Weaselhead/Glenmore Park
SWCRR Impact Study 2016-2022

Environmental Monitoring Report 2020

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 South West 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 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, that would span the years from initiation to completion of the road and quantify the SWCRR's impacts on biophysical components of the park and on park-users. The objective of the biophysical part 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, and the 2018, 2019 and 2020 reports describe conditions during the three years of construction (all reports are available on the Society's website). Table 1 summarises the timeline of the project, monitoring, and spills of sediment from the construction site into a local wetland (these are discussed separately in the annual reports). Figure 1 shows a satellite image of the Weaselhead and TUC (Transportation Utility Corridor) in 2016 before construction started, and figure 2 the same area in Aug. 2020 near the end of the construction phase (the section of the SWCRR adjacent to the Weaselhead opened on 1st October). Major work undertaken in 2020 included completing and paving the north and southbound carriageways of the ring road and the local access road, and of especial interest to the monitoring carried out in this study, completion of a retaining wall along the edge of the northbound carriageway and an adjacent wetland in the Weaselhead, the 'Beaver Pond'.

When contrasted with the baseline conditions of 2016, later conditions offer insights into the long-term effects of the SWCRR on the adjacent ecosystems. Data from annual monitoring can also give early warning about immediate changes in habitat quality and ecological processes – allowing remedial action to be taken before damage worsens and becomes more costly to rectify. These are discussed in the final section of the report '*Final Considerations*'. By continuing to collect data until the end of 2022 when this section of the SWCRR will be have been in operation for two years, the Study will allow an objective evaluation of the road's impact on selected environmental components and the success/failure of the mitigation measures adopted to render the impact on these components acceptable (as detailed in the construction company's contract with Alberta Transport). These data will allow the Society to present arguments for improved mitigation (if required) 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.

The addition of further data, while unable to be compared with pre-construction baselines, may still help the Society to monitor ongoing changes in the Weaselhead and look for relationships with other data collected. The Society began monitoring night sky quality (the amount of light pollution within the Weaselhead) in 2019 as part of an application to become a Nocturnal Preserve, a designation granted by the Royal Astronomical Society of Canada. These data and more information on the Nocturnal Preserve Initiative are found in appendix II.

Table 1: timeline of SWCRR construction phases; monitoring; major spills into the Beaver Pond (Weaselhead wetland adjacent to construction zone)

	construction activities	major events	annual monitoring	spills into Beaver Pond
2015	pre-construction		starts Oct.	n/a
2016			completed	n/a
2017	construction	vegetation clearance and ROW recontouring	completed	none
2018		Elbow River diverted to new channel; bridge decks installed	completed	April 18th; June 23rd
2019		tormwater ponds constructed; retaining wall by Beaver Pond bulit	completed	Aug 19th
2020	post construction: SWCRR section across Elbow Valley opens	traffic lanes paved; revegetation	completed	July 2nd
2021	*SWCRR expected to be completed and fully operational*	*evegetation completed; wildlife fencing installed (??)*	*to be completed*	*??*
2022			*to be completed (study ends Oct 2022)*	*??*

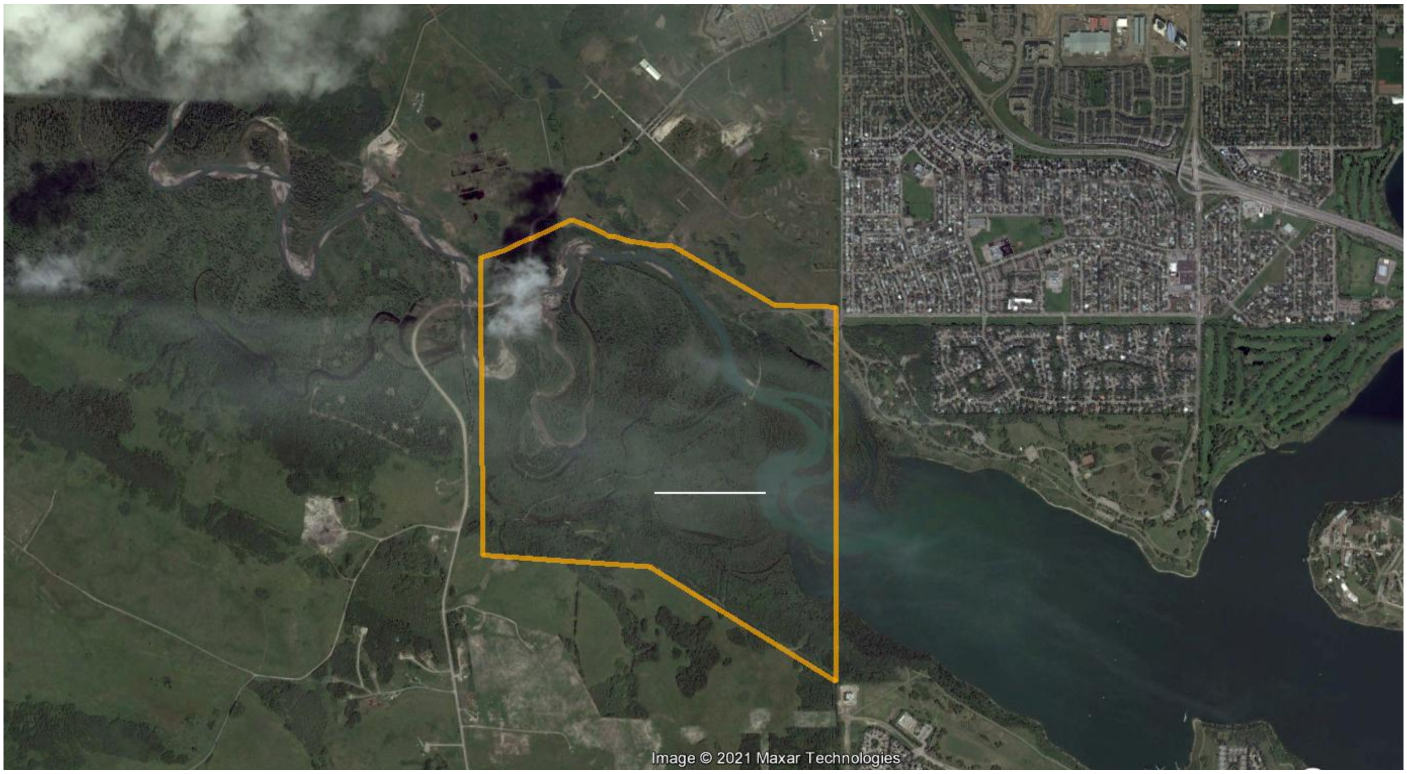

Figure 1: satellite image Sept. 2016 before major construction began *(downloaded from GoogleEarth);* orange line shows Weaselhead boundary; scale: white line = 500m

Figure 2: satellite image Aug 2020, three and a half years after the start of construction *(downloaded from GoogleEarth)*; Weaselhead boundary shown by orange line; scale: white line = 500m; red circle shows location of retaining wall

1. RESULTS: TERRESTRIAL HABITATS

a. Breeding Bird Survey

In 2020 the breeding bird survey was conducted using the same protocol and study design as in 2016, 2017, 2018 and 2019, and as the EIA[1]. In order to produce comparable results, 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: gentle to moderate breeze (Beaufort Scale), mixed sun and cloud, temperature 12˚C-15˚C, and no precipitation.

To comply with the 2020 Covid-19 pandemic recommendations at the time, volunteer groups were limited to two or three people – one expert observer and one recorder (plus assistant). On June 27th 2020, three groups of volunteers carried out the survey, each group visiting a different set of sites (see Fig. 3). Each group was led by an expert ornithologist and followed the method described below:

- Starting at 5:00am (daylight saving time: UTC-6:00) each group hiked to each pre-determined station, located with GPS.
- 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 50 to 100m distant 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 2: 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

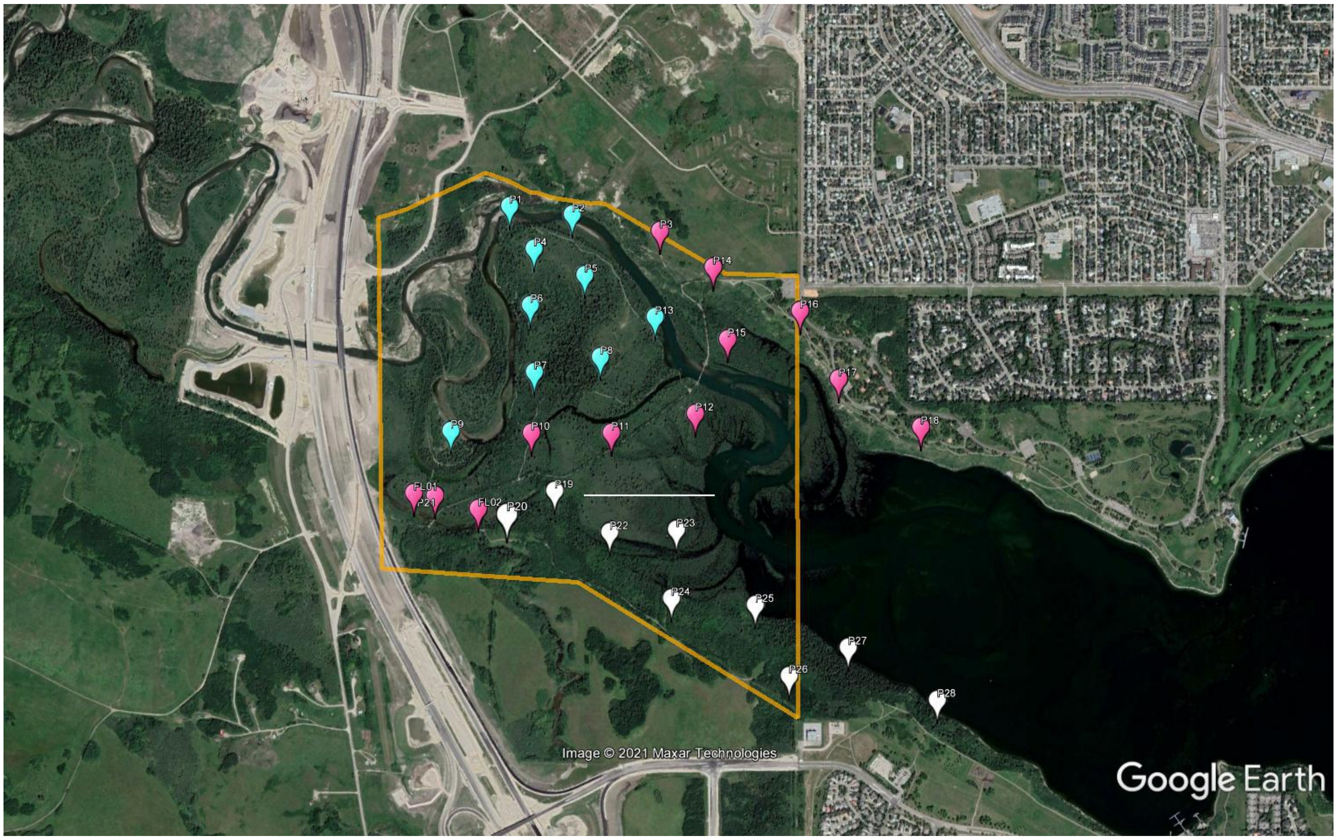

Figure 3: location of breeding bird survey points *(scale: white line = 500m)*

During the 2020 bird survey 450 individuals from 40 different species were identified (raw data is available on request; summaries are shown in tables 3 and 4). As in earlier years the total Simpson's diversity index for the breeding bird survey was high (1-S = 94.63%). However given the high number of unidentified species observed in 2019 and 2020, the data was not considered robust enough to allow an accurate estimation of species density as performed in previous years.

Table 3: Breeding bird survey species list (June 27^{th} 2020) with total individual counts (species indicated as *sensitive; ** may-be-at-risk Alberta Wild Species General Status Listing[2])

Species			**Species**		
Cedar Waxwing	*Bombycilla cedrorum*	*42*	Ruby-crowned Kinglet	*Regulus calendula*	*6*
Cliff Swallow	*Petrochelidon pyrrhonota*	*41*	Alder Flycatcher*	*Empidonax alnorum**	*4*
White-throated Sparrow	*Zonotrichia albicollis*	*39*	Common Raven	*Corvus corax*	*4*
Tree Swallow	*Tachycineta bicolor*	*35*	Black-billed Magpie	*Pica hudsonia*	*3*
Clay-colored Sparrow	*Spizella pallid*	*28*	Northern Flicker	*Colaptes auratus*	*3*
Least Flycatcher*	*Empidonax minimus**	*28*	Hairy Woodpecker	*Leuconotopicus villosus*	*2*
Yellow Warbler	*Setophaga petechia*	*24*	LeConte's Sparrow	*Ammodramus leconteii*	*2*
Veery	*Catharus fuscescens*	*21*	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	*2*
American Robin	*Turdus migratorius*	*20*	Spotted Sandpiper	*Actitis macularius*	*2*
Brown-headed Cowbird	*Molothrus ater*	*20*	White-breasted Nuthatch	*Sitta carolinensis*	*2*
Red-winged Blackbird	*Agelaius phoeniceus*	*16*	Sapsucker spp.	Sphyrapicus spp.	*2*
House Wren	*Troglodytes aedon*	*13*	Barn Swallow	*Hirundo rustica*	*1*
Black-capped Chickadee	*Poecile atricapillus*	*12*	Calliope Hummingbird	*Selasphorus calliope*	*1*
Gray Catbird	*Dumetella carolinensis*	*12*	Chipping Sparrow	*Spizella passerina*	*1*
Downy Woodpecker	*Picoides pubescens*	*11*	Dark-eyed Junco	*Junco hyemalis*	*1*
Pine Siskin	*Spinus pinus*	*9*	Orange-crowned Warbler	*Vermivora celata*	*1*

Song Sparrow	*Melospiza melodia*	*8*	Red-breasted Nuthatch	*Sitta canadensis*	*1*
American Crow	*Corvus brachyrhynchos*	*7*	Swainson's Hawk	*Buteo swainsoni*	*1*
House Finch	*Haemorhous mexicanus*	*7*			
American Goldfinch	*Spinus tristis*	*6*	Hummingbird spp.	Trochilinae spp.	*2*
Baltimore Oriole*	*Icterus galbula**	*6*	Sparrow spp.	Passerellidae spp.	*2*
Red-eyed Vireo	Vireo olivaceus	*6*	Woodpecker spp.	Picidae spp.	*1*

Table 4: Breeding bird survey (June 27th 2020) – birds seen or heard between stations or further than 100m from survey points or flying overhead or

Heard or seen between stations or >100m from station					
Spotted Sandpiper	*Actitis macularius*	*5*	Canada Goose	*Branta canadensis*	*1*
American Goldfinch	*Spinus tristis*	*4*	Chipping Sparrow	*Spizella passerina*	*1*
Red-winged Blackbird	*Agelaius phoeniceus*	*4*	Dark-eyed Junco	*Junco hyemalis*	*1*
Wilson's Snipe	*Gallinago delicata*	*2*	Northern Flicker	*Colaptes auratus*	*1*
Alder Flycatcher	*Empidonax alnorum*	*1*	Savannah Sparrow	*Passerculus sandwichensis*	*1*
American Crow	*Corvus brachyrhynchos*	*1*	Song Sparrow	*Melospiza melodia*	*1*
American Robin	*Turdus migratorius*	*1*	Sora	*Porzana carolina*	*1*
American Wigeon	*Mareca americana*	*1*	Veery	*Catharus fuscescens*	*1*
Black-capped Chickadee	*Poecile atricapillus*	*1*	Western Wood Peewee*	*Contopus sordidulus**	*1*
Brown-headed Cowbird	*Molothrus ater*	*1*	White-breasted Nuthatch	*Sitta carolinensis*	*1*
Flyovers (above canopy)					
Franklin's Gull	*Leucophaeus pipixcan*	*228*	Bank Swallow	*Riparia riparia*	*1*
Cliff Swallow	*Petrochelidon pyrrhonota*	*50*	California Gull	*Larus californicus*	*1*
Tree Swallow	*Tachycineta bicolor*	*44*	Cooper's Hawk	*Accipiter cooperii*	*1*
Common Merganser	*Mergus merganser*	*4*	Double-crested Cormorant	*Phalacrocorax auritus*	*1*
Cedar Waxwing	*Bombycilla cedrorum*	*3*	Golden Eagle*	*Aquila chrysaetos**	*1*
Mallard	*Anas platyrhynchos*	*3*	Gull Species		*1*
Bald Eagle*	*Haliaeetus leucocephalus**	*2*	Swallow Species		*1*

3 species of 'sensitive' status were seen or heard during the survey (not including those seen flying overhead): Alder Flycatcher, Least Flycatcher and Baltimore Oriole, and one species that 'may-be-at-risk': The Western Wood-peewee ([2]Alberta Environment and Parks). Table 5 shows how this compares with previous years.

Table 5: birds of 'sensitive' or 'may-be-at-risk' recorded during surveys 2016 - 2020

	status	2016	2017	2018	2019	2020
Western Wood-peewee	may-be-at-risk	X	X		X	X
Bank Swallow	sensitive	X	X			
Alder Flycatcher	sensitive					X
Least Flycatcher	sensitive	X	X	X	X	X
Olive-sided flycatcher	sensitive			X		
Pileated Woodpecker	sensitive	X	X		X	
Baltimore Oriole	sensitive		X			X
Common Yellowthroat	sensitive		X			
Sora	sensitive		X			

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. A square transformation of the cumulative number of species was used for meeting the normality assumption of the linear regression residuals. The 2020 survey species per area regression follows the general function: CS=0.31A+17.0 (R^2=0.91), 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). In this case an average of 0.31 "new" species were recorded with each additional hectare surveyed. The 2020 slope value (0.31A) is markedly lower than the slope recorded for 2019 (0.44A). Additional surveys on subsequent years are necessary to identify if this represents a trend.

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 80 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 (see fig. 4).

Data from [3]eBird records for June and July 2020 show an additional 64 avian species were observed in the Weaselhead during this period (table 6).

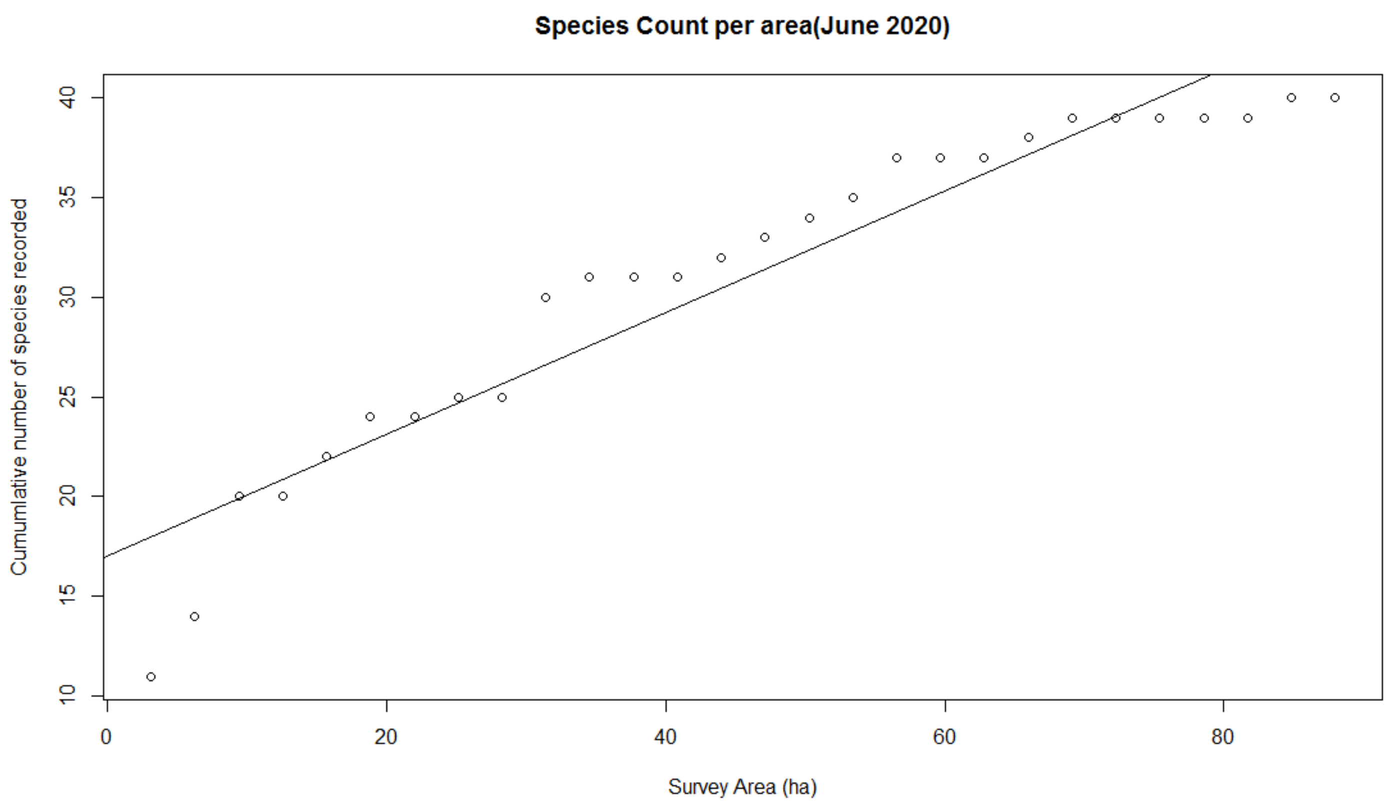

Figure 4: Regression model between cumulative number of species recorded and area, increasing in increments of 3.14ha (= area of a 100m-radius circle around stations in which observations were made)

Table 6: additional 64 species were observed and reported to eBird in June and July 2020 in the Weaselhead but not recorded during WGPPS survey ([3]eBird Basic Dataset Oct 2020); species indicated as *sensitive; ** may-be-at-risk Alberta Wild Species General Status Listing[2])

Common name	species	Common name	species
American Redstart	Setophaga ruticilla	Northern Rough-winged Swallow	Stelgidopteryx serripennis
American White Pelican	Pelecanus erythrorhynchos	Northern Shoveler	Spatula clypeata
Belted Kingfisher	Megaceryle alcyon	Northern Waterthrush	Parkesia noveboracensis
Black Tern*	Chlidonias niger*	Olive-sided Flycatcher**	Contopus cooperi**
Black-backed Woodpecker*	Picoides arcticus*	Osprey	Pandion haliaetus
Blue Jay	Cyanocitta cristata	Pileated Woodpecker*	Dryocopus pileatus*
Blue-headed Vireo	Vireo solitarius	Purple Finch	Haemorhous purpureus
Blue-winged Teal	Spatula discors	Redhead	Aythya americana
Boreal Chickadee	Poecile hudsonicus	Red-naped Sapsucker	Sphyrapicus nuchalis
Brown Creeper	Certhia americana	Red-tailed Hawk	Buteo jamaicensis
Bufflehead	Bucephala albeola	Ring-billed Gull	Larus delawarensis
Common Goldeneye	Bucephala clangula	Ring-necked Duck	Aythya collaris
Common Grackle	Quiscalus quiscula	Rock Pigeon	Columba livia
Common Loon	Gavia immer	Ruby-throated Hummingbird	Archilochus colubris
Common Yellowthroat*	Geothlypis trichas*	Ruffed Grouse	Bonasa umbellus
Eastern Kingbird*	Tyrannus tyrannus*	Rufous Hummingbird	Selasphorus rufus
Eastern Phoebe*	Sayornis phoebe*	Sharp-shinned Hawk	Accipiter striatus
Eurasian Collared-Dove	Streptopelia decaocto	Solitary Sandpiper	Tringa solitaria
European Starling	Sturnus vulgaris	Spotted Towhee	Pipilo maculatus
Gadwall	Mareca strepera	Swainson's Thrush	Catharus ustulatus
Great Blue Heron*	Ardea Herodias*	Tennessee Warbler	Leiothlypis peregrina
Hooded Merganser	Lophodytes cucullatus	Townsend's Warbler	Setophaga townsendi
House Sparrow	Passer domesticus	Trumpeter Swan*	Cygnus buccinator*
Killdeer	Charadrius vociferus	Turkey Vulture	Cathartes aura
Lesser Scaup	Aythya affinis	Vesper Sparrow	Pooecetes gramineus
Lincoln's Sparrow	Melospiza lincolnii	Violet-green Swallow	Tachycineta thalassina
Merlin	Falco columbarius	Warbling Vireo	Vireo gilvus
Mountain Chickadee	Poecile gambeli	Western Tanager*	Piranga ludoviciana*
Mourning Dove	Zenaida macroura	White-crowned Sparrow	Zonotrichia leucophrys
Nashville Warbler	Leiothlypis ruficapilla	White-winged Crossbill	Loxia leucoptera
Nelson's Sparrow	Ammospiza nelsoni	Yellow-bellied Sapsucker	Sphyrapicus varius
Northern Harrier	Circus hudsonius	Yellow-rumped Warbler	Setophaga coronata

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 sound level meter (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 and 3:30 – 6:30 pm) on 2nd July 2020. Levels were measured at the same points (stations) as used in the breeding bird survey (table 2, fig. 3). On each site, the sound level was measured for 2 minutes. The results are shown in table 7. *(Note: 'maximum' and 'minimum' refer to levels calculated from the square root of the mean of the squares of the values within the time period; 'peak' is the instantaneous maximum value reached by the sound pressure wave.)*

Table 7: Sound pressure measured in peak traffic hours for 2020 (minimum, maximum, average and peak)

	Date	Time (UCT-6)		Sound Pressure (dB)		
			Avg*	Max	Min	Peak
P1	02-Jul-20	9:10	55.5	55.8	55.3	68.0
P2	02-Jul-20	18:00	55.4	55.5	55.3	63.6
P3	02-Jul-20	7:28	55.4	55.4	55.3	66.6
P4	02-Jul-20	8:37	55.3	55.3	55.3	62.9
P5	02-Jul-20	9:00	55.5	55.7	55.3	62.9
P6	02-Jul-20	9:29	55.8	56.2	55.4	65.3
P7	02-Jul-20	17:42	56.5	57.1	55.9	63.9
P8	02-Jul-20	17:49	55.4	55.6	55.3	59.8
P9	02-Jul-20	17:24	56.5	57.2	55.9	62.9
P10	02-Jul-20	17:36	57.0	57.8	56.2	63.9
P11	02-Jul-20	18:19	56.3	56.9	55.7	60.6
P12	02-Jul-20	8:03	56.7	57.5	56.0	63.4
P13	02-Jul-20	18:08	55.4	55.5	55.3	60.1
P14	02-Jul-20	7:20	56.1	56.6	55.5	67.4
P15	02-Jul-20	7:48	55.4	55.4	55.3	63.2
P16	02-Jul-20	6:39	55.5	55.7	55.3	66.2
P17	02-Jul-20	6:50	57.1	57.9	56.3	65.7
P18	02-Jul-20	7:01	55.4	55.4	55.3	62.9
P19	02-Jul-20	16:52	55.5	55.6	55.3	62.7
P20	02-Jul-20	17:01	55.5	55.6	55.3	61.9
P21	02-Jul-20	17:12	55.4	55.5	55.3	64.4
P22	02-Jul-20	16:45	56.8	57.6	56.1	60.6
P23	02-Jul-20	16:32	56.6	57.3	55.8	64.3
P24	02-Jul-20	16:21	56.7	57.6	55.9	64.5
P25	02-Jul-20	16:08	55.3	55.3	55.3	62.7
P26	02-Jul-20	15:40	56.6	57.2	55.9	61.8
P27	02-Jul-20	15:58	55.6	55.8	55.3	62.5
P28	02-Jul-20	15:25	55.3	55.3	55.3	59.9

When the values observed between 2016 and 2020 (figure 5) are compared by analysis of variance, the minimum decibel levels recorded were significantly higher after completion of the SWCRR construction in 2020 (Tukey multiple comparison of means, ANOVA, df= 4, 131, $p<0.01$). Possible SWCRR background car traffic noise is reflected in the increased of minimum sound levels.

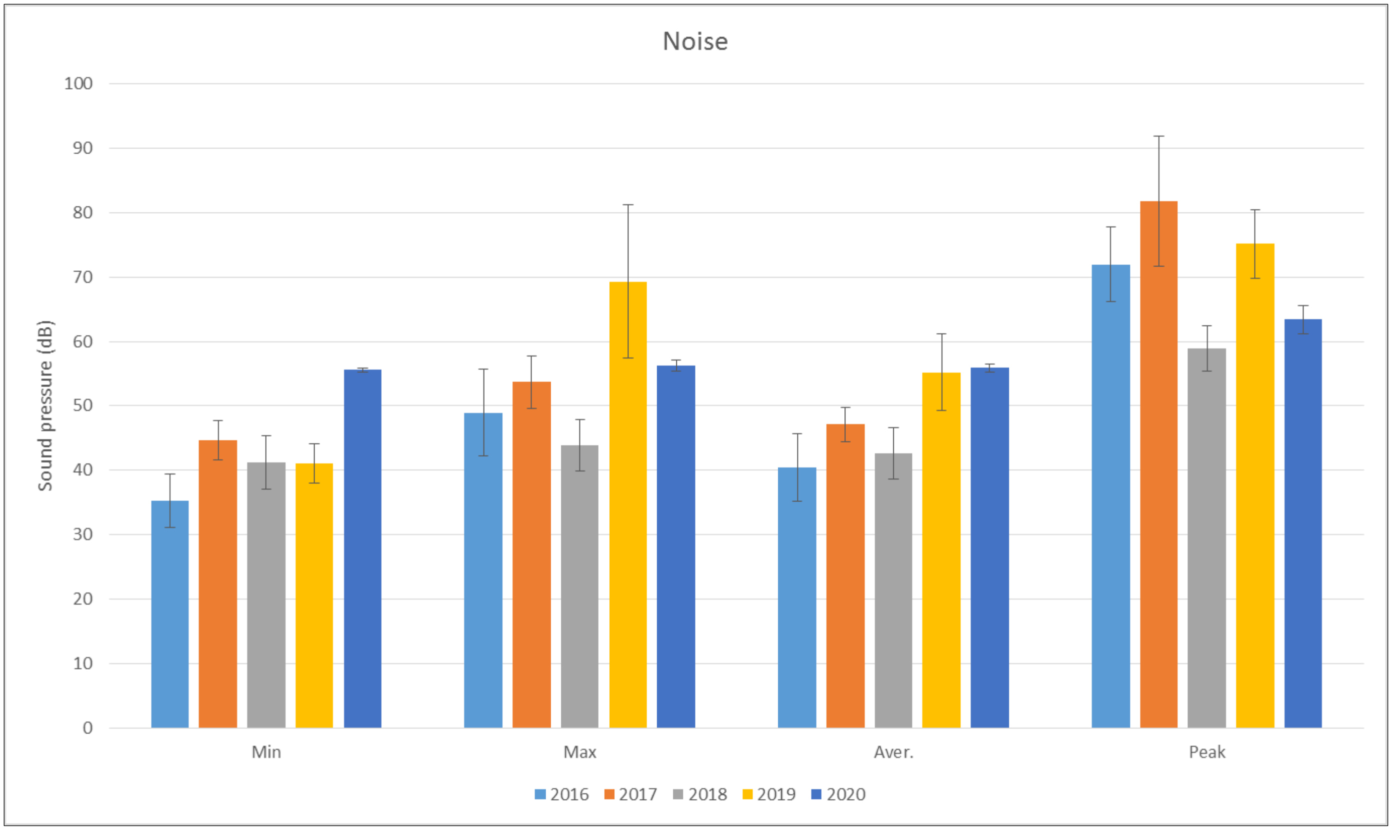

Figure 5: Sound levels measured in the Weaselhead from 2016 to 2020 the error bars represent ± standard deviation).

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 (fig. 6). The results for 2020 are detailed below. The same protocol and site were used as in 2015 to 2019. The assessments from the first 3 years included only flowering plants in the clade 'eudicots'. From 2018 on, estimates of % cover of graminoids and moss have been included as supplemental data. In 2019 and 2020 monocots in the orchid and lily families were found during the survey (and the title of the table of results amended to "vascular plants").

Figure 6: green line shows location of 50m transect used for vegetation survey on the north bank of the beaver Pond; orange line shows Weaselhead boundary

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 (fig. 7). 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. These 15 quadrats represent samples from the Beaver Pond riparian vegetation. On September 12th and 13th 2020 each selected quadrat was comprehensively screened, and individual vascular plants present counted and identified to species level (table 8). 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 9)

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 7: 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 (numbers 4, 7, 9, 13, 14, 17, 20, 24, 25, 36, 37, 40, 44, 47, 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 summarised in Table 8, and information on the [5]USDA wetland classification for ‘Great Plains’ region provided where available.

Table 8: 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
Rosa acicularis	Prickly Rose	14	17.1	FACU
*Cirsium arvense**	Creeping Thistle*	14	10.8	FACU
Viola canadensis	Canada Violet	13	17.2	FACU
Anemone canadensis	Canada Anemone	11	4.7	FACW
Galium boreale	Northern Bedstraw	11	4.1	FACU
Solidago gigantea	Giant Goldenrod	10	18.6	FAC
Amelanchier alnifolia	Saskatoon	10	4.9	FACU
Cornus sericea	Red-Osier Dogwood	10	2.7	_
Symphyotrichum ciliolatum	Lindleys Aster	9	42.4	_
Monarda fistulosa	Wild Bergamot	9	16.0	UPL
*Sonchus arvensis**	Field Sow Thistle*	9	10.6	FAC
Thalictrum venulosum	Veiny Meadow Rue	9	4.9	FAC
Fragaria virginiana	Wild Strawberry	8	26.0	FACU
Symphoricarpos albus	Snowberry	7	11.4	UPL
Antennaria pulcherrima	Showy Everlasting	7	9.4	_
Arctostaphylos uva-ursi	Bearberry	7	8.3	UPL
Senecio pauperculus	Balsam Groundsel	7	5.6	FAC
Elaeagnus commutata	Silverberry	7	3.6	UPL
Potentilla fruticosa	Shrubby cinquefoil, Potentilla	7	2.3	FACW
Persicaria amphibia var. stipulacea	Water smartweed	6	28.0	_
Rubus pubescens	Trailing Raspberry	6	16.0	FACW
Pyrola asarifolia	Common Pink Wintergreen	6	14.0	FACU
Taraxacum officinale[nn]	Common Dandelion[nn]	6	2.0	FACU
Betula occidentalis	Water Birch	6	1.7	FACW
Mentha arvensis	Wild Mint	5	3.0	FACW
Vicia americana	American Vetch	5	1.2	FACU
Salix bebbiana	Bebb's Willow	5	1.2	FACW
Aster hesperium	Western Willow Aster	4	11.5	_
Symphoricarpos occidentalis	Buckbrush	4	6.3	UPL
Salix pseudomonticola	False Mountain Willow	4	1.5	FACW
Lonicera dioica	Twining Honeysuckle	4	1.3	FACU
Scutellaria galericulata	Skullcap	3	6.3	OBL
Shepherdia canadensis	Buffaloberry	3	2.7	FACU
Heracleum maximum	Cow Parsnip	3	1.3	FAC
Achillea millefolium	Common Yarrow	2	4.0	FACU
Mertensia paniculata	Tall lungwort	2	3.5	_
Zizia aptera	Heart-leaved Alexanders	2	3.0	FAC
Stachys pilosa	Hairy Hedgenettle	2	2.5	FACW
Sanicula marilandica	Maryland Sanicle	2	1.0	FACU
Viburnum trilobum	Highbush Cranberry	2	1.0	_
Rhamnus cathartica	Buckthorn	2	1.0	FACU
Ribes oxyacanthoides	Wild Gooseberry	1	5.0	FACU
Solidago canadensis	Canada Goldenrod	1	4.0	FACU

Actaea rubra	Baneberry	1	1.0	FACU
Geum aleppicum	Yellow Avens	1	1.0	FACU
Plantago major	Plantain	1	1.0	FAC
Sorbus aucuparia[nn]	European Mountain Ash[nn]	1	1.0	_
Cotoneaster lucidus[nn]	Shiny Cotoneaster[nn]	1	1.0	_
Prunus virginiana	Chokecherry	1	1.0	FACU
Vascular plants – other	**common name**	**occurrence**	**abundance**	
Equisetum sp	Horsetail	1	1.0	_
Picea glauca	White Spruce	9	7.3	FACU
Vascular plants – monocots (excluding gamminoids)	**common name**	**occurrence**	**abundance**	
Maianthemum stellatum	Solomon's Seal	9	2.4	FACU
Toxicoscordion venenosum	Death Camus	1	6.0	FAC
Orchidacea	orchid species, unable to be further identified	1	3.0	_

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*

Table 9: **occurrence and** estimated % cover of graminoids and byrophytes *(occurrence = total number of quadrats with presence of either taxa;* mean percentage cover = mean of % cover in occupied quadrats *)*

Graminoids (Poaceae and Cyperaceae)		**occurrence**	**mean % cover**	
Calamagrostis canadensis/ C. inexpansa	Canada Reed Grass/ Northern Reed Grass	14	<6%	FACW+_
Poa pratensis[nn]*/Poa palustris/Agrostis stolonifera*	Kentucky Blue Grass[nn], Fowl Blue Grass and Creeping bentgrass	12	<8%	FACU+FACW +FACW
Carex utriculata/Carex capillaris	Small Bottle Sedge/Hair-Like Sedge	10	(incomplete data)	OBL+FACW
Typha latifolia	Cattail	4	4.8	OBL
Juncus balticus	Baltic Rush	4	<3%	FACW
Carex atherodes	Wheat Sedge	3	<4%	OBL
Bromus inermis[nn]	Smooth Brome[nn]	1	<1%	UPL
Bromus ciliatus	Fringed Brome	1	<1%	FAC
Bryophytes	Moss Cover %	13	<19%	

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*

Species diversity of eudicots: The 2020 results show a total taxa richness of 49 species of eudicot plants found in the total area surveyed, 60m^2 (15 quadrats x 4m^2 per quadrat). Lindley's Aster (*Symphyotrichum ciliolatum*) was the dominant species in the area surveyed, comprising 14.2% 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 80.7%±12.9% per quadrat (2m x 2m) in 2020. Figure 8 compares Simpson's Diversity Index (1-S) per quadrat across the 2015 to 2020 sampling campaigns. The diversity has not changed significantly in this period (Kruskal-Wallis rank sum test df = 5, $p>0.05$)

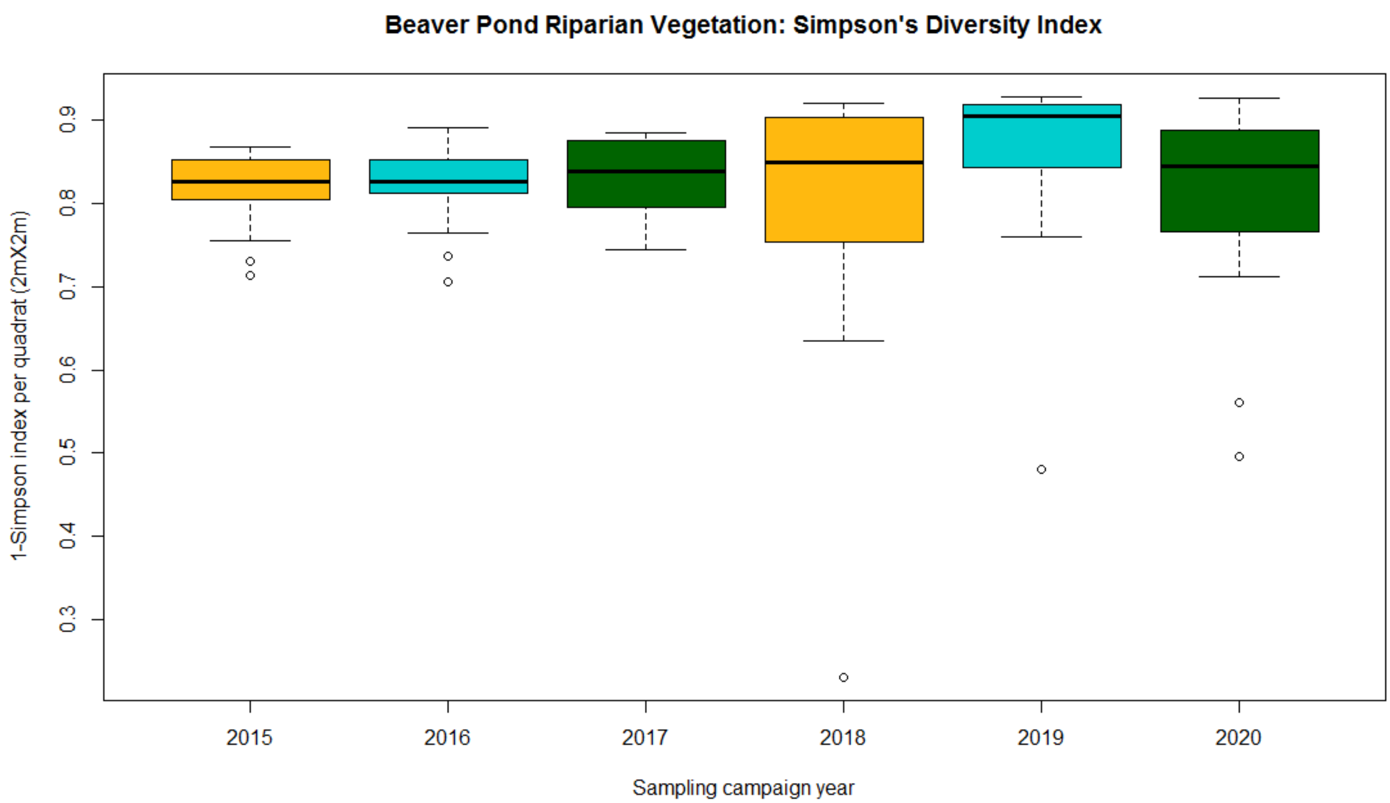

Figure 8: Simpson's Diversity Index (1-S) per quadrat for 2015 to 2020 sampling campaigns.

Species richness of eudicots: 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 2020 (Kruskal-Wallis rank sum test df = 5, $p<0.05$).

The measured mean of eudicot species per square meter along the shore of the Beaver Pond in 2020 was 4.52±1.91 species/m^2, (n=15). Figure 9 compares eudicots species richness per square meter between 2015 and 2020 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 highly 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. Additional data from future years will help to clarify if there is any quantifiable trend in the data.

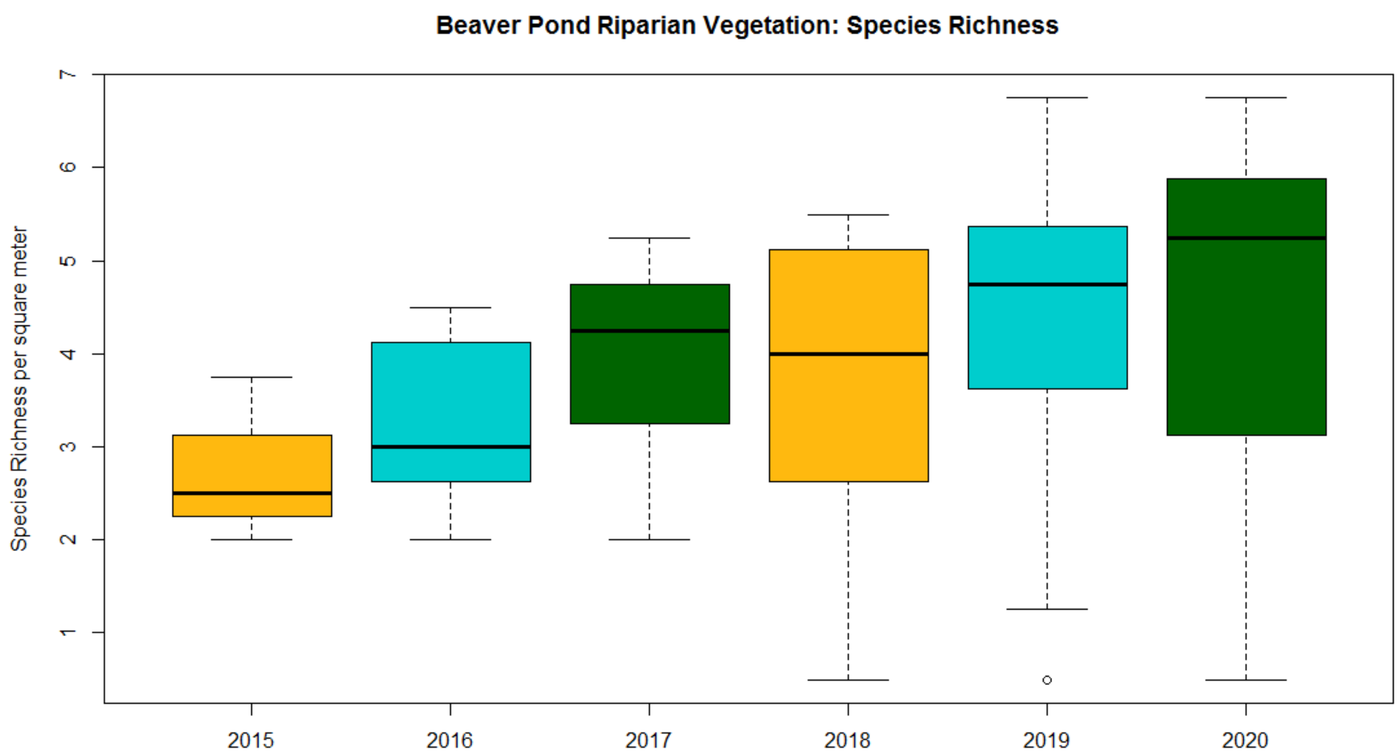

Figure 9: Eudicots species richness per square meter for 2015 to 2020 sampling campaigns.

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 positioned facing the wildlife passages under the SWCRR (cameras 96 and 97, fig. 10). These passages run along each bank of the Elbow River where the SWCRR crosses it on 3 parallel bridges that carry the north and south carriageways and local road (see fig. 12, 13 and 14). It is anticipated results from '*Calgary Captured*' will give 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 identify wildlife approaching the wildlife passages. A preliminary list of species captured by these cameras is shown in table 12*,* including bobcats, moose, black bears, coyotes, a racoon, and white-tailed deer. (Full analysis of the *'Calgary Captured'* data is not expected till later in the project. 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])

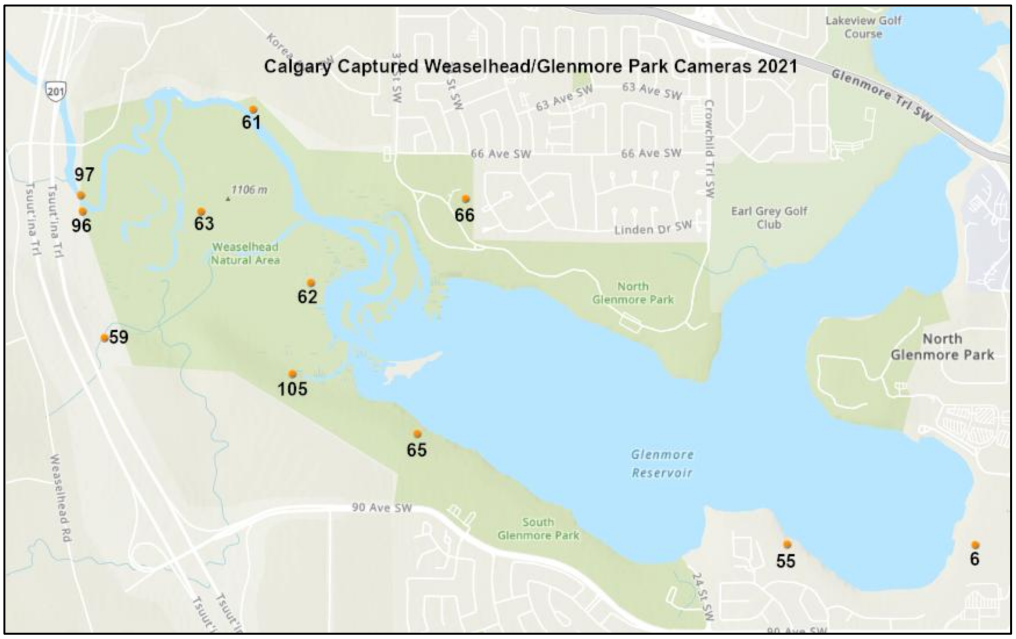

Figure 10: location of '*Calgary Captured'* cameras Feb. 2021 (note – some cameras were replaced and some moved between 2019 and 2020); Weaselhead and Glenmore Parks shown in green, Glenmore Reservoir in blue.

Table 10: species identified in camera-trap photographs in 2020; * indicates photos of young and/or adult with young.

	bobcat		white-tailed deer		moose		Black bear		coyote		cougar		racoon	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Jan														
Feb	X	X												
Mar	X								X	X				
Apr	X		X		X			X	X					
May			X			X*			X					
Jun			X*	X*	X*	X			X	X				
Jul		X	X	X*	X	X								
Aug			X		X	X*	X							
Sep	X			X			X	X		X	X			
Oct						X	X							
Nov		X								X				X
Dec		X												

In a separate study for Alberta Transport (AT) Golder Associates is monitoring use of the wildlife underpasses. Each bank of the river is checked for signs of use (e.g. tracks, scat) every month. The 2020 reports showed large mammal presence (domestic dog, beaver, mink, cougar, deer, coyote) to the east and west of the Elbow River Crossing: however, signs of animals under or between the bridges were much fewer (fig. 11; table11). A *'Calgary Captured'* camera photographed a moose on May 18th moving along the bank of the river towards the Crossing but it is uncertain whether it used the passage under the SWCRR to leave the park and move upstream (no moose tracks were found under the bridges when Golder staff carried out monitoring on 26th May).

Table11: tracks observed in wildlife corridors under one or more bridges, recorded by Golder Associates during monthly monitoring (grey columns are 2019 records, white columns are 2020 records)

	Jan.		Feb		March		April		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.		*total*	
	'19	**'20**	'19	**'20**	'19	**'20**	'19	**'20**	'19	**'20**	'19	**'20**	'19	**'20**	'19	**'20**	'19	**'20**	'19	**'20**	'19	**'20**	'19	**'20**	'19	***'20***
small mammals	x				x		x																		*3*	***0***
mink													x				x								*2*	***0***
domestic dog		**X**			x	**X**																	x		*2*	***2***
deer								**X**															x		*1*	***1***
beaver													x												*1*	***0***
coyote		**X?**																				**X**		**X**		***3***
white-tailed jackrabbit																								**X**		***1***
human		**X**			x																				*1*	***1***

Reluctance to go under the bridges may be because of the active construction noted by Golder on, under, or adjacent to the bridges in all months except October and November 2020, and because vegetation is still sparse in areas (June report). Wildlife use may also have been missed in some months when conditions were not conducive to tracking. However tracks observed in April suggesting a deer, and in November and December showing coyotes passed under the bridges may be a sign that use of the underpasses will increase now construction is completed, once vegetation re-grows, and animals become more used to the changes.

The presence of large mammals such as moose and black bear that require more resources than available in the Weaselhead suggest animals may be crossing the highway to access habitat to the west. Reports of deer, coyotes and moose on the road sides and of several wildlife collisions were received by the Society in the months following the road opening in October 2020. Wildlife fencing intended to prevent access to the SWCRR and to direct animals to the wildlife passages (fig. 11, fig. 12 and fig. 13) unfortunately was not installed in 2020 despite the road opening to traffic in October.

Figure 11: looking west (upstream) under SWCRR; wildlife underpasses on left and right bank; October 2020

Figure 12: View looking Southeast over the SWCRR showing the wildlife corridors in October 2020. (Image taken from http://www.swcrrproject.com/wp-content/uploads/2020/10/elbow-river.jpgFindings).

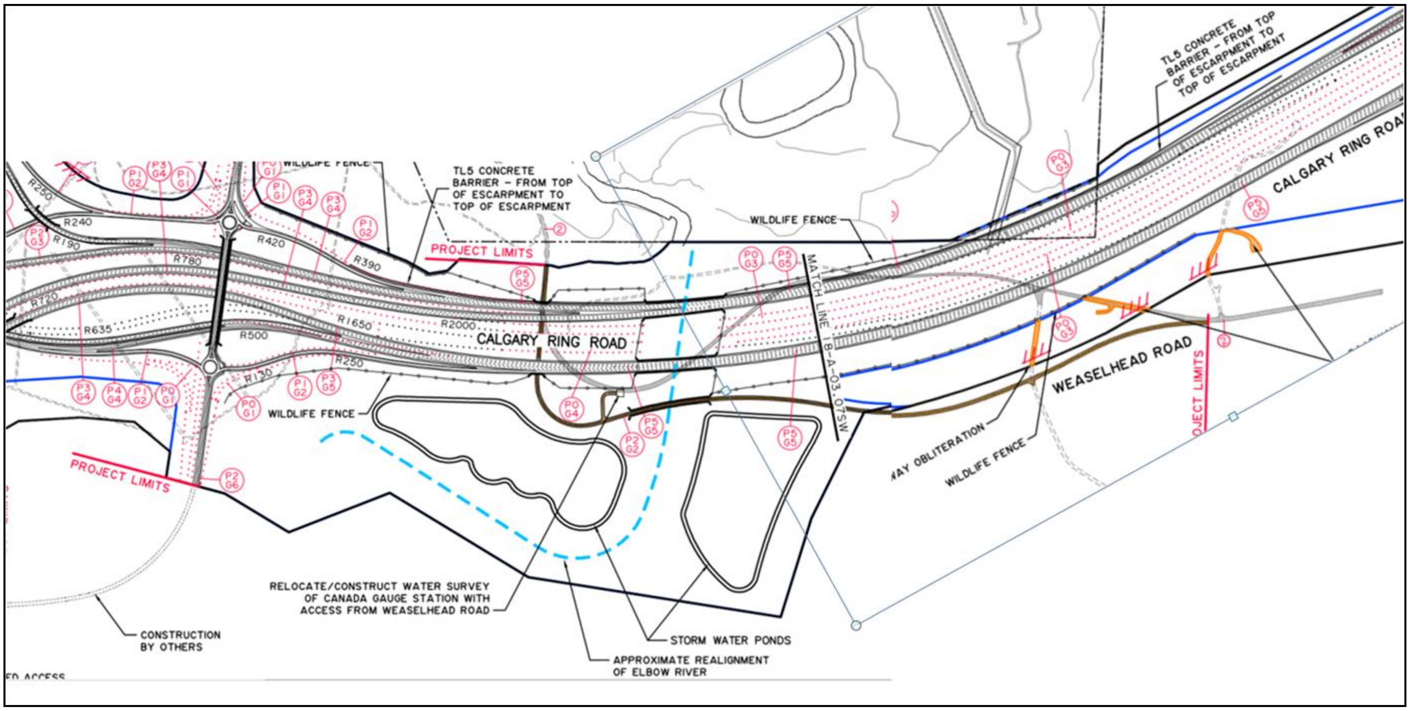

Figure 13: plan showing wildlife fencing along SWCRR in Elbow Valley to prevent access to road and direct wildlife to underpasses (image is orientated with north to left of page, Tsuut'ina Reserve lands 'below' the road and the Weaselhead 'above') [9]SWCRR DBFO Schedule 18 Appendix A pages 22 & 23

Animals reluctant to cross the highway and unable to find (or unwilling to enter) the wildlife passages under the SWCRR may move from the Weaselhead and adjacent Glenmore Parks into surrounding communities to look for resources. A small black bear (possibly the one caught on the *Calgary Captured* cameras in September) was reported by a homeowner ~300m from the park entrance feeding from a bird-feeder on October 18th. The bear was treed by police, tranquillised, and relocated by Fish and Wildlife officers (fig. 14).

Figure 14: black bear on ground after being tranquilized; downloaded from CTV news; photo by Brad Davis https://calgary.ctvnews.ca/black-bear-spotted-dining-on-birdseed-on-porch-of-calgary-home-1.5152171

2. 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. Water quality in an additional wetland, Clearwater Pond, was also assessed. This last habitat is in the Elbow Valley but is upstream of the SWCRR construction zone and not located in the Weaselhead (fig. 15). It is intended to represent a reference site. The Beaver Pond is in immediate proximity to the SWCRR. The Beaver Lagoon with which it is hydrologically connected is further downstream. A drainage plan designed by the SWCRR contractor, KGL (fig. 18) aims to maintain surface flow to these wetlands during and post SWCRR construction.

Water quality data was collected from 2015 to 2020 from 3 sites in each of the three wetlands and from the Elbow River (figs. 16 and 17; table 12). Four additional sample sites were added in 2018: another sample site in each cell (BP4 and BP5) and a sample site (SB and RC) in each of the two intermittent streams that flow into the wetland. Ravine Creek feeds into the east cell of the Beaver Pond and Spring Brook into the west cell. Both these streams have been impacted by construction of the SWCRR across their catchment areas (fig. 18). One of the wetlands, the Beaver Pond, is split into two cells connected by a culvert under a paved pathway.

These wetlands are upstream of the Glenmore Reservoir and dam. In Sept. 2020 the City of Calgary completed updates to the dam to increase the storage capacity of the reservoir. This has resulted in significantly higher water levels in the reservoir than in previous years, with the high levels anticipated to last from June to late fall. In 2021 the Beaver Lagoon water level was increased by ~1.8m for this period.

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; scale: yellow line = 100m

Table 12: Geographic coordinates of water quality monitoring sampling sites

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

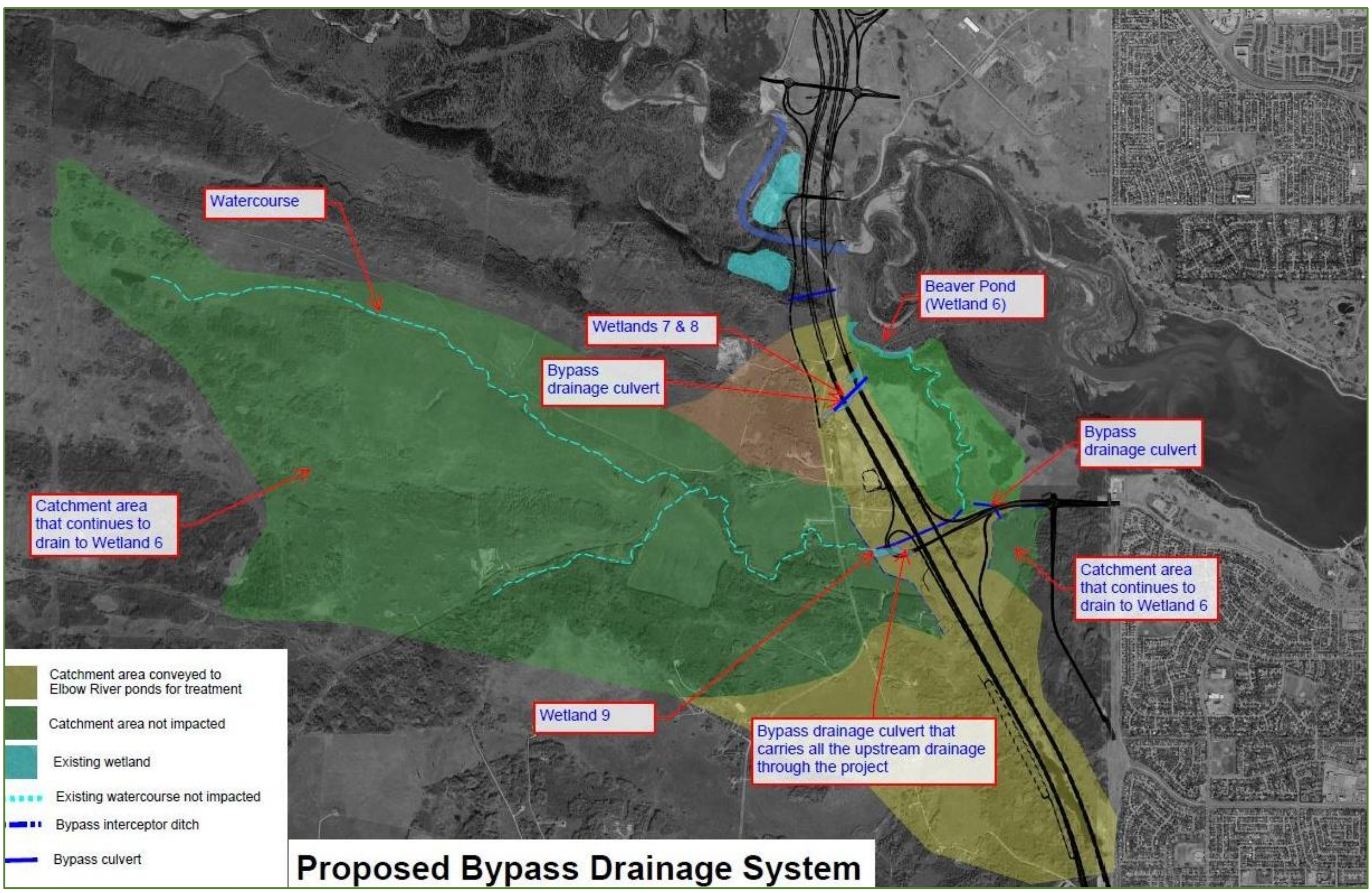

Figure 18: bypass drainage for Spring Brook (northern culvert) and Ravine Creek (southern culvert) intended to maintain surface flow across the Transportation Utility Corridor into the Beaver Pond (*Sept. 201, courtesy of KGL – construction company for the SWCRR)*

Water sampling and in-situ assessments were performed on 27th Aug. and 15th Oct. 2020. A YSI® Pro Plus was used to measure temperature, turbidity, conductivity, pH, and dissolved oxygen; a turbidity tube was used to measure turbidity; and an YSI 9300 Photometer to measure phosphate, chloride salts and nitrate. Water quality data are shown in tables 13 and 14. Table 15 shows the summary statistics for temperature, pH, conductivity, dissolved oxygen, phosphate and chloride.

Statistical hypothesis tests (linear regression analysis) were only conducted for the parameters that were recorded using the same method since the start of the Study in 2016: conductivity, chloride, pH, phosphorous, dissolved oxygen and temperature. Results are discussed separately below.

Table 13: Water quality parameters on August 27 2020

	Water body / Site														
field: August 27th, 2020	Beaver Pond					Beaver Lagoon			Elbow River	Clearwater Pond			Beaver Pond Feeder Streams		
Parameters	**BP1**	**BP2**	**BP3**	**BP4**	**BP5**	**BL1**	**BL2**	**BL3**	**ELR**	**CP1**	**CP2**	**CP3**	**Ravine Creek (eastern)**	**Spring Brook (western)**	**Before Dam**
Turbidity (TDS)*	0.41	0.50	0.41	0.51	0.44	0.28	0.25	0.29	0.29	0.16	0.16	0.15	0.72	0.50	0.57
Turbidity (cm)*	54.00	42.00	29.10	93.00	51.00	120+	120+	120+	120+	120+	120+	86.00		88.00	61.10
Temperature (°C)	15.20	14.16	13.96	13.11	15.91	15.34	16.37	15.36	12.73	19.37	19.41	17.39	10.93	9.94	9.75
pH	7.97	7.88	7.03	7.79	3.84	9.34	7.74	7.94	7.44	9.06	9.18	9.35	7.07	8.38	7.18
Conductivity (- C (µS/cm)	636.00	773.00	629.67	605.33	673.00	356.33	359.00	342.00	338.00	225.00	223.00	197.67	672.67	550.00	628.33
DO (mg/L)	3.41	5.77	4.20	3.52	3.84	9.34	8.11	9.06	12.28	12.66	10.66	8.40	2.53	7.72	3.88
DO (%)	34.87	58.43	41.67	34.20	39.10	94.57	83.37	90.97	122.83	137.87	116.97	89.27	23.90	69.37	34.93
Phosphate (mg/L PO4)**	0.00	0.01	0.03	<<	0	0.03	0.02	0	0.04	0.00	<<	0.00	0.12	0.07	
Chloride (mg/L Cl)**	5.00	4.00	1.00	4.00	11.00	3.00	4.00	5.00	2.00	8.00	14.00	5.00	5.00	5.00	
Salinity (ppm)	0.31	0.37	0.29	0.39	0.38	0.21	0.21	0.21	0.21	0.12	0.12	0.11	0.45	0.37	0.43
Nitrate (mg/L NO3)															
Nitrate (mg/L N)**	0.205	0.115	0.389	0.113	0.705	0.165	0.155	0.225	0.224	0.161	0.128	0.151	0.515	0.301	

Table 14: Water quality parameters on October 15 2020

	Water body / Site													
field: October 15th, 2020	Beaver Pond					Beaver Lagoon			Elbow River	Clearwater Pond			Beaver Pond Feeder Streams	
Parameters	**BP1**	**BP2**	**BP3**	**BP4**	**BP5**	**BL1**	**BL2**	**BL3**	**ELR**	**CP1**	**CP2**	**CP3**	**Ravine Creek (eastern) *******	**Spring Brook (western)**
Turbidity (TDS g/L)*	0.49	0.51	0.49	0.48	0.50	0.30	0.34	0.30	0.29	0.20	0.20	0.19	0.62	0.50
Turbidity (cm)*	14.00	9.50	22.00	16.00	19.00	>120	>120	>120	>120	>120	>120	>120	98.00	>120
Temperature (°C)	3.34	2.33	4.08	3.22	5.53	5.77	5.82	5.06	4.35	5.53	5.30	4.58	1.66	2.36
pH	7.72	8.08	7.65	8.13	8.07	7.21	7.50	7.48	7.12	8.54	8.52	8.85	7.31	8.40
Conductivity (- C (µS/cm)	438.33	442.33	454.33	431.67	486.00	293.00	327.33	283.00	274.00	193.67	196.00	176.33	531.67	436.33
DO (mg/L)	6.91	13.00	7.44	13.04	8.04	12.37	9.27	12.30	12.97	16.21	14.84	16.93	7.22	19.47
DO (%)**	52.10	95.97	57.17	99.13	62.40	100.67	75.13	97.97	100.67	121.97	109.90	126.73	48.83	147.03
Phosphate (mg/L PO4)	0.00	<<	<<	0.03	0.02	0.02	0.00	0.01	<<	0.05	0.01	0.01	0.10	0.04
Chloride (mg/L Cl)	24.00	6.00	8.00	4.00	6.00	2.00	3.00	2.00	0.00	0.00	0.00	6.00	7.00	13.00
Salinity (ppm)***														
Nitrate (mg/L NO3)														
Nitrate (mg/L N)	0.52	0.45	0.95	0.58	0.43	0.16	0.36	0.72	0.42	0.19	0.17	0.14	0.61	0.53

Table 15: 2020 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).

	site	number of replicates	assessment date (2020)	temperature (°C)	pH	conductivity (µS/cm)	DO (%)	phosphate PO4 (mg/L)	chloride (mg/L)
Beaver Pond	BP	3	Aug. 27	14.4 (±0.4)	7.6 (±0.3)	680 (±47)	45 (±7)	0.01 (±0.01)	3.33 (±1.20)
		5	Oct. 15	3.7 (±0.5)	7.9 (±0.1)	451 (±10)	73 (±10)	0.02 (±0.01)	9.60 (±3.66)
Beaver Lagoon	BL	3	Aug. 27	15.7 (±0.3)	8.3 (±0.5)	352 (±5)	90 (±3)	0.02 (±0.01)	4.00 (±0.58)
		3	Oct. 15	5.6 (±0.2)	7.4 (±0.1)	301 (±13)	91 (±8)	0.01 (±0.01)	2.33 (±0.33)
Clearwater Pond	CP	3	Aug. 27	18.7 (±0.7)	9.2 (±0.1)	215 (±9)	115 (±14)	0.00 (±0.00)	9.00 (±2.65)
		3	Oct. 15	5.1 (±0.3)	8.6 (±0.1)	(±6)	120(±5)	0.02 (±0.01)	2.00 (±2.00)

(Note: monitoring of water quality and water flow in the Beaver Pond (referred to as 'wetland 06') was also carried out in 2020 by Hemmera Envirochem Inc. on 28th May and 15th Oct. The 2020 [10]Wetland 06 Annual Water Monitoring Report found elevated zinc concentrations in Spring Brook. It suggests the galvanised culvert that carries this watercourse under the SWCRR may be the source. Further monitoring will be carried out by the consultant.)

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 Oct. 2018 turbidity was measured in NTU using a YSI ProPlus. From Oct. 2018 on the transparency of the water was measured using 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 16, below gives a qualitative rather than quantitative picture of turbidity in the monitored wetlands over the period of the Study.

Table 16: turbidity levels recorded from 2015 to 2020

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

No significant change in turbidity was recorded before 2018 ([13]Enivironmental Monitoring Report 2018, WGPPS). Very high levels of turbidity were recorded intermittently in all three wetlands in 2018, and again in Oct. 2020 turbidity recorded in the Beaver Pond was high (statistical testing of the data was not possible).

(Note: the 2020 [10]Wetland 06 Annual Water Monitoring Report by Hemmera Envirochem (see p.26) also found turbidity higher than historic measurements taken in 2016 and 2017.)

ii) <u>Temperature</u>

Regression analysis of data from the Beaver Pond, Beaver Lagoon and Clearwater Pond for the period 2015 to 2020 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 from 2015 to 2020, see figure 19. However temperature of the wetlands are 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 on in October) as in this study are probably inadequate to measure slow progressive temperature trends.

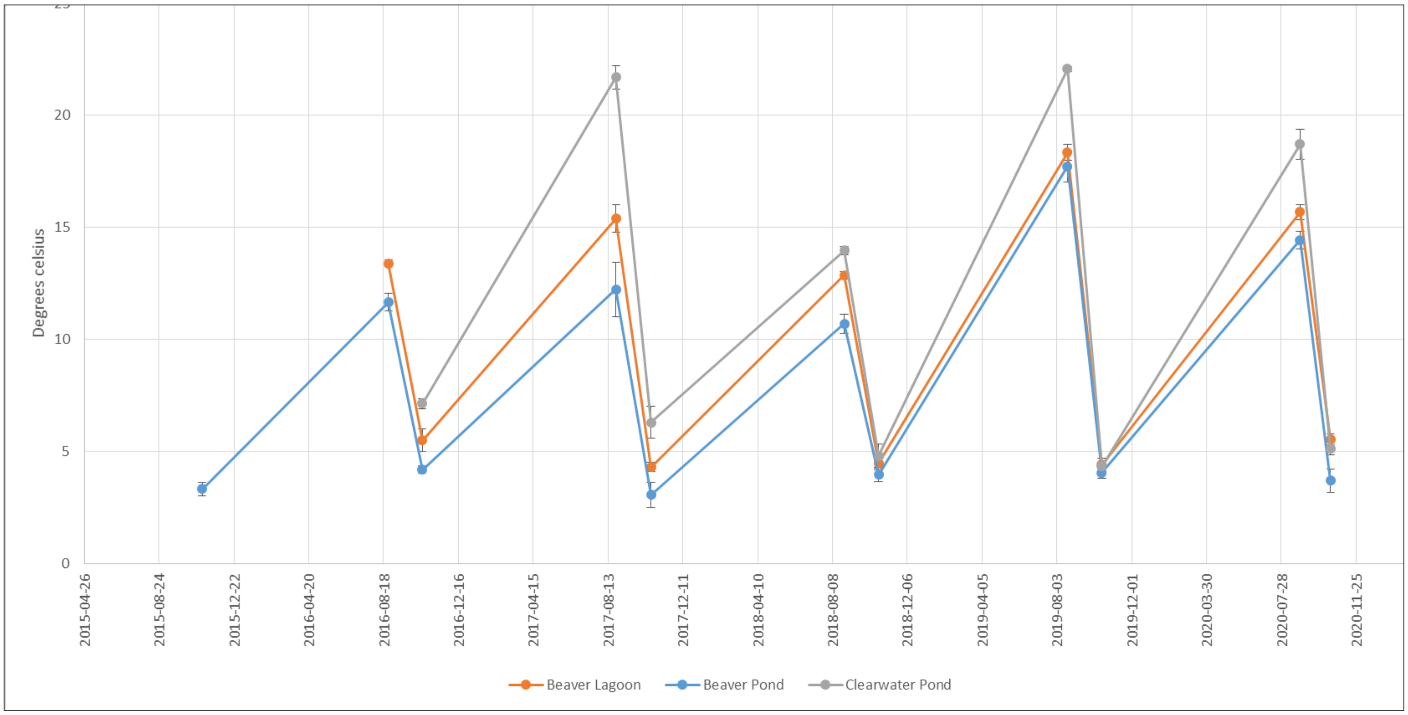

Figure 19: Temperature recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) between 2015 and 2020.

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 for the period between 2016 and 2020 revealed a significant increase in pH with year (linear regression, d.f.= 39, $p<0.05$). During the same period, the reference wetland (Clearwater Pond) and the Beaver Lagoon have not showed any association between pH and time (linear regression, d.f.=3, $p>0.05$). See figure 20.

(Note: the 2020 [10]Wetland 06 Annual Water Monitoring Report by Hemmera Envirochem (see p.26) also found pH higher in the Beaver Pond than historic measurements taken in 2016 and 2017.)

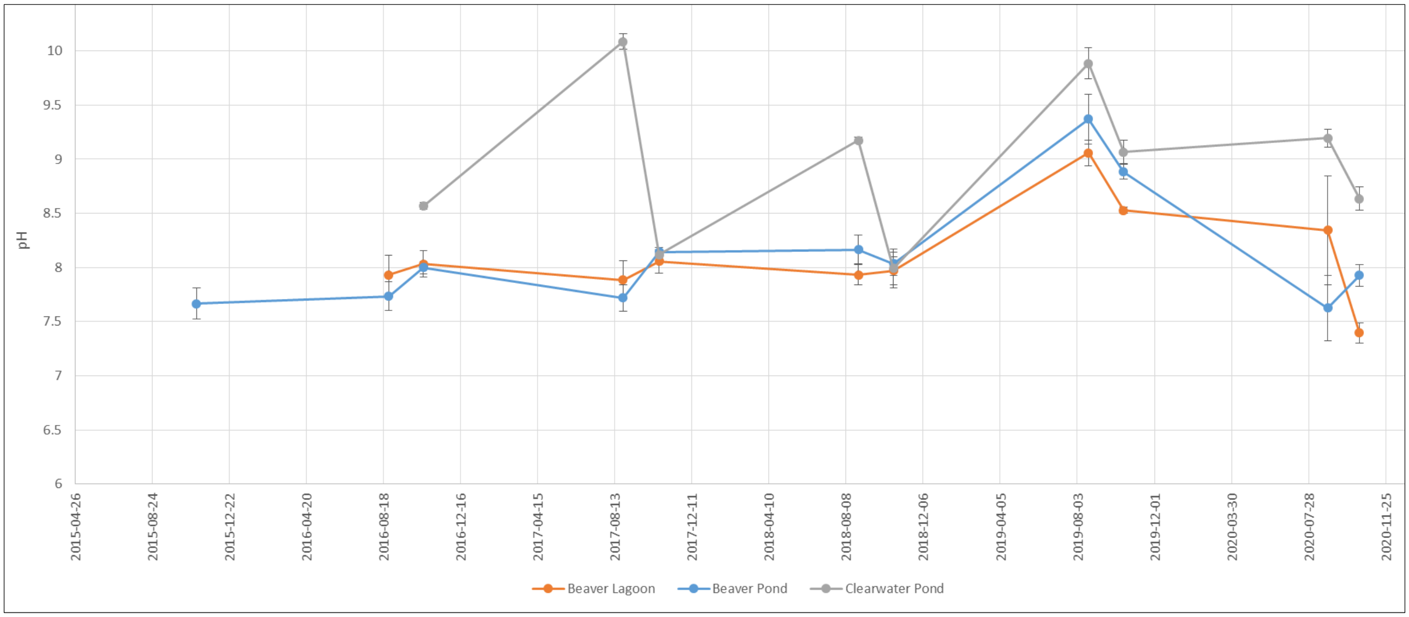

Figure 20: pH recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP) between 2015 and 2020.

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 2020 revealed a significant increase in conductivity over time (linear regression, d.f.=39 (Beaver Pond), $p<0.05$). During the same period, the reference wetland (Clearwater Pond) and the Beaver Lagoon have not showed any association between conductivity and time (linear regression, $p>0.05$). See figure 21.

Conductivity fluctuations in the Beaver Pond between 2015 and 2020 shows the average conductivity levels were typically below 600 uS/cm until 2018 when they peaked, and that averages in both wetlands have remained above 600 uS/cm until summer 2020. A drop to values below 600 uS/cm was observed in fall 2020. In contrast, during this period the reference wetland upstream of the SWCRR development has shown no significant increase in conductivity. For comparison the months when major sediment spills occurred into the Beaver Pond are noted on the chart.

(Note: the 2020 [10]Wetland 06 Annual Water Monitoring Report by Hemmera Envirochem (see p.26) also found conductivity higher in the Beaver Pond than historic measurements taken in 2016 and 2017.)

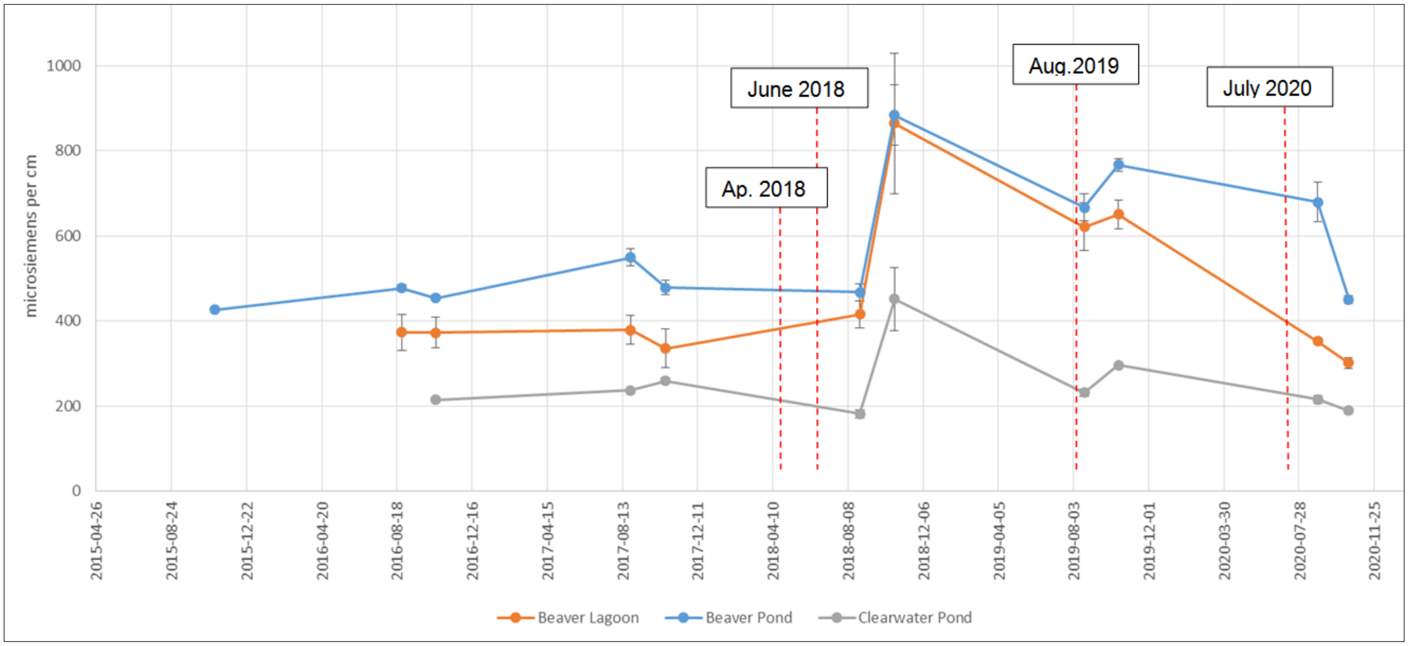

Figure 21: Conductivity recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) between 2015 and 2020, and months of major sediment spills from the construction site into BP

v) <u>Dissolved Oxygen</u>

Regression analysis of data from Beaver Pond, Beaver Lagoon and Clearwater Pond, 2015 to 2020, does not show any association between dissolved oxygen (DO) and time (linear regression, $p>0.05$). See fig. 22.

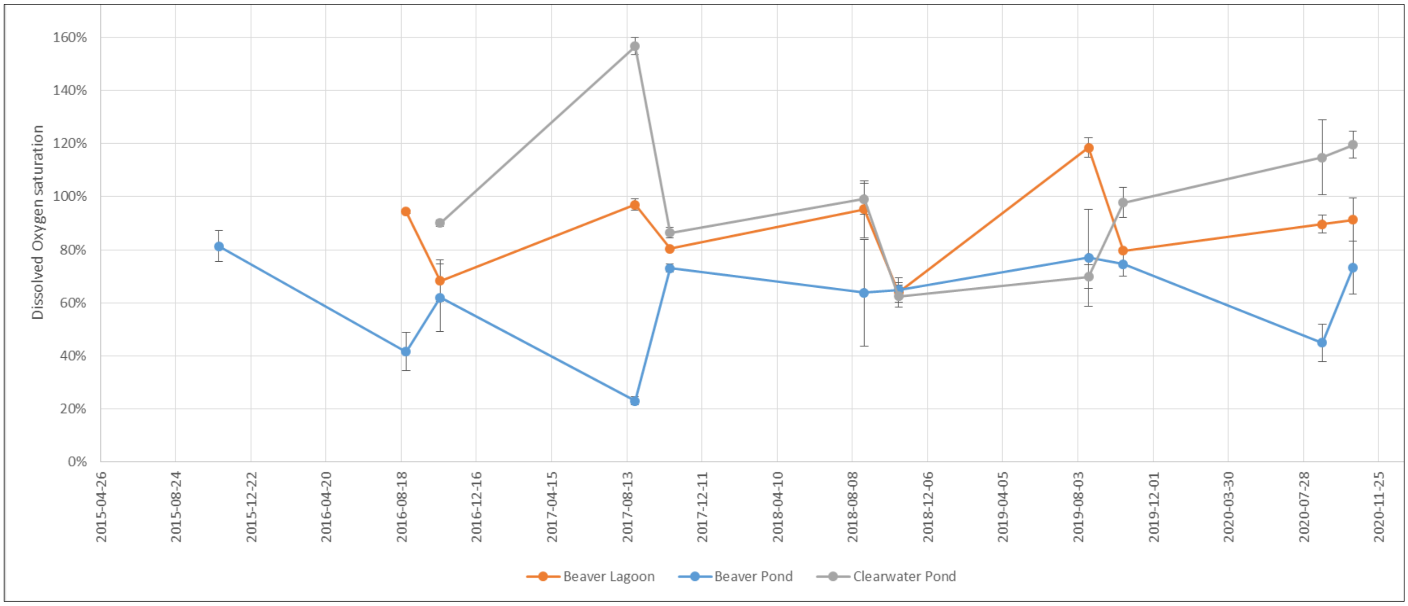

Figure 22: Dissolved oxygen (DO) recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) between 2015 and 2020.

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 future use of de-icing salts on the SWCRR may increase chloride concentration in adjacent wetlands.

No significant changes were detected in the chloride concentration in any of the monitored wetlands prior to 2018 ([13]Enivironmental Monitoring Report 2018, WGPPS). Data from 2018 are incomplete and were not used in the statistical hypothesis testing. A decrease in chloride concentration for BL were observed between 2015 and 2020 (linear regression, d.f.=23, $p>0.05$).

(Note: the 2020 [10]Wetland 06 Annual Water Monitoring Reportby Hemmera Envirochem (see p.26) found chloride higher in the Beaver Pond than historic measurements taken in 2016 and 2017.)

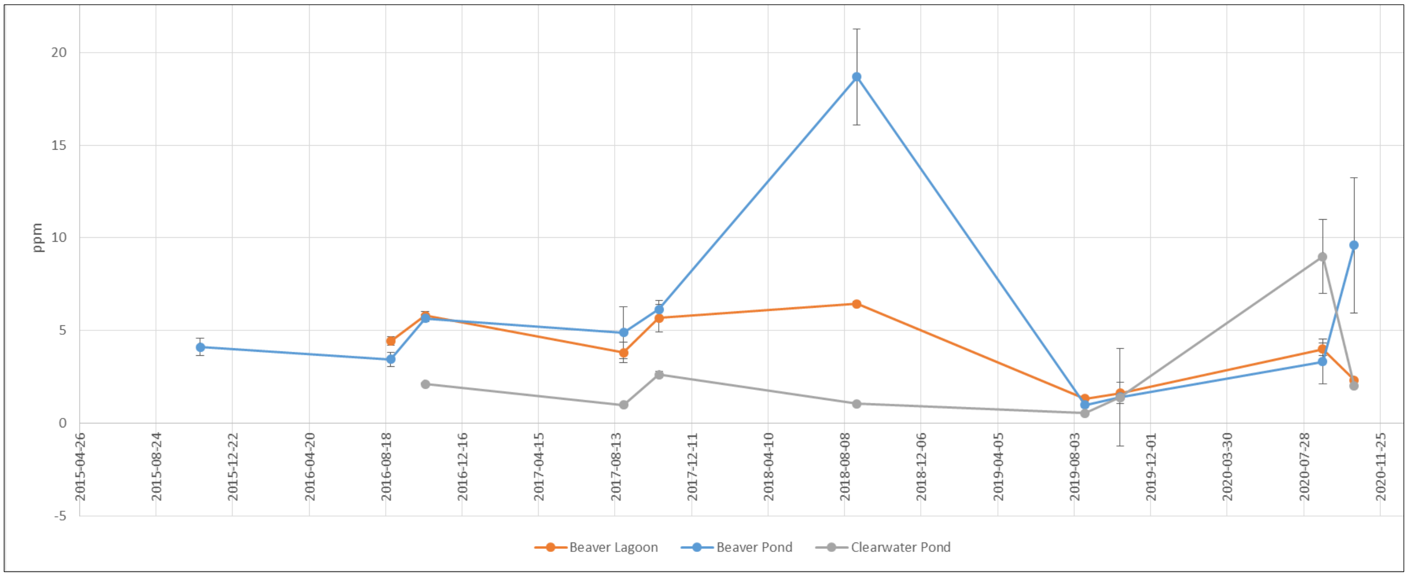

Figure 23: Chloride recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP) between 2015 and 2020.

vii) Nitrate

Nitrate levels have only been measured since 2019. Results in table 17 show a marked increase in total nitrogen concentration in the two creeks that run into the Beaver Pond. *(Note: the test used also responds to nitrite in the water, normally very small in natural waters in comparison to nitrates)*.

Table 17: nitrate concentrations recorded in 2019 and 2020

	Beaver Pond *(n = 5)*	**Beaver Lagoon** *(n = 3)*	**Clearwater Pond** *(n = 3)*	**Ravine Creek** *(n = 1)*	**Spring Brook** *(n = 1)*
Nitrate (mg/L N)) ± SEM					
Aug. 19th/20th 2019	0.19 (±0.05)	0.03 (±0.1)	0.08 (±0.02)	0.14	0.05
Oct. 13th/14th 2019	0.12 (±0.04)	0.09 (±0.01)	0.10 (±0.02)	0.14	0.12
Aug. 17th 2020	0.31 (±0.11)	0.18 (±0.02)	0.15 (±0.01)	0.52	0.30
Oct. 15th 2020	0.58 (±0.09)	0.41 (±0.13)	0.17 (±0.07)	0.61	0.53

viii) Phosphorus

Phosphorus is one of the most important limiting nutrients in aquatic ecosystems ([11]Sawyer *et al.*, 2003). The introduction of phosphorus into a water body can lead to an exponential increase in algal and cyanobacterial productivity, accelerating the rate of eutrophication. The resultant low levels of dissolved oxygen can cause fish and invertebrate mass mortality or decreased fertility

No significant changes were detected between 2015 and 2020 in the phosphate concentrations shown in table 18 and fig. 24, nor in any of the monitored wetlands prior to 2018. Data from 2018 are incomplete and were not used in the statistical hypothesis testing.

Table 18: phosphate concentrations 2015 to 2020

Phosphate PO_4 (mg/L) ±SEM	Beaver Pond *(n=3, *n=5)*	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 2016	0.02 (±0.01)	0.01 (±0.01)	0.02 (±0.01)	0.10	0.04

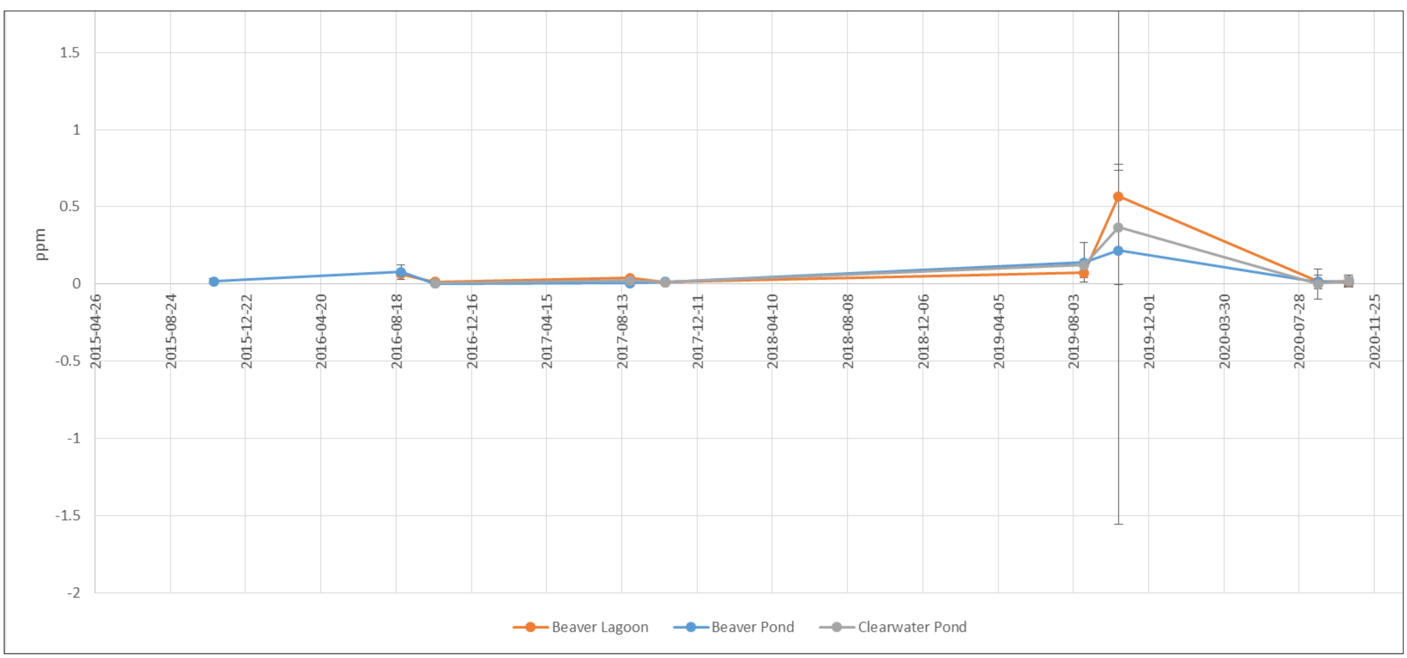

Figure 24: Phosphate recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) between 2015 and 2020.

b. Aquatic macro-invertebrates

In 2020 a total of 991 specimens were identified to 62 taxa for the habitats studied (BP, BL and CP, table 12 and 13). The 62 taxa identified represent the greatest taxonomic resolution achieved in 2020

Table 19: Taxonomic classification for the aquatic macro-invertebrates sampled on August 28th to Sept. 1st 2020

		Beaver Pond			Beaver Lagoon			Clear Water		
	Greatest Taxonomic Resolution Obtained	**BP1**	**BP2**	**BP3**	**BL1**	**BL2**	**BL3**	**CP1**	**CP2**	**CP3**
Mayflies	*Caenis* sp. Stephens, 1835	1	1					1		
	Centroptilum sp. Eaton 1869	1			15	4				
	Callibaetis					2	3			
	Metretopus		1			1	1			3
Caddisflies	*Ptilostomis*					1				
	Phryganea		1		1		2		1	
Dragonflies	*Enallagma* sp. Charpentier, 1840									1
	Somatochlora			1						
True flies	Orthocladiinae			22	1	9				
	Anopheles earlei Vargas, 1943	4								
	Chaoborus					4				
	Dixella			2	2	1				1
	Ceratopogonidae			3						
	Ptychoptera						1			
	Twinnia				2					
Beetles	*Laccophilus* sp. Leach, 1815		1		2					
	Gyrinus		3		1					
	Tropisternus						1			
	Haliplus sp. Latreille, 1802	1	4	2			1		2	
True bugs	Corixidae	116	9	23	10		5		2	
	Limnoporus			1						1
Water mites	Hydrachnidia		1	1	1	5	1			3
	Limnocharidae	1								
	Hydrozetes	3								
Spiders	*Dolomedes triton*									1
Water fleas	Chydoridae	21			5					
	Macrothricidae				1					
	Sida crystallina	3								
	Daphnia	1			21	14	3			
	Ceriodaphnia				2					
	Lynceidae	1				1				
Scuds	*Gammarus lacustris* G.O. Sars, 1864		1		6		16			
	Hyalella azteca (Saussure, 1858)	2	1	2	7	17	35			4
Copepoda	Cyclopidae		1		1					
	Ectocyclops				1					
	Tropocyclops				1					
Gastropoda	*Physa* sp. Draparnaud, 1801	5		12		2	2			
	Aplexa						1			
	Fossaria (Bakerilymnaea) bulimoides (I. Lea,	2		2			1			
	Lymnaea stagnalis			1						
	Lymnaidae					1				
	Stagnicola sp. Jeffreys, 1830	1		2						
	Probythinella lacustris (F. C. Baker, 1928)								3	
	Promenetus umbilicatellus (Cockerell, 1887)	1								1
Leeches	*Batracobdella picta*		1							
Flatworms	*Mesostoma ehrenbergii*					7				

Table 20: Taxonomic classification for the aquatic macroinvertebrates sampled on October 16th to 19th 2020

		Beaver Pond			Beaver Lagoon			Clear Water		
	Greatest Taxonomic Resolution Obtained	**BP1**	**BP2**	**BP3**	**BL1**	**BL2**	**BL3**	**CP1**	**CP2**	**CP3**
Mayflies	*Caenis* sp. Stephens, 1835	7	1	1						
	Centroptilum sp. Eaton 1869				37	16	5			
	Baetis				3	1				
	Callibaetis					16				
	Metretopus	1								
Caddisflies	*Ptilostomis*					1				
	Phryganea				1		4			
Dragonflies	*Ischnura* sp. Charpentier, 1840					2				
	Enallagma sp. Charpentier, 1840	3	1							1
	Lestes					1				
	Aeshna sp. Fabricius, 1775					1				1
True flies	Chironomini	3								
	Diamesinae					1				
	Tanytarsini			1		1				
	Dixella		1		1	1				
Beetles	*Laccophilus* sp. Leach, 1815						1			
	Gyrinus	6	2							
	Haliplus sp. Latreille, 1802	1								
	Peltodytes					1				
True bugs	Corixidae	48			1		1		1	
	Notonecta sp. Linnaeus, 1758	1	1	4				1		
Water fleas	Oxidae			1		1				
	Daphnia					7				
	Simocephalus					4				
	Scapholeberis					2				
Clam shrimps	*Cyzicus mexicanus*					1				
Scuds	*Gammarus lacustris* G.O. Sars, 1864				26	1	16			
	Hyalella azteca (Saussure, 1858)	12			27	14	28			
	Ostracoda					32				1
Gastropods	*Physa* sp. Draparnaud, 1801	1			11	1	1			
	Fossaria (Bakerilymnaea) bulimoides (I. Lea, 1841)	11				1				
	Stagnicola sp. Jeffreys, 1830	1					8		1	
	Valvata sincera				9					
	Gyraulus crista	20	3	1	2					
	Promenetus umbilicatellus (Cockerell, 1887)	1			1			1		
Bivalves	*Pisidium* sp. Pfeiffer, 1821	10	6							

Table 21: Aquatic macroinvertebrates statistics (average ± SEM) (n=3)

Water body	Site	Assessment Date (2020)	Taxa Richness per Site/Sample	Simpson's Diversity Index (1-S) per Site/Sample	% of EPT Taxa
Beaver Pond	**BP**	**August 28th**	14.0 (±1.2)	69.5% (±10.8%)	12.5% (±7.2%)
		October 16th	10.0 (±3.1)	79.0% (±2.9%)	11.8% (±3.0%)
Beaver Lagoon	**BL**	**August 28th**	15.3 (±1.3)	80.9% (±4.9%)	20.4% (±5.1%)
		October 16th	13.7 (±4.3)	78.3% (±3.5%)	7.6% (±4.0%)
Clearwater Pond	**CP**	**August 28th**	4.3 (±2.0)	51.5% (±25.9%)	45.8% (±27.3%)
		October 16th	2.3 (±0.3)	55.6% (±5.6%)	0% (±0%)

Taxa richness, Simpson's Diversity Index and % of EPT were calculated from the data (Table 21). The results are discussed under separate headings below.

Taxa Richness

Regression analysis of data from the Beaver Pond and Beaver Lagoon (Weaselhead sites), for the period between 2016 and 2020, does not reveal any significant association between taxa richness and time (linear regression, d.f.=8, $p>0.05$). For the same period, the data indicate a decrease in taxa richness for the reference site (Clearwater Pond) (linear regression, d.f. = 7, $p<0.05$).

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. A decrease in the Clearwater Pond site richness (Fig 25), however, remains to be explained.

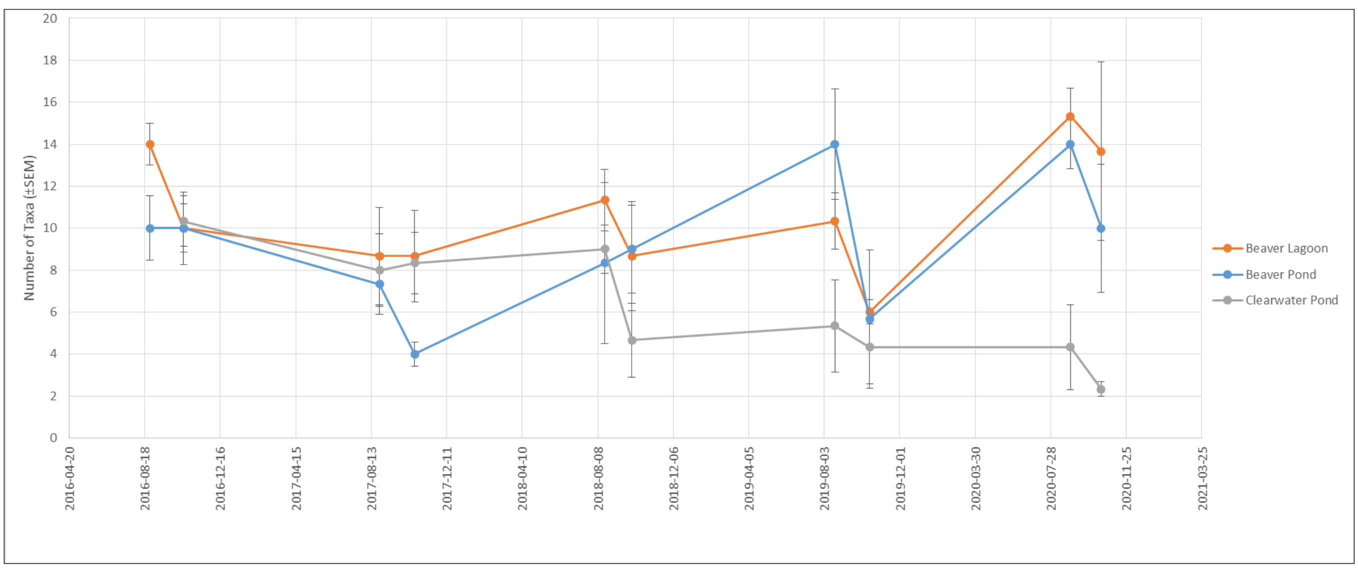

Figure 25: Taxa richness recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) from 2016 to 2020.

Simpson's Diversity Index

The Simpson's diversity index takes into account 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:

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

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 2020, does not reveal any significant association between taxa diversity and time (linear regression, d.f.=8 Beaver Pond and Beaver Lagoon, d.f. = 7 Clearwater Pond, $p>0.05$). Following a drop in taxa diversity recorded in 2018, the diversity seems to have recovered for the Beaver Pond and Beaver Lagoon. See figure 26.

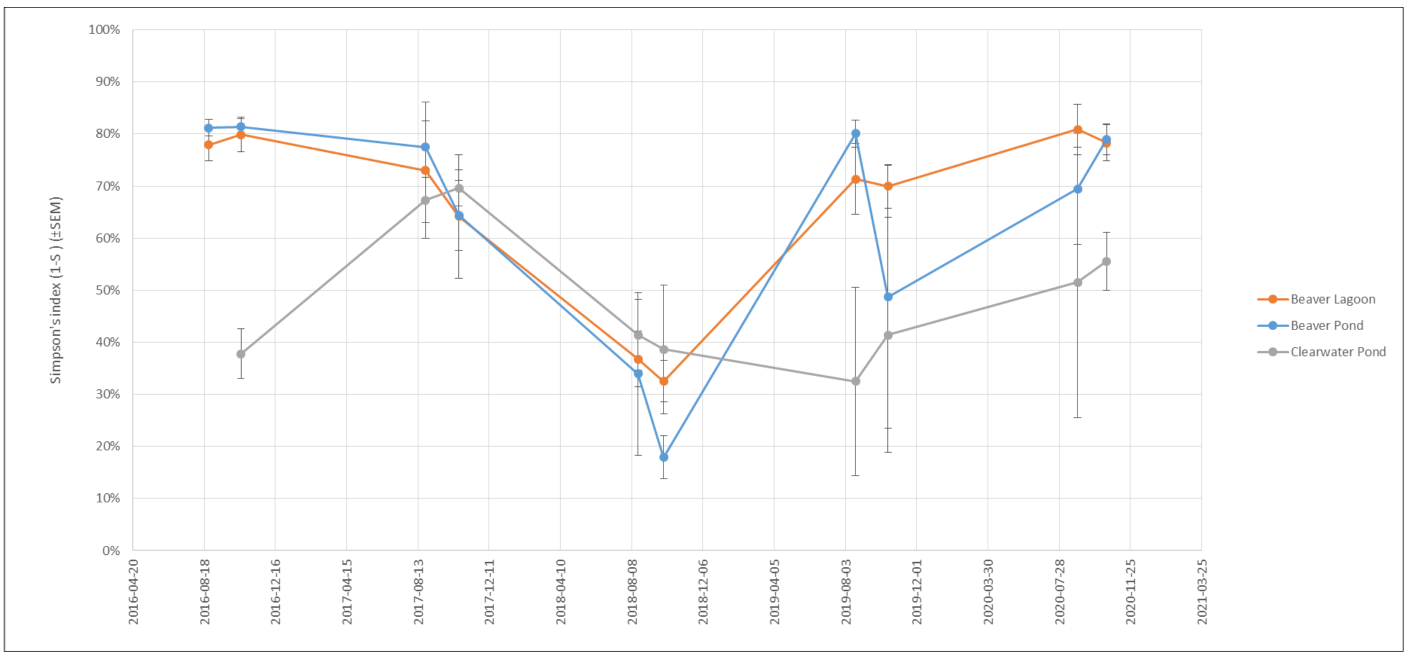

Figure 26: Simpson's diversity index recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) from 2016 to 2020.

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 contain 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 2020, has not revealed any significant association between EPT taxa richness % and time (linear regression, d.f.=8 Beaver Pond and Beaver Lagoon, d.f. = 7 Clearwater Pond, $p>0.05$), see figure 27. This result suggests that the SWCRR Impact Study has not detected any significant trends on EPT taxa % for any sites during this period. After a drop in EPT taxa % (paired t test, df=5, $p<0.05$), observed in 2017 in comparison to 2016, the Beaver Pond site appears to have recovered to more usual values.

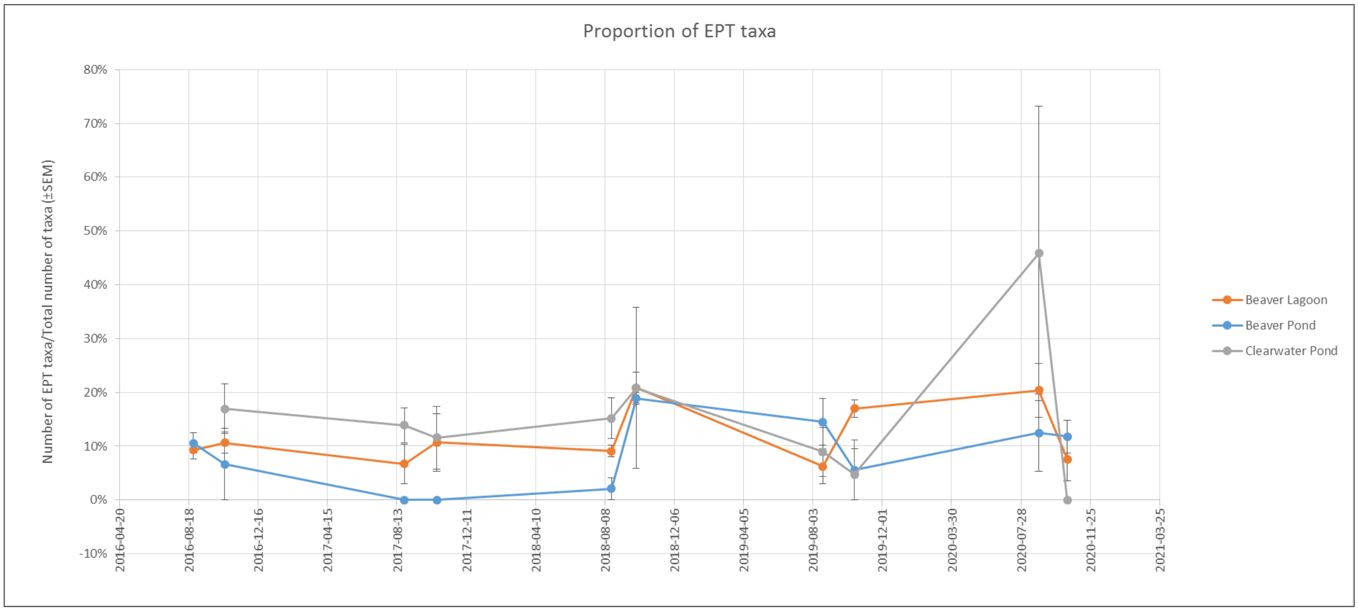

Figure 27: Proportion of EPT tax recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) from 2016 to 2020.

c. Amphibians

Nocturnal amphibian call surveys were done at two locations in the Weaselhead from 2017 to 2020. Only boreal chorus frogs, *Pseudacris maculata* and wood frogs, *Lithobates sylvaticus* were detected (fig. 28, table 22 and 23). The locations match two used in 2012, and are close to one used in 2014 for the EIA[1]. Surveys were carried out between 9pm and 11pm for 20 min. following a protocol developed by the Miistakis Institute for *'Call of the Wetland'*, 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[14] (Lee, T. et al. 2020) 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 28: Locations of amphibian call surveys done in 2012 (green dots) and 2014 (purple dots) carried out for the EIA[1].(red line = boundary of construction zone; pink line = boundary of park;(blue line significance unknown). The 2017 to 2020 monitoring sites are indicated by white arrows.

Table 22: Boreal Chorus frogs heard during surveys conducted in 2012 to 2020; BP = Beaver Pond, OO = Old Oxbow *(2012 and 2014 data from Environmental Impact Assessment for the SWCRR, AMEC 2014[1])*

	EIA 2012 *(no details of abundance)*		EIA 2014 *(no details of abundance)*		2017 *(no. of individuals heard)*		2018 *(no. of individuals heard)*		2019 *(no. of individuals heard)*		2020 *(no. of individuals heard)*	
Boreal Chorus frog	BP	OO	BP	OO	BP	OO	BP	OO	BP	OO	BP	OO
late April	present		present		0	0			0	0	0	0
early May					0	2	0	0	0	0	0	0
mid May	present		present		0	2	0	0			0	0
late May	present		present		1	1			0	0	0	0
early June					0	1			0	0	0	0
late june					0	0					2	0

Table 23: Wood frogs heard during surveys conducted in 2012 to 2020; BP = Beaver Pond, OO = Old Oxbow *(2012 and 2014 data from Environmental Impact Assessment for the SWCRR, AMEC 2014[1])*

	EIA 2012 *(no details of abundance)*		EIA 2014 *(no details of abundance)*		2017 *number of individuals heard)*		2018 *(number of individuals heard)*		2019 *(number of individuals heard)*		2020 *(number of individuals heard)*	
Wood frog	BP	OO	BP	OO	BP	OO	BP	OO	BP	OO	Beaver Pond	Old Oxbow
late April	present		present		3	4			4	0	5	2
early May					2	0	4	0	3	0	10	2
mid May	present		present		0	0	0	0			0	0
late May	present		present		0	0			0	0	0	0
early June					0	0			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 Aug. 2019 and remedial action in Nov. 2019, Alberta Environment and Parks (AEP) has ordered KGL to monitor amphibians in the Beaver Pond for two years. It is hoped that the results of this monitoring will be made available to WGPPS in 2021 and be included in the 2021 Environmental Monitoring Report.

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 each habitat a minnow trap was 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.

Locations for the minnow traps are the same as three of the locations used for the water quality testing and aquatic invertebrate sampling, BP1, BL1 and CP1 (see figs. 15, 16 and 17). AEP identification names/numbers for the wetlands are:

- Beaver Pond Water Body ID 66463 SE-25-23-02-5
- Beaver Lagoon Water Body ID 24267 SE-25-23-02-5
- Elbow River (Clearwater Pond) Water Body ID 2035 SE-5-24-02-5

Minnow traps were set late in the evening on October 14th 2020 and collected early the next morning. Dip netting consisted of three sweeps with a 12 x 15cm net (mesh size ~2mm) through the water at each location.

Results are given in table 24 below:

Table 24: fish caught in minnow traps and caught with dip nets while collecting invertebrate samples, 2017- 2020 *(*Note: students participating in Society's education programs regularly found brook stickleback in the Beaver Pond in 2017 and 2018)*

location	sampling technique	20th Oct 2017	8th Nov 2018	Oct. 14th 2019	15th Oct 2020
Beaver Pond	**minnow trapping** *(BP1)*	11 fathead minnows *(Pimephales promelas)*	no fish caught	no fish caught	no fish caught
	dip netting	n/a*	n/a*	5 brook stickleback *(BP1)* *(Culaea inconstans)* (sizes: 2.6, 3.3, 3.5, 2.5, 2.0 cm)	1 brook stickleback *(BP 3)* *(Culaea inconstans)* (size: ?)
Beaver Lagoon	**minnow trapping** *(BL1)*	no fish caught	no fish caught	no fish caught	no fish caught
	dip netting	n/a	n/a	no fish caught	no fish caught
Clearwater Pond	**minnow trapping** *(CP1)*	19 white suckers *(Catostomus commersonii)*	no fish caught	no fish caught	no fish caught
	dip netting	n/a	n/a	no fish caught	2 brook stickleback *(CP 2)* (sizes: 2.0 and 3.0 cm)

FINAL CONSIDERATIONS

The *Environmental Monitoring Report 2020* is an important step in the evaluation of the mitigation measures adopted during the construction phase of the SWCRR.

Impact on wetlands:

One mitigation measure required by KGL's contract with Alberta Transport is to *'install and maintain appropriate erosion and sediment control methods to prevent sediments from disturbed areas from being transported into watercourses.'* (p. 124, [9]Schedule 18 of DBFO agreement). The revegetation process is one of the last mitigation measures to be installed. KGL photographs, show the state of the SWCRR prior to revegetation are found in appendix I. So far the measures adopted during the construction phase of the project have proved inadequate: two separate spills of sediment into the Beaver Pond occurred in 2018, one directly from the adjacent construction site and one via a creek, 'Spring Brook' that feeds into the wetland ([13]Environmental Monitoring Report 2018, WGPPS); a further spill of *'coarse infill'* (pers. comm. Chris Pipher KGL Environmental Management Team) directly into the Beaver Pond in August of 2019, and again in July 2020 sediment entered the Beaver Pond via a feeder creek (fig. 29) as a result of a failure of erosion control in the SWCRR construction zone following heavy rain.

Figure 29: 2nd July 2020. Spill from construction site into Beaver Pond via Ravine Creek; left photo looking upstream, right photo looking downstream to where creek enters Beaver Pond

The sediment load of Ravine Creek was visibly reduced by a new beaver dam (built in 2019/20; see fig. 30) just upstream of where the creek enters the wetland, however increased turbidity was still noticeable in the ephemeral creek (flowing at the time) that connects the Beaver Pond to the Beaver Lagoon (see fig. 31). The incident was reported by Society staff to AEP for investigation.

Figure 30: 2nd July 2020. Ravine Creek; photo showing beaver dam on right, just upstream of where creek enters the Beaver Pond

Figure 31: 2nd July 2020. noticeable turbidity of creek flowing from the Beaver Pond to the Beaver Lagoon

In addition to recurrent episodes of extremely high turbidity caused by the SWCRR construction, the Golder report of 2020 found **pH, zinc, and DO levels** in the Beaver Pond exceeded CCME (Canadian Council of Minsters of the Environment) guidelines[15] for the protection of aquatic life when sampled. The source of the zinc is suspected to be the galvanised culvert that conveys Spring Brook under the SWCRR.

The results of this Study suggest that during 2018, the Beaver Pond experienced an increase in conductivity and chloride. This fact, combined with some very low DO recorded in the summer 2017, probably is associated with the observed transient drop in invertebrates diversity in 2018. This tendency might be reversing for the Beaver Pond now, with some potential signs of recovery from these disturbances.

Impact on wildlife movement:

The *'Calgary Captured'* cameras in 2020 recorded medium to large mammals in the Weaselhead, including species such as moose (fig. 32) and bear that require ranges far larger that the ~250ha Weaselhead for their needs. These animals are likely to have been using habitat to the west of the SWCRR as land to the east outside of the parks is fully developed. Monthly monitoring by Golder and Associates showed little evidence of wildlife using the designated wildlife passages to cross under the SWCRR and reports of animal seen on or near the highway suggest they may instead be crossing over it. It was disappointing therefore that the SWCRR opened in October without the wildlife fencing intended to direct animals to these passages being installed (See fig 11, fig. 12 and fig 13., and Appendix I).

Figure 32: Aug 2020. A moose browsing caught on *Calgary Captured* camera #63, see fig. 10 for location.

Communication issues:

The 2014 SWCRR [1]EIA (p.556) states *"Ongoing relationships with key stakeholders will be maintained into the construction and operational phase, so that new and emerging issues can be identified and responded to in a timely manner."* However communication with KGL (the construction company) and Alberta Transport has become increasingly difficult as the project has progressed and personnel once known from earlier meetings, discussions and open houses have changed. Requests for information in 2020 almost always required multiple emails/phone calls. This has been especially so since the section of the ring road next to the Weaselhead ('Tsuut'ina Trail') opened in October 2020. The SWCRR project information call centre now relays concerns to Alberta Highways as the Tsuut'ina Trail is 'no longer part of the KGL project'. This difficulty highlights the importance of establishing agreed communication channels at the discussion stage of the project that will be effective throughout the life of the project.

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APPENDIX I

KGL PHOTOS OF SWCRR AND 90TH AVE. INTERSECTION

Work in progress and operational photos of the SWCRR along the Weaselhead taken in Sept. 2020. These show some key drainage features including the bypass drainage culvert outflows to Ravine Creek. (This drains into the Beaver Pond).

Figure 33: looking from SWCRR southwest along 90 Ave SW, Sept. 2020. Culverts carrying bypass drainage to Ravine creek visible. *(Image downloaded from http://www.swcrrproject.com/wp-content/uploads/2020/10/2020-10-01-COC-connection.png)*

Figure 34: view south (90th Ave SW exit ahead), Sept. 2020 showing ongoing construction/remediation (*Image downloaded from http://www.swcrrproject.com/wp-content/uploads/2020/10/2020-10-01-90th-avenue.png).*

APPENDIX II

NIGHT SKY QUALITY (supplemental data – not collected before 2029)

In 2019 the Society began work on an application to have the Weaselhead recognised as a Nocturnal Preserve, a designation assigned by the Royal Astronomical Society of Canada (RASC). Light abatement will benefit the organisms that live and use the area, and increase opportunities for local communities to enjoy dark skies. Recognition as a Nocturnal Preserve will help to preserve the natural night environment of the Weaselhead (which currently has no artificial lighting), encourage light abatement in the surrounding communities (through a required outreach component), and help protect nocturnal species.

The Society started recording Night Sky Quality Readings (NSQR) in 2019 in the Weaselhead to collect data on baseline light levels before the SWCRR opened and before starting efforts to reduce light pollution in the surrounding communities. These data are included here to document an additional stressor – the impact of light - on the biodiversity and habitat health of the Weaselhead.

Night Sky Quality Weaselhead were taken with a Unihedron Sky Quality Meter. Readings measure skyglow, the average brightness over ¼ to ½ of the visible sky. To reduce skyglow from natural causes reading were taken on clear nights when there was no snow on the ground, and at times after the moon had set and during the 'astronomical night' (when the Sun is at least 18º below the local horizon).

Typical readings for different light environments are given in table 25. Locations of observations in the Weaselhead are shown in fig. 35. GPS locations and NSQR data from sampling completed in 2019 and 2020 are shown in table 26.

Table 25: Typical Night Sky Quality Readings [17] in *magnitude per square arcsecond*.

22.0 mpss	By convention, this is often assumed to be the average brightness of a moonless night sky that is completely free of artificial light pollution.
21.0 mpss	This is typical for a rural area in the eastern U.S., with a medium-sized city not far away. It's comparable to the glow of the brightest section of the northern Milky Way, from Cygnus through Perseus.
20.0 mpss	This is typical for the outer suburbs of a major metropolis. The summer Milky Way is readily visible but severely washed out.
19.0 mpss	Typical for a suburb with widely spaced single-family homes. It's a little brighter a remote rural site at the end of nautical twilight, when the Sun is 12° below the horizon.
18.0 mpss	Bright suburb or dark urban neighborhood. It's also a typical zenith skyglow at a rural site when the Moon is full. The Milky Way is invisible, or nearly so.
17.0 mpss	Typical near the center of a major city such as New York or Boston.
13.0 mpss	The zenith skyglow at the end of civil twilight, roughly a half hour after sunset, when the Sun is 6° below the horizon. Venus and Jupiter are easy to see, but bright stars are just beginning to appear.
7.0 mpss	The zenith skyglow at sunrise or sunset.

Table 26: Night Sky readings in *magnitude per square arcsecond*; average of three readings taken at each location; July 2019: road not open and no construction lights; Aug 2020: road not open and construction lights in use

		location	26th July 2019	21st Aug 2020
50° 59.685'N	114° 8.657'W	A	18.74	18.77
50° 59.483'N	114° 8.799'W	B	18.81	18.77
50° 59.350'N	114° 9.060'W	C	19.29	18.97
50° 59.284'N	114° 9.342'W	D	19.30	19.12
50° 59.187'N	114° 9.680'W	E	19.12	18.87

Figure 35: Location of sampling sites for NSQR data. *(downloaded from GoogleEarth);* orange line = Weaselhead boundary.

Figure 36: Nighttime working Sept 2020 showing construction lighting similar to those observed in Aug 2020. (Image downloaded from http://www.swcrrproject.com/wp-content/uploads/2020/09/Bridge-Paving-Sarce.png)