in Columbia Wetlands: Why do we restore beaver dams in the Columbia Wetlands? |
| June 2024 | Jessica Holden | CWSP AGM | Wetlands and beaver dam restoration on western side of Columbia Valley |
| June 2024 | Suzanne Bayley, Jessica Holden, Catriona Leven | Presentation to Shuswap Band biologists | Wetland Restoration with Beaver Dams |
| July 2024 | Catriona Leven | Wildsight Youth Columbia River Field School | An introduction to the Columbia Wetlands and Beaver Dams |
| August 2024 | Catriona Leven | University of Waterloo Thesis Defence | Wetland hydrology and the impacts of beaver dams in the Upper Columbia River floodplain wetlands |
| January 2025 | Catriona Leven | Golden Conservation Action Forum | Beaver Dams Regulate Water Levels In Columbia River Wetlands |

We are also collaborating with and sharing information with organisations such as Living Lakes Canada, the British Columbia Wildlife Federation, and Ducks Unlimited. Specifically, we are advising Ducks Unlimited and BC Parks on their restoration of wetlands at Burgess James Gadsden Provincial Park and have attended site visits and meetings to discuss restoration options and provide data and advice from our work. In May 2024 we assisted Ducks Unlimited and BC Parks with water level logger deployment in Burgess James Gadsden Provincial Park over two days. In July 2024 we visited natural wetlands in the Columbia Valley with Ducks Unlimited representatives discussing how the Columbia River flood pulse shapes these wetlands differently depending on levee gap and beaver dam presence, and looking at the differences between different wetlands, as discussed above. This work is still ongoing, with on-the-ground restoration work planned to start in fall 2025.

We also work closely with and share accommodation with the Columbia Headwaters Aquatic Restoration Secwépemc Strategy team. Dr. Suzanne Bayley was also a part of the Columbia Valley Recreational Planning Initiative, Recreational Plan for Forester Watershed, an ongoing project to better manage recreation in the Forester Watershed in the Columbia Valley.

In August 2024, Catriona Leven successfully defended her thesis titled 'Wetland hydrology and the impacts of beaver dams in the Upper Columbia River floodplain wetlands'. The full thesis is publicly available on the University of Waterloo UWSpace (https://uwspace.uwaterloo.ca/items/058b8547-b6c6-4316-825c-39196f933695). The manuscript is currently being redrafted for publication.

# 5. Acknowledgments

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# 7 Appendices

## 7.1 Appendix 1: List of sites

Including easting and northing, 2020, 2021, 2022, and modal group, and whether bird surveys were conducted at each site.

| Site | Easting | Northing | 2020 Wetland Group | 2021 Wetland Group | 2022 Wetland Group | Modal Group | Bird Surveys |
|---|---|---|---|---|---|---|---|
| 21 | 532535 | 5652873 | 4 - Least Connected | 3 - Least Connected | 3 - Partially Connected - Smaller Gaps | Least Connected | Yes |
| 24 | 535422 | 5651111 | 1 - Most Connected | 1 - Most Connected | 1 - Most Connected | 1 - Most Connected | Yes |
| 29 | 543167 | 5641399 | ND | 1 - Most Connected | 1 - Most Connected | 1 - Most Connected | No |
| 30 | 544030 | 5639666 | 1 - Most Connected | 1 - Most Connected | 1 - Most Connected | 1 - Most Connected | Yes |
| 31 | 545913 | 5637403 | 2 - Partially Connected - Bigger Gaps | 3 - Least Connected | 2 - Partially Connected - Bigger Gaps | Partially Connected | Yes |
| 32 | 545543 | 5637069 | 1 - Most Connected | 1 - Most Connected | 1 - Most Connected | 1 - Most Connected | No |
| 35 | 550776 | 5630949 | 2 - Partially Connected - Bigger Gaps | 3 - Least Connected | 4 - Least Connected | Least Connected | Yes |
| 36 | 551130 | 5630189 | 2 - Partially Connected - Bigger Gaps | 1 - Most Connected | 2 - Partially Connected - Bigger Gaps | Partially Connected | No |
| 38 | 549892 | 5630542 | 4 - Least Connected | 3 - Least Connected | 2 - Partially Connected - Bigger Gaps | Least Connected | Yes |
| 39 | 550531 | 5628689 | 2 - Partially Connected - Bigger Gaps | Partially Connected | 3 - Partially Connected - Smaller Gaps | Partially Connected | No |
| 43 | 555476 | 5623684 | 2 - Partially Connected - Bigger Gaps | 3 - Least Connected | 3 - Partially Connected - Smaller Gaps | Partially Connected | No |
| 47 | 563287 | 5612893 | 4 - Least Connected | 3 - Least Connected | 4 - Least Connected | Least Connected | No |
| 48 | 562874 | 5612685 | 3 - Partially Connected - Smaller Gaps | Partially Connected | ND | Partially Connected | No |
| 49 | 563443 | 5608264 | 4 - Least Connected | 3 - Least Connected | 4 - Least Connected | Least Connected | Yes |

| Site | Easting | Northing | 2020 Wetland Group | 2021 Wetland Group | 2022 Wetland Group | Modal Group | Bird Surveys |
|---|---|---|---|---|---|---|---|
| 51 | 567072 | 5601686 | 3 - Partially Connected - Smaller Gaps | Partially Connected | 2 - Partially Connected - Bigger Gaps | Partially Connected | No |
| 59 | 543772 | 5638706 | 1 - Most Connected | 1 - Most Connected | 1 - Most Connected | 1 - Most Connected | No |
| 62 | 544859 | 5639039 | 3 - Partially Connected - Smaller Gaps | 3 - Least Connected | 3 - Partially Connected - Smaller Gaps | Partially Connected | Yes |
| 64 | 546804 | 5635861 | 1 - Most Connected | 1 - Most Connected | 1 - Most Connected | 1 - Most Connected | No |
| 68 | 545273 | 5635944 | 1 - Most Connected | 1 - Most Connected | 1 - Most Connected | 1 - Most Connected | No |
| 69 | 544325 | 5639373 | 4 - Least Connected | 3 - Least Connected | 2 - Partially Connected - Bigger Gaps | Least Connected | Yes |
| 70 | 551389 | 5627697 | 2 - Partially Connected - Bigger Gaps | 1 - Most Connected | 1 - Most Connected | 1 - Most Connected | No |
| 71 | 550149 | 5630945 | 2 - Partially Connected - Bigger Gaps | 1 - Most Connected | 2 - Partially Connected - Bigger Gaps | Partially Connected | Yes |
| 110 | 542996 | 5638520 | 3 - Partially Connected - Smaller Gaps | Partially Connected | 3 - Partially Connected - Smaller Gaps | Partially Connected | No |
| 126 | 549517 | 5631250 | 2 - Partially Connected - Bigger Gaps | Partially Connected | 4 - Least Connected | Partially Connected | No |
| 127 | 549090 | 5631267 | 4 - Least Connected | 3 - Least Connected | 2 - Partially Connected - Bigger Gaps | Least Connected | Yes |
| 128 | 548571 | 5631699 | 2 - Partially Connected - Bigger Gaps | Partially Connected | 3 - Partially Connected - Smaller Gaps | Partially Connected | No |
| 129 | 528755 | 5654469 | 4 - Least Connected | Partially Connected | 3 - Partially Connected - Smaller Gaps | Partially Connected | No |
| 130 | 528565 | 5654310 | 2 - Partially Connected - Bigger Gaps | 1 - Most Connected | 1 - Most Connected | 1 - Most Connected | No |
| 131 | 528247 | 5655396 | 4 - Least Connected | 3 - Least Connected | 2 - Partially Connected - Bigger Gaps | Least Connected | Yes |

| Site | Easting | Northing | 2020 Wetland Group | 2021 Wetland Group | 2022 Wetland Group | Modal Group | Bird Surveys |
|---|---|---|---|---|---|---|---|
| 132 | 533588 | 5652117 | 1 - Most Connected | 1 - Most Connected | 1 - Most Connected | 1 - Most Connected | Yes |
| 137 | 550568 | 5629167 | 3 - Partially Connected - Smaller Gaps | Partially Connected | 3 - Partially Connected - Smaller Gaps | Partially Connected | No |
| 140 | 543498 | 5641456 | ND | Partially Connected | ND | NA | No |
| 141 | 540750 | 5645785 | ND | Partially Connected | 3 - Partially Connected - Smaller Gaps | Partially Connected | Yes |
| 142 | 536898 | 5649710 | ND | 3 - Least Connected | 3 - Partially Connected - Smaller Gaps | NA | Yes |
| 143 | 531008 | 5653564 | ND | 3 - Least Connected | 3 - Partially Connected - Smaller Gaps | NA | Yes |
| 144 | 523973 | 5657202 | ND | 3 - Least Connected | 2 - Partially Connected - Bigger Gaps | NA | Yes |
| 145 | 523706 | 5657294 | ND | 1 - Most Connected | 1 - Most Connected | 1 - Most Connected | Yes |

## 7.2 Appendix 2: Detailed methods of fieldwork and analysis

**2 Methods**

We conducted research in a total of 38 wetlands (Figure 6), working over three years from 2020 to 2022, with the majority of fieldwork completed in 2021 and 2022. In 2020, only 30 wetlands were studied and eight new wetlands were picked in 2021 to better represent the different types of wetland present in the Columbia Wetlands ecosystem. Wetlands were chosen for inclusion in this study based on local expert knowledge and previous work conducted in the Columbia Wetlands.

***2.1 Fieldwork***

*2.1.1 Wetland Hydrology*

We measured water levels (m) and water temperature at individual wetlands using HOBO U-20 (HOBO by Onset, Cape Cod, Massachusetts, USA) water level loggers, installed each year in May and removed in October, with pressure (later converted to water depth) and temperature being recorded every four hours. All measurements were corrected with a barometric pressure sensor located at Brisco. In 2021 and 2022 there were equipment failures, resulting in data from 37 and 36 wetlands respectively. Similarly, one or both of the two water level loggers in the Columbia River were lost in all three years, so for Columbia River water depth we instead used a publicly available dataset from the Environment and Climate Change Canada hydrometric station on the Columbia River at Nicholson (cite this!).

*2.1.2 Levee Gaps and Beaver Dams*

We identified potential locations of beaver dams, beaver lodges, and levee gaps within the wetland, and within 10m, 20m, and 30m of the 38 study wetlands using ArcGIS Pro 2.8.0 and a combination of orthophotos, satellite imagery, LiDAR imagery, and digital elevation models (Airborne Imagery, 2015; Forest, Lands, and Natural Resource Operations and Rural Development, Geo BC, 2018). These buffer distances were included as in several instances we found that the dam(s) responsible for holding water into the wetland were not within the boundaries of the wetland itself. From the imagery, using ArcGIS Pro 2.8.0 tools, we measured the length of beaver dams, the perimeter length (m) and area ($m^2$) of each wetland and levee gaps. All gaps were included to determine the total gap width (m) in each wetland, regardless of whether these gaps were influencing water levels in the wetlands. Gaps that did not influence wetland water levels were then excluded from further analysis and ‘Inflow

Gaps' were summarized to determine the width of gaps influencing water levels within each wetland. Inflow gaps were determined based on characteristics visible on ArcGIS and then confirmed via in person fieldwork (Appendix 5).

Once we determined the locations of beaver dams and gaps through remote sensing, we conducted in-person fieldwork at each wetland site. In-person fieldwork was essential, as not all dams and gaps were visible from remote sensing sources, and measuring all the required dam dimensions, as well as determining how the dams or gaps affected the hydrology of the wetland itself, was not possible otherwise. All dams and gaps were visited and measured between August 2021 and May 2022, within the same flood year. This timing was important because dams and gaps could not be measured during high water. We walked and/or kayaked the perimeter of each wetland to identify beaver dams and gaps, using the remote sensing derived information as a guide for where there were likely to be dams or gaps; in some instances we located dams on the ground that were not visible through remote sensing. Once at a dam or gap location, we measured the dimensions of the feature (Appendix 6), took notes on building material, beaver activity (active, where there were signs of fresh mud or new sticks; inactive, where there were no such signs but the dam was still in good repair; and old, where the dam was no longer in good repair), water flow, and its influence on the wetland, as well as drawing a rough sketch of the feature. Preliminary digital measurements were then amended based on this ground-truthing in the field.

2.1.3 Migratory bird surveys

We conducted migratory bird surveys in 20 wetlands (Appendix 1). We found that time of day did not have a consistent or large impact on the numbers of species and birds present at a site, after which point we surveyed sites for as long as possible on a single day. In case diurnal patterns are significant, however, with some sites maybe being chosen as roost sites and some as feeding sites, we made sure to vary the times of day at which we surveyed each site, and will take time of survey into account in my analysis. We did not survey in inclement weather (e.g., heavy snow and rain, fog), but on days when such weather was inconsistent we did conduct surveys in the periods of suitable weather. We surveyed each site using binoculars and a spotting scope, and took photographs of birds present, for a minimum of 15 minutes up to however long it took to count and identify to species (if possible) all waterfowl and raptors using the wetland. We also recorded weather conditions, human disturbances, and other factors that might have affected the presence of waterfowl. I also entered count data on eBird.

We have done five or six six spring and fall migratory waterfowl counts at each of the sites since we began. Larson *et al.* (2020) concluded that due to the variability of waterfowl count data, three surveys were the minimum required for data analysis.

## 7.3 Appendix 3: Incidental bird observation data

See attached excel file

## 7.4 Appendix 4: Migratory waterbird survey data

See attached excel file

## 7.5 Appendix 5: List of observed Species at Risk birds

| Scientific Name | English Name | Biogeoclimatic Units | Provincial | BC List | Global | COSEWIC | SARA |
|---|---|---|---|---|---|---|---|
| *Botaurus lentiginosus* | American Bittern | BG; BWBS; CDF; CWH; ICH; IDF; MS; PP; SBPS; SBS | S3B,SNRN (2015) | Blue | G5 (2016) | | |
| *Riparia riparia* | Bank Swallow | | S4?B (2022) | Yellow | G5 (2016) | T | 1-T (2017) |
| *Hirundo rustica* | Barn Swallow | BAFA; BG; BWBS; CDF; CWH; ESSF; ICH; IDF; IMA; MH; MS; PP; SBPS; SBS; SWB | S4B (2022) | Yellow | G5 (2016) | SC | 1-T (2017) |
| *Cypseloides niger* | Black Swift | BAFA; BG; CDF; CMA; CWH; ESSF; ICH; IDF; IMA; MH; MS; PP; SBPS; SBS; SWB | S2S4B (2022) | Blue | G4 (2016) | E | 1-E (2019) |
| *Larus californicus* | California Gull | BG; BWBS; CDF; CWH; ICH; IDF; MS; PP; SBS | S1B,SNRN (2022) | Red | G5 (2016) | | |
| *Chordeiles minor* | Common Nighthawk | BG; BWBS; CDF; CWH; ESSF; ICH; IDF; MH; MS; PP; SBPS; SBS; SWB | S3S5B (2022) | Blue | G5 (2016) | SC | 1-SC (2023) |
| *Nannopterum auritum* | Double-crested Cormorant | BWBS; CDF; CWH; ICH; IDF; PP; SBPS; SBS | S3S4 (2015) | Blue | G5 (2016) | NAR | |
| *Podiceps nigricollis* | Eared Grebe | BAFA; BG; BWBS; CMA; CWH; ESSF; ICH; IDF; IMA; MH; MS; PP; SBPS; SBS | S3B (2015) | Blue | G5 (2016) | | |
| *Chondestes grammacus* | Lark Sparrow | BG; BWBS; CDF; CWH; ICH; IDF; MS; PP; SBPS; SBS | S2S4B (2022) | Blue | G5 (2016) | | |
| *Falco peregrinus* | Peregrine Falcon | BG; BWBS; CDF; CWH; ESSF; ICH; IDF; MS; PP; SBS; SWB | S3 (2015) | No Status | G4 (2016) | SC | 1-SC |
| *Phalaropus lobatus* | Red-necked Phalarope | BG; BWBS; CDF; CWH; ICH; IDF; MS; PP; SBPS; SBS; SWB | S3B,SNRM (2023) | Blue | G4G5 (2016) | SC | 1-SC (2019) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Buteo lagopus* | Rough-legged Hawk | BAFA; BG; BWBS; CDF; CWH; ESSF; ICH; IDF; IMA; MS; PP; SBPS; SBS; SWB | S3N (2015) | Blue | G5 (2016) | NAR | |
| *Cygnus columbianus* | Tundra Swan | | S3N (2015) | Blue | G5 (2016) | | |
| *Aechmophorus occidentalis* | Western Grebe | BG; BWBS; CDF; CWH; ICH; IDF; MS; PP; SBPS; SBS | S1S2B,S2N (2023) | Red | G5 (2016) | SC | 1-SC (2017) |