Water Quality and Invertebrate Analysis of the Beck Creek, Nanaimo B.C.

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Executive Summary

Beck Creek is a small stream with a total drainage of 6.7 square kilometers and a total length of 4.5 kilometers. The goal of this study was to continue VIU's annual study of stream health which began in 2017. Assessment has not taken place since 2020, so surveying the stream in 2022 was critical. In addition, it is important to maintain and monitor a creek that historically supported a Coho run (Oncorhynchus kitsutch). Two sets of water quality samples were done on Beck Creek. These samples were taken and analyzed on October 26, 2022, and November 16, 2022. For each sample day samples were taken at 4 sites to ensure a reflection of overall stream health. At each site the following samples were taken, water quality, riparian health, invertebrates, and hydrology. The samples were taken on these dates to allow for a low and high flow water event. Samples were analyzed at the Vancouver Island University lab and by the ALS (Australian Laboratory Services) lab. During the low flow sample; invertebrates were sampled at sites 2, 3, and 4 and their diversity was found to be poor, water flow was insufficient to conduct the ping pong ball float method, water temperatures and dissolved oxygen hovered around 8 degrees Celsius and 11mg/L. During the high flow samples, invertebrate diversity increased slightly, the ping pong ball method was used at sites 2, 3, and 4, water temperature dropped by 3 degrees to an average of 5 degrees Celsius, and dissolved oxygen averaged at 12.35mg/L. Conductivity was noticeably higher at site 4 compared to other sites. However, this is likely due to site 4 being influenced by saltwater. Adult Coho, fry, and sculpins were noticed within the creek during sampling. The creek had noticeable flow problems due to beaver activity as well as plugged culverts from human interference and debris. The largest health issues for the Beck Creek are excessive levels of phosphorous, poor substrate quality and human debris blocking and littering the stream. Removing litter, adding higher quality substrate and sampling more extensively to locate anthropogenic phosphorous input sources would greatly benefit the overall health of the Beck Creek.

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1.0 Introduction

1.1 Project Overview

Four Natural Resource Management Students at Vancouver Island University continued the annual assessment of Beck Creek under the supervision of Owen Hargrove. This project is done in partnership with the Regional District of Nanaimo and Department of Fisheries and Oceans Canada. This is an ongoing stewardship partnership to study the health of creeks within the Regional District of Nanaimo. The goal of the assessment is to provide ongoing data of stream health within the Beck Creek watershed. Sampling begun in 2017 and ran until 2020. Beck Creek was not sampled between 2020 and 2022. Therefore, the data gathered in 2022 is important to provide an update on the stream's health. Two samples will be taken between October 26th and November 23rd 2023. These dates were chosen to allow for a sample to be taken during a high and low flow period. During our survey we will be using 4 sample sites. Sites 1 and 2 will be accessed off Frames Road, site 3 is accessed off Fielding Road, and site 4 is accessed off Maki Road (as seen in figure 1).

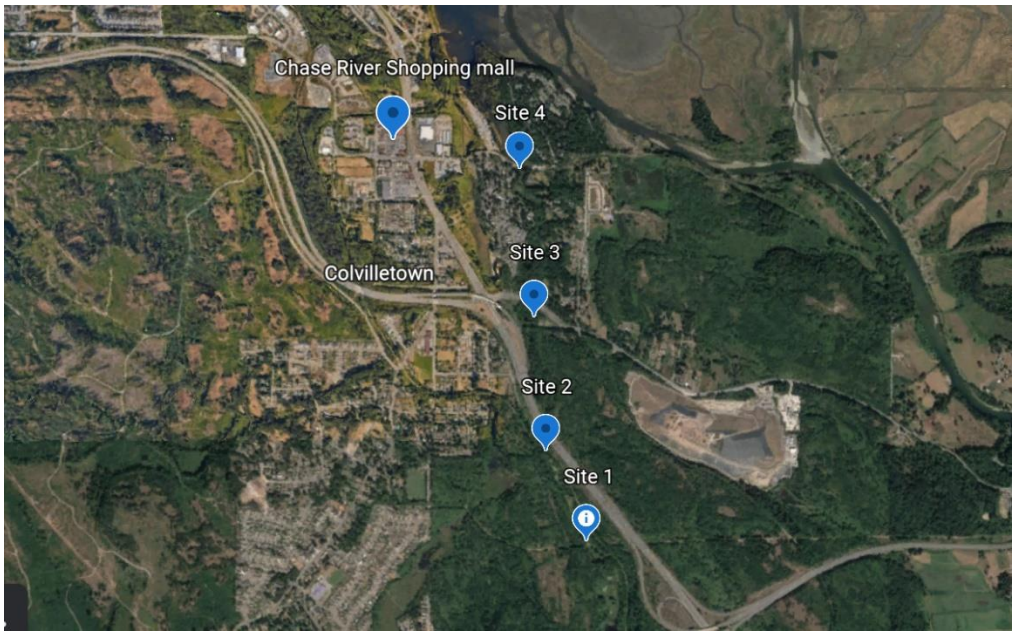

Figure 1: Site locations in proximity to Chase River Mall

1.2 Background

Beck Creek is a short creek at 4.5km in length. Beck Creek's total drainage is 6.7 square kilometers (Irvine et al. 1994). The creek starts at Beck Lake which is situated at sixty meters of elevation. The creek flows northeast into the Nanaimo Estuary. Nanaimo River estuary is Vancouver Island's largest estuary, a biologically significant area. Beck Creek has one main tributary which is Richard's creek, it enters approximately 1.1 kilometers upstream from the estuary (Irvine et al. 1994). Historically the creek supported a Coho salmon (*Oncorhynchus kitsutch*) run in the lower reaches. There is potential for the creek to support a resident trout population as well. However, these stocks have been threatened by urban and rural development. In 1995, the creek was re-routed to make way for the highway. The lower reaches are heavily impacted by residential development and waste. The upper reaches are heavily impacted by agriculture runoff. The creek has had culverts installed and experienced significant bank erosion.

1.3 Environmental Concerns

Due to Beck Creek being in an urban and semi-urban area it has several environmental concerns. The first concern is caused by creek crossings. Culverts have been used to allow water to pass underneath multiple roads. On our site visits we noticed these culverts were plugged with large woody debris and or household garbage. Beaver damns seemed to be very common on our site visit which can act as a barrier to salmon migration. Proximity to roads poses an environmental concern due the potential for deleterious substances spilling from vehicles. These liquids end up on the roads and wash off into the creek via run-off. Urban encroachment of the riparian zone has allowed for less foliage cover. Less canopy cover stimulates algae growth, warms the creek faster and allows erosion to happen more quickly. Further upstream, the creek is surrounded by agriculture land. This agriculture land has potential to seep manure and fertilizers into the creek which could result in eutrophication of Beck Creek. The Regional District of Nanaimo recommends keeping manure and fertilizer at least 15 meters back from the bank.

1.4 Project Objectives

Natural Resource Management students have studied Beck Creek since 2017. Every year water samples have been taken and a study has taken place surrounding water quality and environmental conditions. The primary objective of this project is to continue water sampling in order to compare past and present conditions to assist in the maintenance and restoration of Beck Creek. Beck Creek is an important part of the Nanaimo River system and is abundant with different parts of life. It is vital spawning habitat for Coho and Chum salmon (*Oncorhynchus keta*). Water samples were taken in four locations and tested for hydrology, water quality, and steam invertebrate health. Water samples were analyzed by students at Vancouver Island University and sent to a professional laboratory (Australian Laboratory Services in Burnaby B.C.). This document is a report stating the overall health of Beck Creek as of fall 2022.

2.0 Methods

2.1 Sampling Stations

In order to maintain long term datasets established in 2017, the four sites measured from 2017 to 2020 were remeasured. The remeasurement of these sites in Beck Creek is important, especially because the stream was not assessed in 2021. Repeated data collection and analysis is important in order to observe environmental changes or trends. The four sites were measured on October 26, 2022 and November 16, 2022 for hydrology parameters, water quality measurements, and stream invertebrates. Sites one, two, and three were measured in exactly the same locations as in previous years. Site four was measured on the upstream side of the culvert in an attempt to avoid sampling brackish water.

2.1.1 Locations and Habitat Characteristics

Figure 2: Site One on November 16, 2022

Site one is located furthest upstream at UTM 10 U 433603 E, 5440523 N. This site is accessed by parking on Frames Road and walking past a very large Douglas fir (*Pseudotsuga menziesii*) with graffiti painted on it with blue spray paint. You pass site two on your way to site one. Site one is located just upstream from a culvert and a quad trail. The water levels were higher in this site, forming pools, likely due to a lesser gradient. The pools were stagnant and very murky. Water depth was quite high at site one, even at low flow. An old beaver dam and large quantities of woody debris were observed in site

one. The substrate was observed to be predominantly fines (80%), gravel (15%) boulders (2%) and cobble (3%). The riparian area of this site was limited, and looked as though it had recently been disturbed in some areas by off road vehicles. Canopy cover was estimated at 15 percent. The vegetation that had not been destroyed consisted of grasses, alder (*Alnus rubra*), big leaf maple (*Acer macrophyllum*) and cattail (*Typha latifolia*).

Figure 3: Site Two on November 16, 2022

Site two is located approximately 500 meters downstream of site one at UTM 10 U 433409 E, 5440990 N. To access this site, you walk downstream along the train tracks back towards Frames Road. The site is directly upstream of a large culvert which was partially blocked by woody debris. Sampling took place above the culvert. Water depth was shallower at site two and flow was significantly

increased. The substrate was observed to be predominantly fines (90%), cobble (5%) and boulders (5%). The riparian area of this site consisted of snowberry (*Symphoricarpos albus*), alder (*Alnus Rubra*), bigleaf maple and cedar (*Thuja plicata*). The canopy cover at site two was thicker than site one, estimated at 65 percent. On our first sampling date juvenile Coho salmon were observed here.

Figure 4: Site Three on November 16, 2022

Site three is located across the Trans Canada Highway from sites one and two off of Feilding road. A homeless man and large pile of garbage were observed at the end of Feilding Road on our first site visit which were both safety concerns. This site had very steep banks, and was located at approximately UTM 10 U 433346 E, 5441612 N. The water was clearer here and increased in flow and

depth from October to November. The substrate was observed to be predominately cobble (80%), gravel (10%) fines (5%) and bedrock (5%). Some large pieces of garbage were observed in the stream at site three. The riparian area consisted of cedar, Douglas fir (*Pseudotsuga menziesii*), and swordfern (*Polystichum munitum*). The canopy cover was estimated to be approximately 70 percent.

Figure 5: Site Four on November 16, 2022

Site four is situated at the outflow of Beck Creek into the Nanaimo River Estuary at UTM 10 U 433289 E, 5442348 N. This site was accessed off of Maki Road. The bank of this site was also quite steep. A blue heron (*Ardea herodias*) and mallard duck (*Anas platyrhynchos*) were observed at this site on the first site visit. This site is affected by tidal movements, particularly on the downstream side of the culvert. Adult Coho salmon were observed at this site on both sampling days. The substrate was

predominantly fines (65%), boulders (15%), cobble (10%) and gravel (10%). There was very little riparian coverage (35%) comprised of Garry Oak (*Quercus garryana*), Douglas Fir and various shrubs.

2.1.2 Sampling Frequency

Two sets of field samples were conducted for the assessment of the Beck Creek. Field dates for sampling were October 26, 2022 and November 16, 2022. All sampling activities were done twice, once on each sampling date. The four sites were also visited once on October 19, 2022 to confirm sampling locations and observe hazards.

2.2 Basic Hydrology

Hydrology samples were taken at all four sample sites on Beck Creek. Measurements taken included; bank full width, wetted width, water depth, velocity, discharge, crown and percent cover, and substrate type. The overall health and characteristics of the stream were also observed.

2.3 Water Quality

2.3.1 Field Measurements

Water temperature, discharge and dissolved oxygen were tested for in the field. Temperature and dissolved oxygen were tested for with an electronic probe while discharge was testing for using the float method. The float method involves using a five-meter length of the glide, dropping a ping pong ball in at the upstream end and timing in seconds until the ping pong ball reaches the downstream end of the tape measure. Water discharge is then calculated as average velocity (m/sec) multiplied by the average depth (m), multiplied by the wetted width (m), multiplied by a factor of 0.75 to account for friction slowing down water velocity near the bank and bed of the stream. All other parameters will be tested for in either the VIU lab or the ALS lab.

2.3.2 Water Sample Collections

The water samples for laboratory analysis were taken once at low flow and high flow. A trip blank was taken on each sample day. Additionally, two samples were taken at sites one, two and three on each sample day. One sample was sent to the ALS lab and one was sampled in the VIU lab, which provided replicate data for these three sites on each sample day. Samples were taken midstream and from downstream to upstream. The sample bottles were be rinsed three times prior to being filled, except for the ALS bottles with preservative already inside. The sampling bottles were overfilled to ensure no excess air contaminated the sample. Samples were stored in a cooler until they were analyzed.

2.3.3 VIU Laboratory Analysis

Room 218, building 370 on VIU Nanaimo campus was used to conduct laboratory analysis of samples. On the same day sampling occurred, samples were transported to VIU. Samples were tested for pH, conductivity, turbidity, alkalinity, hardness, nitrate, and phosphate.

2.3.4 ALS Laboratory Analysis

All samples were shipped to an ALS laboratory the same day they were collected and analyzed at the VIU laboratory. The ALS lab tested for the several previously mentioned parameters as well as anions, nutrients and total metals.

2.3.5 Quality Assurance/Quality Control

Many quality assurance and quality control precautions were taken throughout sampling. Gloves were worn when taking samples. Samples were shipped in coolers. Samples were taken in triple rinsed bottles in the mid current of the stream. Replicate samples were taken on each sampling day at three out of the four sampling sites. The parameters that were replicated by ALS were compared to the VIU lab samples using the formula (R1-R2)/((R1+R2)/2) *100% (Hargrove 2022). This formula quantifies the percent of accuracy between samples. One trip blank was taken on each sampling day and analyzed in the VIU laboratory.

2.3.6 Data Analysis, Comparison to Guidelines

The data analysed by the VIU lab and ALS lab was compared to the aquatic life water quality guidelines set by Cavanagh et al. in 1998 as well as other secondary sources. The results section of this report will demonstrate if Beck Creek is suitable for aquatic life based on what parameters are met.

2.4 Stream Invertebrate Communities

2.4.1 Invertebrate Sample Collection

A Hess sampler was utilized to collect stream invertebrates at each site. The Hess sampler was properly rinsed between each site. The samples were analyzed at the VIU lab. The samples were placed in containers filled with 70 percent ethanol to preserve the invertebrates until they were counted. Substrate of gravel or cobble was sampled at each site. Three replicates of the Hess sampler (0.09m2) were taken at sites two and three on both sampling days. Only one replicate was taken at site four due to a lack of suitable substrate on both sampling days. Site one could not be with the Hess sampler either sampling day due to water depth and lack of suitable substrate. A filtration blank was taken through the Hess sampler of before the first sampling to ensure no material from the previous group remained.

2.4.2 VIU Laboratory Analysis

Invertebrates were removed from debris and placed under a dissection microscope to be identified. Invertebrates were identified using *The Streamkeepers Handbook* by Taccogna and Munro as well as other keys (1995). They were classified by taxa and pollution intolerance. Invertebrates from each site were kept separate throughout the sorting and identification process.

2.4.3 Quality Assurance/Quality Control

The same type of substrate was sampled at each site, the Hess sampler was cleaned between each site and the same level of effort was put into sampling at each site (sites two and three both were done three times). A filtration blank was processed through the Hess sampler prior to use and then examined under the microscope for both sampling dates.

2.4.4 Data Analysis

The data derived from stream invertebrates gives an indication of the streams' biodiversity. The EPT index, pollution tolerance index, predominant taxon ratio index and EPT to total ratio were determined and compared to standards set by Taccogna and Munro (1995). An overall site rating was determined using this information. The Shannon-Weinner diversity index was also calculated for each site. This index represents the diversity of the ecosystem, the higher the number the higher the diversity.

3.0 Results and Discussion

3.1 General Field Conditions

Beck Creek is an urban stream that navigates through varying amounts of infrastructure. Large highways, small roadways, train tracks, and a number of access roads cross the creek in a number of locations. Each chosen sampling site has an example of these infrastructure elements. The riparian area varies between sampling sites (See Table 8) but is generally noted to be of a good depth and has a variety of species of vegetation. It was observed that canopy cover varies along the creek, and this is represented within the sample sites (See Table 1). The substate at each site differs but is generally characterized by low to no bedrock and high fines (See Table 2), with Site 3 being an outlier from this observation.

Table 1: Sample site physical characteristics for Beck Creek

Sample Site Variables:	**Site 1:**	**Site 2:**	**Site 3:**	**Site 4:**
Bank-full Channel Width (m)	4.6	6.1	8.7	4.95
Bank-full Channel Depth(s) (cm)	105, 116, 87 (Avg. 102.67)	65, 90, 70 (Avg. 75)	35, 36, 69 (Avg. 46.67)	54, 65, 52 (Avg. 57)
Wetted Channel Width (m) [October 26th 2022]	4.5m	4.9	2.9	4.2
Wetted Chanel Depth(s) (cm) [October 26th 2022]	67, 97, 91 (Avg. 85)	25, 45, 36 (Avg. 35.33)	33, 28, 23 (Avg. 28)	15, 33, 33 (Avg. 27)
Wetted Channel Width (m) [November 16th 2022]	4.8	5.4	3.5	4.76
Wetted Chanel Depth(s) (cm) [November 16th 2022]	71, 120, 104 (Avg. 98.33)	43, 65, 45 (Avg. 51)	15, 42, 23 (Avg. 26.67)	9, 38, 31 (Avg. 26)
Width: Depth ratio (bank-full)	1: 4.48	1: 8.13	1: 18.6	1: 8.68
Canopy Cover (%)	15	65	70	35

Table 2: Substrate composition at each sample site at Beck Creek

Substrate Composition	**Site 1 Value (%)**	**Site 2 Value (%)**	**Site 3 Value (%)**	**Site 4 Value (%)**
Fines	80	90	5	65
Gravel	15	0	10	10
Cobble	3	5	80	10
Boulder	2	5	0	15
Bedrock	0	0	5	0

3.1.1 Basic Hydrology

The elements of hydrology that were measured and calculated involved the wetted width, wetted depth, water velocity, and water discharge (see Table 1; Table 3). On October 26th, 2022, we were unable to calculate water velocity due to stagnant water in all sampling sites. On November 16th, 2022, a slight increase in water level and flow allowed the measurement of water velocity in sample sites 2, 3, and 4 (see Table 3).

Table 3: Basic Hydrology results from sampling conducted October and November 2022

Date	**Hydrology Element**	**Site 1**	**Site 2**	**Site 3**	**Site 4**
October 26th, 2022	Water Velocity (m/s)	**IF**	**IF**	**IF**	**IF**
October 26th, 2022	Discharge (m^3/sec)	-------	-------	-------	--------
November 16th, 2022	Water Velocity (m/s)	**IF**	0.14	0.18	0.10
November 16th, 2022	Discharge (m^3/sec)	-------	0.28	0.13	0.10

IF *– Insufficient Flow*

Since 2018, groups have conducted hydrology measurements and calculations on site 4 on Beck Creek. When we compare the results obtained in 2022 to those of previous years, we see that the water velocity and discharge are significantly lower than they have been since 2018, especially during the month of November (See Figure 6; Figure 7). In 2020, high water caused getting a proper water velocity and discharge impossible, there for it is absent in the comparison in figures 6 and 7.

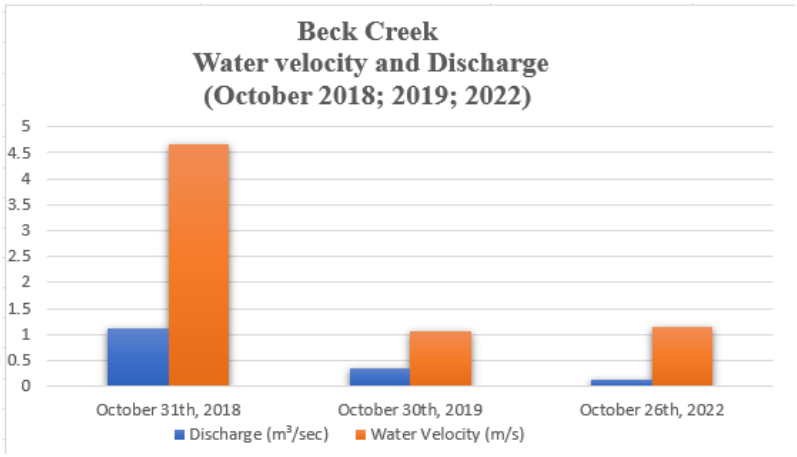

Figure 6. Water velocity and discharge of Beck Creek in 2018; 2019; and 2022 during sampling conducted in the month of October (VIU: de Laplante, Gagne, and Soucy). 2018; VIU: Cooper, Farrow, and Munroe 2019).

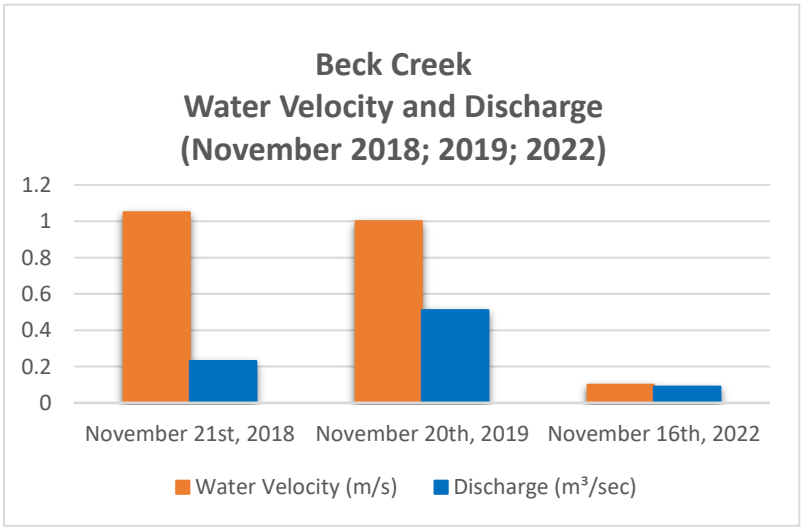

Figure 7. Water velocity and discharge of Beck Creek in 2018; 2019; and 2022 during sampling conducted in the month of November (VIU: de Laplante, Gagne, and Soucy). 2018; VIU: Cooper, Farrow, and Munroe 2019).

3.2 Water Quality

3.2.1 Field Measurements

October 26th, 2022

Conductivity measured within sites 1, 2, & 3 were among a normal range for coastal freshwater streams in BC according to guidelines set out by the BC government (See Table 4). However, site 4 measured at a level > 30x that of the previously mentioned sites. This observation is most likely due to it proximity to the tidal inlet at the outflow of Beck Creek. On the day that sampling occurred [October 26th, 2022] a lack of rain had caused slow to unmeasurable flow, this resulted in limited to no outflow at the mouth of Beck Creek. This lack of outflow is hypothesised to have allowed tidal waters to contaminate the sampling site, causing an incredibly high conductivity reading.

Hardness in sites 1 & 2 is considered by guidelines to be hard and site 3 is considered either hard or soft; however, site 3 is leaning more towards the hard side of the spectrum. Site 4 was above the detection limit as hardness has a direct correlation to the extreme conductivity result noted previously. Alkalinity in all sites are considered “low sensitivity” according to the BC government (BCMECCS 2021).

Phosphorus levels at both sites 2 and 4 were above guidelines for aquatic life according to the BC government (See Table 4). Site 1 was measured to have a level that was extremely, and uncharacteristically high. When compared to the tests done by ALS labs, it appears as though this value was the result of lab testing error. Nitrates in all sample sites are well below maximums set out for aquatic life. Each site was close in value except for site 4.

The field blank that was used to determine contamination from field operations had measured water quality values that were indicative of low to no contamination.

When compared to the data obtained by a group sampling Beck Creek in 2019, values show only slight difference (VIU: Cooper, Farrow, and Munroe 2019). Conductivity on October 26th, 2022 was measured lower than it was on October 27th, 2020. Hardness was observed to be lower on October 27th,

2020 than it was when sampled in this study 2 years later (VIU: Eaglestone-April, Gourlay, and Haime 2020). Alkalinity measurements were on par for both studies. Nitrates and phosphates were of similar value to what was measured in this study with the exception of site 1 on October 26th, 2022 (noted to be a possible lab error).

Table 4: Water Quality measurements (October 26th 2022)

Water Quality Parameter:	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Field Blank**	**Guidelines for aquatic life (BCMECCS 2021)**
Dissolved Oxygen (mg/L)	9.6	9.8	13.2	10.5	----------	Minimum of 5 mg/L
Temperature (°C)	8	7.8	8.1	8.6	----------	10-15, with a Minimum of 2 for incubation
Conductivity (uS/cm)	381	397	382	13230	0	50-1500 $\mu S/cm$
pH	7.6	7.7	8.1	8.0	9.0	6.5-9.0
Turbidity (NTU)	13.1	4.86	2.45	6.12	0.56	10% increase when background value is > 50 NTU
Hardness (mg/L $CaCO_3$)	134	133	105	ADL	20	>120Mg/L are considered hard, <60 Mg/L is considered soft
Nitrate (mg/L NO_3^-)	0.07	0.05	0.06	0.24	0.2	maximum of 10mg/L
Phosphorus (PO_4^{3-})	2.08	0.24	0.07	0.38	+0.01	0.005 – 0.015 mg/L
Alkalinity (mg/L $CaCO_3$)	200	174	135	90	0.4	High Sensitivity is 0-10 mg/L, Medium sensitivity is 10-20mg/L, and low sensitivity is >20 mg/L

ADL – *Above Detectable Limit*

____-- *Of Note*

November 16th, 2022

Variation within dissolved oxygen and temperature between October 26th, 2022 and November 16th, 2022 is in line with seasonal changes. Temperature has dropped below the ideal range but maintains a buffer between the lower threshold for incubation.

Water levels were increased on sampling day two, allowing for measurable flow at site 2, 3, and 4; however, we still were unable to collect flow data at site 1. This higher level of flow did cause the effect of the tidal influence at site 4 to be decreased. The conductivity measured only slightly above the other sample sights. All other sites saw an increase in measured conductivity (See Table 5).

Hardness in all sites except for site 4, saw a drop into the middle ground between what is considered soft and hard. Site 4 on October 26th, 2022 had qualities that made the measurement of hardness not possible; however, on November 16th, 2022, the lowering of site conductivity allowed a value to be obtained that is in between hard and soft classification (BCMECCS 2021).

Nitrates and phosphates saw some slight change between the two sampling days (See Table 4; Table 5). First, sight 1 measured a normal value within the range for aquatic life. Sites 2 and 3 saw a slight drop in phosphates to within the aquatic life guidelines and site 4 saw a drop but still maintained a value above guidelines.

In all sites but site 2, we saw a decrease in turbidity which is counter the expected result when rain inputs were seen from October 26th to November 16th, 2022. This result could be due to the stagnant conditions on October 26th, and the limited amount of flow increase. The rain that was inputted into the creek may have been enough to allow stagnant pools full of fines to clear slightly and not enough flow to see an increase in total suspended solids within Beck Creek.

When we compare our results on this sampling day to those of sampling conducted on November 18th, 2020, we see similar changed in dissolved oxygen and temperature (VIU: Eaglestone-April, Gourlay, and Haime 2020). Conductivity saw an opposite change in 2020 than in our study. We saw a net increase in all site's conductivity (with the exception of site 4 due to tidal effects on October 26th, 2022); whereas in 2020, they saw a net decrease in conductivity in all sampling sites between October 27th, 2020 and November 18th, 2020. Nitrates saw similar to identical values (site 2; 0.06mg/L)

from 2020 to 2022. Phosphorus produced results in 2020 that were far higher than ours and a net increase was seen between their two sampling days as apposed to our observation of a net decrease in phosphates. Farmland above sampling sites and rain input was given as a reason for the 2020 results of a raise on phosphates between sampling days (VIU: Eaglestone-April, Gourlay and Haime 2020). In 2022, we also had rain inputs between sampling days; however, with drought conditions prier to this rain fall, it is possible that less run off from surrounding farmlands was seen as the ground conditions allowed for more absorption of water into the soil.

Table 5**:** Water Quality measurements (November 16th 2022)

Water Quality Parameter:	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Field Blank**	**Guidelines for aquatic life (BCMECCS 2021)**
Dissolved Oxygen (mg/L)	9.6	9.8	13.9	9.8	----------	Minimum of 5 mg/L
Temperature (°C)	5.8	5.6	4.9	5.6	----------	10-15, with a Minimum of 2 for incubation
Conductivity (uS/cm)	441	428	423	542	**BDL**	50-1500 $\mu S/cm$
pH	8.3	8.2	8.2	8.1	9.4	6.5-9.0
Turbidity (NTU)	-4.87	-17.2	-2.81	-3.22	-0.47	10% increase when background value is > 50 NTU
Hardness (mg/L $CaCO_3$)	108	100	104	112	1	>120Mg/L are considered hard, <60 Mg/L is considered soft
Nitrate (mg/L NO_3^-)	0.09	0.06	0.1	0.06	**BDL**	maximum of 10mg/L
Phosphorus (PO_4^{3-})	0.07	0.07	0.04	0.20	0.02	0.005 – 0.015 mg/L
Alkalinity (mg/L CaCO_3)	292	84	156	120	-0.23	High Sensitivity is 0-10 mg/L, Medium sensitivity is 10-20mg/L, and low sensitivity is >20 mg/L

BDL – *Below Detection Limit*

3.2.2 ALS Laboratory Analysis Oct 26, 2022

Samples collected at sites 1, 2, and 3 were preserved and sent to ALS labs for a full analysis. The results that same back showed that a majority of heavy metals analysis were below the maximum for aquatic life; however, there were a couple of results worth mentioning.

Site 1 was found to have an aluminum concentration of 0.2 mg/L, which is above the long-term and short-term maximum for aquatic life (BCMECCS 2021). It is hypothesised that this may be due to its proximity to farmland up stream of site 1 on Beck Creek. The input of fertilizers or other agricultural waste, coupled with low stagnant water levels could be a possible reason for this result. Another hypothesis is the observation of a water treatment device seen at site 1. It is not known what the device is used for, or by, but its location in relation to site one is worth mentioning when examining the results found in the analysis.

3.2.3 ALS Laboratory Analysis Nov 16, 2022

Samples were taken and sent to the ALS laboratory for additional assessment of water quality. Tests performed were similar to those done at the VIU laboratory. Parameters included pH, hardness, conductivity, anions, nutrients, and total dissolved metals. The pH recorded from the ALS Laboratory was recorded at 7.47 for site one, 7.63 for site two and 7.99 for site three (appendix 2.0). All three of these sites fall within the aquatic life guidelines of 6.5 to 9.0 (Cavanagh et al. 1998). Conductivity had an average of 419 uS/cm for all three sites which is higher than most coastal streams (Cavanagh et al.1998). Hardness had an average of 98.5 mg/L $CaCO_3$ for all 3 sites (appendix 2.0). Conductivity and hardness both fell within the water quality guidelines for aquatic life. Nitrate was found in low levels in sites two and three but was below the detection limit in site one. Nitrate is within the aquatic guidelines as it is well below the 200 mg/L maximum. Phosphorus levels were found in eutrophic levels in site one and two (Cavanagh et al. 1998). Site one had 41.7 µg/l of phosphorus while site two had 44.6 µg/l. Site three

was found to be mesotrophic with levels of 24.1 µg/l. All three sites exceed the maximum aquatic life guideline of 5 – 15 µg/l (Cavanagh et al. 1998). This high level of phosphorous could be explained by the farmland upstream, perhaps allowing fertilizer to run off into the Beck. Phosphorous is the principal nutrient required for eutrophication to occur, followed by nitrogen. It is reported that phosphorous restricts 80 percent of lake eutrophication, while nitrogen restricts only 10 percent (Abid et al. 2010). Although our nitrogen levels were normal, excess phosphorous at all three sites sampled could be detrimental to the Beck's overall health as eutrophication ultimately affects aquatic life diversity. Attempting to control artificial phosphorous inputs could be a step in the right direction in restoring the Beck Creek. This would require extensive sampling to pinpoint the phosphorous input.

ALS provided a detailed review of dissolved metals found in Beck Creek. Most of the dissolved metals were under the detectable limit or found in very low quantity, however, iron, sodium and aluminum were found in notable quantities. Iron was found to exceed aquatic life guidelines at all three sites. Iron was recorded at 0.914 for site one, 1.01 for site two and 0.386 for site three. The aquatic life guideline is a short-term exposure of a maximum of 0.35 mg/L (BCMWLAP, 2008). Aluminum was also above aquatic life guidelines in site two at 0.145 mg/L. The aquatic guideline is a maximum of 0.1 mg/l at pH of ≥ 6.5 (Cavanagh et al. 1998). Sodium levels in Beck Creek were below the aquatic life guidelines, although sodium levels were elevated compared to other urban streams sampled by our classmates and analyzed by ALS on the same day our samples were analyzed (BCMWLAP, 2003).

3.2.4 Quality Assurance/Quality Control

Quality assurance measures that were undertaken for water quality sampling included; triple rinsing sample bottles, taking samples midstream, wearing gloves when taking samples, and transporting samples in coolers. Quality control measures that were undertaken for water quality sampling included; taking a trip blank on both sampling days and using the ALS lab results as replicates

for sites one, two and three. Out of 13 sample bottles filled on each sample day, three could be used as replicates and one was a trip blank, resulting in 30.7 percent of our water quality samples being replicates or blanks. This is three times the minimum sampling effort required (Hargrove 2022). Interestingly, our trip blank on the first sampling day had a hardness of 20 mg/L CaCO3 compared to 1 mg/L CaCO3 in the second trip blank. This could be due to human error in the lab, or the water being sourced from the tap rather than distilled water. The City of Nanaimo's drinking water averages at 32mg/L CaCO3, possibly explaining the high hardness levels in the first field blank (City of Nanaimo 2019).

The ALS replicates were compared to the VIU lab samples using the formula (R1-R2)/((R1+R2)/2) *100% (Hargrove 2022). Less than 25 percent difference between parameters is considered acceptable. Tables 6 and 7 demonstrate the differences between parameters that could be compared between the laboratory analysis. On sample day one pH was not done in the VIU lab and therefore could not be compared. On sample day one, the accuracy of phosphate was not acceptable at a percent difference of 196 for site one, 190 for site two, and 159 for site three. The percent difference between the VIU and ALS laboratories was also not acceptable for nitrate with a percent difference of 173 for site one, 163 for site two and 169 for site three. Conductivity and hardness were both acceptable as conductivity had a percent difference of 0.5 percent for all three sites while hardness had a 3 percent difference for site one, a 5 percent difference for site two and a 13 percent difference for site three. On sample day two, nitrate and phosphate did not have an acceptable percent difference between laboratory analysis. Phosphate had percent differences of 113 percent for site one, 120 for site two and 110 for site three. Nitrate had shockingly high percent differences of 179 percent for site one, 107 for site two and 168 for site three. PH, hardness and conductivity all had acceptable percent differences, well below the 25 percent mark. PH had percent differences between data sets of 2 percent for site one, 7 percent for site two, and 3 percent for site three. Hardness had a percent difference of 7 percent for site one, 1 percent

for site two, and 8 percent for site three. Conductivity had a percent difference of 4 percent for site one, 2 percent for site two and 2 percent for site three. The shockingly high percent differences between data sets for the parameters phosphorus and nitrate may indicate the VIU laboratory equipment is not functioning properly for these parameters or it was used incorrectly by students.

Table 6: VIU and ALS Laboratory Results Comparison for Oct 26, 2022

Parameter	Phosphate mg/L	Conductivity µS/cm	Hardness Mg/L CaCO3	Nitrate mg/L
Site One ALS	0.0108	379	130	<0.005
Site One VIU	2.08	381	134	0.07
Site Two ALS	0.006	395	127	<0.005
Site Two VIU	0.24	397	133	0.05
Site Three ALS	0.0079	384	120	<0.005
Site Three VIU	0.07	382	105	0.06

Table 7: VIU and ALS Laboratory Results Comparison for Nov 16, 2022

Parameter	Phosphate mg/L	Conductivity µS/cm	Hardness Mg/L CaCO3	pH	Nitrate mg/L
Site One ALS	0.0194	423	101	7.74	<0.005
Site One VIU	0.07	441	108	8.3	0.09
Site Two ALS	0.0174	420	98.7	7.63	0.0181
Site Two VIU	0.07	428	100	8.2	0.06
Site Three ALS	0.0116	414	95.8	7.99	0.0087
Site Three VIU	0.04	423	104	8.2	0.1

3.3 Stream Invertebrate Communities

3.3.1 Abundance/Density

When looking at the results of the invertebrate sampling, we found that there were differences from each site; however, a common thread through each was a relatively poor to marginally acceptable EPT ratio. All sample sites, but one, (see Appendix 5) had Amphipods as the main taxa of invertebrate found. This was most striking in site 2 on November 16th, 2022, where a total of 71 Amphipods was counted in the sample out of a total 107 invertebrates. When compared to past Hess sampling conducted at Beck creek, we see Amphipods as the main taxa in almost all sampling sites (VIU: Eaglestone-April, Gourlay, and Haime 2020).

3.3.2 Diversity/ Site Ratings

The high number of Amphipods and relatively low number of Caddis Fly, Mayfly, and Stonefly, lead to a poor EPT ratio, as well as a poor diversity of taxa. It was observed that from October 26th, 2022

to November 16th, 2022 there was an increase in both total number of invertebrates collected, as well as higher diversity in taxa observed in each site. This result could have been from the increase in flow that was measured on November 16th as compared to the extremely low flow of October 16th, 2022. When compared to past Hess sampling conducted at Beck creek, we see a similar result of a low EPT ratio in almost all sampling sites (VIU: Eaglestone-April, Gourlay, and Haime 2020). The Shannon-Weinner index was quite poor for all sites (Appendix 4). However, the index greatly increased at all sites from low flow to high flow. This could indicate higher flow promotes invertebrate diversity.

3.3.3 Quality Assurance/ Quality Control

Quality assurance measures that were undertaken included; sampling gravel or cobble at each site, cleaning the Hess sampler between each site and sampling for the same time period at each site. For quality control, a filtration blank was processed through the Hess sampler prior to use and then examined under the microscope in the VIU lab. On each sampling day, three sites were sampled and one filtration blank was taken. This resulted in 25 percent of our invertebrate samples being blanks, which is well over the minimum sampling effort of 10 percent (Hargrove 2022). The first filtration blank, was not clean, it contained one stonefly larvae. This larva likely came from Richards Creek, where the Hess sampler was utilized prior to sampling the Beck. The filtration blank on the second sampling day was clean.

3.4 Riparian Zone Assessment

The riparian area at each sampling site was observed to be quite variable in percent conifer and deciduous trees, as well as depth of understory vegetation (See Table 8). At Site 1 and 2, the infrastructure near the creek is low. A small recreation trail is present next to both Site 1 and 2 along the right bank, as well as an access road that crosses the creek at Site 1. Both site 3 and 4 are relatively close to roadways, as well as residential area. A main roadway (Maki Road) crosses the creek just below Site 4. Site 3 has a municipal access road that crosses the creek above the sampling area. This being said, all

sampling sites maintain a relatively good depth of vegetation (See Table 8) on both banks that provides a buffer between the creek and infrastructure.

Table 8: Riparian area characteristics

Riparian Zone:	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Land Use				
Left Bank	Recreation trail/Access Road	Train Track	Roadway	Residences
Right Bank	Recreation trail	Recreation trail	Recreation trail	Residences and roadway
Vegetation Type				
Left Bank	25% Conifer 75% Deciduous	75% Conifer 25% Deciduous	70% Conifer 30% Deciduous	80% Conifer 20% Deciduous
Right Bank	50% Conifer 50% Deciduous	25% Conifer 75% Deciduous	80% Conifer 20% Deciduous	80% Conifer 20% Deciduous
Vegetation Depth (m)				
Left Bank	5	20	30+	15
Right Bank	30+	30+	30+	20

4.0 Conclusion and Recommendations

Considering the location and urbanization of Beck Creek, it was expected to have poor overall health. However, Beck Creeks overall stream health was found to be mid-grade. Dissolved oxygen and temperature within all sites fall within the BC guidelines for aquatic life at various stages of development. Conductivity, pH, total metals and nitrate levels present in the stream were all within healthy levels. Beck Creek was also surrounded by an adequate riparian area. Unfortunately, Beck Creek had an excess of phosphorous that could lead to eutrophication, especially in sites with low water flow. The Beck also had poor substrate for salmonid spawning and reproduction, with high levels of fines and a lack of gravel and cobble. The poor substrate could have also contributed to the poor stream invertebrate diversity.

Site 1 demonstrated the highest risk for eutrophication with significant algae growth along, poor water flow and high levels of phosphorous. A beaver dam on the downstream side and little gradient have contributed to this low water flow. The site did not have suitable substrate to use the Hess sampler so invertebrate diversity and pollution intolerance could not be assessed. The site lacks an acceptable amount of canopy cover with about 15 percent coverage. Site three presented the best habitat for aquatic life between the 4 sites with decent flow, heavy vegetation, little fines and extensive cobble and gravel riffles for invertebrate production. However, it was heavily impacted by human litter, perhaps affecting the quality of the site. A large garbage pile on the road about 50m from the stream and a truck bed were observed laying on the creek bank.

Some trends we noticed between the high and low water flow sampling events were an increase in velocity, conductivity, and an increase in pollution intolerant invertebrates. We also observed a decrease in temperature and turbidity. The decrease in turbidity and temperature could be beneficial for any salmon eggs recently laid in the stream bed.

Based on our results we believe further sampling throughout the creek would be beneficial. Site 1 could not be properly represented due to poor water flow and lack of suitable substrate for Hess sampling. It would be beneficial to sample more extensively further up the creek. Sampling within the head waters of Beck Lake would be useful to rule out pollution from agriculture and or urban development, as well as pinpoint the source of anthropogenic phosphorus inputs. Using a headwater sample as a control, it would be possible to determine if pollution factors are coming from within the watershed itself. We do believe that remediation efforts to sites 1 and 3 would be beneficial. Site 1 has very little canopy cover which combined with a lack of water flow and excess phosphorous has resulted in excessive algal growth. This could be approached by removing the beaver dam and planting canopy cover trees on the stream bank. Site 3 has good habitat for aquatic life but could benefit from a cleanup to ensure human litter and pollution is not affecting the stream further. Sites one, two and four could also benefit from the implementation of better spawning substrate. Adding gravel and cobble to the stream would increase the spawning area and increase invertebrate production for juvenile salmonid consumption. In conclusion, Beck Creek's health is in an acceptable state, however, further sampling and remediation efforts would be beneficial for the stream's overall health.

5.0 Acknowledgements

Thank you to Owen Hargrove and Mike Lester for setting up laboratory equipment, preparing sample bottles and coordinating with ALS. Special thanks to Owen Hargrove for his suggestions and supervision with this project.

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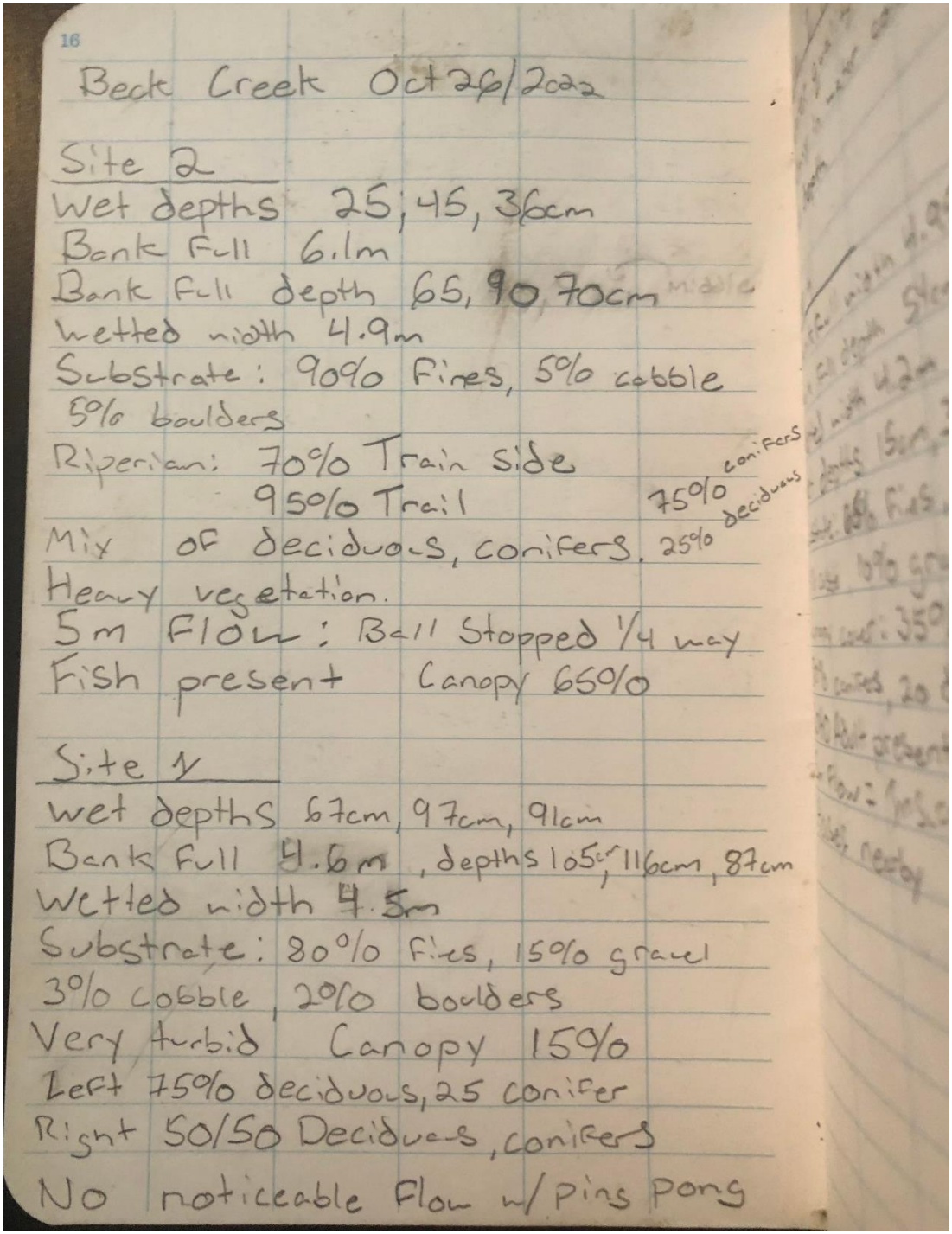
7.0 Appendices

1.0 Raw Field Data Sheets

Oct 26, 2022



16

Beck Creek Oct 26/2022

Site 2

Wet depths 25, 45, 36cm

Bank Full 6.1m

Bank Full depth 65, 90, 70cm

Wetted width 4.9m

Substrate: 90% Fines, 5% cobble 5% boulders

Riperian: 70% Train side 75% conifers deciduous

95% Trail

Mix of deciduous, conifers. 25%

Heavy vegetation.

5m Flow: Ball Stopped 1/4 way

Fish present Canopy 65%

Site 1

wet depths 67cm, 97cm, 91cm

Bank Full 4.6m, depths 105cm, 116cm, 87cm

Wetted width 4.5m

Substrate: 80% Fines, 15% gravel

3% cobble, 2% boulders

Very turbid Canopy 15%

Left 75% deciduous, 25 conifer

Right 50/50 Deciduous, conifers

No noticeable Flow w/ pins pong

Site 3
Bank Full width: 8.7m
Bank Full depth: 35cm, 36cm, 69cm
wetted width 2.9m
wetted depth: 33cm, 28cm, 23cm
Substrate: 80% cobble, 5% bedrock
5% fine, 10% gravel,
Canopy = 70%
70% conifers, 30% deciduous
Heavy vegetation
Flow: Insufficient Flow

Site 2 DO; 9.8mg/L -hess x3
Temp; 7.8°C

site 1 DO; 9.6mg/L -no hess
Temp; 8°C too muddy

Site 3
- 1 crayfish left -hess x3
DO; 13.2mg/L
Temp; 8.1°C

Site 4 DO; 10.5mg/L -hess x2

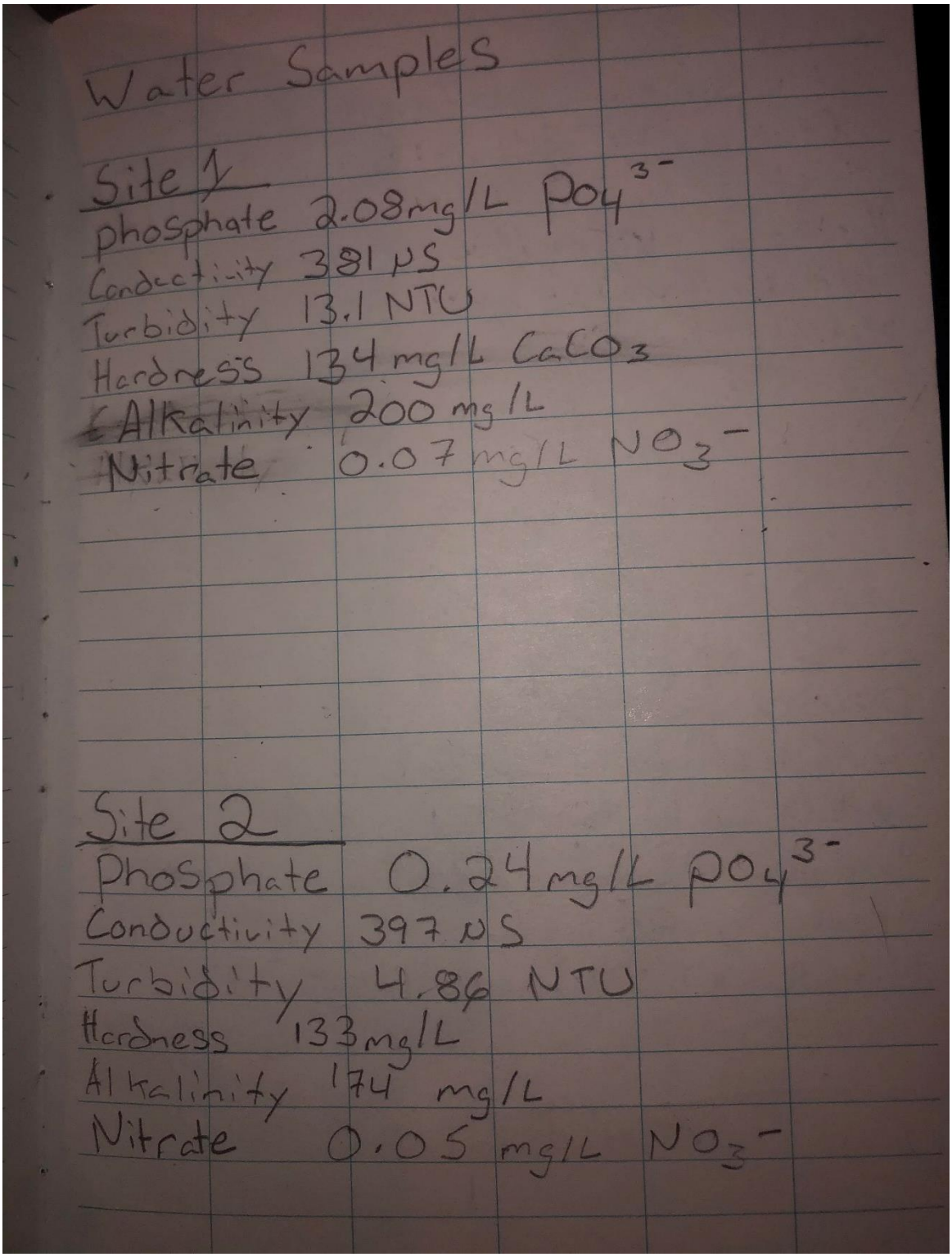
Site 1 (cont'd)

Water quality Samples taken midway in water column. Due to turbidity and depth.

Site 4

Bank Full width 4.95m
Bank Full depth 54cm, 65cm, 52cm
Wetted width 4.2m
Wet depths 15cm, 33cm, 33cm
Substrate: 65% Fines, 15% boulders, 10% cobble, 10% gravel
Canopy cover: 35%
80% conifers, 20 deciduous
COHO Adult present
5m Flow = Insignificant Flow
Houses nearby

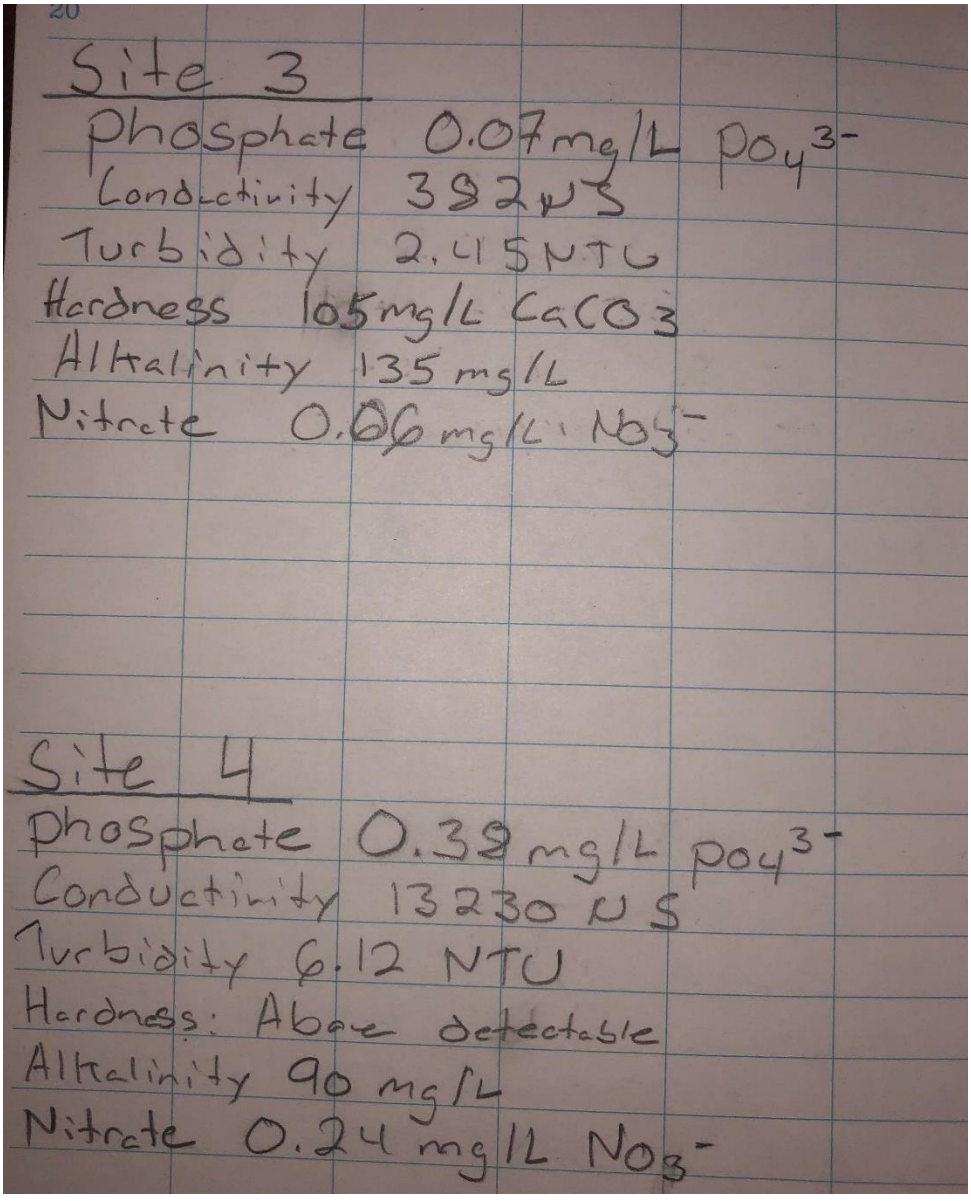
Lab Data Sheets-Oct 26, 2022



Water Samples

Site 1
phosphate 2.08mg/L PO_4^{3-}
Conductivity 381 µS
Turbidity 13.1 NTU
Hardness 134 mg/L $CaCO_3$
Alkalinity 200 mg/L
Nitrate 0.07 mg/L NO_3^-

Site 2
Phosphate 0.24 mg/L PO_4^{3-}
Conductivity 397 µS
Turbidity 4.86 NTU
Hardness 133 mg/L
Alkalinity 174 mg/L
Nitrate 0.05 mg/L NO_3^-

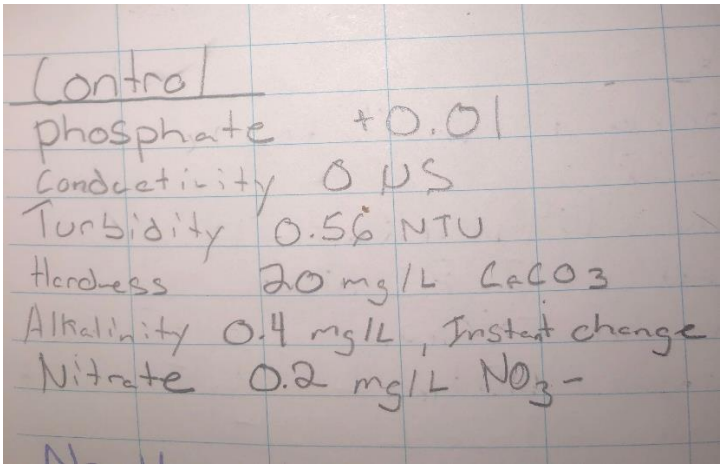


Site 3

Phosphate 0.07 mg/L PO_4^{3-}
Conductivity 392 µS
Turbidity 2.45 NTU
Hardness 105 mg/L $CaCO_3$
Alkalinity 135 mg/L
Nitrate 0.06 mg/L NO_3^-

Site 4

phosphate 0.39 mg/L PO_4^{3-}
Conductivity 13230 µS
Turbidity 6.12 NTU
Hardness: Above detectable
Alkalinity 90 mg/L
Nitrate 0.24 mg/L NO_3^-



Control

phosphate +0.01
Conductivity 0 µS
Turbidity 0.56 NTU
Hardness 20 mg/L $CaCO_3$
Alkalinity 0.4 mg/L, Instant change
Nitrate 0.2 mg/L NO_3^-

Beck Creek
Invertes

Filtration Blank - not clean, one stonefly

Site 2

Scud = HHH HHH HHH IIII

Caddis Fly Larvae = III

Aquatic worm = III

Mayfly = II

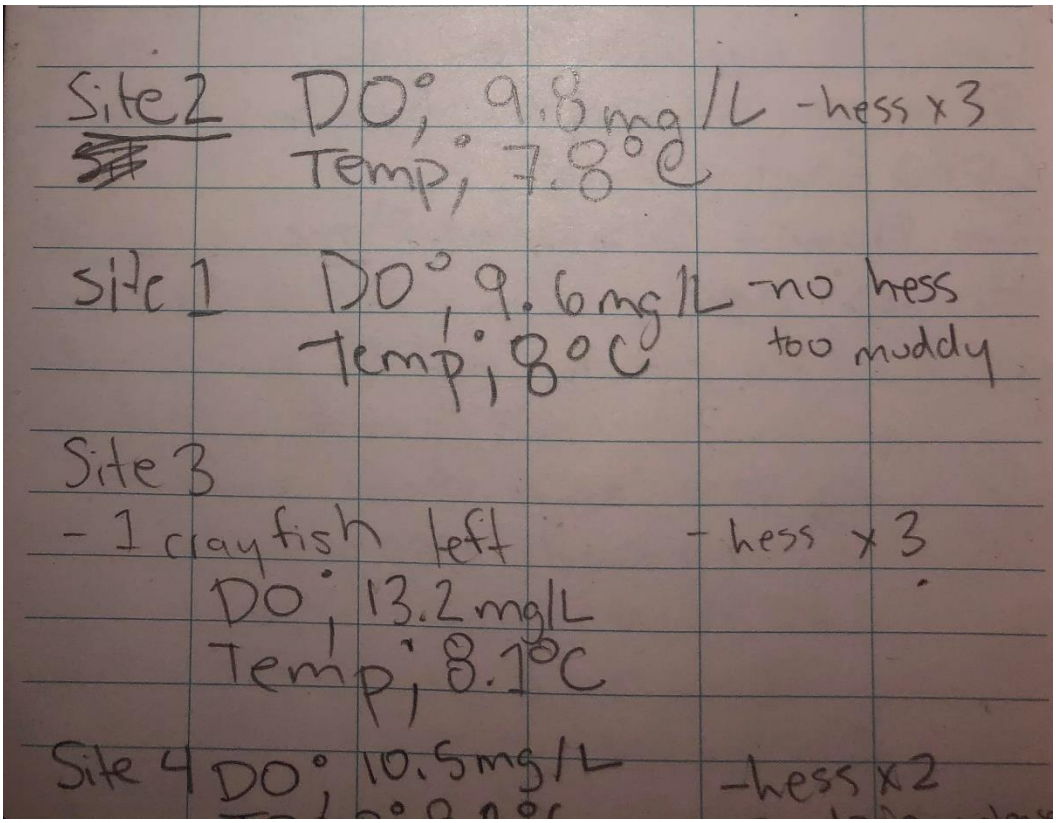
Site 3

Scud - HHH HHH HHH HHH III
Aquatic worm - II
Stonefly - 1
Unidentifiable - 1

Site 4

Scud = HHH HHH III
Water Penny - HHH III
Mayfly - II

Raw Field Data Sheets-Nov 16, 2022



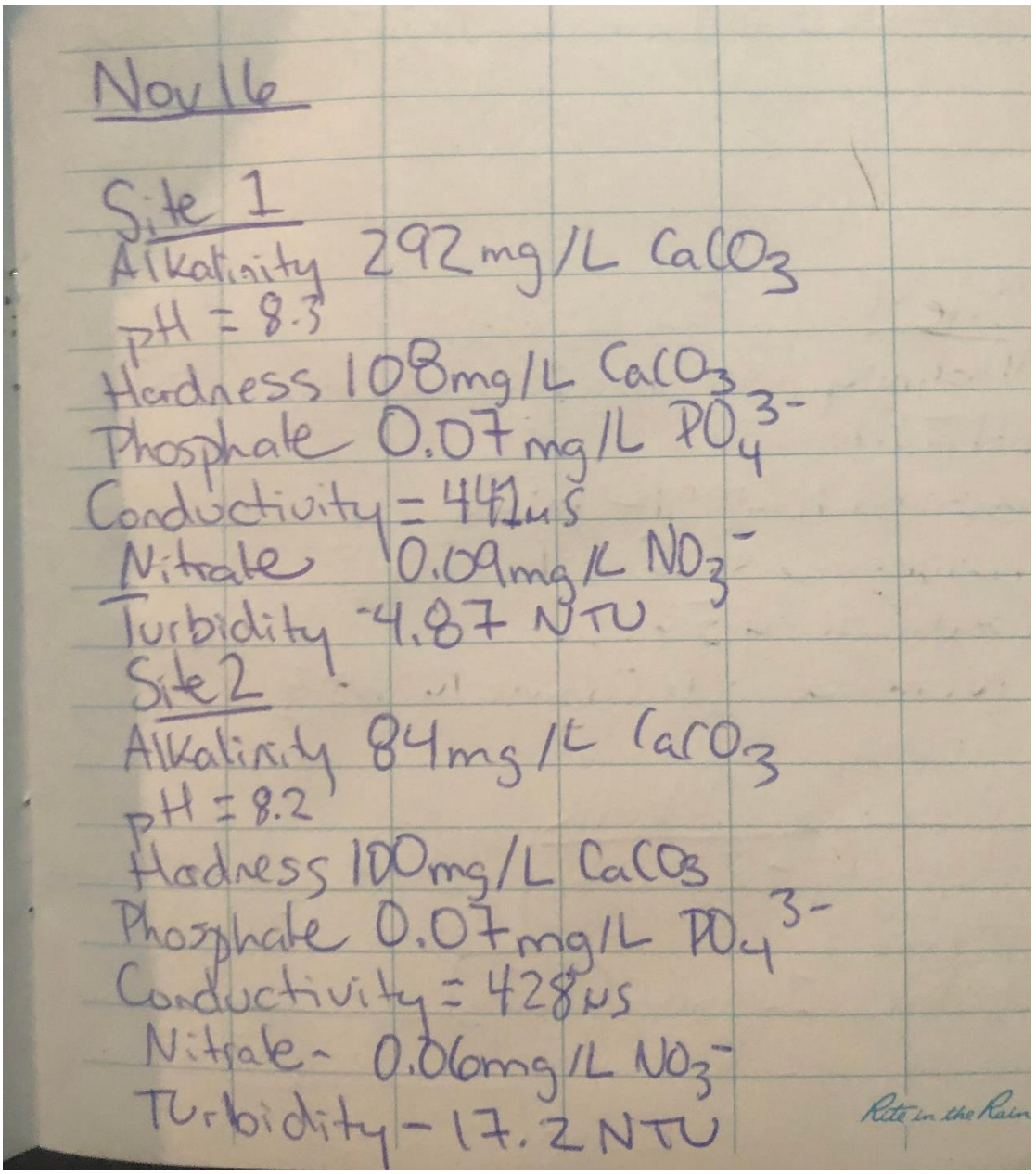
Nov 16 Site 2
wetted width 5.4m
wetted depth 43cm, 64cm, 45cm
Flow = 5m, 36.83 sec, 37.28 sec
DO 9.8mg/L Temp 5.6°C

Site 1
wetted width 4.8m 102
wetted depth 71cm, [redacted]cm, 104cm
Flow = insufficient flow
DO 9.6mg/L Temp 5.8°C

Site 3
wetted width 3.6m
wetted depth 15, 42, 25cm
flow = 5m 25.35 sec
Tem 4.9°C 29.73 sec
DO 13.9mg/L

Site 4
wetted width 4.76m
wetted depth 9cm, 38cm, 31cm
flow 5m, 49sec, 47.5sec
Temp 4.6°C
DO 16.1mg/L
Sculpin in Hess - released
Hess replicate x 1

Lab Data Sheets-Nov 16, 2022



Nov 16

Site 1
Alkalinity 292 mg/L $CaCO_3$
pH = 8.3
Hardness 108 mg/L $CaCO_3$
Phosphate 0.07 mg/L PO_4^{3-}
Conductivity = 441 µS
Nitrate 0.09 mg/L NO_3^-
Turbidity - 4.87 NTU

Site 2
Alkalinity 84 mg/L $CaCO_3$
pH = 8.2
Hadness 100 mg/L $CaCO_3$
Phosphate 0.07 mg/L PO_4^{3-}
Conductivity = 428 µS
Nitrate - 0.06 mg/L NO_3^-
Turbidity - 17.2 NTU

Rite in the Rain

Site 3

Alkalinity 156mg/L $CaCO_3$
pH = 8.2
Hardness 104 mg/L $CaCO_3$
Turbidity - 2.81 NTU
Conductivity = 423 µS
phosphate 0.04 mg/L PO_4^{3-}
Nitrate 0.1mg/L NO_3^-

Site 4

Alkalinity 120 mg/L $CaCO_3$
pH = 8.1
Hardness 112mg/L $CaCO_3$
phosphate 0.20 mg/L PO_4^{3-}
Conductivity 542µS
Nitrate - 0.06mg/L NO_3^-
Turbidity - 3.22 NTU

Filtration Blank

Alkalinity - 23mg/L $CaCO_3$
pH = 9.4
Hardness 1mg/L $CaCO_3$
phosphate 0.02mg/L PO_4^{3-}
Conductivity - 0.47
Nitrate - 0.11mg/L NO_3^-
Turbidity - 0.47 NTU

Beck Creek Invertebrates Nov 16 2022

Filtration Blank: Clean

Site 4

Mayfly ||
Scud 𝍸 𝍸
water penny |

Site 2

Scud 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 |
Leech ||
Caddisfly 𝍸 |||
Stonefly 𝍸 𝍸
Aquatic worm ||
Mayfly larva 𝍸 ||
Alder fly |
Horse fly larva |
Midge ||
Aquatic Sowbug ||
unknown |

Site 3

Mayfly ||||
Stonefly 𝍸
Scud ||
Diving beetle |

2.0 ALS Results

October 26, 2022

1	**Results Summary VA22C6261**					
2						
3	**Project**					
4	**Report To**	Owen Hargrove, Vancouver Island University				
5	**Date Received**	27-Oct-2022 12:00				
6	**Issue Date**	07-Nov-2022 12:36				
7	**Amendment**	0				
8						
9	Client Sample ID			Beck Creek -Site 1	Beck Creek -Site 2	Beck Creek -Site 3
10	Date Sampled			26-Oct-2022	26-Oct-2022	26-Oct-2022
11	Time Sampled			10:25	09:50	11:40
12	ALS Sample ID			VA22C6261-001	VA22C6261-002	VA22C6261-003
13	Analyte	Lowest Detection Limit	Units	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water
15	**Physical Tests (Matrix: Water)**					
16	conductivity	2.0	µS/cm	379	395	384
17	hardness (as CaCO3), from total Ca/Mg	0.50	mg/L	130	127	120
18	pH	0.10	pH units	7.66	7.89	8.19
19						
20	**Anions and Nutrients (Matrix: Water)**					
21	ammonia, total (as N)	0.0050	mg/L	0.0303	0.0123	0.0082
22	nitrate (as N)	0.0050	mg/L	<0.0050	<0.0050	<0.0050
23	nitrite (as N)	0.0010	mg/L	<0.0010	<0.0010	<0.0010
24	nitrogen, total	0.030	mg/L	0.551	0.363	0.334
25	phosphate, ortho-, dissolved (as P)	0.0010	mg/L	0.0108	0.0060	0.0079
26	phosphorus, total	0.0020	mg/L	0.0758	0.0267	0.0214
27						
28	**Total Metals (Matrix: Water)**					
29	aluminum, total	0.0030	mg/L	0.200	0.0240	0.0139

13	Analyte	Lowest Detection Limit	Units	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water
28	**Total Metals (Matrix: Water)**					
29	aluminum, total	0.0030	mg/L	0.200	0.0240	0.0139
30	antimony, total	0.00010	mg/L	<0.00010	<0.00010	<0.00010
31	arsenic, total	0.00010	mg/L	0.00047	0.00024	0.00027
32	barium, total	0.00010	mg/L	0.0605	0.0481	0.0363
33	beryllium, total	0.000020	mg/L	<0.000020	<0.000020	<0.000020
34	bismuth, total	0.000050	mg/L	<0.000050	<0.000050	<0.000050
35	boron, total	0.010	mg/L	0.116	0.119	0.111
36	cadmium, total	0.0000050	mg/L	0.0000874	<0.0000050	0.0000070
37	calcium, total	0.050	mg/L	37.8	37.5	35.3
38	cesium, total	0.000010	mg/L	0.000020	<0.000010	0.000012
39	chromium, total	0.00050	mg/L	0.00062	<0.00050	<0.00050
40	cobalt, total	0.00010	mg/L	0.00029	<0.00010	<0.00010
41	copper, total	0.00050	mg/L	0.00073	<0.00050	0.00055
42	iron, total	0.010	mg/L	2.30	0.403	0.215

9	Client Sample ID			Beck Creek -Site 1	Beck Creek -Site 2	Beck Creek -Site 3
10	Date Sampled			26-Oct-2022	26-Oct-2022	26-Oct-2022
11	Time Sampled			10:25	09:50	11:40
12	ALS Sample ID			VA22C6261-001	VA22C6261-002	VA22C6261-003
13	Analyte	Lowest Detection Limit	Units	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water
43	lead, total	0.000050	mg/L	0.000191	<0.000050	<0.000050
44	lithium, total	0.0010	mg/L	0.0050	0.0047	0.0040
45	magnesium, total	0.0050	mg/L	8.57	8.16	7.85
46	manganese, total	0.00010	mg/L	0.261	0.0733	0.0332
47	molybdenum, total	0.000050	mg/L	0.000199	0.000164	0.000173
48	nickel, total	0.00050	mg/L	0.00131	0.00067	0.00059
49	phosphorus, total	0.050	mg/L	0.094	<0.050	<0.050
50	potassium, total	0.050	mg/L	1.72	1.97	1.79
51	rubidium, total	0.00020	mg/L	0.00236	0.00204	0.00164
52	selenium, total	0.000050	mg/L	0.000054	0.000060	<0.000050
53	silicon, total	0.10	mg/L	9.21	8.35	7.14
54	silver, total	0.000010	mg/L	<0.000010	<0.000010	0.000010
55	sodium, total	0.050	mg/L	34.6	40.0	39.3
56	strontium, total	0.00020	mg/L	0.474	0.479	0.466
57	sulfur, total	0.50	mg/L	2.44	4.38	2.90

13	Analyte	Lowest Detection Limit	Units	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water
58	tellurium, total	0.00020	mg/L	<0.00020	<0.00020	<0.00020
59	thallium, total	0.000010	mg/L	<0.000010	<0.000010	<0.000010
60	thorium, total	0.00010	mg/L	<0.00010	<0.00010	<0.00010
61	tin, total	0.00010	mg/L	<0.00010	<0.00010	<0.00010
62	titanium, total	0.00030	mg/L	0.00936	0.00144	0.00081
63	tungsten, total	0.00010	mg/L	<0.00010	<0.00010	<0.00010
64	uranium, total	0.000010	mg/L	0.000025	0.000024	0.000043
65	vanadium, total	0.00050	mg/L	0.00155	<0.00050	<0.00050
66	zinc, total	0.0030	mg/L	<0.0030	<0.0030	<0.0030
67	zirconium, total	0.00020	mg/L	<0.00020	<0.00020	<0.00020

Nov 16, 2022

Results Summary VA22C8006

Project											
Report To	Owen Hargrove, Vancouver Island University										
Date Received	17-Nov-2022 11:00										
Issue Date	28-Nov-2022 12:10										
Amendment	0										
Client Sample ID			Richards Creek Site 2	Richards Creek Site 3	Richards Creek Site 4	Englishman River Site 2	Englishman River Site 3	Englishman River Site 4	Beck Creek Site 1	Beck Creek Site 2	Beck Creek Site 3
Date Sampled			16-Nov-2022	16-Nov-2022	16-Nov-2022	16-Nov-2022	16-Nov-2022	16-Nov-2022	16-Nov-2022	16-Nov-2022	16-Nov-2022
Time Sampled			10:05	09:42	09:13	09:11	08:56	08:42	10:00	09:41	10:30
ALS Sample ID			VA22C8006-001	VA22C8006-002	VA22C8006-003	VA22C8006-004	VA22C8006-005	VA22C8006-006	VA22C8006-007	VA22C8006-008	VA22C8006-009
Analyte	Lowest Detection Limit	Units	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water
Physical Tests (Matrix: Water)											
conductivity	2.0	µS/cm	195	204	211	99.3	97.6	105	423	420	414
hardness (as CaCO3), from total Ca/Mg	0.50	mg/L	74.8	79.0	79.3	31.2	31.1	37.4	101	98.7	95.8
pH	0.10	pH units	7.53	7.56	6.90	7.18	7.17	7.26	7.47	7.63	7.99
Anions and Nutrients (Matrix: Water)											
ammonia, total (as N)	0.0050	mg/L	0.0064	0.0072	0.248	<0.0050	0.0075	0.0080	0.0763	0.0493	0.0160
nitrate (as N)	0.0050	mg/L	0.878	0.965	0.377	0.0565	0.0502	0.0833	<0.0050	0.0181	0.0087
nitrite (as N)	0.0010	mg/L	0.0015	0.0016	0.0165	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0022
nitrogen, total	0.030	mg/L	0.978	1.10	1.38	0.173	0.103	0.139	0.429	0.486	0.389
phosphate, ortho-, dissolved (as P)	0.0010	mg/L	0.0014	0.0043	0.0580	<0.0010	<0.0010	<0.0010	0.0194	0.0174	0.0116
phosphorus, total	0.0020	mg/L	0.0077	0.0142	0.137	0.0034	0.0048	0.0043	0.0417	0.0446	0.0241

Client Sample ID			Richards Creek Site 2	Richards Creek Site 3	Richards Creek Site 4	Englishman River Site 2	Englishman River Site 3	Englishman River Site 4	Beck Creek Site 1	Beck Creek Site 2	Beck Creek Site 3
Date Sampled			16-Nov-2022	16-Nov-2022	16-Nov-2022	16-Nov-2022	16-Nov-2022	16-Nov-2022	16-Nov-2022	16-Nov-2022	16-Nov-2022
Time Sampled			10:05	09:42	09:13	09:11	08:56	08:42	10:00	09:41	10:30
ALS Sample ID			VA22C8006-001	VA22C8006-002	VA22C8006-003	VA22C8006-004	VA22C8006-005	VA22C8006-006	VA22C8006-007	VA22C8006-008	VA22C8006-009
Analyte	Lowest Detection Limit	Units	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water
Total Metals (Matrix: Water)											
aluminum, total	0.0030	mg/L	0.0326	0.0324	0.0834	0.148	0.0448	0.0496	0.0232	0.145	0.0143
antimony, total	0.00010	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
arsenic, total	0.00010	mg/L	0.00016	0.00018	0.00034	0.00017	0.00014	0.00015	0.00027	0.00030	0.00023
barium, total	0.00010	mg/L	0.0110	0.0111	0.0140	0.00696	0.00616	0.00654	0.0504	0.0488	0.0388
beryllium, total	0.000020	mg/L	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
bismuth, total	0.000050	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
boron, total	0.010	mg/L	0.013	0.012	0.019	0.012	0.012	0.012	0.111	0.110	0.102
cadmium, total	0.0000050	mg/L	<0.0000050	<0.0000050	0.0000141	0.0000112	0.0000113	<0.0000050	0.0000061	0.0000072	0.000581
calcium, total	0.050	mg/L	20.6	21.2	22.8	10.6	10.6	11.9	29.2	28.8	28.0
cesium, total	0.000010	mg/L	<0.000010	<0.000010	<0.000010	0.000012	<0.000010	<0.000010	<0.000010	0.000014	<0.000010
chromium, total	0.00050	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
cobalt, total	0.00010	mg/L	0.00010	<0.00010	0.00032	0.00011	<0.00010	<0.00010	0.00013	0.00021	<0.00010
copper, total	0.00050	mg/L	0.00068	0.00077	0.00141	0.00091	0.00088	0.00147	0.00100	0.00090	0.00131
iron, total	0.010	mg/L	0.144	0.123	0.715	0.280	0.118	0.129	0.914	1.01	0.386

Client Sample ID			Richards Creek Site 2	Richards Creek Site 3	Richards Creek Site 4	Englishman River Site 2	Englishman River Site 3	Englishman River Site 4	Beck Creek Site 1	Beck Creek Site 2	Beck Creek Site 3
Date Sampled			16-Nov-2022	16-Nov-2022	16-Nov-2022	16-Nov-2022	16-Nov-2022	16-Nov-2022	16-Nov-2022	16-Nov-2022	16-Nov-2022
Time Sampled			10:05	09:42	09:13	09:11	08:56	08:42	10:00	09:41	10:30
ALS Sample ID			VA22C8006-001	VA22C8006-002	VA22C8006-003	VA22C8006-004	VA22C8006-005	VA22C8006-006	VA22C8006-007	VA22C8006-008	VA22C8006-009
Analyte	Lowest Detection Limit	Units	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water
lead, total	0.000050	mg/L	<0.000050	<0.000050	0.000093	0.000078	0.000053	0.000322	0.000059	0.000138	<0.000050
lithium, total	0.0010	mg/L	<0.0010	<0.0010	<0.0010	0.0034	0.0033	0.0031	0.0050	0.0050	0.0046
magnesium, total	0.0050	mg/L	5.67	6.32	5.43	1.14	1.13	1.88	6.76	6.51	6.28
manganese, total	0.00010	mg/L	0.0575	0.0146	0.175	0.00908	0.00421	0.00448	0.145	0.106	0.0222
molybdenum, total	0.000050	mg/L	0.000106	0.000105	0.000124	0.000101	0.000124	0.000120	0.000111	0.000139	0.000115
nickel, total	0.00050	mg/L	<0.00050	<0.00050	0.00053	<0.00050	<0.00050	<0.00050	0.00064	0.00085	0.00056
phosphorus, total	0.050	mg/L	<0.050	<0.050	0.138	<0.050	<0.050	<0.050	0.054	0.056	<0.050
potassium, total	0.050	mg/L	0.727	0.851	1.96	0.157	0.162	0.224	1.90	1.88	2.06
rubidium, total	0.00020	mg/L	0.00054	0.00061	0.00160	0.00028	0.00021	0.00023	0.00162	0.00161	0.00164
selenium, total	0.000050	mg/L	<0.000050	<0.000050	0.000059	<0.000050	<0.000050	0.000063	<0.000050	0.000050	<0.000050
silicon, total	0.10	mg/L	9.68	9.48	7.65	2.77	2.64	3.22	7.50	7.59	6.97
silver, total	0.000010	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
sodium, total	0.050	mg/L	8.31	8.16	8.75	5.83	6.14	6.08	56.9	54.4	50.9
strontium, total	0.00020	mg/L	0.0804	0.0890	0.0989	0.0525	0.0514	0.0546	0.384	0.364	0.348
sulfur, total	0.50	mg/L	4.69	5.09	8.44	<0.50	0.54	0.63	5.01	5.37	5.14

Client Sample ID			Richards Creek Site 2	Richards Creek Site 3	Richards Creek Site 4	Englishman River Site 2	Englishman River Site 3	Englishman River Site 4	Beck Creek Site 1	Beck Creek Site 2	Beck Creek Site 3
Date Sampled			16-Nov-2022	16-Nov-2022	16-Nov-2022	16-Nov-2022	16-Nov-2022	16-Nov-2022	16-Nov-2022	16-Nov-2022	16-Nov-2022
Time Sampled			10:05	09:42	09:13	09:11	08:56	08:42	10:00	09:41	10:30
ALS Sample ID			VA22C8006-001	VA22C8006-002	VA22C8006-003	VA22C8006-004	VA22C8006-005	VA22C8006-006	VA22C8006-007	VA22C8006-008	VA22C8006-009
Analyte	Lowest Detection Limit	Units	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water	Sub-Matrix: Water
tellurium, total	0.00020	mg/L	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
thallium, total	0.000010	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
thorium, total	0.00010	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
tin, total	0.00010	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00019	<0.00010	<0.00010	<0.00010
titanium, total	0.00030	mg/L	0.00140	0.00119	0.00326	0.00666	0.00145	0.00234	0.00113	0.00707	0.00057
tungsten, total	0.00010	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
uranium, total	0.000010	mg/L	0.000011	0.000016	<0.000010	0.000011	<0.000010	0.000023	0.000035	0.000036	0.000029
vanadium, total	0.00050	mg/L	0.00059	0.00050	0.00070	0.00079	<0.00050	0.00060	0.00056	0.00110	<0.00050
zinc, total	0.0030	mg/L	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	0.0046	<0.0030	<0.0030	<0.0030
zirconium, total	0.00020	mg/L	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020

3.0 Hydrology Calculations

Formulas:

Velocity = Distance (m) / Time (s)

Discharge = Velocity (m/s) x Depth (m) x Width (m) x 0.75

November 16th, 2022:

Site 2 –

Velocity = 10 m / 74.12 s

= 0.135 m/s

Discharge = (0.135m/s) x (0.51m) x (5.4m) x (0.75)

= 0.279 m^3/s

Site 3 –

Velocity = 10 m / 55.08 s

= 0.182 m/s

Discharge = (0.182m/s) x (0.267m) x (3.5m) x (0.75)

= 0.128 m^3/s

Site 4 –

Velocity = 10 m / 96.5 s

= 0.104 m/s

Discharge = (0.104m/s) x (0.26m) x (4.76m) x (0.75)

= 0.097 m^3/s

4.0 Stream Invertebrates; Shanon-Weinner Diversity Index

Site 2: October 26th, 2022

Invertebrate Common Names	Number of Taxa	Number of Individuals (ni)	Relative Abundance (pi)	ln pi	pi(ln pi)
Caddisfly Larva	1	3	0.111	-2.197224577	-0.244136064
Mayfly Nymph	1	2	0.074	-2.602689685	-0.192791829
Stonefly Nymph	1	0	0.000	#NUM!	#NUM!
Gilled Snail	1	0	0.000	#NUM!	#NUM!
Clam, Mussel\	1	0	0.000	#NUM!	#NUM!
Cranefly Larva	1	0	0.000	#NUM!	#NUM!
Crayfish	1	0	0.000	#NUM!	#NUM!
Damselfly Larva	1	0	0.0000	#NUM!	#NUM!
Scub (Amphiod)	1	19	0.7037	-0.351397887	-0.247279994
Aquatic Worm	1	3	0.1111	-2.197224577	-0.244136064
Blackfly Larva	1	0	0.0000	#NUM!	#NUM!
Midge Larva	1	0	0.0000	#NUM!	#NUM!
Total(s)	12	27	1.000		
				Shanon-Weinner Diversity Index	**0.928343951**
				Evenness	**0.309888824**

Site 2: November 16th, 2022

Invertebrate Common Names	Number of Taxa	Number of Individuals (ni)	Relative Abundance (pi)	ln pi	pi(ln pi)
Caddisfly Larva	1	8	0.075	-2.593387293	-0.193898115
Mayfly Nymph	1	7	0.065	-2.726918685	-0.17839655
Stonefly Nymph	1	10	0.093	-2.370243741	-0.221518107
Leech	1	2	0.019	-3.979681654	-0.074386573
Alderfly Larva	1	1	0.009	-4.672828834	-0.043671298
Cranefly Larva	1	0	0.000	#NUM!	#NUM!
Crayfish	1	0	0.000	#NUM!	#NUM!
Damselfly Larva	1	0	0.0000	#NUM!	#NUM!
Scub (Amphiod)	1	71	0.6636	-0.410148957	-0.272154916
Aquatic Worm	1	2	0.0187	-3.979681654	-0.074386573
Aquatic Snowbug	1	2	0.0187	-3.979681654	-0.074386573
Other	1	2	0.0187	-3.979681654	-0.074386573
Midge Larva	1	2	0.0187	-3.979681654	-0.074386573
Total(s)	13	107	1.000		
				Shanon-Weinner Diversity Index	**1.28157185**
				Evenness	**0.427799193**

Site 3: October 26th, 2022

Invertebrate Common Names	Number of Taxa	Number of Individuals (ni)	Relative Abundance (pi)	ln pi	pi(ln pi)
Caddisfly Larva	1	0	0.000	#NUM!	#NUM!
Mayfly Nymph	1	0	0.000	#NUM!	#NUM!
Stonefly Nymph	1	1	0.038	-3.258096538	-0.125311405
Leech	1	0	0.000	#NUM!	#NUM!
Alderfly Larva	1	0	0.000	#NUM!	#NUM!
Cranefly Larva	1	0	0.000	#NUM!	#NUM!
Crayfish	1	0	0.000	#NUM!	#NUM!
Damselfly Larva	1	0	0.0000	#NUM!	#NUM!
Scub (Amphiod)	1	23	0.8846	-0.122602322	-0.1084559
Aquatic Worm	1	2	0.0769	-2.564949357	-0.197303797
Aquatic Snowbug	1	0			
Blackfly Larva	1	0	0.0000	#NUM!	#NUM!
Midge Larva	1	0	0.0000	#NUM!	#NUM!
Total(s)	13	26	1.000		
				Shanon-Weinner Diversity Index	**0.431071102**
				Evenness	**0.143895069**

Site 3: November 16th, 2022

Invertebrate Common Names	Number of Taxa	Number of Individuals (ni)	Relative Abundance (pi)	ln pi	pi(ln pi)
Caddisfly Larva	1	0	0.000	#NUM!	#NUM!
Mayfly Nymph	1	4	0.333	-1.098612289	-0.366204096
Stonefly Nymph	1	5	0.417	-0.875468737	-0.364778641
Leech	1	0	0.000	#NUM!	#NUM!
Aquatic Beatle	1	1	0.083	-2.48490665	-0.207075554
Cranefly Larva	1	0	0.000	#NUM!	#NUM!
Crayfish	1	0	0.000	#NUM!	#NUM!
Damselfly Larva	1	0	0.0000	#NUM!	#NUM!
Scub (Amphiod)	1	2	0.1667	-1.791759469	-0.298626578
Aquatic Worm	1		0.0000	#NUM!	#NUM!
Aquatic Snowbug	1	0			
Blackfly Larva	1	0	0.0000	#NUM!	#NUM!
Midge Larva	1	0	0.0000	#NUM!	#NUM!
Total(s)	13	12	1.000		
				Shanon-Weinner Diversity Index	**1.236684869**
				Evenness	**0.412815551**

Site 4: October 26th, 2022

Invertebrate Common Names	Number of Taxa	Number of Individuals (ni)	Relative Abundance (pi)	ln pi	pi(ln pi)
Caddisfly Larva	1	0	0.000	#NUM!	#NUM!
Mayfly Nymph	1	2	0.080	-2.525728644	-0.202058292
Stonefly Nymph	1	0	0.000	#NUM!	#NUM!
Water Penny	1	8	0.320	-1.139434283	-0.364618971
Aquatic Beatle	1	0	0.000	#NUM!	#NUM!
Cranefly Larva	1	0	0.000	#NUM!	#NUM!
Crayfish	1	0	0.000	#NUM!	#NUM!
Damselfly Larva	1	0	0.0000	#NUM!	#NUM!
Scub (Amphiod)	1	13	0.5200	-0.653926467	-0.340041763
Aquatic Worm	1	2	0.0800	-2.525728644	-0.202058292
Aquatic Snowbug	1	0			
Blackfly Larva	1	0	0.0000	#NUM!	#NUM!
Midge Larva	1	0	0.0000	#NUM!	#NUM!
Total(s)	13	25	1.000		
				Shanon-Weinner Diversity Index	**1.108777317**
				Evenness	**0.370118961**

Site 4: November 16th, 2022

Invertebrate Common Names	Number of Taxa	Number of Individuals (ni)	Relative Abundance (pi)	ln pi	pi(ln pi)
Caddisfly Larva	1	0	0.000	#NUM!	#NUM!
Mayfly Nymph	1	2	0.154	-1.871802177	-0.287969566
Stonefly Nymph	1	0	0.000	#NUM!	#NUM!
Water Penny	1	1	0.077	-2.564949357	-0.197303797
Aquatic Beatle	1	0	0.000	#NUM!	#NUM!
Cranefly Larva	1	0	0.000	#NUM!	#NUM!
Crayfish	1	0	0.000	#NUM!	#NUM!
Damselfly Larva	1	0	0.0000	#NUM!	#NUM!
Scub (Amphiod)	1	10	0.7692	-0.262364264	-0.201818665
Aquatic Worm	1	0	0.0000	#NUM!	#NUM!
Aquatic Snowbug	1	0			
Blackfly Larva	1	0	0.0000	#NUM!	#NUM!
Midge Larva	1	0	0.0000	#NUM!	#NUM!
Total(s)	13	13	1.000		
				Shanon-Weinner Diversity Index	**0.687092027**
				Evenness	**0.229356953**

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: Beck Creek		Date: October 26th, 2022	
Station Name: Sample Site 3		Flow status: Low/Not Measurable	
Sampler Used: Hess Sampler	Number of replicates: 3	Total area sampled (Hess, Surber = 0.09 m²) x no. replicates	0.27 m²

Column A	Column B	Column C		Column D	
Pollution Tolerance	**Common Name**	**Number Counted**		**Number of Taxa**	
	Caddisfly Larva (EPT)	EPT1		EPT4	
Category 1	Mayfly Nymph (EPT)	EPT2		EPT5	
	Stonefly Nymph (EPT)	EPT3	1	EPT6	1
	Dobsonfly (hellgrammite)				
Pollution Intolerant	Gilled Snail				
	Riffle Beetle				
	Water Penny				
Sub-Total		C1	1	D1	1
	Alderfly Larva				
Category 2	Aquatic Beetle				
	Aquatic Sowbug				
	Clam, Mussel				
	Cranefly Larva				
	Crayfish				
Somewhat Pollution Tolerant	Damselfly Larva				
	Dragonfly Larva				
	Fishfly Larva				
	Amphipod (freshwater shrimp)	23		1	
	Watersnipe Larva				
Sub-Total		C2	23	D2	1
	Aquatic Worm (oligochaete)	2		1	
Category 3	Blackfly Larva				
	Leech				
	Midge Larva (chironomid)				
Pollution Tolerant	Planarian (flatworm)				
	Pouch and Pond Snails				
	True Bug Adult				
	Water Mite				
Sub-Total		C3	2	D3	1
TOTAL	1 = Unknown	CT	27	DT	3

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: CT = 27

DENSITY: Invertebrate density per total area sampled:

27 ÷ 0.27 (From page 1) m^2 = 0.27 / m^2

PREDOMINANT TAXON

S1 = Amphipod

Invertebrate group with the highest number counted (in Col. C)

SECTION 2 - WATER QUALITY ASSESSMENTS

POLLUTION TOLERANCE INDEX: Sub-total number of taxa found in each tolerance category.

Good	Acceptable	Marginal	Poor	3 x D1 + 2 x D2 + D3	S2
>22	22-17	16-11	<11	3 x 1 + 2 x 1 + 1 =	6

EPT INDEX: Total number of EPT taxa.

Good	Acceptable	Marginal	Poor	EPT4 + EPT5 + EPT6	S3
>8	5-8	2-4	0-1	0 + 0 + 1 =	1

EPT TO TOTAL RATIO INDEX: Total number of EPT organisms divided by the total number of organisms.

Good	Acceptable	Marginal	Poor	(EPT1 + EPT2 + EPT3) / CT	S4
0.75-1.0	0.50-0.74	0.25-0.49	<0.25	(0 + 0 + 1) / 27 =	0.04

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 3

PREDOMINANT TAXON RATIO INDEX: Number of invertebrate in the **predominant taxon** (S1) divided by CT.

Good	Acceptable	Marginal	Poor	Col. C for S1 / CT	S5
<0.40	0.40-0.59	0.60-0.79	0.80-1.0	23 / 27 =	0.85

SECTION 4 - OVERALL SITE ASSESSMENT RATING

SITE ASSESSMENT RATING: Assign a rating of 1-4 to each index (S2, S3, S4, S5), then calculate the average.

Assessment Rating	
Good	4
Acceptable	3
Marginal	2
Poor	1

Assessment	Rating		Average Rating
Pollution Tolerance Index	R1	1	Average of R1, R2, R3, R4
EPT Index	R2	1	1
EPT To Total Ratio	R3	1	
Predominant Taxon Ratio	R4	1	

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:		Date:
Beck Creek		October 26th, 2022
Station Name:		**Flow status:**
Sample Site 4		Low/Not Measurable
Sampler Used:	**Number of replicates**	**Total area sampled (Hess, Surber = 0.09 m²) x no. replicates**
Hess Sampler	2	0.18 m²

Column A	Column B	Column C	Column D
Pollution Tolerance	**Common Name**	**Number Counted**	**Number of Taxa**
	Caddisfly Larva (EPT)	EPT1	EPT4
Category 1	Mayfly Nymph (EPT)	EPT2 2	EPT5 1
	Stonefly Nymph (EPT)	EPT3	EPT6
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny	8	1
Sub-Total		C1 10	D1 2
	Alderfly Larva		
Category 2	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva		
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	13	1
	~~Watercpipe~~ Larva		
Sub-Total		C2 13	D2 1
	Aquatic Worm (oligochaete)	2	1
Category 3	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
Pollution Tolerant	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		C3 2	D3 1
TOTAL		CT 25	DT 4

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: CT 25

DENSITY: Invertebrate density per total area sampled:

25 ÷ 0.18 m² (From page 1) = 138.9 / m²

PREDOMINANT TAXON: S1

Invertebrate group with the highest number counted (in Col. C): Amphipod

SECTION 2 - WATER QUALITY ASSESSMENTS

POLLUTION TOLERANCE INDEX: Sub-total number of taxa found in each tolerance category.

Good	Acceptable	Marginal	Poor	3 x D1 + 2 x D2 + D3	S2
>22	22-17	16-11	<11	3 x 2 + 2 x 1 + 1 =	9

EPT INDEX: Total number of EPT taxa.

Good	Acceptable	Marginal	Poor	EPT4 + EPT5 + EPT6	S3
>8	5-8	2-4	0-1	0 + 1 + 0 =	1

EPT TO TOTAL RATIO INDEX: Total number of EPT organisms divided by the total number of organisms.

Good	Acceptable	Marginal	Poor	(EPT1 + EPT2 + EPT3) / CT	S4
0.75-1.0	0.50-0.74	0.25-0.49	<0.25	(0 + 2 + 0) / 25 =	0.08

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 4

PREDOMINANT TAXON RATIO INDEX: Number of ~~invertebrate~~ in the **predominant taxon** (S1) divided by CT.

Good	Acceptable	Marginal	Poor	Col. C for S1 / CT	S5
<0.40	0.40-0.59	0.60-0.79	0.80-1.0	13 / 25 =	0.52

SECTION 4 - OVERALL SITE ASSESSMENT RATING

SITE ASSESSMENT RATING: Assign a rating of 1-4 to each index (S2, S3, S4, S5), then calculate the average.

Assessment	Rating
Good	4
Acceptable	3
Marginal	2
Poor	1

Assessment		Rating	Average Rating
Pollution Tolerance Index	R1	1	Average of R1, R2, R3, R4
EPT Index	R2	1	1.5
EPT To Total Ratio	R3	1	
Predominant Taxon Ratio	R4	3	

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:		Date:
Beck Creek		November 16th, 2022
Station Name:		**Flow status:**
Sample Site 2		Low
Sampler Used:	**Number of replicates**	**Total area sampled (Hess, Surber = 0.09 m²) x no. replicates**
Hess Sampler	3	0.27 m²

Column A	Column B	Column C	Column D
Pollution Tolerance	**Common Name**	**Number Counted**	**Number of Taxa**
	Caddisfly Larva (EPT)	EPT1 8	EPT4 1
Category 1	Mayfly Nymph (EPT)	EPT2 7	EPT5 1
	Stonefly Nymph (EPT)	EPT3 10	EPT6 1
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		C1 25	D1 3
	Alderfly Larva	1	1
Category 2	Aquatic Beetle		
	Aquatic Sowbug	2	1
	Clam, Mussel		
	Cranefly Larva		
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	71	1
	Watersnipe Larva		
Sub-Total		C2 74	D2 3
	Aquatic Worm (oligochaete)	2	1
Category 3	Blackfly Larva		
	Leech	2	1
	Midge Larva (chironomid)	2	1
	Planarian (flatworm)		
Pollution Tolerant	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		C3 6	D3 3
TOTAL	2 - Other	CT 107	DT 9

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: CT 107

DENSITY: Invertebrate density per total area sampled:

107 ÷ From page 1: 0.27 m^2 = 396.30 / m^2

PREDOMINANT TAXON: S1 Amphipod

Invertebrate group with the highest number counted (in Col. C)

SECTION 2 - WATER QUALITY ASSESSMENTS

POLLUTION TOLERANCE INDEX: Sub-total number of taxa found in each tolerance category.

Good	Acceptable	Marginal	Poor
>22	22-17	16-11	<11

3 x D1 + 2 x D2 + D3: 3 x 3 + 2 x 3 + 3 = S2 18

EPT INDEX: Total number of EPT taxa.

Good	Acceptable	Marginal	Poor
>8	5-8	2-4	0-1

EPT4 + EPT5 + EPT6: 1 + 1 + 1 = S3 3

EPT TO TOTAL RATIO INDEX: Total number of EPT organisms divided by the total number of organisms.

Good	Acceptable	Marginal	Poor
0.75-1.0	0.50-0.74	0.25-0.49	<0.25

(EPT1 + EPT2 + EPT3) / CT: (8 + 7 + 10) / 107 = S4 0.234

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 9

PREDOMINANT TAXON RATIO INDEX: Number of invertebrate in the **predominant taxon** (S1) divided by CT.

Good	Acceptable	Marginal	Poor
<0.40	0.40-0.59	0.60-0.79	0.80-1.0

Col. C for S1 / CT: 71 / 107 = S5 0.66

SECTION 4 - OVERALL SITE ASSESSMENT RATING

SITE ASSESSMENT RATING: Assign a rating of 1-4 to each index (S2, S3, S4, S5), then calculate the average.

Assessment Rating	
Good	4
Acceptable	3
Marginal	2
Poor	1

Assessment	Rating	Average Rating
Pollution Tolerance Index	R1 3	Average of R1, R2, R3, R4
EPT Index	R2 2	2
EPT To Total Ratio	R3 1	
Predominant Taxon Ratio	R4 2	

Nov 16, 2022

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:		Date:
Beck Creek		November 16th, 2022
Station Name:		**Flow status:**
Sample Site 3		Low

Sampler Used:	Number of replicates	Total area sampled (Hess, Surber = 0.09 m²) x no. replicates
Hess Sampler	3	0.27 m²

Column A	Column B	Column C	Column D
Pollution Tolerance	**Common Name**	**Number Counted**	**Number of Taxa**
	Caddisfly Larva (EPT)	EPT1	EPT4
Category 1	Mayfly Nymph (EPT)	EPT2 4	EPT5 1
	Stonefly Nymph (EPT)	EPT3 5	EPT6 1
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		C1 9	D1 2
	Alderfly Larva		
Category 2	Aquatic Beetle	1	1
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva		
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	2	1
	Watersnipe Larva		
Sub-Total		C2 3	D2 2
	Aquatic Worm (oligochaete)		
Category 3	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
	Planarian (flatworm)		
Pollution Tolerant	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		C3	D3
TOTAL		CT 12	DT 4

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: CT = 12

DENSITY: Invertebrate density per total area sampled:

12 ÷ (From page 1) 0.27 m² = 44.45 / m²

PREDOMINANT TAXON

Invertebrate group with the highest number counted (in Col. C): S1 = Stone Fly

SECTION 2 - WATER QUALITY ASSESSMENTS

POLLUTION TOLERANCE INDEX: Sub-total number of taxa found in each tolerance category.

Good	Acceptable	Marginal	Poor
>22	22-17	16-11	<11

3 x D1 + 2 x D2 + D3

3 x 2 + 2 x 2 + _____ = S2 = 10

EPT INDEX: Total number of EPT taxa.

Good	Acceptable	Marginal	Poor
>8	5-8	2-4	0-1

EPT4 + EPT5 + EPT6

0 + 1 + 1 = S3 = 2

EPT TO TOTAL RATIO INDEX: Total number of EPT organisms divided by the total number of organisms.

Good	Acceptable	Marginal	Poor
0.75-1.0	0.50-0.74	0.25-0.49	<0.25

(EPT1 + EPT2 + EPT3) / CT

(_____ + 4 + 5) / 12 = S4 = 0.75

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: DT = 4

PREDOMINANT TAXON RATIO INDEX: Number of invertebrate in the **predominant taxon** (S1) divided by CT.

Good	Acceptable	Marginal	Poor
<0.40	0.40-0.59	0.60-0.79	0.80-1.0

Col. C for S1 / CT

5 / 12 = S5 = 0.42

SECTION 4 - OVERALL SITE ASSESSMENT RATING

SITE ASSESSMENT RATING: Assign a rating of 1-4 to each index (S2, S3, S4, S5), then calculate the average.

Assessment Rating	
Good	4
Acceptable	3
Marginal	2
Poor	1

Assessment	Rating	Average Rating
Pollution Tolerance Index	R1 1	Average of R1, R2, R3, R4
EPT Index	R2 2	2.5
EPT To Total Ratio	R3 2	
Predominant Taxon Ratio	R4 4	
	5	

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Beck Creek	Date:	November 16th, 2022
Station Name:	Sample Site 4	Flow status:	Low

Sampler Used:	Number of replicates	Total area sampled (Hess, Surber = 0.09 m²) x no. replicates
Hess Sampler	2	0.18 m²

Column A	Column B	Column C	Column D
Pollution Tolerance	**Common Name**	**Number Counted**	**Number of Taxa**
	Caddisfly Larva (EPT)	EPT1	EPT4
Category 1	Mayfly Nymph (EPT)	EPT2 2	EPT5 1
	Stonefly Nymph (EPT)	EPT3	EPT6
	Dobsonfly (heligrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny	1	1
Sub-Total		C1 3	D1 2
	Alderfly Larva		
Category 2	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva		
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	10	1
	~~Waterpipe~~ Larva		
Sub-Total		C2 10	D2 1
	Aquatic Worm (oligochaete)		
Category 3	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
Pollution Tolerant	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		C3	D3
TOTAL		CT 13	DT 3

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: CT 13

DENSITY: Invertebrate density per total area sampled:

13 ÷ 0.18 m² = 72.22 / m² (0.18 From page 1)

PREDOMINANT TAXON: S1

Invertebrate group with the highest number counted (in Col. C): Amphipod

SECTION 2 - WATER QUALITY ASSESSMENTS

POLLUTION TOLERANCE INDEX: Sub-total number of taxa found in each tolerance category.

Good	Acceptable	Marginal	Poor	3 x D1 + 2 x D2 + D3	S2
>22	22-17	16-11	<11	3 x 2 + 2 x 1 + 0 = 8	8

EPT INDEX: Total number of EPT taxa.

Good	Acceptable	Marginal	Poor	EPT4 + EPT5 + EPT6	S3
>8	5-8	2-4	0-1	0 + 1 + 0 =	1

EPT TO TOTAL RATIO INDEX: Total number of EPT organisms divided by the total number of organisms.

Good	Acceptable	Marginal	Poor	(EPT1 + EPT2 + EPT3) / CT	S4
0.75-1.0	0.50-0.74	0.25-0.49	<0.25	(0 + 2 + 0) / 13 =	0.15

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: DT 3

PREDOMINANT TAXON RATIO INDEX: Number of ~~invertebrate~~ in the **predominant taxon** (S1) divided by CT.

Good	Acceptable	Marginal	Poor	Col. C for S1 / CT	S5
<0.40	0.40-0.59	0.60-0.79	0.80-1.0	10 / 13 =	0.77

SECTION 4 - OVERALL SITE ASSESSMENT RATING

SITE ASSESSMENT RATING: Assign a rating of 1-4 to each index (S2, S3, S4, S5), then calculate the average.

Assessment Rating		Assessment	Rating	Average Rating
Good	4	Pollution Tolerance Index	R1 2	Average of R1, R2, R3, R4
Acceptable	3	EPT Index	R2 1	1.25
Marginal	2	EPT To Total Ratio	R3 1	
Poor	1	Predominant Taxon Ratio	R4 2	