Water Quality and Stream Invertebrate Assessment of the C. W. Young Channel, Englishman River, B.C. (Fall 2016)

Report submitted to: Dr. Eric Demers, Ph. D., R.P. Bio., Professor
Environmental Monitoring, (RMOT 306)
Vancouver Island University
900 Fifth Street, Nanaimo, B.C. Canada V9R 5S5

Report prepared by: Undergraduate Students of Environmental Monitoring (RMOT 306)
Vancouver Island University
900 Fifth Street, Nanaimo, B.C. Canada V9R 5S5

Dylan MacGregor
Tel: (250) 709-7775
Email: dylanmacgregor96@gmail.com

Tristan Montjoy
Tel: (250) 256-9324
Email: montjoytristan@gmail.com

Tamara Stauffert
Tel: (250) 951-3729
Email: tamarastauffert@gmail.com

Mark Walkosky
Tel: (250) 714-3856
Email: walkoskymark@gmail.com

EXECUTIVE SUMMARY

The purpose of this study is to provide an assessment of the C.W. young channel in terms of water quality and stream invertebrate health. The C.W young channel was constructed in 1992 by Timber West and is located off the Englishman River in the Englishman River Regional Park. The Englishman River Regional Park is located between the City of Parksville and Nanoose Bay in British Columbia. The C.W young channel is dependent on a controlled intake valve off the Englishman River allowing the channel to have relatively consistent and stable habitat.

Undergraduate students of Vancouver Island University's Bachelor of Natural Resource Management and Protection program have been conducting this assessment since 2008 and there is a database containing this data. This year however, Dylan MacGregor, Tristan Montjoy, Tamara Stauffert and Mark Walkosky undertook the water quality and stream invertebrate assessment project.

For this project, two separate sampling events occurred during low (October 31, 2016) and high flow (November 21, 2016) to compare variations in water quality with the volume of water within the channel at each given sampling event. Five sites had been chosen and GPS coordinates were provided along the C.W channel by past students. To conserve consistency and accuracy these sites were chosen by this group to conduct the water sampling. During events 1 and 2, water quality samples for analyses at the VIU laboratory were collected at all 5 sites while, water quality samples for analyses by Australian Laboratory Services (ALS) were collected at sites 1, 3 and 4. Basic hydrology was calculated during both sampling events at sites 1 and 4. Stream invertebrate samples and microbiology samples were only collected during event 1 with triplicate stream

invertebrate samples being taken at sites 1, 3 and 4 and microbiology samples were taken at all 5 sites. Additionally, quality assurance and quality control methods were performed through-out the project.

Water quality and stream invertebrate analyses were conducted at the Vancouver Island University laboratory and ALS Laboratories. The objective of this project was to determine the water quality and ecosystem health through parameters measured in water quality, stream hydrology, microbiology, and stream invertebrate assessment. The data acquired through our analyses indicated that the stream was relatively healthy. This is based on our comparison with the British Columbia's Water Quality guidelines for aquatic life. The only component that was outside of the guideline was the total amount of Aluminum, however this is also a trend that was found in previous years. Every other parameter measured had fit British Columbia's Water Quality guidelines for aquatic life. In conclusion to all the parameters measured, we found that the C.W young channel is healthy and well maintained which is supported by the abundance of spawning salmon found through the channel.

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ACKNOWLEDGEMENTS

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1. INTRODUCTION

The CW Young Channel of the Englishman River is located within the Englishman River Regional Park (ERRP), which encompasses 207 hectares of land on the northern and southern sides of the river (Figure 1). The ERRP is located between the City of Parksville and Nanoose Bay, British Columbia and is frequently used by the public for light recreational use. BC Hydro and Fortis BC access the service roads to maintain power and natural gas lines and fisheries and stewardship groups access parts of the channel to manage habitat and for education and restoration. The Englishman River runs in an easterly direction for 40 km from the headwaters on Mt. Arrowsmith and Mt. Moriarty, meanders through the Englishman River Estuary before it drains into the Strait of Georgia (Figure 2). Approximately 6 km upstream from the estuary is the outflow of the CW Young Channel into the Englishman River from the northern bank. The channel is only a few hundred meters upstream from the popular public use area of the Top Bridge crossing.

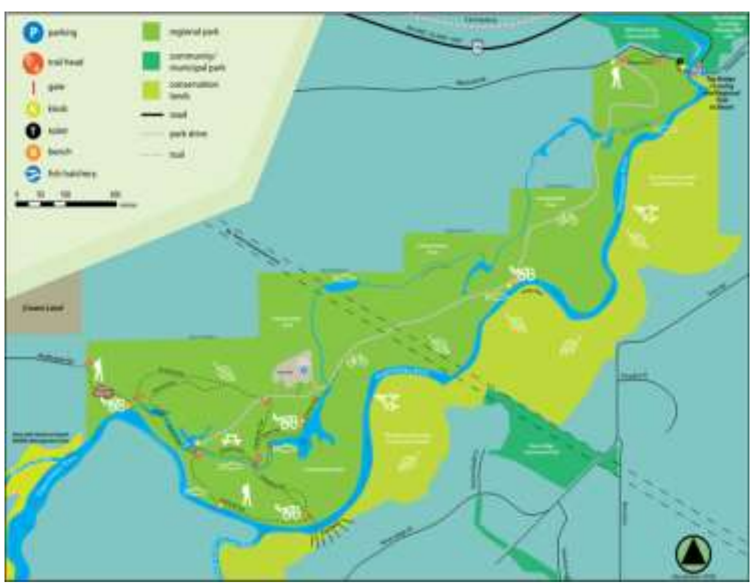

Figure 1. Map showing the Englishman River Regional Park (ERRP) and the trail systems within. The Englishman River runs through the middle of the park and the CW Young Channel is located on the north banks of the Englishman River (RDN 2016).

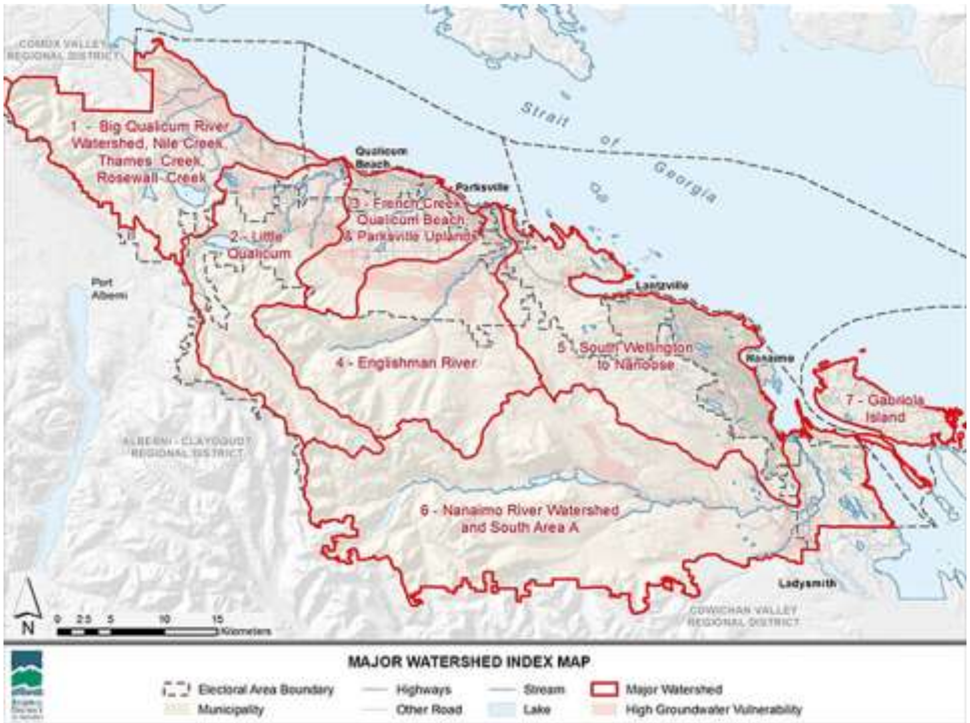

Figure 2. The Englishman River runs in an easterly direction for 40 km, through the Englishman River watershed, draining into the Strait of Georgia (RDN 2014).

Within the park are Coastal Douglas Fir and Western Hemlock forests, wetlands, and ponds (Figure 2). The channel provides 4,600 meters of salmonid spawning and rearing habitat with the ponds, riffles and runs of controlled water flow found here. This provides ideal habitat for Chinook (*Oncorhynchus* tshawytscha), chum (*O.* keta), Coho (*O.* kisutch), pink (*O.* gorbuscha) and sockeye (*O.* nerka) as well as cutthroat (*Oncorhynchus* clarkii) and steelhead (*Oncorhynchus* mykiss). Chum and Coho salmon are the most abundant in adult returns (MVIHES 2013). The waterfalls at the Englishman River Provincial Park, approximately 10 km from the upper reaches of CW Young Channel, present an anadromous fish barrier (RDN 2014). Near the upper reaches of the channel is a small fish hatchery, managed by several fisheries agencies, non-profit organizations and other partnering organizations. Just upstream from the upper reach of the channel are two submerged pipes in the Englishman River. These pipes draw water into the channel and two valves manually control the water flow from the pipes into the channel. The channel is dependent on the controlled water flow from the main stem Englishman River for without it the channel would potentially dry in the summer during low flow events and experience extreme high flow events in the winter resulting in unstable fish habitat. The stable controlled environment the channel provides has proven to support salmonid populations. A salmonid population study between 2009 through 2011determined the side channel supported 42% of the Coho smolt population in the Englishman River (PFLA 2014).

1.1. Historical Review

In 1992, Timber West owned the land where the ERRP is now located, the initial construction of a side channel and a fish hatchery was completed. In 2007, the channel was extended, by a partnership between Timber West (Clay Young) and Weyerhaeuser (Nature Trust). Together these names combined give the channel name, the "CW Young Channel". In 2000, the BC Government identified the Englishman River as a "Sensitive Stream" under the Fish Protection Act, therefore requiring special management attention. In 2003, because of development pressures occurring in the area, The Nature Trust of British Columbia (TNT) spearheaded the acquisition of the land from Timber West Ltd. and Weyerhaeuser. With the Regional District of Nanaimo (RDN) managing the partnerships of TNT with Ducks Unlimited Canada (DUC), Nature Conservancy of Canada (NCC), and the Province of B.C. they formed a protected network along the river. Together these organizations formed the "Englishman River Regional Park: A

Conservation Area along the River Corridor" (ERRPCA). The ERRPCA provides the management and stewardship guidelines to protect and enhance the natural, recreational, and cultural features of the park (RDN 2008).

1.2. Project Overview

Undergraduate students of Vancouver Island University's Bachelor of Natural Resource Management and Protection, Dylan MacGregor, Tristan Montjoy, Tamara Stauffert, and Mark Walkosky undertook a water quality and stream invertebrate assessment project on the CW Young Channel, Englishman River, British Columbia. Samples were collected during two sampling events, October 31, 2016 and November 21, 2016, the low flow and high flow events of the season. The two separate sampling events occurred during low and high flow to compare variations in water quality with the volume of water within the channel at each given sampling event. Water quality and stream invertebrate analyses were conducted at the Vancouver Island University laboratory and for comparison, duplicate water samples were sent to ALS Laboratories in Vancouver, British Columbia. The objective of this project was to determine the water quality and ecosystem health through parameters measured in water quality, stream hydrology, microbiology, and stream invertebrate assessment. The results of this project will contribute to the CW Young Channel database of water quality and ecosystem analyses collected since 2008. The students contributed 100 hours of time in proposal preparation, fieldwork, laboratory analyses, data analyses, research, project presentation preparation, and report writing.

1.3. Potential Environmental Concerns

Surface and Ground Water

Because the CW Young Channel is dependent on the Englishman River main stem, any negative effects within the watershed will impact the channel's ecosystem. The Englishman River watershed is not only an important fisheries system it is also designated a "Community Watershed". The Englishman river provides the surrounding communities of Parksville and Nanoose with additional drinking water in the summer. The watershed use and condition it is in determines the water quality, thus it is important to protect the way in which water is used. With a water license for the Englishman River, waterworks companies, domestic homes and properties requiring water for irrigation, withdraw water from the Englishman River watershed (MOE 2004). There are approximately 52 surface water diversion licenses issued and approximately 245 wells in the Englishman River catchment area. According to the MOE database, this number is likely a fraction of the wells in use or abandoned. Mandatory well logs or well abandonment records are not required and because of this it is difficult to summarize the groundwater demand from private wells nor is it possible to assess the susceptibility the abandoned well may pose on adversely affecting ground water quality (MOE 2016).

Within the Englishman River watershed are several aquifers and the groundwater and surface water is connected. Several of these aquifers are showing a consistent decrease in water levels. This means there is less water to flow into the Englishman River and tributaries for the fish and less water for residents. In the summer when the ground water should contribute to base flow, however, due to the decline in groundwater levels, there is also a decrease in the amount of water available to flow into the streams (RDN 2014).

Fisheries

The Englishman River has a high fisheries value and is recognized as a "Sensitive Stream" due to the low flow events observed in the river, thus it requires special management under the Fisheries Protection Act. As mentioned earlier, there are several partnerships invested in monitoring, maintaining and improving the water quality and fish habitat with the watershed (RDN 2014).

Land Ownership

As mentioned earlier, the communities of Parksville and Nanoose Bay rely on water from the Englishman River watershed, especially during the summer months as well as the fish. The Englishman River watershed encompasses an area of 324 km^2 or 32,400 hectares (MVIHES 2013). The Englishman River community watershed is located on land owned and managed primarily by forestry and logging companies. Island Timberlands owns and manages 69% of the Englishman River watershed and Timber West owns and manages 18%. Rural and urban development, located mainly in the lower reaches of the Englishman River, represents approximately 10% of the watershed, the Englishman River Falls Provincial Park represents 1.4% of the area and Crown Lands represent the remaining 1.6% of the watershed (MOE 2004) (Table 1).

Table 1. Summary of land ownership in the Englishman River Community Watershed.

Land Owner/Manager	% of watershed	# of hectares
Island Timberlands	69	22,356
TimberWest	18	5,832
Rural/urban development	10	3,240
Englishman River Provincial Park	1.4	454
Crown Lands	1.6	518
Total	100	32,400

Forestry and Roads

Forestry practices can influence the amount of water retained and how long it is retained in the surrounding environments within the watershed. The harvesting of trees can see increased response of events within the watershed to high precipitation events and negatively impact the timing when water should naturally be retained and naturally released. The natural low flows are important for insect breeding, to provide pools for juvenile salmonids and to offer riparian plants an opportunity to mature and take strong roots. Natural high flows help shape the channel, move wastes and offers spawning cues for salmonids. Flow events occurring at unnatural times and frequencies that do not benefit the ecology of the stream caused by storm water runoff from impervious surfaces is often seen in urbanized areas (CRD 2016). Another concern of negative impacts of forestry on a watershed is the increased amounts of sediment into the streams, destabilizing stream banks and with the increased responses to precipitation; the river will also see a change in the substrate brought downstream.

Majority of the roadways within the Englishman River watershed have a good buffer of vegetation, however, there are so many networks of roads throughout the watershed, there is bound is be areas where runoff from the roads occurs in an impactful way on the Englishman River with increased turbidity (MOE 2004).

Recreation

The ERRP experiences high use by dog walkers, hikers, bikers, horseback riders, and unlawful ATV and motorbike users accessing the network of trails along the river and near the CW Young Channel. Approximately 10 km upstream from the upper reaches of the CW Young channel is the Englishman River Falls Provincial Park, providing 103 campsites (MOE 2014). While there are not any forestry campsites, there are several logging roads meandering throughout the Englishman River watershed. Management of road access is mainly through deterrents such as gates and signage stating overnight camping is prohibited. Anglers use the river throughout the year and swimmers in the summer, though this type of recreational use is likely minimal in the upper reaches of the watershed and managed fairly well in the lower reaches where it is most accessible for these uses (MOE 2004).

Wildlife

The ERRP provides a diverse habitat to the species of animals found in the area and these include black bear (*Ursus americanus*), cougar (*Puma concolor*), blacktail deer (*Odocoileus hemionus columbianus*), beaver (*Castor Canadensis),* Bald Eagle (*Haliaeetus leucocephalus*), and numerous other species of small mammals, birds and rodents. The presence of this valuable wildlife can contribute to increased coliform counts in water quality.

Environmental

Another contributor to poor water quality is the clay banks along the lower Englishman River. Located a few hundred meters downstream from the input of the Englishman River into the CW Young Channel, the clay banks cover an area of 300m in length by 30m in height and introduce fine sediments into the Englishman River through continual weathering and erosion effects (MOE 2004).

Influences on Water Quality

There is a high population of rural residences and they carry with them the associated household contaminates such as septic fields, livestock and domestic animals. As a result of urbanization and light industrial development in the lower watershed there is an increased amount of impervious surfaces such as roofs, roads and parking lots causing cause storm water runoff potentially carrying lawn fertilizers and pollutants from machinery and the roadways that cross the Englishman River (MOE 2004). The biggest potential anthropogenic impact on water quality in the Englishman River watershed is related to urban, residential, light industrial, forestry and road-building development, agriculture including fecal contamination from livestock and domestic animals and recreational activities.

2. PROJECT OBJECTIVES

As stated previously, the Englishman River watershed is part of an important ecosystem for local communities as well as the flora and fauna that rely on the area. This project is designed to monitor the health of the ecosystem through water quality and stream invertebrate sampling. Over the past nine years, students at Vancouver Island University (VIU) have been conducting these projects as part of an environmental monitoring course in conjunction with the Department of Fisheries and Oceans (DFO) and the Regional District of Nanaimo (RDN). The project sampling events were scheduled to best represent the watershed during high, (late October) and low, (late November) flow periods to ensure the effects of flow rate are considered when determining ecosystem health. Sampling was conducted at five sites primarily confined to the C. W. Young channel that was man made to increase salmonid spawning habitat. The C. W. Young channel is entirely reliant on water flow from the main stem Englishman River and flow is regulated by two valves at the head of the stream. Water quality sampling will determine the health of the water as it relates to aquatic life while stream invertebrate sampling will provide an understanding of ecosystem health through the amount of species diversity found.

3. METHODS

3.1 Sampling Stations

Sampling locations were pre-determined for this project to best represent the ecosystem health within the entire length of the C. W. Young channel. Access, safety and habitat were also used to determine site location. There are five sampling sites; sites one through 4 are located within the channel with site one at the inflow pipe and site 4 downstream near the Englishman confluence. Site five is within the Englishman River main stem adjacent to the channel confluence. Refer to figure 3 for map; all coordinates are in Universal Transvers Mercator (UTM) format and are within the 10U grid zone.

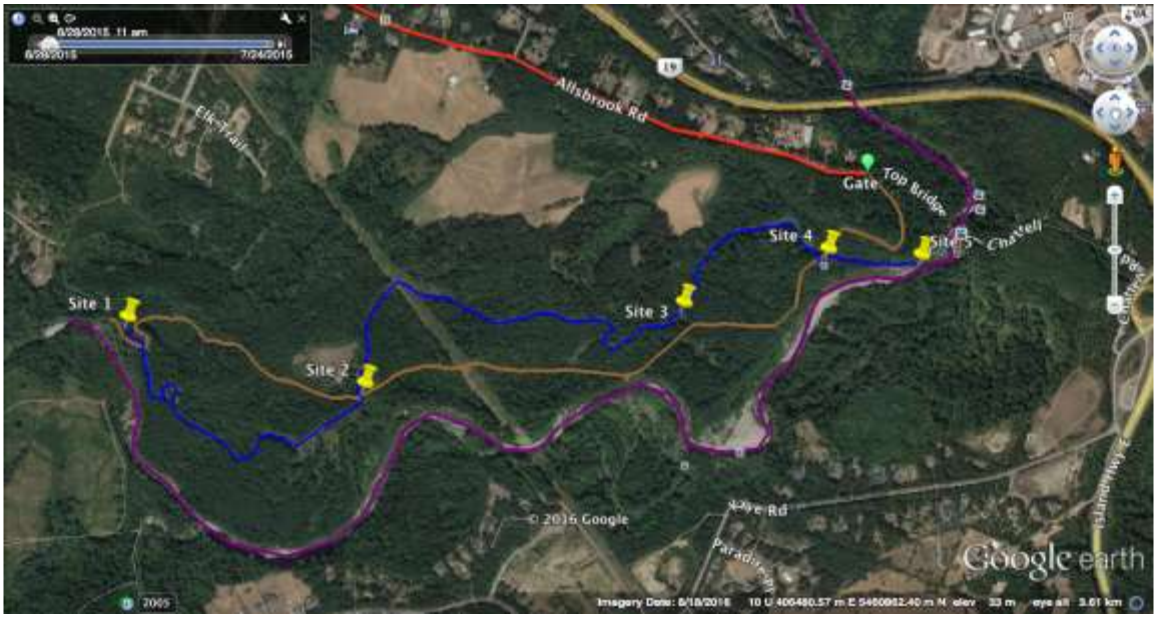

Figure 3. Satellite image showing site locations along C.W. Young Channel (blue) in reference to access road (brown) and Englishman River main stem (purple). (Google Earth 2015)

3.1.1 Site Location and Habitat Characteristics

Site 1 (5459844 mN, 405274 mE) is located approximately 3.68 km from the gate at the end of Allsbrook Rd. The sample site is 1 m downstream of the steel pipe valve that controls the flow of the spawning channel. This site is a glide at the start of the channel and can be accessed easily down a bank off of the access road. The substrate consists of cobble, gravel and fines. It should be noted that water velocity and discharge for all sample sites but site number 5 is regulated by 2 steel pipes fitted with valves under lock that derive their water source from the main stem of the Englishman River.

Site 2 (5459955 mN, 406147 mE) is located at a bridge approximately 2.54 km from the gate and 1250 m downstream distance of site 1. Site 2 is easily accessed adjacent to the access road. This site is a glide coming from a road culvert consisting of cobble and gravel. Large woody debris and boulders are also present nearby.

Site 3 (5460670 mN, 407089 mE) is located 1.25 km from the gate and 2900 m downstream of site 1.It can be access by walking approximately 50 m down a deactivated road stemming from the main access road. We did not get to assess site 3 during our initial recon as upon arrival a large black bear (*Ursus americanus*) was fishing for salmon. As the bear saw us it turned sideways and walked over to the same side of the channel as us and did not appear to be afraid of us. We made noise and backed away slowly. Site 3 is a glide with primarily gravel substrate; however, there are fines present as well. 3 LWD are spread across the site and dense vegetation is on both sides of the channel.

Site 4 (5461051 mN, 407492 mE) is located 0.65 km from the gate and 3800 m downstream of site 1. The site is 1 m downstream of a steel sill structure easily accessed from the access road. This site is a glide with substrate consisting of cobble, gravel and fines. Large woody debris is present nearby and a cement foundation for a foot bridge on either side of the stream channels flow.

Site 5 (5461163 mN, 407812 mE) is located 0.65 km from the gate and is within the Englishman River over 4800 m downstream of site 1. This site can be accessed by walking approximately 340 m down a trail starting along the south side of the access road and ending at the confluence of the C.W. Young channel and the Englishman River. Site 5 is a glide/riffle depending on velocity and discharge of the Englishman River. The substrate consists primarily of cobble, although boulders and gravel are also present.

3.1.2 Sampling Frequency

Sampling parameters for this project included water quality, microbiology, basic hydrology and biological diversity through stream invertebrate sampling. Sampling occurred during two sampling events; October 31st, 2016 (low flow) and November 21st, 2016 (high flow). During events 1 and 2, water quality samples for analyses at the VIU laboratory were collected at all 5 sites while; water quality samples for analyses by Australian Laboratory Services (ALS) were collected at sites 1, 3 and 4. Basic hydrology was calculated during both sampling events at sites 1 and 4. Stream invertebrate samples and microbiology samples were only collected during event 1 with triplicate stream invertebrate samples being taken at sites 1, 3 and 4 and microbiology samples being taken at all 5 sites. A trip blank was transported with all samples and a replicate sample was randomly taken during each event.

3.2. Basic Hydrology

To determine the basic hydrology of the C.W Young Channel, two sites along the channel were chosen. Site #1 and #4 were chosen as they were sites that represented the channel as a whole. At these two sites we took the following measurements: water depth, wetted width and velocity. Wetted width was found by using a measuring tape from one side of the stream towards the other. Water depth was found by using a meter stick and three depths were recorded along a transect. An average depth was recorded. For velocity, a 2 meter line was marked between two of the surveyors. The surveyor upstream held a leaf and dropped it into the water. The surveyor downstream held a stopwatch and clocked this process until the leaf reached them. This method was done three times and an average velocity was recorded using the velocity formula (Velocity= Distance/Time). Using the data listed above, discharge was calculated with the formula (Wetted Width*Average Depth*Average Velocity).

3.3. Water Quality

3.3.1. Field Measurements

The water quality parameters that were measured in the field were temperature and dissolved oxygen. At the five sites along the C.W Young Channel the two parameters were measured using an electronic water probe. The water probe was sub-merged into the water at each of the sites and held for one minute. This field method to measure temperature and dissolved oxygen ensured that an accurate recording was being taken for each of the sites.

3.3.2. Water Sample Collection

For the purpose of our assessment, two sampling dates were used. October 31, 2016 was the first sampling event and November 21, 2016 was considered the second sampling event. The first event was chosen to be a low flow event and the second event was chosen as it would be a high flow event. For each event, six water samples were taken with 500 mL plastic bottles from the five sites including one replicate. Also, five

100 mL samples were collected with whirl bags for microbiology analysis at Vancouver Island University's (VIU) laboratory with the other samples. Additionally, three 1L plastic bottles, three 250 mL amber glass bottles and three 250 mL plastic bottles were collected from three predetermined sites (site #1, 2 and 4) for analysis at the Australian Laboratory Services (ALS) in Burnaby, BC.

All the bottles were first sterilized and labeled before the water collection. At the site, the water collection process started at the furthest site downstream to reduce contamination from the actual water collection process. The bottles were then rinsed three times in the stream, and then the water was collected. When collecting the water samples, the samples were fully submerged to avoid collecting surface water.

When collecting the samples for ALS, we followed the same sampling procedures listed above, however we added preservatives to two of the bottles and wore nitrile gloves. In the 250 mL amber glass bottles we added sulphuric acid as we were testing for total nutrients. In the 250 mL plastic bottles Nitric acid was added as we were testing for total metals.

Once the collection process was completed the samples were stored in a cooler with ice packs for transportation. Once transportation had been completed, the samples were placed within a refrigerator until analysis in the VIU laboratory. The ALS samples were handled appropriately and sent off to the ALS laboratory

3.3.3. VIU Laboratory Analyses

At the VIU laboratory, water quality and invertebrate analyses were conducted on November 2, 2016 for the first event and on November 21, 2016 for the second sampling event. The water was analyzed for the following water quality parameters: microbiology, pH, Conductivity, Nitrate, Phosphate, Alkalinity, Turbidity and Hardness. Total coliform and fecal coliform (*E. coli)* were analyzed for microbiology by using a filtration method. Using an electronic meter results were obtained for pH and Conductivity (µS/cm). Nitrate (mg/L) and Phosphate (mg/L) results were found using a HACH DR2800 spectrophotometer. Alkalinity was found using a titration method. Hardness (mg/L as $CACO_3$) was found using a HACH test kit.

3.3.4. ALS Laboratory Analyses

The nine ALS samples that were collected from sites 1, 2 and 4 were shipped to the ALS laboratories by Dr. Eric Demers. Three samples were taken from each of the sites listed. Preservatives were added to two of the sample types. One 250 mL amber glass water sample was collected and sulphuric acid was added as we were testing for total nutrients. One 250 mL plastic bottle water sample was collected and Nitric acid was added as we were testing for total metals. Additionally, a 1 L bottle for each site list was sent without any preservatives. The water samples were analyzed for the following water quality parameters: conductivity, hardness, pH, nutrients and total metals.

3.3.5. Quality Assurance / Quality Control

Quality assurance and quality control methods were enacted to ensure the accuracy of our results. A standard of care was taken and followed by all the member of the assessment team. The samples were collected in sterilized containers and taken while wearing nitrile gloves. For each sampling event, Dr. Eric Demers, provided the group with a trip blank. A trip blank is a bottle of distilled water that is stored within our cooler and endures the same procedures as our water samples to ensure there is no contamination from the environment. Additionally, a replicate was taken from site #4 during both of the sampling events to ensure the accuracy of results. The trip blank and the replicates were then analyzed at then VIU laboratories to ensure quality control and accuracy.

3.3.6. Data Analyses, Comparison to Guidelines

The data obtained through the analyses from ALS laboratories and from VIU laboratories was organized and referenced to the approved water quality guidelines from the Province of British Columbia. This guideline was referenced to verify that the results found met or exceeded the described parameters for aquatic life and drinking water.

3.4. Stream Invertebrate Communities

3.4.1. Invertebrate Sample Collection

During the stream assessment of Englishman River/ CW Young Channel samples for stream invertebrates were taken on the first visit. These samples taken from sites 1, 3 and 4. For quality control and assurance each site sample was taken with three replicate samples. This gave an accurate representation of each site. To collect the invertebrate samples a Hess Sampler was used which covers $0.9m^2$ of stream substrate. When approaching decided sample locations group members walked from downstream to avoid any site contamination. All of the samples were conducted in similar substrates with sufficient water depths and acceptable water velocity. The Hess Sampler was plunged into the water and placed 5cm into the stream substrate. The sample location was then disturbed by hand until 5cm of substrate was removed. Any large debris in the sampler was gently removed and placed downstream. After each sample was taken, the contents were emptied into pre-labeled plastic sampling jars and into a cooler located in the vehicle used in transport. After sampling was completed the invertebrate samples were placed in a fridge for 24hrs, until VIU laboratory analysis would be conducted. No Ethanol was used as samples were kept alive until lab analysis.

3.4.2 VIU Laboratory Analyses

Once samples were taken to VIU for lab analysis, the three site samples were emptied into a beige sampling tray. Two group members took different site containers, counted and separated species into taxonomic groups by using a dissecting microscope, tweezers, and pipettes. These invertebrates were placed in separate petri dishes by species and placed away from the microscope to ensure no risk of recounting. After completing counts, the data was written into a Pacific Stream Keeper Invertebrate Survey Field Data Sheet. This sheet was used to calculate total density (number per m^2), total number of taxonomic groups, predominant taxonomic group, EPT index, pollution tolerance, EPT to Total Ratio Index, predominant taxon ration index, and overall site assessment rating.

3.4.3 Quality Assurance / Quality Control

Prior to each sample taken to collect invertebrates, the Hess sampler was thoroughly rinsed to remove any material previously stuck in the cod end of the sampler and the mesh was inspected for tears and holes. As mentioned above, all containers used in holding the invertebrates prior to lab analysis were pre-labeled with each site number and number of sample taken from each site. Samples were stored in a fridge located at one group member's house, these were not opened until lab analysis.

During lab analysis the invertebrates were placed in pre cleaned petri dishes, and dissecting microscopes. Specific characteristics of taxon were written in a notebook to ensure double counting would not happen. Numbers of identified species counted were written into a notebook immediately after they were counted, not to be forgotten. The samples in the petri dishes were double checked to ensure no false results occurred.

3.4.4 Data Analyses

After completing counts, the data was written into a Pacific Stream Keeper Invertebrate Survey Field Data Sheet. This sheet was used to calculate total density (number per m^2), total number of taxonomic groups, predominant taxonomic group, EPT index, pollution tolerance, EPT to Total Ratio Index, predominant taxon ration index, and overall site assessment rating (Appendix 3)

4. RESULTS AND DISCUSSION

4.1 General Field Conditions

Heavy amounts of rain during October and November caused the predicted low flow and high flow river levels to change. The heavy rain likely affected the turbidity levels; however, the C. W. Young channel flow is controlled by a pipe and valve system from the main stem of the Englishman River. 233.3 mm of rain fell in the Errington BC area during the month of October causing high flow conditions (theweathernetwork.ca).

During sampling event 1 on October 31st, 2016 the weather was overcast with wind and rain and the ambient temperature was 8° C. 138.1 mm of rain fell in the Errington BC area during the month of November. During sampling event number 2 on November 21st, 2016 the weather was clear with no wind and the ambient temperature was 7° C.

4.2 Water Quality

4.2.1 Field Measurements

Measurements taken in the field included temperature (°C), dissolved oxygen (mg/L), velocity (m/s) and discharge (m^3/s). Temperature and dissolved oxygen measurements were taken at each site during event 1 and 2 with the probe. Results showed a decrease in temperature from event 1 to event 2 with the average temperature during event 1 being 9.4° C and average temperature during event 2, 7.4° C. Temperatures were consistent throughout all 5 sample sites during both events. Dissolved oxygen levels were also constant throughout all 5 sample sites and showed no substantial change between sampling events 1 and 2. The average DO level during sampling event 1 was 10.72mg/L and 11.08mg/L during sampling event 2 both of these DO levels are above 9mg/L required to support abundant fish populations as per the BC water quality guidelines for aquatic life (BC Water Quality Guidelines 1998).

For both sampling events, the dissolved oxygen was highest at site 1, near the beginning of the C.W. Young Channel and site 5 at the output of the C.W. Young Channel into the Englishman River (figure 4). The increase concentration in dissolved oxygen at these sites is not only due to the associated lower water temperatures but also likely attributed to the oxygenating effects of flow and riffles at these sites. There is an observable 1.5 °C temperature difference between the two events and is suspected due to the lower ambient air temperature at the time of the second event. The middle reaches of the channel, between sites 2 and 3, were observed to have an average 0.2 °C increase in water temperature. There is an average decreased 0.92 mg/L of dissolved oxygen in the middle reaches of the channel. The increase in water temperature at these locations is likely due to the shallower depth of the waters in the mid-reaches and the decreased dissolved oxygen also observed would be expected with this.

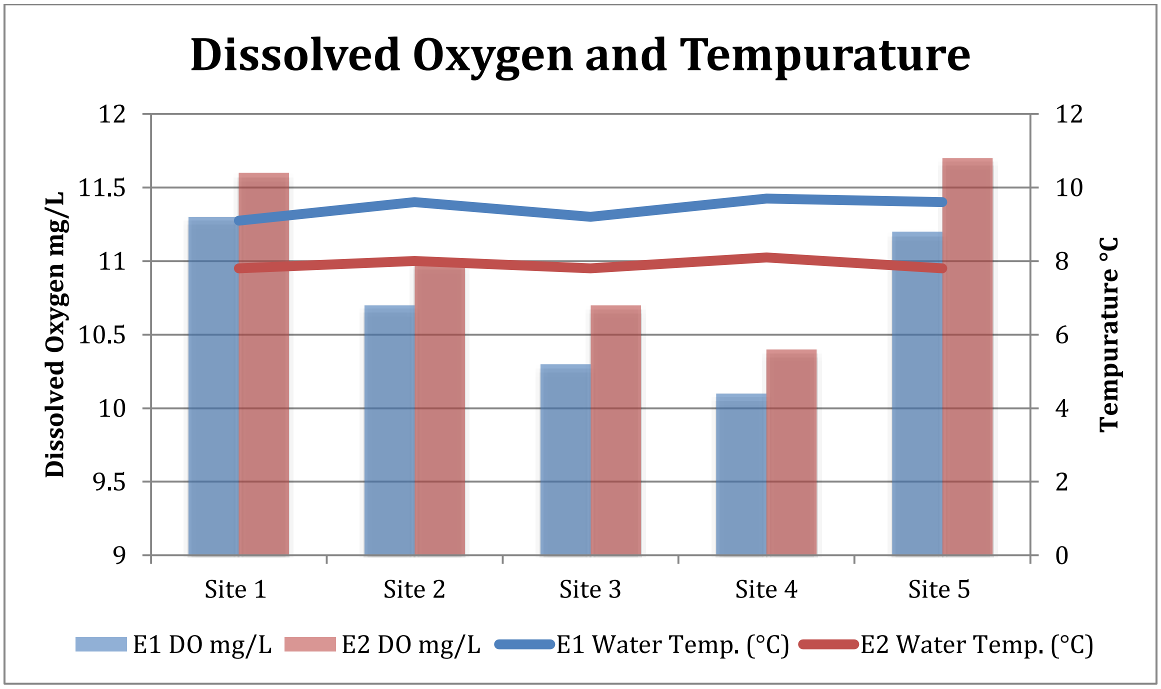

Figure 4. Dissolved oxygen and water temperature during sampling event 1 October 31, 2016 (blue) and sampling event 2 November 21, 2016(red).

No trends were found for discharge between events 1 and 2, this is likely due to the valve controlling channel flow at the head of the channel. As figure 5shows, there was a decrease in velocity and discharge of site 1 between events 1 and 2, whereas, there was a substantial increase in velocity and discharge of site 4 between events 1 and 2. Site

4 had a discharge of 0.313 m^3/s during event 1 then a discharge of 0.636 m^3/s. Heavy rainfall occurring days before each sampling event could have affected these results.

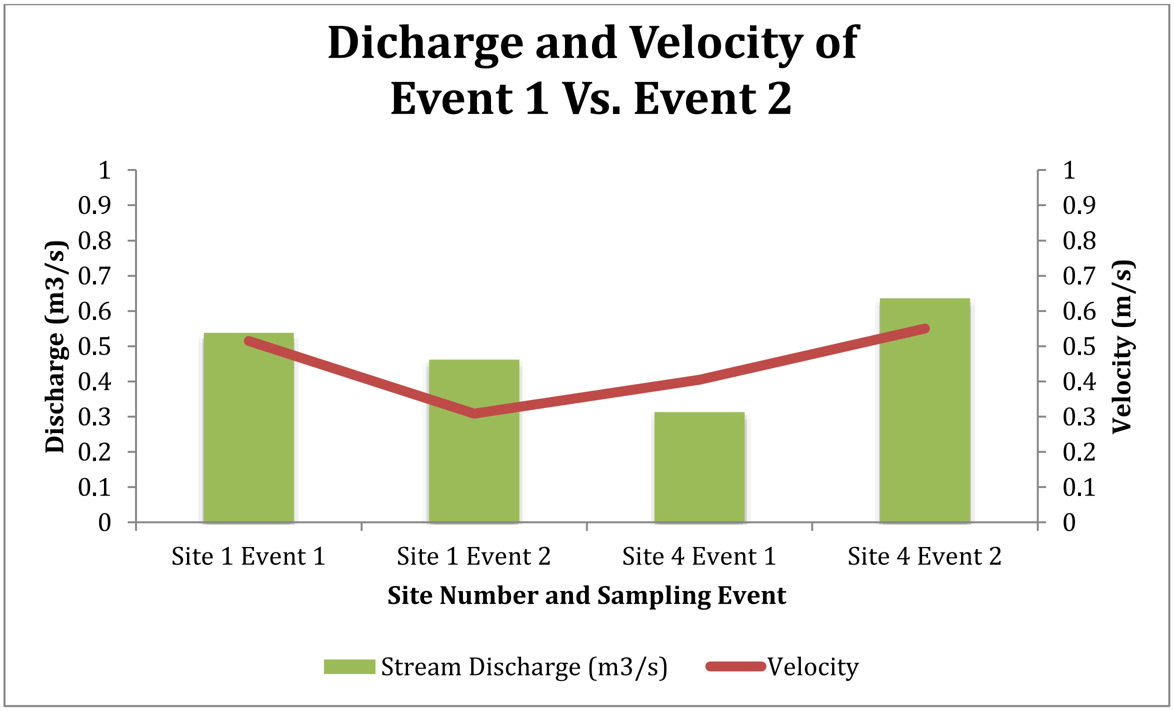

Figure 5. Discharge and velocity measurements reflecting changes in flow between sampling events 1 and 2.

4.2.2 VIU Laboratory Analysis

Stream invertebrate and water quality parameters were analyzed at the Vancouver Island University laboratory within 72 hours of collection. The parameters analyzed at VIU included, alkalinity (mg/L as $CaCO_3$), conductivity (µs/cm), hardness (mg/L as $CaCO_3$), turbidity (NTU), total nitrates (mg/L NO_3^-), total phosphorous (mg/L PO_4^{3-}), and pH (Tables 2 and 3).

Table 2. Event 1 VIU water quality analysis 31 October 2016.

Water Quality Parameters	Units	Site 1	Site 2	Site 3	Site 4	Site 5	Water Quality Guidelines (Aquatic Life)
DO_2	mg/L	11.6	11.0	10.7	10.4	11.7	>5
Water Temperature	°C	9.1	9.6	9.2	9.7	9.6	<15
Conductivity	**µs/cm**	**40**	**40**	**41**	**57**	**37**	**N/A**
Hardness ($CaCO_3$)	**mg/L**	**28**	**28**	**28**	**39**	**22**	**Soft**
pH		**7.3**	**7**	**6.9**	**6.9**	**7**	**6.5-9.0**
Alkalinity ($CaCO_3$)	**mg/L**	**16.8**	**16.7**	**16.8**	**28.1**	**14.8**	**Low Sensitivity**
Nitrate as NO_3^-	**mg/L**	**0.01**	**0.06**	**0.06**	**0.32**	**0.02**	**<200**
Phosphate as PO_4^{3-}	**mg/L**	**0.06**	**0.07**	**0.07**	**0.08**	**0.06**	**N/A**
Turbidity	**NTU**	**4.51**	**3.71**	**3.71**	**3.4**	**2.82**	**5**

Table 3. Event 2 VIU water quality analysis 21 November 2016

Water Quality Parameters	Units	Site 1	Site 2	Site 3	Site 4	Site 5	Water Quality Guidelines (Aquatic Life)
DO_2	mg/L	11.3	10.7	10.3	10.1	11.2	>5
Water Temperature	°C	7.8	8.0	7.8	8.1	7.8	<15
Conductivity	**µs/cm**	**N/A**	**30**	**32**	**49**	**49**	**N/A**
Hardness ($CaCO_3$)	**mg/L**	**N/A**	**18**	**20**	**27**	**19**	**Soft**
pH		**N/A**	**6.5**	**6.6**	**7.4**	**7.3**	**6.5-9.0**
Alkalinity ($CaCO_3$)	**mg/L**	**N/A**	**69**	**163**	**188**	**121**	**Low Sensitivity**
Nitrate as NO_3^-	**mg/L**	**N/A**	**0.01**	**0.01**	**<mdl**	**<mdl**	**<200**
Phosphate as PO_4^{3-}	**mg/L**	**N/A**	**0.05**	**0.14**	**0.11**	**0.05**	**N/A**
Turbidity	**NTU**	**N/A**	**2.32**	**2.37**	**2.94**	**3.08**	**5**

Conductivity

Conductivity (µs/cm) trends observed for both events remained similar with site 4 observed to have the highest conductivity. ALS laboratory results also reflect a similar trend with an increase conductivity noted at site 4. The average conductivity (µs/cm) parameters between VIU and ALS analysis were similar. There was a 15.5 µs/cm variance between VIU and ALS analysis for event 1, and a 5.2 µs/cm variance for event observed. The increased conductivity noted at site 4 may be attributed to the silty bottom pond and the moderate flow of water at area of sampling (Table 4)

Table 4. ALS and VIU analysis comparison of both sampling events.

Parameters	Units	VIU E1	ALS E1	VIU E2	ALS E2
Conductivity	**µs/cm**	43	58.5	40	45.2
Hardness	**mg/L**	29	23.1	21	19.1
pH	**N/A**	7.0	7.45	6.95	7.42

Hardness

Hardness ($CaCO_3$) mg/L was observed to have similar trends through event 1 and event 2. The average hardness observed for event 1 was 29 mg/L and Event 2 was 21 mg/L. Both events experienced an increased hardness measurement at site 4. ALS analysis confirms this trend also, though ALS analysis observed the average hardness to be slightly lower. There was a 5.9 mg/L variance between VIU and ALS analysis for event 1 and a 1.9 mg/L variance for event 2. The analysis of hardness at these levels indicates the C.W. Young Channel has soft water. This means the channel is susceptible to acidification and if an event occurred where metals were deposited into the system this could result in acute toxicity to aquatic life.

pH

The pH was observed to have relatively consistent measurements between the sampling sites for both event 1 and event 2. The average pH for event 1 and event 2 was 7.0 and 6.95 respectively. ALS analysis observed an average pH for event 1 and 2 at 7.45 and 7.42. The pH range 6.95-7.42 observed between VIU and ALS is ideal freshwater habitat and indicates a neutral aquatic environment. The variance between VIU and ALS laboratory analyses follows a similar trend of minimal decrease in pH for event 2. The chemical state of many substances, including metals, which may be present in the aquatic environment, is controlled by pH. A low pH (acidic) will dissolve metals and thus cause toxicity within the environment. A high pH (basic) will cause metals to precipitate and thus aid in containing these metals to the substrate and decrease the effects of metal toxicity.

Alkalinity

Alkalinity for event 1 ranged from 14.8-28.1 mg/L with an average of 18.64 mg/L and alkalinity for event 2 ranged from 6.9-18.8 mg/L with an average of 13.53 mg/L. The trend observed between the two sampling events was a highest alkalinity measurement at site 4 and the lowest alkalinity measurement at site 5. Alkalinity for event 1 was observed to measure consistently through sites 1, 2, and 3 at approximately 16.75 mg/L. Site 4 was observed to have a 11.3 mg/L increase of alkalinity and site 5 alkalinity was observed to decline by 13.3 mg/L. Alkalinity for event 2, site 2 had a measurement of 6.9 mg/L. Between site 2 and site 3 there was an observed increase in alkalinity by approximately 10.6 mg/L and a decline again at site 5 by 6.7 mg/L. On average the alkalinity is between the "moderate sensitivity" range of 10-20 mg/L and this suggests moderate sensitivity to acidic input from the environment.

Nitrate

Nitrate levels analyzed at VIU during event 1 and 2 were well within the BC water quality guidelines of <200 mg/L. Levels among sites 1 through 5 measured between 0.01 mg/L and 0.06 mg/L with the exception of site 4 during event 1 measuring 0.32mg/L. The reason for this spike of nitrate in site 4 is unknown; however, is consistent with previous reports of the C. W. Young channel. Nitrate levels decreased between events 1 and 2 by 0.05 mg/L. There was a trending increase in nitrate levels with distance downstream from sites 1 to 4 with the exception of site 5; however, this is likely due to the location of site 5 being within the main stem of the Englishman River (Figure 6). ALS results showed similar trends; however, due to more accurate sampling machines and methods lower levels were detected ranging from 0.043 mg/L to 0.15 mg/L with the spike levels from site 4. Overall, average nitrate levels between events 1 and 2 appeared lower than the previous two years. Demers, 2016 summary report indicated there had been a noticeable increase in 2014 and 2015; however, this data suggests a decreasing trend. Nitrate levels should continue to be monitored as high nitrate levels can lead to exponential aquatic plant growth.

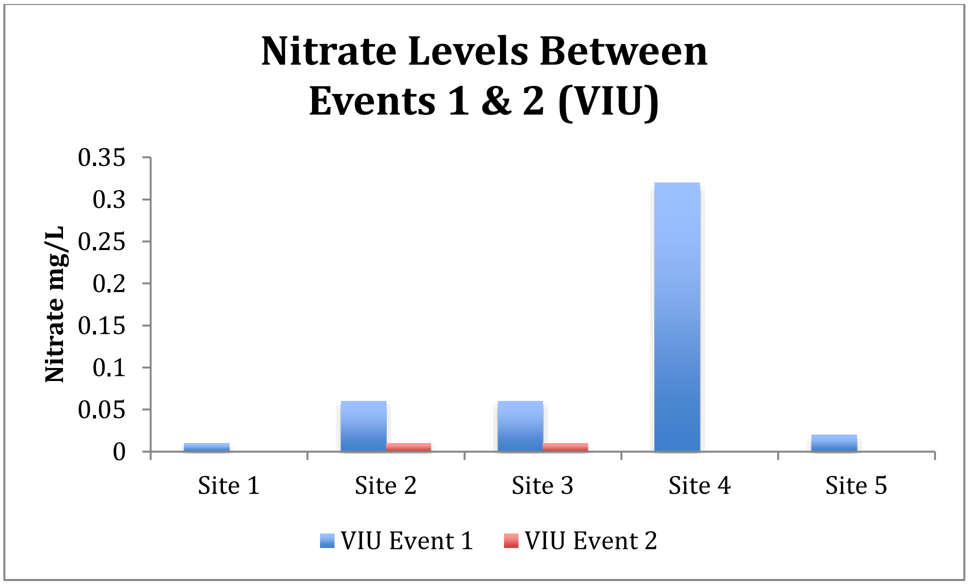

Figure 6. Nitrate levels of sampling sites analyzed at the VIU laboratory comparing events 1 and 2. Note, VIU data was not collected for site 1 during event 2 and nitrate levels were below the minimum detection limit of 0.01 mg/L for sites 4 and 5 during event 2.

Phosphate

Phosphate levels sampled during events 1 and 2 (figure 7) and analyzed at VIU were variable across all 5 sites. This trend was similar in ALS analysis as well as previous C. W. Young channel reports. As with nitrate, higher phosphate levels were found as distance downstream increased with the exception of site 5 being in the Englishman River. VIU analyses found phosphate levels were between 0.06 mg/L and 0.14 mg/L which put the C. W. Young Channel within the eutrophic level of >0.03 mg/L; however, ALS results were from 0.009 mg/L and 0.0273 mg/L which puts the channel from oligotrophic <0.01 mg/L and mesotrophic 0.01 mg/L to 0.03 mg/L. As previously with nitrate, this variance is likely due to the advanced equipment and methods used by the ALS lab. It should be noted that ALS measures for total phosphorus while VIU measures for Phosphate.

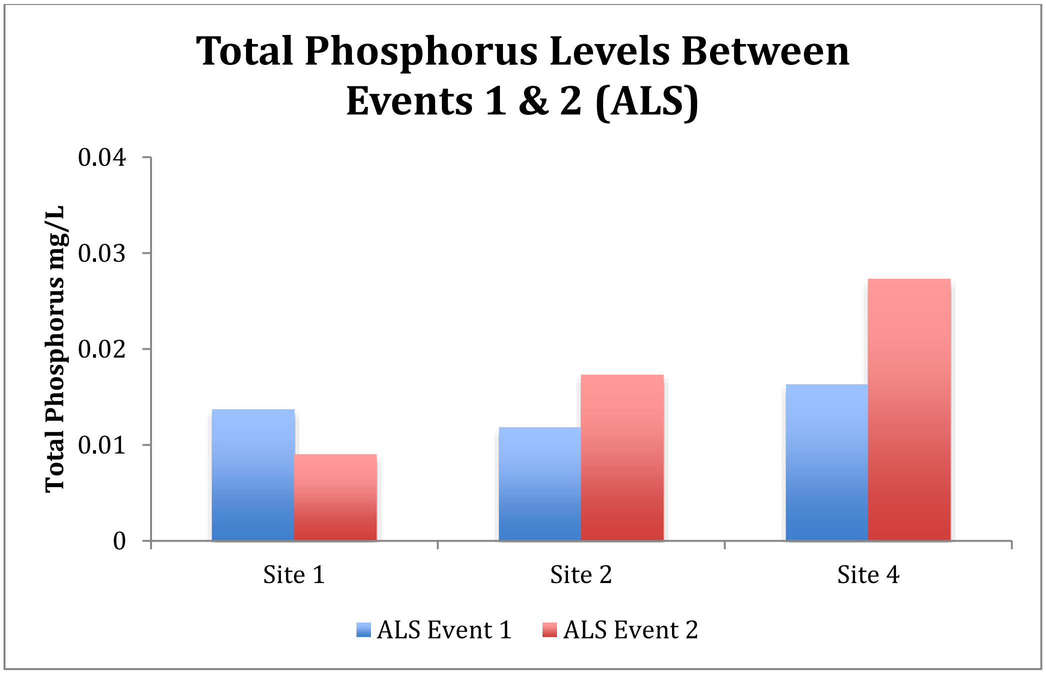

Figure 7. Total phosphorus levels of sampling sites analyzed by ALS. Note, phosphate levels of <0.01 mg/L is oligotrophic, 0.01 mg/L to 0.03 mg/L is mesotrophic and >0.03 mg/L are considered eutrophic.

Turbidity

On average, turbidity levels (figure 8) decreased between events 1 and 2 and decreased with distance downstream. These results are likely due to the amount of rainfall between each sampling event and the flow rate over the length of the channel. The C. W. Young Channel runs through a series of large pools that allow for settlement of suspended solids. Turbidity levels were below the BC Water Quality Guidelines for aquatic life of 5 NTU's.

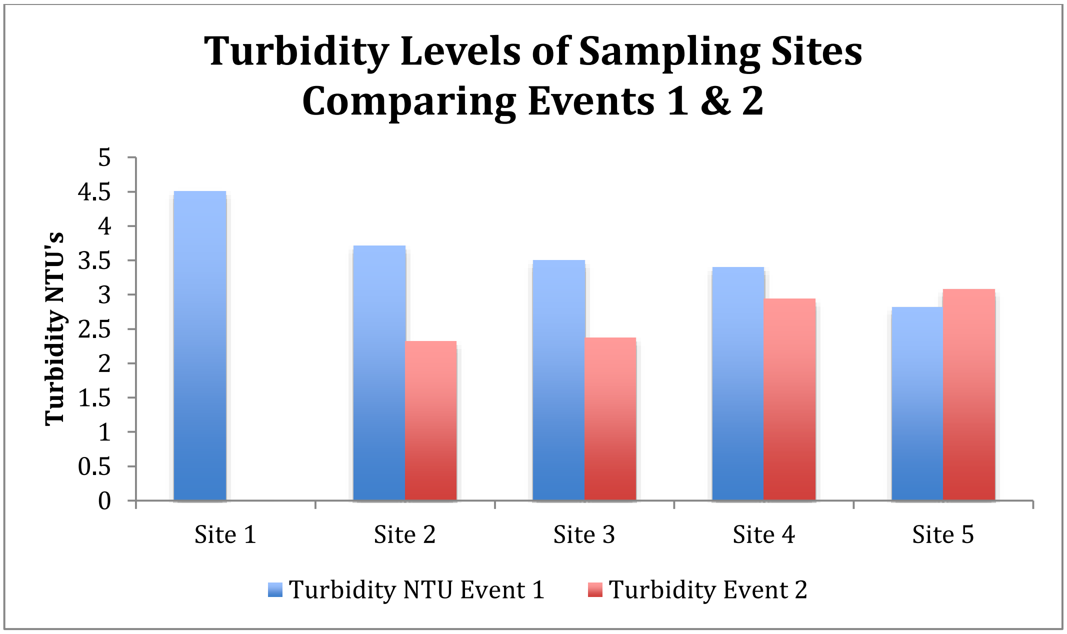

Figure 8. Turbidity levels of sampling sites comparing events 1 and 2 showing a decrease in turbidity as distance downstream increases. Note data was not collected for site 1 during event 2 and site 5 is located in the Englishman River main stem not the C. W. Young Channel.

Microbiology

All sites for event 1 was tested for presence of coliform bacteria and all sites were observed to have fecal coliforms (Table 5) there was a trend of increasing coliform counts from site 1 through to site 3. Site 4 was observed to have a decrease in coliform counts with the highest coliform count at site 5. Site 5 is located fairly close to a walking trail. The overall presence of fecal coliform in the channel could be due to the high park usage of dog walkers, horseback riding, wildlife, potentially abandoned wells within the watershed. This does not affect the water quality for aquatic life and does indicated the water requires treatment for drinking water.

Table 5. Coliform counts from sampling sites during event 1.

Microbiology	Total Coliform CFU/100ml	Fecal Coliform CFU/100ml	Fecal Coliform %
Site 1	196	16	8.16
Site 2	128	60	46.88
Site 3	304	124	40.79
Site 4	220	44	20.00
Site 5	328	100	30.49

4.2.3 ALS Laboratory Analysis

On October 31, 2016 and November 21, 2016 water samples were collected and sent to the ALS Laboratory in Burnaby, B.C. to provide quality assurance of the analyses. The parameters measured at ALS Laboratory include conductivity, hardness, pH, anions, nutrients, and total metals (Appendix 2.1) and were the water samples were collected from sites

Water samples were collected from sites 1, 2, and 4 and the results were compared to the B.C. Water Quality Guidelines for Aquatic Life. Though ALS analyses results for the water quality parameters measured, were consistently higher, the trends between VIU laboratory and ALS laboratory results were observed to be similar. The variance between results is likely attributed to the different analyses equipment used between the laboratories with ALS equipment having a higher accuracy and sensitive detection limits.

All results for metals measured by ALS, were below the BC Water Quality guidelines, except for aluminum and iron. Aluminum was observed to higher than BC Water Quality maximum guidelines for aquatic life at both sampling events and at each site, 1, 2, and 4. As well as iron was detected at higher than BC Water Quality maximum guidelines during sampling event 1 at sites 2 and 4.

The presence of aluminum and iron could be attributed to light industrial production in the area, disturbances of the ground through road construction, faulty sewage systems, abandoned mines etc. within the watershed.

4.2.4 Quality Assurance / Quality Control

Multiple measures were taken to ensure quality assurance of samples taken during the project. All sample bottles used for VIU analysis were pre cleaned and labeled prior to fieldwork, and rinsed three times before sample collection. Hands were kept clean by using hand sanitizer before any contact with sample bottles before during and after sampling and transportation. A cooler with ice packs was used to store samples during fieldwork and transportation and samples were placed in a fridge at 4° C and stored for a minimum of three days to slow biochemical activity ensuring freshness. ALS supplied sample bottles contained preservatives in the form of acids to keep metals suspended for analysis.

Quality was controlled by taking a blank sample provided to us before each sampling event by Dr. Demers. The trip blank sample was pre cleaned and filled with distilled water, this trip blank sample was used to test for contamination in storage and transportation. A replicate sample was taken at a randomly selected site during each sampling event to ensure precision in sampling methods. In the field sampling was conducted within the same area of each site each time to ensure reproducibility.

4.3. Stream Invertebrate Communities

Sampling on October 31/2016 at the Englishman River / C. W Young Channel provided our group with a total number of invertebrates of 262 between sites 1, 3, and 4 with a total Taxa of 27. Samples were taken at medium stream flow rate, however this system is controlled by a valve, therefore the flow is regulated and stays relatively the same. This means samples taken in low, medium, or high flow rates should not differ in stream invertebrate numbers counted. The numbers varied from each site but overall the dominant species included Mayfly Nymphs, and Midge Larva (Appendix 3). Samples from the Englishman River / C.W Young Channel had an average rating between 2.25 to 3.25 for abundance and density. The rating is taken off the Invertebrate Survey Interpretation Sheet used based on levels 4 to 1, 4 beings good and 1 poor. These sites ranged in the area of marginal to acceptable on the overall site assessment (Appendix 3).

4.3.1. Total Density

The Three sites differed in density throughout the system. Site 4 showed the highest number of organisms at which 172 were counted and showed a density of 637.03/m^2. Site 1 had the second highest count at 63 organisms with a density of 233.33/m^2. The lowest count came from site 3 at 27 organisms counted; this showed a density of 100/m^2 (Appendix 3.3)

4.3.2. Taxon Richness and Diversity

Although site 4 had the highest number of pollutant intolerant species at 140 mayfly nymphs, and 15 stonefly nymphs, it was scored as poor in the Predominant Taxon Ratio Index at 0.8139. Site 3 also showed a higher number in pollutant intolerant species with 22 mayfly nymphs and 2 stonefly nymphs. Site 1 still showed a poor Predominant Taxon Ratio Index t 0.8148. Site 1 differed in both predominant species and Predominant taxon Ratio Index. Site 1 had a predominant species of Midge Larva at 20 counted. This gave a good Predominant Taxon Ratio Index of 0.3174 (figure 9).

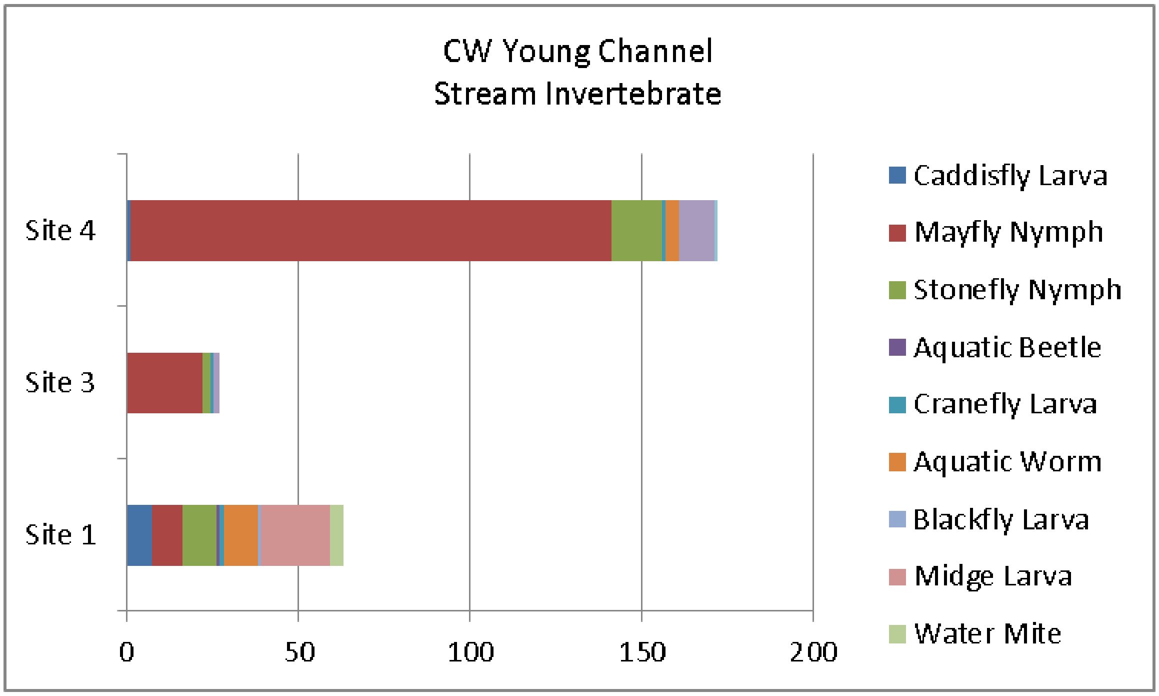

Figure 9. Invertebrate diversity within the C. W. Young Channel during sampling event 1. Note large amount of mayfly nymphs in site 4.

The Midge Larva is a pollution tolerant species (Appendix 3). Although Site 1 showed a different predominant taxon, Mayfly Nymphs were present in good numbers and overall a predominant species throughout each site, this is accurate in comparison with previous year's results that date back to 2008. The Shannon-Weiner Diversity Index was calculated for all three sites. Site 1 index was calculated at 0.84, which was the highest calculation between sites 1, 3, and 4 and shows equal abundance. Site 3 was calculated at 0.49 from 4 different species. This shows a low number if species distribution. The lowest calculated Shannon-Weiner Index was site 4, being 0.37 between

7 species. The average rating between all sites was 0.57 and shows a lower distribution of species throughout.

4.3.3. Quality Assurance / Quality Control

Three sample replicates were taken at each site in similar stream substrates to ensure quality assurance within sites. All samples undertaken were conducted by the same two group members to ensure similar techniques used. The samples were taken in pre-cleaned and rinsed on site containers. These sample invertebrates were kept alive in water, rather than ethanol from previous year's studies, and kept in a cooler with icepacks during the sampling process and then stored in a fridge until laboratory work.

5. CONCLUSION AND RECOMMENDATIONS

After conducting our assessments on the C.W Young Channel and analyzing the water samples from event 1 (October 31, 2016) and event 2 (November 21, 2016) for water quality, microbiology, basic hydrology and stream invertebrate health we have concluded that the C.W Young Channel continues to be a healthy ecosystem.

When reviewing water quality we had compared our findings with British Columbia's Water Quality Guidelines and found that most of the parameters had fallen within the allotted amount for aquatic life. The only parameter that did not fall within the Guidelines was the total Aluminum content. We found that our sites had a slightly more total aluminum content that what the guidelines had stated. This was a trend that was apparent in the previous studies conducted by students from the Bachelor of Natural Resource Protection degree program.

Our microbiology assessment for fecal and non-fecal coliforms was relatively high. The amount of fecal coliforms in our samples was found to be higher than British Columbia’s Water quality lines for drinking water. However, the amount of coliforms was under the guideline for aquatic life. We suspect that the overall high fecal coliforms were present due to the recreation use of the park and a high number of wildlife in the area like spawning salmon and bears.

The stream invertebrate assessment for each of the three sites showed that the stream had a lot of relatively pollution intolerant species which suggests a healthy stream. The C.W young channel sites ranged in the area of marginal to acceptable on the overall site assessment which adds to the conclusion that this is a healthy stream. The average Shannon-Weiner Index for the C.W young channel was 0.57.

Our stream assessment concludes that the C.W Young Channel is relatively healthy, however it is recommended that the program continues to monitor the stream as the data will be important going into the future. Watching how the channel changes overtime will be of interest as more development could potentially put the stream at risk.

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APPENDIX

1. Photos

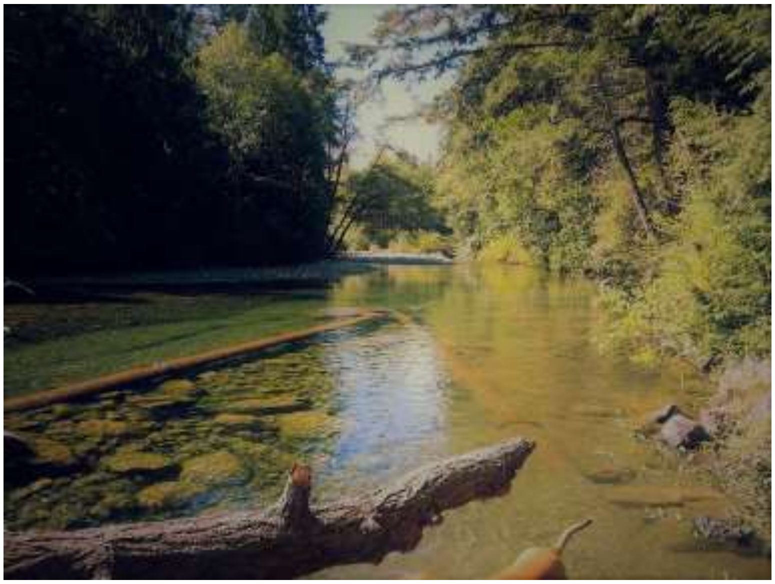
1.1 Englishman River Main Stem Showing Water Intake Pipes.
1.2 Site 1 of C.W. Young channel, looking downstream.
1.3 Site 2 of C.W. Young channel, looking NE.
1.4 Site 3 of C.W. Young channel, looking NW.
1.5 Site 4 of C.W. Young channel, looking upstream.
1.6 Site 5 of C.W. Young channel, looking downstream (confluence with ER).
1.7 Wooden bridge over C.W. Young channel 100m upstream of confluence.
1.8 Wetlands located on north bank of C.W. Young channel.
1.9 Service road approximately 300m from orange gate off Allsbrook Rd.
1.10 Vernal pond between southbank and service rd of C.W. Young channel.
1.11 Trail along ER looking up upstream.
1.12 Northbank of ER looking up stream, large cobble and boulder substrate.
1.13 Steelhead trail along north bank of ER.
1.14 Clay banks located on southbank of ER.

2. Water Quality

2.1 ALS Lab Results for event 1 and 2

3. Invertebrate Data

3.1 Site 1 Invertebrate data sheet.
3.2 Site 1 Invertebrate site assessment sheet.
3.3 Site 3 Invertebrate data sheet.
3.4 Site 3 Invertebrate site assessment sheet.
3.5 Site 4 Invertebrate data sheet.
3.6 Site 4 Invertebrate site assessment sheet.



Photograph 1.1. Englishman River main stem and the water intake pipes for the C.W. Young Channel, approximately 300 m upstream from Site 1. Photograph by Tamara Stauffert, August 2016.

Photograph 1.2. Site 1 looking downstream on the C.W. Young Channel and at one of two blue manual water flow control valves located here and a debris screen placed mid-channel. From the water flow control valve in the photo, the second valve is located upstream approximately 15 m. *Oncorhynchus* Keta *O.* kisutch were observed swimming here. Photo by Tamara Stauffert, 31 October 2016.

Photograph 1.3. Site 2 and looking northeast across the C.W. Young Channel which is flowing from the culvert and meanders into a wetland area. Mark Walkosky obtaining water samples for analyses. An unknown species of salmon was observed swimming in the culvert. Photo by Tamara Stauffert, 31 October 2016.

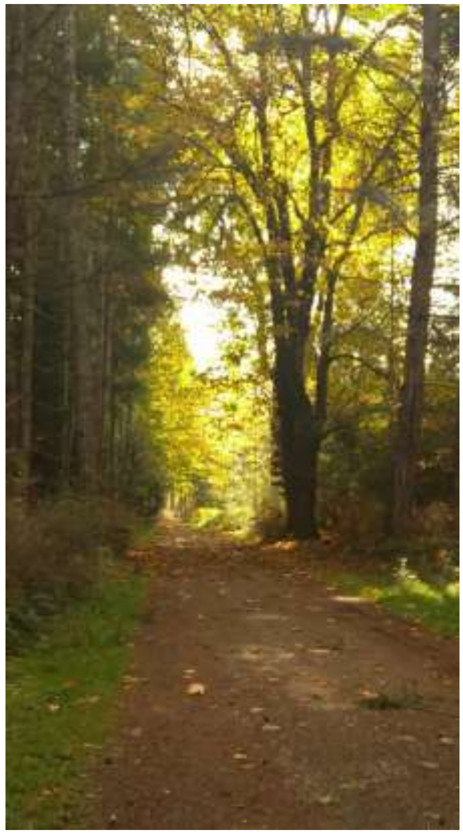
Photograph 1.4. Site 3 looking northwest across the C.W. Young Channel, fairly low/moderate water flow and a high percentage of silty substrate with mixed cobble midstream. Photo by Tamara Stauffert, 31 October 2016.

Photograph 1.5. Site 4 looking upstream into a pond on the C.W. Young Channel. Dylan MacGregor is sampling stream invertebrates following water sampling and hydrology measurements by Tristan Montjoy, Tamara Stauffert, and Mark Walkosky. Photo by Tamara Stauffert, 31 October 2016.

Photograph 1.6. Site 5 looking downstream from the input of the C.W. Young Channel into the Englishman River. Several decaying salmon carcasses were observed on the stream banks. Photo by Tamara Stauffert, 31 October 2016.

Photograph 1.7. Wooden bridge over the C.W. Young channel located approximately 100 m upstream of the channel's output into the Englishman River. Photo by Tamara Stauffert, 15 September, 2016.

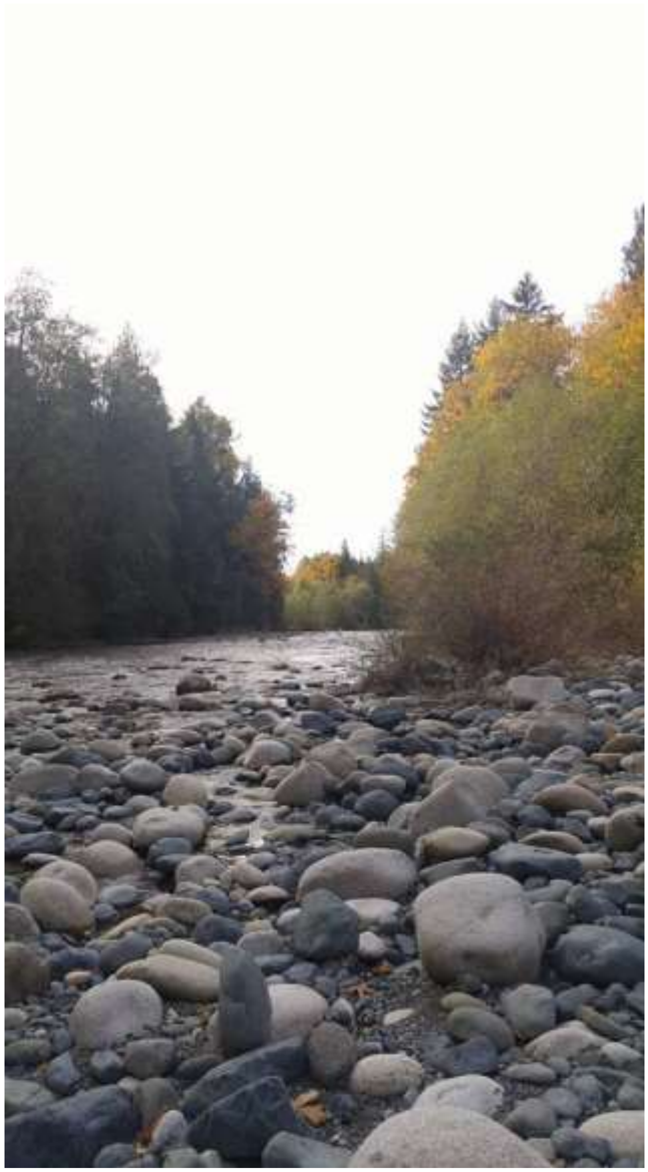
Photograph 1.8. Wetlands located on the northbank of the C.W. Young Channel, approximately 100 m southwest of the service road entrance. Photo by Tamara stauffert, 31 October, 2016.



Photograph 1.9. Approximately 300 m southwest of the service road entrance Douglas Fir and Bigleaf Maple trees surrounding the area. Photo by Tamara Stauffert, 15 September 2015.

Photograph 1.10. Vernal pond between the southbank of the C.W. Young Channel and the service road, approximately 300 m from the service road entrance. Photo taken 31 October, 2016.

Photograph 1.11. Looking upstream along a trail on the northbank of the Englishman River approximately 400 m from the output of the C.W. Young Channel into the Englishman River. Photo by Tamara Stauffert, 31 Oct, 2016.



Photograph 1.12. Looking upstream along the northbank of the Englishman River, approximately 800 m from the service road entrance. Note the large cobble and boulders

indicative of high flow events. Photo By Tamara Stauffert, 31 Oct, 2016.

Photograph 1.13. Located on the Steelhead Trail along the northbank of the Englishman River, approximately 1,200 m from the service road entrance. Photo by Tamara Stauffert, 31 Oct, 2016.

Photograph 1.14. The Clay Banks located on the southbank of the Englishman River approximately 1.5 km upstream from the outlet of the C.W. Young Channel into the Englishman River. This is a concern for erosion and silt deposition into the Englishman River. Photo by Tamara Stauffert, 31, Oct 2016.

2.2 ALS water quality parameters.

Notations

The results are expressed as mg/L except for pH (not expressed in units) and conductivity (µg/cm)
BC Water Quality Guidelines compiled from:
http://www.env.gov.bc.ca/wat/wq/BCguidelines/approv_wq_guide/approved.html
http://www.env.gov.bc.ca/wat/wq/BCguidelines/working.html
and Dr. Eric Demers from:
http://wordpress.viu.ca/rmot306/files/2016/08/VIU-CW-Young-Channel-WQ-Report-2008.pdf

a: Total ammonia guideline is dependent on water temperature and pH. Guideline shown is based water temperature of 7-8°C and a pH of 7.4-8.0 of the water tested.

b: Nitrite guideline is dependent on chloride concentration. Guideline range shown is based on chloride concentration of <2 mg/L.

c: Total Phosphorous <10µg/L oligotrophic - 10-25µg/L mesotrophic - >25µg/L eutrophic
This can be due to sewage treatment plant, agriculture, urban and industrial development

d: Aluminum guidelines for pH ≥ 6.5. Either measured in total or dissolved state in water. It is quickly absorbed into sediments. It is not a serious public health threat. It is important in areas of acidic inputs since it can cause deformation of embryos at low pH. Anthropogenic sources: industrial effluent especially from dye or paper manufacturing, acid mine drainage.

e: Cadmium is measured either in total or dissolved state in water. maximum guideline is 0.001 * 10{0.86 [log(hardness)] - 3.2}mg/L. This guideline is based on hardness of 15-28 mg/L. It has cumulative and highly toxic effects in all chemical forms. It accumulates in plants and has been known to have extreme toxic effects on trout and zooplankton. If copper and zinc are present, it is known this can increase cadmium's toxicity. Anthropogenic sources: industrial effluents,(also can be due to the release of effluents into the atmosphere), and mining.

f: Copper maximum guideline is 0.001 * [0.094(hardness) + 2] mg/L. Is measured in the total or dissolved state in water. Copper is essential for all plant and animal nutrition but can make water distasteful to drink. Prolonged exposure may result in liver damage. It is acutely toxic to most forms of aquatic life at fairly low concentrations. If a large amount of molybdenum is present in forage crops, copper can alleviate molybdenum toxicity and halt onset of molybdenosis in ruminants.

g: Iron maximum guideline is 1 mg/L for total Iron and 0.35 mg/L for dissolved iron. Iron is important for all life forms. At times, total iron concentration in watermay exceed the guideline due to natural cases. (this is true for total iron but not dissolved iron). Usually this is caused by high loads of suspended solids in water during high flow events and the iron's association with it.

h: Lead lowest effect level is 0.031 mg/L. It is measured as either the total or dissolved form in water. Lead is insoluble and absorbed strongly into sediment. It is toxic to all life forms and accumulates in the skeletal system. It is more soluble in soft water than in hard and most natural BC waters contain less than 3 µg/L of lead. Toxic effects decrease with increasing dissolved oxygen and water hardness. Anthropogenic inputs: urban developments, industrial effluents, mining, leaded fuel, motor oils, smelting and refining, batteries(production and disposal).

i: Manganese The BC maximum manganese guideline is 0.01102 * (hardness) + 0.54 mg/L

j: Silver maximum guideline is 0.0001 mg/L for hardness ≤100 mg/L.

k: Zinc maximum guideline is 0.033 mg/L for hardness ≤90 mg/L. Zinc is an essential element in trace amounts for all life forms and relatively non toxic to terrestrial organisms. Acute and chronic toxicity occurs in aquatic organisms, especially fish. Zinc toxicity decreases with increasing hardness and increases with increasing temperature and increases with dissolved oxygen. The concentration of zinc in the natural BC waters is usually low and occasionally high levels have been noted. Anthropogenic inputs: industrial effluent (paint, rubber, textiles, printing) mining activity through bedrock, urban runoff, fertilizers, pesticides, burning fossil fuels.

The BC Water Quality maximum guidelines for these metals are lower than the analytical detection limits of ALS laboratories

3.1 Invertebrate survey data sheet for site 1.

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Englishman River, CW Young Channel	Date:	Nov 2, 16
Station Name:	Site #1	Flow status:	Medium
Sampler Used: Hess Sampler	Number of replicates: 3	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates	0.09x3=0.27 0.27m^2

Column A	Column B	Column C	Column D
Pollution Tolerance	**Common Name**	**Number Counted**	**Number of Taxa**
Category 1	Caddisfly Larva (EPT)	EPT1 7	EPT4 1
	Mayfly Nymph (EPT)	EPT2 9	EPT5 2
	Stonefly Nymph (EPT)	EPT3 10	EPT6 2
Pollution Intolerant	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		C1 26	D1 5
Category 2	Alderfly Larva		
	Aquatic Beetle	1	1
	Aquatic Sowbug		
Somewhat Pollution Tolerant	Clam, Mussel		
	Cranefly Larva	1	1
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)		
	Watersnipe Larva		
Sub-Total		C2 2	D2 2
Category 3	Aquatic Worm (oligochaete)	10	1
	Blackfly Larva	1	1
	Leech		
Pollution Tolerant	Midge Larva (chironomid)	20	2
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite	4	2
Sub-Total		C3 35	D3 6
TOTAL		CT 63	DT 13

3.2 Invertebrate survey site assessment sheet for site 1.

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: S1 63

DENSITY: Invertebrate density per total area sampled:

S1 63 √ 0,27m^2 = S2 233.333/ m^2

PREDOMINANT TAXON:

Invertebrate group with the highest number counted (Col. C) S3 Midge Larva 20

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	S4
>22	17-22	11-16	<11	3 x 5 + 2 x 2 + 6 =	25

EPT INDEX: Total number of EPT taxa.

Good	Acceptable	Marginal	Poor	EPT4 + EPT5 + EPT6	S5
>8	5-8	2-4	0-1	1 + 2 + 2 =	5

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	S6
0.75-1.0	0.50-0.74	0.25-0.49	<0.25	(7 + 9 + 10) / 63 =	0.41269

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 13 S7 13

PREDOMINANT TAXON RATIO INDEX: Number of invertebrate in the **predominant taxon** (S3) divided by CT.

Good	Acceptable	Marginal	Poor	Col. C for S3 / CT	S8
<0.40	0.40-0.59	0.60-0.79	0.80-1.0	20 / 63 =	0.3174

SECTION 4 - OVERALL SITE ASSESSMENT RATING

SITE ASSESSMENT RATING: Assign a rating of 1-4 to each index (S4, S5, S6, S8), then calculate the average.

Assessment Rating	
Good	4
Acceptable	3
Marginal	2
Poor	1

Assessment	Rating
Pollution Tolerance Index	R1 4
EPT Index	R2 3
EPT To Total Ratio	R3 2
Predominant Taxon Ratio	R4 4

Average Rating
Average of R4, R5, R6, R8
3.25

3.3 Invertebrate survey data sheet for site 3.

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Englishman River, CW Young Channel	Date:	Nov 2, 16
Station Name:	Site #3	Flow status:	Medium
Sampler Used: Hess Sampler	Number of replicates 3	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.09x3=0.27	$0.27m^2$

Column A	Column B	Column C	Column D
Pollution Tolerance	**Common Name**	**Number Counted**	**Number of Taxa**
Category 1	Caddisfly Larva (EPT)	EPT1	EPT4
	Mayfly Nymph (EPT)	EPT2 22	EPT5 2
	Stonefly Nymph (EPT)	EPT3 2	EPT6 1
Pollution Intolerant	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		C1 24	D1 3
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
Somewhat Pollution Tolerant	Clam, Mussel		
	Cranefly Larva	1	1
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	2	1
	Watersnipe Larva		
Sub-Total		C2 3	D2 2
Category 3	Aquatic Worm (oligochaete)		
	Blackfly Larva		
	Leech		
Pollution Tolerant	Midge Larva (chironomid)		
	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		C3 0	D3 0
TOTAL		CT 27	DT 5

3.4 Invertebrate survey site assessment sheet for site 3.

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: S1 27

DENSITY: Invertebrate density per total area sampled:

S1 27 √ 0.27m² = S2 100/ m²

PREDOMINANT TAXON: S3 Mayfly Nymph 22

Invertebrate group with the highest number counted (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	17-22	11-16	<11

3 x D1 + 2 x D2 + D3

3 x 3 + 2 x 2 + 0 = S4 13

EPT INDEX: Total number of EPT taxa.

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

EPT4 + EPT5 + EPT6

0 + 2 + 1 = S5 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

(0 + 22 + 2) / 27 = S6 0.8888

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 5 S7 5

PREDOMINANT TAXON RATIO INDEX: Number of invertebrate in the **predominant taxon** (S3) divided by CT.

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

Col. C for S3 / CT

22 / 27 = S8 0.8148

SECTION 4 - OVERALL SITE ASSESSMENT RATING

SITE ASSESSMENT RATING: Assign a rating of 1-4 to each index (S4, S5, S6, S8), then calculate the average.

Assessment Rating	
Good	4
Acceptable	3
Marginal	2
Poor	1

Assessment	Rating
Pollution Tolerance Index	R1 2
EPT Index	R2 2
EPT To Total Ratio	R3 4
Predominant Taxon Ratio	R4 1

Average Rating
Average of R4, R5, R6, R8
2.25

3.5 Invertebrate survey data sheet for site 4.

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name:	Englishman River, CW Young Channel	Date:	Nov 2, 16
Station Name:	Site #4	Flow status:	Medium
Sampler Used: Hess Sampler	Number of replicates 3	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.09x3=0.27	$0.27m^2$

Column A	Column B	Column C	Column D
Pollution Tolerance	**Common Name**	**Number Counted**	**Number of Taxa**
Category 1	Caddisfly Larva (EPT)	EPT1 1	EPT4 1
	Mayfly Nymph (EPT)	EPT2 140	EPT5 3
	Stonefly Nymph (EPT)	EPT3 15	EPT6 1
Pollution Intolerant	Dobsonfly (hellgrammite)		
	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		C1 156	D1 5
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
Somewhat Pollution Tolerant	Clam, Mussel	1	1
	Cranefly Larva	1	1
	Crayfish		
	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	10	1
	Watersnipe Larva		
Sub-Total		C2 12	D2 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		C3 4	D3 1
TOTAL		CT 172	DT 9

3.6 Invertebrate survey site assessment sheet for site 4.

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell **CT**: S1 172

DENSITY: Invertebrate density per total area sampled:

S1 172 √ 0.27m² = S2 637.03/ m²

PREDOMINANT TAXON: S3 Mayfly Nymph 140

Invertebrate group with the highest number counted (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	S4 22
>22	17-22	11-16	<11	3 x 5 + 2 x 3 + 1 =	

EPT INDEX: Total number of EPT taxa.

Good	Acceptable	Marginal	Poor	EPT4 + EPT5 + EPT6	S5 5
>8	5-8	2-4	0-1	1 + 3 + 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	S6 0.906
0.75-1.0	0.50-0.74	0.25-0.49	<0.25	1 + 140 + 15) / 172	

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell **DT**: 9 S7 9

PREDOMINANT TAXON RATIO INDEX: Number of invertebrate in the **predominant taxon** (S3) divided by CT.

Good	Acceptable	Marginal	Poor	Col. C for S3 / CT	S8 0.8139
<0.40	0.40-0.59	0.60-0.79	0.80-1.0	140 / 172 =	

SECTION 4 - OVERALL SITE ASSESSMENT RATING

SITE ASSESSMENT RATING: Assign a rating of 1-4 to each index (S4, S5, S6, S8), then calculate the average.

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

Average Rating

Average of R4, R5, R6, R8

3