Weaselhead/Glenmore Park
SWCRR Impact Study 2016-2023

Environmental Monitoring Report 2019

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

Author: Cassiano Porto, Lisa Dahlseide & Sarah Nevill

Calgary, Jan. 2020

TABLE OF CONTENTS

Cassiano Porto, email: cassianocaue@gmail.com

Lisa Dahlseide, email: biodiversity4u@gmail.com

Sarah Nevill, email: weasel@theweaselhead.com

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 report of 2016 described conditions in the study area 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 2018 and 2019 reports describe conditions during the second and third year of construction (all reports are available on the Society's website). 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 July 2019 half way through the third year of construction. Major work undertaken in 2019 included construction of two stormwater ponds in the valley upstream of the river crossing, construction of the road beds for 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, construction of a retaining wall along the edge of the northbound carriageway and an adjacent wetland in the Weaselhead, the 'Beaver Pond' (see fig. 29, Appendix I).

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 2023 when the SWCRR will be in operation the Study will allow an objective evaluation of the road's impact on selected environmental components and the success 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 there are few studies of 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: satellite image Sept. 2016 before major construction began *(downloaded from GoogleEarth);* orange line shows Weaselhead boundary; scale: white line = 500m

Figure 2: satellite image July 2019, two and a half years after the start of construction *(downloaded from GoogleEarth)*; Weaselhead boundary shown by orange line; scale: white line = 500m (new river channel and two stormwater ponds, one each side of river realignment, visible; red circle shows location of retaining wall)

1. RESULTS: TERRESTRIAL HABITATS

a. Breeding Bird Survey

In 2019 the breeding bird survey was conducted using the same protocol and study design as in 2016, 2017 and 2018, and as the EIA[1]. In order to produce comparable results period of the 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: low to gentle breeze, passing clouds, temperature 8˚C-14˚C, and no precipitation.

On June 22nd 2019, 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 group, 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 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 3: location of breeding bird survey points *(scale: white line = 500m)*

During the 2019 bird survey 337 individuals from 49 different species were identified; summaries are shown in tables 2 and 3). As in previous years, the total Simpson's diversity index for the breeding bird survey was high (1-S = 94.56%).

The mean bird species density for the 2019 survey was 2.61 (standard deviation = ±0.76, n=28) species per hectare. This compares with densities of 2.59 ±0.71 recorded in 2016, and 3.06 ±0.81 in 2017. *(Data from 2018 were insufficiently detailed for density to be calculated)*

As in 2016, 2017 and 2018, the 2019 survey found a significant linear regression slope (d.f.=26, $p<0.05$) 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 2019 survey species per area regression follows the general function: CS=0.44A+13.1 (R^2=0.9547), 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 0.44 "new" species were recorded with each additional hectare surveyed. 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 2019 show an additional 48 species were observed in the Weaselhead during this period (table 4).

Table 2: Breeding bird survey species list (June 22nd 2019) with total individual counts (species indicated as *sensitive; ** may-be-at-risk Alberta Wild Species General Status Listing[2])

species			species		
House Wren	*Troglodytes aedon*	*34*	Western Wood Peewee*	*Contopus sordidulus**	*3*
White-throated Sparrow	*Zonotrichia albicollis*	*33*	Common Goldeneye	*Bucephala clangula*	*2*
Clay-colored Sparrow	*Spizella pallida*	*31*	Hairy Woodpecker	*Leuconotopicus villosus*	*2*
Cliff Swallow	*Petrochelidon pyrrhonota*	*23*	Northern Flicker	*Colaptes auratus*	*2*
Brown-headed Cowbird	*Molothrus ater*	*21*	Northern rough-winged Swallow	*Stelgidopteryx serripennis*	*2*
Yellow Warbler	*Setophaga petechia*	*21*	Warbling Vireo	*Vireo gilvus*	*2*
American Robin	*Turdus migratorius*	*20*	Alder Flycatcher*	*Empidonax alnorum**	*1*
Least Flycatcher*	*Empidonax minimus**	*16*	Belted Kingfisher	*Megaceryle alcyon*	*1*
Red-winged Blackbird	*Agelaius phoeniceus*	*16*	Boreal Chickadee	*Poecile hudsonicus*	*1*
Red-breasted Nuthatch	*Sitta canadensis*	*10*	Brown Thrasher	*Toxostoma rufum*	*1*
Veery	*Catharus fuscescens*	*10*	Calliope Hummingbird	*Selasphorus calliope*	*1*
Cedar Waxwing	*Bombycilla cedrorum*	*8*	Chipping Sparrow	*Spizella passerina*	*1*
Red-eyed Vireo	*Vireo olivaceus*	*8*	Common Raven	*Corvus corax*	*1*
Gray Catbird	*Dumetella carolinensis*	*7*	Cooper's Hawk	*Accipiter cooperii*	*1*
American Goldfinch	*Spinus tristis*	*6*	Golden-crowned Kinglet	*Regulus satrapa*	*1*
Pine Siskin	*Spinus pinus*	*6*	Lincoln's Sparrow	*Melospiza lincolnii*	*1*
Song Sparrow	*Melospiza melodia*	*6*	Pileated Woodpecker*	*Hylatomus pileatus**	*1*
Ring-necked Duck	*Aythya collaris*	*5*	Purple Finch	*Haemorhous purpureus*	*1*
Spotted Sandpiper	*Actitis macularius*	*5*	Savannah Sparrow	*Passerculus sandwichensis*	*1*
Blue Jay	*Cyanocitta cristata*	*4*	Swainson's Thrush	*Catharus ustulatus*	*1*
Downy Woodpecker	*Picoides pubescens*	*4*	White-breasted Nuthatch	*Sitta carolinensis*	*1*
Black-capped Chickadee	*Poecile atricapillus*	*3*	Yellow-bellied Sapsucker	*Sphyrapicus varius*	*1*
Red-naped Sapsucker	*Sphyrapicus nuchalis*	*3*	unknown sparrow sp.		*1*
Ruby-crowned Kinglet	*Regulus calendula*	*3*	unkown thrush sp.		*1*
Tree Swallow	*Tachycineta bicolor*	*3*			

Table 3: Breeding bird survey (June 22nd 2019) – birds observed flying overhead or further than 100m from survey points

Other >100m					
Franklin's Gull	*Leucophaeus pipixcan*	6	Common Merganser	*Mergus merganser*	1
Bald Eagle	*Haliaeetus leucocephalus*	2	Great Horned Owl	*Bubo virginianus*	1
Canada Goose	*Branta canadensis*	2	Song Sparrow	*Melospiza melodia*	1
Common Goldeneye	*Bucephala clangula*	1			
Incidentals/Flyovers					
unknown gull spp.		9	Cedar Waxwing	*Bombycilla cedrorum*	2
American Golfinch	*Spinus tristis*	6	Dark-eyed Junco	*Junco hyemalis*	2
American Crow	*Corvus brachyrhynchos*	4	Spotted Sandpiper	*Actitis macularius*	2
American Robin	*Turdus migratorius*	4	Bald Eagle	*Haliaeetus leucocephalus*	1
Black Capped Chickadee	*Poecile atricapillus*	4	Brown headed Cowbird	*Molothrus ater*	1
Cliff Swallow	*Petrochelidon pyrrhonota*	4	Common Goldeneye	*Bucephala clangula*	1
Osprey	*Pandion haliaetus*	4	Double-crested Cormorant	*Phalacrocorax auritus*	1
Downy Woodpecker	*Picoides pubescens*	3	Gray Catbird	*Dumetella carolinensis*	1
Franklin's Gull	*Leucophaeus pipixcan*	3	Tree Swallow	*Tachycineta bicolor*	1
Red winged Blackbird	*Agelaius phoeniceus*	3	White Throated Sparrow	*Zonotrichia albicollis*	1

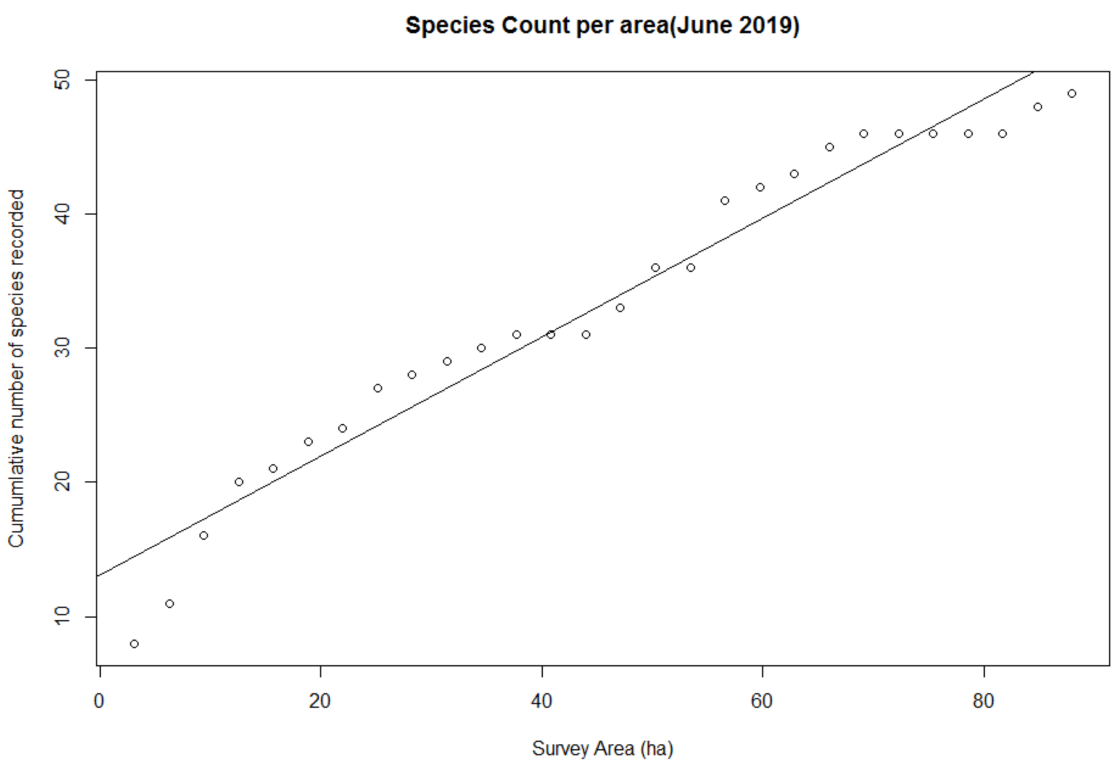

Figure 4: Regression model between cumulative number of species recorded and area, increasing in increments of 3.14ha (= area of a 100m-radius circle around stations in which observations were made)

Table 4: additional 48 species observed in June and July 2019 in the Weaselhead but not recorded during WGPPS survey.([3]eBird Basic Dataset Oct 2019)

species		species	
American Crow	*Corvus brachyrhynchos*	Merlin	*Falco columbarius*
American Three-toed Woodpecker	*Picoides dorsalis*	Mountain Chickadee	*Poecile gambeli*
American Wigeon	*Mareca americana*	Mourning Dove	*Zenaida macroura*
Baltimore Oriole*	*Icterus galbula**	Northern Harrier	*Circus hudsonius*
Bank Swallow*	*Riparia riparia**	Northern Shoveler	*Spatula clypeata*
Black-billed Magpie	*Pica hudsonia*	Northern Waterthrush	*Parkesia noveboracensis*
Blue-winged Teal	*Spatula discors*	Orange-crowned Warbler	*Leiothlypis celata*
Brewer's Blackbird	*Euphagus cyanocephalus*	Pacific-slope Flycatcher	*Empidonax difficilis*
Bufflehead	*Bucephala albeola*	Redhead	*Aythya americana*
Canada Goose	*Branta canadensis*	Red-tailed Hawk	*Buteo jamaicensis*
Common Grackle	*Quiscalus quiscula*	Ring-billed Gull	*Larus delawarensis*
Common Merganser	*Mergus merganser*	Rock Pigeon	*Columba livia*
Common Nighthawk*	*Chordeiles minor**	Ruby-throated Hummingbird	*Archilochus colubris*
Dark-eyed Junco	*Junco hyemalis*	Rufous Hummingbird	*Selasphorus rufus*
Eastern Kingbird*	*Tyrannus tyrannus**	Solitary Sandpiper	*Tringa solitaria*
Eastern Phoebe*	*Sayornis phoebe**	Sora*	*Porzana Carolina**
European Starling	*Sturnus vulgaris*	Swainson's Hawk	*Buteo swainsoni*
Gadwall	*Mareca strepera*	Tennessee Warbler	*Leiothlypis peregrina*
Great Horned Owl	*Bubo virginianus*	Turkey Vulture	*Cathartes aura*
House Finch	*Haemorhous mexicanus*	Vesper Sparrow	*Pooecetes gramineus*
House Sparrow	*Passer domesticus*	Violet-green Swallow	*Tachycineta thalassina*
Killdeer	*Charadrius vociferus*	White-crowned Sparrow	*Zonotrichia leucophrys*
Lesser Scaup	*Aythya affinis*	White-winged Crossbill	*Loxia leucoptera*
Mallard	*Anas platyrhynchos*	Yellow-rumped Warbler	*Setophaga coronata*

3 species of 'sensitive' status were observed during the survey: Alder Flycatcher, Least Flycatcher and Pileated Woodpecker, and one species that 'may-be-at-risk': the Western Wood-peewee ([2]Alberta Environment and Parks). 'Sensitive' species that were recorded in past years but not recorded in 2019 included:

- Recorded in 2018 only: Olive-sided flycatcher
- Recorded in 2017 only: Sora and Baltimore Oriole
- Recorded in 2016 only : Common Yellowthroat

Although not observed during the 2019 survey the Sora and Baltimore Oriole were present in the Weaselhead in June/July 2019, the Olive-sided Flycatcher and Common Yellowthroat however were not ([3]eBird Basic Dataset Oct. 2019).

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 26th and 27th June 2019. Levels were measured at the same points (stations) as used in the breeding bird survey (table 1, fig. 3). On each site, the sound level was measured for 2 minutes. The results are shown in table 5. *(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 5: Sound pressure measured in peak traffic hours for 2019 (minimum, maximum, average and peak)

Site	Time UTC-6	Sound Pressure (dB)			
		Min	**Max**	**Aver.**	**Peak**
P1	8:32	41.00	83.60	62.30	74.00
P2	?	39.40	75.00	57.20	70.50
P3	8:23	43.4	73	58.20	72.9
P4	8:13	42.10	55.00	48.55	75.20
P5	8:52	40.00	78.20	59.10	75.20
P6	8:03	41.50	72.40	56.95	78.70
P7	9:09	39.60	74.00	56.80	85.60
P8	7:52	44.70	72.00	58.35	68.30
P9	18:06	36.90	70.70	53.80	74.10
P10	18:16	38.20	70.90	54.55	72.40
P11	17:29	36.60	73.00	54.80	73.40
P12	9:16	39.40	89.60	64.50	82.00
P13	16:50	43.70	58.60	51.15	83.20
P14	17:19	39.20	44.00	41.60	69.00
P15	16:33	45.50	57.60	51.55	72.50
P16	16:23	41.30	63.50	52.40	79.40
P17	16:07	45.70	59.20	52.45	86.90
P18	17:58	35.70	74.60	55.15	65.30
P19	7:33	37.40	82.60	60.00	71.20
P20	7:40	43.70	70.90	57.30	74.00
P21	17:50	37.50	75.30	56.40	72.40
P22	17:40	36.10	55.60	45.85	76.60
P23	7:22	42.20	68.80	55.50	68.70
P24	6:46	44.40	89.00	66.70	81.50
P25	7:02	41.60	59.40	50.50	73.40
P26	6:37	45.20	86.90	66.05	78.90
P27	6:23	42.70	48.40	45.55	72.00
P28	8:32	41.00	83.60	62.30	74.00
mean		41.0	69.3	55.2	75.1
sd		3.0	11.9	5.9	5.3

When the values observed between 2016 and 2019 (fig. 5) are compared by analysis of variance, the minimum decibel levels recorded were significantly higher during the SWCRR construction phase in 2017 (Tukey multiple comparison of means, ANOVA, df = 3, 104, $p<0.05$). It is notable that the lowest minimum decibel levels were recorded before the beginning of the SWCRR construction in 2016 (Tukey multiple comparison of means, ANOVA, df= 3, 104, $p<0.05$).

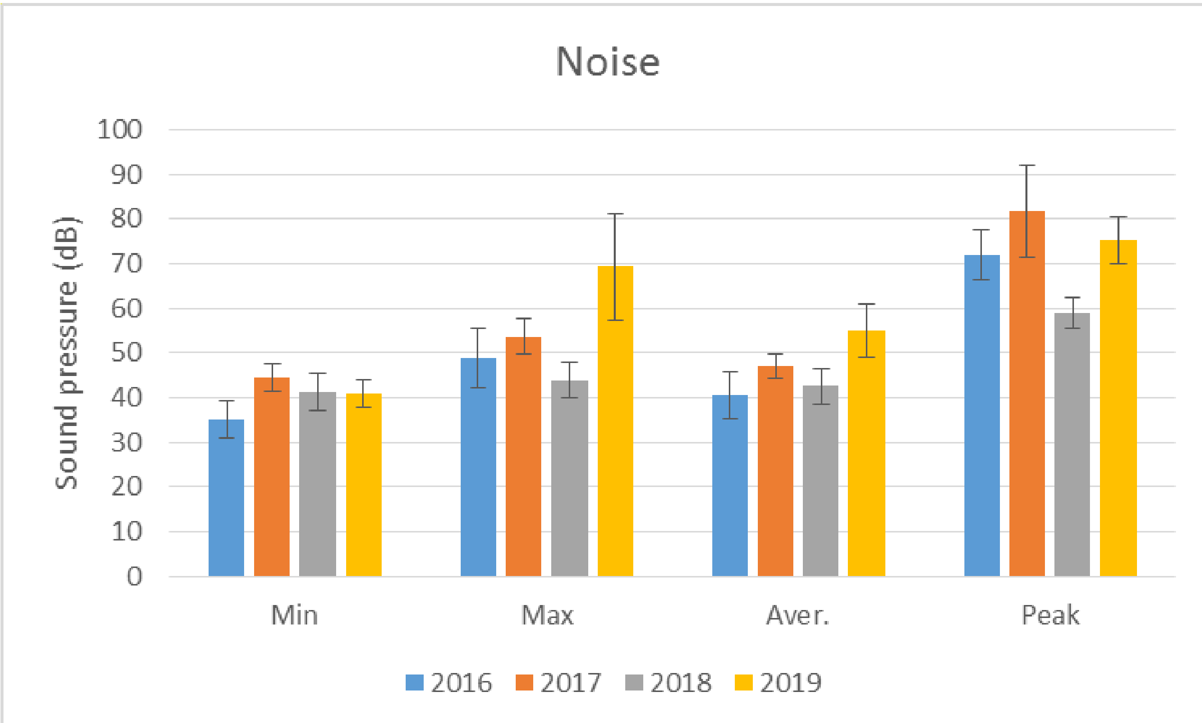

Figure 5: Sound levels measured in the Weaselhead park between 2016 and 2019 (the error bars represent ± standard deviation).

(Note: the variances of the values of 'peak', 'maximum' and 'average' between annual samples are too unequal to compare statistically. High variance in these parameters compared with 'minimum' measures may be because they are more affected by random events during sampling (bird singing, airplane passing etc.))

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 2019 are detailed below. The same protocol and site were used as in 2015, 2016, 2017 and 2018. The assessments from the first 3 years included only flowering plants in the clade 'eudicots'. From 2018 on, grasses and other monocots were included as supplemental data.

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 9th, 10th and 11th 2019 each selected quadrat was comprehensively screened, and the individual eudicot plants and monocot plants (grasses, sedges and rushes) present were counted and identified to species level. In the case of monocots in some instances the percentage of canopy cover was recorded as opposed to counting individual clumps or plants. The percentage cover of moss was also recorded.

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		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 2, 4, 9, 12, 14, 23, 26, 27, 31, 32, 34, 46, 47, 48, 50)

Occurrence (number of quadrats with one or more of the species) and abundance (mean count of species in occupied quadrats) of eudicos are summarised in Table 6, and information on the [6]USDA wetland classification for 'Great Plains' region provided where available.

Table 6: Eudicots and monocots: occurrence (number of quadrats with one or more of the species) and abundance (mean count or mean percentage cover of the species in occupied quadrats); *noxious weed *([5]Alberta Weed Control Act 19/2010);* [nn]non-native species *(unregulated)*

Eudicot species *(note – all are perennials)*	**common name**	**occurrence**	**abundance**	**USDA wetland classification**[6]
Viola canadensis	Canada Violet	14	16.3	FACU
*Cirsium arvense**	Creeping Thistle	13	7.4	FACU
Cornus sericea	Red-Osier Dogwood	13	8.3	FACW``
Persicaria amphibia	Swamp smartweed	13	6.3	OBL
Rosa acicularis	Prickly Rose	12	10.0	FACU
Thalictrum venulosum	Veiny Meadow Rue	12	7.6	FAC
Anemone canadensis	Canada Anemone	11	4.6	FACW
Elaeagnus commutata	Silverberry	11	4.0	UPL
Pyrola asarifolia	Common Pink Wintergreen	11	5.7	FACU
Salix bebbiana	Bebb's Willow	11	4.5	FACW
Solidago gigantea	Giant Goldenrod	11	3.7	FAC
Taraxacum officinale	Dandelion	11	9.1	FACU
Mentha arvensis	Wild Mint	10	4.1	FACW
Symphyotrichum lanceolatum var. hesperium	Western Willow Aster	9	4.0	FACW
Galium boreale	Northern Bedstraw	8	2.4	FACU
*Sonchus arvensis**	Field Sow Thistle	8	3.7	FAC
Rubus pubescens	Trailing Raspberry	7	13.3	FACW
Senecio pauperculus	Balsam Groundsel	7	1.5	FAC
Symphyotrichum laeve	Smooth Blue Aster	7	6.7	FACU
Amelanchier alnifolia	Saskatoon	6	0.8	FACU
Salix pseudomonticola	False Mountain Willow	6	0.6	FACW
Monarda fistulosa	Wild Bergamot	5	2.3	___
Scutellaria galericulata	Skullcap	5	1.8	OBL
Vicia americana	American Vetch	5	1.3	FACU
Fragaria virginiana	Wild Strawberry	4	6.3	FACU
Shepherdia canadensis	Buffaloberry	4	0.9	FACU
Argentina anserina	Silverweed	3	0.9	FACW
Symphoricarpus occidentalis	Buckbrush	3	0.5	UPL
Achillea millefolium	Common Yarrow	2	0.2	FACU
Actaea rubra	Baneberry	2	0.1	FACU
Antennaria pulcherrima	Showy Everlasting	2	0.5	__
Betula occidentalis	Water Birch	2	0.1	FACW
*Sorbus aucuparia**	European Mountain Ash	2	0.2	___
Arctostaphylos uva-ursi	Bearberry	1	0.1	UPL
*Cotoneaster lucidus**	Shiny Cotoneaster	1	0.1	___
Disporum trachycarpum	Fairy Bells	1	0.1	UPL
Geum macrophyllum	Large Leaved Aven	1	0.3	FACW
Heracleum maximum	Cow Parsnip	1	0.1	FAC
Potentilla fruticosa	Shrubby cinquefoil, Potentilla	1	0.4	FACW

Sanicula marilandica	Maryland Sanicle	1	0.1	FACU
Symphoricarpos albus	Snowberry	1	0.1	UPL
Viburnum trilobum	Highbush Cranberry	1	0.1	--
Moncots		**occurrence**	**abundance**	**USDA wetland classification**[6]
Carex capillaris	Hair-Like Sedge	15	<1%	FACW
Poa pratensis , Poa palustris, Agrostis stolonifera	Kentucky Blue Grass+ Fowl Blue Grass + Creeping Bentgrass	14	10%	FACU + FACW + FACW
Calamagrostis inexpansa	Northern Reed Grass	13	12%	—
Carex atherodes	Wheat Sedge (?)	6	18.0	OBL
Carex atherodes	Wheat Sedge (?)	1	20%	OBL
Typha latifolia	Cattail	5	11.2	OBL
Glyceria grandis	Tall Manna grass	4	1.8	OBL
Juncus balticus	Baltic Rush	4	<5%	FACW
Carex utriculata	Small Bottle Sedge	3	17%	OBL
Calamagrostis canadensis	Canada Reed Grass	2	<1%	FACW
Carex disperma	Two seeded sedge	1	22.0	FACW
Moss Cover %		1	22%	

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 2019 results show a total taxa richness of 42 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 11.6% of the total individuals counted. The area revealed an average richness of 4.32±1.76 species per square meter (n=15). 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 ni 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 85.6%±11.7% per quadrat (2m x 2m) in 2019. Figure 8 compares Simpson's Diversity Index (1-S) per quadrat across the 2015 to 2019 sampling campaigns. Although the trend in diversity appears to be increasing, this increase is not statistically significant.

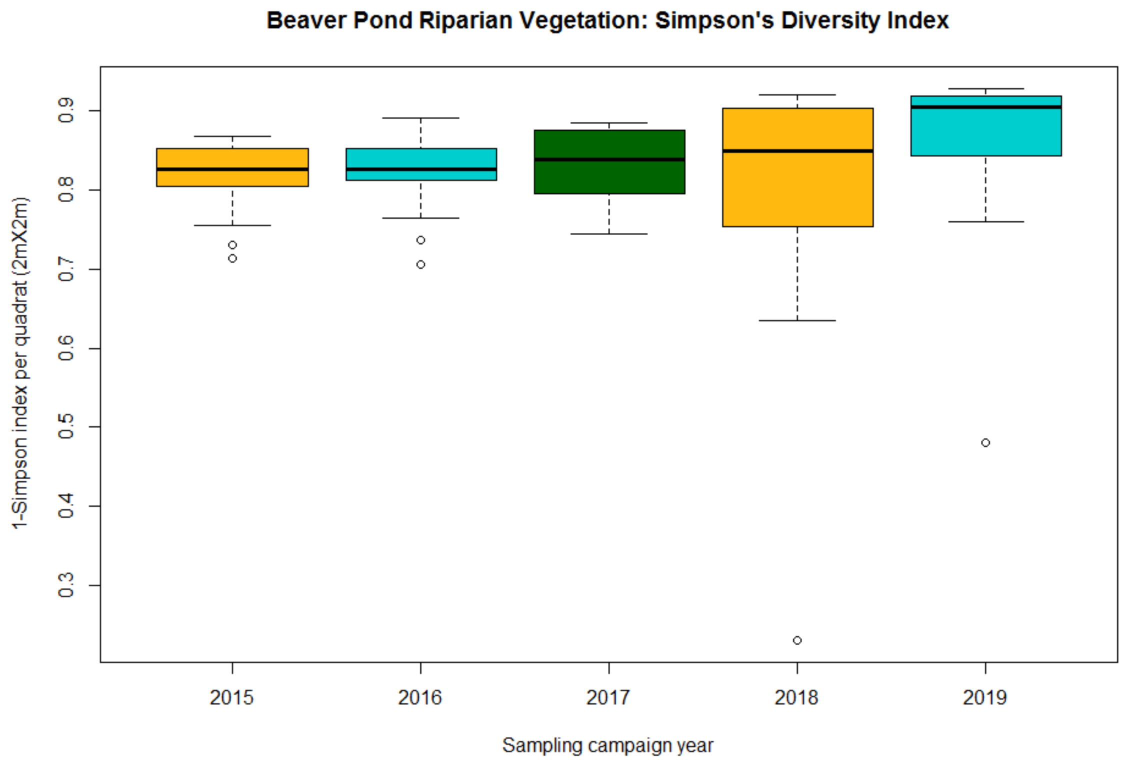

Figure 8: Simpson's Diversity Index (1-S) per quadrat for 2015 to 2019 sampling campaigns.

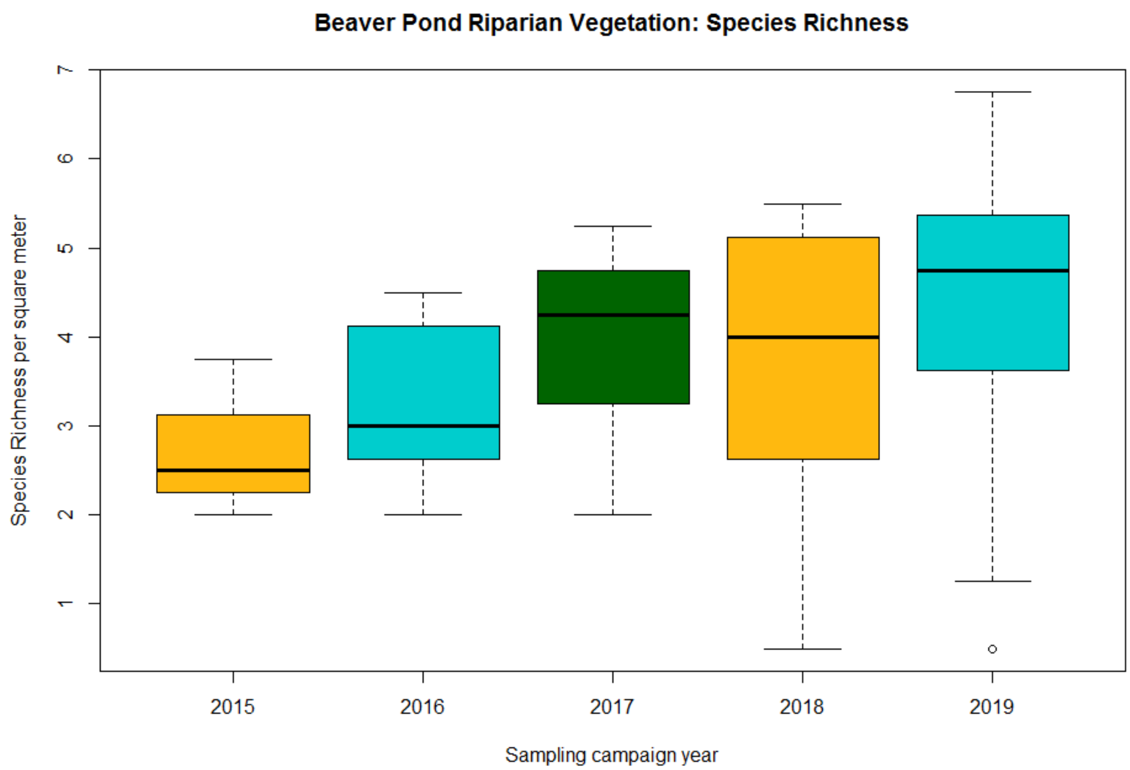

Figure 9: Eudicots species richness per square meter for 2015 to 2019 sampling campaigns.

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 2019 (Kruskal-Wallis rank sum test df = 4, $p<0.05$).

The measured mean of eudicot species per square meter along the shore of the Beaver Pond in 2019 is 4.3±1.8 species/m^2, (n=15). Figure 9 compares eudicots species richness per square meter between 2015 and 2019 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.

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. This project has installed and is collecting data from 12 motion-activated cameras in the Weaselhead and adjacent Glenmore Parks (fig. 10). It is anticipated results will give useful data on any change in presence/absence of species, change in seasonal use, and change in use of the parks for breeding/raising young across the course of the Study. Preliminary results of species' presence are shown up to Sept. 2019 in table 7 (later months' photos have still to be identified. A full data set will be ready in 2020). *(Note: data from a similar project sponsored by the Society and run by SAIT from 2016-2018 investigating medium to large mammal presence in, and use of, the park is still not available.)*

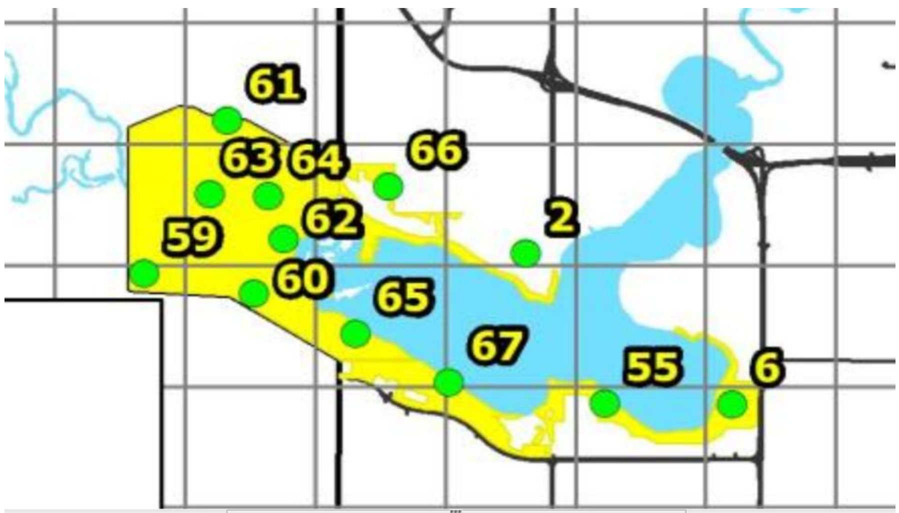

Figure 10: location of '*Calgary Captured'* cameras = green dots; Weaselhead and Glenmore Parks shown in yellow, Glenmore Reservoir in blue.

Table 7: species identified in camera-trap photographs in 2019; * indicates photos include adult with this year's young. (*Note: preliminary results only; data from Oct, Nov. and Dec. are not yet available)*

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

In addition to the above monitoring in the Weaselhead and Glenmore Parks, Golder Associates is monitoring use of the wildlife corridors across the Transportation Utility Corridor (see fig. 12) on behalf of Alberta Transport (AT). Wildlife corridors along ~1.2km of each bank of the Elbow River are checked for signs of use (e.g. tracks) every month. The Jan. to Dec. 2019 reports were shared with the Society by AT. These showed wildlife presence in the wildlife corridors to the east and west of the Elbow River Crossing (three parallel bridges for the SWCRR southbound and northbound carriageways and the local road) but little evidence of animals using the corridors under the bridges (fig. 11; table 8). There is evidence of some animals approaching the bridges but turning back, and on one occasion moose and deer apparently crossing the road construction site rather than going under the bridges. Reluctance to go under the bridges may be because of the active construction on, under or adjacent to the bridges that occurred throughout 2019. Wildlife use may also have been missed as coir matting had been laid under the bridges reducing the likelihood of animals leaving visible tracks. In Dec. 2019 and Jan. 2020 two remotely operated cameras were installed by the *'Calgary Captured'* partnership near the Elbow River Crossing (in the Weaselhead) to help establish if wildlife is using the corridors under the bridges.

Table 8: tracks observed in wildlife corridors under one or more bridges by Golder Associates during monthly monitoring (with total number of months that each species' tracks were observed)

2019	Jan.	Feb	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	*total*
small mammals	x		x	x									*3*
mink							x		x				*2*
domestic dog			x									x	*2*
deer												x	*1*
beaver							x						*1*
human			x										*1*

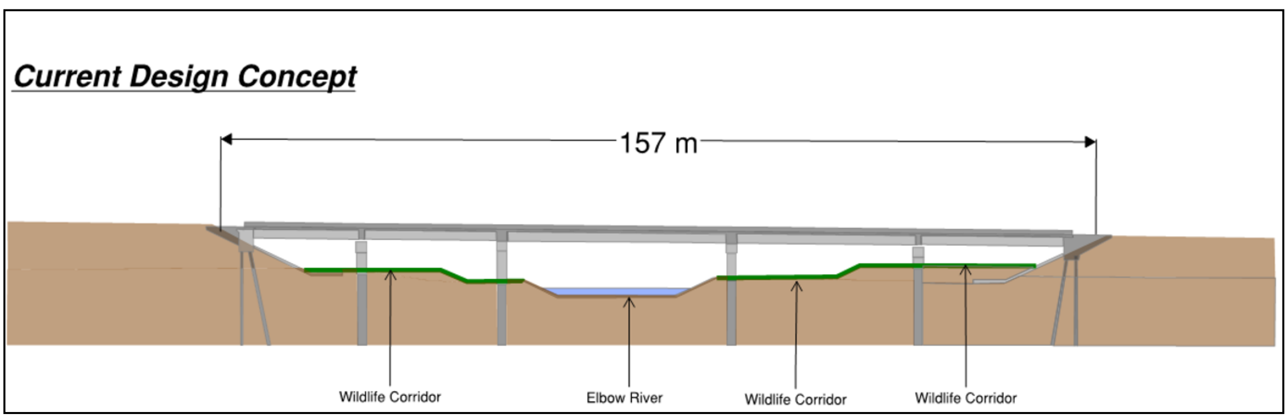

Figure 11: schematic of wildlife corridors under one of the bridges looking west; downloaded from SWCRR Project website March 2019 **http://www.swcrrproject.com/frequently-asked-questions/faq-environment/**

The *'Calgary Captured'* cameras in 2019 recorded medium to large mammals in the Weaselhead, including species such as moose and bear that require ranges far larger that the ~250ha Weaselhead for their needs. Clearly these animals must be accessing other habitat to the west of the SWCRR as land in other directions has been developed and built on (see figure 13). The Golder data indicate that they are not doing this via the designated wildlife corridors under the bridges, but by crossing the as yet unfenced construction zone elsewhere.

Figure 12: looking east towards Weaselhead; southern wildlife corridor across TUC (Transportation Utility Corridor) shown by blue dashed line, northern by red dashed line (both follow river bank under bridges)

Figure 13: Weaselhead Park west of Glenmore reservoir outlined in orange (area 245ha); SWCRR construction site visible running north south on left of image *(Google Earth Image from 22nd July 2019)*

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. 14). 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. 17) aims to maintain surface flow to these wetlands during and post SWCRR construction.

Water quality data was collected from 2015 to 2019 from 3 sites in each of the three wetlands and from the Elbow River (figs. 15 and 16; table 9). 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 of these streams have been impacted by construction of the SWCRR across their catchment areas (fig. 17). One of the wetlands, the Beaver Pond, is split into two cells connected by a culvert under a paved pathway. To better understand the hydrology of this wetland in October 2018 a pressure sensor was lowered to the bed of the wetland near point BP3 to track changes in depth (retrieved in October 2019). Results confirm seasonal variation in the Beaver Pond water level and demonstrate specific influences from rain events (details given in Appendix II).

Figure 14: Location of monitored wetlands

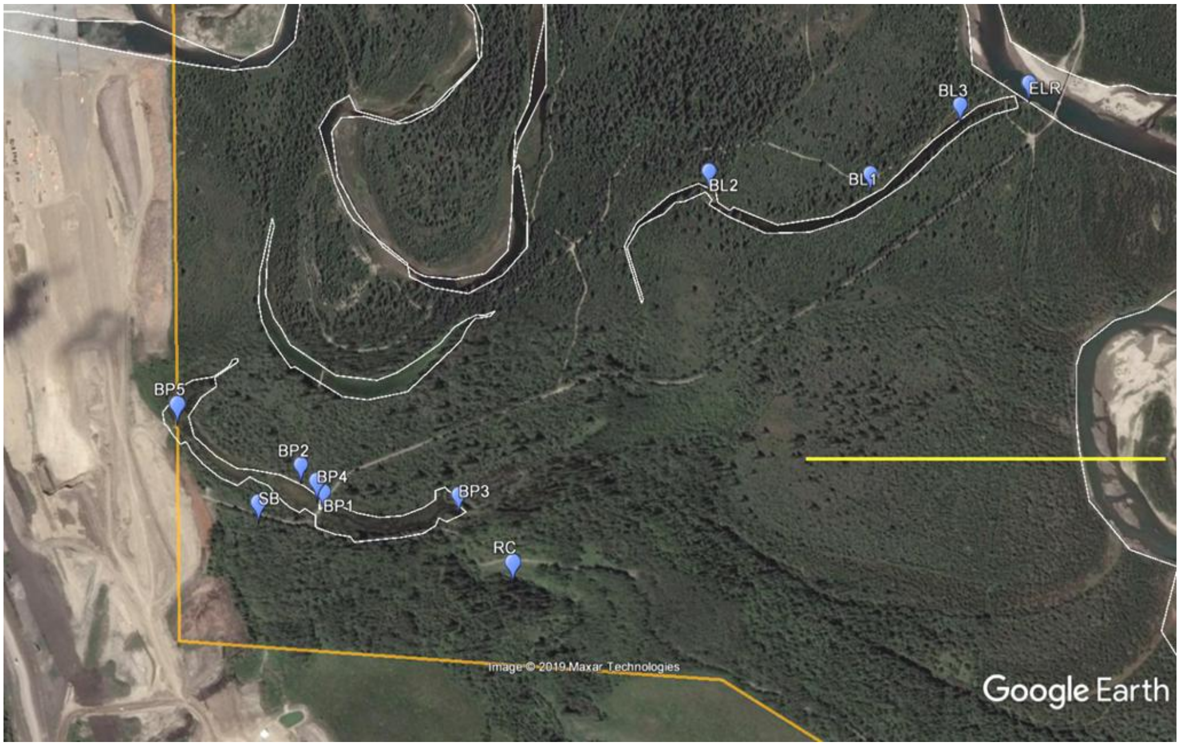

Figure 15: Location of sampling sites at the Beaver Pond (BP), Beaver Lagoon (BL), Spring Brook (SB), Ravine Creek (RC) and Elbow River (ELR); white lines show edges of permanent wetlands; orange line shows park boundary; scale: yellow line = 500m

Figure 16: Location of sampling sites at Clearwater Pond

Table 9: 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

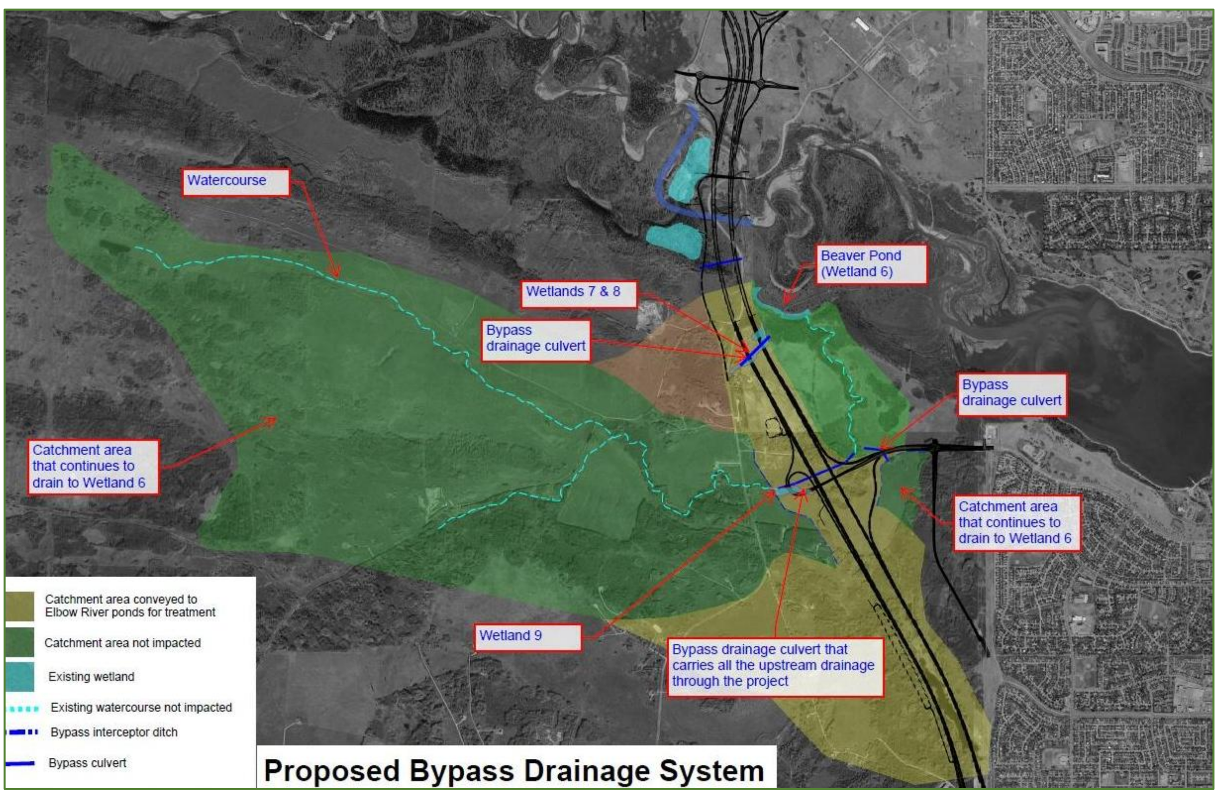

Figure 17: bypass drainage for Spring Brook (northern culvert) and Ravine Creek (southern culvert) intended to maintain surface flow across the Transportation Utility Corridor into the Beaver Pond (*Sept. 201, courtesy of KGL – construction company for the SWCRR)*

Water sampling and in-situ assessments were performed on 19th/20th Aug., and 13th/14th Oct. 2019.

A YSI® Pro Plus was used to measure temperature, conductivity, pH, salinity 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 10 and 11. Table 12 shows the summary statistics for temperature, pH, conductivity, dissolved oxygen, phosphate and chloride.

The method for measuring turbidity changed in fall 2018, and data on nitrates and salinity were not collected prior to 2019. 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.

Monitoring of water quality and water flow in the Beaver Pond (referred to as 'wetland 06') was also carried out in 2019 on behalf of KGL by Hemmera Envirochem Inc. on 29th May and 16th Oct. The summary from the 2019 [8]Wetland 06 Water Monitoring Report will be added to this report when made available.

Table 10: Water quality parameters on August 19 and 20 2019

	Water body / Site **													
field: August 19th and 20th, 2019*	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	Spring Brook
Turbidity (NTU)	17.00	6.00	10.00	5.00	21.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	7.00	0.00
Temperature (°C)	17.80	17.40	18.17	15.50	19.80	17.67	18.53	18.83	15.93	21.90	22.30	22.03	10.00	11.83
pH	8.74	9.35	9.30	9.30	10.17	8.83	9.11	9.23	9.50	9.66	9.85	10.15	9.56	9.64
Conductivity (- C (µS/cm)	650.00	752.00	660.00	710.67	563.07	732.67	574.33	556.57	414.77	246.87	230.43	217.47	952.33	800.00
DO (mg/L)	2.83	7.75	7.34	2.97	10.91	9.96	9.26	10.24	9.34	5.62	5.73	4.77	10.74	8.43
DO (%)	36.30	90.47	90.73	36.37	131.43	118.20	112.03	125.23	107.27	73.17	75.40	61.07	109.87	88.40
Phosphate (mg/L)*	0.16	0.07	0.12	0.30	0.05	0.05	0.07	0.10	0.78	0.03	0.32	0.02	0.79	0.23
Chloride (mg/L)	0.80	0.90	1.20	0.60	1.40	1.50	1.10	1.40	0.80	0.60	0.50	0.50	0.90	1.80
Salinity (ppm)	0.32	9.35	0.32	0.35	0.27	0.36	0.28	0.27	0.20	0.12	0.11	0.10	0.47	0.40
Nitrate (mg/L NO3)	1.00	0.46	1.06	0.28	1.50	0.06	0.16	0.24	0.52	0.48	0.28	0.28	0.60	0.20
Nitrate (mg/L N)	0.23	0.10	0.24	0.06	0.34	0.01	0.04	0.05	0.12	0.11	0.06	0.06	0.14	0.05

Table 11: Water quality parameters on October 13 and 14t 2019

	Water body / Site													
field: October 13 and 14, 2019*	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	Spring Brook
Turbidity (NTU)	9.00	15.00	5.00	15.00	7.00	0.00	6.00	0.00	0.00	12.00	0.00	14.00	0.00	7.00
Temperature (°C)	4.27	4.97	3.57	3.90	3.63	4.03	4.27	4.97	5.40	4.13	4.50	4.40	2.47	3.20
pH	8.76	8.91	8.69	9.01	9.04	8.59	8.50	8.50	9.09	9.28	8.93	8.99	8.49	9.13
Conductivity (- C (µS/cm)	808.97	736.10	796.17	742.77	751.23	629.60	605.83	716.97	419.73	295.13	295.03	298.77	888.67	797.87
DO (mg/L)	6.98	8.72	7.40	9.38	9.89	9.26	9.07	8.92	10.55	12.29	9.83	11.20	2.24	10.06
DO (%)	63.70	78.20	63.87	81.90	85.40	80.10	79.63	78.97	94.57	107.40	87.77	97.83	20.00	85.47
Phosphate (mg/L)*	0.13	0.22	0.25	0.31	0.17	0.60	0.60	0.50	0.10	0.40	0.40	0.30	0.14	0.09
Chloride (mg/L)	1.50	1.20	1.00	1.60	1.80	1.60	1.80	1.50	0.60	1.40	1.60	1.20	2.80	2.10
Salinity (ppm)	0.40	0.36	0.39	0.36	0.36	0.31	0.29	0.35	0.20	0.14	0.14	0.14	0.43	0.39
Nitrate (mg/L NO3)	0.53	0.23	1.15	0.42	0.33	0.37	0.36	0.47	0.61	0.62	0.39	0.26	0.59	0.53
Nitrate (mg/L N)	0.12	0.05	0.26	0.10	0.08	0.09	0.08	0.11	0.14	0.14	0.09	0.06	0.14	0.12

Table 12: Water quality parameters in 2019; each value represents the average (±SEM).

	site	number of replicates	assessment date (2019)	temperature (°C)	pH	conductivity (µS/cm)	DO (%)	phosphate PO4 (mg/L)	chloride (mg/L)
Beaver Pond	BP	5	Aug. 19-20	17.7 (±0.7)	9.4 (±0.2)	667 (±32)	77 (±18)	0.14 (±0.04)	0.98 (±0.14)
		5	Oct. 13-14	4.1 (±0.3)	8.9 (±0.1)	767 (±15)	75 (±5)	0.22 (±0.03)	1.42 (±0.14)
Beaver Lagoon	BL	3	Aug. 19-20	18.3 (±0.3)	9.1 (±0.1)	621 (±56)	118 (±4)	0.07 (±0.01)	1.33 (±0.12)
		3	Oct. 13-14	4.4 (±0.3)	8.5 (±0.0)	651 (±34)	80 (±0)	0.57 (±0.03)	1.63 (±0.09)
Clearwater Pond	CP	3	Aug. 19-20	22.1 (±0.1)	9.9 (±0.1)	232 (±9)	70 (±4)	0.12 (±0.10)	0.53 (±0.03)
		3	Oct. 13-14	4.3 (±0.1)	9.1 (±0.1)	296 (±1)	98 (±6)	0.37±0.03)	1.40 (±0.12)

i) Turbidity

Turbidity is dictated by the concentration of suspended and dissolved solids in the water column ([9]Sawyer *et al.*, 2003), being 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

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 [10]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 13 below gives a qualitative rather than quantitative picture of turbidity in the monitored wetlands over the period of the Study.

Table 13: turbidity levels recorded 2015 to 2019

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

No significant change in turbidity was recorded before 2018 ([11]Enivironmental Monitoring Report 2018, WGPPS). Very high levels of turbidity were recorded in all three wetlands in 2018 (Beaver Pond in August, Beaver Lagoon and Clearwater Pond in October) however the events causing these high levels are unknown. In 2019 turbidity levels appear to have dropped (statistical testing of the data was not possible).

ii) <u>Temperature</u>

Regression analysis of data from the Beaver Pond, Beaver Lagoon and Clearwater Pond for the period 2015 to 2019 does not show any association between water temperature and year when comparing the same months (linear regression, d.f.=31 (Beaver Pond), d.f.=22 (Beaver Lagoon and Clearwater Pond), $p<0.05$), i.e. no trend towards temperature increase or decrease was evident in any of the monitored wetlands across 2015 and 2019. See figure 18.

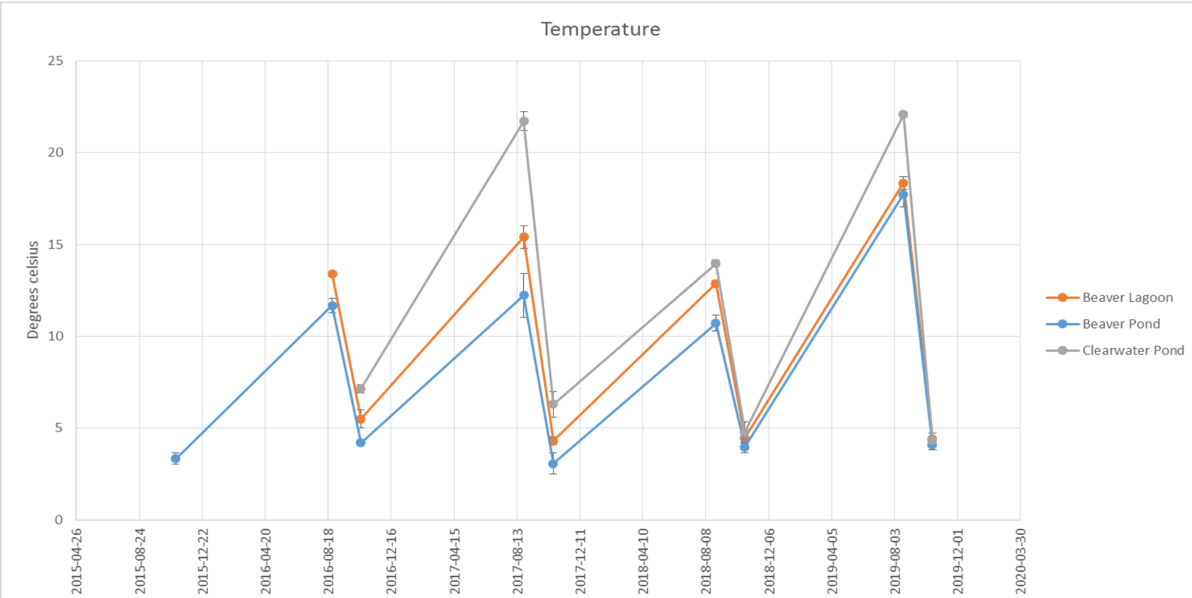

Figure 18: Temperature recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) between 2015 and 2019.

iii) <u>pH</u>

The pH scale reflects the chemical balance of the elements present in water that determine its acidic, neutral or basic conditions ([9]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 and Beaver Lagoon for the period between 2016 and 2019 revealed a significant increase in pH with year (linear regression, d.f.=31 (Beaver Pond), d.f.=22 (Beaver Lagoon), $p<0.05$). During the same period, the reference wetland (Clearwater Pond) has not showed any association between pH and time (linear regression, d.f.=3, $p>0.05$). See figure 19.

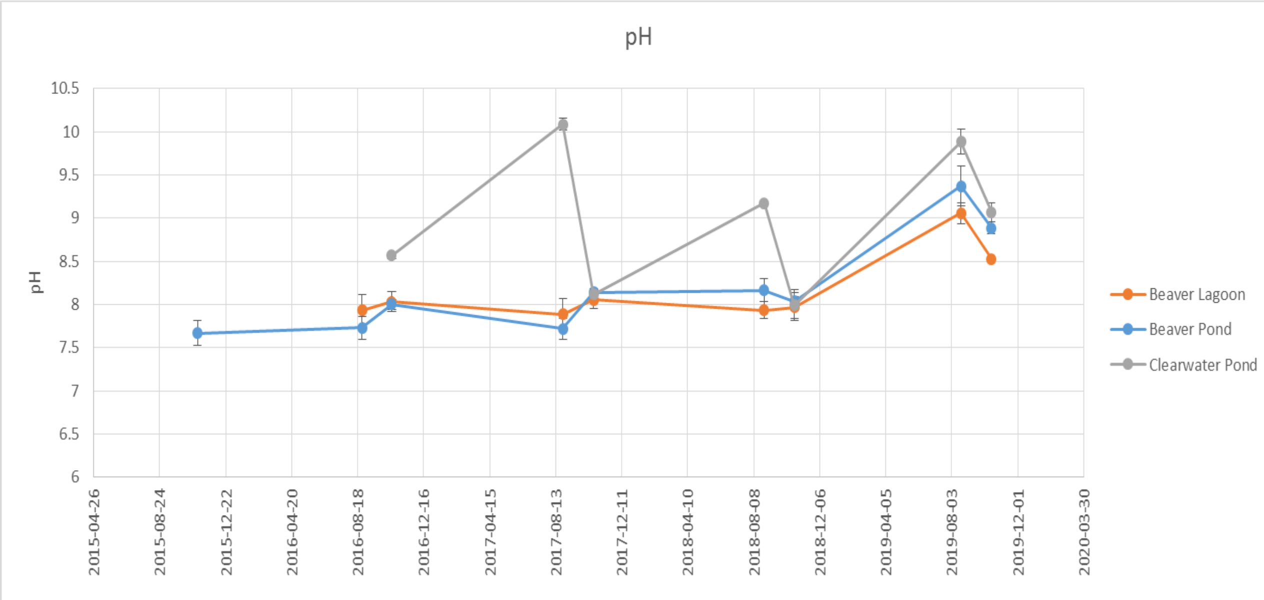

Figure 19: pH recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP) between 2015 and 2019.

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 ([9]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 and Beaver Lagoon (Weaselhead sites that are hydrologically connected) for the period between 2015 and 2019 revealed a significant increase in conductivity over time (linear regression, d.f.=31 (Beaver Pond), d.f.=22 (Beaver Lagoon), $p<0.05$). During the same period, the reference wetland (Clearwater Pond) has not showed any association between conductivity and time (linear regression, d.f.=19, $p>0.05$). See figure 20.

Conductivity fluctuations in the Beaver Pond and Beaver Lagoon between 2015 and 2019 shows the average conductivity levels were typically below 600 uS/cm until 2018 when they peaked, and that averages in both wetlands have remained since then above 600 uS/cm. (Independent spring and fall monitoring of the Beaver Pond by [8]Hemmera has also recorded conductivity values above 600 uS/cm since 2018.) In contrast, during this period the reference wetland upstream of the SWCRR development has shown no significant increase in conductivity.

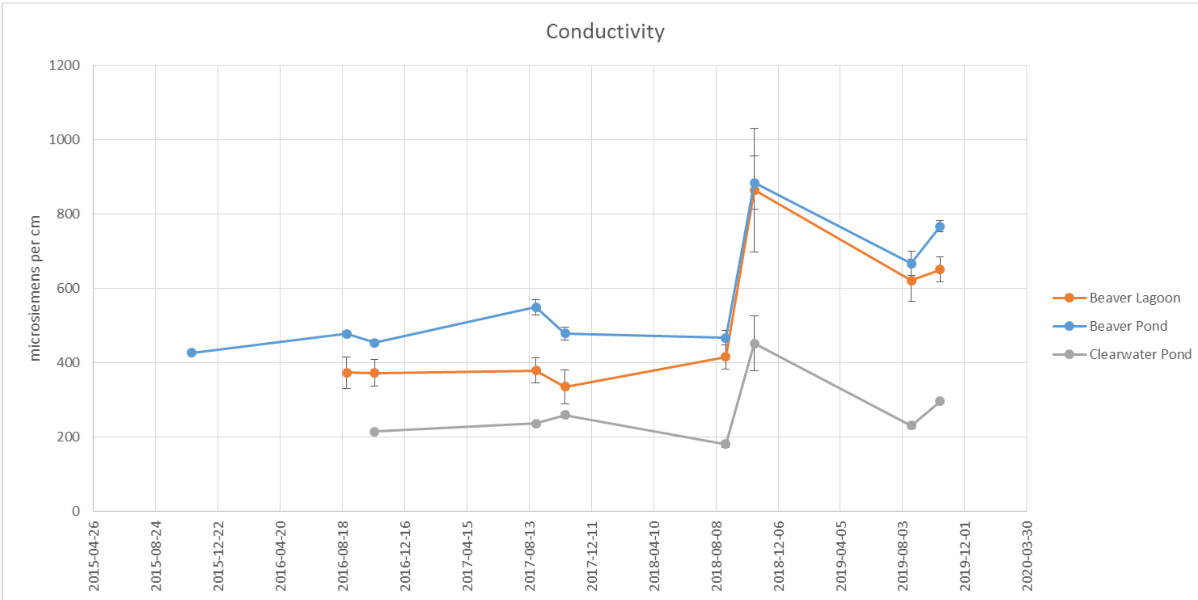

Figure 20: Conductivity recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) between 2015 and 2019.

v) Dissolved Oxygen

Regression analysis of data from the Beaver Pond, Beaver Lagoon and Clearwater Pond, 2015 to 2019, does not show any association between dissolved oxygen (DO) and time (linear regression, d.f.=31 (Beaver Pond), d.f.=22 (Beaver Lagoon and Clearwater Pond), $p<0.05$). See figure 21.

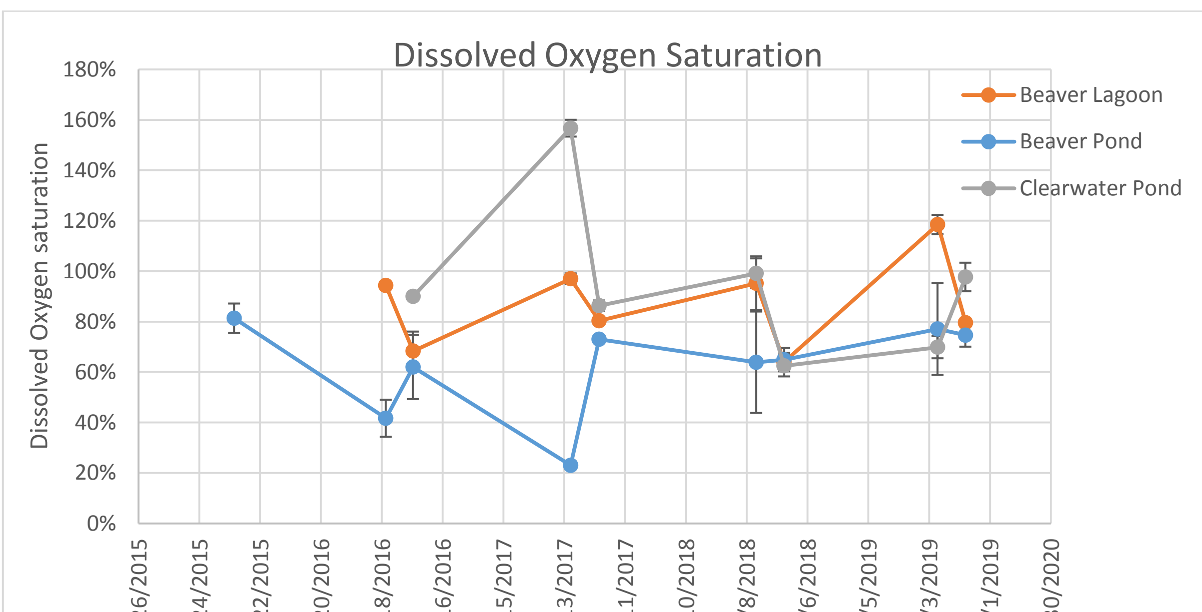

Figure 21: Dissolved oxygen (DO) recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) between 2015 and 2019.

vi) Chloride

Chloride is one of the important dissolved ions that can increase the electric conductivity of water ([9]Sawyer *et al.*, 2003). The measure of chloride (figure 22) 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 ([11]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 2019, a decrease also observed in the control site CP (linear regression, d.f.=17, p>0.05).

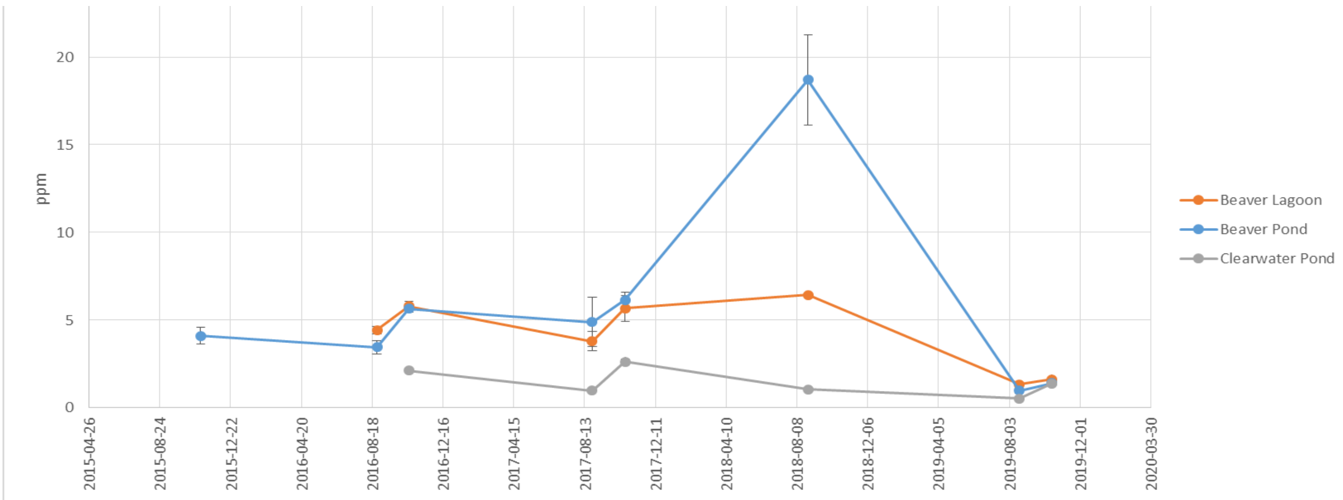

Figure 22: Chloride recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP) between 2015 and 2019.

vii) Nitrate

2019 was the first year that nitrate levels were measured. Results are shown below in table 15.

(note: the test used also responds to nitrite in the water, normally very small in natural waters in comparison to nitrates . This is confirmed in the results of the [8]Hemmera monitoring where nitrites levels on 16th Oct. in the Beaver Pond were measured at 0.033mg/l).

Table 14: nitrate concentrations recorded in 2019

	Beaver Pond *(n = 5)*	**Beaver Lagoon** *(n = 3)*	**Beaver Lagoon** *(n = 3)*	**Ravine Creek** *(n = 1)*	**Spring Brook** *(n = 1)*
Nitrate (mg/L NO3) ± SEM					
Aug. 19th/20th 2019	0.86 (±0.22)	0.15 (±0.05)	0.35 (±0.07)	0.60	0.20
Oct. 13th/14th 2019	0.53 (±0.16)	0.40(±0.03)	0.42 (±0.10)	0.59	0.53
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

viii) Phosphorus

Phosphorus is one of the most important limiting nutrients in aquatic ecosystems ([9]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 in the phosphate concentrations shown in table 14 and fig. 23, in any of the monitored wetlands prior to 2018. Data from 2018 are incomplete and were not used in the statistical hypothesis testing. An increase in phosphate concentration for BP and BL were observed between 2015 and 2019, however this increase was also observed in the control site CP (linear regression, d.f.=17, $p>0.05$).

Table 15: phosphate concentrations 2015 to 2019

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

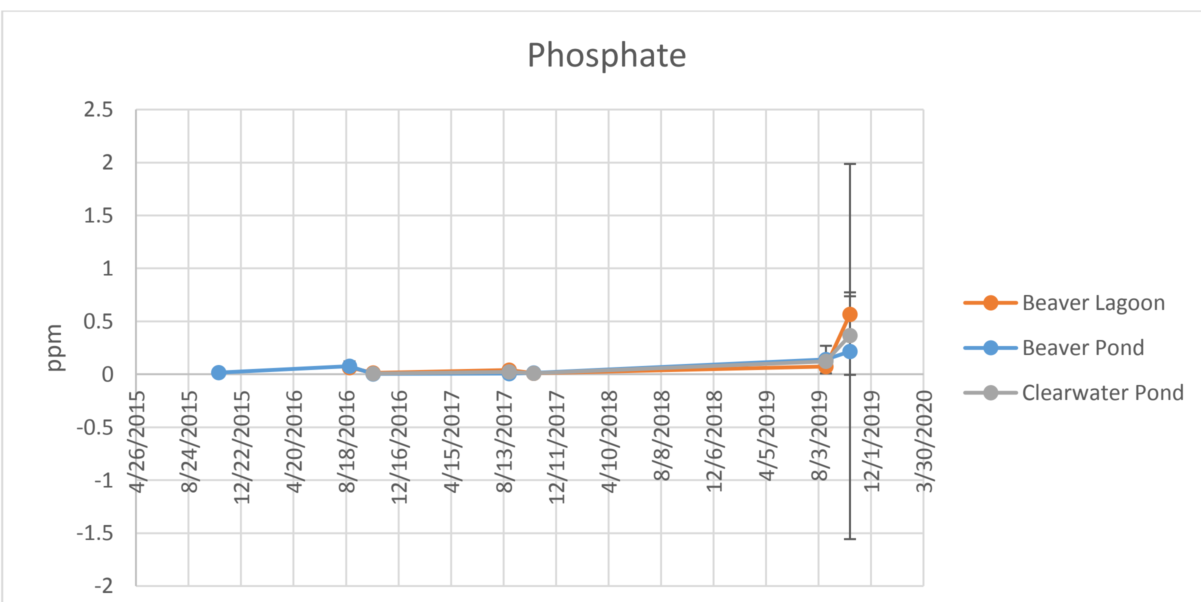

Figure 23: Phosphate recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) between 2015 and 2019.

b. Aquatic macro-invertebrates

In 2019 a total of 741 specimens were identified to 43 taxa for the habitats studied (BP, BL and CP, table 16 & 17). The 43 taxa identified represent the greatest taxonomic resolution achieved and consist of 31 groups identified to genus/species and 12 groups identified to family level or above.

Table 16: Taxonomic classification for the aquatic macro-invertebrates sampled on August 20th 2019

	Greatest Taxonomic Resolution Obtained	Beaver Pond			Beaver Lagoon			Clearwater -		
		BP1	**BP2**	**BP3**	**BL1**	**BL2**	**BL3**	**C1**	**C2**	**C3**
Mayflies	*Caenis* sp. Stephens, 1835	33	2	1						
	Pseudocleon		2							
	Centroptilum sp. Eaton 1869	5	1		1	1				
Caddisflies	*Phryganea* sp									1
	Rhyacophila sp								1	
Dragonflies	Anisoptera					2				
	Lestes sp								1	
	Enallagma sp. Charpentier, 1840					1				
True Flies	Orthocladiinae	1	1	7		1				
	Tanypodinae	2								
	Ceratopogonidae	1								
Beetles	*Potamonectes* sp. Zimmermann, 1921						1			
	Hydroporus sp						1			1
	Colimbetes sp						1			
	Ilybius sp. Erichson, 1832	1								
	Liodessus					3				1
	Laccornis				4					
	Hygrotus sp. Stephens 1828				2					
	Gyrinus sp.			1						
	Haliplus sp. Latreille, 1802	3	6	10		1	1		2	2
True Bugs	Corixidae	4	1		2		1	1	18	1
	Notonecta sp. Linnaeus, 1758	2								
Water mites	Acari	6	25							1
	Hydrachnidia	1			1	1	1			
Water fleas	*Daphnia* sp. (Muller 1785)	6	24			4				
	Chydoridae	18				40				
Scuds	*Gammarus lacustris* G.O. Sars, 1864		2		10	1	7			
	Hyalella azteca (Saussure, 1858)	6	1	4	8	77	9		1	
Snails	*Physa* sp. Draparnaud, 1801	3	10	21		2			2	5
	Lymnaea stagnalis (Linnaeus, 1758)		1							
	Stagnicola sp. Jeffreys, 1830	1			1	1				
	Planorbula campestris (Dawson, 1875)			1						
	Promenetus umbilicatellus (Cockerell, 1887)	3		18					7	48
Freshwater clams	*Pisidium* sp				7		1			
Leeches	*Placobdella montifera* (Moore 1906)		1	1						
	Thermomyzon			1						
	Alboglossiphonia heteroclita (Linnaeus 1761)	2								
Nematods	Nematoda	24								

Table 17: Taxonomic classification for the aquatic macroinvertebrates sampled on October 13th 2019

	Greatest Taxonomic Resolution Obtained	Beaver Pond			Beaver Lagoon			Clearwater - Control		
		BP1	BP2	BP3	BL1	BL2	BL3	C1	C2	C3
Mayflies	*Caenis* sp. Stephens, 1835	1								1
	Baetidae spp	5			13		4			
	Centroptilum sp. Eaton 1869					5				
Caddisflies	*Phryganea* sp				1					
Dragonflies	*Enallagma* sp. Charpentier, 1840	4								
	Aeshna sp. Fabricius, 1775	1		5					1	
Trueflies	*Chironomi*	1					4			
	Orthocladiinae									1
	Tanypodinae						4			
	Ceratopogonidae	6								
Beetles	*Laccophilus* sp. Leach, 1815					1				
	Adephaga sp						10			
	Liodessus			1						
	Haliplus sp. Latreille, 1802			1			10			
True bigs	Corixidae	1						3	1	1
	Notonecta sp. Linnaeus, 1758	1							1	
Water mites	Hydrachnidia	1	1							
Scuds	*Gammarus lacustris* G.O. Sars, 1864				10	9				
	Hyalella azteca (Saussure, 1858)	8			13	1	23			1
Snails	*Physa* sp. Draparnaud, 1801	1		2					2	1
	Stagnicola sp. Jeffreys, 1830	1			1		3			2
	Promenetus umbilicatellus (Cockerell, 1887)								2	18
Freshwater clams	*Pisidium* sp. Pfeiffer, 1821				1	1				

Table 18: Aquatic macroinvertebrates statistics (average ± SEM) (n=3)

Water body	Site	Assessment Date (2019)	Taxa Richness per Site/Sample	Simpson's Diversity Index (1-S) per Site/Sample	% of EPT Taxa
Beaver Pond	**BP**	**August 20th**	14.0 (±2.6)	80.1% (±2.6%)	14.5% (±4.3%)
		October 14th	5.7 (±3.3)	48.7% (±25.2%)	5.6% (±5.6%)
Beaver Lagoon	**BL**	**August 20th**	10.3 (±1.3)	71.4% (±6.8%)	6.3% (±3.3%)
		October 14th	6.0 (±0.6)	70.0% (±4.2%)	17.0% (±1.7%)
Clearwater Pond	**CP**	**August 20th**	5.3 (±2.2)	32.5% (±18.1%)	8.9% (±4.5%)
		October 14th	4.3 (±1.8)	41.4% (±22.5%)	4.8% (±4.8%)

Taxa richness, Simpson's Diversity Index and % of EPT were calculated from the data (Table 18). The results are discussed under separate headings below.

Taxa Richness

Regression analysis of data from the Beaver Pond and Beaver Lagoon (Weaselhead sites), 2016 to 2019, does not reveal any significant association between taxa richness and year (linear regression, d.f.=4 Beaver Lagoon d.f. = 3 Beaver Lagoon, p>0.05). For the same period, the data indicate a significant decrease in taxa richness for the reference site (Clearwater Pond) (linear regression, d.f. = 3, p<0.05).

These results suggest the SWCRR Impact Study has not detected any significant trends in aquatic invertebrate taxa richness from 2016 to 2019 in the studied wetlands. The decrease in the richness of taxa observed in the Clearwater Pond reference site however remains to be explained (fig. 24).

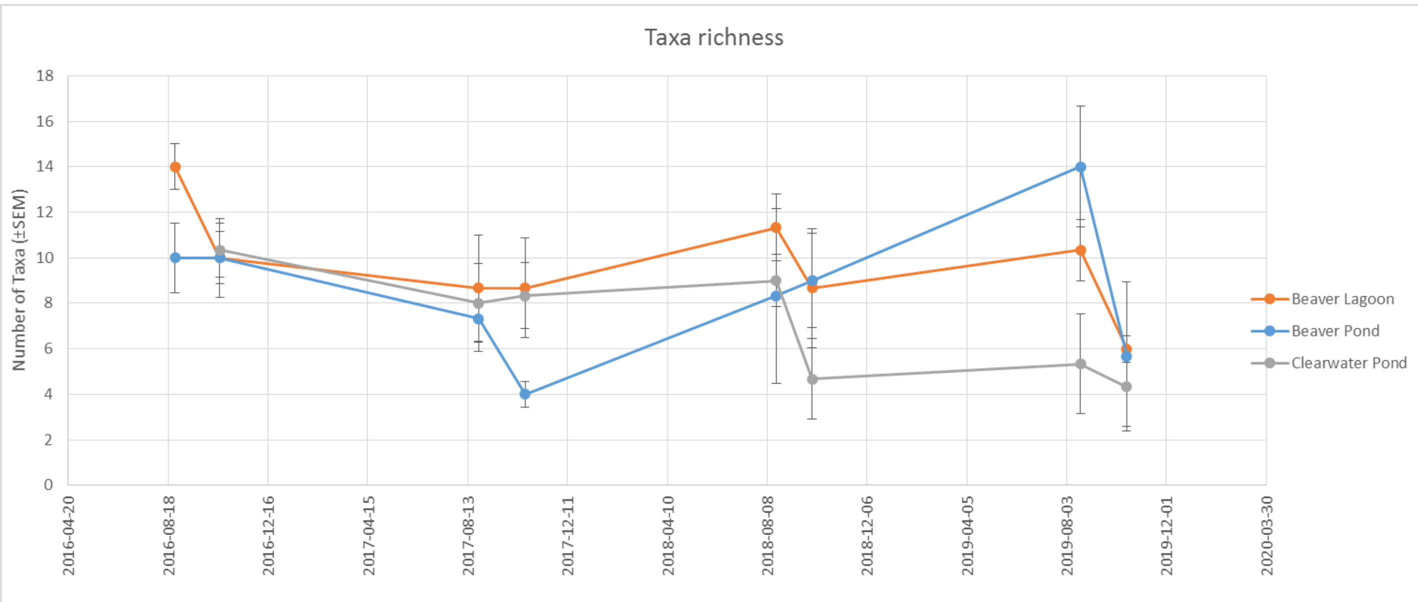

Figure 24: Taxa richness recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) from 2016 to 2019.

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), 2016 to 2019, does not reveal any significant association between taxa diversity and year (linear regression, d.f.=4 Beaver Lagoon d.f. = 3 Beaver Lagoon, d.f. = 3 Clearwater Pond, p>0.05). The diversity of the Beaver Pond and Beaver Lagoon have apparently recovered following a decline in diversity observed in 2018. See figure 25.

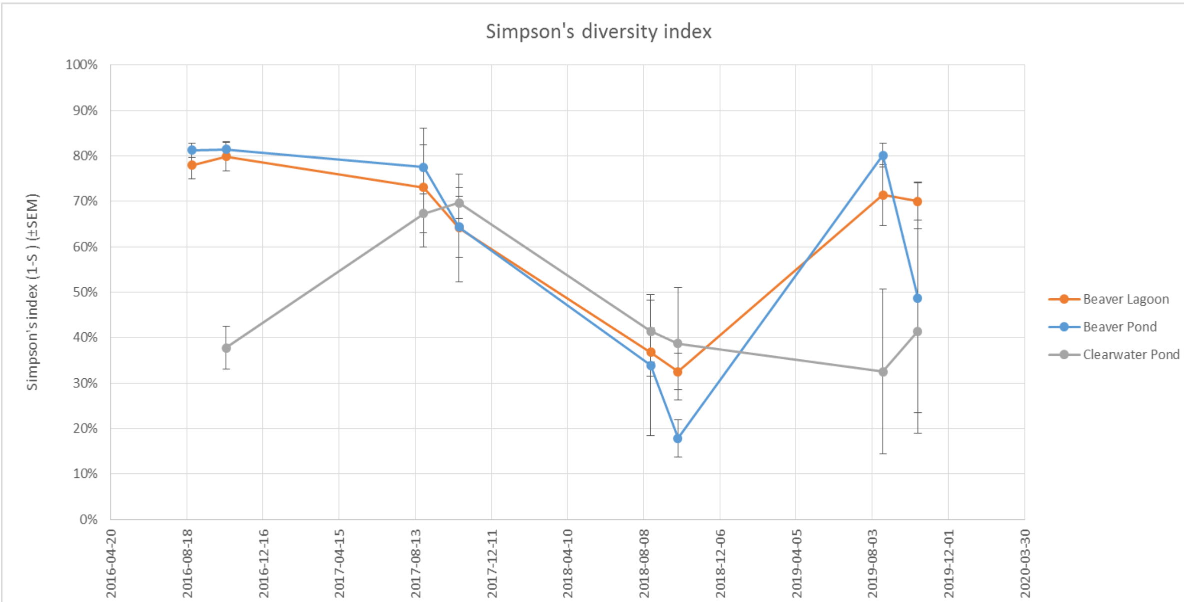

Figure 25: Simpson's diversity index recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) from 2016 to 2019.

<u>EPT taxa %</u>

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 (the reference wetland), 2016 to 2019, does not reveal any significant association between EPT taxa richness % and year (linear regression, d.f.=4 Beaver Pond and Lagoon, d.f. = 3 Clearwater Pond, p>0.05), see figure 26.

This result suggests that the SWCRR Impact Study has not detected any significant trends in EPT taxa % for any sites from 2016 to 2019.

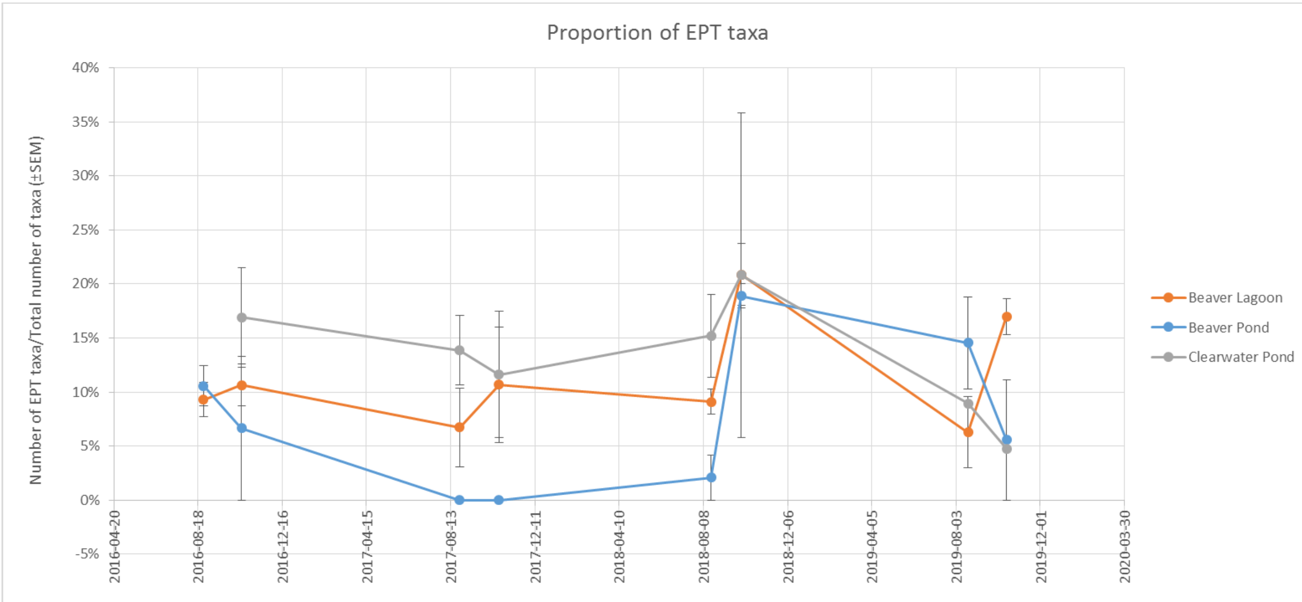

Figure 26: Taxa richness recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) from 2016 to 2019.

c. Amphibians

Nocturnal amphibian call surveys were done at two locations in the Weaselhead in 2017, 2018 and 2019. Only boreal chorus frogs, *Pseudacris maculata* and wood frogs, *Lithobates sylvaticus* were detected (fig. 27, table 19 and 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 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 results from the Weaselhead wetlands will be evaluated in the context of the results from this much larger study when available. The Miistakis Institute is partnering with Calgary Zoo to use these data to better understand the environmental conditions that influence amphibian presence. Outcomes from this research 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.

Figure 27: Locations of amphibian call surveys done in 2012 (green dots) and 2014 (purple dots) carried out for the EIA[1]. 2017, 2018 and 2019 sites indicated by white arrows.

Table 19: Boreal Chorus frogs heard during surveys conducted in 2012, 2014, 2017, 2018 and 2019 *(2012 and 2014 data from Environmental Impact Assessment for the SWCRR, AMEC 2014[1])*

Boreal Chorus frog	EIA 2012 *(no record of abundance)*		EIA 2014 *(no record of abundance)*		2017 *(no. of individuals heard)*		2018 *(no. of individuals heard)*		2019 *(no. of individuals heard)*	
	Beaver Pond	Old Oxbow	Beaver Pond	Old Oxbow	Beaver Pond	Old Oxbow	Beaver Pond	Old Oxbow	Beaver Pond	Old Oxbow
late April	present		present		0	0			0	0
early May					0	2	0	0	0	0
mid May	present		present		0	2	0	0		
late May	present		present		1	1			0	0
early June					0	1			0	0
late june					0	0				

Table 20: Wood frogs heard during surveys conducted in 2012, 2014, 2017, 2018 and 2019. *(2012 and 2014 data from Environmental Impact Assessment for the SWCRR, AMEC 2014[1])*

Wood frog	EIA 2012 *(no record of abundance)*		EIA 2014 *(no record of abundance)*		2017 *number of individuals heard)*		2018 *(number of individuals heard)*		2019 *(number of individuals heard)*	
	Beaver Pond	Old Oxbow	Beaver Pond	Old Oxbow	Beaver Pond	Old Oxbow	Beaver Pond	Old Oxbow	Beaver Pond	Old Oxbow
late April	present		present		3	4			4	0
early May					2	0	4	0	3	0
mid May	present		present		0	0	0	0		
late May	present		present		0	0			0	0
early June					0	0			0	0
late June					0	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 and included in its subsequent Environmental Monitoring Reports.

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. 14, 15 and 16). 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 13th 2019 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 21 below:

Table 21: results of fish trapping 2017- 2019 ***(*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
Beaver Pond	**minnow trapping** *(BP1)*	11 fathead minnows *(Pimephales promelas)*	no fish caught	no fish caught
	dip netting *(BP1)*	n/a*	n/a*	5 brook stickleback *(Culaea inconstans)* (sizes: 2.6, 3.3, 3.5, 2.5, 2.0 cm)
Beaver Lagoon	**minnow trapping** *(BL1)*	no fish caught	no fish caught	no fish caught
	dip netting *(BL1)*	n/a	n/a	no fish caught
Clearwater Pond	**minnow trapping** *(CL1)*	19 white suckers *(Catostomus commersonii)*	no fish caught	no fish caught
	dip netting *(CP1)*	n/a	n/a	no fish caught

FINAL CONSIDERATIONS

The *Environmental Monitoring Report 2019* 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, [12]Schedule 18 of DBFO agreement). 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 that feeds into the Beaver Pond ([11]Environmental Monitoring Report 2018, WGPPS); and a further major spill of *'coarse infill'* (pers. comm. Chris Pipher KGL Environmental Management Team) occurred in August of 2019, again from the adjacent construction site (see figs. 28 and 29).

Figure 28: 19th August 2019. Spill from construction site into Beaver Pond (note: spill occurred sometime before 19th – new sediment fence has been erected); bottom right photo taken 5 days later shows additional sediment has washed into wetland following very heavy rain on 22nd August

Figure 29: same site as shown in figure 27 few days after remediation (photo taken 8th November)

As in the previous spills it appears a heavy rain event overwhelmed the sediment fencing and other measures intended to prevent erosion. Remedial work was required by AEP following the spill and undertaken by KGL between 6th and 8th November. This included removal of sediment, stabilisation of slope and seeding with native plants. In addition AEP has ordered KGL to monitor vegetation establishment, water quality at sediment spill site and amphibian presence in wetland for two years.

The 2018 and 2019 spills had immediate effects on the Beaver Pond water quality parameters, including a visible change in turbidity (see fig. 28), and likely will have other longer term effects. The significant increase in conductivity levels recorded in the Beaver Pond and Beaver Lagoon over time is likely related to these spills. This conclusion is supported by the fact that the Beaver Pond and Beaver Lagoon are hydrologically connected wetlands downstream of the spill, and that that this trend in increasing conductivity was not observed in Clearwater Pond, the reference wetland upstream and uninfluenced by the SWCRR development. Although conductivity may be influenced by annual precipitation regimes and evapotranspiration rates, it is likely the increased levels observed in the Beaver Pond and Beaver Lagoon are result of the 2018 and 2019 spills. These may also account for the increasing pH values observed in the Beaver Pond and Beaver Lagoon since 2018 but not observed in the reference wetland.

It is probably too early to detect the consequences of the above changes in water chemistry to aquatic invertebrates in the Beaver Pond and Beaver Lagoon: a pronounced drop in diversity was observed in 2018, but in 2019 diversity in both wetlands seems to have recovered. Monitoring over the next 3 years of the Study will allow the evaluation of any major effects on community structure, including potential local extirpation of sensitive species.

Impact on breeding birds:

Breeding bird diversity in the Weaselhead remains high and the density in 2019 was similar to that recorded in 2017 prior to the start of construction. Of note are the good numbers of Least Flycatchers recorded every year since the start of monitoring in 2016 – showing the area is and continues to be an important breeding habitat of this sensitive species. Also of significance is the evidence of continued use of the area by another sensitive species, the Pileated Woodpecker. Not observed during the 2109 survey but recorded as present in the Weaselhead ([3]eBird data) was the Sora. Large (>50%) declines in this species have occurred in Alberta and all surrounding jurisdictions since 1994 as wetland habitat has been lost ([2]AEP). Preventing any adverse impact on these three sensitive species in the Weaselhead should be a focus of mitigation efforts and park management plans for the operational phase of the SWCRR.

Impact on wildlife movement:

The *'Calgary Captured'* cameras in 2019 recorded medium to large mammals in the Weaselhead, including species such as moose and bear that require ranges far larger that the ~250ha Weaselhead for their needs. Clearly these animals must be accessing other habitat to the west of the SWCRR as land in other directions has been developed and built on (see fig. 13). Monthly monitoring by Golder and Associates shows little evidence that wildlife is using the designated wildlife corridors along the banks of the river and some evidence they are instead be moving across the construction zone (as yet unfenced). The wildlife corridors are still new, un-vegetated and active construction was ongoing in these areas throughour 2019, however the terms of the contract with Alberta Transport does require measures to allow wildlife to cross the TUC *during* construction (i.e. before the completion of the designated wildlife corridors). It would seem more consideration of how to allow movement across active construction zones during the construction phase of similar large scale projects is required.

The Beaver Pond *(photo by Rebeccah Schwab)*

*****

ACKNOWLEDGEMENTS

The collection of data for this report was generously supported by the Land Stewardship Centre of Canada, Alberta Ecotrust and The Calgary Foundation.

The authors would like to thank the Board and members of the Weaselhead/Glenmore Park Preservation Society for their support of this project, and the following for their help, advice and assistance in carrying out the many hours of field-work involved:

Matthew Wallace	Rebecca Schwab	Wlad Franco-Valias
Jody Allair	Rick Spiegelberg	Stewart Rood
Dan Arndt	Willem Spiegelberg	Gerardo Romero
Bob Lefebvre	Derek Wilcox	Teresa Lynch
Jenna Cross	Tracey Etwell	Youth Central volunteers
Andi Antal	Audrey Lane Cockett	

REFERENCES

[1]Environmental Assessment for the South West Calgary Ring Road (2006, updated Dec. 2014) AMEC Environment and Infrastructure (submitted to Alberta Transportation, Edmonton, Alberta)

[2]Alberta Environment and Parks: Alberta Wild Species Status List 2015; retrieved from https://open.alberta.ca/publications/alberta-wild-species-general-status-listing-2015

[3]eBird Basic Dataset. Version: EBD_relOct-2019. Cornell Lab of Ornithology, Ithaca, New York. Oct 2019.

[4]McClure, C. J. W., Ware, H. E., Carlisle, J. D., Barber, J. R. (2013). An experimental investigation into the effects of traffic noise on distributions of birds: Avoiding the phantom road. *Proceedings of the Royal Society B: Biological Sciences* 280(1773): 20132290.

[5]Alberta Weed Control Act 19/2010); retrieved from http://www.qp.alberta.ca/documents/Regs/2010_019.pdf

[6]USDA Plants Database https://plants.sc.egov.usda.gov/wetinfo.html wetland classification for Great Plains region

[7]City of Calgary: Wildlife Camera Monitoring ' by Nicole Kahal, Tracy Lee and Dr. Tony Clevenger, April 2017, Miistakis Institute

[8]Wetland 06 Water Monitoring Report South West Calgary Ring Road Project, Calgary, Alberta prepared by Hemmera Envirochem Inc. – will be made available online sometime in 2020 http://www.swcrrproject.com/about/environmental-management/

[9]Sawyer, C. N., McCarty, P. L., Parkin, G. F. (2003); Chemistry for Environmental Engineering and Science. New York, NY: McGraw-Hill.

[10]Ohio River Valley Water Sanitation Commission: turbidity for Riverwatchers available online at www.orsanco.org/wp-content/uploads/2016/10/turbidity.pdf)

[11]Enivironmental Monitoring Report 2018, WGPPS; available online at http://theweaselhead.com/wp-wh/assets/Report-2018-final.pdf

[12]Agreement to design, build, finance and operate southwest Calgary ring road Schedule 18: Technical Requirements; available at https://open.alberta.ca/publications/agreement-to-design-build-finance-and-operate-southwest-calgary-ring-road

APPENDIX I

Design details of the retaining wall between the Beaver Pond (one of the wetlands in the Weaselhead being monitored) and the adjacent SWCRR are shown below in fig.29.

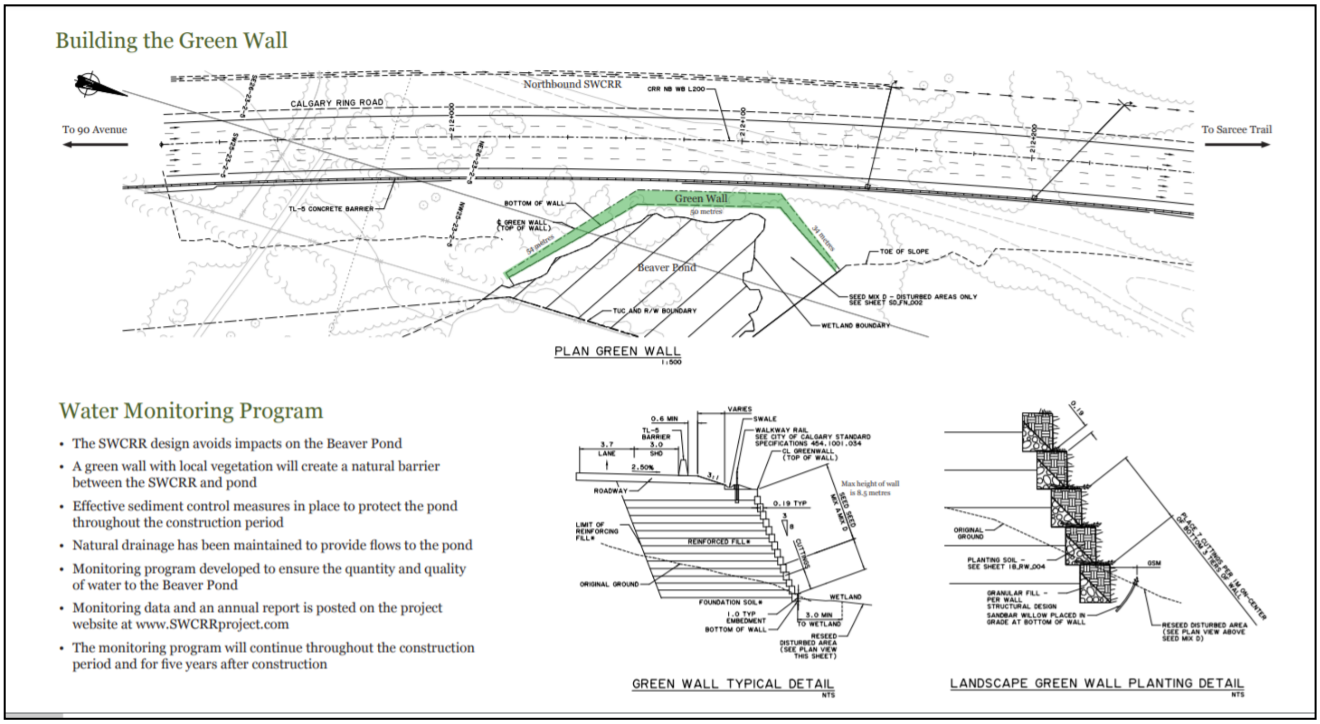

Figure 30: retaining wall ('green wall') between Beaver Pond and SWCRR; downloaded from SWCRR Project website March 2019 http://www.swcrrproject.com/frequently-asked-questions/faq-environment/

APPENDIX II

Seasonal Water Levels in the Weaselhead Beaver Pond, and Weather

The following report is courtesy of Dr. Stewart Rood, Professor of Biology and Environmental Science. Department of Biological Sciences,Univ. **Lethbridge**, Apr 17, 2020 *(text was edited by S.M. Nevill for clarity*)

Method

To track the seasonal changes in the water level (elevation or stage) of the east Beaver Pond (see Section 2, fig. 15 in main text), a Solinst Levelogger pressure transducer was submerged in the pond in autumn 2018 (at point BP3, see fig. 15 in main text). Tracking through the winter was irregular and probably influenced by ice. Ice would persist on the Beaver Pond through March 2019. Thus the level is provided from April through October 2019, i.e. the summer season and into autumn (fig. 31). Data logging was at hourly intervals and for atmospheric pressure correction hourly station (barometric) pressures were obtained for the Calgary Airport. The data record was reasonably confident but there were apparent offsets towards the end of the time series, which were corrected. As a reference, the pond level was set to '0' with averaging around April 1st 2019.

For comparison, daily weather data at the Calgary Airport were obtained from Environment Canada's website:
https://climat.meteo.gc.ca/climate_data/generate_chart_e.html?StationID=50430&wbdisable=true&Month=6&Day=17&Year=2019&timeframe=2&StartYear=1840&EndYear=2019&type=bar&MeasTypeID=totprecip. Other weather measures were provided but only the mean daily temperature (T) and total precipitation (P) are plotted. The total precipitation includes rain and snow, which contributed substantially in April and minimally in May. It should be recognized that there is substantial localized variation, especially with summer precipitation. Consequently, the Calgary Airport precipitation would vary somewhat from that at Weaselhead. Temperatures would also differ, with differences in elevation and from the influences of the sample location in a valley (including from the river, reservoir and riparian woodland).

Findings

The hourly pond levels display 'scalloping' which reflects the diurnal pattern with the daily increase in evaporation and transpiration (combined as evapotranspiration, ET). The magnitude of the diurnal fluctuation was fairly consistent over the interval and was very minor relative to the seasonal variation in the pond level (see fig. 31).

The level of the Beaver Pond water varied slightly more than 0.4 m (40 cm, 16 in) over the season. There was generally a progressive decline in the water level but this recession was interrupted with rain events. The heaviest rain was ~54 mm at the Airport (5.4 cm; ~2 in) which occurred on June 21, the summer solstice. This raised the pond level by ~ 0.2 m (20 cm; ~8 in). The pond level subsequently declined steeply but was raised by about 0.1 m (10 cm; ~4 in) again following rain on July 4 (again, note the precipitation plot is for the Airport, and amount of precipitation at Weaselhead would have differed).

The pond level declined more steeply through the warm and dry interval of mid-July into August. This was followed by a period of multiple, smaller rain events, during which the pond level was correspondingly irregular. The pond level rose slightly in late September and remained relatively constant through October, as the weather cooled. (A comparison of final water level versus the initial level in April has low confidence due to some irregularity in the data in autumn and the offset adjustment.)

These results confirm the seasonal variation in the Beaver Pond water level and demonstrate specific influences from rain events. Such rain events would result in rapid changes in flows in one of the watercourses that feed into the pond, Ravine Creek, while the flow of the other feeder stream, Spring Brook which is groundwater fed, would be more uniform (for locations of these watercourses see fig. 17 in main text)

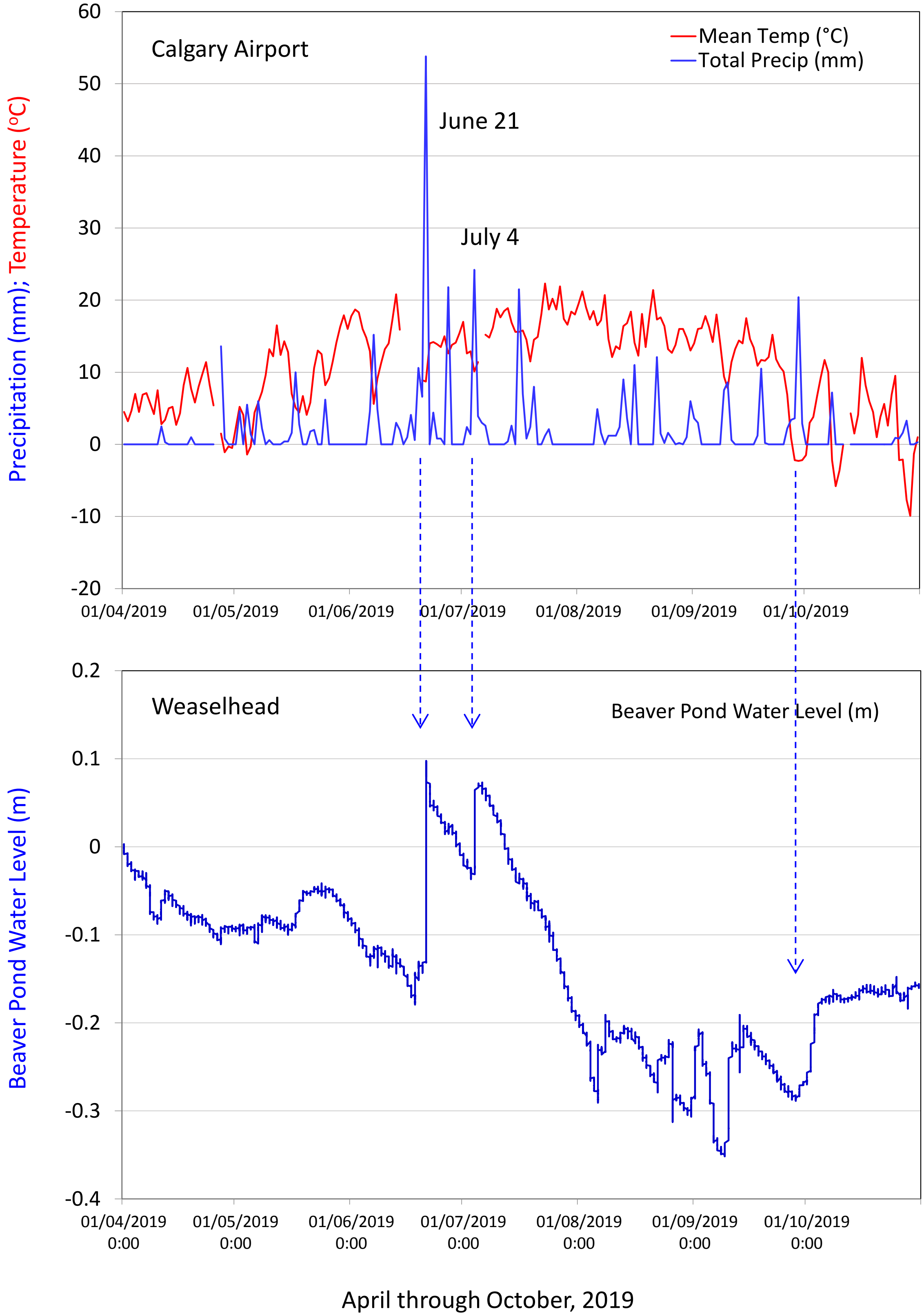

Figure 31. Changes in water levels in Beaver Pond compared with precipitation at Calgary Airport, April 1st 2019 to Oct. 31st 2029