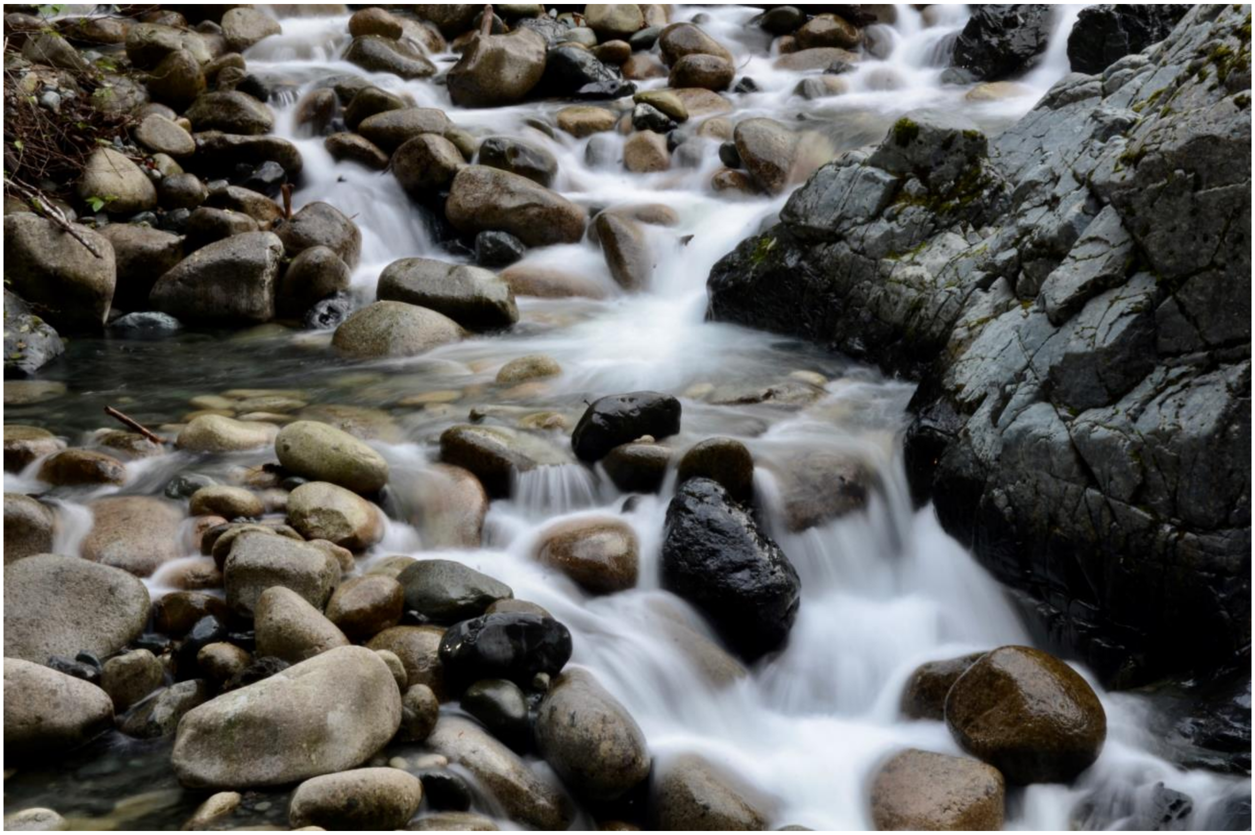
Water Quality and Stream Invertebrate Assessment of the C.W Young Channel, Englishman River, British Columbia (Fall 2023)



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Executive Summary

This document aims to assess the overall health of the C.W Young side channel in Parksville, British Columbia, specifically focusing on the aquatic environment within the Englishman River. The study will compare data collected from 2008-2023 by students enrolled in Vancouver Island University's Environmental Monitoring course. The data collected will cover stream hydrology, water quality, and stream invertebrate sampling. The following data will be obtained from 4 sites, previously established from other years to maintain consistency and allow a more accurate comparison. Analysis will take place at the VIU laboratory in Vancouver and sent off to ALS laboratory services.

The spawning channel was constructed in 1992 to increase salmonid spawning and rearing habitat. The system begins approximately 6km up stream of the Englishman River estuary and runs approximately 4.1kms along the northern side of the main stem Englishman. Anthropogenic factors have particularly extensive logging has significantly altered the Englishman river watershed. The vast removal of vegetation has left the land unable to handle recent atmospheric rivers, causing major floods in the winter, and the summer droughts have proven to be exceptionally devastating to the local flora and fauna. Logging however is not the only anthropogenic factor affecting the Englishman river watershed. The systems close proximity to urban development is also significantly impactful. For this reason, we must monitor systems like the C.W Young side channel as it can be essential to supporting a suffering system such as the Englishman River.

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1.0 Introduction

1.1 Project Overview

Due to the historical and current significance of the Englishman River Watershed (WR4), students enrolled at Vancouver Island University (VIU) taking RMOT 306 (Environmental Monitoring) have been tasked with monitoring the water quality and macroinvertebrates that reside in the C.W Young Channel of the Englishman River. The spawning channel is situated roughly 6 km upstream from the estuary and is approximately 4.1 kilometers long on the north side of the Englishman River, which is located in Parksville, British Columbia.

This project has been carried out by RMOT 306 students since 2008, in attempts to provide more insight to the watersheds change overtime and its effect on the surrounding ecosystem. Evan Black, Tim Waite and Zachary Ohlman will be visiting the 4 different strategically chosen sites on the C.W Young Channel on two occasions in October and November. The sampling will consist of channel morphology measurements, water quality and macroinvertebrate samples. We will then determine specific water quality measurements, identify the species and density of the freshwater invertebrates collected and proceed to analyze the results.

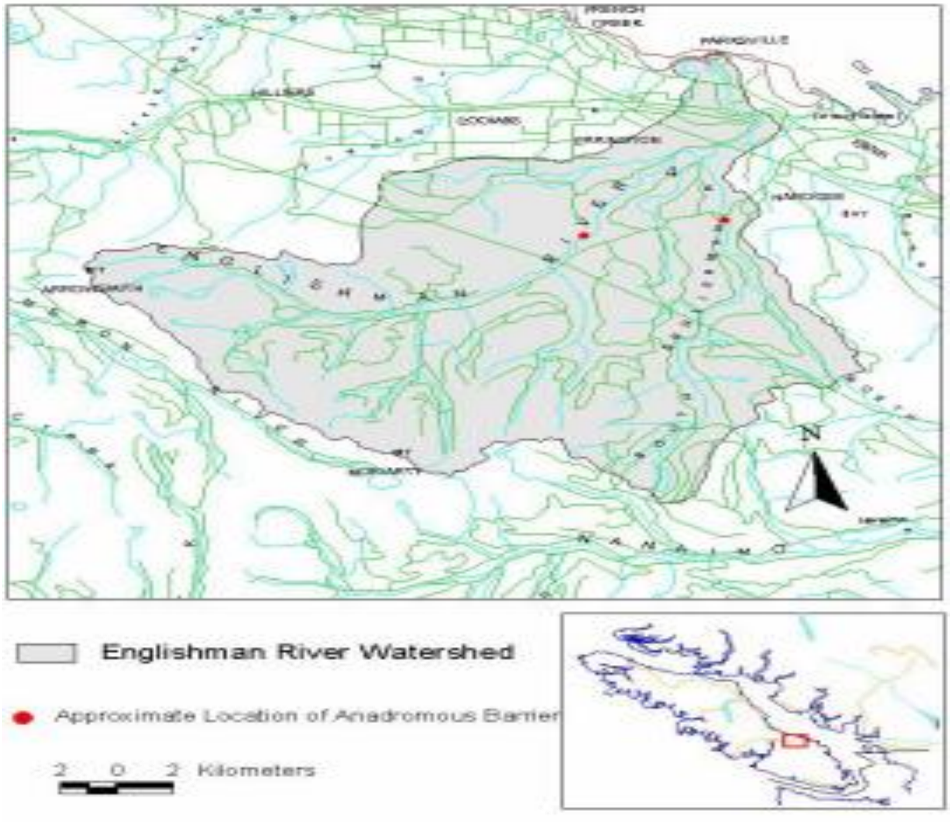

Figure 1: A map highlighting the Englishman River watershed.

1.2 Historical Overview

The habitat of the Englishman River has been heavily impacted by anthropogenic factors throughout its history. Specifically, extensive logging within the watershed has been extremely impactful. In fact, 90% of the forests surrounding the entire Englishmen River Watershed have been logged (Decker et al. 2003). The level of vegetation removal has promoted winter flooding and reduced summer waterflow rates, both dramatically affecting local fish populations, stream morphology and sediment types (David Clough, 2013). Urban development pressures have also had a significant impact on the watershed as the City of Parksville relies entirely on the WR4 for its water supply. To help control the water usage a dam was constructed at Arrowsmith Lake in 1998 (David Clough, 2013). This allowed the city to increase available drinking water and supplement water flows in the summer months for fish.

1.3 Potential Environmental Concerns

As previously mentioned, the Englishman has been under siege by anthropogenic factors since the colonization of the region. A few major factors such as logging and urban development have been the most prominent, but the addition of extensive pollution from a number of different inputs have also been concerning. After years of logging, the land's ability to retain water has diminished, as a result after heavy rain events the system has been prone to flashy flows, this increases sediment loading through the process of bank erosion. The urban development surrounding the lower portion of the river acts as a highway for water containing fine sediments and a number of pollutants such as gasoline and oil, with the addition of copious amounts of salt used to de-ice the surrounding roads. A number of these run-offs end up leading directly into the Englishman river watershed, causing immeasurable harm to the ecosystem.

2.0 Project Objectives

The project objectives for this proposal are to examine the overall aquatic health of the C.W Young side channel of the Englishmen river in Parksville, British Columbia. The data collected during this field sampling will be compiled and compared to the previous studies from 2008 to 2022. There will be 4 collection sites, 3 of which are located in the C.W Young side channel and 1 located at the outflow of the channel to the main stem of the Englishmen river. The data sets to be collected consist of hydrology, water quality, invertebrate sampling and microbiology. The water samples will be assessed at the VIU laboratory as well as sending samples away to ALS laboratory services. After the completion of testing all samples, the results will be compared and analyzed to assess the overall quality of the C.W Young side channel and the Englishman River system.

3.0 Proposed Environmental Sampling and Analytical Procedures

3.1 Proposed Sampling Program

3.1.1 Site Locations and Habitat Characteristics

The proposed sampling stations for this study are 4 of the 5 previous sites used in past studies on the Englishman river. The reasoning for utilizing the 4 sites from previous years is to be able to directly compare the conditions of each area to that of previous years in order to directly compare the quality of the stream to older samples. The C.W Young side channel is a very important salmonid rearing area in the watershed and continued monitoring at these stations can indicate any minor or major changes to this system's environment.

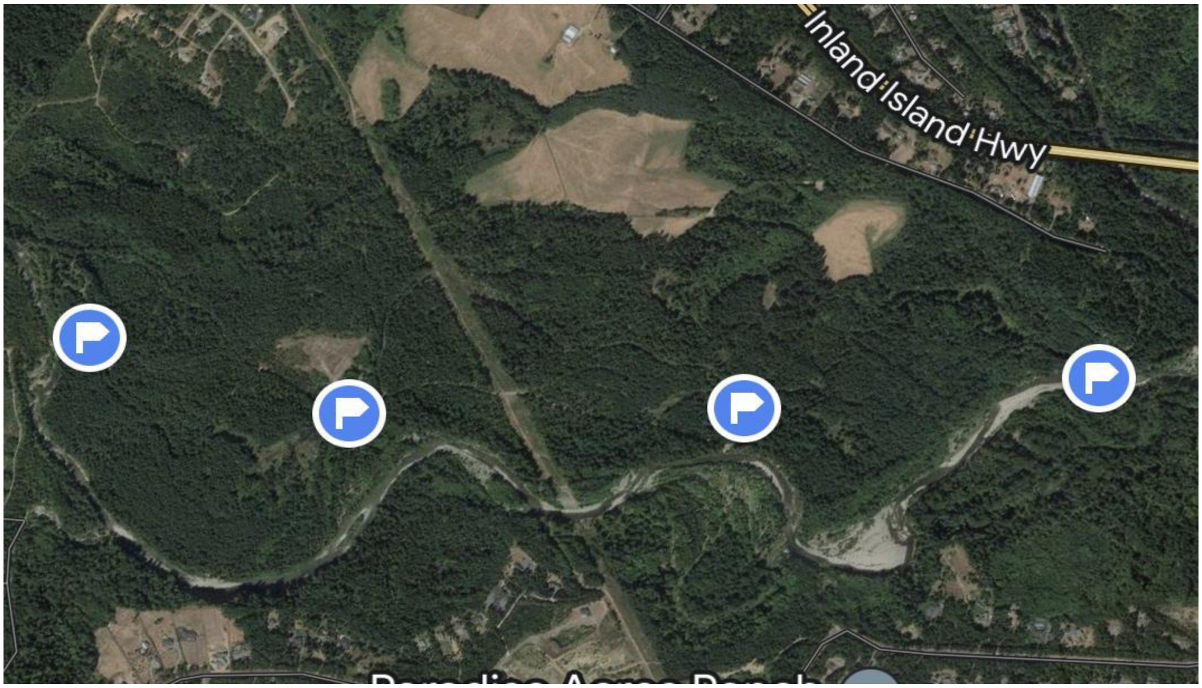

Figure 2: Sampling sites on C.W. Young side channel.

Site 1 (Figure 2) is located at the beginning of the C.W Young side channel where the outflow pipe is located. The UTM's for this sample site is 10U 0405267 mE 5459846 mN, the exact sampling location will be done roughly 1 to 1.5 meters downstream of the beginnings of the side channel. This section of stream displays fine silts, cobble as well as some boulders located in a small pool. The surrounding riparian consists of Oak (*Quercus* spp.) and Alder (*Alnus* spp.) tree species as well as dense Blackberry shrubs (*Rubus fruticosus*).

Site 2 (Figure 2) is located about 1 km downstream from site 1 (Figure 2). The UTM's for this sample site is 10U 0406143 mE 5459962 mN, the sampling will take place near the culvert at this location. The stream morphology in this section consists of cobble, gravel and boulder primarily with presents of finer silts and sands. The riparian area present is largely made up of larger coniferous trees such as cedar (*Cedrus* spp.) and fir (*Albies* spp.). The stream banks have various amounts of grasses and bushes including salal shrubs (*Gaultheria* shallon) and Oregon grape (*Mahonia aquifolium*).

Site 3 (Figure 2) is located 1.7 km downstream from site 2 (Figure 2). The UTM's for this site is 10U 0407089 mE 5460663 mN, this glide section of stream contains cobble and gravel substrate with added large woody debris. Sampling will be collected in the thalweg of the channel. Riparian area of this site is primarily shrubs, berry bushes and grasses, suggesting a highwater flooding zone, with minimal overhead canopy cover.

Site 4 (Figure 2) is located at the outflow of the C.W Young side channel. The UTM's for this site is 10U 0407805 mE 5461177 mN. In this outflow the substrate is primarily made up of a gravel, cobble mix with presence of fines in between the rocky substrate. The riparian area is made up of different grasses and shrubs with the overhead cover consisting of alders and firs.

3.1.2 Sampling Frequency

The sampling will be done twice, all four stations will have water quality samples taken once in October and again in November. This sampling will be evaluated at VIU in the labratory. The ALS sampling collection will be taken at only two sites for this study, and will be sent away for analysis. For invertebrate sampling, it will again be taken twice, once in October and again in November, these samples will also be taken at all four sites. The specimens collected will be assessed in the VIU laboratory.

Table 1: Field measurements, water quality and stream invertebrate sampling activities conducted at each site on the C.W. Young Channel. Legend is listed below to determine which date each letter represents.

Site	**Field Measurements**	**VIU - Water Analysis**	**ALS - Water Analysis**	**Stream Invertebrates**
1	B, E	A, E	**N/A**	D, F
2	B, E	A, E	A, E	D, F
3	B, E	A, E	**N/A**	C, F
4	B, E	A, E	A, E	C, F

LEGEND

A = October 24, 2023 – Water

B = October 26, 2023 – Measure

C = November 7 – Bugs

D = November 8 = Bugs

E = November 21, 2023 – Water/Measure

F = November 29, 2023 – Bugs

3.2 Basic Hydrology

The measurements being taken in this study consist of stream classification measurements. These will include the bank full width, the wetted width, the bank full depth and wetted depth of the stream at the sample sites. Once these parameters have been set, the discharge will be calculated through a series of measurements related to the stream's width and depth at the sample time. The last measurement to be taken at each site is the stream velocity, this will be done using a floating object and a stopwatch in order to assess the stream's velocity at the sample time.

3.3 Water Quality

3.3.1 Field Measurements

The water quality measurements at these sites will be taken at each sample site and will consist of all basic water quality parameters. The in field measurements to be recorded at the sites will include dissolved oxygen and temperature. The other samples to be collected will be pH, conductivity, alkalinity, and hardness. These samples will be taken back and assessed at the VIU laboratory and ALS labs.

3.3.2 Water Sample Collection

The guidelines in place for collection of samples at each site will ensure quality assurance for each of the samples to achieve the most accurate readings possible. During each sampling event, the samples will be taken from the downstream sites first, starting at site 4 (Figure 2). Starting at the furthest downstream location will prevent any possible issues of elevated turbidity in the samples from disturbance of the substrate. The procedure for collecting the sample will follow the BC Governments “Ambient Freshwater and Effluent” sampling guidelines, this will further ensure the quality and consistency of the samples. The bottles will be rinsed and sampled in the water column, with labeling and storage in a cooler to follow the sampling.

3.3.3 VIU Laboratory Analysis

Water samples will be collected and taken to the VIU lab where pH, total hardness (mg/L $CaCO_3$), total alkalinity (mg/L $CaCO_3$), turbidity (mg/L), conductivity (μS/cm), nitrate (mg/L $N0_3^-$), and reactive phosphorus (mg/L PO_4^{3-}) would all be measured and recorded for further action.

3.3.4 ALS Laboratory Analysis

For both sampling days that occurred, two of the sites will each have a water sample taken where the containers will be quickly brought back to the VIU lab to be prepped for shipping. ALS laboratories in Vancouver, BC will be sent the samples in a preserved Styrofoam box with ice within. The staff at ALS will analyze the samples for conductivity, hardness, pH, anions, nutrients, and total metal values which will be returned back to us to be compiled.

3.3.5 Quality Assurance/Quality Control

Samples will be taken at each site once per day of sampling. Two total samples from each site will return back to the lab at VIU. These samples will be taken from the same location each day, and the same location on the C.W. Young Channel that has been sampled since 2008. to ensure consistency and accuracy. Proper techniques will be followed for sampling; personal samples (for VIU lab) will be rinsed and filled without disturbance and the ALS samples will be filled immediately as they bottles are delivered to the school sterile.

3.3.6 Data Analyses, Comparison to Guidelines

All samples that were taken will be analyzed either by the project students at VIU or by the employees at ALS laboratories. The data will be compiled into tables to compare with the guidelines for freshwater aquatic organisms to support the results found.

3.4 Stream Invertebrate Communities

3.4.1 Invertebrate Sample Collection

Evan and Zac obtained two samples from four sites on the C.W Young Channel on three occasions. The first set of samples were collected on November 8-9th and the second set of samples were collected on the 29th of November. To obtain the sample, we used a Hess Sampler. The sampler covers an area of $0.09m^2$, each of our samples consists of 4 subsamples, therefore obtaining a total sample area of $0.36\ m^2$ at each site. The sub-samples allow us to cover more surface area, targeting different habitats to provide a better overall site population estimation.

The Hess sampler performs optimally in shallow riffles, runs and gravelly substrates. When sampling, we ensured each site met the sampler’s optimal performance requirements. Once inserted in the stream Evan or Zac would agitate the sediment with our hands to suspend any invertebrates present in the sampler. Ideally the invertebrates are then washed down the mesh corridor which leads to the capsule at the end, which would be removed and emptied into a shorting dish. It’s imperative to minimize the volume of substrate and detritus in the sample capsule. The buildup of sediment and detritus will affect your ability to separate the insects from the dense substrates, which will slow down the sampling process and ultimately acquire less vertebrates. Once the contents are emptied into the shorting dish, either Zac or Evan would then remove as much detritus as possible while limiting the number of invertebrates discarded. When most of the substrate is removed the insects can now be collected using graduated pipettes. Finally, a swirling technique was used to suspend the remaining detritus and living organisms, further separating them from the remaining heavy substrate. The invertebrates would be transferred to 2 properly labeled sample cups. The sampling cups contained 70% ethanol and 30% river water to limit decomposition.

3.4.2 VIU Laboratory Analyses

The samples collected in the field were kept refrigerated until the sampling days. The sampling cups were brought to be analyzed at the Vancouver Island University Laboratory. In the lab, Evan, Tim and Zac would meticulously sort through each cup by emptying their contents either directly into a deep shorting container or into a small dish that would be placed directly under the microscope. Each method varied by the sample's overall density or quality of detritus and substrates. The samples with higher detritus and organism volumes were dumped into sorting trails and picked through with a pipette, while the less dense samples with low quantities of detritus were dumped directly into a small clear dish that was then immediately analyzed under the dissection microscope. Zac created a spread sheet using Microsoft Excel organizing each sample, site, and species of organism observed and counted. Every invertebrate was added to the document allowing an easy transition to the provided Invertebrate Survey Sheet for further calculations.

3.4.3 Quality Assurance/Quality Control

Quality assurance was guaranteed during our study as we had two separate sampling days in the field. Water quality was conducted at two sites once and the other two sites were sampled twice. Macroinvertebrates were sampled three times at each site for reassurance. Quality control was made-do by following the safe, secure, and sterile procedures when proceeding with any of our sampling or lab work so that accuracy was a priority.

3.4.4 Data Analyses

The pollution tolerance index, EPT (Ephemeroptera, Plecoptera, Trichotera) index, EPT total ration and predominant taxon ratio was calculated using the Invertebrate Survey Field Data Sheet by Zachary Ohlman for each site sampled. Each taxon and species collected was inserted into the data sheet where the totals were sorted and tallied within 3 categories of invertebrates. A three being pollution tolerant, two being somewhat pollution tolerant and category one being intolerant to pollution. Zac also calculated the Shannon-Weiner Index using an online calculator.

4.0 Health and Safety Plan

Safety measures will be implemented and followed during the duration of the study's fieldwork portion. The main necessity is communication as anything can happen when working in unfamiliar locations. Instructor Phillip Morrison will be contacted prior to leaving for the site and once again when returning back home from the site. All three members working on the project will be always in contact with each other by phone at the least but more times than not, working as a group of three. Proper footwear and clothing will ensure students working are in their best interest to prevent the risk of an incident. Risks to be aware of are laid out below (Table 2).

Table 2: Site safety concerns of selected sample sites at the Englishman River during the site assessments (October 7, 2023).

Site #	**1**	**2**	**3**	**4**
Accessibility	Road	Road	Road & Short Trail/Bushwhack Walk	Road & Short Trail Walk
Hazards	Traffic Dogs Brambles	Traffic Dogs Snags	Traffic Fallen Trees Ankle Breakers	Traffic Dogs Brambles
Embankment	Steep & Eroded	Gradual Gravel Slope	Gradual	Large Rocks
Depth	Slightly Deep	Slightly Deep	Shallow	Shallow
Flow Rate	Slightly Fast	Low	Low	Slightly Fast

5.0 Results and Discussion

5.1 General Field Conditions

5.1.1 Stream Measurements & Hydrology

The stream measurements were taken at all four sampling sites for two separate sampling days. Measurements that were taken included: wetted width (m), bank full width (m), bank full depth (m), maximum depth (m), mean depth (m), residual depth (m), stream gradient (%), canopy coverage (%), velocity (m/s), and discharge was calculated afterwards. Tables 3 & 4 below show the comparison of the two different sampling events and how they compare.

Table 3: Stream measurements & hydrology - first sample event (October 26, 2023).

Site	**Wetted Width (m)**	**Bankfull Width (m))**	**Mean Wetted Depth (m)**	**Average Velocity (m/s)**	**Discharge (m^3/s)**	**Canopy Coverage (%)**
1	2.90	5.28	0.27	0.35	0.27	20
2	3.86	4.56	0.34	0.41	0.54	85
3	7.86	10.19	0.27	0.32	0.68	50
4	3.12	5.08	0.29	0.82	0.74	35

Table 4: Stream measurements & hydrology - second sample event (November 23, 2023).

Site	Wetted Width (m)	Bankfull Width (m))	Mean Wetted Depth (m)	Average Velocity (m/s)	Discharge (m^3/s)	Canopy Coverage (%)
1	3.27	5.28	0.37	0.29	0.35	5
2	3.97	4.56	0.33	0.43	0.56	85
3	6.22	10.19	0.23	0.26	0.37	40
4	3.50	5.08	0.21	0.78	0.57	30

With intermittent ponds throughout the C.W. Young Side Channel, water is able to move fairly quickly and hold in these areas. This is viewable by our wetted width results, which both sampling days were affected by recent rainfall but shows how quickly after we reached the channel from those heavy rain days. Wetted depth is the other factor that would fluctuate with these rains as our average measurements in the table varied 10cm in site 1. Working around salmon redds is also a reason that this could change measurements as we don't want to disrupt the gravel in which eggs are being laid. Now, even with rainfall events occurring before our sample days, the velocity and discharge was not affected too much because the side channel is a controlled system. There is a valve at the inflow of the channel that can be adjusted to provide optimal water from the Englishman River into the C.W. Young side channel so that organisms can continue to thrive in the stream. The main reason we found for why site 3 and 4 had a slight decrease in water flow was due to beaver activity between sampling sessions. There was an active dam noticeable on the first sampling day but water was still flowing transparently, but during the second sampling day, the ponds on the lower section were almost flooding and the water was much slower and lower.

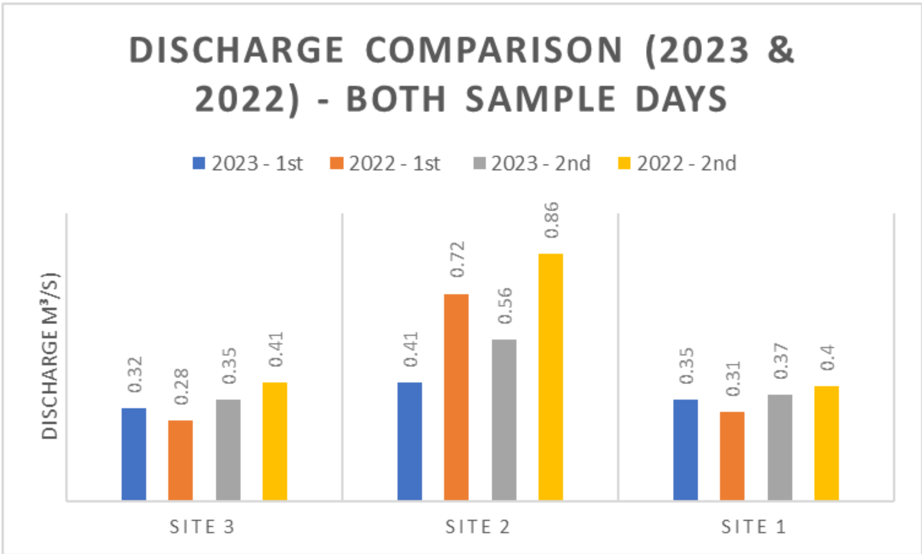

Figure 3: Comparison between discharges in 2023 & 2022 for three of the four sites. Site four was left out due to skewed data.

We used a comparison chart for three of the four sites between this current years survey (2023) and the previous years (2022) to show how little fluctuation there is in this controlled system. Having intermittent ponds helps keeps flows very consistent throughout the stream, as well as the previously mentioned valve at the inflow. However, the spike we see in site 2 (2022) was due to having a completely open valve at the inflow due to the droughts we were facing that year. This was necessary to keep that stream flowing so that survival and regeneration could continue to occur.

5.2 Water Quality

5.2.1 YSI Measurements

Table 5: YSI probe measurements - 1st sample (October 26, 2023).

Site	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)
1	5.16	12.89	77
2	5.19	12.61	79
3	5.16	11.60	80
4	5.26	12.38	96

Table 6: YSI probe measurements - 2nd sample (November 23, 2023).

Site	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)
1	4.80	14.20	17.8
2	4.71	13.38	22.3
3	4.63	13.47	18.1
4	4.94	13.78	43.4

The data shown from two different sampling days shows quite a large variance, especially in the conductivity. Temperatures were ultimately colder the second sample as expected with only a variance of 0.63° at the most, where as dissolved oxygen levels partnered well with this trend showing that colder water does hold more dissolved oxygen than warmer water. The skewed results were the conductivity readings found on the second sample which is believed to be an error in the YSI probe itself. The samples were done with two different probes which unfortunately resulted in non-uniform results. In the year-year comparison chart, just the first sample event was used for this reason (Figure 4).

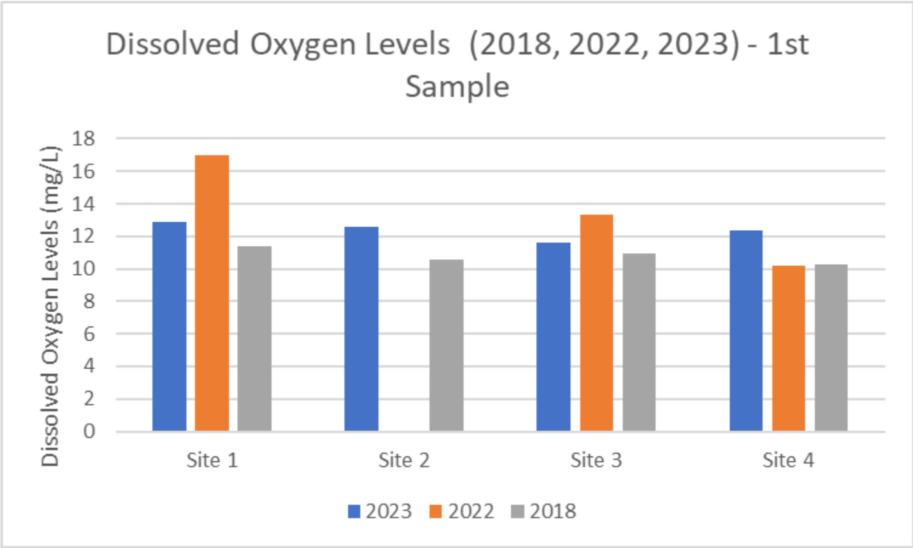

Figure 4: Comparison of dissolved oxygen levels (mg/L) from 2018, 2022 & 2023 for just the first sample event of all four sites.

The dissolved oxygen levels (mg/l) were quite stable in all sites in 2018 and 2023 ranging between 10.30 – 11.40 & 11.60 – 12.89 respectively. In 2022, there was quite a large variation between sites which made us think there was a possibility of non-calibrated equipment as 17.00mg/l is heavily concentrated. Oxygen levels on average were higher at sites 1 and 3 due to the flow coming through the valve at site 1 and the culvert with a higher velocity at site 3. Site 2 for 2022 was forgotten and did not have a result for either sampling efforts.

5.3.1 VIU Laboratory Analyses

5.3.1.1 pH and Alkalinity

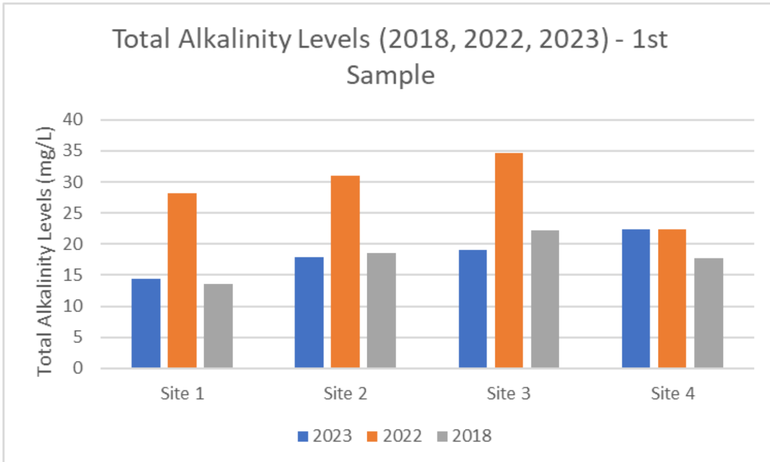

Figure 5: Total alkalinity levels comparison between 2018, 2022 & 2023 - 1st sample event.

Table 7: pH levels comparison between 2018, 2022 & 2023 - 1st sample event.

pH Levels (2018, 2022, 2023) – 1st Sample

Site #	2023	2022	2018
Site 1	7.1	7.9	7.5
Site 2	7.3	7.5	7.3
Site 3	7.4	8	7.2
Site 4	7.3	N/A	7.1

Alkalinity is the measure of the water's ability to neutralize acids. It was measured by taking a water sample and titrating it with sulfuric acid. Different densities of the acid were available, however, due to the expense of the resource and the amount we were needing for our first sample, we did not include our second sample results in a comparison graph as they may not be the most accurate or the same procedure as what other groups had previously done.

We saw a large drop in alkalinity from the previously done report (2022) with ranges from 12 – 18 mg/L this year rather than 22.3 – 35.2 mg/L in 2022. In comparison to our alkalinity ranges collected this year (2023), our pH shows an overall decrease which aids in the idea that our samples came out more acidic but still approaching the neutral point. A note to make is that for site 1, there was a very large change in pH over the last year. 7.9 -> 7.1 is a large drop over a short period of time especially when all sites were consistently lower this year. All values do fit within the range 6.5-9.0 provided by the British Columbia Approved Water Quality Guidelines, however should be a key aspect to closely monitor in future monitoring events (Canadian Council of Ministers of the Environment, 2004).

5.3.1.2 Turbidity & Conductivity

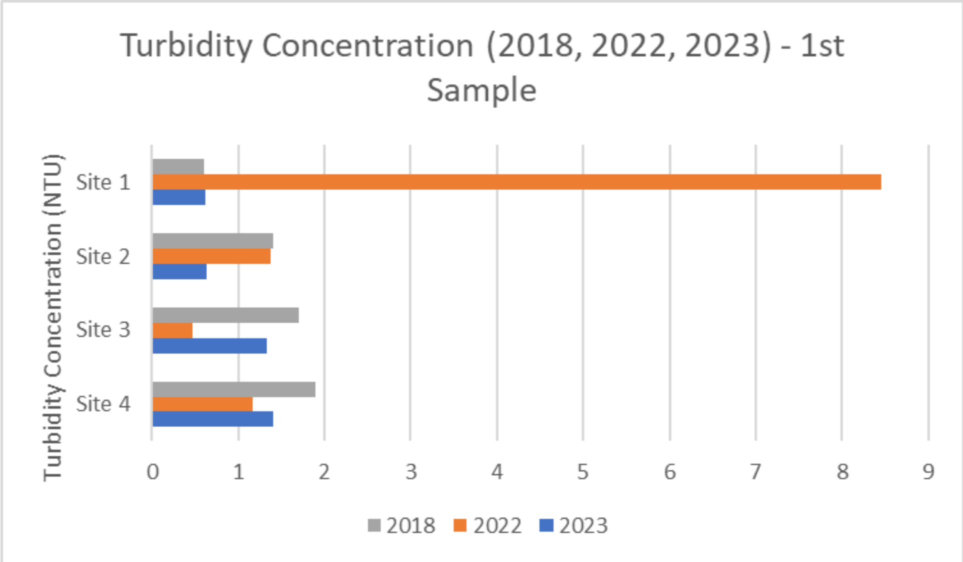

Figure 6:Turbidity concentration comparison between 2018, 2022 & 2023 - 1st sample.

Even though there is no direct relationship between conductivity and turbidity, in some cases the increase of turbidity can also increase the concentration of ions suspended in the water, therefore increasing the conductivity as well. For 2018 and 2023, results followed an expected minor increase as you went downstream. Samples were taken from site 4 (furthest downstream) first then up to site 1 (furthest upstream) to avoid any mis-readings from previously walking in the stream. There is an obvious outlier in this graph with site 1 (2022) which is unknown as the sites substrate is more of a thick quicksand with cobbles rather than fines like other sites. Sites 3 and 4 have more finer substrates which likely was more suspended than in other areas causing a higher turbidity.

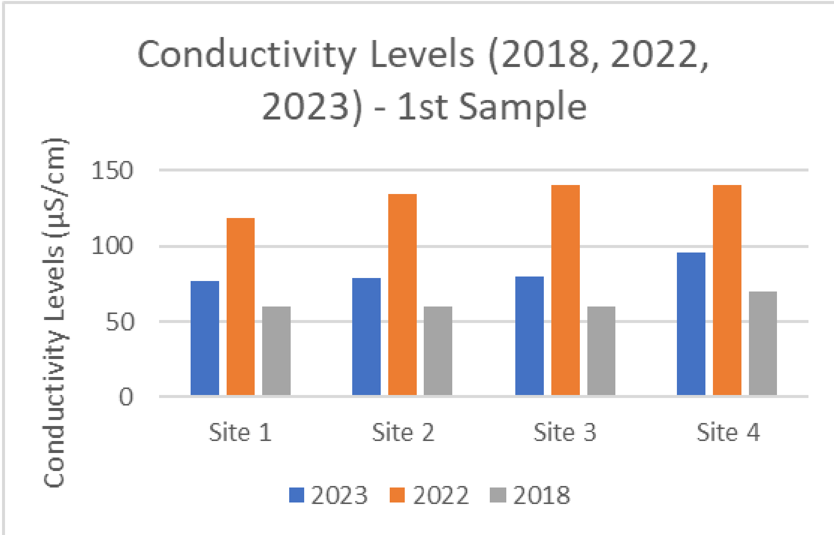

Figure 7:Turbidity concentration comparison between 2018, 2022 & 2023 - 1st sample.

Conductivity levels (µS/cm) were consistent among all sites during the years the data was collected. 2022 showed highly elevated conductivity compared to the other two years presented on the graph. Conductivity, being the relative amount of electricity that can be conducted by water, fluctuates based on the concentration of ions in the water. For this particular stream being quite silty and in an area that receives lots of precipitation throughout the year, conductivity levels will vary based on the time you convey your study with respect to rainfall. The 2022 report does state that there sample was done right after a large amount of rainfall, which would have a large impact on sediment input with it overall being such a dry year. 2023 and 2018 were sampled in similar environmental conditions (more consistent rain), which is why we are seeing a much lower level of conductivity for both years as it wasn't a sudden bloom of precipitation.

5.3.1.3 Nitrates and Phosphates

Nitrates (NO_3^-) are the main source of Nitrogen utilized by aquatic plant life. However, reaching certain concentrations can become very toxic to aquatic organisms. This threshold is 0.3mg/L (BC Approved Water Quality Guidelines, 2023). For our sites it was not varied enough to represent in a graph however the table below shows the values obtained from all four sites on each sample day (Table 8).

Table 8:VIU water quality analysis - Nitrate concentration comparison between all four sites on both sampling events.

Nitrate (NO_3^-) Concentration (mg/L)

Site #	Sample 1 (Oct 31, 2023)	Sample 2 (Nov 28, 2023)
1	0.02	0.02
2	0.02	0.04
3	0.03	0.02
4	0.05	0.03

All our measurements for Nitrate were taken at the VIU laboratory using the equipment provided. The results shown in the table above (Table 8) may not be as precise as the results provided by the ALS samples which will be shown later in this report. The results for our nitrate concentrations, however, all were well below the 0.3mg/L tolerance which suggests that there are no anthropogenic inputs impacting this stream in any harmful way.

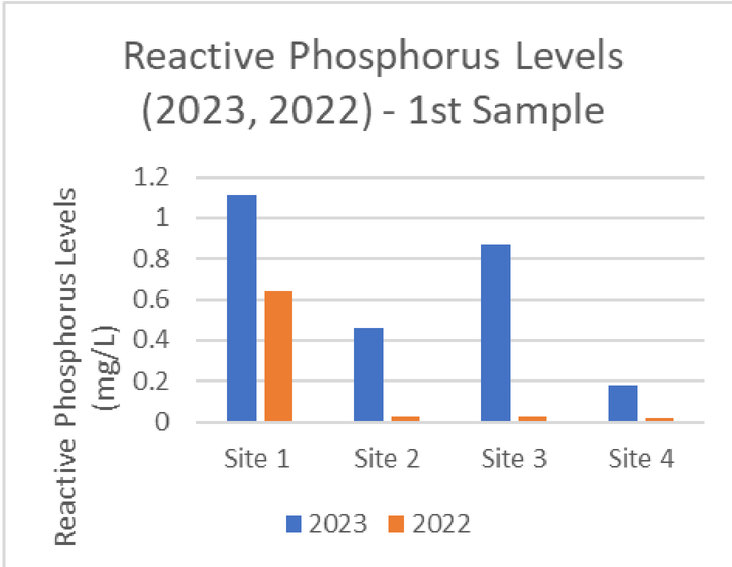

Figure 8: Reactive phosphorus levels comparison between 2022 & 2023 - 1st sample.

Phosphate (PO_4^{3-}) is the main source of phosphorus found in aquatic environments and is also a key nutrient for aquatic plant life. Excessive concentrations of phosphate just like nitrates can lead to very toxic environments, in this case…eutrophication. There is a general basis guideline for determining the trophic status of a body of water when it comes to phosphorus concentration: <0.004 mg/L = ultra-oligotrophic, 0.004-0.01 mg/L = oligotrophic, 0.01-0.02 mg/L = mesotrophic, 0.02-0.035 mg/L = meso-eutrophic, 0.035-0.1 mg/L = eutrophic, > 0.1 = hyper-eutrophic (Canadian Council of Ministers of the Environment, 2004). Looking at the graph above we had much higher phosphorus levels on all sites this year (2023) in comparison to 2022. Reaching as high as 1.11mg/L at site 1. Due to the spike in the results, they were measured twice using the HACH kits provided by VIU and results were identical on all four sites the second time so we are confident with the accuracy. It is presumed that due to this year having active rainfall and a healthy return of salmon, the decomposition of salmon in and along the river have released an abundance of nutrients such as phosphorus (Bird et al., 2020).

The results that we obtained on all four sites have exceeded the ranges previously described. In this case it means that the C.W. Young Side Channel can be classified as hyper-eutrophic and a highly productive system. Now because the water is flowing, full of oxygen and not very dense with aquatic plants, the system is not overly affected by it being hyper-eutrophic.

5.4.1 ALS Laboratory Analyses

5.4.1.1 General Water Quality

The ALS laboratories in Vancouver British Columbia was utilized for data on the stream survey. The samples were collected in specialty bottles from the lab to aid in the individual tests being done at the lab. For the CW Young side channel, we selected site's 2 and 4 for the sampling locations. These were chosen as site 2 will give an accurate representation of the water quality in the middle of the side channel. Site 4 was chosen to represent the outflow of the channel; these different sites can show how the water quality is throughout the channel and indicate if there are any anomalies originating from the channel itself.

Table 9: ALS results (October 24, 2023).

ALS Sample #1	Site 2	Site 4
pH (pH Units)	7.14	7.13
Hardness (Mg/L)	24.1	28
Conductivity (µS/cm)	67.7	77.5
Phosphorus (Mg/L)	0.0084	0.0116

Table 10: ALS results (November 21, 2023).

ALS Sample #2	Site 2	Site 4
pH (pH Units)	7.24	7.36
Hardness (Mg/L)	22.2	28
Conductivity (µS/cm)	63.3	75.3
Phosphorus (Mg/L)	0.0066	0.0094

The values from the tables above show the readings from both sites 2 and 4. The First samples were taken on Oct. 24th of 2023 (Table 9). The samples indicate a stable water system, having consistent values as the water moves through the system. The slightly elevated hardness and conductivity is likely caused by increased movement of fine sediment and minerals as the water flows down into site 4. The Phosphorus levels are low, but they maintain the same trend as the other values, increasing at the outflow of the channel. This is likely due to the flushing of nutrients from the banks, and the decay of the salmon in the channel.

The second sample to ALS was taken on Nov. 21st of 2023 (Table 10). The results of the overall water quality are very similar to the first sample in October. In the second sample there is a minor increase in the pH of both the sample sites. The two sampling results indicate a system that is consistent and can regulate the nutrients that are being added.

5.4.1.2 Anions and Nutrients

Table 11: ALS results - Anions and Nutrients (1st sample).

Anions and Nutrients #1		Site 2	Site 4
Ammonia, total (as N)	mg/L	0.0297	0.0279
Nitrate (as N)	mg/L	0.0616	0.103
Nitrite (as N)	mg/L	0.0019	0.0038
Nitrogen, total	mg/L	0.164	0.225
Phosphate, ortho-, dissolved (as P)	mg/L	0.0012	0.0016
Phosphorus, total	mg/L	0.0084	0.0116

The lab also assessed the nutrient levels in the water (Table 11), these are important indicators to show the waters nutrient levels, and biproduct levels from heightened input of nutrients. During these samples on Oct.24th, there was a rain event possibly affecting the results. The ammonia and phosphate levels in the channel remain consistent throughout, however, the other values do show increases further down the system at site 4. The increase in Nitrate is likely due to the increased presence of ground or rainwater, as this water mixes with the stream it will inject oxygen and convert these values to nitrites. The increase in total phosphorus is likely due to the flushing and decomposition of salmon in the system. This could be a value that increases every fall as the salmon return and breakdown in the side channel. The increase of nitrogen is likely due to the input of chemicals and nutrients from the stream banks, this can be detected better further downstream as more nutrients are added to the stream.

Table 12: ALS results - Anions and Nutrients (2nd sample).

Anions and Nutrients #2		Site 2	Site 4
Ammonia, total (as N)	mg/L	0.0154	0.0128
Nitrate (as N)	mg/L	0.0483	0.105
Nitrite (as N)	mg/L	<0.0010	<0.0010
Nitrogen, total	mg/L	0.140	0.212
Phosphate, ortho-, dissolved (as P)	mg/L	<0.0010	<0.0010
Phosphorus, total	mg/L	0.0066	0.0094

The second sample taken on Nov 21st indicate a drop in levels of all anions and nutrients, (Table 12). The overall drop in these values could be due to the decrease in fish presences, as the salmon die off and finish their annua cycle, their nutrients work its way through the water shed. This later stage in the cycle could cause drops in some of these values such and ammonia and phosphorus. The other values could be lower as these samples were not taken during a rain event. The absence of the water flushing nutrients from the banks could account for the lower presence of these nutrients.

5.4.1.3 Total Metals

The measurements of the metals in the system were taken by ALS labs. Using specialized preservation agents and bottles allows for the transport of the samples to assess the metal values of the CW Young channel. These are important parameters to measure in a stream as the amounts of metals can indicate systems affected by exterior causes. The CW Young channel being a part of the Englishmen watershed, means there could be metals being flushed from the landscape from the logging done in the watershed. Sample number one (Table 13), show that all the readings are within the BC guidelines for aquatic life. The levels of aluminum are approaching the maximum threshold via the BC guidelines. While this value has not breached the guideline, it is very close, this could be a possible issue if the aluminum amounts were to increase. High levels of aluminum can cause issues primarily to fish species such as trout and salmon. The affect that aluminum has is on the organism's ability to regulate ions, this could cause issues for osmoregulation causing the fish to have possible respiratory issues and ion imbalance. However, all the results do fall withing guidelines for sample one.

Table 13: ALS results - total metal concentrations (both samples).

Tests	***Sample # 1***		***Sample # 2***	
Total Metals	**Site 2**	**Site 4**	**Site 2**	**Site 4**
Aluminum (Mg/L)	0.0845	0.0834	0.100	0.0997
Antimony (Mg/L)	<0.00010	<0.00010	<0.00010	<0.00010
Arsenic (Mg/L)	0.00020	0.00026	0.00020	0.00023
Barium (Mg/L)	0.00572	0.00545	0.00526	0.00504
Beryllium (Mg/L)	<0.000020	<0.000020	<0.000020	<0.000020
Bismuth (Mg/L)	<0.000050	<0.000050	<0.000050	<0.000050
Boron (Mg/L)	<0.010	0.012	<0.010	<0.010
Cadmium (Mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Mg/L)	8.17	8.62	7.36	8.46
Cesium (Mg/L)	<0.000010	<0.000010	<0.000010	<0.000010
Chromium (Mg/L)	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Mg/L)	<0.00010	<0.00010	<0.00010	<0.00010
Copper (Mg/L)	0.00088	0.00086	0.00092	0.00090
Iron (Mg/L)	0.190	0.229	0.193	0.226
Lead (Mg/L)	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Mg/L)	0.0022	0.0019	0.0021	0.0019
Magnesium (Mg/L)	0.900	1.57	0.918	1.66
Manganese (Mg/L)	0.00822	0.00808	0.00742	0.00713
Molybdenum (Mg/L)	0.000077	0.000089	0.000083	0.000091
Nickel (Mg/L)	<0.00050	<0.00050	<0.00050	<0.00050
Phosphorus (Mg/L)	<0.050	<0.050	<0.050	<0.050
Potassium (Mg/L)	0.161	0.206	0.164	0.216
Rubidium (Mg/L)	0.00022	0.00023	<0.00020	<0.00020
Selenium (Mg/L)	<0.000050	0.000055	<0.000050	0.000051
Silicon (Mg/L)	2.87	3.25	3.15	3.63
Silver (Mg/L)	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Mg/L)	3.55	3.64	3.47	3.60
Strontium (Mg/L)	0.0341	0.0366	0.0321	0.0344
Sulfur (Mg/L)	0.55	0.67	0.50	0.52
Tellurium (Mg/L)	<0.00020	<0.00020	<0.00020	<0.00020
Thallium (Mg/L)	<0.000010	<0.000010	<0.000010	<0.000010
Thorium (Mg/L)	<0.00010	<0.00010	<0.00010	<0.00010
Tin (Mg/L)	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Mg/L)	0.00312	0.00355	0.00420	0.00489
Tungsten (Mg/L)	<0.00010	<0.00010	<0.00010	<0.00010
Uranium (Mg/L)	0.000012	0.000027	0.000014	0.000026
Vanadium (Mg/L)	0.00066	0.00089	0.00075	0.00097
Zinc (Mg/L)	<0.0030	<0.0030	<0.0030	<0.0030
Zirconium (Mg/L)	<0.00020	<0.00020	<0.00020	<0.00020

Sample number two (Table 13), maintains consistent values among most of the metals tested for, once again there is higher levels of aluminum. Similar to the first sample, this sample shows the levels at the threshold of the BC guidelines. At site 2, the threshold was hit measuring 0.100 Mg/L. This is of concern for the system, having a metal reaching the maximum value could have serious implications to the aquatic life in the system.

The ALS samples demonstrated a system that shows consistent values with samples being done under different weather conditions. The ability to show similar results in the rain as well as dry weather shows a healthy system able to regulate the nutrients. The aluminum being at the maximum end of the guidelines is of concern, and further analysis and sampling should be done to monitor these levels in the future.

5.3 Stream Invertebrates

When Evan and Zac first sampled on November 7-8th the channel was relatively high forcing us to sample less optimal locations. For example, areas of the stream that would typically be extremely shallow or dried up. When we attempted to sample the mainstem we found the velocity was too high, as a result, when we agitated the sediment the fine materials were quickly swept downstream into the collection capsule. We were therefore forced to sample the outskirts of the system, this increased our total number of taxa, but decreased our overall number of macroinvertebrates. When we sampled the channel for the second time on November 30th the system was much lower. The lower water eliminated a number of areas we were forced to sample on the first trip. We therefore did a lot more mainstream sampling which resulted in fewer taxa, but increased the number of invertebrates collected. This is displayed after calculating Shannon index formula. There's a clear decrease in species diversity on the second sample day (Table 14).

Table 14: Assessment rating of each site for each sample.

Site	Sample 1 Rating	Sample 2 Rating
Site 1	Acceptable (2.75)	Marginal/Acceptable (2.5)
Site 2	Marginal/Acceptable (2.5)	Marginal (1.75)
Site 3	Marginal (1.75)	Marginal (1.75)
Site 4	Marginal (2.25)	Poor/Marginal (1.5)
Overall Stream Rating: Marginal (2)		

Table 15: Shannon-Weiner Index of each site.

Site	Sample 1	Sample 2
1	1.58	1.44
2	1.52	0.93
3	1.15	0.81
4	1.3	0.71
Average Index: 1.18		

When we look closely at each site's biodiversity and total population during both sampling sessions, we can clearly see how the midge population consistently dwarfs all other species totals (Table 16). It also displays the increase in abundance during the second sampling session with the exception of site 1 which has the opposite result (Figure 9). We collected nearly double the amount of midge larvae in the first sampling session than the second. This could possibly be a result of a hatch occurring, there were notably more insects flying around when we first sampled site 1, the flying insects consisted of midges and stoneflies. When analyzing the first sample in lab the midge larvae were significantly larger and further along the developmental stages than any other site. In fact, it was the only sample noted having midges that were in the process of emergence.

Table 16. Total abundance of each species after each sampling session per site. Green indicates pollution intolerant species, blue is somewhat pollution tolerant and red are pollution tolerant.

Site 1				
Category	**Species**	**Abbriviation**	**Sample 1**	**Sample 2**
1	Stonefly Nymph (ETP)	SN	16	8
	Caddisfly Larvae (ETP)	CL	12	8
	Mayfly Larvae (ETP)	MFL	27	30
	Dobson Fly	DF	0	3
2	Amphipod	AMP	3	1
	Cranefly Larvae	CF	1	1
3	Midge Larvae	ML	88	46
	Pouch Snail	PS	2	0
	Nematod	NEM	9	4
	Earth Worm	EW	5	0
	Black Fly Larvae	BFL	1	0
	Horse Fly	HF	2	0
	Horse Hair Worm	HHW	1	0
Site 2				
Category	**Species**	**Abbriviation**	**Sample 1**	**Sample 2**
1	Stonefly Nymph (ETP)	SN	3	7
	Caddisfly Larvae (ETP)	CL	9	2
	Mayfly Larvae (ETP)	MFL	62	31
2	Amphipod	AMP	16	86
	Cranefly Larvae	CNL	1	0
3	Midge Larvae	ML	107	237
	Rat Tailed Maggot	RTM	7	0
	Nematod	NEM	9	0
	Earth Worm	EW	5	0
	Blackfly Larvae	BFL	1	0
	Horsefly Larvae	HF	2	0
	Horse Hair Worm	HHW	1	0
Site 3				
Category	**Species**	**Abbriviation**	**Sample 1**	**Sample 2**
1	Stonefly Nymph (ETP)	SN	2	1
	Caddisfly Larvae (ETP)	CL	1	2
	Mayfly Larvae (ETP)	MFL	6	22
2	Amphipod	AMP	22	29
3	Midge Larvae	ML	67	163
	Nematod	NEM	1	0
	Earth Worm	EW	2	0
	Pouch Snail	PS	0	1
Site 4				
Category	**Species**	**Abbriviation**	**Sample 1**	**Sample 2**
1	Stonefly Nymph (ETP)	SN	0	2
	Caddisfly Larvae (ETP)	CL	6	0
	Mayfly Larvae (ETP)	MFL	12	22
2	Amphipod	AMP	8	5
	Cranefly Larvae	CNL	6	0
3	Midge Larvae	ML	59	139
	Nematod	NEM	3	2
	Earth Worm	EW	2	0
	Blackfly Larvae	BL	0	3

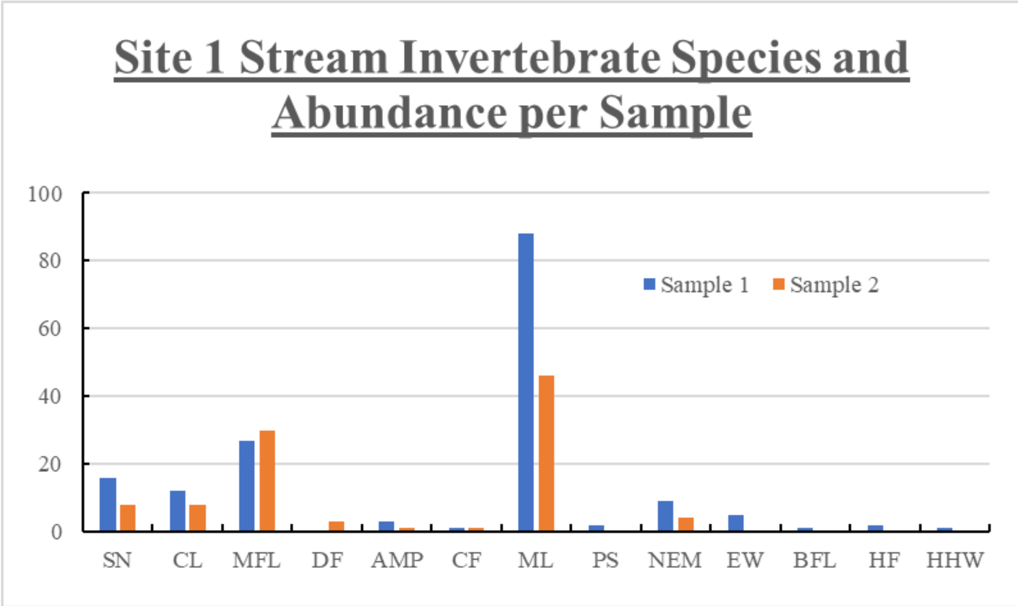

Figure 9: Site 1 species and population abundance across both sampling sessions (Refer to Table 16 for abbreviations).

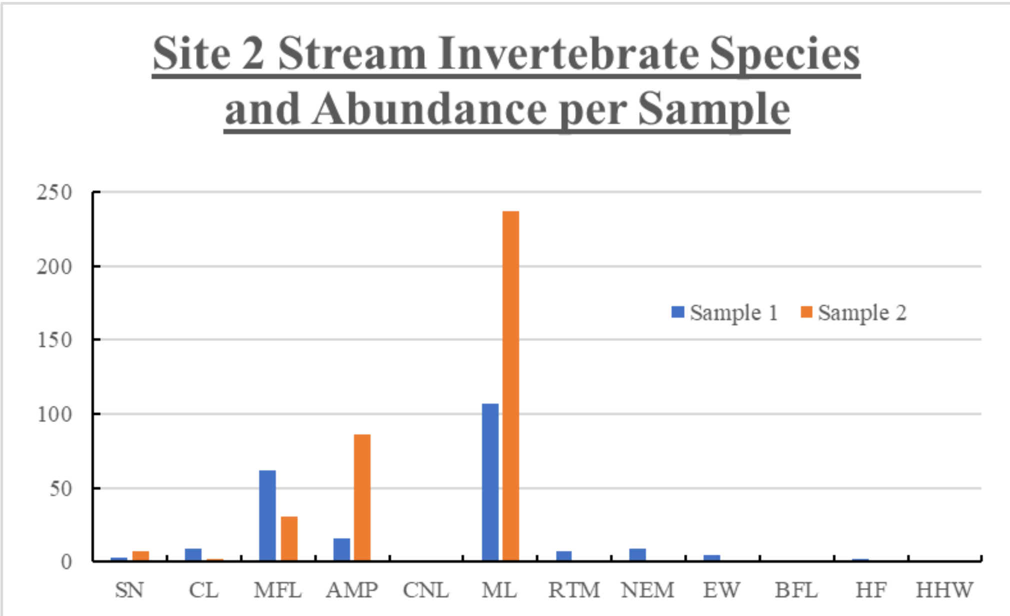

Figure 10: Site 2 species and population abundance across both sampling sessions (Refer to Table 16 for abbreviations).

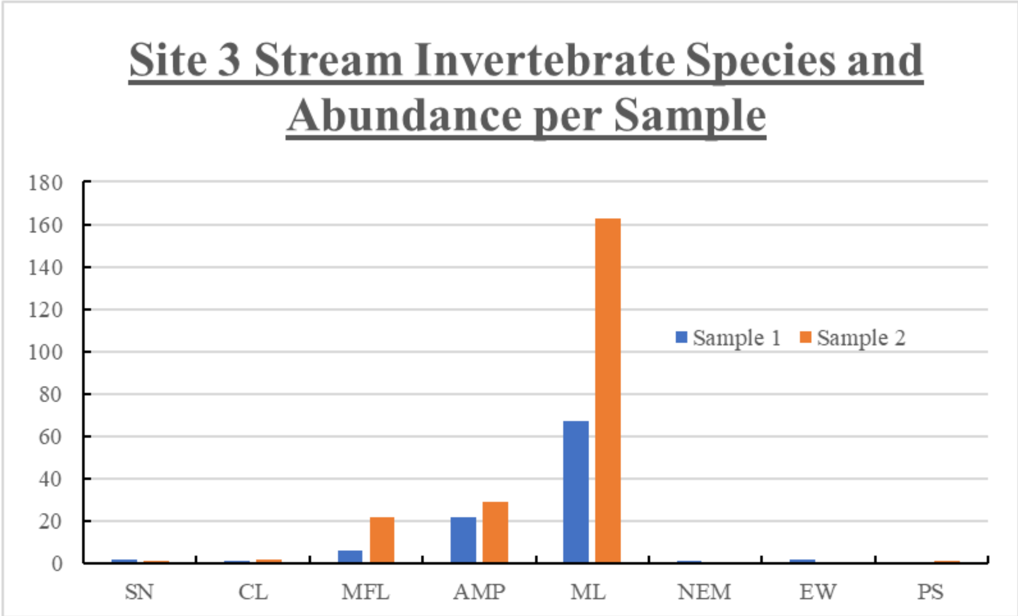

Figure 11: Site 3 species and population abundance across both sampling sessions (Refer to Table 16 for abbreviations).

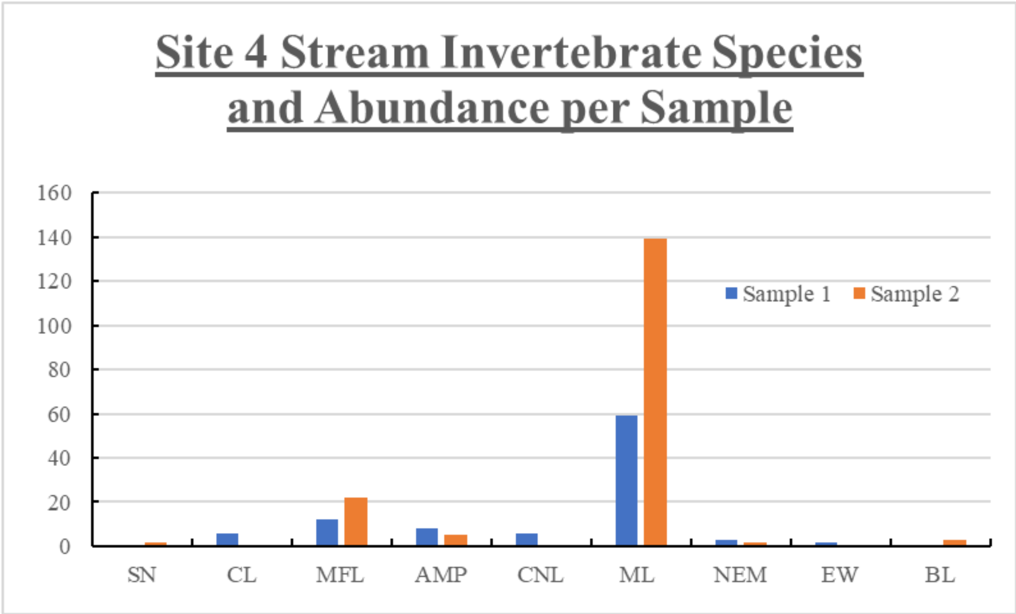

Figure 12: Site 4 species and population abundance across both sampling sessions (Refer to Table 16 for abbreviations).

As result, we were able to collect a total of 1442 insects across four sites, each site being sampled twice. Within this population we were able to identify 12 different taxa. The most dominant species we found was midge larvae (Figure 13). This taxon made up 63% of the total number of invertebrates counted, the second most abundant was mayfly larvae making up 14% of the total number sampled and third was scud closely following up mayflies at 12% (Figure 13). Although midge larvae were the most abundant at each site, the predominant species are the other sites varied significantly. This is not surprising as each site has a notably different instream habitat and stream morphology.

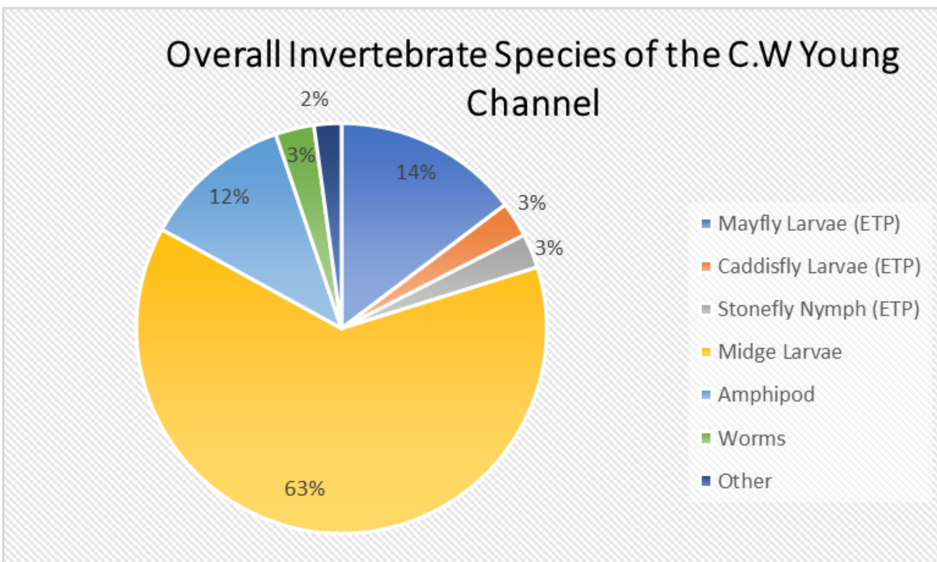

Figure 13:Grand Total of Sampled Invertebrate Derived from All 4 Sites of the C.W Young Channel.

Table 17: Cumulative species count.

Species	Totals
Mayfly Larvae (ETP)	212
Caddisfly Larvae (ETP)	40
Stonefly Nymph (ETP)	39
Midge Larvae	906
Amphipod	170
Worms	44
Other	31

Comparatively in 2022, the previous group Hess sampled 3 sites, making three replicates per site. This is one less site and one less replicate per site sampled than our group. Its mentioned in the previous report that as a result of two sampling days they counted a combined total of 106 invertebrates and 16 taxa. Although they discovered two more taxa than this year’s efforts, this is a significant difference in population totals. The increase if effort in stream invertebrate collection certainly had an impact, but it could also be due to the consecutive years of drought the system suffered, dramatically decreasing the overall aquatic invertebrate population within the C.W Spawning Channel. Drought years will reduce flow, increase water temperatures, reduce oxygen levels within the system and increase predation. All of which would certainly impact sensitive species such as Ephemeropterans, Plecopterans, Trichoterans, critical to overall stream function. This is consistent with comparing the annual stream assessment ratings over the past 5 years, we can see a clear drop of 0.25 a year since 2020, which is when the series of drought periods began occurring (Figure 14).

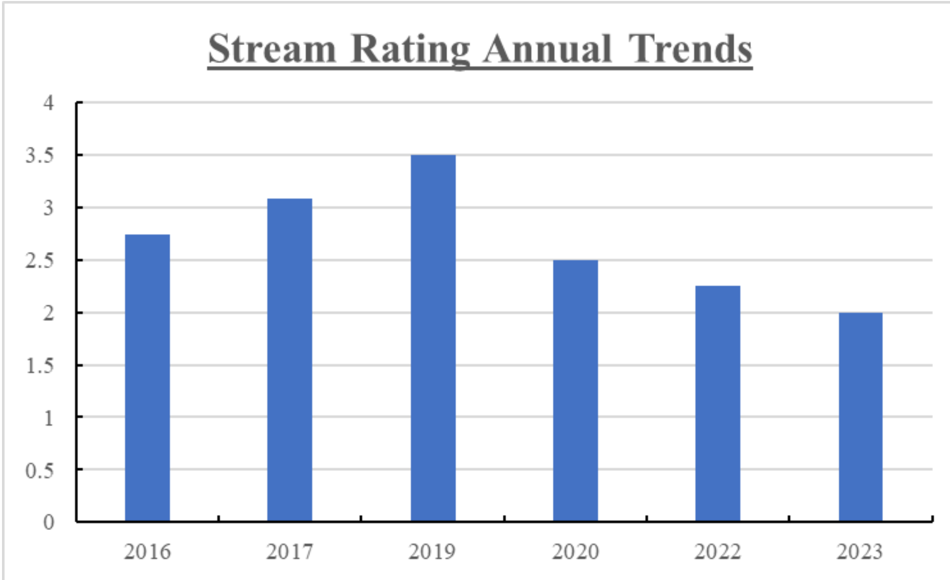

Figure 14:Annual invertebrate stream assessment rating trends.

6.0 Conclusions and Recommendations

During the stream assessment of the C.W. Young side channel, there were multiple days spent sampling different key aspects at each of four sites to obtain the best possible results per sampling session. This was replicated twice to determine any sort of immediate changes to the system over a months period (1^{st} – October, 2^{nd} – November). Our water quality results show consistency across most of our sites while remaining within all but one of the healthy ranges noted by the BC Water Quality Guidelines. The one outlier has been mentioned previously in reports as well and recommendations for that site are noted. Our overall rating for the stream invertebrate assessment concluded at a 2.0 which falls in the marginal range.

Overall, between the stream invertebrate collections and water quality analyses it is determined that the C.W. Young side channel is a healthy watershed that supports many aquatic species. Bears, eagles, and fair numbers of salmon were all noted during this assessment.

Through trends expressed earlier in the report, it is seen to have a slow increase in overall stream health and will continue to provide a healthy ecosystem for organisms that live within.

The recommendations from the authors for this survey are to continue the invertebrate and water quality monitoring. The elevated presence of aluminum in the watershed is of concern, taking more samples for ALS analysis is recommended to monitor the long-term amount of this metal. The water quality in the faster moving sections of the channel was healthy, however, monitoring and water quality is recommended in some of the pond sections of the channel. These areas are vital to the rearing of young salmonids, and it is vital that these areas provide adequate water quality for these species' success. The sampling for invertebrates displayed high amounts of invertebrates, however the diversity of species was low. Continued sampling of these invertebrates is recommended to further evaluate the density and diversity of the stream. Therefore, it is suggested that continued regular monitoring is recommended, and the addition of pond sites could improve upon the data and understanding of the channel's health.

7.0 Acknowledgements

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8.0 Literature Cited

Bird et al., (2020). *The Effect of Spawning Salmon Presence on Riverbank Soil Organic Matter Content.* University of British Columbia.

Canadian Council of Ministers of the Environment (2004). *Canadian Water Quality Guidelines for the Protection of Aquatic Life*. https://ccme.ca/en/res/phosphorus-en-canadian-water-quality-guidelines-for-the-protection-of-aquatic-life.pdf

Clough, David. 2013 "Englishman River Habitat Status Report." Mid Vancouver Island Habitat Enhancement Society, Report prepared by D. R. Clough Consulting.

Decker AS., Lightly MJ., Ladwig AA. 2003. The contribution of two constructed side-channels to coho salmon colt production in the Englishman river. Canadian Technical Report of Fisheries and Aquatic Sciences. 2442: 53p

GovBC. (2023). *Ministry of Water, Land and Resource Stewardship Water Protection & Sustainability Branch*. https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/approved-wqgs/wqg_summary_aquaticlife_wildlife_agri.pdf

9.0 Appendices

Appendix A: Site Photos

Photo 1: Site #1 of the C.W. Young Side Channel (facing downstream).

Photo 2: Site #2 of the C.W. Young Side Channel (facing upstream). This site is right below a culvert that allows water to flow from the pond on the upstream side.

Photo 3: Site #3 of the C.W. Young Side Channel (facing upstream).

Photo 4: Site #4 of the C.W. Young Side Channel. This is the outflow of the side channel (facing upstream).