Baseline Survey Report 2020

Fish, Amphibian and Habitat Surveys
Restoration Opportunities at Sq'ewlets

Prepared For:
Sq'ewlets First Nation
And
Fraser Valley Watersheds Coalition

By
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Acknowledgments

This report was prepared by Mike Pearson, PhD, RPBio. Field work was conducted by Kade Charlie, Isaac Pennier, Jared Hall, of Sq'ewlets and Sts'ailes Petra Wykpis, Roxanne Snook and Mike Pearson of Pearson Ecological. Thanks to James Leon, for facilitating access, to Kim Charlie and Shauneen Charlie for coordinating field technicians, to Cheryl Charlie for arrangement of student participation and to Dave Moore and Natashia Cox for administrative support.

Halq'eméylem species names were compiled by Carrielynn Victor of Ayelstexw Consulting, Cheam.

Cover photos: Fish Trapping in Sq'ewlets Slough East, juvenile Chinook Salmon, juvenile Chum Salmon

Summary

Sq'ewlets Reserve 1 contains Squawkum Creek, Sq'ewlets Slough West and Sq'ewlets Marsh. It also borders Sq'ewlets Slough East. Squawkum Creek 3 Reserve contains Squawkum Creek (outlet stream to Lake Errock), Sasin Creek (BC Gazette Name), Campground Creek (our arbitrary name), the outlet of Sq'ewlets Creek North (our arbitrary name) and 13 spring fed channels that arise in, or just above, the floodplain on the west shore of Harrison Bay.

Watercourses were walked or paddled from their outlets at the Harrison or Fraser River to their source or the reserve boundary. They were divided into reaches of generally similar aquatic and riparian habitat types. At total of 41 reaches encompassing 6,100 m of spring/channel and 44,370 m^2 of pond habitats were surveyed Fish sampling consisted of 100 Gee minnow trap sets, 99 Feddes trap sets, 2 hauls of a 20 foot seine and 9 Fyke net sets. Pools and ponds were walked or paddled and amphibian egg masses in each reach were identified to species and counted. At each reach or trap site water temperature, specific conductivity and dissolved oxygen concentration were also measured.

Over 1800 fish of 11 indigenous and two introduced species were captured in the study (Table 5). Four species of salmonid were captured, all at Squawkum Creek 3 and none at Sq'ewlets 1 reserve. Water quality was generally excellent throughout the waterways surveyed, as expected in late winter and early spring.

At Squawkum Creek 3 Reserve, Coho Salmon juveniles were, by far, the most abundant salmonid in the catch. Most were found in the spring fed pools, channels and beaver ponds in the floodplain of Harrison Bay . A single juvenile Chinook Salmon was caught and a single Chum Salmon were also caught in the floodplain springs and sixty chum salmon were caught a Fyke net in Harrison Bay. Five Coastal Cutthroat Trout were caught, all in beaver ponds near Squawkum Creek.

Areas closest to Harrison Bay had higher indigenous species diversity, higher catches of salmonids and low catches of species that may prey on juvenile salmonids. Areas further inland tended to have higher proportions of empty traps, lower diversity and fewer salmonids, probably due to limited seasonal access due to beaver dams.

Introduced fish (Brown Catfish and Pumpkinseed) comprised over 40% of the total catch in the Sq'ewlets 1 sloughs, but were not found in Squawkum Creek 3 waterways. Over 400 Brassy Minnow, a species on the BC Blue List, were caught in the sloughs of Sq'ewlets 1

Northwestern Salamanders were the most frequently encountered amphibian. Egg mass density was far higher in beaver ponds and the Sq'ewlets 1 sloughs than in other habitats (Table 10). Breeding of Northern Red-legged Frog, a federal listed species at risk, was documented in beaver ponds at Squawkum Creek 3, but were not found in Sq'ewlets 1 Sloughs (Figure 7. Bullfrogs and Green Frogs (introduced species) were found at Sq'ewlets 1, but not at Squawkum Creek 3, although they likely occur there.

There are multiple opportunities for habitat restoration on both Sq'ewlets 1 and Squawkum Creek 3 Reserves Table A lists them in recommended order of priotity. Sq'ewlets Slough East and West projects (priorities 1, 2 and 6) have been listed as among the top twenty candidate sites in the Fraer Valley for restoring fish access to floodplain sloughs in the Resilient Waters project currently underway with BC Salmon Restoration and Innovation Funding (BCSRIF).

Priority	Restoration Opportunity
1	Breech secondary dike at Fraser River to restore fish access to Sq'ewlets Slough East
2	Improve habitat in Sq'ewlets Slough East by adding complexing and deepening 2 sections that currently go dry.
3	Expansion of springs and ponds in the Sq'ewlets Campground
4	Expansion of floodplain springs in Harrison Bay floodplain adjacent to Squawkum Creek 3 Reserve
5	Excavation of springs and ponds east and north of the Sq'ewlets soccer field
6	Retrofit culvert and flood gate at Sq'ewlets Slough West to allow fish passage from Fraser River
7	Excavate grass filled section of upper Sq'ewlets Slough west
8.	Retrofit culvert and flood gate at Sq'ewlets Marsh to allow fish passage from Fraser River and excavate ponds in canary grass areas of marsh to provide habitat.

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Introduction

Pearson Ecological was hired by Fraser Valley Watershed Coalition and Sts'ailes – Sq'ewlets Fisheries authority to complete field surveys of waterways on Sq'ewlets Nation's Reserves 1 and 3 in spring of 2020. The intent is to build on previous work done by Hemmera Consulting by collecting current data on fish distribution, breeding amphibian sites and habitat conditions in all waterways on the two reserves and use the information to identify and prioritize habitat restoration opportunities for salmon. This report summarizes the results of this work.

Overview of Waterbodies

Sq'ewlets Reserve 1 contains Squawkum Creek, Sq'ewlets Slough West and Sq'ewlets Marsh (Figure 1). It also borders Sq'ewlets Slough East. Squawkum Creek 3 Reserve contains Squawkum Creek (outlet stream to Lake Errock), Sasin Creek (BC Gazette Name), Campground Creek (our arbitrary name), the outlet of Sq'ewlets Creek North (our arbitrary name) and 13 spring fed channels that arise in, or just above, the floodplain on the west shore of Harrison Bay (Figure 2).

Very little existing data is available in government databases on these streams. A search of the online FISS (2020) database yielded fish records for only Squawkum Creek. Coho Salmon, Chum Salmon, Cutthroat Trout, Sculpin, and Threespine Stickleback are listed (FISS 2020). Squawkum Creek was stocked with 3000 to 8000 Cutthroat Trout smolts from Chehalis River Hatchery annually from 1987 to 1997. No data on amphibian populations is available.

Figure 1: Waterbodies of Sq'ewlets Reserve 1. Codes refer to reaches identified in the habitat survey.

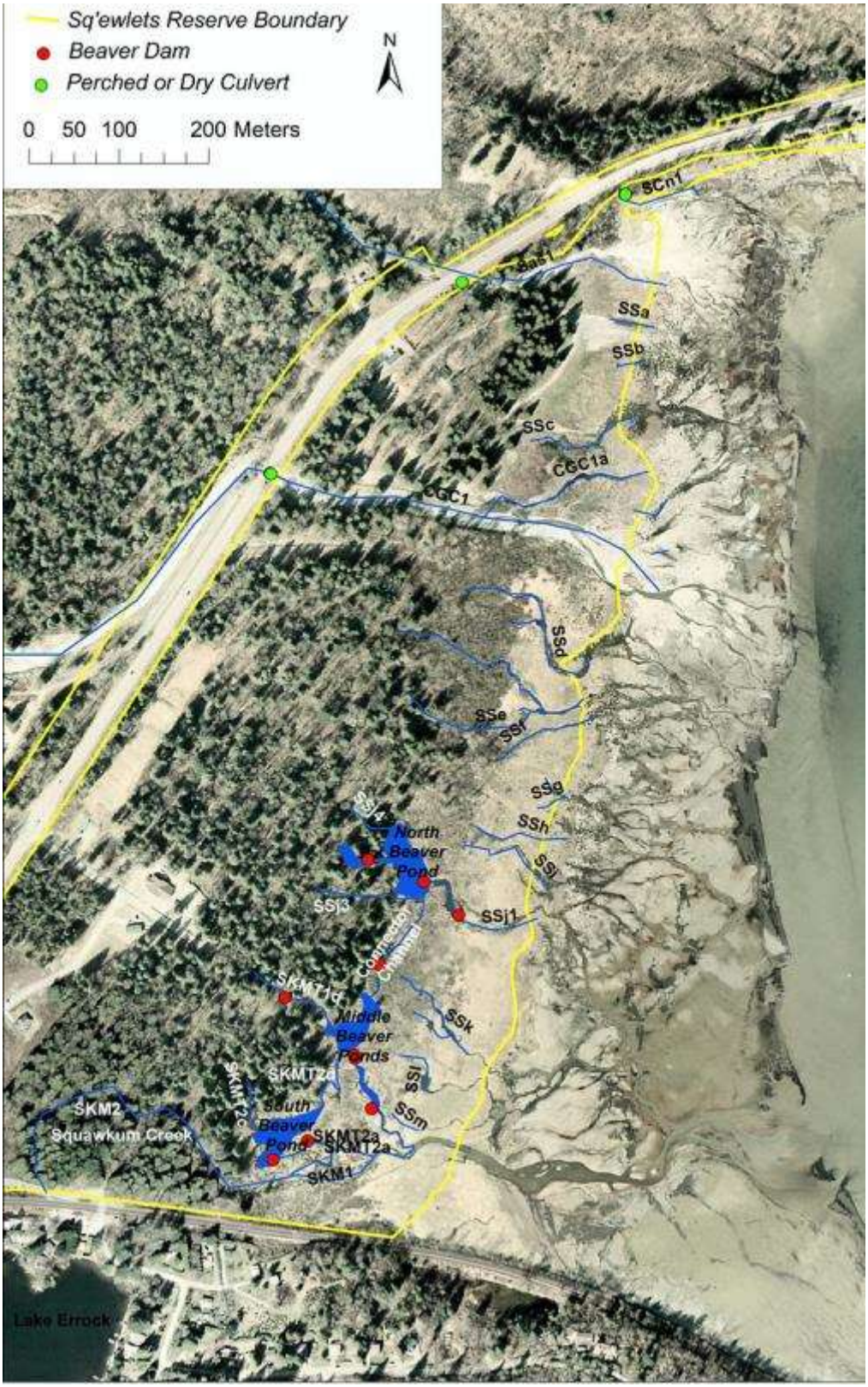


Figure 2: Waterbodies of Squawkum Creek 3 Reserve. Codes refer to reaches identified in the habitat survey. The satellite photo is old (2009) but was chosen because the low water levels are close to what was found in spring 2020, and shows the springs and floodplain channels clearly

Table 1: Summary of Field Work Conducted in 2020

Date (2020)	Activity	Personnel
Feb 10-11	Sq'ewlets 1 fish trapping and habitat surveys Installation of loggers	Kade Charlie, Isaac Pennier, Jared Hall, Roxanne Snook, Mike Pearson
Feb 25-26	Squawkum 3 fish trapping	Kade Charlie, Isaac Pennier, Petra Wykpis, Natasha Wilbrink, Mike Pearson
March 2-3	Surveys of Sasin Creek and Campground Creek Squawkum 3 fish trapping/seining	Kade Charlie, Jared Hall, Petra Wykpis, Roxanne Snook
March 9-13	Squawkum 3 habitat surveys, fish traps, seine and Fyke nets	Kade Charlie, Isaac Pennier, Jared Hall, Petra Wykpis, Roxanne Snook, Mike Pearson
March 26-27	Sq'ewlets 1 Amphibian Survey and fish trapping	Roxanne Snook, Petra Wykpis
April 5	Squawkum 3 habitat and amphibian surveys Installation of loggers	Roxanne Snook, Petra Wykpis Mike Pearson

Methods

Habitat Surveys

Watercourses were walked or paddled from their outlets at the Harrison or Fraser River to their source or the reserve boundary. They were divided into reaches of generally similar aquatic and riparian habitat types. For each reach, wetted and bankfull widths were measured with a tape, surveyor's rod or range finder, as appropriate (n = 3/reach), riparian vegetation type, channel form, and amount of available cover were classified. Notes were taken on channel conditions, types of cover and riparian vegetation and representative photographs taken. Channels were mapped using GPS tracks and waypoints which were projected onto Satellite photos so the locations could be drawn using GIS (ArcMap).

Fish Sampling

Fish sampling consisted of 100 Gee minnow trap sets, 99 Feddes trap sets, 2 hauls of a 20 foot seine (1/4' mesh) and 9 Fyke net sets (3/8'mesh). Gee traps are commercially available double-ended funnel traps measuring 16 ½" x 9". Feddes traps (Pearson 2015) are similarly shaped but larger: 32" x 16" and are able to capture larger fish, providing a more complete inventory of the fish community. Traps were baited with dry dogfood and salted salmon roe and set overnight. They were set overnight 50 - 100 m apart in the best available habitat (deeper water, more cover, low current).

Fyke nets were not baited. Five of the sets were in Harrison Bay facing inland with a 50 foot lead extending to shore to intercept fish moving along the shoreline. The other 4 were set in the outlet of a Springs K and L. Seine hauls were off the mouth of Campground Creek, but proved difficult and posed risk to fish because the net filled with sediment and organic debris.

All fish and amphibians captured were identified to species and released promptly at their point of capture. A photograph was taken of each species captured (Appendix 1) and of each trap location.

Amphibian Egg Mass Surveys

Pools and ponds were walked or paddled and amphibian egg masses in each reach were identified to species and counted. Representative photographs of species encountered were taken (Appendix 1). All observers used polarized glasses to enhance ability to see into the water.

Water Quality

At each reach or trap site water temperature, specific conductivity and dissolved oxygen concentration were measured using a YSI ProSolo meter with an optic dissolved oxygen probe. Measured levels were assessed in relation to the following criteria.

The minimum level of dissolved oxygen suitable for aquatic life is 5-9.5 mg/L, depending upon species and life history stage. For freshwater salmonids, minimum oxygen content criteria range from 6.00 mg/L - 7.75 mg/L for high level of safety (Canadian Council of Resource and Environment Ministers, 1987).

Specific conductivity (SC; electrical conductivity of water standardized to 25 ° C) is a measure of the concentration of ions dissolved in water. High readings indicate that impurities are present in the water, but provide no information on what they are. In the Fraser Valley, mountain streams in forested watersheds, SC is typically less than 100 uS. In agricultural or urban watersheds it is typically 150-350 uS. Values exceeding 400 uS are unusual and may indicate contamination from other sources.

Temperature loggers (Onset HOBO MX2201) and a water depth logger (Onset HOBO Model: E-348-U20L) were installed at key locations in the study area to take hourly readings (Table 2, Figure 3).

Table 2: Installation dates and coordinates of temperature and water level loggers.

Location	Date	Logger Type	UTM E	UTM N
Sq'ewlets Slough East	10-Feb-2020	Temperature	578311	5453562
Sq'ewlets Slough West	10-Feb-2020	Temperature	576989	5453637
Sq'ewlets Spring c	26-Feb-2020	Temperature	573050	5454667
North Beaver Pond	26-Feb-2020	Temperature	572905	5454158
Sq'ewlets Spring i	26-Feb-2020	Temperature	572992	5454209
North Beaver Pond Outlet	4-Apr-2020	Water Level	572291	5454175
Middle Beaver Pond	4-Apr-2020	Temperature	572872	5453925
Sq'ewlets Spring L	4-Apr-2020	Temperature	572908	543957
Squawkum Creek	10-Feb-2020	Temperature	572481	5453873
Lower Beaver Pond	10-Feb-2020	Temperature	572731	5453884

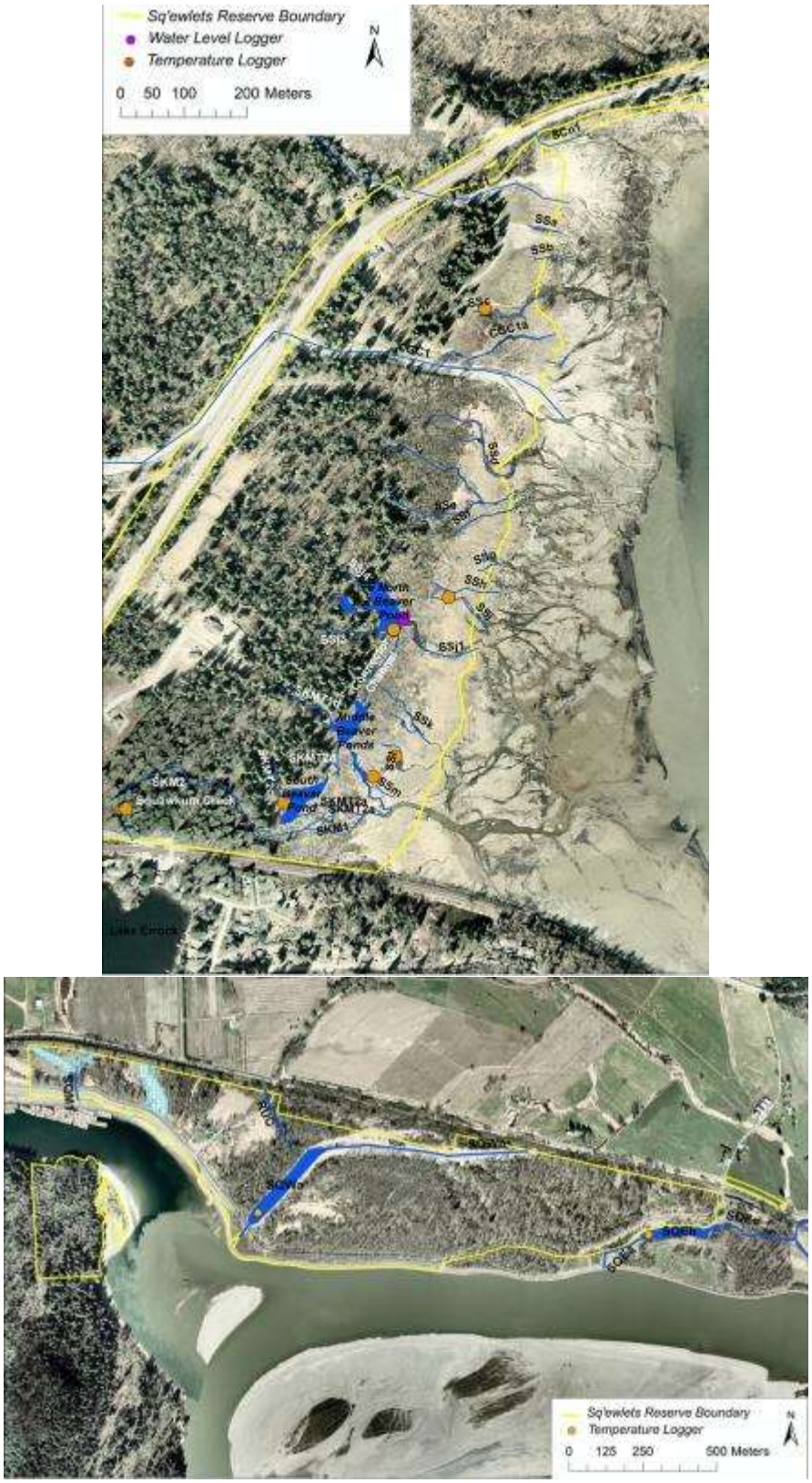


Figure 3: Locations of loggers at Squawkum Creek 3 and Sq'ewlets 1 Reserves.

Results

Habitat Surveys

At total of 41 reaches encompassing 6,100 m of spring/channel and 44,370 m^2 of pond habitats were surveyed (Figure 1, Figure 2). Basic descriptions are provided in Table 3. Detailed descriptions and photographs of surveyed reaches are provided in Appendix 2.

Sq'ewlets 1 Reserve

Sq'ewlets Slough East extends from the Fraser River eastward to Mount Woodside along the south edge of the Sq'ewlets 1 Reserve and just outside the dike. When surveyed on February 10, it was dry in two sections of approximately 50 m each; one at its outlet to the Fraser River and another just west of the Railway crossing. A large deep pool (270 m long; Reach SQEb) is clearly permanent and contains old pilings suggesting a former bridge crossing. Riparian cover is primarily shrub, with sections of mature black cottonwood. One farm crossing (steel culverts) leads to an abandoned barn in a small pasture near the Fraser River. On the east side of the railway tracks the channel passes through actively farmed pasture and has very little riparian cover. The railway culvert is concrete, 4 feet in diameter, and set deeply, so fish passage is completely unimpeded. Instream cover is moderate throughout.

Sq'ewlets Slough East is not currently accessible to fish from the Fraser River. Passage is blocked by a secondary dyke at the river's edge. A culvert was originally installed through it, but this has collapsed and is now completely buried in sediment on the inside of the secondary dike (Figure 4). The secondary dike would be overtopped in at least some freshets, which would provide some temporary fish access.

Sq'ewlets Slough West extends from the Fraser River 400 m to the north east towards the railway tracks, which it then parallels for approximately 700 m. The first 400 m is a large pond 1 to 2.2 m deep when surveyed. It contains minimal cover. The section paralleling the Railway is completely infilled with a floating matt of reed canary grass (*Phalaris arundinacea*). The wide grass floodplain indicates that water levels rise substantially during freshet. Beyond this the riparian area is primarily mature black cottonwood with a shrub understory.

Sq'ewlets Slough West is not accessible to fish from the Fraser River. It is connected through the primary dike by a culvert fitted with a top-hinged flood gate (Figure 4). When the Fraser River is higher than the Slough level (most of the summer) water pressure keeps it shut tightly. When water levels are lower in the Fraser, there is not enough flow coming out of the Slough to open it significantly, because the flap is heavy and the hinges are on top, so it is effectively a permanent and complete barrier.

Sq'ewlets Marsh is situated between the railway and the dike. It formerly contained some open water year round (Kade Charlie pers. comm.), but is now fully vegetated with reed canary grass, cattail (*Typha latifolia*), willows (Salix sp.), rose and a variety of other indigenous shrubs. Open water areas do occur during freshet and following major winter storms. Sq'ewlets Marsh is connected to the Harrison River via a culvert fitted with a top-hinged flood gate. At present there is no open water or fish habitat within the marsh, but it is a potential habitat restoration site (see below) pending addressing access.

Table 3: Locations and descriptions of reaches surveyed. Photos and additional notes are provided in Appendix 2

Reach	Reach Name	Length (m)	Area (m2)	Channel Form	Wb	Ww	Dom Substrate	Cover	Veg Left Bank	Veg Right Bank	Channel Description
CGCa	Campground Creek a	467		Pool riffle	14.9	4.0	Gravel	Rare	Grass	Grass	Wide unstable delta of creek; intermittent pools, but mostly dry
CGCaa	Campground Creek delta channels	274		Creek Delta channel	9.2	2.1	Gravel	Abundant	Grass Herbaceous	Grass	Small marshy spring fed channels: branches of Camground Creek delta at higher flows
Sas1	Sasin Creek	205		Pool riffle	10.6	1.4	Gravel	Rare	Grass	Grass	Main delta channel of Sasin Creek entering Harrison Bay; upstream half dry; groundwater flow for lower 45 m
SCN1	Sq'ewlets Creek North	109		Floodplain Channel	NA	1.8	Gravel	Absent	None	None	Creek running from under highway and into Harrison Bay
SKM1	Squawkum Creek 1	338		Riffle Pool	7.8	7.6	Gravel	Moderate	Grass	Grass	Braided channels, some narrow and deep some shallower and broader
SKM2	Squawkum Creek 2	370		Riffle Pool	9.5	6.4	Gravel	Abundant	Mature Coniferous	Mature Coniferous	Relatively pristine creek; outlet of Lake Errock; complex channel excellent habitat
SKMT1a	Squawkum Creek Trib 1 a	74		Floodplain Stream	2.3	2.3	Gravel	Moderate	Grass	Grass	Channel connecting beaver ponds to Squawkum Creek
SKMT1b	Middle Beaver Ponds		2068	Beaver Ponds	15.0	15.0	Fines	Moderate	Shrub	Shrub	
SKMT1c	Connector Channel	136		Pool/glide	2.0	2.0	Fines	Moderate	Shrub	Shrub	Marshy channel and small beaver pond, channel connection to North Beaver pond not well defined, but flow coming from there
SKMT1d	Squawkum Creek Trib1 d	62		pools	1.5	1.5	Organic	Abundant	Shrub	Shrub	Pools and channel through shrub mature forest
SKMT1e	Squawkum Creek Trib1 e	44		pools	0.8	0.8	Organic	Abundant	Mature Coniferous	Mature Coniferous	above a major debris jam that likely restricts passage
SKMT2a	Squawkum Creek Trib 2 a	77		Riffle Pool	2.5	2.5	Gravel	Abundant	Shrub	Shrub	Braided channel coming out of beaver pond
SKMT2b	South Beaver Pond		2143	Slough Or Pond	31.0	31.0	Organic	Abundant	Shrub	Shrub	Beaver pond
SKMT2c	Squawkum Creek Trib 2 c	60		pool	3.5	3.5	Organic	Abundant	Grass	Grass	channel comount out of forest into beaver pond
SKMT2d	Squawkum Creek Trib 2 d	96		pool	2.8	2.8	Organic	Abundant	Shrub	Mature Deciduous	Slough like channel connecting south beaver pond to middle beave pond (and trib 2 to trib 1)
SQEa	Sq'ewlets Slough East a	186		Slough/ Pond	10.2	2.5	Clay	Moderate	Grass	Young Deciduous	Narrow low flow channel dry for 20 m inside secondary dike at river; rusted sediment filled culvert through; no flap
SQEb	Sq'ewlets Slough East b		7447	Slough/ Pond	35.0	20.0	Organic	Rare	Shrub	Young	Wide deep pond along base of outside of main dike

										Deciduous	
SQEc	Sq'ewlets Slough East c	412		Slough/ Pond	9.1	5.8	Clay	Abundant	Mature Deciduous	Mature Deciduous	Intermittently wetted; middle section of more than 50 m dry
SQEd	Sq'ewlets Slough East d	230		Slough/ Pond	20.	18	Clay	Rare	Grass	Grass	Open pools from railway to mountain through private farmland. Full access through culvert under railway
SQMa	Sq'ewlets Marsh a	93		small channel	6.0	0.5	Organic	Abundant	Mature Deciduous	Mature Deciduous	Very little flow. Drains wetlands, top mounted gate on culvert through dike
SQWa	Sq'ewlets Slough West a		13871	Pond/Slough	40.0	32.0	Organic	Moderate	Mature Deciduous	Mature Deciduous	Wide slough
SQWb	Sq'ewlets Slough West b	683		Slough/ Pond	24.0	80.0	Organic	Abundant	Mature Deciduous	Mature Deciduous	Wide Slough infilled with organic mud and canary grss
Ssa	Sq'ewlets Spring a	50		Spring	NA	5.1	Gravel	Rare	Grass	Grass	Braided stream flowing from under boat launch into Harrison Bay
SSb	Sq'ewlets Spring b	38		Spring	0.9	0.9	Gravel	Moderate	Grass	Grass	Small isolated spring channel flowing into Harrison Bay
SSc	Sq'ewlets Spring c	136		Spring	13.4	17.0	Gravel	Moderate	Grass	Grass	Spring fed floodplain pond outlowing into Harrison Bay
SSd	Sq'ewlets Spring d	264		Spring	27.0	4.1	Gravel	Absent	Grass	Grass	Spring branches 75 m upstream
Sse	Sq'ewlets Spring e	441		Spring	7.0	4.0	Gravel	Moderate	Grass	Grass	50 m upstream forks into two channels; north channel with steady flows
SSf	Sq'ewlets Spring f	121		Spring	3.3	3.3	Gravel	Moderate	Grass	Grass	riffle channel with pools at inland end
SSg	Sq'ewlets Spring g	68		Spring	13.0	6.0	Gravel	Moderate	Grass	Grass	Shallow pool with thick veg where spring emerges and riffle channel to Harrison Bay
SSh	Sq'ewlets Spring h	105		Spring	26.0	1.6	Gravel	Abundant	Grass	Grass	Elongated pool drained by riffle channel
Ssi	Sq'ewlets Spring i	124		Spring	1.4	1.2	Gravel	Moderate	Grass	Grass	
SSj1	Sq'ewlets Spring j	157		Beaver pond outlet	0.0	0.0	Gravel	Moderate	Grass	Grass	Riffle channel close to bay, with long shallow beaver pond; drains large deep beaver pond
SSj2	North Beaver Pond		3079	Beaver Ponds	30.0	30.0	Organic	Abundant	Shrub	Mature Mixed	Deep pond behind 2 m beaver dam
SSj3	Sq'ewlets Spring j3	117		Pool/glide				Abundant	Mature Mixed	Mature Mixed	missed in survey; but evident on satellite photos;
SSj4	Sq'ewlets Spring j4	55		Pool/glide			Organic	Abundant	Shrub	Mature Mixed	Cleared and channelized near soccer field; forested downstream portion; gravel check dams in upper end to control sediment
SSk	Sq'ewlets Spring k	181		Spring	3.1	2.7	Gravel	Rare	Grass	Grass	Spring channel running to Harrison bay, fed by overflowing beaver ponds to north and west
SSl	Sq'ewlets Spring l	73		Spring	12.0	12.0	Gravel	Moderate	Grass	Grass	Small spring pond, 30m long, outlet stream to Harrison bay
SSm	Sq'ewlets Spring m	35		Floodplain	4.5	2.3	Sand	Abundant	Grass	Grass	Slow moving stream from spring; lots of in-stream veg
RUC	Railway Underpass Channel	219		Ditch	10.0	5.0	Organic	Abundant	Mature Deciduous	Mature Deciduous	Not surveyed: Channel that used to drain north under railway, but was blocked by farmers years ago, flooding issue
SQMW	Sq'ewlets Marsh West		7109	Marsh			Organic				Not surveyed , boundaries approximate
SQME	Sq'ewlets Marsh East		8652	Marsh			Organic				Not surveyed Canary grass marsh, boundaries approximate

Railway Underpass Ditch extends from close to the west bank of Sq'ewlets Slough West northwesterly to the railway**.** It formerly passed under the railway and drained northward, but several decades ago farmers blocked it from draining north (Betty Charlie pers. comm.), which has exacerbated flooding affecting nearby houses. It is well wooded with relatively complex habitat, but does not appear to be connected to other waterways at most water levels.

Figure 4: Access barriers to Sq'ewlets Slough East (Top), Sq'ewlets Slough West (bottom left) and Sq'ewlets Marsh (bottom right) on February 10, 2020.

Squawkum Creek 3 Reserve

Squawkum Creek connects Lake Errock to Harrison Bay and its entire length is on the reserve. Most of its length (Reach SKM2) flows through mature coniferous forest with open understory. Habitat conditions are excellent with clean spawning gravel, abundant large woody debris, and complex channel structure. As it exits the forest onto the floodplain of Harrison Bay the channel begins to braid though a complex of shrub and grass islands, alternating between deep pools, and gravel riffles. Two beaver ponded tributary streams enter from the north, also with braided channels. Habitat conditions are excellent for salmonids with a variety of water depths and velocities, and abundance of cover. The beaver ponds also provide deep water, good cover and calm conditions, especially for overwintering Coho Salmon and Cutthroat Trout.

The Harrison Bay floodplain is gently sloping with 5 distinct vegetation zones. At very low water conditions, as during this survey, the zone closest to the water's edge is bare gravel sloping into deep mud and organic debris, much of it clearly originating from the log sort to the north east of the reserve. Above this is a zone of predominantly indigenous sedges and rushes, then a wider zone of predominantly grasses. Further inland, patches of shrubs give way to a zone of dense shrub cover, and finally to mature coniferous and mixed forest. Between Squawkum Creek and the reserve boundary at the north end of Harrison Bay, at least 13 springs emerge from the gravelly floodplain soils. Most emerge in small headwater pools then flow to the bay through shallow gravel bottom channels. Some emerge well inland in the forested area or even in the developed area adjacent to the Sq'ewlets soccer field. Most of these have been dammed by beaver with several of the dams 2 m in height. Most emerge closer to the bay in the shrub or grassy zones. Cover in the channels consists of aquatic vegetation, algae matts (especially in the source pools), undercut banks and woody debris (in the shrub and forest zones).

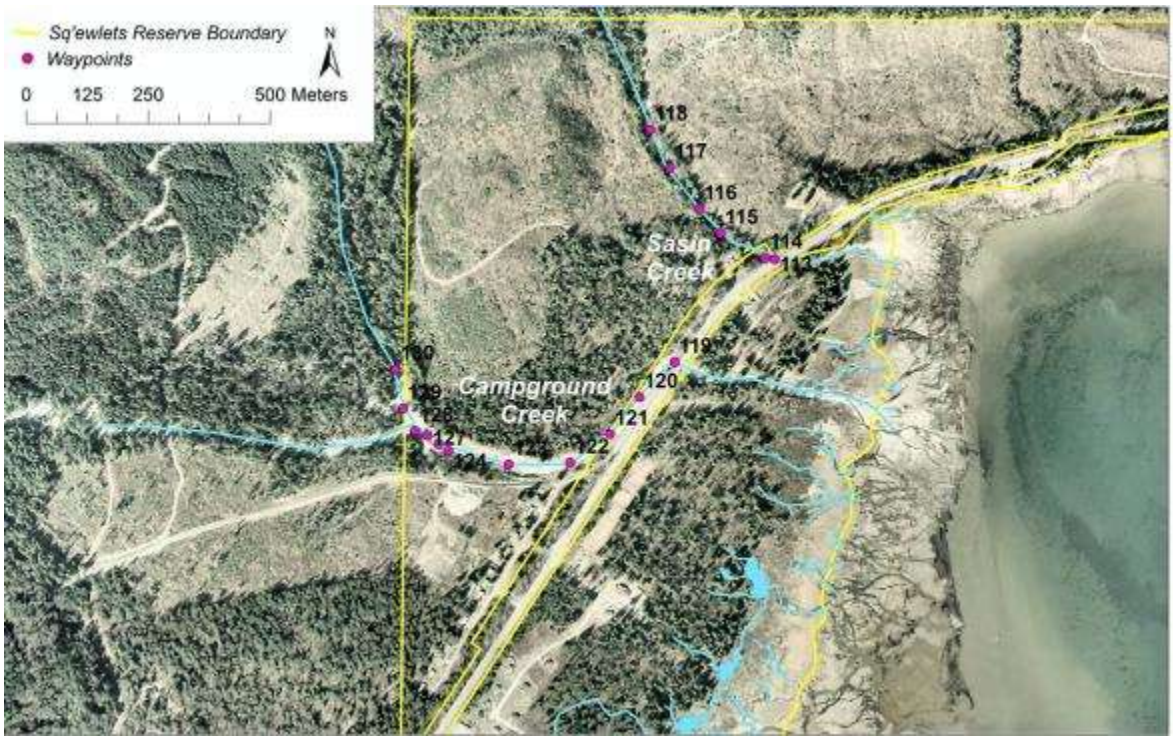


Figure 5 Waypoints in surveys of Sasin and Campground Creeks. Photos appear in Appendix X

Table 4: Locations and descriptions of photos from reconnaissance surveys of Sasin and Campground Creeks. Locations are shown in Figure 5. Distances are upstream from Highway 7.

Waypoint	UTM E	UTM N	Distance (m)	Observations
119	572725	5454633	0	dry
120	572653	5454561	100	dry
121	572593	5454485	200	dry
122	572511	5454427	300	dry
123	572385	5454423	425	dry
124	572261	5454451	555	dry
125	572241	5454465	580	dry
127	572219	5454483	610	Fish barrier: 4 m high drop, concrete structure; dry
128	572192	5454492	640	dry, channel forks (Photo 131,133 west , Photo 132 north).
129	572168	5454538	700	Another fork in stream
130	572153	5454618	775	Water starts here
113	572931	5454844	0	
114	572911	5454847	20	Water starts here
115	572819	5454898	100	
116	572776	5454947	200	Potential fish barrier, large boulders and LWD
117	572716	5455032	300	
118	572675	5455110	380	Potential fish barrier

The lower reaches of the channels, in the herbaceous, grass and shrub zones are very easy to access from the bay for even the smallest salmonid fry.

Most of the fish barriers at Squawkum 3 are seasonal in nature, in that they are beaver dams (Figure 2) that are overtopped during freshet and in some cases more moderate water levels. The dams furthest inland appear to be more permanent barriers, as the habitats above them were among the only areas where we did not find juvenile Coho (Figure 5). Access to inland habitats, in the absence of human intervention, depends primarily on seasonal variations in Fraser River water levels, which vary from year to year.

There are no significant barriers to access on the Squawkum Creek main stem, but all three creeks that cross Highway 7 have access issues. The most northerly was flowing when surveyed in March, but the culvert was perched approximately 2 m above Harrison Bay water level with a steep rocky approach and sheet-flow over a concrete apron below the culvert mouth. We did not survey this creek upstream of the highway as it is off-reserve, so the amount of available habitat or current fish presence is unknown. It may support Cutthroat trout, but given the poor access, anadromous salmonids are unlikely to occur. Sasin Creek (BC Gazette name) and Campground Creek (our arbitrary name) are both dry at the highway at all times except immediately following significant rainfall (Pearson pers. obs.). Intermittent pools emerged in both in the lower floodplain, but these dry completely in late summer. Results of a reconnaissance survey of these creeks upstream of the highway are provided in Table 5 and Figure 4.

Fish Surveys

Over 1800 fish of 11 indigenous and two introduced species were captured in the study (Table 5). Four species of salmonid were captured, all were found at Squawkum Creek 3 and none at Sq'ewlets 1 reserve. In contrast, all of the introduced fish were caught in Sq'ewlets Slough East and Sq'ewlets Slough West). Over 150 Brown Catfish and 200 Pumpkinseed were captured in these sloughs, representing over 40% of the total catch (Table 6, 7). Waterbodies like these, that are isolated by flood infrastructure from the Fraser River typically contain high concentrations of invasive species and have poorer water quality than those that are well connected (Scott et al. 2016; Seifert 2016).

Coho Salmon juveniles were, by far, the most abundant salmonid in the catch. They were found throughout the spring fed pools, channels and beaver ponds in the floodplain of Harrison Bay (Figure 6). They were not found in the mainstem of Squawkum Creek. This is not unusual for winter and early spring, when Coho typically retreat to off- channel areas to overwinter (Peterson 1982; Cunjak 1988; Ebersole et al. 2006).

Table 5: Species of fish captured during the study.

English	Halq'emeylem [1]	Scientific	Status
Coho Salmon	Kwθ́xweth	*Oncorhynchus kisutch*	Indigenous
Chinook Salmon	Tl'éxxel	*Oncorhynchus tshawytscha*	Indigenous, Some stocks COSEWIC Endangered
Chum Salmon	Kw'ó:lexw	*Oncorhynchus keta*	Indigenous
Coastal Cutthroat Trout	Kw'sí:ts	*Oncorhynchus clarki clarki*	Native, BC Blue-list
Largescale Sucker	Q'ó:xel	*Catostomus macrocheilus*	Indigenous
Prickly Sculpin		*Cottus asper*	Indigenous
Brassy Minnow	Sqíqemlò	*Hybognathus hankinsoni*	Indigenous, BC Blue-list
Northern Pikeminnow		*Ptychocheilus oregonensis*	Indigenous
Peamouth		*Mylocheilus caurinus*	Indigenous
Redside Shiner	Sqíqemlò	*Richardsonius balteatus*	Indigenous
Threespine Stickleback	Smó:txw	*Gasterosteus aculeatus*	Indigenous
Northwest Salamander	Pí:txel	*Ambystoma gracile*	Indigenous
Pumpkinseed		*Lepomis gibbosus*	Introduced
Brown Catfish	Mó:txw	*Ameiurus nebulosus*	Introduced

A single juvenile Chinook Salmon was caught and a single Chum Salmon were caught in small spring fed channels in the floodplain in Gee traps. We suspect there were many more of both species present. Neither species typically enters minnow traps, nor were we able to seine these habitats during the study as virtually all areas are used by spawning Chum Salmon, and alevins would have been present in the gravel. Sixty chum salmon were caught in one of the Fyke net sets in Harrison Bay with a lead perpendicular to shore; presumably a school intercepted while moving along the shoreline. Five Coastal Cutthroat Trout were caught, all in beaver ponds of the Squawkum Creek tributaries. Over 400 Brassy Minnow, a species on the BC Blue List, were caught in the sloughs of Sq'ewlets 1 (Figure 7). BC Blue

[1] Halq'eméylem names compiled by Carrielynn Victor of Ayelstexw Consulting, Cheam

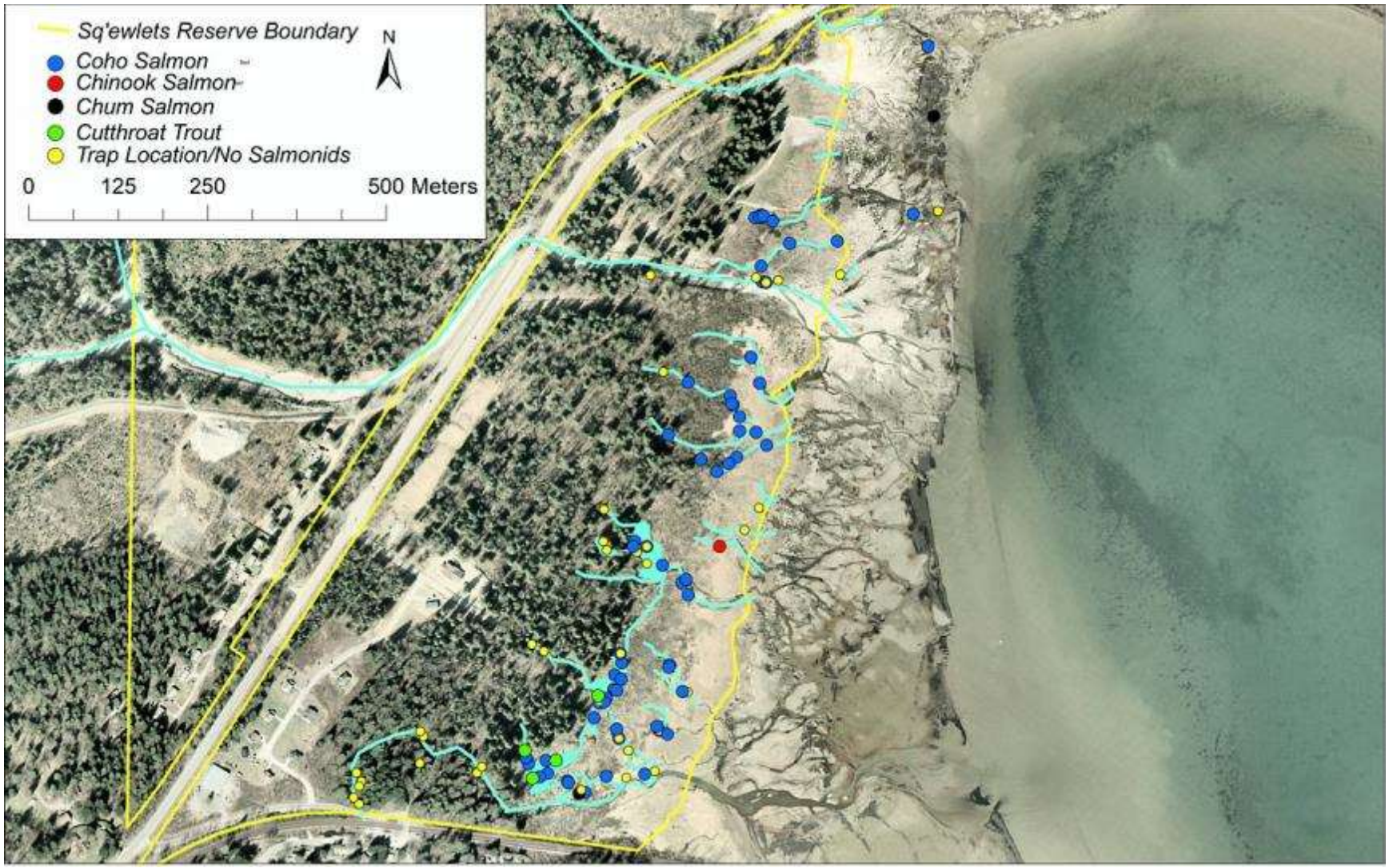


Figure 6: Distribution of salmonids captured at Squawkum Creek 3.

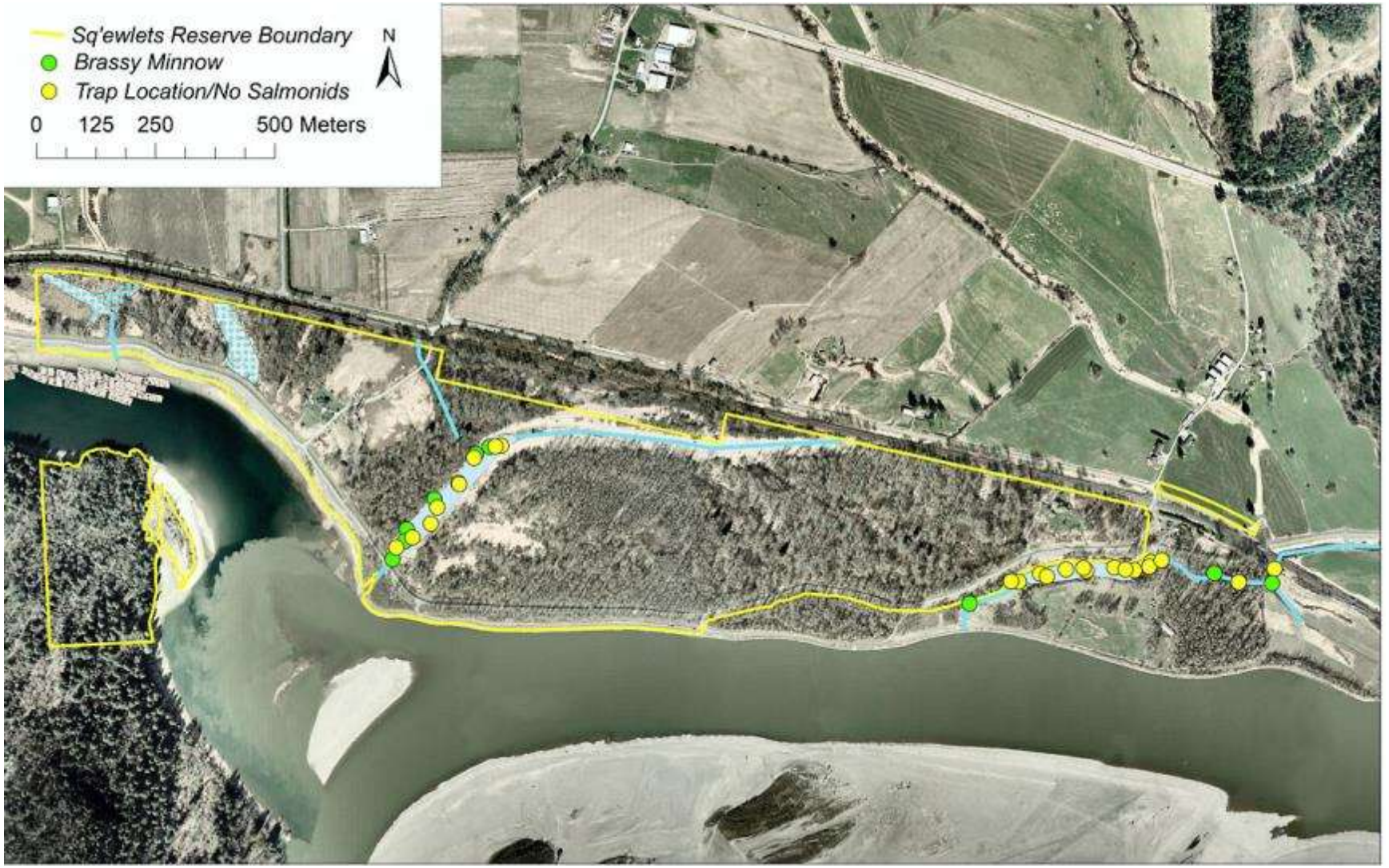


Figure 7: Locations of traps set and Brassy Minnow captured at Sq’ewlets 1.

Table 6: Summary of catch and sampling method for each reach. All floodplain springs have been aggregated. Reach locations are shown on figures 1 and 2.

Species / Reach	All	Campground Creek Pools	Harrison Bay	Floodplain Springs a through m	North Beaver Pond	Middle Beaver Ponds	South Beaver pond	Squawkum Creek		Squawkum Tribs		SQE	SQW
								SKM1	SKM2	SKMT1	SKMT2		
Coho Salmon	491	5	3	251	17	6	62	10		57	80		
Chinook Salmon	1			1									
Chum Salmon	61		60					1					
Coastal Cutthroat Trout	5						1				4		
Largescale Sucker	73			72				1					
Prickly Sculpin	65		12	7	2	1	1	3	20	6		13	
Brassy Minnow	439											310	129
Northern Pikeminnow	51	1	2	37				6		1	4		
Peamouth	35			35									
Redside Shiner	24		1									8	15
Threespine Stickleback	127	1		58		3	9	3	3			16	1
Northwest Salamander	38			1	1	3	19				8	3	3
Pumpkinseed	219											142	77
Brown Catfish	168											94	74
Bullfrog	10											8	2
Green Frog	35											32	3
All Species	1850	7	86	462	20	13	92	24	23	64	96	626	304
Sampling Methods													
Total Effort	211	7	6	58	3	13	18	10	13	8	10	34	31
Number Feddes Traps	99	3		26	3	9	9	5	3	4	4	17	16
Count of Gee Traps	100	3		29		4	9	5	8	4	6	17	15
Count of Trap Empty	41	3		4		7		4	7	1	2	10	3
Count of Seine Hauls 20	2		2										
Count of Fyke Net Single	5			3					2				
Count of Fyke Net Bucket	4		4										

Table 7: Catch per unit effort (average number caught per trap/seine) in each reach. All floodplain springs have been aggregated. Reach locations are shown on figures 1 and 2.

Species / Reach	All	Campground Creek Pools	Harrison Bay	Floodplain Springs a through m	North Beaver Pond	Middle Beaver Ponds	South Beaver pond	Squawkum Creek		Squawkum Tribs		SQE	SQW
								SKM1	SKM2	SKMT1	SKMT2		
Coho Salmon	2.33	0.71	0.50	4.33	5.67	0.46	3.44	1.00		7.13	8.00		
Chinook Salmon	0.00			0.02									
Chum Salmon	0.29		10.00					0.10					
Coastal Cutthroat Trout	0.02						0.06				0.40		
Largescale Sucker	0.35			1.24				0.10					
Prickly Sculpin	0.31		2.00	0.12	0.67	0.08	0.06	0.30	1.54	0.75		0.38	
Brassy Minnow	2.08											9.12	4.16
Northern Pikeminnow	0.24	0.14	0.33	0.64				0.60		0.13	0.40		
Peamouth	0.17			0.60									
Redside Shiner	0.11		0.17									0.24	0.48
Threespine Stickleback	0.60	0.14		1.00		0.23	0.50	0.30	0.23			0.47	0.03
Northwest Salamander	0.18			0.02	0.33	0.23	1.06				0.80	0.09	0.10
Pumpkinseed	1.04											4.18	2.48
Brown Catfish	0.80											2.76	2.39
Bullfrog	0.05											0.24	0.06
Green Frog	0.17											0.94	0.10
All Species	8.77	1.00	14.33	7.97	6.67	1.00	5.11	2.40	1.77	8.00	9.60	18.41	9.81
Sampling Methods													
Total Effort	211	7	6	58	3	13	18	10	13	8	10	34	31
Number Feddes Traps	99	3		26	3	9	9	5	3	4	4	17	16
Count of Gee Traps	100	3		29		4	9	5	8	4	6	17	15
Count of Trap Empty	41	3		4		7		4	7	1	2	10	3
Count of Seine Hauls 20	2		2										
Count of Fyke Net Single	5			3					2				
Count of Fyke Net Bucket	4		4										

Table 8: Fish community indicators of habitat conditions for salmonids and species at risk in sampled reaches. Green indicates a favourable value, yellow a marginal value and red an unfavourable value relative to the range of values in small stream, slough and wetland habitats of the Fraser Valley. Criteria used in these assessments are provided in the lower panel.

Indicator	All	DRC1	Harrison Bay	Flood Plain Springs	NBPS1	NBPS2	SBP	SKM1	SKM2	SKMT1	SKMT2	SQE	SQW
Number Native Fish Species	11	3	5	7	2	3	4	6	2	3	3	4	3
% Catch Salmonid	30.16	71.43	73.26	54.55	85.00	46.15	68.48	45.83	0.00	89.06	87.50	0.00	0.00
CPUE[1] Salmonids	2.64	0.71	10.50	4.34	5.67	0.46	3.50	1.10	0.00	7.13	8.40	0.00	0.00
Fish Species at Risk Present	2	0	0	0	0	0	1	0	0	0	1	1	1
% Catch Threespine Stickleback	6.86	14.29	0.00	12.55	0.00	23.08	9.78	12.50	13.04	0.00	0.00	2.56	0.33
CPUE Predatory Fish/Amphibians	2.41	0.14	2.33	0.76	0.67	0.08	0.11	0.90	1.54	0.88	0.80	7.32	4.87
Number Introduced Fish Species	2	0	0	0	0	0	0	0	0	0	0	2	2
% Catch Introduced Fish Species	20.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	37.70	49.67
% Traps Empty	20.60	50.00		7.27	0.00	53.85	0.00	40.00	63.64	12.50	20.00	29.41	9.68

# Native Fish Species	% Catch Salmonid	CPUE Salmonids	Species at Risk Present	% Catch Threespine Stickleback	CPUE Predatory Species	# Introduced Species	% Introduced Species in Catch	Coho Mean Condition Factor	Coho Mean Fork Length	% Traps Empty
6+	>50	5+	1+	10-50	0-2	0	<5	>1.2	>80	<10
1-5	25-50	1-5	0	Other	2-4	1-2	5-25	1.0-1.2	75-80	10-40
0	0-25	0-1			>4	>2	>25	<1.00	<75	>40

listed species, like Brassy Minnow and Coastal Cutthroat Trout are of conservation interest, but do not have any legal protection or requirements over that afforded salmon or other indigenous fish species.

The structure of a fish community reflects habitat conditions, including seasonal patterns in water quality, access, and predation pressure. Table 8 summarizes a number of such indicators for the reaches fished in this study. In general, flood plain springs and beaver ponds scored well on the most indicators. Areas closest to Harrison Bay had higher indigenous species diversity, higher catches of salmonids and low catches of species that may prey on juvenile salmonids. Areas further inland tended to have higher proportions of empty traps, lower diversity and fewer salmonids, probably due to limited seasonal access due to beaver dams. The sloughs at Sq'ewlets 1 scored lowest overall, because of the complete lack of salmonids, and prevalence of introduced predatory species in the catch.

Amphibian Survey

Two indigenous and two introduced species were encountered (Table 9) during the study. Northwestern Salamanders were the most frequently encountered, both as egg masses and as adults in traps. Egg mass density was far higher in beaver ponds and the Sq'ewlets 1 sloughs than in other habitats (Table 10). Breeding of Northern Red-legged Frog, a federal listed species at risk, was documented in beaver ponds at Squawkum Creek 3, but were not found in Sq'ewlets 1 Sloughs (Figure 7). Both introduced species were found at Sq'ewlets 1, but not at Squawkum Creek 3, although they likely occur there.

Table 9: Amphibian species encountered.

Halq'eméylem Name[2]	English Name	Scientific Name	Conservation Status
Wexés	Northern red-legged frog	*Rana aurora*	Indigenous, SARA Special Concern
Pí:txel	Northwest salamander	*Ambystoma gracile*	Indigenous
Weléx	Bullfrog	Lithobates catesbeianus	Introduced
Weléx	Green Frog	*Rana clamitans*	Introduced

Table 10: Number of egg masses found in each surveyed reach. See locations on Figure 7.

Reach	#	Length	Red Legged Frog		Northwest Salamander	
			Number	Density (/ 100 m)	Number	Density (/ 100 m)
Sq'ewlets Slough East	1	624			65	10.42
Sq'ewlets Slough West	5	915			26	2.84
Campground Spring	1	107				0
Middle Spring	2	183				0
N Beaver Ponds	3	368	7	1.90	29	7.88
South Spring	4	133			1	0.75
Squawkum Trib 1	6	115			4	3.48
S Beaver Pond	7	225	1	0.44	37	16.44
Connector Channel	8	137	4	2.92	1	0.73
Squawkum Trib 2	9	313				0

[2] Halq'eméylem names compiled by Carrielynn Victor of Ayelstexw Consulting, Cheam

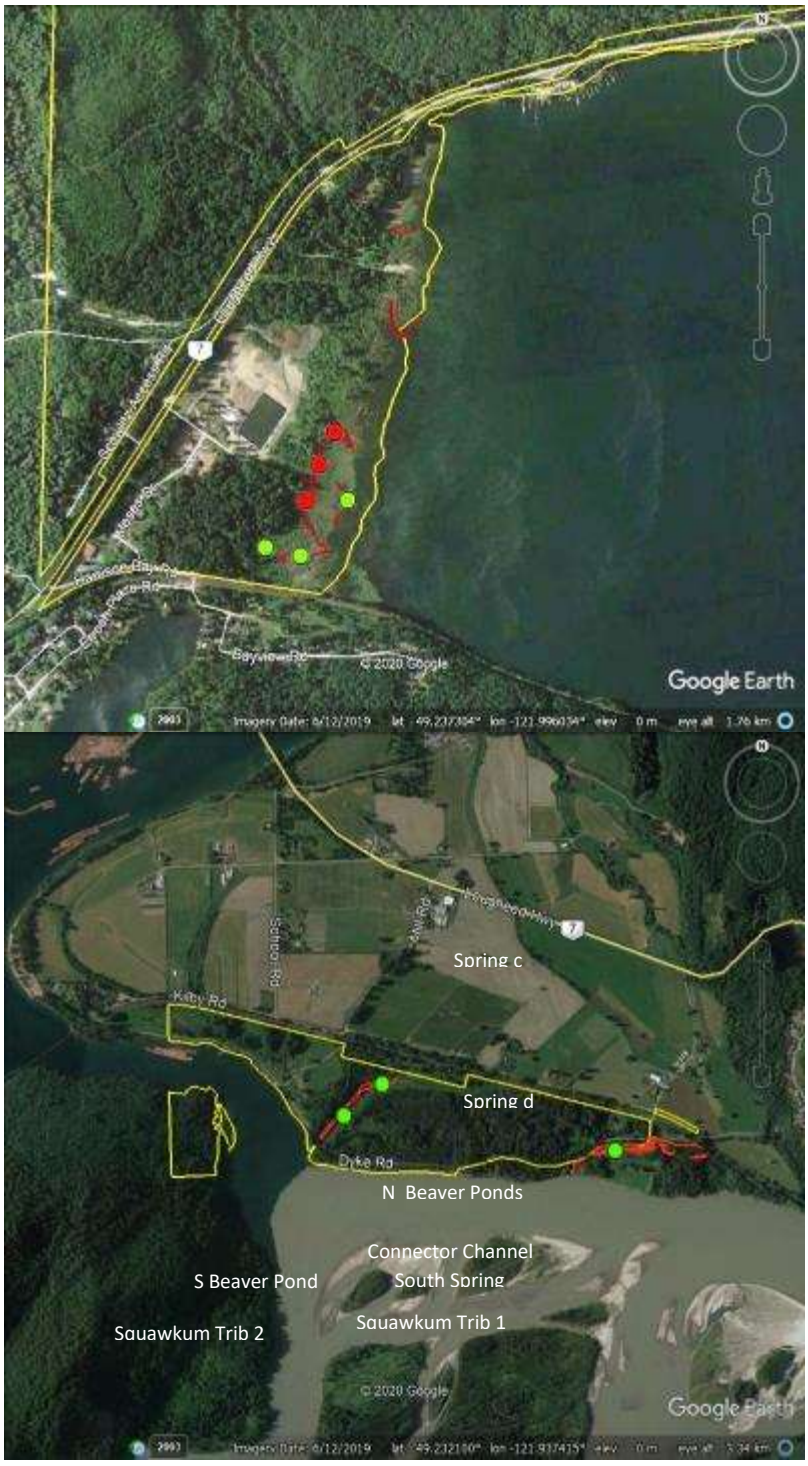


Figure 8: Locations of amphibian breeding found in spring 2020. Numbers found in each reach are provided in Table 8.

Water Quality

Water quality was generally excellent throughout the waterways surveyed, as expected in late winter and early spring (Table 11). Water temperature was under 10 C on all sampling dates at all locations. Dissolved oxygen was well above 5 mg/l at all sites except one area of the south beaver pond with lots of decomposing organic material. Specific conductivity was very low, indicating very pure water, at all sites except Sq'ewlets Slough East, the only waterbody draining an area with significant amount of agriculture. Its value was on the low end of the range typically found in streams draining farmlands.

Table 11: Minimum and maximum temperature, dissolved oxygen and specific conductivity observed in each

Site	Temperature ˚C			Dissolved Oxygen (mg/L)			Specific Conductivity (μS)		
	N	Min.	Max.	N	Min.	Max.	N	Min.	Max.
All	117	4.1	9.8	117	4.55	12.5	43	15.5	132.5
Campground Creek (CGC1)	4	6.1	7.3	4	10.54	11.7	2	18.2	19.4
Harrison Bay	2	7	7.6	2	11.46	11.96			
Floodplain springs	33	5.1	9.4	33	9.01	12.5	6	15.5	24.3
North Beaver Pond	3	8.4	8.8	3	11.4	11.6	3	23.5	24.3
Middle Beaver Ponds	7	6.8	8.7	7	10.5	11.3	5	23.2	26
Sough Beaver Pond	10	5.8	7.7	10	4.55	11.81			
Squawkum Creek SKM1	6	6.1	6.8	6	10.81	12.3	3	24.3	24.6
Squawkum Creek SKM2	10	5.7	7	10	11.46	12.4	4	24.3	25.3
Squawkum Trib 1 SKMT1	3	5.9	7.3	3	10.38	11.67			
Squawkum Trib 2 SKMT2	7	6.2	7.2	7	8.03	12.07	3	22.6	24.5
Sq'ewlets Slough E	18	4.1	9.7	18	6.33	12.4	11	39.6	132.5
Sq'ewlets Slough W	14	4.4	9.8	14	7.22	11.44	6	23.1	23.8

Habitat Restoration Opportunities

There are multiple opportunities for habitat restoration on both Sq'ewlets 1 and Squawkum Creek 3 Reserves (Figure 9, Figure 10). They are briefly described in the paragraphs below.

Squawkum Creek 3

1. **Expansion of floodplain springs**: The best opportunities for habitat enhancement at Squawkum Creek 3 involve expanding spring fed pool and riffle habitats in the floodplain, particularly in the seasonally flooded shrub and herbaceous vegetation zones between the forest and Harrison Bay (Figure 10). These areas are heavily used by Chum Salmon for spawning and incubation and, as our data shows, by overwintering Coho Salmon juveniles and likely by Chinook fry foraging and

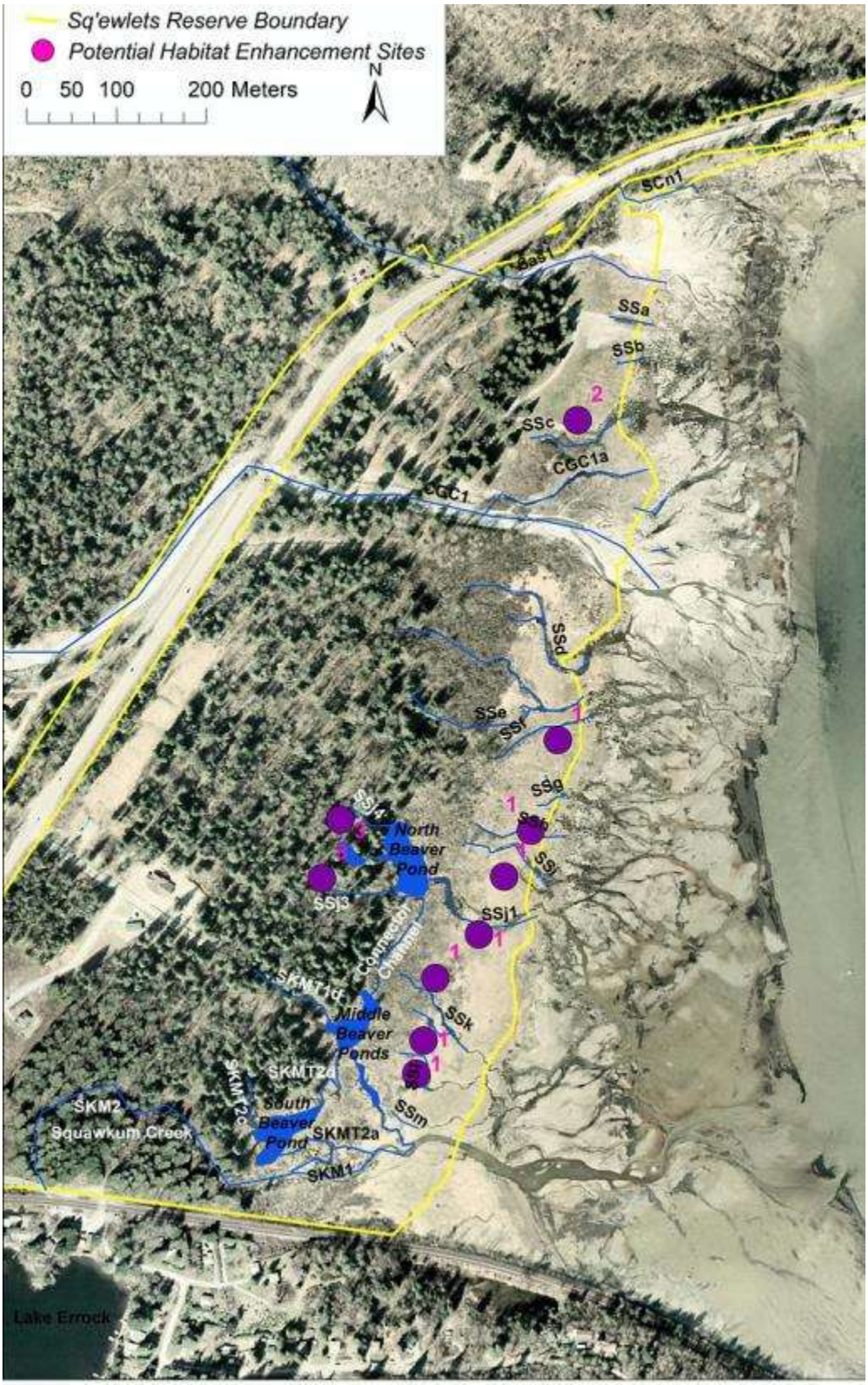


Figure 9: Habitat enhancement opportunities at Squawkum Creek 3. Numbers correspond to descriptions in report text.

resting during migration to the Fraser estuary in spring. These habitats are easily accessible to the smallest fry, are productive foraging areas, and are largely predator-free. Habitat expansion would consist of excavation to expose underlying gravels and connecting to existing channels and pools. Excavation of slightly deeper pools than currently exist would benefit overwintering Coho juveniles, particularly if complexed with woody debris.

Ideally the overburden removed would be trucked out to avoid the need to pile spoil on the seasonally flooded grass, sedge and rush areas, which are very valuable juvenile habitats when flooded at higher river water levels, and to maintain the character of the area. Machine and truck access is feasible from the Sq'ewlets campground at low water levels along the exposed gravels below the vegetated floodplain. Depending on water levels, construction may need to occur during winter or early spring, in which case great care would be required to protect overwintering Coho juveniles and Chum redds in existing springs. The excavator would need to work from pads at all times on the vegetated areas to minimize damage.

2. **Excavation of springs and ponds in the Sq'ewlets Campground**. Existing spring fed channels and ponds could easily be expanded in the campground. Judicious addition of large woody debris and excavation of some deeper areas would benefit overwintering Coho without reducing habitat area for spawning Chum.

3. **Excavation of springs and ponds east and north of the Sq'ewlets soccer field.** Although there is likely abundant groundwater in these areas to facilitate habitat creation, fish access is appears to be limited by beaver dams in the forested and shrub zones to between the soccer field and Harrison Bay. This may be addressed by having fisheries technicians breach certain dams at key times to allow spawners in and smolts out, as is done in some of the recently restored sloughs at Sts'ailes.

4. **Sasin and Campground Creeks**, unfortunately have very limited prospects for successful habitat restoration until issues of upslope instability are addressed. In-'stream habitat in both is severely degraded by channel aggradation, chronic dewatering and lack of channel stability.

Sq'ewlets 1

The primary opportunities at Sq'ewlets 1 involve restoring fish access from the Fraser River to the two Sq'ewlets sloughs, and potentially to Sq'ewlets Marsh (Figure 9). The two sloughs have been identified as among the top 20 priority sites in the Fraser Valley for restoring fish access through dikes in the recently initiated 'Resilient Waters' prioritization project funded by a British Columbia Salmon Restoration and Innovation Fund (BC SRIF) grant to Tides Canada. This project is being led by KWL Engineering with Pearson Ecological conducting field assessments. Field work was scheduled to begin in March 2020, but has been postponed due to the Covid-19 pandemic. Following field work, the 20 projects already identified will be prioritized with for implementation over the next 4 years of the BC SRIF mandate.

Figure 10: Habitat enhancement opportunities at Sq'ewlets 1 Reserve. Numbers correspond to paragraphs below.

5. **Sq'ewlets Slough East** is the most straightforward of the restoration projects as it could simply involve breaching the secondary dike at the Fraser River (which is regularly overtopped during freshets), providing full and permanent fish access to the slough. Additional work in the slough could consist of installation of large woody debris complexing, and deepening the two reaches that currently dry at low water levels. The site is easily accessible for machinery and is not on private land, although it is off –reserve. KWL will be conducting a high level engineering assessment and recommended approach for this project. The report is expected in early 2021, subject to pandemic related delays.

6. **Sq'ewlets Slough West** represents an excellent opportunity to restore access to a habitat isolated by flood infrastructure through retrofitting the existing top mounted flood gate existing culvert through the dike. KWL will be assessing options and feasibility for this from an engineering perspective. Inside the dike, habitat could be improved by increasing habitat complexing through installation of large woody debris. Given the location, this need not be anchored, but could be simply placed to float freely and aggregate naturally. Blackberry removal and understory planting would benefit the riparian area. A second area of opportunity in Sq'ewlets Slough west may be found in the upstream reach, currently overgrown with reed canary grass, removal of the grass, deepening of the channel could be accomplished. A similar area of Mountain Slough near Agassiz was opened up with a narrower meandering channel created within the larger channel in 2005. The machine made pads (small peninsulas) of woody

debris then sat on them to move out into the channel. Excavated spoil was placed on top of the pads which were later planted with indigenous tree and shrubs. The channel remains open and used by fish in 2020, 15 years after construction. The primary challenge to this approach in upper Sq'ewlets Slough West would be access routes for the machine and trucks (for woody debris).

7. **Sq'ewlets Marsh** restoration for fish here would involve retrofitting the top mounted flood gate on the outlet channel. This site is not included in the Resilient Waters project, but solutions appropriate for the Sq'ewlets Slough West flood gate are likely to be applicable here. There is currently no fish habitat inside the dike, but if access were restored it could be created through excavation. As the topography is extremely flat, many sizes and configurations are possible and construction could be phased. Areas of reed canary grass should be targeted, with existing cattail marsh and shrub wetlands left intact. The machine would need to work off pads given the soft ground. A feasibility assessment involving installation of piezometer wells to monitor seasonal groundwater fluctuations would also be advisable.

Recommmendations

1. Pursue feasibility study, design and implementation of habitat restoration projects.. The following table lists them in recommended order of priority.

Priority	Restoration Opportunity
1	Breech secondary dike at Fraser River to restore fish access to Sq'ewlets Slough East
2	Improve habitat in Sq'ewlets Slough East by adding complexing and deepening 2 sections that currently go dry.
3	Expansion of springs and ponds in the Sq'ewlets Campground
4	Expansion of floodplain springs in Harrison Bay floodplain adjacent to Squawkum Creek 3 Reserve
5	Excavation of springs and ponds east and north of the Sq'ewlets soccer field
6	Retrofit culvert and flood gate at Sq'ewlets Slough West to allow fish passage from Fraser River
7	Excavate grass filled section of upper Sq'ewlets Slough west
8.	Retrofit culvert and flood gate at Sq'ewlets Marsh to allow fish passage from Fraser River and excavate ponds in canary grass areas of marsh to provide habitat.

2. Feasilibity studies should include, installation of piezometers to track seasonal changes in groundwater fluctuations
3. Additional fish sampling to understand seasonal changes in habitat use. Seining of spring pools in mid to late spring, after fry emerge from the gravel to assess extent of juvenile Chinook Salmon use is of particular interest.

Literature Cited

CCREM. 2015. Canadian water quality guidelines. Canadian Council of Resource and Environment Ministers, Ottawa. Available from http://ceqg-rcqe.ccme.ca/en/index.html#void.

COSEWIC. 2012. COSEWIC Assessment and update status report of the Salish sucker, *Catostomus* cf. *catostomus*, in Canada. Committee on the Status of Endangered Wildlife In Canada. Ottawa. 29 pp.

Cunjak, R. A. 1988. Physiological consequences of overwintering in streams: the cost of acclimatization. Canadian Journal of Fisheries and Aquatic Science **45**:443–452.

Ebersole, J. L., P. J. Wigington, J. P. Baker, M. a. Cairns, M. R. Church, B. P. Hansen, B. a. Miller, H. R. LaVigne, J. E. Compton, and S. G. Leibowitz. 2006. Juvenile Coho Salmon Growth and Survival across Stream Network Seasonal Habitats. Transactions of the American Fisheries Society **135**:1681–1697. Available from http://www.tandfonline.com/doi/abs/10.1577/T05-144.1 (accessed November 8, 2012).

FISS. 2020. Fisheries Information Summary System database. Accessed February 1, 2020 http://a100.gov.bc.ca/pub/fidq/viewSingleWaterbody.do

Pearson, M. P. 2015. Guidelines for the Capture , Handling , Scientific Study , and Salvage of the Salish Sucker (Catostomus sp .).

Peterson, N. P. 1982. Population characteristics of juvenile coho salmon (Oncorhynchus kisutch) overwintering in riverine ponds. Canadian Journal of Fisheries and Aquatic Science **39**:1303–1307.

Scott, D. C., M. Arbeider, J. Gordon, and J. W. Moore. 2016. Flood control structures in tidal creeks associated with reduction in nursery potential for native fishes and creation of hotspots for invasive species. Canadian Journal of Fisheries and Aquatic Sciences **73**:1138–1148. Available from www.nrcresearchpress.com (accessed January 27, 2020).

Seifert, R. E. 2016. Floodgate Operations and Implications for Tidal Creek Fish Communities MSc thesis, Resource and Environmental Management. Simon Fraser Universtiy, Burnaby.

Appendix 1: Species Photographs

Chinook Salmon

Chum Salmon

Coastal Cutthroat Trout

Coho Salmon

Brassy Minnow

Threespine Stickleback


Pumpkinseed


Brown Catifsh


Prickly Sculpin


Redside Shiner


Largescale Sucker


Peamouth

Northwestern Salamander

Green Frog Tadpole

Bullfrog

Red-legged Frog Egg Mass

Appendix 2: Reach Data and Photographs

Descriptions of Cover and Riparian Areas of Surveyed Reaches. Primary Data is provided in Table 3 of main report.

Reach	Name	Cover Description	Riparian Notes
CGCa	Campground Creek Reach a	patches of shrubs, lots of large cobble	shrubs anddeciduous trees in upstream half
CGCaa	Campground Creek delta channels	Streamside and instream grass	Streamside grasses with patches of willow and hardhack towards inland end
Sas1	Sasin Creek	Some cobble and small undercuts	Some willow clumps
SCN1	Sq'ewlets Creek North		
SKM1	Squawkum Creek Reach 1	Streamside grasses, some hardhack stand	Streamside grasses, some lwd, deep pools
SKM2	Squawkum Creek Reach 2	Instream lwd, overhanging vegetation, boulders, complex channel structure	Coniferous forest; no invasive species, relatively open understory
SKMT1a	Squawkum Creek Trib 1 Reach a	Overhanging grasses and instream grasses and green algae, some undercuts	Streamside grasses, some hardhack and shrubs
SKMT1b	Middle Beaver Ponds	Some woody debris and brush, aquatic vegetation and overhanging veg	Upper pond is on edge of forest, but most in shrub or grass zones
SKMT1c	Connector Channel	Some woody debris and brush, aquatic vegetation and overhanging veg	Mix of shrubs and grasses
SKMT1d	Squawkum Creek Trib1 Reach d	Lots of woody debris and overhanging vegetation	Thick hardhack and willow shrub
SKMT1e	Squawkum Creek Trib1 Reach e	Lots of woody debris and overhanging vegetation	
SKMT2a	Squawkum Creek Trib 2 Reach a	Some woody debris and brush, aquatic vegetation and overhanging veg, complex channels structure, undercuts	Mix of shrubs and grasses
SKMT2b	South Beaver Pond	LWD, instream vegetation: grass, reeds, sedges	Adjacent to mature Coniferous forest
SKMT2c	Squawkum Creek Trib 2 Reach c	Thick in stream grass growth	Mature forest upstream
SKMT2d	Squawkum Creek Trib 2 Reach d	Lots of instream veg and overhanging veg	
SQEa	Sq'ewlets Slough East Reach a	Canary Grass and scattered lwd	Cottonwood and shrubs on right low grass area on left would flood in freshet
SQEb	Sq'ewlets Slough East Reach b	Scattered lwd and deep water	Dike is right bank
SQEc	Sq'ewlets Slough East Reach c	Lots of lwd some deep pool	Dike set back a few m from right bank
SQEd	Sq'ewlets Slough East Reach d	Submerged grass along edge a couple of shrubs in water	Dike on right scattered shrubs but mostly grass . Cultivated field to left
SQMa	Sq'ewlets Marsh reach a	Very little flow	
SQWa	Sq'ewlets Slough West Reach a	Instream vegetation, limited woody debris, water to 2 m deep	Mostly cottonwood
SQWb	Sq'ewlets Slough West Reach b	Thick overgrowth reed canary grass, almost no open water	Mostly cottonwood shrub understory
Ssa	Sq'ewlets Spring a	Grassy islets	Streamside grasses, isolated grass clumps in braided channel
SSb	Sq'ewlets Spring b	Algae, aquatic plants, overhanging grasses	
SSc	Sq'ewlets Spring c	Streamside grasses and isolated instream grass and sedge clumps; instream green algae	Mixed grass and sedges

SSd	Sq'ewlets Spring d	75 m upstream channel narrows and cover becomes mixed Deciduous: willows, hardhack, alders	Low grassy banks
Sse	Sq'ewlets Spring e	Streamside grasses and sedges, some aquatic plants and undercuts in pools	Hardhack and willow shrub further upstream
SSf	Sq'ewlets Spring f	Some instream veg and overhanging sedges, instream algae present too. Woody debris and cutbanks in headwater pools	Upper section shrubby: hardhack, red-osier, crabapple, willow
SSg	Sq'ewlets Spring g	Instream veg and algae with overhanging sedges	
SSh	Sq'ewlets Spring h	Algae growth and small woody debris present in oriigin pool	Grasses and sedges in floodplain, shrub patches toward upstream end
Ssi	Sq'ewlets Spring i		
SSj1	Sq'ewlets Spring j		Scattered shrubs around upstream end
SSj2	North Beaver Pond	Close to 2 m at deepest; lots of woody debris, and brush piles, snags	Dam is in shrubby veg; pond extends back into forest with mature conifers
SSj3	Sq'ewlets Spring j3	Likely abundant cover with lots woody debris	mature mixed forest
SSj4	Sq'ewlets Spring j4	Lots of woody debris	Cleared and channelized near soccer field; forested downstream portion
SSk	Sq'ewlets Spring k	Limited overhanging vegetation and undercuts; bottom flat gravel	Some hardhack, Area submerged during freshet
SSl	Sq'ewlets Spring l	flooded grass, some undercuts, very open pond	RL small stand of hardhack
SSm	Sq'ewlets Spring m	Streamside and instream grasses and sedges	Open grass banks
RUC	Railway Underpass Channel		Shrubs and deciduous trees
SQMW	Sq'ewlets Marsh West		
SQME	Sq'ewlets Marsh East		

Outlet culvert; outside dike

Beaver dam outside below outlet culvert

Reach SQWa

Outlet culvert inside dike; blocked by beaver

Reach SQWb

Sq’ewlets Slough West: February 10, 2020

Outlet culvert; outside dike

Outlet culvert inside dike

Reach SQEa

Reach SQEb

Reach SQEc

Reach SQEd

Sq'ewlets Slough East: February 10, 2020

Outlet culvert; outside dike

Outlet and Harrison River

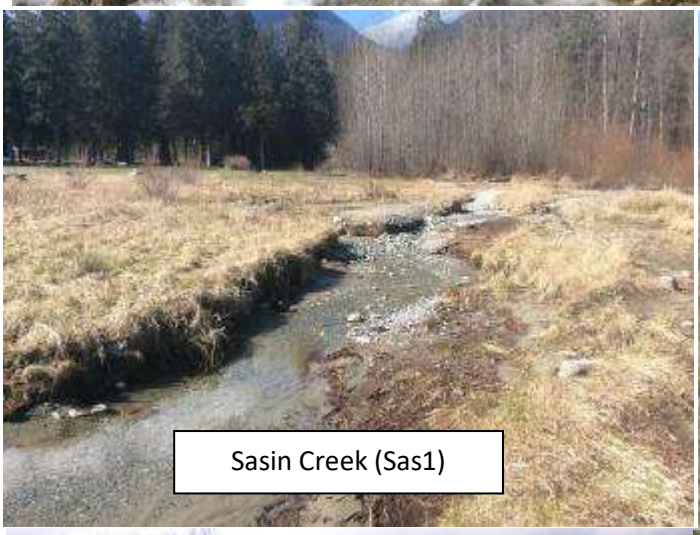
Reach SQMa

Reach SQMw

Sq’ewlets Marsh: February 10, 2020

Sq'ewlets Creek North (SCN1)
Culvert under Highway 7

Sq'ewlets Creek North (SCN1)



Sasin Creek (Sas1)

Sasin Creek (Sas1)

Campground Creek (CGCa)

Campground Creek (CGCa)

Harrison Bay Streams

Campground Creek Delta Channel (CGCaa)

Campground Creek Delta Channel (CGCaa)

Sq'ewlets Spring a (SSa)

Sq'ewlets Spring b SSb)

Sq'ewlets Spring c (SSc)

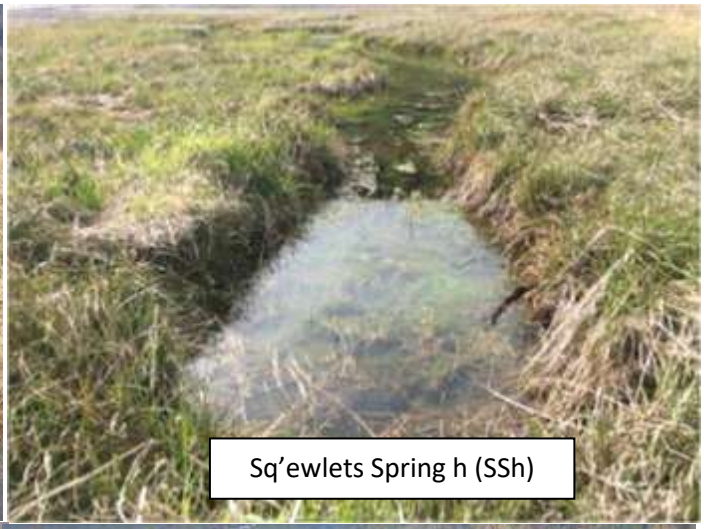
Sq'ewlets Spring d (SSd)

Harrison Bay Springs

Sq'ewlets Spring e (SSe)

Sq'ewlets Spring f (SSf)

Sq'ewlets Spring g (SSg)

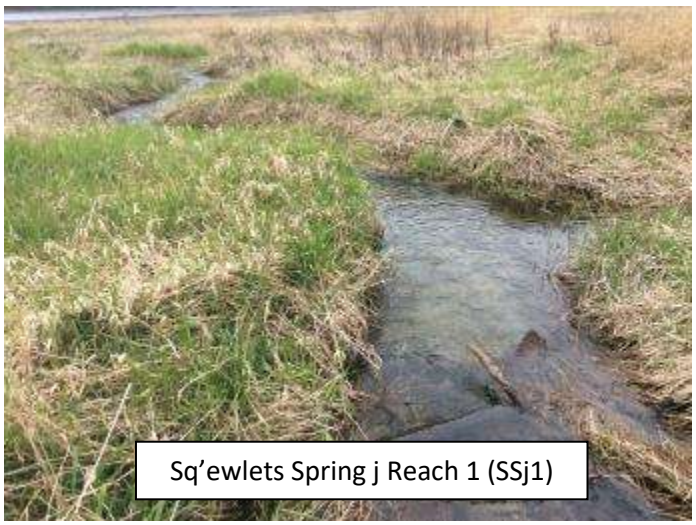


Sq'ewlets Spring h (SSh)

Sq'ewlets Spring c (SSi)

Sq'ewlets Spring h(SSh)

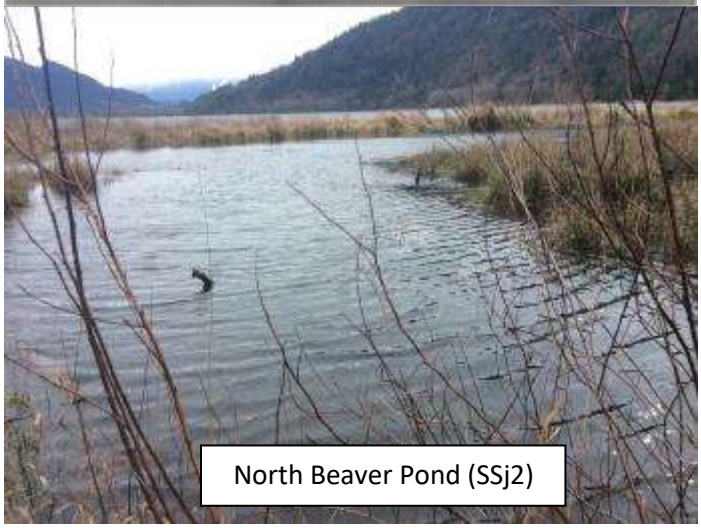
Harrison Bay Springs



Sq'ewlets Spring j Reach 1 (SSj1)

Sq'ewlets Spring j Reach 1 (SSj1)

North Beaver Pond (SSj2)



North Beaver Pond (SSj2)

Sq'ewlets Spring j Reach 3 (SSj3)

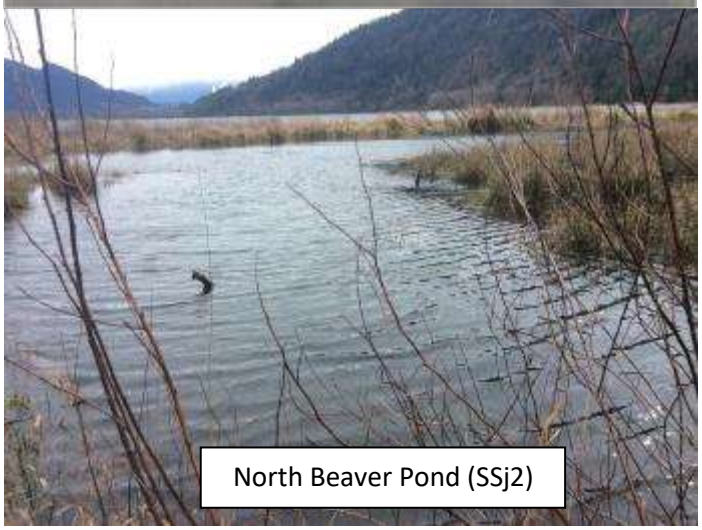
Sq'ewlets Spring k (SSk)

Harrison Bay Springs

Sq’ewlets Spring k Reach 1 (SSk1)

Sq’ewlets Spring l Reach 1 (SSl1)

North Beaver Pond (SSm2)



North Beaver Pond (SSj2)

Harrison Bay Springs

Squawkum Creek Reach 1 (SKM1)

Squawkum Creek Reach 1 (SKM1)

Squawkum Creek Reach 2 (SKM2)

Squawkum Creek Reach 2 (SKM2)

Squawkum Creek Trib 1 Reach a (SKMT1a)

Middle Beaver Pond (SKMT1b)

Squawkum Creek and Tributaries

Squawkum Creek Trib 1 Reach c (SKMT1c)

Squawkum Creek Trib 1 Reach d (SKMT1d)

Squawkum Creek Trib 1 Reach e (SKMT1e)

Squawkum Creek Trib 2 Reach a (SKMT1a)

South Beaver Pond (SKMT2b)

Middle Beaver Pond (SKMT2c)

Squawkum Creek and Tributaries

Campground Creek 0 m upstream of Highway 7

Campground Creek 200 m upstream of Highway 7

Campground Creek 300 m upstream of Highway 7

Campground Creek 425 m upstream of Highway 7

Campground Creek 555 m upstream of Highway 7

Campground Creek 610 m; 4 m high barrier

Campground Creek North of Highway 7

Sasin Creek 0 m upstream of Highway 7

Sasin Creek 20 m upstream of Highway 7

Sasin Creek 100 m upstream of Highway 7

Sasin Creek 200 m upstream of Highway 7

Sasin Creek 300 m upstream of Highway 7

Sasin Creek 380 m upstream of Highway 7

Sasin Creek North of Highway 7