Weaselhead/Glenmore Park
SWCRR Impact Study 2016-2022

Environmental Monitoring Report 2022

birds, noise, vegetation, wildlife movement, water quality, aquatic invertebrates, amphibians, fish.

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Please note that raw data not included in the report is available on request.

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INTRODUCTION

Construction of the Southwest Calgary Ring Road (SWCRR) started in fall 2016. The project's EIA[1] (Environmental Impact Assessment; carried out by AMEC in 2006, updated in 2014) predicted alteration to habitats, and impacts on the environment of the adjacent Weaselhead Natural Environment Park (herein referred to as Weaselhead) both during construction and later at the operational phase of the SWCRR. In this context, the Weaselhead/Glenmore Park Preservation Society embarked upon a seven-year study, the SWCRR Impact Study, (herein referred to as the Study) that would span the years from initiation to completion of the road. The Study aimed to quantify the SWCRR's impacts on biophysical components of the park and on park users. The objective of the biophysical aspect of the Study is not to attempt a comprehensive survey of habitats and ecosystem components and their change over the period of the Study, but to assess the impacts of the SWCRR on selected environmental indicators and compare these with those predicted in the EIA[1].

The first SWCRR Impact Study Environmental Monitoring Report described conditions in the study area in 2016 prior to the extensive disturbance of the Elbow Valley required to accommodate the SWCRR. The 2017 report described conditions at the start of the construction phase. The 2018, 2019 and 2020 reports describe conditions during the three years of construction (all reports are available on the Society's website). The 2021 and 2022 reports assess the operational phase of the road. Figure 1 summarizes the timeline of the project. Figure 2 and Figure 3 show aerial images of the Weaselhead and TUC (Transportation Utility Corridor) in 2016 before construction started (Figure 2), and the same area in May 2021 (Figure 3), after the opening of the section of the SWCRR adjacent to the Weaselhead on October 2, 2020.

When contrasted with the baseline conditions of 2016, later conditions offer insights into the long-term effects of the SWCRR on the adjacent ecosystems. These ecosystems included different features within the Weaselhead, and a number of different parameters indicating ecosystem health were examined throughout the Weaselhead.

The data collected in 2022, allows an objective evaluation of the road's impact on selected environmental components and the success/failure of the mitigation measures adopted and expected to render the impact on these components acceptable (as detailed in the construction company's contract with Alberta Transportation). These data allow the Society to present arguments for improved mitigation based upon verifiable and scientific data. The Society hopes that this long-term study will also help improve global road mitigation efforts as studies are rare that include baseline data, cover the construction period, and continue monitoring into the operational period, and thus allow direct comparison between conditions before and after road construction.

Figure 1. Timeline of assessments & construction phases

Figure 2. An aerial image Sept. 8, 2016, before major construction began (*downloaded from Google Earth); o*range line shows Weaselhead boundary; scale: white line = 500 m.

Figure 3. The same area on June 2, 2022, with the SWCRR complete; Aerial imagery of the Weaselhead and its boundary shown by orange line; scale: white line = 500m.

RESULTS: TERRESTRIAL HABITATS

a. Breeding Bird Survey

In 2022 the breeding bird survey was conducted using the same protocol and study design as in 2016 – 2021 and as the EIA[1]. In order to reduce confounding factors, methodology was consistently maintained from 2016 – 2022. Time of year, location of survey stations, and times of observation were also kept constant. Similar weather conditions as in previous years pertained on the day of the survey: It was 12 ˚C on the morning of June 30, 2022, with light cloud cover and no precipitation.

Volunteer groups were made up of two to three people with at least one expert observer. On June 30, 2022, three groups of volunteers carried out the survey, each group visiting a different set of sites (Figure 4). Groups followed the method described below:

- Starting at 5:00 am (daylight saving time: UTC-6:00) groups hiked to each predetermined station, located with GPS, or google maps leading to survey coordinates.
- Upon arrival at each station the group waited for 2 minutes in silence then recorded on datasheets the birds heard or seen less than 50m from the station, and from a 50m to 100m distance for 10 minutes.
- Birds flushed when approaching the point, flying overhead, or flying through the area (under the canopy) were noted on the sheet, but not included in the total count of species.
- The survey covered 28 stations in total in the Weaselhead area (including 4 stations just outside the boundary of the Weaselhead, two in North and two in South Glenmore Parks) (Table 1).

Table 1. Station coordinates for breeding bird point counts and noise pollution monitoring.

Station	Latitude	Longitude	Station	Latitude	Longitude
P1	50° 59.789' N	114° 09.427' W	P15	50°59.513'N	114° 08.709' W
P2	50° 59.772' N	114° 09.221' W	P16	50°59.572'N	114° 08.470' W
P3	50° 59.738' N	114° 08.931' W	P17	50°59.431'N	114° 08.343' W
P4	50°59.701' N	114°09.347' W	P18	50°59.331'N	114° 08.072' W
P5	50°59.647' N	114°09.180' W	P19	50°59.200'N	114° 09.278' W
P6	50°59.584' N	114°09.359' W	P20	50°59.141'N	114° 09.435' W
P7	50°59.446' N	114°09.346' W	P21	50°59.189'N	114° 09.673' W
P8	50°59.477' N	114°09.128' W	P22	50°59.114'N	114° 09.097' W
P9	50°59.324' N	114°09.621' W	P23	50°59.119'N	114° 08.887' W
P10	50°59.320'N	114° 09.355' W	P24	50°58.977'N	114° 08.894' W
P11	50°59.320'N	114° 09.092' W	P25	50°58.963'N	114° 08.618' W
P12	50°59.359'N	114° 08.815' W	P26	50°58.816'N	114° 08.506' W
P13	50°59.560'N	114° 08.948' W	P27	50°58.875'N	114° 08.312' W
P14	50°59.663'N	114° 08.757' W	P28	50°58.766'N	114° 08.018' W

Figure 4. Location of breeding bird survey points *(scale: white line = 500m)*

During the 2022 bird survey 556 individuals from 54 different species were identified within the 100m of the survey sites (raw data is available on request; summaries are shown in Table 2 and Table 3). As in earlier years the total Simpson's diversity index for the breeding bird survey was high (1-S = 95.58%).

As in previous surveys, a significant linear regression slope (d.f.=26, $p<0.05$) was found between the cumulative number of different species and the cumulative area investigated. The linear interval for the 2022 survey species per area regression follows the general function:

$$CS=0.40A+23.87 \ (R^2=0.9106),$$

where CS is the cumulative number of species and A is the cumulative area observed (ha). The slope value of this equation represents the expected increase in the cumulative number of species found with increased area of search (for the same period of the year and area interval surveyed). In this case an average of 0.40 "new" species were recorded with each additional hectare surveyed. Following lower values observed in

2020 (0.31A), the chance of finding new species improved in 2021 (0.49A) and seems to have reached an intermediate level in 2022 (0.40A).

It is important to note that the linear relationship between the variables considered was only observed within the interval of area studied (particularly between 10 and 60 hectares). A non-linear relationship is expected beyond this interval at both ends, hence an extrapolation of this linear relationship is unlikely to produce realistic outcomes (Figure 5). For the 2022 cumulative bird species data, a non-linear relationship is observed between area and cumulative species number beyond 60 hectares (the curve flattens and seems to form an asymptote).

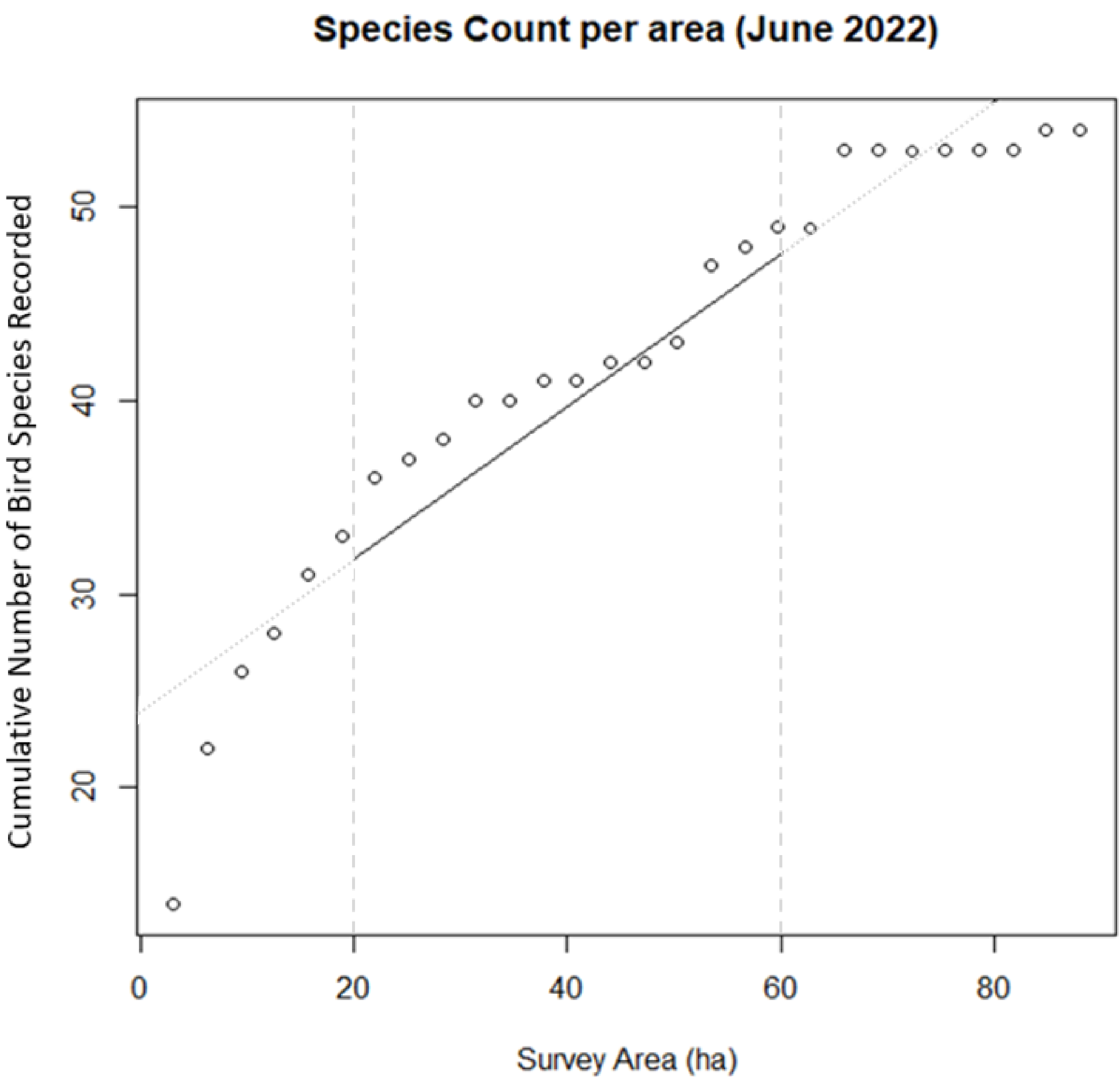

Figure 5. Regression model between cumulative number of species recorded and area, increasing in increments of 3.14ha (= area of a 100m-radius circle around stations in which observations were made). Linear Regression CS=0.40A+23.87 (R2=0.9106, d.f.=26, p<0.05).

The slope of the cumulative bird species bird species richness per surveyed area between 2016 and 2022, varied between 0.31 (in 2020) to 0.49 (in 2021). No clear temporal trend for this parameter is noted for the study period (Figure 6).

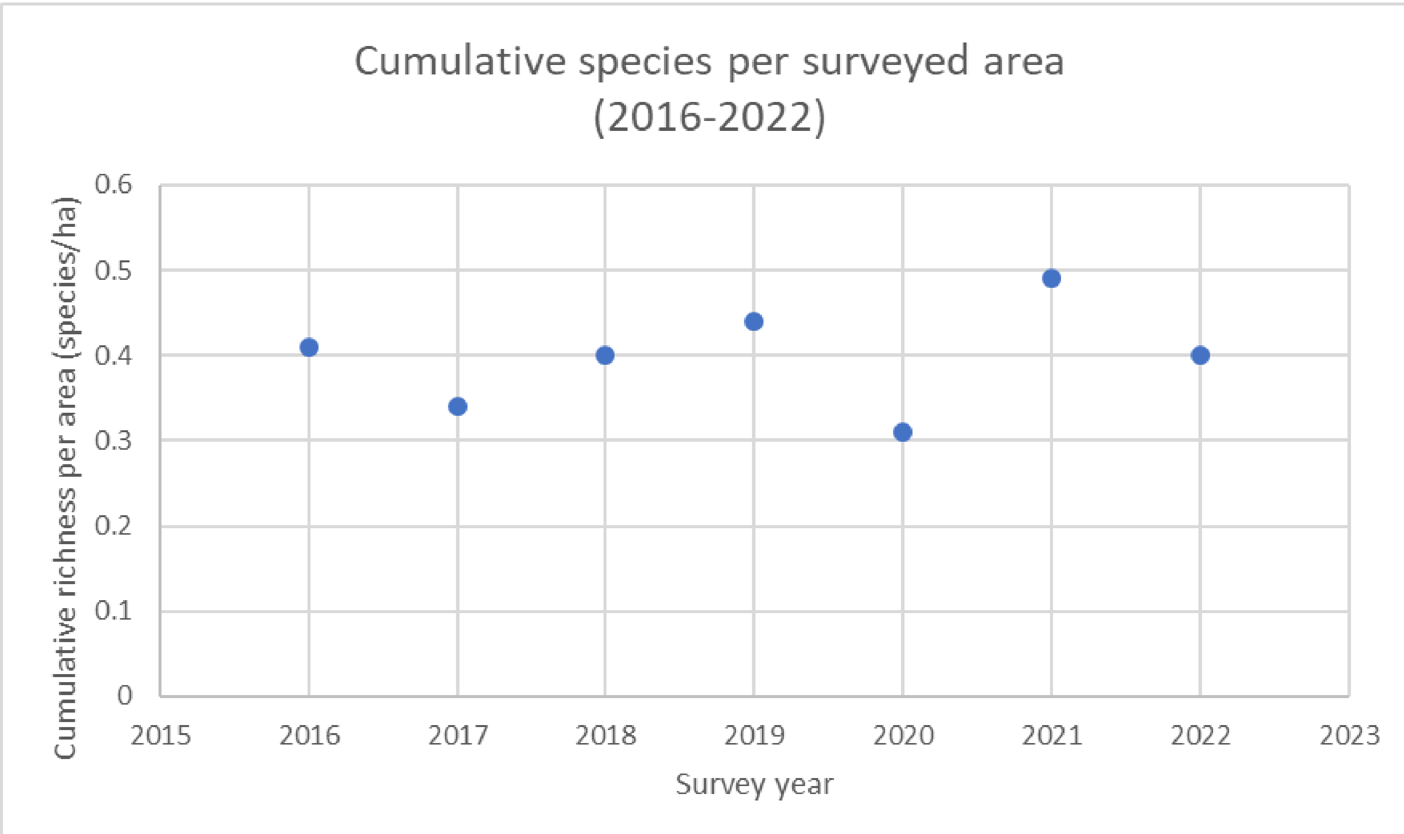

Figure 6. Slope of the linear regression of cumulative bird species richness versus surveyed area in the Weaselhead and Glenmore Park stations between 2016 and 2022.

Table 2. Breeding bird survey species list (June 30, 2022) with total individual counts (species indicated as *sensitive; ** may-be-at-risk Alberta Wild Species General Status Listing[2], *** Previously listed)

Common Name	Species Name	Total Count
Cedar Waxwing	Bombycilla cedrorum	61
Yellow Warbler	*Setophaga petechia*	45
Clay-colored Sparrow	*Spizella pallida*	36
Red-winged Blackbird	*Agelaius phoeniceus*	31
American Robin	*Turdus migratorius*	29
Cliff Swallow	*Petrochelidon pyrrhonota*	27
Pine Siskin	*Spinus pinus*	26

Brown headed Cowbird	*Molothrus ater*	22
Black Capped Chickadee	*Poecile atricapillus*	21
House Wren	*Troglodytes aedon*	20
Least Flycatcher***	*Empidonax minimus*	16
White Crowned Sparrow	*Zonotrichia leucophrys*	15
White Throated Sparrow	*Zonotrichia albicollis*	14
Downy Woodpecker	*Dryobates pubescens*	11
Mallard	*Anas platyrhynchos*	11
Red-breasted Nuthatch	*Sitta canadensis*	11
Veery	*Catharus fuscescens*	11
Bank Swallow*	*Riparia riparia**	10
Bufflehead	*Bucephala albeola*	9
Chipping Sparrow	*Spizella passerina*	9
Common Goldeneye	*Bucephala clangula*	9
Tree Swallow	*Tachycineta bicolor*	9
American Goldfinch	*Spinus tristis*	8
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	8
Red-eyed Vireo	*Vireo olivaceus*	8
Canada Goose	*Branta canadensis*	7
Spotted Sandpiper	*Actitis macularius*	7
Western Wood Peewee**	*Contopus sordidulus***	7
Pileated Woodpecker*	*Dryocopus pileatus**	6
American Avocet	*Recurvirostra americana*	4
Franklin's Gull	*Leucophaeus pipixcan*	4
House Finch	*Carpodacus mexicanus*	4
Song Sparrow	*Melospiza melodia*	4
Killdeer	*Charadrius vociferus*	3
Lincoln's Sparrow	*Melospiza lincolnii*	3

Mountain Chickadee	*Poecile gambeli*	3
White-breasted Nuthatch	*Sitta carolinensis*	3
American Crow	*Corvus brachyrhynchos*	2
Gray Catbird	*Dumetella carolinensis*	2
Hairy Woodpecker	*Dryobates villosus*	2
Red-necked Grebe	*Podiceps grisegena*	2
Tennessee Warbler	*Leiothlypis peregrina*	2
Warbling Vireo	*Vireo gilvus*	2
Yellow-rumped Warbler	*Dendroica coronata*	2
Unknown Duck Species	-	2
American Wigeon	*Mareca americana*	1
Black billed Magpie	*Pica hudsonia*	1
Blue-winged Teal	*Spatual discors*	1
Boreal Chickadee	*Poecile hudsonicus*	1
Calliope Hummingbird	*Stellula calliope*	1
Common Raven	*Corvus corax*	1
Northern Waterthrush	*Seiurus noveboracensis*	1
Red winged Blackbird	*Agelaius phoeniceus*	1
Ruby-crowned kinglet	*Regulus calendula*	1
Sora*	*Porzana Carolina**	1

Table 3. Breeding bird survey (June 30, 2022) – birds seen or heard between stations or further than 100m from survey points or flying overhead.

Birds seen or heard >100 m from survey points		
Species	**Latin Name**	
Canada Goose	*Branta canadensis*	13
Common Goldeneye	*Bucephala clangula*	9
Cliff Swallow	*Petrochelidon pyrrhonota*	6

Western Wood Peewee**	*Contopus sordidulus***	6
American Avocet	*Recurvirostra americana*	5
House Wren	*Troglodytes aedon*	5
American Crow	*Corvus brachyrhynchos*	4
American Robin	*Turdus migratorius*	4
Double-crested Cormorant	*Phalacrocorax auritus*	3
Red-winged Blackbird	*Agelaius phoeniceus*	3
Tree Swallow	*Tachycineta bicolor*	3
Veery	*Catharus fuscescens*	3
Bald Eagle*	*Haliaeetus leucocephalus**	2
Red-eyed Vireo	*Vireo olivaceus*	2
Spotted Sandpiper	*Actitis macularius*	2
American Coot	*Fulica americana*	1
American Goldfinch	*Spinus tristis*	1
Black billed Magpie	*Pica hudsonia*	1
Clay-colored Sparrow	*Spizella pallida*	1
Great Blue Heron*	*Ardea Herodias**	1
Killdeer	*Charadrius vociferus*	1
Least Flycatcher***	*Empidonax minimus****	1
Mallard	*Anas platyrhynchos*	1
Osprey***	*Pandion haliaetus****	1
Red-breasted Nuthatch	*Sitta canadensis*	1
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	1
Sora*	*Porzana Carolina**	1
Unknown Sparrow Species	-	1
Warbling Vireo	*Vireo gilvus*	1
Incidentals/Flyovers		

Franklin's Gull	*Leucophaeus pipixcan*	122
Cedar Waxwing	*Bombycilla cedrorum*	10
Double-crested Cormorant	*Phalacrocorax auritus*	10
Bank Swallow*	*Riparia riparia**	5
American Goldfinch	*Spinus tristis*	3
American Avocet	*Recurvirostra americana*	3
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	2

A number of species of 'sensitive' status were seen or heard during the survey within 100m of survey points (not including those seen flying overhead): Bank Swallow, Pileated Woodpecker, and Sora, and one species that 'may-be-at-risk': The Western Wood-pewee ([2]Alberta Environment and Parks). Table 4 shows how this compares with previous years. Two birds previously categorized as sensitive are no longer listed as sensitive on the 2020 Alberta General Species Status Listing, The Alder Flycatcher and Least Flycatcher.

Table 4. Birds of 'sensitive' or 'may-be-at-risk' status, recorded during surveys 2016 – 2022.

	status	2016	2017	2018	2019	2020	2021	**2022**
Western Wood-pewee	may-be-at-risk	X	X		X	X	X	**X**
Bank Swallow	sensitive	X	X				X	**X**
Olive-sided flycatcher	sensitive			X				
Pileated Woodpecker	sensitive	X	X		X		X	**X**
Baltimore Oriole	sensitive		X			X		
Common Yellowthroat	sensitive		X				X	
Sora	sensitive		X				X	**X**
Alder Flycatcher	Previously listed as sensitive					X	X	
Least Flycatcher	Previously listed as sensitive	X	X	X	X	X	X	**X**

Data from [3]eBird records for species were observed in the Weaselhead during this period (Table 5). This information can be found at https://ebird.org/hotspot/L267671. Three bird species were recorded in the eBird data that are sensitive species on the Alberta Wild Species General Status listing. These are Sandhill Crane, Eastern Kingbird, and the White-faced Ibis, indicated in bold in Table 5. Three species listed as near threatened on the International Union of Conservation of Nature (IUCN) 2022 Red List, were found in the data. These species are the Blackpoll Warbler, the Common Grackle and Rufous Hummingbird, indicated in red in Table 5. It is notable that there has been a large number of species recorded in 2022 through eBird not noted during the breeding bird survey and that this difference is considerably larger than in past years. The causation of this increase is not known and could be attributed to a number of factors including a potential increase in eBird participation or an indication of changing ecology. The increase in mud-flat habitat in the region due to the changes in reservoir water levels from the completed dam construction, may explain the presence of mud-flat loving species such as the White-faced Ibis and the Sandhill Crane noted in the 2022 eBird data.

Table 5. An additional 61 species were observed and reported to eBird in June, and July 2022 in the Weaselhead that were not recorded during the WGPPS survey. (Species indicated with a * were previously listed in the Alberta Wild Species General Status Listing[2]). Species listed in red are listed as near- threatened on the IUCN 2022 red list and species bolded are listed as sensitive species on the Alberta Wild Species General Status Listing.

Common Name	Species Name	Ebird - June	Ebird - July	IUCN 2022 (Red List)	Alberta Wild Species General Status Listing
Alder Flycatcher	*Empidonax alnorum*	X	X	LC	Secure
American Redstart	*Setophaga ruticilla*	X	X	LC	Secure
American White Pelican	*Pelecanus erythrorhynchos*	X	X	LC	Sensitive
Baltimore Oriole	*Icterus galbula*	X	X	LC	Secure (was sensitive in 2010)
Belted Kingfisher	*Megaceryle alcyon*	X	X	LC	Secure
Black-necked Stilt	*Himantopus mexicanus*	X			Sensitive
Blackpoll Warbler	*Setophaga striata*	X		NT	Secure
Blue Jay	*Cyanocitta cristata*	X	X	LC	Secure
Brewer's Blackbird	*Euphagus cyanocephalus*	X		LC	Secure
California Gull	*Larus californicus*		X	LC	Secure
Canvasback	*Aythya valisineria*	X	X	LC	Secure
Cinnamon Teal	*Spatula cyanoptera*	X		LC	Secure
Common Grackle	*Quiscalus quiscula*	X		NT	Secure
Common Merganser	*Mergus merganser*	X	X	LC	Secure
Common Tern	*Sterna hirundo*	X		LC	Secure
Common Yellowthroat	*Geothlypis trichas*	X	X	LC	Secure
Cooper's Hawk	*Accipiter cooperii*	X	X	LC	Secure
Dark-eyed Junco	*Junco hyemalis*	X	X	LC	Secure
Eastern Kingbird	***Tyrannus tyrannus***	**X**		**LC**	**Sensitive**

European Starling	*Sturnus vulgaris*	X	X	LC	Exotic/Alien
Gadwall	*Mareca strepera*	X		LC	Secure
Great Horned Owl	*Bubo virginianus*	X		LC	Sensitive
Green-winged Teal	*Anas crecca*	X			Secure (was Sensitive in 2010)
Hermit Thrush	*Catharus guttatus*	X		LC	Secure
Hooded Merganser	*Lophodytes cucullatus*		X	LC	Secure
House Sparrow	*Passer domesticus*	X	X	LC	Exotic/Alien
LeConte's Sparrow	*Ammospiza leconteii*	X		LC	Secure
Lesser Scaup	*Aythya affinis*	X	X	LC	Secure
Merlin	*Falco columbarius*	X	X	LC	Secure
Mourning Dove	*Zenaida macroura*	X		LC	Secure
Nashville Warbler	*Leiothlypis ruficapilla*	X		LC	Secure
Northern Flicker	*Colaptes auratus*	X	X		Secure
Northern Goshawk	*Accipiter gentilis*	X		LC	Secure
Orange-crowned Warbler	*Leiothlypis celata*	X		LC	Secure
Ovenbird	*Seiurus aurocapilla*	X	X	LC	Secure
Red-naped Sapsucker	*Sphyrapicus nuchalis*	X	X	LC	Undetermined
Red-tailed Hawk	*Buteo jamaicensis*	X	X	LC	Secure
Redhead	*Aythya americana*	X	X	LC	Secure
Ring-billed Gull	*Larus delawarensis*	X	X	LC	Secure
Ring-necked duck	*Aythya collaris*	X	X	LC	Secure
Rock Pigeon	*Columba livia*	X	X	LC	Exotic/Alien
Ruby-throated Hummingbird	*Archilochus colubris*	X		LC	Secure
Ruffed Grouse	*Bonasa umbellus*	X		LC	Secure
Rufous Hummingbird	*Selasphorus rufus*	X	X	NT	Secure
Sandhill Crane	***Antigone canadensis***	**X**		**LC**	**Sensitive**
Savannah Sparrow	*Passerculus sandwichensis*	X	X		Secure
Sharp-shinned Hawk	*Accipiter striatus*	X		LC	Secure

Solitary Sandpiper	*Tringa solitaria*	X	X	LC	Secure
Spotted Towhee	*Pipilo maculatus*	X			Secure
Swainson's Hawk	*Buteo swainsoni*	X	X	LC	Secure (was Sensitive in 2010)
Swainson's Thrush	*Catharus ustulatus*	X			Secure
Trumpeter Swan	*Cygnus buccinator*	X		LC	Secure (was At-Risk in 2010)
Turkey Vulture	*Cathartes aura*	X		LC	Secure (was Sensitive in 2005)
Vesper Sparrow	*Pooecetes gramineus*		X	LC	Secure
Violet-green Swallow	*Tachycineta thalassina*	X		LC	Secure
White-faced Ibis	***Plegadis chihi***	**X**		**LC**	**Sensitive**
White-winged Crossbill	*Loxia leucopyere*	X	X	LC	Secure
Willow Flycatcher	*Empidonax traillii*	X	X	LC	Secure
Wilson's Snipe	*Gallinago delicata*	X		LC	Secure
Yellow-bellied Sapsucker	*Sphyrapicus varius*	X	X	LC	Secure
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*		X	LC	Secure

b. Noise Pollution

Because some bird species can be particularly vulnerable to noise pollution such as is associated with construction and operation of roads ([4]McClure *et al.,* 2013), the ambient noise in the Weaselhead has been monitored since 2016. A 24dB average increase in noise pollution was observed comparing 2016 to 2022 Impact Study data.

A sound level meter, Quest Soundpro SE, (range 0-100 dB LAS *(Slow, A-weighted Sound Level)* was employed to measure noise pollution during weekday traffic peak hours of 6:30 – 9:30 am on June 23rde and 24th 2022. The annual timing was moved up slightly from previous years as the City of Calgary had scheduled to raise the water levels in the Glenmore Reservoir at the end of June or early July. This action results in flooding of several of our survey sites making them inaccessible. In addition in 2022, data was only collected in the morning rush hour times due to the availability of the surveyor. These morning times were within the previously established peak traffic times and are consistent with methodology of the study in previous years. Levels were measured at the same points (stations) as used in the breeding bird survey (Table 1 and Figure 4). On each site, the sound level was measured for 2 minutes (Table 6). The data download in 2022 excluded minimum and maximum data points as compared to previous years. However, the average and peak remain consistent comparable parameters (Figure 7).

Table 6. Sound pressure measured in peak traffic hours in 2022 (average and peak dB).

Sound pressure measured in peak traffic hours for 2022				
Site	Date	Time (UCT-6)	Sound Pressure (dB)	
			Avg	Peak
P1	6/24/2022	7:56	70.5	91.9
P2	6/24/2022	7:47	69.6	90.9
P3	6/23/2022	9:08	71.7	90.8
P4	6/24/2022	7:02	69.4	91.1
P5	6/24/2022	7:12	69.1	90.9
P6	6/24/2022	7:31	58.3	88.5
P7	6/24/2022	6:47	67.9	86.6
P8	6/24/2022	6:40	61.9	81.4
P9	6/23/2022	7:27	61.9	87.9
P10	6/23/2022	7:19	68.1	80.5
P11	6/23/2022	7:12	66.1	86.7
P12	6/23/2022	9:26	72.7	95.1
P13	6/24/2022	6:32	58.6	80.2
P14	6/23/2022	9:14	67.3	85.3
P15	6/23/2022	9:21	68.8	87.5
P16	6/23/2022	8:40	73.3	93.2
P17	6/23/2022	8:47	70.2	95.8
P18	6/23/2022	8:55	76.6	103.2
P19	6/23/2022	7:05	65.2	81.4
P20	6/23/2022	7:42	61.9	86.9
P21	6/23/2022	7:34	72.4	94.5

P22	6/23/2022	6:59		
P23	6/23/2022	6:46	63.3	91.8
P24	6/23/2022	7:55	62.2	92.1
P25	6/23/2022	6:37	65.5	83.2
P26	6/23/2022	8:07	67.4	91
P27	6/23/2022	6:28	61.4	78.9
P28	6/23/2022	8:17	65.8	82.2

The peak sound pressure data did not meet the normality assumption for a parametric test. A regression analysis, however, was possible to be conducted with the average sound pressure recorded between 2016 and 2022 (Figure 8). A significant positive slope was found, revealing an increasing average sound pressure on the monitored stations between 2016 and 2022 (linear regression, d.f.=187, R2= 0.6385, p<0.05).

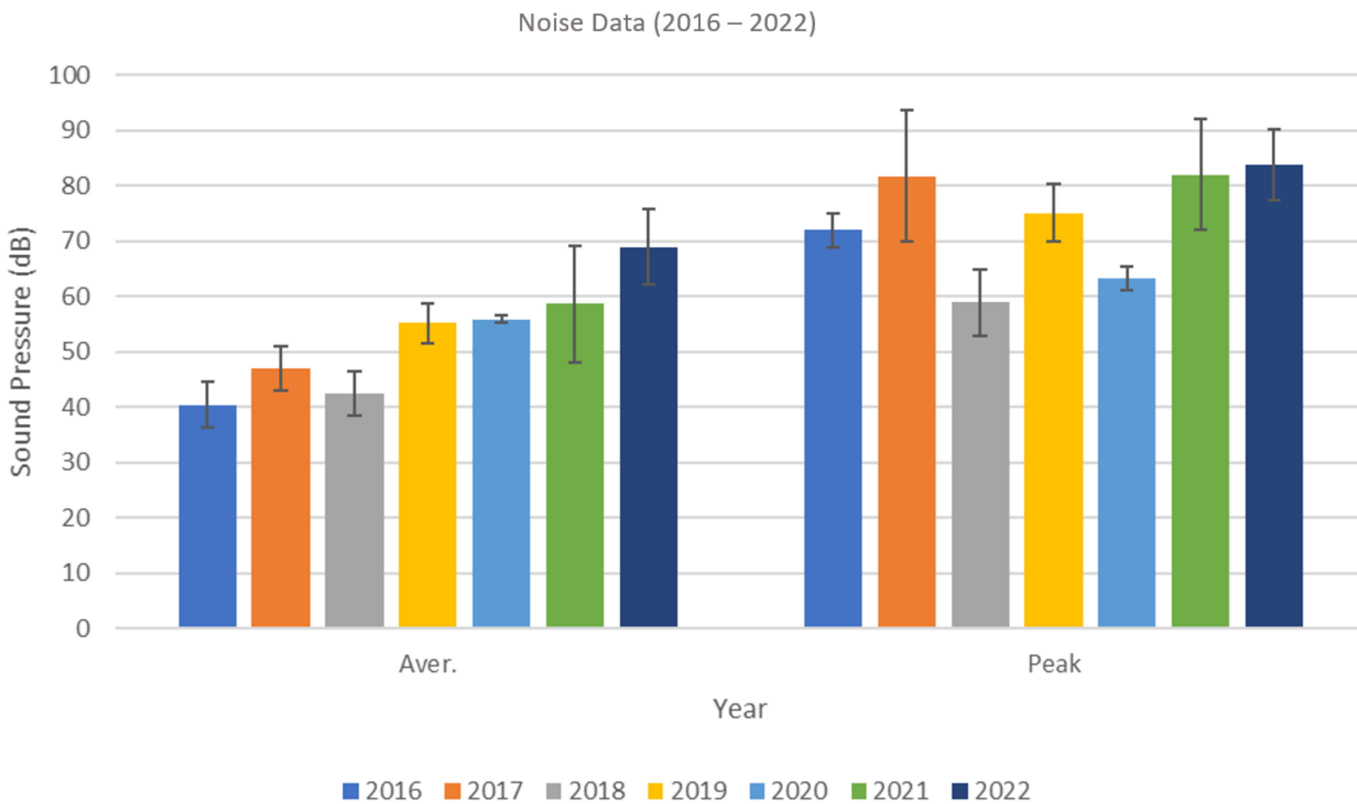

Figure 7. Sound levels measured in the Weaselhead from 2016 to 2022. The error bars represent ± standard deviation.

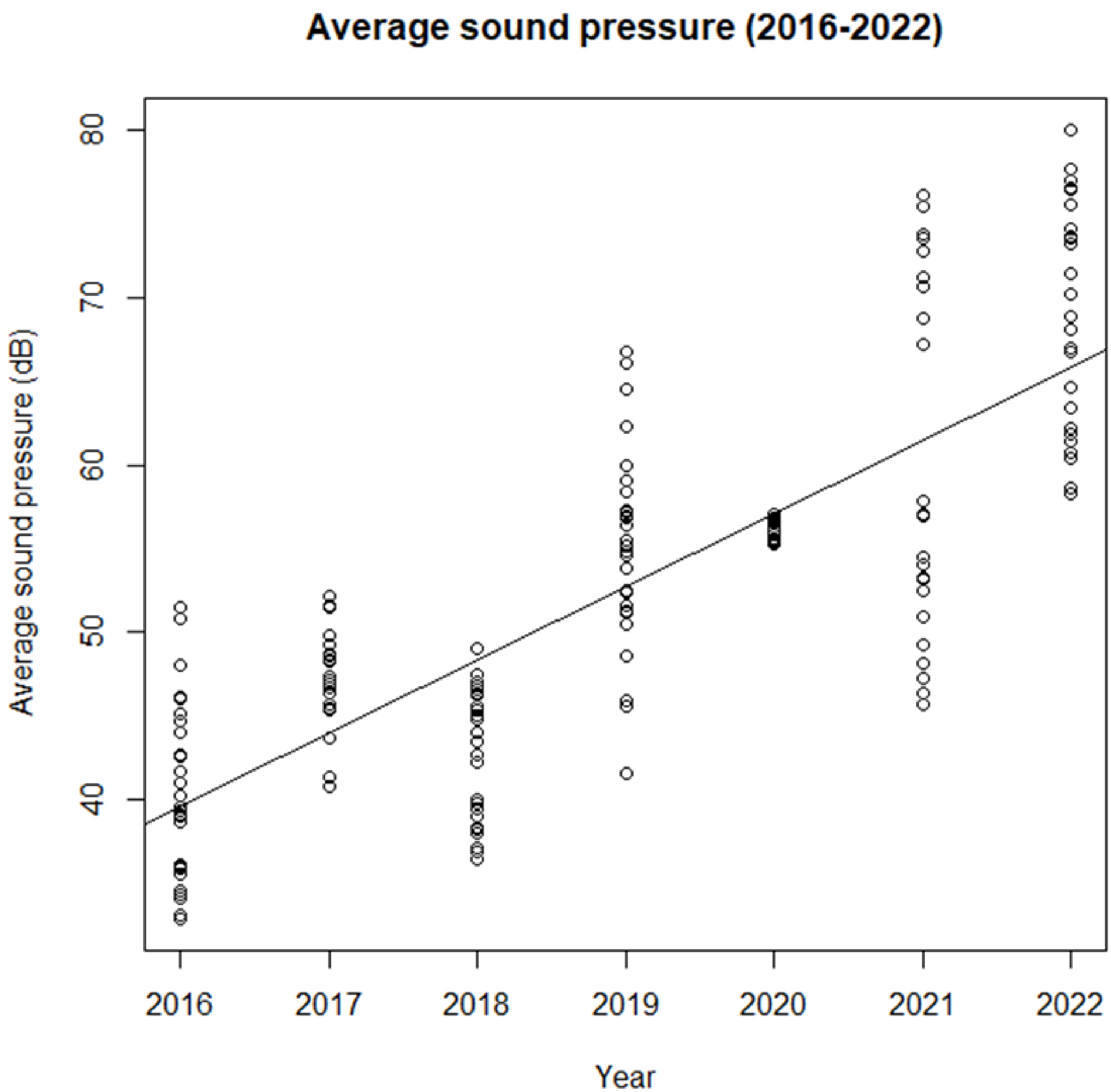

Figure 8. Average sound levels recorded in the Weaselhead and Glenmore Park Stations between 2016 to 2022. (Linear regression, d.f.=187, R2= 0.6385, p<0.05)

c. Beaver Pond Riparian Vegetation

Baseline information was collected in 2015 and 2016 to describe the riparian vegetation by the Beaver Pond in the Weaselhead. This wetland was chosen as its upstream edge is bordered by the SWCRR and so represents riparian habitat in immediate proximity to the SWCRR (Figure 9). The same site was used from 2015 to 2022. The same protocol was used as in 2015 to 2018. The assessments from the first 3 years included only flowering plants in the clade 'eudicot'. From 2018 on, estimates of % cover of graminoids and moss have been included as supplemental data.

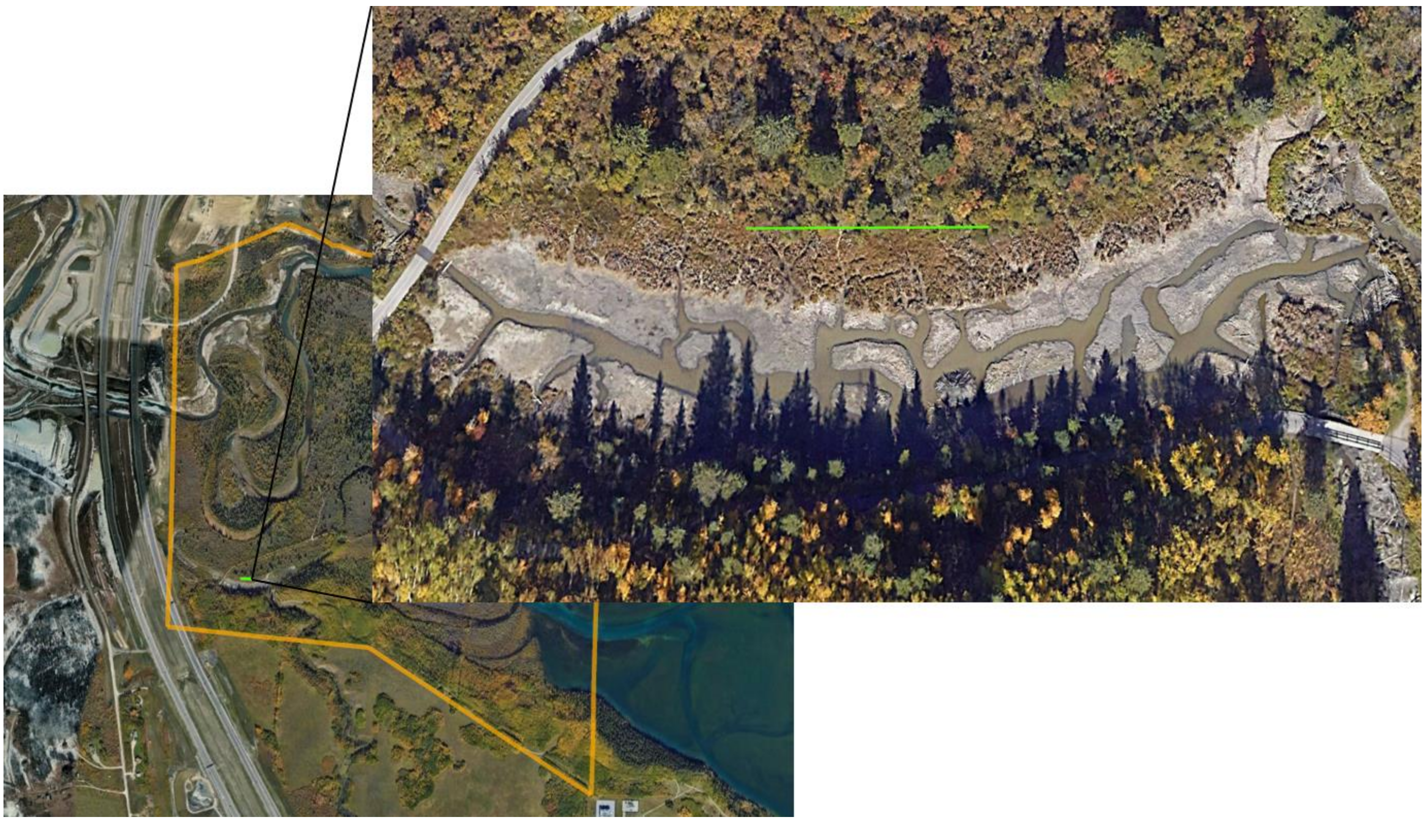

Figure 9. Green line shows location of 50m transect used for vegetation survey on the north bank of the east Beaver Pond; orange line shows the Weaselhead boundary. (Aerial image from Google Earth, June 2, 2022).

A 50-metre transect parallel to the pond shoreline and oriented on the west-east azimuth (from 50˚59'11.29''N; 114˚09'37.38''W to 50˚59'11.29''N; 114˚09'34.78''W) was used as a reference line for 50 adjacent 2m x 2m quadrats (Figure 8). The quadrats were numbered from 1 to 50 from west to east. A random sample was taken of 15 quadrats from the total of 50 (Figure 10). These 15 quadrats represent samples from the Beaver Pond riparian vegetation. On September 9th, 10th, and 11th 2022 each selected quadrat was comprehensively screened, and individual vascular plants present counted and identified to species level (Table 7). For graminoids the percentage of canopy cover was recorded rather than counting individual clumps or plants (except for cattails where individual plants were counted). The percentage cover of moss was also estimated (Table 8).

North

1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49

2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50

Shoreline (south)

Figure 10. Disposition of 50 quadrats (2m x 2m) on a west-east transect along the Beaver Pond shoreline. From these 15 randomly selected quadrats were included in the survey using a random generator app (numbers 2, 3, 10, 12, 19, 21, 25, 30, 33, 34, 36, 40, 45 48, 50).

Occurrence (number of quadrats with one or more of the species) and abundance (mean count of species in occupied quadrats) of vascular plants are summarized (Table 7), and information on the United States Department of Agriculture ([5]USDA) wetland classification for ‘Great Plains’ region provided where available.

Table 7. Vascular plants occurrence (number of quadrats with one or more of the species) and abundance (mean count of the species in occupied quadrats); *noxious weed *([6]Alberta Weed Control Act 19/2010);* [nn]non-native species *(unregulated).*

Vascular plants - eudicots	Common name	Occurrence	Abundance	USDA wetland classification
Viola canadensis	Canada Violet	15	44	FACU
Rosa acicularis	Prickly Rose	15	25	FACU
*Cirsium arvense**	Creeping Thistle*	15	14	FACU
Taraxacum officinale[nn]	Dandelion[nn]	15	13	FACU
Cornus sericea	Red-Osier Dogwood	15	4	-
*Sonchus arvensis**	Field Sow Thistle*	14	16	FAC
Anemone canadensis	Canada Anemone	14	9	FACW
Euthamia graminifolia	Goldenrod (canadian, flat top and giant grouped)	13	23	FAC
Symphyotrichum sp. And Aster Sp.	Grouped Asters (Eaton's, Flat-topped White, Lindleys, Smooth Blue, Western Willow, Purple-stemmed)	12	34	OBL+FAC+FACU+-
Pyrola asarifolia	Common Pink Wintergreen	12	16	-
Galium boreale	Northern Bedstraw	11	18	FACU
Thalictrum venulosum	Veiny Meadow Rue	11	18	FAC
Monarda fistulosa	Wild Bergamot	11	16	UPL
Amelanchier alnifolia	Saskatoon	11	7	FACU
Elaeagnus commutata	Silverberry	11	6	UPL

Rubus pubescens	Trailing Raspberry	10	18	-
Persicaria amphibia var. stipulacea	Water smartweed	10	14	-
Senecio pauperculus	Balsam Groundsel	10	13	FACU
Shepherdia canadensis	Buffaloberry	10	4	FACU
Vicia americana	American Vetch	10	3	FACU
Symphoricarpos albus	Snowberry	9	6	UPL
Lysimachia ciliata	Fringed Loosestrife	8	13	FACW
Fragaria virginiana	Wild Strawberry	8	11	FACU
Salix bebbiana	Bebb's Willow	8	2	FACW
Antennaria pulcherrima	Showy Everlasting	7	34	-
Betula occidentalis	Water Birch	7	4	FACW
Potentilla fruticosa	Shrubby cinquefoil, Potentilla	7	2	FACW
Salix pseudomonticola	False Mountain Willow	6	2	FACW
Mentha arvensis	Wild Mint	5	35	FACW
Scutellaria galericulata	Skullcap	5	19	OBL
Stachys pilosa	Hairy Hedgenettle	5	8	FACW
Geum macrophyllum	Large Leaved Aven	5	2	FACW
Zizia aptera	Heart-leaved Alexanders	4	7	FAC
Sorbus aucuparia[nn]	European Mountain Ash[nn]	4	2	-
Sanicula marilandica	Maryland Sanicle	3	14	FACU
Arctostaphylos uva-ursi	Bearberry	3	9	UPL
Lonicera tatarica[nn]	Tatarian Honeysuckle[nn]	3	4	FACU
Trifolium repens	White Clover	3	3	FACU
Hedysarum alpinum	Alpine Sweetvetch	3	2	FACU
Lonicera dioica	Twining Honeysuckle	2	8	FACU
Mertensia paniculata	Tall lungwort	2	6	-
Achillea millefolium	Common Yarrow	2	3	FACU

Rubus idaeus	American Red Raspberry	2	2	FACU
Symphoricarpus occidentalis	Buckbrush	2	2	UPL
Actaea rubra	Baneberry	2	1	FACU
*Rhamnus cathartica**	Common Buckthorn *	2	1	FACU
Cotoneaster lucidus[nn]	Shiny Cotoneaster[nn]	2	1	-
Geum aleppicum	Yellow Avens	1	4	FACU
Heracleum maximum	Cow Parsnip	1	3	FAC
Gentiana andrewsii	Bottle gentium	1	3	FAC
Rosa woodsii	Wood's Rose (grouped with Prickly)	1	2	FACU
Vascular plants - other	**Common name**	**Occurrence**	**Abundance**	**USDA wetland classification**
Equisetum sp	Horsetail	15	21	FAC
Picea glauca	White Spruce	10	8	FACU
Vascular plants - monocots (excluding graminoids)	**Common name**	**Occurrence**	**Abundance**	**USDA wetland classification**
Maianthemum stellatum	Starry False Lily of the Valley/ Solomon's Seal	15	5	FACU
Prosartes trachycarpa	RoughFruit FairyBells	1	6	UPL
Platanthera aquilonis	North Wind Bog Orchid	1	1	OBL
Orchidacea	orchid species, unable to be further identified	1	1	-

Table 8. Occurrence and estimated % cover of graminoids and bryophytes *(occurrence = total number of quadrats with presence of either taxa;* mean percentage cover = mean of % cover in occupied quadrats*)* *noxious weed *([6]Alberta Weed Control Act 19/2010);* [nn]non-native species *(unregulated).*

Graminoids (Poaceae and Cyperaceae)	Common name	Occurrence	Abundance	Mean % cover	USDA wetland classification
Typha latifolia	Cattail	3	1	-	OBL
Poa pratensis[nn] , *P. palustris, Agrostis gigantea*	Kentucky Blue Grass+ Fowl Blue Grass + Creeping Bentgrass + Red Top	13	-	45%	FACU+FACW

Carex utriculata/C. capillaris	Small Bottle Sedge/Hair-Like Sedge/two seeded sedge/wheat sedge	4	-	<7%	OBL+FACW
Juncus balticus	Baltic Rush	4	-	5%	FACW
Dactylis glomerata	Orchard grass	2	-	15%	FACU
*Bromus inermis*nn	Smooth Bromenn	1	-	10%	UPL
Bryophytes	Moss Cover %	15		20%	

OBL	Obligate Wetland	*Hydrophyte*	*Almost always occur in wetlands*
FACW	Facultative Wetland	*Hydrophyte*	*Usually occur in wetlands, but may occur in non-wetlands*
FAC	Facultative	*Hydrophyte*	*Occur in wetlands and non-wetlands*
FACU	Facultative Upland	*Nonhydrophyte*	*Usually occur in non-wetlands, but may occur in wetlands*
UPL	Obligate Upland	*Nonhydrophyte*	*Almost never occur in wetlands*

Diversity of eudicot species: The 2022 results show a total taxa richness of 57 species of eudicot plants found in the total area surveyed, 60m^2 (15 quadrats x 4m^2 per quadrat). Canada violet (*Viola canadensis*) was the dominant species in the area surveyed, comprising 14.4% of the total eudicot individuals counted. The Simpson's index (S) was calculated for each quadrat as follows:

$$S = \sum_{i=1}^{R} \left(\frac{n_i}{N}\right)^2$$

Where n_i is the total number of organisms of the ith species, R is richness (total number of species in the study) and N is the total number of organisms of all species. The Simpson's index is a diversity indicator. It measures the probability that two individuals selected from a sample will belong to the same species. The 1-Simpson's index (1-S) indicates the probability that two individuals randomly selected from a sample will belong to different species. This index (1-S) has a range from zero (very low diversity) to 100% (very high diversity).

The area investigated in this study showed a mean 1-Simpson's index for eudicot plants of 88.9% ±6.0% per quadrat (2m x 2m) in 2022. Figure 11 compares Simpson's Diversity Index (1-S) per quadrat across the 2015 to 2022 sampling campaigns. The data is neither homoscedastic nor normal, therefore a non-parametric analysis was performed. A Kruskal-Wallis test identifies that the Simpson's index data for different years have non-identical populations, with the lowest mean 1-S value observed in 2018 and the highest was recorded in 2022 (Kruskal-Wallis rank sum test df = 7, $p<0.05$).

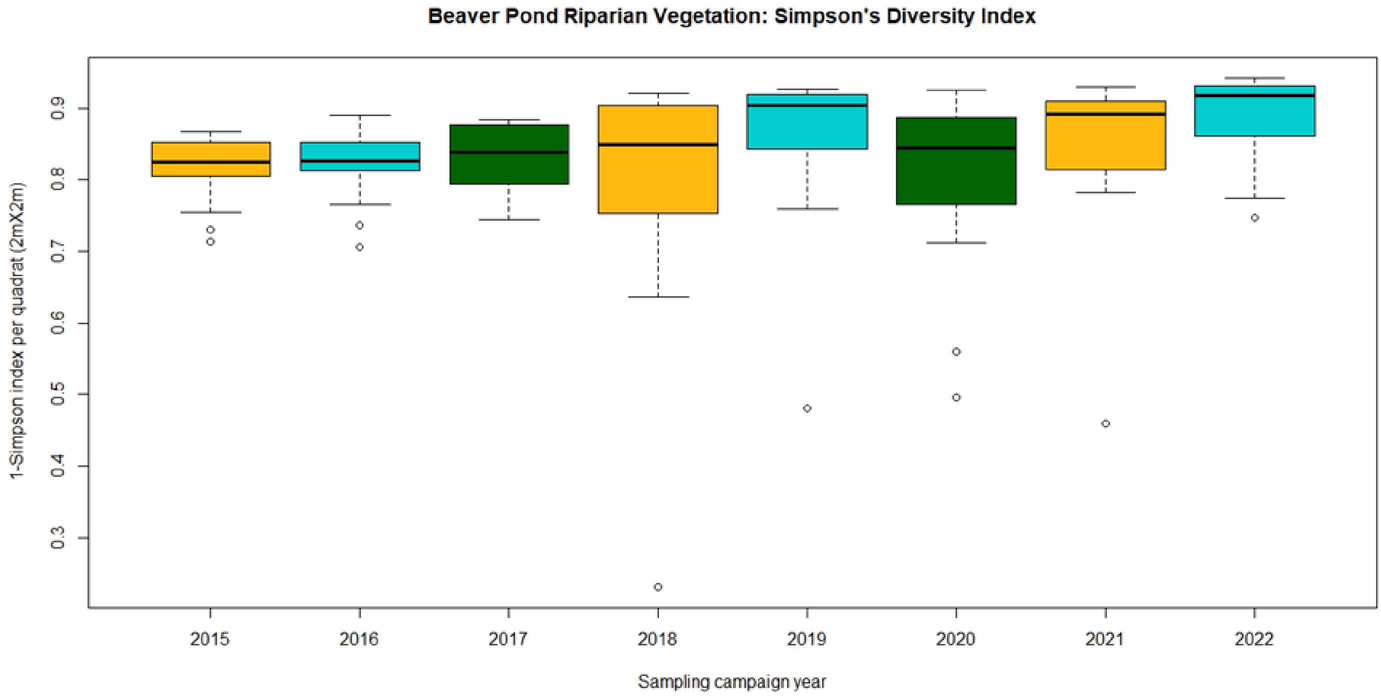

Figure 11. Simpson's Diversity Index (1-S) per quadrant for 2015 to 2022 sampling campaigns.

Richness of eudicot species: The data is neither homoscedastic nor normal, therefore a non-parametric analysis was performed. A Kruskal-Wallis test identifies that the richness data for different years have non-identical populations, with the lowest mean richness observed in 2015 and the highest was recorded in 2022 (Kruskal-Wallis rank sum test df = 7, $p<0.05$).

The measured mean of eudicot species per square meter along the shore of the Beaver Pond in 2022 was 5.92±1.61 species/m^2, (n=15). Figure 12 compares eudicots species richness per square meter between 2015 and 2022 sampling campaigns.

Increasing species richness suggests that the study area is gradually increasing in number of species over time. The species richness in a riparian zone is often limited by the presence of water or periodic inundations. Under these conditions, only species tolerant to water saturated soils would thrive. An increase in plant species richness might indicate a lowering of average water levels in the Beaver Pond, producing drier soil conditions, and allowing the colonization of other species.

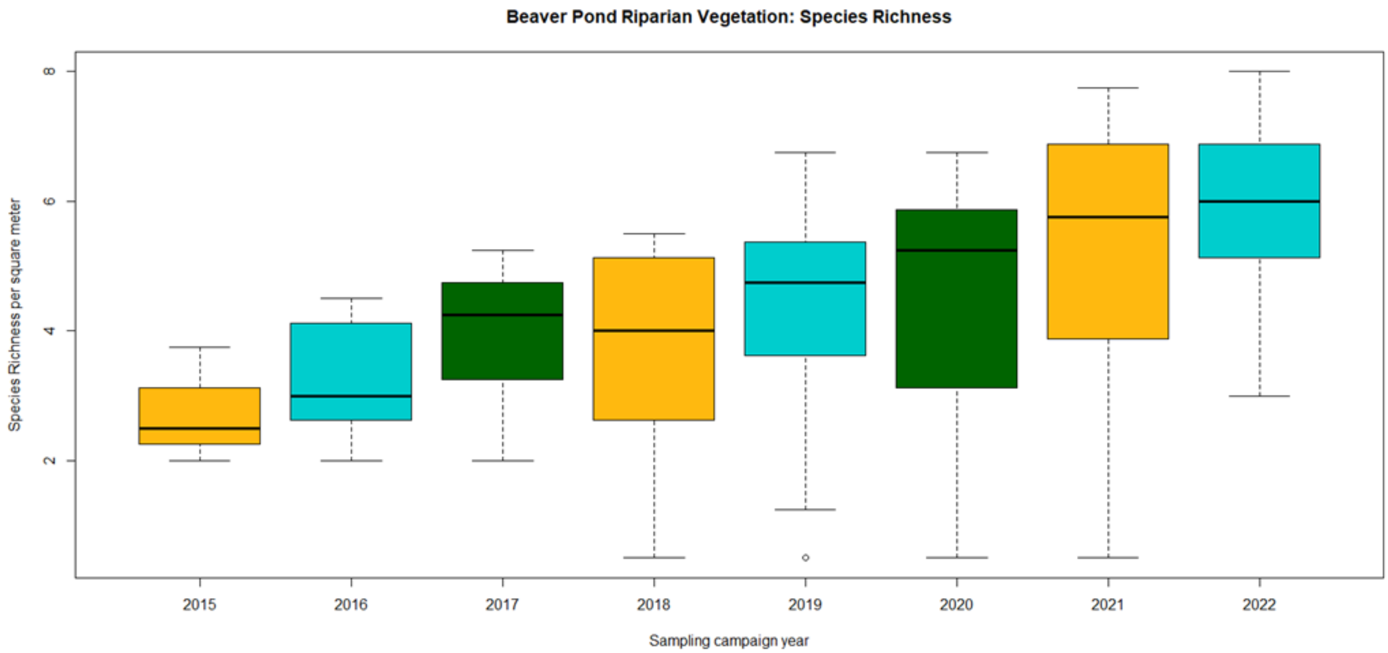

Figure 12. Eudicots species richness per square meter for 2015 to 2022 sampling campaigns.

d. Wildlife Movement

In November 2018, the Society partnered with the Miistakis Institute in a project '*Calgary Captured'* ([7]Kahal *et al,* 2017). The goals of this project are to better understand wildlife occurrence in Calgary's natural areas and to identify key infrastructure associated with roads that wildlife use to move around the urban environment. In 2020 this project collected data from 11 motion-activated cameras in the Weaselhead and adjacent Glenmore Parks, including two cameras relocated in the wildlife passages under the SWCRR (cameras 122, 123 and 134, Figure 13). '*Calgary Captured'* has contributed data on any change in presence/absence of species, change in seasonal use, and change in use of the area for breeding/raising young across the period of the Study, as well as identifying wildlife utilizing the wildlife corridor. A preliminary list of species captured by these cameras (Table 9), including bobcat, moose, coyote, racoon, and white-tailed deer. Data from a similar study of wildlife in the Weaselhead also using motion-activated camera that was sponsored by the Society and run by SAIT from 2016 to 2018 has been incorporated where possible into the '*Calgary Captured'* dataset.[8]

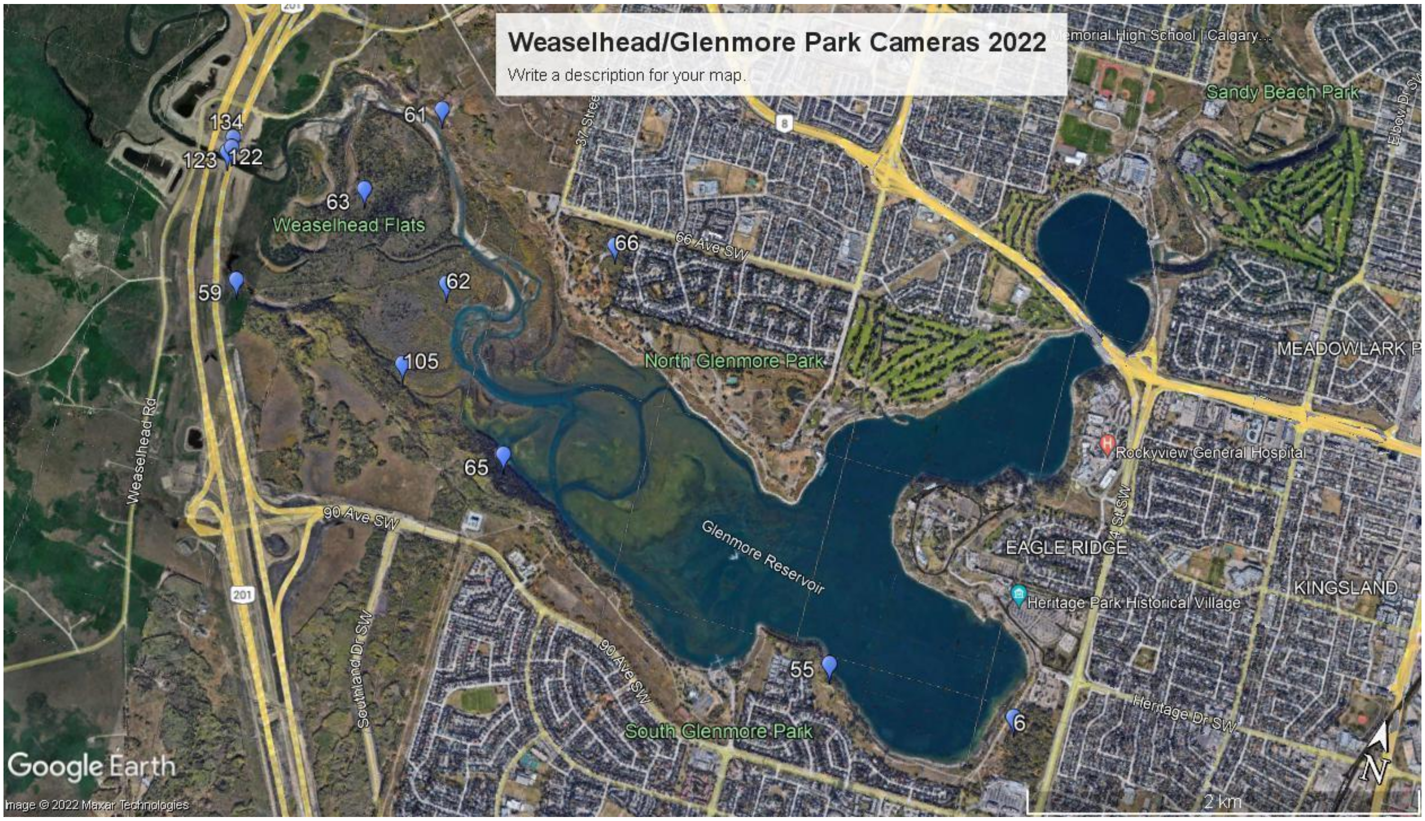

Figure 13. Location of '*Calgary Captured*' cameras in 2022 (note – 2 cameras relocated under bridge in the wildlife corridor)

Table 9. Species identified in camera-trap photographs 2017 - 2022; * indicates photos of young and/or adult with young.

	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Carnivora													
Bobcat (*Lynx rufus*)	2017						X		X	X			
	2018	X	X	X	X	X	X	X		X	X	X	
	2019	X	X	X	X	X	X	X	X	X	X		X
	2020	X	X	X	X	X	X	X	X		X	X	X
	2021	X	X	X	X	X			X	X	X	X	X
	2022	X	X	X	X	X	X	X	X	X	X	X	
Cougar (*Puma concolor*)	2017												
	2018	X		X									
	2019												X
	2020	X			X	X							

	2021												
	2022												
Black Bear (*Ursus americanus)*	2017												
	2018									X			
	2019								X				
	2020				X					X			
	2021												
	2022						X*	X*	X*	X*	X		
Coyote (*Canis latrans)*	2017					X	X	X	X	X		X	X
	2018	X	X	X	X	X	X	X	X	X	X	X	X
	2019	X		X	X	X	X	X	X	X	X	X	X
	2020	X	X	X	X	X	X*	X*	X*	X	X	X	X
	2021	X	X	X	X	X	X	X*	X	X*	X	X	X
	2022	X	X	X	X	X	X*	X*	X*	X	X	X	X
Red Fox (*Vulpes vulpes)*	2017									X			
	2018												
	2019												
	2020			X									
	2021												X
	2022												
Mink (*Neovison vison)*	2017												
	2018												
	2019												
	2020			X									
	2021			X					X				

	2022											X	
Raccoon (*Procyon lotor)*	2017												
	2018												
	2019												
	2020					X						X	
	2021			X				X					
	2022						X		X	X	X		
Striped Skunk (*Mephitis mephitis)*	2017												
	2018			X									
	2019												
	2020			X	X								
	2021		X	X		X				X			
	2022										X		
Rodentia													
Porcupine (*Erethizon dorsatum)*	2017												
	2018												
	2019												
	2020												
	2021											X	
	2022										X	X	
Beaver (*Castor canadensis)*	2017												
	2018												
	2019												
	2020					X		X	X	X			
	2021					X					X		

	2022										X		
Red Squirrel (*Sciurus vulgaris)*	2017									X			
	2018												
	2019										X	X	X
	2020	X	X	X	X	X	X	X	X	X	X	X	X
	2021	X	X	X	X	X	X	X				X	X
	2022	X	X	X	X	X	X	X	X		X	X	X
Lagomorpha													
White-tailed Prairie Hare (*Lepus townsendii)*	2017									X			
	2018												
	2019												
	2020			X	X								
	2021												
	2022	X	X	X	X								
Snowshoe Hare (*Lepus americanus)*	2017					X				X	X	X	X
	2018	X	X	X	X	X	X	X	X	X	X	X	X
	2019	X	X	X	X	X	X	X	X	X	X	X	X
	2020	X	X	X	X	X	X					X	X
	2021	X	X	X	X	X					X		
	2022	X	X										X
Cervidae													
White-tailed Deer (*Odoceoileus virginianus)*	2017					X	X	X	X	X	X	X	X
	2018	X	X	X	X	X	X	X	X	X	X	X	X
	2019	X	X	X	X	X	X*	X	X	X	X*	X	X
	2020	X	X	X	X	X	X*	X*	X*	X*	X	X	X

	2021	X	X	X	X	X	X*	X*	X*	X	X	X	X
	2022	X	X	X	X	X	X*	X*	X*	X*	X*	X	X
Mule Deer (*Odoceoileus hemionus)*	2017					X	X	X	X	X			
	2018					X	X	X	X	X	X		
	2019						X	X		X	X		
	2020					X	X				X	X	X
	2021						X	X	X			X	
	2022			X		X	X	X		X	X		
Moose (*Alces alces)*	2017					X			X		X		
	2018					X	X				X		
	2019				X	X	X*	X	X	X	X	X	
	2020	X				X*	X	X	X*	X	X		
	2021				X	X	X*	X	X*	X*	X*		
	2022				X	X	X*	X*	X*	X*	X*	X	
Aves													
Great Blue Heron (*Ardea herodias)*	2017												
	2018												
	2019												
	2020						X			X			
	2021								X				
	2022							X					
Sora (*Porzana carolina)*	2017												
	2018												
	2019												
	2020							X					

	2021												
	2022												
	Total	8	7	12	10	11	10	12	12	14	12	10	8

In a separate study for Alberta Transportation (AT), Golder Associates is monitoring use of the wildlife underpasses (Table 10). Each bank of the river was checked for signs of use (e.g., tracks, scat) every month between April 2020 until December 2021. The corridor under the road itself was examined as well as the regions just outside of the corridor, called buffer regions. The 2021 reports showed large mammal presence (domestic dog, beaver, mink, cougar, deer, coyote) to the east and west of the Elbow River Crossing using the buffer regions but had limited evidence of corridor use (observation of tracks) under the bridges. Signs of animals under or between the bridges were much fewer than in the buffer regions though '*Calgary Captured*' cameras were able to confirm deer use under the bridges (Figure 14).

Table 10. Mammal tracks observed in wildlife corridors under one or more bridges, recorded by Golder Associates during monthly monitoring (The ? indicates tracks that were unable to be identified between domestic canine or coyote tracks.)

	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Carnivora													
Mink	2019							X		X			
	2020												
	2021												
Domestic dog	2019			X									X
	2020	X	X										
	2021				X								
Bear	2019												
	2020												
	2021												
Coyote	2019												
	2020	X?										X	X
	2021		X		X	X				X		X	X
Rodentia													

Beaver	2019							X					
	2020												
	2021									X			
Lagomorpha													
White-tailed jackrabbit	2019												
	2020												X
	2021												
Cervidae													
Deer	2019												X
	2020				X								
	2021	X							X	X			
Mammalia													
Human	2019			X									
	2020												
	2021								X				
Small mammals	2019	X		X	X								
	2020												
	2021												
	Total	4	2	3	4	1	0	2	2	4	0	2	5

Figure 14. '*Calgary Captured'* photo of deer under bridge in the wildlife corridor.

RESULTS: AQUATIC HABITATS

a. Water Quality Parameters

This section of the study provides information on water quality in two wetlands in the Weaselhead: The Beaver Pond and Beaver Lagoon, as well as Ravine Creek and Spring Brook which feed into the Beaver Pond, and the Elbow River was also sampled annually. Water quality in an additional wetland, Clearwater Pond, was also assessed. Clearwater Pond is in the Elbow Valley, upstream of the SWCRR construction zone and not located in the Weaselhead (Figure 15). It is intended to represent a reference site against which to compare changes observed in the Weaselhead wetlands. The Beaver Pond is in immediate proximity to the SWCRR and is split into two cells by a paved pathway. The two cells are connected by a culvert. The Beaver Lagoon with which it is hydrologically connected, is further downstream. A drainage plan designed by the SWCRR contractor, KGL (Figure 18) aims to maintain surface flow to these wetlands during and post SWCRR construction.

Water quality data was collected from 2015 to 2022 from 3 sites in each of the three wetlands and from the Elbow River (Figure 16, Figure 17, and Table 11). Four additional sample sites were added in 2018: another sample site in the east and west cells of the Beaver Pond (BP4 and BP5) and a sample site (SB and RC) in each of the two intermittent streams that flow into the wetland. Ravine Creek (RC) feeds into the east cell of the Beaver Pond (BP) and Spring Brook (SB) into the west cell. Both these streams have been impacted by construction of the SWCRR across their catchment areas (Figure 19).

These wetlands are upstream of the Glenmore Reservoir and Glenmore Dam. In September 2020 the City of Calgary completed updates to the dam to increase the storage capacity of the reservoir. This resulted in significantly higher June to late fall water levels in the reservoir compared to previous years. During this period the Beaver Lagoon water levels are significantly higher than previous years prior to the dam modifications.

The sampling locations during the 2022 field season were altered due to a significant change in the surface water levels in Ravine Creek and Beaver Pond. Alternate sampling sites nearby were used where appropriate but samples were not obtained for all locations. During the August water sampling date in 2022, the sampling locations for Beaver Pond 2 and Beaver Pond 4 were found to be dry and could not be sampled, the sampling location for Ravine Creek was dry and was relocated downstream, 75 meters northwest of the original sample site.

In October 2022 the original sampling locations for all Beaver Pond sites were found to be dry, alternate sampling locations were found for Beaver Pond 1, 2, 3 and 5. Sampling locations for both Beaver Pond 4 and Ravine Creek were found to be dry, and a suitable alternate sampling location could not be found nearby. The new GPS coordinates for the alternate sampling sites can be found in Table 11.

Figure 15. Location of monitored wetlands.

Figure 16. Location of sampling sites at the Beaver Pond (BP), Beaver Lagoon (BL), Spring Brook (SB), Ravine Creek (RC) and Elbow River (ELR); white lines show edges of permanent wetlands; scale: yellow line = 500m.

Figure 17. Location of sampling sites at Clearwater Pond (CP); scale: yellow line = 100m.

Table 11. Geographic coordinates of water quality monitoring sampling sites with 2022 new sample site locations.

Wetland	Sampling site	Latitude	Longitude
Beaver Pond	BP1	50.9864	-114.161
	BP2	50.9867	-114.162
	BP3	50.9864	-114.159
	BP4	50.9865	-114.161
	BP5	50.9874	-114.164
Spring Brook	SB	50.9862	-114.163
Ravine Creek	RC	50.9855	-114.158
Beaver Lagoon	BL1	50.9903	-114.15
	BL2	50.9903	-114.154
	BL3	50.9911	-114.149
Elbow River	ELR	50.9914	-114.147
Clearwater Pond	CP1	51.0202	114.255
	CP2	51.0205	-114.256
	CP3	51.0204	-114.257

Ravine Creek - August 2022	RC-A	50.9860	-114.158
Beaver Pond - August 2022	BP2 BP4	- -	- -
Ravine Creek - October 2022	RC	-	-
Beaver Pond - October 2022	BP1-O BP2-O BP3-O BP4 BP5-O	50.9862 50.9867 50.9862 - 50.9871	-114.160 -114.162 -114.159 - 114.163

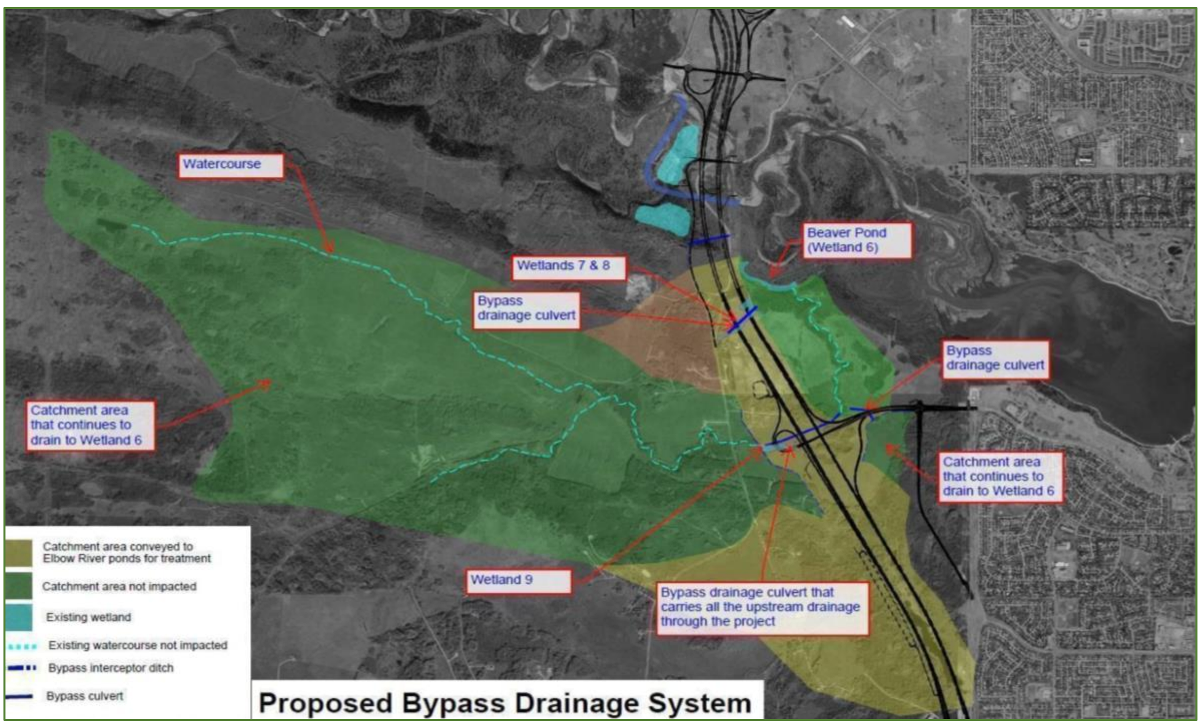

Figure 18. Bypass drainage for Spring Brook (northern culvert) and Ravine Creek (southern culvert) intended to maintain surface flow across the Transportation Utility Corridor into the Beaver Pond (*image courtesy of KGL – construction company for the SWCRR*[9])

Water sampling and in-situ assessments were performed on August 26th and October 21st, 2022. A YSI® Pro DSS Multimeter was employed to measure temperature, turbidity, conductivity, pH, and dissolved oxygen; a turbidity tube was used to measure transparency; and an YSI 9300 Photometer to measure phosphate, chloride salts and nitrate. Water quality data (Table 12, Table 13, and Table 14) and summary statistics for temperature, pH, conductivity, dissolved oxygen, phosphate, and chloride are shown below.

Table 12. Water quality parameters on August 26, 2022.

	Water body/Site													
Field: Aug 26 2022	Beaver Pond					Beaver Lagoon			Elbow River	Clearwater Pond			Beaver Pond Feeder Streams	
Parameters	BP1	BP2	BP3	BP4	BP5	BL1	BL2	BL3	ER	CP1	CP2	CP3	RC	SB
Transparency (cm)	11.00		10.00		2.00	65.00	>120	>120	>120	>120	>120	>120	2.00	>120
Turbidity (NTU)	37.93		226.80		473.83	36.20	247.17	9.57	6.50	1.80	0.10	2.87	51.45	83.13
Temperature (°C)	17.60		14.30		20.93	17.30	17.47	17.70	15.95	20.80	22.00	21.50	12.70	12.55
Electrical Conductivity (uS/cm)	663.00		662.00		784.00	347.30	331.27	352.77	342.10	241.50	260.90	269.30	292.90	581.00
Total Dissolved Solids-TDS (g/L)	505.92		547.89		550.15	265.83	252.73	270.24	269.95	170.60	179.40	187.55	247.65	496.99
Dissolved oxygen (%)	30.07		40.43		14.50	98.53	89.13	87.30	92.43	140.43	112.47	113.20	32.33	81.93
Dissolved oxygen (mg/L)	2.78		4.12		1.22	9.32	8.48	8.45	9.19	12.59	9.84	9.98	3.06	8.71
Field pH	7.75		7.64		7.61	8.28	8.10	8.21	8.32	9.06	8.65	8.66	7.95	8.39
Phosphate (mg/L PO4)	0.00		0.34		0.07	0.48	0.24	0.28	0.57	0.03	0.04	0.03	0.34	0.69
Chloride (mg/L CL)	10.00		7.00		1.00	2.00	2.00	1.00	4.00	1.00	3.00	0.00	0.00	4.00
Nitrate (mg/L N)	0.60		0.34		0.34	0.70	0.16	0.23	0.19	0.38	0.17	0.27	0.07	0.42

Table 13. Water quality parameters on October 21, 2022.

	Water body/Site													
Field: Oct 21 2022	Beaver Pond					Beaver Lagoon			Elbow River	Clearwater Pond			Beaver Pond Feeder Streams	
Parameters	BP1	BP2	BP3	BP4	BP5	BL1	BL2	BL3	ER	CP1	CP2	CP3	RC	SB
Transparency (cm)	11.08	7.00	29.00		24.00	>120	93.00	>120	>120	87.00	91.00	67.00		>120

Turbidity (NTU)	11.08	133.20	26.17		20.28	0.60	0.61	0.33	0.43	7.80	3.93	10.89		3.22
Temperature (°C)	4.40	4.57	2.73		3.77	6.10	5.63	6.10	5.80	4.73	3.80	3.53		3.70
Electrical Conductivity (uS/cm)	560.33	496.57	544.33		941.00	282.30	279.73	291.57	292.10	216.90	213.20	216.80		495.90
Total Dissolved Solids-TDS (g/L)	606.00	527.67	615.67		1051.67	287.00	288.00	297.00	300.00	230.33	233.00	239.00		543.00
Dissolved oxygen (%)	79.83	63.40	72.60		74.13	92.67	84.47	86.87	83.10	81.57	71.73	74.20		85.40
Dissolved oxygen (mg/L)	10.33	8.04	9.74		9.76	11.51	10.53	10.78	10.36	10.48	9.42	9.85		11.25
Field pH	8.16	7.90	8.15		7.96	8.13	8.01	8.08	8.05	7.92	7.74	7.80		8.31
Phosphate (mg/L PO4)	0.36	0.30	0.22		0.02	0.11	0.09	0.28	0.15	0.22	0.88	0.18		0.10
Chloride (mg/L CL)	5.00	<<	4.00		12.00	6.00	26.00	11.00	30.00	0.00	9.00	6.00		19.00
Nitrate (mg/L N)	0.48	0.16	0.98		0.16	0.10	0.17	0.11	0.20	0.17	0.11	0.20		0.36

Table 14. **2022 summary statistics for temperature, pH, conductivity, dissolved oxygen, phosphate, and chloride (only parameter for which statistical testing was conducted); each value represents the average (±SEM). (*indicates 3 replicates).**

	site	**number of replicates**	**assessment date (2022)**	**temperature (°C)**	**pH**	**conductivity (µS/cm)**	**DO (%)**	**phosphate PO4 (mg/L)**	**chloride (mg/L)**
Beaver Pond	BP	3	Aug. 26	17.61 (±3.32)	7.67 (±0.07)	703.00 (±70.15)	28.33 (±13.05)	0.14 (±0.18)	6.0 (±4.58)
		4	Oct. 21	3.87 (±0.83)	8.04 (±0.13)	635.56 (±205.42)	72.49 (±6.81)	0.23 (±0.15)	7.00 (±4.36)*
Beaver Lagoon	BL	3	Aug. 26	17.49 (±0.20)	8.20 (±0.09)	343.78 (±11.17)	91.66 (±6.03)	0.03 (±0.13)	1.67 (±0.58)
		3	Oct. 21	5.94 (±0.27)	8.07 (±0.06)	284.53 (±6.22)	88.0 (±4.22)	0.16 (±0.10)	14.33 (±10.41)
Clearwater Pond	CP	3	Aug. 26	21.43 (±060)	8.79 (±0.23)	257.23 (±14.26)	122.03 (±15.94)	0.03 (±0.006)	1.33 (±1.53)
		3	Oct. 21	4.02 (±0.63)	7.82 (±0.09)	215.63 (±2.11)	75.83 (±5.12)	0.43 (±0.39)	5.00 (±4.58)

(Note: monitoring of water quality and water flow in the Beaver Pond (referred to as 'wetland 06') was also carried out by Ausenco Sustainability Inc. (previously Hemmera Envirochem Inc.) on October 27 and 28, 2022. The report revealed elevated levels of zinc and selenium. The 2022 [10]Wetland 06 Annual Water Monitoring Report found elevated zinc concentrations in the Beaver Pond as a concern.

During the duration of construction and completion of the SWCRR, sediment controls failed leading to sediment spills into the adjacent wetland. The data collected as a part of this study capture some of the impacts as shown in the increase in turbidity and the noted increase in conductivity and chloride coincide with these spills. The timeline below illustrates key dates and spill events (Figure 19).

Figure 19. Construction and sediment spill timeline

i) Turbidity

Turbidity is dictated by the concentration of suspended and dissolved solids in the water column ([11]Sawyer *et al.*, 2003). It is a parameter that is sensitive to mechanical disturbances in the watershed such as erosion processes and sediment transport. Large increases in turbidity can also be linked to algal blooms ([11]Sawyer *et al.*, 2003).

Prior to October 2018 turbidity was measured in NTU using a YSI ProPlus. From October 2018 to 2022 the transparency of the water was measured using a turbidity tube. In 2022 the turbidity was measured using a YSI Pro DSS Multimeter as well as a turbidity tube. A conversion table published by [12]ORSANCO was used to estimate NTU from the turbidity tube results. Results from the former method cannot accurately be compared with the latter, therefore Table 15 below, gives a qualitative rather than quantitative picture of turbidity in the monitored wetlands over the period of the Study.

Table 15. Turbidity levels recorded from 2015 to 2022.

Sampling method	**Turbidity assessment date**	**Beaver Pond** *(n=3, *n=5)*	**Beaver Lagoon** *(n=3)*	**Clearwater Pond** *(n=3)*	**Ravine Creek** *(n=1)*	**Spring Brook** *(n=1)*
using YSI ProPlus (NTU ± SEM)	Nov. 1st 2015	4.3 (±0.8)				
	Aug. 26th 2016	12.0 (±9.4)	2.2 (±0.4)			
	Oct 19th 2016	3.6 (±3.2)	0.0 (±0.0)	11.0 (±1.0)		
	Aug. 26th 2017	19.1 (±5.8)	0.1 (±0.0)	21.7 (±6.9)		
	Oct. 21st 2017	22.8 (±2.1)	0.0 (±0.0)	16.0 (±1.7)		
	Aug. 27th 2018	296.0 (±236.7)	3.1 (±3.8)	1.6 (±1.8)	3.4	4.3
using a turbidity tube (estimated NTU ± SEM)	Oct. 21st 2018	19.8* (±3.9)	81.3 (±7.6)	81.8 (±3.6)	0.0	0.0
	Aug. 19th/20th 2019	11.8* (±3.1)	1.7 (±1.7)	0.0 (±0.0)	7.0	0.0
	Oct 13th/14th 2019	10.2* (±2.1)	2.0 (±2.0)	8.7 (±4.4)	0.0	7.0
	Aug. 27th, 2020	12.8* (±3.4)	<3	<3	<3	4.7
	Oct. 15th 2020	71.3* (±17.1)	<3	<3	4.0	<3
	Aug. 21st 2021	54.4* (±7.0)	<5 (±0)	<11(±3.5)	<5	<5
	Oct. 16th 2021	79.2 (±10.2)	<5 (±0)	<5	41.7 (±23.3)	<5
using YSI Pro DSS (NTU ± SEM)	Aug. 26th 2022	246.19 (±218.60)	97.64 (±130.17)	1.59 (±1.40)	51.45	83.13
	Oct. 21st 2022	47.68 (±57.35)	0.52 (±0.16)	7.54 (±3.49)	-	3.22

From a graph analysis, the turbidity recorded spikes in 2021 and into 2022, however the sample size does not confer enough power to a reliable statistical hypothesis testing (Figure 20).

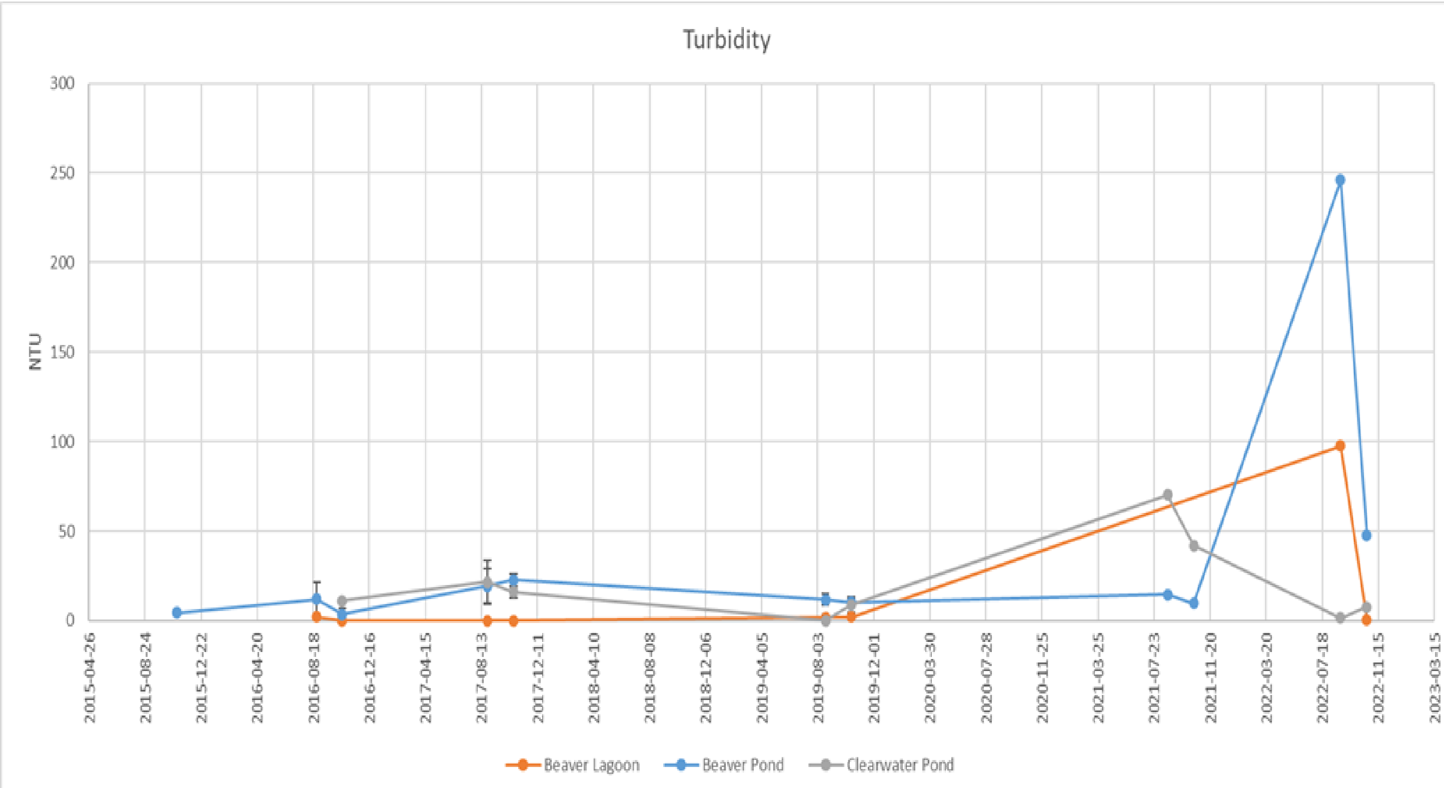

Figure 20. Turbidity recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) between 2015 and 2022.

ii) Temperature

Regression analysis of data from the Beaver Pond, Beaver Lagoon and Clearwater Pond for the period 2015 to 2022 does not show any association between water temperature and year when comparing the same months (linear regression, $p>0.05$), i.e., no trend towards temperature increase or decrease was evident in any of the monitored wetlands for that period (Figure 21). However, temperature of the wetlands is likely to vary with the temperature of inflowing water and the air temperature from day to day, so two annual observations (one in August and one in October) as in this study are probably inadequate to measure slow progressive temperature trends.

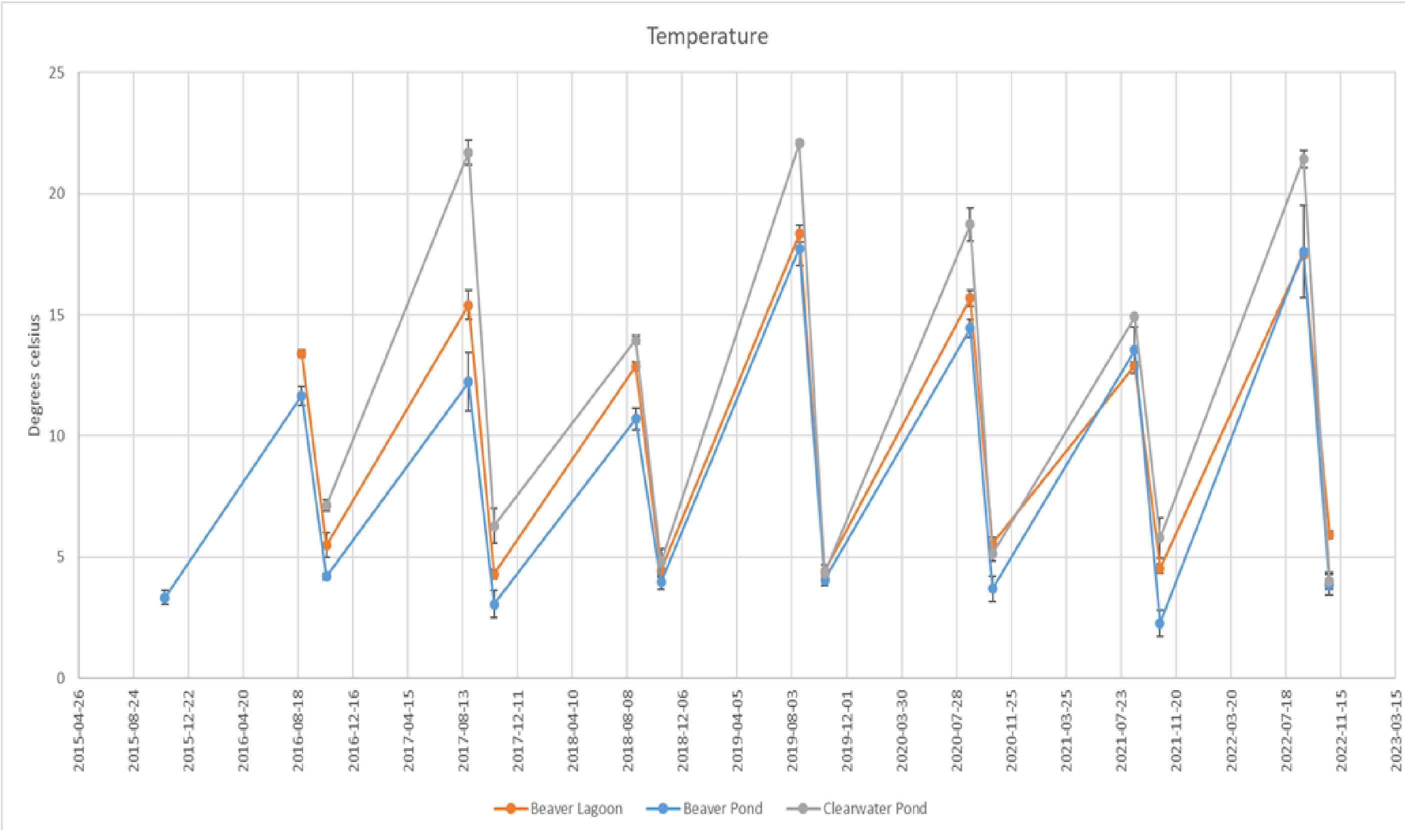

Figure 21. Temperature recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) between 2015 and 2022.

iii) pH

The pH scale reflects the chemical balance of the elements present in water that determine its acidic, neutral, or basic conditions ([11]Sawyer *et al.*, 2003). The pH can be affected by various processes in an aquatic ecosystem, which in turn can affect its chemistry and biology, sometimes dramatically.

A regression analysis for the Beaver Pond, Beaver Lagoon and Clearwater Pond for the period between 2016 and 2022 does not show any association between water pH and year when comparing the same months (linear regression, $p>0.05$) (Figure 22).

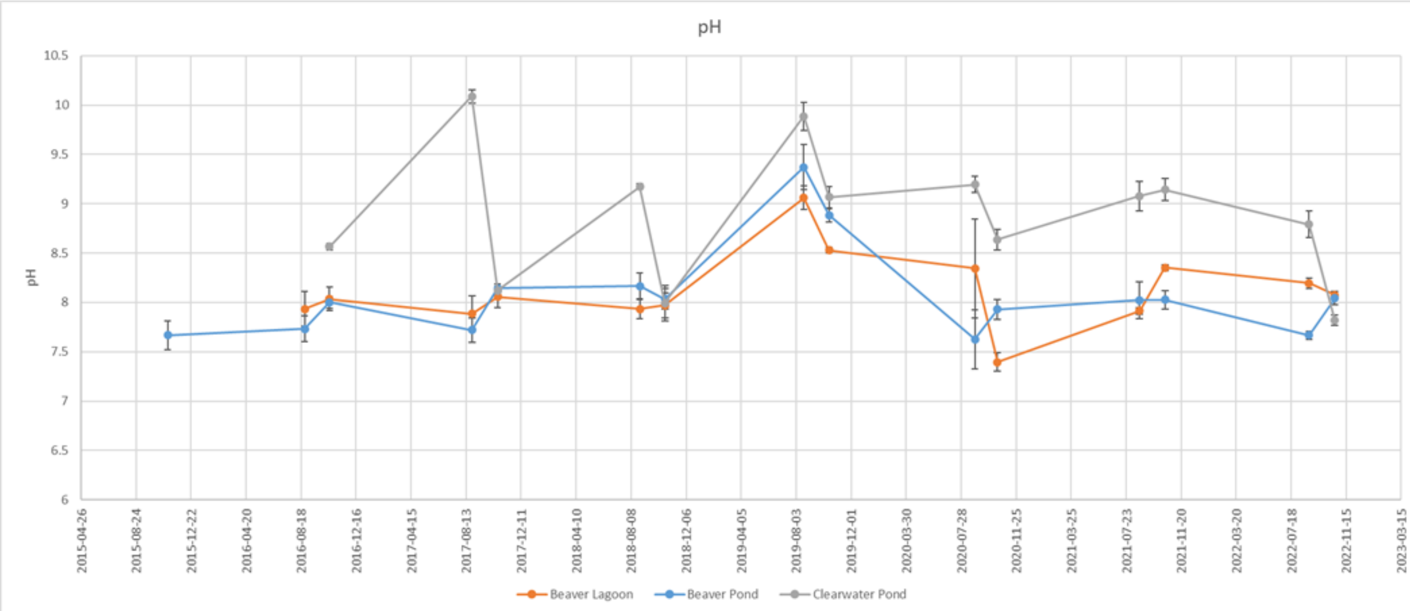

Figure 22. pH recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) between 2015 and 2022.

iv) Conductivity

Conductivity of water is a key parameter for providing early warning of contamination by inorganic pollution (e.g., salts) which can release ions in the water increasing its electric conductivity ([11]Sawyer *et al.*, 2003). Baseline information on the natural range and fluctuations of the conductivity in the studied water body is necessary for distinguishing between natural and disturbed levels of conductivity.

Regression analysis for the Beaver Pond for the period between 2015 and 2022 revealed a significant increase in conductivity over time (linear regression, d.f.=56 (Beaver Pond), $R^2 = 0.162$, $p<0.05$). The reciprocal transformation (1/x) of the Beaver Pond conductivity data was necessary for achieving assumptions of normality and homoscedasticity. During the same period, the reference wetland (Clearwater Pond) and the Beaver Lagoon have not shown any association between conductivity and time (linear regression, $p>0.05$) (Figure 23).

Conductivity fluctuations in the Beaver Pond between 2015 and 2022 shows the average conductivity levels were typically below 600 µS/cm until 2018 when they had a first peak, and that averages in both Weaselhead wetlands have remained above 600 µS/cm until summer 2020. A drop to values below 600 µS/cm was observed in fall 2020. The 2018[13] peak was also observed in the control site in that year. The conductivity values increased dramatically again in 2022, however this time a comparable magnitude of increase was not observed at the reference site or at the Beaver Lagoon.

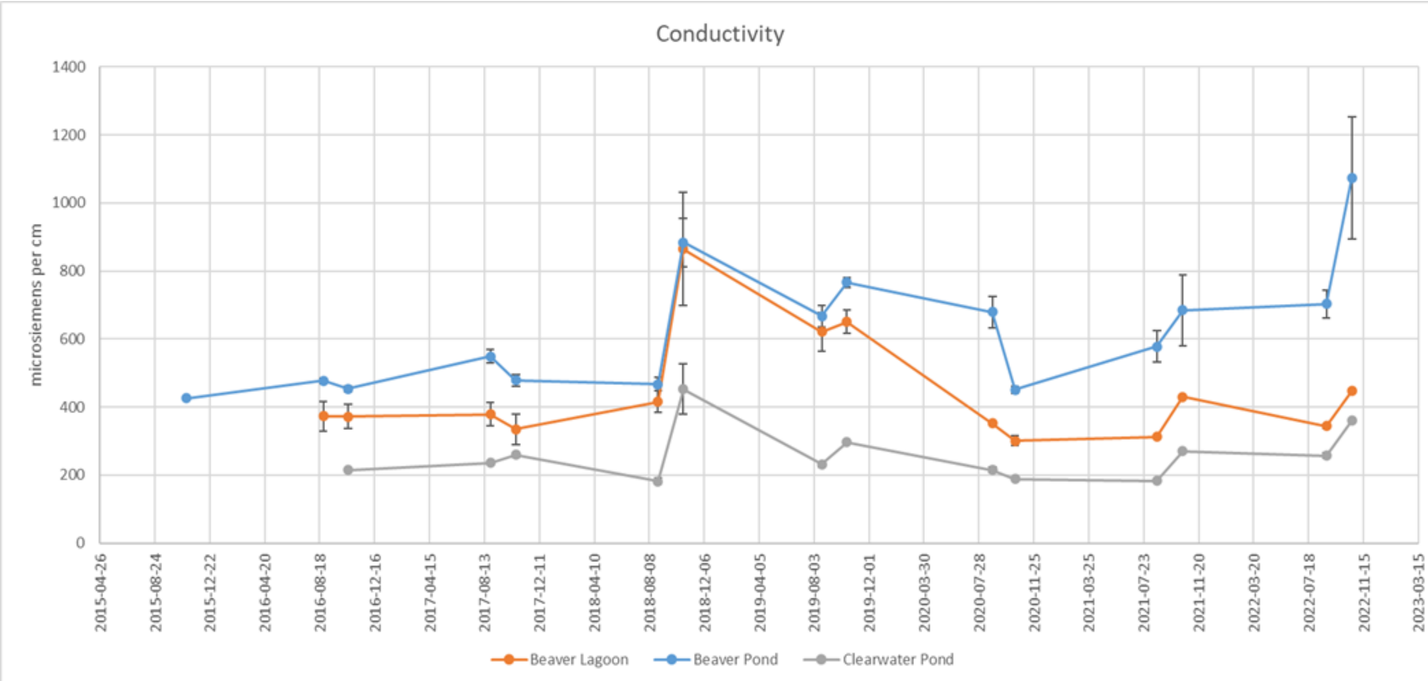

Figure 23. Conductivity recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) between 2015 and 2022.

v) Dissolved Oxygen

Regression analysis of data from Beaver Pond, Beaver Lagoon and Clearwater Pond, 2015 to 2022, does not show any association between dissolved oxygen (DO) and time (linear regression, $p>0.05$) (Figure 24).

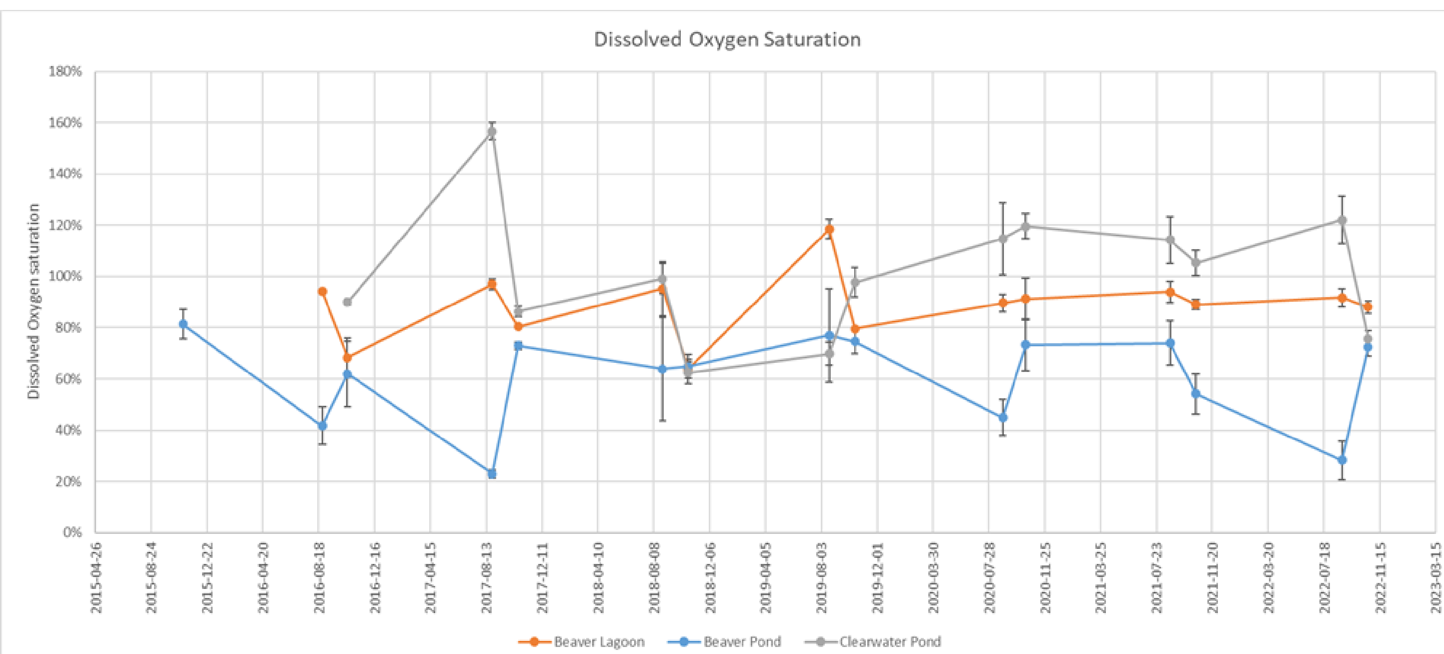

Figure 24. Dissolved oxygen (DO) recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) between 2015 and 2022.

vi) Chloride

Chloride is one of the important dissolved ions that can increase the electric conductivity of water ([11]Sawyer *et al.*, 2003). The measure of chloride (Figure 23) complements the data collected on conductivity by assessing the concentration of an ion that is of special interest in the study: the use of de-icing salts on the SWCRR may increase chloride concentration in adjacent wetlands.

Regression analysis of data from Beaver Pond, Beaver Lagoon and Clearwater Pond, 2015 to 2022, does not show any association between chloride and time (linear regression, $p>0.05$) (Figure 25). However, the peak chloride values in 2018[13] (Beaver Pond) and 2021 (Beaver Pond and Beaver Lagoon) were not observed at the same magnitude in the reference site (Clearwater Pond).

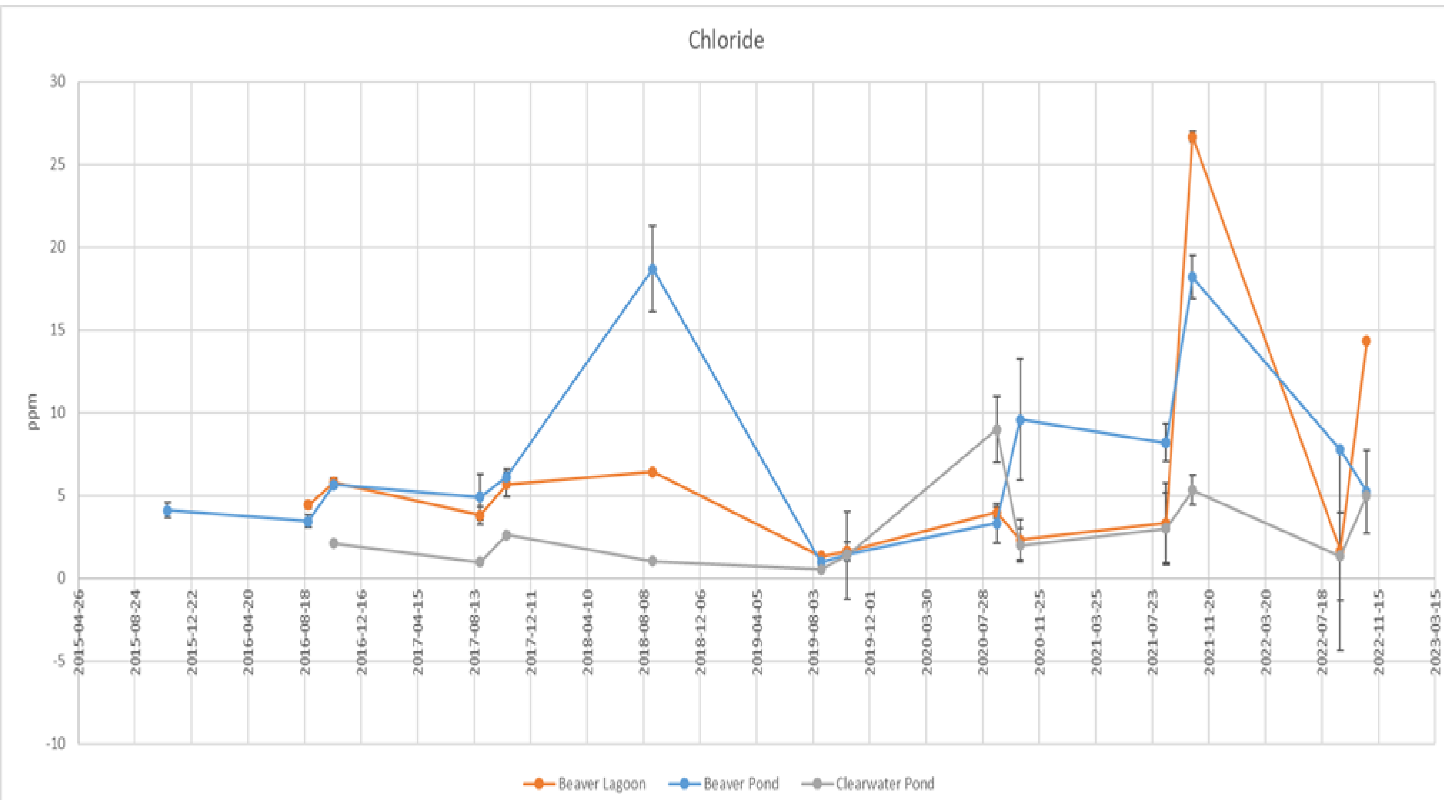

Figure 25. Chloride recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP) between 2015 and 2022.

vii) Nitrate

Nitrate levels have been measured since 2019. *(Note: the test used also responds to nitrite in the water, normally very small in natural waters in comparison to nitrates)*.

A regression analysis for the Beaver Lagoon and Beaver Pond for the period between 2019 and 2022 revealed a significant increase in nitrate over time (linear regression, d.f.=22, R^2 = 0.1915 (Beaver Lagoon), R^2 = 0.3489 (Beaver Pond), $p<0.05$). A square root transformation of the nitrate data was necessary for achieving assumptions of normality and homoscedasticity. During the same period, the reference Clearwater Pond has not shown any association between nitrate and time (linear regression, $p>0.05$) (Figure 26).

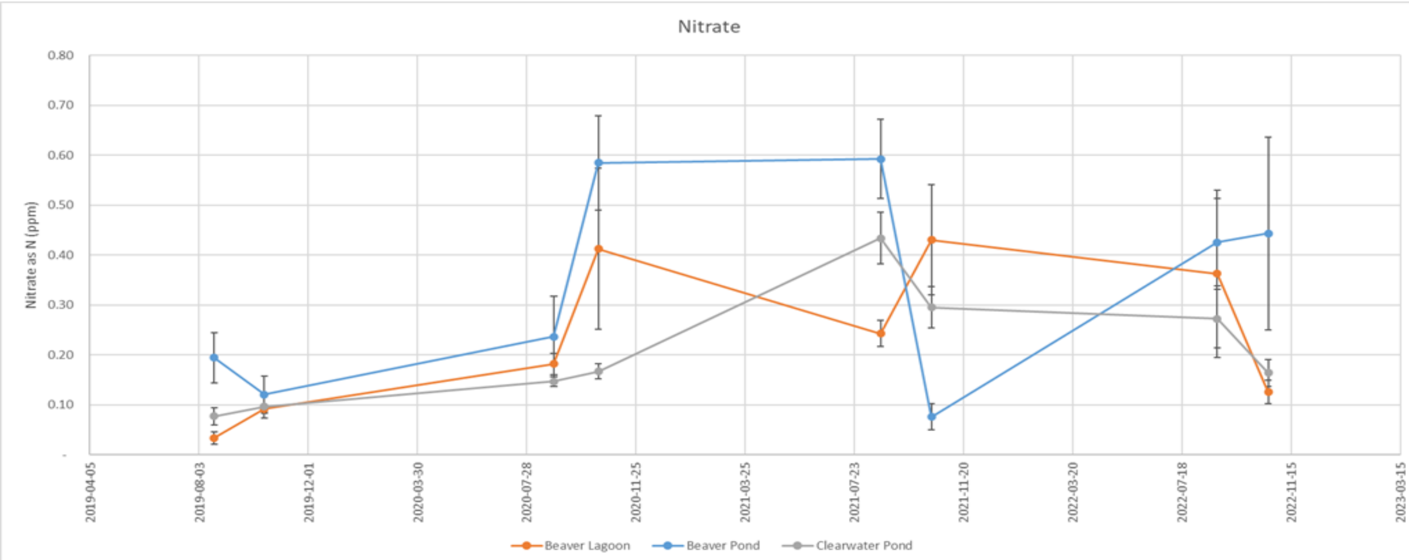

Figure 26. Nitrate recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP) between 2019 and 2022.

viii) Phosphorus

Phosphorus is one of the most important limiting nutrients in aquatic ecosystems (Sawyer *et al.*, 2003)[11]. The introduction of phosphorus into a water body can lead to an exponential increase in algal and cyanobacterial productivity, accelerating the rate of eutrophication (Correll, D.L. 1998)[14]. The resultant low levels of dissolved oxygen can cause fish and invertebrate mass mortality or decreased fertility (Saari *et al.,* 2018)[15]. The phosphorus content in the environment has been measured as phosphate concentration.

Phosphate concentrations have been recorded for each sampling location with the standard error of the mean (Table 16). Regression analyses for all sites for the period between 2015 and 2022 revealed a significant increase in phosphate over time (linear regression, d.f.=51, $R^2 = 0.183$ (Beaver Pond); d.f.=35, $R^2 = 0.1792$ (Beaver Lagoon); d.f.=31 $R^2 = 0.2176$ (Clearwater Pond), $p<0.05$). A square root transformation of the phosphate data was necessary for achieving assumptions of normality and homoscedasticity for the Beaver Lagoon and Clearwater Pond. Data from 2018 are incomplete and were not used in the statistical hypothesis testing. Two peaks can be distinguished, in 2019 and 2021/2022, which are observed in all sampling sites, including the control (Figure 27).

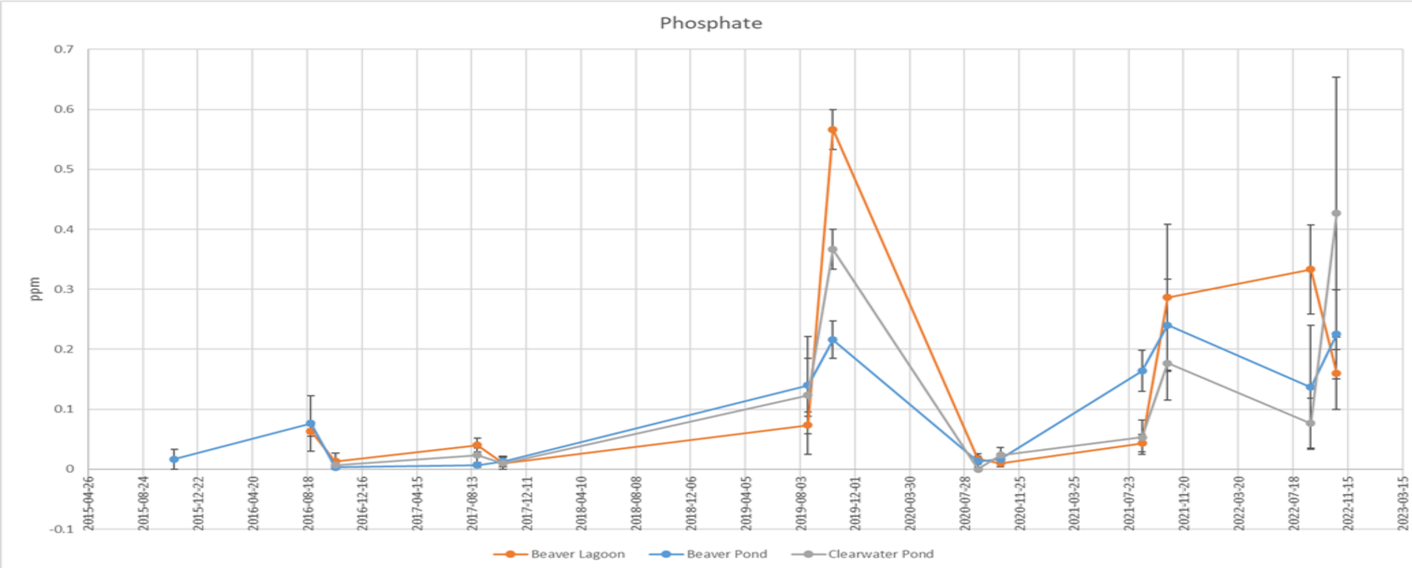

Figure 27. Phosphate recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) between 2015 and 2022.

Table 16. Phosphate concentrations 2015 to 2022.

Phosphate PO_4 (mg/L) ±SEM	**Beaver Pond** *(n=3, *n=5, **n=4)*	**Beaver Lagoon** *(n=3)*	**Clearwater Pond** *(n=3)*	**Ravine Creek** *(n=1)*	**Spring Brook** *(n=1)*
Nov. 1st 2015	0.02 (±0.02)				
Aug. 26th 2016	0.08 (±0.05)	0.06 (±0.01)			
Oct 19th 2016	0.00 (±0.01)	0.01 (±0.01)	0.01 (±0.01)		
Aug. 26th 2017	0.01 (±0.00)	0.04 (±0.01)	0.02 (±0.01)		
Oct. 21st 2017	0.01 (±0.01)	0.01 (±0.02)	0.01 (±0.00)		
Aug. 27th 2018	0.14 (±0.08)	0.03 (±0.00)			
Oct. 21st 2018					
Aug.19th/20th 2019	0.14 (±0.02)*	0.07 (±0.06)	0.12 (±0.06)	0.79	0.23
Oct 13th/14th 2019	0.22 (±0.01)*	0.57 (±0.02)	0.37 ±0.02)	0.14	0.09
Aug. 27th 2020	0.01 (±0.01)	0.02 (±0.01)	0.00 (±0.00)	0.12	0.07
Oct 15th 2020	0.02 (±0.01)	0.01 (±0.01)	0.02 (±0.01)	0.10	0.04
Aug 21st 2021	0.16 (±0.03)	0.04 (±0.01)	0.05 (±0.03)	0.02	0.02
Oct 16th 2021	0.19 (±0.08)	0.29 (±0.12)	0.18 (±0.06)	0.06	0.03
Aug. 26th 2022	0.14 (±0.18)	0.33 (±0.13)	0.03 (±0.01)	0.34	0.69
Oct. 21st 2022	0.23 (±0.15)**	0.16 (±0.10)	0.43 (±0.39)	-	0.1

b. Aquatic Macroinvertebrates

In 2022 a total of 4147 specimens were identified to 63 taxon for the habitats studied (BP, BL and CP, Tables 17 and 18). The 63 taxon identified represent the greatest taxonomic resolution achieved in 2022. Further examination of the data is required but there appears to be a shift in the type of species present, with new species noted as well as prominent species that had previously been recorded, now absent in the samples. A shift towards smaller invertebrates in the Beaver Pond was noted in the samples in 2022 with the majority of the specimen belonging to only two taxon in the August sampling, Daphnia and Calanoida, and the majority belonging to only one taxa in the October sampling, Daphnia. This may be associated with the lower water levels in the Beaver Pond.

Table 17. Taxonomic classification for the aquatic macroinvertebrates sampled on August 26, 2022.

Aug 26, 2022		Beaver Pond			Beaver Lagoon			Clearwater Pond (Control)		
	Greatest Taxonomic Resolution Obtained	**BP1**	**BP2**	**BP3**	**BL 1**	**BL 2**	**BL 3**	**CP 1**	**CP 2**	**CP 3**
Mayflies	*Caenis* sp. (Stephens, 1835)								2	
	Baetis			1	1					
	Centroptilum sp. (Eaton 1869)	1		3						
	Parameletus				1					
	Analetris						1			
	Isonychia			14						
	Metretopus			2						
Caddisflies	*Ptilostomis*						2			
Damselflies	*Nehalennia*			1					1	
	Enallagma sp. (Charpentier, 1840)									1
Dragonflies	*Aeshna* sp. (Fabricius, 1775)			1		1				
	Somatochlora				1					
True flies	Orthocladiinae			6		1				
	Podonominae				6					
	Tanypodinae			1						

	Stratiomyidae			1						
	Culicidae					1	1			
	*Anopheles earlei (*Vargas, 1943)						1			
	Chaoborus	87								
	Dixella					1	1			
	Ceratopogonidae			1						
Beetles	*Ilybius* sp. (Erichson, 1832)				1					
	Hygrotus sp. *(*Stephens 1828)			1						
	Dysticidae			5						
	Hydraenidae					1				
	Ochthebius			1						
	Gyrinidae			1						
	Amphizoidae			4						
	Narpus				1	1				
	Elmidae			2					5	
	Peltodytes			8						
	Haliplus sp. (Latreille, 1802)			11						1
True bugs	Corixidae			4	54	1	1		4	12
	Gerris sp.			2						
Arachnida	*Arrenurus*			1						
	Hydrachnidia	2		1	4			2		
Branchiopoda	*Cladocera sp.*						5			
	Polyphemus pediculus					8				
	Chydoridae			2		2				
	Daphnia	908		159	10	10	2			
	Anostraca					2				
Scuds	*Hyalella azteca* (Saussure, 1858)			1	15	1	1	7		
Copepods	Diaptomidae	15		5						

	Limnocalanus					1				
	Calanoida	557		451	3	2				
	Copepoda			5						
	Ergasilus					1				
	Cyclopoida	1			3	3				1
Oligostraca	Ostracoda	55							2	
	Limocythere			9						
Bivalves	Pelecypoda			1						
	Pelecypoda Sphaeriidae			1						
Gastropoda	*Physa* sp. (Draparnaud, 1801)	2		11		2	1			1
	Lymnaidae			1						
	Stagnicola sp. (Jeffreys, 1830)									1
	Probythinella lacustris (F. C. Baker, 1928)					1			1	1
	Promenetus umbilicatellus (Cockerell, 1887)			3	1					1
Oligochaeta	Naididae			1						
Leeches	*Myzobdella lugubris*				4	2				
	Helobdella stagnalis	1		1						
	Theromyzon maculosum			3						

Table 19. Taxonomic classification for the aquatic macroinvertebrates sampled on October 21st, 2022.

Oct 21, 2022		**Beaver Pond**			**Beaver Lagoon**			**Clearwater Pond (Control)**		
	Greatest Taxonomic Resolution Obtained	**BP1**	**BP2**	**BP3**	**BL1**	**BL2**	**BL3**	**CP1**	**CP2**	**CP3**
Mayflies	Brachycerus							**1**		
	Caenis sp. Stephens, 1835							1		1
	Baetis	3								
	Isonychia	1		5						
Caddisflies	*Glyphopsyche*	1								

	Helicopsyche							1		
	Ephemerella							1		
Damselflies	*Nehalennia*								1	1
	Coenagrionidae		1							
	Calopteryx						1			
True Flies	Tanypodinae	6		8						
	Anopheles earlei Vargas, 1943			15						
	Chaoborus	13								
	Dixella								1	
Beetles	*Hydraena*									1
	Haliplus sp. Latreille, 1802								1	2
True Bugs	*Notonecta* sp. Linnaeus, 1758		1							
Branchiopoda	*Daphnia*	1442	11	26		1				
Scuds	*Hyalella azteca* (Saussure, 1858)	1			3		1			
Oligostraca	Cyprididae	1								13
	Ostracoda							3		
Copepods	Acanthodiaptomus denticornis (Wierzejski, 1987)			1						
	Limnocalanus									1
	Osphranticum								2	
	Orthocyclops					1				
	Paracyclops								2	
	Tropocyclops									2
	Cyclopoida								1	
Gastropoda	*Fossaria (Bakerilymnaea) bulimoides* (I. Lea, 1841)								1	
	Lymnaea stagnalis					1				
	Stagnicola sp. Jeffreys, 1830					3				
	Promenetus umbilicatellus (Cockerell, 1887)				1	1				1

Taxa Richness

Regression analysis of data from the Beaver Pond, Beaver Lagoon (Weaselhead sites) and Clearwater Pond (reference site), for the period between 2016 and 2022, does not reveal any significant association between taxa richness and time (linear regression, d.f.=12 (Beaver Pond and Beaver Lagoon); d.f.=11 (Clearwater Pond); $p>0.05$).

These results suggest that the SWCRR Impact Study has not detected any significant trends of aquatic invertebrate taxa richness during this period on the studied wetlands. (Figure 28).

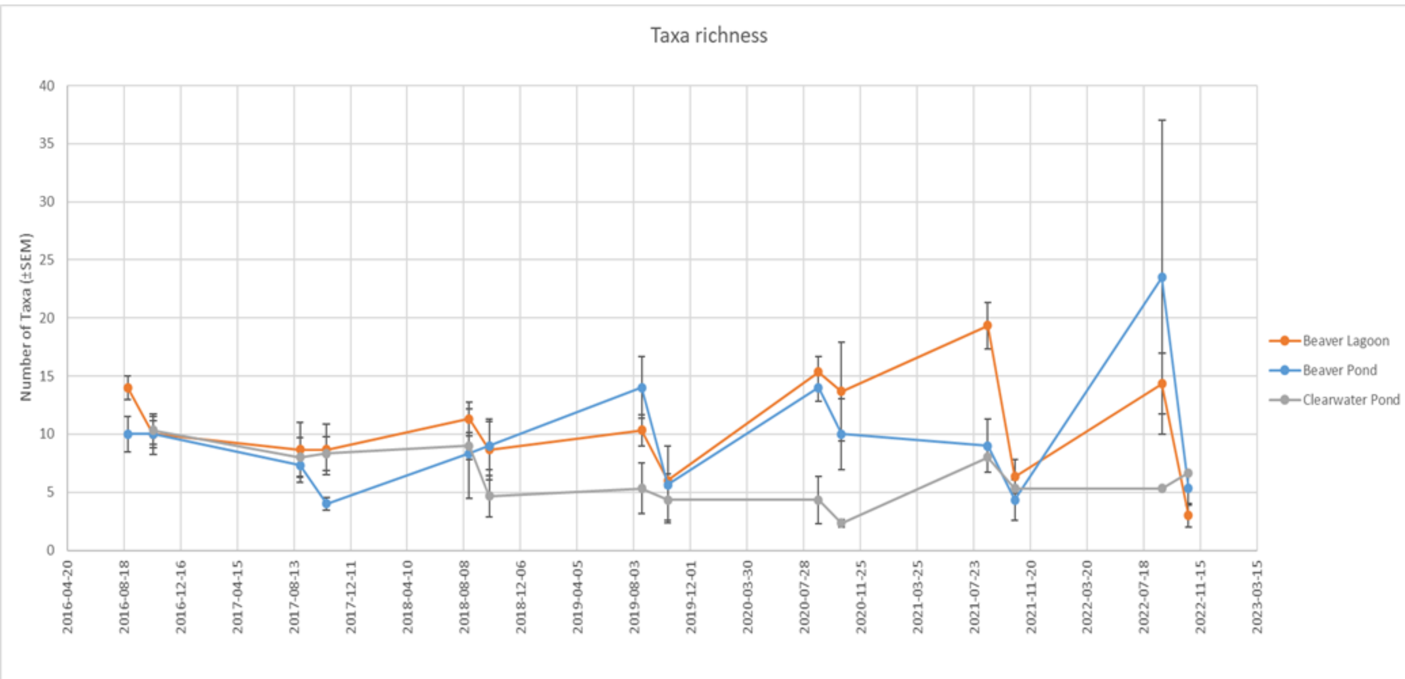

Figure 28. Taxa richness recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) from 2016 to 2022.

Simpson's Diversity Index

The Simpson's diversity index accounts for not only the number of taxa present in a given site, but also the relative abundance of individuals per taxa. It estimates the probability that two individuals randomly taken from a sample will belong to the same taxa (S). Its inverse proportion (1-S) estimates the probability that two randomly selected individuals in a sample will belong to different taxa (from zero to 100%). The Simpson's index (S) is calculated as follows:

Where n_i is the total number of organisms of the i^{th} species, R is richness (total number of species in the study), and N is the total number of organisms of all species.

Regression analysis of data from the Beaver Pond and Beaver Lagoon (Weaselhead sites), for the period between 2016 and 2022 (Figure 29), does not reveal any significant association between taxa diversity and time (linear regression, d.f.=12 Beaver Pond and Beaver Lagoon, d.f. = 11 Clearwater Pond, $p>0.05$).

Nevertheless, an accentuated drop in diversity was observed in October 2022 for the Weaselhead sites (Beaver Pond and Beaver Lagoon), which was not detected in the reference site (Clearwater Pond). This may be attributed to the significant changes in water levels further discussed in the 'Final Considerations' section.

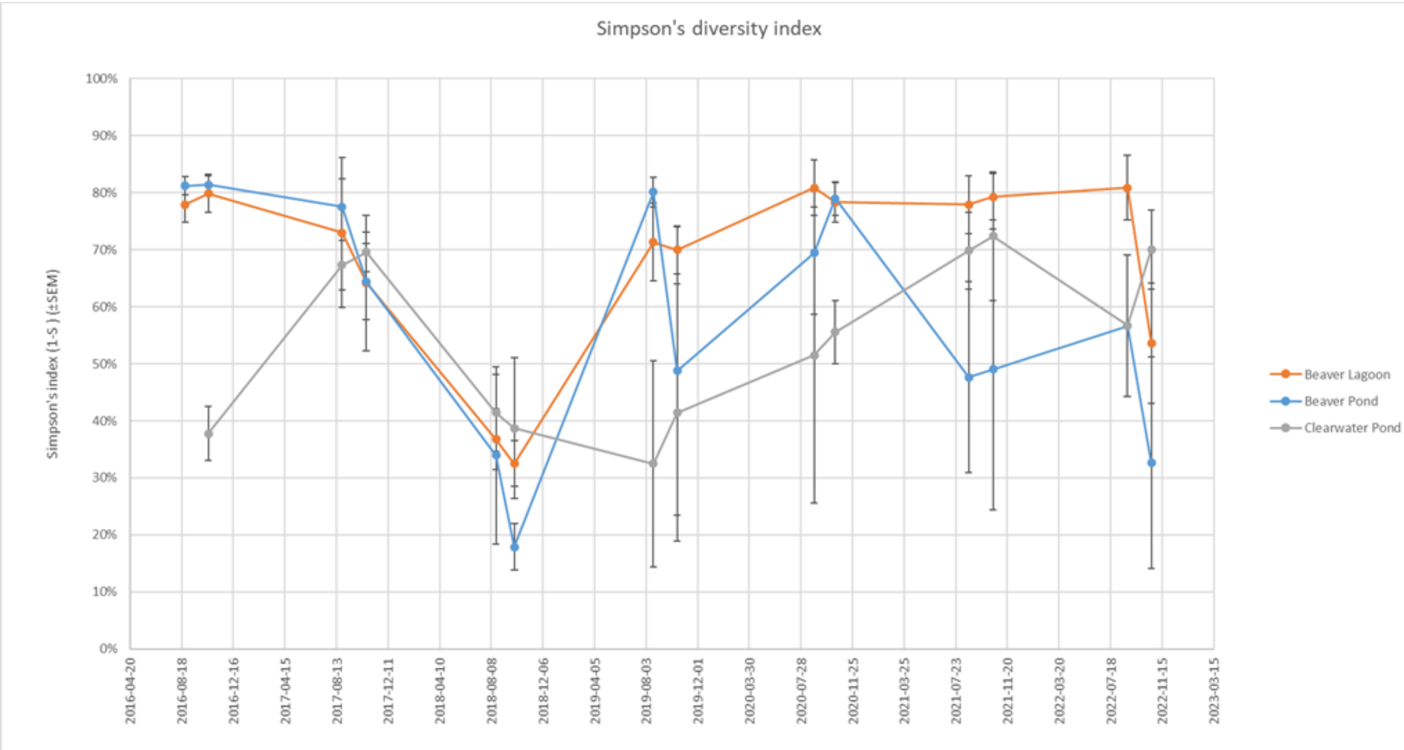

Figure 29. Simpson's diversity index recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) from 2016 to 2022.

EPT taxa %

The proportion of number of taxa from pollution-sensitive groups relative to total number of taxa is often used as a bioindicator parameter. The number of taxa from Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) relative to the total number of taxa, known as EPT taxa richness %, is an example of such a parameter. The EPT group contains a relatively high proportion of species intolerant to water pollution.

A regression analysis of data from the Beaver Pond, Beaver Lagoon (Weaselhead sites) and Clearwater Pond (reference wetland), for the period between 2016 and 2022, has not revealed any significant association between EPT taxa richness % and time (linear regression, d.f.=12 Beaver Pond and Beaver Lagoon, d.f. = 11 Clearwater Pond, $p>0.05$) (Figure 30). This result suggests that the SWCRR Impact Study has not detected any significant trends on EPT taxa % for any sites during this period. A graph analysis of the data, however, indicate that there is a potential decreasing trend of EPT taxa % in the Beaver Lagoon since 2020, including recording zero EPT specimens in the latest sampling, which has not been observed in the other sites. A continued monitoring of this site is justifiable to investigate this potential trend and may be associated with the high-water levels resulting from the Glenmore dam modifications.

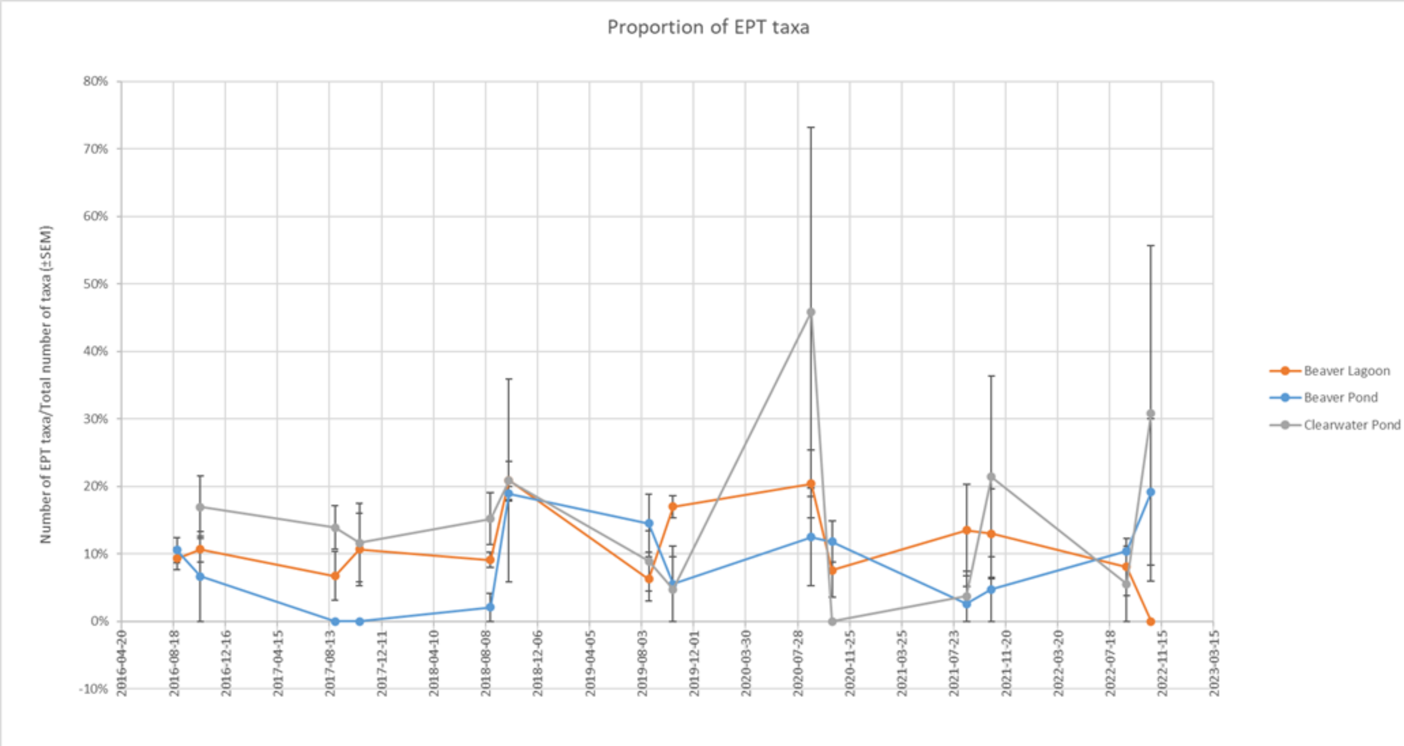

Figure 30. Proportion of EPT tax recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) from 2016 to 2022.

c. Amphibians

Nocturnal amphibian call surveys were done at two locations in the Weaselhead from 2017 to 2022. Only boreal chorus frogs, *Pseudacris maculata,* and wood frogs, *Lithobates sylvaticus,* were detected (Figure 31, Table 19 and Table 20). The locations match two used in 2012 and are close to one used in 2014 for the EIA[1]. Surveys were carried out between 9 pm and 11 pm for 20 min. following a protocol developed by the Miistakis Institute for *'Call of the Wetland'*[16], a three-year study (2017 to 2019) into amphibians in the Calgary area. It is intended that at the completion of the 7 years of this study (2016 – 2022) results from the Weaselhead wetlands will be evaluated in the context of the results from this much larger study. Outcomes from this research (Lee, T. et al. 2020)[17] will help to decide if any changes in amphibian presence observed in the Weaselhead can be attributed to impacts associated with construction of the SWCRR and guide potential restoration of movement corridors.

Figure 31. Locations of amphibian call survey monitoring sites from 2017 to 2022 indicated by green circles.

Table 19. Boreal Chorus frogs heard during surveys conducted in 2012 to 2022; BP = Beaver Pond, OO = Old Oxbow *(2012 and 2014 data from Environmental Impact Assessment for the SWCRR, AMEC 2014[1]).*

	EIA 2012		EIA 2014		2017		2018		2019		2020		2021		2022	
	no details of abundance		*no details of abundance*		*# of individuals heard*		*# of individuals heard*		*# of individuals heard*		*# of individuals heard*		# of individuals heard		# of individuals heard	
Boreal Chorus frog	BP	OO	BP	OO	BP	OO	BP	OO	BP	OO	BP	OO	BP	OO	BP	OO
late April	present		present		0	0			0	0	0	0	0	0		
early May					0	2	0	0	0	0	0	0	0	0	1	0
Mid-May	present		present		0	2	0	0			0	0				
late May	present		present		1	1			0	0	0	0	0	0	4	0
early June					0	1			0	0	0	0			2	2
Mid-June													0	0		
late June					0	0					2	0			1	0

Table 20. Wood frogs heard during surveys conducted in 2012 to 2022; BP = Beaver Pond, OO = Old Oxbow *(2012 and 2014 data from Environmental Impact Assessment for the SWCRR, AMEC 2014[1]).*

	EIA 2012		EIA 2014		2017		2018		2019		2020		2021		2022	
	no details of abundance		*no details of abundance*		*# of individuals heard*		*# of individuals heard*		*# of individuals heard*		*# of individuals heard*		# of individuals heard		# of individuals heard	
Wood frog	BP	OO	BP	OO	BP	OO	BP	OO	BP	OO	BP	OO	BP	OO	BP	OO
late April	present		present		3	4			4	0	5	2	10-20	3	0	0
early May					2	0	4	0	3	0	10	2	0	0	6	0
Mid-May	present		present		0	0	0	0			0	0				
late May	present		present		0	0			0	0	0	0	0	0	1	0
early June					0	0			0	0	0	0			0	0
Mid-June													0	0	0	0
late June					0	0					1	0				

In addition to the above monitoring, following a spill of infill material from the construction site into the Beaver Pond in August 2019 and remedial action in November 2019, Alberta Environment and Parks (AEP) has ordered KGL to monitor amphibians in the Beaver Pond for two years. It was hoped that the results of this monitoring would be available for inclusion in the 2021 and 2022 Environmental Monitoring Report, but unfortunately these results have not been made available.

d. Fish

Fish sampling is a way of monitoring the ichthyofauna diversity in key habitats in the Weaselhead (Beaver Pond and Beaver Lagoon). The third habitat monitored represents a reference site (Clearwater Pond) to which any observed changes in fish richness and diversity can be compared. In previous years of the impact study, each habitat had a minnow trap installed for one night baited with hot dogs, and dip netting carried out at the same location. A Fish Research License was obtained from AEP for the purpose of this research. Species and size of each captured individual was determined then it was released back into its original water body. However, since 2018 we were continuously unsuccessful in catching fish using the minnow trap and the consensus was it was due to the traps mesh being larger than the minnows found in these habitats. Our previous sample methods were determined to be insufficient given the species present in the sample regions. In 2021 and 2022 we decided to utilize only the dip net method, including fish caught in the three random scoops while catching aquatic invertebrates. Fish were removed from the sample, identified, measured, and released back to the water body immediately. The dip netting methodology was deemed to be more effective than the minnow trap.

The locations of the random scoops align with the same sites and methodology described for aquatic invertebrate sampling on August 26 and October 21, 2022. Species names for fish caught in minnow traps and with dip nets from 2017-2022 are shown below while totals are found in Table 21.

Fathead minnow - (Pimephales promelas)

Brook stickleback - (Culaea inconstans)

White suckers - (Catostomus commersonii)

Unknown sp. - Likely brook stickleback or fathead minnow, dorsal line observed may indicate Chrosomus (dace)

Table 21. Fish caught in minnow traps and caught with dip nets while collecting invertebrate samples, 2017- 2022 *(*Note: students participating in Society's education programs regularly found brook stickleback in the Beaver Pond in 2017 and 2018).*

Location	20th Oct. 2017	8th Nov. 2018	14th Oct. 2019	15th Oct. 2020	21st Aug. 2021	16th Oct. 2021	26st Aug. 2022	21st Oct. 2022
Beaver Pond	11 fathead minnows	No fish caught	5 brook stickleback (BP1) (sizes: 2.6, 3.3, 3.5, 2.5, 2.0 cm)	1 brook stickleback (BP 3) (size: ?)	2 brook stickleback (BP 3) (size: 1.7, 2.1cm)	27 brook stickleback (BP1) (sizes: 1.3-3.2cm) (3.2, 3.3, 1.3, 2.6, 3.1, 1.5, 1.7, 2.9, 3.0, 2.6, 1.8, 2.6, 2.5, 1.4, 1.5, 2.4, 1.5, 2.0, 1.6, 1.4, 1.7, 1.6, 1.4, 1.7, 1.6, 1.4, 1.7, 1.6, 1.4, 1.6, 1.7, 1.4, 1.6 cm)	No fish caught	1 brook stickleback (2.5cm)
Beaver Lagoon	No fish caught	No fish caught	No fish caught	No fish caught	No fish caught	No fish caught	No fish caught	No fish caught
Clearwater Pond	19 white suckers	No fish caught	No fish caught	2 brook stickleback (CP 2) (sizes: 2.0 and 3.0 cm)	No fish caught	1 brook stickleback (CP 2) (size: 3.5 cm) 1 unknown sp. (CP 1) (size: 1.8cm)	1 fathead minnow (CP 2) (1.7 cm) 5 fathead minnows (CP 3) (2.1 cm, 2 cm, 0.9cm, 0.9 cm, 0.8 cm)	No fish caught

FINAL CONSIDERATIONS

This document is an important step in the evaluation of the mitigation measures adopted during the construction phase and opening of the SWCRR. The road was opened October 2, 2020, thus the research evaluated in this report now includes 2 years of data collected after the opening of the road.

The Society has identified concerns regarding sediment and erosion control mitigation. These mitigation measures failed multiple times during the construction of the road. This is evident from the many sediment spills including the five major events (Figure 19) that took place into the Beaver Pond. These mitigation failures potentially impacted water quality negatively in Beaver Pond as documented through this research, in particular, the increasing conductivity and nitrate trends. The Society strongly recommends the province to adopt significantly improved erosion and sediment controls to reduce these impacts for all future construction projects within riparian areas.

Wildlife movement mitigation during construction was an additional concern in mitigation measures during construction. The Society recommends the province consult with wildlife connectivity experts to improve standards and assess mitigation efforts to ensure wildlife movement and connectivity is a top priority during road construction and operation.

Elevated noise pollution was an anticipated outcome from the inclusion of a highway running through a natural area. The data collected in this Study illustrate the severity of the noise pollution in the Weaselhead as indicated by the significant upward average sound pressure trend, measured between 2016 and 2022 with an overall average increase of 24 dB, an approximately 60% increase in volume. The Society recommends that the province investigate better ways to reduce noise pollution impacts on natural areas for similar infrastructure projects. Currently, mitigation efforts are only made in areas where human urban residential areas are, excluding natural areas where not only wild animals depend on the quiet spaces, but for humans as well, where access to quiet natural spaces can improve human well-being and health and are highly valued.

The Society also identified failures to control prohibited noxious weeds within the TUC after completion of construction. During invasive plant weeding programs conducted by the Society at the west end of the Weaselhead, a large amount of spotted knapweed was observed by the program coordinator on the TUC. The land manager, Alberta Highway Services Ltd. was contacted and a cooperative event with them and volunteers coordinated through the Society was arranged for July 31st, 2022. This event was too late in the season to adequately remove the invasive plants before propagation and seeding could occur. Areas disturbed by construction are vulnerable to invasive plant establishment and expedient action to revegetate these areas is critical in reducing later costs and increased challenges in the management of invasive species. Behaviour and policy must improve for timely revegetation and in addressing noxious weeds such as Spotted Knapweed (Centaurea stoebe) as this is of significant concern for the preservation of native biodiversity.

Confounding factors influencing study results:

Glenmore reservoir water level

Modifications to Glenmore Dam overflow gates were completed in 2020 to raise the reservoir water elevation by approximately 1.5 to 1.8 m. Additionally, a lower outlet allows greater draw-down prior to June, to increase future flood flow attenuation. Those modifications have resulted in the third summer with prolonged flooding of the outflow delta of the Elbow River into Glenmore Reservoir. As a result of this, we have observed localized die-off of spruce and hypothesize that repetitive and prolonged flooding will lead to progressive mortality of the extensive riparian willows (*Salix* spp.) in the delta zone where the Elbow River flows into Glenmore Reservoir. This may be followed by some upward transitions of willows.

The increased water levels impacted the Beaver lagoon which directly connects its outflow into the Elbow River upstream from the reservoir. As a result, the riparian vegetation is in a transition period as water is now so high in the summer and fall months that the immediate water level engulfs previous terrestrial grasses. It will take time for the aquatic vegetation to adapt. However, with the extreme and prolonged water level fluctuations it is difficult to anticipate how the aquatic vegetation will adapt along the immediate transition zone. This area supports gradients in environmental conditions that are important in supporting aquatic invertebrate life. Our data indicate that there is a potential decreasing trend of EPT taxa % in the Beaver Lagoon since 2020, including recording zero EPT specimens in the latest sampling, which has not been observed in the other sites. A continued monitoring of this site is justifiable to investigate this potential trend. While this Study has the intention of evaluating mitigation efforts from the ring road, we cannot determine the causal source of the decline in EPT taxa. The role that the ring road contributes to this decline cannot be extricated from other potential contributors at this point in time. Continued research may allow some insight into the resulting changes, potential adaptation or recovery of the ecosystem and the causal relationships leading to this observed impact.

Beaver pond drought

While the adjacent reservoir and connected Beaver Lagoon have a significant increase in water volume, the Beaver Pond has experienced a drastic decline in water volume which has impacted our Study results, notably, the vegetation diversity. This decline in water volume is a confounding factor that may be potentially impacting Study results beyond the direct impacts of the ring road.

While there is potential that the ring road construction contributed to this change in water levels, other factors may have influenced the drop in water levels in the wetland as well and the source of this change cannot be determined. We are unable to assess the impact of groundwater flow into the wetland from available data and a knowledge gap exists in this area. A berm was constructed to support the SWCRR. Questions remain on how compaction resulting from the construction and operation of the SWCRR impacts the groundwater flow into the wetland. Additionally, significant changes to the catchment area of Spring Brook and Ravine Creek have been made due to the construction of the road (Figure 19). It is recommended that further investigation into subsurface hydrology and surface water dynamics be explored.

Figure 32 compares May to August water levels in the Beaver Pond in 2020. Compared to the conditions in 2022, (Figure 9) the change in vegetation and open water is evident. The Vegetation survey conducted as a part of this research indicated increasing species richness. The species richness in a riparian zone is often limited by the presence of water or periodic inundations. Under these conditions, only species tolerant to water saturated soils would thrive. An increase in plant species richness is likely resulting from the lowering of average water levels in the Beaver Pond, producing drier soil conditions, and allowing the colonization of other species. As mentioned above, regarding the relationship of water levels from the Glenmore reservoir, we cannot associate this increase in vegetation as a direct result of the ring road impacts. Further examination of the data collected as a part of this research may allow some insights into the potential changing demographics of the plants within the studied transect and a change from obligate wetland plant species towards upland plant species. Figure 33 shows the drought conditions impact on having to locate new sampling sites that contained water to sample.

Figure 32. May 2020, Beaver Pond with highlighted vegetation survey transect compared to August 2020, Beaver Pond water levels (source: Aerial images from Google Earth, May 2020, and August 2020).

Figure 33. October 21, 2022, Beaver Pond drought with researchers at the new sampling location. Previous shore is found beyond cattails, outside of photo.

Next Steps for long term monitoring

In consultation with partnering experts such as Dr. Stewart Rood, Cassiano Porto, the City of Calgary Park Ecologists and more, the Society will determine the best path forward for continued monitoring. Potential continued monitoring to assess long term impacts of the SW Calgary Ring Road and the impacts of potential confounding factors on the Weaselhead Natural Environment Area would allow further exploration into the effectiveness of the mitigation efforts deployed for the development of this road and potential solutions. The Society will explore Citizen Science based opportunities and partnerships with the City of Calgary's Habitat Management planning.

Conclusion

Evidence of mitigation failures, as identified in this report, necessitate further actions to reduce environmental impacts. These will be further explored in a final report that reviews and combines the data and conclusions of the full Study from inception to completion.

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