Water Quality and Stream Invertebrate Assessment for Beck Creek, Nanaimo, BC

(Fall, 2017)

Report Submitted to:

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RMOT 306: Environmental Monitoring

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Submitted on:

December 15, 2017

Executive Summary

In the fall of 2017, Beck Creek located in Nanaimo was monitored during two sampling events. These events took place on October 31, 2017 and November 22, 2017. The purpose of this report was to determine the health of Beck Creek and collect data to aid in the interpretation of the water quality. During the first sampling time hydrology, water quality, stream invertebrates, and microbiology were tested. During the second sampling time only water quality and hydrology were tested. The overall health of the creek was determined poor by indication of stream invertebrates. There was no breach in regulated limits present in any of the water samples taken, both confirmed by VIU in Nanaimo B.C. and ALS in Vancouver B.C. the only abnormality that was found was bismuth. Microbiology was analyzed and fell within the guidelines for most activities listed aside from drinkable water. This was surprising due to the eutrophication noticed within some of the slower moving water. Lastly the creek experienced some blockage of water flow that caused buildup of excess water leading to the blow out of many sections throughout the creek. There was evidence of beaver activity and garbage pileup from human interference.

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1.0 Introduction and Background

1.1 Project Overview

This document proposed the task of implementing an environmental monitoring project at Beck Creek, located in the south end of Nanaimo, BC. Under the supervision of Dr. Eric Demers, three resource management students from Vancouver Island University (VIU) will be conducted the field sampling for water quality and invertebrate analysis. The sampling occurred once up to 5 days before November 1, 2017 and once up to 5 days before November 22, 2017. Two sampling events took place during expected low-flow rates (late October) and high-flow rates (mid-November). This creek has the potential to provide spawning habitat to cutthroat trout (*Oncorhynchus clarkii)* and Coho salmon (*Oncorhynchus kisutch*). Studies on stream health have not been conducted in the past and current water quality and stream invertebrate assessment are not available. Beck Creek flows out of Beck Lake and flows downstream into the Nanaimo River Estuary south of the Chase River. Beck Creek is part of the Nanaimo River Watershed and South Area A (Figure 1). The 4 sampling sites are located downstream of Beck lake within the Regional District if Nanaimo, moving downstream towards the Nanaimo River Estuary (Figure 2). The data collected from the project will reveal current information on potential issues associated with agriculture, urbanization and industrial activity.

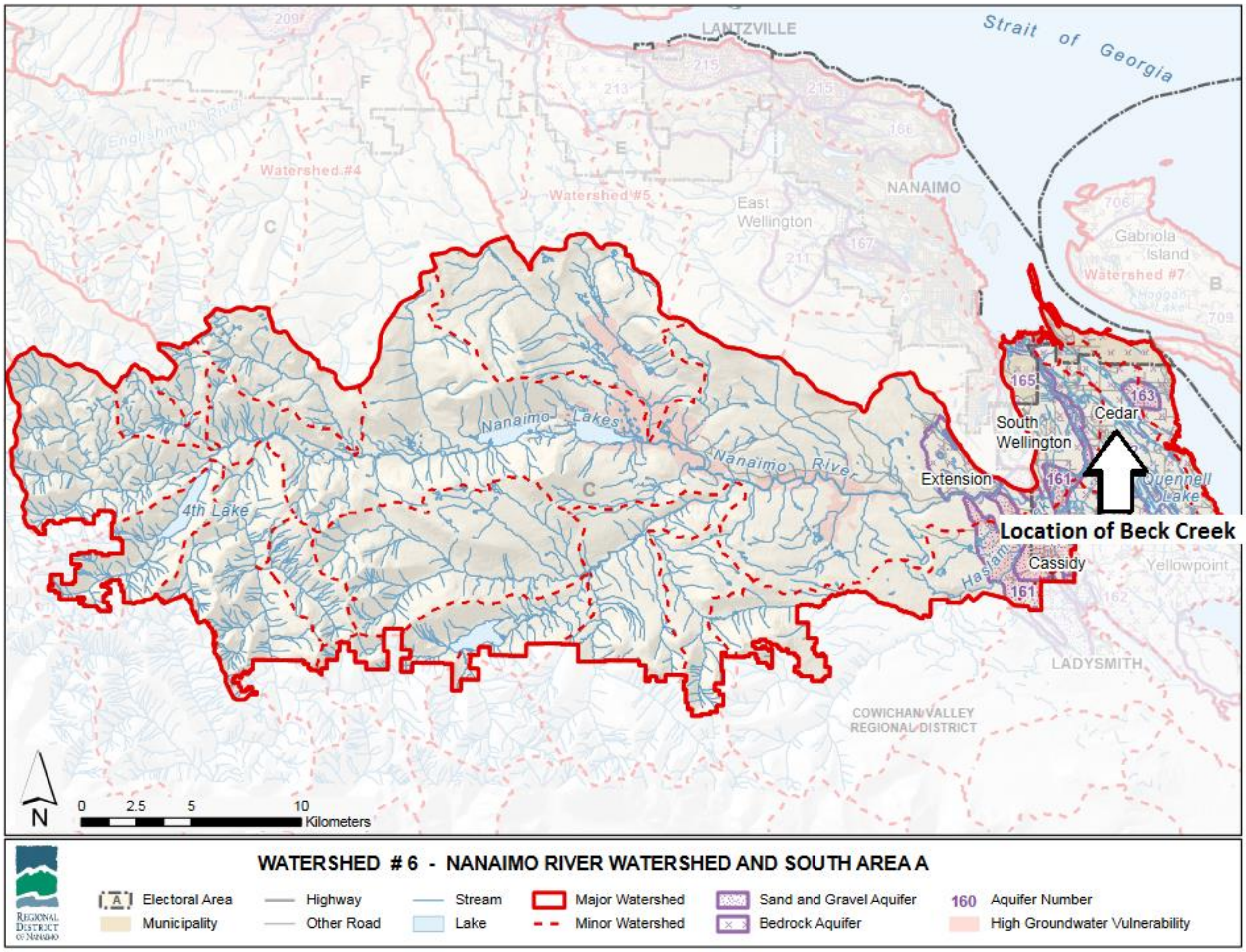

Figure 1: Map of the Nanaimo River Watershed and South Area A (map from Regional District of Nanaimo 2017)

1.2 Background

Beck Creek is located on the eastern side of Vancouver Island near South Nanaimo. It flows, in urban and semi-urban areas of Nanaimo, BC, from Beck Lake to the Nanaimo River Estuary. The Nanaimo River Estuary is Vancouver Island's largest estuary - a highly productive biological area, sandwiched by Duke Point to the East and downtown Nanaimo to the West. Beck Creek's total length from Beck Lake is 4.5km and has a drainage area of 6.7 km2 (Irvine et al. 1994). In past studies by DFO, the section of creek has historically been the lower 2.1 km of Beck Creek (below the beaver dam/pond). The lower section, DFO has completed some restoration near the lower section to improve fish access and spawning grounds. Richard Creek, Beck Creek's main tributary, enters approximately 1.1 kilometres upstream of the estuary mudflat (Irvine et al. 1994). However, there is no flow in Richard Creek for a short distance before it joins Beck Creek in the low flow periods (Cook & Baldwin 1994). Mean gradients are 1.96% as water flows from from Cedar Rd to the tidal mudflats, 0.41% from Cedar Road to Island Highway and 0.24% from the Island Highway to the beaver dam (30 m upstream of site 2) Figure 1). The channel is mainly cobble but is composed of fine gravels and sand in the upper level. The creek is also characterized by the presence of much large woody debris (Irvine et al. 1994). Stream flow downstream of Beck Lake are minimal in the summer. Therefore, the lake does not contribute to downstream flows in Beck Creek during the summer (Cook & Baldwin 1994)

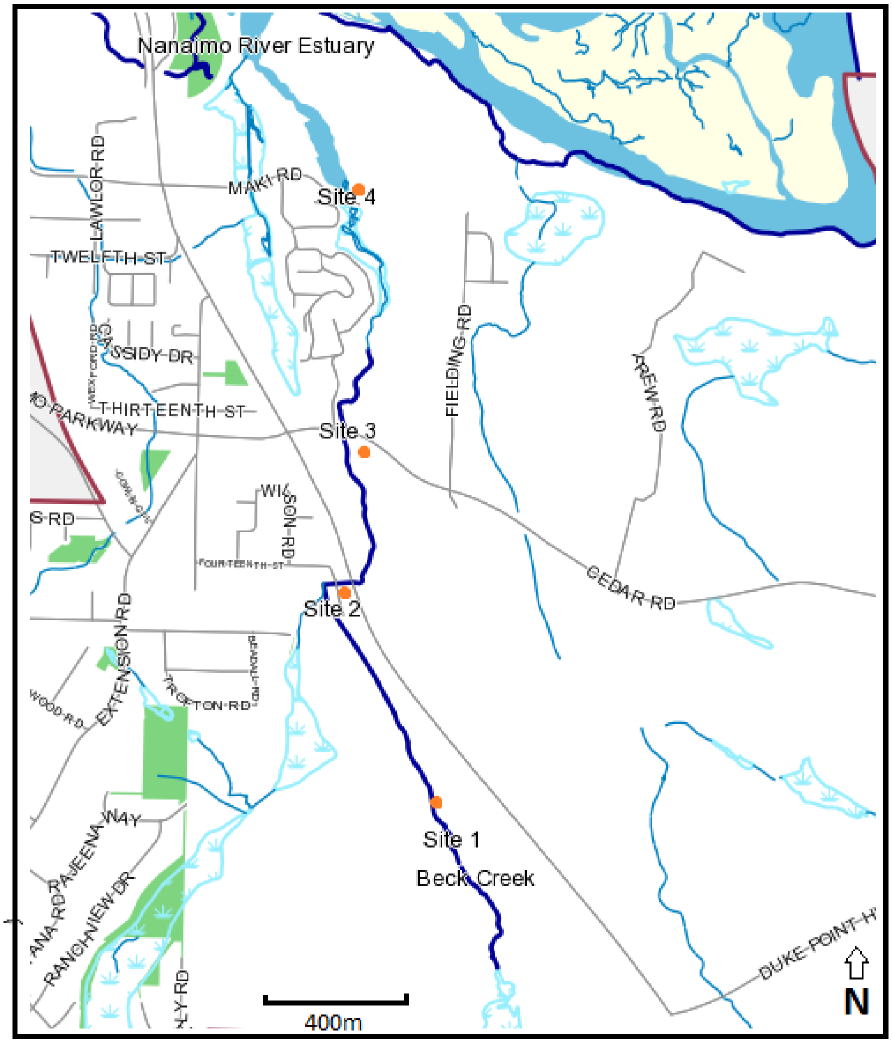

Figure 1: Map of Water Quality and Stream Invertebrate Sampling Sites 1-4 along Beck Creek (map from City of Nanaimo 2017)

1.3 Historical Overview

Beck Creek flows into the tidal mudflats of Nanaimo River Estuary at Maki Road, Nanaimo BC (Figure 2). The upstream limit for fish migration on Beck Creek varies between years. Some years an impassable beaver dam located 30 m upstream of the railway culvert at site 2. However, this blockage can be washed away by flooding, as it was during early winter in 1993 (Irvine et al. 1994). If the creek is clear of blockages, fish may be able to migrate up the entire length of Beck Creek to Beck Lake. Previous restoration and cleanup work has been concluded by the Harbour City River Stewards (Nanaimo News Bulletin 2012) to remove illegal dumping and blockages. Improvements have also been done to the lower end of the creek to improve spawning habitat and access for trout and salmon. Fisheries and Oceans Canada (DFO) has has also conducted studies, including spawning enumeration on Coho salmon (*Oncorhynchus kisutch*) at Chase River and Beck Creek (Irvine et al. 1994). A survey of Beck lake was completed in 1979, revealing pasture/agricultural land surrounding the lake completely. Figure 3, also denotes coal slag in the southeast section of the lake.

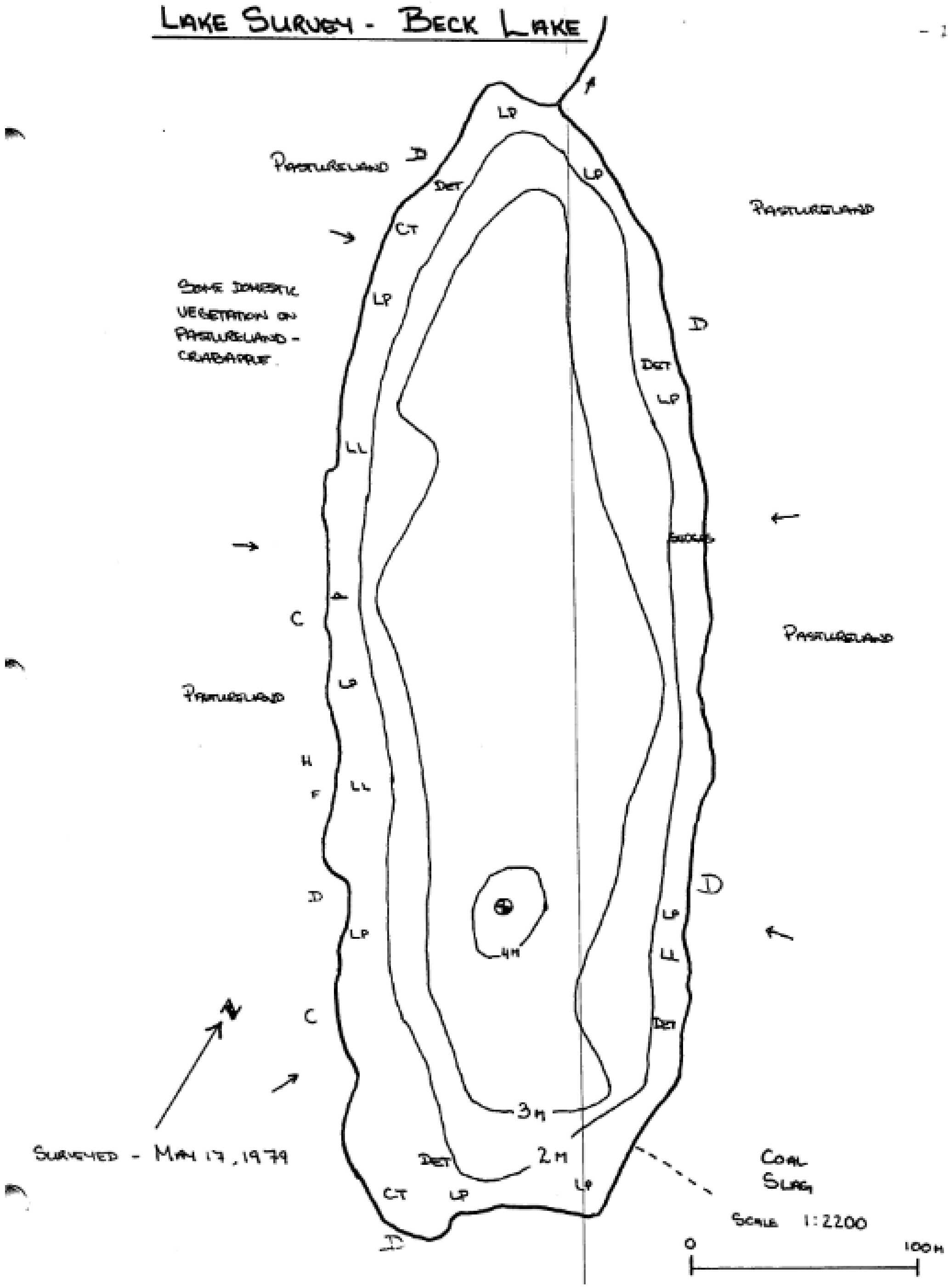

Figure 3: Beck Lake Survey completed by showing surrounding agricultural land use that could impact stream health of Beck Creek (Blackman 1980)

1.4 Potential Environmental Concerns

Sampling site 1 drains through a culvert, flowing downstream under a second culvert where site 2 is located downstream up the railway culvert (Figure 2). On October 19, 2017 we observed recent beaver activity between sites 1 and 2. Red alder (*Alnus rubra)* trees were removed by what appeared to be a beaver. Removal of canopy cover increases sunlight on the pond's surface stimulating algae growth. The concern is increasing eutrophication and biological oxygen demand due to algae growth potentially decreasing fish habitat in Back Creek.

Blocked culverts or beaver dams can also pose a risk to fish accessing the upper level of the creek. On October 19, 2017, we observed, that large woody debris and illegal dumping materials (plywood) were blocking the culvert at site 2. As a result, the blockage could restrict access to fish spawning grounds if the blockage is not removed by flooding. If blockage occurs, fish may not be able to migrate up the entire length of Beck Creek to Beck Lake. Approximately 30 m upstream of the site 2 culvert, there is a beaver dam holding back approximately a 3 m depth of water on the upstream side of the dam. As a result, this could also contribute to a reduction in streamflow and fish access.

Beck Creek's estimated streamflow in the summer months has been reported to be minimal (Figure 4). Due to a lack of streamflow and relative distance to residential and agricultural development, eutrophication of the creek is a concern. Another factor in eutrophication is nutrient enrichment from adjacent agricultural lands surrounding Beck Lake, which supply the main flow to Beck Creek. The creek flows through urban and semi-urban areas of Nanaimo, where septic system runoff or stormwater outfalls may also contribute to general nutrient enrichment.

2.0 Project Objectives

The primary objective for the proposed assessment of Beck Creek was to examine environmental conditions, allowing us to assess the status of the creek and contribute to the long-term monitoring of Beck Creek. This data can then be compared to previous water quality and invertebrate analysis of Beck Creek, providing support for future restoration and monitoring efforts. Samples were taken from four locations in Beck Creek to test hydrology, water quality, microbiology, and stream invertebrate health within the creek (Table 1). Some water samples were analysed by the Australian Laboratory Services (ALS) in Burnaby, BC to determine the water quality characteristics. VIU facilities were also used for water and invertebrate sample analysis.

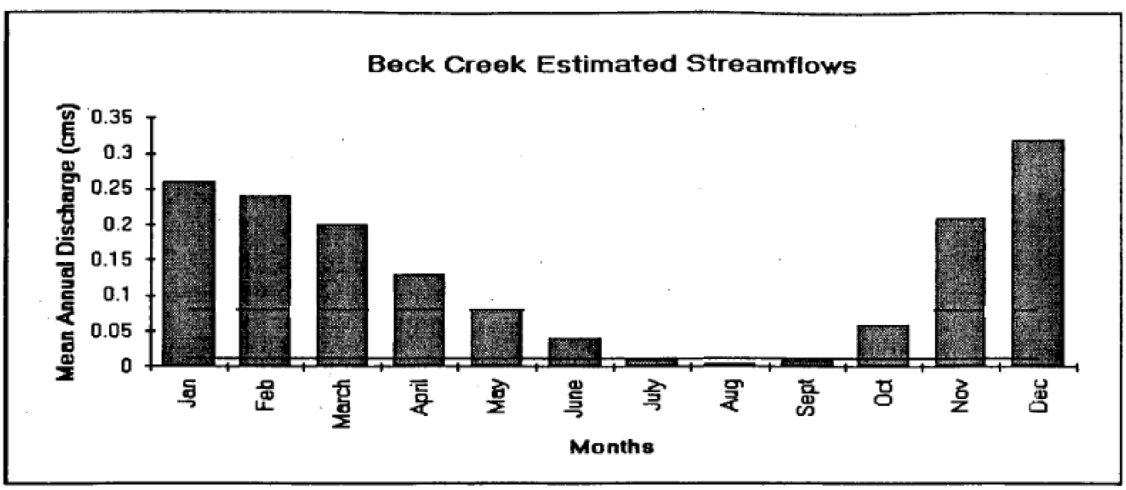

Figure 3: Mean Annual Discharge for Beck Creek (Cook & Baldwin 1994)

3.0 Methods

3.1 Locations and Habitat Characteristics

3.1.1 Sampling Frequency

The sampling program had four proposed sites along Beck Creek at accessible locations. Two sampling events occured, one one October 31, 2017 and the second on November 22, 2017. Sample site 4 receives tidal influences and was sampled at low tide to ensure no salt water or brackish water will be sampled. All other sites did not receive tidal influence and will be sampled consecutively.

Table 1: Water quality and stream invertebrate sampling that was conducted on Beck Creek, during October 31 and November 22. The symbols "A" or "B" indicate when sampling was conducted, October (A) or November (B).

Site #	Locations: UTM coordinates	Hydrology	Water Quality	Microbiology	Stream Invertebrates
1	10U 433603 E 5440523 N	A, B	A, B	A	--
2	10U433409 E 5440990 N	--	A, B	A	A, B
3	10U 433346 E 5441612 N	--	A, B	A	A, B
4	10U 433346 E 5441612 N	--	A, B	A	--

Irvine et al. (1994) states the importance of Beck Creek as it is an important habitat for cutthroat trout (*Oncorhynchus clarkii*) and spawning Coho salmon (*Oncorhynchus kisutch*). This approach will ensure consistent environmental monitoring procedures that can be repeated annually and reveal changes in the study area. The site locations were selected by Dr. Eric Demers to repeat a past study. The four sites selected by Dr. Eric Demers were visited and received initial assessment on Oct 19, 2017 (Table 2).

Table 2: Preliminary Habitat Characteristic Assessment: October 19, 2017

Site	Substrate Composition	Gradient	Canopy	Riparian Zone	Notes
1	Course boulder 30% Gravel 30% Fines 30% LWD 10%	<1 %	Coverage 10% Big Leaf Maple (*Acer macrophyllum*) Western Red Cedar (*Thuja plicata*)	Thimbleberry *(Rubus parviflorus)* Himalayan blackberry (*Rubus armeniacus)*- Sword fern *(Polystichum munitum*) Snowberry *(Symphoricarpos occidentalis)* Various grasses	Sampling area 1m from metal pipe Riffle substrate is grassy Access: Easy
2	Cobble 10% Gravel 10% Fines 70% LWD 10%	<1 %	Coverage 80% Big Leaf Maple (*Acer macrophyllum*) Western Red Cedar (*Thuja plicata*) Red Alder (*Alnus rubra*)	Bracken fern *(Polystichum munitum)* Sword fern *(Polystichum*	Beaver dam 30m upstream of site 2, water depth (upstream side of the dam: 3m) Recent beaver activity (fell trees)observed on the East side between site 1 and 2

					Access: Easy
3	Cobble 25% Gravel 40% Fines 20% LWD 5%	<1 %	Coverage 80% Douglas Fir (*Pseudotsuga menziesii*) Big Leaf Maple (*Acer macrophyllum*) Western Red Cedar (*Thuja plicata*)	Dull Oregon Grape (Mahonia nervosa) Bracken fern *(Polystichum munitum)* Snowberry *(Symphoricarpos occidentalis)*	Riffle 20 m downstream of culvert has good invertebrate sampling substrate Access: Easy on East side
4	Rough boulders 5% Cobble 10% Gravel 20% Fines 60% LWD 5%	<1 %	Coverage 30% Douglas Fir (*Pseudotsuga menziesii*) Western Red Cedar (*Thuja plicata*) Red Alder (*Alnus rubra*) Big Leaf Maple (*Acer macrophyllum*)	Ocean Spray (*Holodiscus discolor*) Thimbleberry *(Rubus parviflorus)* Various Grasses	Riffle nearest the upstream side of culvert has good invertebrate sampling substrate Access: Steep bank to reach sampling site

3.2 Basic Hydrology

At the best represented site, hydrology was measured. This involve measuring the wetted width, bankfull width, gradient, flow rate, canopy cover, water depth, and substrate type. The flow rate was calculated using a submerged float over a measured distance. The time elapsed from when the float is released to when it reaches the end of the desired length will allow for a calculated rate.

3.3 Water Quality

Water quality was sampled at all four stations twice throughout this monitoring timeline. Once on October 31, 2017 and once on November 22, 2017.

3.3.1 Field Measurements

Water temperature, measured as degrees Celsius, and Dissolved Oxygen (DO) was taken in the field. All other analyses was conducted by VIU and ALS in Vancouver.

3.3.2 Water Sample Collection

As mentioned above, there will be two sampling times for water quality within Beck Creek sites. This is setup to target low water flow and high water flow. The first sampling time was to be taken within the time frame of October 28th to November 1st 2017. The second sampling time was to be taken within the time frame of November 18th to November 22nd 2017. For VIU one bottle was filled at each station with one replicate taken from one of the sites. A field blank was also taken along. For ALS there was three bottle types filled at stations 1, 2, and 3.

Certain procedures were taken to provide uncontaminated water samples. Such procedures include; taking water samples from downstream first and working upstream as to not contaminate the water flowing down, rinsing our test bottles a minimum of 3 times to ensure samples are of that water sample only and not from external factors, and consistency was upheld to achieve the most accurate samples possible. Referral to recommended procedures, Guidelines for Designing and Implementing a Water Quality Monitoring Program in British Columbia, and the Ambient Freshwater and Effluent Sampling Guide was done in order to achieve accurate samples as well. Transportation and minimal storage of the samples was done at four degrees Celsius to avoid samples from changing composition.

3.3.3 VIU Laboratory Analysis

The laboratory at Vancouver Island University was used to conduct a water analysis. Water samples taken from the four stations were examined within an appropriate amount of time to achieve accurate results. Tests were conducted to find; total hardness (mg/L $CaCO_3$), Nitrate (mg/L NO_3), phosphate (mg/L PO_4^{3-}), conductivity (uS/cm), and alkalinity (mg/L $CaCO_3$).

3.3.4 ALS Laboratory Analysis

Only sites 1-3 were analyzed by ALS due to cost and availability. Samples were shipped within an appropriate amount of time and in a procedure to preserve the samples appropriately. ALS analyzed the samples to include the general water quality parameters, nutrient analysis, and total metal scan (including up to 30 different metals).

3.3.5 Quality Assurance/ Quality Control

To ensure accuracy, water samples were taken from the same location during both sampling times aside from site 4 where it was unsafe to do so. The locations were noted and marked to help aid in the correct location of samples. For each sample collection day, a field blank was used to ensure no outside elements are affecting the samples as well there was a replicate taken at one of the sites. These were tested along with the original samples to confirm no contamination was present.

3.3.6 Data Analysis, Comparison to Guidelines

The data from both the VIU and ALS labs was compared to one another as well as compared to the Guidelines for Interpreting Water Quality Data prepared by the Ministry of Environment. Results will show whether or not the water is within the parameters or if there is something that is in need of attention, and if the water is sufficient in supporting aquatic plant and animal life.

3.4 Microbiology

Microbiology testing was conducted during the first sampling set only at all four stations. 100-ml sterile Whirlpak bags will be used to collect the water sample. The bags were labeled prior to the sample collection. The sample bags were then taken back to the lab to be studied for chloroform. The samples were pumped through a sterile filter and placed onto sterile petri dishes containing a pad soaked in ColiBlue24 broth to promote bacterial growth. The petri dishes were then be placed in an incubator at 37 degrees celsius overnight and removed the following morning. If Blue colonies appear on the petri dishes it is a sign the water sample contains fecal coliform. Quality Assurance was maintained throughout the testing by wearing gloves, using sanitized containers and proper storage. Quality Control was ensured by using sample blanks and one replicate throughout the analysis.

3.5 Stream Invertebrate Communities

3.5.1 Invertebrate Sample Collection

Stream invertebrates will be sampled from stations 2 and 3; during first sampling event only – occurring on October 31. At each station, we took 4 replicate samples (4 separate samples; 8 samples total. A Hess sampler was used in the collection of invertebrates depending on the substrate and quality of sample area. Notes were taken on the quality of the sample area as well as substrate and overall condition of the stream. The stream depth, width and substrate type was noted in order to determine stream quality for viable habitat. Data sheets were utilized for each sampling location, following The Pacific Streamkeepers' Procedure.

3.5.2 Data Analyses

Stream invertebrates collected were taken back to the lab to be analyzed in lab. Once ready for analysis, the invertebrates were viewed under a dissecting microscope to be identified. Once identified, they were separated based on their taxonomic identity and counted to determine the amount of category 1,2, and 3 invertebrates. The category of invertebrates collected determined the health of the stream based on different sensitivities to pollution for certain species. An invertebrate survey field data sheet was completed for each sample area, as well as the Shannon-Wiener Diversity was calculated for each sample taken.

4.0 Results and Discussion

4.1 General Field Conditions

4.1.1 Hydrology

Field conditions were found to be sufficient for sampling on both sampling dates. The first sampling on October 31st was adequate as water levels were low making sampling of all stations accessible. Site 4 had to be sampled at a later time due to mitigating salt water in the sample with the increasing rise of the tides. Sampling on November 22 was found to be slightly more difficult as the rainfall had increased significantly, increasing the water levels by several feet. To ensure safety samples were taken carefully avoiding the deeper areas of the creek. Site 4 was again difficult to sample as the increasing water levels made it relatively dangerous to acquire a sample, therefore water samples were taken from inside the culvert to ensure safety.

4.2 Water Quality

4.2.1 Field Measurements

Due to the dramatic increase in water flow observed in the second testing period the field measurements are only reflective of the first testing sample. The sites that were chosen for the water samples were for the most part hard to measure and receive accurate depths and widths due to the blockage in the creek. many sites were blown out and holding more water then seemed normal for Beck Creek. For site 1 the wetted width was 2.27 meters and the average depth was 30.3 centimeters. At site 1 the water during both sampling times was above the natural vegetation that occurred therefore making the bankfull channel depth and width the same as the wetted width and depth. For site 2 the water was flowing steady and the wetted width and average depth were 2.54 m and 19 cm respectively. Site 3 was the widest site however the measurements were taken where the water started funnelling into a smaller area. This is where the water samples were taken and the wetted width and depth were 3.4m and 12.3cm respectively. The bankfull channel width was approximately 7.1m however there was two redirected water runs that were included in this measurement. At site 4 there was no accurate way to collect the stream measurements. The last site was more resembling a pond with a very circular shape. The only funnelling part was when the water was redirected into the culvert and pushed out into the estuary.

4.2.2 VIU Laboratory Analyses

The amount of available oxygen in water is measures through the amount of dissolved oxygen ions in water. Overall there was an increase within the four stations tested of dissolved oxygen. The greatest change was observed at station one with an increase in double the oxygen level. Initially in October station 1 had 4 mg/L of dissolved oxygen then it increased to 8.0 mg/L. This increase can be justified in correlation to the decrease of water temperature, therefore the water is able to increase its oxygen holding capacity, and the increase in water flow causing more fast moving, turning water that oxygenates itself more readily. Within stations 2 and 4 there was only an increase ranging from 1.7-0.7 mg/L with an anomaly noticed at station 3. Station 3 actually was the only decrease that was observed respectively from the October to the November sampling times. The dissolved oxygen reading actually decreased from 10.9 mg/L to 10.6 mg/L. Compared to the Guidelines for Interpreting Water Quality Data the water had an acceptable level of dissolved oxygen to support aquatic life, both fish and invertebrates (Ministry of Environment et al, 1998).

As predicted and theoretically proven the temperature dropped between the two sampling times. There was an average temperature drop in the water of approximately 1.1 degrees Celsius. There was an anomaly at station 4, with actually an increase in water temperature by 0.3 degrees Celsius. This could have been due to the location of the sample taken. Due to the high water the original sampling site was inaccessible (the first time the sample was taken we had to pass through a culvert and due to increase flow that was unavailable) so the sample was taken at the outflow of the culvert. The temperature could have been affected from the water salinity level or the location level itself being at the top end of the Nanaimo Estuary. The first three stations all dropped in temperature, the first station being the most dramatic change. Respectively the water temperatures were decreased by 2.4, 1.8, and 0.3 degrees Celsius. When compared to the Guidelines for Interpreting Water Quality Data all the stations had an appropriate temperature to support life (Ministry of Environment et al, 1998).

Conductivity was measured at all stations to determine the dissolved metals present in the water. The greater amount of dissolved metals the more conductive the water will be. Typically coastal streams should be around 100 µS/cm while interior streams are around 500 µS/cm. What was interesting to see in the samples taken from Beck Creek was that during the October sampling time the water was averaging a reading of 409 µS/cm which was more closely related to a stream in the interior. Though the conductivity did drop by almost half during the November sampling periods the numbers were still relatively high for a coastal stream, averaging 194.25 µS/cm. The greatest decrease was noticed at sample station 4, reading in October at 403µS/cm and in November at 154µS/cm (Ministry of Environment et al, 1998).

The pH was measured at all stations and showed an overall decrease in pH between the two sampling times, causing more acidic water to exist in Beck Creek. Typically, the average pH value in coastal streams is between 5.5-6.5. All of our sampling stations read upwards of 7.1 to as high as 8.0. So even though the pH dropped at every station between the two sampling dates it was still above the average coastal stream. The largest decrease observed was at station 3 with a decrease by 0.7 units. When compared to the standards outlined in the Guidelines for Interpreting Water Quality Data the water in Beck Creek falls within the acceptable range for all water types;

recreation, aquatic life, livestock, irrigation, and drinking water (Ministry of Environment et al, 1998).

The turbidity, as predicted, increased between October to November. This was most likely caused by the increase in water flow disrupting the settlement of solids. The turbidity looks at the amount of suspended solids that interferes with natural light penetrating into the water column. The Guidelines for Interpreting Water Quality Data state that to sustain aquatic life there is a flexibility in the turbidity of the water. There is a 10% background increase added to the minimum NTU that can be present in the water. For station one, October was 1.8 NTU and November was 1.98 NTU. Station 2, October was 1.6 NTU and November was 2.03 NTU. Station 3, October was 1.4 NTU and November was 1.95 NTU. Finally, station 4 was 3.5 NTU in October and 2.28 NTU in November. The predicted reason for the abnormality in station 4, the decrease in turbidity, was possibly due to the sampling site change. Originally the sample was taken upstream of the culvert that runs into the Nanaimo Estuary, however with the increase in discharge we were not able to locate that spot safely and took the sample from the flow that ran out of the culvert. The upstream site was more clay/silt bottomed so that could have been in the sample taken and caused the increase in turbidity (Ministry of Environment et al, 1998).

Nitrate is the amount of nitrogen present in the water to assist in growth of living organisms. The Guidelines for Interpreting Water Quality Data state that the safe amount of nitrate present in water for Aquatic life in a maximum of 200 mg/L with an average of 40 mg/L. Of the 4 sample stations there was no excess of nitrate. Though the nitrate levels did increase between the two testing periods the highest reading that was recorded was 0.21 mg/L and this was observed at station3 in November. In October there was a 0.01 mg/L or less reading for each station, and in November the readings increased and ranged from <0.01-0.21 mg/L. Due to these levels the water actually met the guidelines requirement of <10 mg/L for safe recreation and drinking water levels (Ministry of Environment et al, 1998).

The water in Beck Creek was consistent within the soft to hard water concentration levels. Hard water is classified as >120 mg/L of calcium and magnesium in the water, soft water is <60 mg/L. the water in Beck Creek ranged from 56-120 mg/L. The level of calcium and magnesium also decreased between October and November. In October stations 1-4 read at 108 mg/L, 100 mg/L, 120 mg/L, 96 mg/L respectively. In November the stations read 120 mg/L, 100 mg/L, 56 mg/L, 60 mg/L respectively. Though there was an abnormality noticed at station 1 with an increase of 12 mg/L this was the only increase noticed, all other stations decreased. The largest decrease was noticed at station 3, the hardness decreased by 64 mg/L. The Guidelines for Interpreting Water Quality Data state that the optimum hardness range for drinking water is 80-100 mg/L. Some, but not all stations fall within this range. There is no input for supporting aquatic life (Ministry of Environment et al, 1998).

Alkalinity is measured to assess the water's ability to neutralize acids. Coastal waters typically have a lower alkaline value, ranging from 0-10 mg/L whereas interior water can exceed 10 mg/L. Water that has a higher alkalinity value is considered less desirable due to its inability due to high sodium content however, low alkaline values aren’t able to buffer acid as well. the water in Beck Creek exceeds 20 mg/L therefore of considered to have a low sensitivity to addition of acids. In the October sampling the alkalinity measured from 120-170 mg/L, the highest being recorded at station 1, the lowest at station3. And in November the alkalinity measured from 40-80.8 mg/L, the highest being at station 2 and the lowest being at station 4 (Ministry of Environment et al, 1998).

Phosphate was measured in Beck Creek and the overall results showed an increase between the two testing events. In October, stations 1-4 showed phosphate levels of 0.10, 0.08, 0.10, 0.12 mg/L respectively. In November, stations 1-4 showed phosphate levels of 0.35 0.28, 0.31 0.51 respectively. Phosphate in required, along side of nitrate, to aid in life growth and development. Typically, phosphate is the limiting nutrient within the ecosystem of the creek due to the inability to create it organically. There was some possible concern for the phosphate levels to be impacted due to the hobby farms located around stations 1 and 2 (Ministry of Environment et al, 1998).

4.2.3 ALS Laboratory Analyses

Water samples collected from sites 1, 2 and 3 were submitted to ALS Laboratories in Burnaby, British Columbia for water quality analysis. ALS provided results for conductivity, hardness, pH, total nitrogen, total phosphate as well as metal presence levels (Appendix B). ALS analysis results were consistent with VIU analysis results obtained for the same parameters; with the exception from hardness, sampling event 2 results indicated VIU hardness analysis (120 mg/l) was much higher than the ALS analysis of sampling event 2, (42.4-65.4 mg/L.) (Table 3). ALS results for orthophosphate-dissolved (as P) compared to VIU results are considerable lower than the VIU detection limit. In considering the two systems, ALS results will be considered when analyzing orthophosphate-dissolved (as P). Total phosphate levels are also noted to be considerably high ranging from 0.0182 mg/L - 0.0256 mg/l in the ALS report throughout both sampling events for sites 1, 2 and 3. Phosphorus and lake productivity is: <10 µg/L phosphorus yields is considered oligotrophic, 10-25 µg/L P will be found in lakes considered mesotrophic, and >25 µg/L P will be found in lakes considered eutrophic. Beck Creek was mesotrophic during sampling, except on October 31 at sampling station 2 which above 25 µg/L, noting eutrophic levels of total phosphorus.

Table 3. ALS and VIU physical test results from Oct 31 and Nov 22 sampling events.

Site	Conductivity (µS/cm)	Hardness (CaCO3) (mg/L)	pH	Nitrate (NO3-) (mg/L)	Phosphate - Dissolved (as P) (PO43-) (mg/L)
Sampling Event 1: Oct 31 2017					
Site 1: ALS Results VIU Results	445 422	95.3 108	7.77 7.5	<0.0010 <0.01	0.0139 0.10
Site 2: ALS Results VIU Results	428 417	98.7 100	8.01 7.5	<0.0010 <0.01	0.0134 0.08
Site 3: ALS Results VIU Results	403 394	88.5 120	8.16 7.9	<0.0010 0.01	0.0103 0.10
Sampling Event 2 Nov 22 2017					
Site 1: ALS Results VIU Results	244 225	62.1 120	7.66 7.1	0.0840 0.04	0.0039 0.35
Site 2: ALS Results VIU Results	270 244	65.4 100	7.87 7.2	0.0844 <0.01	0.004 0.28
Site 3: ALS Results VIU Results	166 154	42.4 56	7.65 7.3	0.422 0.21	0.0034 0.31

Total metals in the samples taken from Beck Creek were consistently within the British Columbia water quality guidelines (Appendix B). Levels of calcium, strontium, sodium, manganese, silicon, and barium were detected; however there are no BC water quality parameters for these test results. It is also noted that during the second sampling event, due to higher water volume flow, levels decreased on all parameters tested.

4.2.4 Quality Assurance and Quality Control

Samples were taken during the the dates prescribed. ALS sampling bottles were used for water collection. The water samples were stored in the cooler provided and transported to VIU to Eric Demers to be sent to ALS in Burnaby. All chemicals were added immediately after water samples were taken from Beck Creek. Procedures and protocols were followed within prescribed time constraints.

4.3 Microbiology

Water samples were collected from sites 1-4 on October 31 and November 22. Although all water samples were collected within those dates and analyzed in the VIU lab, coliform was only tested and analyzed on October 31st. The coliform was tested following the set-out procedure and analyzed later.

4.3.1 VIU Laboratory Analyses

All water samples collected were found to contain both fecal and non-fecal coliforms. Fecal coliforms were analyzed to range between 5 and 17 found within samples. Non-fecal coliforms were found to range between 222 and 544.8. Fecal coliform count was found to be the highest levels at station 3. This could be the result of an accumulation of coliform from another source. According to the BC water quality guidelines, the water samples contained a level of fecal coliform that was unsafe for drinking water, although the presence of coliforms was low enough to fall within most other uses of freshwater.

4.3.2 Quality Assurance and Quality Control

Quality Assurance and Quality Control Measures were both taken throughout field sampling and lab analysis to ensure accuracy and maintain integrity. Quality Assurance was maintained by ensuring clean containers were utilized. Proper storage was maintained by ensuring the water samples were kept in a cooler once they were collected. Quality control was utilized using a blank and replicate sample of the stream to ensure the accuracy of the sample.

4.4 Stream Invertebrate Communities

4.4.1 Abundance, Density

4.4.2 Diversity and Site Ratings

The invertebrate data collected at sites 2 and 3 revealed unsatisfactory stream health for Beck Creek. The stream health was analysed using site assessment ratings and the Shannon-Wiener Indexes.

Site 2 produced a total of 64 invertebrate species with amphipod as the predominant species resulting in a total of 55. The water quality assessment included the pollution tolerance index, EPT Index, EPT to total radio index, and predominant taxon ratio. Each assessment rating was 1, which is poor (Appendix #) and the overall site assessment rating was 1, which is also poor. The Shannon-Wiener Index for site 2 was calculated at 0.42, which determined the species richness and diversity scored low.

Site 3 produced a total of 86 invertebrate species with amphipod as the predominant species resulting in a total of 73. The water quality assessment for the pollution tolerance index, EPT Index, EPT to total radio index, and predominant taxon ratio all rated poor. Each assessment rating was 1, which is poor (Appendix #) and the overall site assessment rating was 1, which is also poor. The Shannon-Wiener Index for site 3 was calculated at 0.69, which determined the species richness and diversity scored slightly higher than site 2.

The overall site assessment rating averages for sites 2 and 3 were 1, which is poor. The average Shannon-Wiener Index for site 2 and 3 was calculated at is 0.55. This number portrays intermediate diversity within Beck Creek. There were some differences between sites. Site 3 was determined to produce a larger number of invertebrates and rated higher in predominant species. However, the diversity of species was higher in Site 2.

4.4.3 Quality Assurance and Control

Quality Assurance and Quality Control Measures were both taken throughout field sampling and lab analysis to ensure accuracy and maintain integrity. Quality Assurance was maintained by following invertebrate sampling guide procedures. Proper storage was maintained by ensuring the water samples were kept in a cooler once they were collected. Quality control was maintained by rinsing the sampling equipment, choosing similar site conditions, and sampling 3 areas within each site.

5.0 Conclusions and Recommendations

The overall environmental quality of Beck Creek is found to be stable. There are many factors blocking the flow of the stream that can be mitigated such as removal of debris and a local beaver dam between site 1 and 2. The presence of the dam and near by farms has caused eutrophication in the stream at site 1 and 2 by the lack of water flow and the addition of excess nutrients from surrounding agricultural land use. Urbanization is present within all sampling stations as there is traces of garbage and litter within all the stations. It is important to note that the area of study can be influenced, not only by urbanization and development surrounding the creek as it flows downstream, but upstream of the area of study. Beck Lake is outside of the Regional District of Nanaimo and not included in the water sample testing. Additional information on the water quality of Beck Lake would provide more insight as to what is influences Beck Creek as it flows through urban areas of Nanaimo.

The coliform numbers in the stream are reasonable based on location as there is a presence of human activity, farms, storm water runoff and wildlife within the area. Although the stream was found to have adequate quality being below the guidelines, closer monitoring of sites 1 and 2 is recommended to mitigate eutrophication and agricultural runoff.

The invertebrate survey data collected for Beck Creek revealed an assessment rating of poor for overall stream health. The survey utilized sites 2 and 3 for invertebrate sampling; however, it is recommended that site 1 (5 m downstream of the culvert) would also included in invertebrate sampling. In addition, increasing the number of samples from taken at each site from 3 to 5 would also improve the probability of an accurate representation of the creek. Observations were made on the flow of the creek; due to a low gradient between sites 1 and 2, the flow was very slow and almost stagnant. It is recommended to dip net test the area for invertebrates. Dip net testing the slow moving water would provide a better picture of the ecosystem health as there are not many areas that are accessible with preferred substrate and water velocity for adequate use of the Hess sampler.

The water quality and stream invertebrate assessment for Beck Creek concludes that further development of the sampling program is needed. The results reveal that the overall water quality of water is adequate for a healthy ecosystem; however eutrophication is a concern. The invertebrate survey concluded a poor ecosystem health for invertebrates for all indexes. This could due to sampling site 2 and 3 only. Additional sampling may result in a more accurate representation. Further studies are needed to monitor the health of Beck Creek and continue to provide a baseline of data to reduce environmental concerns

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6.0 Acknowledgements

The students who submitted this paper would like to thank Dr. Eric Demers for his continued support throughout the completion of this report and guidance in laboratory analyses. The RMOT program would also like to thanks the Regional District of Nanaimo (RDN) for the funding to complete the Australian Laboratory Services(ALS) water sample analysis.

7.0 REFERENCES

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8.0 APPENDIX

Appendix A: Photos taken of the sampling sites located on Beck Creek on October 21, 2017

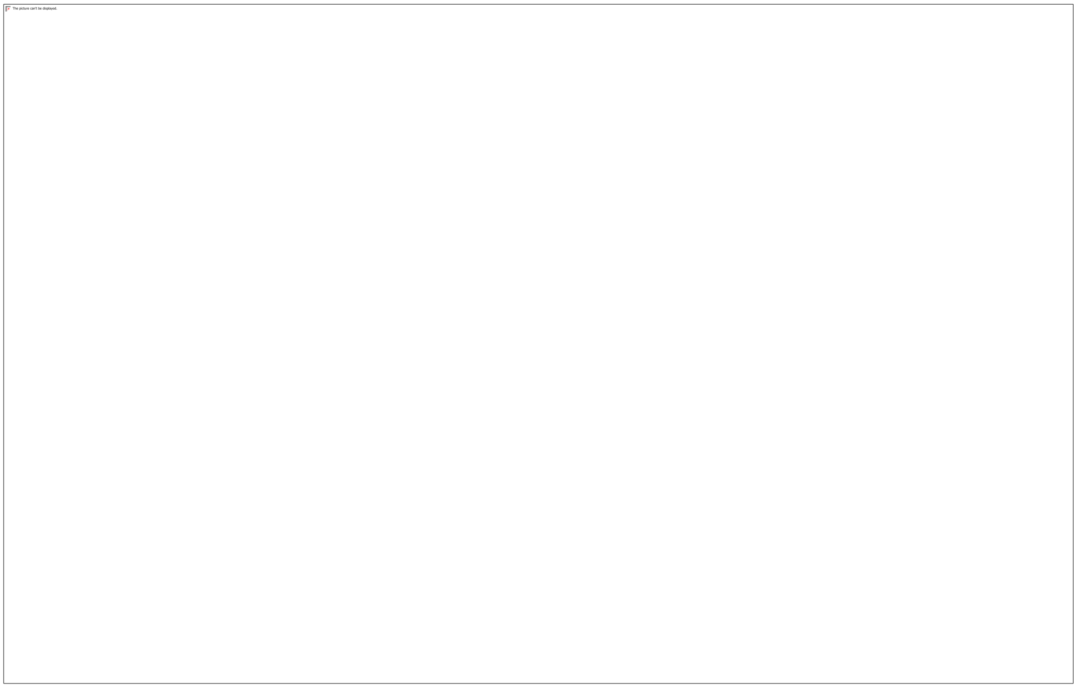

Figure A1: Site 1, location: Beck Creek

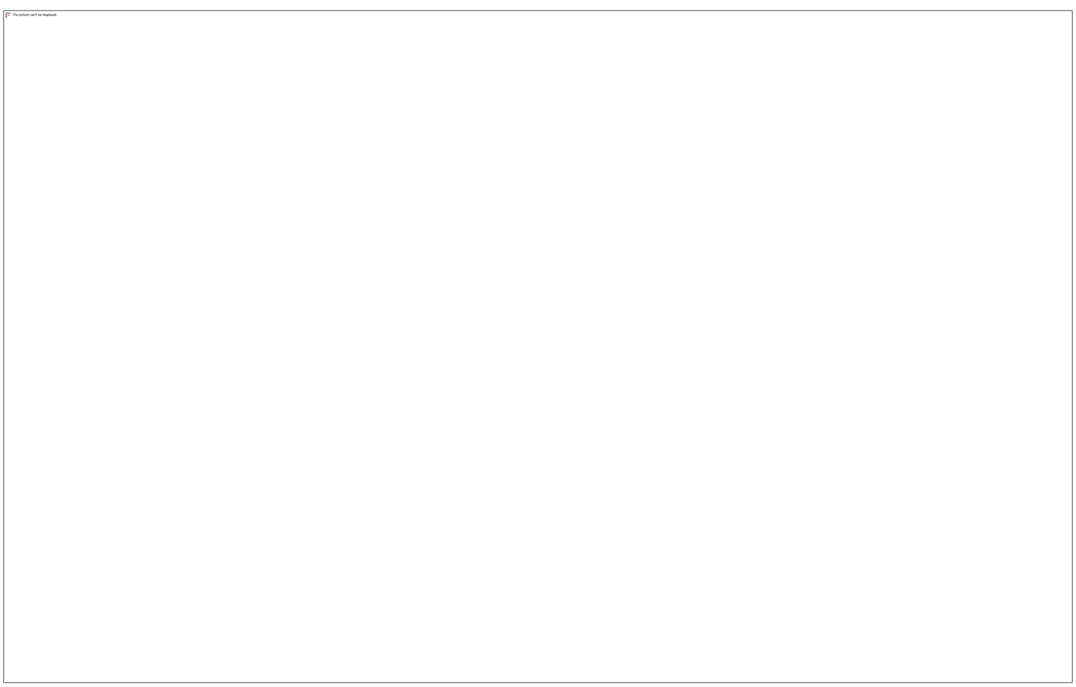

Figure A2: Site 2, location: Beck Creek

Figure A3: Site 3, location: Beck Creek

Figure A4: Site 4, location: Beck Creek

Appendix B: ALS Laboratory Results

Beck Creek Sampling Events 1 and 2

Job Reference	ENVIRONMENTAL MONITORING COUR							
Report To	Eric Demers, Vancouver Island Univers							
Date Received	3-Nov-2017 8:30							
Report Date	10-Nov-2017 18:04							
Report Version	1		**Sampling Event 1**			**Sampling Event 2**		
Client Sample ID			BECK CREEK - STATION 1	BECK CREEK - STATION 2	BECK CREEK - STATION 3	BECK CREEK - STATION 1	BECK CREEK - STATION 2	BECK CREEK - STATION 3
Date Sampled			31-Oct-2017	31-Oct-2017	31-Oct-2017	21-Nov-2017	21-Nov-2017	21-Nov-2017
Time Sampled			12:00	12:00	12:00	12:00	12:00	12:00
ALS Sample ID			L2017715-13	L2017715-14	L2017715-15	L2026212-13	L2026212-14	L2026212-15
Parameter	Lowest Detection Limit	Units	Water	Water	Water	Water	Water	Water
Physical Tests (Water)								
Conductivity	2.0	uS/cm	445	428	403	244	270	166
Hardness (as CaCO3)	0.50	mg/L	95.3	98.7	88.5	62.1	65.4	42.4
pH	0.10	pH	7.77	8.01	8.16	7.66	7.87	7.64
Anions and Nutrients (Water)								
Ammonia, Total (as N)	0.0050	mg/L	0.0419	0.0241	0.0104	0.0159	0.0161	0.0086
Nitrate (as N)	0.0050	mg/L	0.0071	0.0108	0.0183	0.0840	0.0844	0.422
Nitrite (as N)	0.0010	mg/L	<0.0010	<0.0010	<0.0010	0.0011	0.0011	0.0022
Total Nitrogen	0.030	mg/L	0.484	0.484	0.487	0.610	0.509	0.805
Orthophosphate-Dissolved (as P)	0.0010	mg/L	0.0139	0.0134	0.0103	0.0039	0.0040	0.0034
Phosphorus (P)-Total	0.0020	mg/L	0.0237	0.0256	0.0189	0.0199	0.0205	0.0182
N:P	N/A	N/A	20.4	18.9	25.8	30.7	24.8	44.2
Total Metals (Water)								
Aluminum (Al)-Total	0.20	mg/L	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Antimony (Sb)-Total	0.20	mg/L	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Arsenic (As)-Total	0.20	mg/L	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Barium (Ba)-Total	0.010	mg/L	0.041	0.038	0.032	0.021	0.024	0.019
Beryllium (Be)-Total	0.0050	mg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bismuth (Bi)-Total	0.20	mg/L	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Boron (B)-Total	0.10	mg/L	0.12	0.12	0.11	<0.10	<0.10	<0.10
Cadmium (Cd)-Total	0.010	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Calcium (Ca)-Total	0.050	mg/L	28.8	29.8	26.2	18.1	19.2	12.1
Chromium (Cr)-Total	0.010	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Cobalt (Co)-Total	0.010	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Copper (Cu)-Total	0.010	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Iron (Fe)-Total	0.030	mg/L	0.708	0.680	0.505	0.504	0.456	0.350
Lead (Pb)-Total	0.050	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Lithium (Li)-Total	0.010	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Magnesium (Mg)-Total	0.10	mg/L	5.70	5.88	5.60	4.12	4.21	2.92
Manganese (Mn)-Total	0.0050	mg/L	0.0620	0.0656	0.0282	0.0310	0.0293	0.0242
Molybdenum (Mo)-Total	0.030	mg/L	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Nickel (Ni)-Total	0.050	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Phosphorus (P)-Total	0.30	mg/L	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)-Total	2.0	mg/L	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Selenium (Se)-Total	0.20	mg/L	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Silicon (Si)-Total	0.10	mg/L	7.20	7.33	6.71	6.28	6.27	4.80
Silver (Ag)-Total	0.010	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Sodium (Na)-Total	2.0	mg/L	72.3	70.9	62.0	32.1	36.3	20.7
Strontium (Sr)-Total	0.0050	mg/L	0.353	0.351	0.309	0.159	0.190	0.107
Thallium (Tl)-Total	0.20	mg/L	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Tin (Sn)-Total	0.030	mg/L	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Titanium (Ti)-Total	0.010	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Vanadium (V)-Total	0.030	mg/L	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Zinc (Zn)-Total	0.0050	mg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050

Appendix C: VIU Laboratory Results
Beck Creek Sampling Events 1 and 2

Station 1	**October 31**	**November 22**
Dissolved Oxygen	**4.0**	**8.0**
Temperature	**8.4**	**6.0**
Conductivity	**422**	**225**
pH	**7.5**	**7.1**
Turbidity	**1.8**	**1.98**
Nitrate	**<0.01**	**0.04**
Hardness	**108**	**120**
Alkalinity	**170**	**70.4**
Phosphate	**0.10**	**0.35**

Station 2	**October 31**	**November 22**
Dissolved Oxygen	**8.7**	**10.4**
Temperature	**8.0**	**6.2**
Conductivity	**417**	**244**
pH	**7.5**	**7.2**
Turbidity	**1.6**	**2.03**

Nitrate	**<0.01**	**<0.01**
Hardness	**100**	**100**
Alkalinity	**162**	**80.8**
Phosphate	**0.08**	**0.28**

Station 3	**October 31**	**November 22**
Dissolved Oxygen	**10.9**	**10.6**
Temperature	**7.9**	**7.4**
Conductivity	**394**	**154**
pH	**7.9**	**7.3**
Turbidity	**1.4**	**1.95**
Nitrate	**0.01**	**0.21**
Hardness	**120**	**56**
Alkalinity	**148**	**44**
Phosphate	**0.10**	**0.31**

Station 4	**October 31**	**November 22**
Dissolved Oxygen	**10.3**	**11.0**
Temperature	**7.1**	**7.4**

Conductivity	**403**	**154**
pH	**8.0**	**7.3**
Turbidity	**3.5**	**2.28**
Nitrate	**0.01**	**0.08**
Hardness	**96**	**60**
Alkalinity	**138.4**	**40**
Phosphate	**0.12**	**0.51**

Appendix D: Shannon-Wiener Index Results

Site 2 Shannon-Wiener Index table

Common Name	Column C	pi(P/T)	Ln (pi)	pi*ln(pi)
Mayfly	2	0.03	-3.506	-0.105
Amphipod	55	0.86	-0.150	-0.130
Aquatic worm	4	0.06	-2.813	-0.169
Alderfly larva	2	0.03	-3.506	-0.105
Clam, Mussel	1	0.02	-3.912	-0.078
TOTAL	64	--1.00		-0.587
			H = -(-0.587) / ln(5) =	0.693

Site 3 Shannon-Wiener Index table

Common Name	Column C	pi(P/T)	Ln (pi)	pi*ln(pi)
Stonefly	12	0.14	-1.97	-0.276
Amphipod	73	0.85	-0.16	-0.14
Aquatic Worm	1	0.01	-4.61	-0.046
TOTAL	86	--1.00		-0.462
			H = -(-0.462) / ln(3) =	0.421

Appendix E: Invertebrate survey field data sheets sites 2 and 3 (Page 1 of 4)

Stream Name:	Beck Creek	2017-10-31	
Station Name:	Station 2	Flow status	
Sampler Used: Hess	Number of replicates 3	Total area sampled (Hess, Surber = 0.09 m²) x no. replicates 3x0.09=0.27	m²

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1	Caddisfly Larva (EPT)		
	Mayfly Nymph (EPT)	2	1
	Stonefly Nymph (EPT)		
Pollution Intolerant	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		2	1
Category 2	Alderfly Larva	2	1
	Aquatic Beetle		
	Aquatic Sowbug		
Somewhat Pollution Tolerant	Clam, Mussel	1	1
	Cranefly Larva		
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	55	1
	Watersnipe Larva		
Sub-Total		58	3
Category 3	Aquatic Worm (oligochaete)	4	1
	Blackfly Larva		
	Leech		
Pollution Tolerant	Midge Larva (chironomid)		
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		4	1
TOTAL		64	5

Appendix E: Invertebrate survey field data sheets sites 2 and 3 (Page 2 of 4)

SECTION 1 - ABUNDANCE AND DENSITY

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

DENSITY Invertebrate density per total area sampled:

From page 1

64 ÷ 0.27 m^2 = m^2 = 237 / m^2

PREDOMINANT TAXON: 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.POLLUTIO

Good	Acceptable	Marginal	Poor	3 x D1 + 2 x D2 + D3	
>22	22-17	16-11	<11	3 x __1__ + 2 x __3__ + _1___ =	10

EPT INDEX: Total number of EPT taxa.EPT INDEX: Total number of EPT taxa.

Good	Acceptable	Marginal	Poor	EPT4 + EPT5 + EPT6	
>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 organism

Good	Acceptable	Marginal	Poor	(EPT1 + EPT2 + EPT3) / CT	
0.75-1.0	0.50-0.74	0.25-0.49	<0.25	(_0___ + __2__ + __0__) / __64__ =	0.03

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 5

PREDOMINANT TAXON RATIO INDEX: Number of invertebrate in the **predominant taxon** (S1) divid

Good	Acceptable	Marginal	Poor	Col. C for S1 / CT	
<0.40	0.40-0.59	0.60-0.79	0.80-1.0	__55__ / __64__ =	0.86

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 aver

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

Appendix E: Invertebrate survey field data sheets sites 2 and 3 (Page 3 of 4)

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)			
Stream Name:	Beck Creek	2017-10-31	
Station Name:	Station 3	Flow status:	
Sampler Used: Hess	Number of replicates 3	Total area sampled (Hess, Surber = 0.09 m²) x no. replicatesTotal 3x0.09=0.27 m²=²	
Column A	**Column B**	**Column C**	**Column D**
Pollution Tolerance	**Common Name**	**Number Counted**	**Number of Taxa**
Category 1	Caddisfly Larva (EPT)		
	Mayfly Nymph (EPT)		
	Stonefly Nymph (EPT)	12	1
Pollution Intolerant	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		12	1
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
Somewhat Pollution Tolerant	Clam, Mussel		
	Cranefly Larva		
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	73	1
	Watersnipe Larva		
Sub-Total		73	1
Category 3	Aquatic Worm (oligochaete)	1	1
	Blackfly Larva		
	Leech		
Pollution Tolerant	Midge Larva (chironomid)		
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		1	1
TOTAL		86	3

Appendix E: Invertebrate survey field data sheets sites 2 and 3 (Page 4 of 4)

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

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

DENSITY: Invertebrate density per total area sampled:

From page 1

86 ÷ 0.27 $m^2 = m^2$ = 819 / m^2

PREDOMINANT TAXON: 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.POLLUTION TOL

Good	Acceptable	Marginal	Poor	3 x D1 + 2 x D2 + D3	
>22	22-17	16-11	<11	3 x __1___ + 2 x __1__ + _1____ =	6

EPT INDEX: Total number of EPT taxa.EPT INDEX: Total number of EPT taxa.

Good	Acceptable	Marginal	Poor	EPT1 + EPT2 + EPT3	
>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	
0.75-1.0	0.50-0.74	0.25-0.49	<0.25	_0____ + __0__ + __12__) / __86__	0.14

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 b

Good	Acceptable	Marginal	Poor	Col. C for S1 / CT	
<0.40	0.40-0.59	0.60-0.79	0.80-1.0	___73_ / __86___ =	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
Pollution Tolerance Index	1
EPT Index	1
EPT To Total Ratio	1
Predominant Taxon Ratio	1

Average Rating
Average of R1, R2, R3, R4
1

Appendix F: Health and Safety Plan

Safety for each group member will be taken into consideration throughout the duration of this project. Potential hazards while access sampling areas include slips, falls, trips, and sliding down steep terrain. Water flow is also a concern is water levels increase substantially. Each group member will wear proper clothing, carry a cell phone and a GPS. To ensure our location is known, the group will contact Eric Demers before and after the field project is completed during sampling events. Weather and stream conditions will be taken into consideration prior to heading out into the field. Potential hazards will be discussed prior to entering the sampling areas. Route to the nearest emergency area is Nanaimo General Hospital discussed between group members.