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March 27, 2020
File No. 104486-01

Fraser Valley Watershed Coalition
#1-45950 Cheam Avenue
Chilliwack, BC V2P 1N6

Attention: Natashia Cox, Program Director

Re: William and Nancy Phillips Restoration Project - Effectiveness Monitoring Report

1.0 INTRODUCTION

William Phillips and Nancy Phillips sloughs are part of a number of sloughs (Harrison River sloughs) located in the Harrison River floodplain and Chehalis River alluvial fan on the Chehalis Reserve #5**.** The William Phillips and Nancy Phillips Slough Enhancement project (the Project) was completed as part of the Heart of the Fraser Collaborative Partnership led by the Fraser Valley Watershed Coalition to improve access to existing off-channel rearing and over-wintering habitats. Hemmera Envirochem Inc. (Hemmera)and the Sts'ailes First Nation (Sts'ailes) completed construction of the Project in Fall 2019; construction details are provided in the Post Construction Report (Hemmera 2020).

The key objective of the Project was to restore and enhance William Phillips Slough and Nancy Phillips Slough. This was to be completed by creating ~5,297 m^2 of salmon habitat through the excavation of two new off-channel habitats and the restoration/enhancement of 726 m^2 of existing habitat. The total enhancement and restoration value of 6,023 of instream habitat (Hemmera 2020)

The objective of this Effectiveness Monitoring Report is to fulfill the post-construction effectiveness monitoring requirements identified as part of funding; whereby, monitoring is completed to inform restoration success, use by salmonids, water quality suitability for fish habitat, and to provide recommendations for adaptive management and next steps. Specifically, the assessment was aimed to evaluate whether the Project is providing functional off-channel rearing and over-wintering habitat for salmonids following construction.

2.0 MONITORING PARAMETERS AND METHODOLOGY

Effectiveness monitoring was conducted in Spring 2020 following the substantial completion of Project construction on November 8, 2019. The Spring Monitoring Event was conducted by a team of two Hemmera qualified environmental professionals (QEPs) on March 16, 2020. During the monitoring event a qualitative assessment of physical habitat stability was completed (**Section 2.1**); *in-situ* water quality data was collected at established water quality sampling locations (**Section 2.2**); visual observations of salmonid fish presence were documented along each slough channel including an evaluation of fish accessibility (i.e., past weir structures) (**Section 2.3**); and, water depth measurements were taken to evaluate water level suitability for salmonid presence (**Section 2.4**).

2.1 Physical Stability

Physical channel stability was assessed along Nancy Phillips and William Phillips sloughs during the Spring Monitoring Event (after the first winter period) through visual inspections of the constructed habitat. QEPs walked along the west bank of each slough to identify channel substrate and bank conditions, bank disturbance indicators (i.e., slumping), locations at risk of bank failure, and to assess whether installed large woody debris structures (LWD) had moved. Any locations of bank failure or at risk of bank failure or LWD that had moved were documented and georeferenced. During the monitoring event, photo documentation of representative channel conditions was collected; photos at any sites of compromised bank stability were also taken.

2.2 Water Quality

During the Spring Monitoring Event *in situ* water quality data for dissolved oxygen (DO; mg/L), temperature (^{o}C), specific conductivity (uS/cm), and pH were collected by the QEP using a YSI Professional Plus handheld multimeter. The QEP established and georeferenced water quality locations in each slough. Three water quality monitoring locations were established in the Nancy Phillips Slough (Upper Terminus Pool, Mid-Channel, and Lower Channel) and three locations established in the William Phillips Slough (Upper Terminus Pool, Mid-Channel, and Lower Channel). Water quality equipment was calibrated in accordance with manufacturer's instructions prior to water quality sampling. In *situ* water quality data sampling was conducted in accordance with RISC 2001.

2.3 Fish Observations and Accessibility

Visual fish observations were documented during the Spring Monitoring Event on William Phillips and Nancy Phillips sloughs. Two QEPs walked along opposite banks of the slough from the confluence with the Harrison River to the upper terminus pool of each slough. The observers documented the locations of fish presence, evaluated whether fish were salmonid or non-salmonid (e.g., based on behavior, swimming form), and estimated number of fish present (i.e., where schooling was observed). At weir structures, the QEP documented weir length, width, wetted depth, flow connectivity, and reviewed upstream and downstream pooling to evaluate fish accessibility upstream and downstream of these structures.

2.4 Water Levels

During the Spring Monitoring Event two QEPs walked the banks of each slough and established georeferenced transects along the channel at regular intervals (i.e., 10 – 30 m). At each transect, where accessible from the bank, a measuring tape was used to measure the depth along the low flow channel. Where access was limited, channel depths were assessed visually.

3.0 RESULTS

3.1 Physical Stability

Visual assessments of slough channel stability in Nancy Phillips Slough during the Spring Monitoring Event did not note any channel instability concerns. The newly constructed channel and restored/enhanced channel sections were stable and no disturbance indicators (i.e., slumping) were observed. Representative channel bank conditions are shown in **Appendix A** - **Photo 1** and **2**. Riparian vegetation along the east bank of Nancy Phillips Slough is generally intact (**Appendix A**; **Photo 3**); however, riparian vegetation along the west bank was impacted by side-cast material during channel excavation construction and equipment access along this bank (**Appendix A**; **Photo 4**). Channel substrates were dominated by a layer of fines; cobble/gravel substrates were dominant underneath the fines and along restored/enhanced slough habitat areas (**Appendix A**; **Photo 5**). Large woody debris structures within and along the channel banks and were observed to be functional (**Appendix A**; **Photo 6**).

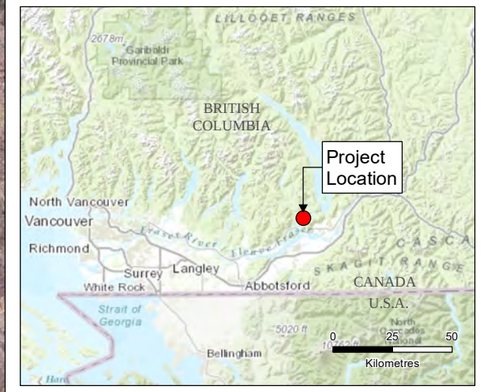
Visual assessments of channel stability in William Phillips Slough during the Spring Monitoring Event did not find any channel instability concerns. The newly constructed channel and restored/enhanced channel sections were stable and no disturbance indicators (i.e., slumping) were observed. Representative channel bank conditions are shown in **Appendix B**; **Photo 1** and **2**. Riparian vegetation along the newly constructed east bank of William Phillips Slough is primarily intact (**Appendix B**; Photo 3); however, riparian vegetation along the west bank was impacted by the side-cast of material during channel excavation construction (**Appendix B**; **Photo 4**). Channel substrates were dominated by a layer of fines; however predominantly characterized by cobble/gravels underneath the accumulated fine material (**Appendix B**; **Photo 5**). Large woody debris structures within and along the channel banks and were observed to be functional (**Appendix B**; **Photo 6**).

3.2 Water Quality

Spring Monitoring Event *in-situ* water quality data for Nancy Phillips and William Phillips sloughs is presented in **Table 1**; water quality sampling locations are presented in **Figure 1**. Water quality temperature measured in both sloughs was within an acceptable range to support over-wintering and rearing habitat for juvenile salmonids. DO levels were generally slightly below optimal levels for over-wintering; however, within the optimal range for juvenile salmonid rearing in both sloughs. The pH levels were below optimal levels; however, low pH is consistent with long-term monitoring data collected for Harrison Slough habitats. Water quality data was collected by Pearson Ecological as part of slough monitoring over the period from September 19, 2017 to September 17, 2019 and indicated temperature data over the period from November 2018 to September 2019 ranged between 3.4 – 13.1 ^{o}C (n= 3,663), pH levels ranged between 6.2 – 6.9 (during mid-late summer sampling; n= 41), specific conductivity ranged from 42 – 61 uS (during mid-late summer sampling; n=41), and turbidity was <5 NTU (n= 7; mid-late summer sampling). Pearson Ecological collected spot measurements in Frank Dan Slough in November 2017, April 2018, October 2018, and April 2019 (**Appendix C**). Temperature and conductivity levels measured in Nancy Phillips and William Phillips sloughs were generally consistent with the data collect for Frank Dan Slough. The pH levels for the Project sloughs were lower than pH levels recorded in nearby Frank Dan Slough in April 2018/2019 (Frank Dan Slough pH Range = 6.4 – 6.9); the DO levels in the Project sloughs were also lower than those recorded in Frank Dan Slough in April 2019 (Frank Dan Slough DO = 8.16 – 12.06 mg/L).

William and Nancy Phillips
Slough Restoration Project

Location and Pre-construction Condition of Nancy and William Phillips Slough



Legend

- Project Location

Notes

1. This map is not intended to be a “stand-alone” document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Contains information licensed under the Open Government Licence - Province of British Columbia
- Orthoimagery at 15 cm resolution.
- Inset Basemap: ESRI World Topographic Map

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NAD 1983 UTM Zone 10N

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Table 1 Spring Monitoring Event *In-Situ* Water Quality Data

Monitoring Location	Temperature (°C)	Dissolved Oxygen (mg/L)	pH	Conductivity (µS/cm)	Turbidity (C=Clear, L=Light, M=Moderate, T=Turbid)
	BCWQG Criteria[1,2]				
	Winter: 4.0 – 13.0 Summer: 9.0 -16.0 Fall: 7.2 – 12.8	Winter: >9, Summer/ Fall: >5	6.5 - 9.0	n/a	n/a
Nancy Phillips Slough					
Upper Terminus Pool	8.2	7.80	5.34	28.4	T
Mid-channel	9.0	7.98	5.86	29.4	C
Lower-channel	9.0	8.14	5.96	29.2	C
William Phillips Slough					
Upper Terminus Pool	9.3	7.85	5.45	29.9	L
Mid-channel	8.3	8.92	5.64	30.1	C
Lower-channel	6.7	10.42	5.37	30	C

Notes:

1 Temperature criterion captures optimum range for the life stages and salmonid anticipated to use the sloughs as follows: Winter: incubation for chum and coho salmon, Summer: rearing for coho salmon, rainbow/cutthroat trout, and bull trout/Dolly Varden, Fall: spawning for chum and coho salmon

2 Dissolved Oxygen criterion is dependent on fish life stage. The instantaneous minimum concentration of DO for protection of aquatic life is 9 mg/L for buried embryo/alevin life stages (used for Winter and Fall) and 5 mg/L for all other life stages (used for Summer).

3.3 Fish Observations and Accessibility

Several salmonid fry were observed schooling downstream of Weir 1A in Nancy Phillips Slough on March 16, 2020.

There are three constructed weirs along Nancy Phillips Slough (Weir 1A – Weir 3A). Weir 1A is the southernmost weir structure and is located immediately upstream of the slough's confluence with the Harrison River. Water flowing over Weir 1A was 0.09 m deep and connected surface flow was observed between the upstream pool and the downstream channel; Weir 1A was determined to be fish passable at the time of assessment (**Appendix A**; **Photo 7**). Weir 2A is located approximately 80 m upstream (north) from Weir 1A. Water flowing over Weir 2A was 0.09 m deep and connected surface flow was observed over this weir weir; Weir 2A was assessed as fish passable (**Appendix A**; **Photo 8**). Weir 3A is located at the outlet of the Upper Terminus Pool at the northern extent of Nancy Phillips Slough. Water flowing over Weir 3 was 0.10 m deep and connected surface flow was observed over this weir structure. Weir 3A was determined to be fish passable at the time of assessment.

Individual and single salmonid fry were observed over the full extent of William Phillips Slough on March 16, 2020.

There are three constructed weirs along William Phillips Slough (Weir 1B – Weir 3B). Weir 1B is the southernmost weir structure and is located immediately upstream of the slough's confluence with the Harrison River. Water flowing over Weir 1B was 0.11 m deep and connected surface flow was observed over the length of this structure; Weir 1B was assessed as fish passable (**Appendix B**; **Photo 7**). Weir 2B is located at the channel fork of William Phillips Slough. Water flowing over Weir 2B was 0.15 m deep and connected surface flow was observed over this structure; Weir 2B was assessed as fish passable (**Appendix B**; **Photo 8**). Weir 3B is at the outlet of the pond habitat at the northern extent of William Phillips Slough. Water flowing over Weir 3B was 0.08 m deep and connected surface flow was observed over this structure. Weir 3B was determined to be fish passable at the time of assessment (**Appendix B**; **Photo 9**).

3.4 Water Levels

Eleven transect measurements were collected at approximately 20 m intervals along the length of Nancy Phillips Slough from the Harrison River Confluence to the Upper Terminus Pool (**Appendix D**). The thalweg water depth was measured at each transect and ranged between approximately 0.37 m – 1.5 m deep. The channel thalweg was deepest in the restoration/enhancement area and shallowest in the newly constructed channel southeast of the terminus pool. Water level depths were generally variable across each channel transect; connected surface flow is present along the length of the slough channel between the Harrison River and Upper Terminus Pool.

Fourteen transect measurements were collected at approximately 10 – 15 m intervals along the length of William Phillips Slough from the Harrison River Confluence to the Upper Terminus Pool (**Appendix D**). The thalweg water depth was measured at each transect and ranged between approximately 0.15 – 1.7 m deep. The channel thalweg was deepest in the restoration/enhancement area and shallowest in the newly constructed channel southeast of the terminus pool. Water level depths were generally variable across each channel transect; connected surface flow is present along the length of the slough channel between the Harrison River and Upper Terminus Pool.

4.0 CONCLUSIONS

Hemmera visually confirmed juvenile salmonid presence and use of habitat in the Nancy Phillips and William Phillips sloughs. Habitat characteristics observed during the assessment indicate the slough channels are physically stable, have functional LWD, are fish accessible, have sufficient water levels to support fish habitat, and water quality measurements are within acceptable ranges to support fish presence and consistent with water quality data measured on other slough projects in the nearby area. Riparian vegetation is predominantly intact along the east bank of both sloughs, and willow-staking of the west bank was conducted in Spring 2020. A long-term monitoring program to confirm effectiveness of the Project and identify adaptive management measures is recommended to support Project objectives related to providing rearing, over-wintering and spawning habitat for salmonid species.

5.0 CLOSURE

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Report prepared by:
Hemmera Envirochem Inc.

Stephanie Cavaghan, B.Sc., BIT
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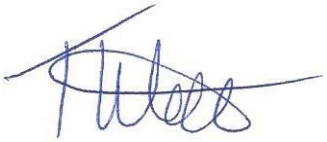


Trevor Welton, R.P.Bio.
Senior Project Advisor

6.0 REFERNCES

Hemmera. 2020. William and Nancy Phillips Slough Restoration – Post Construction Report. Prepared for Sts'ailes First Nation. Burnaby, BC.

Resources Inventory Committee [RISC]. 2001. Reconnaissance (1:20 000) Fish and Fish Habitat Inventory: Standards and Procedures. The Province of British Columbia. Available https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/nr-laws-policy/risc/recce2c.pdf. Accessed March 2020.

FIGURE

TERMINUS POOL HABITAT

6839.6 m²

2147.5 m²

NANCY PHILLIPS SLOUGH

WILLIAM PHILLIPS SLOUGH

553.0 m²

668.1 m²

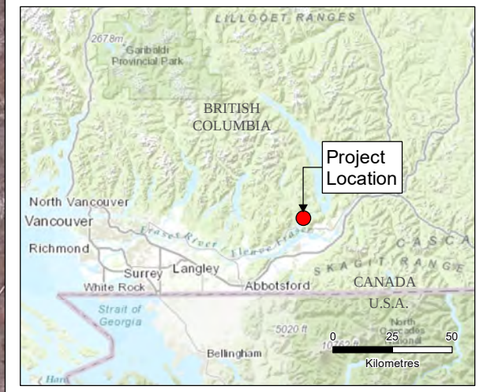
222.9 m²

668.2 m²

DRAFT
For Discussion Purposes Only

William and Nancy Phillips Slough Restoration Project

William and Nancy Phillips Slough As-built Drawing



Legend

- Rock Weir
- Large Woody Debris
- Water Quality Sampling Location
- Access Road
- Existing (Approximate Area: 1,946 m²)
- Enhance (Approximate Area: 726 m²)
- New (Approximate Total Area: 1,916 m²)
  - Nancy Phillips Slough Approximate Area: 1,486 m²
  - William Phillips Slough Approximate Area: 430 m²
- Riparian Planting (Approximate Area: 3,483 m²)
- New Riparian Area (Approximate Area: 7,615 m²)

Notes

1. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Contains information licensed under the Open Government Licence - Province of British Columbia
- Orthoimagery at 15 cm resolution.
- Inset Basemap: ESRI World Topographic Map

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Metres

NAD 1983 UTM Zone 10N

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APPENDIX A

Nancy Phillips Slough Photo Documentation

Photo 1 Looking south along Nancy Phillips west bank at typical new channel construction conditions; large woody debris placement installed (March 16, 2020).

Photo 2 Looking north along the new constructed channel of Nancy Phillips Slough at typical bank conditions (March 16, 2020).

Photo 3 Nancy Phillips Slough east bank riparian vegetation primarily intact; west bank riparian vegetation less intact (March 16, 2020).

Photo 4 Looking south along the west bank of Nancy Phillips Slough; typical riparian vegetation conditions (March 16, 2020).

Photo 5 Typical substrate conditions below Nancy Phillips Slough Weir 1A (March 16, 2020).

Photo 6 Large woody debris structure installed in Nancy Phillips Slough and functional (March 16, 2020).

Photo 7 Looking north at Nancy Phillips Slough Weir 1A closest to the Harrison River confluence (March 16, 2020).

Photo 8 Looking north from Nancy Phillips west bank at Weir 2A (March 16, 2020).

APPENDIX B

William Phillips Slough Photo Documentation

Photo 1 Looking south along William Phillips at typical new channel construction conditions; large woody debris placement installed (March 16, 2020).

Photo 2 Looking north along the new constructed channel of William Phillips Slough at typical bank conditions (March 16, 2020).

Photo 3 William Phillips Slough east bank riparian vegetation primarily intact (March 16, 2020).

Photo 4 Looking north along the west bank of Nancy Phillips Slough; typical riparian vegetation conditions (March 16, 2020).

Photo 5 Typical substrate conditions below William Phillips Slough Channel Fork (March 16, 2020).

Photo 6 Large woody debris structure installed in William Phillips Slough and functional (March 16, 2020).

Photo 7 Looking north at William Phillips Slough Weir 1B closest to the Harrison River confluence (March 16, 2020).

Photo 8 Looking north at William Phillips Slough Weir 2B (March 16, 2020).

Photo 9 Looking north at William Phillips Slough Weir 3B (March 16, 2020).

APPENDIX C

Pearson Ecological Frank Dan Slough Water Quality Report Card

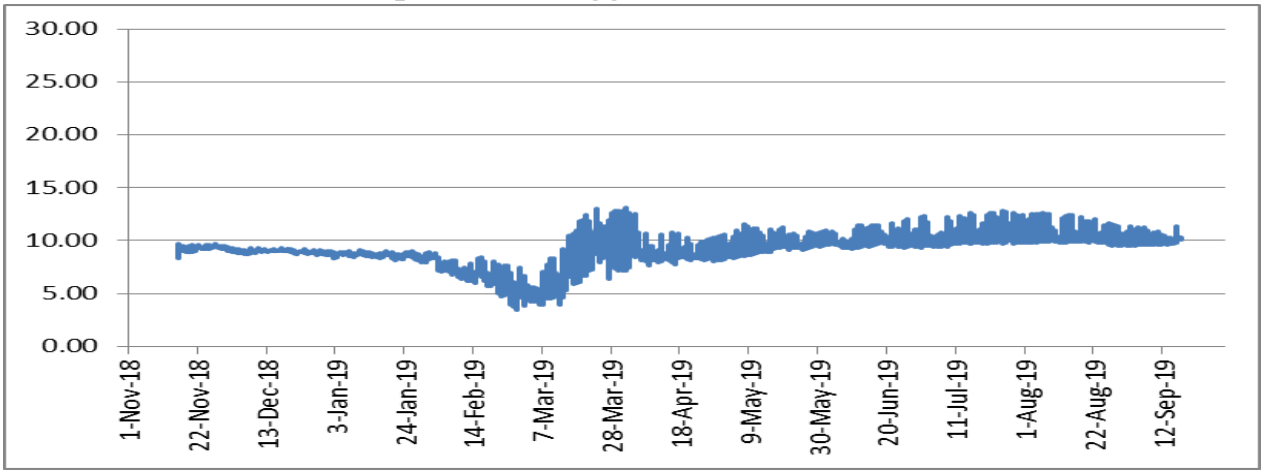
Water Quality Report Card

Site	Frank Dan Slough		Year	1 and 2	Date Range	19-Sep-2017 17-Sep-2019
Temperature	**Dissolved Oxygen**	**pH**	**Spec. Conductivity**		**Turbidity**	
Onset V2 Logger YSI Pro Do Meter	YSI Pro DO Meter (Optic probe)	Oakton Testr 35	Oakton Testr 35		LaMotte Turbidity Tube Visual Observation	

Water Quality Indicator Table

Indicator	Minimum	Maximum	Measurements	Field Days	Mid-Late Summer Sampling
Water Temperature (C)	3.4	13.1	3663	305	Y
Dissolved Oxygen (mg/l)	6.0	12.1	33	6	Y
Specific Conductivity (uS)	42	61	41	5	Y
pH	6.2	6.9	41	4	**Y**
Turbidity (ntu)	<5	<5	7	7	**Y**

Water Temperature Logger at UTM 10U 579565 5459991



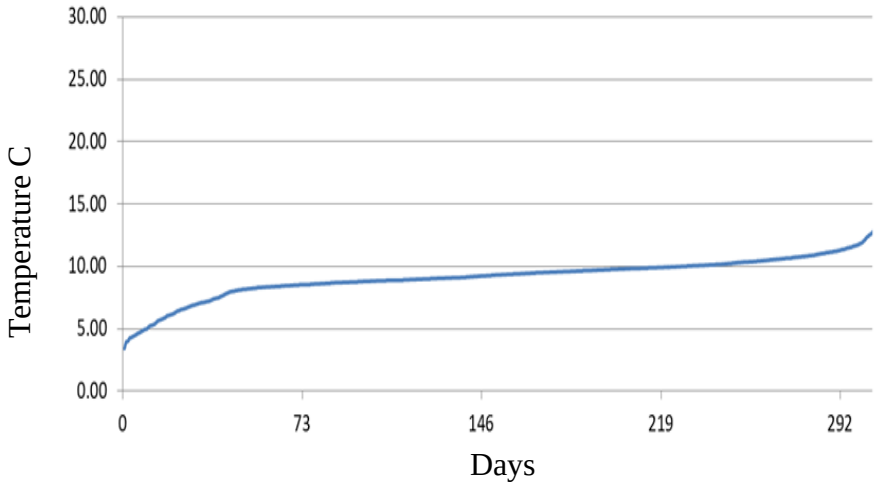
Temperature and Coho Growth

		Year 1		Year 2	
	Start Date	16-Nov-18			
	End Date	16-Sep-19			
Growth Conditions*	**Temp. Range**	**Cumulative Time (days)**	**% Year**	**Cumulative Time (days)**	**% Year**
Dangerously Warm	**>20 C**	0.0		0.0	
Very High Growth*	**18-20 C**	0.0	Requires	0.0	Requires
High Growth*	**15-18 C**	0.0	365 days	0.0	365 days
Medium Growth*	**10-15 C**	76.2	of data	0.0	of data
Low Growth *	**5-10 C**	219.7		0.0	
No Growth	**<5 C**	9.2		0.0	
	Total	306		0	

***Assumes dissolved oxygen concentration is adequate**

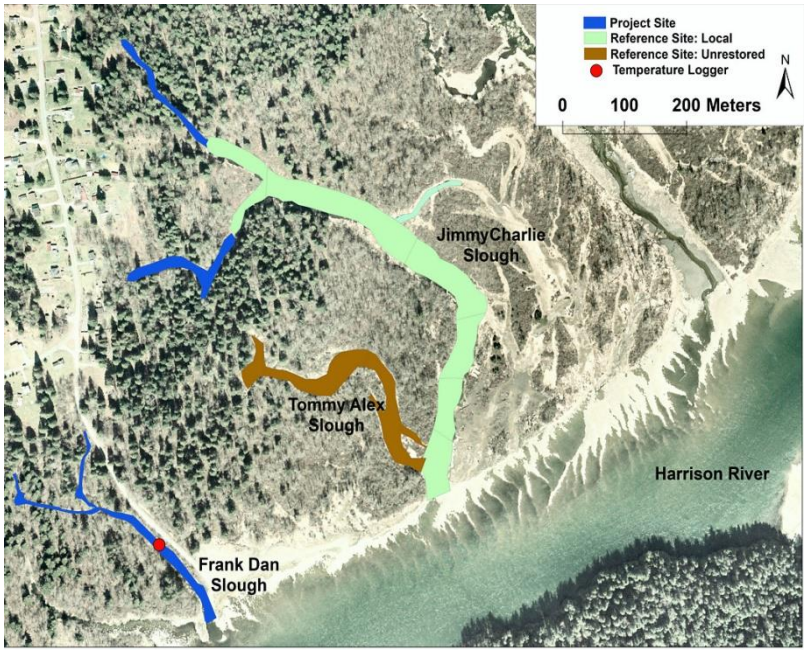
Water Temperature Duration Curves

Temperature on plotted line exceeded for cumulative time of days) to left



Interpretation

- Water temperature is close to 10 C year round, indicating massive inflows of groundwater
- Coho can feed and grow all winter long at these temperatures, but will grow more slowly in summer than in warmer habitats with less groundwater influence
- This habitat is likely to maintain productivity as average water temperatures increases by several degrees with climate change
- Dissolved oxygen concentrations were adequate for salmonids in all sampling periods, but well below saturation at some locations. This is typical in areas of high groundwater flows.
- Specific conductivity was low in all samples, as expected in a location in the floodplain of a large river in the mountains
- pH levels were slightly acidic at all sampling times and within an acceptable range for aquatic life
- Turbidity is exceptionally low, as it is in all sloughs at Sts'ailes



Temperature Logger Location (Red)

Spot Measurements

Date	Temperature ˚C			Dissolved Oxygen (mg/L)			Specific Conductivity (μS)			pH			Turbidity		
	N	Min.	Max.	N	Min.	Max.	N	Min.	Max.	N	Min.	Max.	N	Min.	Max.
22-Nov-17	7	8.70	9.4	7	6.76	8.68	10	59	61	10	6.2	6.4	1	<5	<5
19-Sep-17	1	10.70	10.7	1	7.89	7.89	1	54	54	1	6.5	6.5	1	<5	<5
3-Apr-18	12	6.90	7.5				12	46	53	12	6.4	6.6	1	<5	<5
4-Oct-18	1	9.40	9.4	1	8.25	8.25	1	47	47	1	6.5	6.5	1	<5	<5
30-Oct-18	10	9.80	10.1	10	6.04	8.38							1	<5	<5
3-Apr-19	9	8.40	13.6	9	8.20	11.42	12	42	54	12	6.4	6.9	1	<5	<5
1-Apr-19	5	10.40	14	5	8.16	12.06	5	44	54	5	6.5	6.8	1	<5	<5

Water Quality Indicator Thresholds

Temperature Max.++	>20	18-20	15-18	<15
Temperature Min.	<2	2-4	4-5	>5
Dissolved Oxygen*	<2.5	2.5-5	5-6.5	>6.5
Dissolve Oxygen Eggs/Alevins*+	<5	5-7	7-9.5	>9.5
Specific Conductivity**	>400	250-400	100-250	0-100
pH	<5.5 or >9	5.5-6 or 8.5-9	6-6.5	6.5-8.7
Turbidity	>80	25-80	5-25	<5

*Based on Canadian Water Quality Guidelines for the Protection of Aquatic Life
http://ceqg-rcqe.ccme.ca/download/en/221
**For Fraser Valley, may be higher elsewhere, depending on watershed geology
+ Applicable to spawning habitats from October to April
++ Considers likely impacts of climate change on stream temperature

Coho Growth and Water Temperature Thresholds

Temperature Range		Cumulative Time (Days) Over 365 Day Period		
Dangerously Warm	**>20 C**	>10	0-10	0
Very High Growth*	**18-20 C**		<20	>20
High Growth*	**15-18 C**		<20	>20
Medium Growth*	**10-15 C**		<100	>100
Low Growth *	**5-10 C**		>200	<200
No Growth	**<5 C**	>50	10-50	0-10

APPENDIX D
Channel Measurements

Table 1 Channel Morphology Metrics collected during March 2019 Effectiveness Monitoring

Transect #	Wetted Width (m)	Wetted Depth (m)	Large Woody Debris	Comments
Nancy Phillips Slough				
1-1	8.9	0.40	At right bank 4 m upstream on left bank 19 m upstream on right bank	
1-2	6.4	0.50	1 m upstream on left bank 15 m upstream on left bank	
1-3	7.4	1.50	At transect on left bank 13 m upstream on left bank	
1-4	3.6	0.40	1 m downstream on left bank 25 m upstream on right bank	
1-5	3.7	0.38		
1-6	4.7	0.48	At center of channel ~ 0.5 m upstream of transect	
1-7	3.2	0.37	12 m upstream on left bank	
1-8	2.9	0.50		~ 16 m downstream of Weir 1C; upstream from this transect channel width narrows to 2 m and maximum depth is 0.20 m. Abundant fibrous green algae present.

Transect #	Wetted Width (m)	Wetted Depth (m)	Large Woody Debris	Comments
William Phillips Slough				
2-1	2.6	0.20		
2-2	6.7	0.30		Downstream of Weir 1B
2-3	12.3	1.2	2 m upstream of transect	Wetted depth ranged between 0.35 – 1.2 m
2-4	17.0	1.50		Wetted depth ranged between 0.30 – 1.5 m
2-5	23.4	0.50		
2-6	11.1	1.50		Wetted depth ranged between 0.30 – 1.5 m; low flow channel along right bank
2-7	1.30	1.70	3 m upstream on right bank	Wetted depth ranged between 0.3 – 1.7 m
2-8	13.1	1.20		Wetted depth ranged between 0.20 – 1.2 m
2-9	9.5	1.70	Immediately u/s of transect on right bank	Wetted depth ranged between 0.2 – 1.7 m
2-10	7.6	1.20	4 m upstream on left bank	
2-11	6.0	1.60	3 m upstream on right bank 12 m upstream on right bank	
2-12	6.4	1.00	5 m upstream on left bank	